Appendix E-1a

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project

Final Modeling Protocol

June 27, 2018

This page intentionally left blank.

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project
Final Modeling Protocol

Prepared for:
SESARM, Inc.
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

June 27, 2018

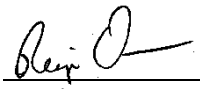
Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

TITLE and APPROVAL SHEET

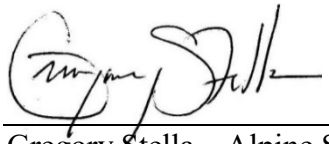
Modeling Protocol Plan for
Southeastern VISTAS II Regional Haze Analysis Project for
SESARM (Final)

This Modeling Protocol is approved by the undersigned and effective on the latest date signed by any party. The organizations implementing the project are Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine).



6/27/2018

Regi Oommen – ERG Program Manager and Technical Project Coordinator — Date



6/27/2018

Gregory Stella – Alpine Subcontract Manager — Date

6/27/2018

John Hornback – SESARM Executive Director — Date

This page is intentionally blank.

Contents

Page

1.0 INTRODUCTION 1
1.1 Overview 1
1.2 Study Background 3
1.2.1 Natural and Current Base Model Period DV Values at the VISTAS Class I Areas 6
1.2.2 Purpose 7
1.3 Lead Agency and Principal Participants 7
1.4 Related Regional Modeling Studies 7
1.4.1 EPA Preliminary 2028 Regional Haze Modeling 7
1.4.2 Maine Department of Environmental Protection Tracking Visibility Progress 2004-2016 9
1.5 Overview of Modeling Approach 10
1.5.1 Episode Selection 10
1.5.2 Model Selection 10
1.5.3 Base and Future Year Emissions Data 11
1.5.4 Emission Input Preparation and QA/QC 11
1.5.5 Meteorology Input Preparation and QA/QC 11
1.5.6 Initial and Boundary Conditions Development 11
1.5.7 Air Quality Modeling Input Preparation and QA/QC 11
1.5.8 Model Performance Evaluation 12
1.5.9 Diagnostic Sensitivity Analyses 12
1.5.10 Future Year Significant Contribution Modeling 12
1.6 Project Participants and Contacts 12
1.7 Communication 13
1.8 Schedule 13
2.0 MODEL SELECTION 16
3.0 EPISODE SELECTION 20
4.0 MODELING DOMAIN SELECTION 21
4.1 Horizontal Domains 21
4.2 Vertical Modeling Domain 22
5.0 DATA AVAILABILITY 23
5.1 Emissions Data 23
5.2 Ambient Air Quality Observations 23
5.3 Meteorological Data 23
5.4 Ozone Column Data 24
5.5 Photolysis Rates 24

5.6 Land Use 24
5.7 Initial and Boundary Conditions Data 24

6.0 MODEL INPUT PREPARATION PROCEDURES 26
6.1 Meteorological Inputs 26
6.1.1 WRF Model Science Configuration 26
6.1.2 WRF Input Data Preparation Procedures 26
6.1.3 WRF Model Performance Evaluation 26
6.1.4 WRFCAMx/MCIP Reformatting Methodology 27
6.1.5 Windowing from EPA 12US2 to VISTAS_12 27
6.2 Emission Inputs 27
6.2.1 Available Emissions Inventory Datasets 27
6.2.2 2011 Base Year Emissions 28
6.2.3 2028 Projection Year Emissions 28
6.3 Emissions Processing 31
6.3.1 QA/QC of CAMx-Ready Emission Files 33
6.4 Photochemical Modeling Inputs 34
6.4.1 CAMx Science Configuration and Input Configuration 34
6.4.2 VISTAS_12 Boundary And Initial Conditions 36
6.4.3 VISTAS_12 Ozone Column 36
6.4.4 Photolysis Rates 36
6.4.5 CAMx Land Use 36
6.5 EPA 2011 and 2028 Base Case Confirmation 36
6.5.1 Differences Between EPA And VISTAS Simulations 37
6.5.2 Confirmation Methodology 37

7.0 MODEL PERFORMANCE EVALUATION 39
7.1 Model Performance Evaluation 39
7.1.1 Overview of EPA Model Performance Evaluation Recommendations 39
7.1.2 VISTAS II Calculated Model Evaluation Statistics 40
7.1.3 Model Performance Evaluation For Weekly Wet And Weekly Dry Deposition Species 42
7.2 Performance Goals and Benchmarks 43
7.2.1 Diagnostic Evaluation 45

8.0 AREA OF INFLUENCE 46

9.0 FUTURE YEAR MODELING 55
9.1 Regional Haze Rule Requirements 55
9.2 Future Year to be Simulated 55
9.3 Future Year Baseline Air Quality Simulations 55
9.4 Calculation of 2028 Visibility 56

9.5 Comparison to Regional Haze "Glidepath" 58
10.0 PSAT SOURCE APPORTIONMENT 59
10.1 Process for Creating PSAT Contributions for Class I Areas 60
11.0 MODELING DOCUMENTATION AND DATA ARCHIVE 63
12.0 REFERENCES 64

TABLES

Table 1-1. VISTAS Region Federal Class I Area List....4
Table 1-2. Natural Conditions and Base Year Deciview (dv) Values on the 20% Clearest and 20% Most Impaired Days at each VISTAS Class I Area for the Base Model Period (2009-2013)....6
Table 1-3. Key Participants and Contact Information for the VISTAS II Modeling Study....12
Table 1-4. Initial Key Deliverables and Dates for the VISTAS II Modeling Through the 2028 Source Apportionment Reporting....14
Table 4-1. VISTAS II Modeling Domain Specifications....22
Table 4-2. WRF and CAMx Layers and Their Approximate Height Above Ground Level....22
Table 5-1. Overview of Routine Ambient Data Monitoring Networks....25
Table 6-1. VISTAS II Simulation Periods....35
Table 6-2. CAMx Simulations for the VISTAS II Project....35
Table 7-1. Fine Particulate Matter Performance Goals and Criteria....44
Table 7-2. Species Mapping from CAMx into Observation Network....45
Table 8-1. IMPROVE Monitors in the VISTAS_12 Domain....47
Table 8-2. Representative IMPROVE Monitor for Each VISTAS Class I Area....50
Table 9-1. SMAT-CE Settings for 2028 Visibility Calculations....57
Table 9-2. Matching of CAMx Raw Output Species to SMAT Input Variables....58
Table 10-1. Matching of CAMx Raw Output Species to SMAT Input Variables....59
Table 10-2. Matching of "Bulk Raw Species", PSAT Output Species, and SMAT Input Variables....60
Table 10-3. Tagged Contribution Calculation Example....61

FIGURES

Figure 1-1. VISTAS Region Class I Areas....5
Figure 4-1. Map of 12km CAMx Modeling Domains. VISTAS_12 Domain Represented as Inner Red Domain....21
Figure 6-1. Emission Processing Paths....32
Figure 8-1. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS 12km Domain....48
Figure 8-2. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS States....49
Figure 8-3. Example EWRT Calculations....53
Figure 8-4. Example (Q/d)*EWRT Calculations....54

ABBREVIATIONS / ACRONYM LIST

3DVAR	Three-dimensional variational
AFWA	Air Force Weather Agency
AGL	Above ground level
AL	Alabama
ARW	Advanced research WRF
AIRMoN	Atmospheric Integrated Research Monitoring Network
Alpine	Alpine Geophysics, LLC
AMET	Atmospheric Evaluation Tool
AoI	Area of Influence
AQS	Air Quality System
ARL	Air Resources Laboratory
BC	Boundary conditions
BEIS	Biogenic Emissions Inventory System
b_{ext}	Beta extinction
BNDEXTR	Program used to extract boundary conditions
CAIR	Clean Air Interstate Rule
CAMD	Clean Air Markets Division
CAMx	Comprehensive Air Quality Model with Extensions
CASTNET	Clean Air Status and Trends Network
CB6r4	Version 6 Revision 4 of the Carbon Bond chemical mechanism
CCRS	Coarse PM species (CAMx PM species)
CEM	Continuous Emissions Monitoring
CFR	Code of Federal Regulation
CIRA	Cooperative Institute for Research in the Atmosphere
Cl	Chorine
CMAQ	Community Multiscale Air Quality
CMV	Commercial marine vessel
CO	Carbon monoxide
CONUS	Continental United States
CPRM	Coarse PM
CSAPR	Cross-state Air Pollution Role
CSN	Chemical Speciation Network
CWT	Concentration weighted trajectory
d	Distance
DJF	December, January, and February
dv	Deciview
EC	Elemental carbon
EDAS	Eta data assimilation system
EF	Emission factor
EGU	Electric generating unit
EIS	Emission Inventory System
EPA	United States Environmental Protection Agency
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee

EWRT	Extinction-weighted residency time
f(RH)	Monthly relative humidity function
FAA	Federal Aviation Administration
FCRS	Crustal fraction of PM
FIPS	Federal Information Processing Standard
$f_L(RH)$	Monthly relative humidity function associated with large size distributions
FLM	Federal Land Manager
FL	Florida
FPRM	Fine Other Primary (diameter ≤2.5 µm)
FR	Federal Register
FSL	Forecast Systems Laboratory
$f_s(RH)$	Monthly relative humidity function associated with small size distribution
$f_{ss}(RH)$	Monthly relative humidity function associated with sea salt
FTP	File Transfer Protocol
g	Gram
GA	Georgia
GB	Gigabyte
GEOS	Goddard Earth Observing Station
GHRSST	Group for High Resolution Sea Surface Temperatures
GIS	Geographic Information System
H^+ as pH	Free acidity
ha	Hectare
Hg	Total mercury
HGP	Particulate mercury
HNO_3	Nitric acid
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory
IC	Initial conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
IPXWRF	Intermediate Processor for Pleim–Xiu for WRF
IPM	Integrated Planning Model
JJA	June, July, and August
K^+	Potassium ion
km	Kilometers
kv	Eddy diffusivity
KY	Kentucky
L	Liter
LAC	Light absorbing carbon
LCP	Landscape
m	Meters
m^2	Square meters
m^3	Cubic meters
MANE-VU	Mid-Atlantic/Northeast Visibility Union
MAM	March, April, and May
MAR	Marine, aircraft, and rail
mb	Millibar
MB	Mean Bias

MDA8	Daily maximum 8-hour average
MDL	Method Detection Level
MDN	Mercury Deposition Network
ME	Mean Error
MFB	Mean Fractional Bias
MFE	Mean Fractional Error
mg	Milligram
Mg^{2+}	Magnesium ion
µg	Microgram
MJO	Multi-Jurisdictional Organization
MLM	Multi-Layer Model
Mm	Megameters
Modeled	Mean Modeled value
MOVES	Motor Vehicles Emissions Simulator
MPE	Model performance evaluation
MPI	Message Passing Interface
MS	Mississippi
Na^{+}	Sodium ion
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NAICS	North American Industry Classification System
NAM-12	North American Mesoscale forecast data at the 12-km level
NC	North Carolina
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEI	National Centers for Environmental Information
NCEP	National Centers for Environmental Prediction
NH_3	Ammonia
NH_4^{+}	Ammonium ion
NLCD	National Land Cover Database
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NO_2	Nitrogen dioxide
NO	Nitric oxide
NO_3^{-}	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NODA	Notice of data availability
NO_x	Oxides of nitrogen
O_3	Ozone
OC	Organic carbon
OCM	Organic carbon mass
OM	Organic matter
OMI	Ozone Monitoring Instrument
ORIS	Plant identifier issued by U.S. Department of Energy
PAL	Particulate Aluminum
PAMS	Photochemical Assessment Monitoring System

Pb	Lead
PBL	Planetary Boundary Layer
PCA	Particulate Calcium
PEC	Primary elemental carbon
PFE	Particulate Iron
PGI	Portland Group, Inc.
PGMs	Photochemical grid models
PiG	Plume-in-Grid
PM	Particulate matter
PM_{10}-PRI	Primary particulate matter less than or equal to 10 microns in aerodynamic diameter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
$PM_{2.5}$-PRI	Primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Ammonium
PNO3	Particulate nitrate
POA	Primary organic carbon
POC	Parameter occurrence code
ppb	parts per billion
PSAT	Particulate Matter Source Apportionment Technology
PSCF	Potential Source Contribution Factor
PSI	Particulate Silicon
PSO4	Sulfate
PTI	Particulate Titanium
Q	Emissions
Q/d	Emissions over distance
QA	Quality Assurance
QC	Quality control
r	Pearson correlation coefficient
r^2	Coefficient of Determination
RH	Relative humidity
RHR	Regional Haze Rule
RPG	Reasonable Progress Goals
RRF	Relative response factor
RRTMG	Rapid Radiative Transfer Model-Global
SC	South Carolina
SCC	Source Classification Code
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SMARTFIRE	Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation
SMAT-CE	Software for Model Attainment Test - Community Edition
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SO_4^{2-}	Sulfate

SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
SON	September, October, and November
TDEP	Total Deposition
TN	Tennessee
TOMS	Total Ozone Mapping Spectrometer
TSD	Technical Support Document
URP	Uniform rate of progress
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
VA	Virginia
VISTAS	Visibility Improvement - State and Tribal Association of the Southeast
VISTAS_12	12-km modeling domain for the VISTAS study area
VMT	Vehicle Miles Travelled
VOC	Volatile organic compounds
WRF	Weather Research Forecast
WV	West Virginia
YSU	Yonsei University

This page is intentionally blank.

1.0 INTRODUCTION

1.1 Overview

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.

B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

is, the focus of state planning will be to establish reasonable progress goals for each Class I area against which progress will be measured during the second planning period. This extension will allow states to incorporate planning for other Federal programs while conducting their regional haze planning. These other programs include: the Mercury and Air Toxics Standards, the 2010 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview (dv)index values. "Most impaired days" are defined as the 20% of monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

This document serves as the air quality Modeling Protocol for SESARM's VISTAS II regional haze modeling analysis in support of estimating regional haze and progress goals at southeastern state Class I areas in projection year 2028. The reasonable progress goals must provide for a rate of improvement sufficient to attain "natural conditions" by 2064, or justify any alternative rate. States are to define controls to meet progress goals every 10 years, starting in 2018 that defines progress periods ending in 2018, 2028, 2038, 2048, 2058 and finally 2064. States will determine whether they are meeting their goals by comparing visibility conditions from one five-year period to another (e.g., 2000-2004 to 2013- 2017). As stated in 40 CFR 51.308 (d) (1), baseline visibility conditions, progress goals, and changes in visibility must be expressed in terms of dv units. The dv unit of visibility impairment is derived from beta light extinction (b_{ext}) as follows:

$$dv = 10 \ln (b_{ext}/10)$$

Where b_{ext} is expressed in terms of inverse megameters ($Mm^{-1} = (10^6 \text{ m})^{-1}$).

This Modeling Protocol describes the overall modeling activities to be performed in order to estimate regional haze and progress at southeastern state Class I areas in projection year 2028. This effort is being undertaken working closely with SESARM and other state, local, and tribal agencies.

A comprehensive Modeling Protocol for regional haze study consists of many elements. Its main function is to serve as a means for planning and communicating how a modeled analysis will be

performed before it occurs. The protocol guides the technical details of a modeling study and provides a formal framework within which the scientific assumptions, operational details, commitments and expectations of the various participants can be set forth explicitly and means for resolution of potential differences of technical and policy opinion can be worked out openly and within prescribed time and budget constraints.

As noted in the EPA regional haze modeling guidance, the Modeling Protocol serves several important functions (EPA, 2007; 2014e):

- Identify the assistance available to SESARM (the lead agencies) to undertake and evaluate the analysis needed to support the analysis;
- Identify how communication will occur among State, Local, and Federal agencies and stakeholders to develop a consensus on various issues;
- Describe the review process applied to key steps in the analysis; and
- Describe how changes in methods and procedures or in the protocol itself will be agreed upon and communicated with stakeholders and the appropriate EPA Regional Office.

1.2 Study Background

In Section 169A of the Clean Air Act, Congress established a visibility protection goal to prevent future and remedy existing impairment of visibility resulting from manmade pollution in certain national parks and wilderness areas. The statute was codified at 42 U.S. Code §7491. EPA issued regulations implementing the visibility protection mandate that may be found at 40 CFR 51.300 through 51.309. These regulations have been amended several times, most recently as published in the Federal Register on January 10, 2017.

The 1999 RHR (64 FR 35714) identified 156 parks and natural areas as “mandatory Class I Federal areas” for which goals would be established to improve visibility to natural conditions. The 18 Class I areas located in the VISTAS region are tabulated in Table 1-1 that follows. Each row contains the official Class I area name, the state(s) in which it is located, estimated total land area in acres based on current available information, and the designated Federal Land Manager (FLM). A map of the VISTAS Class I areas follows in Figure 1-1.

Table 1-1. VISTAS Region Federal Class I Area List

(State) Class I Area Name	Approx. Acreage	Federal Land Manager
AL – Sipsey Wilderness Area	12,726	USDA Forest Service
FL – Chassahowitzka Wilderness Area	23,579	USDI Fish and Wildlife Service
FL – Everglades National Park	1,399,078	USDI National Park Service
FL – Saint Marks Wilderness Area	17,350	USDI Fish and Wildlife Service
GA/TN – Cohutta Wilderness Area	GA – 35,268 TN – 1,709	USDA Forest Service
GA – Okefenokee Wilderness Area	353,981	USDI Fish and Wildlife Service
GA – Wolf Island Wilderness	5,126	USDI Fish and Wildlife Service
KY – Mammoth Cave National Park	52,830	USDI National Park Service
NC/TN – Great Smoky Mountains National Park	NC – 277,432 TN – 244,645	USDI National Park Service
NC/TN – Joyce Kilmer-Slickrock Wilderness	NC – 13,590 TN – 3,820	USDA Forest Service
NC – Linville Gorge Wilderness Area	11,651	USDA Forest Service
NC – Shining Rock Wilderness Area	18,479	USDA Forest Service
NC – Swanquarter Wilderness Area	8,800	USDI Fish and Wildlife Service
SC – Cape Romain Wilderness	29,000	USDI Fish and Wildlife Service
VA – James River Face Wilderness	8,907	USDA Forest Service
VA – Shenandoah National Park	199,173	USDI National Park Service
WV – Dolly Sods Wilderness	17,776	USDA Forest Service
WV – Otter Creek Wilderness	20,706	USDA Forest Service

USDA – United States Department of Agriculture. USDI – United States Department of Interior.

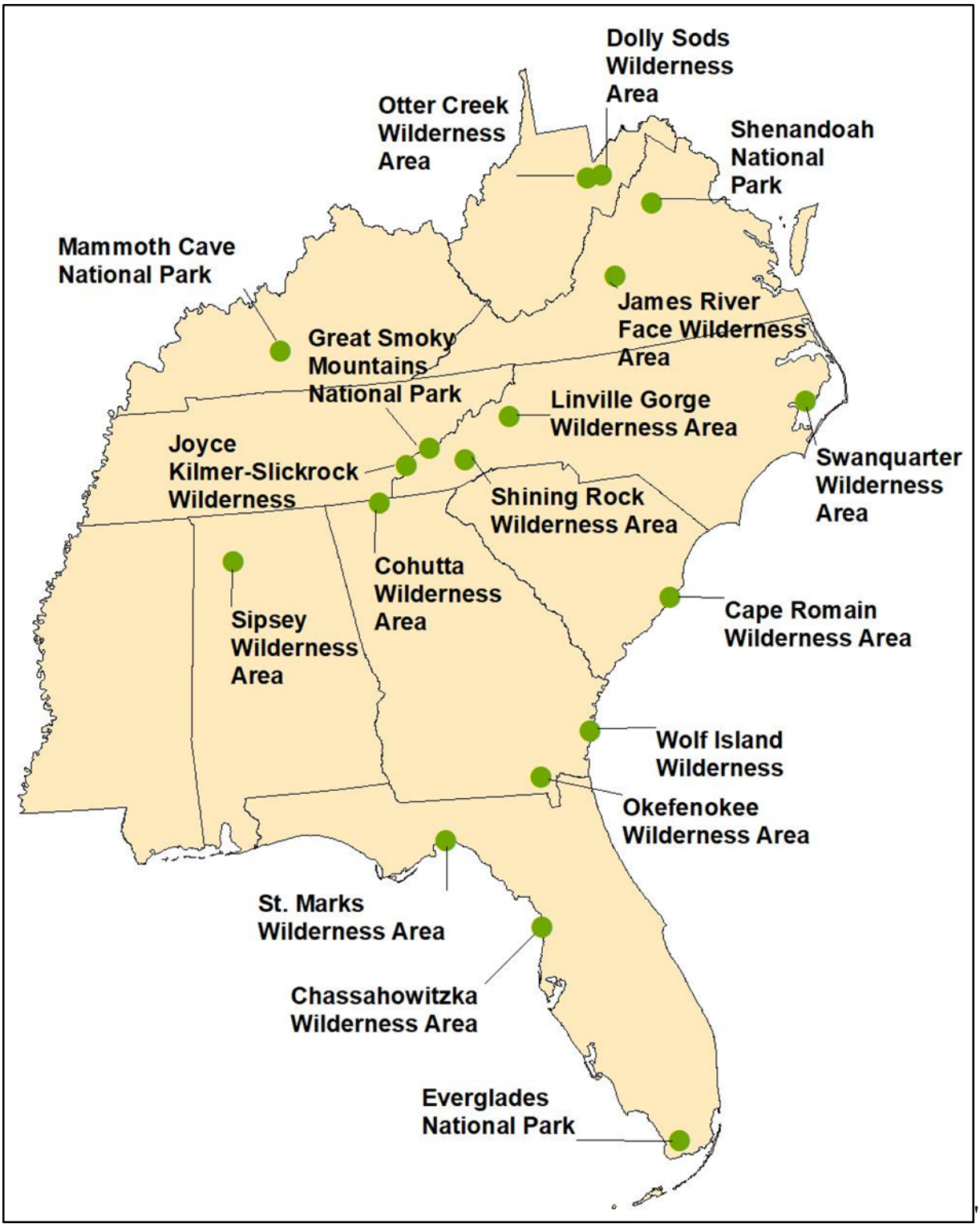


Figure 1-1. VISTAS Region Class I Areas.

The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and improve visibility systematically to reach natural visibility conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% clearest days. States were required to submit SIPs by December 17, 2007 demonstrating reasonable progress to achieve incremental visibility improvements for the 2008-2018 planning period.

The RHR requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years. States are to consult with FLMs in developing the SIPs.

1.2.1 Natural and Current Base Model Period DV Values at the VISTAS Class I Areas

Table 1-2 shows the U.S. EPA calculated natural conditions on the 20% most impaired days and dv values on the 20% clearest and most impaired days at each VISTAS Class I area for the base model period (2009-2013).

Table 1-2. Natural Conditions and Base Year Deciview (dv) Values on the 20% Clearest and 20% Most Impaired Days at each VISTAS Class I Area for the Base Model Period (2009-2013)[2]

Class I Area Site ID	Class I Area Name	IMPROVE Site ID	Natural Conditions 20% Most Impaired Days (dv)	Base Year (2009-2013) 20% Clearest Days (dv)	Base Year (2009-2013) 20% Most Impaired Days (dv)
CHAS	Chassahowitzka	CHAS1	8.97	13.76	19.94
COHU	Cohutta Wilderness	COHU1	9.52	10.94	21.19
DOSO	Dolly Sods Wilderness	DOSO1	8.92	9.03	21.59
EVER	Everglades NP	EVER1	8.34	11.23	16.30
GRSM	Great Smoky Mountains NP	GRSM1	10.05	10.63	21.39
JARI	James River Face Wilderness	JARI1	9.48	11.79	21.37
JOYC	Joyce-Kilmer-Slickrock Wilderness	GRSM1	10.05	10.63	21.39
LIGO	Linville Gorge Wilderness	LIGO1	9.70	9.70	20.39
MACA	Mammoth Cave NP	MACA1	9.79	13.69	24.04
OKEF	Okefenokee	OKEF1	9.47	13.34	20.70
OTCR	Otter Creek Wilderness	DOSO1	8.92	9.03	21.59
ROMA	Cape Romain	ROMA1	9.79	13.59	21.48
SAMA	St. Marks	SAMA1	9.19	13.33	20.11

[2] Tables 3-2 and 3-3, EPA, 2017b.

Table 1-2. Natural Conditions and Base Year Deciview (dv) Values on the 20% Clearest and 20% Most Impaired Days at each VISTAS Class I Area for the Base Model Period (2009-2013)[2]

Class I Area Site ID	Class I Area Name	IMPROVE Site ID	Natural Conditions 20% Most Impaired Days (dv)	Base Year (2009-2013) 20% Clearest Days (dv)	Base Year (2009-2013) 20% Most Impaired Days (dv)
SHEN	Shenandoah NP	SHEN1	9.52	8.60	20.72
SHRO	Shining Rock Wilderness*	LIGO1	9.70	9.70	19.91
SIPS	Sipsey Wilderness	SIPS1	9.55	12.84	21.67
SWAN	Swanquarter	SWAN1	9.79	11.76	19.76
WOLF	Wolf Island	OKEF1	9.47	13.34	20.70

* The base year model period dv value for the 20% most impaired days was adjusted to account for the effects that missing IMPROVE monitoring data for 2010 and 2011 may have on the base year model period dv. A ratio calculated for a nearby donor site, Linville Gorge Wilderness Area (i.e., the 5-year average of 2009-2013 IMPROVE data divided by the 3-year average of 2009, 2012, and 2013 IMPROVE data) was applied to the 3-year average of 2009, 2012, and 2013 data for the Shining Rock Wilderness Area to calculate the adjusted base year dv.

1.2.2 Purpose

This document serves as the first draft of the Air Quality Modeling Protocol plan for the VISTAS II Regional Haze modeling analysis to be performed by the contractor team Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine) with the purpose of estimating regional haze and progress at southeastern state Class I areas in projection year 2028. It is presumed that this information will be used by SESARM-participating states in the regional haze SIP development process.

1.3 Lead Agency and Principal Participants

SESARM is the lead agency in the development of this regional haze modeling analysis. EPA Region 4 in Atlanta, GA is the EPA Regional Office that will take the lead in the review and approval process for this project.

1.4 Related Regional Modeling Studies

There are other regional haze modeling studies related to the VISTAS II regional haze modeling analysis whose results may be useful to SESARM.

1.4.1 EPA Preliminary 2028 Regional Haze Modeling

EPA recently conducted preliminary visibility modeling (EPA, 2017b) for year 2028 with the intention of informing the regional haze SIP development process. For their assessment, air quality modeling was used to project visibility levels at individual Class I areas (represented by Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites) to 2028 and to estimate emissions sector contributions to 2028 particulate matter (PM) concentrations and visibility. The projected 2028 PM concentrations were converted to light extinction coefficients and then to dvs; these values are used to evaluate visibility progress as of

2028. In addition, 2028 visibility contribution information by major emissions source sector was calculated using particulate source apportionment technology (PSAT).

EPA found that visibility at most eastern Class I areas on the 20% most anthropogenically impaired days is projected to be below the unadjusted glidepath in 2028, with a relatively higher percentage of the light extinction due to domestic anthropogenic sources.

Based on their assessment of these results, EPA also identified a number of uncertainties and model performance issues that should be addressed in future EPA, state, multistate, or stakeholder modeling that may be used in SIP development. They have identified several aspects of this initial modeling that should be improved upon through coordination with interested stakeholders. These include, but are not limited to:

- *Expanded domain size* to reduce the impact of the boundary conditions assumptions on predictions, especially near the domain edge.
    - The boundary conditions were found to be the largest contributor to visibility at many Class I areas, especially those near the edge of the modeling domain. Expanding the regional photochemical modeling domain will potentially reduce the influence from global or hemispheric model derived boundary conditions. Those models have much coarser grid resolution and use global emissions inventories which may not be year specific or up to date.
    - There may also be recirculation of U.S. emissions in boundary conditions derived from global models, especially where the boundary is very close to the U.S. mainland. Moving the domain boundary further from the contiguous U.S. will minimize this issue.

- *Updated emission inventory and projections* for certain sectors.
    - More recent nationwide photochemical modeling has incorporated updates in future year emissions inventories that should be considered for 2028.
        - Remove the Clean Power Plan and Texas regional haze FIP from the electric generating unit (EGU) assumptions.
        - Updates to the oil and gas emissions projections.
        - New Canadian base and future year emissions.
        - Other emissions updates based on more recent information.

- *Updated boundary conditions* based on more recent modeling of international emissions as well as additional modeling to help quantify and distinguish anthropogenic and natural international contributions.
    - The 2011 boundary conditions used for the regional haze modeling came from an older version of Goddard Earth Observing System (GEOS)-Chem which did not contain the latest international emissions estimates for 2011.
    - In addition to projecting U.S. emissions to 2028, international emissions are changing between 2011 and 2028 as well. Consideration should be given to estimating future year global emissions to provide an alternate estimate of future year boundary conditions.

  - Global or hemispheric models can potentially be used to adjust the visibility glidepath for impacts from international anthropogenic sources. Sensitivity runs and additional refinements to international inventories may be needed in order to provide more confidence in the model results.

- *Improved treatment of fire and fugitive dust emissions* in the model.
  - The current Comprehensive air quality model with extensions (CAMx) modeling platform does not include estimates of natural windblown dust emissions. Windblown dust (primarily contributing to coarse mass) is an important component of regional haze in some Class I areas.
  - The current modeling used year-specific fire emissions from 2011 which may not be representative of a "typical year" or multi-year period. The IMPROVE measurements used to establish both the base period impairment measurements and progress towards natural conditions, use a five-year average of IMPROVE measurements. Therefore, alternative estimates of fire emissions, which may better represent a longer term average, may be more appropriate for use in visibility projections.
  - Further refinements of fire emissions may also allow exploration of possible adjustments of the glidepath for prescribed fire impacts.

- *Treatment of secondary organic aerosols (SOA)* should be reviewed.
  - In many locations, there is relatively high modeled SOA as a fraction of total organic aerosols. Using the RRF approach, this apportions the modeled SOA as a fraction of the measured total organics. There is considerable uncertainty in the modeled SOA concentrations, which therefore translates into uncertainty in the apportioned SOA mass.
  - Additional information can be gained by running PSAT with SOA source apportionment turned on.

- *Estimation of "natural visibility conditions"* used in the glidepath framework should be further reviewed.
  - Further refinements in the draft methodology can be explored.
  - Further analysis of the IMPROVE data combined with modeled source apportionment information may be useful in evaluating the natural conditions estimates.

All of these options were considered for this project; however due to schedule and resource constraints SESARM chose only to move forward with correcting the emission projections.

1.4.2 Maine Department of Environmental Protection Tracking Visibility Progress 2004-2016

This document (ME DEP, 2018), prepared by the Maine Department of Environmental Protection for the Mid-Atlantic/Northeast Visibility Union (MANE-VU), presents visibility trends at IMPROVE monitoring sites at federal Class I areas in and adjacent to the MANE-VU region that are subject to the USEPA's RHR. This document also presents visibility trends at IMPROVE Protocol monitoring sites in and adjacent to the MANE-VU region. The analyses

were performed to determine the extent of progress in meeting short-term and long-term visibility goals for the first RHR SIP period that ends in 2018 using metrics specified in the state SIPs.

The technical document provides an analysis of visibility data collected at the IMPROVE monitoring sites, starting in the baseline period of 2000-2004 through 2012-2016, the most recent five-year period with available data.

The results of the analysis continue to show the following:

- There continue to be definite downward trends in overall haze level at all Class I areas in and adjacent to the MANE-VU region and at IMPROVE Protocol monitoring sites.
- Based on rolling five-year averages demonstrating progress since the 2000-2004 baseline period, the MANE-VU Class I areas are on track to meet their 2018 Reasonable Progress Goals (RPGs) for both 20% clearest and 20% most impaired visibility days.
- The trends are mainly driven by large reductions in sulfate light extinction, and to a lesser extent, nitrate light extinction.
- Levels of organic carbon mass (OCM) and light absorbing carbon (LAC) appear to be approaching natural background levels at most of the MANE-VU Class I areas.
- In all cases, the levels set by 2018 RPG's have already been met, and progress beyond these goals appears achievable.
- The percent contribution of nitrate light extinction has been significantly increasing at most of the MANE-VU Class I areas.

1.5 Overview of Modeling Approach

The VISTAS II modeling proposed here will include particulate matter simulations and source apportionment studies using the 12 kilometer (km) grid based on EPA's 2011/2028el modeling platform and preliminary source contribution assessment (EPA, 2017b) updated to include a 12km subdomain over the VISTAS region and augmented with revisions to EGU and non-EGU point source projections.

1.5.1 Episode Selection

Episode selection is an important component of any modeling analysis. EPA guidance recommends that one choose time periods which reflect the variety of meteorological conditions which represent visibility impairment on the 20% clearest and 20% most impaired days in the Class I areas being modeled (high and low concentrations necessary). This is best accomplished by modeling a full year. For this analysis, Alpine will be modeling the full 2011 calendar year with 10 days of model spin-up in 2010.

1.5.2 Model Selection

Details on the rationale for model selection are provided in Section 2. The Weather Research Forecast (WRF) prognostic meteorological model was selected for the VISTAS II modeling. Emissions processing will be completed using the Sparse Matrix Operator Kernel Emissions (SMOKE) model for most source categories. The exceptions are that Biogenic Emissions

Inventory System (BEIS) model was used for biogenic emissions and there are special processors for fires, windblown dust, lightning and sea salt emissions. The 2014 Motor Vehicle Emissions Simulator (MOVES) onroad mobile source emissions model was used by EPA with SMOKE-MOVES to generate onroad mobile source emissions with EPA generated vehicle activity data provided in the 2028 regional haze analysis. The CAMx photochemical grid model, which supports two-way grid nesting will also be used. The setup is based on the same WRF/SMOKE/BEIS/CAMx modeling system used in the EPA 2011/2028el platform modeling.

During the preparation of this Modeling Protocol, it was noted that a newer version of CAMx, Version 6.50, was released (April 30, 2018). After discussions with SESARM, the CC, and the TAWG, it was decided to not use the newer version due to insufficient testing and application history necessary for to ensure confidence in modelling results.

1.5.3 Base and Future Year Emissions Data

A 2011 base year and 2028 future year will be used for the VISTAS II modeling to be consistent with the requirements of EPA's RHR. The 2011 base case and 2028 future year emissions will be founded on EPA's "el" modeling platform with no adjustments made to 2011 estimates. Updates will be made to EGU and non-EGU point source data within the VISTAS states for 2028 and the Eastern Regional Technical Advisory Committee (ERTAC) EGU v.2.7 outputs will be used for non-VISTAS EGUs in the projection year.

1.5.4 Emission Input Preparation and QA/QC

Quality assurance (QA) and quality control (QC) of the emissions datasets are critical steps in performing air quality modeling studies. Because emissions processing is tedious, time consuming and involves complex manipulation of many different types of large databases, rigorous QA measures are a necessity to prevent errors in emissions processing from occurring. The VISTAS II modeling study will utilize methods applied to the emissions platform that follows a multistep emissions QA/QC approach.

1.5.5 Meteorology Input Preparation and QA/QC

The CAMx 2011 12 km meteorological inputs will be based on WRF meteorological modeling conducted by EPA. Details on the EPA 2011 WRF application and evaluation are provided by EPA (EPA 2014d).

1.5.6 Initial and Boundary Conditions Development

Initial concentrations (IC) and Boundary Conditions (BCs) are important inputs to the CAMx model. Alpine intends to run 10 days of model spin-up before the first days occur in the modeling episode so the ICs are washed out of the modeling domain before the first day of the annual 2011 modeling period. The lateral boundary and initial species concentrations are provided by a three-dimensional global atmospheric chemistry model, GEOS-Chem (Yantosca, 2004) standard version 8-03-02 with 8-02-01 chemistry.

1.5.7 Air Quality Modeling Input Preparation and QA/QC

Each step of the air quality modeling will be subjected to QA/QC procedures. These procedures will include verification of model configurations, confirmation that the correct data were used and were processed correctly and other procedures.

1.5.8 Model Performance Evaluation

An operational model performance evaluation will be performed for particulate matter ($PM_{2.5}$ species components and coarse PM) and regional haze to examine the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. This evaluation will focus on graphical analyses and statistical metrics of model predictions versus observations.

1.5.9 Diagnostic Sensitivity Analyses

Depending on the confirmation run results of the CAMx 2011 base case modeling and MPE on Alpine's modeling system, diagnostic sensitivity tests may be conducted to try and improve model performance. The definition of these diagnostic sensitivity tests will depend on the results of the initial MPE for these domains.

1.5.10 Future Year Significant Contribution Modeling

PM predictions from 2011 and 2028 CAMx model simulations will be used to project 2009-2013 IMPROVE visibility data to 2028 following the approach described in EPA's ozone, $PM_{2.5}$ and regional haze modeling guidance (US EPA, 2014b). The guidance describes the recommended modeling analysis used to help set RPGs that reflect emissions controls in a regional haze SIP. The CAMx PSAT method will be utilized for this effort.

1.6 Project Participants and Contacts

SESARM is the lead agency in the development of the VISTAS II modeling analysis. They will work closely with other local agencies, other local cities and agencies, and EPA Region 4 in the study, including the sharing of interim results as they become available. SESARM will also work with local, state, and tribal agencies and stakeholders in the modeling analysis, where stakeholders may include environmental groups and industry. Key participants in the VISTAS II study and their contact information are provided in Table 1-3.

Table 1-3. Key Participants and Contact Information for the VISTAS II Modeling Study

Organization	Individual(s) [Role]	Address	Contact Numbers
Southeastern States Air Resource Managers, Inc. (SESARM)			
Metro 4/ SESARM	Mr. John Hornback SESARM Executive Director	Southeastern States Air Resource Managers, Inc. 205 Corporate Center Drive, Suite D Stockbridge, GA 30281-7383	(404) 361-4000 hornback@metro4-sesarm.org
EPA Region 4			
EPA Region 4	Mr. Rick Gillam Environmental Engineer	EPA Region 4 Sam Nunn Atlanta Federal Center 61 Forsyth St., SW Atlanta, GA 30303	(404) 562-9049 gillam.rick@epa.gov
Contractors (Modeling team)			
Eastern Research Group, Inc.	Mr. Regi Oommen ERG Program Manager	Eastern Research Group, Inc. 1600 Perimeter Park Drive, Suite 200	(919) 468.7829 regi.oommen@erg.com

Table 1-3. Key Participants and Contact Information for the VISTAS II Modeling Study

Organization	Individual(s) [Role]	Address	Contact Numbers
		Morrisville, NC 27560	
Eastern Research Group, Inc.	Ms. Bebhinn Do ERG Senior Scientist	Eastern Research Group, Inc. 1600 Perimeter Park Drive, Suite 200 Morrisville, NC 27560	(919) 468-7840 bebhinn.do@erg.com
Alpine Geophysics, LLC	Mr. Gregory Stella Alpine Subcontract Manager	Senior Scientist 387 Pollard Mine Road Burnsville, NC 28714	(828) 675-9045 gms@alpinegeophysics.com
Alpine Geophysics, LLC	Mr. Dennis McNally Alpine Senior Scientist	Senior Scientist 7341 Poppy Way Arvada, CO 80007	(303) 421- 2211 dem@alpinegeophysics.com

1.7 Communication

Frequent communication between SESARM and the Modeling team and other participants is anticipated. These communications will include e-mails, conference calls, and face-to-face meetings. SESARM envisions that EPA and others will review interim products as they become available so that comments can be received during the study to allow for corrective action as necessary. These interim deliverables would include, but not be limited to, preliminary CAMx model performance evaluation, preliminary current and future-year emissions assumptions and results, and preliminary future year visibility projections and source apportionment results.

1.8 Schedule

Table 1-4 lists the current schedule for the initial key deliverables under the VISTAS II modeling study.

Table 1-4. Initial Key Deliverables and Dates for the VISTAS II Modeling Through the 2028 Source Apportionment Reporting

Task	Subtask	Deliverable	Due Date
2	2.1	2011 Base year emissions inventories	6/30/2018[a]
	2.2a	Projection Year Emissions Inventory Comparisons, draft	5/18/2018
	2.2b	Projection Year Emissions Inventories, final	6/30/2018[a]
	2.3a1	2028 EGU Point Source Emissions, draft	5/18/2018
	2.3a2	2028 EGU Point Source Emissions, final	6/30/2018[a]
	2.3b1	2028 Non-EGU Point Source Emissions, draft	5/18/2018
	2.3b2	2028 Non-EGU Point Source Emissions, final	6/30/2018[a]
	2.3c1	2028 Emissions for Other Categories, draft	5/18/2018
	2.3c2	2028 Emissions for Other Categories, final	6/30/2018[a]
	2.3d1	Emission Comparisons from 2028v6.3el and 2023v6.3en, draft	5/18/2018
	2.3d2	Emission Comparisons from 2028v6.3el and 2023v6.3en, final	6/30/2018[a]
	2.3e1	2028 Documentation, draft	5/18/2018
	2.3e2	2028 Documentation, final	6/30/2018[a]
	2.4	Emissions summaries and Quality Assurance	6/30/2018[a]
3	3.1	Create Photochemical Model-Ready EGU emissions files for 2028	7/13/2018[a]
	3.1.2	Scale Hourly EGU SMOKE emissions to match annual 2028	7/13/2018[a]
	3.2	Create Photochemical Model-Ready Non-EGU emissions files for 2028	7/13/2018[a]
	3.3a	Merge EGU/non-EGU data from Subtasks 3.1 and 3.2 for CAMx Model	7/13/2018[a]
	3.3b*	Merge area/MAR data from Subtasks 3.1 and 3.2 for CAMx Model	7/13/2018[a]
4	4	Data acquisition and preparation	6/1/2018
	4.1	Acid deposition in watersheds	6/1/2018
5	5	Area of Influence Analysis	9/1/2018
	5.1	SO_2 and NO_x emissions contribution rankings	No later than 9/1/2018
6	6.1a	Modeling protocol, draft	5/2/2018
	6.1b	Modeling protocol, final	6/30/2018[a]
	6.2	2011 base year air quality modeling	9/1/2018
	6.3	2028 projection year air quality modeling	12/1/2018
7	7	Source apportionment tagging - 250 tags (final number to be determined)	4/19/2019[a]
8	8	Model performance evaluation	10/1/2018
	8.1	Model performance evaluation (related to Subtask 4.1)	10/1/2018
9	9a	Future-year model projections – 250 tags (final number to be determined)	4/19/2019
	9.1	Calculate Relative Response Factors (related to Subtask 4.1)	5/3/2019
10	10	Website/FTP Site Development; Data Transfer and Archival	Ongoing
11	11.1a	Extraction of state-specific modeling initial conditions/boundary conditions (5 states)	Within 1 week after completion of Task 6.1 and 6.2 activities

Table 1-4. Initial Key Deliverables and Dates for the VISTAS II Modeling Through the 2028 Source Apportionment Reporting

Task	Subtask	Deliverable	Due Date
	11.1b*	Additional extraction of state-specific modeling initial conditions/boundary conditions (5 states)	Within 1 week after completion of Task 6.1 and 6.2 activities
	11.2a	Extraction of state-specific meteorological files (5 states)	Within 1 week after regions are defined by the time the meteorological data is windowed for the VISTAS_12 domain
	11.2b*	Additional extraction of state-specific meteorological files (5 states)	Within 1 week after regions are defined by the time the meteorological data is windowed for the VISTAS_12 domain

[a] Revised dates based on Amendment 1, dated 5/31/2018
* Optional Task, no decision yet whether to perform it.

2.0 MODEL SELECTION

This section introduces the models to be used in the VISTAS II regional haze modeling study. The selection methodology presented in this chapter mirrors EPA's preliminary 2028 regional haze modeling (EPA, 2017b).

40 CFR Part 51 Appendix W does not identify a "preferred model" for use in reasonable progress assessments for regional haze and therefore, EPA does not recommend a specific model for use in these analyses. The latest EPA modeling guidance (EPA, 2014e) explicitly mentions the Community Multiscale Air Quality Modeling System (CMAQ) and CAMx photochemical grid models (PGMs) as the most commonly used PGMs that would satisfy EPA's selection criteria but notes that this is not an exhaustive list and does not imply that they are "preferred" over other PGMs that could also be considered and used with appropriate justification. EPA's current modeling guidelines lists the following criteria for model selection (EPA, 2014e):

- It should not be proprietary;
- It should have received a scientific peer review;
- It should be appropriate for the specific application on a theoretical basis;
- It should be used with data bases which are available and adequate to support its application;
- It should be shown to have performed well in past modeling applications;
- It should be applied consistently with an established protocol on methods and procedures;
- It should have a User's guide and technical description;
- The availability of advanced features (e.g., probing tools or science algorithms) is desirable; and
- When other criteria are satisfied, resource considerations may be important and are a legitimate concern.

Alpine and ERG have been directed by SESARM to use EPA's 2011el-based air quality modeling platform which includes emissions, meteorology, and other inputs for 2011 as the base year for the modeling described in their regional haze TSD (EPA, 2017b). EPA has projected the 2011 base year emissions to a 2028 future year base case scenario. This will be the foundation of the emissions with revisions for this analysis as described elsewhere. The 2011 modeling platform and projected 2028 emissions will be used to drive the 2011 base year and 2028 base case air quality model simulations. As noted in EPA's documentation, the 2011 base year emissions and methods for projecting these emissions to 2028 are in large part similar to the data and methods used by EPA in the final Cross-State Air Pollution Rule (CSAPR) Update[3] and the subsequent notice of data availability (NODA)[4] to support ozone transport for the 2015 ozone NAAQS.

[3] https://www.epa.gov/airmarkets/final-cross-state-air-pollution-rule-update
[4] https://www.epa.gov/airmarkets/notice-data-availability-preliminary-interstate-ozone-transport-modeling-data-2015-ozone

The 2011 and 2028 emissions used for EPA's regional haze modeling are described in the documents:

- "Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform";[5]
- "Technical Support Document (TSD) Updates to Emissions Inventories for the Version 6.3 2011 Emissions Modeling Platform for the Year 2028";[6] and
- "EPA Base Case v.5.16 for 2023 Ozone Transport NODA Using IPM Incremental Documentation."[7]

The meteorological data and initial and boundary concentrations used for this regional haze assessment, as described below, are the same as those used for the Final CSAPR Update air quality modeling and the 2015 ozone transport NAAQS NODA.

For the VISTAS II regional haze modeling analysis, Alpine and ERG propose to use the WRF/SMOKE/MOVES2014/BEIS/CAMx-PSAT modeling system as the primary tool for modeling PM concentrations and visibility and in the calculation of significant contribution to downwind Class I areas. The proposed modeling system satisfies all of EPA's selection criteria. The key models to be used in this regional haze modelling effort are described below:

- WRF/ARW: The Weather Research and Forecasting (WRF)[8] Model is a mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs (Skamarock, 2004; 2006; Skamarock et al., 2005). The Advanced Research WRF (ARW) version of WRF will be used in this regional haze analysis study. It features multiple dynamical cores, a 3-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. WRF is suitable for a broad spectrum of applications across scales ranging from meters to thousands of kilometers. The effort to develop WRF has been a collaborative partnership, principally among the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (NOAA), the National Centers for Environmental Prediction (NCEP) and the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, the University of Oklahoma, and the Federal Aviation Administration (FAA). WRF allows researchers the ability to conduct simulations reflecting either real data or idealized configurations. WRF provides operational forecasting a model that is flexible and efficient computationally, while offering the advances in physics, numerics, and data assimilation contributed by the research community.
- MOVES2014: MOVES2014[9] is EPA's latest onroad mobile source emissions model that was first released in July 2014 (EPA, 2014a; 2014b; 2014c). MOVES2014 includes the

[5] https://www.epa.gov/air-emissions-modeling/2011-version-63-technical-support-document
[6] https://www.epa.gov/air-emissions-modeling/2011-version-63-platform
[7] https://www.epa.gov/airmarkets/epa-base-case-v516-2015-ozone-naaqs-transport-noda-using-ipm-incremental-documentation
[8] http://www.wrf-model.org/index.php
[9] http://www.epa.gov/otaq/models/moves/

latest onroad mobile source emissions factor information. Emission factors developed by EPA will be used in this analysis.

- SMOKE: The SMOKE[10] modeling system is an emissions modeling system that generates hourly gridded speciated emission inputs of mobile, nonroad, nonpoint area, point, fire and biogenic emission sources for photochemical grid models (Coats, 1995; Houyoux and Vukovich, 1999). As with most 'emissions models', SMOKE is principally an emission processing system and not a true emissions modeling system in which emissions estimates are simulated from 'first principles'. This means that, with the exception of mobile and biogenic sources, its purpose is to provide an efficient, modern tool for converting an existing base emissions inventory data into the hourly gridded speciated formatted emission files required by a photochemical grid model. SMOKE will be used to prepare emission inputs for nonroad mobile, nonpoint area, and point sources.
- SMOKE-MOVES[11]: SMOKE-MOVES uses an Emissions Factor (EF) Look-Up Table from MOVES, county-level gridded vehicle miles travelled (VMT) and other activity data, and hourly gridded meteorological data (typically from WRF) to generate hourly gridded speciated onroad mobile source emissions inputs.
- ERTAC EGU Forecasting Tool: The ERTAC EGU Forecasting Tool[12] was developed through a collaborative effort to improve emission inventories among the Northeastern, Mid-Atlantic, Southeastern, and Lake Michigan area states; other member states; industry representatives; and multi-jurisdictional organization (MJO) representatives. The tool can be used to grow base year hourly EGU emissions inventories into future projection years. The tool uses base year hourly EPA Clean Air Markets Division (CAMD) data, fuel specific growth rates, and other information to estimate future emissions.
- BEIS: Biogenic emissions were modeled by EPA using version 3.61 of BEIS. First developed in 1988, BEIS estimates volatile organic compound (VOC) emissions from vegetation and nitric oxide (NO) emissions from soils. Because of resource limitations, recent BEIS development has been restricted to versions that are built within the SMOKE system.
- CAMx: The CAMx[13] model is a state-of-science "One-Atmosphere" photochemical grid model capable of addressing ozone, PM, visibility, and acid deposition at a regional scale for periods up to one year (Ramboll Environ, 2016). CAMx is a publicly-available open-source computer modeling system for the integrated assessment of gaseous and particulate air pollution. Built on today's understanding that air quality issues are complex, interrelated, and reach beyond the urban scale, CAMx is designed to: (a) simulate air quality over many geographic scales; (b) treat a wide variety of inert and chemically active pollutants including ozone, inorganic and organic $PM_{2.5}$ and PM_{10} and mercury and toxics; (c) provide source-receptor, sensitivity, and process analyses; and (d) be computationally efficient and easy to use. The U.S. EPA has approved the use of CAMx for numerous ozone, PM, and regional haze SIPs throughout the U.S. and has used this model to evaluate regional mitigation strategies including those for most recent

[10] http://www.smoke-model.org/index.cfm
[11] https://www.epa.gov/sites/production/files/2016-06/documents/smoke-moves-2011.pdf
[12] http://www.marama.org/2013-ertac-egu-forecasting-tool-documentation
[13] http://www.camx.com

regional-scale rules (e.g., Transport Rule, Clean Air Interstate Rule (CAIR), NO_X SIP Call, etc.). CAMx Version 6.40 will be used in this study, with the secondary organic aerosol partitioning (SOAP) algorithm module as the default.

- During the preparation of this Modeling Protocol, it was noted that a newer version of CAMx, Version 6.50, was released (April 30, 2018). After discussions with SESARM, the CC, and the TAWG, it was decided to not use the newer version due to insufficient testing and practical usage necessary for to ensure confidence in potential modelling results.
- PSAT: The PSAT tool of CAMx was selected to develop source contribution and significant contribution calculations.

3.0 EPISODE SELECTION

EPA's most recent regional haze modeling guidance (EPA, 2014e) contains recommended procedures for selecting modeling episodes. The VISTAS II regional haze modeling will use the annual calendar year 2011 modeling period because it satisfies the most criteria in EPA's modeling guidance episode selection discussion and is consistent with the base year modeling platform. Specifically, EPA's guidance recommends choosing a time period which reflects the variety of meteorological conditions that represent visibility impairment on the 20% clearest and 20% most-impaired days in the Class I areas being modeled (high and low concentrations necessary). This is best accomplished by modeling a full calendar year.

4.0 MODELING DOMAIN SELECTION

This section summarizes the modeling domain definitions for the VISTAS II regional haze modeling, including the domain coverage, resolution, and map projection. It also discusses emissions, aerometric, and other data available for use in model input preparation and performance testing.

4.1 Horizontal Domains

The VISTAS II modeling will use a 12 km continental U.S. (CONUS_12 or 12US2) domain. The 12 km nested grid modeling domain configuration is shown in Figure 4-1. The 12 km domain shown in Figure 4-1 represents the CAMx 12km air quality and SMOKE/BEIS emissions modeling domain. The WRF meteorological modeling was run on larger 12 km modeling domains than used for CAMx as demonstrated in EPA's meteorological model performance evaluation document (EPA, 2014d). The WRF meteorological modeling domains are defined larger than the air quality modeling domains because meteorological models can sometimes produce artifacts in the meteorological variables near the boundaries as the prescribed boundary conditions come into dynamic balance with the coupled equations and numerical methods in the meteorological model.

An additional VISTAS_12 domain will be prepared that is a subset of the CONUS_12 domain, with dimensions for both provided in Table 4-1. Development of the VISTAS_12 domain (also presented in Figure 4-1) will require the EPA CONUS_12 simulation to be run using CAMx Version 6.40 modeling saving 3-dimensional concentration fields for extraction using the CAMx BNDEXTR program.

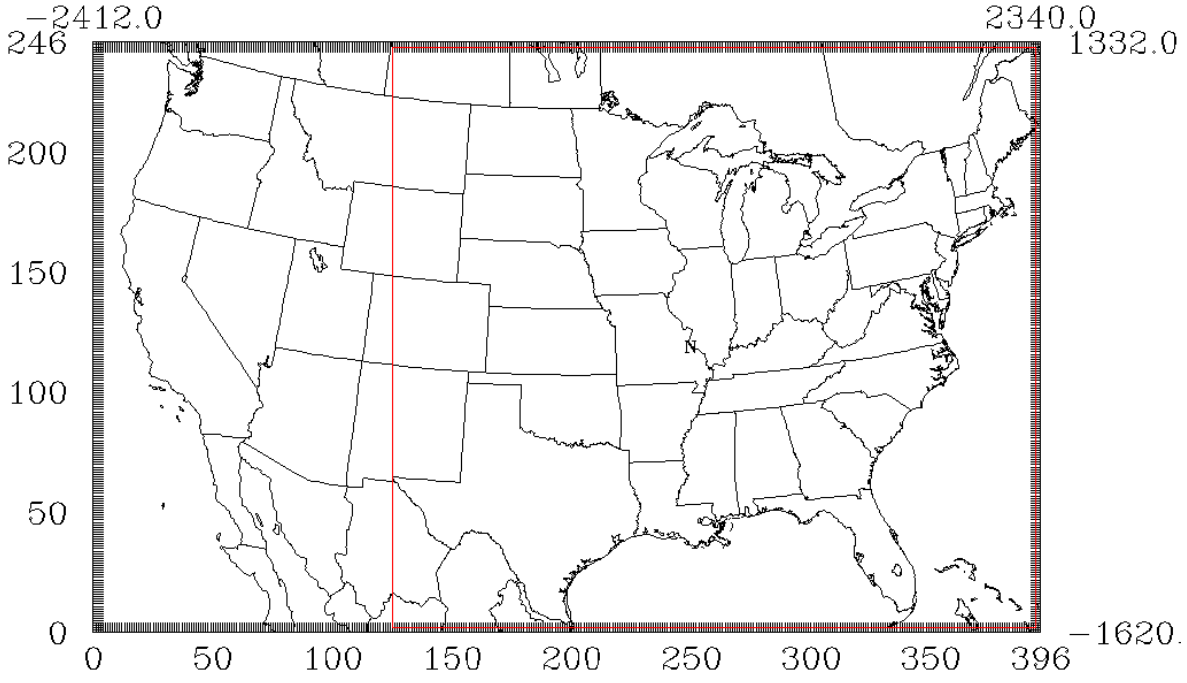


Figure 4-1. Map of 12km CAMx Modeling Domains. VISTAS_12 Domain Represented as Inner Red Domain.

Table 4-1. VISTAS II Modeling Domain Specifications

Domain	Columns	Rows	Vertical Layers	X Origin (km)	Y Origin (km)
CONUS_12	396	246	25	-2,412	-1,620
VISTAS_12	269	242	25	-912	-1,596

4.2 Vertical Modeling Domain

The CAMx vertical structure is primarily defined by the vertical layers used in the WRF meteorological modeling. The WRF model employs a terrain following coordinate system defined by pressure, using multiple layer interfaces that extend from the surface to 50 mb (approximately 19 km above sea level). EPA ran WRF using 35 vertical layers. A layer averaging scheme is adopted for CAMx simulations whereby multiple WRF layers are combined into one CAMx layer to reduce the air quality model computational time. Table 4-2 displays the approach for collapsing the WRF 35 vertical layers to 25 vertical layers in CAMx and is consistent with EPA's draft 2028 regional haze modeling.[14]

Table 4-2. WRF and CAMx Layers and Their Approximate Height Above Ground Level

CAMx Layer	WRF Layers	Sigma P	Pressure (mb)	Approx. Height (m AGL)
25	35	0.00	50.00	17,556
	34	0.05	97.50	14,780
24	33	0.10	145.00	12,822
	32	0.15	192.50	11,282
23	31	0.20	240.00	10,002
	30	0.25	287.50	8,901
22	29	0.30	335.00	7,932
	28	0.35	382.50	7,064
21	27	0.40	430.00	6,275
	26	0.45	477.50	5,553
20	25	0.50	525.00	4,885
	24	0.55	572.50	4,264
19	23	0.60	620.00	3,683
18	22	0.65	667.50	3,136
17	21	0.70	715.00	2,619
16	20	0.74	753.00	2,226
15	19	0.77	781.50	1,941
14	18	0.80	810.00	1,665
13	17	0.82	829.00	1,485
12	16	0.84	848.00	1,308
11	15	0.86	867.00	1,134
10	14	0.88	886.00	964
9	13	0.90	905.00	797
	12	0.91	914.50	714
8	11	0.92	924.00	632

[14] Table 2-2, EPA, 2017b.

Table 4-2. WRF and CAMx Layers and Their Approximate Height Above Ground Level

CAMx Layer	WRF Layers	Sigma P	Pressure (mb)	Approx. Height (m AGL)
	10	0.93	933.50	551
7	9	0.94	943.00	470
	8	0.95	952.50	390
6	7	0.96	962.00	311
5	6	0.97	971.50	232
4	5	0.98	981.00	154
	4	0.99	985.75	115
3	3	0.99	990.50	77
2	2	1.00	995.25	38
1	1	1.00	997.63	19

5.0 DATA AVAILABILITY

The CAMx modeling systems requires emissions, meteorology, surface characteristics, initial and boundary conditions (IC/BC), and ozone column data for defining the inputs.

5.1 Emissions Data

Without exception, as directed by SESARM, the 2011 base year emissions inventories for this analysis will be based on emissions obtained from the EPA's "el" modeling platform. This platform was prepared by EPA and used in the regional haze modeling for 2028. Emissions for 2028 will be based on a mixture of EPA's 2028el sectors and updated emissions as prepared by SESARM for inclusion in this study.

5.2 Ambient Air Quality Observations

Year 2011 data from all available ambient air monitoring networks for gas and PM species are used in the model performance evaluation. Table 5-1 summarizes routine ambient gaseous and PM monitoring networks available in the U.S. Alpine will focus on the ambient data collected from the IMPROVE network. This network began in 1985 as a cooperative visibility monitoring effort between EPA, federal land management agencies, and state air agencies (IMPROVE, 2011). Data are collected at Class I areas across the United States mostly at National Parks, National Wilderness Areas, and other protected pristine areas. Currently, there are approximately 181 IMPROVE sites that have complete annual $PM_{2.5}$ mass and/or $PM_{2.5}$ species data. There are 110 IMPROVE monitoring sites which represent air quality at the 156 designated Class I areas. The 71 additional IMPROVE sites are "IMPROVE protocol" sites which are generally located in rural areas throughout the U.S. Although these sites use the IMPROVE monitoring samplers and collection routines, they are not located at Class I areas.

5.3 Meteorological Data

The 2011 meteorological data for the air quality modeling of 2011 and 2028 will be derived from EPA's run of Version 3.4 of the WRF Model (Skamarock, et al., 2008) as completed for their regional haze modeling analysis for 2028 (EPA, 2017b).

5.4 Ozone Column Data

Ozone column data were derived by EPA using the Total Ozone Mapping Spectrometer (TOMS) with aboard Ozone Monitoring Instrument (OMI) satellite platform[15] for 2011 at a daily, 1 degree resolution. These data will be used as obtained directly from EPA for the 12US2 simulations. For the VISTAS_12 domain simulations, the data will be windowed onto the smaller VISTAS_12 domain.

5.5 Photolysis Rates

Photolysis rates were calculated using the NCAR Tropospheric Ultraviolet and Visible (TUV) Radiation Model Version 4.8. These data will be used as obtained directly from EPA.

5.6 Land Use

Land use and land cover data is based on the 2006 National Land Cover Database (NLCD2006) data.[16] These data will be used as obtained directly from EPA for the 12US2 simulations. For the VISTAS_12 domain simulations, the data will be windowed onto the smaller region.

5.7 Initial and Boundary Conditions Data

The lateral boundary and initial species concentrations are provided by a three-dimensional global atmospheric chemistry model, GEOS-Chem (Yantosca, 2004) standard version 8-03-02 with 8-02-01 chemistry. The global GEOS-Chem model simulates atmospheric chemical and physical processes driven by assimilated meteorological observations from the NASA's GEOS-5.[17] This model was run for 2011 with a grid resolution of 2.0 degrees x 2.5 degrees (latitude-longitude). The predictions were used to provide one-way dynamic boundary concentrations at one-hour intervals and an initial concentration field for the CAMx simulations. The 2011 boundary concentrations from GEOS-Chem were used for the 2011 and 2028 model simulations. The procedures for translating GEOS-Chem predictions to initial and boundary concentrations are described elsewhere (Henderson, 2014). More information about the GEOS-Chem model and other applications using this tool is available at: http://www-as.harvard.edu/chemistry/trop/geos.

[15] https://ozoneaq.gsfc.nasa.gov/data/
[16] The 2006 NLCD data are available at http://www.mrlc.gov/nlcd06_data.php
[17] Additional information available at: http://gmao.gsfc.nasa.gov/GEOS/ and http://wiki.seas.harvard.edu/geos-chem/index.php/GEOS-5

Table 5-1. Overview of Routine Ambient Data Monitoring Networks

Monitoring Network	Chemical Species Measured	Sampling Period	Data Availability/Source
The Interagency Monitoring of Protected Visual Environments (IMPROVE)	Speciated $PM_{2.5}$ and PM_{10} (see species mappings); light extinction data	1 in 3 days; 24-hour average	http://vista.cira.colostate.edu/improve/Data/IMPROVE/improve_data.htm
Clean Air Status and Trends Network (CASTNET)	Speciated $PM_{2.5}$, and O_3 (see species mappings)	Approximately 1-week average	http://www.epa.gov/castnet/data.html
National Atmospheric Deposition Program (NADP)	Wet deposition (hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium)), Mercury	1-week average	http://nadp.sws.uiuc.edu/
Air Quality System (AQS)	CO, NO_2, O_3, SO_2, $PM_{2.5}$, PM_{10}, lead (Pb), HAPs	Typically hourly average to 24-hour average	http://www.epa.gov/air/data/
Chemical Speciation Network (CSN)	Speciated $PM_{2.5}$	24-hour average	http://www.epa.gov/ttn/amtic/amticpm.html
Photochemical Assessment Monitoring Stations (PAMS)	Varies for each of 4 station types.	Varies by station	http://www.epa.gov/ttn/amtic/pamsmain.html
National Park Service Gaseous Pollutant Monitoring Network	Acid deposition (Dry; SO_4^{2-}, NO_3^-, HNO_3, NH_4, SO_2), O_3, meteorological data	Hourly	http://www2.nature.nps.gov/ard/gas/netdata1.htm

6.0 MODEL INPUT PREPARATION PROCEDURES

This section summarizes the procedures to be used in developing the meteorological, emissions, and air quality inputs to the CAMx model for the VISTAS II modeling on the 12 km grids for the annual 2011 period. The 12 km CAMx modeling databases are largely based on the EPA "el" platform databases.

6.1 Meteorological Inputs

The meteorological inputs in EPA's "el" platform will be used directly without revision. Details of EPA's annual 2011 meteorological model simulation and evaluation are provided in a separate technical support document (EPA, 2014a), which can be obtained at: http://www.epa.gov/ttn/scram/reports/MET_TSD_2011_final_11-26-14.pdf.

6.1.1 WRF Model Science Configuration

Version 3.4 of the WRF model ARW core (Skamarock, 2008) was used for generating the 2011 simulations. Selected physics options include Pleim-Xiu land surface model, Asymmetric Convective Model Version 2 planetary boundary layer scheme, KainFritsch cumulus parameterization utilizing the moisture-advection trigger (Ma and Tan, 2009), Morrison double moment microphysics, and Rapid Radiative Transfer Model-Global (RRTMG) longwave and shortwave radiation schemes (Iacono et al., 2008). The WRF model configuration was prepared by EPA (EPA, 2014d).

6.1.2 WRF Input Data Preparation Procedures

The WRF model simulation was initialized using the 12km North American Model (NAM-12) analysis product provided by the National Climatic Data Center (NCDC). Where NAM-12 data were unavailable, the 40km Eta Data Assimilation System (EDAS) analysis (ds609.2) from the National Center for Atmospheric Research (NCAR) was used. Analysis nudging for temperature, wind, and moisture was applied above the boundary layer only. The model simulations were conducted in 5.5 day blocks with soil moisture and temperature carried from one block to the next via the Intermediate Processor for Pleim–Xiu for WRF (IPXWRF) program (Gilliam and Pleim, 2010). Land use and land cover data were based on the 2006 National Land Cover Database (NLCD2006) data.[18] Sea surface temperatures at 1 km resolution were obtained from the Group for High Resolution Sea Surface Temperatures (GHRSST) (Stammer, et al., 2003).

As shown in Table 4-2, the WRF simulations were performed with 35 vertical layers up to 50 mb, with the thinnest layers being nearest the surface to better resolve the planetary boundary layer (PBL). The WRF 35-layer structure was collapsed to 25 layers for the CAMx air quality model simulations, as shown in Table 4-2.

6.1.3 WRF Model Performance Evaluation

The WRF model performance evaluation is provided in EPA's Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation documentation report (EPA, 2014d). The WRF model evaluation approach was based on a combination of qualitative and quantitative analyses. The quantitative analysis was divided into monthly summaries of 2-m temperature, 2-m

[18] The 2006 NLCD data are available at http://www.mrlc.gov/nlcd06_data.php

mixing ratio, and 10-m wind speed using the boreal seasons to help generalize the model bias and error relative to a set of standard model performance benchmarks. The qualitative approach was to compare spatial plots of model estimated monthly total precipitation with the monthly PRISM precipitation.

6.1.4 WRFCAMx/MCIP Reformatting Methodology

The WRF meteorological model output data was processed to provide inputs for the CAMx photochemical grid model. The WRFCAMx processor maps WRF meteorological fields to the format required by CAMx. It also calculates turbulent vertical exchange coefficients (Kv) that define the rate and depth of vertical mixing in CAMx. The methodology used by EPA to reform the meteorological data into CAMx format is provided in documentation provided with the wrfcamx conversion utility[19].

The meteorological data generated by the WRF simulations were processed by EPA using WRFCAMx v4.3 (Ramboll Environ, 2014) meteorological data processing program to create model-ready meteorological inputs to CAMx. In running WRFCAMx, vertical eddy diffusivities (Kv) were calculated using the Yonsei University (YSU) (Hong and Dudhia, 2006) mixing scheme. Alpine used a minimum Kv of 0.1 m^2/sec except for urban grid cells where the minimum Kv was reset to 1.0 m^2/sec within the lowest 200 m of the surface in order to enhance mixing associated with the nighttime "urban heat island" effect. In addition, EPA invoked the subgrid convection and subgrid stratoform stratiform cloud options in our wrfcamx run for 2011.

6.1.5 Windowing from EPA 12US2 to VISTAS_12

The meteorological data will be windowed from the EPA 12US2 domain onto the VISTAS_12 domain using a slightly modified version of the CAMx utility program "window".[20] The only required change to the distributed version program is to allow the program to window three-dimension files instead of just two-dimensional files.

6.2 Emission Inputs

6.2.1 Available Emissions Inventory Datasets

The base year emission inventories to be used in the VISTAS II modeling study will be based on EPA's 2011el modeling platform without exception. Complete documentation for the 2011 emissions used for EPA's regional haze modeling are described in the documents, "Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform."

Emissions for the 2028 base year will include EPA 2028el projections for most sectors (onroad and nonroad mobile sources, marine, aircraft, railroad, fires, nonpoint area, biogenic, and international sources) augmented with updated EGU and non-EGU point source emission estimates provided by SESARM.

Documentation on EPA's 2028el platform can be found in "Technical Support Document (TSD) Updates to Emissions Inventories for the Version 6.3 2011 Emissions Modeling Platform for the

[19] http://www.camx.com/getmedia/7f3ee9dc-d430-42d6-90d5-dedb3481313f/wrfcamx-11jul17.tgz
[20] http://www.camx.com/getmedia/88755b80-6992-4f07-bcaa-596d05e1b4b8/window-6may13_1.tgz

Year 2028". Adjustments planned for the SESARM adjusted source categories are documented below.

Outside of the VISTAS states, source categories and their associated emissions will be taken directly from the EPA 2028el modeling platform. The exception to this will be for EGU sources where data obtained from the projections to 2028 for EGU point source emissions by the ERTAC EGU projection tool[21] from the most recent CONUS 2.7 run will be used.

6.2.2 2011 Base Year Emissions

The emissions data in the 2011 platform are primarily based on the 2011NEIv2 for point sources, nonpoint sources, commercial marine vessels (CMV), nonroad mobile sources and fires. The onroad mobile source emissions are similar to those in the 2011NEIv2, but were generated using the released 2014a version of the Motor Vehicle Emissions Simulator (MOVES2014a). Fugitive dust emissions from anthropogenic sources (i.e., agricultural tilling and unpaved roads) are included in the nonpoint sector of the inventory, but wind-blown dust from natural sources is not accounted for in the inventory.

2011 CAMx-ready emission inputs were generated by EPA mainly by the SMOKE and BEIS emissions models. CAMx requires two emission input files for each day: (1) low level gridded emissions that are emitted directly into the first layer of the model from sources at the surface with little or no plume rise; and (2) elevated point sources (stacks) containing stack parameters from which the model can calculate plume rise. As noted earlier, EPA's 2011el emission platform in CAMx-ready format will be used without exception.

6.2.3 2028 Projection Year Emissions

Certain 2011 emission sectors were also projected by EPA to 2028 using various sector dependent methodologies. Onroad and nonroad mobile source emissions were created for 2028 using the MOVES and NONROAD models, respectively. Nonpoint area source emissions were prepared using growth and control factors simulating changes in economic conditions and environmental regulation anticipated to be fully implemented by calendar year 2028. For these categories, Alpine will be using EPA's estimates from the 2028el platform, unless a VISTAS state provides an update that is authorized by the SESARM contract.

Projections to 2028 for EGU and non-EGU point source emissions for 2028 will be derived from files produced by the ERTAC EGU projection tool from the most recent CONUS 2.7 run and from SESARM review of EPA 2028el emissions augmented with state-provided growth and control adjustments, respectively. ERG will review the emissions adjustments and work with states to ensure that the revised values are reasonable. ERG will also document the source of the revised 2028 emissions.

ERG will prepare state-specific summary comparisons of EPA's 2028v6.3el modeling platform emissions to the 2023v6.3en modeling platform emissions for stationary electricity generating unit (EGU) and non-EGU stationary point sources to facilitate review by each VISTAS state. The summaries between the two inventories will be grouped by Emission Inventory System

[21] http://www.marama.org/2013-ertac-egu-forecasting-tool-documentation

(EIS) facility, emissions unit, process, and release point identifiers and source classification code (SCC) for annual emissions of:

- Oxides of nitrogen (NO_x);
- Volatile organic compounds (VOC);
- Primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter ($PM_{2.5}$-PRI);
- Primary particulate matter less than or equal to 10 microns in aerodynamic diameter (PM_{10}-PRI);
- Carbon monoxide (CO);
- Sulfur dioxide (SO_2); and
- Ammonia (NH_3).

If the 2023v6.3en emissions are selected for the final 2028 emissions inventory, ERG will document these updates.

ERG will work with SESARM on the final format of the comparison tables, including additional fields that may be useful for review, such as: facility information; SCC descriptions; unit, process, and release point descriptions; ORIS boiler identifiers; control information; and absolute and percentage differences between the two emissions inventories. All data will be provided in a single Excel file, unless the file size is prohibitive, at which point ERG will work with SESARM on the best way to divide the data across multiple files.

6.2.3.1 EGU Point Source Emissions

For EGU sources only, the ERG/Alpine team will use an already-obtained version of the 2028 emissions forecast and associated files produced by the ERTAC EGU projection tool from the most recent CONUS 2.7 run available. The team will prepare state-specific summary comparisons of EPA's 2028v6.3el modeling platform emissions to EPA's 2023v6.3en modeling platform emissions to the ERTAC 2028 modeling platform emissions for EGU point sources to facilitate the VISTAS state review. The summaries will be produced in Microsoft Excel format grouped by EIS facility, emissions unit, process, and release point identifiers, ORIS ID, and SCC for annual emissions of NO_X, VOC, $PM_{2.5}$-PRI, PM_{10}-PRI, CO, SO_2, and NH_3 between the two emissions inventories.

ERG will work with SESARM on the final format of the comparison tables, including additional fields that may be useful for review, such as: facility information; SCC descriptions; unit, process, and release point descriptions; ORIS boiler identifiers; control information; and absolute and percentage differences between the two emissions inventories.

SESARM will identify for ERG in the final comparison tables which emissions projection platform (e.g., EPA 2023en, EPA 2028el, ERTAC EGU, or state provided) should be used in the final 2028 modeling file preparation. For any one EGU source, only a single platform should be selected. In other words, emissions from one platform cannot be mixed with emissions from another platform at the same unit.

6.2.3.2 Non-EGU Point Source Emissions

Similar to the work being conducted for EGU point sources, ERG will update the 2028 non-EGU point source projection year mass emissions inventories based on the information collected from SESARM's review of prepared comparison tables. All revisions will be documented to account for changes in emissions due to retirements, control enhancements, and/or fuel switches, as well as any additional metadata to describe the data. For certain situations, a state may wish to develop their own revised 2028 point sources emissions inventory using updated growth and/or control factors on the 2011 point sources emissions inventory. In these cases, ERG will work with the state agencies to provide the data into the format needed for integration.

6.2.3.3 Nonpoint Area, Onroad, and Nonroad Mobile Source Emissions

Emissions data for 2028 nonpoint area, onroad mobile, and nonroad mobile sources will be used from the 2011/2028el modeling platform. These sources will be spatially allocated to the grid using an appropriate surrogate distribution (e.g., population for home heating, etc.) and will be temporally allocated by month, by day of week, and by hour of day using the EPA source-specific temporal allocation factors. The SMOKE source-specific CB6r4 speciation allocation profiles will also be used for all categories.

6.2.3.4 Biogenic Source Emissions

Biogenic emissions were generated by EPA using the BEIS biogenic emissions model within SMOKE. BEIS uses high resolution GIS data on plant types and biomass loadings and the WRF surface temperature fields, and solar radiation (modeled or satellite-derived) to develop hourly emissions for biogenic species on the 12 km grids. BEIS generates gridded, speciated, temporally allocated emission files. EPA's 2011 biogenic emissions will be used for the 2028 modeling platform.

6.2.3.5 Wildfires, Prescribed Burns, Agricultural Burns

Fire emissions in 2011NEIv2 were developed based on Version 2 of the Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) system (Sullivan, et al., 2008). SMARTFIRE2 was the first version of SMARTFIRE to assign all fires as either prescribed burning or wildfire categories. In past inventories, a significant number of fires were published as unclassified, which impacted the emissions values and diurnal emissions pattern. Recent updates to SMARTFIRE include improved emission factors for prescribed burning. These emissions as prepared by EPA will be included in both the 2011 and 2028 emission platforms. EPA's 2011 fire emissions will be used for the 2028 modeling platforms. It should be noted that there were large wildfires in the Okefenokee Swamp and Eastern North Carolina in 2011. However, contributions from these wildfires should not impact the development of reasonable progress goals since EPA's new 20% most impaired days metric removes IMPROVE days that were significantly impacted by these wildfires from the analysis.

6.3 Emissions Processing

CAMx requires detailed emissions inventories containing temporally allocated (i.e., hourly) emissions for each grid-cell in the modeling domain for a large number of chemical species that act as primary pollutants and precursors to secondary pollutants. Annual emission inventories for 2011 and 2028 will be preprocessed into SMOKE-ready modeling system (Houyoux et al., 2000) inputs for eventually additional processing and use in CAMx. For this analysis, CAMx will be operated using Version 6 revision 4 of the Carbon Bond chemical mechanism (CB6r4).

For emission segments that are unchanged from the EPA distribution, the emission will be windowed from the EPA 12US2 domain onto the VISTAS_12 domain using the CAMx "window"[22] utility program. For VISTAS state specific emission segments, the emissions will be developed on the VISTAS_12 domain.

Steps necessary to prepare SMOKE-ready input files from the mass emissions data is outlined in the VISTAS II workplan, Task 2. In that task, Alpine will ensure that annual emission changes submitted or authorized by SESARM are carried through to all relevant input files consistent with EPA's 2011 and 2028 v6.3el platform processing. Upon the completed development of these new input files, Alpine will use EPA's modeling platform scripts, with the updated input files from this task, to generate CAMx photochemical model Version 6.40-ready inputs using the SMOKE Modeling System.

The CMAQ and CAMx models require hourly emissions of specific gas and particle species for the horizontal and vertical grid cells contained within the modeled region (i.e., modeling domain). To provide emissions in the form and format required by the model, it is necessary to "pre-process" the "raw" emissions (i.e., emissions input to SMOKE) for the sectors described above. In brief, the process of emissions modeling transforms the emissions inventories from their original temporal resolution, pollutant resolution, and spatial resolution into the hourly, speciated, gridded resolution required by the air quality model.

The emission processing for this project will take two different "paths" as shown in Figure 6-1.

For emission segments that are being updated for the project, the emissions will be processed using SMOKE version 3.7 with the emissions being output directly into CAMx format for the VISTAS_12 domain. For emission segments that are unchanged from the EPA simulation the emissions will be converted from the EPA supplied CMAQ format into CAMx format using the CMAQtoCAMx processor and windowed onto the VISTAS_12 domain using the "WINDOW" program. The CMAQ2CAMx converter reformats the files, converts units, and transforms the CMAQ in-line elevated emissions into CAMx elevated format and low level files into CAMx format. As a final step before running the CAMx model, the low-level emissions will be merged into the single low level and elevated files.

[22] http://www.camx.com/getmedia/88755b80-6992-4f07-bcaa-596d05e1b4b8/window-6may13_1.tgz

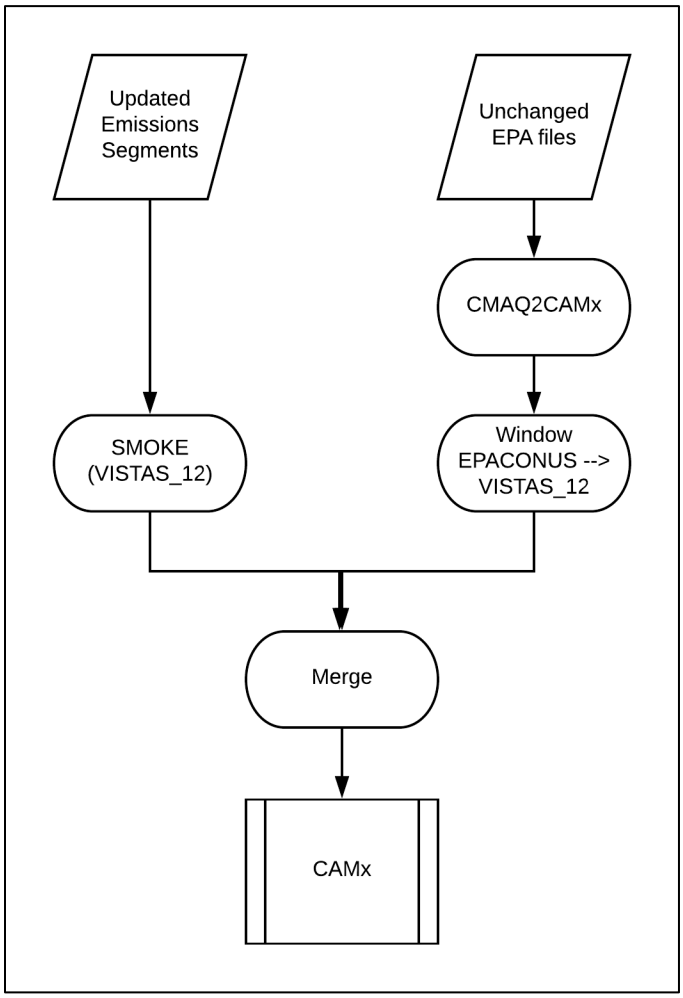


Figure 6-1. Emission Processing Paths

While the 2028 projection year non-EGU and EGU point source inventory will be updated to reflect requested changes by SESARM, the steps associated with the emissions processing of these files remains the same as EPA's methods for the 2028 regional haze modeling analysis. Details of the temporal, spatial, and speciation data and methods are described in EPA's technical support document for the development of the 2028 platform.[23]

Other than the preparation of data for an additional modeling domain (VISTAS_12) for this analysis, all other emissions processing steps, methods, and ancillary data and associations will be identical to EPA's documented processing steps.

No plume-in-grid (PiG) subgrid-scale plume treatment will be used in this project.

Scripts to perform the emissions merging of the appropriate biogenic, onroad, nonroad, nonpoint area, low-level, fire, and point emission files will be written to generate the CAMx-ready two-dimensional day and domain-specific hourly speciated gridded emission inputs. The point source

[23] https://www.epa.gov/sites/production/files/2017-11/documents/2011v6.3_2028_update_emismod_tsd_oct2017.pdf

and, as available elevated fire, emissions would be processed into the day-specific hourly speciated emissions in the CAMx-ready point source format.

6.3.1 QA/QC of CAMx-Ready Emission Files

For quality assurance of the emissions modeling steps, emissions totals for all species across the entire model domain will be output as reports that are then compared to reports generated by SMOKE on the input inventories to ensure that mass is not lost or gained during the emissions modeling process.

In addition to the CAMx-ready emission input files generated for each hour of all days modeled in the annual 2011 or 2028 modeling period, a number of QA files may be prepared and used to check for gross errors in the emissions inputs. The model-ready emissions will be imported into visualization tools and Alpine will examine both the spatial and temporal distribution of the emission to investigate the quality and accuracy of the emissions inputs.

- Visualizing the model-ready emissions with the scale of the plots set to a very low value, Alpine can determine whether there are areas omitted from the raw inventory or if emissions sources are erroneously located in water cells;
- Spot-checking the holiday emissions files to confirm that they are temporally allocated like Sundays;
- Producing pie charts emission summaries that highlight the contribution of each emissions source component (e.g. nonroad mobile); and
- Normalizing the emissions by population for each state will illustrate where the inventories may be deficient and provide a reality check of the inventories.

State inventory summaries prepared prior to the emissions processing will be used to compare against SMOKE output report totals generated after each major step of the emissions generation process. To check the chemical speciation of the emissions to CB6 species, Alpine will compare reports generated with SMOKE to target these specific areas of the processing. For speciation, the inventory state import totals will be compared against the same state totals with the speciation matrix applied.

The quantitative QA analyses often reveal significant deficiencies in the input data or the model setup. It may become necessary to tailor these procedures to track down sources of any identified major problem. As such, Alpine can only outline the basic quantitative QA steps that are performed by Alpine to reveal the underlying problems with the inventories or processing.

Standard inventory assessment methods may be employed to generate the future year emissions data QA files including, but not limited to: (a) visualizing the model-ready emissions graphically, (b) spot-checking the holiday emissions files to confirm that they are temporally allocated like Sundays, (c) producing pie charts emission summaries for each source category, and (d) normalizing the emissions by population for each state to reveal where the future year inventories may be suspect. Of particular importance will be the comparison of the 2011 base year and 2028 future year emissions by source category to make sure the expected changes have been appropriately accounted for in the modeling inventories.

The resultant CAMx model-ready emissions will be subjected to a final QA using spatial maps to assure that: (1) the emissions were merged properly; (2) CAMx inputs contain the same total emissions; and (3) to provide additional QA/QC information.

Emissions are processed by major source category in several different "streams", including nonpoint area sources, onroad mobile sources, nonroad mobile sources, biogenic sources, non-CEM point sources, CEM point sources using day-specific hourly emissions, and emissions from fires. Separate Quality Assurance (QA) and Quality Control (QC) will be performed for each stream of emissions processing and in each step following the procedures outlined in the project QAPP. SMOKE includes advanced quality assurance features that include error logs when emissions are dropped or added. In addition, Alpine will generate visual displays that include:

- Spatial plots of the hourly emissions for each major species (e.g., NO_X, VOC, some speciated VOC, SO_2, NH_3, PM and CO).
- Summary tables of emissions for major species for each grid and by major source category.
- This QA information will be examined against the original point and nonpoint area source data and summarized in an overall QA/QC assessment.

6.4 Photochemical Modeling Inputs

6.4.1 CAMx Science Configuration and Input Configuration

This section describes the model configuration and science options to be used in the VISTAS II modeling effort. Version 6.40 of CAMx will be used for this modeling.

CAMx is a three-dimensional grid-based Eulerian air quality model designed to simulate the formation and fate of oxidant precursors, primary and secondary particulate matter concentrations, and deposition over regional and urban spatial scales (e.g., the contiguous U.S.). Consideration of the different processes (e.g., transport and deposition) that affect primary (directly emitted) and secondary (formed by atmospheric processes) pollutants at the regional scale in different locations is fundamental to understanding and assessing the effects of emissions on air quality concentrations.

Figure 4-1 presented the geographic extent of the modeling domains (12US2 and VISTAS_12) that will be used for air quality modeling in this analysis. The 12US2 domain covers the 48 contiguous states along with the southern portions of Canada and the northern portions of Mexico. The VISTAS_12 domain covers the continental US eastward from the western extent of Texas along with the southern portions of Canada and the northern portions of Mexico. As discussed later, the limited coverage of Canada and Mexico is an important consideration when interpreting the modeling results. This modeling domain contains 25 vertical layers with a top at about 17,550 meters, or 50 millibars (mb), and horizontal grid resolution of 12 km x 12 km. The model simulations produce hourly air quality concentrations for each 12 km grid cell across the modeling domain.

For the simulations that use the EPA 12US2 domain, the model will be applied using the same time segments as EPA. The model will be applied from December 22, 2010 through April 30,

2011 and from April 21, 2011 through December 31, 2011. The beginning of each segment, December 21-31, 2010 for the first segment and April 21-30, 2011 for the second segment are used as spin-up periods and will not be analyzed.

For the simulation on the VISTAS_12 domain, the model will be applied quarterly using the definitions in Table 6-1. The initial conditions for each quarter, and hourly boundary conditions will be extracted from the CAMx version 6.40 simulations performed over the EPA 12US2 CONUS domain.

Table 6-1. VISTAS II Simulation Periods

Quarter Number	Starting Date	Ending Date
1	December 22, 2010	March 31, 2011
2	March 15, 2011	June 30, 2011
3	June 15, 2011	September 30, 2011
4	September 15, 2011	December 31, 2011

CAMx requires a variety of input files that contain information pertaining to the modeling domain and simulation period. These include gridded, hourly emissions estimates and meteorological data, and boundary concentrations. Separate emissions inventories will be prepared for the 2011 base year and the 2028 base case. Meteorological fields will be specified for the 2011 base year model application and remained unchanged for the future-year model simulations.[24] The IC/BC for VISTAS_12 in 2028 will be based on 12US_2 domain as mentioned in section 5.5.2.

Ten CAMx model runs, associated with up to 250 tagged sources, are currently planned for this analysis. The simulations are summarized in Table 6-2.

Table 6-2. CAMx Simulations for the VISTAS II Project

Simulation Number	Description	CAMx Version	Grid	Task	Time
1	EPA 2011el Confirmation	6.32	12US2	6.2	EPA 1,2*
2	EPA 2011el saving 3-D average for VISTAS12 IC/BC Extracts	6.40	12US2	6.2	EPA 1,2
3	EPA 2028el Confirmation	6.32	12US2	6.3	EPA 1,2
4	VISTAS 2028 saving 3-D average for VISTAS12 IC/BC extracts	6.40	12US2	6.3	EPA 1,2
5	EPA 2011el saving 3-D average for state domains IC/BC extracts	6.40	VISTAS_12	6.2	Q1,2,3,4
6	VISTAS 2028 saving 3-D average for state domain IC/BC extracts	6.40	VISTAS_12	6.3	Q1,2,3,4
7	VISTAS 2028 PSAT with selected sources 1-50 tagged	6.40	VISTAS_12	7	Q1,2,3,4

[24] The CAMx annual simulations for 2011 and 2028 were each performed using two time segments (January 1 through April 30, 2011 with a 10-day ramp-up period at the end of December 2010 and May 1 through December 31, 2011 with a 10-day ramp-up period at the end of April 2011).

Table 6-2. CAMx Simulations for the VISTAS II Project

Simulation Number	Description	CAMx Version	Grid	Task	Time
8	VISTAS 2028 PSAT with selected sources 51-100 tagged	6.40	VISTAS_12	7	Q1,2,3,4
9	VISTAS 2028 PSAT with selected sources 101-150 tagged	6.40	VISTAS_12	7	Q1,2,3,4
10	VISTAS 2028 PSAT with selected sources 151-200 tagged	6.40	VISTAS_12	7	Q1,2,3,4
11	VISTAS 2028 PSAT with selected sources 201-250 tagged	6.40	VISTAS_12	7	Q1,2,3,4

*EPA twice annual segments from December 22, 2010 through April 30, 2011 and April 21, 2011 through December 31, 2011.

6.4.2 VISTAS_12 Boundary And Initial Conditions

Boundary and initial conditions for the VISTAS_12 domain will be extracted from simulations using the EPA 12US2 domain. For the 2011 baseline simulation, the EPA 2011el platform for the 12US2 domain will be run using CAMx 6.40 and the resultant three-dimensional outputs will be saved. For the 2028 future year simulation, the EPA 2028el point source emissions will be reprocessed to include updated point source emissions, and CAMx 6.40 will be run saving three-dimensional outputs. The boundary and initial conditions for the VISTAS_12 domain will be extracted from the respective three-dimensional output files using the CAMx BNDEXTR program.

6.4.3 VISTAS_12 Ozone Column

The ozone column data for the VISTAS_12 domain will be windowed from the EPA 12US2 domain. The ozone column data is a simple text file and new code will be developed to extract data for the smaller VISTAS_12 domain.

6.4.4 Photolysis Rates

The EPA photolysis rates used will be unchanged in the VISTAS_12 domain.

6.4.5 CAMx Land Use

The land use file for the VISTAS_12 domain will be windowed from the EPA 12US2 domain. The land use file is a simple text file and new code will be developed to extract data for the smaller VISTAS_12 domain.

6.5 EPA 2011 and 2028 Base Case Confirmation

The numerics in photochemical grid models are very complex and it is typical to get slightly different model concentrations based on the version of the computer and compilers. When comparing simulations, it is critical to isolate the changes in concentrations to the changes in the model inputs, and not on the computing details (i.e., compiler version, computer architecture, parallelization options). This is especially problematic when looking at particulate matter, since the particulate treatments have multiple pathways, and small concentration differences can lead to different pathways through the code and different concentrations.

Sources of the difference can come from the options used in CAMx compilation, the version of the compiler, the compiler vendor, and how the model calculation is split onto different processors (parallelization).

Alpine will execute two confirmation runs, one for the 2011el base year and one for the 2028el base case, to confirm the contract team's ability to replicate EPA's results and to ensure that the EPA data, models, and scripts operated in a consistent manner as EPA's procedure.

6.5.1 Differences Between EPA And VISTAS Simulations

EPA ran the 2011v6.3el platform on EPA's supercomputer with the model configured to use four (4) processor nodes with 16 processors per node. The use of multiple processor nodes with multiple processors per node is efficient on the EPA supercomputer due to the low latency interconnect between the nodes. On more typical computer clusters with the nodes interconnected with Ethernet, like the Alpine cluster and most likely the State and stakeholder clusters, the latency between nodes is sufficiently high that it is inefficient to spread processing between nodes. Our experience with the EPA platform has shown that on an Ethernet connected cluster with 12 Intel XEON processors per node and hyperthreading enabled it is most efficient to use a single node configured with 10 Message Passing Interface (MPI) instances, each with 2 OpenMP threads.

EPA used the Intel FORTRAN compiler. Alpine, and the CAMx developers, use the Portland Group (PGI) FORTRAN compiler. The PGI compiler has been the standard compiler for CAMx applications for many years and it's anticipated this compiler will be more widely used by the States and stakeholders. The version of CAMx 6.32 EPA distributed with the 2011el platform will be recompiled on the Alpine computer system and used for the confirmation.

As noted in Section 5.5.1, EPA ran the model in two time segments. The first segment, typically used only for PM applications, runs from December 22, 2010 through April 30, 2011. The second segment runs from April 21, 2011 through December 31, 2011. The VISTAS confirmation run will use the same two segments. December 22-31, 2010 and the April portion of the second segment are spin-ups and will not be analysed.

6.5.2 Confirmation Methodology

The simulations on the Alpine computer cluster and the EPA computer will be based on hourly differences in ozone, $PM_{2.5}$, POC, Particulate Nitrate and Particulate Sulfate. The metric for comparison will be the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$\left(C_{vistas} - C_{epa}\right)$$

(Equation 2) $$\frac{\left(C_{vistas} - C_{epa}\right)}{\left(C_{epa}\right)}$$

Where C_{epa} is the concentration at each grid cell hour for the EPA simulation and C_{vistas} is the concentration at each grid cell hour for the simulation on the Alpine computers.

The comparison will be done both graphically (e.g., scatter density plots) and quantitatively (e.g., residual distributions) for reviewed concentrations. Analysis products will be hourly spatial plots of the absolute differences. Should significant differences be noted between the confirmation runs and EPA's original simulations, Alpine will generate an electronic appendix of the spatial plots and discuss with SESARM and others as requested. If it is determined that noted differences are the result of modeling errors, Alpine will propose to SESARM recommended approaches to correct the issues and will correct configurations based on negotiation action.

The following confirmation runs will be performed:

1. EPA 2011 with CAMx_6.32 (CONUS) vs. Alpine 2011 with CAMx_6.32 (CONUS)
2. EPA 2028 with CAMx_6.32 (CONUS) vs. Alpine 2028 with CAMx_6.32 (CONUS)
3. Alpine 2011 with CAMx_6.32 (CONUS) vs. Alpine 2011 with CAMx_6.40 (CONUS)
4. Alpine 2028 with CAMx_6.32 (CONUS) vs. Alpine 2028 with CAMx_6.40 (CONUS)
5. Alpine 2011 with CAMx_6.40 (CONUS) vs. Alpine 2011 with CAMx_6.40 (VISTAS)
6. Alpine 2028 with CAMx_6.40 (CONUS) vs. Alpine 2028 with CAMx_6.40 (VISTAS)

7.0 MODEL PERFORMANCE EVALUATION

An operational model performance evaluation will be conducted for total fine particulate matter ($PM_{2.5}$), $PM_{2.5}$ species components (e.g., SO_4, NO_3, NH_4, EC, and OC), measured gas phase species (e.g., O_3, HNO_3, SO_2, VOCs, NO_2, and NO), and speciated components of light extinction to examine the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. This evaluation will focus on graphical analyses and statistical metrics of model predictions versus observations. Note that as EPA did not publish an evaluation of $PM_{2.5}$ gas phase species in their 2028 regional haze modeling we will not have a basis for comparison of these metrics.

The CAMx 2011 base case model estimates will be compared against the observed concentrations to establish that the model is capable of reproducing the current year observed concentrations so that it can be considered a reliable tool for estimating future year PM and regional haze levels.

The model evaluation will focus on the ability of the model to predict visibility-reducing PM at VISTAS Class I areas (represented by IMPROVE monitoring sites). The analysis will look at monthly and seasonal average PM species component performance at IMPROVE and other PM monitoring networks, and performance on the 20% most impaired (and 20% clearest) days at individual IMPROVE sites. This will provide a comprehensive assessment of the components that make up visibility performance.

The measured concentrations of PM components such as nitrate on the 20% most impaired days at many Class I areas are extremely small. Numerous Class I areas in the Eastern U.S. have average nitrate observations (on the 20% most impaired days) of less than 1 $\mu g/m^3$. This makes it challenging to correctly model observed visibility. Assumptions regarding particular emissions categories and boundary conditions can have a large impact on model performance. Even when model performance appears to be accurate, it is difficult (without further modeling and analysis) to determine if the answers observed are right for the right reasons (for example, when the extinction is dominated by modeled boundary conditions).

7.1 Model Performance Evaluation

7.1.1 Overview of EPA Model Performance Evaluation Recommendations

EPA current (EPA, 2007) and draft (EPA, 2014e) ozone, PM, and regional haze modeling guidance recommendations for model performance evaluation (MPE) describes a MPE framework that has four components:

- Operation evaluation that includes statistical and graphical analysis aimed at determining how well the model simulates observed concentrations (i.e., does the model get the right answer).
- Diagnostic evaluation that focuses on process-oriented evaluation and whether the model simulates the important processes for the air quality problem being studied (i.e., does the model get the right answer for the right reason).

- Dynamic evaluation that assess the ability of the model air quality predictions to correctly respond to changes in emissions and meteorology.
- Probabilistic evaluation that assess the level of confidence in the model predictions through techniques such as ensemble model simulations.

EPA's guidance notes that there is no single definitive test for evaluating model performance. All of the tests mentioned here have strengths and weaknesses. Further, even with a single performance test, it is not appropriate to assign "bright line" criteria that distinguish between adequate and inadequate model performance. In this regard, EPA recommends that a "weight of evidence" approach be used to determine whether a particular modeling application is valid for assessing the future attainment status of an area.

EPA recommends that air agencies conduct a variety of performance tests and weigh them qualitatively to assess model performance. Provided suitable databases are available, greater weight should be given to those tests which assess the model capabilities most closely related to how the model is used in the analysis (i.e. tests that provide insight into the accuracy of the model's relative response to emissions reductions). Generally, additional confidence should be attributed to model applications in which a variety of the tests described here are applied and the results indicate that the model is performing well.

From an operational standpoint, EPA recommends that air agencies compare their evaluation results against similar modeling exercises to ensure that the model performance approximates the quality of other applications. Recent literature reviews (Simon et al, 2012, Emery 2017) summarized photochemical model performance for applications published in the peer-reviewed literature between 2006 and 2012.

Because this 2011 VISTAS II modeling is using a CAMx 2011 modeling database developed by EPA, Alpine will also include by reference the air quality modeling performance evaluation as conducted by EPA (EPA, 2017b) on the national 12km domain.

Alpine will review EPA's current operational MPE for particulate matter ($PM_{2.5}$ species components, coarse PM, and total $PM_{2.5}$) and light extinction (total and species components) to compare the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. Using a combination of the Atmospheric Model Evaluation Tool (AMET) and internal scripts used by Alpine, comprehensive MPE statistics and graphics from the 2011 CAMx simulation using data from the IMPROVE network will be prepared in formats that will be accessible for stakeholder review and use. Alpine will use the current IMPROVE equation (see Section 8) inclusive of the monthly relative humidity function [f(RH)] values for both observed and modeled data to develop performance statistics at each IMPROVE monitor in the VISTAS_12 domain.

7.1.2 VISTAS II Calculated Model Evaluation Statistics

In order to estimate the ability of CAMx to replicate the 2011 base year concentrations of particulate matter, an operational model performance evaluation will be conducted. For this evaluation, mean bias and normalized mean bias, mean error and normalized mean error, and Pearson's correlation coefficient will be used and directly compared to EPA's results using these

same statistics. Mean fractional bias, mean fractional error, and root mean squared error may also be calculated but as these statistics were not calculated by EPA in its evaluation, there will be no basis for comparison for these metrics.

Mean bias (MB) is the average difference between predicted (P) and observed (O) concentrations for a given number of samples (n):

$$MB(\mu g\ m^{-3}\ or\ Mm^{-1}) = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

Mean error (ME) is the average absolute value of the difference between predicted and observed concentrations for a given number of samples:

$$ME(\mu g\ m^{-3}\ or\ Mm^{-1}) = \frac{1}{n}\sum_{i=1}^{n}|P_i - O_i|$$

Normalized mean bias (NMB) is the sum of the difference between predicted and observed values divided by the sum of the observed values:

$$NMB(\%) = \frac{\sum_1^n(P-O)}{\sum_1^n(O)} * 100$$

Normalized mean error (NME) is the sum of the absolute value of the difference between predicted and observed values divided by the sum of the observed values:

$$NME(\%) = \frac{\sum_1^n|P-O|}{\sum_1^n(O)} * 100$$

Pearson's correlation coefficient (r) is defined as:

$$r = \frac{\sum_{i=1}^n(P_i - \overline{P})(O_i - \overline{O})}{\sqrt{\sum_{i=1}^n(P_i - \overline{P})^2}\sqrt{\sum_{i=1}^n(O_i - \overline{O})^2}}$$

Mean Fractional Bias (MFB) is defined as:

$$MFB(\%) = \frac{2}{N}\sum_1^N\left(\frac{P-O}{P+O}\right) \times 100$$

Mean Fractional Error (MFE) is defined as:

$$MFE(\%) = \frac{2}{N}\sum_1^N\left(\frac{|P-O|}{P+O}\right) \times 100$$

Root Mean Squared Error (RMSE) is defined as:

$$RSME = \sqrt{\frac{\sum_1^N (P - O)^2}{N}}$$

Model predictions of PM species will be paired in space and time with observational data from the IMPROVE monitoring network. These results will be organized by IMPROVE monitor and season (winter (DJF), spring (MAM), summer (JJA), and fall (SON)).

ERG/Alpine expects the model performance of the replicated 2011 CAMx run to be slightly different from EPA published MPE metrics due to the differences in the version of CAMx being used and the modeling domain. If performance is not comparable to EPA's MPE, then data files will be reviewed to determine the cause. If the difference is not explainable by the changes in domain or model version, a call will be convened between ERG, Alpine, SESARM, and the appropriate EPA staff to identify any inconsistencies and come to consensus on appropriate corrective actions. Any of the metrics outside published proposed criteria levels will be noted as part of the uncertainty associated with the modeling.

Additional statistical analysis may also be performed, as determined necessary. All statistics will be calculated consistent with the respective pollutants NAAQS averaging time.

Tables and plots will be prepared for VISTAS and identified non-VISTAS IMPROVE monitors as directed to demonstrate light extinction model performance in a graphical manner. Scatter (with linear regression and r^2 value), bugle, and soccer plots for all light extinction and speciated components will be developed for the 20% most impaired and 20% clearest days for each IMPROVE monitor in the VISTAS_12 modeling domain.

Alpine will develop the individual day-by-day and site-by-site stacked bar plots of total b_{ext} and speciated components of b_{ext} for these most impaired and clearest days. Metrics and plots generated for the most impaired days will be consistent with the latest definition of this classification as "anthropogenically impaired" days as defined by EPA.

7.1.3 Model Performance Evaluation For Weekly Wet And Weekly Dry Deposition Species

The modeling team will also perform a MPE for weekly wet deposition and weekly dry deposition species collected in workplan Subtask 4.1. For this MPE, VISTAS CAMx deposition values will be aggregated to appropriate time periods to match the various NADP monitoring network's concentration collection times. To prevent confounding the MPE, the networks with different collection time (i.e., biweekly versus weekly) will be examined separately.

For wet deposition, NADP networks typically present measurements as concentration in mg/L, which is equivalent to g/m^3. These concentrations are then multiplied by the precipitation in meters to yield wet deposition rates in units of g/m^2. The CAMx wet deposition outputs are provided in grams per hectare (g/ha), which will be converted to grams per meter squared (g/m^2), using the conversion of 1 ha = 10,000 m^2, to have consistent units with the NADP monitoring networks. CAMx estimates of wet deposition can also be adjusted to account for the error present

in the model estimated precipitation through a ratio of the observed to estimated precipitation.[25] Dry deposition values from CASTNET can be developed from the observed concentration multiplied by a deposition velocity generated by the Multi-Layer Model (MLM)[26] for the site. The MLM generated deposition velocities are available for download with the CASTNET observations.[27]

Annual mean MPE statistics, like the statistics for the base year MPE, will be developed for the wet deposition and dry deposition species available. Analysis will also include scatter plots of NADP network observations versus CAMx predictions, and their correlation (r), both annually and by season. Statistical and scatter plots will also be examined by VISTAS states to provide more refined MPE information to facilitate further use by the states.

Additionally, annual deposition totals will be produced from the VISTAS II base year modeling and compared to the annual Total Deposition Maps developed by the NADP and EPA. These total deposition maps are produced via a hybrid approach that combines the monitored data with modeled data to produce a gridded map of total sulfate and nitrate depositions. While not entirely observed truth, these hybrid estimates could provide the ability to evaluate generally the MPE for the entire domain in areas where data availability is limited due to incomplete records from the monitoring sites.

7.2 Performance Goals and Benchmarks

Establishment of performance goals and benchmarks for regulatory modeling is a necessary but difficult activity. Here, performance goals refer to targets that Alpine believes a good performing model should achieve, whereas performance benchmarks are based on historical model performance measures for the best performing simulations. Performance goals are necessary in order to provide consistency in model applications and expectations across the region and to provide standardization in how much weight may be accorded modeling study results in the decision-making process. These performance goals should not be interpreted as a "bright line" where metrics below the value are judged as adequate and values above the line are unusable. Rather they should be interpreted as the performance for a particular metric with good performance should be more highly relied upon for decision making where a less well performing pollutant may be less relied upon.

It is a problematic activity, though, because many areas present unique challenges and no one set of performance goals is likely to fit all needs. Equally concerning is the very real danger that modeling studies will be truncated when the 'statistics look right' before full assessment of the model's reliability is made. This has the potential from breeding built-in compensating errors as modelers strive to get good statistics as opposed to searching for the explanations for poor performance and then rectifying them.

[25] Appel, K. W., et al. 2011. "A multi-resolution assessment of the Community Multiscale Air Quality (CMAQ) model v4. 7 wet deposition estimates for 2002–2006." Geoscientific Model Development 4.2 (2011): 357-371.

[26] Meyers, T. P., Finkelstein, P., Clarke, J., Ellestad, T.G., and Sims, P.F. 1998. A Multilayer Model for Inferring Dry Deposition Using Standard Meteorological Measurements. J. Geophys. Res., 103(D17): 22,645-22,661, DOI: 10.1029/98jd01564.

[27] https://java.epa.gov/castnet/clearsession.do

For this analysis, Alpine will pair model predictions in space and time with observational data from the IMPROVE, CSN, and CASTNET monitoring networks. These results will be compared by network and season (winter (Dec, Jan, Feb), spring (Mar, Apr, May), summer (Jun, Jul, Aug), and fall (Sep, Oct, Nov)).

Recommended benchmarks for photochemical model performance statistics (Boylan, 2006; Emery, 2017) will be used to assess the applicability of this modeled simulation for regulatory purposes. The goal and criteria values noted in Table 7-1 below will be used for this study.

Table 7-1. Fine Particulate Matter Performance Goals and Criteria

	NMB		NME	
Species	**Goal**	**Criteria**	**Goal**	**Criteria**
24-hr $PM_{2.5}$ and Sulfate	<± 10%	<± 30%	< 35%	< 50%
24-hr Nitrate	<± 10%	<± 65%	< 65%	< 115%
24-hr OC	<± 15%	<± 50%	< 45%	< 65%
24-hr EC	<± 20%	<± 40%	< 50%	< 75%

In addition to these goals, Alpine will compare performance evaluation metrics generated using CAMx 6.40 for each modeled species to EPA's evaluation metrics for the same simulation using CAMx 6.32. In cases where the VISTAS II performance metrics differ by more than 10% from EPA's regional haze metrics, Alpine will document the differences and provide summaries to SESARM for discussion and resolution, as necessary.

Because $PM_{2.5}$ is a mixture, current EPA PM modeling guidance (EPA, 2014e) recommends that a meaningful performance evaluation should include an assessment of how well the model is able to predict individual chemical components that constitute $PM_{2.5}$.

Consistent with EPA's performance evaluation of the regional haze 2028 analysis, in addition to total $PM_{2.5}$, components of $PM_{2.5}$ Alpine will assess:

- Sulfate ion (SO_4^{2-})
- Nitrate ion (NO_3^-)
- Ammonium ion (NH_4^+)
- Elemental Carbon (EC)
- Organic Carbon (OC) and/or Organic Carbon Mass (OCM)
- Crustal (weighted average of the most abundant trace elements in ambient air)
- Sea salt constituents (Na and Cl)

The mapping of the CAMx species into the observed species are presented in Table 7-2.

Table 7-2. Species Mapping from CAMx into Observation Network

Network	Observed Species	CAMx Species
IMPROVE	NO_3	PNO3
	SO_4	PSO4
	NH_4	PNH4
	OM = 1.8*OC	SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB +POA
	EC	PEC
	SOIL	FPRM+FCRS
	$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+ SOA7+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
CSN	$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+ SOA7+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
	NO_3	PNO3
	SO_4	PSO4
	NH_4	PNH4
	OM = 1.4*OC	SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB +POA
	EC	PEC

7.2.1 Diagnostic Evaluation

If the annual CAMx model base case simulations present performance challenges, it may necessitate focused diagnostic and sensitivity testing in order for them to be resolved. If needed, it is hopeful that these diagnostic and/or sensitivity tests can be adequately carried out within the resources and schedule of this contract. If not, then it may be necessary to draw upon the Optional Task 11 resources to conduct the necessary work. Where practical, diagnostic or sensitivity analyses, if needed, could be performed on selected episodes within the annual cycle, thereby avoiding the time-consuming task of running CAMx for the full 2011 period. Upon identification of performance evaluation failure, Alpine will identify the types of diagnostic and sensitivity testing methods that might be employed in diagnosing inadequate model performance and devising appropriate methods for improving the model response. Upon discussion, negotiation, and approval with and by SESARM and EPA of evaluation procedures to conduct, Alpine will execute the tests, identify the issues, propose and resolution to the problem, and apply any changes as approved.

8.0 AREA OF INFLUENCE

Under this task, ERG will identify the 20% most impaired days for each Class I area in the VISTAS_12 modeling domain over the 2011-2016 period based on the IMPROVE monitoring website RHR summary of the 20% most-impaired visibility days.[28] Due to the presence of large SO_2 emission reductions during this six-year period, the area of influence (AoI) analysis will be set up to look at: 1) each year individually; 2) two separate periods of 2011-2013 and 2014-2016; and 3) for all years combined.

The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model[29] developed by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL) will be run for each of these days to identify areas most likely influencing visibility. The HYSPLIT runs will use the NAM-12 hybrid meteorology and trajectory will be run for starting heights of 100 meters (m), 500 m, 1,000 m, and 1,500 m. Trajectories will be run 72 hours backwards in time at each height and location. The AoI analysis will be set up to look at: 1) each starting height individually and 2) all starting heights combined.

Trajectories will be run with start times of 12AM (midnight of the start of the day), 6AM, 12PM, 6PM, and 12AM (midnight at the end of the day) local time. Trajectories will originate from each of the forty (40) IMPROVE monitors in the VISTAS_12 domain (Table 8-1 and Figure 8-1). Based on analysis from NC, ERG omitted several western states, as trajectories originating in Class I areas in those states do not pass over a SESARM state (hatched shading in Figure 8-1).

In certain instances, the trajectory origin will be the centroid of the Class I area. Class I areas without a dedicated IMPROVE monitor will have their trajectories originate from the centroid of the Class I area. Visibility data will be based on an appropriate IMPROVE monitor, as previously determined by the federal Land Managers. Another example when the monitor is remove from the Class I area. For example, the Breton Island trajectory will start from the centroid of the Class I, as the monitor has been moved further on shore in Louisiana. There are nine (9) such areas identified in the VISTAS 12km domain.

In instances where all years are not available at an IMPROVE monitoring site, the 20% most impaired days from the year years available will be analyzed. For example, Shining Rock Wilderness area does not have data for 2011, as a result the trajectories for area of influence analysis will only cover the 2012 to 2016 period.

Three VISTAS region Class I areas do not have an IMPROVE monitor: Wolf Island, Joyce Kilmer-Slickrock and Otter Creek. For these sites, trajectories will originate from the centroid of the Class I area (Figure 8-2). The 20% most impaired dates will be based off a representative IMPROVE monitor, which are listed in Table 8-2.

[28] http://vista.cira.colostate.edu/Improve/rhr-summary-data/

[29] Stein, A.F., Draxler, R.R, Rolph, G.D., Stunder, B.J.B., Cohen, M.D., and Ngan, F., (2015). NOAA's HYSPLIT atmospheric transport and dispersion modeling system, Bull. Amer. Meteor. Soc., 96, 2059-2077, http://dx.doi.org/10.1175/BAMS-D-14-00110.1

Table 8-1. IMPROVE Monitors in the VISTAS_12 Domain

IMPROVE Site	IMPROVE Site Code	State	FIPS Code	Latitude	Longitude	Start Date	End Date
Sipsey Wilderness	SIPS1	AL	01079	34.3433	-87.3388	03/04/1992	04/28/2017
Caney Creek	CACR1	AR	05113	34.4544	-94.1429	06/24/2000	04/28/2017
Upper Buffalo Wilderness	UPBU1	AR	05101	35.8258	-93.2030	12/04/1991	04/28/2017
Chassahowitzka NWR	CHAS1	FL	12017	28.7484	-82.5549	03/03/1993	04/28/2017
Everglades NP	EVER1	FL	12086	25.3910	-80.6806	09/03/1988	04/28/2017
St. Marks	SAMA1	FL	12129	30.0926	-84.1614	08/16/2000	04/28/2017
Cohutta	COHU1	GA	13213	34.7852	-84.6265	06/03/2000	04/28/2017
Okefenokee NWR	OKEF1	GA	13049	30.7405	-82.1283	09/04/1991	04/28/2017
Mammoth Cave NP	MACA1	KY	21061	37.1318	-86.1479	09/04/1991	04/28/2017
Breton Island	BRIS1	LA	22075	30.1086	-89.7617	01/16/2008	04/28/2017
Acadia NP	ACAD1	ME	23009	44.3771	-68.2610	03/02/1988	04/28/2017
Moosehorn NWR	MOOS1	ME	23029	45.1259	-67.2661	12/03/1994	04/28/2017
Isle Royale NP	ISLE1	MI	26083	47.4596	-88.1491	11/17/1999	04/28/2017
Seney	SENE1	MI	26153	46.2889	-85.9503	11/17/1999	04/28/2017
Boundary Waters Canoe Area	BOWA1	MN	27075	47.9466	-91.4955	06/01/1991	04/28/2017
Voyageurs NP #2	VOYA2	MN	27137	48.4126	-92.8286	03/02/1988	04/28/2017
Hercules-Glades	HEGL1	MO	29213	36.6138	-92.9221	03/02/2001	04/28/2017
Mingo	MING1	MO	29207	36.9717	-90.1432	06/03/2000	04/28/2017
Linville Gorge	LIGO1	NC	37011	35.9723	-81.9331	04/01/2000	04/28/2017
Shining Rock Wilderness	SHRO1	NC	37087	35.3937	-82.7744	06/01/1994	04/28/2017
Swanquarter	SWAN1	NC	37095	35.4510	-76.2075	06/10/2000	04/28/2017
Great Gulf Wilderness	GRGU1	NH	33007	44.3082	-71.2177	06/03/1995	04/28/2017
Brigantine NWR	BRIG1	NJ	34001	39.4650	-74.4492	09/04/1991	04/28/2017
Bandelier NM	BAND1	NM	35028	35.7797	-106.2664	03/02/1988	04/28/2017
Bosque del Apache	BOAP1	NM	35053	33.8695	-106.8520	04/15/2000	04/28/2017
Salt Creek	SACR1	NM	35005	33.4598	-104.4042	04/08/2000	04/28/2017
San Pedro Parks	SAPE1	NM	35039	36.0139	-106.8447	08/16/2000	04/28/2017
Wheeler Peak	WHPE1	NM	35055	36.5854	-105.4520	08/16/2000	04/28/2017
White Mountain	WHIT1	NM	35027	33.4687	-105.5349	12/03/2001	04/28/2017
Wichita Mountains	WIMO1	OK	40031	34.7323	-98.7130	03/02/2001	04/28/2017
Cape Romain NWR	ROMA1	SC	45019	32.9410	-79.6572	09/03/1994	04/28/2017
Great Smoky Mountains NP	GRSM1	TN	47009	35.6334	-83.9416	03/02/1988	04/28/2017
Big Bend NP	BIBE1	TX	48043	29.3027	-103.1780	03/02/1988	04/28/2017
Guadalupe Mountains NP	GUMO1	TX	48109	31.8330	-104.8094	03/02/1988	04/28/2017
James River Face Wilderness	JARI1	VA	51163	37.6266	-79.5125	06/03/2000	04/28/2017
Shenandoah NP	SHEN1	VA	51113	38.5229	-78.4348	03/02/1988	04/28/2017
Lye Brook Wilderness	LYBR1	VT	50003	43.1482	-73.1268	09/04/1991	09/30/2012
Lye Brook Wilderness	LYEB1	VT	50025	42.9561	-72.9098	01/01/2012	04/28/2017
Dolly Sods Wilderness	DOSO1	WV	54093	39.1053	-79.4261	09/04/1991	04/28/2017

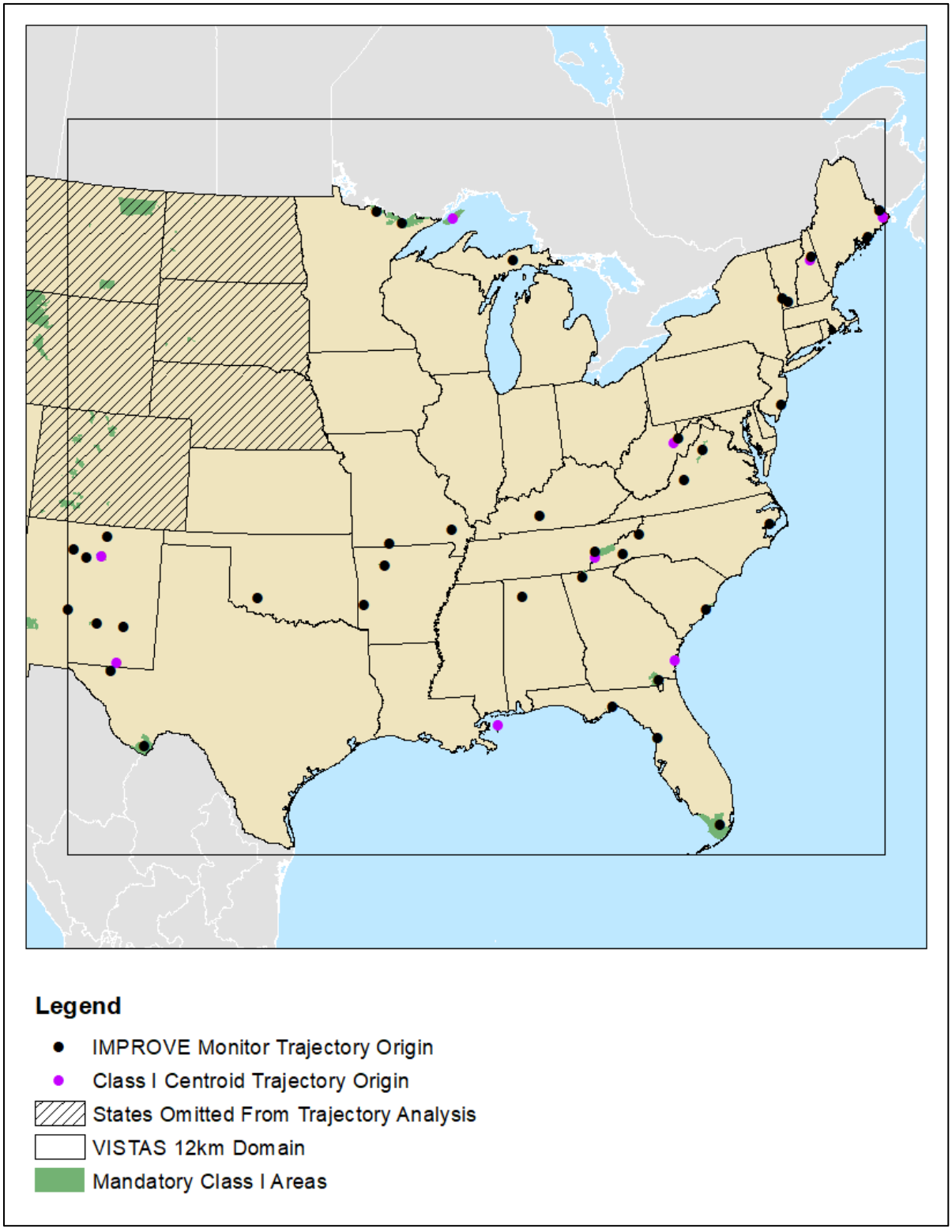


Figure 8-1. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS 12km Domain

Figure 8-2. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS States

Table 8-2. Representative IMPROVE Monitor for Each VISTAS Class I Area

Class I Area	Representative IMPROVE Site	IMPROVE Site Code	State	FIPS County Code	Latitude	Longitude
AL - Sipsey Wilderness Area	Sipsey Wilderness	SIPS1	AL	01079	34.3433	-87.3388
FL - Chassahowitzka Wilderness Area	Chassahowitzka NWR	CHAS1	FL	12017	28.7484	-82.5549
FL - Everglades National Park	Everglades NP	EVER1	FL	12086	25.391	-80.6806
FL - St. Marks Wilderness Area	St. Marks	SAMA1	FL	12129	30.0926	-84.1614
GA - Cohutta Wilderness Area	Cohutta	COHU1	GA	13213	34.7852	-84.6265
GA - Okefenokee Wilderness Area	Okefenokee NWR	OKEF1	GA	13049	30.7405	-82.1283
GA - Wolf Island Wilderness Area	Okefenokee NWR	OKEF1	GA	13049	30.7405	-82.1283
KY - Mammoth Cave National Park	Mammoth Cave NP	MACA1	KY	21061	37.1318	-86.1479
NC/TN - Great Smoky Mountains National Park	Great Smoky Mountains NP	GRSM1	TN	47009	35.6334	-83.9416
NC/TN - Joyce Kilmer-Slickrock Wilderness	Great Smoky Mountains NP	GRSM1	TN	47009	35.6334	-83.9416
NC - Linville Gorge Wilderness Area	Linville Gorge	LIGO1	NC	37011	35.9723	-81.9331
NC - Shining Rock Wilderness Area	Shining Rock Wilderness	SHRO1	NC	37087	35.3937	-82.7744
NC - Swanquarter Wilderness Area	Swanquarter	SWAN1	NC	37095	35.451	-76.2075
SC - Cape Romain Wilderness Area	Cape Romain NWR	ROMA1	SC	45019	32.941	-79.6572
VA - James River Face Wilderness Area	James River Face Wilderness	JARI1	VA	51163	37.6266	-79.5125
VA - Shenandoah National Park	Shenandoah NP	SHEN1	VA	51113	38.5229	-78.4348
WV - Dolly Sods Wilderness Area	Dolly Sods Wilderness	DOSO1	WV	54093	39.1053	-79.4261
WV - Otter Creek Wilderness Area	Dolly Sods Wilderness	DOSO1	WV	54093	39.1053	-79.4261

Trajectories will be run utilizing the SplitR package (https://github.com/rich-iannone/SplitR), which allows the control of HYSPLIT through the R statistical software. This allows for automation of the HYSPLIT runs for each location, while still generating the GIS shapefiles and separate files of the endpoint for further use in R.

The back trajectories for the 20% most impaired days will then be used to develop residency time (RT) plots via the openair[30] package for R. The RT plots define the geographic areas with the highest probability of influencing the monitor on the 20% most impaired visibility days.

The RT is calculated as the number of trajectory hours that pass through each grid cell. This can be presented as a percentage of the total number of trajectory hours. The grid used would align with the photochemical modeling 12km grid for consistency with emission analysis. For further analysis, R allows the residence time plots to be split by time increments (i.e., year, season). Images of the RT plots will be generated for QA and review purposes. Images will at least cover the VISTAS 12-km domain and include outlines of states and counties.

The trajectory data will also be weighted by ammonium sulfate and ammonium nitrate and used to produce separate sulfate and nitrate extinction weighted residency time (EWRT) plots. This allows separate analysis for sulfate and nitrate that is weighted toward the days influenced most by those constituents and not days most influenced by other constituents, like organic carbon.

In this project, the Concentration Weighted Trajectory (CWT)[31] approach will be used to develop the EWRT, substituting the extinction value for the concentration. The extinction attributable to each pollutant is paired with the trajectory for that day. R then calculates the mean weighted extinction of the pollutant species for each grid cell. The mean weighted extinction is calculated by:

$$\bar{E}_{ij} = EWRT = \frac{1}{\sum_{k=1}^{N} \tau_{ijk}} \sum_{k=1}^{N} (bext_k)\, \tau_{ijk}$$

where i and j are the indices of grid, k the index of trajectory, N the total number of trajectories used in analysis, b_{extk} is the 24-hour extinction attributed to the pollutant measured upon arrival of trajectory k, and τ_{ijk} the number of trajectory hours that pass through each grid cell (i, j) (where "i" is the row and "j" is the column).[32] The higher the value of the EWRT ($\bar{E}_{ij}$), the more likely that the air parcels passing over cell (i, j) would cause higher extinction at the receptor site for that light extinction species. Since this method uses the extinction value for weighting, trajectories passing over large sources are more discernible from those passing over moderate sources. A point filter can be used to eliminate grid cell with few trajectory hours from the

[30] Carslaw DC and Ropkins K (2012). "openair — An R package for air quality data analysis." Environmental Modelling & Software, 27–28(0), pp. 52–61. ISSN 1364-8152, doi: 10.1016/j.envsoft.2011.09.008.

[31] Hsu, Y.-K., T. M. Holsen and P. K. Hopke (2003). "Comparison of hybrid receptor models to locate PCB sources in Chicago". In: Atmospheric Environment 37.4, pp. 545–562. DOI: 10.1016/S1352-2310(02)00886-5

[32] Carslaw, D.C. (2015). The openair manual — open-source tools for analyzing air pollution data. Manual for Version 1.1-4, King's College London. http://www.openair-project.org/PDF/OpenAir_Manual.pdf

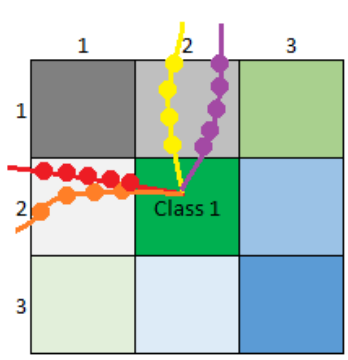
analysis. As this distinction can help refine control strategy development, using the CWT method to create the EWRT is ERG's recommendation for the analysis.

The EWRT results can be normalized by the domain total to present the results as a percentage in images. Images of the extinction weighted RT plots will be generated for QA and review purposes. Images will at least cover the VISTAS 12-km domain and include outlines of states and counties. An example calculation is provided in Figure 8-3, which has been simplified to only four trajectories. In this example, two trajectories pass through the cell (1,2). The first of these trajectories (yellow) has an extinction value ($bext_k$) of 50 Mm^{-1} associated with it. The four yellow dots in the cell denote that four hours of the back trajectory are spent in the cell. This yields "$\tau_{1,2,yellow}$" equal to 4 hours. Multiplying by the extinction ($bext_k$) for the cell yields a trajectory weight of 200 Mm^{-1}hrs. This is added to the weight of the second (purple) trajectory for a total extinction weight of 450 Mm^{-1}hrs. This is then divided by the total number of trajectory hours in the analysis (18 hours) to yield the final EWRT for the cell of 25 Mm^{-1}. The same calculation is done for cell (2,1). While the cells have the same number of trajectories and endpoints, the weight given to cell (2,1) is higher due to the higher extinctions associated with the trajectories.

The next phase of the analysis will combine the EWRT values with the distance weighted gridded emission data to determine the sources most likely contributing to the elevated extinction levels. Distances (d) for the weighting, calculated using ArcGIS, will be calculated from the location of the point source to the trajectory origin in kilometers. The weighted emission file is comprised of the EGU and non-EGU point source emissions value for each grid cell (Q, in tons per year) divided by the distance (d, in kilometres) to the trajectory origin; that is the final value is (Q/d). Each of these grid cell values is multiplied by its respective sulfate or nitrate EWRT plot values (i.e., EWRT *(Q/d)). A simplified example calculation for a single point source per cell is provided in Figure 8-4. Continuing with weights calculated in Figure 8-3, point sources in cell (1,2) emit 100 tons per year (Q=100 tpy), with the centroid 12km away from the trajectory origin. This yields a "Q/d" of 8.33 tpy/km for the source. This "Q/d" term is multiplied by the EWRT previously calculated at 25 Mm^{-1} to yield a source weighted EWRT value that indicates the potential importance of the sources in this cell to impaired visibility days in the Class I area. Alternately, the EWRT*(Q/d) can be calculated for each source in a cell, and totalled for a grid cell total. Similar to the EWRT plots, these contribution plots can be normalized by the domain total to present them as a percentage in plots. Images of the results will be mapped over the VISTAS 12-km modeling domain, with state and county boundaries for review and QA purposes.

These gridded results will then be linked with the 2011 and 2028 point source inventories to calculate the emission contribution from each source. ArcGIS will be used to spatially join the gridded information with shapefiles the point source information. This will create a dataset that combines the point source metadata facility identifying information (i.e., Facility ID, Facility Name, State, County, Federal Information Processing Standard (FIPS), North American Industry Classification System (NAICS), and industry description), and the gridded information (i.e., SO_2 and NO_2 emissions, d, Q/d, EWRT, EWRT *(Q/d)). The Q/d values will be calculated by dividing facility-wide emissions (tons per year) by distance (km) to the Class I area. In the alternate strategy proposed above, this step would be completed first, then totalled for

visualization. Additional information can be added as deemed necessary in making control strategy decisions. The information from these spatial files can then be exported to separate Excel spreadsheets for each Class I area in the VISTAS_12 domain for further review by the states.



EWRT

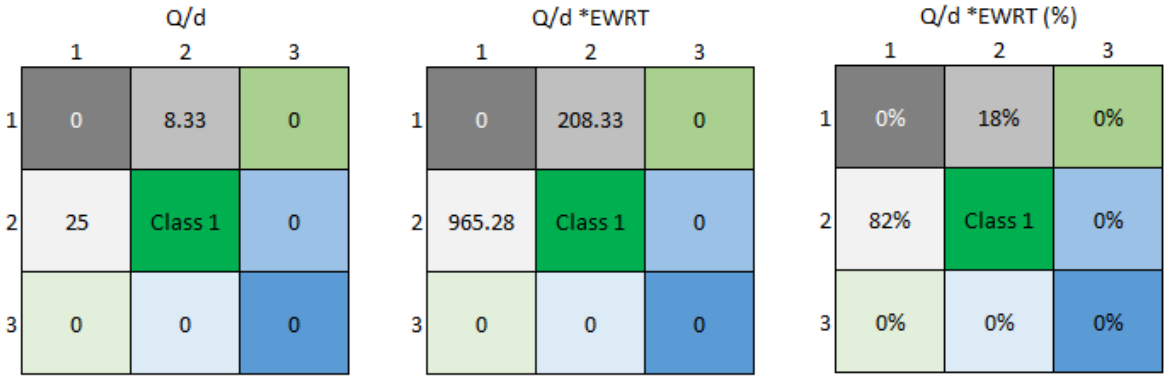
	1	2	3
1	0.00	25.00	0.00
2	38.61	Class 1	0.00
3	0.00	0.00	0.00

EWRT (%)

	1	2	3
1	0%	39%	0%
2	61%	Class 1	0%
3	0%	0%	0.00

Row (i)	Col (j)	# Trajectory hours	Trajectory (k)	Extinction ($bext_k$) [Mm^{-1}]	τ_{ijk} [hrs]	$(bext_k)\tau_{ijk}$ [Mm^{-1} hrs]	$\Sigma\tau_{ij}$ [hrs]	$\Sigma(bext_k)\tau_{ijk}$ [Mm^{-1} hrs]	EWRT [Mm^{-1}]
2	1	5	1 (Red)	75	5	375	18	695	38.61
		4	2 (Orange)	80	4	320			
1	2	4	1 (Yellow)	50	4	200	18	450	25
		5	2 (Purple)	50	5	250			

Figure 8-3. Example EWRT Calculations



Row (i)	Col (j)	ΣQ [tpy]	d [km]	Q/d [tpy km^{-1}]	Q/d*EWRT [tpy km^{-1} Mm^{-1}]	Q/d*EWRT [%]
2	1	300	12	25	965.28	82%
1	2	100	12	8.33	208.33	11%

Figure 8-4. Example (Q/d)*EWRT Calculations

Similar analysis will be conducted to rank SO_2 and NO_2 emissions contributions for onroad, nonroad, fires, and area source sectors from each county. The process will be similar to the process for point sources previously described, except calculations of RT and EWRT will be done to counties as opposed to grids. ERG will determine if the trajectories can be weighted further for the time spent in the county. The length of the trajectory within the county would be used as a proxy for time, so that trajectories that only cross a small corner of the county are not weight as much as trajectories passing through the center of the county. This will be done in GIS using the same calculation method as in *R* (i.e., CWT). The calculation of d would then be from the centroid of the county to the trajectory origin, in kilometers. Similar to point sources, the final spatial join would be to the county level EWRT and a shapefile of the source information at the county level, for each sector. All county and emissions source identifying information will be provided along with inventory emissions, distance, Q/d and Q/d^2 values, EWRT, EWRT*(Q/d), fraction and sum contributions, and any other information deemed necessary in making control strategy decisions for each source.

All images, shapefiles, and spreadsheets will be uploaded to the files sharing platform, as designed in Task 10, in separate folders for each Class I area or IMPROVE monitor in the VISTAS_12 domain. Each analysis element (e.g., RT plots, summary spreadsheets) will be contained in separate subfolders for ease of navigation. SESARM will be notified when the files are available and ready for use. A technical memorandum/interim report describing the area of influence calculations, and the results, will be prepared for SESARM and other stakeholders for use in their implementation plans.

9.0 FUTURE YEAR MODELING

This chapter discusses the future year modeling using the annual modeling databases and how these results will be used to project 2009-2013 IMPROVE visibility data to 2028 following the approach used in EPA's regional haze modeling guidance (EPA, 2014e).

9.1 Regional Haze Rule Requirements

As required by the RHR, RPGs must provide for an improvement in visibility for the 20 percent most anthropogenically impaired days relative to baseline visibility conditions and ensure no degradation in visibility for the 20 percent clearest days relative to baseline visibility conditions. The baseline for each Class I area is the average visibility (in dvs) for the years 2000 through 2004. The visibility conditions in these years are the benchmark for the "provide for an improvement" and "no degradation" requirements. In addition, states are required to determine the rate of improvement in visibility needed to reach natural conditions by 2064 for the 20 percent most anthropogenically impaired days. A line drawn between the end of the 2000-2004 baseline period and 2064 (dv/year) shows a uniform rate of progress (URP) between these two points. This "glidepath" is the amount of visibility improvement needed in each implementation period, starting from the baseline period, to stay on a linear path towards visibility improvement to natural conditions by 2064. The glidepath represents a linear or uniform rate of progress. This is a framework for consideration but there is no requirement to be on or below the glidepath.

The RHR requires states to submit an implementation plan that evaluates reasonable progress for implementation periods in approximately ten year increments. The next regional haze SIP is due in 2021, for the implementation period which ends in 2028 (period of 2019-2028).

Therefore, modeling is being conducted to project visibility to 2028 using a 2028 emissions inventory with "on-the-books" controls. The EPA Software for Model Attainment Test-Community Edition (SMAT-CE) tool[33] will be used to calculate 2028 dv values on the 20% most impaired and 20% clearest days at each Class I Area (IMPROVE site). SMAT-CE is an EPA software tool which implements the procedures in the modeling guidance to project visibility to a future year.

9.2 Future Year to be Simulated

As discussed in Section 1, to support the preliminary 2028 regional haze modeling requested by SESARM, Alpine will conduct air quality modeling to project particulate matter concentrations at individual monitoring sites to 2028 and to estimate changes in regional haze as a result of those concentrations.

9.3 Future Year Baseline Air Quality Simulations

The 2028 future year base case CAMx simulation will be conducted and particulate matter concentration calculations made following the procedures in Section 5 and that are consistent with EPA's latest regional haze modeling analysis (EPA, 2017b).

[33] https://www.epa.gov/scram/photochemical-modeling-tools

9.4 Calculation of 2028 Visibility

The visibility projections will follow the procedures in EPA's modeling guidance (EPA, 2014e). Based on the recommendation in the modeling guidance, the observed base period visibility data will be linked to the base modeling year. This is the 5-year ambient data base period centered about the base modeling year. In this case, for a base modeling year of 2011, the ambient IMPROVE data will be from the 2009-2013 period.

The visibility calculations will use the "revised" IMPROVE equation (Hand, 2006); (Pitchford, 2007), which has replaced the original IMPROVE equation and has been used in most regional haze SIPs over the last 10 years. The IMPROVE equation (or algorithm), which uses PM species concentrations and relative humidity data to calculate visibility impairment, or b_{ext}, in units of inverse megameters (Mm^{-1}), is presented below:

$$b_ext \approx 2.2 \times f_s(RH) \times [Small\ Sulfate] + 4.8 \times f_L(RH) \times [Large\ Sulfate] + 2.4 \times f_s(RH) \times [Small\ Nitrate] + 5.1 \times f_L(RH) \times [Large\ Nitrate] + 2.8 \times [Small\ Organic\ Mass] + 6.1 \times [Large\ Organic\ Mass] + 10 \times [Elemental\ Carbon] + 1 \times [Fine\ Soil] + 1.7 \times f_SS(RH) \times [Sea\ Salt] + 0.6 \times [Coarse\ Mass] + Rayleigh\ Scattering\ (Site\ Specific) + 0.33 \times [NO_2\ (ppb)]$$

The total sulfate, nitrate, and organic carbon compound concentrations are each split into two fractions, representing small and large size distributions of those components. Site-specific Rayleigh scattering is calculated based on the elevation and annual average temperature of each IMPROVE monitoring site.

The 2028 future year visibility on the 20% most impaired days and 20% clearest days at each Class I area will be estimated using the observed IMPROVE data (2009-2013) and the relative percent modeled change in PM species between 2011 and 2028. The process is described in the following six steps.

1. For each Class I area (IMPROVE site), estimate anthropogenic impairment[34] on each day using observed speciated $PM_{2.5}$ data plus PM_{10} data (and other information) for each of the 5 years comprising the base period (2009-2013 in this case) and rank the days on this indicator. This ranking will determine the 20 percent most anthropogenically impaired days. For each Class I area, also rank observed visibility (in dvs) on each day using observed speciated $PM_{2.5}$ data plus PM_{10} data for each of the 5 years comprising the base period. This ranking will determine the 20 percent clearest days.

2. For each of the 5 years comprising the base period, calculate the mean dvs for the 20 percent most anthropogenically impaired days and 20 percent clearest days. For each Class I area, calculate the 5 year mean dvs for most impaired and clearest days from the 5 year-specific values.

3. Use an air quality model to simulate air quality with base period (2011) emissions and future year (2028) emissions. Use the resulting information to develop site-specific relative response factors (RRFs) for each component of PM identified in the "revised"

[34] http://vista.cira.colostate.edu/Improve/rhr-summary-data/

IMPROVE equation. The RRFs are an average percent change in species concentrations based on the measured 20% most impaired and 20% clearest days from 2011 (the calendar days identified from the IMPROVE data above are matched to the same modeled days).

4. Multiply the species-specific RRFs by the measured daily species concentration data during the 2009-2013 base period (for each day in the measured 20% most impaired day set and each day in the 20% clearest day set), for each site. This results in daily future year 2028 PM species concentration data.

5. Using the results in Step 4 and the IMPROVE algorithm, calculate the future daily extinction values for the previously identified 20 percent most impaired days and 20 percent clearest days in each of the five base years.

6. Calculate daily dv values (from total daily extinction) and then compute the future year (2028) average mean dvs for the 20 percent most impaired days and 20 percent clearest days for each year. Average the five years together to get the final future mean dv values for the 20 percent most impaired days and 20 percent clearest days.

The SMAT-CE tool will be used to generate individual year and 5-year average base year and future year dv values on the 20% most impaired days and 20% clearest days. Additional SMAT output variables include the results of intermediate calculations such as species specific extinction values (both base and future year) and species specific RRFs (on the 20% most impaired and clearest days).

Table 9-1 details the settings to be used for the SMAT runs to generate the 2028 future year dv projections:

Table 9-1. SMAT-CE Settings for 2028 Visibility Calculations

SMAT-CE Option	Setting or File Used
IMPROVE algorithm	Use new version
Grid cells at monitor or Class I area centroid?	Use grid cells at monitor
IMPROVE data file	ClassIareas_NEWIMPROVEALG_2000to2015_2017april27_IMPAIRMENT.csv
Temporal adjustment at monitor	3 x 3
Start monitor year	2009
End monitor year	2013
Base Model year	2011
Minimum years required for a valid monitor	3

In order for Alpine to conduct the source apportionment runs, the CAMx 2011 and 2028 model output will be post-processed using a “species definition file” that cross references raw CAMx output species names with PM species needed for SMAT. The results of the post-processing are 24-hour average PM species with the “combine file” output names. These are matched to the SMAT species as shown in Table 10-1.

Table 9-2. Matching of CAMx Raw Output Species to SMAT Input Variables

SMAT Species	"Combine File" Output Name	Raw CAMx 6.40 Species
Sulfate	PM25_SO4	PSO4
Nitrate	PM25_NO3	PNO3
Ammonium	PM25_NH4	PNH4
Organic carbon	PM25_OM	POA+SOA1+SOA2+SOPA+SOA3+SOA4+SOA5 +SOA6+SOA7+SOPB
Elemental carbon	PM25_EC	PEC
Crustal	CRUSTAL	FCRS+FPRM
Coarse PM	PMC_TOT	CCRS+CPRM
PM2.5	PM25_SMAT	CRUSTAL+PSO4+PNO3+PNH4+PEC+NA+PCL+ SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7 +SOPA+SOPB+POA

9.5 Comparison to Regional Haze "Glidepath"

The future year 2028 dv projections will be compared to the unadjusted visibility "glidepath" at each Class I area. The unadjusted "glidepath" represents the amount of visibility improvement needed in each implementation period, starting from the baseline 2000-2004 period, to stay on a linear path to natural visibility conditions by 2064. Visibility on the 20% most impaired days is compared to the relevant value of the glidepath, in this case for a future year of 2028. Since the glidepath is a linear path between 2004 and 2064, a glidepath value (in dvs) can be calculated for any future year, using a simple equation. The following formula will be used to calculate the 2028 glidepath value:

$$Glidepath_{2028} = Baseline\ average\ dv - (((Baseline\ average\ dv - Natural\ conditions)/60)*24)$$

Where,

Baseline average dv = average observed dv value on the 20% most impaired days for 2000-2004

Natural conditions= Natural conditions on the 20% most impaired days at the Class I area (in dv)

Once calculated, the 2028 future year projected dv values can be compared to the unadjusted glidepath for 2028 to determine if the Class I area is projected to be above, below, or on the glidepath. While the RHR requires future year projected visibility impairment be compared to the glidepath, it does not require the RPGs be on or below the glidepath. However, the rule has different requirements depending on whether the projected value (RPG) is above or below the glidepath.

10.0 PSAT SOURCE APPORTIONMENT

In order to gain a better understanding of the source contributions to modeled visibility, Alpine will use CAMx Particulate Source Apportionment Technology (PSAT) modeling. PSAT uses multiple tracer families to track the fate of both primary and secondary PM (Yarwood et al., 2004). PSAT is designed to apportion the following classes of CAMx PM species:

- Sulfate (PSO_4)
- Particulate nitrate (PNO_3)
- Ammonium (PNH_4)
- Secondary organic aerosol (SOA)
- Primary PM (PEC, POA, FCRS, FPRM, CCRS, and CPRM)
- Particulate mercury (HGP)

PSAT allows emissions to be tracked (tagged) by various combinations of sectors and geographic areas (e.g., by state or facility). For this application, 2028 emissions will be tagged ("tag") using SESARM-identified combinations of region, facilities, and/or source category. Each combination accounts for a single "tag" with SESARM planning to identify up to 250 individual tagged combinations. Each of these emissions combinations will be processed separately through SMOKE and tracked in PSAT as individual source tags. Receptors, identified as all the Class I areas in the VISTAS_12 modeling domain, will be used to analyze the results and impacts of each tagged combination.

For this application, only sulfate and nitrate will be tracked using PSAT. Tracking of other contributions may also be of use, but is not requested in this analysis. In the PSAT post processing the data will be converted from the UTC based modeling data into 24-hour average grid cell local standard time using the HR2DAY[35] utility program. The HR2DAY program matches each grid cell in the model to a timezone and performs the 24-hour average on the timezone adjusted hourly data. This is the same program that EPA uses in their national modeling.

In order for Alpine to conduct the source apportionment runs, the CAMx 2011 and 2028 model output will be post-processed using a "species definition file" that cross references raw CAMx output species names with PM species needed for SMAT. The results of the post-processing are 24-hour average PM species with the "combine file" output names. These are matched to the SMAT species as shown in Table 10-1.

Table 10-1. Matching of CAMx Raw Output Species to SMAT Input Variables

SMAT Species	Raw CAMx 6.40 Species
Sulfate (SO4)	PSO4
Nitrate (NO3)	PNO3
Ammonium (NH4)	PNH4
Organic carbon (OC)	POA+SOA1+SOA2+SOPA+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA +SOPB

[35] https://www.airqualitymodeling.org/index.php/CMAQv5.1_Tools_and_Utilities#HR2DAY_utility_program

Table 10-1. Matching of CAMx Raw Output Species to SMAT Input Variables

SMAT Species	Raw CAMx 6.40 Species
Elemental carbon (EC)	PEC
Crustal (CRUSTAL)	FCRS+CFRM
Coarse PM (CM)	CPRM+CCRS
PM2.5 (PM25)	PSO4+PNO3+PNH4+POA+PEC+FCRS+FPRM+SOA1+SOA2+SOA3+ SOA4+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB

10.1 Process for Creating PSAT Contributions for Class I Areas

The CAMx hourly concentration data will be post-processed to create SMAT input files. This will involve processing both the 2028 "full model" and the specific source apportionment outputs. The "full model" results are the total PM species concentrations (e.g. sulfate, nitrate) and are identical to the total species concentrations from the non-source apportionment model run for 2028 (e.g., future year base case). The source apportionment outputs contain the sulfate and/or nitrate contributions for each tagged source.

The PSAT source apportionment tracking uses slightly different variables names for the source apportionment variables. Table 10-2 below shows the SMAT species definition matching to be used for the 2028 full model and 2028 source apportionment results in the VISTAS II analysis.

Table 10-2. Matching of "Bulk Raw Species", PSAT Output Species, and SMAT Input Variables

SMAT Species	2028 Full Model Species	2028 PSAT Tag Raw Species
Sulfate	PSO4	PS4
Nitrate	PNO3	PN3

This analysis will use a slightly different method than was documented by EPA in the regional haze modeling for 2028. For example, in this study we are looking at the SMAT-CE generated visibility/extinction deltas. The EPA approach, however, was designed for a different purpose than just to estimate emissions sector contributions to 2028 particulate matter concentrations and visibility. Their configuration of the SMAT simulations and post-processed calculations allowed EPA to better understand the sources of future visibility impairment (including domestic anthropogenic, domestic natural, international anthropogenic, and natural sources). Since these latter issues are not being investigated by SESARM in this study, our presented approach is conceptually simpler and more straightforward to implement and to document. SESARM is only looking for sector contributions to visibility impairment based on a set of to-be-defined sulfate and nitrate tags and not looking to establish species-based contribution metrics.

The following approach will be used in preparing the SMAT input files, running the SMAT software, and analysing the results:

1. Regional haze SMAT will be run for the 2028 future case using "standard" 2011 and 2028 full model SMAT input files. This prepares the 2028 output files which will be used as the basis for comparison with the "tagged" SMAT output described below.

2. Alpine with then create future year, tag-specific SMAT input files by subtracting the 2028 hourly tags from the hourly full model concentration files. This simple arithmetic will be implemented using standard IOAPI utility programs and will generate files similar to EPA's source category-based tagged SMAT input files. Once the hourly files are created, the same processing stream as was used in Step 1 will be used create the tagged SMAT input files from the hourly model concentration files.

3. SMAT will be run (in batch mode) for each future year tag-specific input file generated in Step 2 using the "standard" 2011 SMAT input file as the base year. In these runs, SMAT will be configured identically as in Step 1 except for using the future year "tagged" input files. These individual runs will generate SMAT output files that contain the forecasted extinction data *absent* the tagged contribution.

4. The total extinction (on the 20% most impaired days) for each tag will be calculated from the SMAT bulk output file and each of the tag output files. The visibility impacts of each tag will be computed by subtracting the SMAT output *absent* the tag (created in Step 3) from the full model SMAT output file (created in Step 1).

An example calculation for Cohutta using EPA's 2028 draft regional haze modeling SMAT input and generated output files is provided in Table 10-3 below. In this calculation, we use the 2011 base year and 2028 base case simulation compared to the 2011 base year and Sector 9 (no EGUs) simulation. Visibility (in dv), large sulfate, small nitrate, and bext are provided as examples; numbers are rounded in this example and may not sum due to rounding.

Table 10-3. Tagged Contribution Calculation Example

SMAT Calculated Value	2028 Base Case		2028 Sector 9 (Absent EGUs)		Delta (Base – Sector 9) Tag Impact	
	Best 20% Days	Most Impaired 20% Days	Best 20% Days	Most Impaired 20% Days	Best 20% Days	Most Impaired 20% Days
Visibility (dv_f)	9.11	17.69	8.07	16.07	1.04	1.62
$SO_{4,Large}$_f ($\mu g/m^3$)	0.037	0.326	0.017	0.148	0.020	0.178
$NO_{3,Small}$_f ($\mu g/m^3$)	0.208	0.238	0.187	0.221	0.021	0.018
Bext_f (Mm^{-1})	25.41	59.75	22.79	50.9	2.62	8.84

In summary, since SMAT directly provides visibility metrics for the 20% most impaired and 20% clearest days, our proposed application is to subtract the visibility results of the tagged run (deciviews absent the tag) from the 2028 base case run to determine to contribution of each tag to the total base case visibility value.

Alpine will continue to review this method with SESARM and EPA and should a change be warranted in the calculation steps, we will change the calculation to meet the needs of SESARM prior to running the contribution steps.

Finally, using data from the resulting calculations, Alpine will create the day-by-day stacked bar charts of total and speciated component b_{ext} (ammonium sulfate, ammonium nitrate, OC, EC, crustals, CM) for the 20% most impaired and 20% clearest days per site for each IMPROVE monitor in the VISTAS_12 modeling domain and as directed by SESARM will also modify the similar 2011 site-by-site charts to include 2028 modeled data.

11.0 MODELING DOCUMENTATION AND DATA ARCHIVE

EPA recommends that certain types of documentation be provided along with a photochemical modeling attainment demonstration. ERG and Alpine Geophysics are committed to supplying the material needed to ensure that the technical support for this analysis is understood by all stakeholders, EPA, and SESARM.

Alpine plans to archive all documentation and modeling input/output files generated as part of the VISTAS II modeling analysis and will provide a copy to SESARM for permanent archival, additional internal use, and public distribution. Key participants in this modeling effort will be given data access to the archived modeling information.

12.0 REFERENCES

Abt. 2014. Modeled Attainment Test Software – User's Manual. Abt Associates Inc., Bethesda, MD. April. (http://www.epa.gov/ttn/scram/guidance/guide/MATS_2-6-1_manual.pdf).

Arnold, J.R., R.L. Dennis, and G.S. Tonnesen. 2003. "Diagnostic Evaluation of Numerical Air Quality Models with Specialized Ambient Observations: Testing the Community Multiscale Air Quality Modeling System (CMAQ) at Selected SOS 95 Ground Sites", *Atmos. Environ.*, Vol. 37, pp. 1185-1198.

Arnold, J.R.; R.L. Dennis, and G.S. Tonnesen. 1998. Advanced techniques for evaluating Eulerian air quality models: background and methodology. In: Preprints of the 10th Joint Conference on the Applications of Air Pollution Meteorology with the Air & Waste Management Association, January, Phoenix, Arizona. American Meteorological Society, Boston, Massachusetts, paper no. 1.1, pp. 1-5.

Arunachalam, S. 2009. Peer Review of Source Apportionment Tools in CAMx and CMAQ. University of North Carolina Institute for the Environment, Chapel Hill, NC. August 31. (http://www.epa.gov/scram001/reports/SourceApportionmentPeerReview.pdf).

Boylan, J. W. 2004. "Calculating Statistics: Concentration Related Performance Goals", paper presented at the EPA PM Model Performance Workshop, Chapel Hill, NC. 11 February.

Boylan, J.W., and A.G. Russell. 2006. PM and light extinction model performance metrics, goals, and criteria for three dimensional air quality models. Atmos. Environ. 40:4946–59. doi:10.1016/j.atmosenv.2005.09.087.

Byun, D.W., and J.K.S. Ching. 1999. "Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System", EPA/600/R-99/030.

Coats, C.J. 1995. Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System, MCNC Environmental Programs, Research Triangle Park, NC.

Colella, P., and P.R. Woodward. 1984. The Piecewise Parabolic Method (PPM) for Gasdynamical Simulations. *J. Comp. Phys.*, **54**, 174201.

Emery, C.A., E. Tai, E., R. E. Morris, G. Yarwood. 2009a. Reducing Vertical Transport Over Complex Terrain in CMAQ and CAMx; AWMA Guideline on Air Quality Models Conference, Raleigh, NC, October 26-30, 2009.

Emery, C.A., E. Tai, R.E. Morris, G. Yarwood. 2009b. Reducing Vertical Transport Over Complex Terrain in Photochemical Grid Models; 8th Annual CMAS Conference, Chapel Hill, NC, October 19-21, 2009.

Emery, C.A., E. Tai, G. Yarwood and R. Morris. 2011. Investigation into approaches to reduce excessive vertical transport over complex terrain in a regional photochemical grid model. *Atmos. Env.*, Vol. 45, Issue 39, December 2011, pp. 7341-7351. (http://www.sciencedirect.com/science/article/pii/S1352231011007965).

Emery, C.A., Z. Liu, A. Russell, M. Odman, G. Yarwood and N. Kumar. 2017. Recommendations on statistics and benchmarks to assess photochemical model performance, Journal of the Air & Waste Management Association, 67:5, 582-598, DOI: 10.1080/10962247.2016.1265027

EPA. 2001. "Guidance Demonstrating Attainment Air Quality Goals for $PM_{2.5}$ and Regional Haze". Draft Final (17 February 2005), U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C.

EPA. 2003a. A Conceptual Model to Adjust Fugitive Dust Emissions to Account for Near Source Particle Removal in Grid Model Applications, prepared by Tom Pace, U.S. EPA, August. http://www.epa.gov/ttn/chief/emch/invent/statusfugdustemissions_082203.pdf.

EPA. 2005a. Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hr Ozone NAAQS -- Final. U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C. October.

EPA. 2005b. "Regional Haze Regulations and Guidelines for Best Available Technology (BART) Determinations". Fed. Reg./Vol. 70, No. 128/Wed. July, Rules and Regulations, pp. 39104-39172. 40 CFR Part 51, FRL-7925-9, RIN AJ31.

EPA. 2007. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-454/B-07-002. April. (http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf).

EPA. 2014a. Motor Vehicle Emissions Simulator (MOVES) – User Guide for MOVES2014. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-055). July. (http://www.epa.gov/oms/models/moves/documents/420b14055.pdf).

EPA. 2014b. Motor Vehicle Emissions Simulator (MOVES) –MOVES2014 User Interface Manual. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-067). July. (http://www.epa.gov/oms/models/moves/documents/420b14057.pdf).

EPA. 2014c. Motor Vehicle Emissions Simulator (MOVES) –MOVES2014 Software Design Reference Manual. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-058). December. (http://www.epa.gov/oms/models/moves/documents/420b14056.pdf).

EPA. 2014d. Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation, U.S. Environmental Protection Agency. November 2014.

EPA. 2014e. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze, U.S. Environmental Protection Agency. December 2014.

EPA. 2015. Air Quality Modeling Technical Support Document for the 2008 Ozone NAAQS Transport Assessment. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. January. (http://www.epa.gov/airtransport/O3TransportAQModelingTSD.pdf).

EPA. 2016a. Technical Support Document (TSD) Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform. U.S. Environmental Protection Agency. August 2016.

EPA. 2016b. Air Quality Modeling Technical Support Document for the 2015 Ozone NAAQS Preliminary Interstate Transport Assessment. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. December 2016.

EPA. 2017a. Use of Photochemical Grid Models for Single-Source Ozone and secondary PM2.5 impacts for Permit Program Related Assessments and for NAAQS Attainment Demonstrations for Ozone, $PM_{2.5}$ and Regional Haze. Memorandum from Tyler Fox, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. August 2017. https://www3.epa.gov/ttn/scram/guidance/clarification/20170804-Photochemical_Grid_Model_Clarification_Memo.pdf

EPA. 2017b. Documentation for the EPA's Preliminary 2028 Regional Haze Modeling. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October.

Gery, M. W., G.Z. Whitten, J.P. Killus, and M.C. Dodge. 1989. A photochemical mechanism for urban and regional-scale computer modeling. *J. Geophys. Res.* 94, 12925-12956.

Gilliam, R. 2010. Evaluation of Multi-Annual CONUS 12 km WRF Simulations. U.S. Environmental Protection Agency, NREL, Atmospheric Modeling and Analysis Division. (http://epa.gov/scram001/adhoc/gilliam2010.pdf).

Gilliam, R.C. and J.E. Pleim, 2010. Performance Assessment of New Land Surface and Planetary Boundary Layer Physics in the WRF-ARW. J. Appl. Meteor. Climatol., 49, 760–774.

Hand, J. L., and W. C. Malm (2006), Review of the IMPROVE equation for estimating ambient light extinction coefficients, CIRA Report, ISSN: 0737-5352-71, Colo. State Univ., Fort Collins. http://vista.cira.colostate.edu/improve/Publications/GrayLit/016_IMPROVEeqReview/IMPROVEeqReview.htm

Henderson, B.H., F. Akhtar, H.O.T. Pye, S.L. Napelenok, W.T. Hutzell, 2014. A Database and Tool for Boundary Conditions for Regional Air Quality Modeling: Description and Evaluations, Geoscientific Model Development, 7, 339-360.

Hong, S-Y, Y. Noh, and J. Dudhia, 2006. A New Vertical Diffusion Package with an Explicit Treatment of Entrainment Processes. Mon. Wea. Rev., 134, 2318–2341.

Houyoux, M.R., Vukovich, J.M., Coats, C.J., Wheeler, N.J.M., Kasibhatla, P.S.,2000. Emissions Inventory Development and Processing for the Seasonal Model for Regional Air Quality. (SMRAQ) project, Journal of Geophysical Research – Atmospheres, 105(D7), 9079-9090.

Iacono, M.J., J.S. Delamere, E.J. Mlawer, M.W. Shephard, S.A Clough, and W.D. Collins, 2008. Radiative Forcing by Long-Lived Greenhouse Gases: Calculations with the AER Radiative Transfer Models, J. Geophys. Res., 113, D13103.

Kain, J.S., 2004. The Kain-Fritsch Convective Parameterization: An Update, J. Appl. Meteor.,43, 170-181.

Ma, L-M. and Tan Z-M, 2009. Improving the Behavior of Cumulus Parameterization for Tropical Cyclone Prediction: Convective Trigger, Atmospheric Research, 92, 190-211.

ME DEP, 2018. Tracking Visibility Progress, 2004-2016, (1st RH SIP Metrics). Maine Department of Environmental Protection for the Mid-Atlantic/Northeast Visibility Union. February.

Michalakes, J., J. Dudhia, D. Gill, J. Klemp and W. Skamarock. 1998. Design of a Next-Generation Regional Weather Research and Forecast Model. Mesoscale and Microscale Meteorological Division, National Center for Atmospheric Research, Boulder, CO. (http://www.mcs.anl.gov/~michalak/ecmwf98/final.html).

Michalakes, J., S. Chen, J. Dudhia, L. Hart, J. Klemp, J. Middlecoff and W. Skamarock. 2001. Development of a Next-Generation Regional Weather Research and Forecast Model. Developments in Teracomputing: Proceedings of the 9th ECMWF Workshop on the Use of High Performance Computing in Meteorology. Eds. Walter Zwieflhofer and Norbet Kreitz. World Scientific, Singapore. Pp. 269-276. (http://www.mmm.ucar.edu/mm5/mpp/ecmwf01.htm).

Michalakes, J., J. Dudhia, D. Gill, T. Henderson, J. Klemp, W. Skamarock and W. Wang. 2004. The Weather Research and Forecast Model: Software Architecture and Performance. Proceedings of the 11th ECMWF Workshop on the Use of High Performance Computing in Meteorology. October 25-29, 2005, Reading UK. Ed. George Mozdzynski. (http://wrf-model.org/wrfadmin/docs/ecmwf_2004.pdf).

Morrison, H.J., A. Curry, and V.I. Khvorostyanov, 2005. A New Double-Moment Microphysics Parameterization for Application in Cloud and Climate Models. Part I: Description, J. Atmos. Sci., 62, 1665–1677.

Morrison, H. and A. Gettelman, 2008. A New Two-Moment Bulk Stratiform Cloud Microphysics Scheme in the Community Atmosphere Model, Version 3 (CAM3). Part I: Description and Numerical Tests, J. Climate, 21, 3642-3659.

Pleim, J.E. and A. Xiu, 2003. Development of a Land-Surface Model. Part II: Data Assimilation, J. Appl. Meteor., 42, 1811–1822

Pleim, J.E., 2007a. A Combined Local and Nonlocal Closure Model for the Atmospheric Boundary Layer. Part I: Model Description and Testing, J. Appl. Meteor. Climatol., 46, 1383-1395.

Pleim, J.E., 2007b. A Combined Local and Nonlocal Closure Model for the Atmospheric Boundary Layer. Part II: Application and Evaluation in a Mesoscale Meteorological Model, J. Appl. Meteor. Climatol., 46, 1396–1409.

Ramboll Environ, 2014. wrfcamx Version 4.3 Release Notes. December 17, 2014.www.camx.com. Ramboll Environ International Corporation, Novato, CA.

Ramboll Environ, 2016. User's Guide Comprehensive Air Quality Model with Extensions Version 6.40, www.camx.com. Ramboll Environ International Corporation, Novato, CA.

Simon, H., K. Baker and S. Phillips. 2012. Compilations and Interpretation of Photochemical Model Performance Statistics Published between 2006 and 2012. *Atmos. Env.* 61 (2012) 124-139. December. (http://www.sciencedirect.com/science/article/pii/S135223101200684X).

Skamarock, W. C. 2004. Evaluating Mesoscale NWP Models Using Kinetic Energy Spectra. *Mon. Wea. Rev.*, Volume 132, pp. 3019-3032. December. (http://www.mmm.ucar.edu/individual/skamarock/spectra_mwr_2004.pdf).

Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, W. Wang and J. G. Powers. 2005. A Description of the Advanced Research WRF Version 2. National Center for Atmospheric Research (NCAR), Boulder, CO. June. (http://www.mmm.ucar.edu/wrf/users/docs/arw_v2.pdf)

Skamarock, W. C. 2006. Positive-Definite and Monotonic Limiters for Unrestricted-Time-Step Transport Schemes. *Mon. Wea. Rev.*, Volume 134, pp. 2241-2242. June. (http://www.mmm.ucar.edu/individual/skamarock/advect3d_mwr.pdf).

Stammer, D., F.J. Wentz, and C.L. Gentemann, 2003. Validation of Microwave Sea Surface Temperature Measurements for Climate Purposes, J. of Climate, 16(1), 73-87.

Sullivan D.C., Raffuse S.M., Pryden D.A., Craig K.J., Reid S.B., Wheeler N.J.M., Chinkin L.R., Larkin N.K., Solomon R., and Strand T. (2008) Development and applications of systems for modeling emissions and smoke from fires: the BlueSky smoke modeling framework and SMARTFIRE: 17th International Emissions Inventory Conference, Portland, OR, June 2-5. Available at: http://www.epa.gov/ttn/chief/conferences.html.

UNC. 2008. Atmospheric Model Evaluation Tool (AMET) User's Guide. Institute for the Environment, University of North Carolina at Chapel Hill. May 30. (https://www.cmascenter.org/amet/documentation/1.1/AMET_Users_Guide_V1.1.pdf).

UNC and ENVIRON, 2014a. Three-State Air Quality Modeling Study (3SAQS) – Draft Modeling Protocol 2011 Emissions & Air Quality Modeling. University of North Carolina at Chapel Hill and ENVIRON International Corporation, Novato, CA. July. (http://vibe.cira.colostate.edu/wiki/Attachments/Modeling/3SAQS_2011_Modeling_Protocol_Finalv2.pdf).

UNC. 2015. SMOKE v3.6.5 User's Manual. University of North Carolina at Chapel Hill, Institute for the Environment. (https://www.cmascenter.org/smoke/documentation/3.6.5/html/).

UNC and ENVIRON, 2015a. Three-State Air Quality Modeling Study (3SAQS) – Weather Research Forecast 2011 Meteorological Model Application/Evaluation. University of North Carolina at Chapel Hill and ENVIRON International Corporation, Novato, CA. March 5. (http://vibe.cira.colostate.edu/wiki/Attachments/Modeling/3SAQS_2011_WRF_MPE_v05Mar2015.pdf).

Wesely, M.L. 1989. Parameterization of Surface Resistances to Gaseous Dry Deposition in Regional-Scale Numerical Models. *Atmos. Environ.*, 23, 1293-1304.

Xiu, A. and J.E. Pleim. 2000. Development of a land surface model. Part I: application in a mesoscale meteorology model. *J. App. Met.*, 40, pp. 192-209.

Yantosca, B. 2004. GEOS-CHEMv7-01-02 User's Guide, Atmospheric Chemistry Modeling Group, Harvard University, Cambridge, MA.

Yarwood, G., R.E. Morris, G.M. Wilson. 2004. Particulate Matter Source Apportionment Technology (PSAT) in the CAMx Photochemical Grid Model. Proceedings of the 27th NATO/ CCMS International Technical Meeting on Air Pollution Modeling and Application. Springer Verlag (Available from http://camx.com/publ/pdfs/yarwood_itm_paper.pdf).

Yarwood, G., J. Jung, G. Z. Whitten, G. Heo, J. Mellberg and M. Estes. 2010. Updates to the Carbon Bond Mechanism for Version 6 (CB6). 2010 CMAS Conference, Chapel Hill, NC. October. (http://www.cmascenter.org/conference/2010/abstracts/emery_updates_carbon_2010.pdf)

Zhang, L., S. Gong, J. Padro, L. Barrie. 2001. A size-segregated particle dry deposition scheme for an atmospheric aerosol module. *Atmos. Environ.*, **35**, 549-560.

Zhang, L., J. R. Brook, and R. Vet. 2003. A revised parameterization for gaseous dry deposition in air-quality models. *Atmos. Chem. Phys*., **3**, 2067–2082.

Appendix E-1b

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project

Final Modeling Protocol Update and Addendum

August 31, 2020

This page intentionally left blank.

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project
Final Modeling Protocol

Update and Addendum to the Approved Modeling Protocol for Task 6.1 (June 2018)

Prepared for:
SESARM, Inc.
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final - August 31, 2020

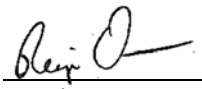
Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

TITLE and APPROVAL SHEET

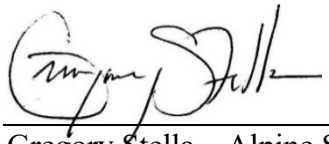
Modeling Protocol Plan for
Southeastern VISTAS II Regional Haze Analysis Project for
SESARM (Final)

This Modeling Protocol is approved by the undersigned and effective on the latest date signed by any party. The organizations implementing the project are Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine).



8/31/2020

Regi Oommen – ERG Program Manager and Technical Project Coordinator — Date



8/31/2020

Gregory Stella – Alpine Subcontract Manager — Date

8/31/2020

John Hornback – SESARM Executive Director — Date

This page is intentionally blank.

Contents

Page

1.0 INTRODUCTION 1
1.1 Overview 1
1.2 Study Background 3
1.2.1 Natural and Current Base Model Period DV Values at the VISTAS Class I Areas 6
1.2.2 Purpose 7
1.3 Lead Agency and Principal Participants 7
1.4 Related Regional Modeling Studies 7
1.4.1 EPA Preliminary 2028 Regional Haze Modeling 7
1.4.2 Maine Department of Environmental Protection Tracking Visibility Progress 2004-2016 9
1.5 Overview of Modeling Approach 10
1.5.1 Episode Selection 10
1.5.2 Model Selection 10
1.5.3 Base and Future Year Emissions Data 11
1.5.4 Emission Input Preparation and QA/QC 11
1.5.5 Meteorology Input Preparation and QA/QC 11
1.5.6 Initial and Boundary Conditions Development 11
1.5.7 Air Quality Modeling Input Preparation and QA/QC 12
1.5.8 Model Performance Evaluation 12
1.5.9 Diagnostic Sensitivity Analyses 12
1.5.10 Future Year Significant Contribution Modeling 12
1.6 Project Participants and Contacts 12
1.7 Communication 13
1.8 Schedule 13
2.0 MODEL SELECTION 16
3.0 EPISODE SELECTION 20
4.0 MODELING DOMAIN SELECTION 21
4.1 Horizontal Domains 21
4.2 Vertical Modeling Domain 22
5.0 DATA AVAILABILITY 23
5.1 Emissions Data 23
5.2 Ambient Air Quality Observations 23
5.3 Meteorological Data 23
5.4 Ozone Column Data 24
5.5 Photolysis Rates 24

5.6 Land Use 24
5.7 Initial and Boundary Conditions Data 24

6.0 MODEL INPUT PREPARATION PROCEDURES 27
6.1 Meteorological Inputs 27
6.1.1 WRF Model Science Configuration 27
6.1.2 WRF Input Data Preparation Procedures 27
6.1.3 WRF Model Performance Evaluation 27
6.1.4 WRFCAMx/MCIP Reformatting Methodology 28
6.1.5 Windowing from EPA 12US2 to VISTAS_12 28
6.2 Emission Inputs 28
6.2.1 Available Emissions Inventory Datasets 28
6.2.2 2011 Base Year Emissions 29
6.2.3 2028 Projection Year Emissions 29
6.3 Emissions Processing 32
6.3.1 QA/QC of CAMx-Ready Emission Files 34
6.4 Photochemical Modeling Inputs 35
6.4.1 CAMx Science Configuration and Input Configuration 35
6.4.2 VISTAS_12 Boundary And Initial Conditions 37
6.4.3 VISTAS_12 Ozone Column 37
6.4.4 Photolysis Rates 37
6.4.5 CAMx Land Use 37
6.5 EPA 2011 and 2028 Base Case Confirmation 38
6.5.1 Differences Between EPA And VISTAS Simulations 38
6.5.2 Confirmation Methodology 38

7.0 MODEL PERFORMANCE EVALUATION 40
7.1 Model Performance Evaluation 40
7.1.1 Overview of EPA Model Performance Evaluation Recommendations 40
7.1.2 VISTAS II Calculated Model Evaluation Statistics 41
7.1.3 Model Performance Evaluation For Weekly Wet And Weekly Dry Deposition Species 43
7.2 Performance Goals and Benchmarks 44
7.2.1 Diagnostic Evaluation 46

8.0 AREA OF INFLUENCE 47

9.0 FUTURE YEAR MODELING 56
9.1 Regional Haze Rule Requirements 56
9.2 Future Year to be Simulated 56
9.3 Future Year Baseline Air Quality Simulations 56
9.4 Calculation of 2028 Visibility 57

9.5 Comparison to Regional Haze "Glidepath" 59
10.0 PSAT SOURCE APPORTIONMENT 60
10.1 Process for Creating PSAT Contributions for Class I Areas 61
11.0 MODELING DOCUMENTATION AND DATA ARCHIVE 64
12.0 REFERENCES 65

TABLES

Table 1-1. VISTAS Region Federal Class I Area List....4
Table 1-2. Natural Conditions and Base Year Deciview (dv) Values on the 20% Clearest and 20% Most Impaired Days at each VISTAS Class I Area for the Base Model Period (2009-2013)....6
Table 1-3. Key Participants and Contact Information for the VISTAS II Modeling Study....13
Table 1-4. Initial Key Deliverables and Dates for the VISTAS II Modeling Through the 2028 Source Apportionment Reporting....14
Table 4-1. VISTAS II Modeling Domain Specifications....22
Table 4-2. WRF and CAMx Layers and Their Approximate Height Above Ground Level....22
Table 5-1. Overview of Routine Ambient Data Monitoring Networks....26
Table 6-1. VISTAS II Simulation Periods....36
Table 6-2. CAMx Simulations for the VISTAS II Project....36
Table 7-1. Fine Particulate Matter Performance Goals and Criteria....45
Table 7-2. Species Mapping from CAMx_6.40 into Observation Network....46
Table 8-1. IMPROVE Monitors in the VISTAS_12 Domain....48
Table 8-2. Representative IMPROVE Monitor for Each VISTAS Class I Area....51
Table 9-1. SMAT-CE Settings for 2028 Visibility Calculations....58
Table 9-2. Matching of CAMx_6.40 Raw Output Species to SMAT Input Variables....59
Table 10-1. Matching of CAMx Raw Output Species to SMAT Input Variables....60
Table 10-2. Matching of "Bulk Raw Species", PSAT Output Species, and SMAT Input Variables....61
Table 10-3. Tagged Contribution Calculation Example....62

FIGURES

Figure 1-1. VISTAS Region Class I Areas....5
Figure 4-1. Map of 12km CAMx Modeling Domains. VISTAS_12 Domain Represented as Inner Red Domain....21
Figure 6-1. Emission Processing Paths....33
Figure 8-1. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS 12km Domain....49
Figure 8-2. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS States....50
Figure 8-3. Example EWRT Calculations....54
Figure 8-4. Example (Q/d)*EWRT Calculations....55

ABBREVIATIONS / ACRONYM LIST

3DVAR	Three-dimensional variational
AFWA	Air Force Weather Agency
AGL	Above ground level
AL	Alabama
ARW	Advanced research WRF
AIRMoN	Atmospheric Integrated Research Monitoring Network
Alpine	Alpine Geophysics, LLC
AMET	Atmospheric Evaluation Tool
AoI	Area of Influence
AQS	Air Quality System
ARL	Air Resources Laboratory
BC	Boundary conditions
BEIS	Biogenic Emissions Inventory System
b_{ext}	Beta extinction
BNDEXTR	Program used to extract boundary conditions
CAIR	Clean Air Interstate Rule
CAMD	Clean Air Markets Division
CAMx	Comprehensive Air Quality Model with Extensions
CASTNET	Clean Air Status and Trends Network
CB6r4	Version 6 Revision 4 of the Carbon Bond chemical mechanism
CCRS	Coarse PM species (CAMx PM species)
CEM	Continuous Emissions Monitoring
CFR	Code of Federal Regulation
CIRA	Cooperative Institute for Research in the Atmosphere
Cl	Chorine
CMAQ	Community Multiscale Air Quality
CMV	Commercial marine vessel
CO	Carbon monoxide
CONUS	Continental United States
CPRM	Coarse PM
CSAPR	Cross-state Air Pollution Role
CSN	Chemical Speciation Network
CWT	Concentration weighted trajectory
d	Distance
DJF	December, January, and February
dv	Deciview
EC	Elemental carbon
EDAS	Eta data assimilation system
EF	Emission factor
EGU	Electric generating unit
EIS	Emission Inventory System
EPA	United States Environmental Protection Agency
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee

EWRT	Extinction-weighted residency time
f(RH)	Monthly relative humidity function
FAA	Federal Aviation Administration
FCRS	Crustal fraction of PM
FIPS	Federal Information Processing Standard
$f_L(RH)$	Monthly relative humidity function associated with large size distributions
FLM	Federal Land Manager
FL	Florida
FPRM	Fine Other Primary (diameter ≤2.5 µm)
FR	Federal Register
FSL	Forecast Systems Laboratory
$f_s(RH)$	Monthly relative humidity function associated with small size distribution
$f_{ss}(RH)$	Monthly relative humidity function associated with sea salt
FTP	File Transfer Protocol
g	Gram
GA	Georgia
GB	Gigabyte
GEOS	Goddard Earth Observing Station
GHRSST	Group for High Resolution Sea Surface Temperatures
GIS	Geographic Information System
H^+ as pH	Free acidity
ha	Hectare
Hg	Total mercury
HGP	Particulate mercury
HNO_3	Nitric acid
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory
IC	Initial conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
IPXWRF	Intermediate Processor for Pleim–Xiu for WRF
IPM	Integrated Planning Model
JJA	June, July, and August
K^+	Potassium ion
km	Kilometers
kv	Eddy diffusivity
KY	Kentucky
L	Liter
LAC	Light absorbing carbon
LCP	Landscape
m	Meters
m^2	Square meters
m^3	Cubic meters
MANE-VU	Mid-Atlantic/Northeast Visibility Union
MAM	March, April, and May
MAR	Marine, aircraft, and rail
mb	Millibar
MB	Mean Bias

MDA8	Daily maximum 8-hour average
MDL	Method Detection Level
MDN	Mercury Deposition Network
ME	Mean Error
MFB	Mean Fractional Bias
MFE	Mean Fractional Error
mg	Milligram
Mg^{2+}	Magnesium ion
µg	Microgram
MJO	Multi-Jurisdictional Organization
MLM	Multi-Layer Model
Mm	Megameters
Modeled	Mean Modeled value
MOVES	Motor Vehicles Emissions Simulator
MPE	Model performance evaluation
MPI	Message Passing Interface
MS	Mississippi
Na^{+}	Sodium ion
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NAICS	North American Industry Classification System
NAM-12	North American Mesoscale forecast data at the 12-km level
NC	North Carolina
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEI	National Centers for Environmental Information
NCEP	National Centers for Environmental Prediction
NH_3	Ammonia
NH_4^{+}	Ammonium ion
NLCD	National Land Cover Database
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NO_2	Nitrogen dioxide
NO	Nitric oxide
NO_3^{-}	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NODA	Notice of data availability
NO_x	Oxides of nitrogen
O_3	Ozone
OC	Organic carbon
OCM	Organic carbon mass
OM	Organic matter
OMI	Ozone Monitoring Instrument
ORIS	Plant identifier issued by U.S. Department of Energy
PAL	Particulate Aluminum
PAMS	Photochemical Assessment Monitoring System

Pb	Lead
PBL	Planetary Boundary Layer
PCA	Particulate Calcium
PEC	Primary elemental carbon
PFE	Particulate Iron
PGI	Portland Group, Inc.
PGMs	Photochemical grid models
PiG	Plume-in-Grid
PM	Particulate matter
PM_{10}-PRI	Primary particulate matter less than or equal to 10 microns in aerodynamic diameter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
$PM_{2.5}$-PRI	Primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Ammonium
PNO3	Particulate nitrate
POA	Primary organic carbon
POC	Parameter occurrence code
ppb	parts per billion
PSAT	Particulate Matter Source Apportionment Technology
PSCF	Potential Source Contribution Factor
PSI	Particulate Silicon
PSO4	Sulfate
PTI	Particulate Titanium
Q	Emissions
Q/d	Emissions over distance
QA	Quality Assurance
QC	Quality control
r	Pearson correlation coefficient
r^2	Coefficient of Determination
RH	Relative humidity
RHR	Regional Haze Rule
RPG	Reasonable Progress Goals
RRF	Relative response factor
RRTMG	Rapid Radiative Transfer Model-Global
SC	South Carolina
SCC	Source Classification Code
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SMARTFIRE	Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation
SMAT-CE	Software for Model Attainment Test - Community Edition
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SO_4^{2-}	Sulfate

SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
SON	September, October, and November
TDEP	Total Deposition
TN	Tennessee
TOMS	Total Ozone Mapping Spectrometer
TSD	Technical Support Document
URP	Uniform rate of progress
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
VA	Virginia
VISTAS	Visibility Improvement - State and Tribal Association of the Southeast
VISTAS_12	12-km modeling domain for the VISTAS study area
VMT	Vehicle Miles Travelled
VOC	Volatile organic compounds
WRF	Weather Research Forecast
WV	West Virginia
YSU	Yonsei University

This page is intentionally blank.

1.0 INTRODUCTION

1.1 Overview

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.

B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

is, the focus of state planning will be to establish reasonable progress goals for each Class I area against which progress will be measured during the second planning period. This extension will allow states to incorporate planning for other Federal programs while conducting their regional haze planning. These other programs include: the Mercury and Air Toxics Standards, the 2010 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview (dv)index values. "Most impaired days" are defined as the 20% of monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

This document serves as the air quality Modeling Protocol for SESARM's VISTAS II regional haze modeling analysis in support of estimating regional haze and progress goals at southeastern state Class I areas in projection year 2028. The reasonable progress goals must provide for a rate of improvement sufficient to attain "natural conditions" by 2064, or justify any alternative rate. States are to define controls to meet progress goals every 10 years, starting in 2018 that defines progress periods ending in 2018, 2028, 2038, 2048, 2058 and finally 2064. States will determine whether they are meeting their goals by comparing visibility conditions from one five-year period to another (e.g., 2000-2004 to 2013- 2017). As stated in 40 CFR 51.308 (d) (1), baseline visibility conditions, progress goals, and changes in visibility must be expressed in terms of dv units. The dv unit of visibility impairment is derived from beta light extinction (b_{ext}) as follows:

$$dv = 10 \ln (b_{ext}/10)$$

Where b_{ext} is expressed in terms of inverse megameters ($Mm^{-1} = (10^6 \text{ m})^{-1}$).

This Modeling Protocol describes the overall modeling activities to be performed in order to estimate regional haze and progress at southeastern state Class I areas in projection year 2028. This effort is being undertaken working closely with SESARM and other state, local, and tribal agencies.

A comprehensive Modeling Protocol for regional haze study consists of many elements. Its main function is to serve as a means for planning and communicating how a modeled analysis will be

performed before it occurs. The protocol guides the technical details of a modeling study and provides a formal framework within which the scientific assumptions, operational details, commitments and expectations of the various participants can be set forth explicitly and means for resolution of potential differences of technical and policy opinion can be worked out openly and within prescribed time and budget constraints.

As noted in the EPA regional haze modeling guidance, the Modeling Protocol serves several important functions (EPA, 2007; 2014e):

- Identify the assistance available to SESARM (the lead agencies) to undertake and evaluate the analysis needed to support the analysis;
- Identify how communication will occur among State, Local, and Federal agencies and stakeholders to develop a consensus on various issues;
- Describe the review process applied to key steps in the analysis; and
- Describe how changes in methods and procedures or in the protocol itself will be agreed upon and communicated with stakeholders and the appropriate EPA Regional Office.

Update and Addendum to the June 2018 Modeling Protocol

As the modeling study has evolved since approval of this modeling protocol, certain technical aspects have been updated to account for changes in emissions inventories, modeling software and procedures, and quality assurance procedures. These updates have been incorporated into this version of the Modeling Protocol.

1.2 Study Background

In Section 169A of the Clean Air Act, Congress established a visibility protection goal to prevent future and remedy existing impairment of visibility resulting from manmade pollution in certain national parks and wilderness areas. The statute was codified at 42 U.S. Code §7491. EPA issued regulations implementing the visibility protection mandate that may be found at 40 CFR 51.300 through 51.309. These regulations have been amended several times, most recently as published in the Federal Register on January 10, 2017.

The 1999 RHR (64 FR 35714) identified 156 parks and natural areas as “mandatory Class I Federal areas” for which goals would be established to improve visibility to natural conditions. The 18 Class I areas located in the VISTAS region are tabulated in Table 1-1 that follows. Each row contains the official Class I area name, the state(s) in which it is located, estimated total land area in acres based on current available information, and the designated Federal Land Manager (FLM). A map of the VISTAS Class I areas follows in Figure 1-1.

Table 1-1. VISTAS Region Federal Class I Area List

(State) Class I Area Name	Approx. Acreage	Federal Land Manager
AL – Sipsey Wilderness Area	12,726	USDA Forest Service
FL – Chassahowitzka Wilderness Area	23,579	USDI Fish and Wildlife Service
FL – Everglades National Park	1,399,078	USDI National Park Service
FL – Saint Marks Wilderness Area	17,350	USDI Fish and Wildlife Service
GA/TN – Cohutta Wilderness Area	GA – 35,268 TN – 1,709	USDA Forest Service
GA – Okefenokee Wilderness Area	353,981	USDI Fish and Wildlife Service
GA – Wolf Island Wilderness	5,126	USDI Fish and Wildlife Service
KY – Mammoth Cave National Park	52,830	USDI National Park Service
NC/TN – Great Smoky Mountains National Park	NC – 277,432 TN – 244,645	USDI National Park Service
NC/TN – Joyce Kilmer-Slickrock Wilderness	NC – 13,590 TN – 3,820	USDA Forest Service
NC – Linville Gorge Wilderness Area	11,651	USDA Forest Service
NC – Shining Rock Wilderness Area	18,479	USDA Forest Service
NC – Swanquarter Wilderness Area	8,800	USDI Fish and Wildlife Service
SC – Cape Romain Wilderness	29,000	USDI Fish and Wildlife Service
VA – James River Face Wilderness	8,907	USDA Forest Service
VA – Shenandoah National Park	199,173	USDI National Park Service
WV – Dolly Sods Wilderness	17,776	USDA Forest Service
WV – Otter Creek Wilderness	20,706	USDA Forest Service

USDA – United States Department of Agriculture. USDI – United States Department of Interior.

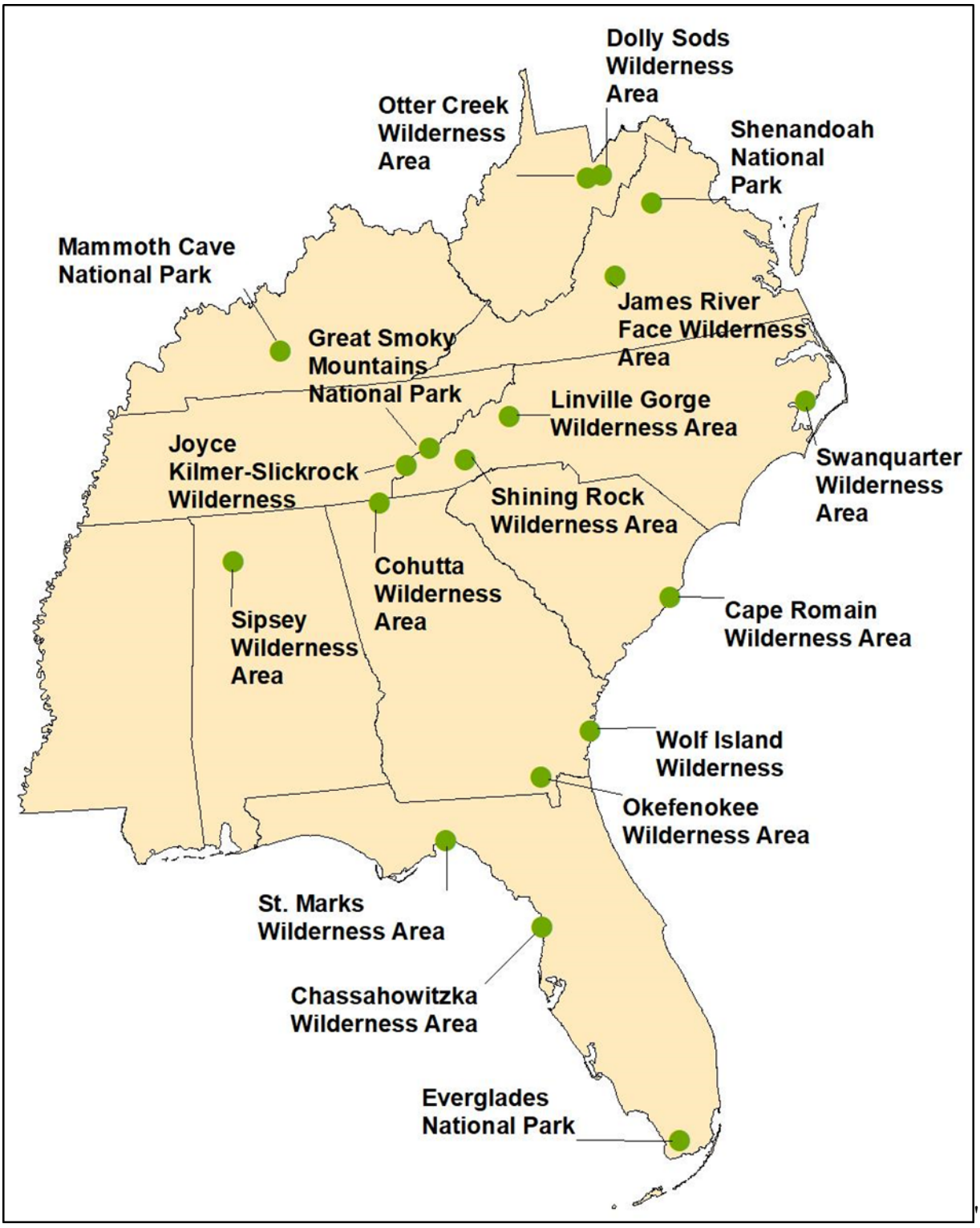


Figure 1-1. VISTAS Region Class I Areas.

The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and improve visibility systematically to reach natural visibility conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% clearest days. States were required to submit SIPs by December 17, 2007 demonstrating reasonable progress to achieve incremental visibility improvements for the 2008-2018 planning period.

The RHR requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years. States are to consult with FLMs in developing the SIPs.

1.2.1 Natural and Current Base Model Period DV Values at the VISTAS Class I Areas

Table 1-2 shows the U.S. EPA calculated natural conditions on the 20% most impaired days and dv values on the 20% clearest and most impaired days at each VISTAS Class I area for the base model period (2009-2013).

Table 1-2. Natural Conditions and Base Year Deciview (dv) Values on the 20% Clearest and 20% Most Impaired Days at each VISTAS Class I Area for the Base Model Period (2009-2013)[2]

Class I Area Site ID	Class I Area Name	IMPROVE Site ID	Natural Conditions 20% Most Impaired Days (dv)	Base Year (2009-2013) 20% Clearest Days (dv)	Base Year (2009-2013) 20% Most Impaired Days (dv)
CHAS	Chassahowitzka	CHAS1	8.97	13.76	19.94
COHU	Cohutta Wilderness	COHU1	9.52	10.94	21.19
DOSO	Dolly Sods Wilderness	DOSO1	8.92	9.03	21.59
EVER	Everglades NP	EVER1	8.34	11.23	16.30
GRSM	Great Smoky Mountains NP	GRSM1	10.05	10.63	21.39
JARI	James River Face Wilderness	JARI1	9.48	11.79	21.37
JOYC	Joyce-Kilmer-Slickrock Wilderness	GRSM1	10.05	10.63	21.39
LIGO	Linville Gorge Wilderness	LIGO1	9.70	9.70	20.39
MACA	Mammoth Cave NP	MACA1	9.79	13.69	24.04
OKEF	Okefenokee	OKEF1	9.47	13.34	20.70
OTCR	Otter Creek Wilderness	DOSO1	8.92	9.03	21.59
ROMA	Cape Romain	ROMA1	9.79	13.59	21.48

[2] Tables 3-2 and 3-3, EPA, 2017b.

Table 1-2. Natural Conditions and Base Year Deciview (dv) Values on the 20% Clearest and 20% Most Impaired Days at each VISTAS Class I Area for the Base Model Period (2009-2013)[2]

Class I Area Site ID	Class I Area Name	IMPROVE Site ID	Natural Conditions 20% Most Impaired Days (dv)	Base Year (2009-2013) 20% Clearest Days (dv)	Base Year (2009-2013) 20% Most Impaired Days (dv)
SAMA	St. Marks	SAMA1	9.19	13.33	20.11
SHEN	Shenandoah NP	SHEN1	9.52	8.60	20.72
SHRO	Shining Rock Wilderness*	SHRO1	9.70	5.36	19.05
SIPS	Sipsey Wilderness	SIPS1	9.55	12.84	21.67
SWAN	Swanquarter	SWAN1	9.79	11.76	19.76
WOLF	Wolf Island	OKEF1	9.47	13.34	20.70

* The IMPROVE monitor at Shinning Rock Wilderness Area is missing complete data for 2010 and 2011. After consultation with North Carolina, a 3-year average of 2009, 2012, and 2013 IMPROVE data was used to calculate the visibility (dv) for both the 20% clearest and 20% most impaired days at Shinning Rock.

1.2.2 Purpose

This document serves as the first draft of the Air Quality Modeling Protocol plan for the VISTAS II Regional Haze modeling analysis to be performed by the contractor team Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine) with the purpose of estimating regional haze and progress at southeastern state Class I areas in projection year 2028. It is presumed that this information will be used by SESARM-participating states in the regional haze SIP development process.

1.3 Lead Agency and Principal Participants

SESARM is the lead agency in the development of this regional haze modeling analysis. EPA Region 4 in Atlanta, GA is the EPA Regional Office that will take the lead in the review and approval process for this project.

1.4 Related Regional Modeling Studies

There are other regional haze modeling studies related to the VISTAS II regional haze modeling analysis whose results may be useful to SESARM.

1.4.1 EPA Preliminary 2028 Regional Haze Modeling

EPA recently conducted preliminary visibility modeling (EPA, 2017b) for year 2028 with the intention of informing the regional haze SIP development process. For their assessment, air quality modeling was used to project visibility levels at individual Class I areas (represented by Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring sites) to 2028 and to estimate emissions sector contributions to 2028 particulate matter (PM) concentrations and visibility. The projected 2028 PM concentrations were converted to light extinction coefficients and then to dvs; these values are used to evaluate visibility progress as of

2028. In addition, 2028 visibility contribution information by major emissions source sector was calculated using particulate source apportionment technology (PSAT).

EPA found that visibility at most eastern Class I areas on the 20% most anthropogenically impaired days is projected to be below the unadjusted glidepath in 2028, with a relatively higher percentage of the light extinction due to domestic anthropogenic sources.

Based on their assessment of these results, EPA also identified a number of uncertainties and model performance issues that should be addressed in future EPA, state, multistate, or stakeholder modeling that may be used in SIP development. They have identified several aspects of this initial modeling that should be improved upon through coordination with interested stakeholders. These include, but are not limited to:

- *Expanded domain size* to reduce the impact of the boundary conditions assumptions on predictions, especially near the domain edge.
    - The boundary conditions were found to be the largest contributor to visibility at many Class I areas, especially those near the edge of the modeling domain. Expanding the regional photochemical modeling domain will potentially reduce the influence from global or hemispheric model derived boundary conditions. Those models have much coarser grid resolution and use global emissions inventories which may not be year specific or up to date.
    - There may also be recirculation of U.S. emissions in boundary conditions derived from global models, especially where the boundary is very close to the U.S. mainland. Moving the domain boundary further from the contiguous U.S. will minimize this issue.

- *Updated emission inventory and projections* for certain sectors.
    - More recent nationwide photochemical modeling has incorporated updates in future year emissions inventories that should be considered for 2028.
        - Remove the Clean Power Plan and Texas regional haze FIP from the electric generating unit (EGU) assumptions.
        - Updates to the oil and gas emissions projections.
        - New Canadian base and future year emissions.
        - Other emissions updates based on more recent information, such as state review of facilities of interest within the VISTAS domain.

- *Updated boundary conditions* based on more recent modeling of international emissions as well as additional modeling to help quantify and distinguish anthropogenic and natural international contributions.
    - The 2011 boundary conditions used for the regional haze modeling came from an older version of Goddard Earth Observing System (GEOS)-Chem which did not contain the latest international emissions estimates for 2011.
    - In addition to projecting U.S. emissions to 2028, international emissions are changing between 2011 and 2028 as well. Consideration should be given to estimating future year global emissions to provide an alternate estimate of future year boundary conditions.

  - Global or hemispheric models can potentially be used to adjust the visibility glidepath for impacts from international anthropogenic sources. Sensitivity runs and additional refinements to international inventories may be needed in order to provide more confidence in the model results.

- *Improved treatment of fire and fugitive dust emissions* in the model.
  - The current Comprehensive air quality model with extensions (CAMx) modeling platform does not include estimates of natural windblown dust emissions. Windblown dust (primarily contributing to coarse mass) is an important component of regional haze in some Class I areas.
  - The current modeling used year-specific fire emissions from 2011 which may not be representative of a "typical year" or multi-year period. The IMPROVE measurements used to establish both the base period impairment measurements and progress towards natural conditions, use a five-year average of IMPROVE measurements. Therefore, alternative estimates of fire emissions, which may better represent a longer term average, may be more appropriate for use in visibility projections.
  - Further refinements of fire emissions may also allow exploration of possible adjustments of the glidepath for prescribed fire impacts.

- *Treatment of secondary organic aerosols (SOA)* should be reviewed.
  - In many locations, there is relatively high modeled SOA as a fraction of total organic aerosols. Using the RRF approach, this apportions the modeled SOA as a fraction of the measured total organics. There is considerable uncertainty in the modeled SOA concentrations, which therefore translates into uncertainty in the apportioned SOA mass.
  - Additional information can be gained by running PSAT with SOA source apportionment turned on.

- *Estimation of "natural visibility conditions"* used in the glidepath framework should be further reviewed.
  - Further refinements in the draft methodology can be explored.
  - Further analysis of the IMPROVE data combined with modeled source apportionment information may be useful in evaluating the natural conditions estimates.

All of these options were considered for this project; however due to schedule and resource constraints SESARM chose only to move forward with correcting the emission projections.

1.4.2 Maine Department of Environmental Protection Tracking Visibility Progress 2004-2016

This document (ME DEP, 2018), prepared by the Maine Department of Environmental Protection for the Mid-Atlantic/Northeast Visibility Union (MANE-VU), presents visibility trends at IMPROVE monitoring sites at federal Class I areas in and adjacent to the MANE-VU region that are subject to the USEPA's RHR. This document also presents visibility trends at IMPROVE Protocol monitoring sites in and adjacent to the MANE-VU region. The analyses

were performed to determine the extent of progress in meeting short-term and long-term visibility goals for the first RHR SIP period that ends in 2018 using metrics specified in the state SIPs.

The technical document provides an analysis of visibility data collected at the IMPROVE monitoring sites, starting in the baseline period of 2000-2004 through 2012-2016, the most recent five-year period with available data.

The results of the analysis continue to show the following:

- There continue to be definite downward trends in overall haze level at all Class I areas in and adjacent to the MANE-VU region and at IMPROVE Protocol monitoring sites.
- Based on rolling five-year averages demonstrating progress since the 2000-2004 baseline period, the MANE-VU Class I areas are on track to meet their 2018 Reasonable Progress Goals (RPGs) for both 20% clearest and 20% most impaired visibility days.
- The trends are mainly driven by large reductions in sulfate light extinction, and to a lesser extent, nitrate light extinction.
- Levels of organic carbon mass (OCM) and light absorbing carbon (LAC) appear to be approaching natural background levels at most of the MANE-VU Class I areas.
- In all cases, the levels set by 2018 RPG's have already been met, and progress beyond these goals appears achievable.
- The percent contribution of nitrate light extinction has been significantly increasing at most of the MANE-VU Class I areas.

1.5 Overview of Modeling Approach

The VISTAS II modeling proposed here will include particulate matter simulations and source apportionment studies using the 12 kilometer (km) grid based on EPA's 2011/2028el modeling platform and preliminary source contribution assessment (EPA, 2017b) updated to include a 12km subdomain over the VISTAS region and augmented with revisions to EGU and non-EGU point source projections.

1.5.1 Episode Selection

Episode selection is an important component of any modeling analysis. EPA guidance recommends that one choose time periods which reflect the variety of meteorological conditions which represent visibility impairment on the 20% clearest and 20% most impaired days in the Class I areas being modeled (high and low concentrations necessary). This is best accomplished by modeling a full year. For this analysis, Alpine will be modeling the full 2011 calendar year with 10 days of model spin-up in 2010.

1.5.2 Model Selection

Details on the rationale for model selection are provided in Section 2. The Weather Research Forecast (WRF) prognostic meteorological model was selected for the VISTAS II modeling. Emissions processing will be completed using the Sparse Matrix Operator Kernel Emissions (SMOKE) model for most source categories. The exceptions are that Biogenic Emissions

Inventory System (BEIS) model was used for biogenic emissions and there are special processors for fires, windblown dust, lightning and sea salt emissions. The 2014 Motor Vehicle Emissions Simulator (MOVES) onroad mobile source emissions model was used by EPA with SMOKE-MOVES to generate onroad mobile source emissions with EPA generated vehicle activity data provided in the 2028 regional haze analysis. The CAMx photochemical grid model, which supports two-way grid nesting will also be used. The setup is based on the same WRF/SMOKE/BEIS/CAMx modeling system used in the EPA 2011/2028el platform modeling.

During the preparation of this Modeling Protocol, it was noted that a newer version of CAMx, Version 6.50, was released (April 30, 2018). After discussions with SESARM, the CC, and the TAWG, it was decided to not use the newer version due to insufficient testing and application history necessary for to ensure confidence in modelling results.

1.5.3 Base and Future Year Emissions Data

A 2011 base year and 2028 future year will be used for the VISTAS II modeling to be consistent with the requirements of EPA's RHR. The 2011 base case and 2028 future year emissions will be founded on EPA's "el" modeling platform with no adjustments made to 2011 estimates. Updates will be made to EGU and non-EGU point source data within the VISTAS domain for 2028, as documented in the Task 2B report for SESARM states and Task 3B report for the non-SESARM states. One such example is the replacement of the Eastern Regional Technical Advisory Committee (ERTAC) EGU v.2.7 outputs with the more recent 16.0 and 16.1 outputs based on state direction. Additionally, some states chose to not replace their EGU emissions from the original modeling.

1.5.4 Emission Input Preparation and QA/QC

Quality assurance (QA) and quality control (QC) of the emissions datasets are critical steps in performing air quality modeling studies. Because emissions processing is tedious, time consuming and involves complex manipulation of many different types of large databases, rigorous QA measures are a necessity to prevent errors in emissions processing from occurring. The VISTAS II modeling study will utilize methods applied to the emissions platform that follows a multistep emissions QA/QC approach. Additional QA/QC involves more robust scrutinization of products from the multiple Benchmark Comparisons, as listed in Section 6.5.2 of this document.

1.5.5 Meteorology Input Preparation and QA/QC

The CAMx 2011 12 km meteorological inputs will be based on WRF meteorological modeling conducted by EPA. Details on the EPA 2011 WRF application and evaluation are provided by EPA (EPA 2014d).

1.5.6 Initial and Boundary Conditions Development

Initial concentrations (IC) and Boundary Conditions (BCs) are important inputs to the CAMx model. Alpine intends to run 10 days of model spin-up before the first days occur in the modeling episode so the ICs are washed out of the modeling domain before the first day of the annual 2011 modeling period. The lateral boundary and initial species concentrations are provided by a three-dimensional global atmospheric chemistry model, GEOS-Chem (Yantosca, 2004) standard version 8-03-02 with 8-02-01 chemistry.

1.5.7 Air Quality Modeling Input Preparation and QA/QC

Each step of the air quality modeling will be subjected to QA/QC procedures. These procedures will include verification of model configurations, confirmation that the correct data were used and were processed correctly and other procedures.

1.5.8 Model Performance Evaluation

An operational model performance evaluation will be performed for particulate matter ($PM_{2.5}$ species components and coarse PM) and regional haze to examine the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. This evaluation will focus on graphical analyses and statistical metrics of model predictions versus observations.

1.5.9 Diagnostic Sensitivity Analyses

Depending on the confirmation run results of the CAMx 2011 base case modeling and MPE on Alpine's modeling system, diagnostic sensitivity tests may be conducted to try and improve model performance. The definition of these diagnostic sensitivity tests will depend on the results of the initial MPE for these domains.

1.5.10 Future Year Significant Contribution Modeling

PM predictions from 2011 and 2028 CAMx model simulations will be used to project 2009-2013 IMPROVE visibility data to 2028 following the approach described in EPA's ozone, $PM_{2.5}$ and regional haze modeling guidance (US EPA, 2014b). The guidance describes the recommended modeling analysis used to help set RPGs that reflect emissions controls in a regional haze SIP. The CAMx PSAT method will be utilized for this effort.

1.6 Project Participants and Contacts

SESARM is the lead agency in the development of the VISTAS II modeling analysis. They will work closely with other local agencies, other local cities and agencies, and EPA Region 4 in the study, including the sharing of interim results as they become available. SESARM will also work with local, state, and tribal agencies and stakeholders in the modeling analysis, where stakeholders may include environmental groups and industry. Key participants in the VISTAS II study and their contact information are provided in Table 1-3.

Table 1-3. Key Participants and Contact Information for the VISTAS II Modeling Study

Organization	Individual(s) [Role]	Address	Contact Numbers
Southeastern States Air Resource Managers, Inc. (SESARM)			
Metro 4/ SESARM	Mr. John Hornback SESARM Executive Director	Southeastern States Air Resource Managers, Inc. 205 Corporate Center Drive, Suite D Stockbridge, GA 30281-7383	(404) 361-4000 hornback@metro4-sesarm.org
EPA Region 4			
EPA Region 4	Mr. Rick Gillam Environmental Engineer	EPA Region 4 Sam Nunn Atlanta Federal Center 61 Forsyth St., SW Atlanta, GA 30303	(404) 562-9049 gillam.rick@epa.gov
Contractors (Modeling team)			
Eastern Research Group, Inc.	Mr. Regi Oommen ERG Program Manager	Eastern Research Group, Inc. 1600 Perimeter Park Drive, Suite 200 Morrisville, NC 27560	(919) 468.7829 regi.oommen@erg.com
Alpine Geophysics, LLC	Mr. Gregory Stella Alpine Subcontract Manager	Senior Scientist 387 Pollard Mine Road Burnsville, NC 28714	(828) 675-9045 gms@alpinegeophysics.com
Alpine Geophysics, LLC	Mr. Dennis McNally Alpine Senior Scientist	Senior Scientist 7341 Poppy Way Arvada, CO 80007	(303) 421- 2211 dem@alpinegeophysics.com

1.7 Communication

Frequent communication between SESARM and the Modeling team and other participants is anticipated. These communications will include e-mails, conference calls, and face-to-face meetings. SESARM envisions that EPA and others will review interim products as they become available so that comments can be received during the study to allow for corrective action as necessary. These interim deliverables would include, but not be limited to, preliminary CAMx model performance evaluation, preliminary current and future-year emissions assumptions and results, and preliminary future year visibility projections and source apportionment results.

1.8 Schedule

Table 1-4 lists the current schedule for the initial key deliverables under the VISTAS II modeling study.

Table 1-4. Initial Key Deliverables and Dates for the VISTAS II Modeling Through the 2028 Source Apportionment Reporting

Task	Subtask	Deliverable	Initial Due Date	Updated Due Date
2	2.1	2011 Base year emissions inventories	6/30/2018[a]	No change
	2.2a	Projection Year Emissions Inventory Comparisons, draft	5/18/2018	1/10/2020
	2.2b	Projection Year Emissions Inventories, final	6/30/2018[a]	1/22/2020
	2.3a1	2028 EGU Point Source Emissions, draft	5/18/2018	3/15/2020
	2.3a2	2028 EGU Point Source Emissions, final	6/30/2018[a]	3/31/2020
	2.3b1	2028 Non-EGU Point Source Emissions, draft	5/18/2018	3/15/2020
	2.3b2	2028 Non-EGU Point Source Emissions, final	6/30/2018[a]	3/31/2020
	2.3c1	2028 Emissions for Other Categories, draft	5/18/2018	No change
	2.3c2	2028 Emissions for Other Categories, final	6/30/2018[a]	No change
	2.3d1	Emission Comparisons from 2028v6.3el and 2023v6.3en, draft	5/18/2018	No change
	2.3d2	Emission Comparisons from 2028v6.3el and 2023v6.3en, final	6/30/2018[a]	No change
	2.3e1	2028 Documentation, draft	5/18/2018	5/22/2020
	2.3e2	2028 Documentation, final	6/30/2018[a]	9/1/2020
	2.4	Emissions summaries and Quality Assurance	6/30/2018[a]	3/31/2020
3	3.1	Create Photochemical Model-Ready EGU emissions files for 2028	7/13/2018[a]	4/6/2020
	3.1.2	Scale Hourly EGU SMOKE emissions to match annual 2028	7/13/2018[a]	4/6/2020
	3.2	Create Photochemical Model-Ready Non-EGU emissions files for 2028	7/13/2018[a]	4/6/2020
	3.3a	Merge EGU/non-EGU data from Subtasks 3.1 and 3.2 for CAMx Model	7/13/2018[a]	4/13/2020
	3.3b*	Merge area/MAR data from Subtasks 3.1 and 3.2 for CAMx Model	7/13/2018[a]	No change
4	4	Data acquisition and preparation	6/1/2018	No change
	4.1	Acid deposition in watersheds	6/1/2018	No change
5	5	Area of Influence Analysis	9/1/2018	6/20/2019
	5.1	SO_2 and NO_x emissions contribution rankings	No later than 9/1/2018	6/20/2019
6	6.1a	Modeling protocol, draft	5/2/2018	8/10/2020
	6.1b	Modeling protocol, final	6/30/2018[a]	9/15/2020
	6.2	2011 base year air quality modeling	9/1/2018	No change
	6.3	2028 projection year air quality modeling	12/1/2018	6/29/2020
7	7	Source apportionment tagging - 250 tags (final number to be determined)	4/19/2019[a]	6/4/2020
8	8	Model performance evaluation	10/1/2018	12/1/2019
	8.1	Model performance evaluation (related to Subtask 4.1)	10/1/2018	12/1/2019
9	9a	Future-year model projections	4/19/2019	7/15/2020
	9.1	Calculate Relative Response Factors (related to Subtask 4.1)	5/3/2019	9/1/2020
10	10	Website/FTP Site Development; Data Transfer and Archival	Ongoing	9/30/2020

Table 1-4. Initial Key Deliverables and Dates for the VISTAS II Modeling Through the 2028 Source Apportionment Reporting

Task	Subtask	Deliverable	Initial Due Date	Updated Due Date
11	11.1a	Extraction of state-specific modeling initial conditions/boundary conditions (5 states)	Within 1 week after completion of Task 6.2 and 6.3 activities	No change
	11.1b*	Additional extraction of state-specific modeling initial conditions/boundary conditions (5 states)	Within 1 week after completion of Task 6.2 and 6.3 activities	No change
	11.2a	Extraction of state-specific meteorological files (5 states)	Within 1 week after regions are defined by the time the meteorological data is windowed for the VISTAS_12 domain	No change
	11.2b*	Additional extraction of state-specific meteorological files (5 states)	Within 1 week after regions are defined by the time the meteorological data is windowed for the VISTAS_12 domain	No change

[a] Revised dates based on Amendment 1, dated 5/31/2018
* Optional Task, no decision yet whether to perform it.

2.0 MODEL SELECTION

This section introduces the models to be used in the VISTAS II regional haze modeling study. The selection methodology presented in this chapter mirrors EPA's preliminary 2028 regional haze modeling (EPA, 2017b).

40 CFR Part 51 Appendix W does not identify a "preferred model" for use in reasonable progress assessments for regional haze and therefore, EPA does not recommend a specific model for use in these analyses. The latest EPA modeling guidance (EPA, 2014e) explicitly mentions the Community Multiscale Air Quality Modeling System (CMAQ) and CAMx photochemical grid models (PGMs) as the most commonly used PGMs that would satisfy EPA's selection criteria but notes that this is not an exhaustive list and does not imply that they are "preferred" over other PGMs that could also be considered and used with appropriate justification. EPA's current modeling guidelines lists the following criteria for model selection (EPA, 2014e):

- It should not be proprietary;
- It should have received a scientific peer review;
- It should be appropriate for the specific application on a theoretical basis;
- It should be used with data bases which are available and adequate to support its application;
- It should be shown to have performed well in past modeling applications;
- It should be applied consistently with an established protocol on methods and procedures;
- It should have a User's guide and technical description;
- The availability of advanced features (e.g., probing tools or science algorithms) is desirable; and
- When other criteria are satisfied, resource considerations may be important and are a legitimate concern.

Alpine and ERG have been directed by SESARM to use EPA's 2011el-based air quality modeling platform which includes emissions, meteorology, and other inputs for 2011 as the base year for the modeling described in their regional haze TSD (EPA, 2017b). EPA has projected the 2011 base year emissions to a 2028 future year base case scenario. This will be the foundation of the emissions with revisions for this analysis as described elsewhere. The 2011 modeling platform and projected 2028 emissions will be used to drive the 2011 base year and 2028 base case air quality model simulations. As noted in EPA's documentation, the 2011 base year emissions and methods for projecting these emissions to 2028 are in large part similar to the data and methods used by EPA in the final Cross-State Air Pollution Rule (CSAPR) Update[3] and the subsequent notice of data availability (NODA)[4] to support ozone transport for the 2015 ozone NAAQS.

[3] https://www.epa.gov/airmarkets/final-cross-state-air-pollution-rule-update
[4] https://www.epa.gov/airmarkets/notice-data-availability-preliminary-interstate-ozone-transport-modeling-data-2015-ozone

The 2011 and 2028 emissions used for EPA's regional haze modeling are described in the documents:

- "Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform";[5]
- "Technical Support Document (TSD) Updates to Emissions Inventories for the Version 6.3 2011 Emissions Modeling Platform for the Year 2028";[6] and
- "EPA Base Case v.5.16 for 2023 Ozone Transport NODA Using IPM Incremental Documentation."[7]

The meteorological data and initial and boundary concentrations used for this regional haze assessment, as described below, are the same as those used for the Final CSAPR Update air quality modeling and the 2015 ozone transport NAAQS NODA.

For the VISTAS II regional haze modeling analysis, Alpine and ERG propose to use the WRF/SMOKE/MOVES2014/BEIS/CAMx-PSAT modeling system as the primary tool for modeling PM concentrations and visibility and in the calculation of significant contribution to downwind Class I areas. The proposed modeling system satisfies all of EPA's selection criteria. The key models to be used in this regional haze modelling effort are described below:

- WRF/ARW: The Weather Research and Forecasting (WRF)[8] Model is a mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs (Skamarock, 2004; 2006; Skamarock et al., 2005). The Advanced Research WRF (ARW) version of WRF will be used in this regional haze analysis study. It features multiple dynamical cores, a 3-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. WRF is suitable for a broad spectrum of applications across scales ranging from meters to thousands of kilometers. The effort to develop WRF has been a collaborative partnership, principally among the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (NOAA), the National Centers for Environmental Prediction (NCEP) and the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, the University of Oklahoma, and the Federal Aviation Administration (FAA). WRF allows researchers the ability to conduct simulations reflecting either real data or idealized configurations. WRF provides operational forecasting a model that is flexible and efficient computationally, while offering the advances in physics, numerics, and data assimilation contributed by the research community.
- MOVES2014: MOVES2014[9] is EPA's latest onroad mobile source emissions model that was first released in July 2014 (EPA, 2014a; 2014b; 2014c). MOVES2014 includes the

[5] https://www.epa.gov/air-emissions-modeling/2011-version-63-technical-support-document
[6] https://www.epa.gov/air-emissions-modeling/2011-version-63-platform
[7] https://www.epa.gov/airmarkets/epa-base-case-v516-2015-ozone-naaqs-transport-noda-using-ipm-incremental-documentation
[8] http://www.wrf-model.org/index.php
[9] http://www.epa.gov/otaq/models/moves/

latest onroad mobile source emissions factor information. Emission factors developed by EPA will be used in this analysis.

- SMOKE: The SMOKE[10] modeling system is an emissions modeling system that generates hourly gridded speciated emission inputs of mobile, nonroad, nonpoint area, point, fire and biogenic emission sources for photochemical grid models (Coats, 1995; Houyoux and Vukovich, 1999). As with most 'emissions models', SMOKE is principally an emission processing system and not a true emissions modeling system in which emissions estimates are simulated from 'first principles'. This means that, with the exception of mobile and biogenic sources, its purpose is to provide an efficient, modern tool for converting an existing base emissions inventory data into the hourly gridded speciated formatted emission files required by a photochemical grid model. SMOKE will be used to prepare emission inputs for nonroad mobile, nonpoint area, and point sources.
- SMOKE-MOVES[11]: SMOKE-MOVES uses an Emissions Factor (EF) Look-Up Table from MOVES, county-level gridded vehicle miles travelled (VMT) and other activity data, and hourly gridded meteorological data (typically from WRF) to generate hourly gridded speciated onroad mobile source emissions inputs.
- ERTAC EGU Forecasting Tool: The ERTAC EGU Forecasting Tool[12] was developed through a collaborative effort to improve emission inventories among the Northeastern, Mid-Atlantic, Southeastern, and Lake Michigan area states; other member states; industry representatives; and multi-jurisdictional organization (MJO) representatives. The tool can be used to grow base year hourly EGU emissions inventories into future projection years. The tool uses base year hourly EPA Clean Air Markets Division (CAMD) data, fuel specific growth rates, and other information to estimate future emissions.
- BEIS: Biogenic emissions were modeled by EPA using version 3.61 of BEIS. First developed in 1988, BEIS estimates volatile organic compound (VOC) emissions from vegetation and nitric oxide (NO) emissions from soils. Because of resource limitations, recent BEIS development has been restricted to versions that are built within the SMOKE system.
- CAMx: The CAMx[13] model is a state-of-science "One-Atmosphere" photochemical grid model capable of addressing ozone, PM, visibility, and acid deposition at a regional scale for periods up to one year (Ramboll Environ, 2016). CAMx is a publicly-available open-source computer modeling system for the integrated assessment of gaseous and particulate air pollution. Built on today's understanding that air quality issues are complex, interrelated, and reach beyond the urban scale, CAMx is designed to: (a) simulate air quality over many geographic scales; (b) treat a wide variety of inert and chemically active pollutants including ozone, inorganic and organic $PM_{2.5}$ and PM_{10} and mercury and toxics; (c) provide source-receptor, sensitivity, and process analyses; and (d) be computationally efficient and easy to use. The U.S. EPA has approved the use of CAMx for numerous ozone, PM, and regional haze SIPs throughout the U.S. and has used this model to evaluate regional mitigation strategies including those for most recent

[10] http://www.smoke-model.org/index.cfm
[11] https://www.epa.gov/sites/production/files/2016-06/documents/smoke-moves-2011.pdf
[12] http://www.marama.org/2013-ertac-egu-forecasting-tool-documentation
[13] http://www.camx.com

regional-scale rules (e.g., Transport Rule, Clean Air Interstate Rule (CAIR), NO_X SIP Call, etc.). CAMx Version 6.40 will be used in this study, with the secondary organic aerosol partitioning (SOAP) algorithm module as the default.

- During the preparation of this Modeling Protocol, it was noted that a newer version of CAMx, Version 6.50, was released (April 30, 2018). After discussions with SESARM, the CC, and the TAWG, it was decided to not use the newer version due to insufficient testing and practical usage necessary for to ensure confidence in potential modelling results.
- PSAT: The PSAT tool of CAMx was selected to develop source contribution and significant contribution calculations.

3.0 EPISODE SELECTION

EPA's most recent regional haze modeling guidance (EPA, 2014e) contains recommended procedures for selecting modeling episodes. The VISTAS II regional haze modeling will use the annual calendar year 2011 modeling period because it satisfies the most criteria in EPA's modeling guidance episode selection discussion and is consistent with the base year modeling platform. Specifically, EPA's guidance recommends choosing a time period which reflects the variety of meteorological conditions that represent visibility impairment on the 20% clearest and 20% most-impaired days in the Class I areas being modeled (high and low concentrations necessary). This is best accomplished by modeling a full calendar year.

4.0 MODELING DOMAIN SELECTION

This section summarizes the modeling domain definitions for the VISTAS II regional haze modeling, including the domain coverage, resolution, and map projection. It also discusses emissions, aerometric, and other data available for use in model input preparation and performance testing.

4.1 Horizontal Domains

The VISTAS II modeling will use a 12 km continental U.S. (CONUS_12 or 12US2) domain. The 12 km nested grid modeling domain configuration is shown in Figure 4-1. The 12 km domain shown in Figure 4-1 represents the CAMx 12km air quality and SMOKE/BEIS emissions modeling domain. The WRF meteorological modeling was run on larger 12 km modeling domains than used for CAMx as demonstrated in EPA's meteorological model performance evaluation document (EPA, 2014d). The WRF meteorological modeling domains are defined larger than the air quality modeling domains because meteorological models can sometimes produce artifacts in the meteorological variables near the boundaries as the prescribed boundary conditions come into dynamic balance with the coupled equations and numerical methods in the meteorological model.

An additional VISTAS_12 domain will be prepared that is a subset of the CONUS_12 domain, with dimensions for both provided in Table 4-1. Development of the VISTAS_12 domain (also presented in Figure 4-1) will require the EPA CONUS_12 simulation to be run using CAMx Version 6.40 modeling saving 3-dimensional concentration fields for extraction using the CAMx BNDEXTR program.

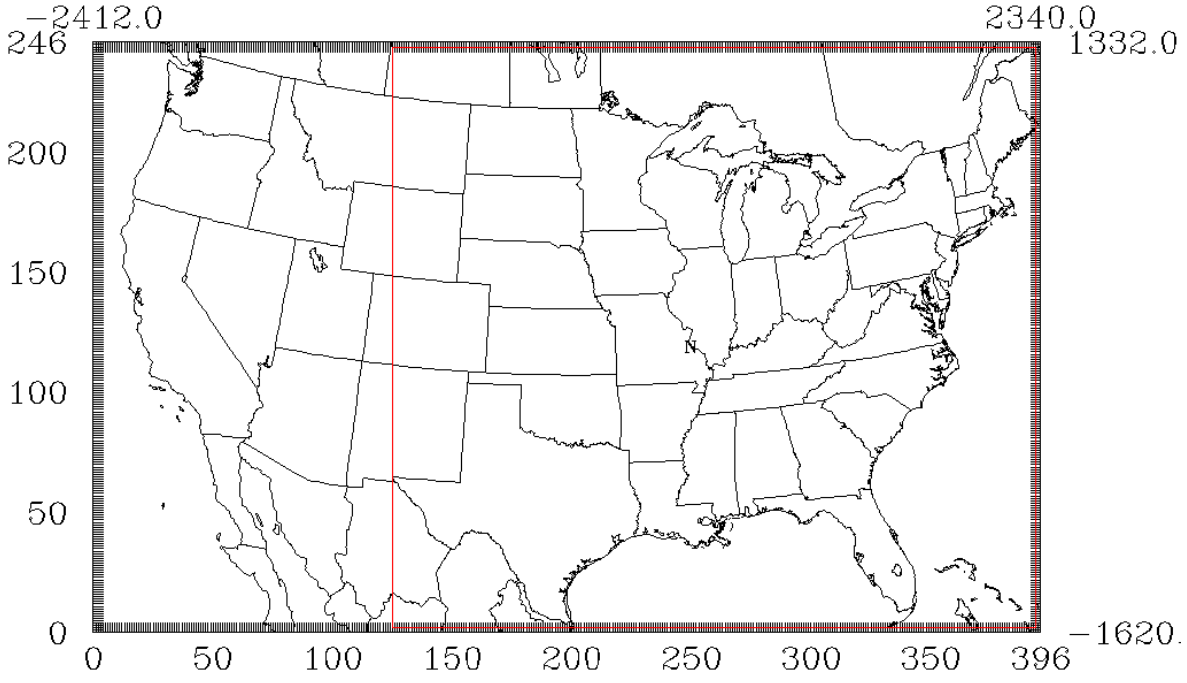


Figure 4-1. Map of 12km CAMx Modeling Domains. VISTAS_12 Domain Represented as Inner Red Domain.

Table 4-1. VISTAS II Modeling Domain Specifications

Domain	Columns	Rows	Vertical Layers	X Origin (km)	Y Origin (km)
CONUS_12	396	246	25	-2,412	-1,620
VISTAS_12	269	242	25	-912	-1,596

4.2 Vertical Modeling Domain

The CAMx vertical structure is primarily defined by the vertical layers used in the WRF meteorological modeling. The WRF model employs a terrain following coordinate system defined by pressure, using multiple layer interfaces that extend from the surface to 50 mb (approximately 19 km above sea level). EPA ran WRF using 35 vertical layers. A layer averaging scheme is adopted for CAMx simulations whereby multiple WRF layers are combined into one CAMx layer to reduce the air quality model computational time. Table 4-2 displays the approach for collapsing the WRF 35 vertical layers to 25 vertical layers in CAMx and is consistent with EPA's draft 2028 regional haze modeling.[14]

Table 4-2. WRF and CAMx Layers and Their Approximate Height Above Ground Level

CAMx Layer	WRF Layers	Sigma P	Pressure (mb)	Approx. Height (m AGL)
25	35	0.00	50.00	17,556
	34	0.05	97.50	14,780
24	33	0.10	145.00	12,822
	32	0.15	192.50	11,282
23	31	0.20	240.00	10,002
	30	0.25	287.50	8,901
22	29	0.30	335.00	7,932
	28	0.35	382.50	7,064
21	27	0.40	430.00	6,275
	26	0.45	477.50	5,553
20	25	0.50	525.00	4,885
	24	0.55	572.50	4,264
19	23	0.60	620.00	3,683
18	22	0.65	667.50	3,136
17	21	0.70	715.00	2,619
16	20	0.74	753.00	2,226
15	19	0.77	781.50	1,941
14	18	0.80	810.00	1,665
13	17	0.82	829.00	1,485
12	16	0.84	848.00	1,308
11	15	0.86	867.00	1,134
10	14	0.88	886.00	964
9	13	0.90	905.00	797
	12	0.91	914.50	714
8	11	0.92	924.00	632

[14] Table 2-2, EPA, 2017b.

Table 4-2. WRF and CAMx Layers and Their Approximate Height Above Ground Level

CAMx Layer	WRF Layers	Sigma P	Pressure (mb)	Approx. Height (m AGL)
	10	0.93	933.50	551
7	9	0.94	943.00	470
	8	0.95	952.50	390
6	7	0.96	962.00	311
5	6	0.97	971.50	232
4	5	0.98	981.00	154
	4	0.99	985.75	115
3	3	0.99	990.50	77
2	2	1.00	995.25	38
1	1	1.00	997.63	19

5.0 DATA AVAILABILITY

The CAMx modeling systems requires emissions, meteorology, surface characteristics, initial and boundary conditions (IC/BC), and ozone column data for defining the inputs.

5.1 Emissions Data

Without exception, as directed by SESARM, the 2011 base year emissions inventories for this analysis will be based on emissions obtained from the EPA's "el" modeling platform. This platform was prepared by EPA and used in the regional haze modeling for 2028. Emissions for 2028 will be based on a mixture of EPA's 2028el sectors and updated emissions as prepared by SESARM for inclusion in this study.

5.2 Ambient Air Quality Observations

Year 2011 data from all available ambient air monitoring networks for gas and PM species are used in the model performance evaluation. Table 5-1 summarizes routine ambient gaseous and PM monitoring networks available in the U.S. Alpine will focus on the ambient data collected from the IMPROVE network. This network began in 1985 as a cooperative visibility monitoring effort between EPA, federal land management agencies, and state air agencies (IMPROVE, 2011). Data are collected at Class I areas across the United States mostly at National Parks, National Wilderness Areas, and other protected pristine areas. Currently, there are approximately 181 IMPROVE sites that have complete annual $PM_{2.5}$ mass and/or $PM_{2.5}$ species data. There are 110 IMPROVE monitoring sites which represent air quality at the 156 designated Class I areas. The 71 additional IMPROVE sites are "IMPROVE protocol" sites which are generally located in rural areas throughout the U.S. Although these sites use the IMPROVE monitoring samplers and collection routines, they are not located at Class I areas.

5.3 Meteorological Data

The 2011 meteorological data for the air quality modeling of 2011 and 2028 will be derived from EPA's run of Version 3.4 of the WRF Model (Skamarock, et al., 2008) as completed for their regional haze modeling analysis for 2028 (EPA, 2017b).

5.4 Ozone Column Data

Ozone column data were derived by EPA using the Total Ozone Mapping Spectrometer (TOMS) with aboard Ozone Monitoring Instrument (OMI) satellite platform[15] for 2011 at a daily, 1 degree resolution. These data will be used as obtained directly from EPA for the 12US2 simulations. EPA developed new ozone column data for their more current 2023en simulation. This more recent data will be used for the final VISTAS 2011 and 2028 modeling. For the VISTAS_12 domain simulations, the data will be windowed onto the smaller VISTAS_12 domain.

5.5 Photolysis Rates

Photolysis rates were calculated using the NCAR Tropospheric Ultraviolet and Visible (TUV) Radiation Model Version 4.8. These data will be used as obtained directly from EPA. The final VISTAS 2011 and 2028 simulations will use the updated photolysis data EPA developed for the 2023en simulation.

5.6 Land Use

Land use and land cover data is based on the 2006 National Land Cover Database (NLCD2006) data.[16] These data will be used as obtained directly from EPA for the 12US2 simulations. For the VISTAS_12 domain simulations, the data will be windowed onto the smaller region.

5.7 Initial and Boundary Conditions Data

The lateral boundary and initial species concentrations are provided by a three-dimensional global atmospheric chemistry model, GEOS-Chem (Yantosca, 2004) standard version 8-03-02 with 8-02-01 chemistry. The global GEOS-Chem model simulates atmospheric chemical and physical processes driven by assimilated meteorological observations from the NASA's GEOS-5.[17] This model was run for 2011 with a grid resolution of 2.0 degrees x 2.5 degrees (latitude-longitude). The predictions were used to provide one-way dynamic boundary concentrations at one-hour intervals and an initial concentration field for the CAMx simulations. The 2011 boundary concentrations from GEOS-Chem were used for the 2011 and 2028 model simulations. The procedures for translating GEOS-Chem predictions to initial and boundary concentrations are described elsewhere (Henderson, 2014). More information about the GEOS-Chem model and other applications using this tool is available at: http://www-as.harvard.edu/chemistry/trop/geos.

The initial and boundary condition files were used, as obtained from EPA. When CAMx was updated from 6.32 to 6.40 the species in the secondary organic aerosol (SOA) scheme changed. The SOA5, SOA6, and SOA7 were removed and SOA3 and SOA4 were redefined. Neither EPA nor this study will remap the boundary conditions to account for this change. EPA examined the regional haze summary data for all Class I areas and found the total organic carbon (OC) species (not just SOA) accounted for 1-5% of the boundary condition impairment at the Southeastern

[15] https://ozoneaq.gsfc.nasa.gov/data/
[16] The 2006 NLCD data are available at http://www.mrlc.gov/nlcd06_data.php
[17] Additional information available at: http://gmao.gsfc.nasa.gov/GEOS/ and http://wiki.seas.harvard.edu/geos-chem/index.php/GEOS-5

Class I areas.[18] This is a small impact on regional haze and the impact of SOA on regional haze is even smaller.

[18] Brian Timin, EPA Office of Air Quality Planning and Standards (OAQPS) personal communication October 11, 2018.

Table 5-1. Overview of Routine Ambient Data Monitoring Networks

Monitoring Network	Chemical Species Measured	Sampling Period	Data Availability/Source
The Interagency Monitoring of Protected Visual Environments (IMPROVE)	Speciated $PM_{2.5}$ and PM_{10} (see species mappings); light extinction data	1 in 3 days; 24-hour average	http://vista.cira.colostate.edu/improve/Data/IMPROVE/improve_data.htm
Clean Air Status and Trends Network (CASTNET)	Speciated $PM_{2.5}$, and O_3 (see species mappings)	Approximately 1-week average	http://www.epa.gov/castnet/data.html
National Atmospheric Deposition Program (NADP)	Wet deposition (hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium)), Mercury	1-week average	http://nadp.sws.uiuc.edu/
Air Quality System (AQS)	CO, NO_2, O_3, SO_2, $PM_{2.5}$, PM_{10}, lead (Pb), HAPs	Typically hourly average to 24-hour average	http://www.epa.gov/air/data/
Chemical Speciation Network (CSN)	Speciated $PM_{2.5}$	24-hour average	http://www.epa.gov/ttn/amtic/amticpm.html
Photochemical Assessment Monitoring Stations (PAMS)	Varies for each of 4 station types.	Varies by station	http://www.epa.gov/ttn/amtic/pamsmain.html
National Park Service Gaseous Pollutant Monitoring Network	Acid deposition (Dry; SO_4^{2-}, NO_3^-, HNO_3, NH_4, SO_2), O_3, meteorological data	Hourly	http://www2.nature.nps.gov/ard/gas/netdata1.htm

6.0 MODEL INPUT PREPARATION PROCEDURES

This section summarizes the procedures to be used in developing the meteorological, emissions, and air quality inputs to the CAMx model for the VISTAS II modeling on the 12 km grids for the annual 2011 period. The 12 km CAMx modeling databases are largely based on the EPA "el" platform databases.

6.1 Meteorological Inputs

The meteorological inputs in EPA's "el" platform will be used directly without revision. Details of EPA's annual 2011 meteorological model simulation and evaluation are provided in a separate technical support document (EPA, 2014a), which can be obtained at: http://www.epa.gov/ttn/scram/reports/MET_TSD_2011_final_11-26-14.pdf.

6.1.1 WRF Model Science Configuration

Version 3.4 of the WRF model ARW core (Skamarock, 2008) was used for generating the 2011 simulations. Selected physics options include Pleim-Xiu land surface model, Asymmetric Convective Model Version 2 planetary boundary layer scheme, KainFritsch cumulus parameterization utilizing the moisture-advection trigger (Ma and Tan, 2009), Morrison double moment microphysics, and Rapid Radiative Transfer Model-Global (RRTMG) longwave and shortwave radiation schemes (Iacono et al., 2008). The WRF model configuration was prepared by EPA (EPA, 2014d).

6.1.2 WRF Input Data Preparation Procedures

The WRF model simulation was initialized using the 12km North American Model (NAM-12) analysis product provided by the National Climatic Data Center (NCDC). Where NAM-12 data were unavailable, the 40km Eta Data Assimilation System (EDAS) analysis (ds609.2) from the National Center for Atmospheric Research (NCAR) was used. Analysis nudging for temperature, wind, and moisture was applied above the boundary layer only. The model simulations were conducted in 5.5 day blocks with soil moisture and temperature carried from one block to the next via the Intermediate Processor for Pleim–Xiu for WRF (IPXWRF) program (Gilliam and Pleim, 2010). Land use and land cover data were based on the 2006 National Land Cover Database (NLCD2006) data.[19] Sea surface temperatures at 1 km resolution were obtained from the Group for High Resolution Sea Surface Temperatures (GHRSST) (Stammer, et al., 2003).

As shown in Table 4-2, the WRF simulations were performed with 35 vertical layers up to 50 mb, with the thinnest layers being nearest the surface to better resolve the planetary boundary layer (PBL). The WRF 35-layer structure was collapsed to 25 layers for the CAMx air quality model simulations, as shown in Table 4-2.

6.1.3 WRF Model Performance Evaluation

The WRF model performance evaluation is provided in EPA's Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation documentation report (EPA, 2014d). The WRF model evaluation approach was based on a combination of qualitative and quantitative analyses. The quantitative analysis was divided into monthly summaries of 2-m temperature, 2-m

[19] The 2006 NLCD data are available at http://www.mrlc.gov/nlcd06_data.php

mixing ratio, and 10-m wind speed using the boreal seasons to help generalize the model bias and error relative to a set of standard model performance benchmarks. The qualitative approach was to compare spatial plots of model estimated monthly total precipitation with the monthly PRISM precipitation.

6.1.4 WRFCAMx/MCIP Reformatting Methodology

The WRF meteorological model output data was processed to provide inputs for the CAMx photochemical grid model. The WRFCAMx processor maps WRF meteorological fields to the format required by CAMx. It also calculates turbulent vertical exchange coefficients (Kv) that define the rate and depth of vertical mixing in CAMx. The methodology used by EPA to reform the meteorological data into CAMx format is provided in documentation provided with the wrfcamx conversion utility.[20]

The meteorological data generated by the WRF simulations were processed by EPA using WRFCAMx v4.3 (Ramboll Environ, 2014) meteorological data processing program to create model-ready meteorological inputs to CAMx. In running WRFCAMx, vertical eddy diffusivities (Kv) were calculated using the Yonsei University (YSU) (Hong and Dudhia, 2006) mixing scheme. Alpine used a minimum Kv of 0.1 m^2/sec except for urban grid cells where the minimum Kv was reset to 1.0 m^2/sec within the lowest 200 m of the surface in order to enhance mixing associated with the nighttime "urban heat island" effect. In addition, EPA invoked the subgrid convection and subgrid stratoform stratiform cloud options in our wrfcamx run for 2011.

6.1.5 Windowing from EPA 12US2 to VISTAS_12

The meteorological data will be windowed from the EPA 12US2 domain onto the VISTAS_12 domain using a slightly modified version of the CAMx utility program "window".[21] The only required change to the distributed version program is to allow the program to window three-dimension files instead of just two-dimensional files.

6.2 Emission Inputs

6.2.1 Available Emissions Inventory Datasets

The base year emission inventories to be used in the VISTAS II modeling study will be based on EPA's 2011el modeling platform without exception. Complete documentation for the 2011 emissions used for EPA's regional haze modeling are described in the documents, "Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform."

Emissions for the 2028 base year will include EPA 2028el projections for most sectors (onroad and nonroad mobile sources, marine, aircraft, railroad, fires, nonpoint area, biogenic, and international sources) augmented with updated EGU and non-EGU point source emission estimates provided by SESARM.

Documentation on EPA's 2028el platform can be found in "Technical Support Document (TSD) Updates to Emissions Inventories for the Version 6.3 2011 Emissions Modeling Platform for the

[20] http://www.camx.com/getmedia/7f3ee9dc-d430-42d6-90d5-dedb3481313f/wrfcamx-11jul17.tgz
[21] http://www.camx.com/getmedia/88755b80-6992-4f07-bcaa-596d05e1b4b8/window-6may13_1.tgz

Year 2028". Adjustments planned for the SESARM adjusted source categories are documented below.

Outside of the VISTAS states, source categories and their associated emissions will be taken directly from the EPA 2028el modeling platform. The exceptions to this will be:

- For EGU sources where data obtained from the projections to 2028 for EGU point source emissions by the ERTAC EGU projection tool[22] from the most recent CONUS 16.0/16.1 runs will be used, based on state direction.
- For non-SESARM states providing emissions updates for facilities of interest based on the Area Of Influence Analysis.

6.2.2 2011 Base Year Emissions

The emissions data in the 2011 platform are primarily based on the 2011NEIv2 for point sources, nonpoint sources, commercial marine vessels (CMV), nonroad mobile sources and fires. The onroad mobile source emissions are similar to those in the 2011NEIv2, but were generated using the released 2014a version of the Motor Vehicle Emissions Simulator (MOVES2014a). Fugitive dust emissions from anthropogenic sources (i.e., agricultural tilling and unpaved roads) are included in the nonpoint sector of the inventory, but wind-blown dust from natural sources is not accounted for in the inventory.

2011 CAMx-ready emission inputs were generated by EPA mainly by the SMOKE and BEIS emissions models. CAMx requires two emission input files for each day: (1) low level gridded emissions that are emitted directly into the first layer of the model from sources at the surface with little or no plume rise; and (2) elevated point sources (stacks) containing stack parameters from which the model can calculate plume rise. As noted earlier, EPA's 2011el emission platform in CAMx-ready format will be used without exception.

6.2.3 2028 Projection Year Emissions

Certain 2011 emission sectors were also projected by EPA to 2028 using various sector dependent methodologies. Onroad and nonroad mobile source emissions were created for 2028 using the MOVES and NONROAD models, respectively. Nonpoint area source emissions were prepared using growth and control factors simulating changes in economic conditions and environmental regulation anticipated to be fully implemented by calendar year 2028. For these categories, Alpine will be using EPA's estimates from the 2028el platform, unless a VISTAS state provides an update that is authorized by the SESARM contract.

Projections to 2028 for EGU and non-EGU point source emissions for 2028 will be derived from files produced by the ERTAC EGU projection tool from the most recent CONUS runs (2.7, 16.0, and 16.1) and from SESARM review of EPA 2028el emissions augmented with state-provided growth and control adjustments, respectively. Additionally, states will also review EPA's most recent 2028 projected emissions from the 2016 modeling platform.[23] ERG will review the

[22] http://www.marama.org/2013-ertac-egu-forecasting-tool-documentation
[23] https://www.epa.gov/air-emissions-modeling/2016v1-platform

emissions adjustments and work with states to ensure that the revised values are reasonable. ERG will also document the source of the revised 2028 emissions.

ERG will prepare state-specific summary comparisons of EPA's 2028v6.3el modeling platform emissions to the 2023v6.3en modeling platform emissions for stationary electricity generating unit (EGU) and non-EGU stationary point sources to facilitate review by each VISTAS state. The summaries between the two inventories will be grouped by Emission Inventory System (EIS) facility, emissions unit, process, and release point identifiers and source classification code (SCC) for annual emissions of:

- Oxides of nitrogen (NO_x);
- Volatile organic compounds (VOC);
- Primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter ($PM_{2.5}$-PRI);
- Primary particulate matter less than or equal to 10 microns in aerodynamic diameter (PM_{10}-PRI);
- Carbon monoxide (CO);
- Sulfur dioxide (SO_2); and
- Ammonia (NH_3).

If the 2023v6.3en emissions are selected for the final 2028 emissions inventory, ERG will document these updates.

ERG will work with SESARM on the final format of the comparison tables, including additional fields that may be useful for review, such as: facility information; SCC descriptions; unit, process, and release point descriptions; ORIS boiler identifiers; control information; and absolute and percentage differences between the two emissions inventories. All data will be provided in a single Excel file, unless the file size is prohibitive, at which point ERG will work with SESARM on the best way to divide the data across multiple files.

6.2.3.1 EGU Point Source Emissions

For EGU sources only, the ERG/Alpine team will use an already-obtained version of the 2028 emissions forecast, the 2028 projected emissions based on EPA's 2016 modeling platform, and associated files produced by the ERTAC EGU projection tool from the most recent CONUS 2.7, 16.0, and 16.1 runs available. The specific runs for each EGU are documented in the Task 2B (for SESARM states) and Task 3B (for non-SESARM states) reports. The team will prepare state-specific summary comparisons of EPA's 2028v6.3el modeling platform emissions to EPA's 2023v6.3en modeling platform emissions to the ERTAC 2028 modeling platform emissions for EGU point sources to facilitate the VISTAS state review. The summaries will be produced in Microsoft Excel format grouped by EIS facility, emissions unit, process, and release point identifiers, ORIS ID, and SCC for annual emissions of NO_X, VOC, $PM_{2.5}$-PRI, PM_{10}-PRI, CO, SO_2, and NH_3 between the two emissions inventories.

ERG will work with SESARM on the final format of the comparison tables, including additional fields that may be useful for review, such as: facility information; SCC descriptions; unit, process, and release point descriptions; ORIS boiler identifiers; control information; and absolute and percentage differences between the two emissions inventories.

SESARM will identify for ERG in the final comparison tables which emissions projection platform (e.g., EPA 2023en, EPA 2028el, ERTAC EGU, or state provided) should be used in the final 2028 modeling file preparation. For any individual EGU source, only a single platform should be selected. In other words, emissions from one platform cannot be mixed with emissions from another platform at the same unit.

6.2.3.2 Non-EGU Point Source Emissions

Similar to the work being conducted for EGU point sources, ERG will update the 2028 non-EGU point source projection year mass emissions inventories based on the information collected from SESARM's review of prepared comparison tables. All revisions will be documented to account for changes in emissions due to retirements, control enhancements, and/or fuel switches, as well as any additional metadata to describe the data. For certain situations, a state may wish to develop their own revised 2028 point sources emissions inventory using updated growth and/or control factors on the 2011 point sources emissions inventory. In these cases, ERG will work with the state agencies to provide the data into the format needed for integration.

6.2.3.3 Nonpoint Area, Onroad, and Nonroad Mobile Source Emissions

Emissions data for 2028 nonpoint area, onroad mobile, and nonroad mobile sources will be used from the 2011/2028el modeling platform. These sources will be spatially allocated to the grid using an appropriate surrogate distribution (e.g., population for home heating, etc.) and will be temporally allocated by month, by day of week, and by hour of day using the EPA source-specific temporal allocation factors. The SMOKE source-specific CB6r4 speciation allocation profiles will also be used for all categories.

6.2.3.4 Biogenic Source Emissions

Biogenic emissions were generated by EPA using the BEIS biogenic emissions model within SMOKE. BEIS uses high resolution GIS data on plant types and biomass loadings and the WRF surface temperature fields, and solar radiation (modeled or satellite-derived) to develop hourly emissions for biogenic species on the 12 km grids. BEIS generates gridded, speciated, temporally allocated emission files. EPA's 2011 biogenic emissions will be used for the 2028 modeling platform.

6.2.3.5 Wildfires, Prescribed Burns, Agricultural Burns

Fire emissions in 2011NEIv2 were developed based on Version 2 of the Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) system (Sullivan, et al., 2008). SMARTFIRE2 was the first version of SMARTFIRE to assign all fires as either prescribed burning or wildfire categories. In past inventories, a significant number of fires were published as unclassified, which impacted the emissions values and diurnal emissions pattern. Recent updates to SMARTFIRE include improved emission factors for prescribed burning. These emissions as prepared by EPA will be included in both the 2011 and 2028 emission

platforms. EPA's 2011 fire emissions will be used for the 2028 modeling platforms. It should be noted that there were large wildfires in the Okefenokee Swamp and Eastern North Carolina in 2011. However, contributions from these wildfires should not impact the development of reasonable progress goals since EPA's new 20% most impaired days metric removes IMPROVE days that were significantly impacted by these wildfires from the analysis.

6.3 Emissions Processing

CAMx requires detailed emissions inventories containing temporally allocated (i.e., hourly) emissions for each grid-cell in the modeling domain for a large number of chemical species that act as primary pollutants and precursors to secondary pollutants. Annual emission inventories for 2011 and 2028 will be preprocessed into SMOKE-ready modeling system (Houyoux et al., 2000) inputs for eventually additional processing and use in CAMx. For this analysis, CAMx will be operated using Version 6 revision 4 of the Carbon Bond chemical mechanism (CB6r4).

For emission segments that are unchanged from the EPA distribution, the emission will be windowed from the EPA 12US2 domain onto the VISTAS_12 domain using the CAMx "window"[24] utility program. For VISTAS state specific emission segments, the emissions will be developed on the VISTAS_12 domain.

Steps necessary to prepare SMOKE-ready input files from the mass emissions data is outlined in the VISTAS II workplan, Task 2. In that task, Alpine will ensure that annual emission changes submitted or authorized by SESARM are carried through to all relevant input files consistent with EPA's 2011 and 2028 v6.3el platform processing. Upon the completed development of these new input files, Alpine will use EPA's modeling platform scripts, with the updated input files from this task, to generate CAMx photochemical model Version 6.40-ready inputs using the SMOKE Modeling System.

The CMAQ and CAMx models require hourly emissions of specific gas and particle species for the horizontal and vertical grid cells contained within the modeled region (i.e., modeling domain). To provide emissions in the form and format required by the model, it is necessary to "pre-process" the "raw" emissions (i.e., emissions input to SMOKE) for the sectors described above. In brief, the process of emissions modeling transforms the emissions inventories from their original temporal resolution, pollutant resolution, and spatial resolution into the hourly, speciated, gridded resolution required by the air quality model.

The emission processing for this project will take two different "paths" as shown in Figure 6-1.

For emission segments that are being updated for the project, the emissions will be processed using SMOKE version 3.7 with the emissions being output directly into CAMx format for the VISTAS_12 domain. For emission segments that are unchanged from the EPA simulation the emissions will be converted from the EPA supplied CMAQ format into CAMx format using the CMAQtoCAMx processor and windowed onto the VISTAS_12 domain using the "WINDOW" program. The CMAQ2CAMx converter reformats the files, converts units, and transforms the CMAQ in-line elevated emissions into CAMx elevated format and low level files into CAMx

[24] http://www.camx.com/getmedia/88755b80-6992-4f07-bcaa-596d05e1b4b8/window-6may13_1.tgz

format. As a final step before running the CAMx model, the low-level emissions will be merged into the single low level and elevated files.

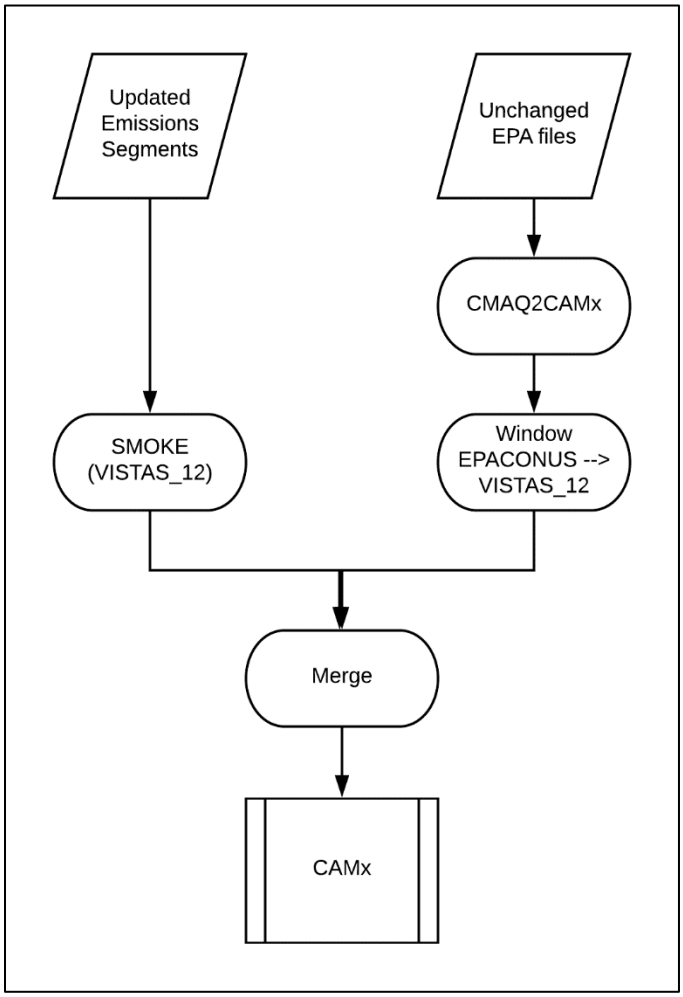


Figure 6-1. Emission Processing Paths

While the 2028 projection year non-EGU and EGU point source inventory will be updated to reflect requested changes by SESARM, the steps associated with the emissions processing of these files remains the same as EPA's methods for the 2028 regional haze modeling analysis. Details of the temporal, spatial, and speciation data and methods are described in EPA's technical support document for the development of the 2028 platform.[25]

Other than the preparation of data for an additional modeling domain (VISTAS_12) for this analysis, all other emissions processing steps, methods, and ancillary data and associations will be identical to EPA's documented processing steps.

[25] https://www.epa.gov/sites/production/files/2017-11/documents/2011v6.3_2028_update_emismod_tsd_oct2017.pdf

No plume-in-grid (PiG) subgrid-scale plume treatment will be used in this project.

Scripts to perform the emissions merging of the appropriate biogenic, onroad, nonroad, nonpoint area, low-level, fire, and point emission files will be written to generate the CAMx-ready two-dimensional day and domain-specific hourly speciated gridded emission inputs. The point source and, as available elevated fire, emissions would be processed into the day-specific hourly speciated emissions in the CAMx-ready point source format.

6.3.1 QA/QC of CAMx-Ready Emission Files

For quality assurance of the emissions modeling steps, emissions totals for all species across the entire model domain will be output as reports that are then compared to reports generated by SMOKE on the input inventories to ensure that mass is not lost or gained during the emissions modeling process.

In addition to the CAMx-ready emission input files generated for each hour of all days modeled in the annual 2011 or 2028 modeling period, a number of QA files may be prepared and used to check for gross errors in the emissions inputs. The model-ready emissions will be imported into visualization tools and Alpine will examine both the spatial and temporal distribution of the emission to investigate the quality and accuracy of the emissions inputs.

- Visualizing the model-ready emissions with the scale of the plots set to a very low value, Alpine can determine whether there are areas omitted from the raw inventory or if emissions sources are erroneously located in water cells;
- Spot-checking the holiday emissions files to confirm that they are temporally allocated like Sundays;
- Producing pie charts emission summaries that highlight the contribution of each emissions source component (e.g. nonroad mobile); and
- Normalizing the emissions by population for each state will illustrate where the inventories may be deficient and provide a reality check of the inventories.

State inventory summaries prepared prior to the emissions processing will be used to compare against SMOKE output report totals generated after each major step of the emissions generation process. To check the chemical speciation of the emissions to CB6 species, Alpine will compare reports generated with SMOKE to target these specific areas of the processing. For speciation, the inventory state import totals will be compared against the same state totals with the speciation matrix applied.

The quantitative QA analyses often reveal significant deficiencies in the input data or the model setup. It may become necessary to tailor these procedures to track down sources of any identified major problem. As such, Alpine can only outline the basic quantitative QA steps that are performed by Alpine to reveal the underlying problems with the inventories or processing.

Standard inventory assessment methods may be employed to generate the future year emissions data QA files including, but not limited to: (a) visualizing the model-ready emissions graphically, (b) spot-checking the holiday emissions files to confirm that they are temporally

allocated like Sundays, (c) producing pie charts emission summaries for each source category, and (d) normalizing the emissions by population for each state to reveal where the future year inventories may be suspect. Of particular importance will be the comparison of the 2011 base year and 2028 future year emissions by source category to make sure the expected changes have been appropriately accounted for in the modeling inventories.

The resultant CAMx model-ready emissions will be subjected to a final QA using spatial maps to assure that: (1) the emissions were merged properly; (2) CAMx inputs contain the same total emissions; and (3) to provide additional QA/QC information.

Emissions are processed by major source category in several different "streams", including nonpoint area sources, onroad mobile sources, nonroad mobile sources, biogenic sources, non-CEM point sources, CEM point sources using day-specific hourly emissions, and emissions from fires. Separate Quality Assurance (QA) and Quality Control (QC) will be performed for each stream of emissions processing and in each step following the procedures outlined in the project QAPP. SMOKE includes advanced quality assurance features that include error logs when emissions are dropped or added. In addition, Alpine will generate visual displays that include:

- Spatial plots of the hourly emissions for each major species (e.g., NO_X, VOC, some speciated VOC, SO_2, NH_3, PM and CO).
- Summary tables of emissions for major species for each grid and by major source category.
- This QA information will be examined against the original point and nonpoint area source data and summarized in an overall QA/QC assessment.

6.4 Photochemical Modeling Inputs

6.4.1 CAMx Science Configuration and Input Configuration

This section describes the model configuration and science options to be used in the VISTAS II modeling effort. Version 6.40 of CAMx will be used for this modeling.

CAMx is a three-dimensional grid-based Eulerian air quality model designed to simulate the formation and fate of oxidant precursors, primary and secondary particulate matter concentrations, and deposition over regional and urban spatial scales (e.g., the contiguous U.S.). Consideration of the different processes (e.g., transport and deposition) that affect primary (directly emitted) and secondary (formed by atmospheric processes) pollutants at the regional scale in different locations is fundamental to understanding and assessing the effects of emissions on air quality concentrations.

Figure 4-1 presented the geographic extent of the modeling domains (12US2 and VISTAS_12) that will be used for air quality modeling in this analysis. The 12US2 domain covers the 48 contiguous states along with the southern portions of Canada and the northern portions of Mexico. The VISTAS_12 domain covers the continental US eastward from the western extent of Texas along with the southern portions of Canada and the northern portions of Mexico. As discussed later, the limited coverage of Canada and Mexico is an important consideration when interpreting the modeling results. This modeling domain contains 25 vertical layers with a top at

about 17,550 meters, or 50 millibars (mb), and horizontal grid resolution of 12 km x 12 km. The model simulations produce hourly air quality concentrations for each 12 km grid cell across the modeling domain.

For the simulations that use the EPA 12US2 domain, the model will be applied using the same time segments as EPA. The model will be applied from December 22, 2010 through April 30, 2011 and from April 21, 2011 through December 31, 2011. The beginning of each segment, December 21-31, 2010 for the first segment and April 21-30, 2011 for the second segment are used as spin-up periods and will not be analyzed.

For the simulation on the VISTAS_12 domain, the model will be applied quarterly using the definitions in Table 6-1. The initial conditions for each quarter, and hourly boundary conditions will be extracted from the CAMx version 6.40 simulations performed over the EPA 12US2 CONUS domain.

Table 6-1. VISTAS II Simulation Periods

Quarter Number	Starting Date	Ending Date
1	December 22, 2010	March 31, 2011
2	March 15, 2011	June 30, 2011
3	June 15, 2011	September 30, 2011
4	September 15, 2011	December 31, 2011

CAMx requires a variety of input files that contain information pertaining to the modeling domain and simulation period. These include gridded, hourly emissions estimates and meteorological data, and boundary concentrations. Separate emissions inventories will be prepared for the 2011 base year and the 2028 base case. Meteorological fields will be specified for the 2011 base year model application and remained unchanged for the future-year model simulations.[26] The IC/BC for VISTAS_12 in 2028 will be based on 12US_2 domain as mentioned in section 5.5.2.

Ten CAMx model runs, associated with up to 250 tagged sources, are currently planned for this analysis. The simulations are summarized in Table 6-2.

Table 6-2. CAMx Simulations for the VISTAS II Project

Simulation Number	Description	CAMx Version	Grid	Task	Time
1	EPA 2011el Confirmation	6.32	12US2	6.2	EPA 1,2*
2	EPA 2011el saving 3-D average for VISTAS12 IC/BC Extracts	6.40	12US2	6.2	EPA 1,2
3	EPA 2028el Confirmation	6.32	12US2	6.3	EPA 1,2
4	VISTAS 2028 saving 3-D average for VISTAS12 IC/BC extracts	6.40	12US2	6.3	EPA 1,2

[26] The CAMx annual simulations for 2011 and 2028 were each performed using two time segments (January 1 through April 30, 2011 with a 10-day ramp-up period at the end of December 2010 and May 1 through December 31, 2011 with a 10-day ramp-up period at the end of April 2011).

Table 6-2. CAMx Simulations for the VISTAS II Project

Simulation Number	Description	CAMx Version	Grid	Task	Time
5	EPA 2011el saving 3-D average for state domains IC/BC extracts	6.40	VISTAS_12	6.2	Q1,2,3,4
6	VISTAS 2028 saving 3-D average for state domain IC/BC extracts	6.40	VISTAS_12	6.3	Q1,2,3,4
7	VISTAS 2028 PSAT with selected sources 1-50 tagged	6.40	VISTAS_12	7	Q1,2,3,4
8	VISTAS 2028 PSAT with selected sources 51-100 tagged	6.40	VISTAS_12	7	Q1,2,3,4
9	VISTAS 2028 PSAT with selected sources 101-150 tagged	6.40	VISTAS_12	7	Q1,2,3,4
10	VISTAS 2028 PSAT with selected sources 151-200 tagged	6.40	VISTAS_12	7	Q1,2,3,4
11	VISTAS 2028 PSAT with selected sources 201-250 tagged	6.40	VISTAS_12	7	Q1,2,3,4

*EPA twice annual segments from December 22, 2010 through April 30, 2011 and April 21, 2011 through December 31, 2011.

6.4.2 VISTAS_12 Boundary And Initial Conditions

Boundary and initial conditions for the VISTAS_12 domain will be extracted from simulations using the EPA 12US2 domain. For the 2011 baseline simulation, the EPA 2011el platform for the 12US2 domain will be run using CAMx 6.40 and the resultant three-dimensional outputs will be saved. For the 2028 future year simulation, the EPA 2028el point source emissions will be reprocessed to include updated point source emissions, and CAMx 6.40 will be run saving three-dimensional outputs. The boundary and initial conditions for the VISTAS_12 domain will be extracted from the respective three-dimensional output files using the CAMx BNDEXTR program.

6.4.3 VISTAS_12 Ozone Column

EPA developed new ozone column data for their more current 2023en simulation. This more recent data will be used for the final VISTAS 2011 and 2028 modeling. The ozone column data for the VISTAS_12 domain will be windowed from the EPA 12US2 domain. The ozone column data is a simple text file and new code will be developed to extract data for the smaller VISTAS_12 domain.

6.4.4 Photolysis Rates

The final VISTAS 2011 and 2028 simulations will use the updated photolysis data EPA developed for the 2023en simulation. The EPA photolysis rates used will be unchanged in the VISTAS_12 domain.

6.4.5 CAMx Land Use

The land use file for the VISTAS_12 domain will be windowed from the EPA 12US2 domain. The land use file is a simple text file and new code will be developed to extract data for the smaller VISTAS_12 domain.

6.5 EPA 2011 and 2028 Base Case Confirmation

The numerics in photochemical grid models are very complex and it is typical to get slightly different model concentrations based on the version of the computer and compilers. When comparing simulations, it is critical to isolate the changes in concentrations to the changes in the model inputs, and not on the computing details (i.e., compiler version, computer architecture, parallelization options). This is especially problematic when looking at particulate matter, since the particulate treatments have multiple pathways, and small concentration differences can lead to different pathways through the code and different concentrations.

Sources of the difference can come from the options used in CAMx compilation, the version of the compiler, the compiler vendor, and how the model calculation is split onto different processors (parallelization).

Alpine will execute two confirmation runs, one for the 2011el base year and one for the 2028el base case, to confirm the contract team's ability to replicate EPA's results and to ensure that the EPA data, models, and scripts operated in a consistent manner as EPA's procedure.

6.5.1 Differences Between EPA And VISTAS Simulations

EPA ran the 2011v6.3el platform on EPA's supercomputer with the model configured to use four (4) processor nodes with 16 processors per node. The use of multiple processor nodes with multiple processors per node is efficient on the EPA supercomputer due to the low latency interconnect between the nodes. On more typical computer clusters with the nodes interconnected with Ethernet, like the Alpine cluster and most likely the State and stakeholder clusters, the latency between nodes is sufficiently high that it is inefficient to spread processing between nodes. Our experience with the EPA platform has shown that on an Ethernet connected cluster with 12 Intel XEON processors per node and hyperthreading enabled it is most efficient to use a single node configured with 10 Message Passing Interface (MPI) instances, each with 2 OpenMP threads.

EPA used the Intel FORTRAN compiler. Alpine, and the CAMx developers, use the Portland Group (PGI) FORTRAN compiler. The PGI compiler has been the standard compiler for CAMx applications for many years and it's anticipated this compiler will be more widely used by the States and stakeholders. The version of CAMx 6.32 EPA distributed with the 2011el platform will be recompiled on the Alpine computer system and used for the confirmation.

As noted in Section 5.5.1, EPA ran the model in two time segments. The first segment, typically used only for PM applications, runs from December 22, 2010 through April 30, 2011. The second segment runs from April 21, 2011 through December 31, 2011. The VISTAS confirmation run will use the same two segments. December 22-31, 2010 and the April portion of the second segment are spin-ups and will not be analysed.

6.5.2 Confirmation Methodology

The simulations on the Alpine computer cluster and the EPA computer will be based on hourly differences in ozone, $PM_{2.5}$, POC, Particulate Nitrate and Particulate Sulfate. The metric for comparison will be the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$(C_{vistas} - C_{epa})$$

(Equation 2) $$\frac{(C_{vistas} - C_{epa})}{(C_{epa})}$$

Where C_{epa} is the concentration at each grid cell hour for the EPA simulation and C_{vistas} is the concentration at each grid cell hour for the simulation on the Alpine computers.

The comparison will be done both graphically (e.g., scatter density plots) and quantitatively (e.g., residual distributions) for reviewed concentrations. Analysis products will be hourly spatial plots of the absolute differences. Should significant differences be noted between the confirmation runs and EPA's original simulations, Alpine will generate an electronic appendix of the spatial plots and discuss with SESARM and others as requested. If it is determined that noted differences are the result of modeling errors, Alpine will propose to SESARM recommended approaches to correct the issues and will correct configurations based on negotiation action.

The following confirmation benchmark runs will be performed:

1. Benchmark Run #1 - EPA 2011 with CAMx_6.32 (CONUS) vs. Alpine 2011 with CAMx_6.32 (CONUS), as documented in Benchmark Report #1.
2. Benchmark Run #2 - EPA 2028 with CAMx_6.32 (CONUS) vs. Alpine 2028 with CAMx_6.32 (CONUS), as documented in Benchmark Report #1.
3. Benchmark Run #3 - Alpine 2011 with CAMx_6.32 (CONUS) vs. Alpine 2011 with CAMx_6.40 (CONUS), as documented in Benchmark Report #2.
4. Benchmark Run #4 - Alpine 2028 with CAMx_6.32 (CONUS) vs. Alpine 2028 with CAMx_6.40 (CONUS), as documented in Benchmark Report #4.
5. Benchmark Run #5 - Alpine 2011 with CAMx_6.40 (CONUS) vs. Alpine 2011 with CAMx_6.40 (VISTAS), as documented in Benchmark Report #3.
6. Benchmark Run #6 - Alpine 2028 with CAMx_6.40 (CONUS) vs. Alpine 2028 with CAMx_6.40 (VISTAS), as documented in Benchmark Report #5.
7. Benchmark Run #7 - Alpine 2028elv3 with CAMx_6.40 (VISTAS) vs. Alpine 2028elv5 with CAMx_6.40 (VISTAS), as documented in Benchmark Report #6.

7.0 MODEL PERFORMANCE EVALUATION

An operational model performance evaluation will be conducted for total fine particulate matter ($PM_{2.5}$), $PM_{2.5}$ species components (e.g., SO_4, NO_3, NH_4, EC, and OC), measured gas phase species (e.g., O_3, HNO_3, SO_2, VOCs, NO_2, and NO), and speciated components of light extinction to examine the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. This evaluation will focus on graphical analyses and statistical metrics of model predictions versus observations. Note that as EPA did not publish an evaluation of $PM_{2.5}$ gas phase species in their 2028 regional haze modeling we will not have a basis for comparison of these metrics.

The CAMx 2011 base case model estimates will be compared against the observed concentrations to establish that the model is capable of reproducing the current year observed concentrations so that it can be considered a reliable tool for estimating future year PM and regional haze levels.

The model evaluation will focus on the ability of the model to predict visibility-reducing PM at VISTAS Class I areas (represented by IMPROVE monitoring sites). The analysis will look at monthly and seasonal average PM species component performance at IMPROVE and other PM monitoring networks, and performance on the 20% most impaired (and 20% clearest) days at individual IMPROVE sites. This will provide a comprehensive assessment of the components that make up visibility performance.

The measured concentrations of PM components such as nitrate on the 20% most impaired days at many Class I areas are extremely small. Numerous Class I areas in the Eastern U.S. have average nitrate observations (on the 20% most impaired days) of less than 1 $\mu g/m^3$. This makes it challenging to correctly model observed visibility. Assumptions regarding particular emissions categories and boundary conditions can have a large impact on model performance. Even when model performance appears to be accurate, it is difficult (without further modeling and analysis) to determine if the answers observed are right for the right reasons (for example, when the extinction is dominated by modeled boundary conditions).

7.1 Model Performance Evaluation

7.1.1 Overview of EPA Model Performance Evaluation Recommendations

EPA current (EPA, 2007) and draft (EPA, 2014e) ozone, PM, and regional haze modeling guidance recommendations for model performance evaluation (MPE) describes a MPE framework that has four components:

- Operation evaluation that includes statistical and graphical analysis aimed at determining how well the model simulates observed concentrations (i.e., does the model get the right answer).
- Diagnostic evaluation that focuses on process-oriented evaluation and whether the model simulates the important processes for the air quality problem being studied (i.e., does the model get the right answer for the right reason).

- Dynamic evaluation that assess the ability of the model air quality predictions to correctly respond to changes in emissions and meteorology.
- Probabilistic evaluation that assess the level of confidence in the model predictions through techniques such as ensemble model simulations.

EPA's guidance notes that there is no single definitive test for evaluating model performance. All of the tests mentioned here have strengths and weaknesses. Further, even with a single performance test, it is not appropriate to assign "bright line" criteria that distinguish between adequate and inadequate model performance. In this regard, EPA recommends that a "weight of evidence" approach be used to determine whether a particular modeling application is valid for assessing the future attainment status of an area.

EPA recommends that air agencies conduct a variety of performance tests and weigh them qualitatively to assess model performance. Provided suitable databases are available, greater weight should be given to those tests which assess the model capabilities most closely related to how the model is used in the analysis (i.e. tests that provide insight into the accuracy of the model's relative response to emissions reductions). Generally, additional confidence should be attributed to model applications in which a variety of the tests described here are applied and the results indicate that the model is performing well.

From an operational standpoint, EPA recommends that air agencies compare their evaluation results against similar modeling exercises to ensure that the model performance approximates the quality of other applications. Recent literature reviews (Simon et al, 2012, Emery 2017) summarized photochemical model performance for applications published in the peer-reviewed literature between 2006 and 2012.

Because this 2011 VISTAS II modeling is using a CAMx 2011 modeling database developed by EPA, Alpine will also include by reference the air quality modeling performance evaluation as conducted by EPA (EPA, 2017b) on the national 12km domain.

Alpine will review EPA's current operational MPE for particulate matter ($PM_{2.5}$ species components, coarse PM, and total $PM_{2.5}$) and light extinction (total and species components) to compare the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. Using a combination of the Atmospheric Model Evaluation Tool (AMET) and internal scripts used by Alpine, comprehensive MPE statistics and graphics from the 2011 CAMx simulation using data from the IMPROVE network will be prepared in formats that will be accessible for stakeholder review and use. Alpine will use the current IMPROVE equation (see Section 8) inclusive of the monthly relative humidity function [f(RH)] values for both observed and modeled data to develop performance statistics at each IMPROVE monitor in the VISTAS_12 domain.

7.1.2 VISTAS II Calculated Model Evaluation Statistics

In order to estimate the ability of CAMx to replicate the 2011 base year concentrations of particulate matter, an operational model performance evaluation will be conducted. For this evaluation, mean bias and normalized mean bias, mean error and normalized mean error, and Pearson's correlation coefficient will be used and directly compared to EPA's results using these

same statistics. Mean fractional bias, mean fractional error, and root mean squared error may also be calculated but as these statistics were not calculated by EPA in its evaluation, there will be no basis for comparison for these metrics.

Mean bias (MB) is the average difference between predicted (P) and observed (O) concentrations for a given number of samples (n):

$$MB(\mu g\ m^{-3}\ or\ Mm^{-1}) = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

Mean error (ME) is the average absolute value of the difference between predicted and observed concentrations for a given number of samples:

$$ME(\mu g\ m^{-3}\ or\ Mm^{-1}) = \frac{1}{n}\sum_{i=1}^{n}|P_i - O_i|$$

Normalized mean bias (NMB) is the sum of the difference between predicted and observed values divided by the sum of the observed values:

$$NMB(\%) = \frac{\sum_1^n(P-O)}{\sum_1^n(O)} * 100$$

Normalized mean error (NME) is the sum of the absolute value of the difference between predicted and observed values divided by the sum of the observed values:

$$NME(\%) = \frac{\sum_1^n|P-O|}{\sum_1^n(O)} * 100$$

Pearson's correlation coefficient (r) is defined as:

$$r = \frac{\sum_{i=1}^n(P_i - \overline{P})(O_i - \overline{O})}{\sqrt{\sum_{i=1}^n(P_i - \overline{P})^2}\sqrt{\sum_{i=1}^n(O_i - \overline{O})^2}}$$

Mean Fractional Bias (MFB) is defined as:

$$MFB(\%) = \frac{2}{N}\sum_{1}^{N}\left(\frac{P-O}{P+O}\right) \times 100$$

Mean Fractional Error (MFE) is defined as:

$$MFE(\%) = \frac{2}{N}\sum_{1}^{N}\left(\frac{|P-O|}{P+O}\right) \times 100$$

Root Mean Squared Error (RMSE) is defined as:

$$RSME = \sqrt{\frac{\sum_1^N (P - O)^2}{N}}$$

Model predictions of PM species will be paired in space and time with observational data from the IMPROVE monitoring network. These results will be organized by IMPROVE monitor and season (winter (DJF), spring (MAM), summer (JJA), and fall (SON)).

ERG/Alpine expects the model performance of the replicated 2011 CAMx run to be slightly different from EPA published MPE metrics due to the differences in the version of CAMx being used and the modeling domain. If performance is not comparable to EPA's MPE, then data files will be reviewed to determine the cause. If the difference is not explainable by the changes in domain or model version, a call will be convened between ERG, Alpine, SESARM, and the appropriate EPA staff to identify any inconsistencies and come to consensus on appropriate corrective actions. Any of the metrics outside published proposed criteria levels will be noted as part of the uncertainty associated with the modeling.

Additional statistical analysis may also be performed, as determined necessary. All statistics will be calculated consistent with the respective pollutants NAAQS averaging time.

Tables and plots will be prepared for VISTAS and identified non-VISTAS IMPROVE monitors as directed to demonstrate light extinction model performance in a graphical manner. Scatter (with linear regression and r^2 value), bugle, and soccer plots for all light extinction and speciated components will be developed for the 20% most impaired and 20% clearest days for each IMPROVE monitor in the VISTAS_12 modeling domain.

Alpine will develop the individual day-by-day and site-by-site stacked bar plots of total b_{ext} and speciated components of b_{ext} for these most impaired and clearest days. Metrics and plots generated for the most impaired days will be consistent with the latest definition of this classification as "anthropogenically impaired" days as defined by EPA.

7.1.3 Model Performance Evaluation For Weekly Wet And Weekly Dry Deposition Species

The modeling team will also perform a MPE for weekly wet deposition and weekly dry deposition species collected in workplan Subtask 4.1. For this MPE, VISTAS CAMx deposition values will be aggregated to appropriate time periods to match the various NADP monitoring network's concentration collection times. To prevent confounding the MPE, the networks with different collection time (i.e., biweekly versus weekly) will be examined separately.

For wet deposition, NADP networks typically present measurements as concentration in mg/L, which is equivalent to g/m^3. These concentrations are then multiplied by the precipitation in meters to yield wet deposition rates in units of g/m^2. The CAMx wet deposition outputs are provided in grams per hectare (g/ha), which will be converted to grams per meter squared (g/m^2), using the conversion of 1 ha = 10,000 m^2, to have consistent units with the NADP monitoring networks. CAMx estimates of wet deposition can also be adjusted to account for the error present

in the model estimated precipitation through a ratio of the observed to estimated precipitation.[27] Dry deposition values from CASTNET can be developed from the observed concentration multiplied by a deposition velocity generated by the Multi-Layer Model (MLM)[28] for the site. The MLM generated deposition velocities are available for download with the CASTNET observations.[29]

Annual mean MPE statistics, like the statistics for the base year MPE, will be developed for the wet deposition and dry deposition species available. Analysis will also include scatter plots of NADP network observations versus CAMx predictions, and their correlation (r), both annually and by season. Statistical and scatter plots will also be examined by VISTAS states to provide more refined MPE information to facilitate further use by the states.

Additionally, annual deposition totals will be produced from the VISTAS II base year modeling and compared to the annual Total Deposition Maps developed by the NADP and EPA. These total deposition maps are produced via a hybrid approach that combines the monitored data with modeled data to produce a gridded map of total sulfate and nitrate depositions. While not entirely observed truth, these hybrid estimates could provide the ability to evaluate generally the MPE for the entire domain in areas where data availability is limited due to incomplete records from the monitoring sites.

7.2 Performance Goals and Benchmarks

Establishment of performance goals and benchmarks for regulatory modeling is a necessary but difficult activity. Here, performance goals refer to targets that Alpine believes a good performing model should achieve, whereas performance benchmarks are based on historical model performance measures for the best performing simulations. Performance goals are necessary in order to provide consistency in model applications and expectations across the region and to provide standardization in how much weight may be accorded modeling study results in the decision-making process. These performance goals should not be interpreted as a "bright line" where metrics below the value are judged as adequate and values above the line are unusable. Rather they should be interpreted as the performance for a particular metric with good performance should be more highly relied upon for decision making where a less well performing pollutant may be less relied upon.

It is a problematic activity, though, because many areas present unique challenges and no one set of performance goals is likely to fit all needs. Equally concerning is the very real danger that modeling studies will be truncated when the 'statistics look right' before full assessment of the model's reliability is made. This has the potential from breeding built-in compensating errors as modelers strive to get good statistics as opposed to searching for the explanations for poor performance and then rectifying them.

[27] Appel, K. W., et al. 2011. "A multi-resolution assessment of the Community Multiscale Air Quality (CMAQ) model v4. 7 wet deposition estimates for 2002–2006." Geoscientific Model Development 4.2 (2011): 357-371.

[28] Meyers, T. P., Finkelstein, P., Clarke, J., Ellestad, T.G., and Sims, P.F. 1998. A Multilayer Model for Inferring Dry Deposition Using Standard Meteorological Measurements. J. Geophys. Res., 103(D17): 22,645-22,661, DOI: 10.1029/98jd01564.

[29] https://java.epa.gov/castnet/clearsession.do

For this analysis, Alpine will pair model predictions in space and time with observational data from the IMPROVE, CSN, and CASTNET monitoring networks. These results will be compared by network and season (winter (Dec, Jan, Feb), spring (Mar, Apr, May), summer (Jun, Jul, Aug), and fall (Sep, Oct, Nov)).

Recommended benchmarks for photochemical model performance statistics (Boylan, 2006; Emery, 2017) will be used to assess the applicability of this modeled simulation for regulatory purposes. The goal and criteria values noted in Table 7-1 below will be used for this study.

Table 7-1. Fine Particulate Matter Performance Goals and Criteria

	NMB		NME	
Species	**Goal**	**Criteria**	**Goal**	**Criteria**
24-hr $PM_{2.5}$ and Sulfate	<± 10%	<± 30%	< 35%	< 50%
24-hr Nitrate	<± 10%	<± 65%	< 65%	< 115%
24-hr OC	<± 15%	<± 50%	< 45%	< 65%
24-hr EC	<± 20%	<± 40%	< 50%	< 75%

In addition to these goals, Alpine will compare performance evaluation metrics generated using CAMx 6.40 for each modeled species to EPA's evaluation metrics for the same simulation using CAMx 6.32. In cases where the VISTAS II performance metrics differ by more than 10% from EPA's regional haze metrics, Alpine will document the differences and provide summaries to SESARM for discussion and resolution, as necessary.

Because $PM_{2.5}$ is a mixture, current EPA PM modeling guidance (EPA, 2014e) recommends that a meaningful performance evaluation should include an assessment of how well the model is able to predict individual chemical components that constitute $PM_{2.5}$.

Consistent with EPA's performance evaluation of the regional haze 2028 analysis, in addition to total $PM_{2.5}$, components of $PM_{2.5}$ Alpine will assess:

- Sulfate ion (SO_4^{2-})
- Nitrate ion (NO_3^-)
- Ammonium ion (NH_4^+)
- Elemental Carbon (EC)
- Organic Carbon (OC) and/or Organic Carbon Mass (OCM)
- Crustal (weighted average of the most abundant trace elements in ambient air)
- Sea salt constituents (Na and Cl)

The mapping of the CAMx species into the observed species are presented in Table 7-2.

Table 7-2. Species Mapping from CAMx_6.40 into Observation Network

Network	Observed Species	CAMx Species
IMPROVE	NO_3	PNO3
	SO_4	PSO4
	NH_4	PNH4
	OM = 1.8*OC	SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA
	EC	PEC
	SOIL	FPRM+FCRS
	$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
CSN	$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
	NO_3	PNO3
	SO_4	PSO4
	NH_4	PNH4
	OM = 1.4*OC	SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA
	EC	PEC

7.2.1 Diagnostic Evaluation

If the annual CAMx model base case simulations present performance challenges, it may necessitate focused diagnostic and sensitivity testing in order for them to be resolved. If needed, it is hopeful that these diagnostic and/or sensitivity tests can be adequately carried out within the resources and schedule of this contract. If not, then it may be necessary to draw upon the Optional Task 11 resources to conduct the necessary work. Where practical, diagnostic or sensitivity analyses, if needed, could be performed on selected episodes within the annual cycle, thereby avoiding the time-consuming task of running CAMx for the full 2011 period. Upon identification of performance evaluation failure, Alpine will identify the types of diagnostic and sensitivity testing methods that might be employed in diagnosing inadequate model performance and devising appropriate methods for improving the model response. Upon discussion, negotiation, and approval with and by SESARM and EPA of evaluation procedures to conduct, Alpine will execute the tests, identify the issues, propose and resolution to the problem, and apply any changes as approved.

8.0 AREA OF INFLUENCE

Under this task, ERG will identify the 20% most impaired days for each Class I area in the VISTAS_12 modeling domain over the 2011-2016 period based on the IMPROVE monitoring website RHR summary of the 20% most-impaired visibility days.[30] Due to the presence of large SO_2 emission reductions during this six-year period, the area of influence (AoI) analysis will be set up to look at: 1) each year individually; 2) two separate periods of 2011-2013 and 2014-2016; and 3) for all years combined.

The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model[31] developed by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL) will be run for each of these days to identify areas most likely influencing visibility. The HYSPLIT runs will use the NAM-12 hybrid meteorology and trajectory will be run for starting heights of 100 meters (m), 500 m, 1,000 m, and 1,500 m. Trajectories will be run 72 hours backwards in time at each height and location. The AoI analysis will be set up to look at: 1) each starting height individually and 2) all starting heights combined.

Trajectories will be run with start times of 12AM (midnight of the start of the day), 6AM, 12PM, 6PM, and 12AM (midnight at the end of the day) local time. Trajectories will originate from each of the forty (40) IMPROVE monitors in the VISTAS_12 domain (Table 8-1 and Figure 8-1). Based on analysis from NC, ERG omitted several western states, as trajectories originating in Class I areas in those states do not pass over a SESARM state (hatched shading in Figure 8-1).

In certain instances, the trajectory origin will be the centroid of the Class I area. Class I areas without a dedicated IMPROVE monitor will have their trajectories originate from the centroid of the Class I area. Visibility data will be based on an appropriate IMPROVE monitor, as previously determined by the federal Land Managers. Another example when the monitor is remove from the Class I area. For example, the Breton Island trajectory will start from the centroid of the Class I, as the monitor has been moved further on shore in Louisiana. There are nine (9) such areas identified in the VISTAS 12km domain.

In instances where all years are not available at an IMPROVE monitoring site, the 20% most impaired days from the year years available will be analyzed. For example, Shining Rock Wilderness area does not have data for 2011, as a result the trajectories for area of influence analysis will only cover the 2012 to 2016 period.

Three VISTAS region Class I areas do not have an IMPROVE monitor: Wolf Island, Joyce Kilmer-Slickrock and Otter Creek. For these sites, trajectories will originate from the centroid of the Class I area (Figure 8-2). The 20% most impaired dates will be based off a representative IMPROVE monitor, which are listed in Table 8-2.

[30] http://vista.cira.colostate.edu/Improve/rhr-summary-data/

[31] Stein, A.F., Draxler, R.R, Rolph, G.D., Stunder, B.J.B., Cohen, M.D., and Ngan, F., (2015). NOAA's HYSPLIT atmospheric transport and dispersion modeling system, Bull. Amer. Meteor. Soc., 96, 2059-2077, http://dx.doi.org/10.1175/BAMS-D-14-00110.1

Table 8-1. IMPROVE Monitors in the VISTAS_12 Domain

IMPROVE Site	IMPROVE Site Code	State	FIPS Code	Latitude	Longitude	Start Date	End Date
Sipsey Wilderness	SIPS1	AL	01079	34.3433	-87.3388	03/04/1992	04/28/2017
Caney Creek	CACR1	AR	05113	34.4544	-94.1429	06/24/2000	04/28/2017
Upper Buffalo Wilderness	UPBU1	AR	05101	35.8258	-93.2030	12/04/1991	04/28/2017
Chassahowitzka NWR	CHAS1	FL	12017	28.7484	-82.5549	03/03/1993	04/28/2017
Everglades NP	EVER1	FL	12086	25.3910	-80.6806	09/03/1988	04/28/2017
St. Marks	SAMA1	FL	12129	30.0926	-84.1614	08/16/2000	04/28/2017
Cohutta	COHU1	GA	13213	34.7852	-84.6265	06/03/2000	04/28/2017
Okefenokee NWR	OKEF1	GA	13049	30.7405	-82.1283	09/04/1991	04/28/2017
Mammoth Cave NP	MACA1	KY	21061	37.1318	-86.1479	09/04/1991	04/28/2017
Breton Island	BRIS1	LA	22075	30.1086	-89.7617	01/16/2008	04/28/2017
Acadia NP	ACAD1	ME	23009	44.3771	-68.2610	03/02/1988	04/28/2017
Moosehorn NWR	MOOS1	ME	23029	45.1259	-67.2661	12/03/1994	04/28/2017
Isle Royale NP	ISLE1	MI	26083	47.4596	-88.1491	11/17/1999	04/28/2017
Seney	SENE1	MI	26153	46.2889	-85.9503	11/17/1999	04/28/2017
Boundary Waters Canoe Area	BOWA1	MN	27075	47.9466	-91.4955	06/01/1991	04/28/2017
Voyageurs NP #2	VOYA2	MN	27137	48.4126	-92.8286	03/02/1988	04/28/2017
Hercules-Glades	HEGL1	MO	29213	36.6138	-92.9221	03/02/2001	04/28/2017
Mingo	MING1	MO	29207	36.9717	-90.1432	06/03/2000	04/28/2017
Linville Gorge	LIGO1	NC	37011	35.9723	-81.9331	04/01/2000	04/28/2017
Shining Rock Wilderness	SHRO1	NC	37087	35.3937	-82.7744	06/01/1994	04/28/2017
Swanquarter	SWAN1	NC	37095	35.4510	-76.2075	06/10/2000	04/28/2017
Great Gulf Wilderness	GRGU1	NH	33007	44.3082	-71.2177	06/03/1995	04/28/2017
Brigantine NWR	BRIG1	NJ	34001	39.4650	-74.4492	09/04/1991	04/28/2017
Bandelier NM	BAND1	NM	35028	35.7797	-106.2664	03/02/1988	04/28/2017
Bosque del Apache	BOAP1	NM	35053	33.8695	-106.8520	04/15/2000	04/28/2017
Salt Creek	SACR1	NM	35005	33.4598	-104.4042	04/08/2000	04/28/2017
San Pedro Parks	SAPE1	NM	35039	36.0139	-106.8447	08/16/2000	04/28/2017
Wheeler Peak	WHPE1	NM	35055	36.5854	-105.4520	08/16/2000	04/28/2017
White Mountain	WHIT1	NM	35027	33.4687	-105.5349	12/03/2001	04/28/2017
Wichita Mountains	WIMO1	OK	40031	34.7323	-98.7130	03/02/2001	04/28/2017
Cape Romain NWR	ROMA1	SC	45019	32.9410	-79.6572	09/03/1994	04/28/2017
Great Smoky Mountains NP	GRSM1	TN	47009	35.6334	-83.9416	03/02/1988	04/28/2017
Big Bend NP	BIBE1	TX	48043	29.3027	-103.1780	03/02/1988	04/28/2017
Guadalupe Mountains NP	GUMO1	TX	48109	31.8330	-104.8094	03/02/1988	04/28/2017
James River Face Wilderness	JARI1	VA	51163	37.6266	-79.5125	06/03/2000	04/28/2017
Shenandoah NP	SHEN1	VA	51113	38.5229	-78.4348	03/02/1988	04/28/2017
Lye Brook Wilderness	LYBR1	VT	50003	43.1482	-73.1268	09/04/1991	09/30/2012
Lye Brook Wilderness	LYEB1	VT	50025	42.9561	-72.9098	01/01/2012	04/28/2017
Dolly Sods Wilderness	DOSO1	WV	54093	39.1053	-79.4261	09/04/1991	04/28/2017

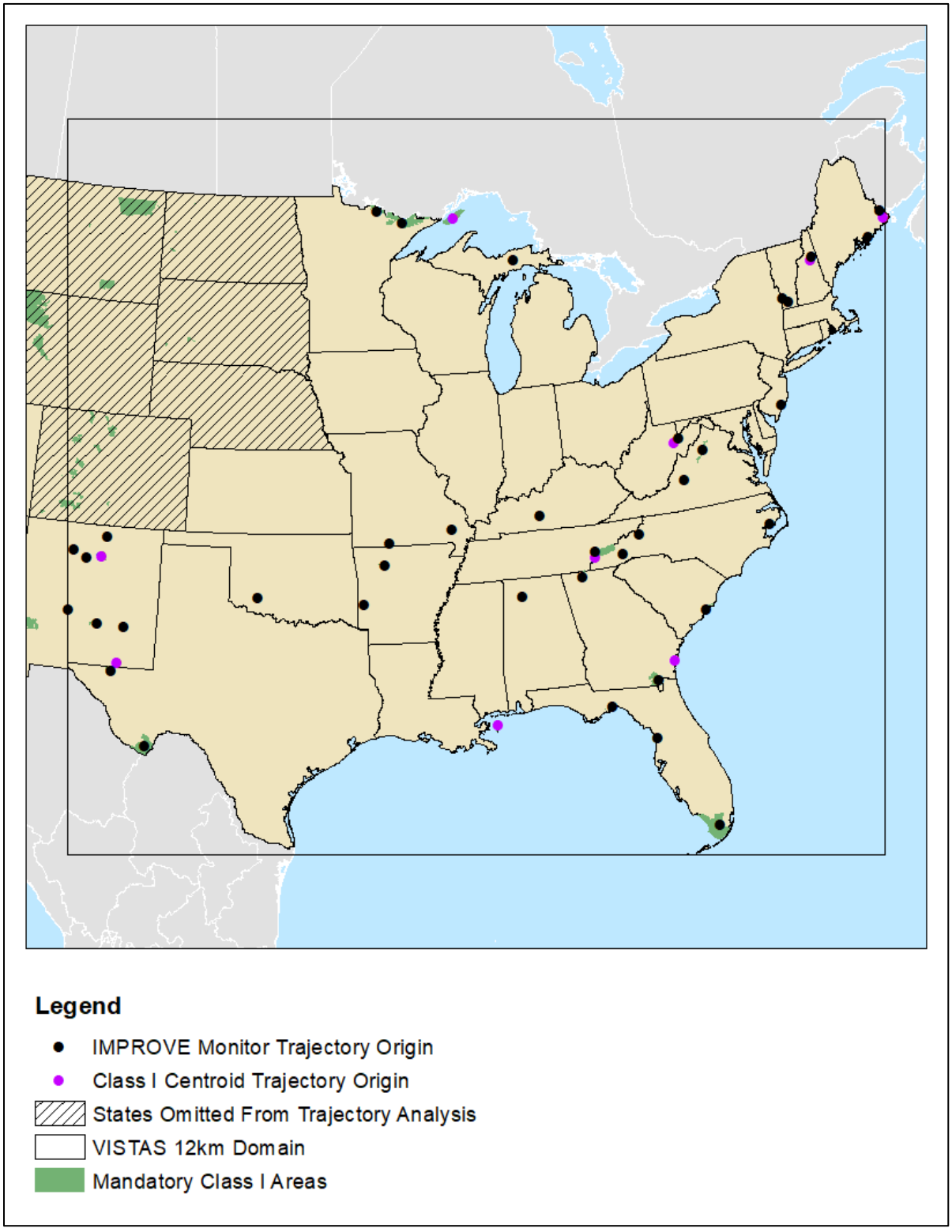


Figure 8-1. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS 12km Domain

Figure 8-2. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS States

Table 8-2. Representative IMPROVE Monitor for Each VISTAS Class I Area

Class I Area	Representative IMPROVE Site	IMPROVE Site Code	State	FIPS County Code	Latitude	Longitude
AL - Sipsey Wilderness Area	Sipsey Wilderness	SIPS1	AL	01079	34.3433	-87.3388
FL - Chassahowitzka Wilderness Area	Chassahowitzka NWR	CHAS1	FL	12017	28.7484	-82.5549
FL - Everglades National Park	Everglades NP	EVER1	FL	12086	25.391	-80.6806
FL - St. Marks Wilderness Area	St. Marks	SAMA1	FL	12129	30.0926	-84.1614
GA - Cohutta Wilderness Area	Cohutta	COHU1	GA	13213	34.7852	-84.6265
GA - Okefenokee Wilderness Area	Okefenokee NWR	OKEF1	GA	13049	30.7405	-82.1283
GA - Wolf Island Wilderness Area	Okefenokee NWR	OKEF1	GA	13049	30.7405	-82.1283
KY - Mammoth Cave National Park	Mammoth Cave NP	MACA1	KY	21061	37.1318	-86.1479
NC/TN - Great Smoky Mountains National Park	Great Smoky Mountains NP	GRSM1	TN	47009	35.6334	-83.9416
NC/TN - Joyce Kilmer-Slickrock Wilderness	Great Smoky Mountains NP	GRSM1	TN	47009	35.6334	-83.9416
NC - Linville Gorge Wilderness Area	Linville Gorge	LIGO1	NC	37011	35.9723	-81.9331
NC - Shining Rock Wilderness Area	Shining Rock Wilderness	SHRO1	NC	37087	35.3937	-82.7744
NC - Swanquarter Wilderness Area	Swanquarter	SWAN1	NC	37095	35.451	-76.2075
SC - Cape Romain Wilderness Area	Cape Romain NWR	ROMA1	SC	45019	32.941	-79.6572
VA - James River Face Wilderness Area	James River Face Wilderness	JARI1	VA	51163	37.6266	-79.5125
VA - Shenandoah National Park	Shenandoah NP	SHEN1	VA	51113	38.5229	-78.4348
WV - Dolly Sods Wilderness Area	Dolly Sods Wilderness	DOSO1	WV	54093	39.1053	-79.4261
WV - Otter Creek Wilderness Area	Dolly Sods Wilderness	DOSO1	WV	54093	39.1053	-79.4261

Trajectories will be run utilizing the SplitR package (https://github.com/rich-iannone/SplitR), which allows the control of HYSPLIT through the R statistical software. This allows for automation of the HYSPLIT runs for each location, while still generating the GIS shapefiles and separate files of the endpoint for further use in R.

The back trajectories for the 20% most impaired days will then be used to develop residency time (RT) plots via the openair[32] package for R. The RT plots define the geographic areas with the highest probability of influencing the monitor on the 20% most impaired visibility days.

The RT is calculated as the number of trajectory hours that pass through each grid cell. This can be presented as a percentage of the total number of trajectory hours. The grid used would align with the photochemical modeling 12km grid for consistency with emission analysis. For further analysis, R allows the residence time plots to be split by time increments (i.e., year, season). Images of the RT plots will be generated for QA and review purposes. Images will at least cover the VISTAS 12-km domain and include outlines of states and counties.

The trajectory data will also be weighted by ammonium sulfate and ammonium nitrate and used to produce separate sulfate and nitrate extinction weighted residency time (EWRT) plots. This allows separate analysis for sulfate and nitrate that is weighted toward the days influenced most by those constituents and not days most influenced by other constituents, like organic carbon.

In this project, the Concentration Weighted Trajectory (CWT)[33] approach will be used to develop the EWRT, substituting the extinction value for the concentration. The extinction attributable to each pollutant is paired with the trajectory for that day. R then calculates the mean weighted extinction of the pollutant species for each grid cell. The mean weighted extinction is calculated by:

$$\bar{E}_{ij} = EWRT = \frac{1}{\sum_{k=1}^{N} \tau_{ijk}} \sum_{k=1}^{N} (bext_k)\, \tau_{ijk}$$

where i and j are the indices of grid, k the index of trajectory, N the total number of trajectories used in analysis, b_{extk} is the 24-hour extinction attributed to the pollutant measured upon arrival of trajectory k, and τ_{ijk} the number of trajectory hours that pass through each grid cell (i, j) (where "i" is the row and "j" is the column).[34] The higher the value of the EWRT ($\bar{E}_{ij}$), the more likely that the air parcels passing over cell (i, j) would cause higher extinction at the receptor site for that light extinction species. Since this method uses the extinction value for weighting, trajectories passing over large sources are more discernible from those passing over moderate sources. A point filter can be used to eliminate grid cell with few trajectory hours from the

[32] Carslaw DC and Ropkins K (2012). "openair — An R package for air quality data analysis." Environmental Modelling & Software, 27–28(0), pp. 52–61. ISSN 1364-8152, doi: 10.1016/j.envsoft.2011.09.008.

[33] Hsu, Y.-K., T. M. Holsen and P. K. Hopke (2003). "Comparison of hybrid receptor models to locate PCB sources in Chicago". In: Atmospheric Environment 37.4, pp. 545–562. DOI: 10.1016/S1352-2310(02)00886-5

[34] Carslaw, D.C. (2015). The openair manual — open-source tools for analyzing air pollution data. Manual for Version 1.1-4, King's College London. http://www.openair-project.org/PDF/OpenAir_Manual.pdf

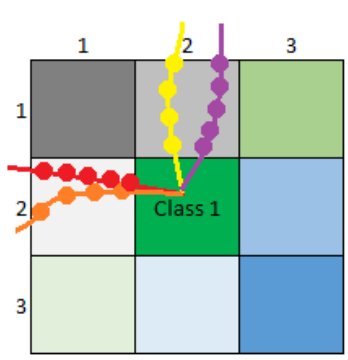
analysis. As this distinction can help refine control strategy development, using the CWT method to create the EWRT is ERG's recommendation for the analysis.

The EWRT results can be normalized by the domain total to present the results as a percentage in images. Images of the extinction weighted RT plots will be generated for QA and review purposes. Images will at least cover the VISTAS 12-km domain and include outlines of states and counties. An example calculation is provided in Figure 8-3, which has been simplified to only four trajectories. In this example, two trajectories pass through the cell (1,2). The first of these trajectories (yellow) has an extinction value ($bext_k$) of 50 Mm^{-1} associated with it. The four yellow dots in the cell denote that four hours of the back trajectory are spent in the cell. This yields "$\tau_{1,2,yellow}$" equal to 4 hours. Multiplying by the extinction ($bext_k$) for the cell yields a trajectory weight of 200 Mm^{-1}hrs. This is added to the weight of the second (purple) trajectory for a total extinction weight of 450 Mm^{-1}hrs. This is then divided by the total number of trajectory hours in the analysis (18 hours) to yield the final EWRT for the cell of 25 Mm^{-1}. The same calculation is done for cell (2,1). While the cells have the same number of trajectories and endpoints, the weight given to cell (2,1) is higher due to the higher extinctions associated with the trajectories.

The next phase of the analysis will combine the EWRT values with the distance weighted gridded emission data to determine the sources most likely contributing to the elevated extinction levels. Distances (d) for the weighting, calculated using ArcGIS, will be calculated from the location of the point source to the trajectory origin in kilometers. The weighted emission file is comprised of the EGU and non-EGU point source emissions value for each grid cell (Q, in tons per year) divided by the distance (d, in kilometres) to the trajectory origin; that is the final value is (Q/d). Each of these grid cell values is multiplied by its respective sulfate or nitrate EWRT plot values (i.e., EWRT *(Q/d)). A simplified example calculation for a single point source per cell is provided in Figure 8-4. Continuing with weights calculated in Figure 8-3, point sources in cell (1,2) emit 100 tons per year (Q=100 tpy), with the centroid 12km away from the trajectory origin. This yields a "Q/d" of 8.33 tpy/km for the source. This "Q/d" term is multiplied by the EWRT previously calculated at 25 Mm^{-1} to yield a source weighted EWRT value that indicates the potential importance of the sources in this cell to impaired visibility days in the Class I area. Alternately, the EWRT*(Q/d) can be calculated for each source in a cell and totalled for a grid cell total. Similar to the EWRT plots, these contribution plots can be normalized by the domain total to present them as a percentage in plots. Images of the results will be mapped over the VISTAS 12-km modeling domain, with state and county boundaries for review and QA purposes.

These gridded results will then be linked with the 2011 and 2028 point source inventories to calculate the emission contribution from each source. ArcGIS will be used to spatially join the gridded information with shapefiles the point source information. This will create a dataset that combines the point source metadata facility identifying information (i.e., Facility ID, Facility Name, State, County, Federal Information Processing Standard (FIPS), North American Industry Classification System (NAICS), and industry description), and the gridded information (i.e., SO_2 and NO_2 emissions, d, Q/d, EWRT, EWRT *(Q/d)). The Q/d values will be calculated by dividing facility-wide emissions (tons per year) by distance (km) to the Class I area. In the alternate strategy proposed above, this step would be completed first, then totalled for

visualization. Additional information can be added as deemed necessary in making control strategy decisions. The information from these spatial files can then be exported to separate Excel spreadsheets for each Class I area in the VISTAS_12 domain for further review by the states.



EWRT

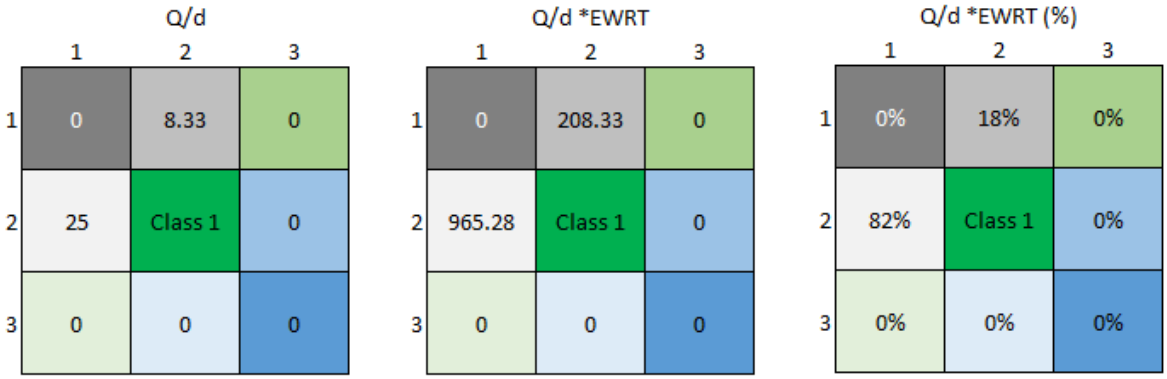
	1	2	3
1	0.00	25.00	0.00
2	38.61	Class 1	0.00
3	0.00	0.00	0.00

EWRT (%)

	1	2	3
1	0%	39%	0%
2	61%	Class 1	0%
3	0%	0%	0.00

Row (i)	Col (j)	# Trajectory hours	Trajectory (k)	Extinction ($bext_k$) [Mm^{-1}]	τ_{ijk} [hrs]	$(bext_k)\tau_{ijk}$ [Mm^{-1} hrs]	$\Sigma\tau_{ij}$ [hrs]	$\Sigma(bext_k)\tau_{ijk}$ [Mm^{-1} hrs]	EWRT [Mm^{-1}]
2	1	5	1 (Red)	75	5	375	18	695	38.61
		4	2 (Orange)	80	4	320			
1	2	4	1 (Yellow)	50	4	200	18	450	25
		5	2 (Purple)	50	5	250			

Figure 8-3. Example EWRT Calculations



Row (i)	Col (j)	ΣQ [tpy]	d [km]	Q/d [tpy km^{-1}]	Q/d*EWRT [tpy km^{-1} Mm^{-1}]	Q/d*EWRT [%]
2	1	300	12	25	965.28	82%
1	2	100	12	8.33	208.33	11%

Figure 8-4. Example (Q/d)*EWRT Calculations

Similar analysis will be conducted to rank SO_2 and NO_2 emissions contributions for onroad, nonroad, fires, and area source sectors from each county. The process will be similar to the process for point sources previously described, except calculations of RT and EWRT will be done to counties as opposed to grids. ERG will determine if the trajectories can be weighted further for the time spent in the county. The length of the trajectory within the county would be used as a proxy for time, so that trajectories that only cross a small corner of the county are not weight as much as trajectories passing through the center of the county. This will be done in GIS using the same calculation method as in *R* (i.e., CWT). The calculation of d would then be from the centroid of the county to the trajectory origin, in kilometers. Similar to point sources, the final spatial join would be to the county level EWRT and a shapefile of the source information at the county level, for each sector. All county and emissions source identifying information will be provided along with inventory emissions, distance, Q/d and Q/d^2 values, EWRT, EWRT*(Q/d), fraction and sum contributions, and any other information deemed necessary in making control strategy decisions for each source.

All images, shapefiles, and spreadsheets will be uploaded to the files sharing platform, as designed in Task 10, in separate folders for each Class I area or IMPROVE monitor in the VISTAS_12 domain. Each analysis element (e.g., RT plots, summary spreadsheets) will be contained in separate subfolders for ease of navigation. SESARM will be notified when the files are available and ready for use. A technical memorandum/interim report describing the area of influence calculations, and the results, will be prepared for SESARM and other stakeholders for use in their implementation plans.

9.0 FUTURE YEAR MODELING

This chapter discusses the future year modeling using the annual modeling databases and how these results will be used to project 2009-2013 IMPROVE visibility data to 2028 following the approach used in EPA's regional haze modeling guidance (EPA, 2014e).

9.1 Regional Haze Rule Requirements

As required by the RHR, RPGs must provide for an improvement in visibility for the 20 percent most anthropogenically impaired days relative to baseline visibility conditions and ensure no degradation in visibility for the 20 percent clearest days relative to baseline visibility conditions. The baseline for each Class I area is the average visibility (in dvs) for the years 2000 through 2004. The visibility conditions in these years are the benchmark for the "provide for an improvement" and "no degradation" requirements. In addition, states are required to determine the rate of improvement in visibility needed to reach natural conditions by 2064 for the 20 percent most anthropogenically impaired days. A line drawn between the end of the 2000-2004 baseline period and 2064 (dv/year) shows a uniform rate of progress (URP) between these two points. This "glidepath" is the amount of visibility improvement needed in each implementation period, starting from the baseline period, to stay on a linear path towards visibility improvement to natural conditions by 2064. The glidepath represents a linear or uniform rate of progress. This is a framework for consideration but there is no requirement to be on or below the glidepath.

The RHR requires states to submit an implementation plan that evaluates reasonable progress for implementation periods in approximately ten-year increments. The next regional haze SIP is due in 2021, for the implementation period which ends in 2028 (period of 2019-2028).

Therefore, modeling is being conducted to project visibility to 2028 using a 2028 emissions inventory with "on-the-books" controls. The EPA Software for Model Attainment Test-Community Edition (SMAT-CE) tool[35] will be used to calculate 2028 dv values on the 20% most impaired and 20% clearest days at each Class I Area (IMPROVE site). SMAT-CE is an EPA software tool which implements the procedures in the modeling guidance to project visibility to a future year.

9.2 Future Year to be Simulated

As discussed in Section 1, to support the preliminary 2028 regional haze modeling requested by SESARM, Alpine will conduct air quality modeling to project particulate matter concentrations at individual monitoring sites to 2028 and to estimate changes in regional haze as a result of those concentrations.

9.3 Future Year Baseline Air Quality Simulations

The 2028 future year base case CAMx simulation will be conducted, and particulate matter concentration calculations made following the procedures in Section 5 and that are consistent with EPA's latest regional haze modeling analysis (EPA, 2017b).

[35] https://www.epa.gov/scram/photochemical-modeling-tools

9.4 Calculation of 2028 Visibility

The visibility projections will follow the procedures in EPA's modeling guidance (EPA, 2014e). Based on the recommendation in the modeling guidance, the observed base period visibility data will be linked to the base modeling year. This is the 5-year ambient data base period centered about the base modeling year. In this case, for a base modeling year of 2011, the ambient IMPROVE data will be from the 2009-2013 period.

The visibility calculations will use the "revised" IMPROVE equation (Hand, 2006); (Pitchford, 2007), which has replaced the original IMPROVE equation and has been used in most regional haze SIPs over the last 10 years. The IMPROVE equation (or algorithm), which uses PM species concentrations and relative humidity data to calculate visibility impairment, or b_{ext}, in units of inverse megameters (Mm^{-1}), is presented below:

$$b_ext \approx 2.2 \times f_s(RH) \times [Small\ Sulfate] + 4.8 \times f_L(RH) \times [Large\ Sulfate] + 2.4 \times f_s(RH) \times [Small\ Nitrate] + 5.1 \times f_L(RH) \times [Large\ Nitrate] + 2.8 \times [Small\ Organic\ Mass] + 6.1 \times [Large\ Organic\ Mass] + 10 \times [Elemental\ Carbon] + 1 \times [Fine\ Soil] + 1.7 \times f_SS(RH) \times [Sea\ Salt] + 0.6 \times [Coarse\ Mass] + Rayleigh\ Scattering\ (Site\ Specific) + 0.33 \times [NO_2\ (ppb)]$$

The total sulfate, nitrate, and organic carbon compound concentrations are each split into two fractions, representing small and large size distributions of those components. Site-specific Rayleigh scattering is calculated based on the elevation and annual average temperature of each IMPROVE monitoring site.

The 2028 future year visibility on the 20% most impaired days and 20% clearest days at each Class I area will be estimated using the observed IMPROVE data (2009-2013) and the relative percent modeled change in PM species between 2011 and 2028. The process is described in the following six steps.

1. For each Class I area (IMPROVE site), estimate anthropogenic impairment[36] on each day using observed speciated $PM_{2.5}$ data plus PM_{10} data (and other information) for each of the 5 years comprising the base period (2009-2013 in this case) and rank the days on this indicator. This ranking will determine the 20 percent most anthropogenically impaired days. For each Class I area, also rank observed visibility (in dvs) on each day using observed speciated $PM_{2.5}$ data plus PM_{10} data for each of the 5 years comprising the base period. This ranking will determine the 20 percent clearest days.

2. For each of the 5 years comprising the base period, calculate the mean dvs for the 20 percent most anthropogenically impaired days and 20 percent clearest days. For each Class I area, calculate the 5 year mean dvs for most impaired and clearest days from the 5 year-specific values.

3. Use an air quality model to simulate air quality with base period (2011) emissions and future year (2028) emissions. Use the resulting information to develop site-specific relative response factors (RRFs) for each component of PM identified in the "revised"

[36] http://vista.cira.colostate.edu/Improve/rhr-summary-data/

IMPROVE equation. The RRFs are an average percent change in species concentrations based on the measured 20% most impaired and 20% clearest days from 2011 (the calendar days identified from the IMPROVE data above are matched to the same modeled days).

4. Multiply the species-specific RRFs by the measured daily species concentration data during the 2009-2013 base period (for each day in the measured 20% most impaired day set and each day in the 20% clearest day set), for each site. This results in daily future year 2028 PM species concentration data.

5. Using the results in Step 4 and the IMPROVE algorithm, calculate the future daily extinction values for the previously identified 20 percent most impaired days and 20 percent clearest days in each of the five base years.

6. Calculate daily dv values (from total daily extinction) and then compute the future year (2028) average mean dvs for the 20 percent most impaired days and 20 percent clearest days for each year. Average the five years together to get the final future mean dv values for the 20 percent most impaired days and 20 percent clearest days.

The SMAT-CE tool will be used to generate individual year and 5-year average base year and future year dv values on the 20% most impaired days and 20% clearest days. Additional SMAT output variables include the results of intermediate calculations such as species-specific extinction values (both base and future year) and species specific RRFs (on the 20% most impaired and clearest days).

Table 9-1 details the settings to be used for the SMAT runs to generate the 2028 future year dv projections:

Table 9-1. SMAT-CE Settings for 2028 Visibility Calculations

SMAT-CE Option	Setting or File Used
IMPROVE algorithm	Use new version
Grid cells at monitor or Class I area centroid?	Use grid cells at monitor
IMPROVE data file	ClassIareas_NEWIMPROVEALG_2000to2015_2017april27_IMPAIRMENT.csv
Temporal adjustment at monitor	3 x 3
Start monitor year	2009
End monitor year	2013
Base Model year	2011
Minimum years required for a valid monitor	3

In order for Alpine to conduct the source apportionment runs, the CAMx 2011 and 2028 model output will be post-processed using a “species definition file” that cross references raw CAMx output species names with PM species needed for SMAT. The results of the post-processing are 24-hour average PM species with the “combine file” output names. These are matched to the SMAT species as shown in Table 10-1.

Table 9-2. Matching of CAMx_6.40 Raw Output Species to SMAT Input Variables

SMAT Species	"Combine File" Output Name	Raw CAMx 6.40 Species
Sulfate	PM25_SO4	PSO4
Nitrate	PM25_NO3	PNO3
Ammonium[1]	PM25_NH4	PNH4
Organic Matter	PM25_OM	POA+SOA1+SOA2+SOPA+SOA3+SOA4+ SOPB
Elemental carbon	PM25_EC	PEC
Crustal	CRUSTAL	FCRS+FPRM
Coarse PM	PMC_TOT	CCRS+CPRM
PM2.5[2]	PM25_SMAT	CRUSTAL+PSO4+PNO3+PNH4+PEC+NA+PCL+ SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA

[1] Modeled ammonium concentrations are not used in the post-processing of the 2028 visibility values because the IMPROVE network does not measure ammonium and there is not an ammonium term in the IMPROVE visibility equation.

[2] Note that total $PM_{2.5}$ concentration data is needed as a SMAT input variable, but it is not used in the visibility calculations for regional haze. Visibility calculations only use the species-specific model outputs.

9.5 Comparison to Regional Haze "Glidepath"

The future year 2028 dv projections will be compared to the unadjusted visibility "glidepath" at each Class I area. The unadjusted "glidepath" represents the amount of visibility improvement needed in each implementation period, starting from the baseline 2000-2004 period, to stay on a linear path to natural visibility conditions by 2064. Visibility on the 20% most impaired days is compared to the relevant value of the glidepath, in this case for a future year of 2028. Since the glidepath is a linear path between 2004 and 2064, a glidepath value (in dvs) can be calculated for any future year, using a simple equation. The following formula will be used to calculate the 2028 glidepath value:

$$Glidepath_{2028} = Baseline\ average\ dv - (((Baseline\ average\ dv - Natural\ conditions)/60)*24)$$

Where,

Baseline average dv = average observed dv value on the 20% most impaired days for 2000-2004

Natural conditions= Natural conditions on the 20% most impaired days at the Class I area (in dv)

Once calculated, the 2028 future year projected dv values can be compared to the unadjusted glidepath for 2028 to determine if the Class I area is projected to be above, below, or on the glidepath. While the RHR requires future year projected visibility impairment be compared to the glidepath, it does not require the RPGs be on or below the glidepath. However, the rule has different requirements depending on whether the projected value (RPG) is above or below the glidepath.

10.0 PSAT SOURCE APPORTIONMENT

In order to gain a better understanding of the source contributions to modeled visibility, Alpine will use CAMx Particulate Source Apportionment Technology (PSAT) modeling. PSAT uses multiple tracer families to track the fate of both primary and secondary PM (Yarwood et al., 2004). PSAT is designed to apportion the following classes of CAMx PM species:

- Sulfate (PSO_4)
- Particulate nitrate (PNO_3)
- Ammonium (PNH_4)
- Secondary organic aerosol (SOA)
- Primary PM (PEC, POA, FCRS, FPRM, CCRS, and CPRM)
- Particulate mercury (HGP)

PSAT allows emissions to be tracked (tagged) by various combinations of sectors and geographic areas (e.g., by state or facility). For this application, 2028 emissions will be tagged ("tag") using SESARM-identified combinations of region, facilities, and/or source category. Each combination accounts for a single "tag" with SESARM planning to identify up to 250 individual tagged combinations. Each of these emissions combinations will be processed separately through SMOKE and tracked in PSAT as individual source tags. Receptors, identified as all the Class I areas in the VISTAS_12 modeling domain, will be used to analyze the results and impacts of each tagged combination.

For this application, only sulfate and nitrate will be tracked using PSAT. Tracking of other contributions may also be of use but is not requested in this analysis. In the PSAT post processing the data will be converted from the UTC based modeling data into 24-hour average grid cell local standard time using the HR2DAY[37] utility program. The HR2DAY program matches each grid cell in the model to a time zone and performs the 24-hour average on the time zone adjusted hourly data. This is the same program that EPA uses in their national modeling.

In order for Alpine to conduct the source apportionment runs, the CAMx 2011 and 2028 model output will be post-processed using a "species definition file" that cross references raw CAMx output species names with PM species needed for SMAT. The results of the post-processing are 24-hour average PM species with the "combine file" output names. These are matched to the SMAT species as shown in Table 10-1.

Table 10-1. Matching of CAMx Raw Output Species to SMAT Input Variables

SMAT Species	Raw CAMx 6.40 Species
Sulfate (SO4)	PSO4
Nitrate (NO3)	PNO3
Ammonium (NH4)[1]	PNH4
Organic Matter (OM)	POA+SOA1+SOA2 +SOA3+SOA4+SOPA+SOPB
Elemental carbon (EC)	PEC
Crustal (CRUSTAL)	FPRM+FCRS

[37] https://www.airqualitymodeling.org/index.php/CMAQv5.1_Tools_and_Utilities#HR2DAY_utility_program

Table 10-1. Matching of CAMx Raw Output Species to SMAT Input Variables

SMAT Species	Raw CAMx 6.40 Species
Coarse PM (CM)	CPRM+CCRS
PM2.5 (PM25)[2]	PSO4+PNO3+PNH4+POA+PEC+FCRS+FPRM+SOA1+SOA2+SOA3+ SOA4+SOA4+SOPA+SOPB+NA+PCL

[1] Modeled ammonium concentrations are not used in the post-processing of the 2028 visibility values because the IMPROVE network does not measure ammonium and there is not an ammonium term in the IMPROVE visibility equation.

[2] Note that total $PM_{2.5}$ concentration data is needed as a SMAT input variable, but it is not used in the visibility calculations for regional haze. Visibility calculations only use the species-specific model outputs.

10.1 Process for Creating PSAT Contributions for Class I Areas

The CAMx hourly concentration data will be post-processed to create SMAT input files. This will involve processing both the 2028 "full model" and the specific source apportionment outputs. The "full model" results are the total PM species concentrations (e.g. sulfate, nitrate) and are identical to the total species concentrations from the non-source apportionment model run for 2028 (e.g., future year base case). The source apportionment outputs contain the sulfate and/or nitrate contributions for each tagged source.

The PSAT source apportionment tracking uses slightly different variables names for the source apportionment variables. Table 10-2 below shows the SMAT species definition matching to be used for the 2028 full model and 2028 source apportionment results in the VISTAS II analysis.

Table 10-2. Matching of "Bulk Raw Species", PSAT Output Species, and SMAT Input Variables

SMAT Species	2028 Full Model Species	2028 PSAT Tag Raw Species
Sulfate	PSO4	PS4
Nitrate	PNO3	PN3
Ammonium	PNH4	PN4

This analysis will use a comparable method that was documented by EPA in the regional haze modeling for 2028. Slight differences do occur as in this study we are looking at the SMAT-CE generated visibility/extinction deltas whereas EPA's approach was designed for a different purpose than just to estimate emissions sector contributions to 2028 particulate matter concentrations and visibility. As a reminder, SESARM is only looking for individual facility or sector contributions to visibility impairment based on defined sulfate and nitrate tags and not looking to establish a full list of species-based contribution metrics.

The following approach will be used in preparing the SMAT input files, running the SMAT software, and analysing the results:

1. Regional haze SMAT will be run for the 2028 future case using "standard" 2011 and 2028 SMAT input files. In this SMAT run, the advanced option "Create forecast IMPROVE visibility file" will be invoked to create an output file with future year (2028) daily species extinction values at each IMPROVE monitor for each of the 20% best and most impaired days (based on 2011 ambient data). These are the extinction values that

are added and averaged to get the 2028 base case projected deciview values for each site. SMAT generates a new output file called "scenario_name Forecast IMPROVE Daily Data.csv" that was re-used to calculate the sector tag fractions.

2. Alpine will then create future year, tag-specific SMAT input files by subtracting the 2028 hourly tags from the hourly full model concentration files. This simple arithmetic will be implemented using standard IOAPI utility programs and generating files similar to EPA's source category-based tagged SMAT input files. Once the hourly files are created, the same processing stream as was used in Step 1 will be used create the tagged SMAT input files from the hourly model concentration files.

3. SMAT will then run again for each sector tag, using the "advanced options" accessing the "Forecast IMPROVE Daily Data" file (created as an output file from step 1 above) as the "advanced option" input file, the 2028 base case SMAT input file is used as the "Baseline file", and each 2028 sector tag SMAT input file will be used as the "Forecast file".

4. The total extinction (on the 20% most impaired days) for each tag will be calculated from the SMAT bulk output file and each of the tag output files. The visibility impacts of each tag will be computed by subtracting the SMAT output *absent* the tag (created in Step 3) from the full model SMAT output file (created in Step 1).

An example calculation for Cohutta using EPA's 2028 draft regional haze modeling SMAT input and generated output files is provided in Table 10-3 below. In this calculation, we use the 2011 base year and 2028 base case simulation compared to the 2011 base year and Sector 9 (no EGUs) simulation. Visibility (in dv) and bext are provided as examples; numbers are rounded in this example and may not sum due to rounding.

Table 10-3. Tagged Contribution Calculation Example

SMAT Calculated Value	2028 Base Case		2028 Sector 9 (Absent EGUs)		Delta (Base – Sector 9) Tag Impact	
	Best 20% Days	Most Impaired 20% Days	Best 20% Days	Most Impaired 20% Days	Best 20% Days	Most Impaired 20% Days
Visibility (dv_f)	9.11	17.69	8.07	16.07	1.04	1.62
Bext_f (Mm^{-1})	25.41	59.75	22.79	50.9	2.62	8.84

In summary, since SMAT directly provides visibility metrics for the 20% most impaired and 20% clearest days, our proposed application is to subtract the visibility results of the tagged run (deciviews absent the tag) from the 2028 base case run to determine to contribution of each tag to the total base case visibility value.

Alpine will continue to review this method with SESARM and EPA and should a change be warranted in the calculation steps, we will change the calculation to meet the needs of SESARM prior to running the contribution steps.

Finally, using data from the resulting calculations, Alpine will create the day-by-day stacked bar charts of total and speciated component b_{ext} (ammonium sulfate, ammonium nitrate, OC, EC, crustals, CM) for the 20% most impaired and 20% clearest days per site for each IMPROVE monitor in the VISTAS_12 modeling domain and as directed by SESARM will also modify the similar 2011 site-by-site charts to include 2028 modeled data.

11.0 MODELING DOCUMENTATION AND DATA ARCHIVE

EPA recommends that certain types of documentation be provided along with a photochemical modeling attainment demonstration. ERG and Alpine Geophysics are committed to supplying the material needed to ensure that the technical support for this analysis is understood by all stakeholders, EPA, and SESARM.

Alpine plans to archive all documentation and modeling input/output files generated as part of the VISTAS II modeling analysis and will provide a copy to SESARM for permanent archival, additional internal use, and public distribution. Key participants in this modeling effort will be given data access to the archived modeling information.

12.0 REFERENCES

Abt. 2014. Modeled Attainment Test Software – User's Manual. Abt Associates Inc., Bethesda, MD. April. (http://www.epa.gov/ttn/scram/guidance/guide/MATS_2-6-1_manual.pdf).

Arnold, J.R., R.L. Dennis, and G.S. Tonnesen. 2003. "Diagnostic Evaluation of Numerical Air Quality Models with Specialized Ambient Observations: Testing the Community Multiscale Air Quality Modeling System (CMAQ) at Selected SOS 95 Ground Sites", *Atmos. Environ.*, Vol. 37, pp. 1185-1198.

Arnold, J.R.; R.L. Dennis, and G.S. Tonnesen. 1998. Advanced techniques for evaluating Eulerian air quality models: background and methodology. In: Preprints of the 10th Joint Conference on the Applications of Air Pollution Meteorology with the Air & Waste Management Association, January, Phoenix, Arizona. American Meteorological Society, Boston, Massachusetts, paper no. 1.1, pp. 1-5.

Arunachalam, S. 2009. Peer Review of Source Apportionment Tools in CAMx and CMAQ. University of North Carolina Institute for the Environment, Chapel Hill, NC. August 31. (http://www.epa.gov/scram001/reports/SourceApportionmentPeerReview.pdf).

Boylan, J. W. 2004. "Calculating Statistics: Concentration Related Performance Goals", paper presented at the EPA PM Model Performance Workshop, Chapel Hill, NC. 11 February.

Boylan, J.W., and A.G. Russell. 2006. PM and light extinction model performance metrics, goals, and criteria for three dimensional air quality models. Atmos. Environ. 40:4946–59. doi:10.1016/j.atmosenv.2005.09.087.

Byun, D.W., and J.K.S. Ching. 1999. "Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System", EPA/600/R-99/030.

Coats, C.J. 1995. Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System, MCNC Environmental Programs, Research Triangle Park, NC.

Colella, P., and P.R. Woodward. 1984. The Piecewise Parabolic Method (PPM) for Gasdynamical Simulations. *J. Comp. Phys.*, **54**, 174201.

Emery, C.A., E. Tai, E., R. E. Morris, G. Yarwood. 2009a. Reducing Vertical Transport Over Complex Terrain in CMAQ and CAMx; AWMA Guideline on Air Quality Models Conference, Raleigh, NC, October 26-30, 2009.

Emery, C.A., E. Tai, R.E. Morris, G. Yarwood. 2009b. Reducing Vertical Transport Over Complex Terrain in Photochemical Grid Models; 8th Annual CMAS Conference, Chapel Hill, NC, October 19-21, 2009.

Emery, C.A., E. Tai, G. Yarwood and R. Morris. 2011. Investigation into approaches to reduce excessive vertical transport over complex terrain in a regional photochemical grid model. *Atmos. Env.*, Vol. 45, Issue 39, December 2011, pp. 7341-7351. (http://www.sciencedirect.com/science/article/pii/S1352231011007965).

Emery, C.A., Z. Liu, A. Russell, M. Odman, G. Yarwood and N. Kumar. 2017. Recommendations on statistics and benchmarks to assess photochemical model performance, Journal of the Air & Waste Management Association, 67:5, 582-598, DOI: 10.1080/10962247.2016.1265027

EPA. 2001. "Guidance Demonstrating Attainment Air Quality Goals for $PM_{2.5}$ and Regional Haze". Draft Final (17 February 2005), U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C.

EPA. 2003a. A Conceptual Model to Adjust Fugitive Dust Emissions to Account for Near Source Particle Removal in Grid Model Applications, prepared by Tom Pace, U.S. EPA, August. http://www.epa.gov/ttn/chief/emch/invent/statusfugdustemissions_082203.pdf.

EPA. 2005a. Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hr Ozone NAAQS -- Final. U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C. October.

EPA. 2005b. "Regional Haze Regulations and Guidelines for Best Available Technology (BART) Determinations". Fed. Reg./Vol. 70, No. 128/Wed. July, Rules and Regulations, pp. 39104-39172. 40 CFR Part 51, FRL-7925-9, RIN AJ31.

EPA. 2007. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-454/B-07-002. April. (http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf).

EPA. 2014a. Motor Vehicle Emissions Simulator (MOVES) – User Guide for MOVES2014. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-055). July. (http://www.epa.gov/oms/models/moves/documents/420b14055.pdf).

EPA. 2014b. Motor Vehicle Emissions Simulator (MOVES) –MOVES2014 User Interface Manual. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-067). July. (http://www.epa.gov/oms/models/moves/documents/420b14057.pdf).

EPA. 2014c. Motor Vehicle Emissions Simulator (MOVES) –MOVES2014 Software Design Reference Manual. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-058). December. (http://www.epa.gov/oms/models/moves/documents/420b14056.pdf).

EPA. 2014d. Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation, U.S. Environmental Protection Agency. November 2014.

EPA. 2014e. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze, U.S. Environmental Protection Agency. December 2014.

EPA. 2015. Air Quality Modeling Technical Support Document for the 2008 Ozone NAAQS Transport Assessment. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. January. (http://www.epa.gov/airtransport/O3TransportAQModelingTSD.pdf).

EPA. 2016a. Technical Support Document (TSD) Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform. U.S. Environmental Protection Agency. August 2016.

EPA. 2016b. Air Quality Modeling Technical Support Document for the 2015 Ozone NAAQS Preliminary Interstate Transport Assessment. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. December 2016.

EPA. 2017a. Use of Photochemical Grid Models for Single-Source Ozone and secondary PM2.5 impacts for Permit Program Related Assessments and for NAAQS Attainment Demonstrations for Ozone, $PM_{2.5}$ and Regional Haze. Memorandum from Tyler Fox, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. August 2017. https://www3.epa.gov/ttn/scram/guidance/clarification/20170804-Photochemical_Grid_Model_Clarification_Memo.pdf

EPA. 2017b. Documentation for the EPA's Preliminary 2028 Regional Haze Modeling. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October.

Gery, M. W., G.Z. Whitten, J.P. Killus, and M.C. Dodge. 1989. A photochemical mechanism for urban and regional-scale computer modeling. *J. Geophys. Res.* 94, 12925-12956.

Gilliam, R. 2010. Evaluation of Multi-Annual CONUS 12 km WRF Simulations. U.S. Environmental Protection Agency, NREL, Atmospheric Modeling and Analysis Division. (http://epa.gov/scram001/adhoc/gilliam2010.pdf).

Gilliam, R.C. and J.E. Pleim, 2010. Performance Assessment of New Land Surface and Planetary Boundary Layer Physics in the WRF-ARW. J. Appl. Meteor. Climatol., 49, 760–774.

Hand, J. L., and W. C. Malm (2006), Review of the IMPROVE equation for estimating ambient light extinction coefficients, CIRA Report, ISSN: 0737-5352-71, Colo. State Univ., Fort Collins. http://vista.cira.colostate.edu/improve/Publications/GrayLit/016_IMPROVEeqReview/IMPROVEeqReview.htm

Henderson, B.H., F. Akhtar, H.O.T. Pye, S.L. Napelenok, W.T. Hutzell, 2014. A Database and Tool for Boundary Conditions for Regional Air Quality Modeling: Description and Evaluations, Geoscientific Model Development, 7, 339-360.

Hong, S-Y, Y. Noh, and J. Dudhia, 2006. A New Vertical Diffusion Package with an Explicit Treatment of Entrainment Processes. Mon. Wea. Rev., 134, 2318–2341.

Houyoux, M.R., Vukovich, J.M., Coats, C.J., Wheeler, N.J.M., Kasibhatla, P.S.,2000. Emissions Inventory Development and Processing for the Seasonal Model for Regional Air Quality. (SMRAQ) project, Journal of Geophysical Research – Atmospheres, 105(D7), 9079-9090.

Iacono, M.J., J.S. Delamere, E.J. Mlawer, M.W. Shephard, S.A Clough, and W.D. Collins, 2008. Radiative Forcing by Long-Lived Greenhouse Gases: Calculations with the AER Radiative Transfer Models, J. Geophys. Res., 113, D13103.

Kain, J.S., 2004. The Kain-Fritsch Convective Parameterization: An Update, J. Appl. Meteor.,43, 170-181.

Ma, L-M. and Tan Z-M, 2009. Improving the Behavior of Cumulus Parameterization for Tropical Cyclone Prediction: Convective Trigger, Atmospheric Research, 92, 190-211.

ME DEP, 2018. Tracking Visibility Progress, 2004-2016, (1st RH SIP Metrics). Maine Department of Environmental Protection for the Mid-Atlantic/Northeast Visibility Union. February.

Michalakes, J., J. Dudhia, D. Gill, J. Klemp and W. Skamarock. 1998. Design of a Next-Generation Regional Weather Research and Forecast Model. Mesoscale and Microscale Meteorological Division, National Center for Atmospheric Research, Boulder, CO. (http://www.mcs.anl.gov/~michalak/ecmwf98/final.html).

Michalakes, J., S. Chen, J. Dudhia, L. Hart, J. Klemp, J. Middlecoff and W. Skamarock. 2001. Development of a Next-Generation Regional Weather Research and Forecast Model. Developments in Teracomputing: Proceedings of the 9th ECMWF Workshop on the Use of High Performance Computing in Meteorology. Eds. Walter Zwieflhofer and Norbet Kreitz. World Scientific, Singapore. Pp. 269-276. (http://www.mmm.ucar.edu/mm5/mpp/ecmwf01.htm).

Michalakes, J., J. Dudhia, D. Gill, T. Henderson, J. Klemp, W. Skamarock and W. Wang. 2004. The Weather Research and Forecast Model: Software Architecture and Performance. Proceedings of the 11th ECMWF Workshop on the Use of High Performance Computing in Meteorology. October 25-29, 2005, Reading UK. Ed. George Mozdzynski. (http://wrf-model.org/wrfadmin/docs/ecmwf_2004.pdf).

Morrison, H.J., A. Curry, and V.I. Khvorostyanov, 2005. A New Double-Moment Microphysics Parameterization for Application in Cloud and Climate Models. Part I: Description, J. Atmos. Sci., 62, 1665–1677.

Morrison, H. and A. Gettelman, 2008. A New Two-Moment Bulk Stratiform Cloud Microphysics Scheme in the Community Atmosphere Model, Version 3 (CAM3). Part I: Description and Numerical Tests, J. Climate, 21, 3642-3659.

Pleim, J.E. and A. Xiu, 2003. Development of a Land-Surface Model. Part II: Data Assimilation, J. Appl. Meteor., 42, 1811–1822

Pleim, J.E., 2007a. A Combined Local and Nonlocal Closure Model for the Atmospheric Boundary Layer. Part I: Model Description and Testing, J. Appl. Meteor. Climatol., 46, 1383-1395.

Pleim, J.E., 2007b. A Combined Local and Nonlocal Closure Model for the Atmospheric Boundary Layer. Part II: Application and Evaluation in a Mesoscale Meteorological Model, J. Appl. Meteor. Climatol., 46, 1396–1409.

Ramboll Environ, 2014. wrfcamx Version 4.3 Release Notes. December 17, 2014.www.camx.com. Ramboll Environ International Corporation, Novato, CA.

Ramboll Environ, 2016. User's Guide Comprehensive Air Quality Model with Extensions Version 6.40, www.camx.com. Ramboll Environ International Corporation, Novato, CA.

Simon, H., K. Baker and S. Phillips. 2012. Compilations and Interpretation of Photochemical Model Performance Statistics Published between 2006 and 2012. *Atmos. Env.* 61 (2012) 124-139. December. (http://www.sciencedirect.com/science/article/pii/S135223101200684X).

Skamarock, W. C. 2004. Evaluating Mesoscale NWP Models Using Kinetic Energy Spectra. *Mon. Wea. Rev.*, Volume 132, pp. 3019-3032. December. (http://www.mmm.ucar.edu/individual/skamarock/spectra_mwr_2004.pdf).

Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, W. Wang and J. G. Powers. 2005. A Description of the Advanced Research WRF Version 2. National Center for Atmospheric Research (NCAR), Boulder, CO. June. (http://www.mmm.ucar.edu/wrf/users/docs/arw_v2.pdf)

Skamarock, W. C. 2006. Positive-Definite and Monotonic Limiters for Unrestricted-Time-Step Transport Schemes. *Mon. Wea. Rev.*, Volume 134, pp. 2241-2242. June. (http://www.mmm.ucar.edu/individual/skamarock/advect3d_mwr.pdf).

Stammer, D., F.J. Wentz, and C.L. Gentemann, 2003. Validation of Microwave Sea Surface Temperature Measurements for Climate Purposes, J. of Climate, 16(1), 73-87.

Sullivan D.C., Raffuse S.M., Pryden D.A., Craig K.J., Reid S.B., Wheeler N.J.M., Chinkin L.R., Larkin N.K., Solomon R., and Strand T. (2008) Development and applications of systems for modeling emissions and smoke from fires: the BlueSky smoke modeling framework and SMARTFIRE: 17th International Emissions Inventory Conference, Portland, OR, June 2-5. Available at: http://www.epa.gov/ttn/chief/conferences.html.

UNC. 2008. Atmospheric Model Evaluation Tool (AMET) User's Guide. Institute for the Environment, University of North Carolina at Chapel Hill. May 30. (https://www.cmascenter.org/amet/documentation/1.1/AMET_Users_Guide_V1.1.pdf).

UNC and ENVIRON, 2014a. Three-State Air Quality Modeling Study (3SAQS) – Draft Modeling Protocol 2011 Emissions & Air Quality Modeling. University of North Carolina at Chapel Hill and ENVIRON International Corporation, Novato, CA. July. (http://vibe.cira.colostate.edu/wiki/Attachments/Modeling/3SAQS_2011_Modeling_Protocol_Finalv2.pdf).

UNC. 2015. SMOKE v3.6.5 User's Manual. University of North Carolina at Chapel Hill, Institute for the Environment. (https://www.cmascenter.org/smoke/documentation/3.6.5/html/).

UNC and ENVIRON, 2015a. Three-State Air Quality Modeling Study (3SAQS) – Weather Research Forecast 2011 Meteorological Model Application/Evaluation. University of North Carolina at Chapel Hill and ENVIRON International Corporation, Novato, CA. March 5. (http://vibe.cira.colostate.edu/wiki/Attachments/Modeling/3SAQS_2011_WRF_MPE_v05Mar2015.pdf).

Wesely, M.L. 1989. Parameterization of Surface Resistances to Gaseous Dry Deposition in Regional-Scale Numerical Models. *Atmos. Environ.*, 23, 1293-1304.

Xiu, A. and J.E. Pleim. 2000. Development of a land surface model. Part I: application in a mesoscale meteorology model. *J. App. Met.*, 40, pp. 192-209.

Yantosca, B. 2004. GEOS-CHEMv7-01-02 User's Guide, Atmospheric Chemistry Modeling Group, Harvard University, Cambridge, MA.

Yarwood, G., R.E. Morris, G.M. Wilson. 2004. Particulate Matter Source Apportionment Technology (PSAT) in the CAMx Photochemical Grid Model. Proceedings of the 27th NATO/ CCMS International Technical Meeting on Air Pollution Modeling and Application. Springer Verlag (Available from http://camx.com/publ/pdfs/yarwood_itm_paper.pdf).

Yarwood, G., J. Jung, G. Z. Whitten, G. Heo, J. Mellberg and M. Estes. 2010. Updates to the Carbon Bond Mechanism for Version 6 (CB6). 2010 CMAS Conference, Chapel Hill, NC. October. (http://www.cmascenter.org/conference/2010/abstracts/emery_updates_carbon_2010.pdf)

Zhang, L., S. Gong, J. Padro, L. Barrie. 2001. A size-segregated particle dry deposition scheme for an atmospheric aerosol module. *Atmos. Environ.*, **35**, 549-560.

Zhang, L., J. R. Brook, and R. Vet. 2003. A revised parameterization for gaseous dry deposition in air-quality models. *Atmos. Chem. Phys*., **3**, 2067–2082.

Appendix E-2a

Regional Haze Modeling for Southwestern VISTAS II Regional Haze Analysis Project 2011el and 2028el CAMx Benchmarking Report

Benchmark Runs #1 and #2

August 17, 2020

This page intentionally left blank.

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project
2011el and 2028el CAMx Benchmarking Report

Task 6 Benchmark Report #1
Covering Benchmark Runs #1 and #2

Prepared for:
Southeastern States Air Resource Managers, Inc.
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final - August 17, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 EPA 2011 AND 2028 BASE CASE CONFIRMATION 1
2.0 DIFFERENCES BETWEEN EPA AND VISTAS SIMULATIONS.....2
3.0 CONFIRMATION METHODOLOGY.....3
4.0 CAMX 6.32 2011EL COMPARISON 4
4.1 Ozone 4
4.2 $PM_{2.5}$ 27
4.3 Sulfate 50
4.4 Nitrate 73
4.5 Organic Carbon (OC).....96
5.0 CAMX 6.32 2028EL COMPARISON 119
5.1 Ozone 119
5.2 $PM_{2.5}$ 142
5.3 Sulfate 165
5.4 Nitrate 188
5.5 Organic Carbon (OC).....211
6.0 CONCLUSION.....234

TABLES

Table 4-1. Comparison of 2011el CAMx 6.32 Simulation Ozone Concentrations (ppb) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 5

Table 4-2. Comparison of 2011el CAMx 6.32 Simulation $PM_{2.5}$ Concentrations ($\mu g/m^3$) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 28

Table 4-3. Comparison of 2011el CAMx 6.32 Simulation Sulfate Concentrations ($\mu g/m^3$) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 51

Table 4-4. Comparison of 2011el CAMx 6.32 Simulation Nitrate Concentrations ($\mu g/m^3$) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 74

Table 4-5. Comparison of 2011el CAMx 6.32 Simulation Organic Carbon Concentrations ($\mu g/m^3$) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 97

Table 5-1. Comparison of 2028el CAMx 6.32 Simulation Ozone Concentrations (ppb) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 120

Table 5-2. Comparison of 2028el CAMx 6.32 Simulation $PM_{2.5}$ Concentrations ($\mu g/m^3$) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 143

Table 5-3. Comparison of 2028el CAMx 6.32 Simulation Sulfate Concentrations ($\mu g/m^3$) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 166

Table 5-4. Comparison of 2028el CAMx 6.32 Simulation Nitrate Concentrations ($\mu g/m^3$) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 189

Table 5-5. Comparison of 2028el CAMx 6.32 Simulation Organic Carbon Concentrations ($\mu g/m^3$) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown. 212

FIGURES

Figure 4-1: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference) 6

Figure 4-2: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference)....7

Figure 4-3: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference)....8

Figure 4-4: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference)....9

Figure 4-5: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference)....10

Figure 4-6: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference) 11

Figure 4-7: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference)....12

Figure 4-8: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference)....13

Figure 4-9: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference) 14

Figure 4-10: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference) 15

Figure 4-11: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference)....16

Figure 4-12: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference) 17

Figure 4-13: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference) 18

Figure 4-14: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference) 19

Figure 4-15: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference) 20

Figure 4-16: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference) 21

Figure 4-17: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference) 22

Figure 4-18: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference) 23

Figure 4-19: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference) 24

Figure 4-20: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference) 25

Figure 4-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine). 26

Figure 4-22: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference) 29

Figure 4-23: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference) 30

Figure 4-24: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference) 31

Figure 4-25: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference) 32

Figure 4-26: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference) 33

Figure 4-27: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference) 34

Figure 4-28: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference) 35

Figure 4-29: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference) 36

Figure 4-30: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference) 37

Figure 4-31: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference) 38

Figure 4-32: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference) 39

Figure 4-33: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference) 40

Figure 4-34: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference) 41

Figure 4-35: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference) 42

Figure 4-36: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference) 43

Figure 4-37: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference) 44

Figure 4-38: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference) 45

Figure 4-39: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference) 46

Figure 4-40: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference) 47

Figure 4-41: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference) 48

Figure 4-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine) 49

Figure 4-43: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference) 52

Figure 4-44: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference) 53

Figure 4-45: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference) 54

Figure 4-46: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference) 55

Figure 4-47: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference) 56

Figure 4-48: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference) 57

Figure 4-49: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference) 58

Figure 4-50: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference) 59

Figure 4-51: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference) 60

Figure 4-52: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference) 61

Figure 4-53: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference) 62

Figure 4-54: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference) 63

Figure 4-55: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference) 64

Figure 4-56: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference) 65

Figure 4-57: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference) 66

Figure 4-58: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference) 67

Figure 4-59: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference) 68

Figure 4-60: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference) 69

Figure 4-61: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference) 70

Figure 4-62: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference) 71

Figure 4-63: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine) 72

Figure 4-64: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference) 75

Figure 4-65: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference) 76

Figure 4-66: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference) 77

Figure 4-67: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference) 78

Figure 4-68: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference) 79

Figure 4-69: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference) 80

Figure 4-70: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference) 81

Figure 4-71: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference) 82

Figure 4-72: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference) 83

Figure 4-73: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference) 84

Figure 4-74: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference)....85

Figure 4-75: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference) 86

Figure 4-76: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference)....87

Figure 4-77: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference) 88

Figure 4-78: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference) 89

Figure 4-79: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference) 90

Figure 4-80: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference) 91

Figure 4-81: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference) 92

Figure 4-82: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference)....93

Figure 4-83: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference) 94

Figure 4-84: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine)....95

Figure 4-85: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference) 98

Figure 4-86: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference)....99

Figure 4-87: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference) 100

Figure 4-88: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference)....101

Figure 4-89: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference)....102

Figure 4-90: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference)....103

Figure 4-91: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference) 104

Figure 4-92: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference).....105

Figure 4-93: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference) 106

Figure 4-94: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference) 107

Figure 4-95: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference).....108

Figure 4-96: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference) 109

Figure 4-97: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference).....110

Figure 4-98: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference) 111

Figure 4-99: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference) 112

Figure 4-100: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference) 113

Figure 4-101: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference).....114

Figure 4-102: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference) 115

Figure 4-103: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference).....116

Figure 4-104: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference) 117

Figure 4-105: Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine).....118

Figure 5-1: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference) 121

Figure 5-2: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference).....122

Figure 5-3: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference).....123

Figure 5-4: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference) 124

Figure 5-4: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference) 125

Figure 5-6: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference) 126

Figure 5-7: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference) 127

Figure 5-8: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference) 128

Figure 5-9: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference) 129

Figure 5-10: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference) 130

Figure 5-11: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference) 131

Figure 5-12: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference) 132

Figure 5-13: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference) 133

Figure 5-14: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference) 134

Figure 5-15: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference) 135

Figure 5-16: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference) 136

Figure 5-17: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference) 137

Figure 5-18: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference) 138

Figure 5-19: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference) 139

Figure 5-20: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference) 140

Figure 5-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine). 141

Figure 5-22: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference) 144
Figure 5-23: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference)....145
Figure 5-24: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference)....146
Figure 5-25: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference)....147
Figure 5-26: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Positive Difference)....148
Figure 5-27: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference)....149
Figure 5-28: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference)....150
Figure 5-29: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference)....151
Figure 5-30: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference) 152
Figure 5-31: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference) 153
Figure 5-32: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference)....154
Figure 5-33: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference) 155
Figure 5-34: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference) 156
Figure 5-35: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference) 157
Figure 5-36: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference) 158
Figure 5-37: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference) 159
Figure 5-38: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference) 160
Figure 5-39: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference) 161
Figure 5-40: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference)....162

Figure 5-41: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference).....163

Figure 5-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine).....164

Figure 5-43: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference) 167

Figure 5-44: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference).....168

Figure 5-45: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference).....169

Figure 5-46: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference).....170

Figure 5-47: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Positive Difference).....171

Figure 5-48: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference) 172

Figure 5-49: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference).....173

Figure 5-50: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference).....174

Figure 5-51: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference) 175

Figure 5-52: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference) 176

Figure 5-53: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference).....177

Figure 5-54: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference) 178

Figure 5-55: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference) 179

Figure 5-56: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference) 180

Figure 5-57: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference) 181

Figure 5-58: Comparison of Sulfate Concentrations ($\mu g/m^3$) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference) 182

Figure 5-59: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference) 183

Figure 5-60: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference) 184

Figure 5-61: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference) 185

Figure 5-62: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference) 186

Figure 5-63: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine) 187

Figure 5-64: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference) 190

Figure 5-65: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference) 191

Figure 5-66: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference) 192

Figure 5-67: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference) 193

Figure 5-68: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Positive Difference) 194

Figure 5-69: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference) 195

Figure 5-70: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference) 196

Figure 5-71: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference) 197

Figure 5-72: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference) 198

Figure 5-73: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference) 199

Figure 5-74: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference) 200

Figure 5-75: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference) 201

Figure 5-76: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference) 202

Figure 5-77: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference) 203

Figure 5-78: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference) 204

Figure 5-79: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference) 205

Figure 5-80: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference) 206

Figure 5-81: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference) 207

Figure 5-82: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference).....208

Figure 5-83: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference) 209

Figure 5-84: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine).....210

Figure 5-85: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference) 213

Figure 5-86: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference).....214

Figure 5-87: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference) 215

Figure 5-88: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference).....216

Figure 5-89: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Positive Difference).....217

Figure 5-90: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference).....218

Figure 5-91: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference) 219

Figure 5-92: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference).....220

Figure 5-93: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference) 221

Figure 5-94: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference) 222

Figure 5-95: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference).....223

Figure 5-96: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference).....224

Figure 5-97: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference).....225

Figure 5-98: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference).....226

Figure 5-99: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference).....227

Figure 5-100: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference).....228

Figure 5-101: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference).....229

Figure 5-102: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference).....230

Figure 5-103: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference).....231

Figure 5-104: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference).....232

Figure 5-105: Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine).....233

1.0 EPA 2011 AND 2028 BASE CASE CONFIRMATION

Alpine has executed two confirmation runs, one for the 2011el base year and one for the 2028el base case, to confirm the contract team's ability to replicate EPA's results and to ensure that the EPA data, models, and scripts operated in a consistent manner as EPA's procedure.

The data for this analysis are paired in space and time, meaning that each plot represents a comparison of the two simulations at the same monitor on the same day. Although there is some variability between the two runs, the runs are not expected to be exactly the same due to numerical differences that arises from the different computing architectures used for the U.S. EPA and Alpine simulations. The numerics in photochemical grid models are very complex and it is typical to get slightly different model concentrations based on the version of the computer and compilers. When comparing simulations, it is critical to isolate the changes in concentrations to the changes in the model inputs, and not on the computing details (i.e., compiler version, computer architecture, parallelization options). This is especially problematic when looking at particulate matter, since the particulate treatments have multiple pathways, and small concentration differences can lead to different pathways through the code and different concentrations.

Sources of the difference can come from the options used in CAMx compilation, the version of the compiler, the compiler vendor, and how the model calculation is split onto different processors (parallelization).

2.0 DIFFERENCES BETWEEN EPA AND VISTAS SIMULATIONS

EPA ran the 2011v6.3el platform on EPA's supercomputer with the model configured to use four (4) processor nodes with 16 processors per node. The use of multiple processor nodes with multiple processors per node is efficient on the EPA supercomputer due to the low latency interconnect between the nodes. On more typical computer clusters with the nodes interconnected with Ethernet, like the Alpine cluster and most likely the State and stakeholder clusters, the latency between nodes is sufficiently high that it is inefficient to spread processing between nodes. Our experience with the EPA platform has shown that on an Ethernet connected cluster with 12 Intel XEON processors per node and hyperthreading enabled it is most efficient to use a single node configured with 10 Message Passing Interface (MPI) instances, each with two OpenMP threads.

EPA used the Intel FORTRAN compiler. Alpine, and the CAMx developers, use the Portland Group (PGI) FORTRAN compiler. The PGI compiler has been the standard compiler for CAMx applications for many years and it's anticipated this compiler will be more widely used by the States and stakeholders. The version of CAMx 6.32 EPA distributed with the 2011el platform will be recompiled on the Alpine computer system and used for the confirmation.

EPA ran the model in two time segments. The first segment, typically used only for PM applications, runs from December 22, 2010 through April 30, 2011. The second segment runs from April 21, 2011 through December 31, 2011. The VISTAS confirmation run used the same two segments. December 22-31, 2010 and the April portion of the second segment are spin-ups and are not analyzed due to overlap with the first segment.

3.0 CONFIRMATION METHODOLOGY

The comparison of simulations on the Alpine computer cluster and the EPA computer are based on hourly differences in ozone, particulate matter less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$), organic carbon (OC), Particulate Nitrate, and Particulate Sulfate. The metrics for comparison are the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$\left(C_{vistas} - C_{epa}\right)$$

(Equation 2) $$\frac{\left(C_{vistas} - C_{epa}\right)}{\left(C_{epa}\right)}$$

where: C_{epa} is the concentration at each grid cell hour for the EPA simulation and

C_{vistas} is the concentration at each grid cell hour for the simulation on the Alpine computers.

The results are presented for the hours with the largest difference between the EPA and VISTAS simulations. A table presents the hours with the top 10 positive and negative absolute differences. Spatial maps are presented for the hours with the top 10 highest positive and negative differences. To provide context for the differences, the concentration maps are also presented for each of the hours of high difference. On each spatial plot the maximum positive and negative values, along with the grid cell in which these occur, are presented at the top of the graphic. The coordinates refer to the row and columns of the cell referenced to the cell coordinates on the bottom (column) and left (row) of the graphic.

Hourly animations have also been prepared and are available on the VISTAS II project ftp site. Where appropriate, this report also reports and interprets on the animations.

4.0 CAMX 6.32 2011EL COMPARISON

This section presents comparisons of the 2011el simulations using CAMx 6.32 performed on the Alpine and EPA computer systems.

4.1 Ozone

Ozone results for the top 10 positive and negative hours are presented in tabular format in Table 4-1. The maximum positive difference is 3.13 ppb falling to 2.01 ppb for the 10th high. The maximum negative difference is -2.65 ppb falling to -1.79 for the 10th high. The highest differences are occurring on relatively low ozone hours with concentrations ranging from 30 ppb to 51 ppb for the EPA simulation. The maximum positive and negative percent differences are both 7.4%.

The top ten positive impact hours are presented in Figures 4-1 through 4-10 and the top ten negative impact hours are presented in Figures 4-11 through 4-20. The locations of the impacts are very localized and have seemingly no spatial pattern. On the hours with the maximum impacts the overwhelming number of grid cells have impacts less than 0.01 ppb.

Scatterplots of the daily average ozone concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-21. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a near perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0001 ppb and an R2 of 1.0000.

Examination of the animations show that the differences appear suddenly over very limited areas, then the areas of difference disperse and travel downwind and become less than the 0.01 ppb plotting threshold typically within six (6) hours of forming.

Table 4-1. Comparison of 2011el CAMx 6.32 Simulation Ozone Concentrations (ppb) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (ppb)	Percent Difference	Column	Row
Maximum Positive									
2011	7	14	22	45.15	42.02	3.13	7.4%	292	77
2011	8	18	23	53.60	50.83	2.77	5.5%	286	152
2011	8	19	0	45.25	42.64	2.61	6.1%	286	152
2011	7	6	23	48.49	45.90	2.59	5.6%	197	156
2011	8	30	14	32.28	29.96	2.33	7.8%	110	217
2011	8	7	16	37.14	34.94	2.20	6.3%	257	103
2011	8	27	12	34.34	32.22	2.13	6.6%	295	143
2011	8	23	22	44.30	42.22	2.08	4.9%	323	47
2011	8	8	23	39.44	37.43	2.01	5.4%	217	184
2011	7	7	0	43.63	41.62	2.01	4.8%	197	156
Maximum Negative									
2011	8	16	0	33.32	35.96	-2.65	-7.4%	251	134
2011	7	15	21	48.71	51.16	-2.44	-4.8%	224	159
2011	8	15	23	36.83	39.27	-2.44	-6.2%	251	134
2011	6	18	22	33.70	36.07	-2.37	-6.6%	196	187
2011	6	26	22	34.14	36.40	-2.26	-6.2%	206	183
2011	7	7	16	39.38	41.34	-1.97	-4.8%	216	180
2011	8	11	18	35.28	37.21	-1.92	-5.2%	332	28
2011	3	30	10	42.23	44.13	-1.90	-4.3%	117	19
2011	7	16	19	48.28	50.08	-1.80	-3.6%	196	189
2011	6	18	23	32.77	34.57	-1.79	-5.2%	196	187

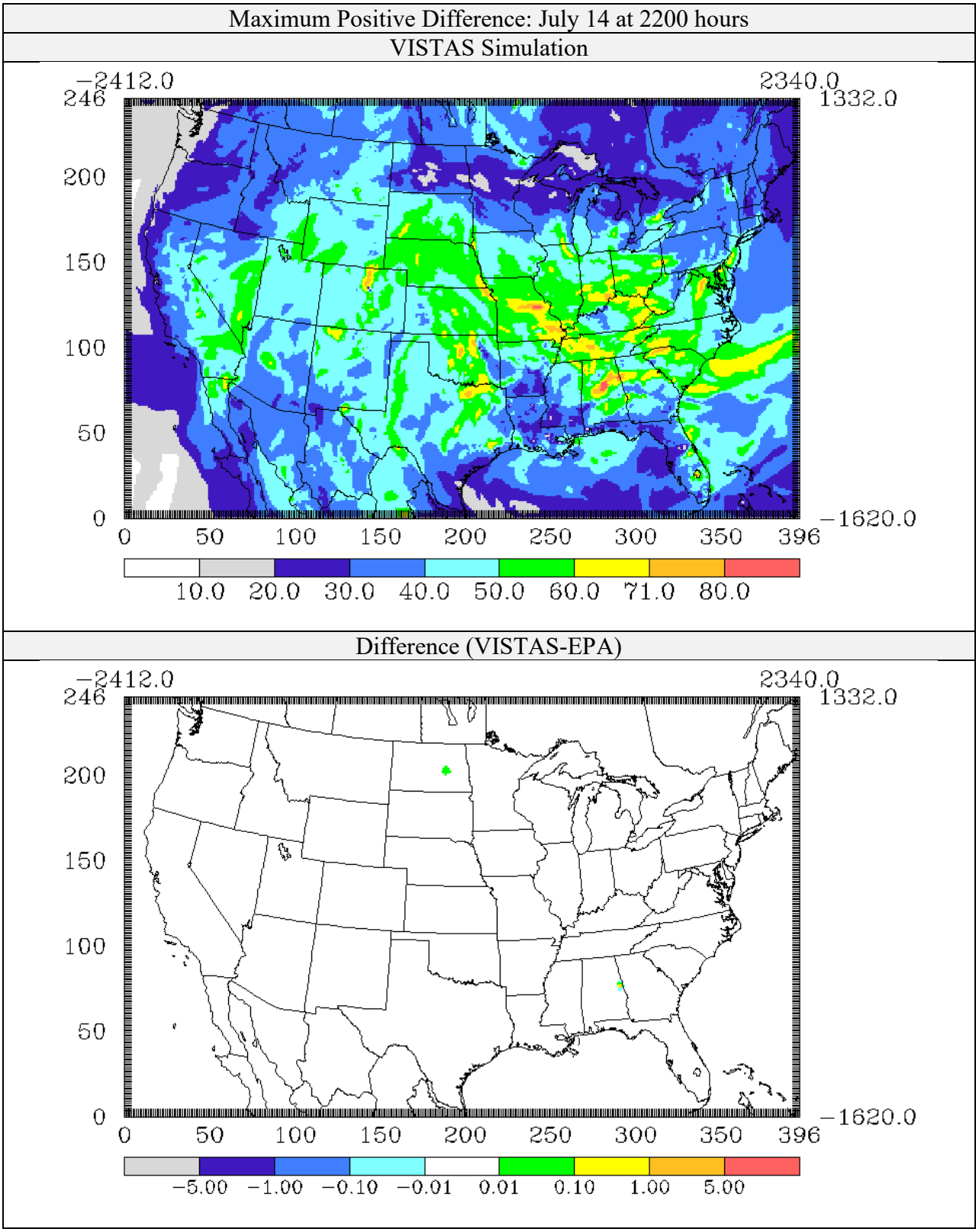


Figure 4-1: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference)

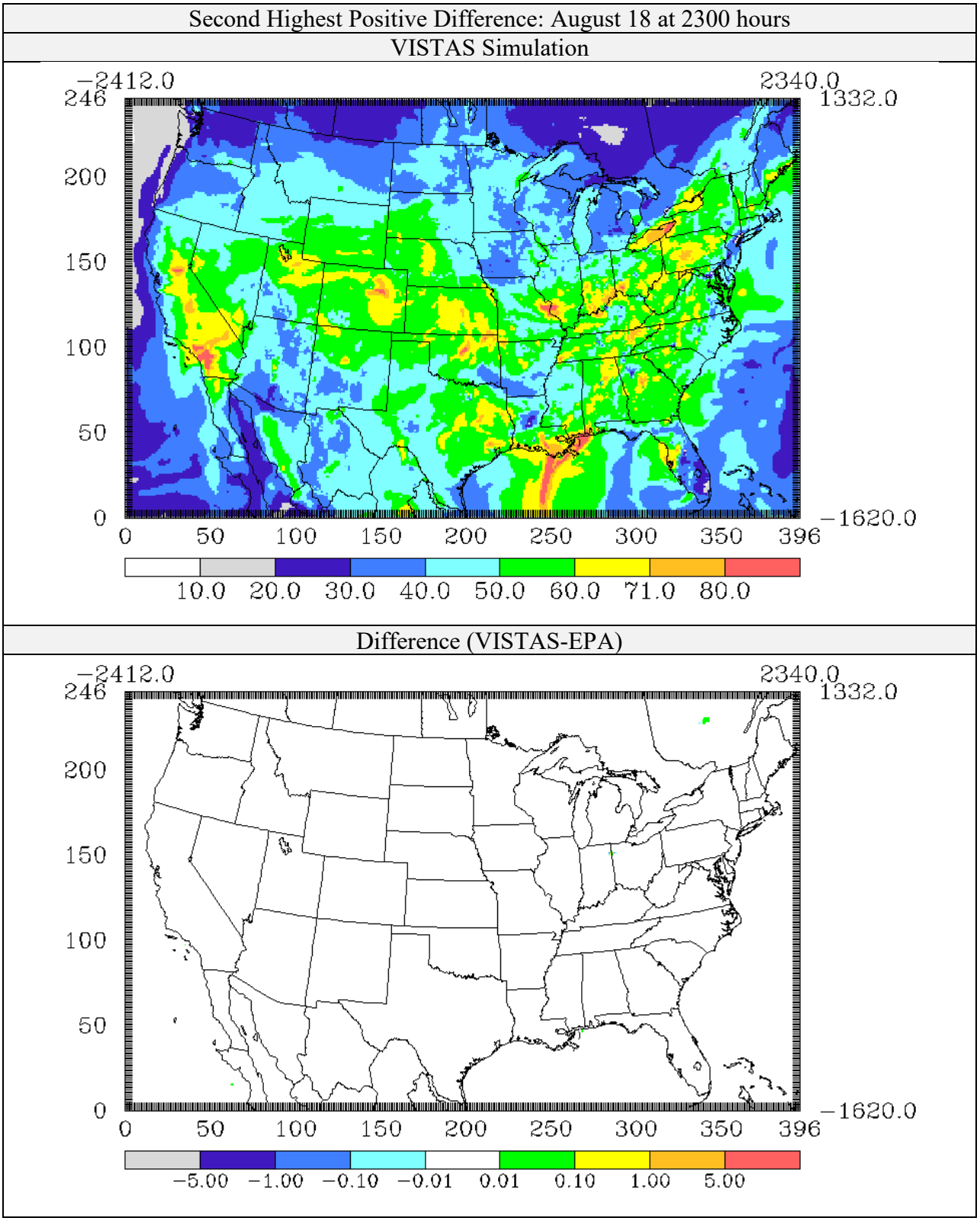


Figure 4-2: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference)

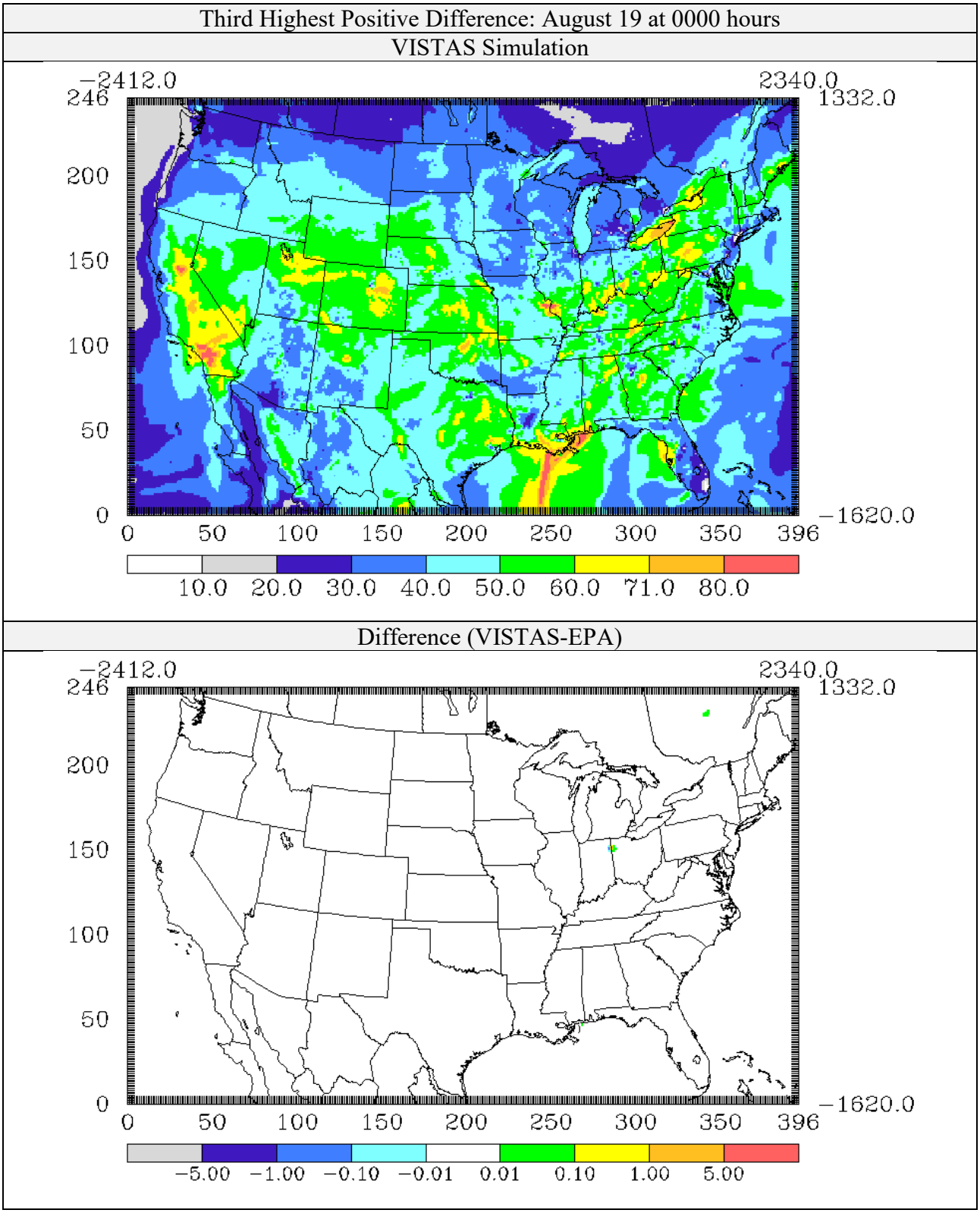


Figure 4-3: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference)

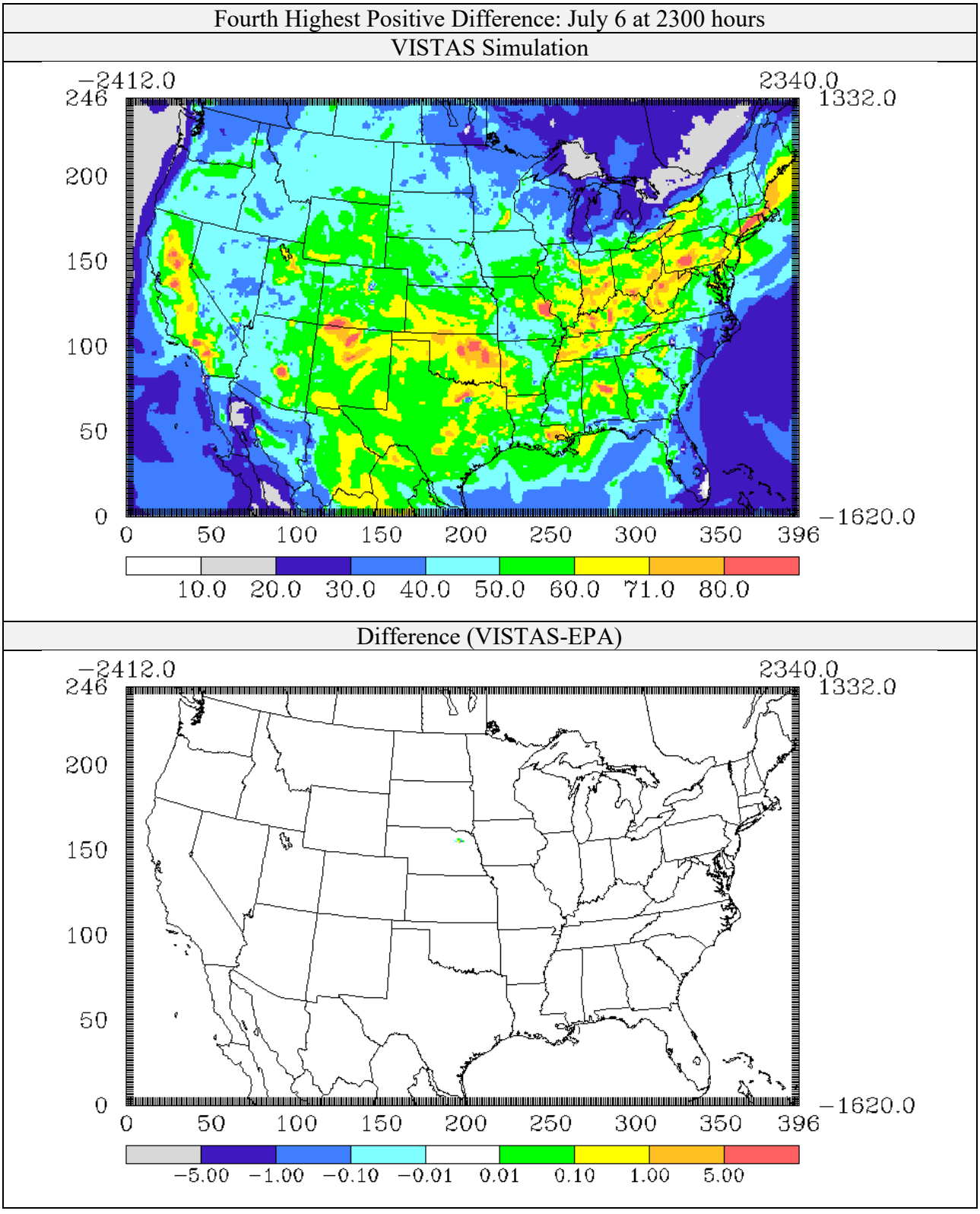


Figure 4-4: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference)

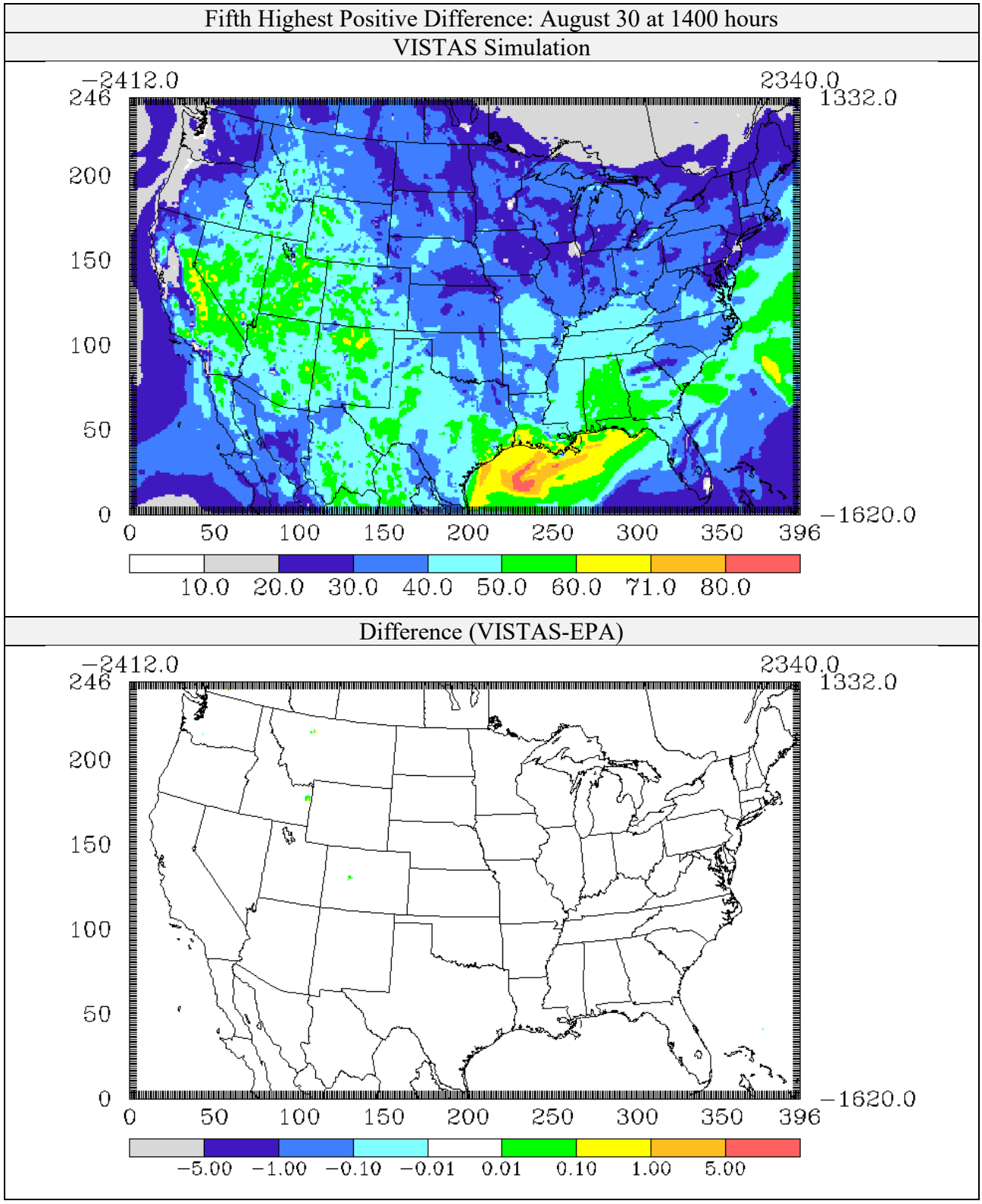


Figure 4-5: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference)

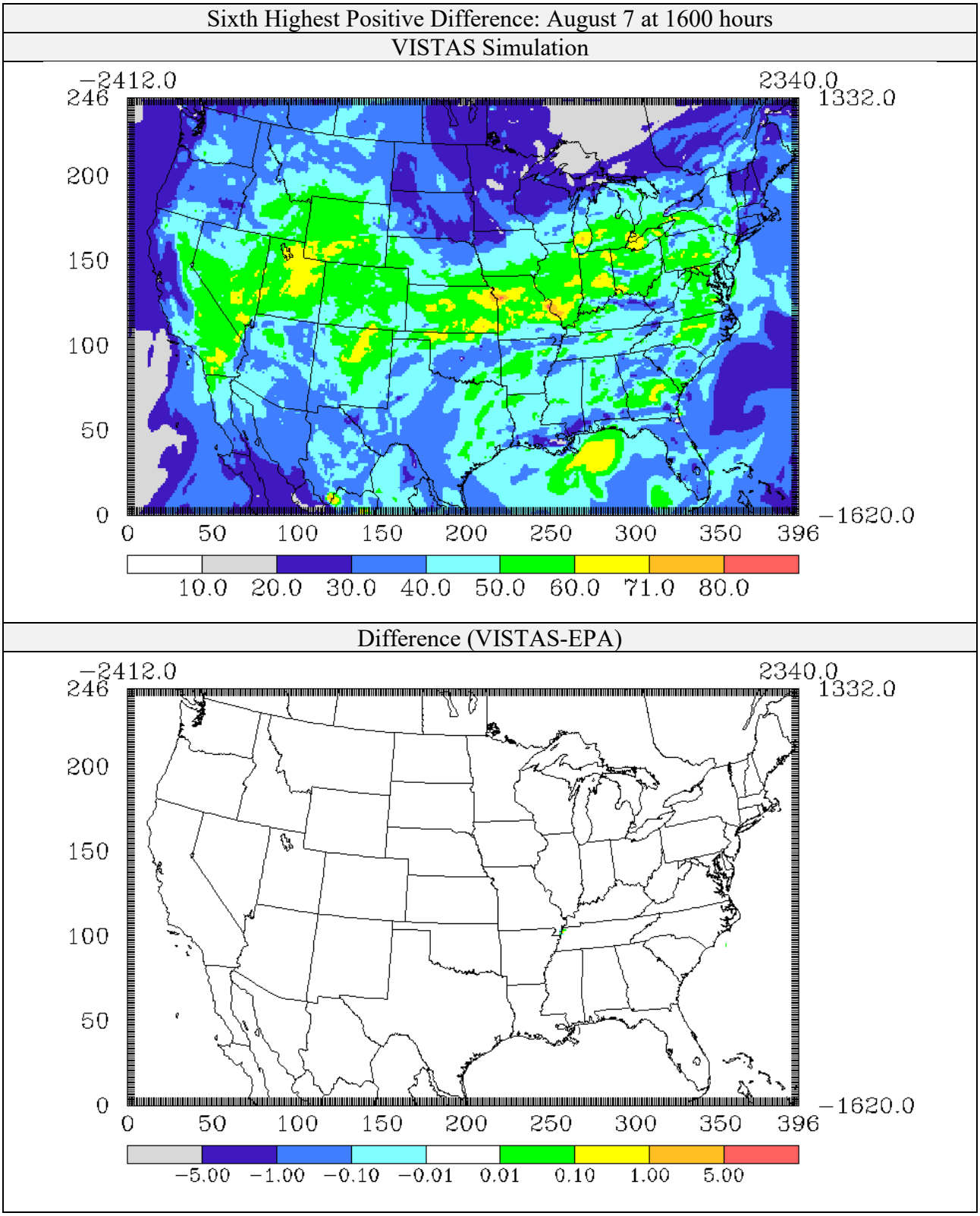


Figure 4-6: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference)

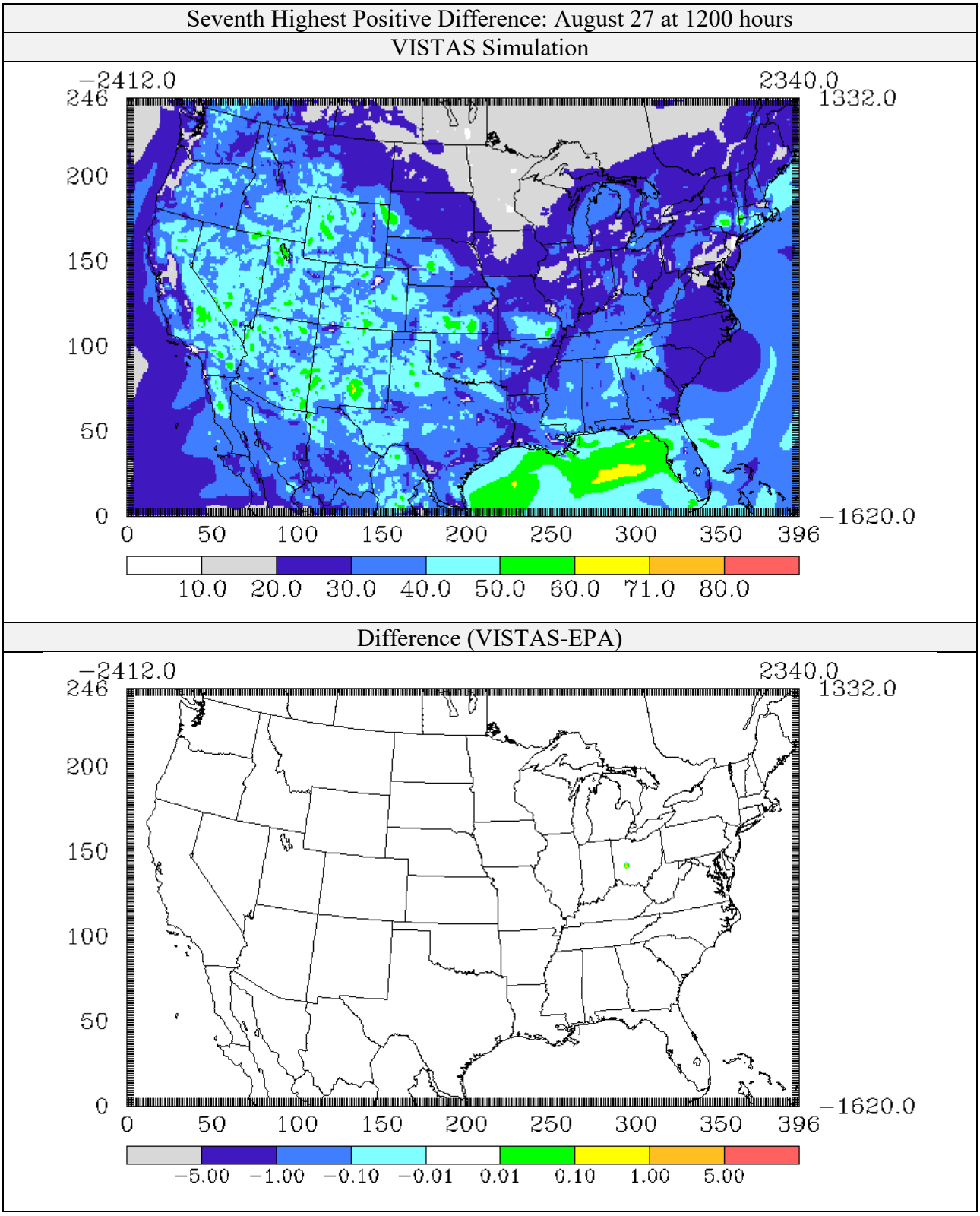


Figure 4-7: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference)

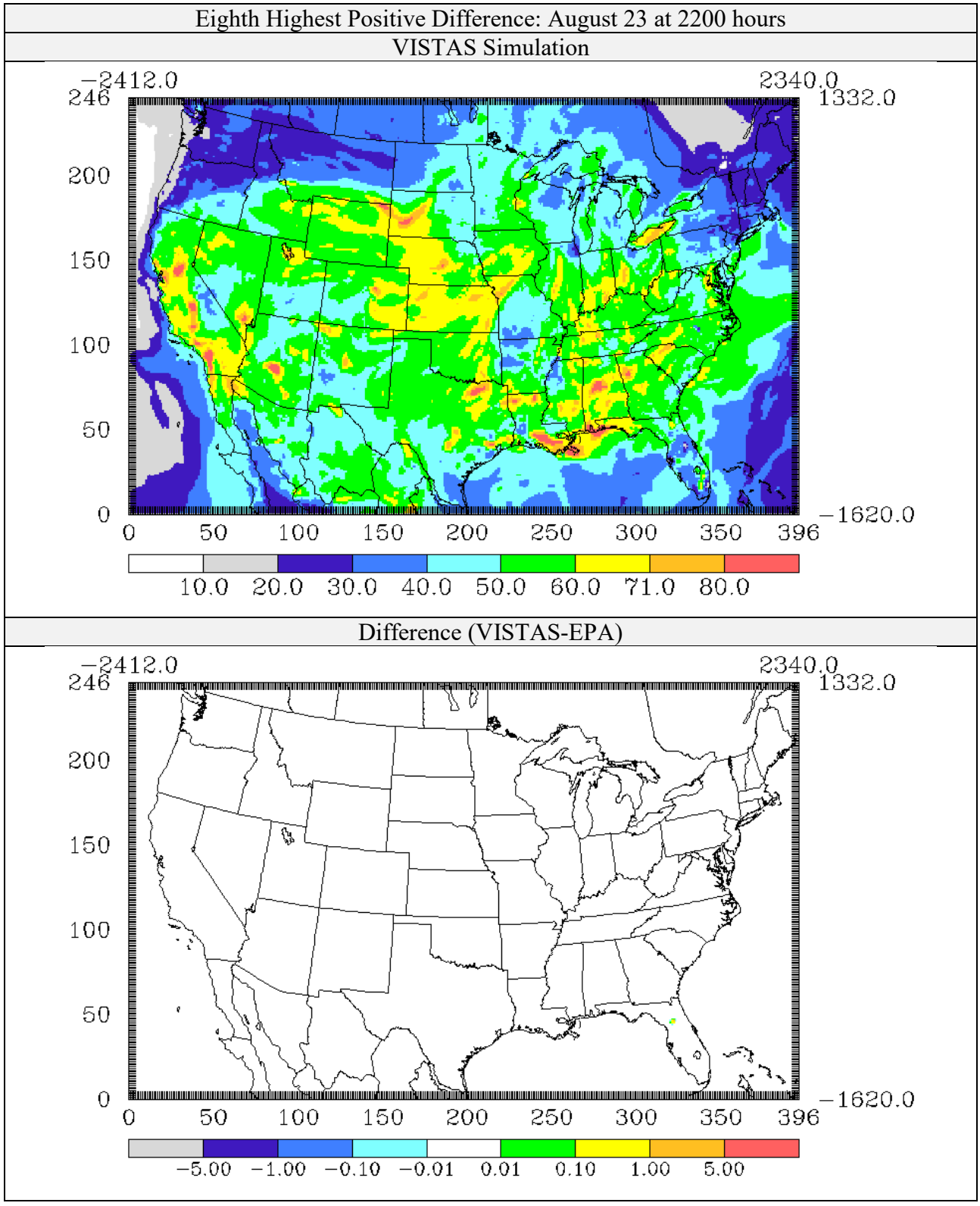


Figure 4-8: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference)

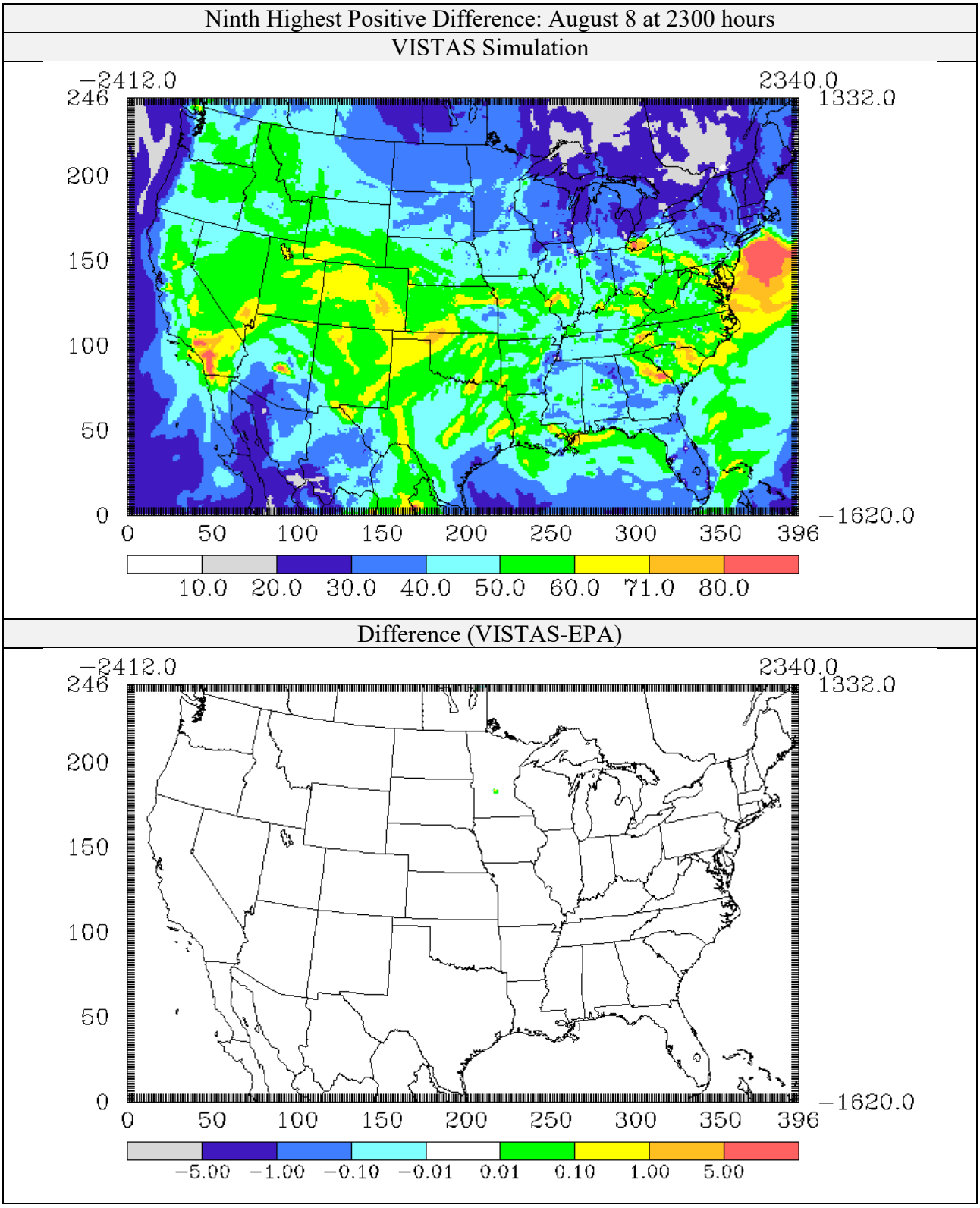


Figure 4-9: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference)

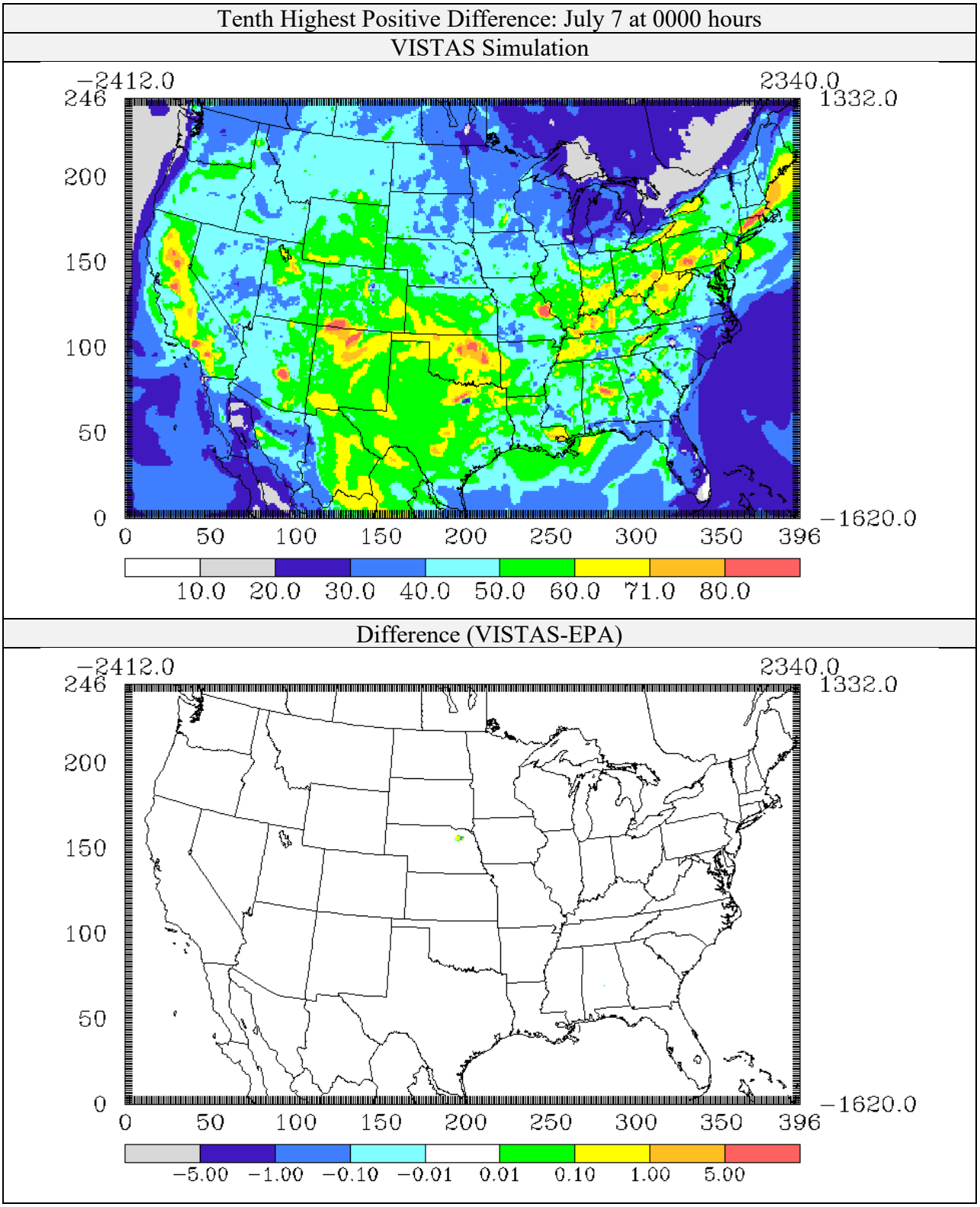


Figure 4-10: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference)

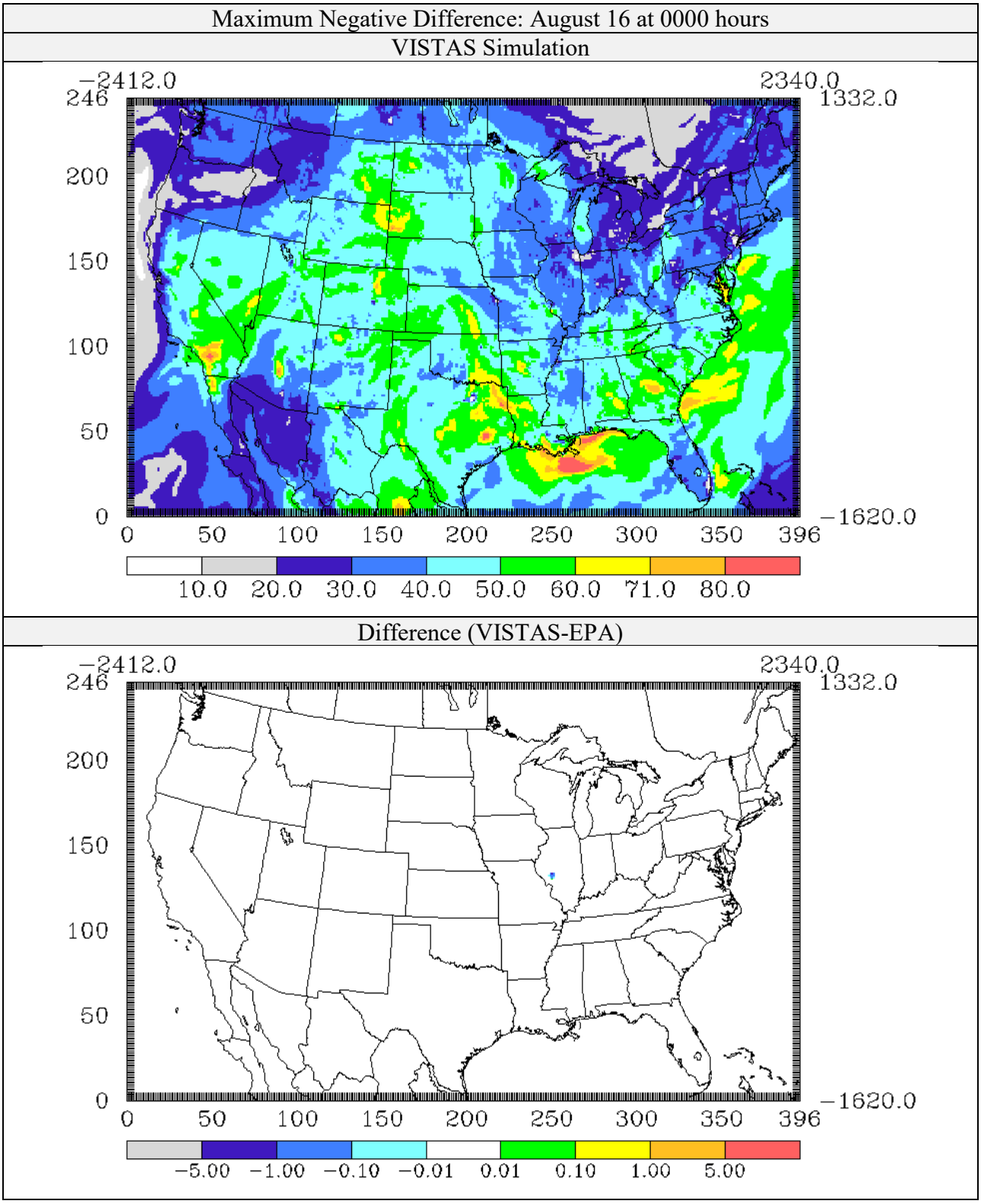


Figure 4-11: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference)

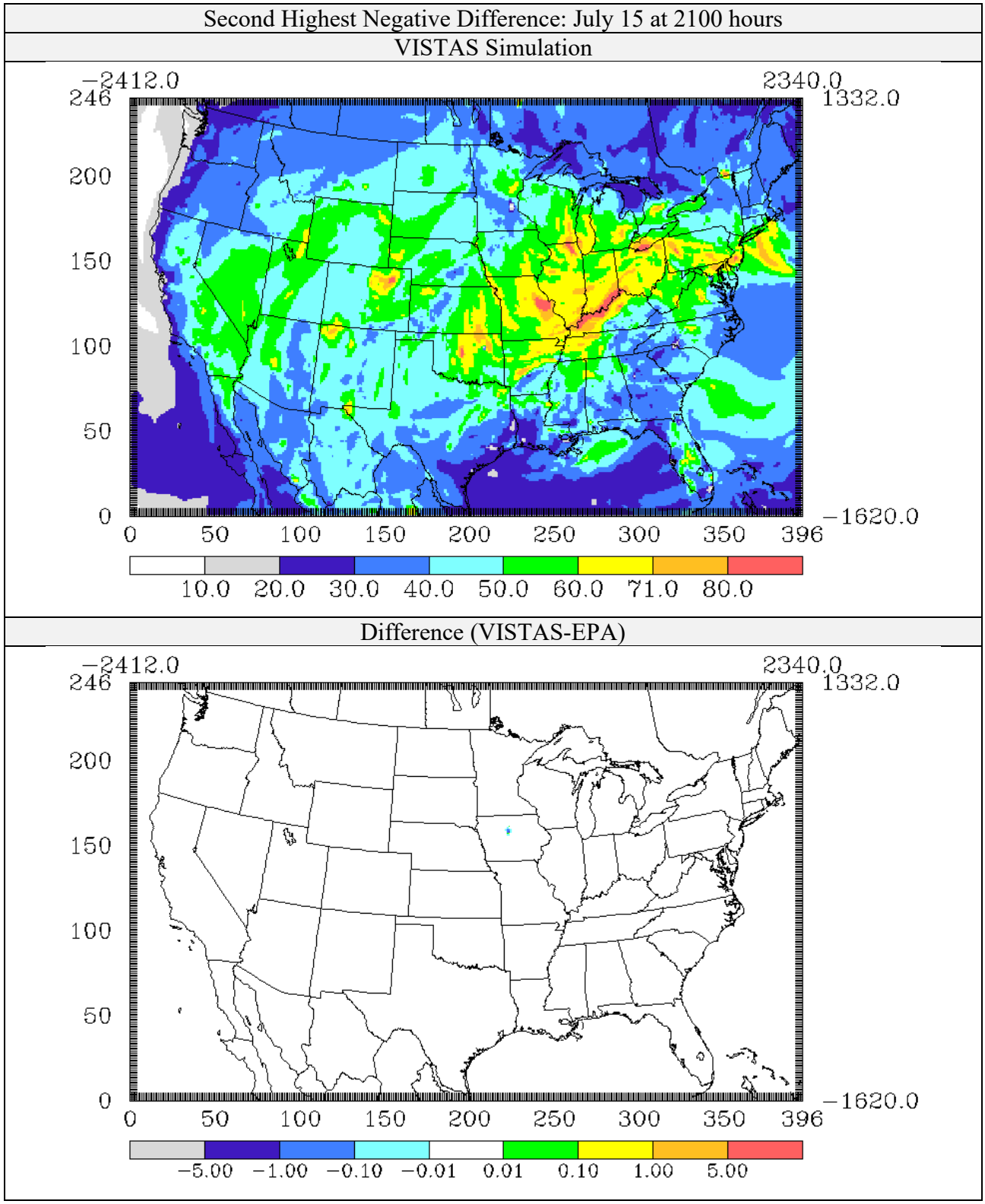


Figure 4-12: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference)

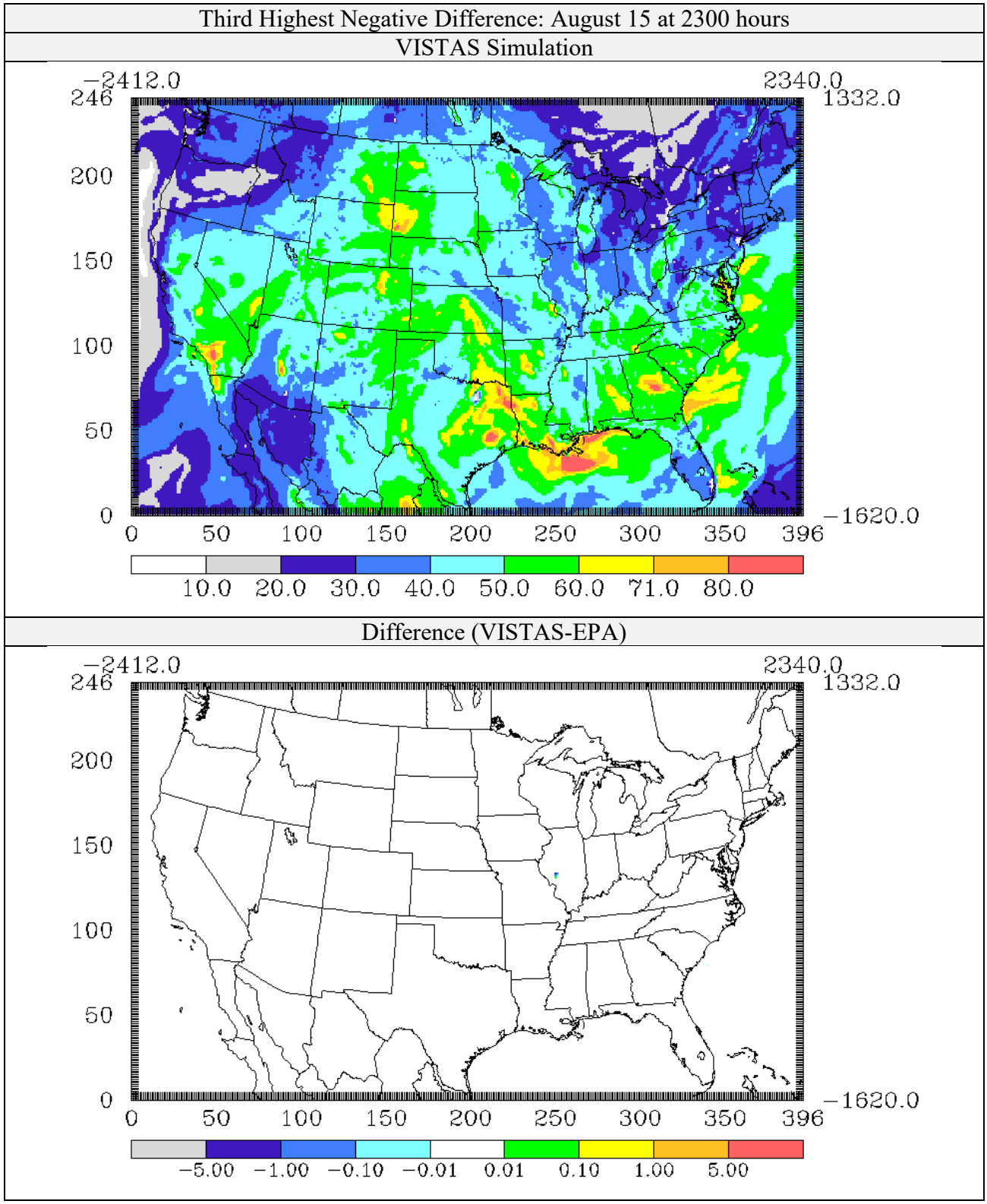


Figure 4-13: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference)

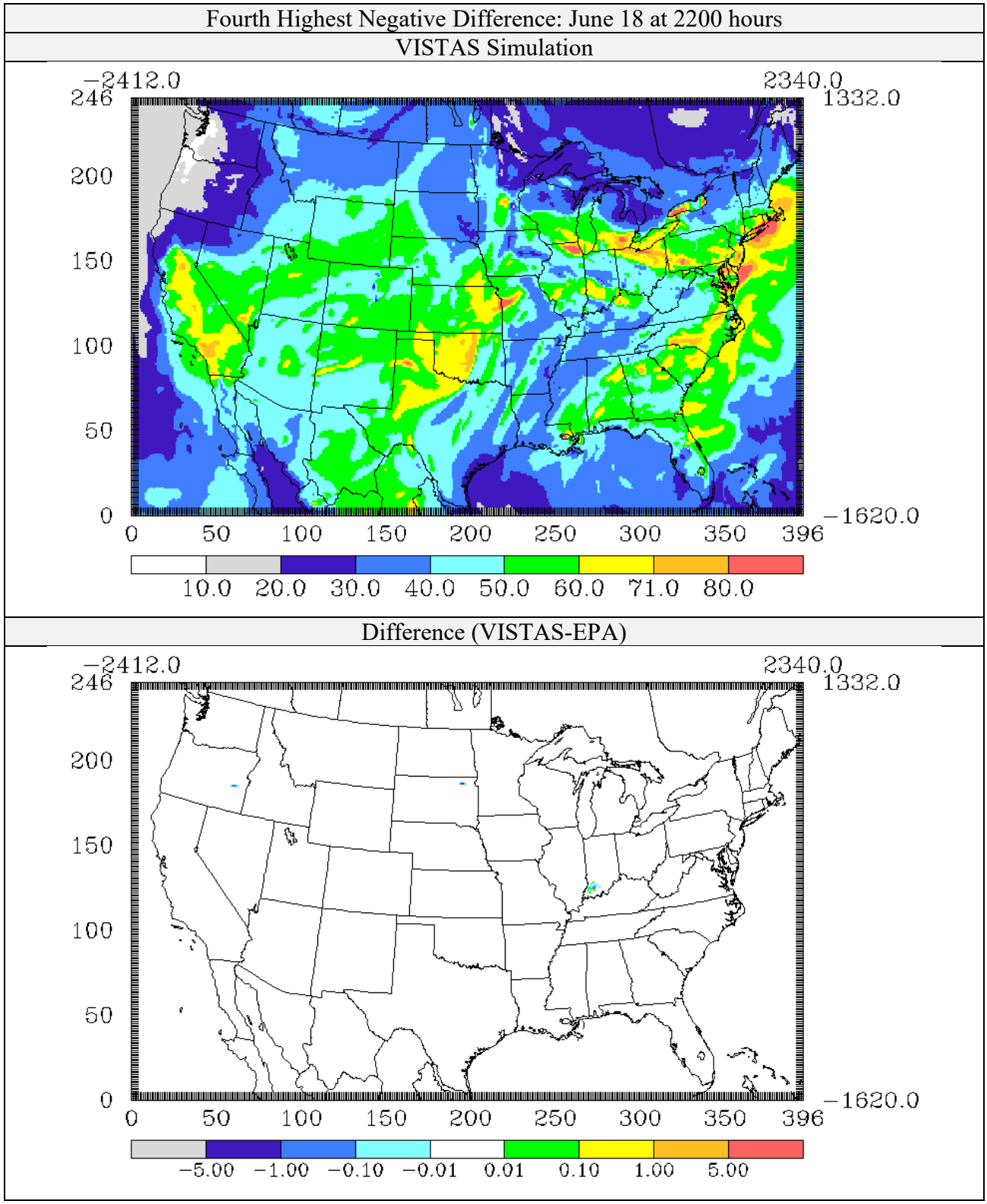


Figure 4-14: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference)

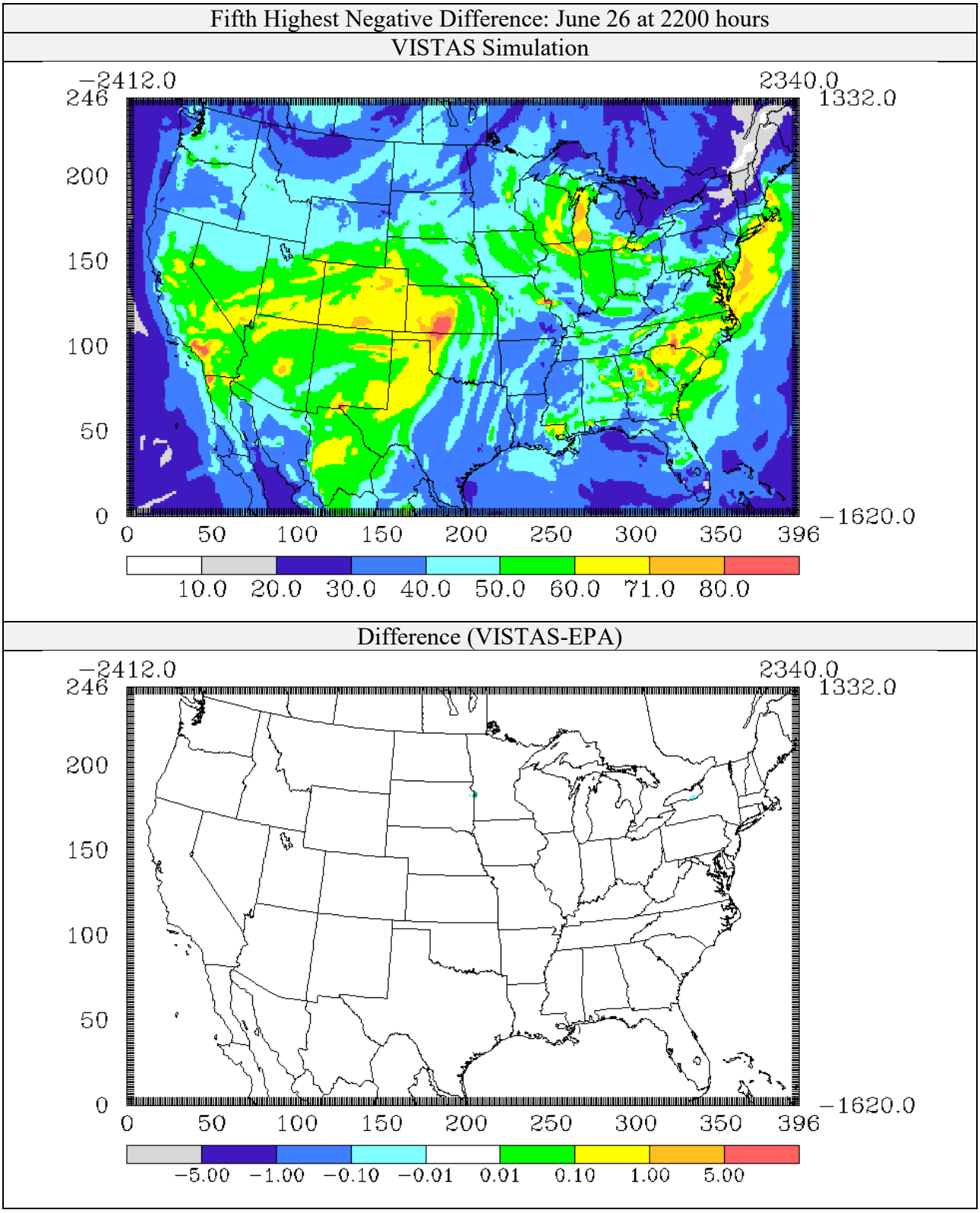


Figure 4-15: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference)

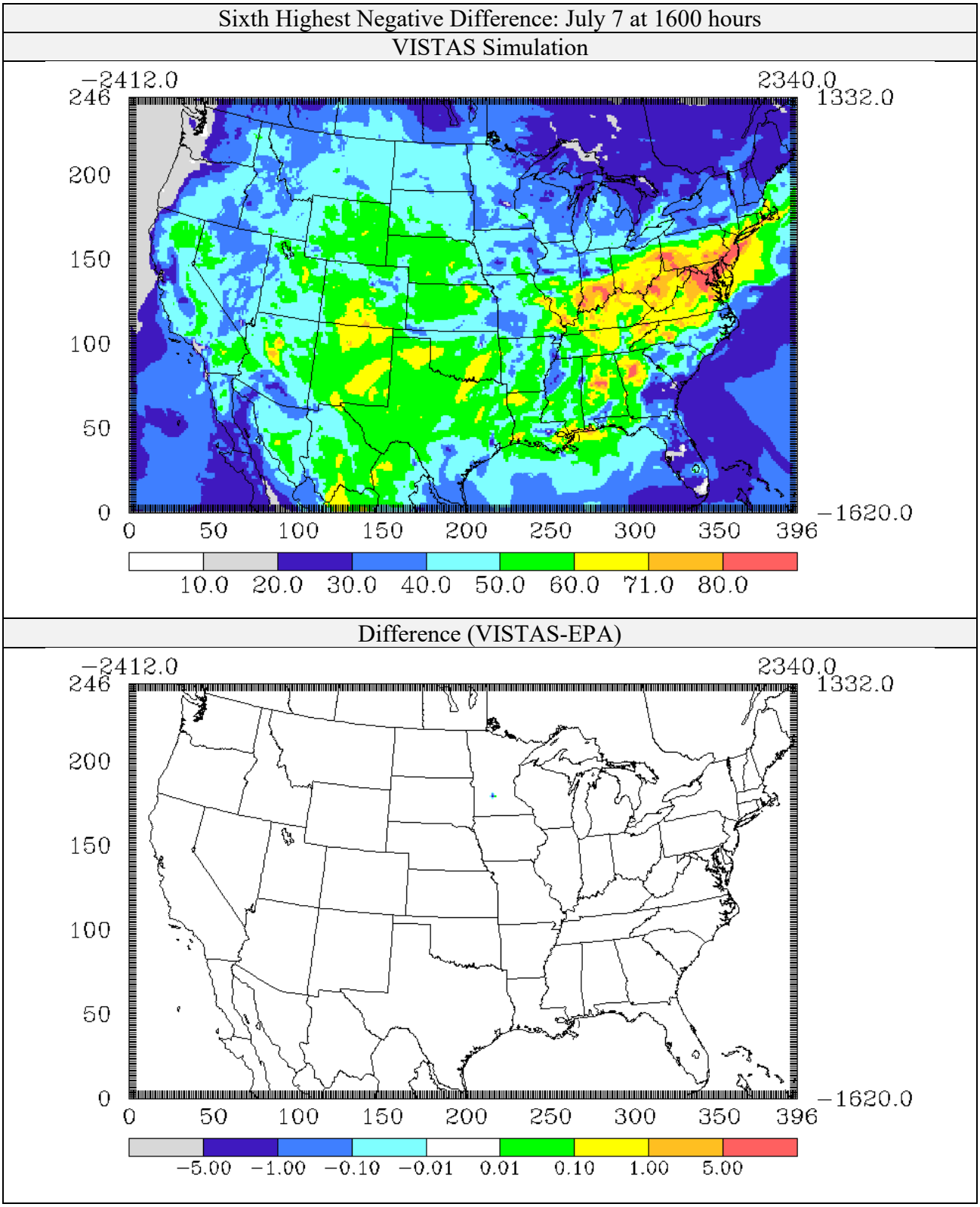


Figure 4-16: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference)

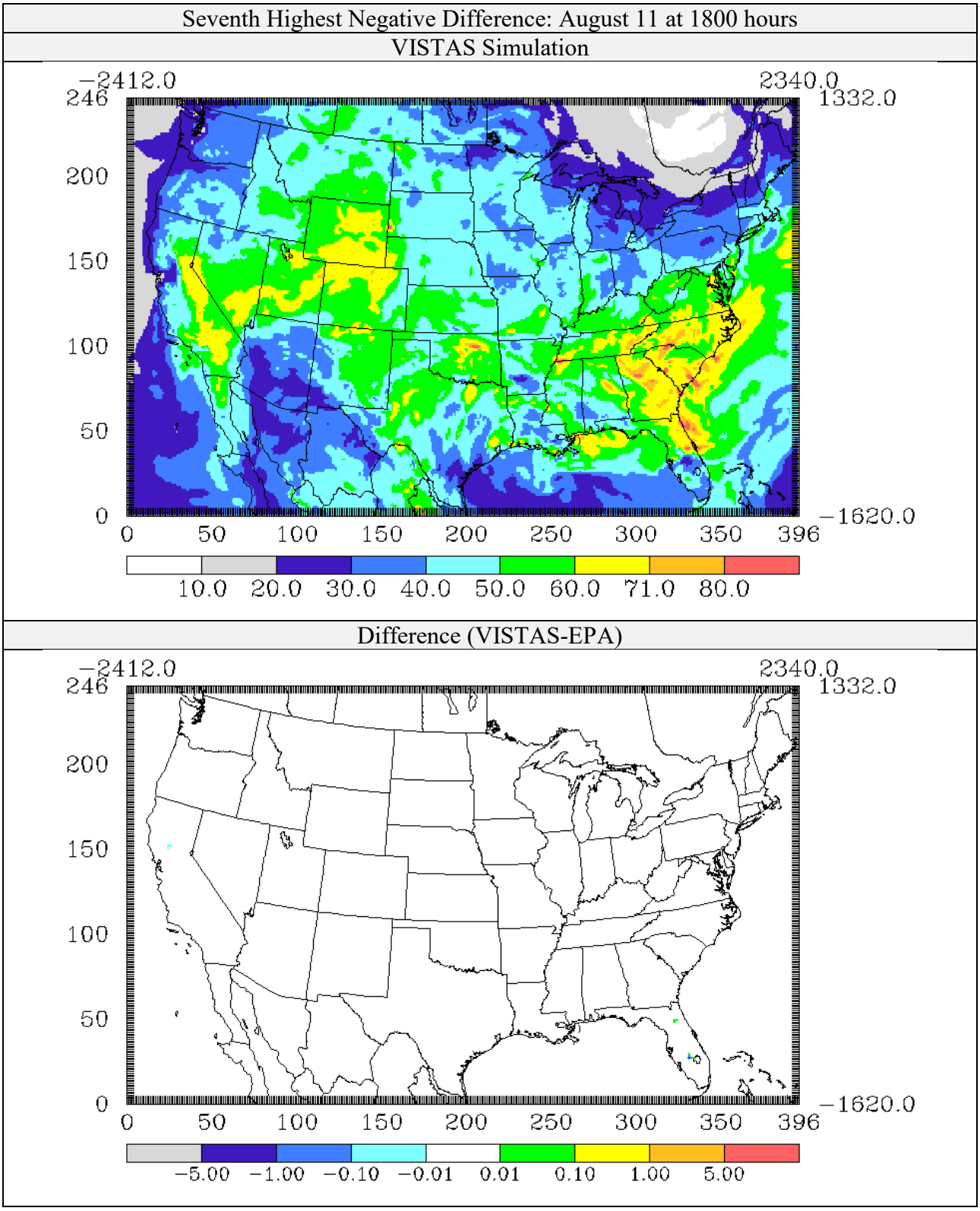


Figure 4-17: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference)

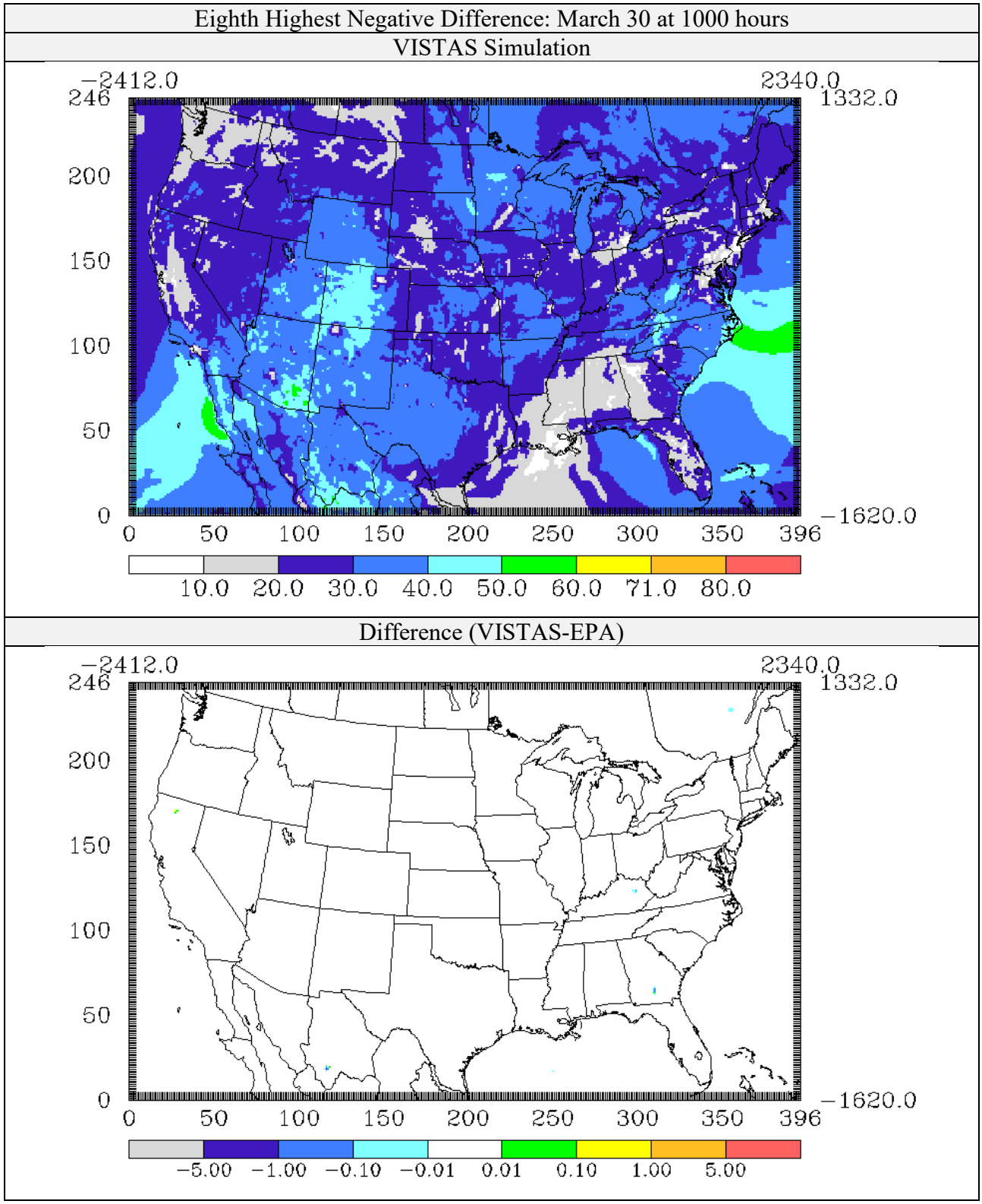


Figure 4-18: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference)

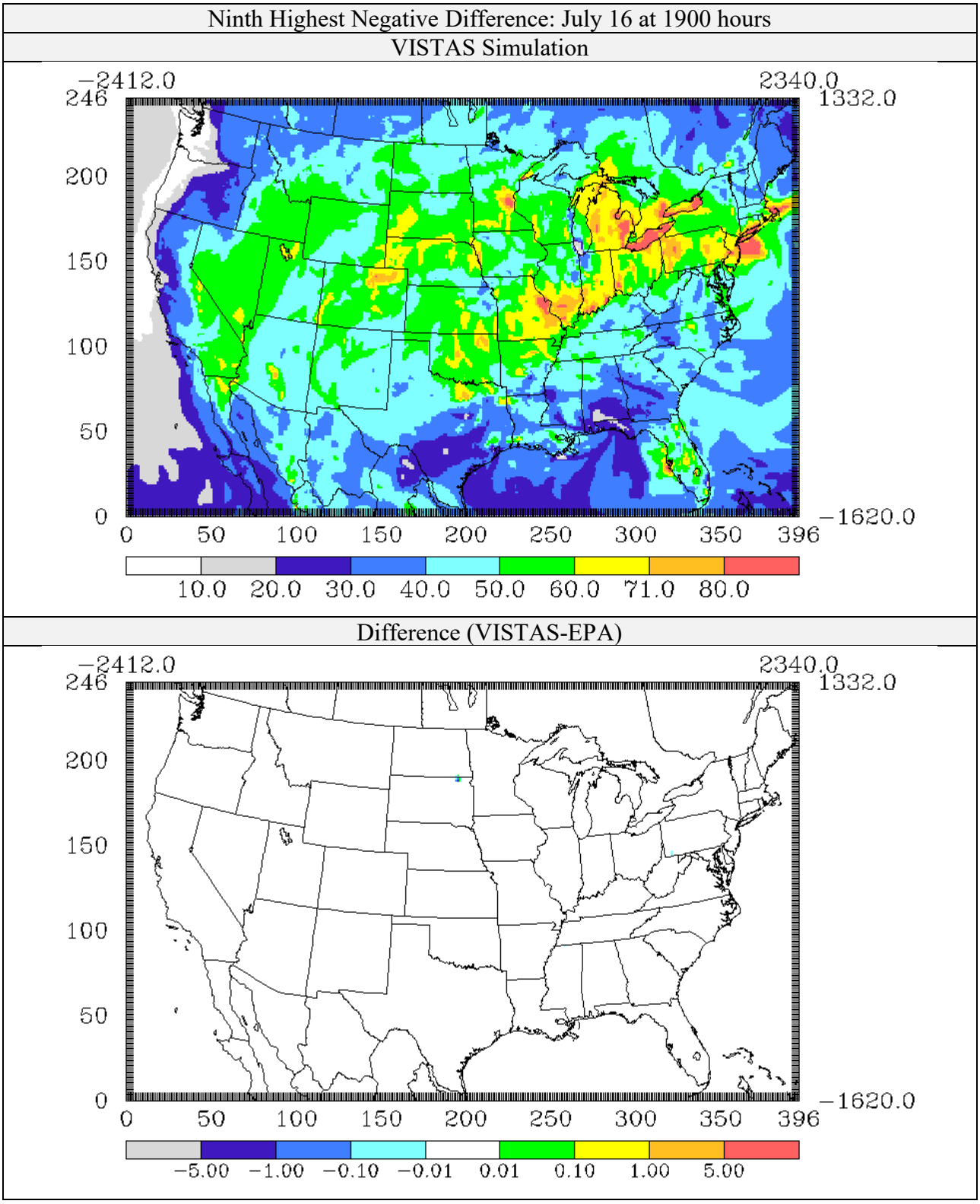


Figure 4-19: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference)

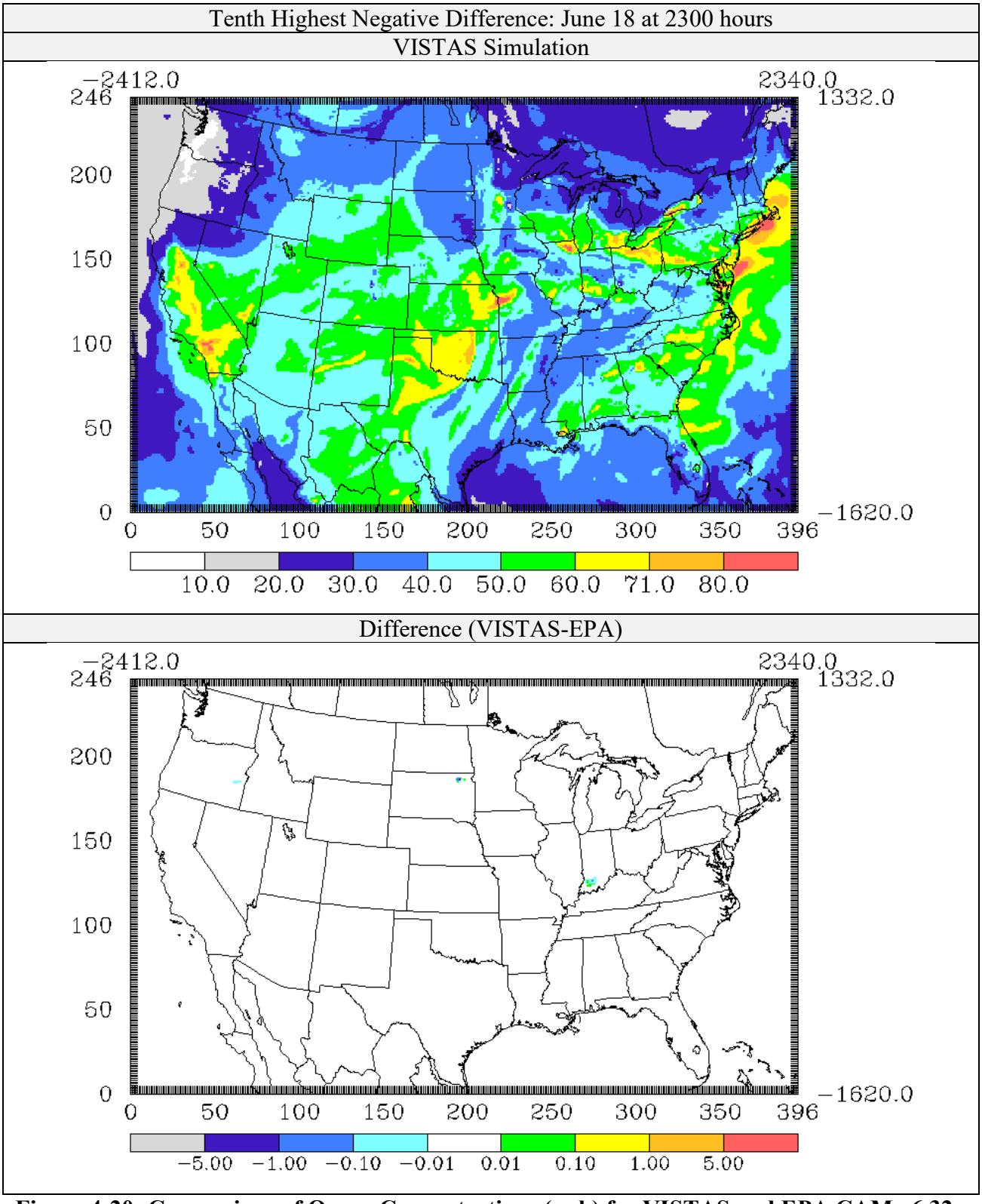


Figure 4-20: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference)

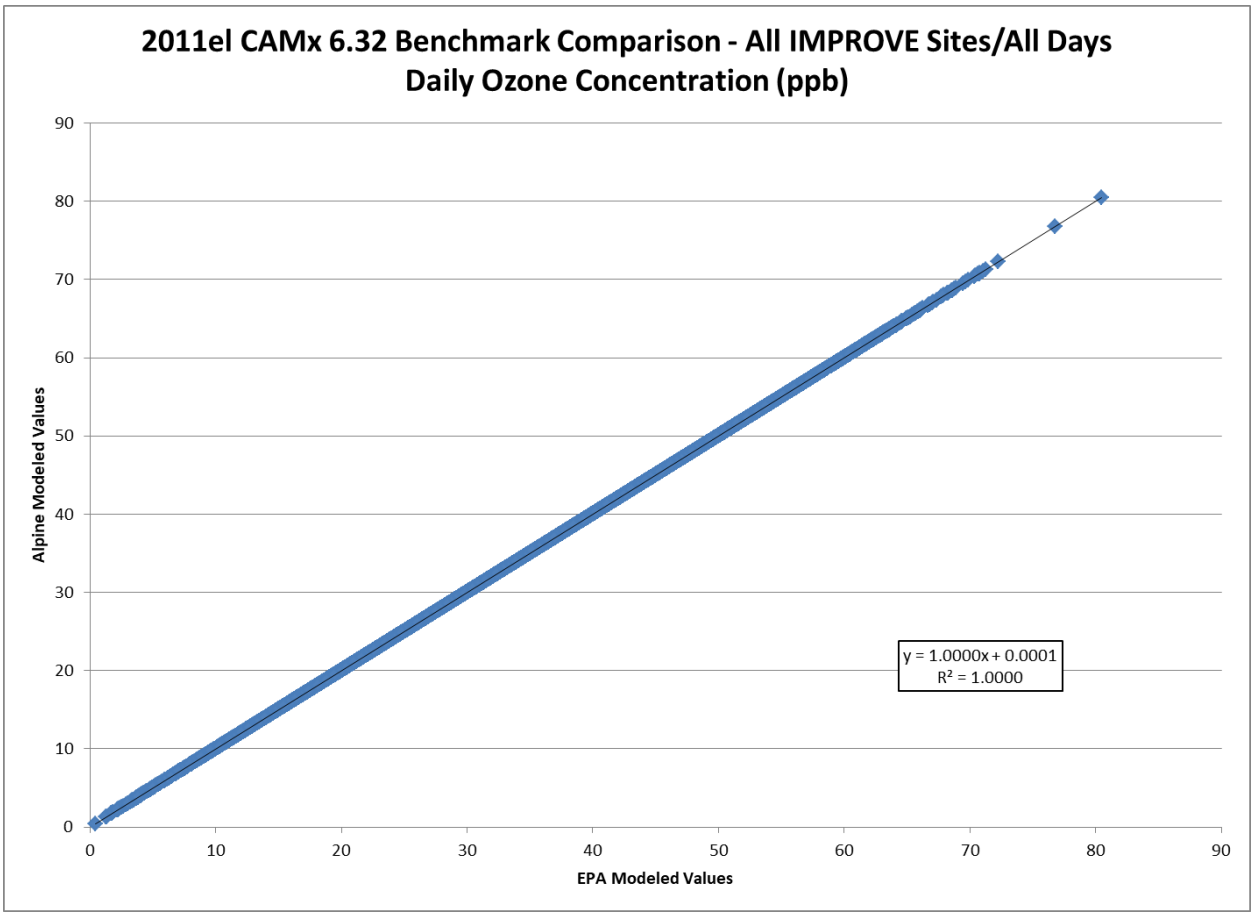


Figure 4-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine).

4.2 $PM_{2.5}$

$PM_{2.5}$ results for the top 10 positive and negative hours are presented in tabular format in Table 4-2. The maximum positive difference is 6.73 $\mu g/m^3$ falling to 2.21 $\mu g/m^3$ for the 10^{th} high. The maximum negative difference is -5.41 $\mu g/m^3$ falling to -1.97 $\mu g/m^3$ for the 10^{th} high. The maximum positive percent difference from these days is 44.5% and negative percent difference of -31.7%, both on low $PM_{2.5}$ concentration days.

The top 10 positive impact hours are presented in Figures 4-22 through 4-31 and the top 10 negative impact hours are presented in Figures 4-32 through 4-41. The locations of the impacts are again localized and tending to occur in Canada near the relatively high concentration entering the domain through the northern boundary. Comparison with the Nitrate results in Section 4.4 shows that on many days the principal difference in the $PM_{2.5}$ concentrations is a result of the differences in the Nitrate predictions.

Scatterplots of the daily average $PM_{2.5}$ concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-42. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

Examination of the animations shows that the majority of the differences are occurring in Canada and the Northern U.S. with the differences occurring in the areas of relatively high $PM_{2.5}$. We speculate that the differences are primarily from the difference in the Particulate Nitrate and most likely from different pathways being taken in the ISOROPIA algorithm.

Table 4-2. Comparison of 2011el CAMx 6.32 Simulation $PM_{2.5}$ Concentrations (µg/m^3) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	1	3	4	34.86	28.13	6.73	23.93%	156	236
2011	1	3	5	32.54	26.77	5.77	21.56%	156	236
2011	1	3	6	34.49	29.16	5.33	18.28%	156	235
2011	1	27	7	14.19	9.82	4.37	44.52%	349	244
2011	1	3	3	31.52	28.34	3.17	11.20%	156	236
2011	1	27	11	11.67	8.91	2.76	30.91%	349	243
2011	1	27	6	11.37	8.71	2.66	30.59%	343	244
2011	1	14	9	14.03	11.54	2.49	21.60%	164	222
2011	1	27	4	11.82	9.56	2.26	23.63%	343	244
2011	1	3	21	21.51	19.29	2.21	11.47%	164	236
Maximum Negative									
2011	1	14	6	20.84	26.26	-5.41	-20.62%	120	243
2011	1	27	8	8.56	12.22	-3.67	-30.01%	350	243
2011	1	15	9	14.60	17.96	-3.36	-18.70%	126	220
2011	1	27	11	8.58	11.77	-3.19	-27.10%	342	245
2011	1	27	12	6.20	9.08	-2.88	-31.69%	342	243
2011	1	27	5	7.89	10.74	-2.85	-26.53%	342	244
2011	1	3	10	38.42	40.87	-2.45	-5.99%	155	235
2011	1	14	2	27.61	29.94	-2.32	-7.76%	134	242
2011	1	3	4	28.64	30.77	-2.13	-6.93%	157	237
2011	1	3	6	27.75	29.72	-1.97	-6.61%	159	234

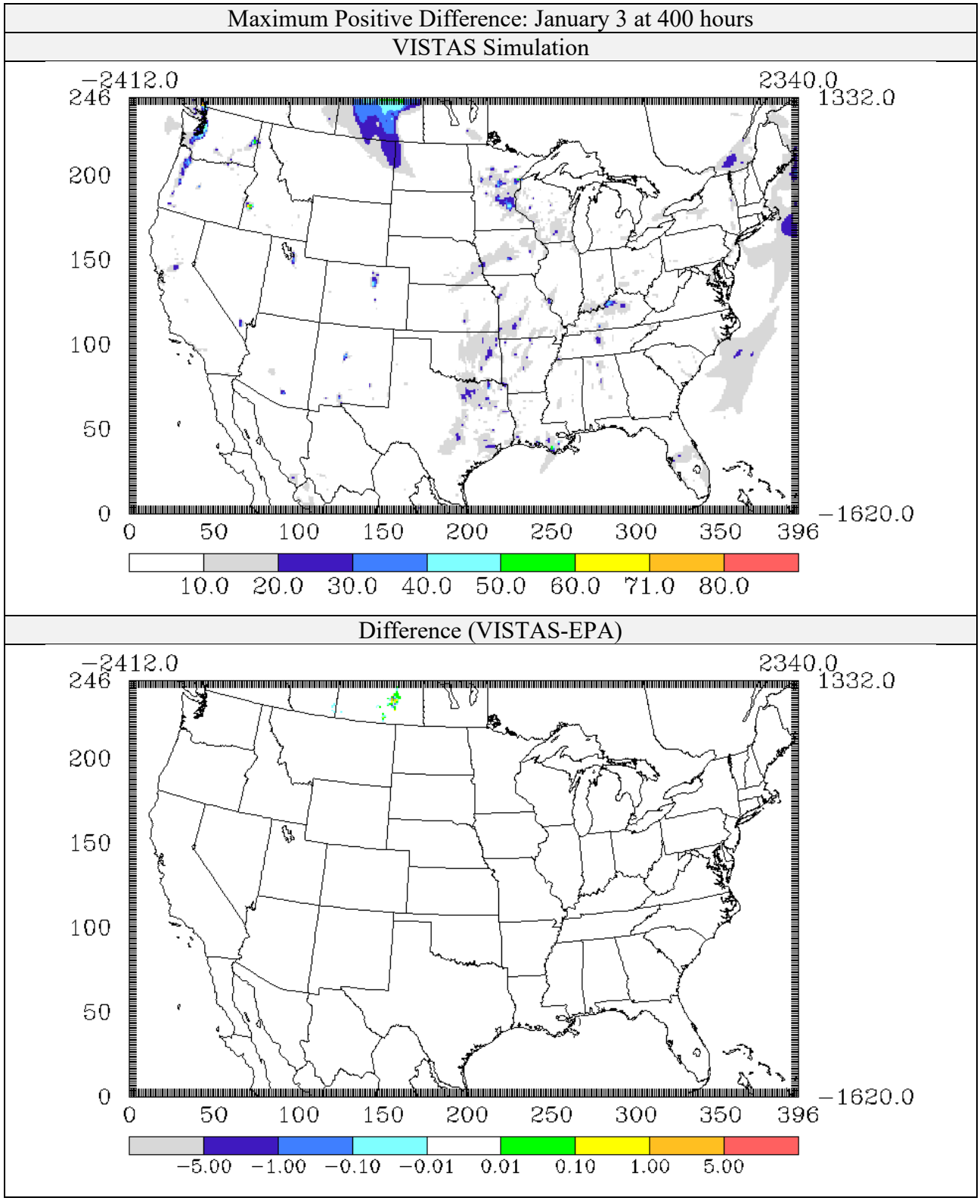


Figure 4-22: Comparison of $PM_{2.5}$ Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference)

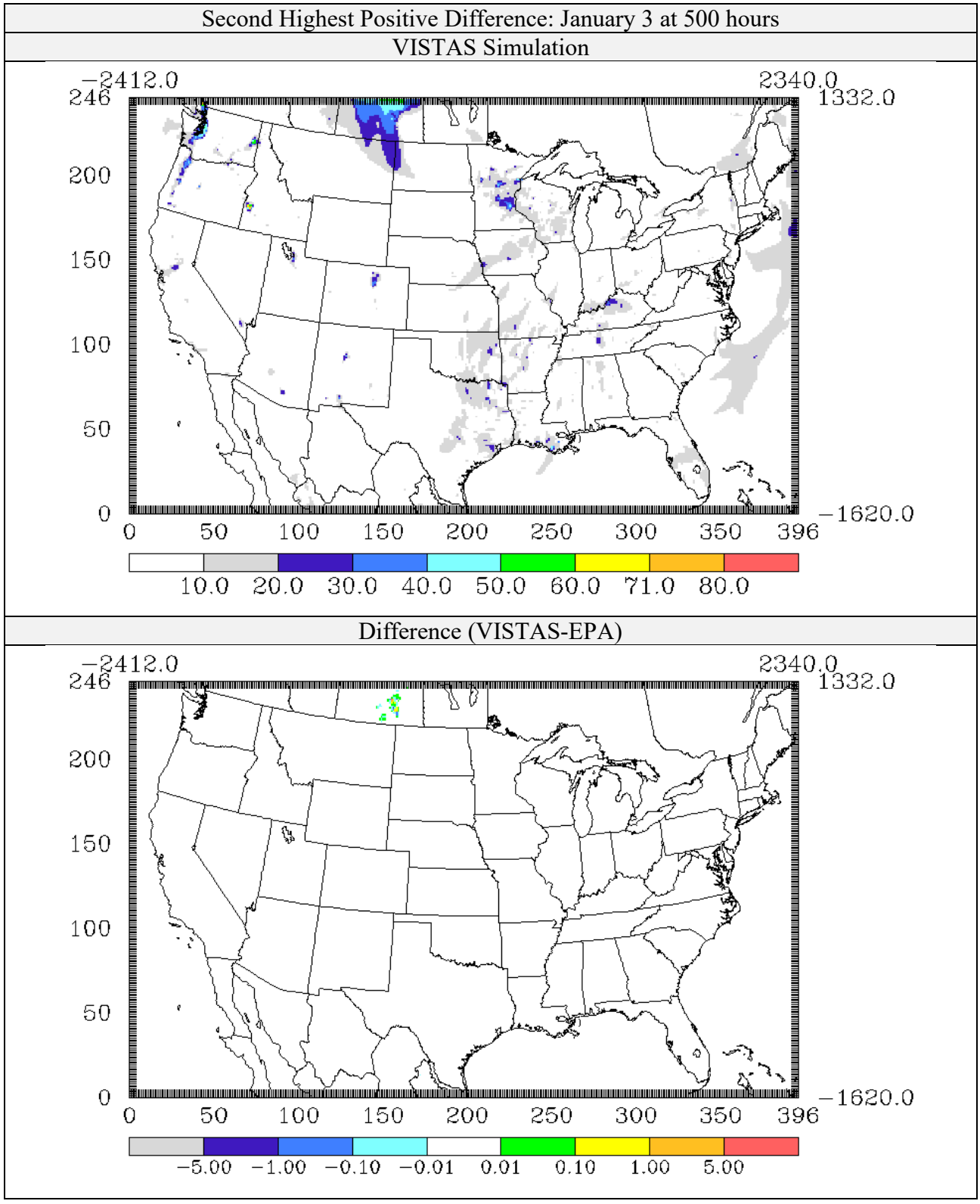


Figure 4-23: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference)

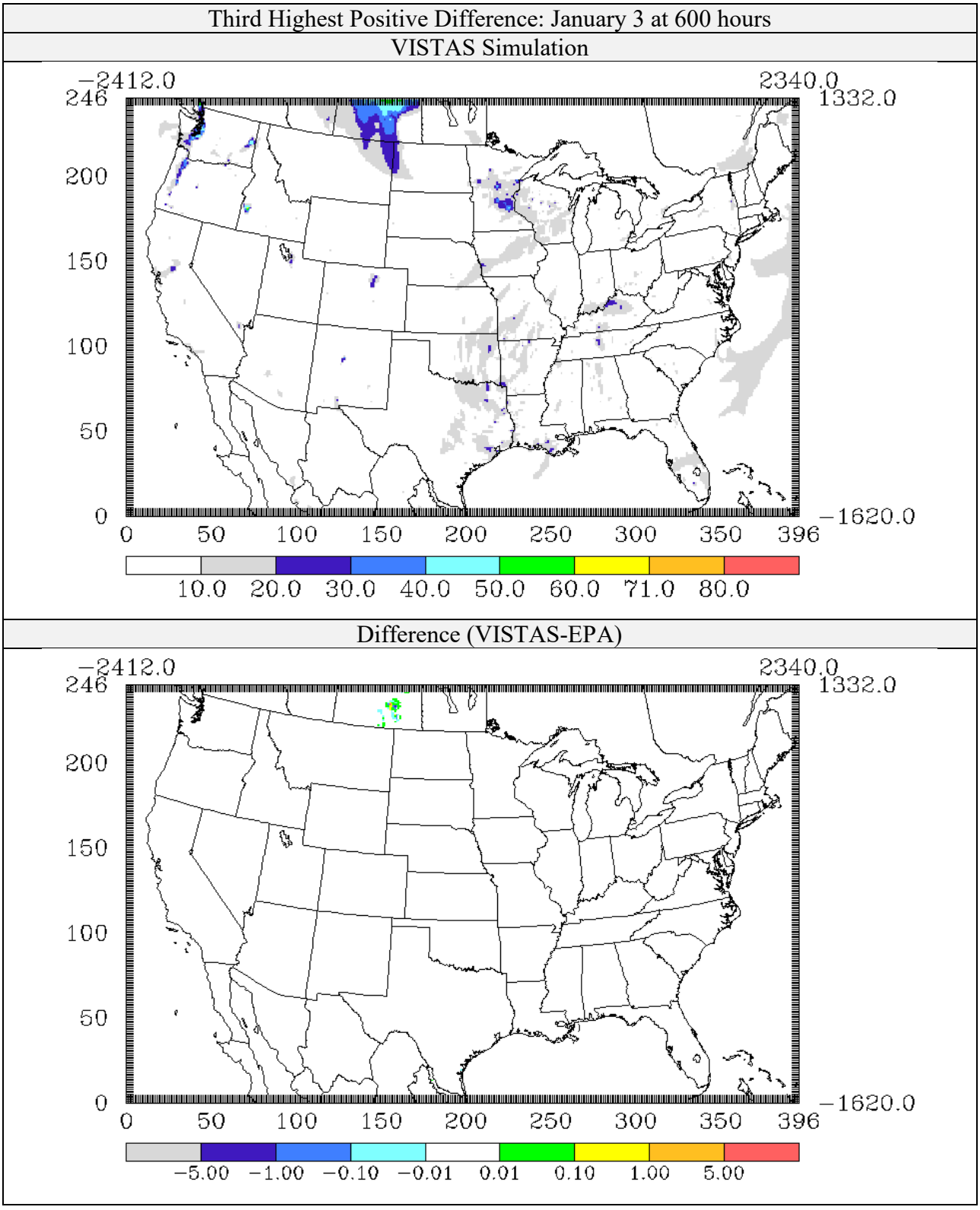


Figure 4-24: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference)

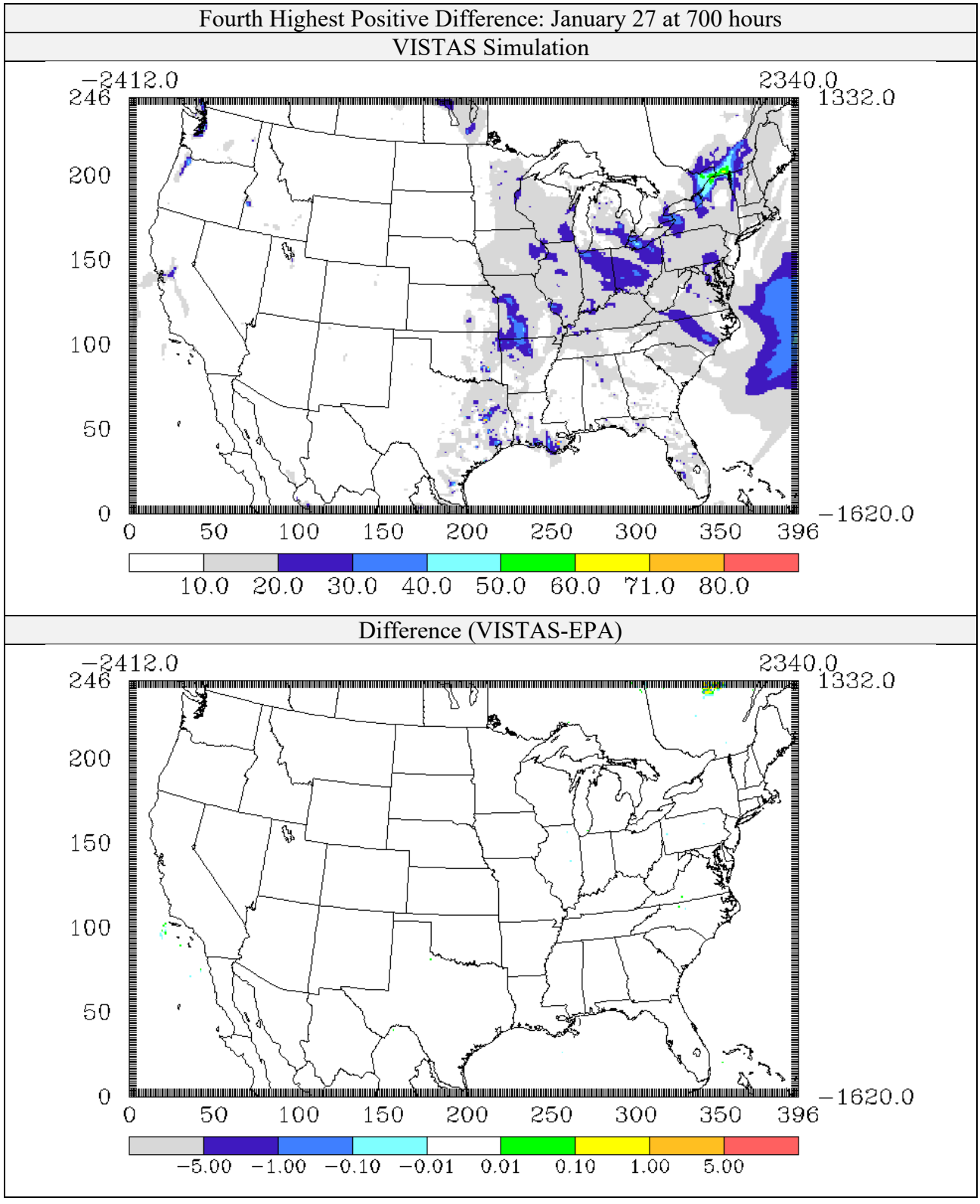


Figure 4-25: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference)

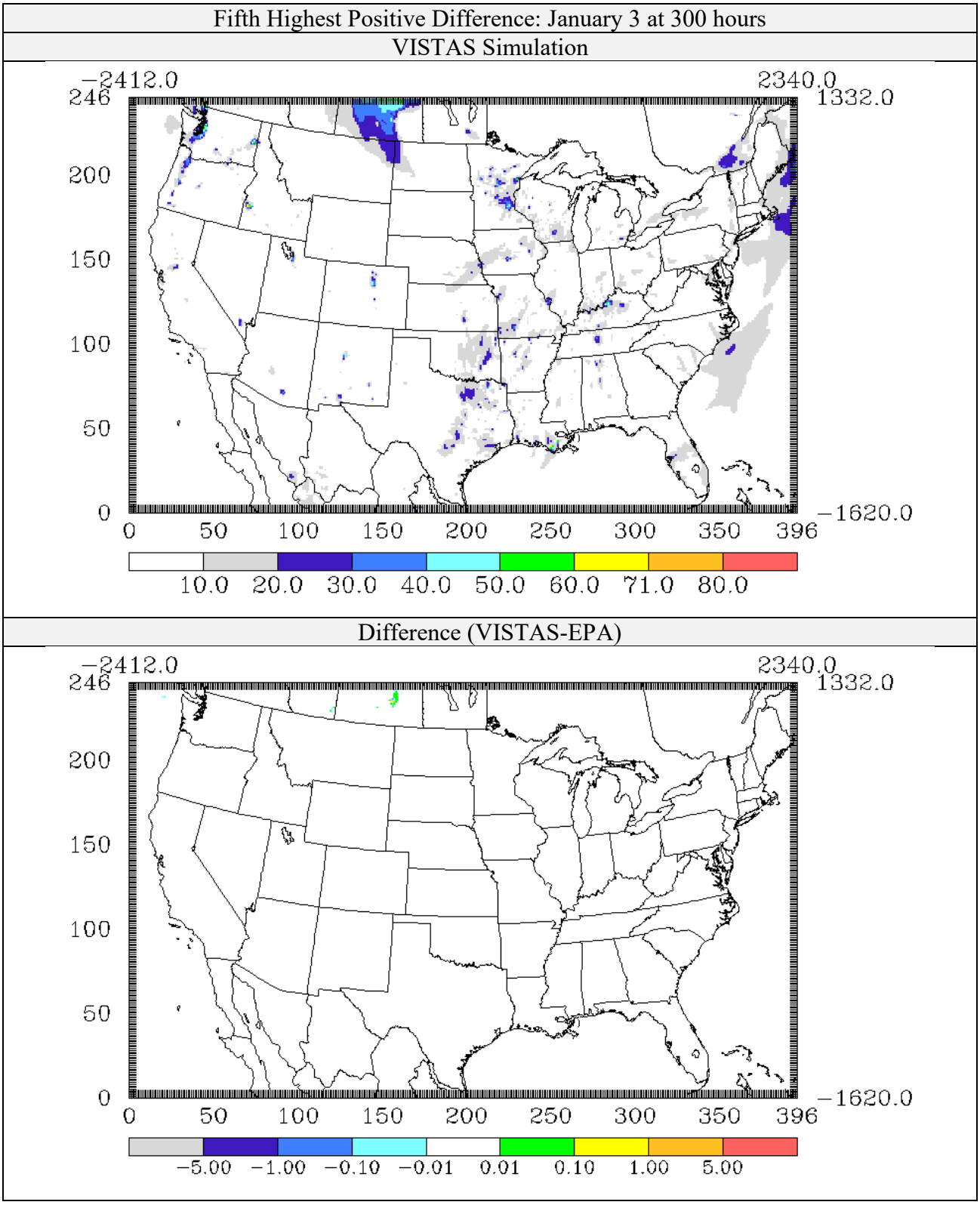


Figure 4-26: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference)

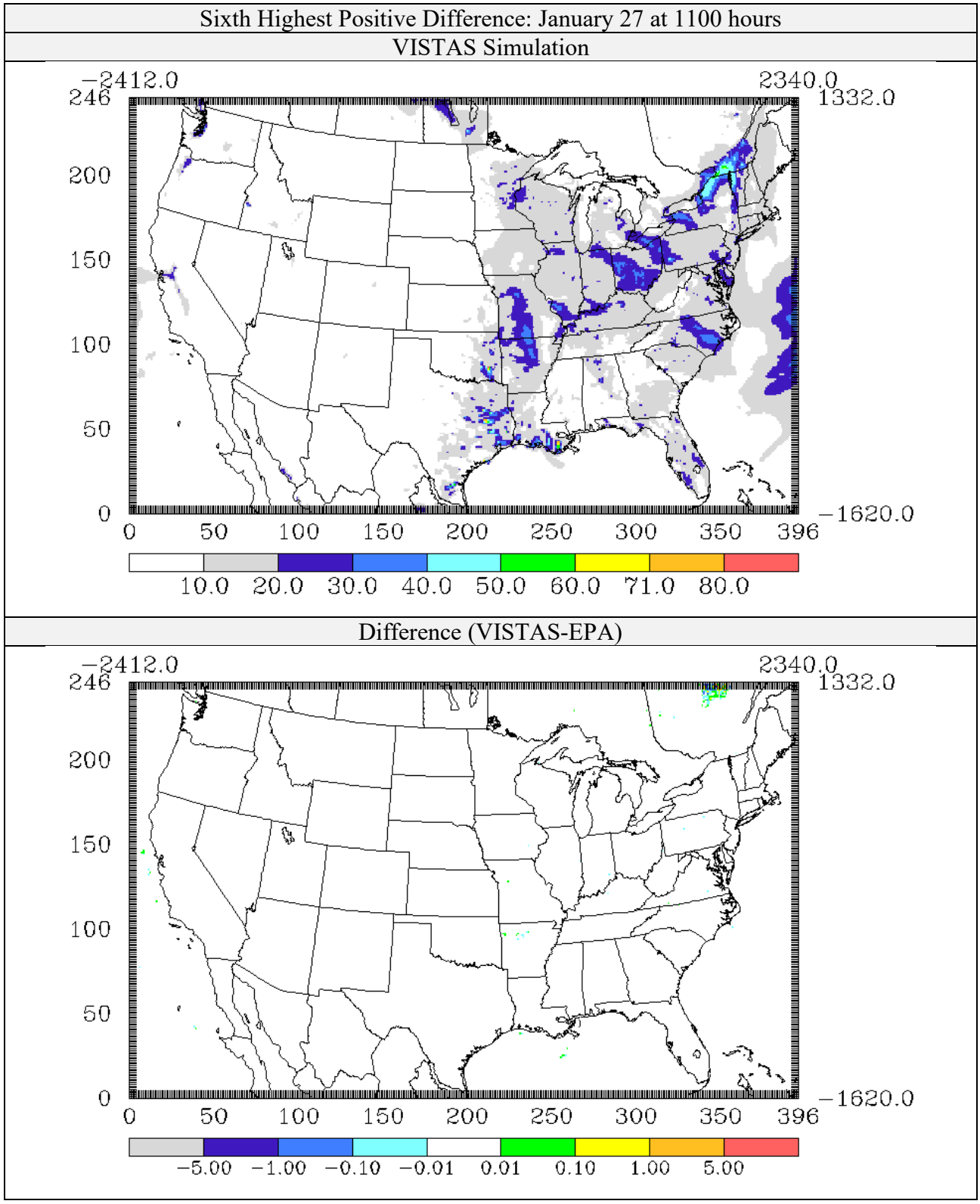


Figure 4-27: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference)

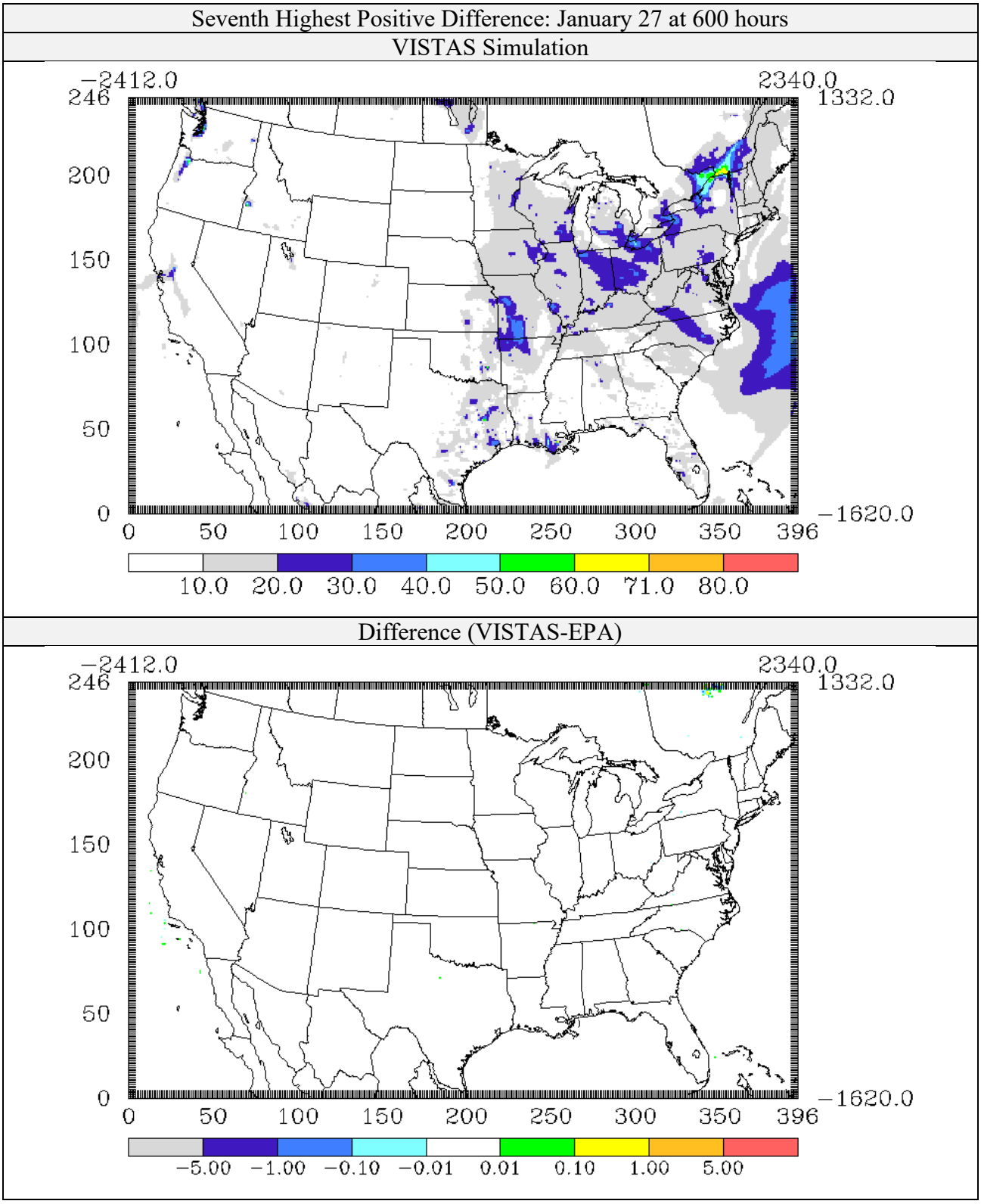


Figure 4-28: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference)

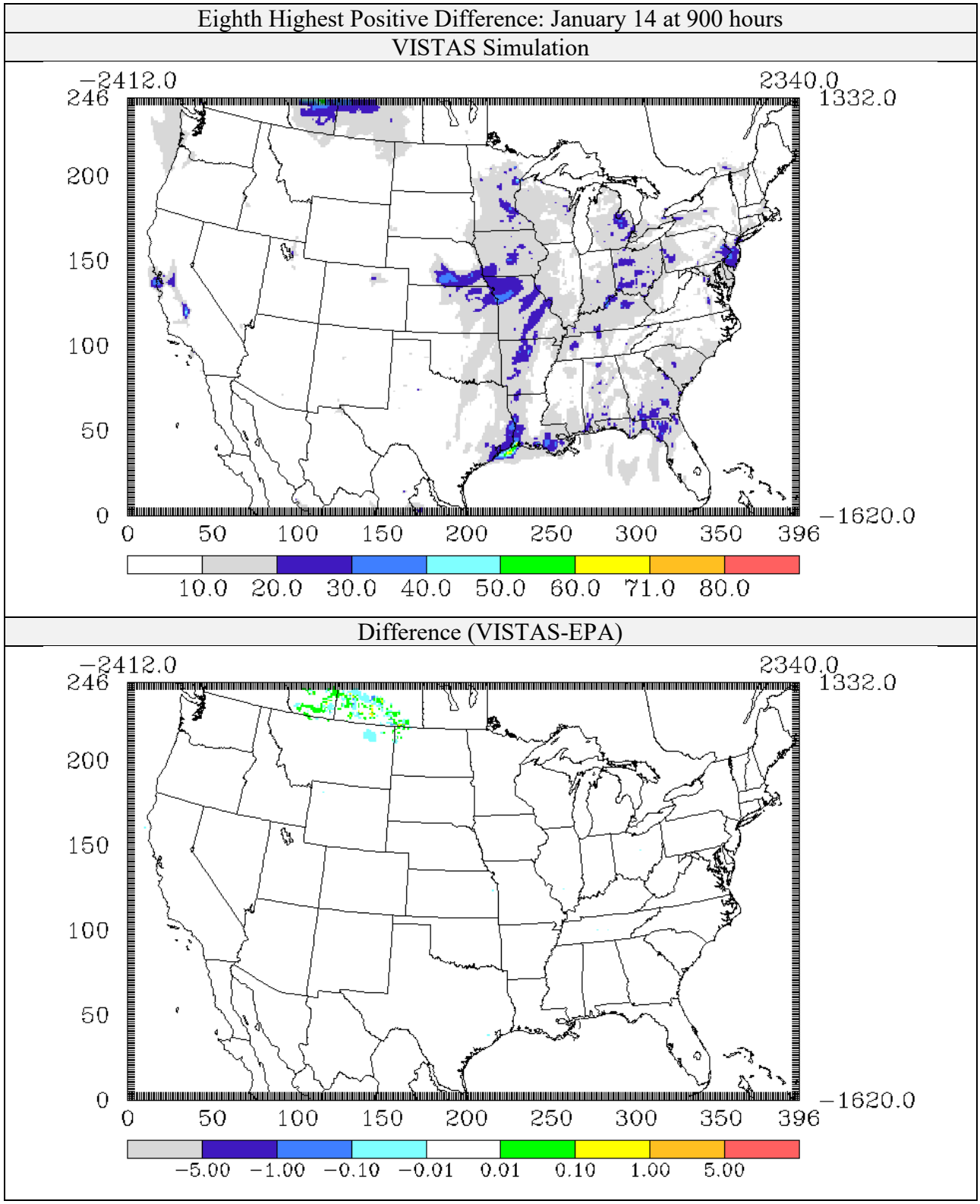


Figure 4-29: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference)

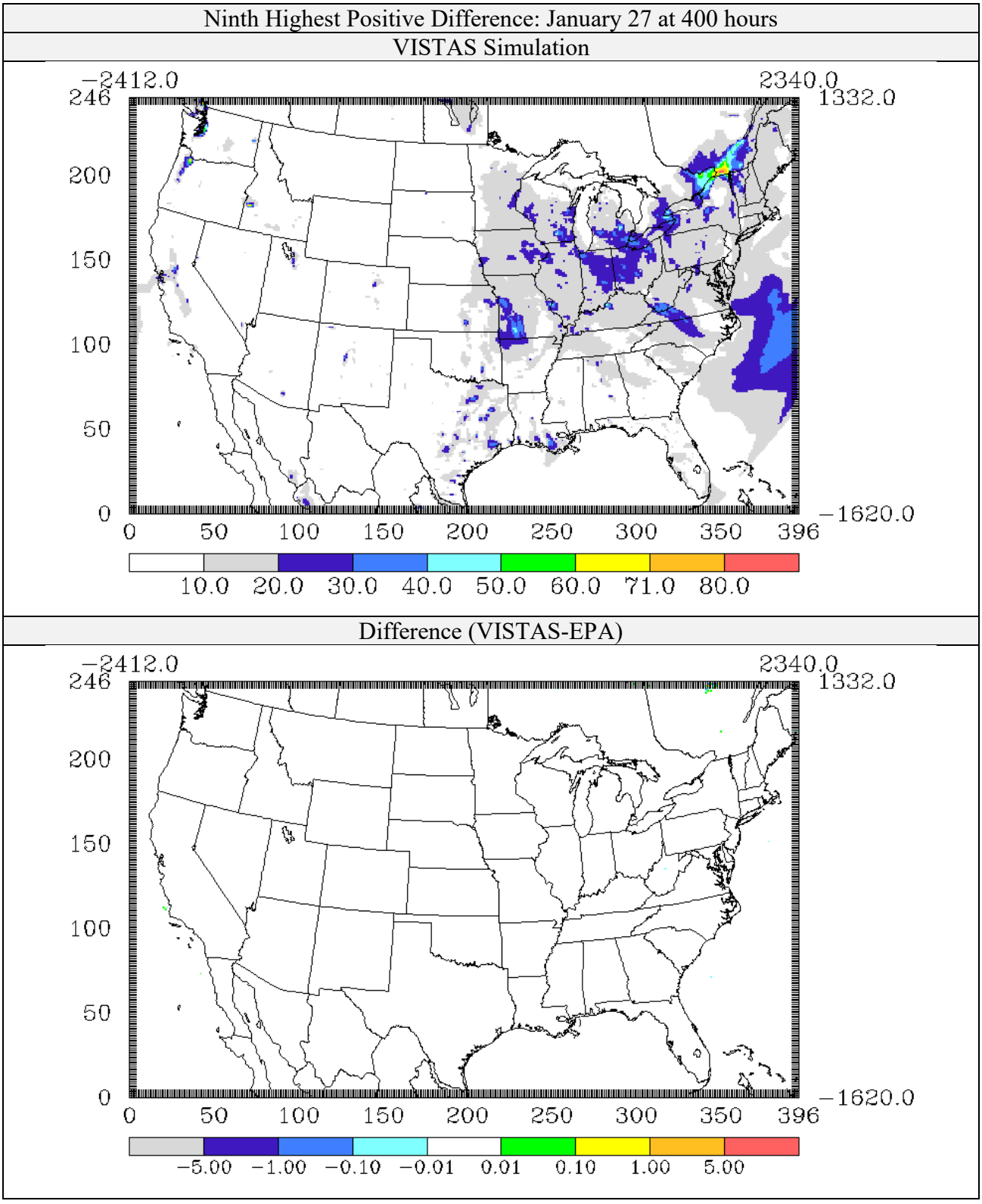


Figure 4-30: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference)

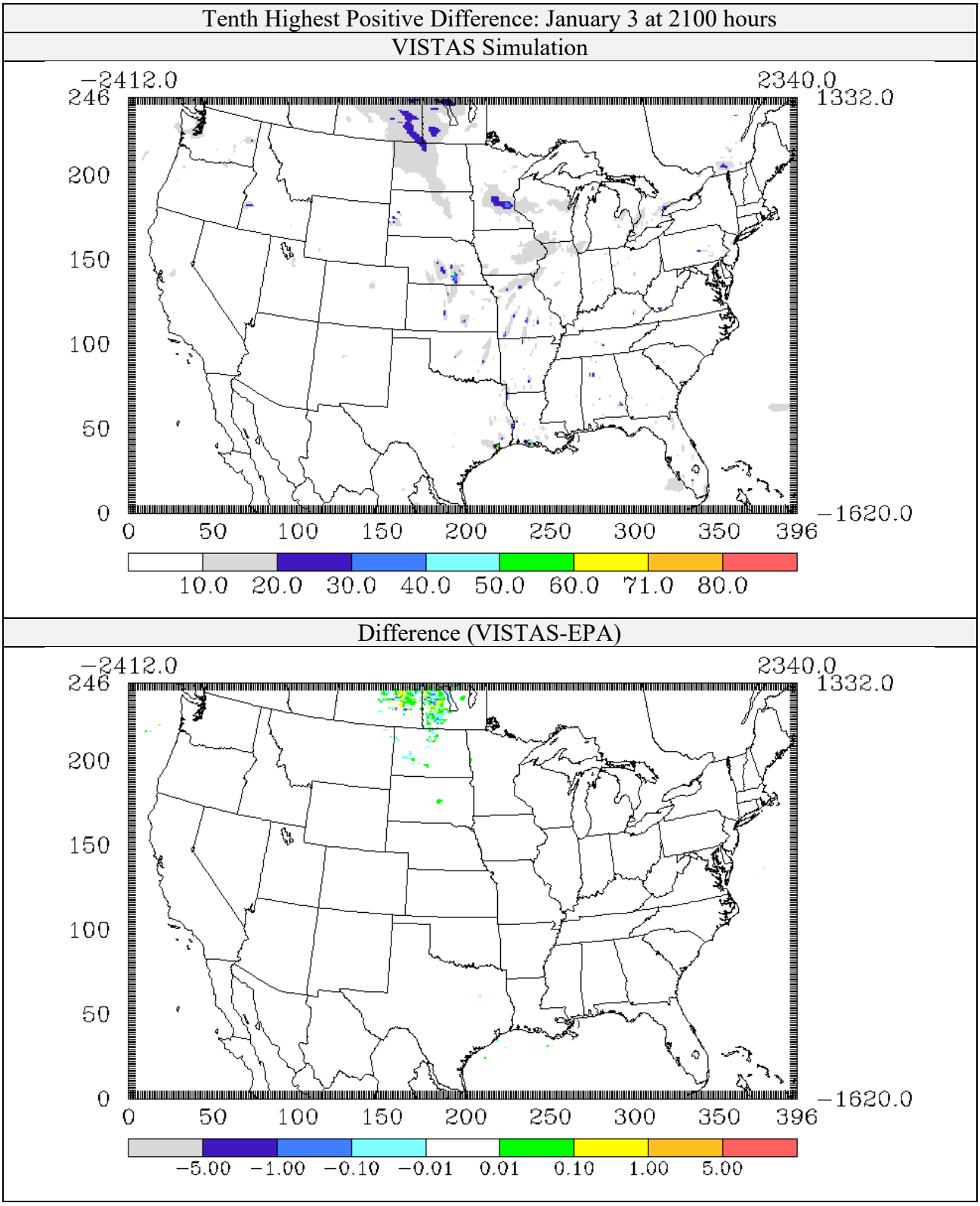


Figure 4-31: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference)

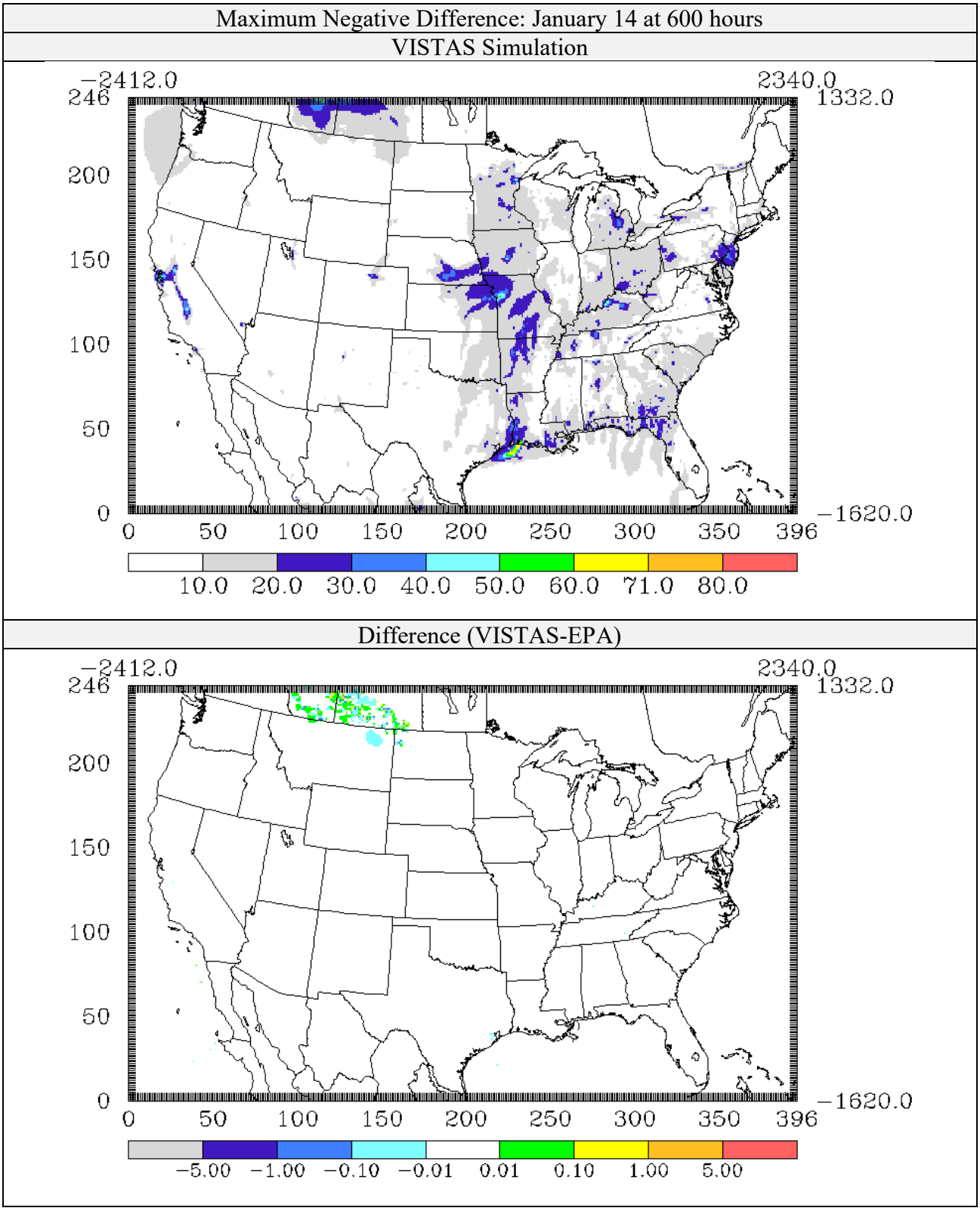


Figure 4-32: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference)

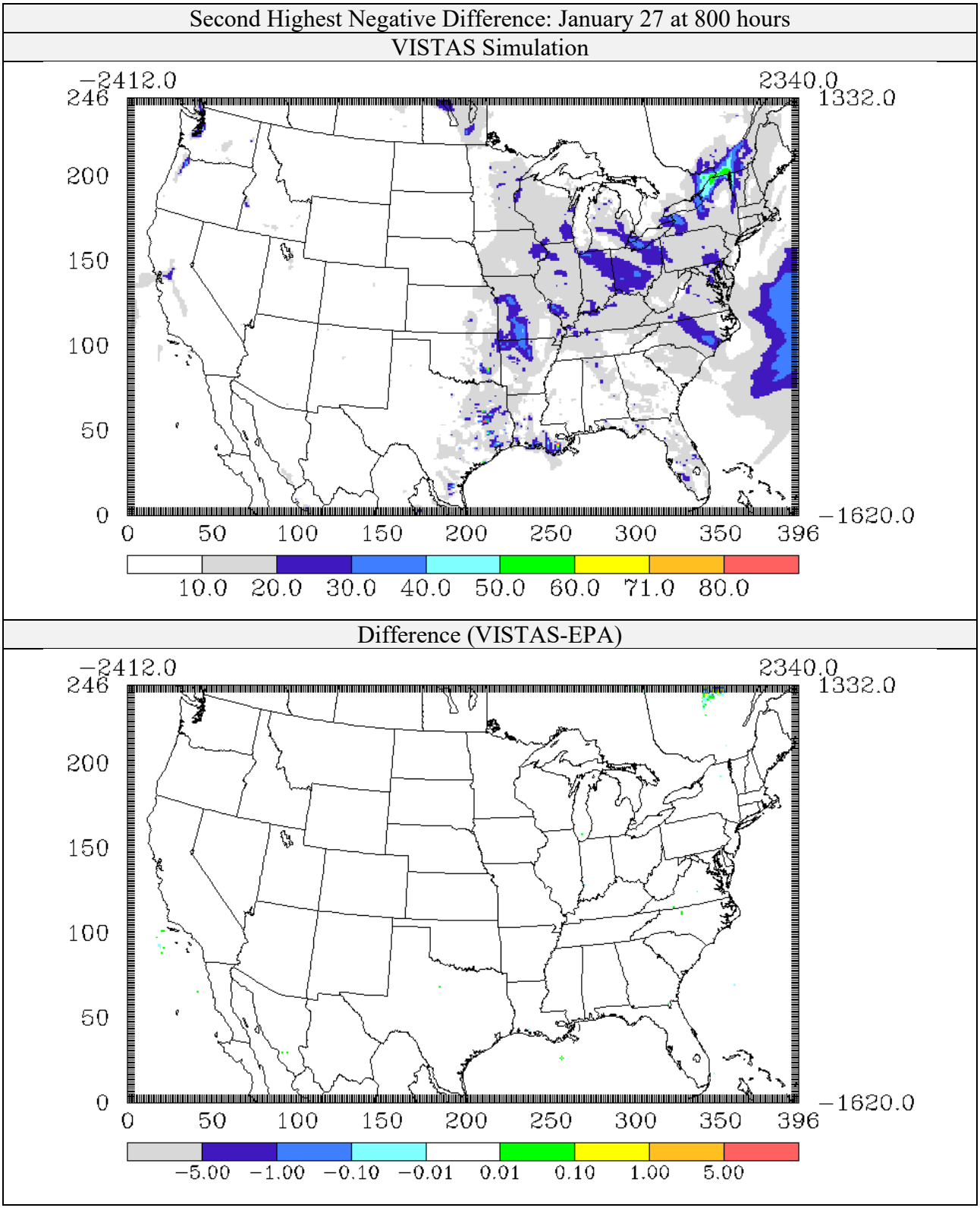


Figure 4-33: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference)

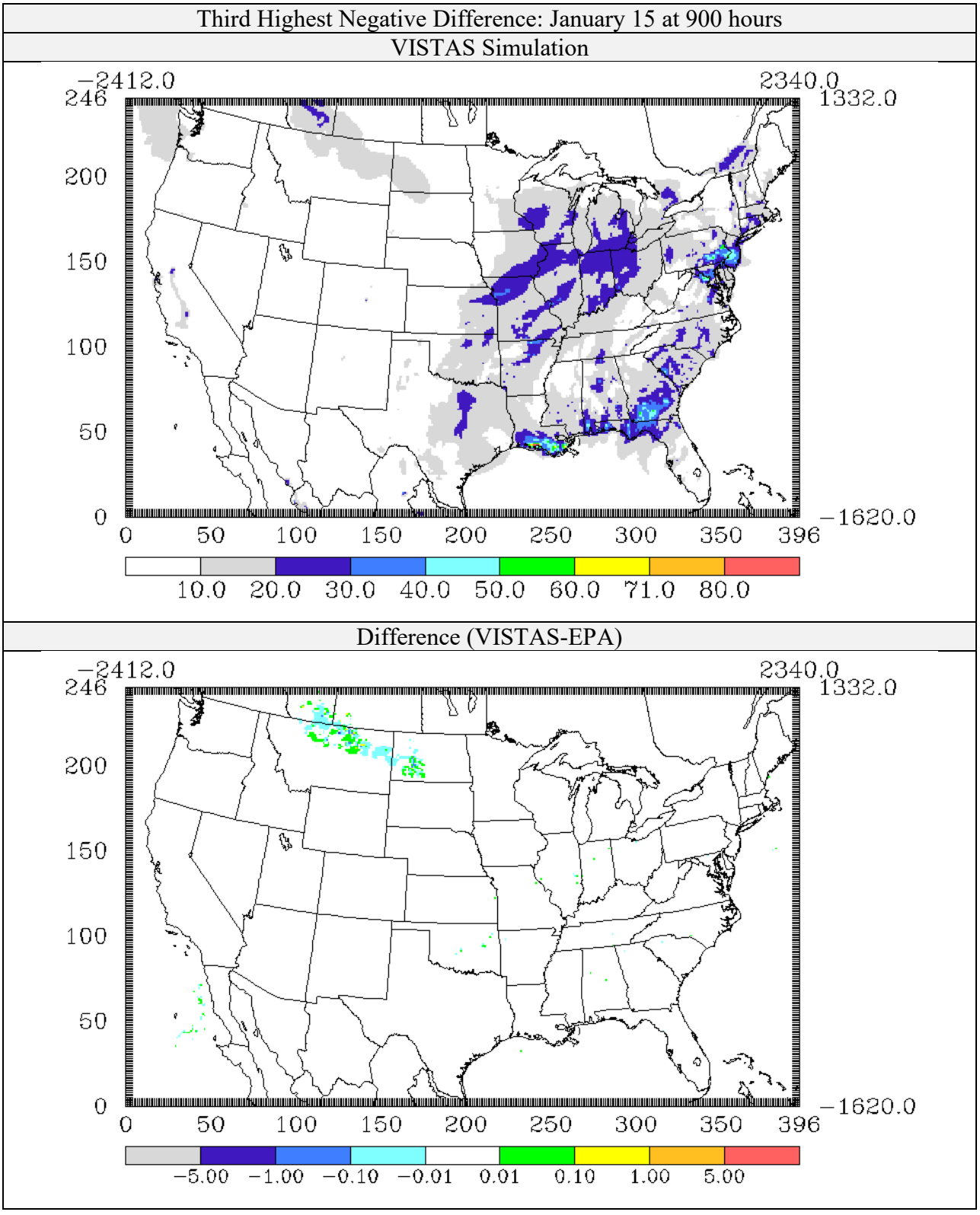


Figure 4-34: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference)

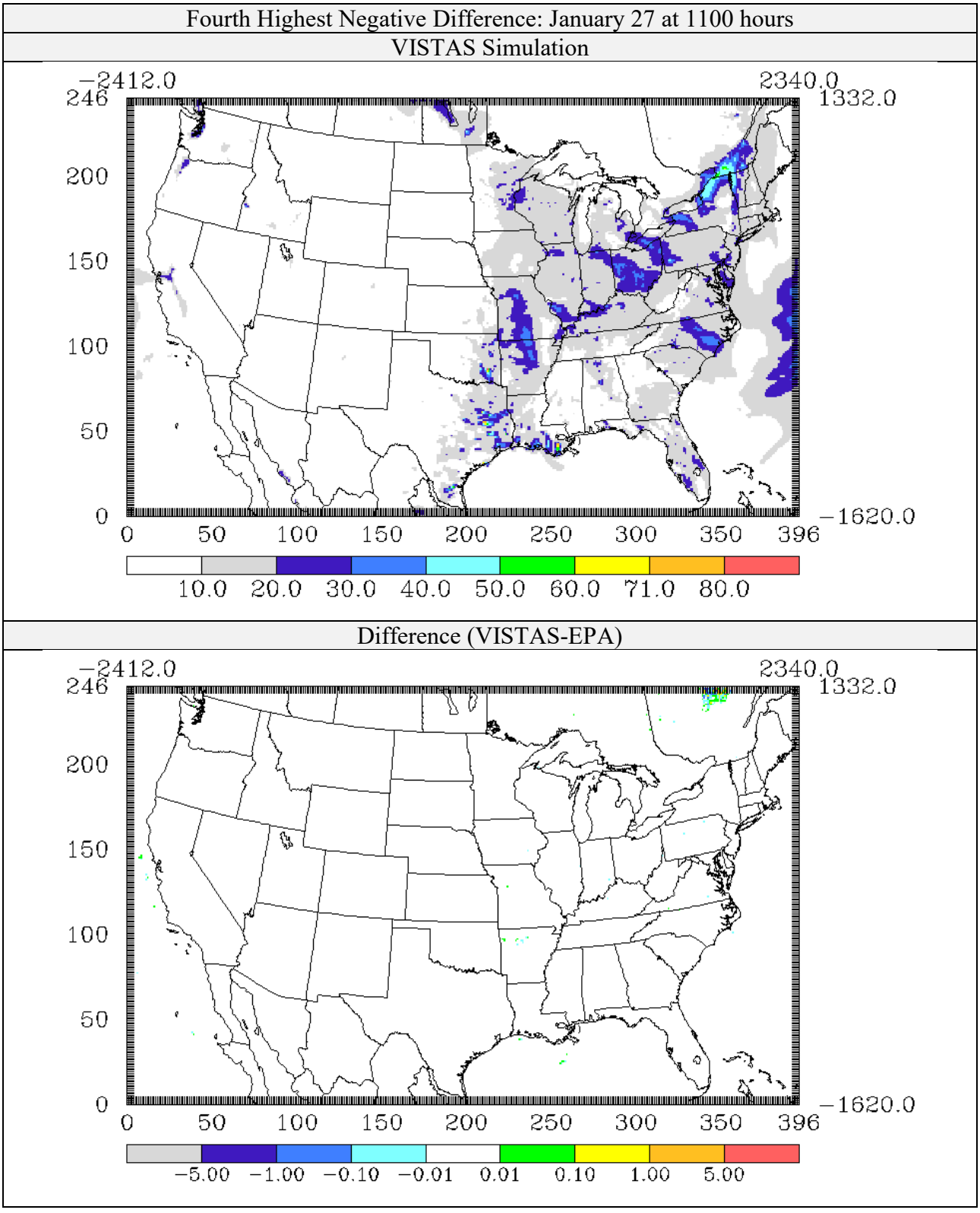


Figure 4-35: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference)

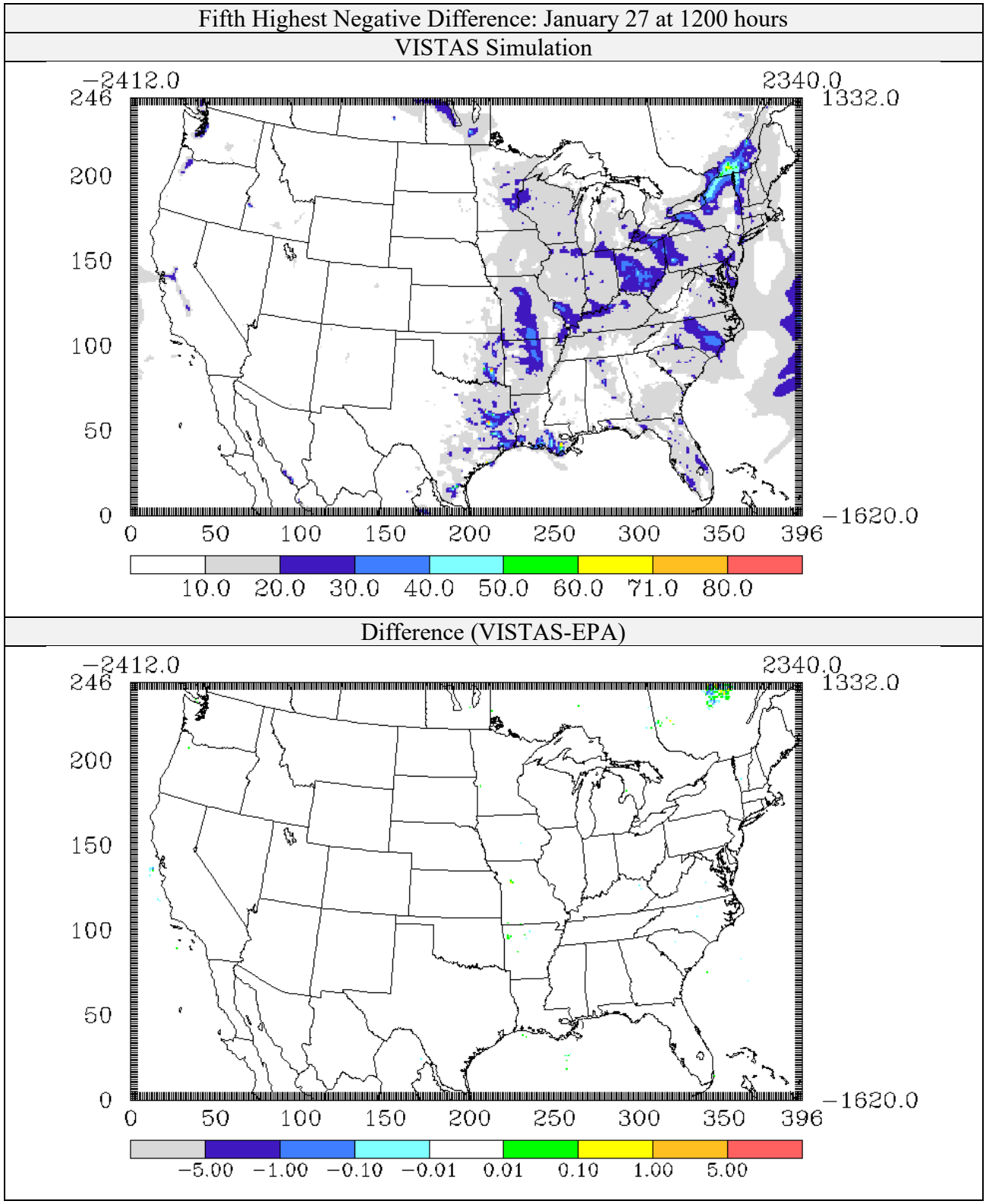


Figure 4-36: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference)

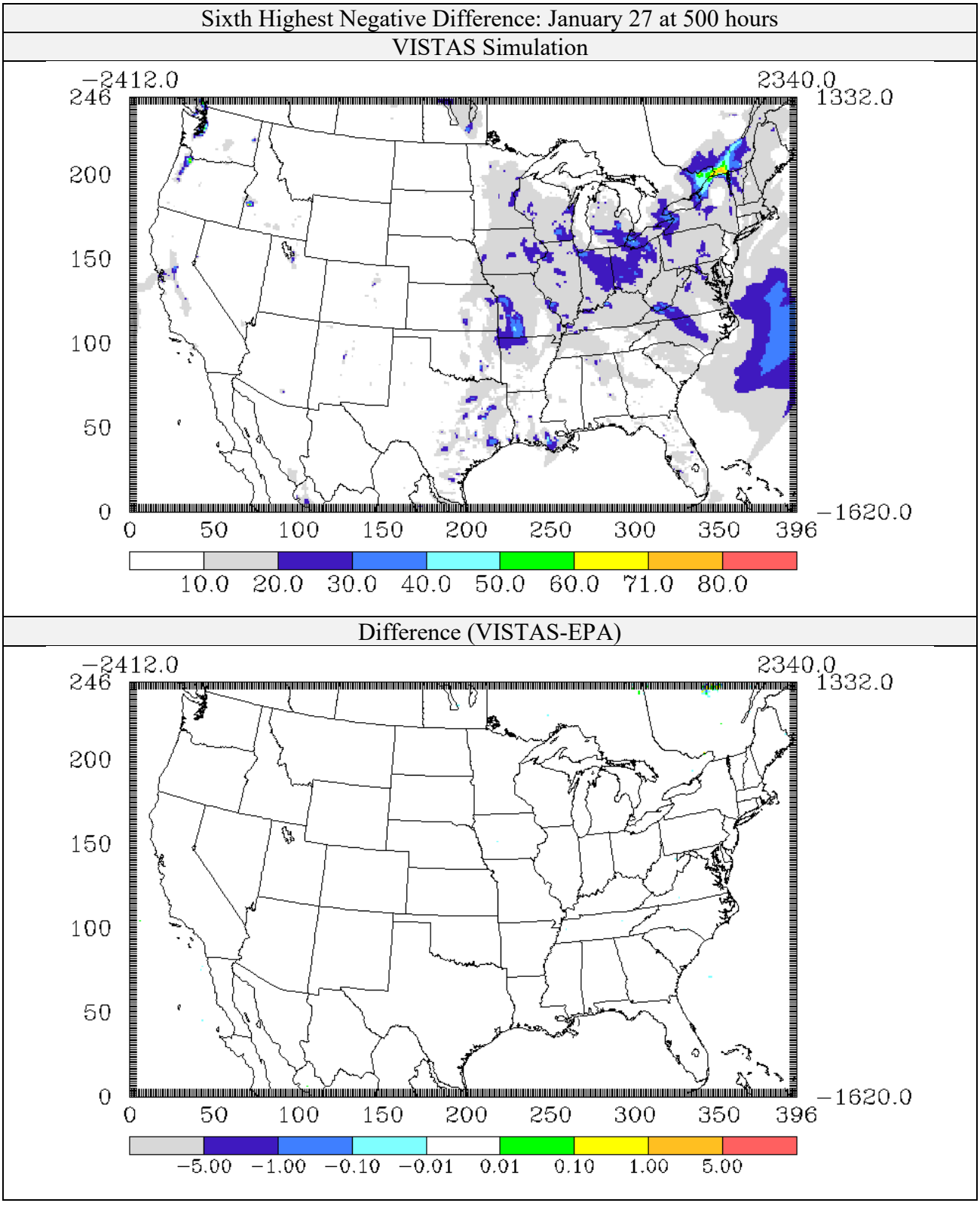


Figure 4-37: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference)

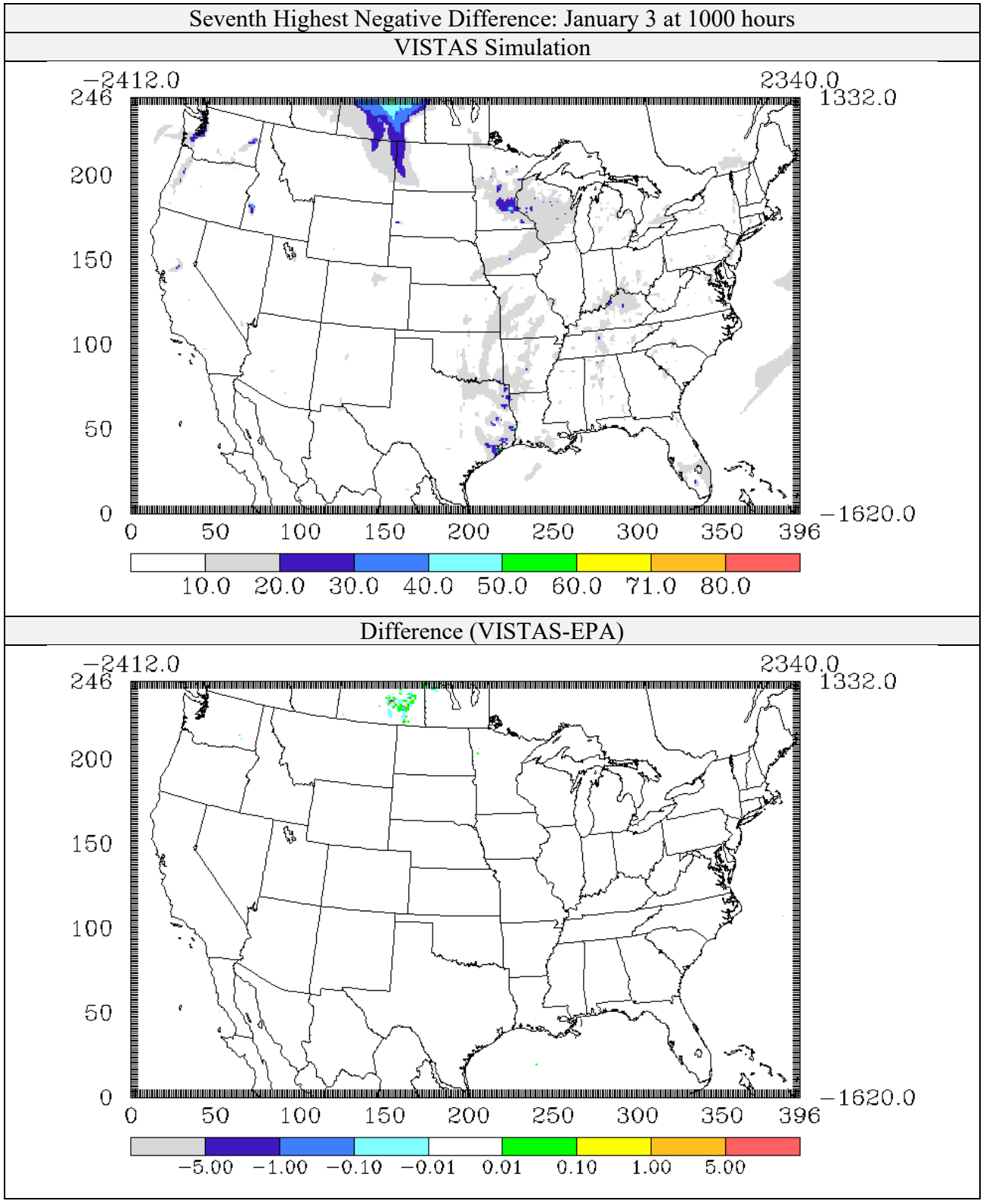


Figure 4-38: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference)

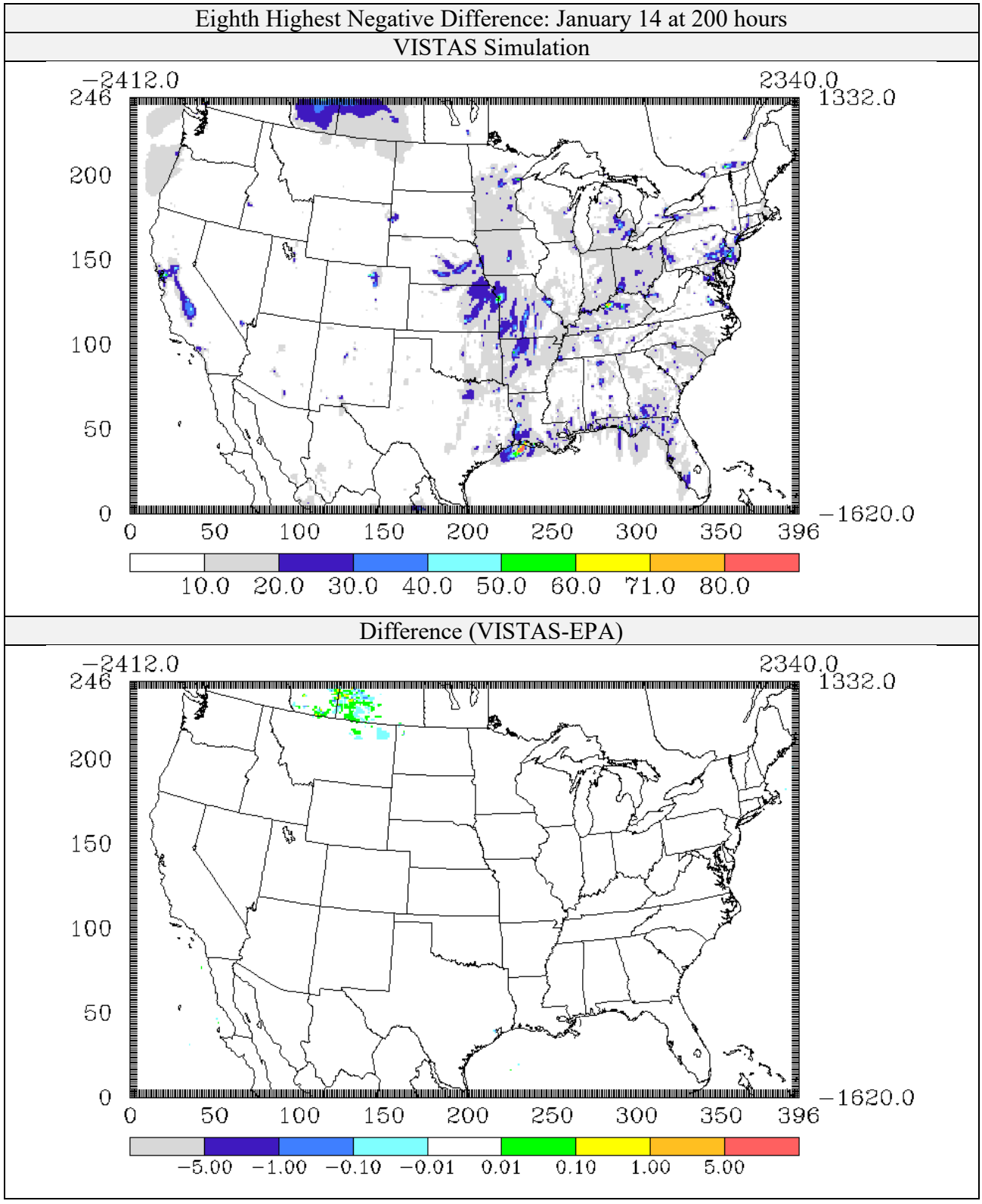


Figure 4-39: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference)

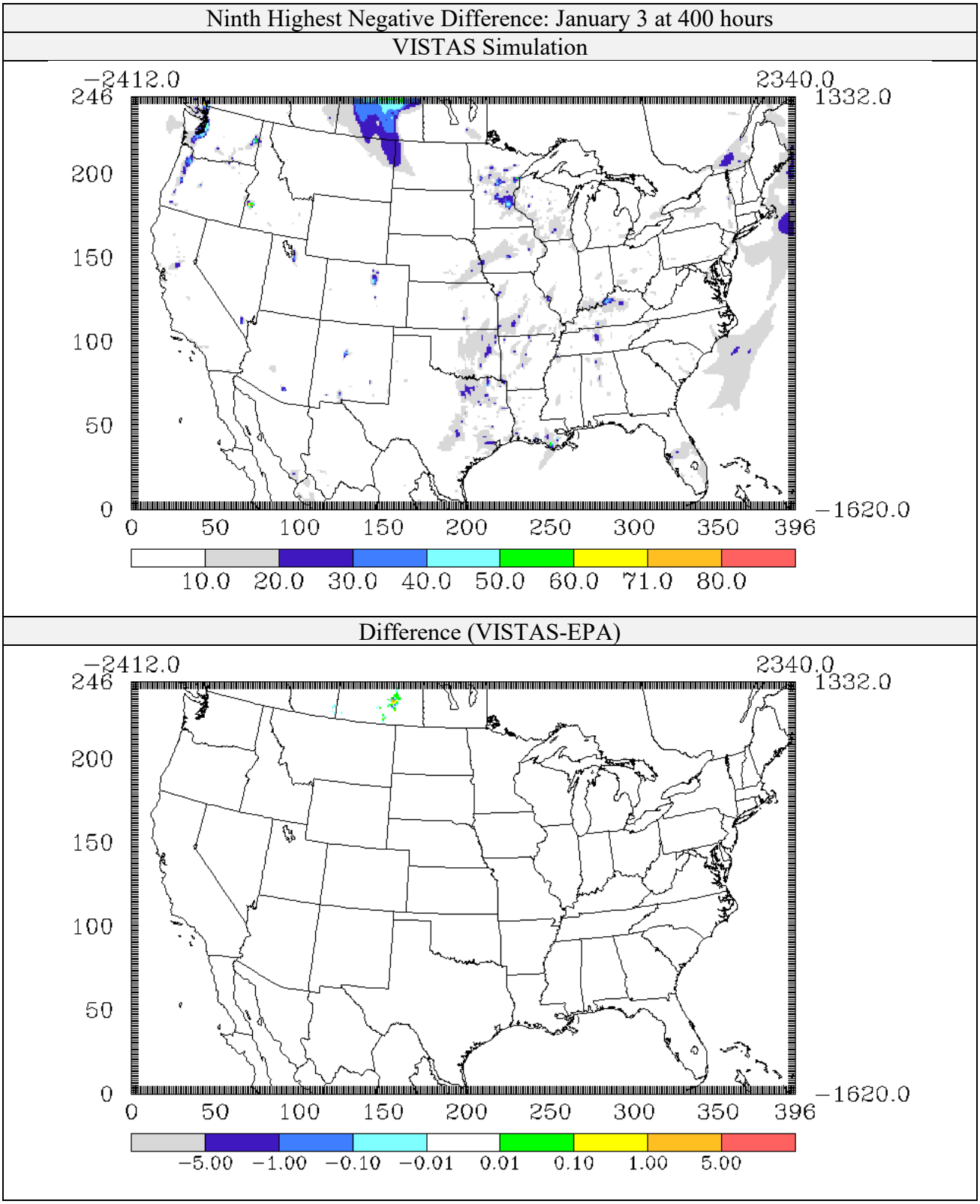


Figure 4-40: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference)

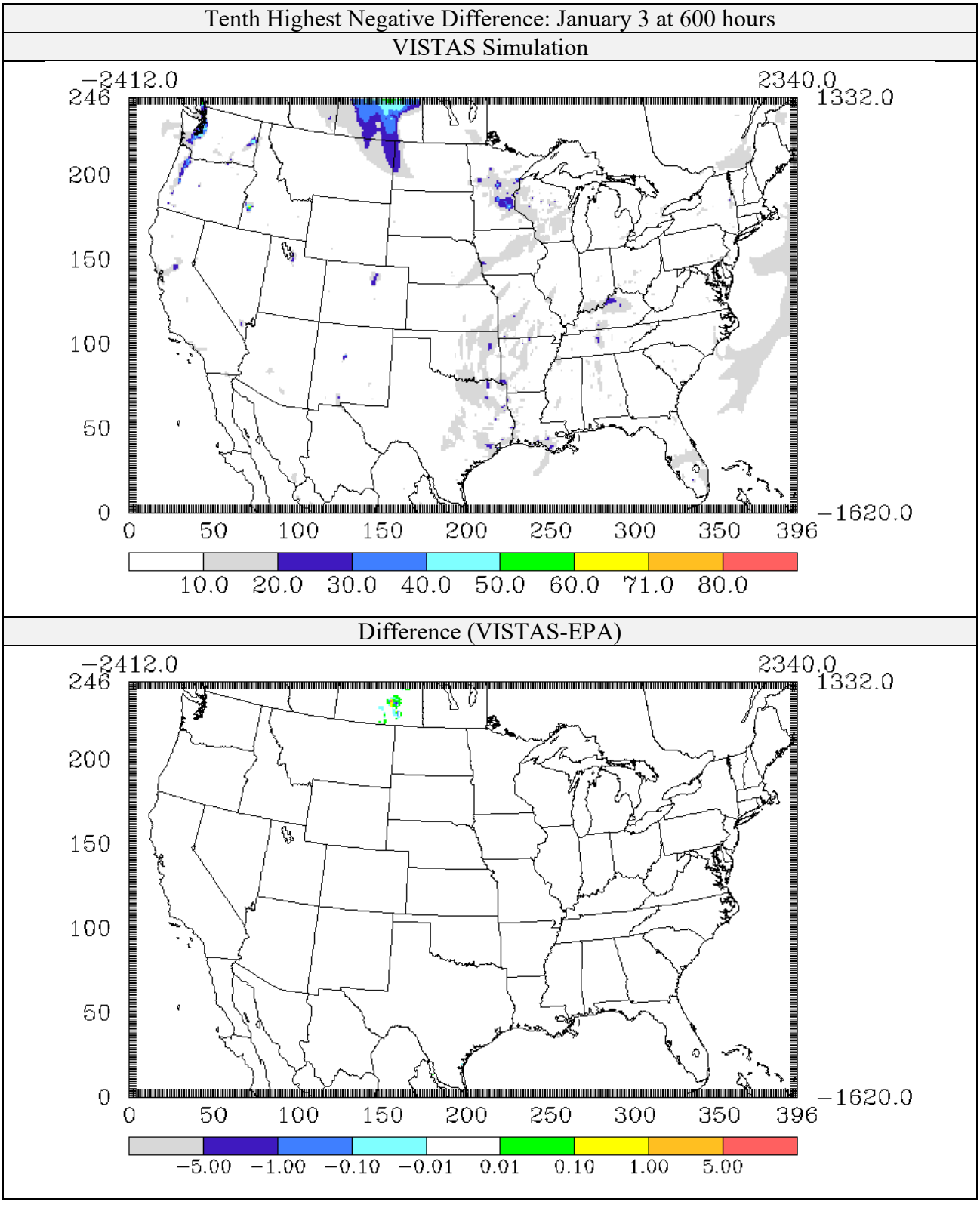


Figure 4-41: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference)

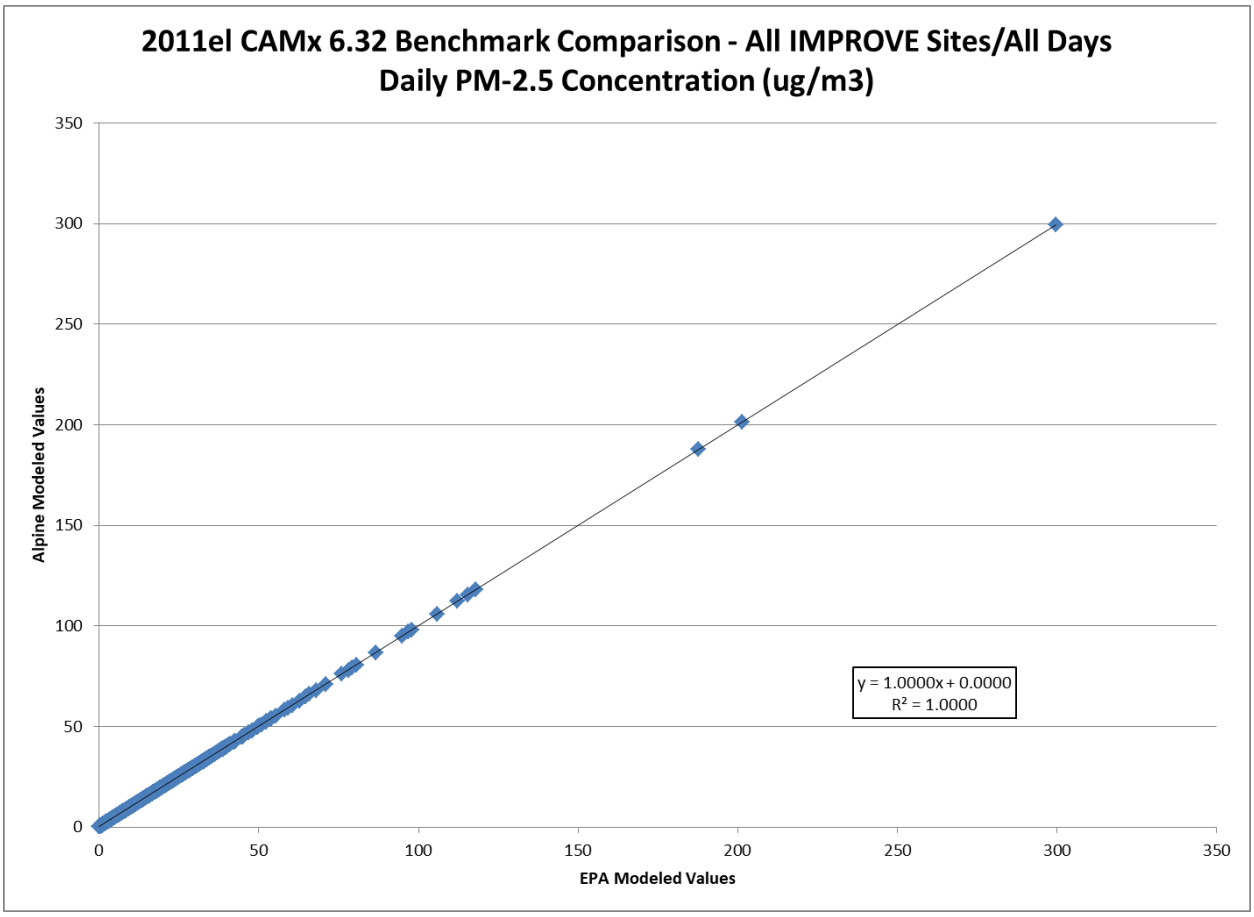


Figure 4-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine).

4.3 Sulfate

Sulfate results for the top 10 positive and negative hours are presented in tabular format in Table 4-3. The maximum positive difference is 0.31 µg/m^3 falling to 0.19 µg/m^3 for the 10th high. The maximum negative difference is -0.40 µg/m^3 falling to -0.14 µg/m^3 for the 10th high. The maximum positive percent difference from these days is 15.09% and negative percent difference of -18.5%.

The top 10 positive impact hours are presented in Figures 4-43 through 4-52 and the top 10 negative impact hours are presented in Figures 4-53 through 4-62. The locations of the impacts are considerably more localized than the nitrate differences, and are not occurring in any systematic location, but are tending to occur in the colder months. The area of the differences does not appear to be correlated with areas of high sulfate concentrations.

Scatterplots of the daily average sulfate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-63. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

Table 4-3. Comparison of 2011el CAMx 6.32 Simulation Sulfate Concentrations (µg/m^3) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	12	31	16	14.98	14.67	0.31	2.12%	247	47
2011	11	29	15	4.91	4.60	0.31	6.74%	206	155
2011	1	10	3	2.20	1.91	0.29	15.09%	259	174
2011	12	31	15	14.06	13.78	0.28	2.06%	247	47
2011	12	14	22	6.46	6.18	0.28	4.54%	282	175
2011	4	9	9	6.40	6.14	0.26	4.21%	156	210
2011	4	8	2	7.66	7.41	0.25	3.31%	172	229
2011	11	29	16	4.44	4.22	0.23	5.36%	206	153
2011	4	9	10	6.46	6.23	0.22	3.57%	156	209
2011	4	9	8	6.19	6.00	0.19	3.19%	156	211
Maximum Negative									
2011	12	6	0	5.65	6.05	-0.40	-6.55%	364	164
2011	12	14	22	5.28	5.63	-0.35	-6.22%	282	173
2011	12	6	1	5.48	5.77	-0.30	-5.13%	364	164
2011	2	6	17	3.72	3.95	-0.23	-5.79%	211	140
2011	5	28	7	2.39	2.61	-0.22	-8.39%	336	186
2011	2	6	16	3.11	3.29	-0.17	-5.29%	211	141
2011	5	14	7	0.64	0.79	-0.15	-18.53%	354	236
2011	12	18	11	3.06	3.21	-0.14	-4.51%	282	115
2011	12	29	16	4.24	4.38	-0.14	-3.28%	209	194
2011	12	30	11	2.82	2.95	-0.14	-4.68%	313	178

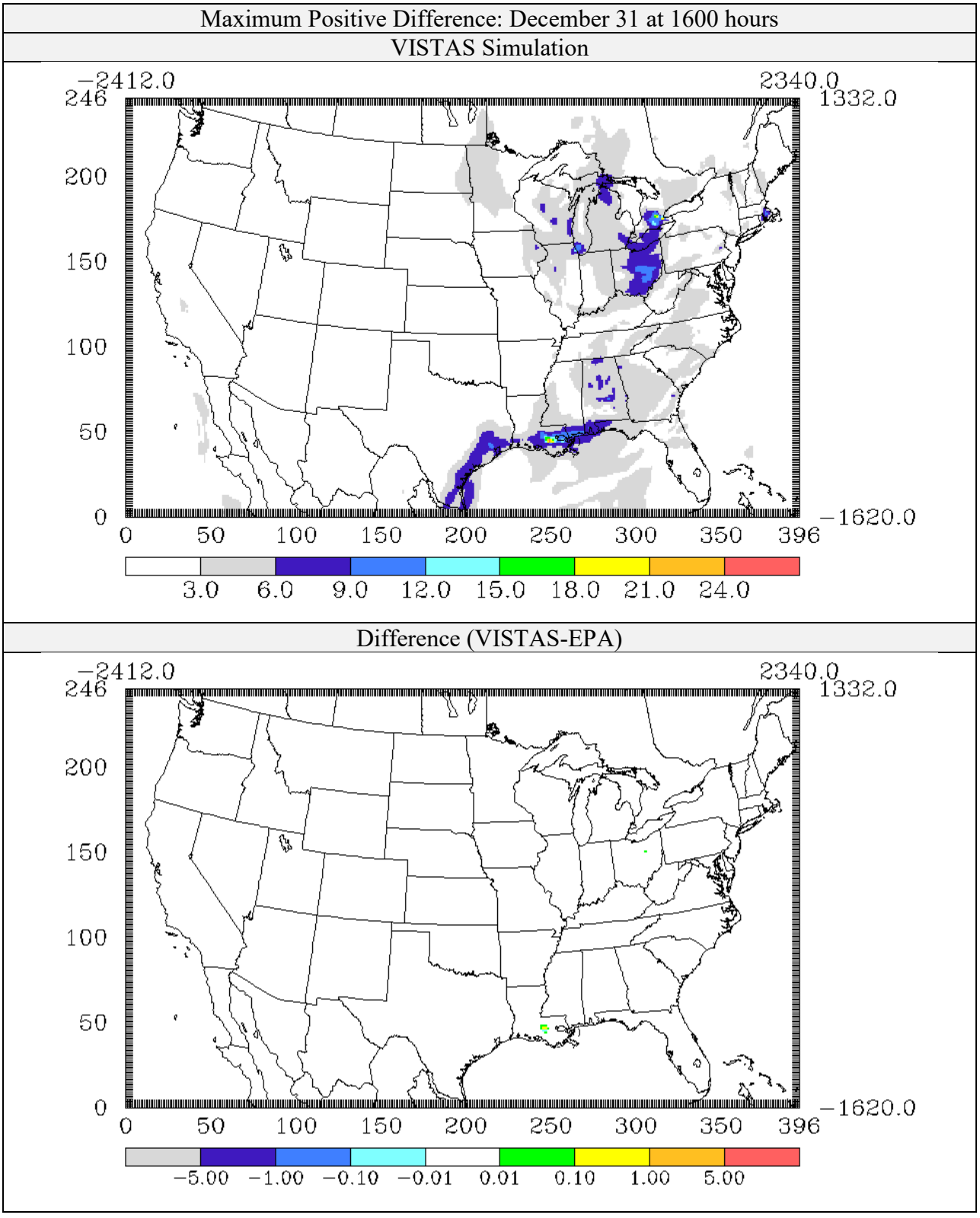


Figure 4-43: Comparison of Sulfate Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference)

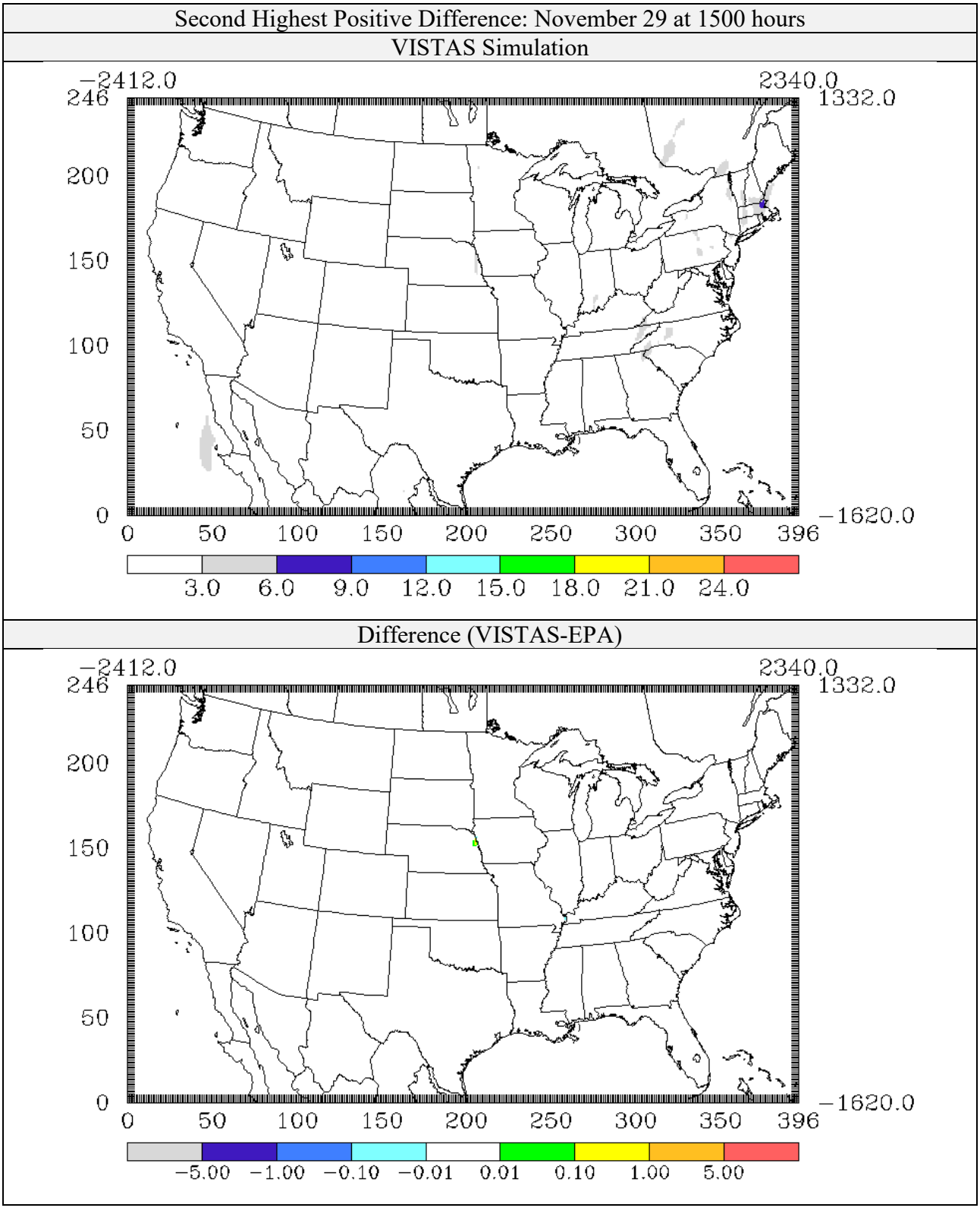


Figure 4-44: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference)

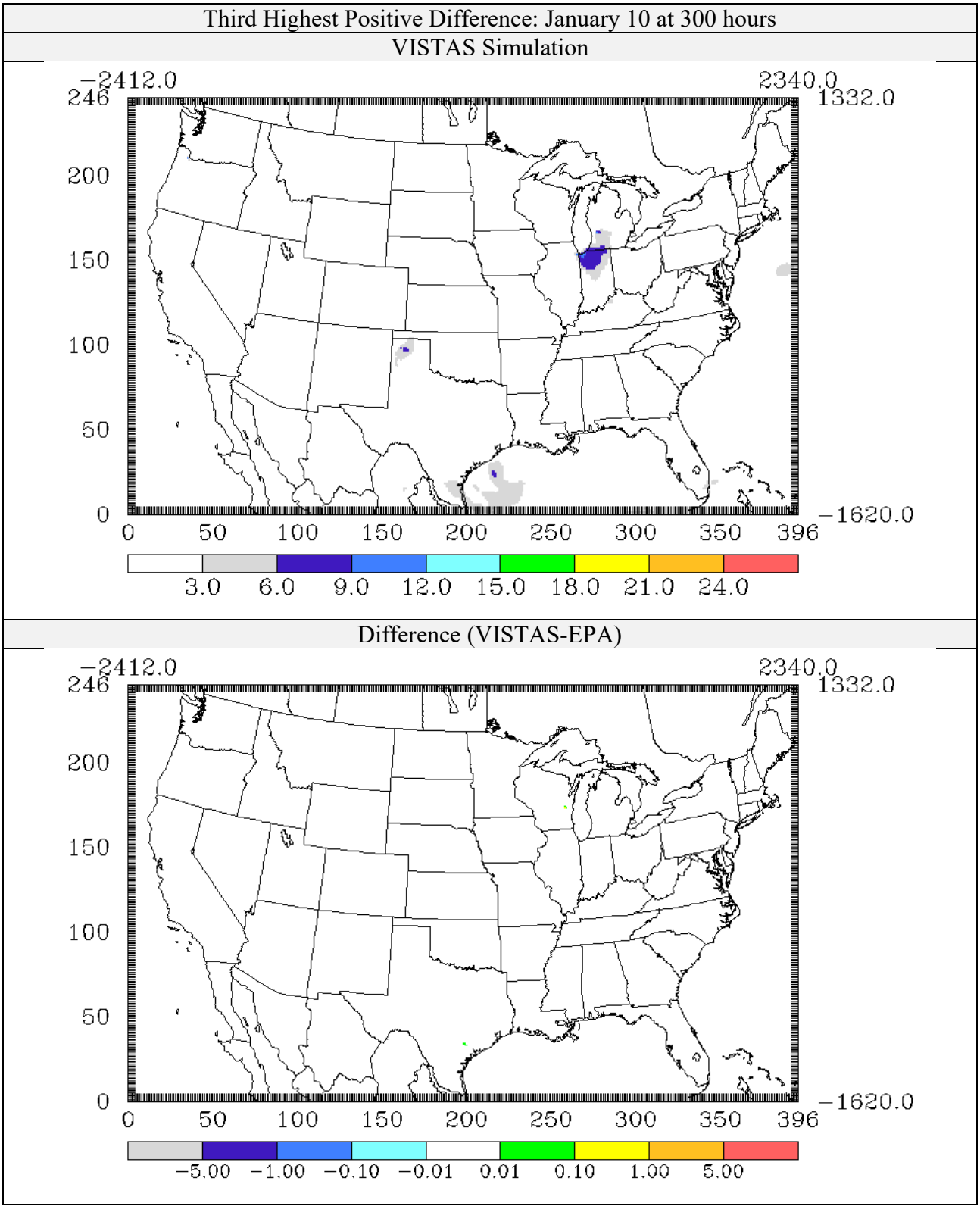


Figure 4-45: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference)

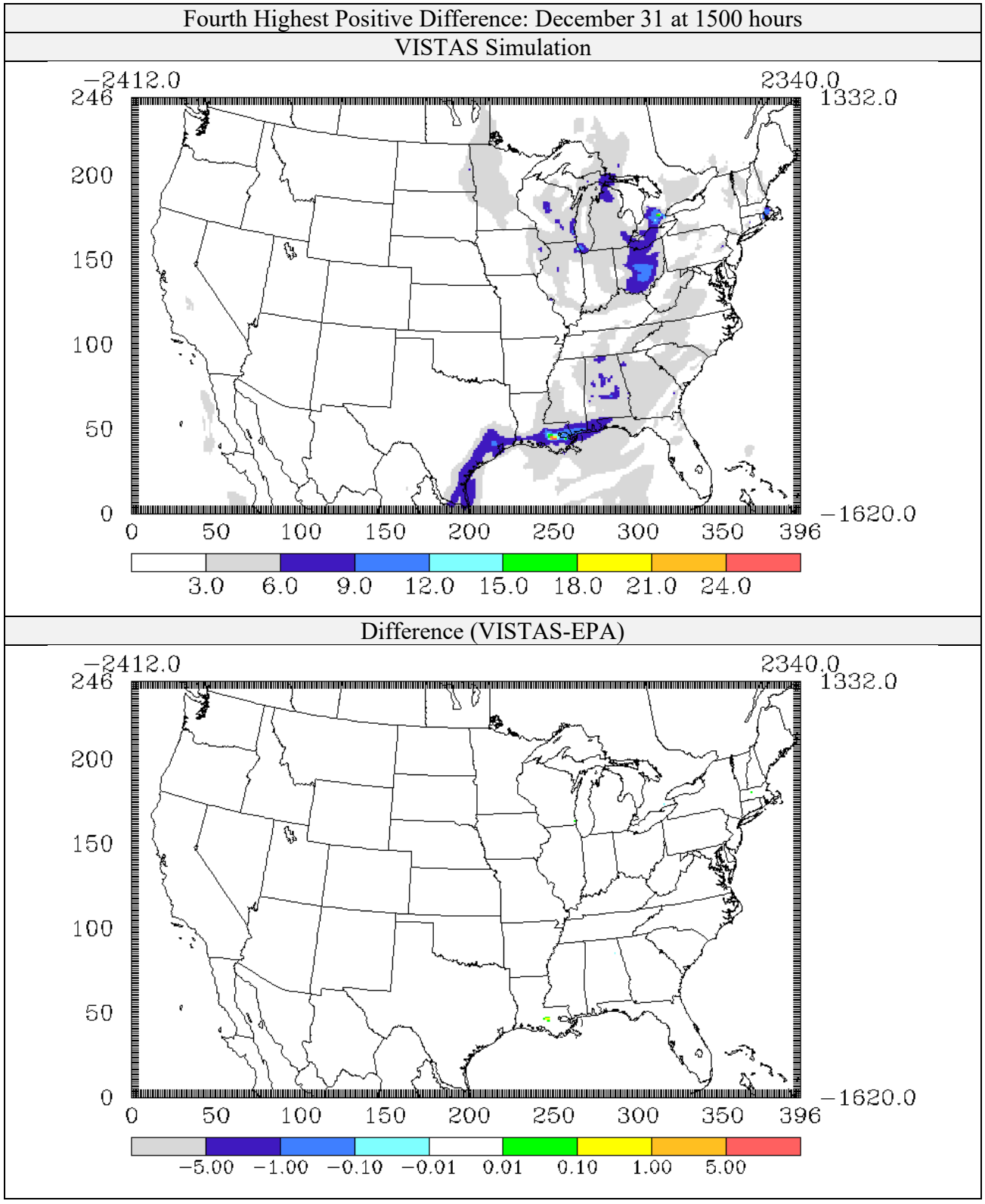


Figure 4-46: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference)

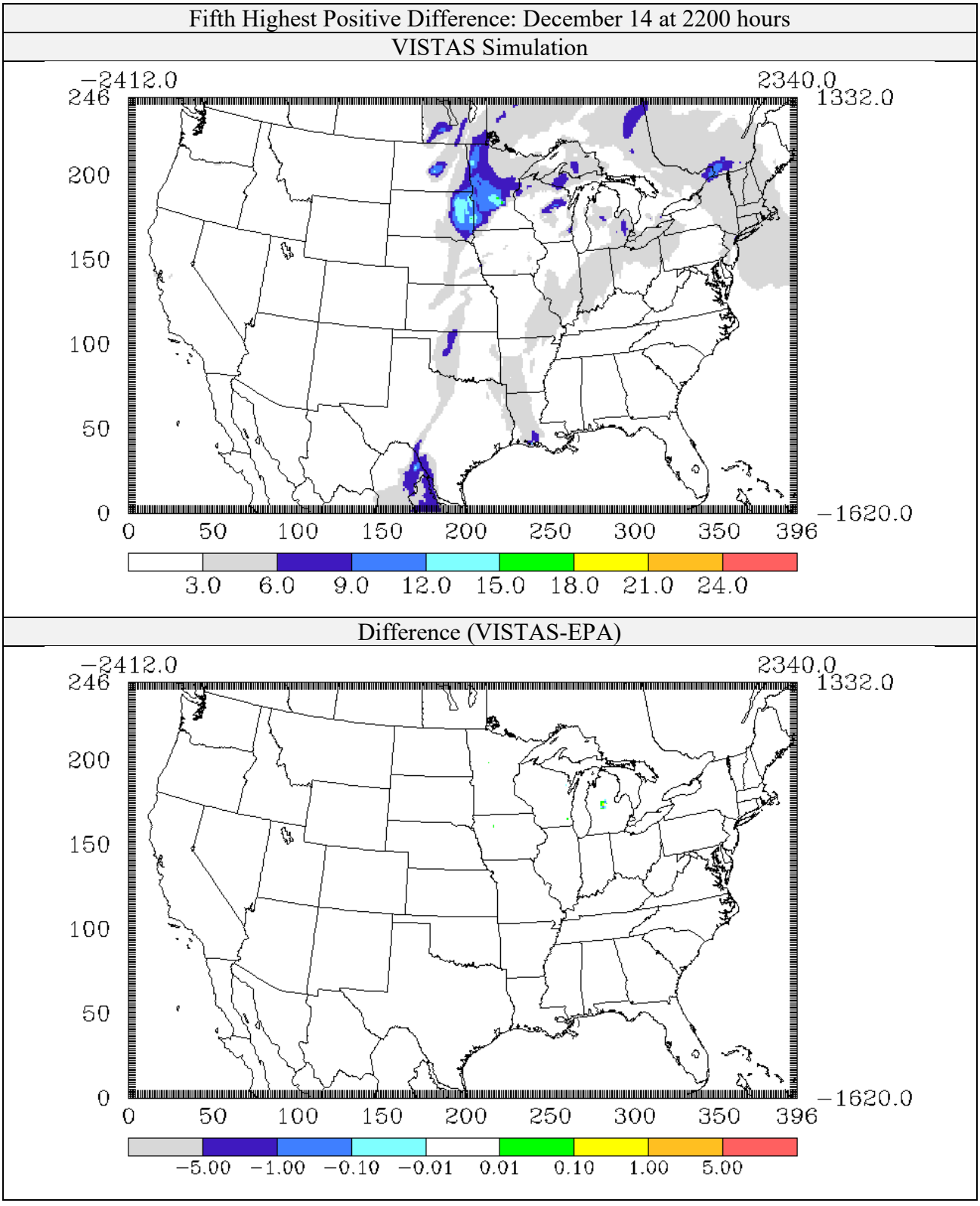


Figure 4-47: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference)

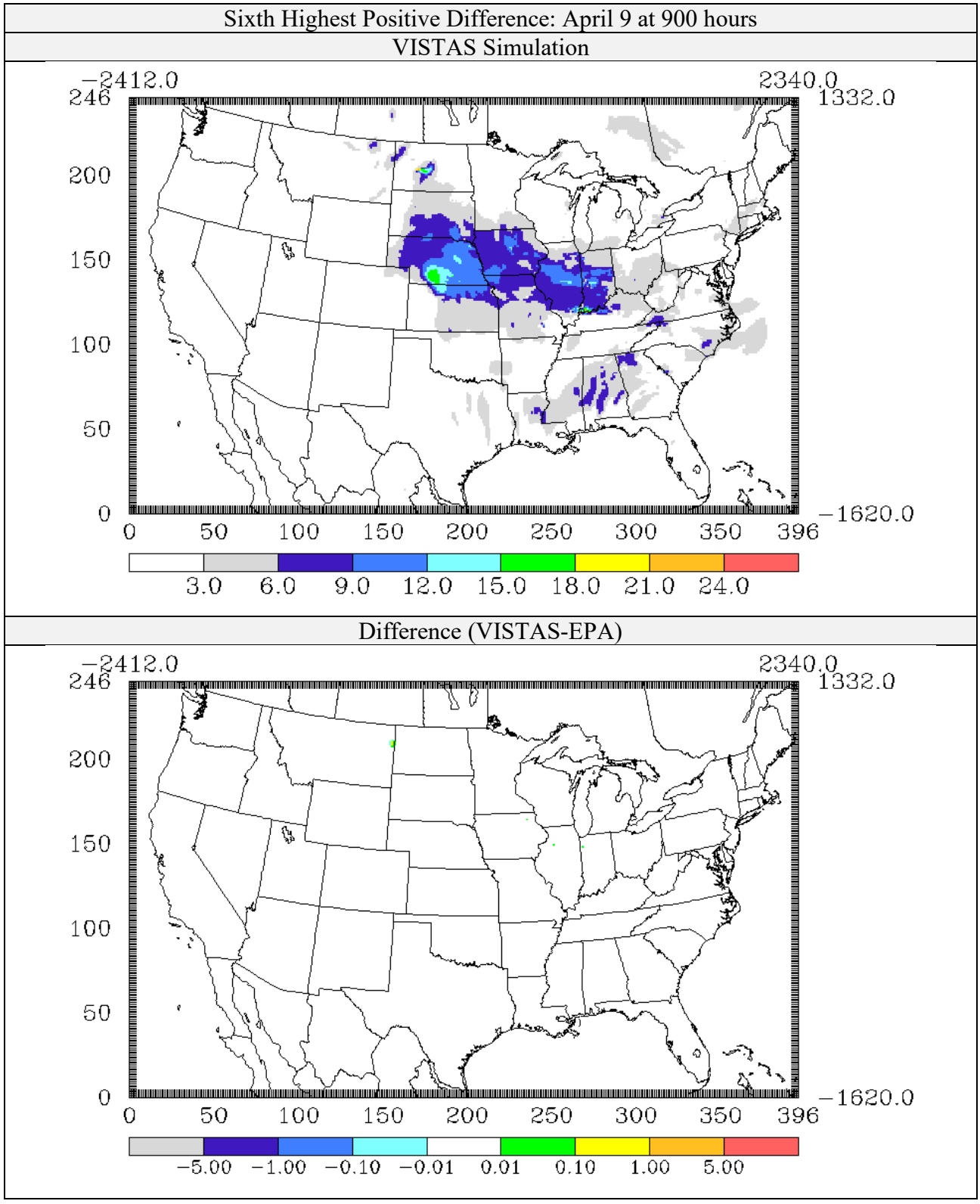


Figure 4-48: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference)

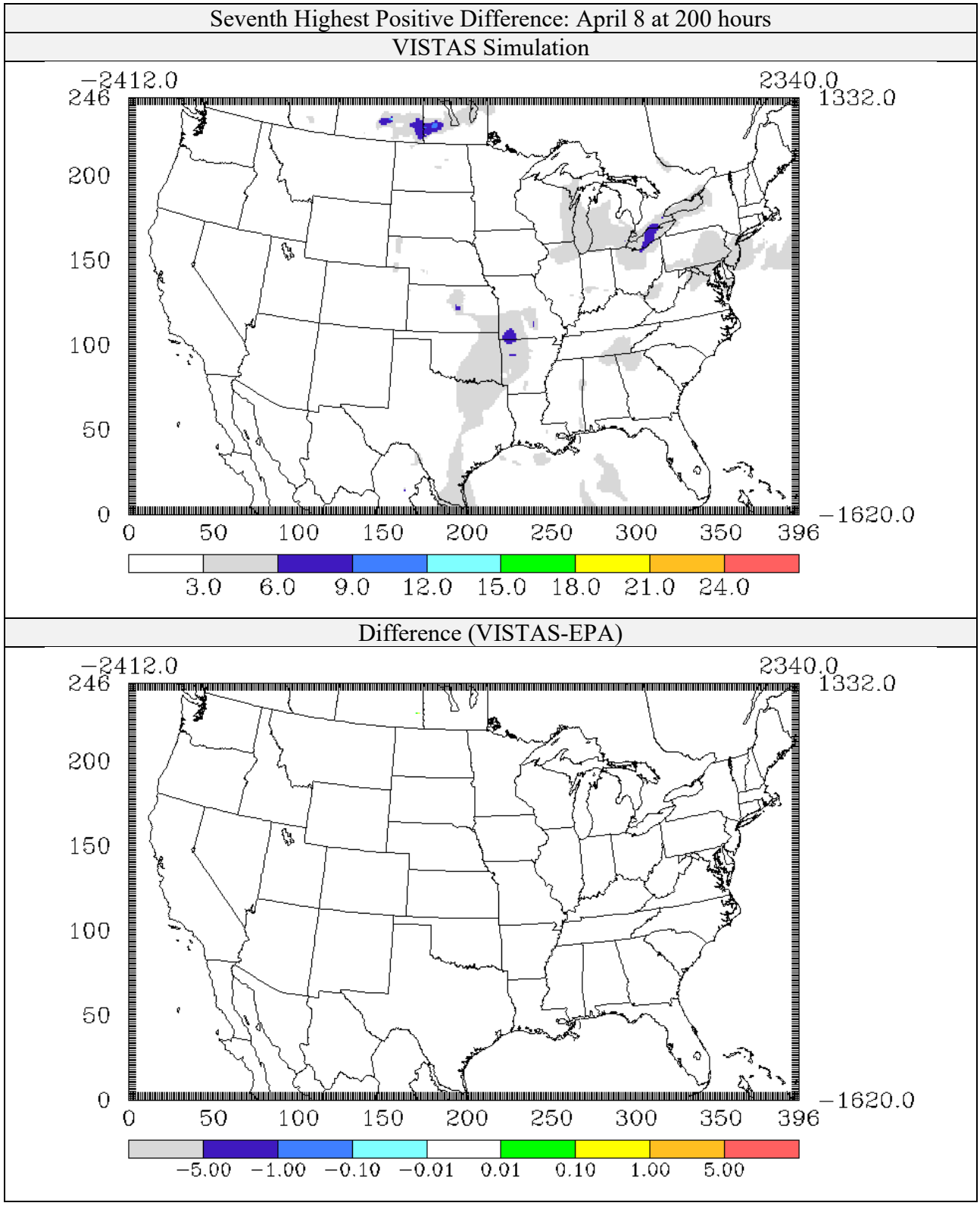


Figure 4-49: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference)

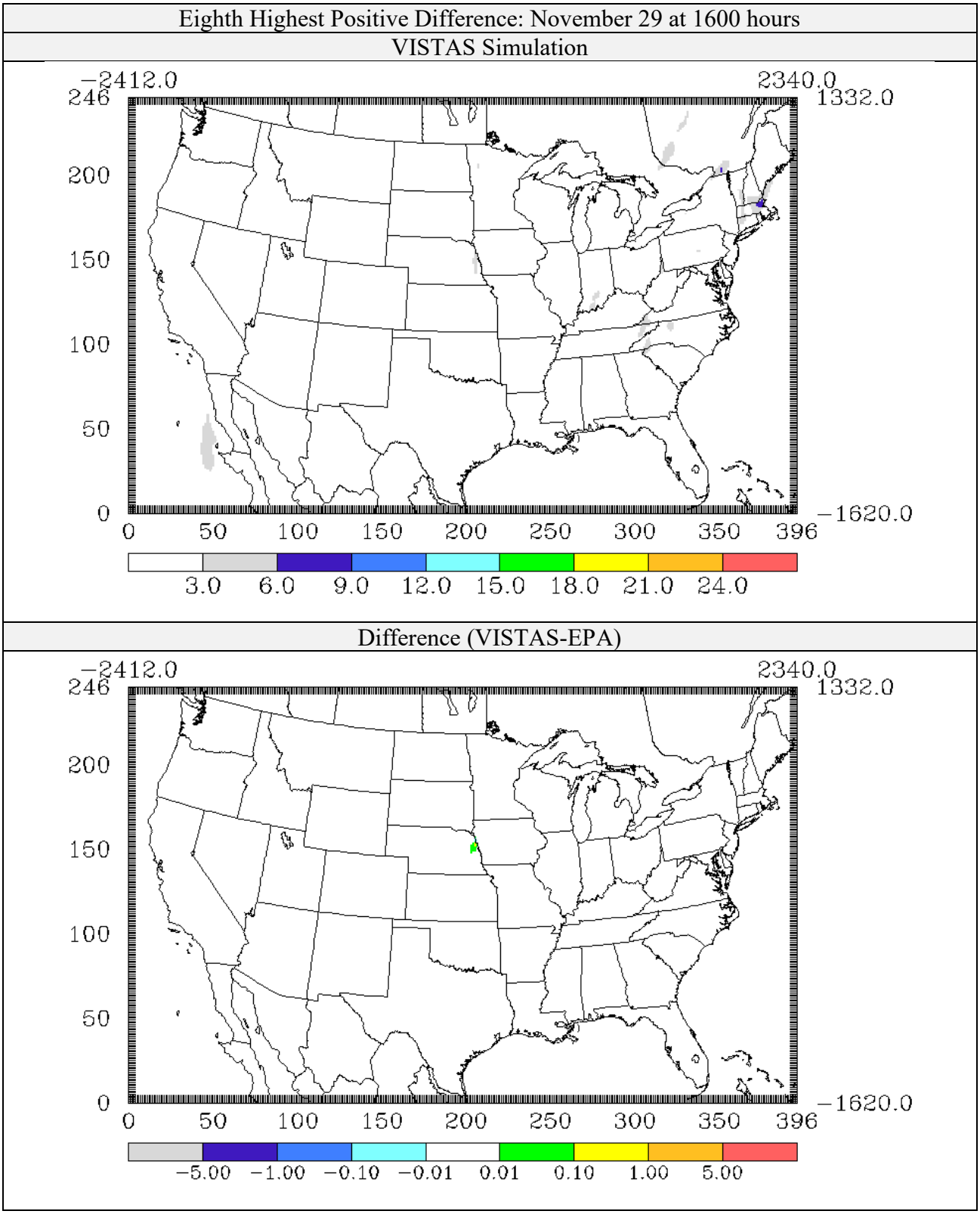


Figure 4-50: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference)

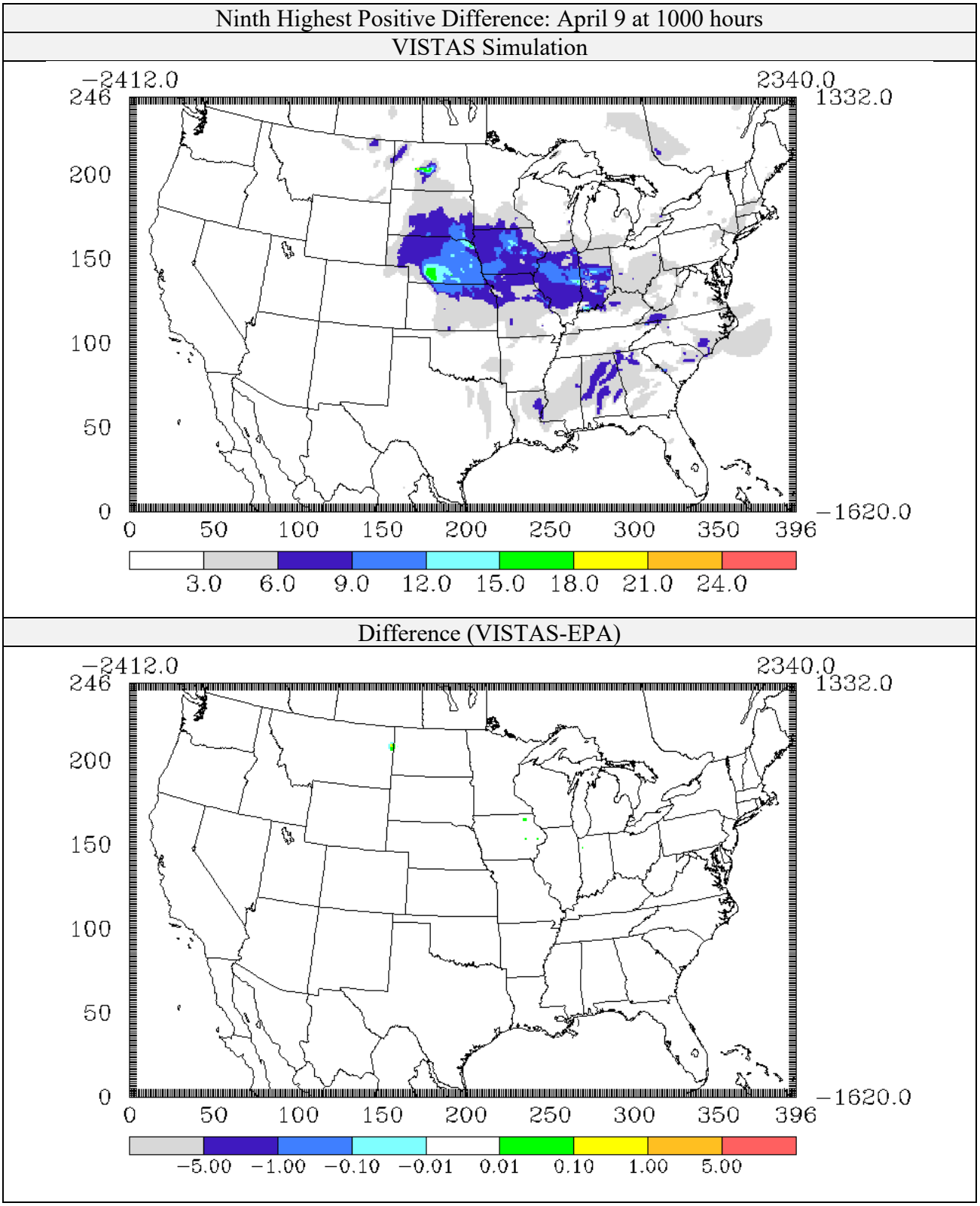


Figure 4-51: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference)

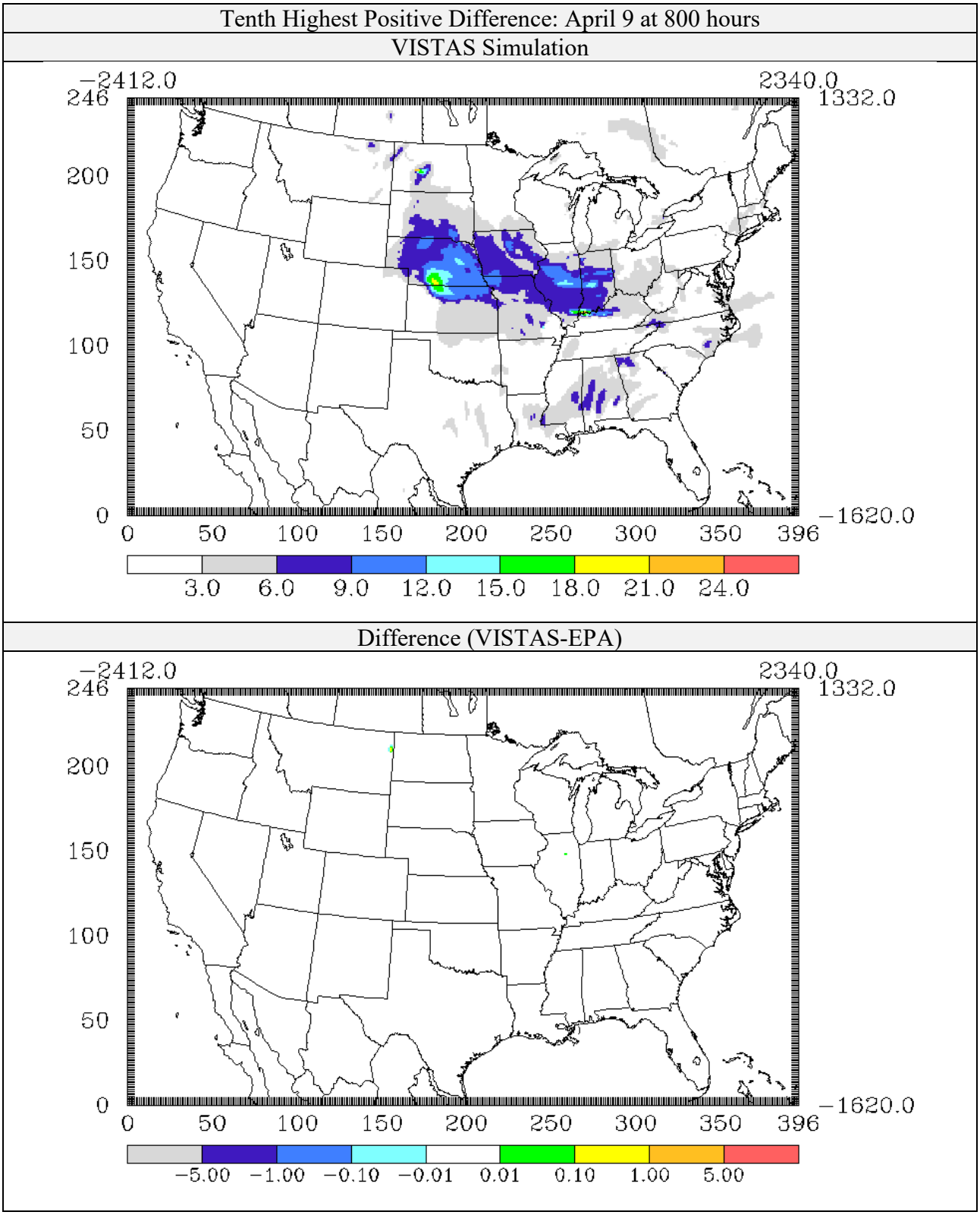


Figure 4-52: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference)

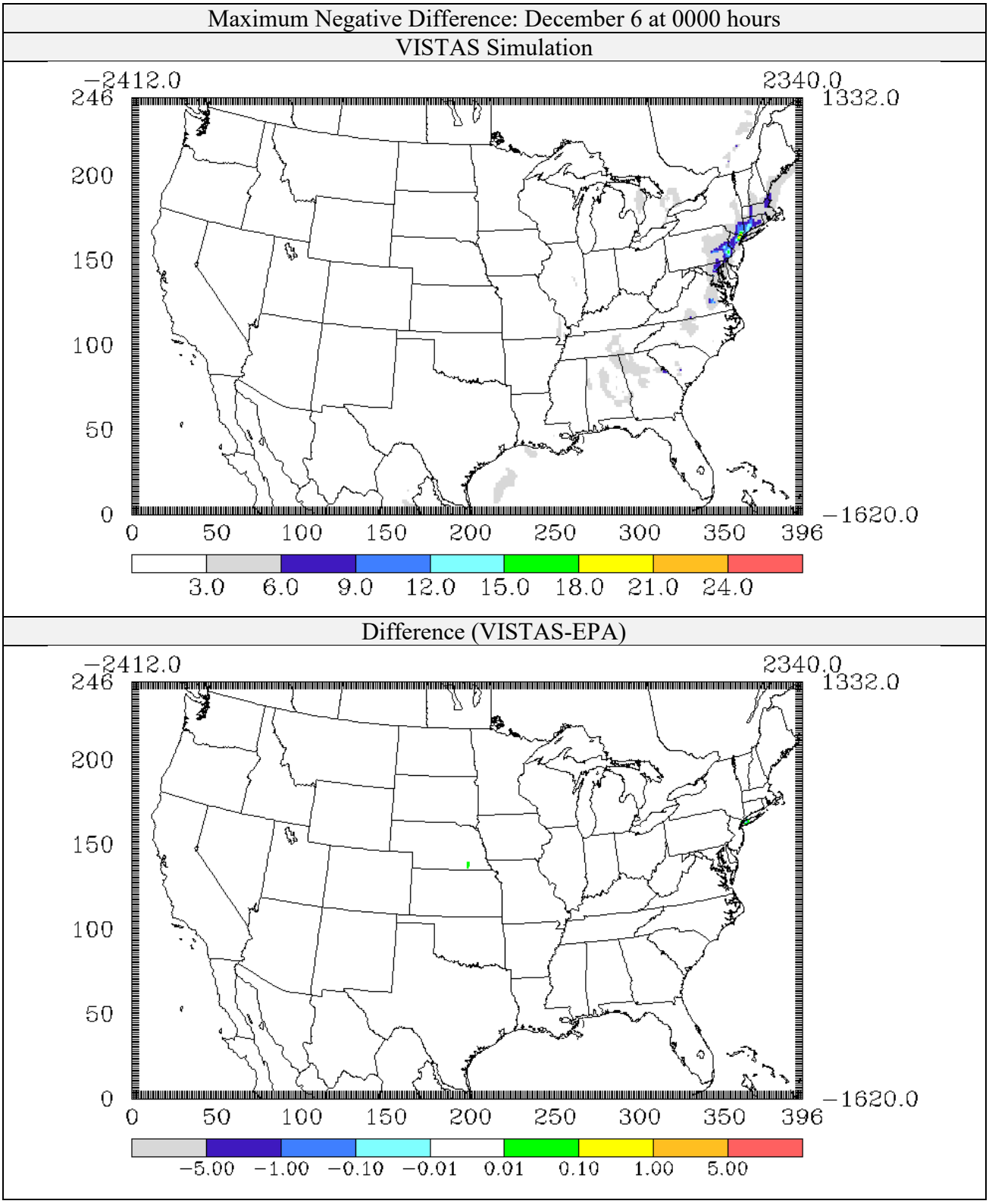


Figure 4-53: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference)

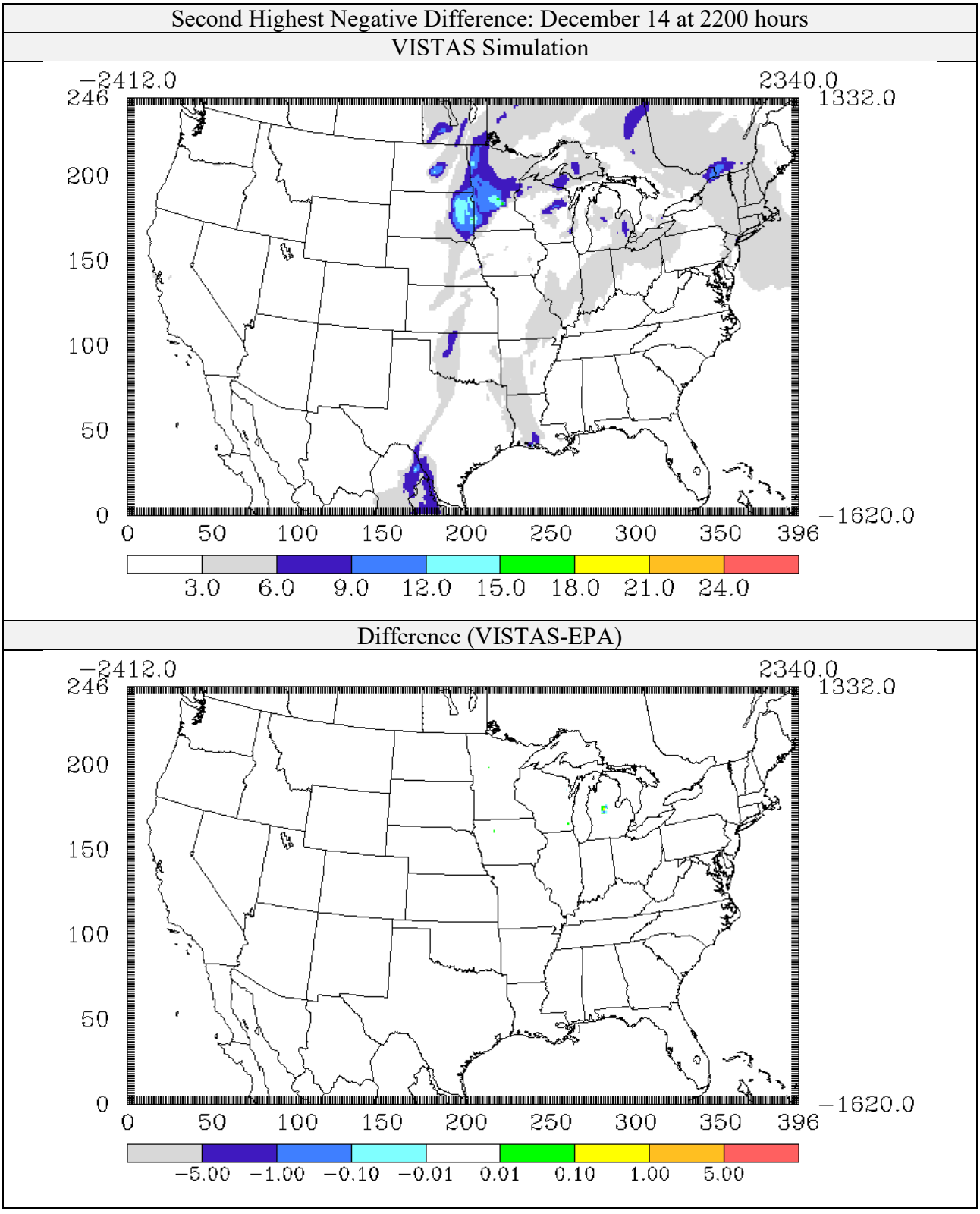


Figure 4-54: Comparison of Sulfate Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference)

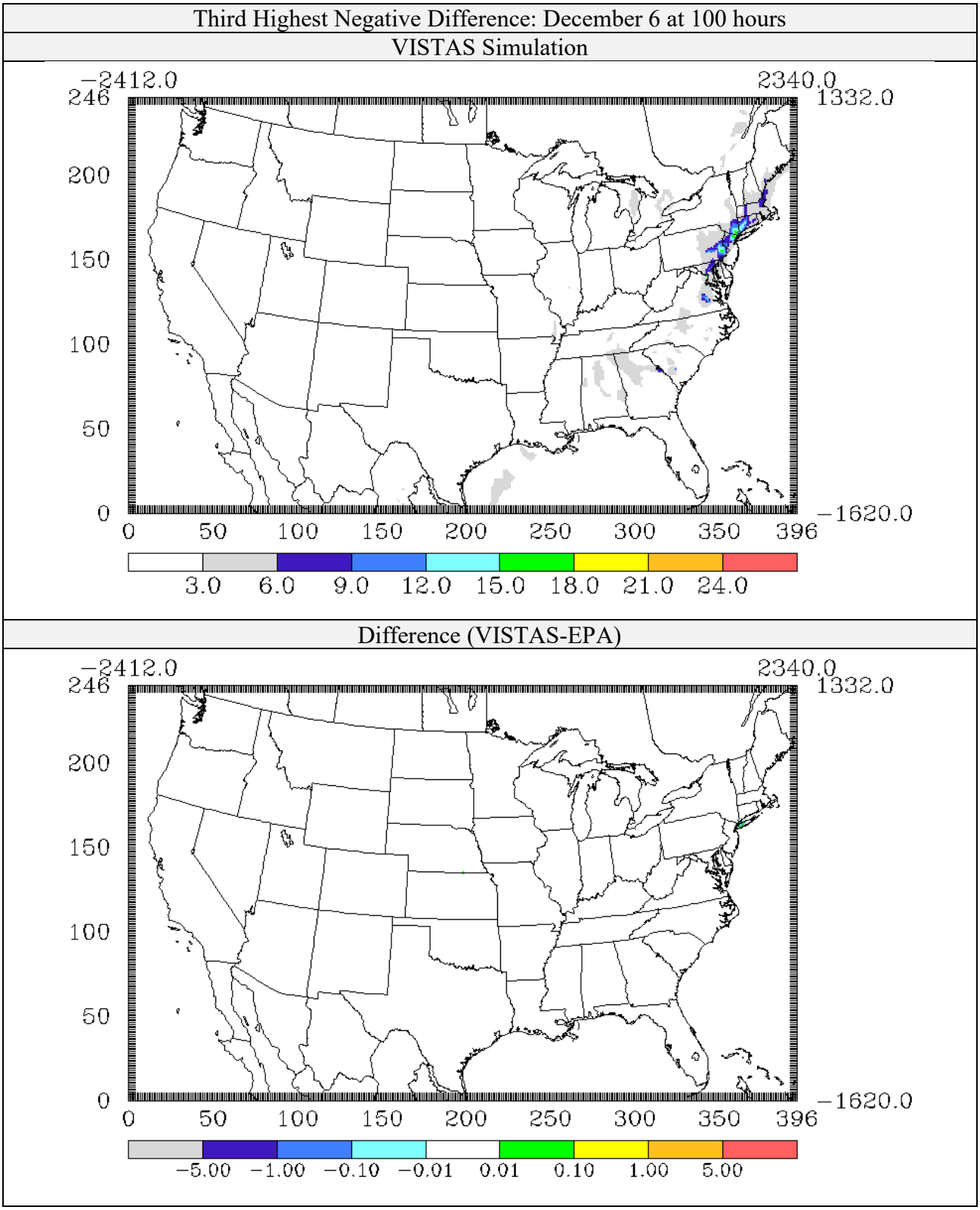


Figure 4-55: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference)

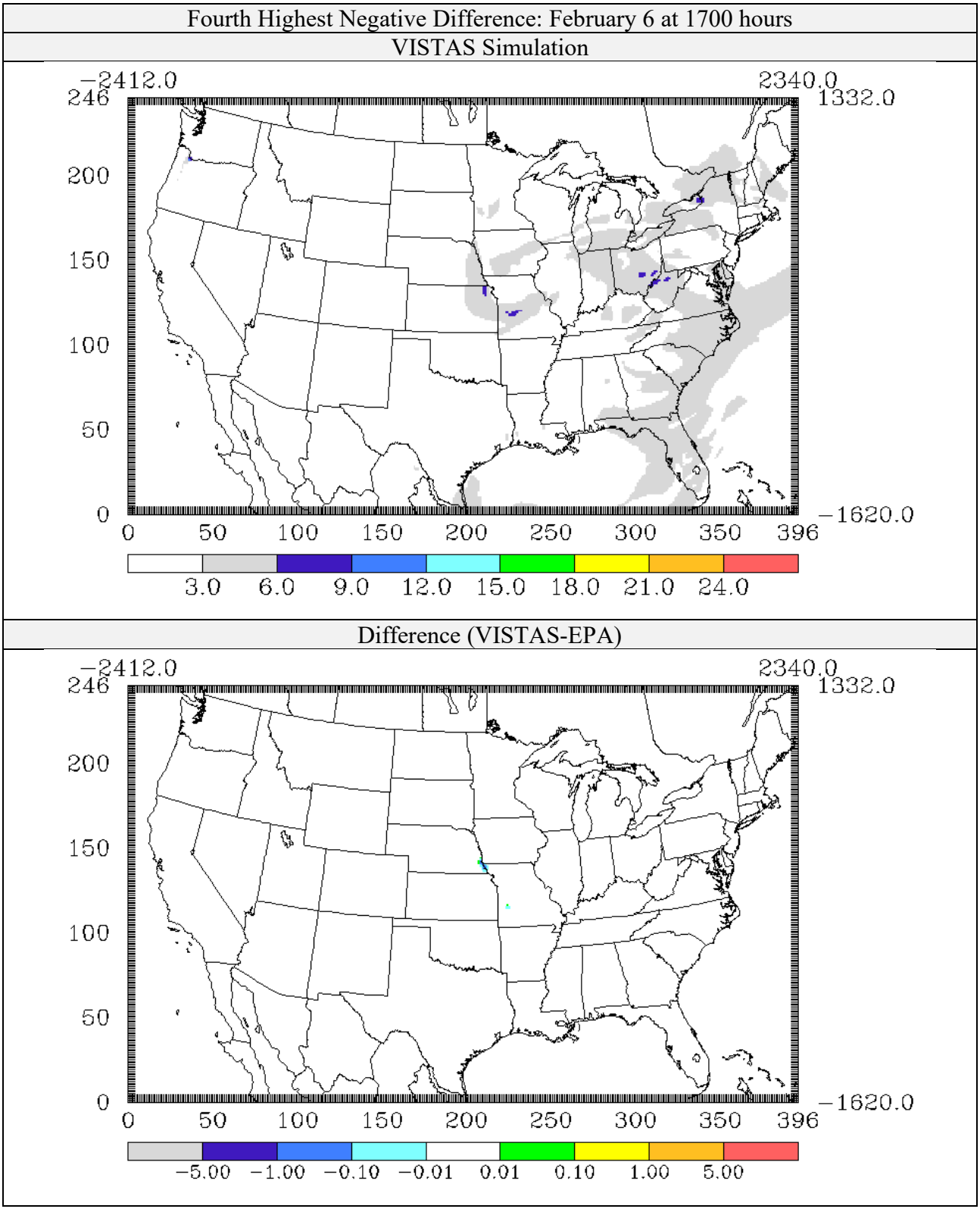


Figure 4-56: Comparison of Sulfate Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference)

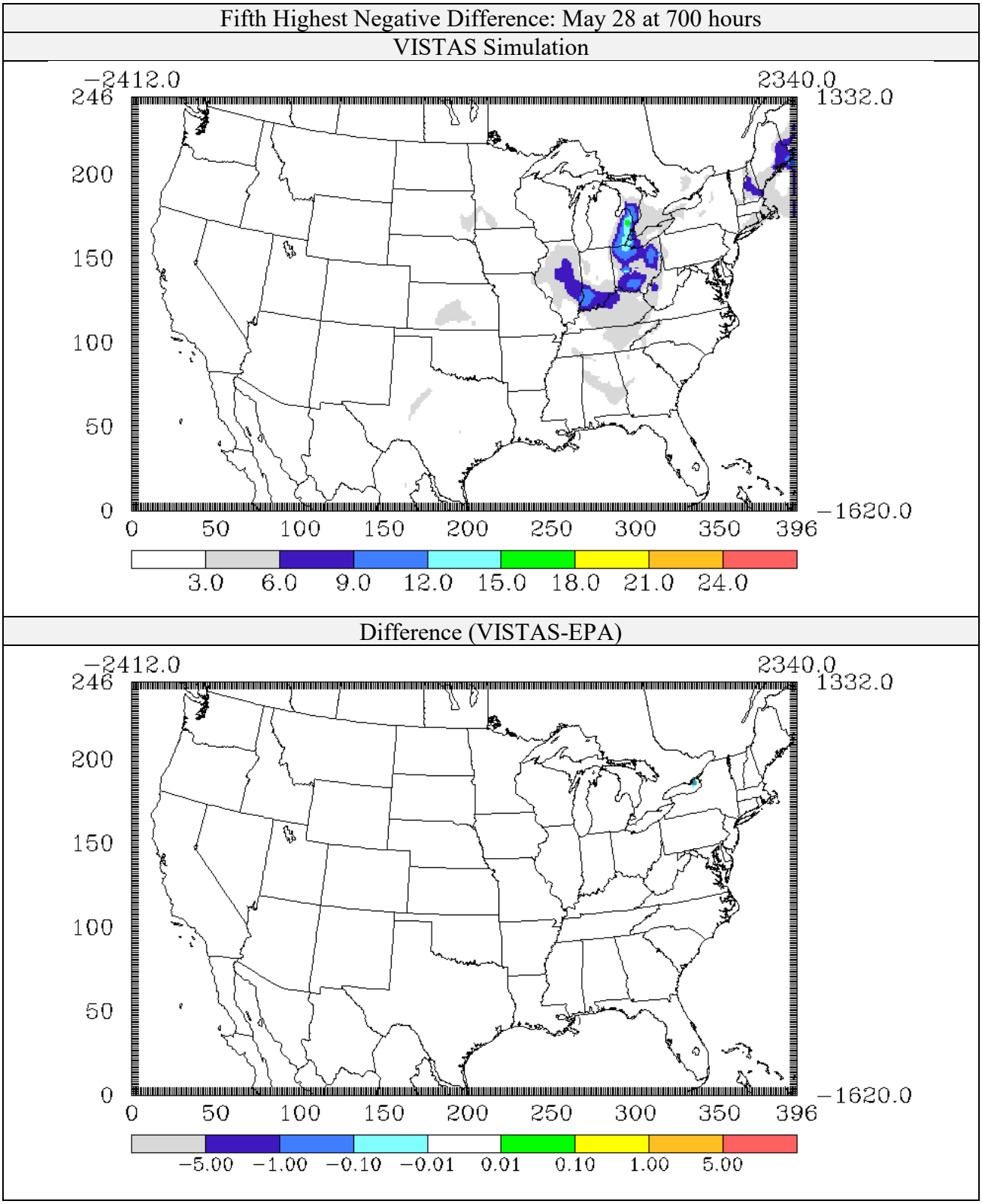


Figure 4-57: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference)

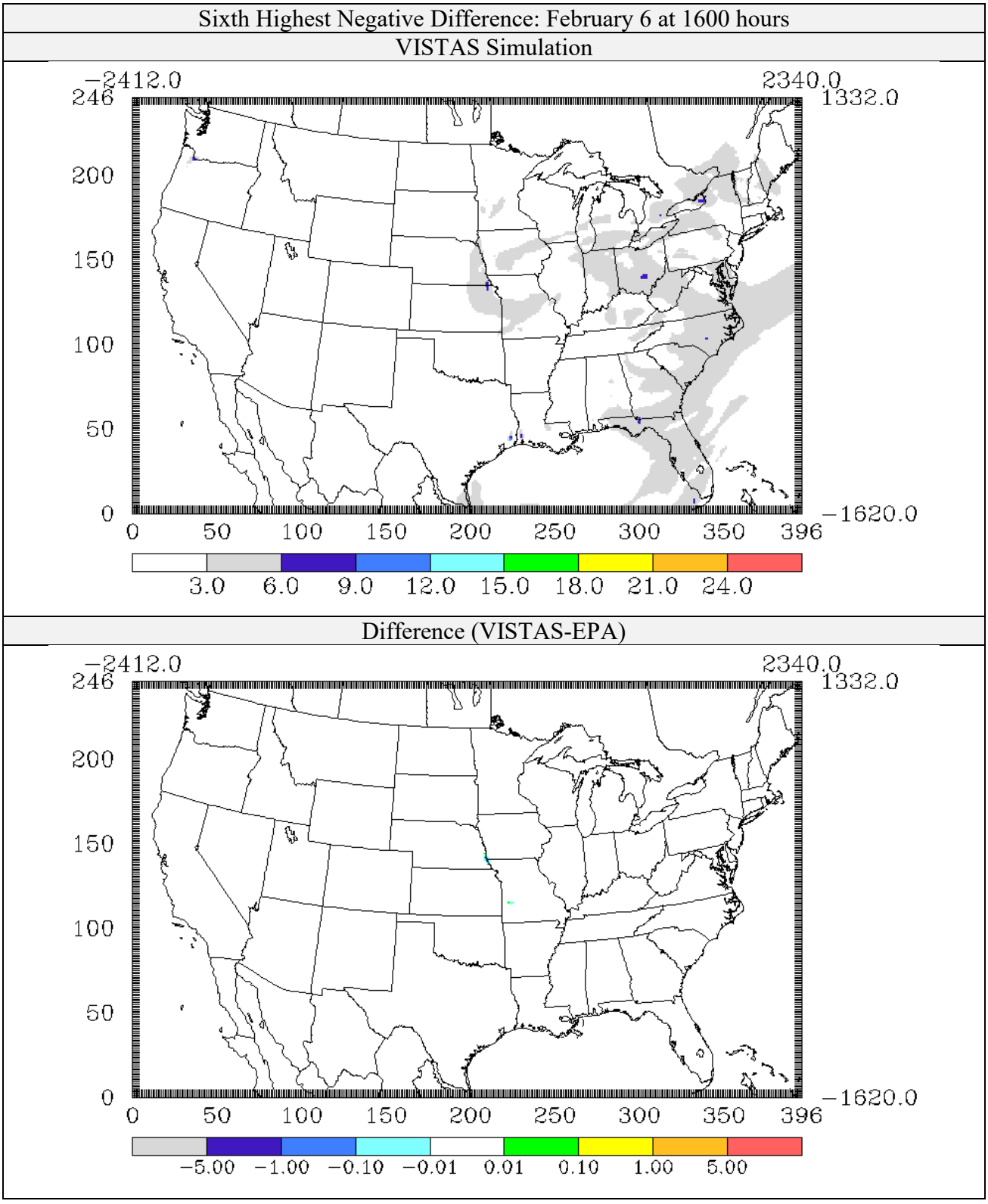


Figure 4-58: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference)

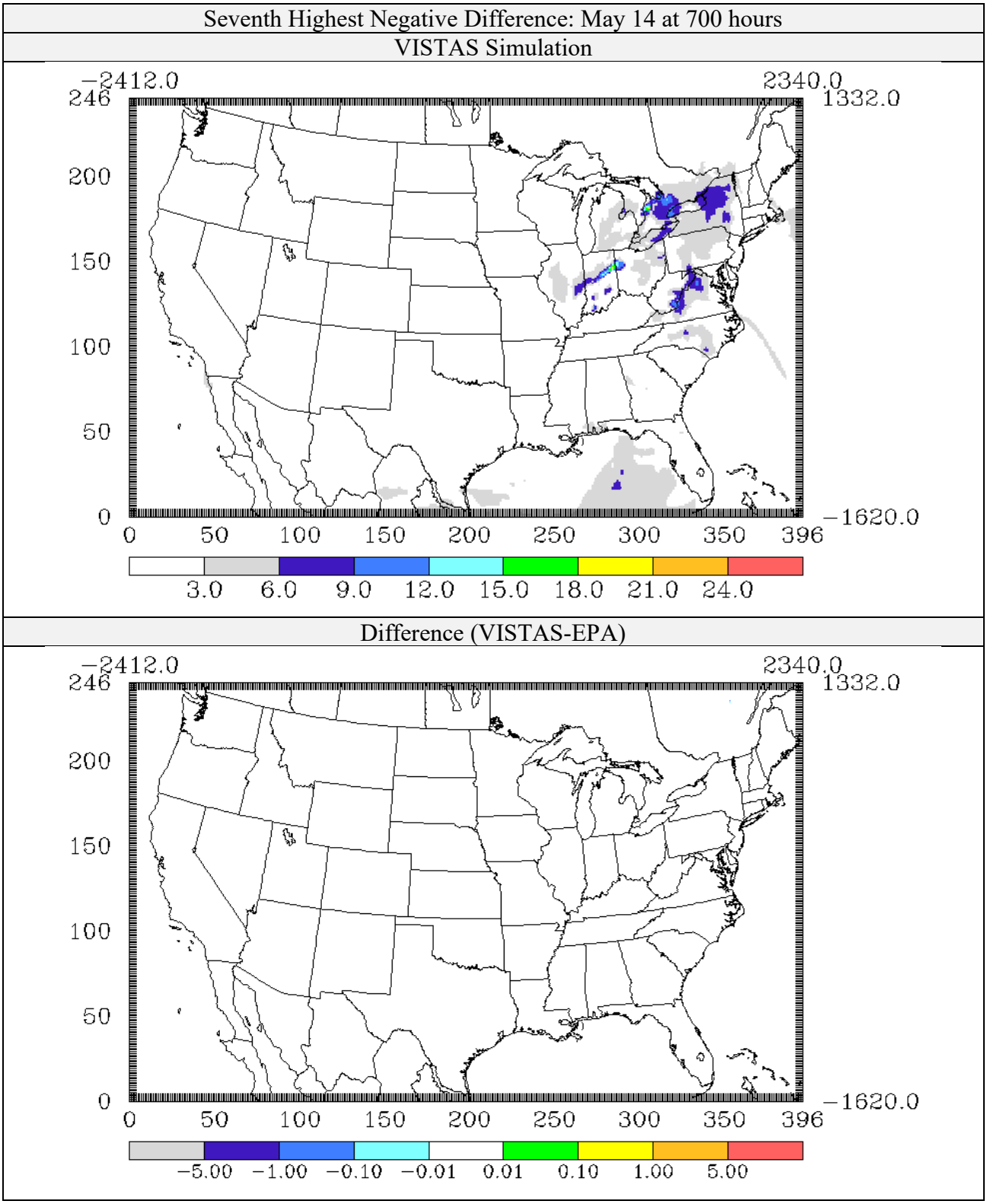


Figure 4-59: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference)

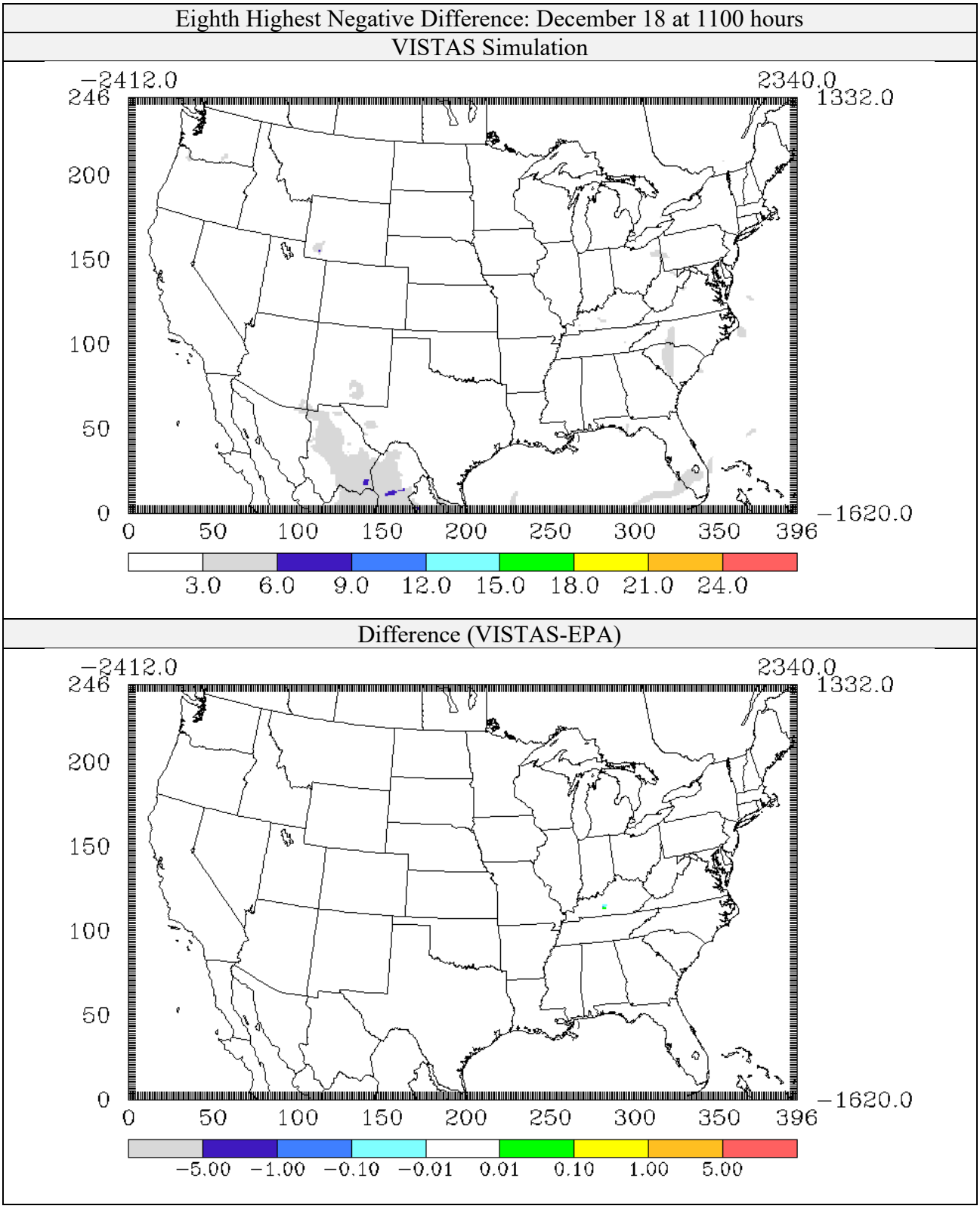


Figure 4-60: Comparison of Sulfate Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference)

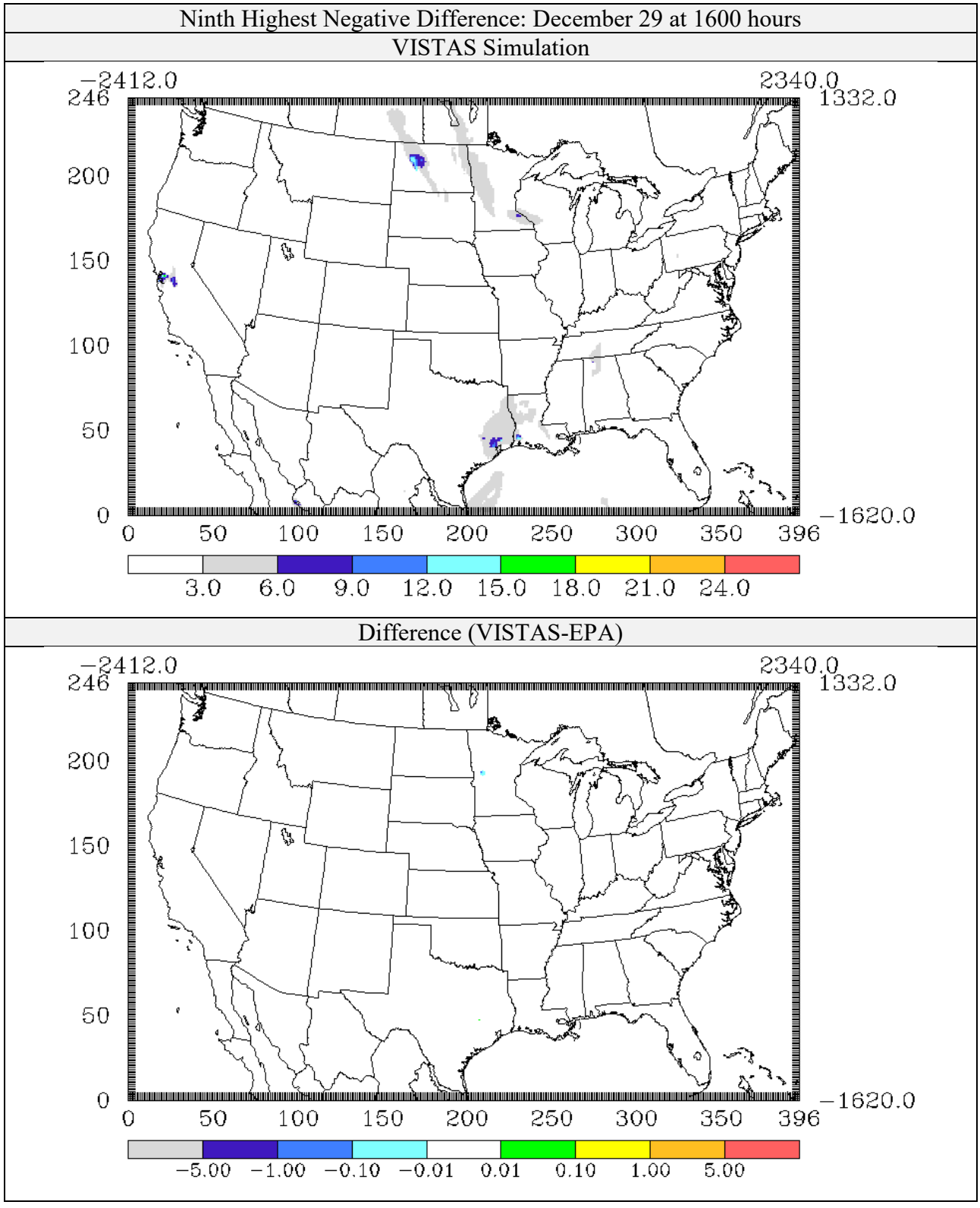


Figure 4-61: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference)

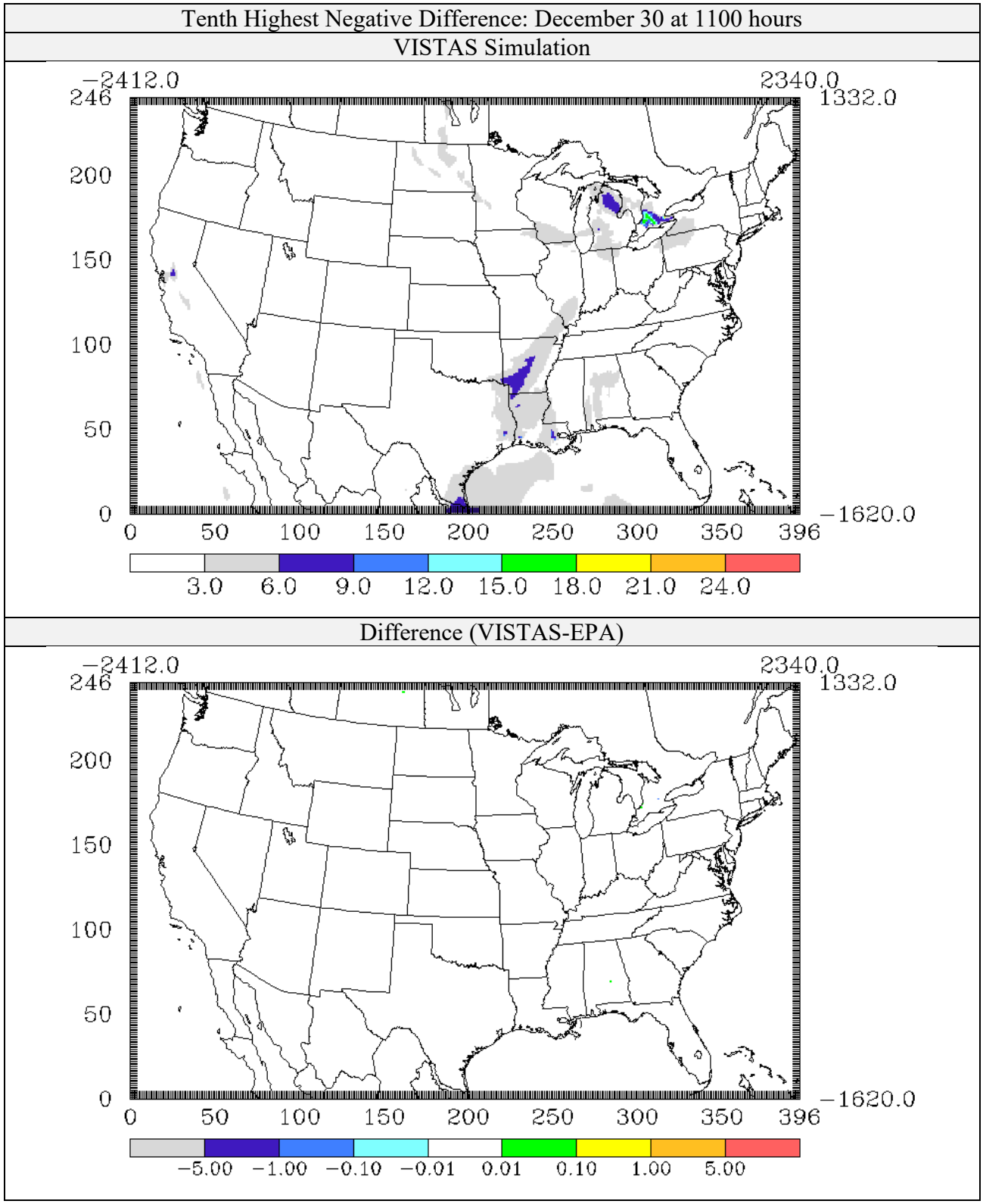


Figure 4-62: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference)

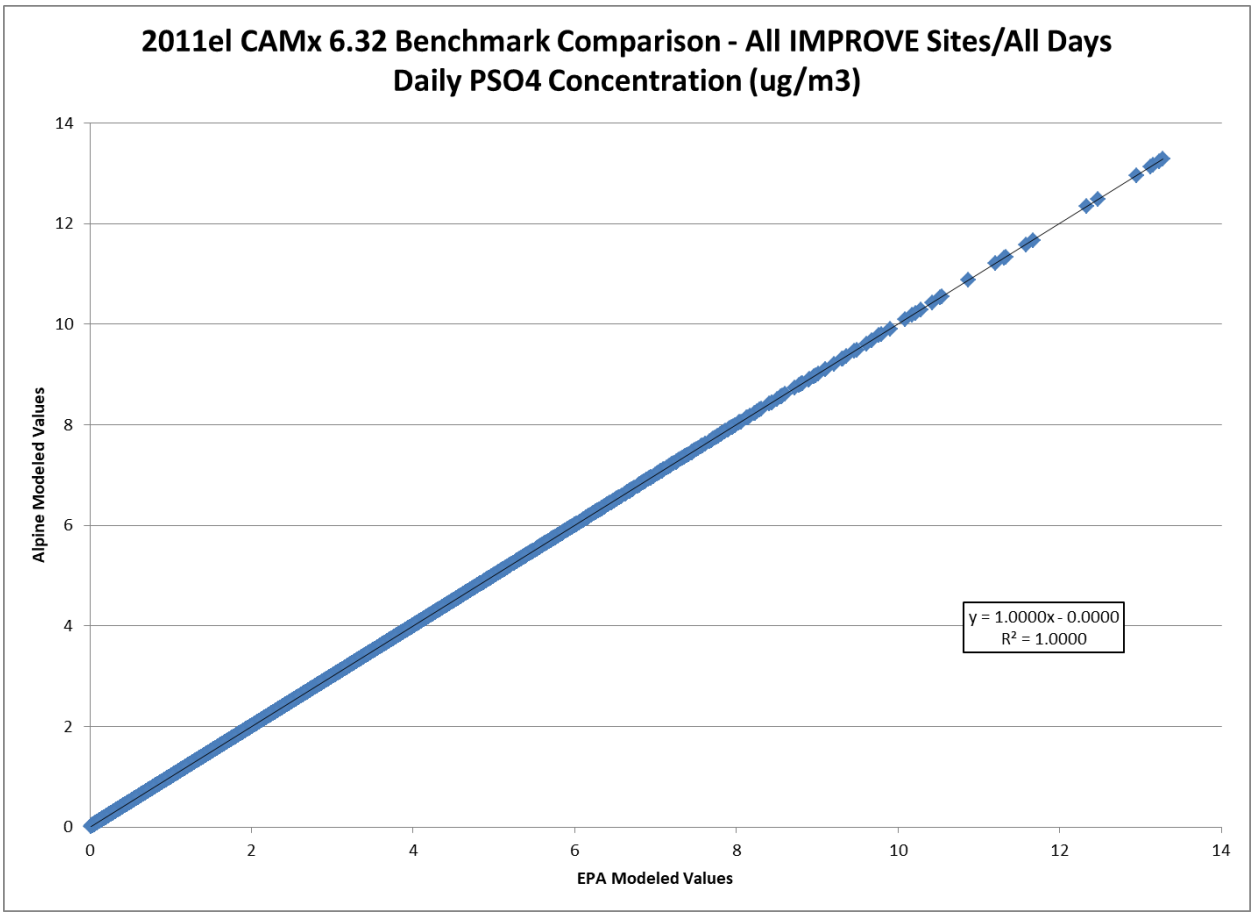


Figure 4-63: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine).

4.4 Nitrate

Nitrate results for the top 10 positive and negative hours are presented in tabular format in Table 4-4. The maximum positive difference is 5.34 µg/m^3 falling to 1.93 µg/m^3 for the 10th high. The maximum negative difference is -4.20 µg/m^3 falling to -1.65 µg/m^3 for the 10th high. The maximum positive percent difference from these days is 110.0% and negative percent difference of -54.5%, both on low Nitrate concentration days.

The top 10 positive impact hours are presented in Figures 4-64 through 4-73 and the top 10 negative impact hours are presented in Figures 4-74 through 4-83. As was discussed in Section 4.2 for the $PM_{2.5}$ concentrations, the differences are tending to occur in January along the northern border in Canada.

Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-84. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

Examination of the animations shows that the majority of the differences are occurring in Canada and the Northern U.S. with the differences occurring in the areas of relatively high $PM_{2.5}$. We speculate that the differences are primarily from the difference in the Particulate Nitrate and most likely from different pathways being taken in the ISOROPIA algorithm.

Table 4-4. Comparison of 2011el CAMx 6.32 Simulation Nitrate Concentrations (µg/m^3) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	1	3	4	24.70	19.36	5.34	27.60%	156	236
2011	1	3	5	22.87	18.32	4.55	24.84%	156	236
2011	1	27	7	8.33	3.97	4.36	110.03%	349	244
2011	1	3	6	23.13	18.99	4.15	21.84%	156	235
2011	1	27	11	6.60	3.95	2.65	66.94%	349	243
2011	1	3	3	21.99	19.49	2.50	12.85%	156	236
2011	1	27	6	5.72	3.22	2.50	77.54%	343	244
2011	1	27	4	8.79	6.61	2.18	33.08%	344	245
2011	5	19	13	6.83	4.90	1.94	39.59%	314	168
2011	1	14	9	8.78	6.84	1.93	28.24%	164	222
Maximum Negative									
2011	1	14	6	14.35	18.55	-4.20	-22.62%	120	243
2011	1	27	8	2.99	6.64	-3.64	-54.92%	350	243
2011	1	27	11	3.82	6.97	-3.15	-45.21%	342	245
2011	1	27	12	2.25	4.96	-2.70	-54.54%	342	243
2011	1	27	5	2.53	5.17	-2.64	-51.13%	342	244
2011	1	15	9	9.50	12.11	-2.60	-21.51%	126	220
2011	1	3	10	25.95	27.85	-1.90	-6.83%	155	235
2011	1	27	9	4.37	6.21	-1.84	-29.60%	342	244
2011	1	14	2	19.31	21.10	-1.79	-8.50%	134	242
2011	1	3	4	19.76	21.41	-1.65	-7.72%	157	237

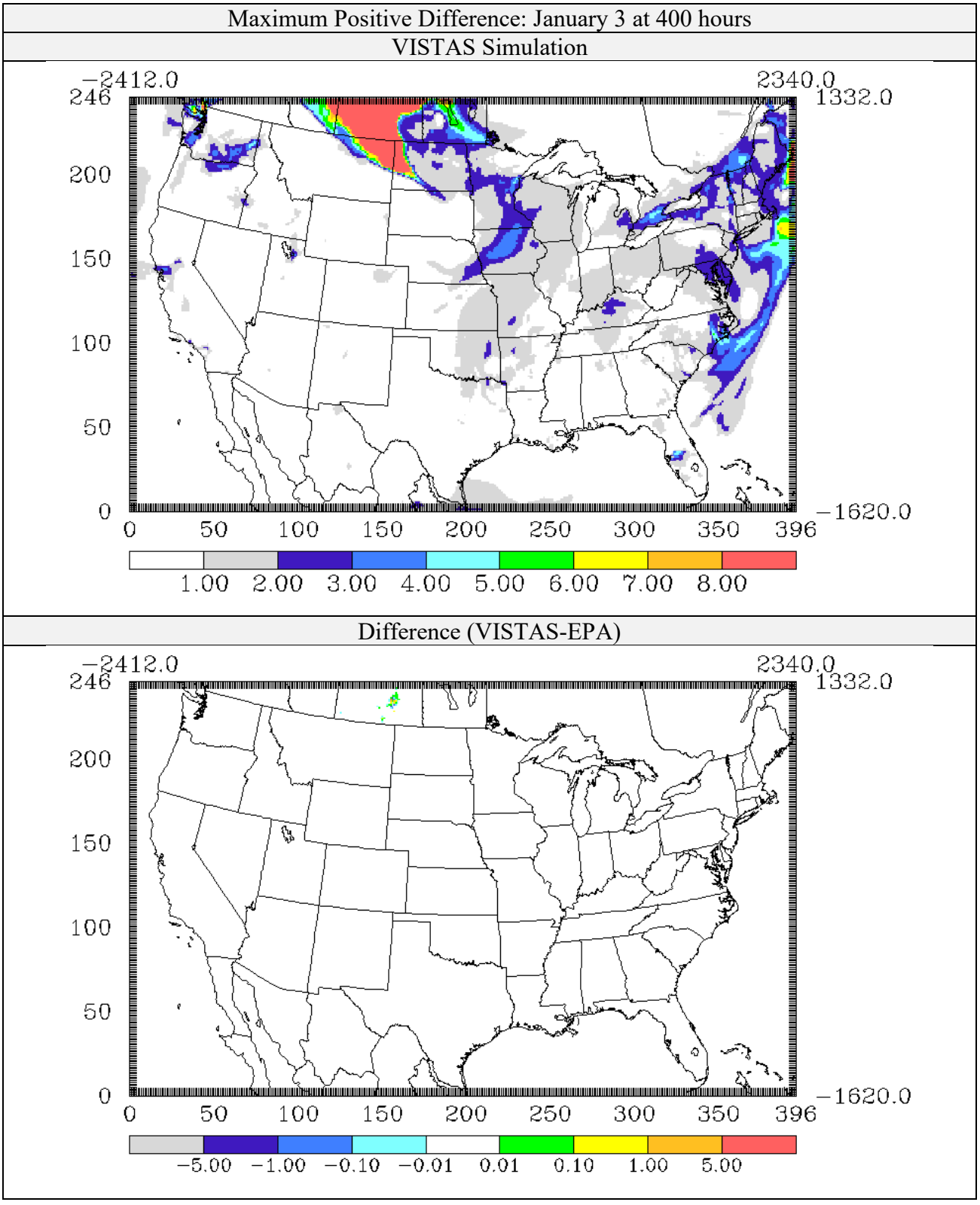


Figure 4-64: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference)

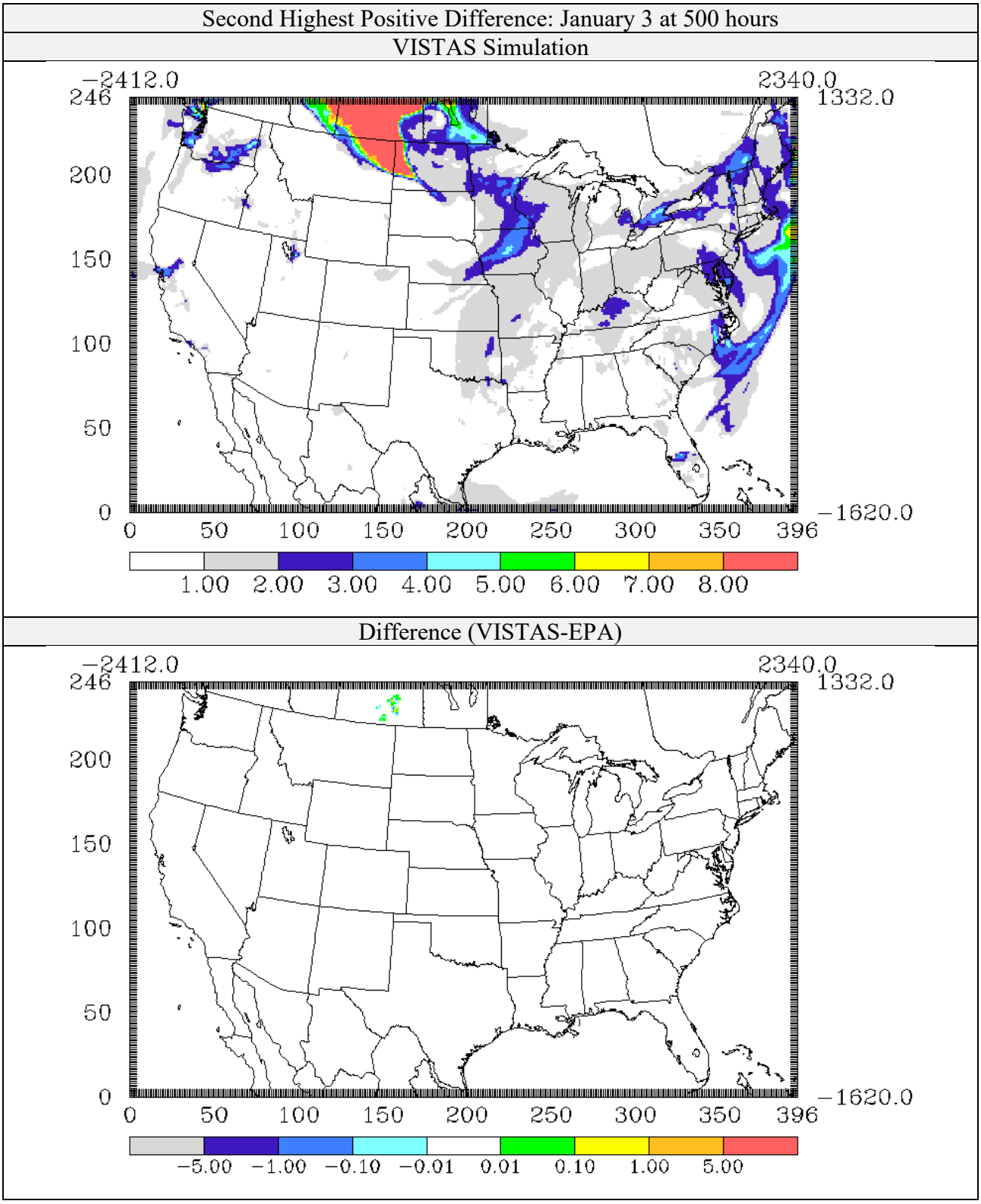


Figure 4-65: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference)

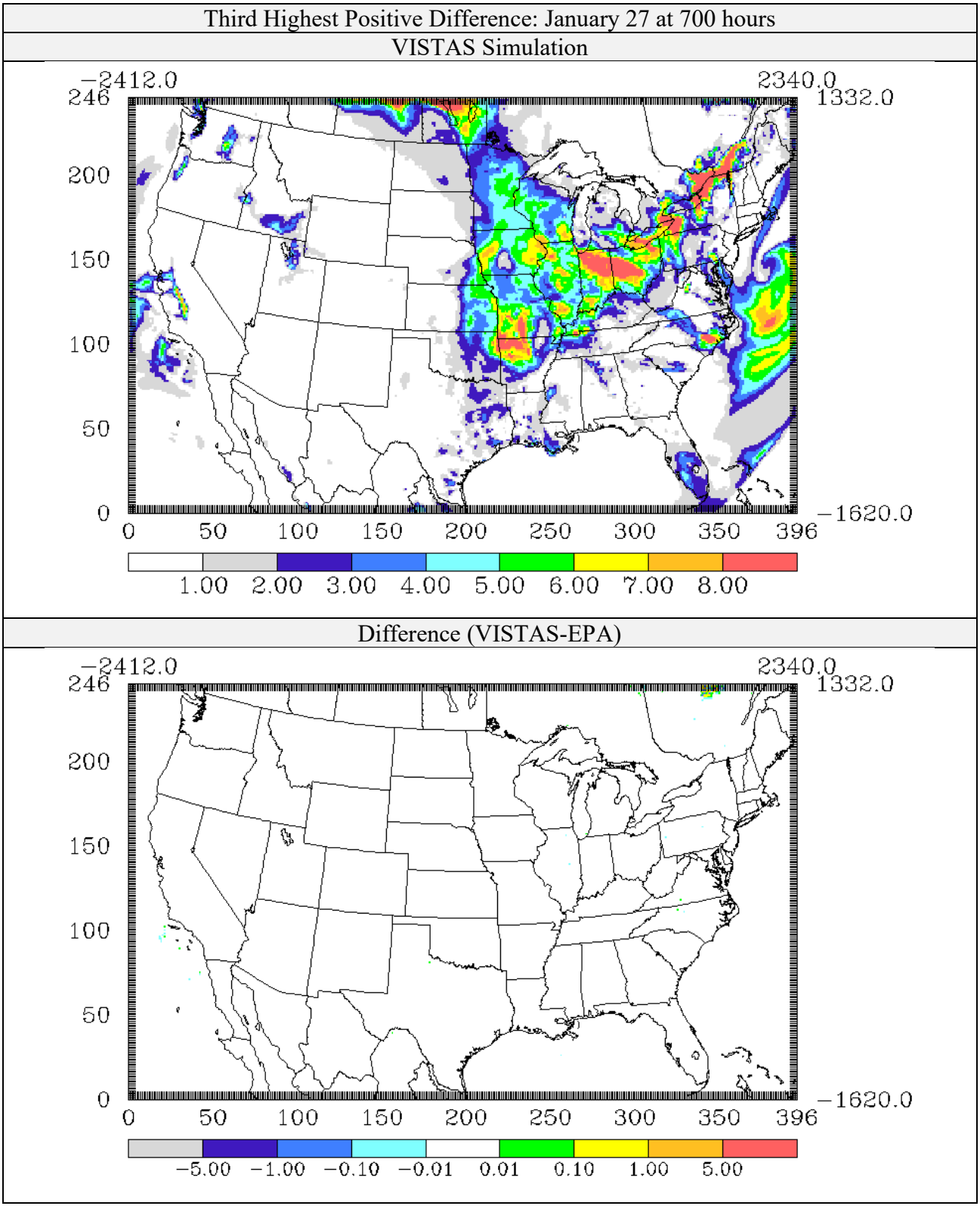


Figure 4-66: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference)

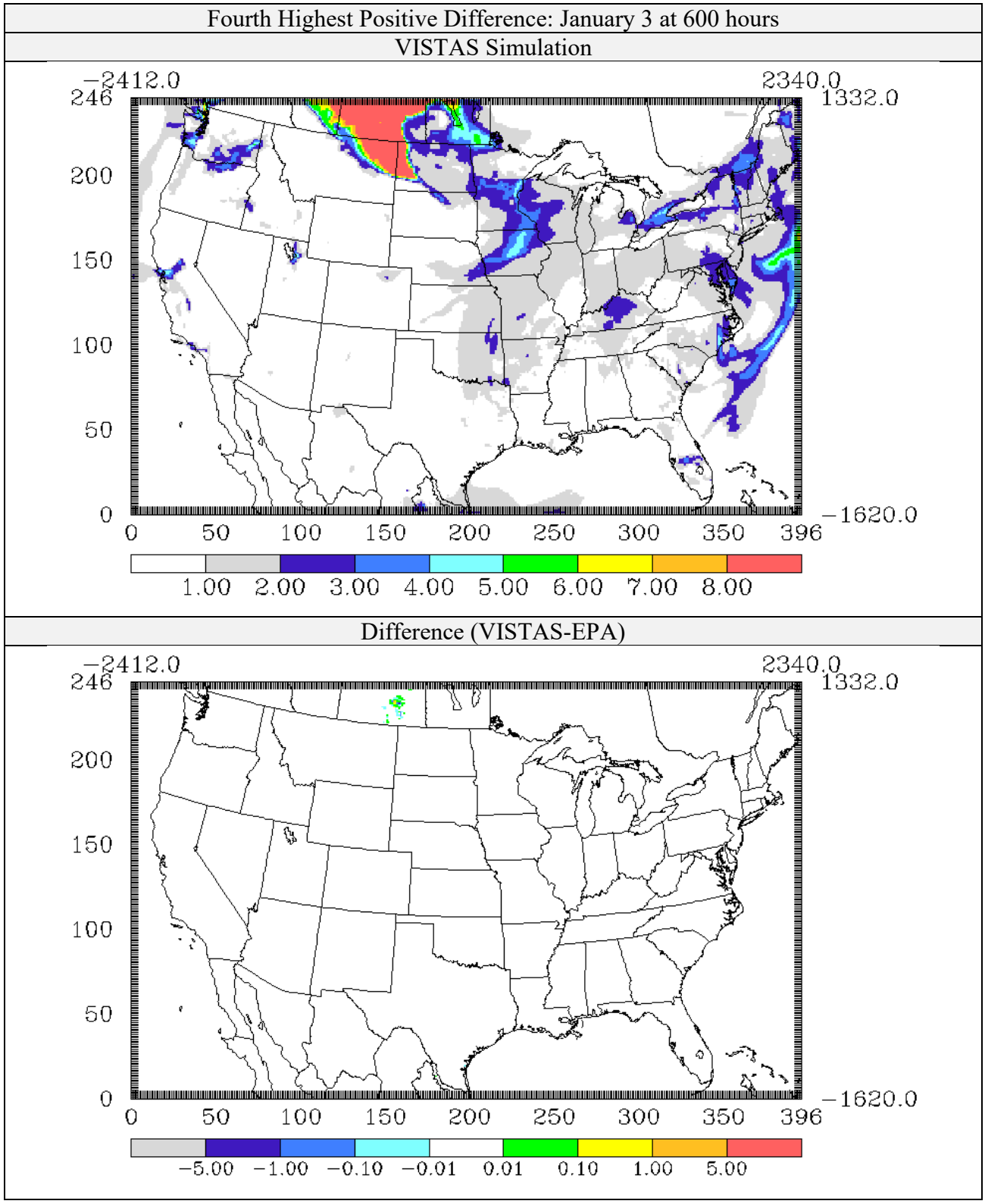


Figure 4-67: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference)

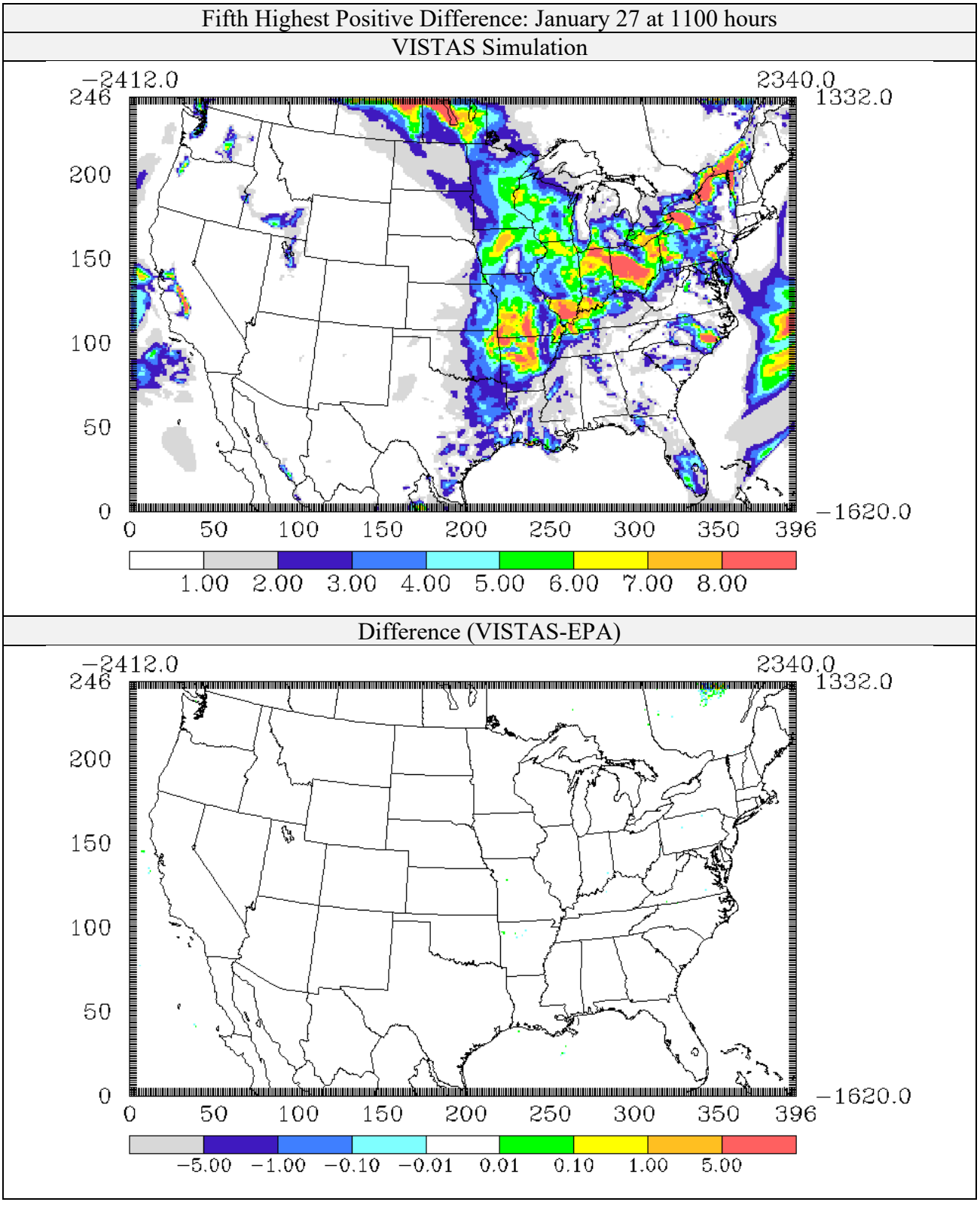


Figure 4-68: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference)

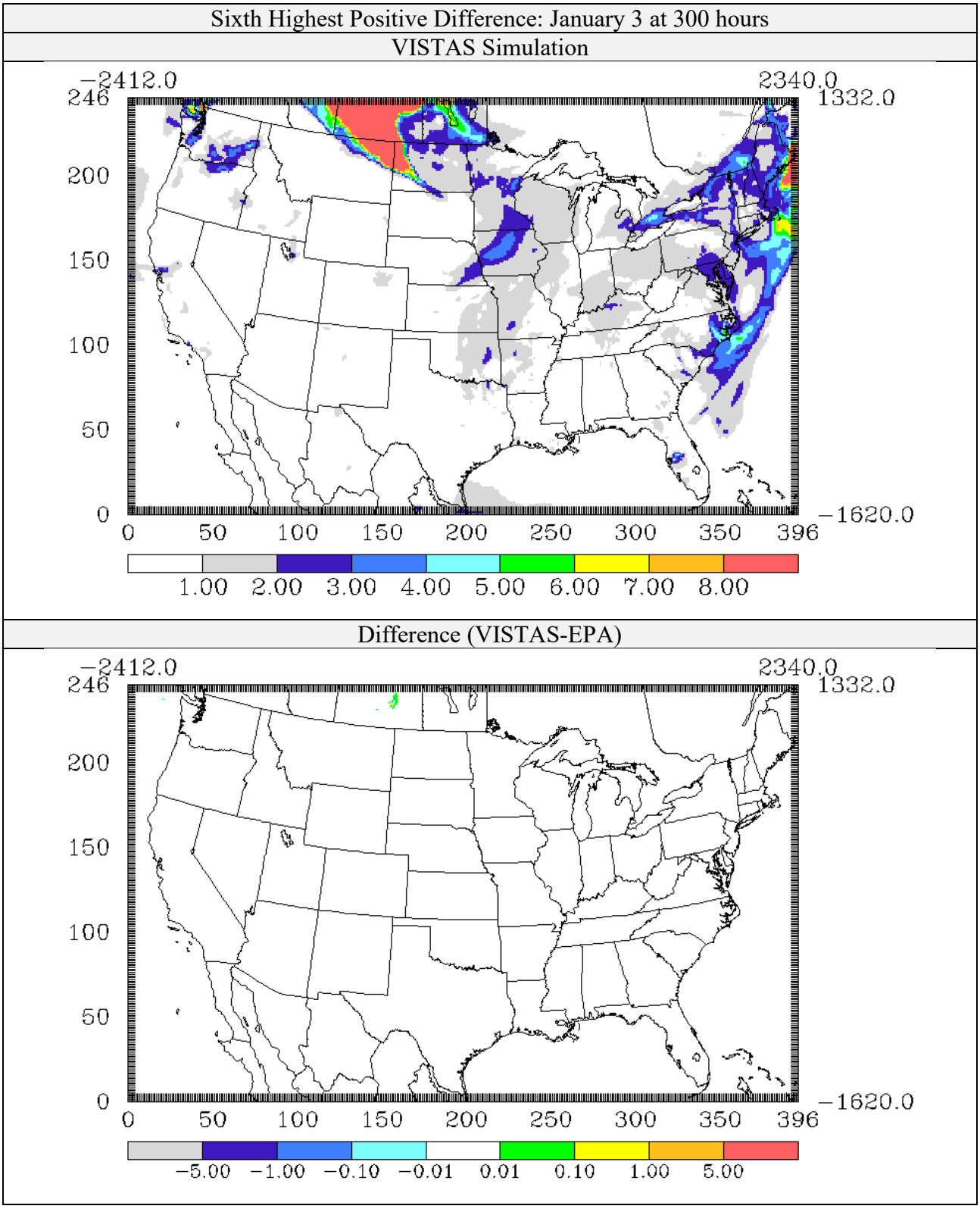


Figure 4-69: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference)

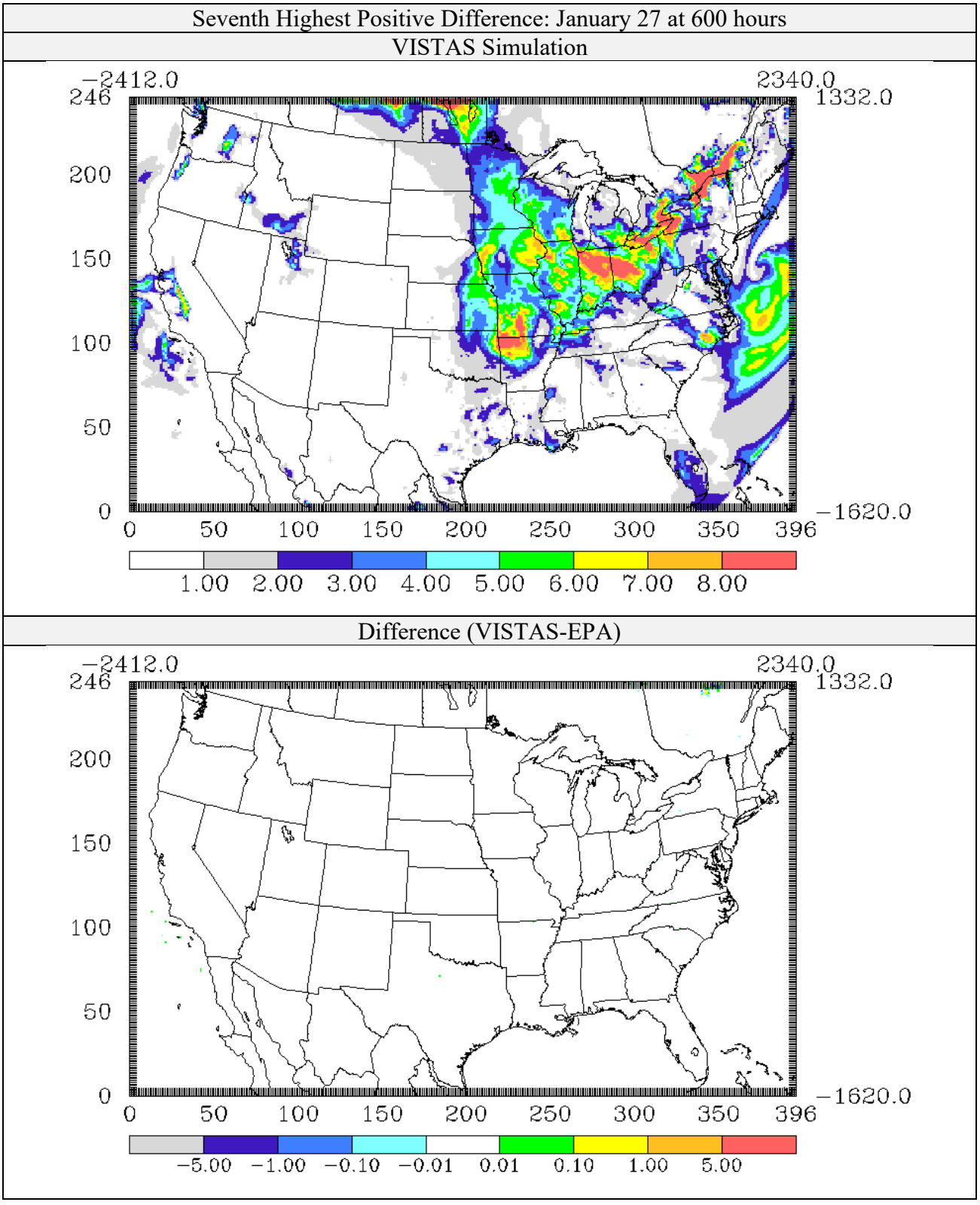


Figure 4-70: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference)

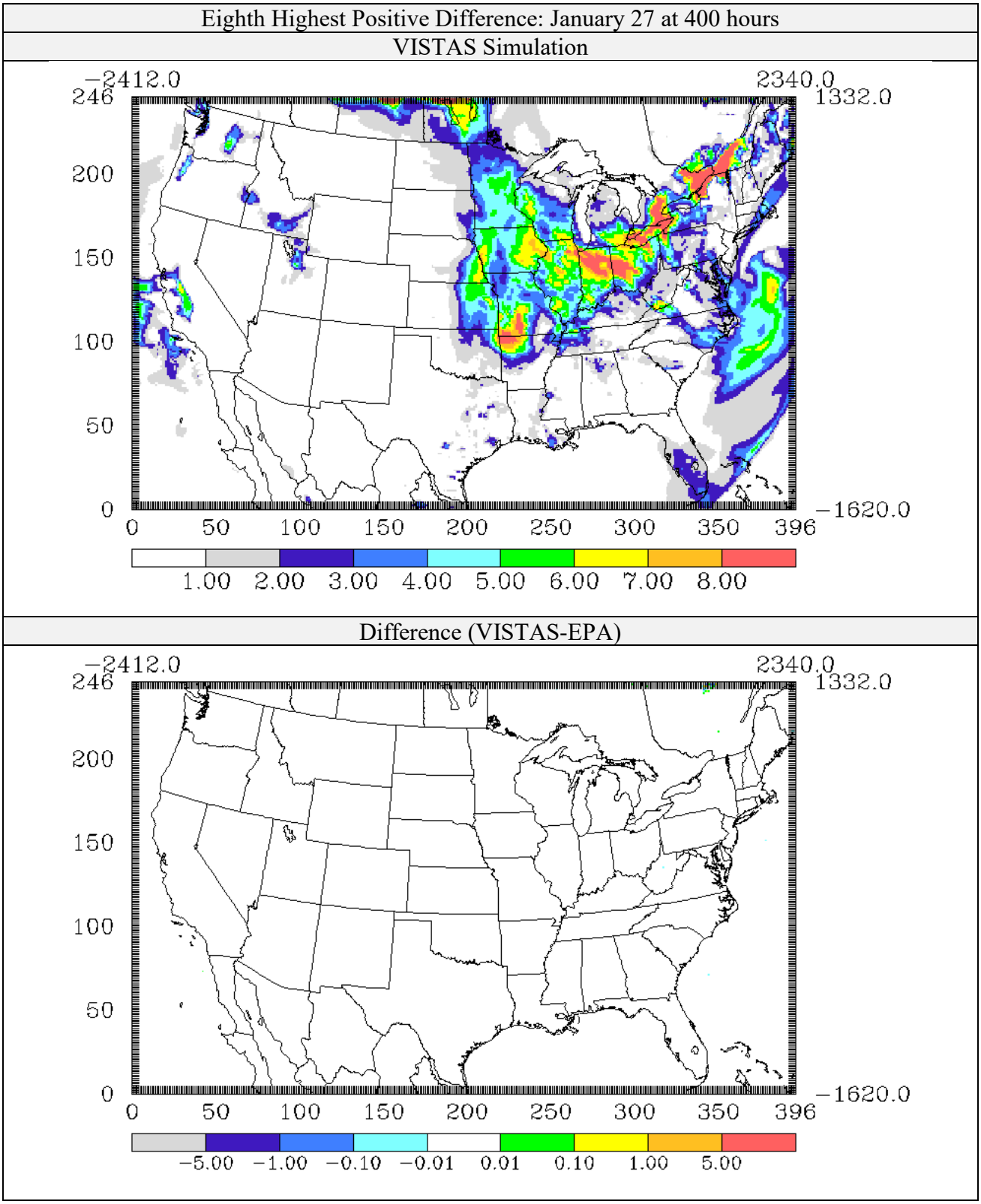


Figure 4-71: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference)

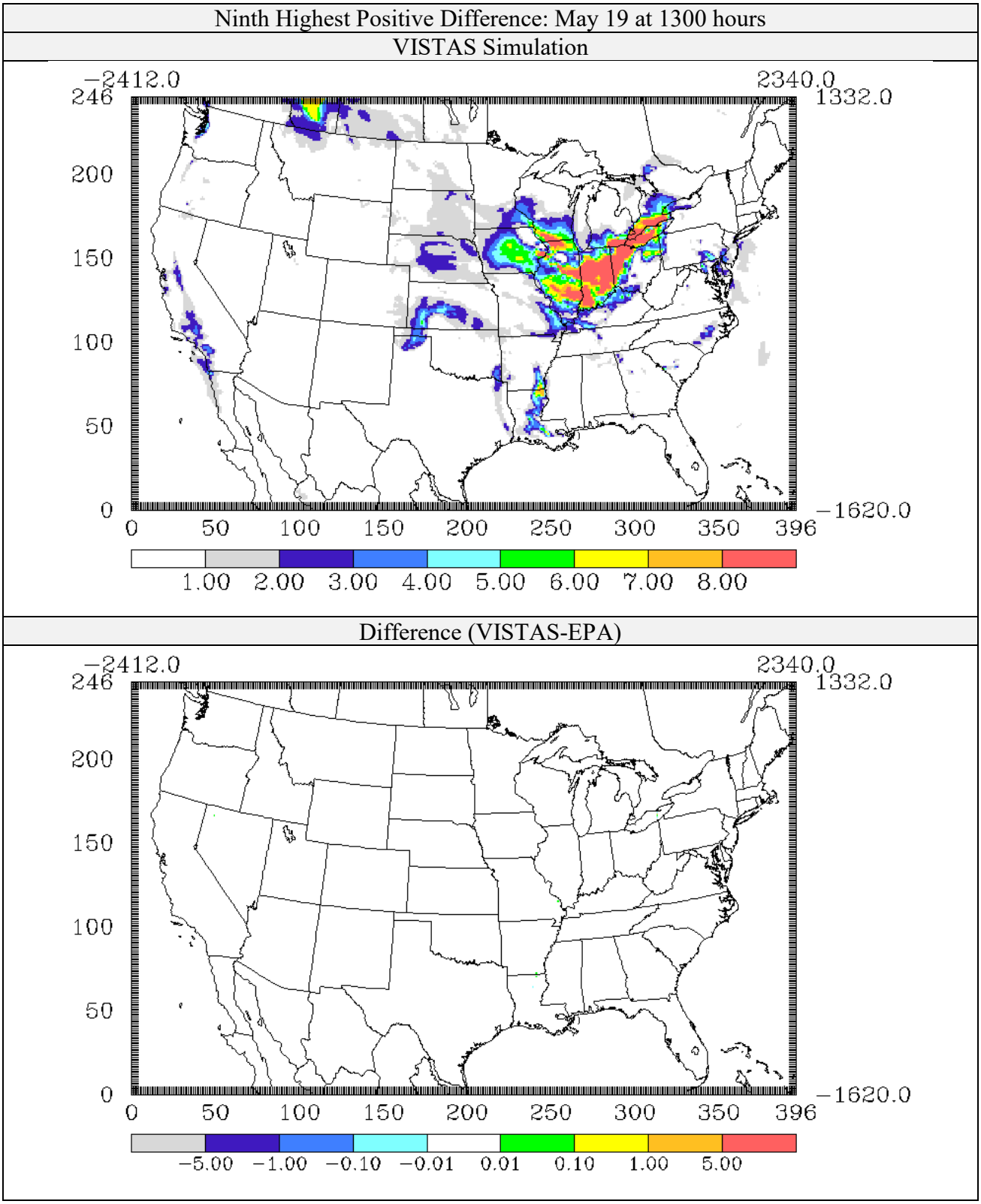


Figure 4-72: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference)

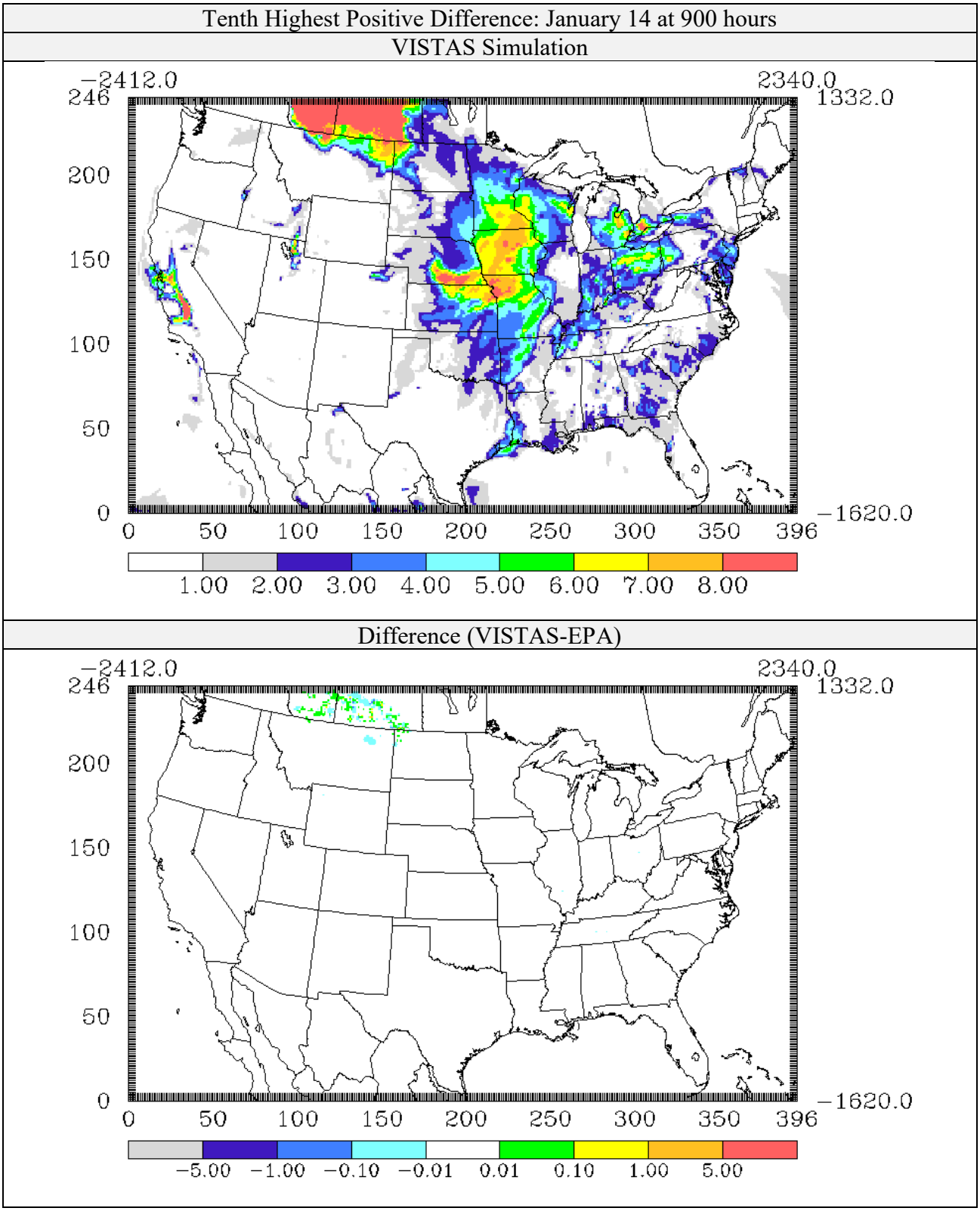


Figure 4-73: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference)

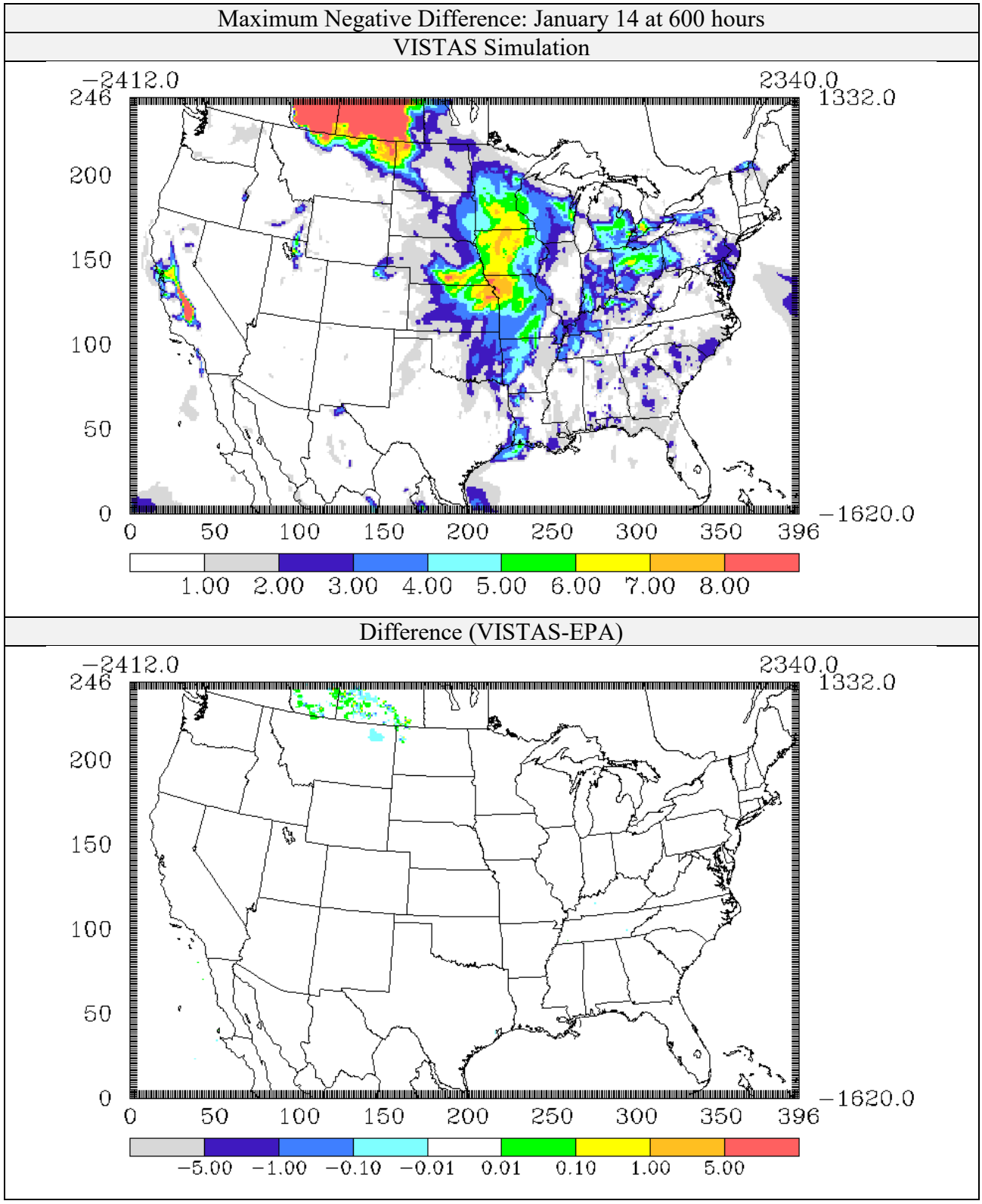


Figure 4-74: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference)

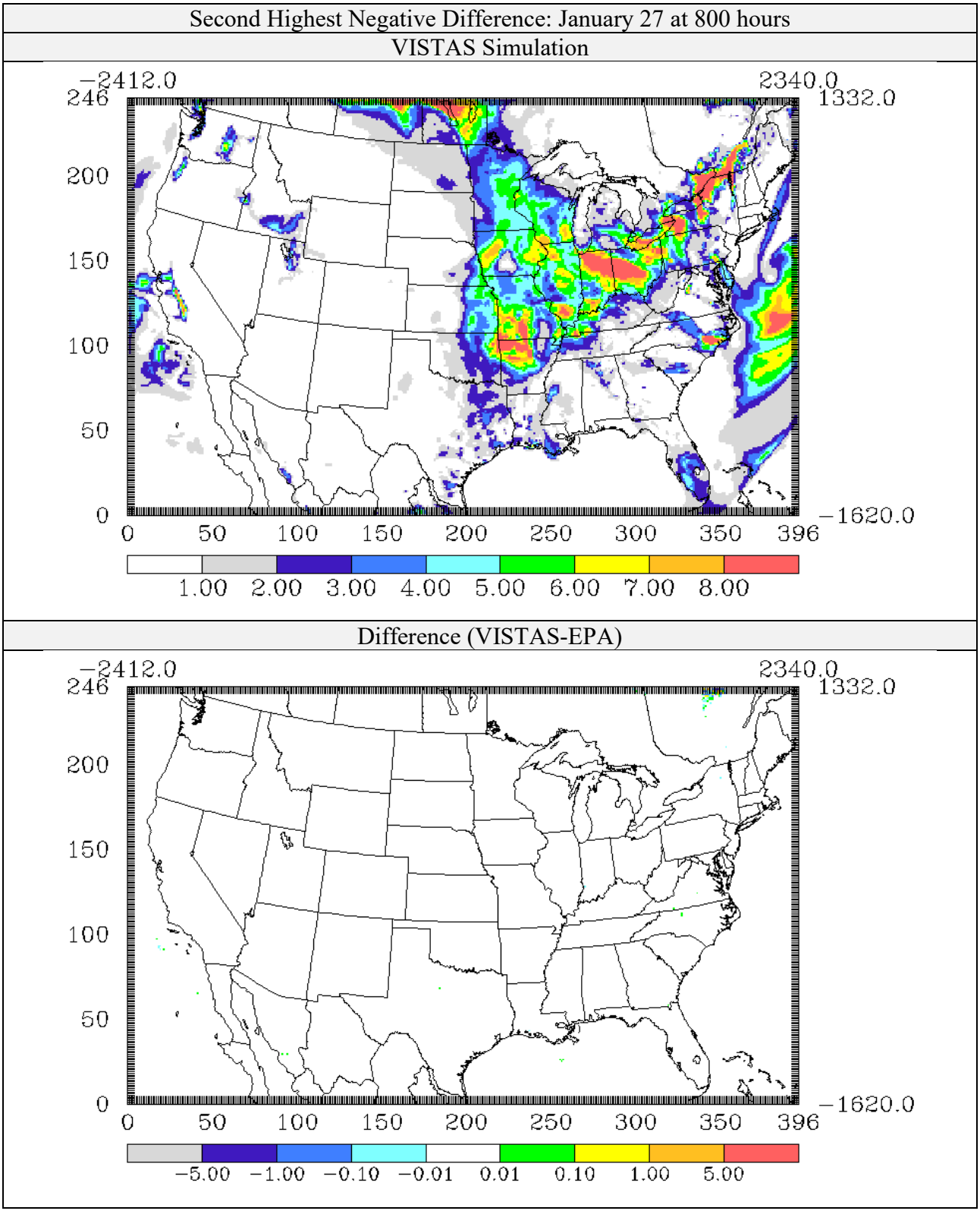


Figure 4-75: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference)

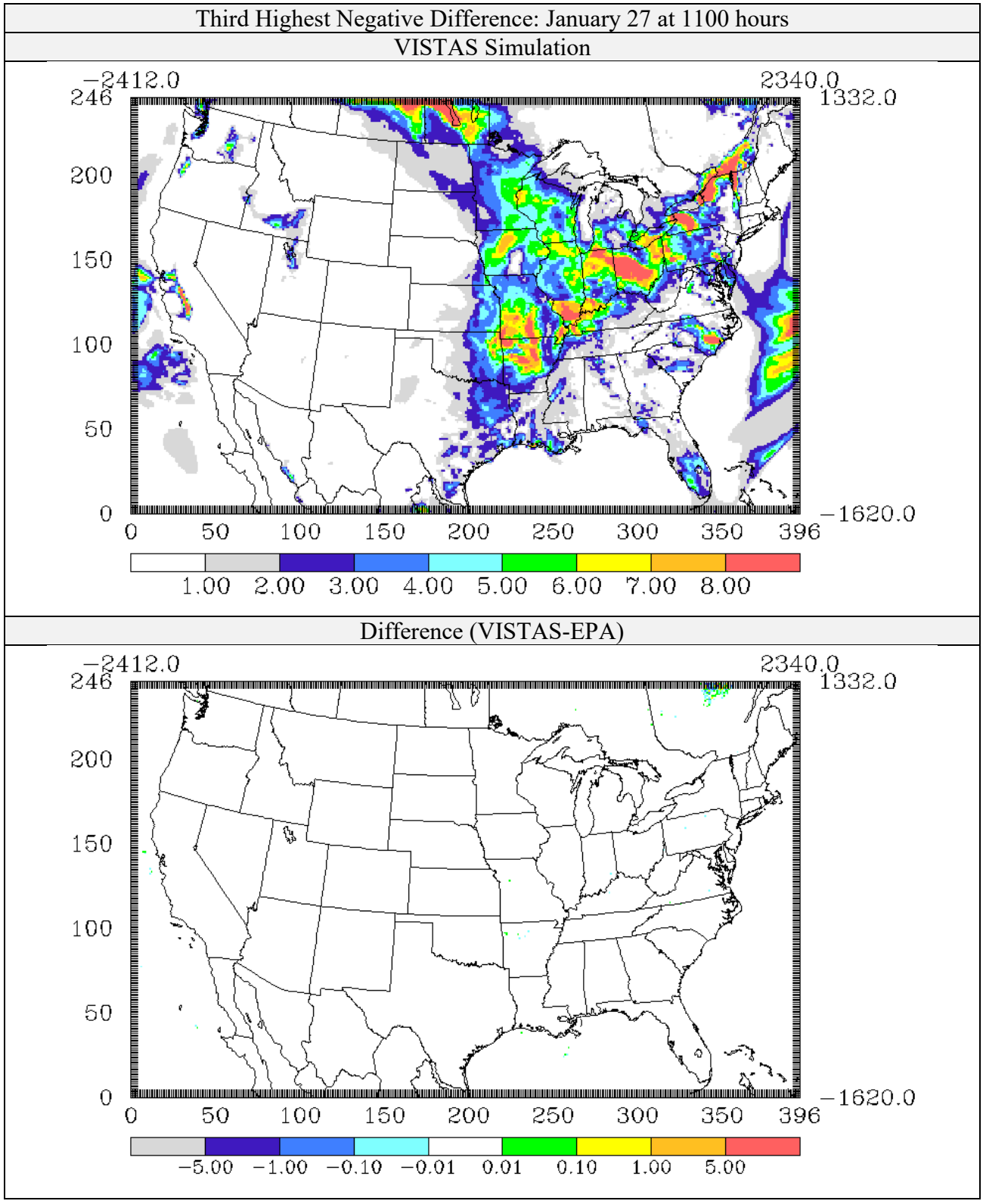


Figure 4-76: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference)

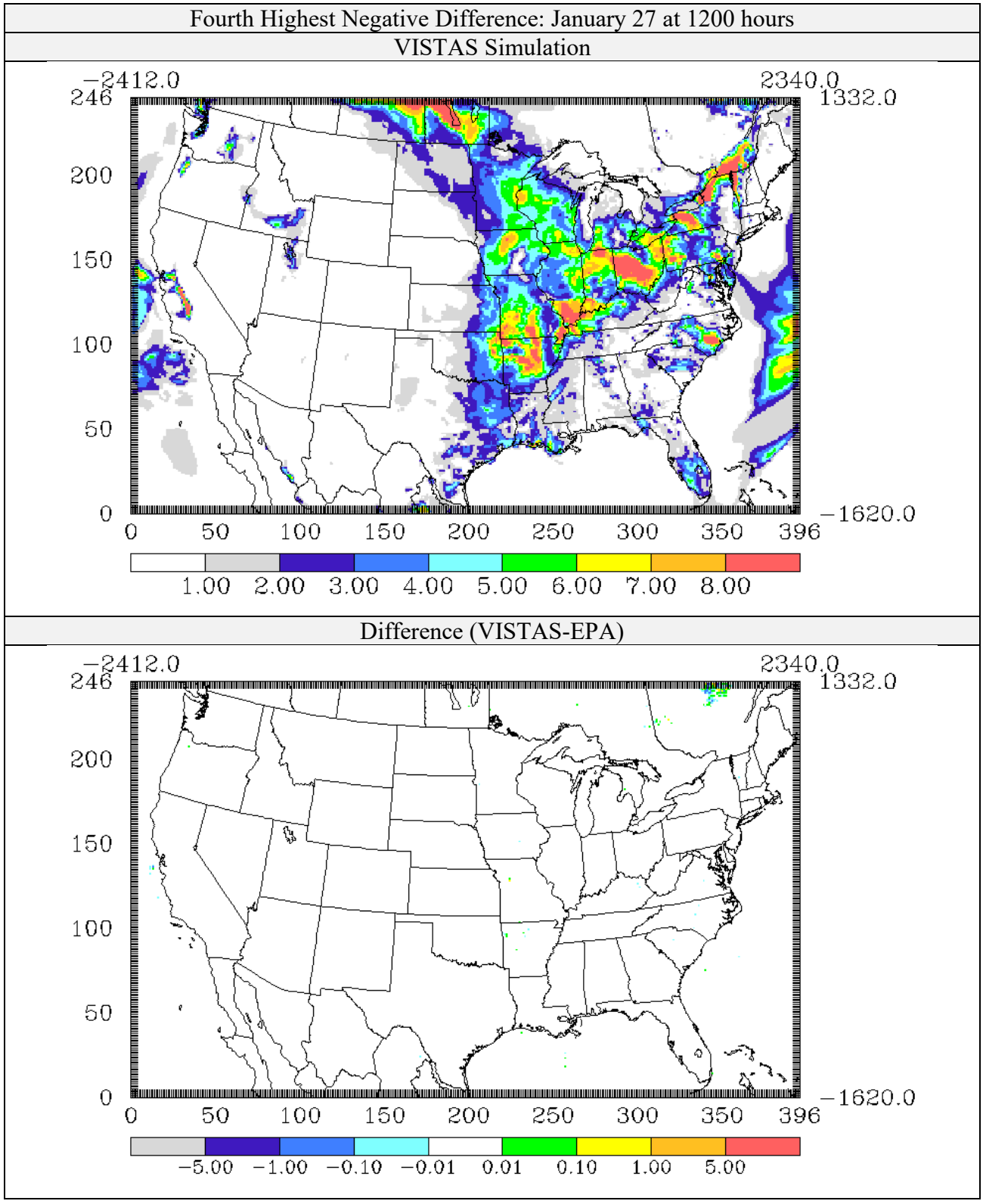


Figure 4-77: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference)

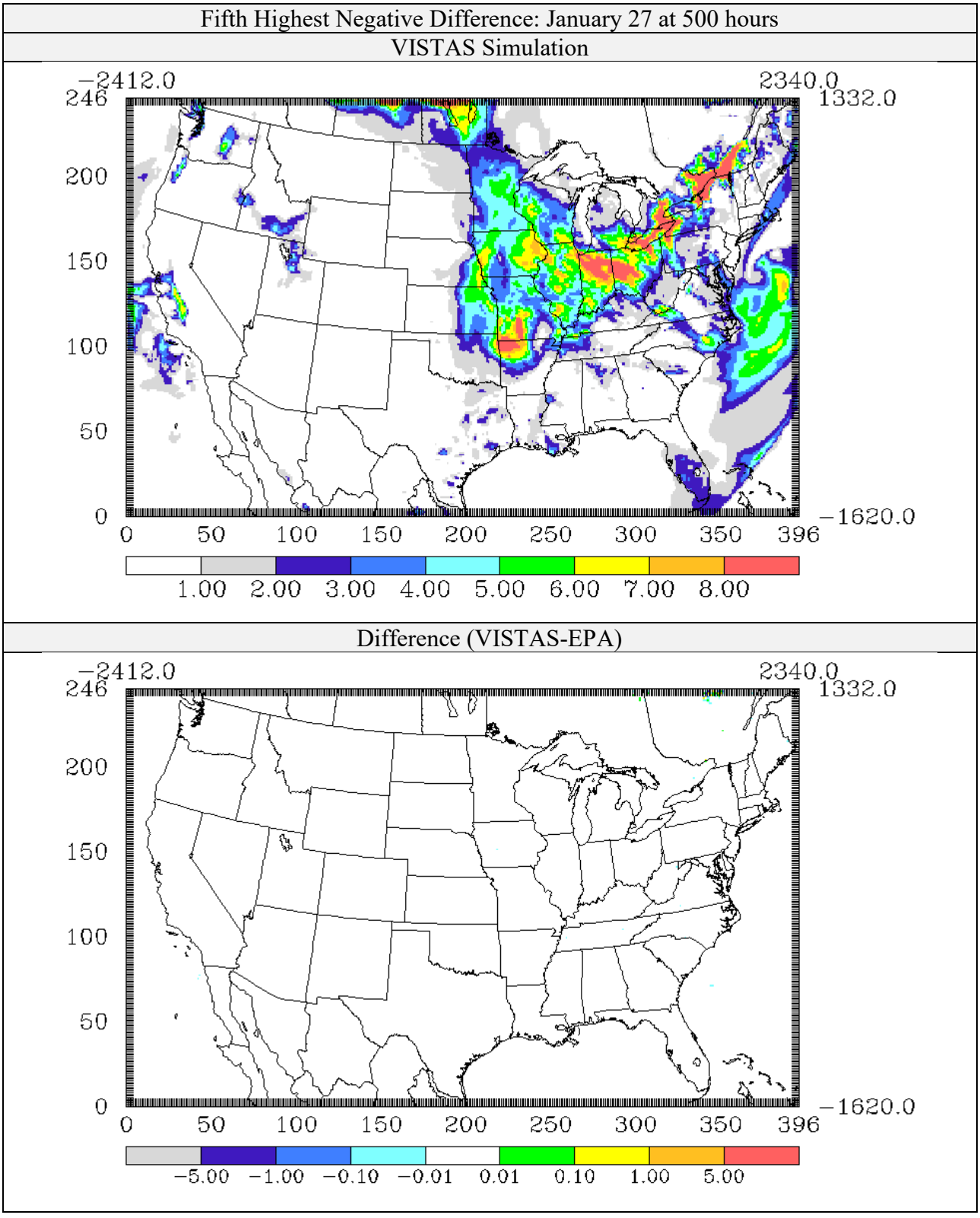


Figure 4-78: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference)

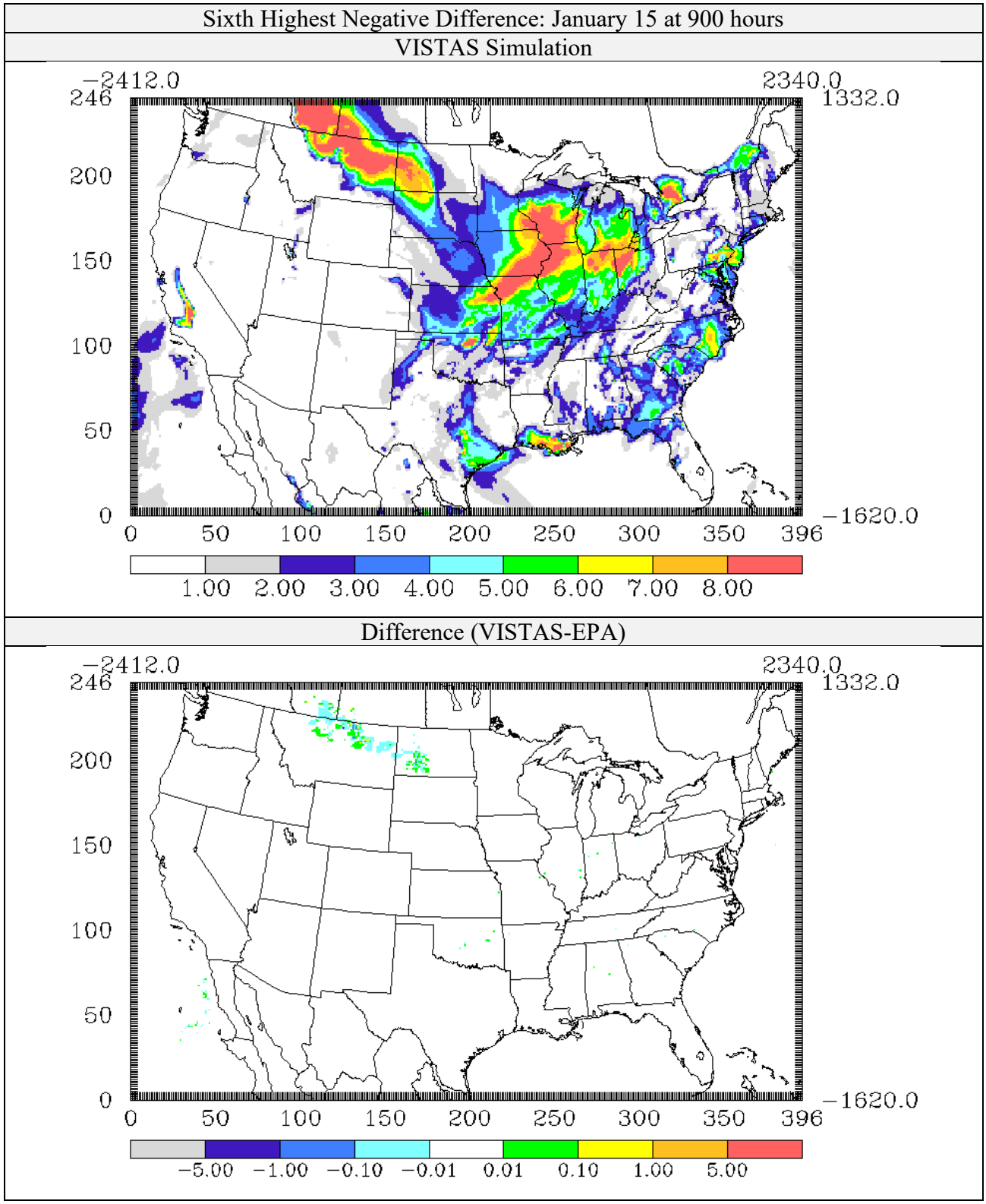


Figure 4-79: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference)

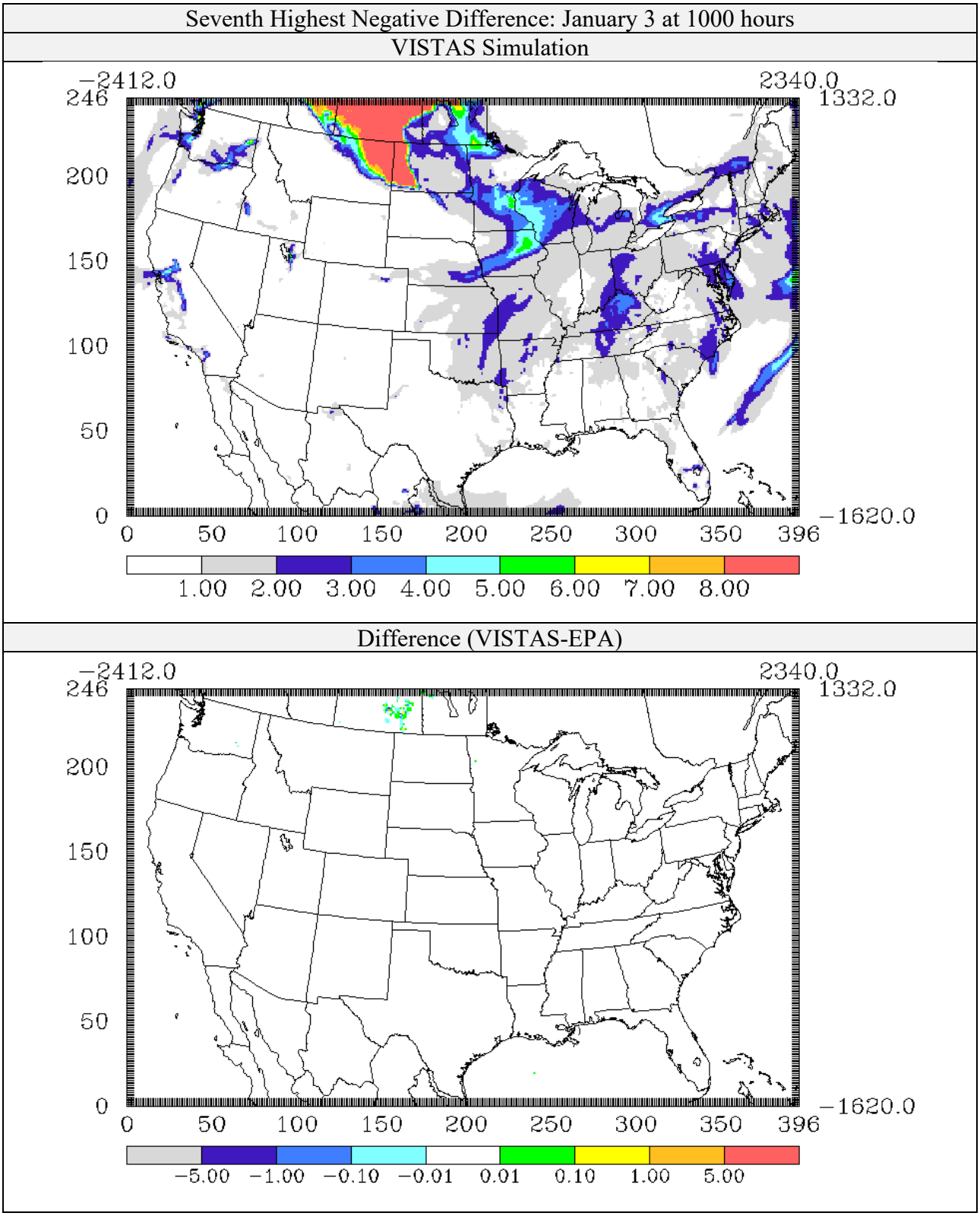


Figure 4-80: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference)

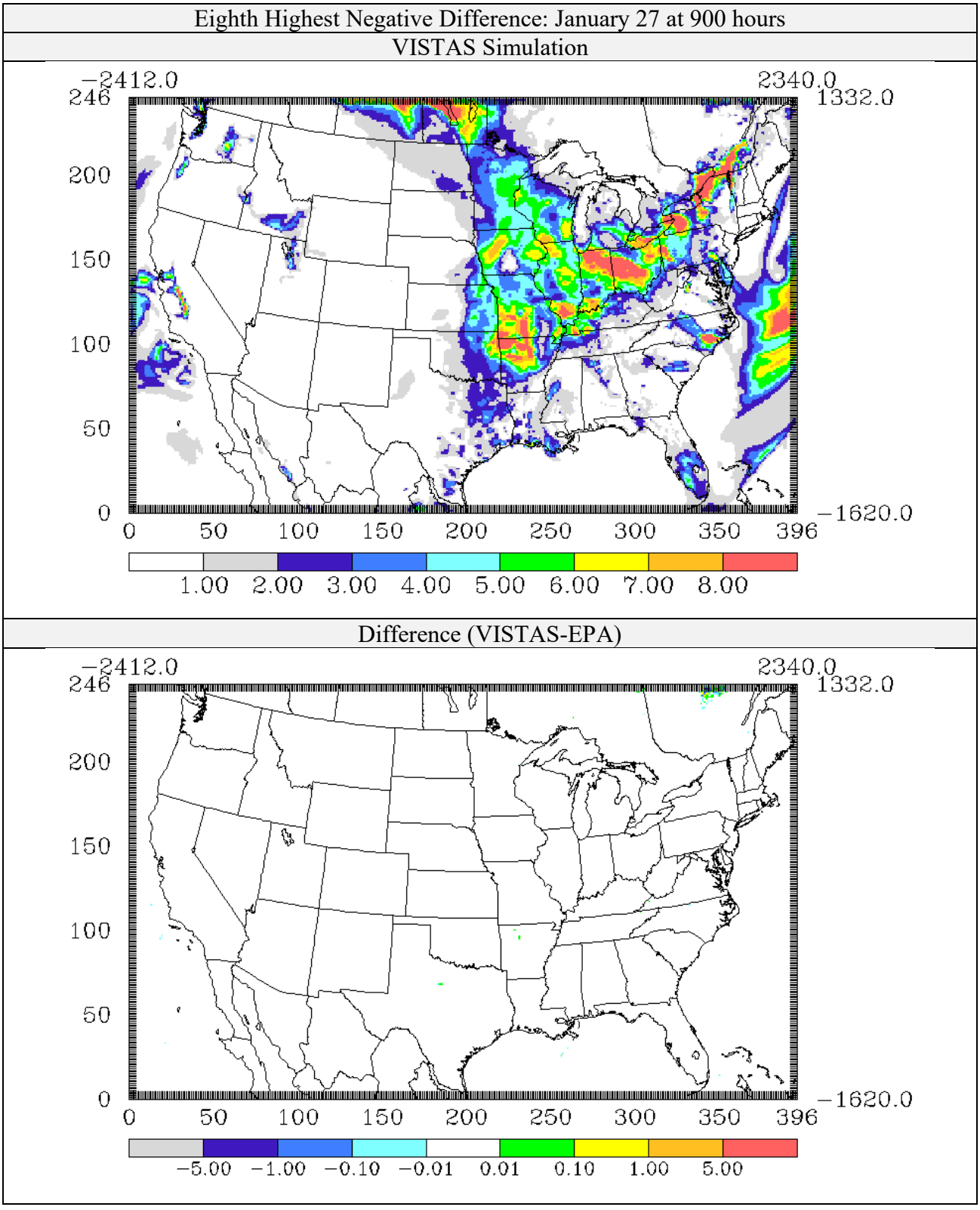


Figure 4-81: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference)

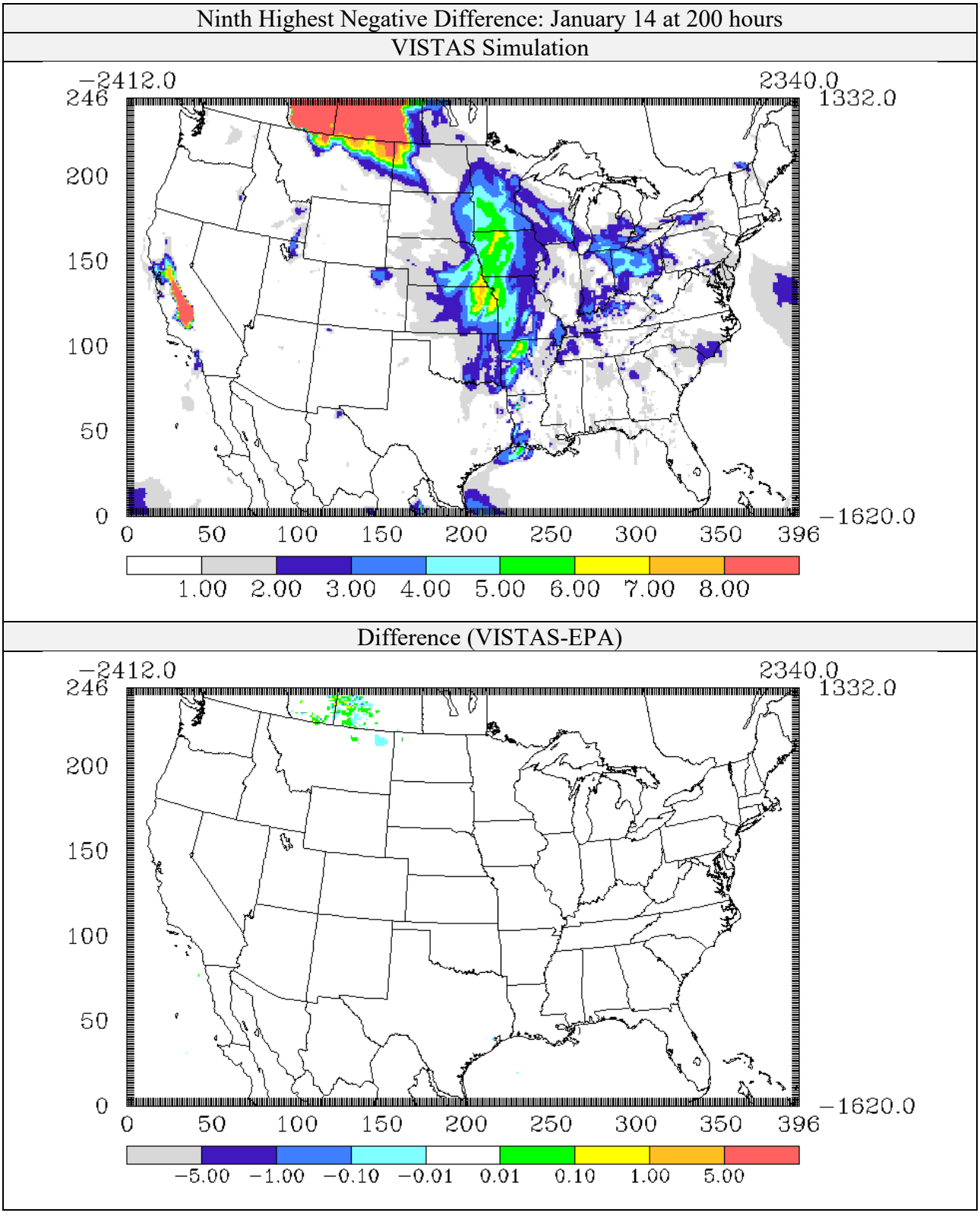


Figure 4-82: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference)

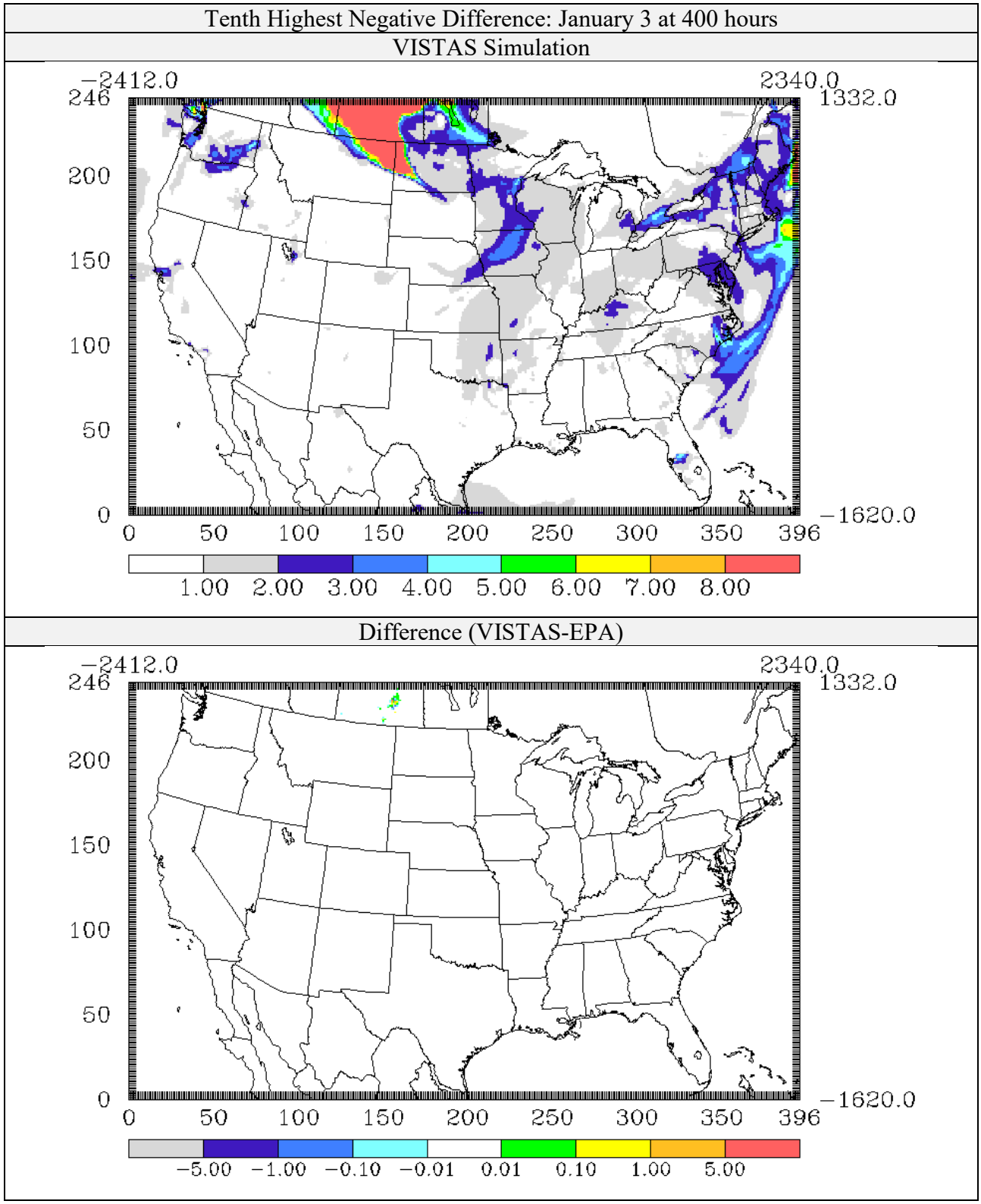


Figure 4-83: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference)

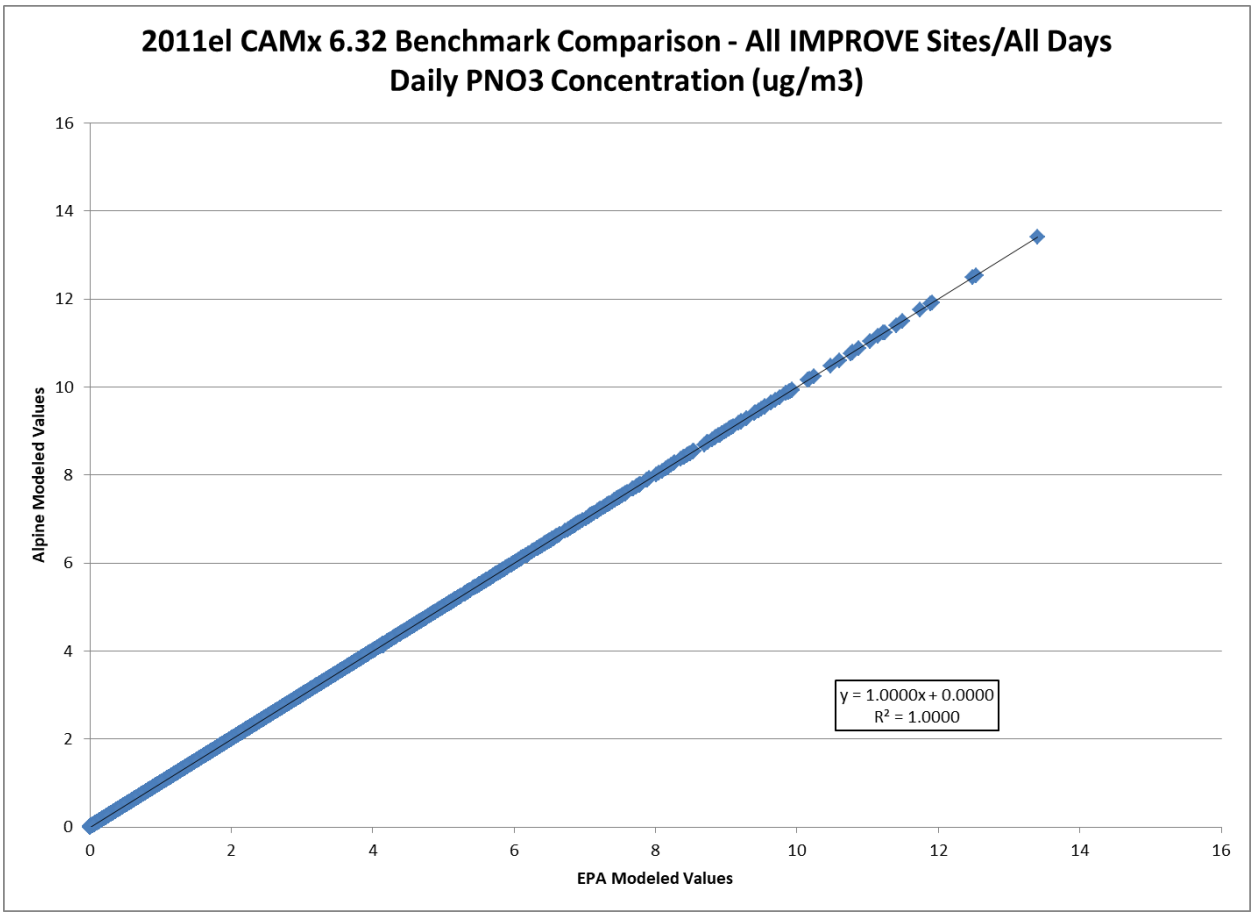


Figure 4-84: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine).

4.5 Organic Carbon (OC)

Organic Carbon (OC) results for the top 10 positive and negative hours are presented in tabular format in Table 4-5. The maximum positive difference is 0.18 µg/m^3 falling to 0.09 µg/m^3 for the 10th high. The maximum negative difference is -0.33 µg/m^3 falling to -0.08 µg/m^3 for the 10th high. The maximum positive percent difference from these days is 1.28% and negative percent difference of -2.89%.

The top 10 positive impact hours are presented in Figures 4-85 through 4-94 and the top 10 negative impact hours are presented in Figures 4-95 through 4-104. The locations of the impacts are extremely localized.

Scatterplots of the daily average OC concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-105. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

Table 4-5. Comparison of 2011el CAMx 6.32 Simulation Organic Carbon Concentrations (µg/m^3) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	6	26	12	17.32	17.13	0.18	1.08%	288	74
2011	5	20	12	11.46	11.32	0.14	1.23%	286	84
2011	8	26	12	10.82	10.69	0.14	1.28%	295	57
2011	5	20	13	10.89	10.77	0.12	1.16%	286	84
2011	12	15	17	25.91	25.80	0.12	0.45%	143	115
2011	7	14	22	5.30	5.19	0.11	2.03%	292	77
2011	6	26	13	12.40	12.31	0.10	0.79%	288	74
2011	7	26	12	10.30	10.21	0.09	0.93%	236	95
2011	8	26	13	7.69	7.60	0.09	1.23%	295	57
2011	8	23	22	7.38	7.29	0.09	1.28%	323	47
Maximum Negative									
2011	12	20	9	10.97	11.30	-0.33	-2.89%	313	89
2011	12	20	8	11.31	11.59	-0.28	-2.39%	313	89
2011	5	21	0	8.28	8.39	-0.11	-1.37%	331	95
2011	12	20	10	11.20	11.31	-0.11	-0.96%	313	89
2011	2	14	23	18.47	18.58	-0.11	-0.57%	271	69
2011	2	14	22	16.07	16.17	-0.10	-0.65%	271	69
2011	8	4	14	13.21	13.31	-0.10	-0.75%	213	89
2011	7	19	12	7.28	7.37	-0.09	-1.22%	253	100
2011	8	1	0	8.21	8.29	-0.08	-1.01%	261	70
2011	7	15	13	5.29	5.38	-0.08	-1.56%	314	98

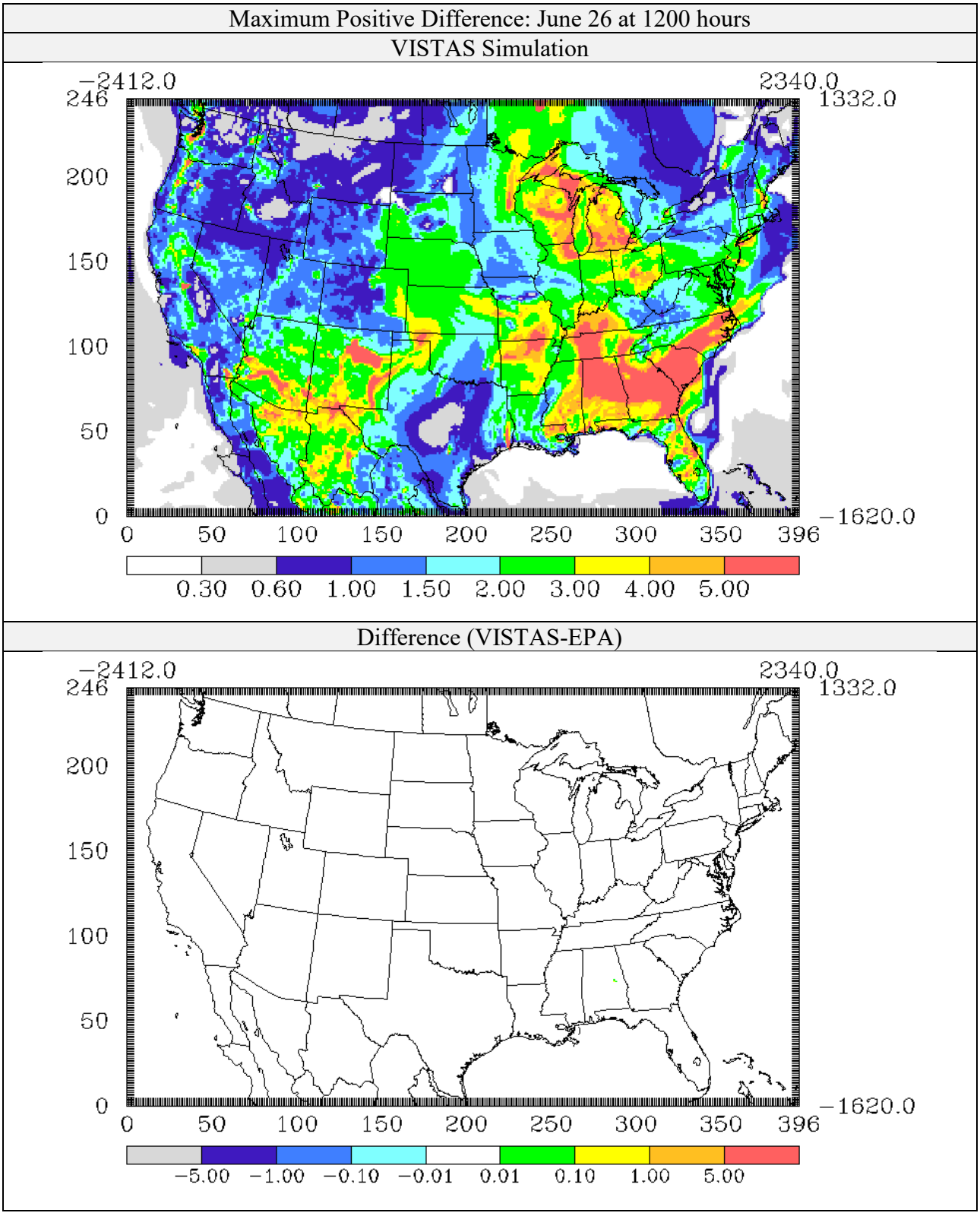


Figure 4-85: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Positive Difference)

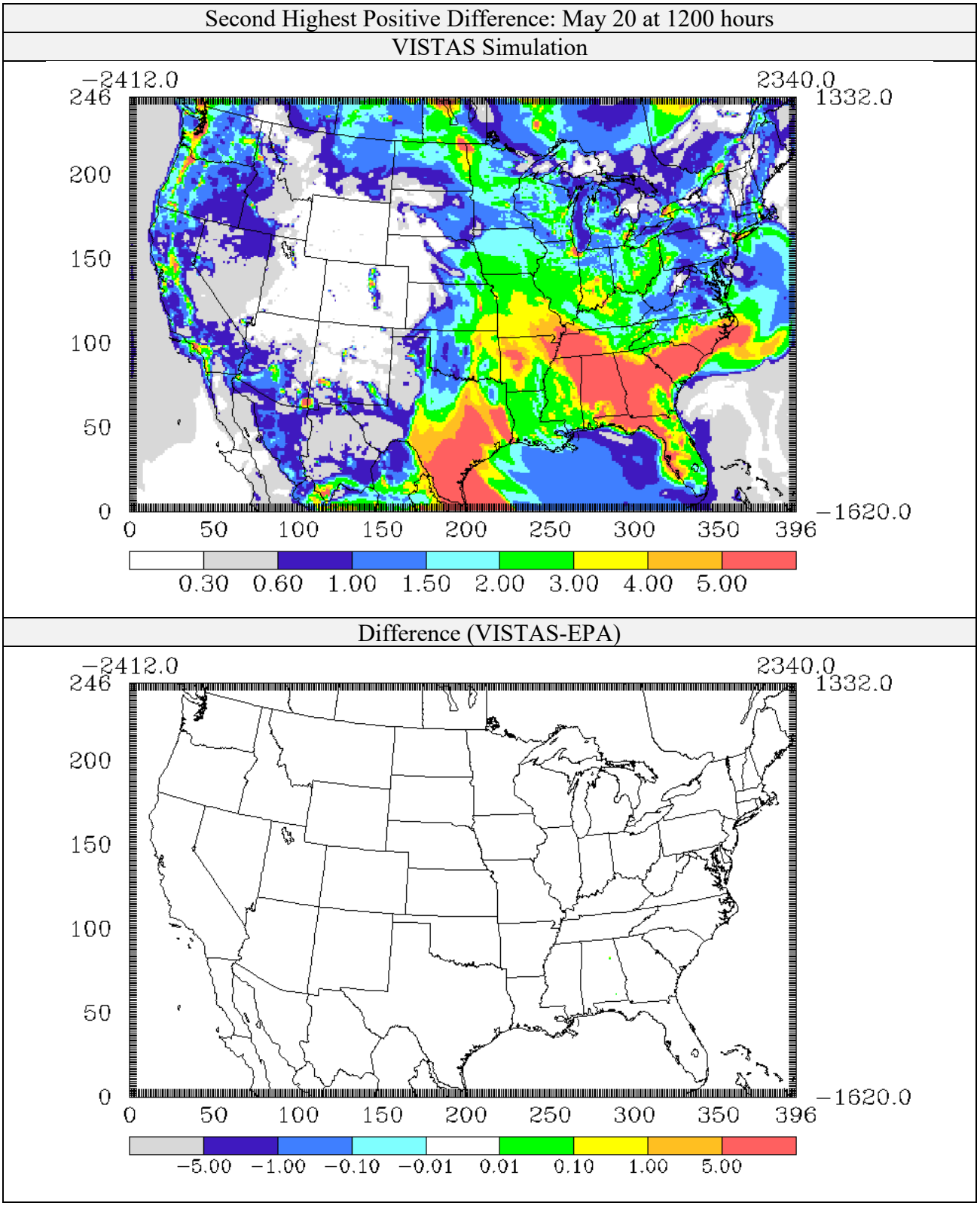


Figure 4-86: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Positive Difference)

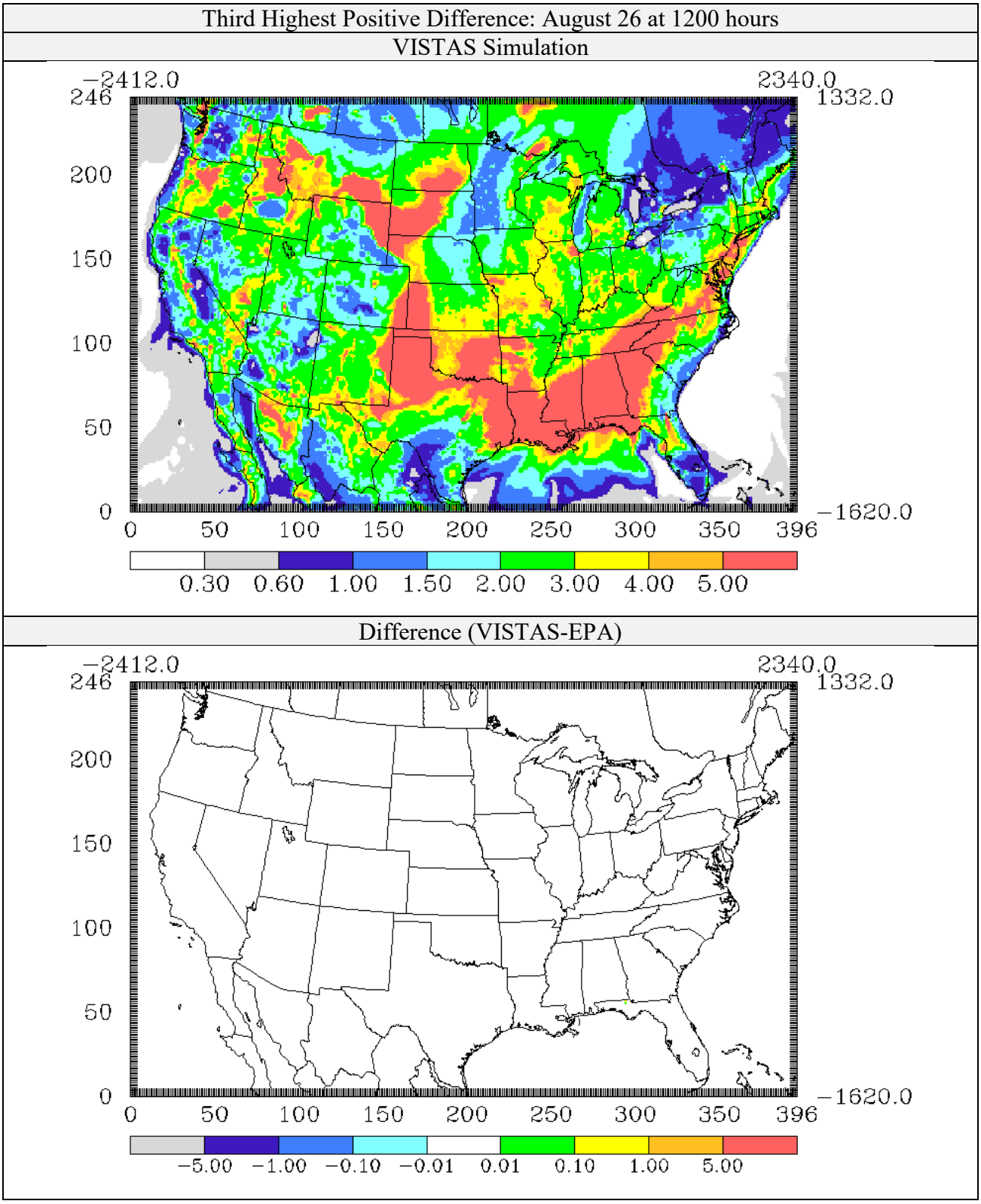


Figure 4-87: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Positive Difference)

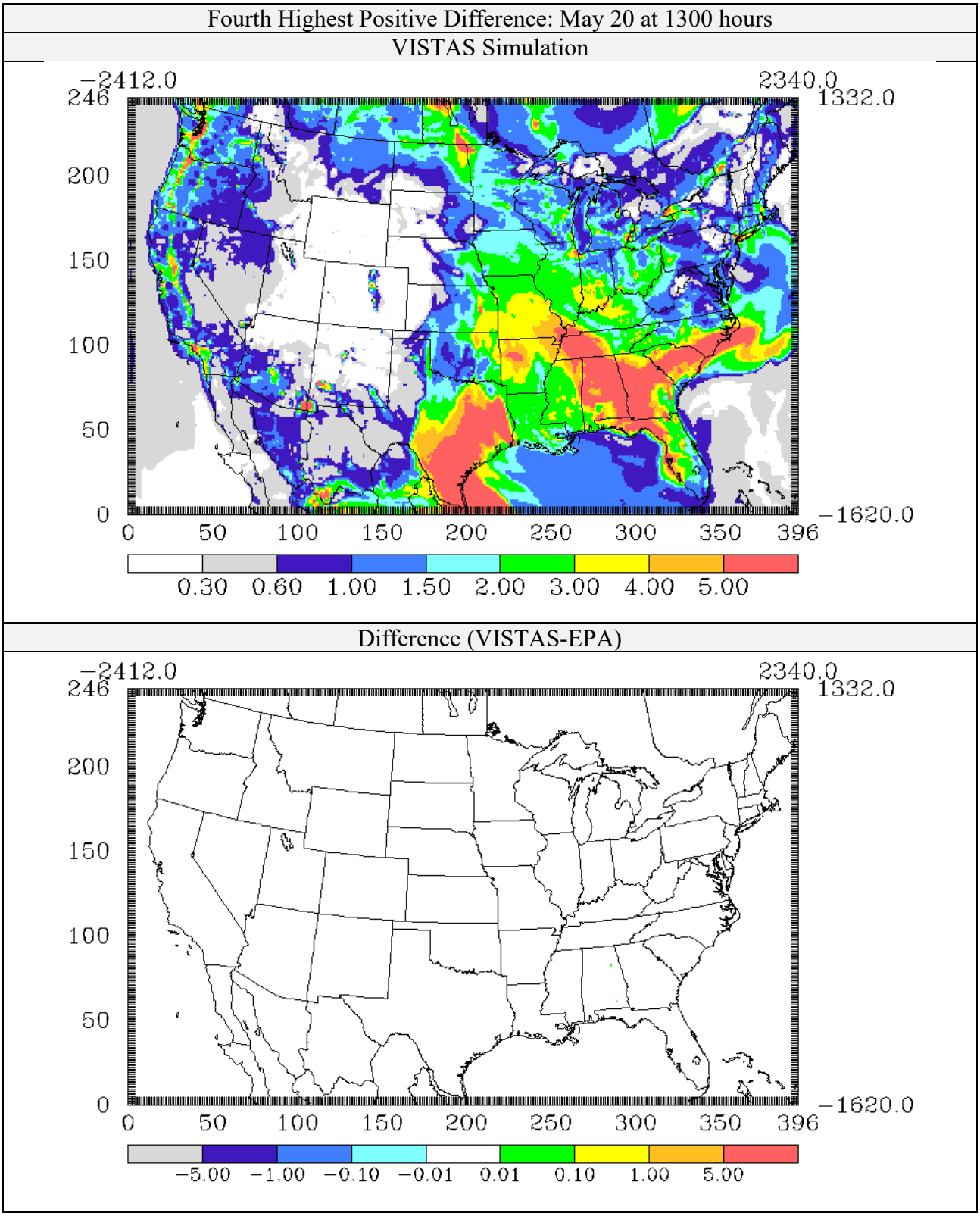


Figure 4-88: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Positive Difference)

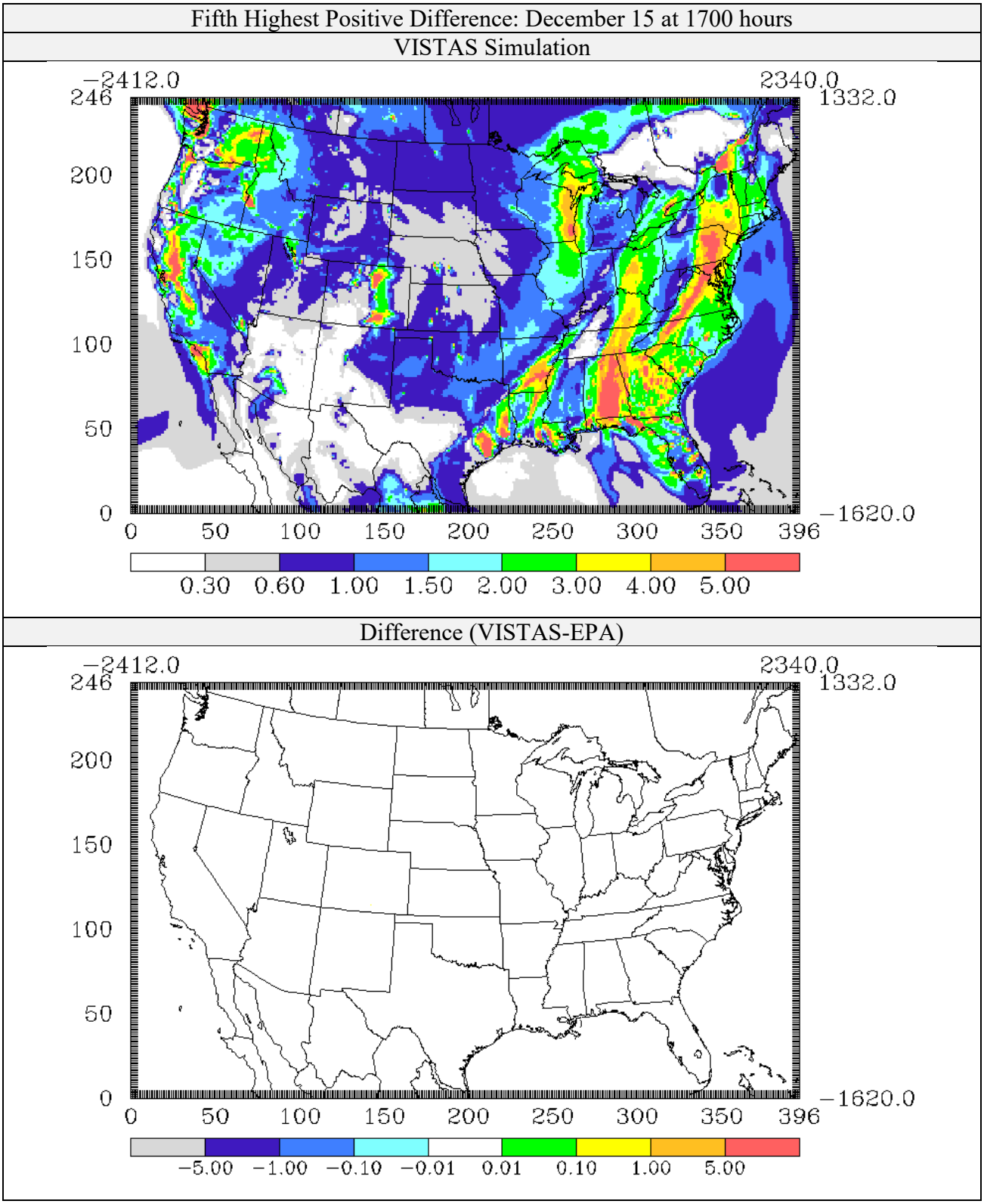


Figure 4-89: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Positive Difference)

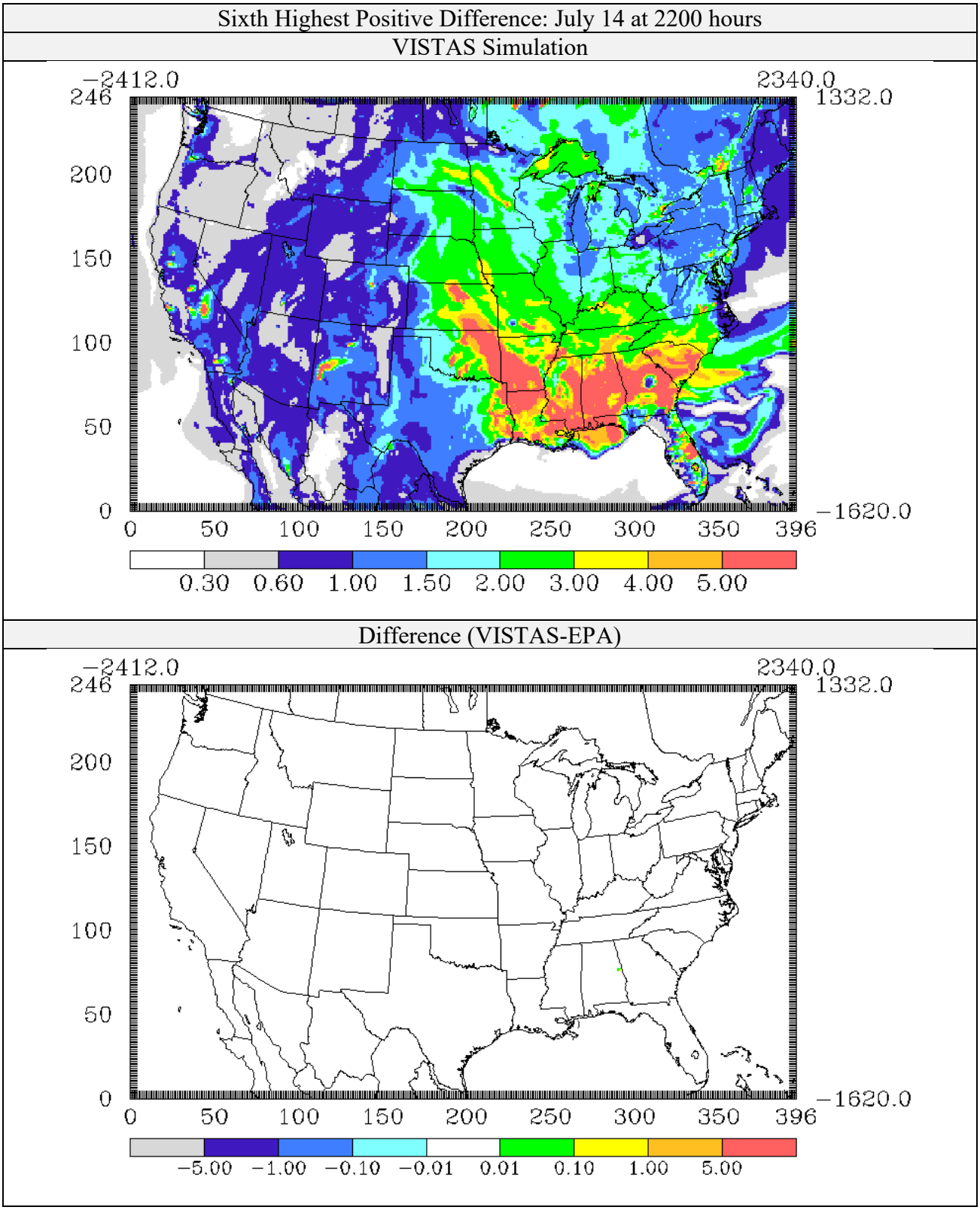


Figure 4-90: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Positive Difference)

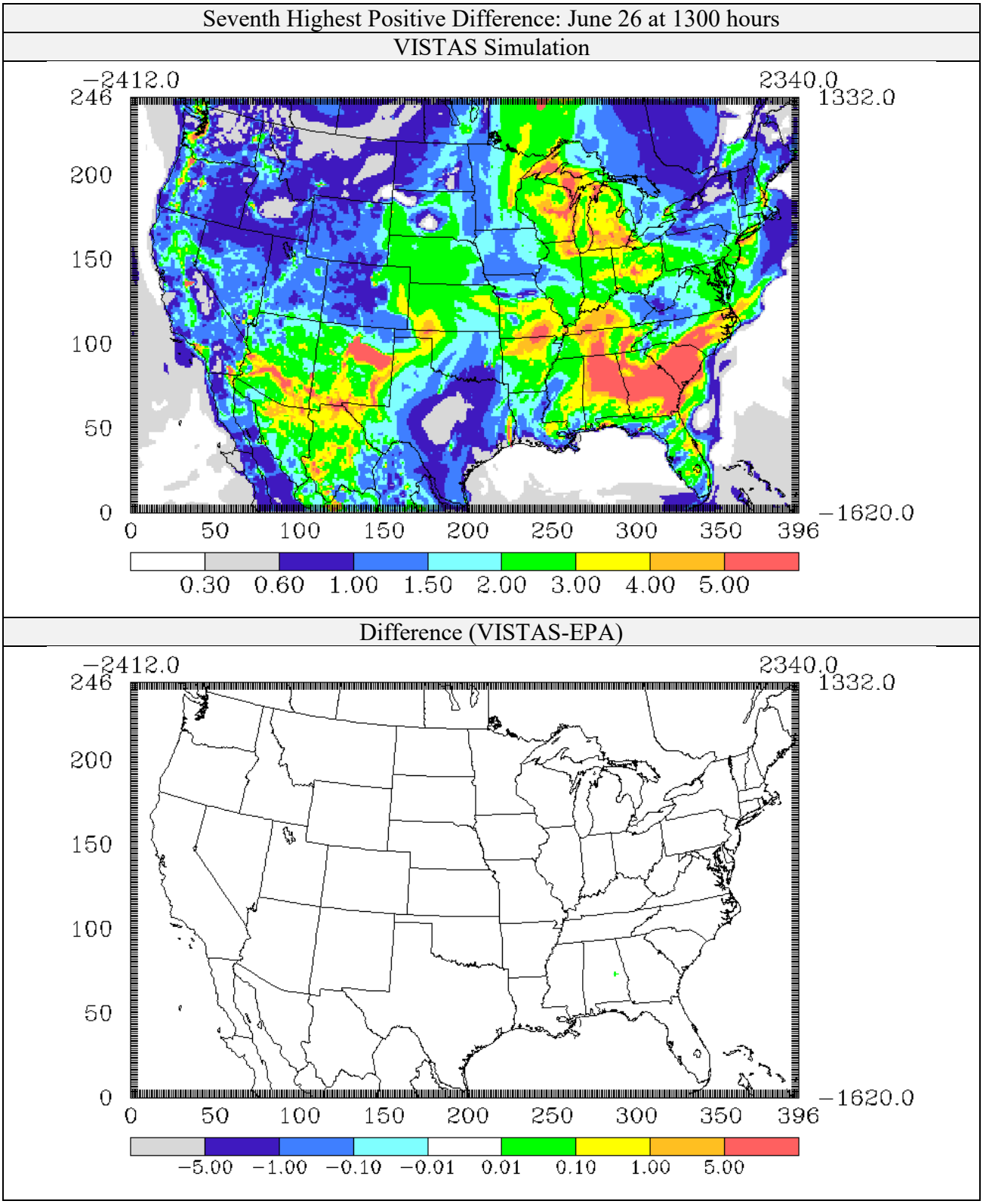


Figure 4-91: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Positive Difference)

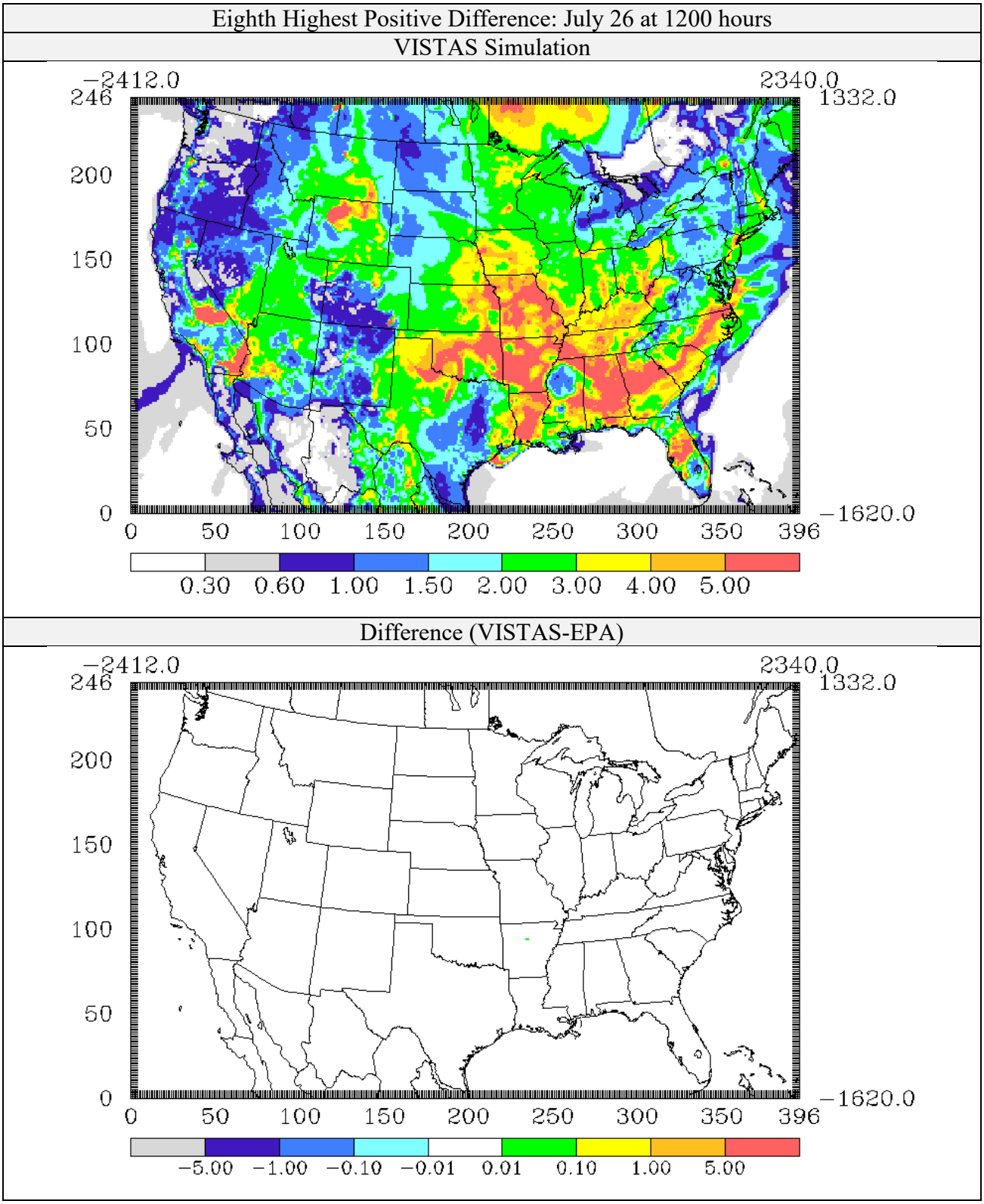


Figure 4-92: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Positive Difference)

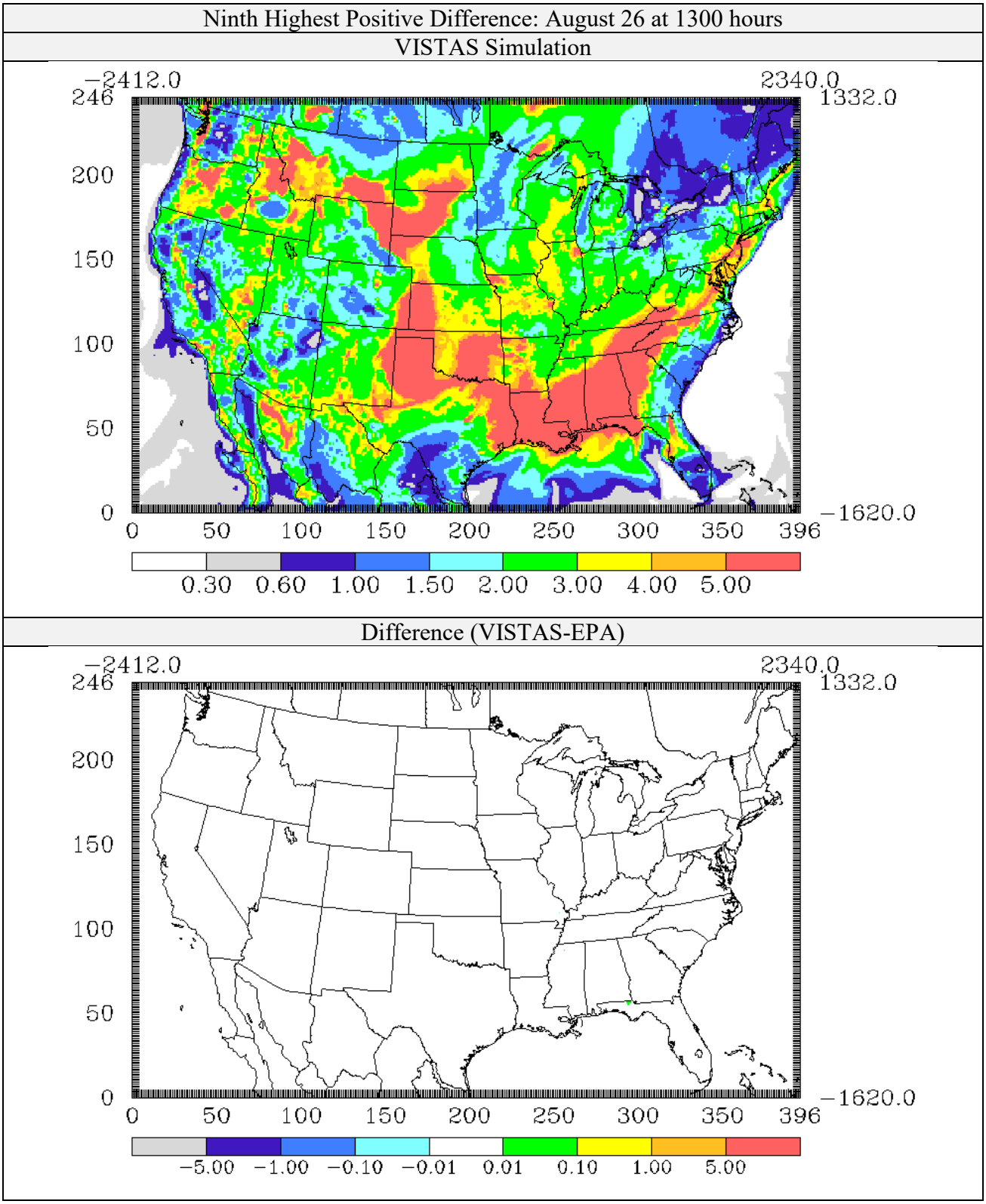


Figure 4-93: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Positive Difference)

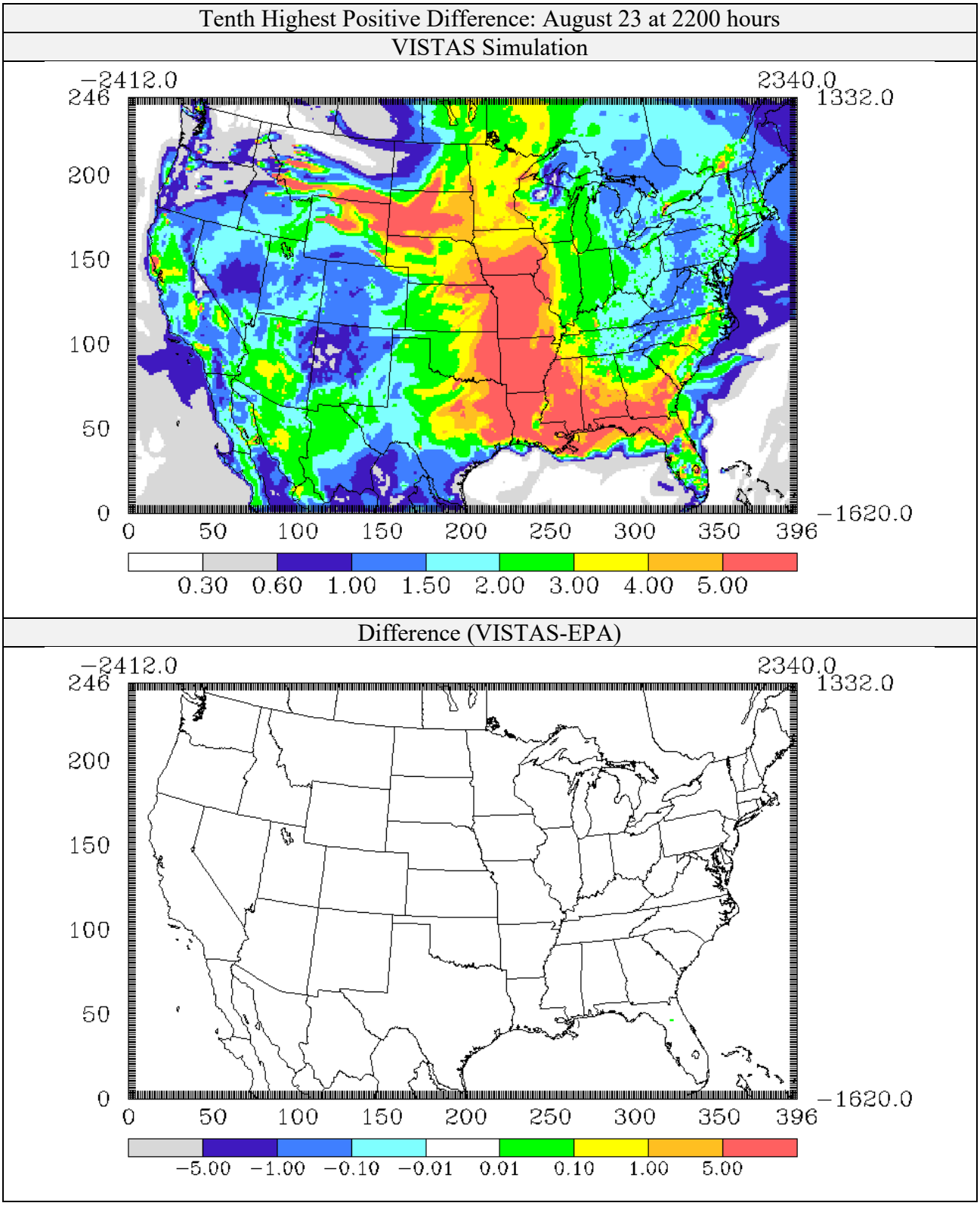


Figure 4-94: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Positive Difference)

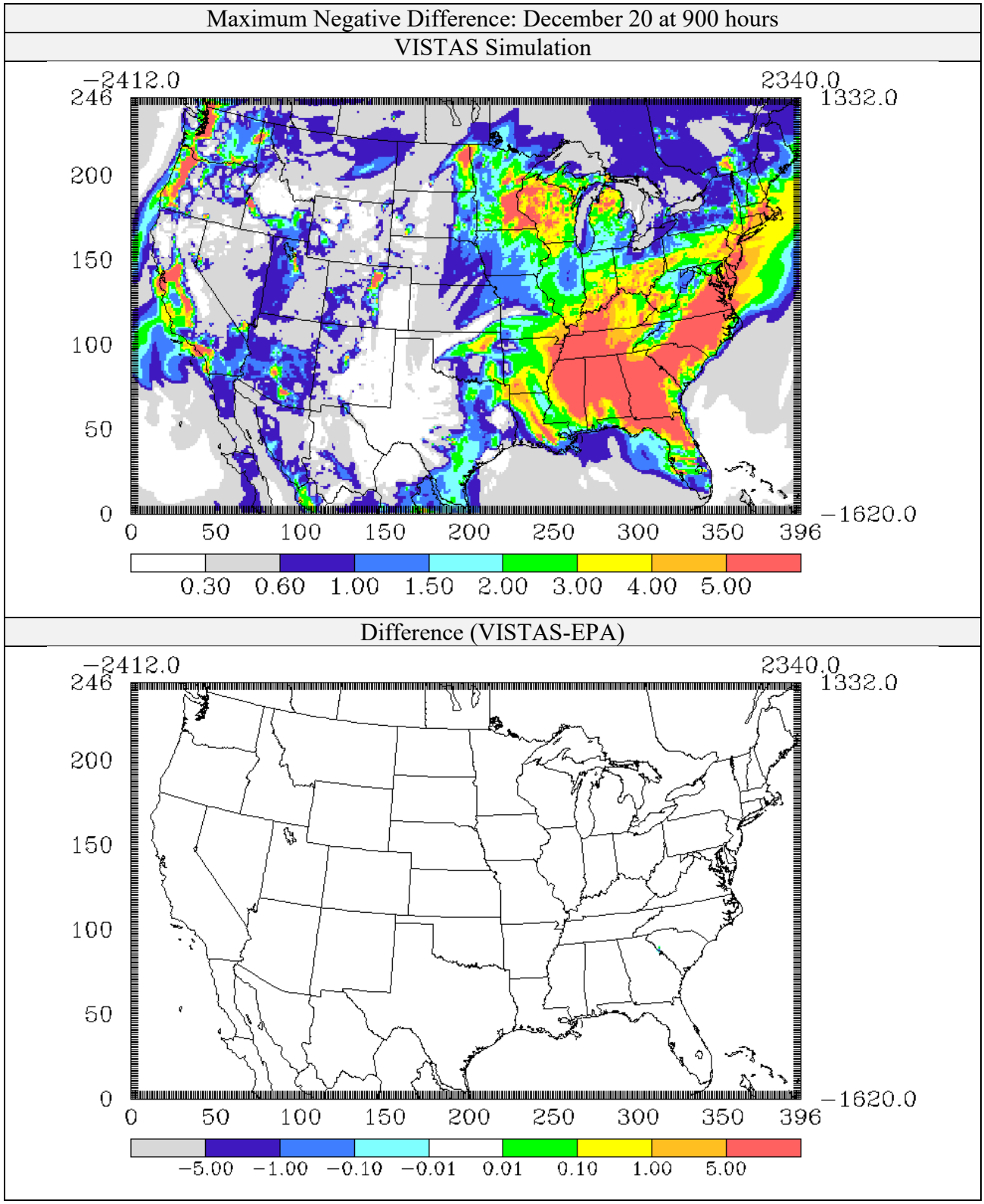


Figure 4-95: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Maximum Negative Difference)

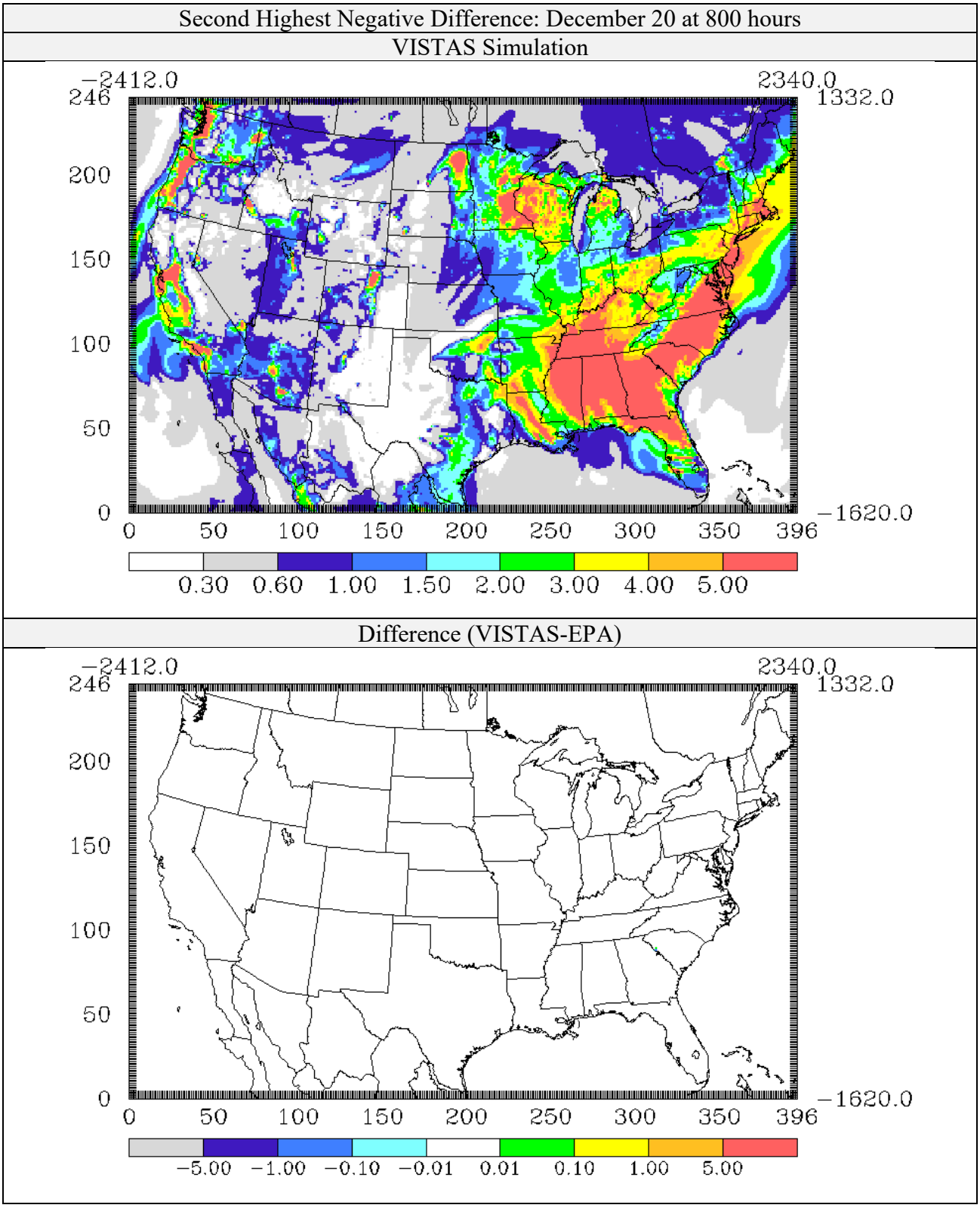


Figure 4-96: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Second Highest Negative Difference)

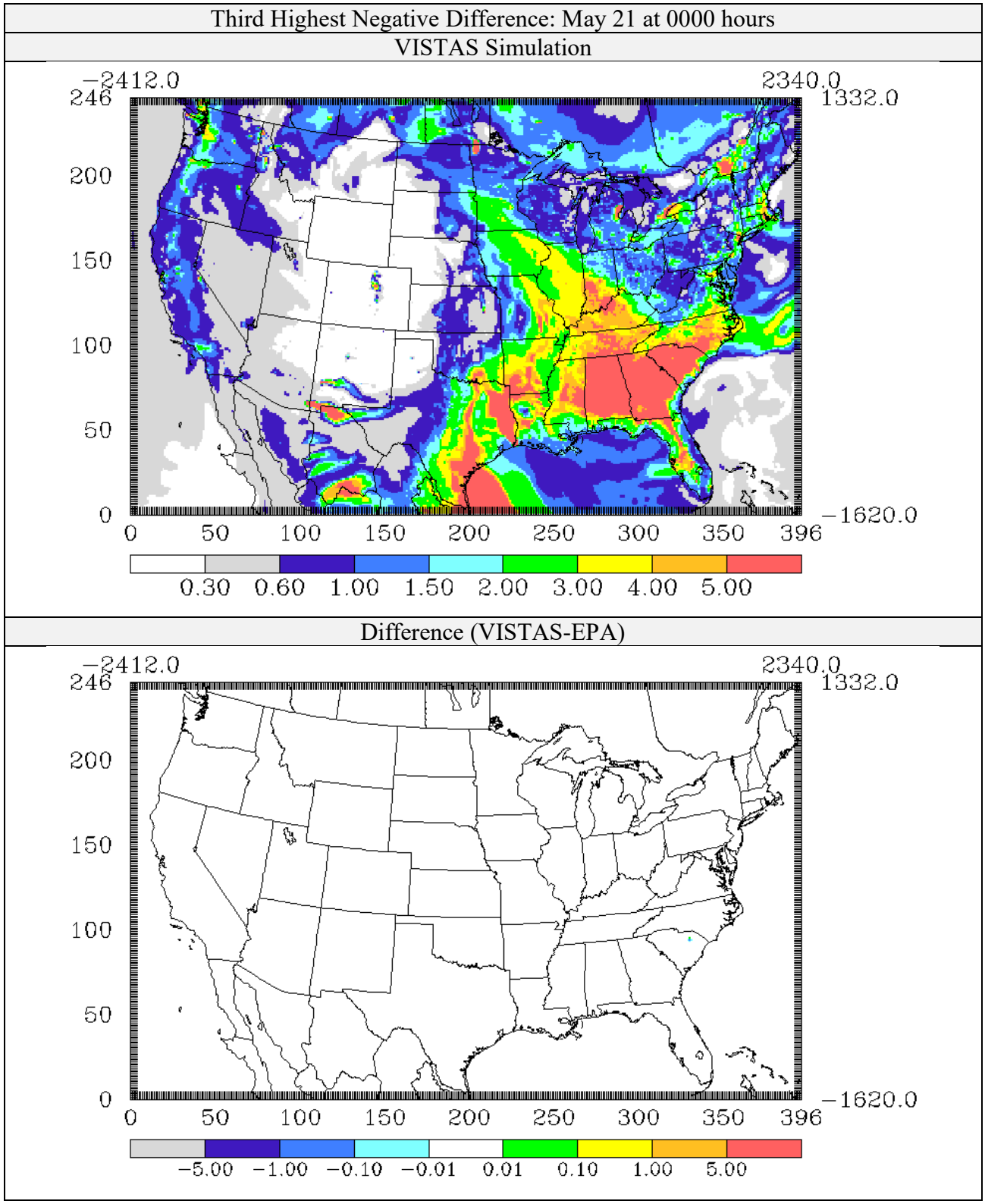


Figure 4-97: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Third Highest Negative Difference)

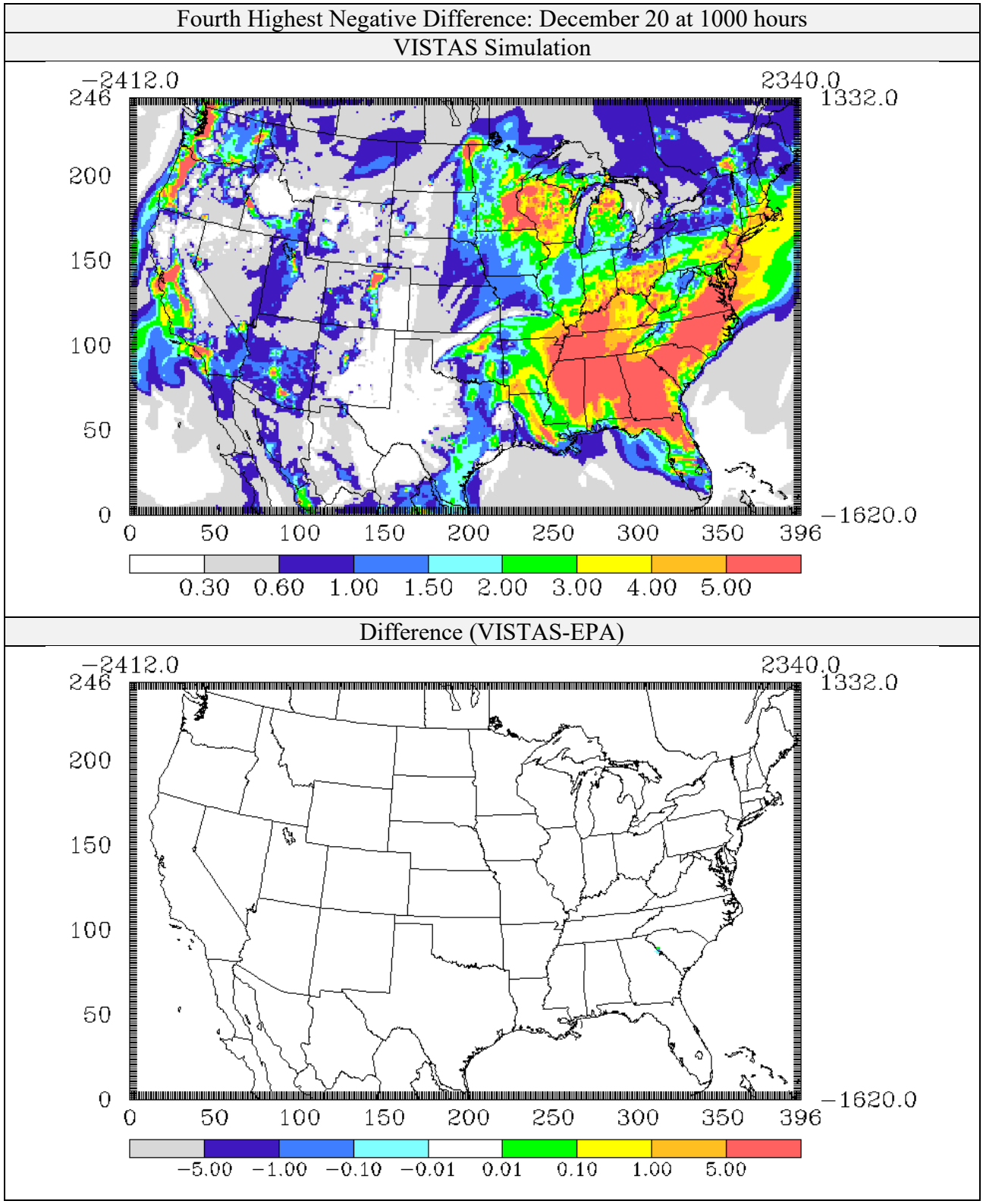


Figure 4-98: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fourth Highest Negative Difference)

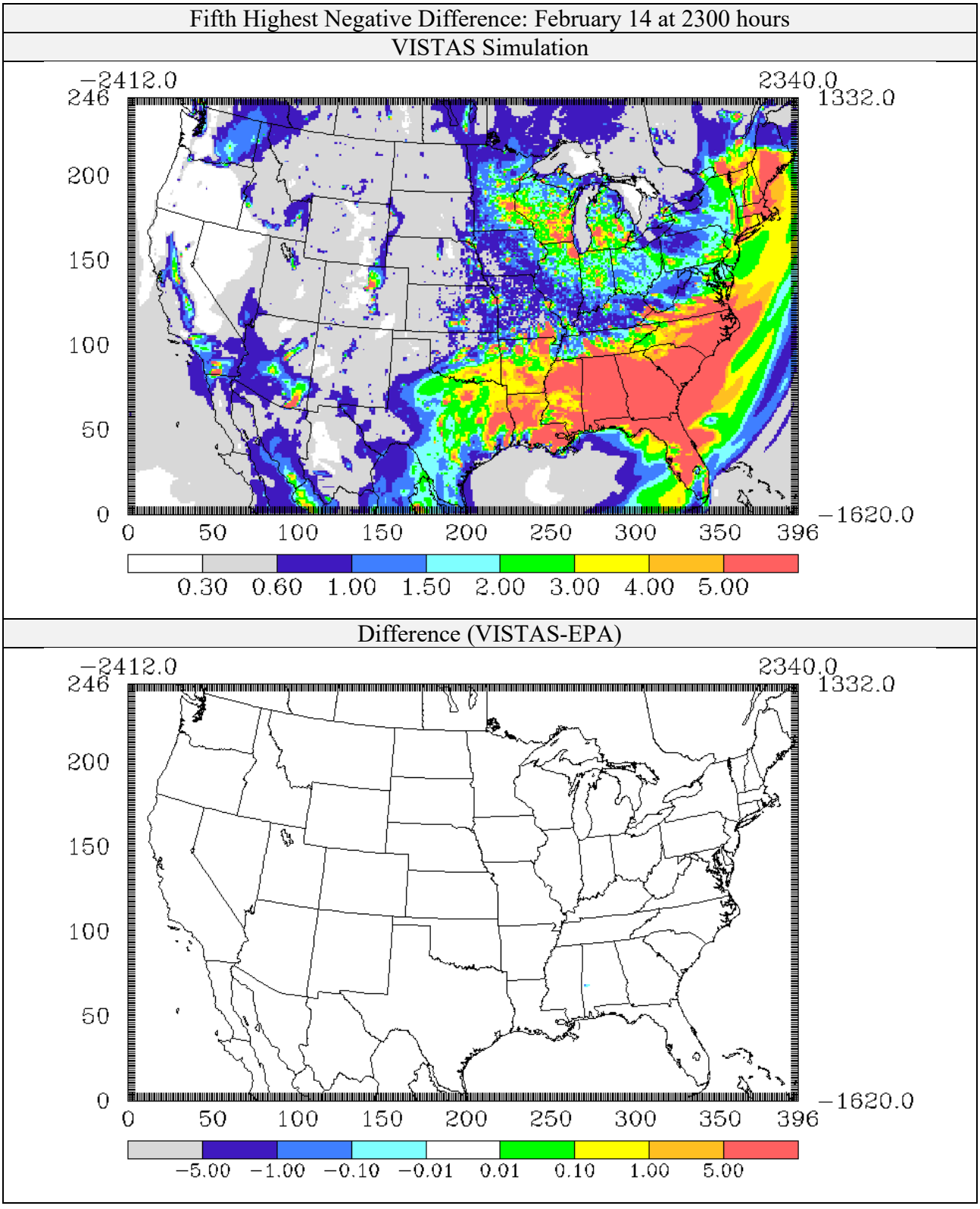


Figure 4-99: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Fifth Highest Negative Difference)

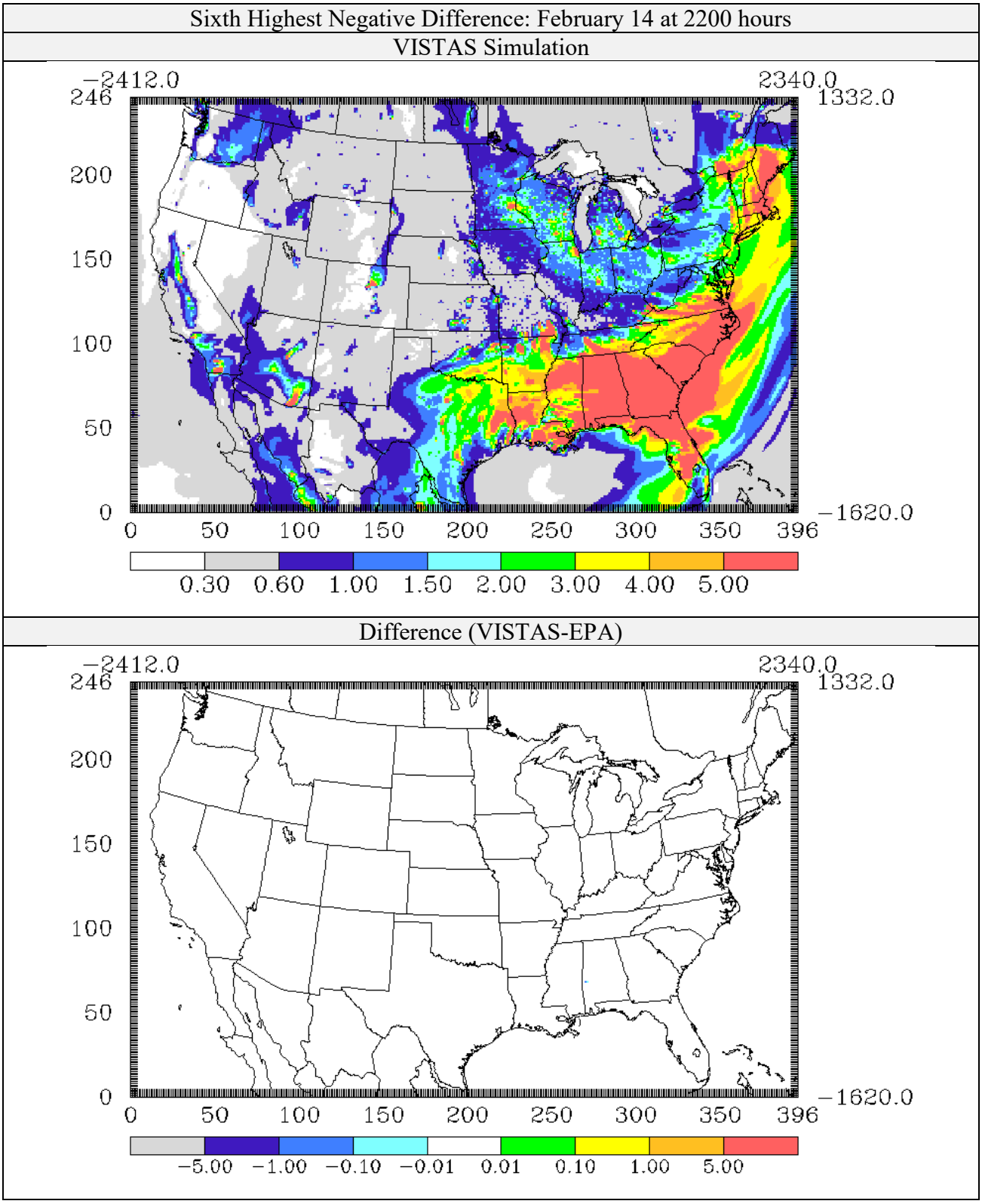


Figure 4-100: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Sixth Highest Negative Difference)

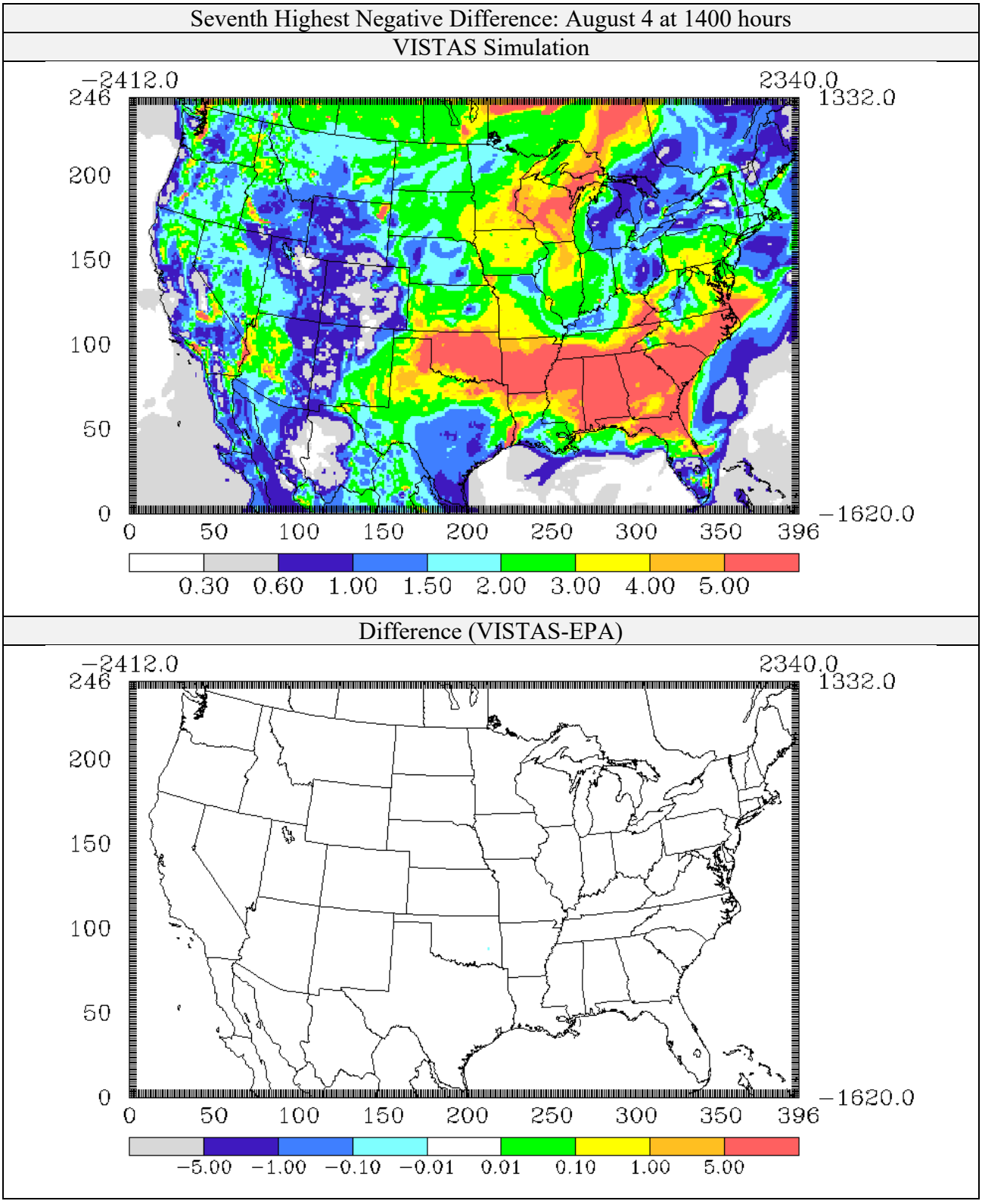


Figure 4-101: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Seventh Highest Negative Difference)

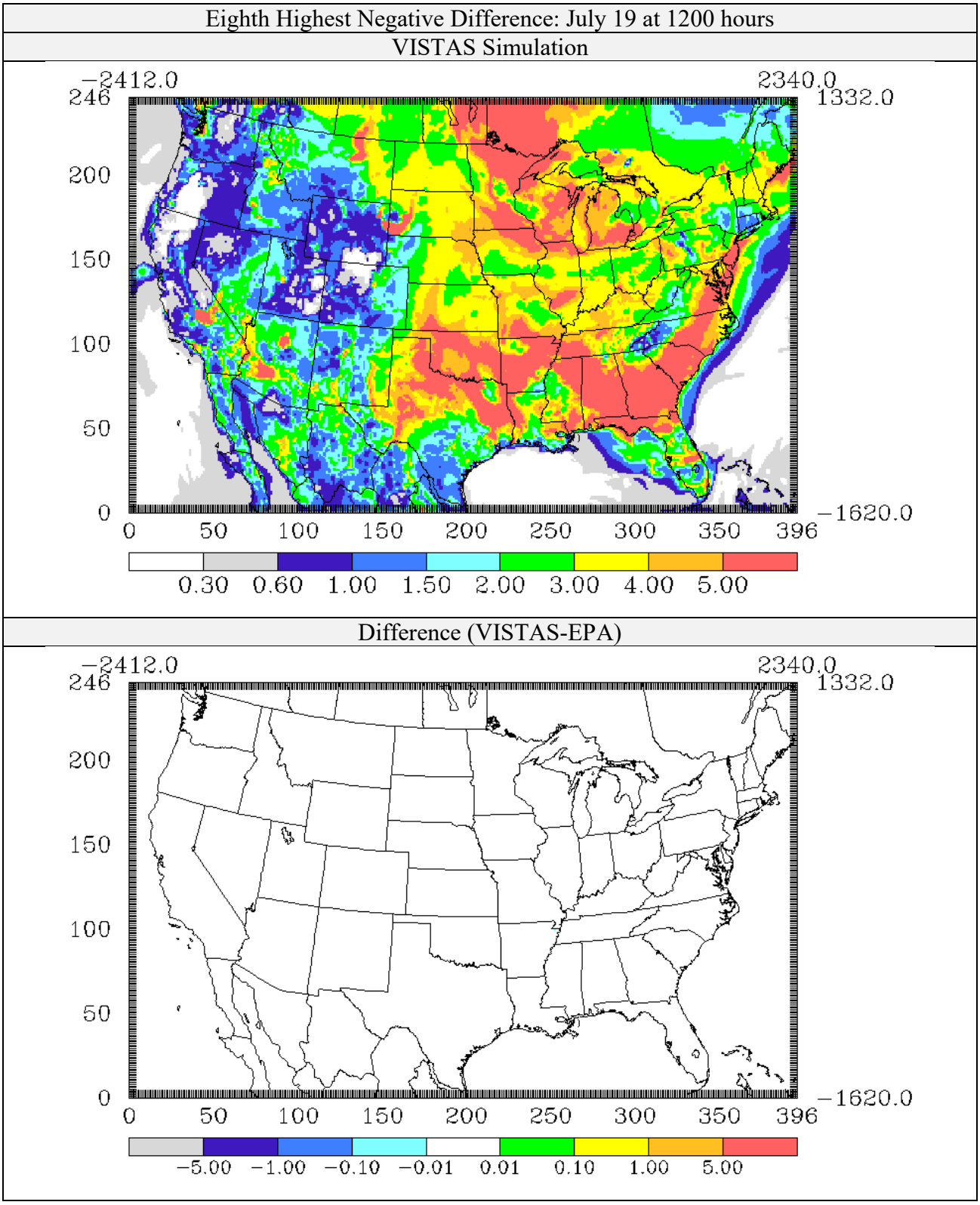


Figure 4-102: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Eighth Highest Negative Difference)

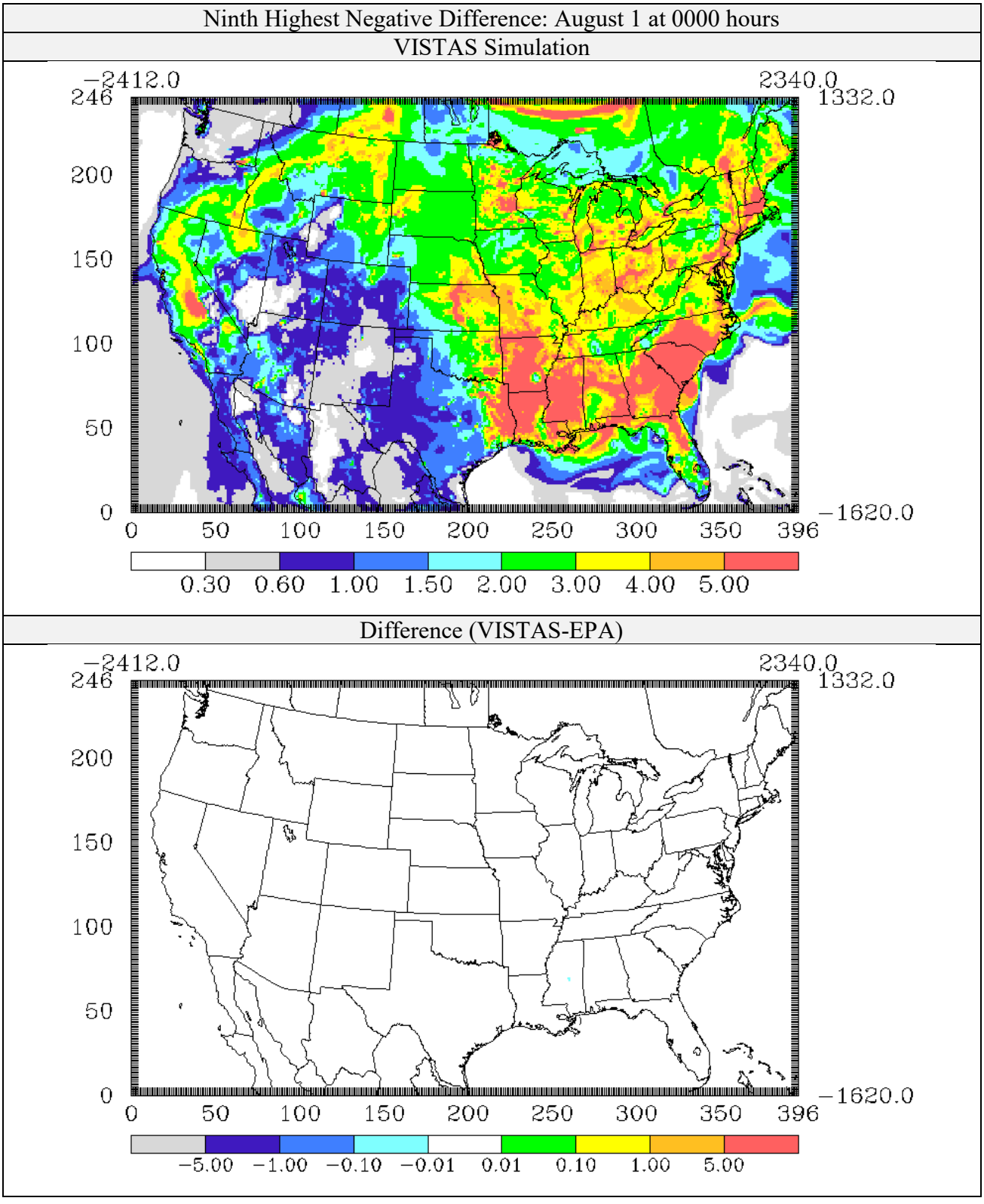


Figure 4-103: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Ninth Highest Negative Difference)

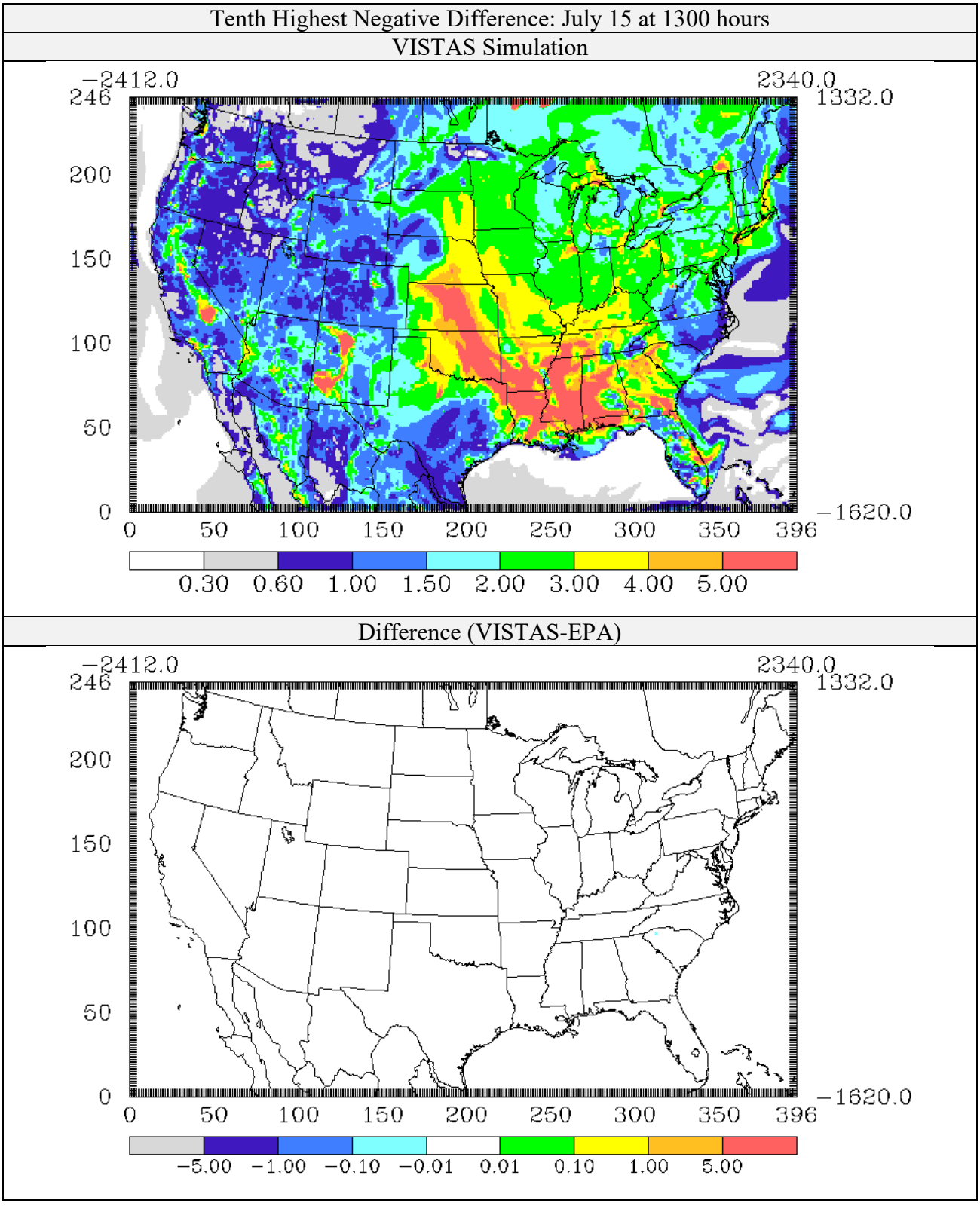


Figure 4-104: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2011el Simulations (Tenth Highest Negative Difference)

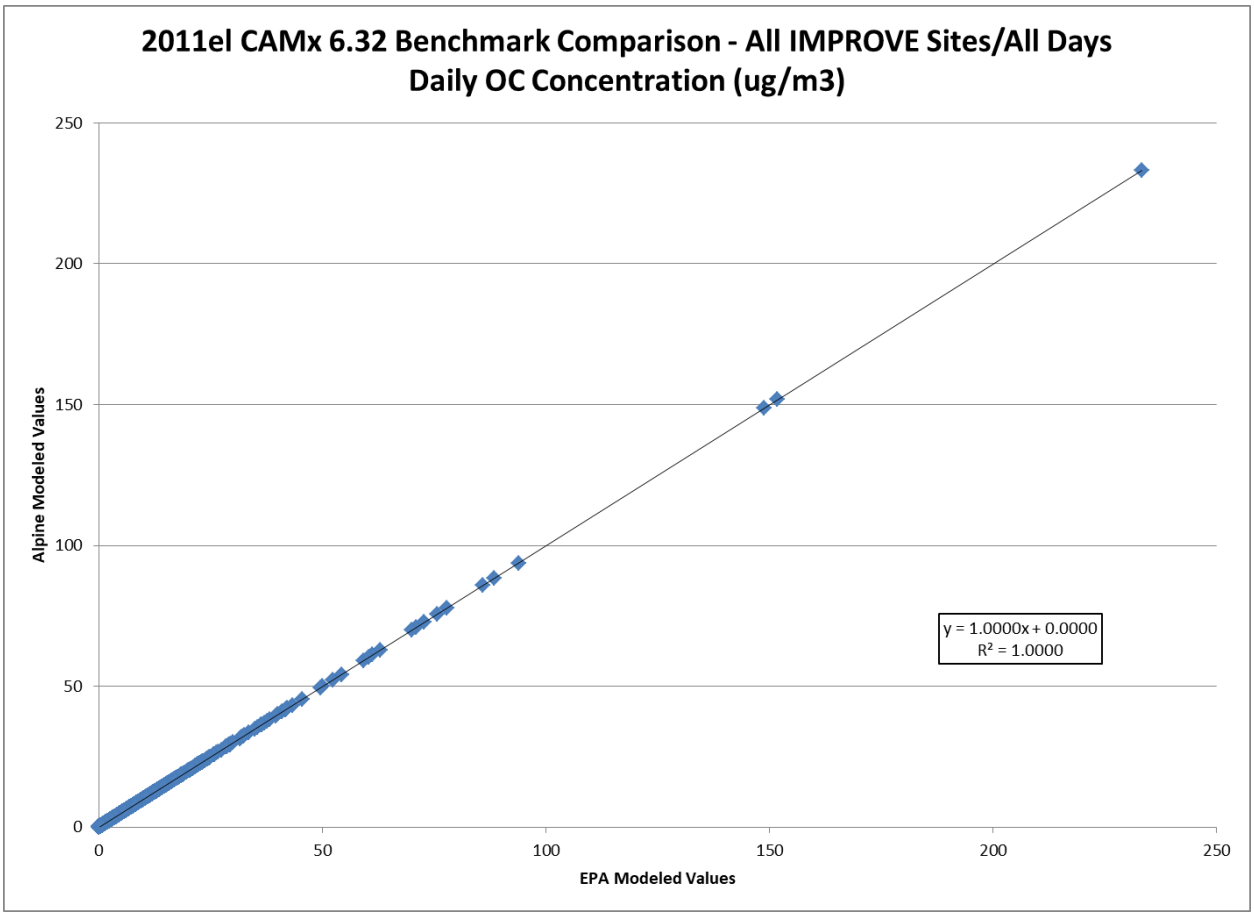


Figure 4-105: Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2011el Simulations Performed by EPA and VISTAS (Alpine).

5.0 CAMX 6.32 2028EL COMPARISON

This section presents comparisons of the 2028el simulations using CAMx 6.32 performed on the Alpine and EPA computer systems.

5.1 Ozone

Ozone results for the top 10 positive and negative hours are presented in tabular format in Table 5-1. The maximum positive difference is 2.24 ppb falling to 1.74 ppb for the 10th high. The maximum negative difference is -2.25 ppb falling to -1.60 ppb for the 10th high. The highest differences are occurring on relatively low ozone hours with concentrations ranging from 30 ppb to 50 ppb for the EPA simulation. The maximum positive percent difference is 7.8% and the maximum negative percent difference is -6.6%

The top ten positive impact hours are presented in Figures 5-1 through 5-10 and the top ten negative impact hours are presented in Figures 5-11 through 5-20. The locations of the impacts are very localized. On the hours with the maximum impacts the overwhelming number of grid cells have impacts less than 0.01 ppb.

Scatterplots of the daily average ozone concentrations in local standard time at the IMPROVE monitors are presented in Figure 5-21. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

The hours of the maximum differences, and the spatial patterns on those hours, are very similar between the 2011el (Section 4.1) and 2028el. This is not surprising given that the simulations differ only in the anthropogenic emissions inventories.

Table 5-1. Comparison of 2028el CAMx 6.32 Simulation Ozone Concentrations (ppb) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (ppb)	Percent Difference	Column	Row
Maximum Positive									
2011	7	6	23	42.43	40.19	2.24	5.58%	197	156
2011	8	18	23	44.64	42.43	2.21	5.21%	286	152
2011	7	14	22	31.20	29.06	2.13	7.34%	292	77
2011	8	30	14	28.50	26.43	2.06	7.81%	110	217
2011	8	27	12	29.93	28.01	1.92	6.85%	295	143
2011	9	11	23	52.26	50.35	1.91	3.79%	167	218
2011	8	19	0	38.39	36.52	1.87	5.12%	286	152
2011	8	8	23	35.67	33.85	1.82	5.39%	217	184
2011	8	7	16	30.17	28.38	1.80	6.33%	257	103
2011	7	7	0	38.27	36.52	1.74	4.78%	197	156
Maximum Negative									
2011	8	16	0	27.88	30.14	-2.25	-7.47%	251	134
2011	6	18	22	30.88	33.06	-2.18	-6.59%	196	187
2011	8	15	23	30.96	33.06	-2.10	-6.34%	251	134
2011	7	15	21	38.77	40.69	-1.92	-4.73%	224	159
2011	3	30	10	42.39	44.30	-1.91	-4.30%	117	19
2011	6	26	22	27.84	29.67	-1.83	-6.17%	206	183
2011	7	7	16	35.85	37.67	-1.82	-4.84%	216	180
2011	8	11	18	31.40	33.11	-1.72	-5.19%	332	28
2011	6	18	23	30.11	31.76	-1.65	-5.19%	196	187
2011	7	16	19	43.39	45.00	-1.60	-3.57%	196	189

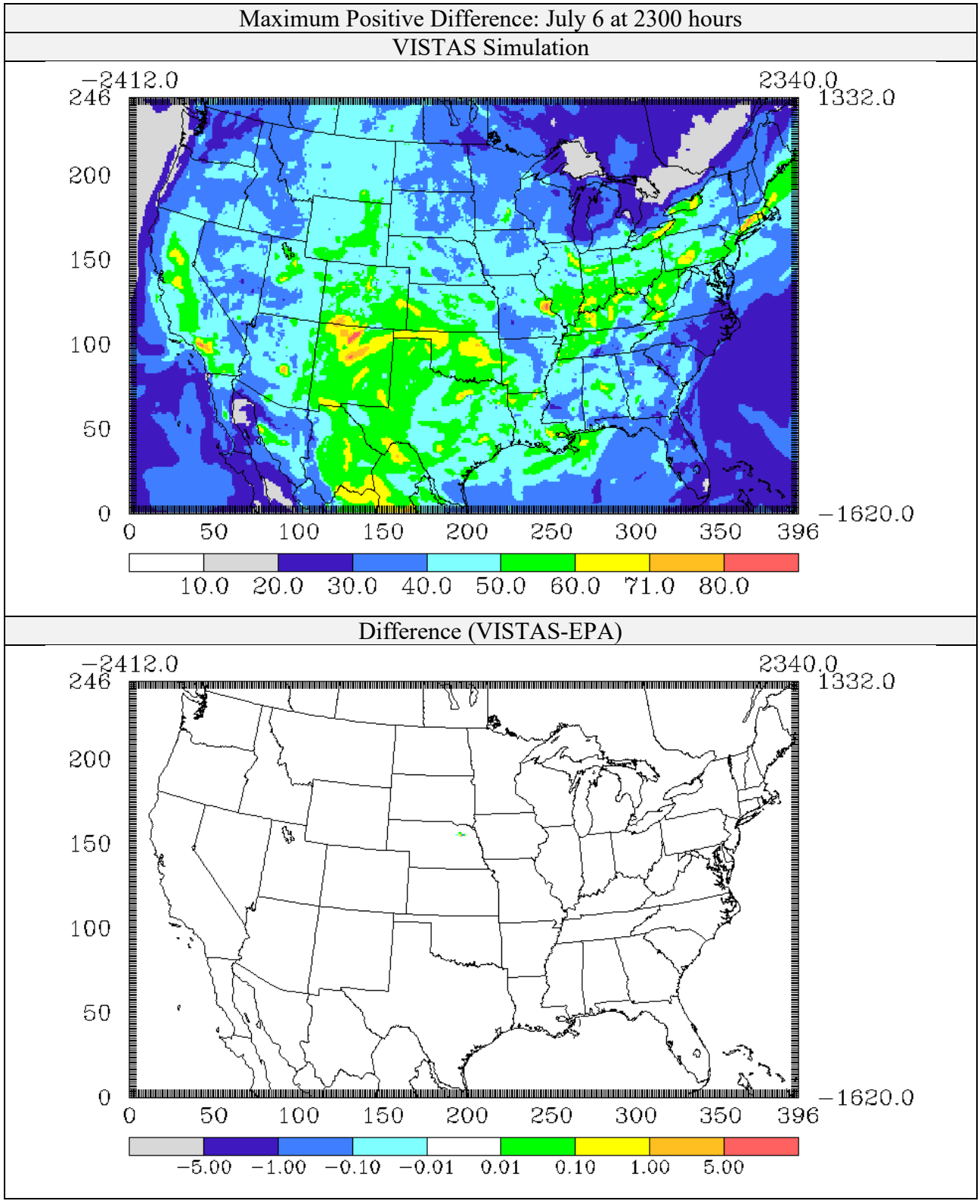


Figure 5-1: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference)

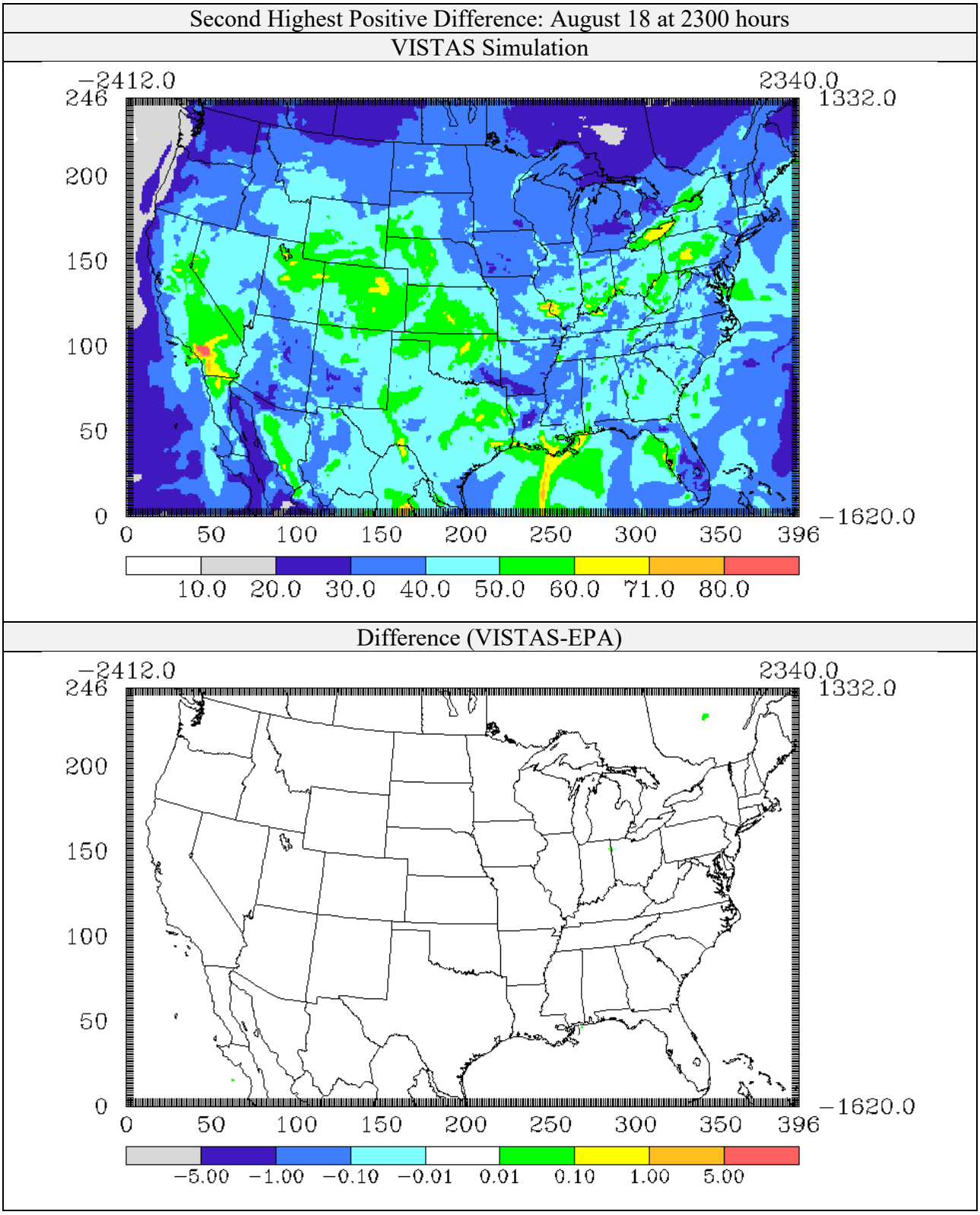


Figure 5-2: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference)

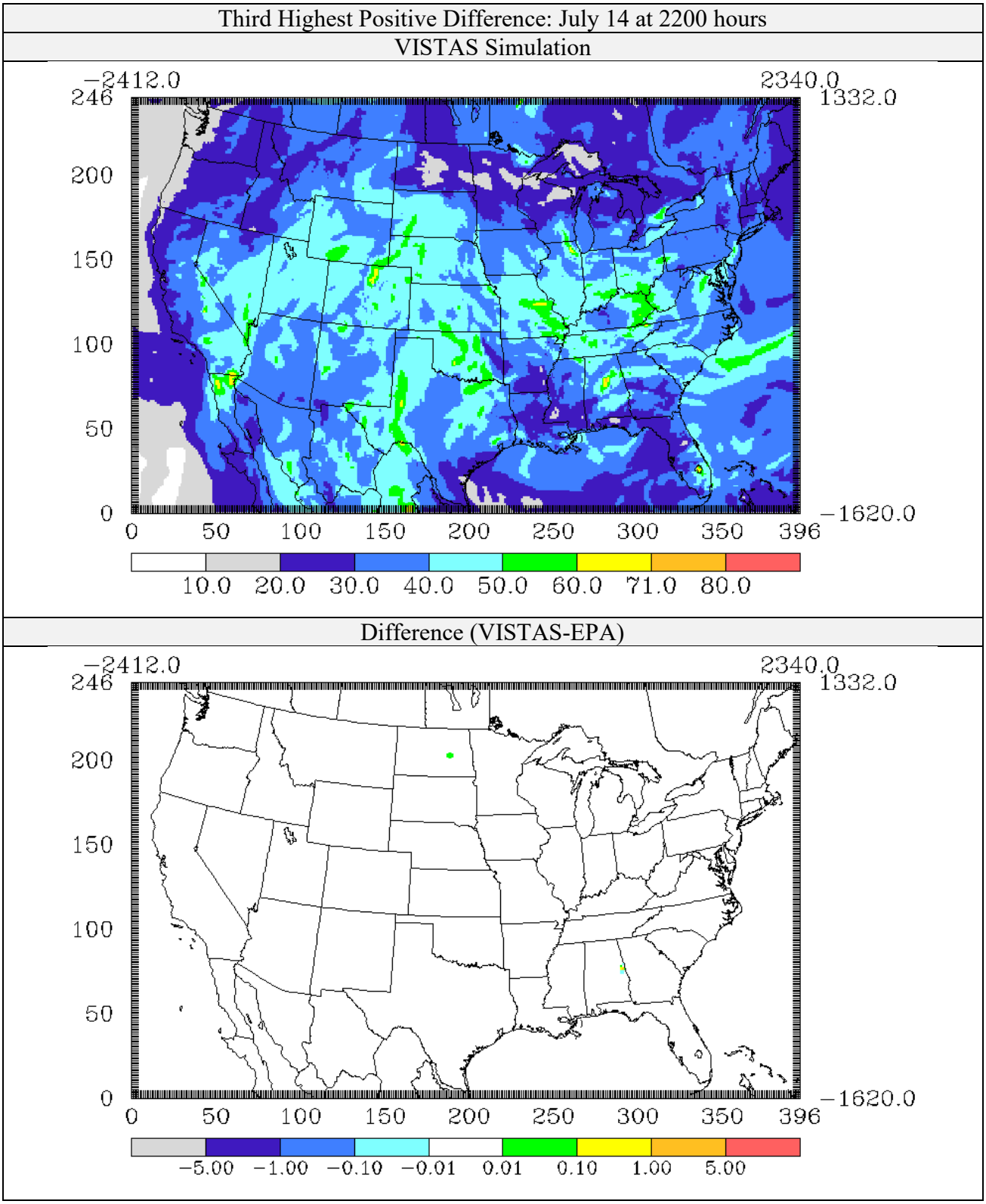


Figure 5-3: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference)

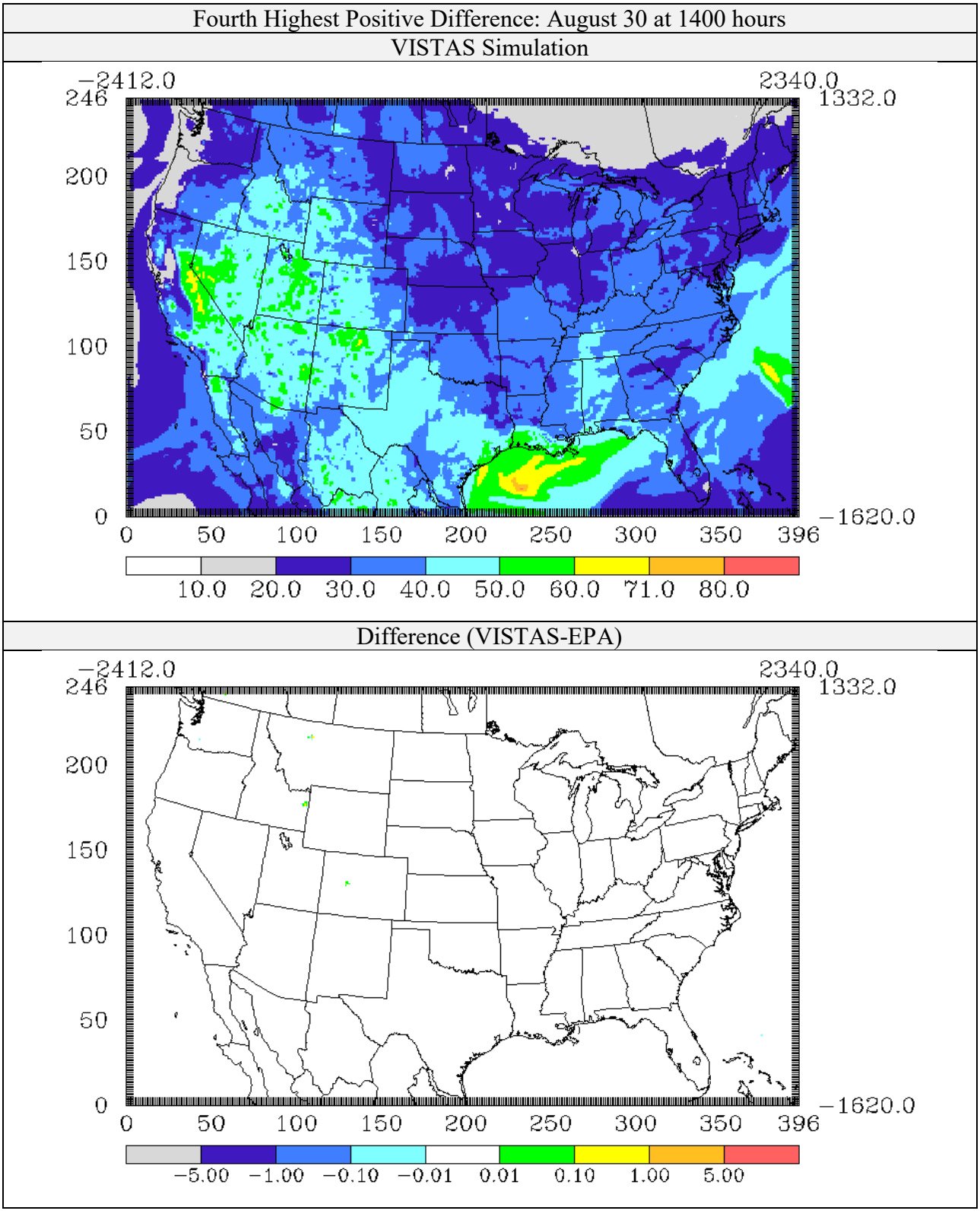


Figure 5-4: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference)

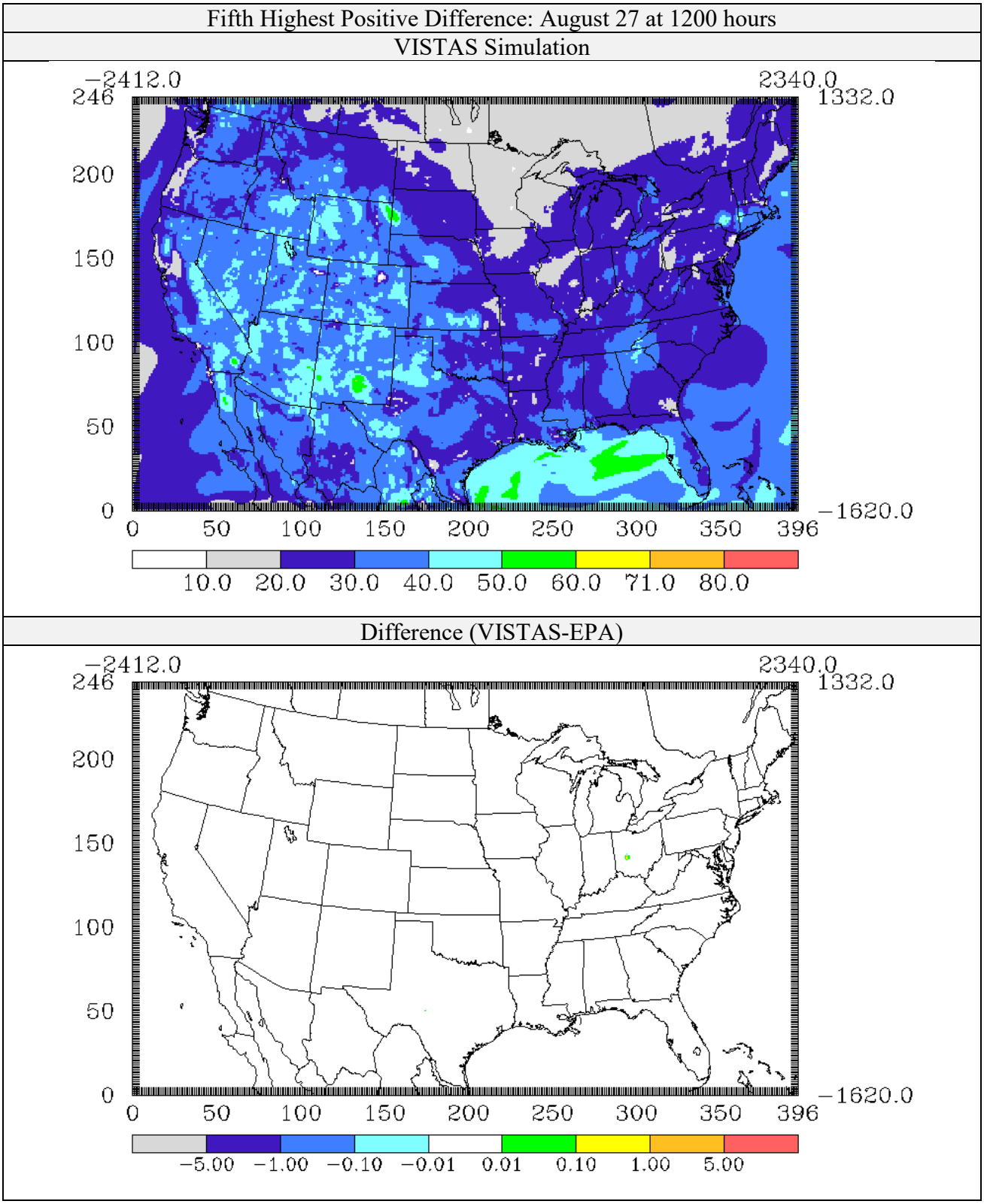


Figure 5-5: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference)

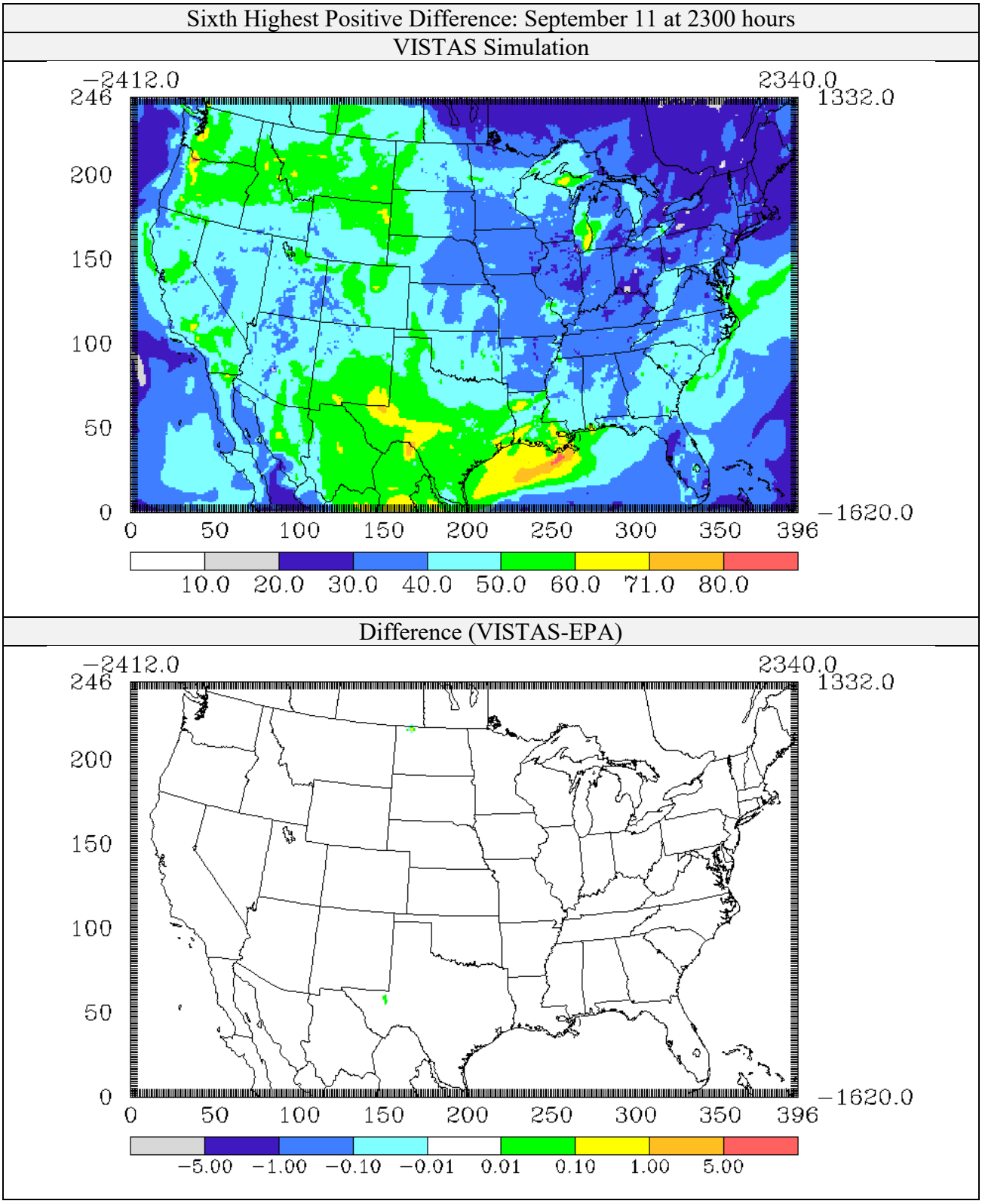


Figure 5-6: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference)

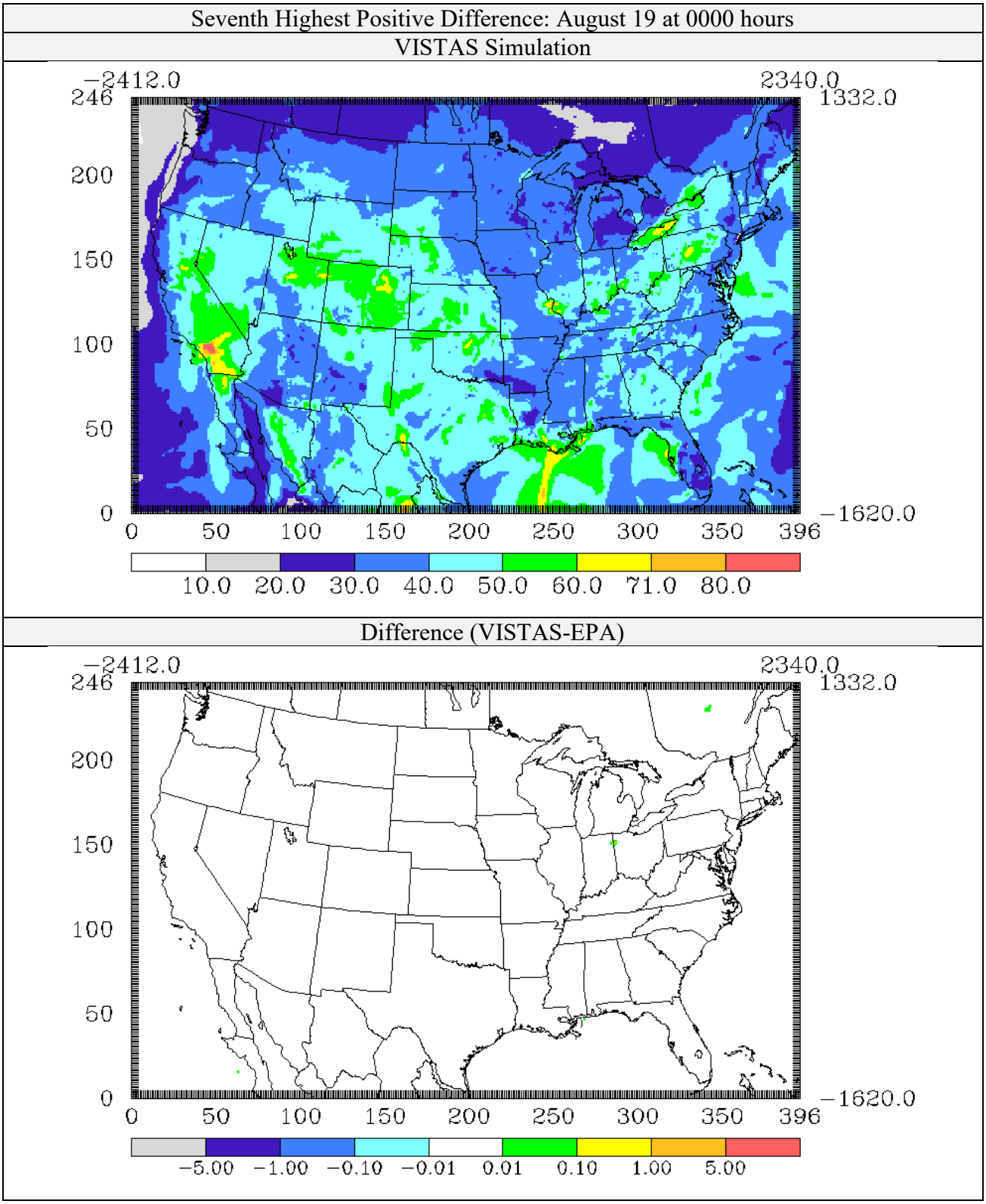


Figure 5-7: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference)

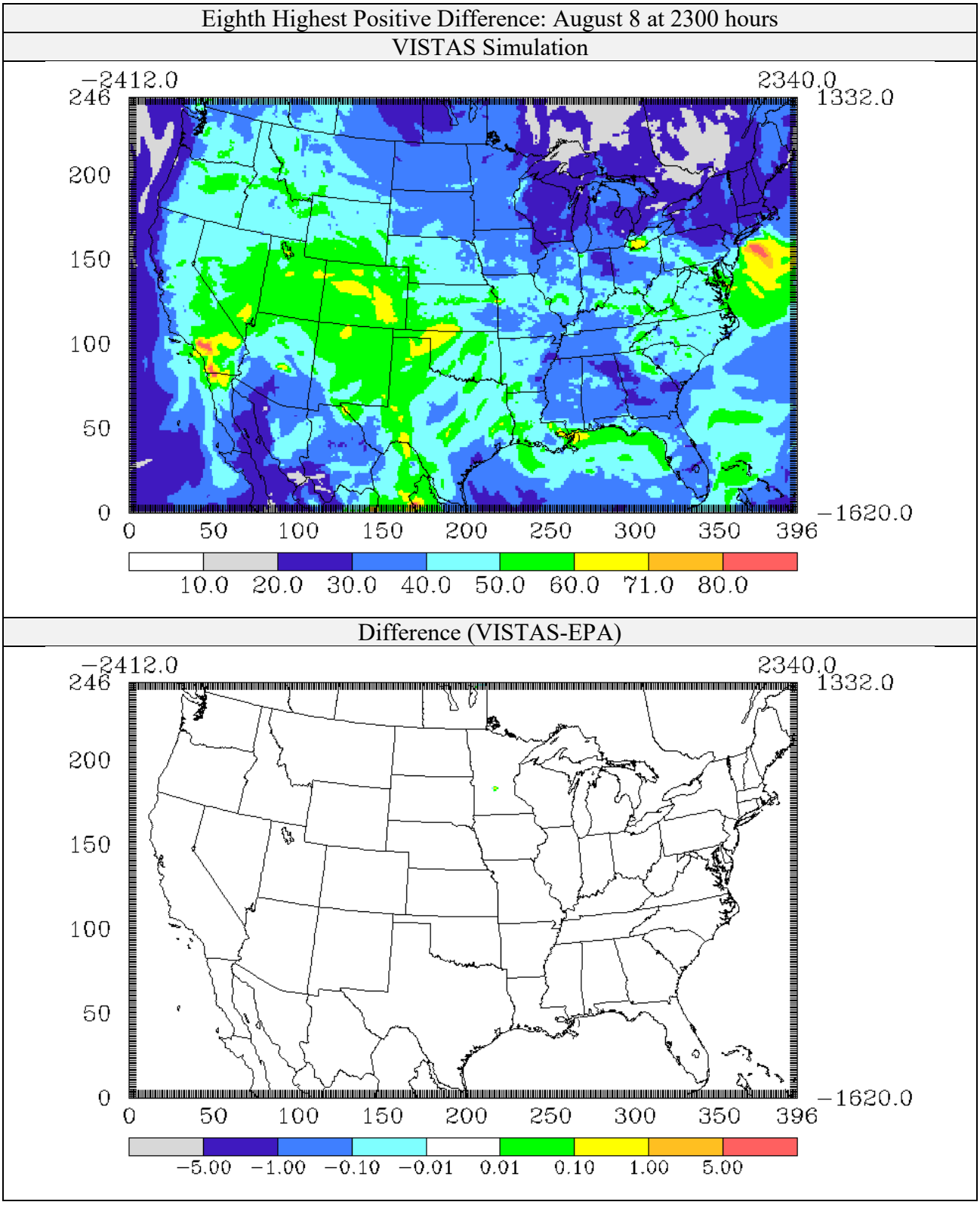


Figure 5-8: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference)

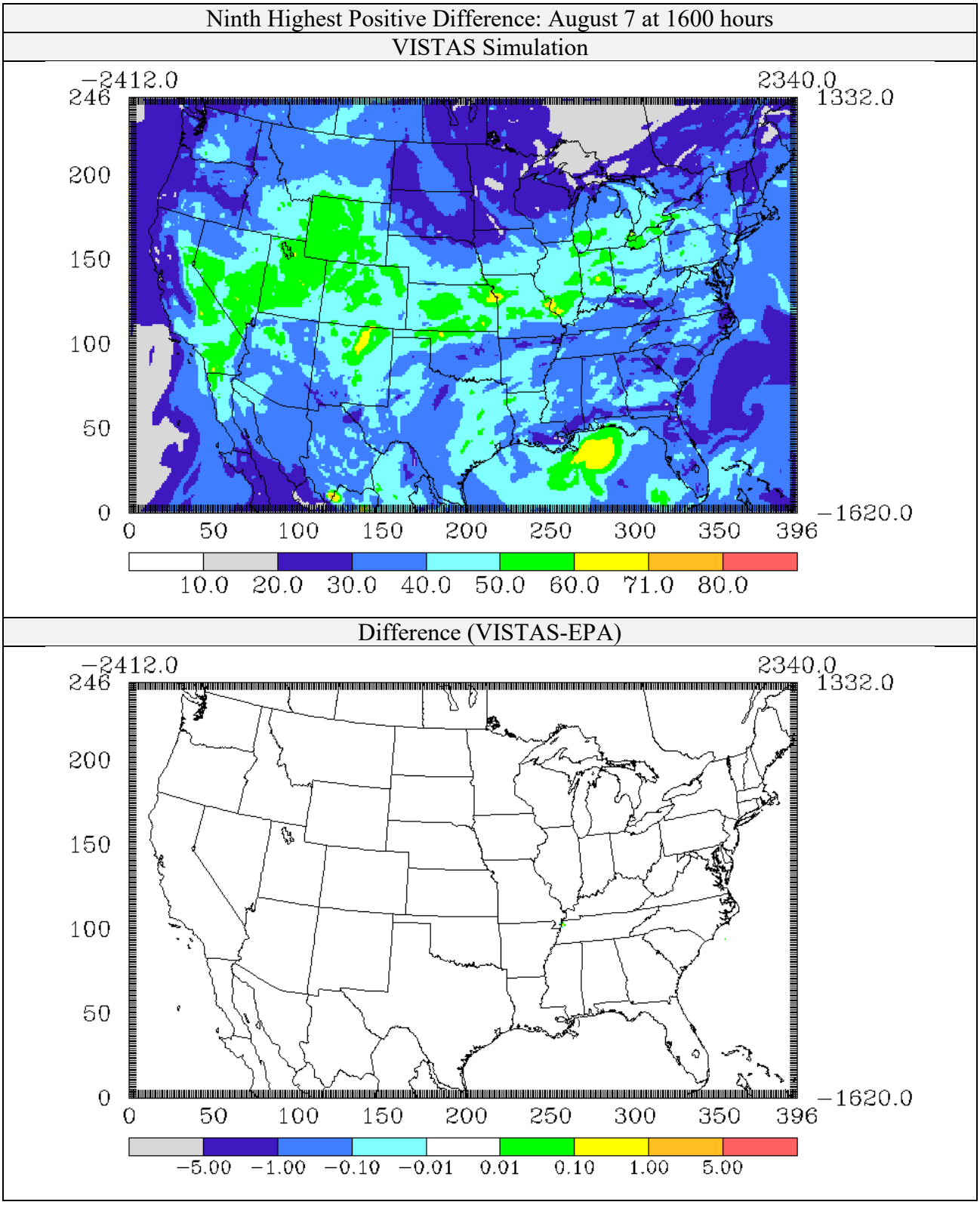


Figure 5-9: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference)

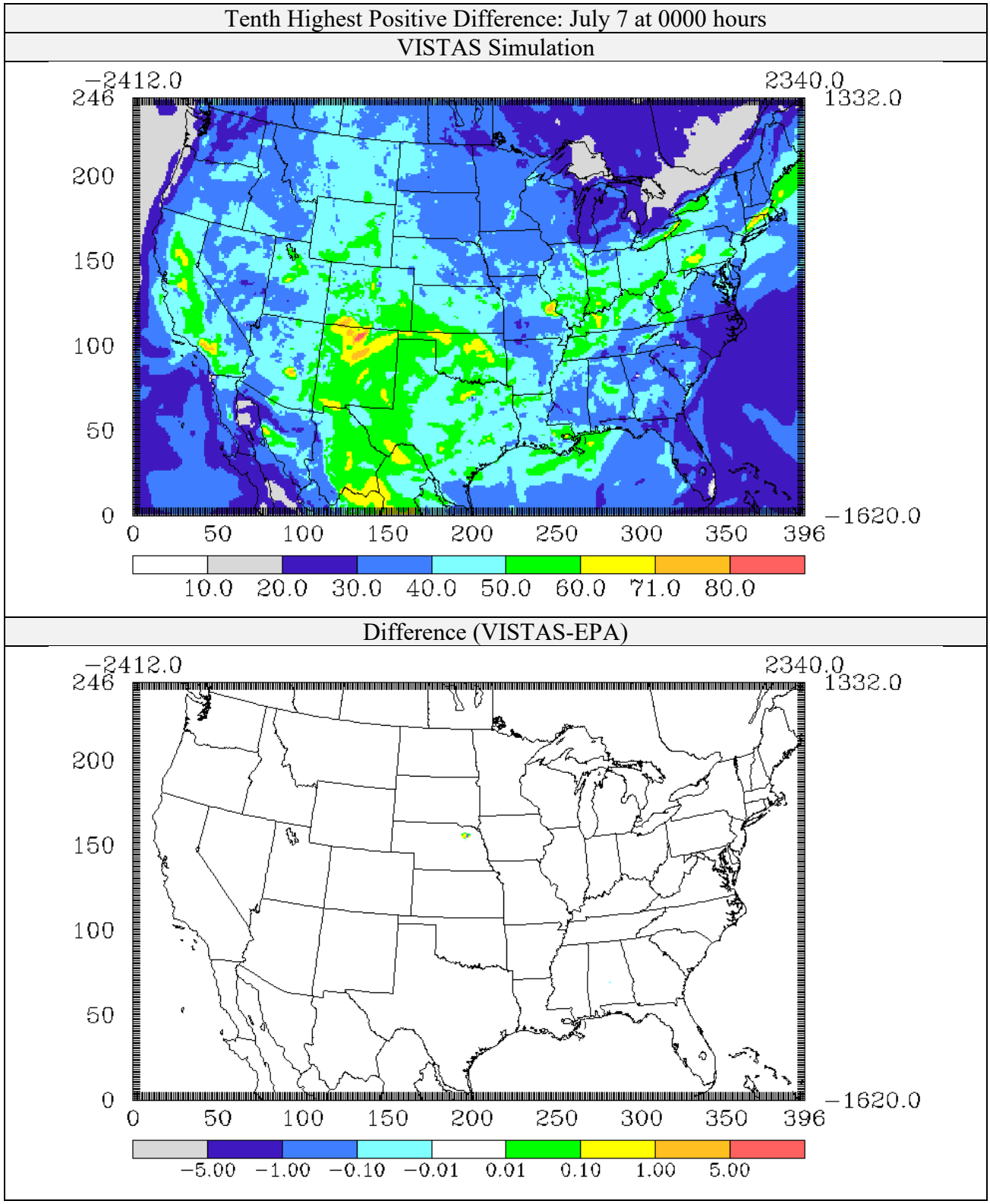


Figure 5-10: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference)

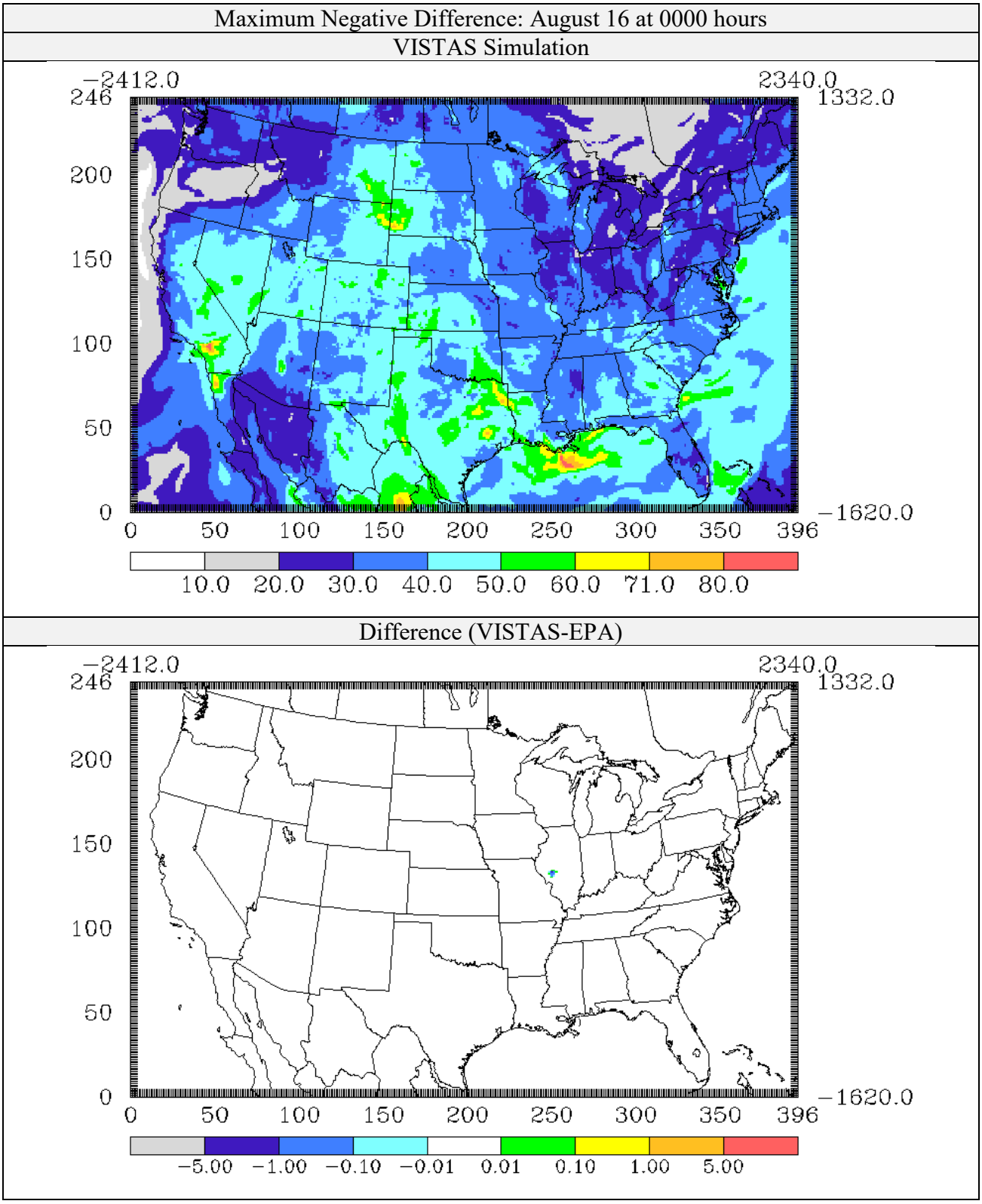


Figure 5-11: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference)

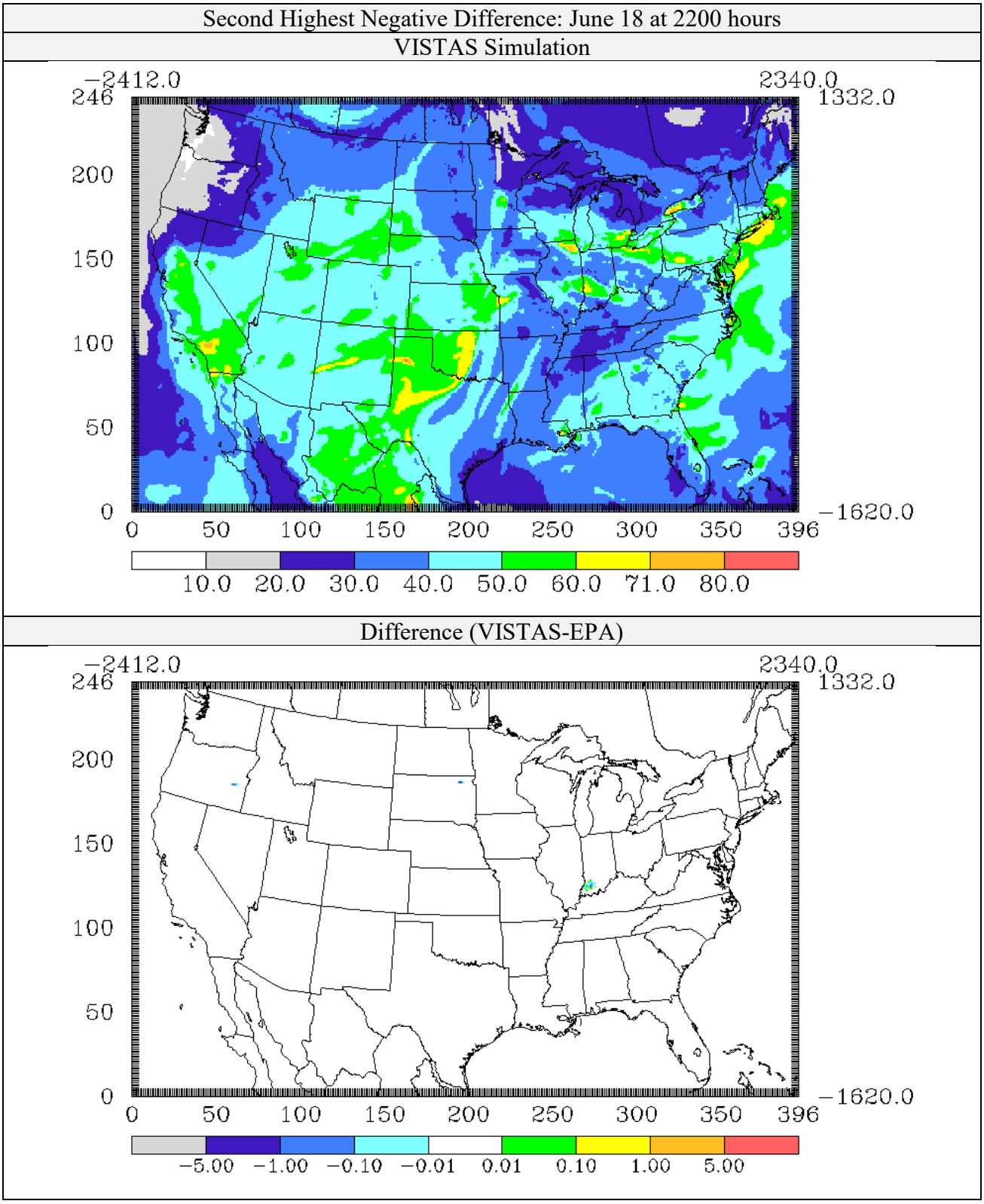


Figure 5-12: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference)

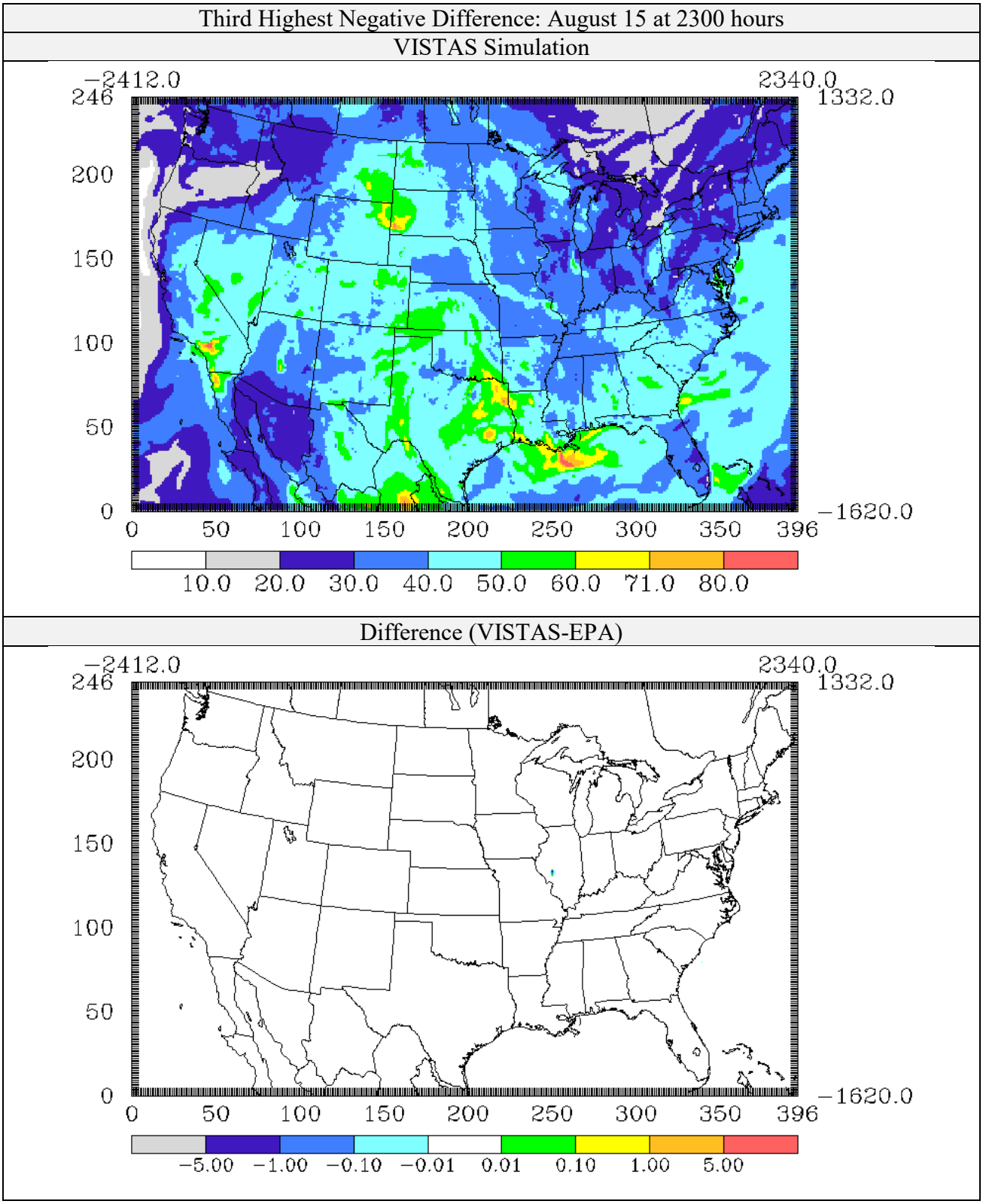


Figure 5-13: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference)

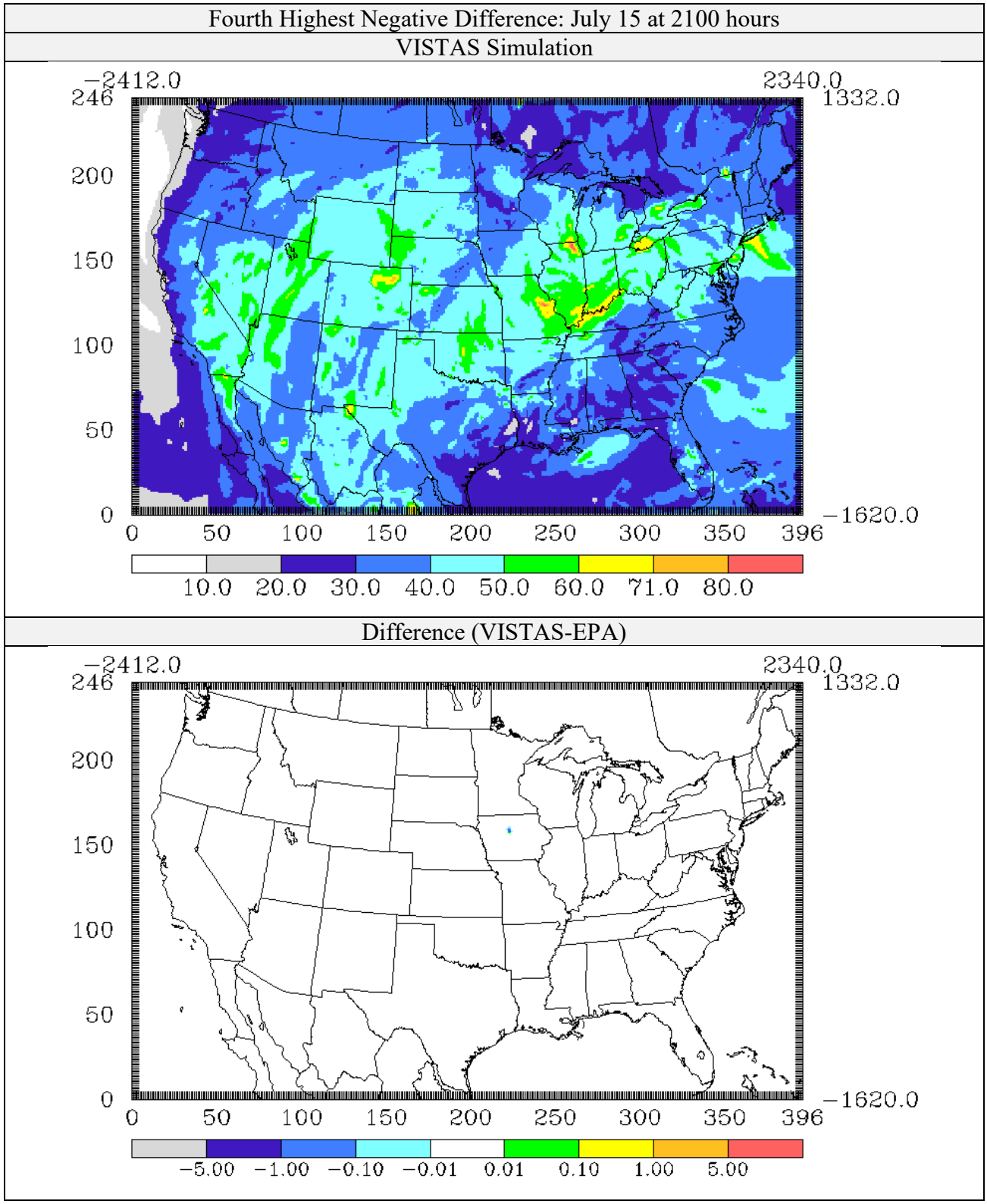


Figure 5-14: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference)

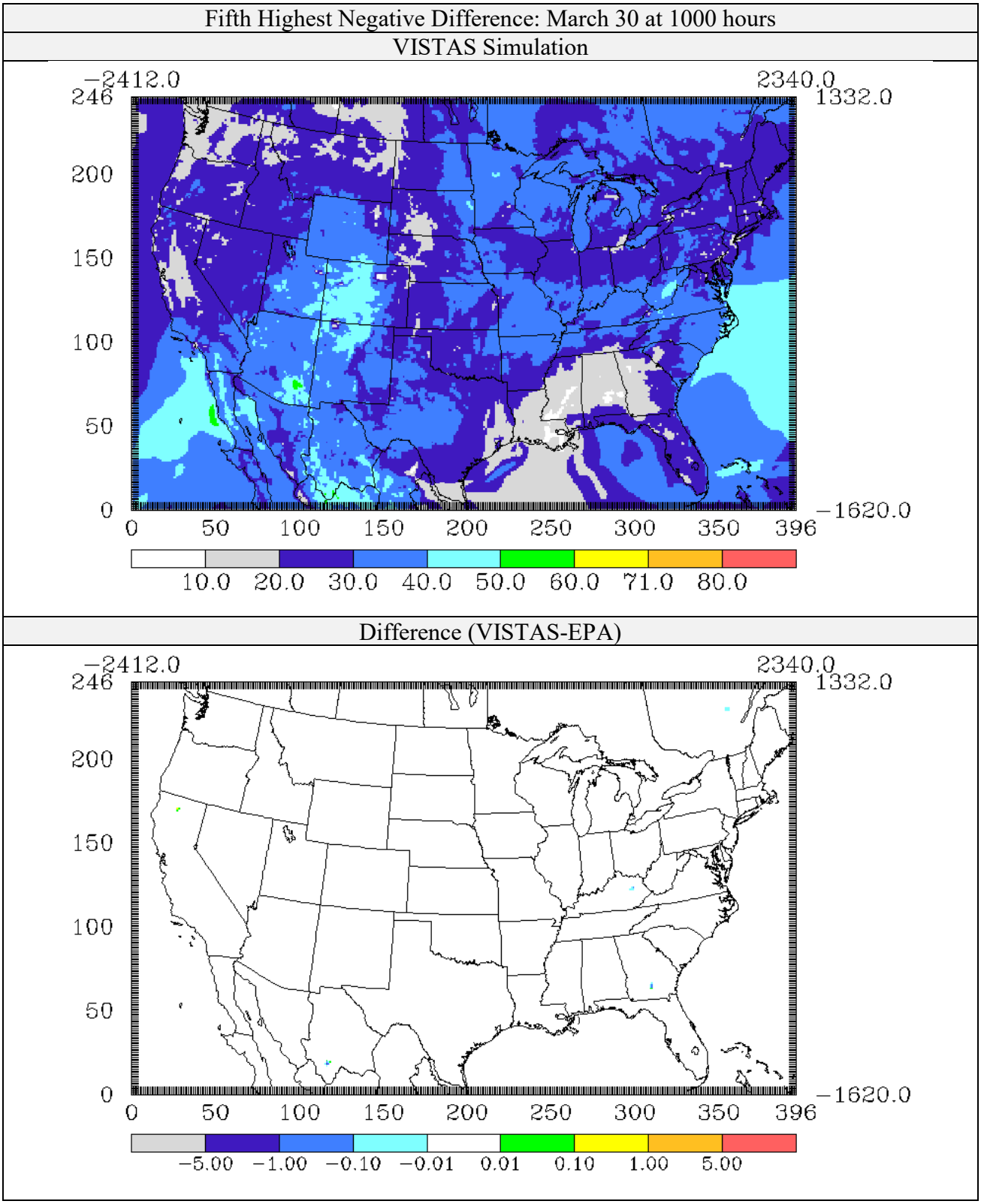


Figure 5-15: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference)

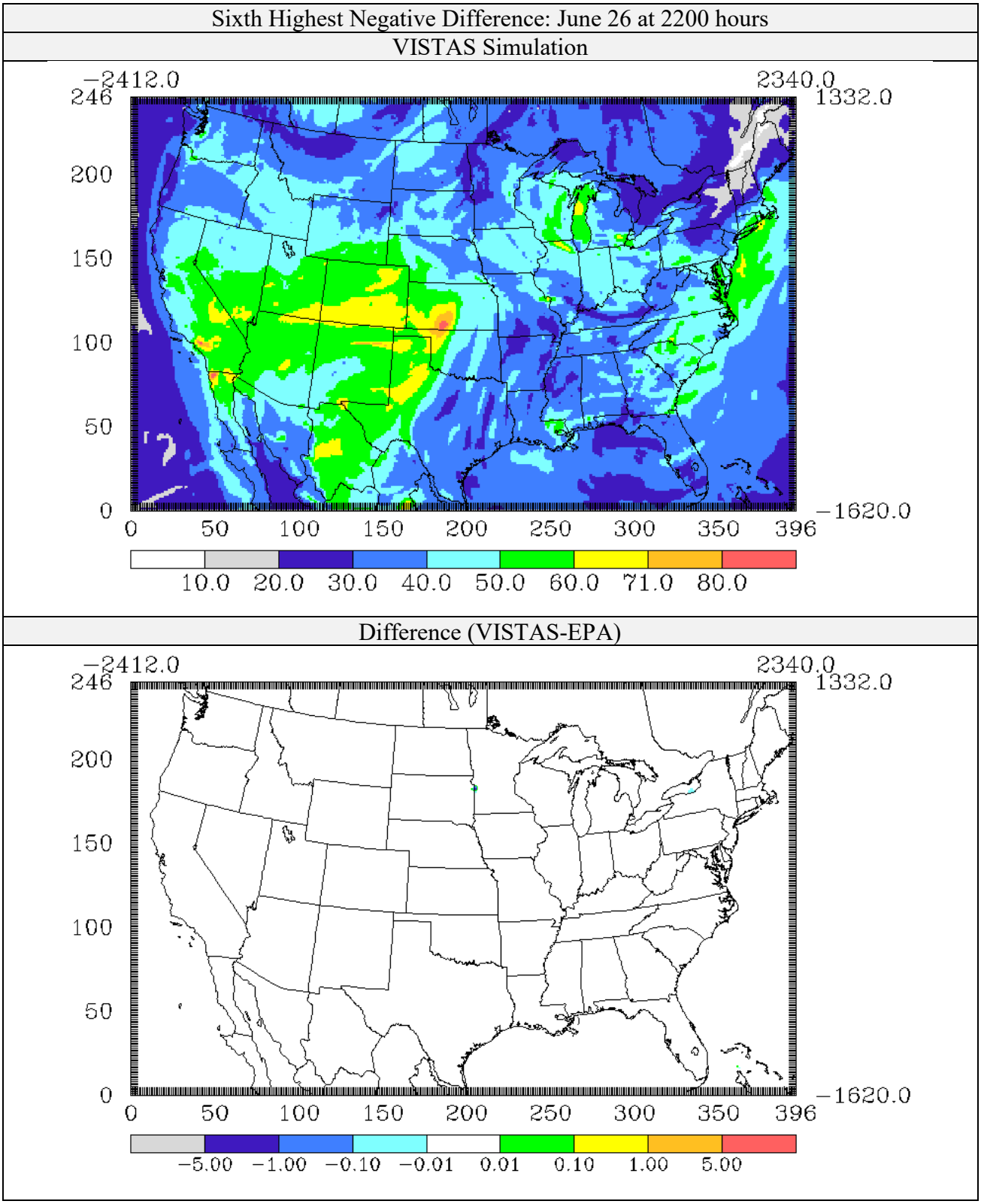


Figure 5-16: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference)

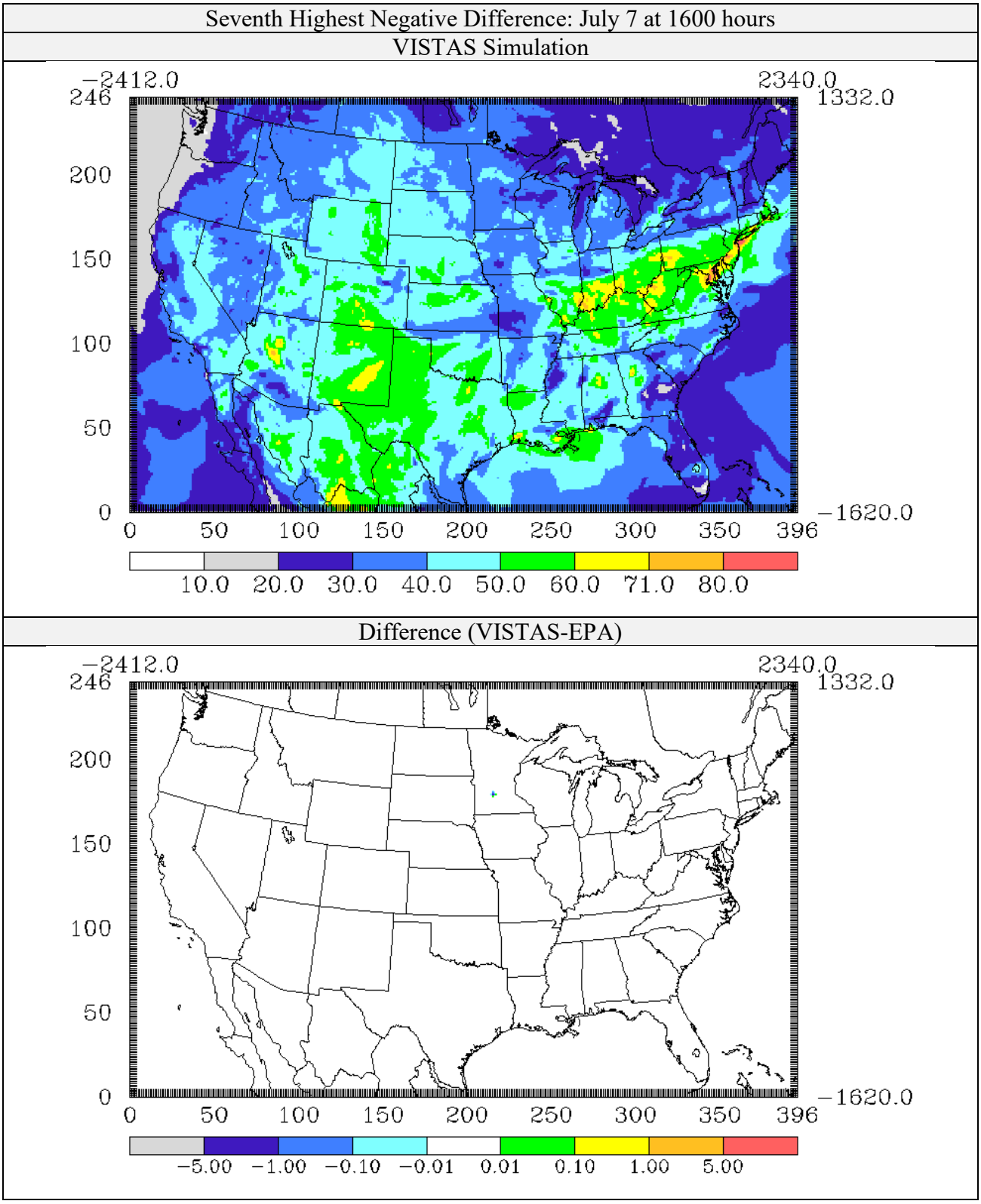


Figure 5-17: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference)

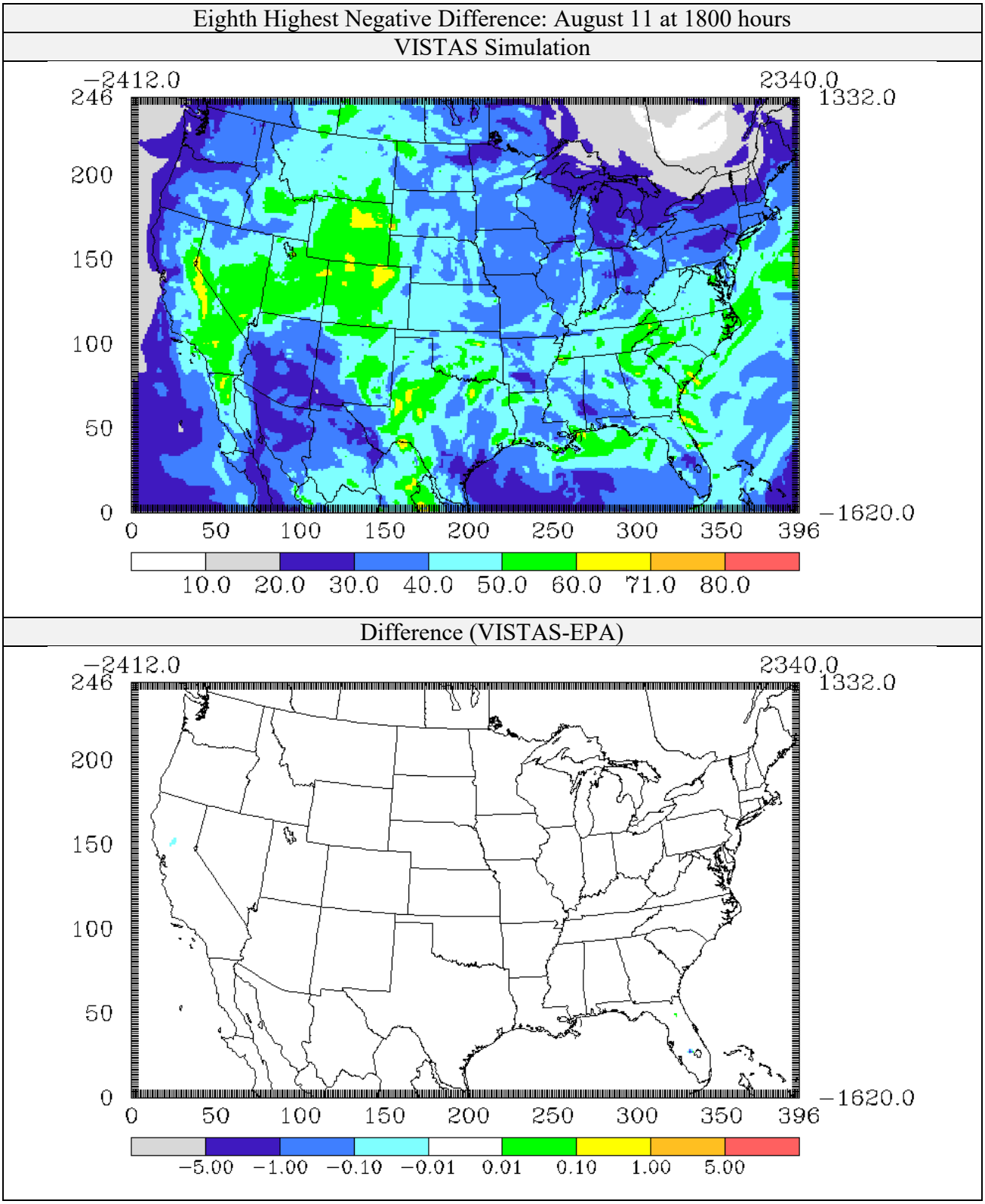


Figure 5-18: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference)

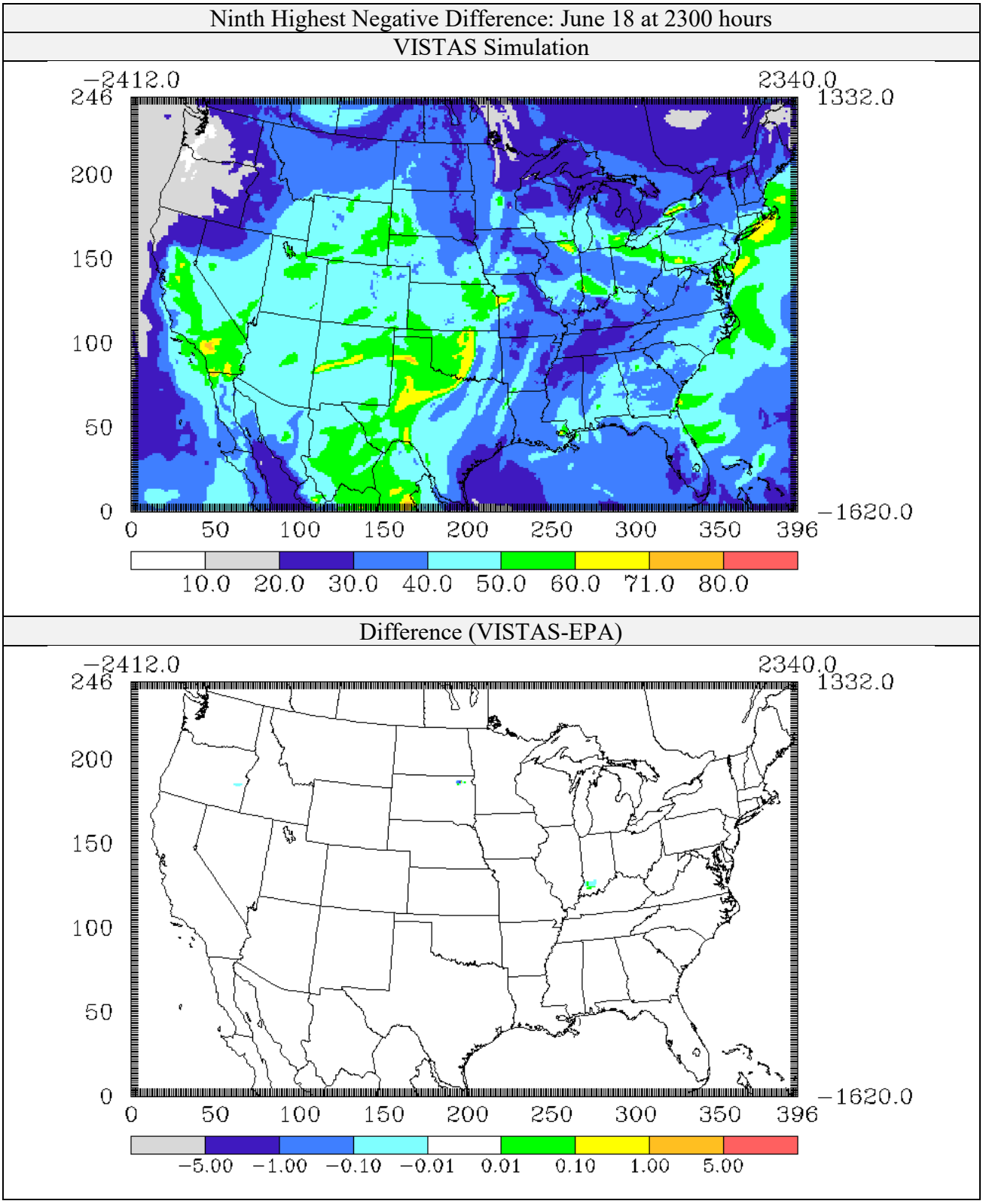


Figure 5-19: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference)

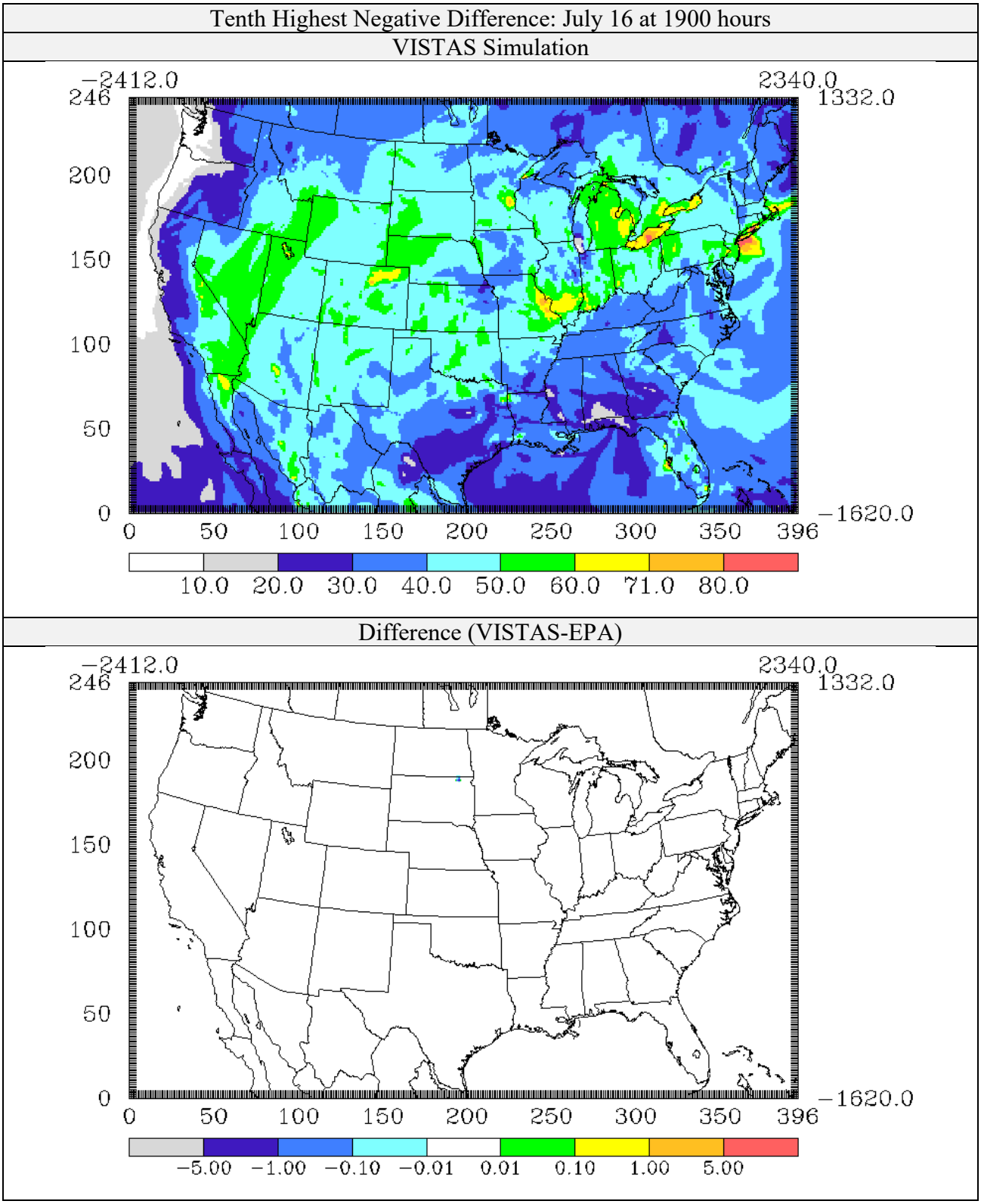


Figure 5-20: Comparison of Ozone Concentrations (ppb) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference)

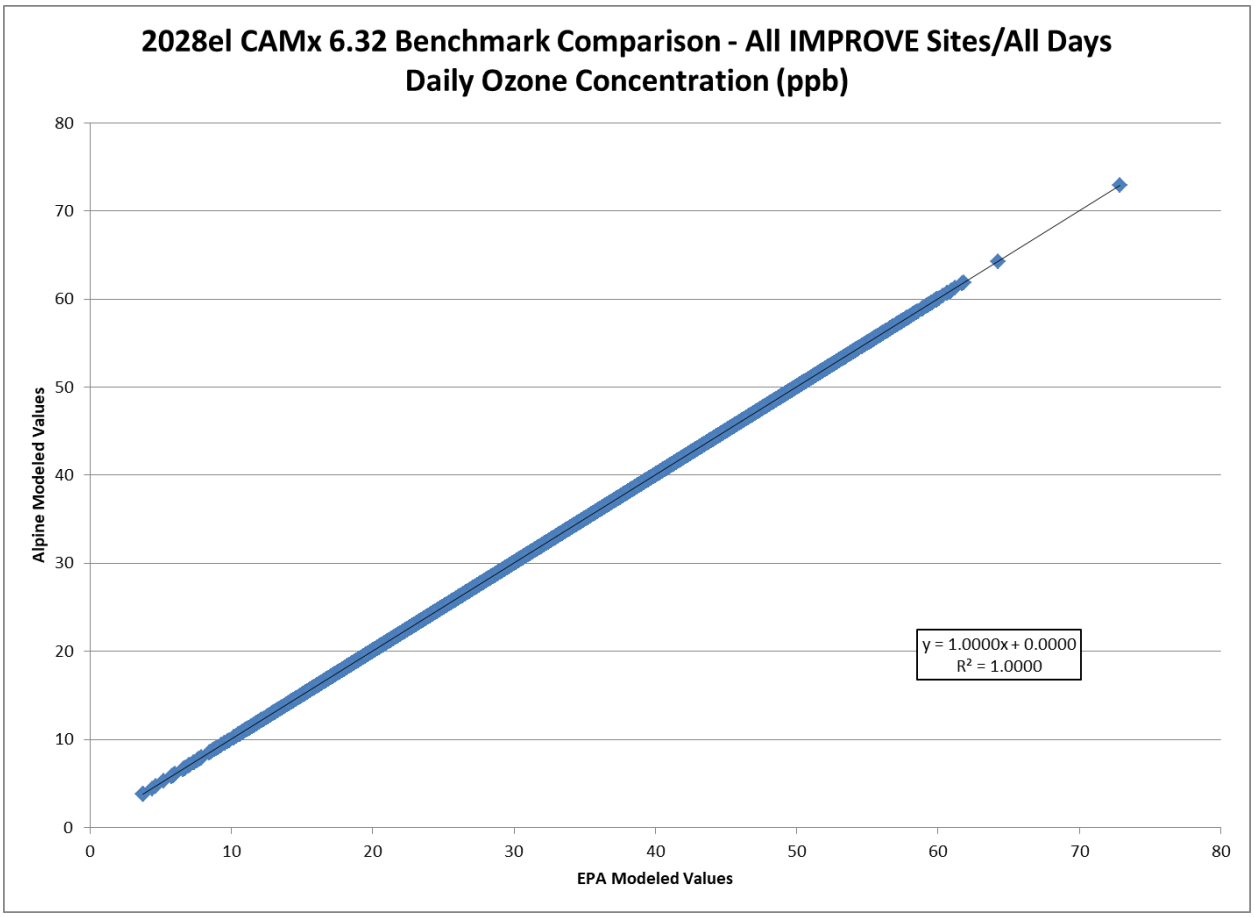


Figure 5-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine).

5.2 $PM_{2.5}$

$PM_{2.5}$ results for the top 10 positive and negative hours are presented in tabular format in Table 5-2. The maximum positive difference is 5.15 $\mu g/m^3$ falling to 2.84 $\mu g/m^3$ for the 10^{th} high. The maximum negative difference is -4.61 $\mu g/m^3$ falling to -2.45 $\mu g/m^3$ for the 10^{th} high. The maximum positive percent difference from these days is 48.4% and negative percent difference of -32.9%, both on low $PM_{2.5}$ concentration days.

The top 10 positive impact hours are presented in Figures 5-22 through 5-31 and the top 10 negative impact hours are presented in Figures 5-32 through 5-41. The locations of the impacts are again localized and tending to occur in Canada near the relatively high concentration entering the domain through the northern boundary. Comparison with the nitrate results in Section 5.4 shows that on many days the principal difference in the $PM_{2.5}$ concentrations is a result of the differences in the nitrate predictions.

Scatterplots of the daily average $PM_{2.5}$ concentrations in local standard time at the IMPROVE monitors are presented in Figure 5-42. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

Examination of the animations shows that the majority of the differences are occurring in Canada and the Northern U.S. with the differences occurring in the areas of relatively high $PM_{2.5}$. We speculate that the differences are primarily from the difference in the Nitrate and most likely from different pathways being taken in the ISOROPIA algorithm.

Table 5-2. Comparison of 2028el CAMx 6.32 Simulation $PM_{2.5}$ Concentrations (µg/m^3) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	1	3	4	35.87	30.72	5.15	16.77%	155	237
2011	1	3	12	37.94	33.42	4.53	13.54%	159	237
2011	1	27	7	13.15	8.86	4.29	48.41%	346	245
2011	1	27	9	13.30	9.65	3.65	37.86%	347	245
2011	1	14	6	20.06	16.88	3.17	18.80%	148	237
2011	1	27	12	11.44	8.32	3.12	37.47%	343	245
2011	1	14	4	34.11	31.05	3.07	9.88%	123	244
2011	1	14	9	22.40	19.36	3.04	15.70%	144	240
2011	1	14	2	33.74	30.85	2.89	9.35%	132	243
2011	1	15	13	14.87	12.03	2.84	23.63%	125	222
Maximum Negative									
2011	1	27	8	9.38	13.98	-4.61	-32.95%	348	245
2011	1	3	7	33.90	37.85	-3.95	-10.44%	155	235
2011	1	27	5	9.70	13.65	-3.95	-28.92%	345	245
2011	1	27	11	6.80	9.98	-3.18	-31.88%	343	244
2011	1	27	9	8.93	12.11	-3.18	-26.23%	348	244
2011	1	27	10	7.21	10.27	-3.06	-29.78%	343	245
2011	1	27	12	7.26	10.21	-2.96	-28.95%	342	244
2011	1	3	21	16.59	19.10	-2.51	-13.15%	164	231
2011	1	14	3	24.38	26.86	-2.48	-9.24%	137	242
2011	1	27	3	11.37	13.82	-2.45	-17.75%	343	245

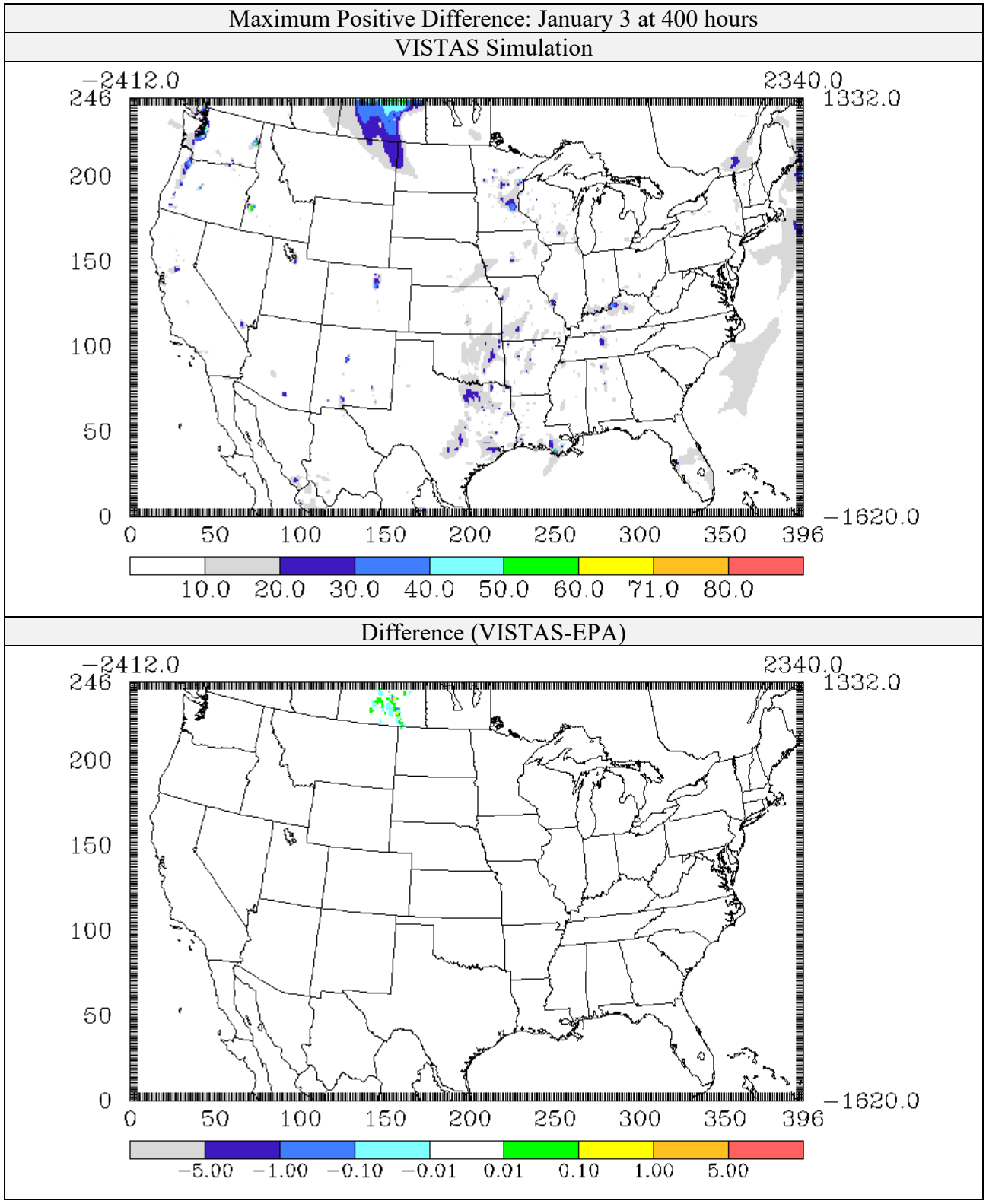


Figure 5-22: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference)

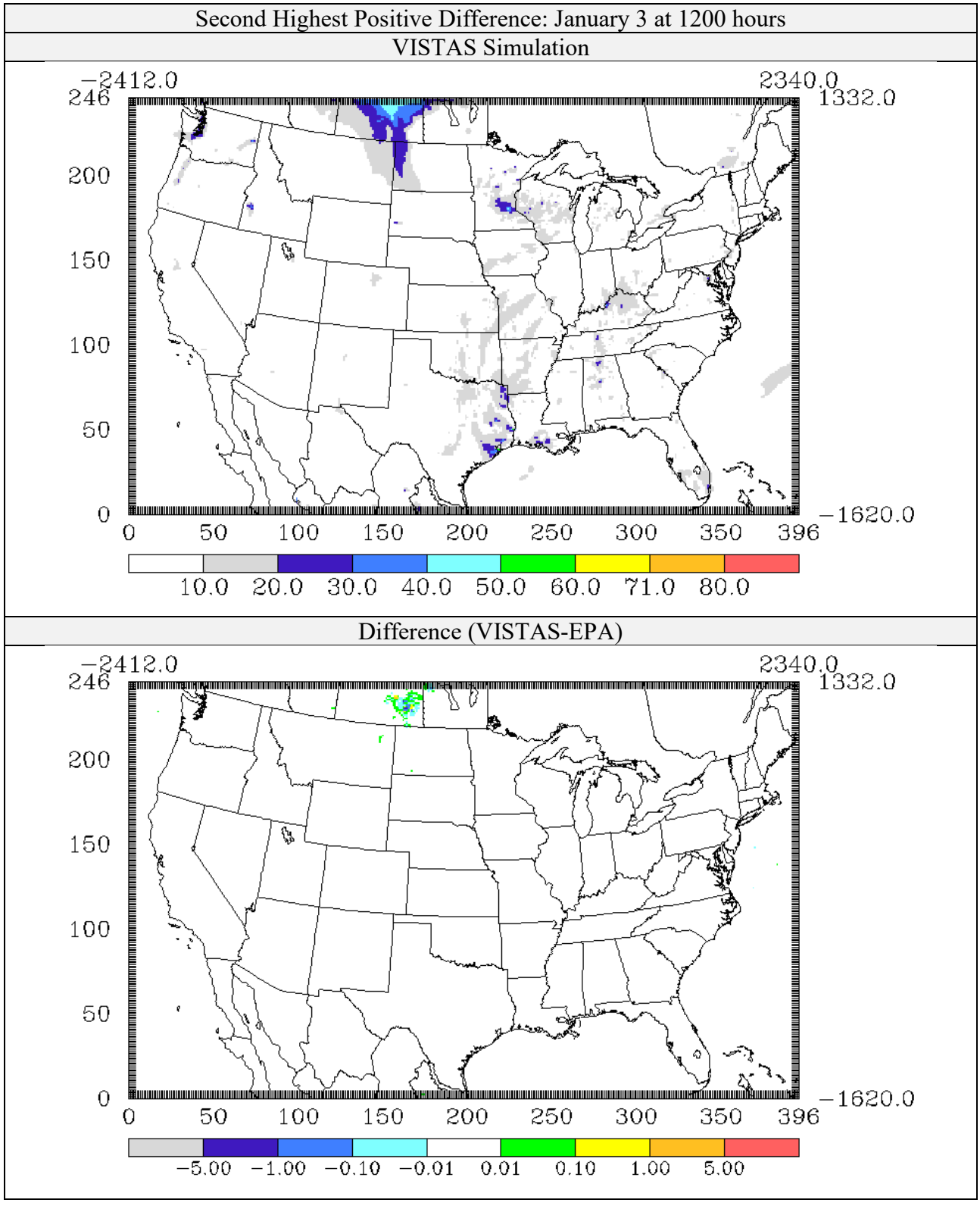


Figure 5-23: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference)

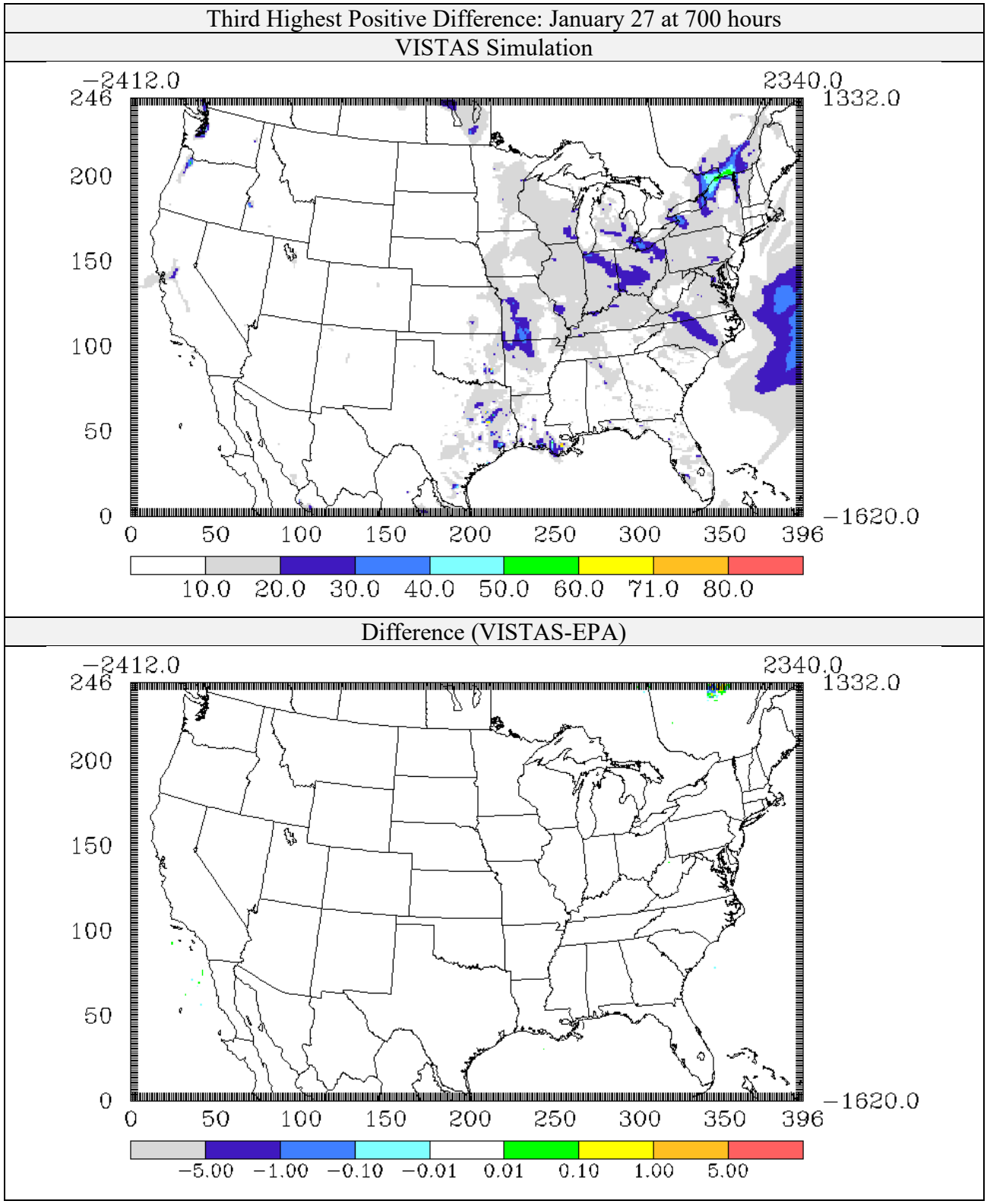


Figure 5-24: Comparison of $PM_{2.5}$ Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference)

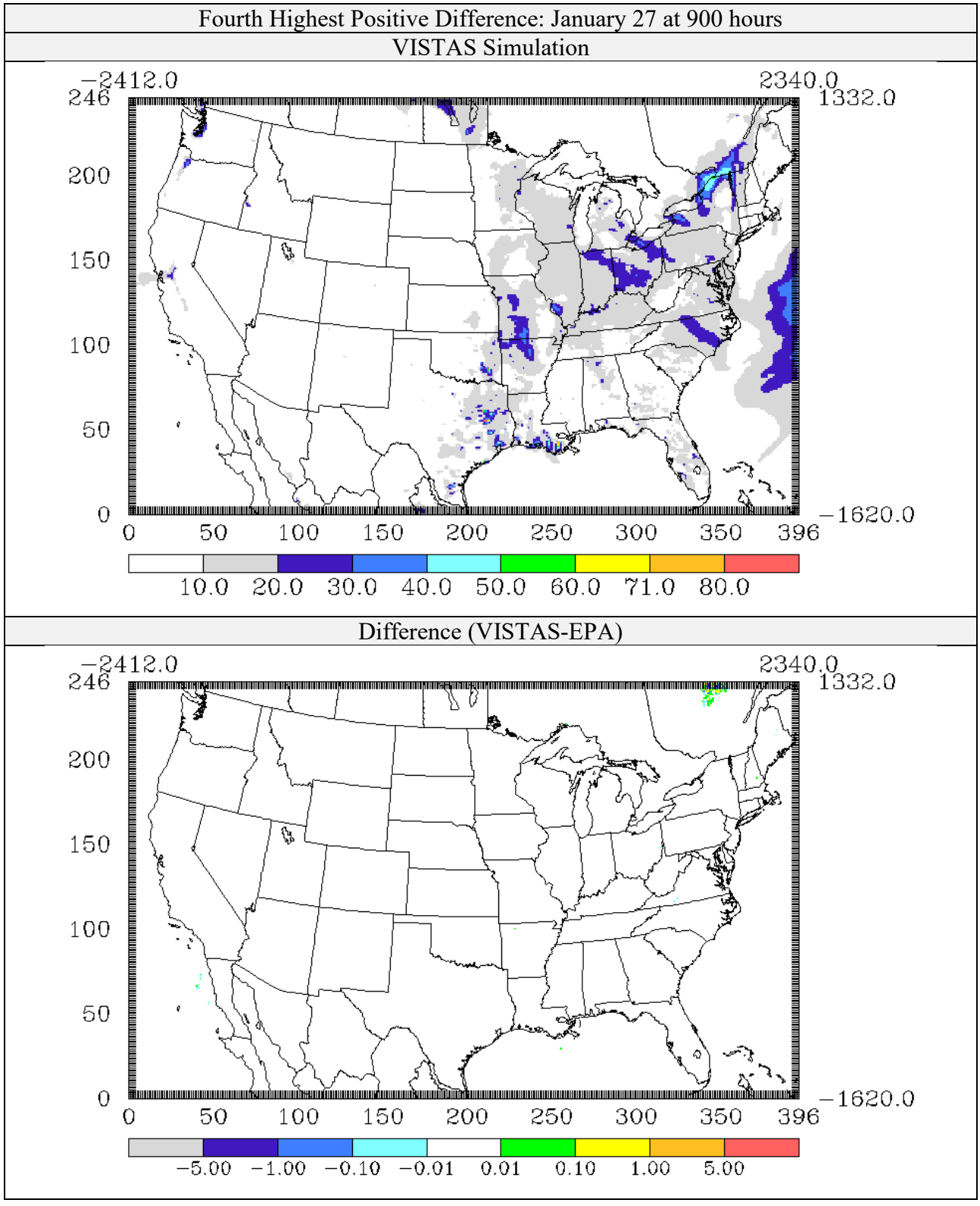


Figure 5-25: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference)

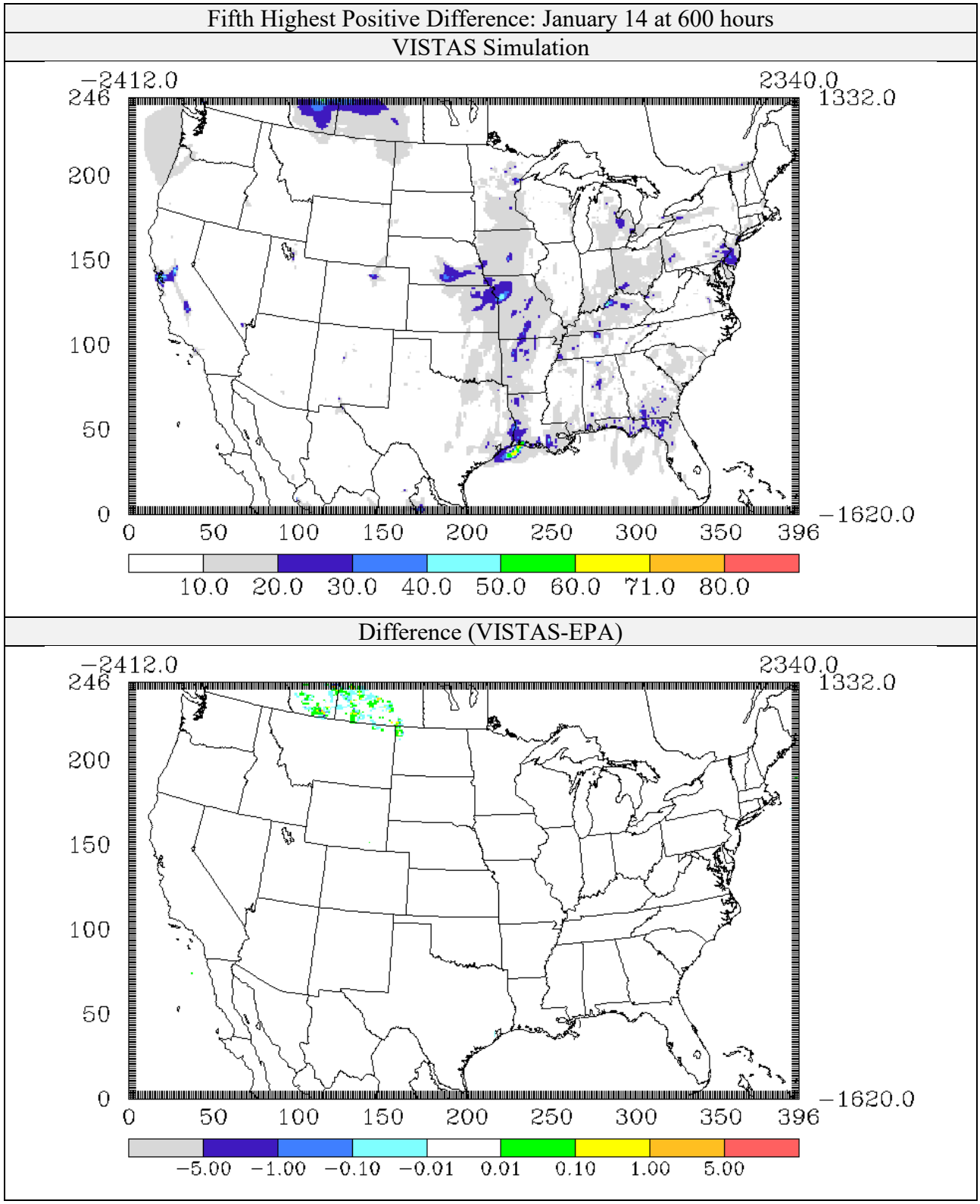


Figure 5-26: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Positive Difference)

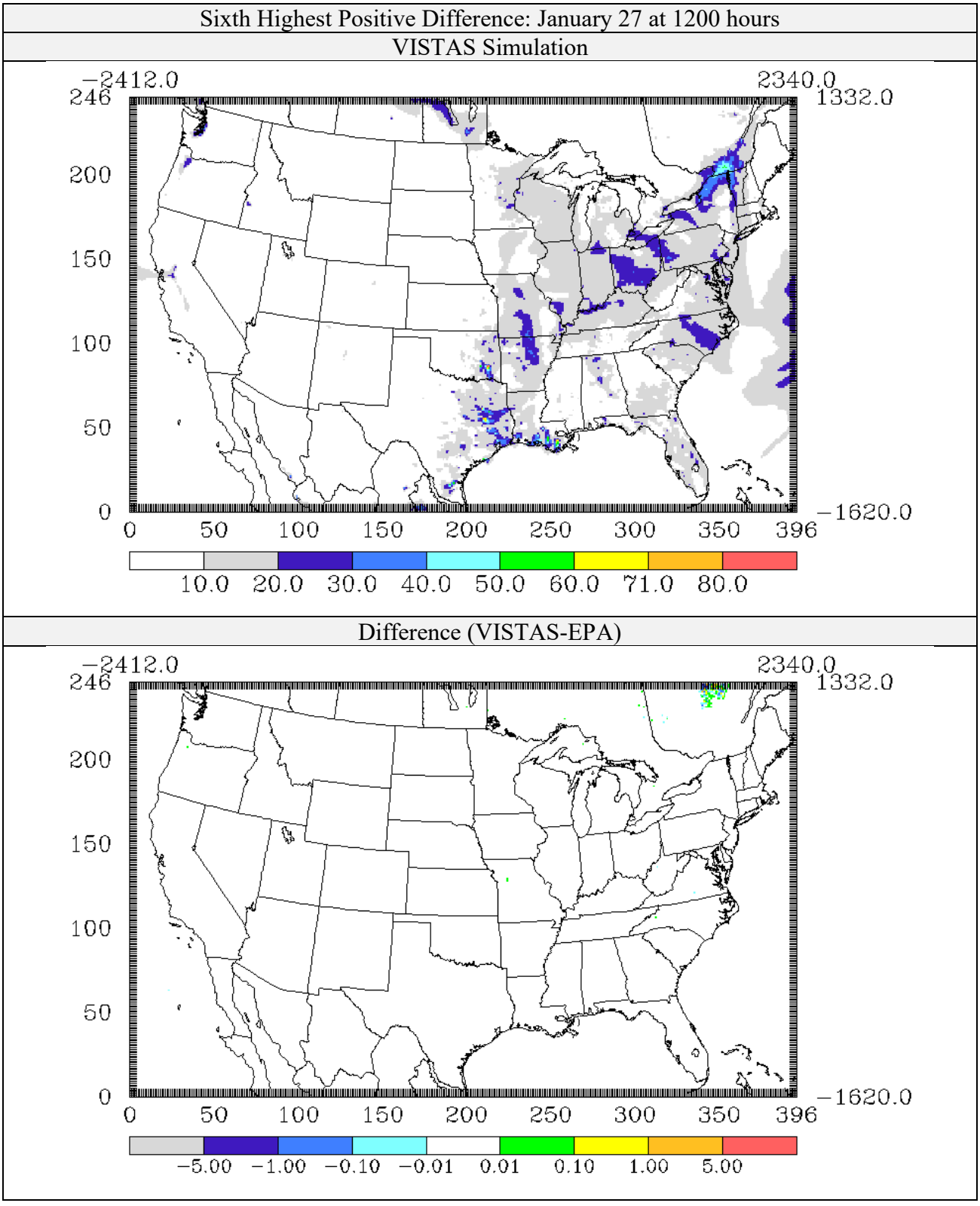


Figure 5-27: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference)

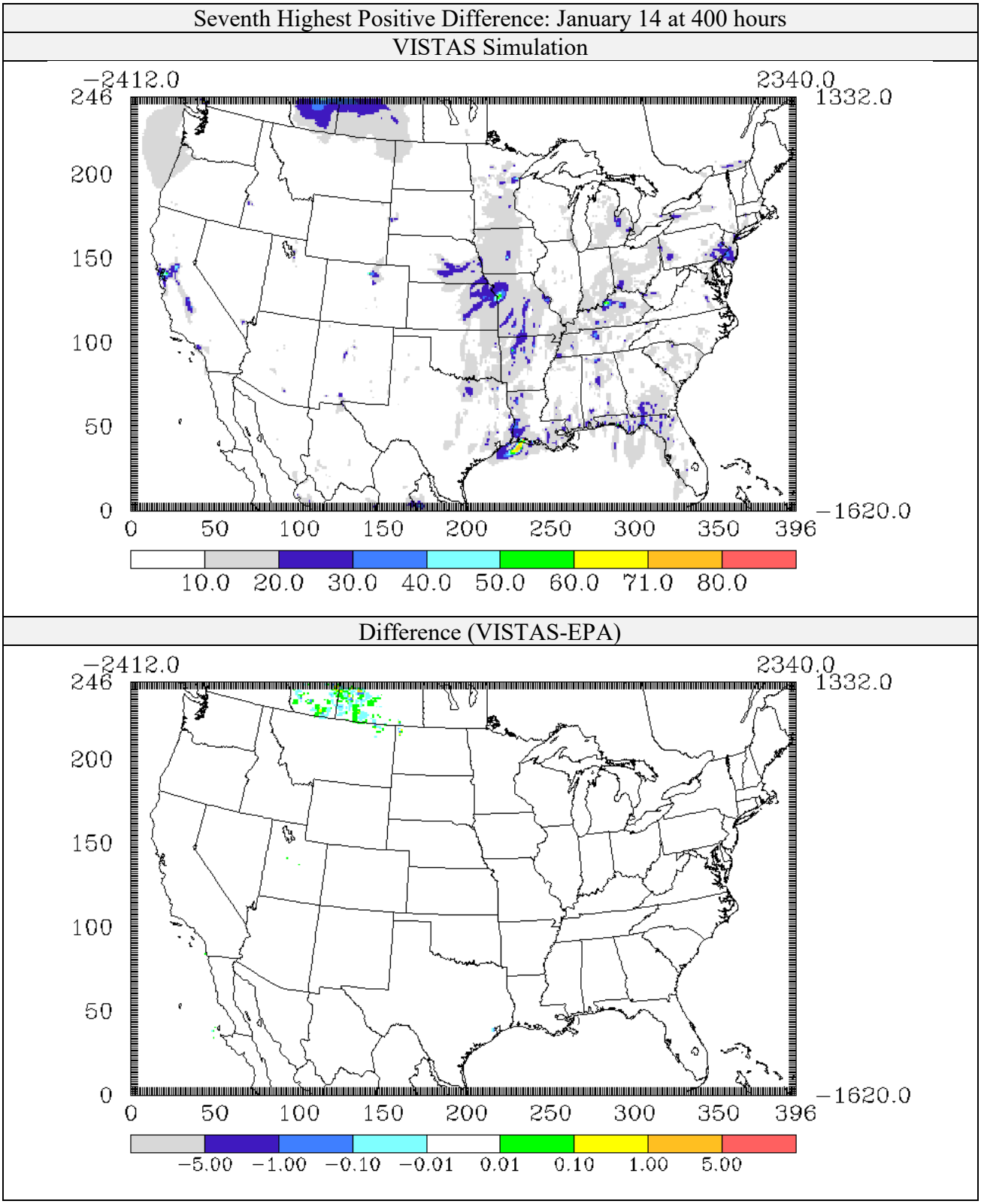


Figure 5-28: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference)

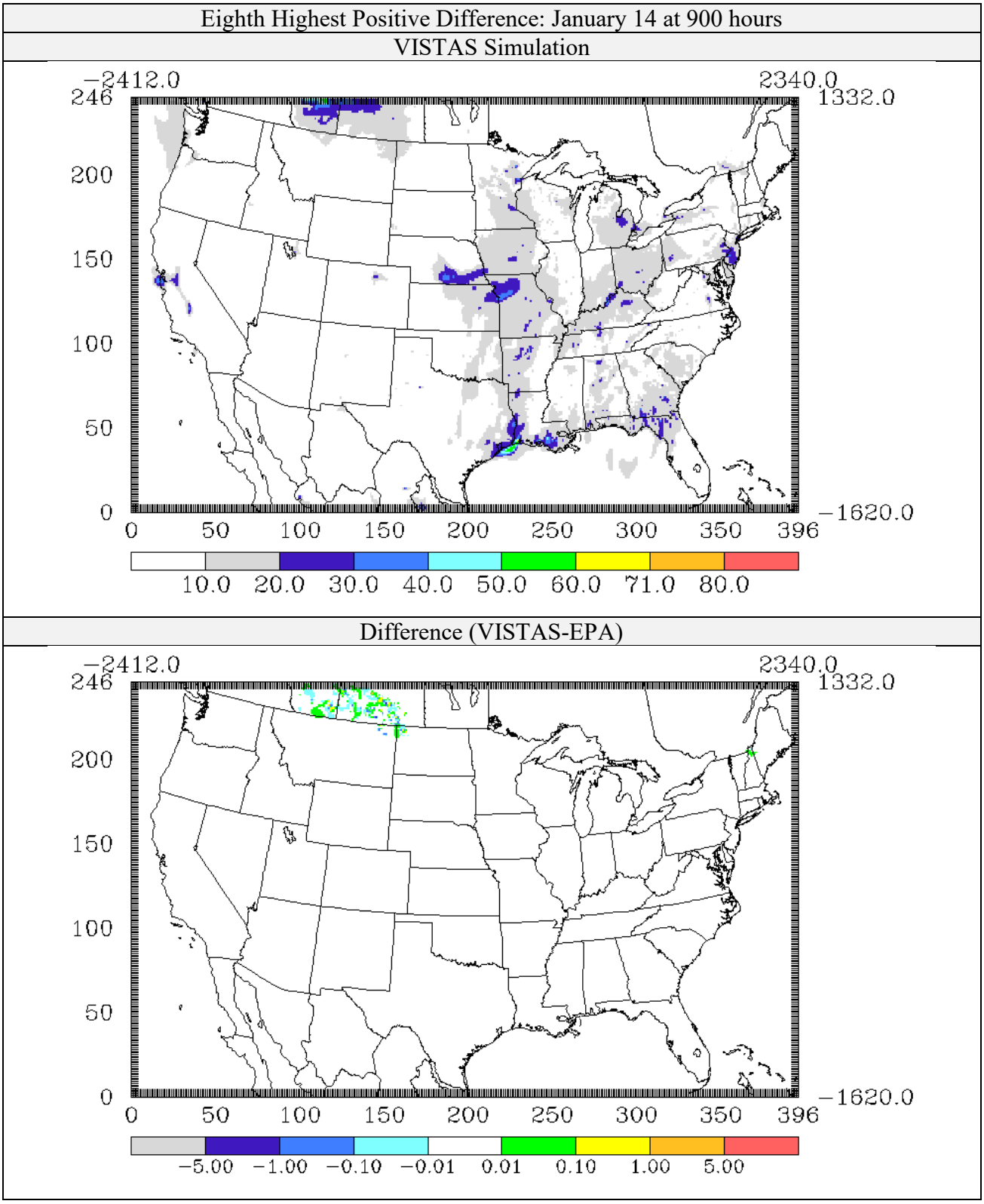


Figure 5-29: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference)

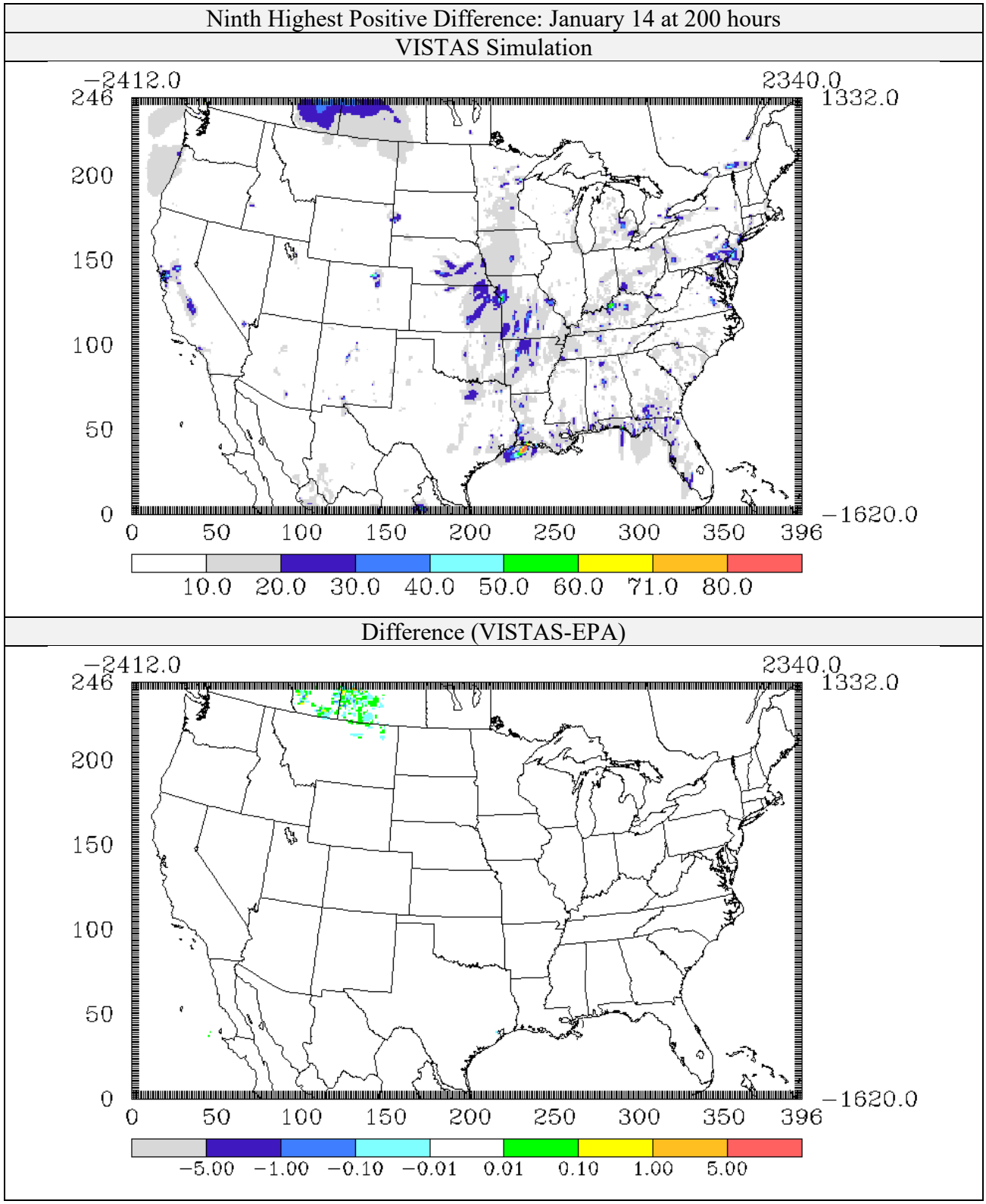


Figure 5-30: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference)

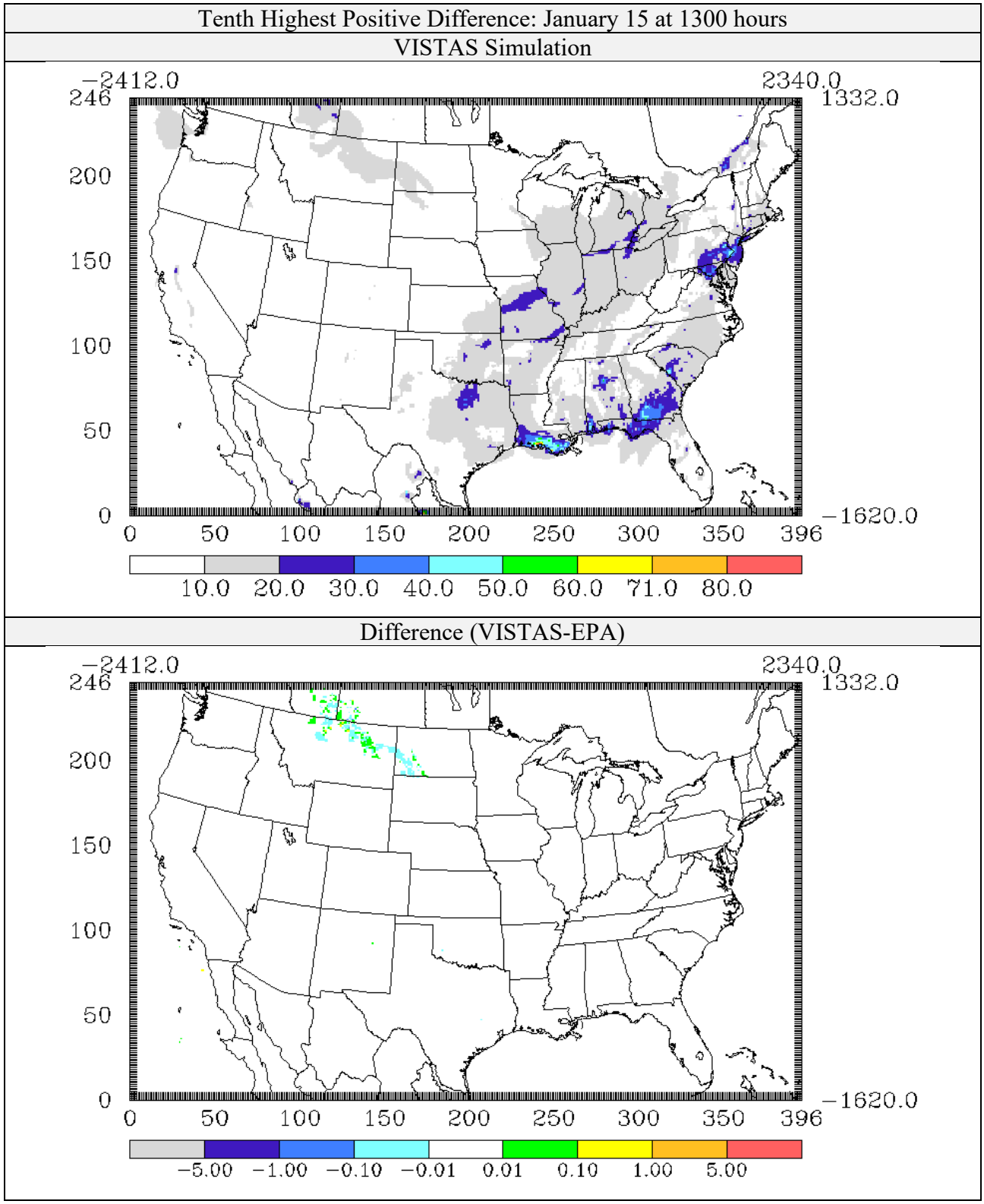


Figure 5-31: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference)

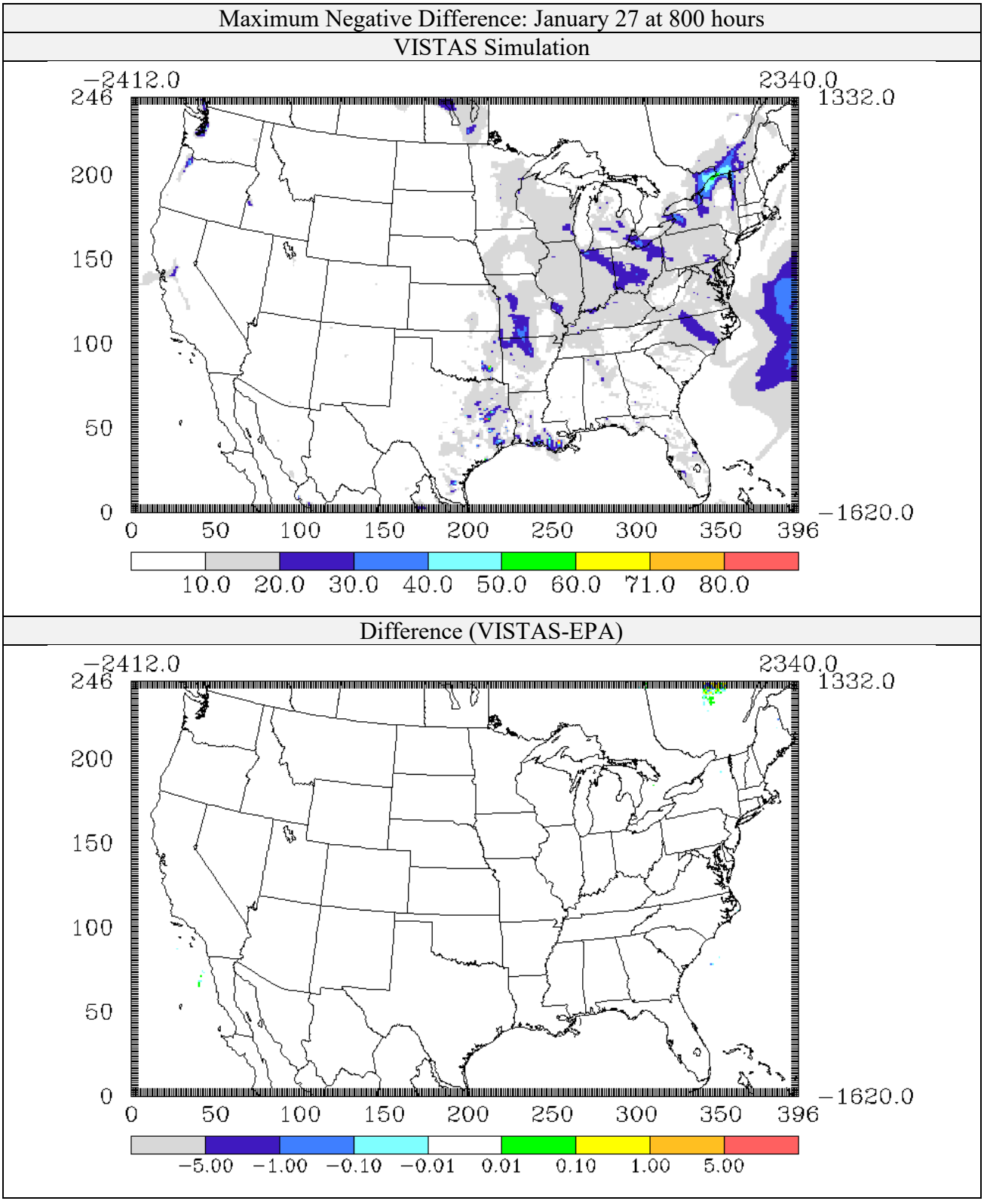


Figure 5-32: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference)

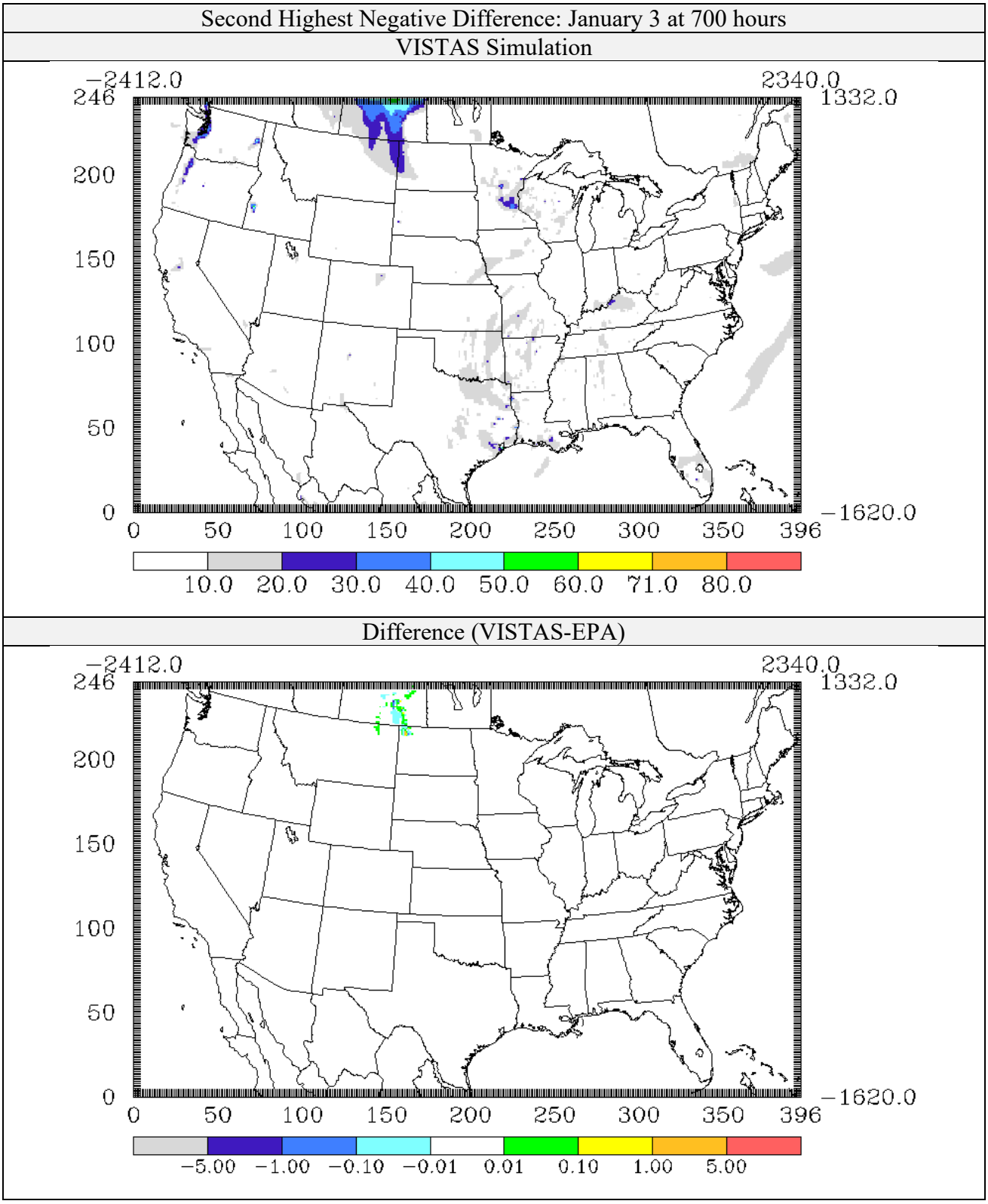


Figure 5-33: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference)

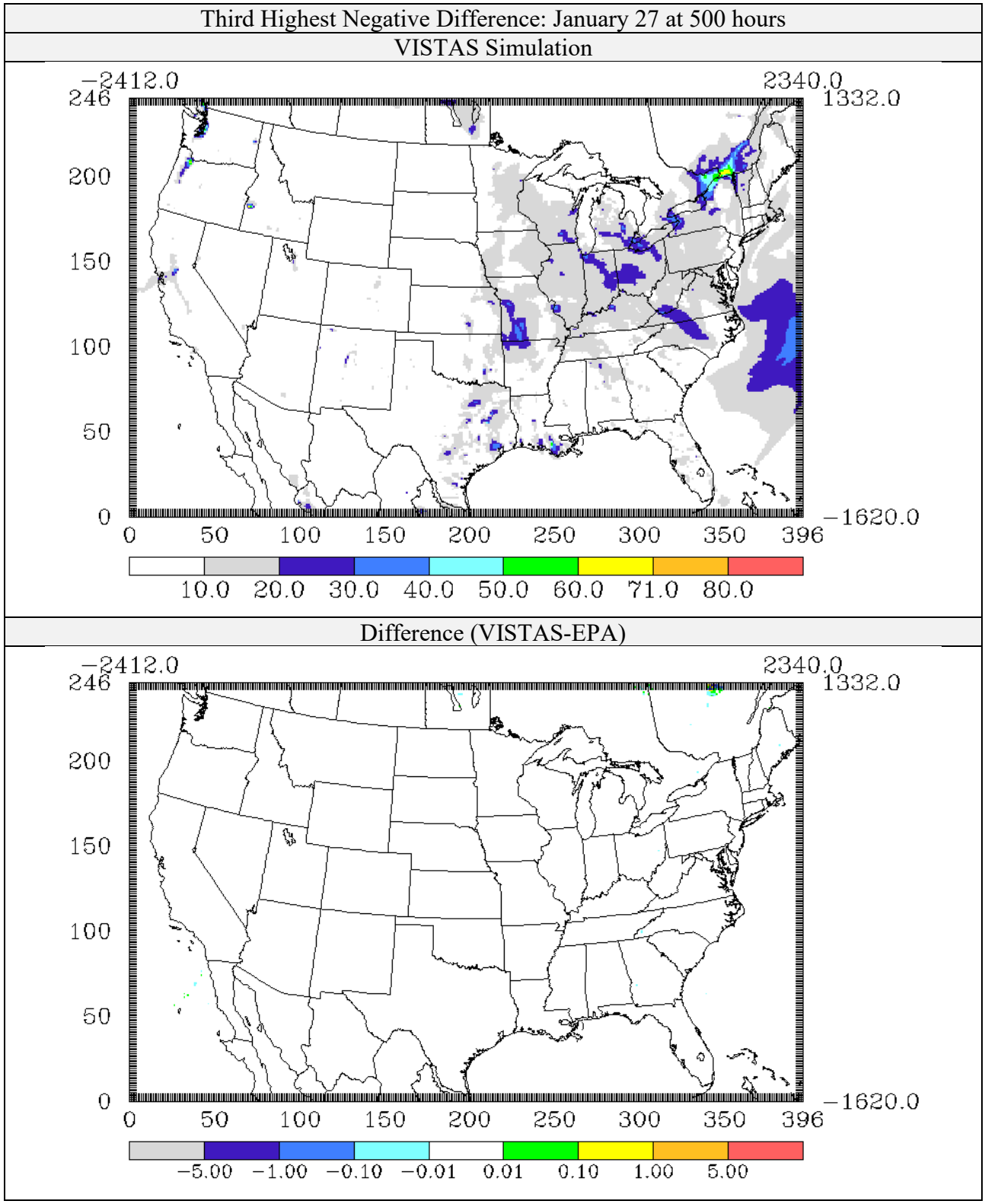


Figure 5-34: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference)

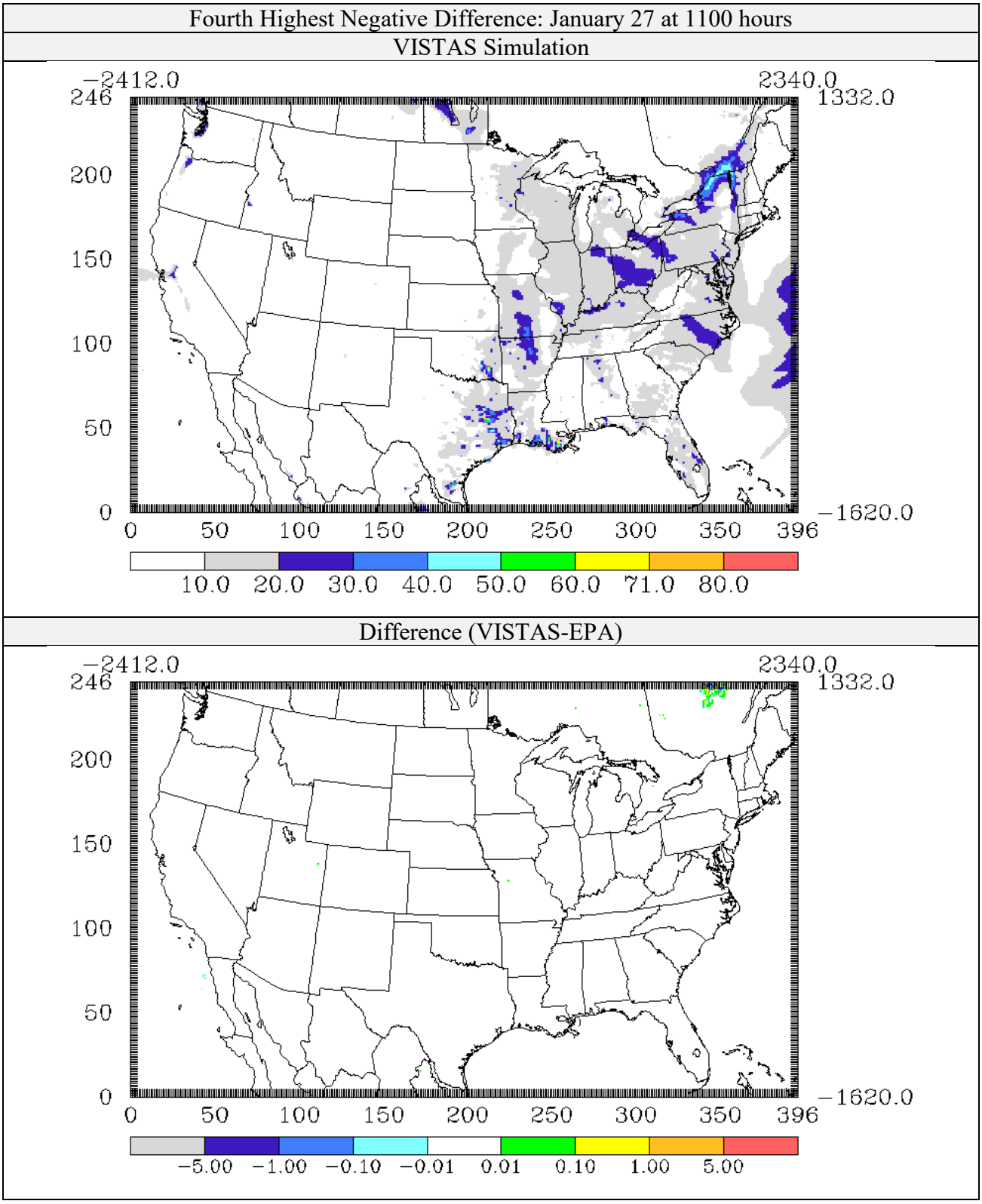


Figure 5-35: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference)

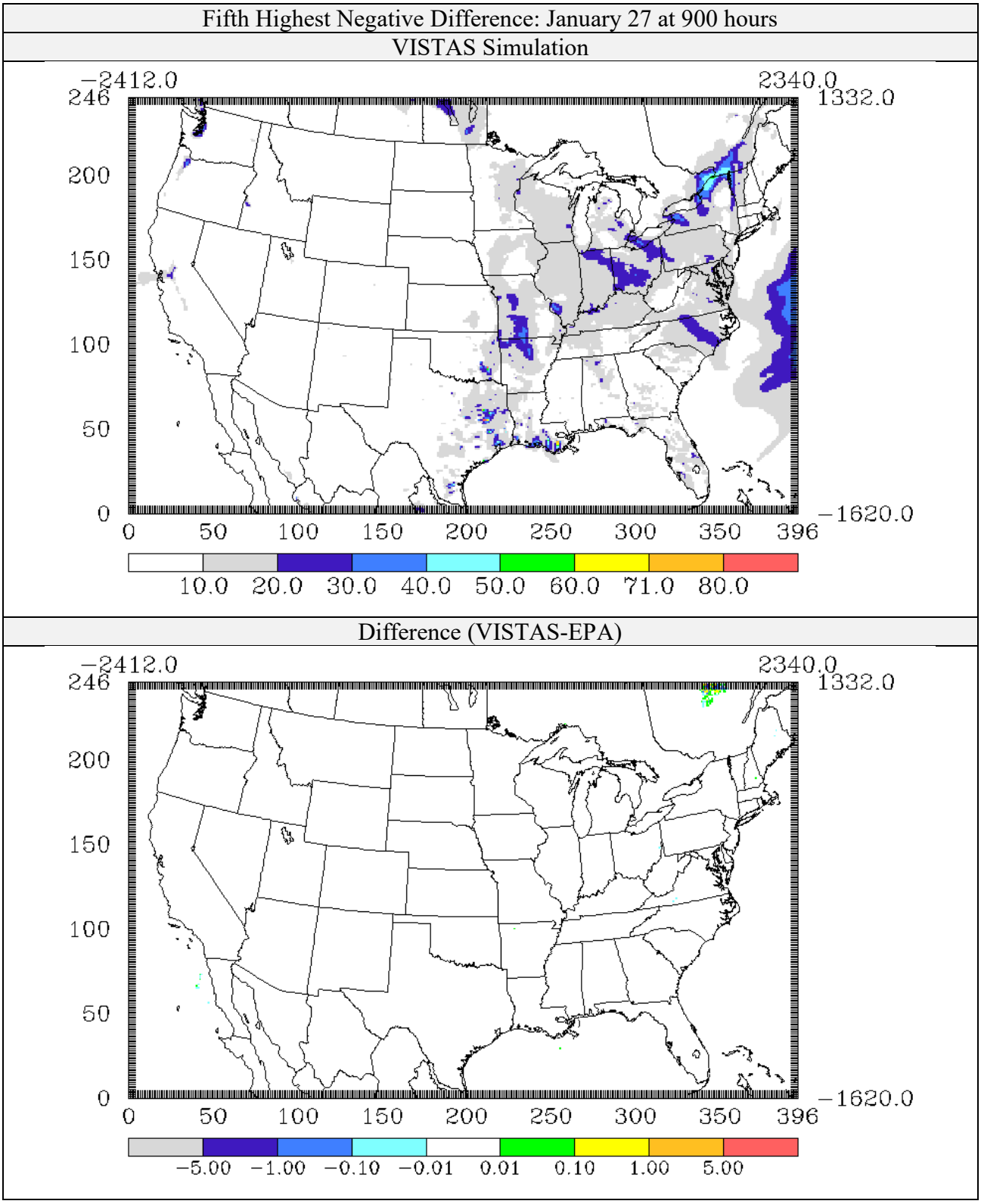


Figure 5-36: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference)

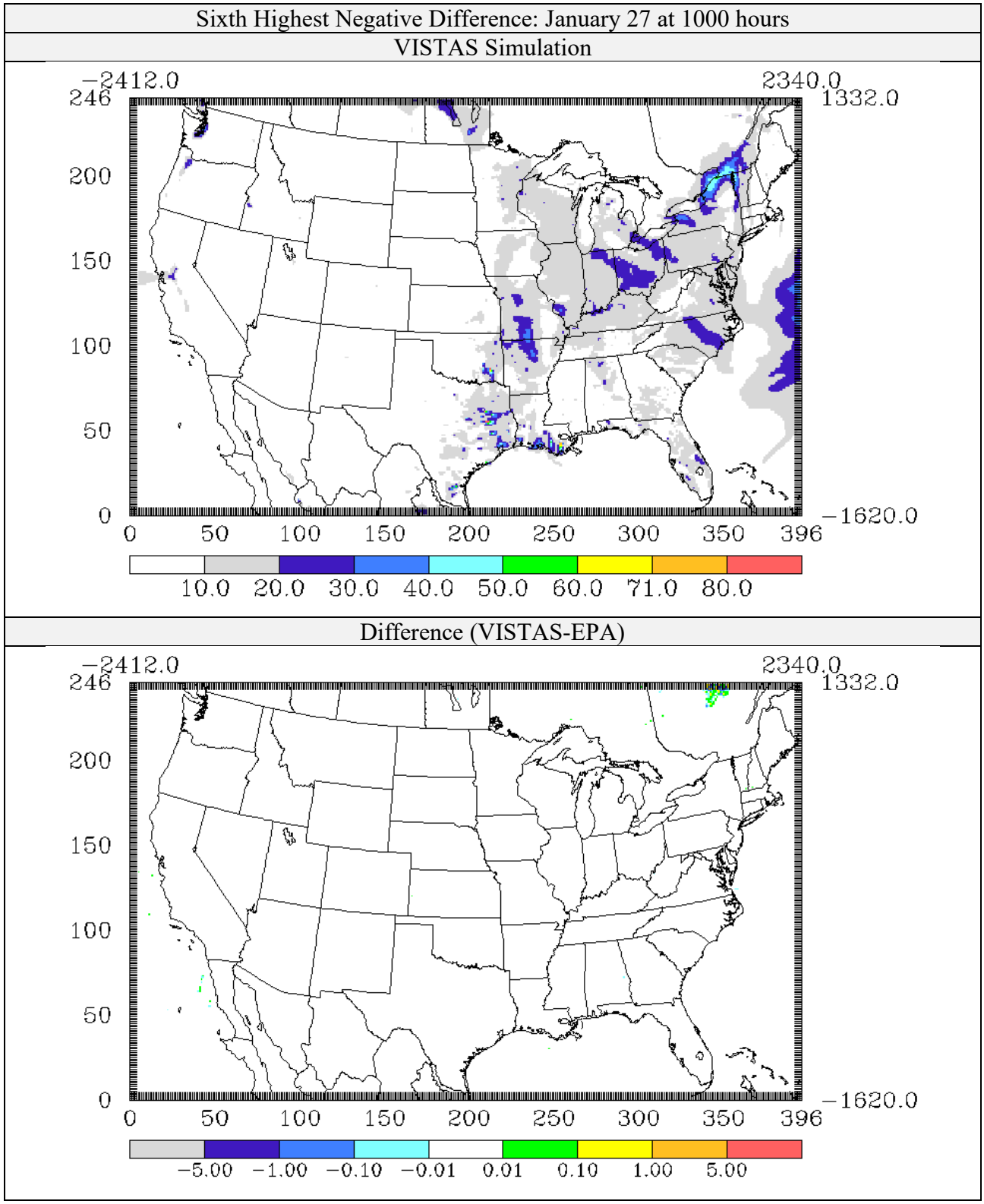


Figure 5-37: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference)

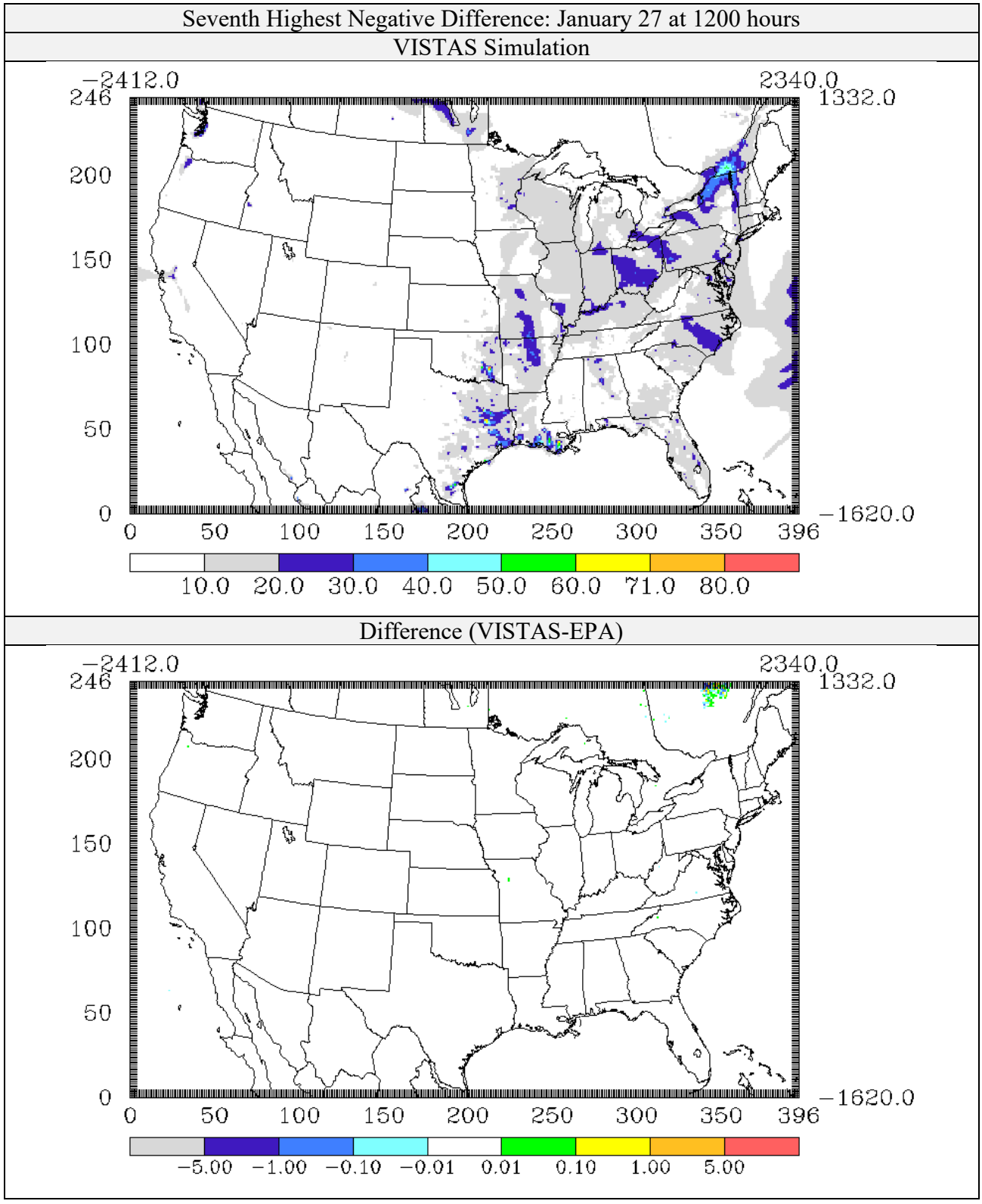


Figure 5-38: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference)

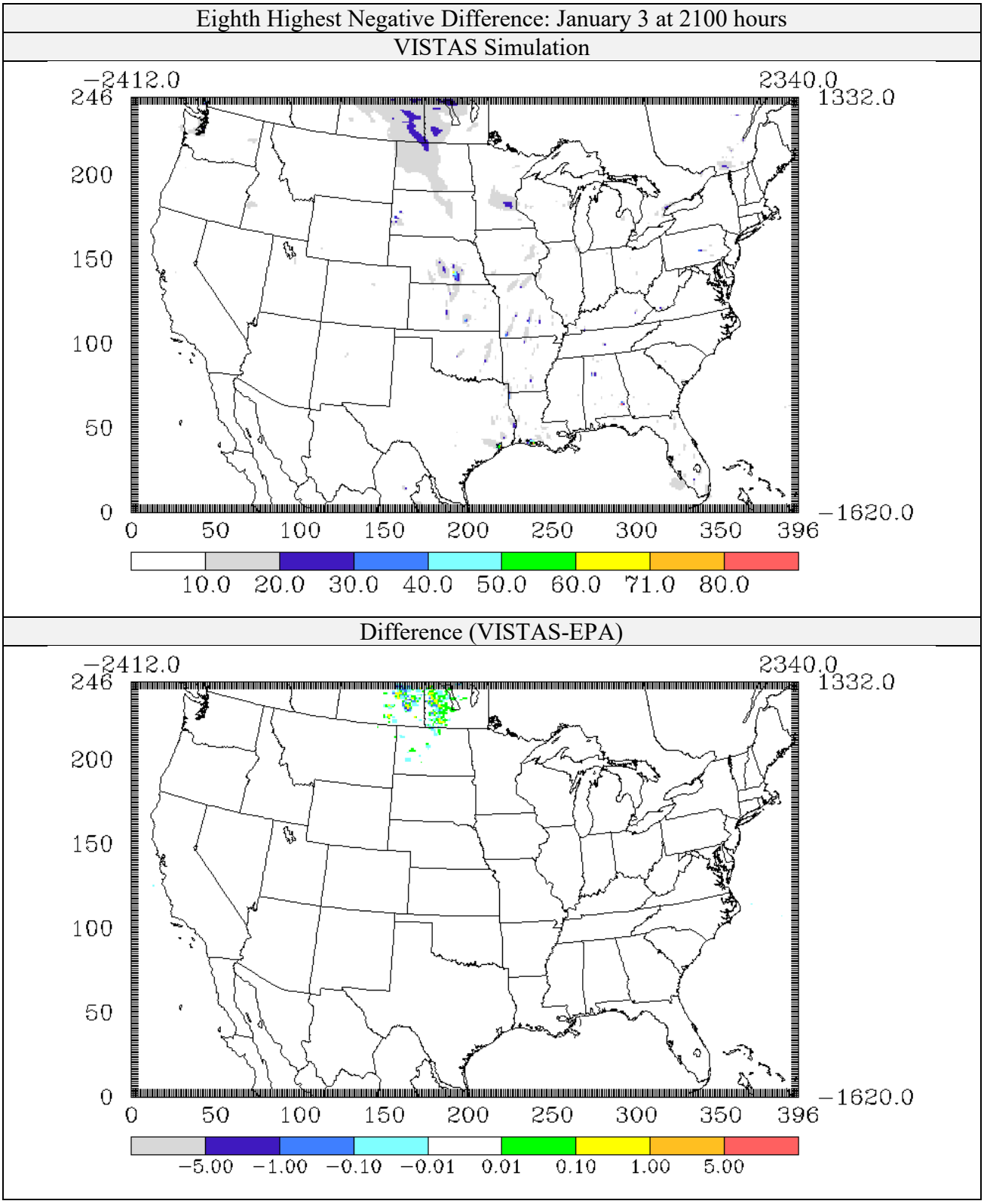


Figure 5-39: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference)

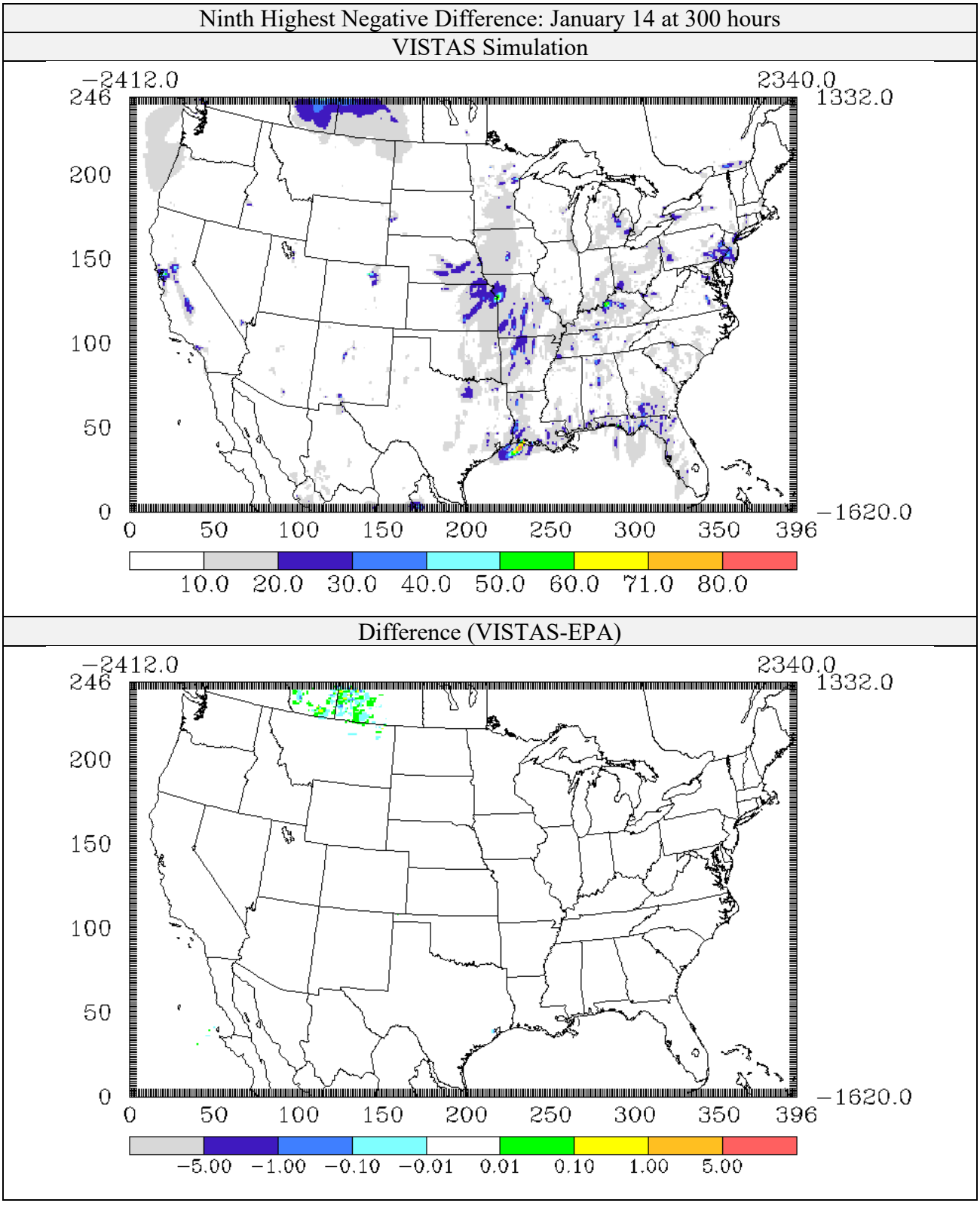


Figure 5-40: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference)

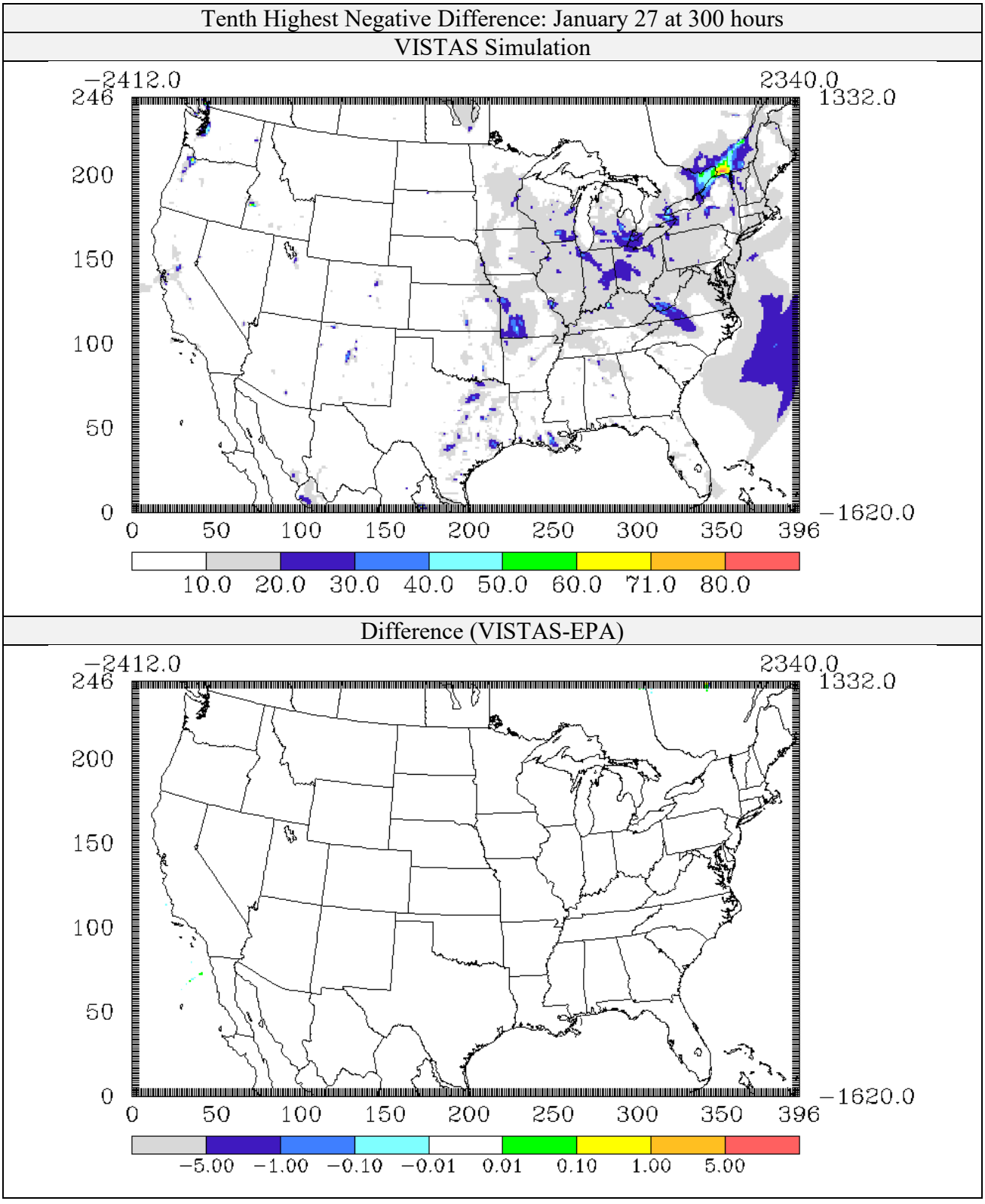


Figure 5-41: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference)

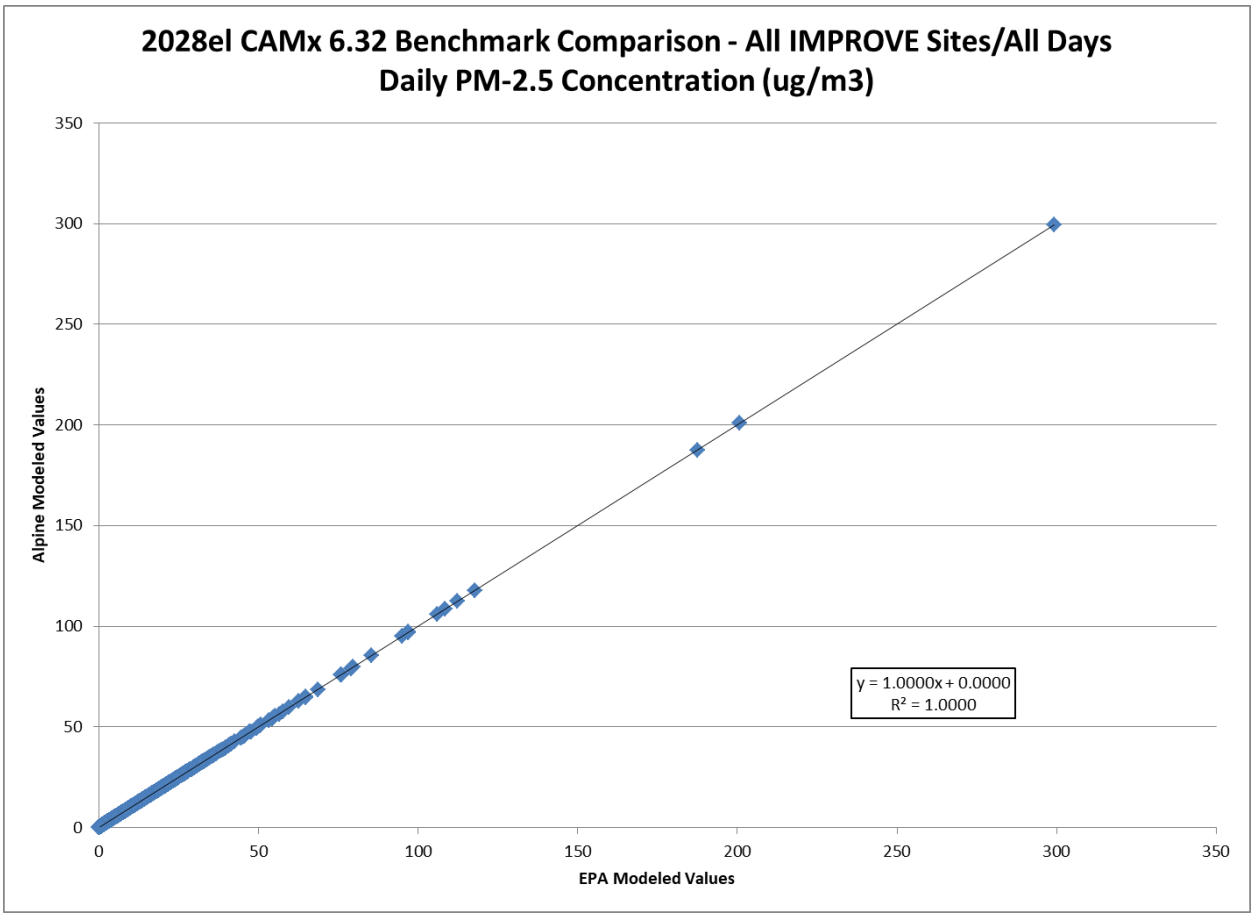


Figure 5-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine).

5.3 Sulfate

Sulfate results for the top 10 positive and negative hours are presented in tabular format in Table 5-3. The maximum positive difference is 0.31 μg/m^3 falling to 0.17 μg/m^3 for the 10th high. The maximum negative difference is -0.14 μg/m^3 falling to -0.08 μg/m^3 for the 10th high. The maximum positive percent difference from these days is 17.8% and negative percent difference of -6.8%.

The top 10 positive impact hours are presented in Figures 5-43 through 5-52 and the top 10 negative impact hours are presented in Figures 5-53 through 5-62. The locations of the impacts are considerably more localized than the $PM_{2.5}$ differences, and are not occurring in any systematic location, but are tending to occur in the colder months. The area of the differences does not appear to be correlated with areas of high Sulfate concentrations.

Scatterplots of the daily average sulfate concentrations in local standard time at the IMPROVE monitors are presented in Figure 5-63. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

Table 5-3. Comparison of 2028el CAMx 6.32 Simulation Sulfate Concentrations (µg/m^3) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	1	26	11	2.08	1.77	0.31	17.80%	209	205
2011	12	13	11	4.75	4.45	0.30	6.79%	170	116
2011	11	23	13	3.43	3.17	0.26	8.23%	215	100
2011	1	26	12	2.31	2.06	0.25	11.99%	209	205
2011	3	16	9	5.22	5.00	0.22	4.49%	227	181
2011	11	23	12	3.27	3.06	0.22	7.12%	215	100
2011	3	5	14	3.45	3.24	0.20	6.27%	183	161
2011	1	26	10	1.92	1.73	0.19	10.81%	209	205
2011	3	5	15	3.63	3.45	0.18	5.31%	183	161
2011	3	8	5	3.33	3.16	0.17	5.39%	112	241
Maximum Negative									
2011	1	26	9	4.01	4.15	-0.14	-3.26%	375	181
2011	3	20	13	7.25	7.38	-0.13	-1.74%	359	212
2011	12	26	10	1.74	1.87	-0.13	-6.78%	292	115
2011	5	11	12	2.09	2.19	-0.11	-4.80%	274	135
2011	2	17	4	2.68	2.78	-0.10	-3.72%	147	215
2011	4	13	23	3.38	3.48	-0.10	-2.88%	360	162
2011	2	15	14	3.96	4.06	-0.09	-2.31%	246	156
2011	1	18	12	3.62	3.71	-0.09	-2.31%	303	71
2011	2	15	13	4.16	4.24	-0.08	-1.96%	246	156
2011	12	18	11	2.68	2.76	-0.08	-3.00%	282	115

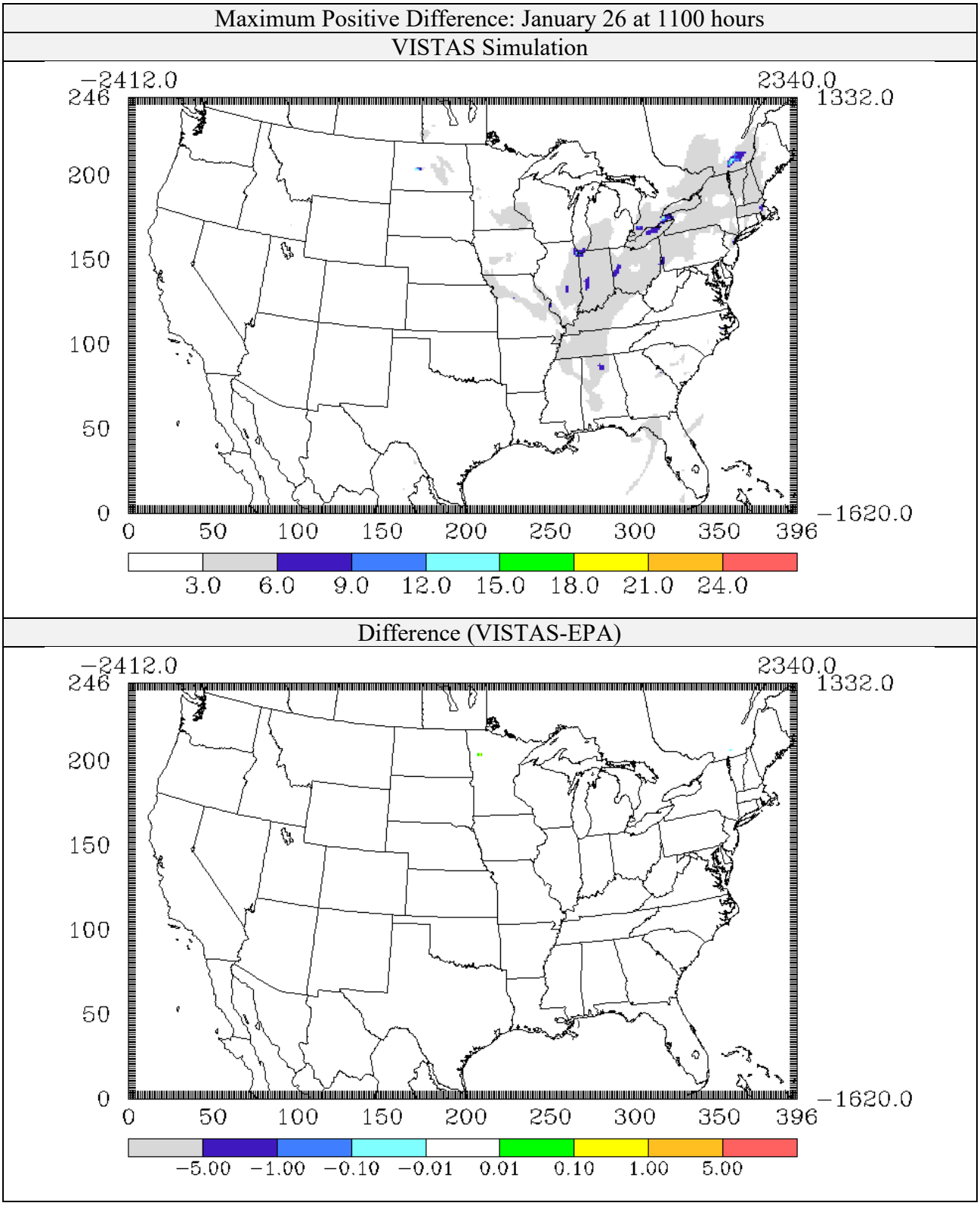


Figure 5-43: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference)

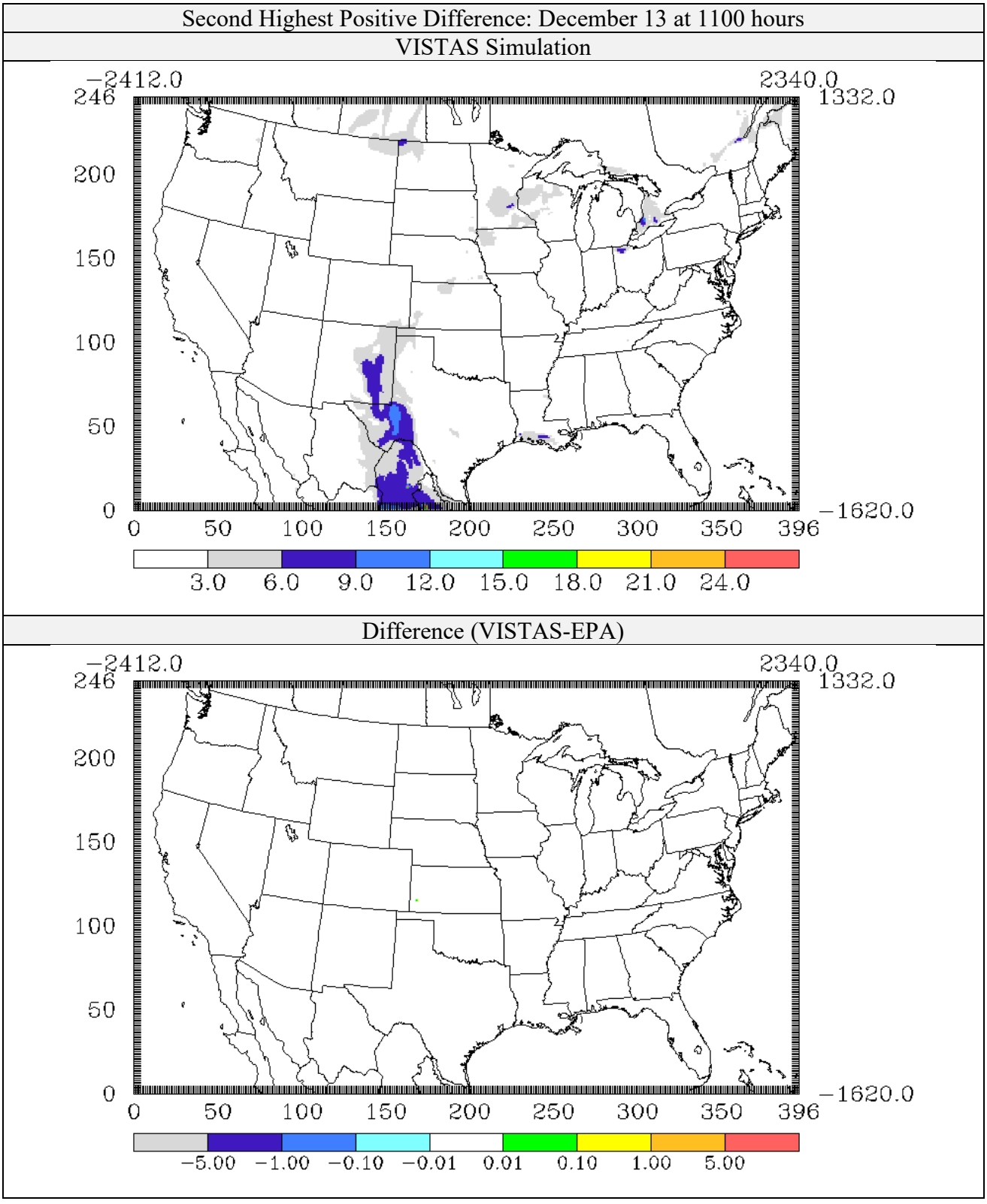


Figure 5-44: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference)

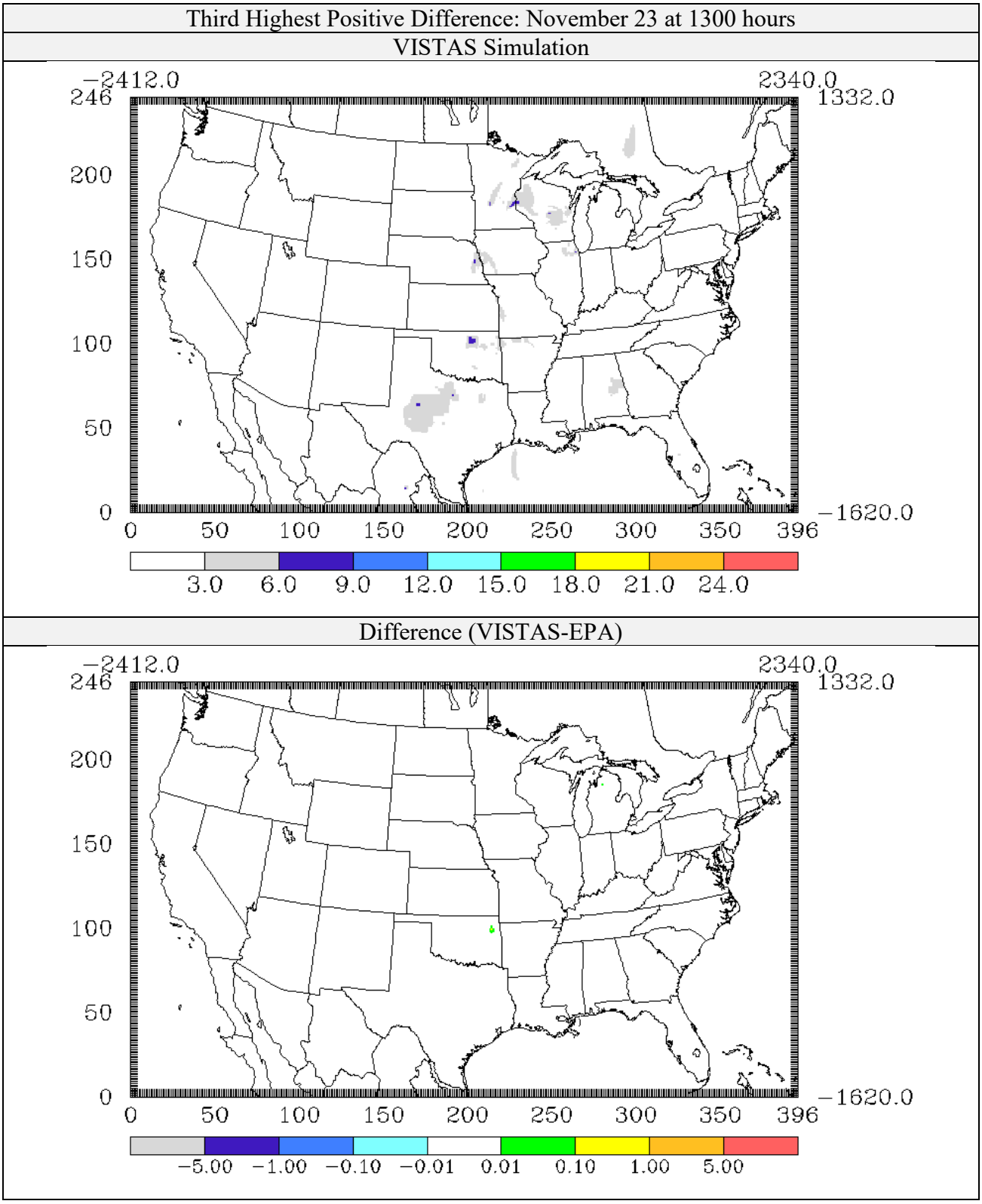


Figure 5-45: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference)

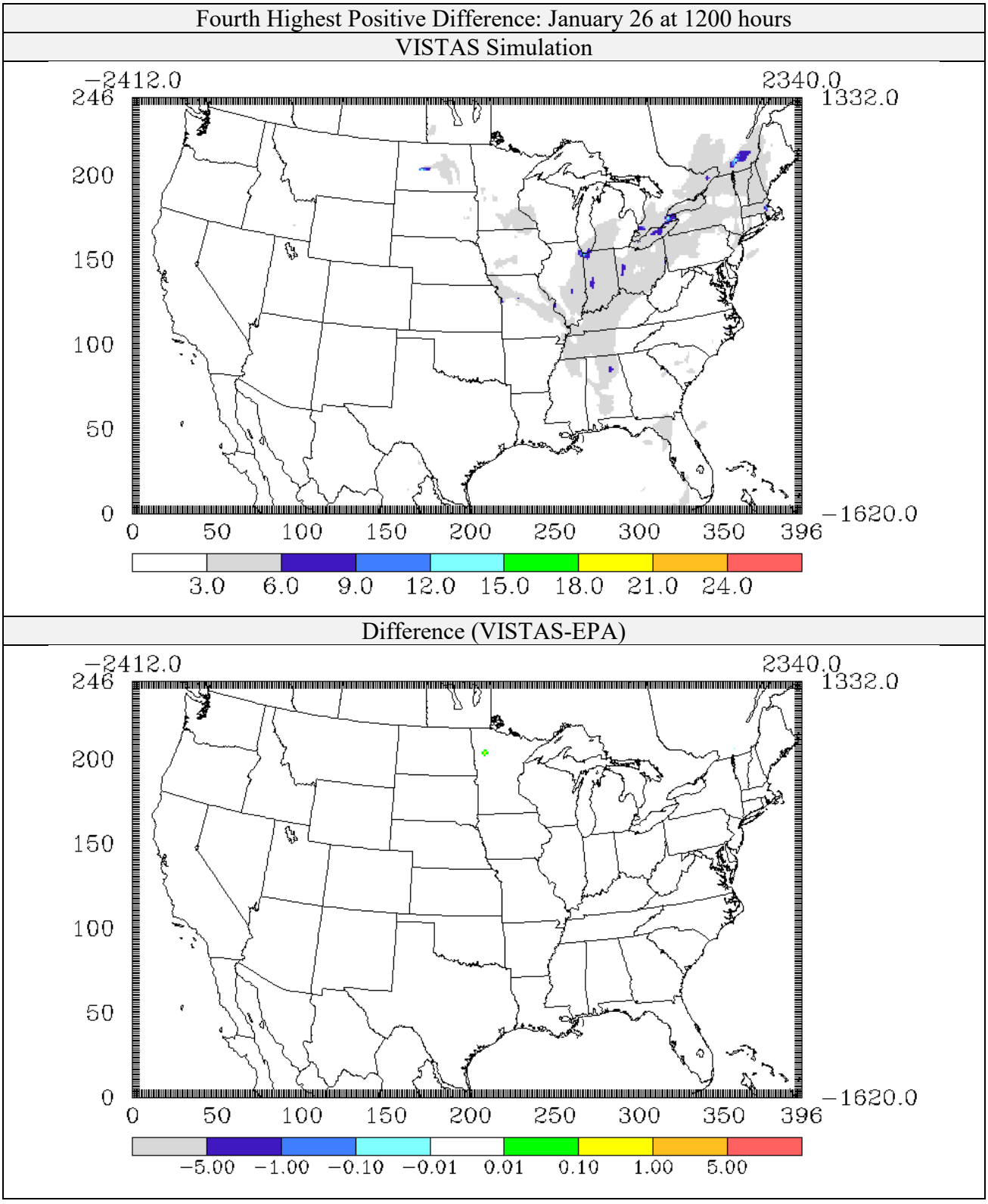


Figure 5-46: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference)

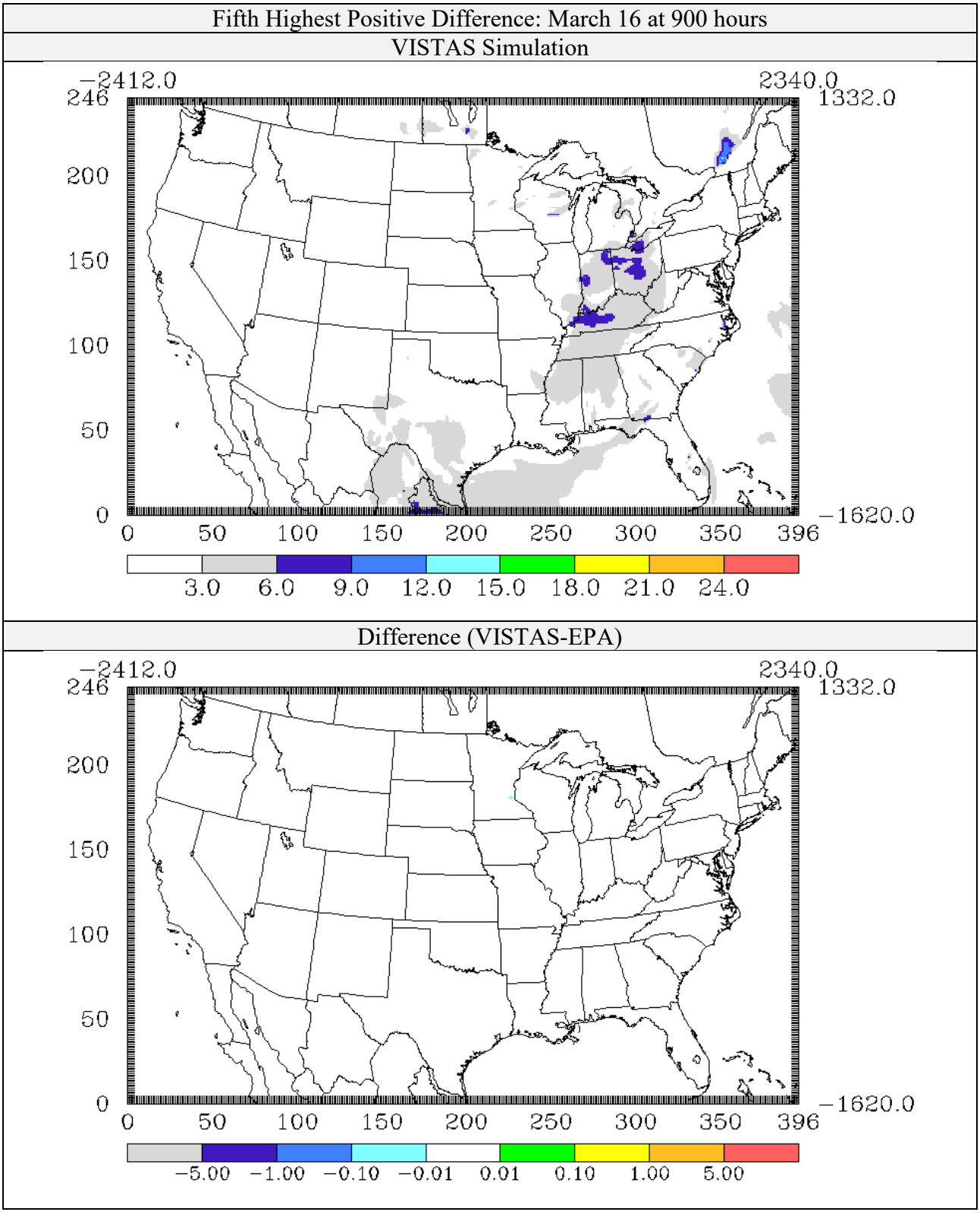


Figure 5-47: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Positive Difference)

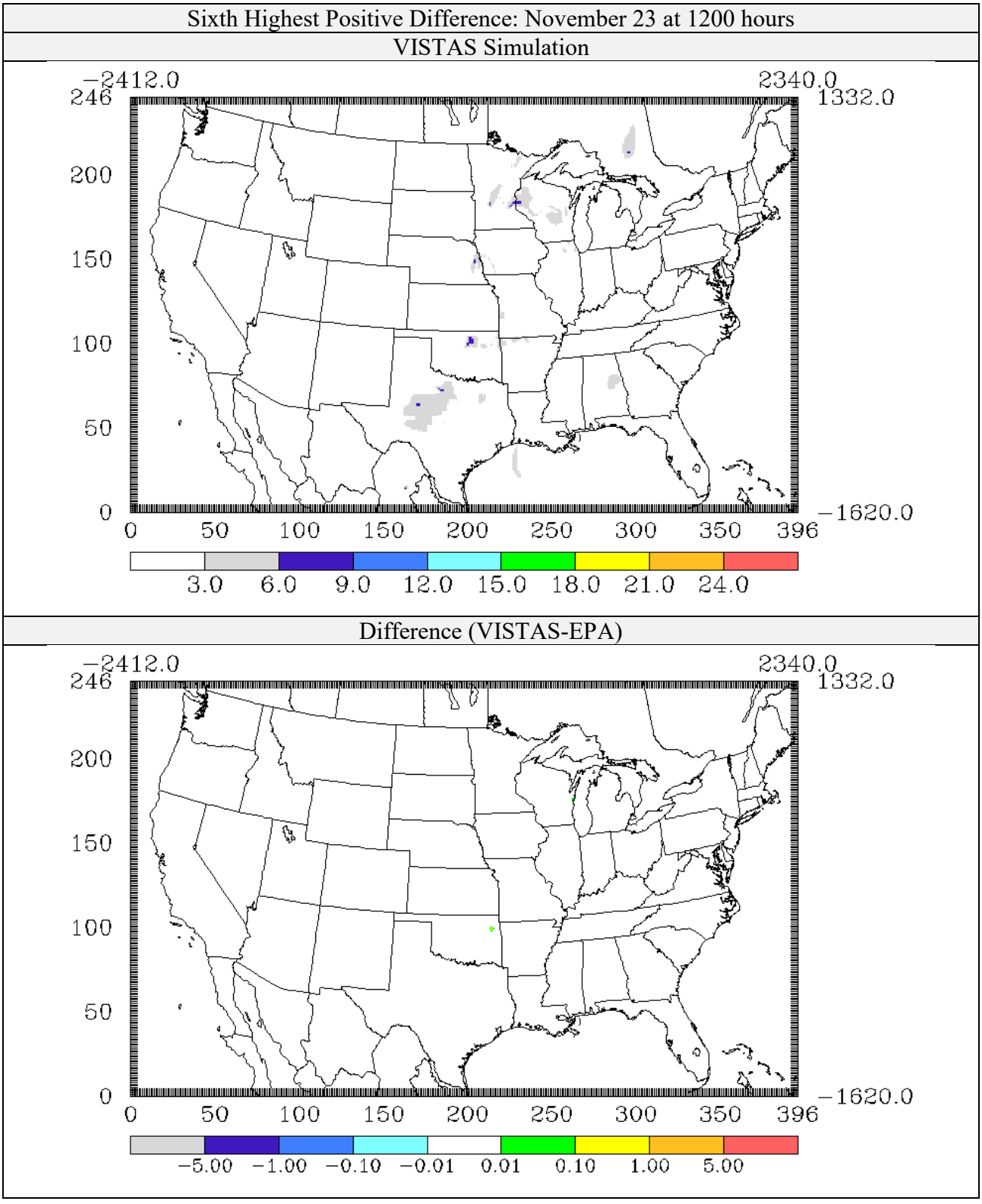


Figure 5-48: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference)

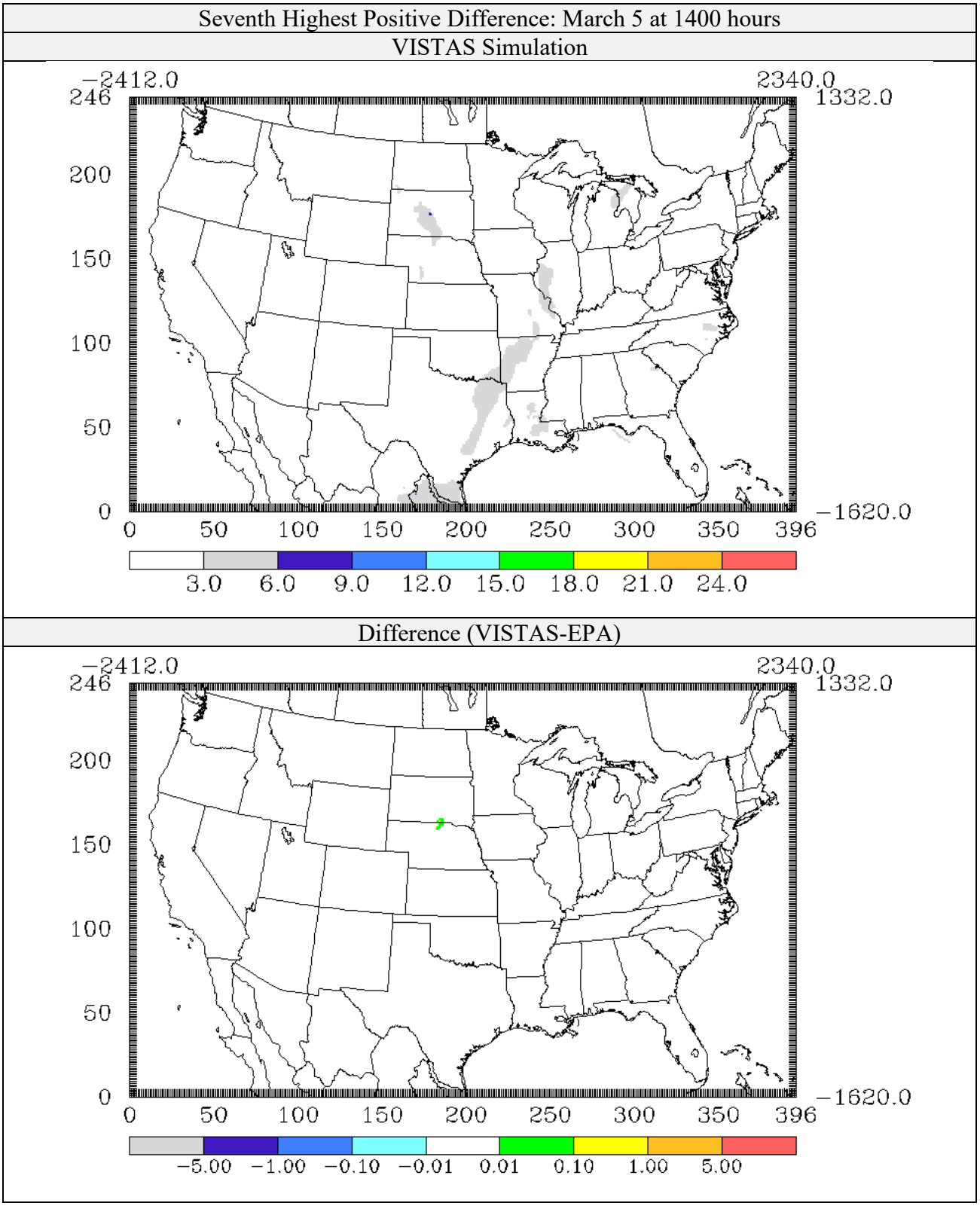


Figure 5-49: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference)

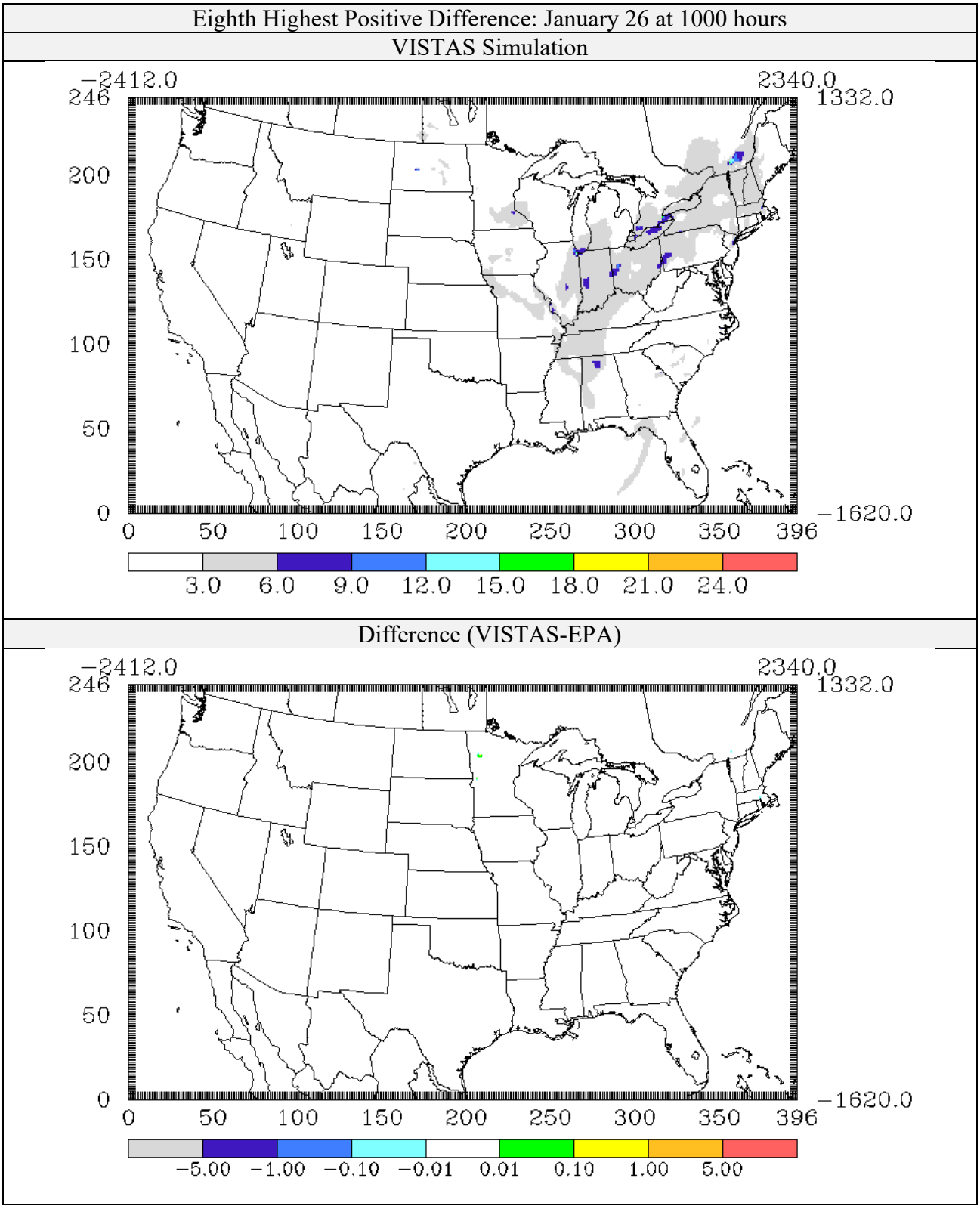


Figure 5-50: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference)

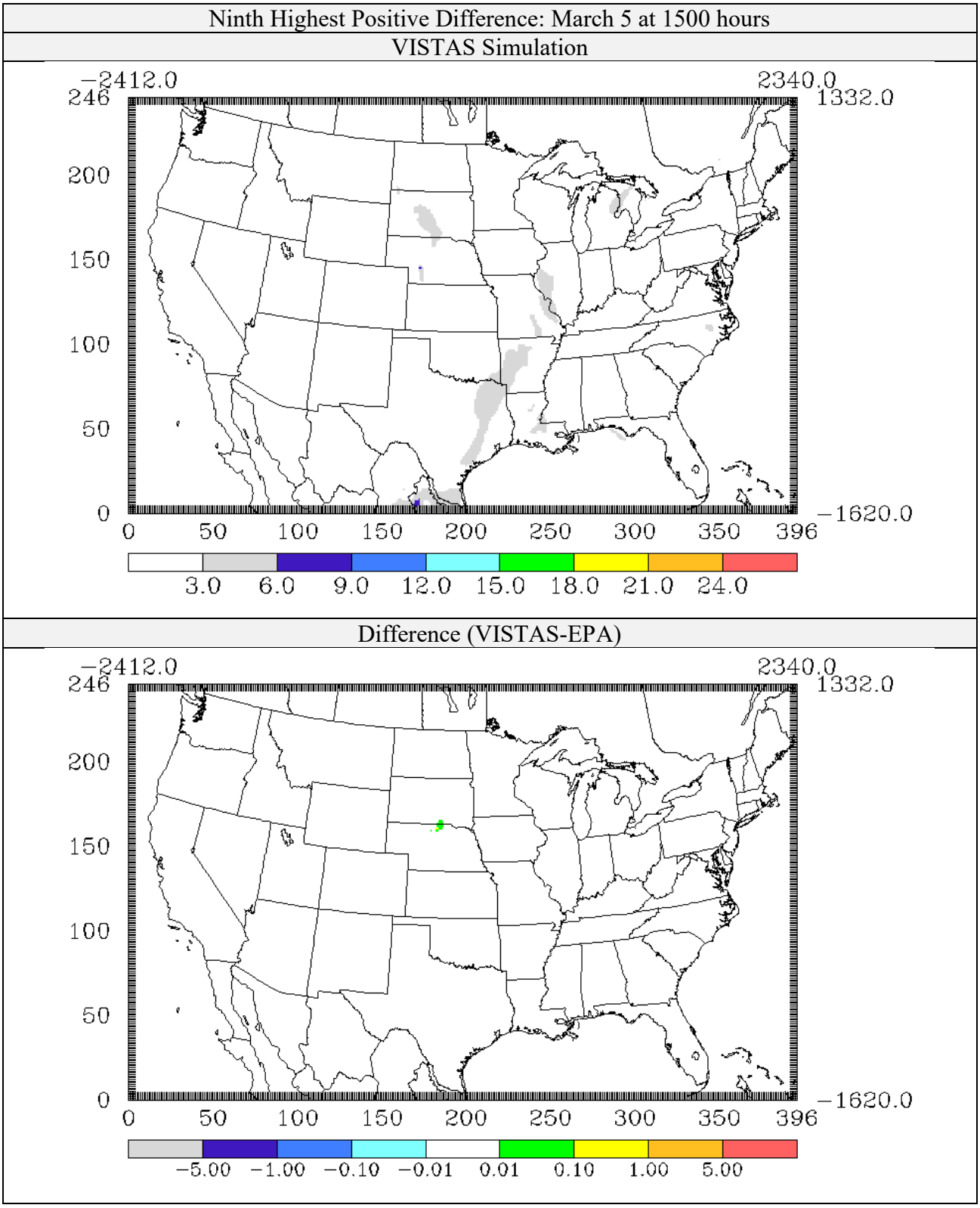


Figure 5-51: Comparison of Sulfate Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference)

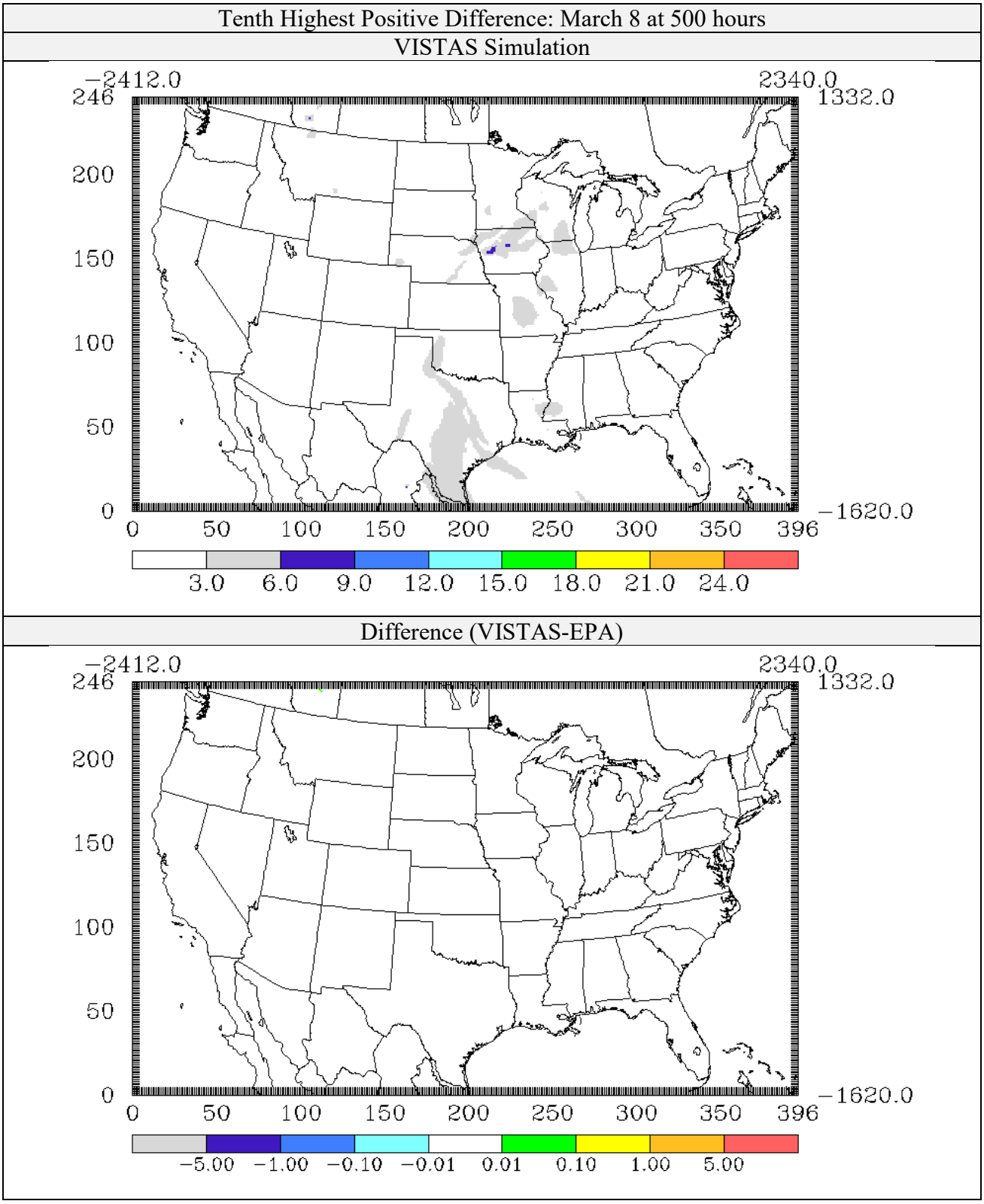


Figure 5-52: Comparison of Sulfate Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference)

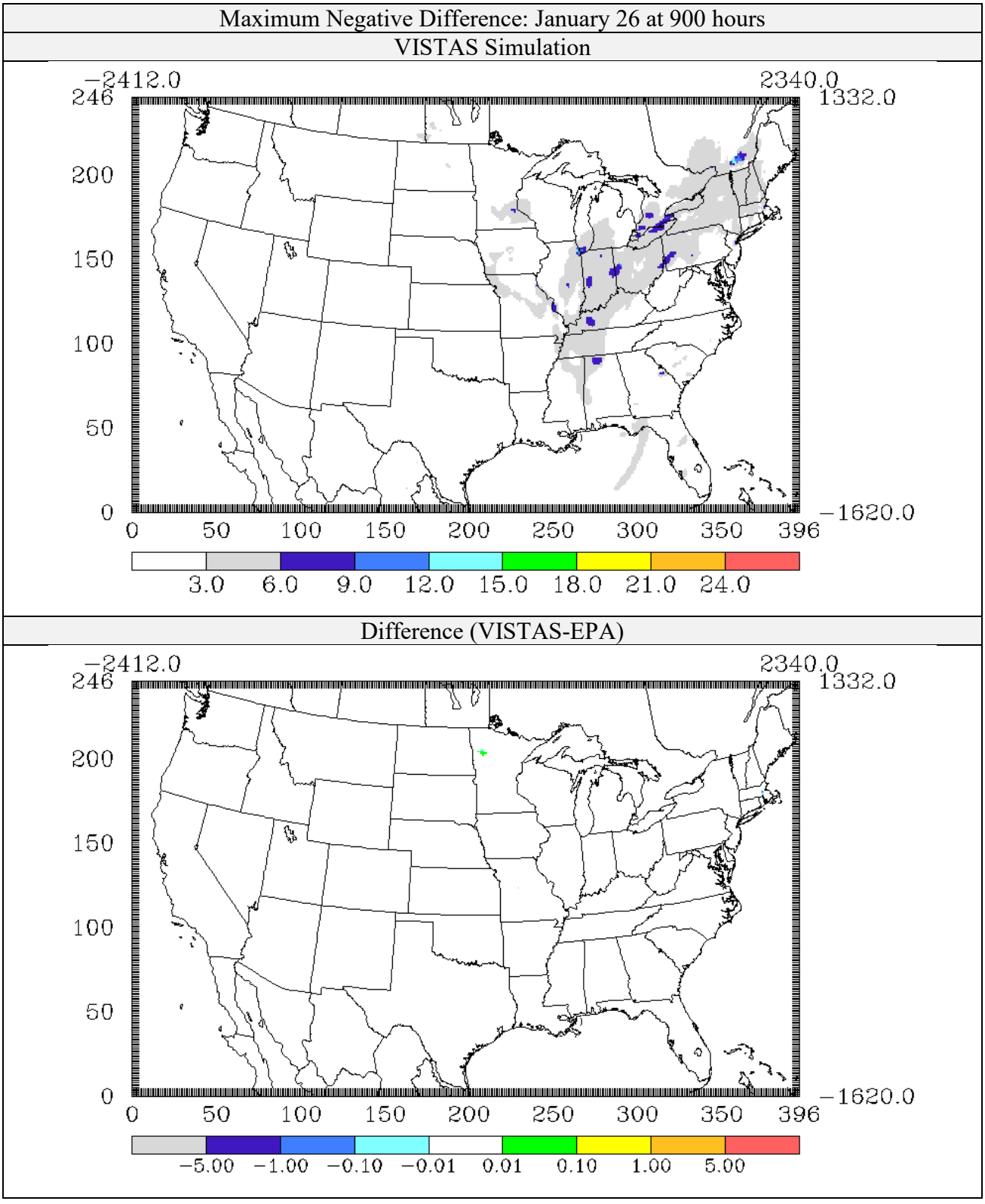


Figure 5-53: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference)

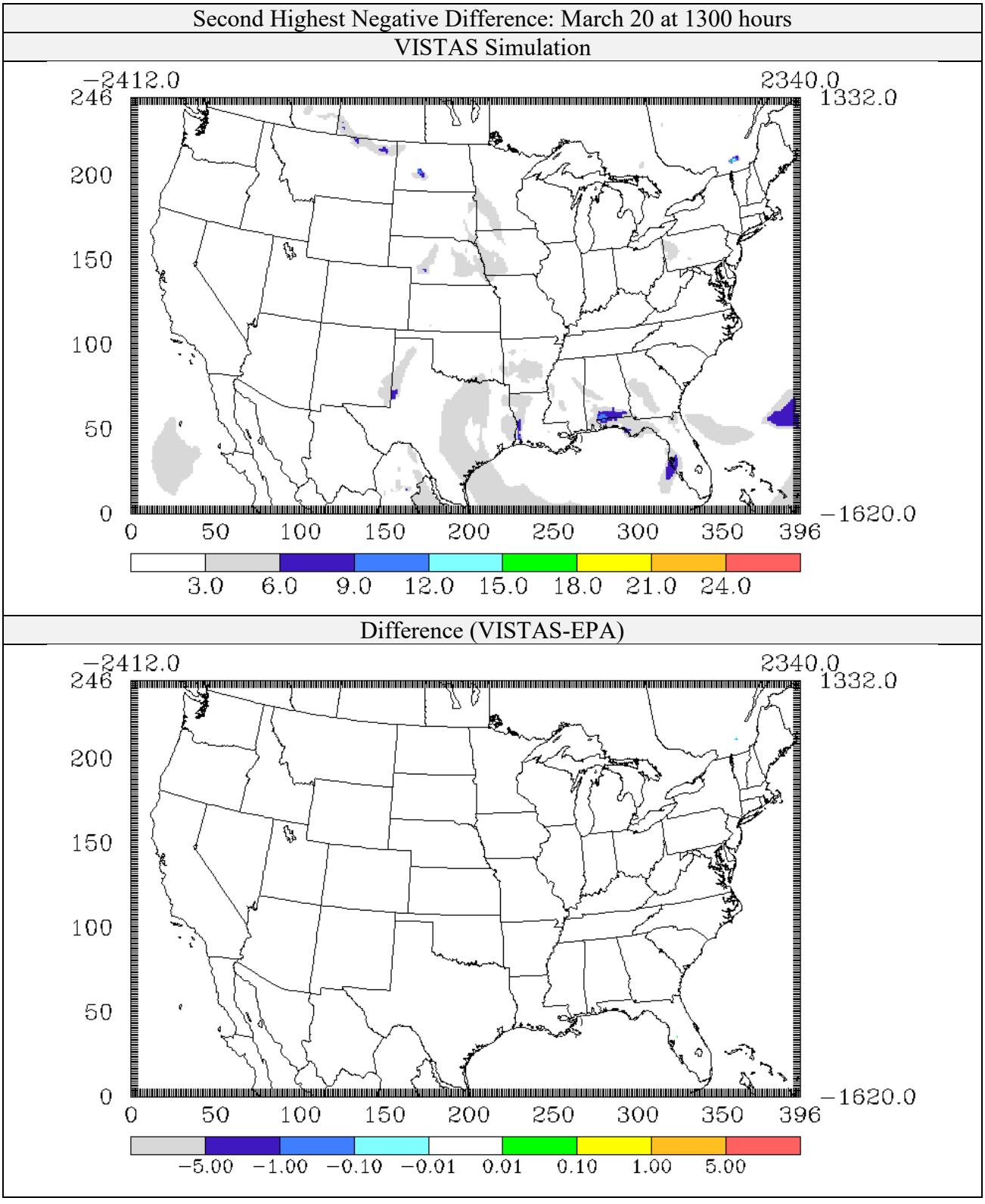


Figure 5-54: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference)

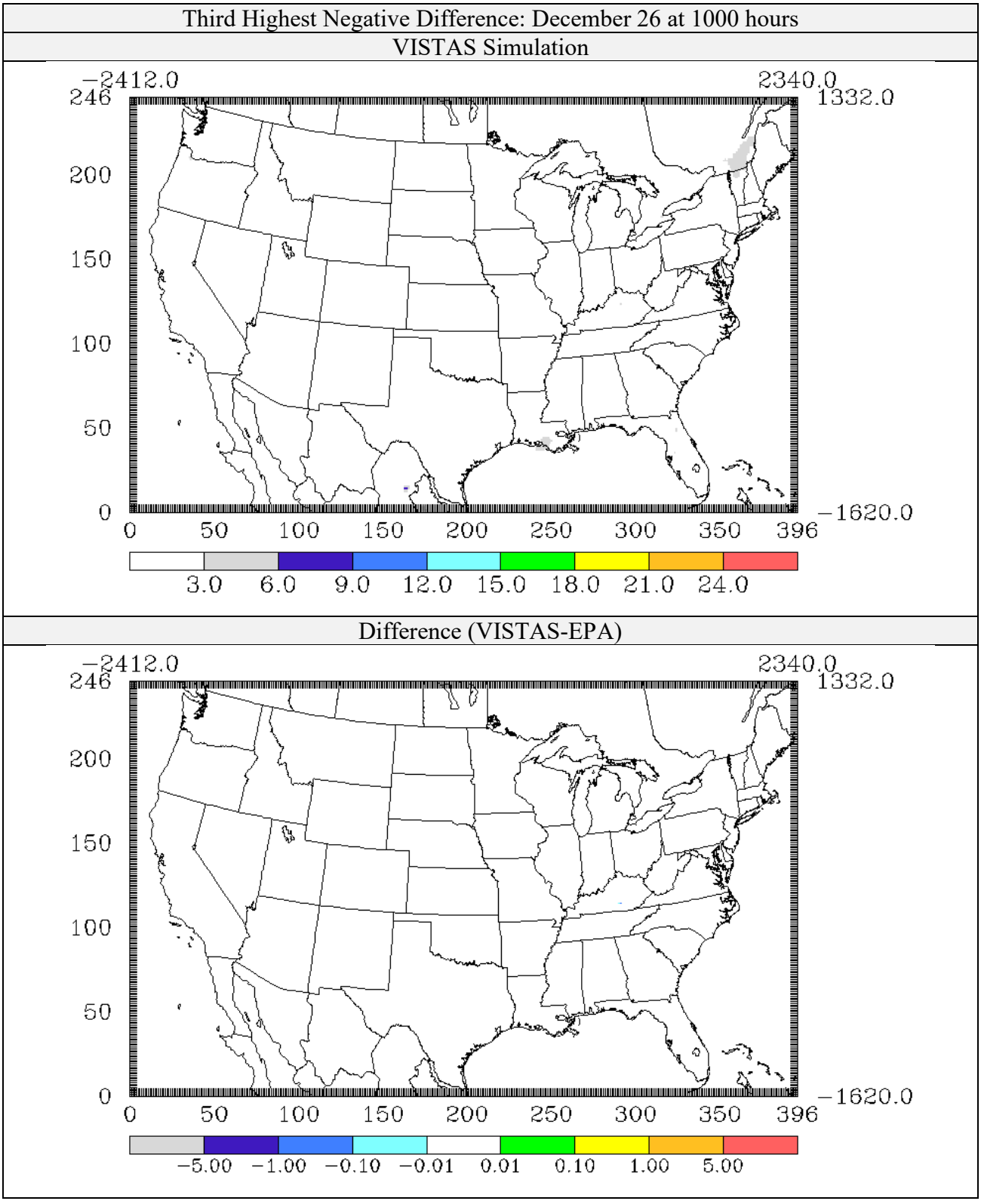


Figure 5-55: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference)

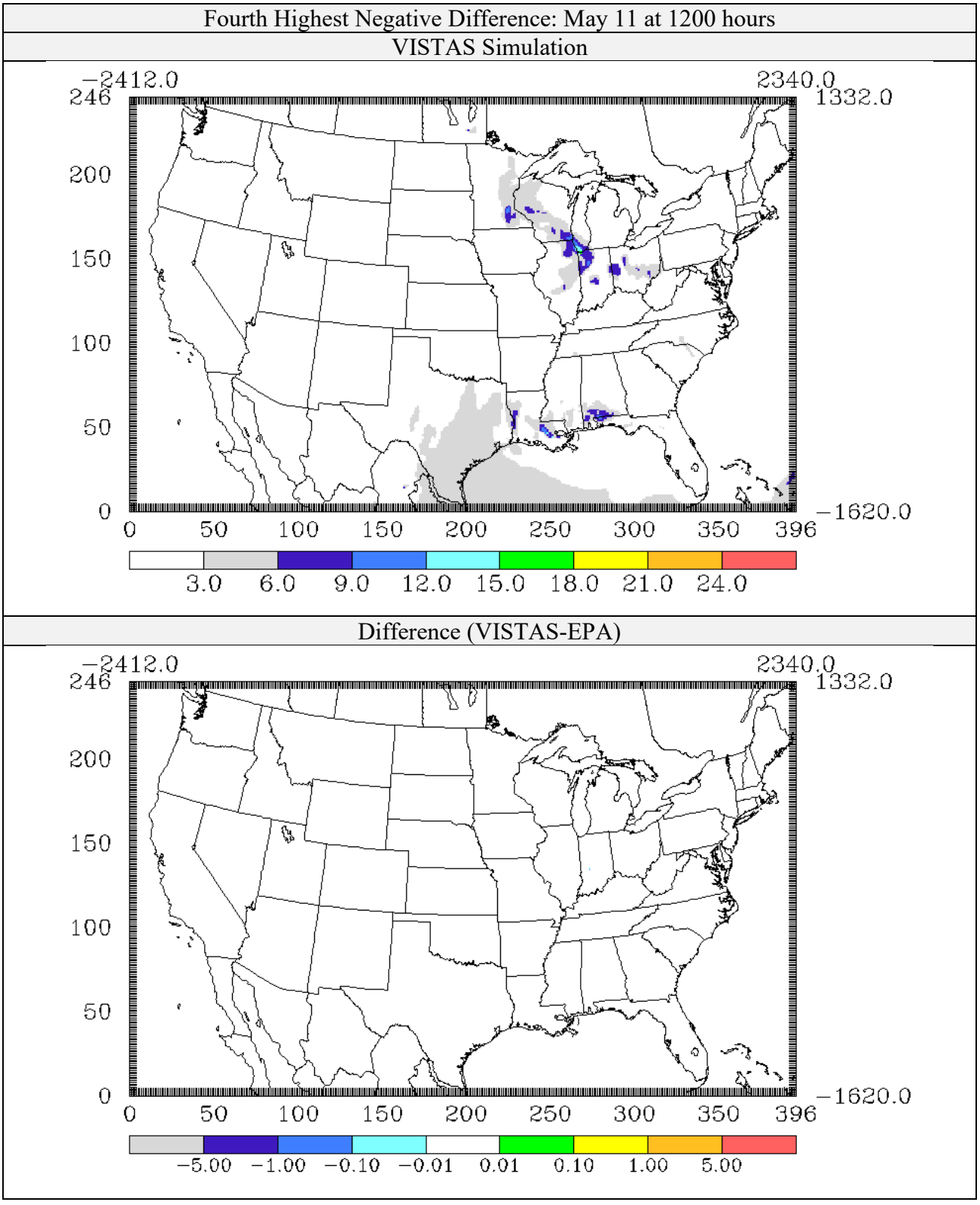


Figure 5-56: Comparison of Sulfate Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference)

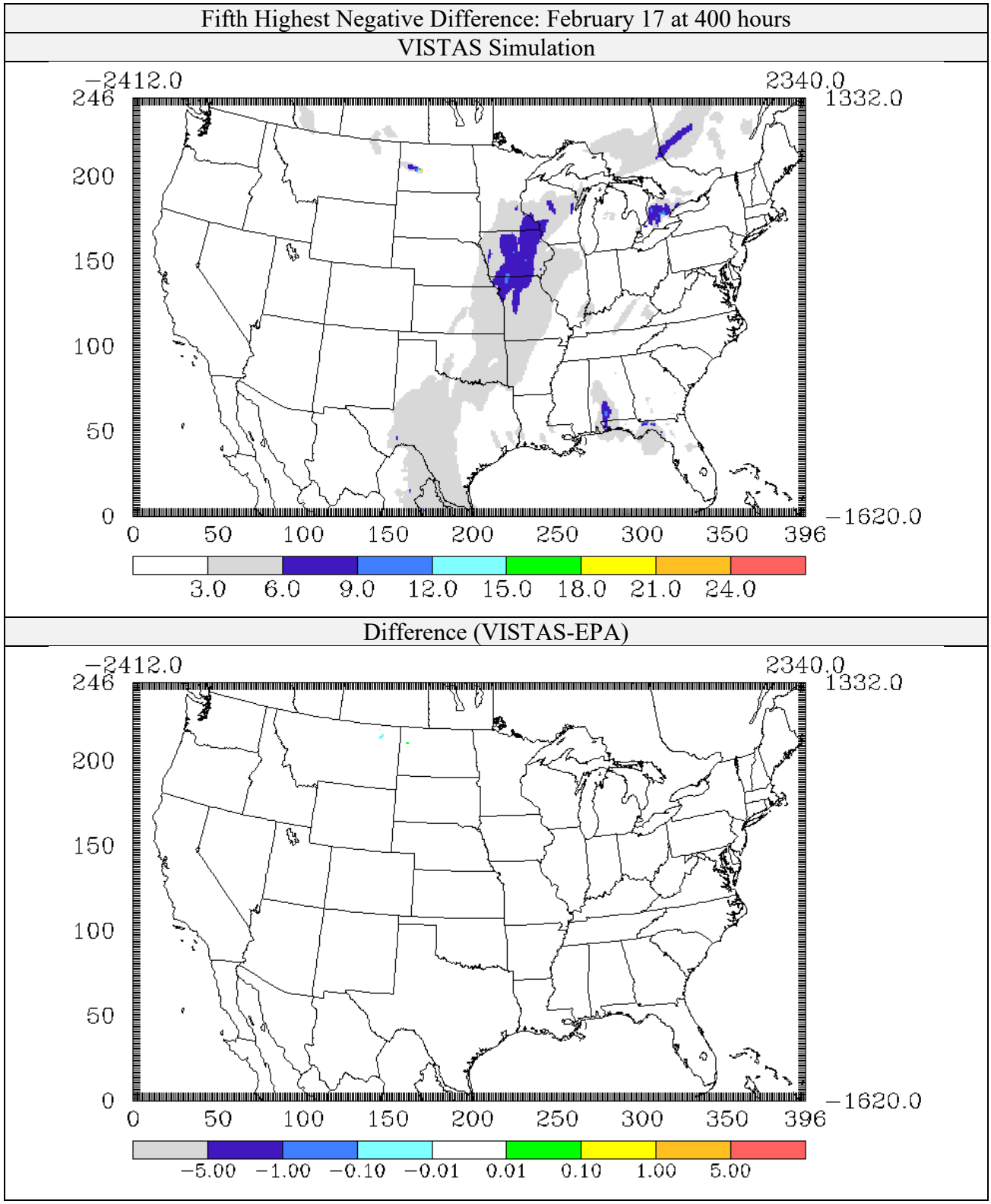


Figure 5-57: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference)

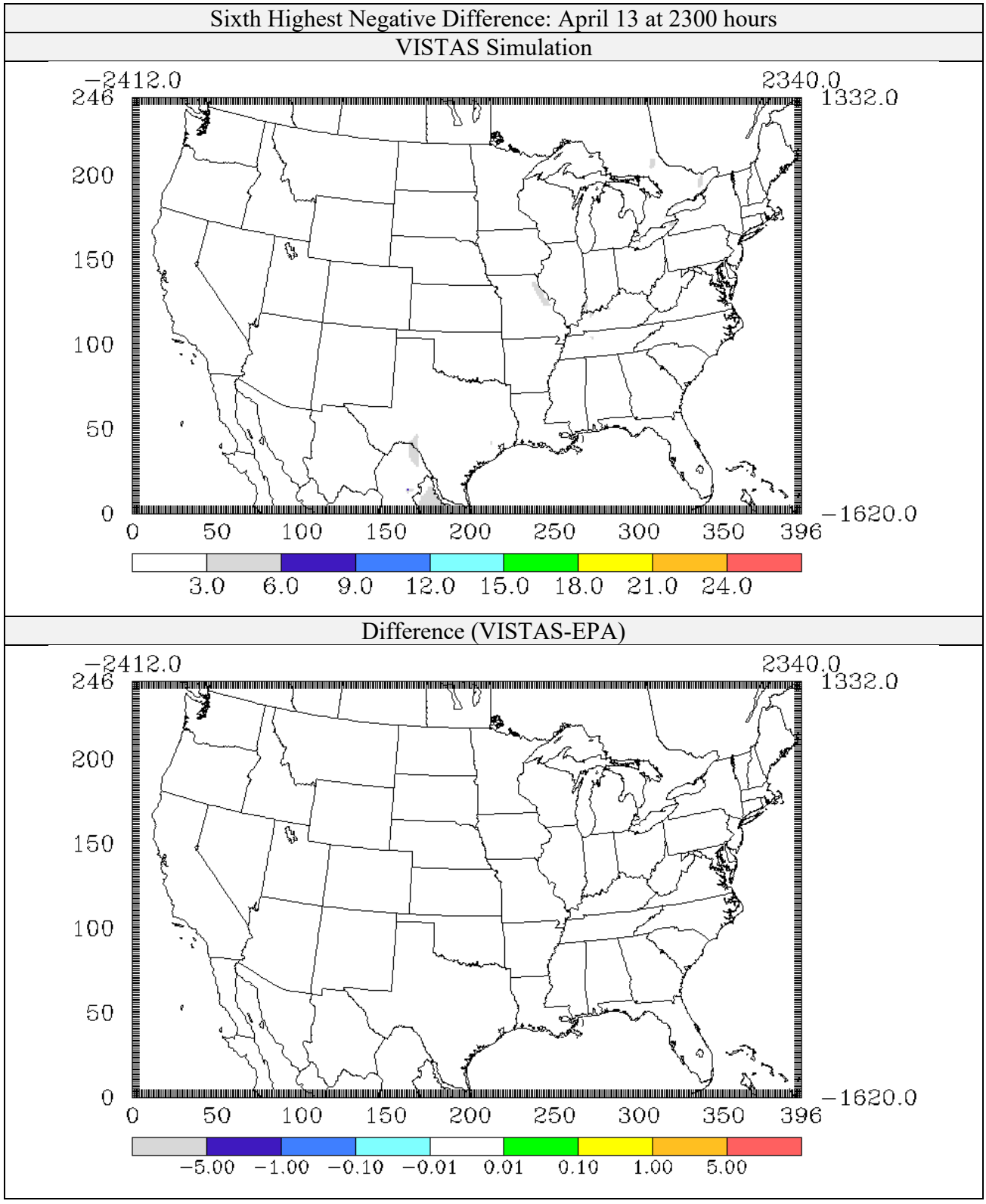


Figure 5-58: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference)

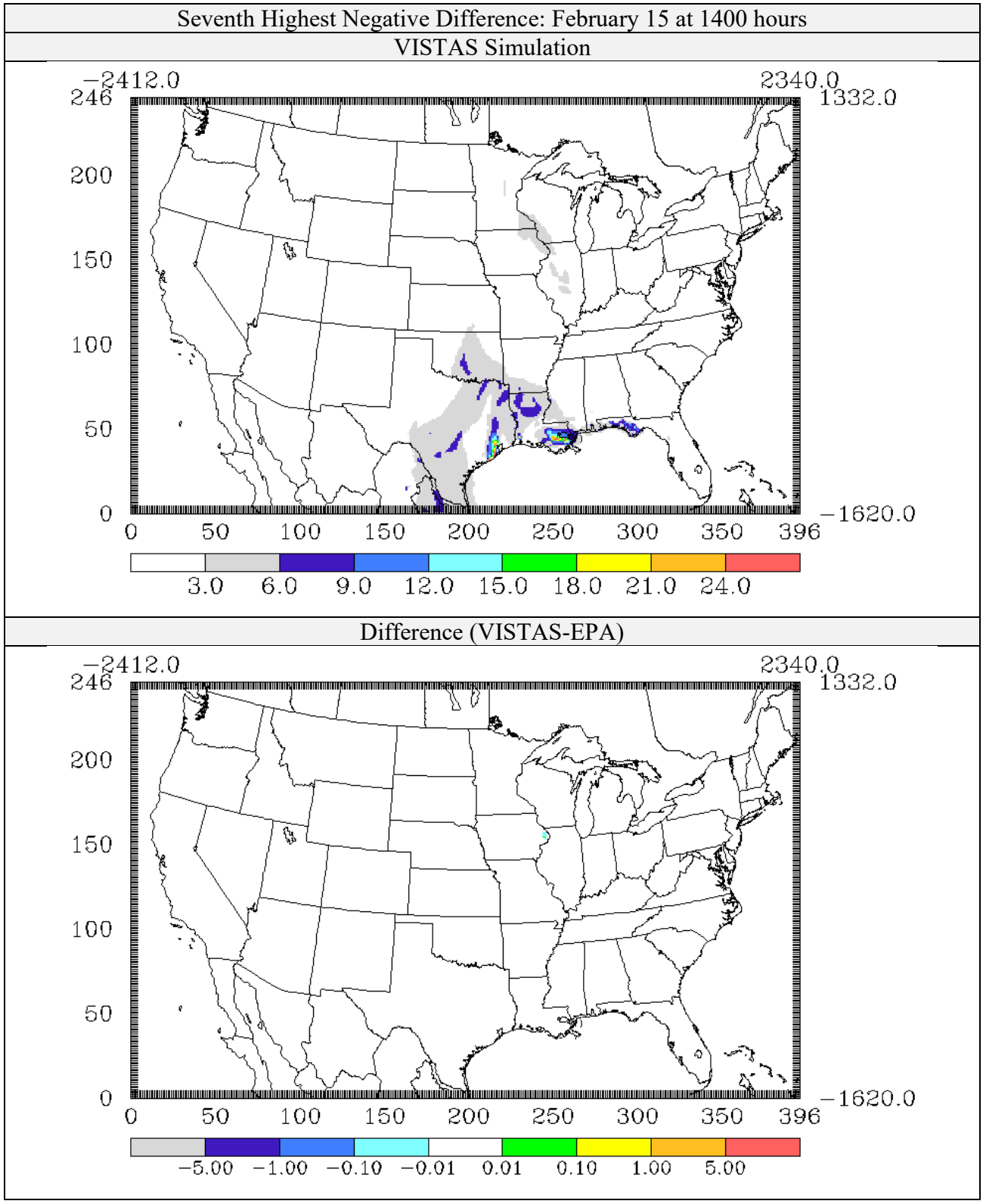


Figure 5-59: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference)

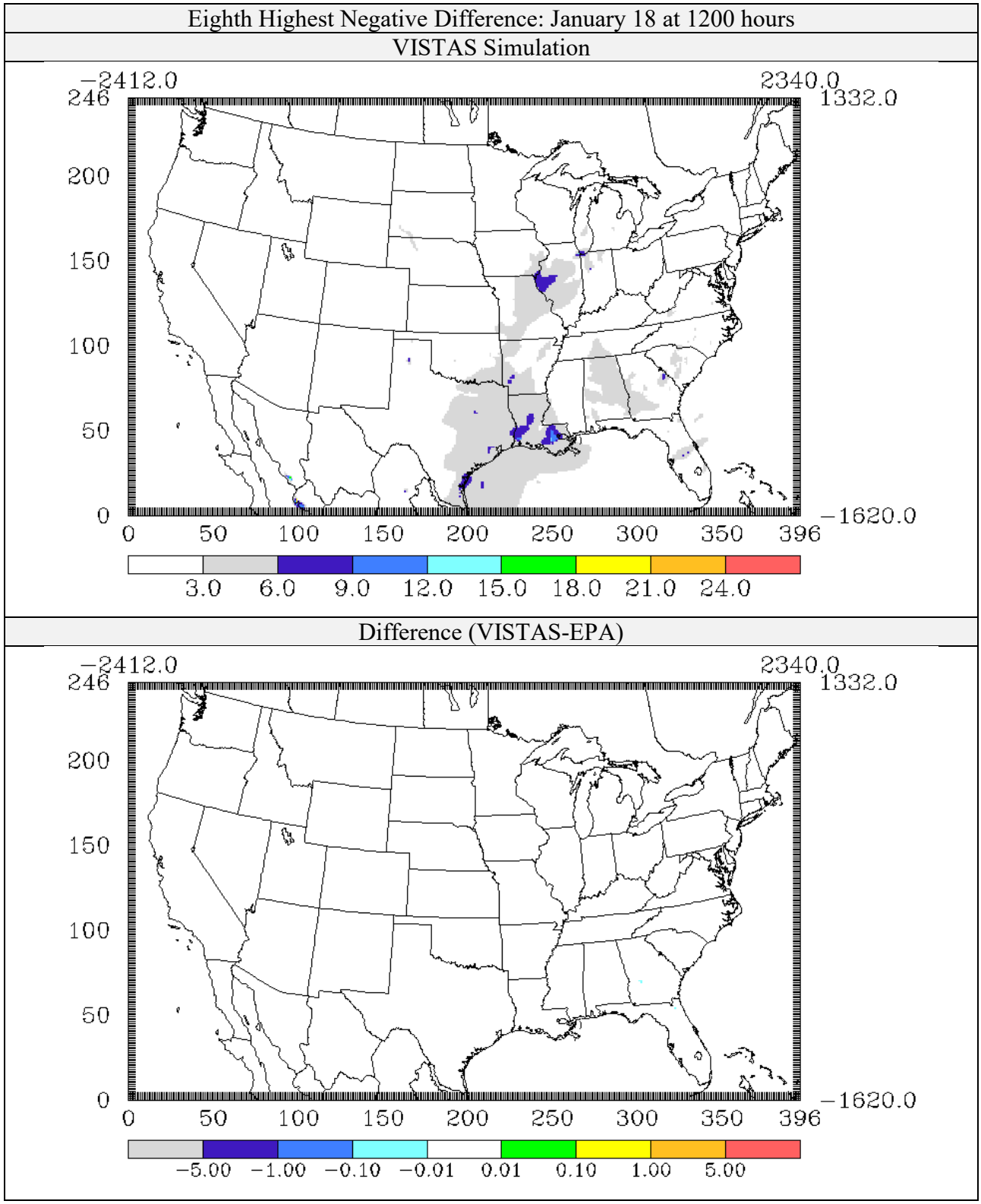


Figure 5-60: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference)

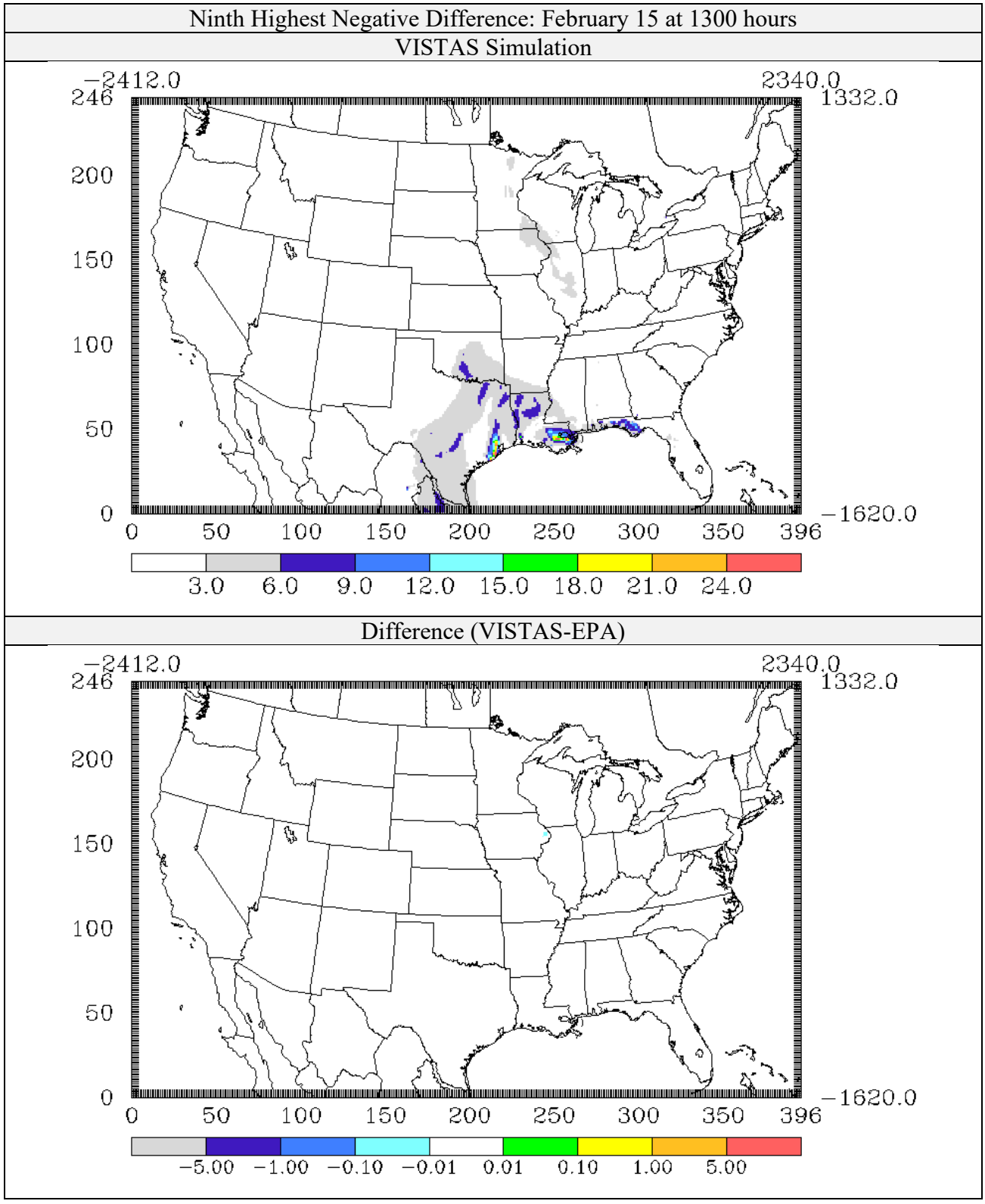


Figure 5-61: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference)

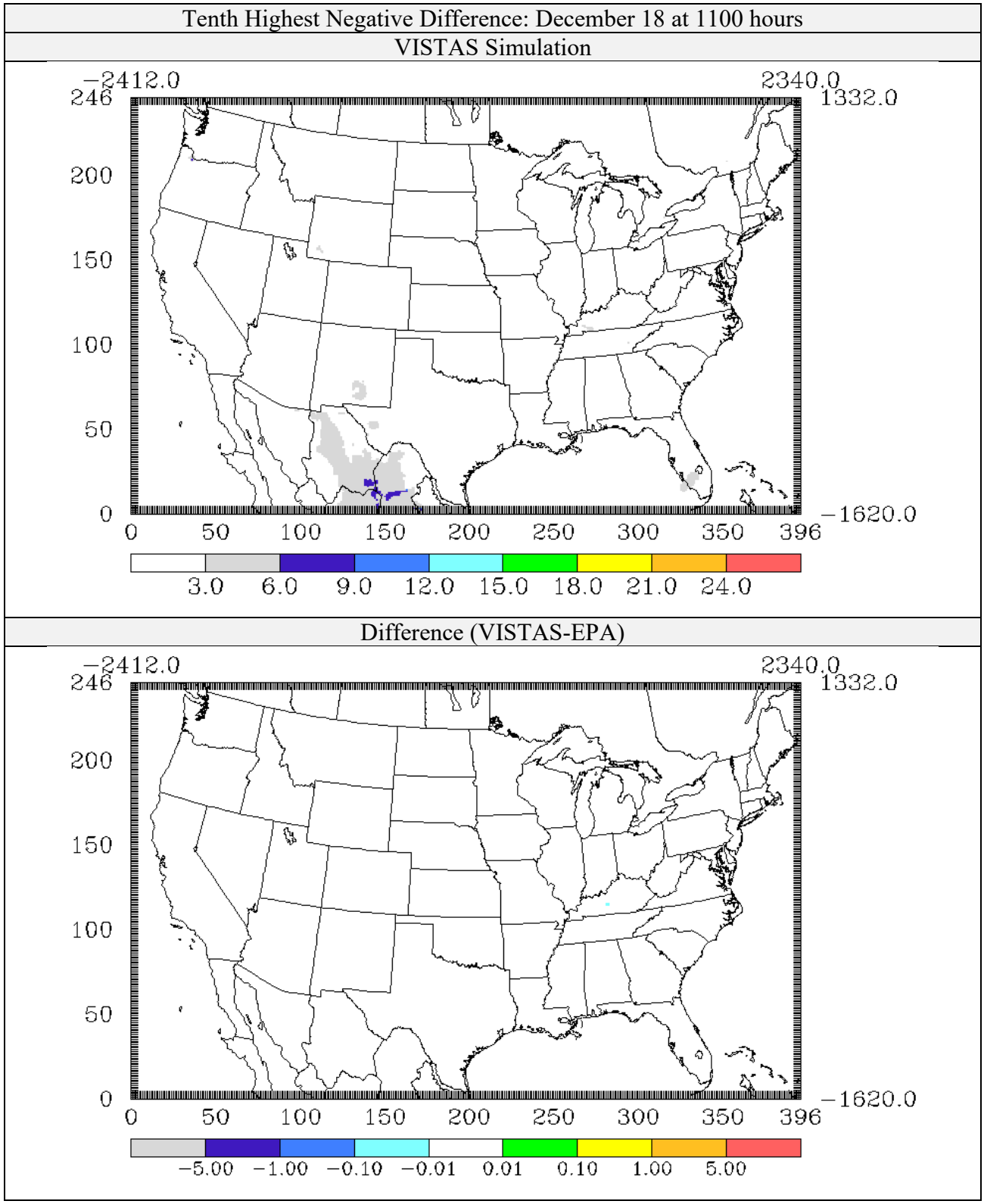


Figure 5-62: Comparison of Sulfate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference)

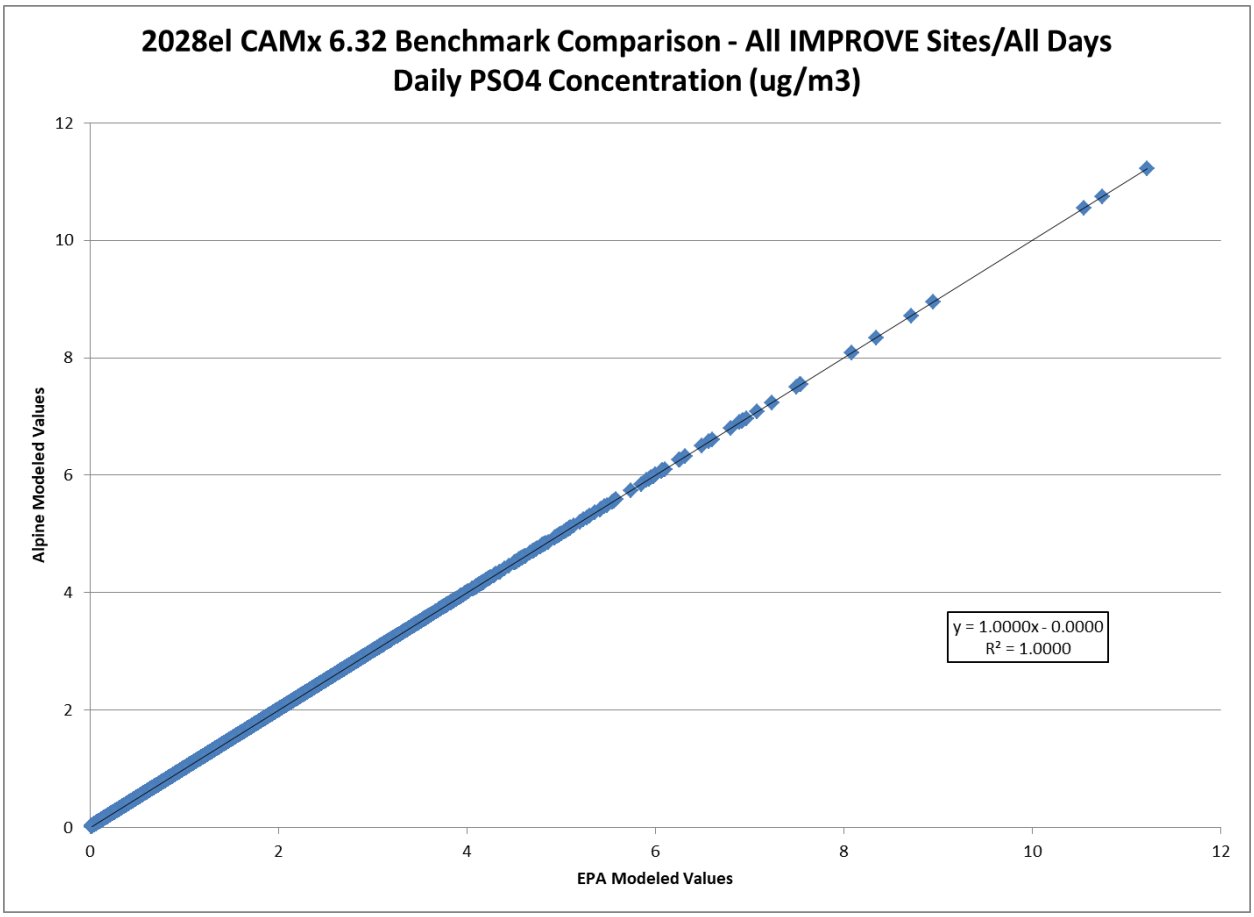


Figure 5-63: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine).

5.4 Nitrate

Nitrate results for the top 10 positive and negative hours are presented in tabular format in Table 5-4. The maximum positive difference is 4.13µg/m^3 falling to 2.23 µg/m^3 for the 10th high. The maximum negative difference is -4.28 µg/m^3 falling to -1.92 µg/m^3 for the 10th high. The maximum positive percent difference from these days is 116% and negative percent difference of -52%, both on low Nitrate concentration days.

The top 10 positive impact hours are presented in Figures 5-64 through 5-73 and the top 10 negative impact hours are presented in Figures 5-74 through 5-83. As was discussed in Section 5.2 for the $PM_{2.5}$ concentrations, the differences are tending to occur in January along the northern border in Canada.

Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 5-84. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

Examination of the animations shows that the majority of the differences are occurring in Canada and the Northern U.S. with the differences occurring in the areas of relatively high $PM_{2.5}$. We speculate that the differences are primarily from the difference in the Particulate Nitrate and most likely from different pathways being taken in the ISOROPIA algorithm.

Table 5-4. Comparison of 2028el CAMx 6.32 Simulation Nitrate Concentrations (µg/m^3) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	1	27	7	7.66	3.54	4.13	116.71%	346	245
2011	1	3	4	25.36	21.37	3.99	18.69%	155	237
2011	1	27	9	8.03	4.38	3.65	83.38%	347	245
2011	1	3	12	26.92	23.41	3.51	14.98%	159	237
2011	1	27	12	6.62	3.55	3.08	86.81%	343	245
2011	1	27	11	6.85	4.05	2.80	69.19%	342	245
2011	1	14	6	14.01	11.55	2.46	21.30%	148	237
2011	1	14	4	24.18	21.80	2.37	10.89%	123	244
2011	1	14	9	15.75	13.39	2.36	17.64%	144	240
2011	1	14	2	23.79	21.56	2.23	10.35%	132	243
Maximum Negative									
2011	1	27	8	4.01	8.29	-4.28	-51.60%	348	245
2011	1	27	5	3.91	7.68	-3.77	-49.11%	345	245
2011	1	3	7	23.34	26.41	-3.07	-11.61%	155	235
2011	1	27	9	3.72	6.65	-2.92	-44.00%	348	244
2011	1	27	12	3.03	5.93	-2.89	-48.81%	342	244
2011	1	27	11	2.44	5.14	-2.70	-52.58%	343	244
2011	1	27	10	2.53	5.16	-2.63	-50.89%	343	245
2011	1	27	3	5.12	7.48	-2.35	-31.48%	343	245
2011	1	3	21	10.25	12.20	-1.95	-15.98%	164	231
2011	1	14	3	17.01	18.94	-1.92	-10.15%	137	242

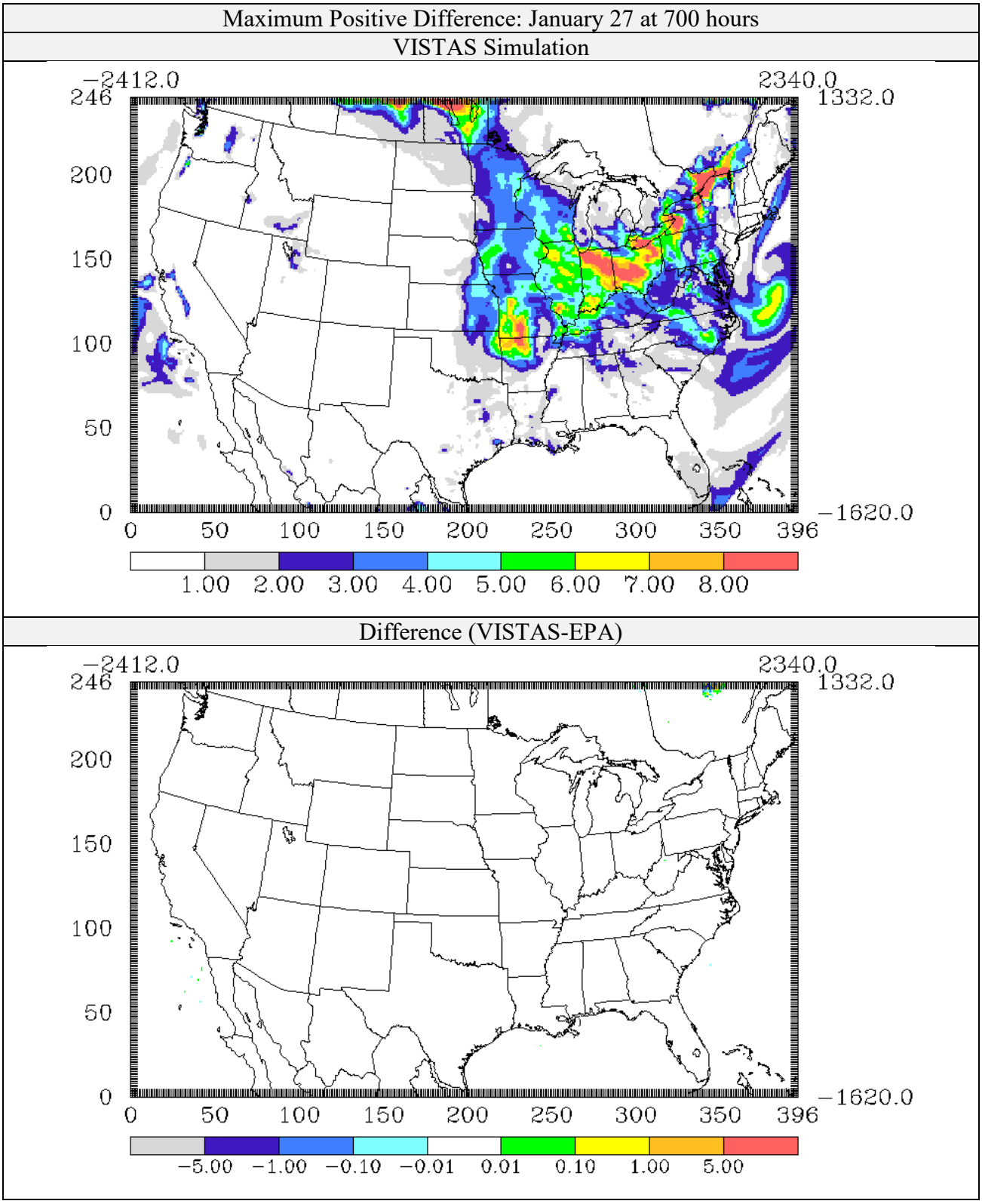


Figure 5-64: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference)

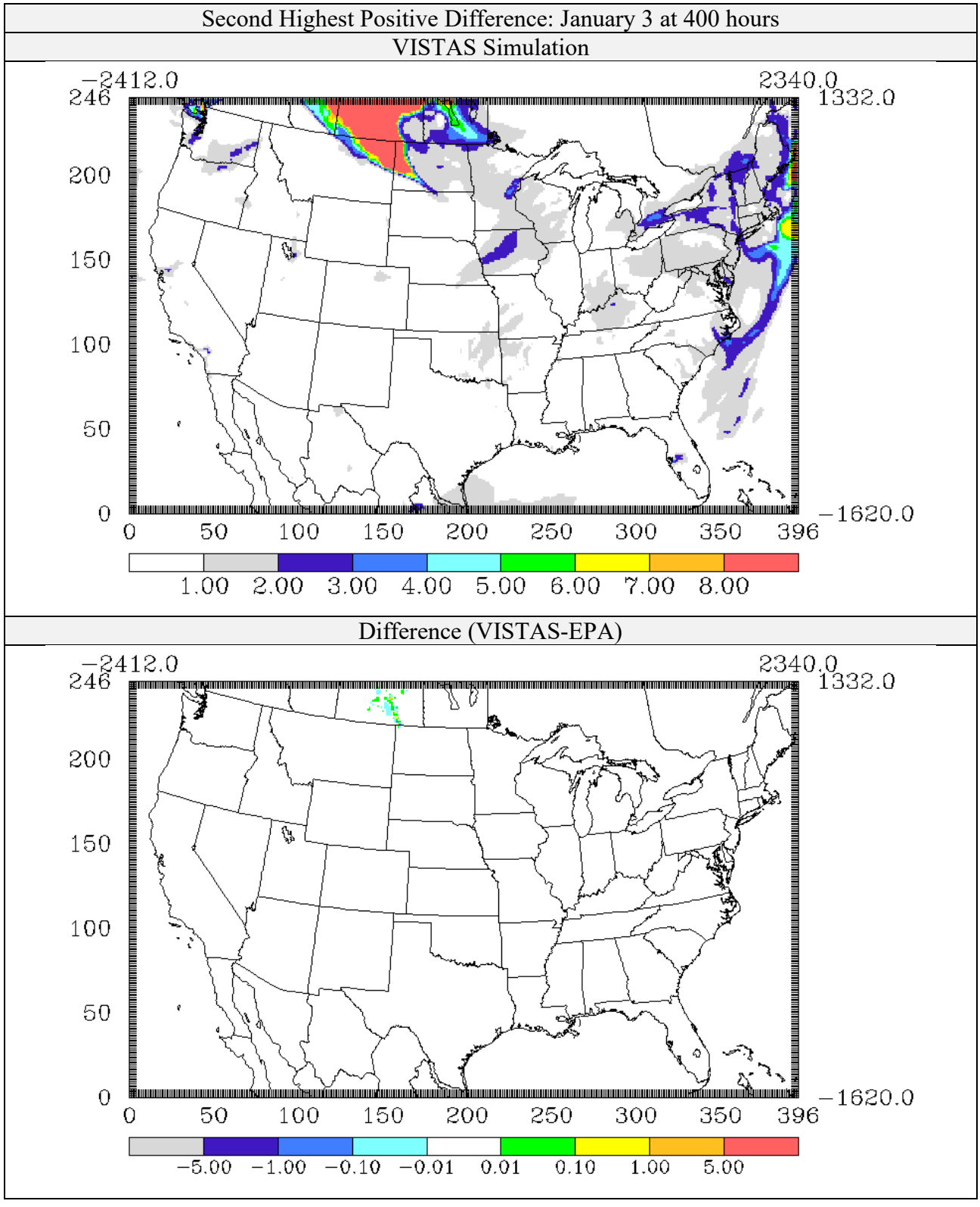


Figure 5-65: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference)

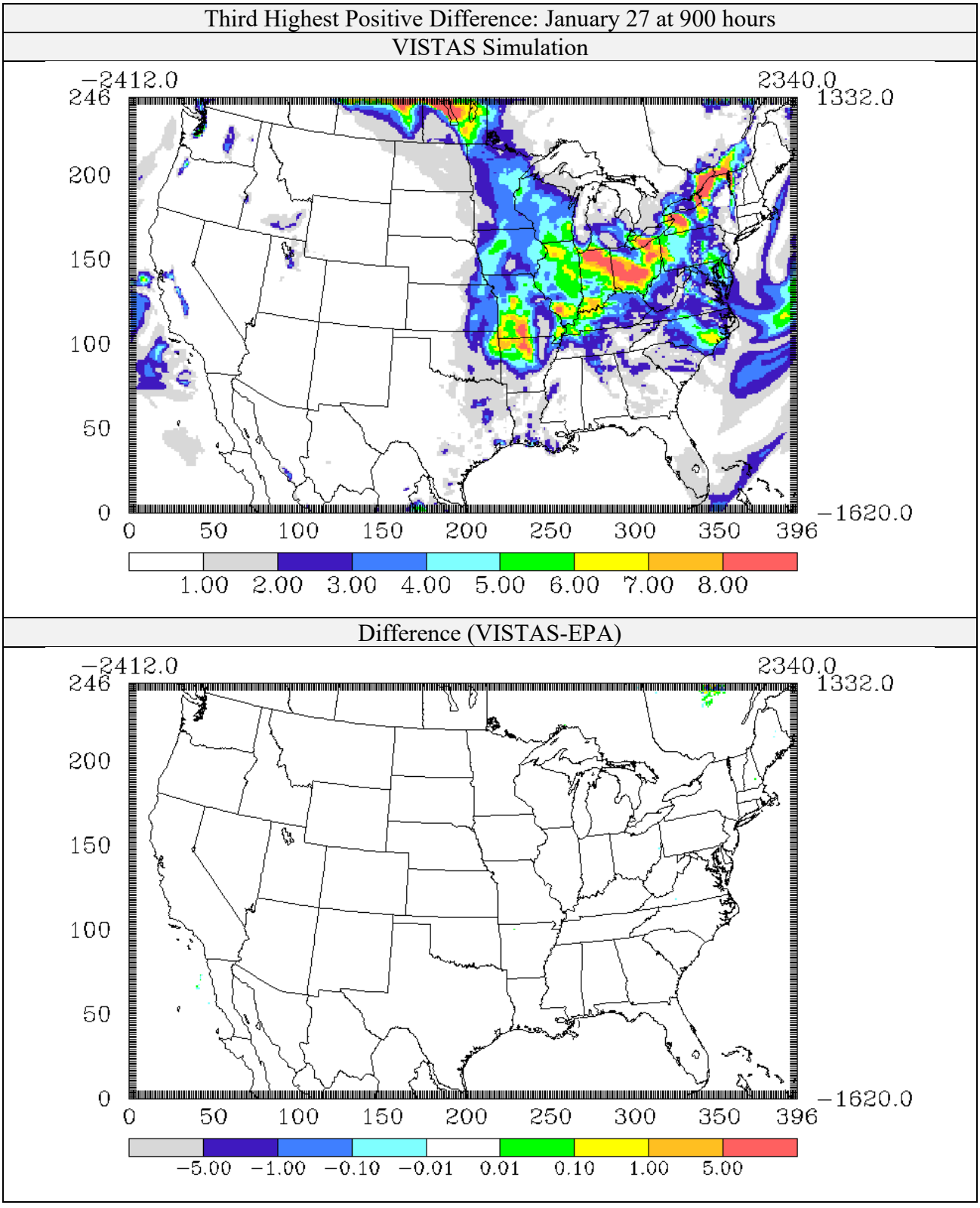


Figure 5-66: Comparison of Nitrate Concentrations (µg/m³) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference)

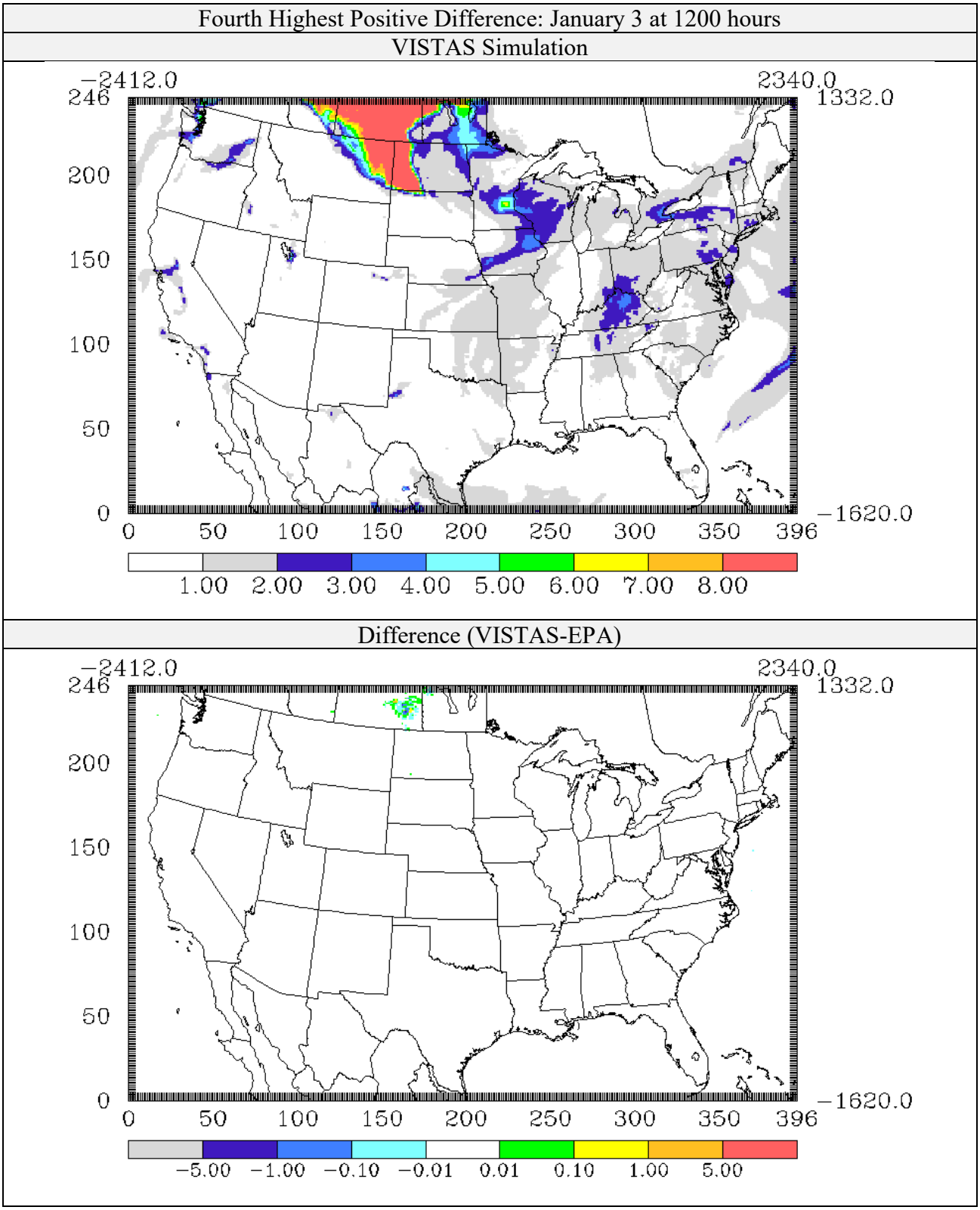


Figure 5-67: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference)

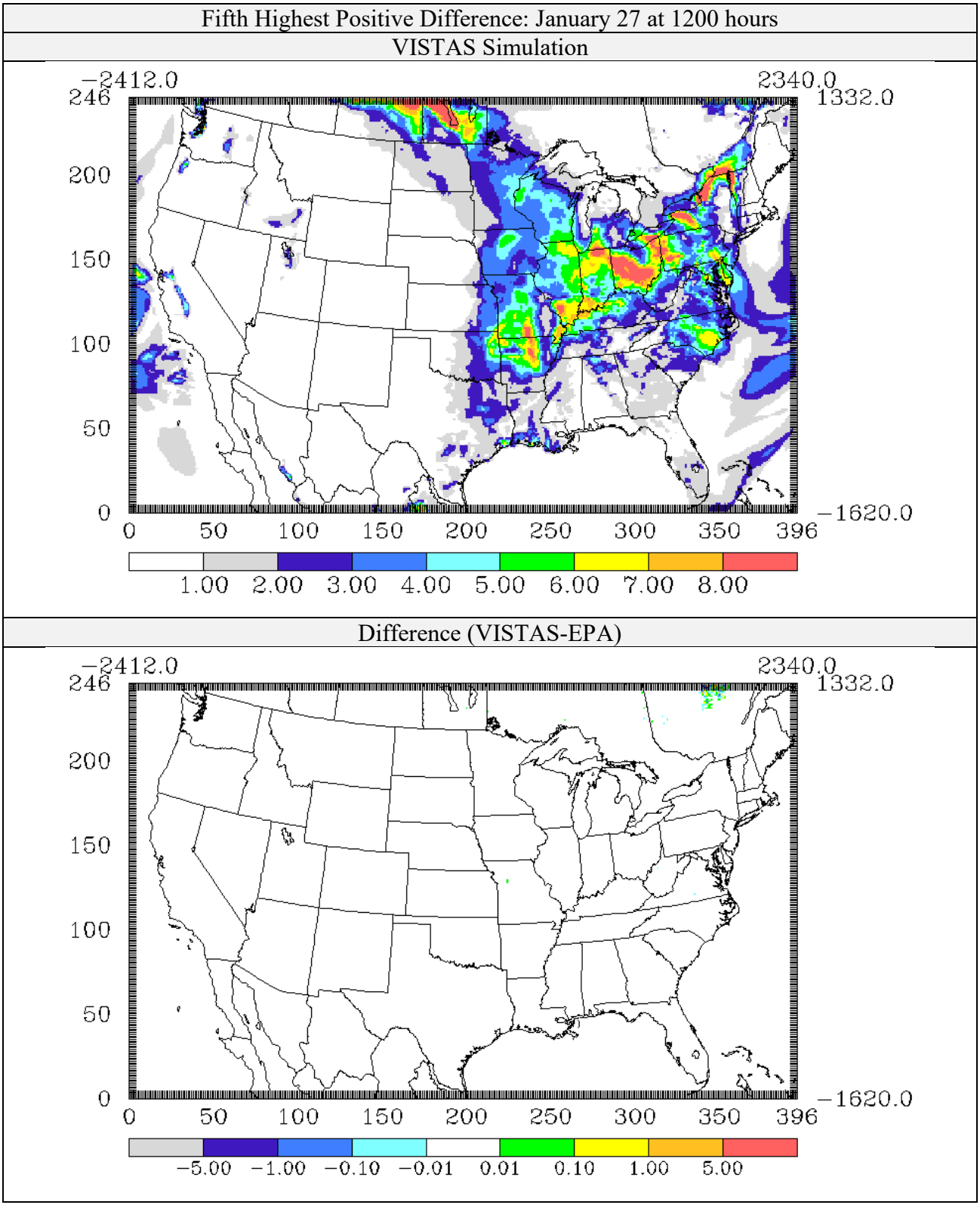


Figure 5-68: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Positive Difference)

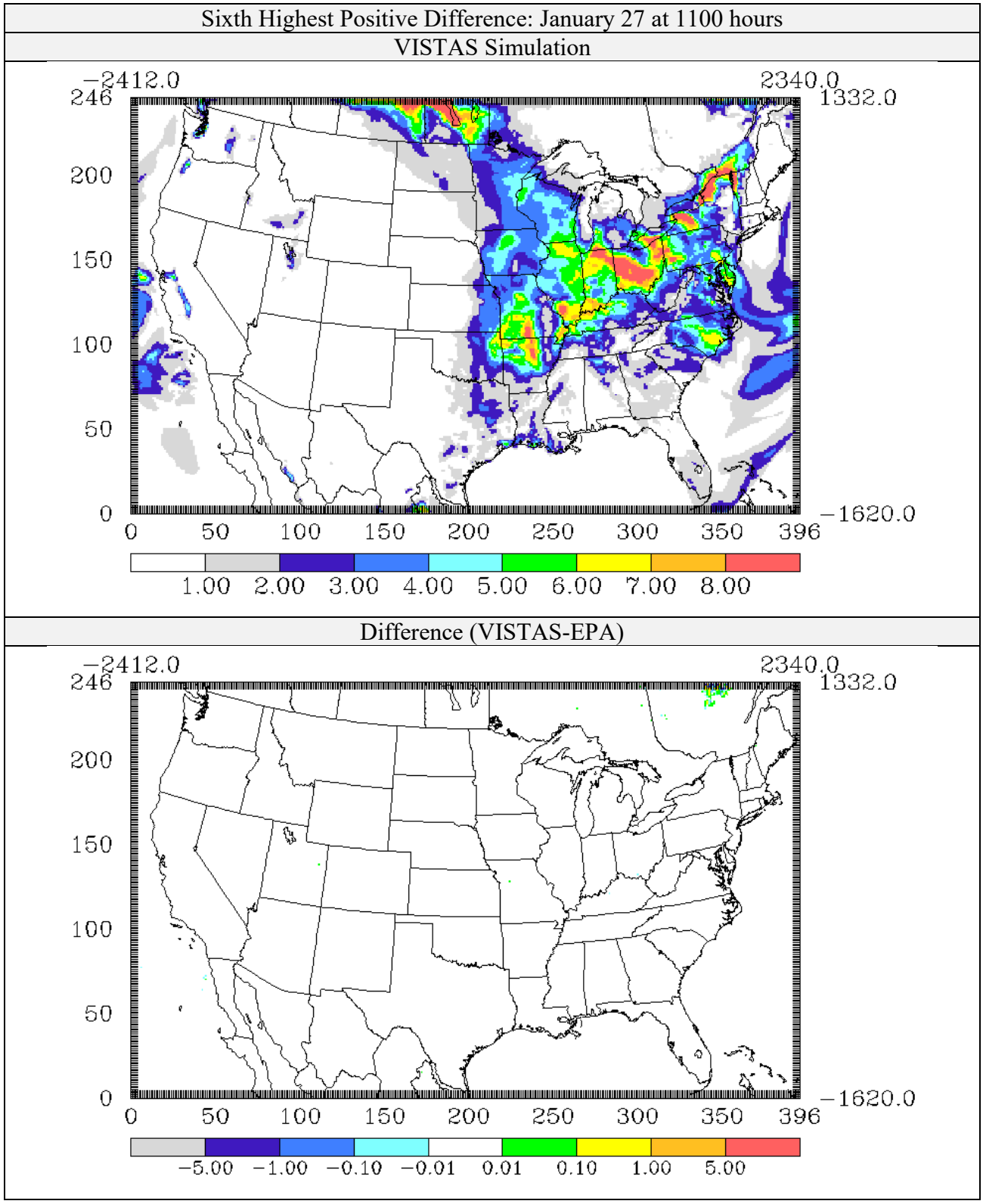


Figure 5-69: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference)

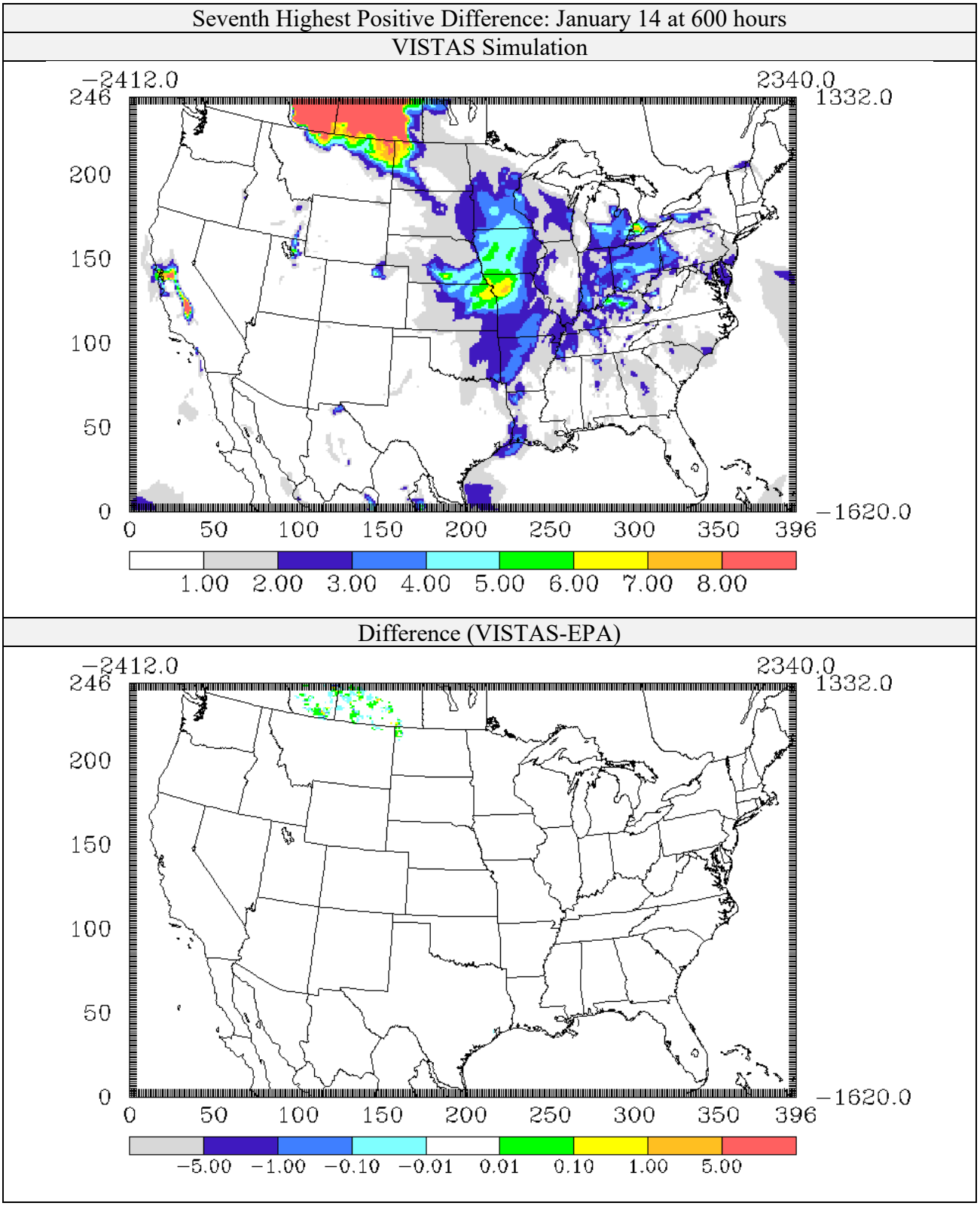


Figure 5-70: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference)

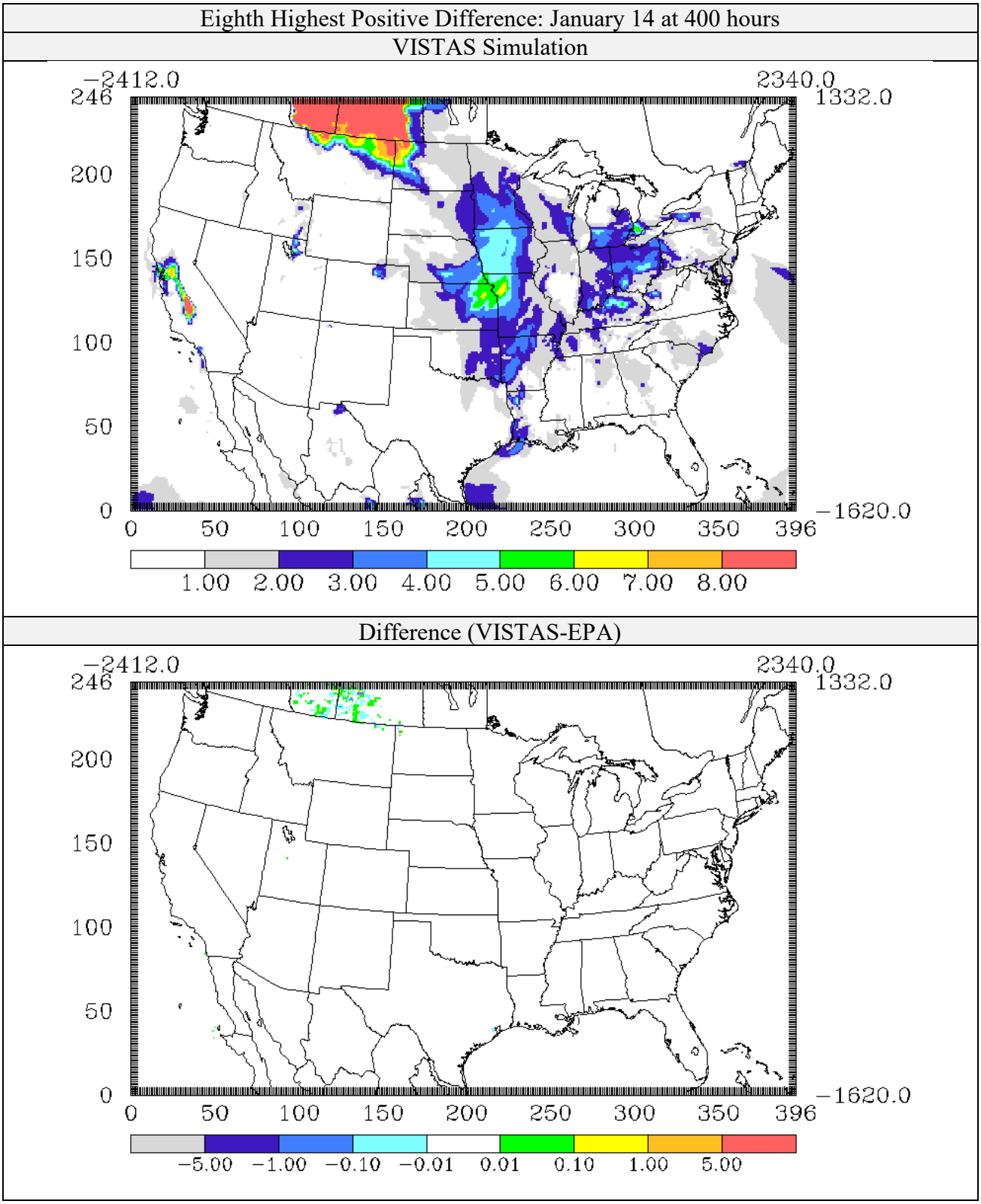


Figure 5-71: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference)

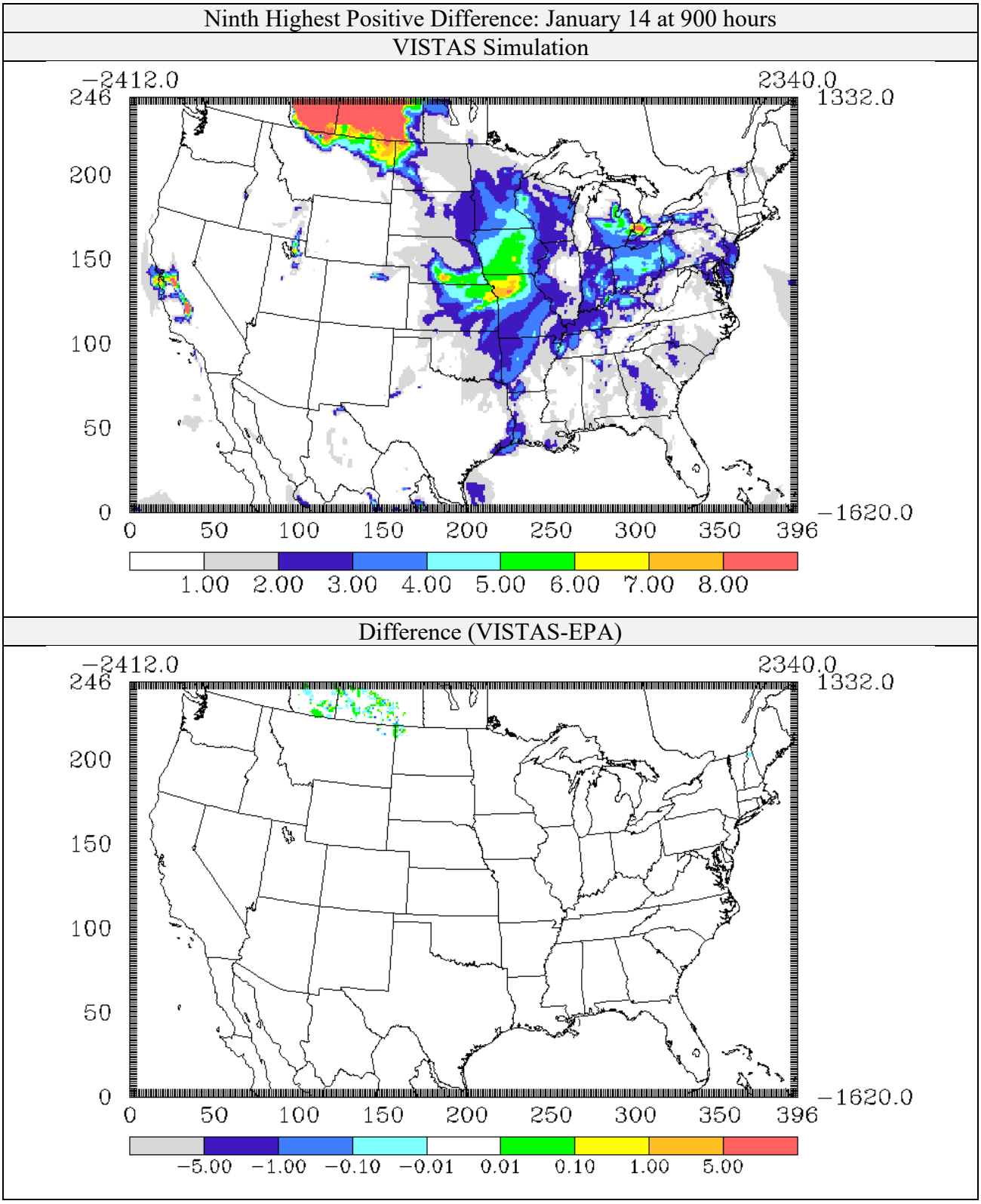


Figure 5-72: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference)

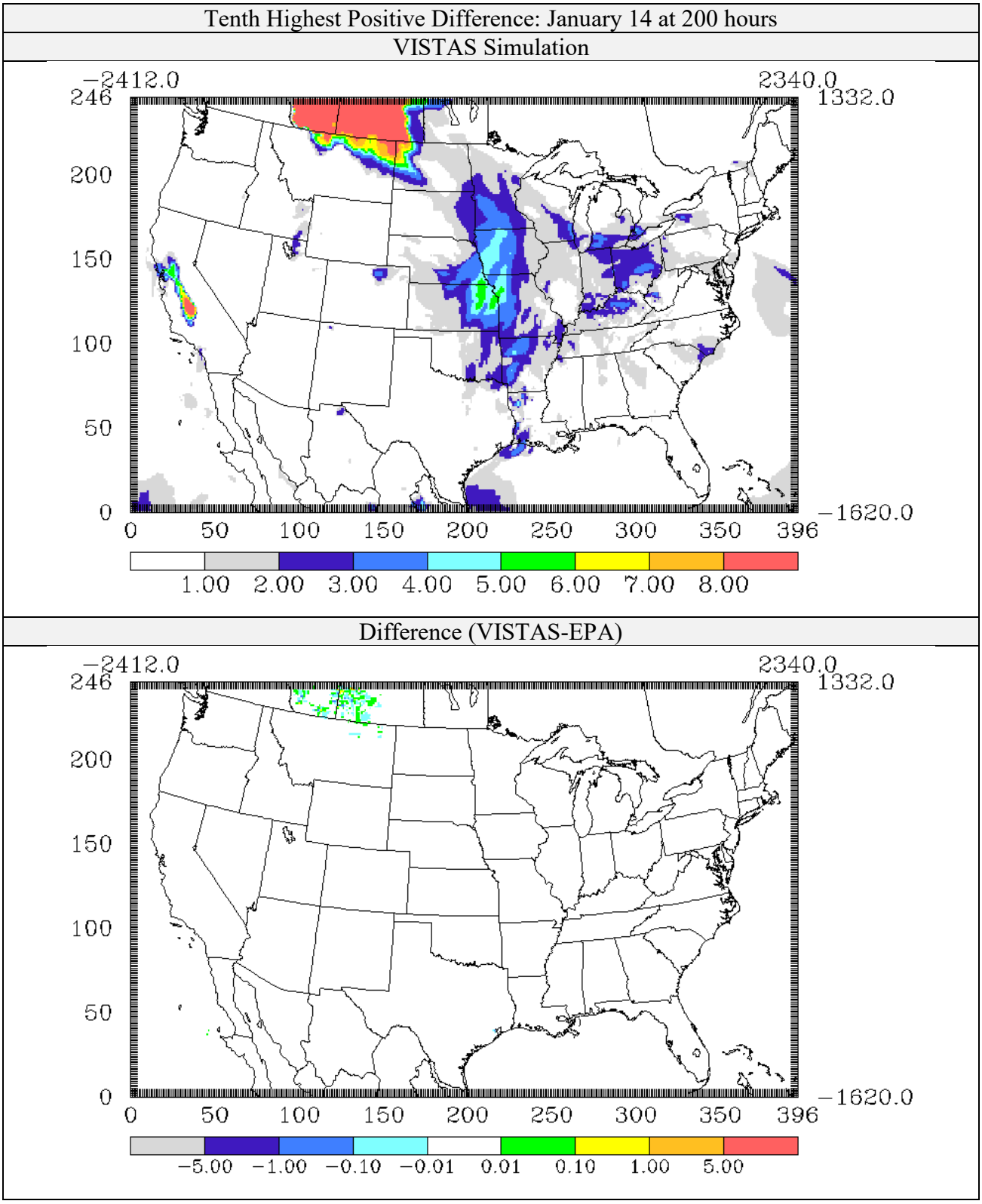


Figure 5-73: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference)

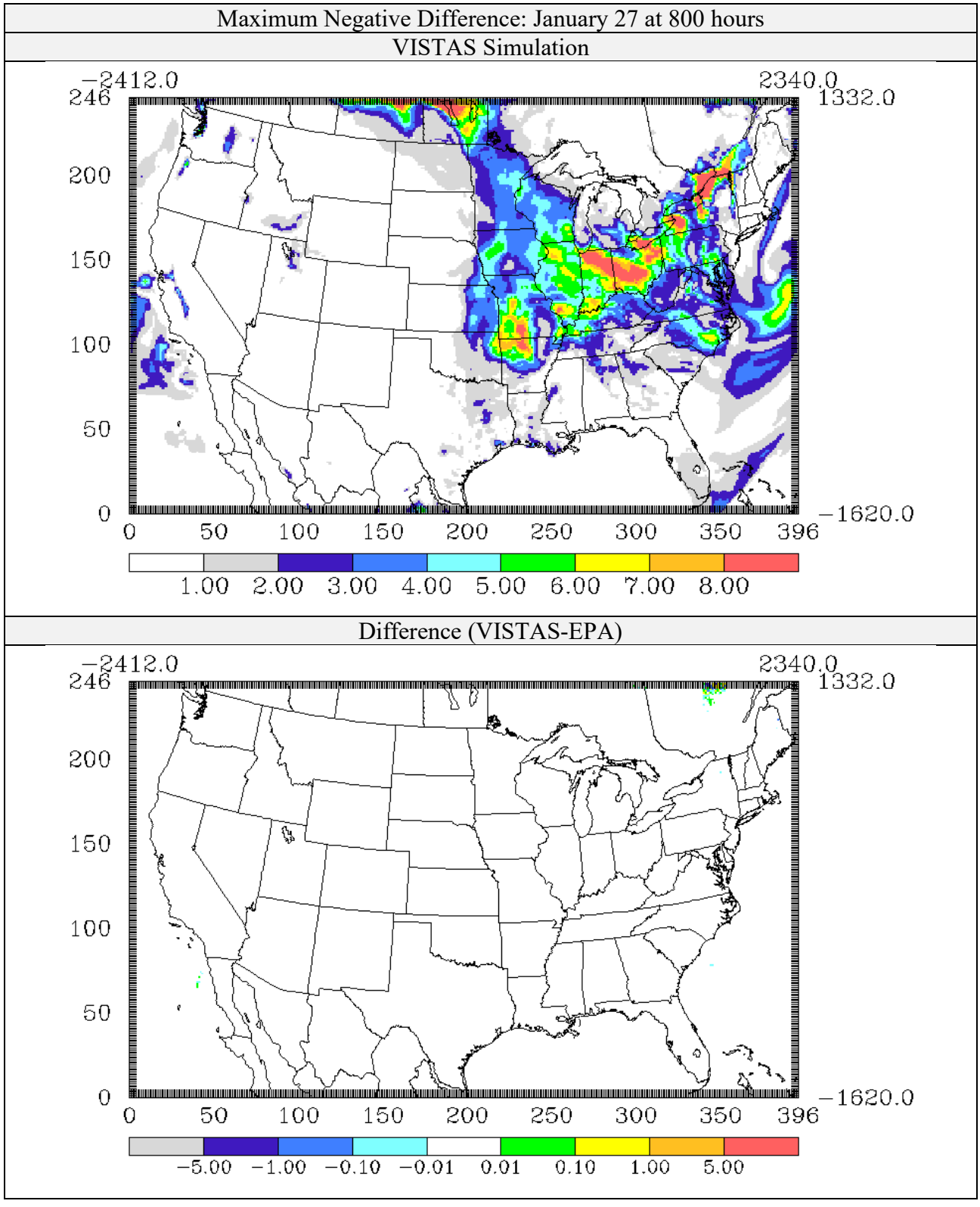


Figure 5-74: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference)

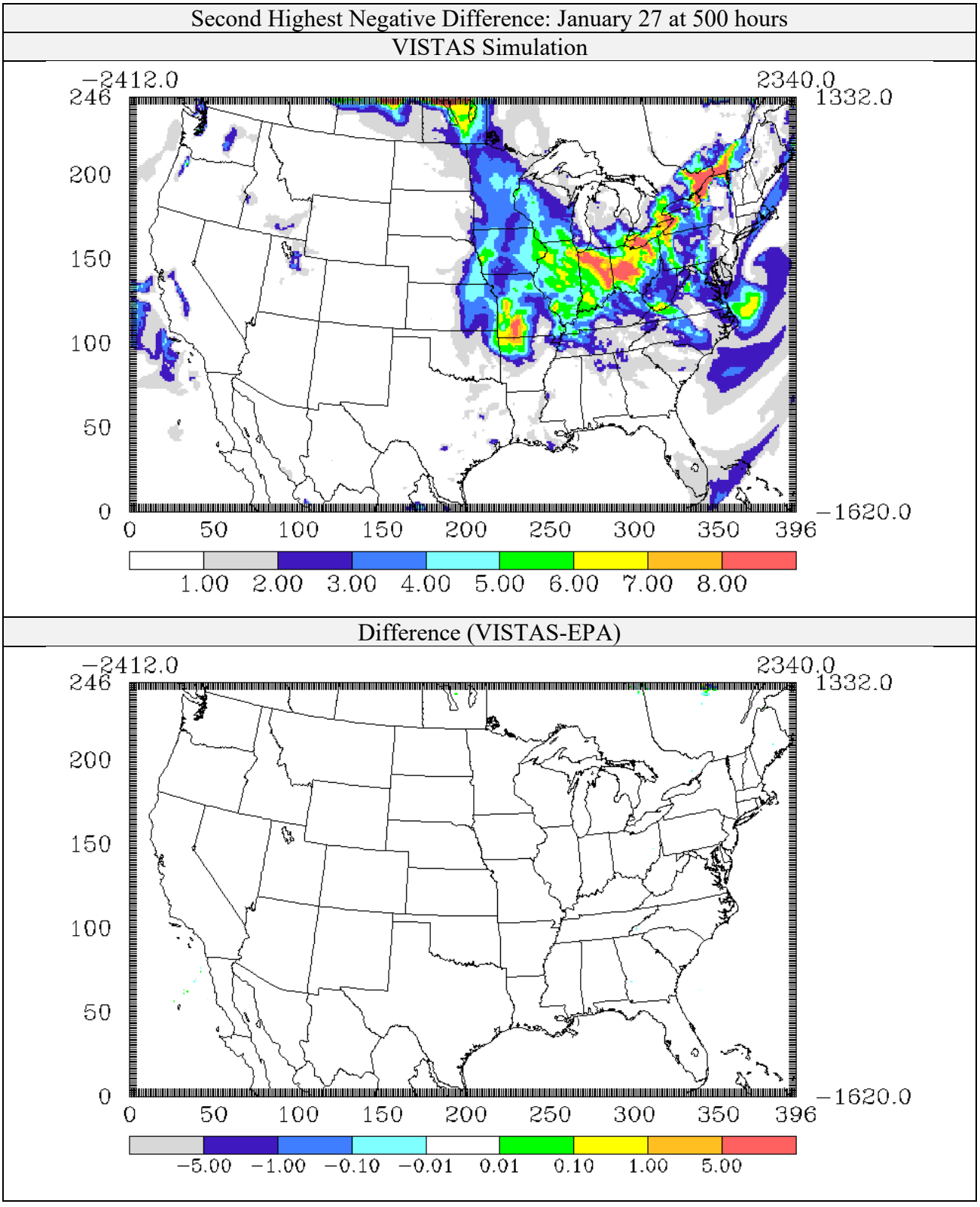


Figure 5-75: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference)

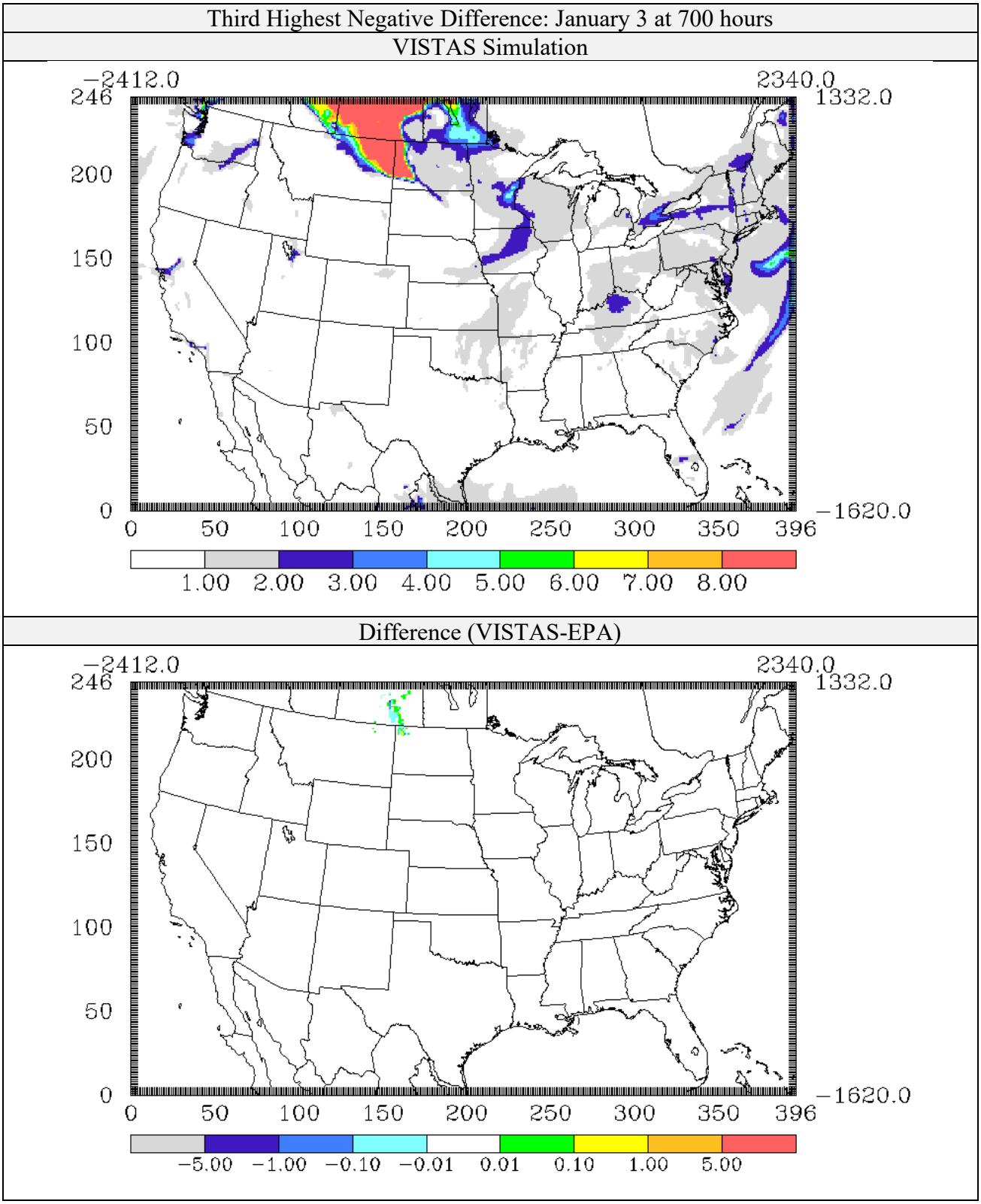


Figure 5-76: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference)

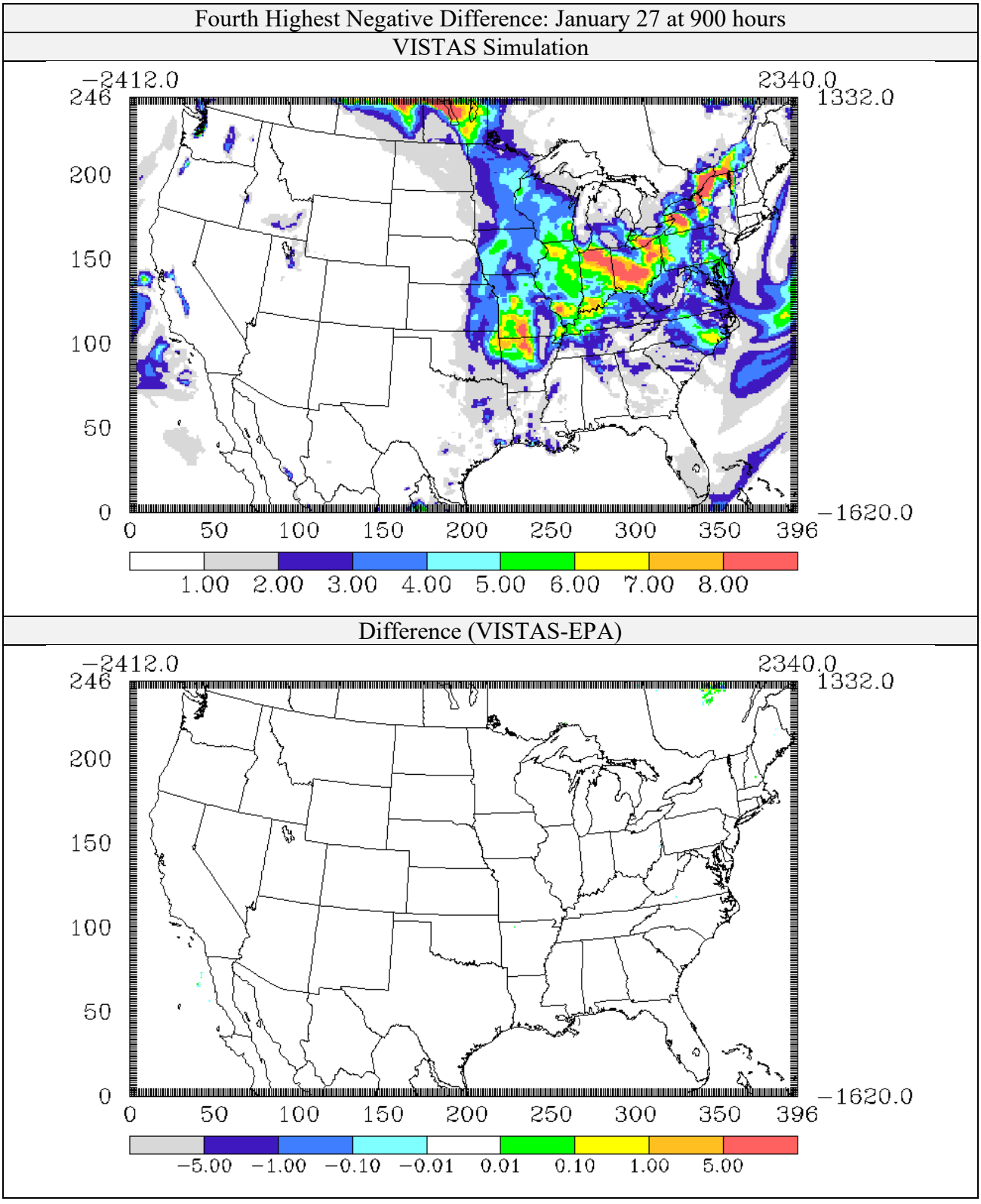


Figure 5-77: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference)

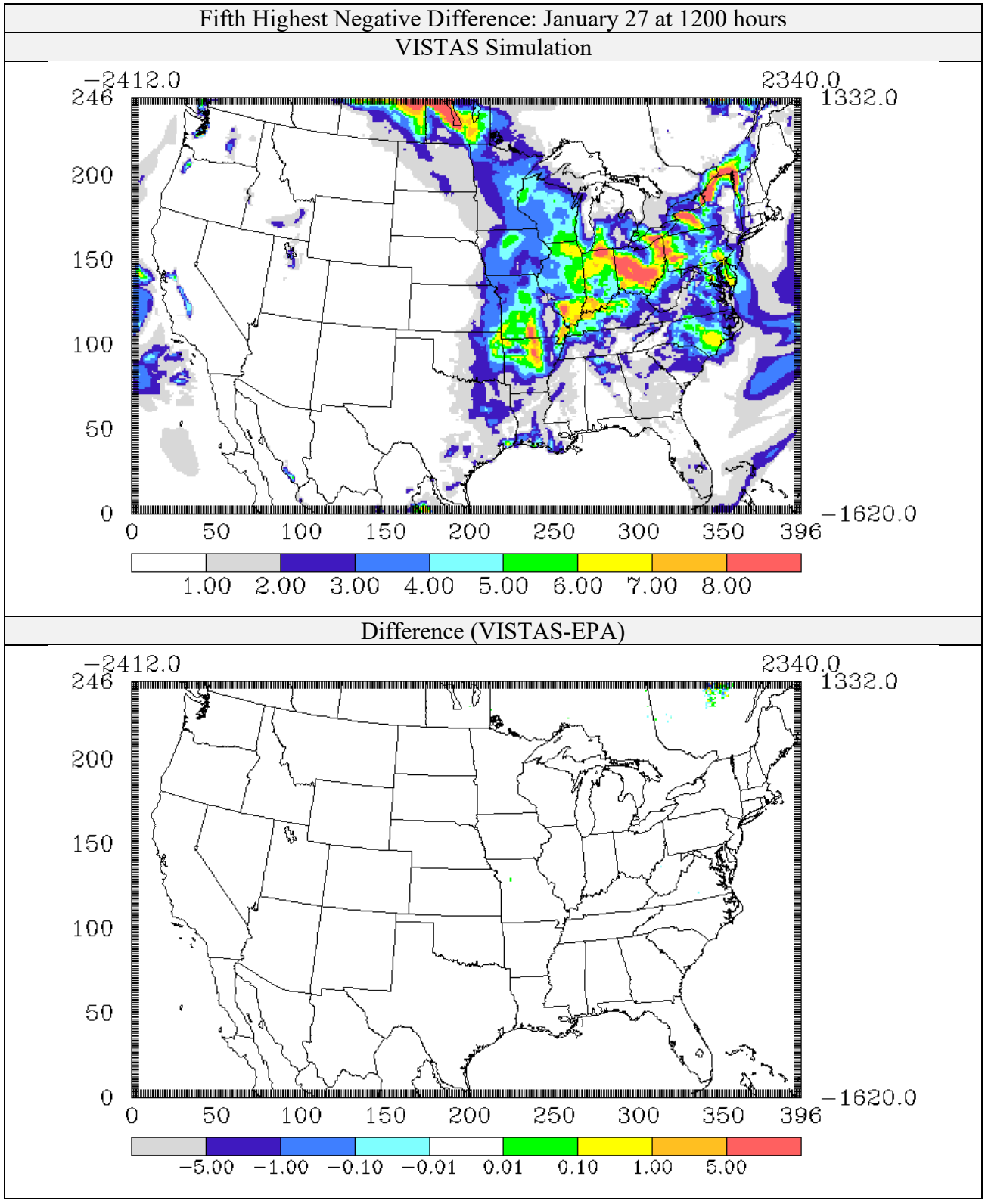


Figure 5-78: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference)

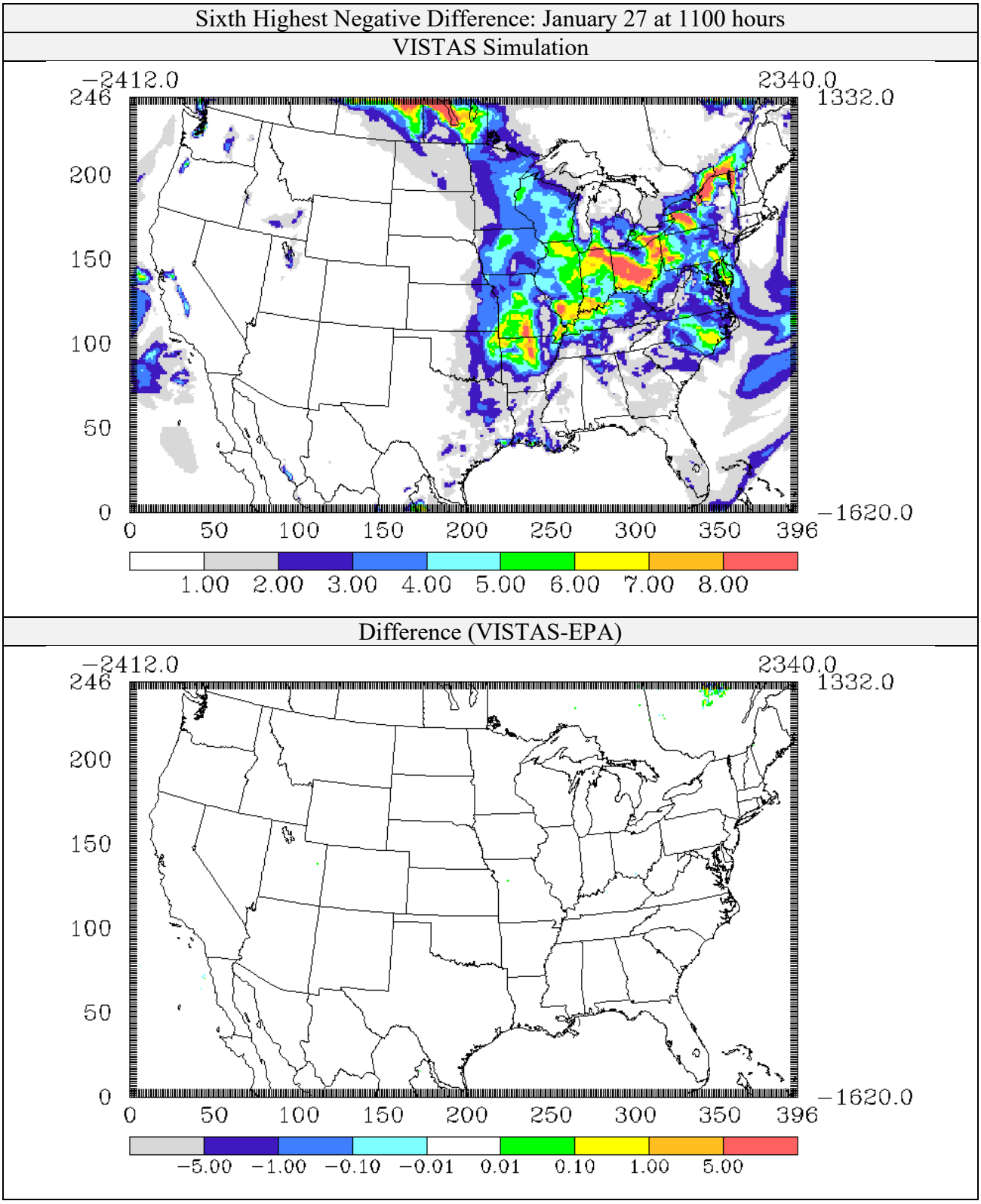


Figure 5-79: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference)

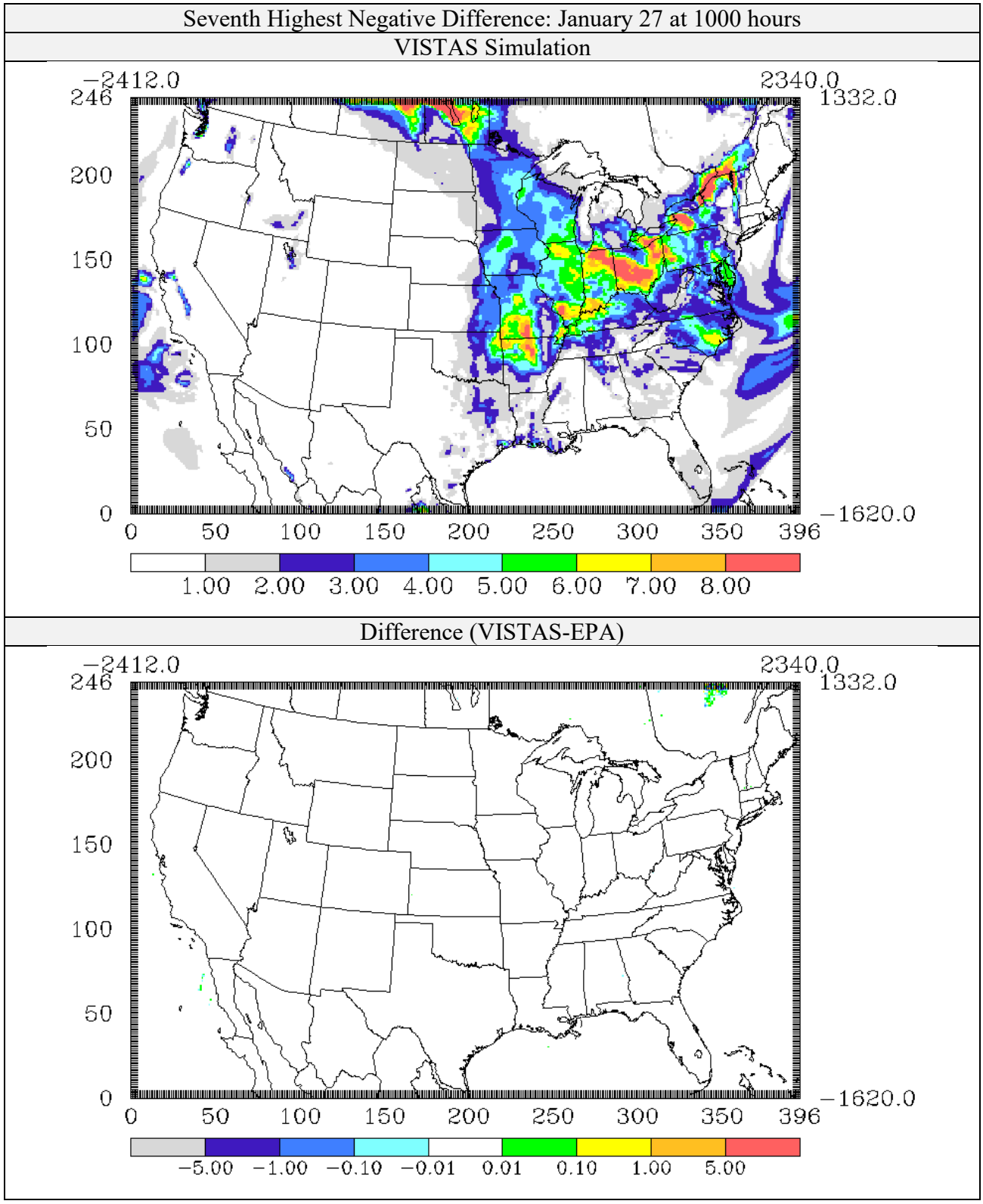


Figure 5-80: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference)

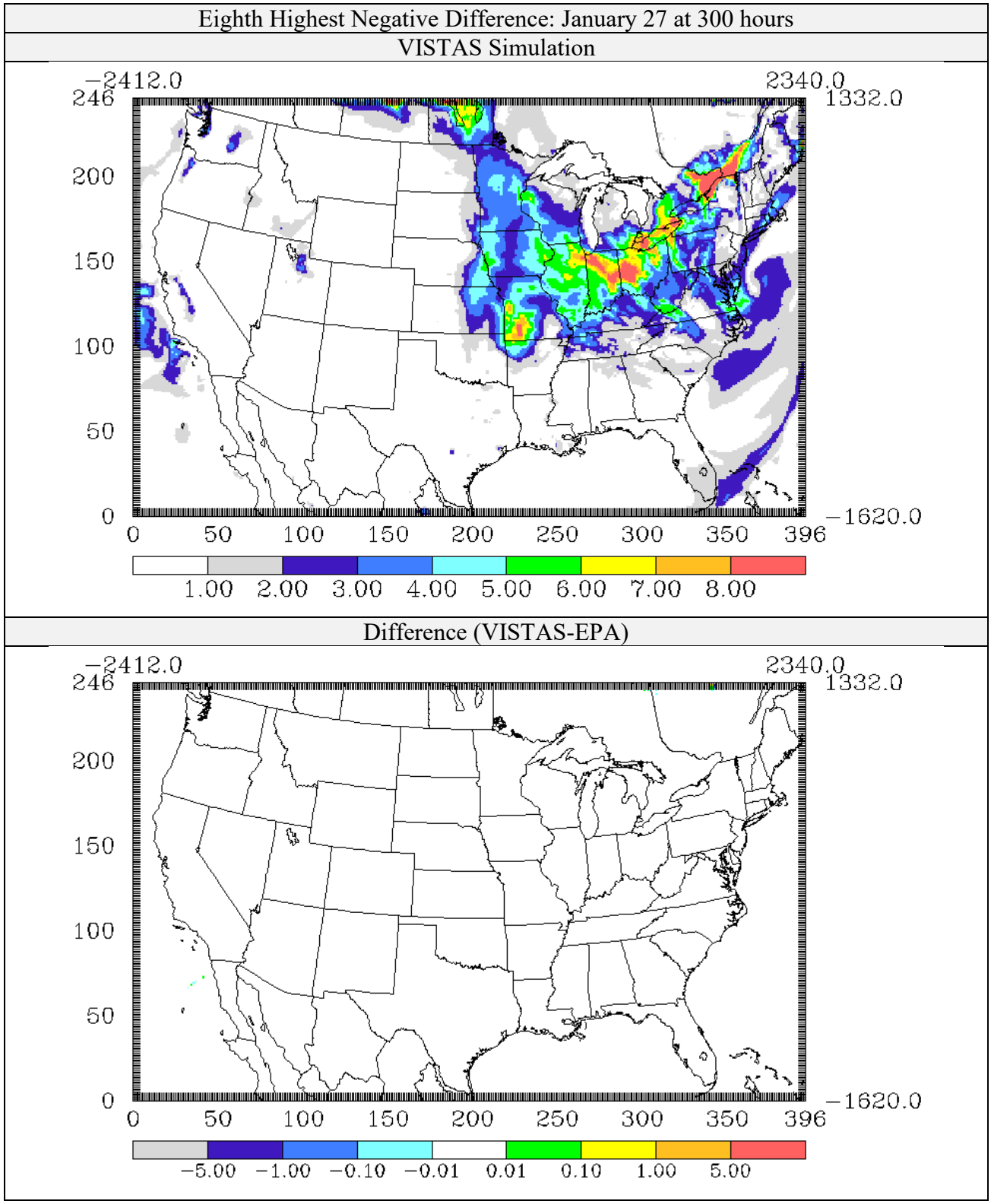


Figure 5-81: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference)

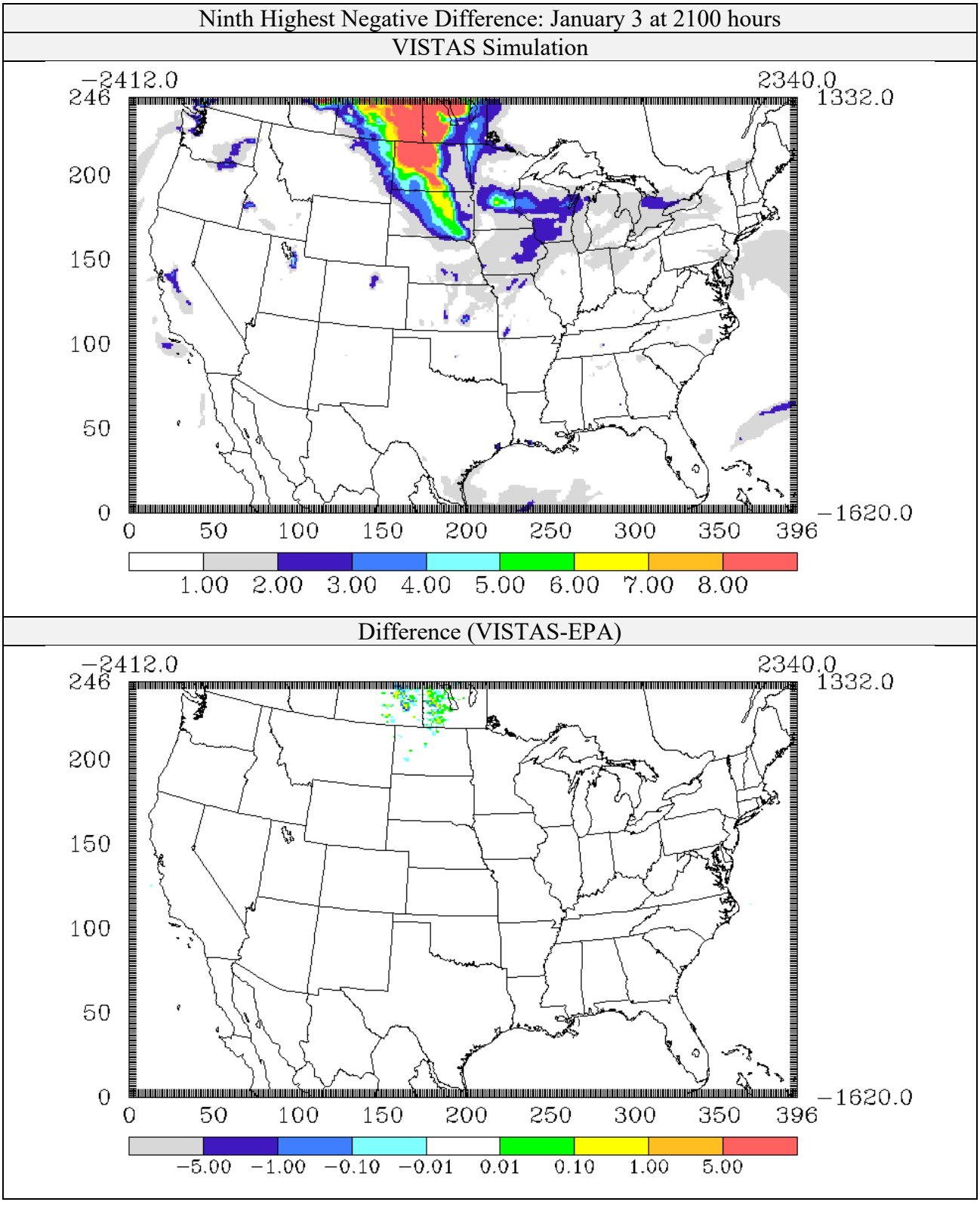


Figure 5-82: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference)

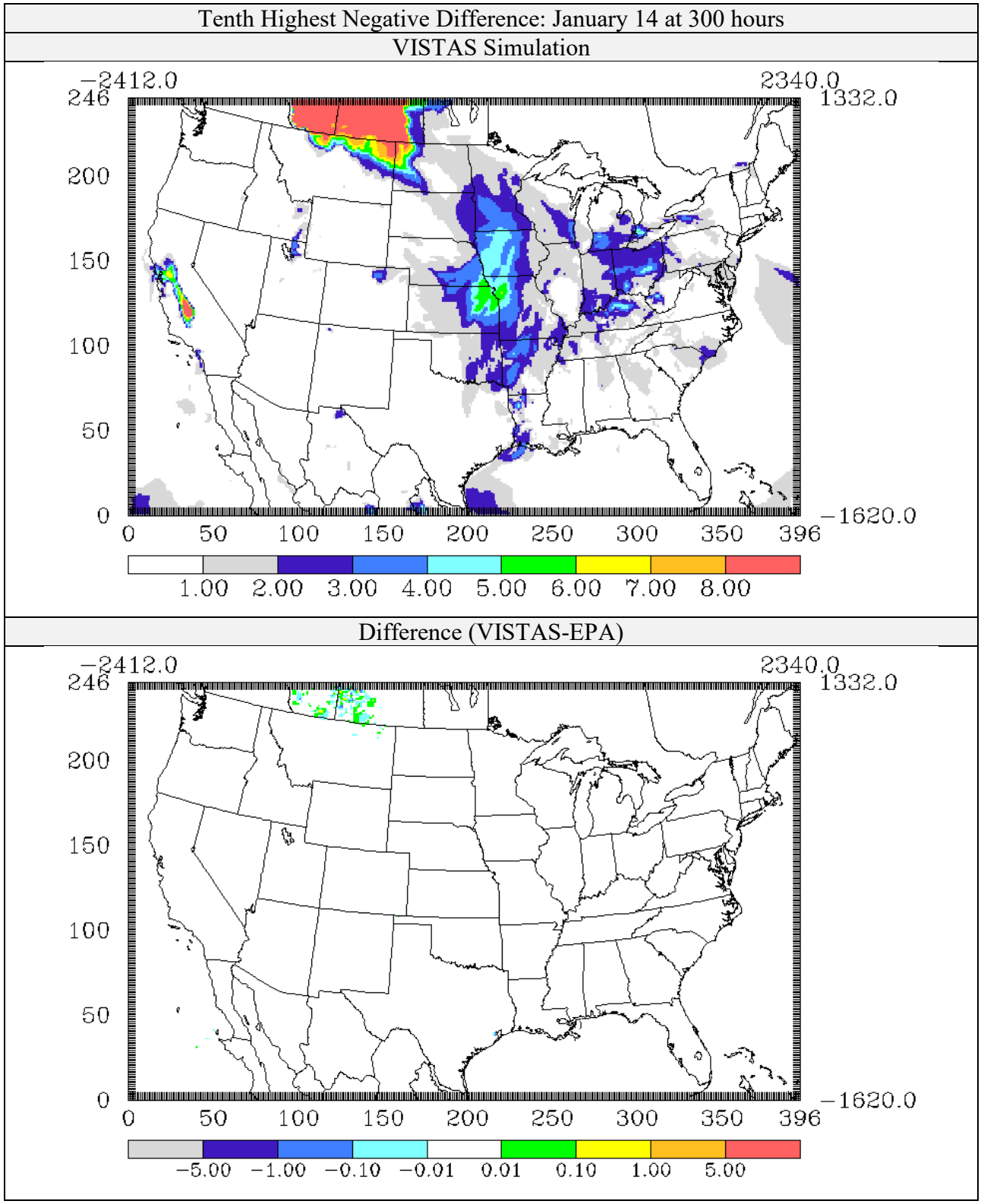


Figure 5-83: Comparison of Nitrate Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference)

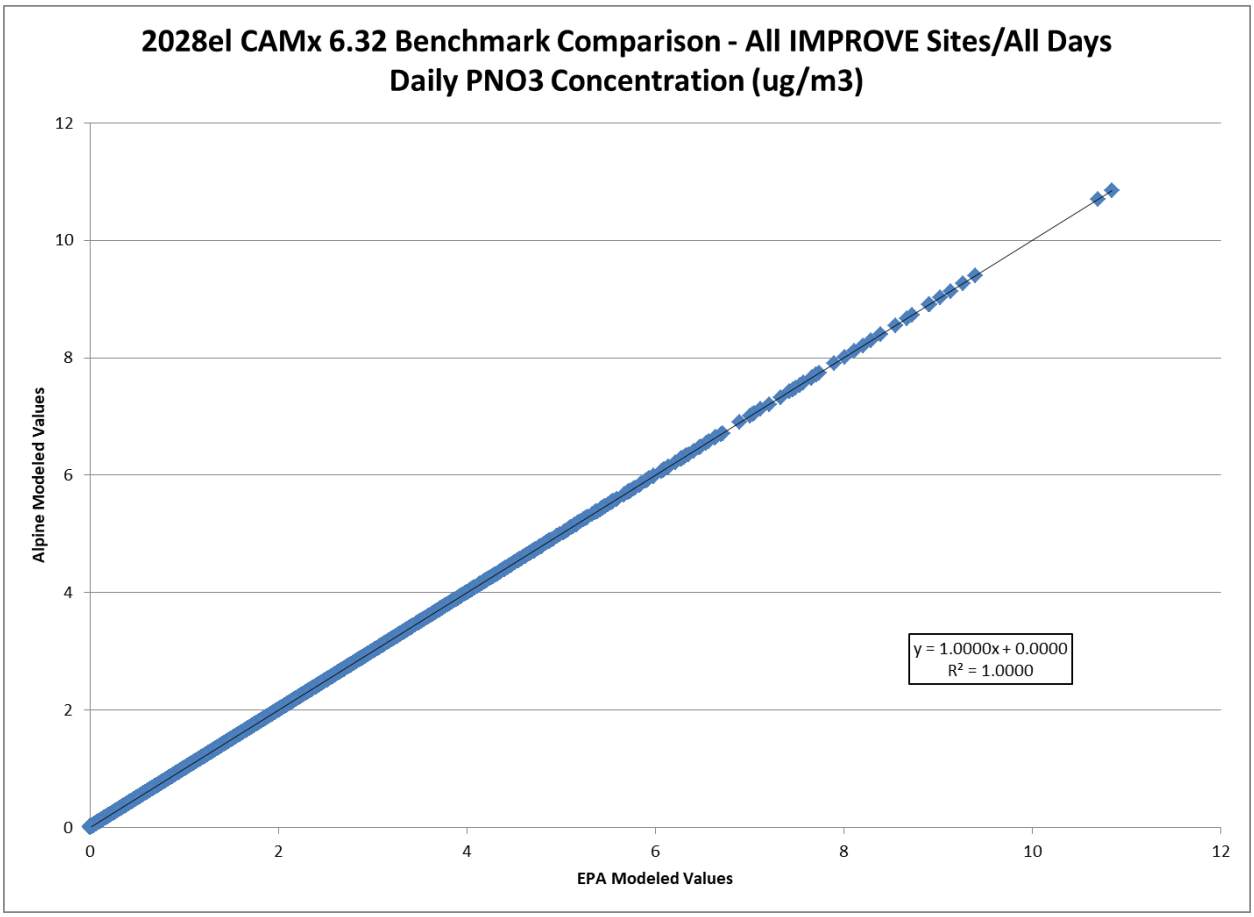


Figure 5-84: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine).

5.5 Organic Carbon (OC)

Organic Carbon (OC) results for the top 10 positive and negative hours are presented in tabular format in Table 5-5. The maximum positive difference is 0.17 µg/m^3 falling to 0.09 µg/m^3 for the 10th high. The maximum negative difference is -0.30 µg/m^3 falling to -0.08 µg/m^3 for the 10th high. The maximum positive percent difference from these days is 2.11% and negative percent difference of -2.86%.

The top 10 positive impact hours are presented in Figures 5-85 through 5-94 and the top 10 negative impact hours are presented in Figures 5-95 through 5-104. The locations of the impacts are extremely localized.

Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 5-105. The EPA results are plotted on the x-axis and the VISTAS (Alpine) results are plotted on the y-axis. The data has a perfect degree of correlation with a line of best fit with a slope of 1.0000, an intercept of 0.0000 ppb and an R^2 of 1.0000.

Table 5-5. Comparison of 2028el CAMx 6.32 Simulation Organic Carbon Concentrations (μg/m^3) Run on VISTAS and EPA Computer Systems. Hours with the Top 10 Maximum Positive and Maximum Negative Differences are Shown.

Year	Month	Day	Hour	VISTAS Conc.	EPA Conc.	Difference (μg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	6	26	12	16.16	15.99	0.17	1.06%	288	74
2011	5	20	12	11.03	10.90	0.14	1.25%	286	84
2011	8	26	12	10.24	10.11	0.13	1.25%	295	57
2011	5	20	13	10.66	10.54	0.12	1.17%	286	84
2011	12	15	17	25.87	25.76	0.12	0.45%	143	115
2011	7	14	22	4.99	4.89	0.10	2.11%	292	77
2011	8	23	22	7.08	6.98	0.09	1.33%	323	47
2011	6	26	13	11.74	11.65	0.09	0.76%	288	74
2011	7	26	12	9.66	9.57	0.09	0.91%	236	95
2011	8	26	13	7.39	7.30	0.09	1.19%	295	57
Maximum Negative									
2011	12	20	9	10.16	10.46	-0.30	-2.86%	313	89
2011	12	20	8	10.43	10.69	-0.25	-2.37%	313	89
2011	5	21	0	7.46	7.56	-0.11	-1.41%	331	95
2011	12	20	10	10.41	10.51	-0.11	-1.00%	313	89
2011	2	14	22	16.01	16.11	-0.10	-0.65%	271	69
2011	2	14	23	18.33	18.43	-0.10	-0.56%	271	69
2011	8	4	14	13.16	13.26	-0.10	-0.74%	213	89
2011	7	19	12	7.01	7.10	-0.09	-1.28%	253	100
2011	7	15	13	5.01	5.09	-0.08	-1.63%	314	98
2011	10	2	15	8.09	8.17	-0.08	-1.00%	136	181

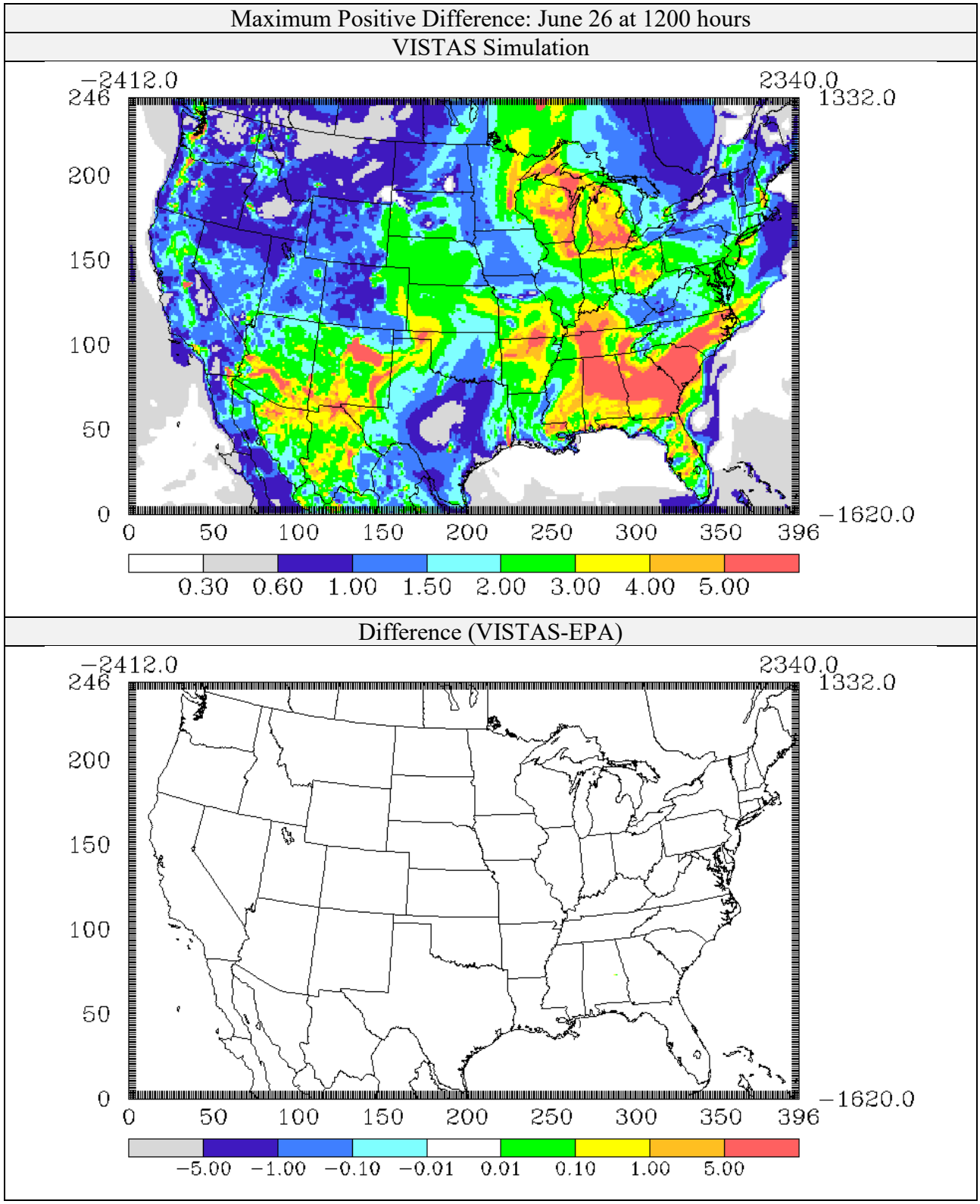


Figure 5-85: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Positive Difference)

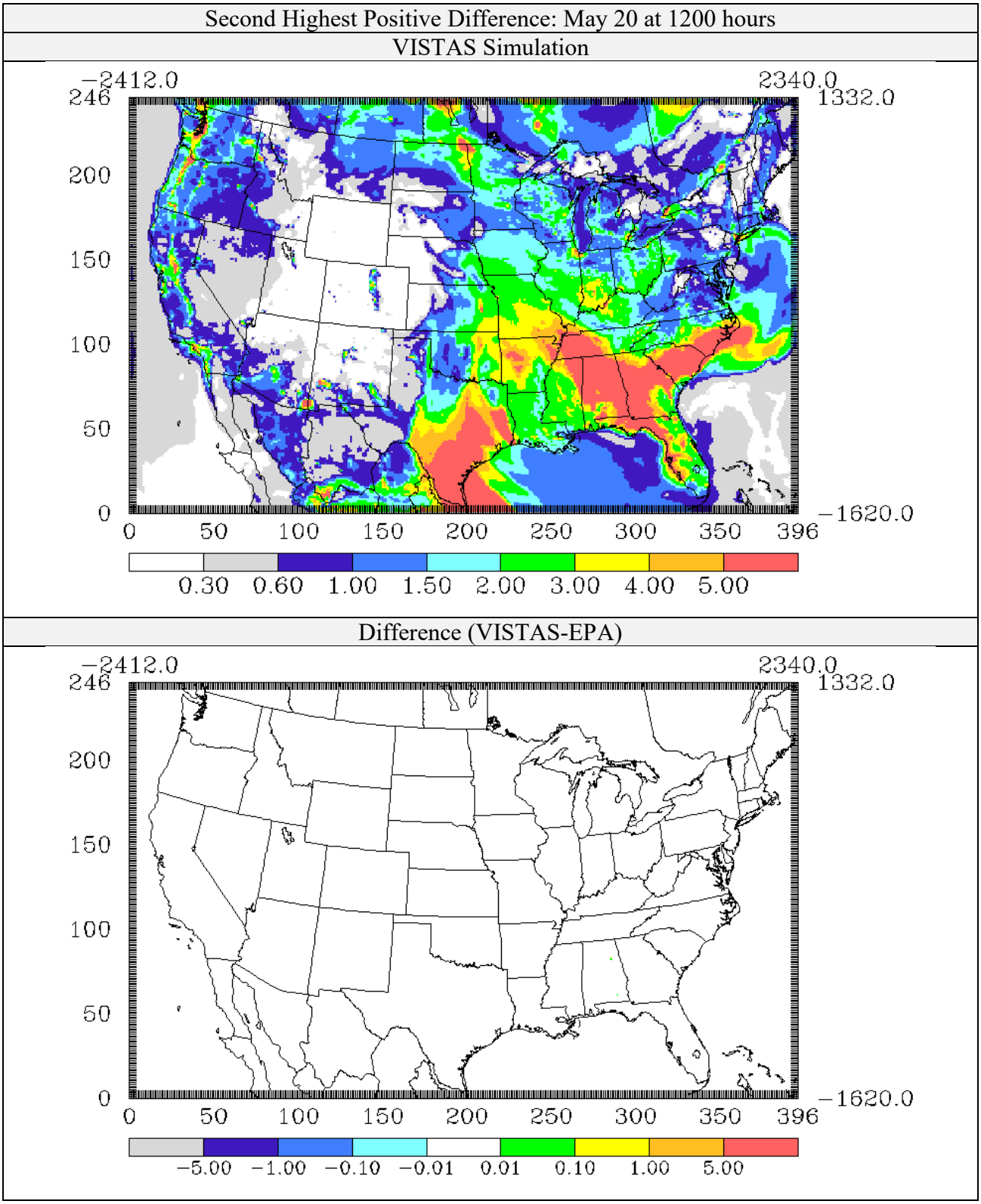


Figure 5-86: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Positive Difference)

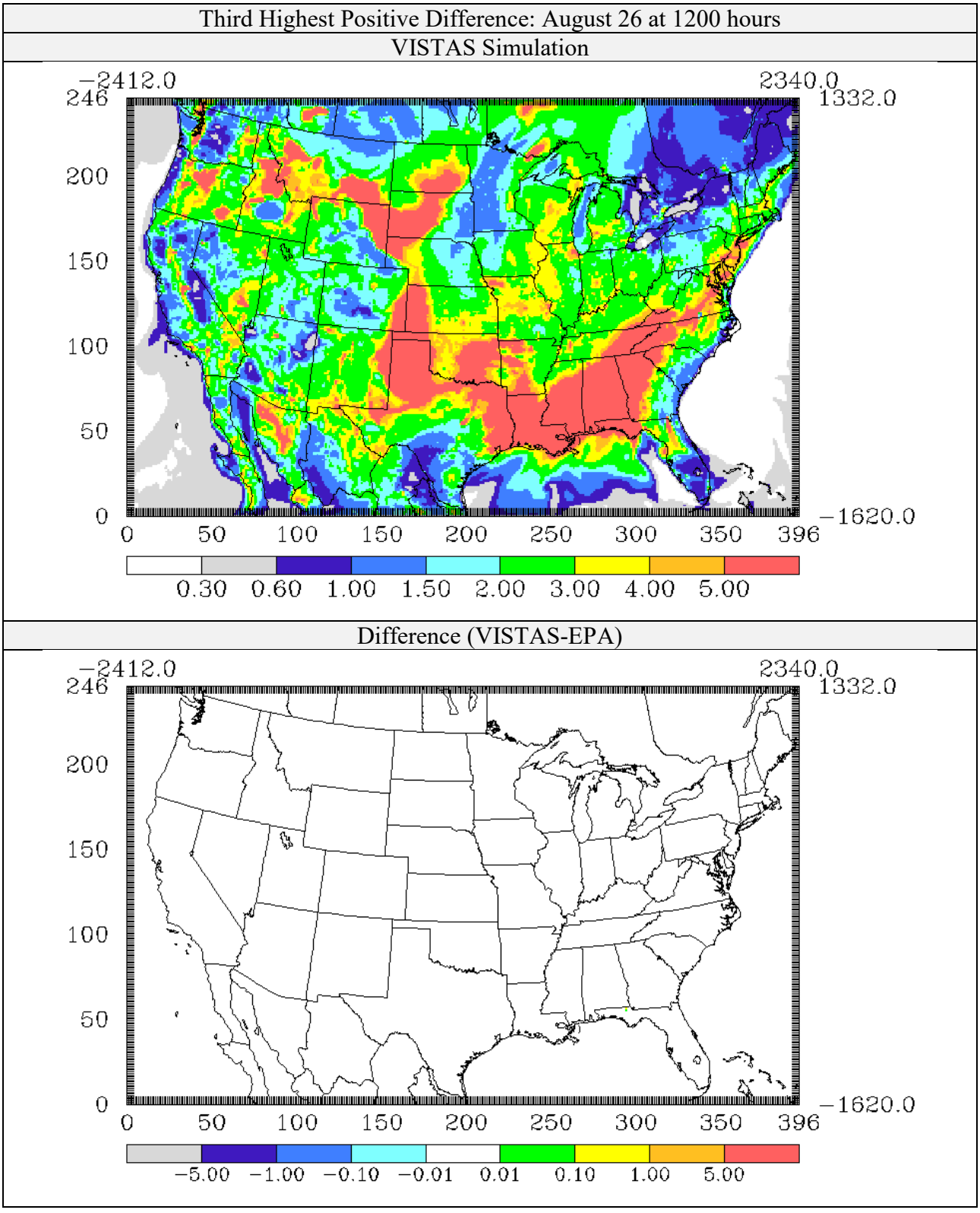


Figure 5-87: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Positive Difference)

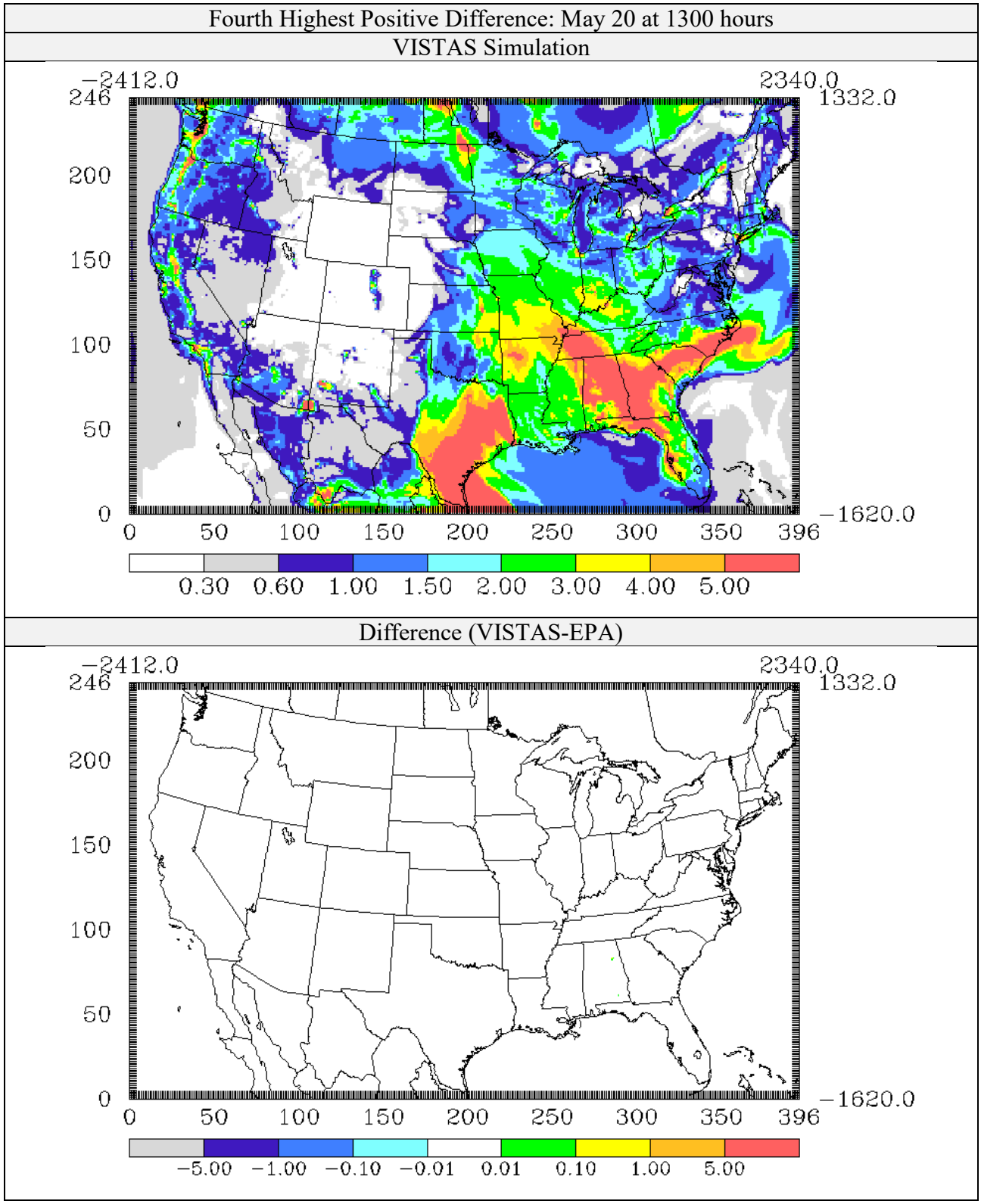


Figure 5-88: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Positive Difference)

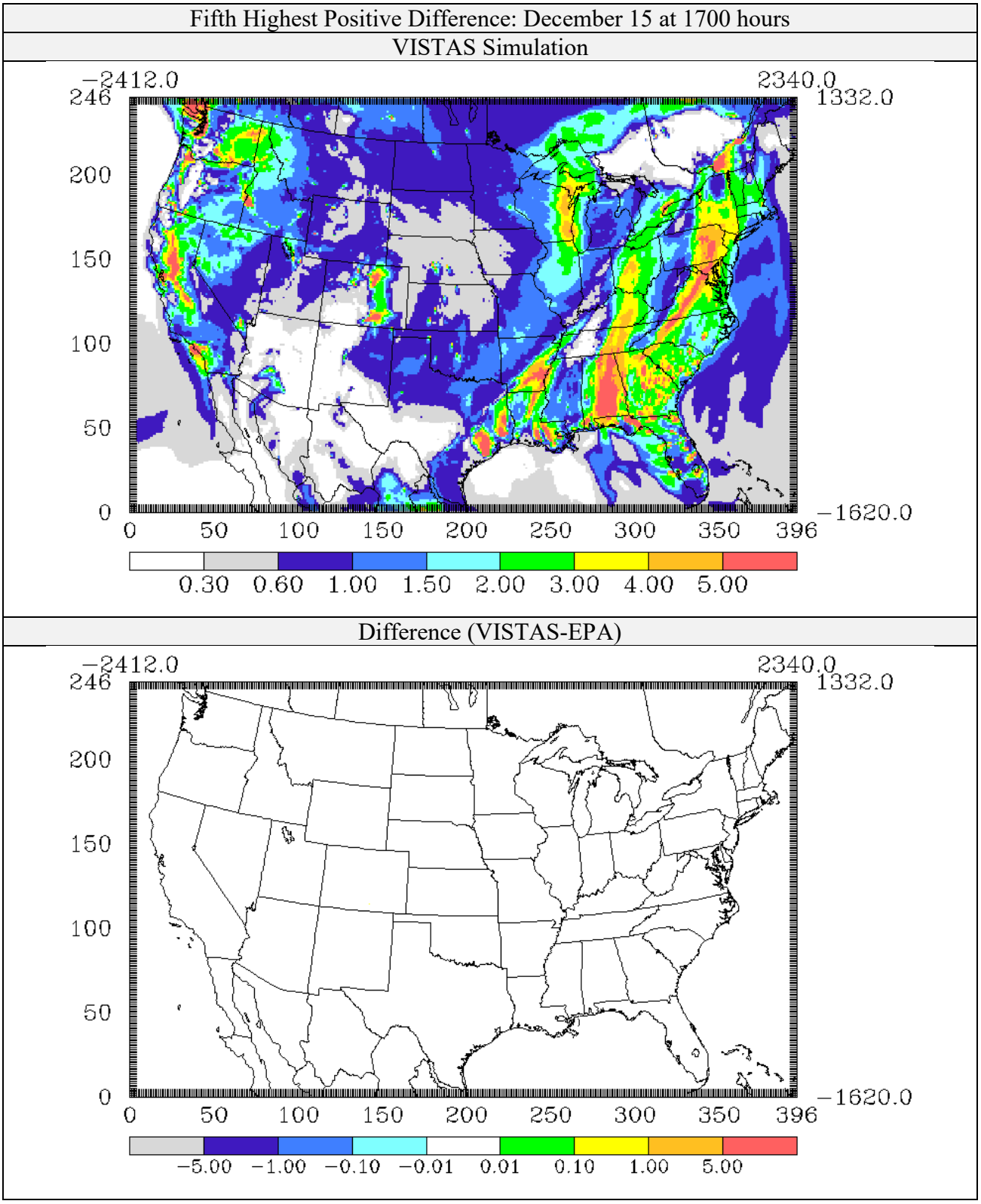


Figure 5-89: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Positive Difference)

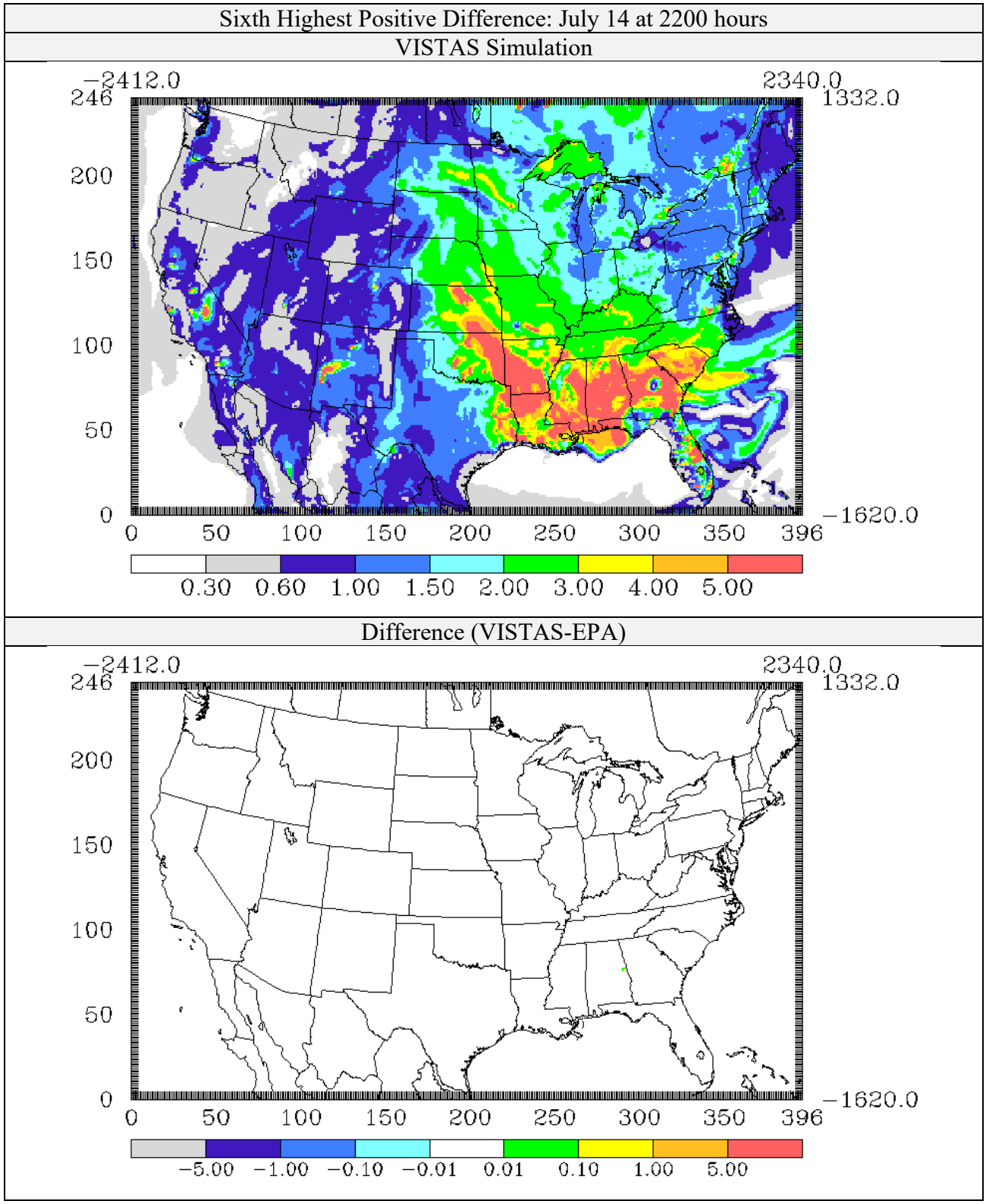


Figure 5-90: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Positive Difference)

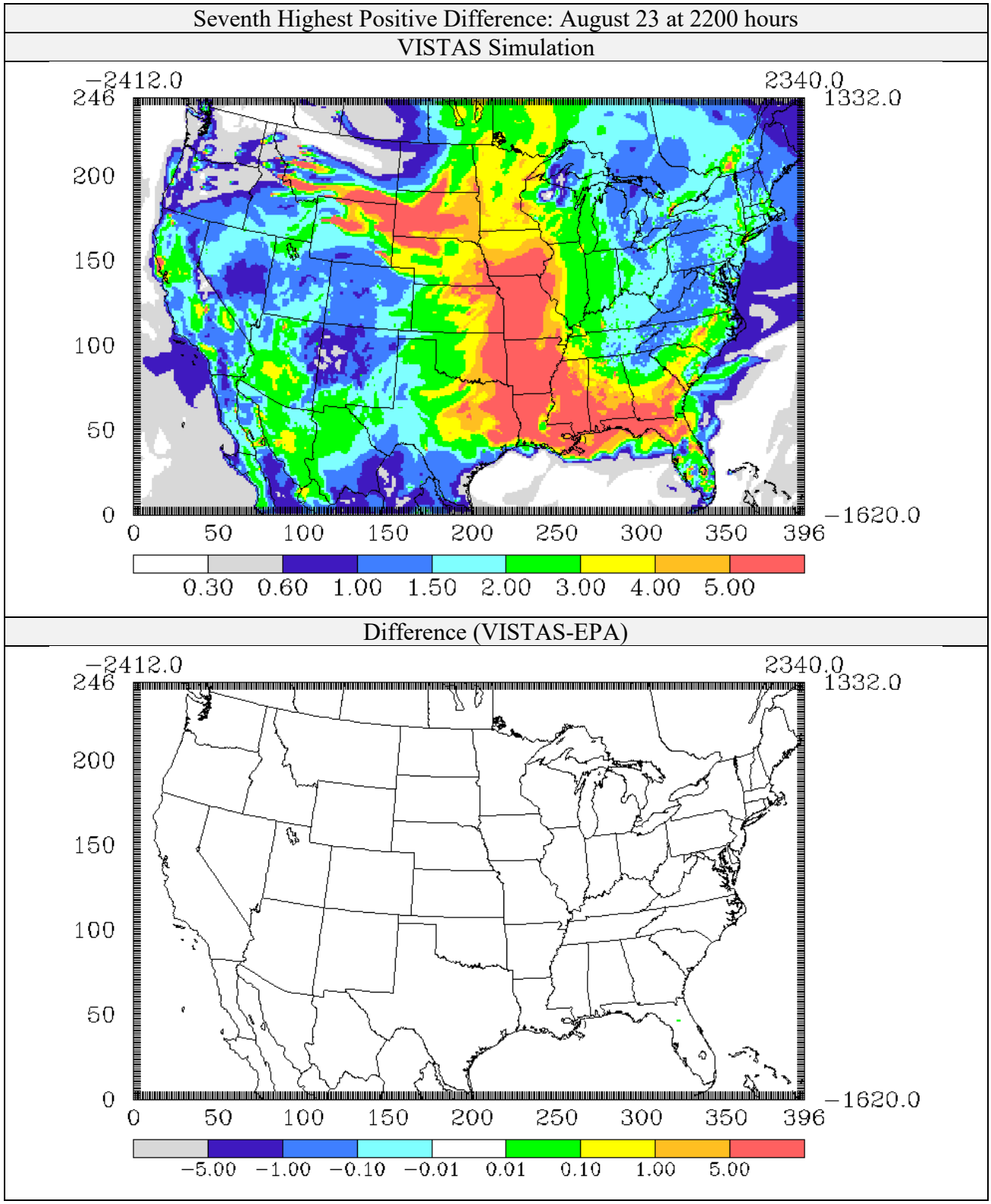


Figure 5-91: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Positive Difference)

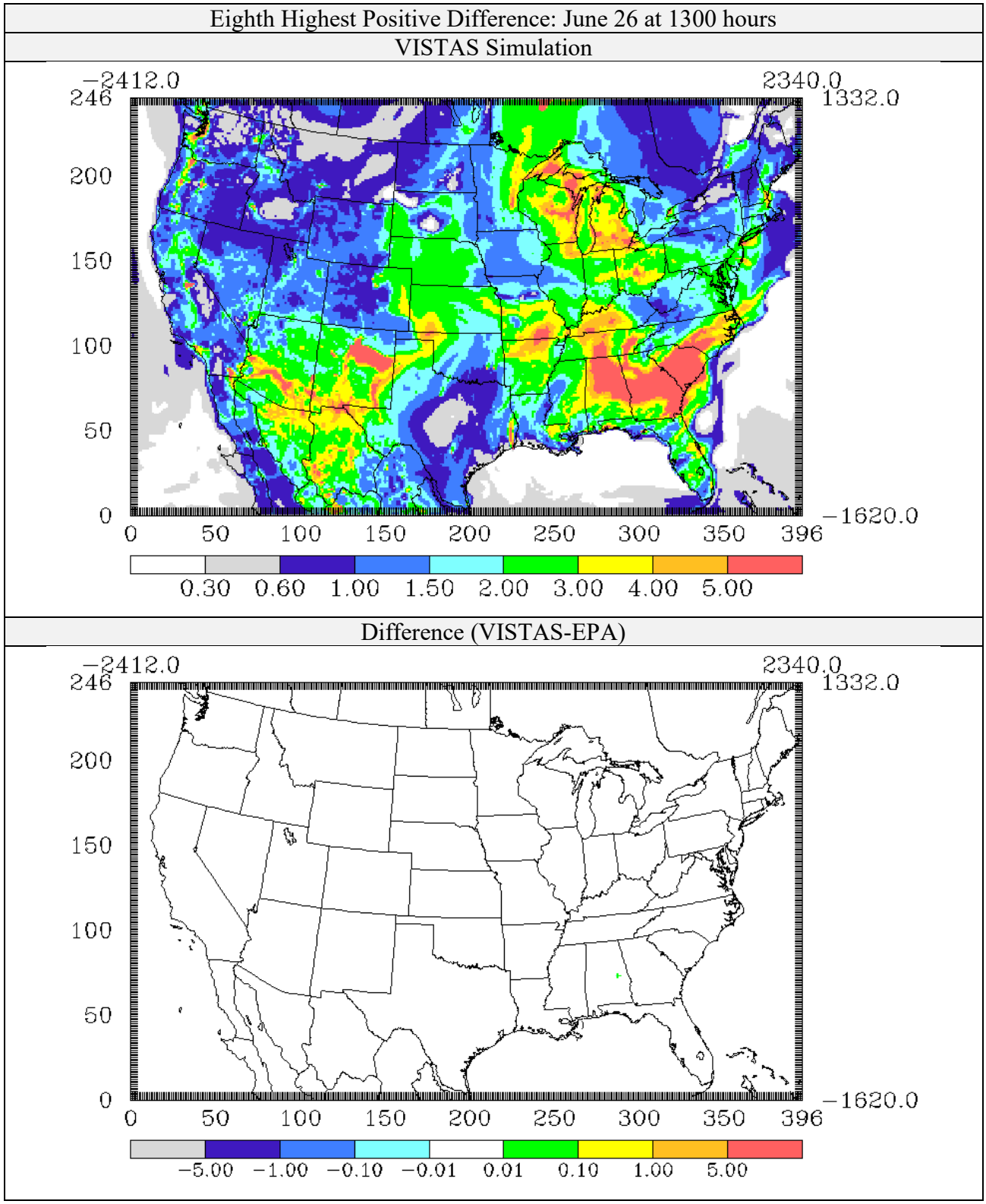


Figure 5-92: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Positive Difference)

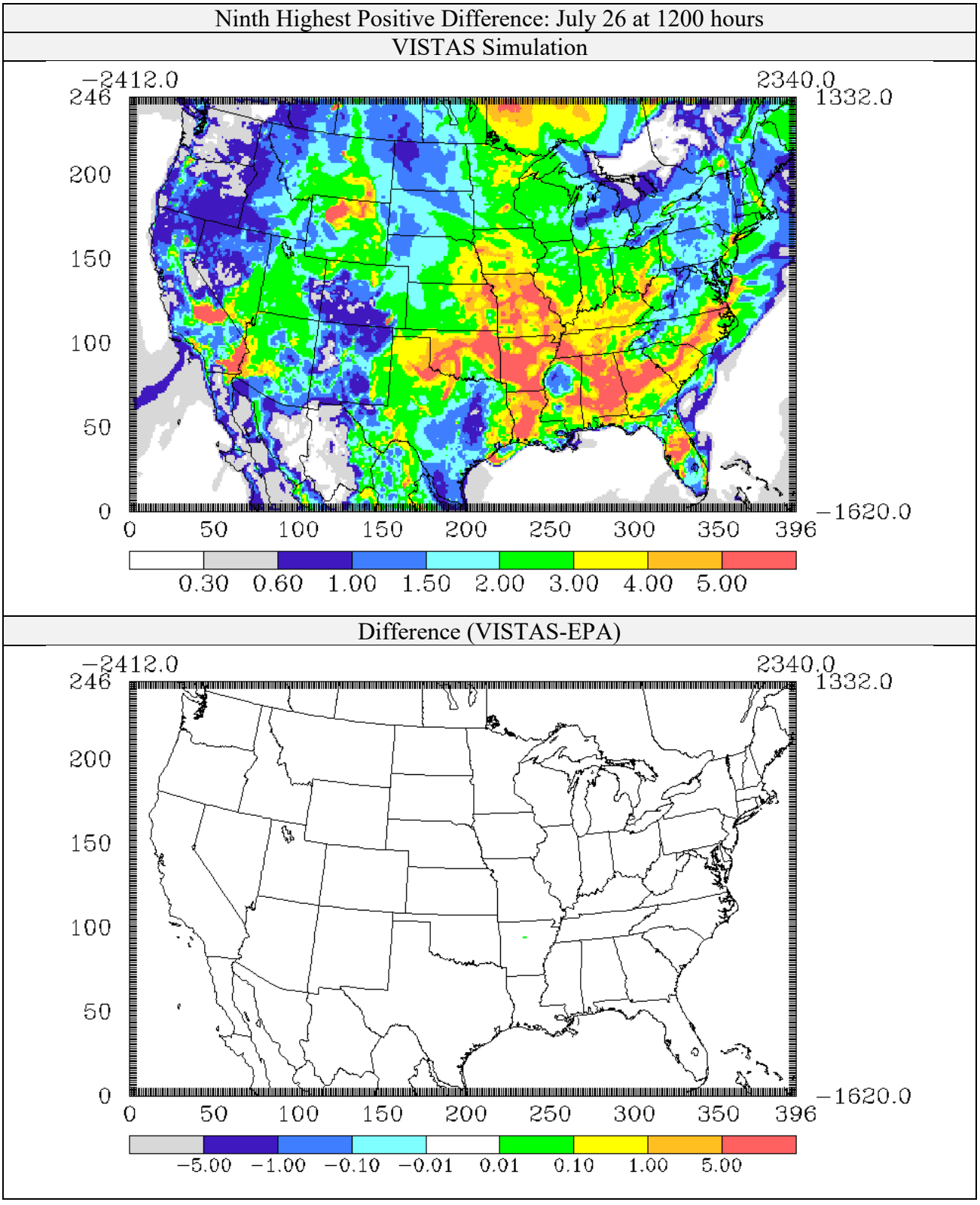


Figure 5-93: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Positive Difference)

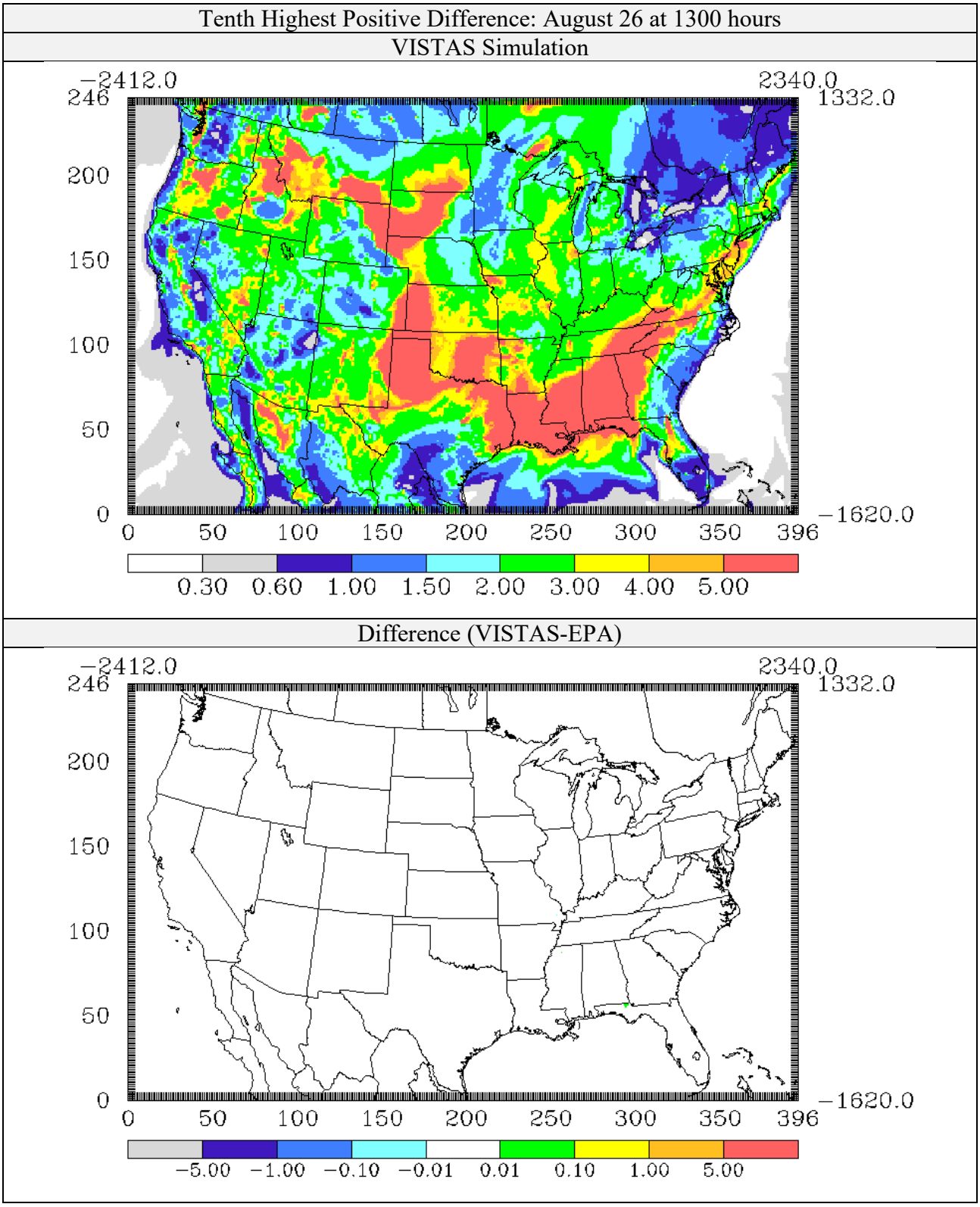


Figure 5-94: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Positive Difference)

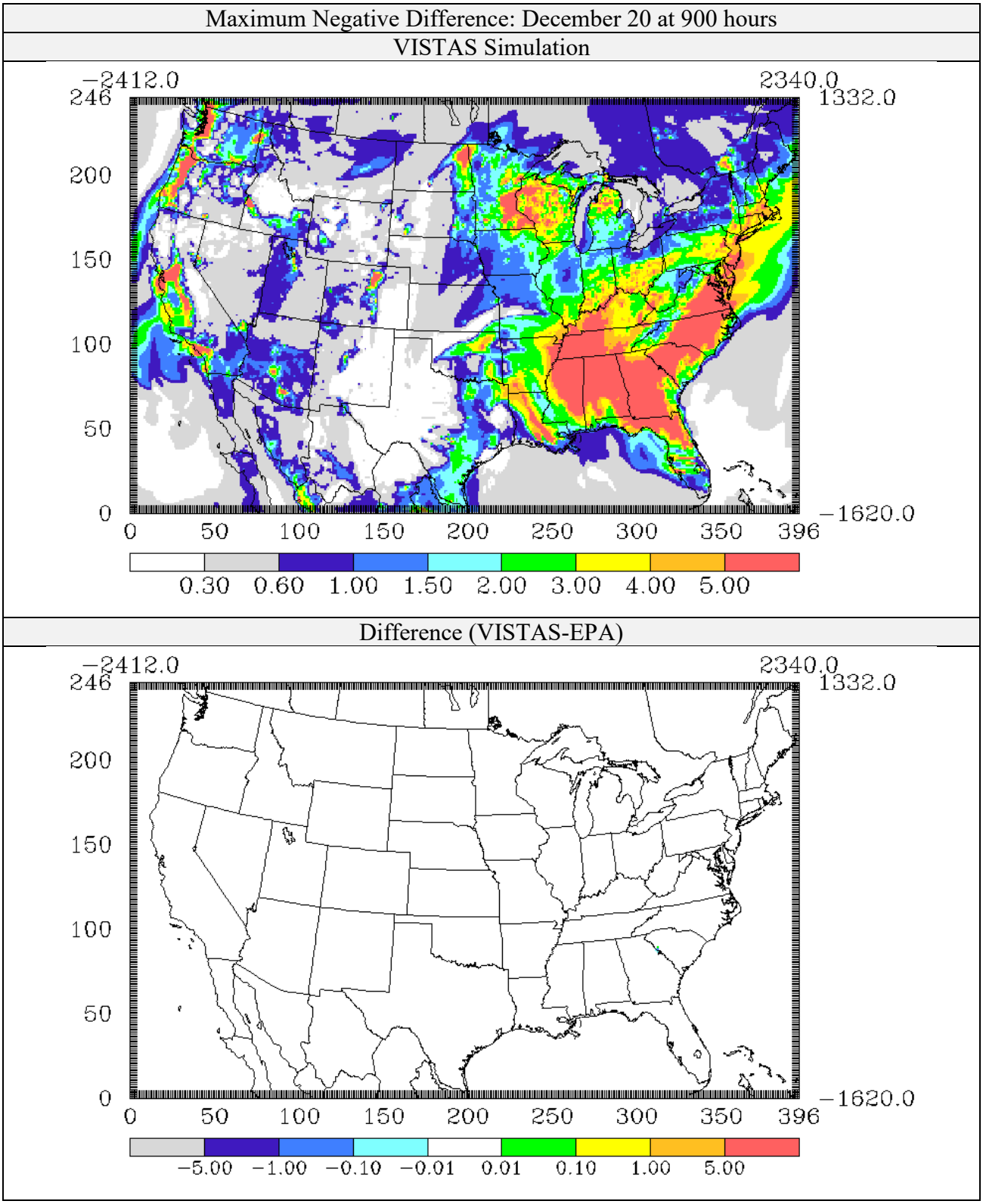


Figure 5-95: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Maximum Negative Difference)

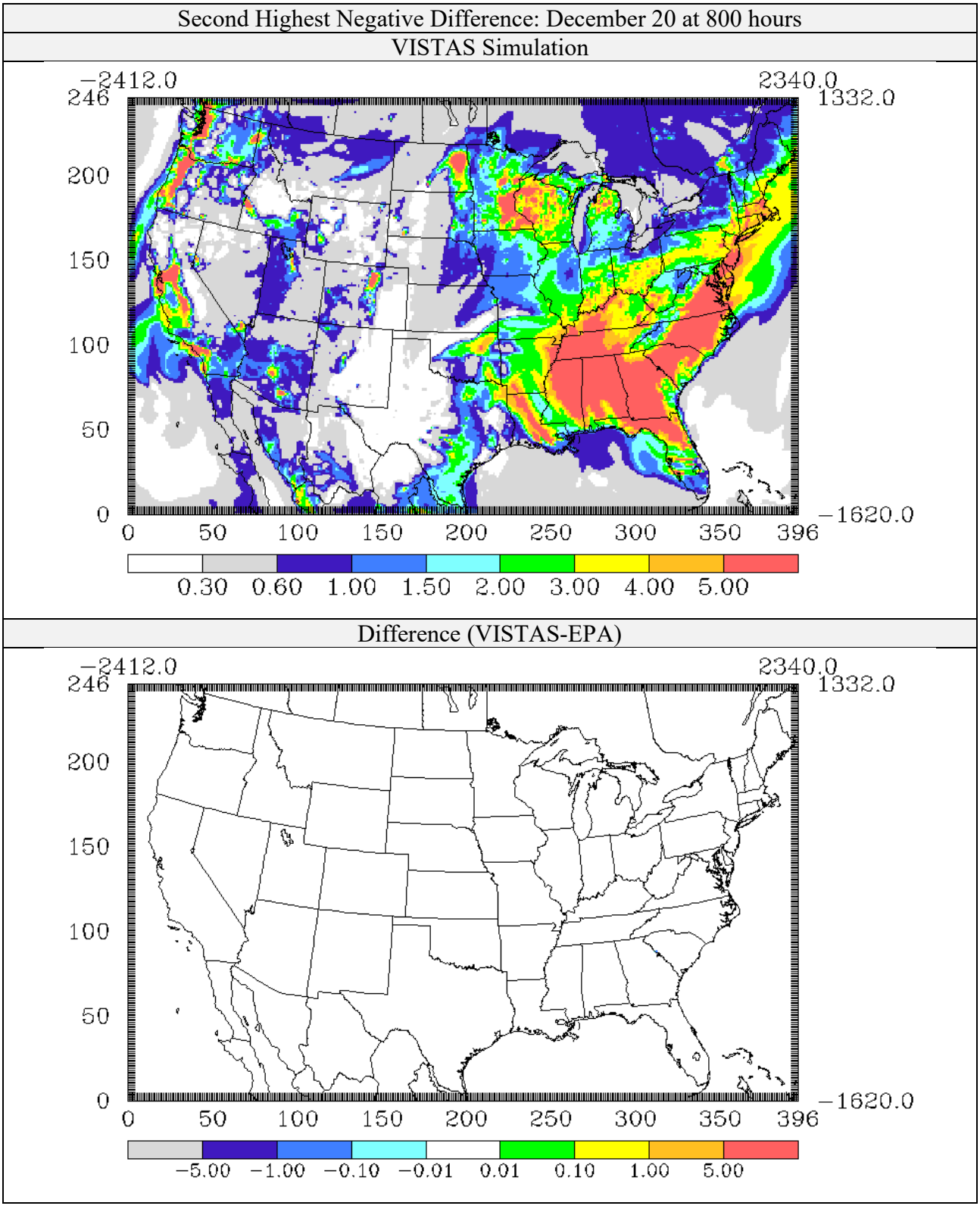


Figure 5-96: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Second Highest Negative Difference)

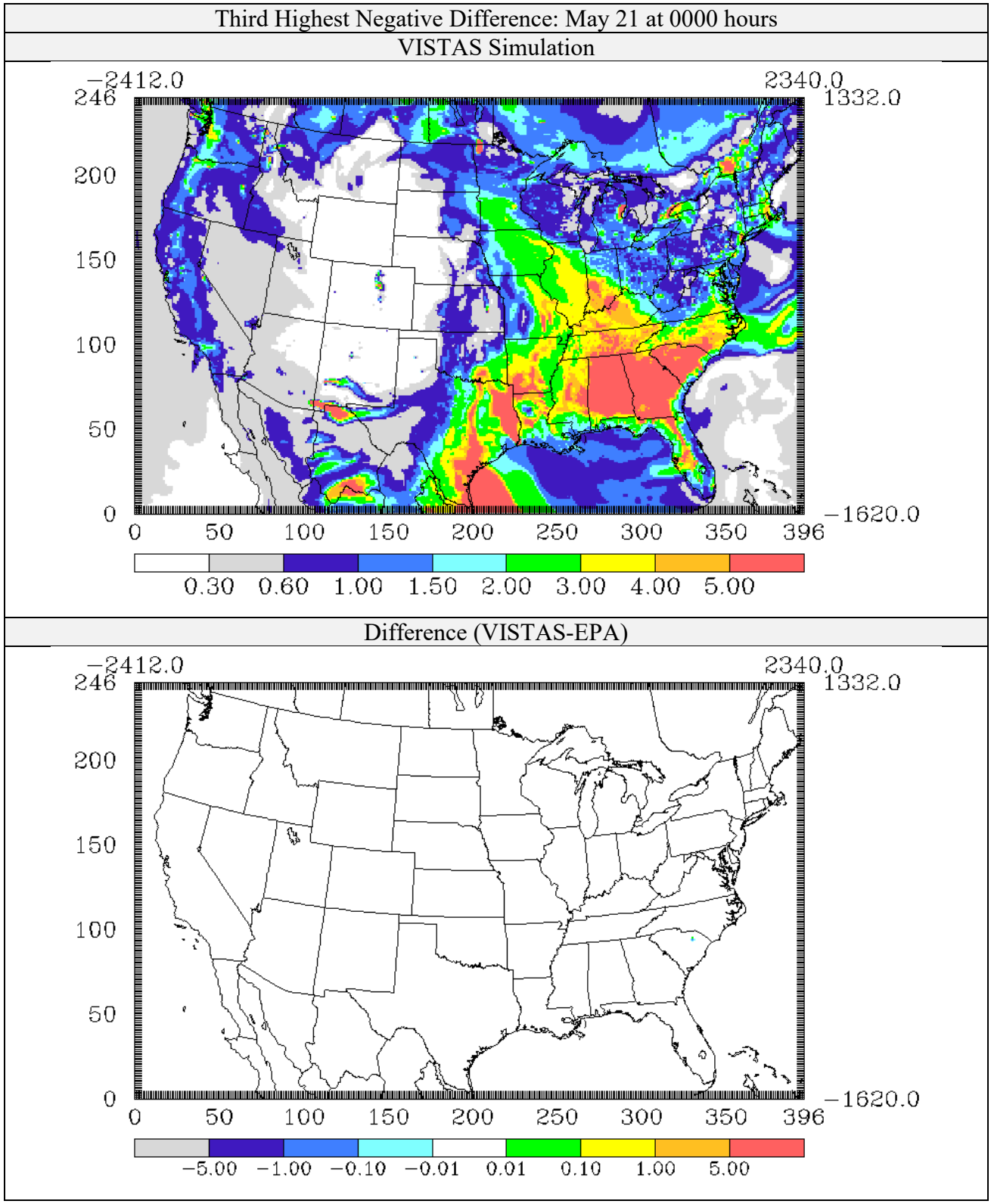


Figure 5-97: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Third Highest Negative Difference)

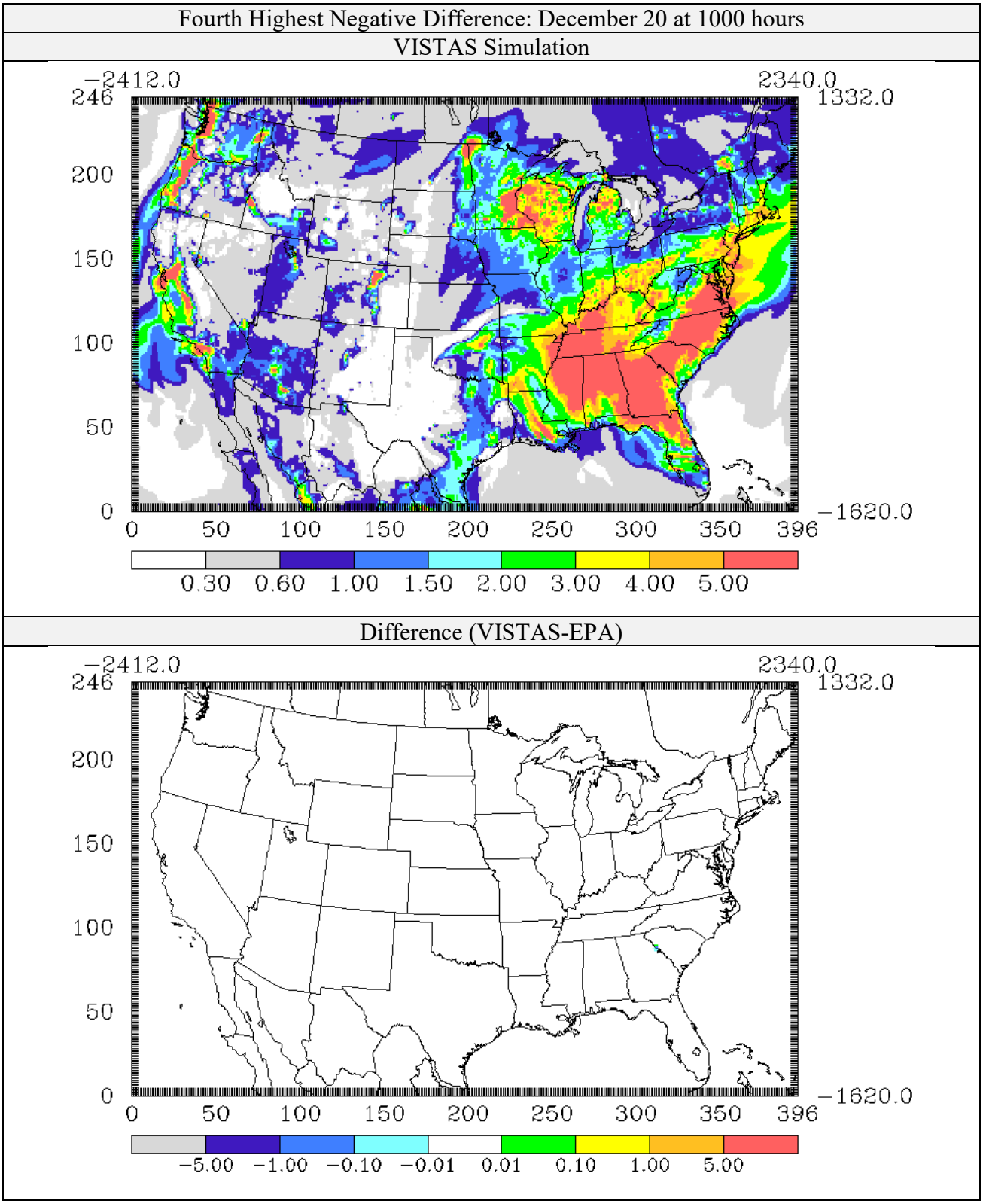


Figure 5-98: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fourth Highest Negative Difference)

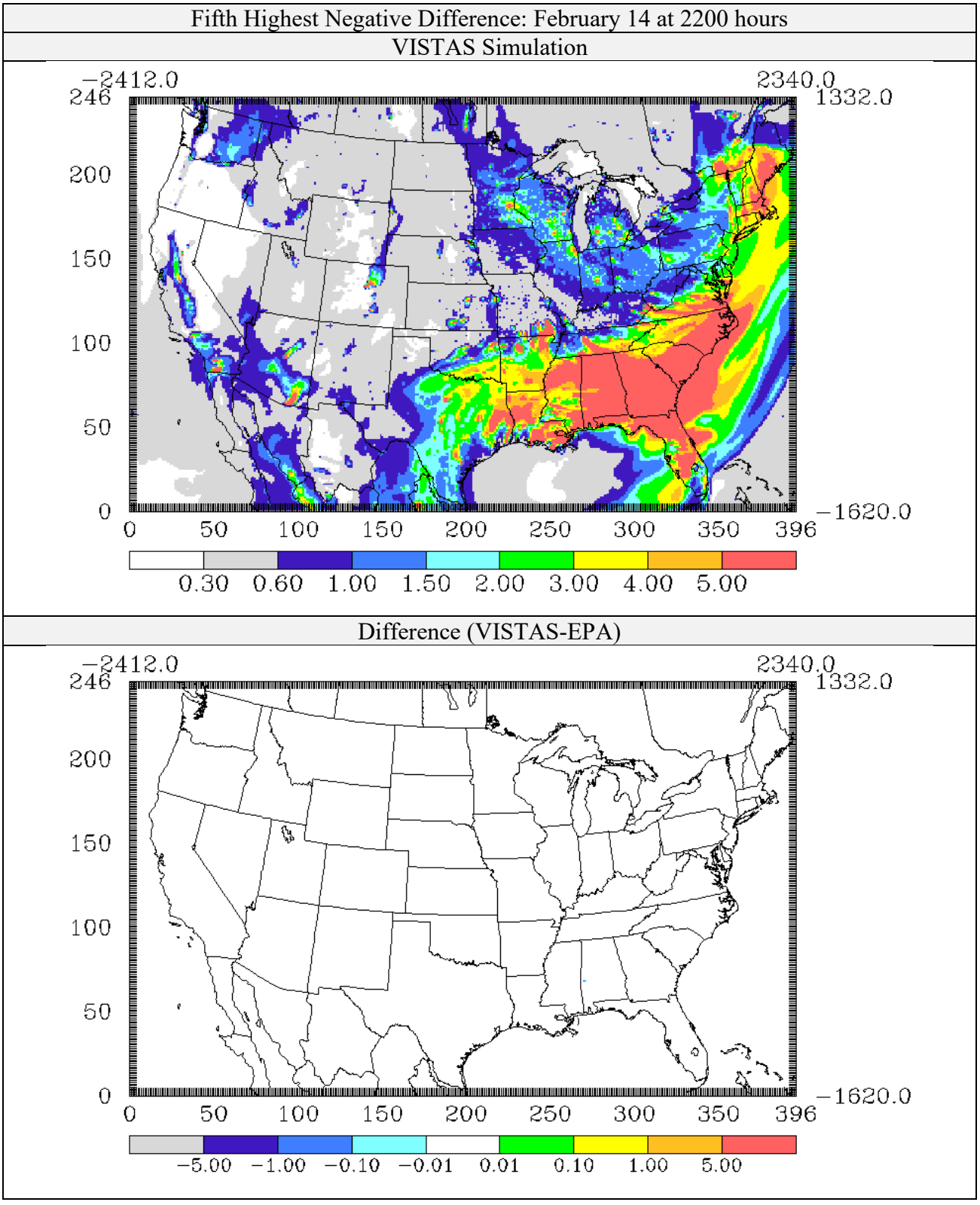


Figure 5-99: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Fifth Highest Negative Difference)

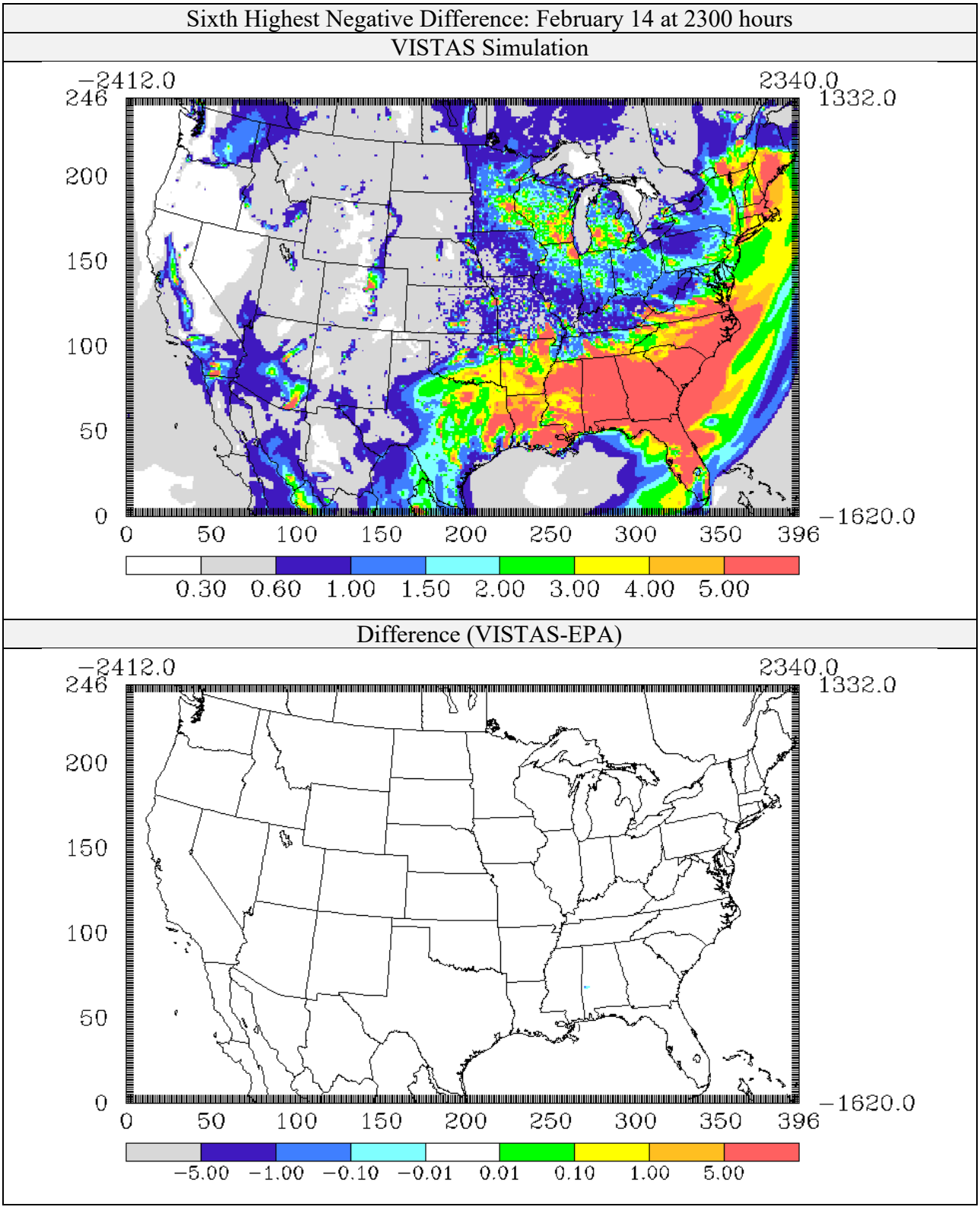


Figure 5-100: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Sixth Highest Negative Difference)

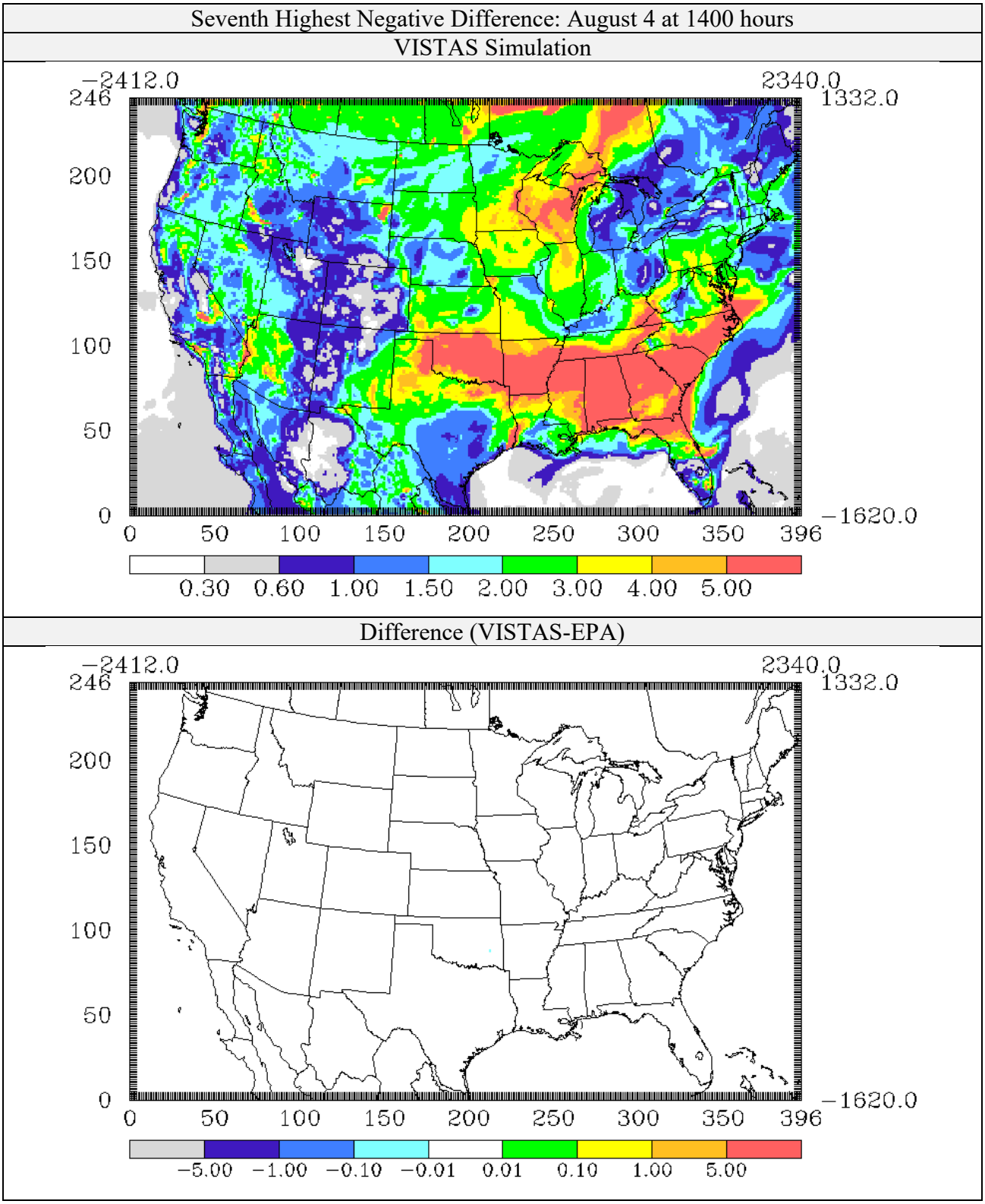


Figure 5-101: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Seventh Highest Negative Difference)

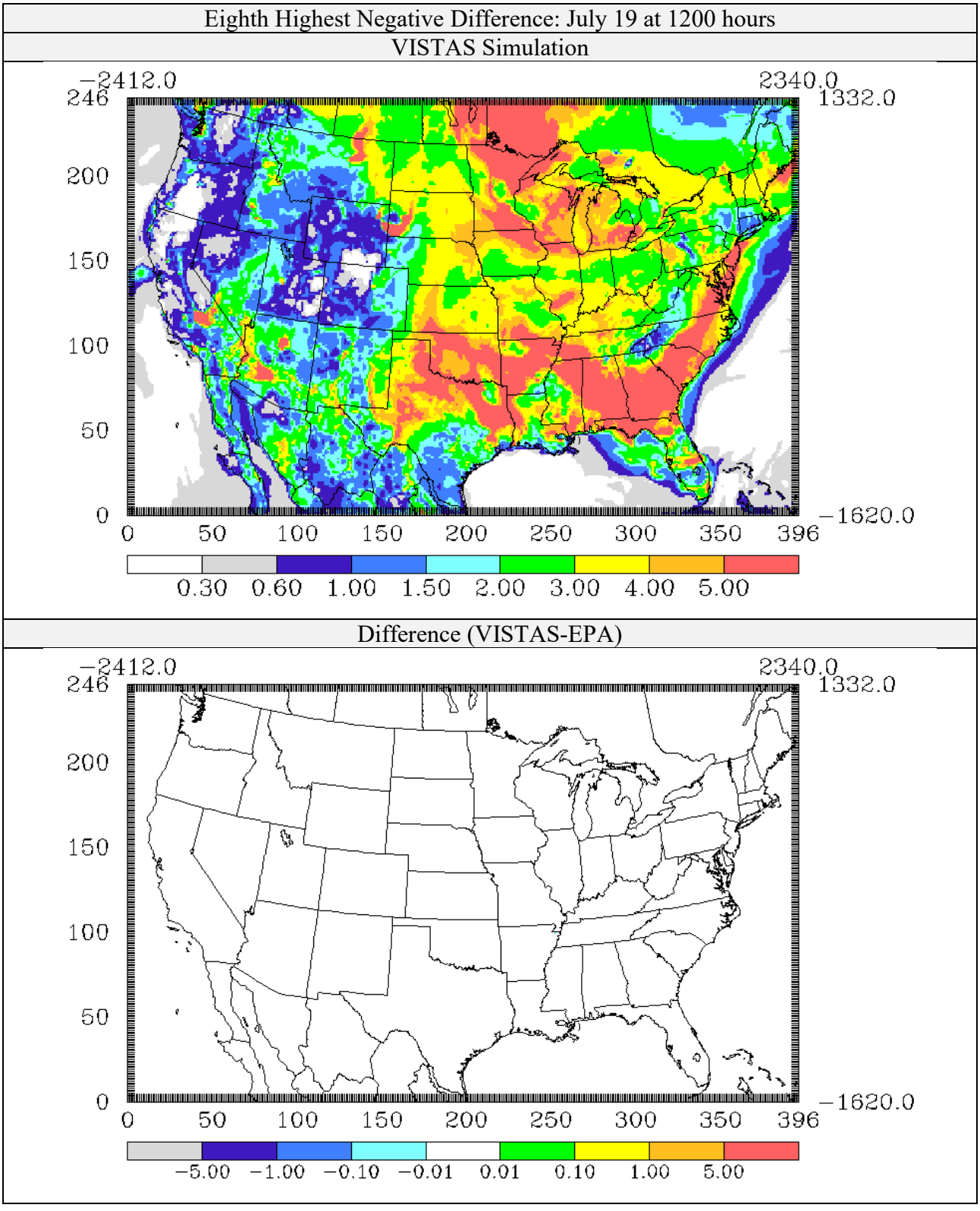


Figure 5-102: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Eighth Highest Negative Difference)

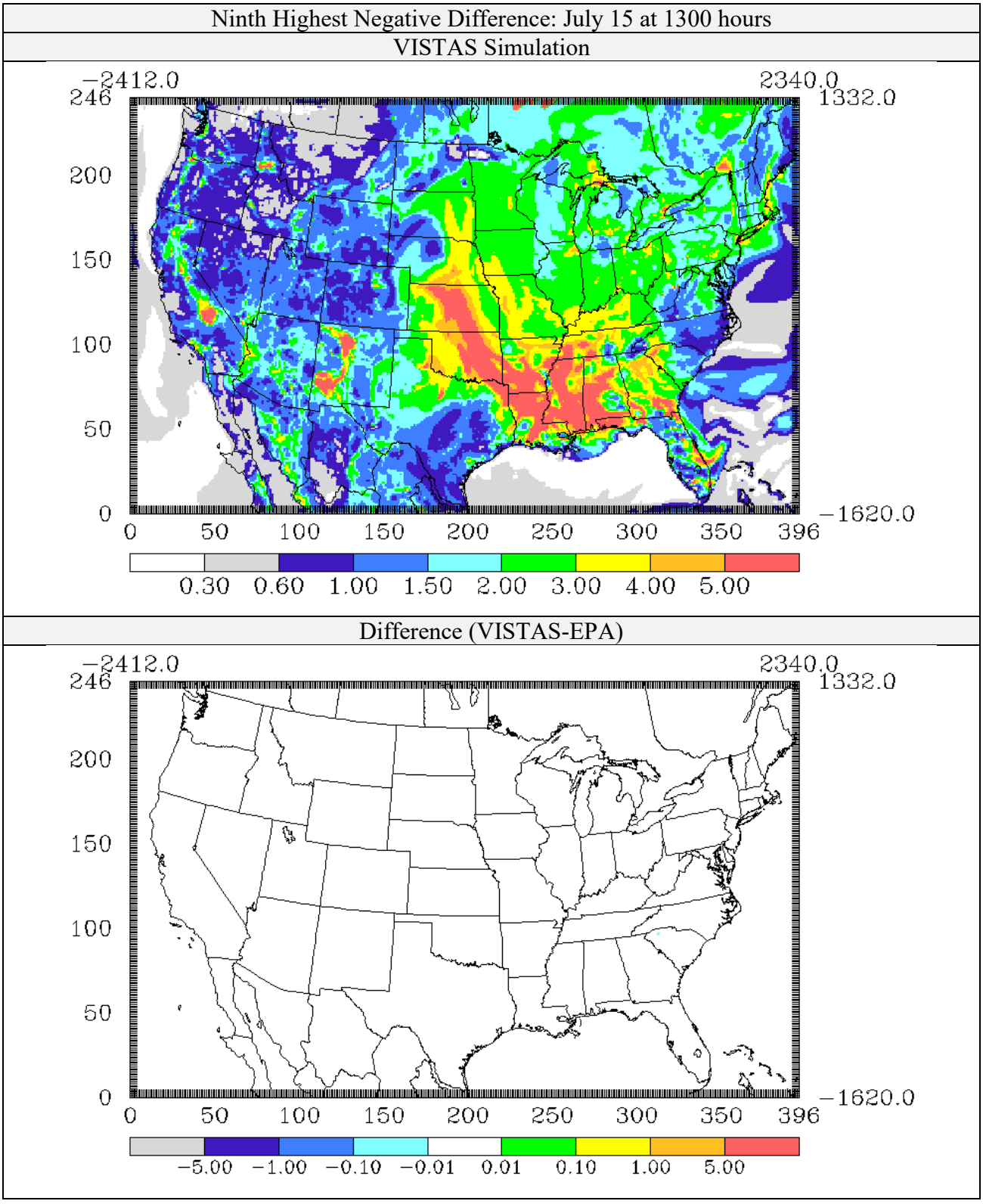


Figure 5-103: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Ninth Highest Negative Difference)

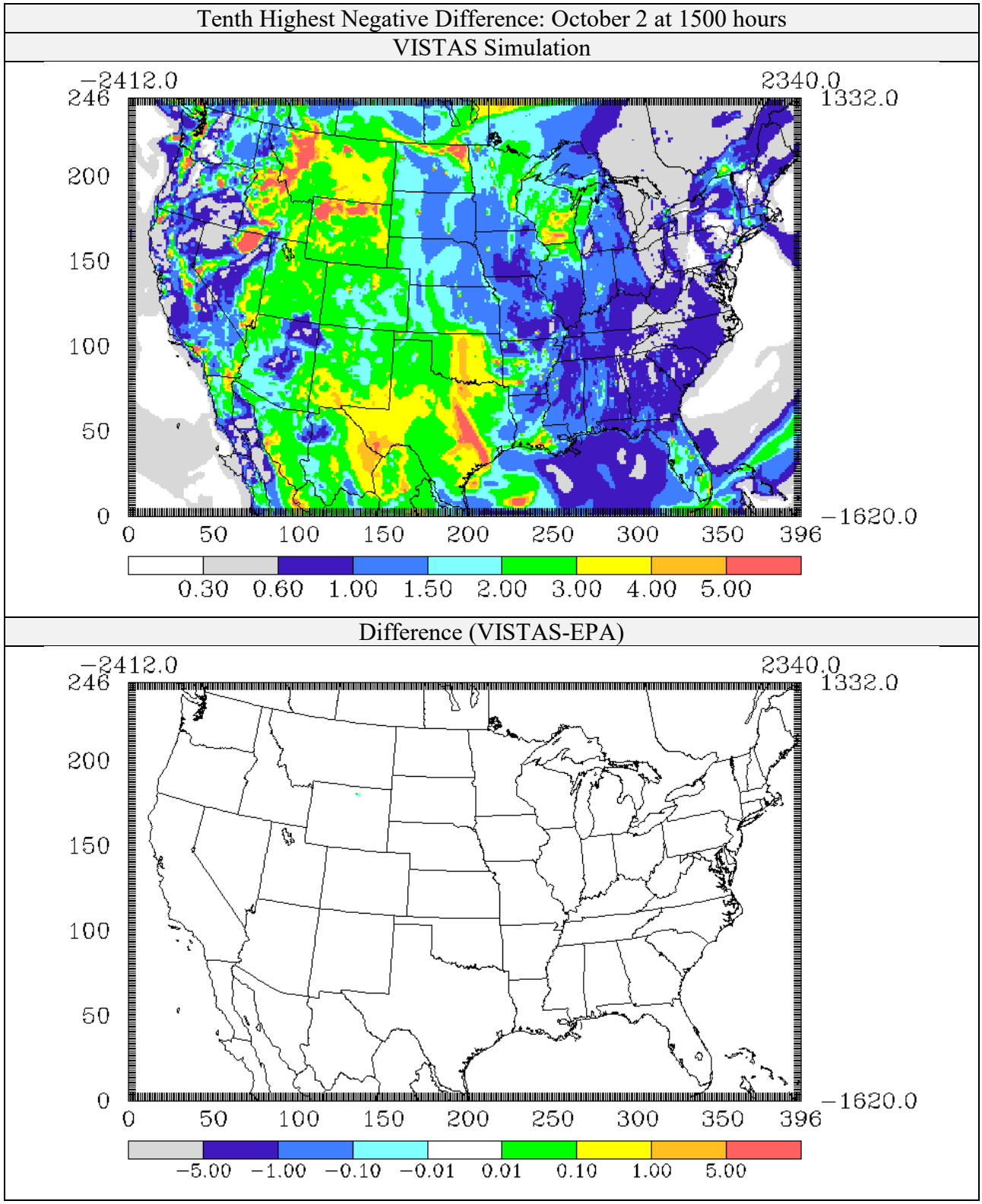


Figure 5-104: Comparison of Organic Carbon Concentrations (µg/m^3) for VISTAS and EPA CAMx 6.32 2028el Simulations (Tenth Highest Negative Difference)

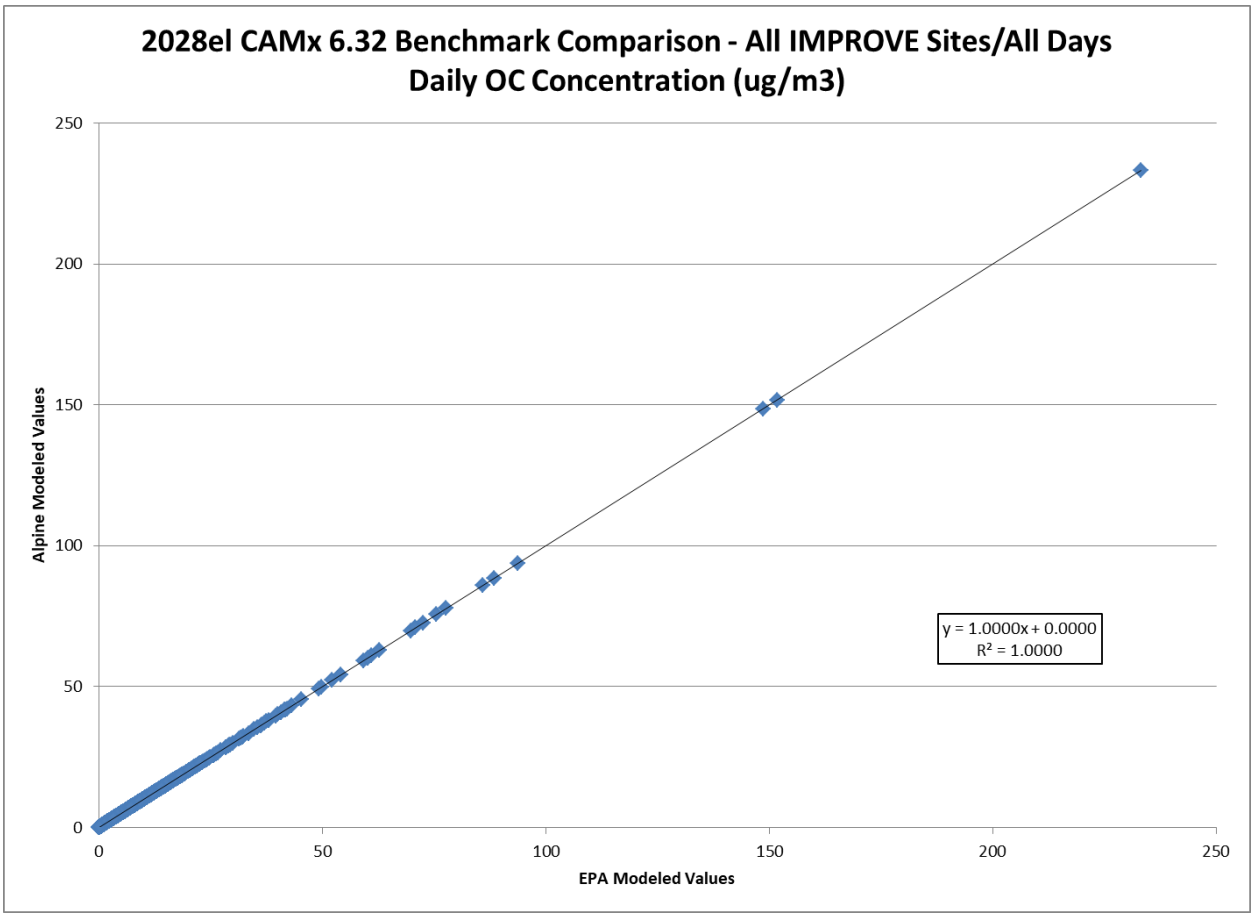


Figure 5-105: Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 2028el Simulations Performed by EPA and VISTAS (Alpine).

6.0 CONCLUSION

A comparison has been made between 2011el and 2028el CAMx 6.32 simulations performed on the EPA computer and simulations using the same input files and configuration performed on the Alpine Geophysics computer system for the VISTAS project. The comparison was conducted for ozone, $PM_{2.5}$, sulfate, nitrate and organic carbon and included an examination both of hourly gridded concentrations, and at daily average concentrations at the IMPROVE monitors.

The hourly gridded comparison showed limited areas of differences with the location, date and time of the largest differences being similar for both 2011 and 2028, although the magnitude of the differences are slightly different. For ozone the maximum differences occurred suddenly over a limited area and then dispersed over several hours. For particulate species the differences tended to occur near the northern boundary of the domain in areas with high in-flow boundary condition. The majority of the differences in total $PM_{2.5}$ concentrations are due to wintertime nitrate as a result of different pathway being taken in the ISOROPIA algorithm.

A comparison of the daily average concentrations at the IMPROVE monitors showed very near perfect agreement with the EPA results with slopes of 1.0000, intercepts at or very near zero and R^2 of 1.0000. Alpine Geophysics has no reservations that the model is operating in a consistent manner with the simulations performed at EPA.

Appendix E-2b

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project 2011el CAMx Version 6.32 and 6.40 Comparison Report

Benchmark Run #3

August 17, 2020

This page intentionally left blank.

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project
2011el CAMx Version 6.32 and 6.40 Comparison Report

Task 6 Benchmark Report #2
Covering Benchmark Run #3

Prepared for:
Southeastern States Air Resource Managers, Inc.
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final – August 17, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 INTRODUCTION 1
1.1 Overview 1
1.2 2011el CAMx 6.32 and CAMx 6.40 Comparison 3
2.0 DIFFERENCES BETWEEN CAMX 6.32 AND 6.40 SIMULATIONS 3
2.1 Model Differences 3
2.2 Configurations Difference 4
3.0 CONFIRMATION METHODOLOGY 5
3.1 CAMx Species Mapping 6
4.0 CAMX 6.32 AND CAMX 6.40 2011EL COMPARISON 6
4.1 Ozone 6
4.2 $PM_{2.5}$ 30
4.3 Sulfate 54
4.4 Nitrate 77
4.5 Organic Matter (OM) 100
5.0 CONCLUSIONS 124

This page is intentionally blank.

TABLES

Table 3-1. Species Mapping from CAMx into Aggregated Species 6

Table 4-1. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of Ozone Concentrations (ppb). Hours with the top 10 maximum positive and maximum negative differences are shown. 8

Table 4-2. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of $PM_{2.5}$ Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 31

Table 4-3. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of Sulfate Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 55

Table 4-4. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of Nitrate Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 78

Table 4-5. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of Organic Matter Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 101

FIGURES

Figure 4-1: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference) 9

Figure 4-2: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference) 10

Figure 4-3: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference) 11

Figure 4-4: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference) 12

Figure 4-5: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference) 13

Figure 4-6: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference) 14

Figure 4-7: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Positive Difference) 15

Figure 4-8: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference) 16

Figure 4-9: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference) 17
Figure 4-10: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference) 18
Figure 4-11: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference)....19
Figure 4-12: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference) 20
Figure 4-13: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference) 21
Figure 4-14: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference) 22
Figure 4-15: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference) 23
Figure 4-16: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference) 24
Figure 4-17: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference) 25
Figure 4-18: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference....26
Figure 4-19: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference)....27
Figure 4-20: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference)....28
Figure 4-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine). 29
Figure 4-22: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference) 32
Figure 4-23: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference)....33
Figure 4-24: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference)....34
Figure 4-25: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference)....35
Figure 4-26: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference)....36

Figure 4-27: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference) 37

Figure 4-28: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Positive Difference) 38

Figure 4-29: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference) 39

Figure 4-30: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference) 40

Figure 4-31: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference) 41

Figure 4-32: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference) 42

Figure 4-33: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference) 43

Figure 4-34: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference) 44

Figure 4-35: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference) 45

Figure 4-36: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference) 46

Figure 4-37: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference) 47

Figure 4-38: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference) 48

Figure 4-39: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference) 49

Figure 4-40: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference) 50

Figure 4-41: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference) 51

Figure 4-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine). 52

Figure 4-43: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine); Modified Scale. 53

Figure 4-44: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference) 56
Figure 4-45: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference)....57
Figure 4-46: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference)....58
Figure 4-47: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference)....59
Figure 4-48: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference)....60
Figure 4-49: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference) 61
Figure 4-50: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations....62
Figure 4-51: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference)....63
Figure 4-52: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference) 64
Figure 4-53: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference) 65
Figure 4-54: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference)....66
Figure 4-55: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference) 67
Figure 4-56: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference) 68
Figure 4-57: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference) 69
Figure 4-58: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference) 70
Figure 4-59: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference) 71
Figure 4-60: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference) 72
Figure 4-61: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference) 73
Figure 4-62: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference)....74

Figure 4-63: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference).....75

Figure 4-64: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine). 76

Figure 4-65: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference) 79

Figure 4-66: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference).....80

Figure 4-67: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference).....81

Figure 4-68: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference).....82

Figure 4-69: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference).....83

Figure 4-70: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference) 84

Figure 4-71: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Positive Difference).....85

Figure 4-72: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference).....86

Figure 4-73: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference) 87

Figure 4-74: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference) 88

Figure 4-75: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference).....89

Figure 4-76: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference) 90

Figure 4-77: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference) 91

Figure 4-78: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference) 92

Figure 4-79: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference) 93

Figure 4-80: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference) 94

Figure 4-81: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference) 95

Figure 4-82: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference) 96

Figure 4-83: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference).....97

Figure 4-84: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference).....98

Figure 4-85: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine). 99

Figure 4-86: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference) 102

Figure 4-87: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference).....103

Figure 4-88: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference) 104

Figure 4-89: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference).....105

Figure 4-90: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference).....106

Figure 4-91: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference).....107

Figure 4-92: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Positive Difference) 108

Figure 4-93: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference).....109

Figure 4-94: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference) 110

Figure 4-95: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference).....111

Figure 4-96: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference).....112

Figure 4-97: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference).....113

Figure 4-98: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference).....114

Figure 4-99: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference) 115

Figure 4-100: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference) 116

Figure 4-101: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference) 117

Figure 4-102: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference) 118

Figure 4-103: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference) 119

Figure 4-104: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference).....120

Figure 4-105: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference) 121

Figure 4-106: Scatterplot Comparing 24-hour Average Predicted Organic Matter Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine). 122

Figure 4-107: Scatterplot Comparing 24-hour Average Predicted Organic Matter Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine); Modified Scale. 123

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
CAMx	Comprehensive Air quality Model with eXtensions
dv	Deciview
ERG	Eastern Research Group, Inc.
EPA	Environmental Protection Agency
FCRS	Crustal fraction of PM
FLM	Federal Land Manager
FPRM	Fine other primary (diameter ≤ 2.5µm)
FR	Federal Register
IMPROVE	Interagency Monitoring of Protected Visual Environments
$\mu g/m^3$	microgram per cubic meter
NAAQS	National Ambient Air Quality Standard
NA	Sodium
OAQPS	Office of Air Quality Planning and Standards
O_3	Ozone
OC	Organic carbon
OM	Organic matter
OSAT	Ozone Source Apportionment Technology
PCL	Primary chlorine
PEC	Primary elemental carbon
PM	Particulate matter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Particulate ammonium
PNO3	Particulate nitrate
POA	Primary Organic Aerosol
ppb	Parts per billion
PSAT	Particulate Source Apportionment Technology
PSO4	Particulate sulfate
R^2	Pearson correlation coefficient squared
RADM-AQ	Regional Acid Deposition Model – aqueous chemistry
RHR	Regional Haze Rule
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SO_2	Sulfur dioxide
SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
U.S.	United States
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast

1.0 INTRODUCTION

1.1 Overview

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States (U.S.) Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.

B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that is, the focus of state planning will be to establish reasonable progress goals for each Class I area against which progress will be measured during the second planning period. This extension will allow states to incorporate planning for other Federal programs while conducting their regional haze planning. These other programs include: the Mercury and Air Toxics Standards, the 2010 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview (dv) index values. "Most impaired days" are defined as the 20% of

monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

1.2 2011el CAMx 6.32 and CAMx 6.40 Comparison

Recent EPA 2011el and 2028el platform simulations were performed with Comprehensive Air quality Model with eXtensions (CAMx) version 6.32. Since that time the CAMx model has been updated to include better physical treatment, and to correct any model flaws that were discovered after the release of 6.32.

Alpine Geophysics, LLC (Alpine), under subcontract with Eastern Research Group, Inc. (ERG), has executed two air quality simulations for the 2011el base year modeling platform; one run with CAMx 6.32 and one with CAMx 6.40. We note that CAMx 6.50 has now been released, however that model release was too late to be included with sufficient certainty in the VISTAS II project schedule.

This comparison is to document the differences in model estimates between 2011EL simulated with CAMx 6.32 and CAMx 6.40 as is discussed in the VISTAS II Modeling Protocol[2] in Section 6.5.2 model comparison number 3.

2.0 DIFFERENCES BETWEEN CAMX 6.32 AND 6.40 SIMULATIONS

Differences in modeled output concentrations between the CAMx 6.32 and 6.40 simulations were as a result both of changes to the CAMx model code and changes to the model inputs.

Model Differences

Many updates to the CAMx model were implemented between the 6.32 and 6.40 release. According to the CAMx 6.40 release notes, the significant changes included:

[2] "Regional Haze Modeling for Southeastern VISTAS II Region Haze Analysis Project, Final Modeling Protocol." Prepared for SESARM under Contract No. V-2018-03-01. Prepared by Alpine Geophysics, LLC and Eastern Research Group, Inc. June 27, 2018.

1. Updates to the chemistry to include a condensed halogen mechanism for ocean-borne inorganic reactive iodine, hydrolysis of isoprene-derived organic nitrate and SO_2 oxidation on primary crustal fine particulate matter (PM). This update includes the changes to the Ozone and Particulate Source Apportionment Technology (OSAT/PSAT) algorithms;

2. Inclusion of in-line inorganic iodine emissions to support halogen chemical mechanisms;

3. A major revision to the secondary organic aerosol portioning (SOAP) chemistry/ partitioning algorithm;

4. Updates to the Regional Acid Deposition Model – aqueous chemistry (RADM-AQ) algorithm; and

5. A major revision to the wet deposition algorithm to identify assumptions or processes that were unintentionally or otherwise unreasonably limiting gas and PM update into precipitation. The wet deposition algorithm was simplified and improved in several ways, resulting in the increased scavenging of gases and PM.

Configurations Difference

In addition to the model version, the CAMx 6.32 and 6.40 simulations contained differences in the EPA modeling platform that had been made subsequent to the 2011el/2028el model release. In the most current 2023en simulation, EPA developed new photolysis rates and ozone column data. These updates were included in the updated modeling platform and resulting CAMx 6.40 simulation and were used in the VISTAS II 2011el simulations.

Another configuration difference is how the boundary conditions were mapped for speciation in the two versions of the model. EPA and the VISTAS CAMx 6.32 and 6.40 simulations all used the same boundary condition files. However, when CAMx was updated from 6.32 to 6.40 the species in the secondary organic aerosol (SOA) scheme changed. The SOA5, SOA6, and SOA7 were removed and SOA3 and SOA4 were redefined. Neither EPA nor this study remapped the boundary conditions to account for this change. EPA examined the regional haze summary data for all Class I areas and found the total organic carbon (OC) species

(not just SOA) accounted for 1-5% of the boundary condition impairment at the Southeastern Class I areas.[3] This is a small impact on regional haze and the impact of SOA on regional haze is even smaller.

3.0 CONFIRMATION METHODOLOGY

The presented comparison of model simulations are based on hourly differences in ozone (O_3), $PM_{2.5}$, Organic Matter (OM), Particulate Nitrate (PNO3), and Particulate Sulfate (PSO4). The metric for comparison are the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$(C_{6.32} - C_{6.40})$$

(Equation 2) $$\frac{(C_{6.32} - C_{6.40})}{(C_{6.40})}$$

Where $C_{6.40}$ is the concentration at each grid cell hour for the CAMx 6.40 simulation and $C_{6.32}$ is the concentration at each grid cell hour for the CAMx 6.32 simulation.

The results are presented for the hours with the largest difference between the simulations. A table presents the hours with the top 10 positive and negative absolute differences. Spatial maps are presented for the hours with the top 10 highest positive and negative differences. To provide context for the differences, the concentration maps are also presented for each of the hours of high difference. On each spatial plot the maximum positive and negative values, along with the grid cell in which these occur, are presented at the top of the graphic. The coordinates refer to the row and columns of the cell referenced to the cell coordinates on the bottom (column) and left (row) of the graphic.

Hourly animations have also been prepared and are available on the VISTAS II project ftp site. Where appropriate, this report also reports and interprets on the animations.

[3] Brian Timin, EPA Office of Air Quality Planning and Standards (OAQPS) personal communication October 11, 2018.

CAMx Species Mapping

Updates to the CAMx model between version 6.32 and 6.40 necessitated making changes to how the individual CAMx species were aggregated to the presented species. The CAMx species mapping between the two compared versions are presented in Table 3-1.

Table 3-1. Species Mapping from CAMx into Aggregated Species

Aggregated Species	CAMx 6.32 Species	CAMx 6.40 Species
Ozone	O3	O3
$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
Sulfate	PSO4	PSO4
Nitrate	PNO3	PNO3
Organic Matter (OM)	SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB+POA[1]	SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA

[1] SOAH was not included in the 6.32 comparison since it was not included as an output species in the EPA simulation.

4.0 CAMX 6.32 AND CAMX 6.40 2011EL COMPARISON

This section presents comparisons of the simulations using CAMx 6.32 and CAMx 6.40 performed on the Alpine computer system using EPA's 2011el modeling platform.

4.1 Ozone

Ozone results for the top 10 positive and negative hours are presented in tabular format in Table 4-1. The maximum positive difference is 14.48 parts per billion (ppb) falling to 10.47 ppb for the 10th high. The maximum negative difference is -13.74 ppb falling to -9.61 for the 10th high. The highest positive differences are occurring on relatively high ozone hours with concentrations ranging from 80 ppb to 113 ppb for the CAMx 6.32 simulation. The maximum negative difference days generally are on hours with more modest concentrations of 51 to 72 ppb, except for a July 18th day with a 150 ppb estimate. The maximum positive percent difference is 18.9% and the maximum negative percent difference is -18.5%.

The top ten positive impact hours are presented in Figures 4-1 through 4-10. The regions of highest positive differences, meaning that estimates with CAMx 6.32 are higher that CAMx 6.40, tend to occur over the western edge of Lake Michigan. The concentration difference

summed over the entire domain show a negative concentration, meaning that estimates with CAMx 6.40 is overall producing more ozone.

The top ten negative impact hours are presented in Figures 4-11 through 4-20. On days with high negative differences the areas of maximum difference vary hour to hour with the maximum difference most often over the eastern Gulf of Mexico. On five of the top ten negative days CAMx 6.32 estimates higher ozone, and on five of the days CAMx 6.40 estimates higher ozone.

Scatterplots of the daily average ozone concentrations in local standard time at the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors across all modeled days are presented in Figure 4-21. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 0.9975, an intercept of 0.0592 ppb and an R^2 of 0.9995.

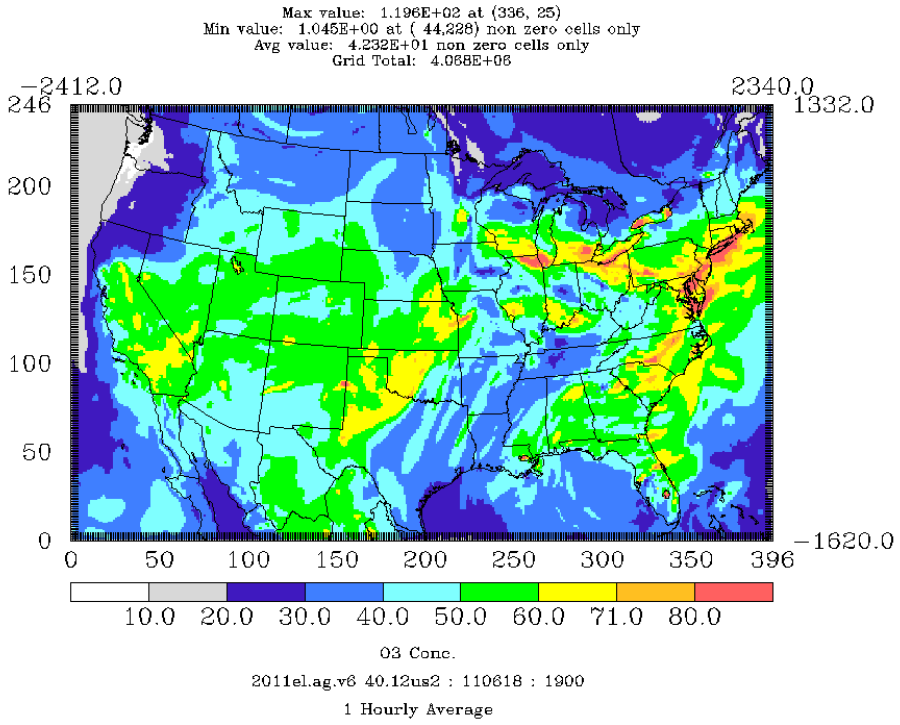
Examination of the animations show that in general CAMx 6.32 makes more ozone in the southern U.S. and intermountain west, and CAMx 6.40 makes more ozone in the northern U.S.

Table 4-1. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of Ozone Concentrations (ppb). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	6.32 Conc.	6.40 Conc.	Difference (ppb)	Percent Difference	Column	Row
Maximum Positive									
2011	6	18	19	112.01	97.54	14.48	14.8%	266	159
2011	6	18	20	108.71	94.81	13.90	14.7%	266	158
2011	5	22	21	96.36	83.07	13.29	16.0%	264	170
2011	5	30	20	98.40	85.45	12.95	15.2%	263	170
2011	5	22	20	94.40	81.49	12.91	15.8%	265	169
2011	5	30	19	79.99	67.27	12.73	18.9%	263	170
2011	5	22	19	85.52	73.75	11.78	16.0%	266	166
2011	5	22	22	95.40	83.90	11.50	13.7%	264	171
2011	6	18	18	97.04	86.28	10.76	12.5%	267	159
2011	6	18	17	113.30	102.83	10.47	10.2%	374	171
Maximum Negative									
2011	4	11	17	60.41	74.16	-13.74	-18.5%	327	56
2011	4	11	18	65.23	77.66	-12.43	-16.0%	327	57
2011	4	11	16	74.52	85.97	-11.45	-13.3%	321	31
2011	7	18	15	150.15	161.50	-11.35	-7.0%	230	239
2011	5	13	21	61.51	72.62	-11.11	-15.3%	224	37
2011	5	13	20	61.36	72.25	-10.89	-15.1%	225	38
2011	4	11	19	72.21	82.25	-10.04	-12.2%	330	42
2011	4	11	20	51.39	61.28	-9.89	-16.1%	220	37
2011	4	12	0	50.55	60.29	-9.74	-16.2%	46	91
2011	4	11	21	60.86	70.47	-9.61	-13.6%	221	36

Maximum Positive Difference: June 18 at 1900 hours

CAMx 6.40



Difference (6.32 - 6.40)

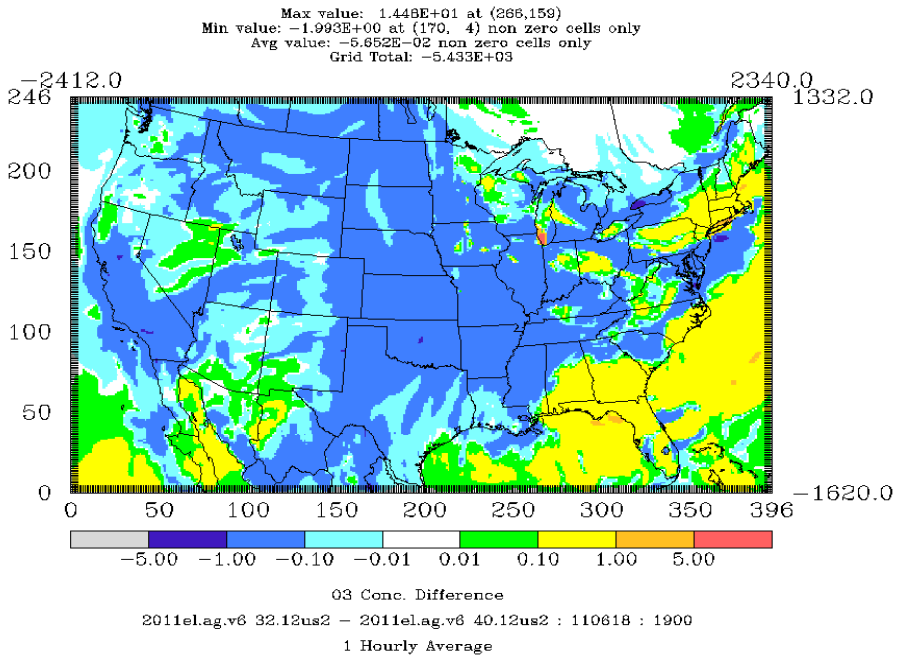
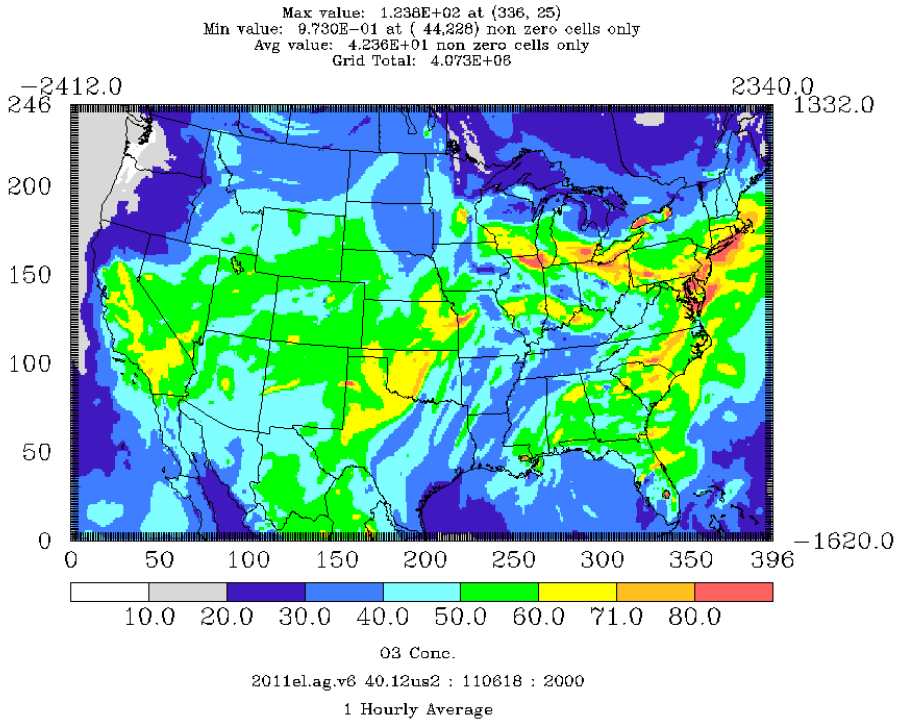


Figure 4-1: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: June 18 at 2000 hours

CAMx 6.40



Difference (6.32 - 6.40)

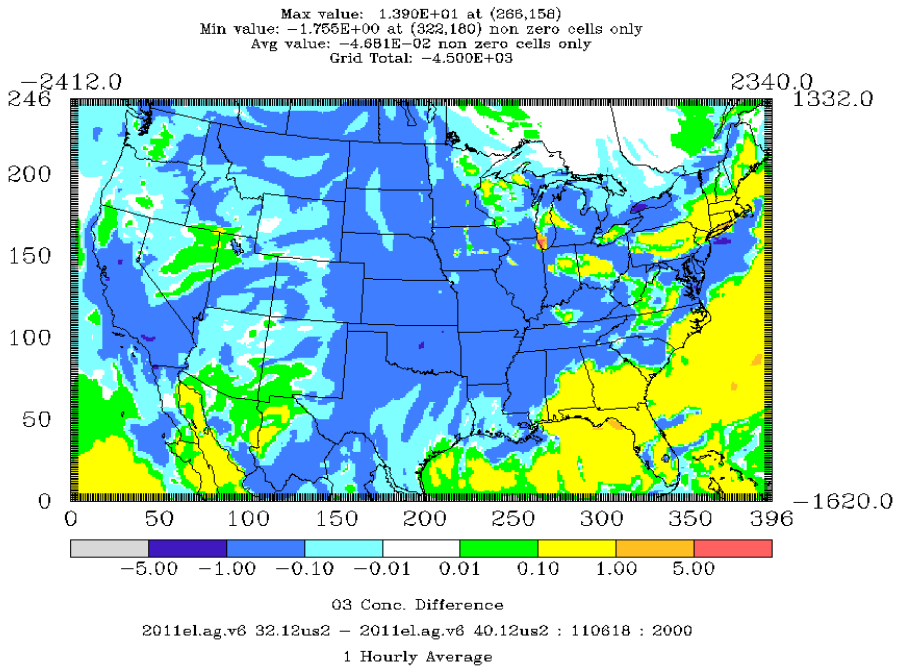
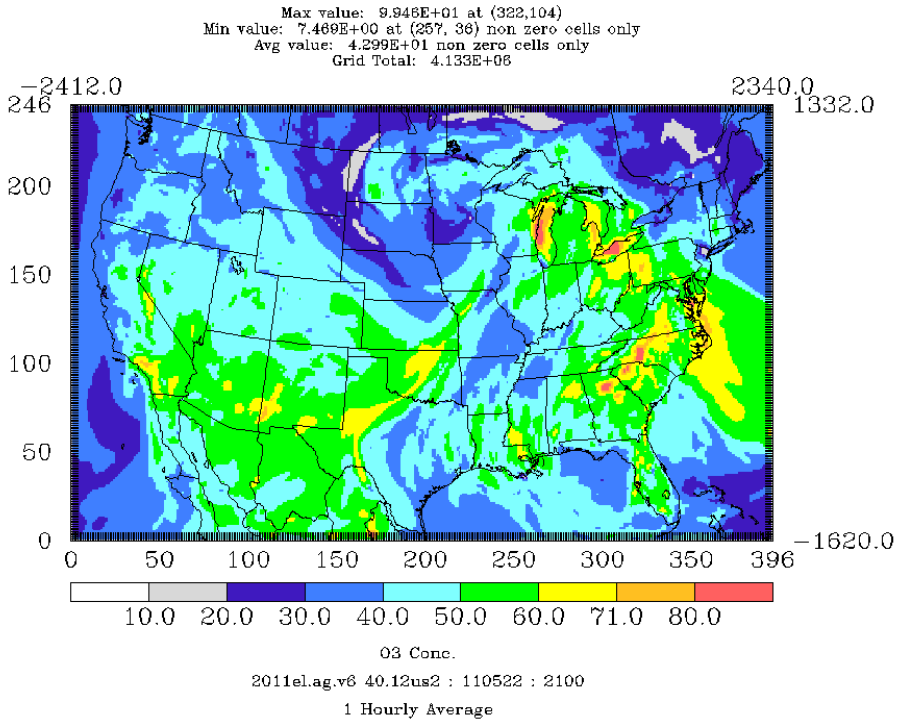


Figure 4-2: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: May 22 at 2100 hours

CAMx 6.40



Difference (6.32 - 6.40)

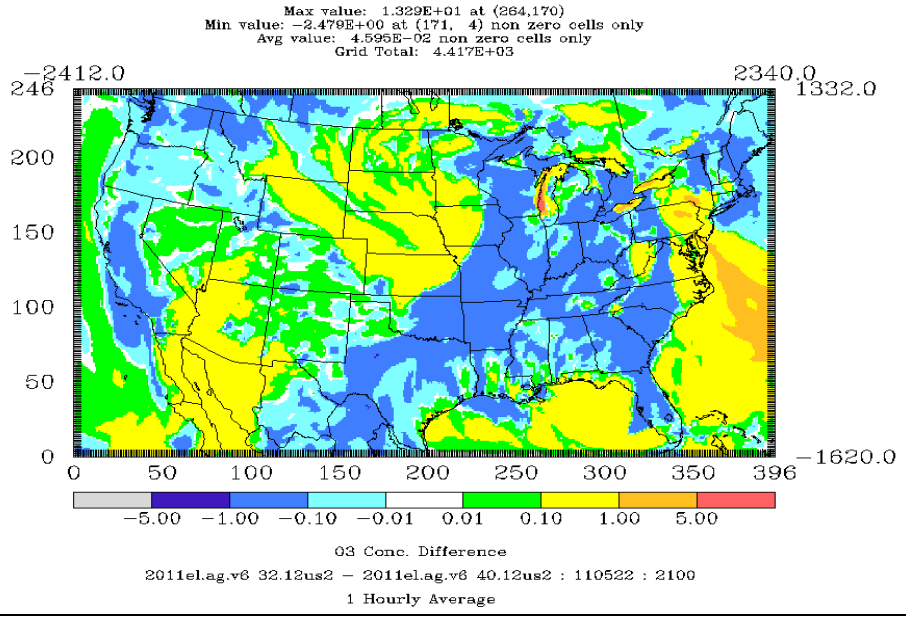
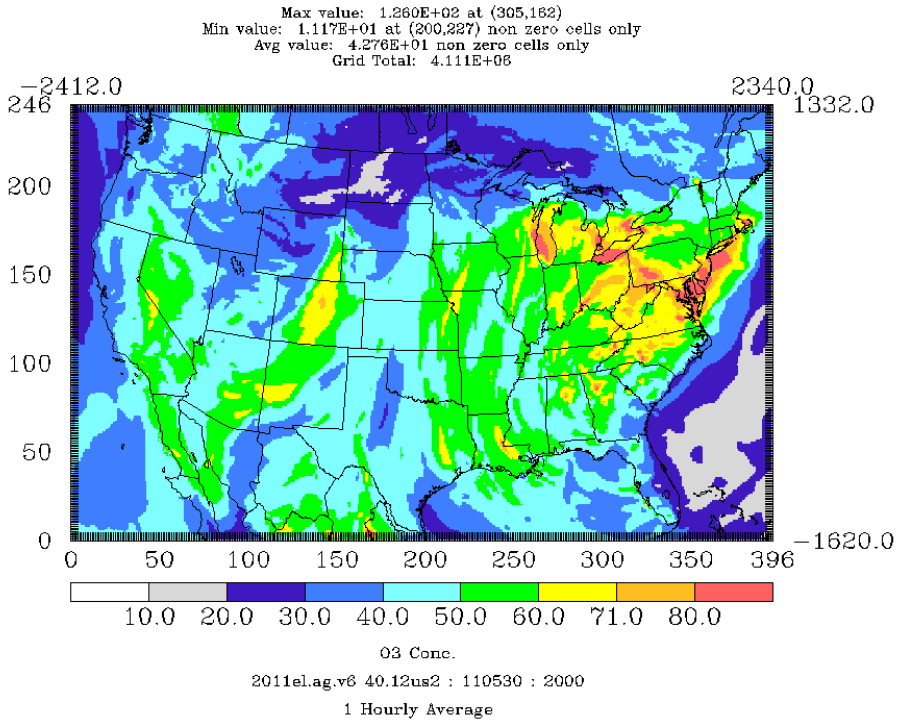


Figure 4-3: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: May 30 at 2000 hours

CAMx 6.40



Difference (6.32 - 6.40)

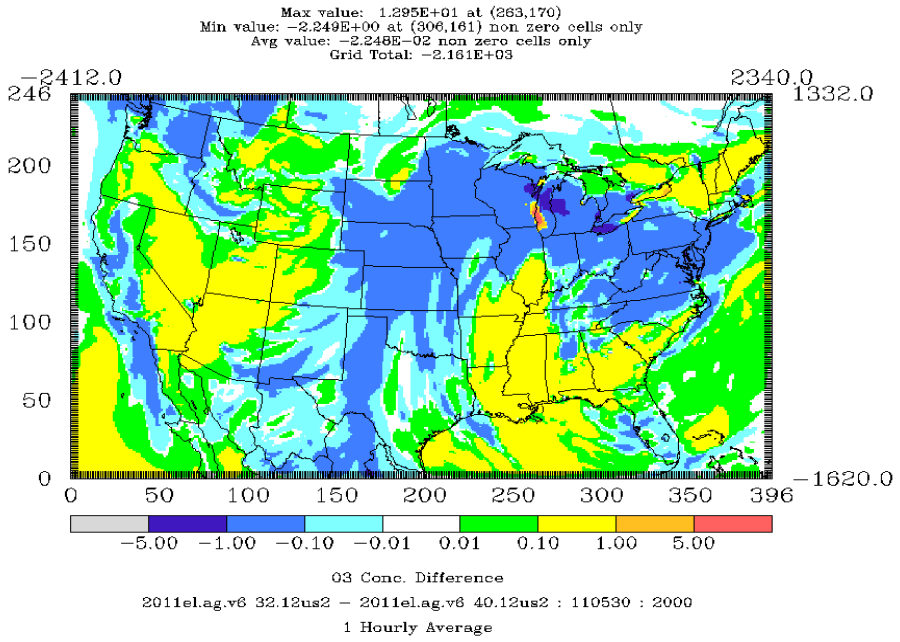
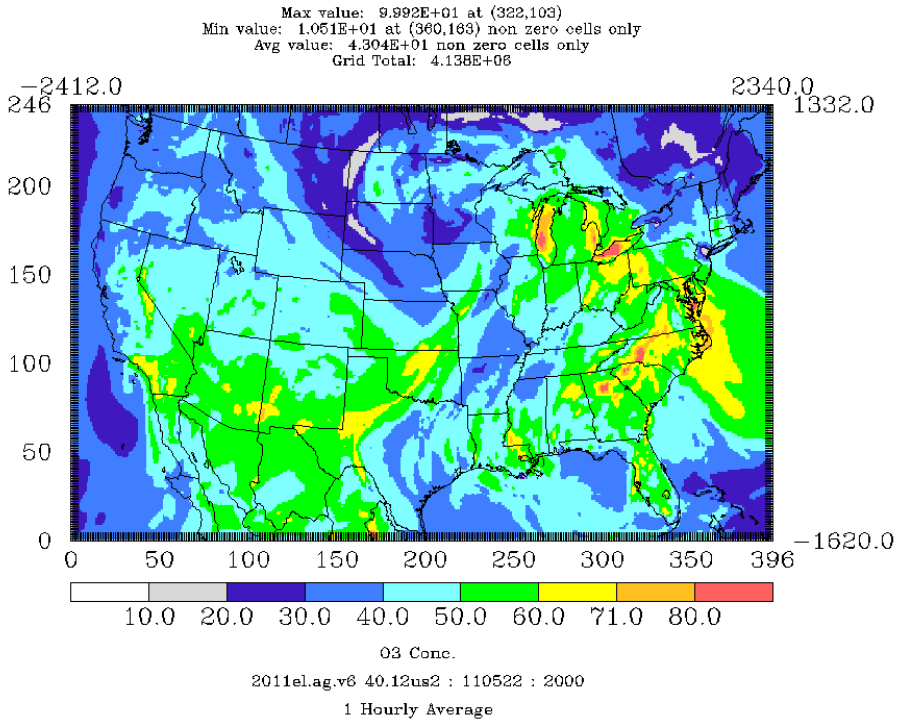


Figure 4-4: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: May 22 at 2000 hours

CAMx 6.40



Difference (6.32 - 6.40)

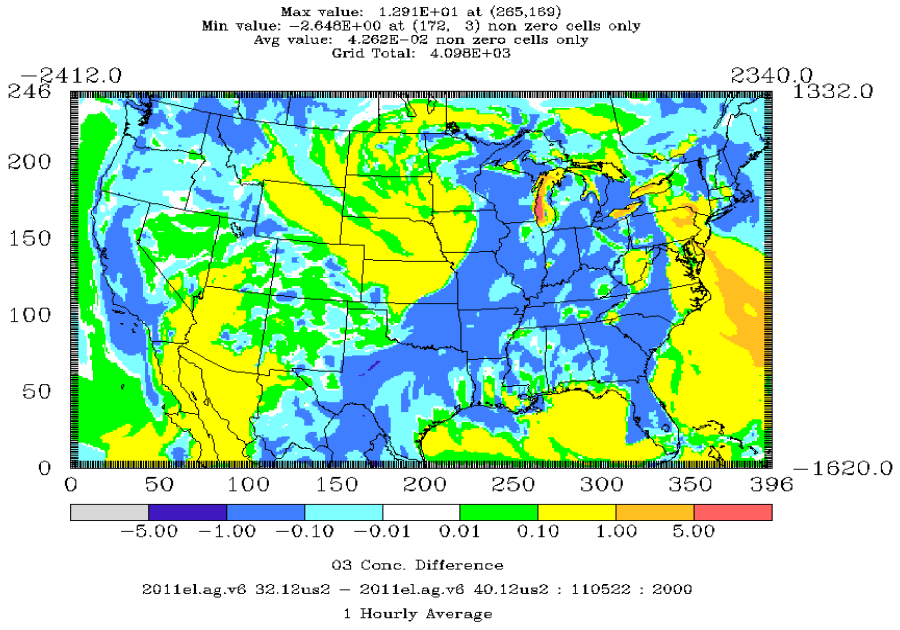
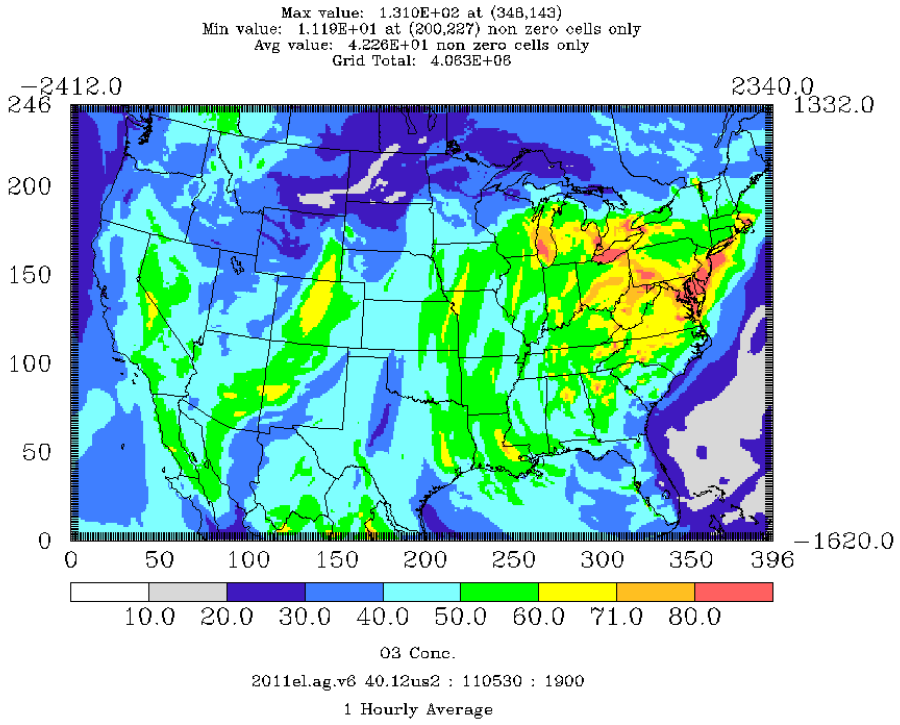


Figure 4-5: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: May 30 at 1900 hours

CAMx 6.40



Difference (6.32 - 6.40)

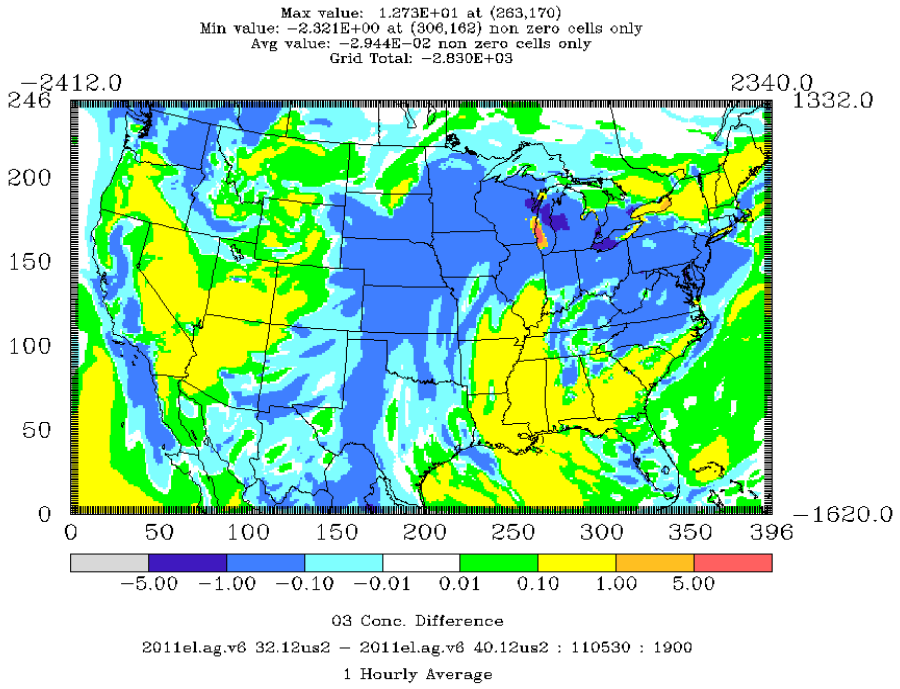
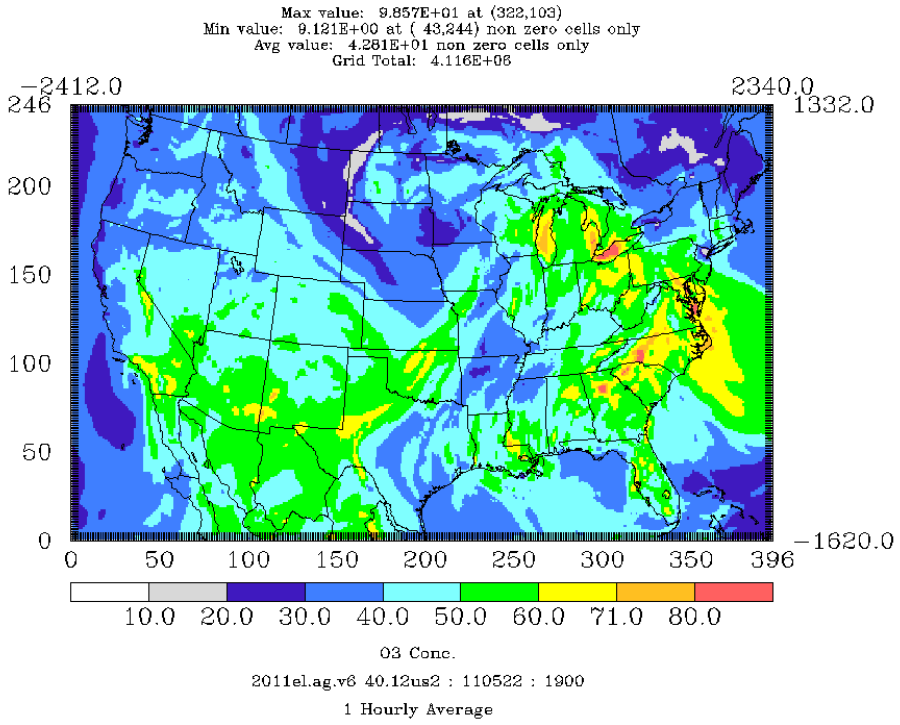


Figure 4-6: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: May 22 at 1900 hours

CAMx 6.40



Difference (6.32 - 6.40)

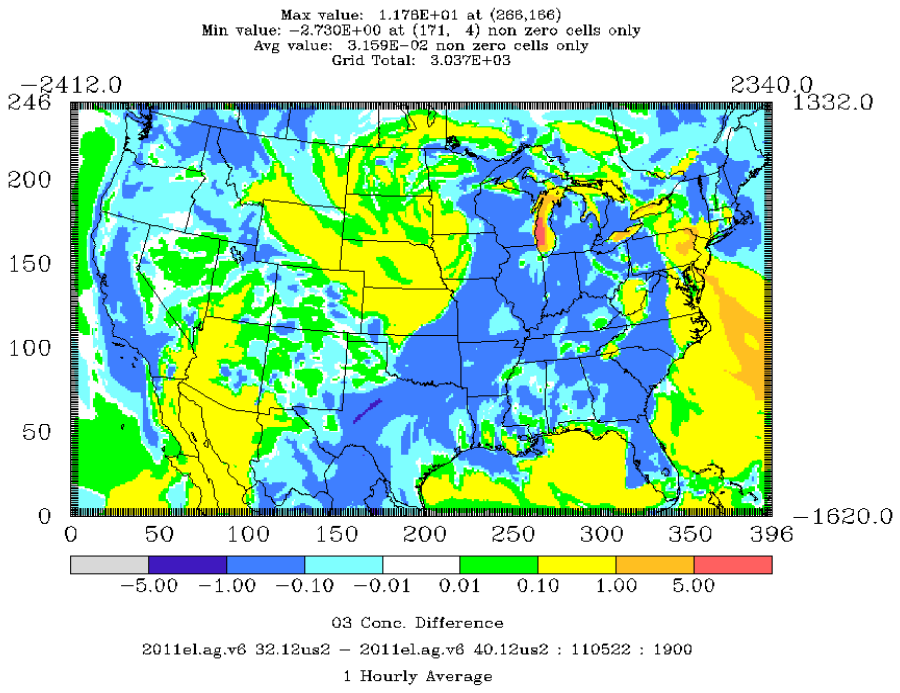
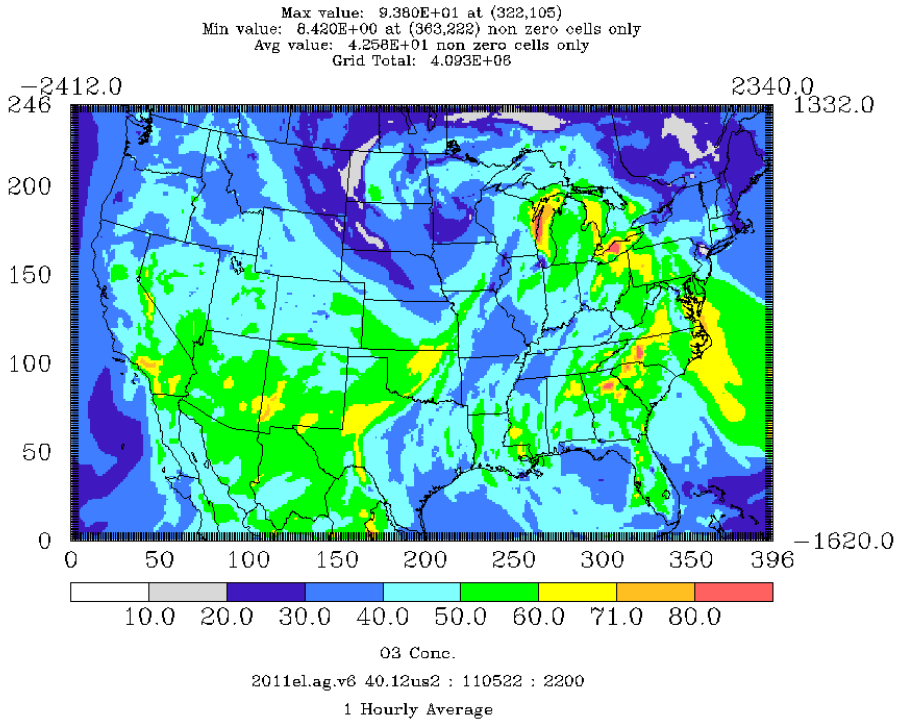


Figure 4-7: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: May 22 at 2200 hours

CAMx 6.40



Difference (6.32 - 6.40)

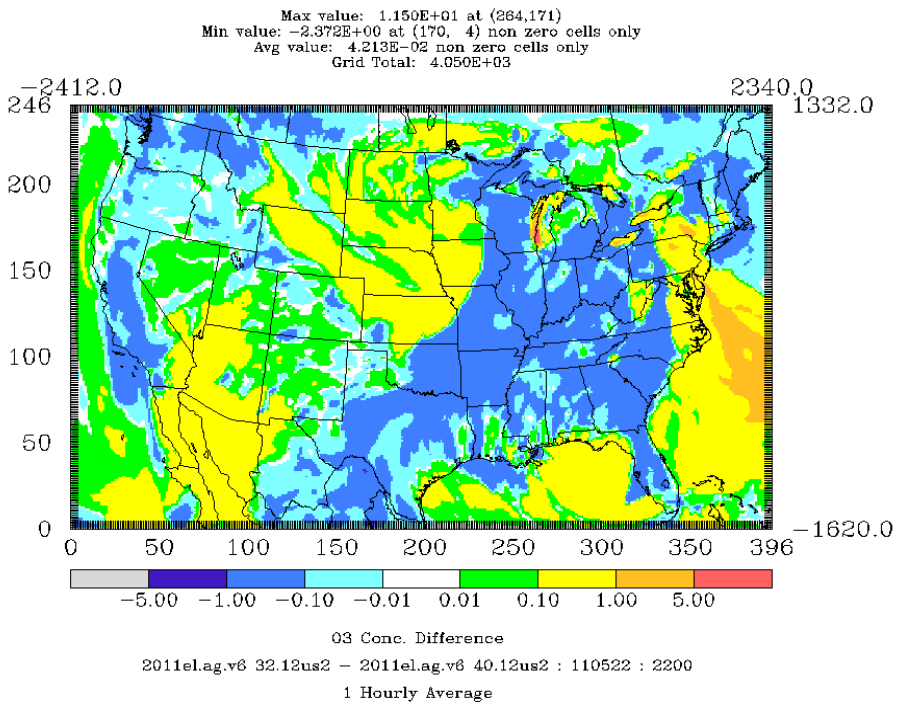
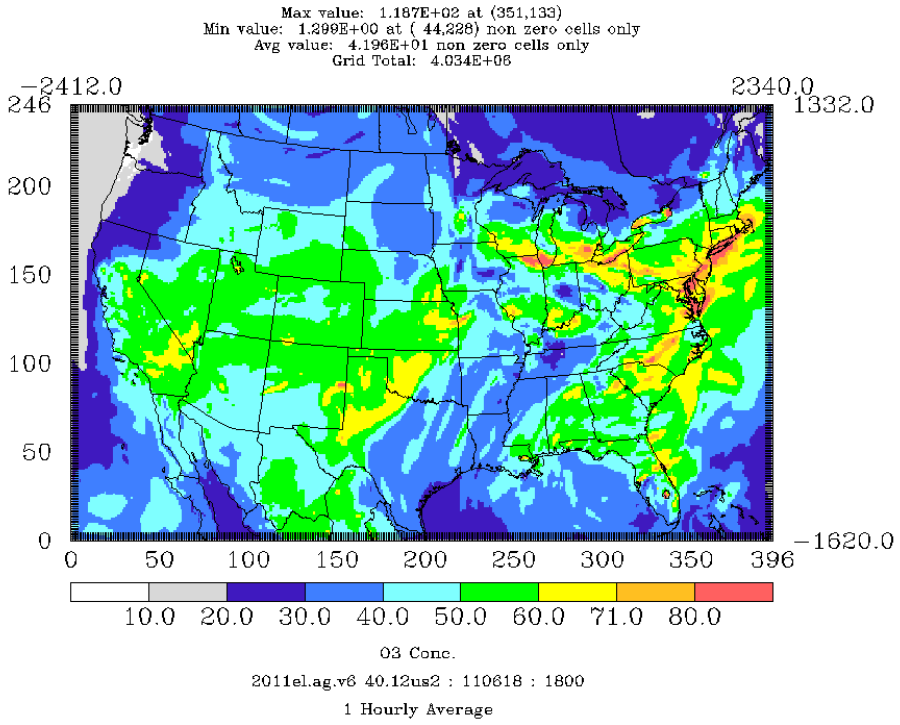


Figure 4-8: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: June 18 at 1800 hours

CAMx 6.40



Difference (6.32 - 6.40)

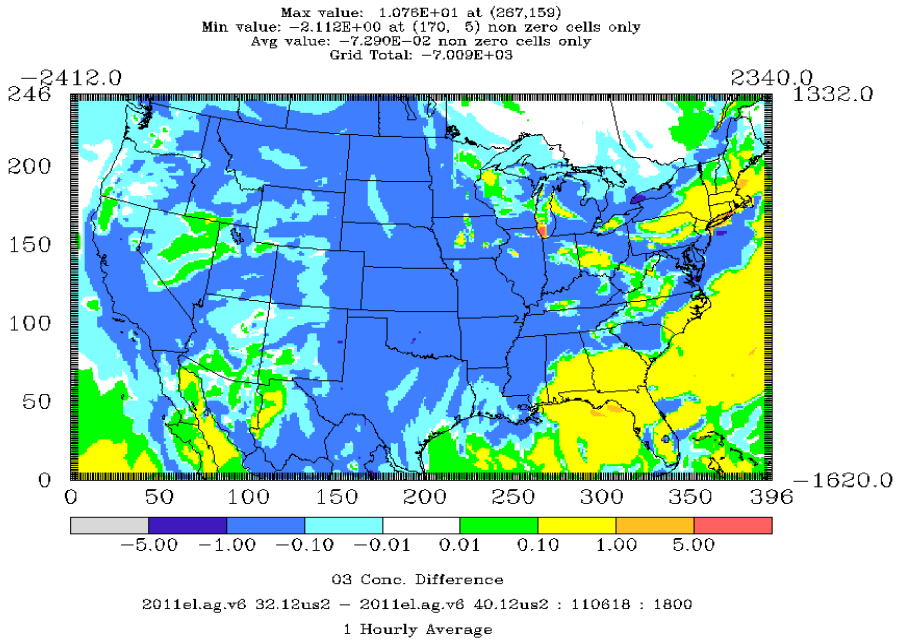
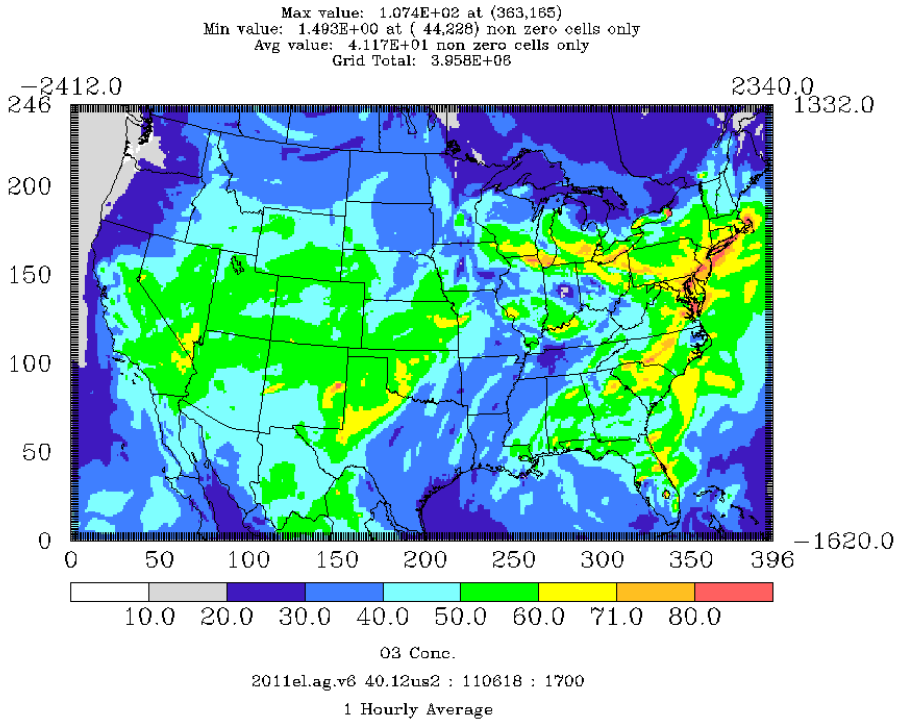


Figure 4-9: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: June 18 at 1700 hours

CAMx 6.40



Difference (6.32 - 6.40)

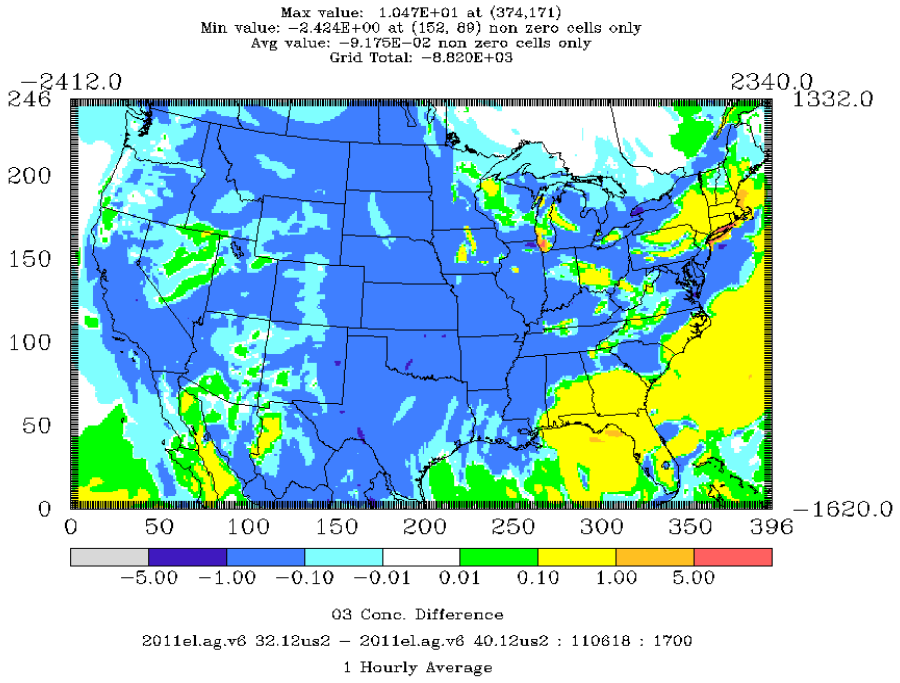
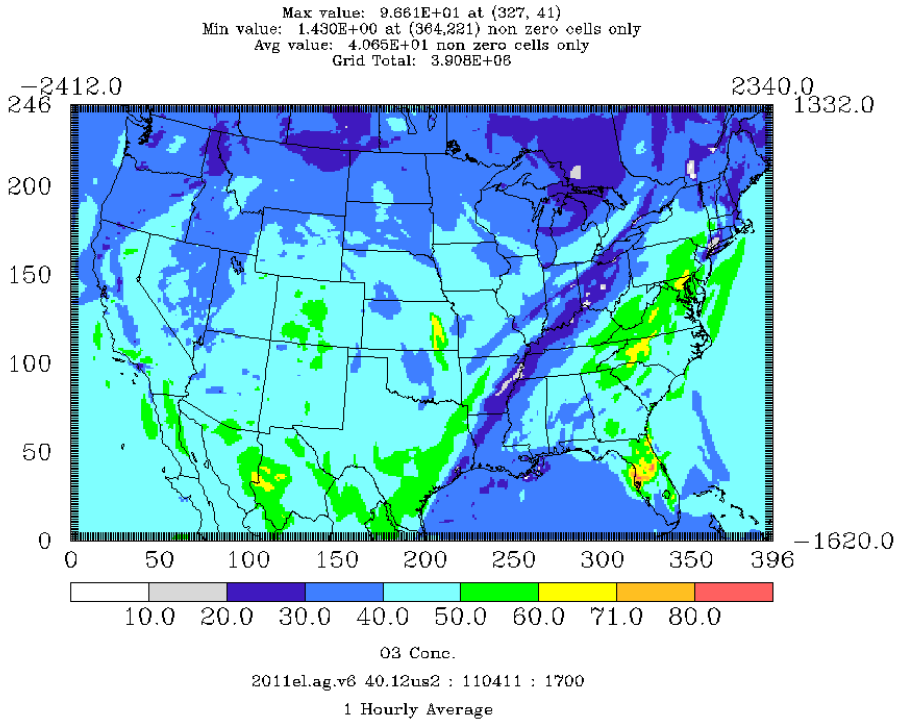


Figure 4-10: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: April 11 at 1700 hours

CAMx 6.40



Difference (6.32 - 6.40)

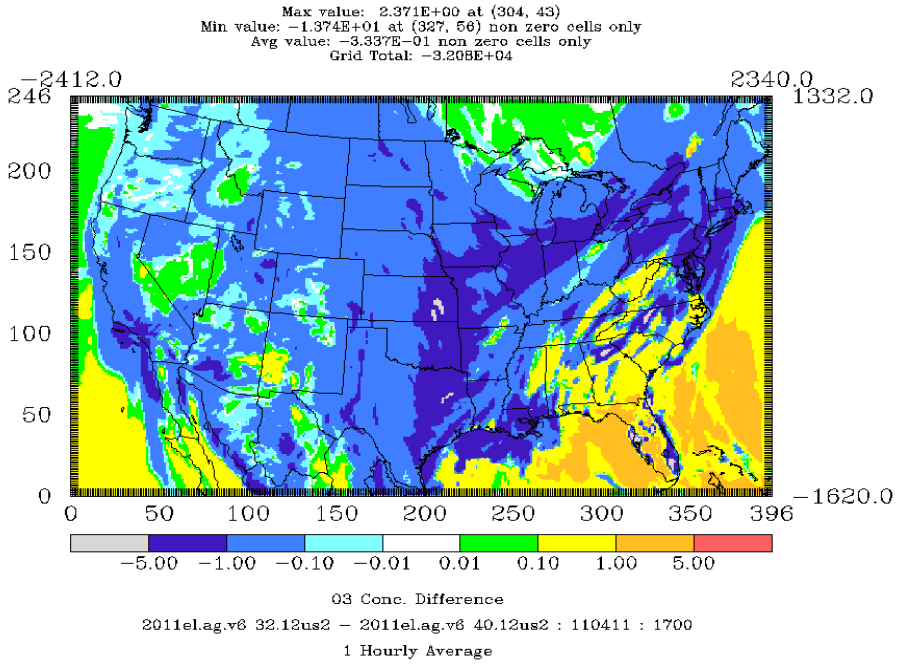
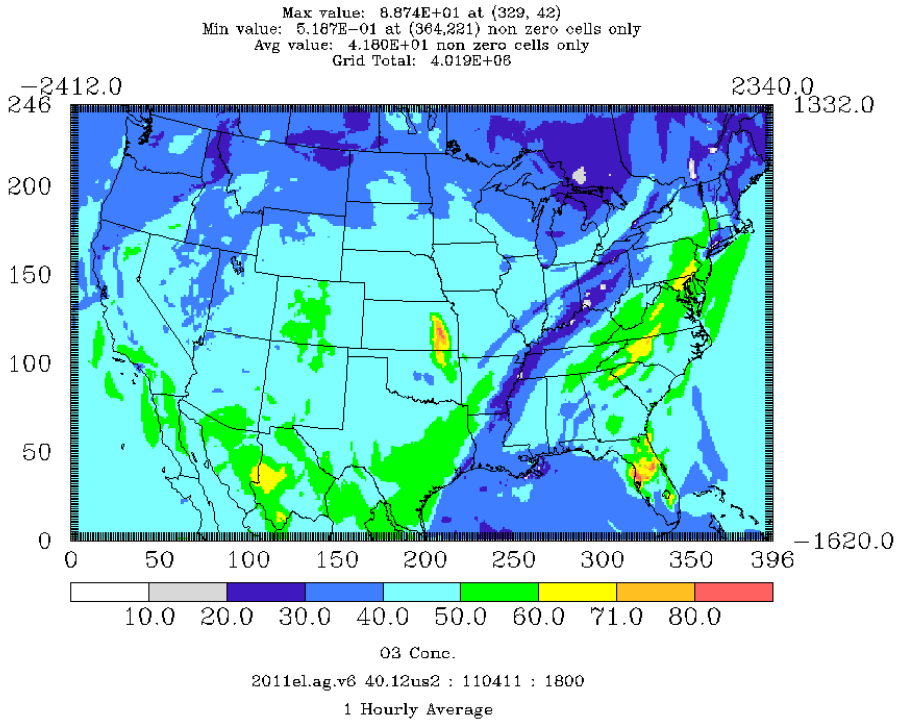


Figure 4-11: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: April 11 at 1800 hours

CAMx 6.40



Difference (6.32 - 6.40)

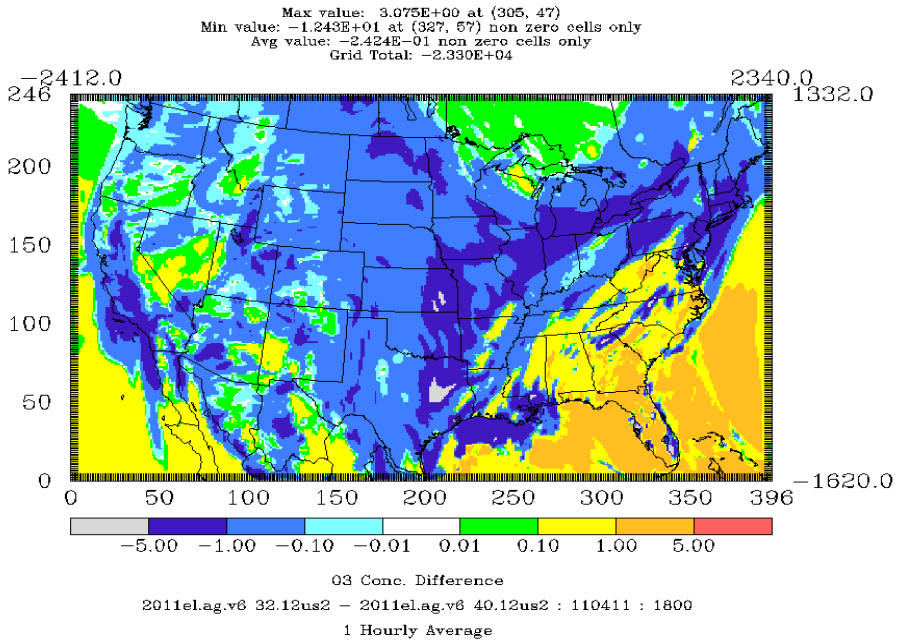
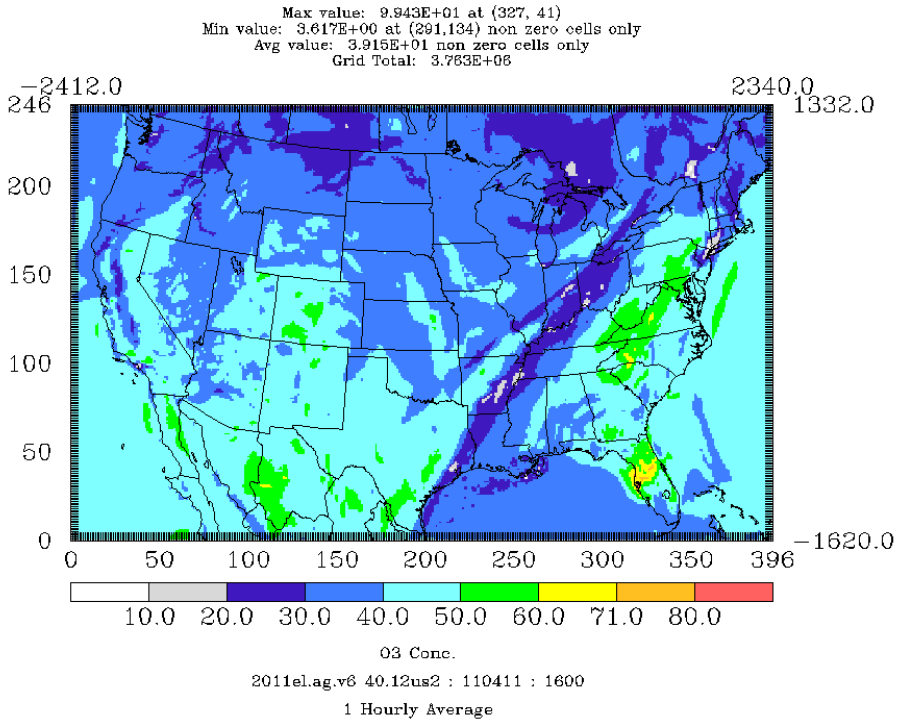


Figure 4-12: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: April 11 at 1600 hours

CAMx 6.40



Difference (6.32 - 6.40)

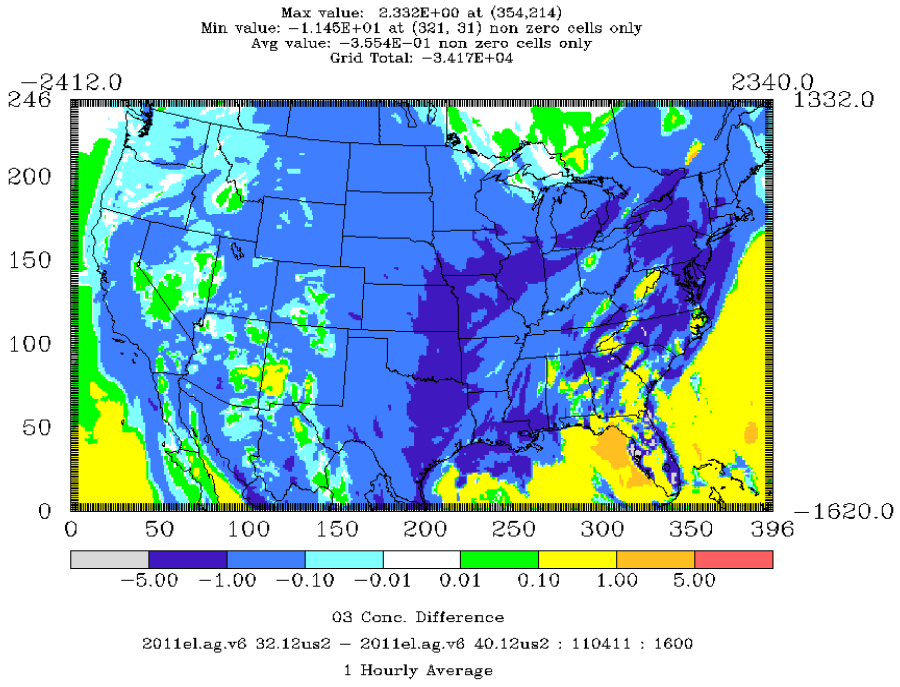
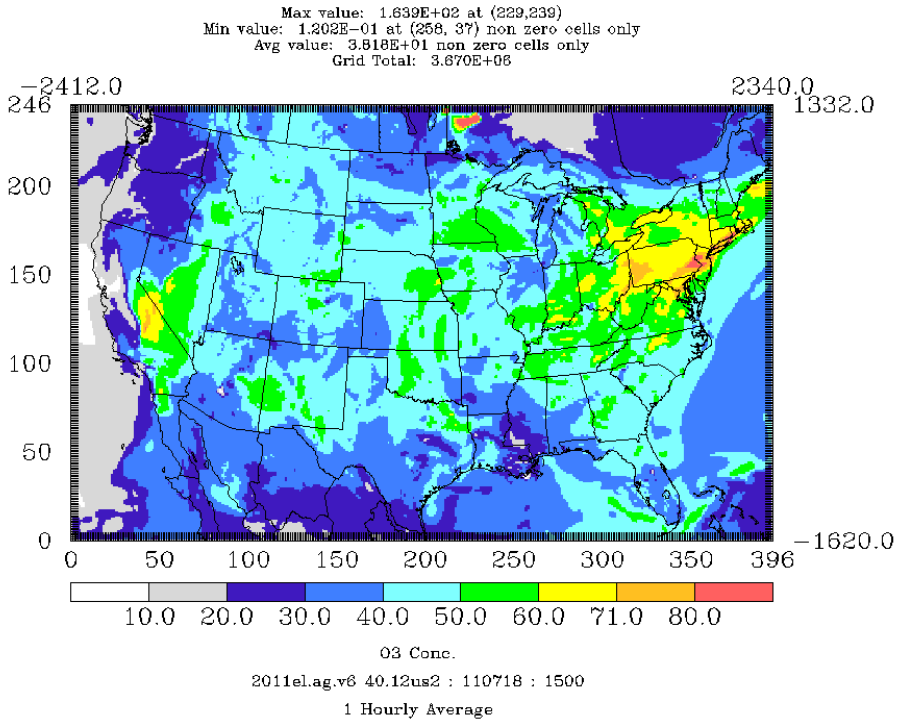


Figure 4-13: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 18 at 1500 hours

CAMx 6.40



Difference (6.32 - 6.40)

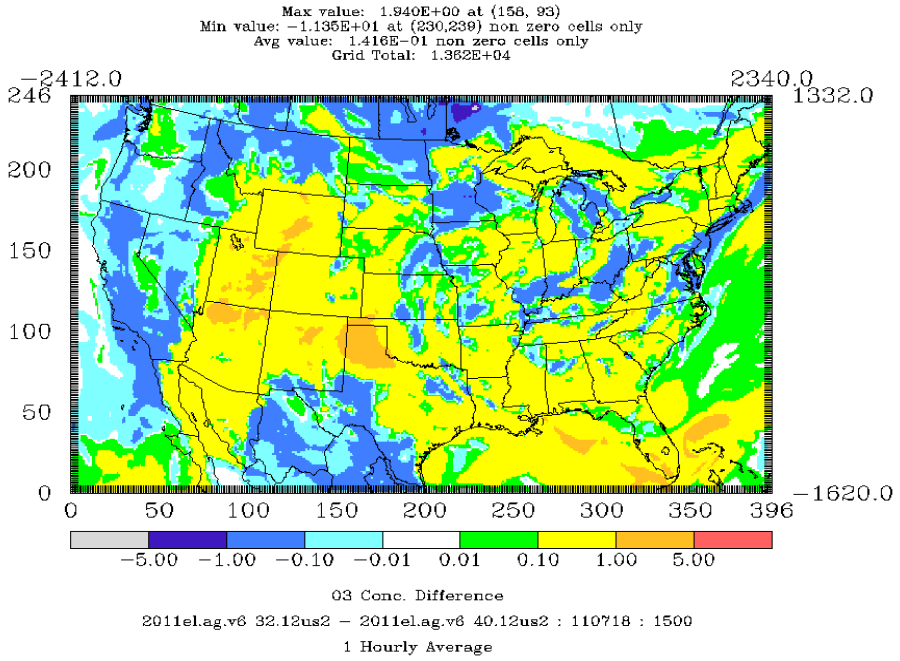
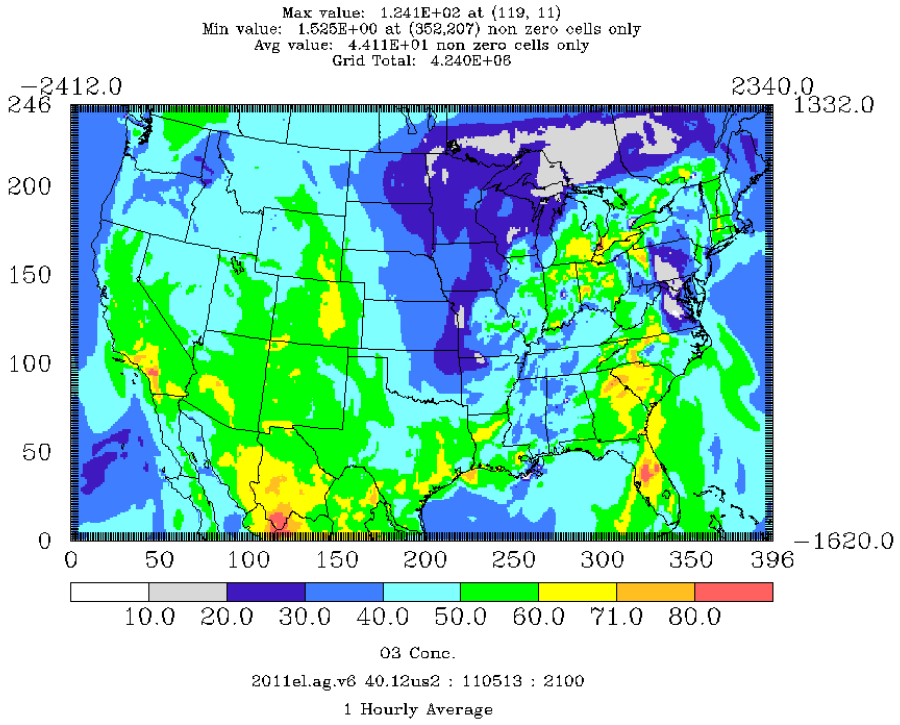


Figure 4-14: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: May 13 at 2100 hours

CAMx 6.40



Difference (6.32 - 6.40)

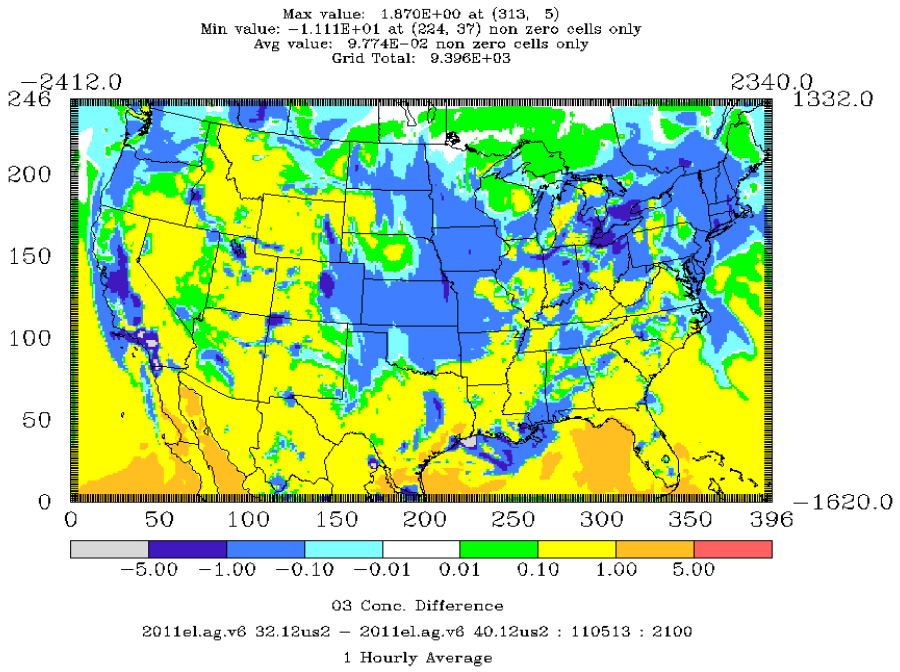
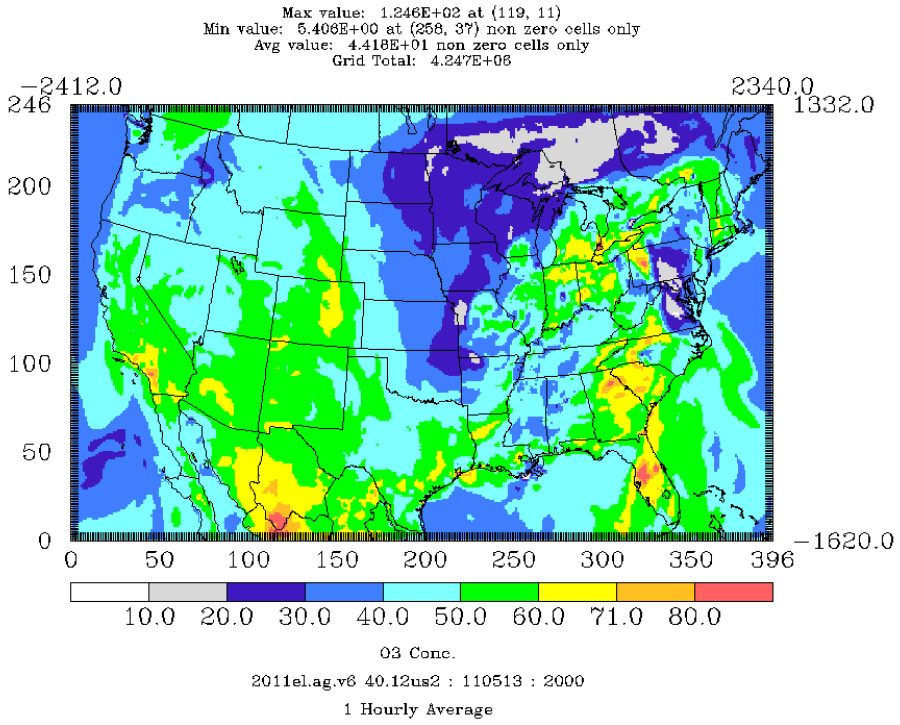


Figure 4-15: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: May 13 at 2000 hours

CAMx 6.40



Difference (6.32 - 6.40)

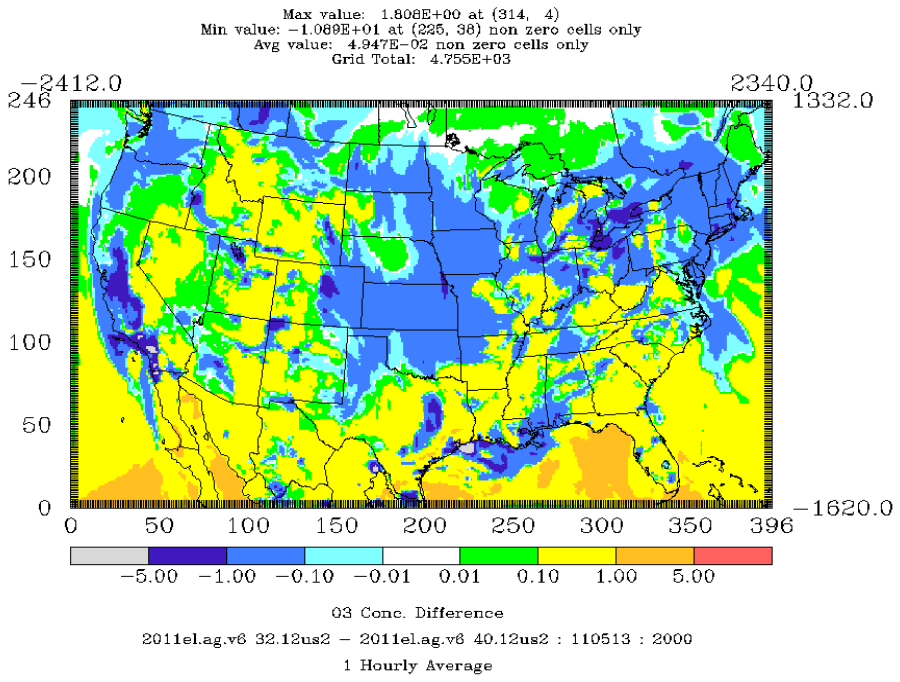
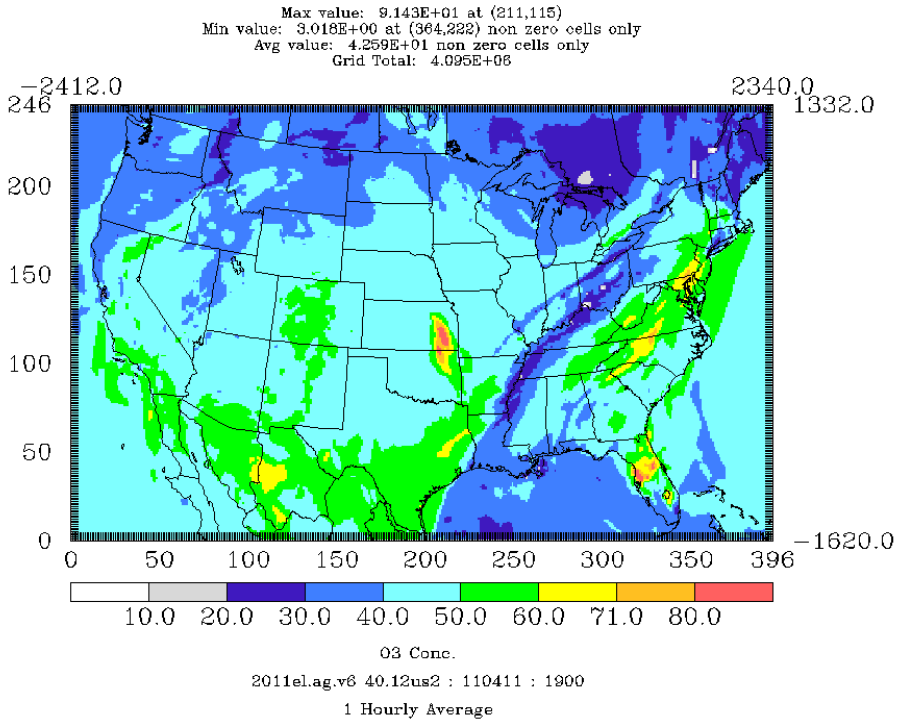


Figure 4-16: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: April 11 at 1900 hours

CAMx 6.40



Difference (6.32 - 6.40)

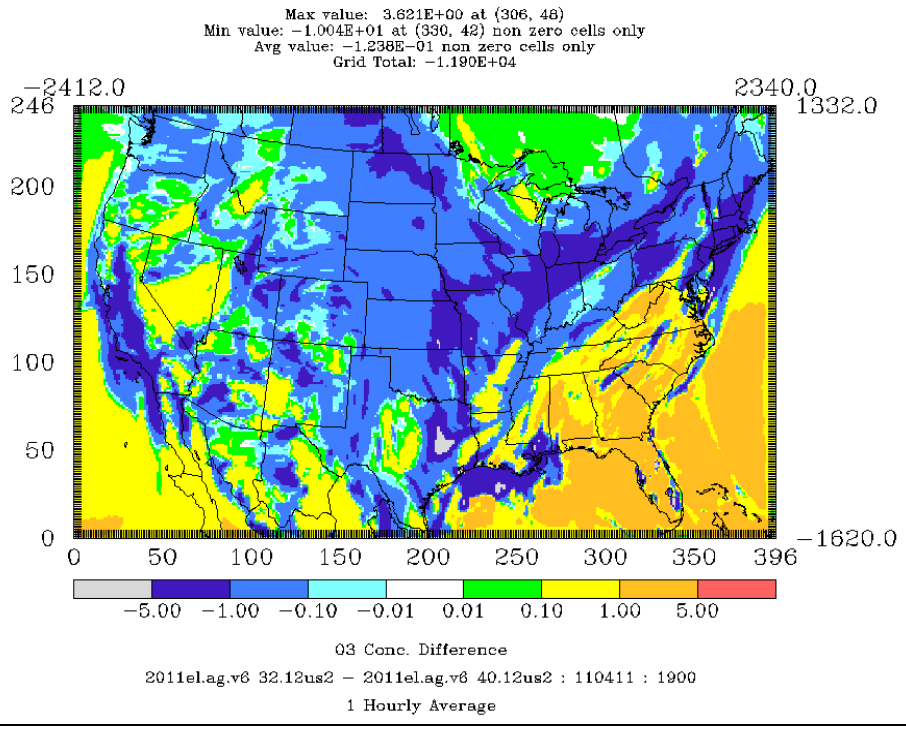
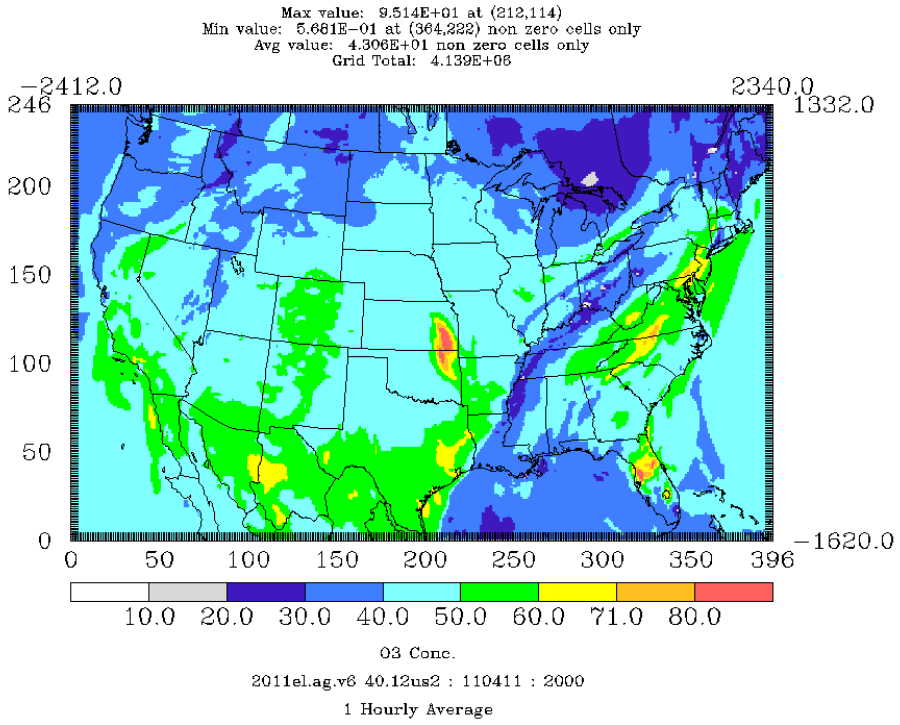


Figure 4-17: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: April 11 at 2000 hours

CAMx 6.40



Difference (6.32 - 6.40)

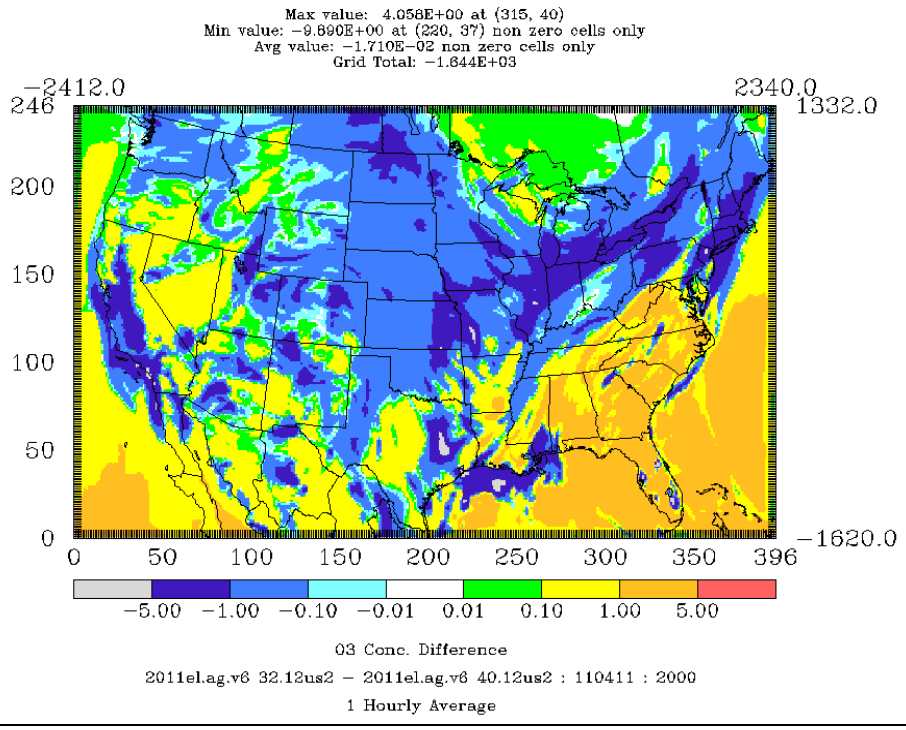
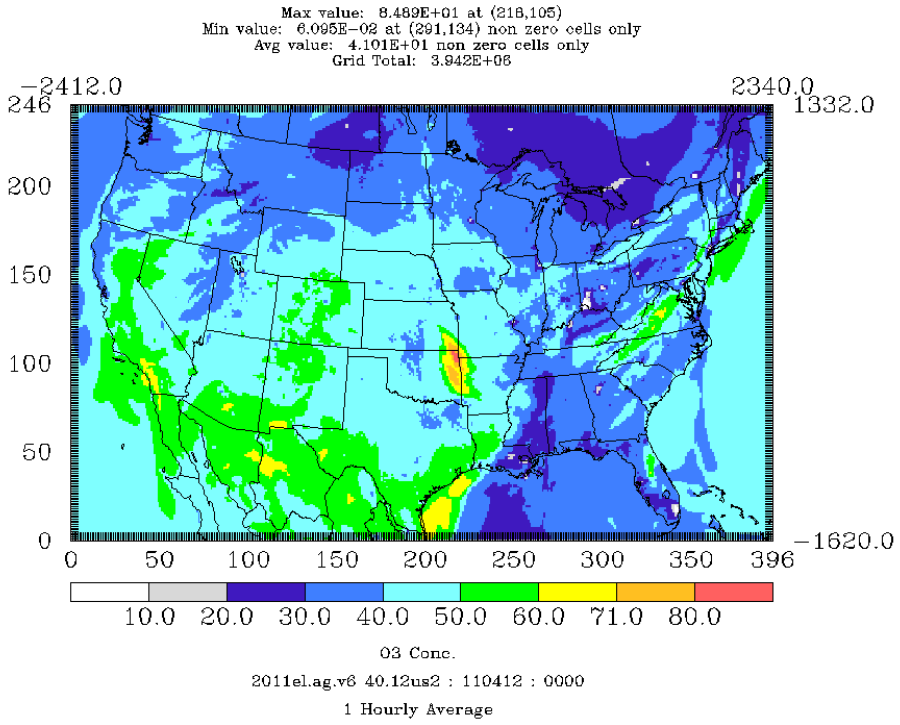


Figure 4-18: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference

Ninth Highest Negative Difference: April 12 at 0000 hours

CAMx 6.40



Difference (6.32 - 6.40)

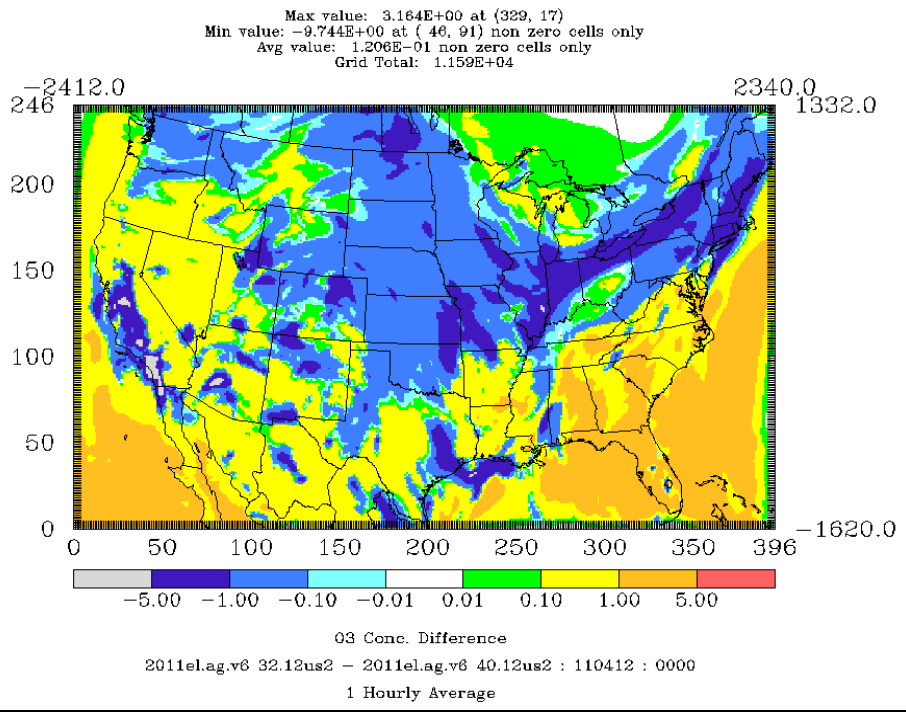
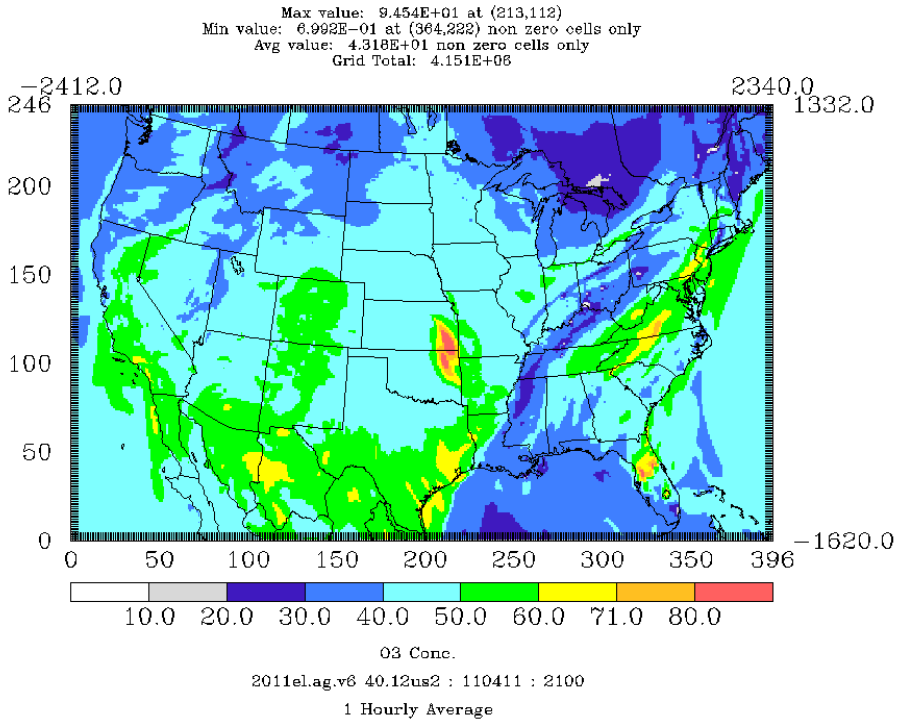


Figure 4-19: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: April 11 at 2100 hours

CAMx 6.40



Difference (6.32 - 6.40)

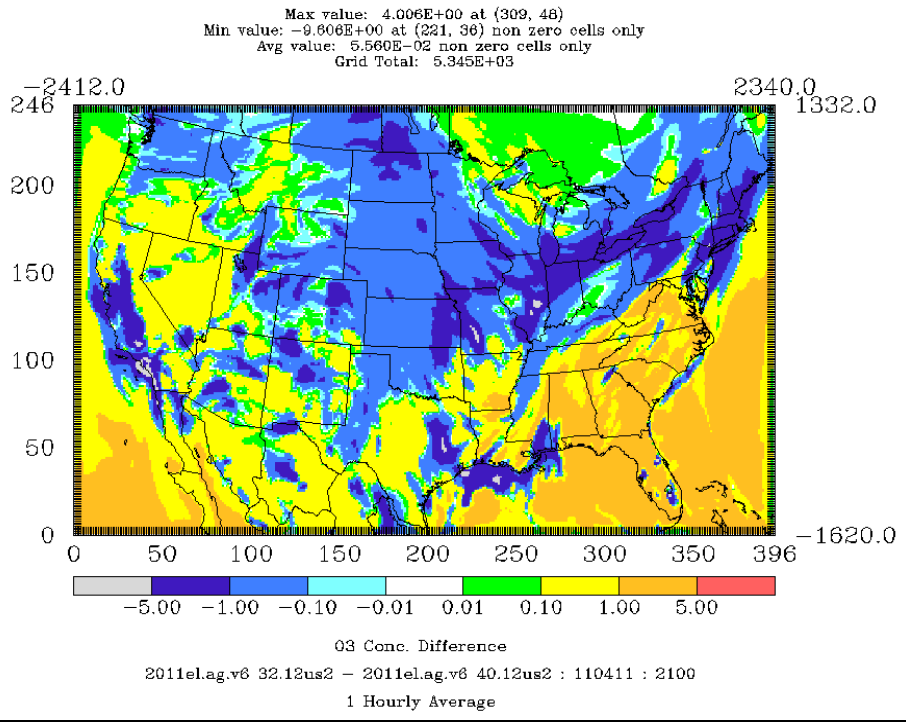


Figure 4-20: Comparison of Ozone Concentrations (ppb) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference)

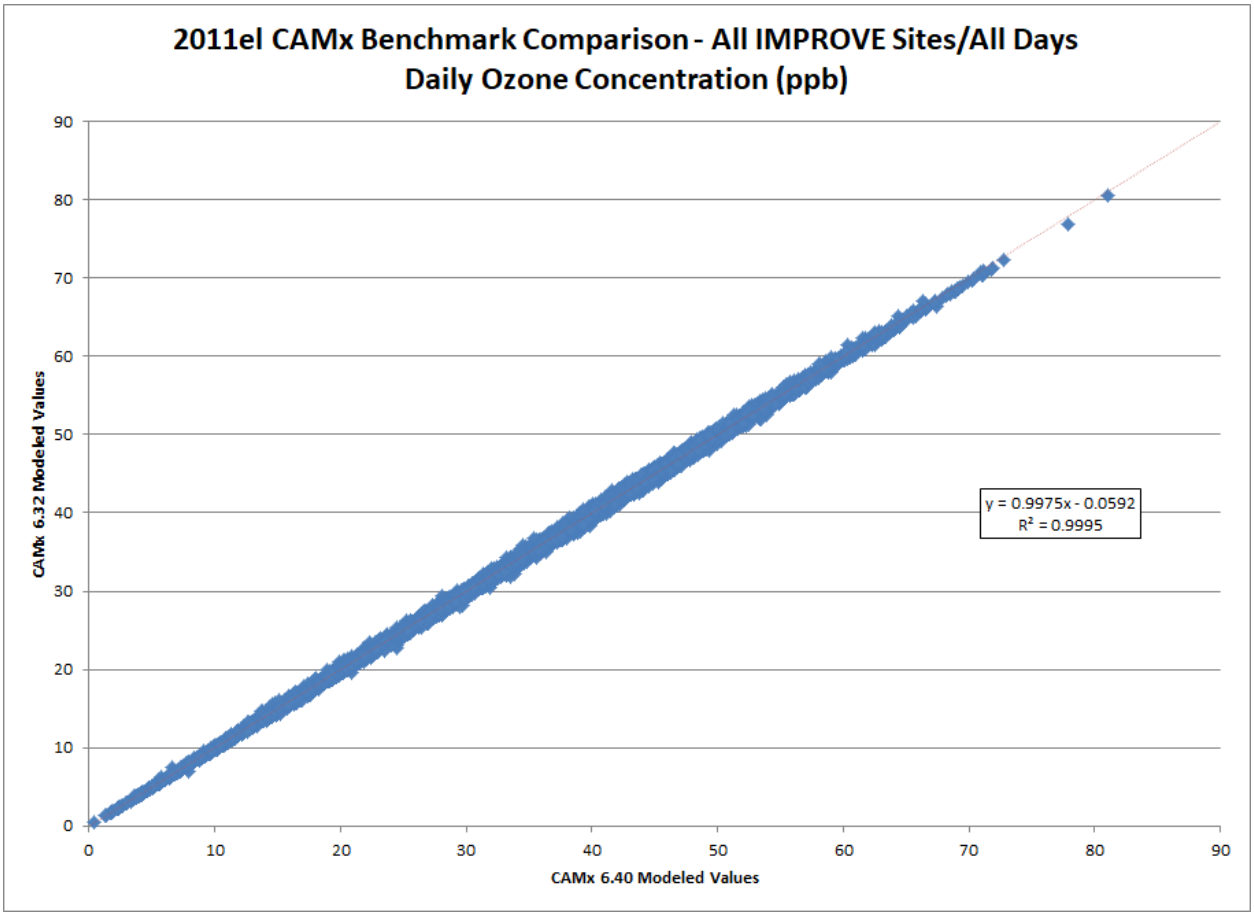


Figure 4-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine).

4.2 $PM_{2.5}$

$PM_{2.5}$ results for the top 10 positive and negative hours are presented in tabular format in Table 4-2. The maximum positive difference is 64.76 micrograms per cubic meter ($\mu g/m^3$) falling to 52.61 $\mu g/m^3$ for the 10th high. The maximum negative difference is -35.09 $\mu g/m^3$ falling to -18.42 $\mu g/m^3$ for the 10th high. The maximum positive percent difference from these days is 1445% and negative percent difference of -59%. On the day of the maximum positive difference (September 24 at 0400) the maximum difference in $PM_{2.5}$ concentration was 64. $\mu g/m^3$ ppb. At this hour the difference in the sulfate, nitrate, and OM concentrations were 10.26 $\mu g/m^3$, 28.08 $\mu g/m^3$, 9.28 $\mu g/m^3$, respectively with the difference dominated by the differences in the nitrate estimates.

The top 10 positive difference hours are presented in Figures 4-22 through 4-31. The hours of the maximum positive difference are tending to occur in two periods on August 26 and September 24. The CAMx 6.40 results are significantly lower that CAMx 6.32 throughout the majority of the domain. On August 26 the region of the maximum difference is offshore of Florida, Georgia, and South Carolina. This appears to be Hurricane Irene that was active during this time

The top 10 negative impact hours are presented in Figures 4-32 through 4-41. While the majority of the domain shows positive difference (CAMx 6.32 with higher concentrations), there are scattered regions where CAMx 6.40 is higher.

Scatterplots of the daily average $PM_{2.5}$ concentrations in local standard time at the IMPROVE monitors are presented in Figures 4-42 and 4-43. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0083, an intercept of 0.4966 $\mu g/m^3$and an R^2 of 0.9875. The agreement between the models is higher at higher concentrations. At lower concentrations the CAMx 6.32 results are higher than the CAMx 6.40 results.

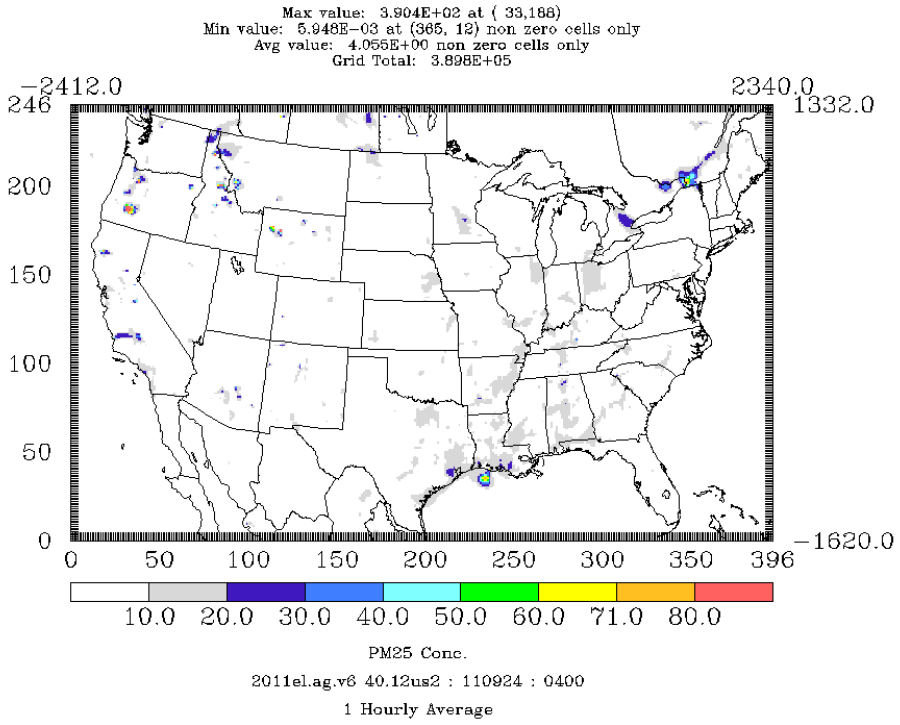
Examination of the animations clearly shows the Hurricane Irene entering the domain on August 24th and moving up the eastern seaboard through August 28th.

Table 4-2. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of $PM_{2.5}$ Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	6.32 Conc.	6.40 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	9	24	4	69.24	4.48	64.76	1445.0%	342	201
2011	9	24	3	72.57	10.31	62.27	604.0%	343	201
2011	8	26	14	71.90	11.64	60.27	517.9%	358	62
2011	9	24	5	63.70	5.32	58.37	1096.3%	342	200
2011	8	26	12	73.55	15.55	58.00	373.0%	359	58
2011	8	26	13	74.13	17.34	56.79	327.5%	359	60
2011	8	26	15	67.82	12.01	55.81	464.5%	357	64
2011	8	26	17	68.07	13.57	54.49	401.5%	357	69
2011	8	26	16	85.96	32.42	53.54	165.2%	357	68
2011	8	26	20	64.19	11.58	52.61	454.3%	355	75
Maximum Negative									
2011	7	20	14	4,665.24	4,700.33	-35.09	-0.7%	231	244
2011	7	20	12	6,908.06	6,937.38	-29.32	-0.4%	231	244
2011	7	20	13	5,435.89	5,464.69	-28.79	-0.5%	231	244
2011	7	20	11	8,766.18	8,789.09	-22.92	-0.3%	231	243
2011	7	20	15	5,136.34	5,157.34	-21.00	-0.4%	230	243
2011	7	20	18	1,471.59	1,492.23	-20.64	-1.4%	227	244
2011	7	3	21	12.76	31.44	-18.68	-59.4%	269	156
2011	8	19	5	80.11	98.72	-18.61	-18.9%	216	52
2011	7	3	22	13.37	31.92	-18.54	-58.1%	269	156
2011	7	20	19	1,215.64	1,234.06	-18.42	-1.5%	226	244

Maximum Positive Difference: September 24 at 400 hours

CAMx 6.40



Difference (6.32 - 6.40)

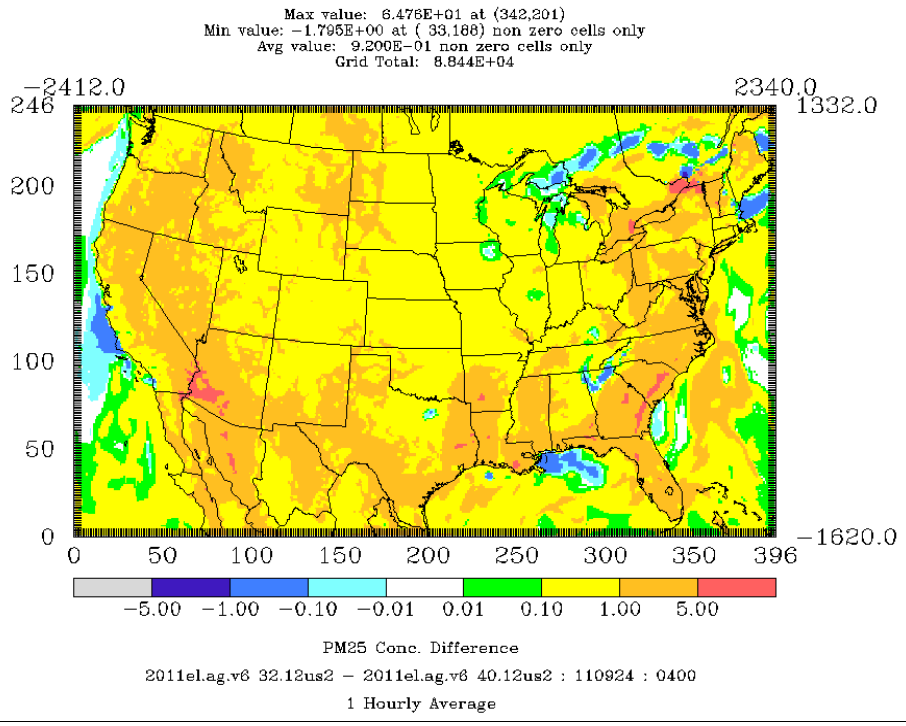
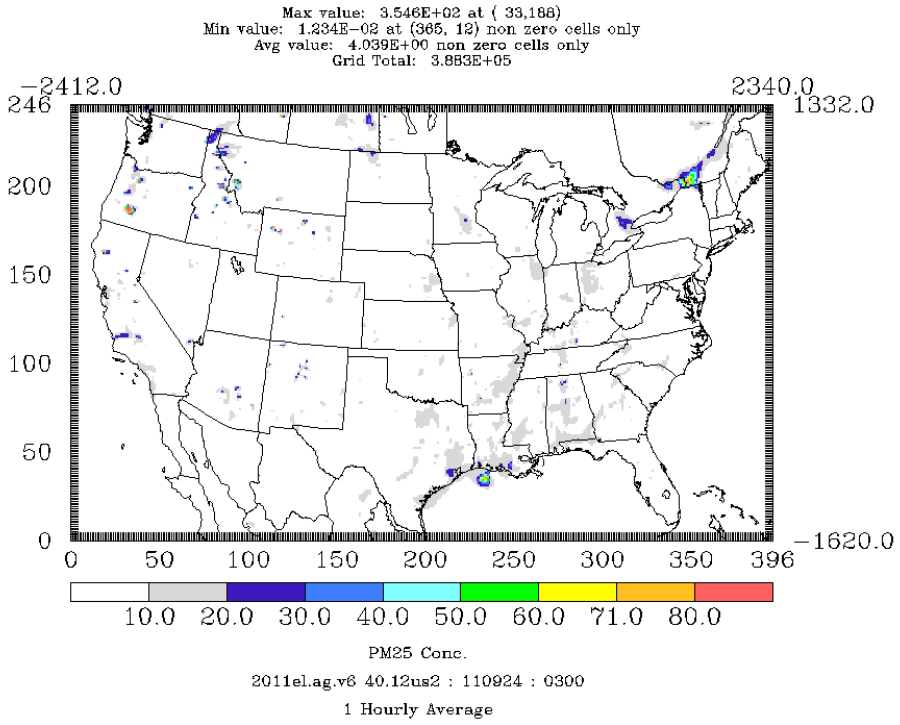


Figure 4-22: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: September 24 at 300 hours

CAMx 6.40



Difference (6.32 - 6.40)

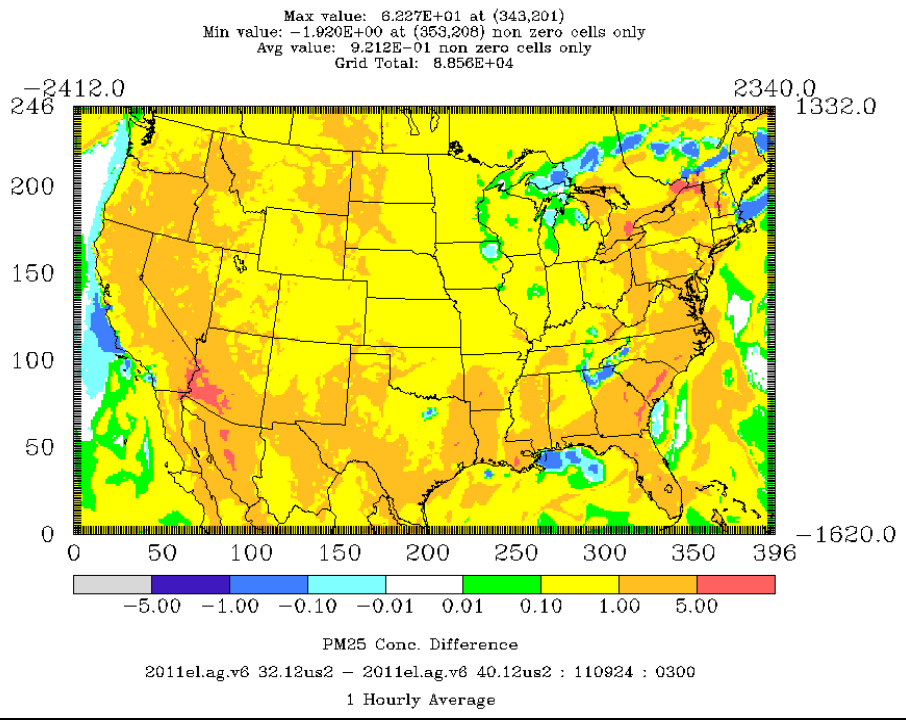
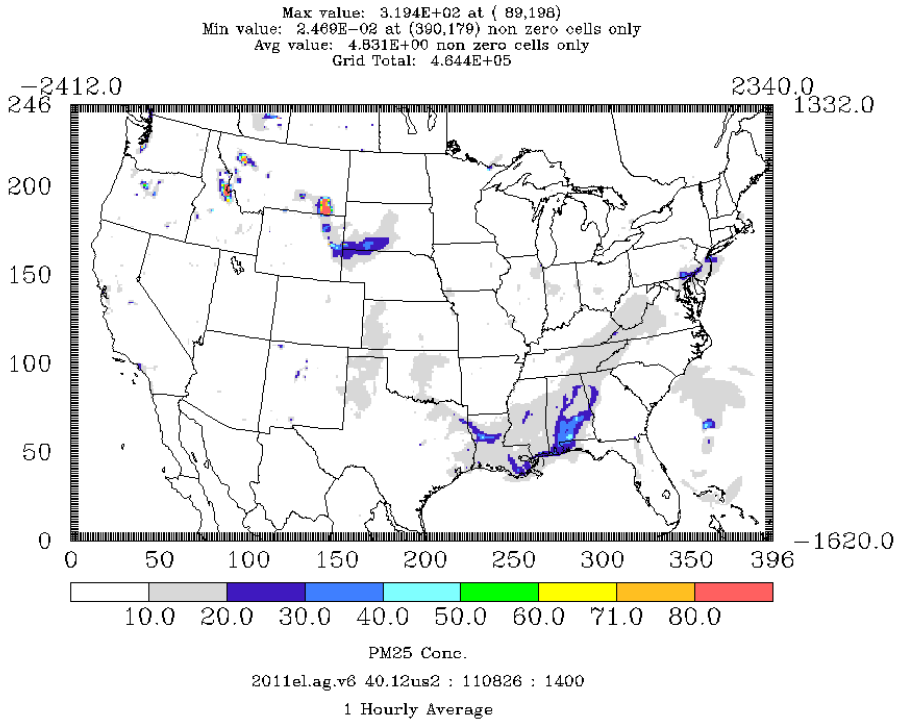


Figure 4-23: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: August 26 at 1400 hours

CAMx 6.40



Difference (6.32 - 6.40)

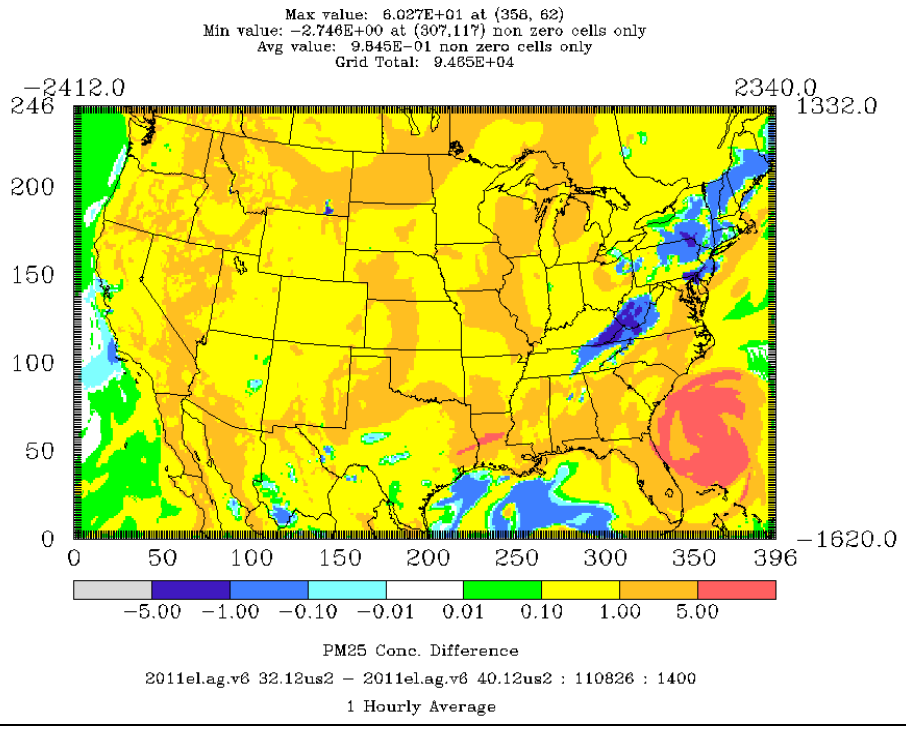
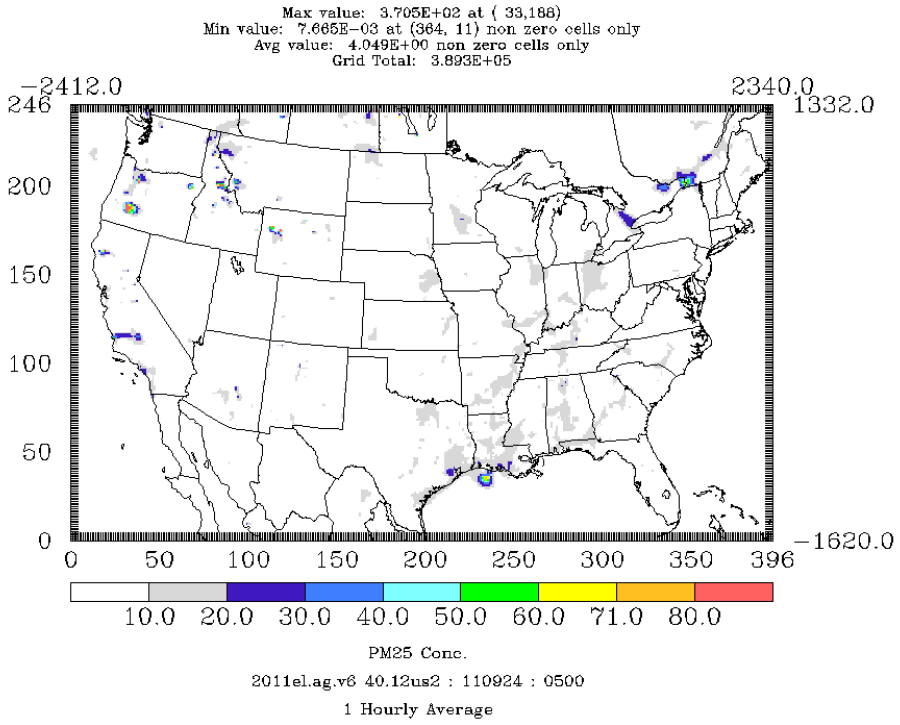


Figure 4-24: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: September 24 at 500 hours

CAMx 6.40



Difference (6.32 - 6.40)

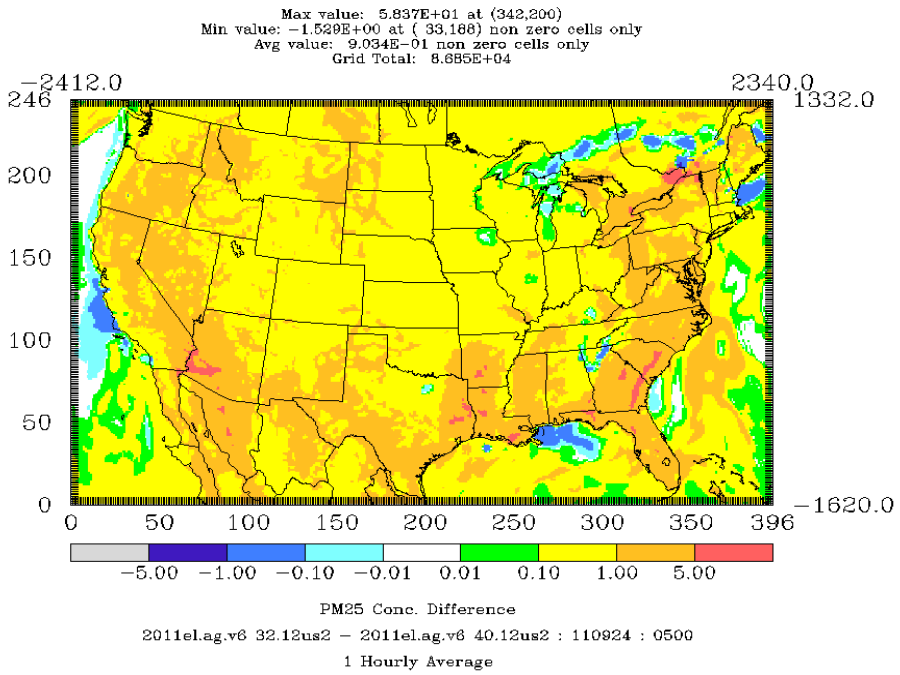
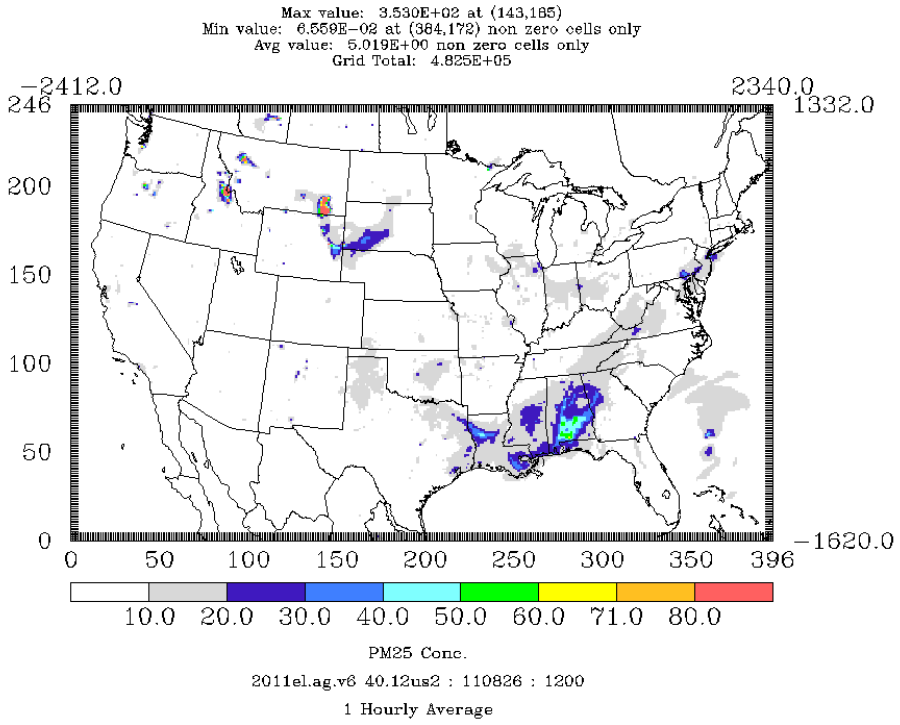


Figure 4-25: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: August 26 at 1200 hours

CAMx 6.40



Difference (6.32 - 6.40)

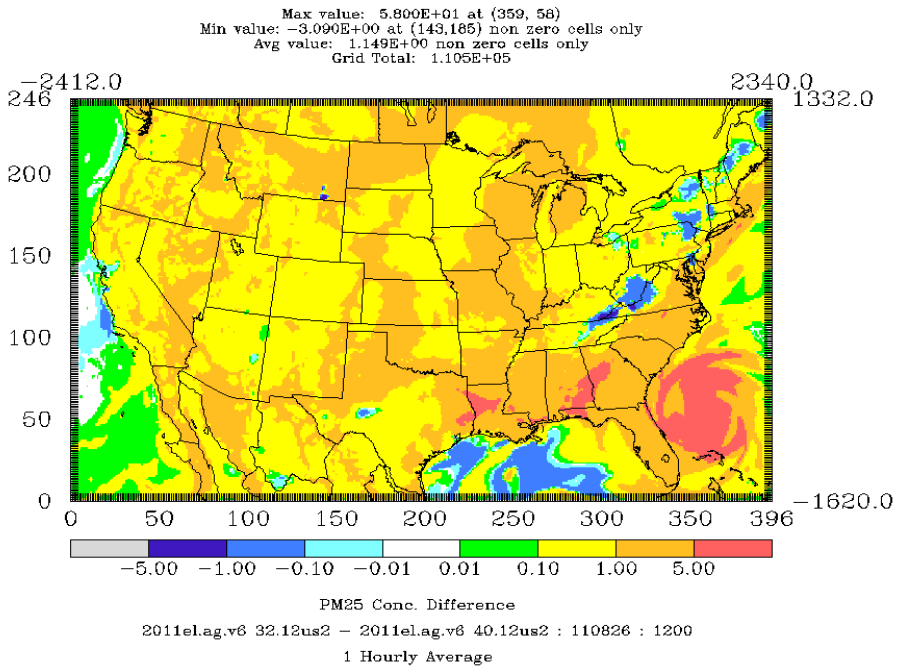
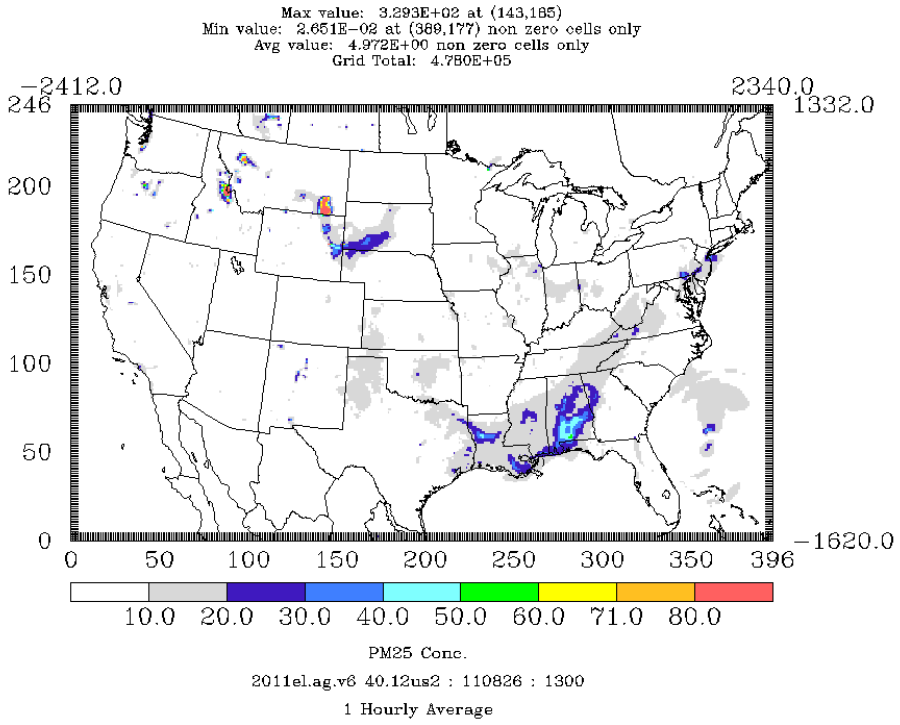


Figure 4-26: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: August 26 at 1300 hours

CAMx 6.40



Difference (6.32 - 6.40)

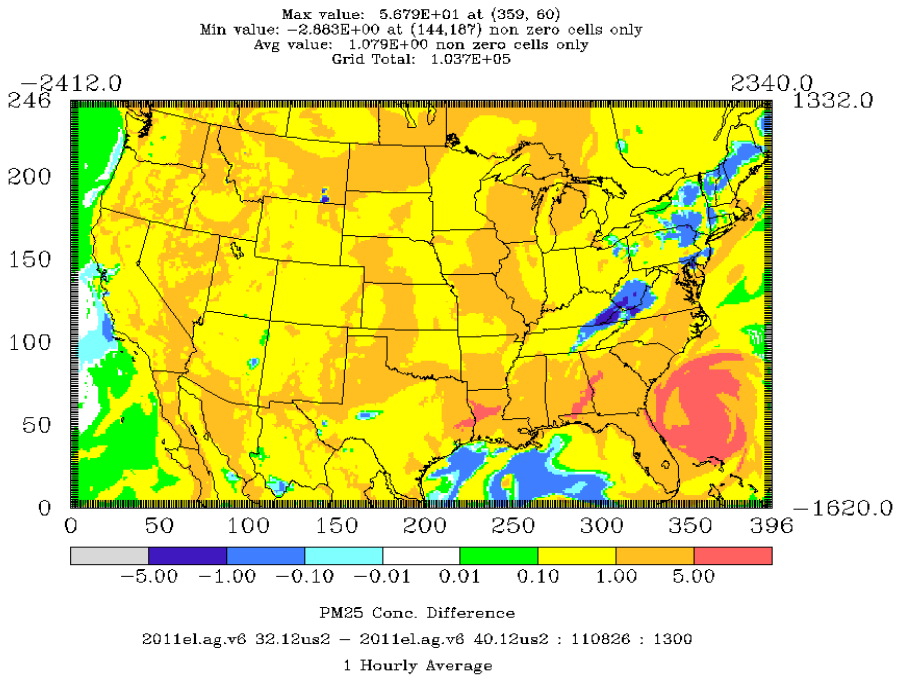
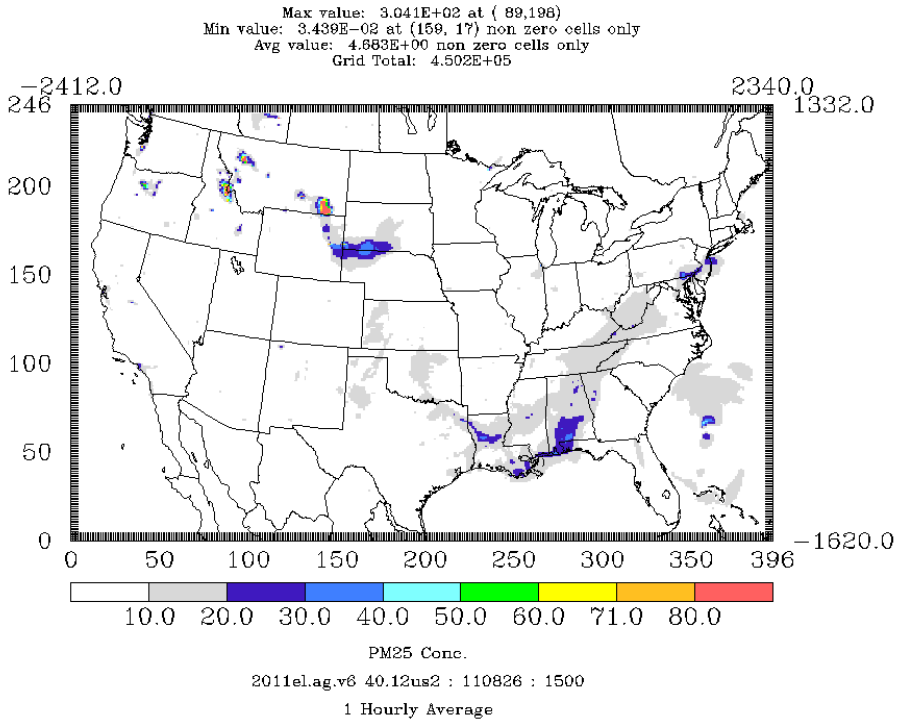


Figure 4-27: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: August 26 at 1500 hours

CAMx 6.40



Difference (6.32 - 6.40)

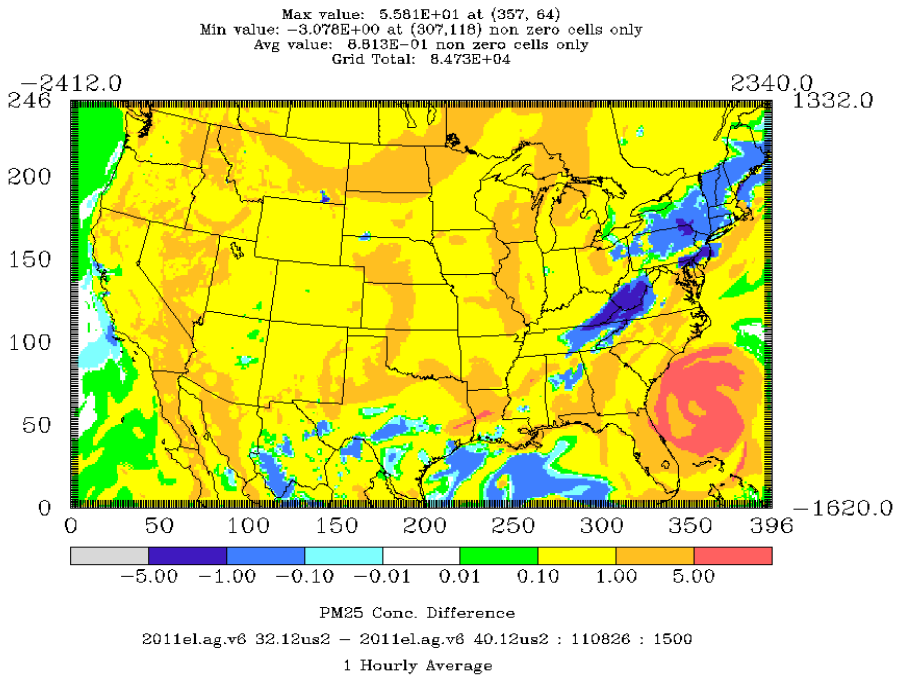
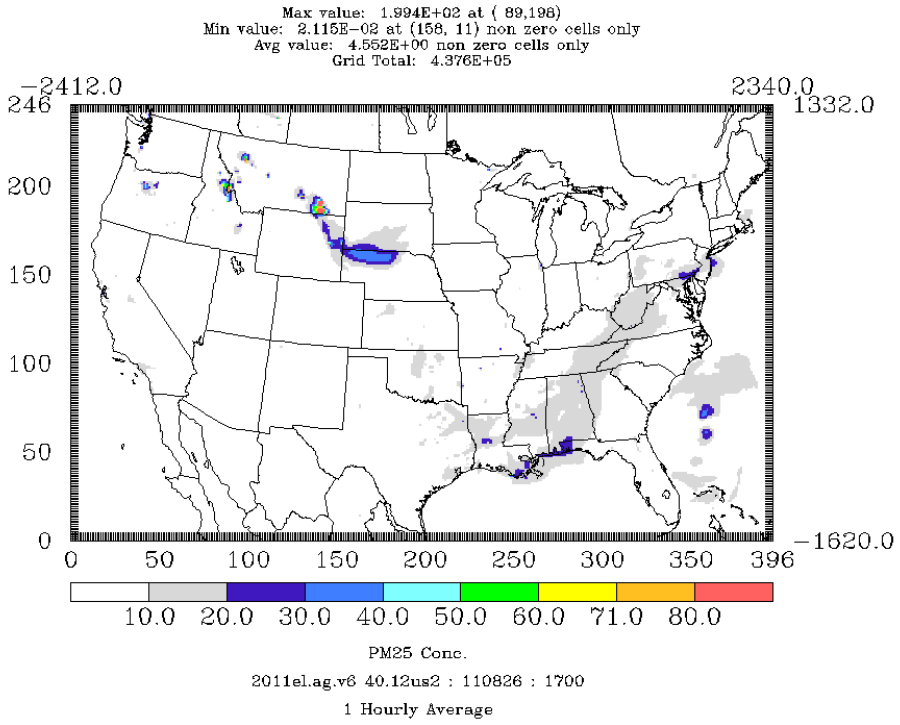


Figure 4-28: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: August 26 at 1700 hours

CAMx 6.40



Difference (6.32 - 6.40)

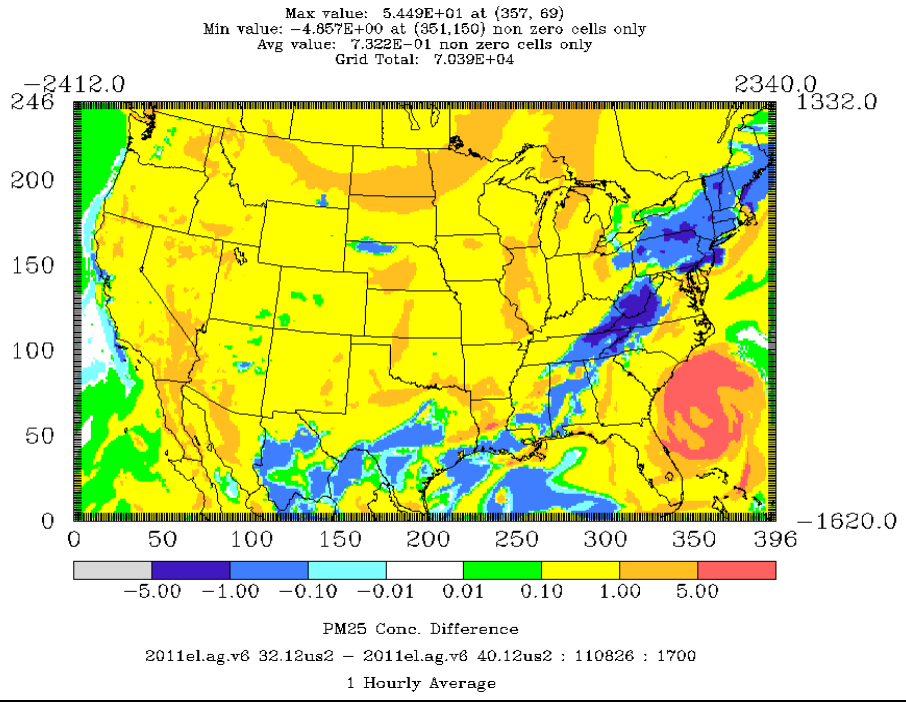
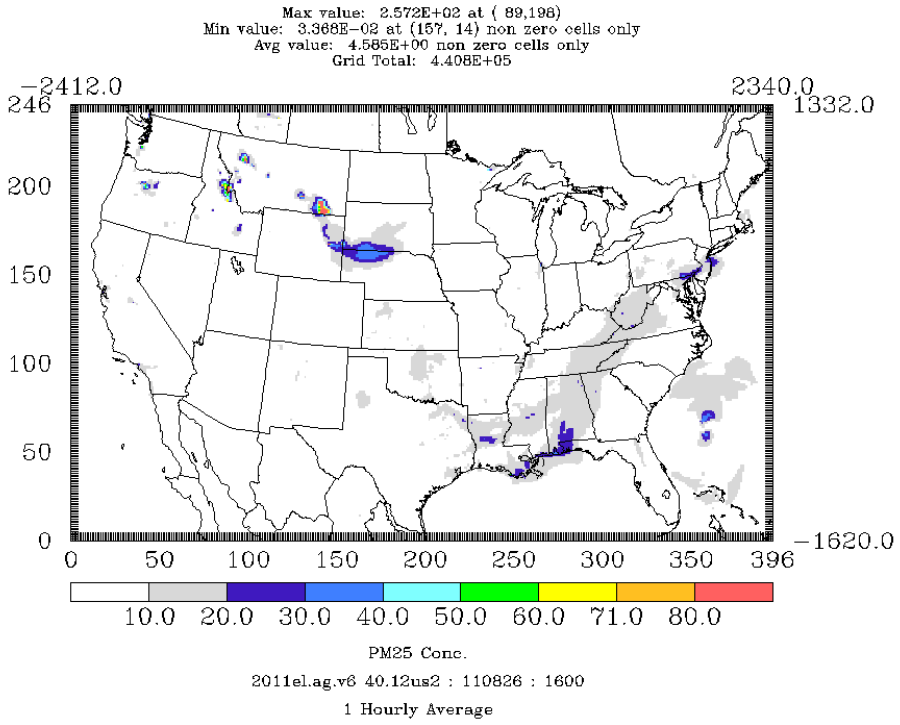


Figure 4-29: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: August 26 at 1600 hours

CAMx 6.40



Difference (6.32 - 6.40)

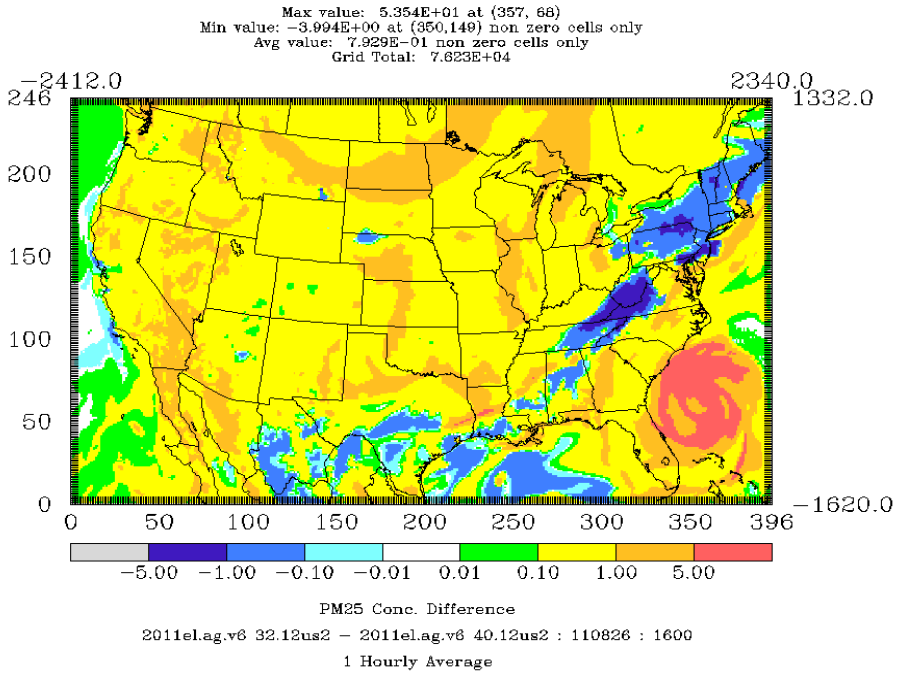
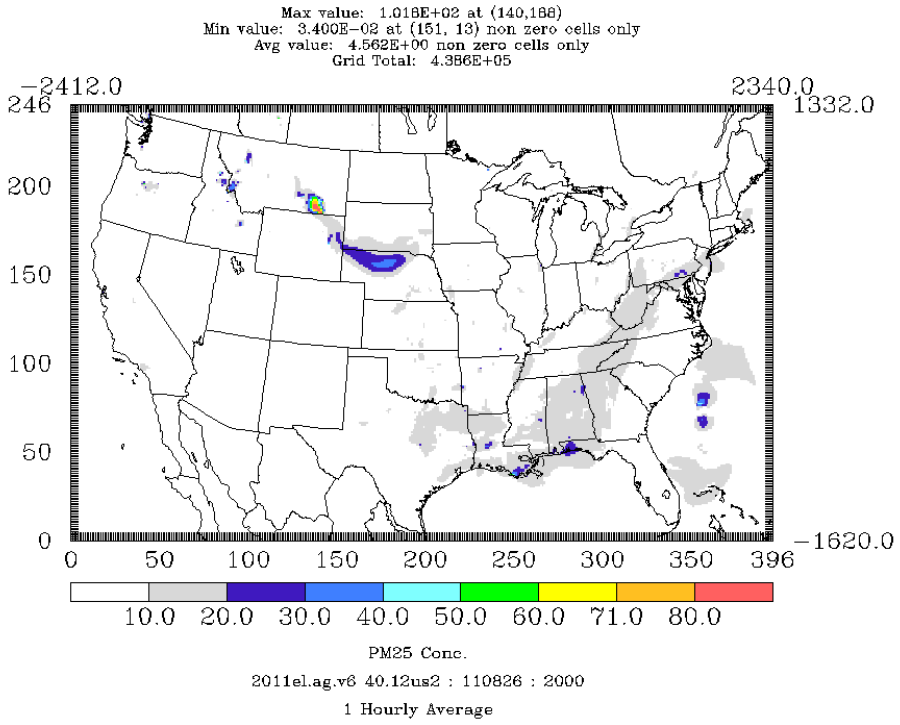


Figure 4-30: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: August 26 at 2000 hours

CAMx 6.40



Difference (6.32 - 6.40)

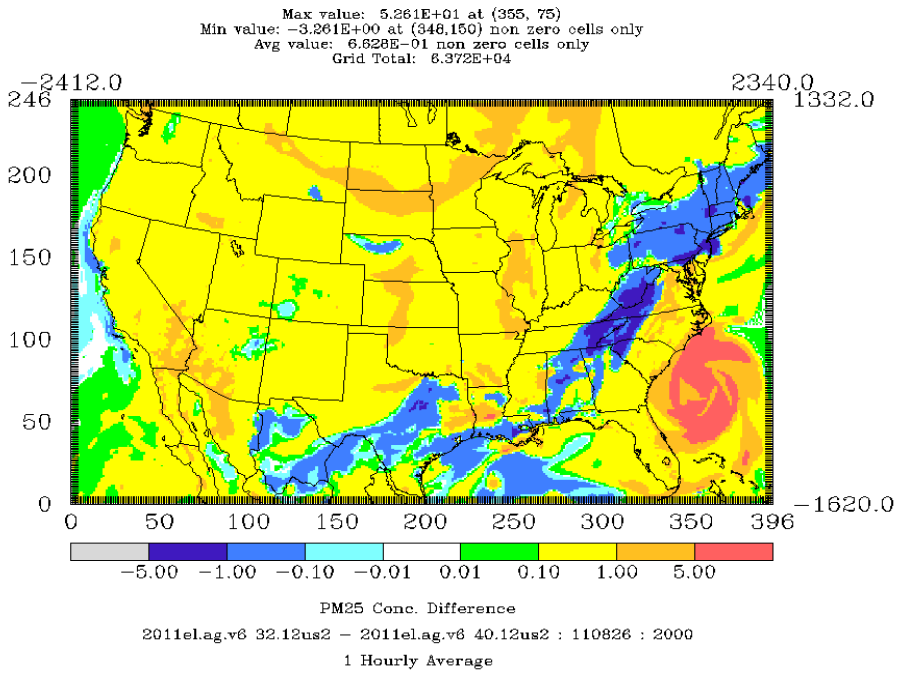
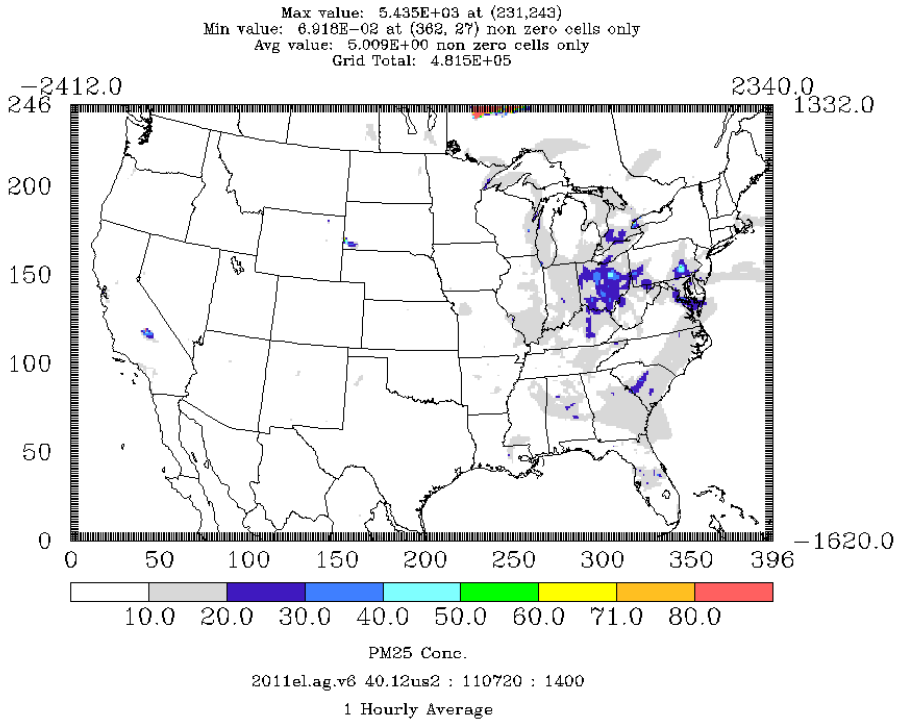


Figure 4-31: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1400 hours

CAMx 6.40



Difference (6.32 - 6.40)

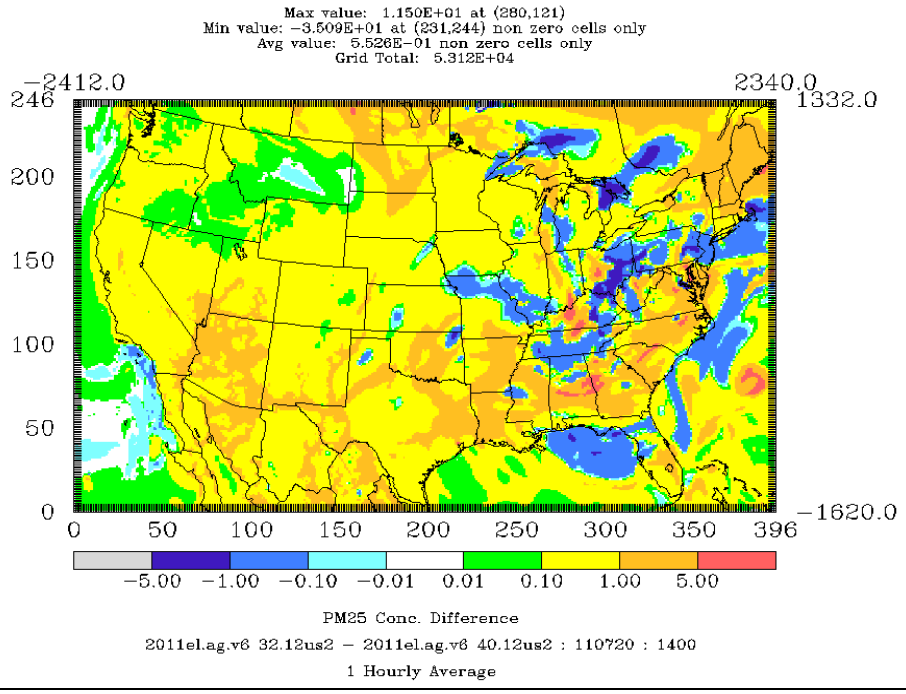
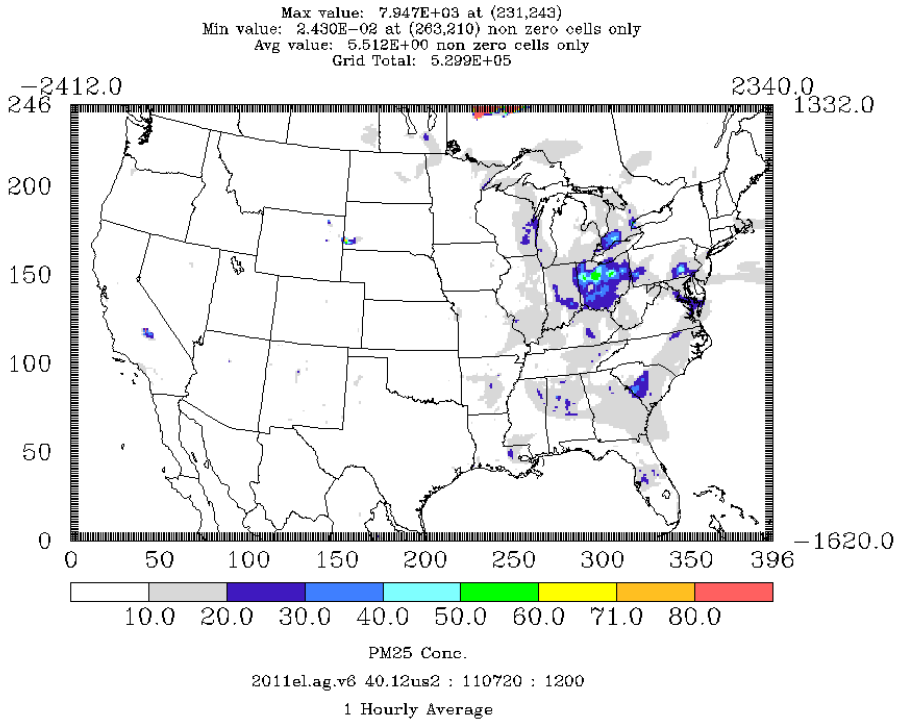


Figure 4-32: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1200 hours

CAMx 6.40



Difference (6.32 - 6.40)

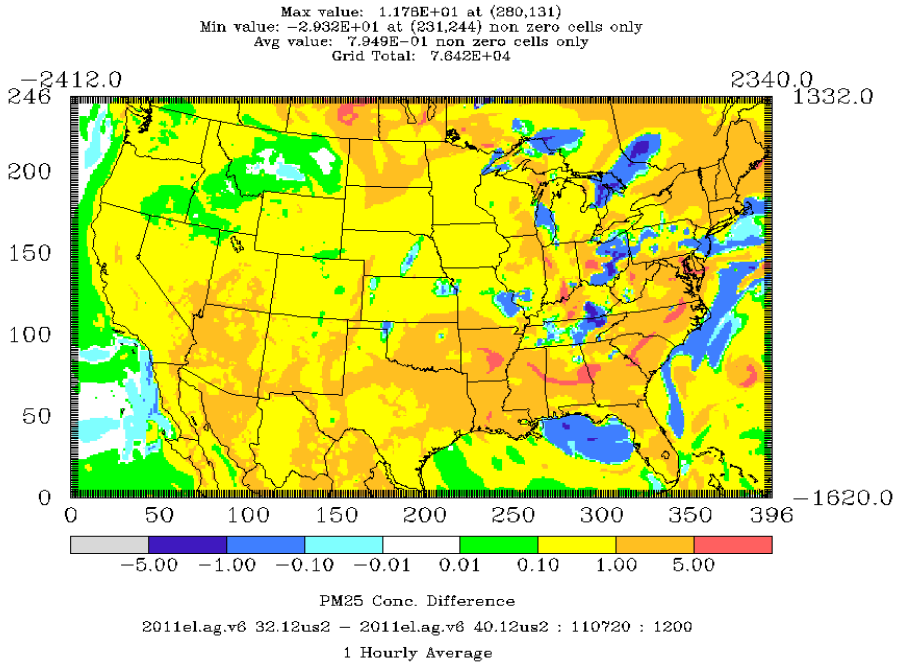
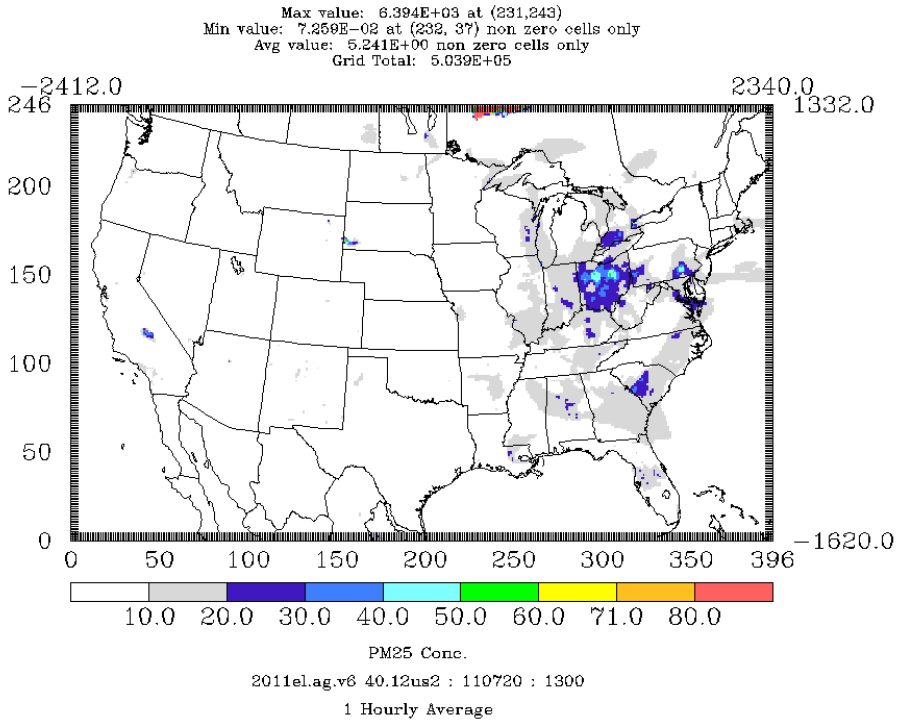


Figure 4-33: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1300 hours

CAMx 6.40



Difference (6.32 - 6.40)

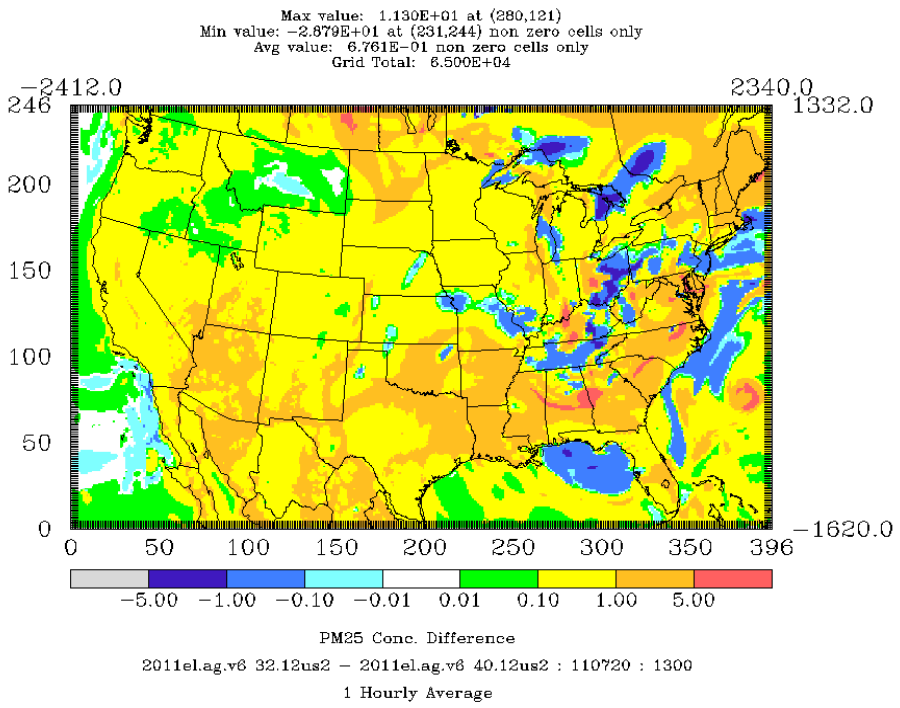
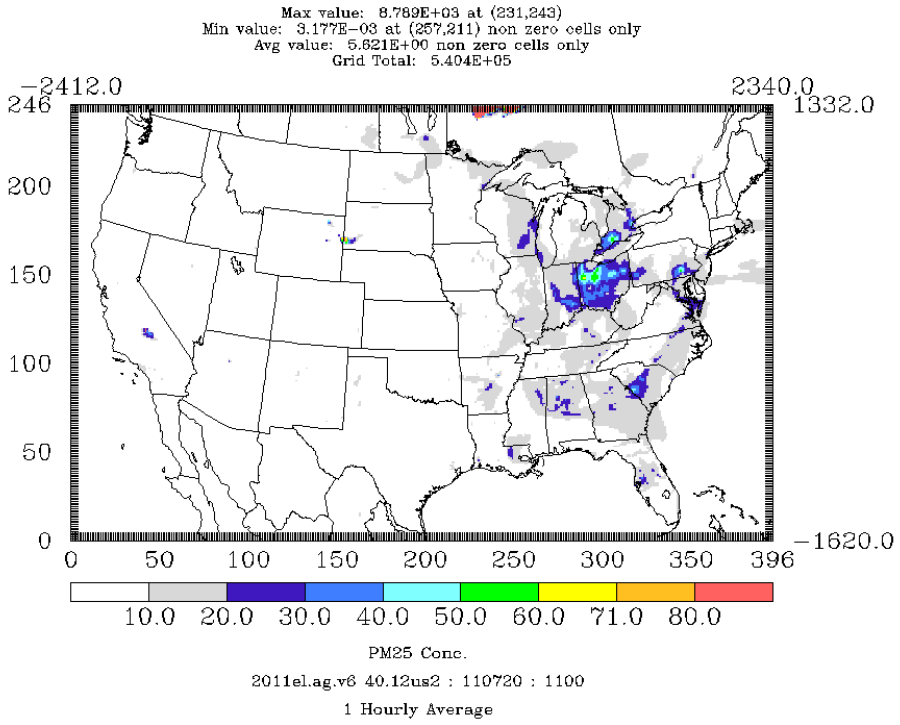


Figure 4-34: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 20 at 1100 hours

CAMx 6.40



Difference (6.32 - 6.40)

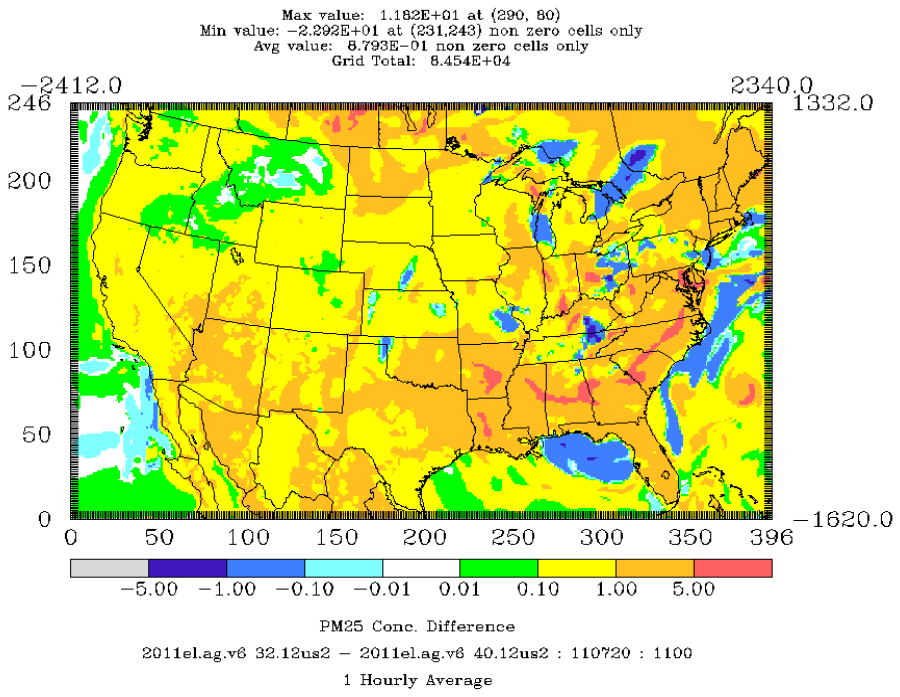
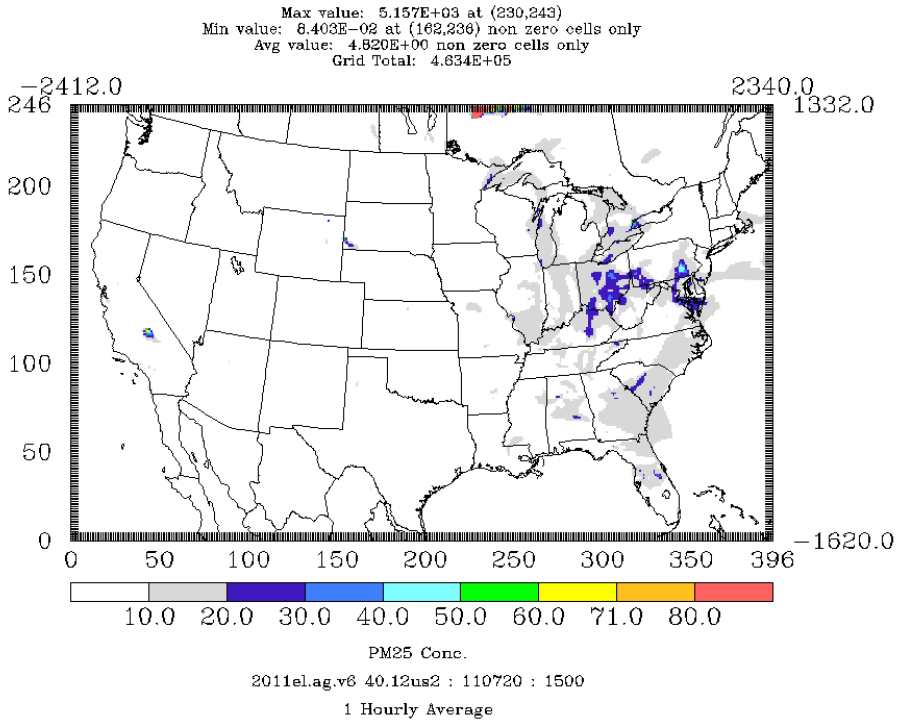


Figure 4-35: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 20 at 1500 hours

CAMx 6.40



Difference (6.32 - 6.40)

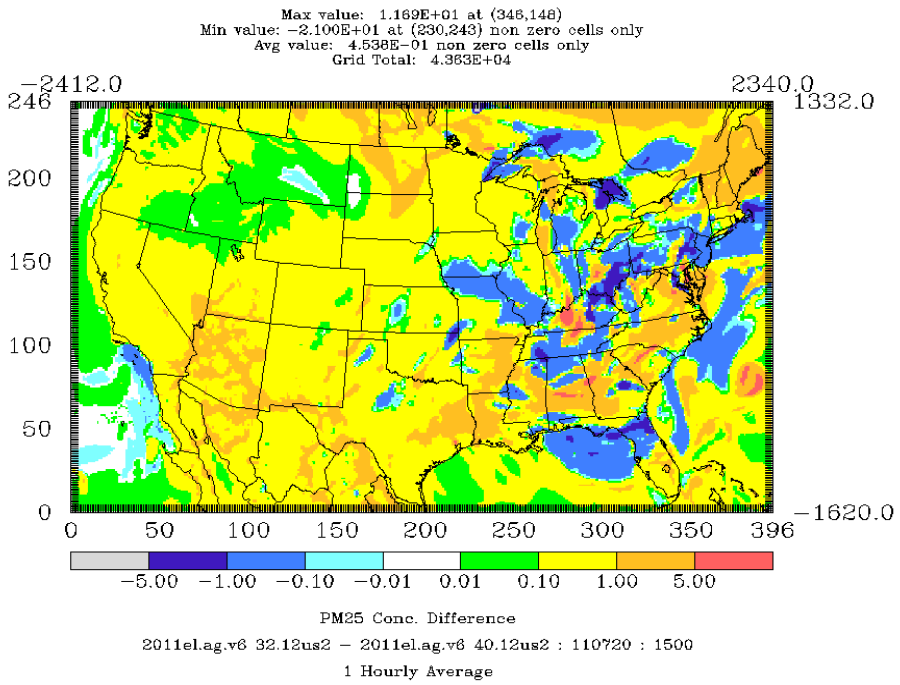
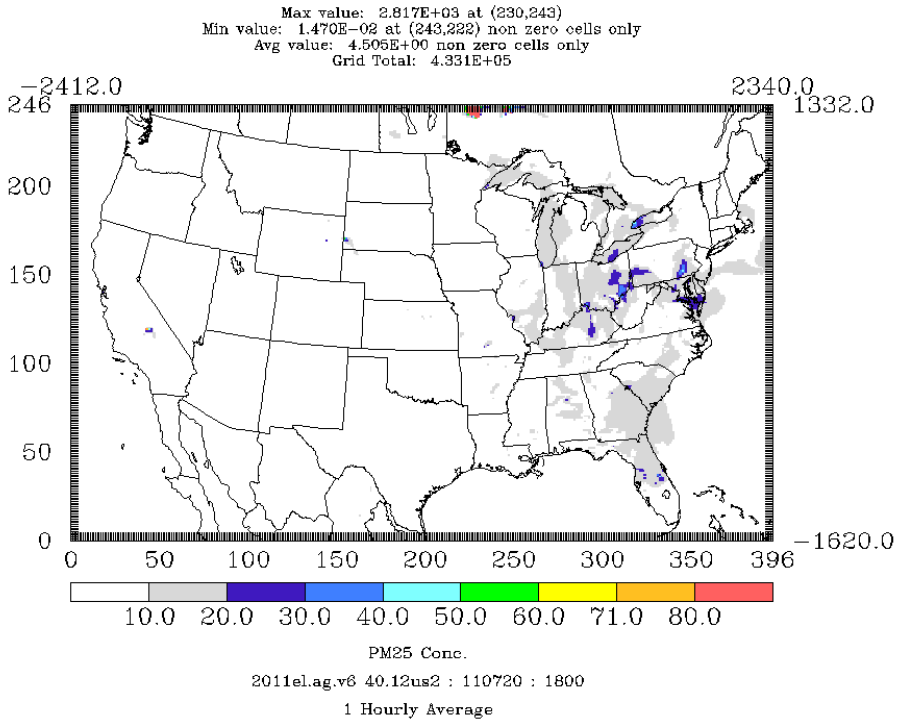


Figure 4-36: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 20 at 1800 hours

CAMx 6.40



Difference (6.32 - 6.40)

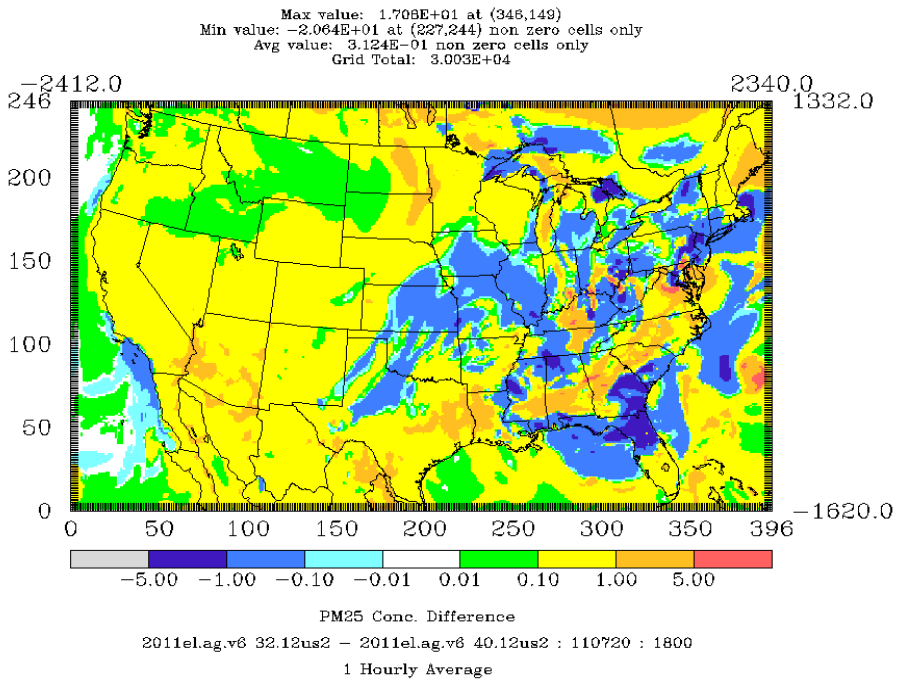
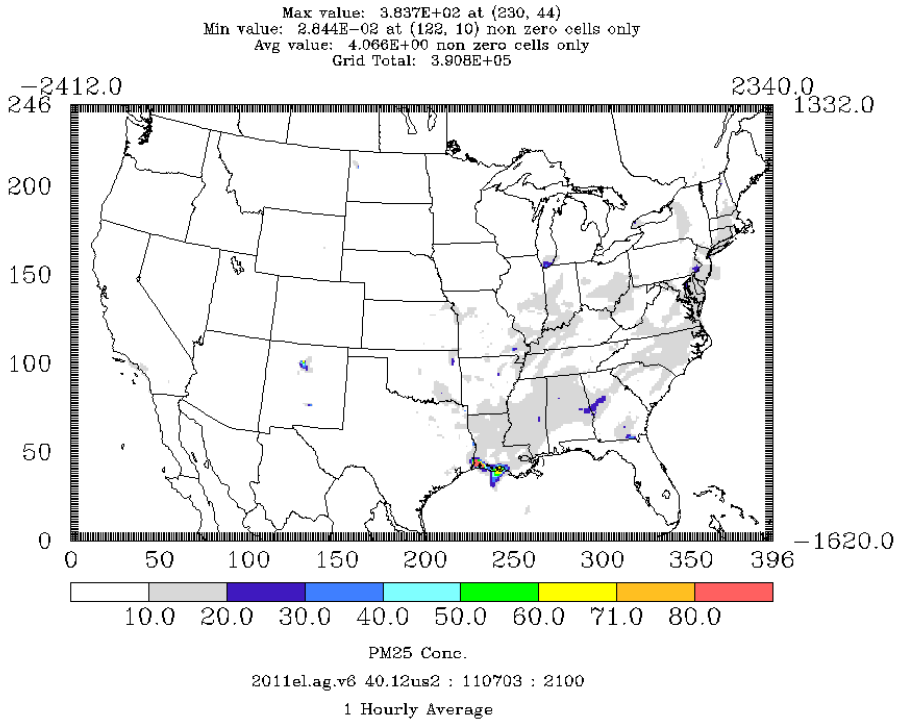


Figure 4-37: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 3 at 2100 hours

CAMx 6.40



Difference (6.32 - 6.40)

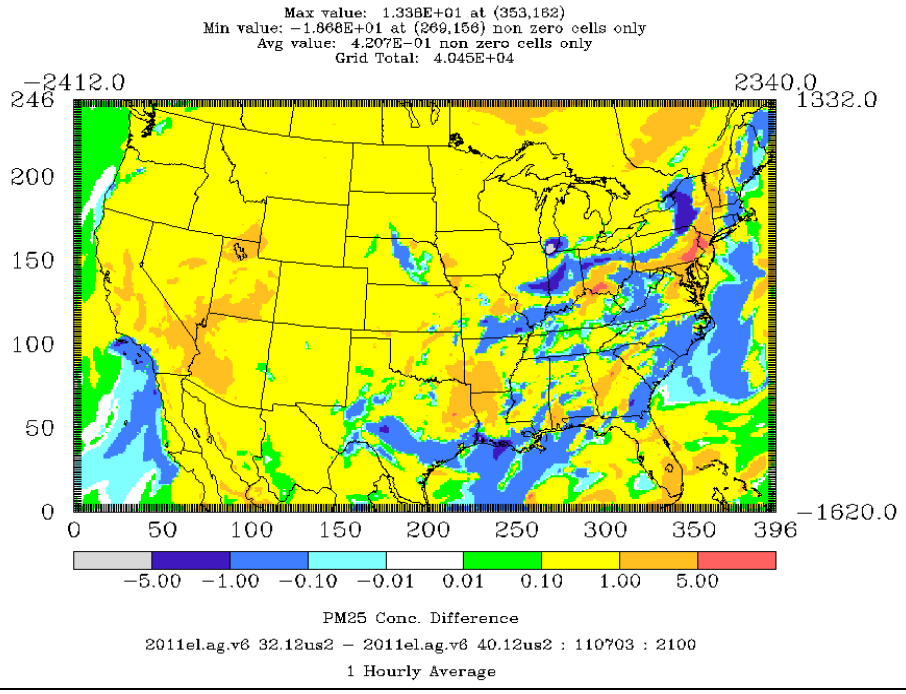
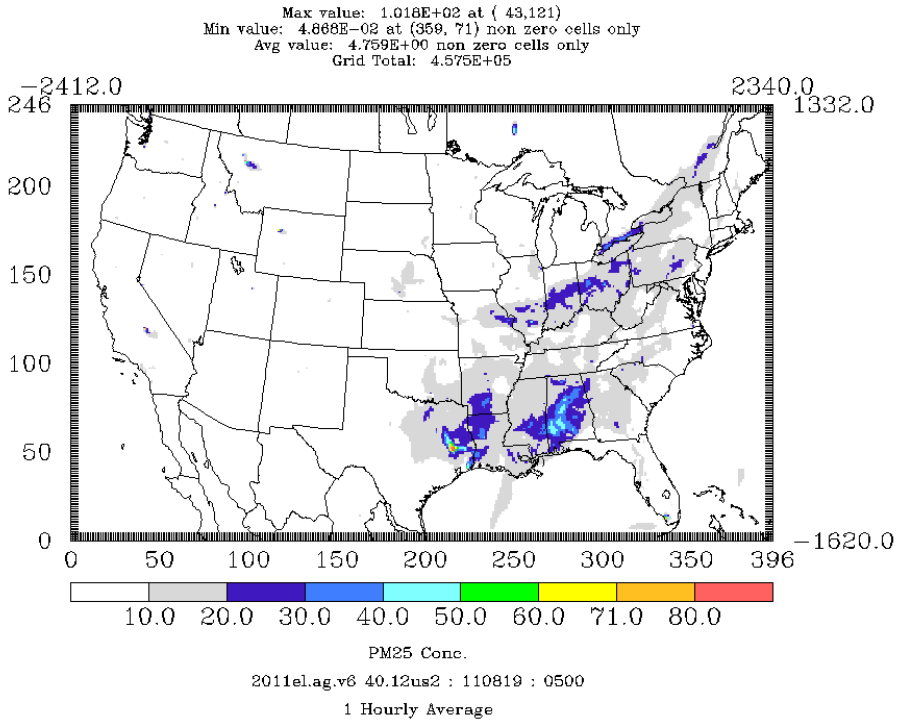


Figure 4-38: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: August 19 at 500 hours

CAMx 6.40



Difference (6.32 - 6.40)

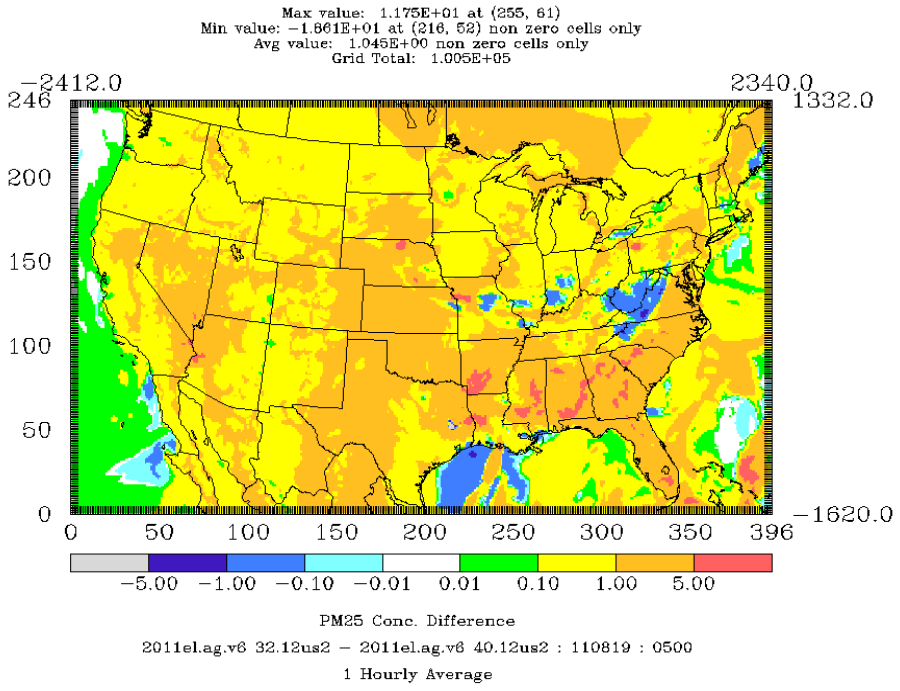
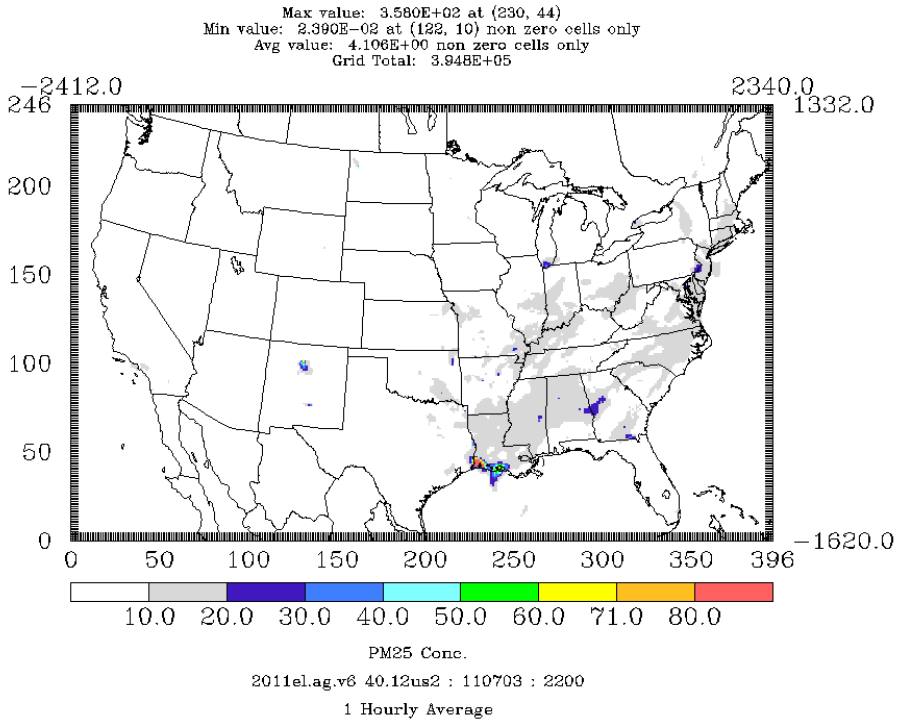


Figure 4-39: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 3 at 2200 hours

CAMx 6.40



Difference (6.32 - 6.40)

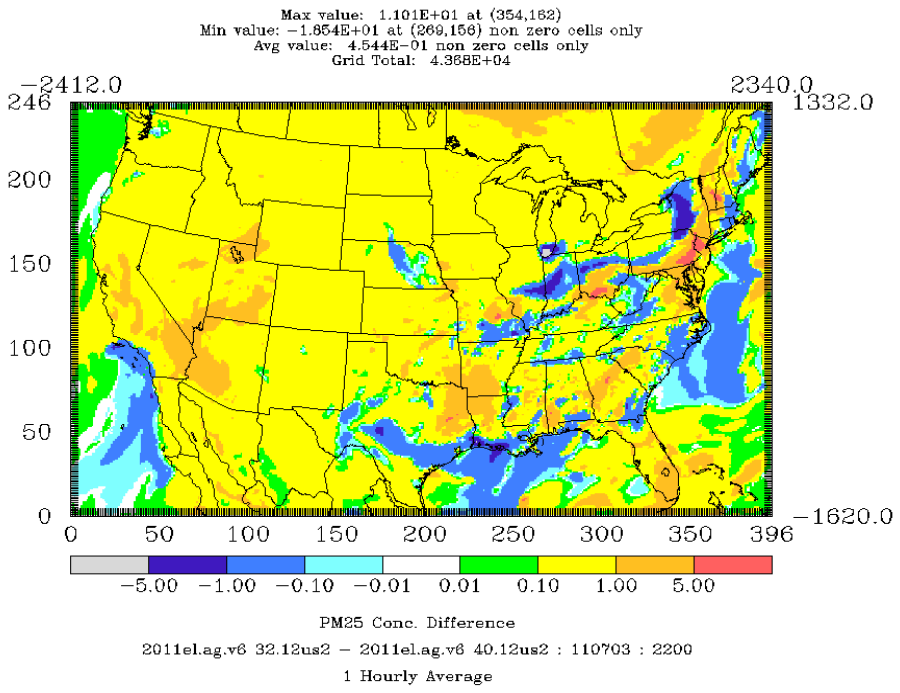
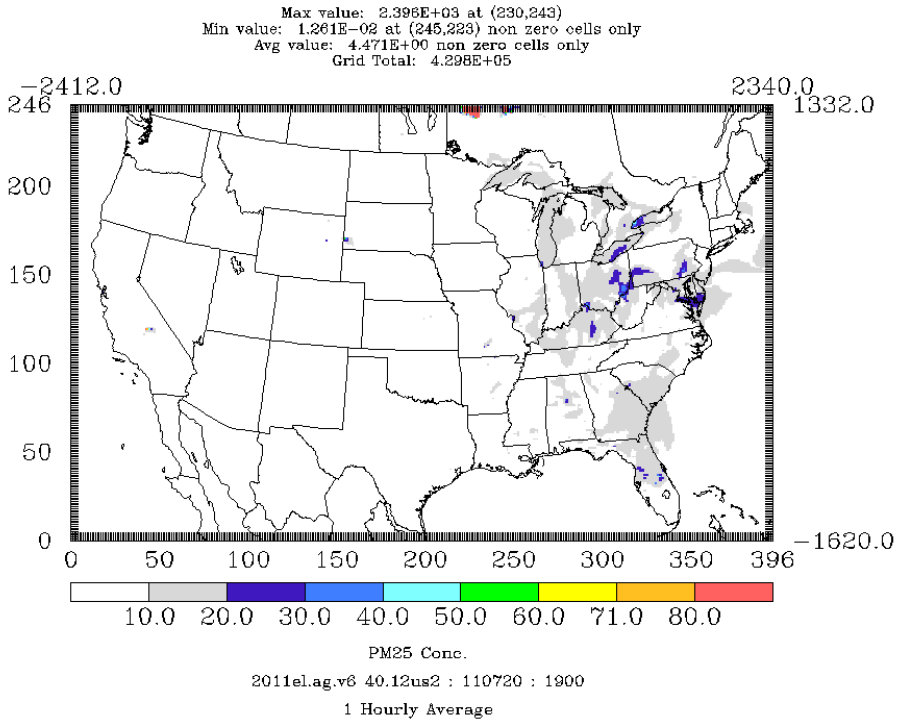


Figure 4-40: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 20 at 1900 hours

CAMx 6.40



Difference (6.32 - 6.40)

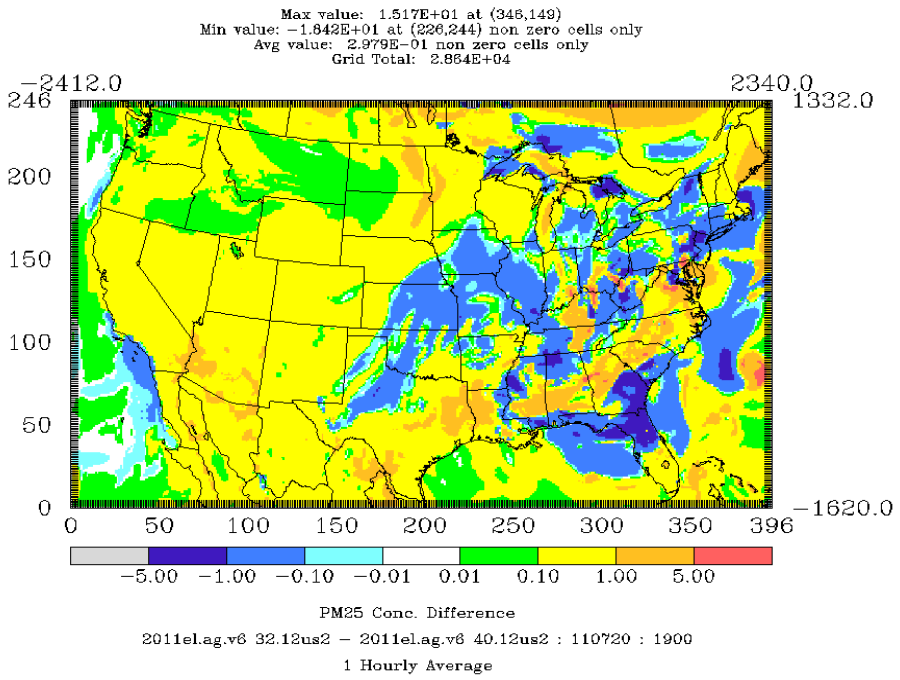


Figure 4-41: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference)

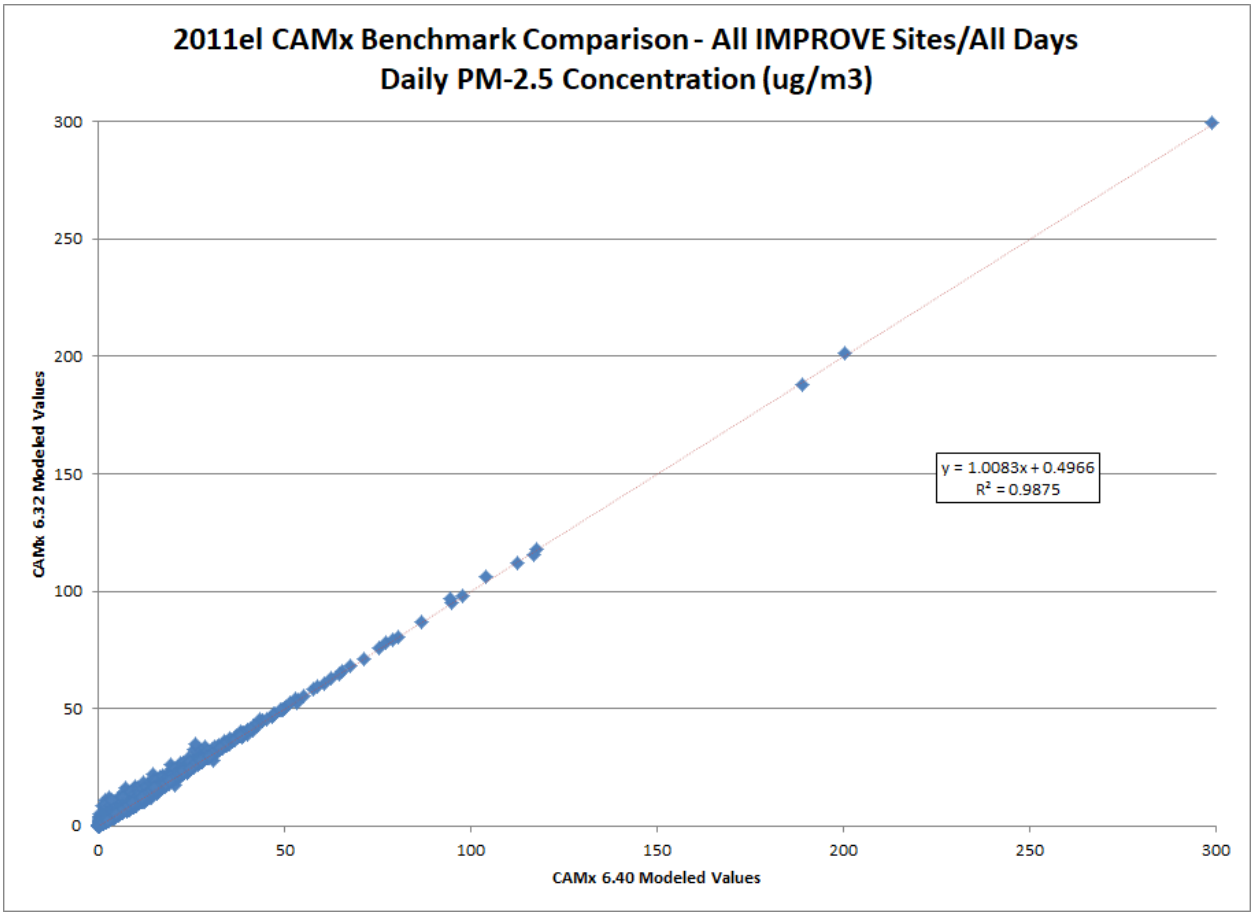


Figure 4-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine).

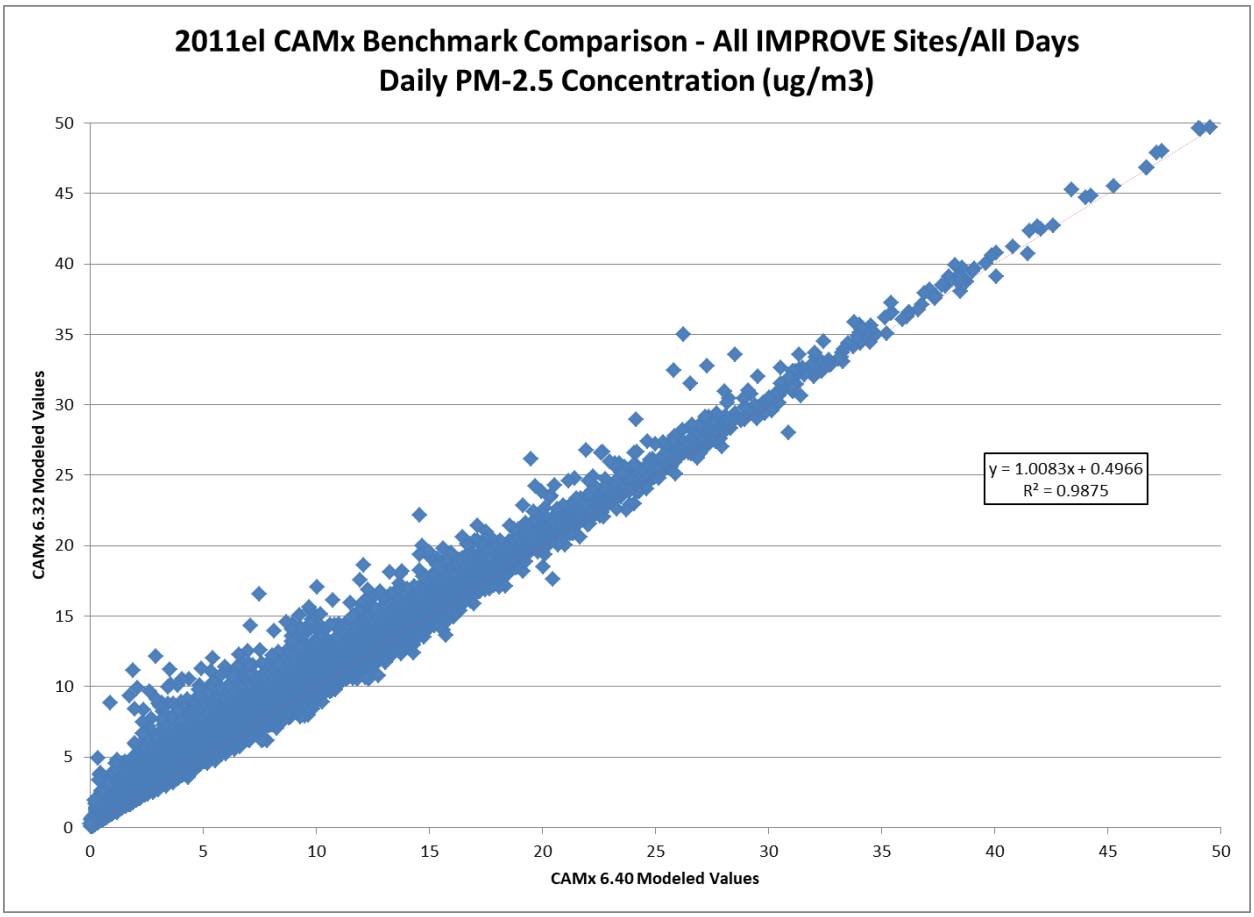


Figure 4-43: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine); Modified Scale.

4.3 Sulfate

Sulfate results for the top 10 positive and negative hours are presented in tabular format in Table 4-3. The maximum positive difference is 23.32 µg/m^3 falling to 14.769 µg/m^3 for the 10th high. The maximum negative difference is -17.77 µg/m^3 falling to -5.76 µg/m^3 for the 10th high. The maximum positive percent difference from these days is 171% and negative percent difference of -26.9%.

The top 10 positive difference hours are presented in Figures 4-44 through 4-53. The regions of the maximum impact are highly variable. The maximum and several other days shows the maximum difference is located near the Chicago metro area. The second and third highest maximum and other days show impacts along the Gulf of Mexico coast.

The top 10 negative difference hours are presented in Figures 4-54 through 4-63. The maximum negative differences for all but one day are occurring on July 20 or 21 along the northern U.S. border, north of Minnesota.

Scatterplots of the daily average sulfate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-64. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has considerably more scatter than the ozone or $PM_{2.5}$ results with a line of best fit with a slope of 1.0842, an intercept of 0.0832 µg/m^3 and an R^2 of 0.9068. The vast majority of the points are above the 1:1 line, meaning that the CAMx 6.32 modeled values are higher than the CAMx 6.40 results. This is likely a result of the changes in the wet deposition algorithms and the oxidation of SO_2 on primary crustal particles and updates to the RADM-AQ algorithm.

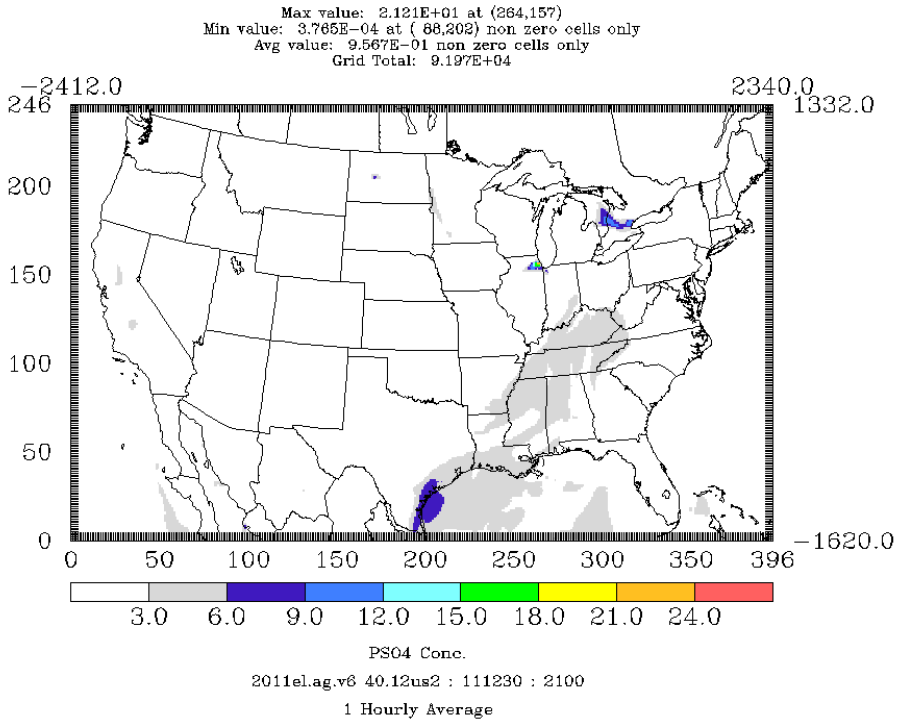
Examination of the CAMx 6.40 animations show generally lower concentrations compared to CAMx 6.32, particularly in the Southeastern U.S.

Table 4-3. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of Sulfate Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	6.32 Conc.	6.40 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	12	30	21	44.45	21.13	23.32	110.4%	265	157
2011	5	12	11	71.22	51.23	19.99	39.0%	258	45
2011	5	8	9	43.25	23.36	19.88	85.1%	258	45
2011	12	21	14	46.03	27.37	18.66	68.2%	316	176
2011	3	16	1	29.04	10.70	18.34	171.5%	291	145
2011	5	12	12	75.61	60.06	15.55	25.9%	258	45
2011	5	9	10	42.96	27.94	15.02	53.7%	258	45
2011	12	30	22	45.61	30.69	14.92	48.6%	265	157
2011	5	12	10	56.99	42.11	14.88	35.3%	258	45
2011	5	20	3	26.13	11.37	14.76	129.8%	352	206
Maximum Negative									
2011	7	20	12	87.16	104.93	-17.77	-16.9%	231	244
2011	7	20	11	95.08	109.81	-14.72	-13.4%	231	244
2011	7	20	13	68.92	82.16	-13.24	-16.1%	231	244
2011	7	20	14	59.18	69.69	-10.51	-15.1%	231	244
2011	7	21	3	67.32	77.08	-9.76	-12.7%	230	244
2011	7	21	2	108.88	117.08	-8.19	-7.0%	230	243
2011	7	20	15	43.94	51.06	-7.11	-13.9%	231	244
2011	7	21	4	35.42	42.46	-7.05	-16.6%	230	245
2011	7	20	10	94.54	100.83	-6.29	-6.2%	231	241
2011	1	4	18	15.63	21.39	-5.76	-26.9%	170	29

Maximum Positive Difference: December 30 at 2100 hours

CAMx 6.40



Difference (6.32 - 6.40)

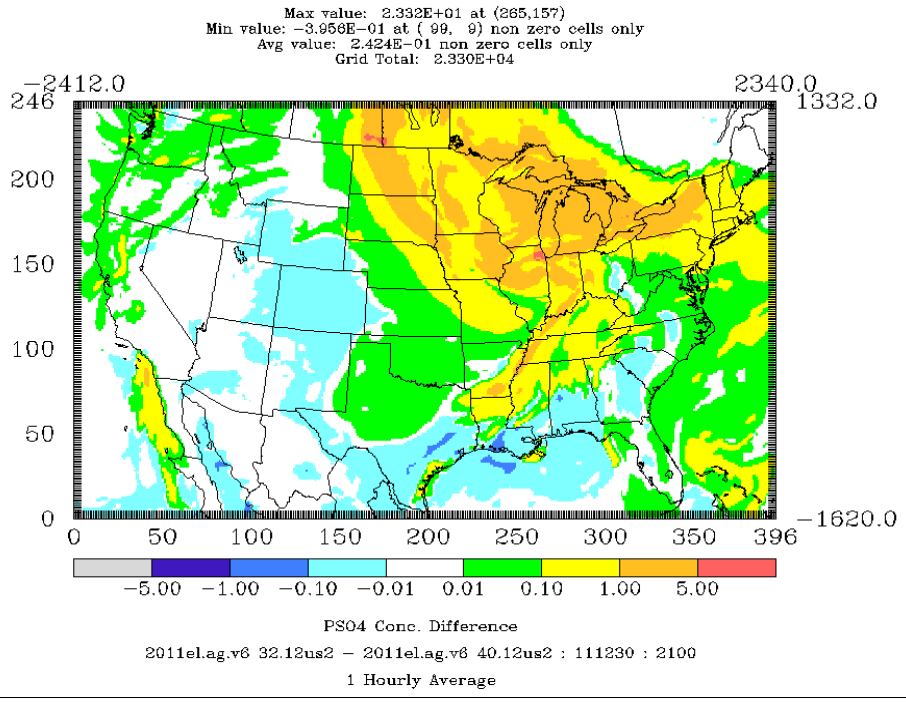
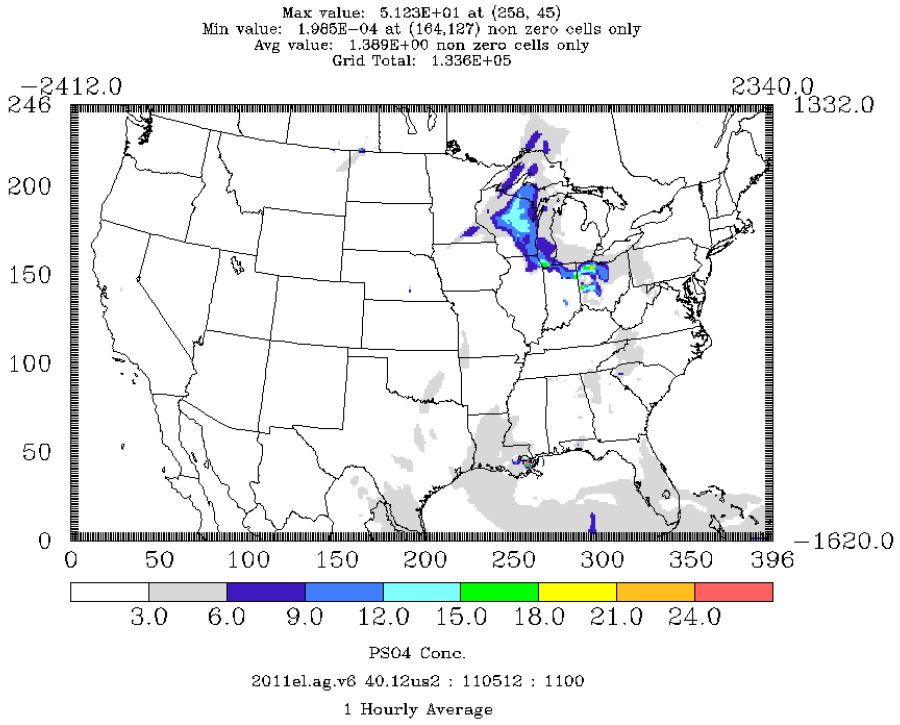


Figure 4-44: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: May 12 at 1100 hours

CAMx 6.40



Difference (6.32 - 6.40)

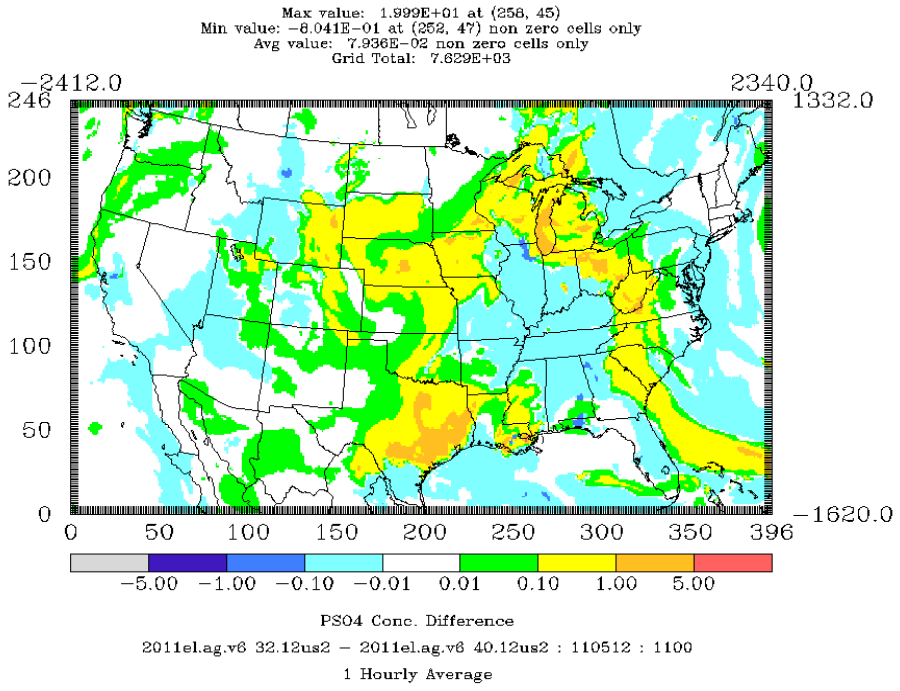
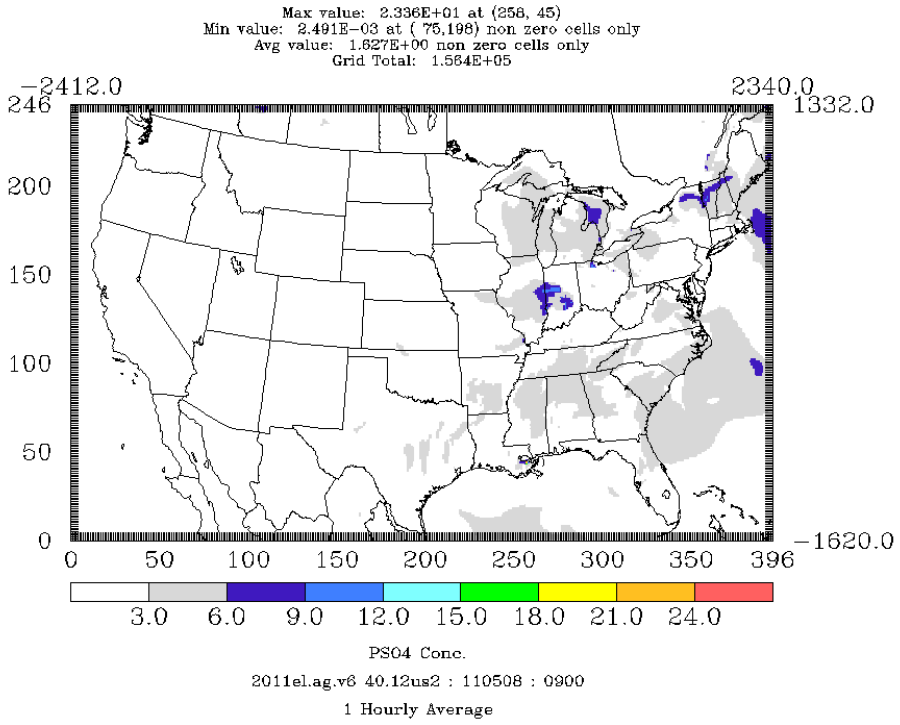


Figure 4-45: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: May 8 at 900 hours

CAMx 6.40



Difference (6.32 - 6.40)

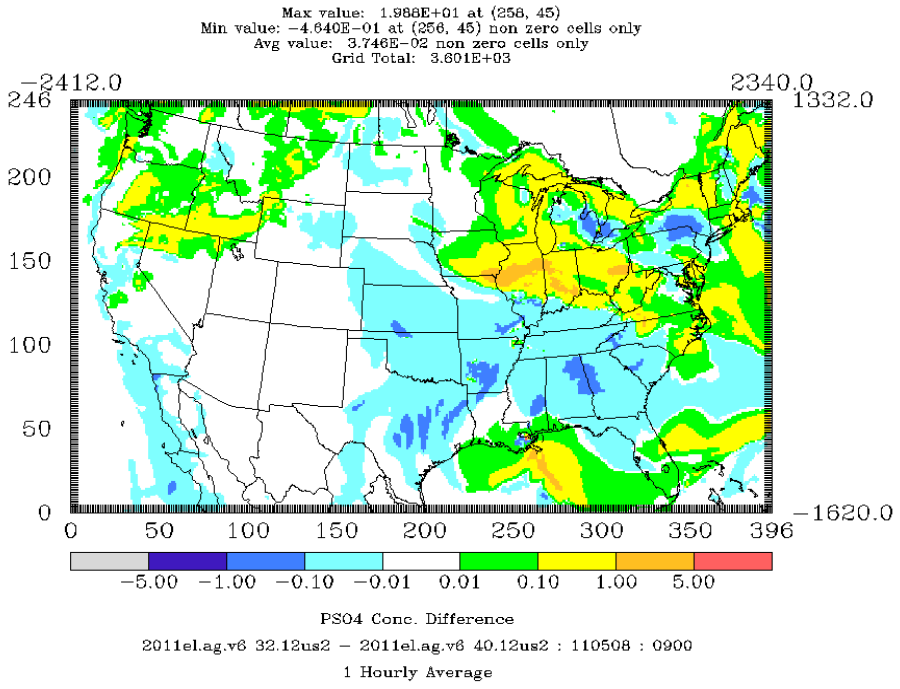
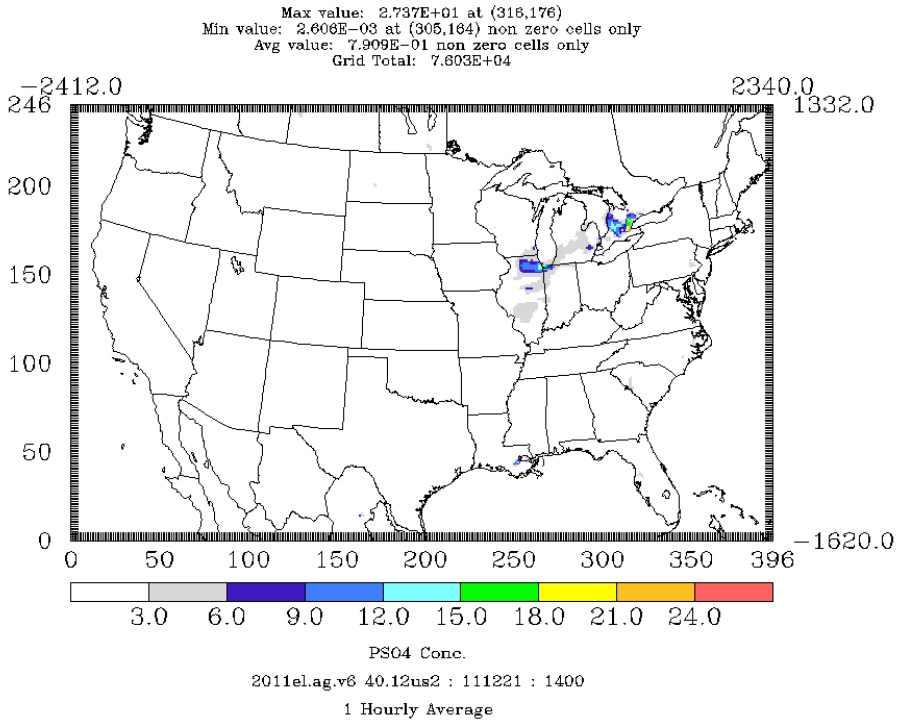


Figure 4-46: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: December 21 at 1400 hours

CAMx 6.40



Difference (6.32 - 6.40)

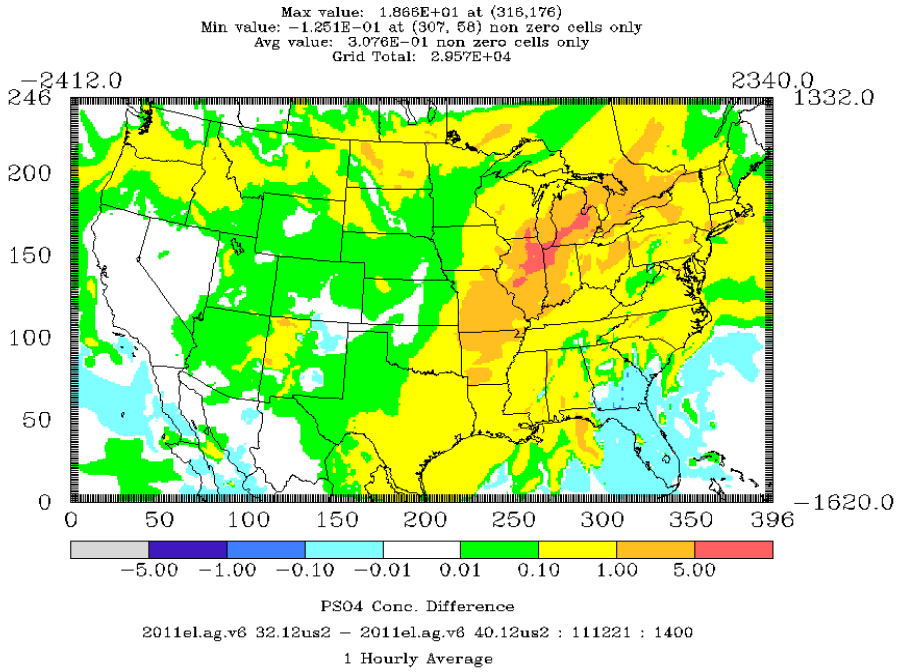
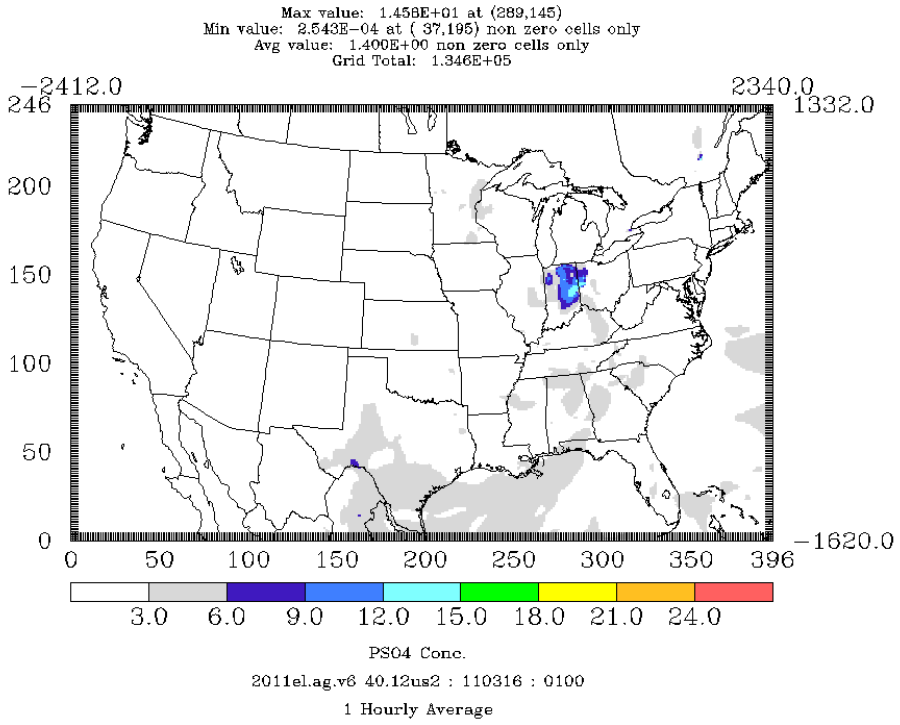


Figure 4-47: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: March 16 at 100 hours

CAMx 6.40



Difference (6.32 - 6.40)

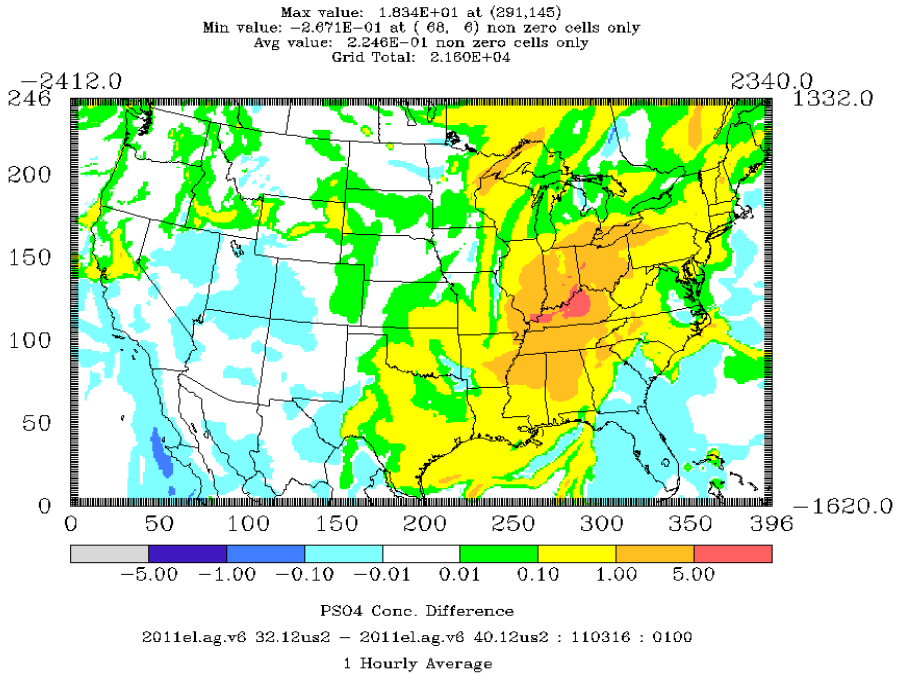
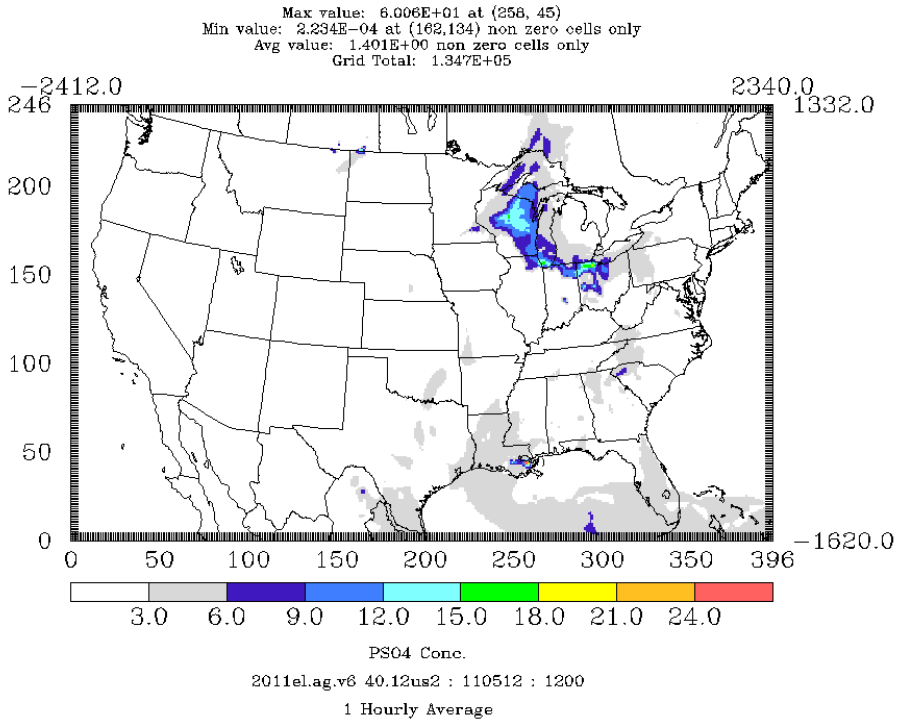


Figure 4-48: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: May 12 at 1200 hours

CAMx 6.40



Difference (6.32 - 6.40)

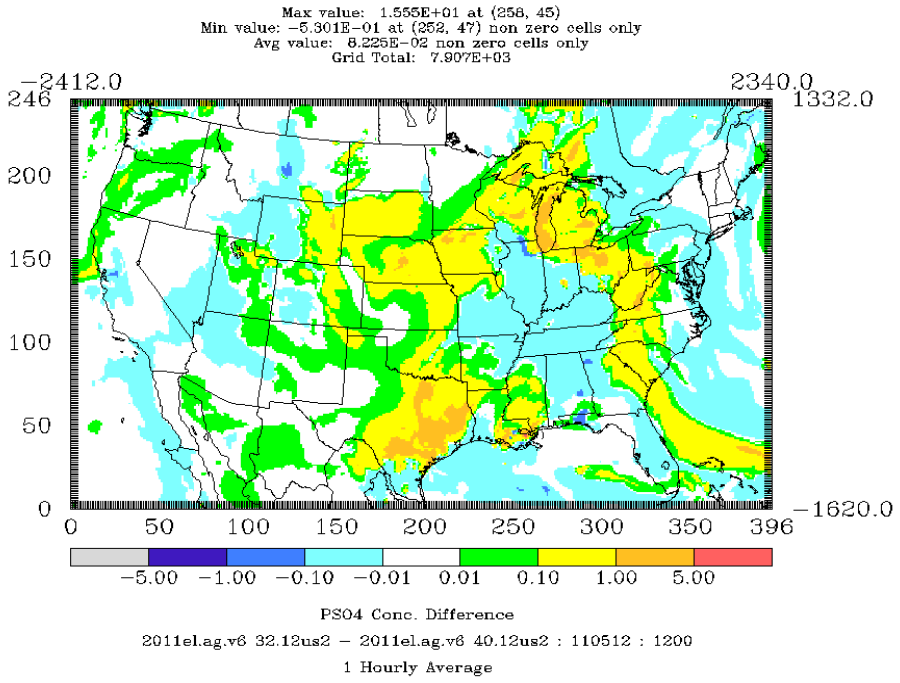
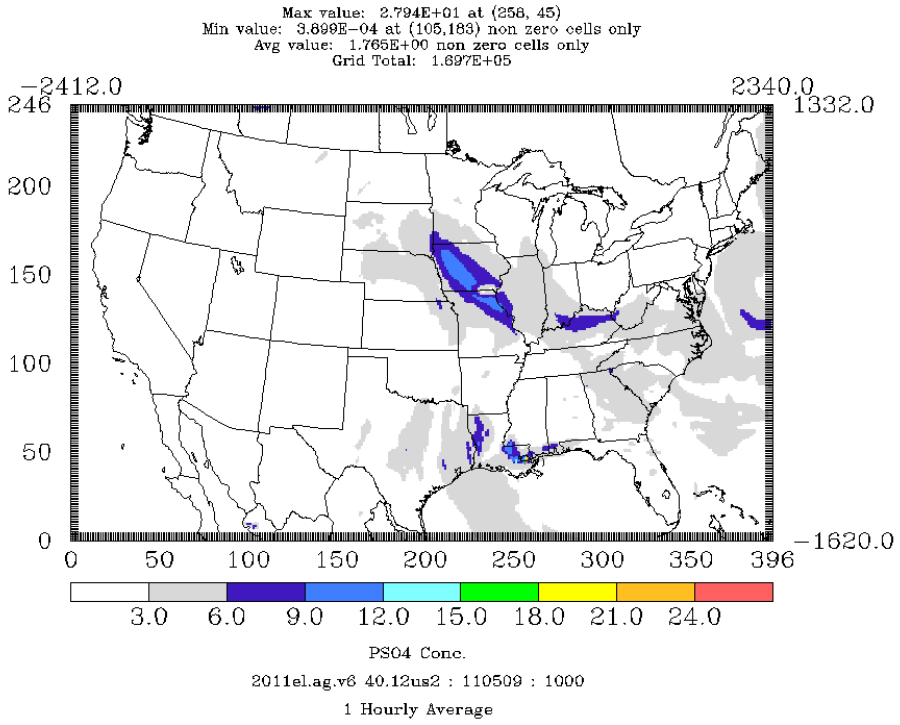


Figure 4-49: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: May 9 at 1000 hours

CAMx 6.40



Difference (6.32 - 6.40)

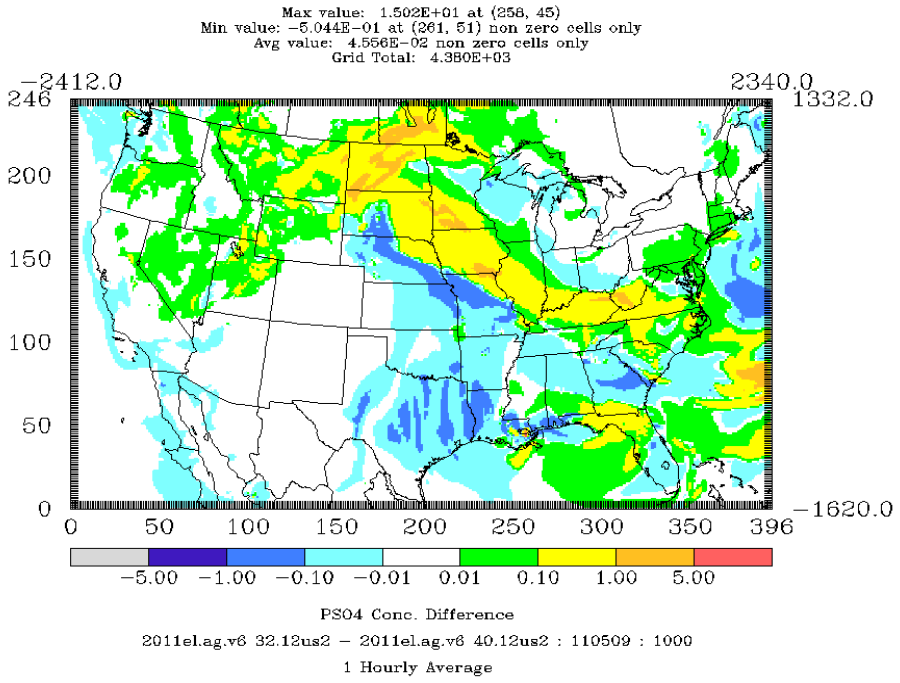
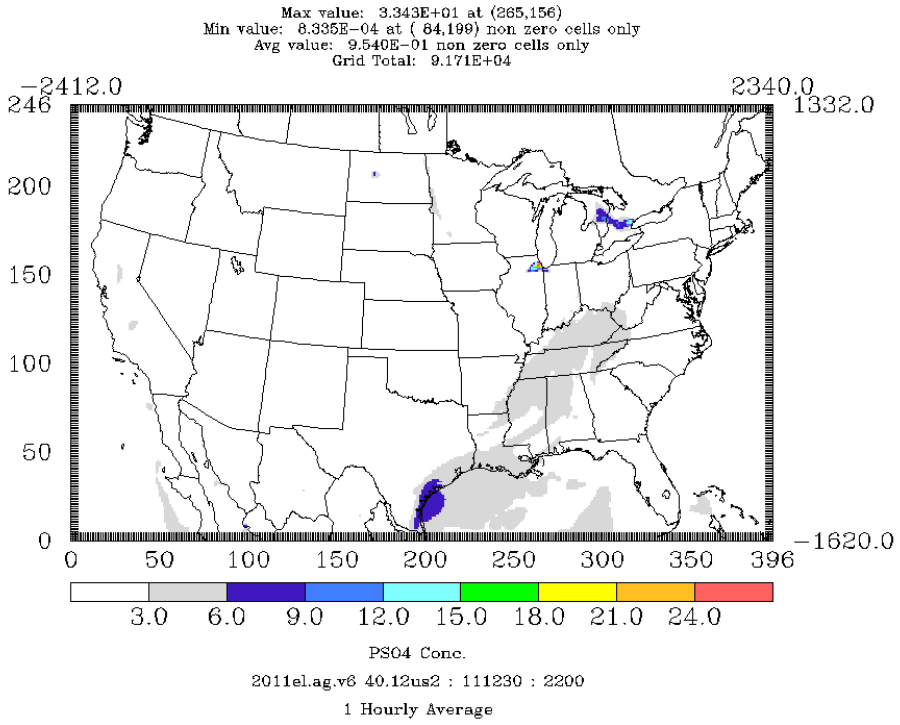


Figure 4-50: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations

Eighth Highest Positive Difference: December 30 at 2200 hours

CAMx 6.40



Difference (6.32 - 6.40)

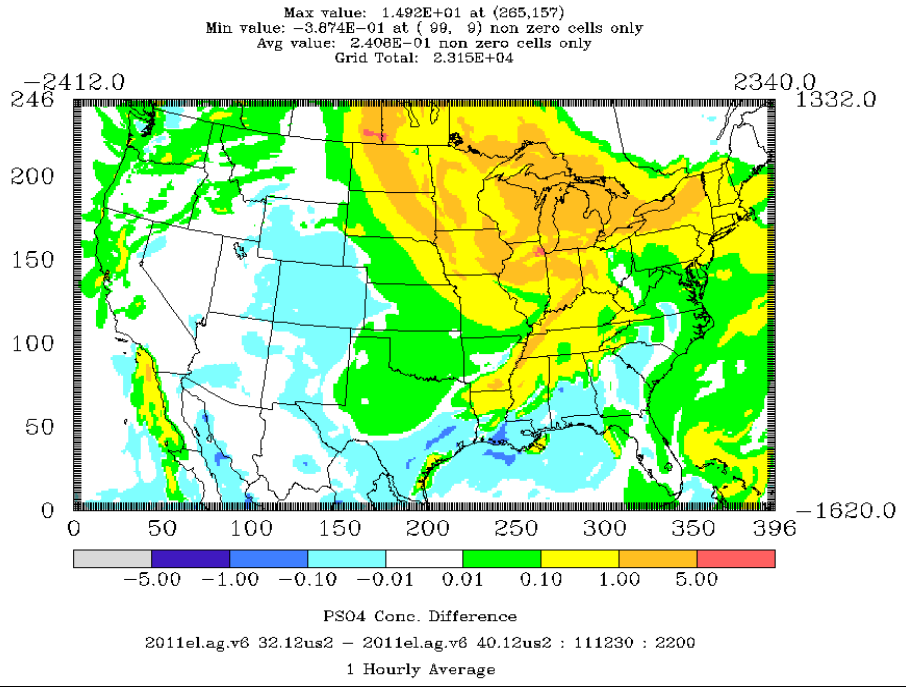
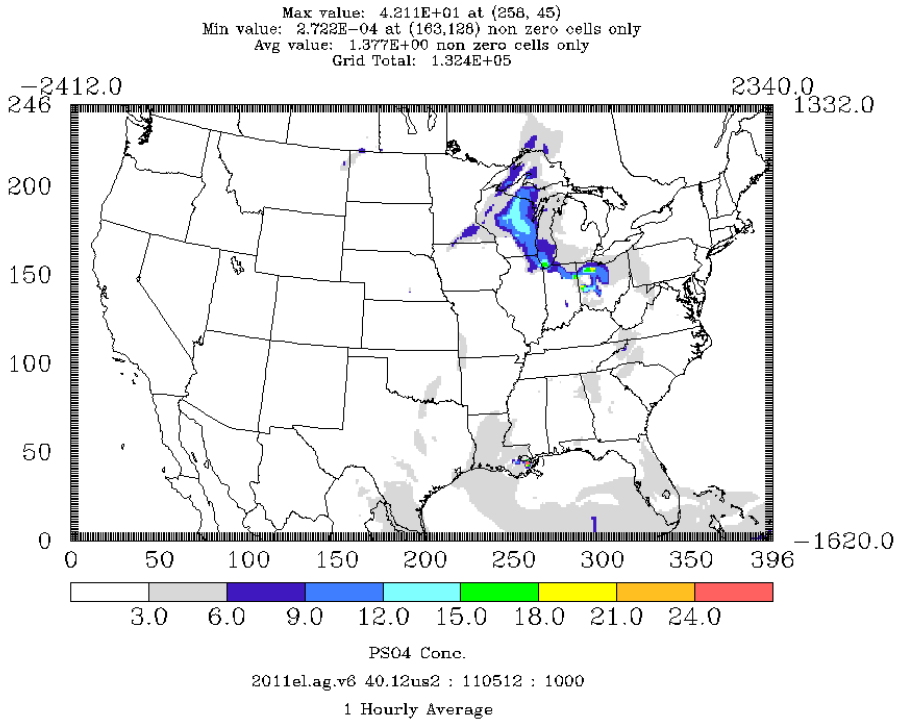


Figure 4-51: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: May 12 at 1000 hours

CAMx 6.40



Difference (6.32 - 6.40)

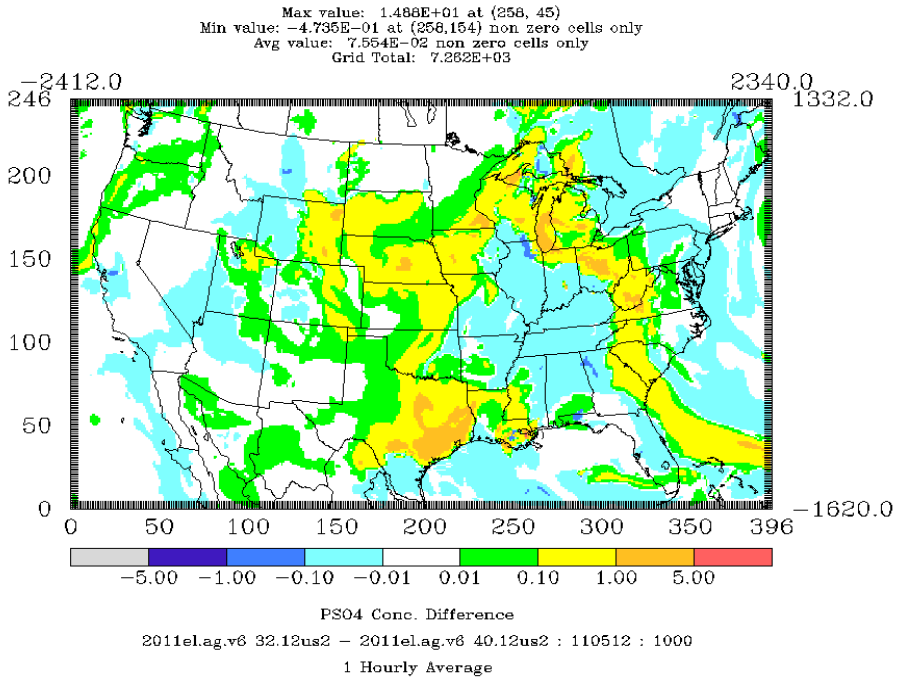
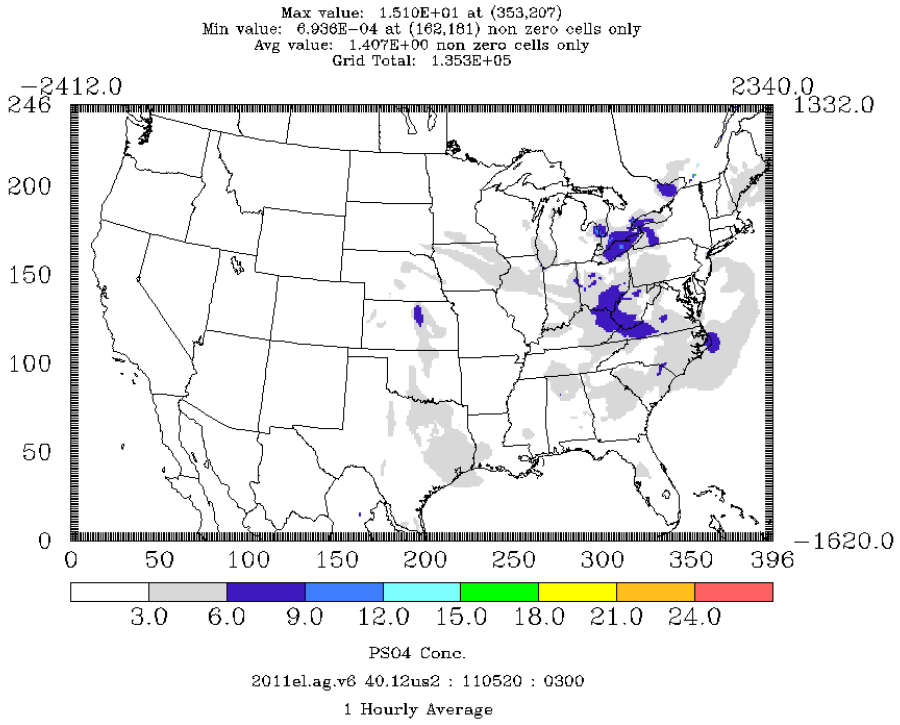


Figure 4-52: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: May 20 at 300 hours

CAMx 6.40



Difference (6.32 - 6.40)

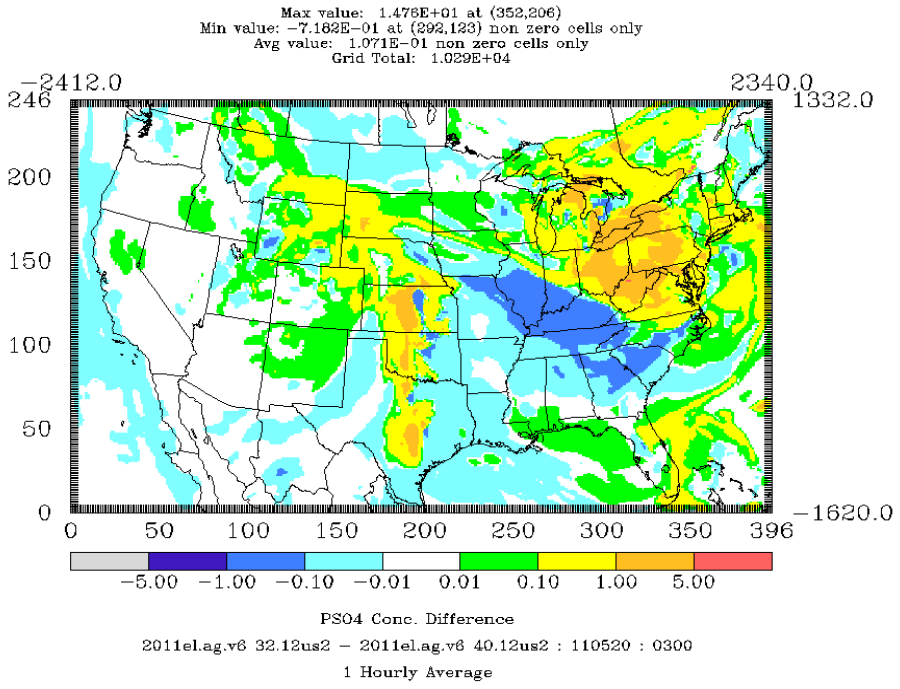
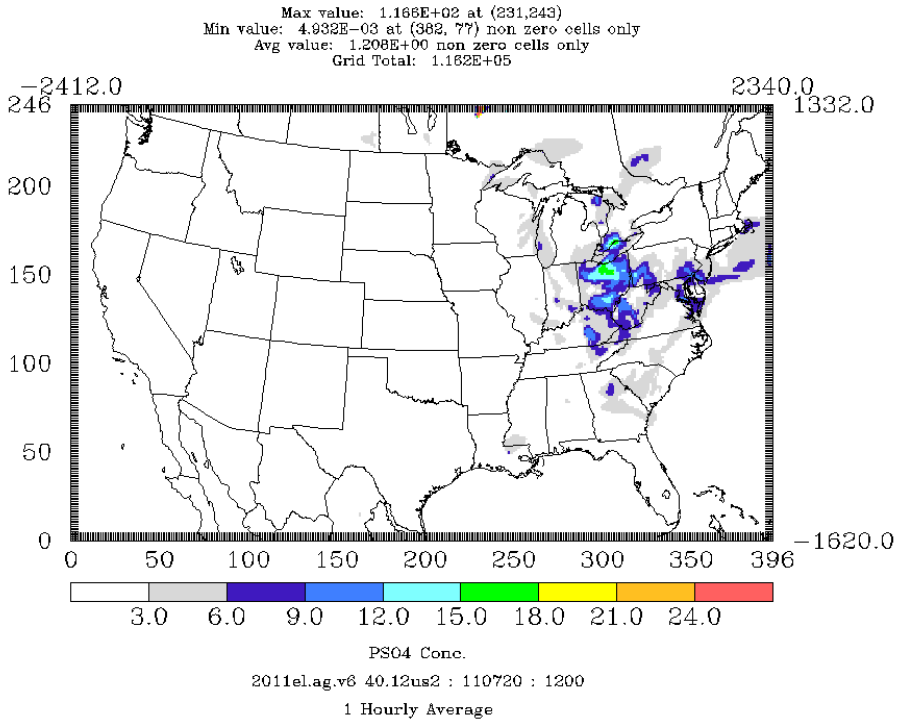


Figure 4-53: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1200 hours

CAMx 6.40



Difference (6.32 - 6.40)

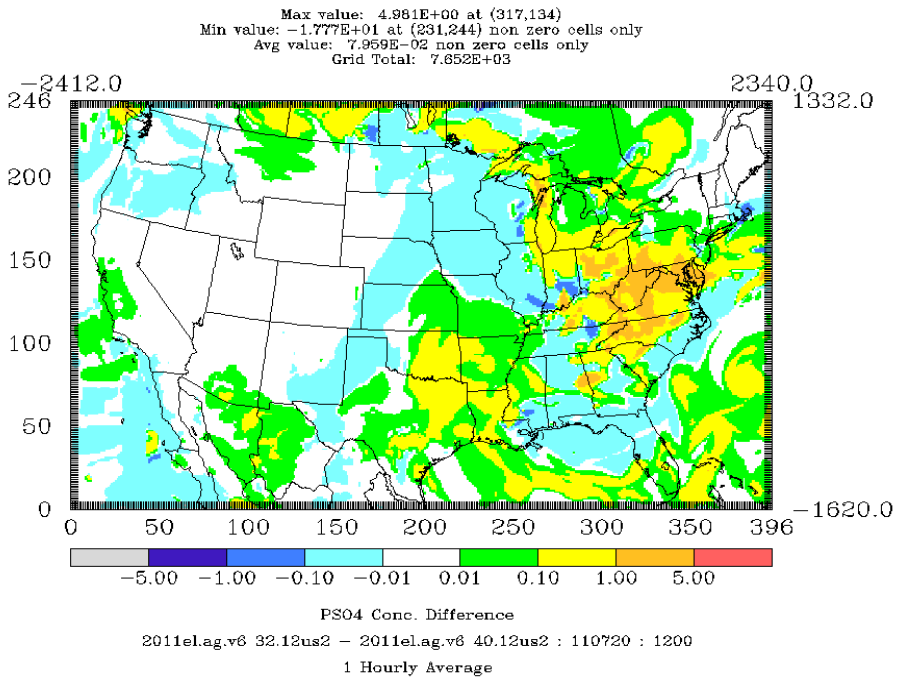
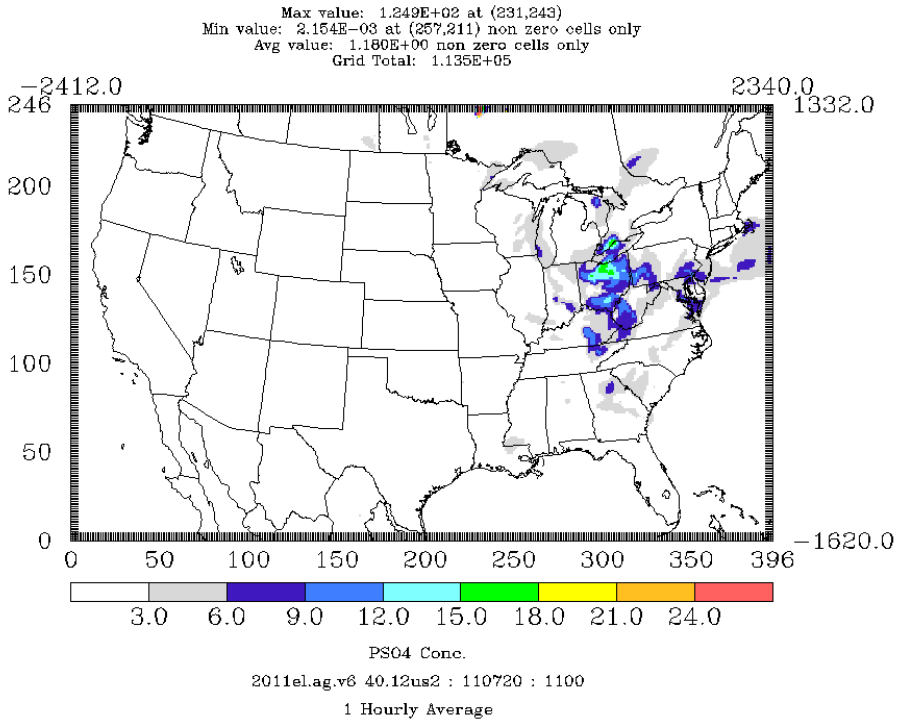


Figure 4-54: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1100 hours

CAMx 6.40



Difference (6.32 - 6.40)

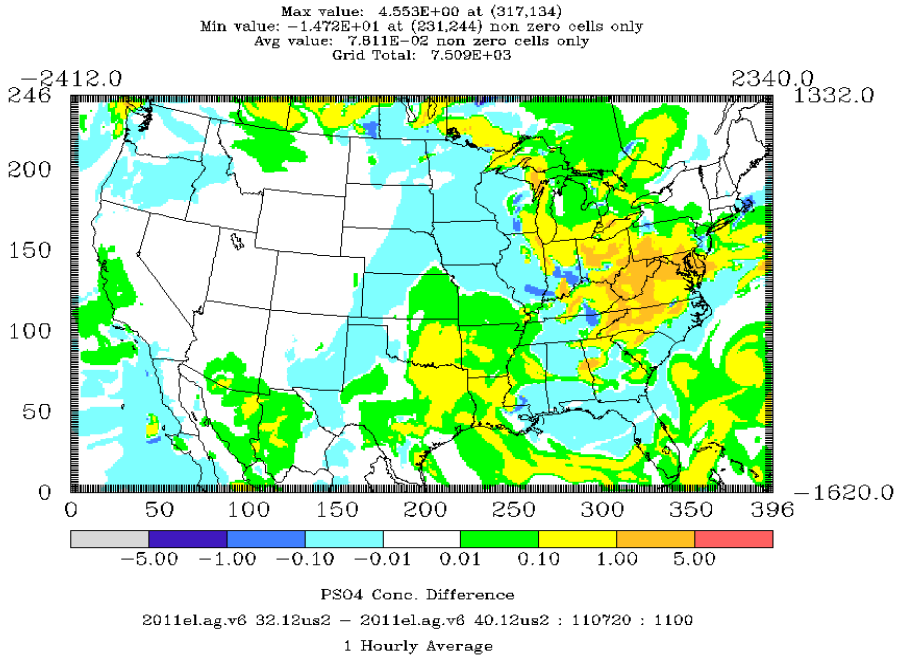
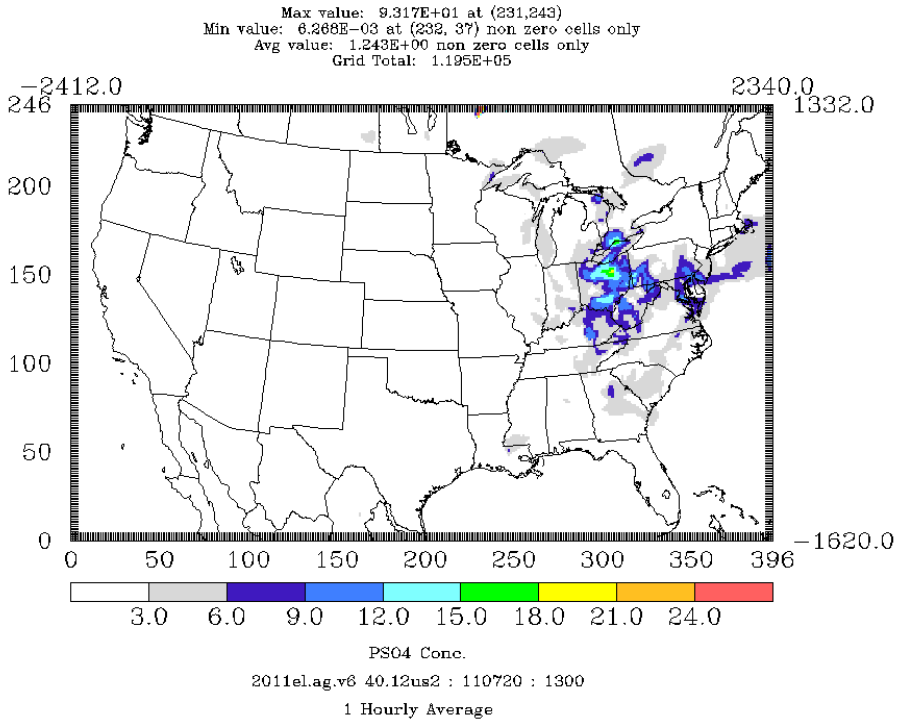


Figure 4-55: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1300 hours

CAMx 6.40



Difference (6.32 - 6.40)

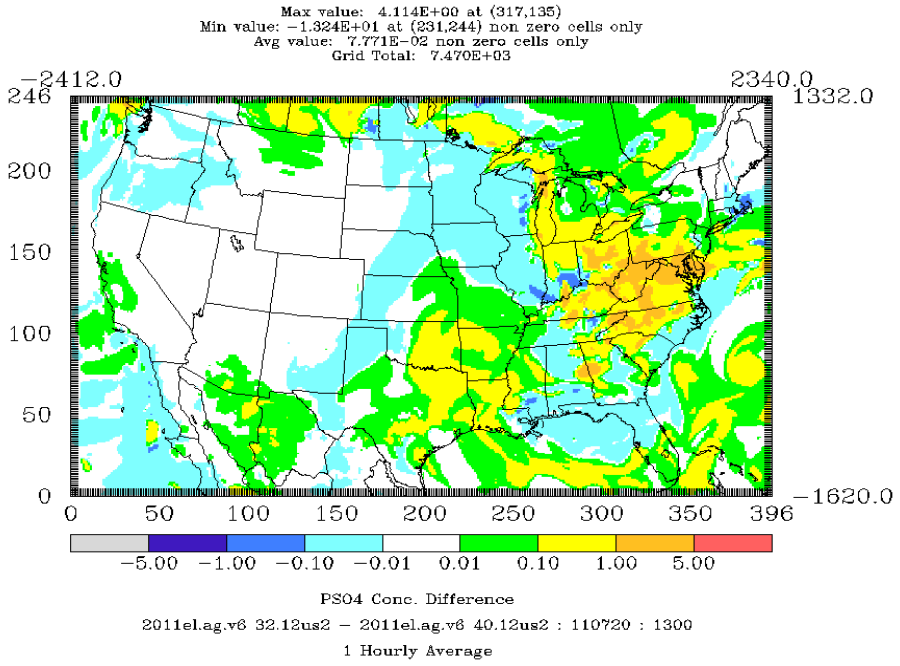
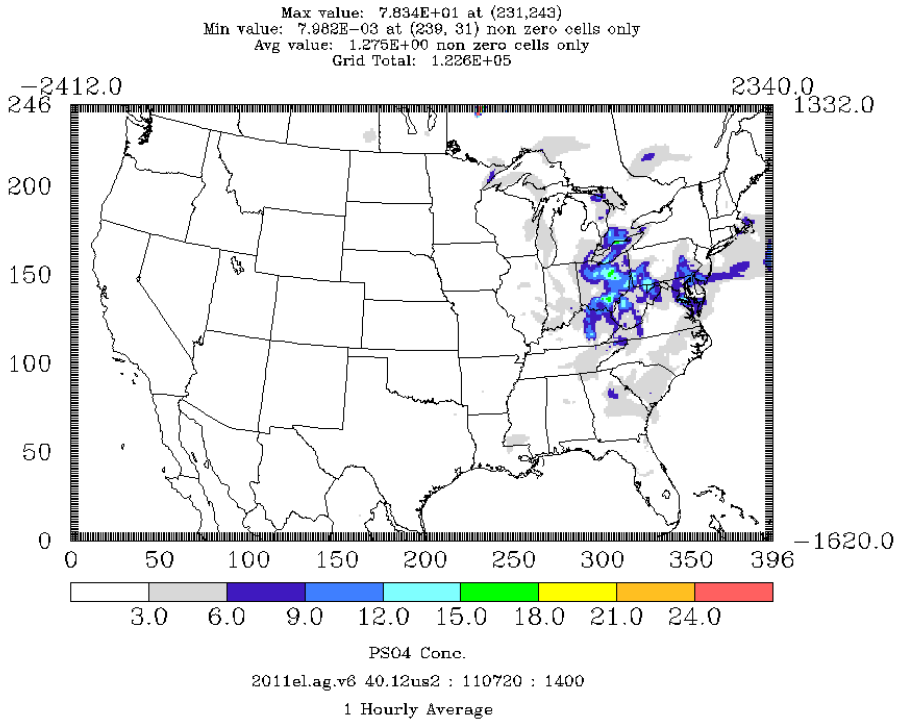


Figure 4-56: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 20 at 1400 hours

CAMx 6.40



Difference (6.32 - 6.40)

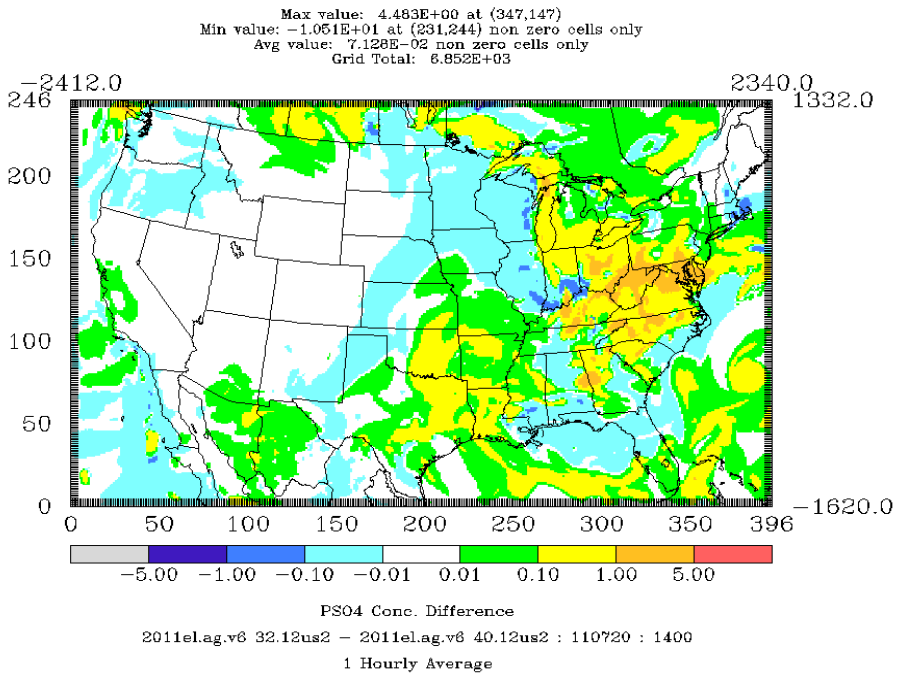
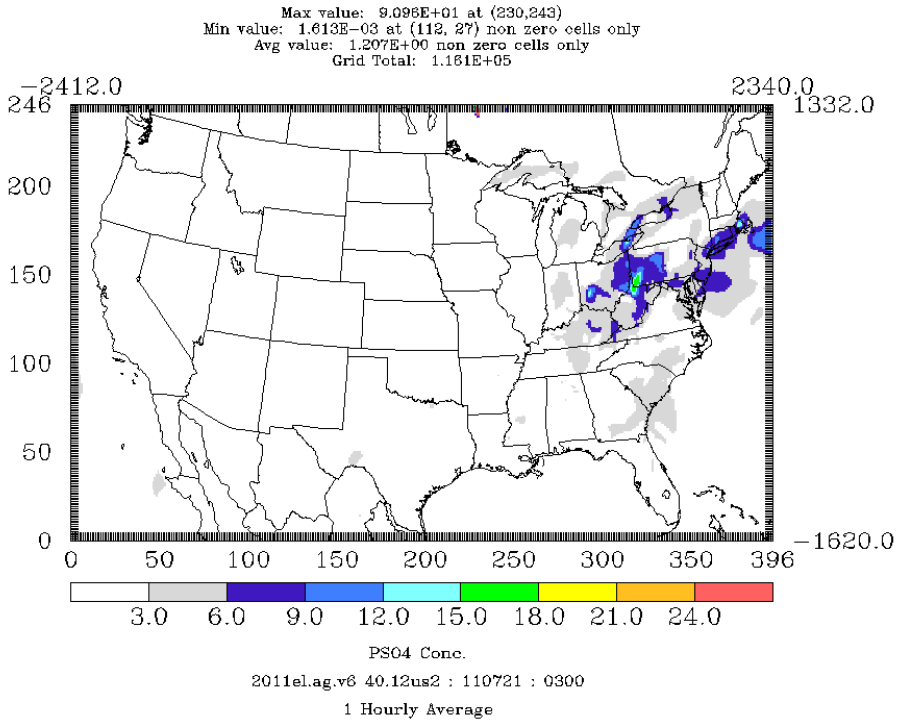


Figure 4-57: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 21 at 300 hours

CAMx 6.40



Difference (6.32 - 6.40)

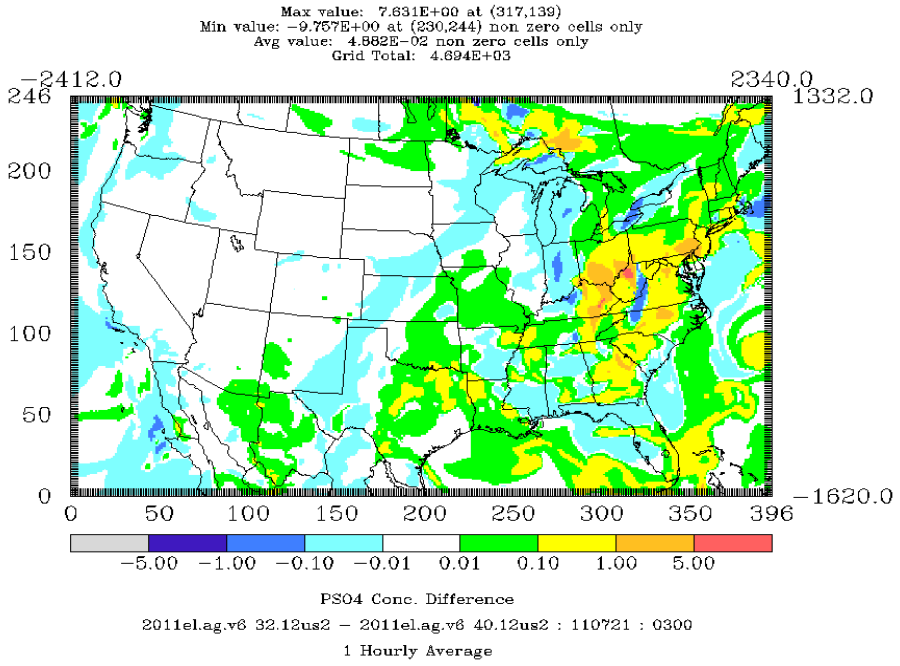
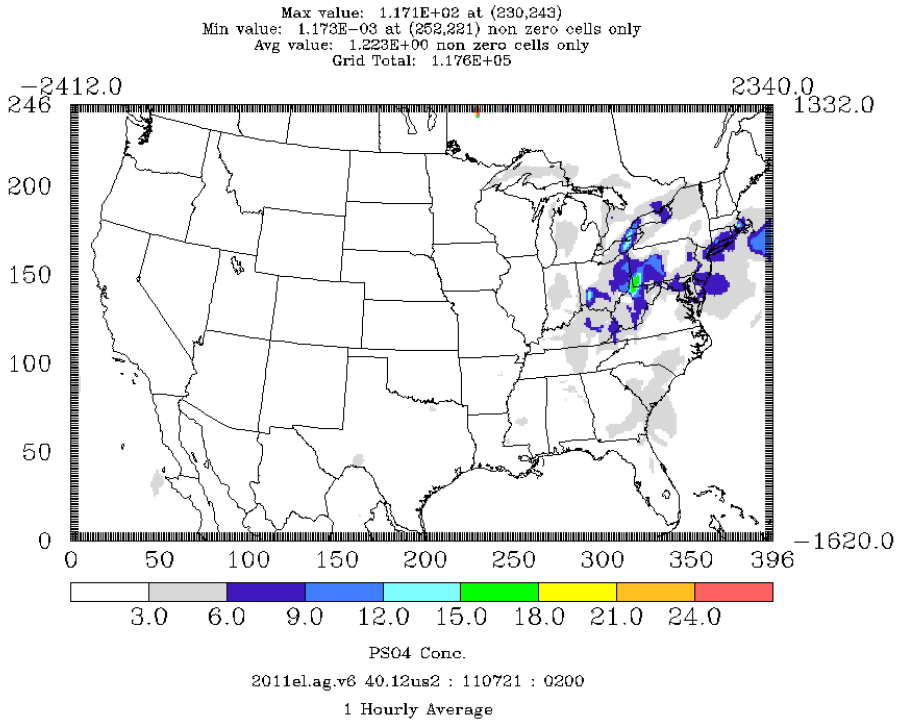


Figure 4-58: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 21 at 200 hours

CAMx 6.40



Difference (6.32 - 6.40)

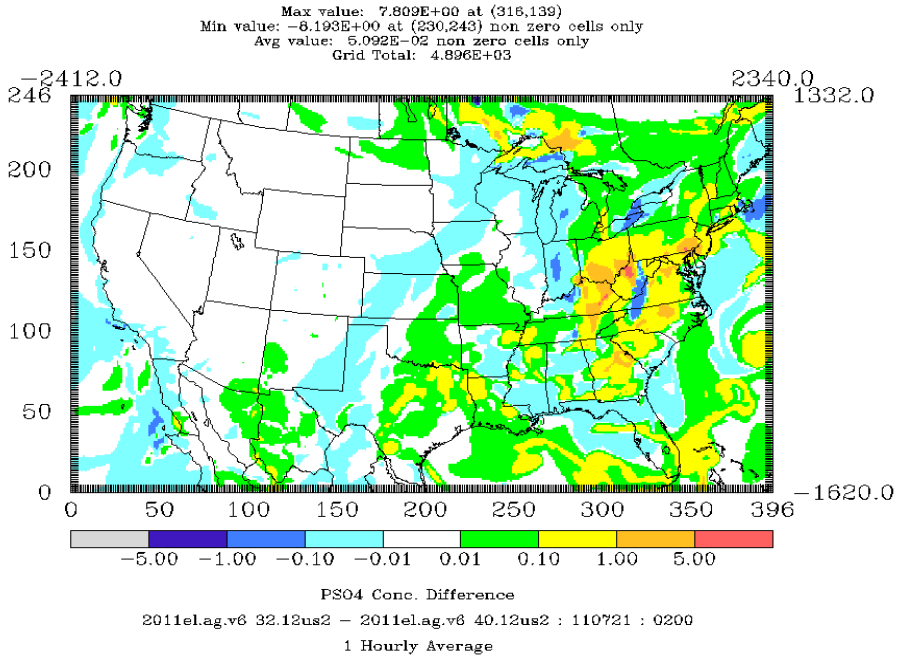
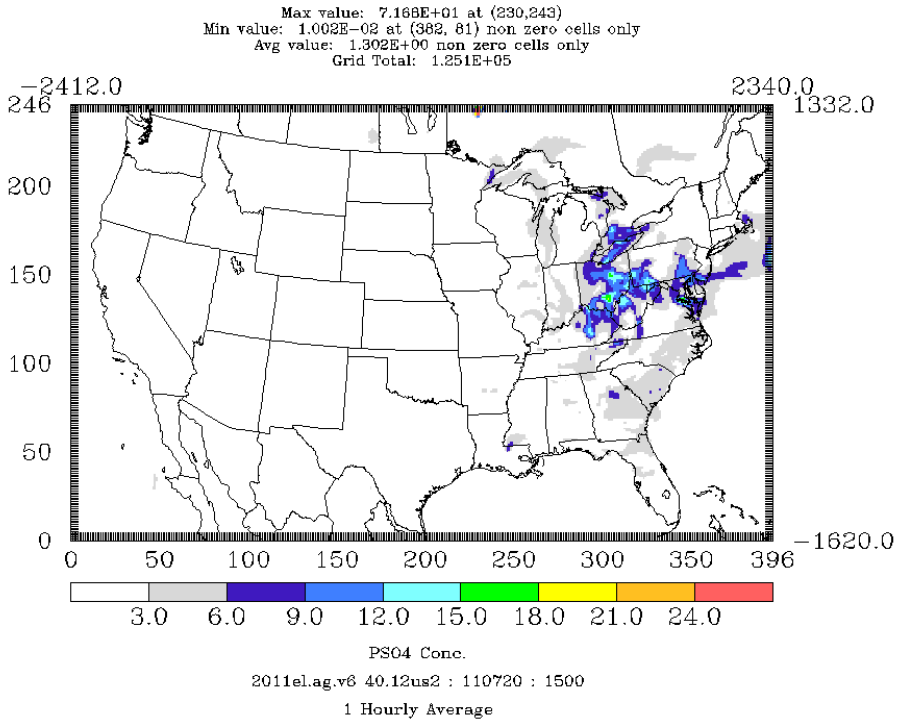


Figure 4-59: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 20 at 1500 hours

CAMx 6.40



Difference (6.32 - 6.40)

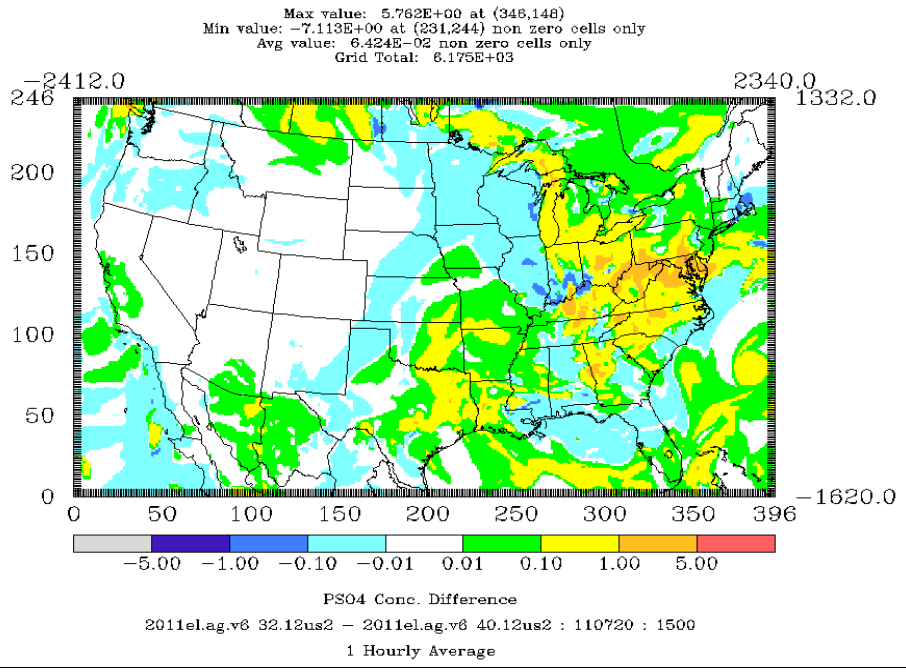
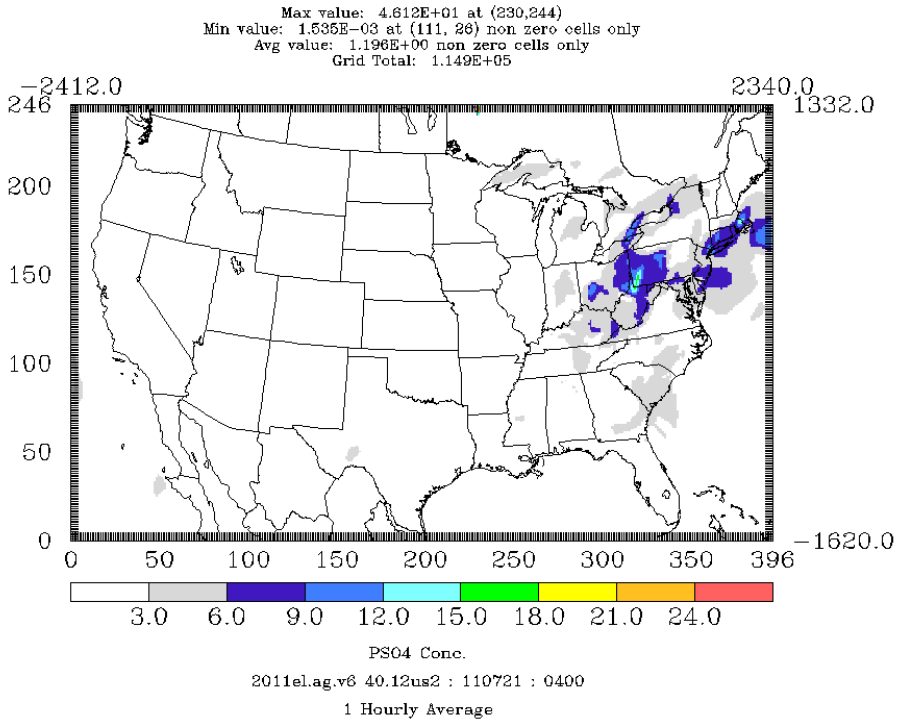


Figure 4-60: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 21 at 400 hours

CAMx 6.40



Difference (6.32 - 6.40)

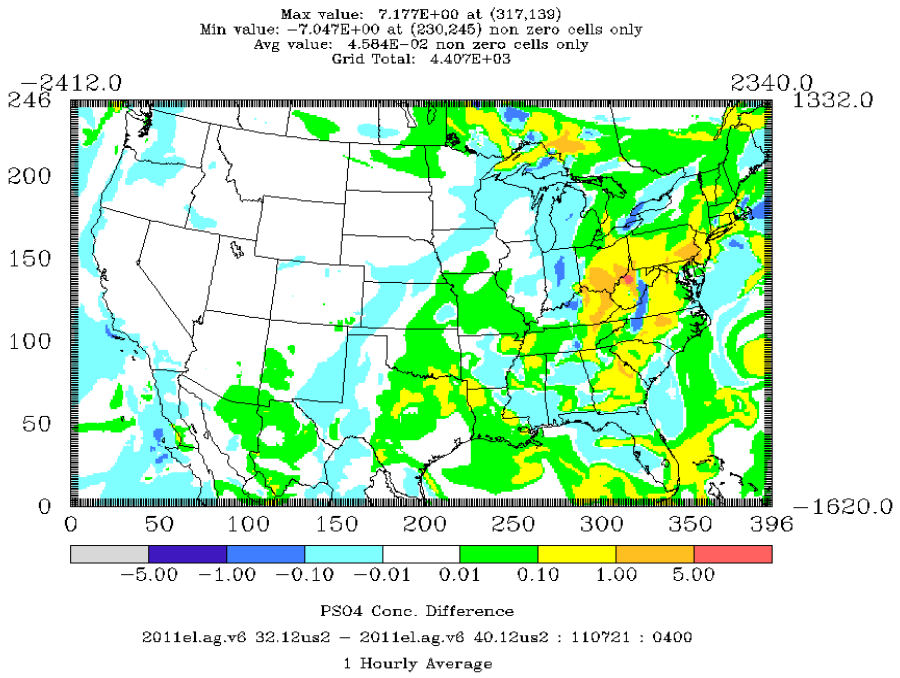
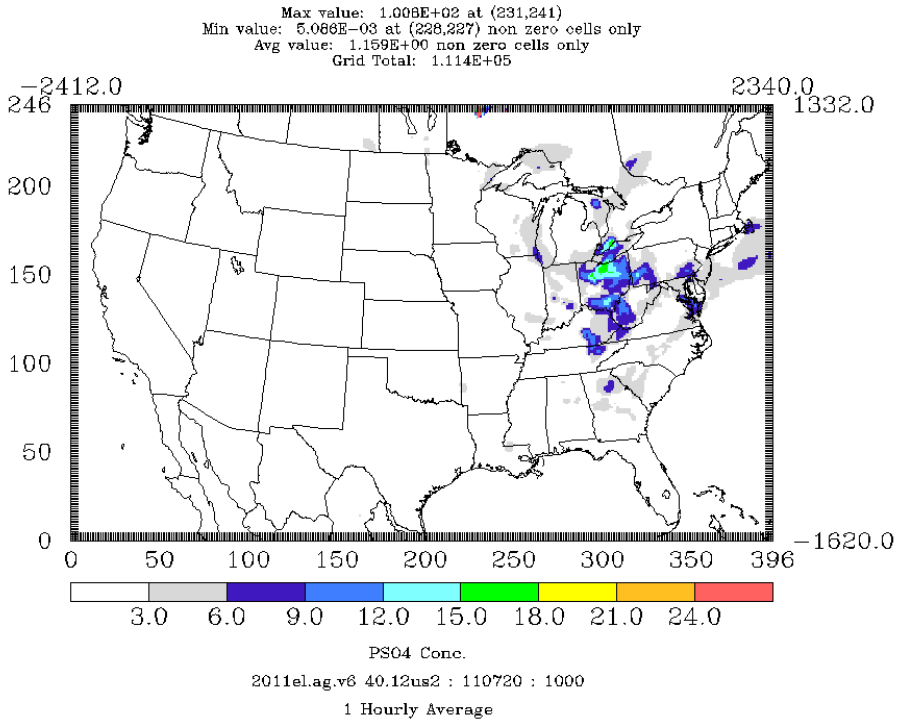


Figure 4-61: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 20 at 1000 hours

CAMx 6.40



Difference (6.32 - 6.40)

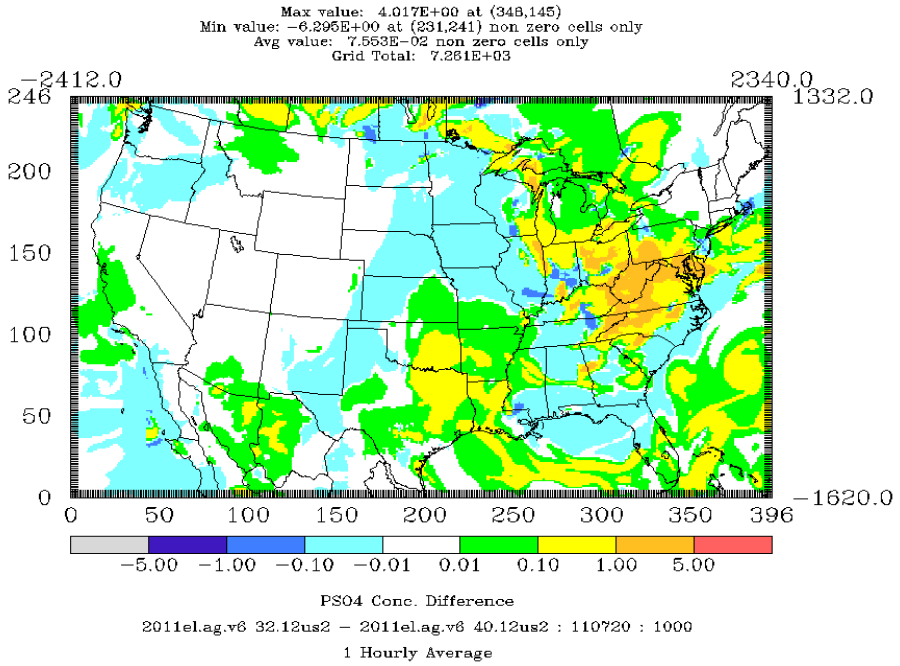
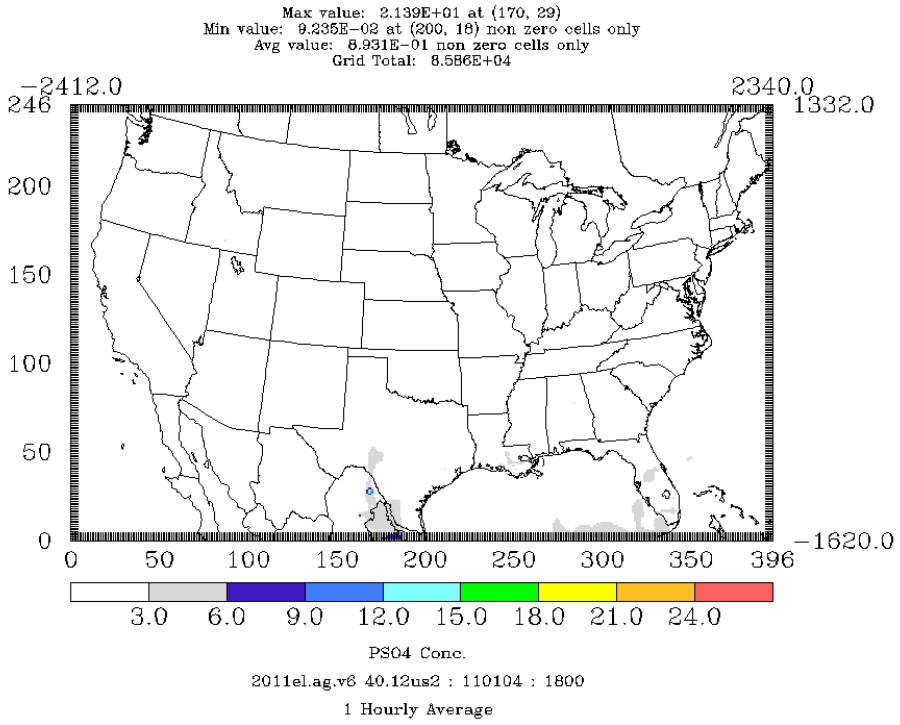


Figure 4-62: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: January 4 at 1800 hours

CAMx 6.40



Difference (6.32 - 6.40)

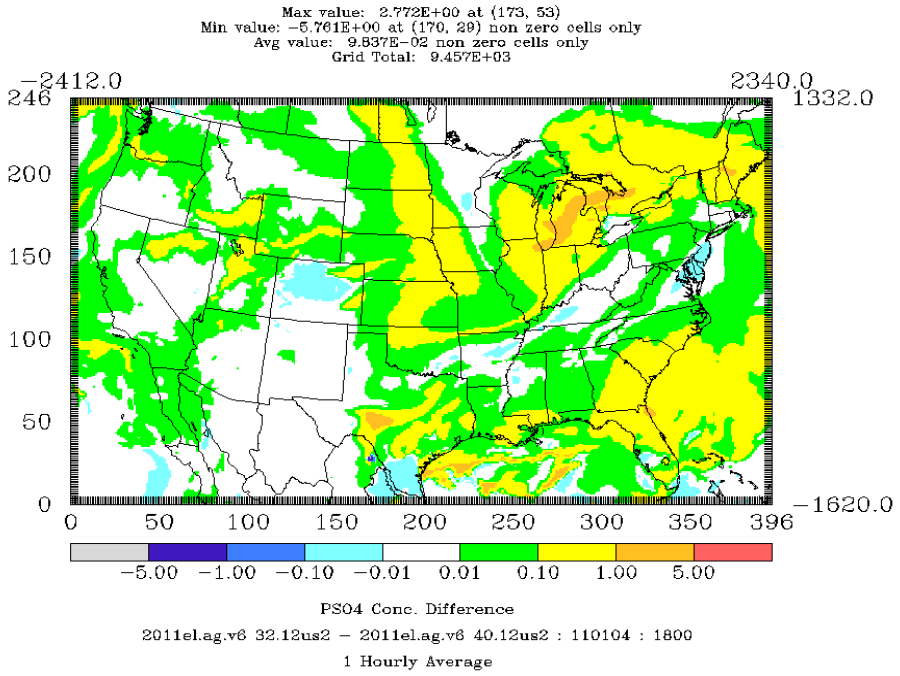


Figure 4-63: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference)

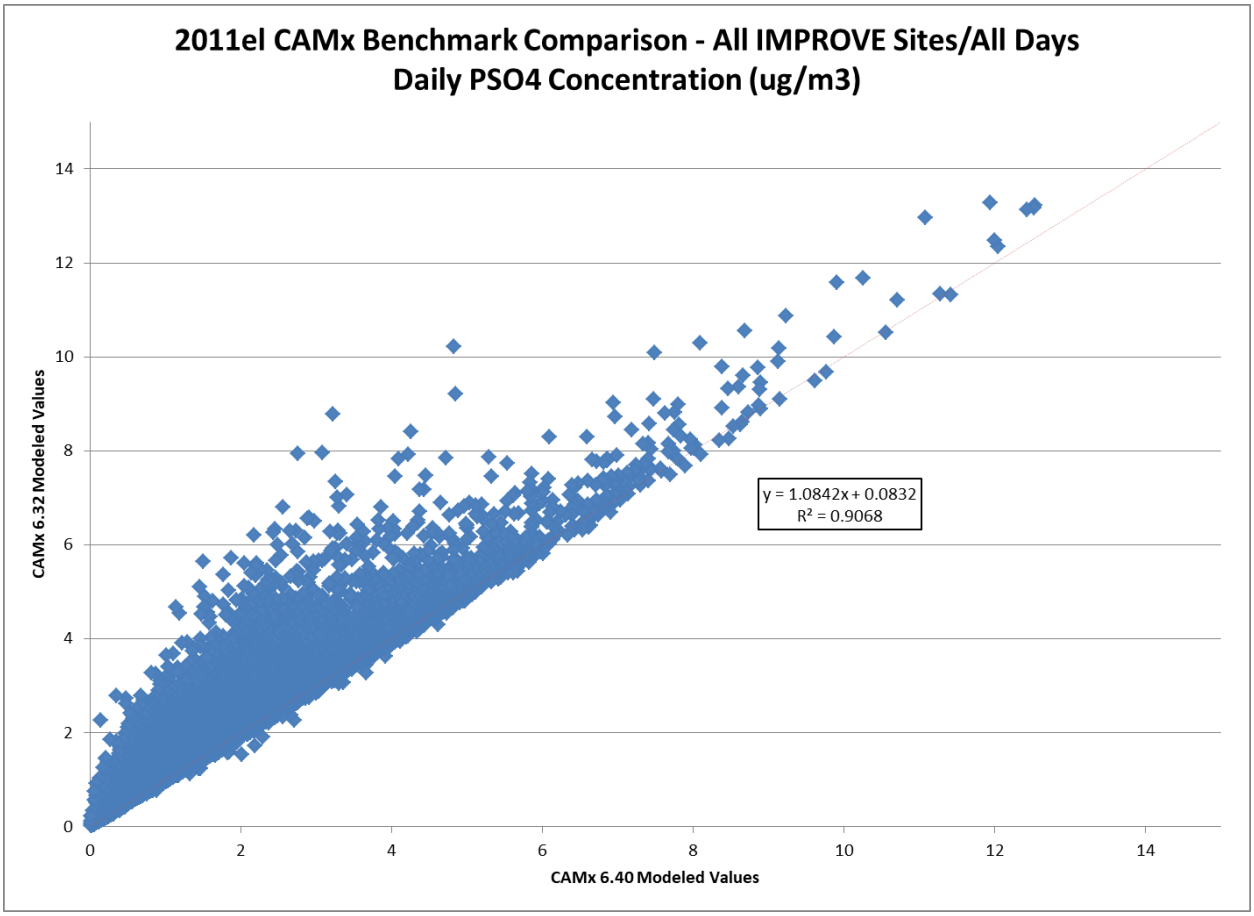


Figure 4-64: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine).

4.4 Nitrate

Nitrate results for the top 10 positive and negative hours are presented in tabular format in Table 4-4. The maximum positive difference is 28.08 µg/m^3 falling to 21.00 µg/m^3 for the 10th high. The maximum negative difference is -7.05 µg/m^3 falling to -6.16 µg/m^3 for the 10th high. The maximum positive percent difference from these days is 2512% and negative percent difference of -79.6%.

The top 10 positive difference hours are presented in Figures 4-65 through 4-74. The maximum positive difference hours all occur on either September 24th or May 14th. On September 24th the peak impacts are in Canada just north of the New York border. On May 14th the peak impacts are again in Canada, but somewhat further west, north of Lake Erie.

The top 10 negative difference hours are presented in Figures 4-75 through 4-84. The peak hours are either on January 25th, January 26th, or February 1. For the January days the peak impact is occurring in southern Indiana. For the February day the peak impact is in eastern Oklahoma. These are both areas for high local nitrate concentrations in CAMx 6.40.

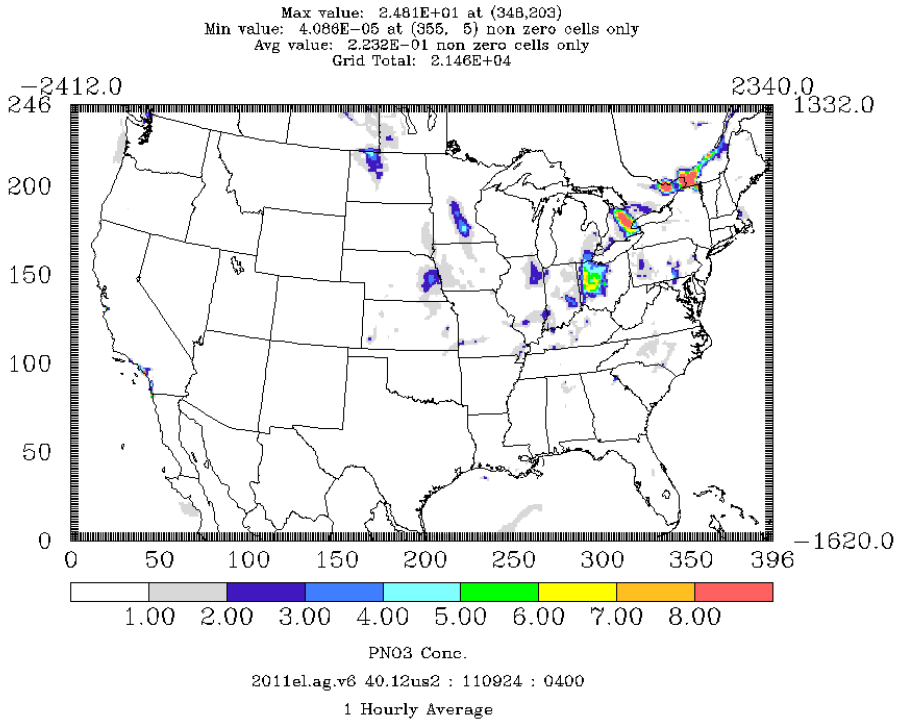
Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-85. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has considerably more scatter than the ozone or $PM_{2.5}$ results with a line of best fit with a slope of 0.9276, an intercept of 0.0013 µg/m^3 and an R^2 of 0.9635. Unlike the sulfate results which showed the CAMx 6.32 results nearly uniformly higher that CAMx 6.40, the nitrate results show more uniform scatter around the 1:1 line. Nitrate in most inland areas of the eastern U.S. appears slightly higher in v6.4 during the majority of hours. Superimposed on this slight increase there are occasional periods where when CAMx 6.40 is lower than CAMx 6.32, and other periods when CAMx 6.40 is higher than CAMx 6.32. The net results demonstrate a fairly uniform scatter around the 1:1 line.

Table 4-4. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of Nitrate Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	6.32 Conc.	6.40 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	9	24	4	30.90	2.82	28.08	997.3%	342	201
2011	9	24	3	32.93	5.53	27.40	495.7%	343	201
2011	5	14	13	31.25	4.39	26.86	611.1%	306	181
2011	5	14	14	27.89	1.67	26.22	1570.6%	305	182
2011	5	14	15	26.94	1.03	25.91	2512.0%	305	182
2011	9	24	5	29.33	3.63	25.70	708.6%	342	200
2011	5	14	12	33.53	8.61	24.92	289.6%	306	181
2011	5	14	16	24.38	1.67	22.71	1362.8%	305	182
2011	5	14	11	33.01	10.58	22.43	211.9%	306	180
2011	9	24	6	27.46	6.47	21.00	324.7%	341	199
Maximum Negative									
2011	1	25	22	2.57	9.62	-7.05	-73.3%	274	122
2011	1	25	21	4.19	11.19	-7.00	-62.5%	274	123
2011	1	25	23	2.75	9.67	-6.92	-71.6%	274	120
2011	1	25	20	5.50	12.17	-6.68	-54.9%	274	123
2011	1	26	0	2.61	9.27	-6.66	-71.9%	274	119
2011	2	1	6	1.68	8.23	-6.55	-79.6%	220	92
2011	2	1	5	1.56	8.08	-6.52	-80.7%	219	92
2011	1	25	19	6.37	12.59	-6.22	-49.4%	274	124
2011	1	26	3	4.80	10.99	-6.20	-56.4%	279	149
2011	2	1	4	2.68	8.84	-6.16	-69.6%	211	86

Maximum Positive Difference: September 24 at 400 hours

CAMx 6.40



Difference (6.32 - 6.40)

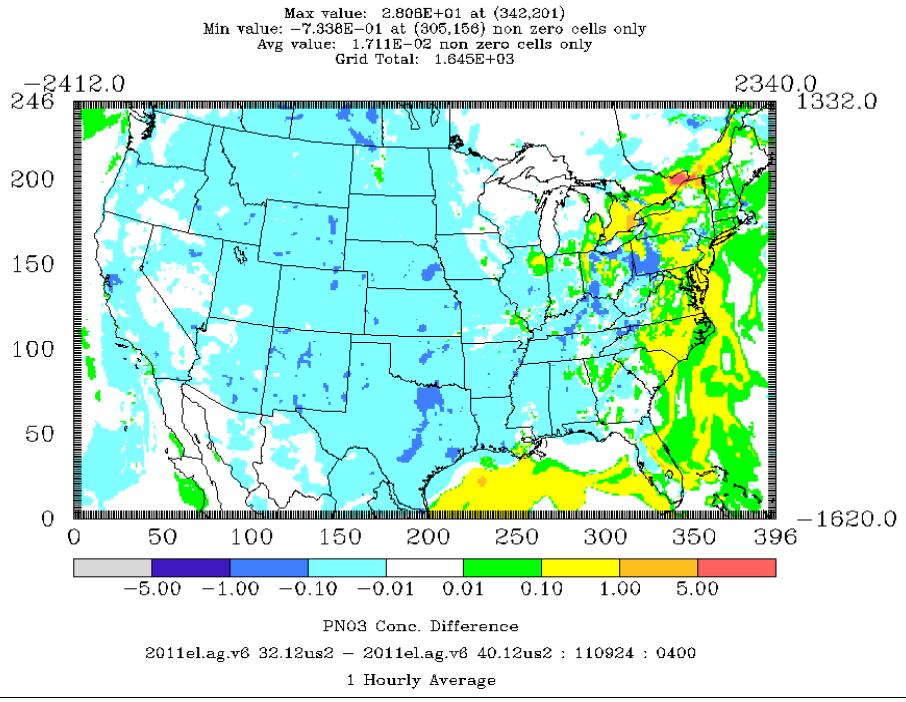
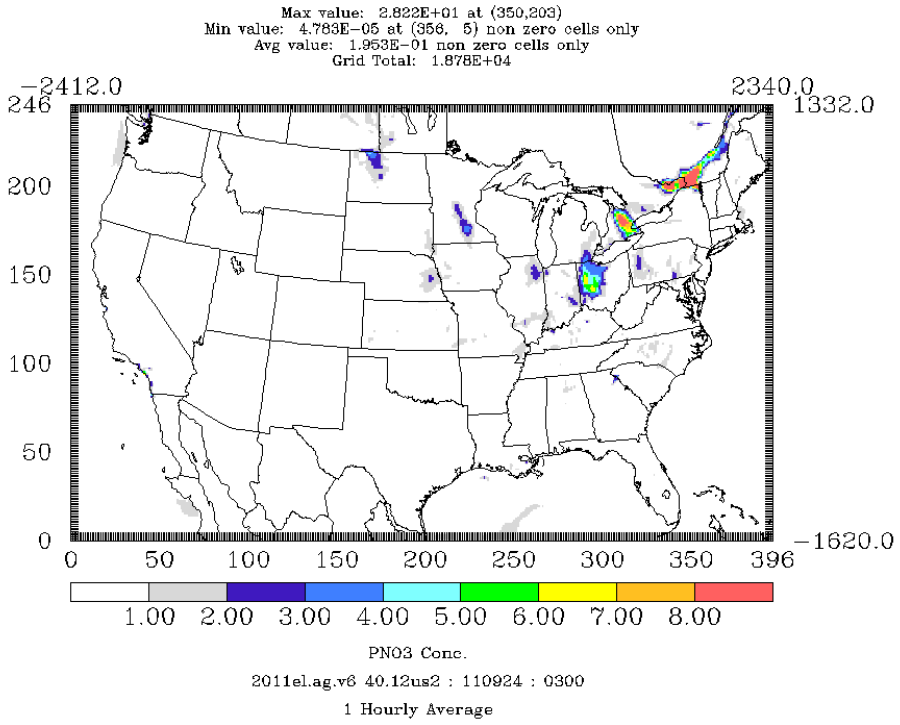


Figure 4-65: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: September 24 at 300 hours

CAMx 6.40



Difference (6.32 - 6.40)

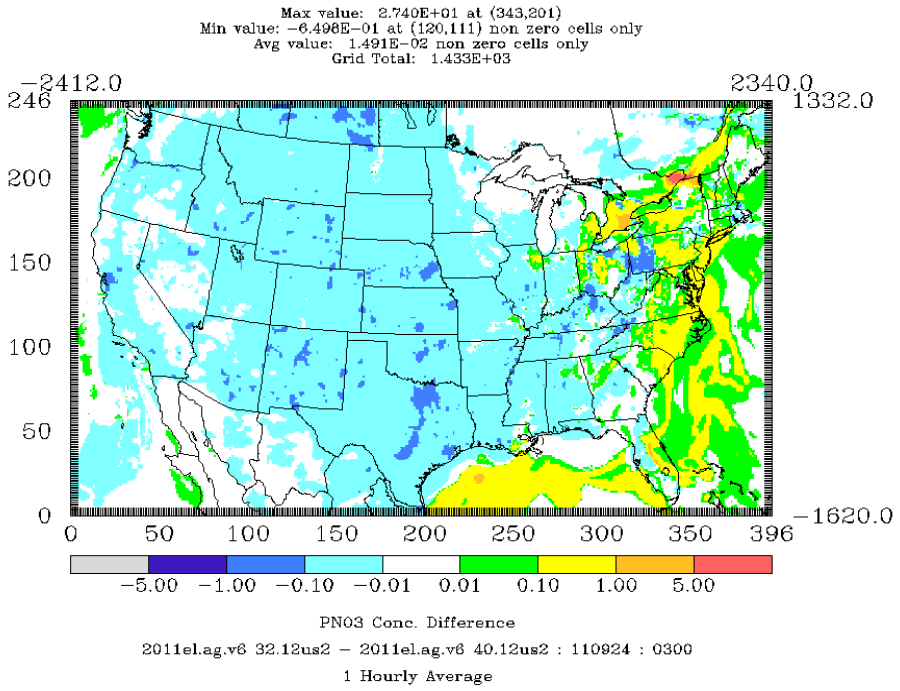
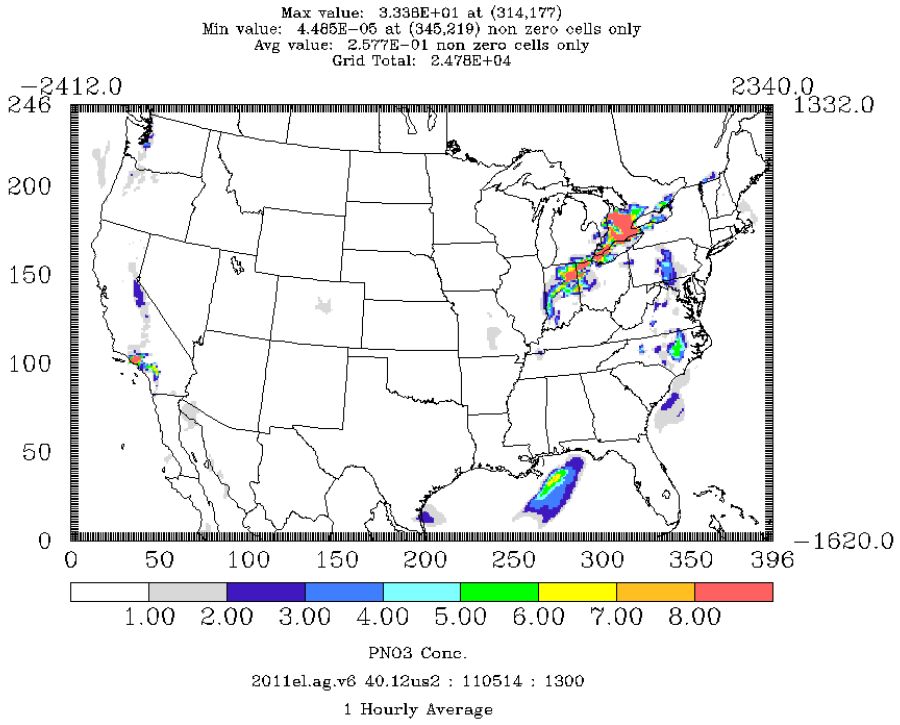


Figure 4-66: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: May 14 at 1300 hours

CAMx 6.40



Difference (6.32 - 6.40)

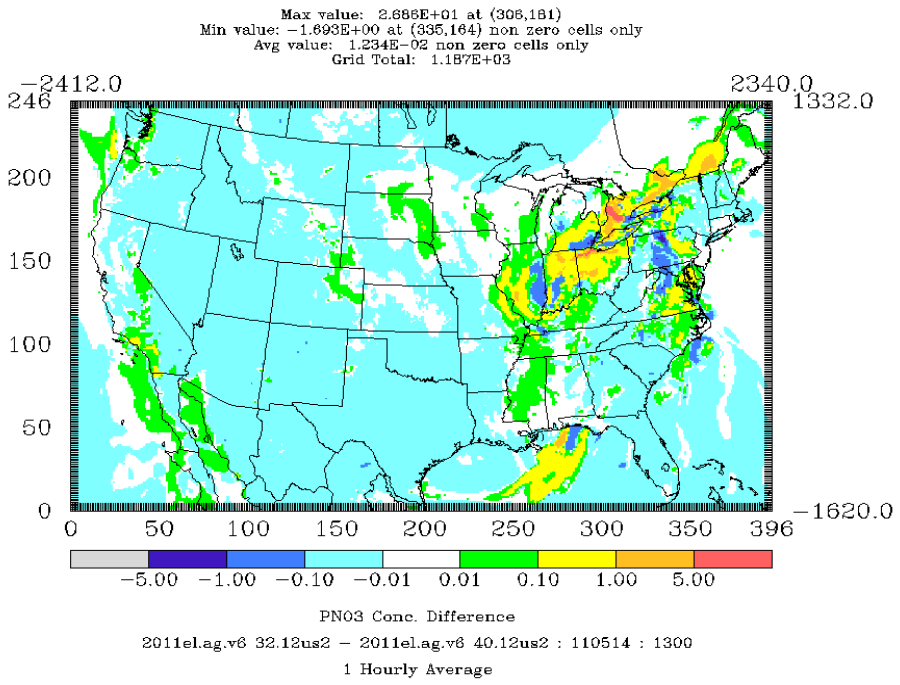
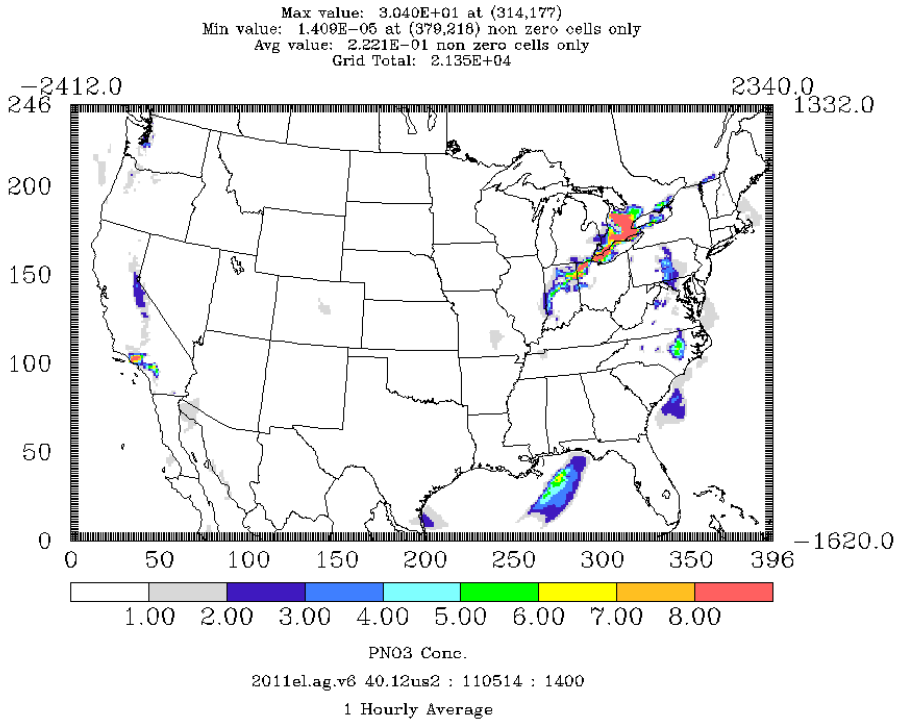


Figure 4-67: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: May 14 at 1400 hours

CAMx 6.40



Difference (6.32 - 6.40)

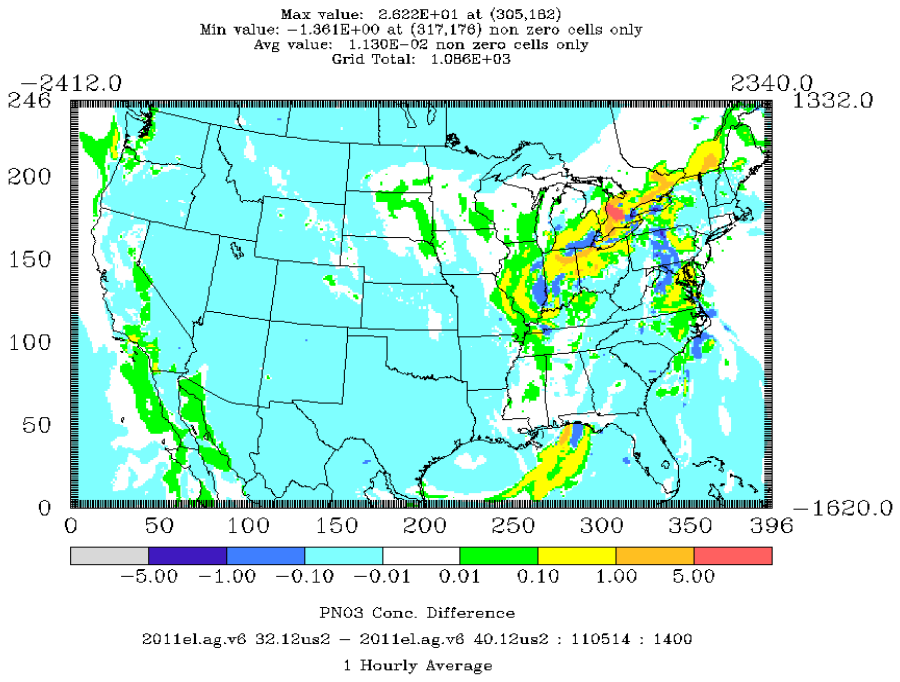
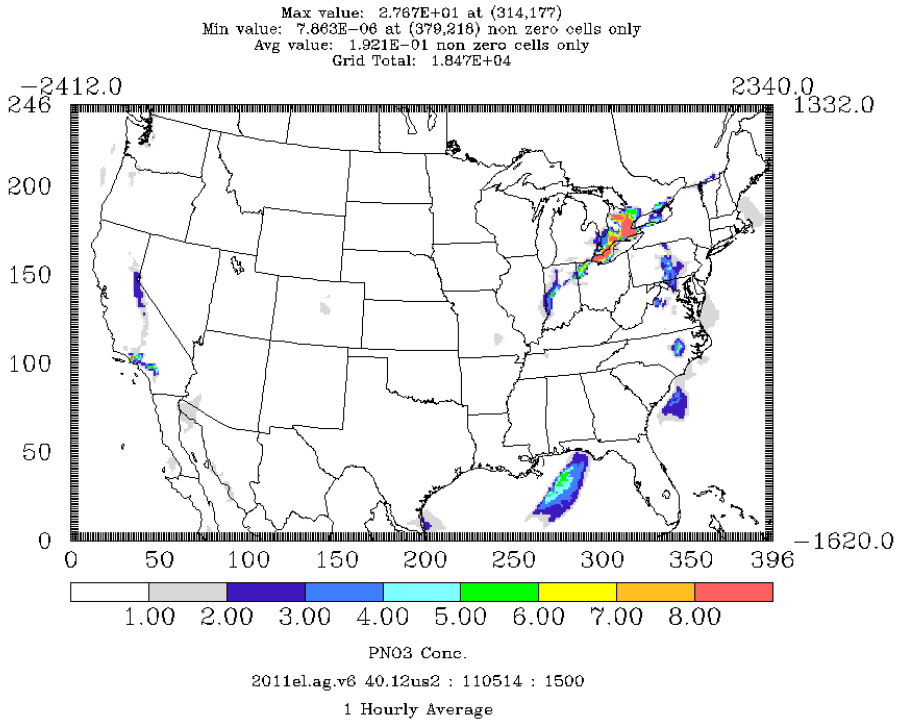


Figure 4-68: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: May 14 at 1500 hours

CAMx 6.40



Difference (6.32 - 6.40)

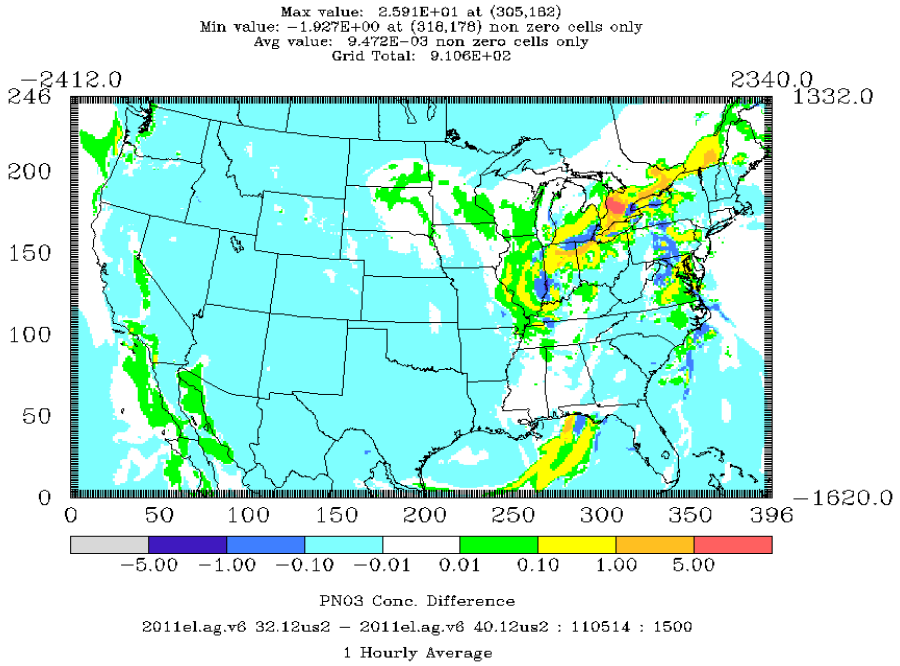
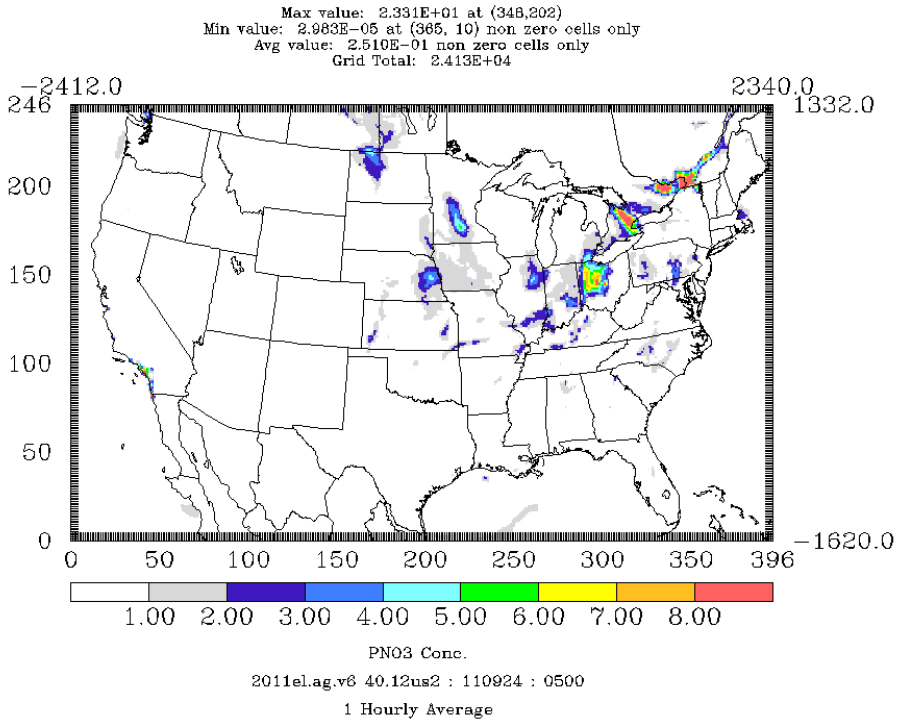


Figure 4-69: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: September 24 at 500 hours

CAMx 6.40



Difference (6.32 - 6.40)

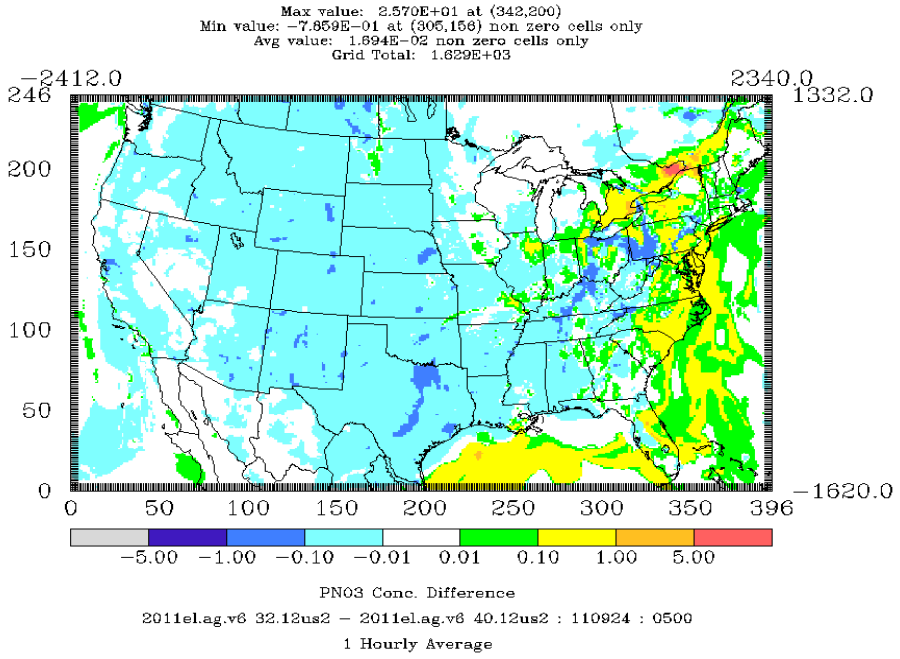
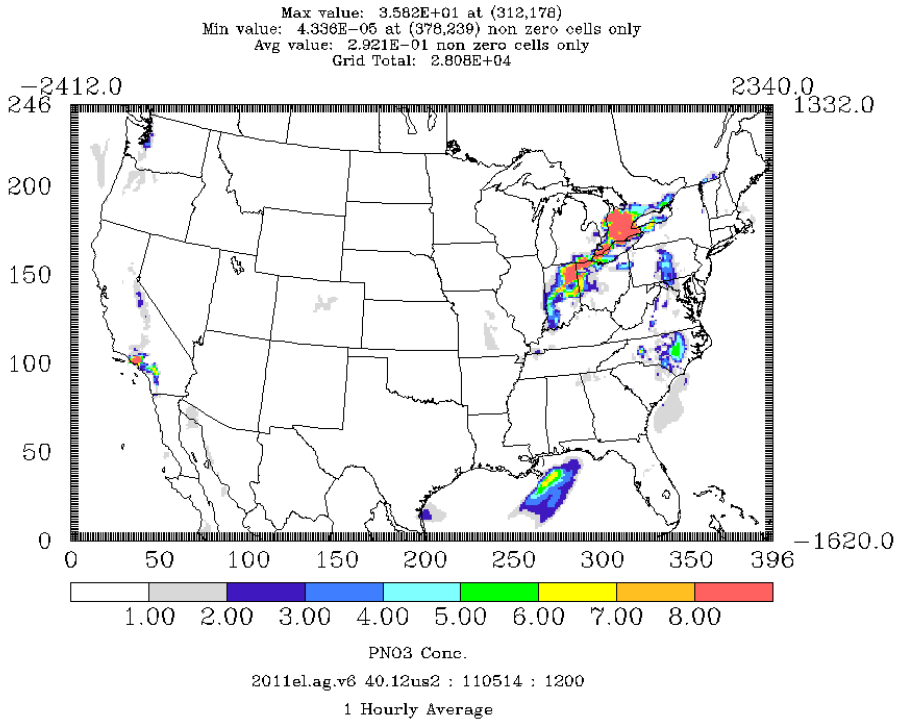


Figure 4-70: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: May 14 at 1200 hours

CAMx 6.40



Difference (6.32 - 6.40)

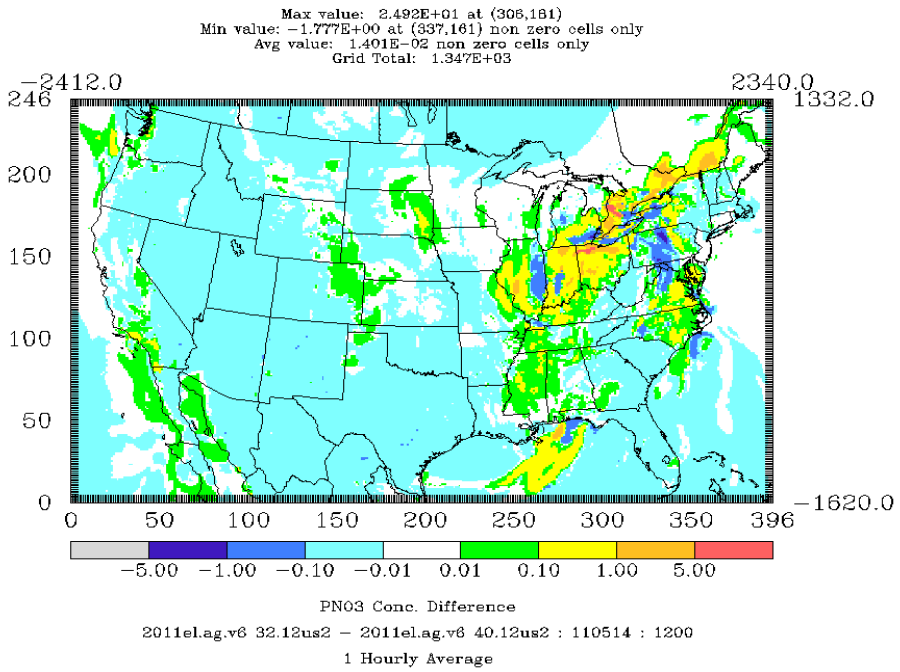
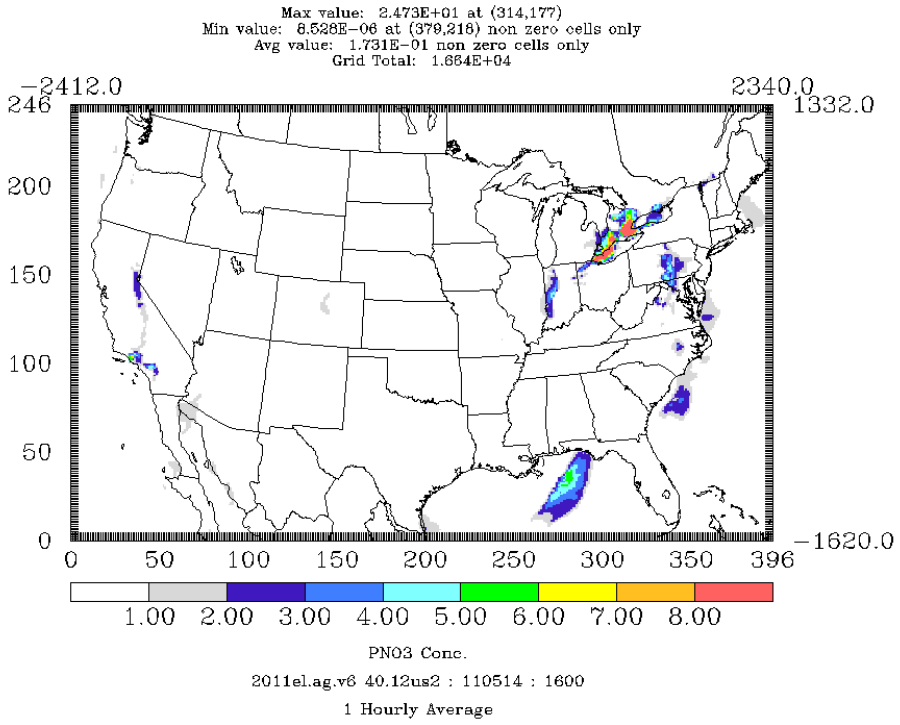


Figure 4-71: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: May 14 at 1600 hours

CAMx 6.40



Difference (6.32 - 6.40)

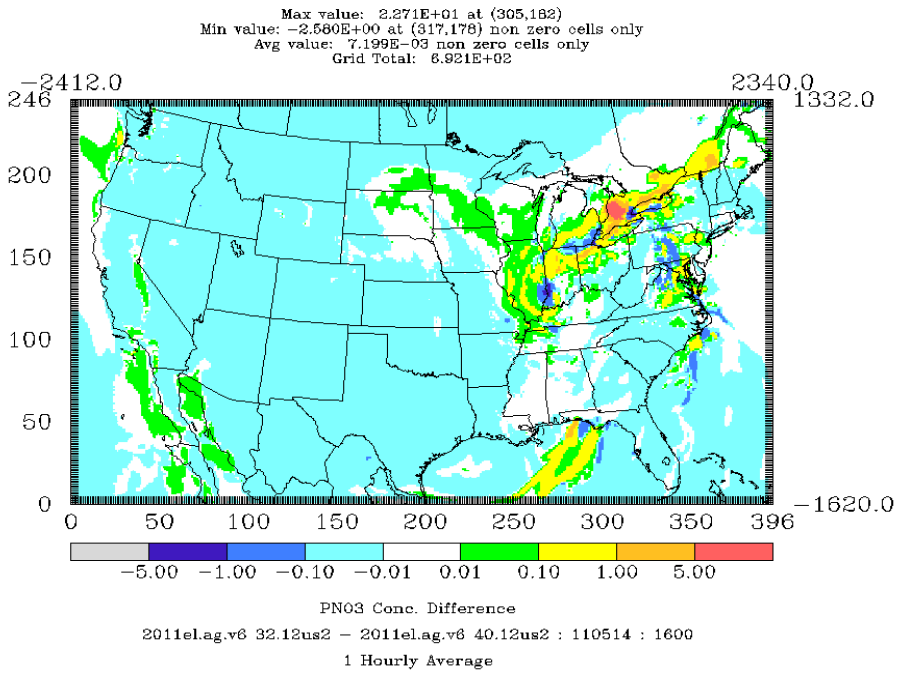
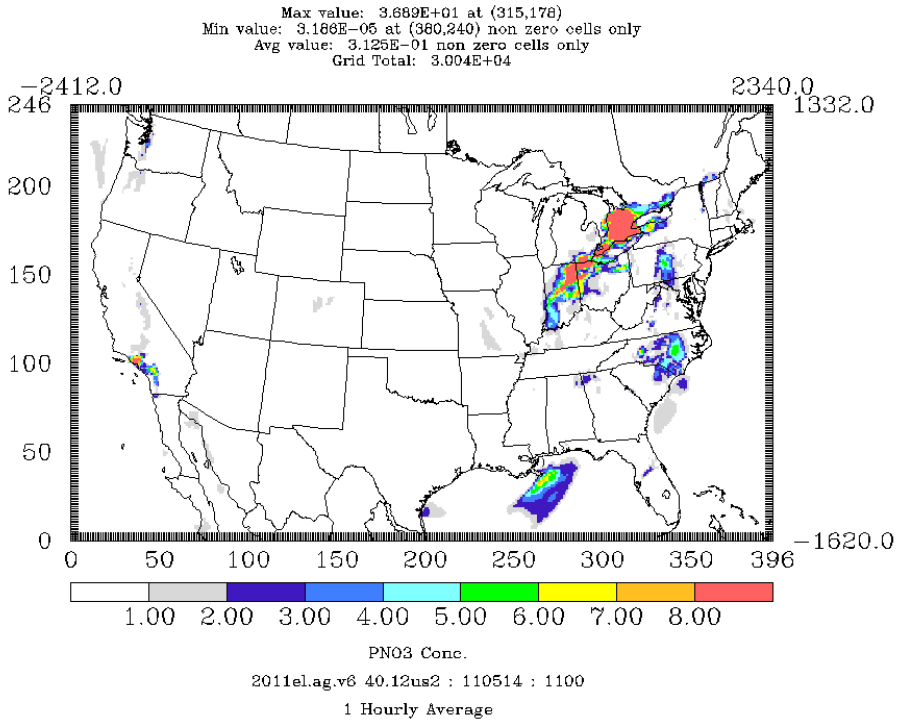


Figure 4-72: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: May 14 at 1100 hours

CAMx 6.40



Difference (6.32 - 6.40)

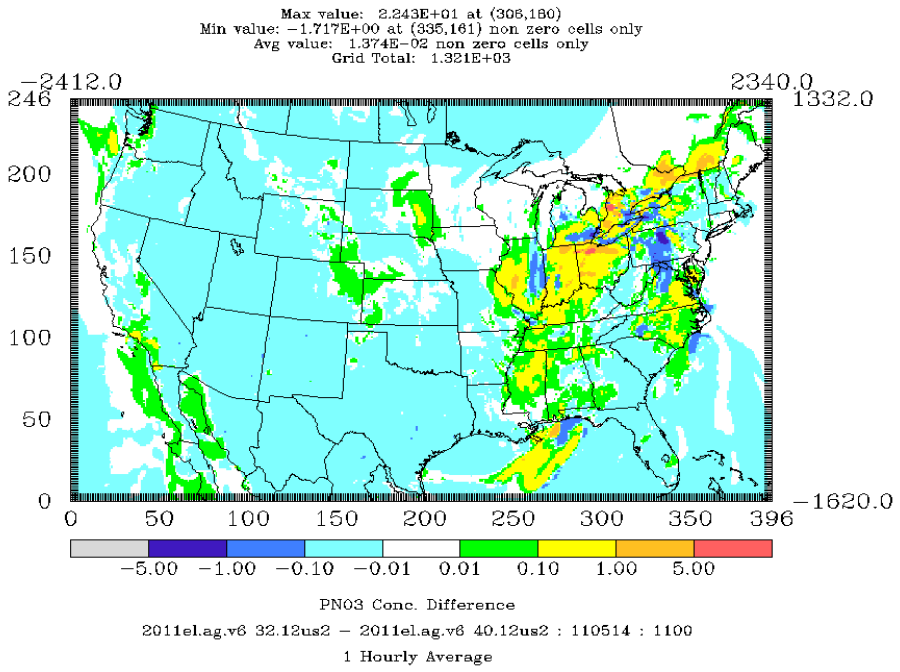
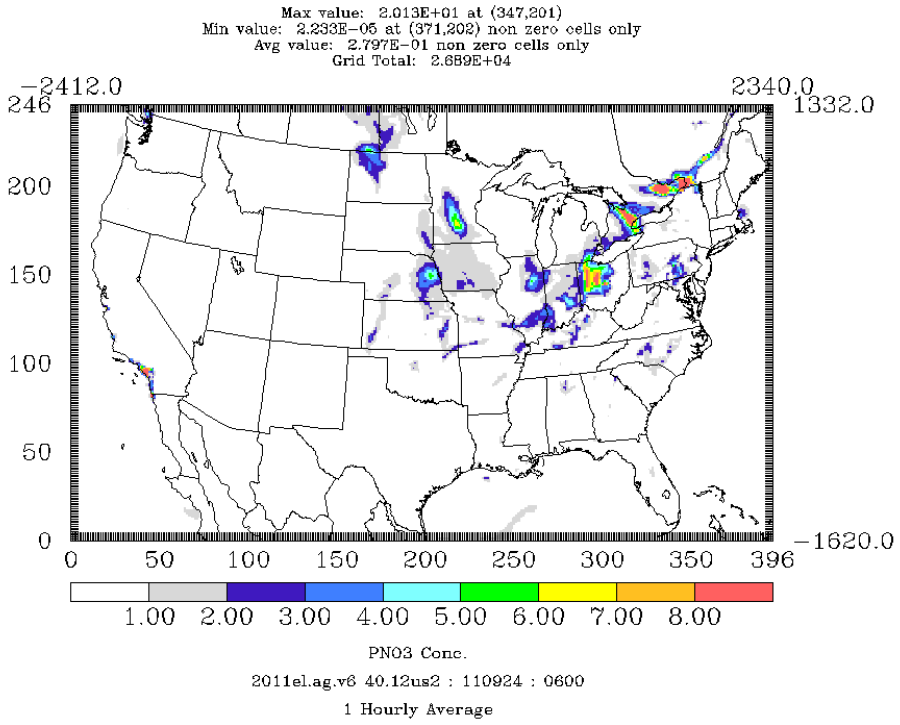


Figure 4-73: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: September 24 at 600 hours

CAMx 6.40



Difference (6.32 - 6.40)

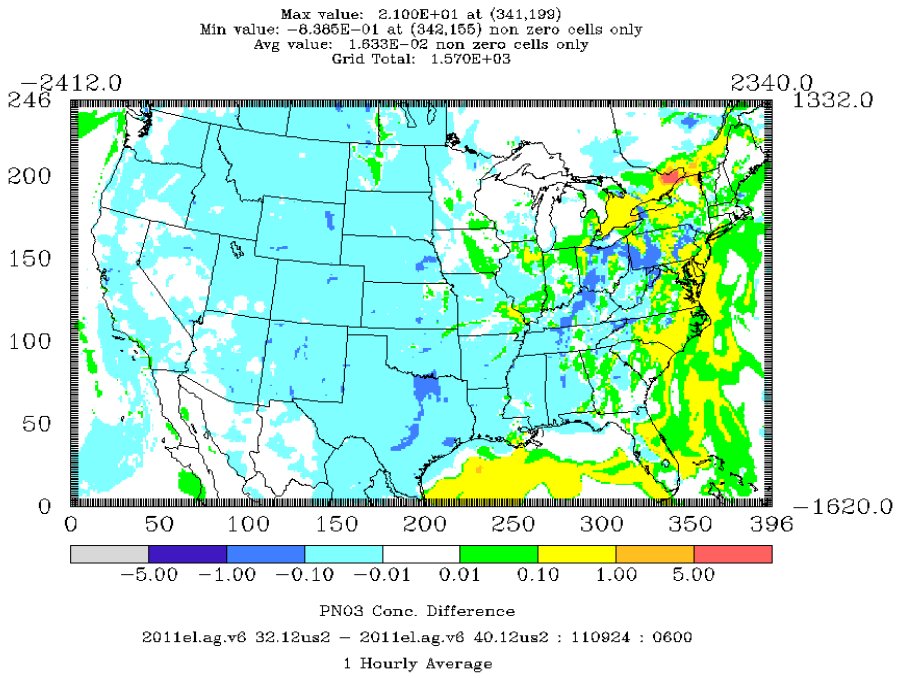
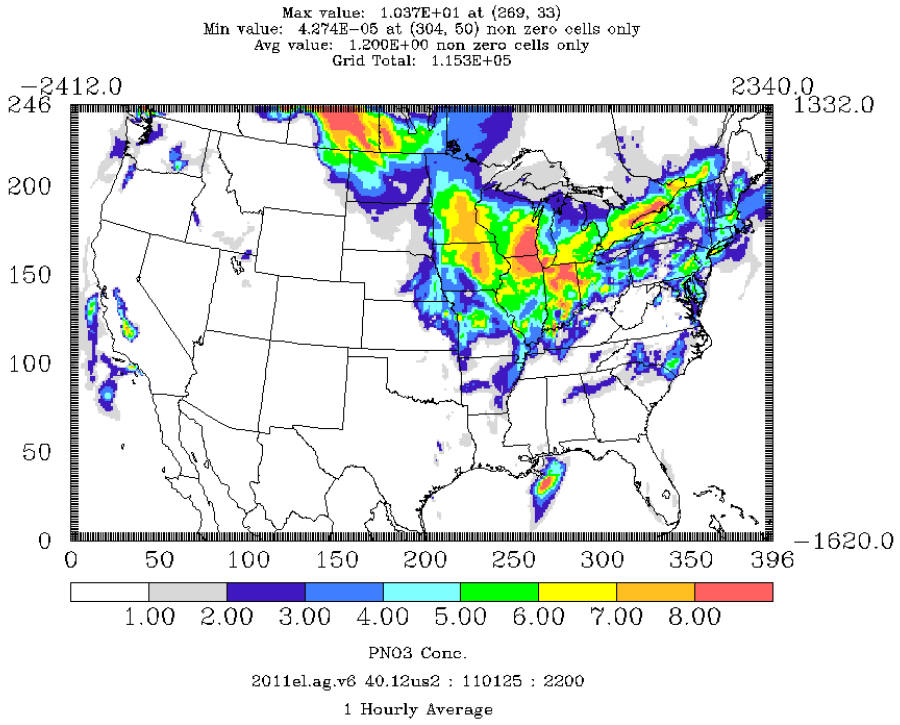


Figure 4-74: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: January 25 at 2200 hours

CAMx 6.40



Difference (6.32 - 6.40)

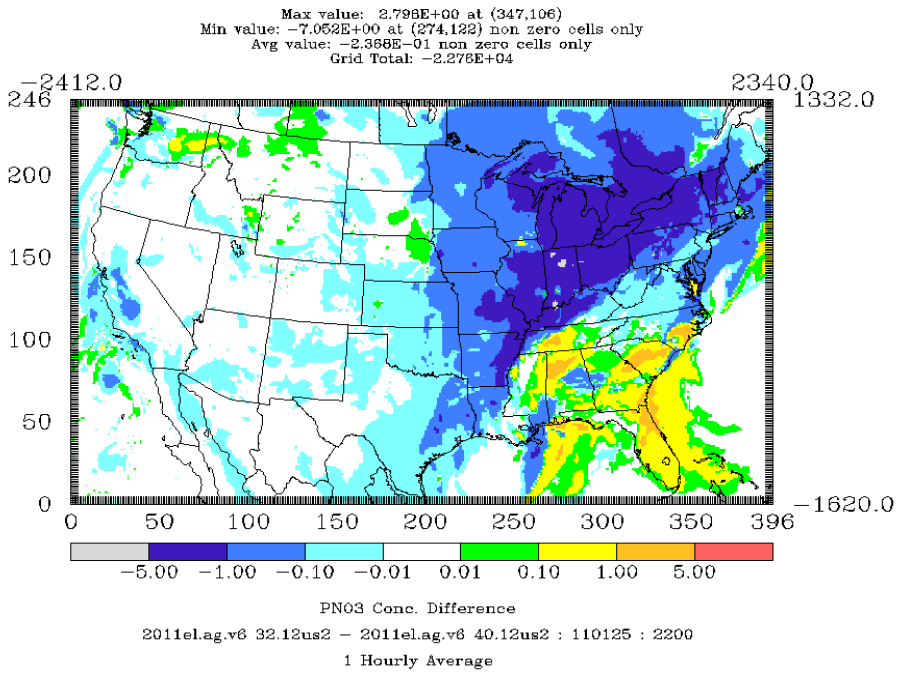
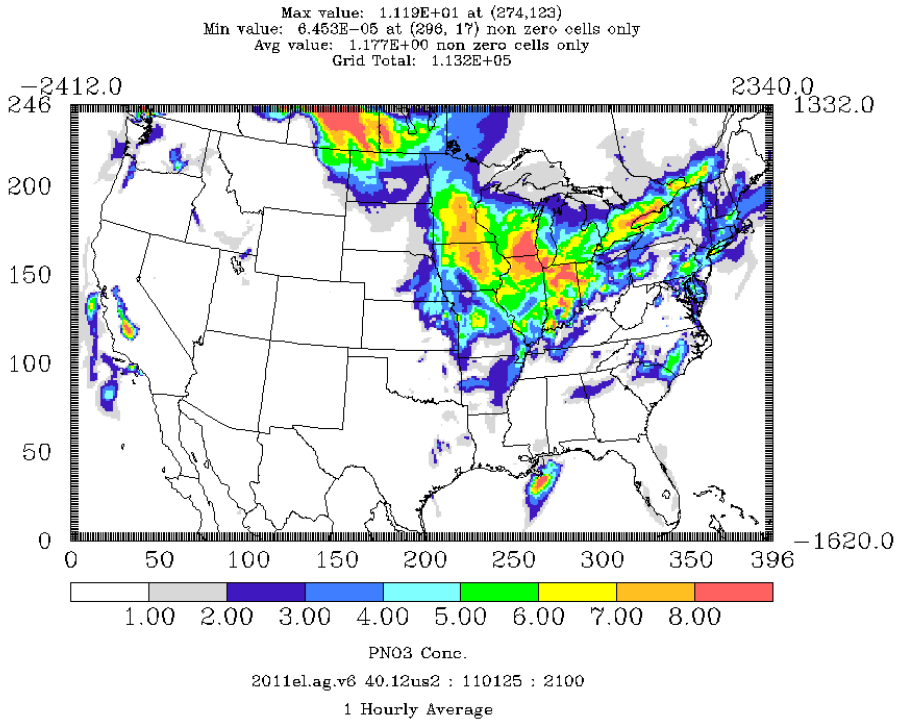


Figure 4-75: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: January 25 at 2100 hours

CAMx 6.40



Difference (6.32 - 6.40)

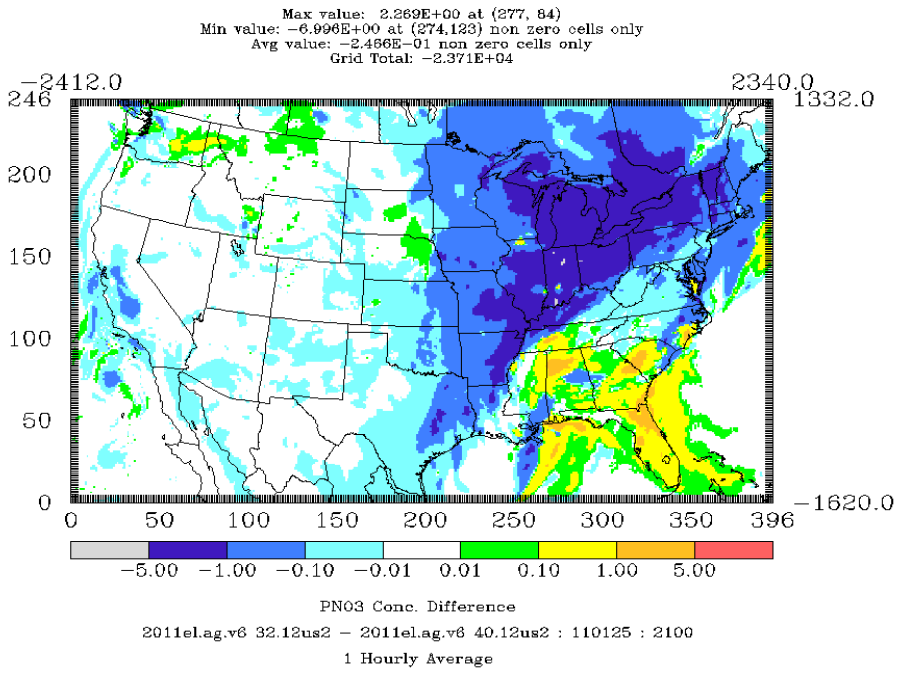
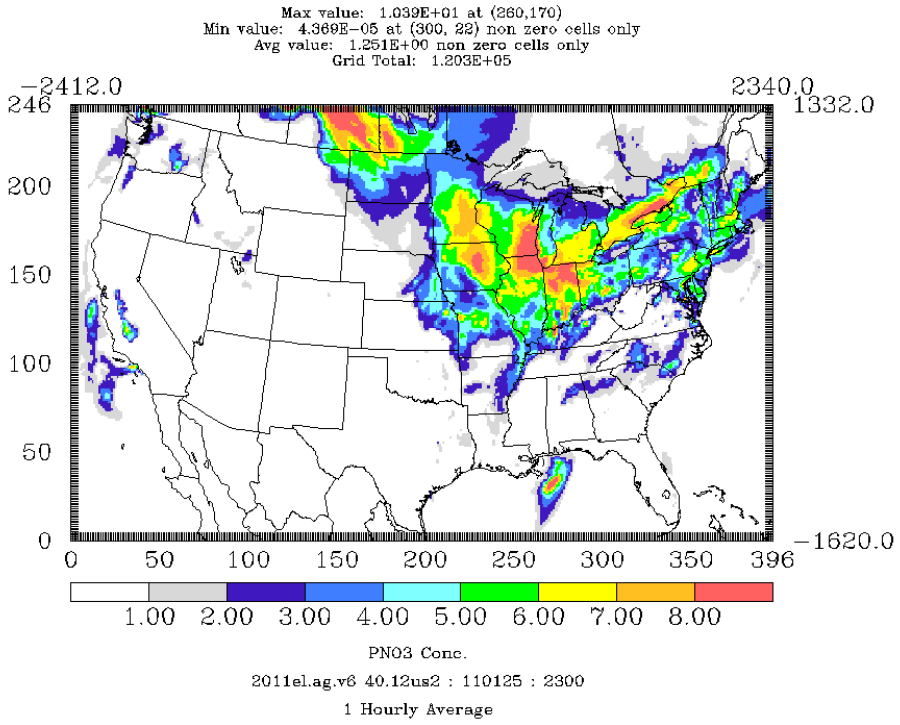


Figure 4-76: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: January 25 at 2300 hours

CAMx 6.40



Difference (6.32 - 6.40)

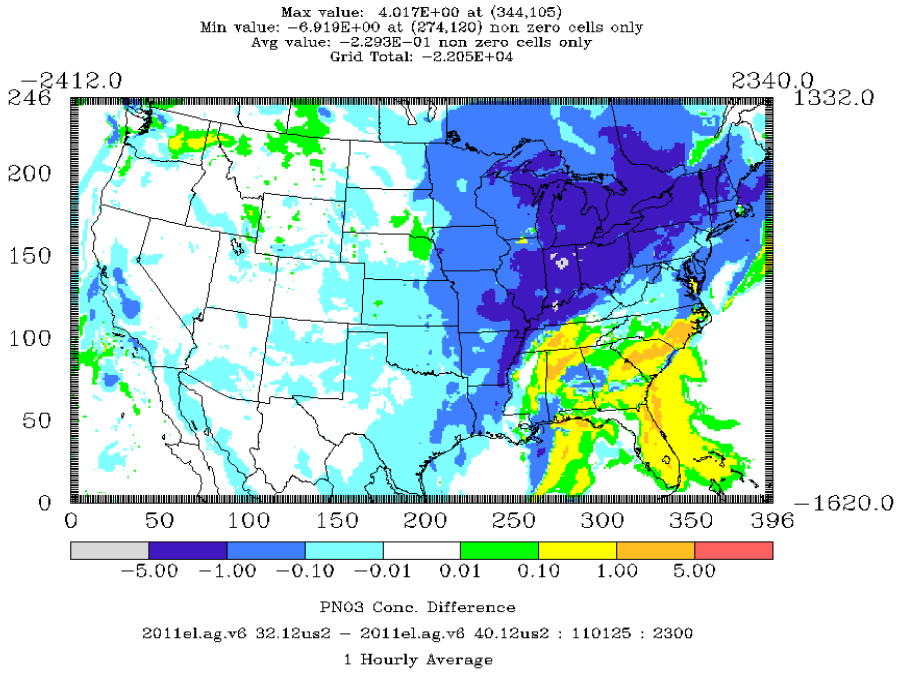
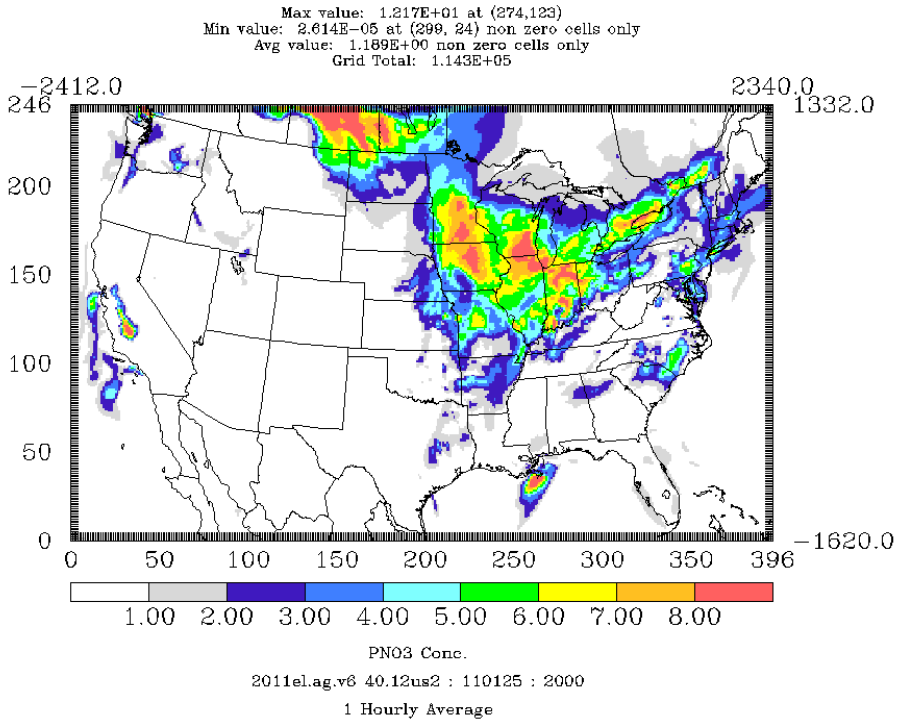


Figure 4-77: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: January 25 at 2000 hours

CAMx 6.40



Difference (6.32 - 6.40)

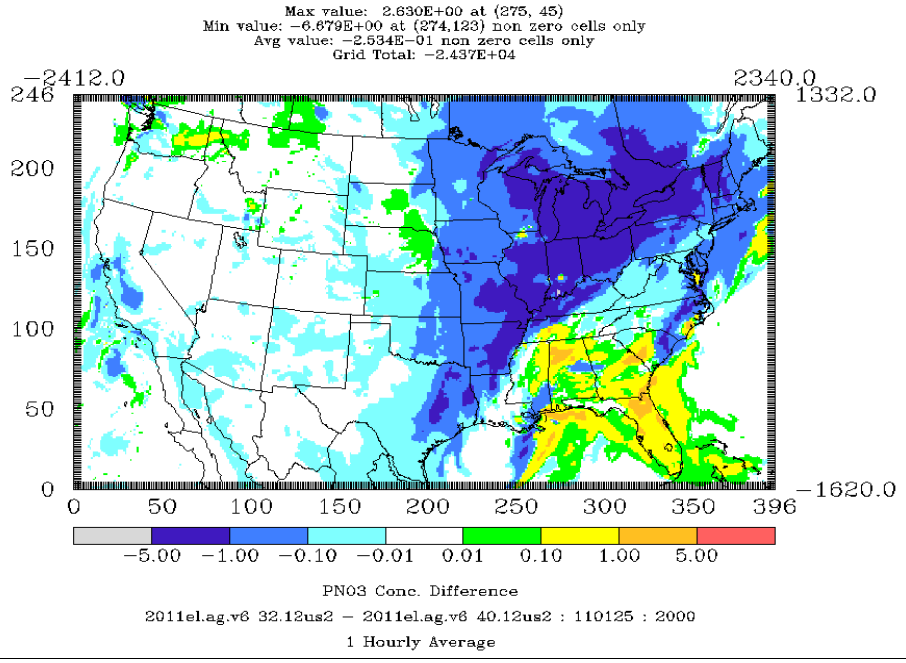
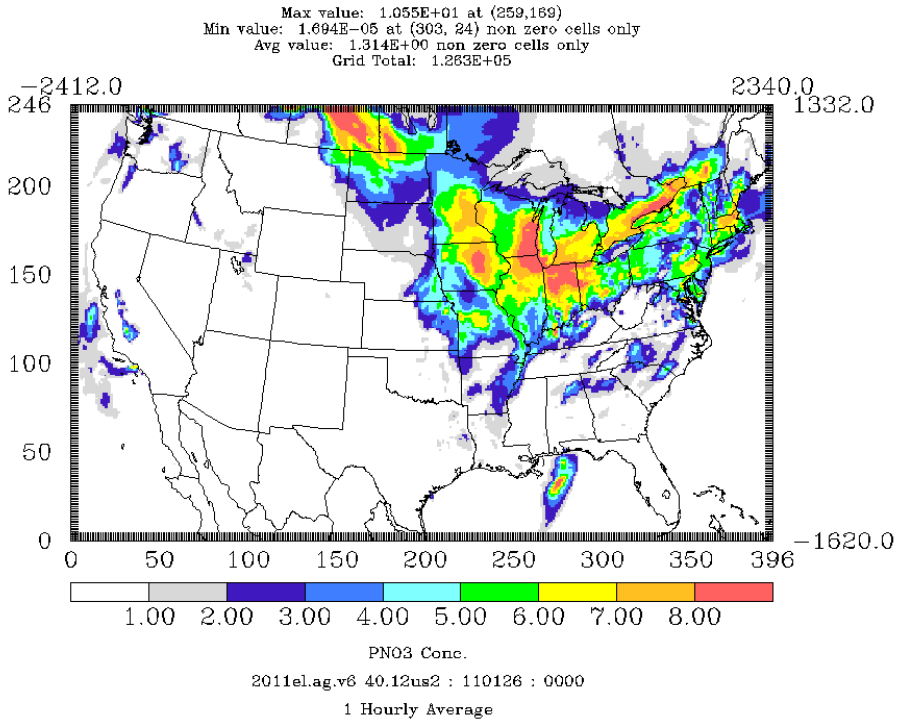


Figure 4-78: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: January 26 at 0000 hours

CAMx 6.40



Difference (6.32 - 6.40)

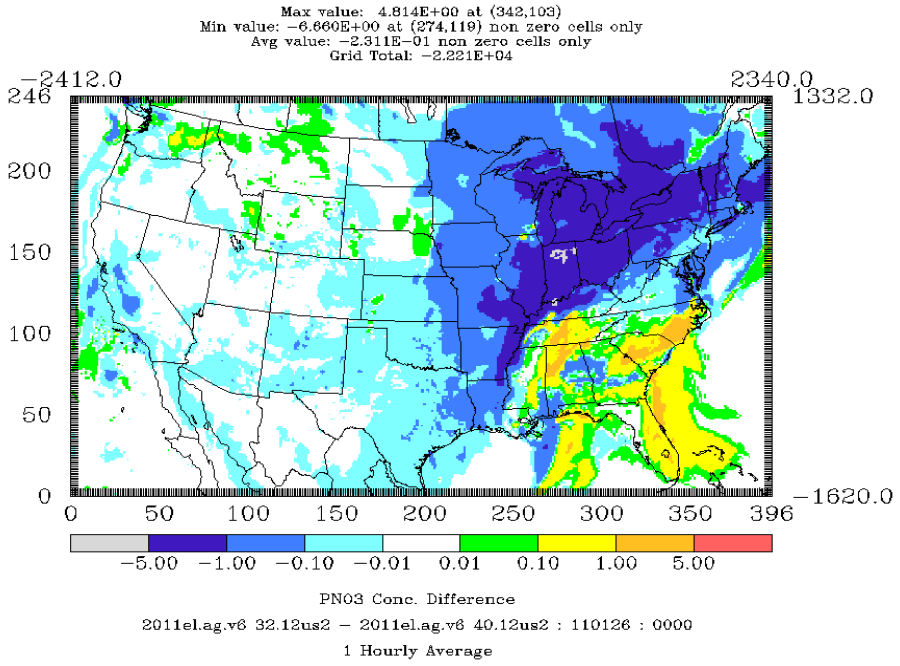
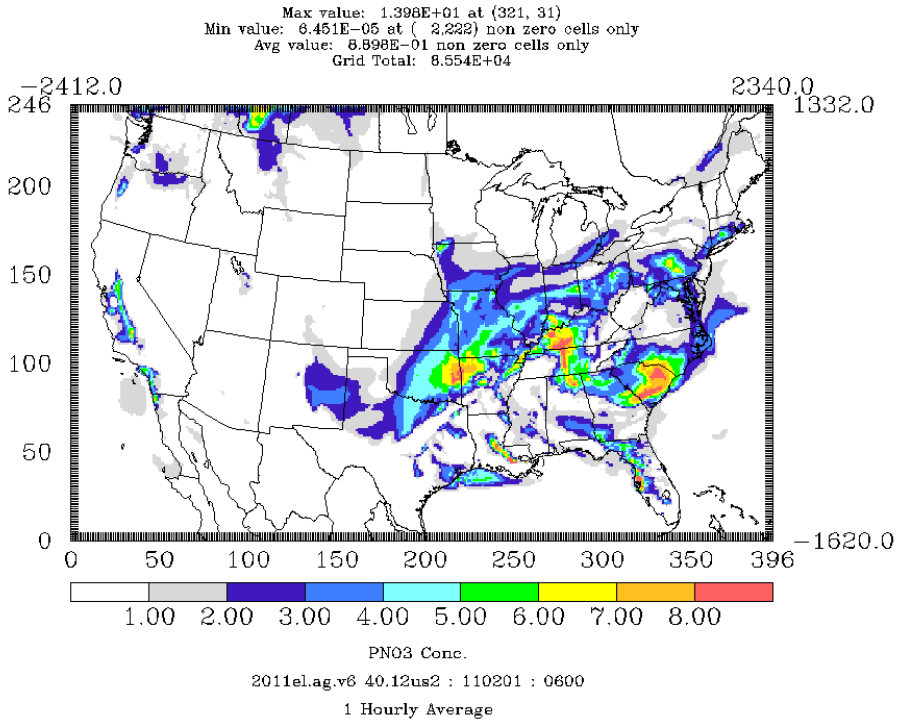


Figure 4-79: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: February 1 at 600 hours

CAMx 6.40



Difference (6.32 - 6.40)

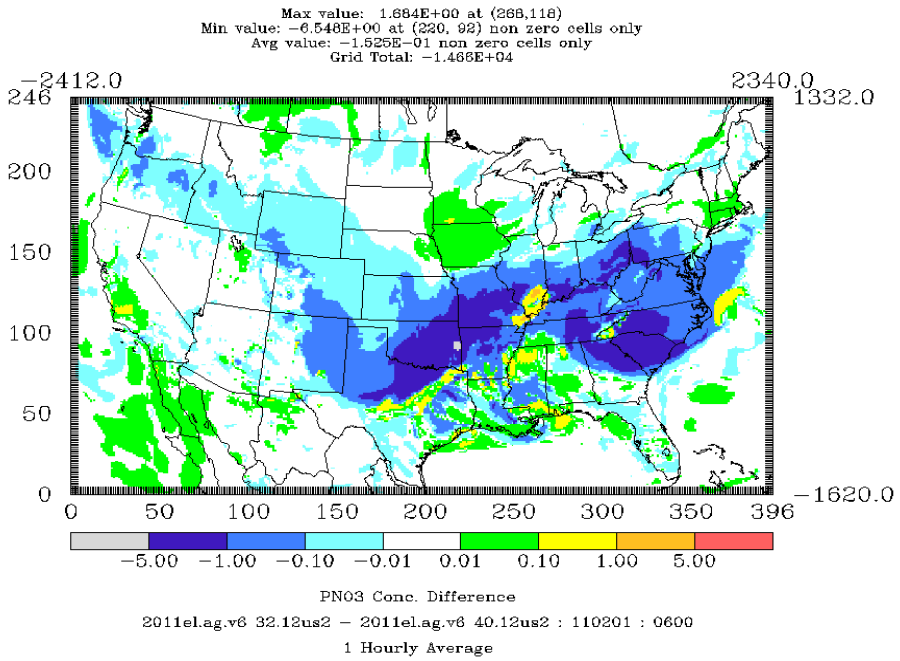
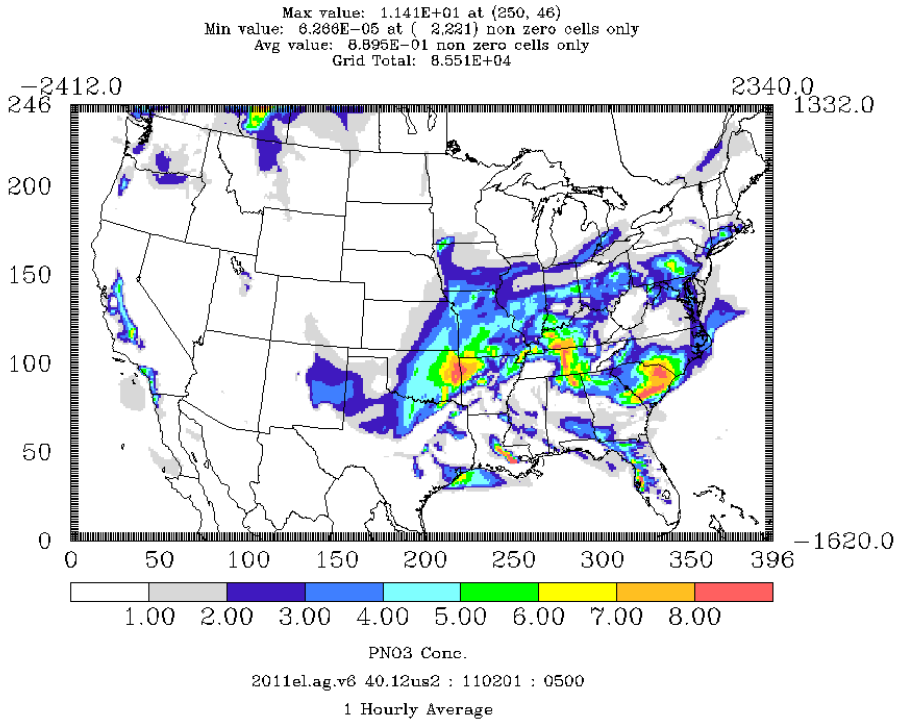


Figure 4-80: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: February 1 at 500 hours

CAMx 6.40



Difference (6.32 - 6.40)

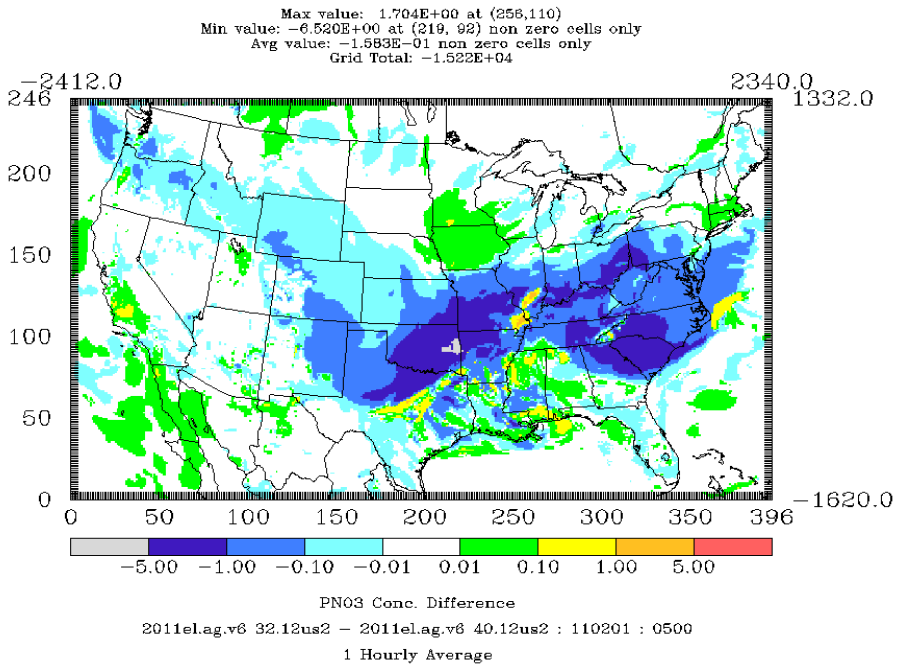
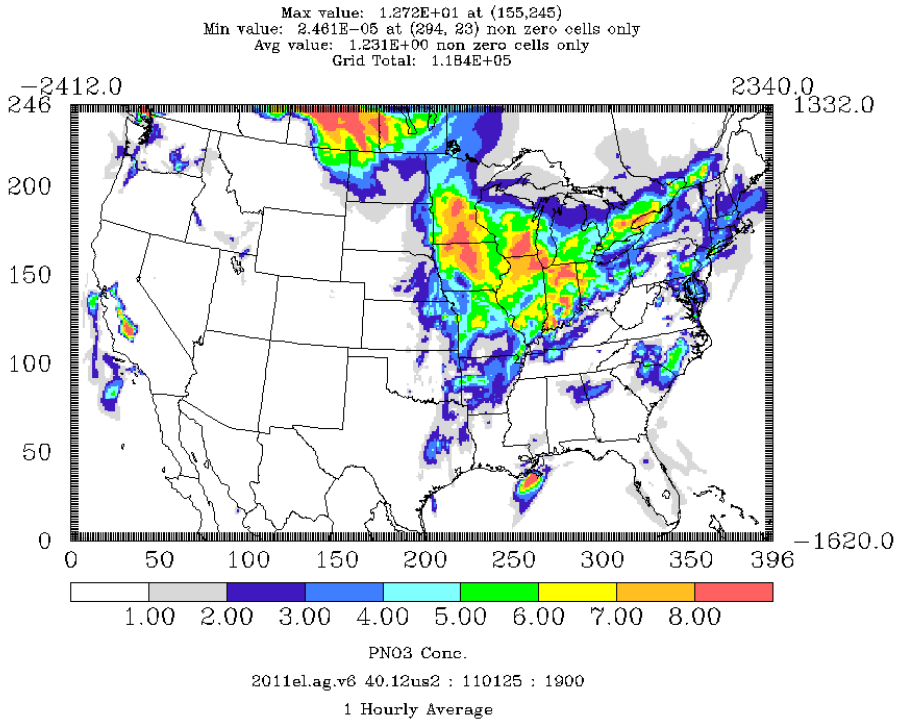


Figure 4-81: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: January 25 at 1900 hours

CAMx 6.40



Difference (6.32 - 6.40)

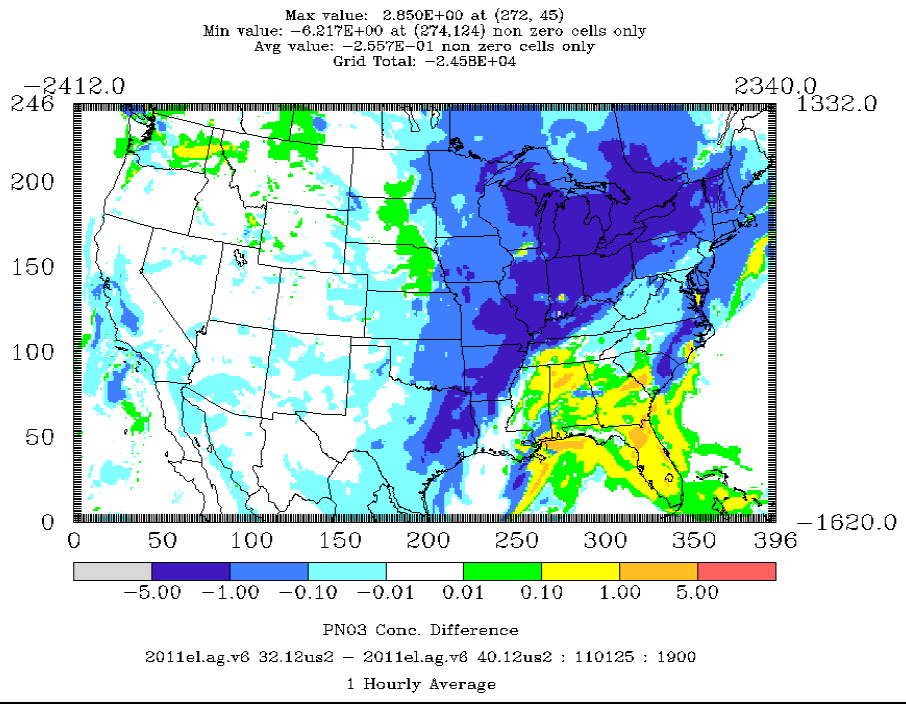
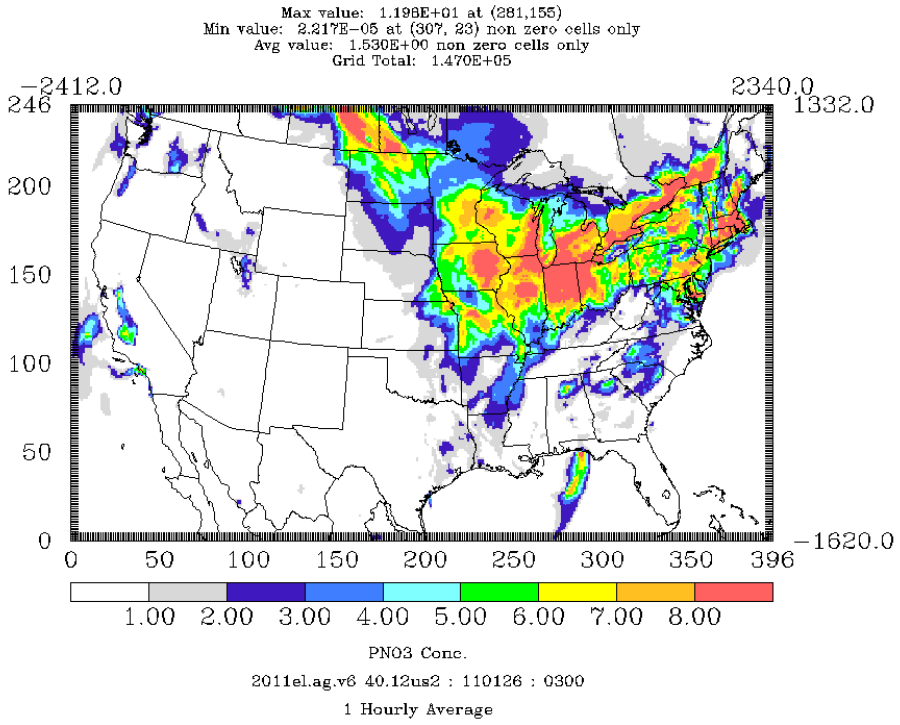


Figure 4-82: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: January 26 at 300 hours

CAMx 6.40



Difference (6.32 - 6.40)

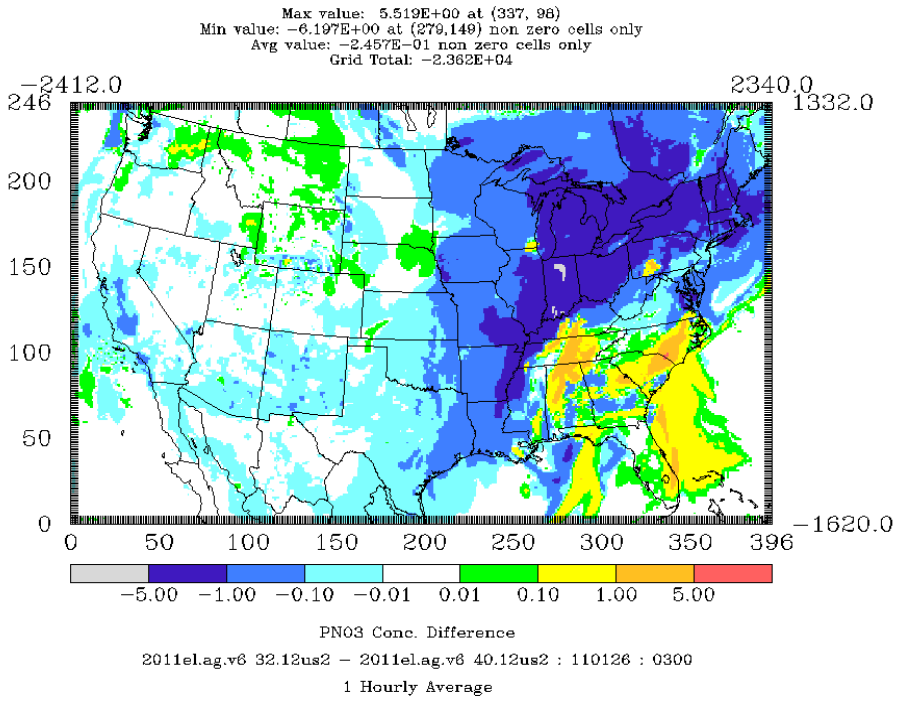
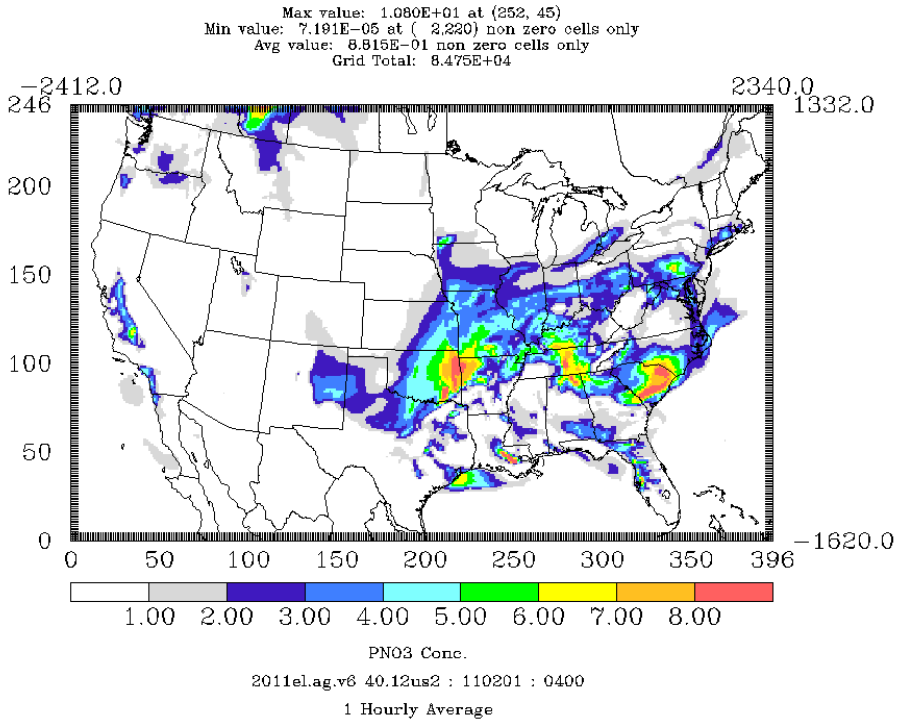


Figure 4-83: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: February 1 at 400 hours

CAMx 6.40



Difference (6.32 - 6.40)

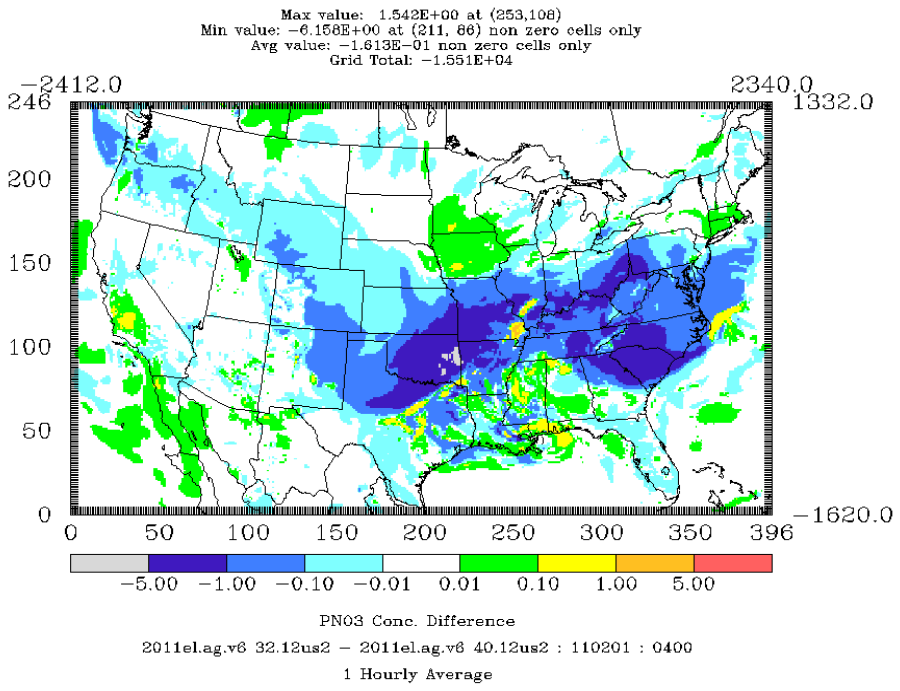


Figure 4-84: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference)

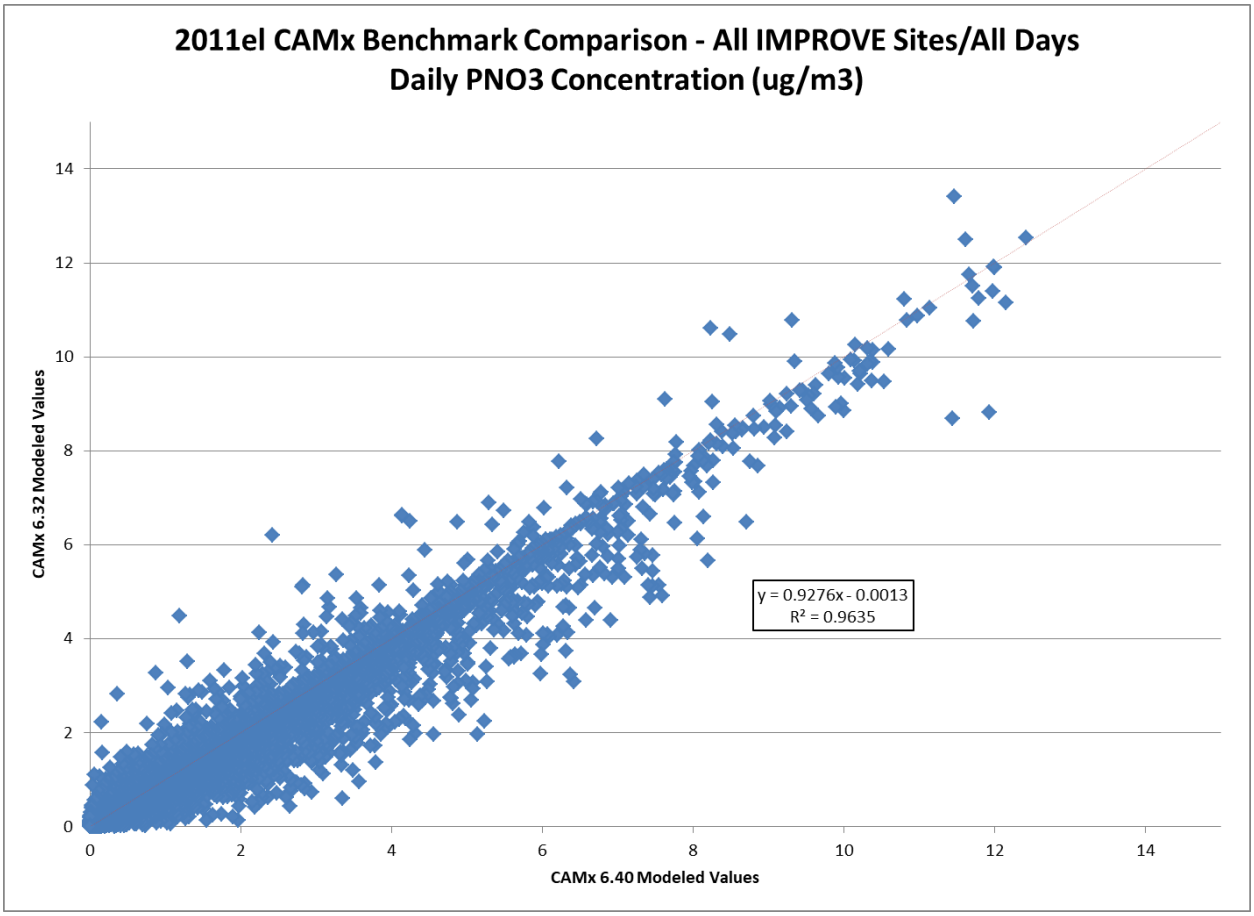


Figure 4-85: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine).

4.5 Organic Matter (OM)

Organic Matter (OM) results for the top 10 positive and negative hours are presented in tabular format in Table 4-5. The maximum positive difference is 30.29 μg/m^3 falling to 25.25 μg/m^3 for the 10th high. The maximum negative difference is -28.67 μg/m^3 falling to -16.60 μg/m^3 for the 10th high. The maximum positive percent difference from these days is 801% and negative percent difference of -80%.

The top 10 positive difference hours are presented in Figures 4-86 through 4-95. The differences on the two highest days are in the Pacific Northwest. On other days the peaks are scattered across Southern Canada, north of New York and the south eastern U.S.

The top 10 negative impact hours are presented in Figures 4-96 through 4-105. Five of the top ten hours occur on July 20th. On this day the location of the peak is along the northern border of the U.S., north of Minnesota. This is an area where CAMx simulations are showing very high OM concentrations and an area heavily influenced by boundary conditions. As was discussed in Section 2, the SOA species definitions changed between CAMx 6.32 and 6.40, but the mapping of the boundary conditions was not updated between model versions to reflect this change. This difference in boundary condition species mapping is likely the reason for the concentration deltas. On July 3, the peak difference is over Lake Michigan; on August 19 the peak is in eastern Texas.

Scatterplots of the daily average organic matter concentrations in local standard time at the IMPROVE monitors are presented in Figures 4-106 and 4-107. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0122, an intercept of 0.2973 ppb and an R^2 of 0.983.

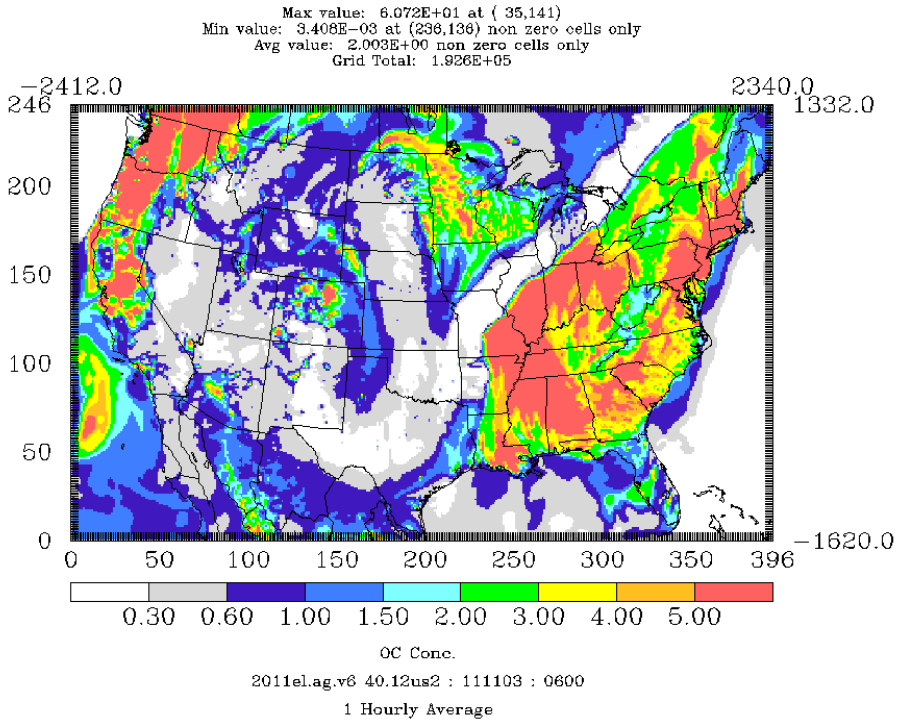
Examination of the animations reveals that away from frontal boundaries and low pressure areas, OM in CAMx 6.40 is generally slightly lower compared to CAMx 6.32. While near frontal boundaries and low pressure areas the opposite is true. These positive and negative difference seem to balance give a high degree of correlation between the model versions.

Table 4-5. Comparison of 2011el CAMx 6.32 and CAMx 6.40 Simulation of Organic Matter Concentrations (µg/m³). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	6.32 Conc.	6.40 Conc.	Difference (µg/m³)	Percent Difference	Column	Row
Maximum Positive									
2011	11	3	6	70.40	40.11	30.29	75.5%	38	213
2011	11	3	5	70.91	41.19	29.72	72.2%	39	214
2011	12	6	2	57.66	29.11	28.55	98.1%	354	207
2011	5	21	11	33.46	5.75	27.71	481.9%	226	47
2011	12	6	1	62.13	34.78	27.35	78.6%	353	209
2011	1	26	15	57.93	30.97	26.96	87.1%	314	125
2011	12	6	3	39.21	12.97	26.24	202.3%	355	207
2011	1	26	16	63.39	37.28	26.11	70.0%	314	125
2011	5	21	12	28.46	3.16	25.30	801.3%	225	48
2011	5	21	10	33.98	8.73	25.25	289.4%	226	47
Maximum Negative									
2011	7	20	15	3,944.01	3,972.68	-28.67	-0.7%	230	243
2011	7	20	14	3,589.46	3,616.33	-26.88	-0.7%	231	244
2011	7	20	16	3,261.57	3,285.59	-24.02	-0.7%	230	243
2011	7	3	21	4.58	23.21	-18.63	-80.3%	269	156
2011	8	19	5	72.72	91.27	-18.55	-20.3%	216	52
2011	7	3	22	4.62	23.11	-18.50	-80.0%	269	156
2011	7	20	17	1,657.89	1,675.83	-17.94	-1.1%	229	244
2011	7	20	13	2,382.39	2,399.65	-17.26	-0.7%	231	245
2011	7	3	20	4.43	21.62	-17.18	-79.5%	269	156
2011	8	19	6	70.62	87.22	-16.60	-19.0%	216	52

Maximum Positive Difference: November 3 at 600 hours

CAMx 6.40



Difference (6.32 - 6.40)

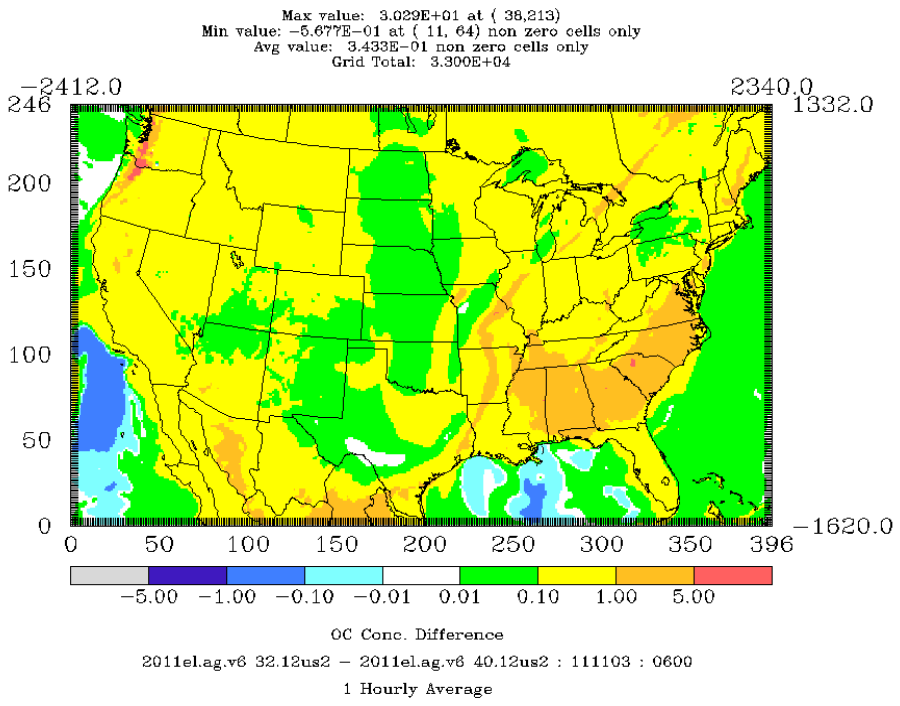
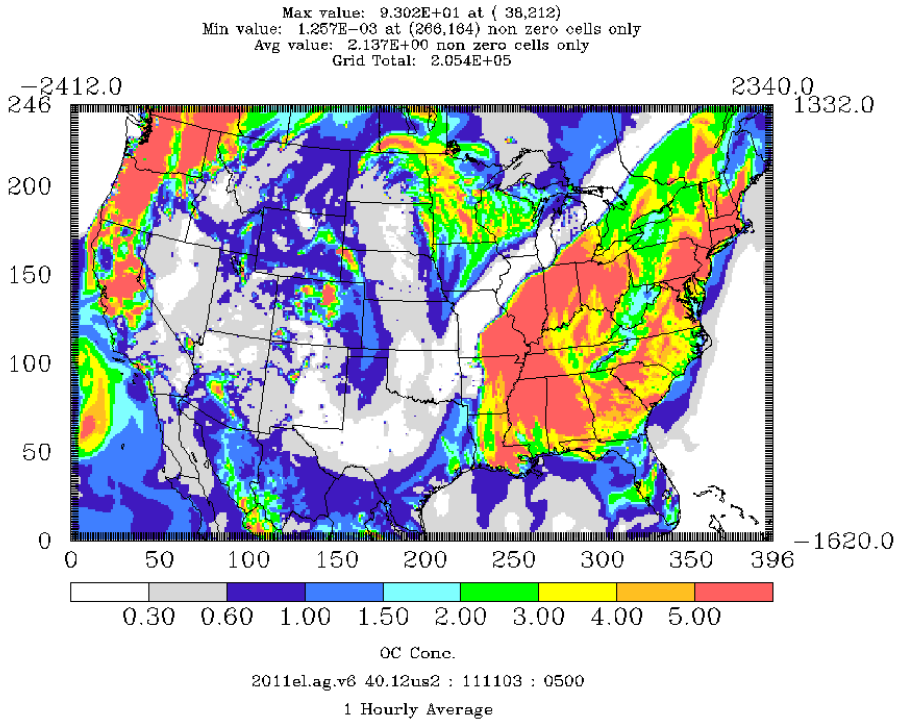


Figure 4-86: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: November 3 at 500 hours

CAMx 6.40



Difference (6.32 - 6.40)

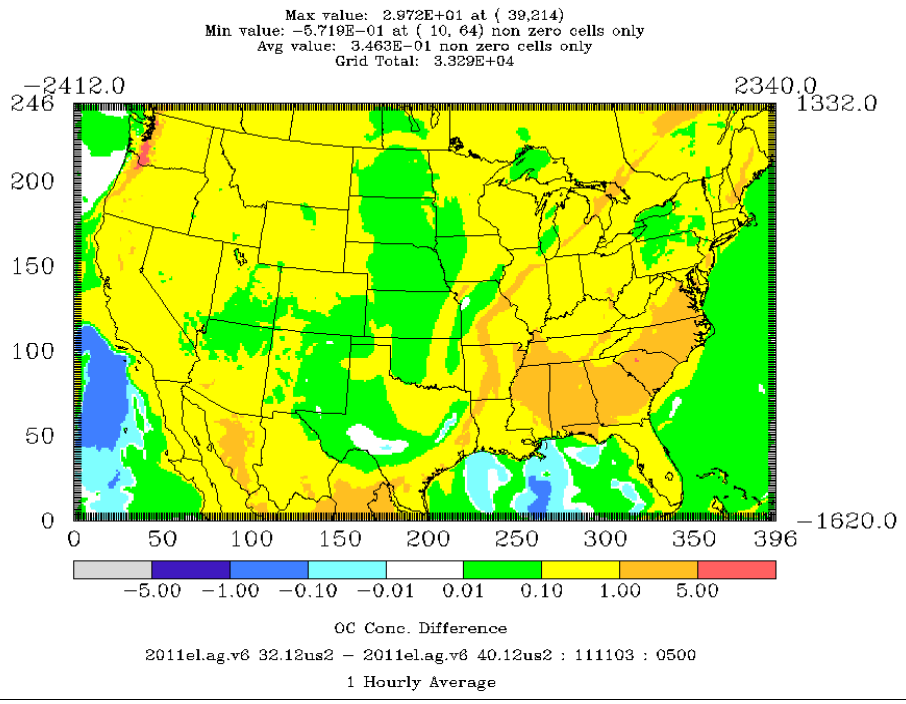
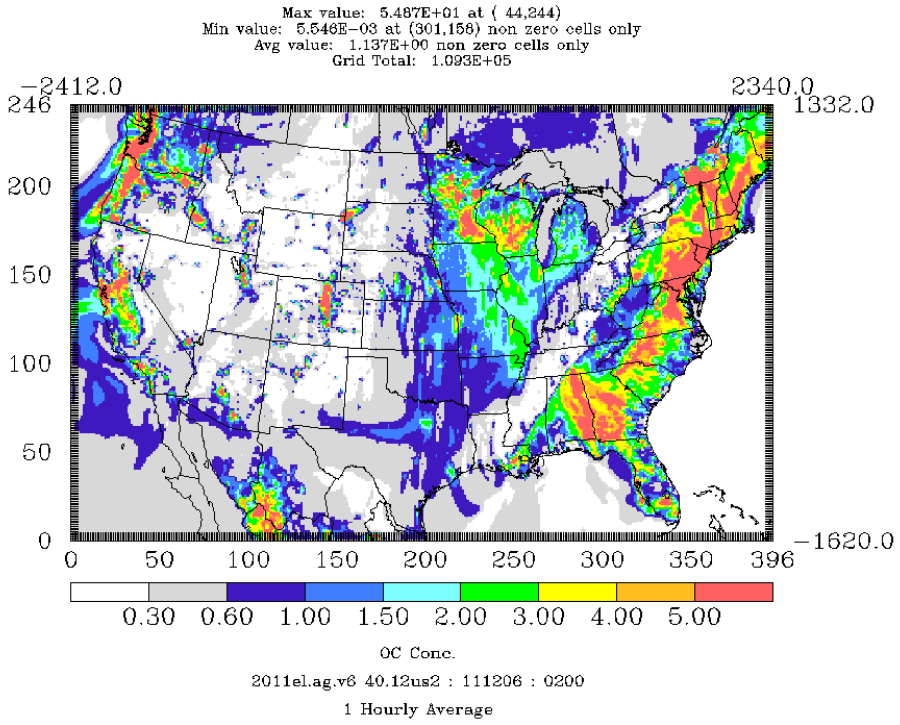


Figure 4-87: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: December 6 at 200 hours

CAMx 6.40



Difference (6.32 - 6.40)

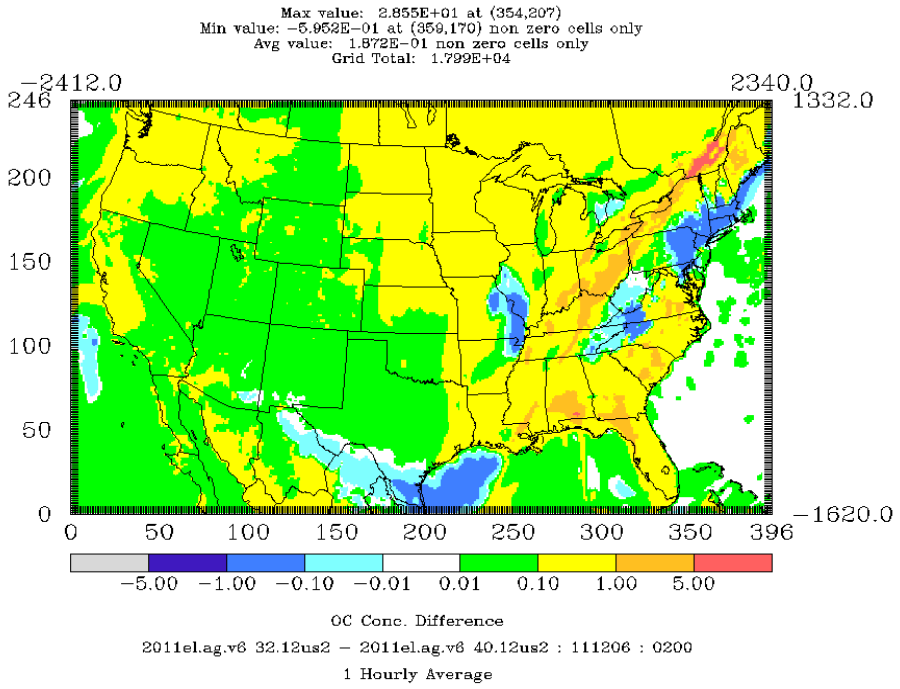
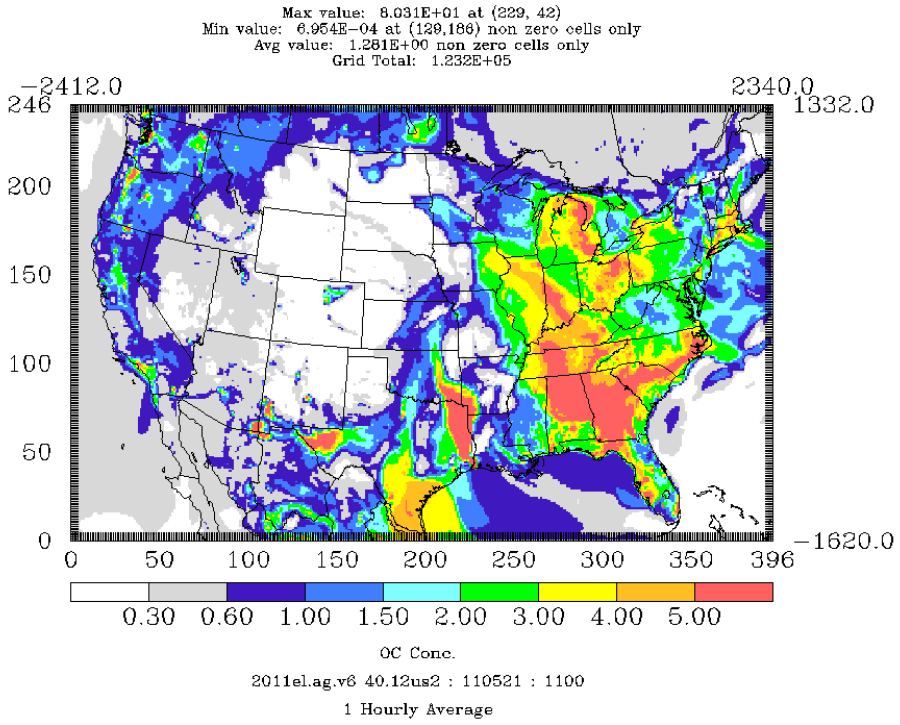


Figure 4-88: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: May 21 at 1100 hours

CAMx 6.40



Difference (6.32 - 6.40)

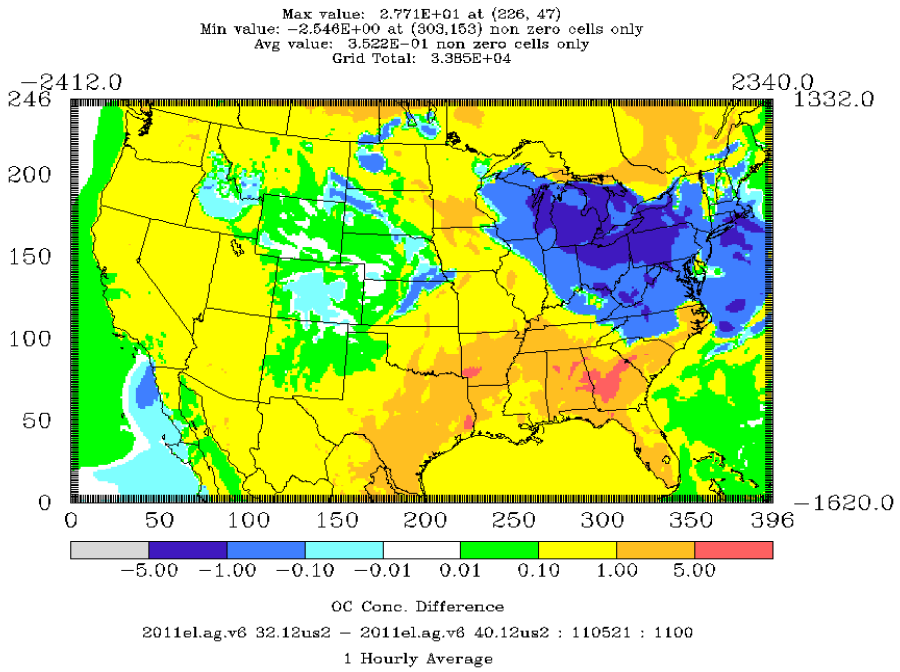
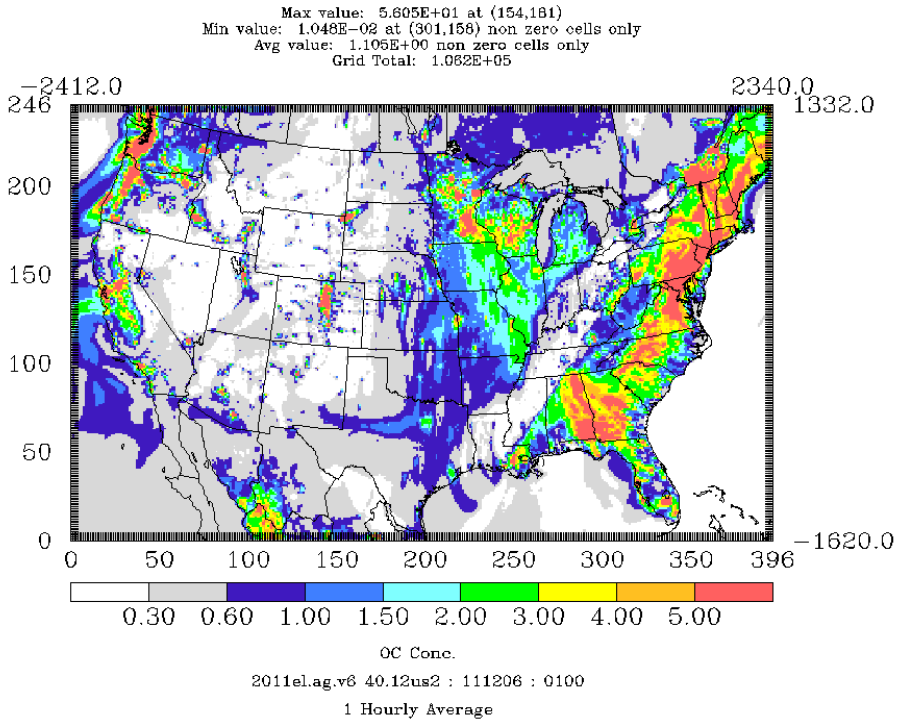


Figure 4-89: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: December 6 at 100 hours

CAMx 6.40



Difference (6.32 - 6.40)

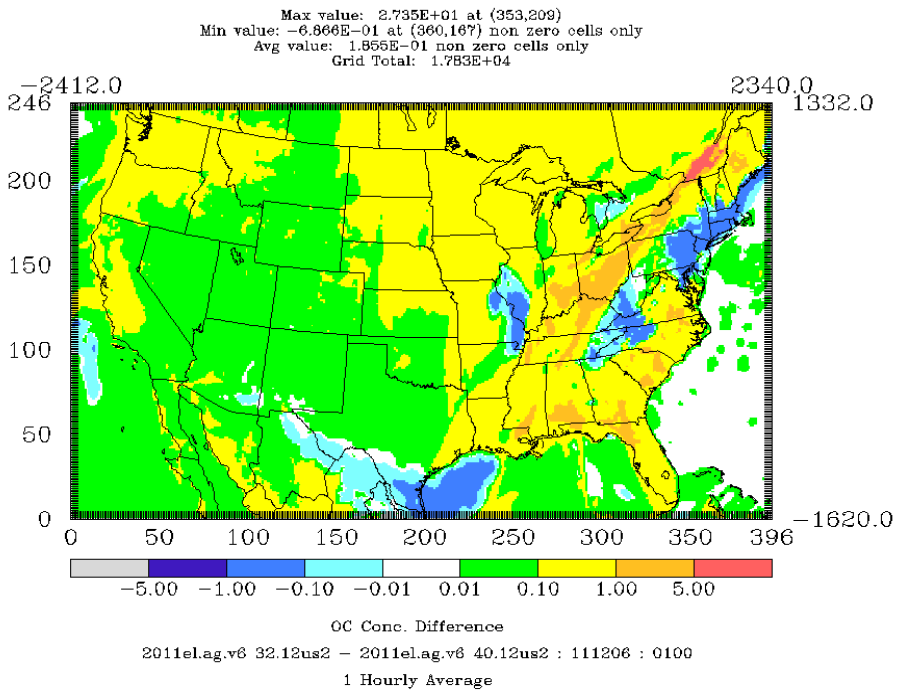
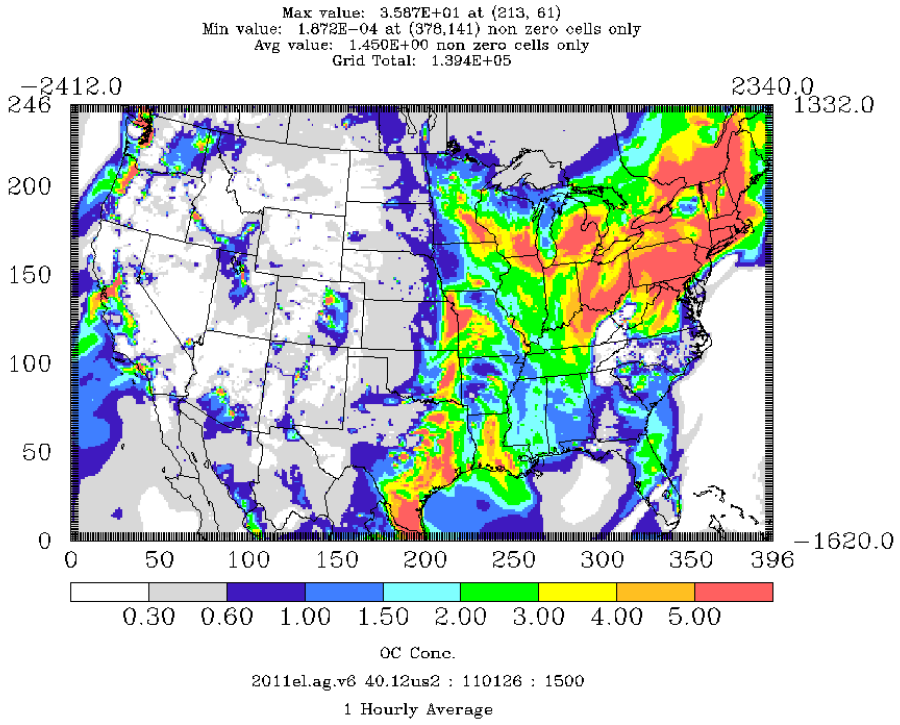


Figure 4-90: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: January 26 at 1500 hours

CAMx 6.40



Difference (6.32 - 6.40)

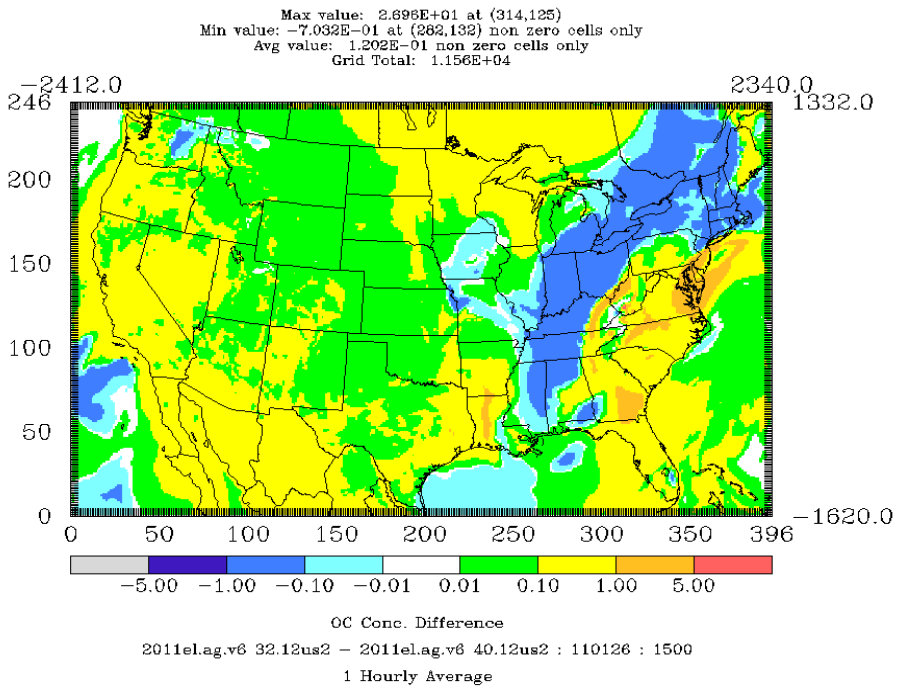
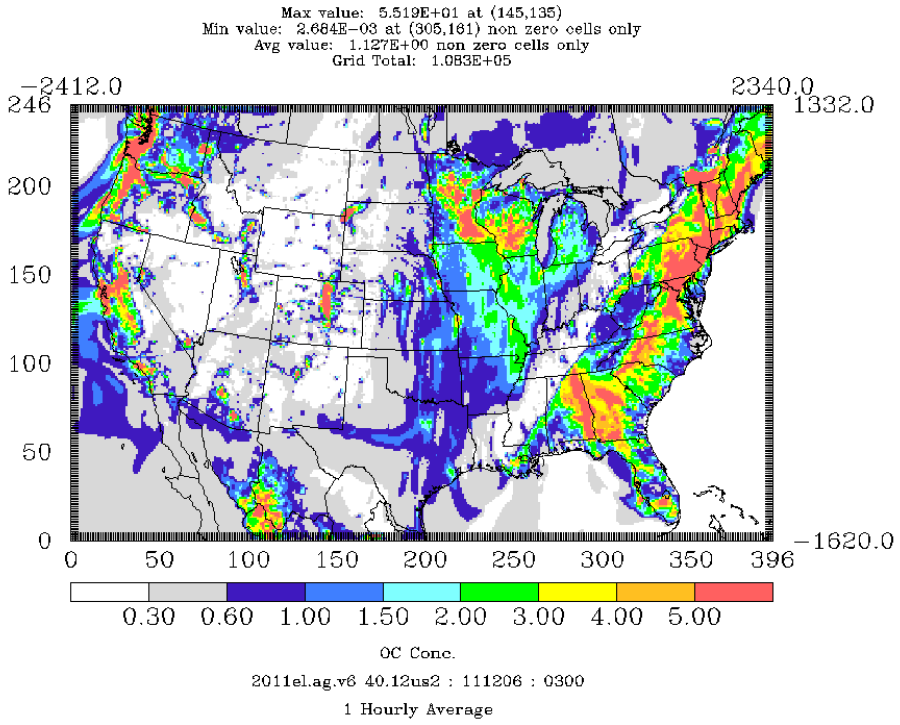


Figure 4-91: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: December 6 at 300 hours

CAMx 6.40



Difference (6.32 - 6.40)

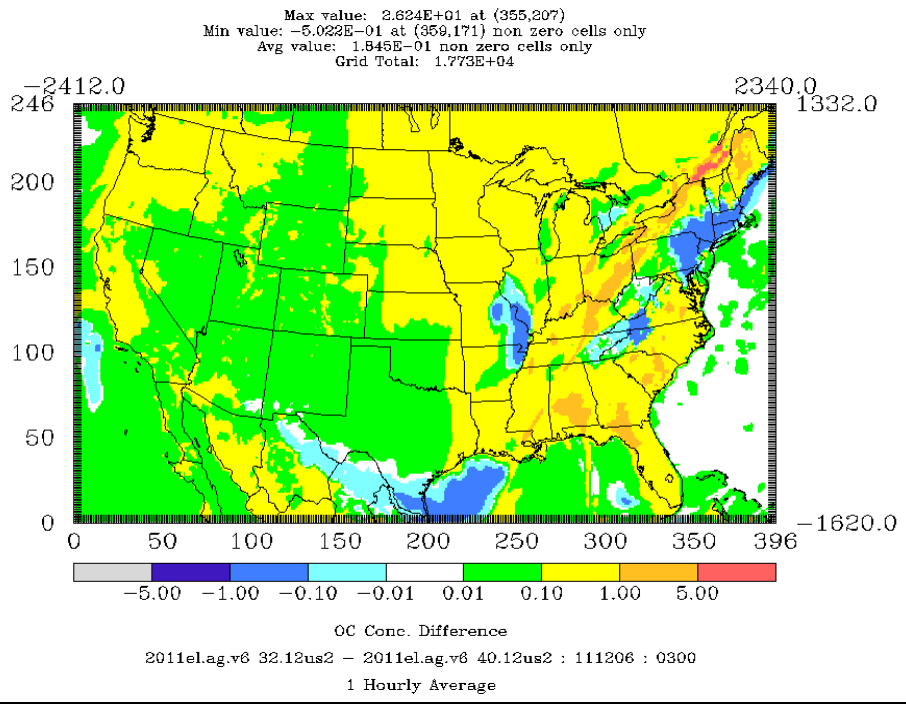
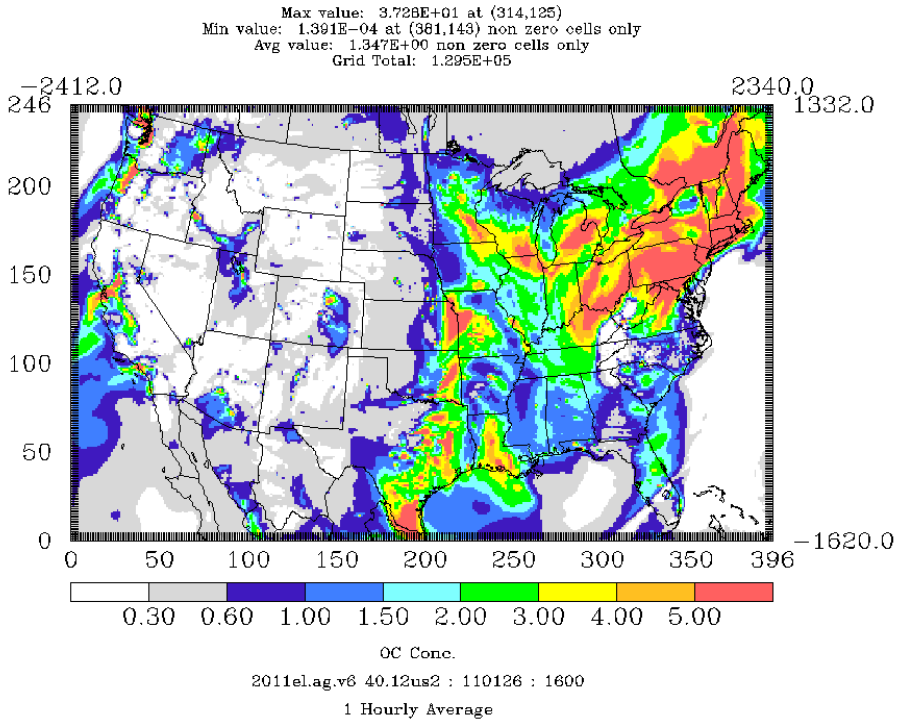


Figure 4-92: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: January 26 at 1600 hours

CAMx 6.40



Difference (6.32 - 6.40)

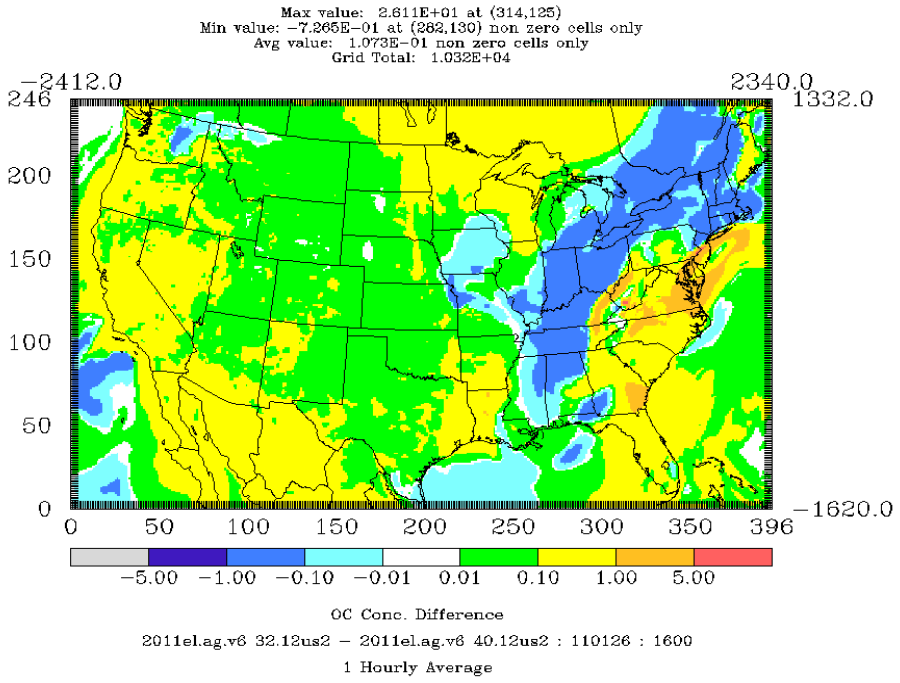
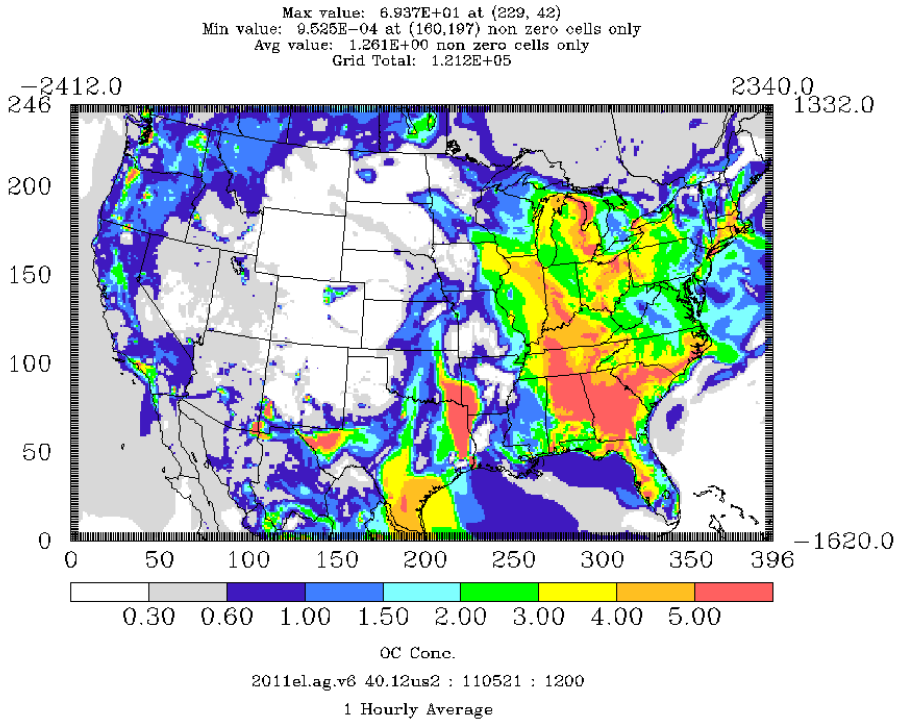


Figure 4-93: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: May 21 at 1200 hours

CAMx 6.40



Difference (6.32 - 6.40)

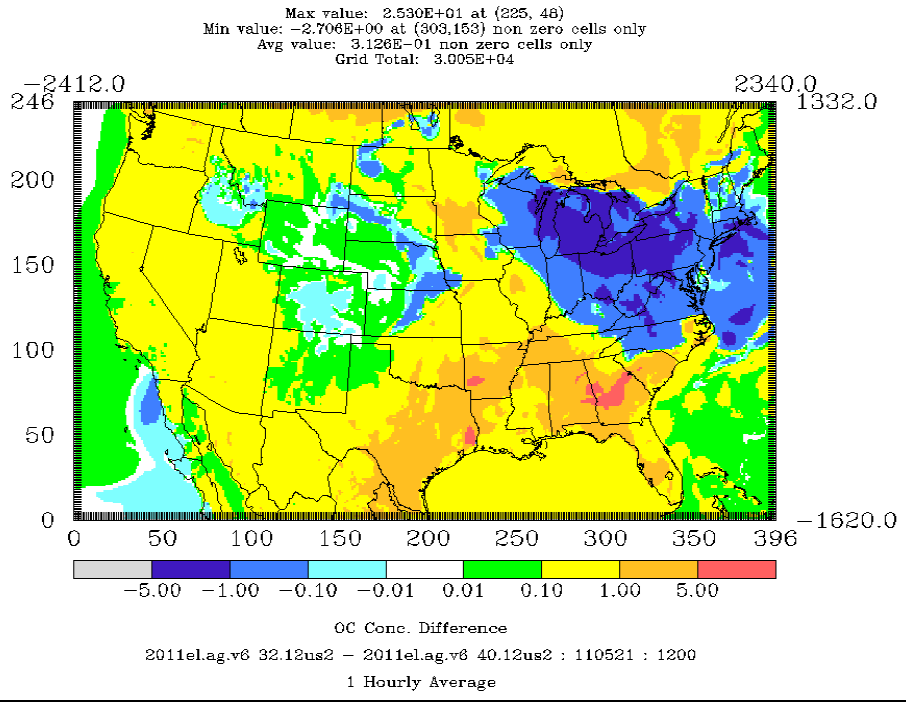
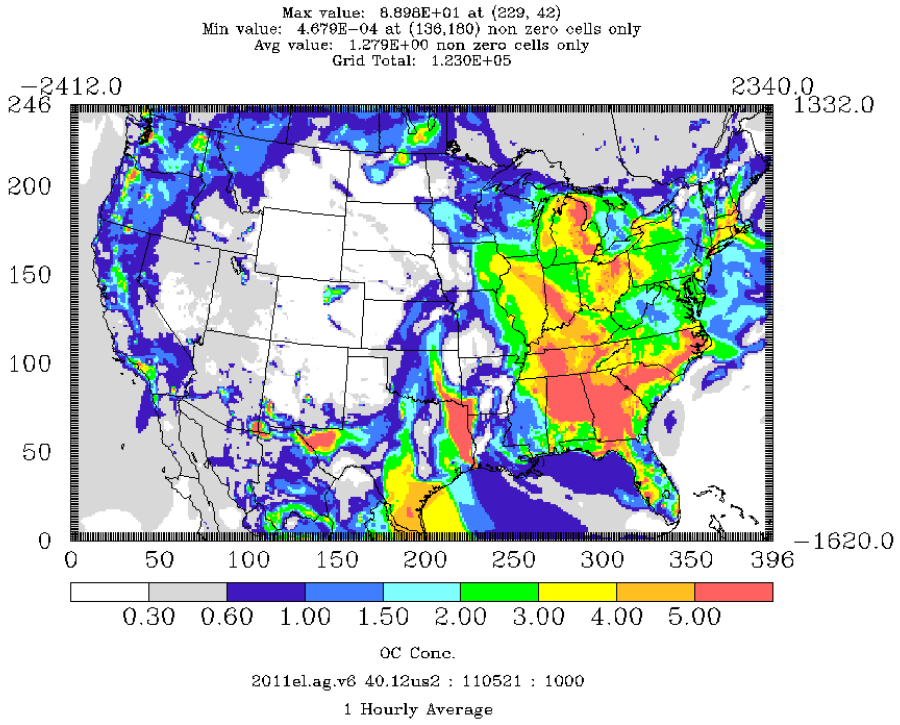


Figure 4-94: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: May 21 at 1000 hours

CAMx 6.40



Difference (6.32 - 6.40)

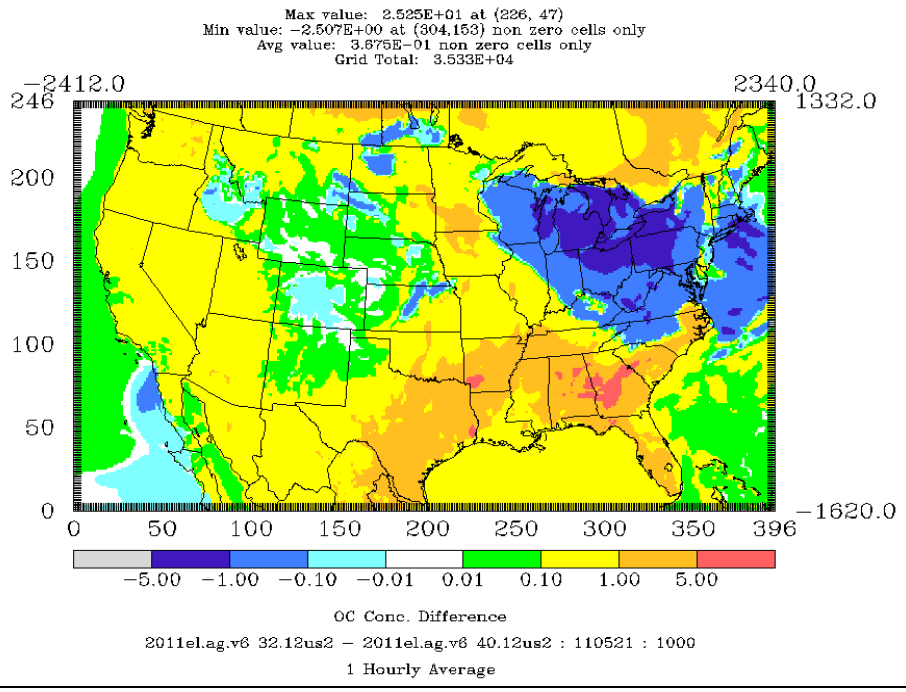
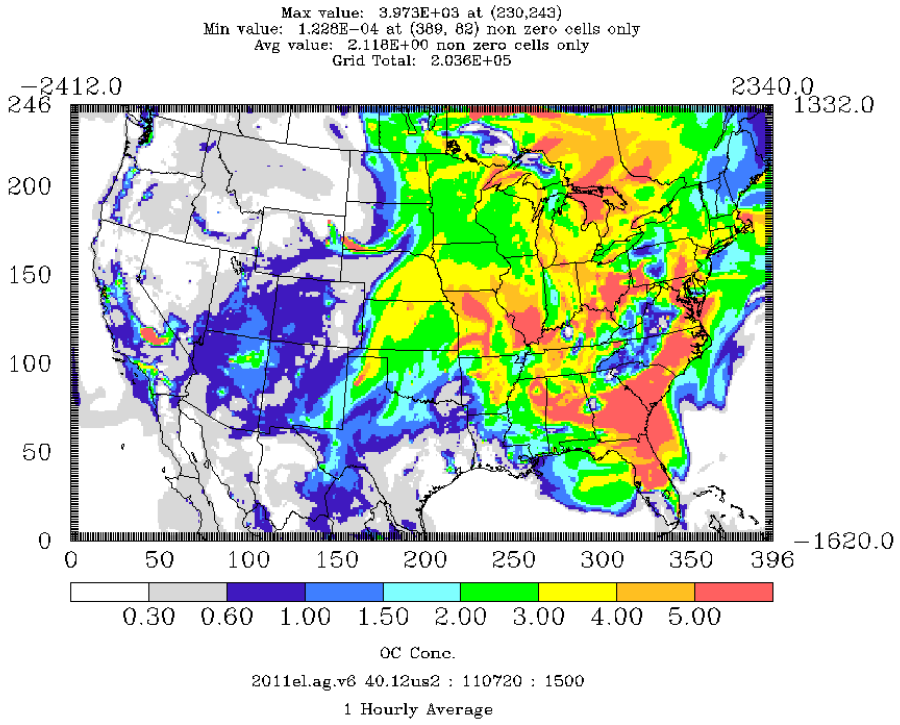


Figure 4-95: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1500 hours

CAMx 6.40



Difference (6.32 - 6.40)

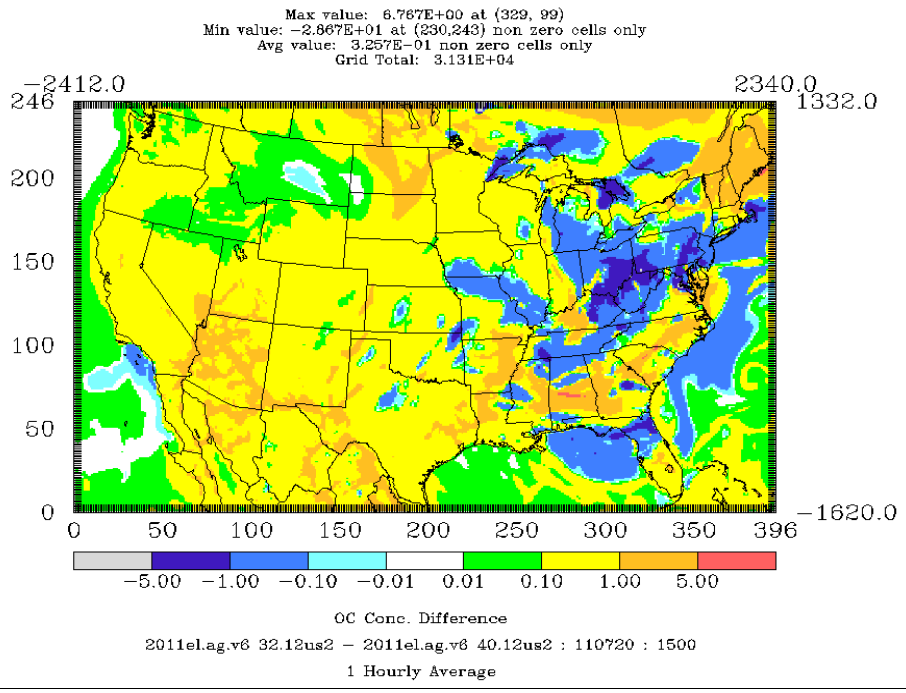
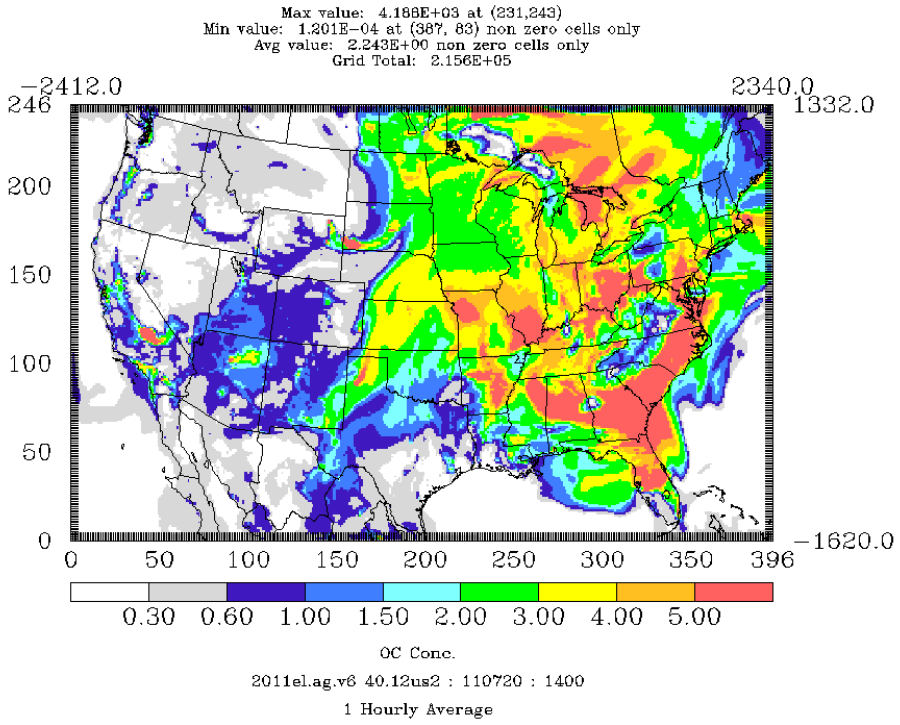


Figure 4-96: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1400 hours

CAMx 6.40



Difference (6.32 - 6.40)

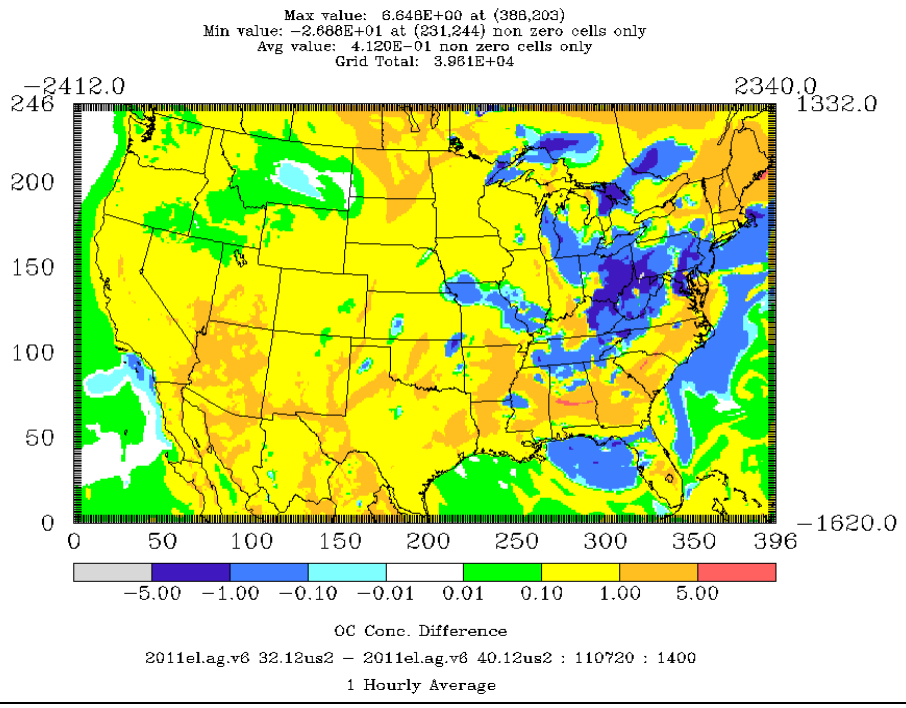
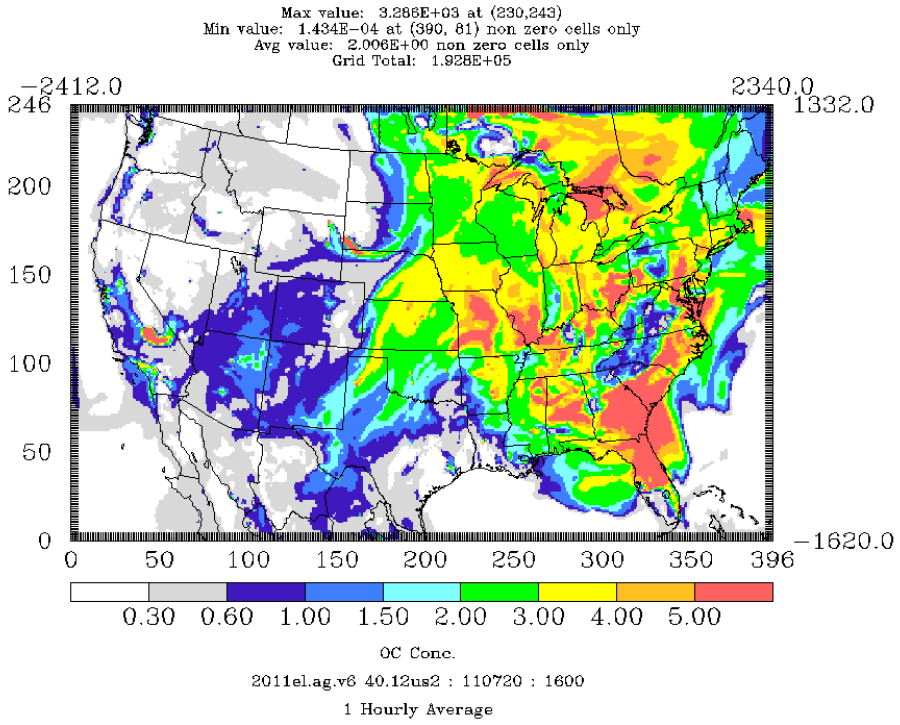


Figure 4-97: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1600 hours

CAMx 6.40



Difference (6.32 - 6.40)

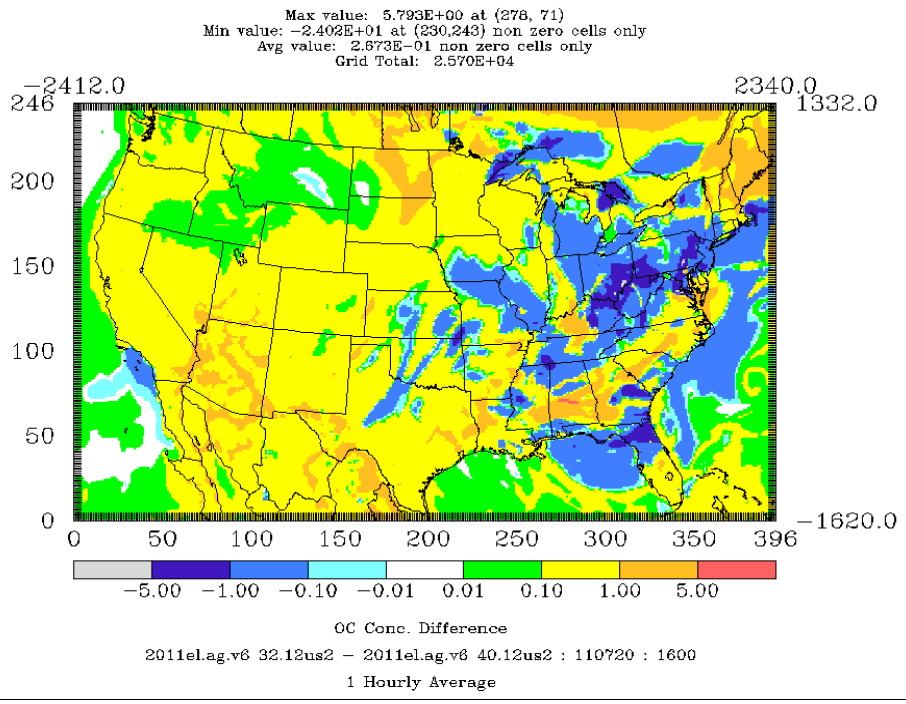
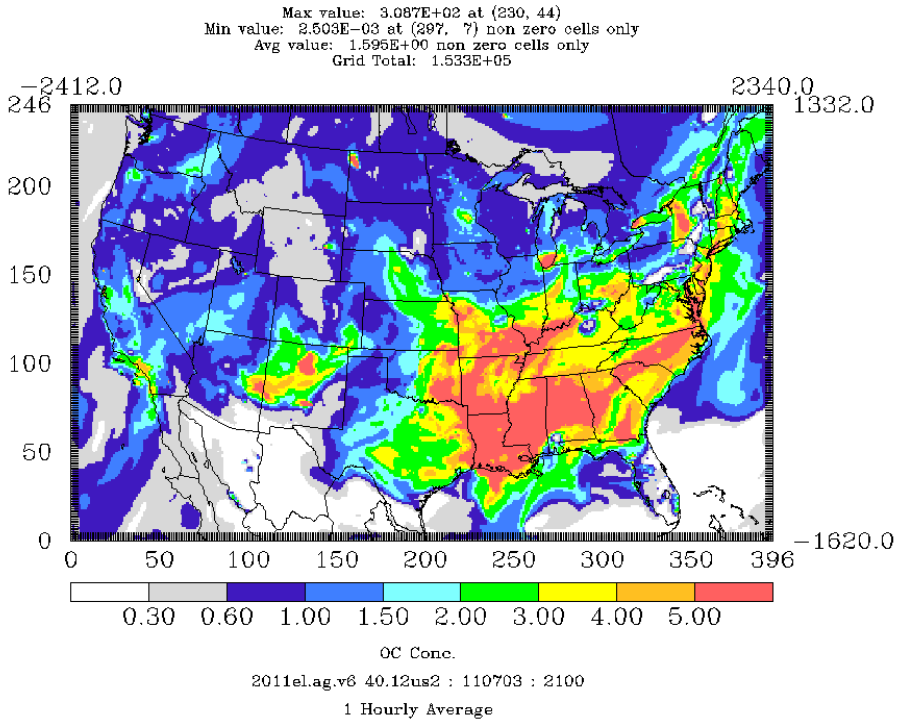


Figure 4-98: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 3 at 2100 hours

CAMx 6.40



Difference (6.32 - 6.40)

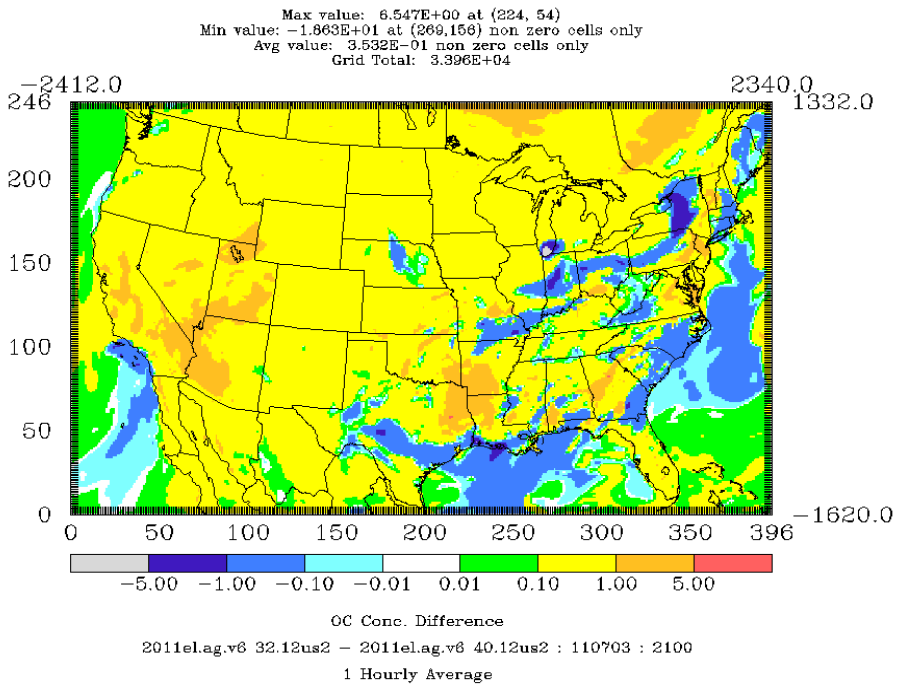
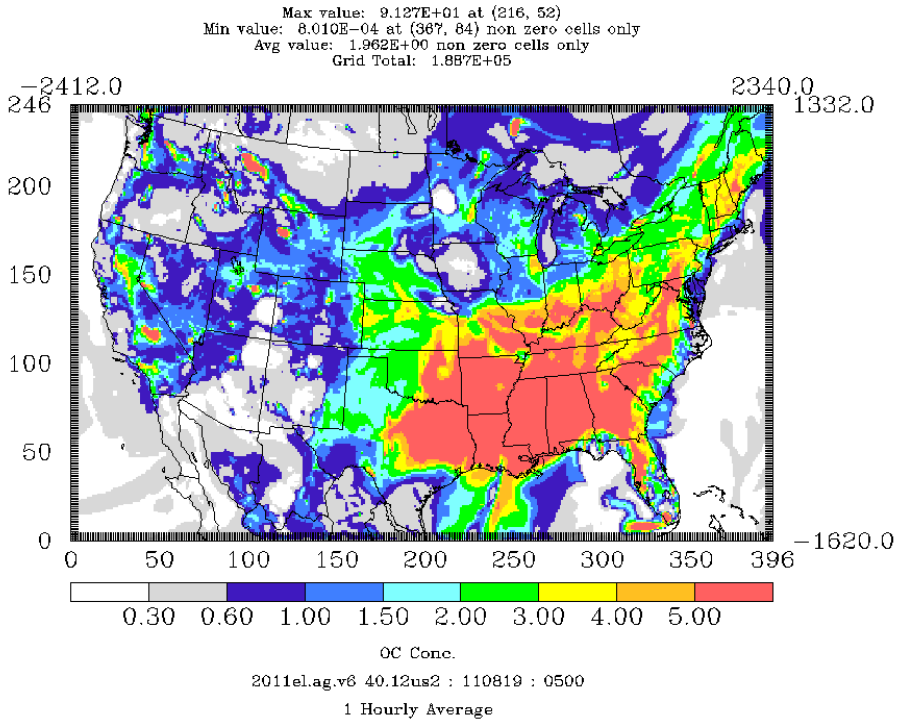


Figure 4-99: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: August 19 at 500 hours

CAMx 6.40



Difference (6.32 - 6.40)

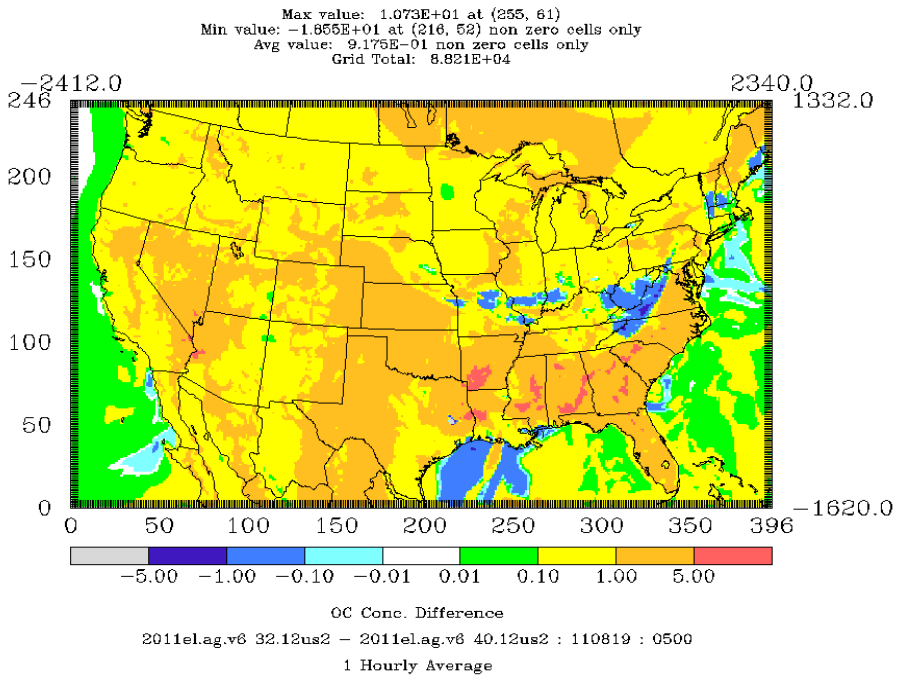
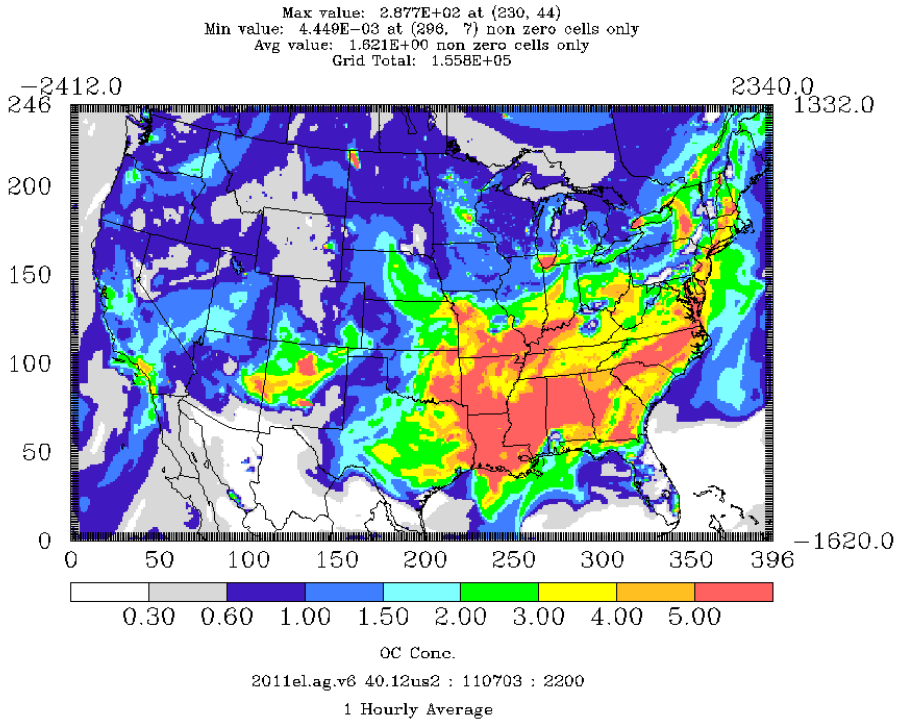


Figure 4-100: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 3 at 2200 hours

CAMx 6.40



Difference (6.32 - 6.40)

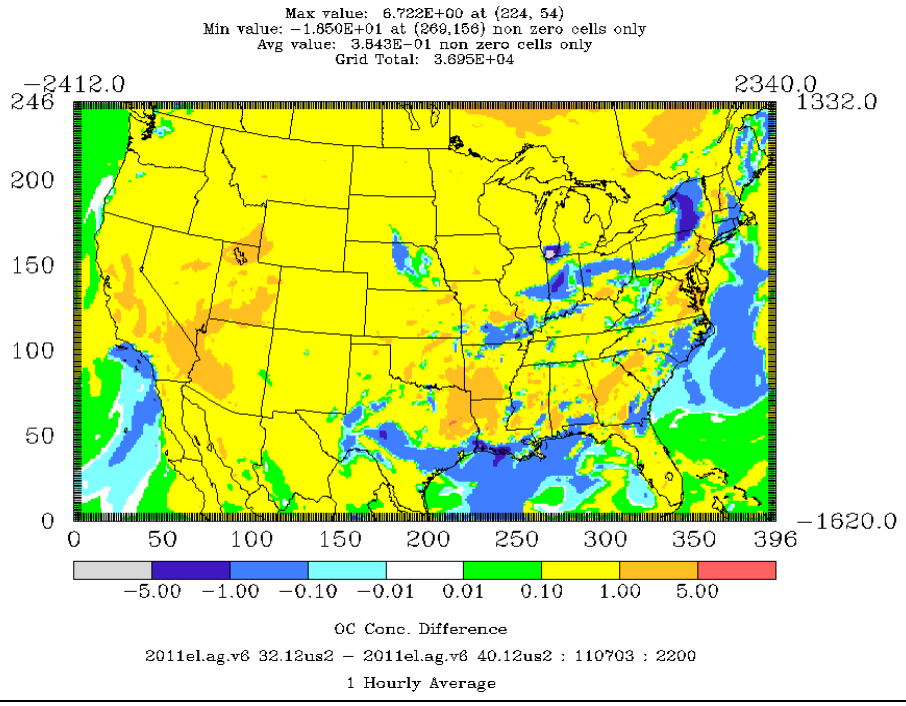
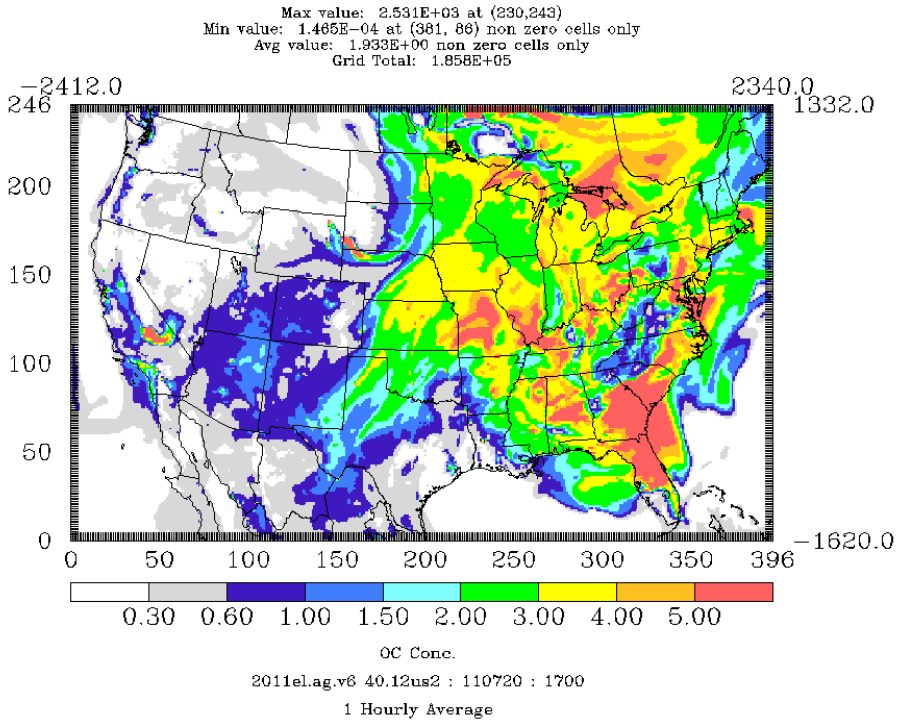


Figure 4-101: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 20 at 1700 hours

CAMx 6.40



Difference (6.32 - 6.40)

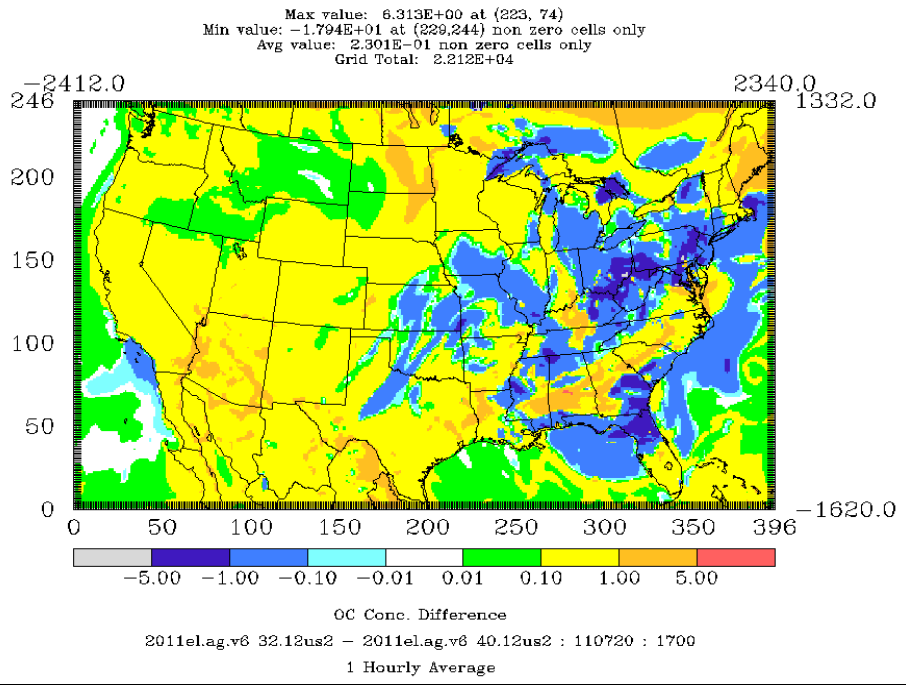
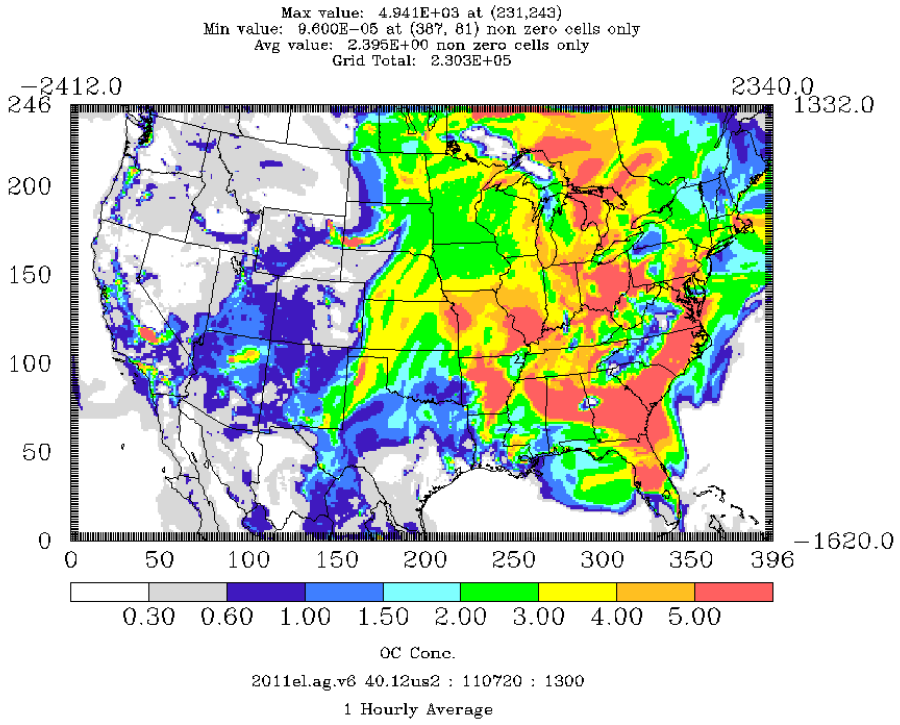


Figure 4-102: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 20 at 1300 hours

CAMx 6.40



Difference (6.32 - 6.40)

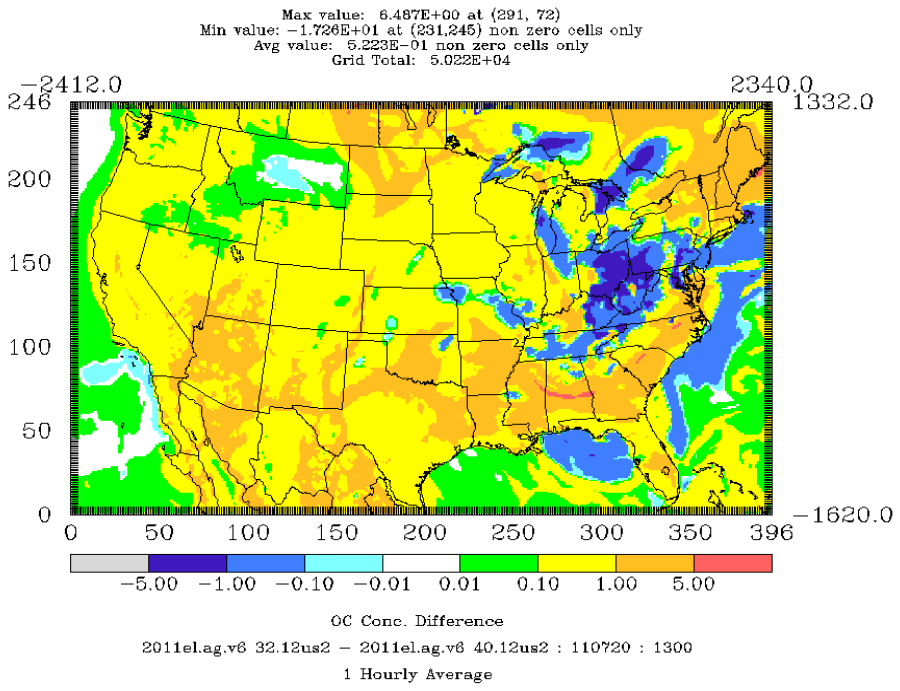
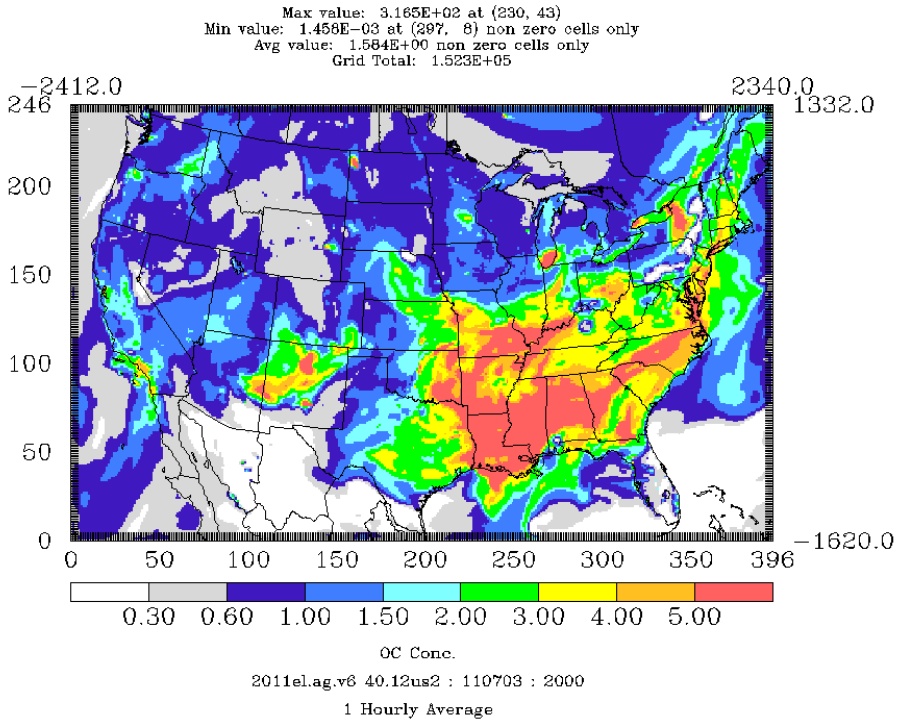


Figure 4-103: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 3 at 2000 hours

CAMx 6.40



Difference (6.32 - 6.40)

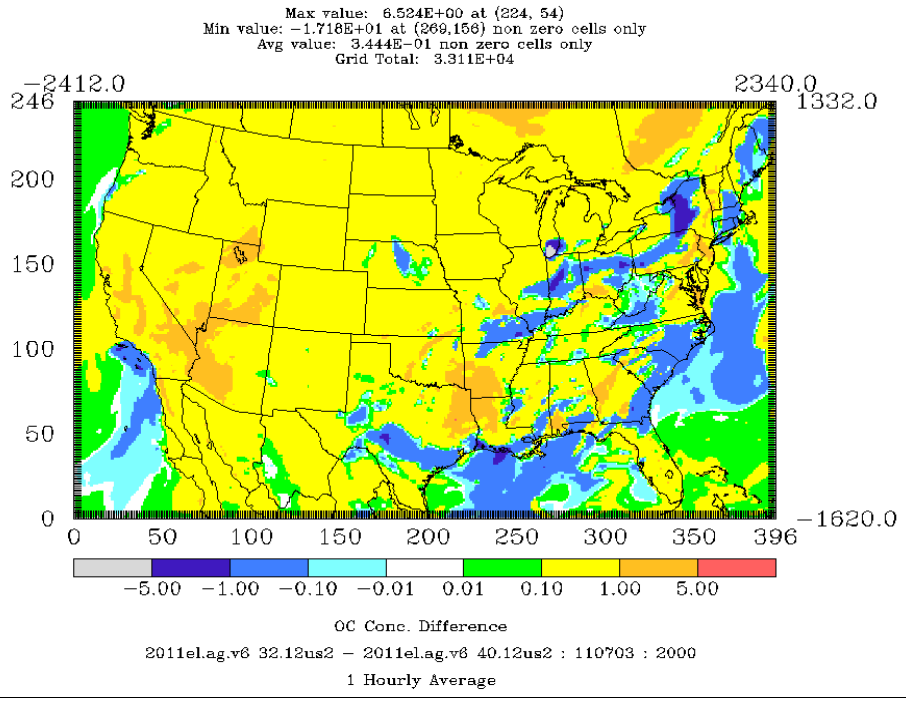
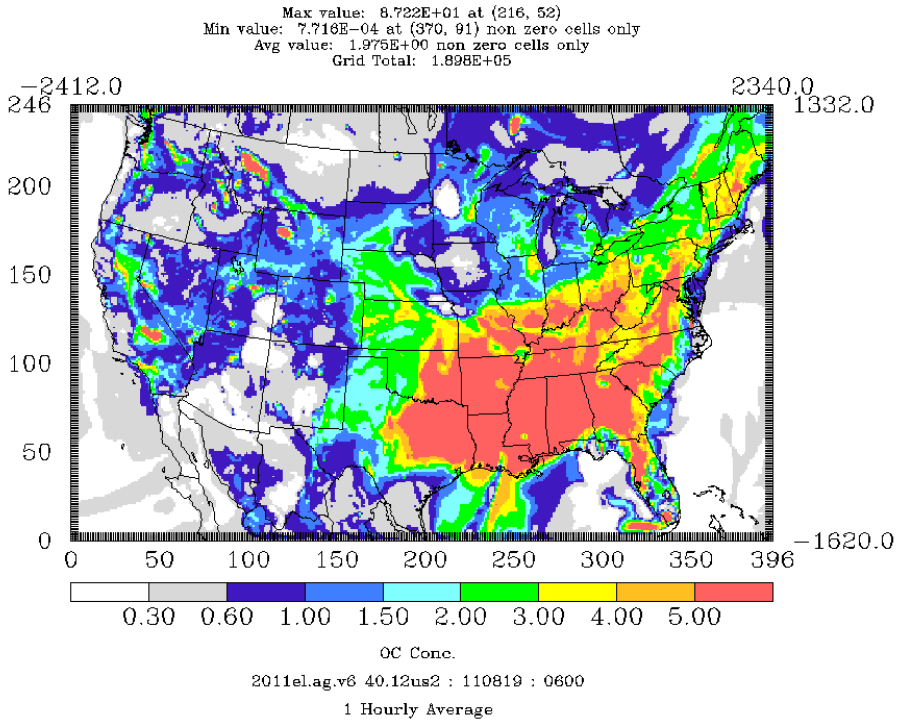


Figure 4-104: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: August 19 at 600 hours

CAMx 6.40



Difference (6.32 - 6.40)

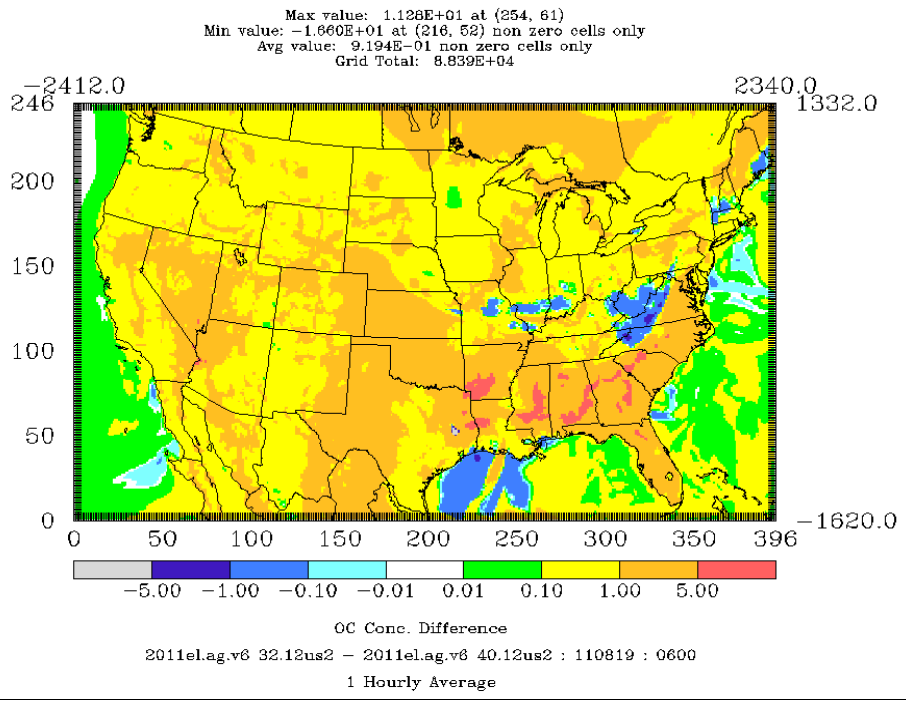


Figure 4-105: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.32 and CAMx 6.40 2011el Simulations (Tenth Highest Negative Difference)

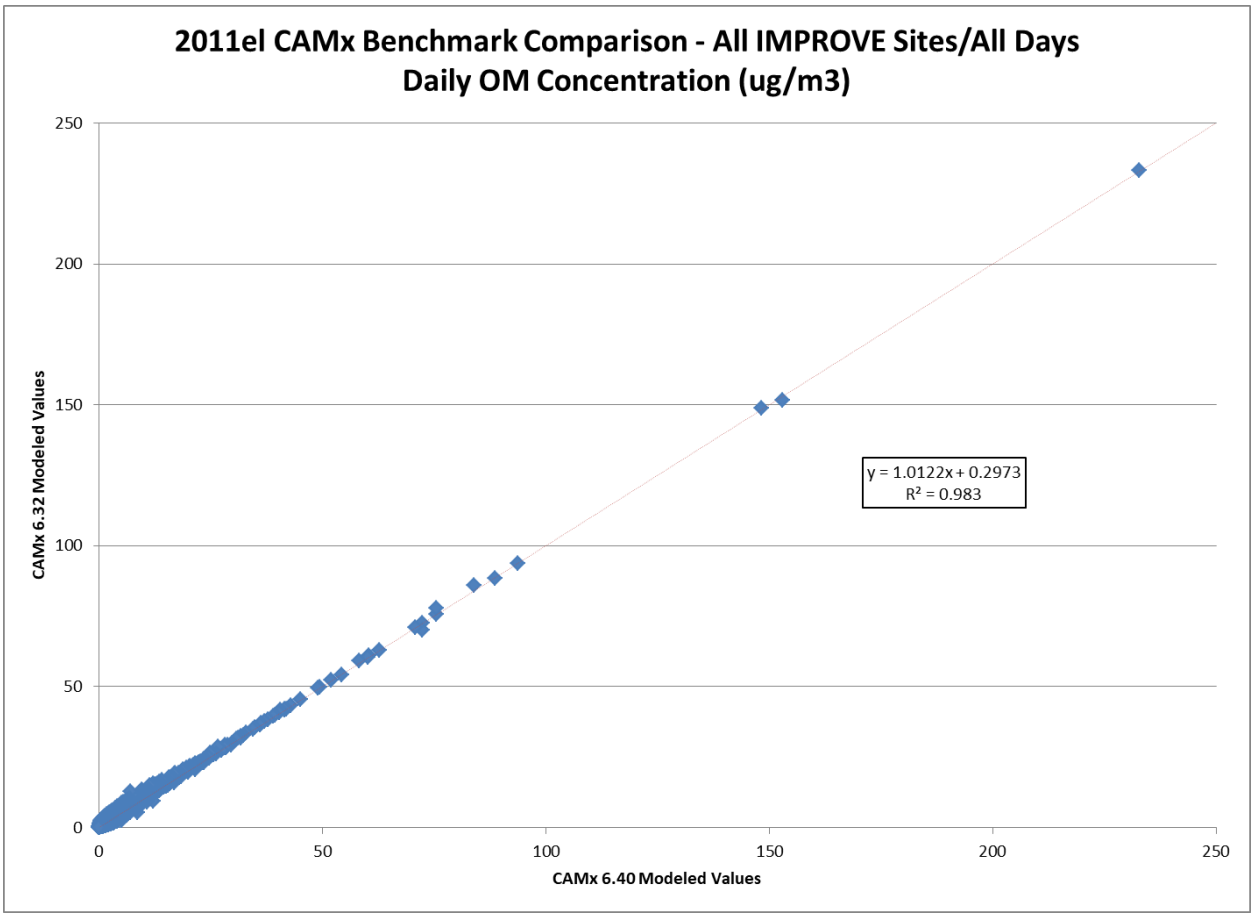


Figure 4-106: Scatterplot Comparing 24-hour Average Predicted Organic Matter Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine).

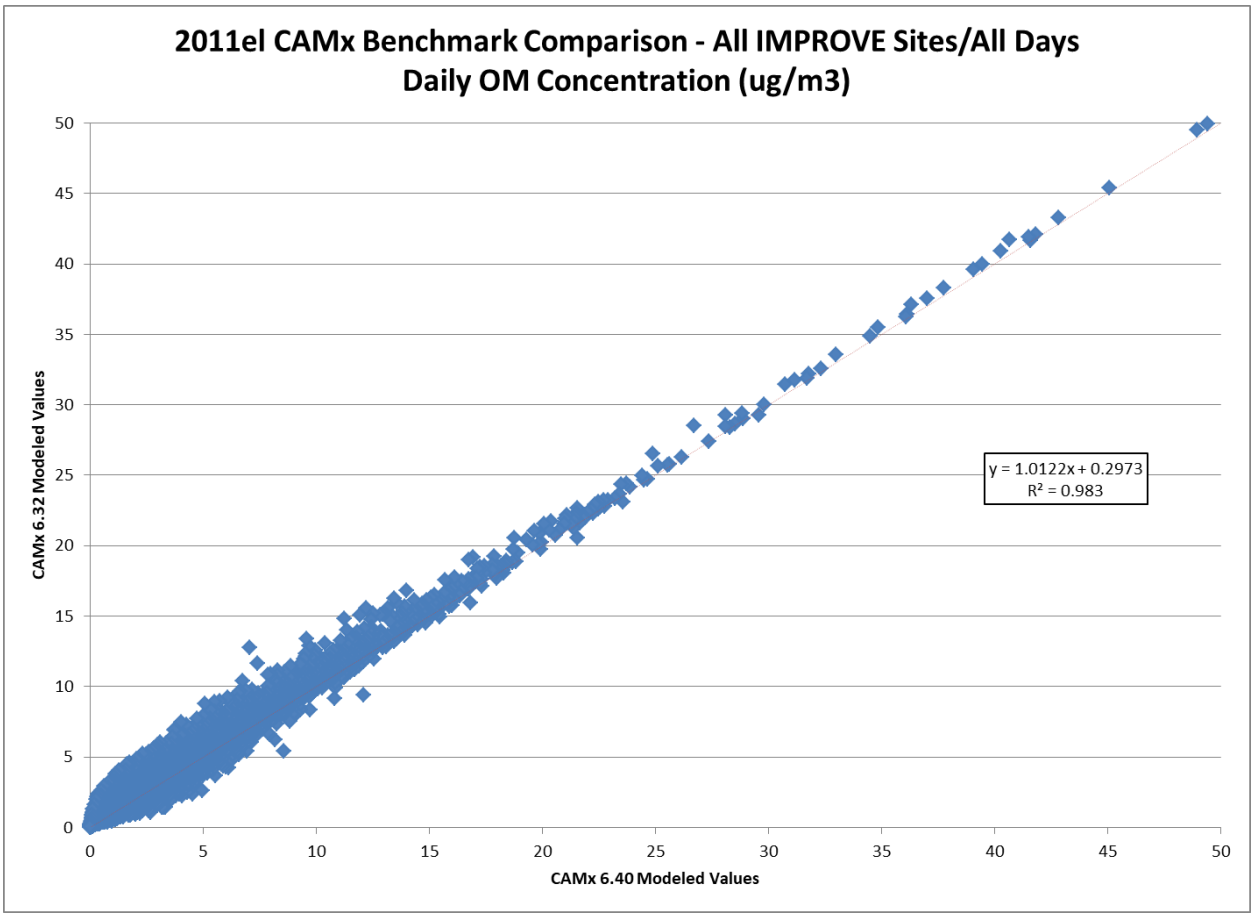


Figure 4-107: Scatterplot Comparing 24-hour Average Predicted Organic Matter Concentrations (μg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2011el Simulations Performed by VISTAS (Alpine); Modified Scale.

5.0 CONCLUSIONS

A comparison has been made between CAMx 6.32 and CAMx 6.40 simulations using EPA's 2011el modeling platform as performed on the Alpine Geophysics computer system for the VISTAS project. The comparison was conducted for ozone, $PM_{2.5}$, sulfate, nitrate and organic carbon and included an examination both of hourly gridded concentrations, and at daily average concentrations at the IMPROVE monitors.

The hourly gridded comparison showed areas of differences across the domain that varied hour to hour with the maximum hourly differences varying greatly.

A comparison of the daily average concentrations at the IMPROVE monitors showed fairly small differences for ozone and OM. For sulfate, the CAMx 6.40 results were generally lower than CAMx 6.32. For nitrate, the CAMx 6.32 and CAMx 6.40 results differed, with neither version of the model consistently higher than the other. There appears to be a trend where CAMx 6.40 is generally slightly higher that CAMx 6.32 during dry periods, but CAMx 6.32 is generally slightly higher during wet periods. The $PM_{2.5}$ results generally showed higher CAMx 6.32 concentrations compared to CAMx 6.40 at lower concentration levels, with consistent results at higher concentrations.

The comparison of CAMx 6.32 and 6.40 showed differences in model concentration estimates. This is to be expected given the changes to the model from the inclusion of new science into CAMx 6.40 over that which was included in CAMx 6.32. Alpine does not see any features in the modeling that would preclude the use of the better science in CAMx 6.40 for use in the VISTAS air quality planning.

Appendix E-2c

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project 2011el CAMx Version 6.40 12km VISTAS and EPA 12km Continental Grid Comparison Report

Benchmark Run #5

August 17, 2020

This page intentionally left blank.

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project
2011el CAMx Version 6.40 12km VISTAS and EPA 12km Continental Grid Comparison Report

Task 6 Benchmark Report #3
Covering Benchmark Run #5

Prepared for:
Southeastern States Air Resource Managers, Inc.
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final – August 17, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 INTRODUCTION 1
1.1 Overview 1
1.2 CAMx 6.40 2011el VISTAS12 and EPA 12US2 Comparison 3
2.0 DEVELOPMENT OF VISTAS12 INPUTS 4
3.0 CONFIRMATION METHODOLOGY 5
3.1 CAMx Species Mapping 6
4.0 VISTAS12 AND 12US2 CAMX 6.40 2011EL COMPARISON 6
4.1 Ozone 6
4.2 $PM_{2.5}$ 30
4.3 Sulfate 53
4.4 Nitrate 76
4.5 Organic Matter (OM) 99
5.0 CONCLUSIONS 122

This page is intentionally blank.

TABLES

Table 1-1. VISTAS II Modeling Domain Specifications 3

Table 3-1. Species Mapping from CAMx into Aggregated Species 6

Table 4-1. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of Ozone Concentrations (ppb). Hours with the top 10 maximum positive and maximum negative differences are shown. 8

Table 4-2. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of $PM_{2.5}$ Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 31

Table 4-3. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of Sulfate Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 54

Table 4-4. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of Nitrate Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 77

Table 4-5. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of Organic Matter Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 100

FIGURES

Figure 1-1. Map of 12km CAMx Modeling Domains. VISTAS_12 Domain Represented as Inner Red Domain. 3

Figure 4-1: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference) 9

Figure 4-2: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference) 10

Figure 4-3: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference) 11

Figure 4-4: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference) 12

Figure 4-5: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference) 13

Figure 4-6: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference) 14

Figure 4-7: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Positive Difference) 15

Figure 4-8: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference) 16

Figure 4-9: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference) 17

Figure 4-10: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference) 18

Figure 4-11: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference) 19

Figure 4-12: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference) 20

Figure 4-13: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference) 21

Figure 4-14: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference) 22

Figure 4-15: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference) 23

Figure 4-16: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference) 24

Figure 4-17: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference) 25

Figure 4-18: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference) 26

Figure 4-19: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference) 27

Figure 4-20: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference) 28

Figure 4-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine). 29

Figure 4-22: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference) 32

Figure 4-23: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference) 33

Figure 4-24: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference) 34

Figure 4-25: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference) 35

Figure 4-26: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference) 36

Figure 4-27: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference).....37

Figure 4-28: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Positive Difference) 38

Figure 4-29: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference) 39

Figure 4-30: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference).....40

Figure 4-31: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference).....41

Figure 4-32: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference) 42

Figure 4-33: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference).....43

Figure 4-34: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference).....44

Figure 4-35: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference).....45

Figure 4-36: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference).....46

Figure 4-37: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference) 47

Figure 4-38: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference).....48

Figure 4-39: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference).....49

Figure 4-40: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference) 50

Figure 4-41: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference) 51

Figure 4-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations (µg/m3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine)....52

Figure 4-43: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference).....55

Figure 4-44: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference) 56

Figure 4-45: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference) 57

Figure 4-46: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference) 58

Figure 4-47: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference) 59

Figure 4-48: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference).....60

Figure 4-49: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations 61

Figure 4-50: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference) 62

Figure 4-51: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference).....63

Figure 4-52: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference).....64

Figure 4-53: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference) 65

Figure 4-54: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference).....66

Figure 4-55: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference).....67

Figure 4-56: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference).....68

Figure 4-57: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference).....69

Figure 4-58: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference) 70

Figure 4-59: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference).....71

Figure 4-60: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference).....72

Figure 4-61: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference) 73

Figure 4-62: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference) 74

Figure 4-63: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine)....75

Figure 4-64: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference).....78

Figure 4-65: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference) 79

Figure 4-66: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference) 80

Figure 4-67: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference) 81

Figure 4-68: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference) 82

Figure 4-69: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference).....83

Figure 4-70: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Positive Difference) 84

Figure 4-71: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference) 85

Figure 4-72: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference).....86

Figure 4-73: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference).....87

Figure 4-74: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference) 88

Figure 4-75: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference).....89

Figure 4-76: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference).....90

Figure 4-77: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference).....91

Figure 4-78: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference).....92

Figure 4-79: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference) 93

Figure 4-80: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference).....94

Figure 4-81: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference).....95

Figure 4-82: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference) 96

Figure 4-83: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference) 97

Figure 4-84: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine)....98

Figure 4-85: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference)..101

Figure 4-86: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference) 102

Figure 4-87: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference) 103

Figure 4-88: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference) 104

Figure 4-89: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference) 105

Figure 4-90: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference) 106

Figure 4-91: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Positive Difference) 107

Figure 4-92: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference) 108

Figure 4-93: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference) 109

Figure 4-94: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference) 110

Figure 4-95: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference) 111

Figure 4-96: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference) 112

Figure 4-97: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference) 113

Figure 4-98: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference) 114

Figure 4-99: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference) 115

Figure 4-100: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference) 116

Figure 4-101: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference) 117

Figure 4-102: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference) 118

Figure 4-103: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference) 119

Figure 4-104: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference) 120

Figure 4-105: Scatterplot Comparing 24-hour Average Predicted Organic Matter Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine). 121

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
BNDEXTR	Boundary extraction program
CAMx	Comprehensive Air quality Model with eXtensions
CONUS	Continental U.S.
dv	Deciview
ERG	Eastern Research Group, Inc.
EPA	Environmental Protection Agency
FCRS	Crustal fraction of PM
FLM	Federal Land Manager
FORTRAN	Formula Translation programming language
FPRM	Fine other primary (diameter ≤ 2.5µm)
FR	Federal Register
IMPROVE	Interagency Monitoring of Protected Visual Environments
km	kilometer
µg/m^3	microgram per cubic meter
NAAQS	National Ambient Air Quality Standard
NA	Sodium
OAQPS	Office of Air Quality Planning and Standards
O_3	Ozone
OC	Organic carbon
OM	Organic matter
PCL	Particulate chlorine
PEC	Primary elemental carbon
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Particulate ammonium
PNO3	Particulate nitrate
POA	Primary Organic Aerosol
ppb	Parts per billion
PSO4	Particulate sulfate
R^2	Pearson correlation coefficient squared
RHR	Regional Haze Rule
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SO_2	Sulfur dioxide
SOA	Secondary organic aerosol
U.S.	United States
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast

1.0 INTRODUCTION

1.1 Overview

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States (U.S.) Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone (O_3) as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.

B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that is, the focus of state planning will be to establish reasonable progress goals for each Class I area against which progress will be measured during the second planning period. This extension will allow states to incorporate planning for other Federal programs while conducting their regional haze planning. These other programs include: the Mercury and Air Toxics Standards, the 2010 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview (dv) index values. "Most impaired days" are defined as the 20% of

monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

1.2 CAMx 6.40 2011el VISTAS12 and EPA 12US2 Comparison

The VISTAS II air quality modeling is being performed on a smaller computational grid than EPA used in developing the 2011el platform. The use of the smaller domain is designed to allow SESARM to more efficiently look at air quality issues in the southeastern U.S.

Alpine Geophysics, LLC (Alpine), under subcontract with Eastern Research Group, Inc. (ERG), has executed two air quality simulations for the 2011el base year modeling platform; one run with Comprehensive Air quality Model with eXtensions (CAMx) 6.40 over the EPA continental US domain (12US2) and one for the VISTAS12 domain. The domains are presented in Figure 1-1 with the 12US2 domain as the outer grid and the VISTAS12 domain is shown as the red box. The domain definitions for the two domains are presented in Table 1-1.

Table 1-1. VISTAS II Modeling Domain Specifications

Domain	Columns	Rows	Vertical Layers	X Origin (km)	Y Origin (km)
CONUS_12	396	246	25	-2,412	-1,620
VISTAS_12	269	242	25	-912	-1,596

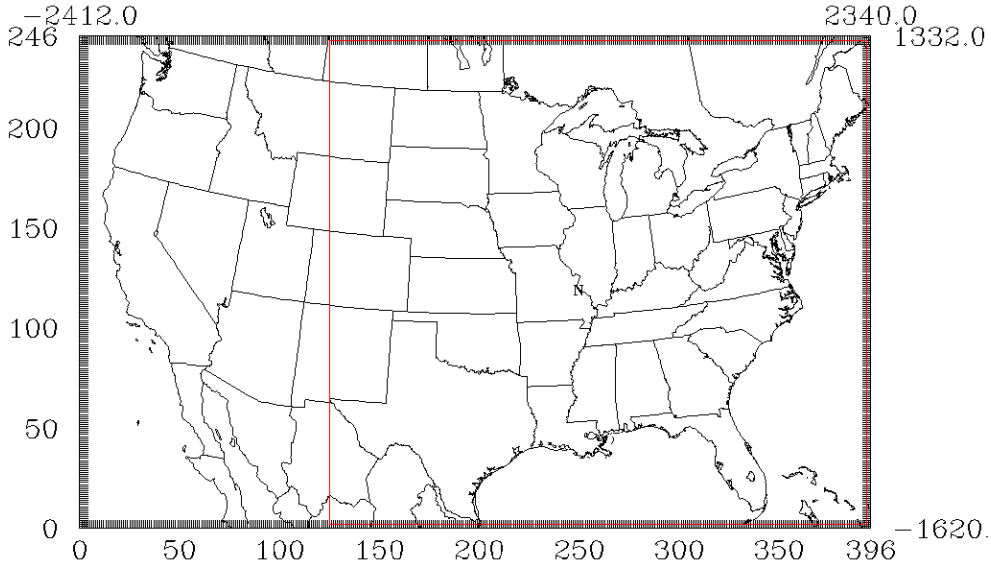


Figure 1-1. Map of 12km CAMx Modeling Domains. VISTAS_12 Domain Represented as Inner Red Domain.

2.0 DEVELOPMENT OF VISTAS12 INPUTS

The inputs for the VISTAS12 domain were developed by extracting a subdomain from the CAMx ready model inputs (commonly referred to as windowing). The meteorology and emissions inputs were windowed using a slightly modified version of the CAMx utility program "window".[2] The only required change to the distributed version program is to allow the program to window three-dimension files instead of just two-dimensional files. The CAMx ozone column and watermask inputs were windowed using new Formula Translation (FORTRAN) programs using the same windowing algorithm as is contained in the "window" code. The windowing code was checked graphically to assure that the VISTAS12 results were consistent with the 12US2 results. The boundary and initial conditions for the VISTAS12 domain will be extracted from the 12US2 three-dimensional output files using the CAMx Boundary Extraction (BNDEXTR) program.

Two issues have been identified that have noted impact on the use of the VISTAS12 domain relative to the 12US2 domain.[3] The first, and likely the most significant, noted issue is a time-step difference at the boundary where concentration conditions from outside of the domain are injected into the modeling domain at one hour intervals compared to the model generated (sub-hourly) time-step interval within the modeling domain. These differences can create initial, significant concentration gradients along the boundary that can be carried through the episode and transported to grid cells within the modeling domain. The second issue is related to the time step in the model. The time step is determined by the maximum wind in the modeling domain. If the highest wind in the 12US2 domain occurs somewhere outside the VISTAS12 domain, the time step in the 12US2 simulation will be longer than in the VISTAS12 domain.

We note that in modeling the VISTAS12 domain with 12US2 boundary conditions, both of these issues are exacerbated in the modeling due to large emission sources located near the boundary of the 12US2/VISTAS12 boundary, particularly in Canada.

[2] http://www.camx.com/getmedia/88755b80-6992-4f07-bcaa-596d05e1b4b8/window-6may13_1.tgz
[3] Brian Timin, EPA Office of Air Quality Planning and Standards (OAQPS) personal communication October 11, 2018.

3.0 CONFIRMATION METHODOLOGY

The presented comparisons of model simulations are based on hourly differences in O_3, $PM_{2.5}$, Organic Matter (OM), Particulate Nitrate (PNO3), and Particulate Sulfate (PSO4). The metric for comparison are the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$(C_{VISTAS12} - C_{12US2})$$

(Equation 2) $$\frac{(C_{VISTAS12} - C_{12US2})}{(C_{12US2})}$$

Where $C_{VISTAS12}$ is the concentration at each grid cell hour for the CAMx simulation over the VISTAS12 simulation and C_{12US2} is the concentration at each grid cell hour for the CAMx simulation over the 12US2.

To facilitate the comparison of the results over the same spatial domain, the 12US2 simulation output files were windowed onto the VISTAS2 domain using the I/O API[4] m3wndw code.

The results are presented for the hours with the largest difference between the simulations. A table presents the hours with the top 10 positive and negative absolute differences. Spatial maps are presented for the hours with the top 10 highest positive and negative differences. To provide context for the differences, the concentration maps are also presented for each of the hours of high difference. On each spatial plot the maximum positive and negative values, along with the grid cell in which these occur, are presented at the top of the graphic. The coordinates refer to the row and columns of the cell referenced to the cell coordinates on the bottom (column) and left (row) of the graphic. Because the CAMx results are unduly influenced by the boundary concentrations around the edges, the analysis does not include the edge rows and columns of the CAMx domain.

Hourly animations have also been prepared and are available on the VISTAS II project ftp site. Where appropriate, this report also reports and interprets on the animations.

[4] https://www.cmascenter.org/ioapi/

3.1 CAMx Species Mapping

Several of the key particulate matter species of interest are combinations of CAMx output variable. The CAMx 6.40 species mapping are presented in Table 3-1.

Table 3-1. Species Mapping from CAMx into Aggregated Species

Aggregated Species	CAMx 6.40 Species
Ozone	O3
PM2.5	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
Sulfate	PSO4
Nitrate	PNO3
Organic Matter (OM)	SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA

4.0 VISTAS12 AND 12US2 CAMX 6.40 2011EL COMPARISON

This section presents comparisons of the simulations using CAMx 6.40 performed on the Alpine computer system using EPA's 2011el modeling platform over the VISTAS12 and 12US2 domains.

4.1 Ozone

Ozone results for the top 10 positive and negative hours are presented in tabular format in Table 4-1. The maximum positive difference is 17.75 parts per billion (ppb) falling to 9.16 ppb for the 10th high. The maximum negative difference is -17.41 ppb falling to -12.19 for the 10th high. Generally the highest positive and negative differences are occurring on relatively high ozone hours with concentrations up to 145.94 ppb for the VISTAS12 simulation. The maximum positive and negative percent differences are 28.1% and -16.0%, respectively.

As expected, the maximum impacts on the top 10 positive and negative hours are occurring very near the border (Rows close to 1 or 268 and Columns near 1 or 241). As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly average boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated at every model-generated timestep from the cells outside the VISTAS12 domain. Additionally, as noted in an earlier section, the CAMx model does not include emissions in the

border cells. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous model-determined concentrations and the CAMx model excluding emissions along the border.

The top ten positive impact hours are presented in Figures 4-1 through 4-10. The top ten negative impact hours are presented in Figures 4-11 through 4-20. The regions of highest differences tend to occur along the northern and western boundary and during short-term periods of time.

Scatterplots of the daily average ozone concentrations in local standard time at the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors across all modeled days are presented in Figure 4-21. The 12US2 results are plotted on the x-axis and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0002, an intercept of 0.0088 ppb and an R^2 of 1.0000.

Examination of the difference animations shows some interesting results. On many hours the differences are fairly smooth without much horizontal difference, as seen in Figure 4-10. Then, in a single hour regions of small local gradients occur and the spatial field resembles Figure 4-8. Often, over a period of several hours, these small differences disappear and the smooth structure is restored.

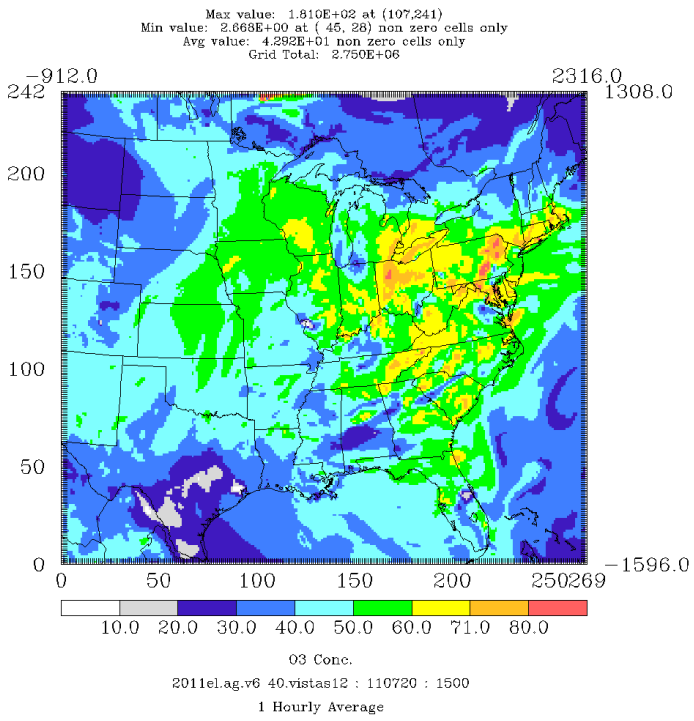
These differences are likely caused by a combination of factors The first, and likely the most significant, noted issue is a time-step difference at the boundary where concentration conditions from outside of the domain are injected into the modeling domain at one hour intervals compared to the model generated (sub-hourly) time-step interval within the modeling domain. The other difference is the time step in the integration of the CAMx model. The CAMx model determines the time step based on the highest wind speed in the domain. When the highest wind speed is located in the VISTAS12 region, the time step for the VISTAS12 and 12US2 simulations are the same. When the highest wind speed in the 12US2 domain occurs outside the VISTAS12 domain, the time steps are different in the two simulations. This difference in the time step will yield slightly different concentrations between the two region simulations.

Table 4-1. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of Ozone Concentrations (ppb). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (ppb)	Percent Difference	Column	Row
Maximum Positive									
2011	7	20	15	145.94	128.19	17.75	13.8%	108	241
2011	7	20	16	129.49	114.45	15.04	13.1%	107	241
2011	7	20	17	83.66	69.46	14.20	20.4%	107	241
2011	7	20	21	59.32	47.12	12.20	25.9%	97	241
2011	7	20	18	72.85	61.55	11.30	18.4%	122	241
2011	7	20	14	125.74	114.97	10.77	9.4%	109	241
2011	7	20	19	60.33	49.62	10.71	21.6%	122	241
2011	2	24	0	48.61	37.95	10.66	28.1%	44	2
2011	2	23	23	52.52	42.89	9.63	22.5%	46	2
2011	7	20	20	88.49	79.33	9.16	11.5%	97	241
Maximum Negative									
2011	7	17	16	111.00	128.41	-17.41	-13.6%	92	241
2011	7	17	15	124.25	141.30	-17.05	-12.1%	90	241
2011	7	17	18	83.38	98.40	-15.02	-15.3%	93	240
2011	7	17	14	127.70	142.71	-15.00	-10.5%	90	241
2011	7	17	17	96.52	111.24	-14.72	-13.2%	92	241
2011	7	17	19	78.68	92.74	-14.06	-15.2%	92	240
2011	7	18	19	70.35	83.73	-13.38	-16.0%	89	241
2011	7	18	18	74.07	87.43	-13.36	-15.3%	89	241
2011	7	18	15	94.25	107.58	-13.34	-12.4%	88	241
2011	7	18	20	68.25	80.44	-12.19	-15.2%	90	240

Maximum Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

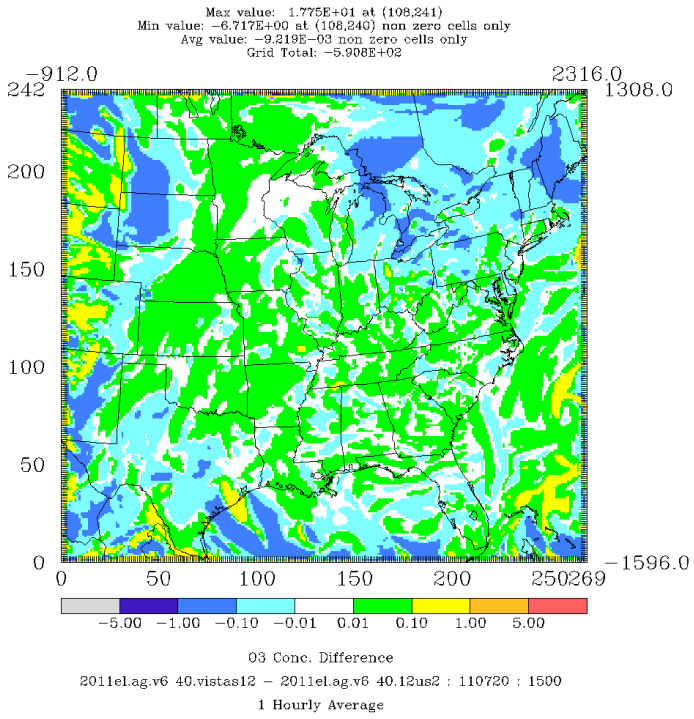
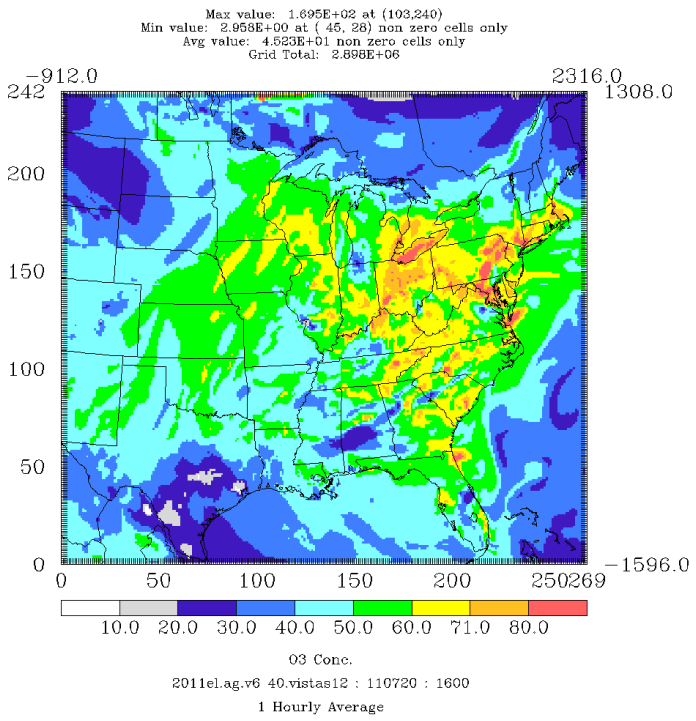


Figure 4-1: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: July 20 at1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

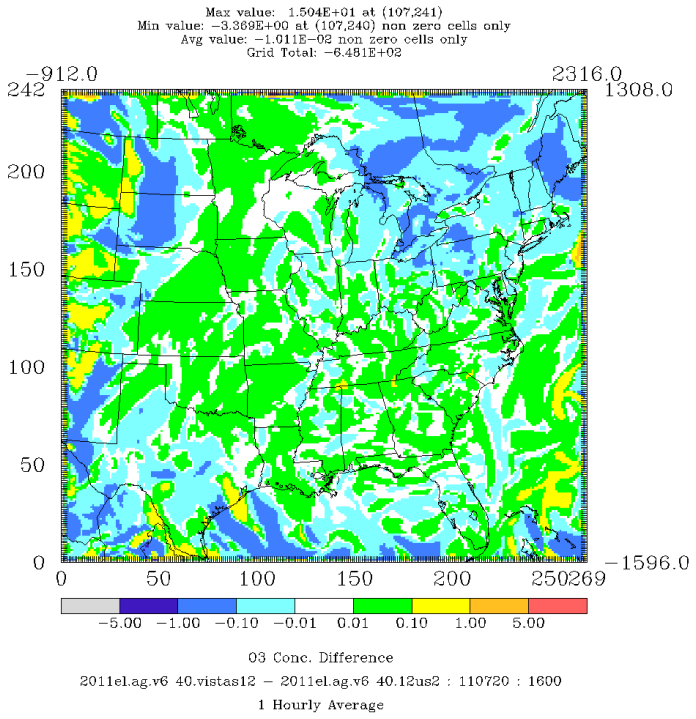
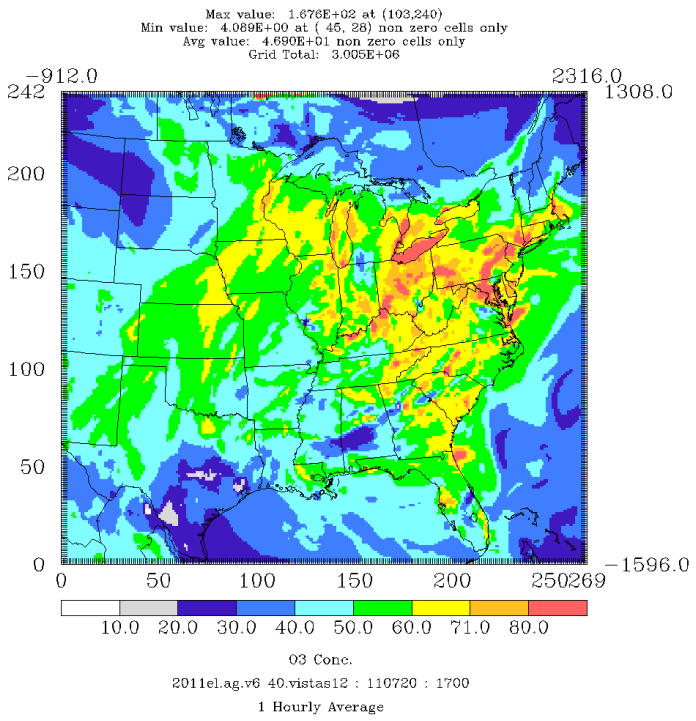


Figure 4-2: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: July 20 at 1700 hours

VISTAS12



Difference (VISTAS12 - 12US2)

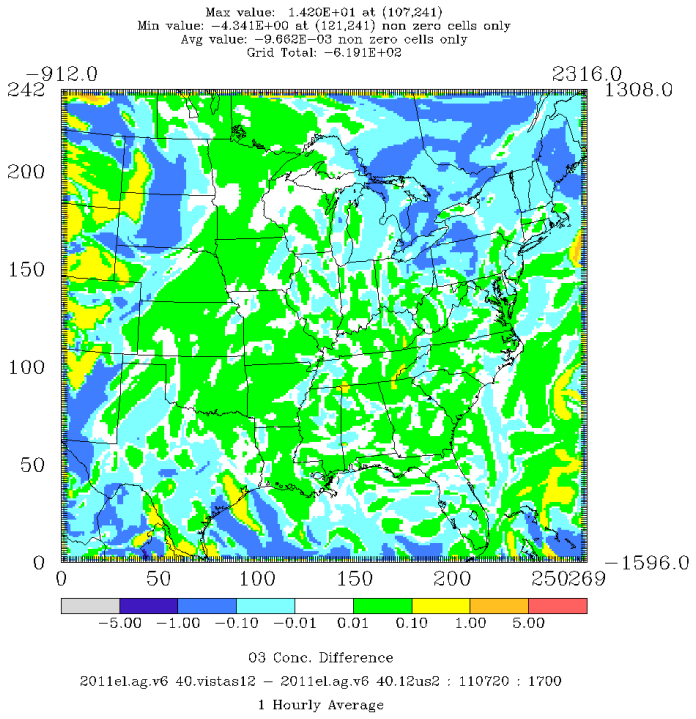
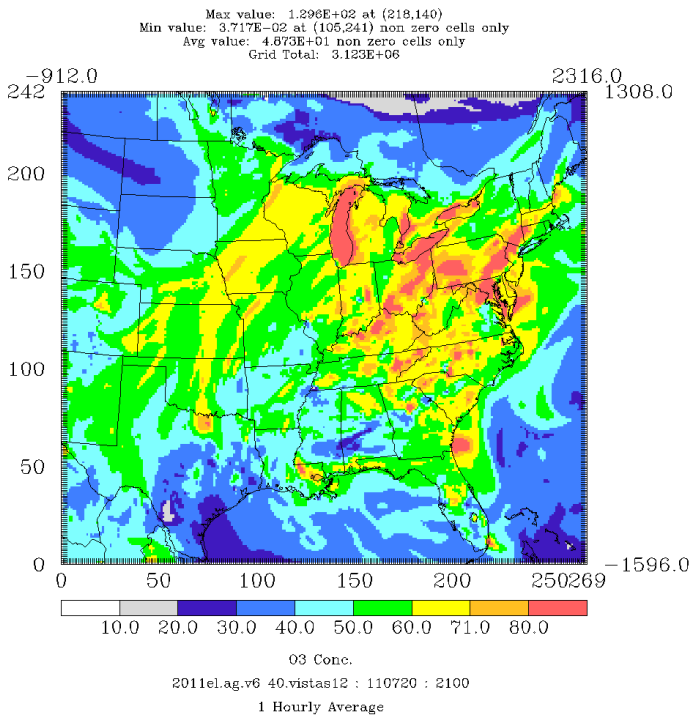


Figure 4-3: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: July 20 at 2100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

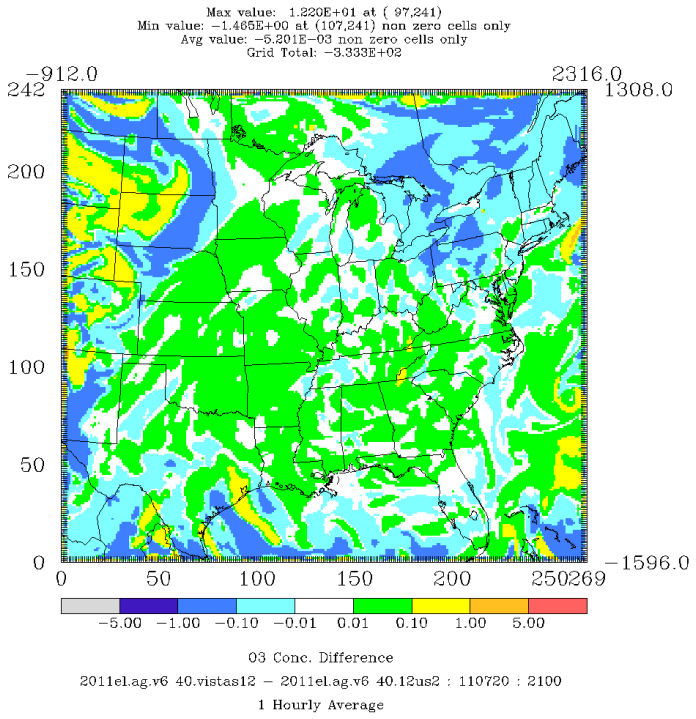
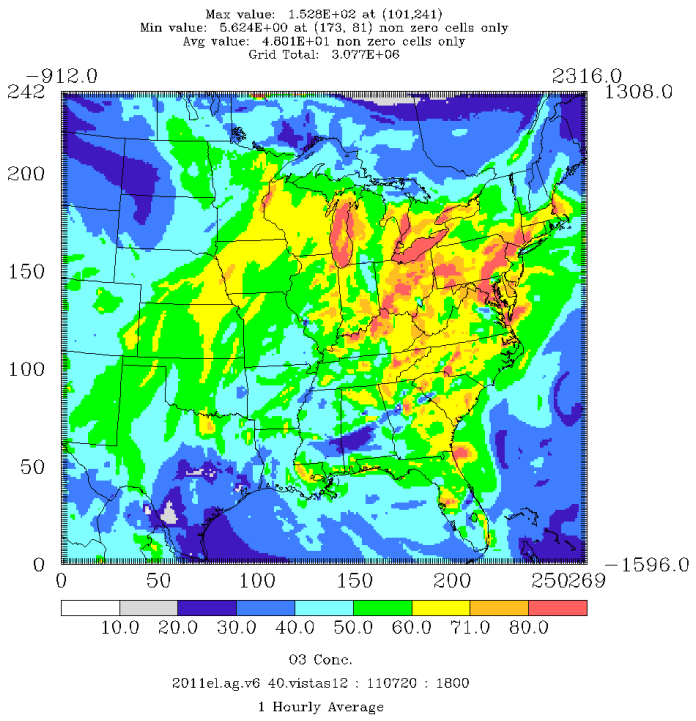


Figure 4-4: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: July 20 at 1800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

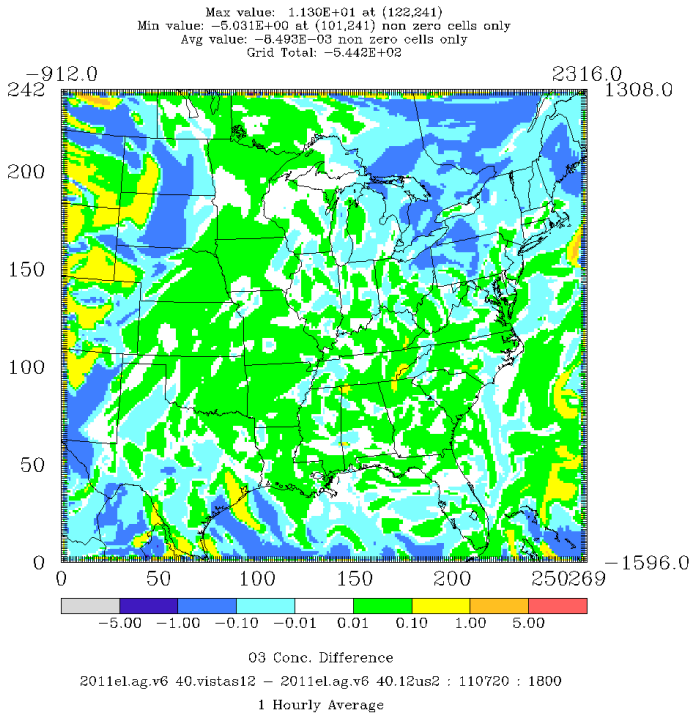
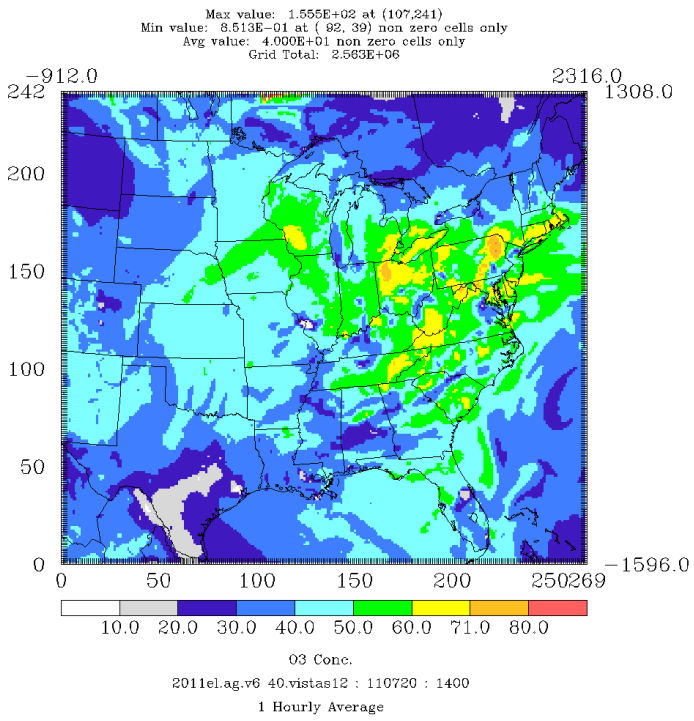


Figure 4-5: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

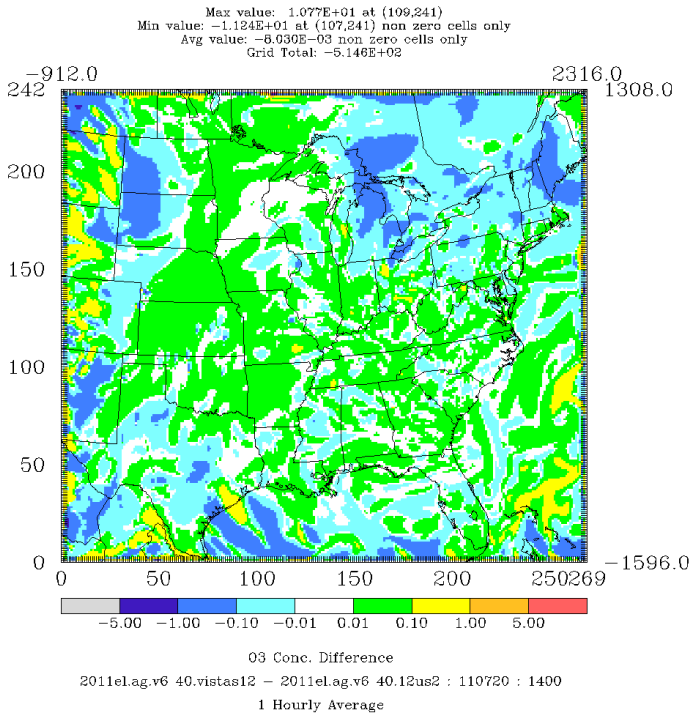
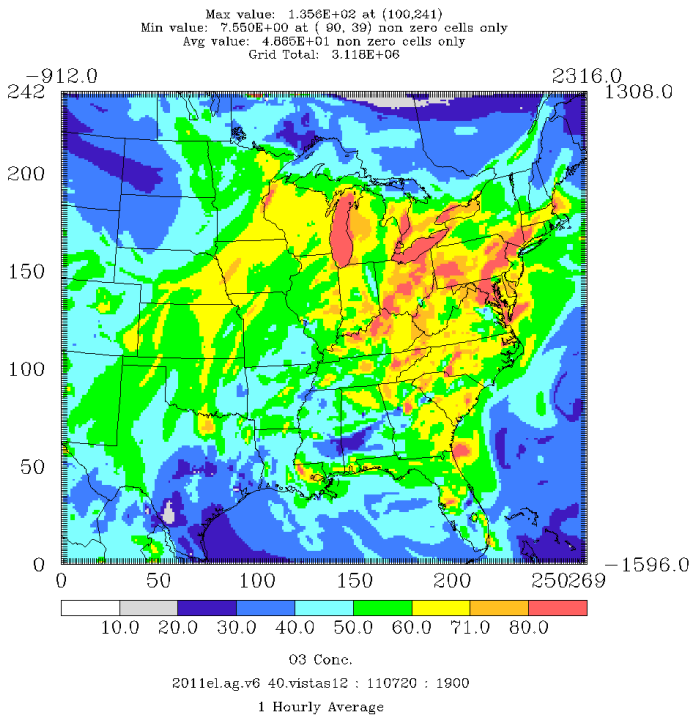


Figure 4-6: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: July 20 at 1900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

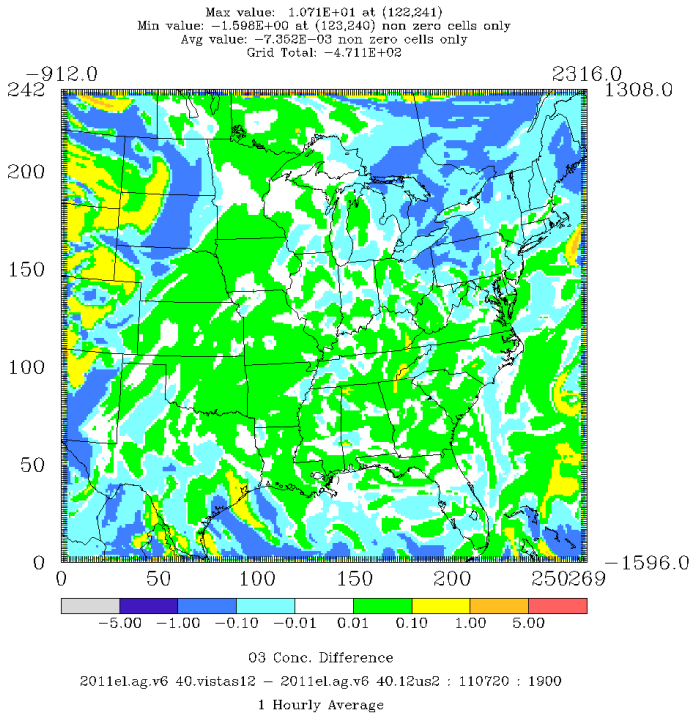
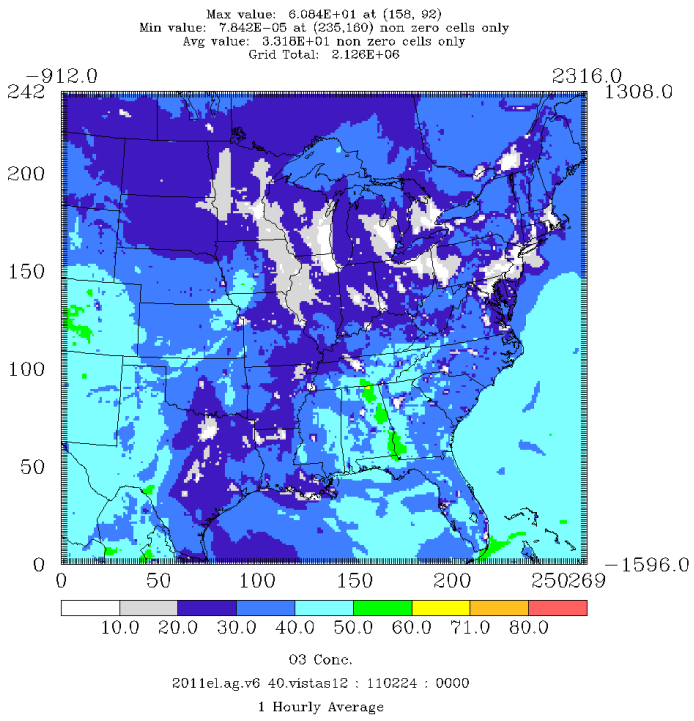


Figure 4-7: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: February 24 at 0000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

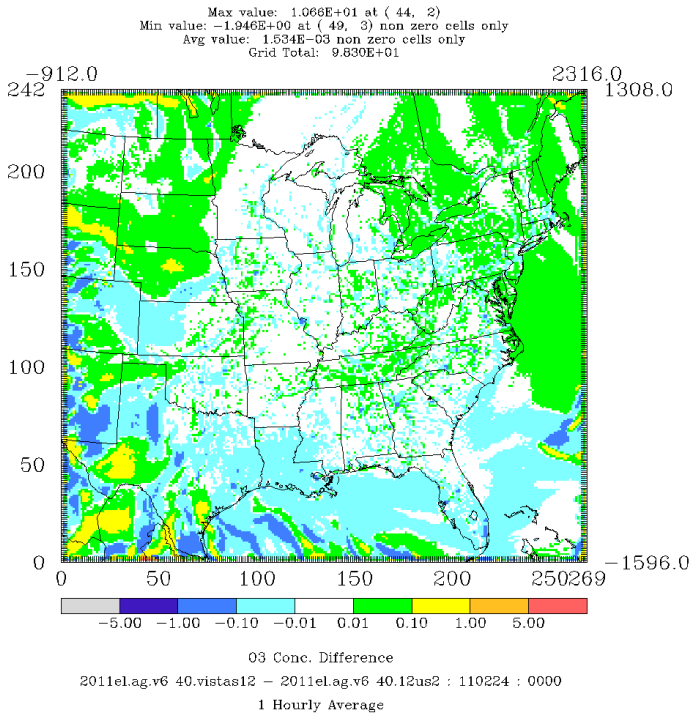
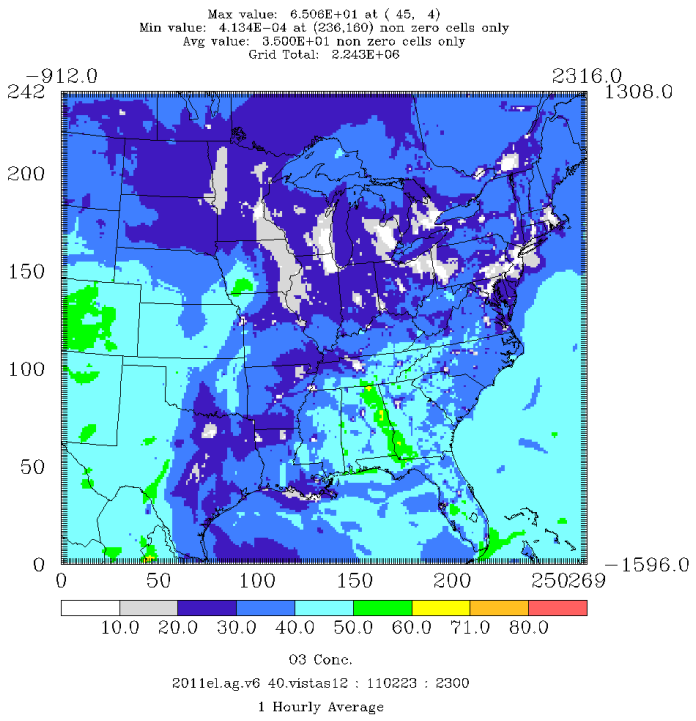


Figure 4-8: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: February 23 at 2300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

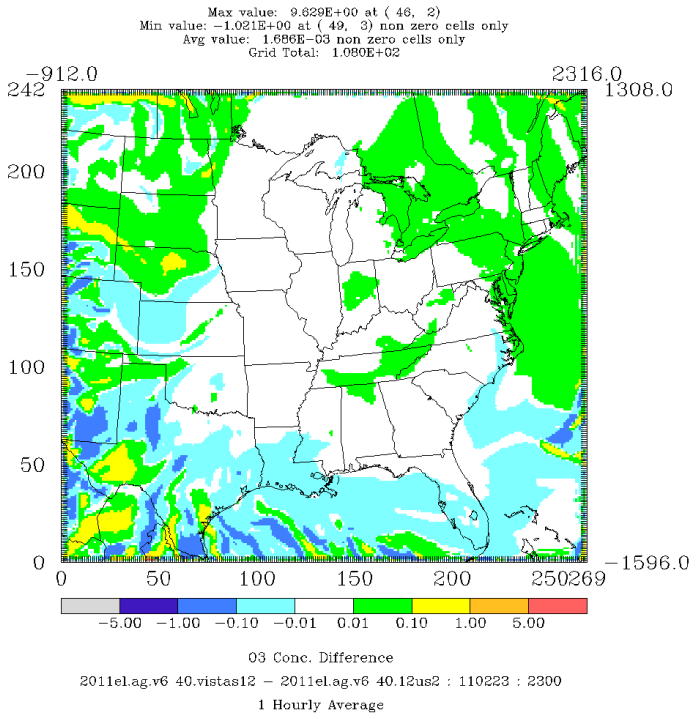
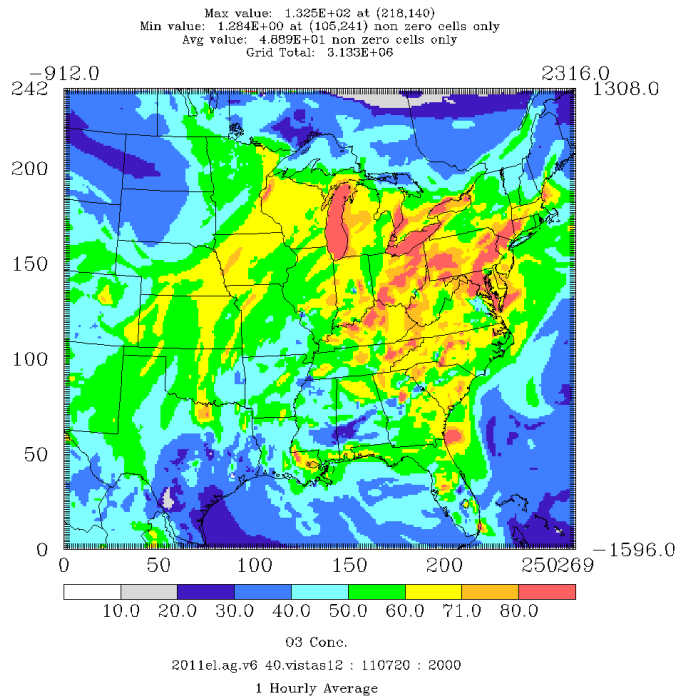


Figure 4-9: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 2000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

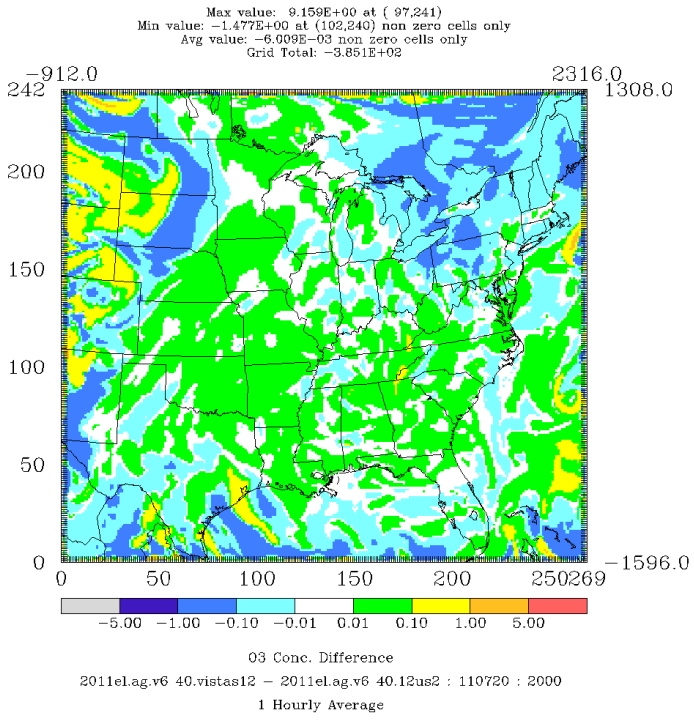
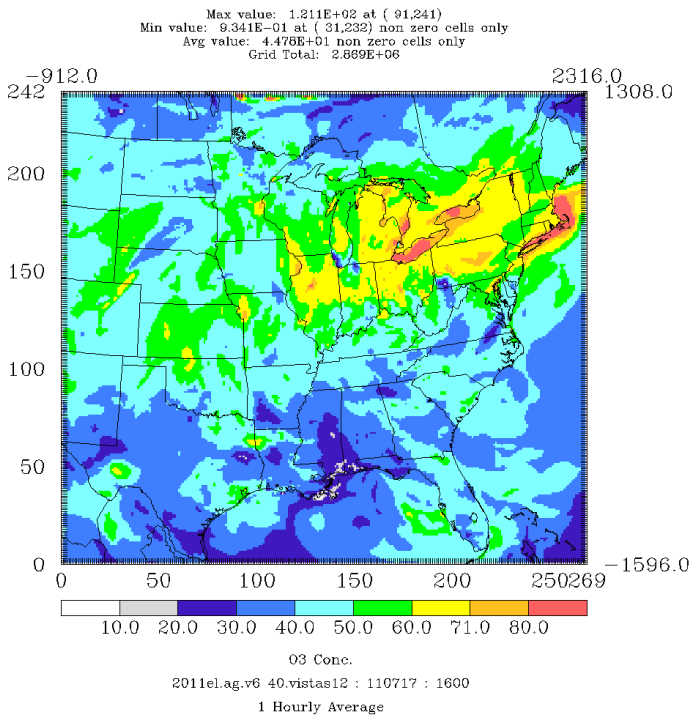


Figure 4-10: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 17 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

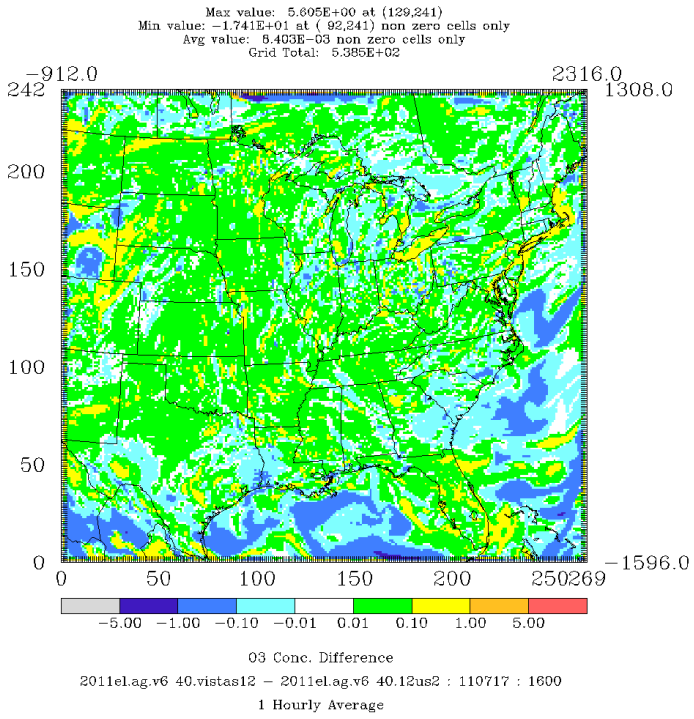
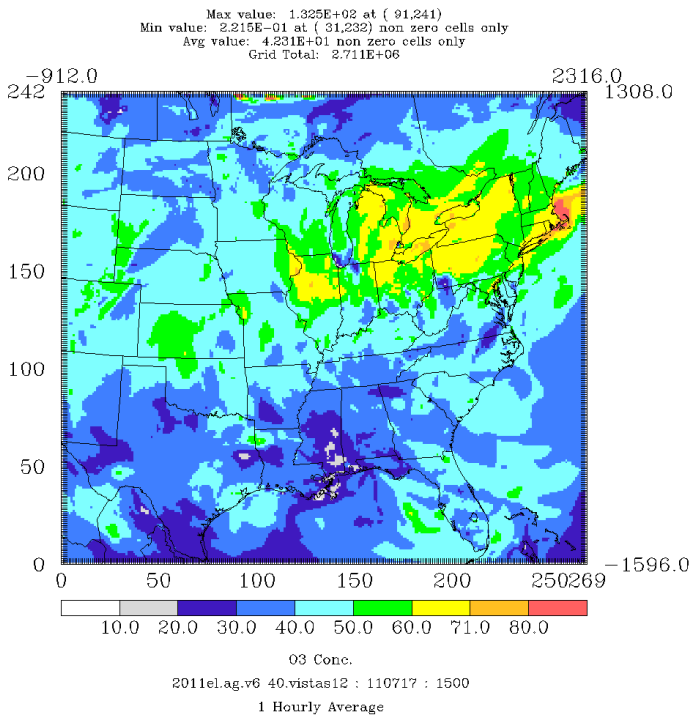


Figure 4-11: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 17 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

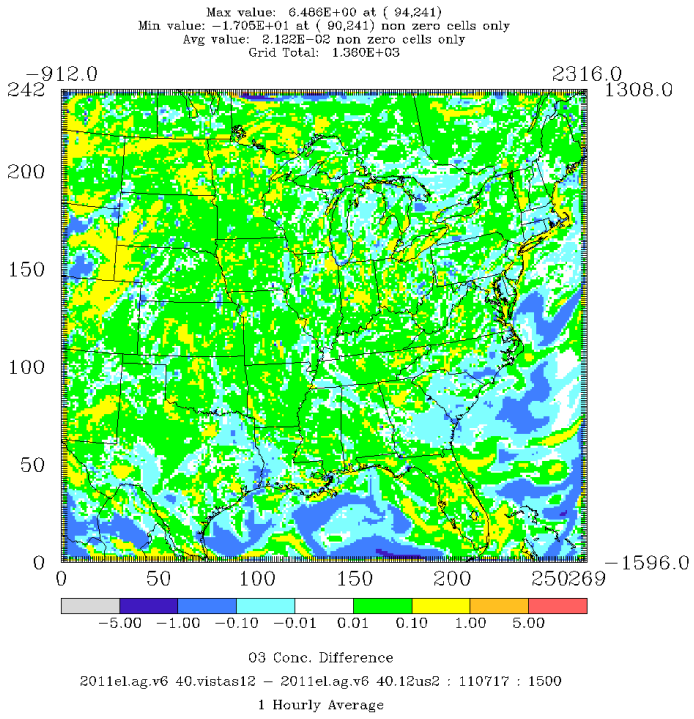
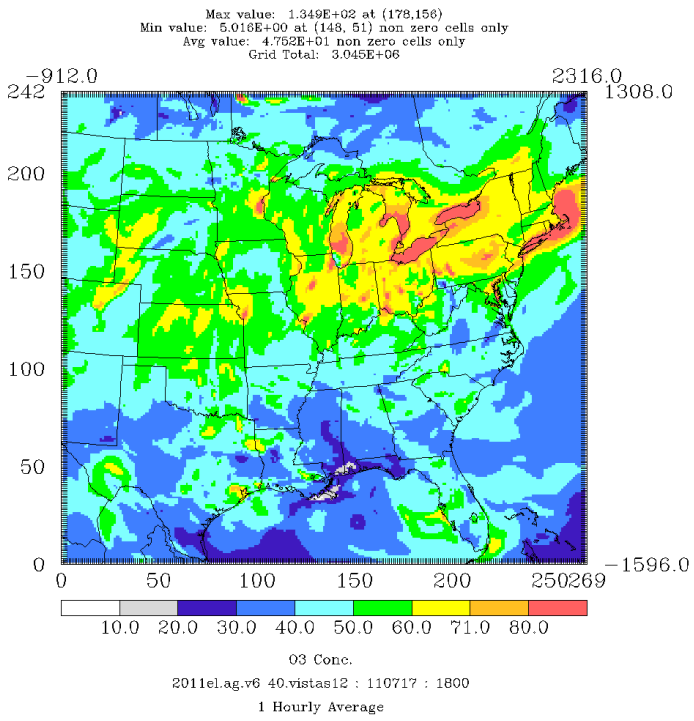


Figure 4-12: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 17 at 1800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

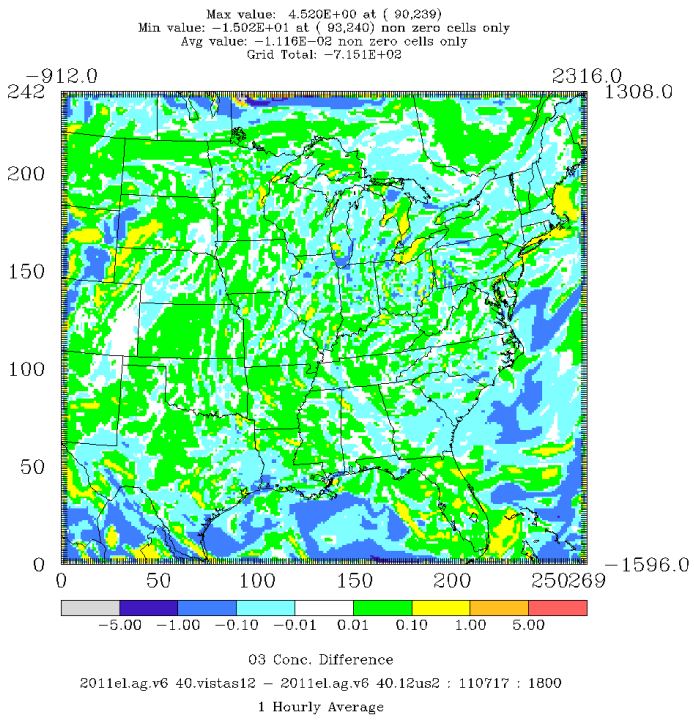
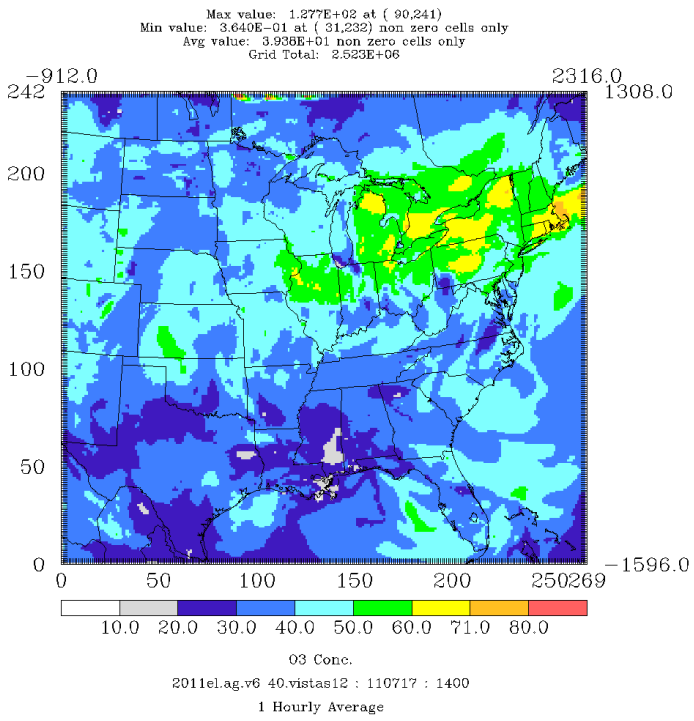


Figure 4-13: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 17 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

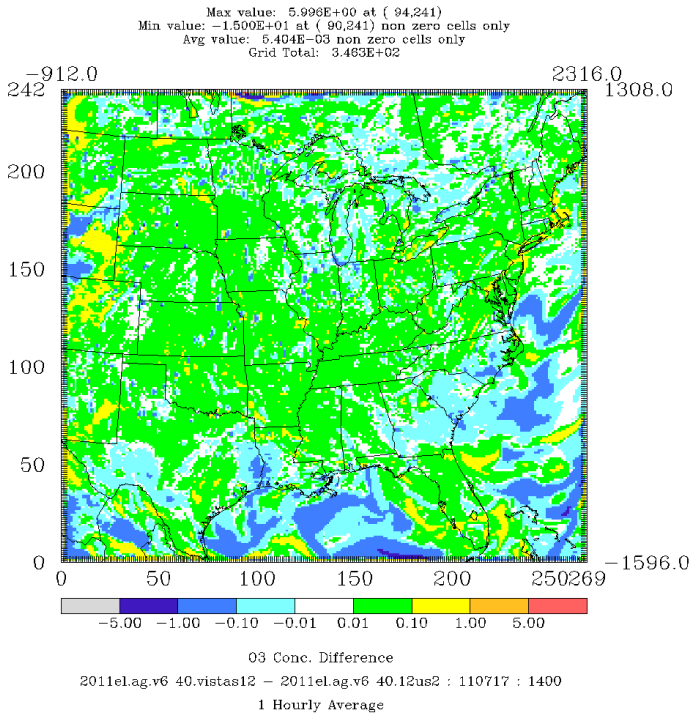
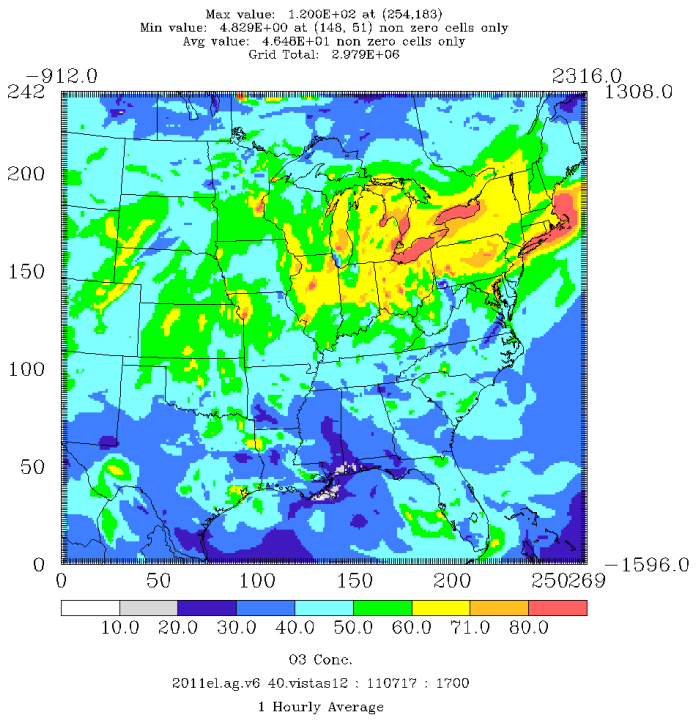


Figure 4-14: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 17 at 1700 hours

VISTAS12



Difference (VISTAS12 - 12US2)

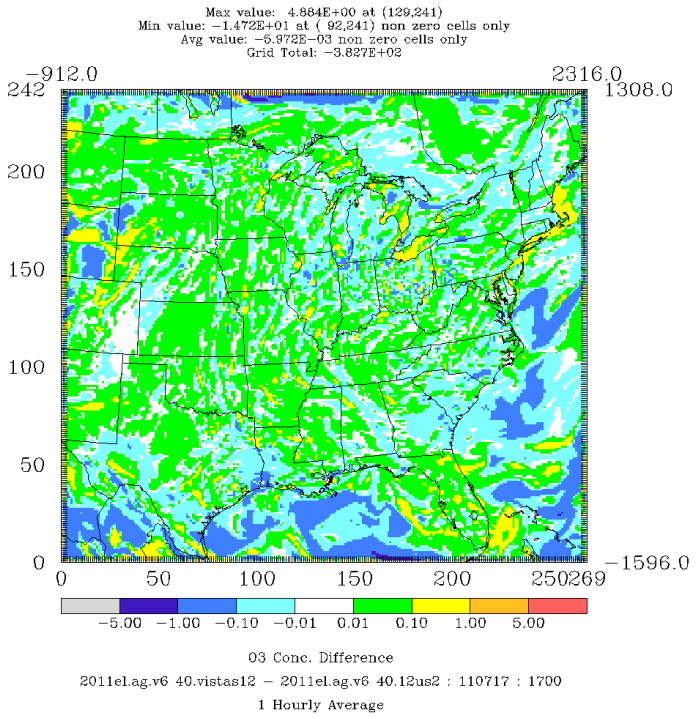
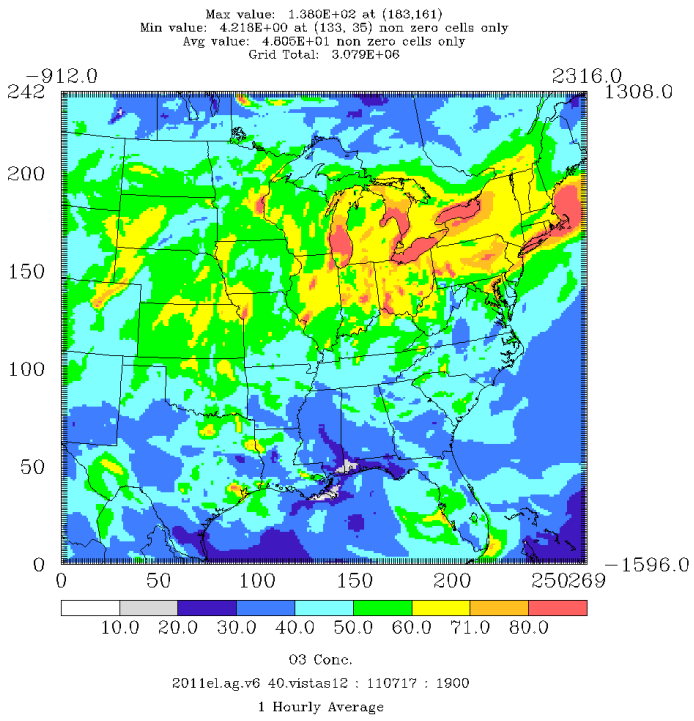


Figure 4-15: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 17 at 1900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

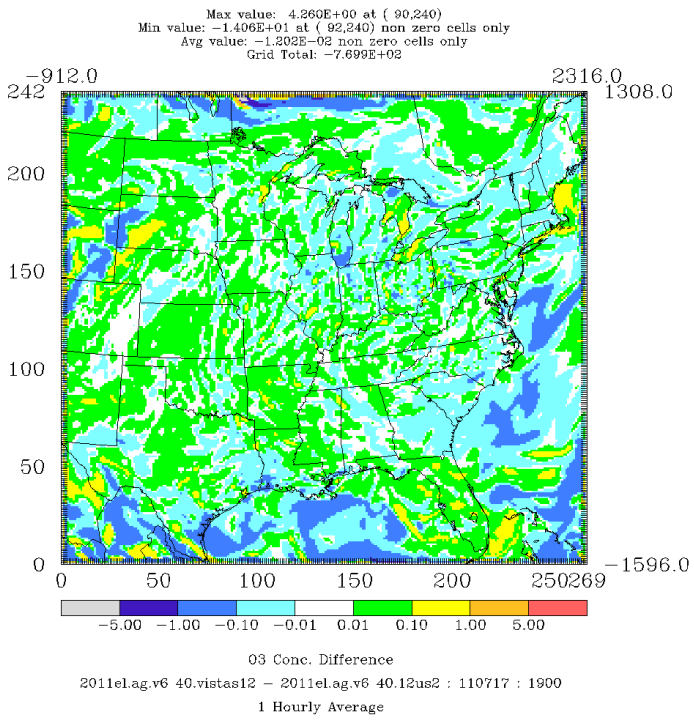
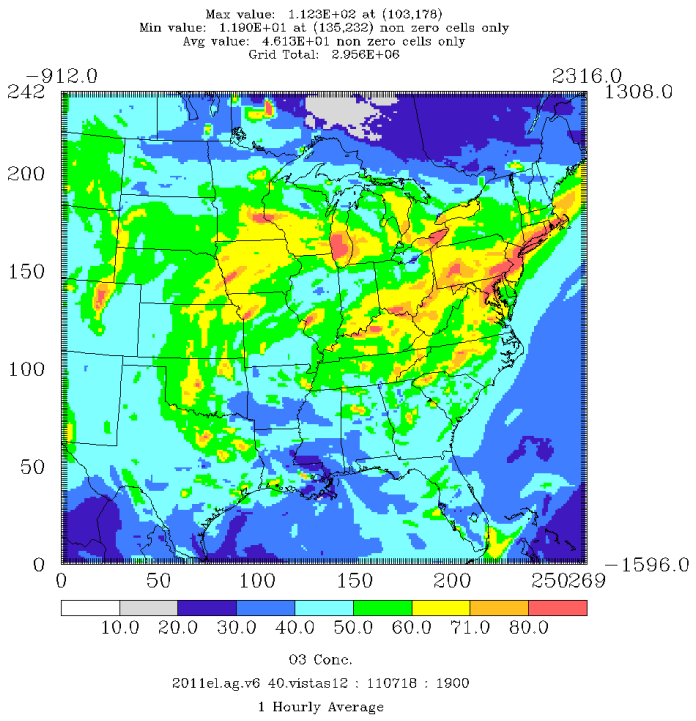


Figure 4-16: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 18 at 1900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

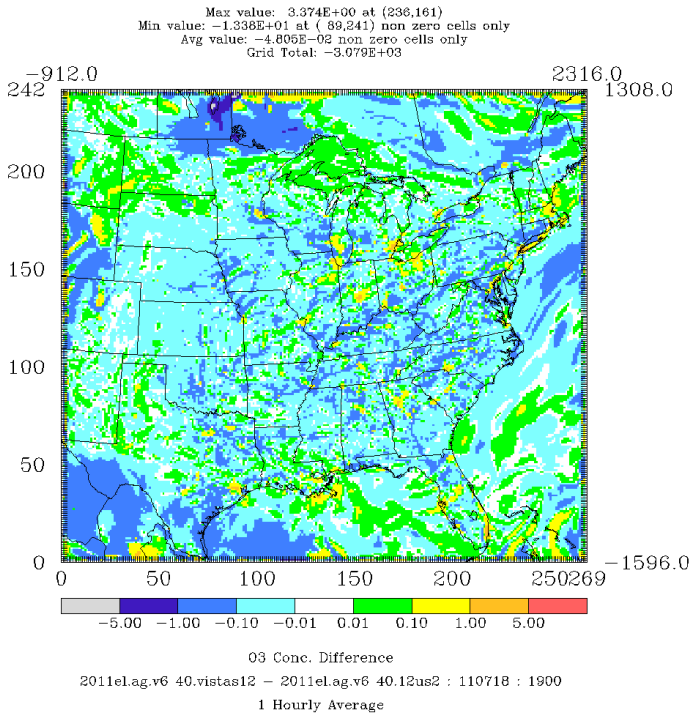
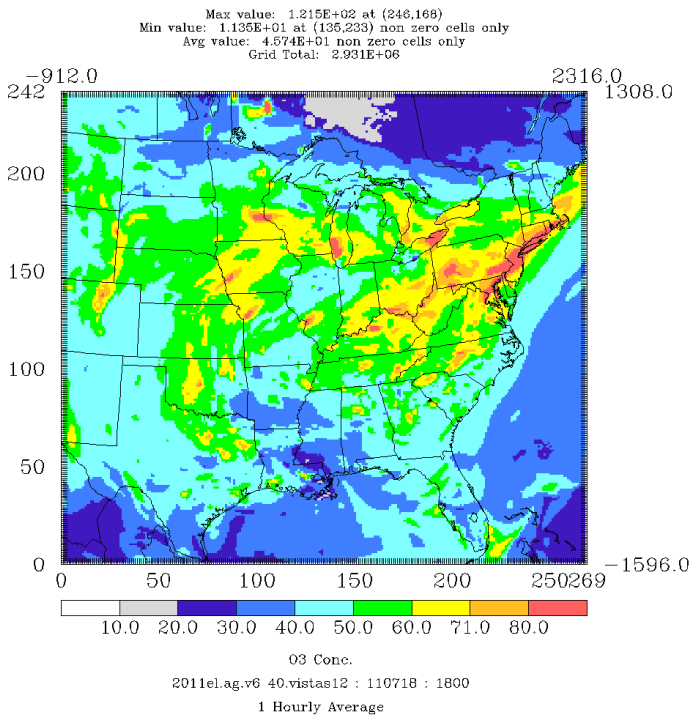


Figure 4-17: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 18 at 1800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

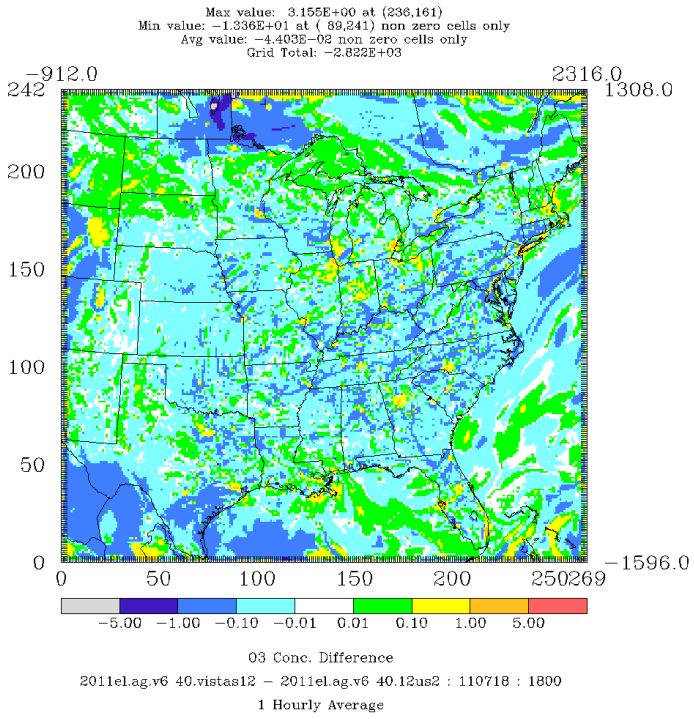
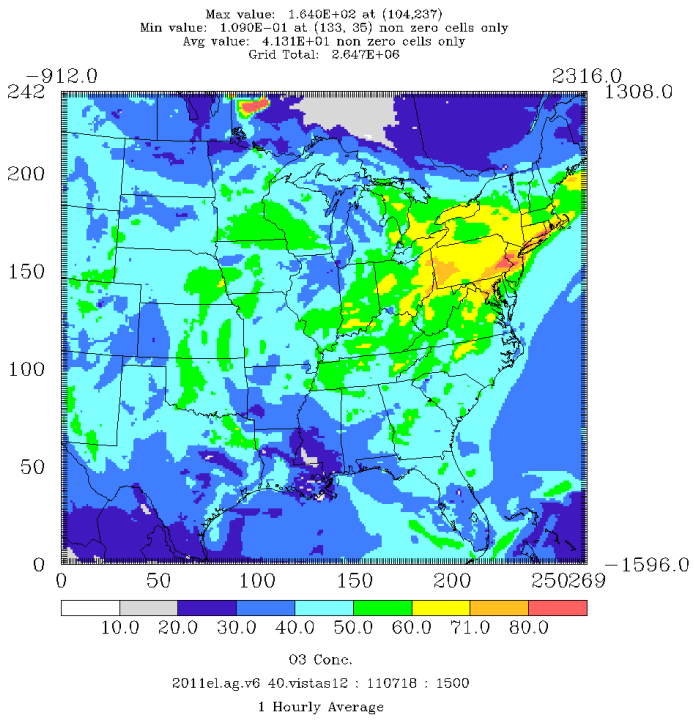


Figure 4-18: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 18 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

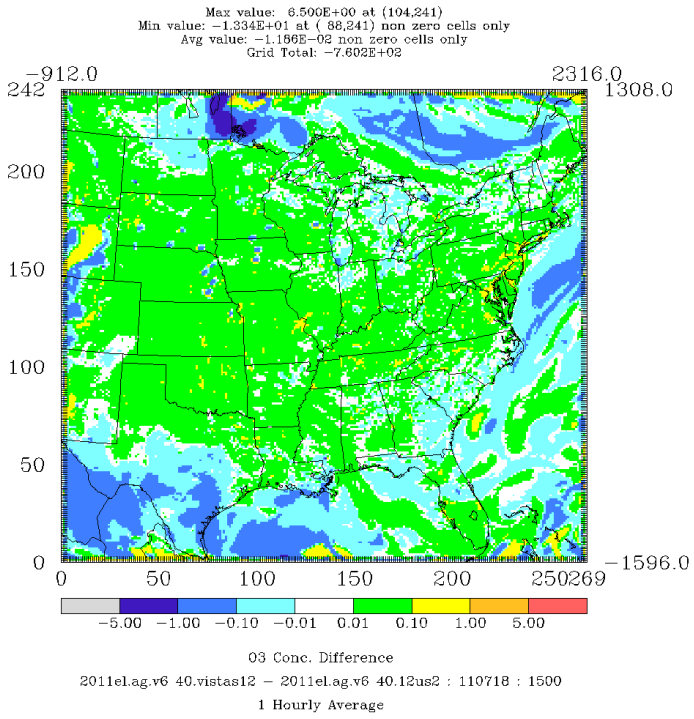
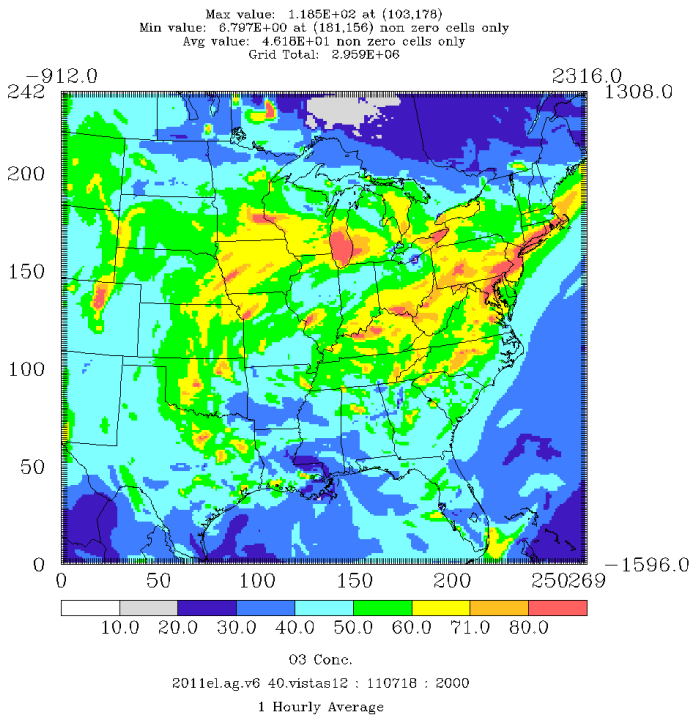


Figure 4-19: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 18 at 2000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

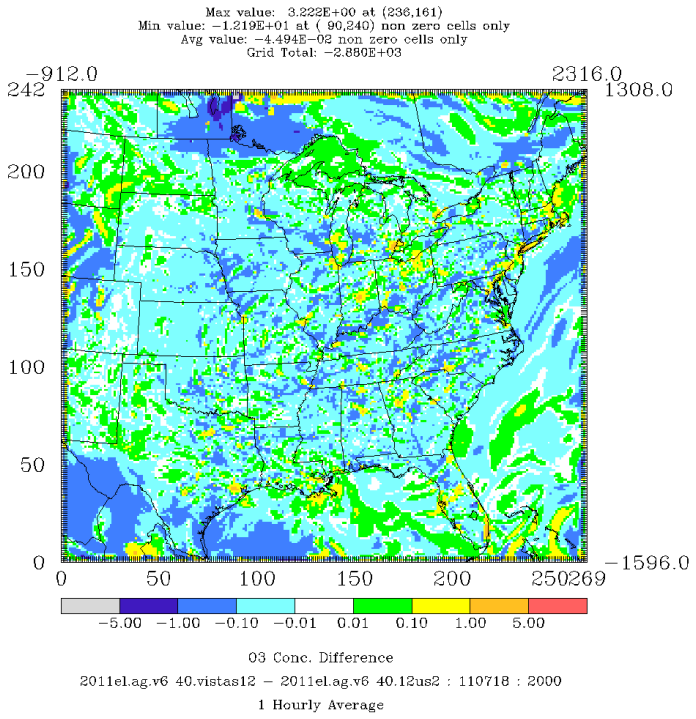


Figure 4-20: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference)

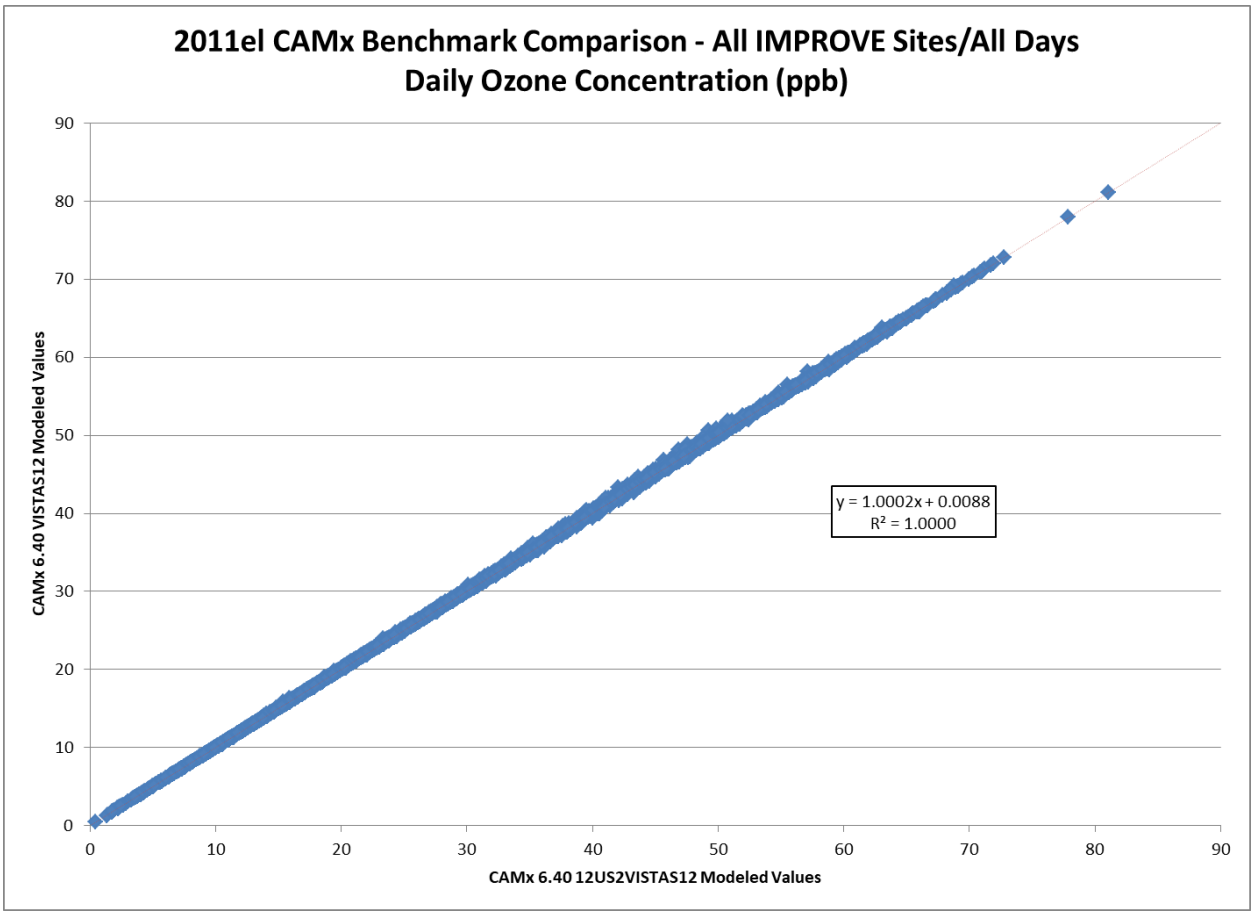


Figure 4-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine).

4.2 $PM_{2.5}$

$PM_{2.5}$ results for the top 10 positive and negative hours are presented in tabular format in Table 4-2. The maximum positive difference is 383.55 micrograms per cubic meter ($\mu g/m^3$) falling to 211.10 $\mu g/m^3$ for the 10th high. The maximum negative difference is -297.25 $\mu g/m^3$ falling to -174.08 $\mu g/m^3$ for the 10th high. The maximum positive percent difference from these days is 101.8% and negative percent difference of -33.4%.

As expected and consistent with our ozone findings in the previous section, the maximum impacts on the top 10 positive and negative hours are occurring very near the border. As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated from the cells outside the VISTAS12 domain. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous concentrations. Additionally, and likely more significant to concentration differences, the CAMx model does not include emissions from the boundary cells.

The top 10 positive difference hours are presented in Figures 4-22 through 4-31 and the top 10 negative impact hours are presented in Tables 4-32 through 4-41. The hours of the maximum differences are tending to occur in July 17-21. There were wildfires in Canada in the area of the maximum difference during this period. It is not surprising that the largest difference is occurring where noted large source emissions are input into the model near a boundary where the time averaging of the pollutants flowing into the cells are different. On the day of the maximum positive difference (July 21 at 0400) the maximum difference in $PM_{2.5}$ concentration was 383.55 $\mu g/m^3$ ppb. At this hour the difference in the sulfate, nitrate, and OM concentrations were 5.76 $\mu g/m^3$, 0.86 $\mu g/m^3$, 296.07 $\mu g/m^3$, respectively with the difference dominated by the differences in the OM estimates. The high local emissions dominated by OM as is expected from wildfire emissions.

Scatterplots of the daily average $PM_{2.5}$ concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-42. The 12US2 results are plotted on the x-axis

and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0002, an intercept of 0.0034 ppb and an R^2 of 1.0000.

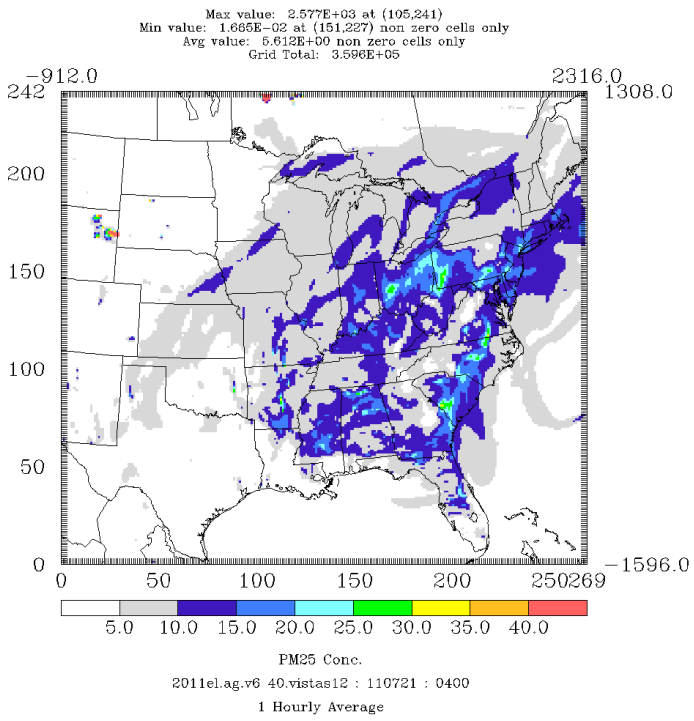
Examination of the difference animations often show differences along the boundary becoming lower as the plumes along the boundary move into the domain.

Table 4-2. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of $PM_{2.5}$ Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	7	21	4	951.35	567.80	383.55	67.6%	104	241
2011	7	20	14	1,662.72	1,356.15	306.56	22.6%	107	241
2011	7	20	15	841.28	561.77	279.51	49.8%	107	241
2011	7	20	11	2,742.54	2,473.65	268.90	10.9%	107	241
2011	7	21	3	3,178.52	2,915.78	262.74	9.0%	104	241
2011	7	21	1	2,371.59	2,112.20	259.39	12.3%	104	241
2011	7	20	12	3,026.16	2,789.42	236.74	8.5%	107	241
2011	7	20	23	450.23	223.09	227.15	101.8%	102	241
2011	7	21	0	734.03	509.91	224.12	44.0%	103	241
2011	7	20	9	6,965.70	6,754.60	211.10	3.1%	105	241
Maximum Negative									
2011	7	20	15	4,860.10	5,157.34	-297.25	-5.8%	105	241
2011	7	20	16	4,005.14	4,267.91	-262.78	-6.2%	105	241
2011	7	20	14	5,172.55	5,434.63	-262.08	-4.8%	106	241
2011	7	17	11	508.75	761.84	-253.09	-33.2%	89	241
2011	7	20	13	6,150.56	6,393.80	-243.24	-3.8%	106	241
2011	7	17	12	496.65	725.14	-228.48	-31.5%	89	241
2011	7	20	12	7,721.58	7,946.51	-224.93	-2.8%	106	241
2011	7	19	10	815.91	1,032.49	-216.58	-21.0%	104	241
2011	7	17	10	429.25	644.93	-215.68	-33.4%	89	241
2011	7	19	9	828.90	1,002.97	-174.08	-17.4%	103	241

Maximum Positive Difference: July 21 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

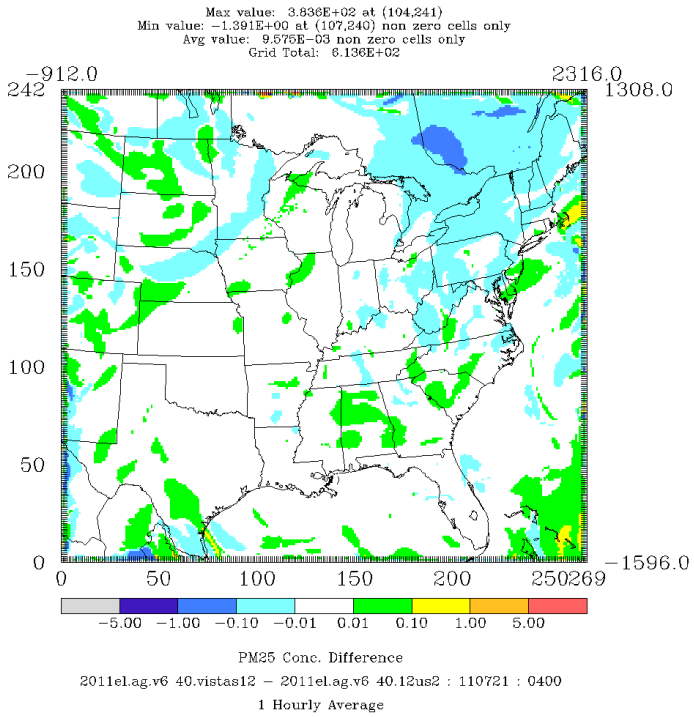
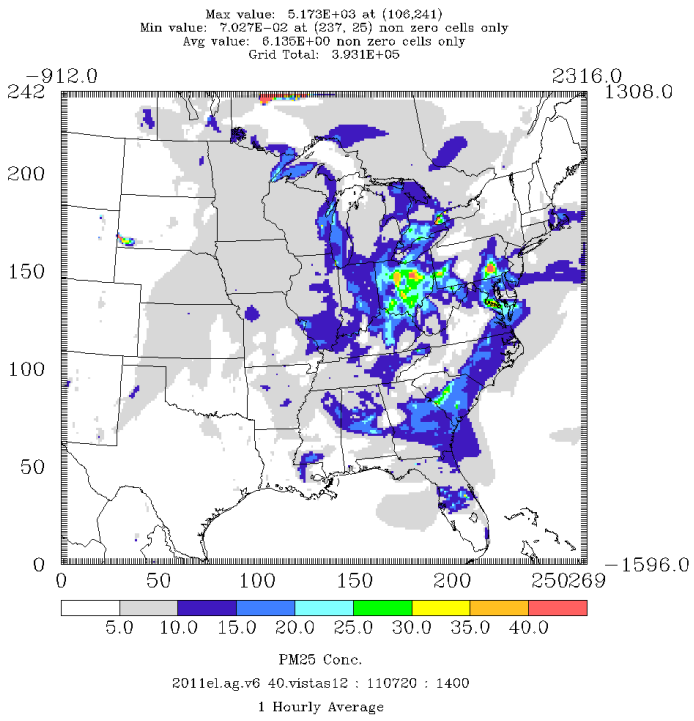


Figure 4-22: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

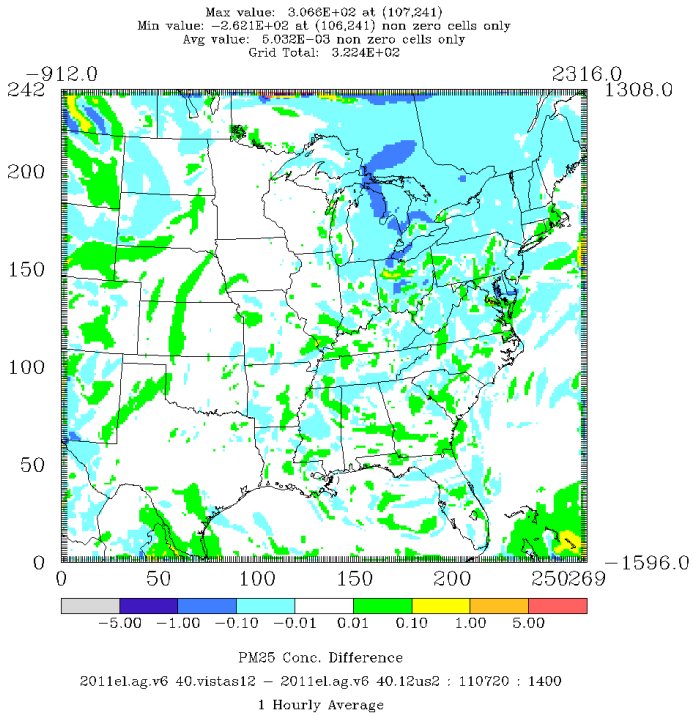
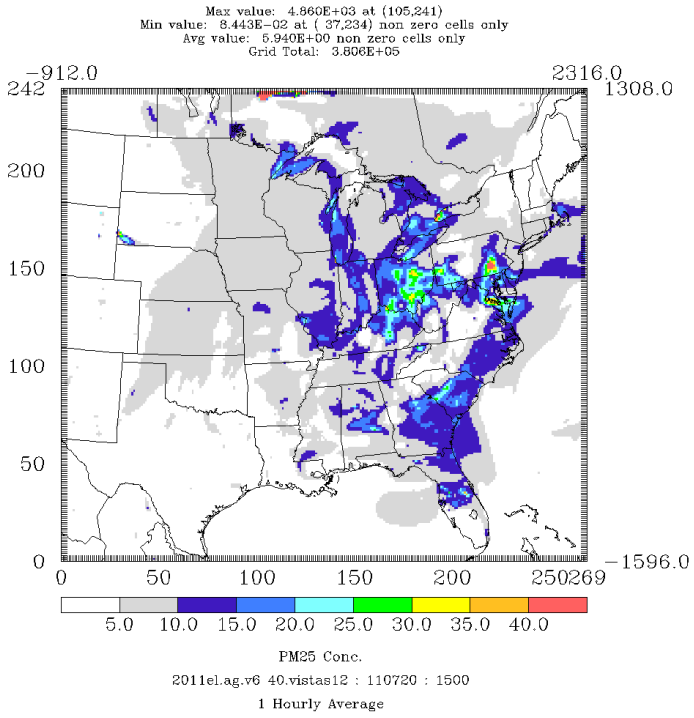


Figure 4-23: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

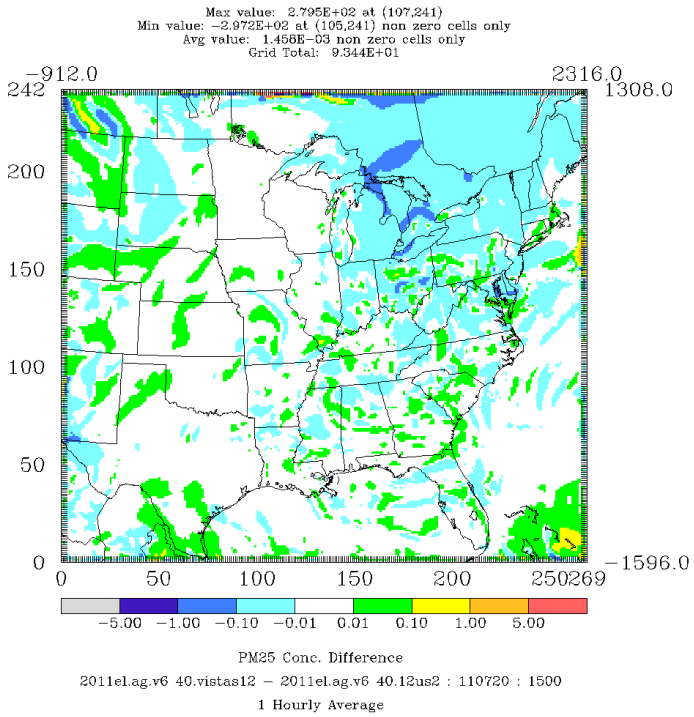
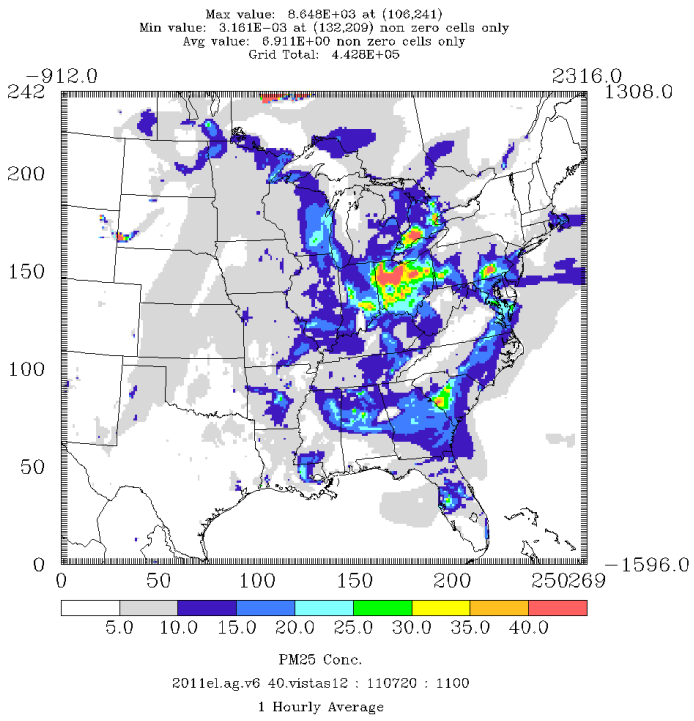


Figure 4-24: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: July 20 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

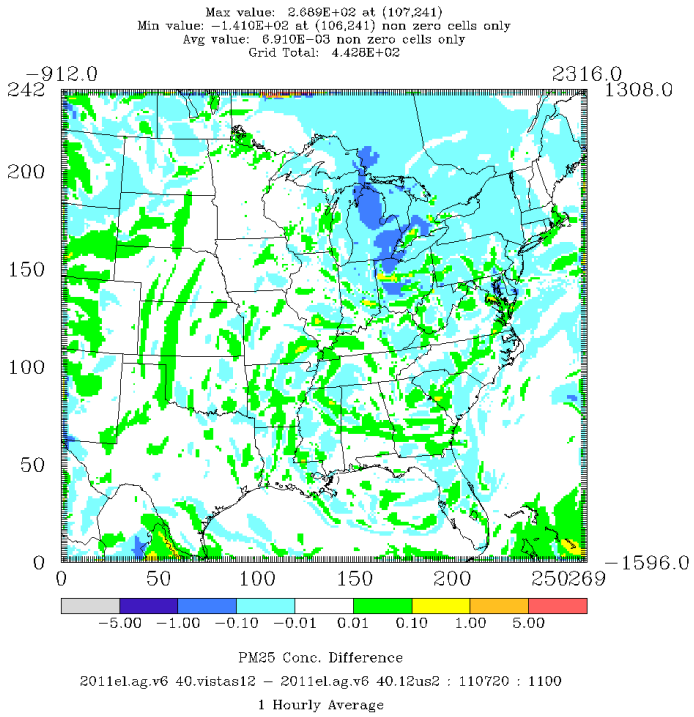
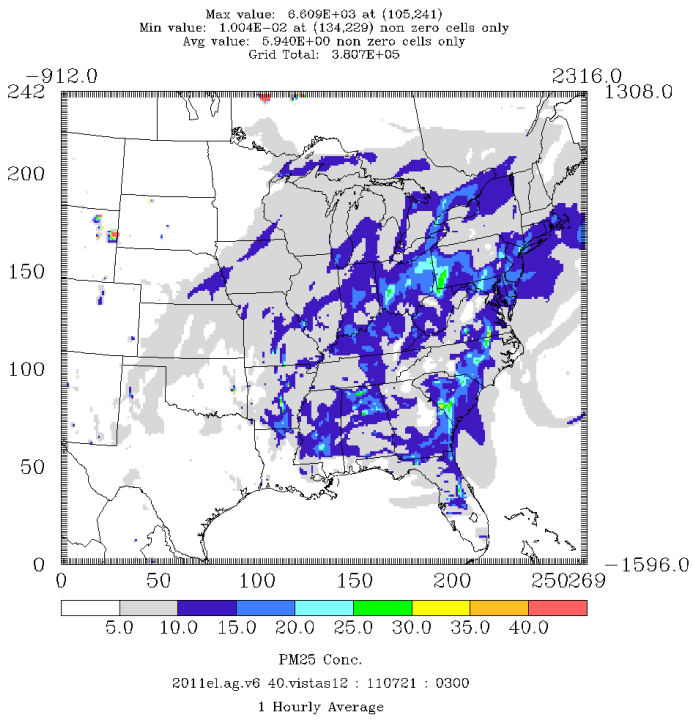


Figure 4-25: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: July 21 at 300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

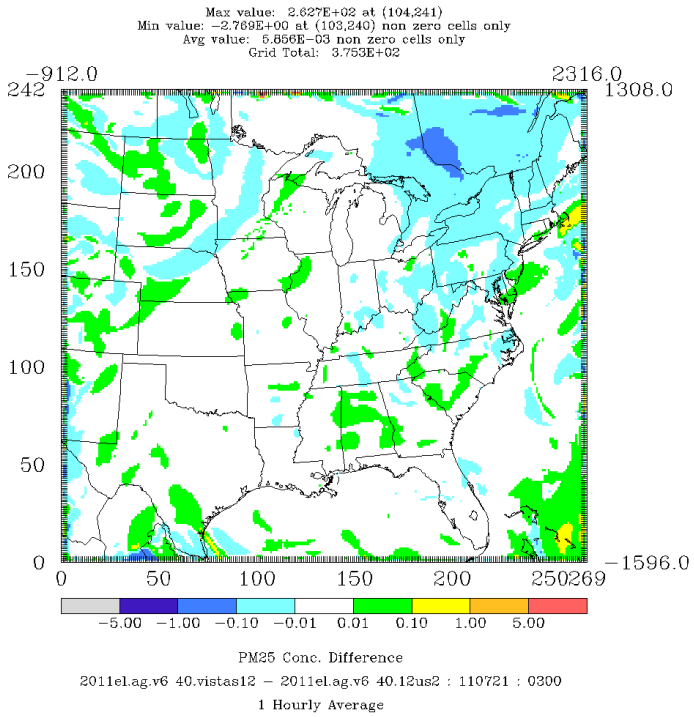
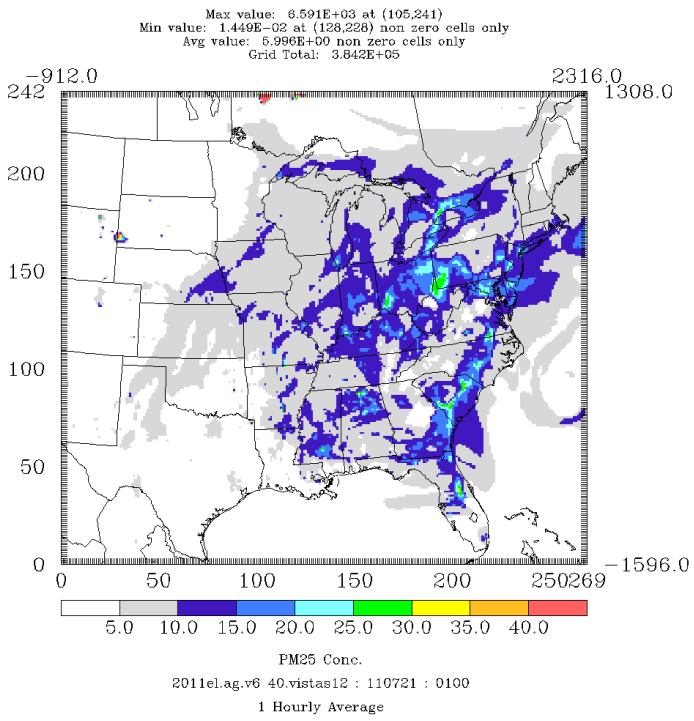


Figure 4-26: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 21 at 100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

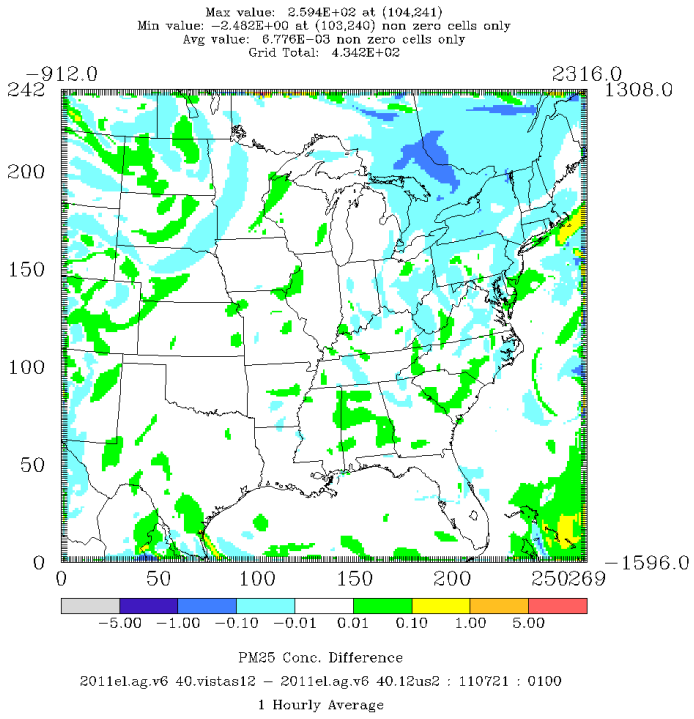
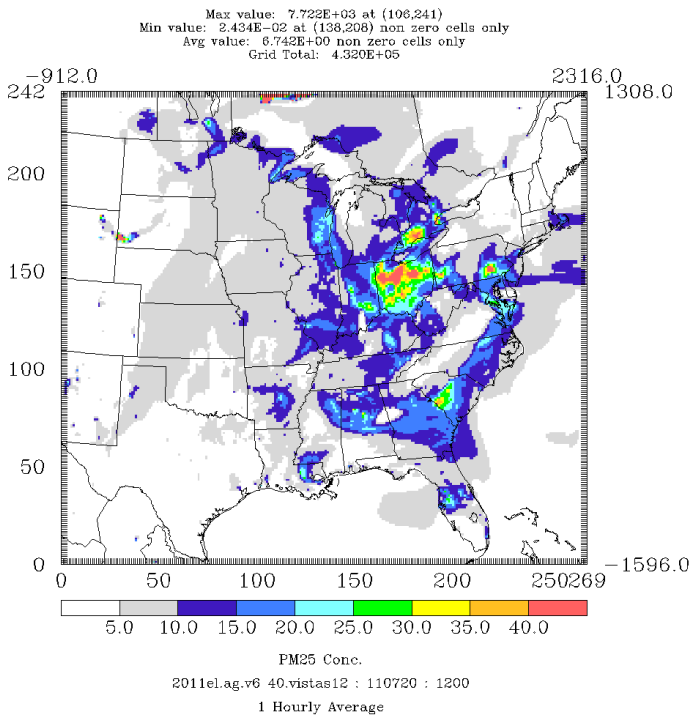


Figure 4-27: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

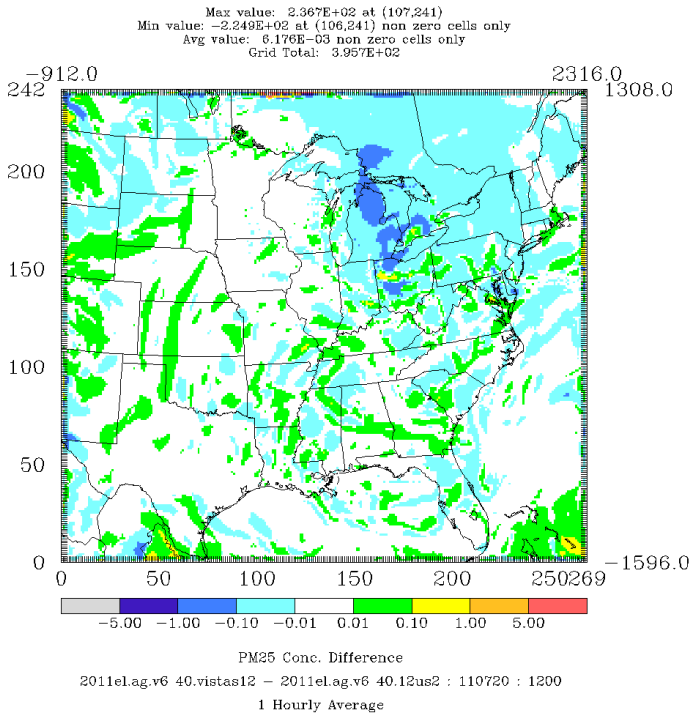
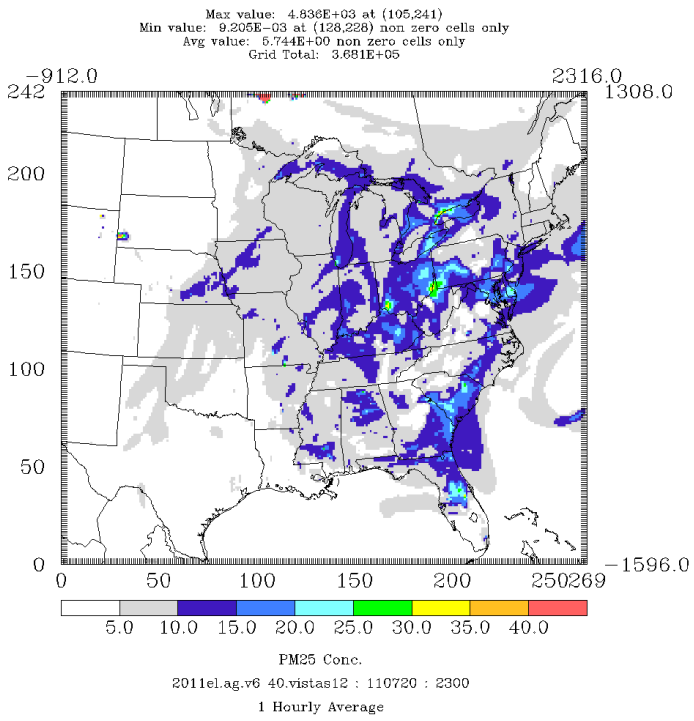


Figure 4-28: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: July 20 at 2300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

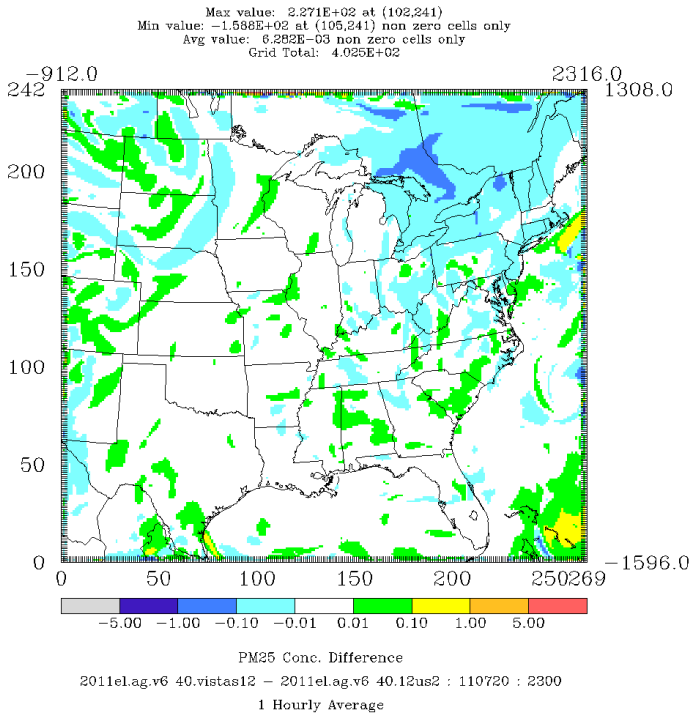
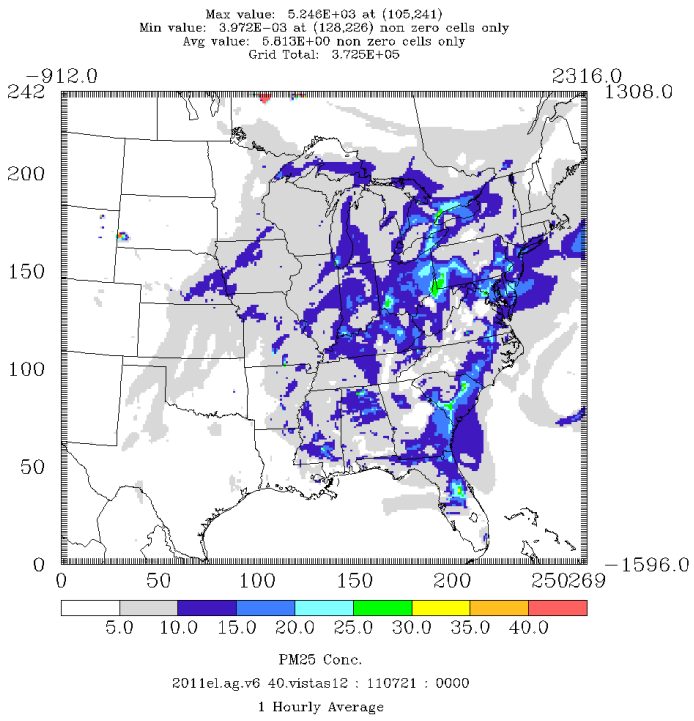


Figure 4-29: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: July 21 at 0000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

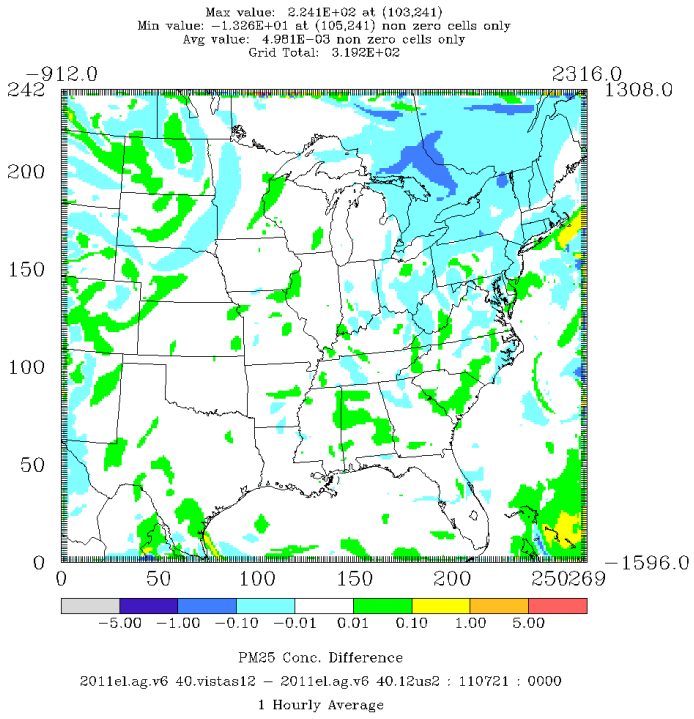
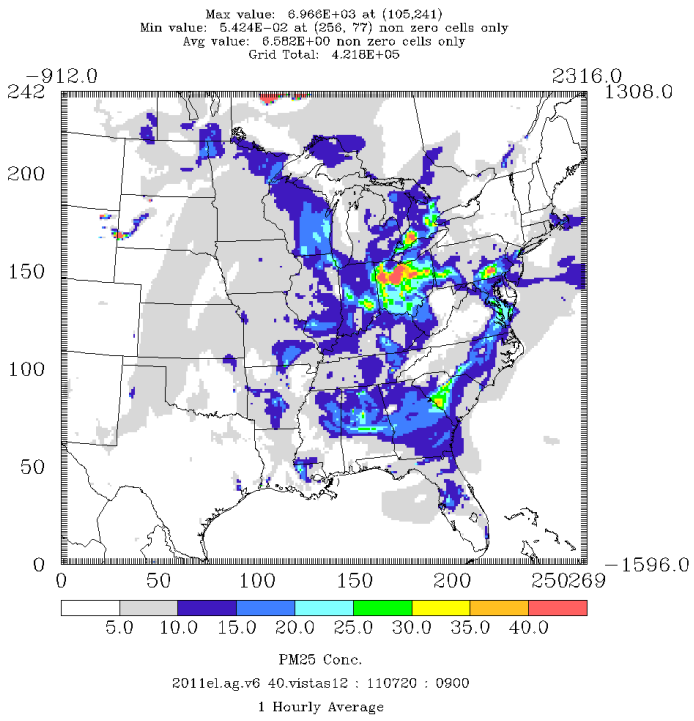


Figure 4-30: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

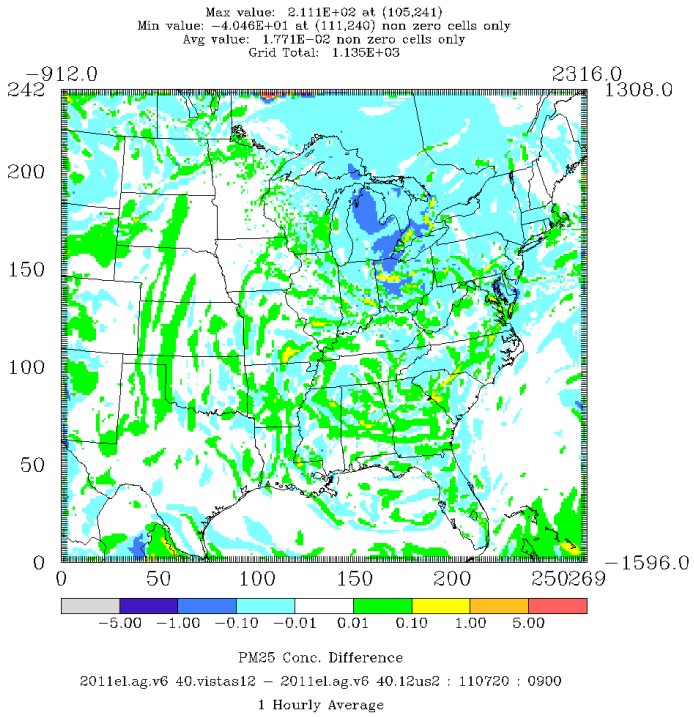
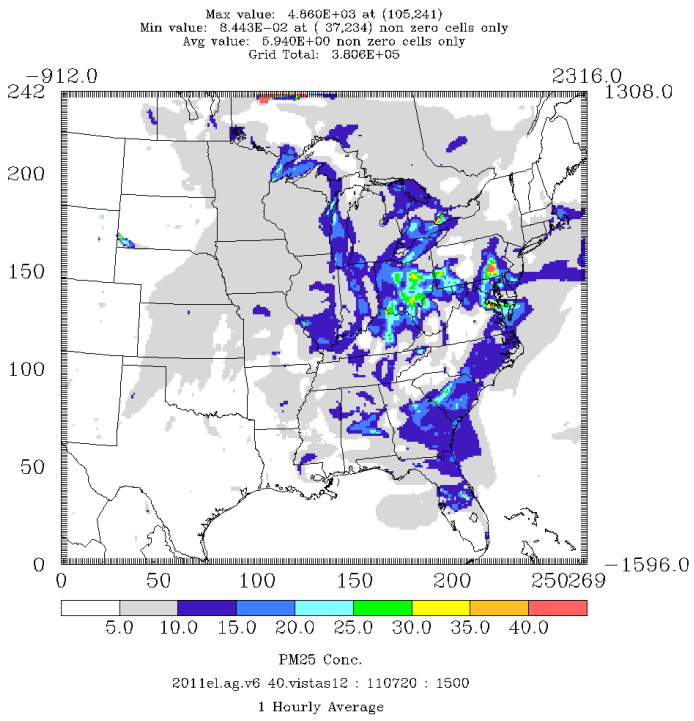


Figure 4-31: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

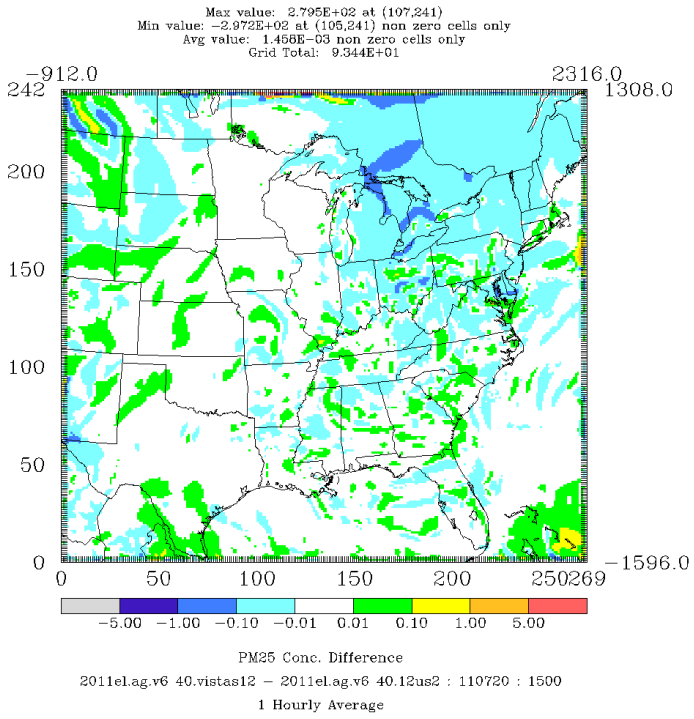
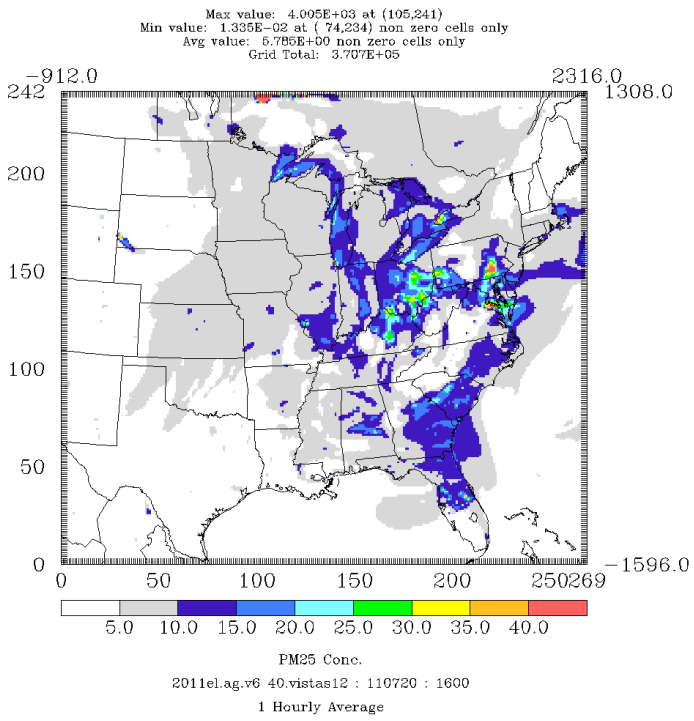


Figure 4-32: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

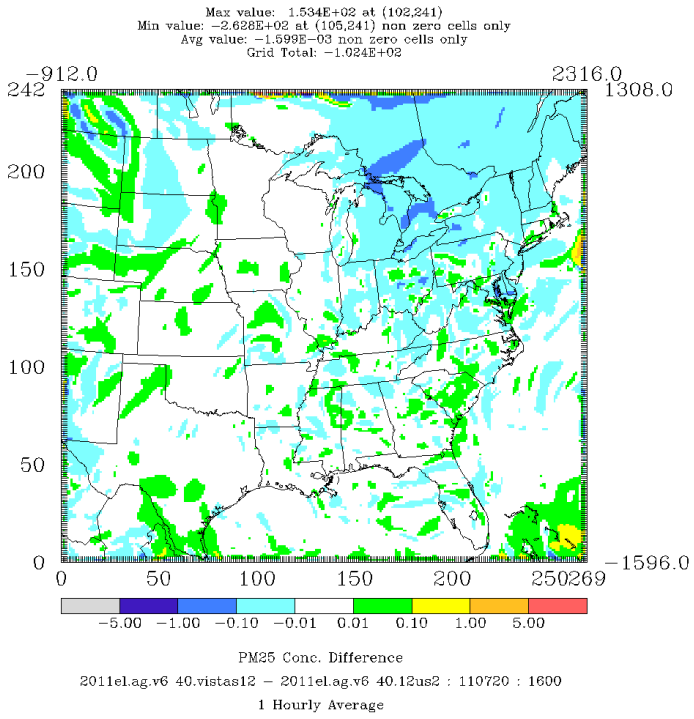
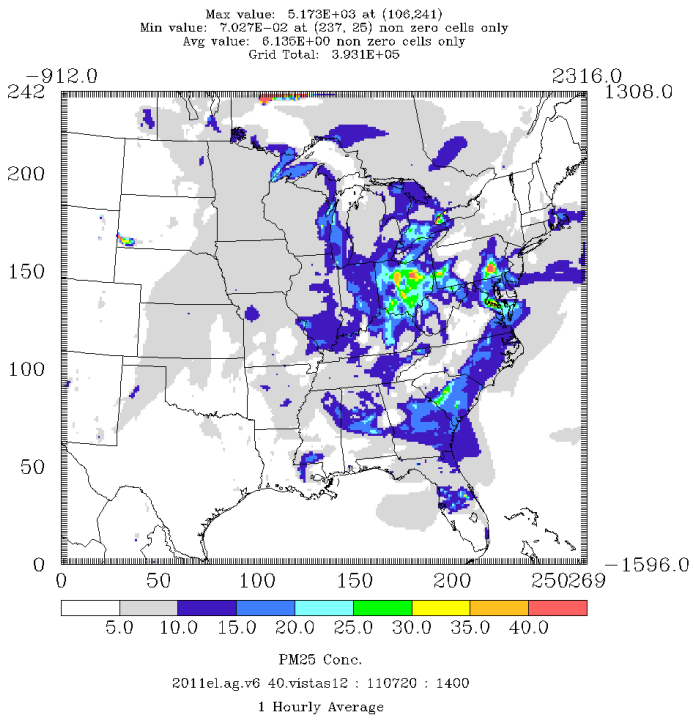


Figure 4-33: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

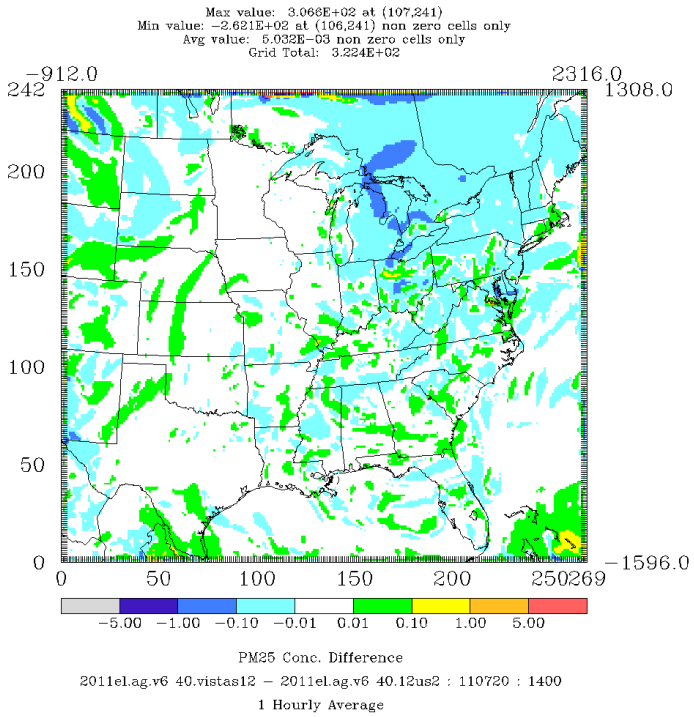
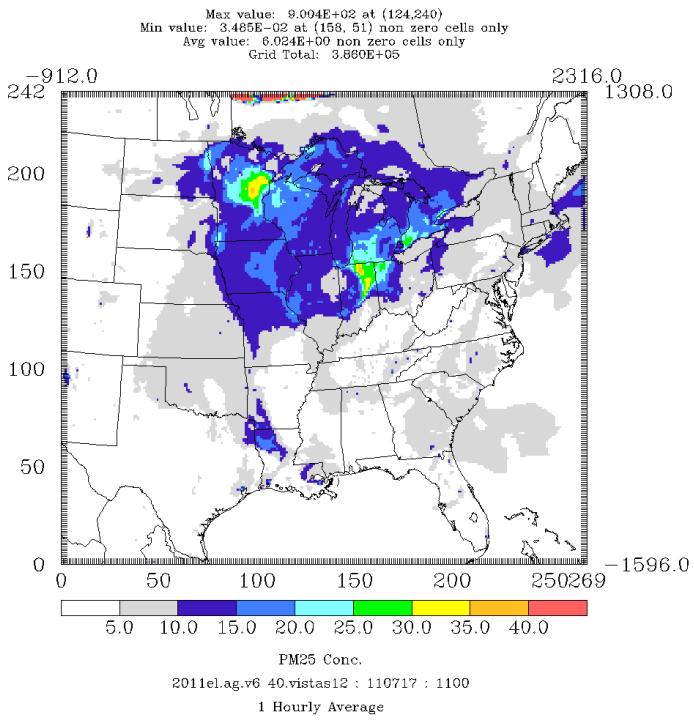


Figure 4-34: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 17 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

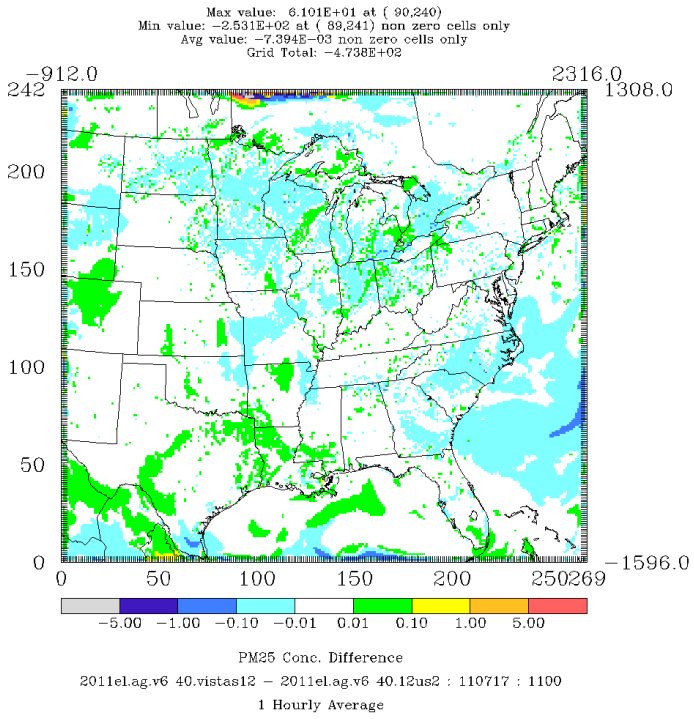
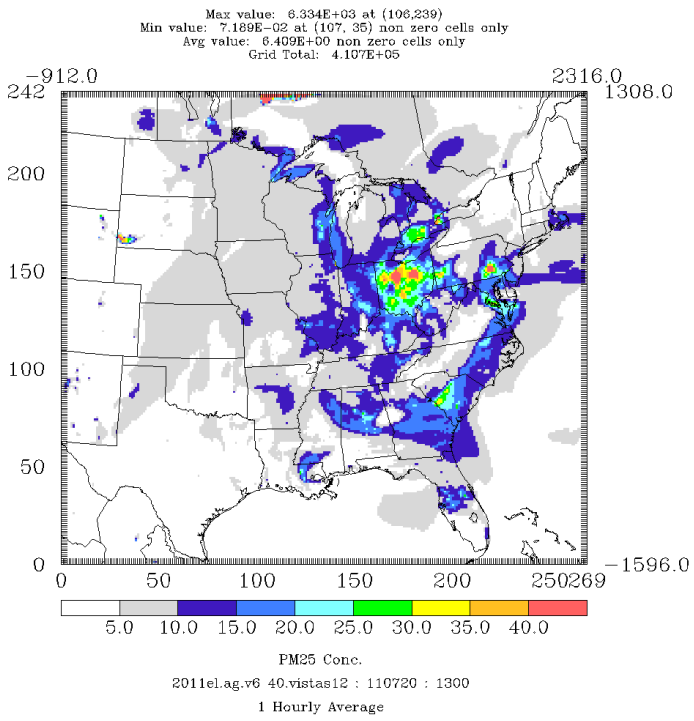


Figure 4-35: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 20 at 1300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

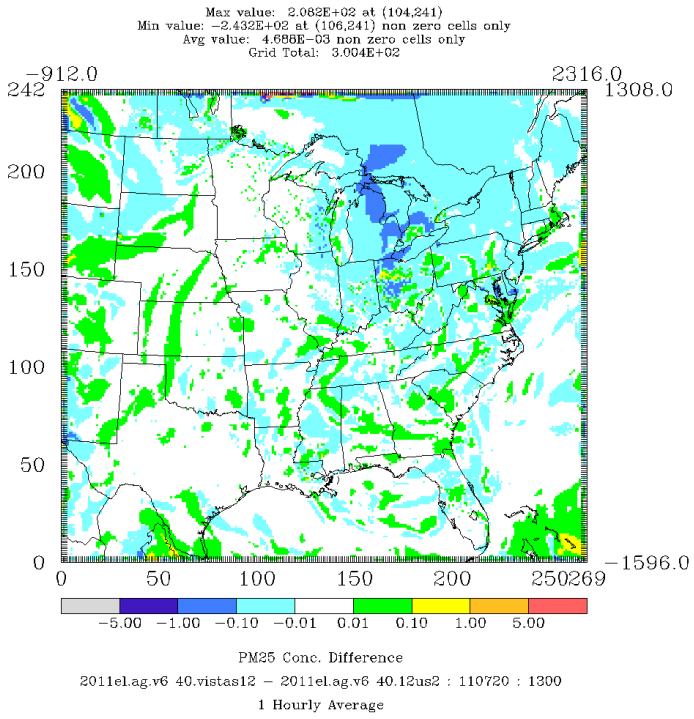
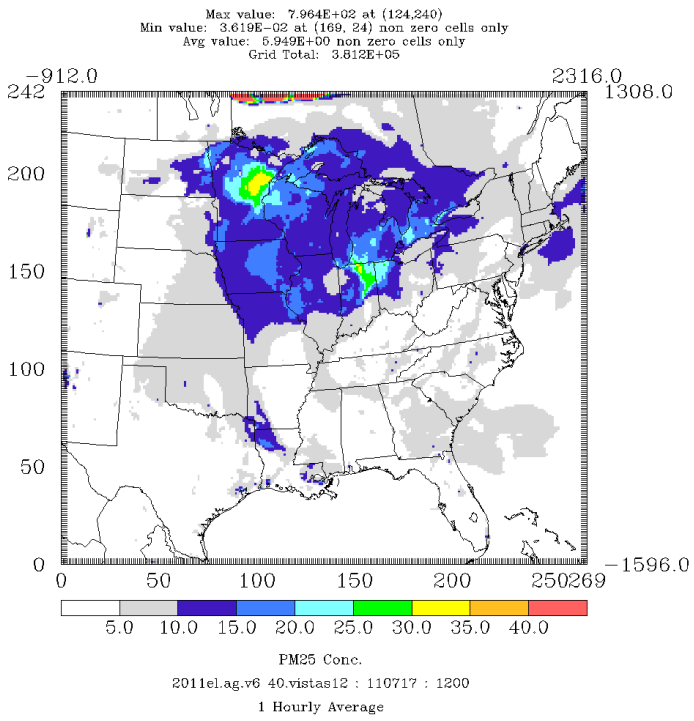


Figure 4-36: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 17 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

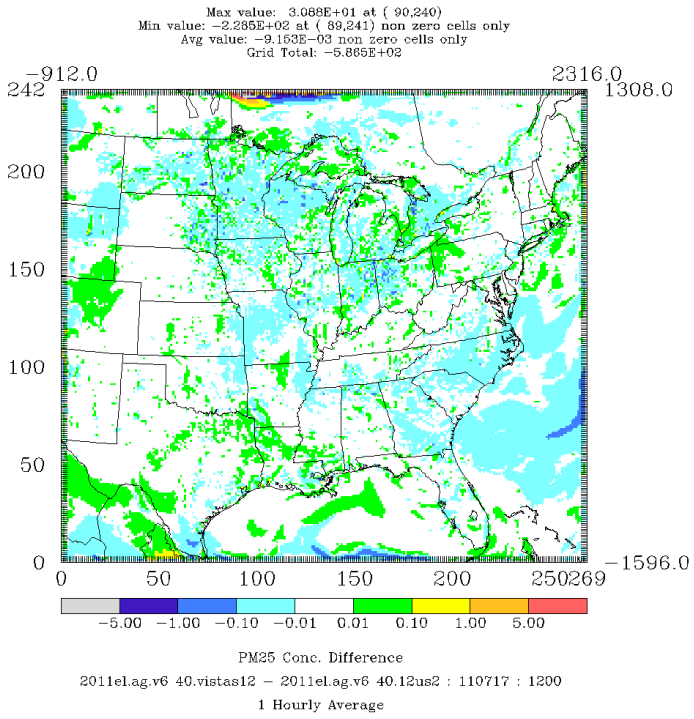
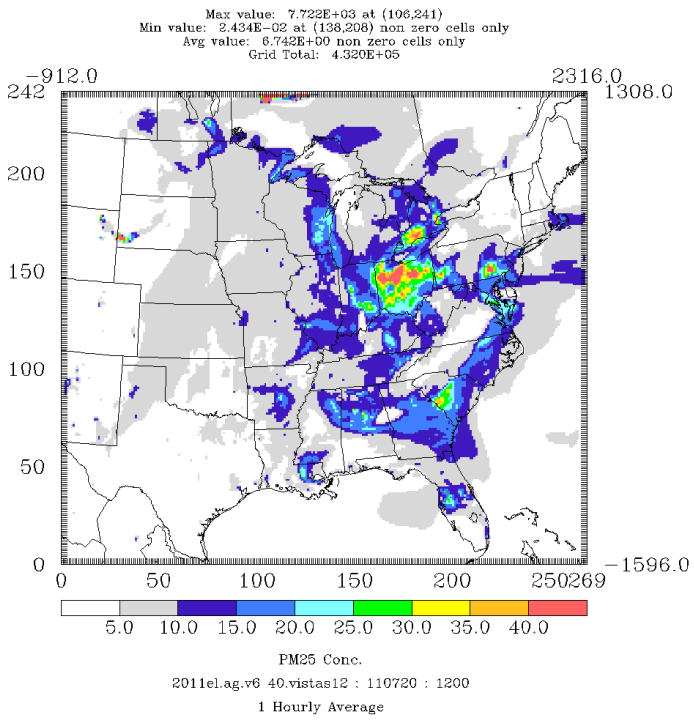


Figure 4-37: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

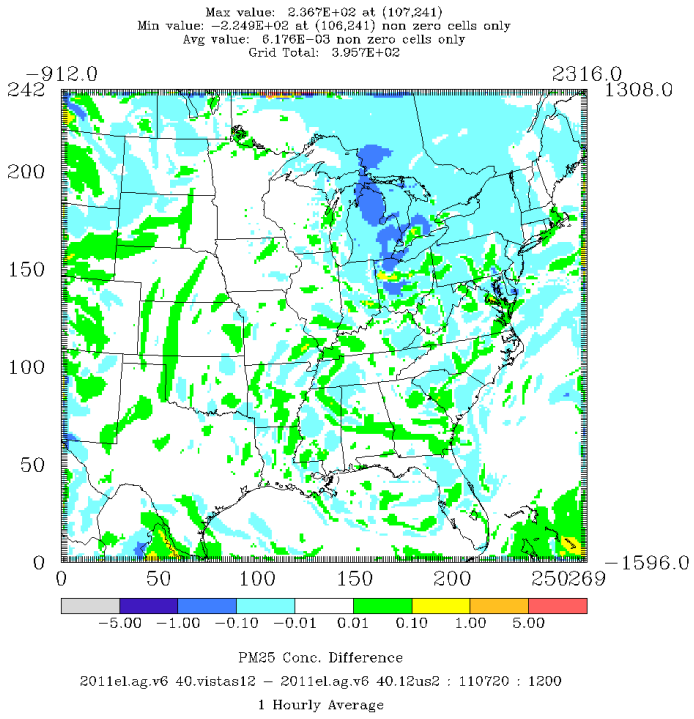
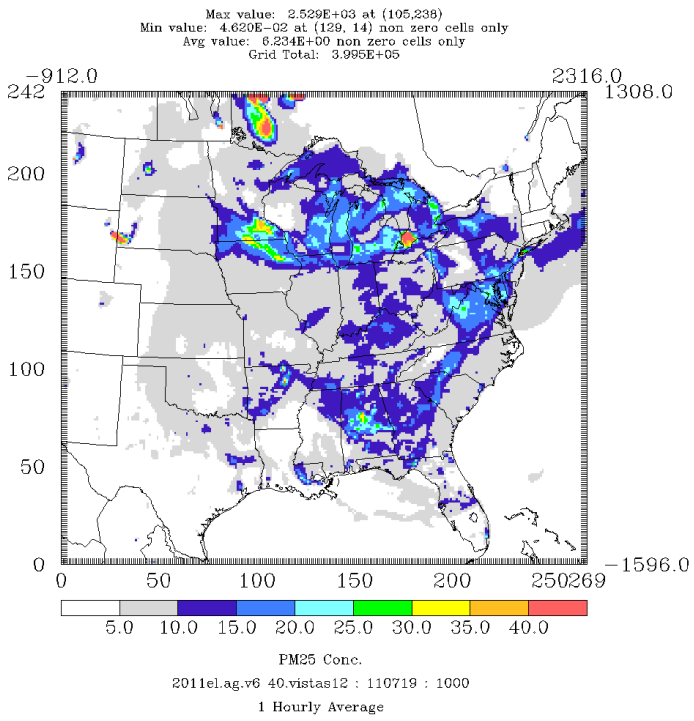


Figure 4-38: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 19 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

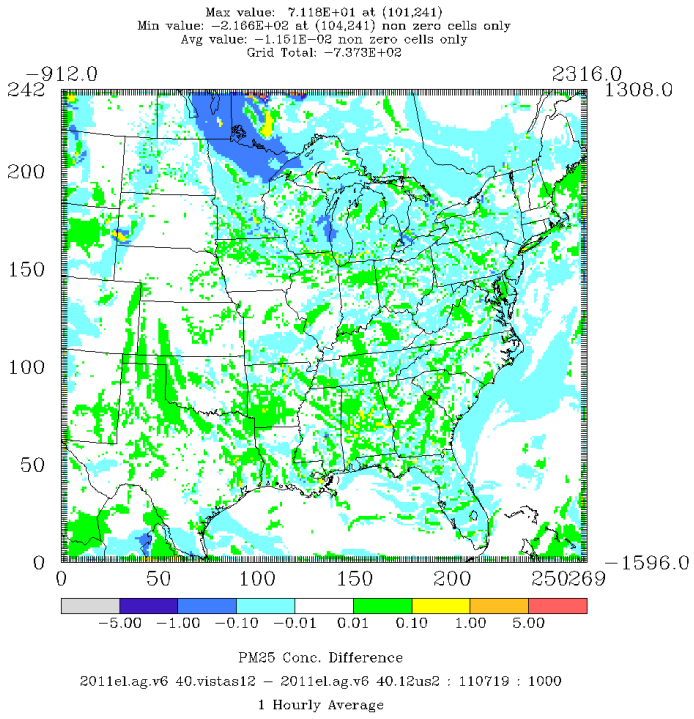
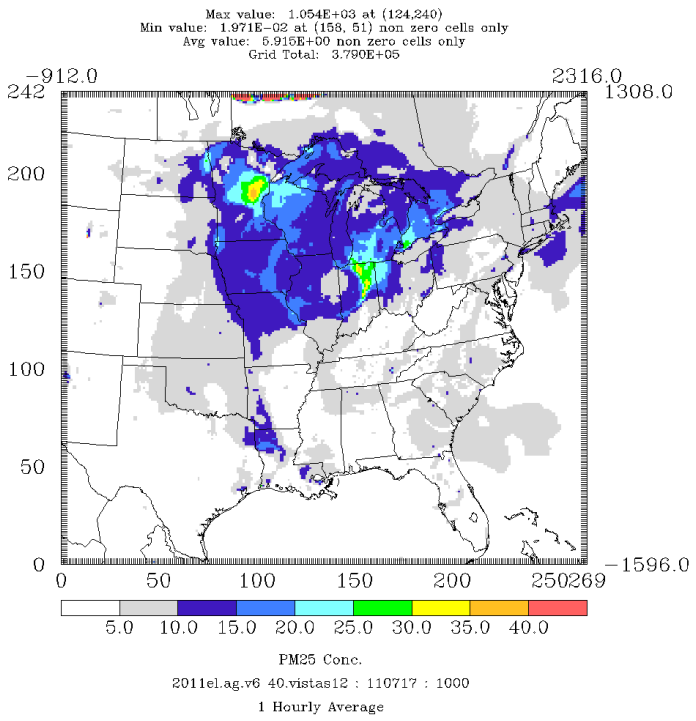


Figure 4-39: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 17 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

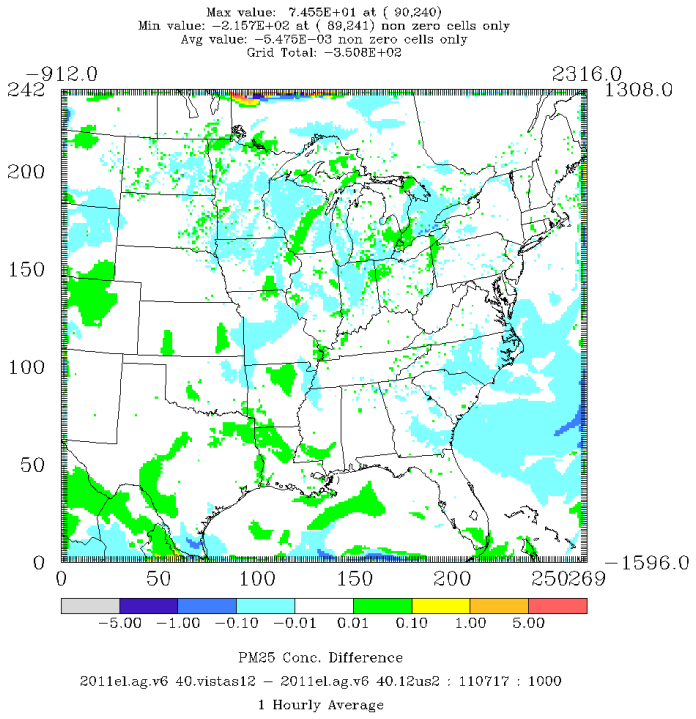
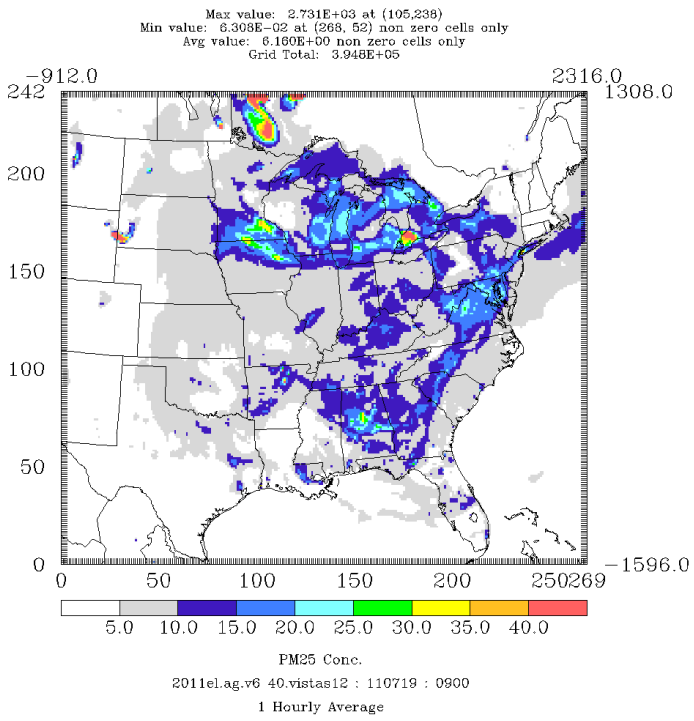


Figure 4-40: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 19 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

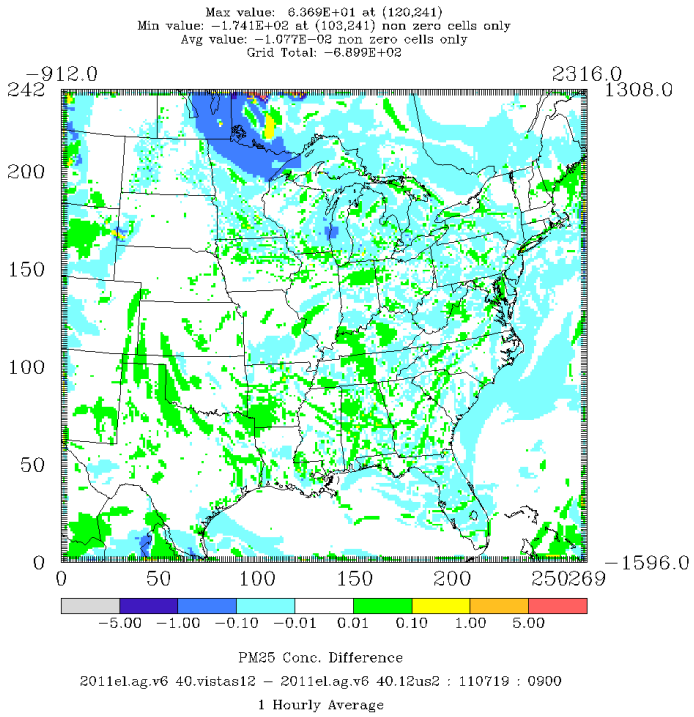


Figure 4-41: Comparison of $PM_{2.5}$ Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference)

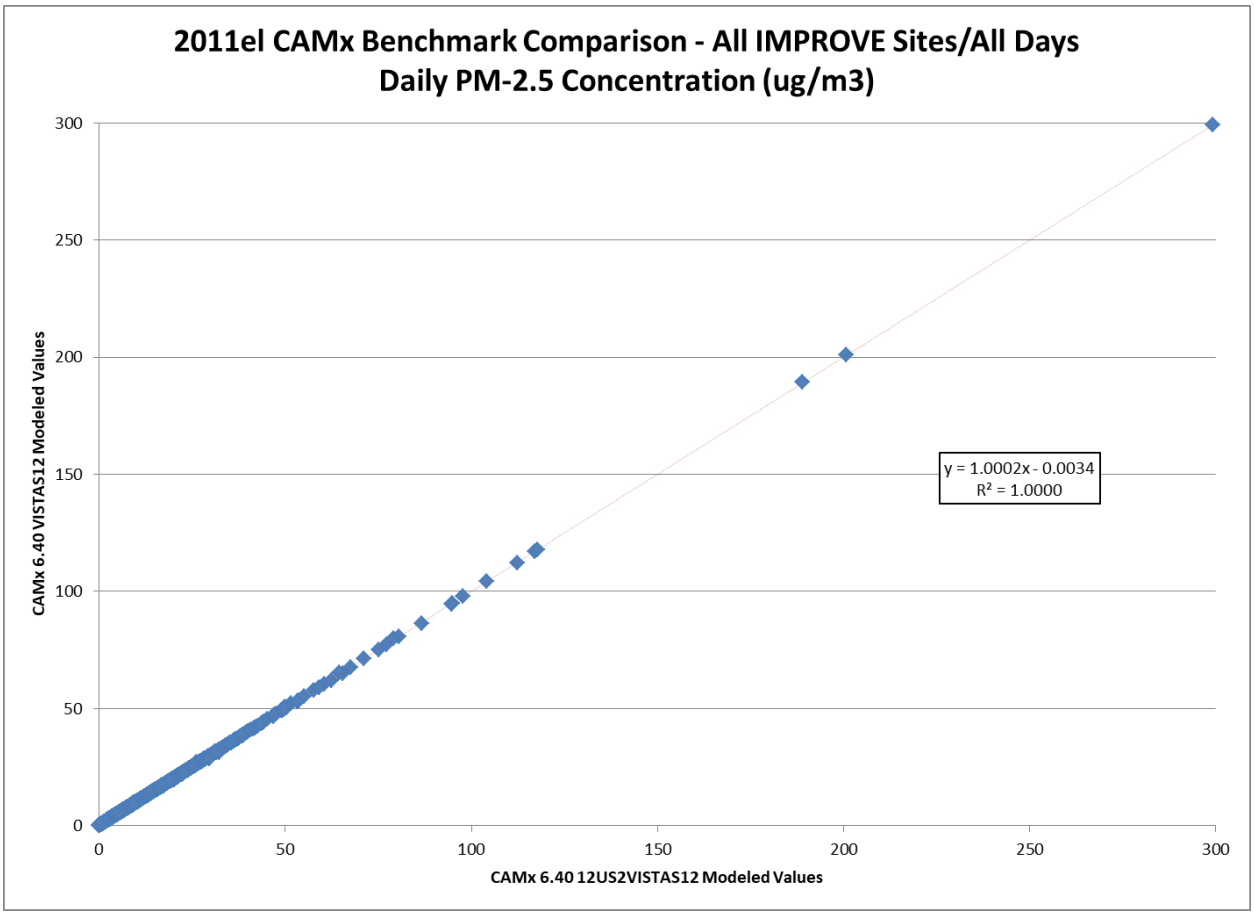


Figure 4-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations (µg/m3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine).

4.3 Sulfate

Sulfate results for the top 10 positive and negative hours are presented in tabular format in Table 4-3. The maximum positive difference is 5.76 μg/m^3 falling to 3.39 μg/m^3 for the 10th high. The maximum negative difference is -4.58 μg/m^3 falling to -2.34 μg/m^3 for the 10th high. The maximum positive percent difference on these days is 89.3% and negative percent difference of -32.6%.

As expected, the maximum impacts on the top 10 positive and negative hours are occurring very near the border. As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated from the cells outside the VISTAS12 domain. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous concentrations. The top 10 positive difference hours are presented in Figures 4-43 through 4-52 and the top 10 negative difference hours are presented in Tables 4-53 through 4-62. The peak differences are occurring between July 17 and July 20. The area of the peak impact is very near the northern border, north of Minnesota.

Scatterplots of the daily average sulfate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-63. The 12US2 results are plotted on the x-axis and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0006, an intercept of 0.0002 ppb and an R^2 of 1.0000.

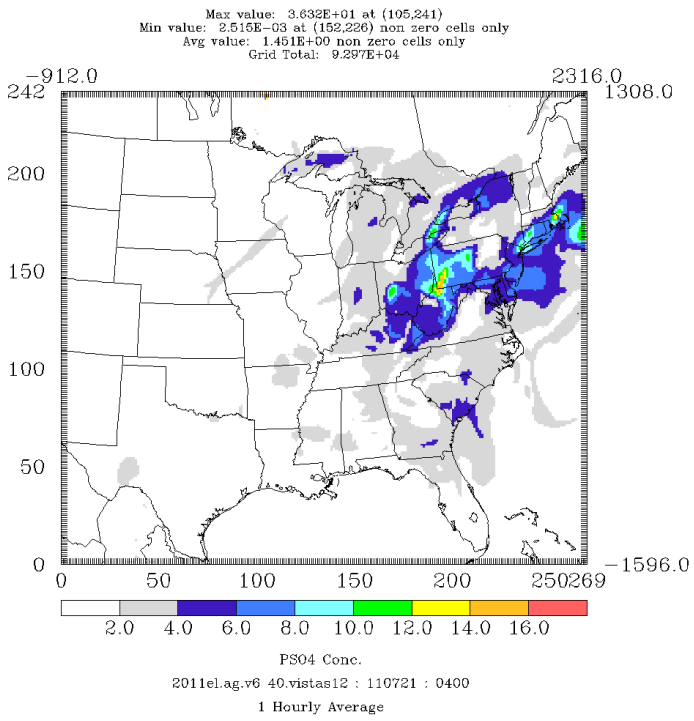
Examination of the difference animations often show differences along the boundary becoming lower as the plumes along the boundary move into the domain.

Table 4-3. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of Sulfate Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	7	21	4	13.65	7.89	5.76	73.0%	104	241
2011	7	20	14	25.76	20.98	4.77	22.7%	107	241
2011	7	21	3	44.79	40.52	4.28	10.6%	104	241
2011	7	20	15	13.63	9.51	4.13	43.4%	107	241
2011	7	21	1	31.59	27.59	4.01	14.5%	104	241
2011	7	20	12	46.13	42.24	3.88	9.2%	107	241
2011	7	20	11	40.06	36.21	3.84	10.6%	107	241
2011	7	21	0	10.36	6.79	3.57	52.6%	103	241
2011	7	20	23	7.40	3.91	3.49	89.3%	102	241
2011	7	20	22	8.48	5.09	3.39	66.5%	102	241
Maximum Negative									
2011	7	20	14	73.77	78.34	-4.58	-5.8%	106	241
2011	7	20	15	67.17	71.68	-4.51	-6.3%	105	241
2011	7	20	13	88.93	93.17	-4.23	-4.5%	106	241
2011	7	20	16	55.19	59.22	-4.04	-6.8%	105	241
2011	7	20	12	112.55	116.55	-4.01	-3.4%	106	241
2011	7	17	11	6.89	10.22	-3.33	-32.6%	89	241
2011	7	17	12	6.88	9.91	-3.04	-30.6%	89	241
2011	7	19	10	11.25	14.18	-2.93	-20.6%	104	241
2011	7	17	10	5.81	8.60	-2.79	-32.4%	89	241
2011	7	19	9	11.52	13.86	-2.34	-16.9%	103	241

Maximum Positive Difference: July 21 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

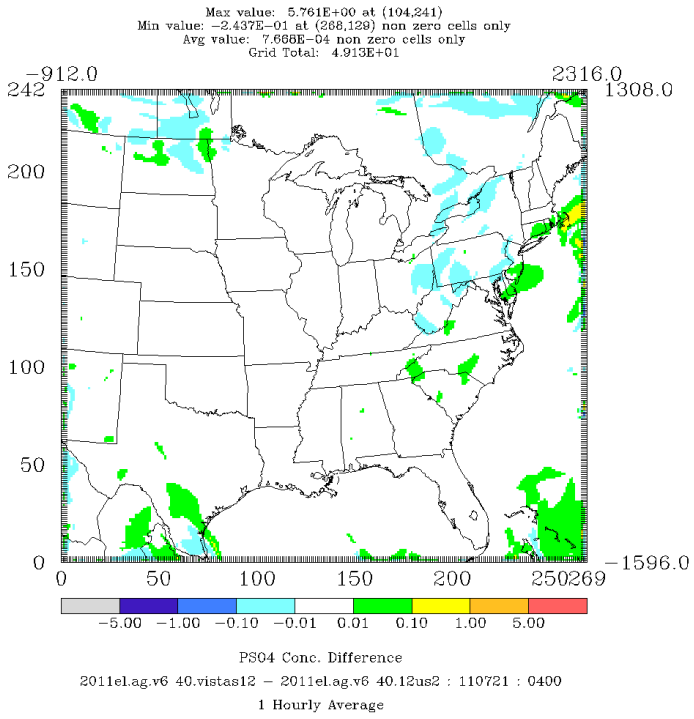
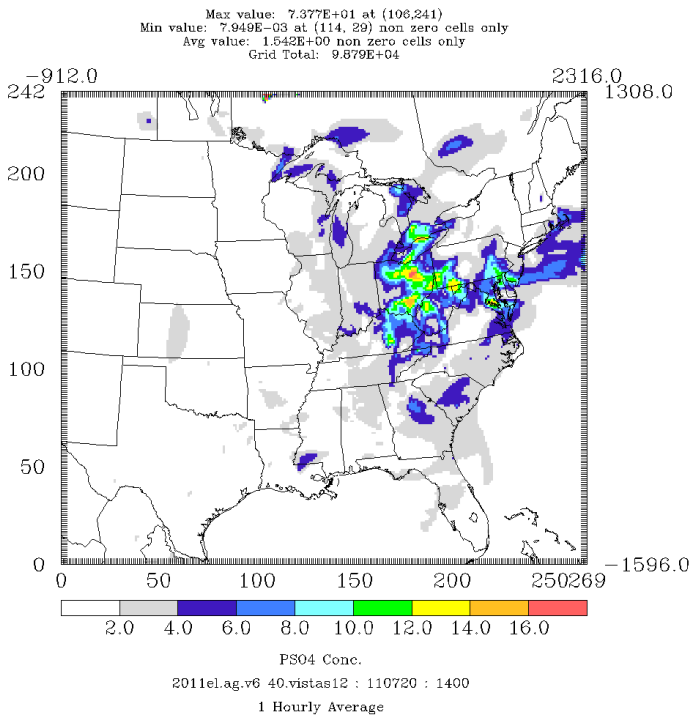


Figure 4-43: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

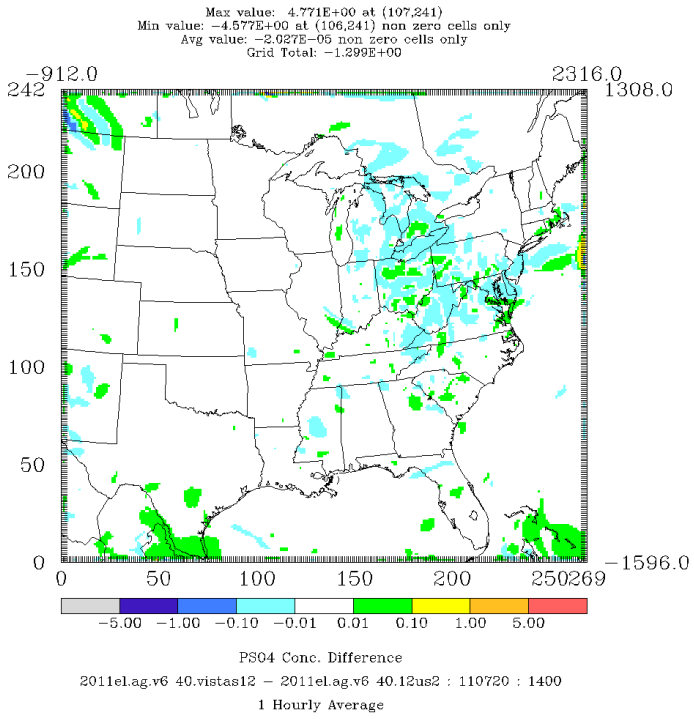
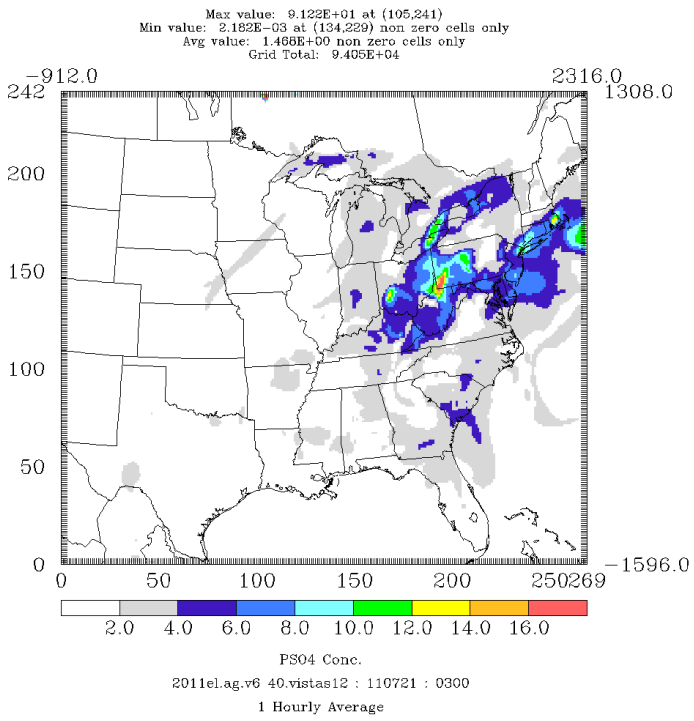


Figure 4-44: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: July 21 at 300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

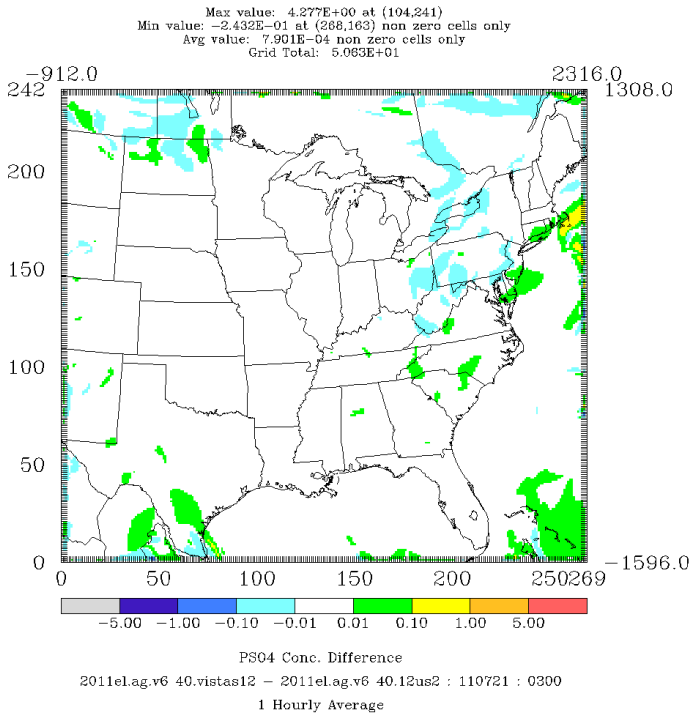
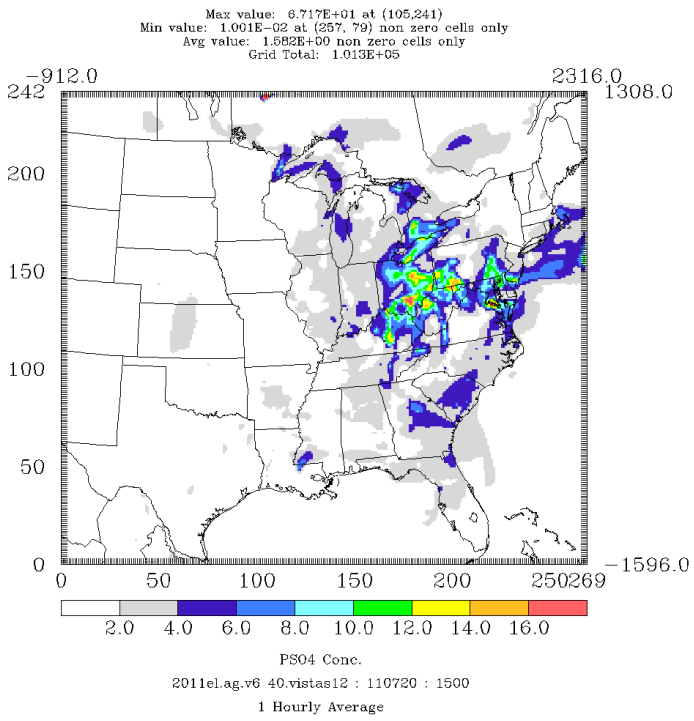


Figure 4-45: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

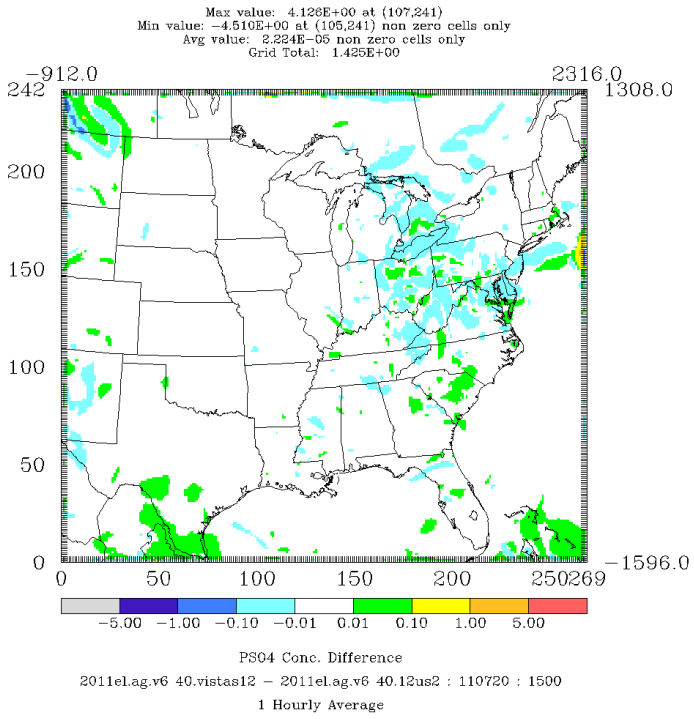
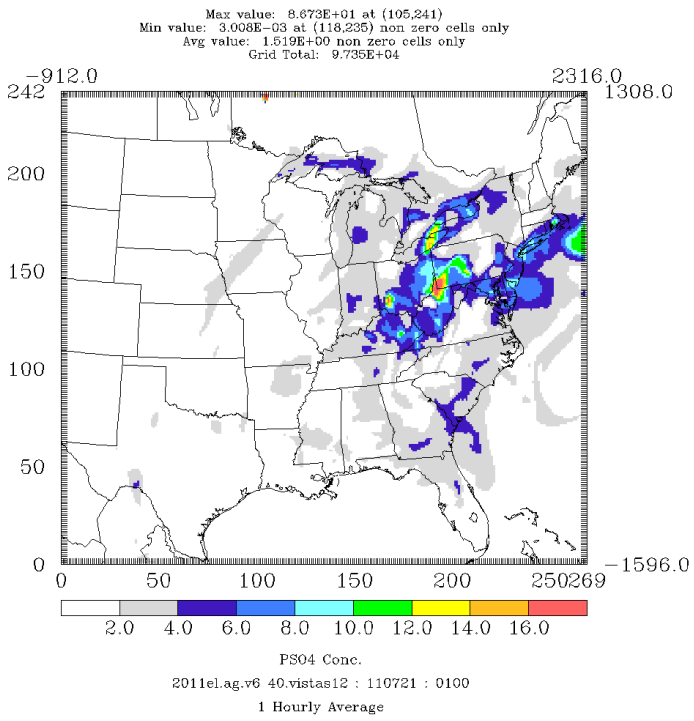


Figure 4-46: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: July 21 at 100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

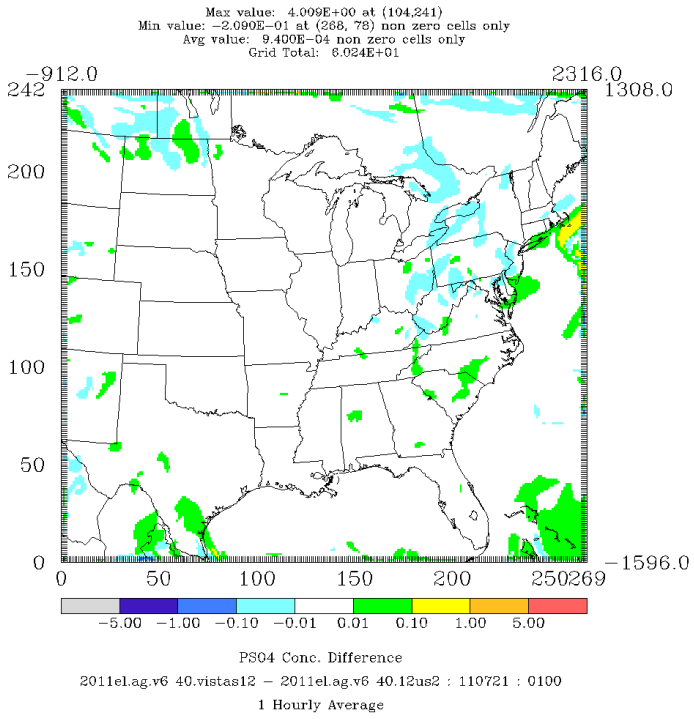
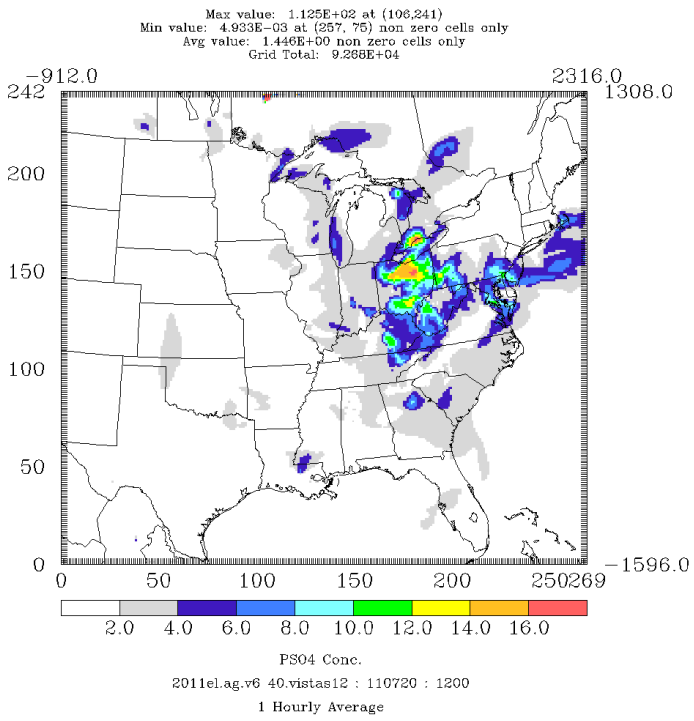


Figure 4-47: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

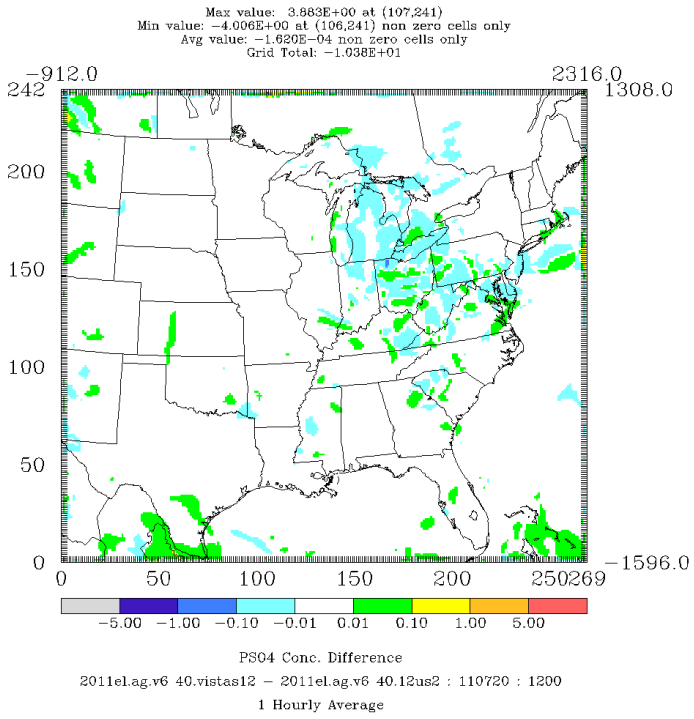
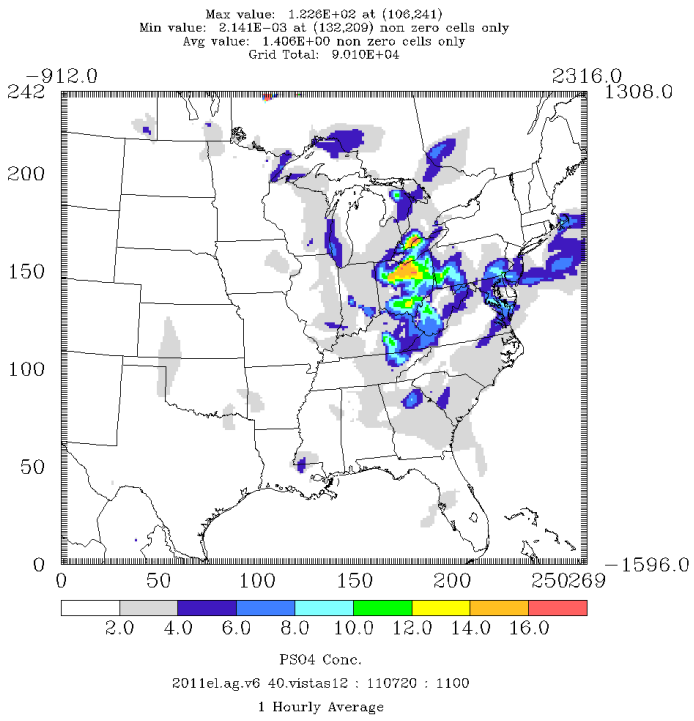


Figure 4-48: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: July 20 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

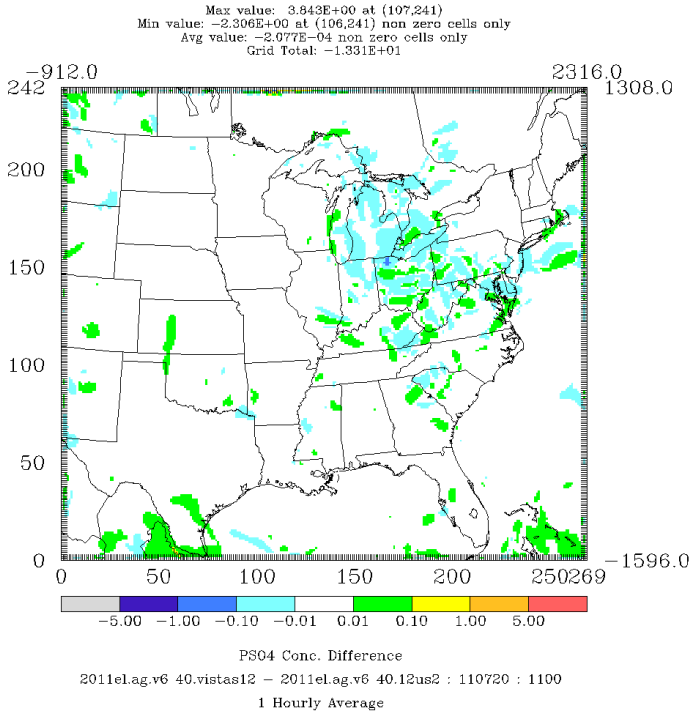
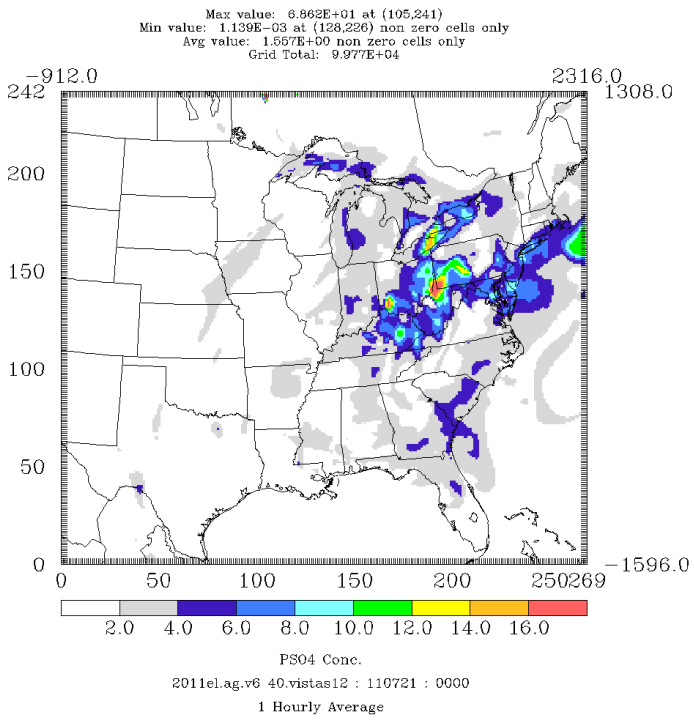


Figure 4-49: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations

Eighth Highest Positive Difference: July 21 at 0000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

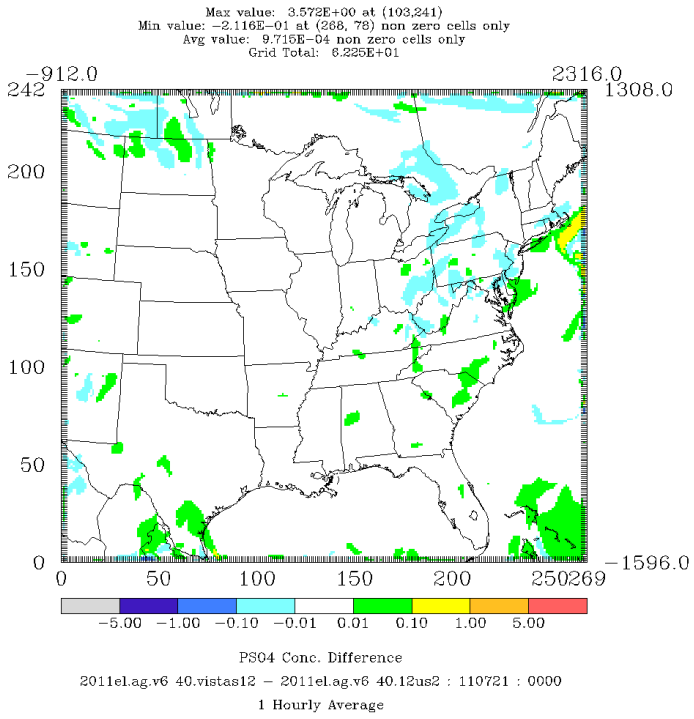
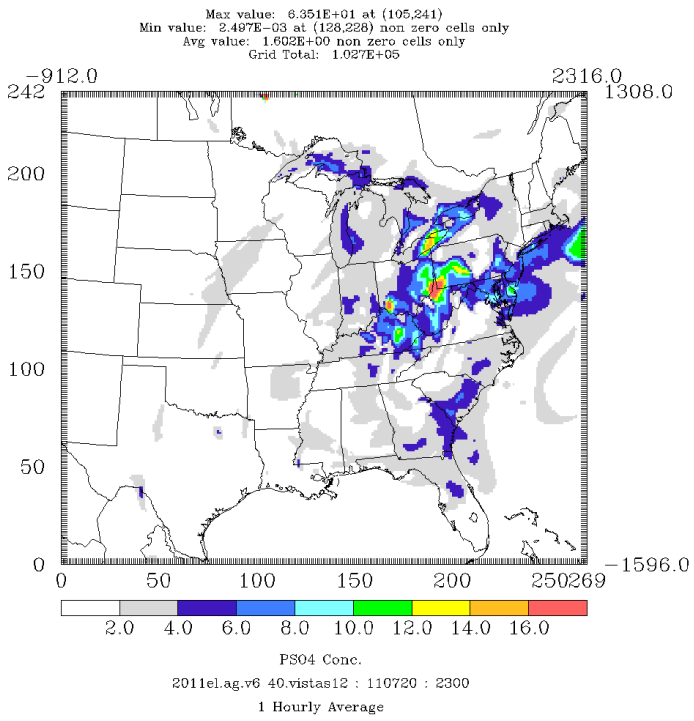


Figure 4-50: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: July 20 at 2300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

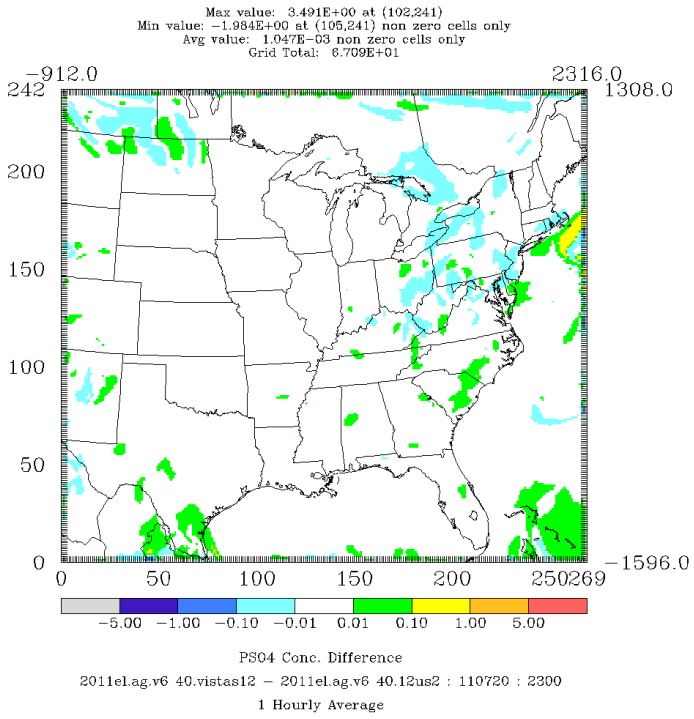
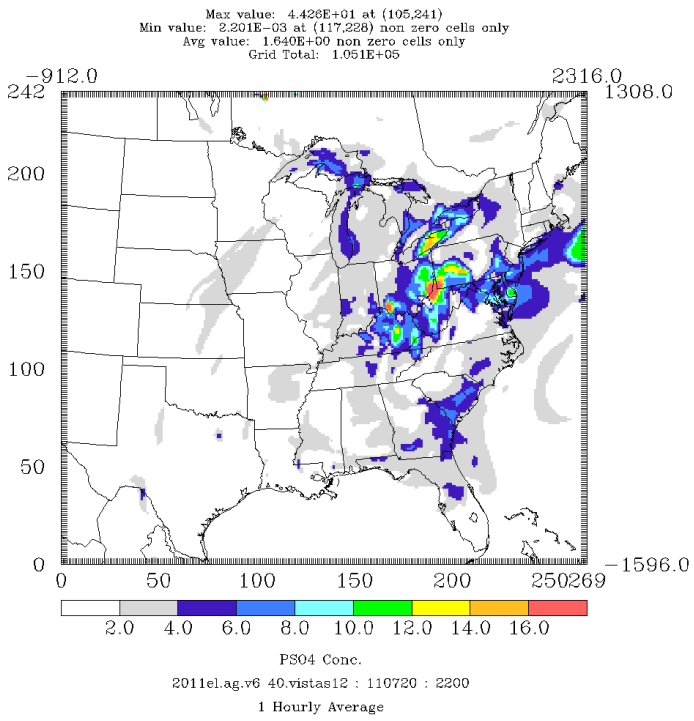


Figure 4-51: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 2200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

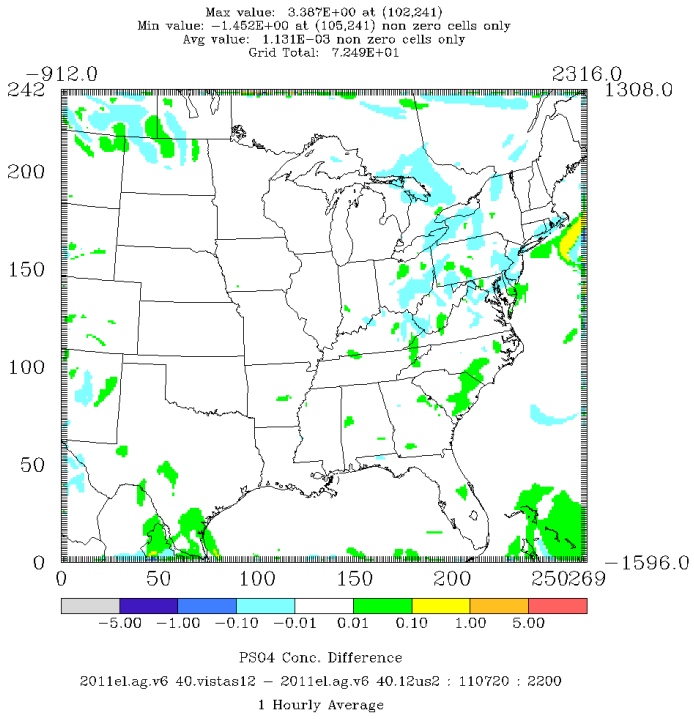
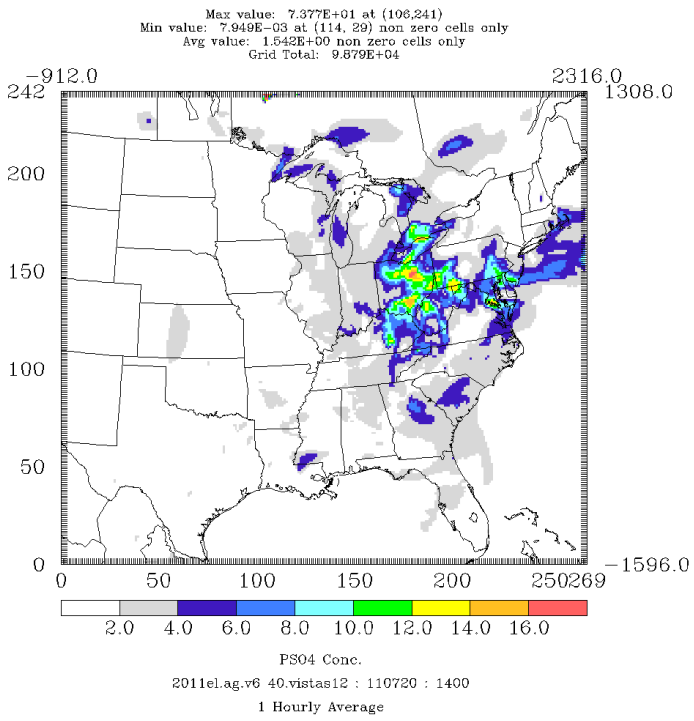


Figure 4-52: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

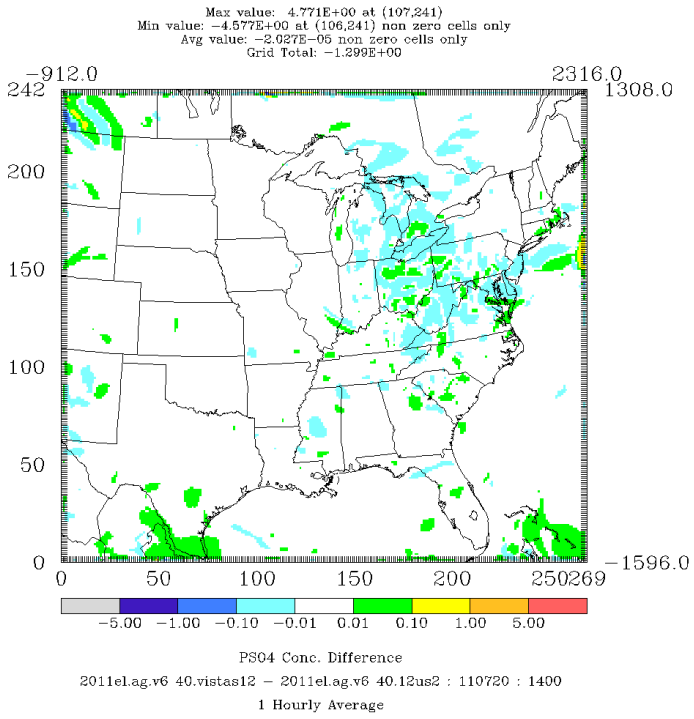
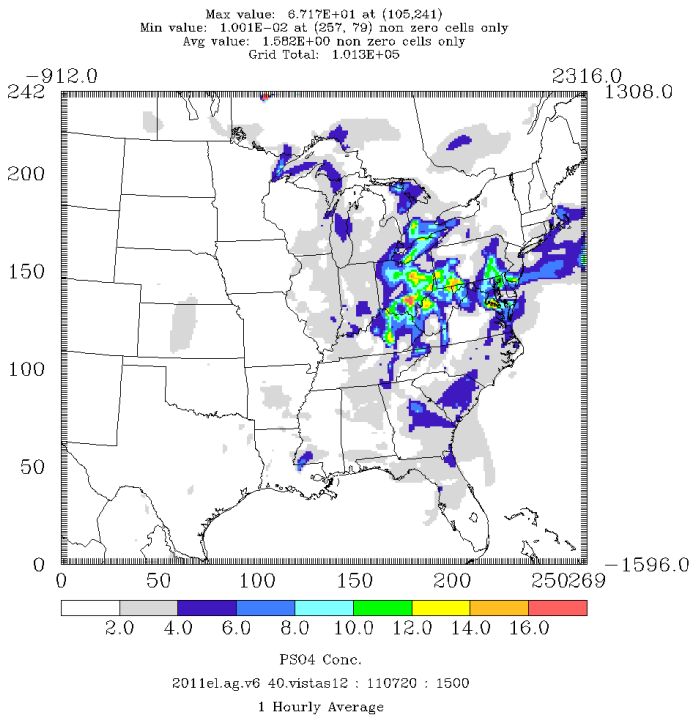


Figure 4-53: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

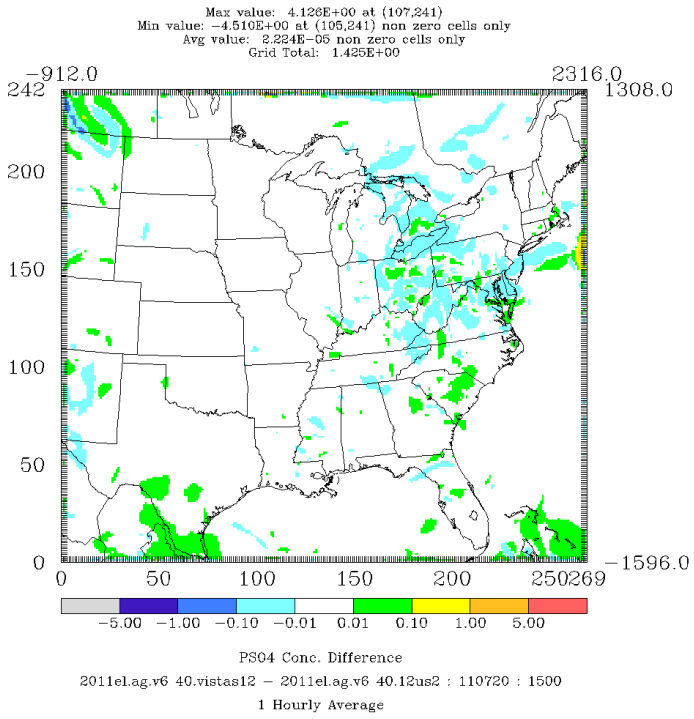
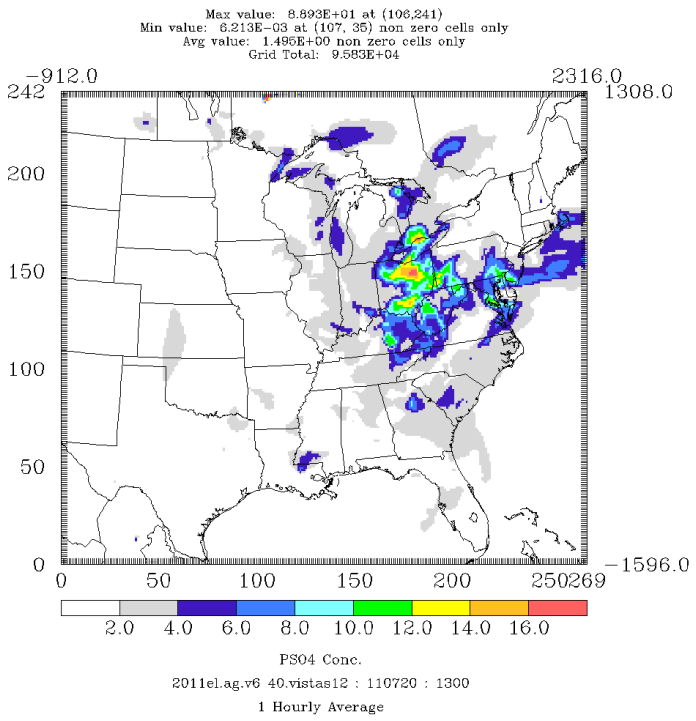


Figure 4-54: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

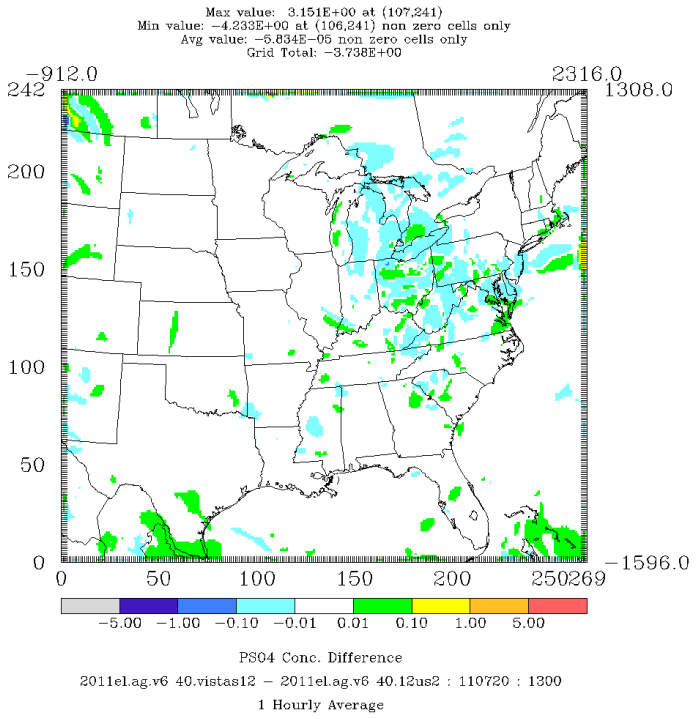
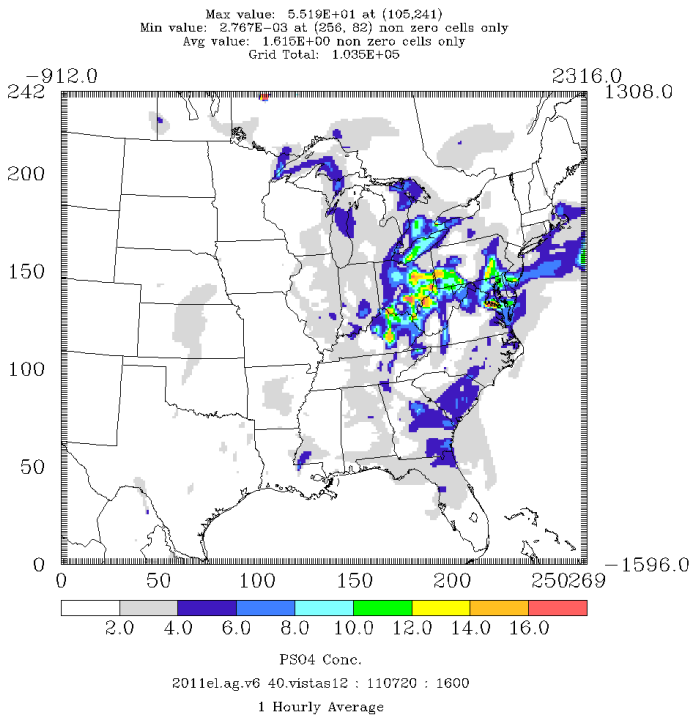


Figure 4-55: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 20 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

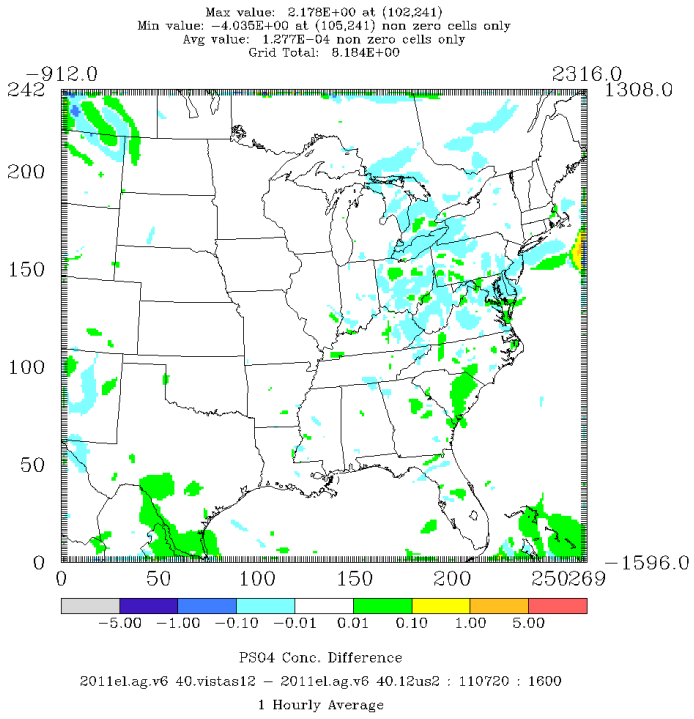
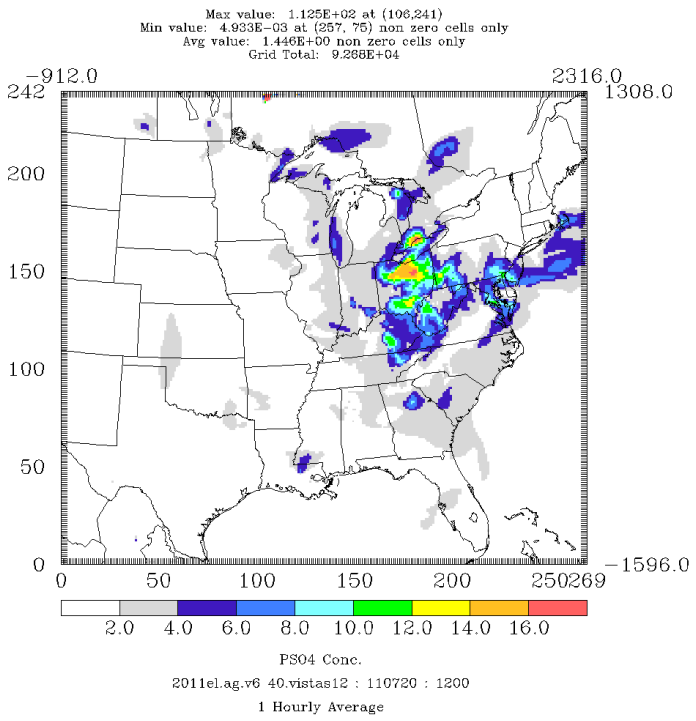


Figure 4-56: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

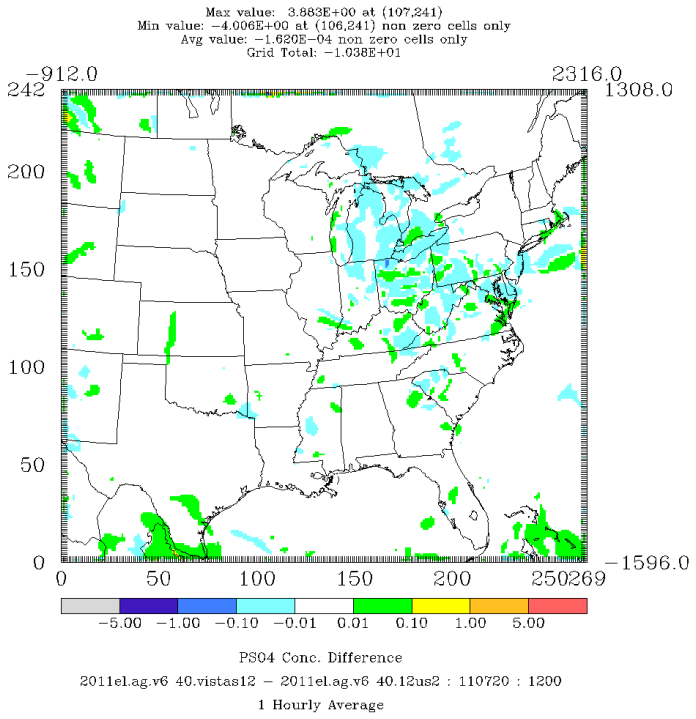
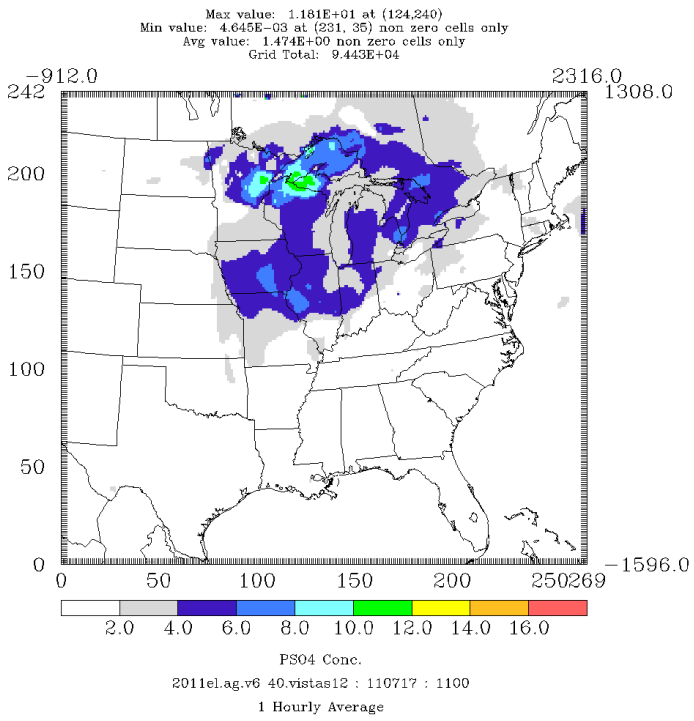


Figure 4-57: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 17 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

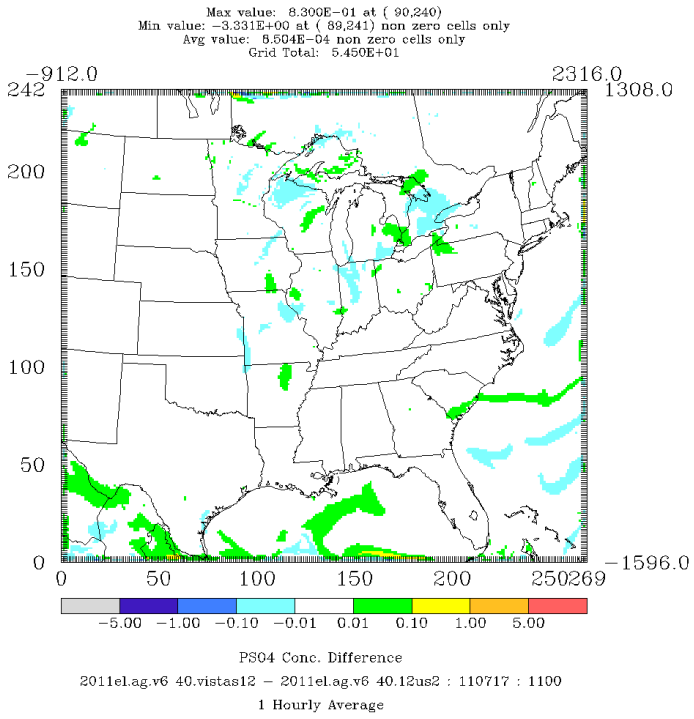
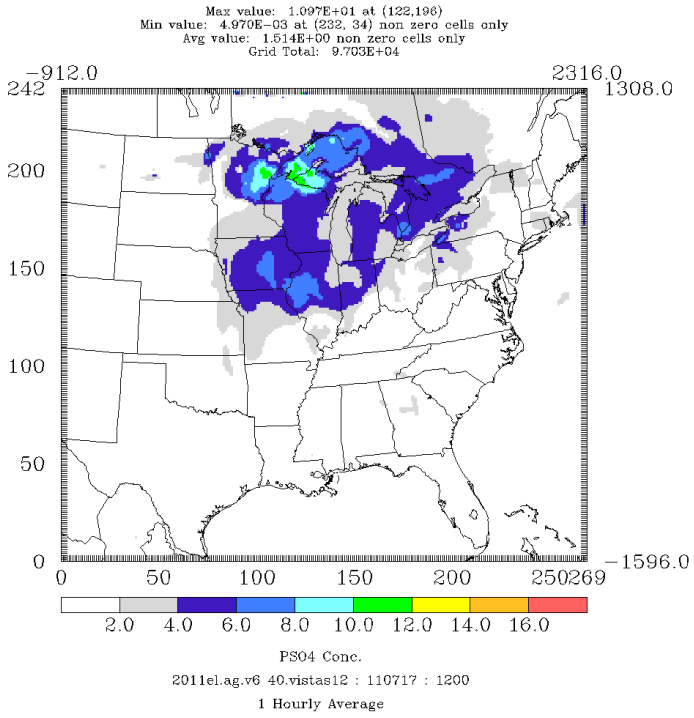


Figure 4-58: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 17 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

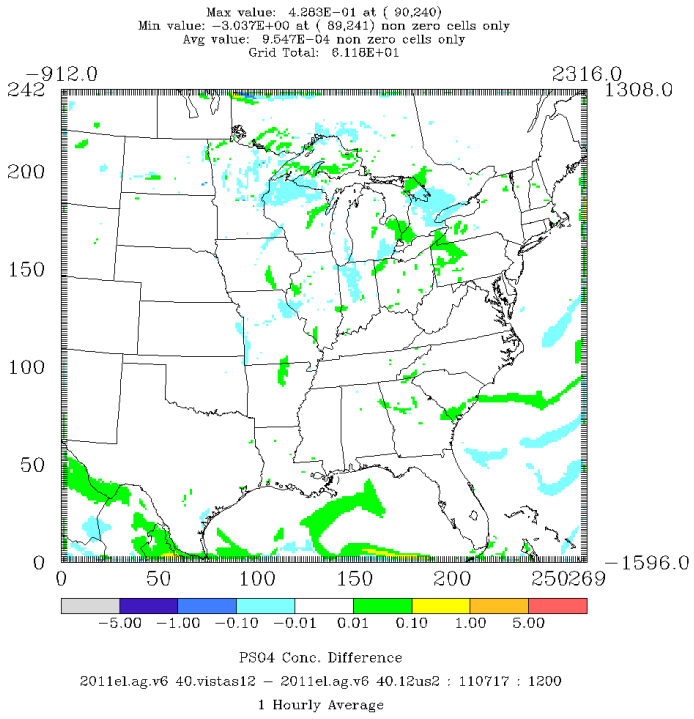
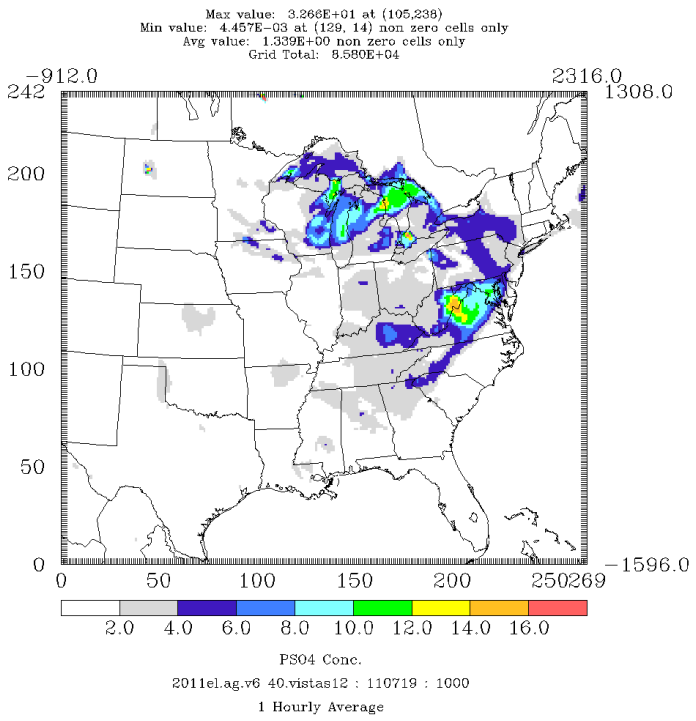


Figure 4-59: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 19 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

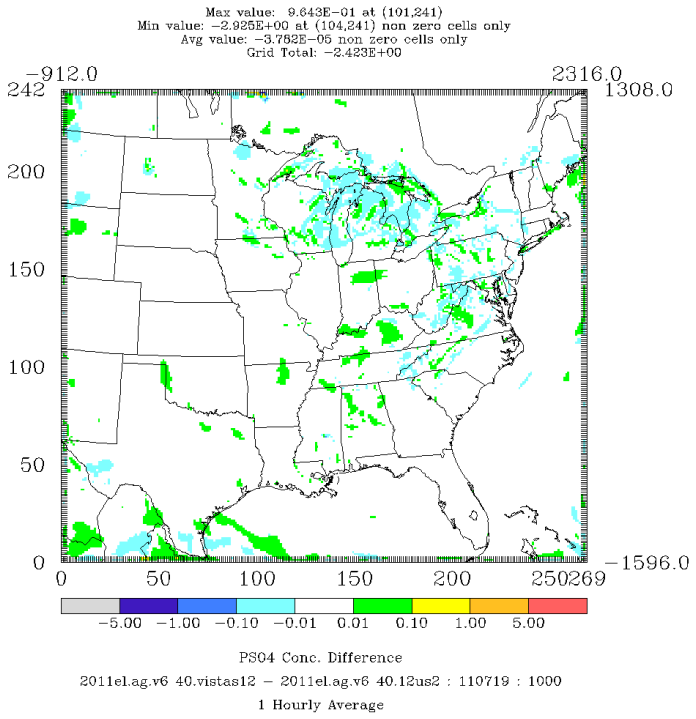
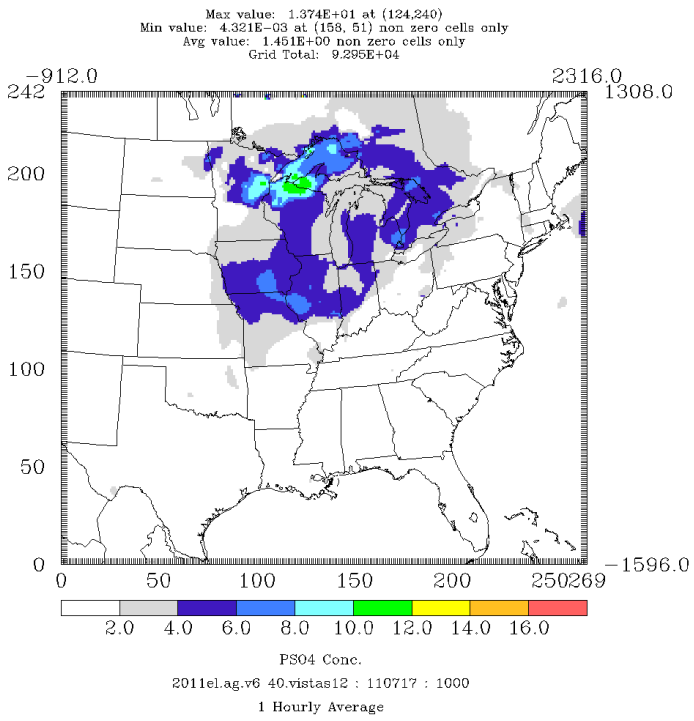


Figure 4-60: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 17 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

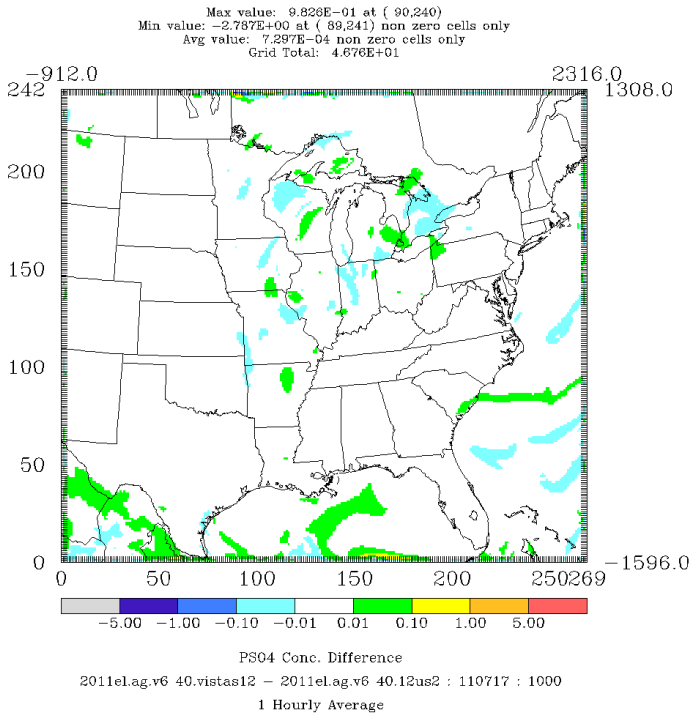
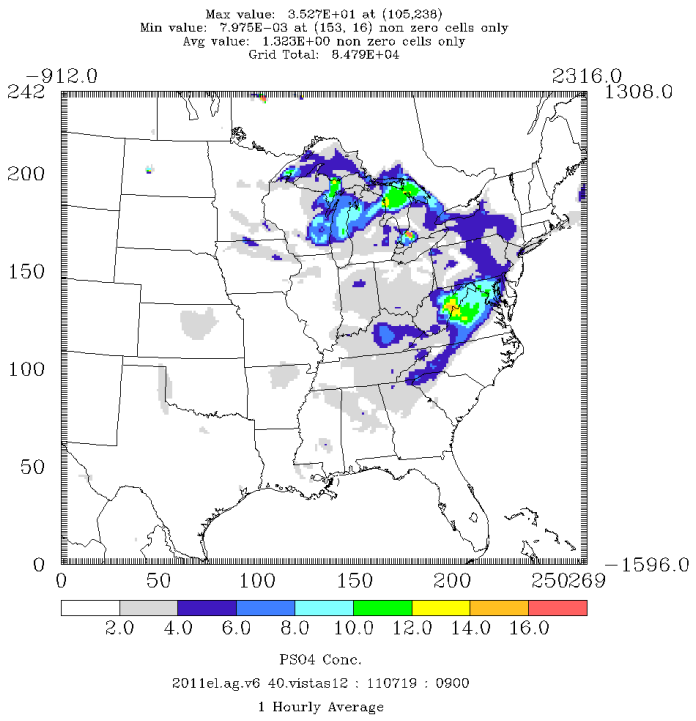


Figure 4-61: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 19 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

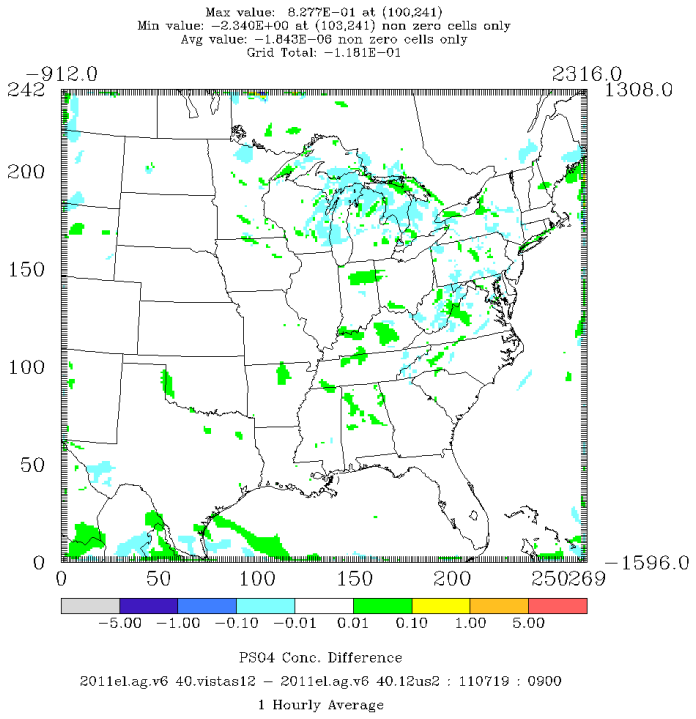


Figure 4-62: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference)

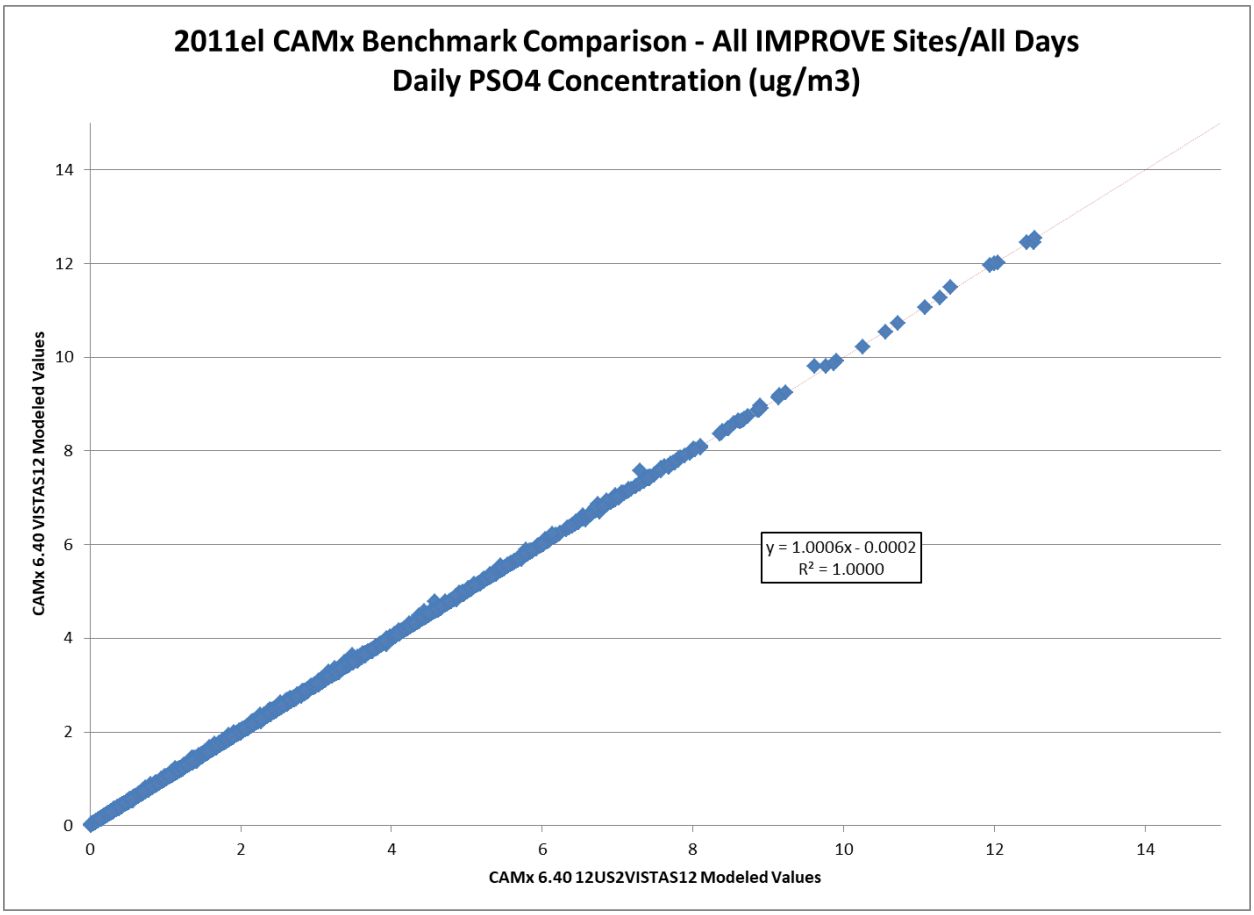


Figure 4-63: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine).

4.4 Nitrate

Nitrate results for the top 10 positive and negative hours are presented in tabular format in Table 4-4. The maximum positive difference is 7.62 μg/m^3 falling to 5.55 μg/m^3 for the 10th high. The maximum negative difference is -5.37 μg/m^3 falling to -3.14 μg/m^3 for the 10th high. The maximum positive percent difference from these days is 129.2% and negative percent difference of -49.16%.

As expected, the maximum impacts on the top 10 positive and negative hours are occurring very near the border. As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated from the cells outside the VISTAS12 domain. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous concentrations

The top 10 positive difference hours are presented in Figures 4-64 through 4-73 and the top 10 negative difference hours are presented in Figures 4-74 through 4-83. The peak differences are generally occurring on January 3, July 17 and July 20. On January 3 the area of the difference is generally in the north western portion of the domain in an area of a plume entering the domain from Canada. On July 20 the differences are along the northern border, north of Minnesota.

Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-83. The 12US2 results are plotted on the x-axis and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 0.9996, an intercept of 0.0006 ppb and an R^2 of 1.0000.

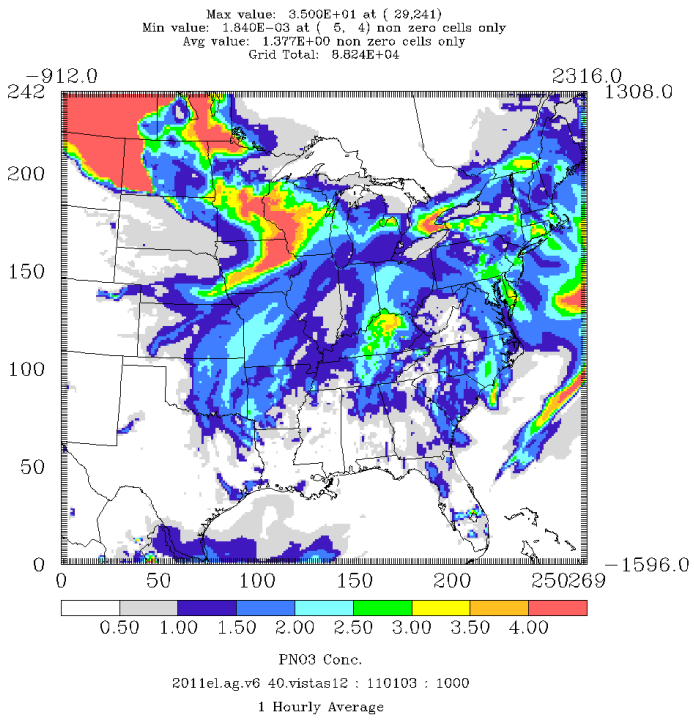
Examination of the difference animations often show differences along the boundary becoming lower as the plumes along the boundary move into the domain.

Table 4-4. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of Nitrate Concentrations (μg/m³). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (μg/m³)	Percent Difference	Column	Row
Maximum Positive									
2011	1	3	10	27.71	20.09	7.62	37.9%	33	235
2011	1	3	7	26.59	19.39	7.21	37.2%	32	235
2011	1	3	6	26.46	19.27	7.19	37.3%	32	235
2011	1	3	5	26.33	19.18	7.15	37.3%	32	235
2011	1	3	4	26.63	19.65	6.98	35.5%	32	235
2011	7	20	20	10.81	4.72	6.10	129.2%	99	241
2011	1	3	11	28.26	22.33	5.93	26.5%	33	235
2011	1	3	9	27.00	21.15	5.84	27.6%	33	235
2011	1	3	8	26.83	21.02	5.81	27.6%	32	235
2011	7	20	15	25.96	20.41	5.55	27.2%	107	241
Maximum Negative									
2011	1	3	4	19.35	24.71	-5.37	-21.7%	31	234
2011	1	3	8	18.91	23.44	-4.53	-19.3%	33	233
2011	1	3	5	18.34	22.84	-4.50	-19.7%	31	234
2011	7	17	15	4.66	9.14	-4.49	-49.1%	90	241
2011	7	17	14	9.11	13.25	-4.14	-31.3%	90	241
2011	1	3	3	18.48	22.24	-3.76	-16.9%	32	233
2011	1	27	10	3.71	7.21	-3.50	-48.6%	224	241
2011	7	20	16	41.55	44.92	-3.37	-7.5%	104	241
2011	1	3	12	16.46	19.80	-3.34	-16.9%	13	240
2011	1	3	13	18.72	21.85	-3.14	-14.4%	24	239

Maximum Positive Difference: January 3 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

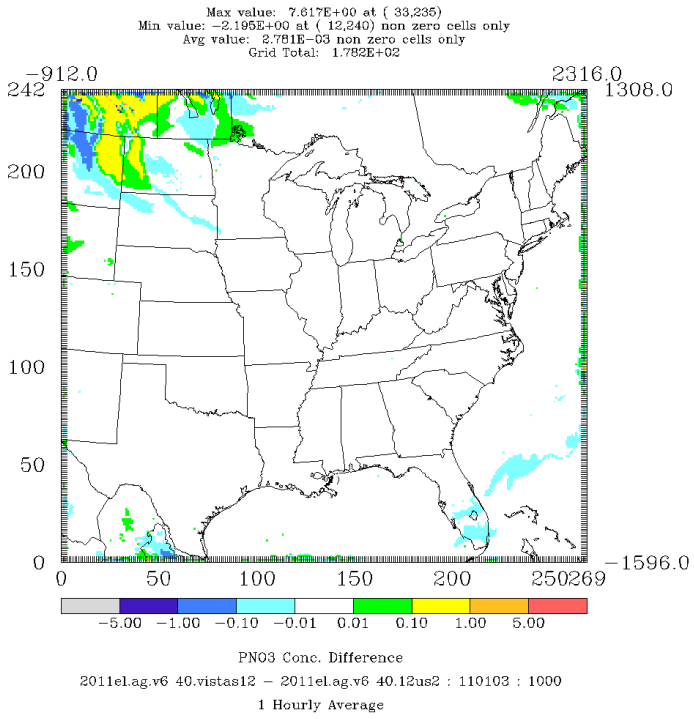
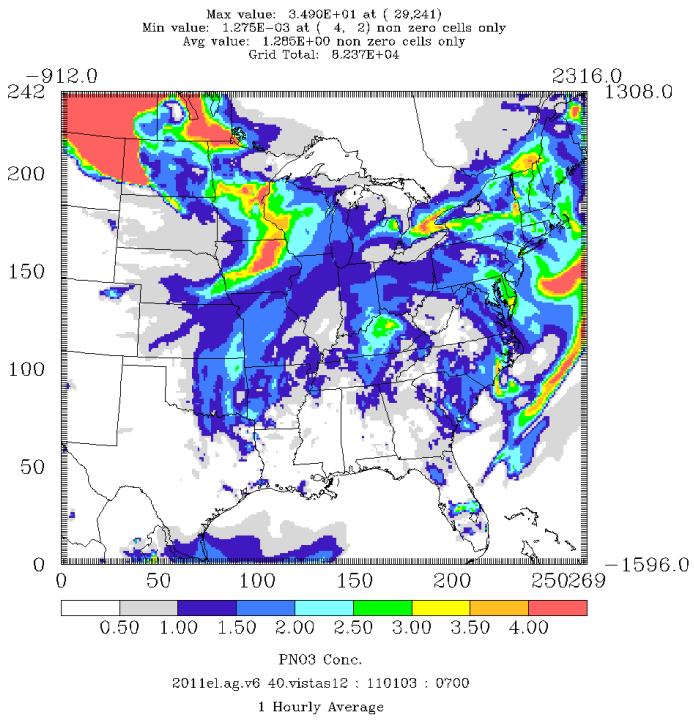


Figure 4-64: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: January 3 at 700 hours

VISTAS12



Difference (VISTAS12 - 12US2)

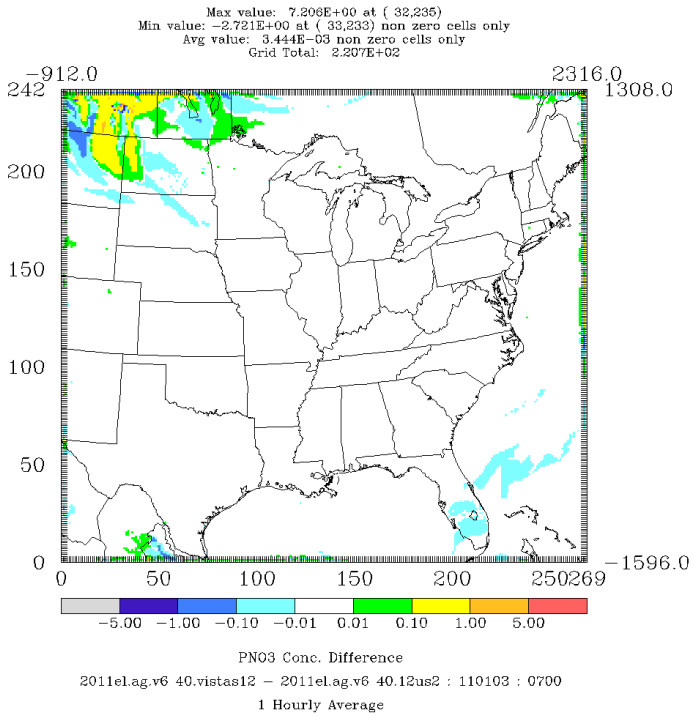
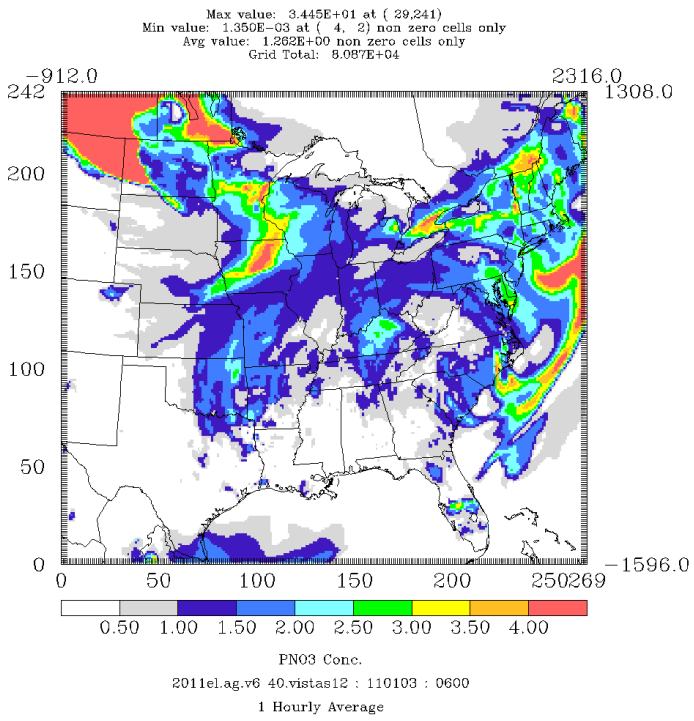


Figure 4-65: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: January 3 at 600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

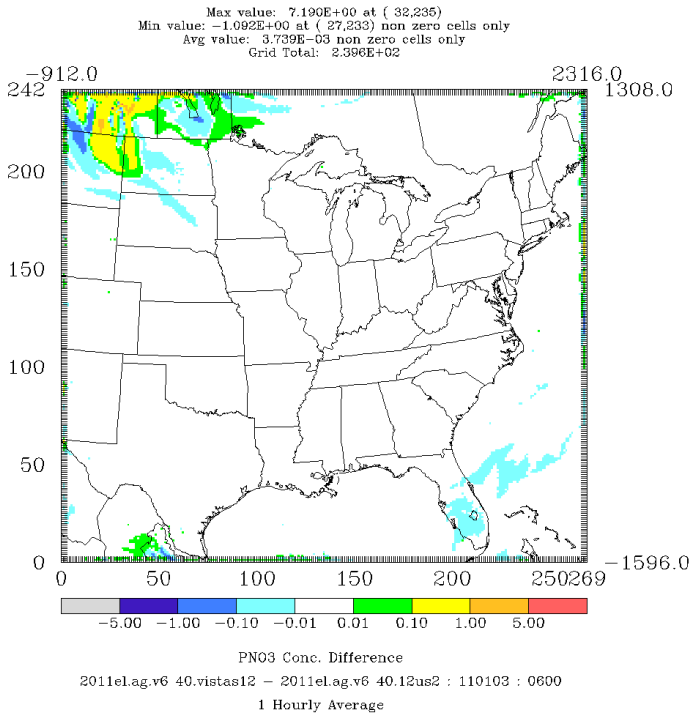
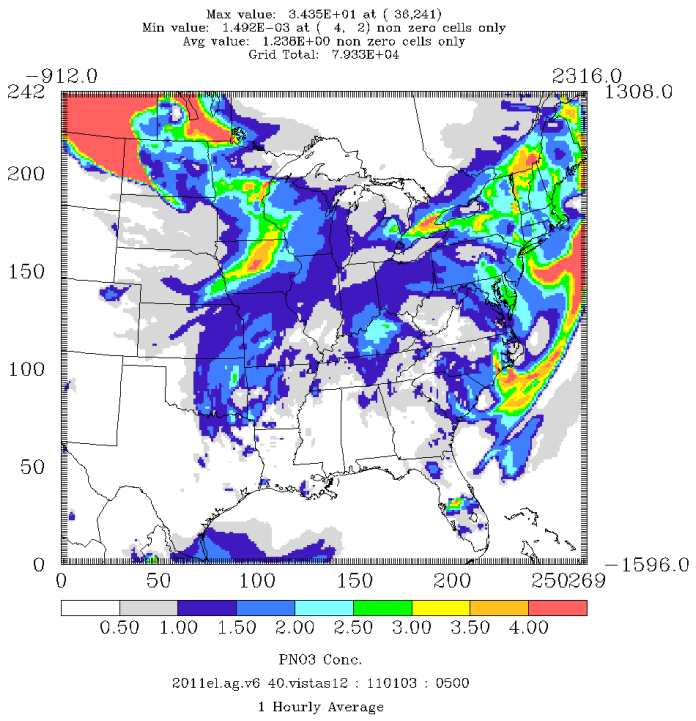


Figure 4-66: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: January 3 at 500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

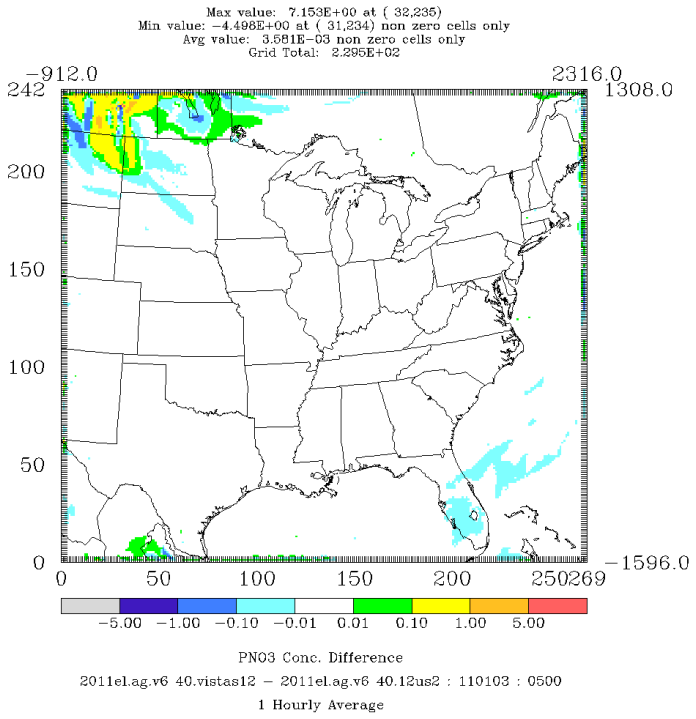
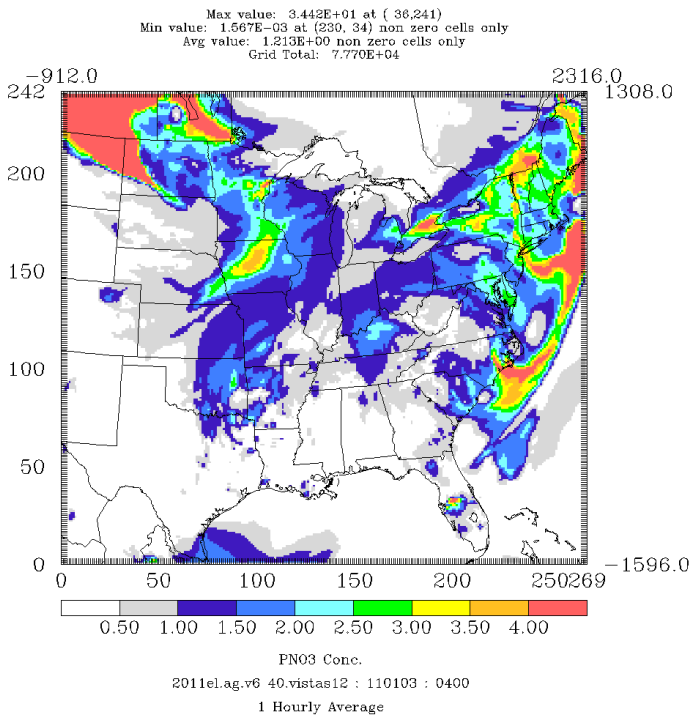


Figure 4-67: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: January 3 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

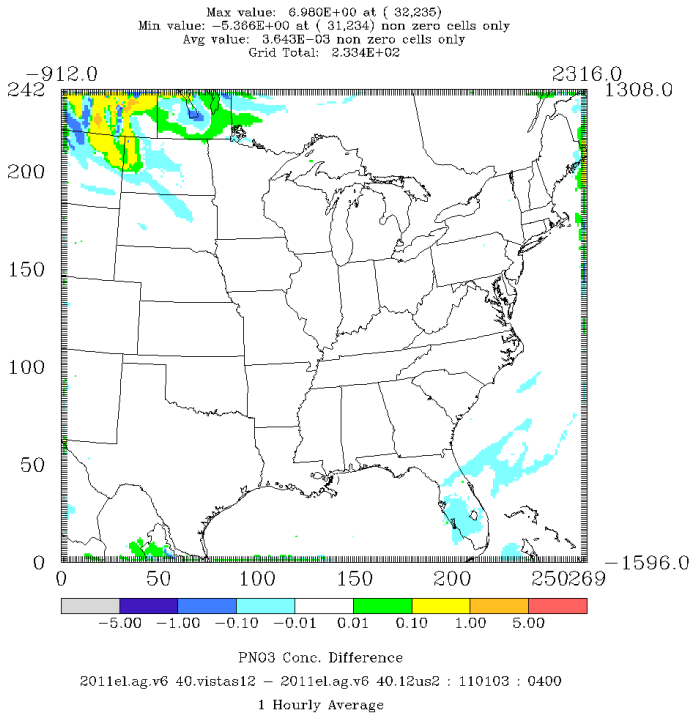
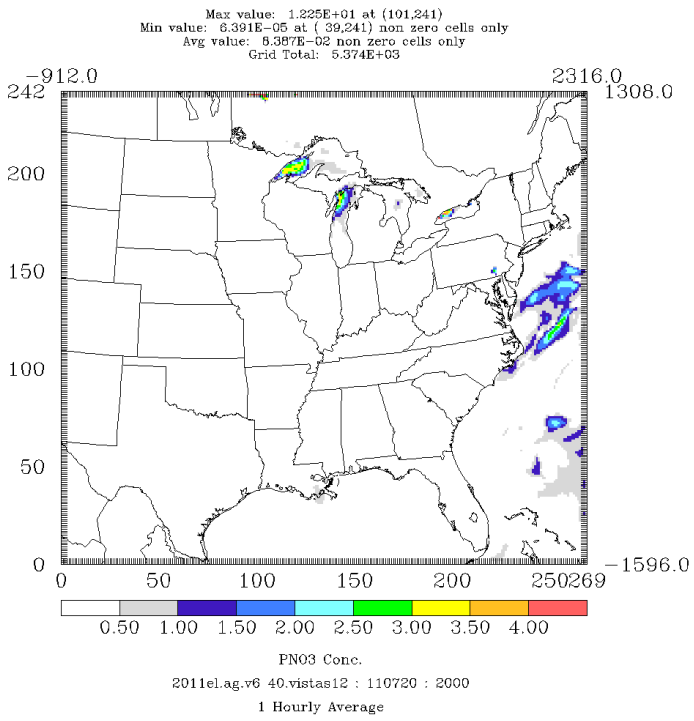


Figure 4-68: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 20 at 2000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

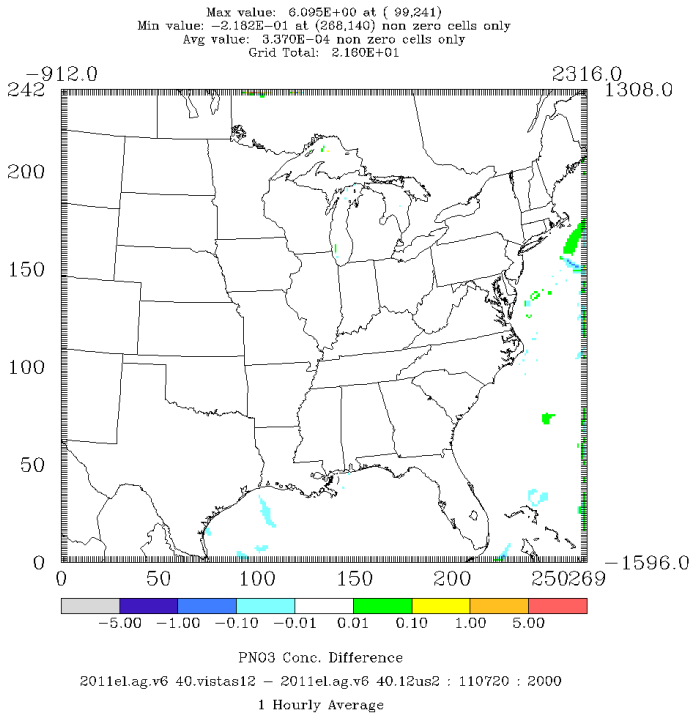
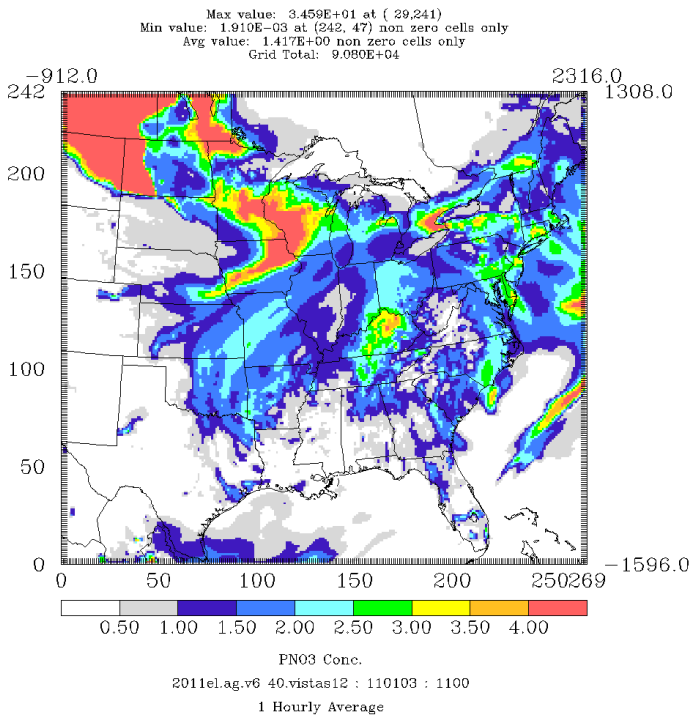


Figure 4-69: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: January 3 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

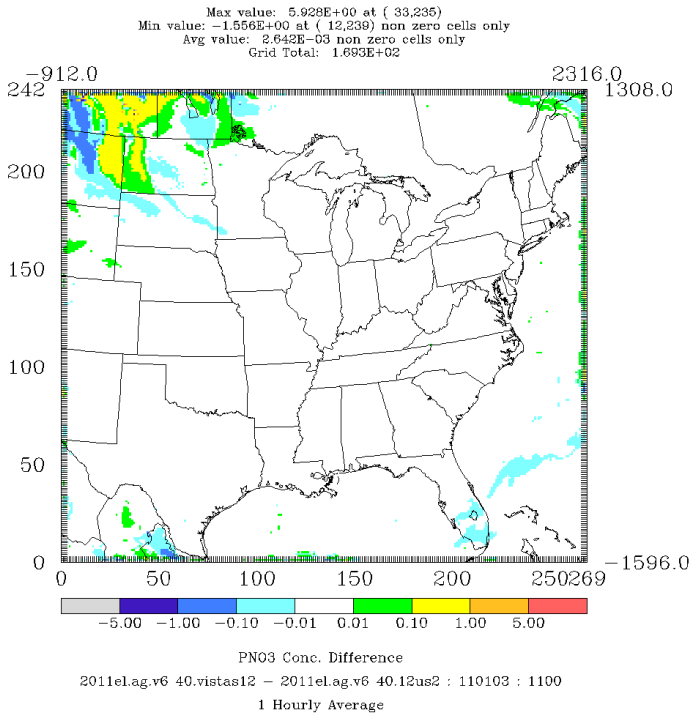
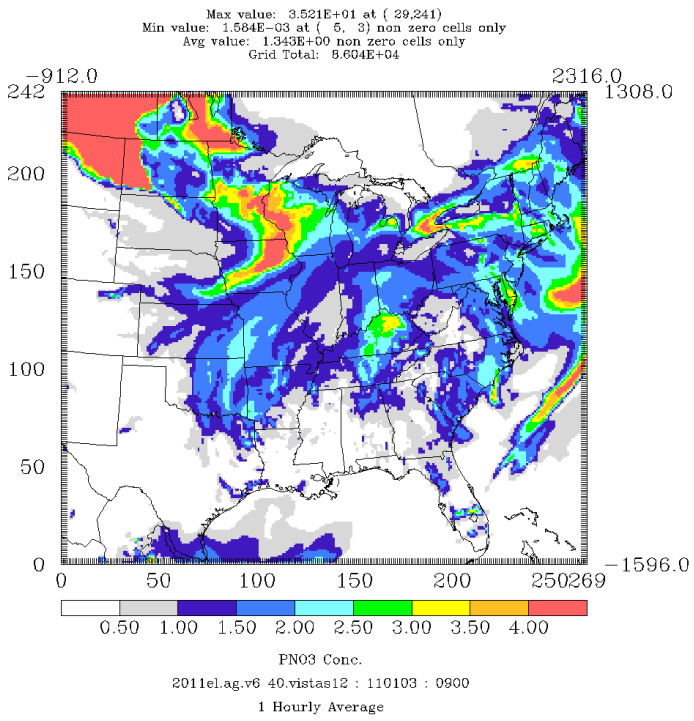


Figure 4-70: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: January 3 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

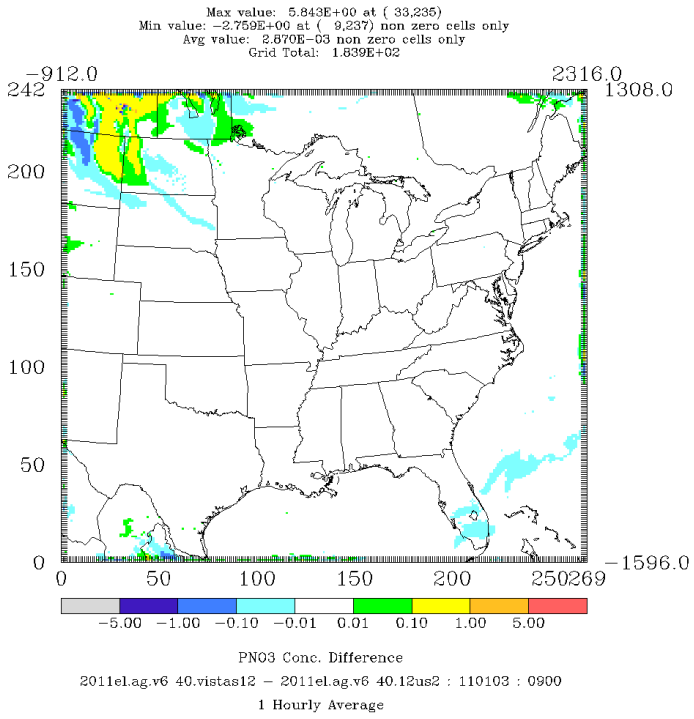
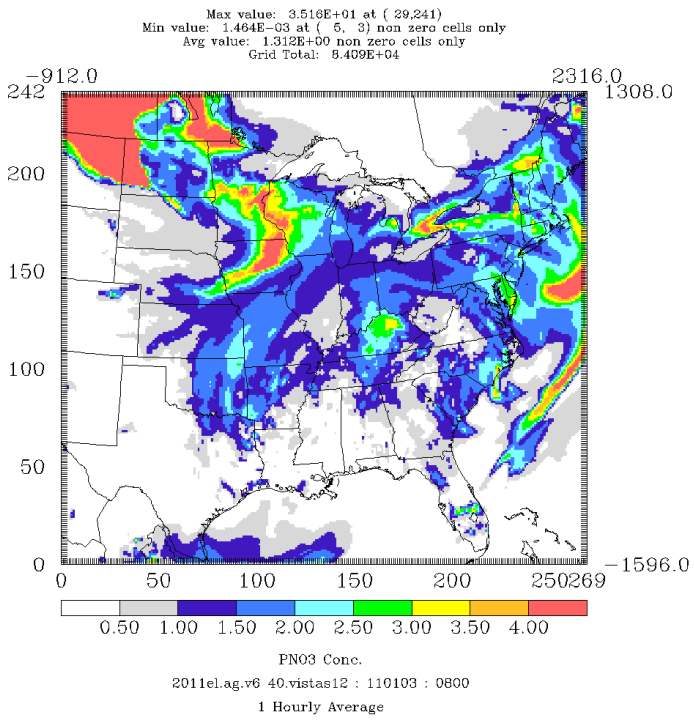


Figure 4-71: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: January 3 at 800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

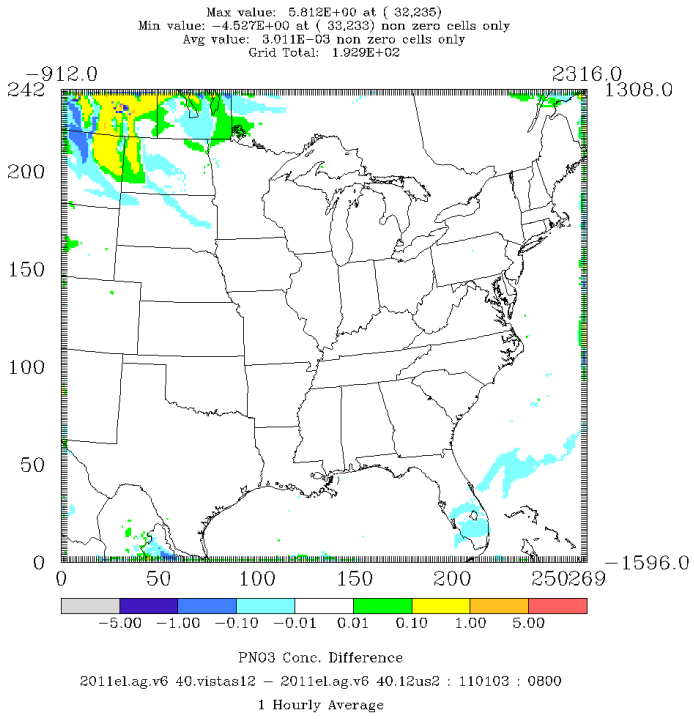
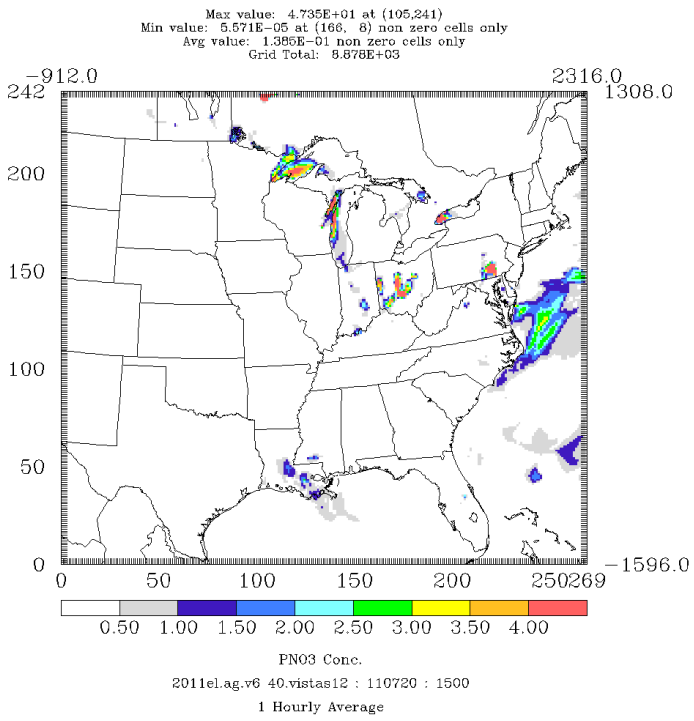


Figure 4-72: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

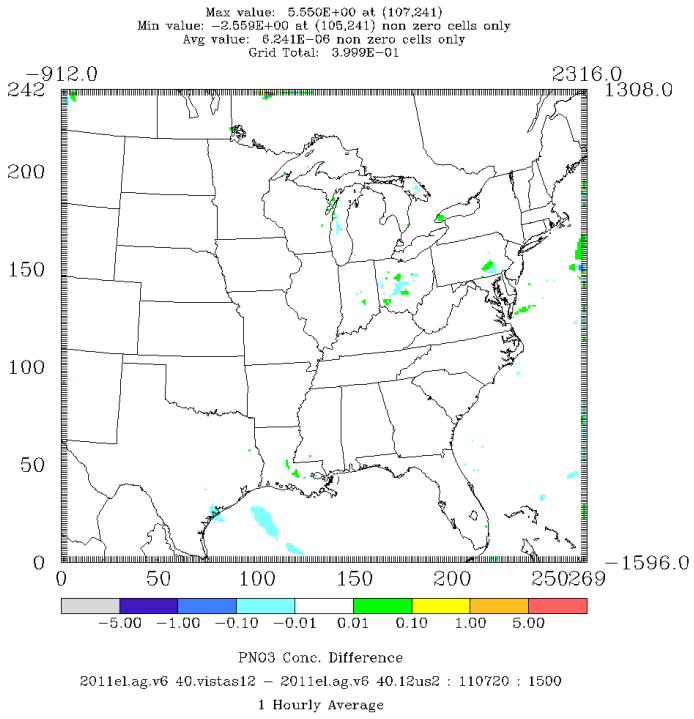
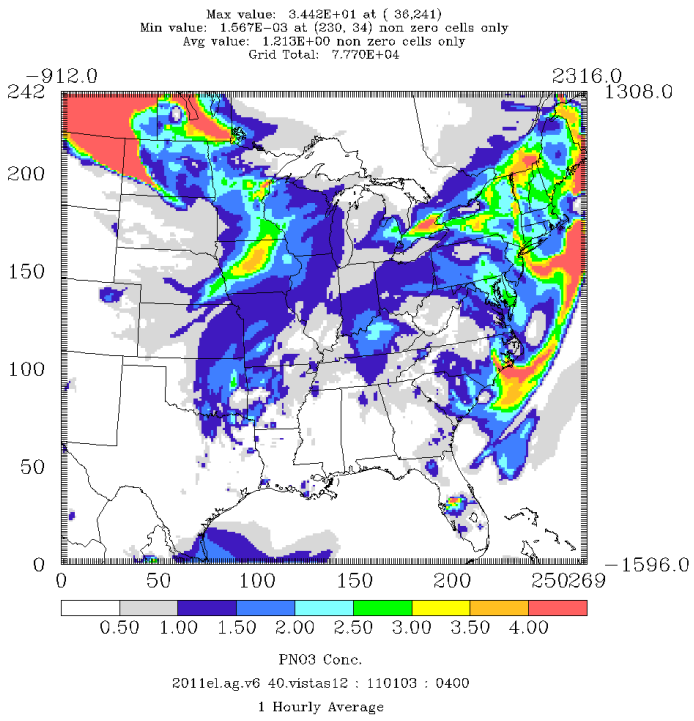


Figure 4-73: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: January 3 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

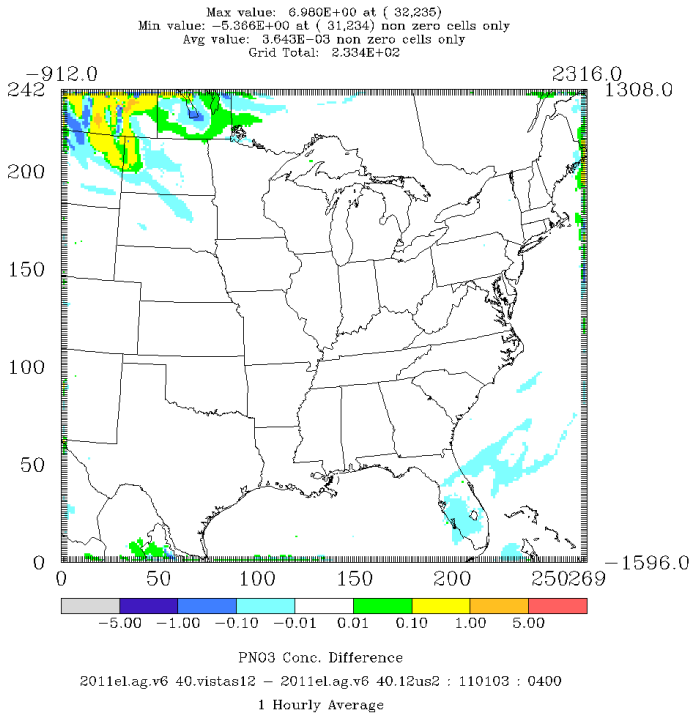
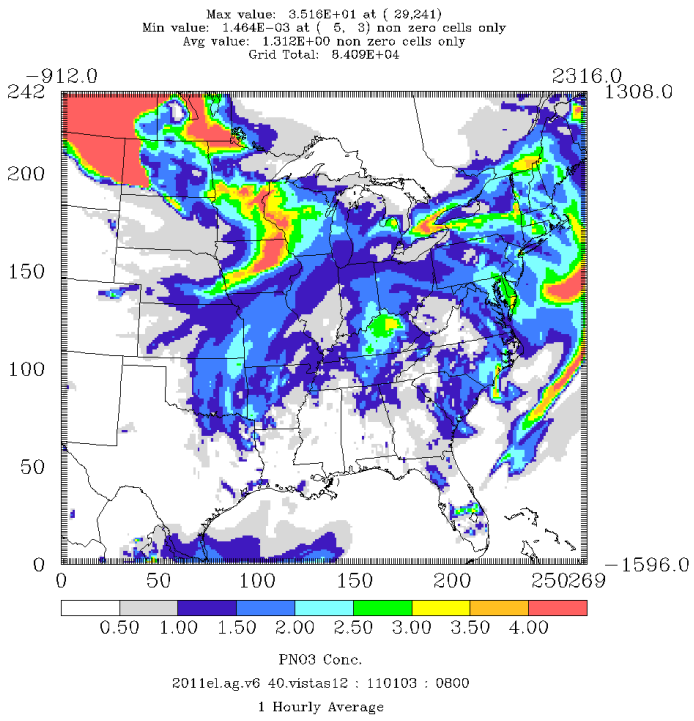


Figure 4-74: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: January 3 at 800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

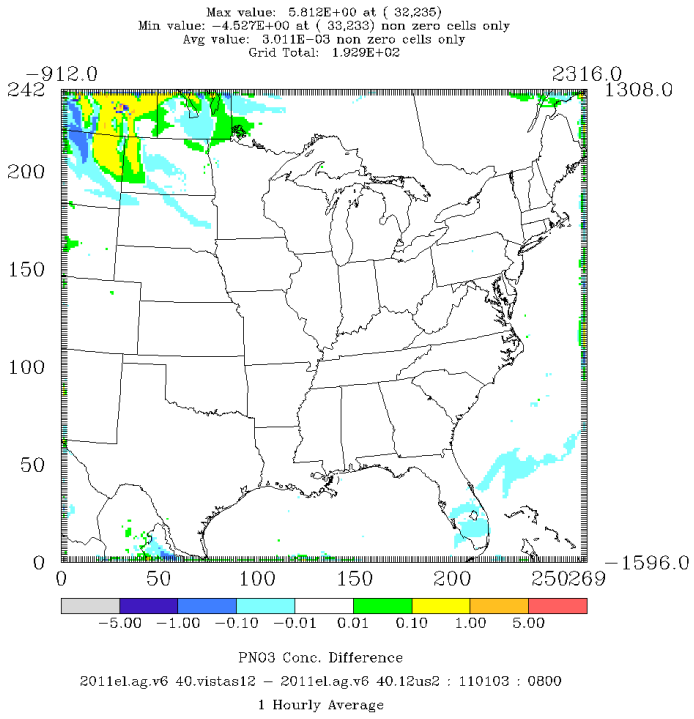
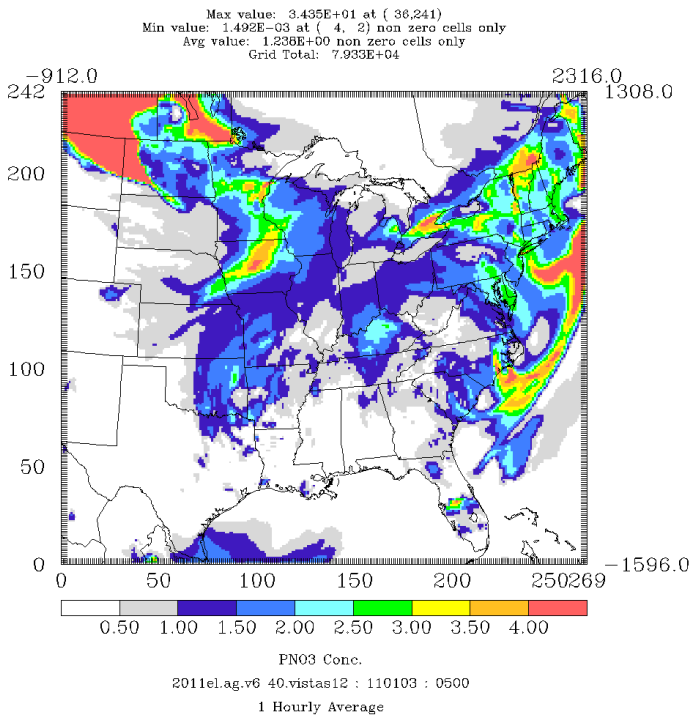


Figure 4-75: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: January 3 at 500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

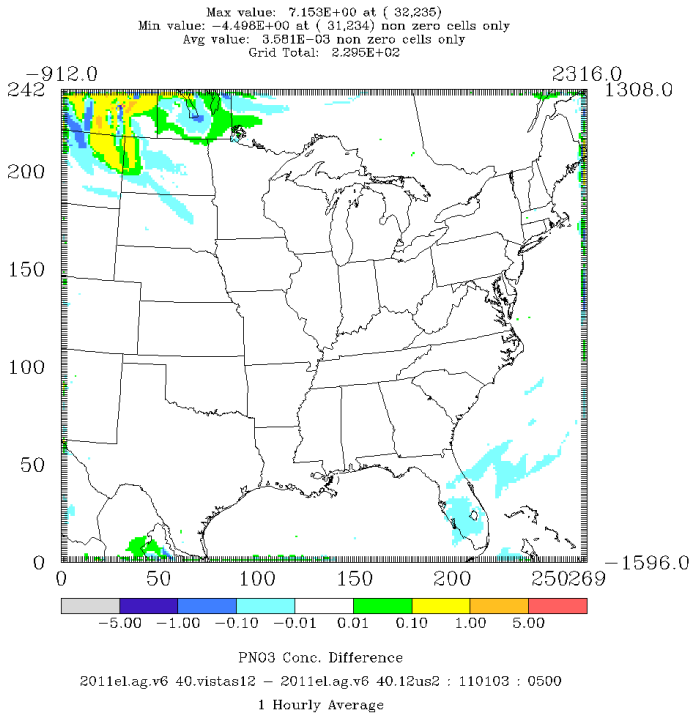
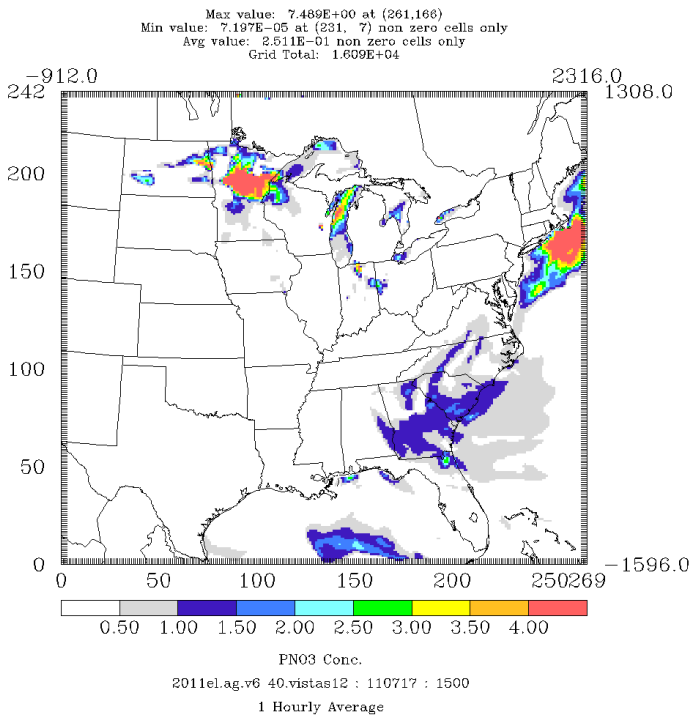


Figure 4-76: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 17 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

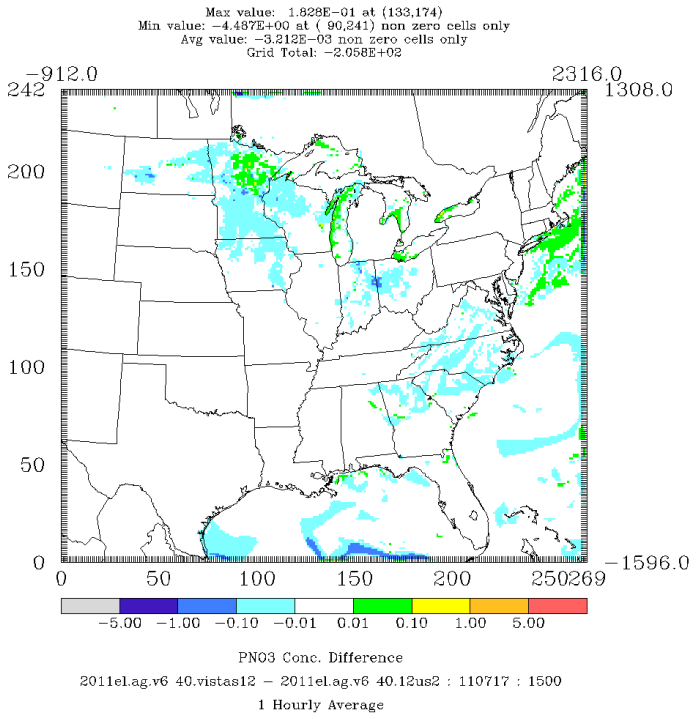
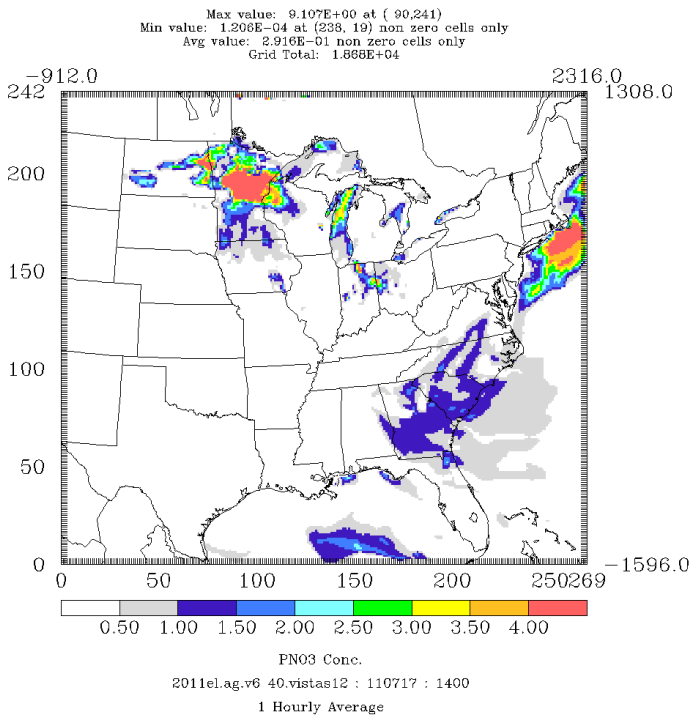


Figure 4-77: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 17 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

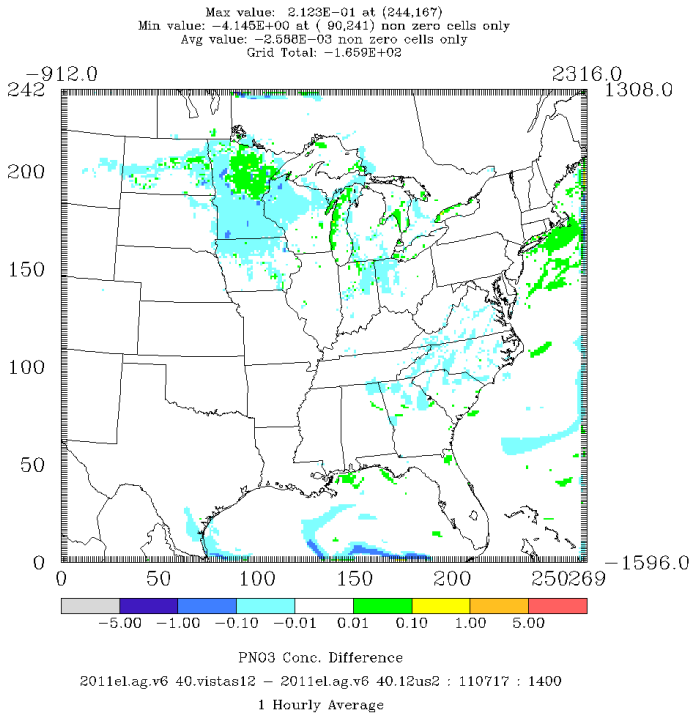
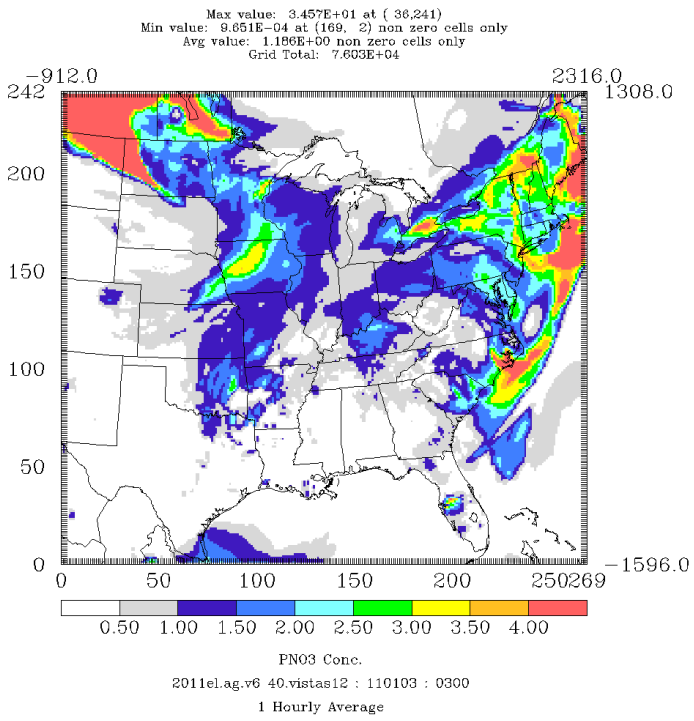


Figure 4-78: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: January 3 at 300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

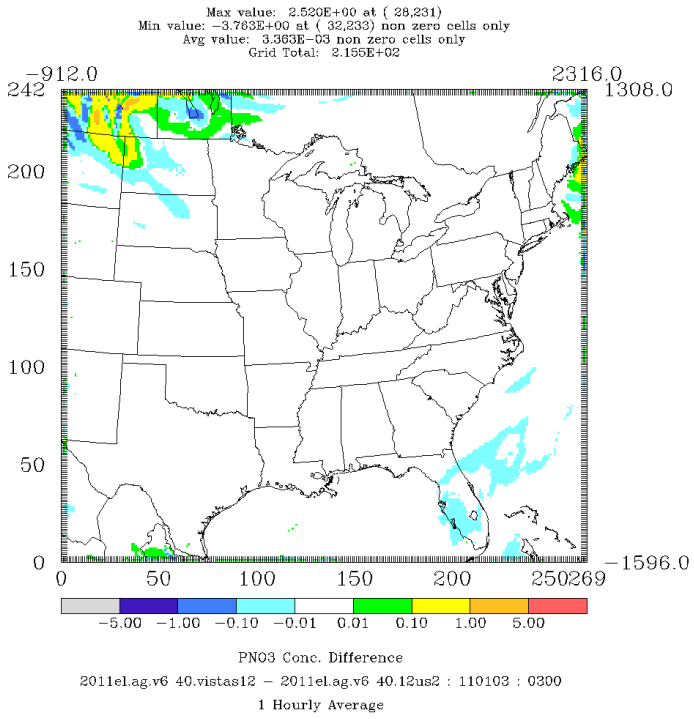
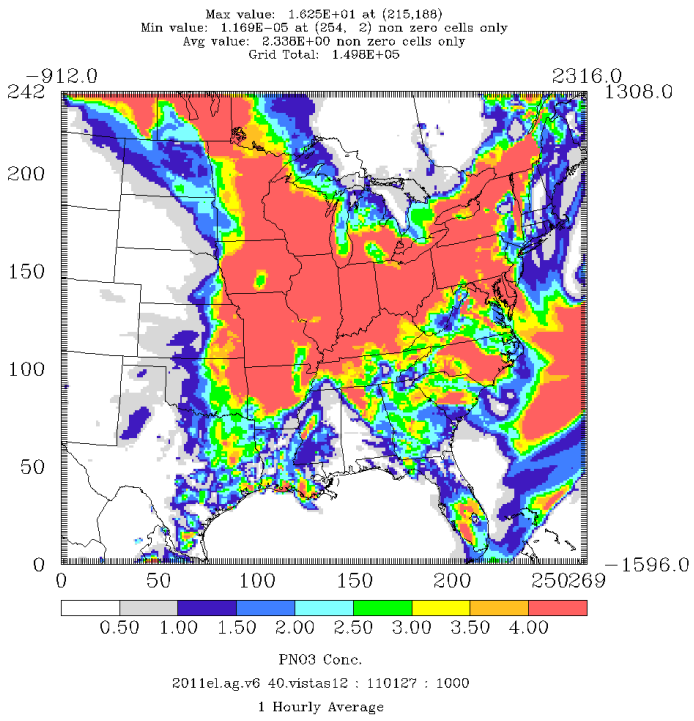


Figure 4-79: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: January 27 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

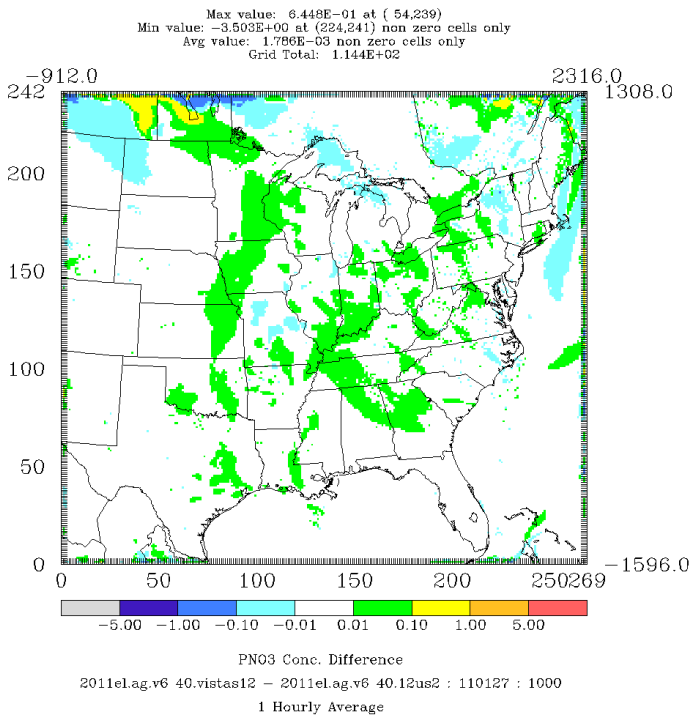
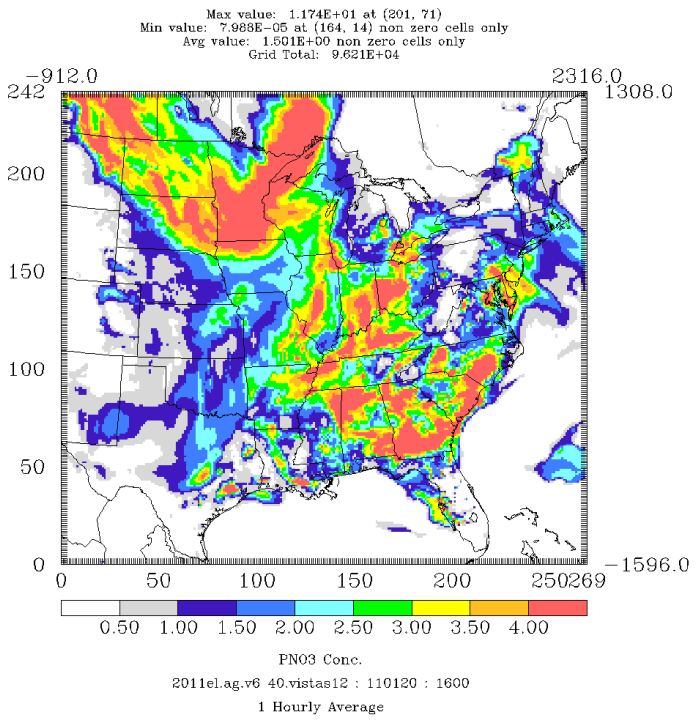


Figure 4-80: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 20 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

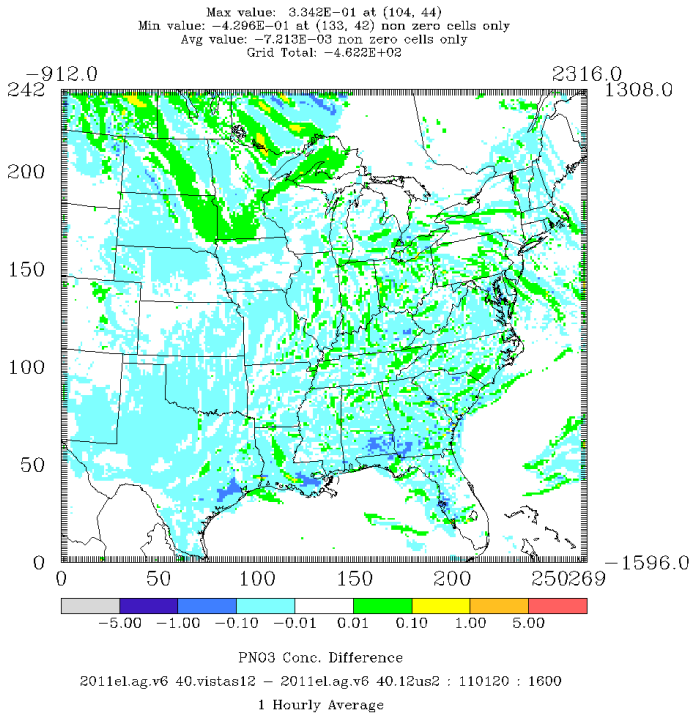
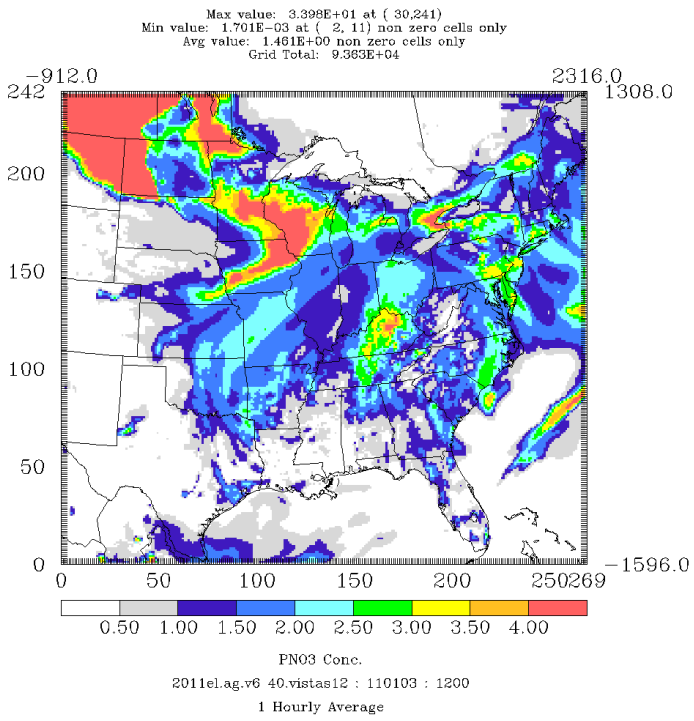


Figure 4-81: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: January 3 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

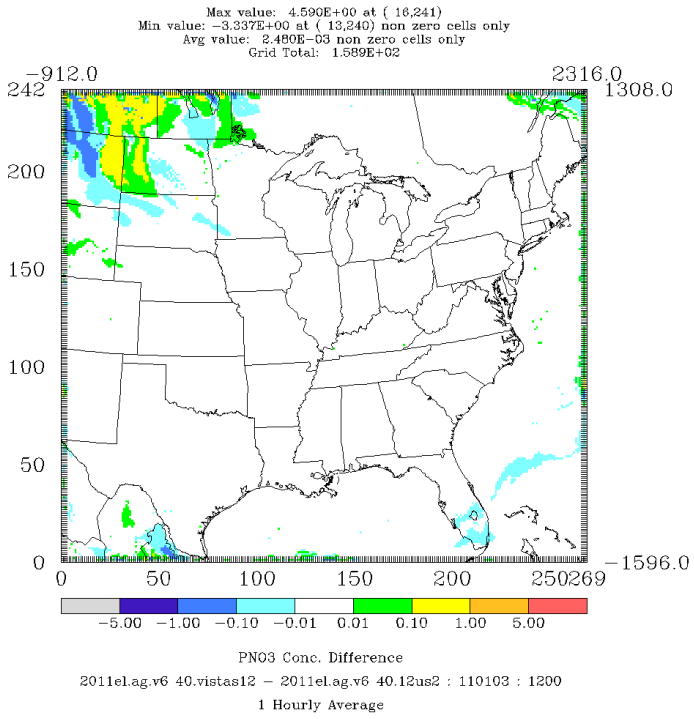
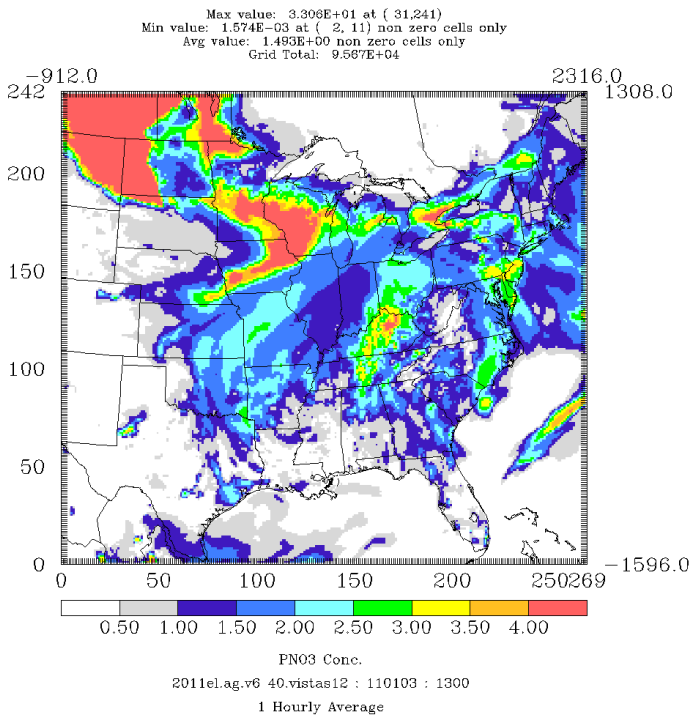


Figure 4-82: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: January 3 at 1300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

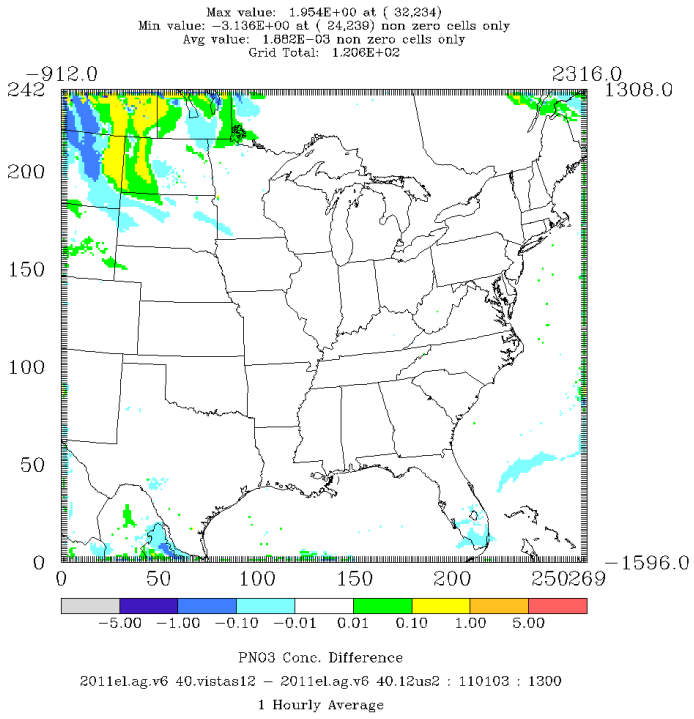


Figure 4-83: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference)

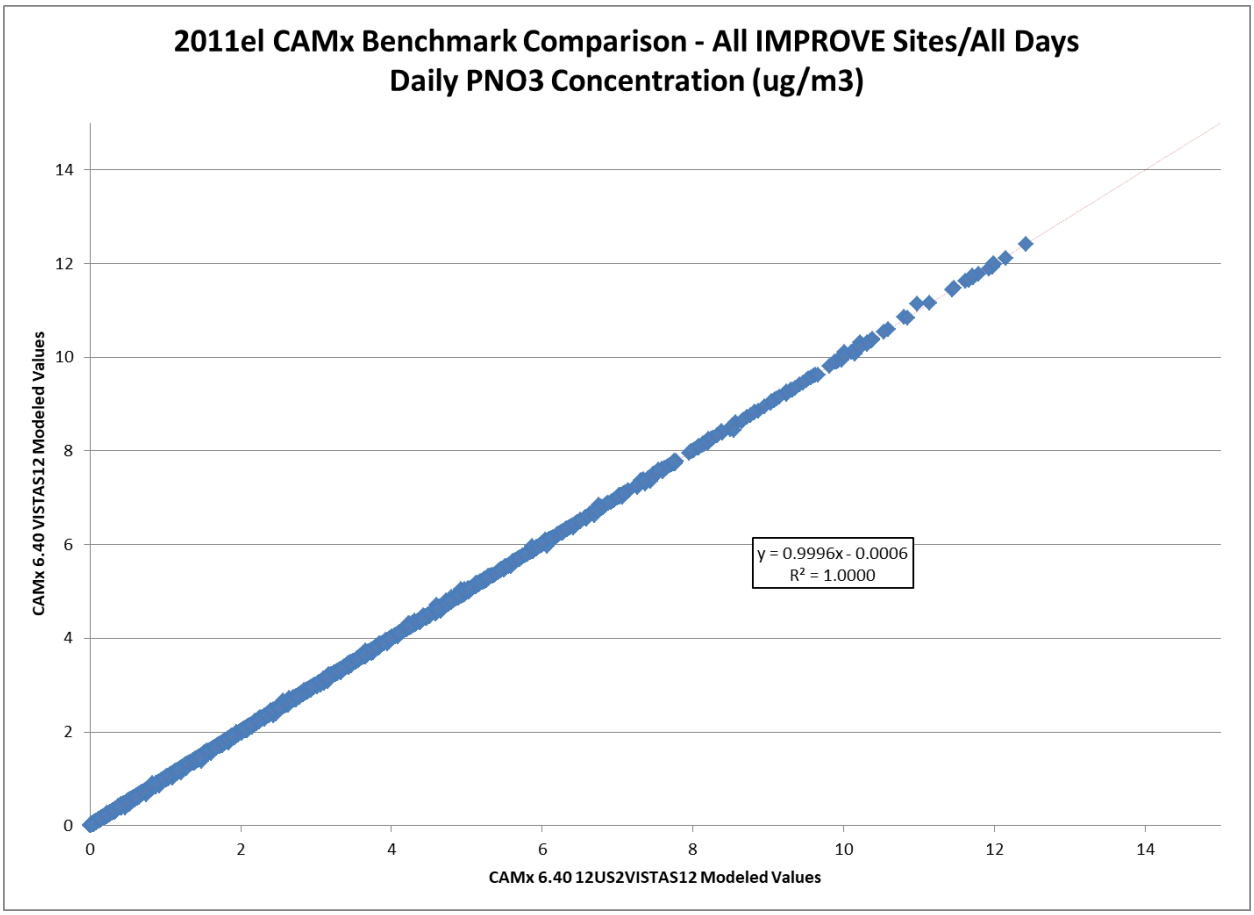


Figure 4-84: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine).

4.5 Organic Matter (OM)

Organic Matter (OM) results for the top 10 positive and negative hours are presented in tabular format in Table 4-5. The maximum positive difference is 296.08 μg/m^3 falling to 161.79 μg/m^3 for the 10th high. The maximum negative difference is -288.20 μg/m^3 falling to -134.56 μg/m^3 for the 10th high. The maximum positive percent difference from these days is 97.4% and negative percent difference of -33.7%.

As expected, the maximum impacts on the top 10 positive and negative hours are occurring very near the border. As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated from the cells outside the VISTAS12 domain. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous concentrations

The top 10 positive difference hours are presented in Figures 4-85 through 4-94 and the top 10 negative impact hours are presented in Tables 4-95 through 4-104. As with sulfate, the peak differences are occurring between July 17 and July 20. The area of the peak impact is very near the northern border, north of Minnesota. This is an area where CAMx simulations are showing very high OC concentrations in an area heavily influenced by boundary conditions.

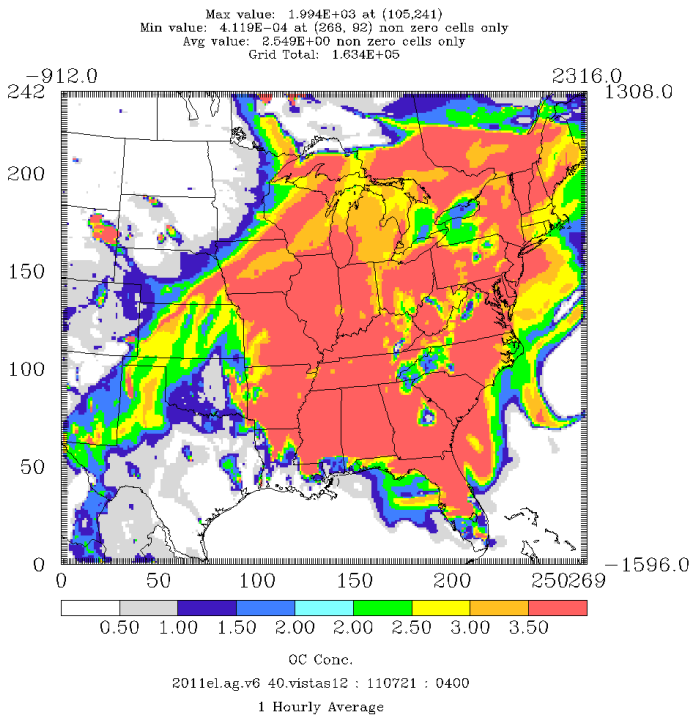
Scatterplots of the daily average OM concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-105. The 12US2 results are plotted on the x-axis and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0004, an intercept of 0.0018 ppb and an R^2 of 1.0000.

Table 4-5. Comparison of 2011el CAMx 6.40 VISTAS12 and 12US2 Simulation of Organic Matter Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	7	21	4	736.29	440.21	296.08	67.3%	104	241
2011	7	20	14	1,262.61	1,025.92	236.69	23.1%	107	241
2011	7	20	15	633.92	422.80	211.12	49.9%	107	241
2011	7	20	11	2,119.48	1911.31	208.17	10.9%	107	241
2011	7	21	3	2,458.44	2,255.90	202.55	9.0%	104	241
2011	7	21	1	1,836.67	1,635.91	200.76	12.3%	104	241
2011	7	20	12	2,333.70	2,150.90	182.79	8.5%	107	241
2011	7	20	23	352.61	178.67	173.94	97.4%	102	241
2011	7	21	0	569.44	397.24	172.19	43.3%	103	241
2011	7	20	9	5,412.65	5,250.86	161.79	3.1%	105	241
Maximum Negative									
2011	7	20	15	3,744.48	3,972.68	-228.20	-5.7%	105	241
2011	7	20	16	3,083.95	3,285.59	-201.65	-6.1%	105	241
2011	7	20	14	3,987.40	4,188.32	-200.92	-4.8%	106	241
2011	7	17	11	396.30	591.67	-195.37	-33.0%	89	241
2011	7	20	13	4,753.09	4,940.52	-187.43	-3.8%	106	241
2011	7	17	12	386.73	562.33	-175.61	-31.2%	89	241
2011	7	20	12	5,974.30	6,147.42	-173.13	-2.8%	106	241
2011	7	19	10	634.35	802.35	-168.00	-20.9%	104	241
2011	7	17	10	335.27	501.88	-166.62	-33.2%	89	241
2011	7	17	9	265.29	399.85	-134.56	-33.7%	89	241

Maximum Positive Difference: July 21 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

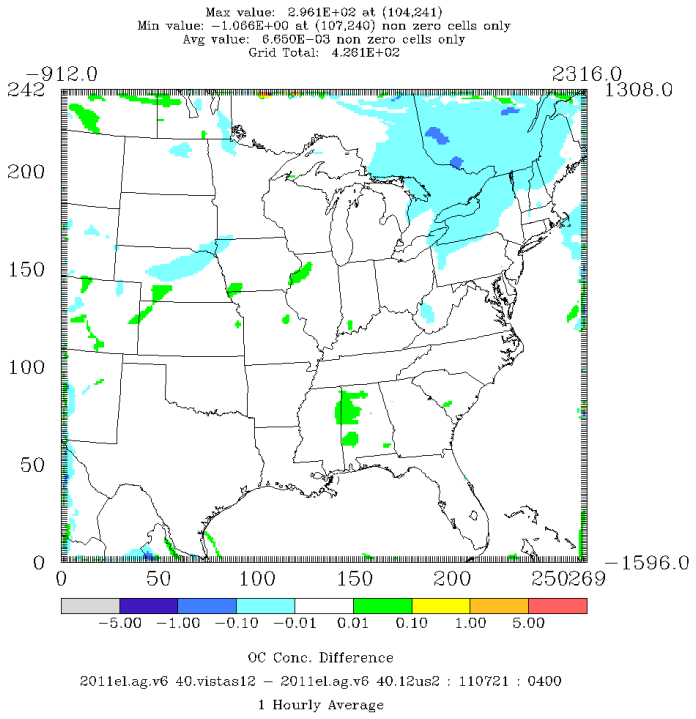
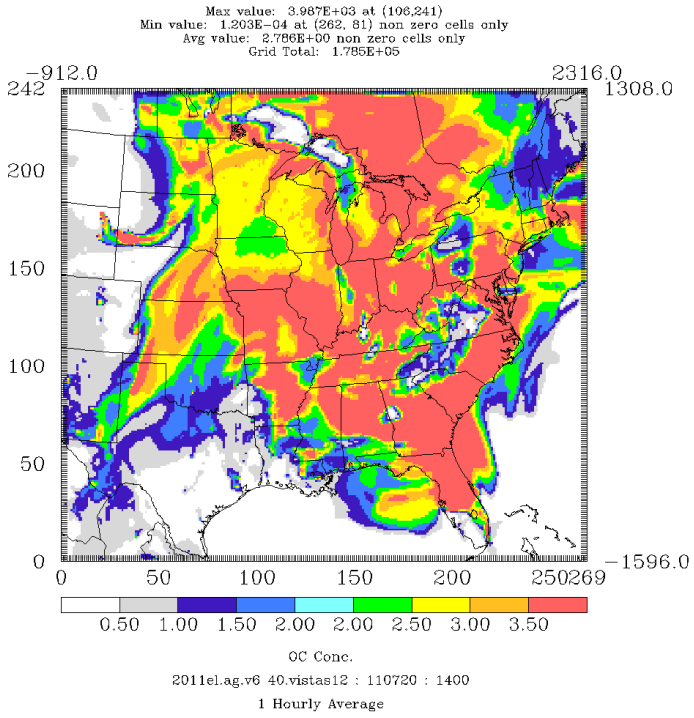


Figure 4-85: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Positive Difference)

Second Highest Positive Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

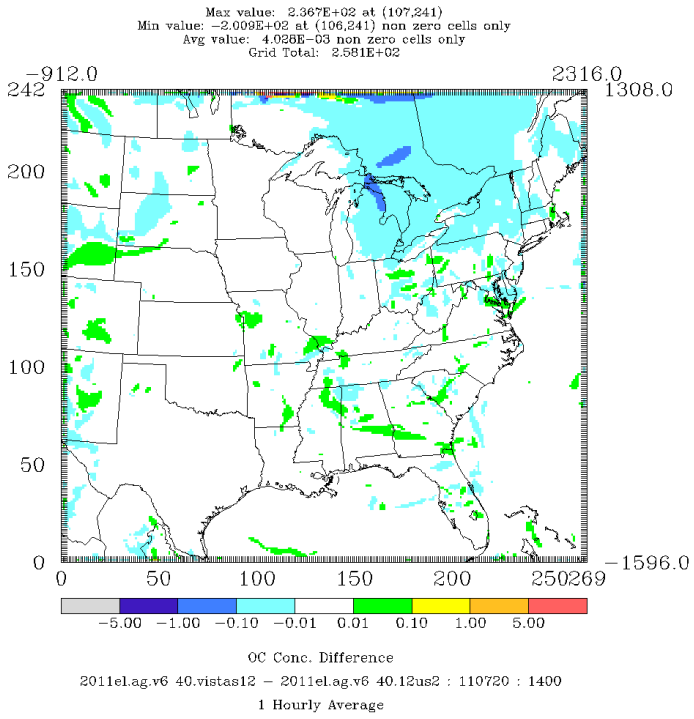
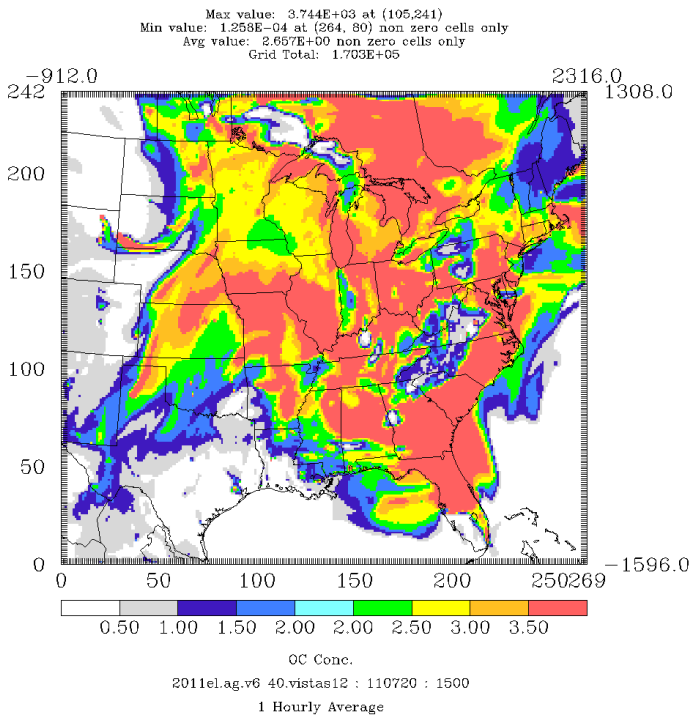


Figure 4-86: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

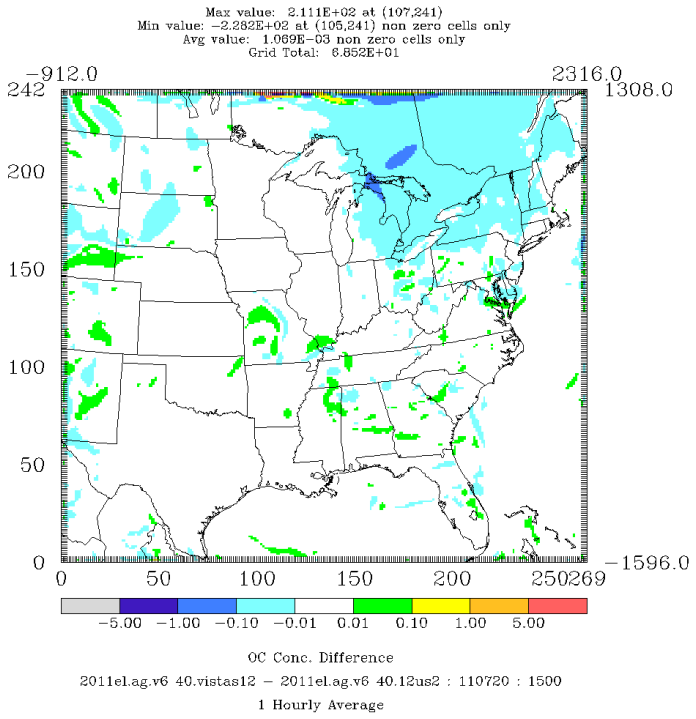
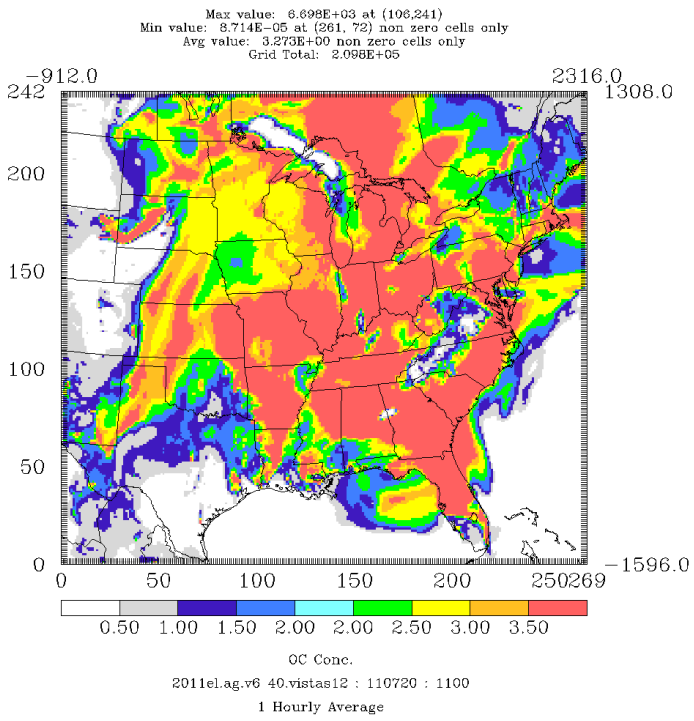


Figure 4-87: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: July 20 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

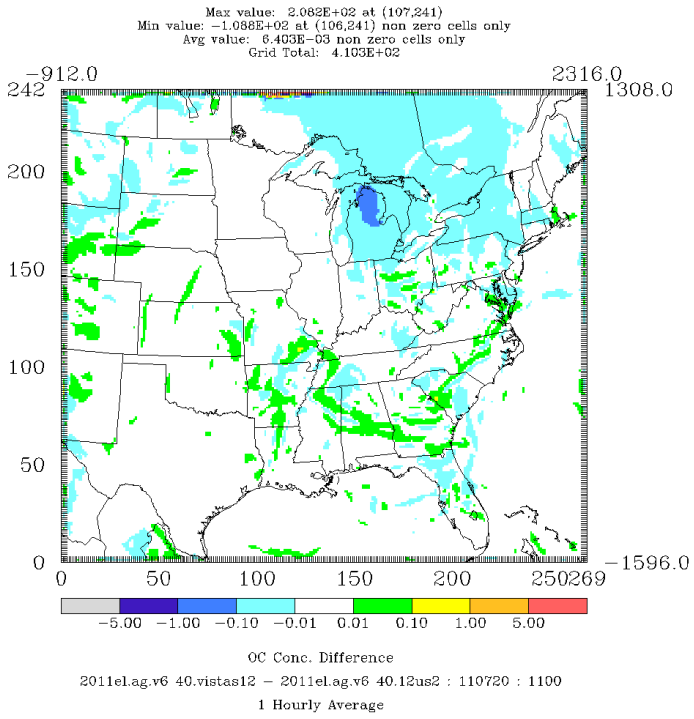
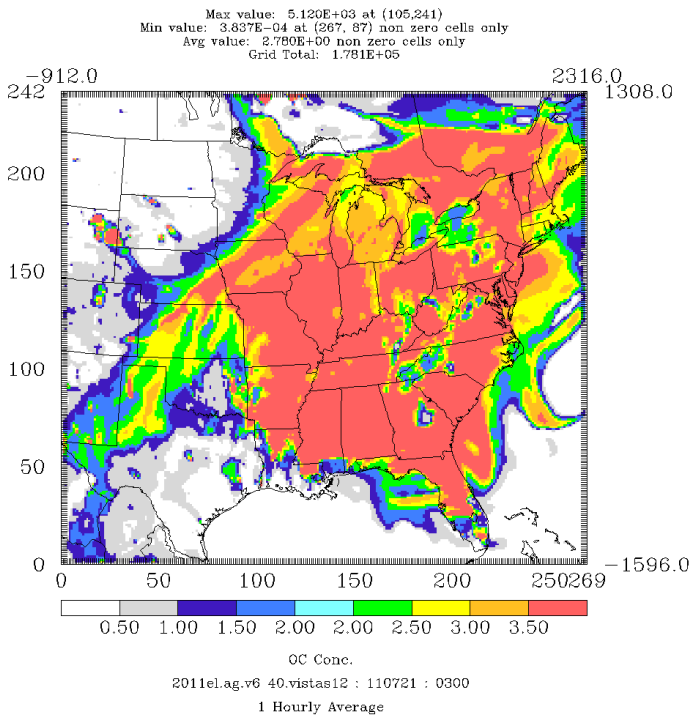


Figure 4-88: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: July 21 at 300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

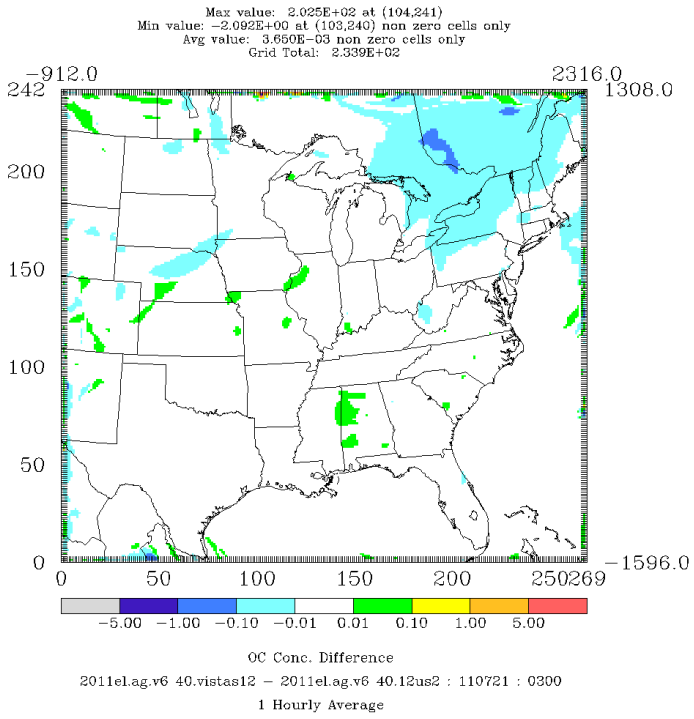
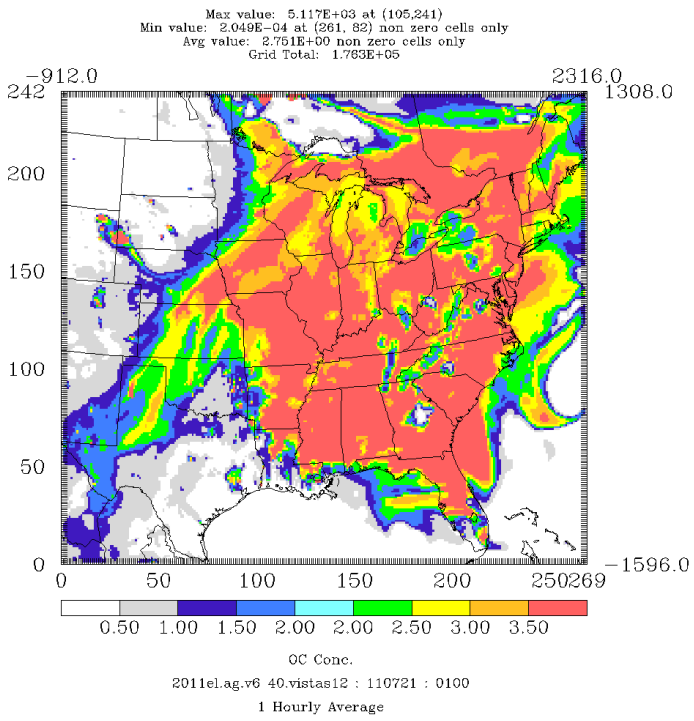


Figure 4-89: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 21 at 100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

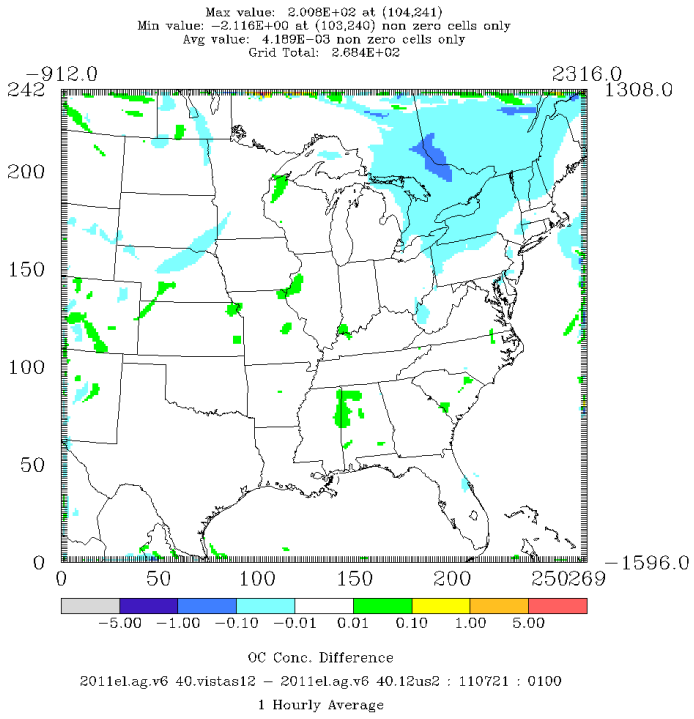
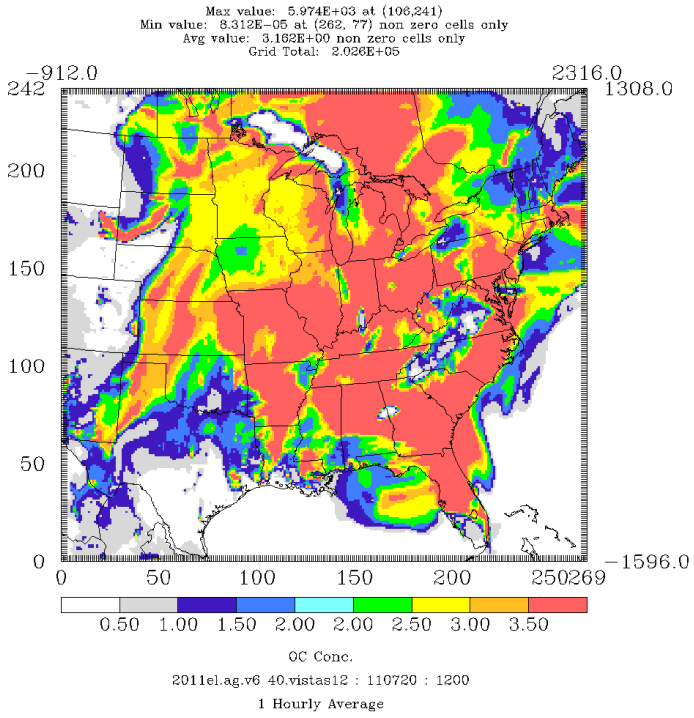


Figure 4-90: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

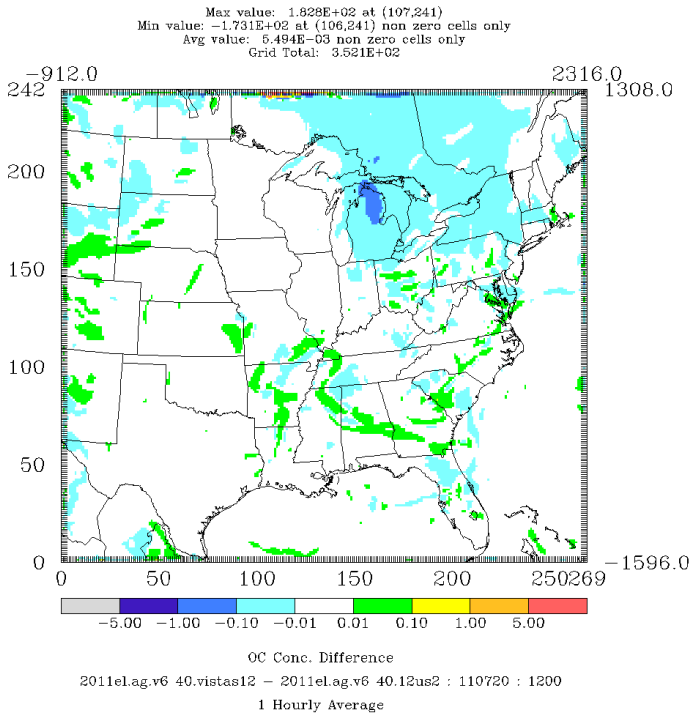
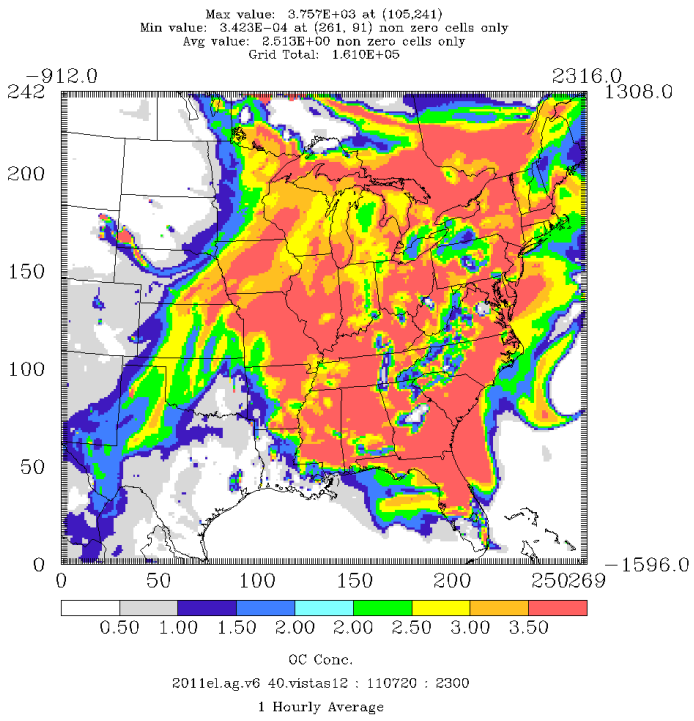


Figure 4-91: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: July 20 at 2300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

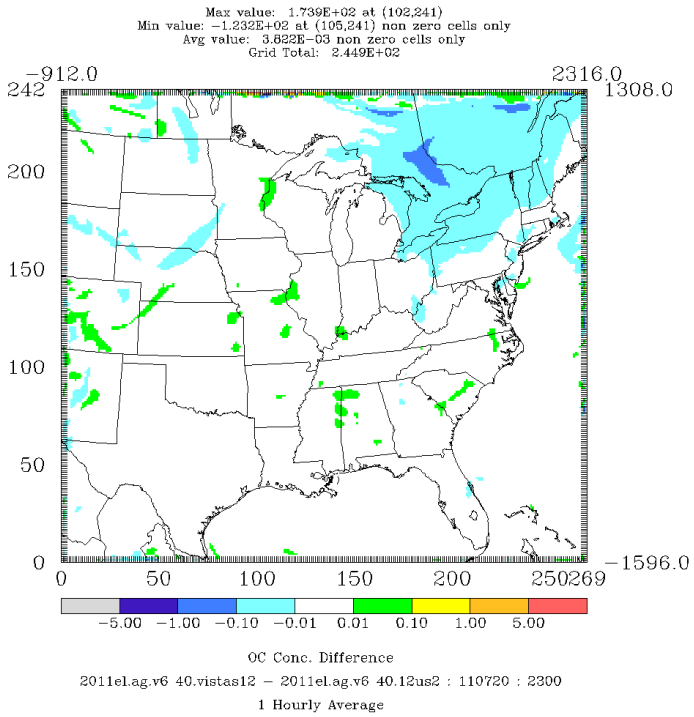
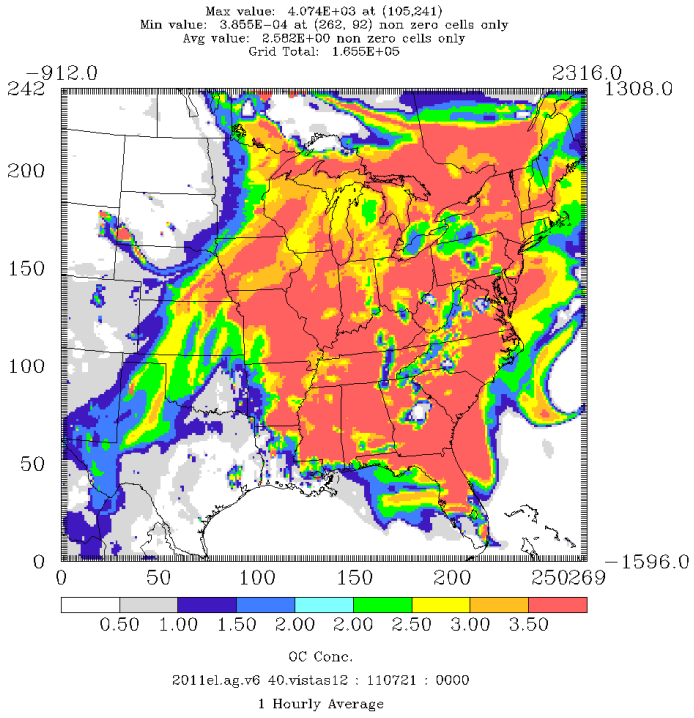


Figure 4-92: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: July 21 at 0000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

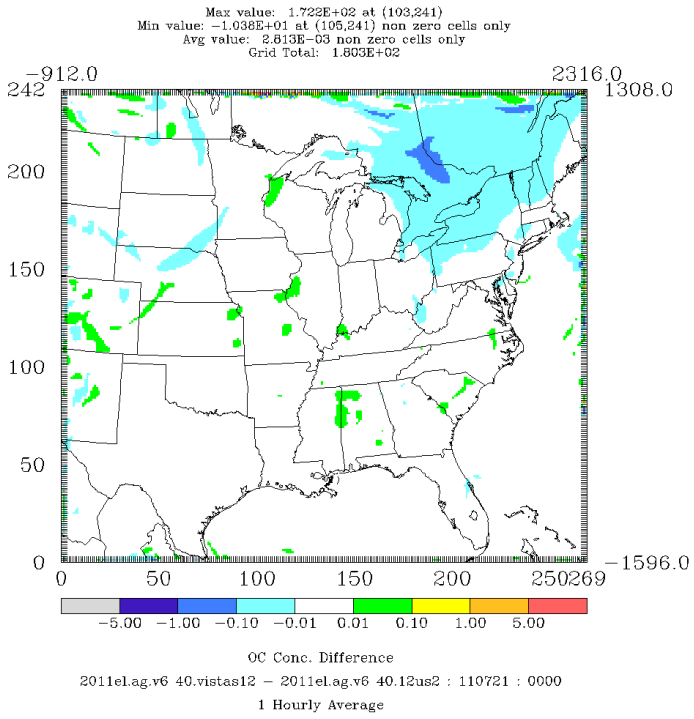
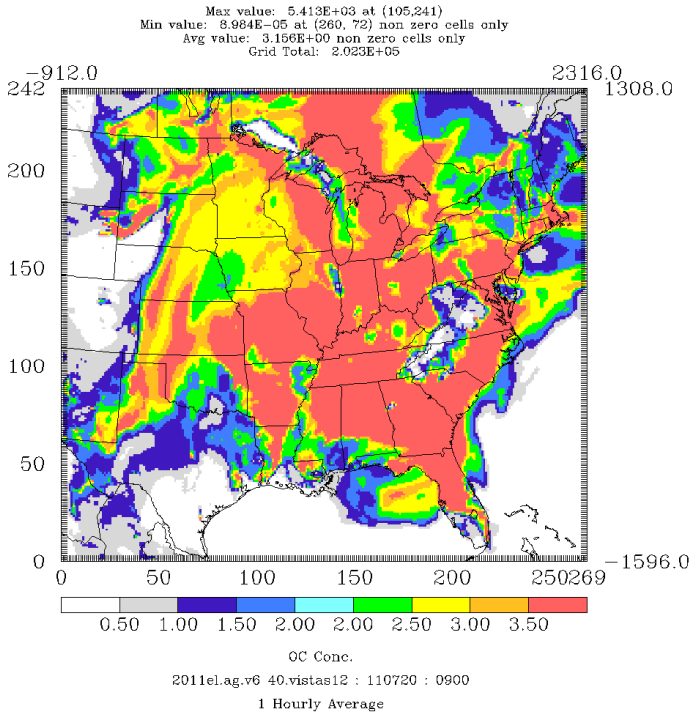


Figure 4-93: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

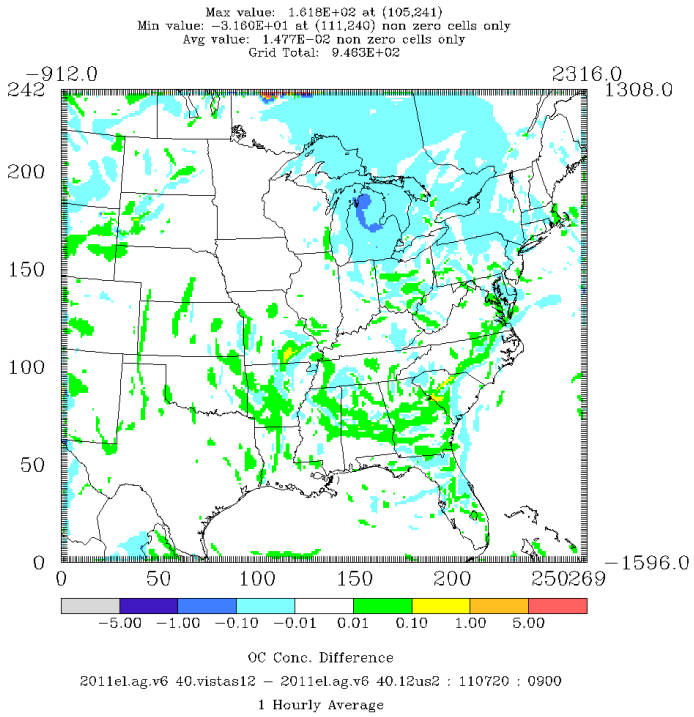
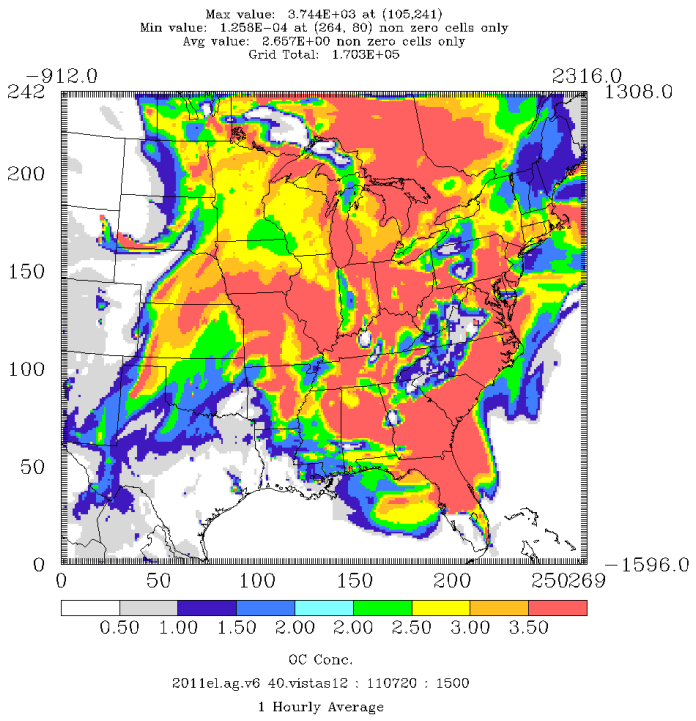


Figure 4-94: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

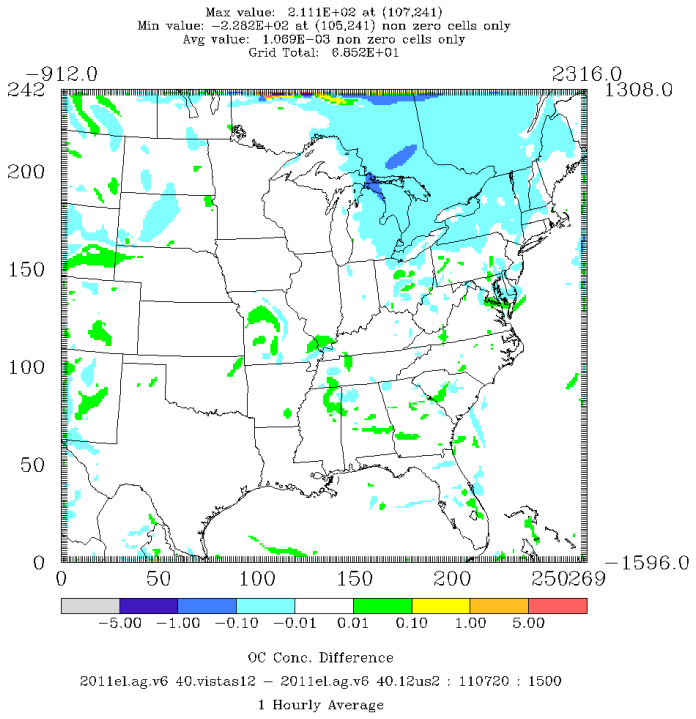
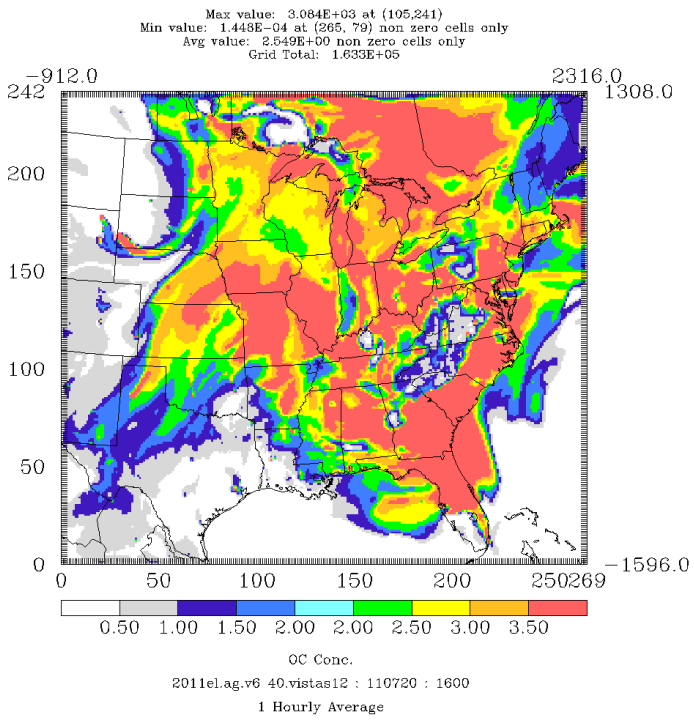


Figure 4-95: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

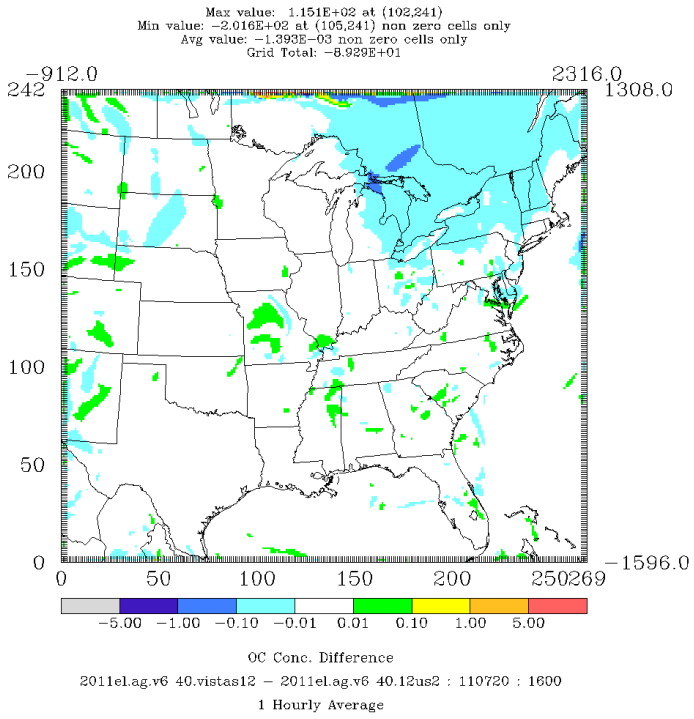
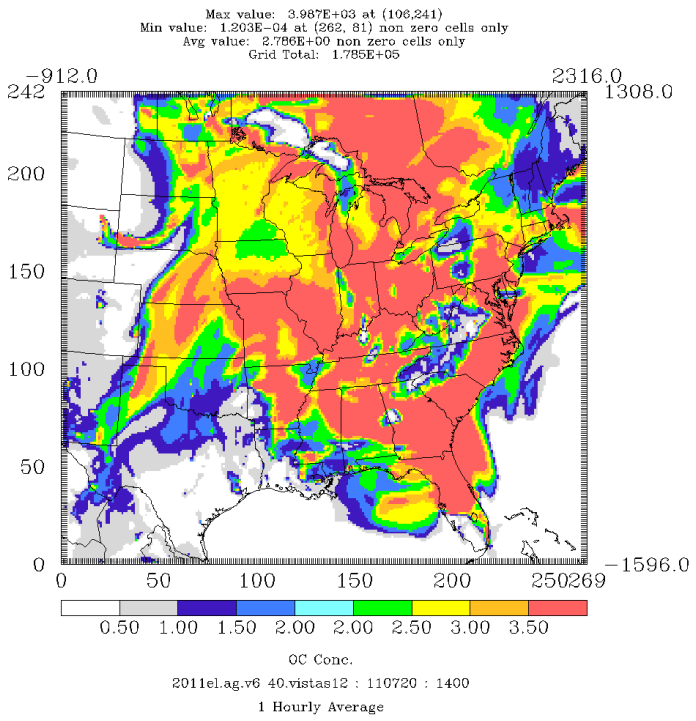


Figure 4-96: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

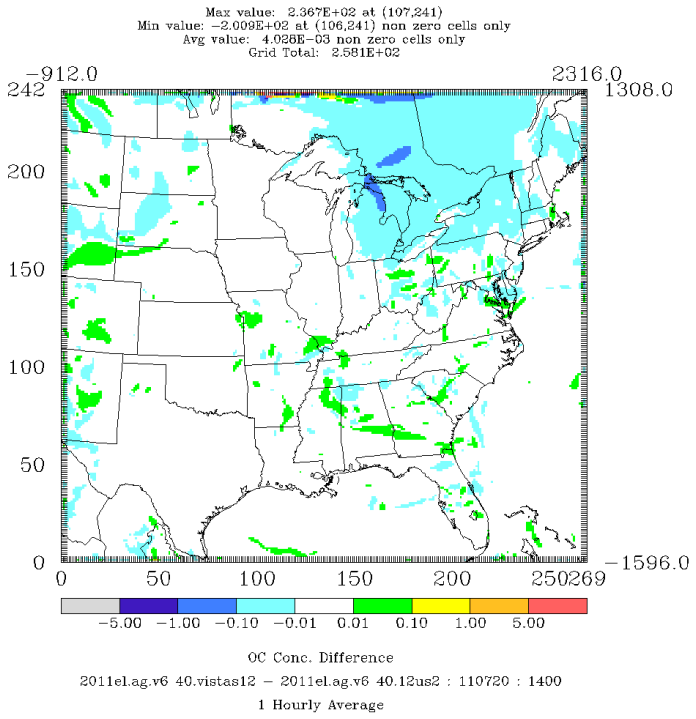
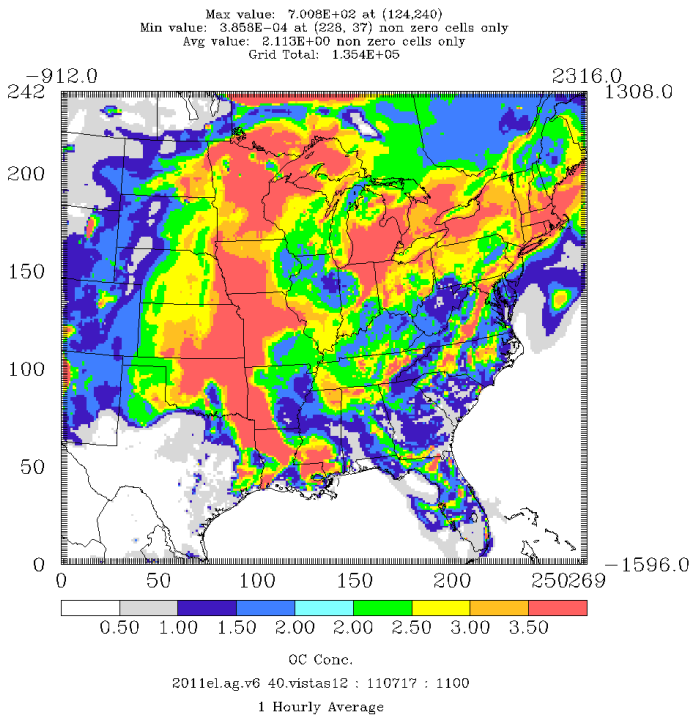


Figure 4-97: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 17 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

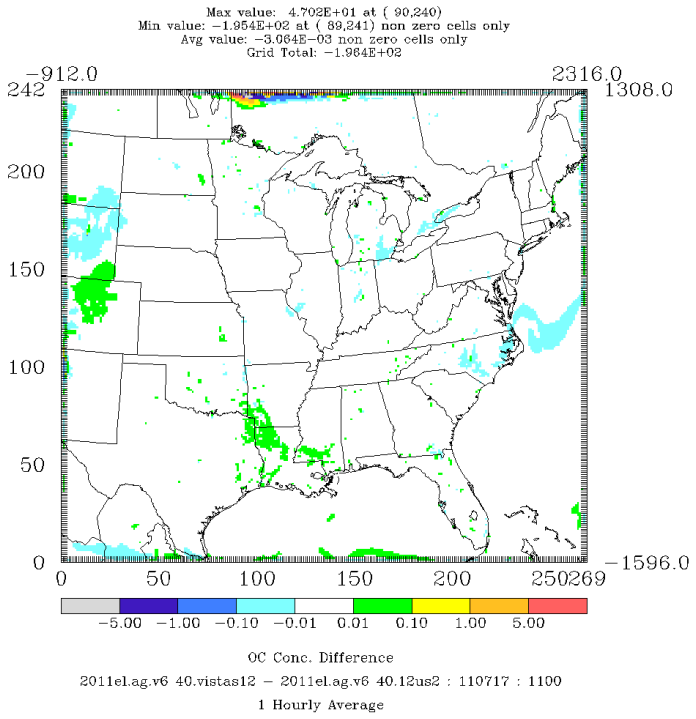
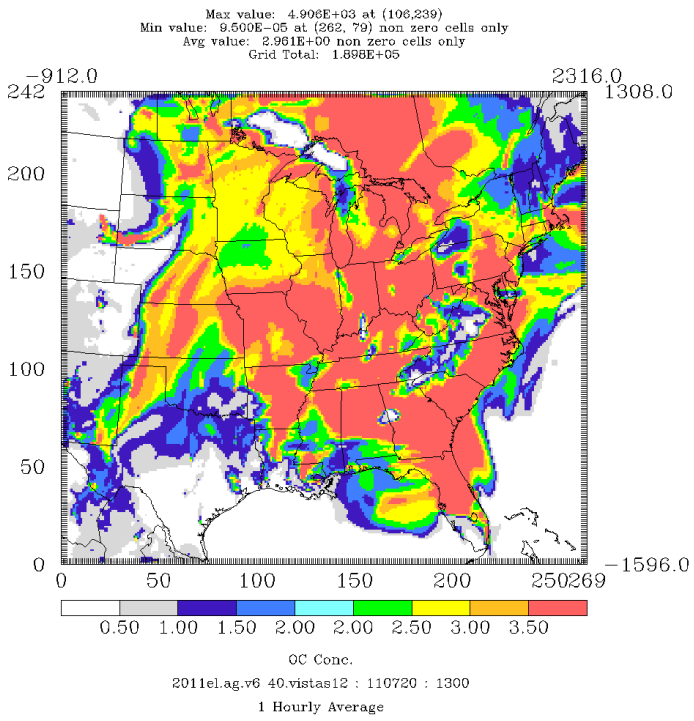


Figure 4-98: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 20 at 1300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

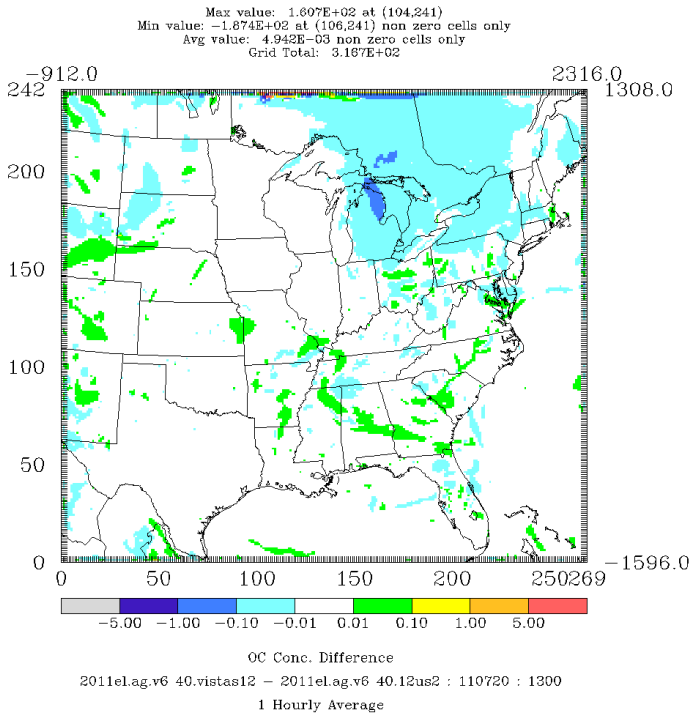
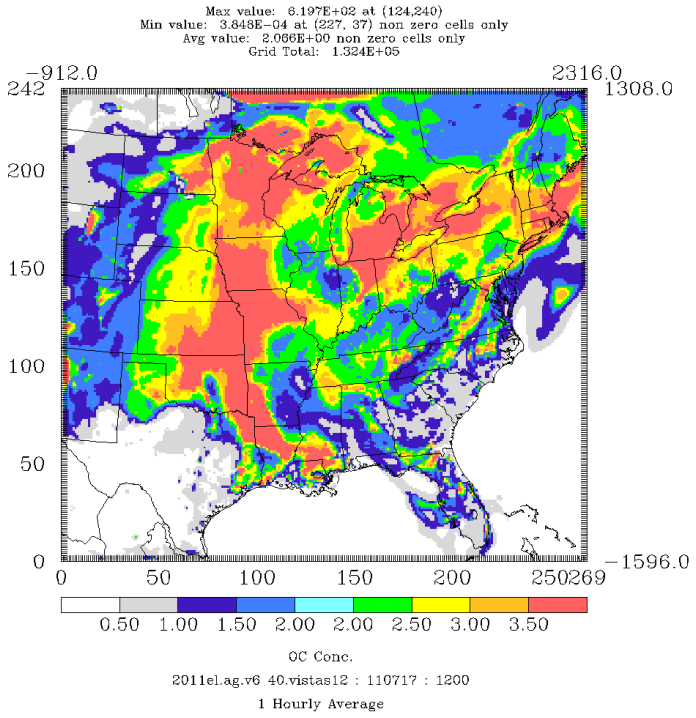


Figure 4-99: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 17 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

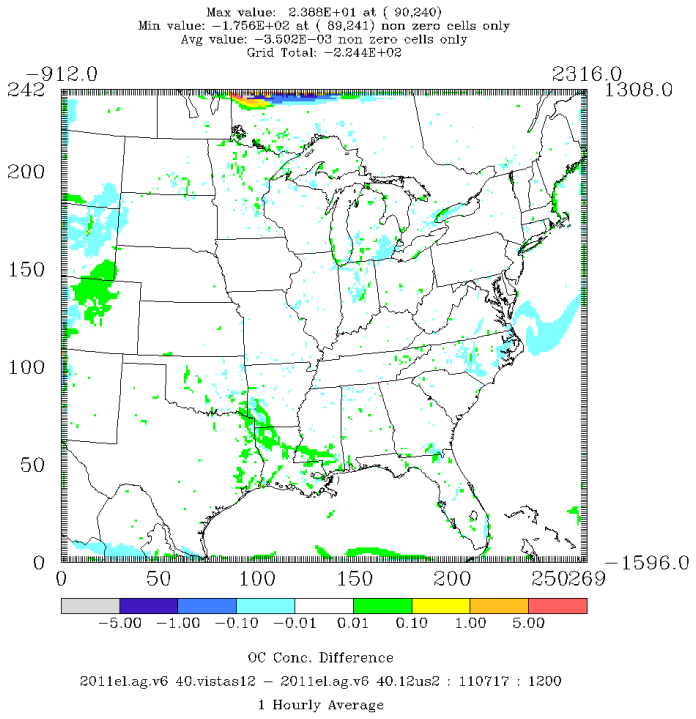
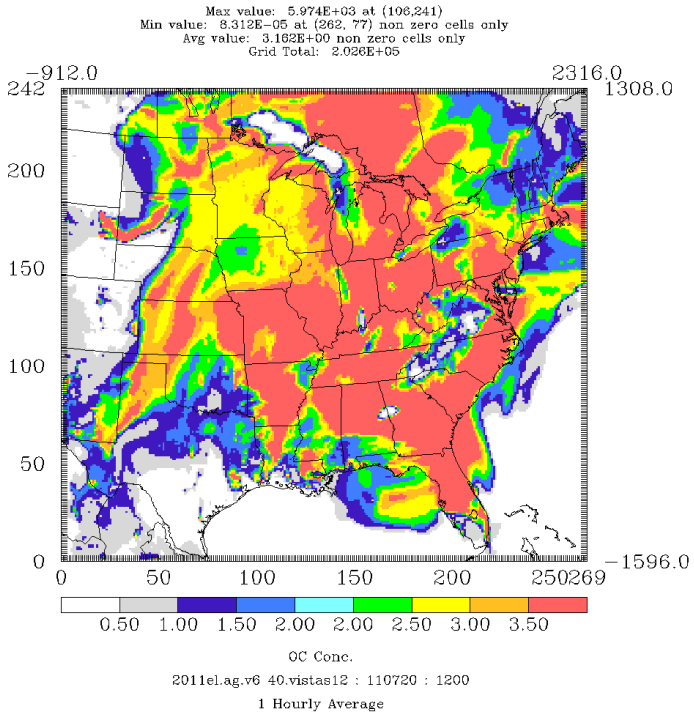


Figure 4-100: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

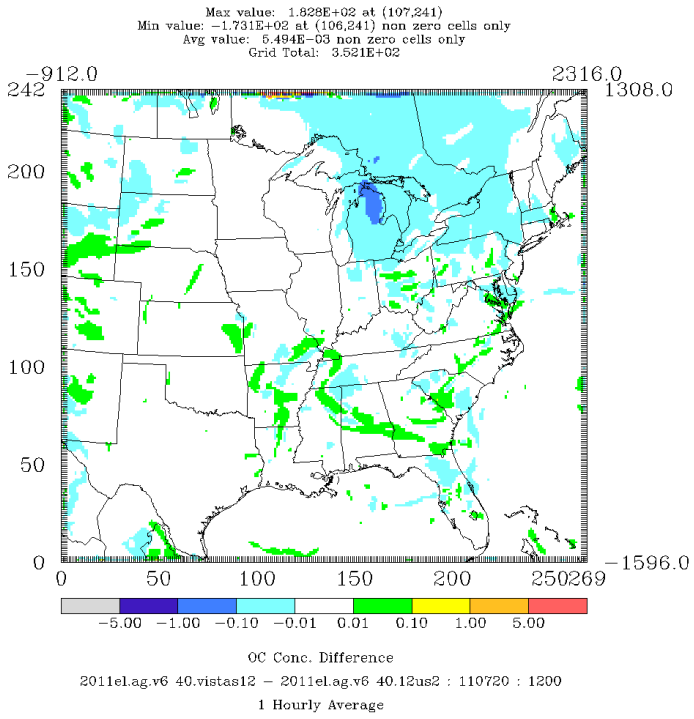
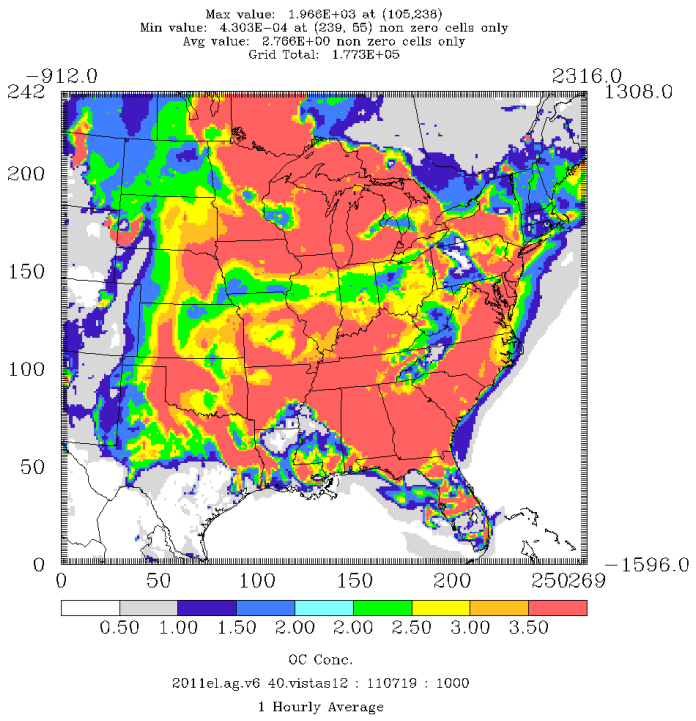


Figure 4-101: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 19 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

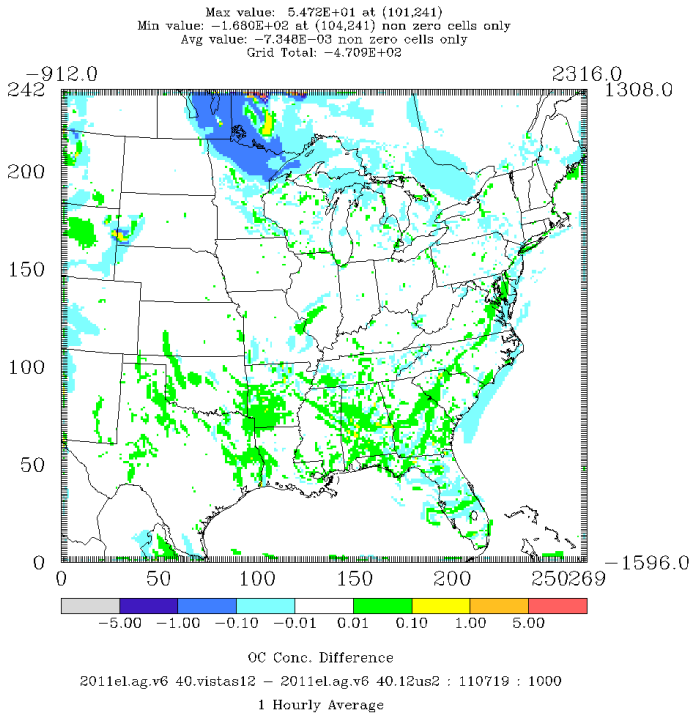
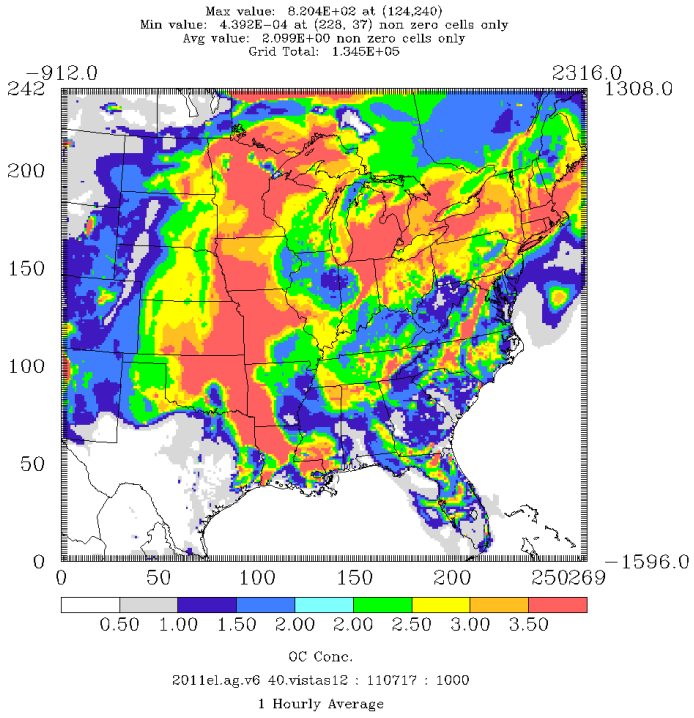


Figure 4-102: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 17 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

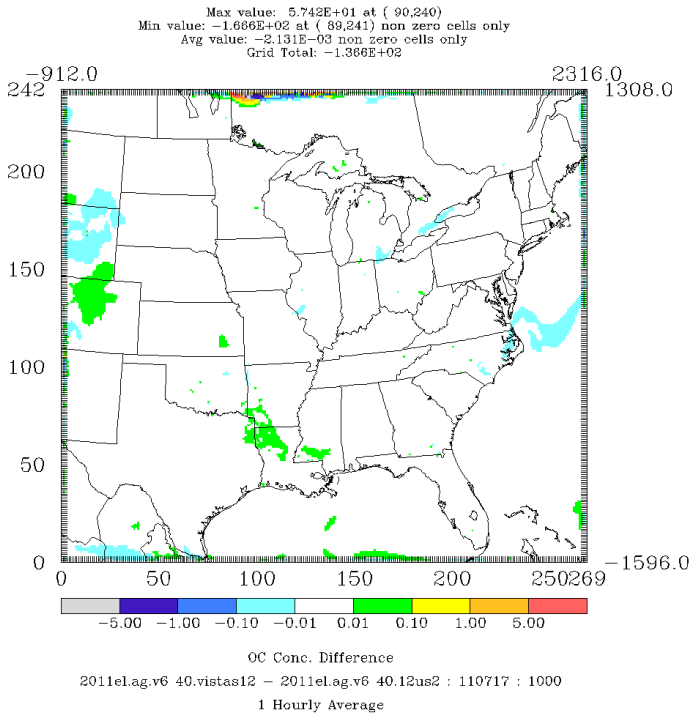
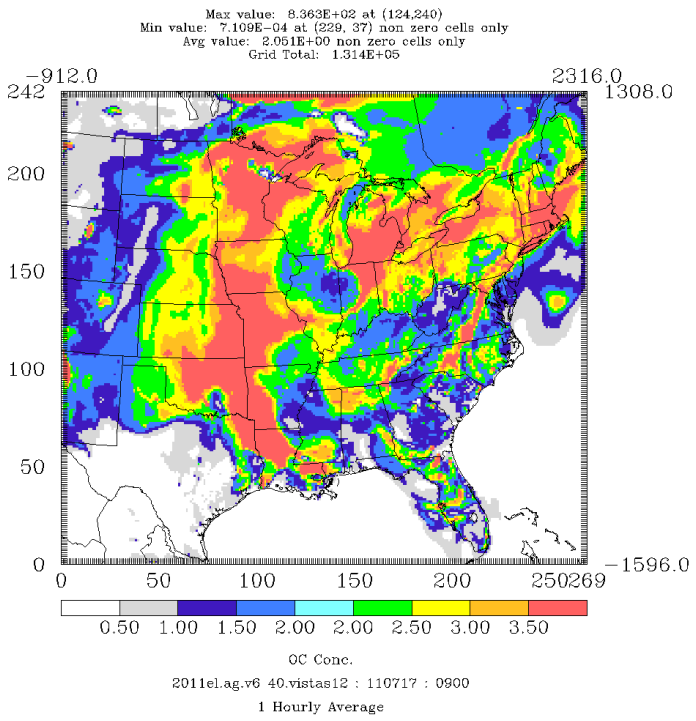


Figure 4-103: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 17 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

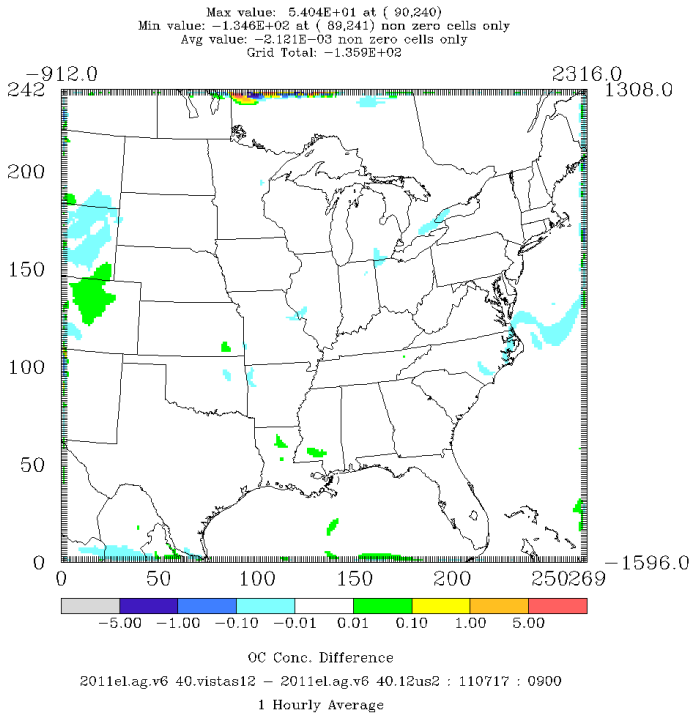


Figure 4-104: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations (Tenth Highest Negative Difference)

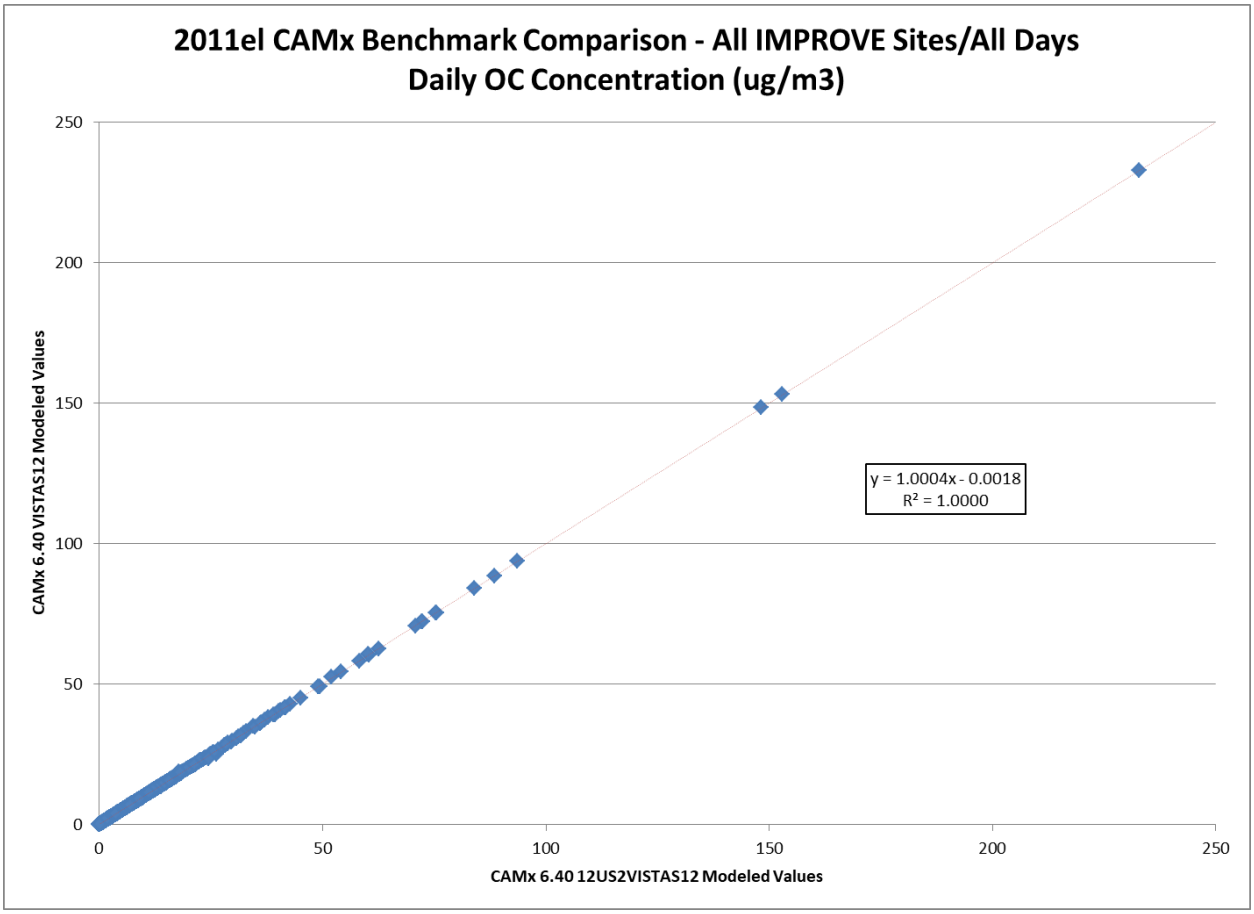


Figure 4-105: Scatterplot Comparing 24-hour Average Predicted Organic Matter Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 domains 2011el Simulations Performed by VISTAS (Alpine).

5.0 CONCLUSIONS

A comparison has been made between CAMx 6.40 simulations using EPA's 2011el modeling platform as performed on the Alpine Geophysics computer system for the VISTAS12 and EPA continental US 12km (12US2) grid. The comparison was conducted for ozone, $PM_{2.5}$, sulfate, nitrate and organic carbon and included an examination both of hourly gridded concentrations and at daily average concentrations at the IMPROVE monitors.

The hourly gridded comparison showed areas of maximum differences along the border with the differences decreasing with distance into the VISTAS12 domain.

Two issues have been identified that have noted impact on the use of the VISTAS12 domain relative to the 12US2 domain. The first, and likely the most significant issue is a time-step difference at the boundary where concentration conditions from outside of the domain are injected into the modeling domain at one hour intervals compared to the model generated (sub-hourly) time-step interval within the modeling domain. These differences can create initial, significant concentration gradients along the boundary that can be carried through the episode and transported to grid cells within the modeling domain. The second issue is related to the time step in the model. The time step is determined by the maximum wind in the modeling domain. If the highest wind in the 12US2 domain occurs somewhere outside the VISTAS12 domain, the time step in the 12US2 simulation will be longer than in the VISTAS12 domain.

We note that in modeling the VISTAS12 domain with 12US2 boundary conditions, both of these issues are exacerbated in the modeling due to large emission sources located near the boundary of the 12US2/VISTAS12 boundary.

A comparison of the daily average concentrations at the IMPROVE monitors showed very small differences with an R^2 of 1.0000 for all pollutants.

Alpine does not see any features in the modeling that would preclude the use of the VISTAS12 modeling domain for use in the VISTAS air quality planning, yet recognizes the impacts related to the current configuration of the VISTAS12 domain and issues related to border grid cells. While the analysis at the IMPROVE monitors has shown that the impact is

negligible at the IMPROVE monitors, if these differences are unacceptable to SESARM, SESARM should consider using the 12US2 domain for regional haze modeling.

This page is intentionally blank.

Appendix E-2d

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project 2028 CAMx Version 6.32 and 6.40 Comparison Report

Benchmark Run #4

August 17, 2020

This page intentionally left blank.

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project
2028 CAMx Version 6.32 and 6.40 Comparison Report

Task 6 Benchmark Report #4
Covering Benchmark Run #4

Prepared for:

Southeastern States Air Resource Managers, Inc. (SESARM)

205 Corporate Center Drive, Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final – August 17, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 INTRODUCTION 1
1.1 Overview 1
1.2 2028 CAMx 6.32 and CAMx 6.40 Comparison 3
2.0 DIFFERENCES BETWEEN CAMX 6.32 AND 6.40 SIMULATIONS 3
2.1 Model Code Differences 3
2.2 Configurations Difference 4
2.3 Emissions Differences 5
3.0 CONFIRMATION METHODOLOGY 5
3.1 CAMx Species Mapping 6
4.0 CAMX 6.32 2028EL AND CAMX 6.40 2028ELV3 COMPARISON 7
4.1 Emissions 7
4.2 Annual $PM_{2.5}$ Design Value 25
4.3 24-Hour (Daily) $PM_{2.5}$ Design Value 34
4.4 Scatterplots of Ozone and PM Species Concentrations 42
5.0 CONCLUSIONS 49

This page is intentionally blank.

TABLES

Table 3-1. Species Mapping from CAMx into Aggregated Species 6

Table 4-1. Comparison of 2028el CAMx 6.32 and 2028elv2/v3 CAMx 6.40 Annual Emissions 8

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for FRM Monitors in VISTAS States 26

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values ($\mu g/m^3$) 35

FIGURES

Figure 4-1. Comparison of Elevated NO_X Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations 9

Figure 4-2. Comparison of Elevated VOC Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations 10

Figure 4-3. Comparison of Elevated PEC Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations 12

Figure 4-4. Comparison of Elevated PNH4 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations 13

Figure 4-5. Comparison of Elevated PNO3 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations 14

Figure 4-6. Comparison of Elevated POA Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations 15

Figure 4-7. Comparison of Elevated PSO4 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations 16

Figure 4-8. Comparison of Low Level NO_X Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations 17

Figure 4-9. Comparison of Low Level VOC Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations 18

Figure 4-10. Comparison of Low Level SO_2 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations 19

Figure 4-11. Comparison of Low Level PEC Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations 20

Figure 4-12. Comparison of Low Level PNH4 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations 21

Figure 4-13. Comparison of Low Level PNO3 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations 22

Figure 4-14. Comparison of Low Level POA Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations 23

Figure 4-15. Comparison of Low Level PSO4 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations 24

Figure 4-16. Comparison of Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations 32

Figure 4-17. Scatterplot Comparing Annual Average Predicted $PM_{2.5}$ Design Values ($\mu g/m^3$) at all Monitor Locations for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations Performed by VISTAS (Alpine) 33

Figure 4-18. Comparison of Daily $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations 40

Figure 4-19. Comparison of Daily $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations 41

Figure 4-20. Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine) 42

Figure 4-21. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine) 43

Figure 4-22. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine); Modified Scale 44

Figure 4-23. Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine) 45

Figure 4-24. Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine) 46

Figure 4-25. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine) 47

Figure 4-26. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine); Modified Scale 48

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
CAMx	Comprehensive Air Quality Model with Extensions
dv	Deciview
DV	Design Value
EGU	Electric Generating Unit
EPA	Environmental Protection Agency
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee
FLM	Federal Land Manager
FR	Federal Register
IPM	Integrated Planning Model
km	kilometer
$\mu g/m^3$	microgram per cubic meter
NAAQS	National Ambient Air Quality Standard
NO_x	Oxides of nitrogen
OAQPS	Office of Air Quality Planning and Standards
O_3	Ozone
OC	Organic carbon
OSAT	Ozone Source Apportionment Technology
PEC	Primary elemental carbon
PM	Particulate matter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Particulate ammonium
PNO3	Particulate nitrate
POA	Primary Organic Aerosol
PSAT	Particulate Source Apportionment Technology
PSO4	Particulate sulfate
R^2	Pearson correlation coefficient squared
RADM-AQ	Regional Acid Deposition Model – aqueous chemistry
RHR	Regional Haze Rule
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SMAT-CE	Software for Model Attainment Test – Community Edition
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
tpy	Tons per year
U.S.	United States
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast
VOC	Volatile organic compounds

This page is intentionally blank.

1.0 INTRODUCTION

1.1 Overview

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States (U.S.) Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone (O_3) as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.

B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that is, the focus of state planning will be to establish reasonable progress goals for each Class I area against which progress will be measured during the second planning period. This extension will allow states to incorporate planning for other Federal programs while conducting their regional haze planning. These other programs include: the Mercury and Air Toxics Standards, the 2010 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview (dv) index values. "Most impaired days" are defined as the 20% of

monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

1.2 2028 CAMx 6.32 and CAMx 6.40 Comparison

Recent EPA 2011el and 2028el platform simulations were performed with the Comprehensive Air Quality Model with Extensions (CAMx) version 6.32. Since that time the CAMx model has been updated to include better physical treatment, and to correct any model flaws that were discovered after the release of 6.32.

Under subcontract to Eastern Research Group, Inc, (ERG), Alpine Geophysics, LLC (Alpine) has executed two air quality simulations for the 2028el projection year modeling platform; one run with CAMx 6.32 and one with CAMx 6.40. We note that CAMx 6.50 has now been released, however that model release was too late to be included with sufficient certainty in the VISTAS II project schedule.

This comparison is to document the differences in model estimates between 2028el simulated with CAMx 6.32 and 2028elv3 CAMx 6.40 as is discussed in the VISTAS II Modeling Protocol[2] in Section 6.5.2 model comparison number 4.

2.0 DIFFERENCES BETWEEN CAMX 6.32 AND 6.40 SIMULATIONS

Differences in modeled output concentrations between the 2028el CAMx 6.32 and 2028elv3 6.40 simulations were as a result both of changes to the CAMx model code, changes to the model configuration and changes to the emissions inventory.

2.1 Model Code Differences

Many updates to the CAMx model were implemented between the 6.32 and 6.40 release. According to the CAMx 6.40 release notes, the significant changes included:

[2] "Regional Haze Modeling for Southeastern VISTAS II Region Haze Analysis Project, Final Modeling Protocol." Prepared for SESARM under Contract No. V-2018-03-01. Prepared by Alpine Geophysics, LLC and Eastern Research Group, Inc. June 27, 2018.

1. Updates to the chemistry to include a condensed halogen mechanism for ocean-borne inorganic reactive iodine, hydrolysis of isoprene-derived organic nitrate and SO_2 oxidation on primary crustal fine particulate matter (PM). This update includes the changes to the Ozone and Particulate Source Apportionment Technology (OSAT/PSAT) algorithms;

2. Inclusion of in-line inorganic iodine emissions to support halogen chemical mechanisms;

3. A major revision to the secondary organic aerosol partitioning (SOAP) secondary algorithm;

4. Updates to the Regional Acid Deposition Model – aqueous chemistry (RADM-AQ) algorithm; and

5. A major revision to the wet deposition algorithm to identify assumptions or processes that were unintentionally or otherwise unreasonably limiting gas and PM update into precipitation. The wet deposition algorithm was simplified and improved in several ways, resulting in the increased scavenging of gases and PM.

2.2 Configurations Difference

In addition to the model version, the CAMx 6.32 and 6.40 simulations contained differences in the EPA modeling platform that had been made subsequent to the 2011el/2028el model release. In the most current 2023en simulation, EPA developed new photolysis rates and ozone column data. These updates were included in the updated modeling platform and resulting CAMx 6.40 simulation and were consistent with those used in the VISTAS II 2011el simulations.

Another configuration difference is how the boundary conditions were mapped for speciation in the two versions of the model. EPA and the VISTAS CAMx 6.32 and 6.40 simulations all used the same boundary condition files. However, when CAMx was updated from 6.32 to 6.40 the species in the secondary organic aerosol (SOA) scheme changed. The SOA5, SOA6, and SOA7 were removed and SOA3 and SOA4 were redefined. Neither EPA nor

this study remapped the boundary conditions to account for this change. EPA examined the regional haze summary data for all Class I areas and found the total organic carbon (OC) species (not just SOA) accounted for 1-5% of the boundary condition impairment at the Southeastern Class I areas.[3] This is a small impact on regional haze and the impact of SOA on regional haze is even smaller.

2.3 Emissions Differences

Finally, there are notable emissions inventory differences used in the modeling by SESARM compared to EPA's 2028el modeling platform. SESARM updated the 2028 emissions inventory used in this analysis (2028elv2) with changes to both electric generating unit (EGU) and non-EGU point source emissions. A summary of the emission differences are presented in the Task 2 emissions inventory report[4] for this study and summarized in Section 4.1.

3.0 CONFIRMATION METHODOLOGY

The presented comparison of model simulations are based on annual and 24-hour $PM_{2.5}$ design values as generated from the output of the two 12US2-based simulations; CAMx 6.32 with 2028el and CAMx 6.40 with 2028elv2 emissions. This report does not compare hourly concentrations for each PM species as the model version, platform configuration and processing methods, and the underlying projection year emissions inventories differ significantly between the two model runs making it difficult, if not impossible, to determine the cause of any differences seen in concentrations. We also provide a comparison of gridded 12-kilometer (km) annual elevated and low level emissions for the domain. The metric for comparison of the design values are the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$(C_{6.40} - C_{6.32})$$

(Equation 2) $$\frac{(C_{6.40} - C_{6.32})}{(C_{6.32})}$$

Where $C_{6.40}$ is the design value at each receptor for the CAMx 6.40 simulation and $C_{6.32}$ is the design value at each receptor for the CAMx 6.32 simulation. The order of the comparison

[3] Brian Timin, EPA Office of Air Quality Planning and Standards (OAQPS) personal communication October 11, 2018.
[4] Southeastern States Air Resource Managers, Inc. "Southeastern VISTAS II Regional Haze Analysis Project - Task 2 Emission Inventory Report." Prepared by Eastern Research Group, Inc. under Contract V-2018-03-01. Revised Final. August 28, 2018.

variables differs from earlier benchmark reports as the intention of this report is to confirm appropriate use of the CAMx 6.40 configuration as compared to the CAMx 6.32 configuration and therefore by using the switched order, we give more weight to the CAMx 6.40 run. For the emission comparison plots, only Equation 1 results were calculated for each grid cell and plotted for review.

The results are presented for each receptor in the VISTAS states within the larger 12US2 domain for each of the two design values. Spatial maps are presented for the domain as a whole. On each spatial emissions difference plot presented, the maximum positive and negative values, along with the grid cell in which these occur, are presented at the top of the graphic. The coordinates refer to the row and columns of the cell referenced to the cell coordinates on the bottom (column) and left (row) of the graphic.

Scatterplots of the daily average concentrations of ozone and the various calculated PM species in local standard time at the Interagency Monitoring for Protected Visual Environment (IMPROVE) monitors across all modeled days are also presented with the CAMx 6.40 results plotted on the x-axis and the CAMx 6.32 results plotted on the y-axis.

3.1 CAMx Species Mapping

Updates to the CAMx model between version 6.32 and 6.40 necessitated making changes to how the individual CAMx species were aggregated to the presented species. The CAMx species mapping between the two compared versions are presented in Table 3-1.

Table 3-1. Species Mapping from CAMx into Aggregated Species

Aggregated Species	CAMx 6.32 Species	CAMx 6.40 Species
Ozone	O3	O3
$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
Sulfate	PSO4	PSO4
Nitrate	PNO3	PNO3
Organic Matter (OM)	SOA1+SOA2+SOA3+SOA4+SOA5+SOA6+SOA7+SOPA+SOPB+POA[1]	SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA

[1] SOAH was not included in the 6.32 comparison since it was not included as an output species in the EPA simulation.

4.0 CAMX 6.32 2028EL AND CAMX 6.40 2028ELV3 COMPARISON

This section presents comparisons of the simulations using CAMx 6.32 2028el and CAMx 6.40 2028elv3 performed on the Alpine computer system. Emissions presented are the post-processed results of the Sparse Matrix Operator Kernel Emissions (SMOKE) emissions tool, including oxides of nitrogen (NO_X), volatile organic compounds (VOC), and speciated $PM_{2.5}$ components (e.g., particulate nitrate (PNO3), particulate sulfate (PSO4), etc.) for elevated and low level sources. Annual and 24-Hour $PM_{2.5}$ design values are the result of running each of the model platforms through the Software for the Modeled Attainment Test - Community Edition (SMAT-CE) tool to generate receptor-level values.

4.1 Emissions

Annual emission summaries have been prepared from the model-ready input files for both elevated and low level sources. Elevated sources include all CEM-based emissions in the modeling platform, non-EGU point sources with explicit latitude and longitude release coordinates and calculated plume rise greater than or equal to twenty (20) meters, emissions from wildfires, and international commercial marine emissions not otherwise associated with specific U.S. states. Low-level sources are comprised of all other anthropogenic source types including non-EGU point sources with a calculated plume rise of less than twenty (20) meters, agricultural and prescribed fires, biogenic and other natural source emissions, and commercial marine emissions associated with sources assigned to specific U.S. states. Results presented include maps of the 12US2 domain with annual emissions (tons per year) and emission differences by grid cell and pollutant. Table 4-1 presents summary results by pollutant over the entire 12US2 domain for elevated and low level comparisons. Figures 4-1 through 4-7 present the annual emissions and emission differences for elevated sources by pollutant in the 12US2 modeling domain. Figures 4-8 through 4-15 present annual emissions and emission differences for low level sources, by pollutant, in the 12US2 modeling domain.

As expected with the changes in emission inventories between the EPA 2028el and SESARM 2028elv2 platforms, we see the largest changes in elevated (point source) emissions largely concentrated in the southeastern sector of the modeling domain with scattered differences in other regions. These changes are related to the replacement of 2028 Integrated Planning Model (IPM) EGU emissions with 2028 Eastern Regional Technical Advisory Committee

(ERTAC) EGU emissions in the 2028elv2 emissions platform. These differences are consistent with the emission inventory changes documented[4] for this project. Low-level emission changes are also seen predominantly in the VISTAS states for areas where emission inventory modifications were applied for this analysis with scattered changes elsewhere due to the replacement of IPM with ERTAC as noted above. Note that as a result of reprocessing the 2028elv2 elevated emissions to correct an earlier omission, results are reported in this document 2028elv3 where appropriate.

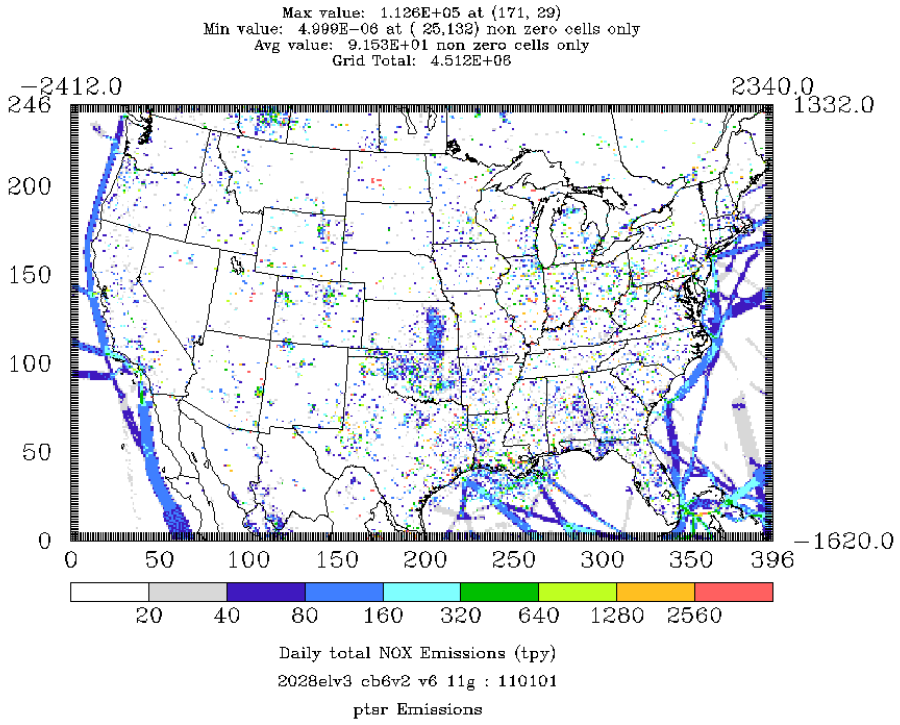
Table 4-1. Comparison of 2028el CAMx 6.32 and 2028elv2/v3 CAMx 6.40 Annual Emissions

		2028 Annual Emissions				
		CAMx 6.40	6.40 - 6.32	Domain Wide	Individual Grid Cell	
Source Type	Pollutant	Total Tons	Total Change	% Change	Max Increase	Max Decrease
Elevated	NO_X	4,512,000	489,300	10.84%	25,810	-25,250
Elevated	VOC[a]	4,707,000	-8,096	-0.17%	2,046	-2,615
Elevated	SO_2	3,977,000	795,000	19.99%	54,910	-38,780
Elevated	PEC	261,300	16,620	6.36%	358	-126
Elevated	PNH4[b]	14,690	3.47E+01	0.24%	32	-15
Elevated	PNO3	15,460	8.64E+02	5.59%	20	-25
Elevated	POA	1,734,000	12,240	0.71%	323	-1,269
Elevated	PSO4	83,570	1,814	2.17%	388	-298
Low Level	NO_X	7,302,000	5,788	0.08%	632	-1,695
Low Level	VOC	60,670,000	45,170	0.07%	2,615	-861
Low Level	SO_2	321,500	2,623	0.82%	1,487	-501
Low Level	PEC	151,900	324	0.21%	77	-9
Low Level	PNH4[b]	6,696	13	0.20%	6	-3
Low Level	PNO3	4,671	44	0.95%	12	-5
Low Level	POA	909,600	-2,630	-0.29%	54	-87
Low Level	PSO4	198,300	1,223	0.62%	82	-19

[a] VOC emissions are approximate since calculated from CB6 speciated emissions.
[b] PNH4 = Particulate ammonium

Annual NO_X Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

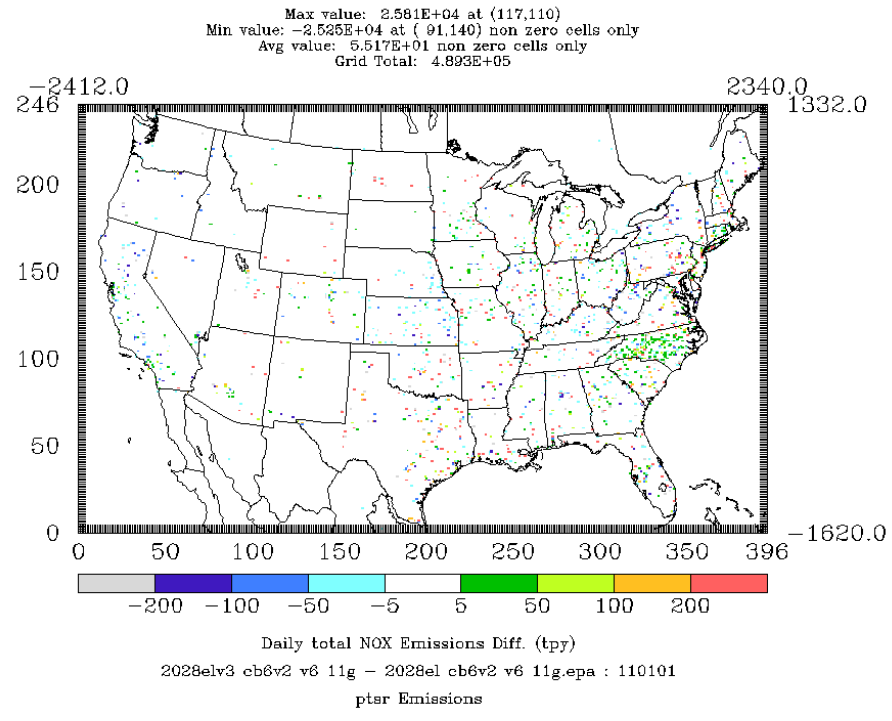
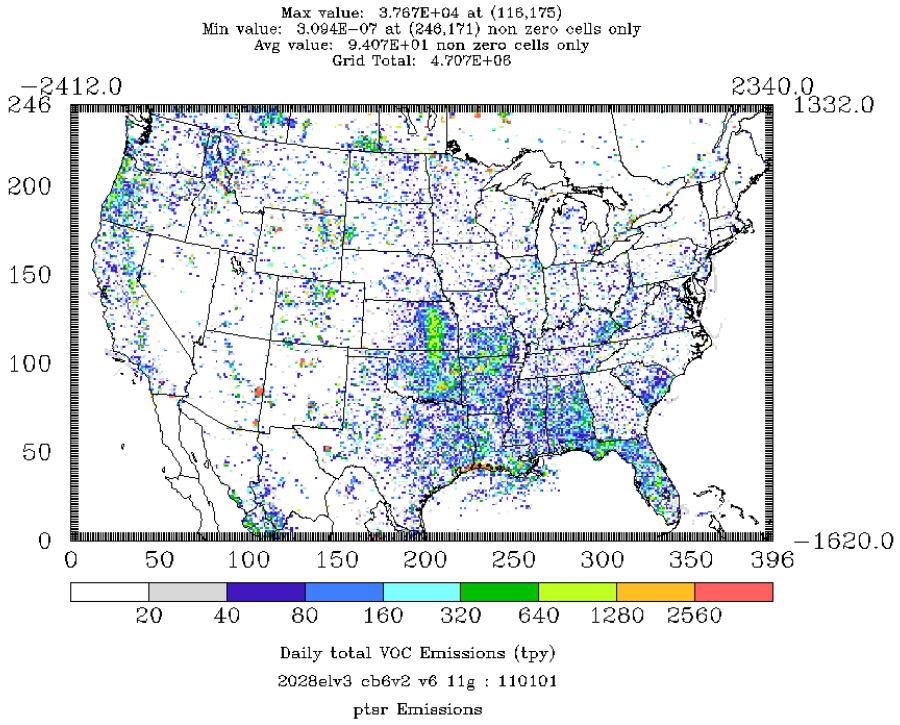


Figure 4-1. Comparison of Elevated NO_X Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual VOC Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

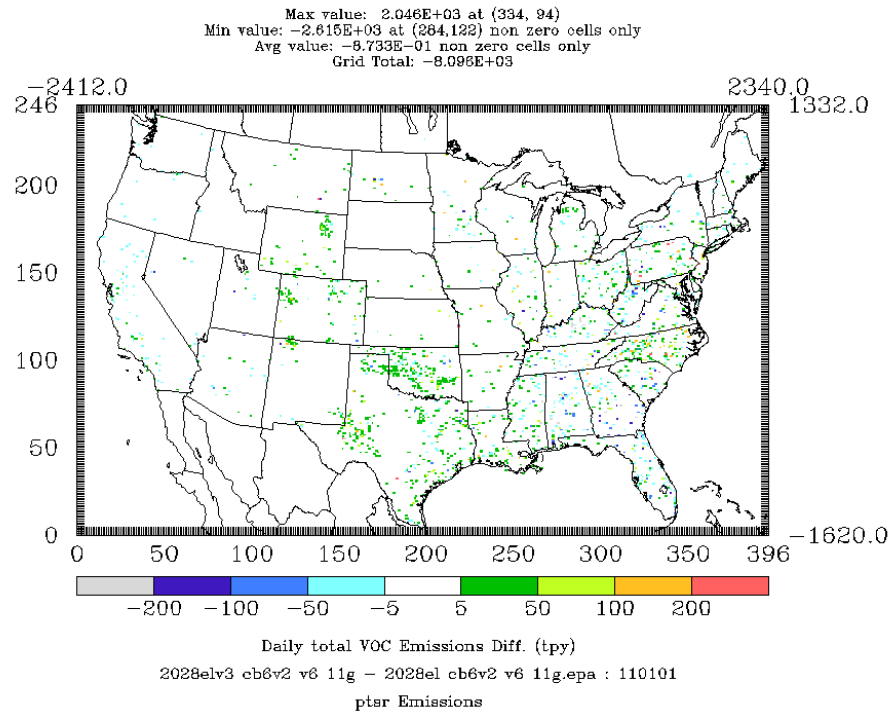
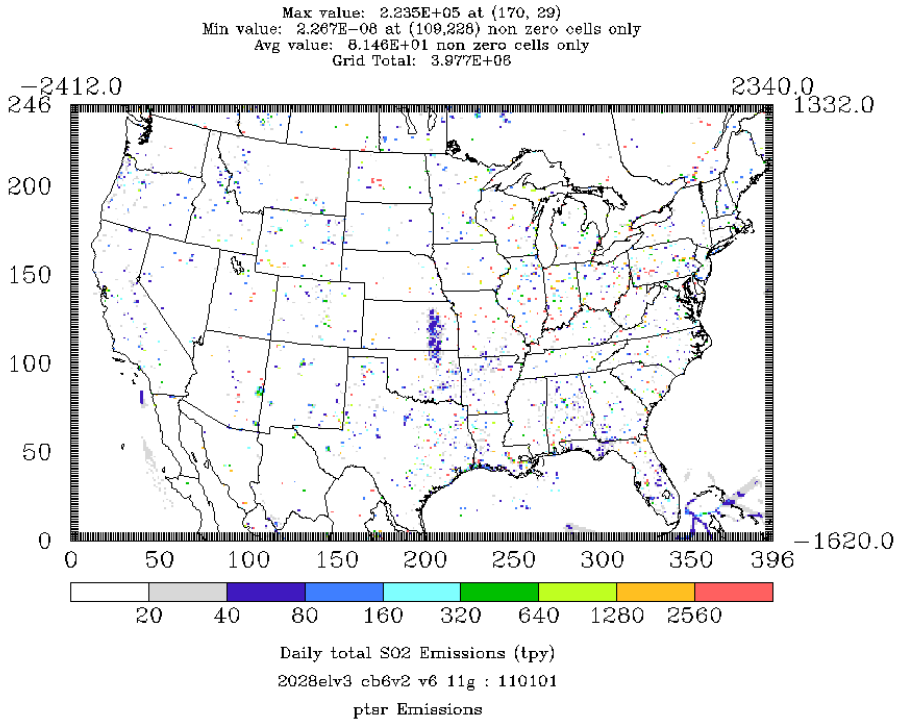


Figure 4-2. Comparison of Elevated VOC Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual SO_2 Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

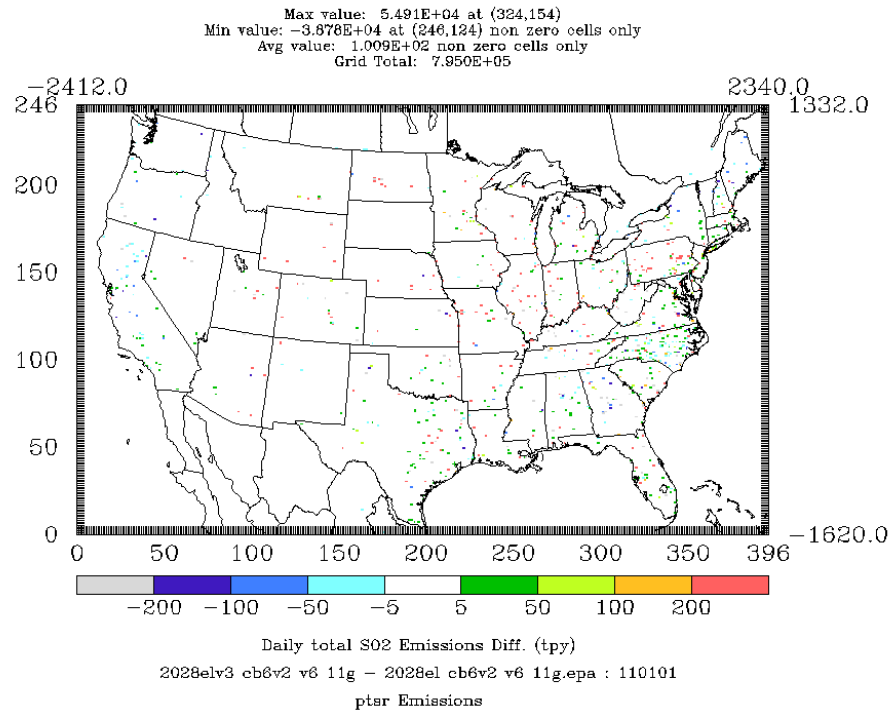
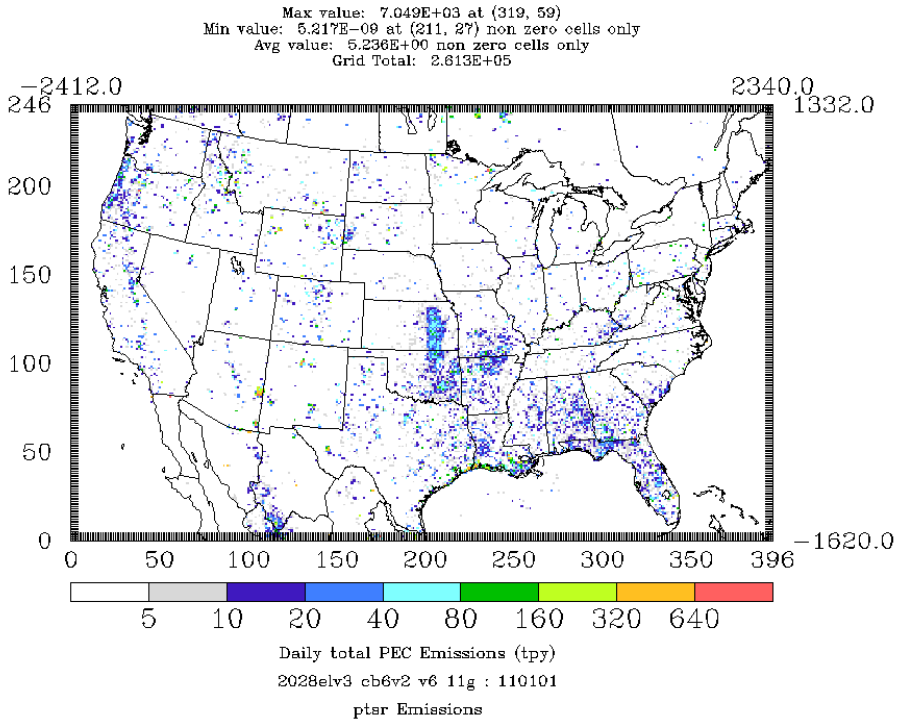


Figure 4-3. Comparison of Elevated SO_2 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual PEC Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

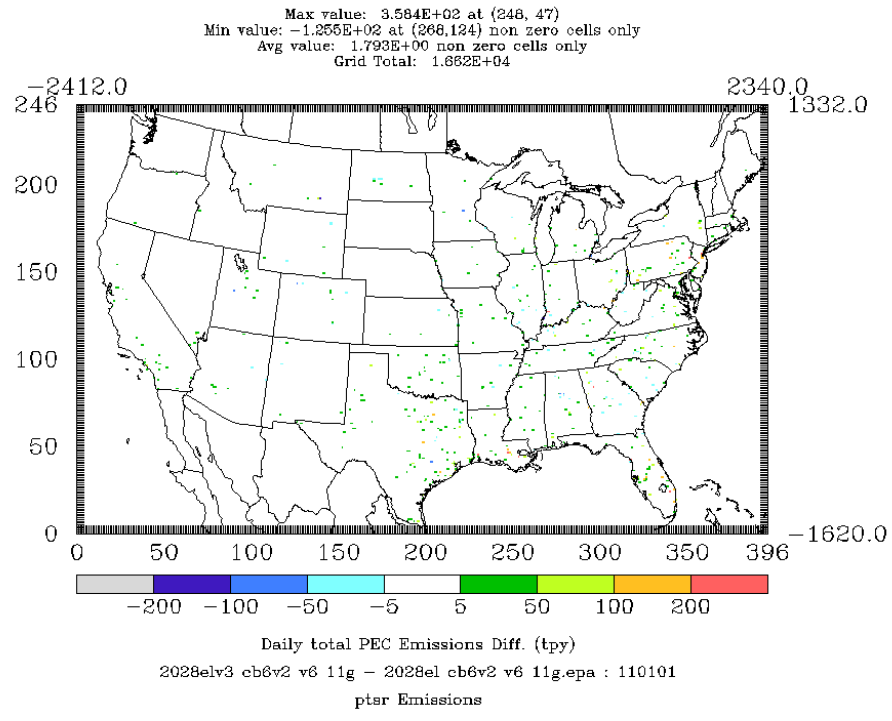
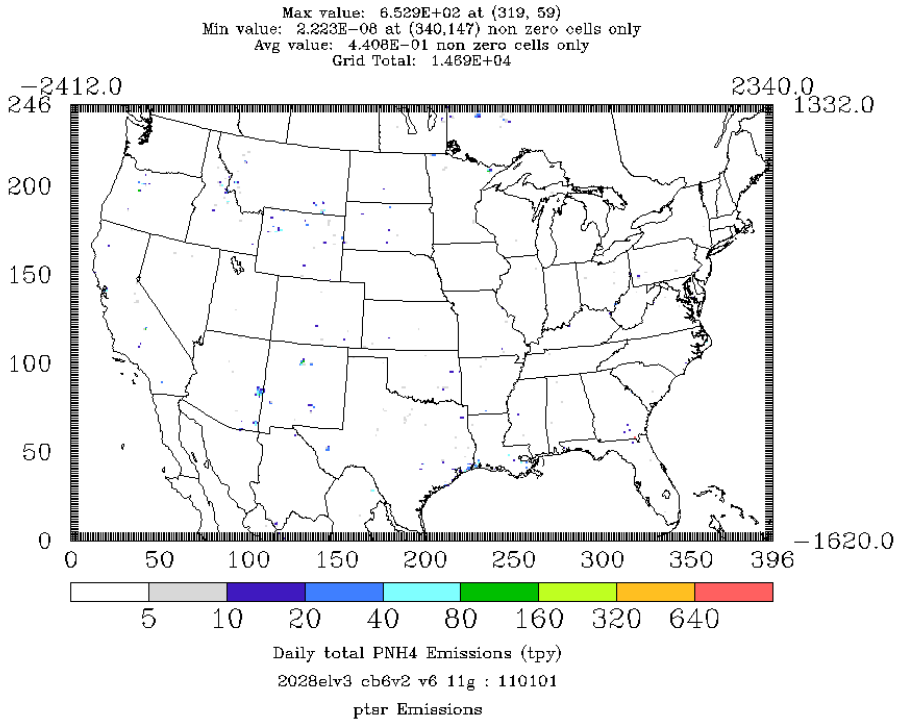


Figure 4-3. Comparison of Elevated PEC Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual PNH4 Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

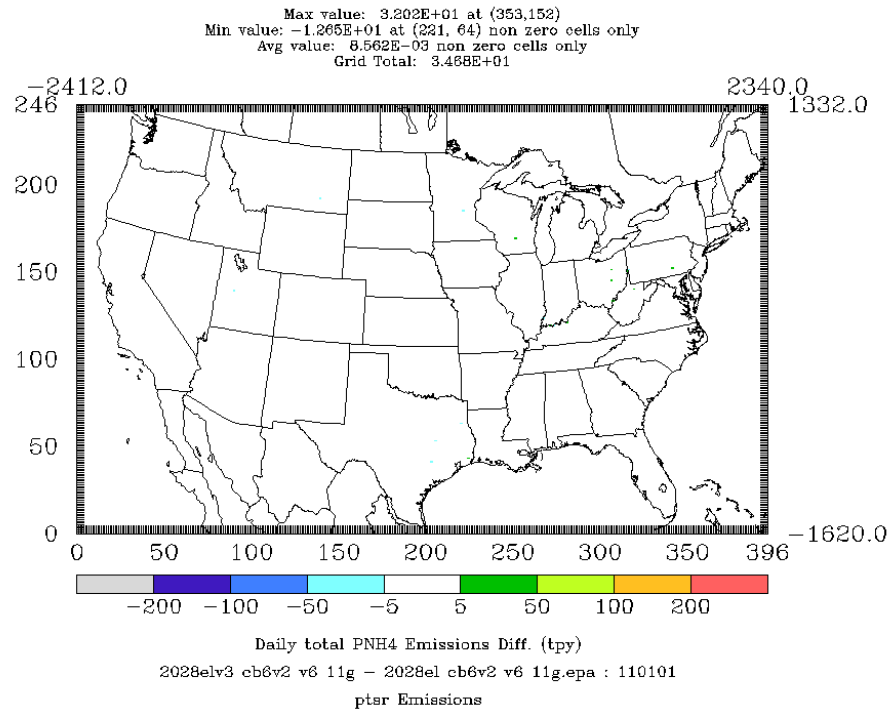
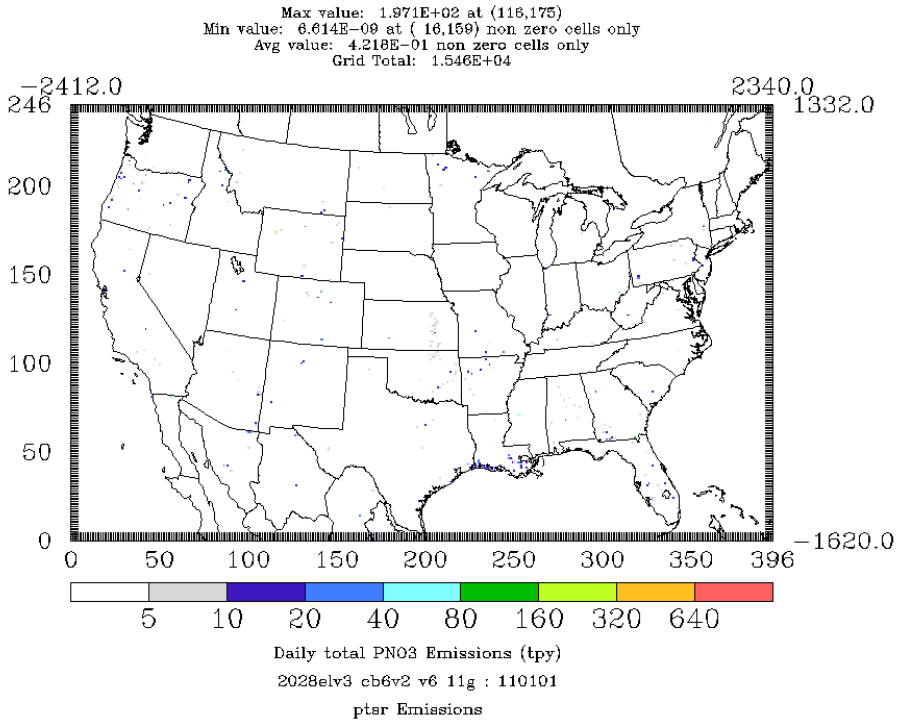


Figure 4-4. Comparison of Elevated PNH4 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual PNO3 Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

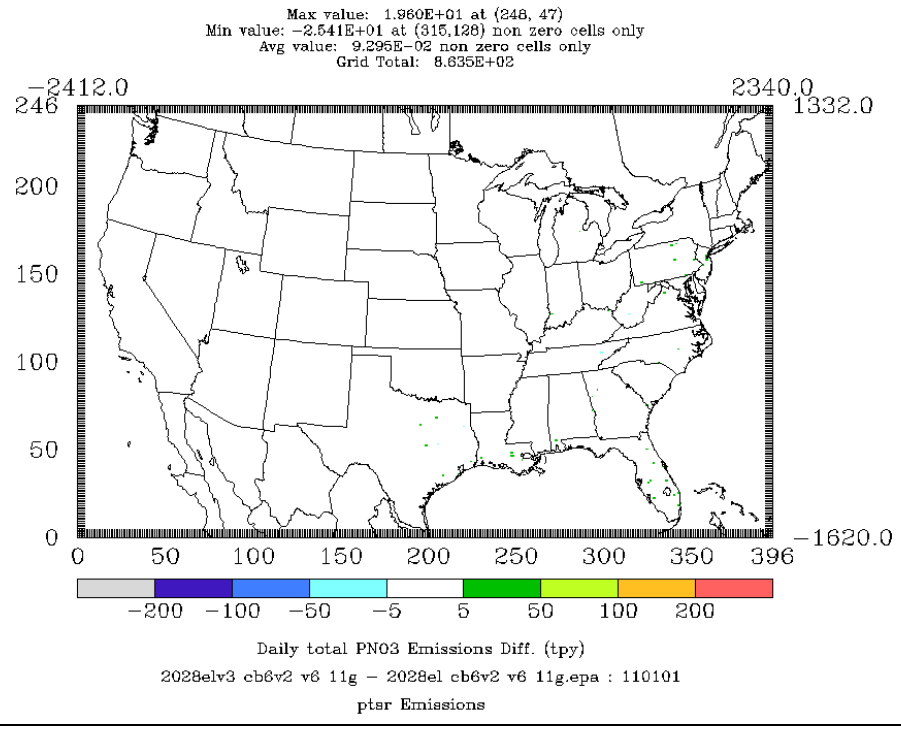
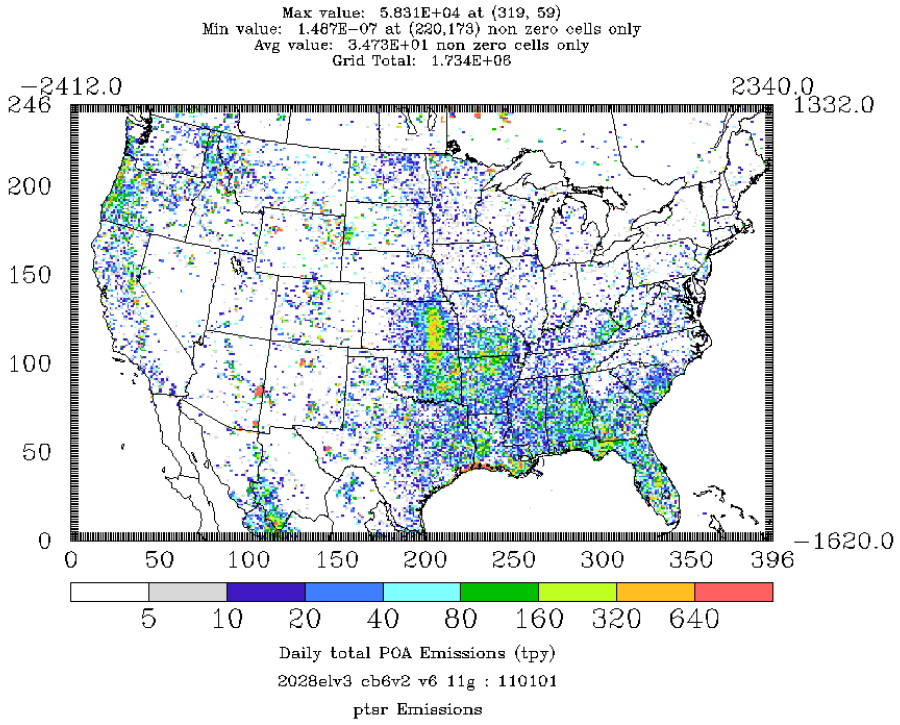


Figure 4-5. Comparison of Elevated PNO3 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual POA Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

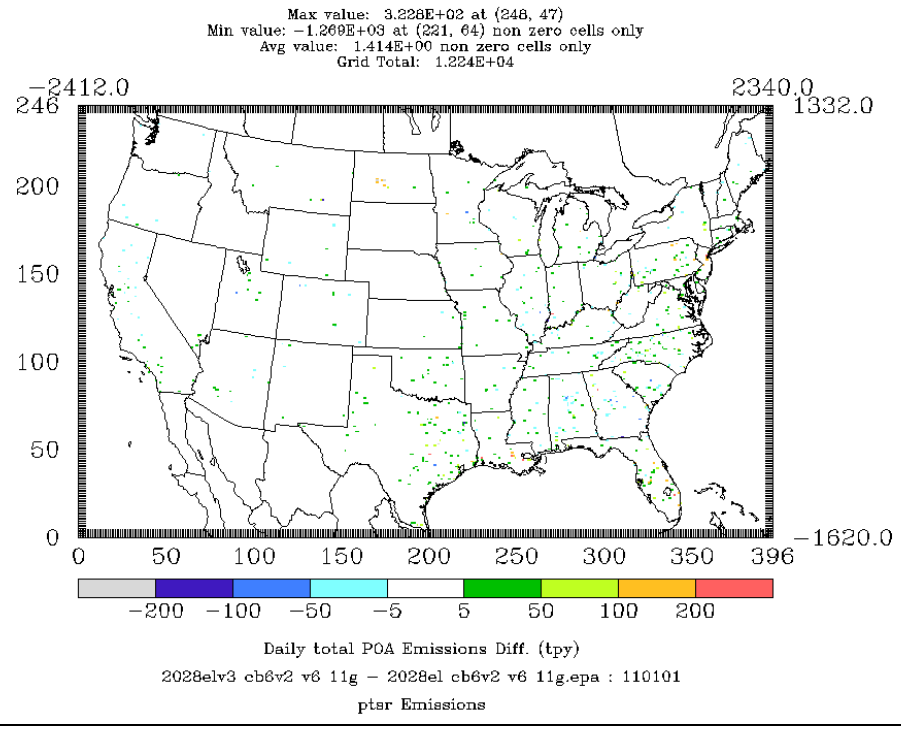
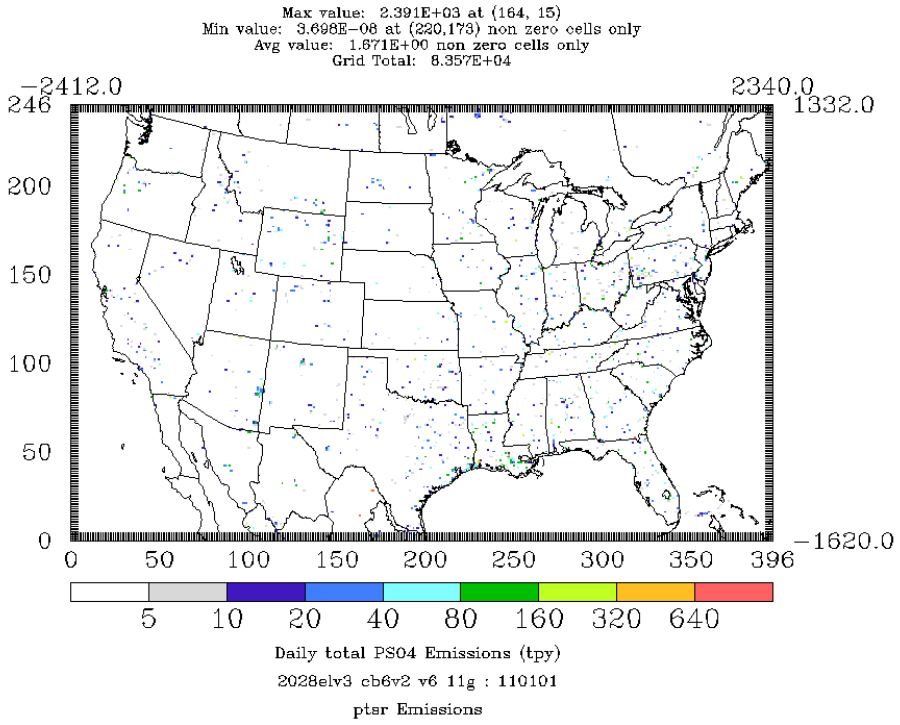


Figure 4-6. Comparison of Elevated POA Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual PSO4 Emissions – Elevated Sources

2028elv3



Difference (2028elv3 - 2028el)

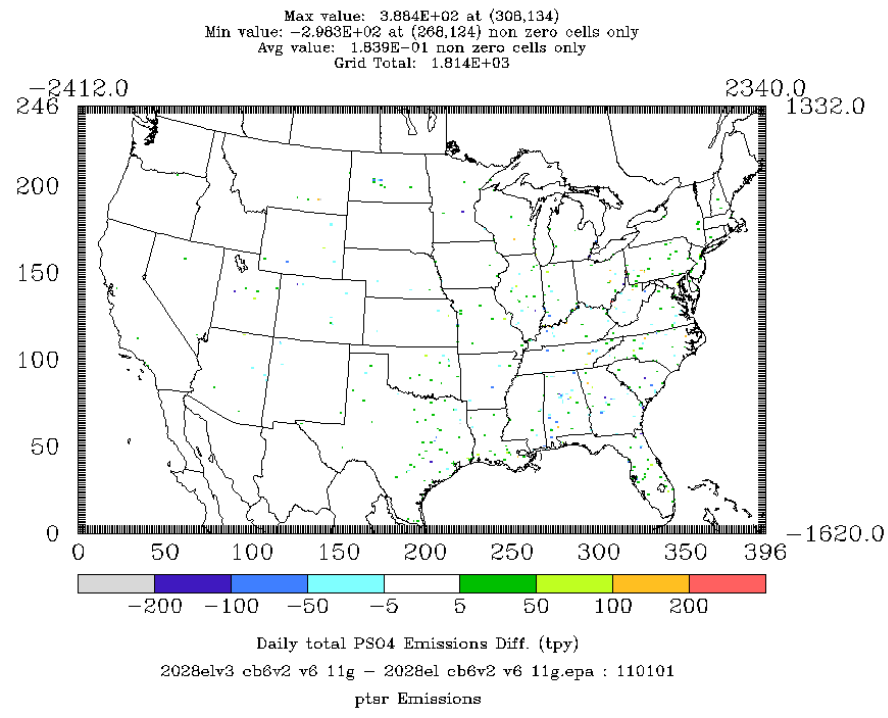
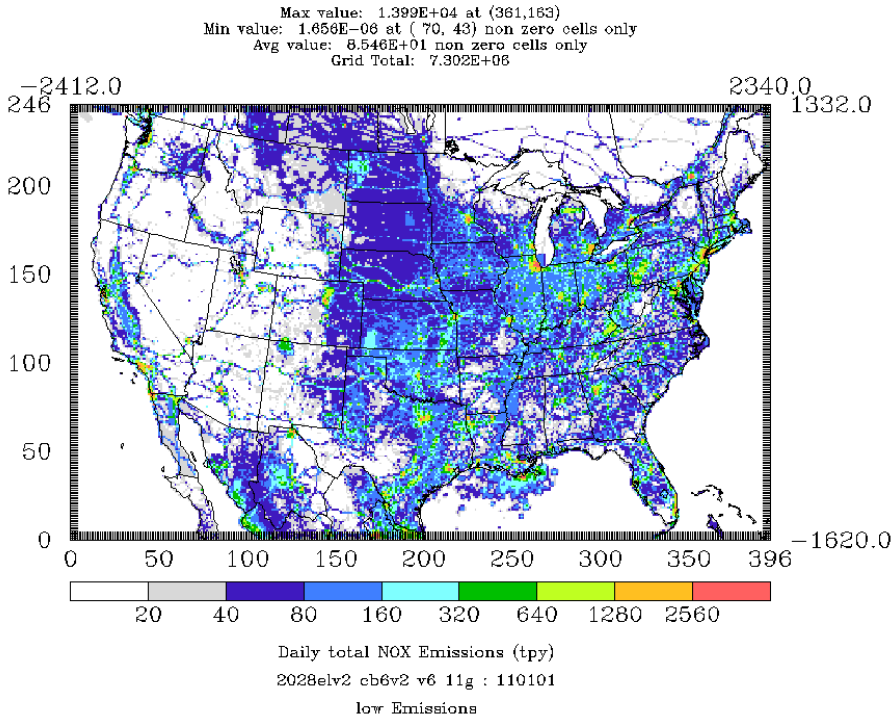


Figure 4-7. Comparison of Elevated PSO4 Emissions (tpy) for CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulations

Annual NO_X Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

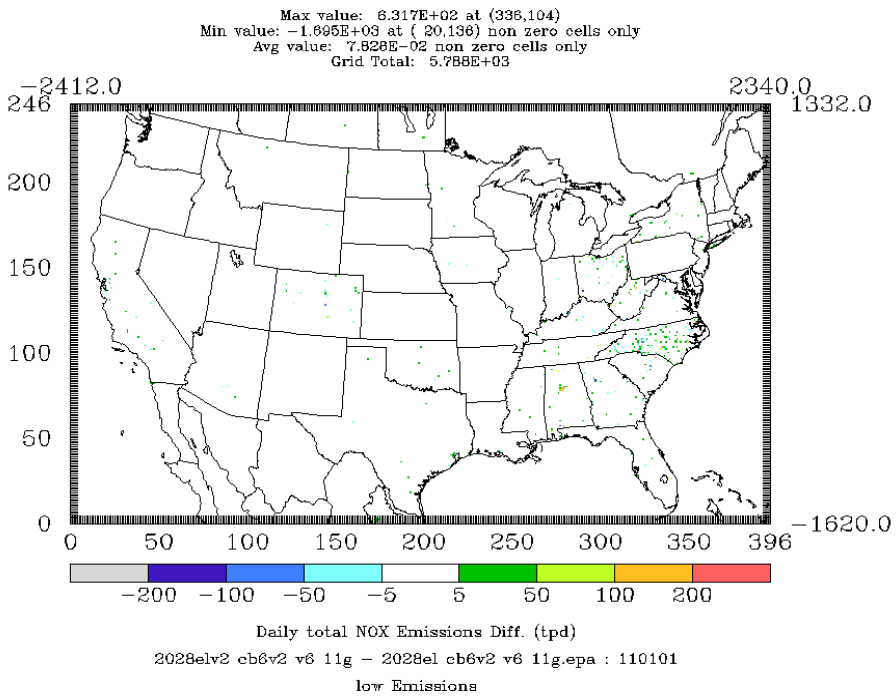
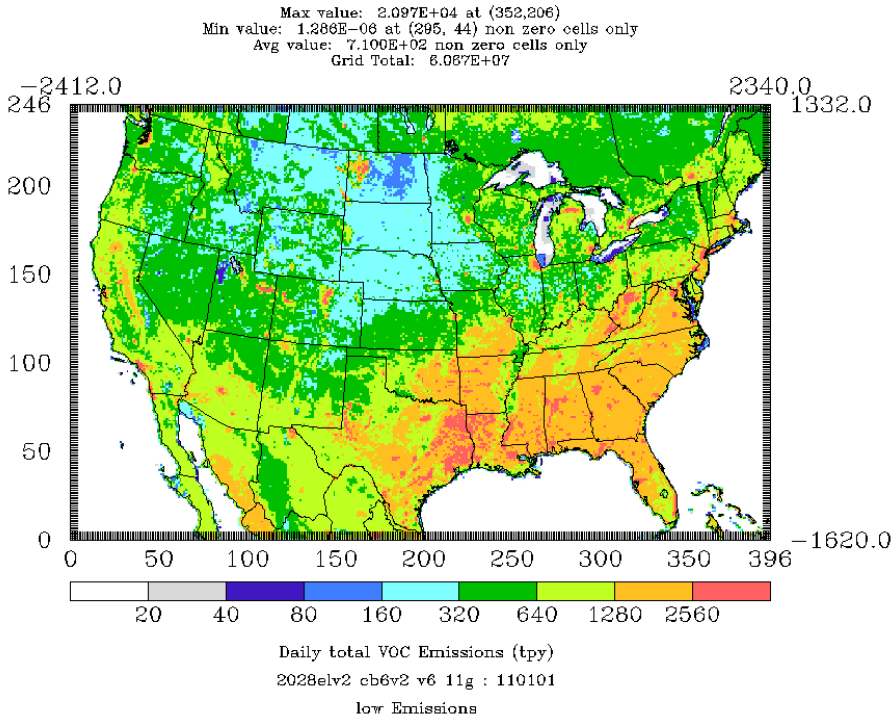


Figure 4-8. Comparison of Low Level NO_X Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual VOC Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

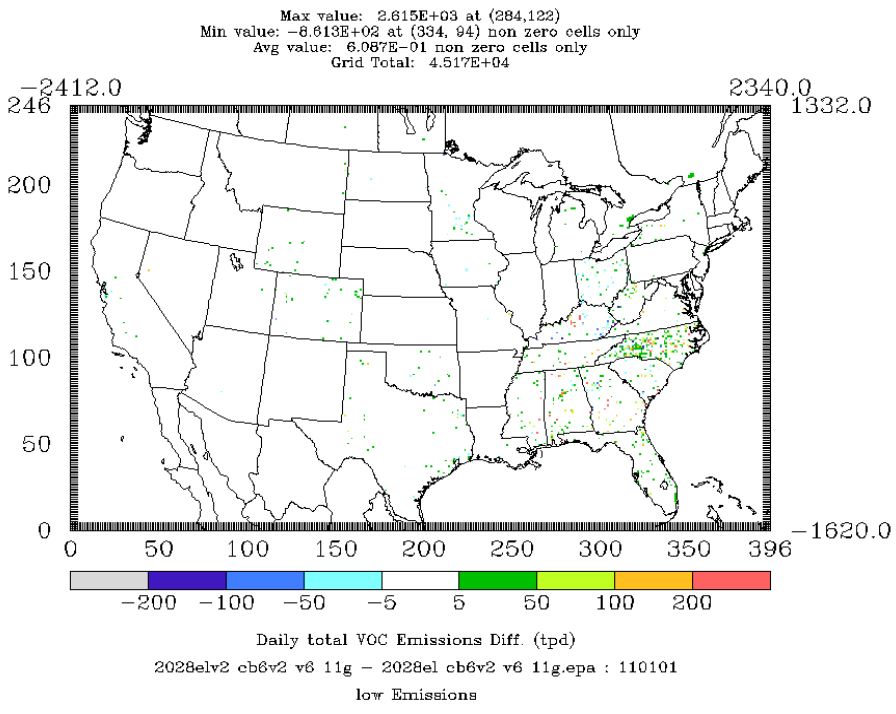
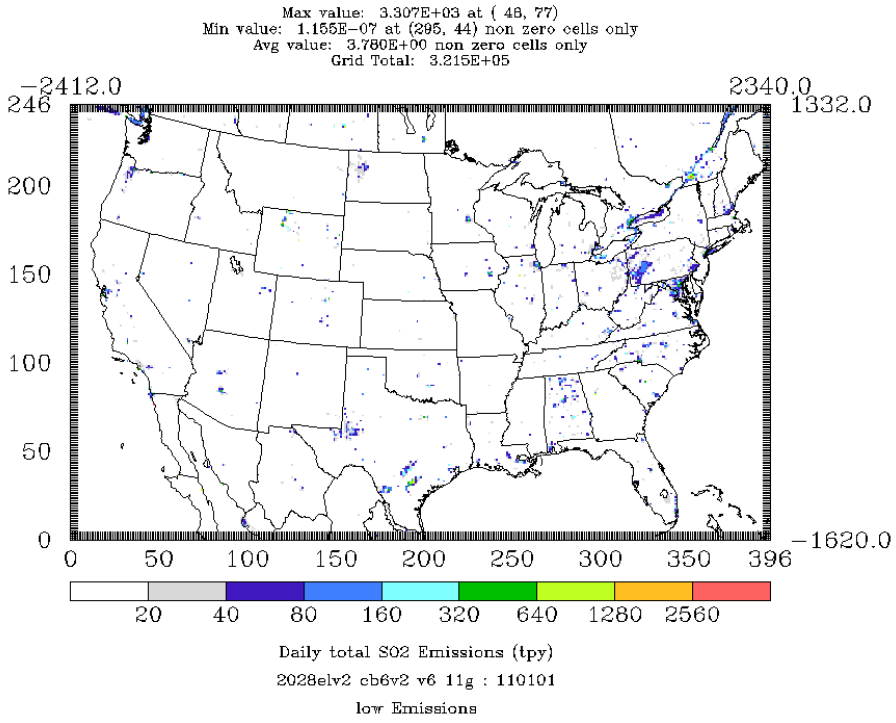


Figure 4-9. Comparison of Low Level VOC Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual SO_2 Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

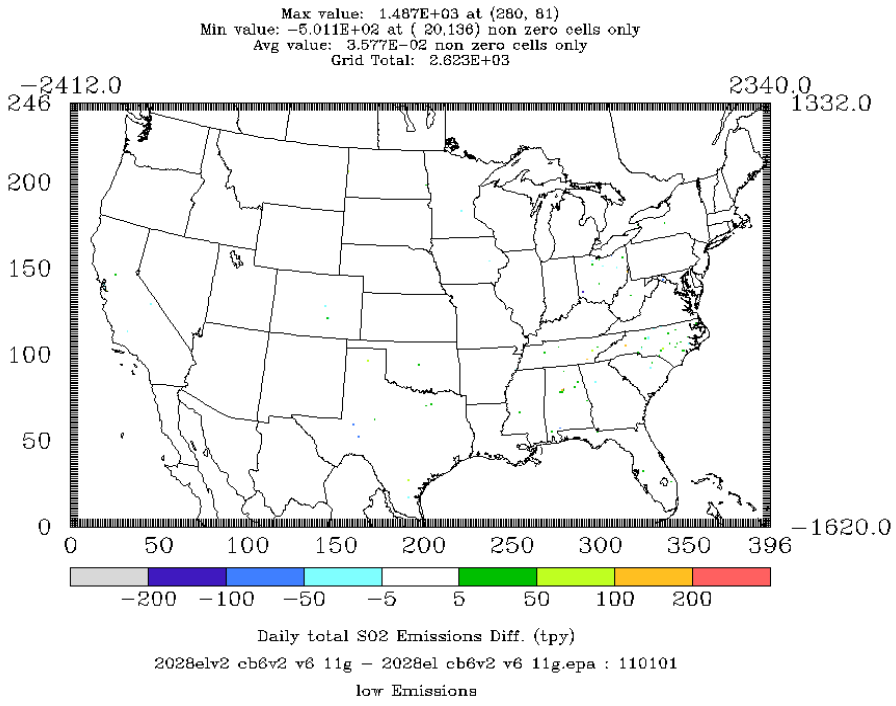
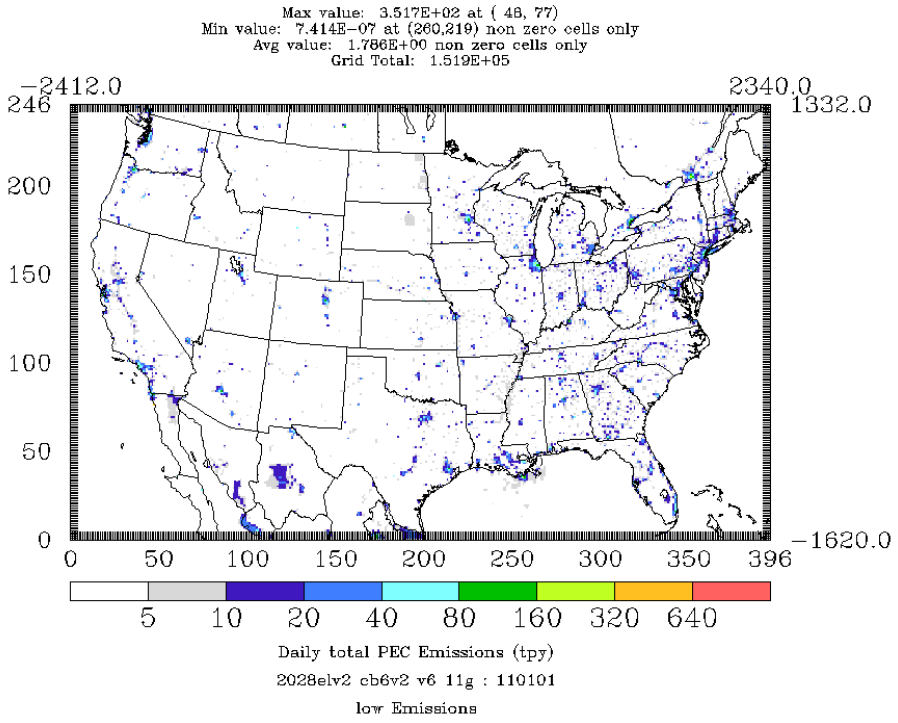


Figure 4-10. Comparison of Low Level SO_2 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual PEC Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

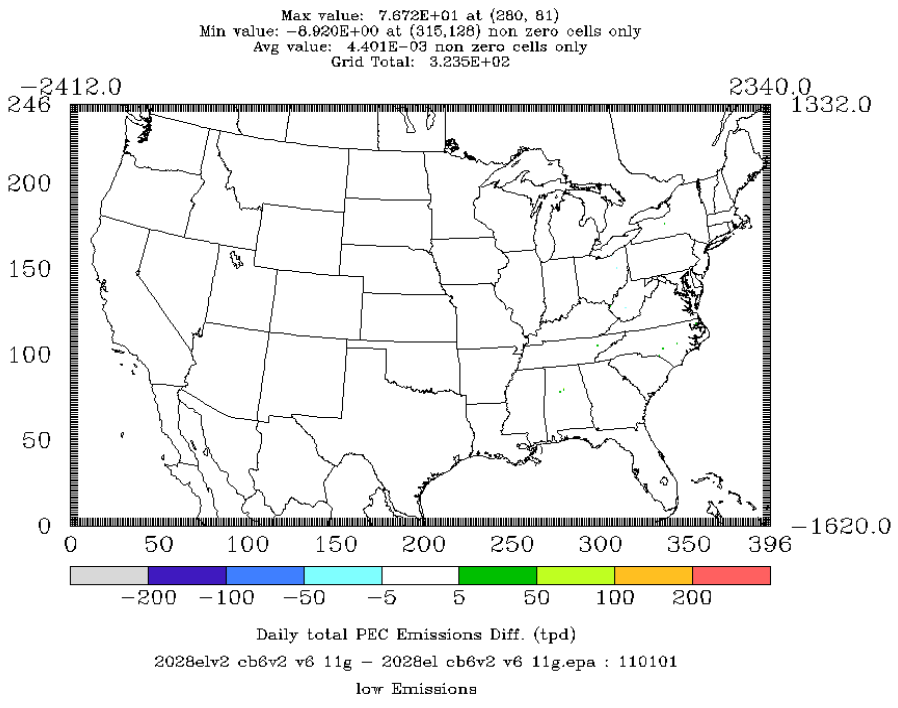
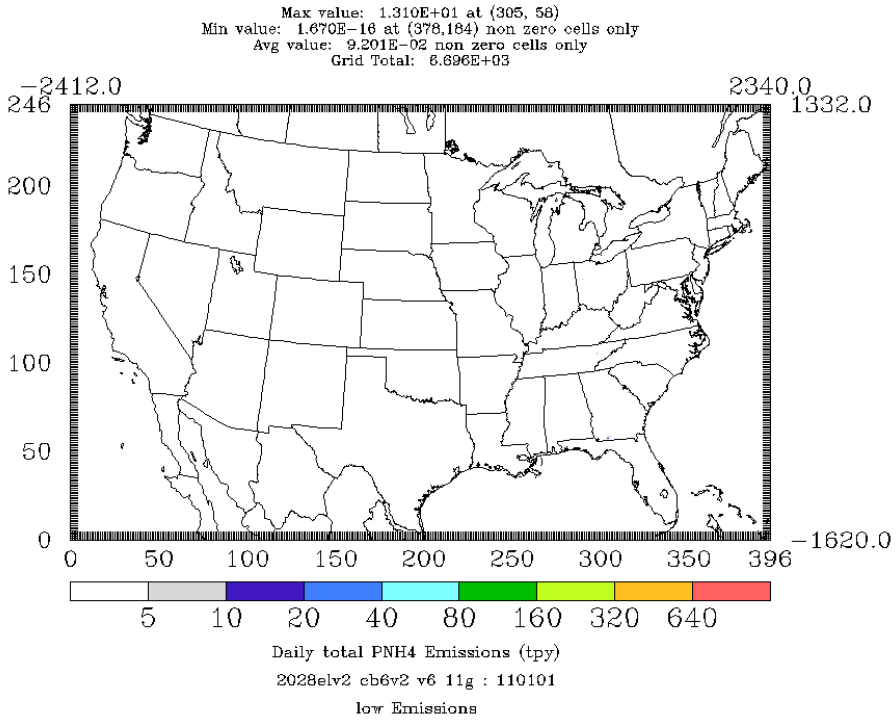


Figure 4-11. Comparison of Low Level PEC Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual PNH4 Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

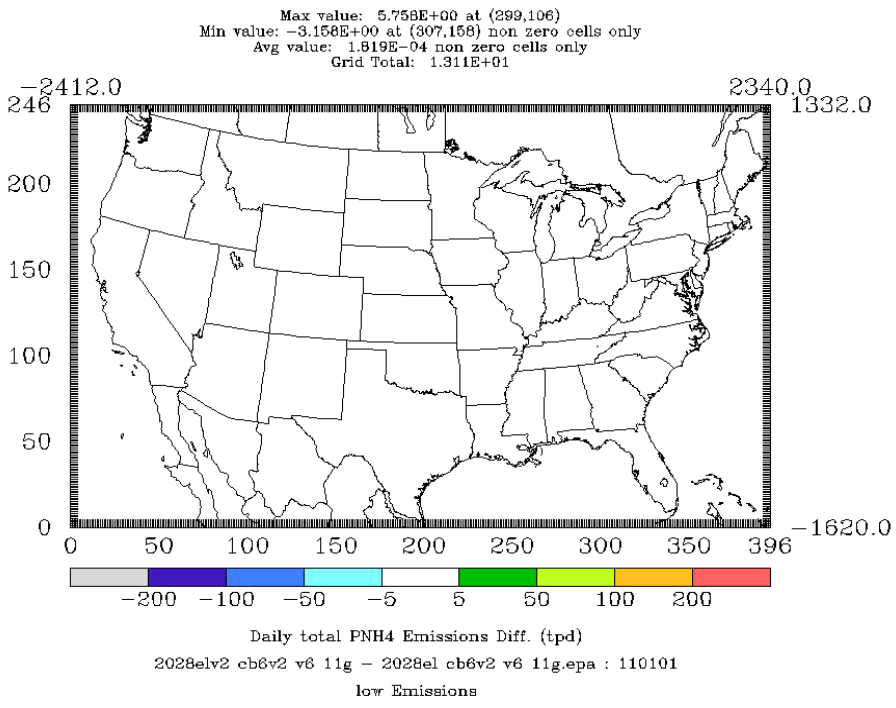
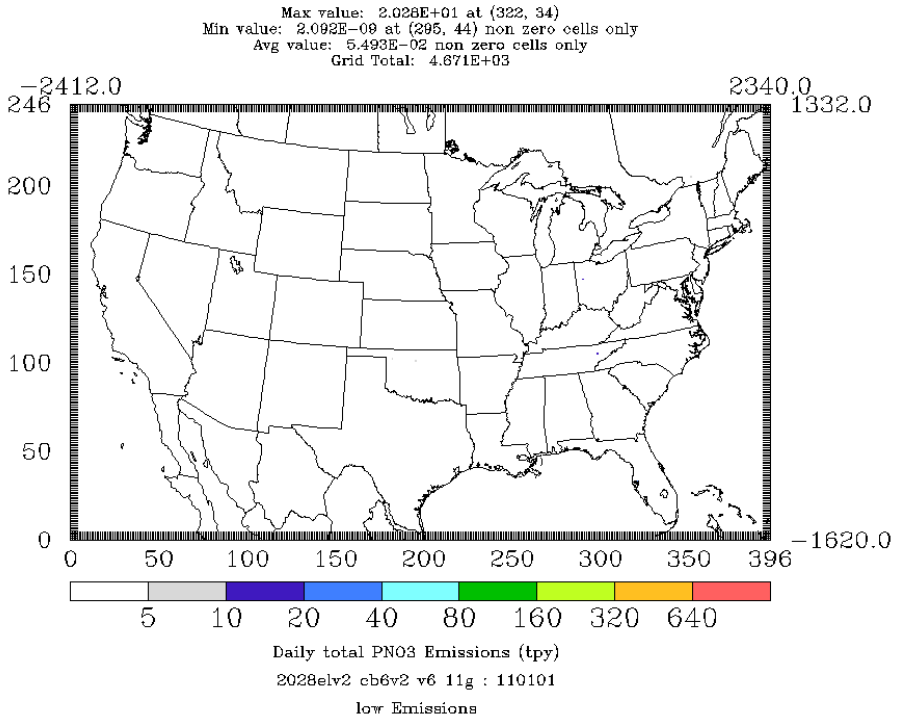


Figure 4-12. Comparison of Low Level PNH4 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual PNO3 Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

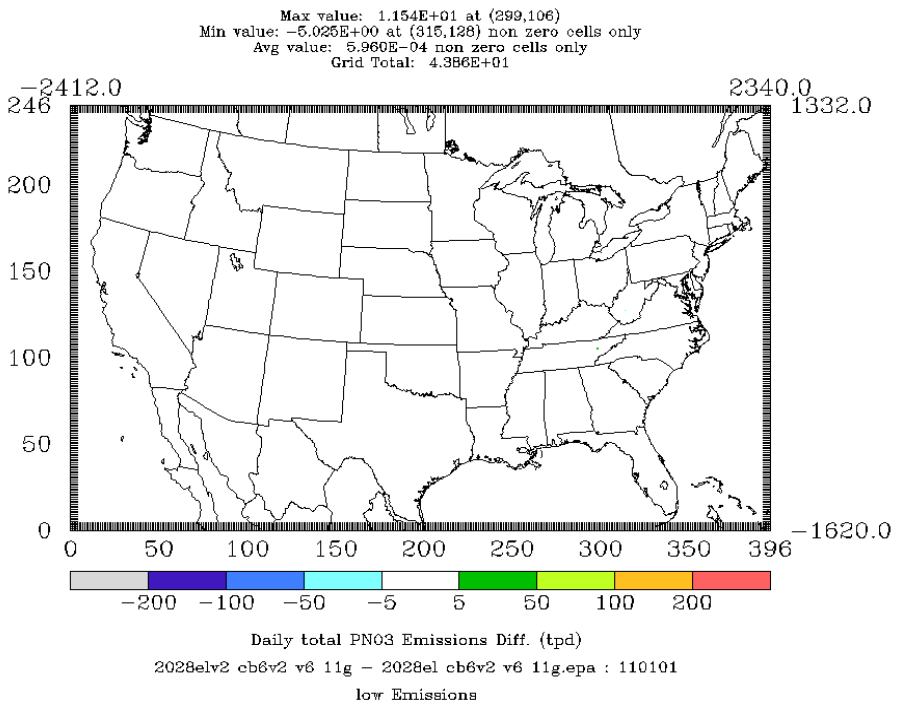
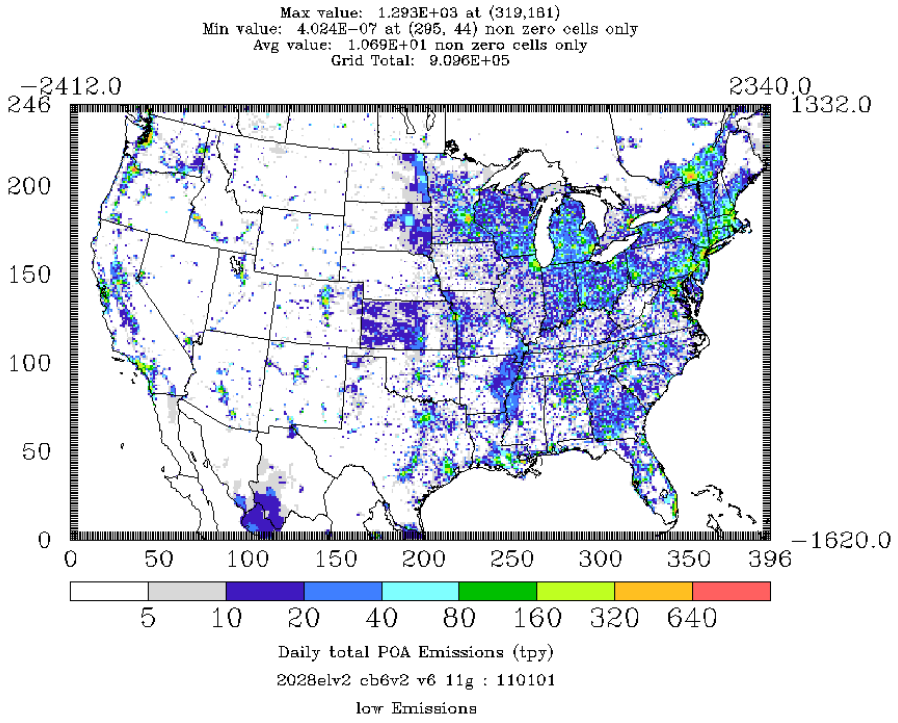


Figure 4-13. Comparison of Low Level PNO3 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual POA Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

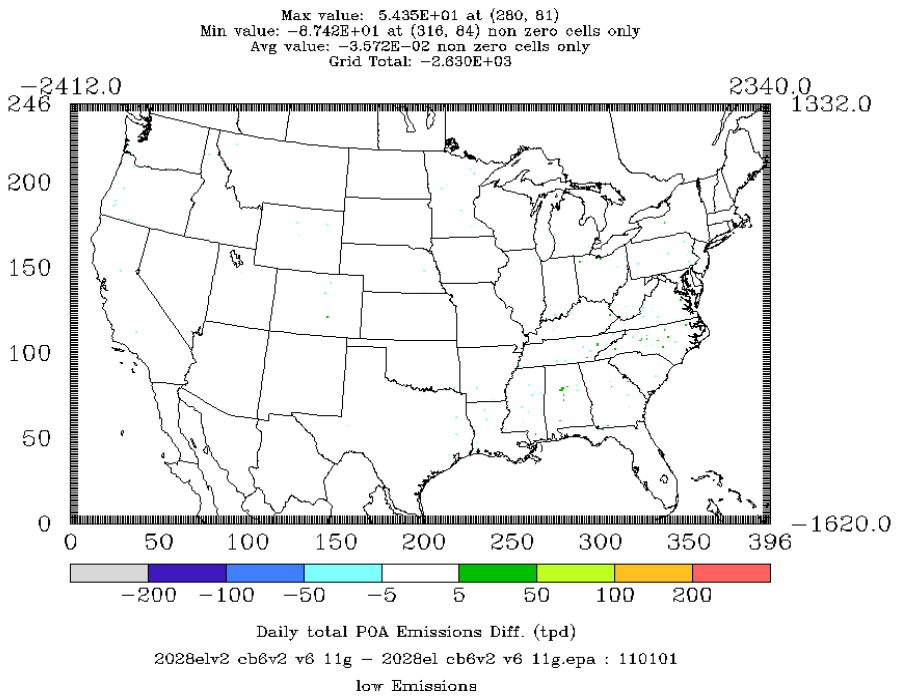
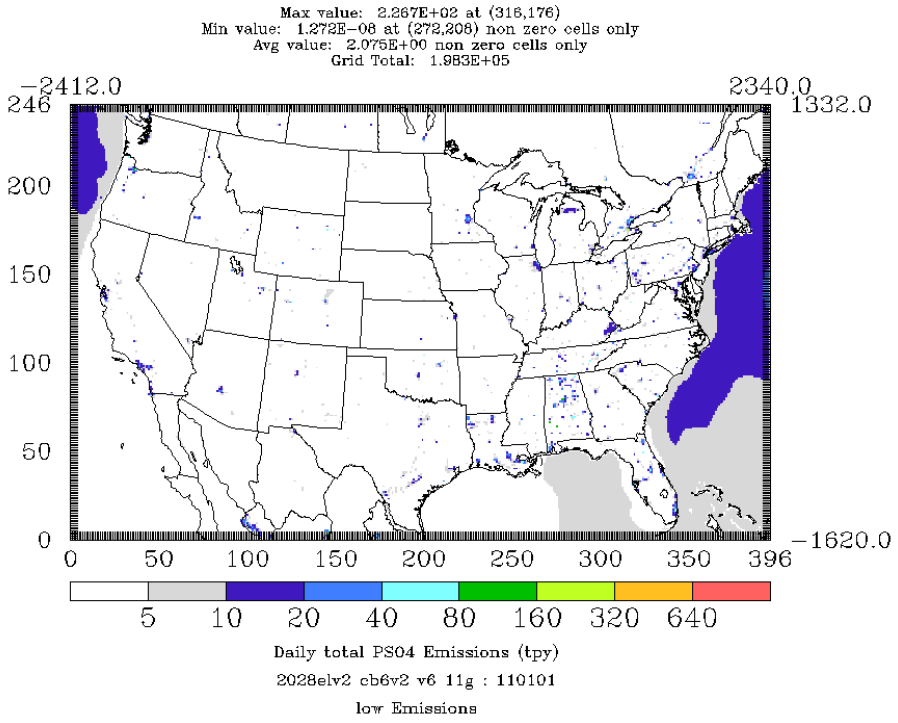


Figure 4-14. Comparison of Low Level POA Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

Annual PSO4 Emissions – Low Level Sources

2028elv2



Difference (2028elv2 - 2028el)

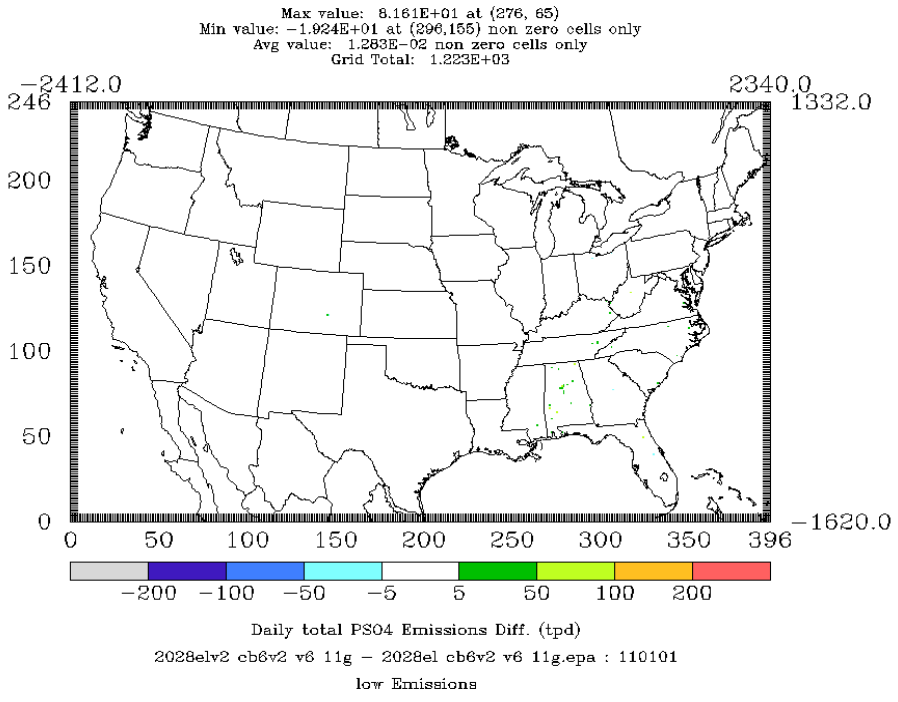


Figure 4-15. Comparison of Low Level PSO4 Emissions (tpy) for CAMx 6.40 2028elv2 and CAMx 6.32 2028el Simulations

4.2 Annual $PM_{2.5}$ Design Value

Annual $PM_{2.5}$ design values were generated using the results of each individual CAMx simulation (version 6.32 with EPA's 2028el platform and version 6.40 with SESARM's 2028elv3 emissions platform) and the SMAT-CE tool. Results for each individual receptor in the VISTAS states are presented in tabular format in Table 4-2 along with the absolute difference and percent difference in design value.

The maximum calculated increase is 0.51 $\mu g/m^3$ at monitor 510590030 in Fairfax, Virginia (7% increase between 6.32 and 6.40) and maximum decrease is 0.43 $\mu g/m^3$ at monitor 210290006 in Bullitt County, Kentucky (4% decrease going from 6.32 to 6.40). The average change in annual design value for all monitors in the VISTAS states is an increase of 0.20 $\mu g/m^3$, with an average annual percent increase of 3% at these same locations.

Geographic distribution of the 6.40 annual $PM_{2.5}$ design values and differences in design values compared to the 6.32 simulation is presented in Figure 4-16. In the VISTAS state region, the largest annual $PM_{2.5}$ design value fractional change is seen along the Atlantic coast and through much of North Carolina. The smallest fractional changes seen inside the heart of the SESARM state domain consistent with significant emission reductions modeled from updated EGU inventories within these states.

A scatterplot of the annual $PM_{2.5}$ design values for all FRM monitors in the 12US2 domain is presented in Figure 4-17. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 0.9875, an intercept of -0.1058 $\mu g/m^3$and an R^2 of 0.9825. The agreement between the models is higher at lower concentrations. CAMx 6.40 concentrations appear to be marginally higher compared to CAMx 6.32 at low and medium concentration ranges and slightly lower than the CAMx 6.32 results in high concentration ranges.

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m³)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
010030010	Alabama	Baldwin	7.98	8.06	0.08	1%
010270001	Alabama	Clay	7.78	7.92	0.14	2%
010331002	Alabama	Colbert	8.21	8.37	0.16	2%
010491003	Alabama	DeKalb	8.33	8.52	0.19	2%
010550010	Alabama	Etowah	8.66	8.84	0.18	2%
010690003	Alabama	Houston	8.12	8.25	0.13	2%
010730023	Alabama	Jefferson	10.92	11.17	0.25	2%
010731005	Alabama	Jefferson	9.25	9.33	0.08	1%
010731009	Alabama	Jefferson	8.16	8.24	0.08	1%
010731010	Alabama	Jefferson	9.44	9.56	0.12	1%
010732003	Alabama	Jefferson	10.14	10.31	0.17	2%
010732006	Alabama	Jefferson	9.42	9.50	0.08	1%
010735002	Alabama	Jefferson	8.74	8.97	0.23	3%
010735003	Alabama	Jefferson	8.55	8.68	0.13	2%
010890014	Alabama	Madison	8.94	9.15	0.21	2%
010970003	Alabama	Mobile	8.02	8.16	0.14	2%
010972005	Alabama	Mobile	7.74	7.83	0.09	1%
011011002	Alabama	Montgomery	9.33	9.58	0.25	3%
011030011	Alabama	Morgan	8.53	8.73	0.20	2%
011130001	Alabama	Russell	9.98	10.17	0.19	2%
011170006	Alabama	Shelby	8.11	8.18	0.07	1%
011210002	Alabama	Talladega	9.02	9.14	0.12	1%
011250004	Alabama	Tuscaloosa	8.60	8.74	0.14	2%
011270002	Alabama	Walker	9.00	9.12	0.12	1%
120990008	Florida	Palm Beach	6.84	6.94	0.10	1%
120990009	Florida	Palm Beach	5.70	5.85	0.15	3%
130210007	Georgia	Bibb	10.70	10.60	-0.10	-1%
130210012	Georgia	Bibb	8.08	7.95	-0.13	-2%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
130510091	Georgia	Chatham	8.57	8.54	-0.03	0%
130590002	Georgia	Clarke	8.01	8.13	0.12	1%
130630091	Georgia	Clayton	9.30	9.43	0.13	1%
130670004	Georgia	Cobb	8.48	8.73	0.25	3%
130890002	Georgia	DeKalb	8.60	8.76	0.16	2%
130950007	Georgia	Dougherty	10.33	10.41	0.08	1%
131150003	Georgia	Floyd	9.31	9.48	0.17	2%
131210039	Georgia	Fulton	10.18	10.36	0.18	2%
131390003	Georgia	Hall	7.94	8.07	0.13	2%
131530001	Georgia	Houston	8.60	8.55	-0.05	-1%
132150001	Georgia	Muscogee	10.59	10.78	0.19	2%
132450005	Georgia	Richmond	9.53	9.27	-0.26	-3%
132450091	Georgia	Richmond	9.87	9.54	-0.33	-3%
132950002	Georgia	Walker	7.90	8.02	0.12	2%
133190001	Georgia	Wilkinson	10.26	9.97	-0.29	-3%
210130002	Kentucky	Bell	8.68	8.80	0.12	1%
210190017	Kentucky	Boyd	8.00	8.31	0.31	4%
210290006	Kentucky	Bullitt	9.75	9.32	-0.43	-4%
210373002	Kentucky	Campbell	7.36	7.61	0.25	3%
210430500	Kentucky	Carter	6.57	6.80	0.23	4%
210470006	Kentucky	Christian	8.28	8.39	0.11	1%
210590005	Kentucky	Daviess	9.11	9.25	0.14	2%
210670012	Kentucky	Fayette	7.76	7.97	0.21	3%
210930006	Kentucky	Hardin	8.30	8.40	0.10	1%
211010014	Kentucky	Henderson	8.68	8.96	0.28	3%
211110067	Kentucky	Jefferson	9.53	9.44	-0.09	-1%
211451004	Kentucky	McCracken	8.57	8.84	0.27	3%
211510003	Kentucky	Madison	6.77	6.97	0.20	3%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m³)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
211950002	Kentucky	Pike	7.71	8.03	0.32	4%
212270008	Kentucky	Warren	8.72	8.83	0.11	1%
280330002	Mississippi	DeSoto	8.15	8.36	0.21	3%
280350004	Mississippi	Forrest	9.81	9.92	0.11	1%
280430001	Mississippi	Grenada	7.81	8.00	0.19	2%
280450003	Mississippi	Hancock	8.31	8.23	-0.08	-1%
280470008	Mississippi	Harrison	7.99	7.99	0.00	0%
280490010	Mississippi	Hinds	9.45	9.58	0.13	1%
280590006	Mississippi	Jackson	7.91	7.90	-0.01	0%
280670002	Mississippi	Jones	10.01	10.10	0.09	1%
280750003	Mississippi	Lauderdale	9.13	9.20	0.07	1%
280810005	Mississippi	Lee	9.21	9.36	0.15	2%
370010002	North Carolina	Alamance	7.01	7.36	0.35	5%
370210034	North Carolina	Buncombe	6.77	6.97	0.20	3%
370330001	North Carolina	Caswell	6.22	6.57	0.35	6%
370350004	North Carolina	Catawba	7.71	7.98	0.27	4%
370370004	North Carolina	Chatham	5.73	6.07	0.34	6%
370510009	North Carolina	Cumberland	7.38	7.65	0.27	4%
370570002	North Carolina	Davidson	8.14	8.54	0.40	5%
370610002	North Carolina	Duplin	6.36	6.48	0.12	2%
370630015	North Carolina	Durham	6.69	7.00	0.31	5%
370650004	North Carolina	Edgecombe	6.35	6.66	0.31	5%
370670022	North Carolina	Forsyth	6.91	7.33	0.42	6%
370670030	North Carolina	Forsyth	6.91	7.34	0.43	6%
370710016	North Carolina	Gaston	7.52	7.77	0.25	3%
370810013	North Carolina	Guilford	6.59	6.97	0.38	6%
370810014	North Carolina	Guilford	6.72	7.13	0.41	6%
370870012	North Carolina	Haywood	7.84	7.86	0.02	0%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
370990006	North Carolina	Jackson	7.06	7.15	0.09	1%
371010002	North Carolina	Johnston	6.38	6.70	0.32	5%
371070004	North Carolina	Lenoir	6.59	6.85	0.26	4%
371110004	North Carolina	McDowell	7.37	7.60	0.23	3%
371170001	North Carolina	Martin	6.01	6.38	0.37	6%
371190041	North Carolina	Mecklenburg	7.86	8.11	0.25	3%
371190042	North Carolina	Mecklenburg	8.21	8.45	0.24	3%
371190043	North Carolina	Mecklenburg	7.37	7.64	0.27	4%
371210001	North Carolina	Mitchell	7.04	7.19	0.15	2%
371230001	North Carolina	Montgomery	6.62	6.95	0.33	5%
371290002	North Carolina	New Hanover	5.39	5.61	0.22	4%
371470006	North Carolina	Pitt	5.98	6.29	0.31	5%
371550005	North Carolina	Robeson	7.29	7.51	0.22	3%
371590021	North Carolina	Rowan	7.54	7.84	0.30	4%
371730002	North Carolina	Swain	7.40	7.50	0.10	1%
371830014	North Carolina	Wake	7.58	7.89	0.31	4%
371830020	North Carolina	Wake	6.78	7.09	0.31	5%
371890003	North Carolina	Watauga	6.07	6.28	0.21	3%
371910005	North Carolina	Wayne	7.14	7.40	0.26	4%
450190048	South Carolina	Charleston	6.91	7.11	0.20	3%
450190049	South Carolina	Charleston	6.66	6.88	0.22	3%
450250001	South Carolina	Chesterfield	7.46	7.69	0.23	3%
450370001	South Carolina	Edgefield	8.01	8.03	0.02	0%
450410003	South Carolina	Florence	8.45	8.65	0.20	2%
450450009	South Carolina	Greenville	8.41	8.65	0.24	3%
450450015	South Carolina	Greenville	8.68	8.92	0.24	3%
450630008	South Carolina	Lexington	8.57	8.64	0.07	1%
450830011	South Carolina	Spartanburg	8.26	8.47	0.21	3%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m³)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
470650031	Tennessee	Hamilton	8.43	8.55	0.12	1%
470651011	Tennessee	Hamilton	8.32	8.45	0.13	2%
470654002	Tennessee	Hamilton	8.16	8.30	0.14	2%
510030001	Virginia	Albemarle	6.32	6.67	0.35	6%
510360002	Virginia	Charles	6.23	6.57	0.34	5%
510410003	Virginia	Chesterfield	7.06	7.44	0.38	5%
510590030	Virginia	Fairfax	6.87	7.38	0.51	7%
510690010	Virginia	Frederick	7.70	8.19	0.49	6%
510870014	Virginia	Henrico	6.81	7.17	0.36	5%
510870015	Virginia	Henrico	6.38	6.76	0.38	6%
511071005	Virginia	Loudoun	7.08	7.57	0.49	7%
511390004	Virginia	Page	6.77	7.13	0.36	5%
511650003	Virginia	Rockingham	7.56	7.89	0.33	4%
515200006	Virginia	Bristol City	7.53	7.73	0.20	3%
516500008	Virginia	Hampton City	5.65	5.93	0.28	5%
516800015	Virginia	Lynchburg City	6.24	6.52	0.28	4%
517100024	Virginia	Norfolk City	6.77	7.04	0.27	4%
517700015	Virginia	Roanoke City	7.47	7.73	0.26	3%
517750011	Virginia	Salem City	7.24	7.50	0.26	4%
518100008	Virginia	Virginia Beach City	6.71	6.98	0.27	4%
540030003	West Virginia	Berkeley	8.90	9.38	0.48	5%
540090005	West Virginia	Brooke	9.10	9.59	0.49	5%
540110006	West Virginia	Cabell	8.81	9.09	0.28	3%
540291004	West Virginia	Hancock	8.27	8.73	0.46	6%
540390010	West Virginia	Kanawha	7.84	8.14	0.30	4%
540391005	West Virginia	Kanawha	8.97	9.27	0.30	3%
540490006	West Virginia	Marion	8.75	9.21	0.46	5%
540511002	West Virginia	Marshall	9.85	10.03	0.18	2%

Table 4-2. Comparison of 2028el CAMx 6.32 and 2028elv3 CAMx 6.40 Predicted Annual $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
540610003	West Virginia	Monongalia	7.57	8.07	0.50	7%
540690010	West Virginia	Ohio	8.37	8.72	0.35	4%
540810002	West Virginia	Raleigh	6.68	6.99	0.31	5%
541071002	West Virginia	Wood	8.91	9.12	0.21	2%

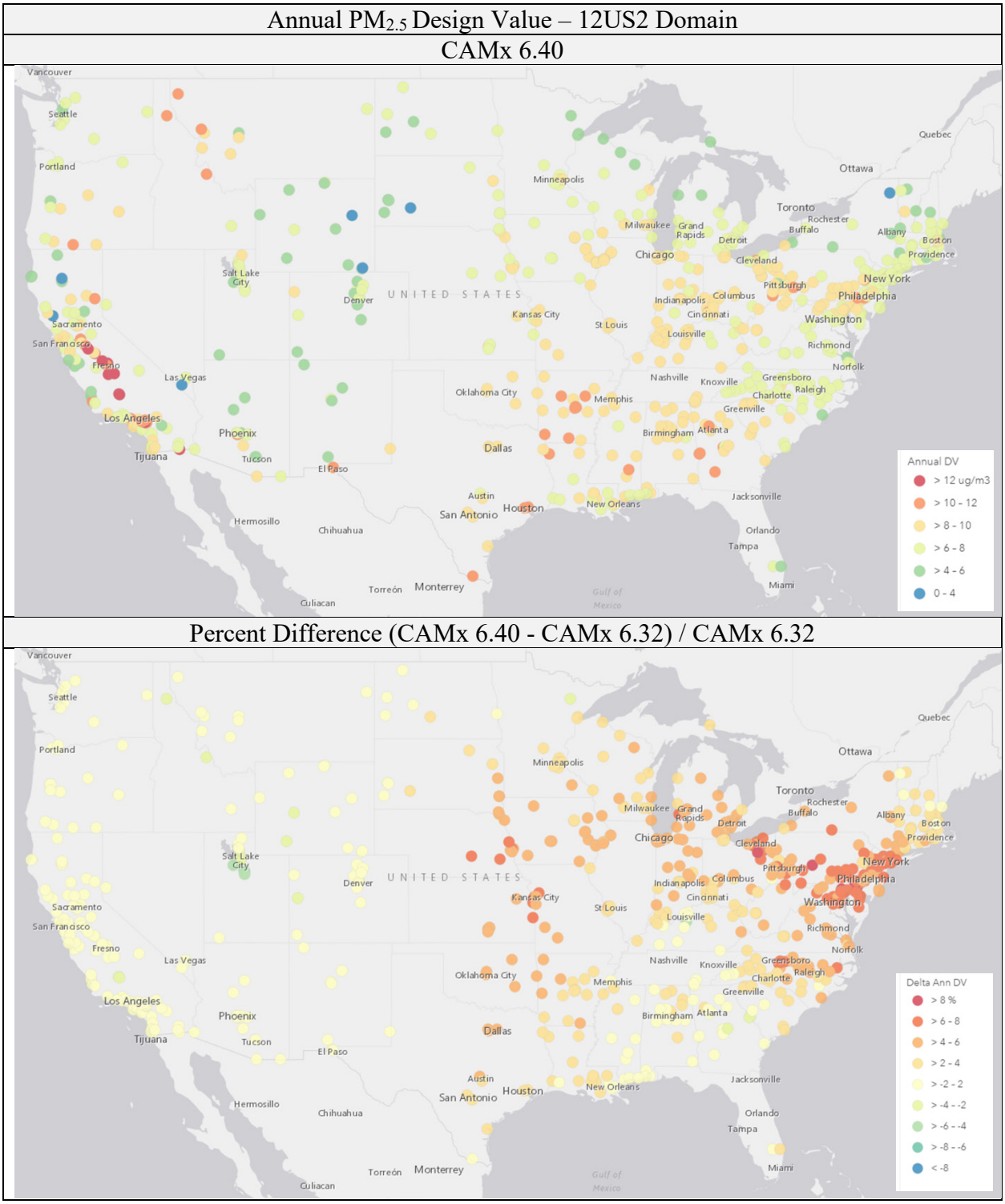


Figure 4-16. Comparison of Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations

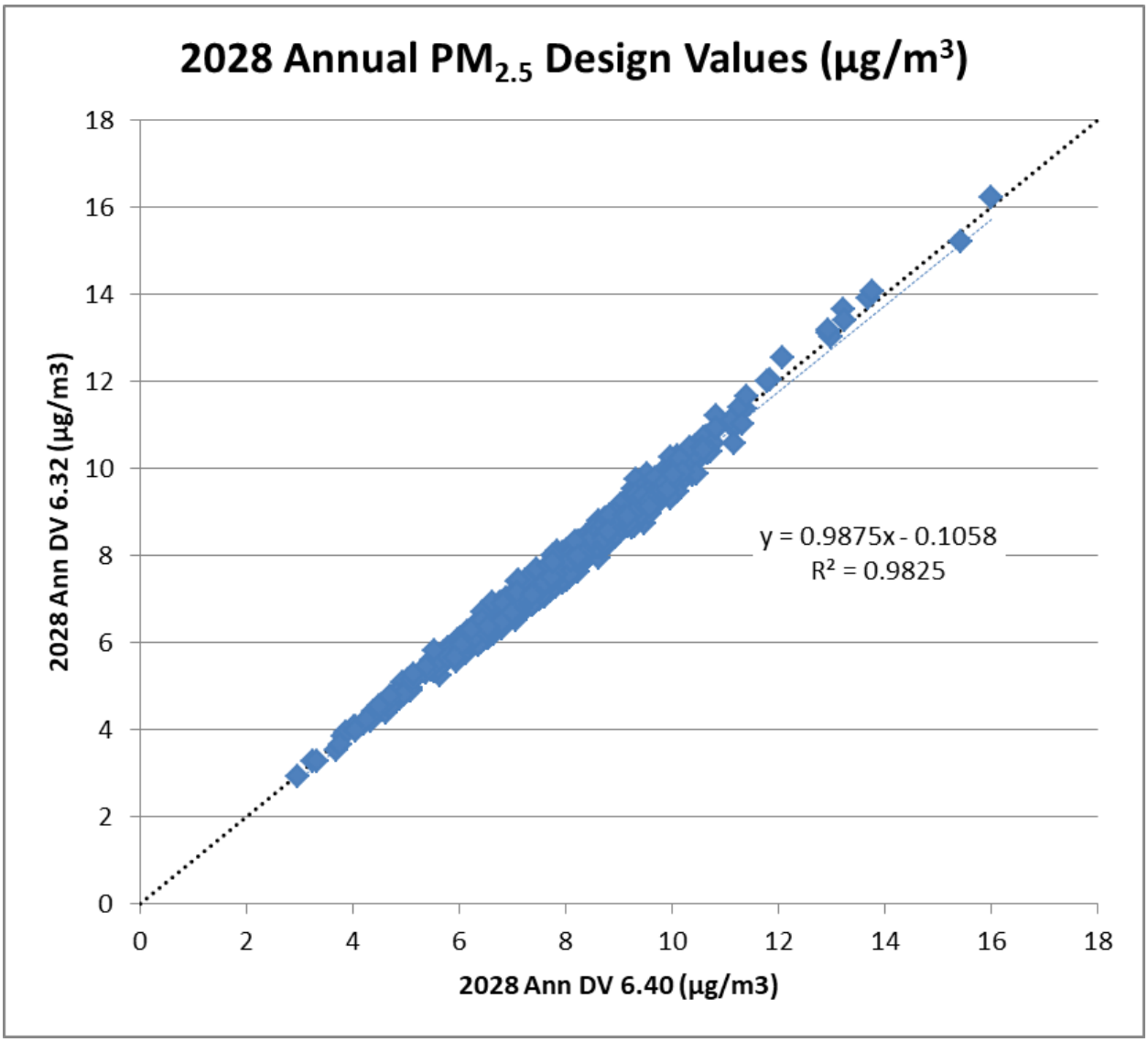


Figure 4-17. Scatterplot Comparing Annual Average Predicted $PM_{2.5}$ Design Values ($\mu g/m^3$) at all Monitor Locations for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations Performed by VISTAS (Alpine)

4.3 24-Hour (Daily) $PM_{2.5}$ Design Value

Daily $PM_{2.5}$ design values were generated using the results of each individual CAMx simulation (version 6.32 with EPA's 2028el platform and version 6.40 with SESARM's 2028elv3 platform) and the SMAT-CE tool. Results for each individual receptor in the VISTAS states are presented in tabular format in Table 4-3 along with the absolute difference and percent difference in design value.

The maximum calculated increase is 1.1 $\mu g/m^3$ at monitor 510030001 in Albemarle, Virginia (9% increase going from CAMx 6.32 to 6.40) and maximum calculated decrease is 0.7 $\mu g/m^3$ at monitor 130210007 in Bibb, Georgia (3% decrease going from CAMx 6.32 to 6.40). The average change in daily design value for all monitors in the VISTAS states is 0.20 $\mu g/m^3$, with an average daily percent difference of 2% at these same locations.

Geographic distribution of the 6.40 daily $PM_{2.5}$ design values and differences in design values compared to the 6.32 simulation is presented in Figure 4-18. As similarly seen in the annual $PM_{2.5}$ design values, daily $PM_{2.5}$ design values have the smallest fractional change within the middle of the VISTAS state domain and the largest daily design value fractional changes are seen across much of the central states region, running north to south along the western border of the VISTAS domain and along the northeastern boundary of the VISTAS domain, adjacent to MARAMA state boundaries.

A scatterplot of the daily $PM_{2.5}$ design values for all FRM monitors in the 12US2 domain is presented in Figure 4-19. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0395, an intercept of -1.1381 $\mu g/m^3$ and an R^2 of 0.9895. CAMx 6.40 concentrations appear to be marginally higher compared to CAMx 6.32 at low concentration ranges and slightly lower than the CAMx 6.32 results in medium to high concentration ranges.

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3)

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
010030010	Alabama	Baldwin	15.8	15.9	0.1	1%
010270001	Alabama	Clay	17.1	17.2	0.1	1%
010331002	Alabama	Colbert	16.4	16.2	-0.2	-1%
010491003	Alabama	DeKalb	16.9	17.1	0.2	1%
010550010	Alabama	Etowah	17.8	17.7	-0.1	-1%
010690003	Alabama	Houston	17.0	17.0	0.0	0%
010730023	Alabama	Jefferson	22.8	22.9	0.1	0%
010731005	Alabama	Jefferson	18.0	17.8	-0.2	-1%
010731009	Alabama	Jefferson	17.8	17.8	0.0	0%
010731010	Alabama	Jefferson	18.2	18.3	0.1	1%
010732003	Alabama	Jefferson	20.9	21.2	0.3	1%
010732006	Alabama	Jefferson	18.6	18.6	0.0	0%
010735002	Alabama	Jefferson	17.6	17.4	-0.2	-1%
010735003	Alabama	Jefferson	17.8	17.7	-0.1	-1%
010890014	Alabama	Madison	18.5	18.6	0.1	1%
010970003	Alabama	Mobile	16.0	16.1	0.1	1%
010972005	Alabama	Mobile	16.6	16.7	0.1	1%
011011002	Alabama	Montgomery	19.9	19.9	0.0	0%
011030011	Alabama	Morgan	16.5	16.5	0.0	0%
011130001	Alabama	Russell	23.3	23.4	0.1	0%
011170006	Alabama	Shelby	15.8	15.8	0.0	0%
011210002	Alabama	Talladega	18.5	18.5	0.0	0%
011250004	Alabama	Tuscaloosa	18.9	19.0	0.1	1%
011270002	Alabama	Walker	17.8	17.8	0.0	0%
120990008	Florida	Palm Beach	15.6	15.7	0.1	1%
120990009	Florida	Palm Beach	13.5	13.6	0.1	1%
130210007	Georgia	Bibb	22.8	22.1	-0.7	-3%
130210012	Georgia	Bibb	18.3	17.9	-0.4	-2%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3)

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
130510017	Georgia	Chatham	24.7	24.3	-0.4	-2%
130510091	Georgia	Chatham	24.3	24.4	0.1	0%
130590002	Georgia	Clarke	17.4	17.6	0.2	1%
130670004	Georgia	Cobb	16.9	17.1	0.2	1%
130890002	Georgia	DeKalb	17.1	17.2	0.1	1%
130950007	Georgia	Dougherty	24.4	24.3	-0.1	0%
131390003	Georgia	Hall	16.3	16.5	0.2	1%
131530001	Georgia	Houston	19.7	19.5	-0.2	-1%
132950002	Georgia	Walker	17.5	17.2	-0.3	-2%
133190001	Georgia	Wilkinson	20.5	20.2	-0.3	-1%
280330002	Mississippi	DeSoto	15.6	15.9	0.3	2%
280350004	Mississippi	Forrest	19.5	19.5	0.0	0%
280430001	Mississippi	Grenada	15.5	15.8	0.3	2%
280450003	Mississippi	Hancock	18.4	18.3	-0.1	-1%
280470008	Mississippi	Harrison	15.3	15.1	-0.2	-1%
280490010	Mississippi	Hinds	18.1	18.5	0.4	2%
280590006	Mississippi	Jackson	17.7	17.6	-0.1	-1%
280670002	Mississippi	Jones	20.1	20.3	0.2	1%
280750003	Mississippi	Lauderdale	18.5	18.6	0.1	1%
280810005	Mississippi	Lee	17.0	17.4	0.4	2%
370010002	North Carolina	Alamance	14.7	15.2	0.5	3%
370210034	North Carolina	Buncombe	13.0	13.5	0.5	4%
370330001	North Carolina	Caswell	12.7	12.8	0.1	1%
370350004	North Carolina	Catawba	16.3	16.4	0.1	1%
370370004	North Carolina	Chatham	12.6	13.0	0.4	3%
370510009	North Carolina	Cumberland	16.6	17.0	0.4	2%
370570002	North Carolina	Davidson	15.4	15.9	0.5	3%
370610002	North Carolina	Duplin	14.2	14.4	0.2	1%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3)

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
370630015	North Carolina	Durham	13.6	13.9	0.3	2%
370650004	North Carolina	Edgecombe	14.3	14.7	0.4	3%
370670022	North Carolina	Forsyth	14.9	15.3	0.4	3%
370670030	North Carolina	Forsyth	14.4	14.8	0.4	3%
370710016	North Carolina	Gaston	16.2	16.4	0.2	1%
370810013	North Carolina	Guilford	15.5	16.1	0.6	4%
370810014	North Carolina	Guilford	13.5	14.4	0.9	7%
370870012	North Carolina	Haywood	18.7	18.8	0.1	1%
370990006	North Carolina	Jackson	13.9	13.8	-0.1	-1%
371010002	North Carolina	Johnston	13.8	14.1	0.3	2%
371070004	North Carolina	Lenoir	15.3	15.8	0.5	3%
371110004	North Carolina	McDowell	15.1	15.4	0.3	2%
371170001	North Carolina	Martin	16.5	17.3	0.8	5%
371190041	North Carolina	Mecklenburg	17.2	17.5	0.3	2%
371190042	North Carolina	Mecklenburg	17.7	17.9	0.2	1%
371190043	North Carolina	Mecklenburg	15.0	15.2	0.2	1%
371210001	North Carolina	Mitchell	13.8	13.8	0.0	0%
371230001	North Carolina	Montgomery	14.5	14.9	0.4	3%
371290002	North Carolina	New Hanover	15.6	15.9	0.3	2%
371470006	North Carolina	Pitt	14.8	15.4	0.6	4%
371550005	North Carolina	Robeson	16.3	16.9	0.6	4%
371590021	North Carolina	Rowan	14.9	15.3	0.4	3%
371730002	North Carolina	Swain	15.5	15.6	0.1	1%
371830014	North Carolina	Wake	16.9	17.4	0.5	3%
371830020	North Carolina	Wake	14.1	14.4	0.3	2%
371890003	North Carolina	Watauga	12.6	13.0	0.4	3%
371910005	North Carolina	Wayne	15.3	15.8	0.5	3%
450190048	South Carolina	Charleston	16.2	16.3	0.1	1%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3)

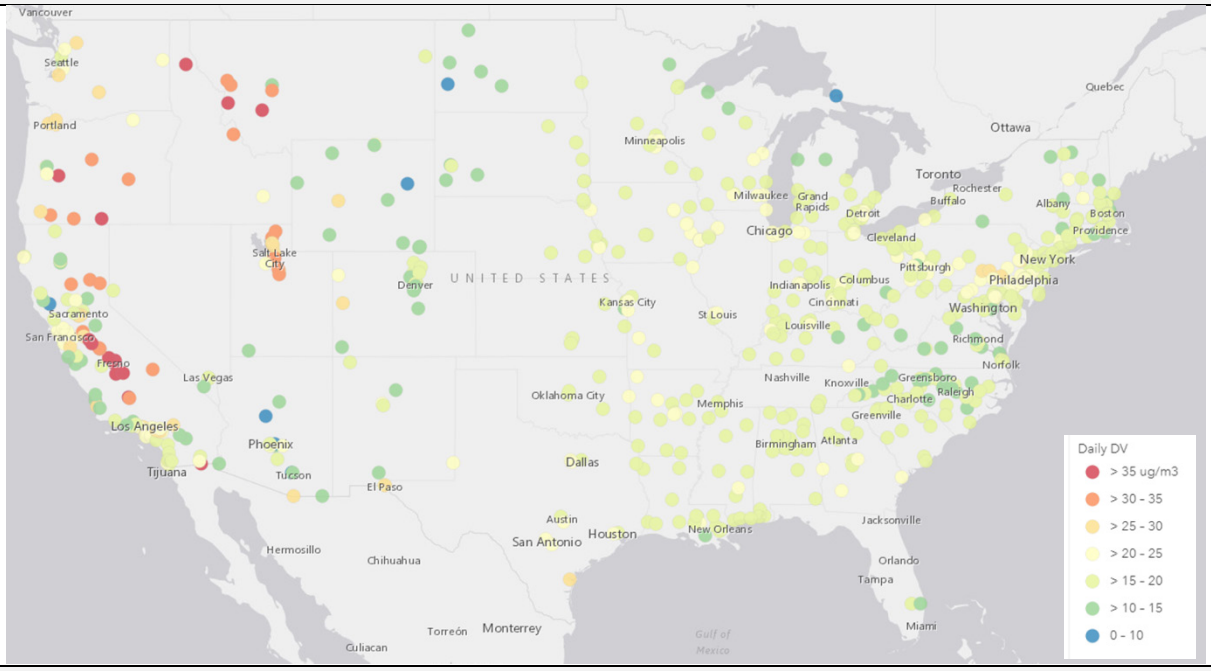
Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
450190049	South Carolina	Charleston	15.6	15.9	0.3	2%
450250001	South Carolina	Chesterfield	15.5	15.5	0.0	0%
450370001	South Carolina	Edgefield	17.0	16.9	-0.1	-1%
450410003	South Carolina	Florence	18.2	18.4	0.2	1%
450450009	South Carolina	Greenville	17.9	18.1	0.2	1%
450450015	South Carolina	Greenville	19.2	19.3	0.1	1%
450630008	South Carolina	Lexington	18.9	19.0	0.1	1%
450790019	South Carolina	Richland	19.5	19.4	-0.1	-1%
450830011	South Carolina	Spartanburg	17.2	17.4	0.2	1%
470650031	Tennessee	Hamilton	18.6	18.6	0.0	0%
470651011	Tennessee	Hamilton	17.3	17.0	-0.3	-2%
470654002	Tennessee	Hamilton	17.0	16.7	-0.3	-2%
510030001	Virginia	Albemarle	12.7	13.8	1.1	9%
510360002	Virginia	Charles	13.2	13.9	0.7	5%
510410003	Virginia	Chesterfield	14.7	15.5	0.8	5%
510590030	Virginia	Fairfax	17.3	18.0	0.7	4%
510690010	Virginia	Frederick	18.1	18.6	0.5	3%
510870014	Virginia	Henrico	15.4	16.1	0.7	5%
510870015	Virginia	Henrico	13.1	14.1	1.0	8%
511071005	Virginia	Loudoun	16.1	16.5	0.4	2%
511390004	Virginia	Page	15.2	16.1	0.9	6%
511650003	Virginia	Rockingham	17.1	17.7	0.6	4%
515200006	Virginia	Bristol City	15.7	16.2	0.5	3%
516500008	Virginia	Hampton City	14.1	14.9	0.8	6%
516800015	Virginia	Lynchburg City	13.4	13.9	0.5	4%
517100024	Virginia	Norfolk City	15.0	15.7	0.7	5%
517700015	Virginia	Roanoke City	16.4	16.9	0.5	3%
517750011	Virginia	Salem City	14.6	15.0	0.4	3%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and CAMx 6.32 2028el Simulation of Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3)

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			6.32 2028el	6.40 2028elv3	Difference	Percent Difference
518100008	Virginia	Virginia Beach City	16.4	16.8	0.4	2%
540030003	West Virginia	Berkeley	22.8	23.5	0.7	3%
540090005	West Virginia	Brooke	18.9	19.2	0.3	2%
540110006	West Virginia	Cabell	17.9	18.8	0.9	5%
540291004	West Virginia	Hancock	19.6	20.5	0.9	5%
540390010	West Virginia	Kanawha	16.1	17.0	0.9	6%
540391005	West Virginia	Kanawha	18.2	18.6	0.4	2%
540490006	West Virginia	Marion	19.1	19.3	0.2	1%
540511002	West Virginia	Marshall	23.1	23.3	0.2	1%
540610003	West Virginia	Monongalia	16.2	17.1	0.9	6%
540690010	West Virginia	Ohio	17.7	17.9	0.2	1%
540810002	West Virginia	Raleigh	13.9	14.3	0.4	3%
541071002	West Virginia	Wood	18.6	18.6	0.0	0%

Daily $PM_{2.5}$ Design Value – 12US2 Domain

CAMx 6.40



Percent Difference (CAMx 6.40 – CAMx 6.32) / CAMx 6.32

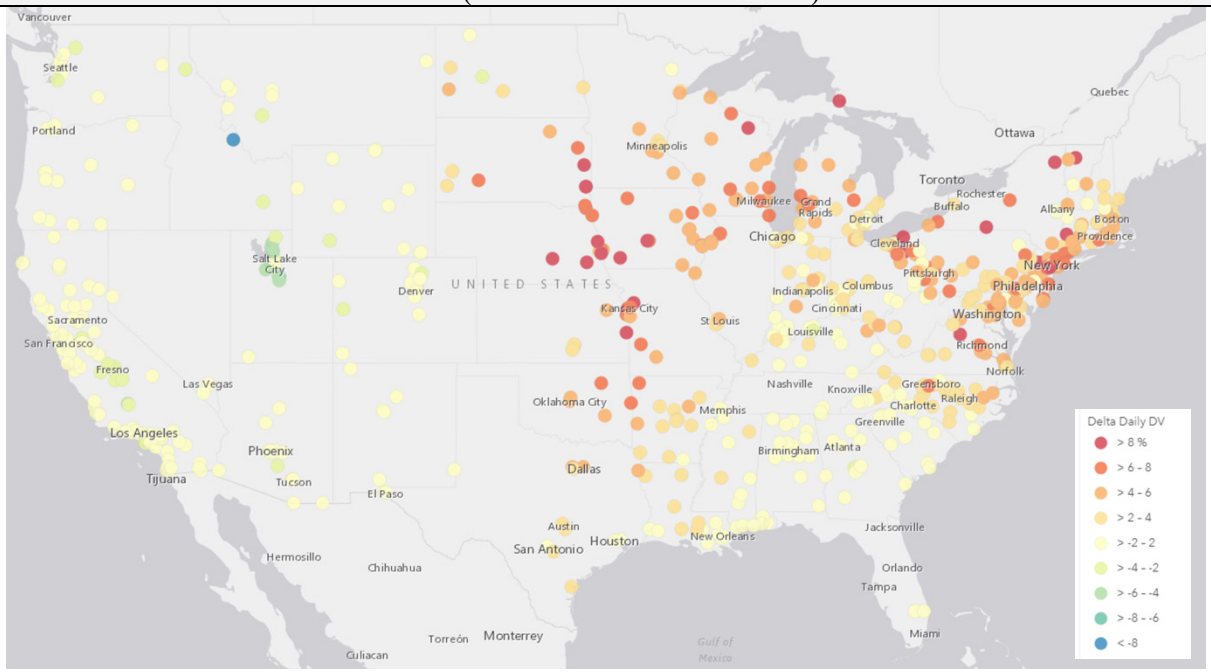


Figure 4-18. Comparison of Daily $PM_{2.5}$ Design Values (µg/m^3) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations

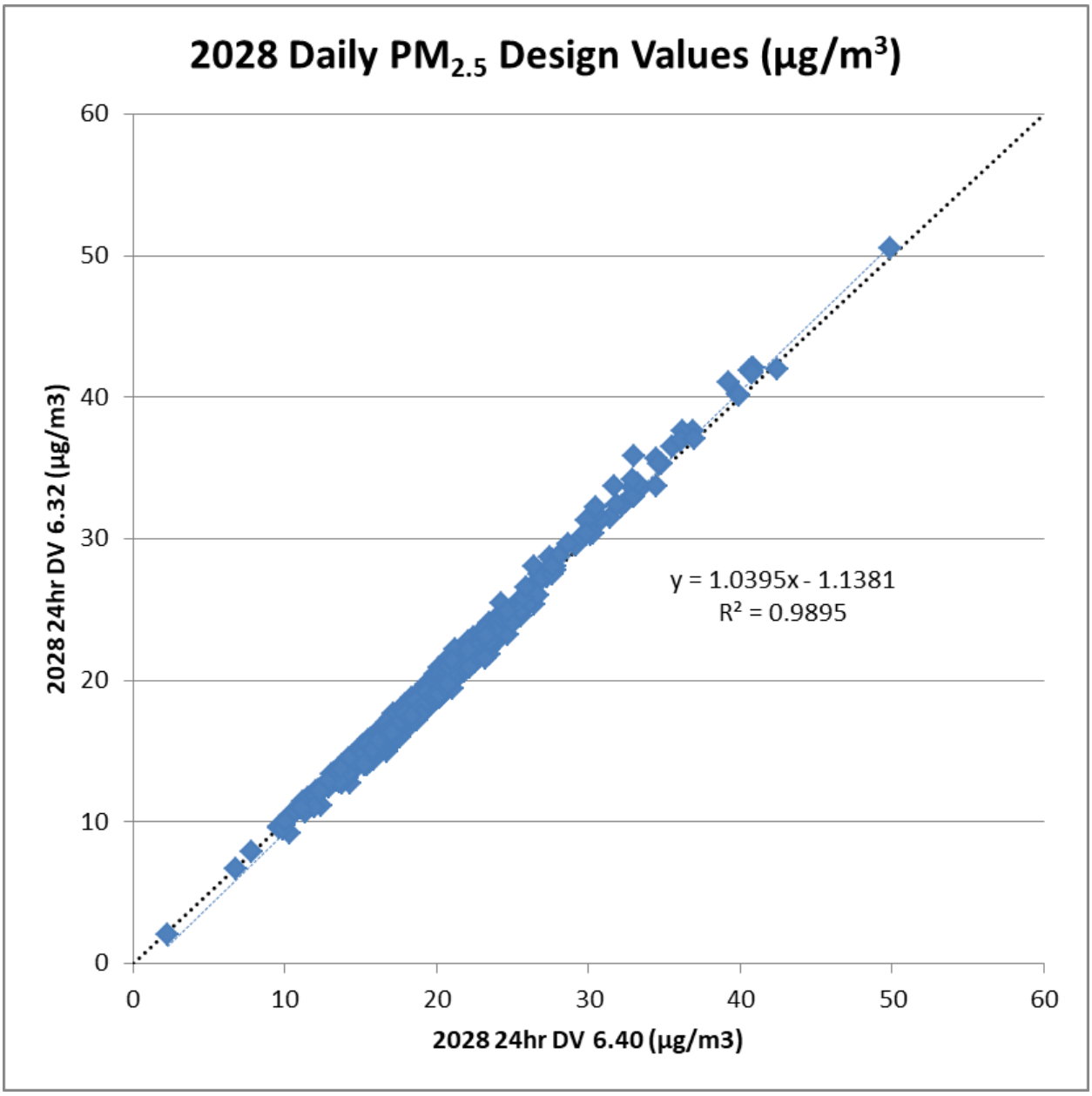


Figure 4-19. Comparison of Daily $PM_{2.5}$ Design Values (µg/m^3) for CAMx 6.32 2028el and CAMx 6.40 2028elv3 Simulations

4.4 Scatterplots of Ozone and PM Species Concentrations

Scatterplots of the daily average concentrations of ozone and the various calculated PM species in local standard time at the Interagency Monitoring for Protected Visual Environment (IMPROVE) monitors across all modeled days are presented in Figures 4-20 through 4-26. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis.

Figure 4-20 exhibits concentrations for ozone have a high degree of correlation with a line of best fit with a slope of 0.9754, an intercept of 0.5203 ppb and an R^2 of 0.9974. Results are scattered both above and below the 1:1 line, with marginally higher concentrations estimated by CAMx 6.40 across the concentration range.

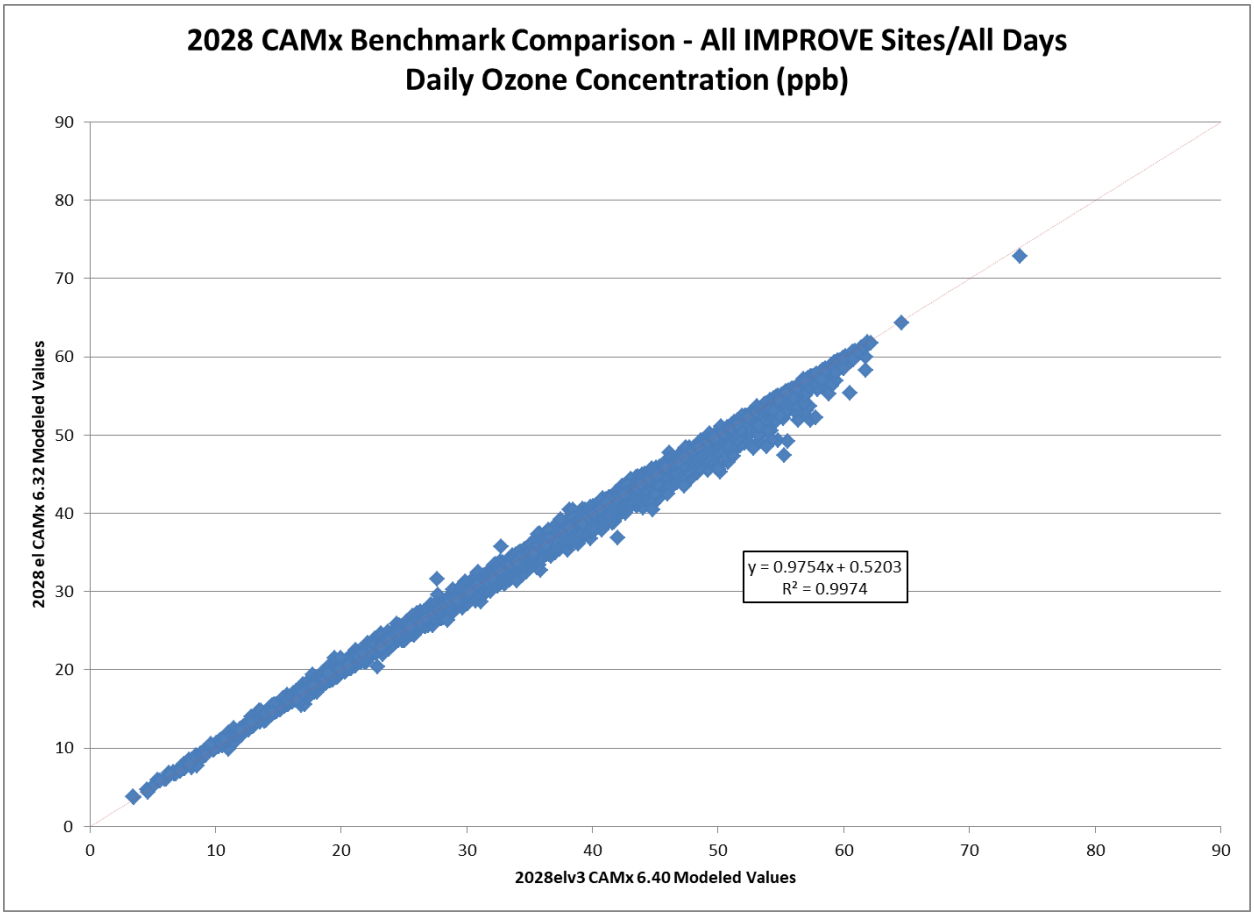


Figure 4-20. Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average $PM_{2.5}$ concentrations in local standard time at the IMPROVE monitors are presented in Figures 4-21 and 4-22 with different axis scaling to facilitate analysis over the full range of concentrations. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 0.9973, an intercept of 0.3731 $\mu g/m^3$and an R^2 of 0.9845. The agreement between the models is higher at higher concentrations. At lower concentrations the CAMx 6.32 results are slightly higher than the CAMx 6.40 results.

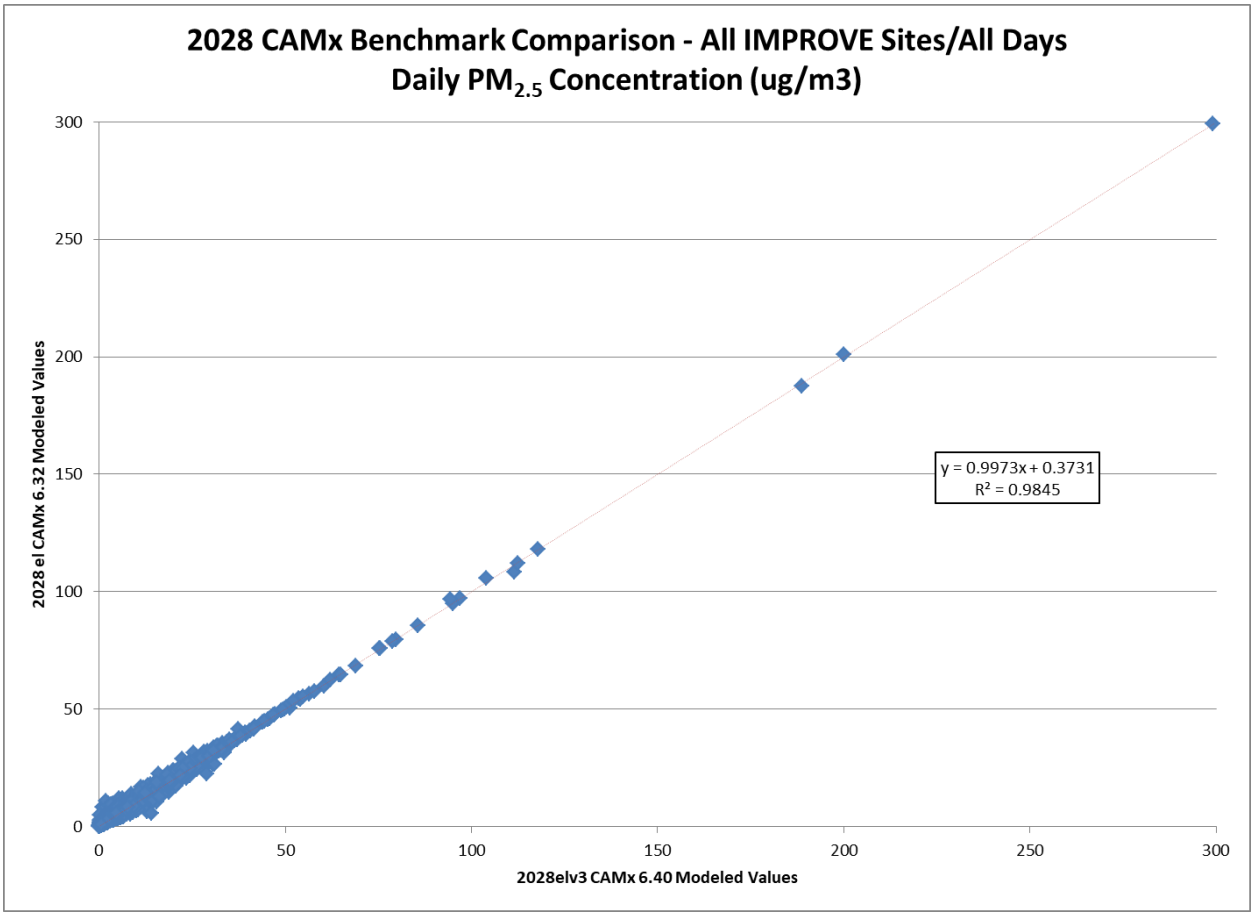


Figure 4-21. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

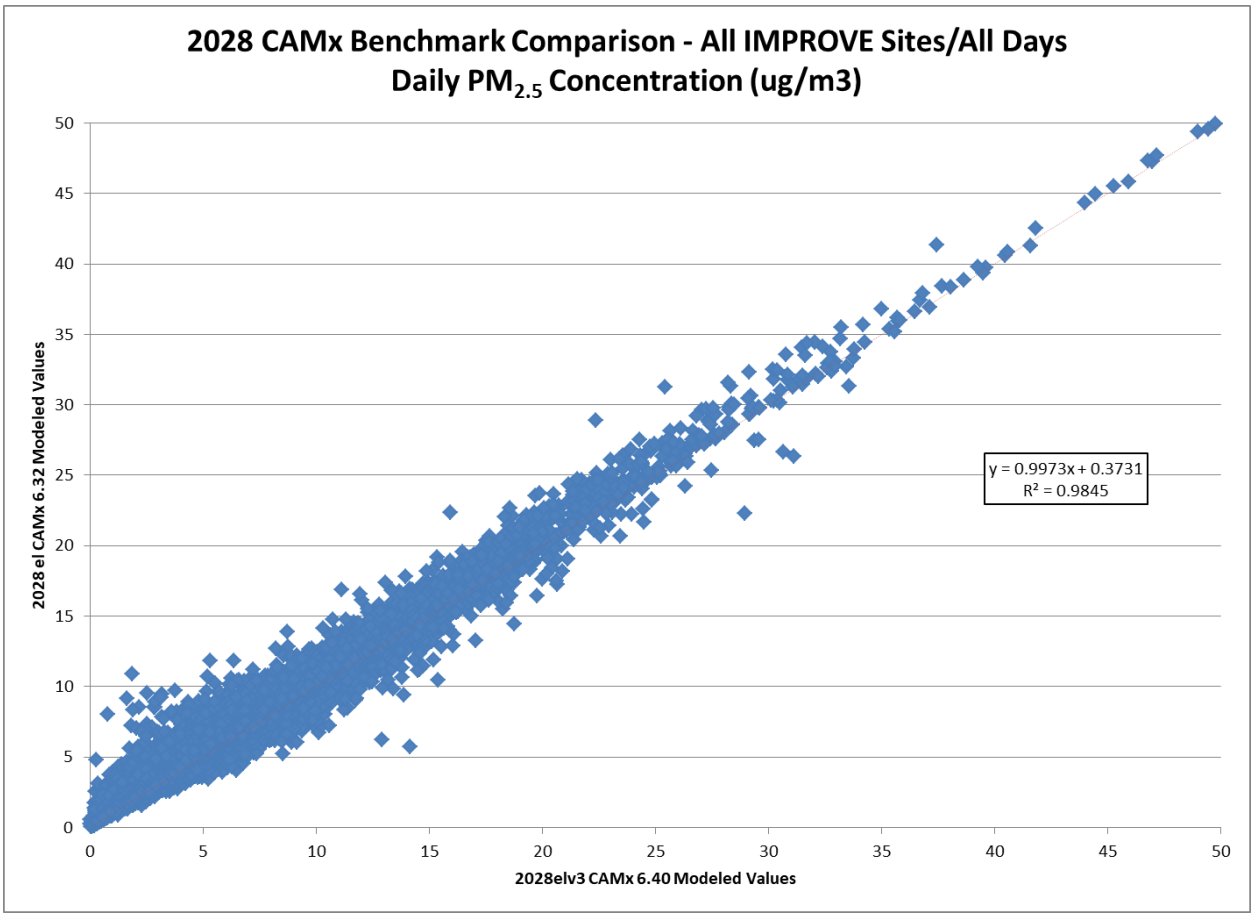


Figure 4-22. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine); Modified Scale

Scatterplots of the daily average sulfate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-23. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has considerably more scatter than the ozone or $PM_{2.5}$ results with a line of best fit with a slope of 0.9057, an intercept of 0.0.092 $\mu g/m^3$ and an R^2 of 0.8566. The vast majority of the points at low concentrations are above the 1:1 line, meaning that the CAMx 6.32 modeled values are higher than the CAMx 6.40 results. The reverse is true at medium and high concentrations where CAMx 6.40 tends to estimate higher concentrations than CAMx 6.32. These are likely a result of the changes in the wet deposition algorithms and the oxidation of SO_2 on primary crustal particles and updates to the RADM aqueous chemistry algorithm in addition to the changes in the elevated SO_2 emissions.

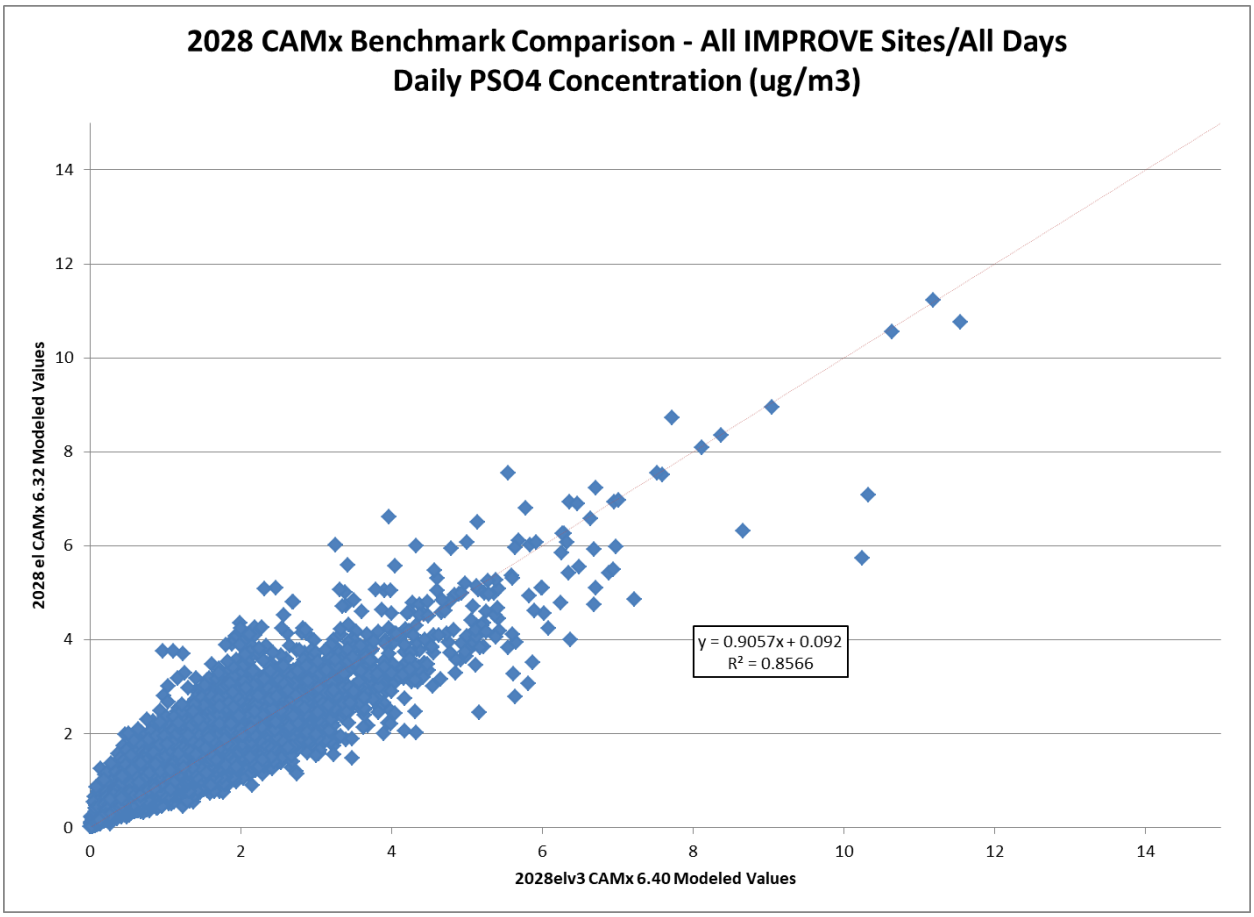


Figure 4-23. Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (μg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-24. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has slightly more scatter than the ozone or $PM_{2.5}$ results with a line of best fit with a slope of 0.9266, an intercept of 0.0009 μg/m^3 and an R^2 of 0.9743. Unlike the sulfate results which showed more uniform scatter around the 1:1 line, the CAMx 6.40 nitrate results are marginally higher than CAMx 6.32 except at low concentrations.

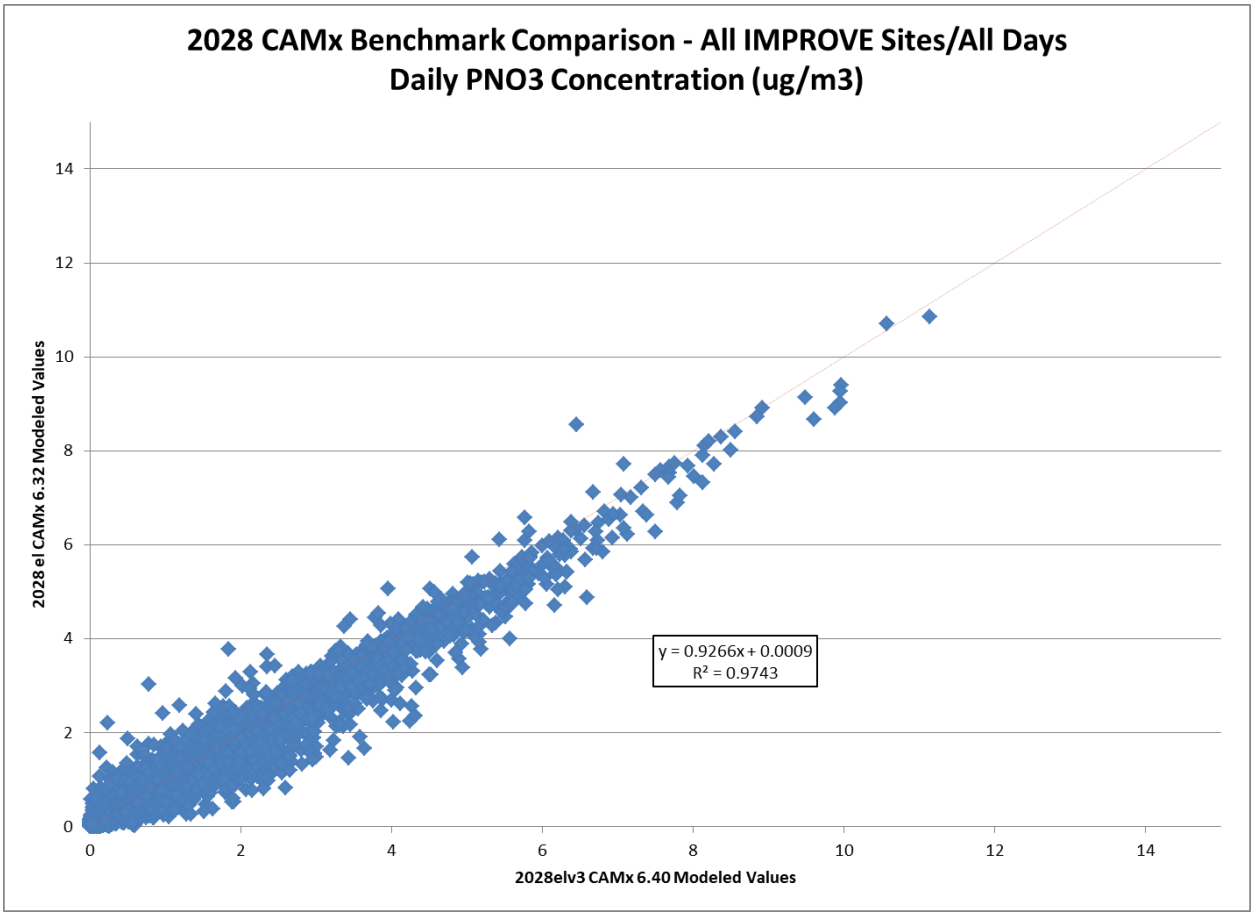


Figure 4-24. Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average organic carbon concentrations in local standard time at the IMPROVE monitors are presented in Figures 4-24 and 4-25 with different axis scaling to facilitate analysis over the full range of concentrations. The CAMx 6.40 results are plotted on the x-axis and the CAMx 6.32 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0146, an intercept of 0.3025 ppb and an R^2 of 0.9837. The CAMx 6.40 results are slightly lower than CAMx 6.32 across the concentration range.

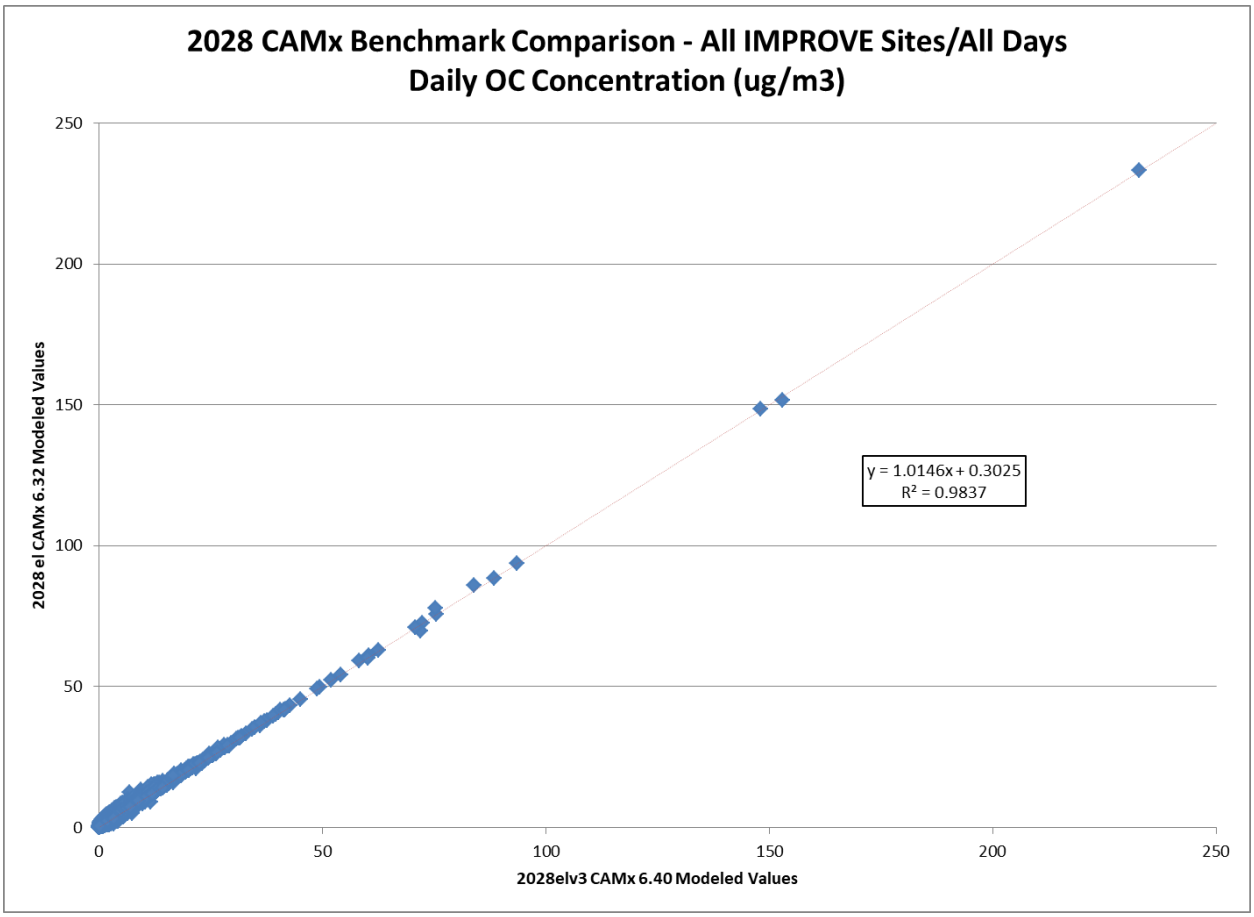


Figure 4-25. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine)

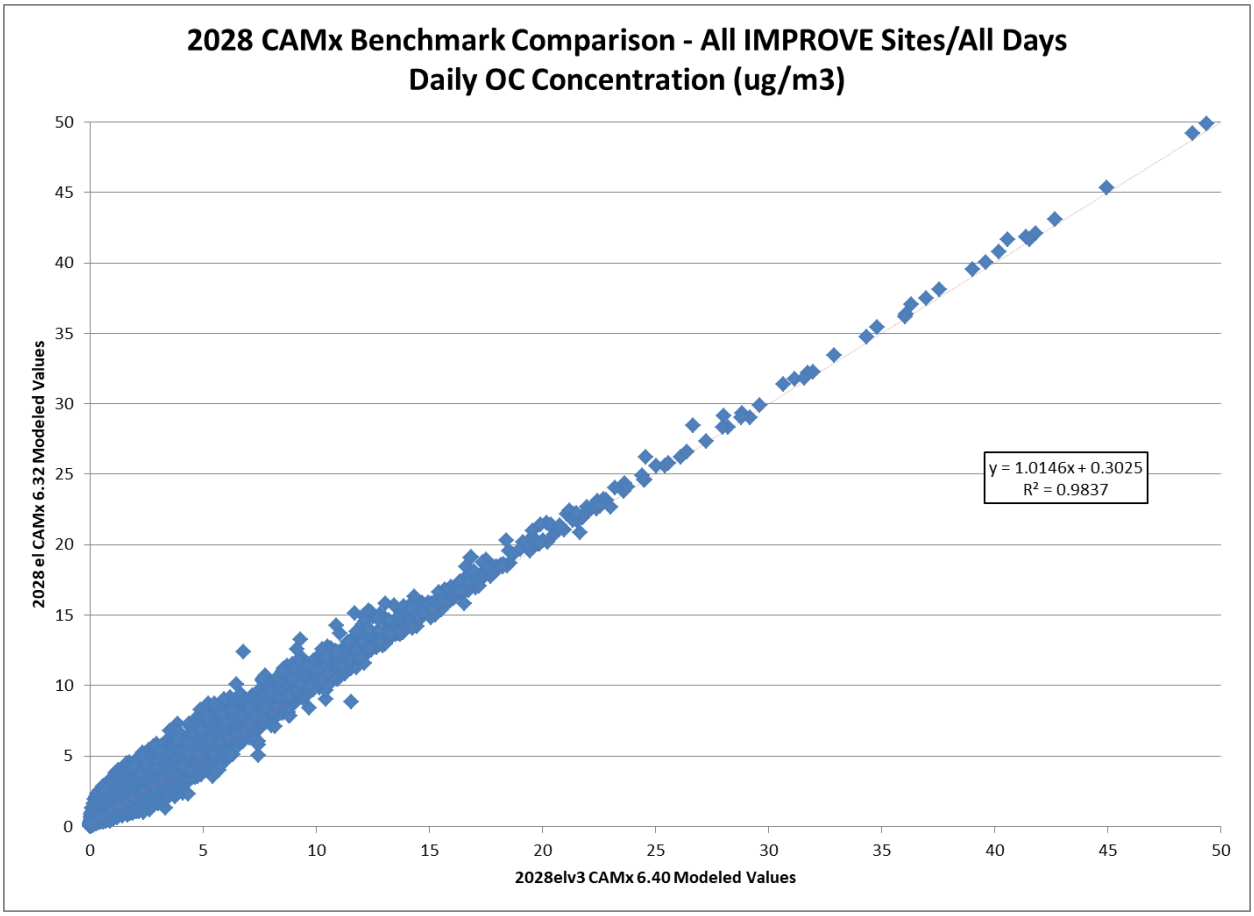


Figure 4-26. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.32 and CAMx 6.40 2028 Simulations Performed by VISTAS (Alpine); Modified Scale

5.0 CONCLUSIONS

A comparison has been made between CAMx 6.32 and CAMx 6.40 simulations using EPA's 2028el and SESARM's 2028elv3 modeling platform as performed on the Alpine Geophysics computer system. The comparison was conducted for $PM_{2.5}$ and included an examination both of annual emissions for elevated and low level sources and annual and daily future year design values at monitors in the modeling domain.

The annual emissions comparisons showed areas of differences across the domain that are consistent with documented changes in the 2028 emissions inventories used by SESARM for this analysis. A comparison of the annual and daily $PM_{2.5}$ design values at the monitors in the 12US2 modeling domain showed a systematic increase for the majority of FRM monitors for both values between the CAMx 6.32 and CAMx 6.40 platform. The greatest change in design values are seen in and around boundaries of VISTAS states and other outside regions (e.g., OTC and CENRAP) with smallest change noted centrally within the VISTAS state domain itself.

A comparison of the daily average concentrations at the IMPROVE monitors showed fairly small differences for ozone between the two simulations with CAMx 6.40 estimating slightly larger values in the high concentration range. Organic Carbon was estimated as slightly lower across all concentration ranges using CAMx 6.40 compared to CAMx 6.32. For sulfate, the CAMx 6.40 results were generally higher than CAMx 6.32, especially across the medium and high concentration ranges. This is likely a result of the changes in the wet deposition algorithms, the oxidation of SO_2 on primary crustal particles, and updates to the RADM aqueous chemistry algorithm and changes in SO_2 emissions. For nitrate, the CAMx 6.40 results were consistently higher across all ranges compared to CAMx 6.32 except at very low concentrations. The $PM_{2.5}$ results generally showed lower CAMx 6.40 concentrations compared to CAMx 6.32 at low concentration levels.

The comparison of CAMx 6.32 and 6.40 showed differences in both annual and daily $PM_{2.5}$ design values as well as in daily concentrations of various $PM_{2.5}$ species. This is to be expected given the changes to the model from the inclusion of new science into CAMx 6.40 over that which was included in CAMx 6.32 and the changes made in the 2028 projection emission inventory across the modeling domain. Alpine Geophysics does not see any features in the

modeling that would preclude the use of the better science and updated emission inventories in CAMx 6.40 for use in the VISTAS air quality planning.

Appendix E-2e

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project 2028elv3 CAMx Version 6.40 12km VISTAS and EPA 12km Continental Grid Comparison Report

Benchmark Run #6

August 17, 2020

This page intentionally left blank.

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project

2028elv3 CAMx Version 6.40 12km VISTAS and EPA 12km Continental Grid Comparison Report

Task 6 Benchmark Report #5
Covering Benchmark Run #6

Prepared for:

Southeastern States Air Resource Managers, Inc. (SESARM)

205 Corporate Center Drive, Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final – August 17, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 INTRODUCTION 1
1.1 Overview 1
1.2 CAMx 6.40 2028elv3 VISTAS12 and EPA 12US2 Comparison 3
2.0 DEVELOPMENT OF VISTAS12 INPUTS 4
3.0 CONFIRMATION METHODOLOGY 4
3.1 CAMx Species Mapping 6
4.0 VISTAS12 AND 12US2 CAMX 6.40 2018ELV3 COMPARISON 6
4.1 Ozone 6
4.2 $PM_{2.5}$ 30
4.3 Sulfate 53
4.4 Nitrate 76
4.5 Organic Matter (OM) 99
5.0 CONCLUSIONS 122

This page is intentionally blank.

TABLES

Table 1-1. VISTAS II Modeling Domain Specifications 3

Table 3-1. Species Mapping from CAMx into Aggregated Species 6

Table 4-1. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of Ozone Concentrations (ppb). Hours with the top 10 maximum positive and maximum negative differences are shown. 8

Table 4-2. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of $PM_{2.5}$ Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 31

Table 4-3. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of Sulfate Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 54

Table 4-4. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of Nitrate Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 77

Table 4-5. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of Organic Matter Concentrations ($\mu g/m^3$). Hours with the top 10 maximum positive and maximum negative differences are shown. 100

FIGURES

Figure 1-1. Map of 12km CAMx Modeling Domains. VISTAS12 Domain Represented as Inner Red Domain. 3

Figure 4-1: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference) 9

Figure 4-2: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference) 10

Figure 4-3: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference) 11

Figure 4-4: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference) 12

Figure 4-5: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference) 13

Figure 4-6: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference) 14

Figure 4-7: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Positive Difference) 15

Figure 4-8: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference) 16

Figure 4-9: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference).....17

Figure 4-10: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference).....18

Figure 4-11: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference) 19

Figure 4-12: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference).....20

Figure 4-13: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference) 21

Figure 4-14: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference).....22

Figure 4-15: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference).....23

Figure 4-16: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference).....24

Figure 4-17: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference) 25

Figure 4-18: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference).....26

Figure 4-19: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference) 27

Figure 4-20: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference) 28

Figure 4-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by V ISTAS (Alpine).....29

Figure 4-22: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference).....32

Figure 4-23: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference) 33

Figure 4-24: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference) 34

Figure 4-25: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference) 35

Figure 4-26: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference) 36

Figure 4-27: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference).....37

Figure 4-28: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Positive Difference) 38

Figure 4-29: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference) 39

Figure 4-30: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference) 40

Figure 4-31: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference).....41

Figure 4-32: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference) 42

Figure 4-33: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference).....43

Figure 4-34: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference).....44

Figure 4-35: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference).....45

Figure 4-36: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference).....46

Figure 4-37: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference) 47

Figure 4-38: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference).....48

Figure 4-39: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference).....49

Figure 4-40: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference) 50

Figure 4-41: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference) 51

Figure 4-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on

VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by VISTAS (Alpine). 52

Figure 4-43: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference) 55

Figure 4-44: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference) 56

Figure 4-45: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference) 57

Figure 4-46: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference) 58

Figure 4-47: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference) 59

Figure 4-48: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference)....60

Figure 4-49: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations 61

Figure 4-50: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference) 62

Figure 4-51: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference) 63

Figure 4-52: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference)....64

Figure 4-53: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference) 65

Figure 4-54: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference)....66

Figure 4-55: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference)....67

Figure 4-56: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference)....68

Figure 4-57: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference)....69

Figure 4-58: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference) 70

Figure 4-59: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference)....71

Figure 4-60: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference).....72

Figure 4-61: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference) 73

Figure 4-62: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference) 74

Figure 4-63: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by VISTAS (Alpine). 75

Figure 4-64: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference).....78

Figure 4-65: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference) 79

Figure 4-66: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference) 80

Figure 4-67: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference) 81

Figure 4-68: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference) 82

Figure 4-69: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference).....83

Figure 4-70: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Positive Difference) 84

Figure 4-71: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference) 85

Figure 4-72: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference).....86

Figure 4-73: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference).....87

Figure 4-74: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference) 88

Figure 4-75: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference).....89

Figure 4-76: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference).....90

Figure 4-77: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference).....91

Figure 4-78: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference).....92

Figure 4-79: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference).....93

Figure 4-80: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference).....94

Figure 4-81: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference).....95

Figure 4-82: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference).....96

Figure 4-83: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference).....97

Figure 4-84: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by VISTAS (Alpine).....98

Figure 4-85: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference).....101

Figure 4-86: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference).....102

Figure 4-87: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference).....103

Figure 4-88: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference).....104

Figure 4-89: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference).....105

Figure 4-90: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference).....106

Figure 4-91: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Positive Difference).....107

Figure 4-92: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference) 108

Figure 4-93: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference) 109

Figure 4-94: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference) 110

Figure 4-95: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference) 111

Figure 4-96: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference) 112

Figure 4-97: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference) 113

Figure 4-98: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference) 114

Figure 4-99: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference) 115

Figure 4-100: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference) 116

Figure 4-101: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference) 117

Figure 4-102: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference) 118

Figure 4-103: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference) 119

Figure 4-104: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference) 120

Figure 4-105: Scatterplot Comparing 24-hour Average Predicted Organic Matter Concentrations (μg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by VISTAS (Alpine). 121

This page is intentionally blank.

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
BNDEXTR	Boundary extraction program
CAMx	Comprehensive Air quality Model with eXtensions
CONUS	Continental U.S.
dv	Deciview
ERG	Eastern Research Group, Inc.
EPA	Environmental Protection Agency
FCRS	Crustal fraction of PM
FLM	Federal Land Manager
FORTRAN	Formula Translation programming language
FPRM	Fine other primary (diameter ≤ 2.5µm)
FR	Federal Register
IMPROVE	Interagency Monitoring of Protected Visual Environments
km	kilometer
µg/m^3	microgram per cubic meter
NA	Sodium
NAAQS	National Ambient Air Quality Standard
OAQPS	Office of Air Quality Planning and Standards
O_3	Ozone
OM	Organic matter
PCL	Particulate chlorine
PEC	Primary elemental carbon
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Particulate ammonium
PNO3	Particulate nitrate
POA	Primary Organic Aerosol
ppb	Parts per billion
PSO4	Particulate sulfate
R^2	Pearson correlation coefficient squared
RHR	Regional Haze Rule
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SO_2	Sulfur dioxide
SOA	Secondary organic aerosol
U.S.	United States
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast

1.0 INTRODUCTION

1.1 Overview

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.

B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that is, the focus of state planning will be to establish reasonable progress goals for each Class I area against which progress will be measured during the second planning period. This extension will allow states to incorporate planning for other Federal programs while conducting their regional haze planning. These other programs include: the Mercury and Air Toxics Standards, the 2010 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview (dv) index values. "Most impaired days" are defined as the 20% of

monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

1.2 CAMx 6.40 2028elv3 VISTAS12 and EPA 12US2 Comparison

The VISTAS II air quality modeling is being performed on a smaller computational grid than EPA used in developing the 2011el platform. The use of the smaller domain is designed to allow SESARM to more efficiently look at air quality issues in the southeastern US.

Alpine has executed two air quality simulations for the 2028elv3 base year modeling platform; one run with CAMx 6.40 over the EPA continental US domain (12US2) and one for the VISTAS12 domain. The domains are presented in Figure 1-1 with the 12US2 domain as the outer grid and the VISTAS12 domain is shown as the red box. The domain definitions for the two domains are presented in Table 1-1.

Table 1-1. VISTAS II Modeling Domain Specifications

Domain	Columns	Rows	Vertical Layers	X Origin (km)	Y Origin (km)
CONUS_12	396	246	25	-2,412	-1,620
VISTAS_12	269	242	25	-912	-1,596

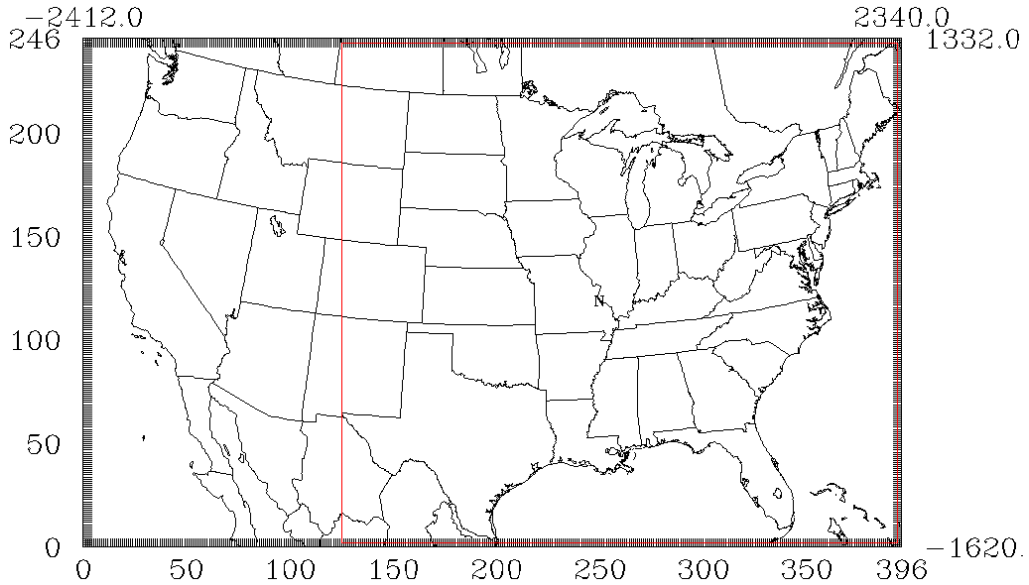


Figure 1-1. Map of 12km CAMx Modeling Domains. VISTAS12 Domain Represented as Inner Red Domain.

2.0 DEVELOPMENT OF VISTAS12 INPUTS

The inputs for the VISTAS12 domain were developed by extracting a subdomain from the CAMx ready model inputs (commonly referred to as windowing). The meteorology and emissions inputs were windowed using a slightly modified version of the CAMx utility program "window".[2] The only required change to the distributed version program is to allow the program to window three-dimension files instead of just two-dimensional files. The CAMx ozone column and watermask inputs were windowed using new FORTRAN programs using the same windowing algorithm as is contained in the "window" code. The windowing code was checked graphically to assure that the VISTAS12 results were consistent with the 12US2 results. The boundary and initial conditions for the VISTAS12 domain will be extracted from the 12US2 three-dimensional output files using the CAMx BNDEXTR program.

Two issues have been identified that have noted impact on the use of the VISTAS12 domain relative to the 12US2 domain.[3] The first, and likely the most significant, noted issue is a time-step difference at the boundary where concentration conditions from outside of the domain are injected into the modeling domain at one hour intervals compared to the model generated (sub-hourly) time-step interval within the modeling domain. These differences can create initial, significant concentration gradients along the boundary that can be carried through the episode and transported to grid cells within the modeling domain. The second issue is related to the time step in the model. The time step is determined by the maximum wind in the modeling domain. If the highest wind in the 12US2 domain occurs somewhere outside the VISTAS12 domain, the time step in the 12US2 simulation will be longer than in the VISTAS12 domain.

We note that in modeling the VISTAS12 domain with 12US2 boundary conditions, both of these issues are exacerbated in the modeling due to large emission sources located near the boundary of the 12US2/VISTAS12 boundary, particularly in Canada.

3.0 CONFIRMATION METHODOLOGY

The presented comparisons of model simulations are based on hourly differences in ozone, $PM_{2.5}$, Organic Matter (OM), Particulate Nitrate (PNO3), and Particulate Sulfate (PSO4).

[2] http://www.camx.com/getmedia/88755b80-6992-4f07-bcaa-596d05e1b4b8/window-6may13_1.tgz
[3] Brian Timin, EPA Office of Air Quality Planning and Standards (OAQPS) personal communication October 11, 2018.

The metric for comparison are the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$(C_{VISTAS12} - C_{12US2})$$

(Equation 2) $$\frac{(C_{VISTAS12} - C_{12US2})}{(C_{12US2})}$$

Where $C_{VISTAS12}$ is the concentration at each grid cell hour for the CAMx simulation over the VISTAS12 simulation and C_{12US2} is the concentration at each grid cell hour for the CAMx simulation over the 12US2.

To facilitate the comparison of the results over the same spatial domain, the 12US2 simulation output files were windowed onto the VISTAS2 domain using the I/O API[4] m3wndw code.

The results are presented for the hours with the largest difference between the simulations. Each table presents the hours with the top 10 positive and negative absolute differences. Spatial maps are presented for the hours with the top 10 highest positive and negative differences. To provide context for the differences, the concentration maps are also presented for each of the hours of high difference. On each spatial plot the maximum positive and negative values, along with the grid cell in which these occur, are presented at the top of the graphic. The coordinates refer to the row and columns of the cell referenced to the cell coordinates on the bottom (column) and left (row) of the graphic. Because the CAMx results are unduly influenced by the boundary concentrations around the edges, the analysis does not include the edge rows and columns of the CAMx domain.

Hourly animations have also been prepared and are available on the VISTAS II project ftp site. Where appropriate, this report also reports and interprets on the animations.

[4] https://www.cmascenter.org/ioapi/

3.1 CAMx Species Mapping

Several of the key particulate matter species of interest are combinations of CAMx output variable. The CAMx 6.40 species mapping are presented in Table 3-1.

Table 3-1. Species Mapping from CAMx into Aggregated Species

Aggregated Species	CAMx 6.40 Species
Ozone	O3
$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
Sulfate	PSO4
Nitrate	PNO3
Organic Matter (OM)	SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA

4.0 VISTAS12 AND 12US2 CAMX 6.40 2018ELV3 COMPARISON

This section presents comparisons of the simulations using CAMx 6.40 performed on the Alpine computer system using the SESARM 2028elv3 modeling platform over the VISTAS12 and 12US2 domains.

4.1 Ozone

Ozone results for the top 10 positive and negative hours are presented in tabular format in Table 4-1. The maximum positive difference is 18.00 ppb falling to 11.76 ppb for the 10th high. The maximum negative difference is -17.43 ppb falling to -12.19 for the 10th high. Generally the highest positive and negative differences are occurring on relatively high ozone hours with concentrations up to 144.19 ppb for the VISTAS12 simulation. The maximum positive and negative percent differences are 82.1% and -16.0%, respectively.

As expected, the maximum impacts on the top 10 positive and negative hours are occurring very near the border (Rows close to 1 or 268 and Columns near 1 or 241). As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly average boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated at every model-generated timestep from the cells outside the VISTAS12 domain. Additionally, as noted in an earlier section, the CAMx model does not include emissions in the

border cells. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous model-determined concentrations and the CAMx model excluding emissions along the border.

The top ten positive impact hours are presented in Figures 4-1 through 4-10. The top ten negative impact hours are presented in Figures 4-11 through 4-20. The regions of highest differences tend to occur along the northern and western boundary and during short-term periods of time.

Scatterplots of the daily average ozone concentrations in local standard time at the IMPROVE monitors across all modeled days are presented in Figure 4-21. The 12US2 results are plotted on the x-axis and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0002, an intercept of 0.0090 ppb and an R^2 of 0.9999.

Examination of the difference animations shows some interesting results. On many hours the differences are fairly smooth without much horizontal difference, as seen in Figure 4-10. Then, in a single hour, regions of small local gradients occur and the spatial field resembles Figure 4-8. Often, over a period of several hours, these small differences disappear and the smooth structure is restored.

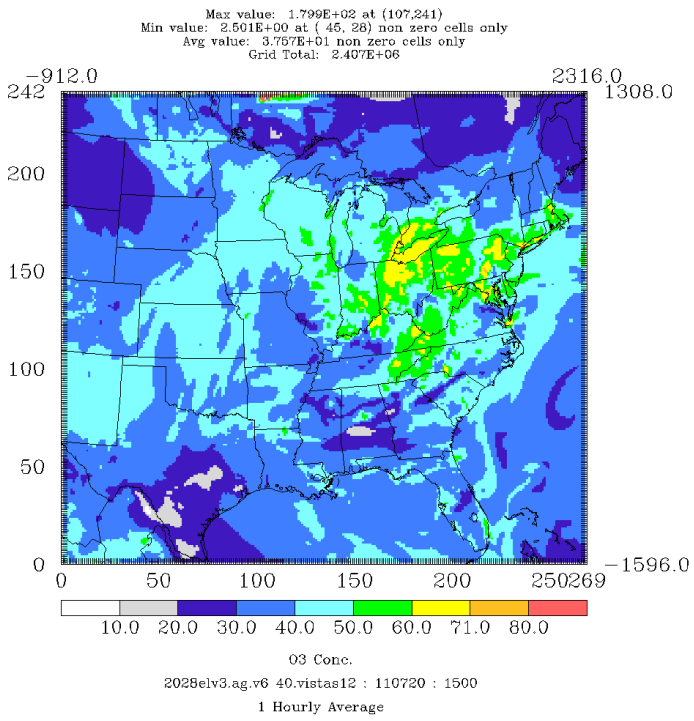
These differences are likely caused by a combination of factors. The first, and likely the most significant, noted issue is a time-step difference at the boundary where concentration conditions from outside of the domain are injected into the modeling domain at one hour intervals compared to the model generated (sub-hourly) time-step interval within the modeling domain. The other difference is the time step in the integration of the CAMx model. The CAMx model determines the time step based on the highest wind speed in the domain. When the highest wind speed is located in the VISTAS12 region, the time step for the VISTAS12 and 12US2 simulations are the same. When the highest wind speed in the 12US2 domain occurs outside the VISTAS12 domain, the time steps are different in the two simulations. This difference in the time step will yield slightly different concentrations between the two region simulations.

Table 4-1. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of Ozone Concentrations (ppb). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (ppb)	Percent Difference	Column	Row
Maximum Positive									
2011	7	20	15	144.19	126.19	18.00	14.3%	108	240
2011	7	20	16	127.78	112.36	15.42	13.7%	107	240
2011	7	20	17	81.19	66.76	14.43	21.6%	121	241
2011	5	17	8	30.48	17.32	13.17	76.0%	60	6
2011	5	17	7	28.95	15.90	13.05	82.1%	60	5
2011	7	20	21	56.21	43.52	12.69	29.2%	107	241
2011	9	6	8	39.02	26.46	12.56	47.5%	51	2
2011	5	17	9	30.86	18.65	12.21	65.4%	267	107
2011	2	24	0	46.52	34.54	11.98	34.7%	49	3
2011	9	6	9	38.17	26.41	11.76	44.5%	51	2
Maximum Negative									
2011	7	17	16	110.95	128.38	-17.43	-13.6%	92	241
2011	7	17	15	124.11	141.25	-17.14	-12.1%	90	241
2011	7	17	14	127.73	142.75	-15.03	-10.5%	90	241
2011	7	17	18	83.33	98.35	-15.02	-15.3%	93	240
2011	7	17	17	96.46	111.21	-14.74	-13.3%	92	241
2011	7	17	19	78.65	92.71	-14.06	-15.2%	92	240
2011	7	18	19	70.35	83.73	-13.38	-16.0%	89	241
2011	7	18	18	74.07	87.43	-13.36	-15.3%	89	241
2011	7	18	15	94.25	107.58	-13.34	-12.4%	88	241
2011	7	18	20	68.25	80.44	-12.19	-15.2%	90	240

Maximum Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

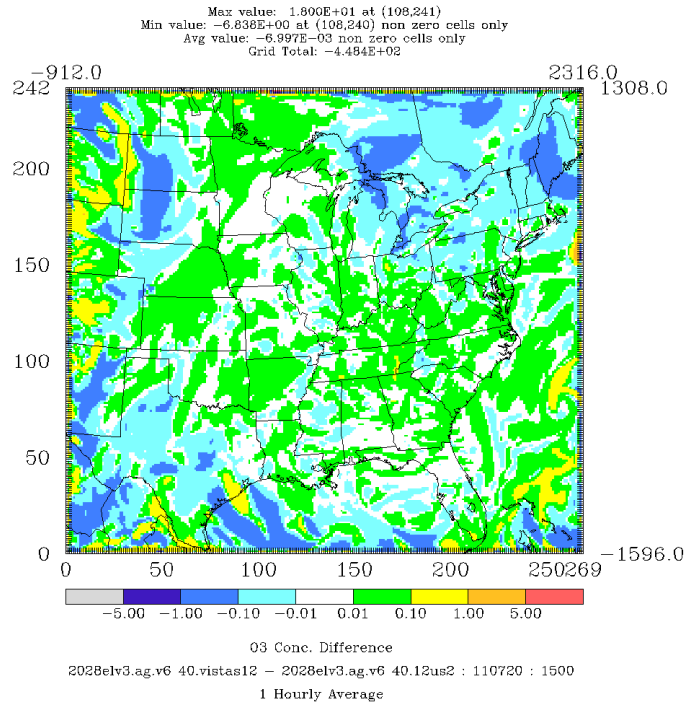
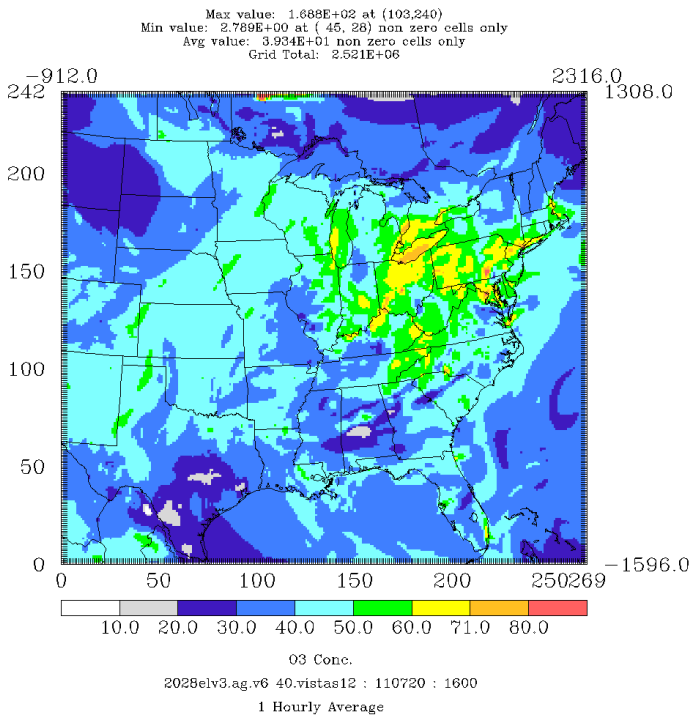


Figure 4-1: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference)

Second Highest Positive Difference: July 20 at1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

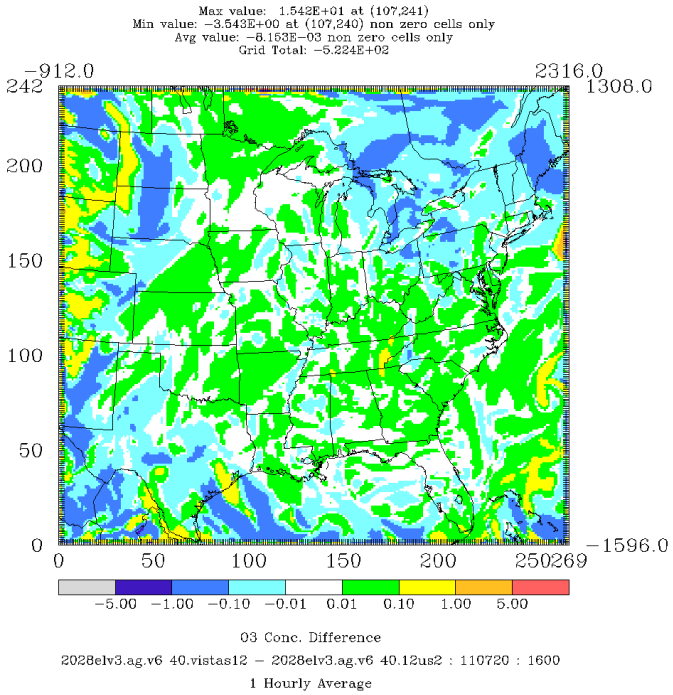
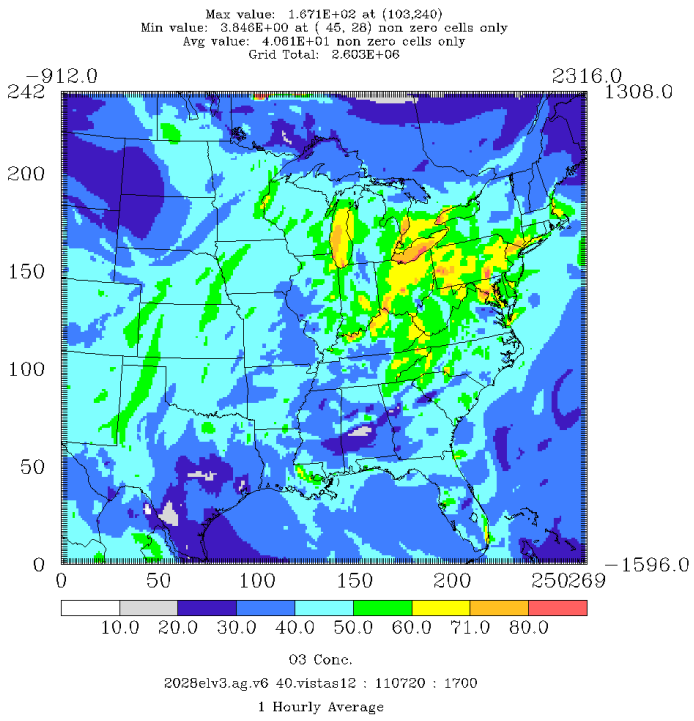


Figure 4-2: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: July 20 at 1700 hours

VISTAS12



Difference (VISTAS12 - 12US2)

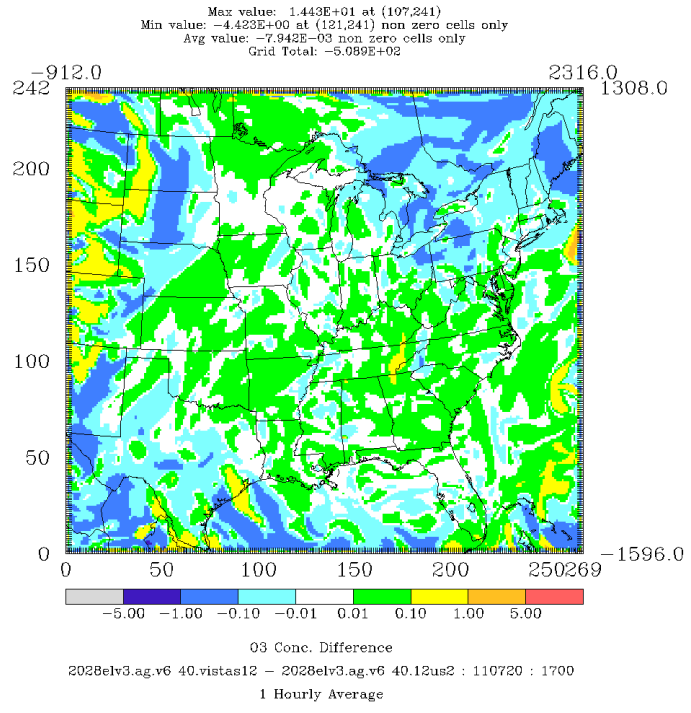
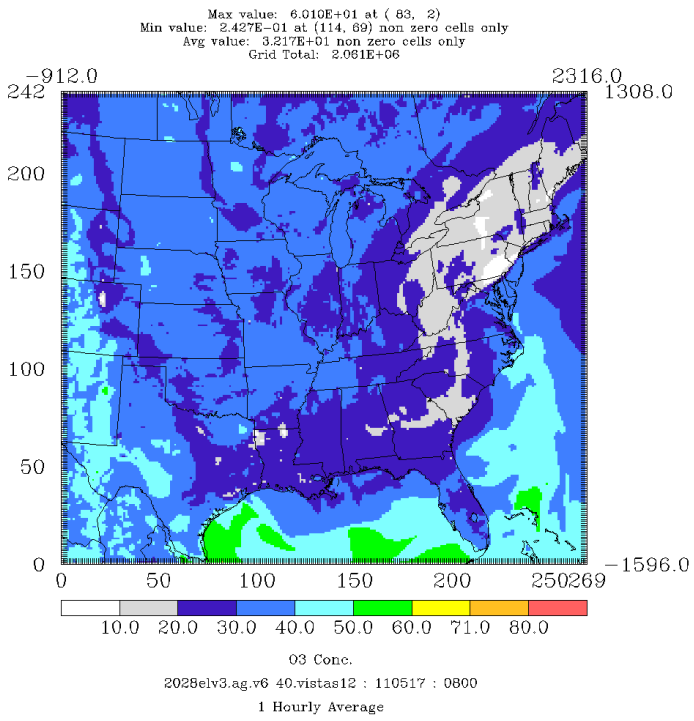


Figure 4-3: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: May 17 at 800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

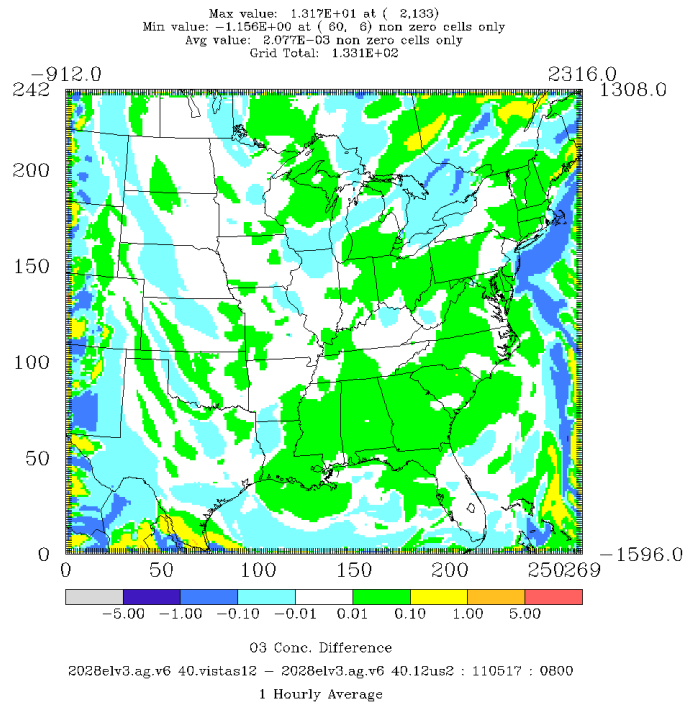
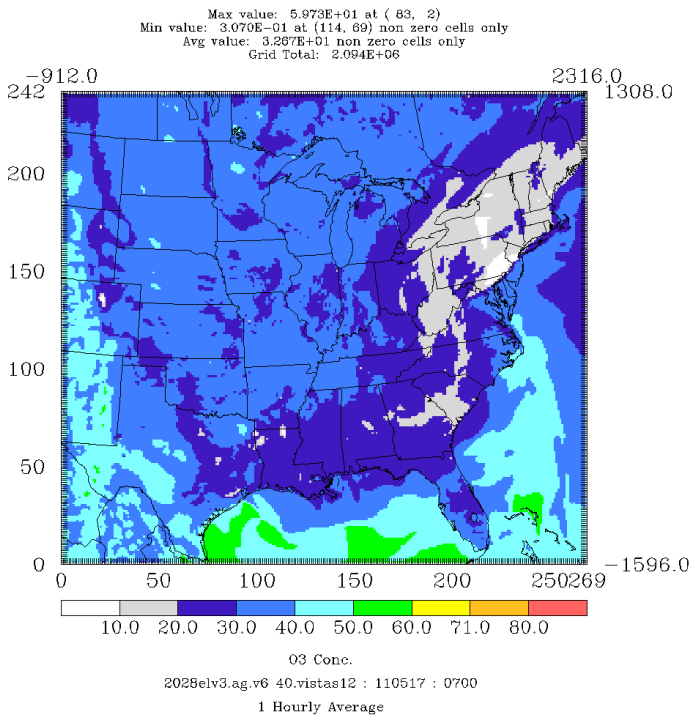


Figure 4-4: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: May 17 at 700 hours

VISTAS12



Difference (VISTAS12 - 12US2)

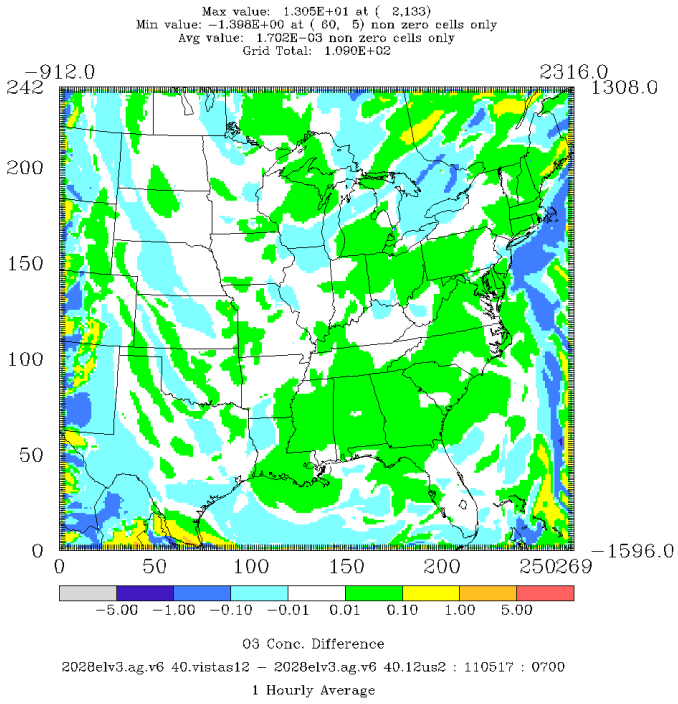
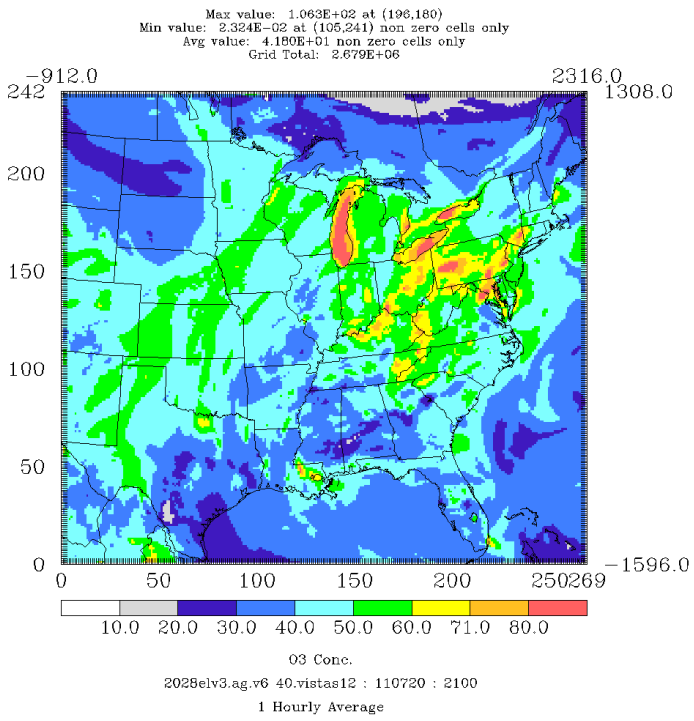


Figure 4-5: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 20 at 2100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

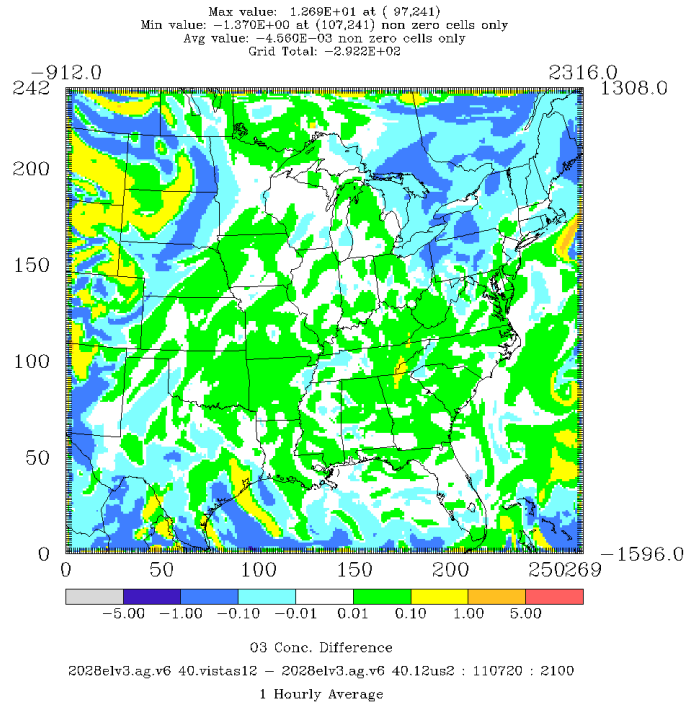
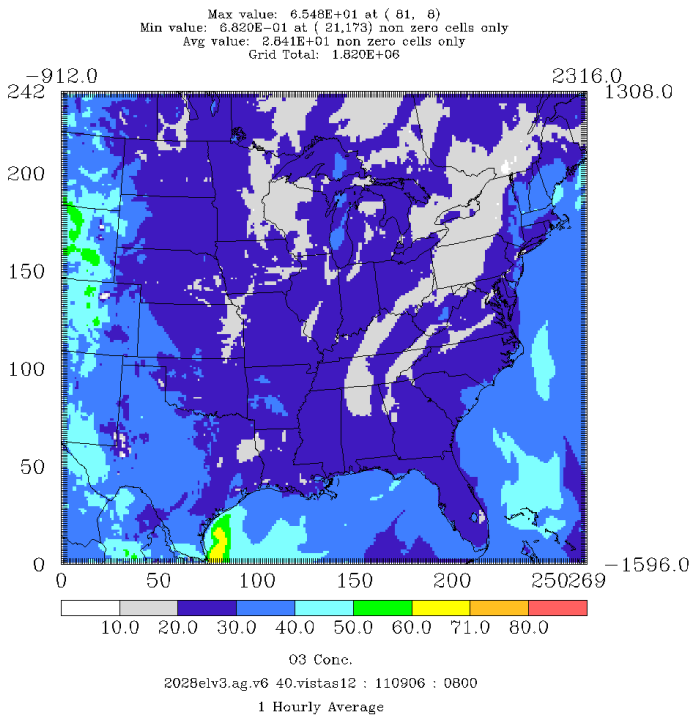


Figure 4-6: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: September 6 at 800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

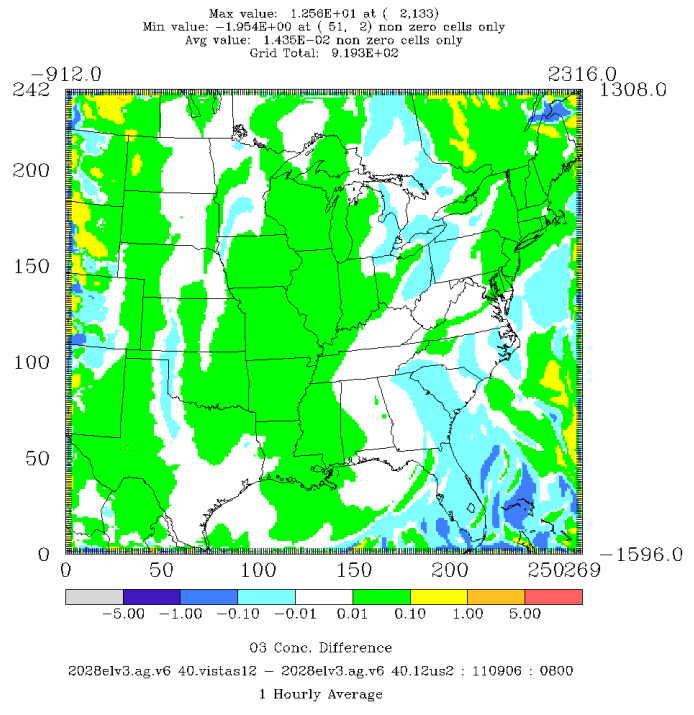
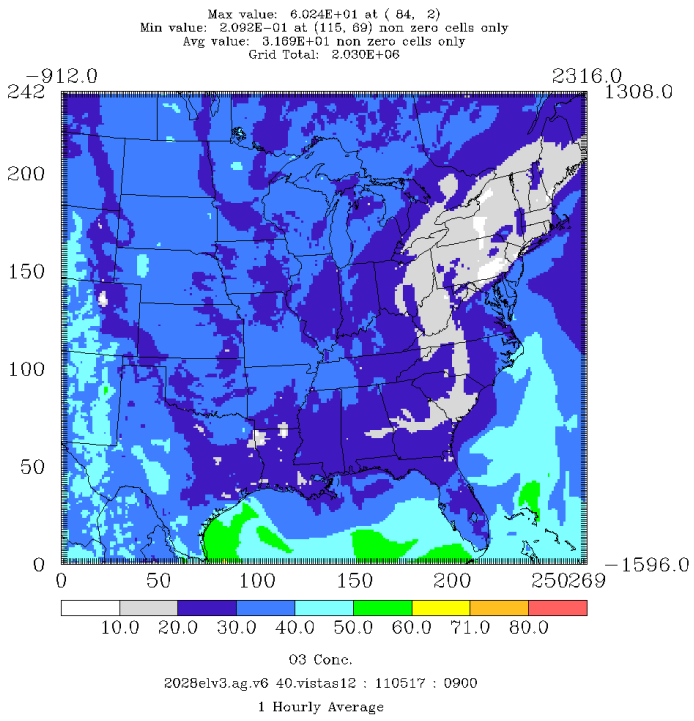


Figure 4-7: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: May 17 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

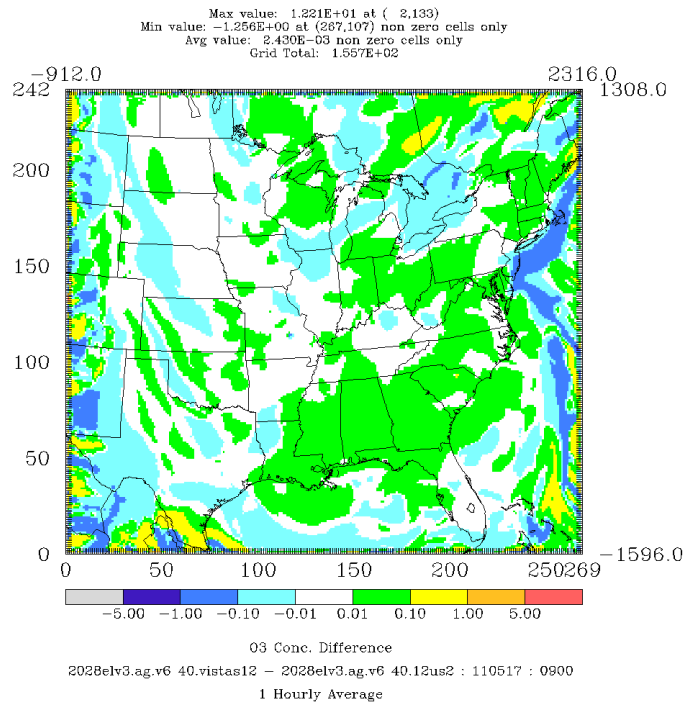
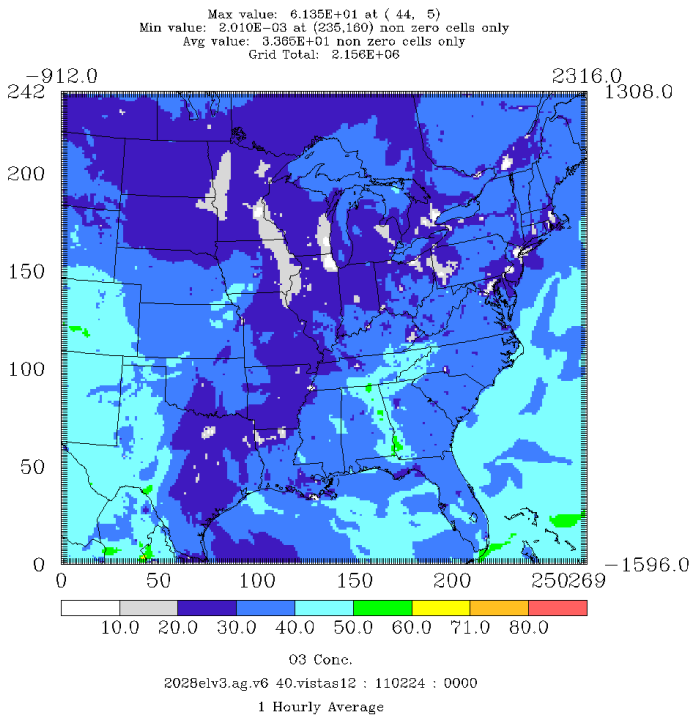


Figure 4-8: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: February 24 at 0000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

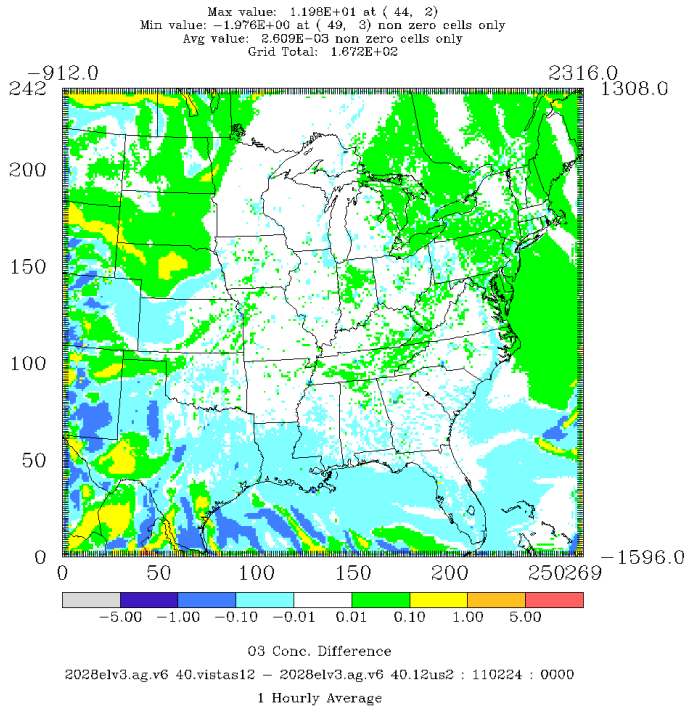
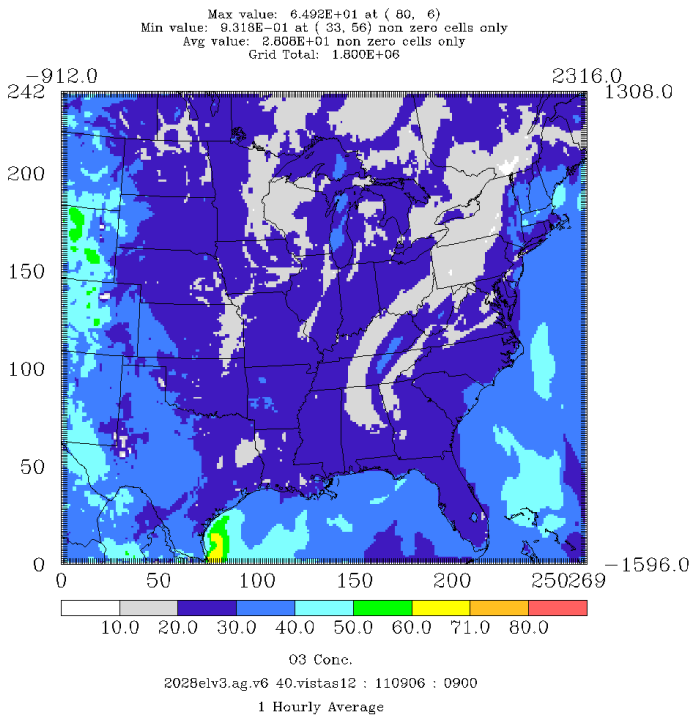


Figure 4-9: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: September 6 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

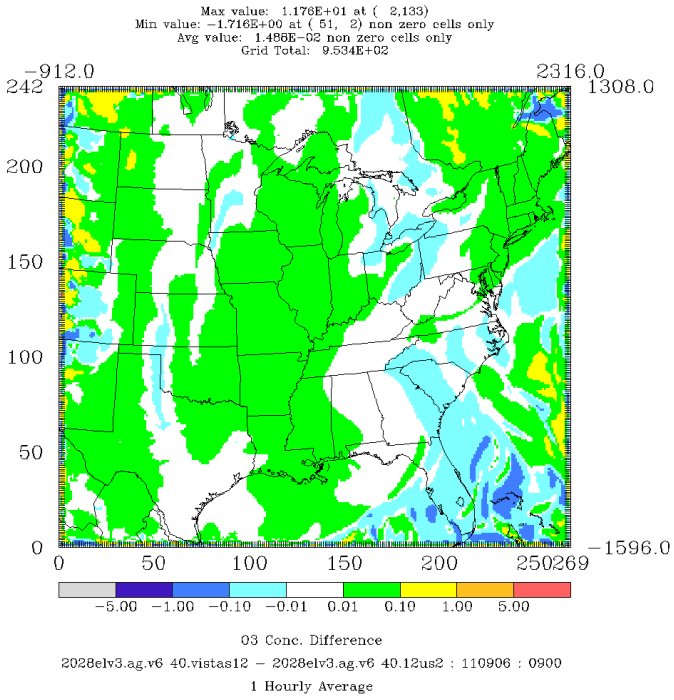
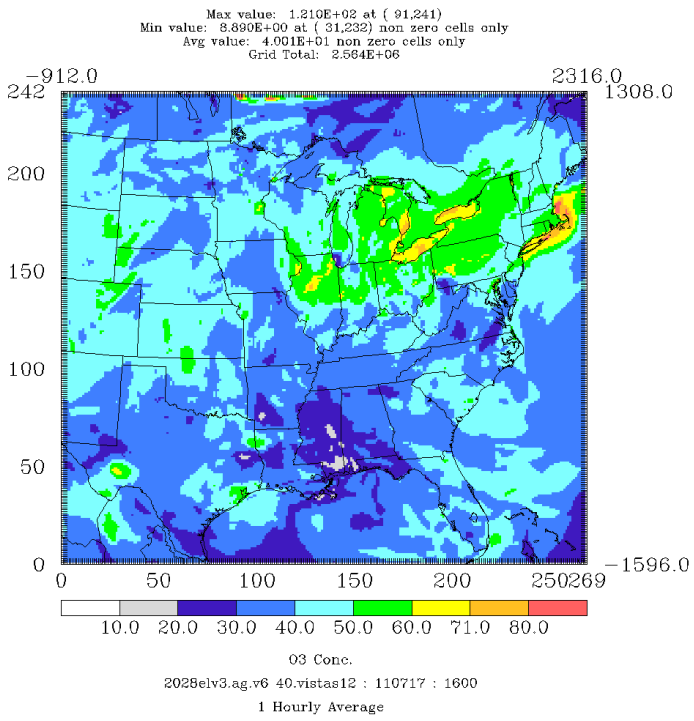


Figure 4-10: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 17 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

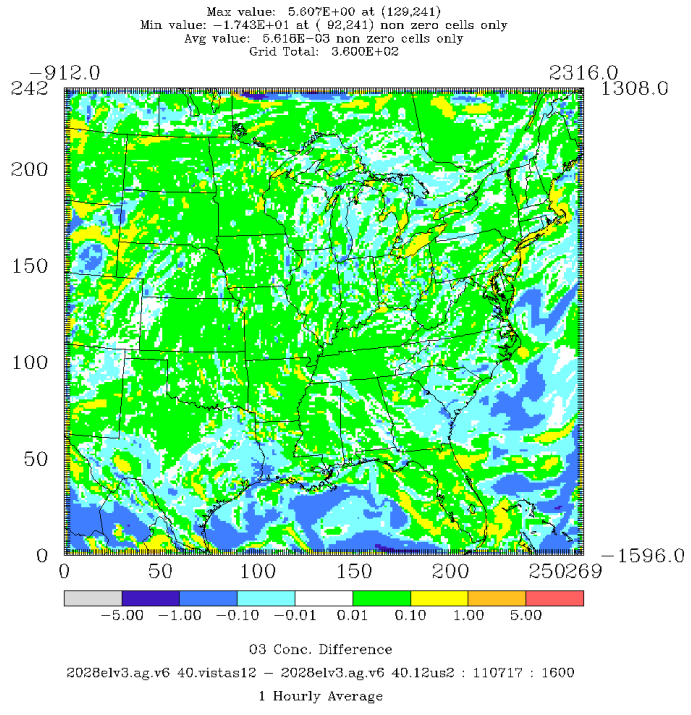
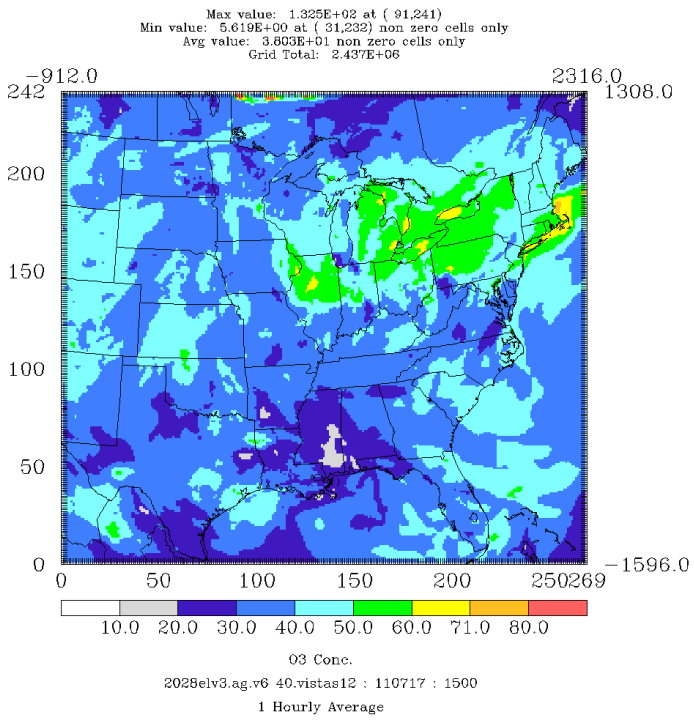


Figure 4-11: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 17 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

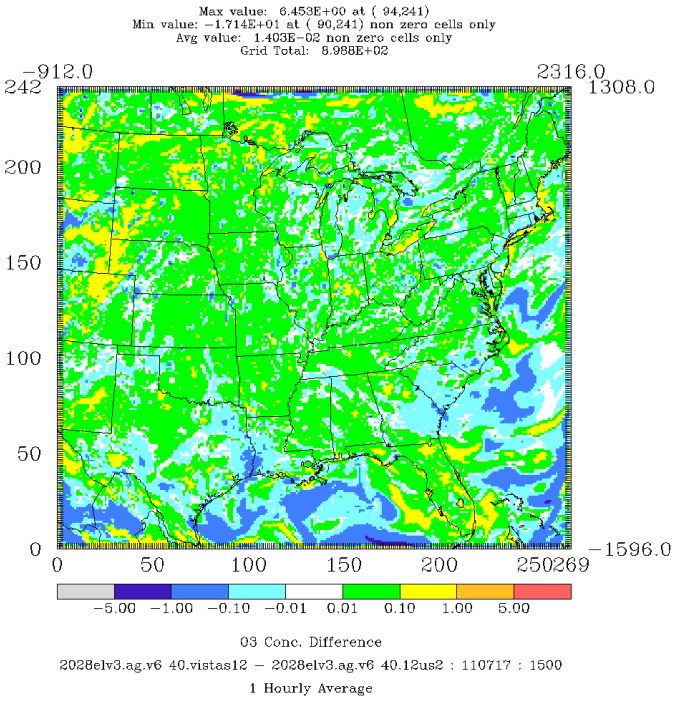
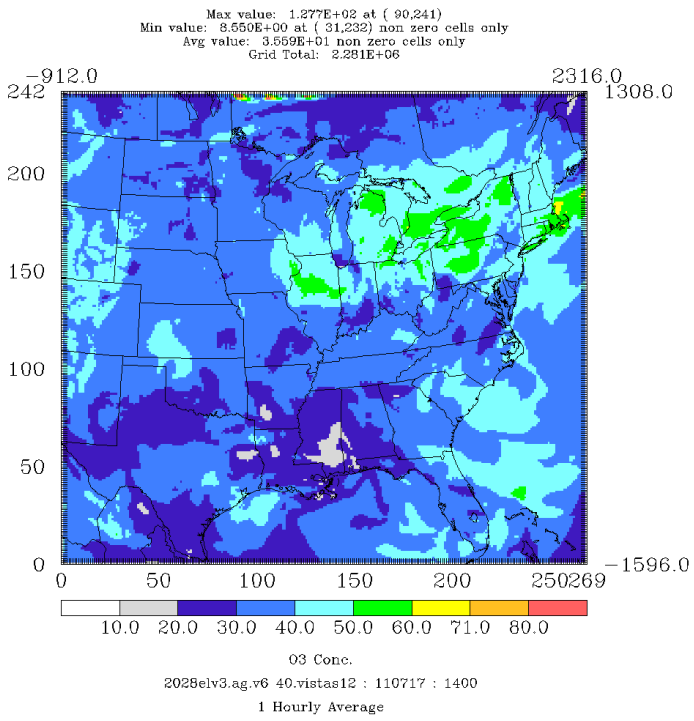


Figure 4-12: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 17 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

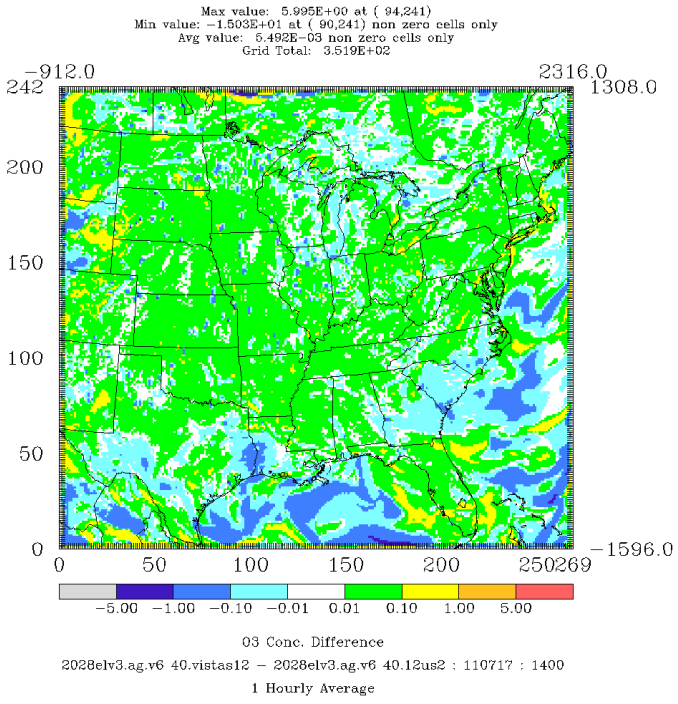
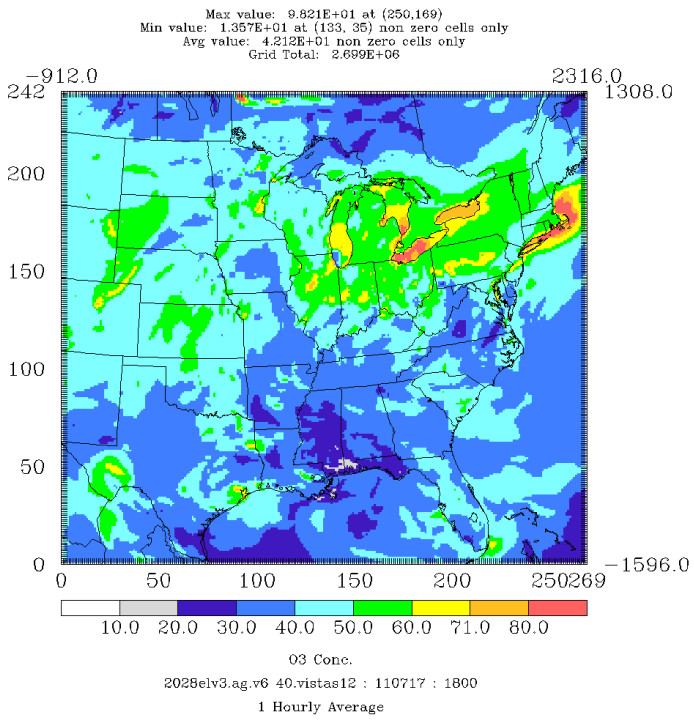


Figure 4-13: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 17 at 1800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

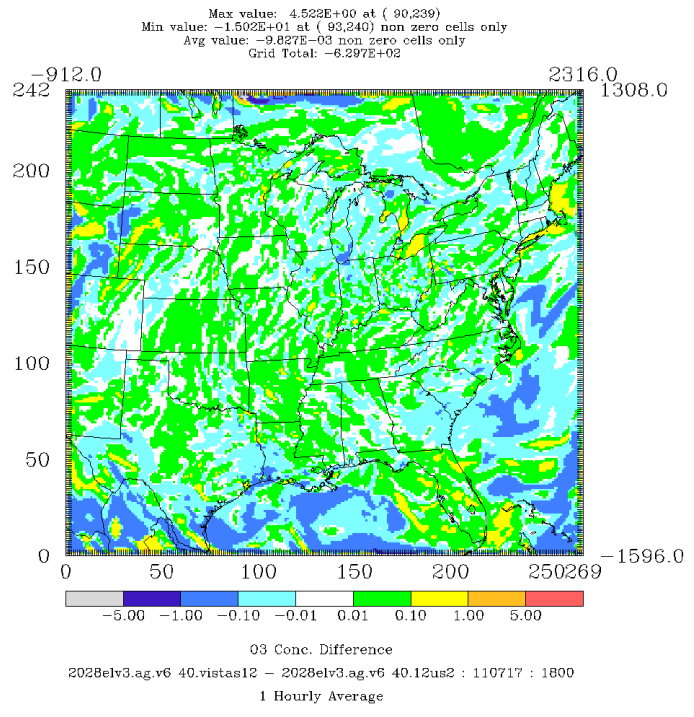
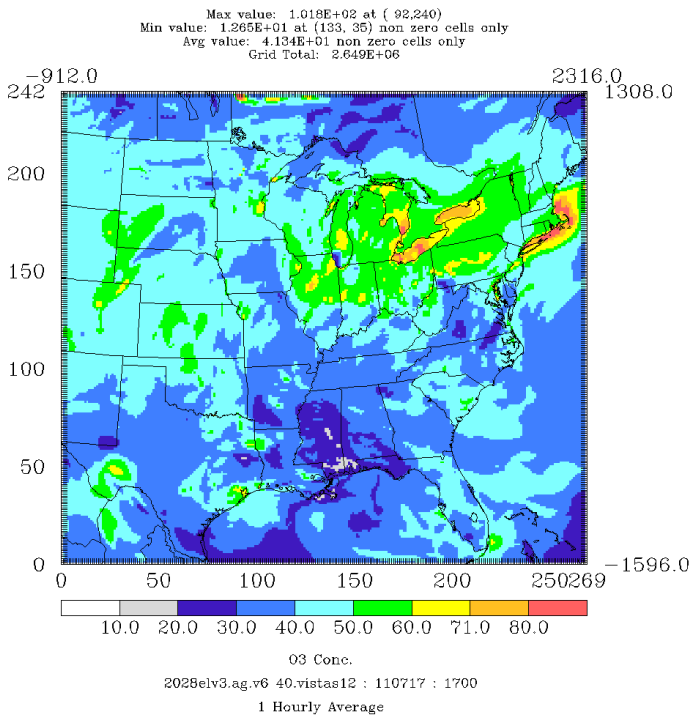


Figure 4-14: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 17 at 1700 hours

VISTAS12



Difference (VISTAS12 - 12US2)

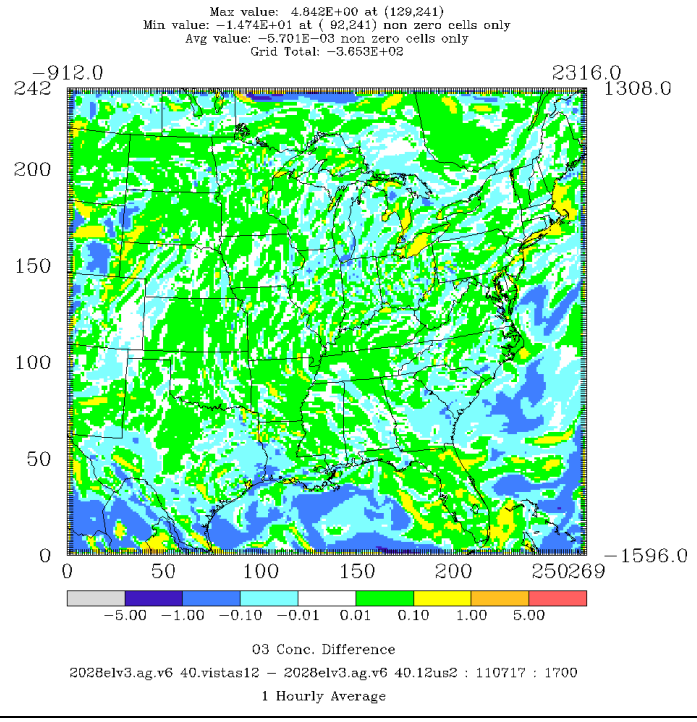
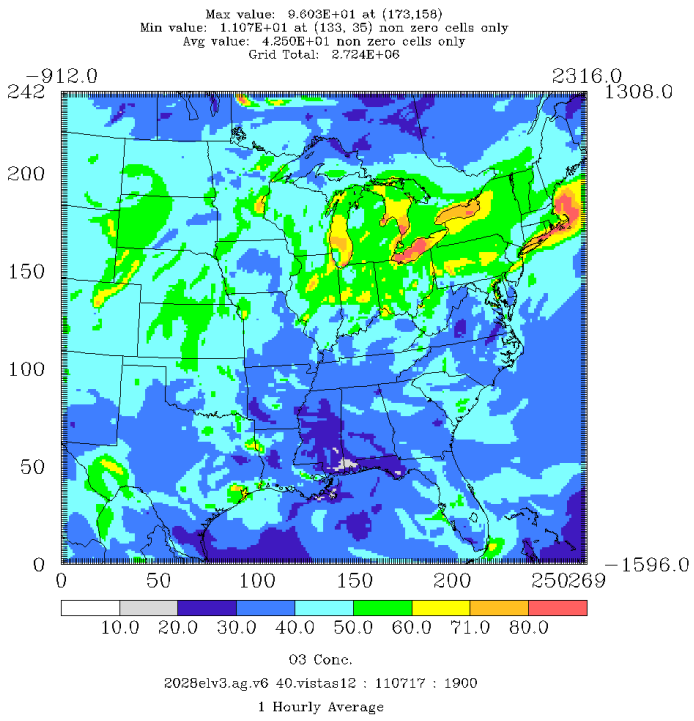


Figure 4-15: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 17 at 1900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

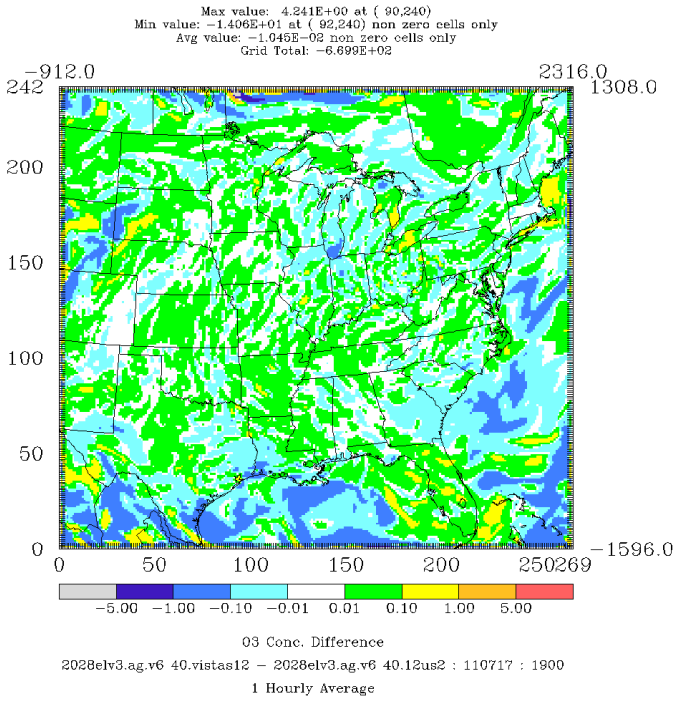
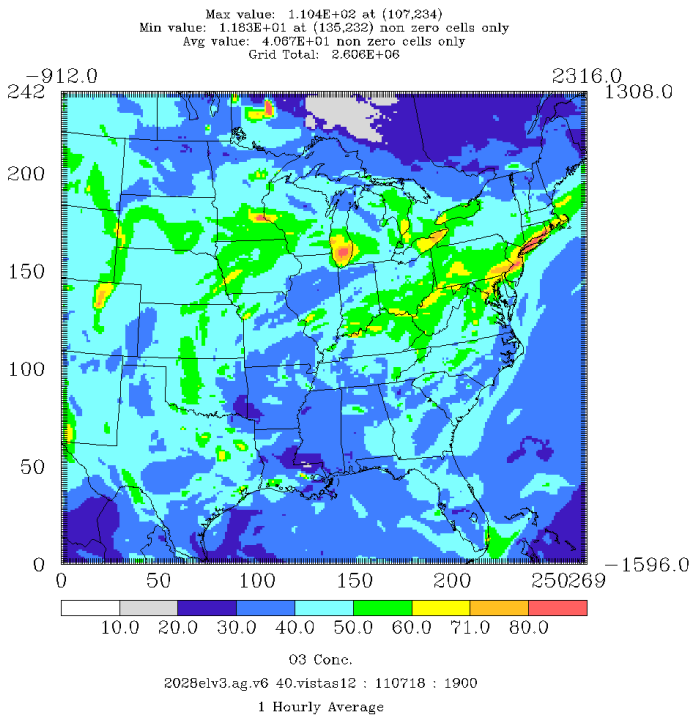


Figure 4-16: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 18 at 1900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

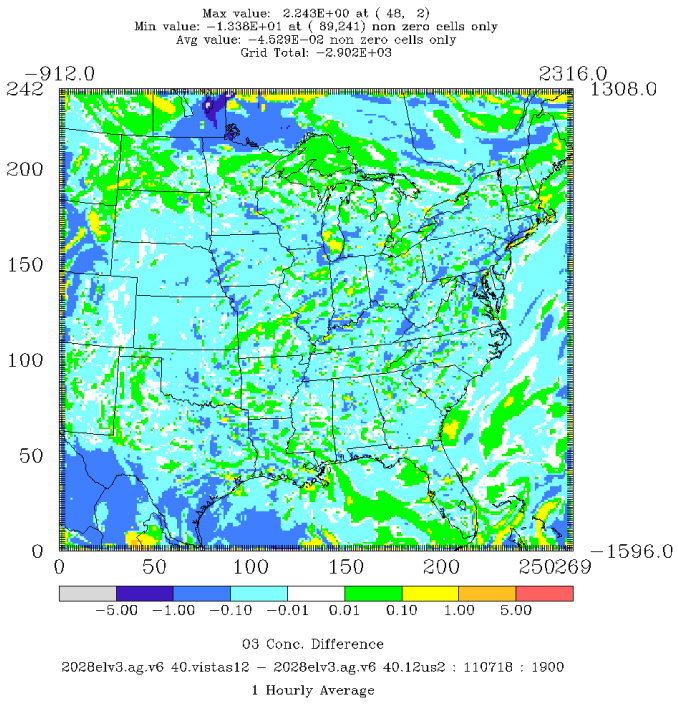
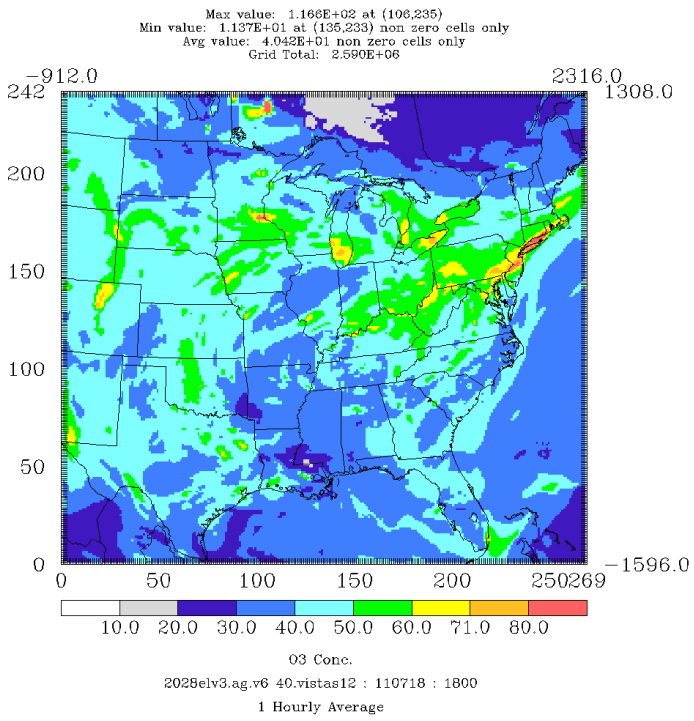


Figure 4-17: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 18 at 1800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

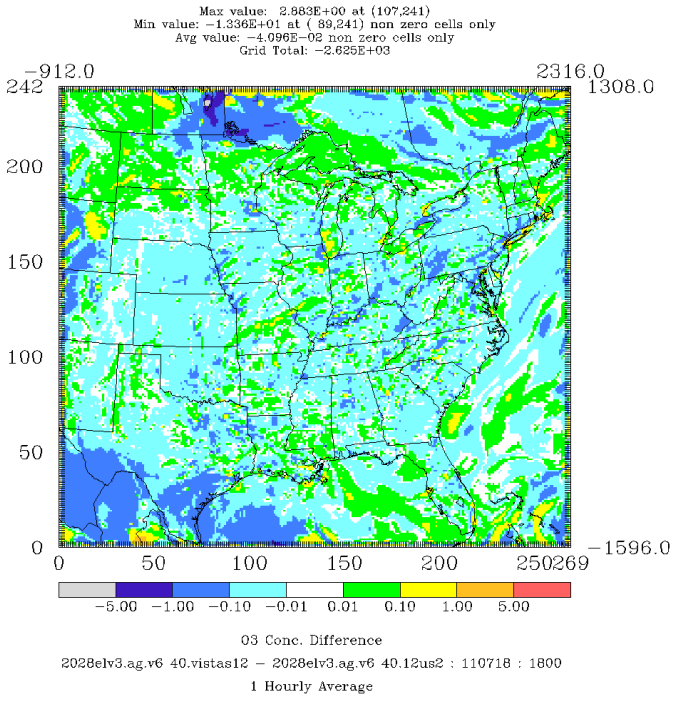
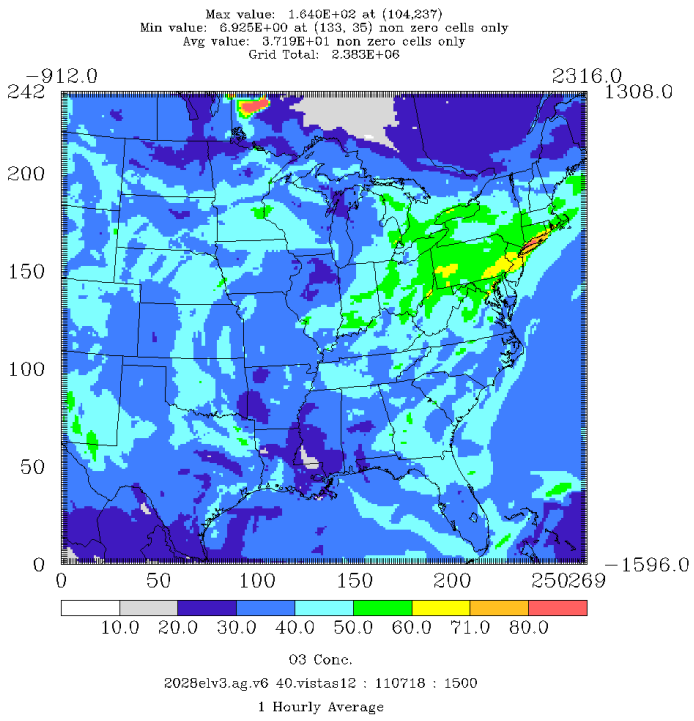


Figure 4-18: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 18 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

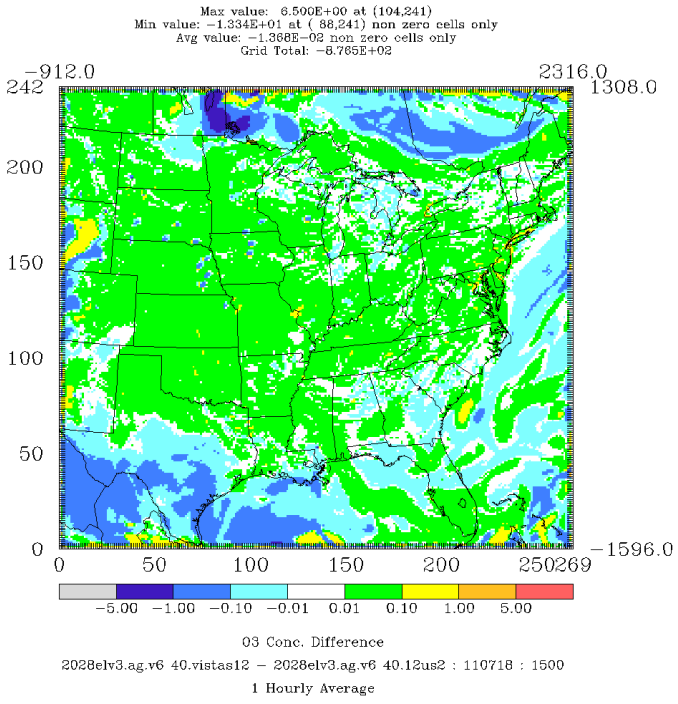
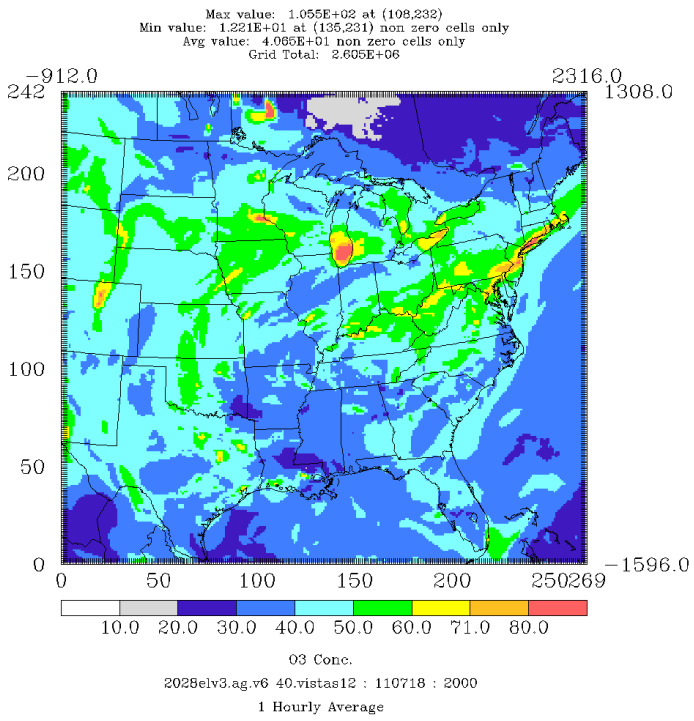


Figure 4-19: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 18 at 2000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

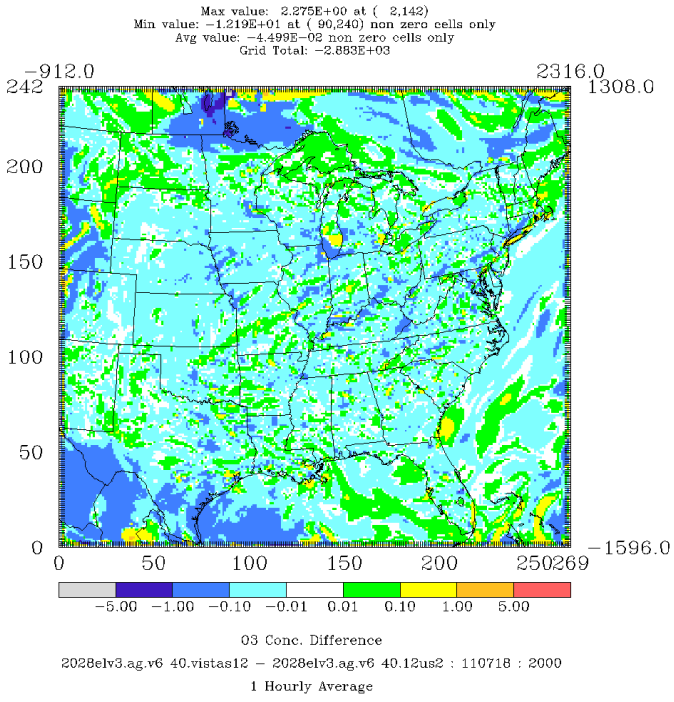


Figure 4-20: Comparison of Ozone Concentrations (ppb) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference)

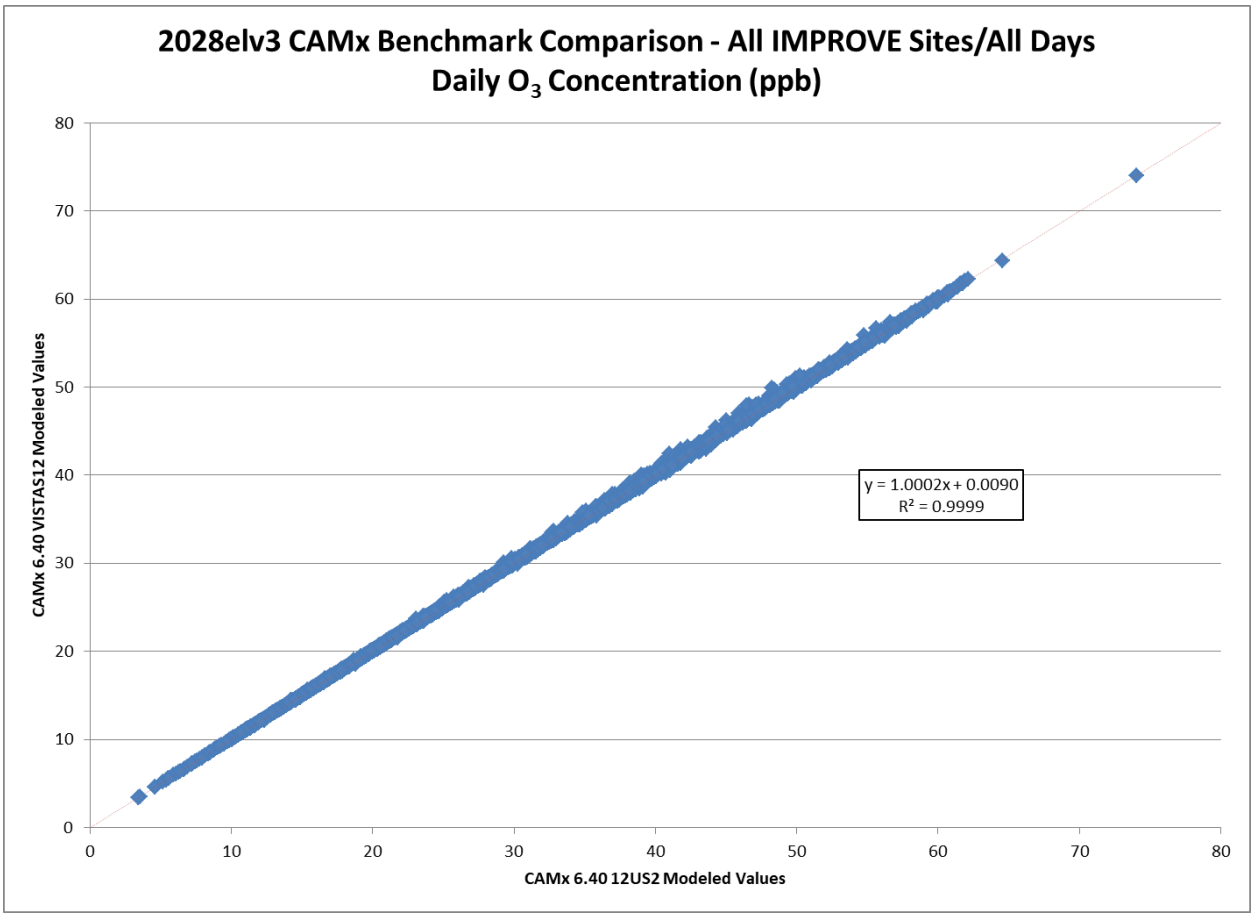


Figure 4-21: Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by V ISTAS (Alpine).

4.2 $PM_{2.5}$

$PM_{2.5}$ results for the top 10 positive and negative hours are presented in tabular format in Table 4-2. The maximum positive difference is 383.37 μg/m^3 falling to 211.49 μg/m^3 for the 10th high. The maximum negative difference is -296.69 μg/m^3 falling to -174.08 μg/m^3 for the 10th high. The maximum positive percent difference from these days is 102.4% and negative percent difference of -33.5%.

As expected and consistent with our ozone findings in the previous section, the maximum impacts on the top 10 positive and negative hours are occurring very near the border. As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated from the cells outside the VISTAS12 domain. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous concentrations. Additionally, and likely more significant to concentration differences, the CAMx model does not include emissions from the boundary cells.

The top 10 positive difference hours are presented in Figures 4-22 through 4-31 and the top 10 negative impact hours are presented in Tables 4-32 through 4-41. The hours of the maximum differences are tending to occur in July 17-21. There were wildfires in Canada in the area of the maximum difference during this period. It is not surprising that the largest difference is occurring where noted large source emissions are input into the model near a boundary where the time averaging of the pollutants flowing into the cells are different. On the day of the maximum positive difference (July 21 at 0400) the maximum difference in $PM_{2.5}$ concentration was 383.43 μg/m^3 ppb. At this hour at this grid cell the difference in the sulfate, nitrate, and OM concentrations were 5.762 μg/m^3, 0.835 μg/m^3, 295.99 μg/m^3, respectively with the difference dominated by the differences in the OM estimates. The high local emissions dominated by OM as is expected from wildfire emissions.

Scatterplots of the daily average $PM_{2.5}$ concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-42. The 12US2 results are plotted on the x-axis

and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0003, an intercept of 0.0031 µg/m^3 and an R^2 of 1.0000.

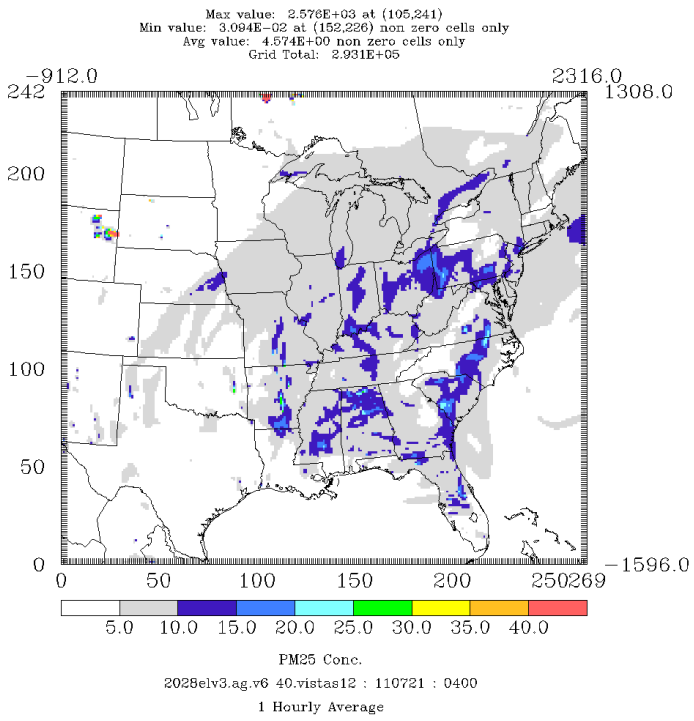
Examination of the difference animations often show differences along the boundary becoming lower as the plumes along the boundary move into the domain.

Table 4-2. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of $PM_{2.5}$ Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	7	21	4	949.91	566.54	383.37	67.7%	104	241
2011	7	20	14	1660.05	1353.59	306.46	22.6%	107	241
2011	7	20	15	839.18	559.74	279.44	49.9%	107	241
2011	7	20	11	2740.11	2470.87	269.24	10.9%	107	241
2011	7	21	3	3176.80	2914.06	262.74	9.0%	104	241
2011	7	21	1	2369.71	2110.12	259.59	12.3%	104	241
2011	7	20	12	3022.91	2785.90	237.01	8.5%	107	241
2011	7	20	23	448.18	221.41	226.78	102.4%	102	241
2011	7	21	0	732.17	508.25	223.92	44.1%	103	241
2011	7	20	9	6964.26	6752.77	211.49	3.1%	105	241
Maximum Negative									
2011	7	20	15	4857.63	5154.32	-296.69	-5.8%	105	241
2011	7	20	16	4003.88	4266.41	-262.54	-6.2%	105	241
2011	7	20	14	5167.65	5429.55	-261.90	-4.8%	106	241
2011	7	17	11	508.55	761.67	-253.12	-33.2%	89	241
2011	7	20	13	6146.56	6389.86	-243.30	-3.8%	106	241
2011	7	17	12	496.56	725.04	-228.48	-31.5%	89	241
2011	7	20	12	7718.44	7943.32	-224.88	-2.8%	106	241
2011	7	19	10	815.91	1032.49	-216.58	-21.0%	104	241
2011	7	17	10	429.07	644.79	-215.71	-33.5%	89	241
2011	7	19	9	828.90	1002.97	-174.08	-17.4%	103	241

Maximum Positive Difference: July 21 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

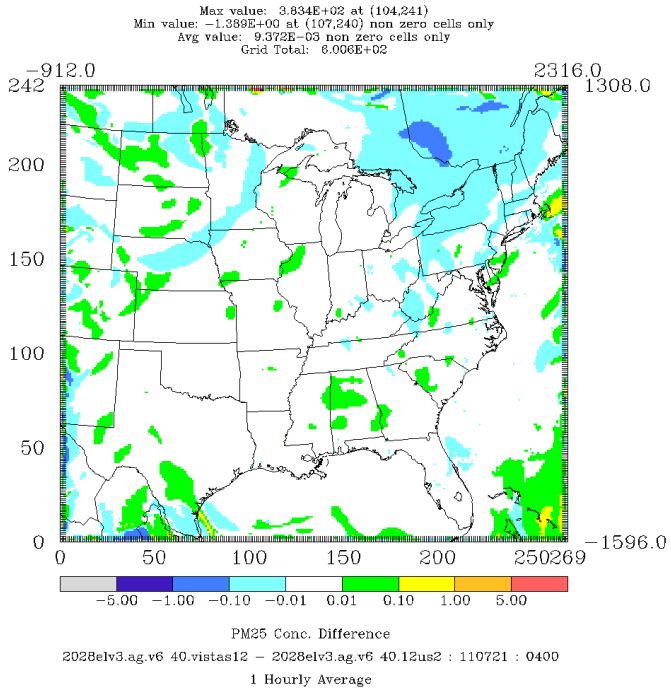
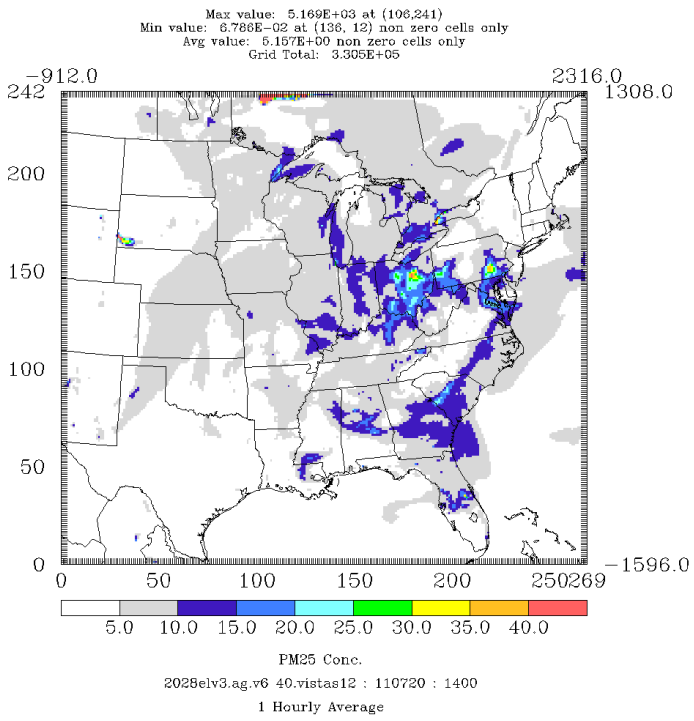


Figure 4-22: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference)

Second Highest Positive Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

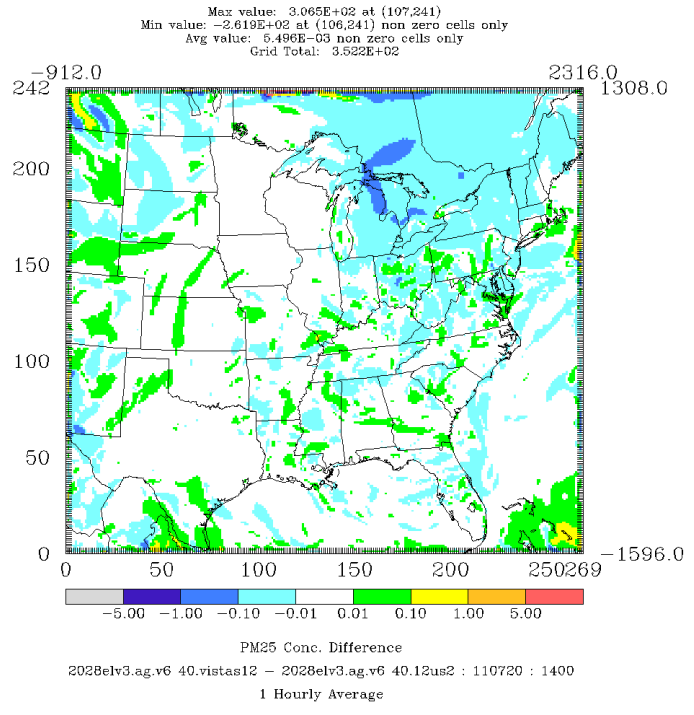
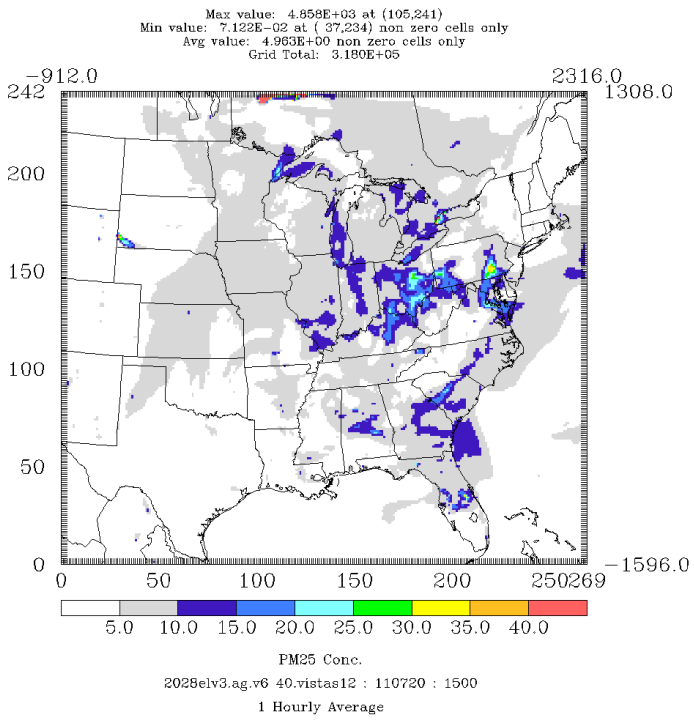


Figure 4-23: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

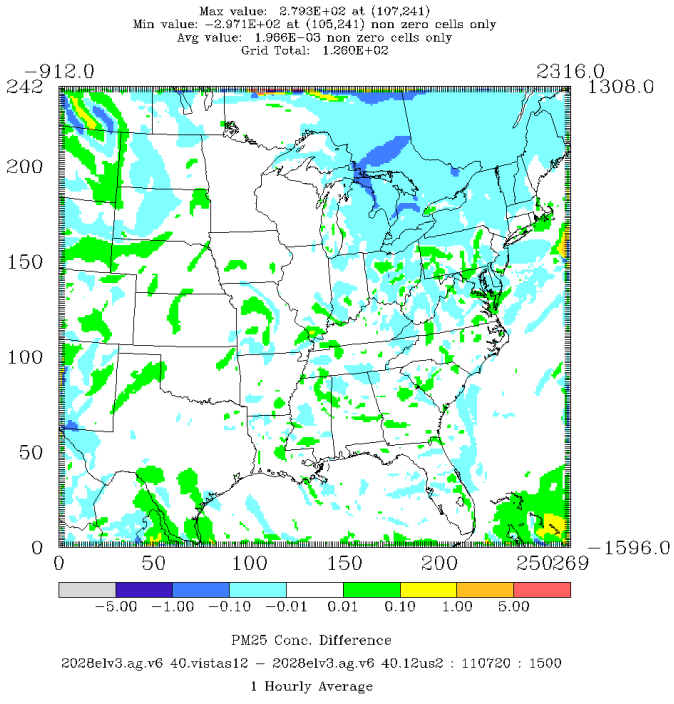
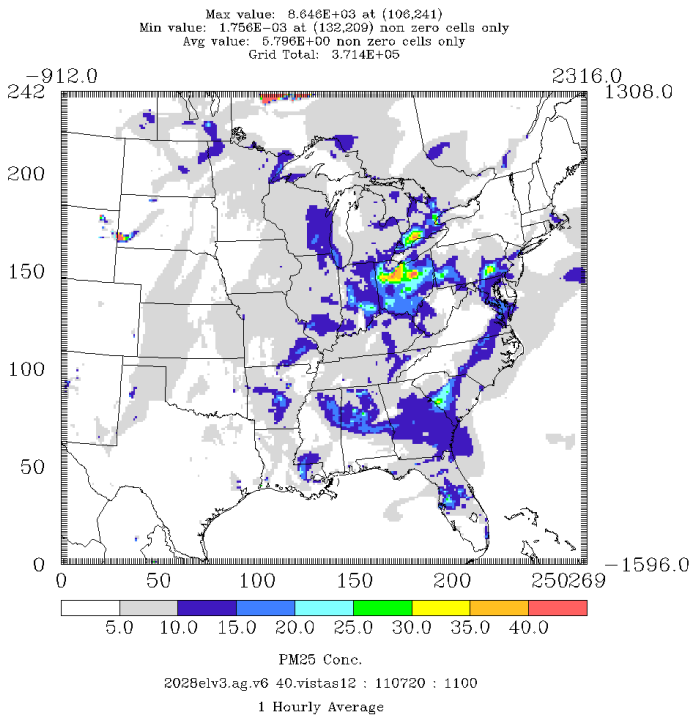


Figure 4-24: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: July 20 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

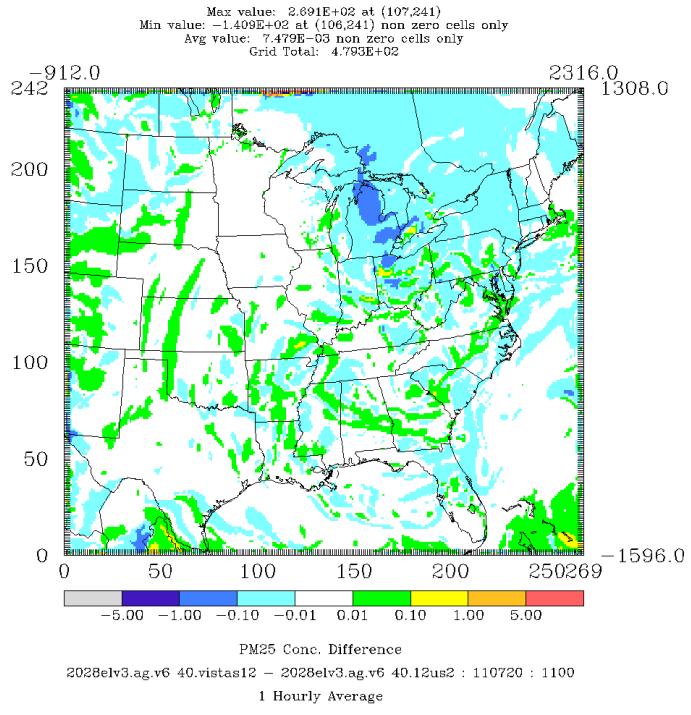
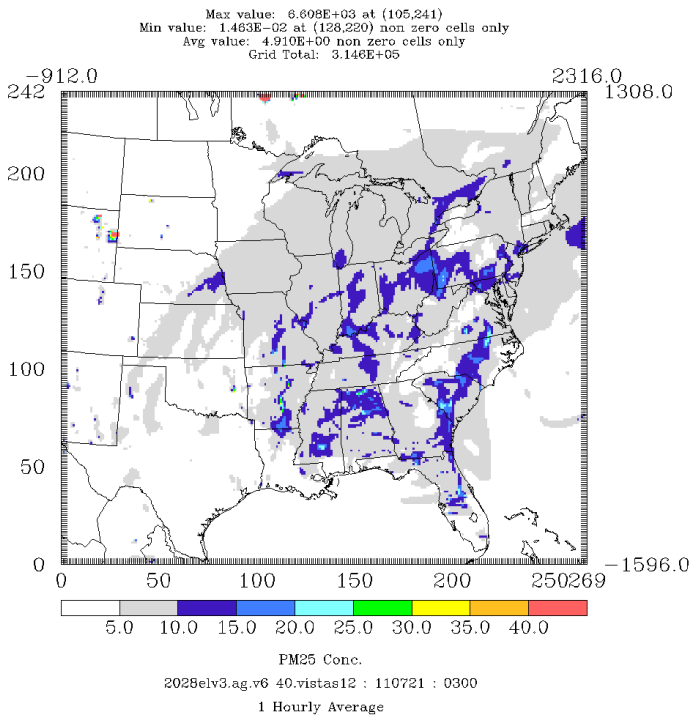


Figure 4-25: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: July 21 at 300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

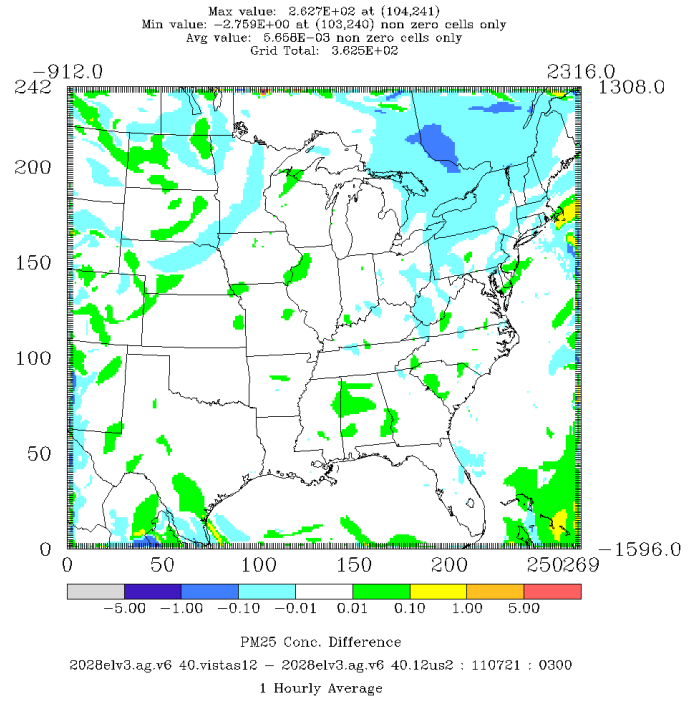
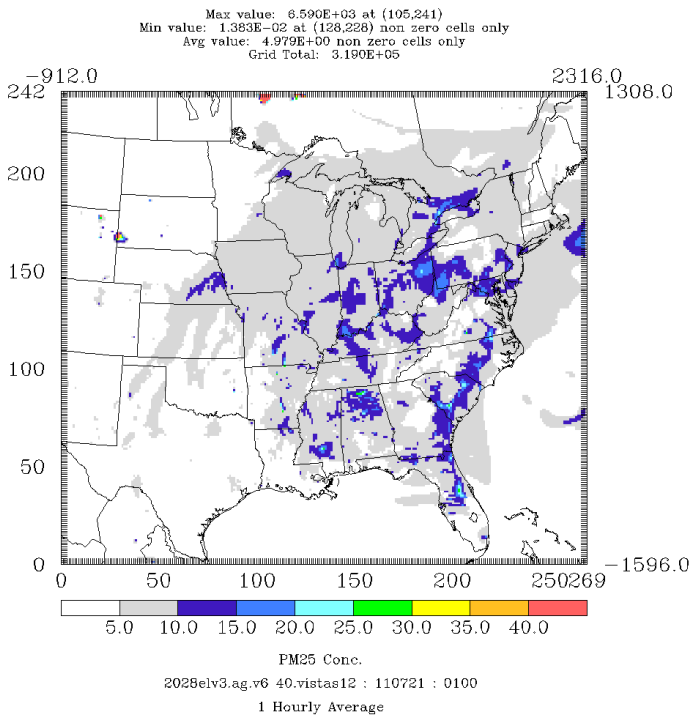


Figure 4-26: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 21 at 100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

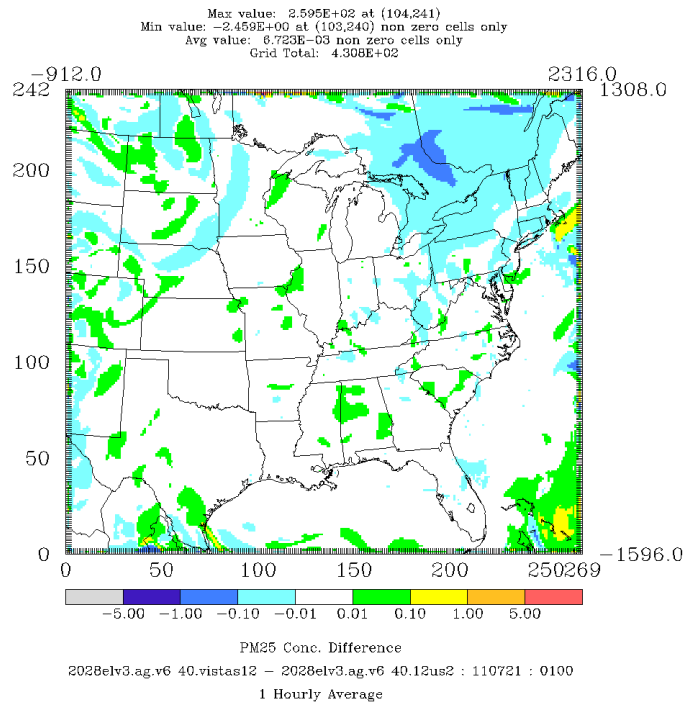
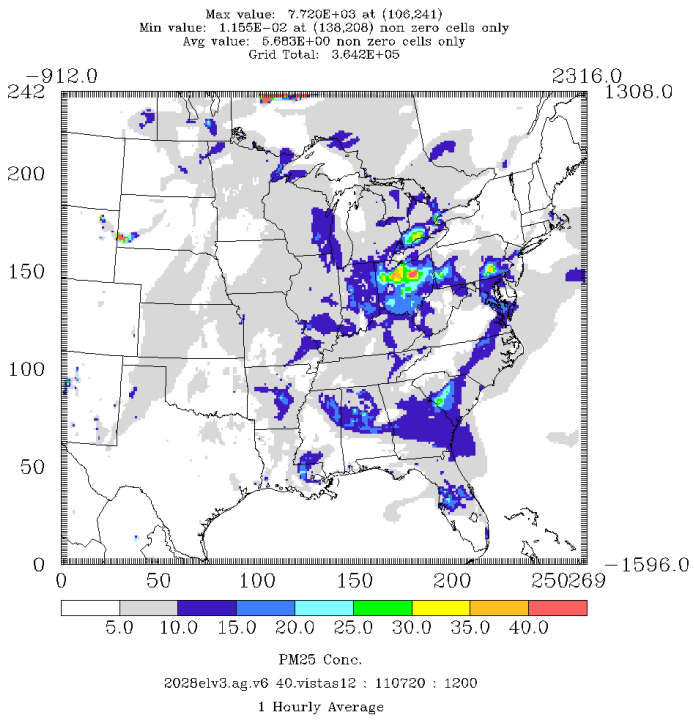


Figure 4-27: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

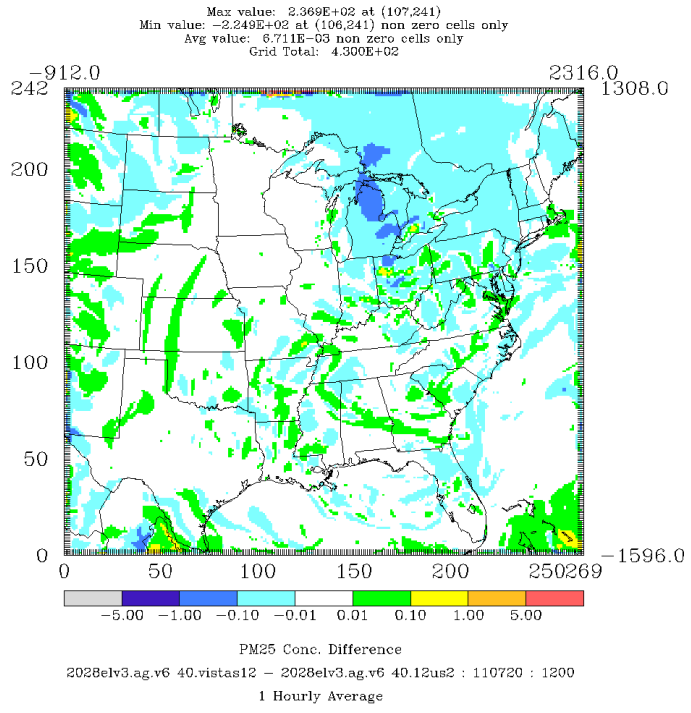
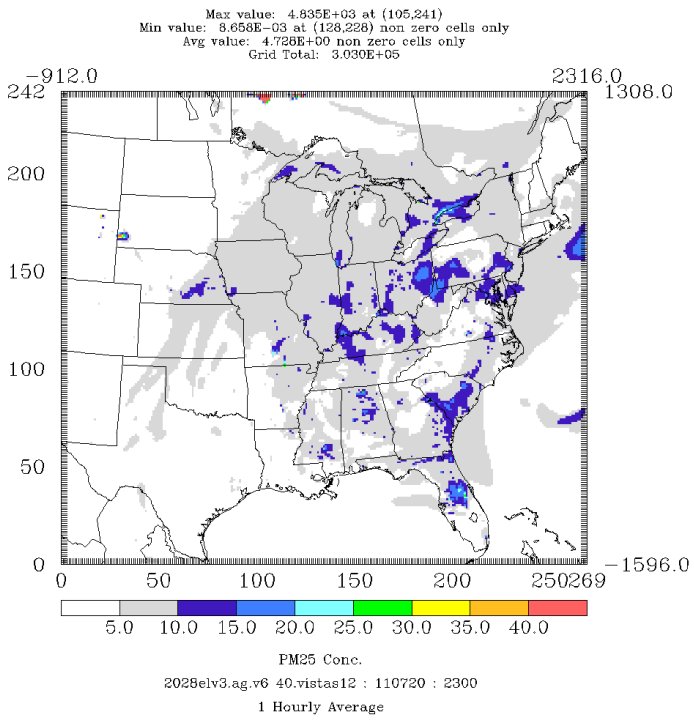


Figure 4-28: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: July 20 at 2300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

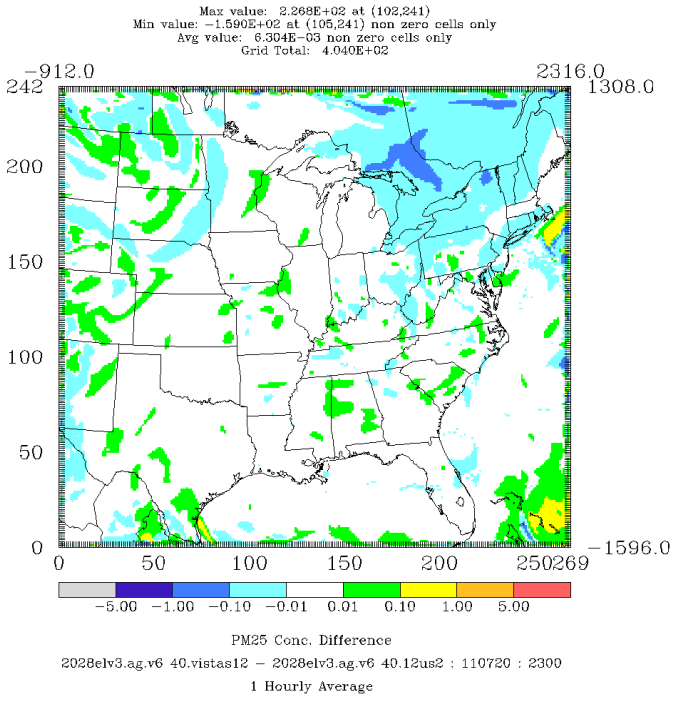
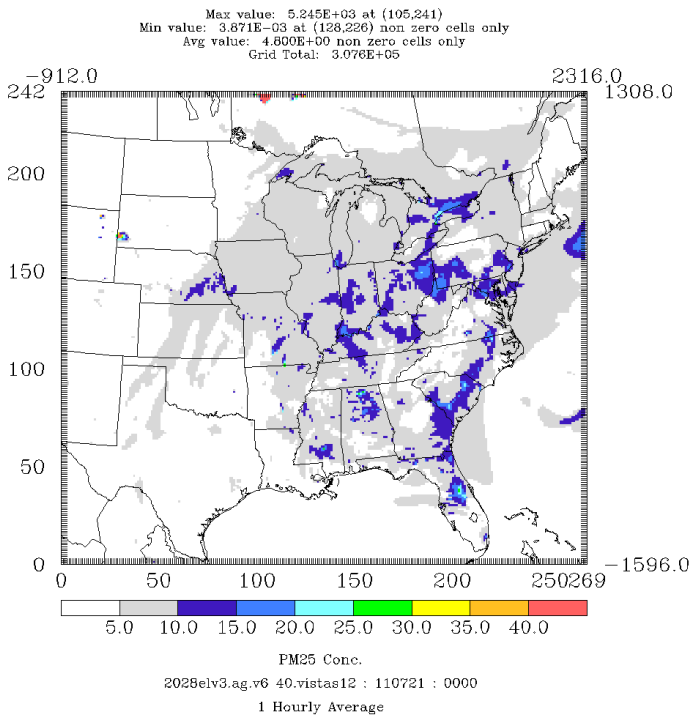


Figure 4-29: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: July 21 at 0000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

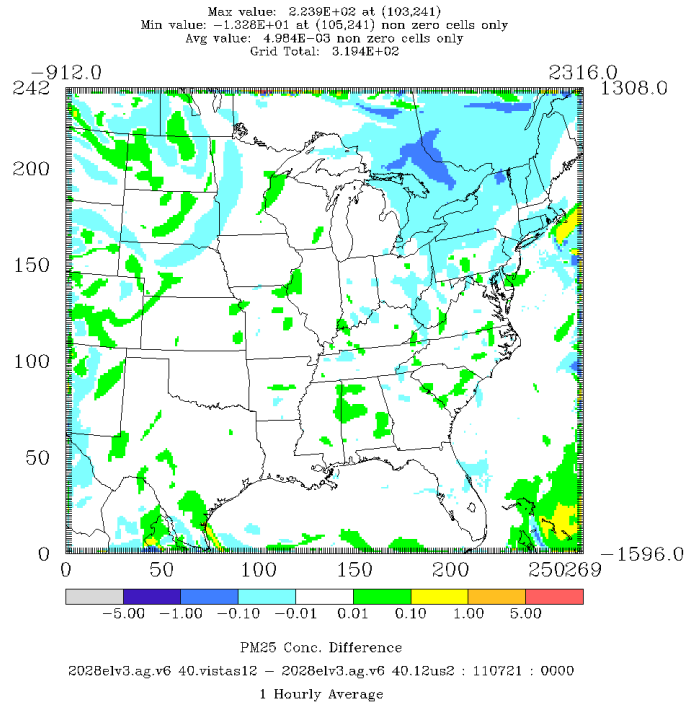
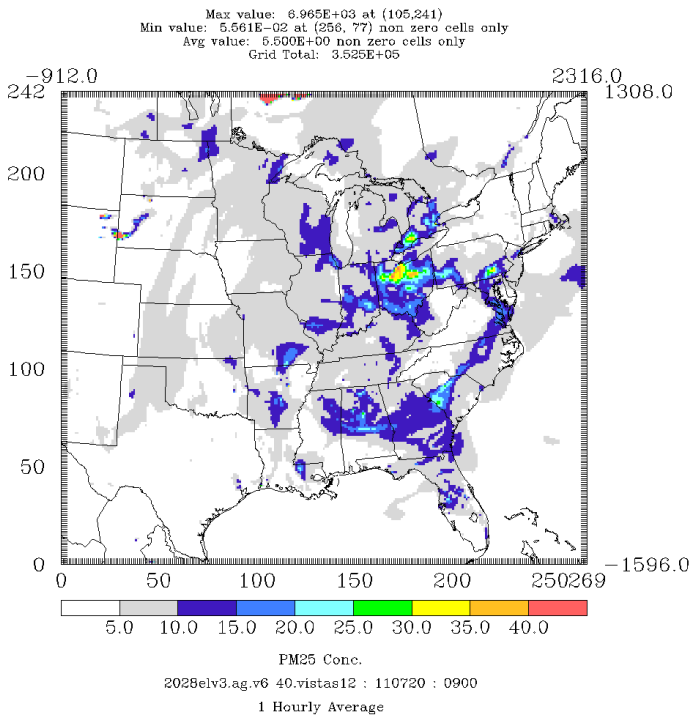


Figure 4-30: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

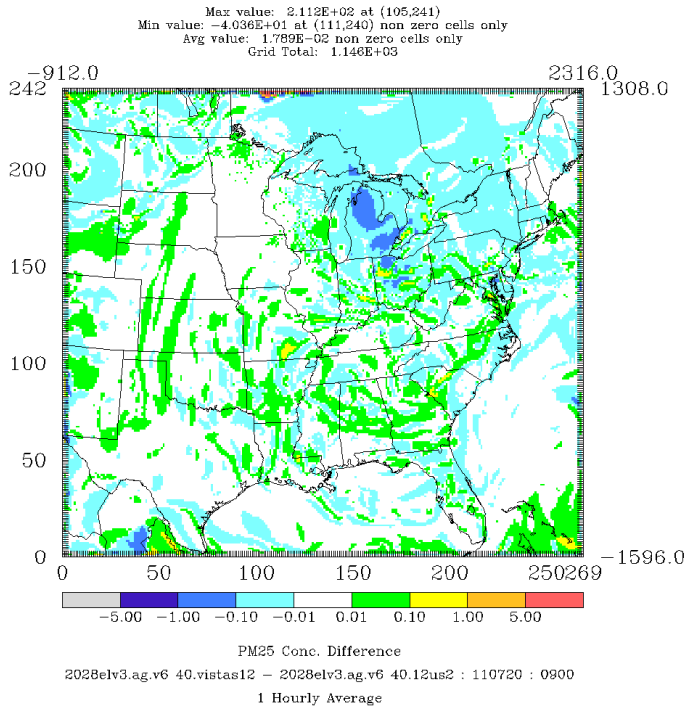
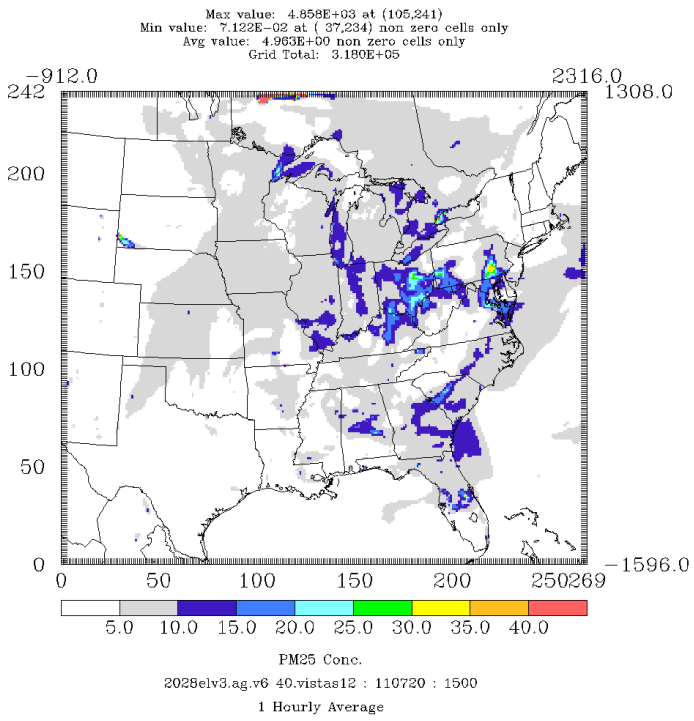


Figure 4-31: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

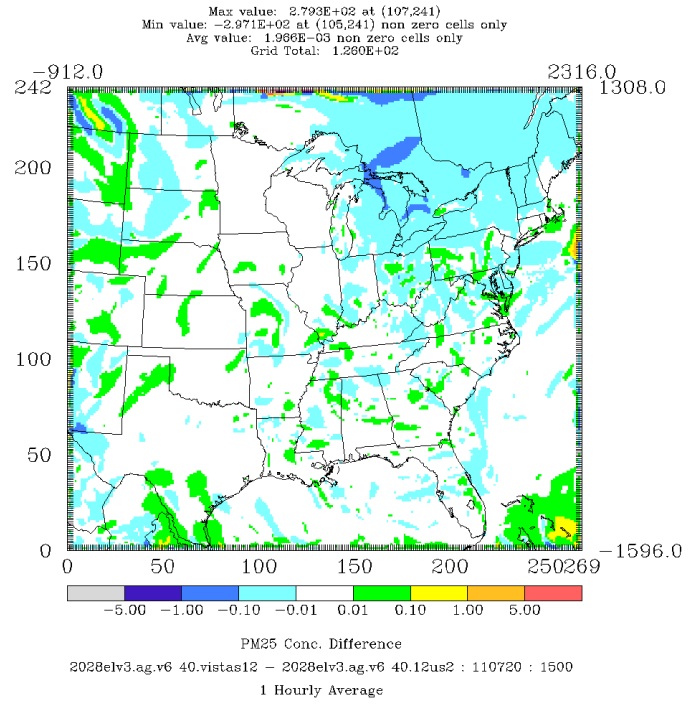
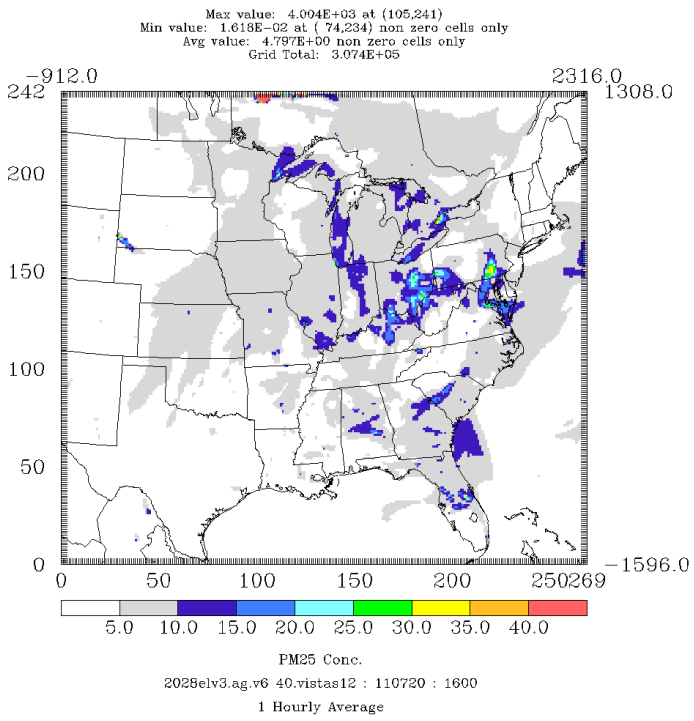


Figure 4-32: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

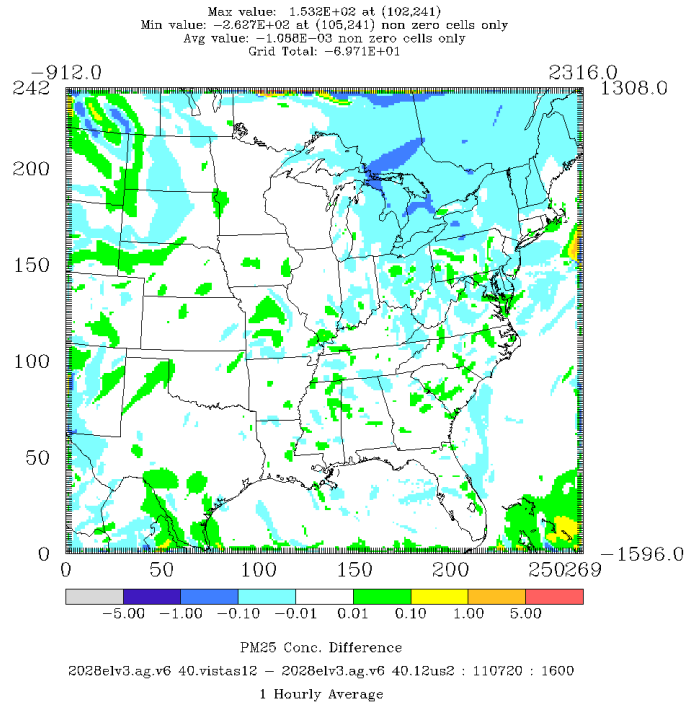
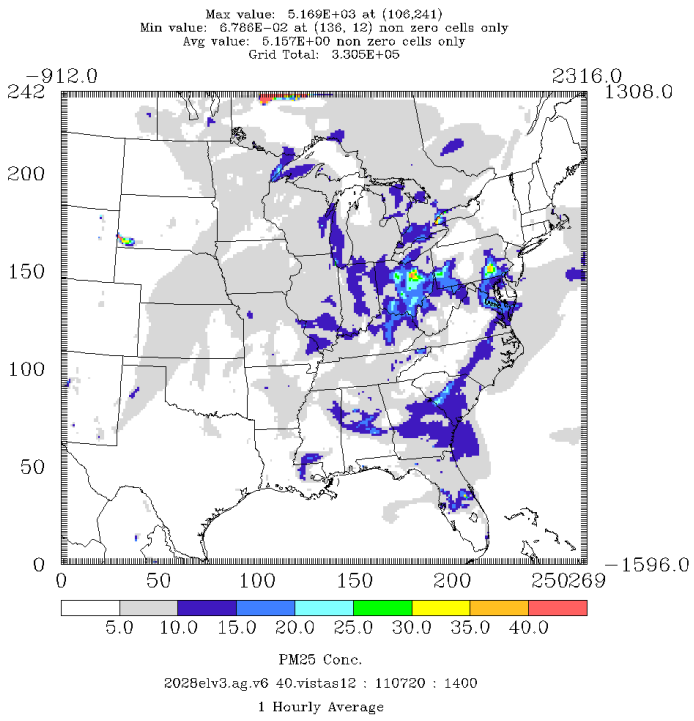


Figure 4-33: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

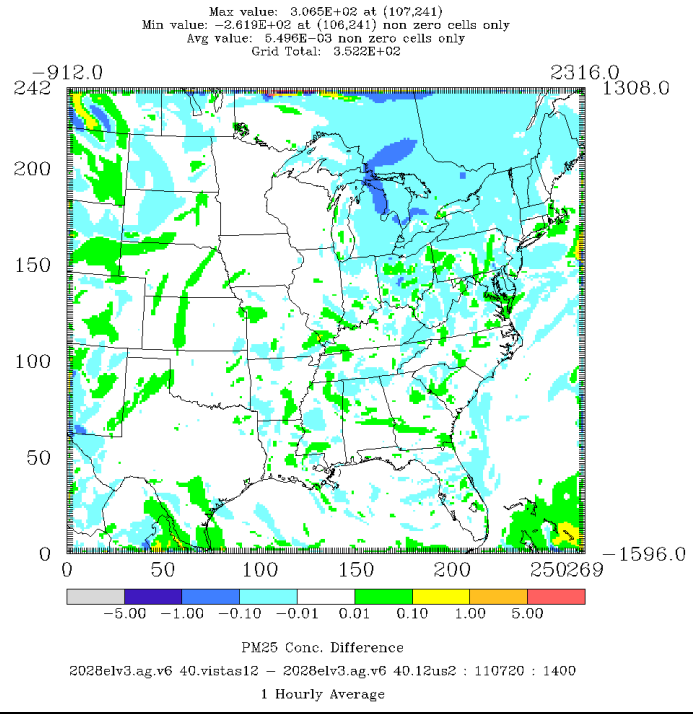
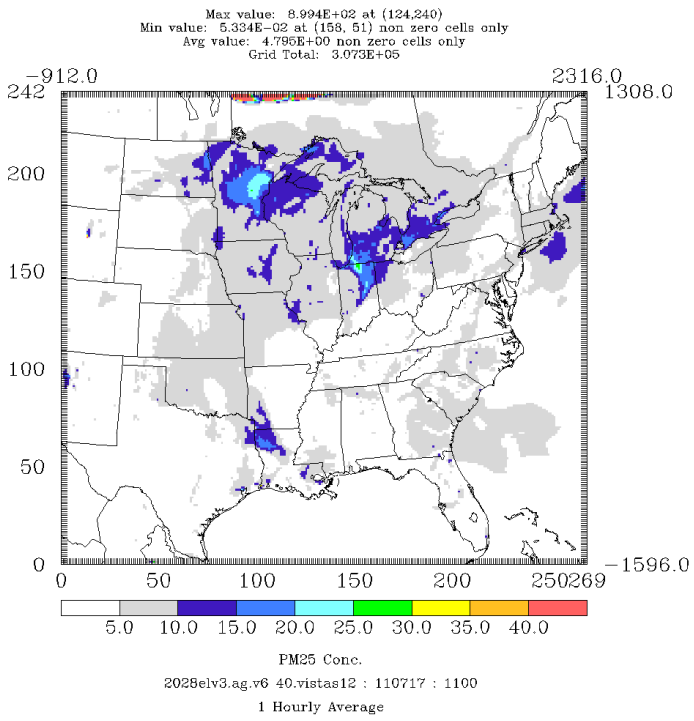


Figure 4-34: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 17 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

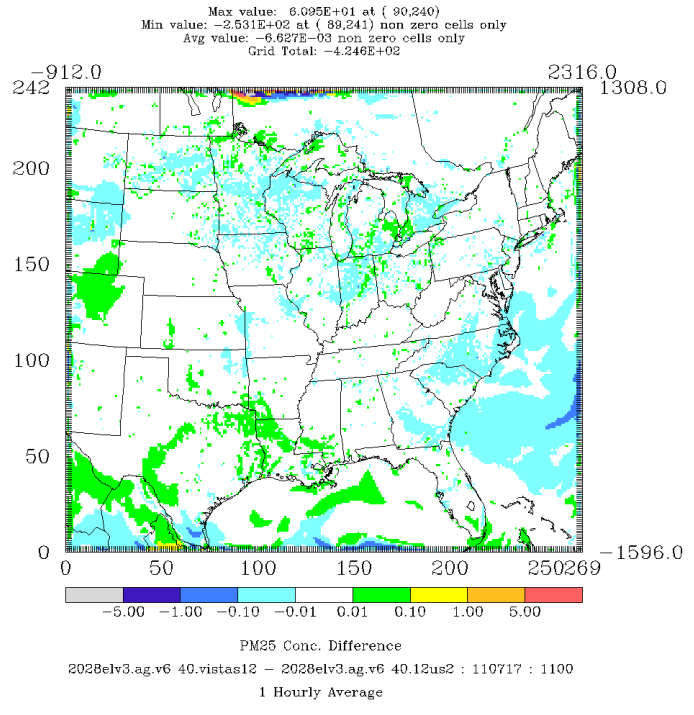
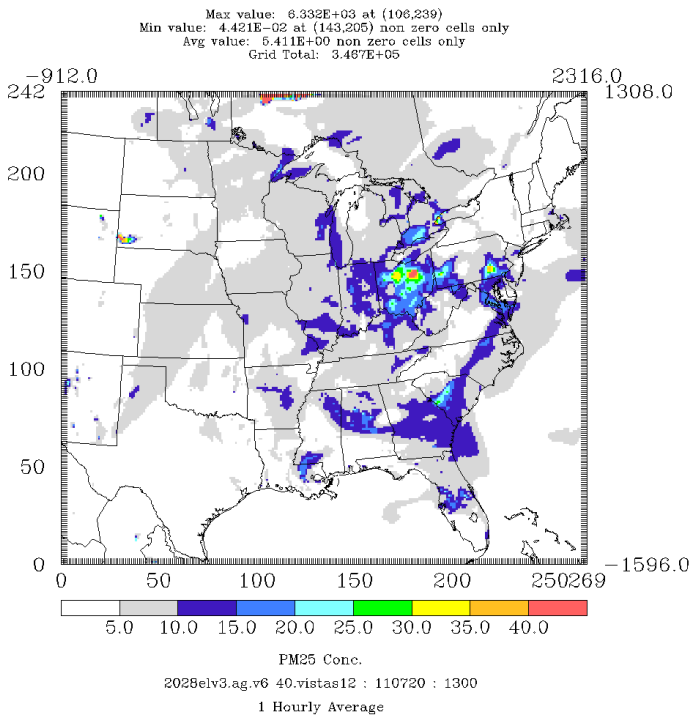


Figure 4-35: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 20 at 1300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

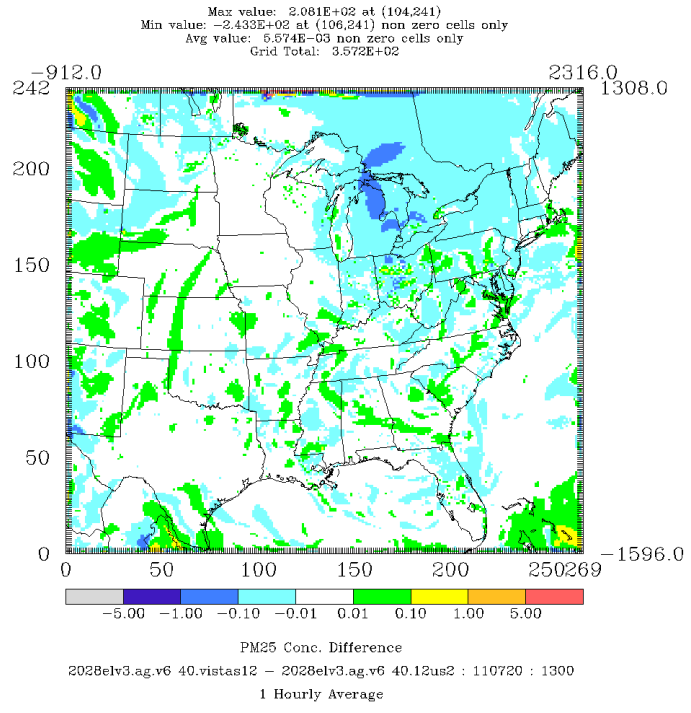
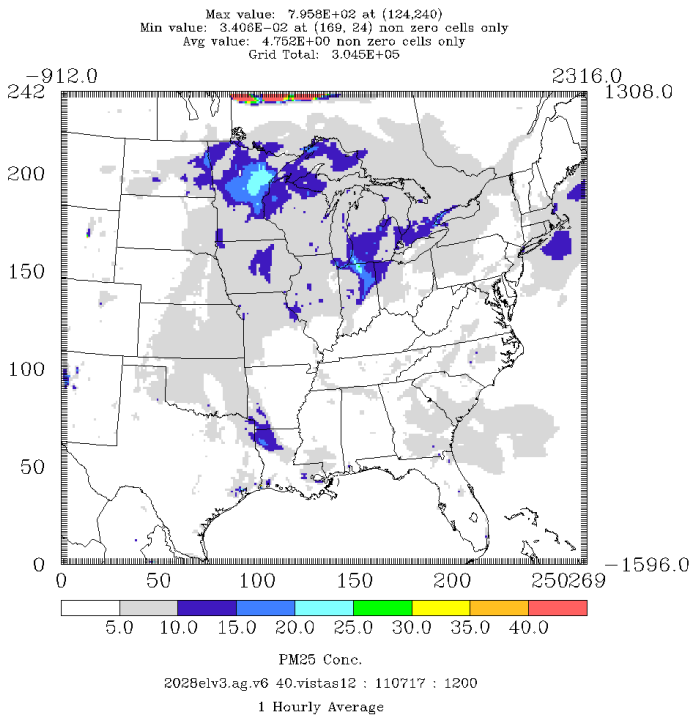


Figure 4-36: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 17 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

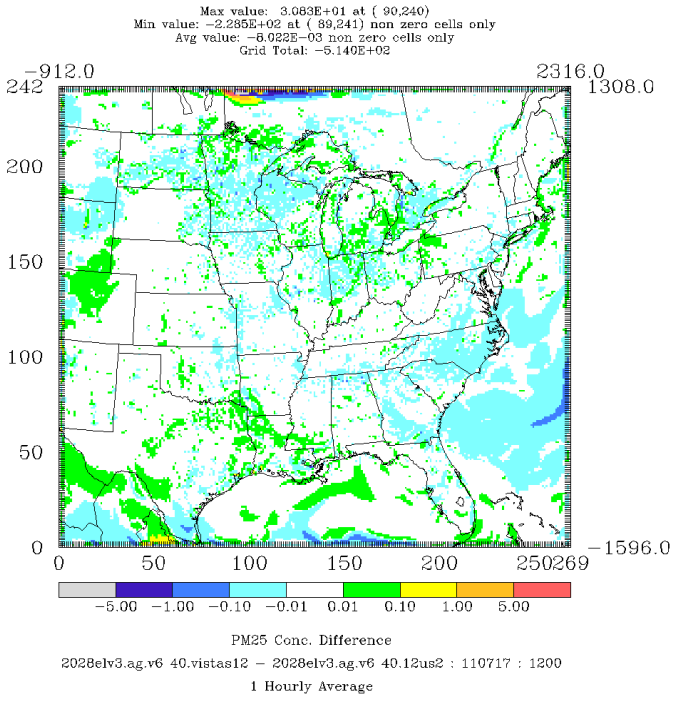
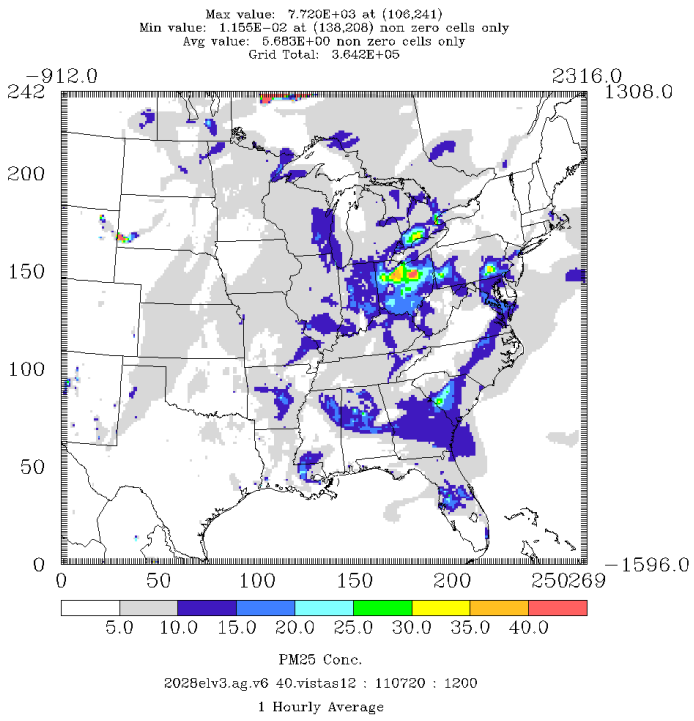


Figure 4-37: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

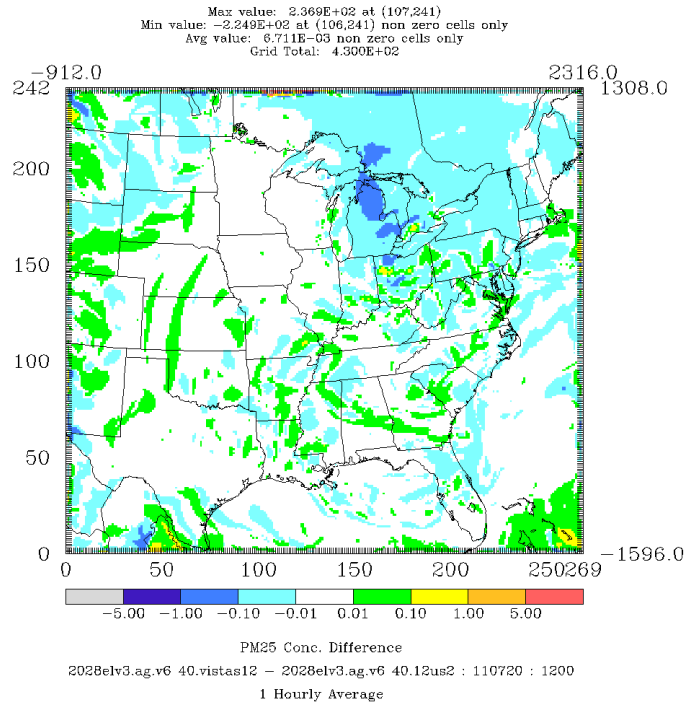
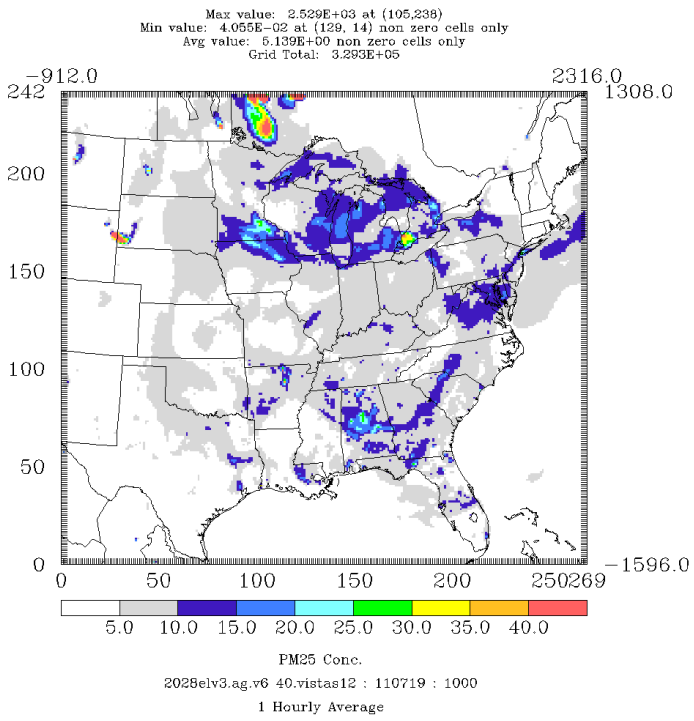


Figure 4-38: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 19 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

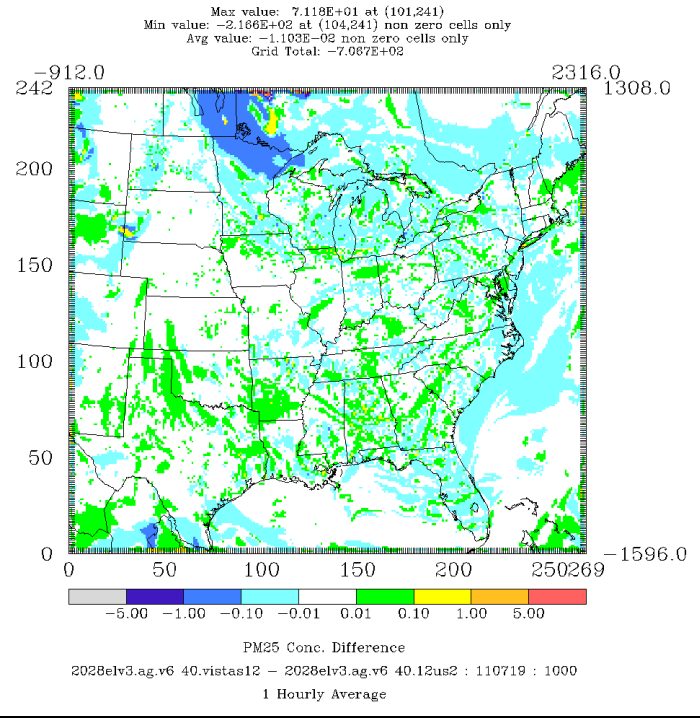
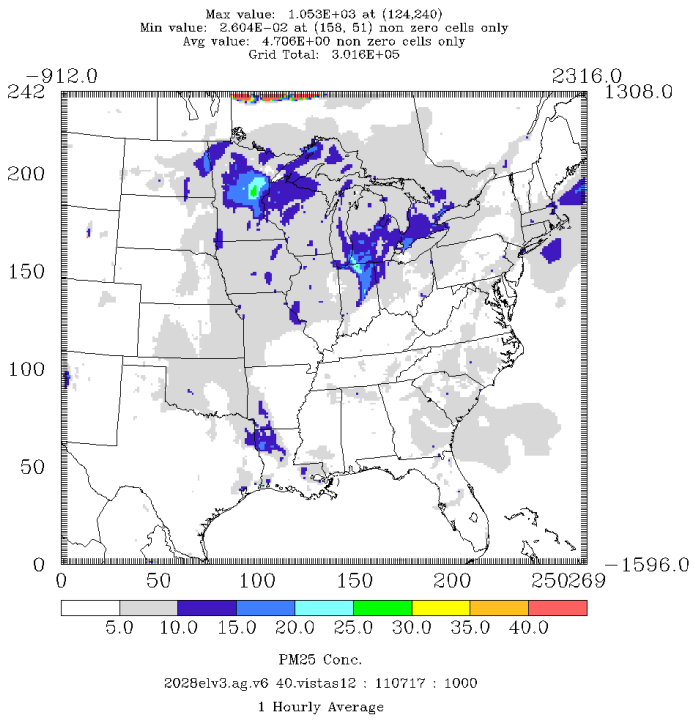


Figure 4-39: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 17 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

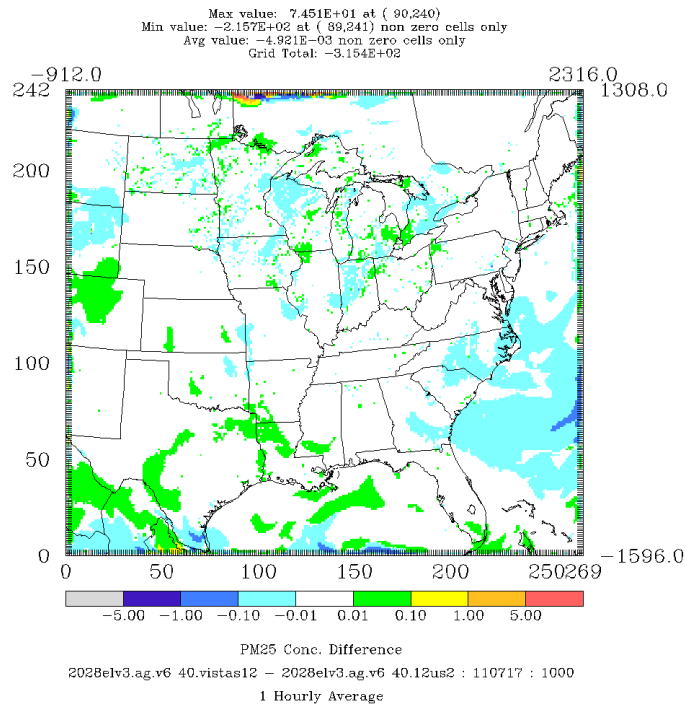
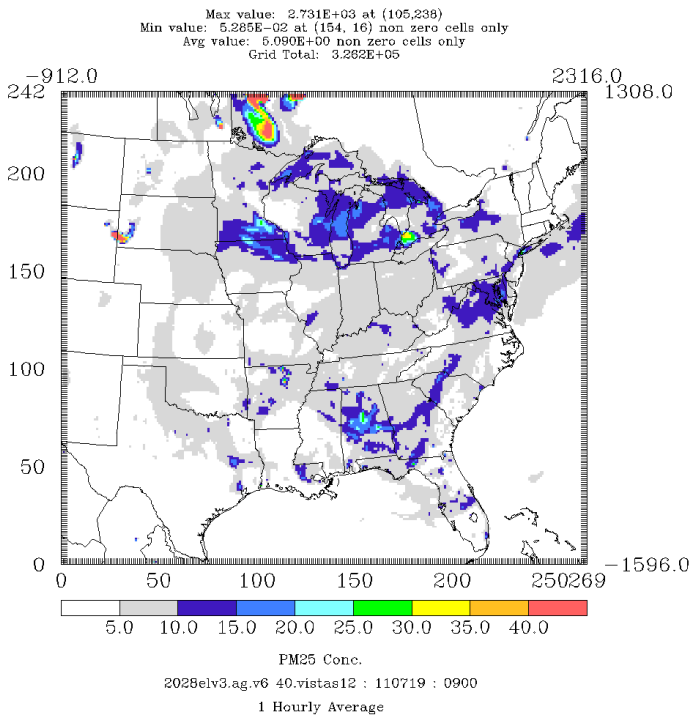


Figure 4-40: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 19 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

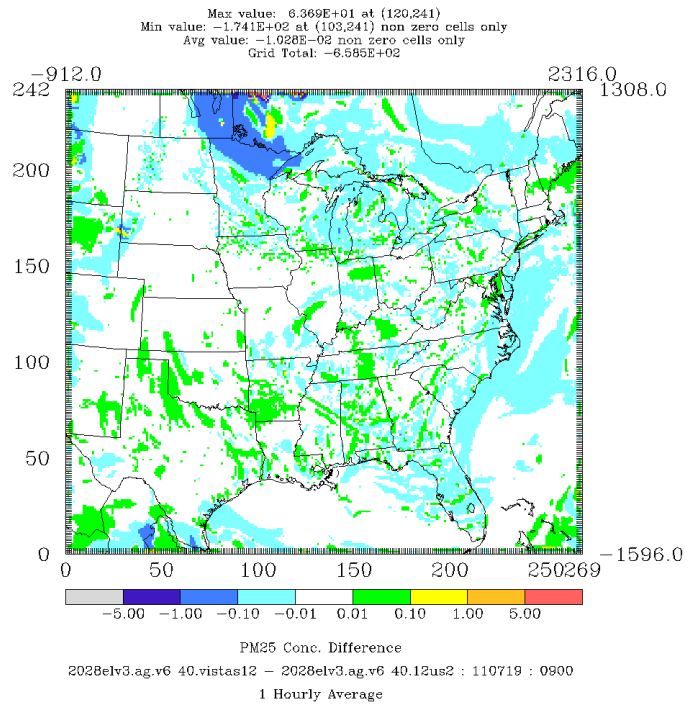


Figure 4-41: Comparison of $PM_{2.5}$ Concentrations ($\mu g/m^3$) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference)

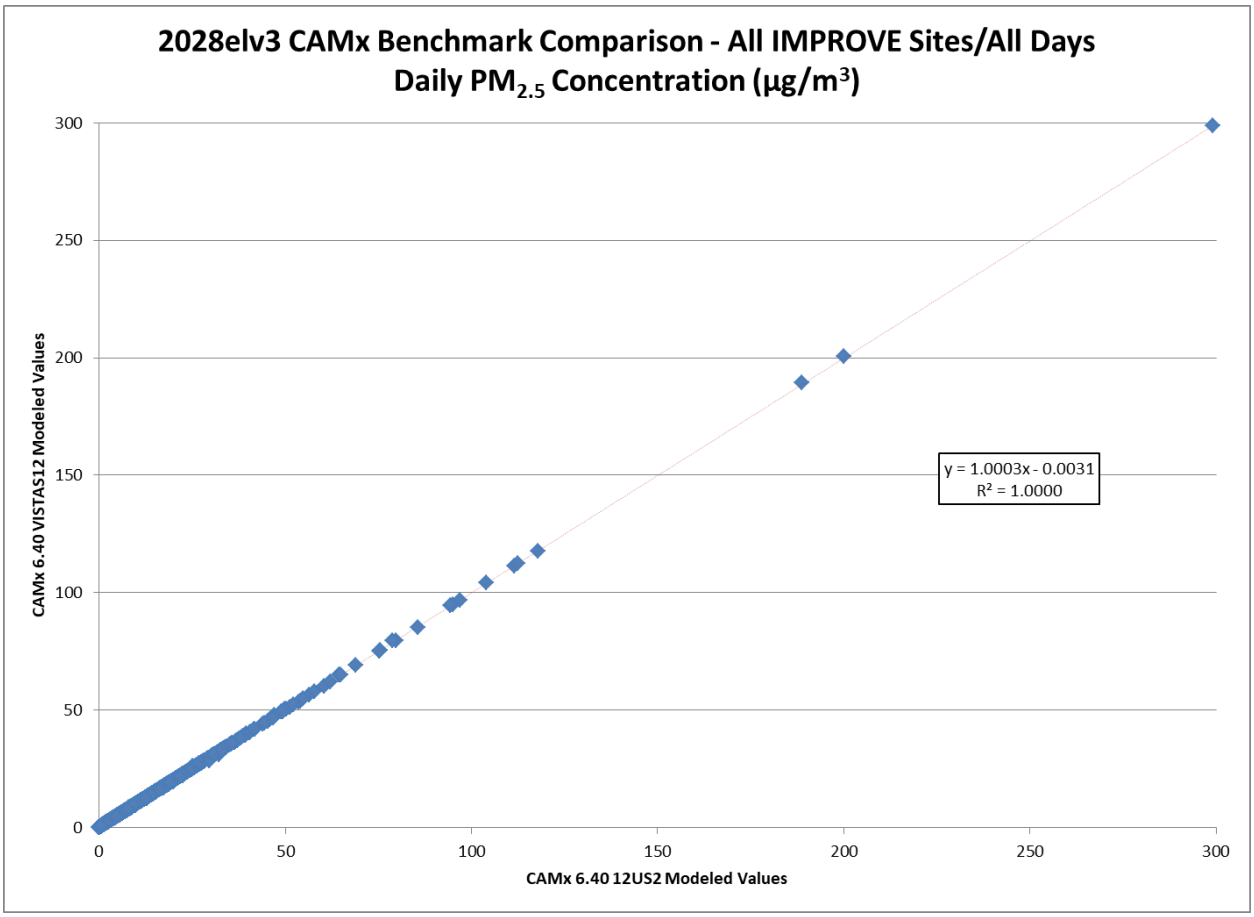


Figure 4-42: Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by VISTAS (Alpine).

4.3 Sulfate

Sulfate results for the top 10 positive and negative hours are presented in tabular format in Table 4-3. The maximum positive difference is 5.76 μg/m^3 falling to 3.43 μg/m^3 for the 10th high. The maximum negative difference is -4.57 μg/m^3 falling to -2.34 μg/m^3 for the 10th high. The maximum positive percent difference on these days is 94.5% and negative percent difference of -32.7%.

As expected, the maximum impacts on the top 10 positive and negative hours are occurring very near the border. As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated from the cells outside the VISTAS12 domain. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous concentrations. The top 10 positive difference hours are presented in Figures 4-43 through 4-52 and the top 10 negative difference hours are presented in Tables 4-53 through 4-62. The peak differences are occurring between July 17 and July 20. The area of the peak impact is very near the northern border, north of Minnesota.

Scatterplots of the daily average sulfate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-63. The 12US2 results are plotted on the x-axis and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0019, an intercept of 0.0008 μg/m^3 and an R^2 of 0.9999.

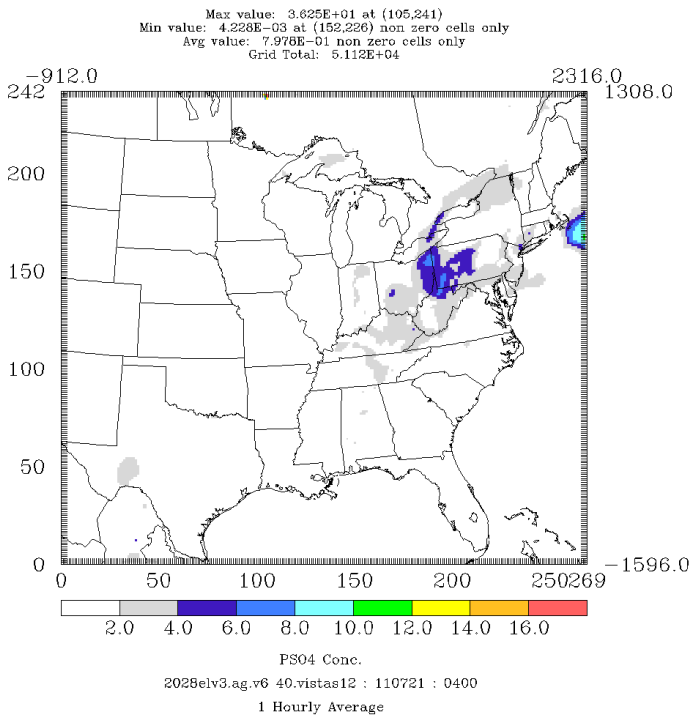
Examination of the difference animations often show differences along the boundary becoming lower as the plumes along the boundary move into the domain.

Table 4-3. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of Sulfate Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	7	21	4	13.56	7.80	5.76	73.9%	104	241
2011	7	20	14	25.43	20.65	4.79	23.2%	107	241
2011	7	21	3	44.72	40.44	4.28	10.6%	104	241
2011	7	20	15	13.32	9.20	4.12	44.8%	107	241
2011	7	21	1	31.50	27.50	4.00	14.5%	104	241
2011	7	20	12	45.82	41.92	3.90	9.3%	107	241
2011	7	20	11	39.79	35.92	3.87	10.8%	107	241
2011	7	21	0	10.21	6.66	3.55	53.2%	103	241
2011	7	20	23	7.17	3.69	3.48	94.5%	102	241
2011	7	20	22	8.31	4.88	3.43	70.3%	102	241
Maximum Negative									
2011	7	20	14	73.45	78.03	-4.57	-5.9%	106	241
2011	7	20	15	66.90	71.41	-4.51	-6.3%	105	241
2011	7	20	13	88.61	92.84	-4.23	-4.6%	106	241
2011	7	20	16	54.97	59.00	-4.03	-6.8%	105	241
2011	7	20	12	112.23	116.24	-4.00	-3.4%	106	241
2011	7	17	11	6.88	10.22	-3.34	-32.7%	89	241
2011	7	17	12	6.87	9.91	-3.04	-30.7%	89	241
2011	7	19	10	11.25	14.18	-2.93	-20.6%	104	241
2011	7	17	10	5.80	8.59	-2.79	-32.5%	89	241
2011	7	19	9	11.52	13.86	-2.34	-16.9%	103	241

Maximum Positive Difference: July 21 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

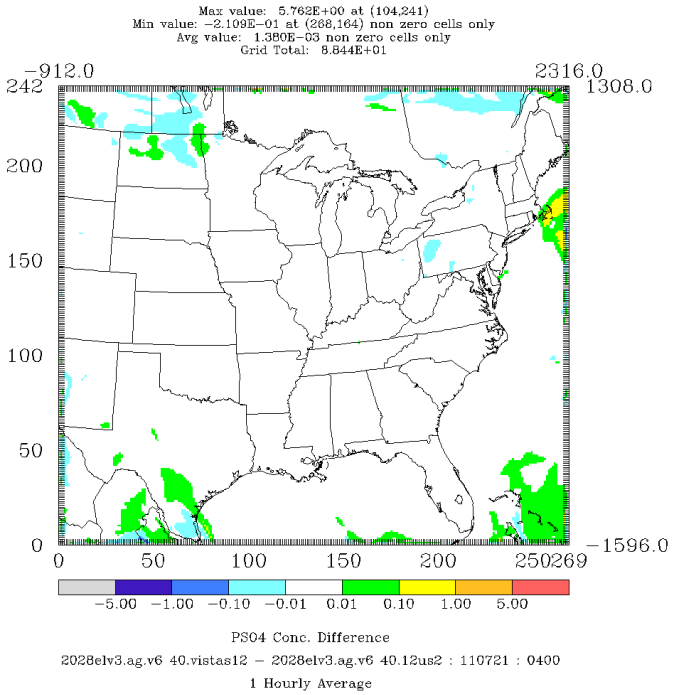
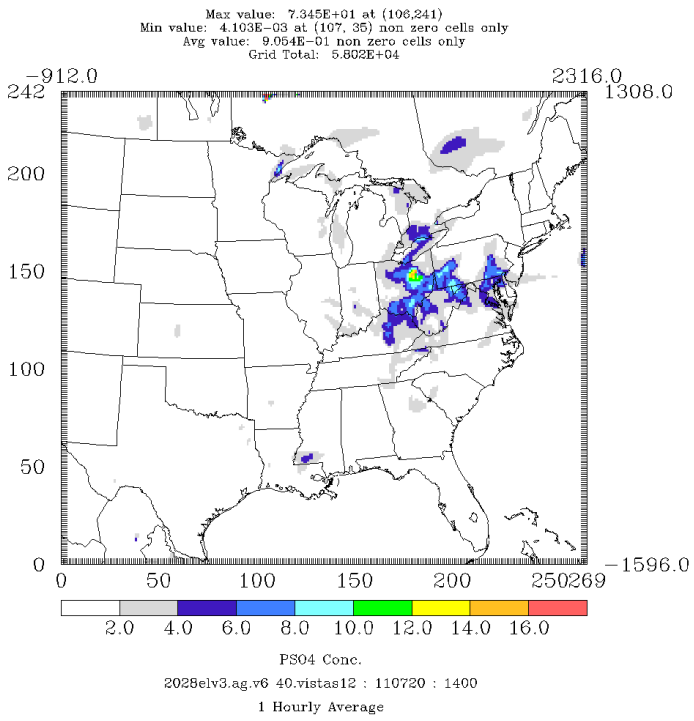


Figure 4-43: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference)

Second Highest Positive Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

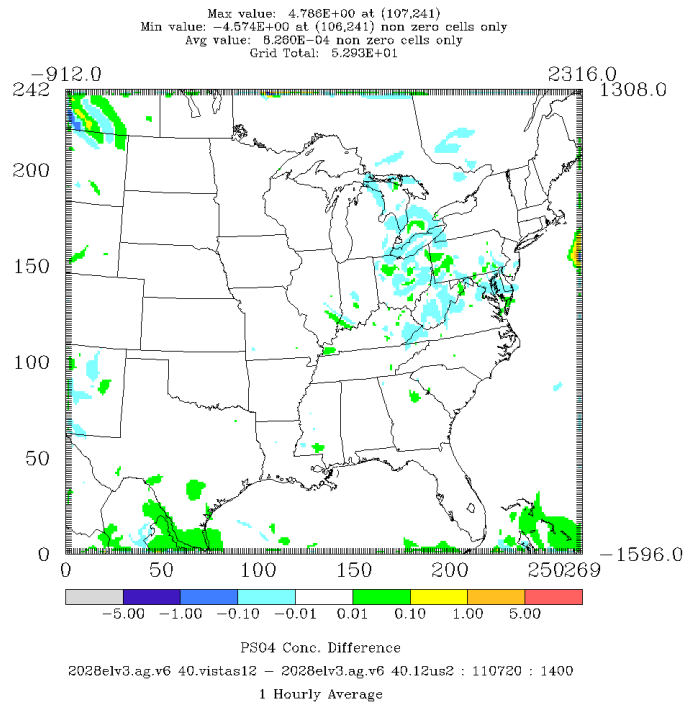
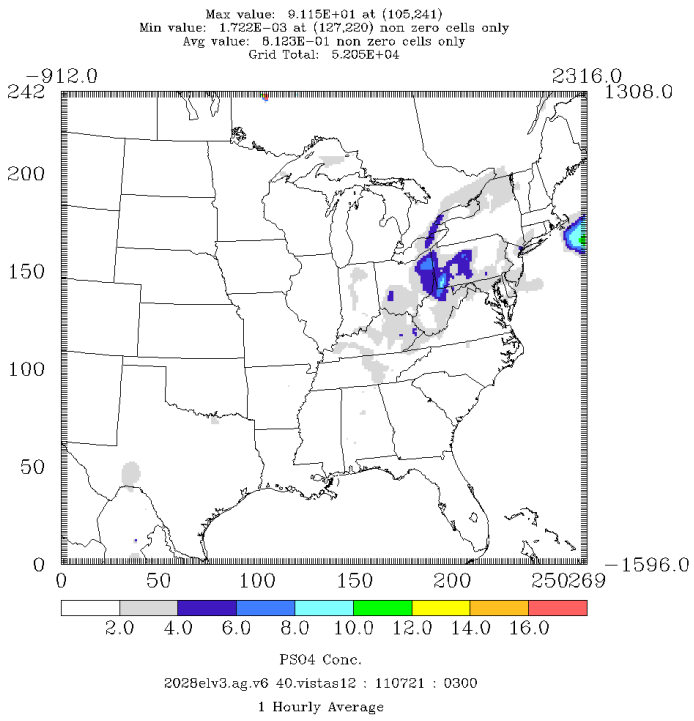


Figure 4-44: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: July 21 at 300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

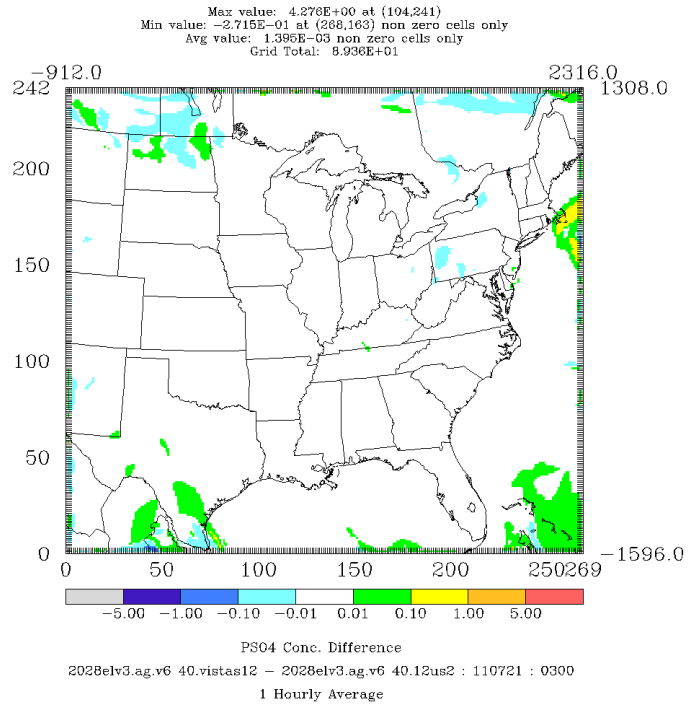
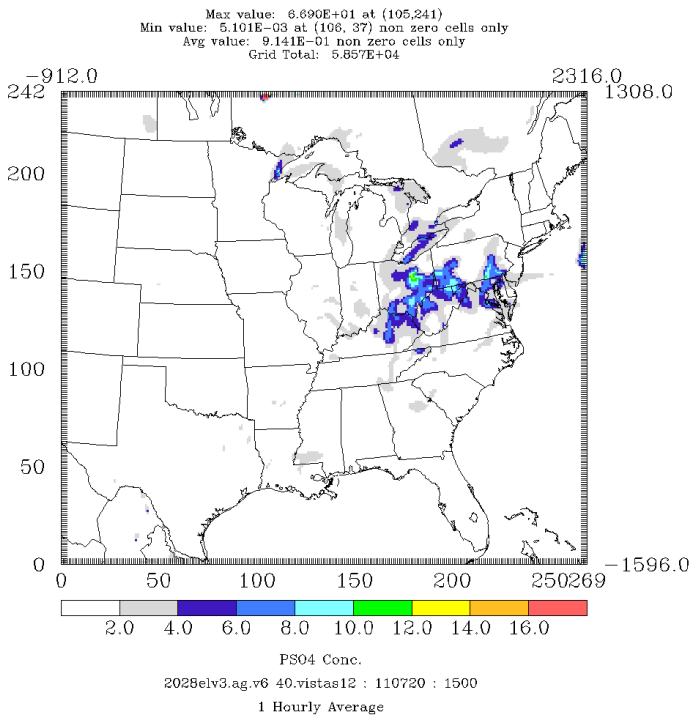


Figure 4-45: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

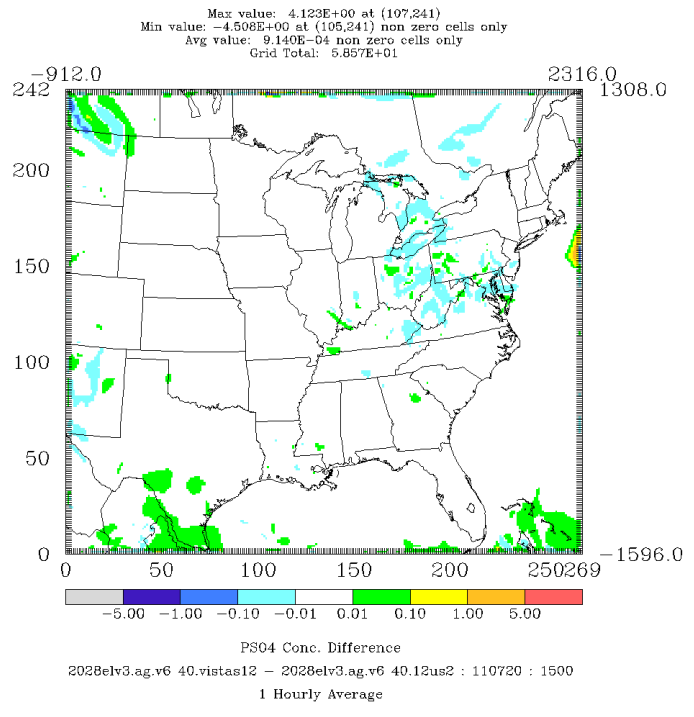
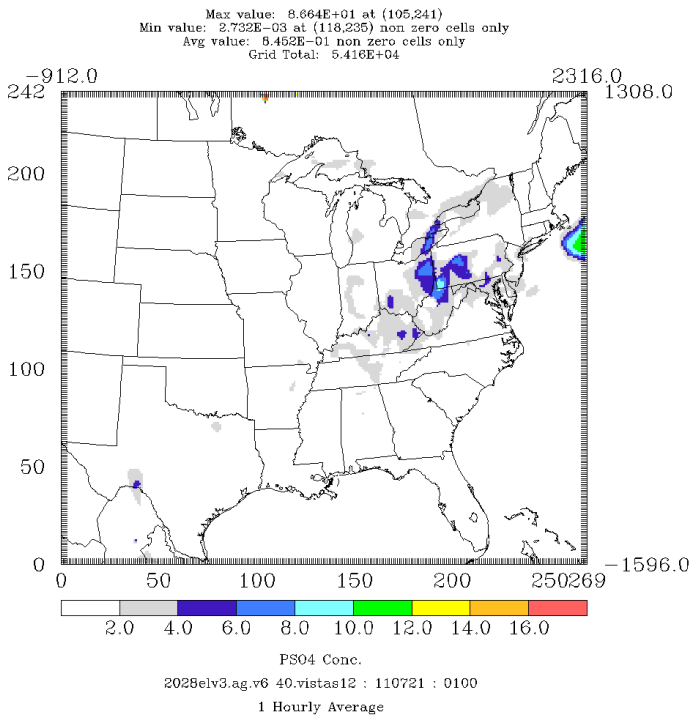


Figure 4-46: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: July 21 at 100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

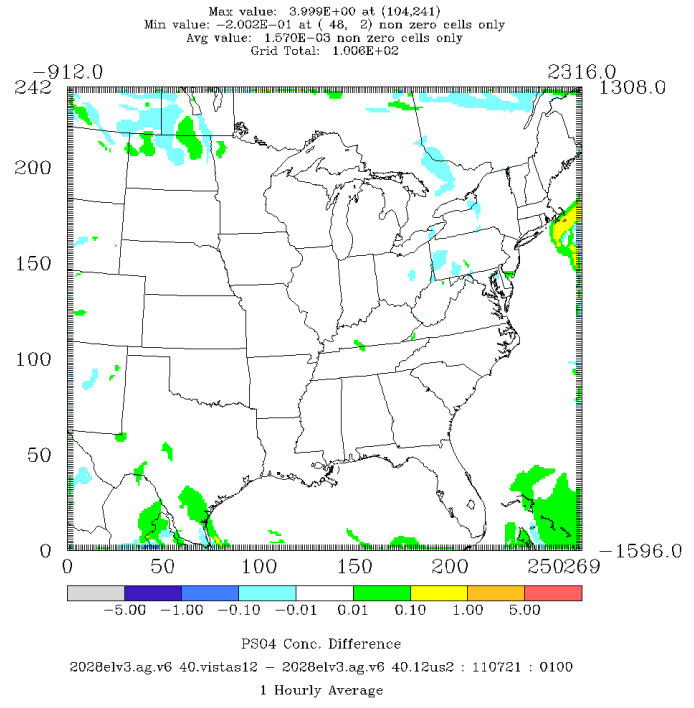
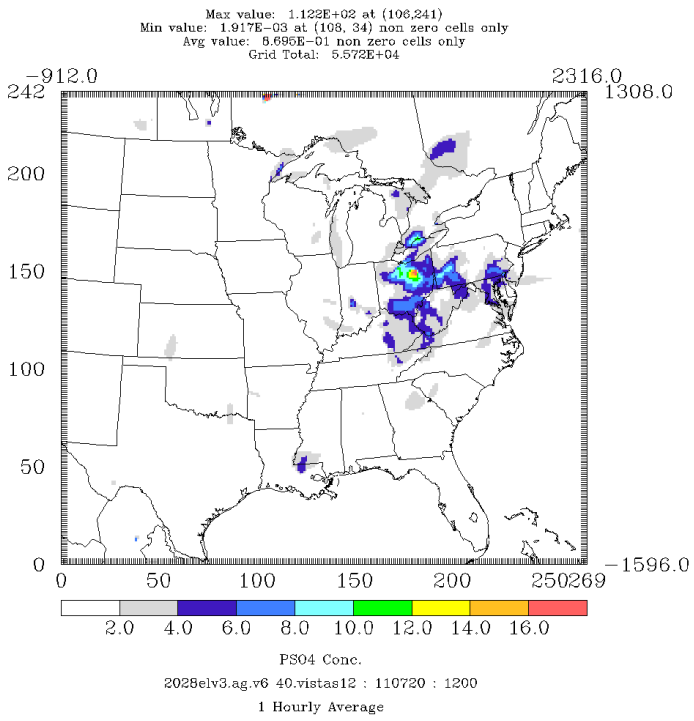


Figure 4-47: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

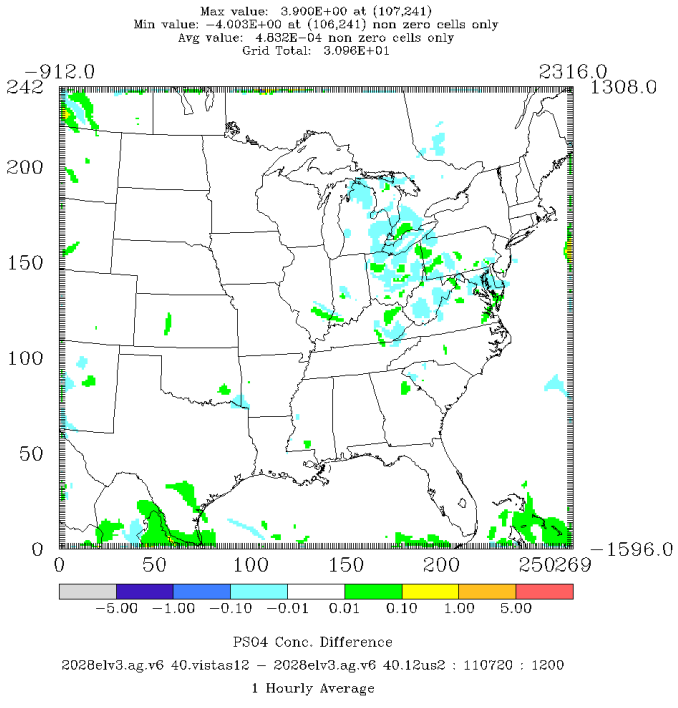
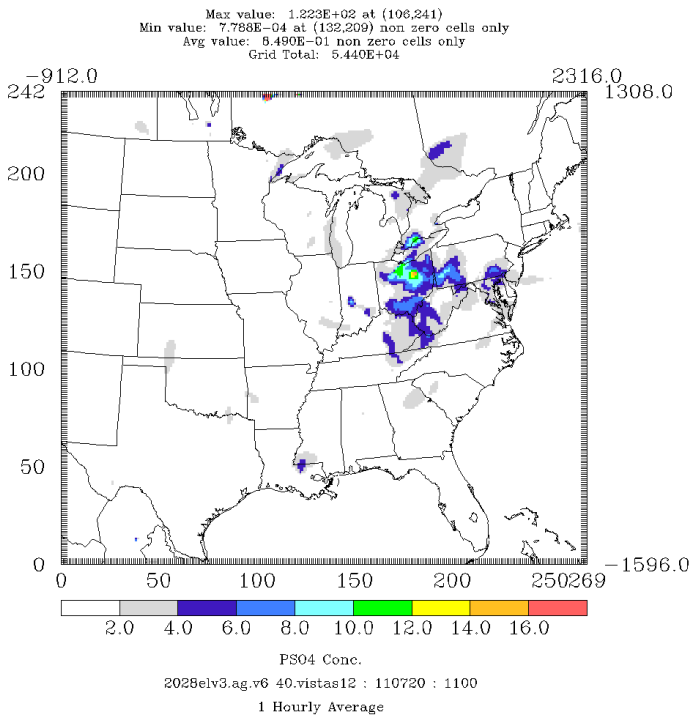


Figure 4-48: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: July 20 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

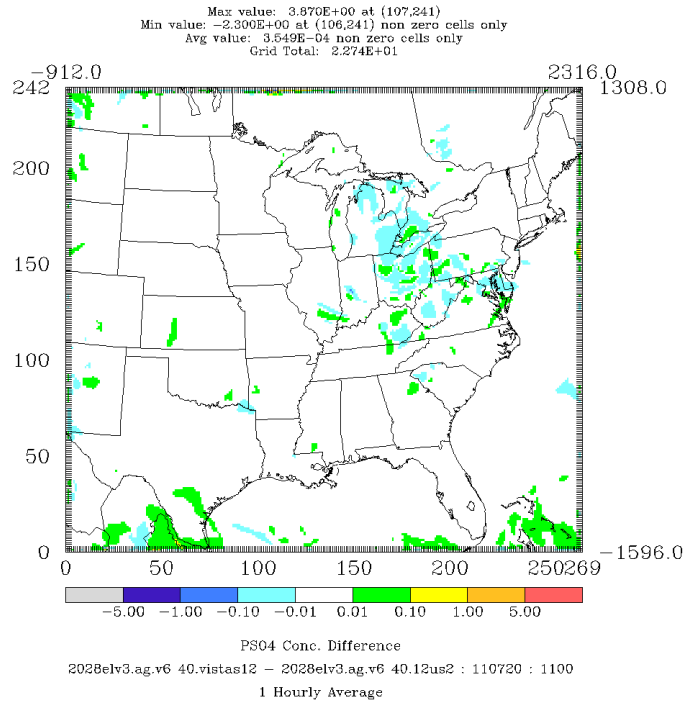
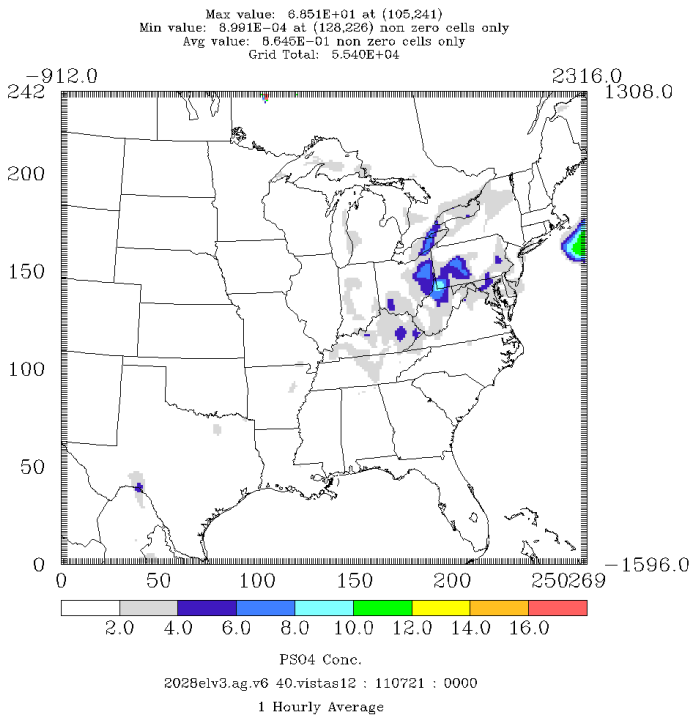


Figure 4-49: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations

Eighth Highest Positive Difference: July 21 at 0000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

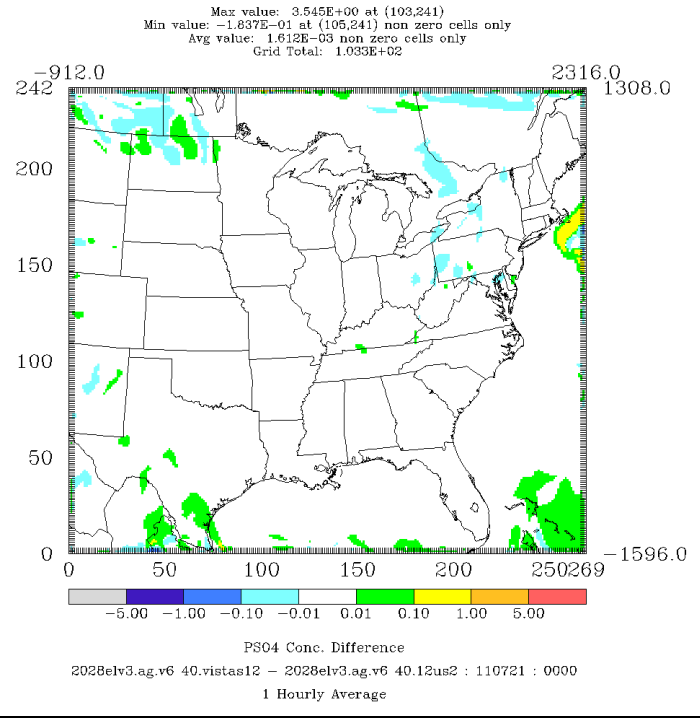
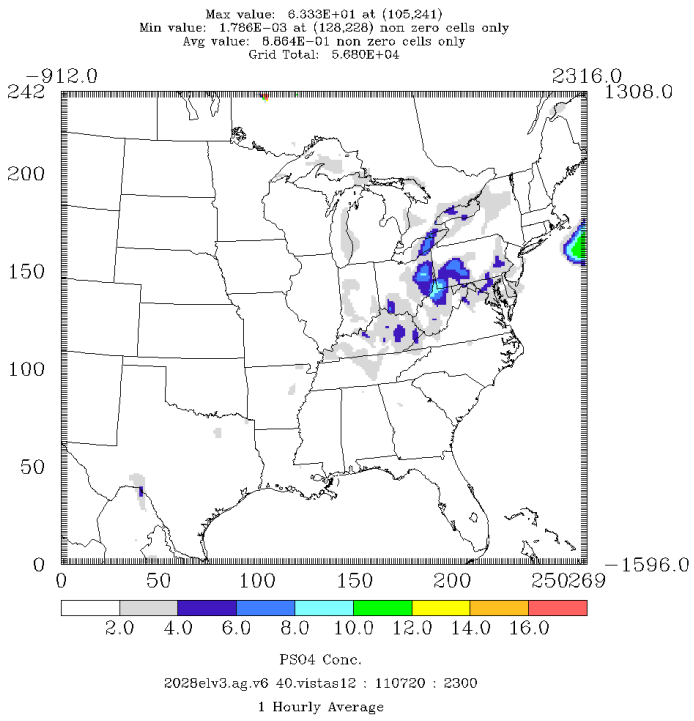


Figure 4-50: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: July 20 at 2300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

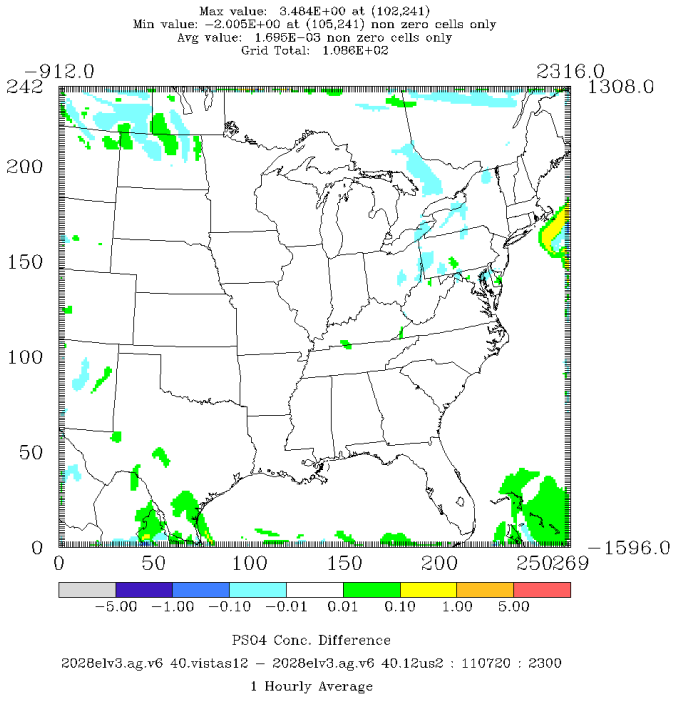
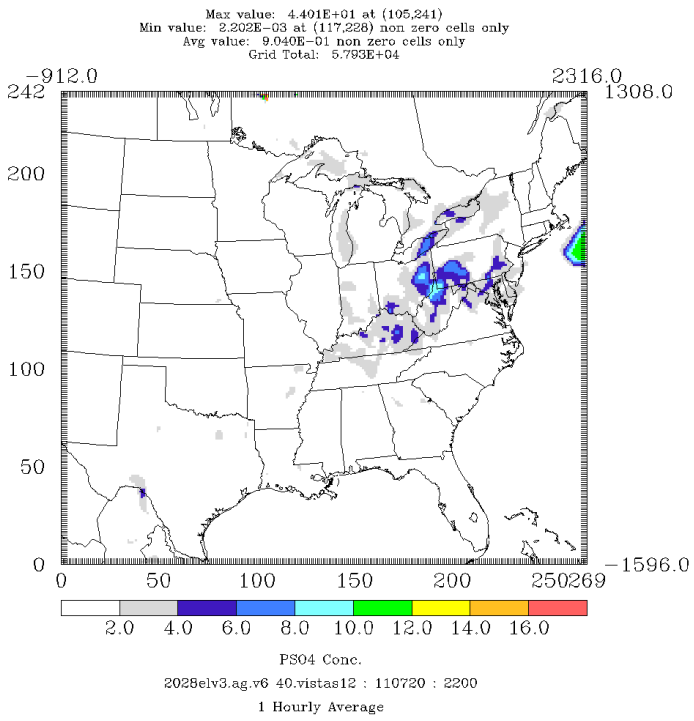


Figure 4-51: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 2200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

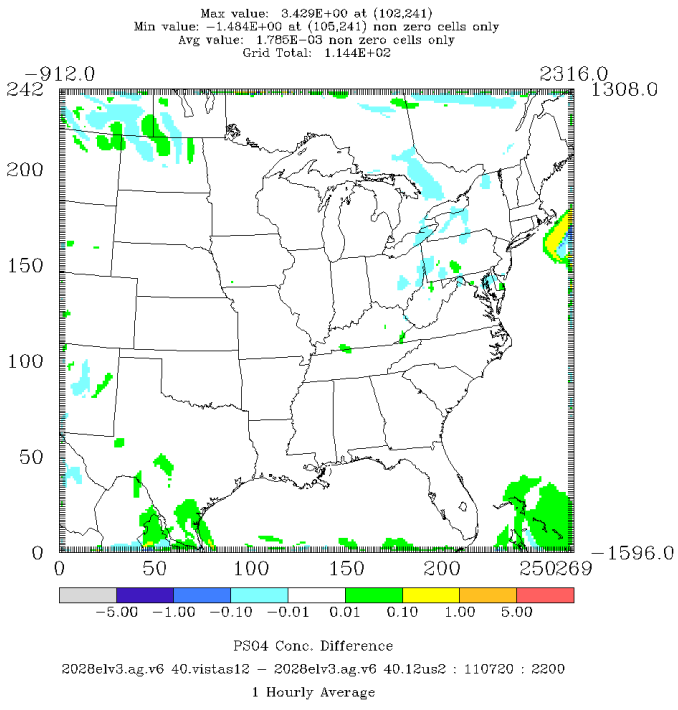
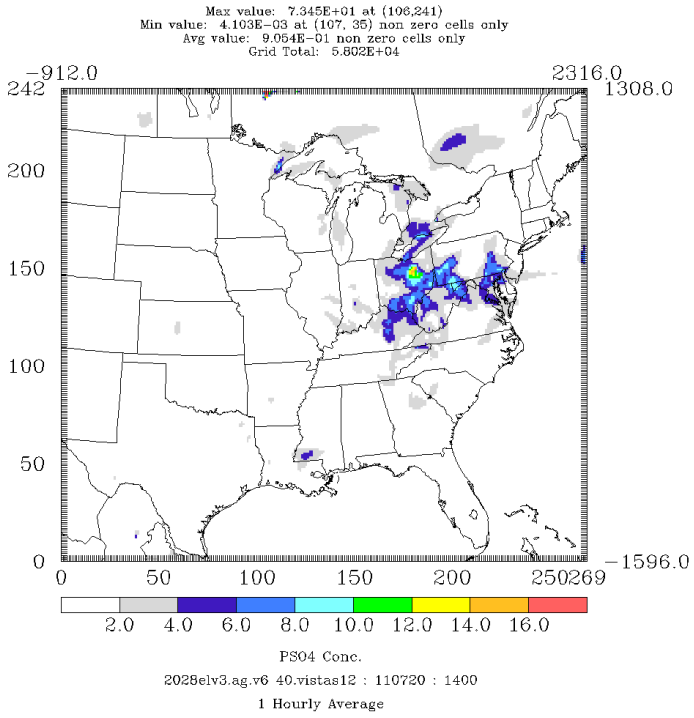


Figure 4-52: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

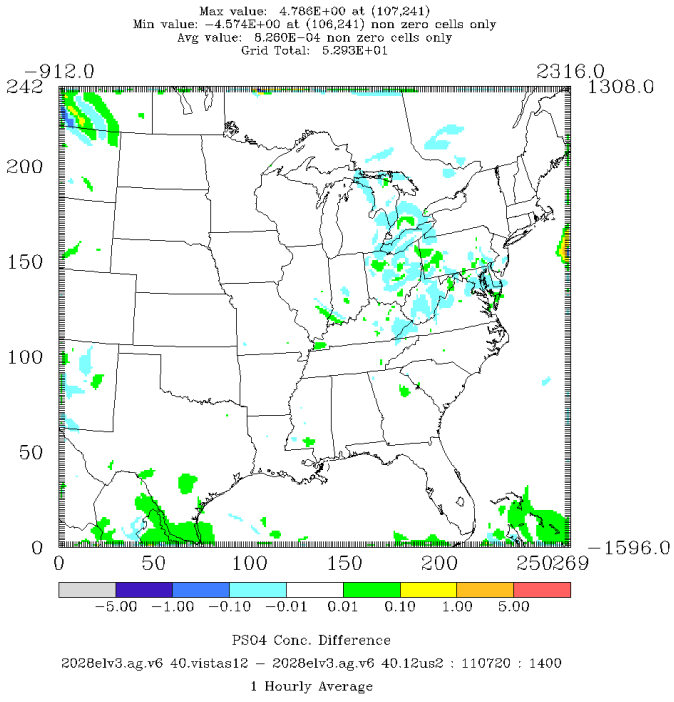
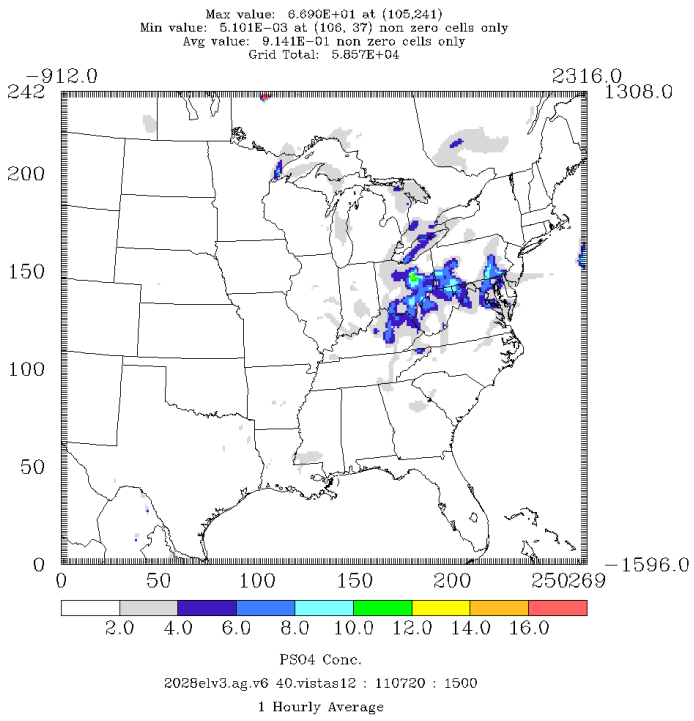


Figure 4-53: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

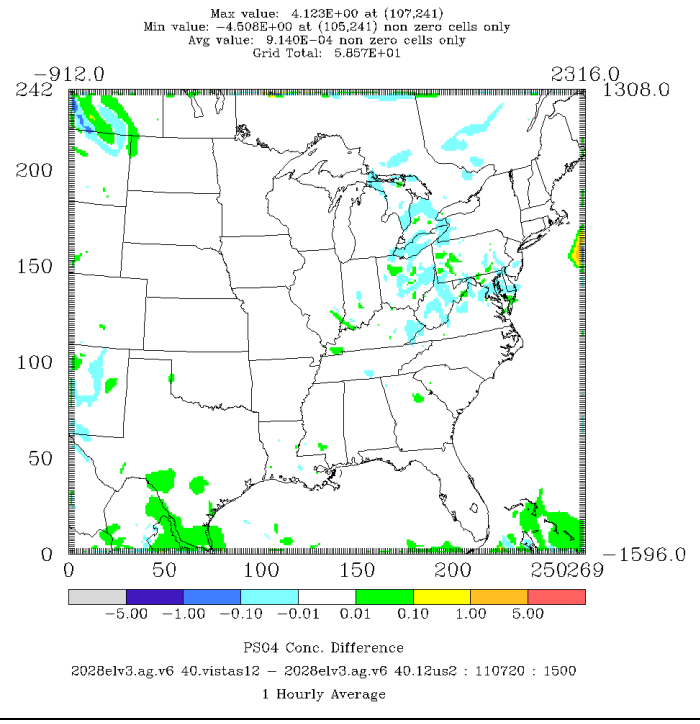
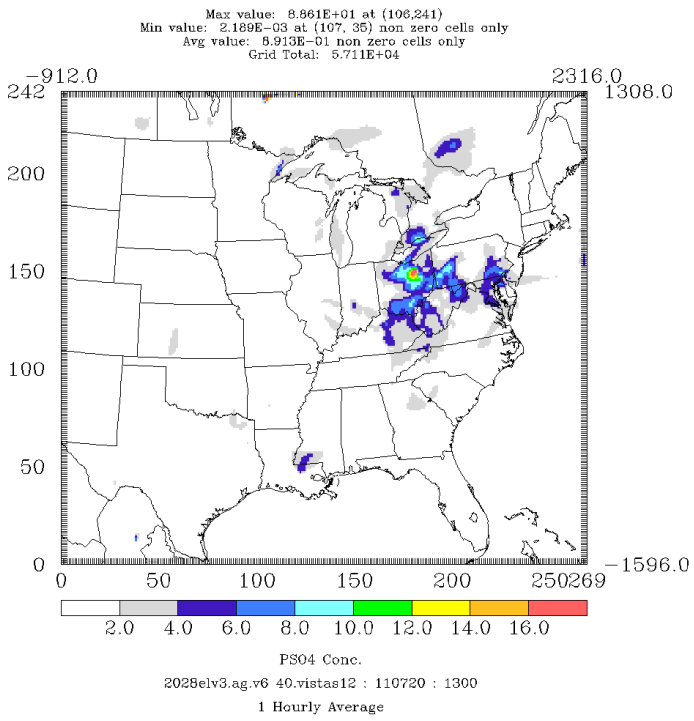


Figure 4-54: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

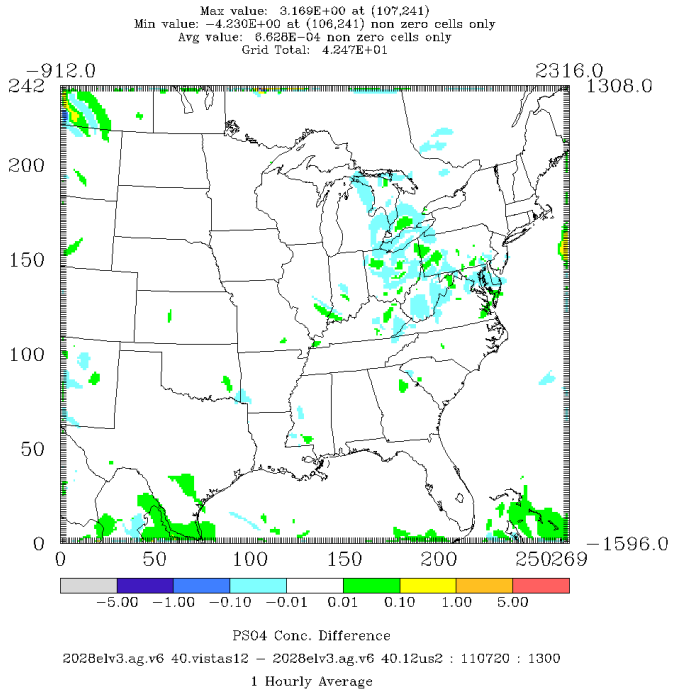
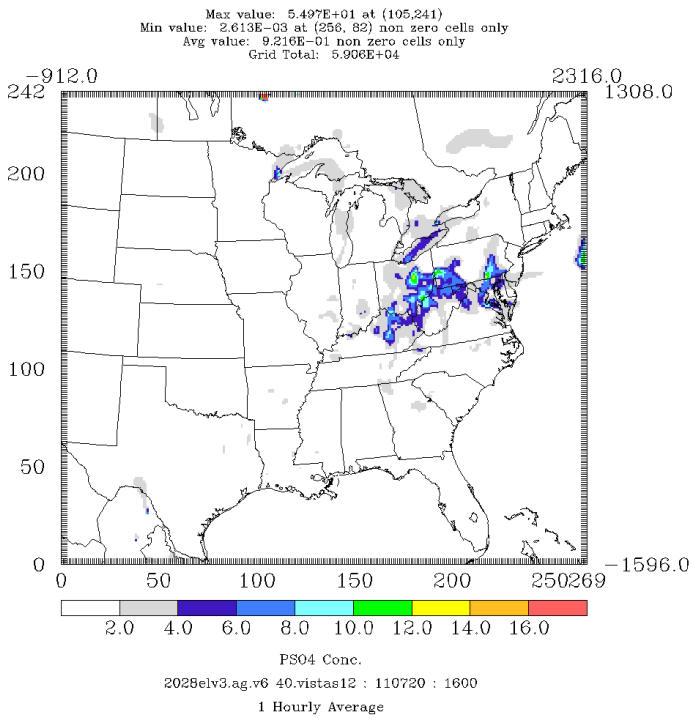


Figure 4-55: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 20 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

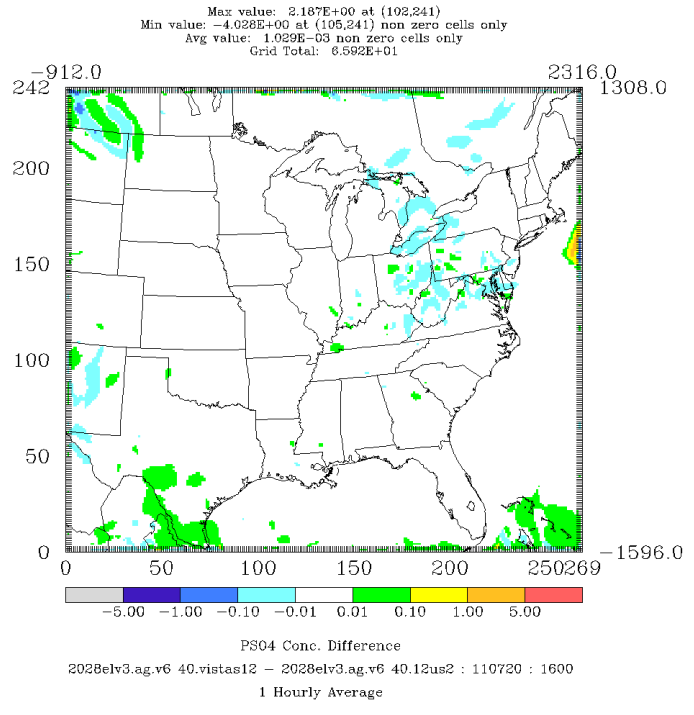
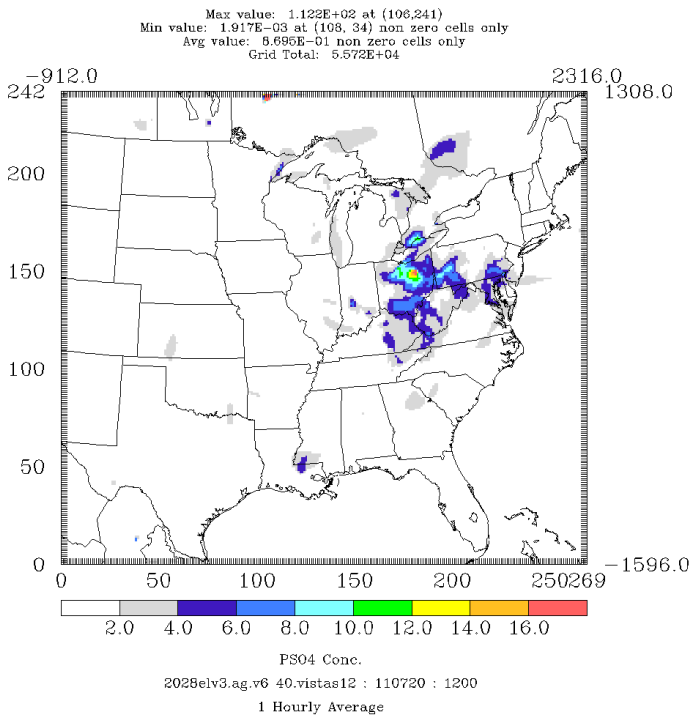


Figure 4-56: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

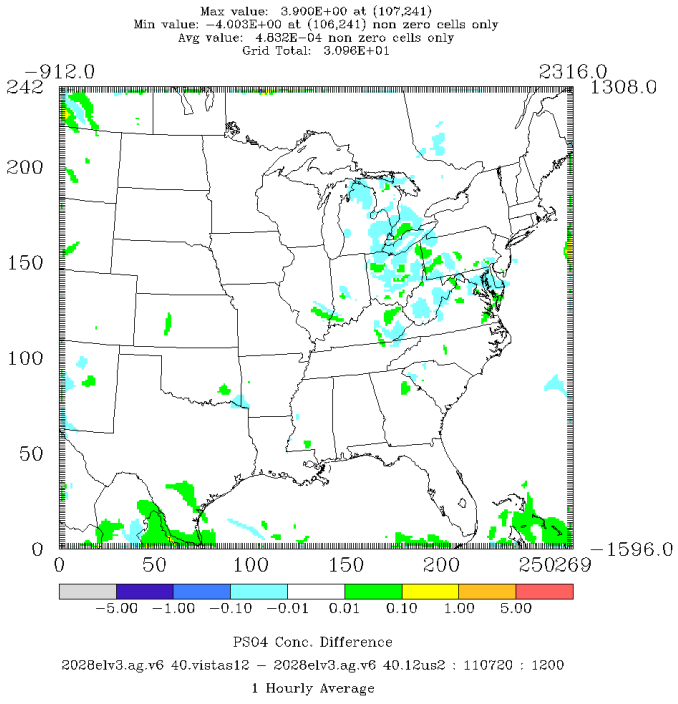
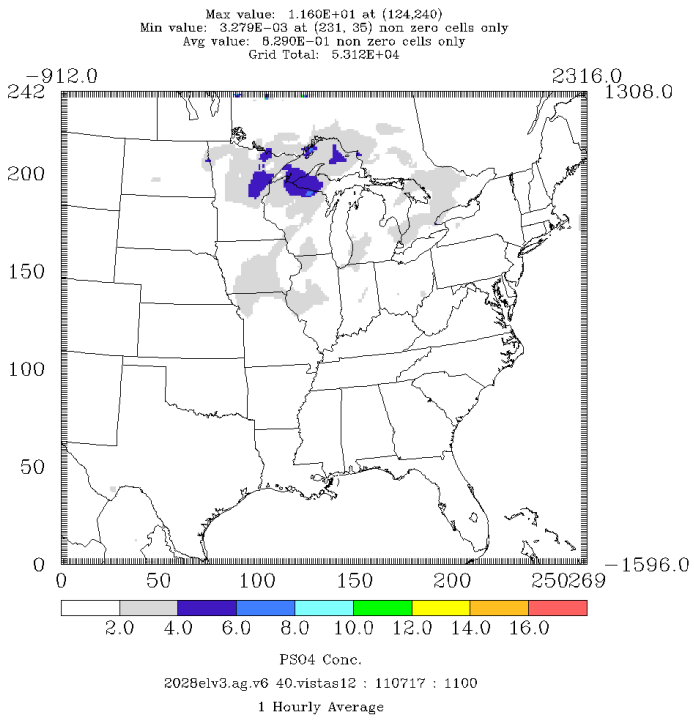


Figure 4-57: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 17 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

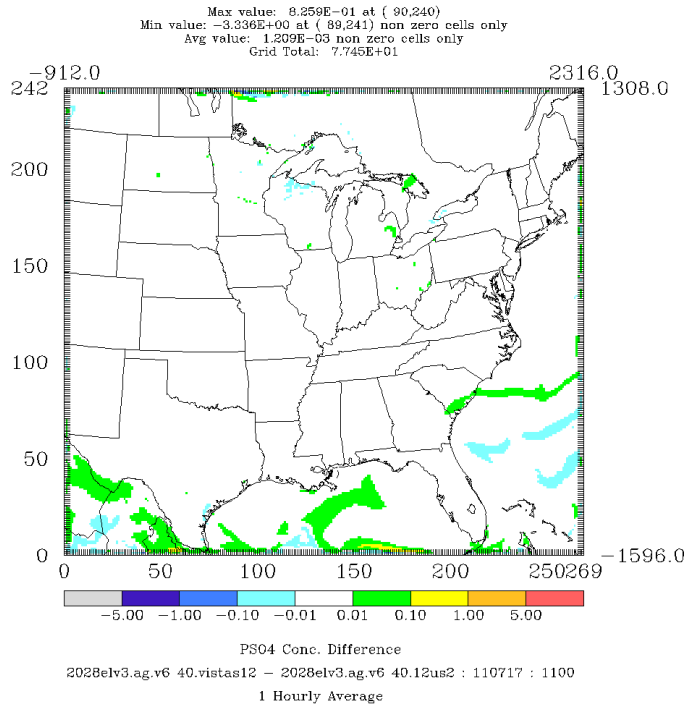
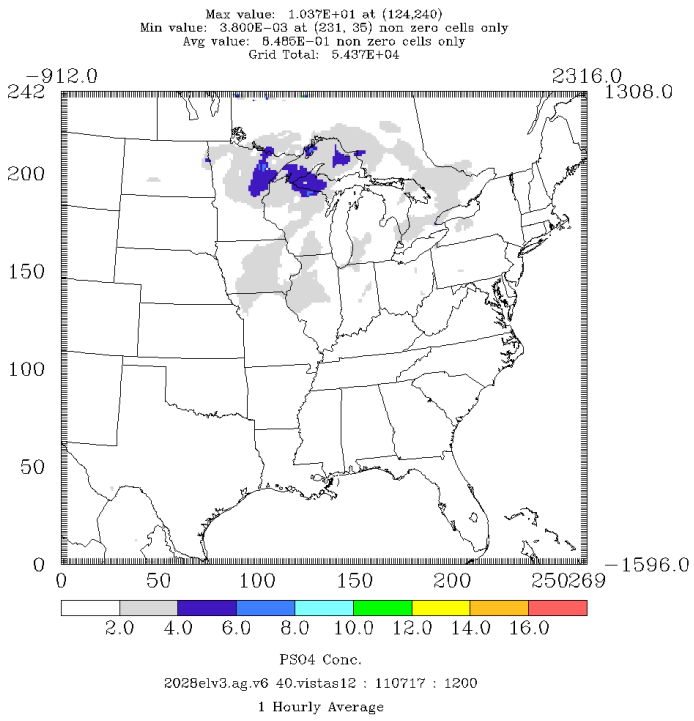


Figure 4-58: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 17 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

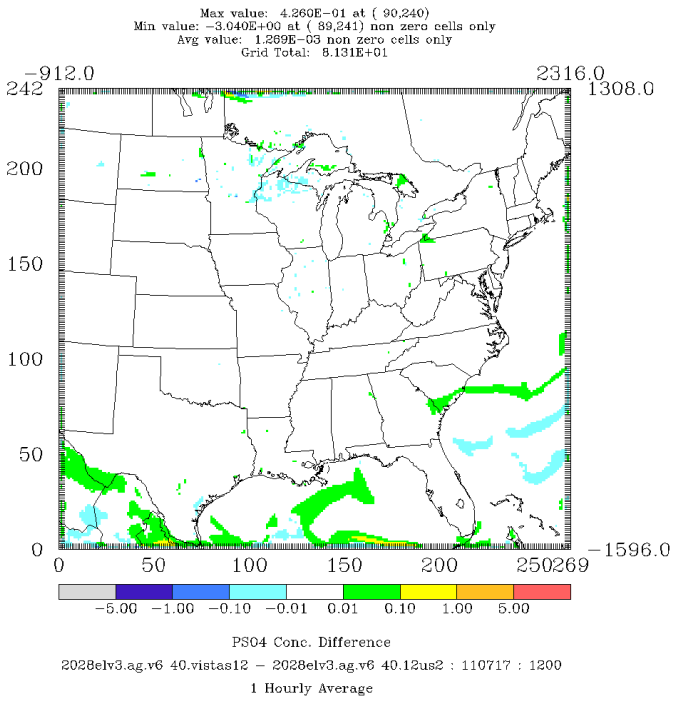
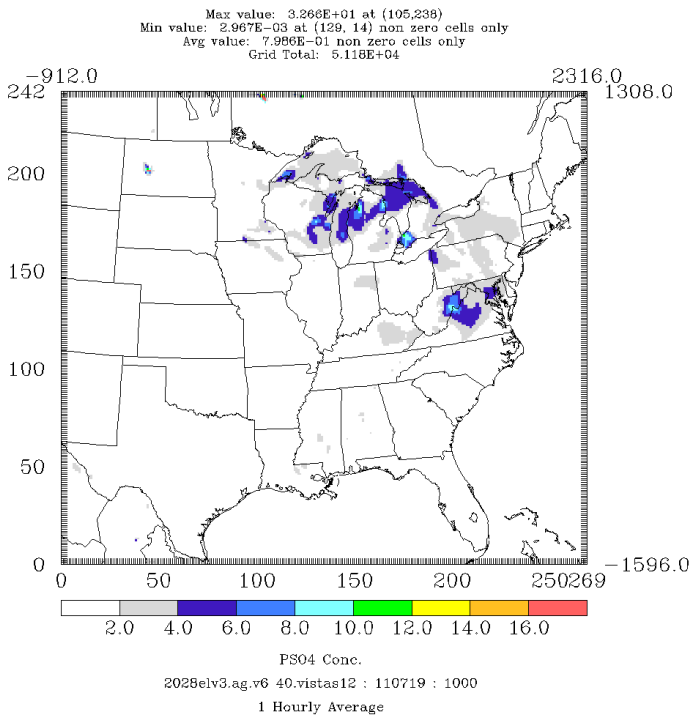


Figure 4-59: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 19 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

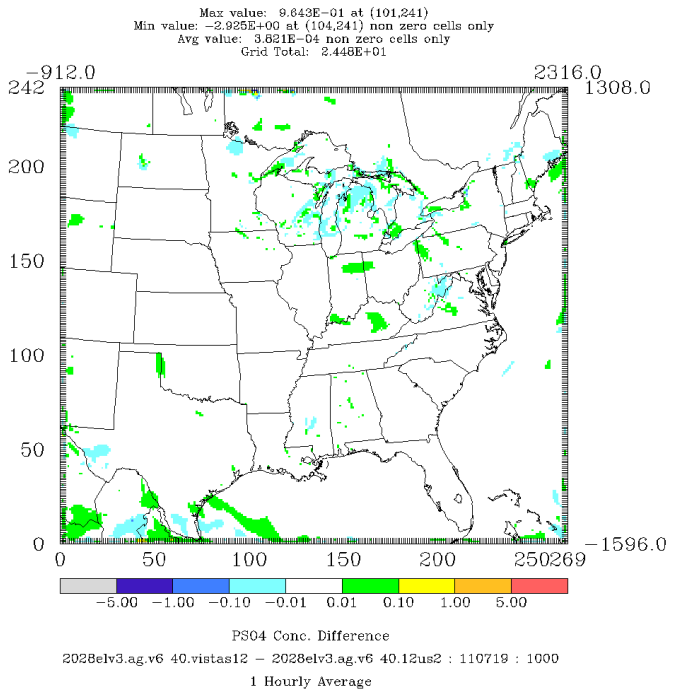
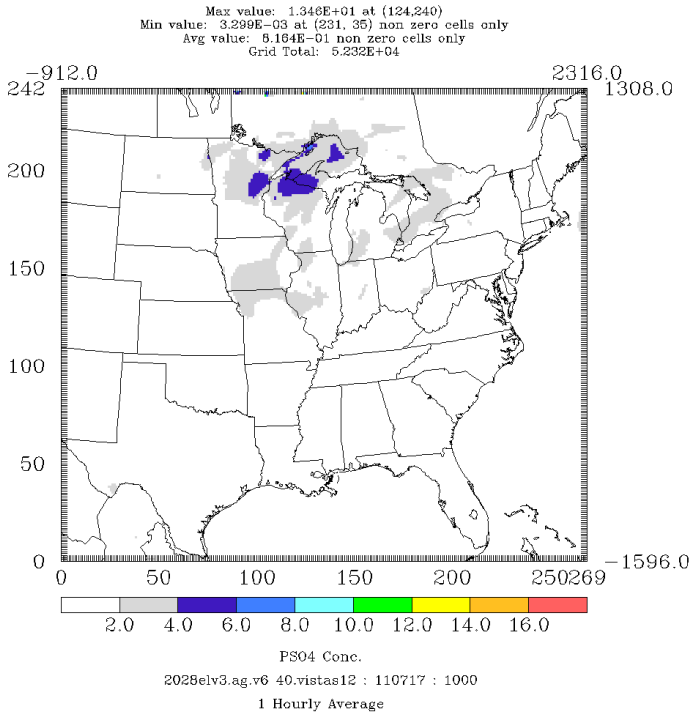


Figure 4-60: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 17 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

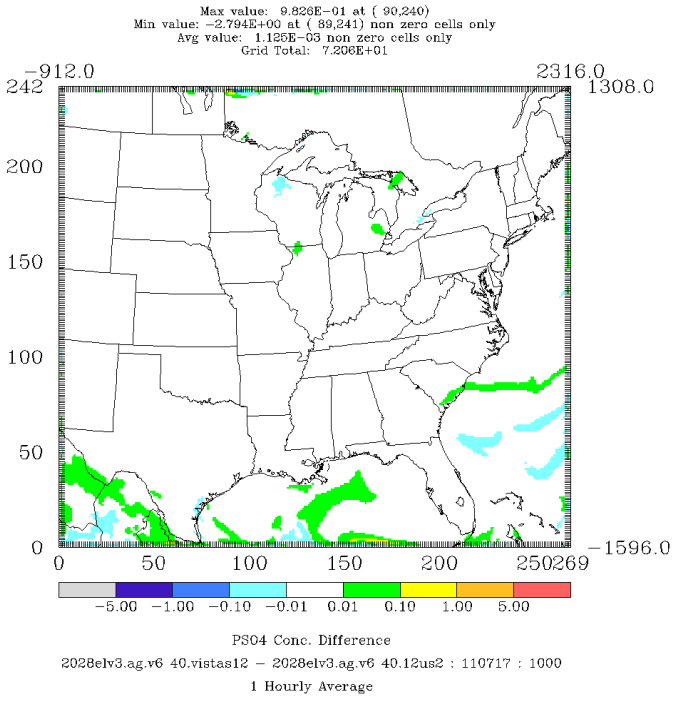
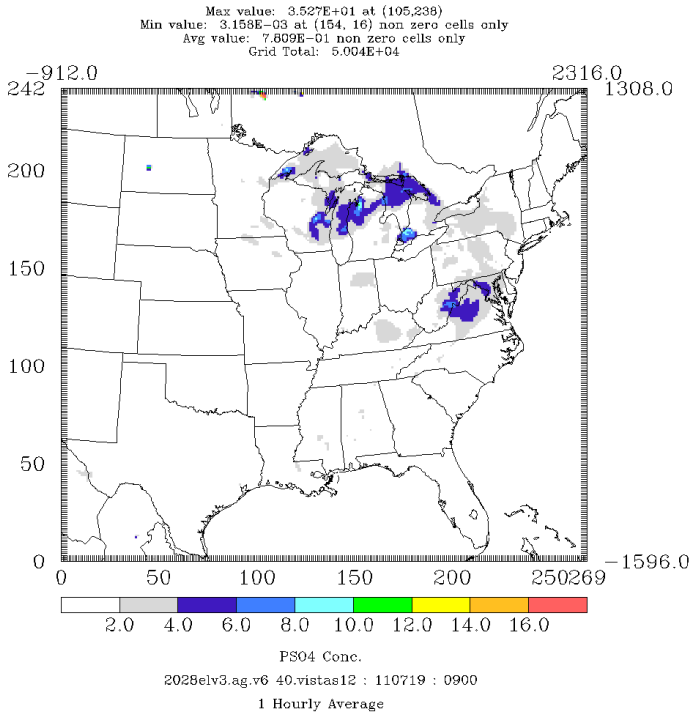


Figure 4-61: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 19 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

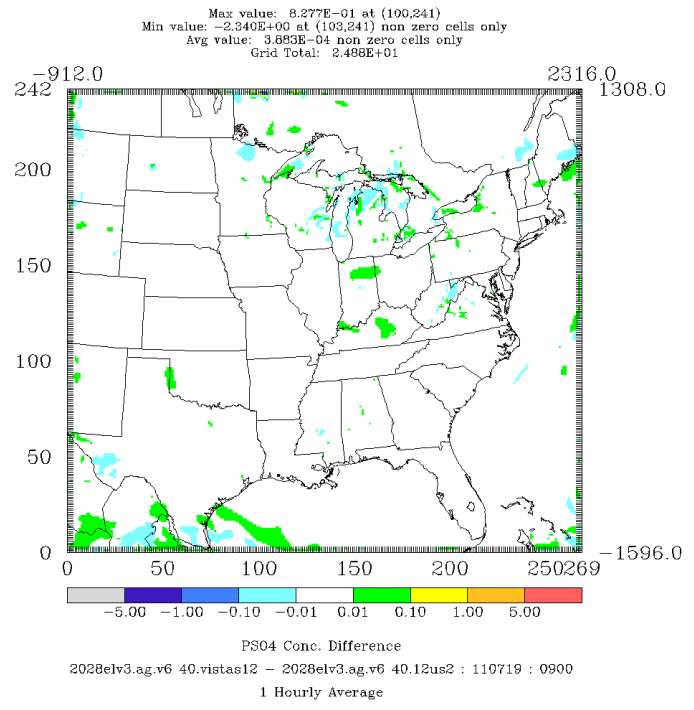


Figure 4-62: Comparison of Sulfate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference)

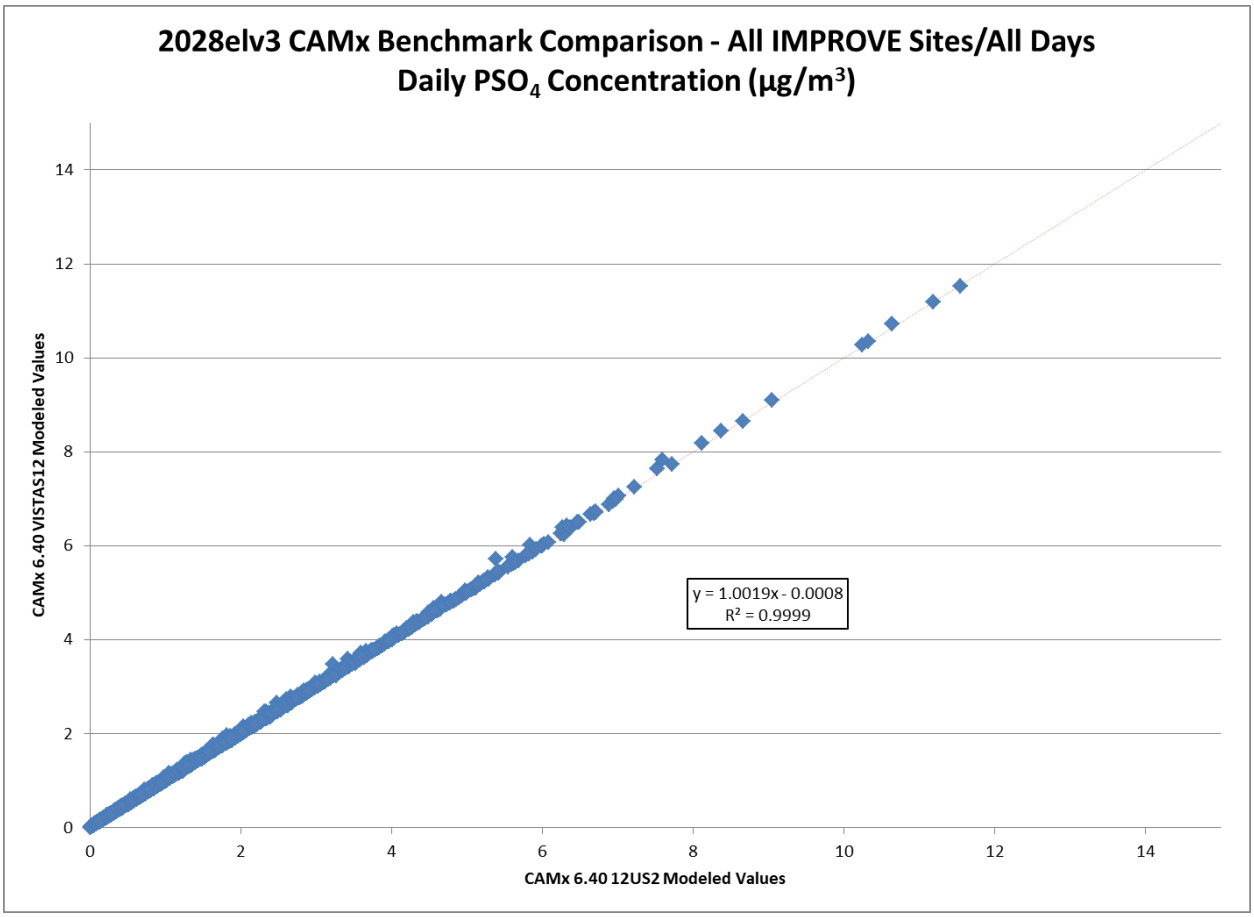


Figure 4-63: Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by VISTAS (Alpine).

4.4 Nitrate

Nitrate results for the top 10 positive and negative hours are presented in tabular format in Table 4-4. The maximum positive difference is 7.21 μg/m^3 falling to 4.22 μg/m^3 for the 10th high. The maximum negative difference is -4.63 μg/m^3 falling to -2.96 μg/m^3 for the 10th high. The maximum positive percent difference from these days is 130.1% and negative percent difference of -49.2%.

As expected, the maximum impacts on the top 10 positive and negative hours are occurring very near the border. As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated from the cells outside the VISTAS12 domain. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous concentrations.

The top 10 positive difference hours are presented in Figures 4-64 through 4-73 and the top 10 negative difference hours are presented in Figures 4-74 through 4-83. The peak differences are generally occurring on January 3, July 17 and July 20. On January 3 the area of the difference is generally in the north western portion of the domain in an area of a plume entering the domain from Canada. On July 20 the differences are along the northern border, north of Minnesota.

Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-83. The 12US2 results are plotted on the x-axis and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 0.9996, an intercept of 0.0006 μg/m^3 and an R^2 of 1.0000.

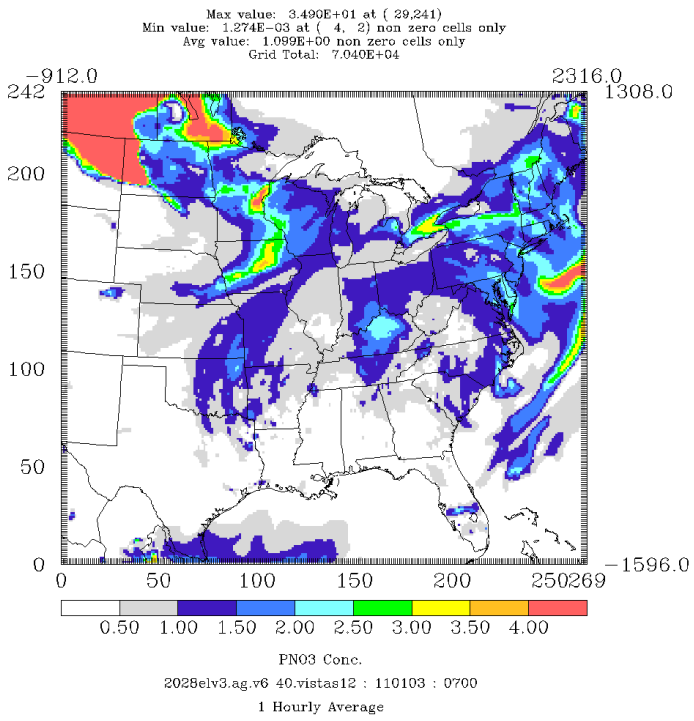
Examination of the difference animations often show differences along the boundary becoming lower as the plumes along the boundary move into the domain.

Table 4-4. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of Nitrate Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	1	3	7	26.59	19.38	7.21	37.2%	32	235
2011	1	3	6	26.46	19.29	7.16	37.1%	32	235
2011	1	3	5	26.34	19.24	7.10	36.9%	32	235
2011	7	20	20	10.58	4.60	5.98	130.1%	99	241
2011	1	3	10	27.68	21.79	5.89	27.0%	33	235
2011	1	3	8	26.83	21.02	5.81	27.6%	32	235
2011	7	20	15	25.48	20.00	5.47	27.4%	107	241
2011	1	3	4	26.62	21.41	5.21	24.3%	32	235
2011	1	3	12	20.45	15.87	4.59	28.9%	16	241
2011	7	20	19	14.19	9.98	4.22	42.3%	99	241
Maximum Negative									
2011	1	3	8	18.88	23.51	-4.63	-19.7%	33	233
2011	7	17	15	4.64	9.14	-4.49	-49.2%	90	241
2011	1	3	7	18.28	22.49	-4.21	-18.7%	33	233
2011	7	17	14	9.10	13.25	-4.15	-31.3%	90	241
2011	1	27	10	3.73	7.31	-3.58	-49.0%	224	241
2011	1	3	10	24.33	27.81	-3.48	-12.5%	30	233
2011	1	3	12	16.46	19.80	-3.33	-16.8%	13	240
2011	1	27	11	3.62	6.74	-3.12	-46.3%	224	241
2011	1	3	9	21.84	24.86	-3.02	-12.2%	33	234
2011	7	17	16	2.29	5.25	-2.96	-56.4%	91	241

Maximum Positive Difference: January 3 at 700 hours

VISTAS12



Difference (VISTAS12 - 12US2)

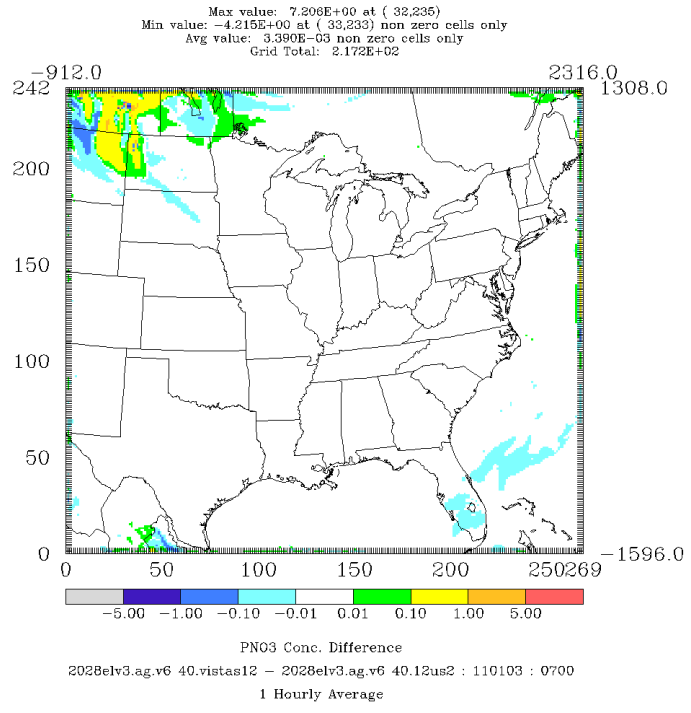
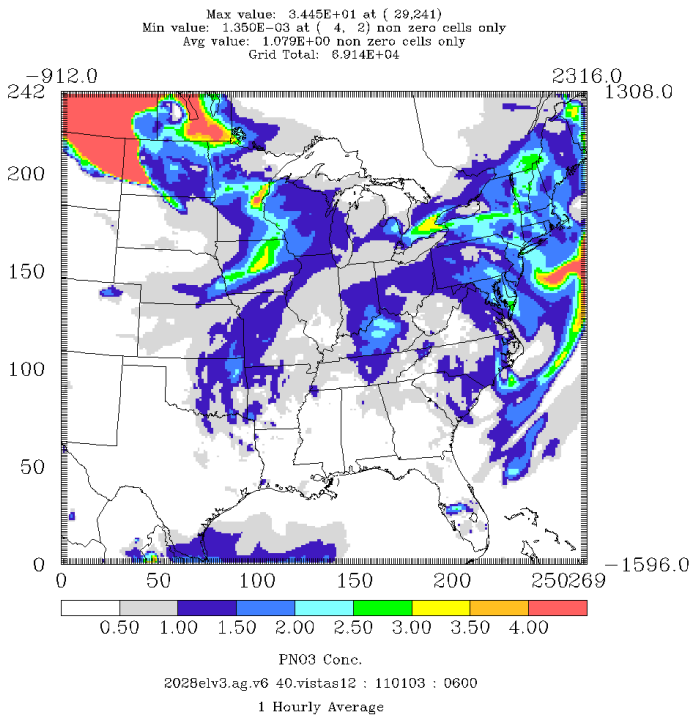


Figure 4-64: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference)

Second Highest Positive Difference: January 3 at 600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

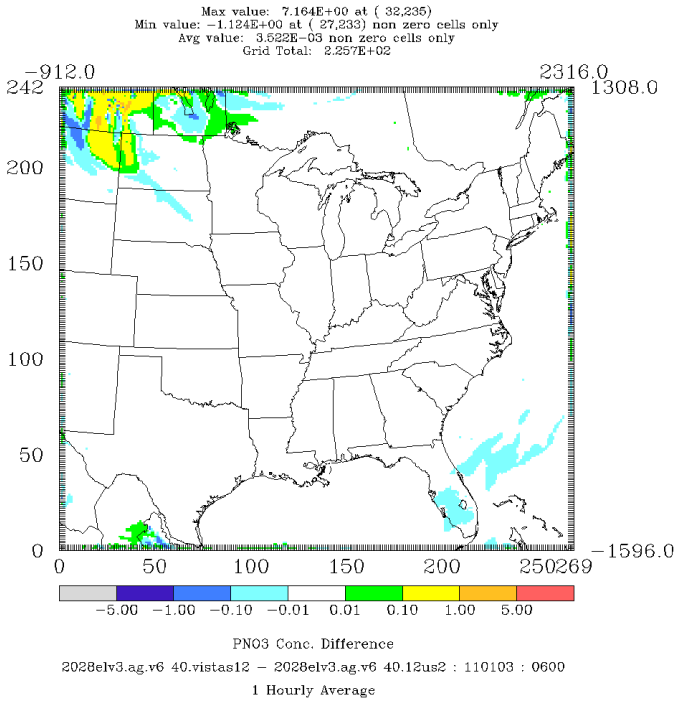
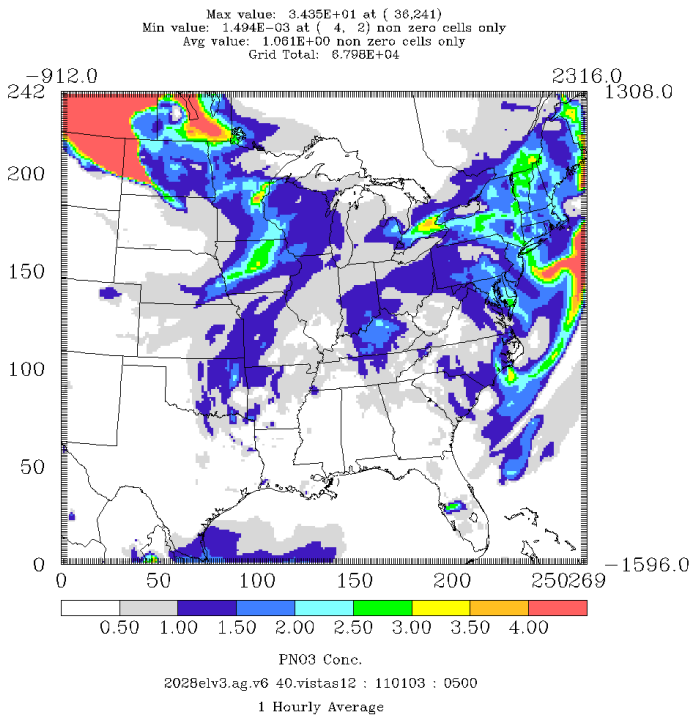


Figure 4-65: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: January 3 at 500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

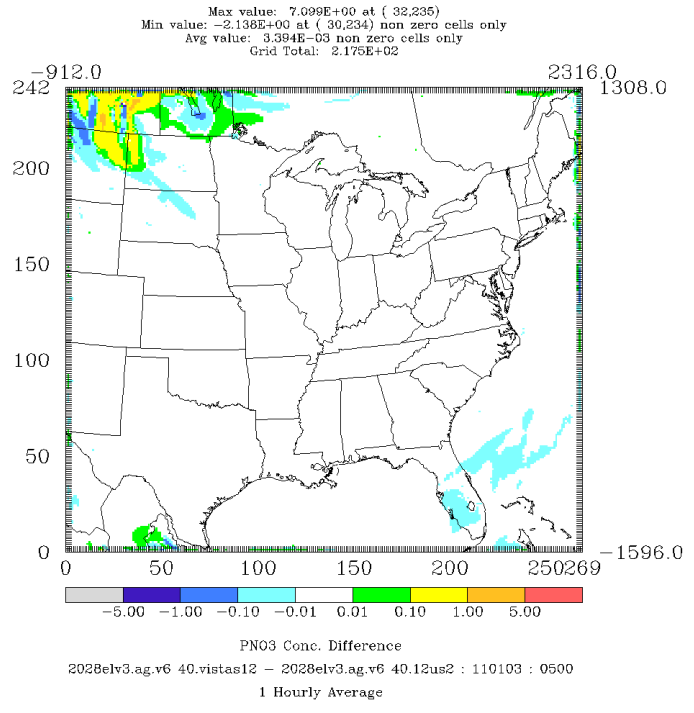
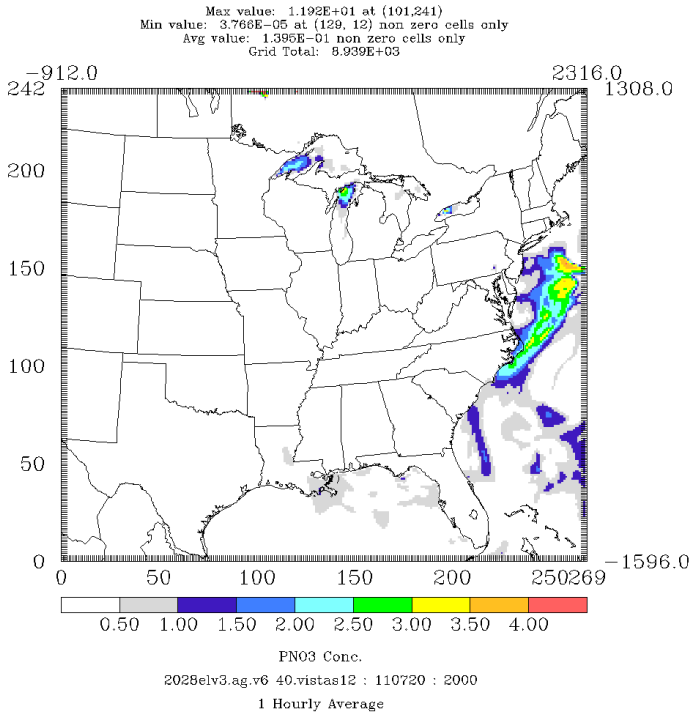


Figure 4-66: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: July 20 at 2000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

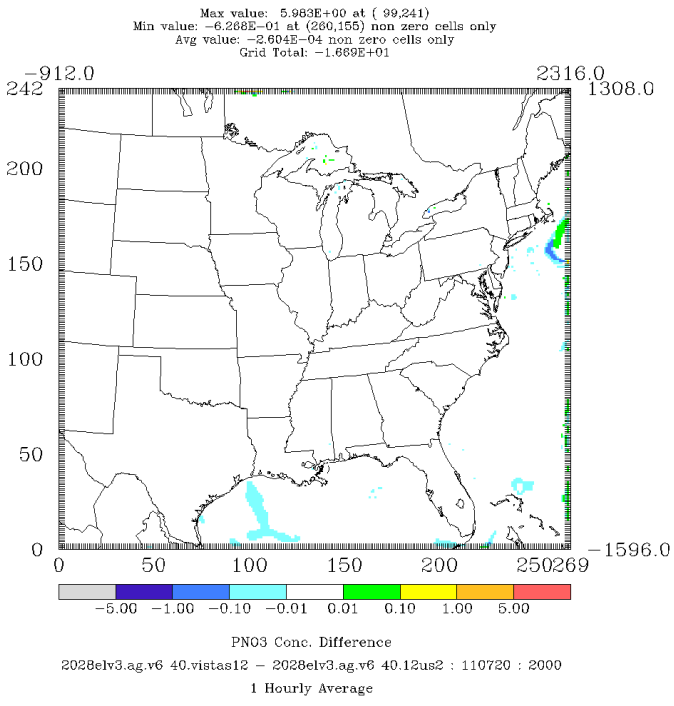
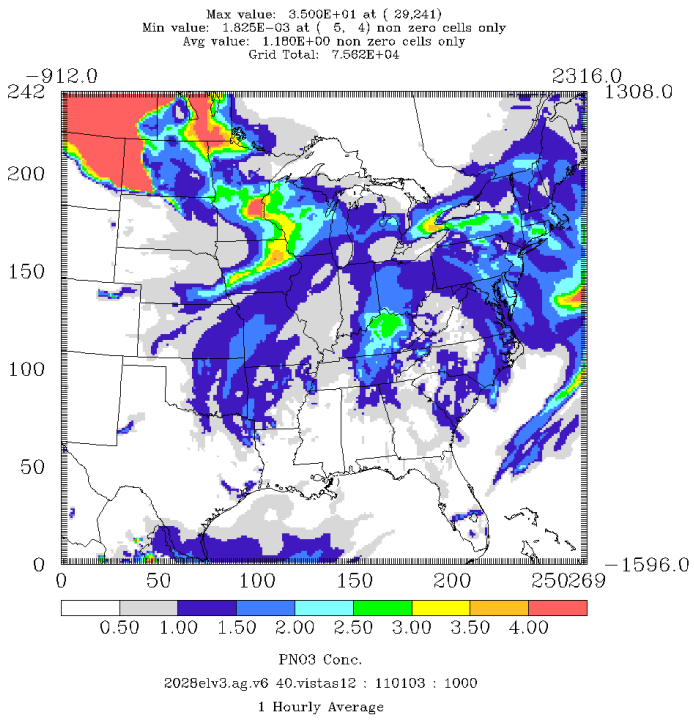


Figure 4-67: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: January 3 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

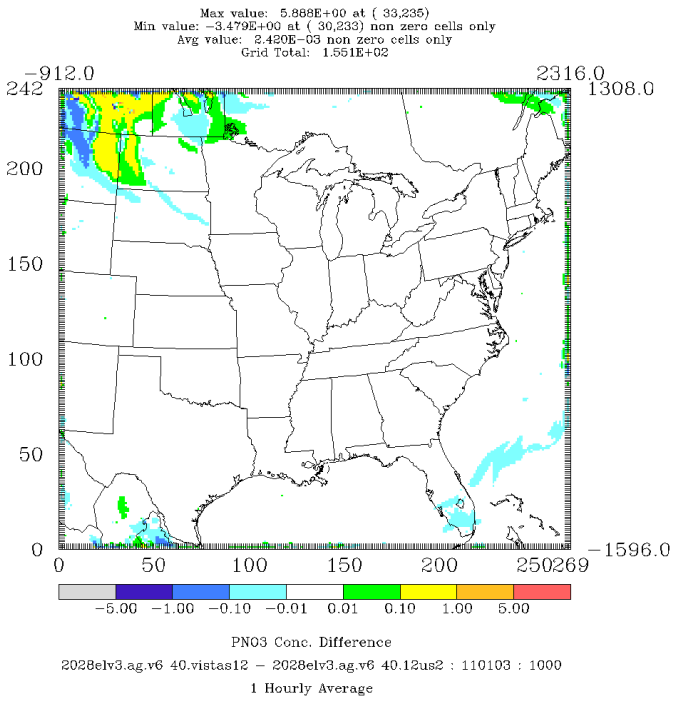
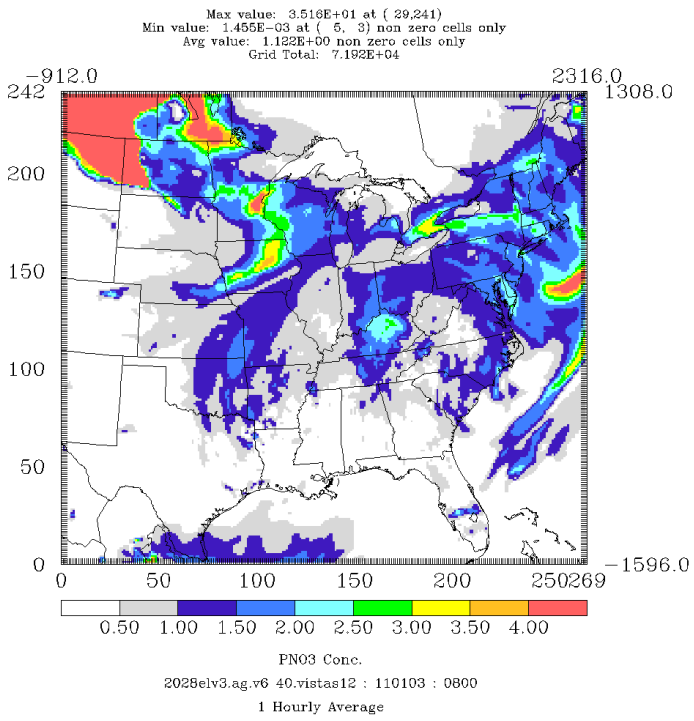


Figure 4-68: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: January 3 at 800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

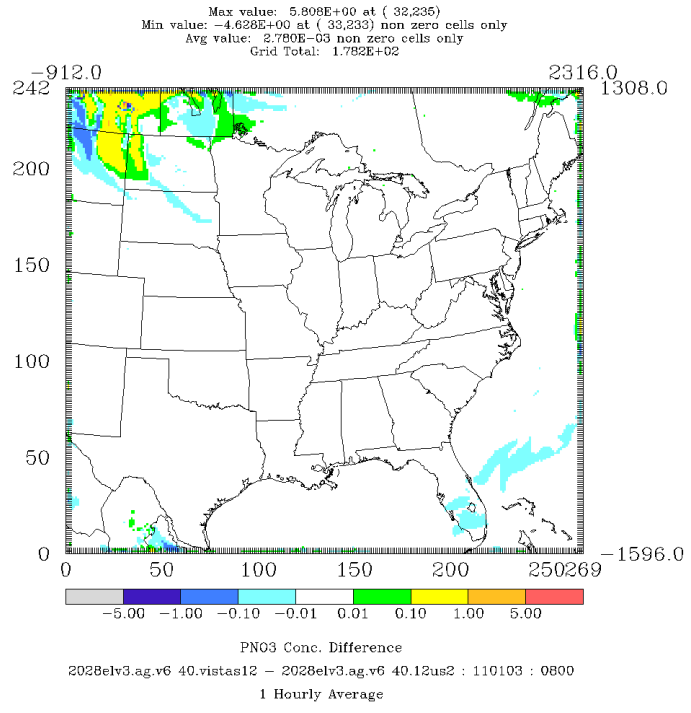
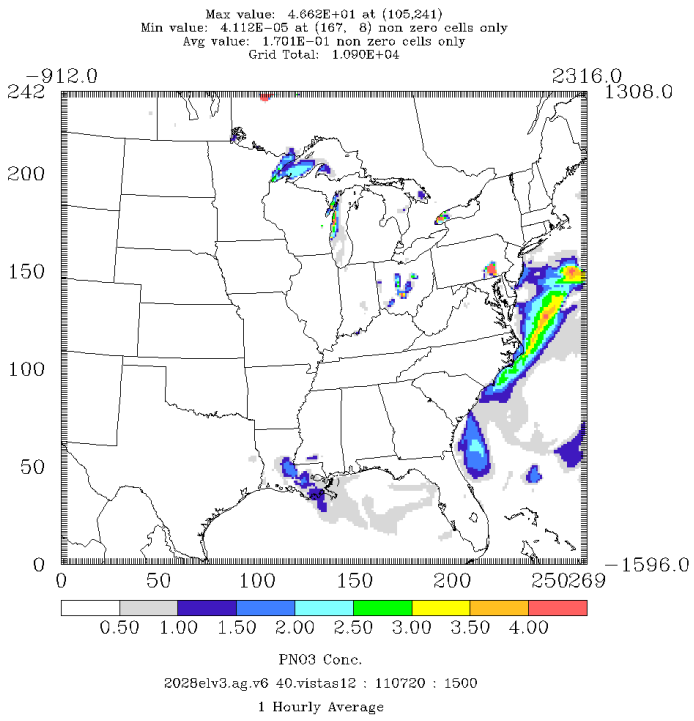


Figure 4-69: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

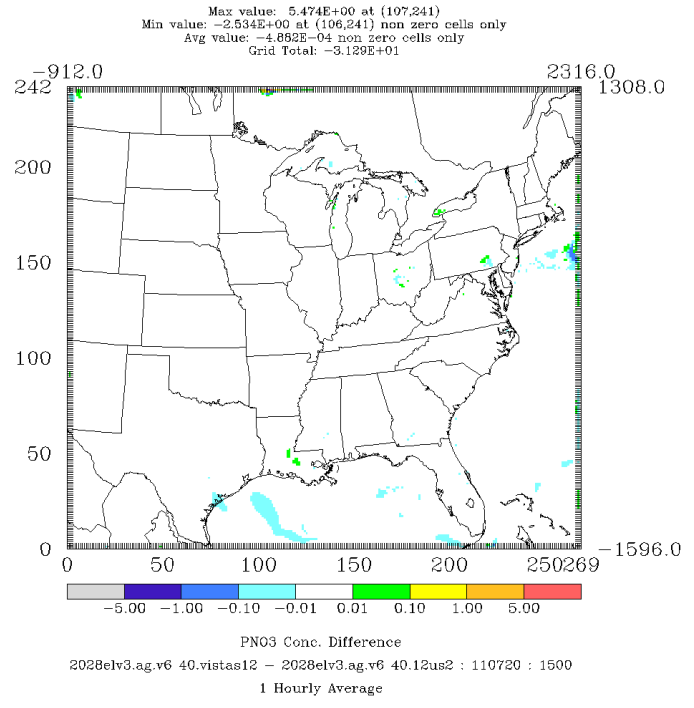
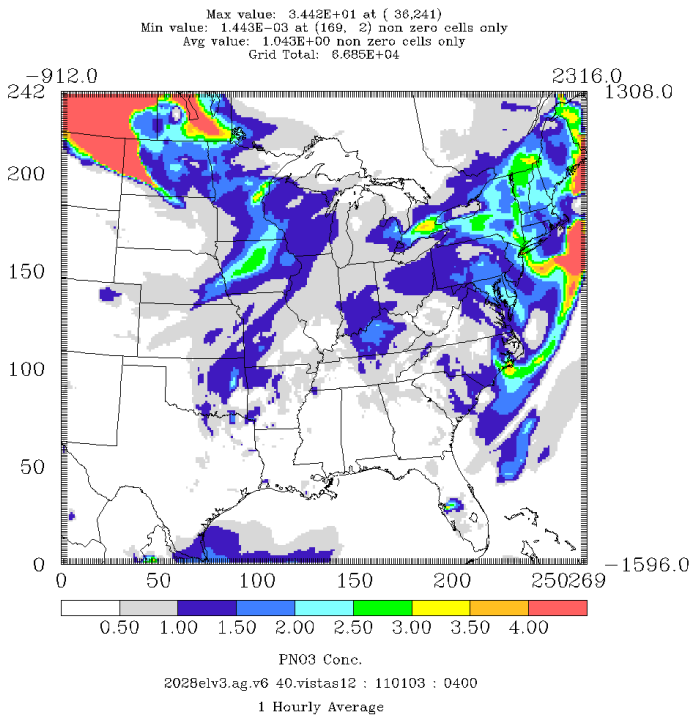


Figure 4-70: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: January 3 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

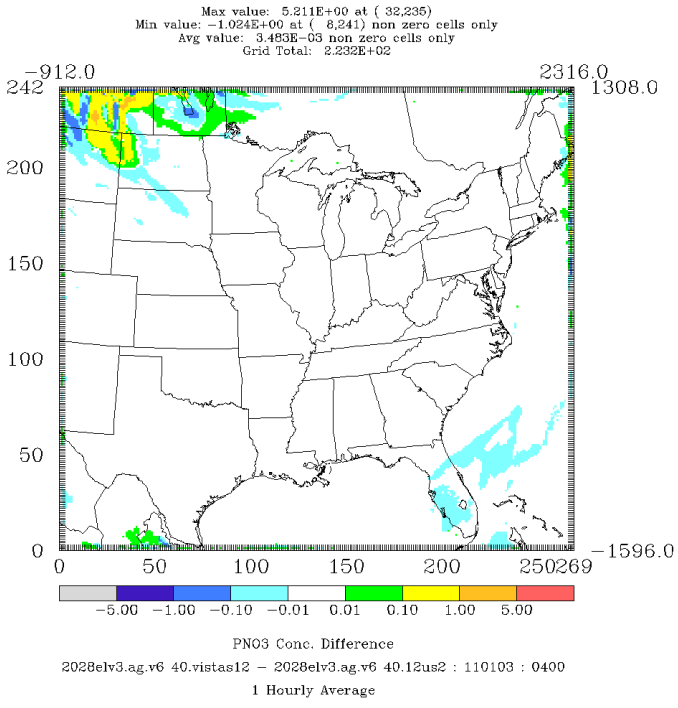
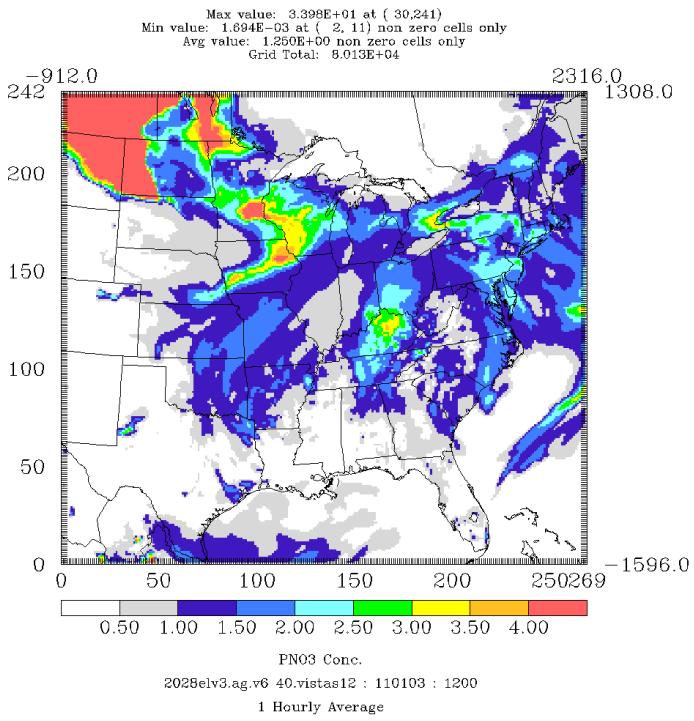


Figure 4-71: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: January 3 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

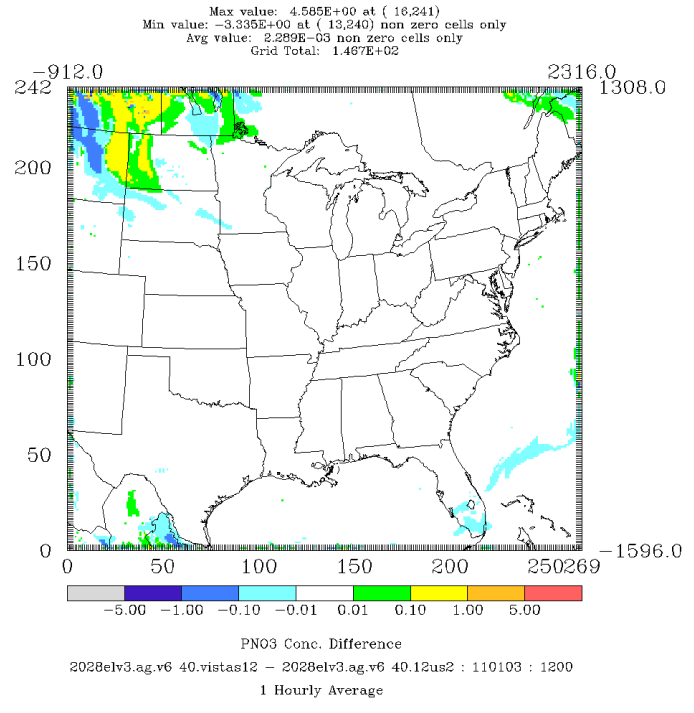
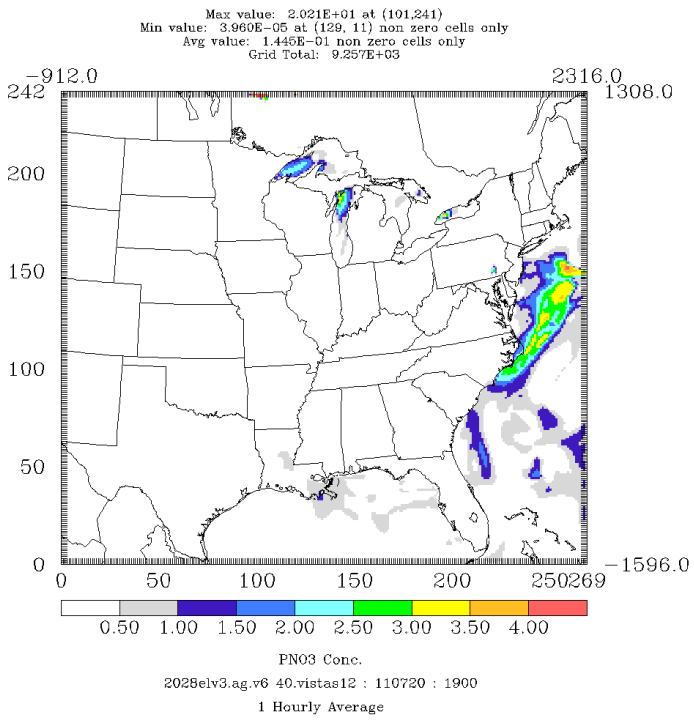


Figure 4-72: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 1900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

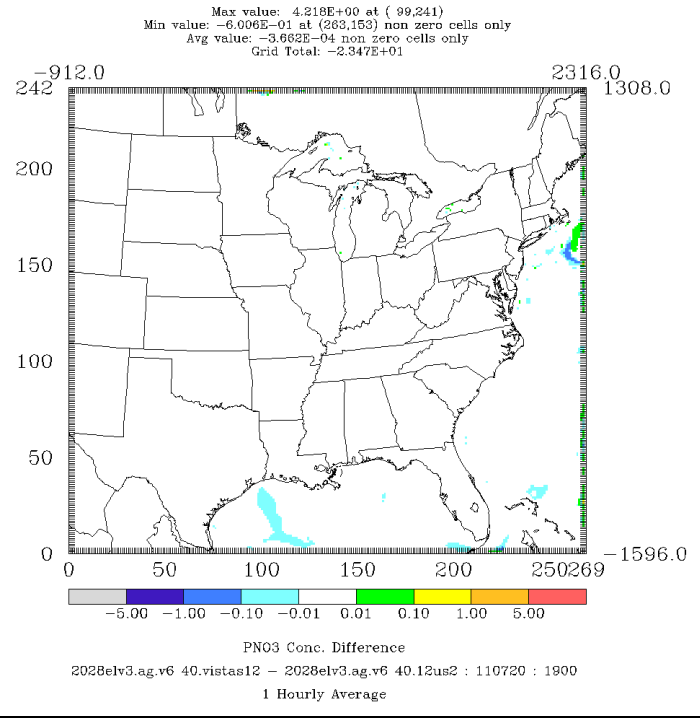
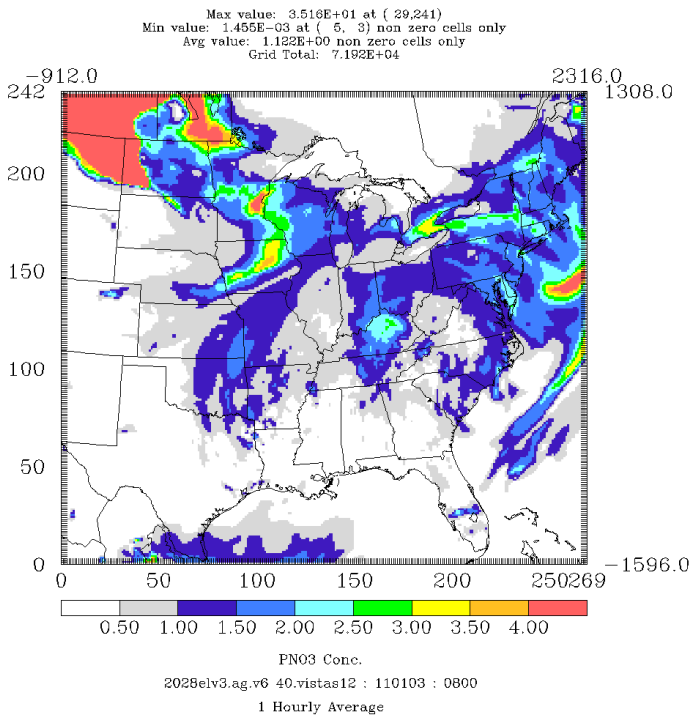


Figure 4-73: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: January 3 at 800 hours

VISTAS12



Difference (VISTAS12 - 12US2)

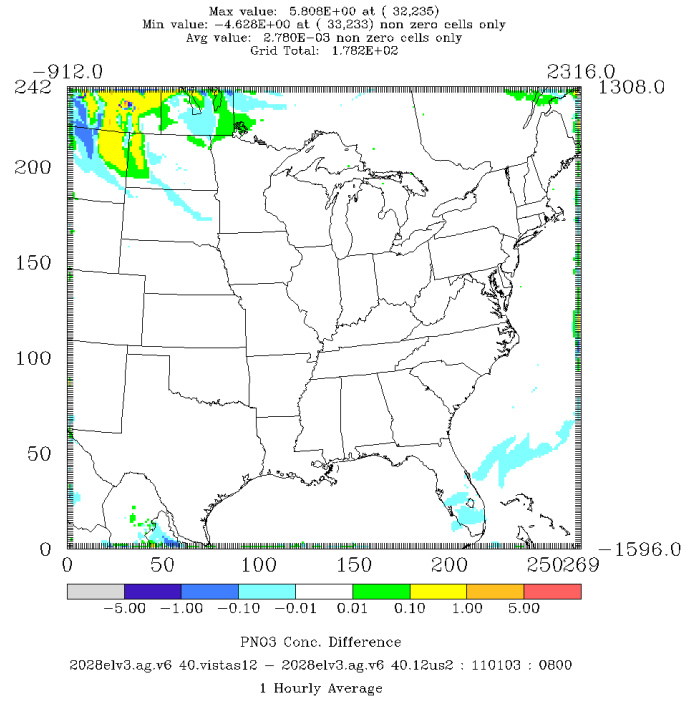
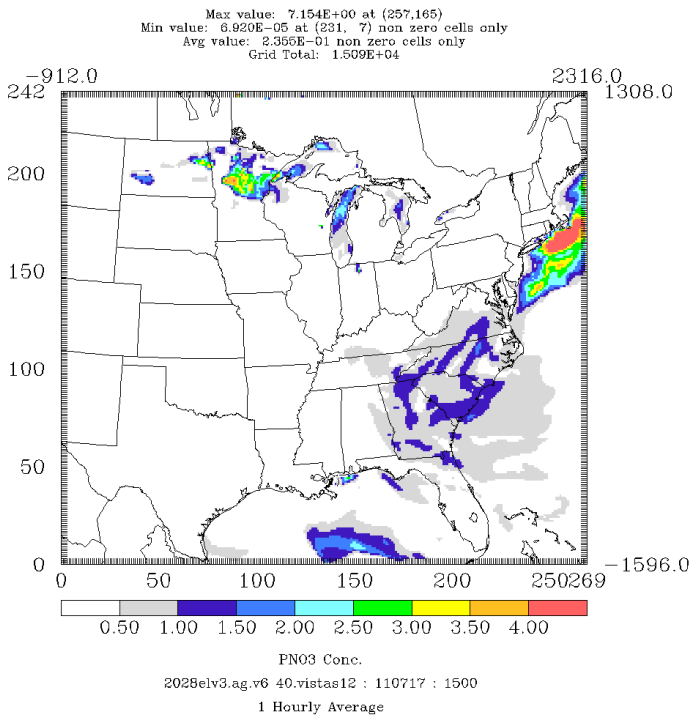


Figure 4-74: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 17 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

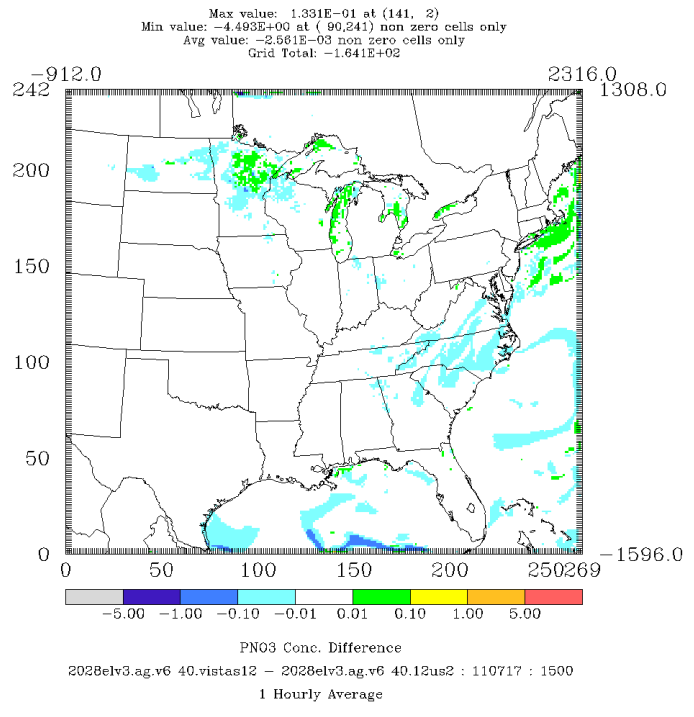
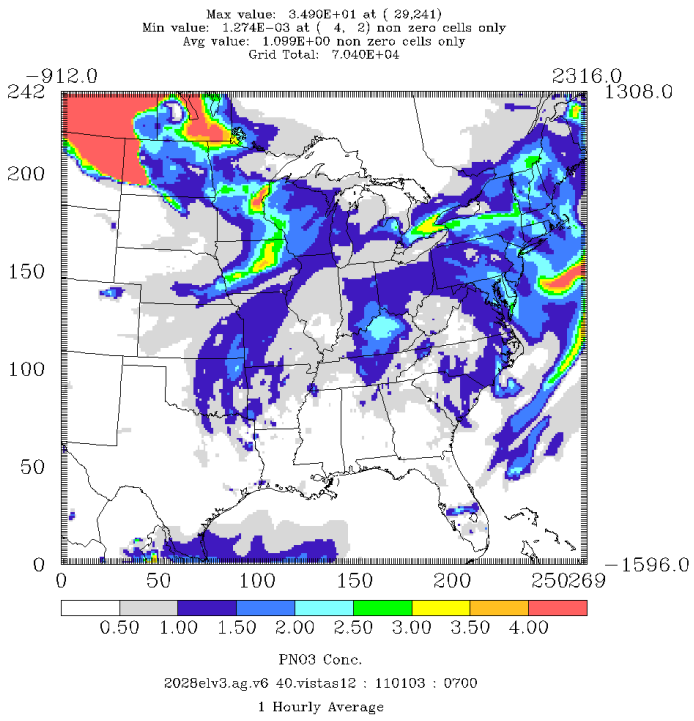


Figure 4-75: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: January 3 at 700 hours

VISTAS12



Difference (VISTAS12 - 12US2)

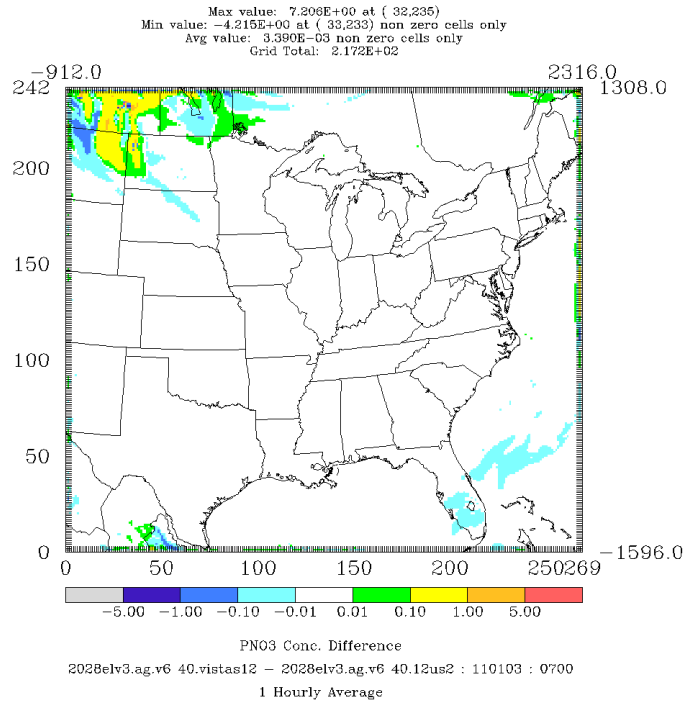
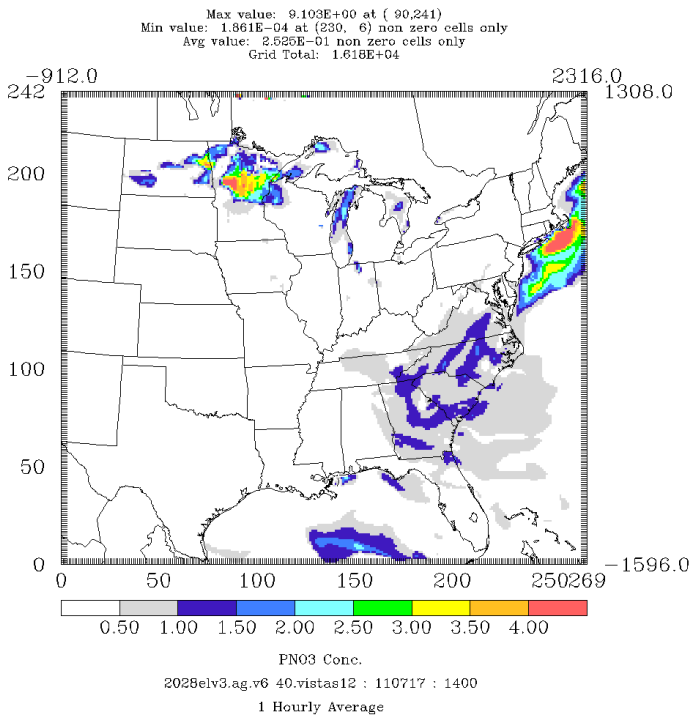


Figure 4-76: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 17 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

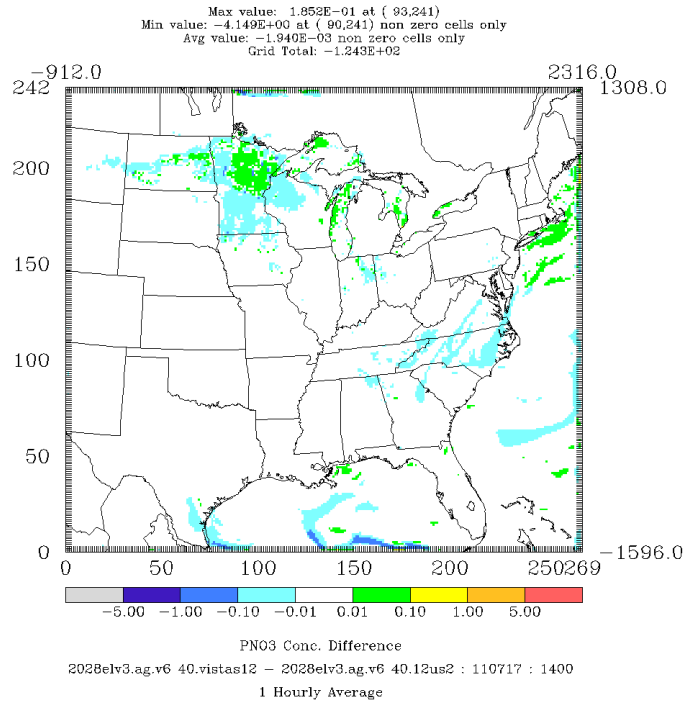
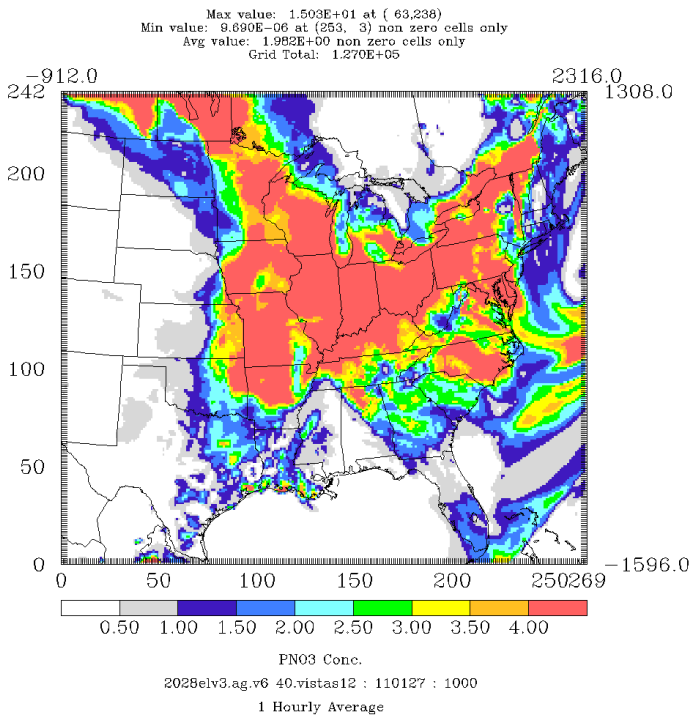


Figure 4-77: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: January 27 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

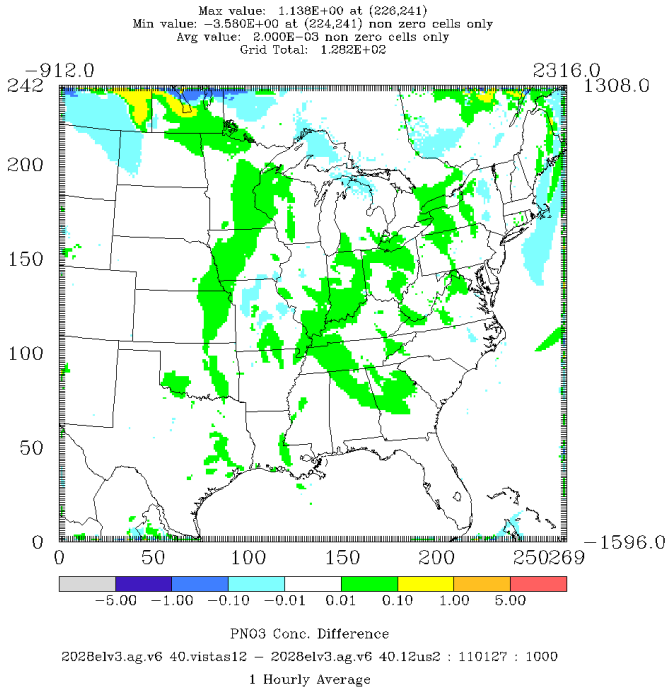
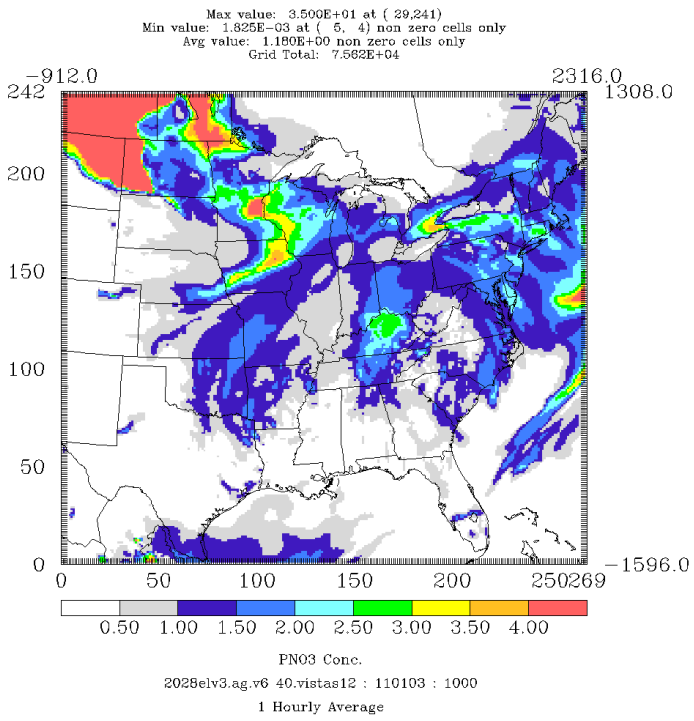


Figure 4-78: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: January 3 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

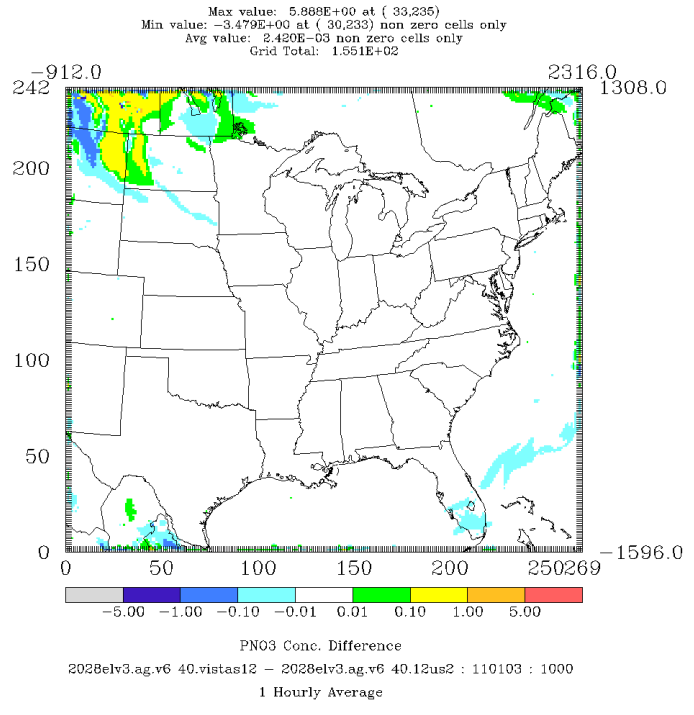
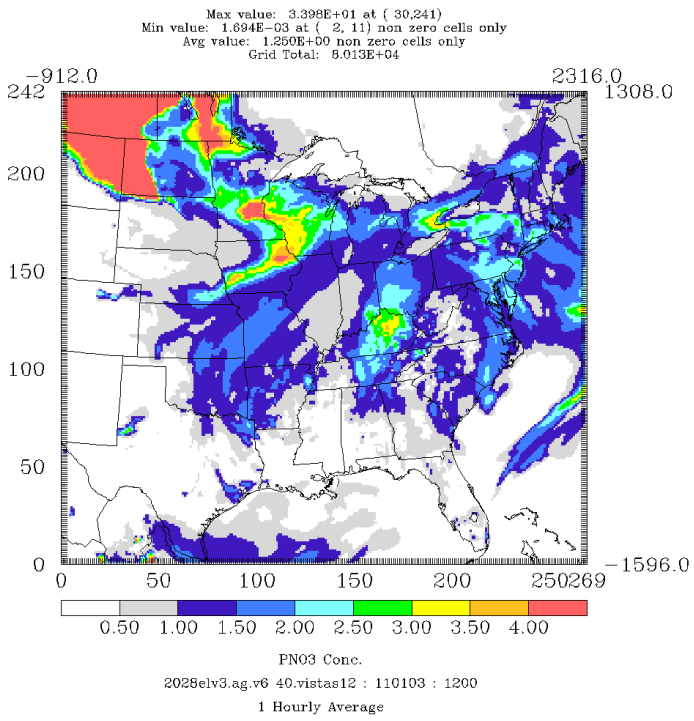


Figure 4-79: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: January 3 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

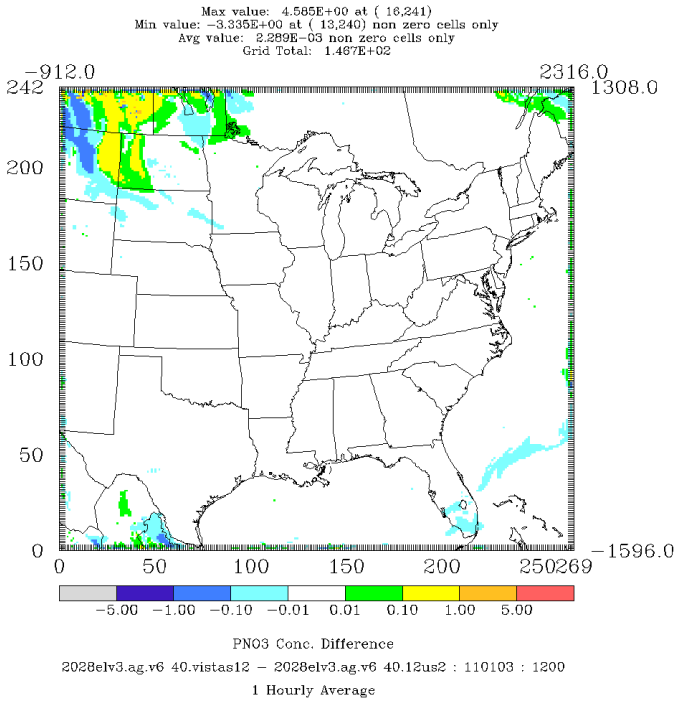
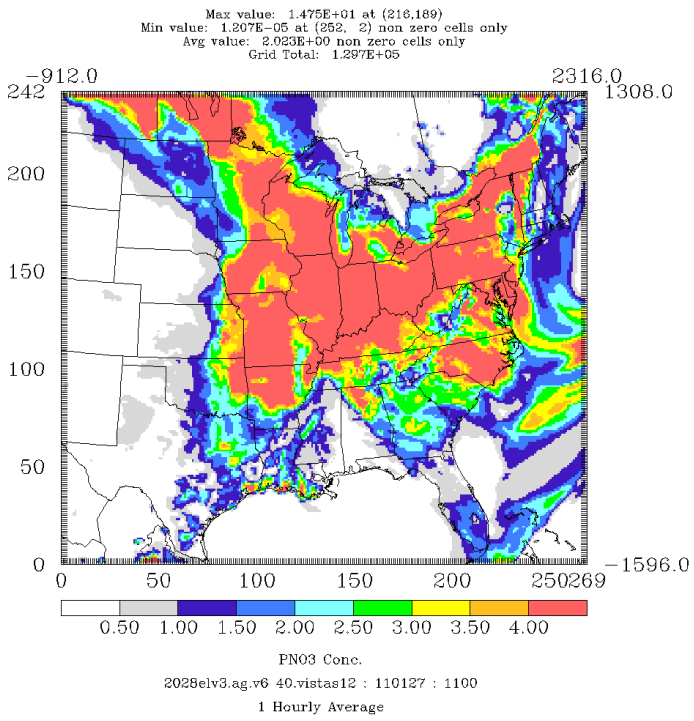


Figure 4-80: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: January 27 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

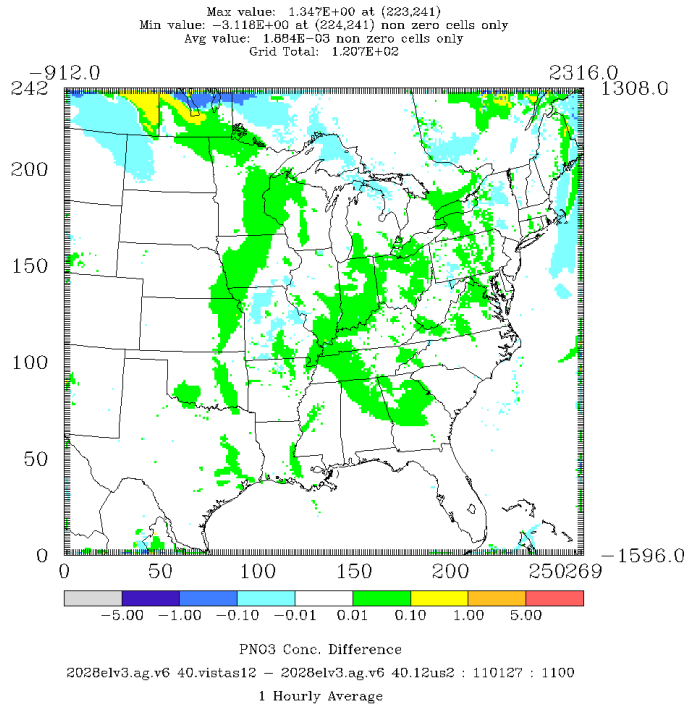
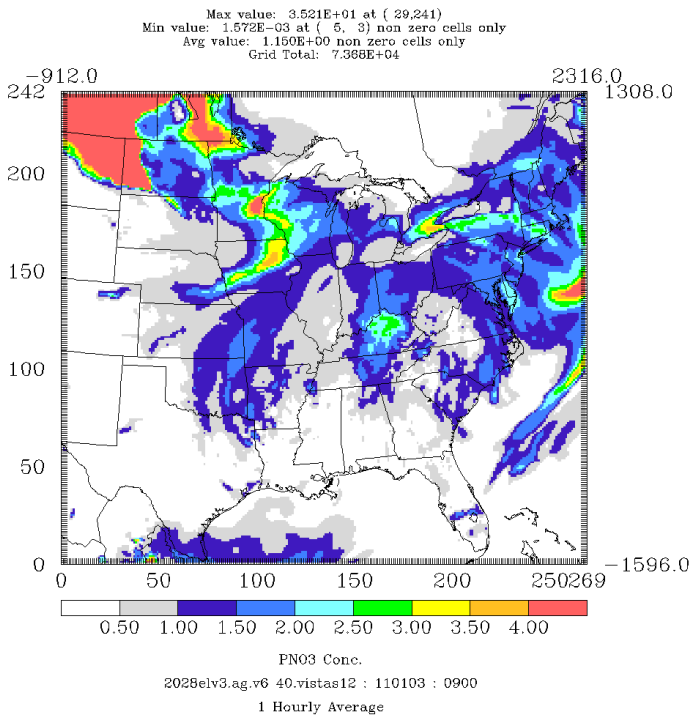


Figure 4-81: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: January 3 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

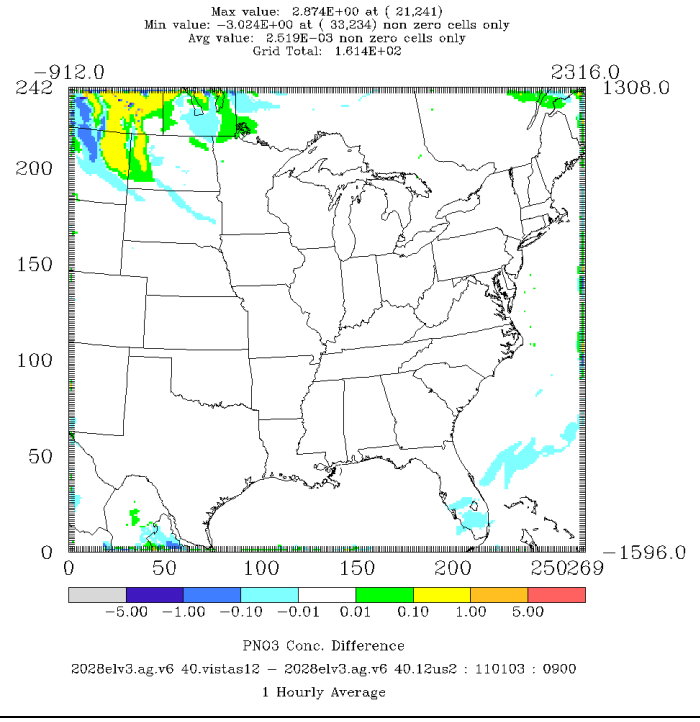
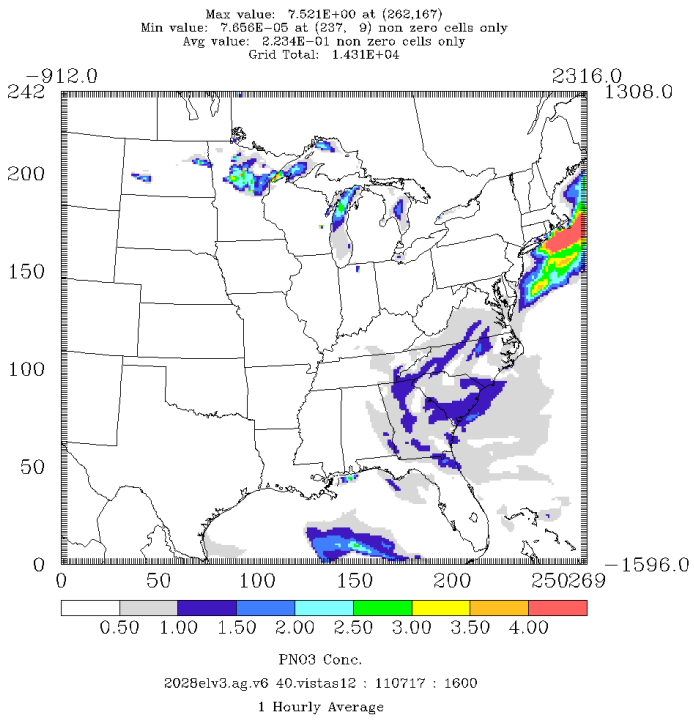


Figure 4-82: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 17 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

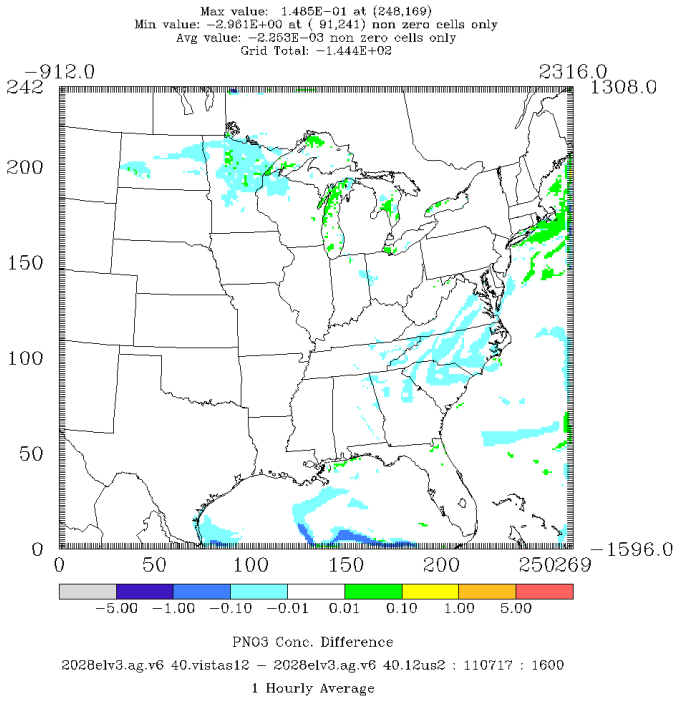


Figure 4-83: Comparison of Nitrate Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference)

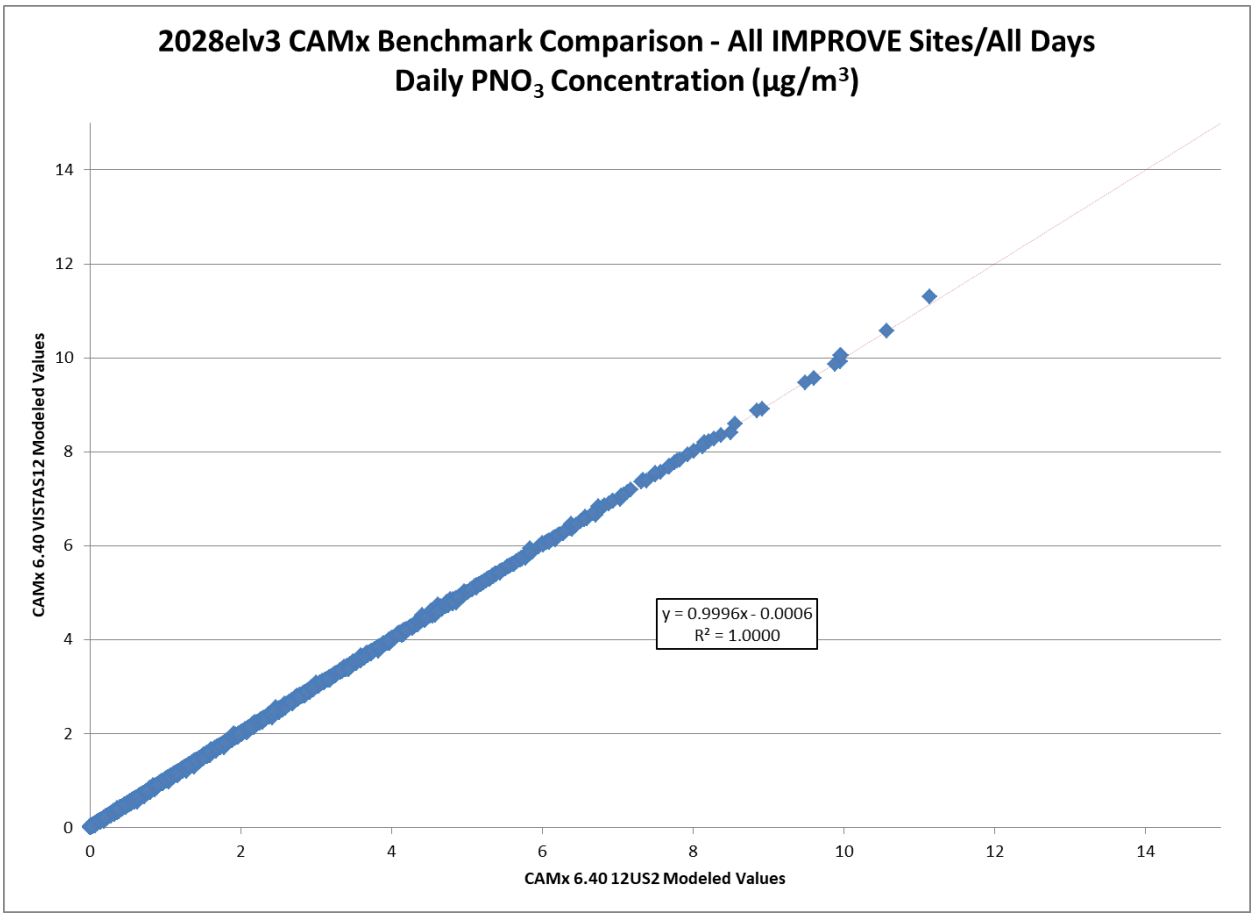


Figure 4-84: Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by VISTAS (Alpine).

4.5 Organic Matter (OM)

Organic Matter (OM) results for the top 10 positive and negative hours are presented in tabular format in Table 4-5. The maximum positive difference is 296.00 μg/m^3 falling to 161.83 μg/m^3 for the 10th high. The maximum negative difference is -228.07 μg/m^3 falling to -134.62 μg/m^3 for the 10th high. The maximum positive percent difference from these days is 97.4% and negative percent difference of -33.7%.

As expected, the maximum impacts on the top 10 positive and negative hours are occurring very near the border. As was described in Section 2, the two CAMx simulations used the same input data, except that the pollutant concentrations on in-flow boundary cells. For the simulation on the VISTAS12 domain the in-flow concentrations are specified in hourly boundary conditions extracted from the 12US2 simulation. For the 12US2 simulation the in-flow concentrations were continuously updated from the cells outside the VISTAS12 domain. It would be expected that concentration differences would occur from the differences in hourly average concentrations, versus in the instantaneous concentrations.

The top 10 positive difference hours are presented in Figures 4-85 through 4-94 and the top 10 negative impact hours are presented in Tables 4-95 through 4-104. As with sulfate, the peak differences are occurring between July 17 and July 20. The area of the peak impact is very near the northern border, north of Minnesota. This is an area where CAMx simulations are showing very high OC concentrations in an area heavily influenced by boundary conditions.

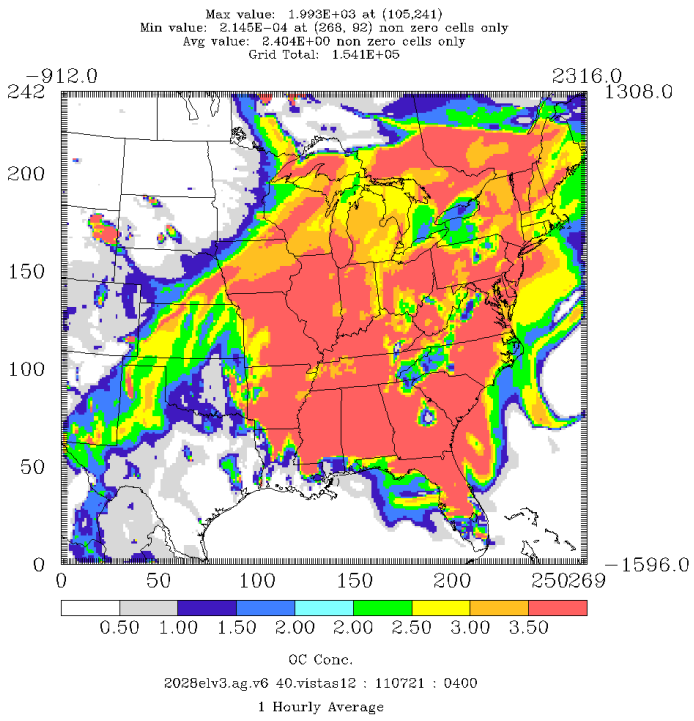
Scatterplots of the daily average OM concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-105. The 12US2 results are plotted on the x-axis and the VISTAS12 results are plotted on the y-axis. The data has a high degree of correlation with a line of best fit with a slope of 1.0004, an intercept of 0.0017 μg/m^3 and an R^2 of 1.0000.

Table 4-5. Comparison of 2028elv3 CAMx 6.40 VISTAS12 and 12US2 Simulation of Organic Matter Concentrations (µg/m^3). Hours with the top 10 maximum positive and maximum negative differences are shown.

Year	Month	Day	Hour	VISTAS12 Conc.	12US2 Conc.	Difference (µg/m^3)	Percent Difference	Column	Row
Maximum Positive									
2011	7	21	4	735.71	439.71	296.00	67.3%	104	241
2011	7	20	14	1262.44	1025.84	236.60	23.1%	107	241
2011	7	20	15	633.93	422.81	211.12	49.9%	107	241
2011	7	20	11	2118.91	1910.65	208.27	10.9%	107	241
2011	7	21	3	2457.80	2255.25	202.56	9.0%	104	241
2011	7	21	1	1835.92	1635.03	200.90	12.3%	104	241
2011	7	20	12	2332.91	2150.04	182.88	8.5%	107	241
2011	7	20	23	352.04	178.32	173.73	97.4%	102	241
2011	7	21	0	568.80	396.74	172.07	43.4%	103	241
2011	7	20	9	5412.29	5250.46	161.83	3.1%	105	241
Maximum Negative									
2011	7	20	15	3744.14	3972.21	-228.07	-5.7%	105	241
2011	7	20	16	3083.95	3285.59	-201.64	-6.1%	105	241
2011	7	20	14	3985.64	4186.45	-200.81	-4.8%	106	241
2011	7	17	11	396.17	591.55	-195.38	-33.0%	89	241
2011	7	20	13	4751.92	4939.42	-187.49	-3.8%	106	241
2011	7	17	12	386.67	562.26	-175.59	-31.2%	89	241
2011	7	20	12	5973.55	6146.67	-173.11	-2.8%	106	241
2011	7	19	10	634.35	802.35	-168.00	-20.9%	104	241
2011	7	17	10	335.13	501.78	-166.65	-33.2%	89	241
2011	7	17	9	265.14	399.76	-134.62	-33.7%	89	241

Maximum Positive Difference: July 21 at 400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

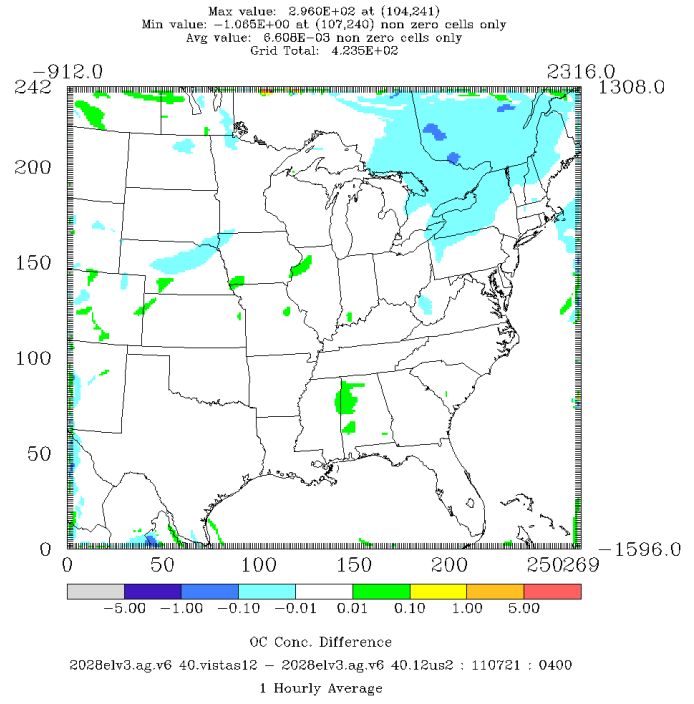
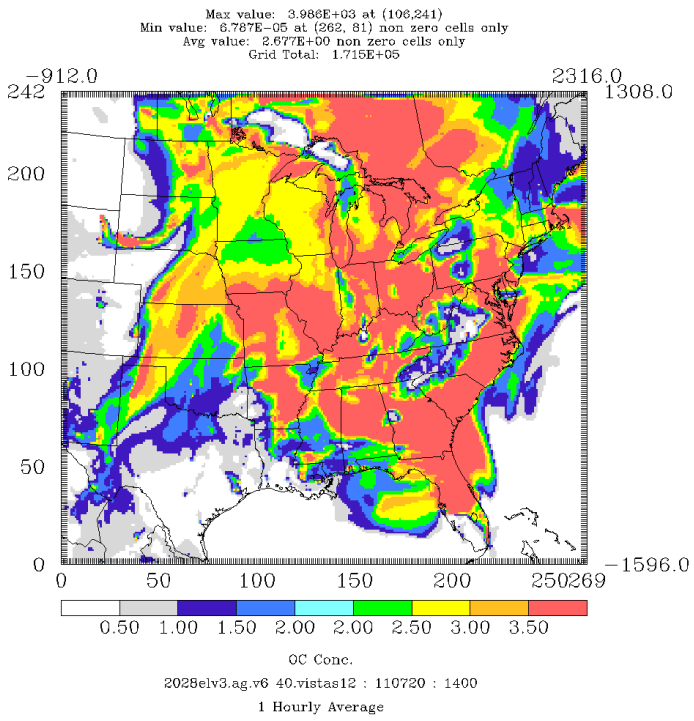


Figure 4-85: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Positive Difference)

Second Highest Positive Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

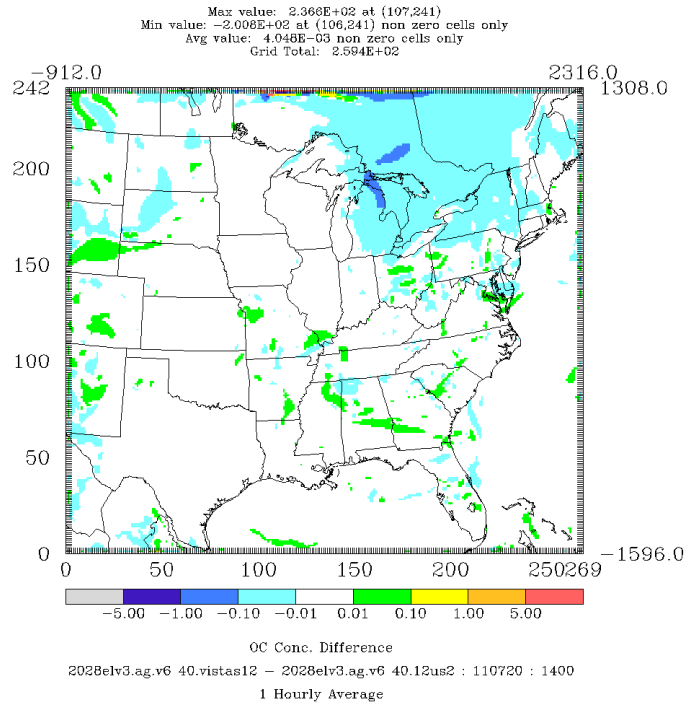
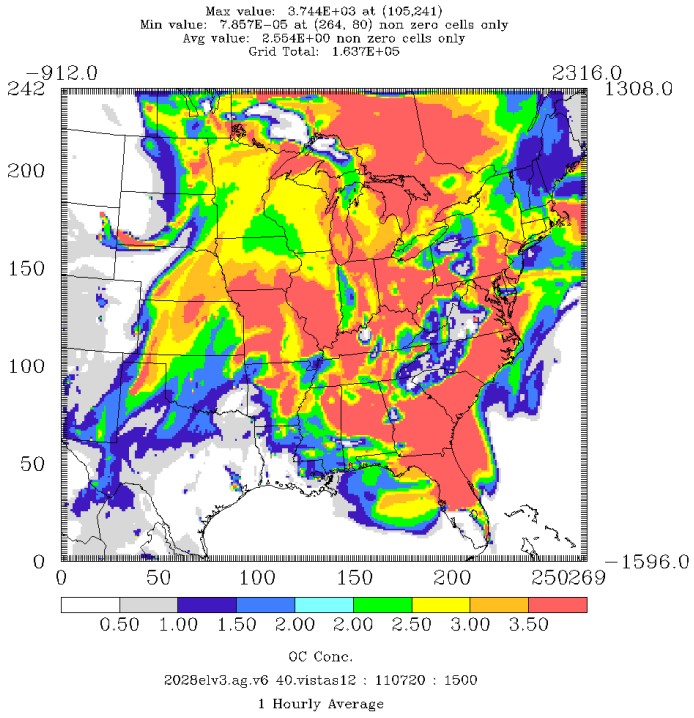


Figure 4-86: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Positive Difference)

Third Highest Positive Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

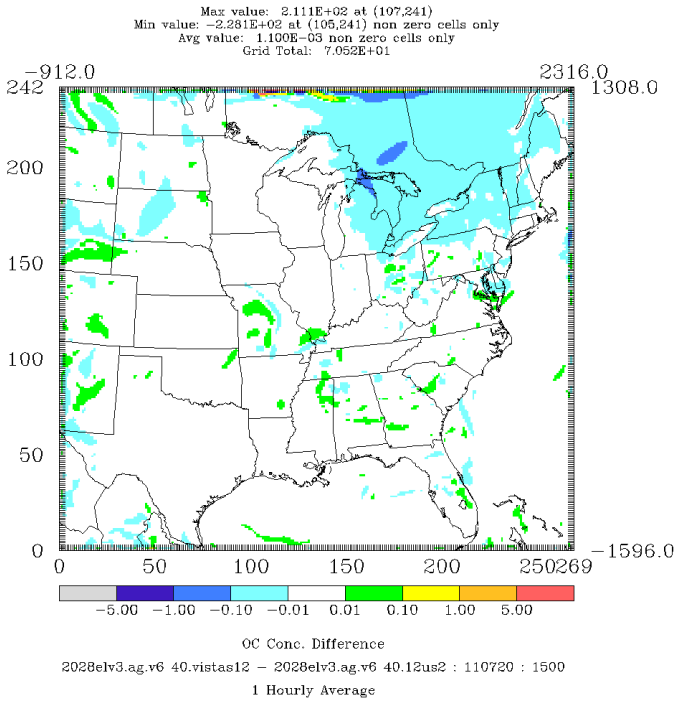
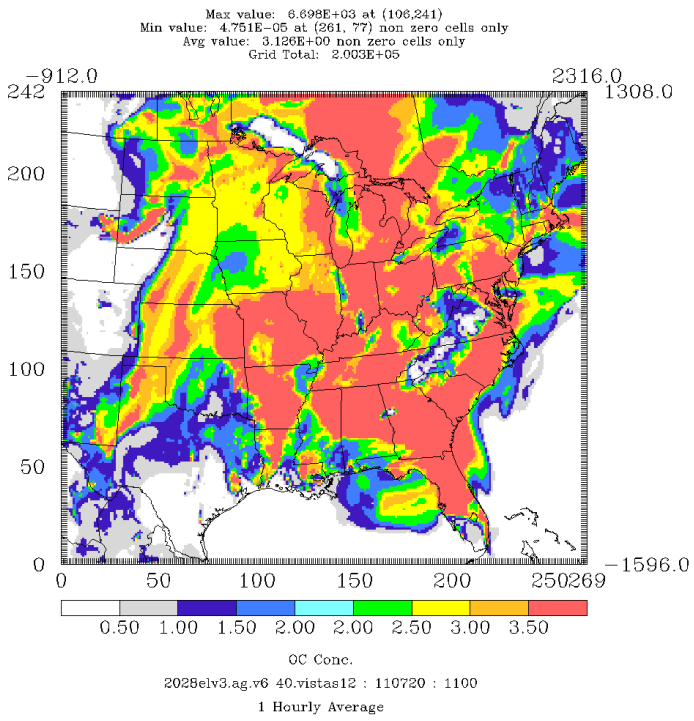


Figure 4-87: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Positive Difference)

Fourth Highest Positive Difference: July 20 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

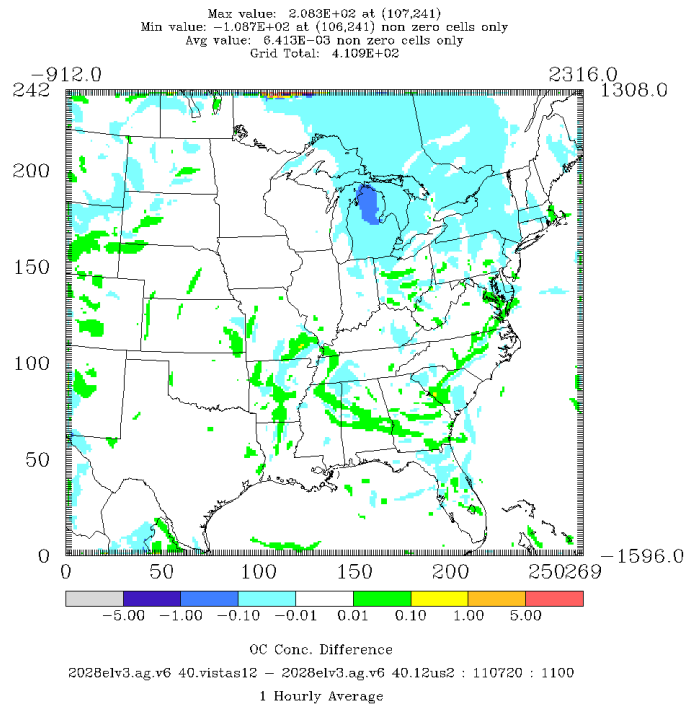
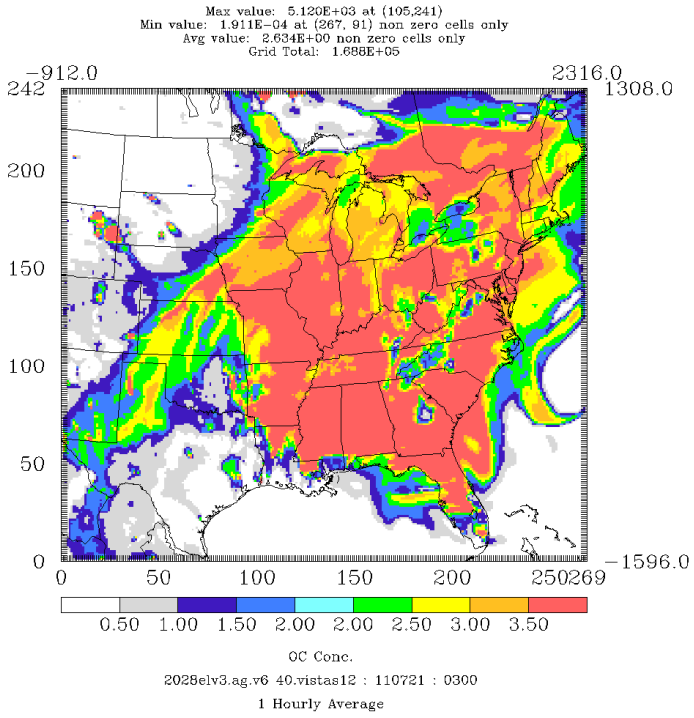


Figure 4-88: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Positive Difference)

Fifth Highest Positive Difference: July 21 at 300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

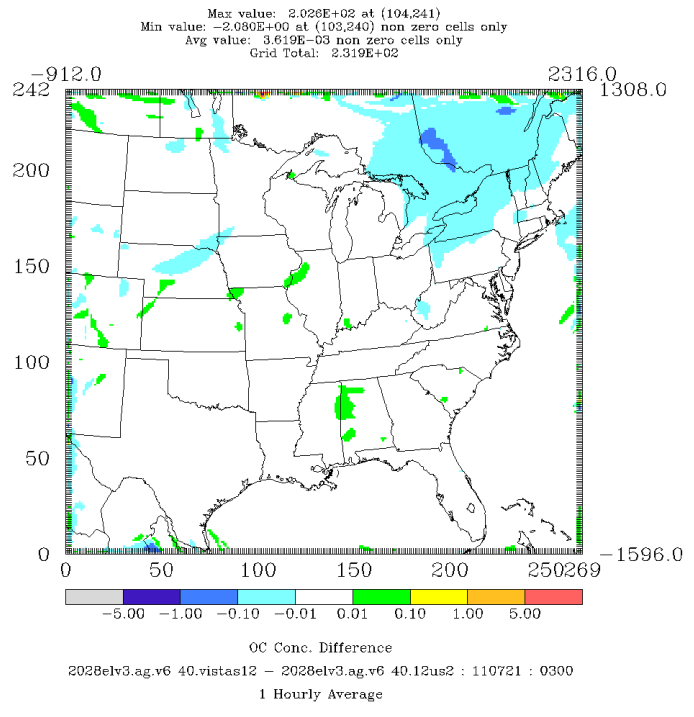
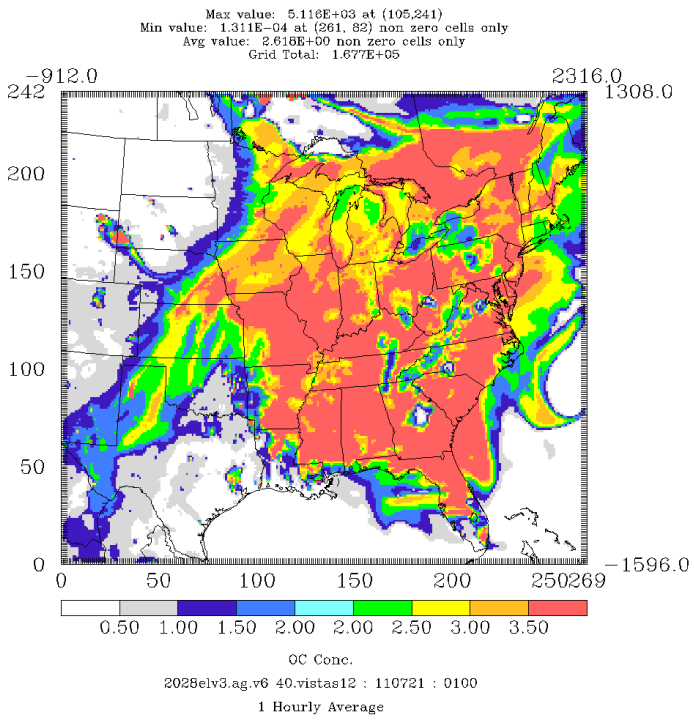


Figure 4-89: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Positive Difference)

Sixth Highest Positive Difference: July 21 at 100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

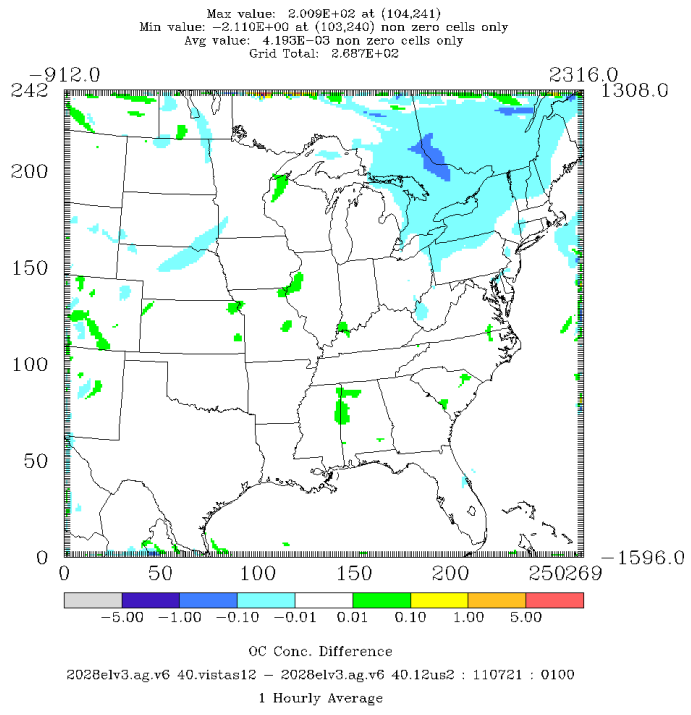
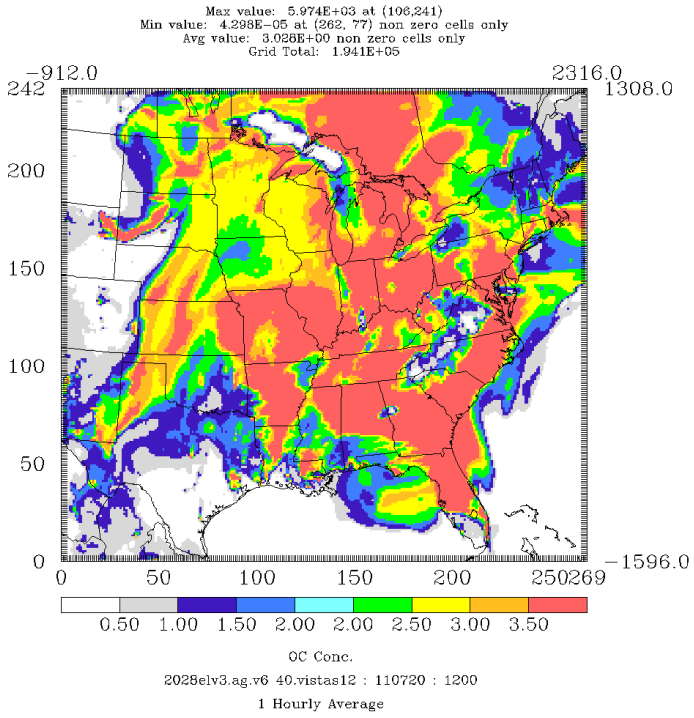


Figure 4-90: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Positive Difference)

Seventh Highest Positive Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

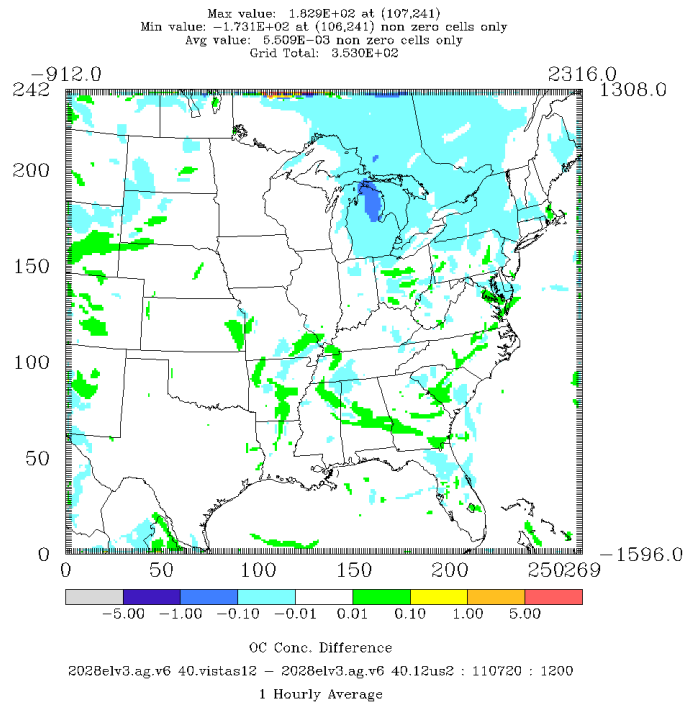
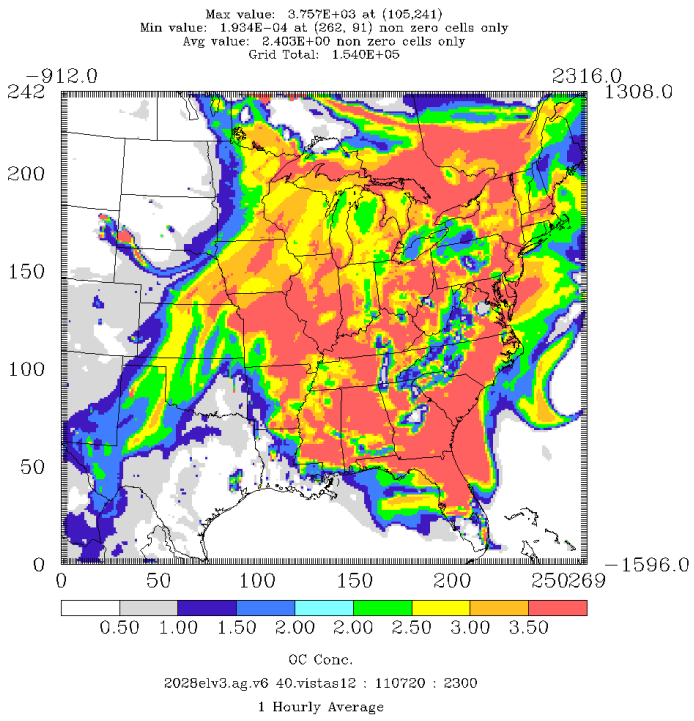


Figure 4-91: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Positive Difference)

Eighth Highest Positive Difference: July 20 at 2300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

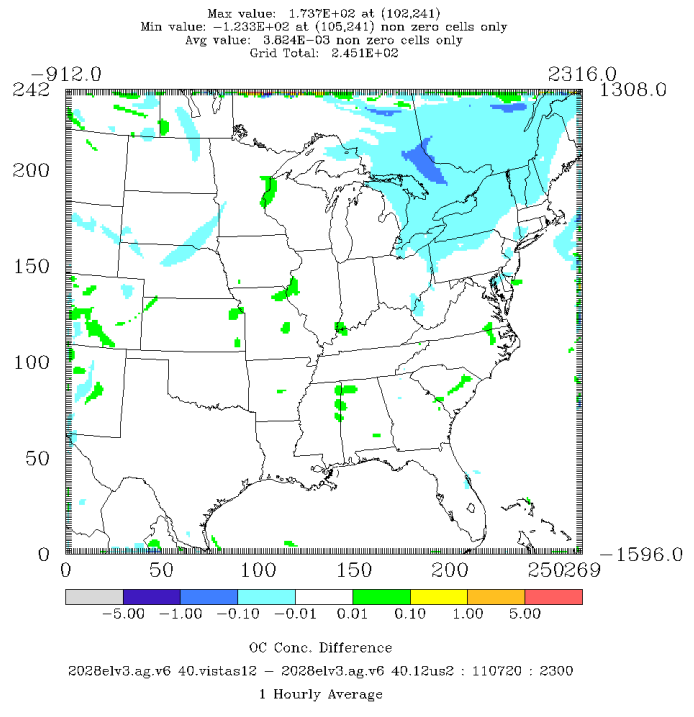
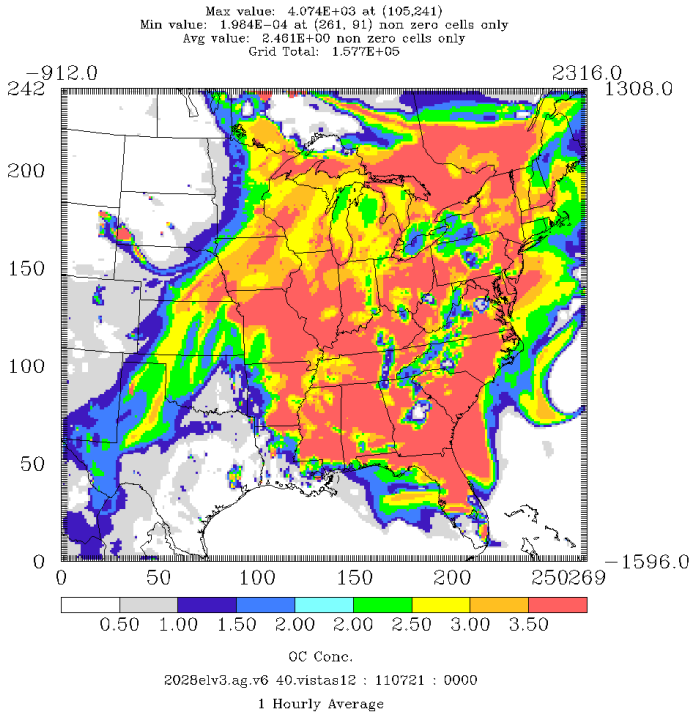


Figure 4-92: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Positive Difference)

Ninth Highest Positive Difference: July 21 at 0000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

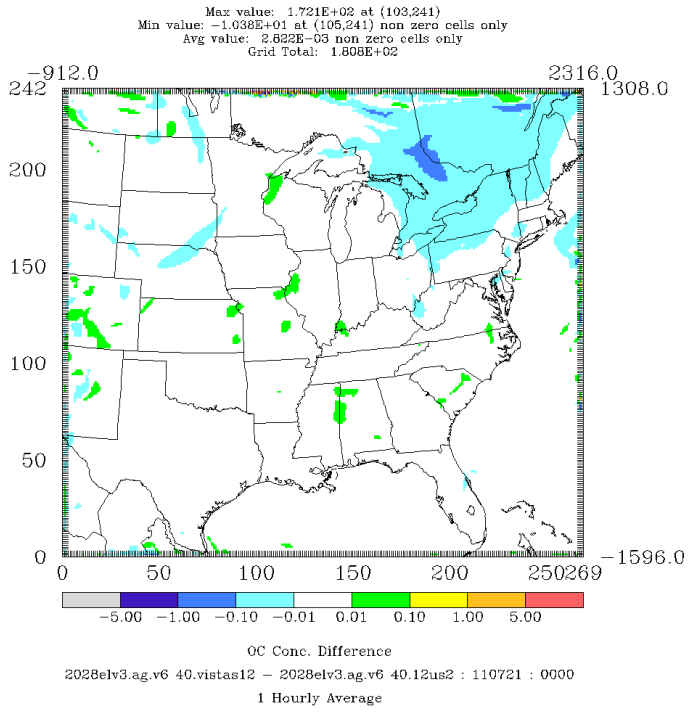
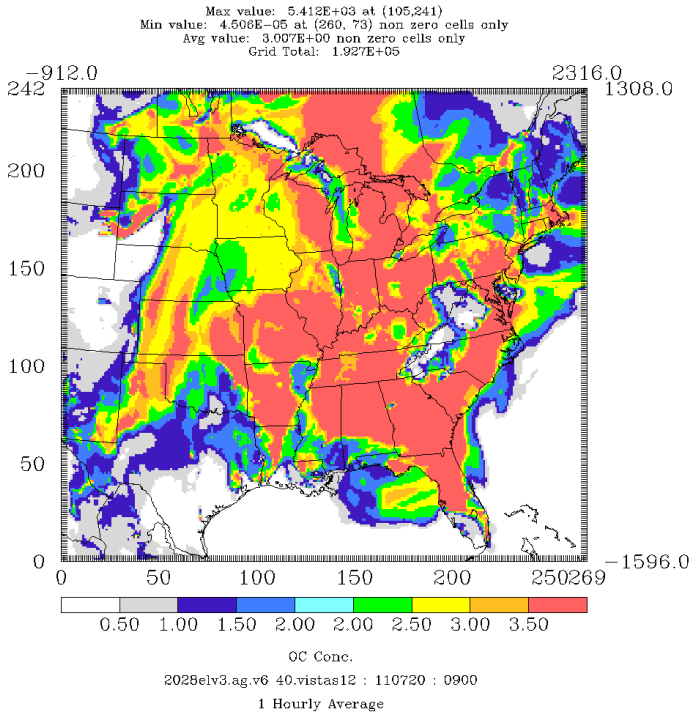


Figure 4-93: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Positive Difference)

Tenth Highest Positive Difference: July 20 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

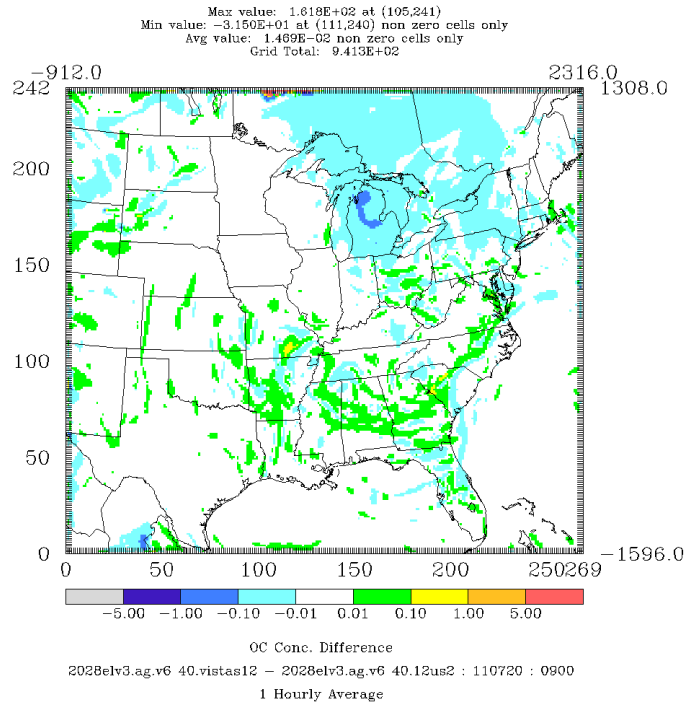
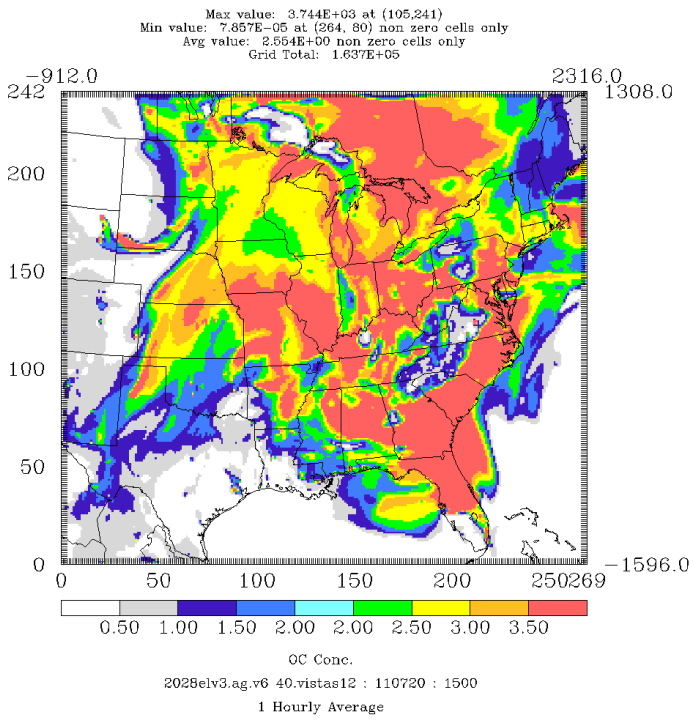


Figure 4-94: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Positive Difference)

Maximum Negative Difference: July 20 at 1500 hours

VISTAS12



Difference (VISTAS12 - 12US2)

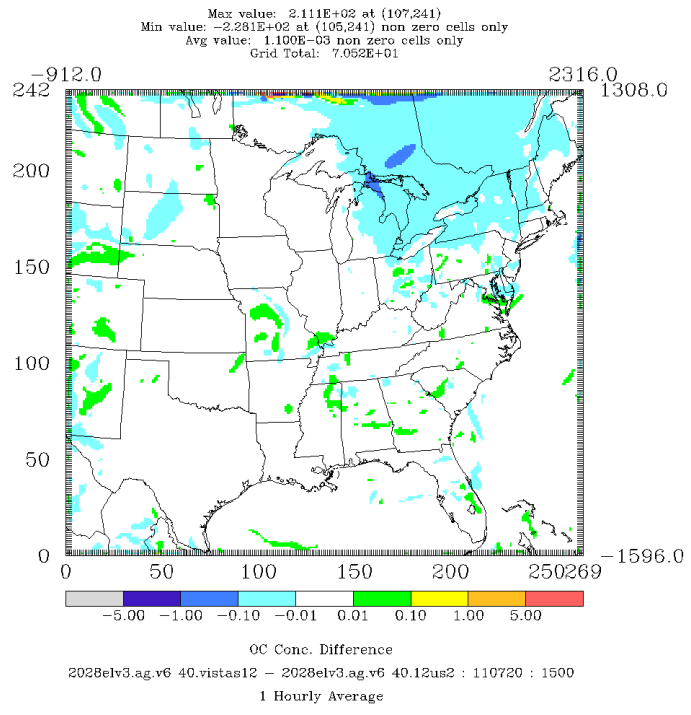
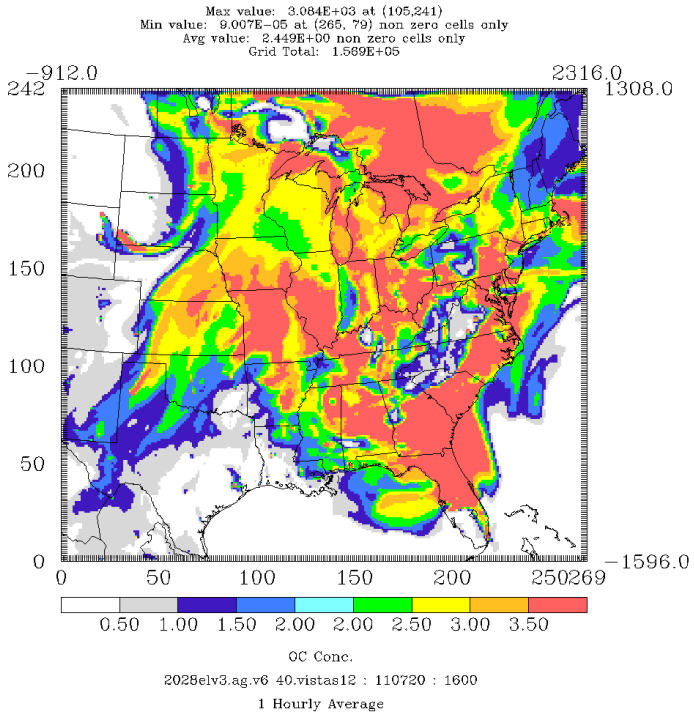


Figure 4-95: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Maximum Negative Difference)

Second Highest Negative Difference: July 20 at 1600 hours

VISTAS12



Difference (VISTAS12 - 12US2)

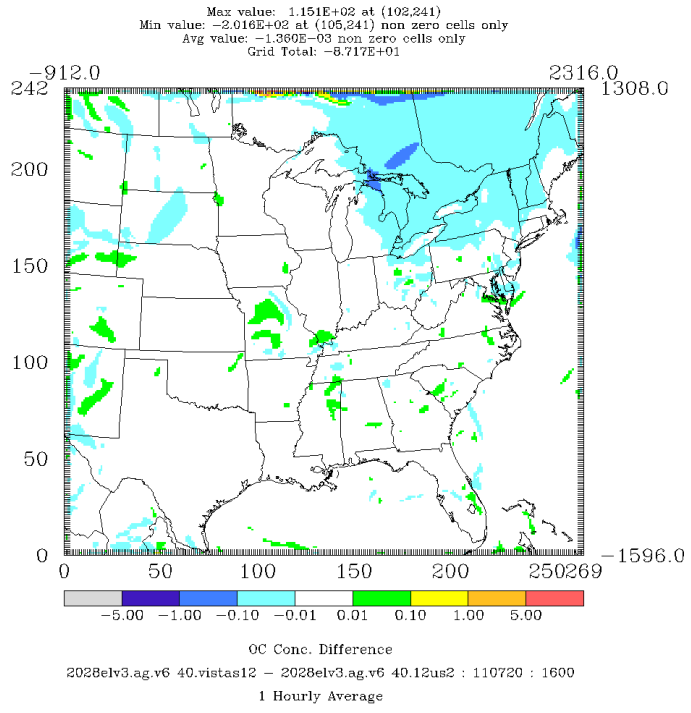
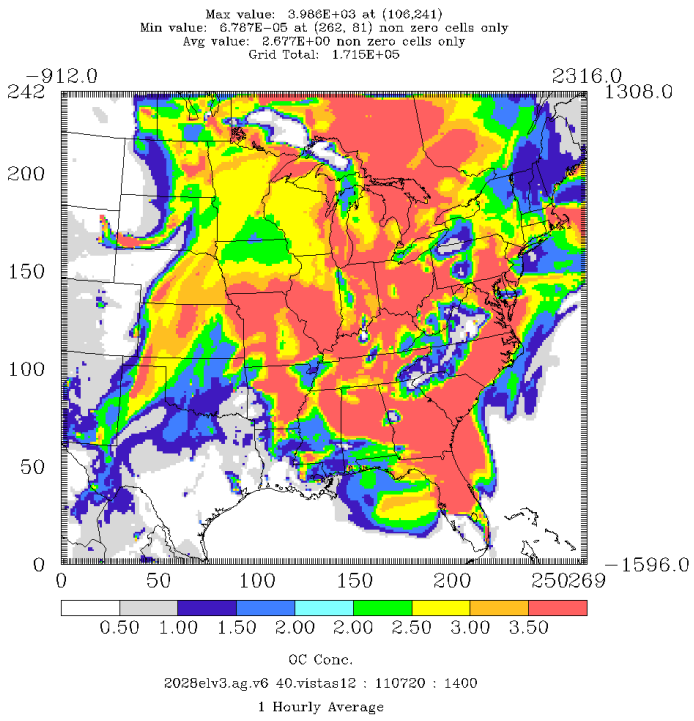


Figure 4-96: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Second Highest Negative Difference)

Third Highest Negative Difference: July 20 at 1400 hours

VISTAS12



Difference (VISTAS12 - 12US2)

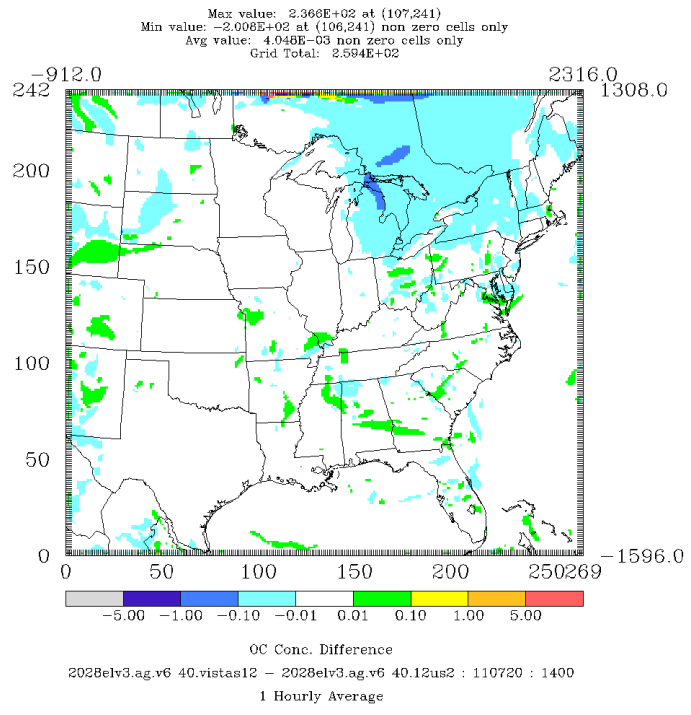
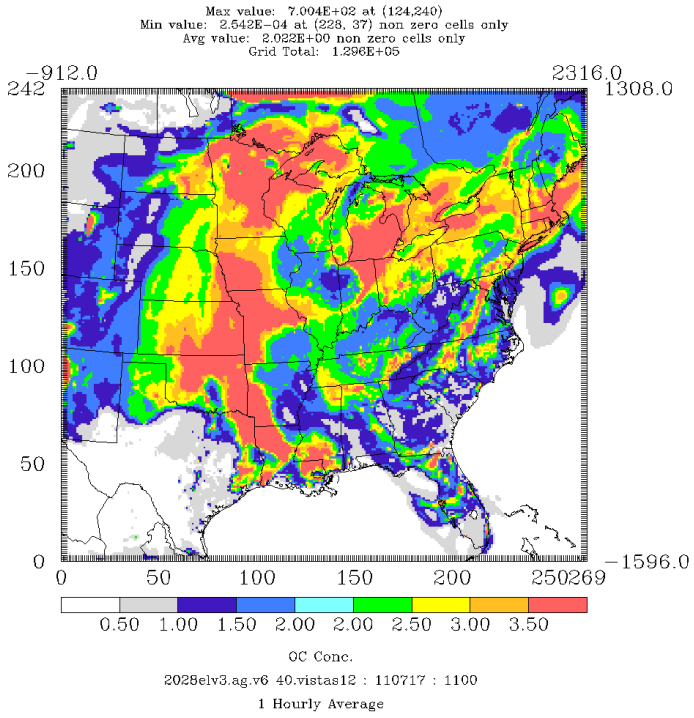


Figure 4-97: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Third Highest Negative Difference)

Fourth Highest Negative Difference: July 17 at 1100 hours

VISTAS12



Difference (VISTAS12 - 12US2)

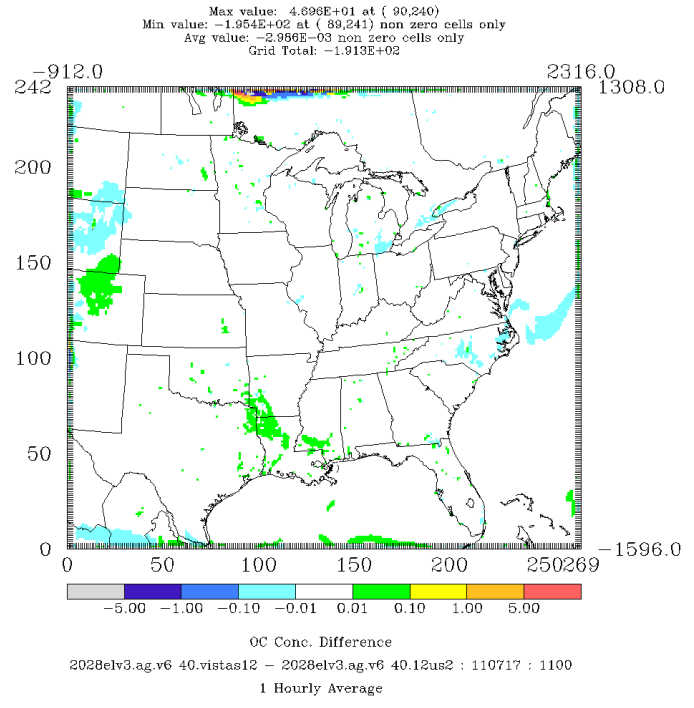
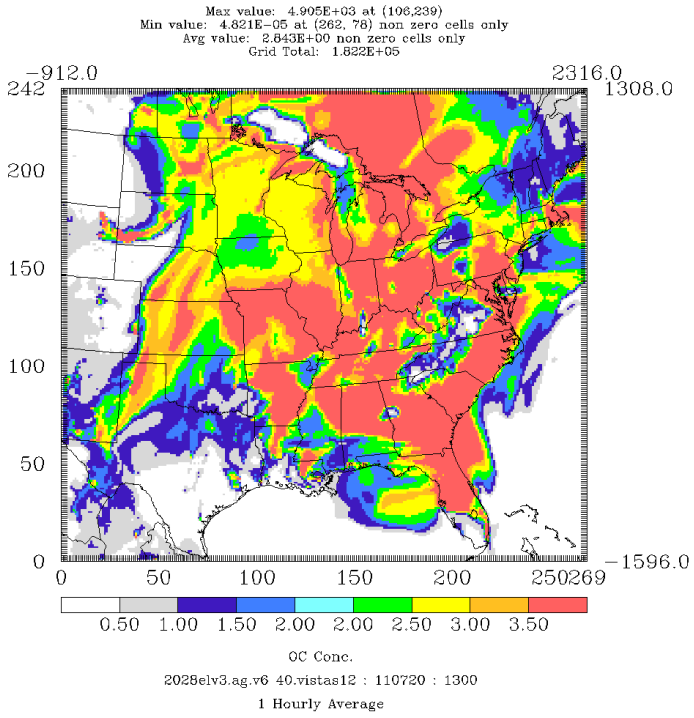


Figure 4-98: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fourth Highest Negative Difference)

Fifth Highest Negative Difference: July 20 at 1300 hours

VISTAS12



Difference (VISTAS12 - 12US2)

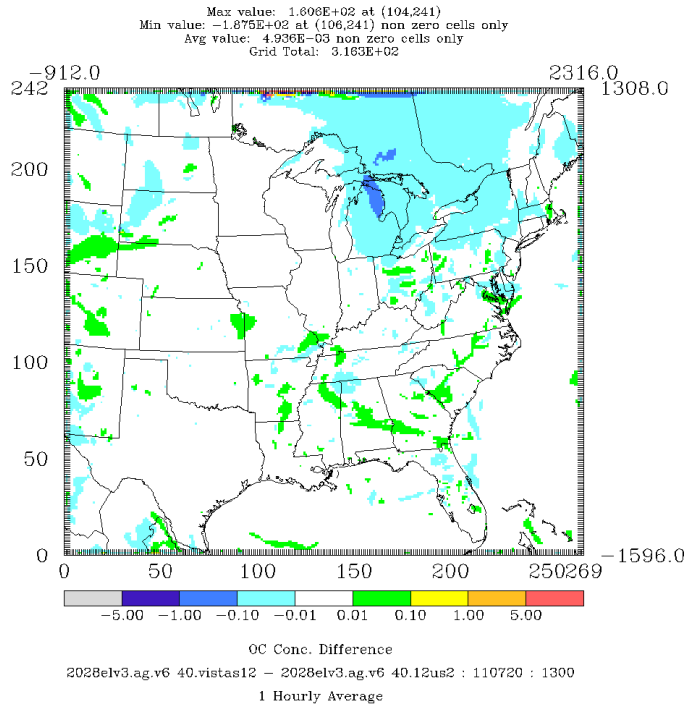
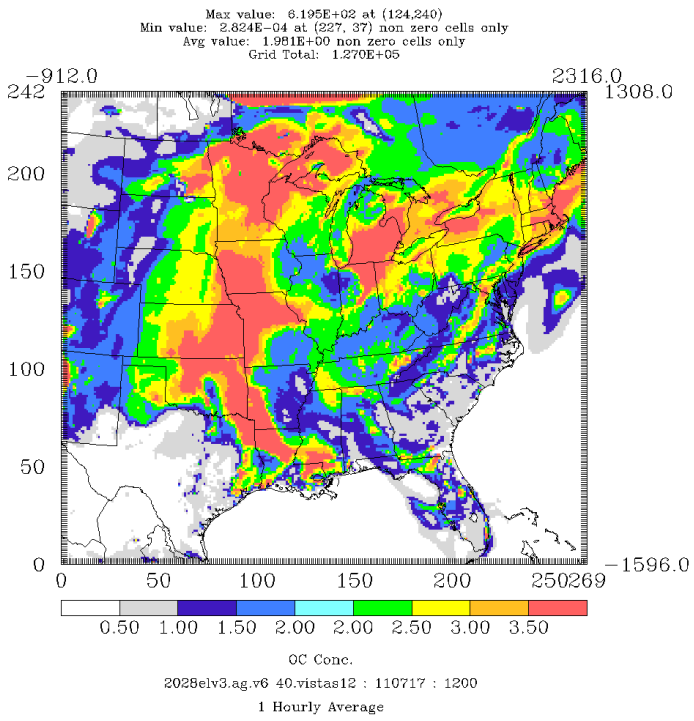


Figure 4-99: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Fifth Highest Negative Difference)

Sixth Highest Negative Difference: July 17 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

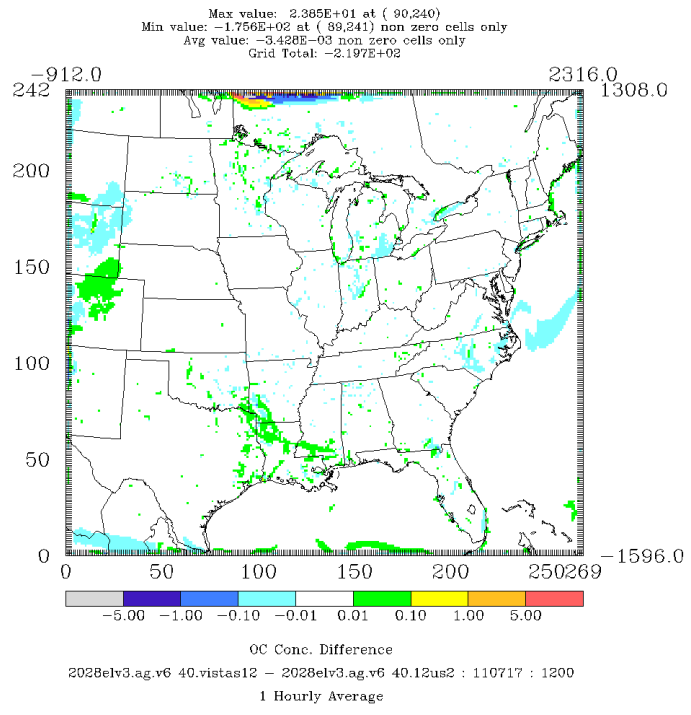
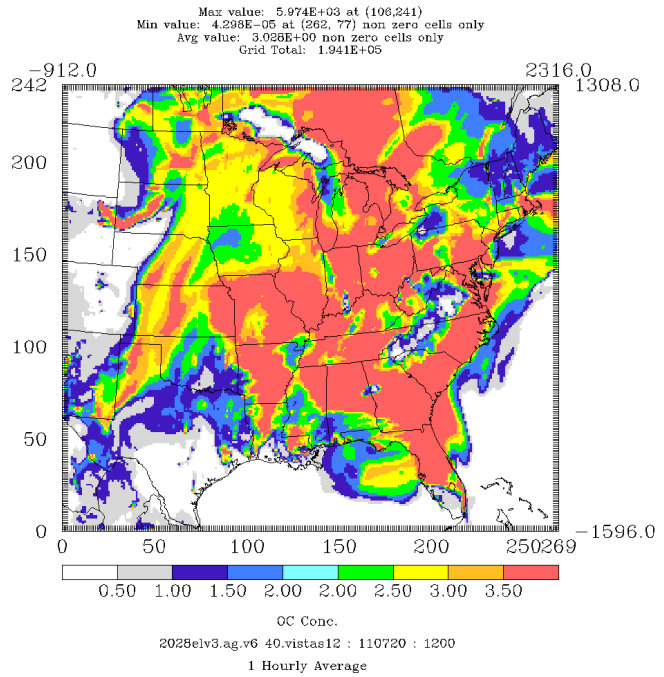


Figure 4-100: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Sixth Highest Negative Difference)

Seventh Highest Negative Difference: July 20 at 1200 hours

VISTAS12



Difference (VISTAS12 - 12US2)

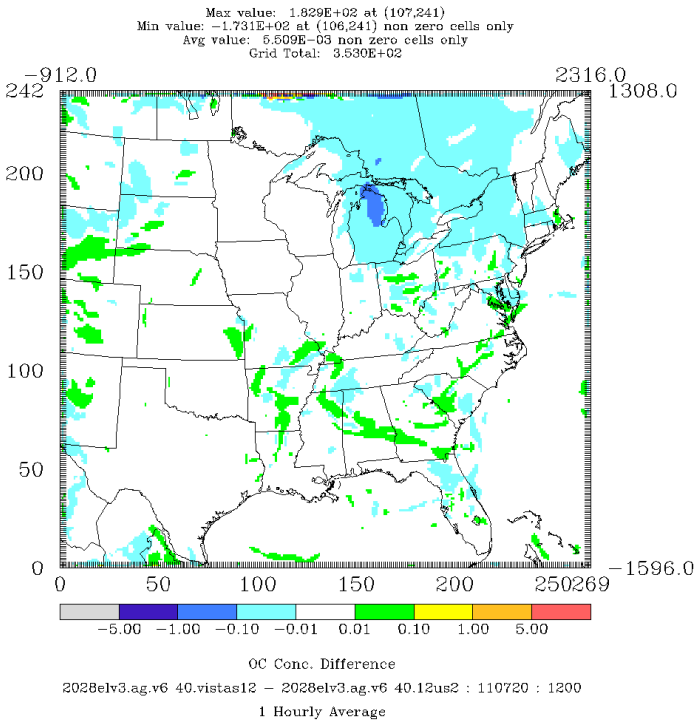
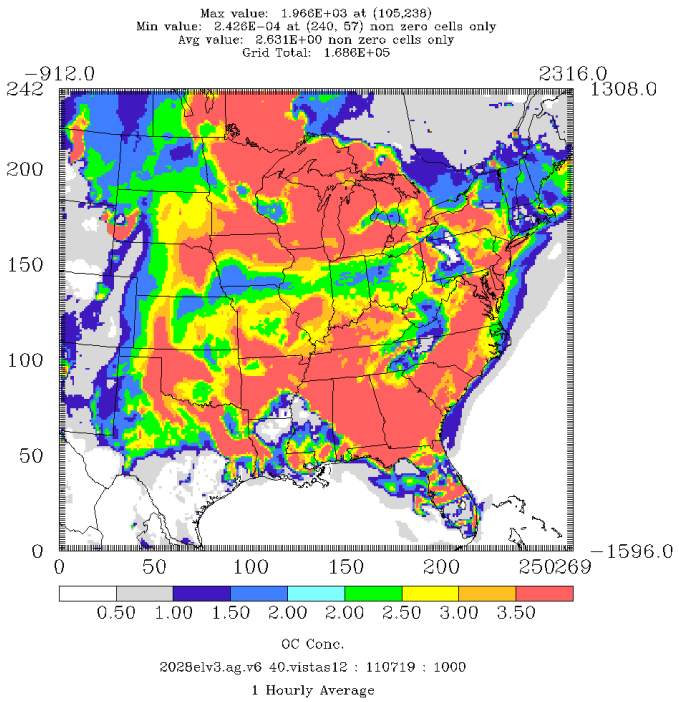


Figure 4-101: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Seventh Highest Negative Difference)

Eighth Highest Negative Difference: July 19 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

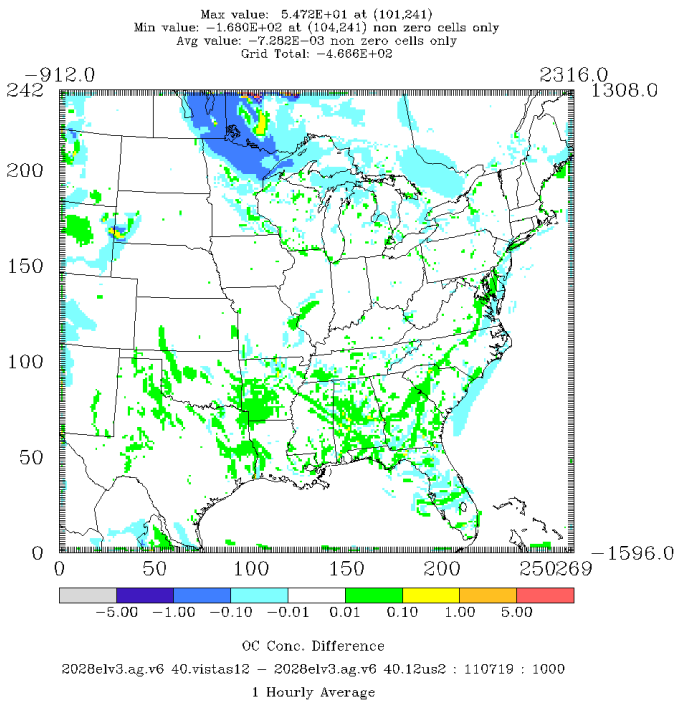
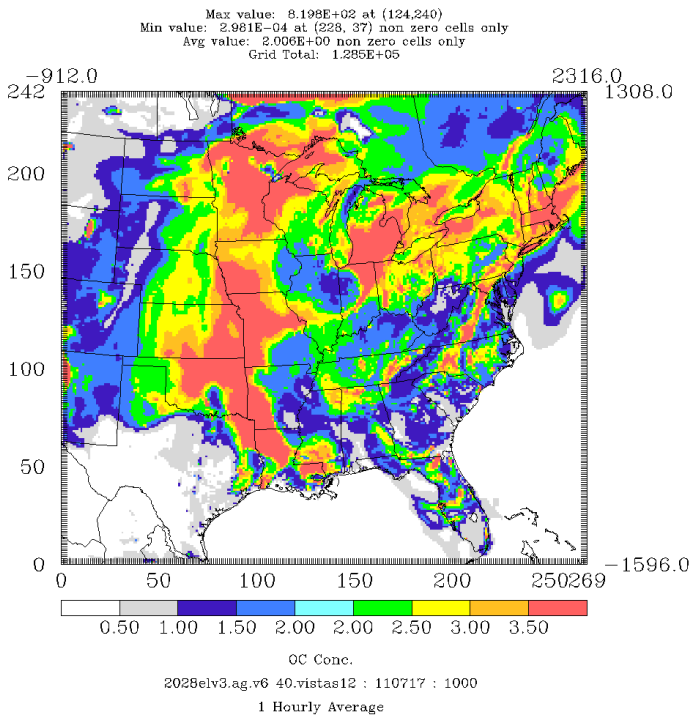


Figure 4-102: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Eighth Highest Negative Difference)

Ninth Highest Negative Difference: July 17 at 1000 hours

VISTAS12



Difference (VISTAS12 - 12US2)

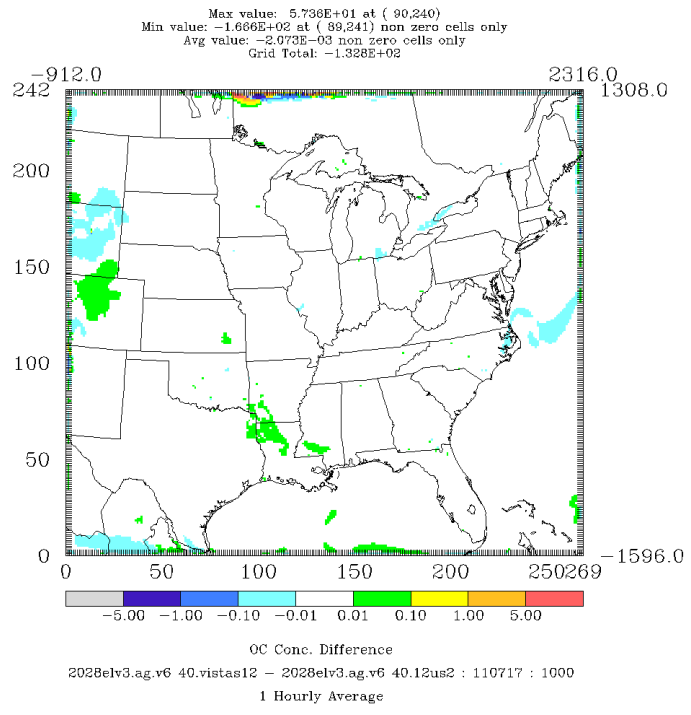
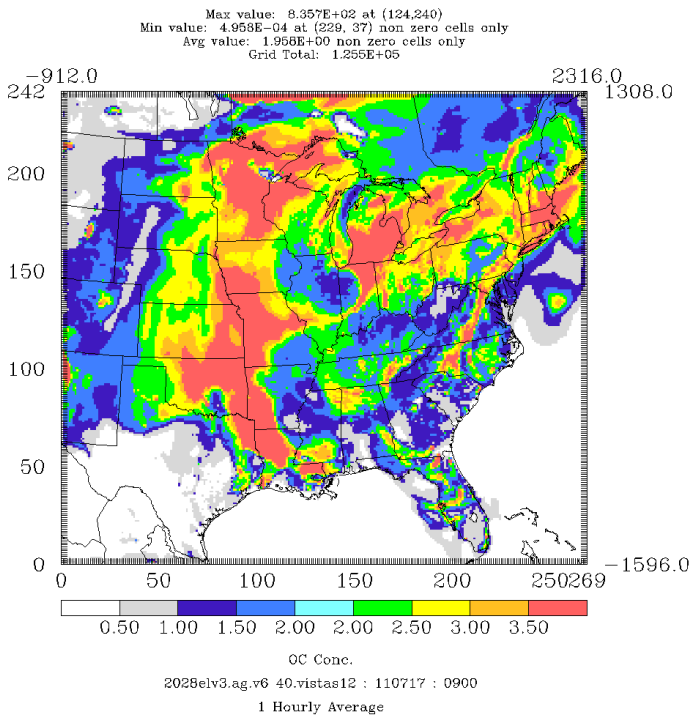


Figure 4-103: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Ninth Highest Negative Difference)

Tenth Highest Negative Difference: July 17 at 900 hours

VISTAS12



Difference (VISTAS12 - 12US2)

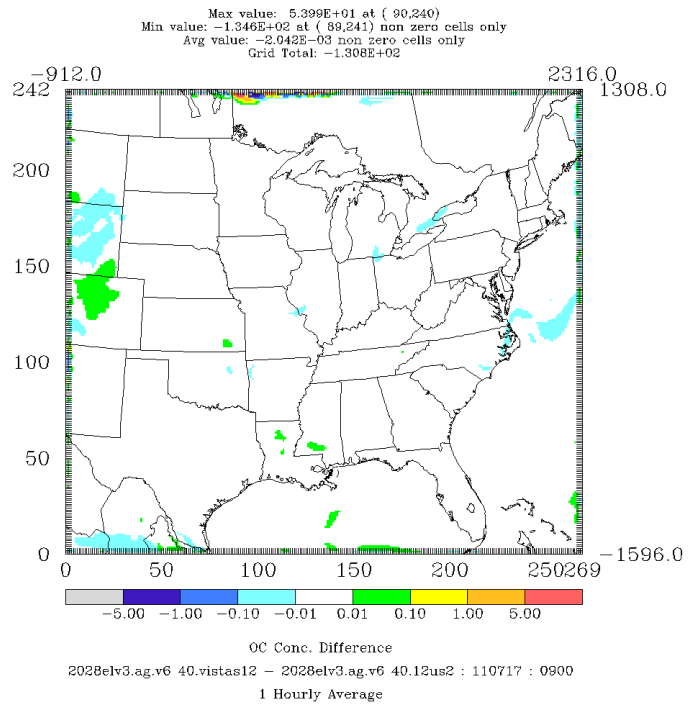


Figure 4-104: Comparison of Organic Matter Concentrations (µg/m^3) for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations (Tenth Highest Negative Difference)

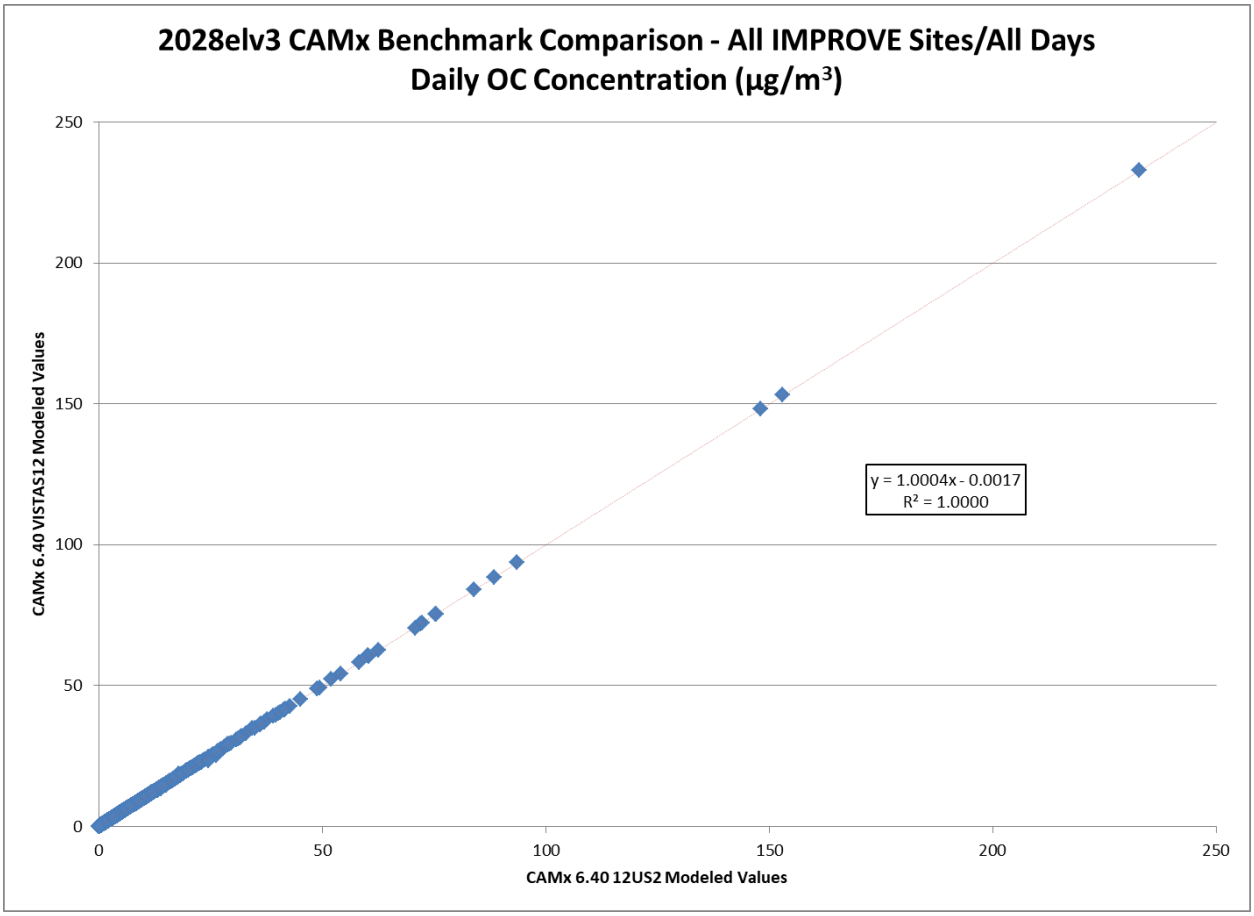


Figure 4-105: Scatterplot Comparing 24-hour Average Predicted Organic Matter Concentrations (µg/m^3) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 on VISTAS12 and 12US2 Domains 2028elv3 Simulations Performed by VISTAS (Alpine).

5.0 CONCLUSIONS

A comparison has been made between CAMx 6.40 simulations using EPA's 2028el modeling platform as performed on the Alpine Geophysics computer system for the VISTAS12 and EPA continental US 12km (12US2) grid. The comparison was conducted for ozone, $PM_{2.5}$, sulfate, nitrate and organic carbon and included an examination both of hourly gridded concentrations and at daily average concentrations at the IMPROVE monitors. The hourly gridded comparison showed areas of maximum differences along the border with the differences decreasing with distance into the VISTAS12 domain.

Two issues have been identified that have noted impact on the use of the VISTAS12 domain relative to the 12US2 domain. The first, and likely the most significant issue is a time-step difference at the boundary where concentration conditions from outside of the domain are injected into the modeling domain at one hour intervals compared to the model generated (sub-hourly) time-step interval within the modeling domain. These differences can create initial, significant concentration gradients along the boundary that can be carried through the episode and transported to grid cells within the modeling domain. The second issue is related to the time step in the model. The time step is determined by the maximum wind in the modeling domain. If the highest wind in the 12US2 domain occurs somewhere outside the VISTAS12 domain, the time step in the 12US2 simulation will be longer than in the VISTAS12 domain.

We note that in modeling the VISTAS12 domain with 12US2 boundary conditions, both of these issues are exacerbated in the modeling due to large emission sources located near the boundary of the 12US2/VISTAS12 boundary. A comparison of the daily average concentrations at the IMPROVE monitors showed very small differences with an R^2 of no less than 0.9999 for all pollutants.

Alpine Geophysics does not see any features in the modeling that would preclude the use of the VISTAS12 modeling domain for use in the VISTAS air quality planning, yet recognizes the impacts related to the current configuration of the VISTAS12 domain and issues related to border grid cells. While the analysis at the IMPROVE monitors has shown that the impact is negligible at the IMPROVE monitors, if these differences are unacceptable to SESARM, SESARM should consider using the 12US2 domain for regional haze modeling.

Appendix E-2f

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project 2028 Emissions Version V3 and V5 Comparison Report

Benchmark Run #7

September 22, 2020

This page intentionally left blank.

Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project
2028 Emissions Version V3 and V5 Comparison Report

Task 6 Benchmark Report #6
Covering Benchmark Run #7

Prepared for:

Southeastern States Air Resource Managers, Inc. (SESARM)

205 Corporate Center Drive, Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

September 22, 2020
Final

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 INTRODUCTION 1
1.1 Overview 1
1.2 Emissions Update 3
1.3 2028elv3 and 2028elv5 CAMx 6.40 Comparison 3
2.0 DIFFERENCES BETWEEN 2028ELV3 AND 2028ELV5 SIMULATIONS 4
3.0 CONFIRMATION METHODOLOGY 4
3.1 CAMx Species Mapping 5
4.0 CAMX 2028ELV3 AND 2028ELV5 COMPARISON 6
4.1 Emissions 6
4.2 Annual $PM_{2.5}$ Design Value 24
4.3 24-Hour (Daily) $PM_{2.5}$ Design Value 32
4.4 Scatterplots of Ozone and PM Species Concentrations 39
5.0 CONCLUSIONS 46

This page is intentionally blank.

TABLES

Table 3-1. Species Mapping from CAMx into Aggregated Species 5

Table 4-1. Comparison of CAMx 6.40 2028elv5 and 2028elv3 Annual Emissions 7

Table 4-2. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for FRM Monitors in VISTAS States 25

Table 4-3. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Daily (24-Hour) $PM_{2.5}$ Design Values ($\mu g/m^3$) for FRM Monitors in VISTAS States 33

FIGURES

Figure 4-1. Comparison of Elevated NO_X Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations 8

Figure 4-2. Comparison of Elevated VOC Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations 9

Figure 4-3. Comparison of Elevated PEC Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations 11

Figure 4-4. Comparison of Elevated PNH4 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....12

Figure 4-5. Comparison of Elevated PNO3 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....13

Figure 4-6. Comparison of Elevated POA Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations 14

Figure 4-7. Comparison of Elevated PSO4 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....15

Figure 4-8. Comparison of Low Level NO_X Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....16

Figure 4-9. Comparison of Low Level VOC Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....17

Figure 4-10. Comparison of Low Level SO_2 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....18

Figure 4-11. Comparison of Low Level PEC Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....19

Figure 4-12. Comparison of Low Level PNH4 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....20

Figure 4-13. Comparison of Low Level PNO3 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations.....21

Figure 4-14. Comparison of Low Level POA Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations....22

Figure 4-15. Comparison of Low Level PSO4 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations....23

Figure 4-16. Comparison of Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.40 2028elv5 and 2028elv3 Simulations....30

Figure 4-17. Scatterplot Comparing Annual Average Predicted $PM_{2.5}$ Design Values ($\mu g/m^3$) at all Monitor Locations for CAMx 6.40 2028elv3 and 2028elv5 Simulations Performed by VISTAS (Alpine)....31

Figure 4-18. Comparison of Daily $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.40 2028elv5 and 2028elv3 Simulations....37

Figure 4-19. Scatterplot Comparing Daily (24-hr) Average Predicted $PM_{2.5}$ Design Values ($\mu g/m^3$) at all Monitor Locations for CAMx 6.40 2028elv3 and 2028elv5 Simulations Performed by VISTAS (Alpine)....38

Figure 4-20. Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)....39

Figure 4-21. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)....40

Figure 4-22. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine); Modified Scale....41

Figure 4-23. Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations ($\mu g/m^3$) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)....42

Figure 4-24. Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations ($\mu g/m^3$) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)....43

Figure 4-25. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations ($\mu g/m^3$) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)....44

Figure 4-26. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations ($\mu g/m^3$) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine); Modified Scale....45

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
CAMx	Comprehensive Air Quality Model with Extensions
dv	Deciview
DV	Design Value
EGU	Electric Generating Unit
EPA	Environmental Protection Agency
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee
FLM	Federal Land Manager
FR	Federal Register
IPM	Integrated Planning Model
km	kilometer
$\mu g/m^3$	microgram per cubic meter
NAAQS	National Ambient Air Quality Standard
NO_x	Oxides of nitrogen
OAQPS	Office of Air Quality Planning and Standards
O_3	Ozone
OC	Organic carbon
OSAT	Ozone Source Apportionment Technology
PSAT	Particulate Source Apportionment Technology
PEC	Primary elemental carbon
PM	Particulate matter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Particulate ammonium
PNO3	Particulate nitrate
POA	Primary Organic Aerosol
PSAT	Particulate Source Apportionment Technology
PSO4	Particulate sulfate
R^2	Pearson correlation coefficient squared
RADM-AQ	Regional Acid Deposition Model – aqueous chemistry
RHR	Regional Haze Rule
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SMAT-CE	Software for Model Attainment Test – Community Edition
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
tpy	Tons per year
U.S.	United States
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast
VOC	Volatile organic compounds

This page is intentionally blank.

1.0 INTRODUCTION

1.1 Overview

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States (U.S.) Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone (O_3) as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.

B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that is, the focus of state planning will be to establish reasonable progress goals for each Class I area against which progress will be measured during the second planning period. This extension will allow states to incorporate planning for other Federal programs while conducting their regional haze planning. These other programs include: the Mercury and Air Toxics Standards, the 2010 1-hour sulfur dioxide (SO_2) National Ambient Air Quality Standards (NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview (dv) index values. "Most impaired days" are defined as the 20% of

monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

1.2 Emissions Update

Since the completion of the original round of emissions inventory development, emissions processing, modeling, and Particulate Source Apportionment Technology (PSAT), SESARM concluded that the 2028 point electric generating unit (EGU) and non-EGU emissions needed to be reviewed and updated for selected sources. These include data review from:

- Point source emissions updates identified in the Area of Influence report;
- Updated EGU emissions developed by the Eastern Regional Technical Advisory Committee (ERTAC);
- EPA's 2028 point source emissions based on the 2016 modeling platform; and
- Additional facility emission updates after PSAT analysis.

Specific updates related to development of the 2028 emissions inventory updates are presented in the Task 2 and Task 3 updated reports.[2,3]

1.3 2028elv3 and 2028elv5 CAMx 6.40 Comparison

Under subcontract to Eastern Research Group, Inc, (ERG), Alpine Geophysics, LLC (Alpine) has executed two air quality simulations for the 2028el projection year modeling platform using CAMx 6.40. We note that CAMx 6.50 has now been released, however that model release was too late to be included with sufficient certainty in the VISTAS II project schedule.

This comparison is to document the differences in model estimates between CAMx 6.40 2028elv3 and 2028elv5 as is discussed in the VISTAS II Modeling Protocol.[4]

---

[2] Southeastern States Air Resource Managers, Inc. "Southeastern VISTAS II Regional Haze Analysis Project - Task 2 and Task 11.3 Emission Inventory Updates Report." Prepared by Eastern Research Group, Inc. under Contract V-2018-03-01. Final. September 2020.

[3] Southeastern States Air Resource Managers, Inc. "Conversion of the Task 2B 2028 Point Source Remodeling Files for Emissions Processing with SMOKE, Task 3." Prepared by Alpine Geophysics, LLC and Eastern Research Group, Inc. under Contract V-2018-03-01. Final. September 2020.

[4] "Regional Haze Modeling for Southeastern VISTAS II Region Haze Analysis Project, Final Modeling Protocol. Update and Addendum to the Approved Modeling Protocol for Task 6.1 (June 2018)." Prepared for SESARM under Contract No. V-2018-03-01. Prepared by Alpine Geophysics, LLC and Eastern Research Group, Inc. August 31, 2020.

2.0 DIFFERENCES BETWEEN 2028ELV3 AND 2028ELV5 SIMULATIONS

Differences in modeled output concentrations between the 2028elv3 and 2028elv5 CAMx 6.40 simulations were as a result solely of changes to the emissions inventory.

There are notable emissions inventory differences used in the modeling by SESARM compared to EPA's 2028el modeling platform. SESARM updated the 2028 emissions inventory used in this analysis (2028elv5) with changes to both electric generating unit (EGU) and non-EGU point source emissions. Summaries of the emission differences are presented in the updated Task 2 and 3 reports[2,3] for this study, the Alpine Geophysics memo "Task 6 – Benchmark #7 Review and 2028elv3 Reassessment" (Appendix A), and summarized in Section 4.1.

The VISTAS emissions processing was restricted to 2011, however, the CAMx model has a "spin-up" period from December 22 through December 31, 2010 to minimize the influence of the global model-derived initial conditions. For the 2028elv3 simulation the spin-up period for the low level emissions were based on the EPA supplied 2028el emissions for the December 2010 period. The elevated 2028elv3 emissions and the 2028elv5 low level and elevated emissions were copied by day of week from the beginning of 2011. This small difference in emissions handling led to differences in model concentrations during January 1-2, 2011. January 1-2 do not represent any 20% clearest or 20% most anthropogenically impaired days at any Class I area and therefore our results here do not include these days in the 2028elv3 and 2028elv5 modeled value scatterplots.

3.0 CONFIRMATION METHODOLOGY

The presented comparison of model simulations are based on annual and 24-hour $PM_{2.5}$ design values as generated from the output of the two VISTAS12-based simulations; CAMx 6.40 with 2028elv3 and 2028elv5 emissions. This report does not compare hourly concentrations for each PM species as the model version, platform configuration and processing methods, and the underlying projection year emissions inventories differ significantly between the two model runs making it difficult, if not impossible, to determine the cause of any differences seen in concentrations. We also provide a comparison of gridded 12-kilometer (km) annual elevated and

low level emissions for the domain. The metric for comparison of the design values are the absolute difference (Equation 1) and percent difference (Equation 2) defined as:

(Equation 1) $$(C_{2028elv5} - C_{2028elv3})$$

(Equation 2) $$\frac{(C_{2028elv5} - C_{2028elv3})}{(C_{2028elv3})}$$

Where $C_{2028elv5}$ is the design value at each FRM monitor for the CAMx simulation with the 2028elv5 emissions and $C_{2028elv3}$ is the design value at each FRM monitor for the CAMx simulation with the 2028elv3 emissions. For the emission comparison plots, only Equation 1 results were calculated for each grid cell and plotted for review.

The results are presented for each FRM monitor in the VISTAS states for each of the two design values. Emission density spatial maps are presented for only the nested VISTAS12 modeling domain that was reprocessed with updated emissions. On each spatial emissions difference plot presented, the maximum positive and negative values, along with the grid cell in which these occur, are presented at the top of the graphic. The coordinates refer to the row and columns of the cell referenced to the cell coordinates on the bottom (column) and left (row) of the graphic.

Scatterplots of the daily average concentrations of ozone and the various calculated PM species in local standard time at the Interagency Monitoring for Protected Visual Environment (IMPROVE) monitors across all modeled days are also presented with the CAMx 2028elv5 results plotted on the x-axis and the CAMx 2028elv3 results plotted on the y-axis.

3.1 CAMx Species Mapping

The CAMx species mapping from version 6.40 of the model is presented in Table 3-1.

Table 3-1. Species Mapping from CAMx into Aggregated Species

Aggregated Species	CAMx 6.40 Species
Ozone	O3
$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA+PEC +FPRM+FCRS+NA+PCL
Sulfate	PSO4
Nitrate	PNO3
Organic Matter (OM)	SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+POA

4.0 CAMX 2028ELV3 AND 2028ELV5 COMPARISON

This section presents comparisons of the simulations using CAMx 2028elv3 and CAMx 2028elv5 performed on the Alpine computer system. Emissions presented are the post-processed results of the Sparse Matrix Operator Kernel Emissions (SMOKE) emissions tool, including oxides of nitrogen (NO_X), volatile organic compounds (VOC), and speciated $PM_{2.5}$ components (e.g., particulate nitrate (PNO3), particulate sulfate (PSO4), etc.) for elevated and low level sources. Annual and 24-Hour $PM_{2.5}$ design values are the result of running each of the model platforms through the Software for the Modeled Attainment Test - Community Edition (SMAT-CE) tool to generate receptor-level values.

4.1 Emissions

Annual emission summaries have been prepared from the model-ready input files for both elevated and low level sources. Elevated sources include all CEM-based emissions in the modeling platform, non-EGU point sources with explicit latitude and longitude release coordinates and calculated plume rise greater than or equal to twenty (20) meters, emissions from wildfires, and international commercial marine emissions not otherwise associated with specific U.S. states. Low-level sources are comprised of all other anthropogenic source types including non-EGU point sources with a calculated plume rise of less than twenty (20) meters, agricultural and prescribed fires, biogenic and other natural source emissions, and commercial marine emissions associated with sources assigned to specific U.S. states. Results presented include maps of the VISTAS12 domain with annual emissions (tons per year) and emission differences by grid cell and pollutant. Table 4-1 presents summary results by pollutant over the VISTAS12 domain for elevated and low level comparisons. Figures 4-1 through 4-7 present the annual emissions and emission differences for elevated sources by pollutant in the VISTAS12 modeling domain. Figures 4-8 through 4-15 present annual emissions and emission differences for low level sources, by pollutant, in the VISTAS12 modeling domain.

As expected with the changes in modeled emission inventories between the SESARM 2028elv3 and 2028elv5 platforms, we see the changes in elevated (point source) emissions fairly uniformly throughout of the modeling domain. Low-level emission changes are also seen predominantly in the VISTAS states for areas where emission inventory modifications were

applied for this analysis with scattered changes elsewhere due to the replacement of first-layer emitting point sources as noted above.

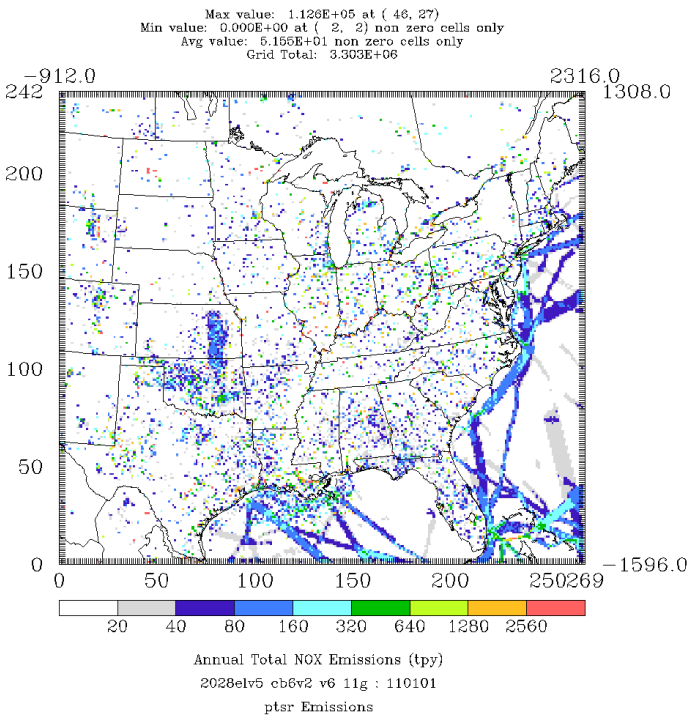
Table 4-1. Comparison of CAMx 6.40 2028elv5 and 2028elv3 Annual Emissions

		2028 Annual Emissions (tons)				
		2028elv5	Elv5-elv3[e]	Domain Wide	Individual Grid Cell	
Source Type	Pollutant	Total Tons	Total Change	% Change	Max Increase	Max Decrease
Elevated	NO_X[a]	3,303,000	-364,300	-11.03%	8,106	-17,730
Elevated	VOC[b]	3,293,000	-8,109	-0.25%	1,194	-2,331
Elevated	SO_2[c]	2,737,000	-918,000	-33.54%	7,247	-53,910
Elevated	PEC	183,300	-4,977	-2.72%	140	-290
Elevated	PNH4[d]	9,808	-208	-2.12%	6	-15
Elevated	PNO3	11,760	-179	-1.52%	22	-16
Elevated	POA	1,208,000	-5,856	-0.48%	180	-406
Elevated	PSO4	62,220	-6,059	-9.74%	165	-445
Low Level	NO_X	5,805,000	-759	-0.01%	61	-157
Low Level	VOC	46,160,000	-6,035	-0.01%	1,147	-1,201
Low Level	SO_2[c]	257,300	2,321	0.90%	2,849	-157
Low Level	PEC	118,400	-52	-0.04%	2	-13
Low Level	PNH4[b]	5,831	-1	-0.02%	0	-1
Low Level	PNO3	3,770	-7	-0.17%	0	-1
Low Level	POA	757,200	-142	-0.02%	2	-36
Low Level	PSO4	150,000	-217	-0.14%	15	-69

[a] NO_X is calculated as the sum of NO plus NO_2
[b] VOC emissions are approximate since calculated from CB6 speciated emissions.
[c] The molecular weight for SO_2 in these totals was 3% higher than the true molecular weight.
[d] PNH4 = Particulate ammonium
[e] Emission differences are discussed in the updated Task 2 and 3 reports[2,3] for this study and the Alpine Geophysics memo "Task 6 – Benchmark #7 Review and 2028elv3 Reassessment" (Appendix A).

Annual NO_X Emissions – Elevated Sources

2028elv5



Difference (2028elv5 – 2028elv3)

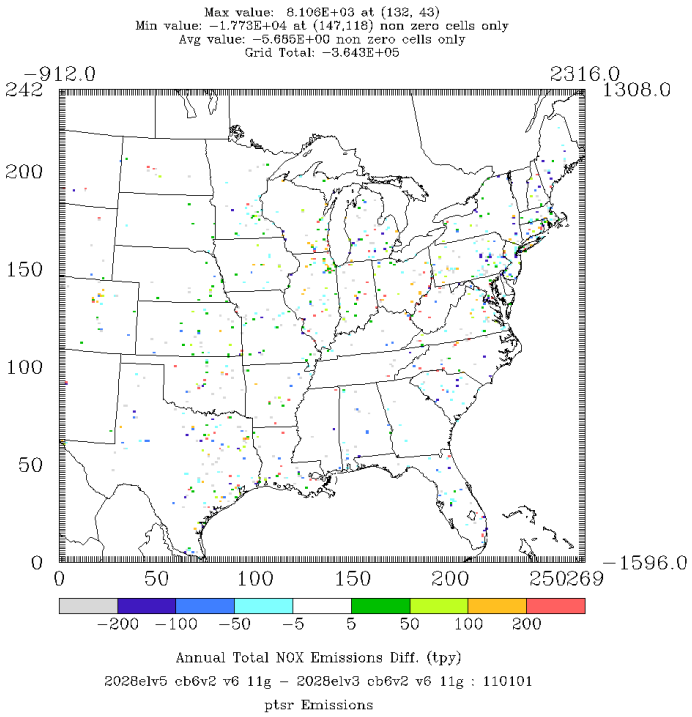
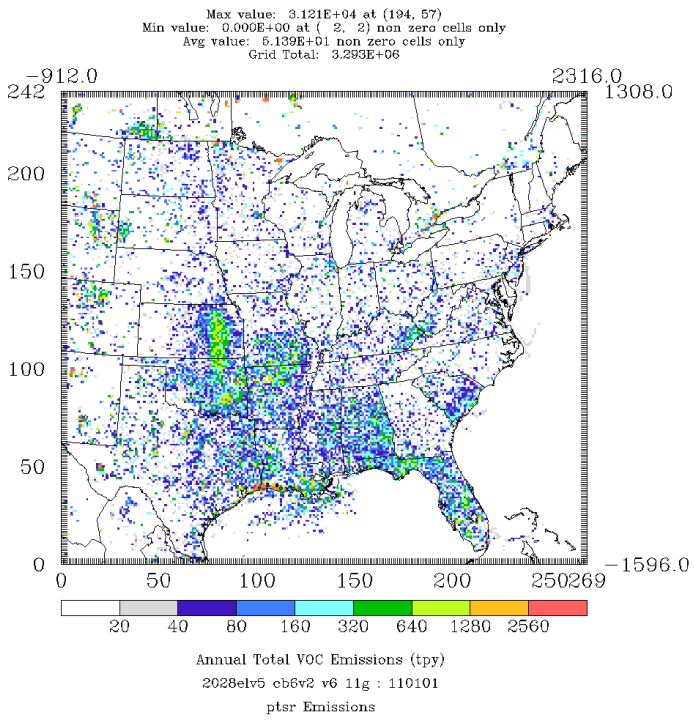


Figure 4-1. Comparison of Elevated NO_X Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual VOC Emissions – Elevated Sources

2028elv5



Difference (2028elv5 – 2028elv3)

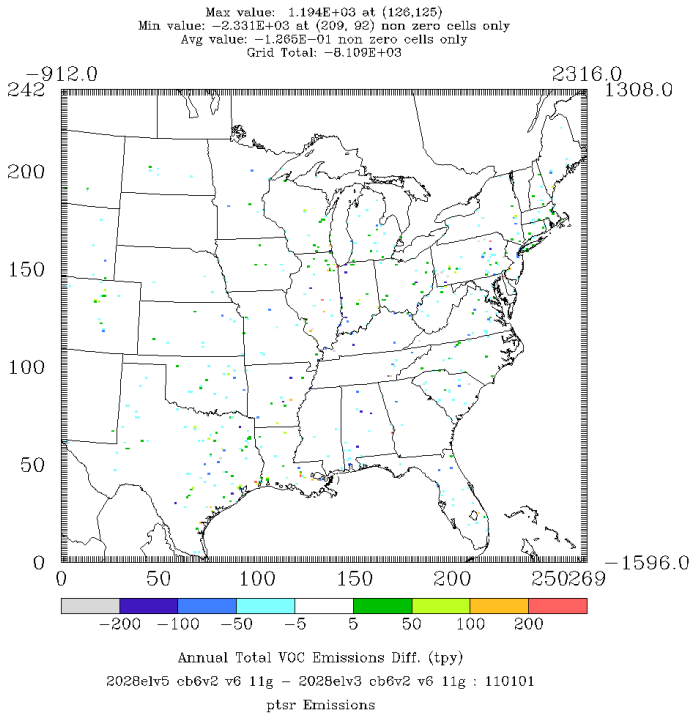
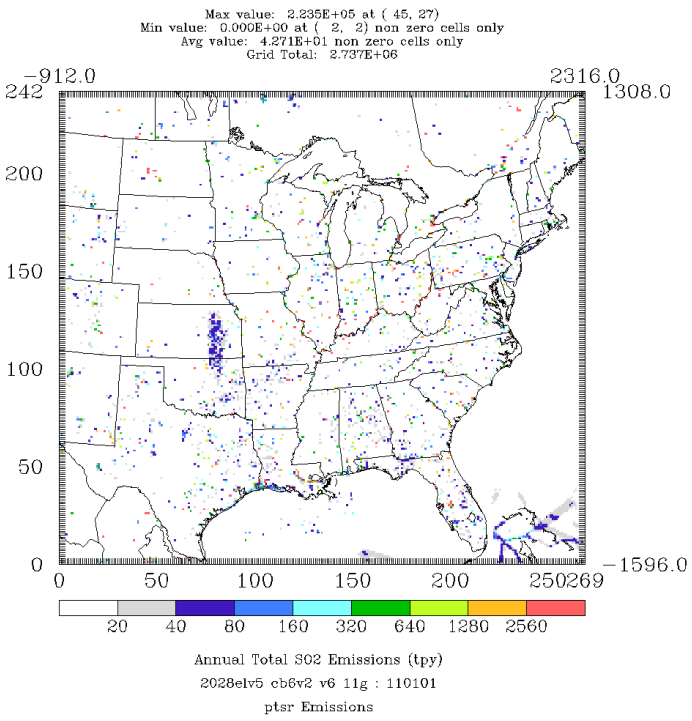


Figure 4-2. Comparison of Elevated VOC Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual SO_2 Emissions – Elevated Sources

2028elv5



Difference (2028elv5 – 2028elv3)

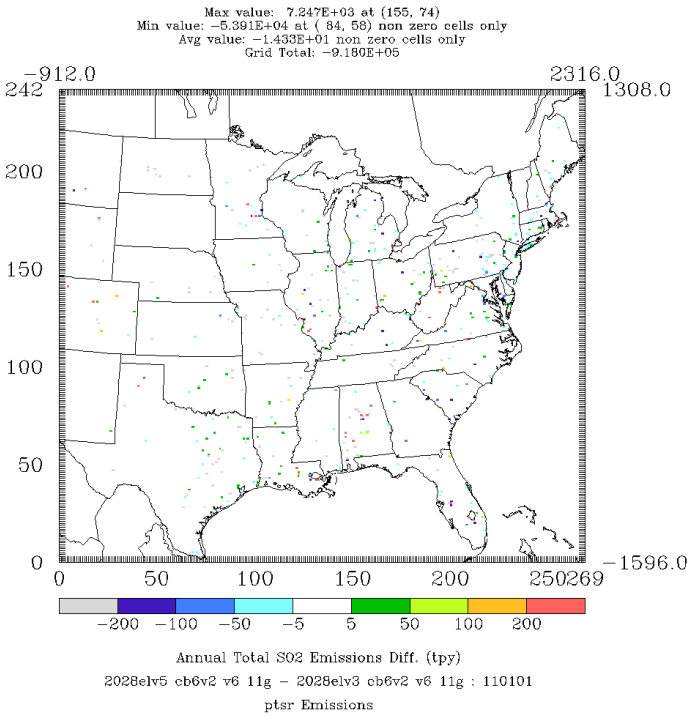
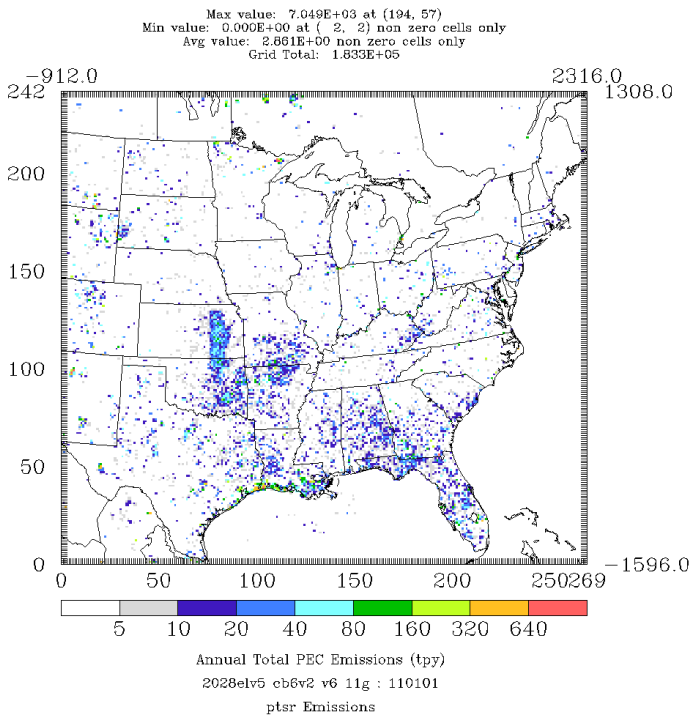


Figure 4-3. Comparison of Elevated SO_2 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual PEC Emissions – Elevated Sources

2028elv5



Difference (2028elv5 – 2028elv3)

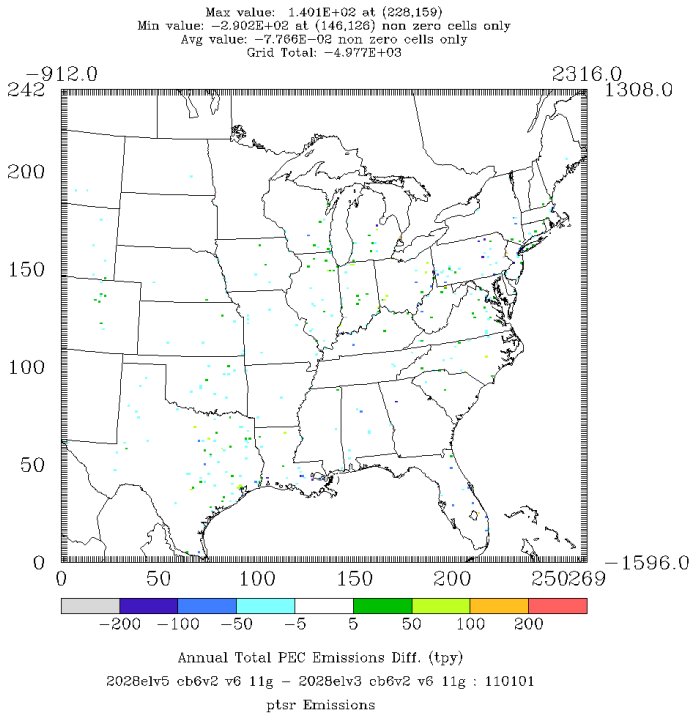
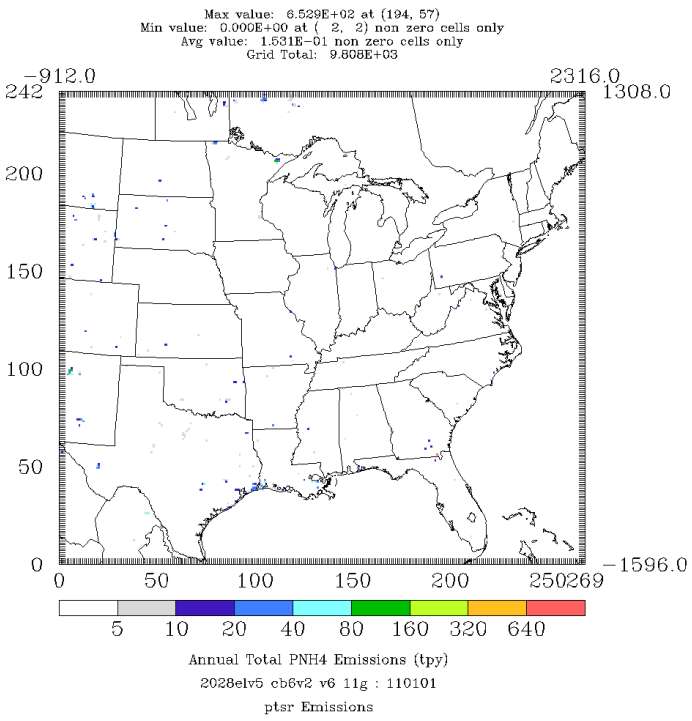


Figure 4-3. Comparison of Elevated PEC Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual PNH4 Emissions – Elevated Sources

2028elv5



Difference (2028elv5 – 2028elv3)

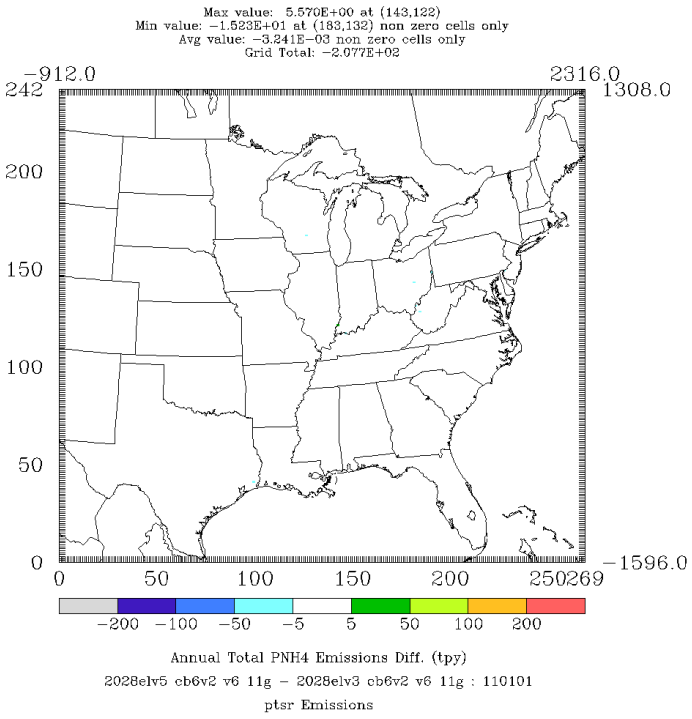
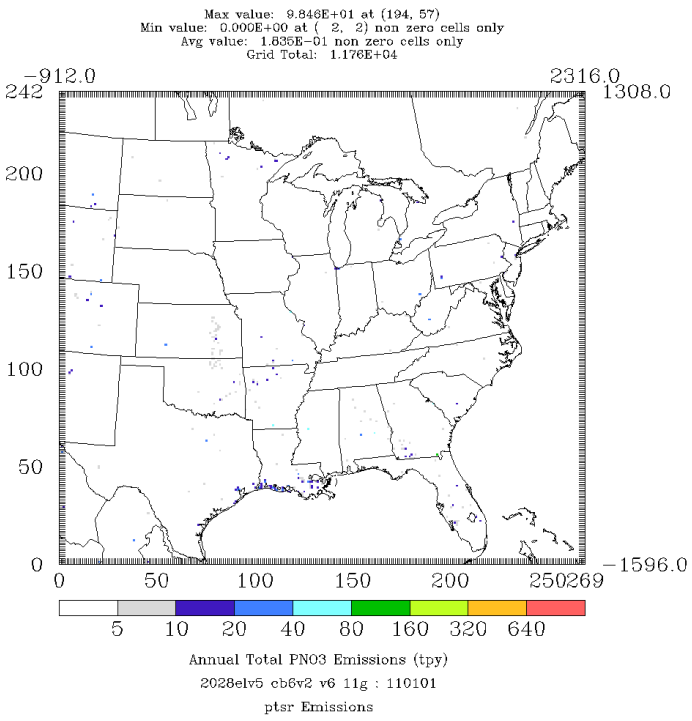


Figure 4-4. Comparison of Elevated PNH4 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual PNO3 Emissions – Elevated Sources

2028elv5



Difference (2028elv5 – 2028elv3)

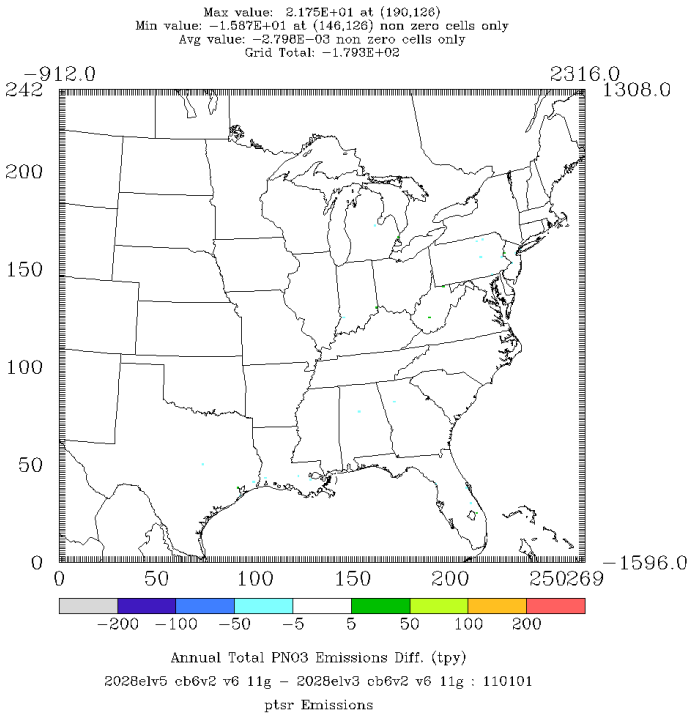
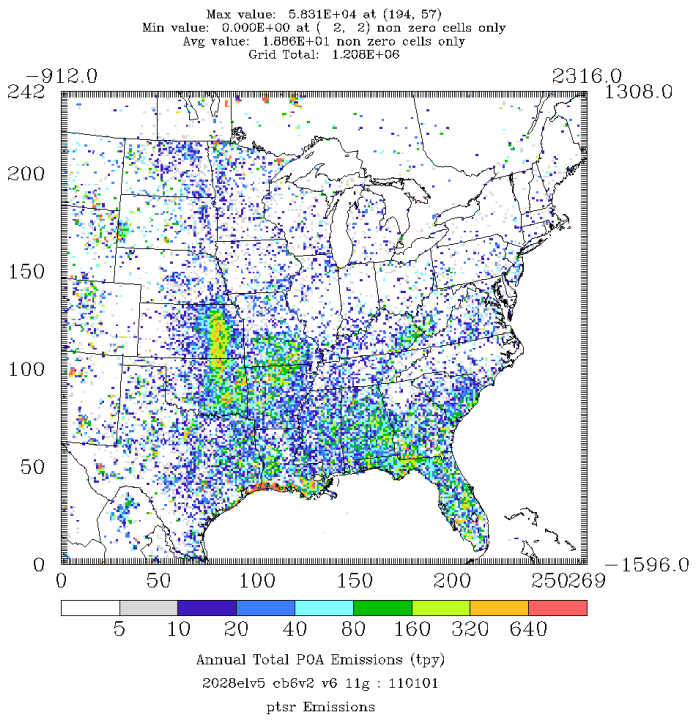


Figure 4-5. Comparison of Elevated PNO3 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual POA Emissions – Elevated Sources

2028elv5



Difference (2028elv5 – 2028elv3)

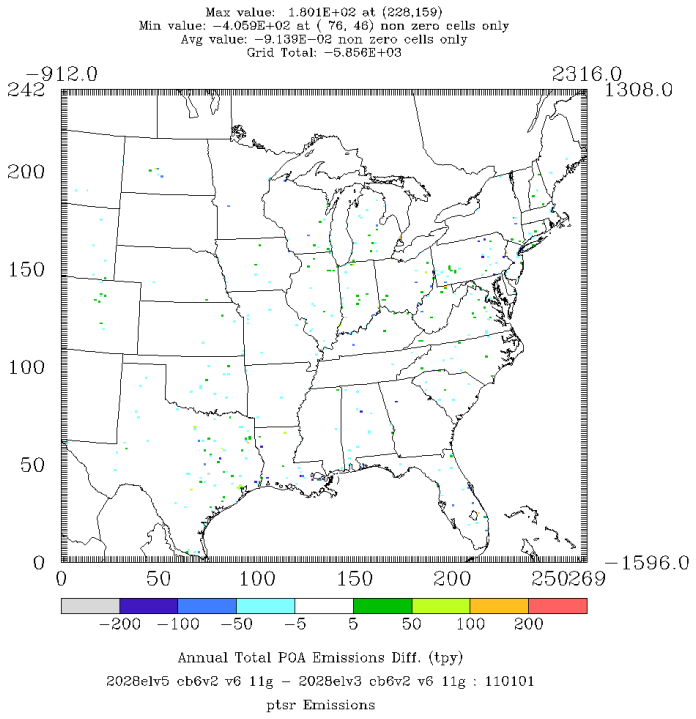
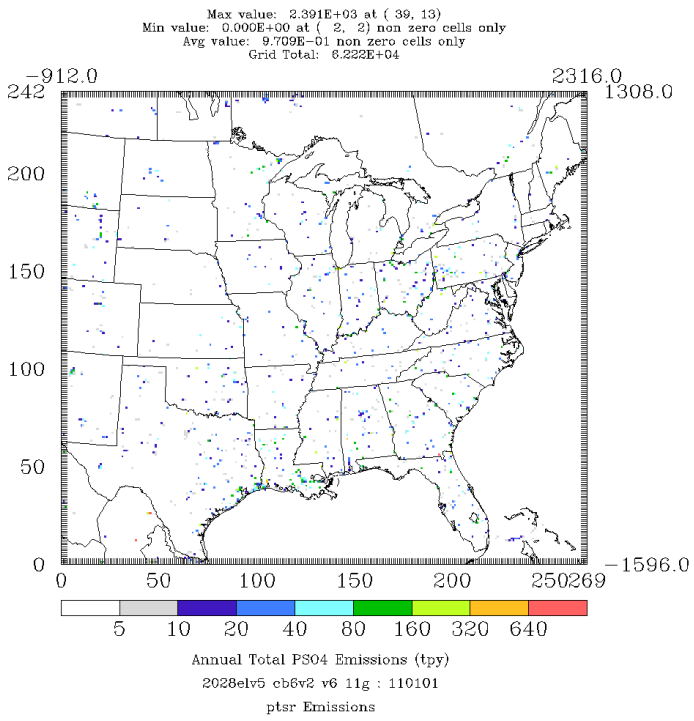


Figure 4-6. Comparison of Elevated POA Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual PSO4 Emissions – Elevated Sources

2028elv5



Difference (2028elv5 – 2028elv3)

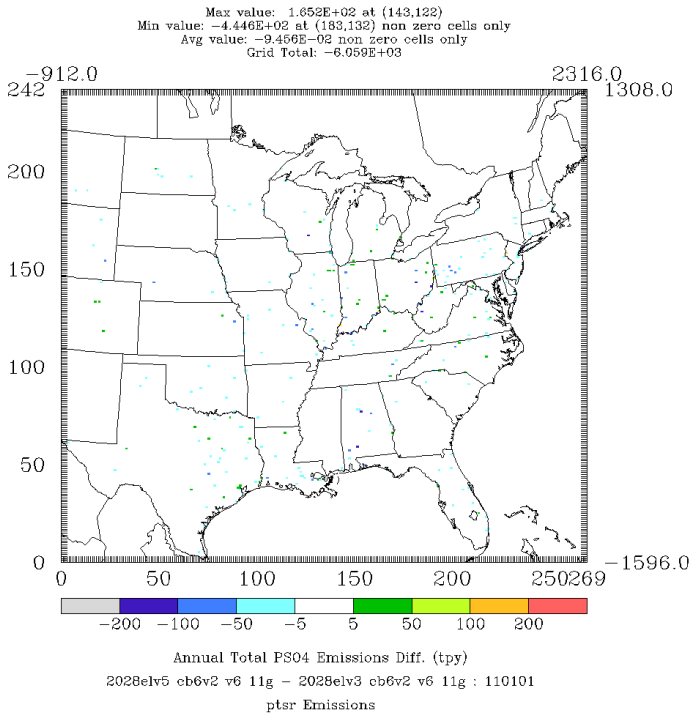
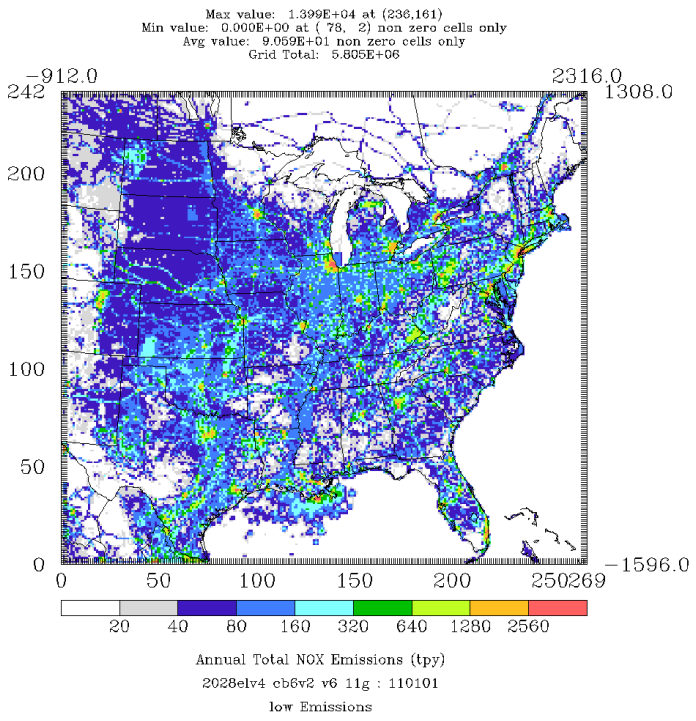


Figure 4-7. Comparison of Elevated PSO4 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual NO_X Emissions – Low Level Sources

2028elv5



Difference (2028elv5 – 2028elv3)

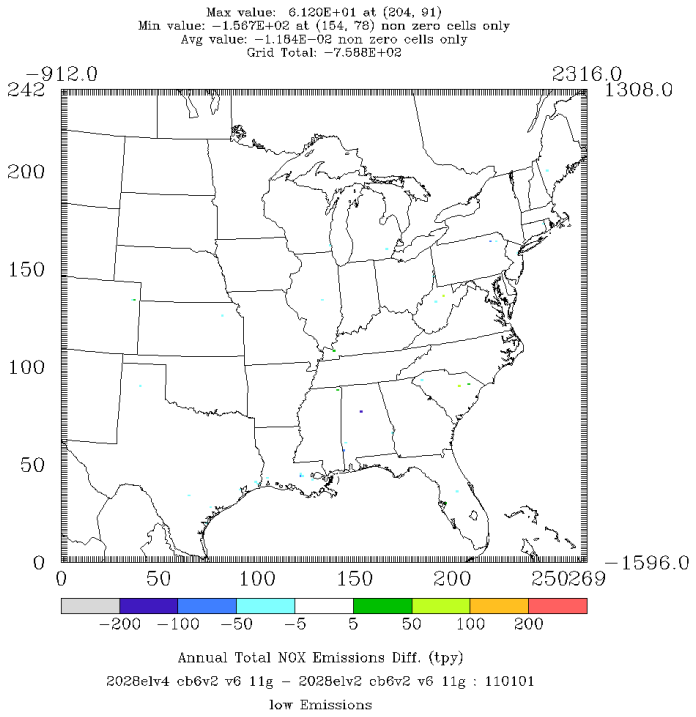
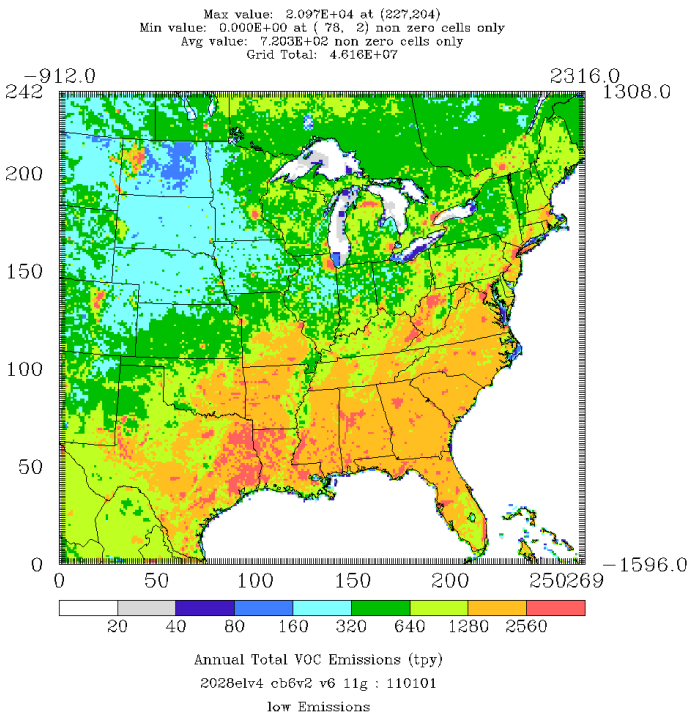


Figure 4-8. Comparison of Low Level NO_X Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual VOC Emissions – Low Level Sources

2028elv5



Difference (2028elv5 – 2028elv3)

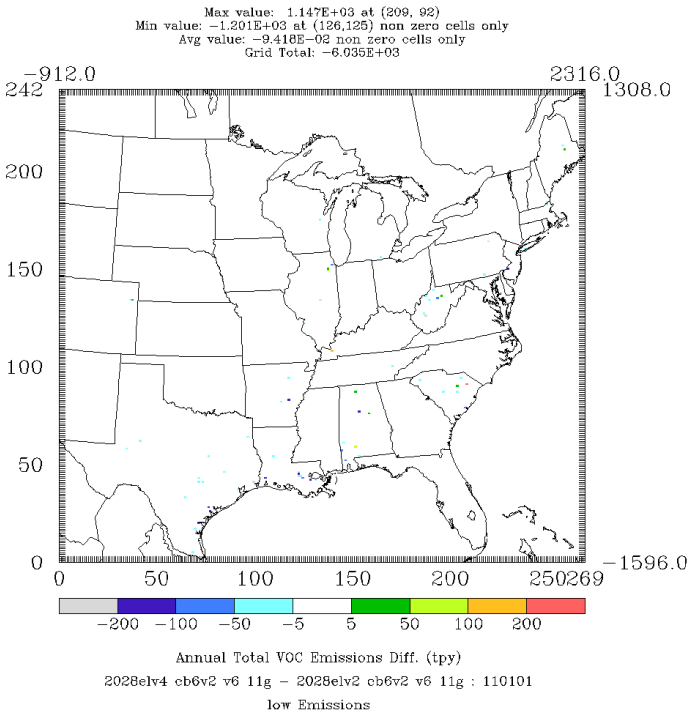
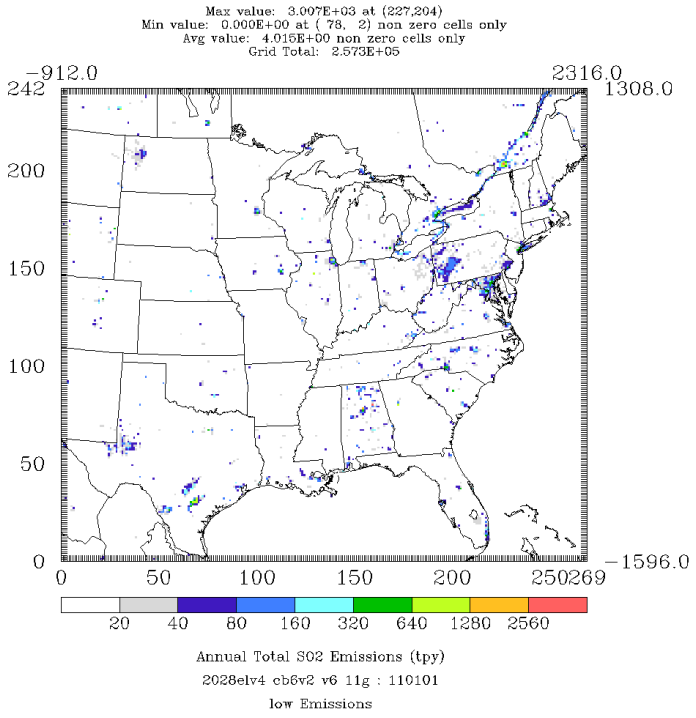


Figure 4-9. Comparison of Low Level VOC Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual SO_2 Emissions – Low Level Sources

2028elv5



Difference (2028elv5 – 2028elv3)

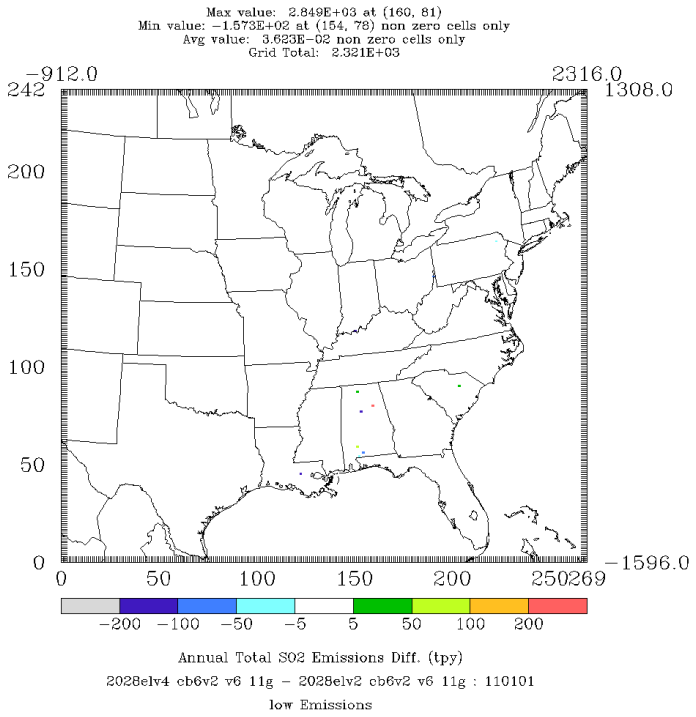
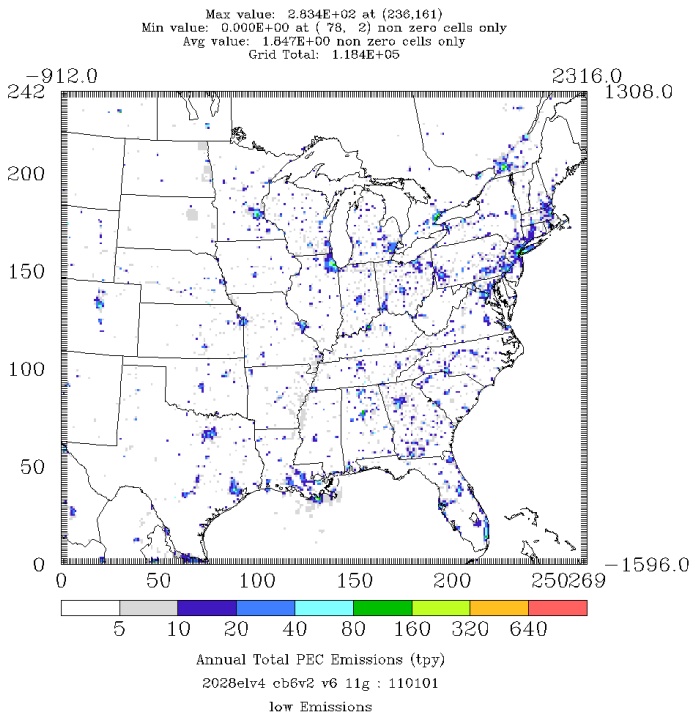


Figure 4-10. Comparison of Low Level SO_2 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual PEC Emissions – Low Level Sources

2028elv5



Difference (2028elv5 – 2028elv3)

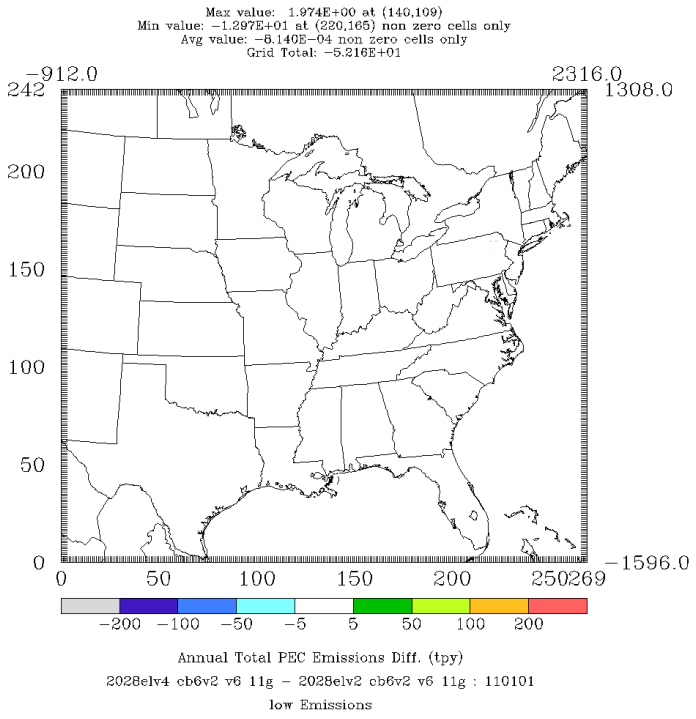
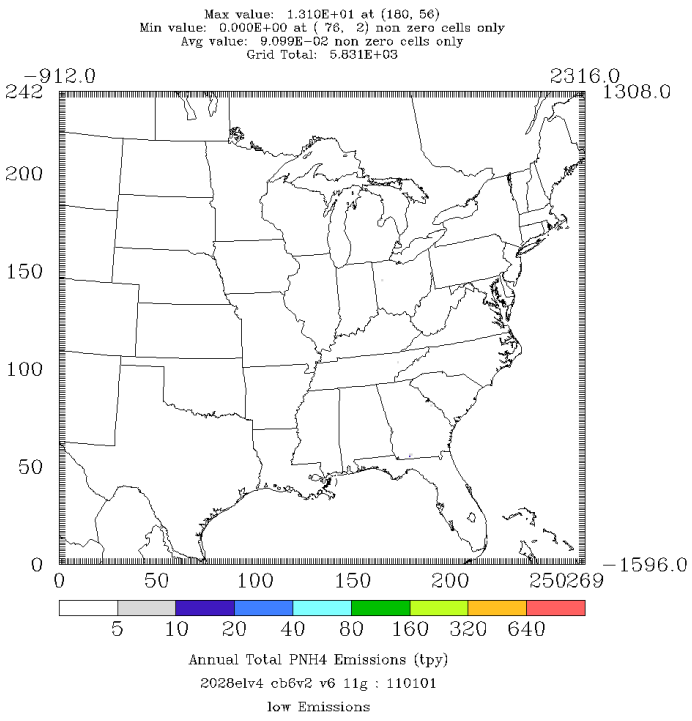


Figure 4-11. Comparison of Low Level PEC Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual PNH4 Emissions – Low Level Sources

2028elv5



Difference (2028elv5 – 2028elv3)

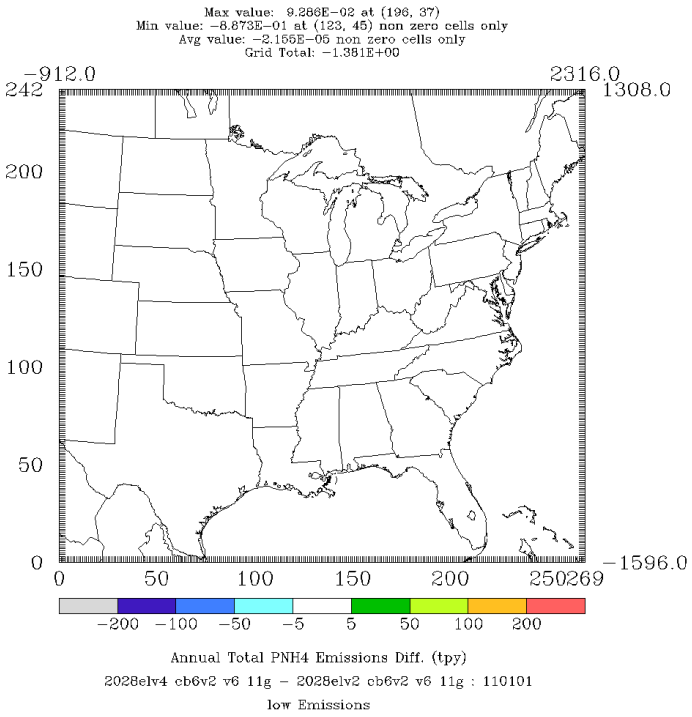
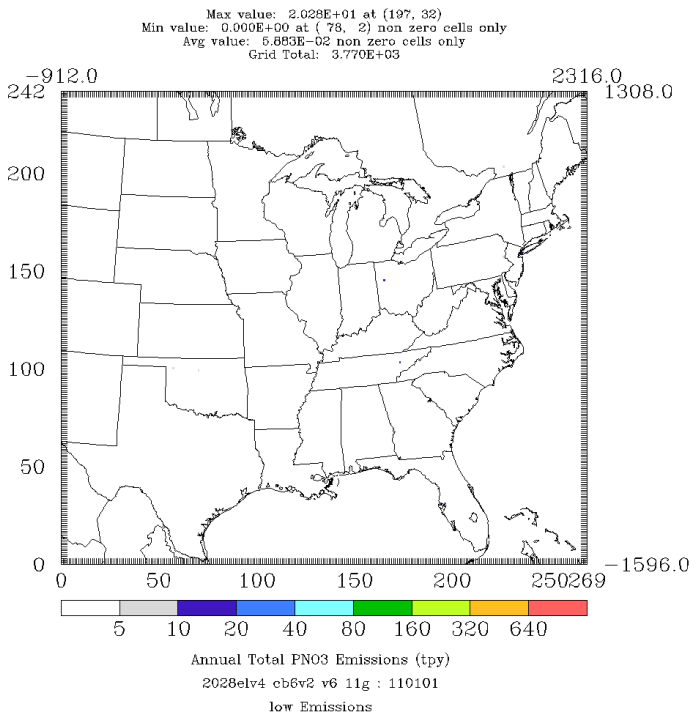


Figure 4-12. Comparison of Low Level PNH4 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual PNO3 Emissions – Low Level Sources

2028elv5



Difference (2028elv5 – 2028elv3)

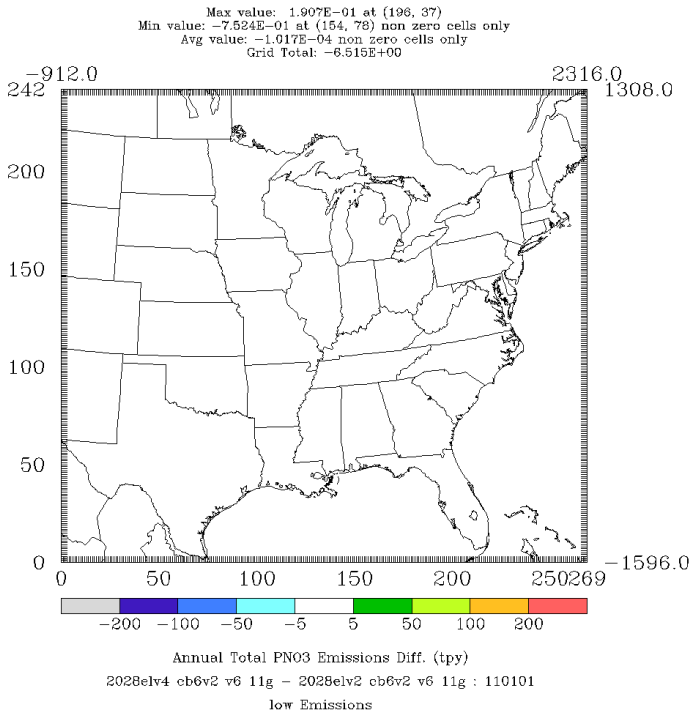
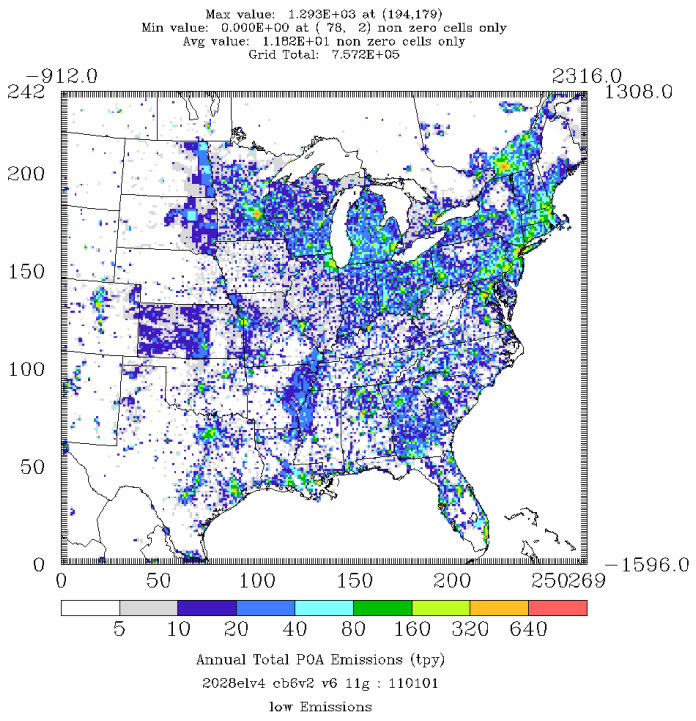


Figure 4-13. Comparison of Low Level PNO3 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual POA Emissions – Low Level Sources

2028elv5



Difference (2028elv5 – 2028elv3)

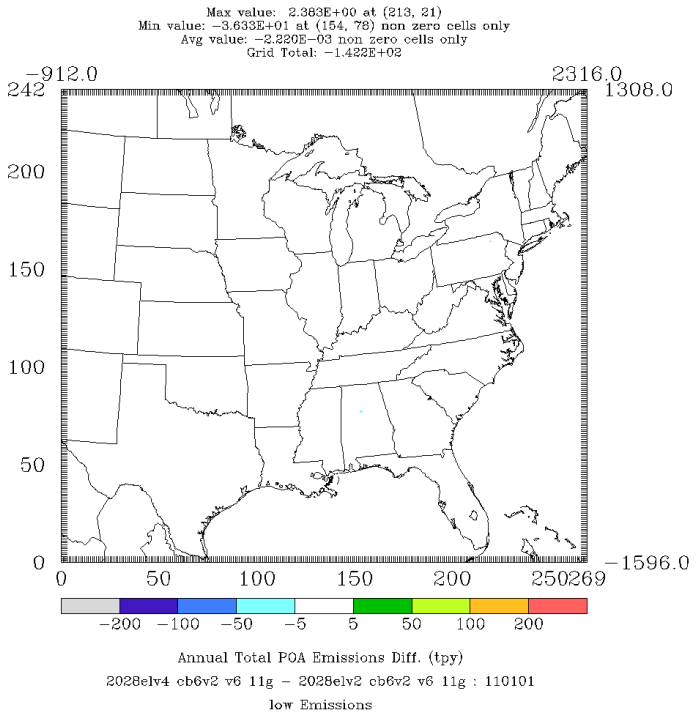
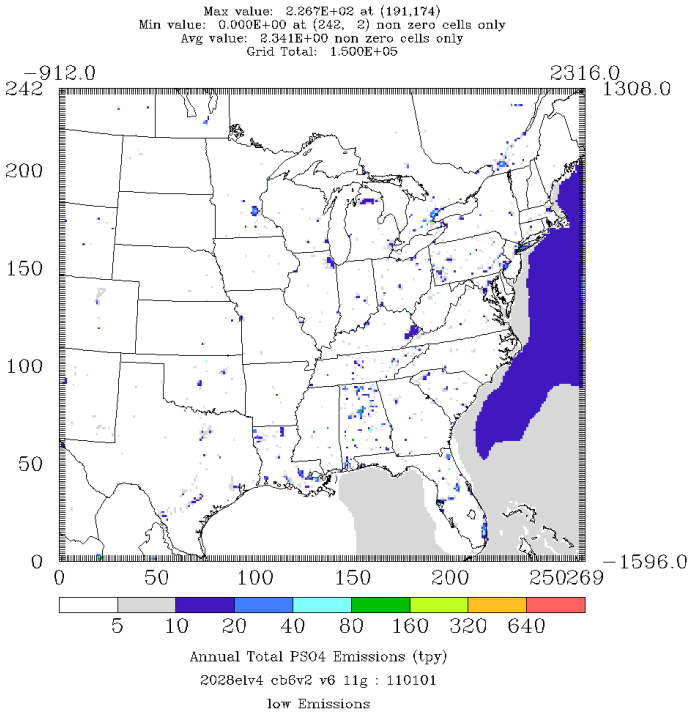


Figure 4-14. Comparison of Low Level POA Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

Annual PSO4 Emissions – Low Level Sources

2028elv5



Difference (2028elv5 – 2028elv3)

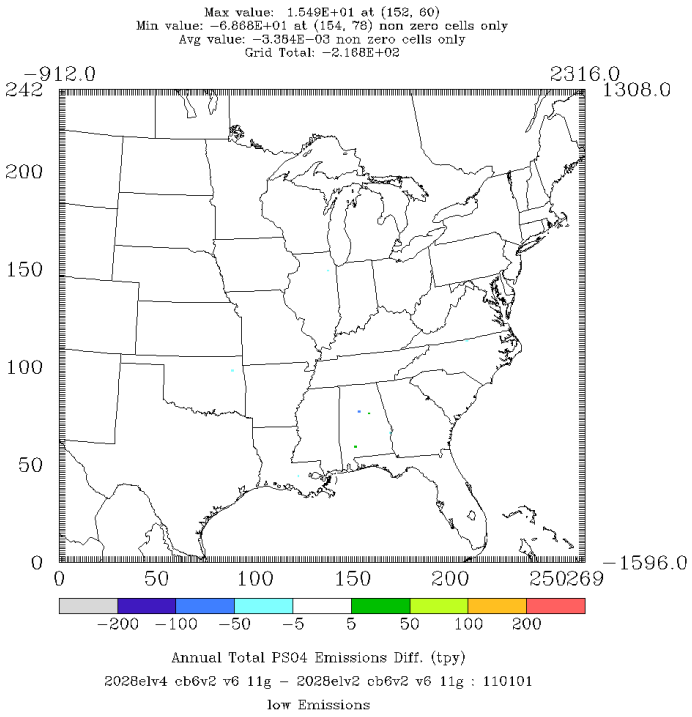


Figure 4-15. Comparison of Low Level PSO4 Emissions (tpy) for CAMx 2028elv5 and 2028elv3 Simulations

4.2 Annual $PM_{2.5}$ Design Value

Annual $PM_{2.5}$ design values were generated using the results of each individual CAMx simulation (version 6.40 with SESARM's 2028elv5 and modeled 2028elv3 emissions platforms) and the SMAT-CE tool. Results for each individual FRM monitor in the VISTAS states are presented in tabular format in Table 4-2 along with the absolute difference and percent difference in design value.

The maximum calculated decrease is 0.67 $\mu g/m^3$ at monitor 211010014 in Henderson, Kentucky (7% decrease between 2028elv3 and 2028elv5). No increases are calculated at any FRM monitor in the VISTAS states because of the move from 2028elv3 to 2028elv5. The average change in annual design value for all monitors in the VISTAS states is a decrease of 0.33 $\mu g/m^3$, with an average annual percent decrease of 4% at these same locations.

Geographic distribution of the 2028elv5 annual $PM_{2.5}$ design values and differences in design values compared to the modeled 2028elv3 simulation are presented in Figure 4-16. In the VISTAS12 domain, the largest annual $PM_{2.5}$ design value decreases are seen in areas consistent with the largest reduction in SO_2 and NO_X emissions between modeled 2028elv3 and 2020elv5. The smallest changes are seen on the boundaries of the VISTAS12 domain, consistent with not reprocessing the larger 12US2 region.

A scatterplot of the annual $PM_{2.5}$ design values for all FRM monitors in the VISTAS12 domain is presented in Figure 4-17. The CAMx 6.40 2028elv5 results are plotted on the x-axis and the 2028elv3 results are plotted on the y-axis. The data have a line of best fit with a slope of 1.0277, an intercept of 0.1346 $\mu g/m^3$and an R^2 of 0.9948. As expected, due to the lower emissions associated with the 2028elv5 platform compared to modeled 2028elv3, new 2028elv5 annual $PM_{2.5}$ design values are lower at all monitors across all concentration ranges.

Table 4-2. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Annual $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m³)			
			2028elv3	2028elv5	Difference	Percent Difference
010030010	Alabama	Baldwin	8.06	7.73	-0.33	-4%
010270001	Alabama	Clay	7.92	7.59	-0.33	-4%
010331002	Alabama	Colbert	8.37	8.03	-0.34	-4%
010491003	Alabama	DeKalb	8.52	8.21	-0.31	-4%
010550010	Alabama	Etowah	8.84	8.55	-0.29	-3%
010690003	Alabama	Houston	8.25	7.98	-0.27	-3%
010730023	Alabama	Jefferson	11.17	10.55	-0.62	-6%
010731005	Alabama	Jefferson	9.33	8.89	-0.44	-5%
010731009	Alabama	Jefferson	8.24	7.80	-0.44	-5%
010731010	Alabama	Jefferson	9.56	9.18	-0.38	-4%
010732003	Alabama	Jefferson	10.31	9.68	-0.63	-6%
010732006	Alabama	Jefferson	9.50	8.96	-0.54	-6%
010735002	Alabama	Jefferson	8.97	8.59	-0.38	-4%
010735003	Alabama	Jefferson	8.68	8.22	-0.46	-5%
010890014	Alabama	Madison	9.15	8.84	-0.31	-3%
010970003	Alabama	Mobile	8.17	7.80	-0.37	-5%
010972005	Alabama	Mobile	7.83	7.50	-0.33	-4%
011011002	Alabama	Montgomery	9.58	9.26	-0.32	-3%
011030011	Alabama	Morgan	8.73	8.40	-0.33	-4%
011130001	Alabama	Russell	10.17	9.86	-0.31	-3%
011170006	Alabama	Shelby	8.18	7.79	-0.39	-5%
011210002	Alabama	Talladega	9.14	8.77	-0.37	-4%
011250004	Alabama	Tuscaloosa	8.74	8.36	-0.38	-4%
011270002	Alabama	Walker	9.12	8.68	-0.44	-5%
120990008	Florida	Palm Beach	6.94	6.85	-0.09	-1%
120990009	Florida	Palm Beach	5.85	5.73	-0.12	-2%
130210007	Georgia	Bibb	10.60	10.32	-0.28	-3%
130210012	Georgia	Bibb	7.96	7.69	-0.27	-3%
130510091	Georgia	Chatham	8.54	8.31	-0.23	-3%
130590002	Georgia	Clarke	8.13	7.81	-0.32	-4%
130630091	Georgia	Clayton	9.43	9.11	-0.32	-3%
130670004	Georgia	Cobb	8.73	8.39	-0.34	-4%
130890002	Georgia	DeKalb	8.76	8.44	-0.32	-4%
130950007	Georgia	Dougherty	10.41	10.14	-0.27	-3%
131150003	Georgia	Floyd	9.48	9.13	-0.35	-4%

Table 4-2. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Annual $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m³)			
			2028elv3	2028elv5	Difference	Percent Difference
131210039	Georgia	Fulton	10.36	10.02	-0.34	-3%
131390003	Georgia	Hall	8.07	7.76	-0.31	-4%
131530001	Georgia	Houston	8.55	8.28	-0.27	-3%
132150001	Georgia	Muscogee	10.78	10.47	-0.31	-3%
132450005	Georgia	Richmond	9.27	9.01	-0.26	-3%
132450091	Georgia	Richmond	9.54	9.28	-0.26	-3%
132950002	Georgia	Walker	8.02	7.69	-0.33	-4%
133190001	Georgia	Wilkinson	9.97	9.71	-0.26	-3%
210130002	Kentucky	Bell	8.80	8.45	-0.35	-4%
210190017	Kentucky	Boyd	8.31	7.96	-0.35	-4%
210290006	Kentucky	Bullitt	9.32	8.83	-0.49	-5%
210373002	Kentucky	Campbell	7.61	7.20	-0.41	-5%
210430500	Kentucky	Carter	6.80	6.46	-0.34	-5%
210470006	Kentucky	Christian	8.39	7.91	-0.48	-6%
210590005	Kentucky	Daviess	9.25	8.64	-0.61	-7%
210670012	Kentucky	Fayette	7.97	7.52	-0.45	-6%
210930006	Kentucky	Hardin	8.4	7.90	-0.50	-6%
211010014	Kentucky	Henderson	8.96	8.29	-0.67	-7%
211110067	Kentucky	Jefferson	9.44	8.98	-0.46	-5%
211451004	Kentucky	McCracken	8.84	8.32	-0.52	-6%
211510003	Kentucky	Madison	6.97	6.54	-0.43	-6%
211950002	Kentucky	Pike	8.03	7.69	-0.34	-4%
212270008	Kentucky	Warren	8.83	8.40	-0.43	-5%
280330002	Mississippi	DeSoto	8.36	7.98	-0.38	-5%
280350004	Mississippi	Forrest	9.92	9.51	-0.41	-4%
280430001	Mississippi	Grenada	8.00	7.62	-0.38	-5%
280450003	Mississippi	Hancock	8.23	7.93	-0.30	-4%
280470008	Mississippi	Harrison	7.99	7.69	-0.30	-4%
280490010	Mississippi	Hinds	9.58	9.21	-0.37	-4%
280590006	Mississippi	Jackson	7.90	7.51	-0.39	-5%
280670002	Mississippi	Jones	10.1	9.71	-0.39	-4%
280750003	Mississippi	Lauderdale	9.20	8.79	-0.41	-4%
280810005	Mississippi	Lee	9.36	9.00	-0.36	-4%
370010002	North Carolina	Alamance	7.36	7.03	-0.33	-4%
370210034	North Carolina	Buncombe	6.97	6.65	-0.32	-5%

Table 4-2. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Annual $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m³)			
			2028elv3	2028elv5	Difference	Percent Difference
370330001	North Carolina	Caswell	6.57	6.23	-0.34	-5%
370350004	North Carolina	Catawba	7.98	7.67	-0.31	-4%
370370004	North Carolina	Chatham	6.07	5.74	-0.33	-5%
370510009	North Carolina	Cumberland	7.66	7.37	-0.29	-4%
370570002	North Carolina	Davidson	8.54	8.23	-0.31	-4%
370610002	North Carolina	Duplin	6.48	6.21	-0.27	-4%
370630015	North Carolina	Durham	7.00	6.67	-0.33	-5%
370650004	North Carolina	Edgecombe	6.66	6.35	-0.31	-5%
370670022	North Carolina	Forsyth	7.33	6.97	-0.36	-5%
370670030	North Carolina	Forsyth	7.34	6.99	-0.35	-5%
370710016	North Carolina	Gaston	7.78	7.49	-0.29	-4%
370810013	North Carolina	Guilford	6.97	6.62	-0.35	-5%
370810014	North Carolina	Guilford	7.14	6.78	-0.36	-5%
370870012	North Carolina	Haywood	7.86	7.59	-0.27	-3%
370990006	North Carolina	Jackson	7.15	6.87	-0.28	-4%
371010002	North Carolina	Johnston	6.70	6.40	-0.30	-4%
371070004	North Carolina	Lenoir	6.85	6.57	-0.28	-4%
371110004	North Carolina	McDowell	7.60	7.30	-0.30	-4%
371170001	North Carolina	Martin	6.39	6.08	-0.31	-5%
371190041	North Carolina	Mecklenburg	8.11	7.82	-0.29	-4%
371190042	North Carolina	Mecklenburg	8.45	8.17	-0.28	-3%
371190043	North Carolina	Mecklenburg	7.64	7.34	-0.30	-4%
371210001	North Carolina	Mitchell	7.19	6.91	-0.28	-4%
371230001	North Carolina	Montgomery	6.95	6.66	-0.29	-4%
371290002	North Carolina	New Hanover	5.61	5.37	-0.24	-4%
371470006	North Carolina	Pitt	6.29	6.00	-0.29	-5%
371550005	North Carolina	Robeson	7.51	7.23	-0.28	-4%
371590021	North Carolina	Rowan	7.85	7.55	-0.30	-4%
371730002	North Carolina	Swain	7.50	7.21	-0.29	-4%
371830014	North Carolina	Wake	7.89	7.58	-0.31	-4%
371830020	North Carolina	Wake	7.09	6.78	-0.31	-4%
371890003	North Carolina	Watauga	6.29	5.99	-0.30	-5%
371910005	North Carolina	Wayne	7.40	7.16	-0.24	-3%
450190048	South Carolina	Charleston	7.11	6.88	-0.23	-3%
450190049	South Carolina	Charleston	6.88	6.64	-0.24	-3%

Table 4-2. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Annual $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

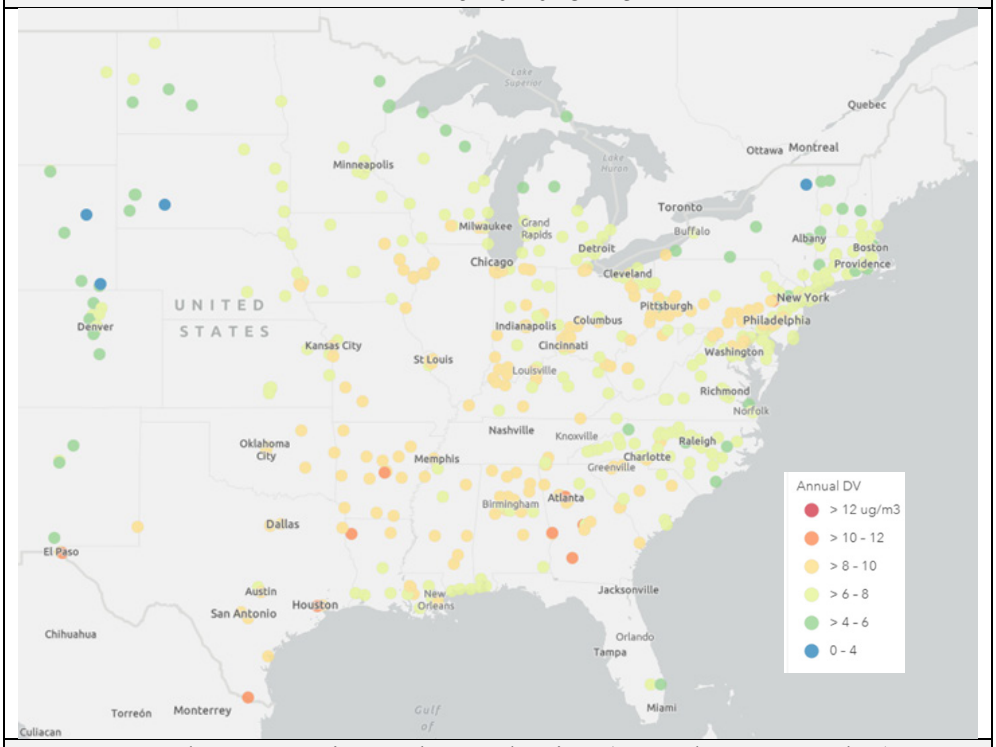
Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m³)			
			2028elv3	2028elv5	Difference	Percent Difference
450250001	South Carolina	Chesterfield	7.69	7.41	-0.28	-4%
450370001	South Carolina	Edgefield	8.03	7.76	-0.27	-3%
450410003	South Carolina	Florence	8.65	8.36	-0.29	-3%
450450009	South Carolina	Greenville	8.65	8.31	-0.34	-4%
450450015	South Carolina	Greenville	8.92	8.58	-0.34	-4%
450630008	South Carolina	Lexington	8.64	8.40	-0.24	-3%
450830011	South Carolina	Spartanburg	8.47	8.16	-0.31	-4%
470650031	Tennessee	Hamilton	8.55	8.20	-0.35	-4%
470651011	Tennessee	Hamilton	8.45	8.08	-0.37	-4%
470654002	Tennessee	Hamilton	8.30	7.92	-0.38	-5%
510030001	Virginia	Albemarle	6.67	6.34	-0.33	-5%
510360002	Virginia	Charles	6.57	6.24	-0.33	-5%
510410003	Virginia	Chesterfield	7.44	7.08	-0.36	-5%
510590030	Virginia	Fairfax	7.38	6.99	-0.39	-5%
510690010	Virginia	Frederick	8.19	7.78	-0.41	-5%
510870014	Virginia	Henrico	7.17	6.83	-0.34	-5%
510870015	Virginia	Henrico	6.76	6.41	-0.35	-5%
511071005	Virginia	Loudoun	7.57	7.20	-0.37	-5%
511390004	Virginia	Page	7.13	6.77	-0.36	-5%
511650003	Virginia	Rockingham	7.89	7.55	-0.34	-4%
515200006	Virginia	Bristol City	7.73	7.45	-0.28	-4%
516500008	Virginia	Hampton City	5.93	5.64	-0.29	-5%
516800015	Virginia	Lynchburg City	6.52	6.18	-0.34	-5%
517100024	Virginia	Norfolk City	7.04	6.75	-0.29	-4%
517700015	Virginia	Roanoke City	7.73	7.38	-0.35	-5%
517750011	Virginia	Salem City	7.50	7.15	-0.35	-5%
518100008	Virginia	Virginia Beach City	6.98	6.70	-0.28	-4%
540030003	West Virginia	Berkeley	9.38	8.96	-0.42	-4%
540090005	West Virginia	Brooke	9.59	9.08	-0.51	-5%
540110006	West Virginia	Cabell	9.10	8.74	-0.36	-4%
540291004	West Virginia	Hancock	8.73	8.23	-0.50	-6%
540390010	West Virginia	Kanawha	8.14	7.72	-0.42	-5%
540391005	West Virginia	Kanawha	9.27	8.83	-0.44	-5%
540490006	West Virginia	Marion	9.21	8.81	-0.40	-4%

Table 4-2. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Annual $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Annual $PM_{2.5}$ Design Value (µg/m^3)			
			2028elv3	2028elv5	Difference	Percent Difference
540511002	West Virginia	Marshall	10.03	9.58	-0.45	-4%
540610003	West Virginia	Monongalia	8.08	7.64	-0.44	-5%
540690010	West Virginia	Ohio	8.72	8.22	-0.50	-6%
540810002	West Virginia	Raleigh	6.99	6.61	-0.38	-5%
541071002	West Virginia	Wood	9.12	8.73	-0.39	-4%

Annual $PM_{2.5}$ Design Value – VISTAS12 Domain

CAMx 6.40 2028elv5



Annual $PM_{2.5}$ Design Value Reduction (2028elv3 – 2028elv5)

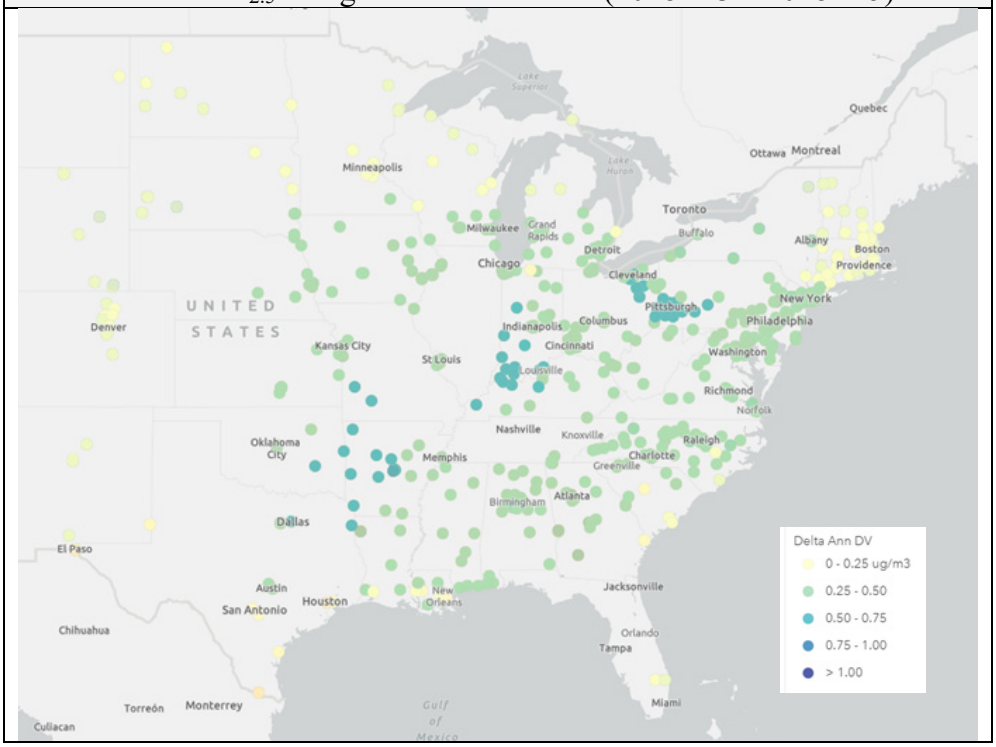


Figure 4-16. Comparison of Annual $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.40 2028elv5 and 2028elv3 Simulations

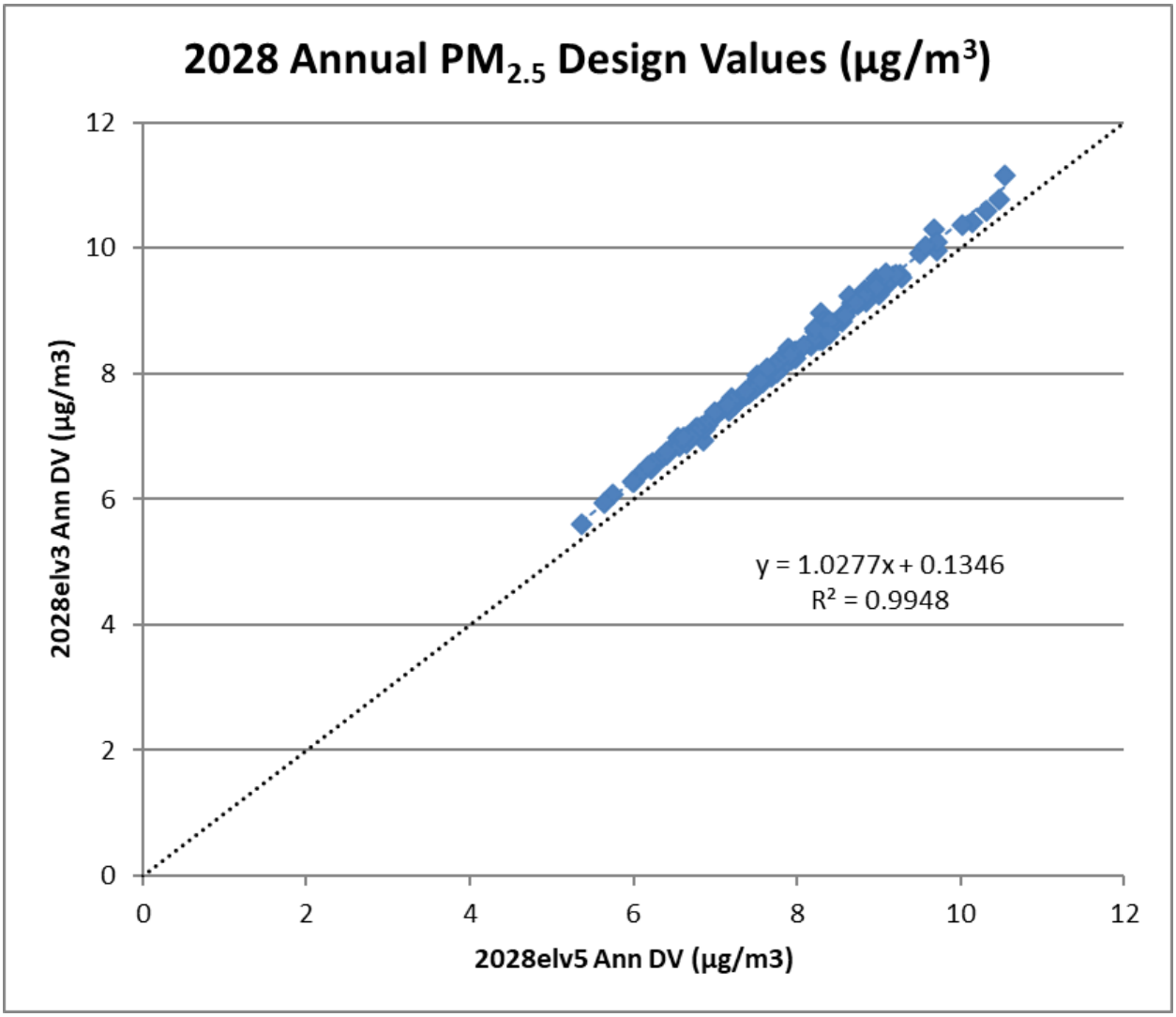


Figure 4-17. Scatterplot Comparing Annual Average Predicted $PM_{2.5}$ Design Values ($\mu g/m^3$) at all Monitor Locations for CAMx 6.40 2028elv3 and 2028elv5 Simulations Performed by VISTAS (Alpine)

4.3 24-Hour (Daily) $PM_{2.5}$ Design Value

Daily $PM_{2.5}$ design values were generated using the results of each individual CAMx simulation (version 6.40 with SESARM's 2028 elv5 and modeled 2028elv3 emissions platform) and the SMAT-CE tool. Results for each individual FRM monitor in the VISTAS states are presented in tabular format in Table 4-3 along with the absolute difference and percent difference in design value.

The maximum calculated decrease is 2.4 $\mu g/m^3$ at monitor 010732003 in Jefferson, Alabama (11% decrease going from 2028elv3 to 2028elv5). No increases are calculated at any FRM monitor in the VISTAS states because of the move from 2028elv3 to 2028elv5. The average change in annual design value for all monitors in the VISTAS states is a decrease of 0.7 $\mu g/m^3$, with an average annual percent decrease of 4% at these same locations.

Geographic distribution of the 6.40 2028elv5 daily $PM_{2.5}$ design values and reductions in design values compared to the modeled 2028elv3 simulation are presented in Figure 4-18. Daily $PM_{2.5}$ design values have widespread change throughout the VISTAS12 modeling domain with the smallest daily design value changes seen along the western border of the region.

A scatterplot of the daily $PM_{2.5}$ design values for all FRM monitors in the VISTAS12 domain is presented in Figure 4-19. The CAMx 6.40 2028elv5 results are plotted on the x-axis and the modeled 2028elv3 results are plotted on the y-axis. The data has a slope of 0.9977, an intercept of 0.688 $\mu g/m^3$ and an R^2 of 0.9854. 2028elv5 concentrations are lower compared to modeled 2028elv3 across all concentration ranges which is consistent with the change in emissions between the two platforms.

Table 4-3. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m³) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m³)			
			2028elv3	2028elv5	Difference	Percent Difference
10030010	Alabama	Baldwin	15.9	15.3	-0.6	-4%
10270001	Alabama	Clay	17.2	16.6	-0.6	-3%
10331002	Alabama	Colbert	16.2	15.7	-0.5	-3%
10491003	Alabama	DeKalb	17.1	16.5	-0.6	-4%
10550010	Alabama	Etowah	17.7	17.3	-0.4	-2%
10690003	Alabama	Houston	17.0	16.7	-0.3	-2%
10730023	Alabama	Jefferson	22.9	22.3	-0.6	-3%
10731005	Alabama	Jefferson	17.8	16.9	-0.9	-5%
10731009	Alabama	Jefferson	17.8	16.9	-0.9	-5%
10731010	Alabama	Jefferson	18.3	17.7	-0.6	-3%
10732003	Alabama	Jefferson	21.2	18.8	-2.4	-11%
10732006	Alabama	Jefferson	18.6	17.9	-0.7	-4%
10735002	Alabama	Jefferson	17.4	16.7	-0.7	-4%
10735003	Alabama	Jefferson	17.7	16.9	-0.8	-5%
10890014	Alabama	Madison	18.6	18.1	-0.5	-3%
10970003	Alabama	Mobile	16.1	15.5	-0.6	-4%
10972005	Alabama	Mobile	16.7	16.0	-0.7	-4%
11011002	Alabama	Montgomery	19.9	19.4	-0.5	-3%
11030011	Alabama	Morgan	16.5	15.8	-0.7	-4%
11130001	Alabama	Russell	23.4	23.0	-0.4	-2%
11170006	Alabama	Shelby	15.8	15.1	-0.7	-4%
11210002	Alabama	Talladega	18.5	18.0	-0.5	-3%
11250004	Alabama	Tuscaloosa	19.0	18.4	-0.6	-3%
11270002	Alabama	Walker	17.8	17.0	-0.8	-4%
120990008	Florida	Palm Beach	15.7	15.5	-0.2	-1%
120990009	Florida	Palm Beach	13.6	13.4	-0.2	-1%
130210007	Georgia	Bibb	22.1	21.6	-0.5	-2%
130210012	Georgia	Bibb	17.9	17.5	-0.4	-2%
130510017	Georgia	Chatham	24.3	23.7	-0.6	-2%
130510091	Georgia	Chatham	24.4	23.8	-0.6	-2%
130590002	Georgia	Clarke	17.6	17.1	-0.5	-3%
130670004	Georgia	Cobb	17.1	16.5	-0.6	-4%
130890002	Georgia	DeKalb	17.2	16.7	-0.5	-3%
130950007	Georgia	Dougherty	24.3	24.0	-0.3	-1%
131390003	Georgia	Hall	16.5	15.9	-0.6	-4%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			2028elv3	2028elv5	Difference	Percent Difference
131530001	Georgia	Houston	19.5	19.1	-0.4	-2%
132950002	Georgia	Walker	17.2	16.8	-0.4	-2%
133190001	Georgia	Wilkinson	20.2	19.8	-0.4	-2%
210130002	Kentucky	Bell	20.6	20.2	-0.4	-2%
210190017	Kentucky	Boyd	17.8	17.1	-0.7	-4%
210373002	Kentucky	Campbell	16.0	15.1	-0.9	-6%
210430500	Kentucky	Carter	14.9	14.3	-0.6	-4%
210470006	Kentucky	Christian	15.8	14.7	-1.1	-7%
210590005	Kentucky	Daviess	19.9	18.3	-1.6	-8%
210670012	Kentucky	Fayette	16.2	15.3	-0.9	-6%
210930006	Kentucky	Hardin	17.0	16.1	-0.9	-5%
211010014	Kentucky	Henderson	18.5	16.7	-1.8	-10%
211110067	Kentucky	Jefferson	20.4	19.4	-1.0	-5%
211451004	Kentucky	McCracken	17.0	15.8	-1.2	-7%
211510003	Kentucky	Madison	14.3	13.5	-0.8	-6%
211950002	Kentucky	Pike	18.1	17.4	-0.7	-4%
212270008	Kentucky	Warren	16.3	15.3	-1.0	-6%
280330002	Mississippi	DeSoto	15.9	15.2	-0.7	-4%
280350004	Mississippi	Forrest	19.5	19.0	-0.5	-3%
280430001	Mississippi	Grenada	15.8	14.9	-0.9	-6%
280450003	Mississippi	Hancock	18.3	17.9	-0.4	-2%
280470008	Mississippi	Harrison	15.1	14.8	-0.3	-2%
280490010	Mississippi	Hinds	18.5	17.9	-0.6	-3%
280590006	Mississippi	Jackson	17.6	16.9	-0.7	-4%
280670002	Mississippi	Jones	20.3	19.8	-0.5	-2%
280750003	Mississippi	Lauderdale	18.6	17.9	-0.7	-4%
280810005	Mississippi	Lee	17.4	16.6	-0.8	-5%
370010002	North Carolina	Alamance	15.2	14.6	-0.6	-4%
370210034	North Carolina	Buncombe	13.5	12.9	-0.6	-4%
370330001	North Carolina	Caswell	12.8	12.4	-0.4	-3%
370350004	North Carolina	Catawba	16.4	16.1	-0.3	-2%
370370004	North Carolina	Chatham	13.0	12.3	-0.7	-5%
370510009	North Carolina	Cumberland	17.0	16.6	-0.4	-2%
370570002	North Carolina	Davidson	15.9	15.5	-0.4	-3%
370610002	North Carolina	Duplin	14.4	14.0	-0.4	-3%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			2028elv3	2028elv5	Difference	Percent Difference
370630015	North Carolina	Durham	13.9	13.5	-0.4	-3%
370650004	North Carolina	Edgecombe	14.7	14.1	-0.6	-4%
370670022	North Carolina	Forsyth	15.3	14.8	-0.5	-3%
370670030	North Carolina	Forsyth	14.8	14.5	-0.3	-2%
370710016	North Carolina	Gaston	16.4	15.8	-0.6	-4%
370810013	North Carolina	Guilford	16.1	15.6	-0.5	-3%
370810014	North Carolina	Guilford	14.4	13.9	-0.5	-3%
370870012	North Carolina	Haywood	18.8	18.4	-0.4	-2%
370990006	North Carolina	Jackson	13.8	13.4	-0.4	-3%
371010002	North Carolina	Johnston	14.1	13.6	-0.5	-4%
371070004	North Carolina	Lenoir	15.8	15.0	-0.8	-5%
371110004	North Carolina	McDowell	15.4	14.9	-0.5	-3%
371170001	North Carolina	Martin	17.3	16.3	-1.0	-6%
371190041	North Carolina	Mecklenburg	17.5	17.0	-0.5	-3%
371190042	North Carolina	Mecklenburg	17.9	17.4	-0.5	-3%
371190043	North Carolina	Mecklenburg	15.2	14.8	-0.4	-3%
371210001	North Carolina	Mitchell	13.8	13.3	-0.5	-4%
371230001	North Carolina	Montgomery	14.9	14.4	-0.5	-3%
371290002	North Carolina	New Hanover	15.9	15.2	-0.7	-4%
371470006	North Carolina	Pitt	15.4	14.8	-0.6	-4%
371550005	North Carolina	Robeson	16.9	16.3	-0.6	-4%
371590021	North Carolina	Rowan	15.3	14.9	-0.4	-3%
371730002	North Carolina	Swain	15.6	15.0	-0.6	-4%
371830014	North Carolina	Wake	17.4	16.8	-0.6	-3%
371830020	North Carolina	Wake	14.4	13.9	-0.5	-3%
371890003	North Carolina	Watauga	13.0	12.5	-0.5	-4%
371910005	North Carolina	Wayne	15.8	15.4	-0.4	-3%
450190048	South Carolina	Charleston	16.3	15.8	-0.5	-3%
450190049	South Carolina	Charleston	15.9	15.3	-0.6	-4%
450250001	South Carolina	Chesterfield	15.5	15.1	-0.4	-3%
450370001	South Carolina	Edgefield	16.9	16.3	-0.6	-4%
450410003	South Carolina	Florence	18.4	18.0	-0.4	-2%
450450009	South Carolina	Greenville	18.1	17.6	-0.5	-3%
450450015	South Carolina	Greenville	19.3	19.0	-0.3	-2%
450630008	South Carolina	Lexington	19.0	18.6	-0.4	-2%

Table 4-3. Comparison of CAMx 6.40 2028elv3 and 2028elv5 Predicted Daily (24-Hour) $PM_{2.5}$ Design Values (µg/m^3) for FRM Monitors in VISTAS States

Monitor	State	County	2028 Daily (24-Hr) $PM_{2.5}$ Design Value (µg/m^3)			
			2028elv3	2028elv5	Difference	Percent Difference
450790019	South Carolina	Richland	19.4	18.9	-0.5	-3%
450830011	South Carolina	Spartanburg	17.4	16.8	-0.6	-3%
470650031	Tennessee	Hamilton	18.6	18.0	-0.6	-3%
470651011	Tennessee	Hamilton	17.0	16.4	-0.6	-4%
470654002	Tennessee	Hamilton	16.7	16.3	-0.4	-2%
510030001	Virginia	Albemarle	13.8	12.8	-1.0	-7%
510360002	Virginia	Charles	13.9	12.9	-1.0	-7%
510410003	Virginia	Chesterfield	15.5	14.8	-0.7	-5%
510590030	Virginia	Fairfax	18.0	17.3	-0.7	-4%
510690010	Virginia	Frederick	18.6	17.9	-0.7	-4%
510870014	Virginia	Henrico	16.1	15.3	-0.8	-5%
510870015	Virginia	Henrico	14.1	13.1	-1.0	-7%
511071005	Virginia	Loudoun	16.5	16.1	-0.4	-2%
511390004	Virginia	Page	16.1	15.0	-1.1	-7%
511650003	Virginia	Rockingham	17.7	17.2	-0.5	-3%
515200006	Virginia	Bristol City	16.2	15.6	-0.6	-4%
516500008	Virginia	Hampton City	14.9	14.0	-0.9	-6%
516800015	Virginia	Lynchburg City	13.9	13.2	-0.7	-5%
517100024	Virginia	Norfolk City	15.7	14.9	-0.8	-5%
517700015	Virginia	Roanoke City	16.9	16.2	-0.7	-4%
517750011	Virginia	Salem City	15.0	14.4	-0.6	-4%
518100008	Virginia	Virginia Beach City	16.8	16.3	-0.5	-3%
540030003	West Virginia	Berkeley	23.5	22.8	-0.7	-3%
540090005	West Virginia	Brooke	19.2	18.3	-0.9	-5%
540110006	West Virginia	Cabell	18.8	18.0	-0.8	-4%
540291004	West Virginia	Hancock	20.5	19.5	-1.0	-5%
540390010	West Virginia	Kanawha	17.0	16.1	-0.9	-5%
540391005	West Virginia	Kanawha	18.6	17.9	-0.7	-4%
540490006	West Virginia	Marion	19.3	18.6	-0.7	-4%
540511002	West Virginia	Marshall	23.3	22.6	-0.7	-3%
540610003	West Virginia	Monongalia	17.1	16.4	-0.7	-4%
540690010	West Virginia	Ohio	17.9	17.0	-0.9	-5%
540810002	West Virginia	Raleigh	14.3	13.5	-0.8	-6%
541071002	West Virginia	Wood	18.6	17.7	-0.9	-5%

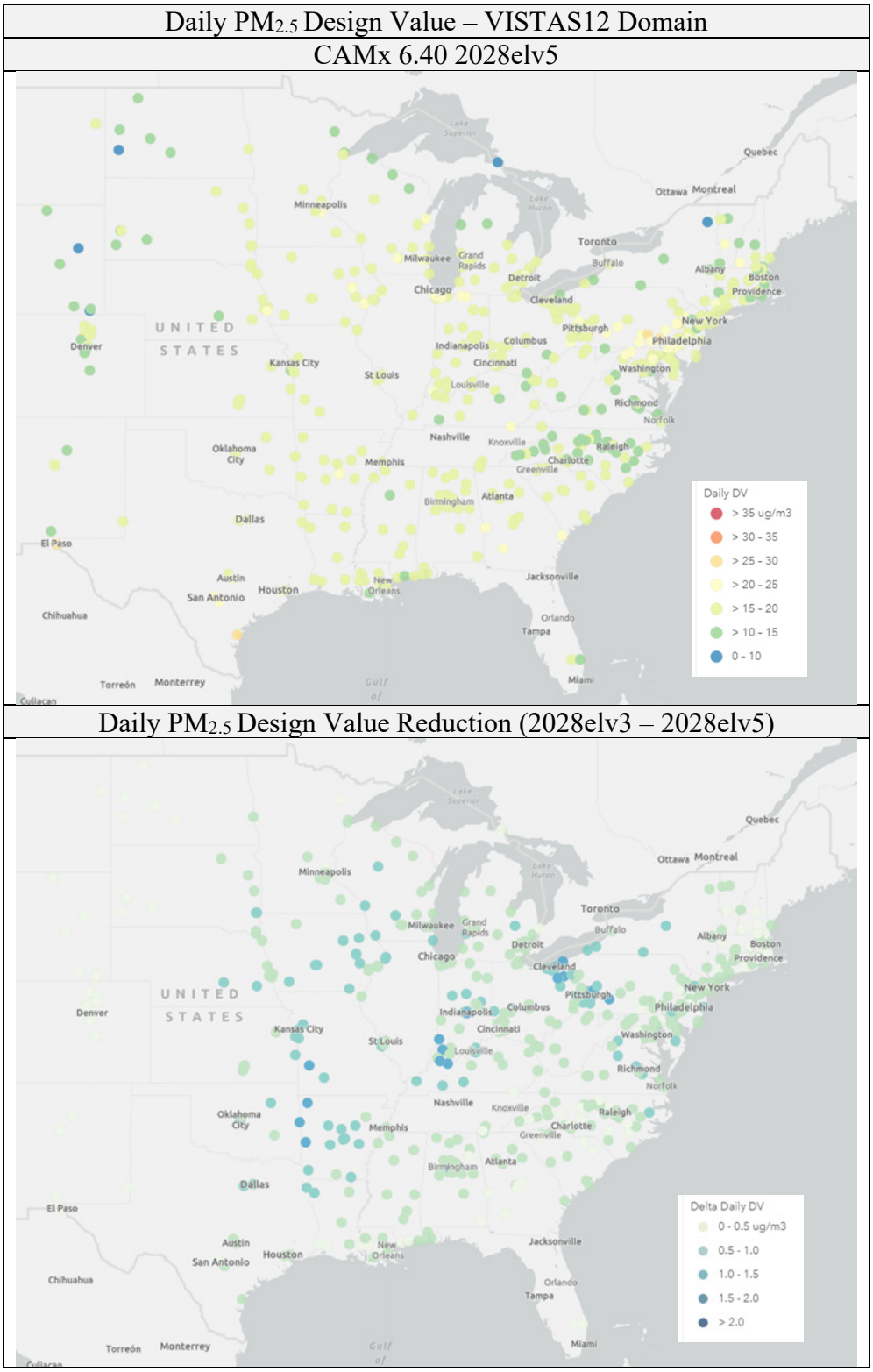


Figure 4-18. Comparison of Daily $PM_{2.5}$ Design Values ($\mu g/m^3$) for CAMx 6.40 2028elv5 and 2028elv3 Simulations

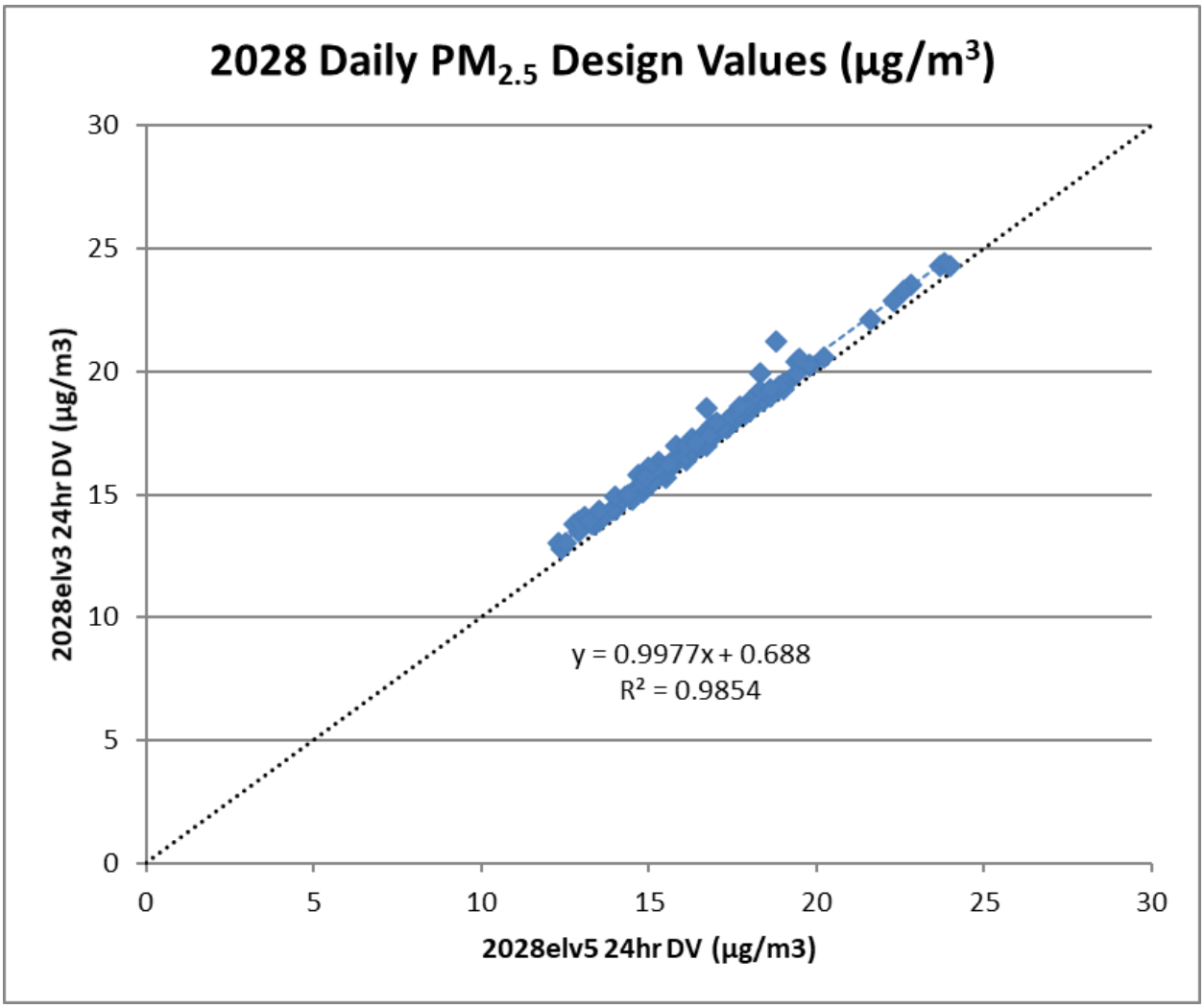


Figure 4-19. Scatterplot Comparing Daily (24-hr) Average Predicted $PM_{2.5}$ Design Values ($\mu g/m^3$) at all Monitor Locations for CAMx 6.40 2028elv3 and 2028elv5 Simulations Performed by VISTAS (Alpine)

4.4 Scatterplots of Ozone and PM Species Concentrations

Scatterplots of the daily average concentrations of ozone and the various calculated PM species in local standard time at the Interagency Monitoring for Protected Visual Environment (IMPROVE) monitors across all modeled days are presented in Figures 4-20 through 4-26. The CAMx 6.40 20282elv5 results are plotted on the x-axis and the 2028elv3 results are plotted on the y-axis.

Figure 4-20 exhibits concentrations for ozone with a line of best fit with a slope of 1.0147, an intercept of -0.3588 ppb and an R^2 of 0.9986. Results are scattered both above and below the 1:1 line, with marginally higher concentrations estimated by CAMx 6.40 2028elv3 across the concentration range.

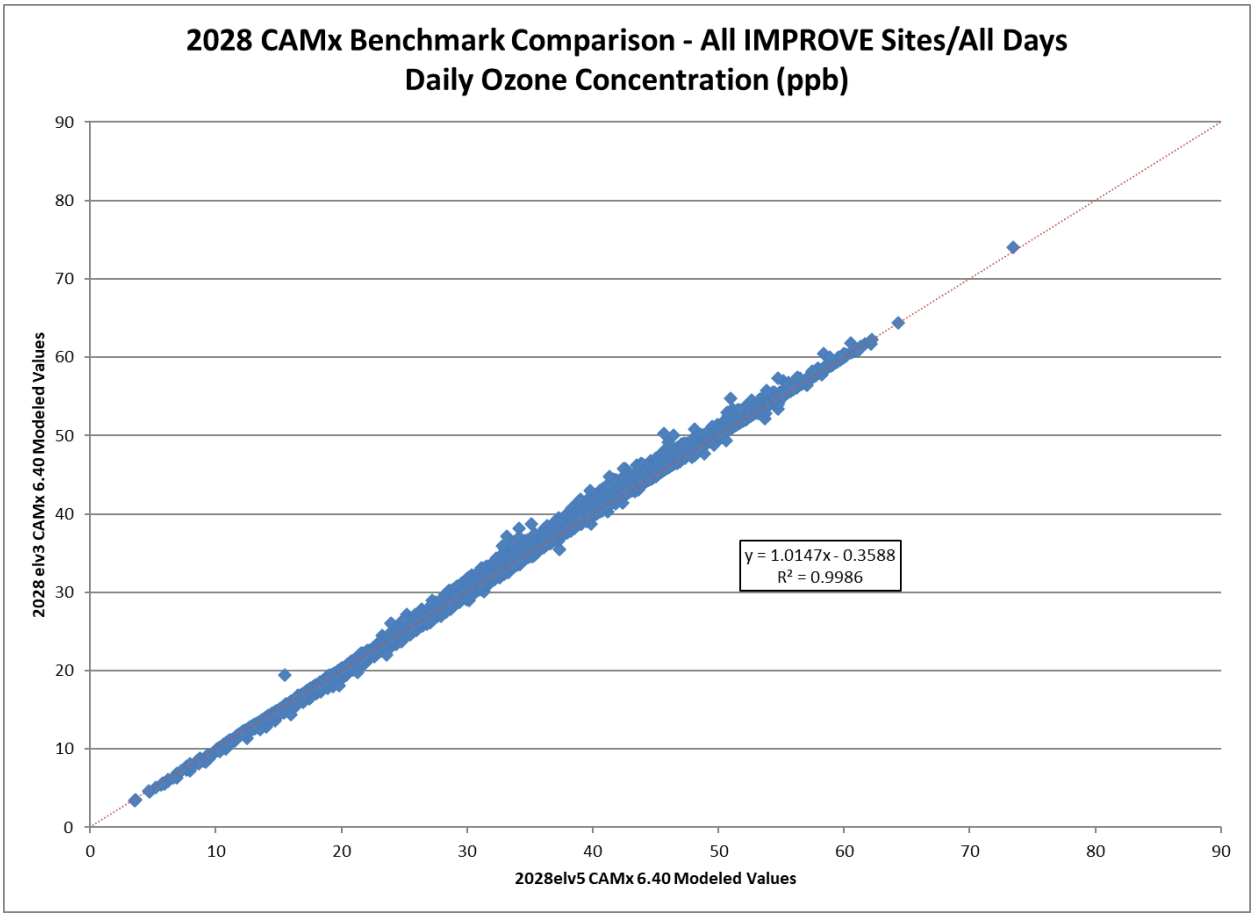


Figure 4-20. Scatterplot Comparing 24-hour Average Predicted Ozone Concentrations (ppb) for All Days at all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average $PM_{2.5}$ concentrations in local standard time at the IMPROVE monitors are presented in Figures 4-21 and 4-22 with different axis scaling to facilitate analysis over the full range of concentrations. The CAMx 6.40 2028elv5 results are plotted on the x-axis and the 2028elv3 results are plotted on the y-axis. The data has a line of best fit with a slope of 1.0197, an intercept of 0.0652 $\mu g/m^3$and an R^2 of 0.9978. As expected with the change in emissions, 2028elv5 predicts lower concentrations across most locations in the domain although a few sites at lower concentrations (< 20 $\mu g/m^3$) show significantly higher concentrations with 2028elv5. These are largely associated with increased NO_X (and NO_3) emissions from changes made in the 2028elv5 inventory compared to modeled 2028elv3.

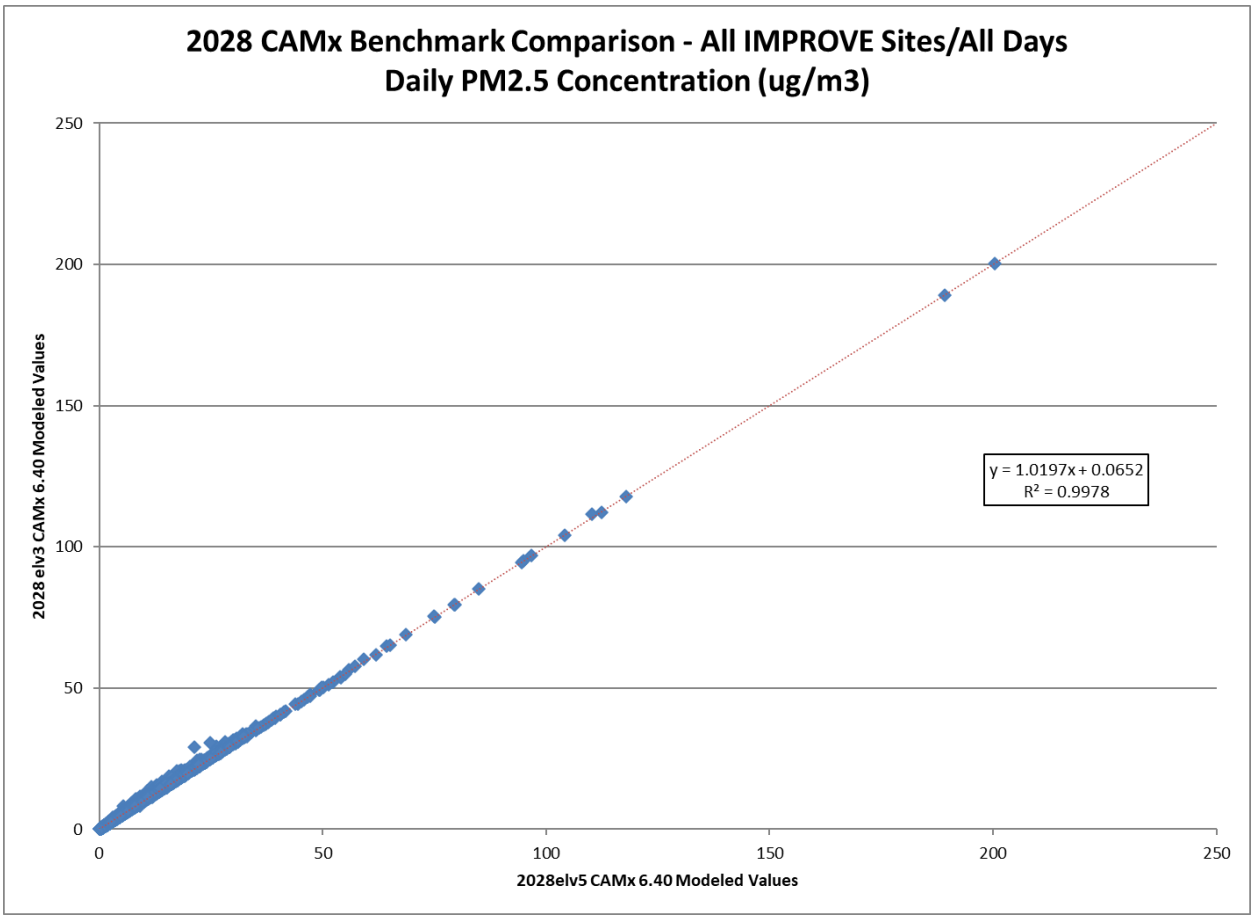


Figure 4-21. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)

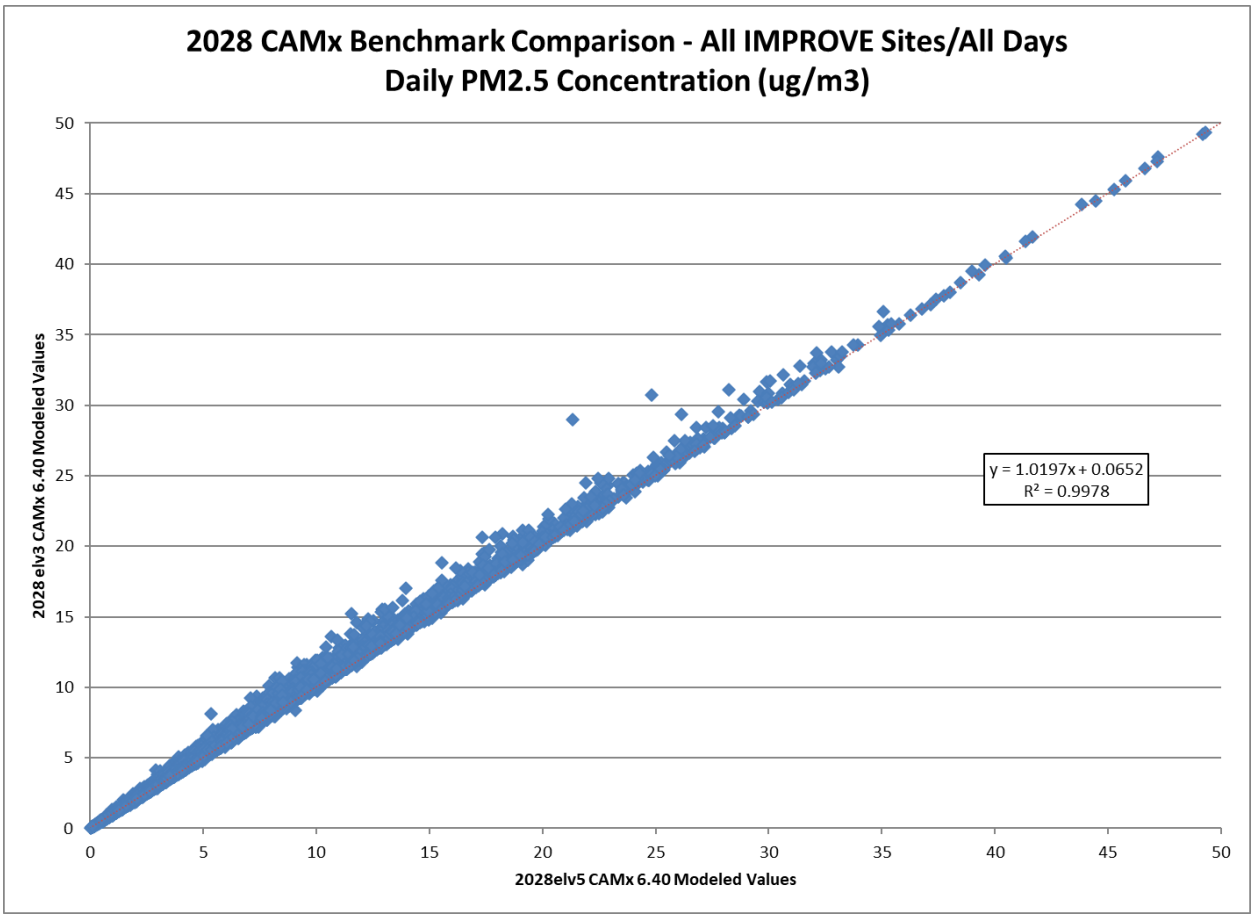


Figure 4-22. Scatterplot Comparing 24-hour Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine); Modified Scale

Scatterplots of the daily average sulfate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-23. The CAMx 6.40 2028elv5 results are plotted on the x-axis and the 2028elv3 results are plotted on the y-axis. The data have a line of best fit with a slope of 1.156, an intercept of -0.0317 µg/m^3 and an R^2 of 0.9572. As expected with the change in emissions, 2028elv5 predicts lower concentrations across most locations.

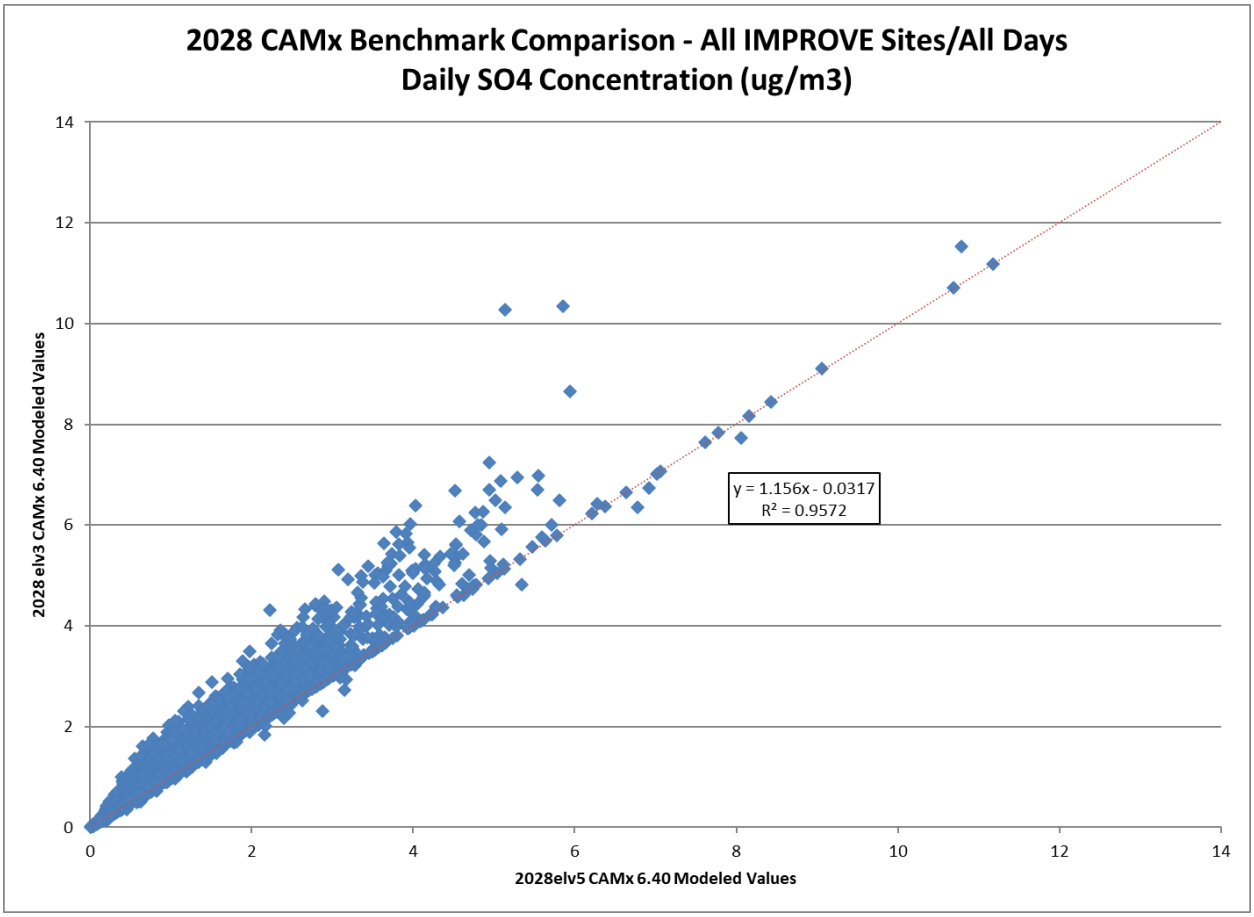


Figure 4-23. Scatterplot Comparing 24-hour Average Predicted Sulfate Concentrations (µg/m^3) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average nitrate concentrations in local standard time at the IMPROVE monitors are presented in Figure 4-24. The CAMx 6.40 2028elv5 results are plotted on the x-axis and the 2028elv3 results are plotted on the y-axis. The data have a line of best fit with a slope of 1.0141, an intercept of -0.0007 µg/m^3 and an R^2 of 0.9975. As expected with the change in NOx emissions, 2028elv5 predicts lower concentrations across many locations. However, many other locations show higher nitrate concentrations. This is likely due to the decrease in sulfate formation (see Figure 4-23) resulting in more available free ammonia that can be used to form additional ammonium nitrate.

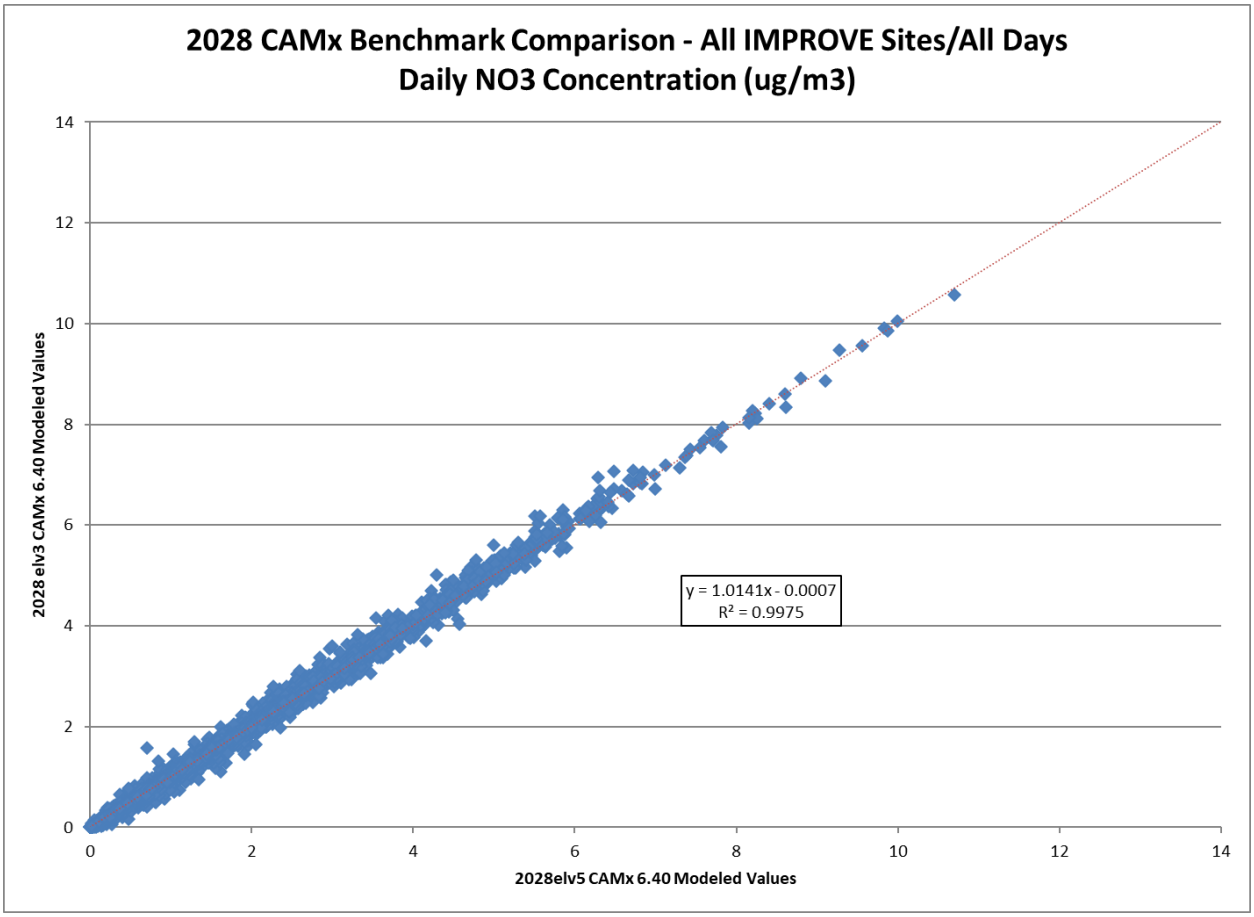


Figure 4-24. Scatterplot Comparing 24-hour Average Predicted Nitrate Concentrations (µg/m^3) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)

Scatterplots of the daily average organic carbon concentrations in local standard time at the IMPROVE monitors are presented in Figures 4-24 and 4-25 with different axis scaling to facilitate analysis over the full range of concentrations. The CAMx 6.40 2028elv5 results are plotted on the x-axis and the 2028elv3 results are plotted on the y-axis. The data have a line of best fit with a slope of 1.0012, an intercept of 0.0017 ppb and an R^2 of 1.000. The two simulations show nearly identical results for organic carbon.

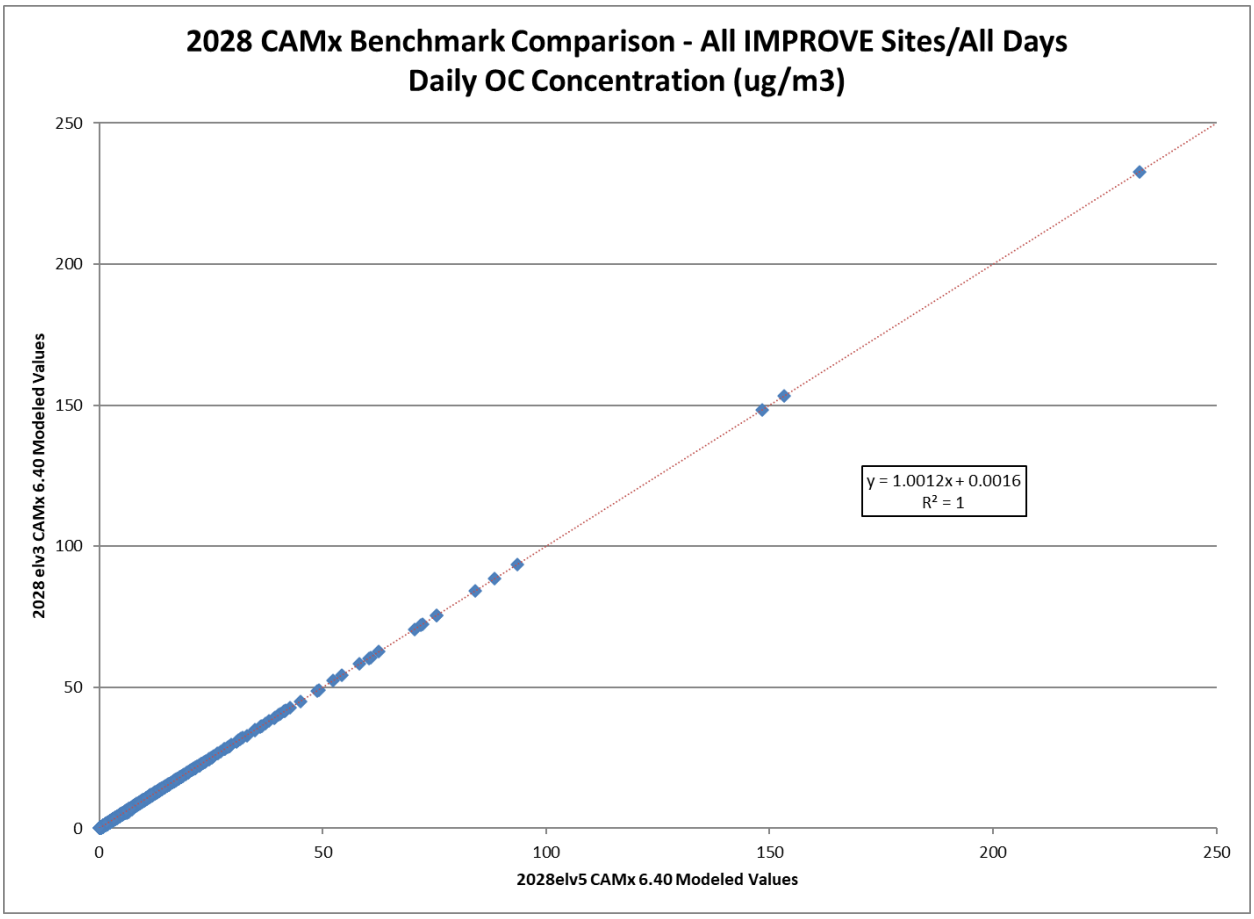


Figure 4-25. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine)

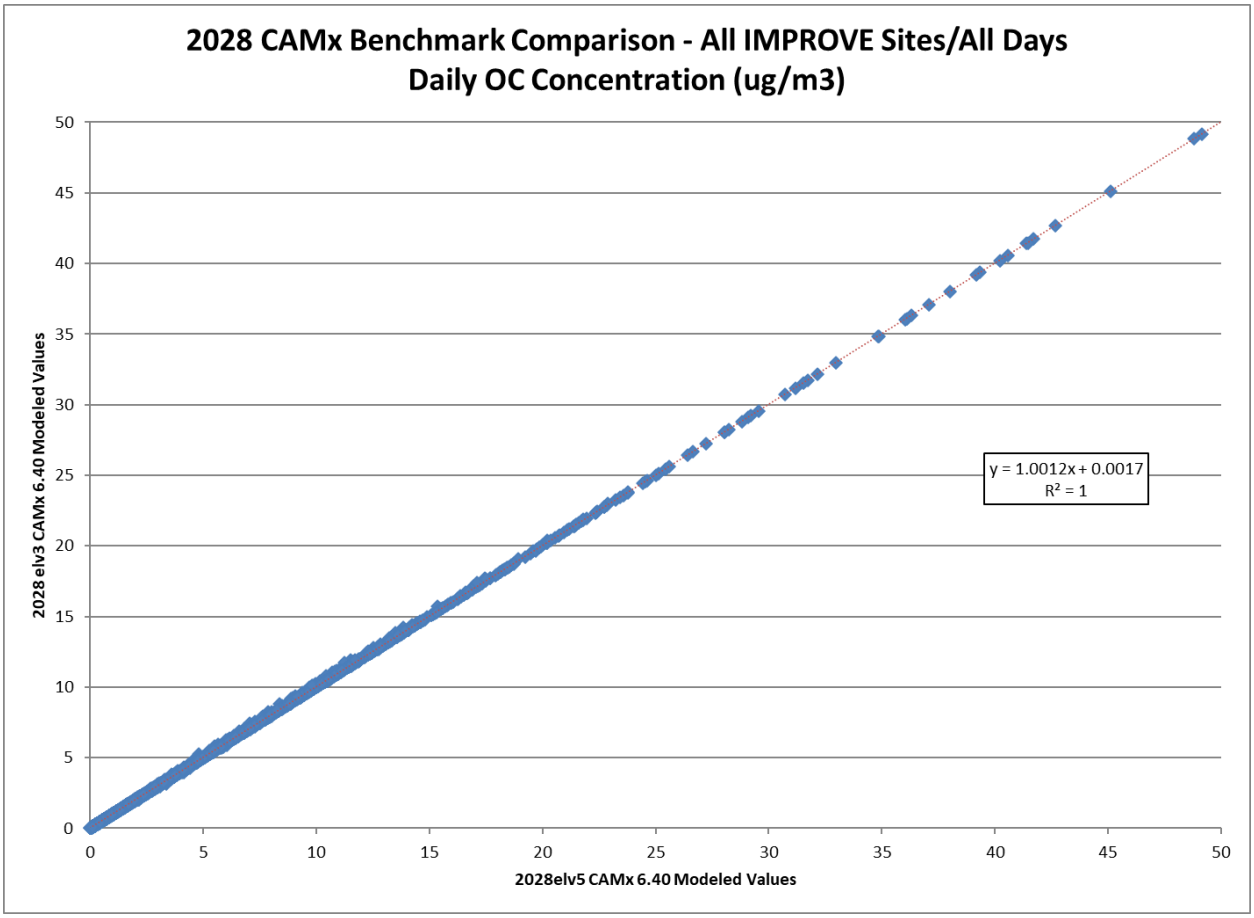


Figure 4-26. Scatterplot Comparing 24-hour Average Predicted Organic Carbon Concentrations (µg/m^3) for All Days all IMPROVE Monitor Locations for CAMx 6.40 2028elv5 and 2028elv3 Simulations Performed by VISTAS (Alpine); Modified Scale

5.0 CONCLUSIONS

A comparison has been made between modeled CAMx 6.40 2028elv5 and 2028elv3 simulations as performed on the Alpine Geophysics computer system. The comparison was conducted for $PM_{2.5}$ and included an examination both of annual emissions for elevated and low level sources and annual and daily future year design values at monitors in the modeling domain.

The annual emissions comparisons showed areas of differences across the domain that are consistent with changes in the modeled 2028 emissions inventories used for this analysis. A comparison of the annual and daily $PM_{2.5}$ design values at the monitors in the VISTAS12 modeling domain showed a systematic decrease for all FRM monitors for both values between the modeled 2028elv3 and 2028elv5 platforms. The greatest change in design values are seen in the central regions of the VISTAS12 modeling domain with smallest change noted along the borders of the domain itself.

A comparison of the daily average concentrations at the IMPROVE monitors showed fairly small differences for ozone between the two simulations with CAMx 6.40 2028elv5 estimating slightly lower values across most of the concentration range. Because of the changes in emissions between the modeled 2028elv3 and 2028elv5 modeling platforms, $PM_{2.5}$ and sulfate generally decreased. Nitrate concentrations showed decreases at some sites and increases at others. Organic carbon concentrations are nearly identical with the modeled 2028elv3 and 2028elv5 emissions.

The comparison of modeled CAMx 6.40 2028elv3 and 2028elv5 showed differences in both annual and daily $PM_{2.5}$ design values as well as in daily concentrations of various $PM_{2.5}$ species. This is to be expected given the changes made in the modeled 2028 projection emission inventory across the modeling domain. Alpine Geophysics does not see any features in the modeling that would preclude the use of the updated emission inventories in CAMx 6.40 2028elv5 platform for use in the VISTAS air quality planning.

Appendix A

Task 6 – Benchmark Run #7 Report Review and 2028 elv3 Reassessment

(see APP_A_ELV3_REASSESSMENT.zip)

This page is intentionally left blank.

Appendix E-3

Model Performance Evaluation for Particulate Matter and Regional Haze of the CAMx 6.40 Modeling System and the VISTAS II 2011 Updated Modeling Platform

October 29, 2020

This page intentionally left blank.

Model Performance Evaluation for Particulate Matter and Regional Haze of the CAMx 6.40 Modeling System and the VISTAS II 2011 Updated Modeling Platform for Task 8.0

Prepared for:
Southeastern States Air Resource Managers, Inc.
1252 W. Government St., #1375
Brandon, MS 39043

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final – October 29, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 Introduction 1

2.0 Model Performance Evaluation 5
- 2.1 Graphical Presentations 7
- 2.2 Ambient Measurement Networks 14
  - 2.2.1 Ambient Air Quality Observations 14
  - 2.2.2 IMPROVE 15
  - 2.2.3 CASTNET 15
  - 2.2.4 CSN 16
- 2.3 CAMx Species Mapping 16
- 2.4 Summary and Comparison to EPA MPE Results 17

3.0 $PM_{2.5}$ Sulfate 18

4.0 $PM_{2.5}$ Nitrate 25

5.0 $PM_{2.5}$ Ammonium 32

6.0 $PM_{2.5}$ OC 38

7.0 $PM_{2.5}$ EC 43

8.0 Total $PM_{2.5}$ 48

9.0 Performance on 20% Most-Impaired Days 53

10.0 $PM_{2.5}$ Composition and Contributions to Light Extinction 60

Appendix A VISTAS12 Modeling Domain Model Performance Metrics by Network, Station, Pollutant, and Season

Appendix A-1 VISTAS12 Modeling Domain CASTNET Model Performance Metrics by Station, Pollutant, and Season

Appendix A-2 VISTAS12 Modeling Domain CSN Model Performance Metrics by Station, Pollutant, and Season

Appendix A-3 VISTAS12 Modeling Domain IMPROVE Model Performance Metrics by Station, Pollutant, and Season

Appendix B VISTAS12 Modeling Domain Scatter Plots of $PM_{2.5}$ Species by Network, Pollutant, and Month

Appendix C Scatter, Soccer, and Bugle Plots by Class I Area for the 20% Most Impaired Days and 20% Clearest Days

Appendix D VISTAS12 Modeling Domain Soccer Plots of $PM_{2.5}$ Species by Network, Pollutant, and Month

Appendix E VISTAS12 Modeling Domain Bugle Plots of $PM_{2.5}$ Species by Network, Pollutant, and Month

Appendix F VISTAS12 Modeling Domain Observed and Modeled Concentration and Light Extinction Comparisons

TABLES

Table 2-1. Fine Particulate Matter Performance Goals and Criteria 6
Table 2-2. Overview of Utilized Ambient Data Monitoring Networks.....15
Table 2-3. Species Mapping from CAMx into Observation Network.....16
Table 3-1. Model Performance Statistics for $PM_{2.5}$ Sulfate by Region, Network, and Season. 19
Table 4-1. Model Performance Statistics for $PM_{2.5}$ Nitrate by Region, Network, and Season. 26
Table 5-1. Model Performance Statistics for $PM_{2.5}$ Ammonium by Region, Network, and Season 33
Table 6-1. Model Performance Statistics for $PM_{2.5}$ OC by Region, Network, and Season. 38
Table 7-1. Model Performance Statistics for $PM_{2.5}$ EC by Region, Network, and Season.....43
Table 8-1. Model Performance Statistics for $PM_{2.5}$ by Region, Network, and Season. 48

FIGURES

Figure 1-1. IMPROVE Monitor Locations and the VISTAS 12km Domain. 4
Figure 2-1. Example Scatter Plot of Average 2011 Monthly Sulfate Concentration at IMPROVE Sites in VISTAS States (left) and 20% Clearest Days at Everglades National Park (right). 7
Figure 2-2. Example Box Plot of Monthly Average Nitrate Concentration for Non-VISTAS State CSN Sites. 8
Figure 2-3. Example Spatial Plot of Nitrate NMB by Network for Summer Months (Circle = IMPROVE, Square = CASTNET, Diamond = CSN). 9
Figure 2-4. Example Soccer Plot of Monthly Nitrate Normalized Mean Bias and Error for CASTNET Sites in VISTAS States (left) and $PM_{2.5}$ Species on the 20% Most Anthropogenically Impaired Days at Great Smoky Mountains National Park (right). 10
Figure 2-5. Example Bugle Plot of Monthly Mean Fractional Bias as a Function of Modeled Concentration at IMPROVE Sites in VISTAS States (top) and Mean Fractional Error for PM2.5 Species on the 20% Clearest Days at Saint Marks (bottom). 11
Figure 2-6. Example Mass Daily Stacked Bar Chart for $PM_{2.5}$ Species on the 20% Most Anthropogenically Impaired Days at Shaenandoah.....12
Figure 2-7. Example Extinction Daily Stacked Bar Chart for $PM_{2.5}$ Species on the 20% Most Anthropogenically Impaired Days at Shaenandoah.....13
Figure 2-8. Example Observed (Obs) and Predicted (Mod) Mass Concentrations (Left) and Light Extinctions (Right) at the Dolly Sods Wilderness on the Observed 20% Most Anthropogenically Impaired Days. 14
Figure 3-1. Boxplot Comparisons of Model Predictions and IMRPOVE Sulfate Observations for Each Climate Region by Month. 20

Figure 3-2. Boxplot Comparisons of Model Predictions and CSN Sulfate Observations for Each Climate Region by Month. 21
Figure 3-3. Boxplot Comparisons of Model Predictions and CASTNET Sulfate Observations for Each Climate Region by Month. 22
Figure 3-4. Spatial Plots of Sulfate NMB by Season and Network (Circle = IMPROVE, Square = CASTNET, Diamond = CSN). 23
Figure 3-5. Spatial Plots of Sulfate NME by Season and Network (Circle = IMPROVE, Square = CASTNET, Diamond = CSN). 24
Figure 4-1. Boxplot Comparisons of Model Predictions and IMPROVE Nitrate Observations for Each Climate Region by Month. 27
Figure 4-2. Boxplot Comparisons of Model Predictions and CSN Nitrate Observations for Each Climate Region by Month. 28
Figure 4-3. Boxplot Comparisons of Model Predictions and CASTNET Nitrate Observations for Each Climate Region by Month. 29
Figure 4-4. Spatial Plots of Nitrate NMB by Season and Network (Circle = IMPROVE, Square = CASTNET, Diamond = CSN). 30
Figure 4-5. Spatial Plots of Nitrate NME by Season and Network (Circle = IMPROVE, Square = CASTNET, Diamond = CSN). 31
Figure 5-1. Boxplot Comparisons of Model Predictions and CSN Ammonium Observations for Each Climate Region by Month. 34
Figure 5-2. Boxplot Comparisons of Model Predictions and CASTNET Ammonium Observations for Each Climate Region by Month. 35
Figure 5-3. Spatial Plots of Ammonium NMB by Season and Network (Square = CASTNET, Diamond = CSN). 36
Figure 5-4. Spatial Plots of Ammonium NME by Season and Network (Square = CASTNET, Diamond = CSN). 37
Figure 6-1. Boxplot Comparisons of Model Predictions and IMPROVE Organic Carbon (OC) Observations for Each Climate Region by Month. 39
Figure 6-2. Boxplot Comparisons of Model Predictions and CSN Organic Carbon (OC) Observations for Each Climate Region by Month. 40
Figure 6-3. Spatial plots of organic carbon (OC) NMB by season and network (Circle = IMPROVE, Diamond = CSN). 41
Figure 6-4. Spatial plots of organic carbon (OC) NME by season and network (Circle = IMPROVE, Diamond = CSN). 42
Figure 7-1. Boxplot Comparisons of Model Predictions and IMPROVE Elemental Carbon (EC) Observations for Each Climate Region by Month. 44
Figure 7-2. Boxplot Comparisons of Model Predictions and CSN Elemental Carbon (EC) Observations for Each Climate Region by Month. 45

Figure 7-3. Spatial plots of elemental carbon (EC) NMB by season and network (Circle = IMPROVE, Diamond = CSN). 46

Figure 7-4. Spatial plots of elemental carbon (EC) NME by season and network (Circle = IMPROVE, Diamond = CSN). 47

Figure 8-1. Boxplot Comparisons of Model Predictions and IMPROVE Total $PM_{2.5}$ Observations for Each Climate Region by Month. 49

Figure 8-2. Boxplot Comparisons of Model Predictions and CSN Total $PM_{2.5}$ Observations for Each Climate Region by Month. 50

Figure 8-3. Spatial plots of total $PM_{2.5}$ NMB by season and network (Circle = IMPROVE, Diamond = CSN). 51

Figure 8-4. Spatial plots of total $PM_{2.5}$ NME by season and network (Circle = IMPROVE, Diamond = CSN). 52

Figure 9-1. Observed Sulfate (Top) and Modeled NMB (Bottom) for Sulfate on the 20% Most-impaired Days at IMPROVE Monitor Locations. 54

Figure 9-2. Observed Nitrate (Top) and Modeled NMB (Bottom) for Nitrate on the 20% Most-impaired Days at IMPROVE Monitor Locations. 55

Figure 9-3. Observed OC (Top) and Modeled NMB (Bottom) for OC on the 20% Most-impaired Days at IMPROVE Monitor Locations. 56

Figure 9-4. Observed EC (Top) and Modeled NMB (Bottom) for EC on the 20% Most-impaired Days at IMPROVE Monitor Locations. 57

Figure 9-5. Observed Total $PM_{2.5}$ (Top) and Modeled NMB (Bottom) for Total $PM_{2.5}$ on the 20% Most-impaired Days at IMPROVE Monitor Locations. 58

Figure 9-6. Observed NACL (Top) and Modeled NMB (Bottom) for NACL on the 20% Most-impaired Days at IMPROVE Monitor Locations. 59

Figure 10-1. Example Daily Observed (Obs) and Predicted (Mod) Total Mass Concentrations (Top) and Light Extinctions (Bottom) at the St. Mark's Wildlife Refuge on the Observed 20% Clearest Days. 61

Figure 10-2. Example Averaged Observed (Obs) and Predicted (Mod) Total Mass Concentrations (Left) and Light Extinctions (Right) at the St. Mark's Wildlife Refuge on the Observed 20% Clearest Days. 62

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
AQS	Air Quality Subsystem
CAMx	Comprehensive Air quality Model with eXtensions
CASTNET	Clean Air Status and Trends Network
CM	Coarse Mass
CSN	Chemical Speciation Network
DJF	December, January, and February (i.e., Winter)
EC	Elemental carbon
ERG	Eastern Research Group, Inc.
EGU	Electric Generating Unit
EPA	United States Environmental Protection Agency
FCRS	Crustal fraction of PM
FPRM	Fine other primary (diameter ≤ 2.5µm)
FRM	Federal Reference Method
IMPROVE	Interagency Monitoring of Protected Visual Environments
JJA	June, July, and August (i.e., Summer)
km	Kilometer
MAM	March, April, and May (i.e., Spring)
MB	Mean Bias
ME	Mean Error
MFB	Mean Fractional Bias
MFE	Mean Fractional Error
MPE	Model Performance Evaluation
N	Number of observations
NACL	Sodium chloride
NH_4^+	Ammonium Ion
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NO_3^-	Nitrate
O_3	Ozone
OC	Organic carbon
OM	Organic matter
OMC	Organic mass carbon
OSAT	Ozone Source Apportionment Technology
PEC	Primary elemental carbon
PM	Particulate matter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Particulate ammonium
PNO3	Particulate nitrate
PSAT	Particulate Source Apportionment Technology
PSO4	Particulate sulfate
r	Pearson correlation coefficient
R	Programming software language called *R*

RADM-AQ	Regional Acid Deposition Model – aqueous chemistry
RHR	Regional Haze Rule
RMSE	Root Mean Squared Error
SESARM	Southeastern States Air Resource Managers, Inc.
SIPS	State Implementation Plans
SMAT-CE	Software for Model Attainment Test – Community Edition
SO_4^{2-}	Sulfate
SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
SON	September, October, and November (i.e., Fall)
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast

1.0 INTRODUCTION

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

To demonstrate progress toward the improvement goals, the SESARM partners modeled visibility and air quality conditions for a base year of 2011 and future year of 2028. The SESARM VISTAS II Regional Haze modeling analysis was performed by the contractor team Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine). The preparation and modeling were conducted over several contract tasks, including emission inventory development, ambient data collection, CAMx modeling, and model performance evaluation of the base year. The VISTAS II modeling included particulate matter simulations and source apportionment studies using the 12-kilometer (km) grid based on EPA's 2011/2028el modeling platform and preliminary source contribution assessment,[2] updated to include a 12km subdomain over the VISTAS region and augmented with revisions to electric generating unit (EGU) and non-EGU point source projections. The air quality modeling was conducted using Comprehensive Air quality Model with extensions (CAMx). A detailed description of the modeling platform can be found in the Task 6 modeling report.

Under Task 8 of the Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project, a thorough model performance evaluation (MPE) was conducted for particulate matter less than or equal to 2.5 microns in aerodynamic diameter ($PM_{2.5}$) species components and light extinction to examine the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. This report documents the MPE for that base year CAMx modeling.

The VISTAS II modeling for 2011 is based on the EPA modeling conducted for Regional Haze Analysis, sometimes referred to as the "2011el" modeling. Updates to the EPA platform in the VISTAS II modeling include updating the version of CAMx from version 6.32 to 6.40. Many updates to the CAMx model were implemented between the 6.32 and 6.40 release. According to the CAMx 6.40 release notes, the significant changes included:

[2] EPA. 2017. Documentation for the EPA's Preliminary 2028 Regional Haze Modeling. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October. Available at: https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

1. Updates to the chemistry to include a condensed halogen mechanism for ocean-borne inorganic reactive iodine, hydrolysis of isoprene-derived organic nitrate and SO_2 oxidation on primary crustal fine PM. This update includes the changes to the Ozone and Particulate Source Apportionment Technology (OSAT/PSAT) algorithms;
2. Inclusion of in-line inorganic iodine emissions to support halogen chemical mechanisms;
3. A major revision to the Secondary organic aerosol partitioning (SOAP) and secondary organic aerosol (SOA) chemistry algorithm;
4. Updates to the Regional Acid Deposition Model aqueous chemistry (RADM-AQ) algorithm; and
5. A major revision to the wet deposition algorithm to identify assumptions or processes that were unintentionally or otherwise unreasonably limiting gas and PM update into precipitation. The wet deposition algorithm was simplified and improved in several ways, resulting in the increased scavenging of gases and PM.

In addition to the model version, the CAMx 6.32 and 6.40 simulations contained differences from the EPA modeling platform that had been made subsequent to the 2011el/2028el model release. In the most current 2023en simulation, EPA developed new photolysis rates and ozone column data. These updates were included in the updated modeling platform and resulting CAMx 6.40 simulation and were used in the VISTAS II 2011el simulations.

Another configuration difference is how the boundary conditions were mapped for speciation from the two versions of the model. EPA and the VISTAS CAMx 6.32 and 6.40 simulations all used the same boundary condition files. However, when CAMx was updated from 6.32 to 6.40 the species in the SOA scheme changed. The SOA5, SOA6, and SOA7 were removed and SOA3 and SOA4 were redefined. However, neither EPA nor this study remapped the boundary conditions to account for this change. EPA examined the regional haze summary data for all Class I areas and found the total organic carbon (OC) species (not just SOA) accounted for 1-5% of the boundary condition impairment at the Southeastern Class I areas.[3] This is a small impact on regional haze and the impact of SOA on regional haze is even smaller.

[3] Brian Timin, EPA Office of Air Quality Planning and Standards (OAQPS) personal communication October 11, 2018.

Figure 1-1 presents the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitor locations in the VISTAS 12-km domain.

Figure 1-1. IMPROVE Monitor Locations and the VISTAS 12km Domain.

2.0 MODEL PERFORMANCE EVALUATION

In order to estimate the ability of CAMx to replicate the 2011 base year concentrations of particulate matter and light extinction, an operational model performance evaluation was conducted following the approach outlined in the modeling protocol. For this evaluation, mean bias and normalized mean bias, mean error and normalized mean error, and Pearson's correlation coefficient were used and directly compared to EPA's results[4] using these same statistics and observed concentrations. In addition, mean fractional bias (MFB) and mean fractional error (MFE) were calculated.

Mean bias (MB) is the average difference between predicted (P) and observed (O) concentrations for a given number of samples (n):

$$MB(\mu g\ m^{-3}\ or\ Mm^{-1}) = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

Mean error (ME) is the average absolute value of the difference between predicted and observed concentrations for a given number of samples:

$$ME(\mu g\ m^{-3}\ or\ Mm^{-1}) = \frac{1}{n}\sum_{i=1}^{n}|P_i - O_i|$$

Normalized mean bias (NMB) is the sum of the difference between predicted and observed values divided by the sum of the observed values:

$$NMB(\%) = \frac{\sum_1^n(P-O)}{\sum_1^n(O)} * 100$$

Normalized mean error (NME) is the sum of the absolute value of the difference between predicted and observed values divided by the sum of the observed values:

$$NME(\%) = \frac{\sum_1^n|P-O|}{\sum_1^n(O)} * 100$$

[4] https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

Pearson's correlation coefficient (r) is defined as:

$$r = \frac{\sum_{i=1}^{n}(P_i - \overline{P})(O_i - \overline{O})}{\sqrt{\sum_{i=1}^{n}(P_i - \overline{P})^2}\sqrt{\sum_{i=1}^{n}(O_i - \overline{O})^2}}$$

Mean Fractional Bias (MFB) is defined as:

$$MFB(\%) = \frac{2}{N}\sum_{1}^{N}\left(\frac{P - O}{P + O}\right) \times 100$$

Mean Fractional Error (MFE) is defined as:

$$MFE(\%) = \frac{2}{N}\sum_{1}^{N}\left(\frac{|P - O|}{P + O}\right) \times 100$$

Model predictions of PM species were paired in space and time with observational data from the IMPROVE, Chemical Speciation Network (CSN), and the Clean Air Status and Trends Network (CASTNET) monitoring sites. These results are organized by network and season (winter (DJF), spring (MAM), summer (JJA), and fall (SON)), for receptors located within the ten VISTAS states and outside of the region.

Recommended benchmarks for photochemical model performance statistics (Boylan, 2006; Emery, 2017) will be used to assess the applicability of this modeled simulation for regulatory purposes. The goal and criteria values noted in Table 2-1 below will be used for this study.

Table 2-1. Fine Particulate Matter Performance Goals and Criteria

	NMB		NME	
Species	**Goal**	**Criteria**	**Goal**	**Criteria**
24-hr $PM_{2.5}$ and Sulfate	<± 10%	<± 30%	< 35%	< 50%
24-hr Nitrate	<± 10%	<± 65%	< 65%	< 115%
24-hr OC	<± 15%	<± 50%	< 45%	< 65%
24-hr EC	<± 20%	<± 40%	< 50%	< 75%

Appendix A presents the MPE statistics in tabular formats for the CASTNET (Appendix A-1), CSN (Appendix A-2), and IMPROVE (Appendix A-3) datasets.

2.1 Graphical Presentations

In addition to statistical summaries, graphical displays of data allow for a fuller characterization of model performance. Therefore, plots play a key role in any model performance evaluation. Below are examples of the types of plots that are used in this evaluation.

- **Scatter plots** (Figure 2-1) present the time and space ordered pairs with observations on the x-axis and the model predicted concentrations on y-axis. These plots are useful for indicating trends of either over, or under prediction across the range of values. Scatter plots have been prepared for $PM_{2.5}$ species by network, pollutant, and month (Appendix B) and for SO_4, NO_3, EC, OC, OM, NACL, $PM_{2.5}$, PMC, and soils on the 20% clearest and 20% most anthropogenically impaired days at each Class I area in the VISTAS 12 domain (Appendix C).

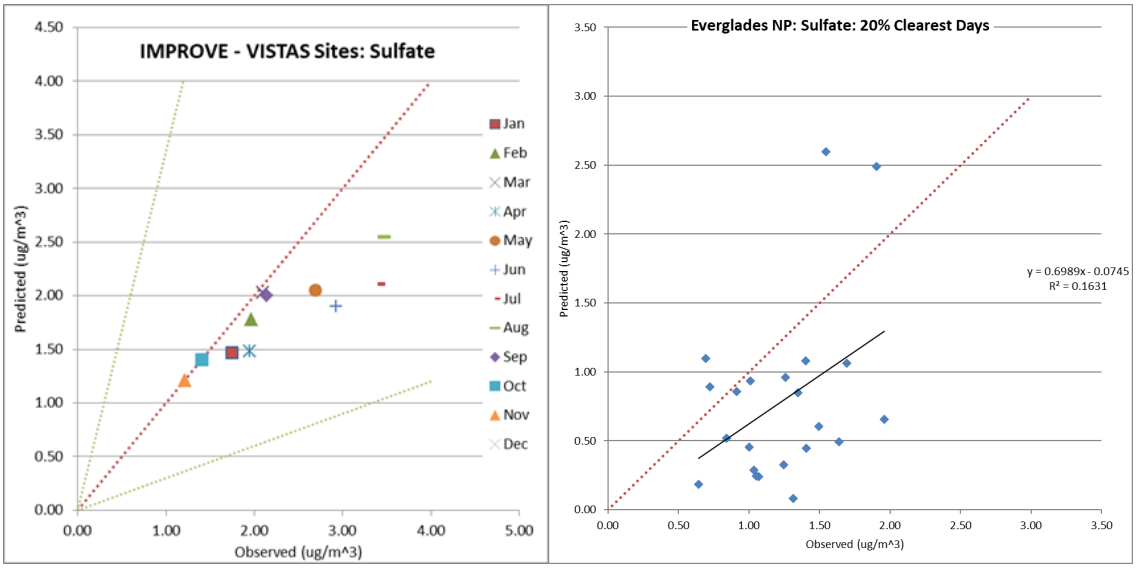


Figure 2-1. Example Scatter Plot of Average 2011 Monthly Sulfate Concentration at IMPROVE Sites in VISTAS States (left) and 20% Clearest Days at Everglades National Park (right).

- **Box plots** (Figure 2-2) can be for a useful tool for evaluating model performance evaluation. These types of plots show the distribution of observations, model estimates, or performance metrics. In this report box plots in this evaluation are grouped by monthly observed and modeled concentrations by species, network, and region. Our box plots show several quantities: the 25% to 75% percentiles are represented by the lower and upper extent of the box, the median values by the line across the box, and outliers as

points outside the box. The monthly box plots presented can be used to quickly visualize model performance across the entire year, highlighting the seasonal change in model performance.

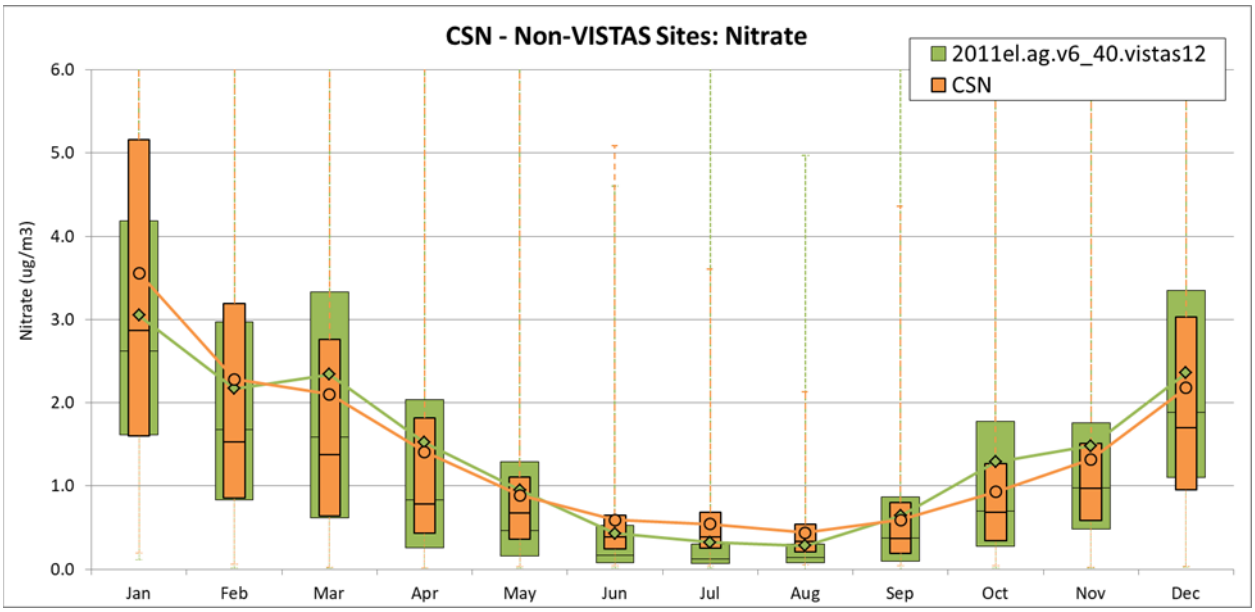


Figure 2-2. Example Box Plot of Monthly Average Nitrate Concentration for Non-VISTAS State CSN Sites.

- **Spatial plots of model performance at monitor locations** (Figure 2-3) provide an overall picture of the geographic patterns in model performance. Any performance metric can be plotted in this manner and we include spatial plots of MB, ME, NMB, and NME. The markers are plotted at the monitor location with the color of the marker keyed to the value of the metric being presented.

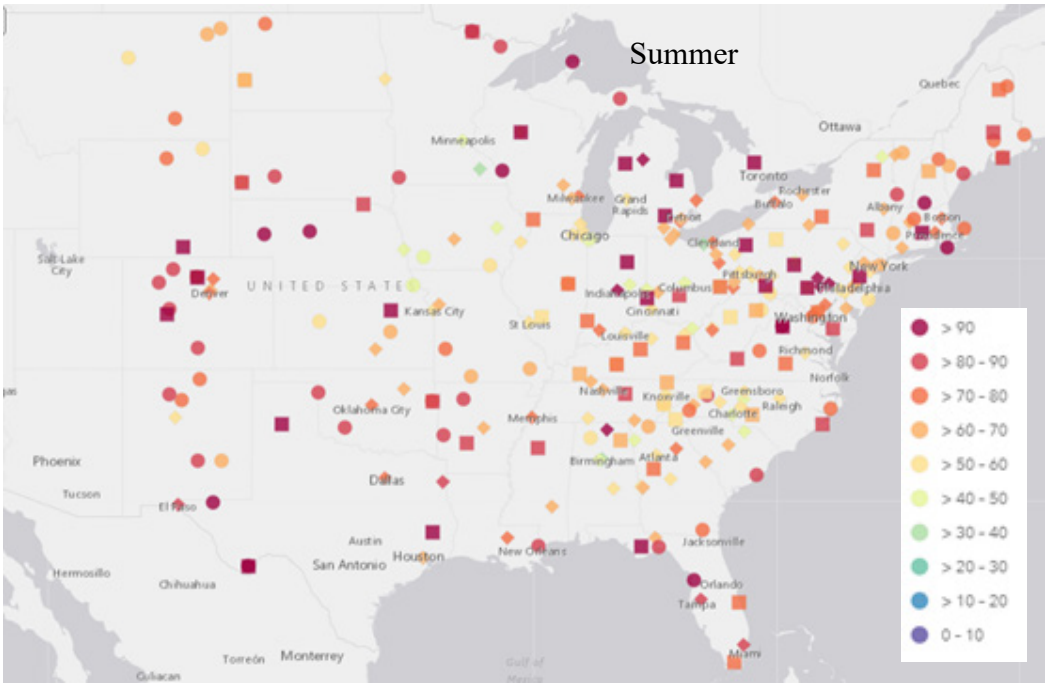


Figure 2-3. Example Spatial Plot of Nitrate NMB by Network for Summer Months (Circle = IMPROVE, Square = CASTNET, Diamond = CSN).

- **The soccer plot** (Figure 2-4) is so named because the dotted lines illustrating performance goals resemble a soccer goal. The error is plotted on the y-axis and the bias plotted on the x-axis. The plot is a convenient way to visualize both bias and error model performance on a single plot. As bias and error approach zero, the points are plotted closer to or within the "goal," represented by the dashed boxes. The size of the goal is developed from historical values of the metric for each variable from comparable modeling studies. Soccer plots have been prepared for $PM_{2.5}$ species by network, pollutant, and month (Appendix D) and by species on the 20% clearest and 20% most anthropogenically impaired days at each Class I area in the VISTAS 12 domain (Appendix C).

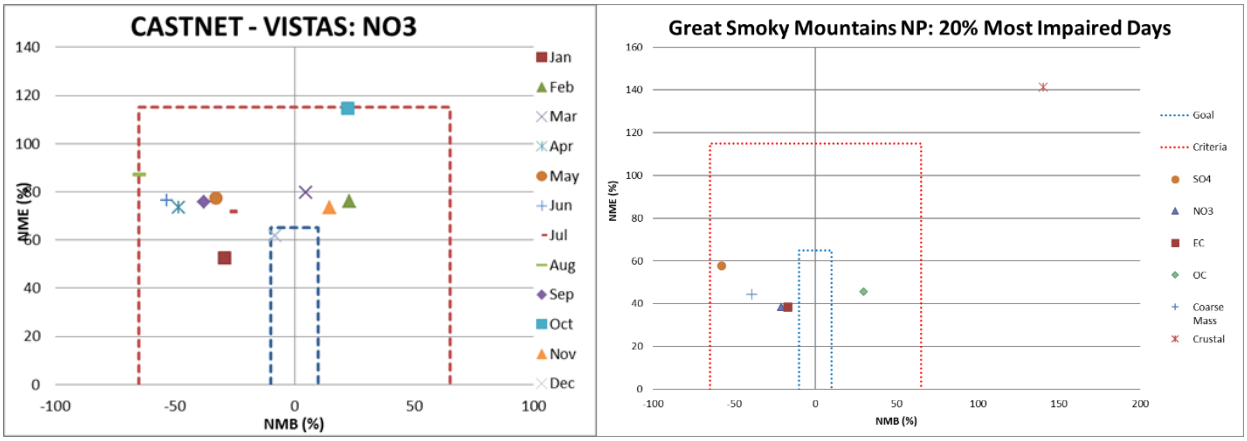


Figure 2-4. Example Soccer Plot of Monthly Nitrate Normalized Mean Bias and Error for CASTNET Sites in VISTAS States (left) and $PM_{2.5}$ Species on the 20% Most Anthropogenically Impaired Days at Great Smoky Mountains National Park (right).

- **The bugle plot** (Figure 2-5), named for the shape formed by the criteria and goal lines. The bugle plots are shaped as such because the goal and criteria lines are adjusted based on the average concentration of the observed species. As the average concentration becomes smaller, the criteria and goal lines become larger to adjust for the model's ability to predict at low concentrations. Bugle plots for the mean fractional bias and mean fractional error have been prepared for $PM_{2.5}$ species by network, pollutant, and month (Appendix E) and by species on the 20% clearest and 20% most anthropogenically impaired days at each Class I area in the VISTAS 12 domain (Appendix C).

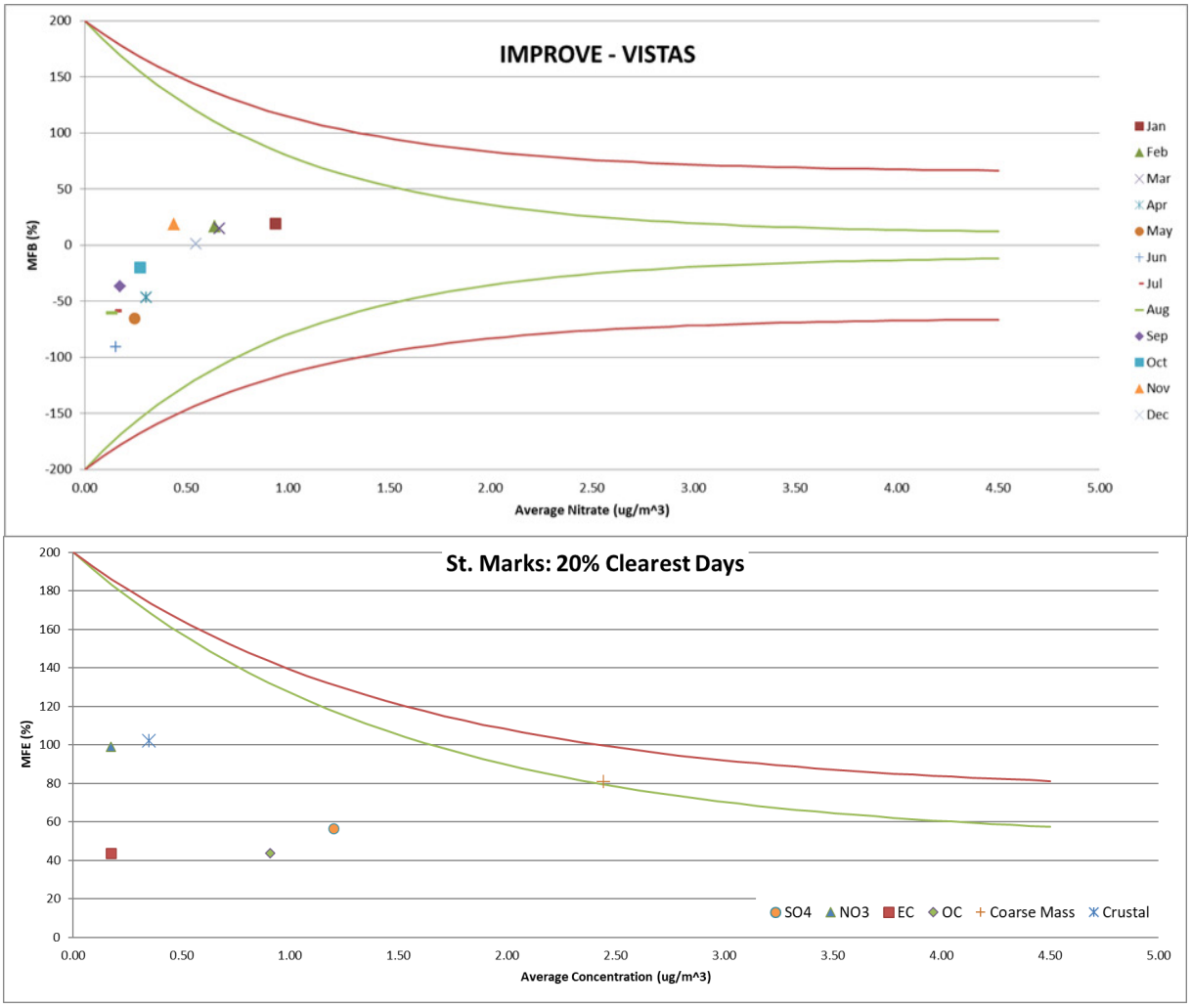


Figure 2-5. Example Bugle Plot of Monthly Mean Fractional Bias as a Function of Modeled Concentration at IMPROVE Sites in VISTAS States (top) and Mean Fractional Error for PM2.5 Species on the 20% Clearest Days at Saint Marks (bottom).

- **Mass daily stacked bar charts** (Figure 2-6) compare 2011 observations to 2011 model values by $PM_{2.5}$ species mass concentration. Mass daily stacked bar charts have been prepared for the 20% clearest and 20% most anthropogenically impaired days at each Class I area in the VISTAS 12 domain (Appendix F).

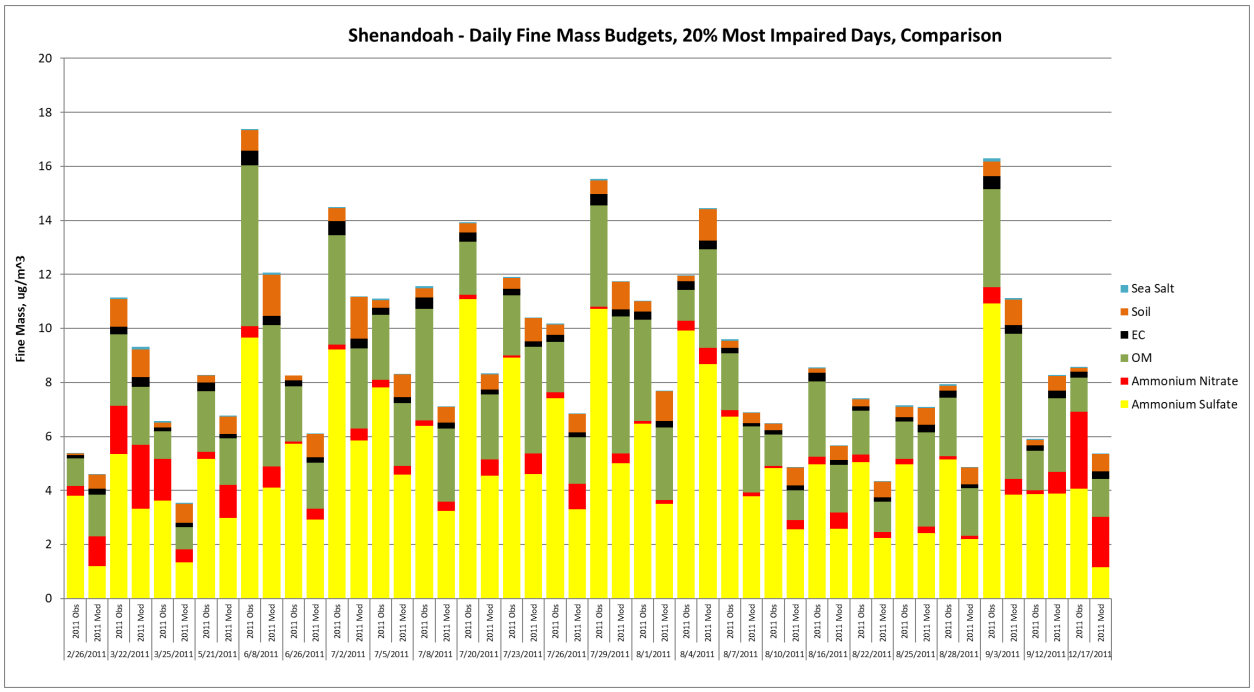


Figure 2-6. Example Mass Daily Stacked Bar Chart for $PM_{2.5}$ Species on the 20% Most Anthropogenically Impaired Days at Shaenandoah.

- **Extinction daily stacked bar charts** (Figure 2-7) compare 2011 observations to 2011 model values by $PM_{2.5}$ species light extinction. Extinction daily stacked bar charts have been prepared for the 20% clearest and 20% most anthropogenically impaired days at each Class I area in the VISTAS 12 domain (Appendix F).

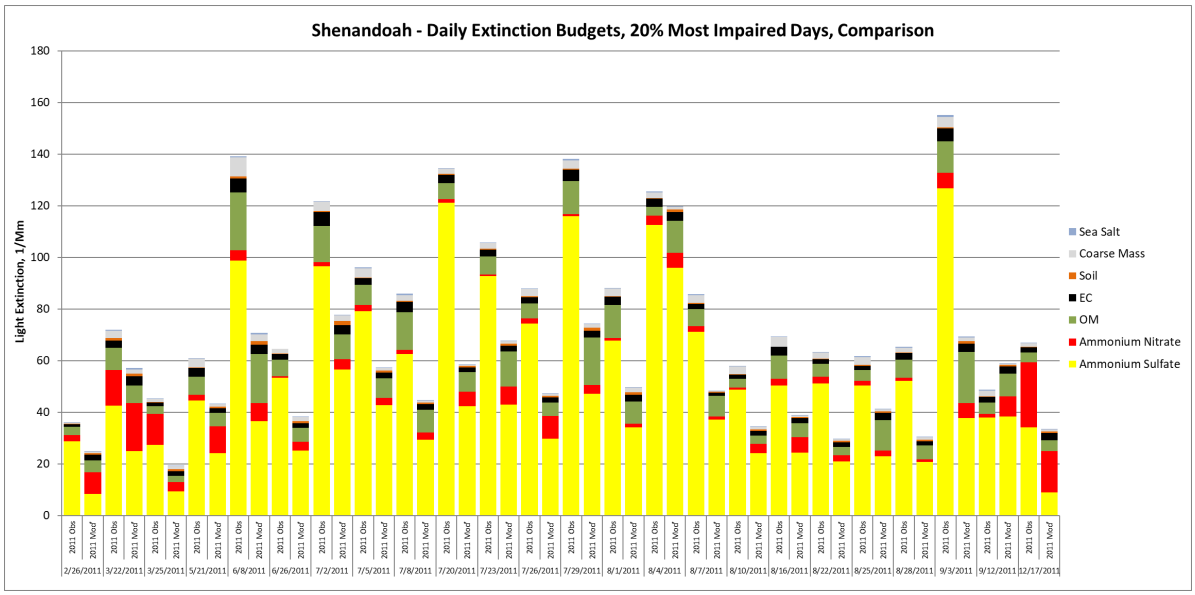


Figure 2-7. Example Extinction Daily Stacked Bar Chart for $PM_{2.5}$ Species on the 20% Most Anthropogenically Impaired Days at Shaenandoah.

- **Mass average stacked bar charts** (Figure 2-8) compare 2011 average $PM_{2.5}$ species mass concentration observations to 2011 average model values. Mass average stacked bar charts have been prepared for the 20% clearest and 20% most anthropogenically impaired days at each Class I area in the VISTAS 12 domain (Appendix F).
- **Extinction average stacked bar charts** (also Figure 2-8) compare 2011 average $PM_{2.5}$ species light extinction observations to 2011 average model values. Mass average stacked bar charts have been prepared for the observed 20% clearest and 20% most anthropogenically impaired days at each Class I area in the VISTAS 12 domain (Appendix F).

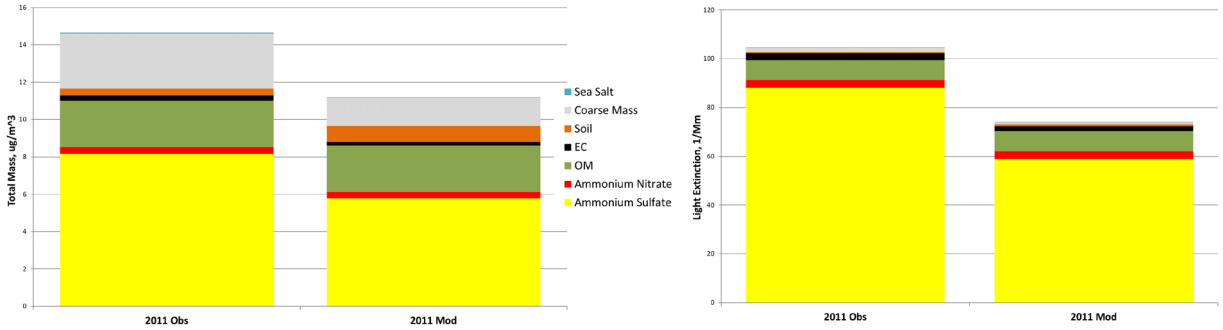


Figure 2-8. Example Observed (Obs) and Predicted (Mod) Mass Concentrations (Left) and Light Extinctions (Right) at the Dolly Sods Wilderness on the Observed 20% Most Anthropogenically Impaired Days.

2.2 Ambient Measurement Networks

Provided below is an overview of the various ambient air monitoring networks used in this evaluation. Network methods and procedures are subject to change annually due to systematic review and/or updates to the existing monitoring network/program.

2.2.1 Ambient Air Quality Observations

Year 2011 data from available ambient air monitoring networks for PM species are used in the model performance evaluation. Table 2-2 summarizes routine PM monitoring networks used in this analysis. Alpine focused on the ambient data collected from the IMPROVE network. This network began in 1985 as a cooperative visibility monitoring effort between EPA, federal land management agencies, and state air agencies (IMPROVE, 2011). Data are collected at Class I areas across the United States mostly at National Parks, National Wilderness Areas, and other protected pristine areas. Currently, there are approximately 181 IMPROVE sites that have complete annual $PM_{2.5}$ mass and/or $PM_{2.5}$ species data. There are 110 IMPROVE monitoring sites which represent air quality at the 156 designated Class I areas. The 71 additional IMPROVE sites are "IMPROVE protocol" sites which are generally located in rural areas throughout the U.S. Although these sites use the IMPROVE monitoring samplers and collection routines, they are not located at Class I areas.

Table 2-2. Overview of Utilized Ambient Data Monitoring Networks

Monitoring Network	Chemical Species Measured	Sampling Period
IMPROVE	Speciated $PM_{2.5}$ and PM_{10}; light extinction data	1 in 3 days; 24-hour average
CASTNET	Speciated $PM_{2.5}$, and O_3	Approximately 1-week average
CSN	Speciated $PM_{2.5}$	24-hour average

2.2.2 IMPROVE

The IMPROVE network began in 1985 as a cooperative visibility monitoring effort between EPA, federal land management agencies, and state air agencies (IMPROVE, 2011). Data are collected at Class I areas across the U.S., mostly at national parks, national wilderness areas, and national wildlife refuges. As of 2018, there were approximately 160 IMPROVE sites that have complete annual $PM_{2.5}$ mass and/or $PM_{2.5}$ species data. There are 110 IMPROVE monitoring sites which represent air quality at the 156 designated Class I areas. The additional IMPROVE sites are "IMPROVE protocol" sites, which are generally located in rural areas throughout the U.S., although there are also a handful of urban sites in the U.S. These protocol sites provide additional spatial information across the country, being generally located in areas where there are few Class I areas. The protocol sites use the IMPROVE monitoring samplers and collection routines. In addition to IMPROVE data that is available in AQS, the IMPROVE program provides summary datasets that contains information and pre-calculated data needed for Regional Haze Rule analyses. This includes daily average and annual data for the 20% most impaired and 20% clearest visibility days.

2.2.3 CASTNET

Established in 1987, CASTNET is a dry deposition monitoring network where PM data are collected and reported as weekly average data (U.S. EPA, 2012a). In addition, this network measures and reports hourly ozone concentrations. CASTNET provides atmospheric data on the dry deposition component of total acid deposition, ground-level ozone and other forms of atmospheric pollution. The data (except for ozone) are collected in filter packs that sample the ambient air continuously during the week. As of 2018, CASTNET is comprised of 95 monitoring stations across the U.S. The longest data records are primarily at eastern U.S. sites.

2.2.4 CSN

CSN, formerly known as STN: The Speciation Trends Network, began operation in 1999 to provide nationally consistent speciated $PM_{2.5}$ data for the assessment of trends at representative sites in urban areas in the U.S. The CSN was established by regulation and is a companion network to the mass-based Federal Reference Method (FRM) network implemented in support of the $PM_{2.5}$ NAAQS. As part of a routine monitoring program, the CSN quantifies mass concentrations and $PM_{2.5}$ constituents, including numerous trace elements, ions (sulfate, nitrate, sodium, potassium, and ammonium), elemental carbon (EC), and organic carbon (OC). As of 2018, there were 52 trends sites in the CSN nationally. CSN trends sites are largely static urban monitoring stations with protocols for sampling methods that are dedicated to characterizing aerosol mass components in urban areas of the U.S. to discern long term trends and provide an accountability mechanism to assess the effectiveness of control programs. In addition, in 2018, there were approximately 100 supplemental speciation sites that are also part of the CSN. The CSN data at trends sites are collected 1 in every 3 days, whereas supplemental sites collect data either 1 in every 3 days or 1 in every 6 days.

2.3 CAMx Species Mapping

The CAMx model species are not directly comparable with the species measured at the monitoring networks described in Section 2.2. The CAMx species mapping was presented in the modeling protocol and is repeated in Table 2-3.

Table 2-3. Species Mapping from CAMx into Observation Network

Network	Observed Species	CAMx Species
IMPROVE	NO_3	PNO3
	SO_4	PSO4
	NH_4	PNH4
	OM = 1.8*OC	SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA
	EC	PEC
	SOIL	FPRM+FCRS
	$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
CSN	$PM_{2.5}$	PSO4+PNO3+PNH4+SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA+PEC+FPRM+FCRS+NA+PCL
	NO_3	PNO3
	SO_4	PSO4
	NH_4	PNH4

Table 2-3. Species Mapping from CAMx into Observation Network

Network	Observed Species	CAMx Species
	OM = 1.4*OC	SOA1+SOA2+SOA3+SOA4 +SOPA+SOPB+POA
	EC	PEC

2.4 Summary and Comparison to EPA MPE Results

Comparing model performance statistics of EPA's CAMx 6.32 and VISTAS CAMx 6.40 simulations using EPA's 2011el modeling platform showed relatively similar results with the VISTAS results showing slightly improved performance for all $PM_{2.5}$ species except sulfate and OC at IMPROVE, CSN, and CASTNET monitors in the southeastern state region.

For sulfate and OC, CAMx 6.40 concentrations were lower than CAMx 6.32 creating an under prediction bias for most of the VISTAS12 modeling domain and seasons in VISTAS simulation compared to EPA's CAMx 6.32 results. For nitrate, ammonium, and EC, the CAMx 6.32 and CAMx 6.40 results differed slightly, with neither version of the model consistently demonstrating performance better than the other. The total $PM_{2.5}$ performance results were consistent between both simulations even as results generally showed higher CAMx 6.32 concentrations compared to CAMx 6.40 at lower concentration levels, with consistent performance at higher concentrations. There appears to be a trend where CAMx 6.40 concentrations are generally slightly higher that CAMx 6.32 during dry periods and CAMx 6.32 generally slightly higher during wet periods. This is not surprising given the update to the wet deposition algorithm between CAMx 6.32 and 6.40.

The comparison of CAMx 6.32 and 6.40 showed differences in model concentration estimates with little difference noted in performance between the two model configurations for most species. The only noted differences were seen in sulfate performance. This was expected given the changes to the model due to the inclusion of new science in CAMx6.40. Alpine Geophysics does not see any features in the modeling that would preclude the use of the more up-to-date science in CAMx 6.40 for use in the VISTAS air quality planning.

3.0 $PM_{2.5}$ SULFATE

Table 3-1 summarizes model performance statistics for $PM_{2.5}$ sulfate. Boxplot comparisons of model predictions and observations (IMPROVE, CSN, and CASTNET) by month for each climate region are shown in Figures 3-1, 3-2, and 3-3. VISTAS12 modeling domain spatial plots of NMB and NME for each season are shown in Figures 3-4 and 3-5.

Sulfate performance across seasons, networks, and regions is generally mixed. A notable under prediction of sulfate is observed across the VISTAS12 domain consistent with our findings of CAMx v. 6.40 in comparison to the CAMx v. 6.32 simulations from EPA. NMBs range from --37.5% to -3.38% in the VISTAS states across all seasons and networks. Both the observations and the model consistently predicted the highest average sulfate concentrations in the summer, although the model performance is showing the largest underestimation in the summer. This under prediction is also noticeable during all other seasons, though the magnitude of the under prediction is less. Sulfate is also under predicted outside of the VISTAS states in all networks with the single notable over prediction at non-VISTAS IMPROVE sites in the fall (0.13%).

The greatest over prediction of sulfate is seen on the western boundary of the VISTAS12 modeling domain during winter months and in the northeastern region of the domain during spring and summer months. Under predictions are noted along the southern boundary of the domain during summer months.

Table 3-1. Model Performance Statistics for $PM_{2.5}$ Sulfate by Region, Network, and Season.

Region	Network	Season	N	Avg. Obs. (µg/m³)	Avg. Pre. (µg/m³)	r	NMB (%)	NME (%)	MB (µg/m³)	ME (µg/m³)
VISTAS	IMPROVE	Winter	389	1.65	1.48	0.59	-10.40	34.17	-0.17	0.56
		Spring	405	2.24	1.87	0.60	-16.64	34.14	-0.37	0.76
		Summer	390	3.28	2.20	0.73	-32.81	38.58	-1.08	1.27
		Fall	381	1.61	1.55	0.75	-3.38	33.54	-0.05	0.54
		All	1565	2.20	1.78	0.71	-19.13	35.69	-0.42	0.78
	CSN	Winter	623	1.94	1.60	0.52	-17.40	36.32	-0.34	0.70
		Spring	647	2.67	2.20	0.58	-17.60	34.01	-0.47	0.91
		Summer	674	3.56	2.52	0.70	-29.17	35.17	-1.04	1.25
		Fall	638	1.72	1.63	0.58	-5.39	27.80	-0.09	0.48
		All	2582	2.49	2.00	0.70	-19.79	33.82	-0.49	0.84
	CASTNET	Winter	241	2.16	1.54	0.28	-28.71	39.26	-0.62	0.85
		Spring	302	2.84	1.77	0.31	-37.50	42.94	-1.06	1.22
		Summer	274	3.75	2.38	0.64	-36.57	43.33	-1.37	1.62
		Fall	277	1.70	1.50	0.18	-12.18	50.52	-0.21	0.86
		All	1094	2.63	1.80	0.52	-31.43	43.65	-0.83	1.15
Non-VISTAS	IMPROVE	Winter	1612	1.05	0.86	0.70	-18.17	40.99	-0.19	0.43
		Spring	1752	1.32	1.25	0.64	-5.32	41.10	-0.07	0.54
		Summer	1703	1.55	1.20	0.78	-22.85	41.62	-0.36	0.65
		Fall	1656	0.99	0.99	0.82	0.13	33.44	0.00	0.33
		All	6723	1.23	1.08	0.73	-12.46	39.72	-0.15	0.49
	CSN	Winter	1783	1.88	1.34	0.57	-28.96	42.24	-0.55	0.80
		Spring	1888	2.08	1.93	0.71	-7.50	31.91	-0.16	0.66
		Summer	1908	2.93	2.32	0.83	-20.86	33.13	-0.61	0.97
		Fall	1831	1.66	1.52	0.81	-8.78	29.87	-0.15	0.50
		All	7410	2.15	1.79	0.77	-16.96	34.13	-0.36	0.73
	CASTNET	Winter	427	1.69	0.99	0.54	-41.49	50.85	-0.70	0.86
		Spring	551	1.91	1.33	0.40	-30.07	49.04	-0.57	0.94
		Summer	521	2.56	1.65	0.51	-35.45	53.51	-0.91	1.37
		Fall	530	1.46	1.32	0.38	-9.55	50.33	-0.14	0.74
		All	2029	1.91	1.34	0.48	-29.94	51.17	-0.57	0.98

Figure 3-1. Boxplot Comparisons of Model Predictions and IMRPOVE Sulfate Observations for Each Climate Region by Month.

Figure 3-2. Boxplot Comparisons of Model Predictions and CSN Sulfate Observations for Each Climate Region by Month.

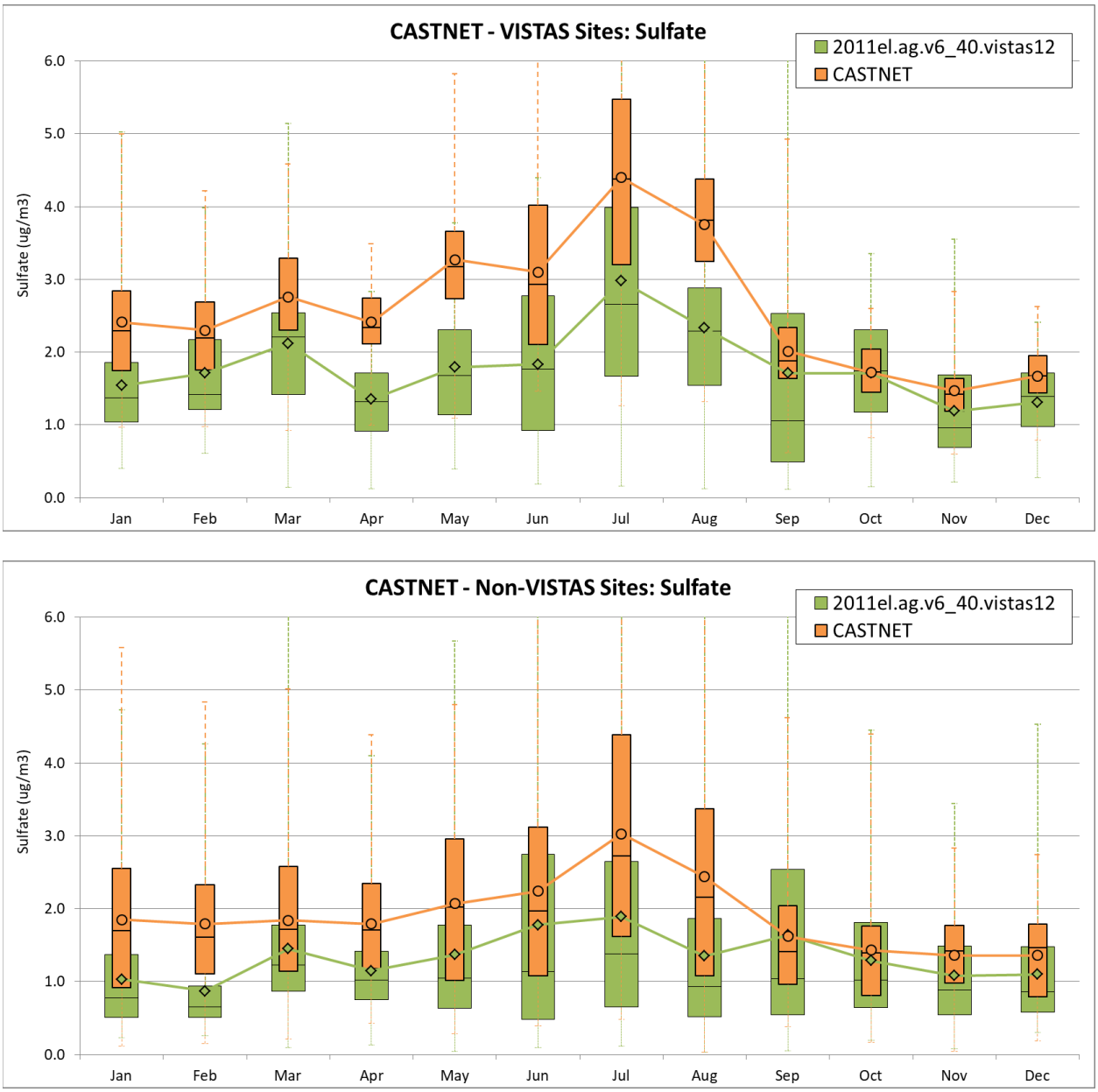


Figure 3-3. Boxplot Comparisons of Model Predictions and CASTNET Sulfate Observations for Each Climate Region by Month.

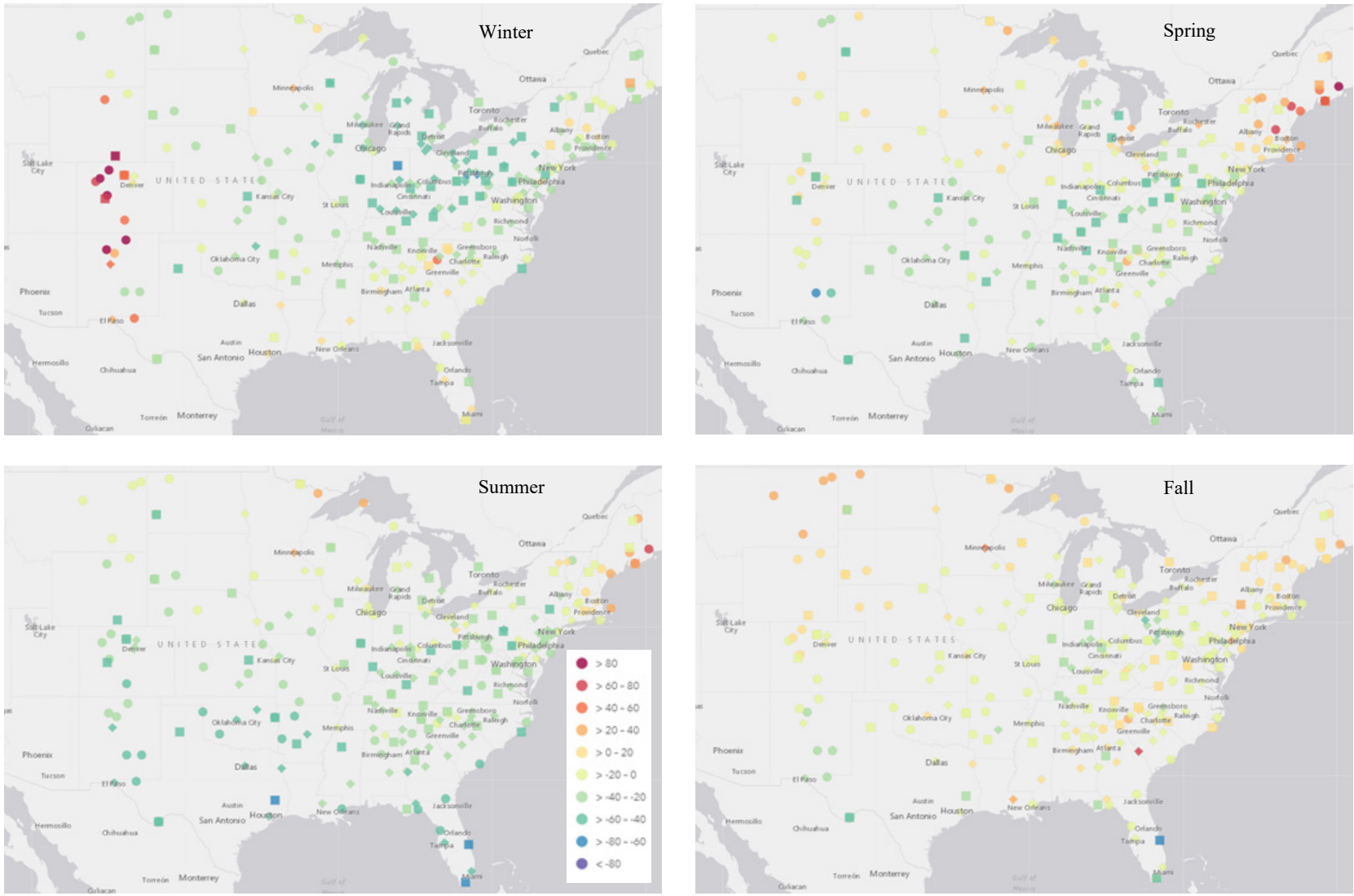


Figure 3-4. Spatial Plots of Sulfate NMB by Season and Network (Circle = IMPROVE, Square = CASTNET, Diamond = CSN).

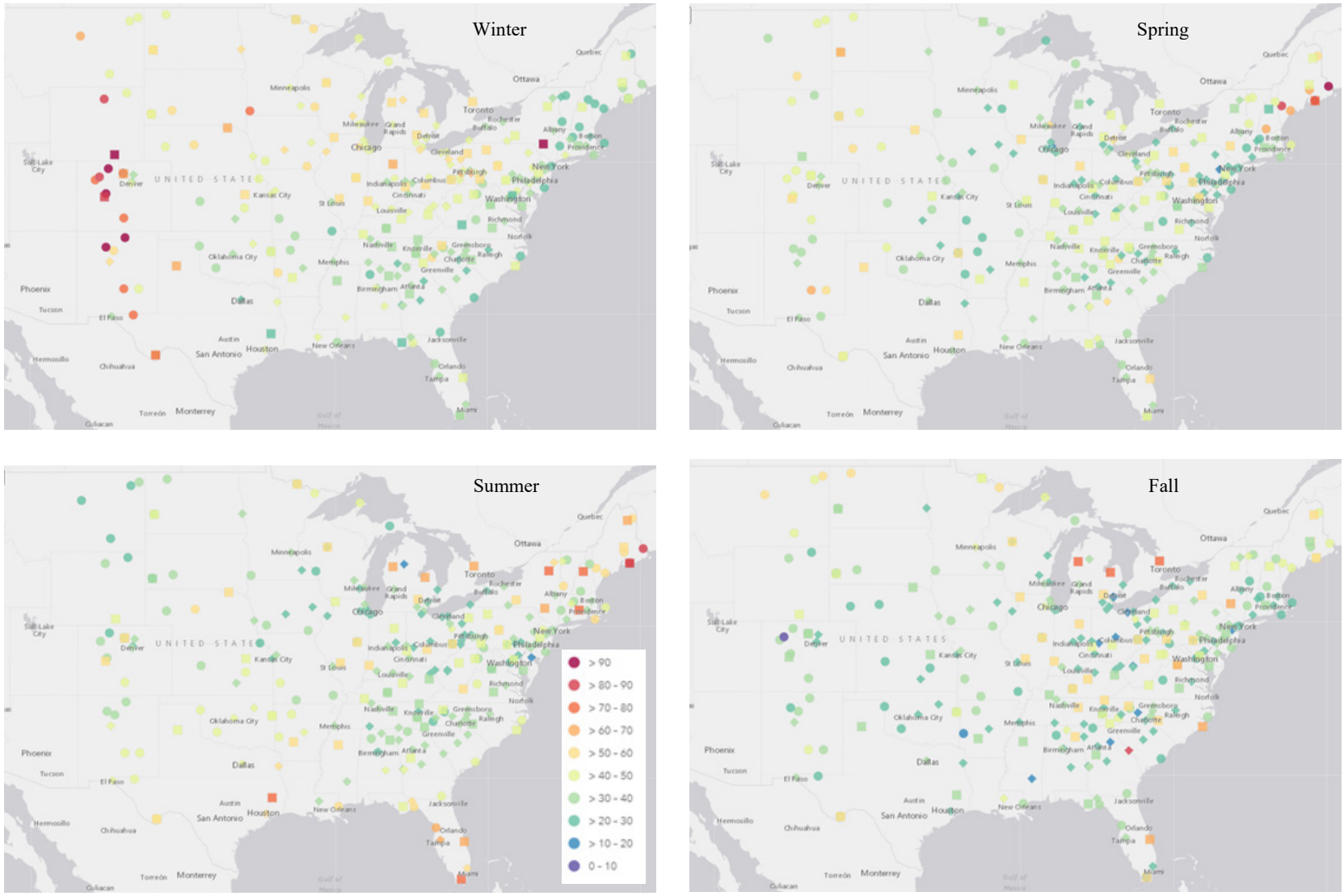


Figure 3-5. Spatial Plots of Sulfate NME by Season and Network (Circle = IMPROVE, Square = CASTNET, Diamond = CSN).

4.0 $PM_{2.5}$ NITRATE

Table 4-1 summarizes model performance statistics for $PM_{2.5}$ nitrate. Boxplot comparisons of model predictions and observations (IMPROVE, CSN, and CASTNET) by month for each climate region are shown in Figures 4-1, 4-2, and 4-3. VISTAS12 modeling domain spatial plots of NMB and NME for each season are shown in Figures 4-4 and 4-5.

Nitrate performance in the VISTAS12 modeling domain shows strong seasonal variation. The model under predicts at networks in the summer months (-30.96% to -49.69%) and over predicts at networks during the fall (7.60% to 51.78%). Both the model and the observation show the lowest average nitrate concentrations in the summer. Under predictions of nitrate persist across all seasons and networks with low observed nitrate concentrations and significantly over predictions during months when observed nitrate is highest. An exception is noted regarding under prediction in non-VISTAS states in both the CASTNET and CSN observations during the highest observed nitrate concentrations in winter months.

Over prediction of nitrate is seen geographically across most of the VISTAS12 modeling domain especially in the northeast during most months and the northwestern quadrant of the domain during the cooler months of winter and fall.

Under prediction of nitrate is noted at networks in most of the VISTAS states during the summer months and along the western border of the domain in spring and summer.

Table 4-1. Model Performance Statistics for $PM_{2.5}$ Nitrate by Region, Network, and Season.

Region	Network	Season	N	Avg. Obs. (µg/m³)	Avg. Pre. (µg/m³)	r	NMB (%)	NME (%)	MB (µg/m³)	ME (µg/m³)
VISTAS	IMPROVE	Winter	389	0.62	0.81	0.55	29.14	75.87	0.18	0.47
		Spring	405	0.39	0.46	0.32	20.09	97.74	0.08	0.38
		Summer	390	0.18	0.12	0.22	-30.96	78.32	-0.05	0.14
		Fall	381	0.24	0.34	0.43	41.04	102.06	0.10	0.25
		All	1565	0.36	0.43	0.51	21.25	86.61	0.08	0.31
	CSN	Winter	623	1.07	1.40	0.52	31.82	70.18	0.34	0.75
		Spring	647	0.55	0.68	0.38	23.04	84.80	0.13	0.47
		Summer	675	0.28	0.17	0.26	-37.94	62.40	-0.10	0.17
		Fall	636	0.39	0.60	0.49	51.78	94.99	0.20	0.37
		All	2581	0.56	0.70	0.58	24.18	77.02	0.14	0.43
	CASTNET	Winter	241	1.26	1.12	0.47	-11.28	60.57	-0.14	0.77
		Spring	302	0.61	0.49	0.22	-20.01	77.22	-0.12	0.47
		Summer	274	0.28	0.14	0.31	-49.69	78.85	-0.14	0.22
		Fall	277	0.52	0.56	0.17	7.60	87.38	0.04	0.45
		All	1094	0.65	0.56	0.48	-13.89	72.31	-0.09	0.47
Non-VISTAS	IMPROVE	Winter	1611	1.05	1.26	0.70	19.69	66.59	0.21	0.70
		Spring	1750	0.60	0.75	0.82	25.43	69.75	0.15	0.42
		Summer	1703	0.19	0.11	0.52	-39.73	76.22	-0.08	0.15
		Fall	1655	0.33	0.50	0.80	52.12	91.85	0.17	0.30
		All	6719	0.54	0.65	0.76	20.89	72.17	0.11	0.39
	CSN	Winter	1784	2.67	2.53	0.70	-5.45	41.71	-0.15	1.11
		Spring	1889	1.48	1.62	0.79	9.15	51.33	0.14	0.76
		Summer	1899	0.52	0.34	0.52	-34.52	64.58	-0.18	0.34
		Fall	1829	0.94	1.14	0.75	20.28	59.15	0.19	0.56
		All	7401	1.39	1.39	0.78	0.06	49.46	0.00	0.69
	CASTNET	Winter	427	1.88	1.77	0.46	-6.09	70.27	-0.11	1.32
		Spring	551	0.85	0.99	0.56	17.1	88.84	0.14	0.75
		Summer	521	0.33	0.22	0.10	-35.05	99.67	-0.12	0.33
		Fall	530	0.73	0.97	0.52	34.12	100.28	0.25	0.73
		All	2029	0.90	0.95	0.54	5.56	84.10	0.05	0.76

Figure 4-1. Boxplot Comparisons of Model Predictions and IMPROVE Nitrate Observations for Each Climate Region by Month.

Figure 4-2. Boxplot Comparisons of Model Predictions and CSN Nitrate Observations for Each Climate Region by Month.

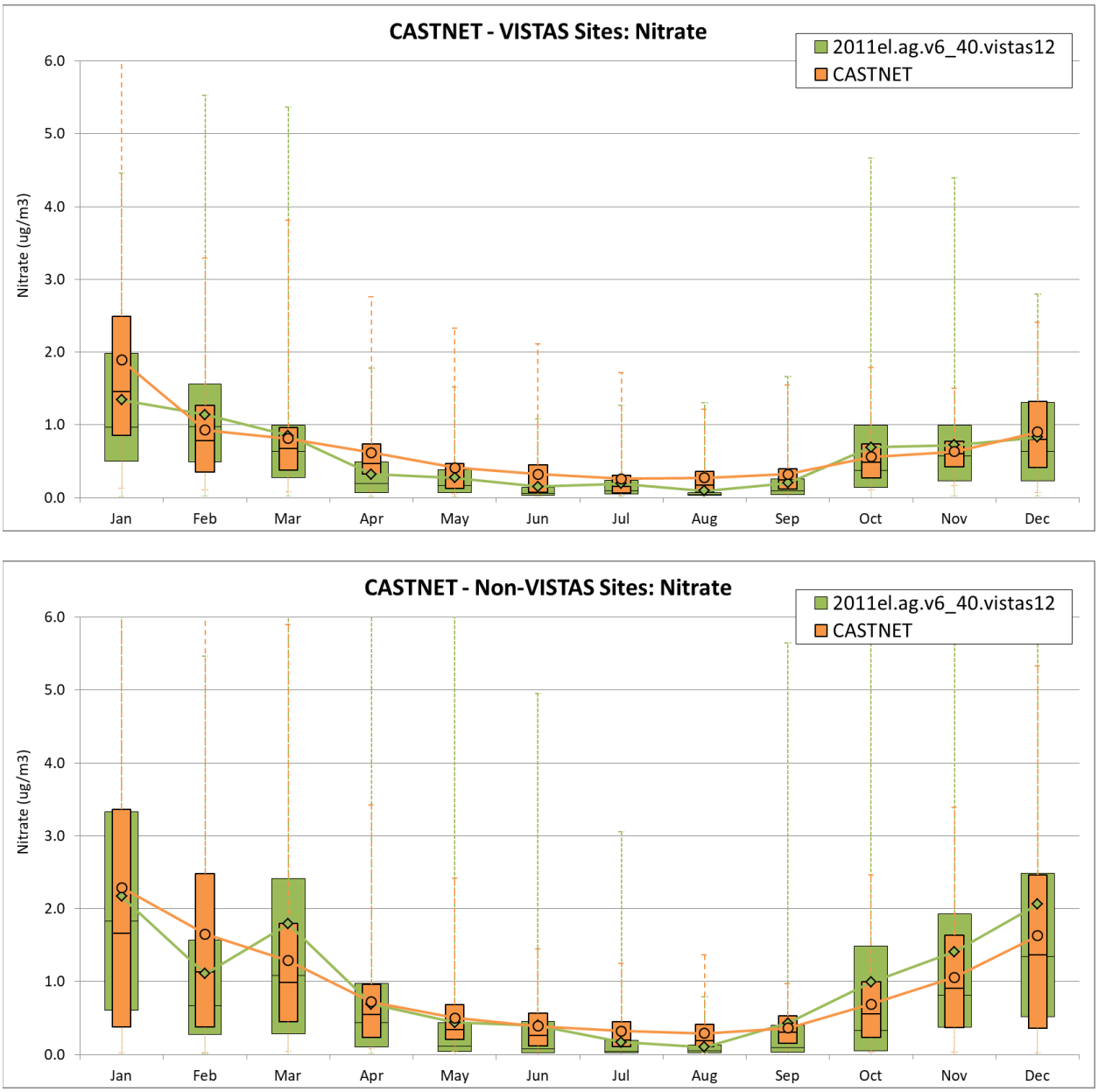


Figure 4-3. Boxplot Comparisons of Model Predictions and CASTNET Nitrate Observations for Each Climate Region by Month.

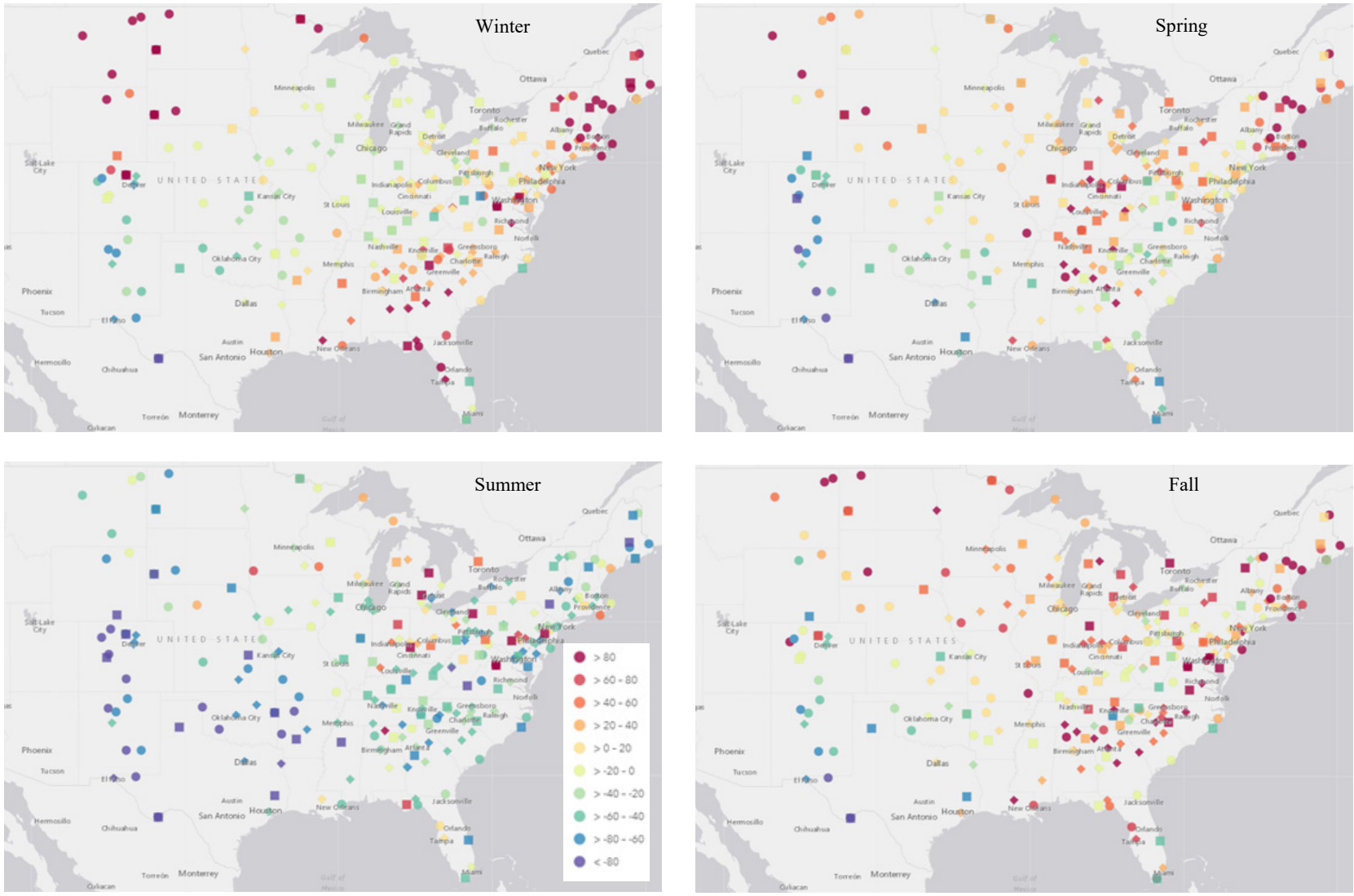


Figure 4-4. Spatial Plots of Nitrate NMB by Season and Network (Circle = IMPROVE, Square = CASTNET, Diamond = CSN).

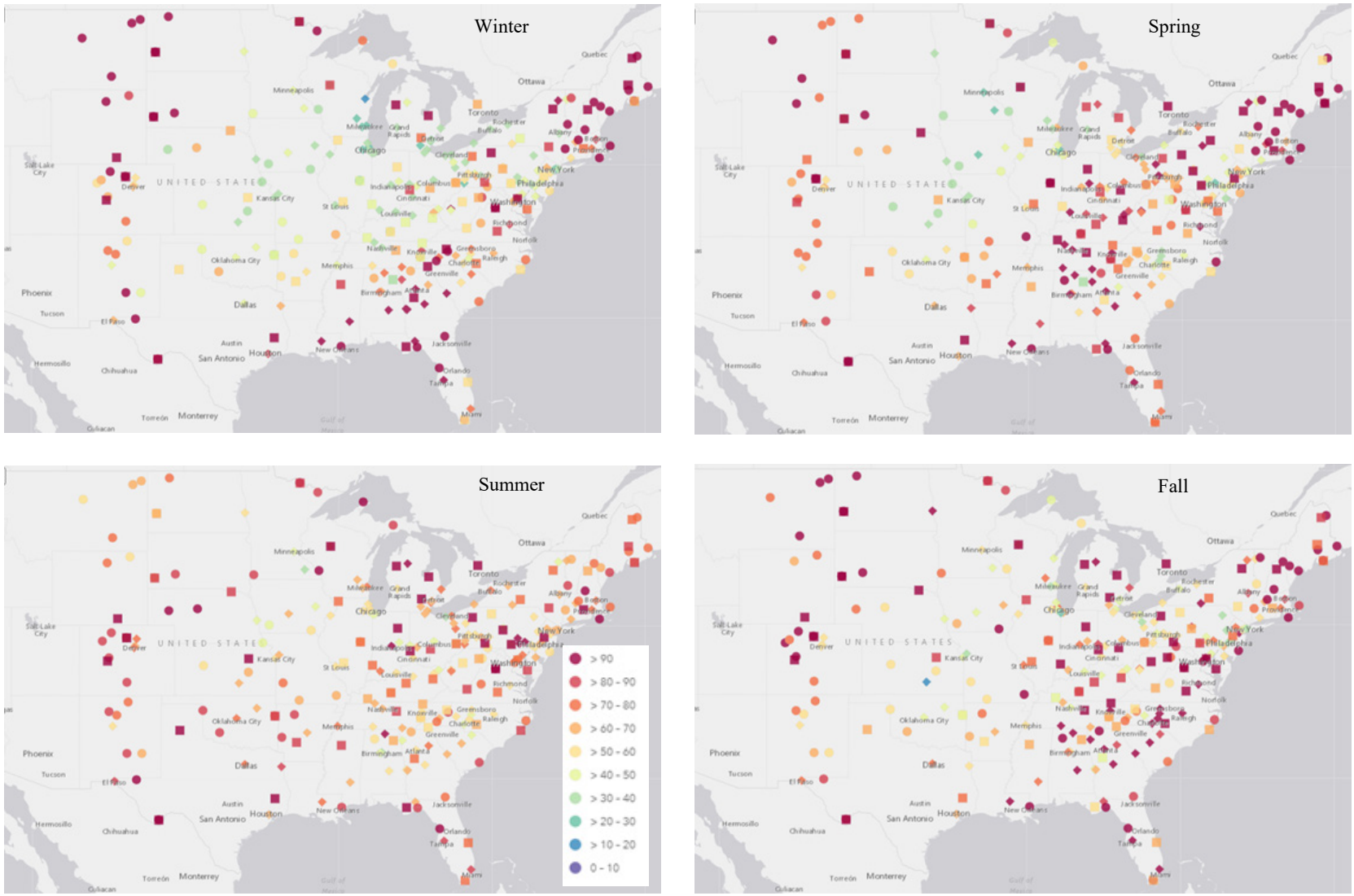


Figure 4-5. Spatial Plots of Nitrate NME by Season and Network (Circle = IMPROVE, Square = CASTNET, Diamond = CSN).

5.0 $PM_{2.5}$ AMMONIUM

Table 5-1 summarizes model performance statistics for $PM_{2.5}$ ammonium. Boxplot comparisons of model predictions and observations (CSN and CASTNET) by month for each climate region are shown in Figures 5-1 and 5-2. VISTAS12 modeling domain spatial plots of NMB and NME for each season are shown in Figures 5-3 and 5-4 (note that the IMPROVE network does not measure ammonium).

Ammonium is generally under predicted across the VISTAS12 domain in all seasons, with the exception of over prediction in the fall months. In the VISTAS state receptor networks, ammonium is generally under predicted with a significant over prediction observed during the lowest observed concentration fall months in the CSN. While both the model and the observations in the VISTAS states show the lowest average ammonium concentrations in the fall, the model predictions show less seasonal variability than the observations.

Over prediction of ammonium is seen across much of the eastern half of the VISTAS12 modeling domain during fall months and along the northern border of the domain during most seasons with noted under prediction seen at peninsular Florida CASTNET sites across most seasons.

Table 5-1. Model Performance Statistics for $PM_{2.5}$ Ammonium by Region, Network, and Season

Region	Network	Season	N	Avg. Obs. (µg/m³)	Avg. Pre. (µg/m³)	r	NMB (%)	NME (%)	MB (µg/m³)	ME (µg/m³)
VISTAS	CSN	Winter	618	0.82	0.88	0.61	7.65	42.73	0.06	0.35
		Spring	644	0.82	0.80	0.61	-2.93	41.52	-0.02	0.34
		Summer	673	0.88	0.80	0.69	-8.88	34.35	-0.08	0.30
		Fall	624	0.42	0.67	0.68	60.09	70.46	0.25	0.29
		All	2559	0.74	0.79	0.63	6.73	43.58	0.05	0.32
	CASTNET	Winter	241	0.93	0.71	0.57	-23.39	38.57	-0.22	0.36
		Spring	302	0.87	0.63	0.42	-28.38	44.38	-0.25	0.39
		Summer	274	1.17	0.70	0.61	-40.17	45.97	-0.47	0.54
		Fall	277	0.55	0.57	0.32	2.89	59.60	0.02	0.33
		All	1094	0.88	0.65	0.48	-26.16	45.97	-0.23	0.40
Non-VISTAS	CSN	Winter	1781	1.31	1.19	0.69	-9.57	38.97	-0.13	0.51
		Spring	1873	1.01	1.10	0.78	8.25	37.59	0.08	0.38
		Summer	1884	0.87	0.83	0.79	-5.17	37.97	-0.05	0.33
		Fall	1796	0.62	0.82	0.77	32.80	52.20	0.20	0.32
		All	7334	0.95	0.98	0.75	3.02	40.46	0.03	0.39
	CASTNET	Winter	427	1.02	0.82	0.55	-20.05	51.55	-0.20	0.53
		Spring	551	0.74	0.71	0.57	-4.44	50.62	-0.03	0.38
		Summer	521	0.85	0.59	0.50	-31.14	53.61	-0.27	0.46
		Fall	530	0.59	0.69	0.39	16.02	66.97	0.10	0.40
		All	2029	0.79	0.70	0.48	-12.06	54.91	-0.10	0.43

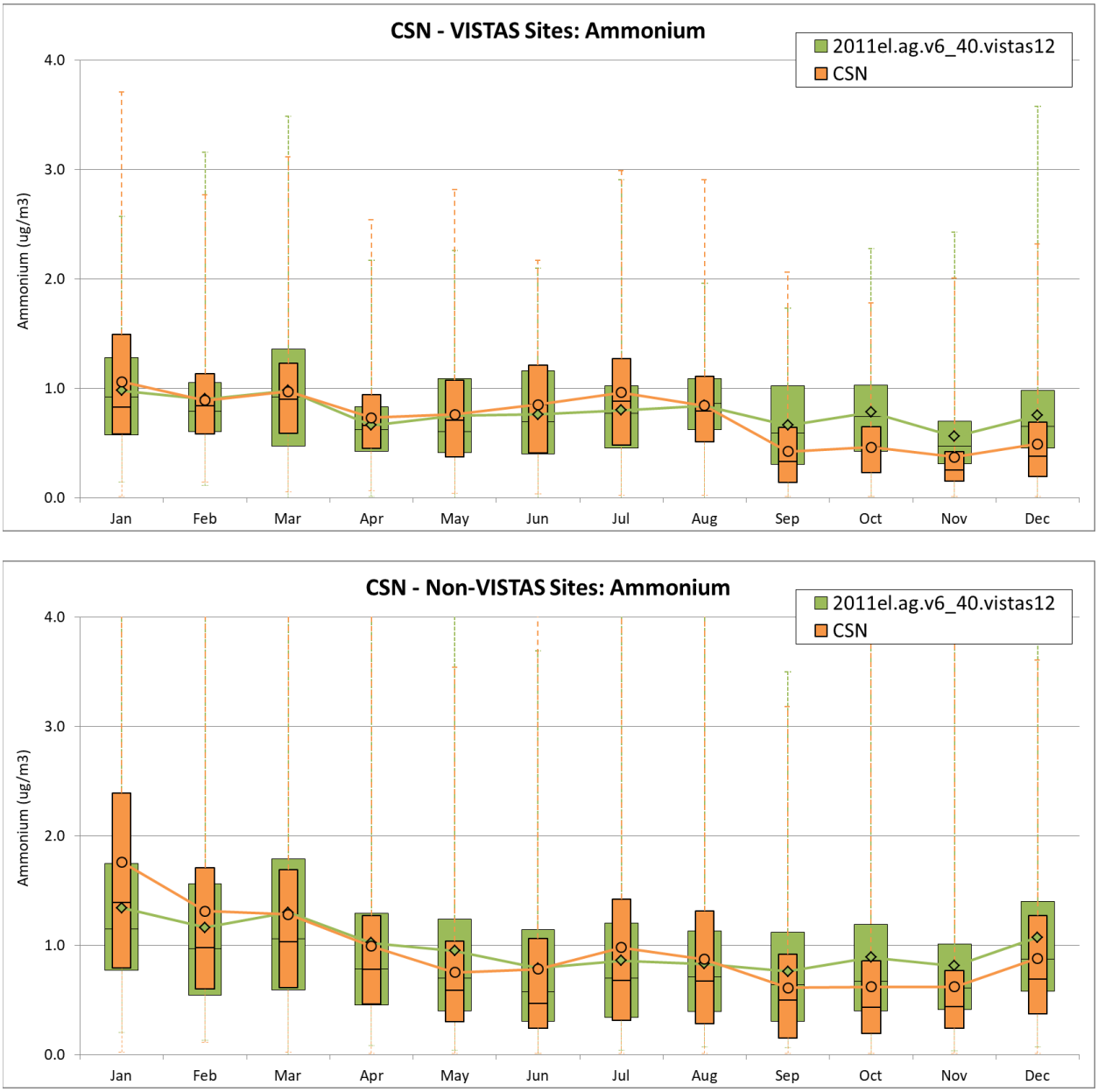


Figure 5-1. Boxplot Comparisons of Model Predictions and CSN Ammonium Observations for Each Climate Region by Month.

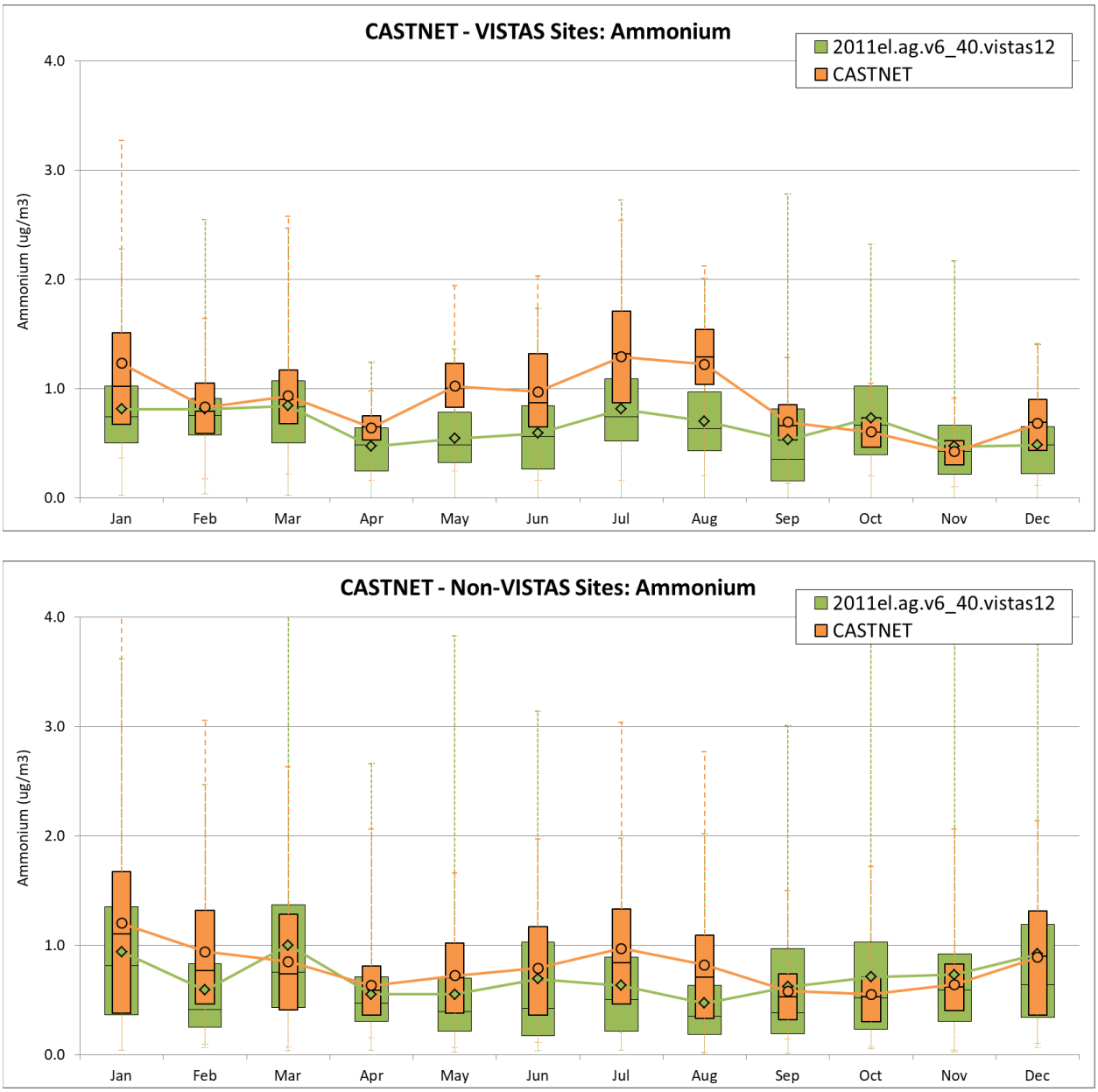


Figure 5-2. Boxplot Comparisons of Model Predictions and CASTNET Ammonium Observations for Each Climate Region by Month.

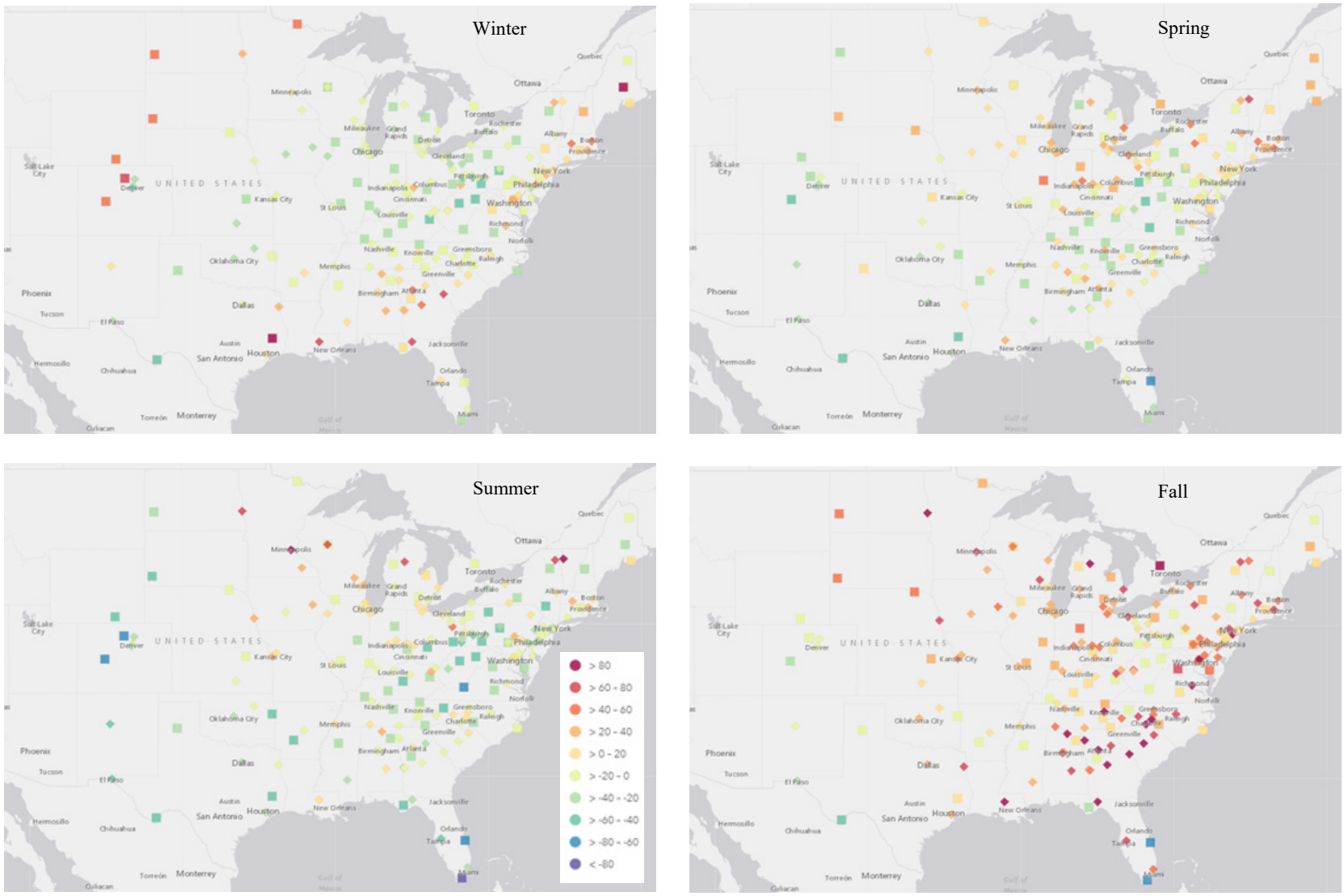


Figure 5-3. Spatial Plots of Ammonium NMB by Season and Network (Square = CASTNET, Diamond = CSN).

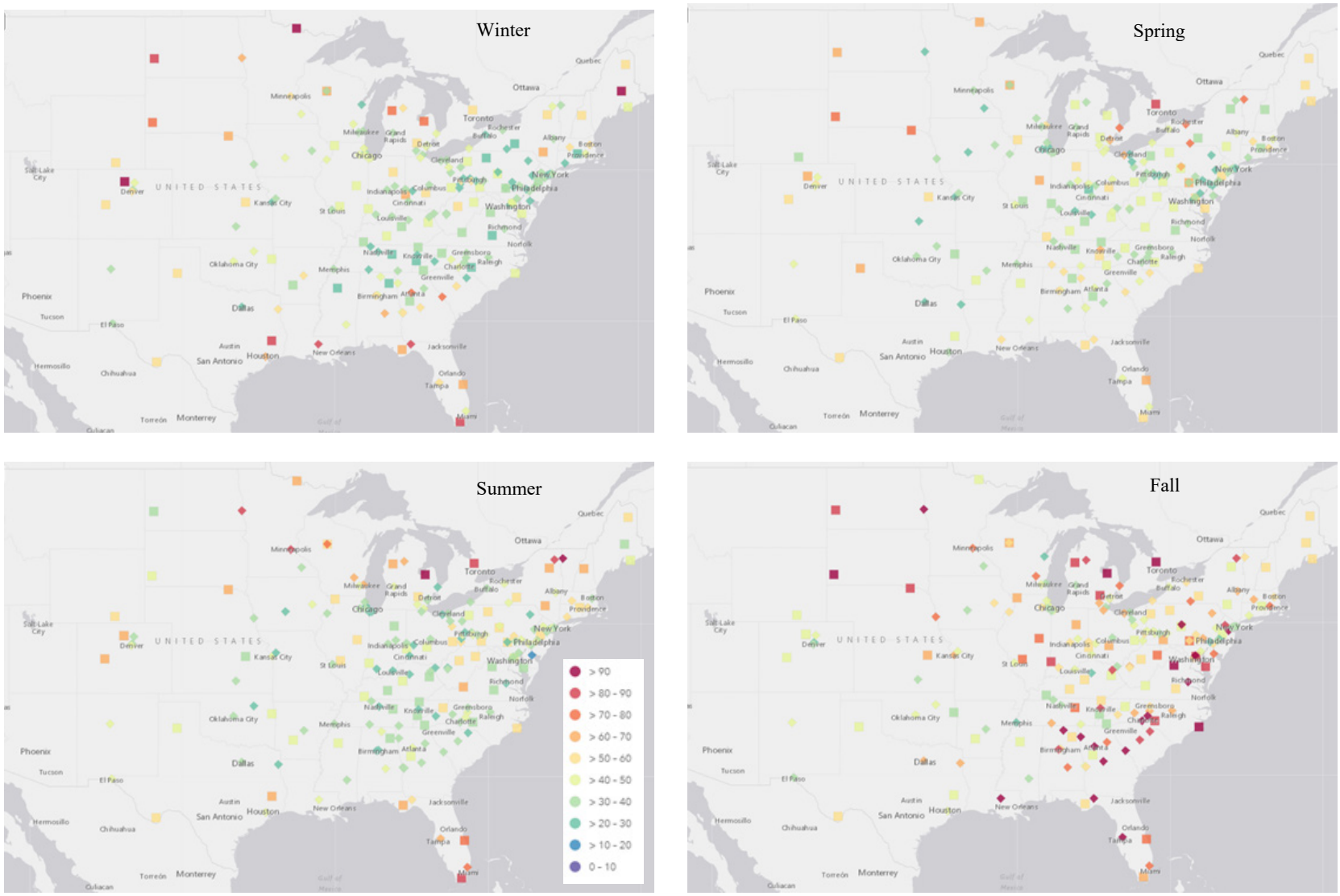


Figure 5-4. Spatial Plots of Ammonium NME by Season and Network (Square = CASTNET, Diamond = CSN).

6.0 $PM_{2.5}$ OC

Table 6-1 summarizes model performance statistics for $PM_{2.5}$ organic carbon (OC). To provide a direct comparison to the observational data, as noted in Table 2-2, CAMx's OM was divided by 1.8 and 1.4, respectively, to generate OC for IMPROVE and CSN receptors. Boxplot comparisons of model predictions and observations (IMPROVE and CSN) by month for each climate region are shown in Figures 6-1 and 6-2. VISTAS12 modeling domain spatial plots of NMB and NME for each season are shown in Figures 6-3 and 6-4.

Both the model and the observations show the highest average OC concentrations in the summer. OC is generally overestimated for the CSN network and underestimated for the IMPROVE network. OC is generally over predicted in the VISTAS12 domain across seasons outside of the summer. The greatest noted NMB includes winter month over prediction (163.33%) in non-VISTAS receptors from the CSN.

The most significant over prediction of OC is seen across the northern half of the VISTAS12 modeling domain during winter months with high over predictions also seen in the region during spring and fall seasons.

Table 6-1. Model Performance Statistics for $PM_{2.5}$ OC by Region, Network, and Season.

Region	Network	Season	N	Avg. Obs. (µg/m³)	Avg. Pre. (µg/m³)	r	NMB (%)	NME (%)	MB (µg/m³)	ME (µg/m³)
VISTAS	IMPROVE	Winter	406	1.32	1.49	0.63	12.62	48.46	0.17	0.64
		Spring	433	1.81	1.22	0.35	-32.46	49.52	-0.59	0.90
		Summer	425	2.18	1.60	0.31	-26.87	47.47	-0.59	1.04
		Fall	411	1.31	1.09	0.38	-16.76	48.67	-0.22	0.64
		All	1675	1.66	1.35	0.35	-18.89	48.47	-0.31	0.81
	CSN	Winter	607	1.94	3.31	0.57	71.02	85.84	1.37	1.66
		Spring	612	1.83	2.38	0.60	29.73	51.48	0.55	0.94
		Summer	664	2.61	3.78	0.39	44.82	64.15	1.17	1.67
		Fall	617	1.68	2.49	0.63	48.12	63.72	0.81	1.07
		All	2500	2.03	3.00	0.55	48.22	66.28	0.98	1.34
Non-VISTAS	IMPROVE	Winter	1666	0.75	1.19	0.51	59.06	87.07	0.44	0.65
		Spring	1831	0.84	0.81	0.57	-3.52	56.96	-0.03	0.48
		Summer	1764	1.43	1.15	0.49	-19.53	46.28	-0.28	0.66
		Fall	1700	0.98	1.06	0.70	8.30	55.31	0.08	0.54
		All	6961	1.00	1.05	0.62	4.69	58.08	0.05	0.58
	CSN	Winter	1706	1.57	4.13	0.52	163.33	169.30	2.56	2.66
		Spring	1824	1.27	2.20	0.30	72.88	90.62	0.93	1.15
		Summer	1903	2.01	2.35	0.54	16.61	40.83	0.33	0.82
		Fall	1763	1.44	2.41	0.64	68.03	76.19	0.98	1.09
		All	7196	1.58	2.75	0.40	74.16	89.18	1.17	1.41

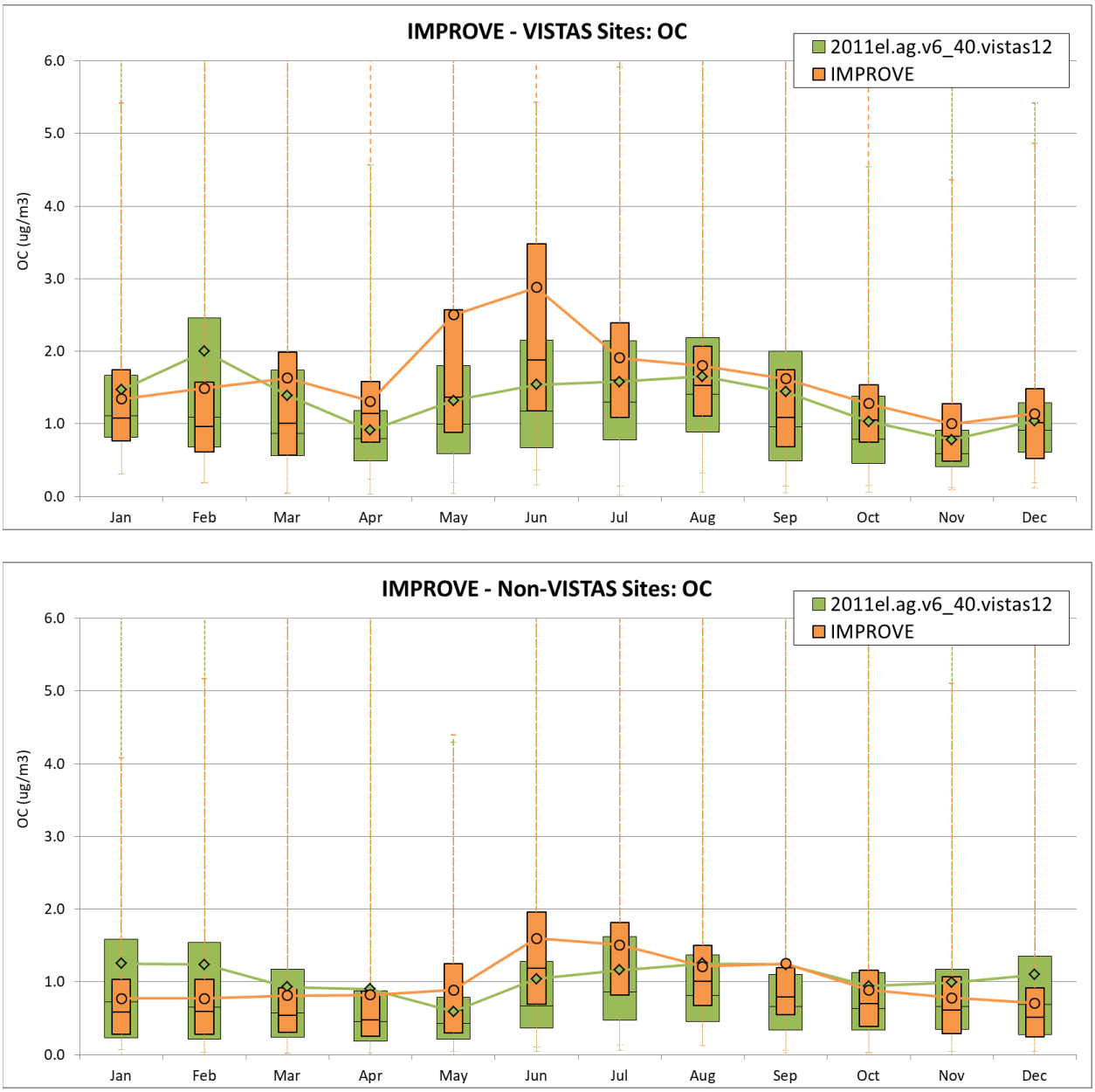


Figure 6-1. Boxplot Comparisons of Model Predictions and IMPROVE Organic Carbon (OC) Observations for Each Climate Region by Month.

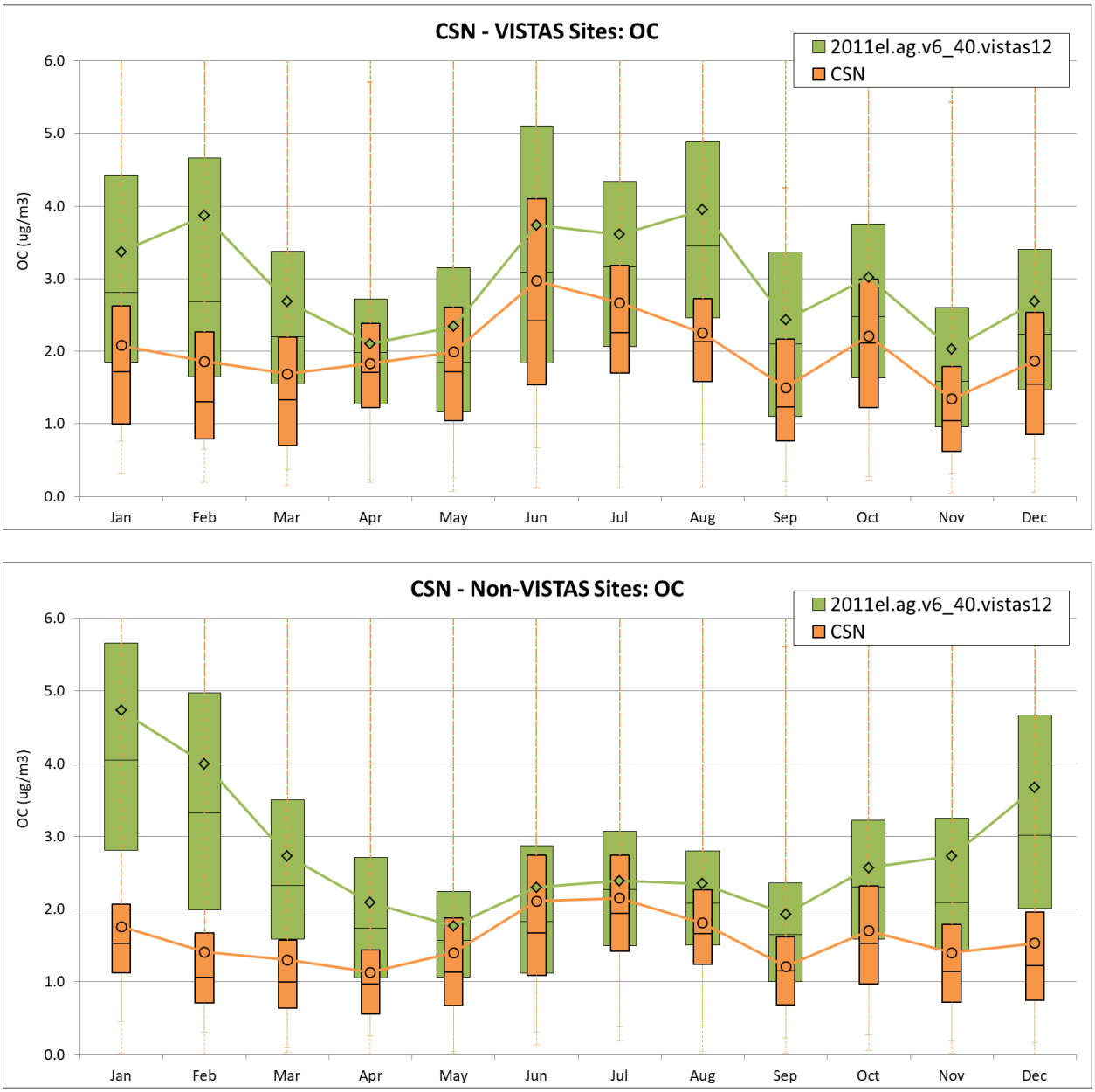


Figure 6-2. Boxplot Comparisons of Model Predictions and CSN Organic Carbon (OC) Observations for Each Climate Region by Month.

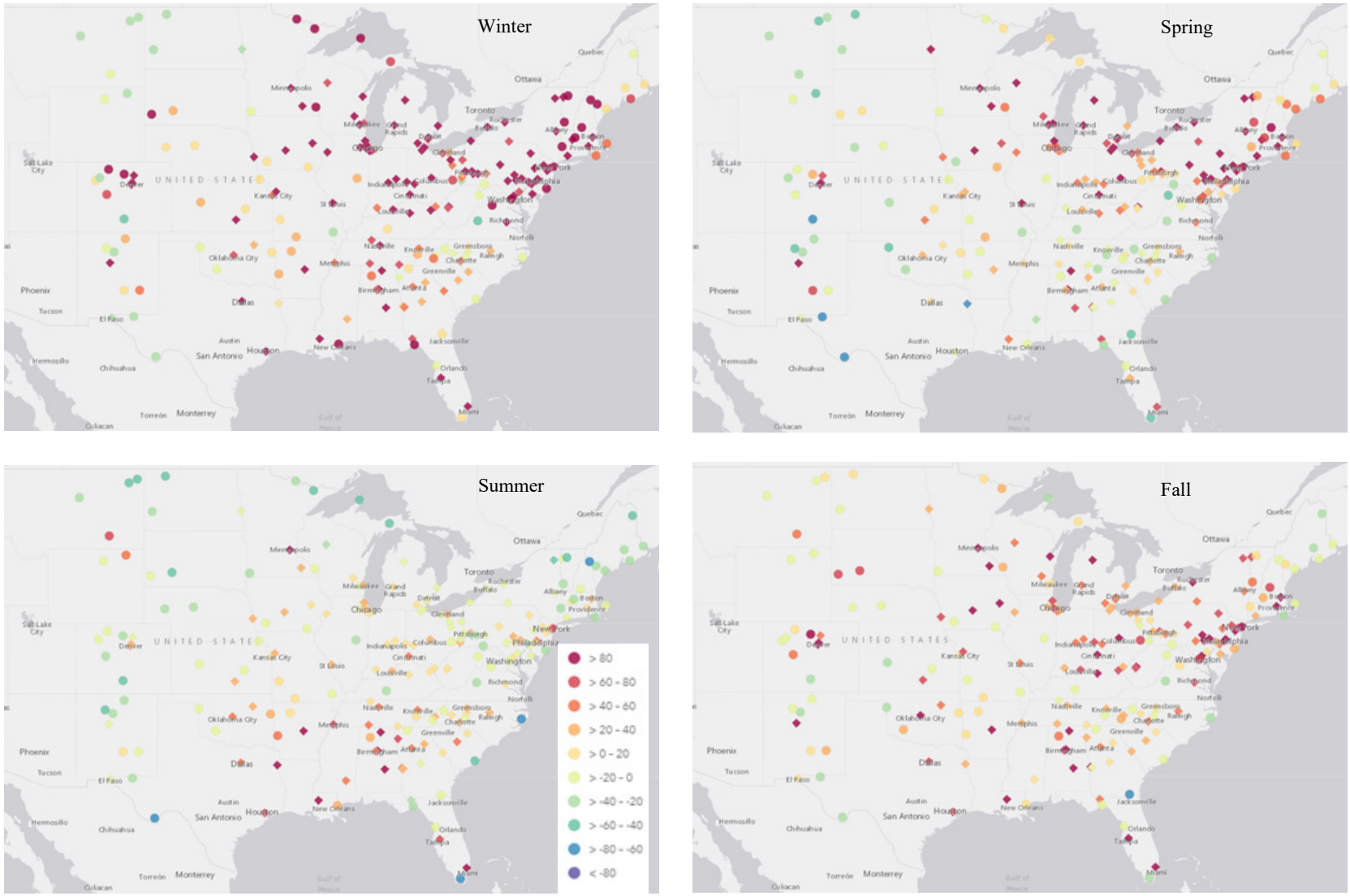


Figure 6-3. Spatial plots of organic carbon (OC) NMB by season and network (Circle = IMPROVE, Diamond = CSN).

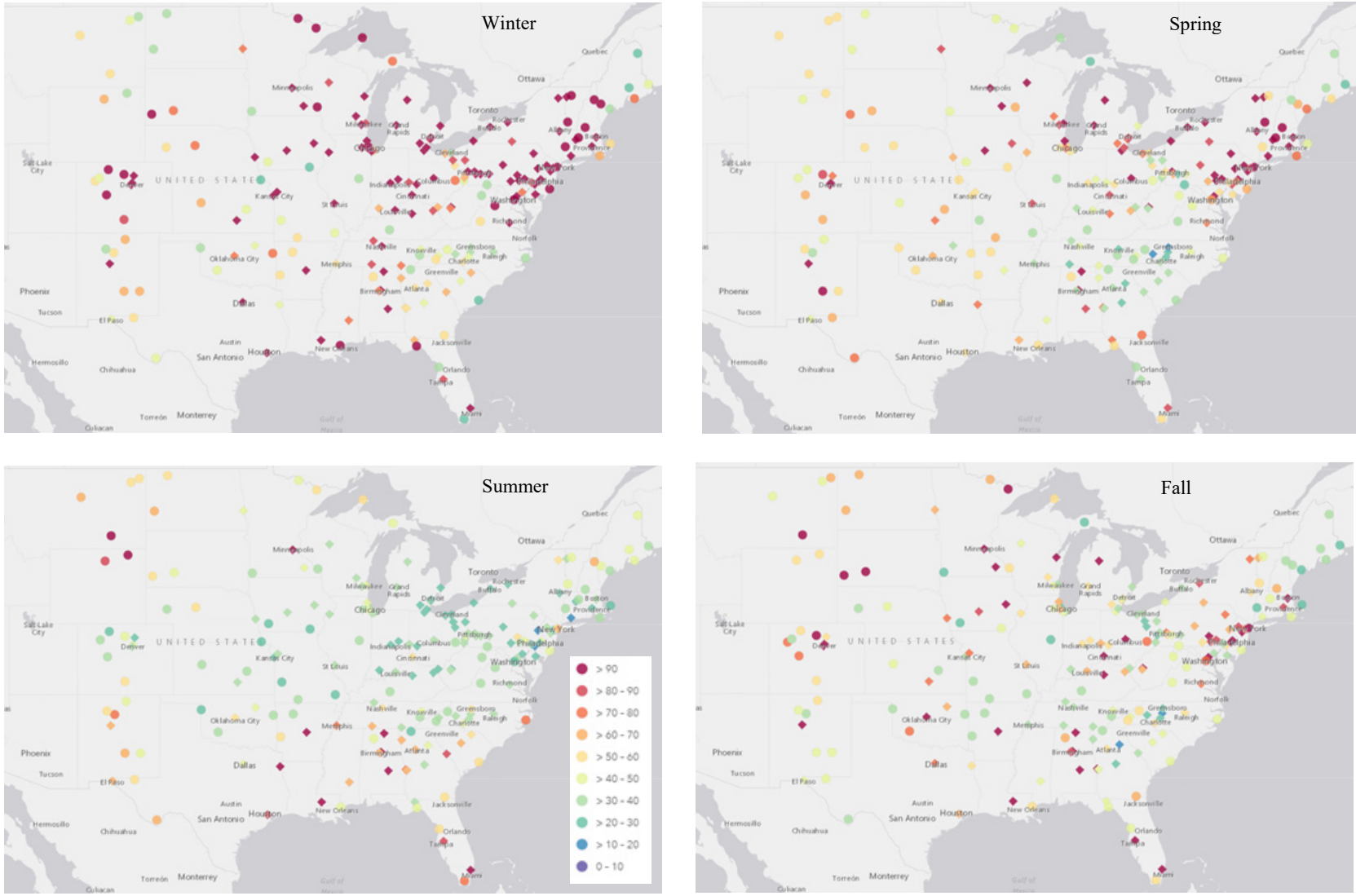


Figure 6-4. Spatial plots of organic carbon (OC) NME by season and network (Circle = IMPROVE, Diamond = CSN).

7.0 $PM_{2.5}$ EC

Table 7-1 summarizes model performance statistics for $PM_{2.5}$ EC. Boxplot comparisons of model predictions and observations (IMPROVE and CSN) by month for each climate region are shown in Figures 7-1 and 7-2. VISTAS12 modeling domain spatial plots of NMB and NME for each season are shown in Figures 7-3 and 7-4.

In the VISTAS states, EC concentrations averaged over the entire year show fairly close agreement with observations with a NMB of 0.20% at the IMPROVE monitors and 14.58% at the CSN monitors. However, on a seasonal basis the model is underestimating EC in the spring and summer and overestimating in the winter at the IMPROVE monitors. At the CSN monitors the model is overestimating except in the summer where the model NMB is a very low 0.26%.

Significant over prediction of EC is seen across most of the VISTAS12 modeling domain during winter months with high over predictions also seen in the northern half of the domain during spring and fall seasons.

Table 7-1. Model Performance Statistics for $PM_{2.5}$ EC by Region, Network, and Season.

Region	Network	Season	N	Avg. Obs. (µg/m³)	Avg. Pre. (µg/m³)	r	NMB (%)	NME (%)	MB (µg/m³)	ME (µg/m³)
VISTAS	IMPROVE	Winter	406	0.30	0.40	0.64	34.89	56.66	0.10	0.17
		Spring	433	0.31	0.27	0.38	-10.71	45.46	-0.03	0.14
		Summer	423	0.28	0.21	0.46	-24.74	42.01	-0.07	0.12
		Fall	412	0.25	0.25	0.60	0.18	38.63	0.00	0.10
		All	1674	0.28	0.28	0.45	-0.20	45.98	0.00	0.13
	CSN	Winter	610	0.67	0.87	0.56	29.28	58.09	0.20	0.39
		Spring	613	0.56	0.63	0.49	12.19	48.72	0.07	0.27
		Summer	664	0.67	0.67	0.29	-0.26	47.28	0.00	0.32
		Fall	619	0.61	0.72	0.55	18.32	49.89	0.11	0.31
		All	2506	0.63	0.72	0.49	14.58	51.03	0.09	0.32
Non-VISTAS	IMPROVE	Winter	1671	0.19	0.31	0.63	62.79	83.18	0.12	0.16
		Spring	1829	0.17	0.21	0.65	25.86	59.94	0.04	0.10
		Summer	1763	0.21	0.21	0.55	-0.97	44.60	0.00	0.10
		Fall	1702	0.20	0.28	0.61	36.63	62.53	0.07	0.13
		All	6965	0.19	0.25	0.56	29.70	61.71	0.06	0.12
	CSN	Winter	1713	0.61	1.10	0.57	80.48	95.49	0.49	0.58
		Spring	1834	0.49	0.75	0.48	53.10	72.00	0.26	0.35
		Summer	1904	0.70	0.79	0.56	12.60	44.43	0.09	0.31
		Fall	1774	0.66	0.94	0.67	42.67	60.96	0.28	0.40
		All	7225	0.62	0.89	0.56	44.59	66.31	0.27	0.41

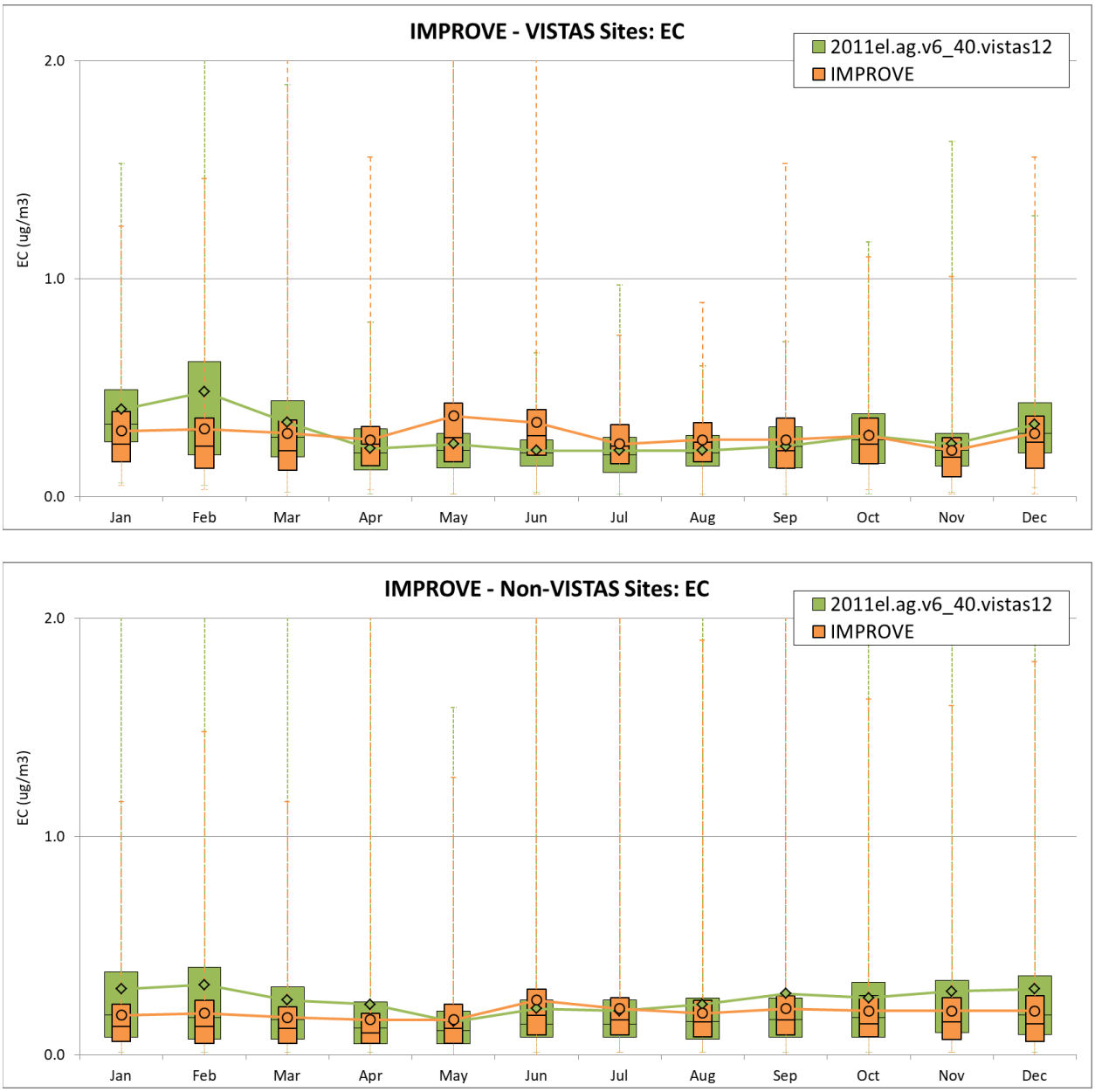


Figure 7-1. Boxplot Comparisons of Model Predictions and IMPROVE Elemental Carbon (EC) Observations for Each Climate Region by Month.

Figure 7-2. Boxplot Comparisons of Model Predictions and CSN Elemental Carbon (EC) Observations for Each Climate Region by Month.

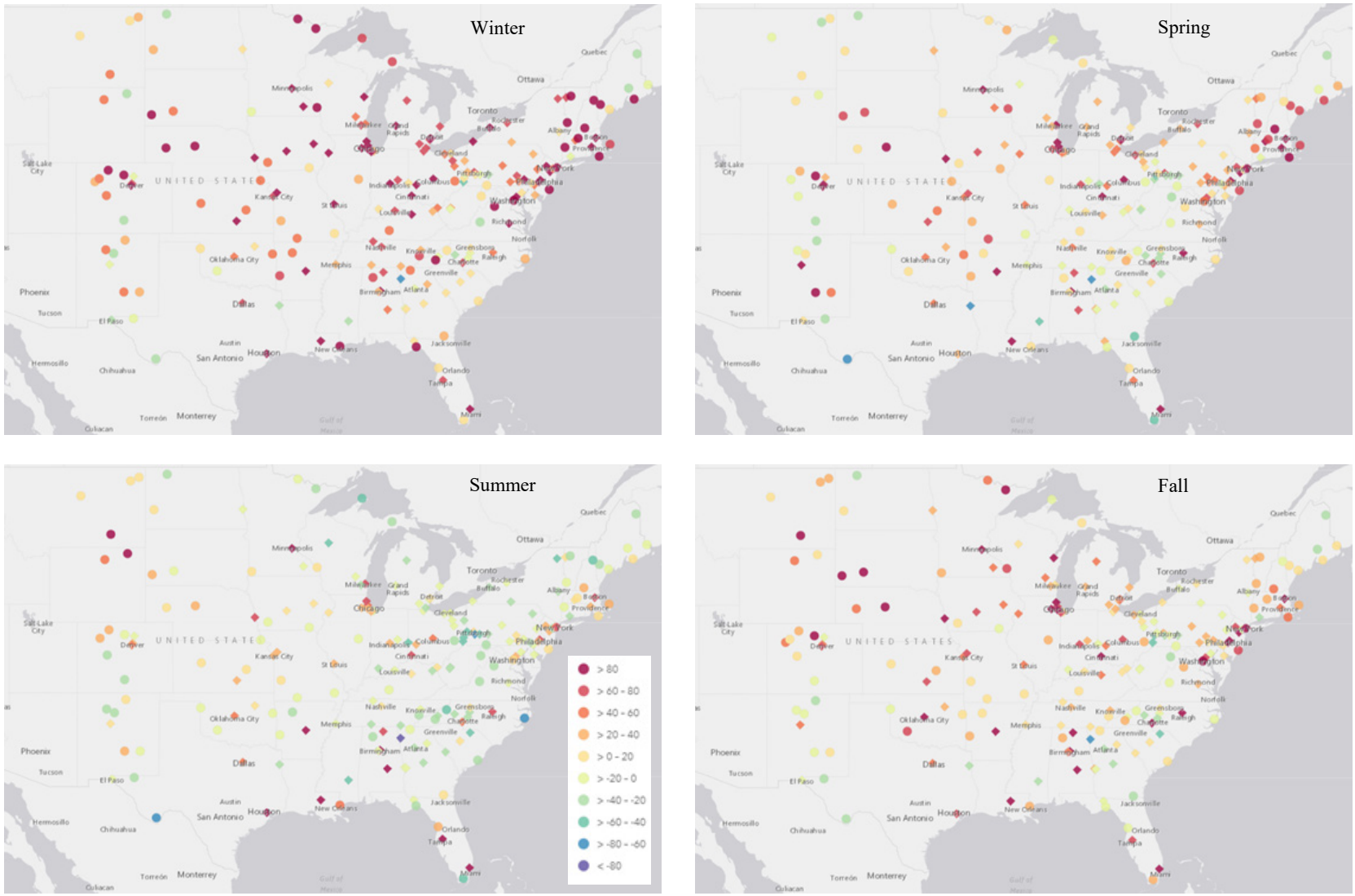


Figure 7-3. Spatial plots of elemental carbon (EC) NMB by season and network (Circle = IMPROVE, Diamond = CSN).

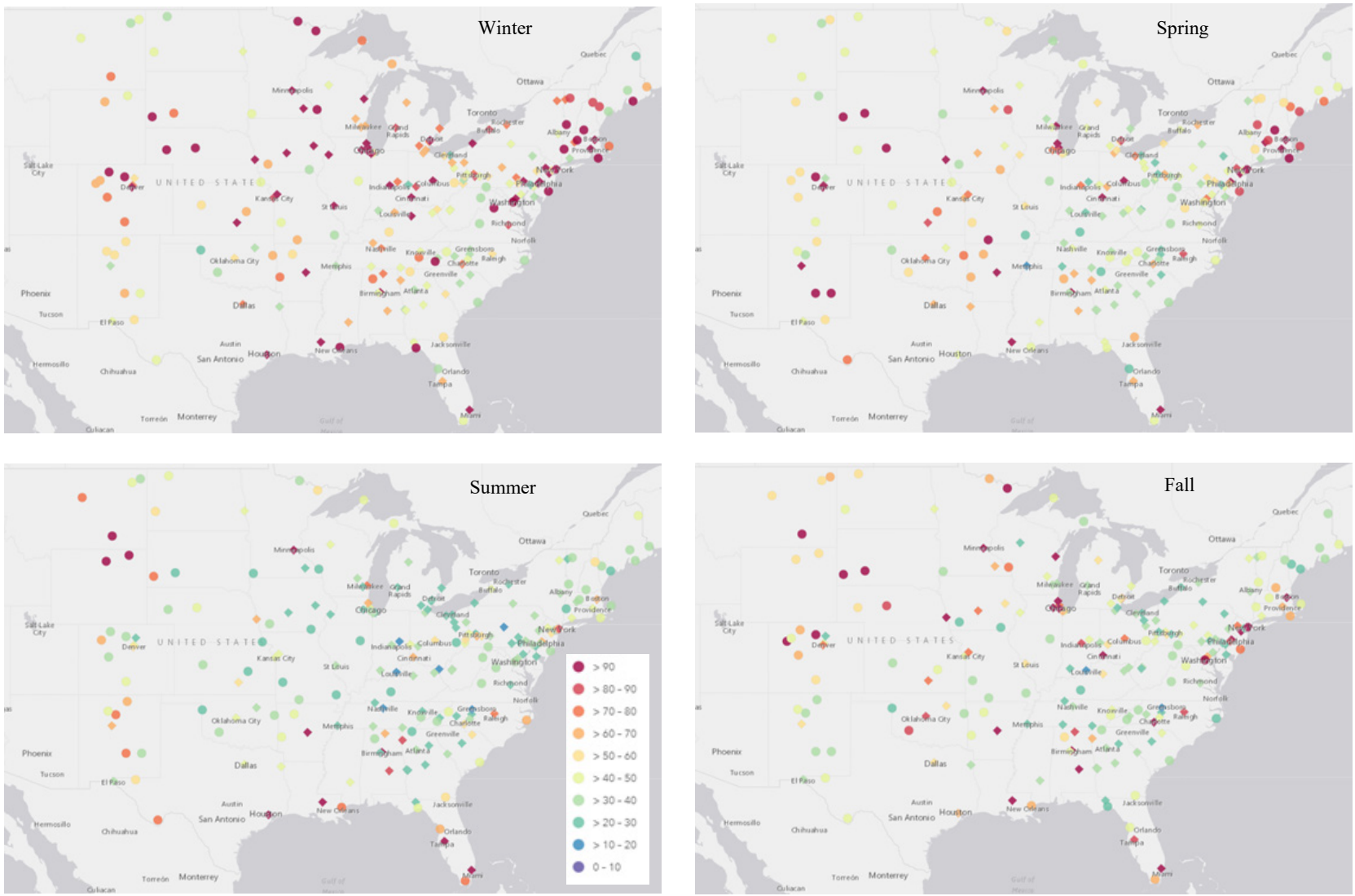


Figure 7-4. Spatial plots of elemental carbon (EC) NME by season and network (Circle = IMPROVE, Diamond = CSN).

8.0 TOTAL $PM_{2.5}$

Table 8-1 summarizes model performance statistics for total $PM_{2.5}$. Boxplot comparisons of model predictions and observations (IMPROVE and CSN) by month for each climate region are shown in Figures 8-1 and 8-2. VISTAS12 modeling domain spatial plots of NMB and NME for each season are shown in Figures 8-3 and 8-4.

$PM_{2.5}$ is over predicted across both networks during the winter season and under predicted across both networks during the summer season. Model performance varies between VISTAS and non-VISTAS regions, especially during the spring and fall seasons, with slightly better performance typically seen at the VISTAS state locations (compared to non-VISTAS receptors) at high observed concentrations and slightly worse performance at these same locations at low observed concentrations.

Table 8-1. Model Performance Statistics for $PM_{2.5}$ by Region, Network, and Season.

Region	Network	Season	N	Avg. Obs. (µg/m³)	Avg. Pre. (µg/m³)	r	NMB (%)	NME (%)	MB (µg/m³)	ME (µg/m³)
VISTAS	IMPROVE	Winter	403	5.86	6.96	0.67	18.87	38.66	1.11	2.26
		Spring	413	7.86	6.35	0.53	-19.16	36.82	-1.51	2.89
		Summer	423	10.95	6.68	0.57	-39.02	42.12	-4.27	4.61
		Fall	413	5.79	5.40	0.74	-6.63	31.04	-0.38	1.80
		All	1652	7.64	6.35	0.55	-16.96	38.01	-1.30	2.91
	CSN	Winter	627	9.86	11.25	0.64	14.08	35.17	1.39	3.47
		Spring	651	11.00	9.35	0.54	-15.00	33.16	-1.65	3.65
		Summer	677	15.85	11.25	0.52	-29.03	36.52	-4.60	5.79
		Fall	639	8.80	8.84	0.65	0.54	30.89	0.05	2.72
		All	2594	11.45	10.18	0.55	-11.07	34.36	-1.27	3.93
Non-VISTAS	IMPROVE	Winter	1660	4.55	5.97	0.68	31.36	53.57	1.43	2.44
		Spring	1812	5.29	5.11	0.63	-3.30	44.48	-0.17	2.35
		Summer	1762	6.92	4.80	0.66	-30.69	40.01	-2.12	2.77
		Fall	1704	4.54	4.86	0.63	7.08	40.04	0.32	1.82
		All	6938	5.34	5.18	0.61	-3.09	43.93	-0.16	2.35
	CSN	Winter	1773	11.26	13.83	0.61	22.84	42.32	2.57	4.76
		Spring	1881	9.44	10.17	0.56	7.70	36.89	0.73	3.48
		Summer	1906	12.75	9.55	0.72	-25.12	32.43	-3.20	4.14
		Fall	1826	8.67	9.82	0.61	13.27	37.14	1.15	3.22
		All	7386	10.54	10.80	0.58	2.47	36.94	0.26	3.89

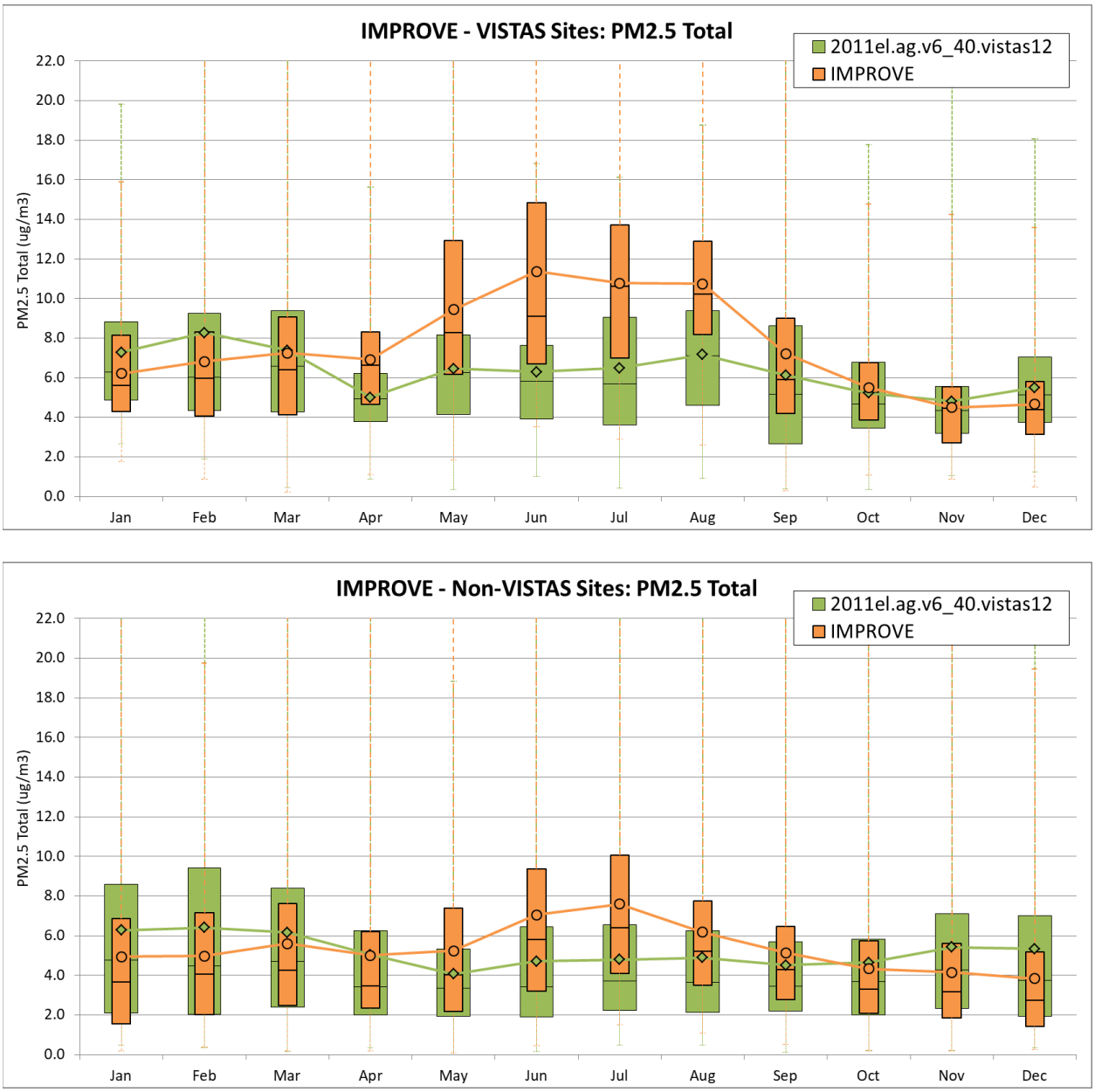


Figure 8-1. Boxplot Comparisons of Model Predictions and IMPROVE Total $PM_{2.5}$ Observations for Each Climate Region by Month.

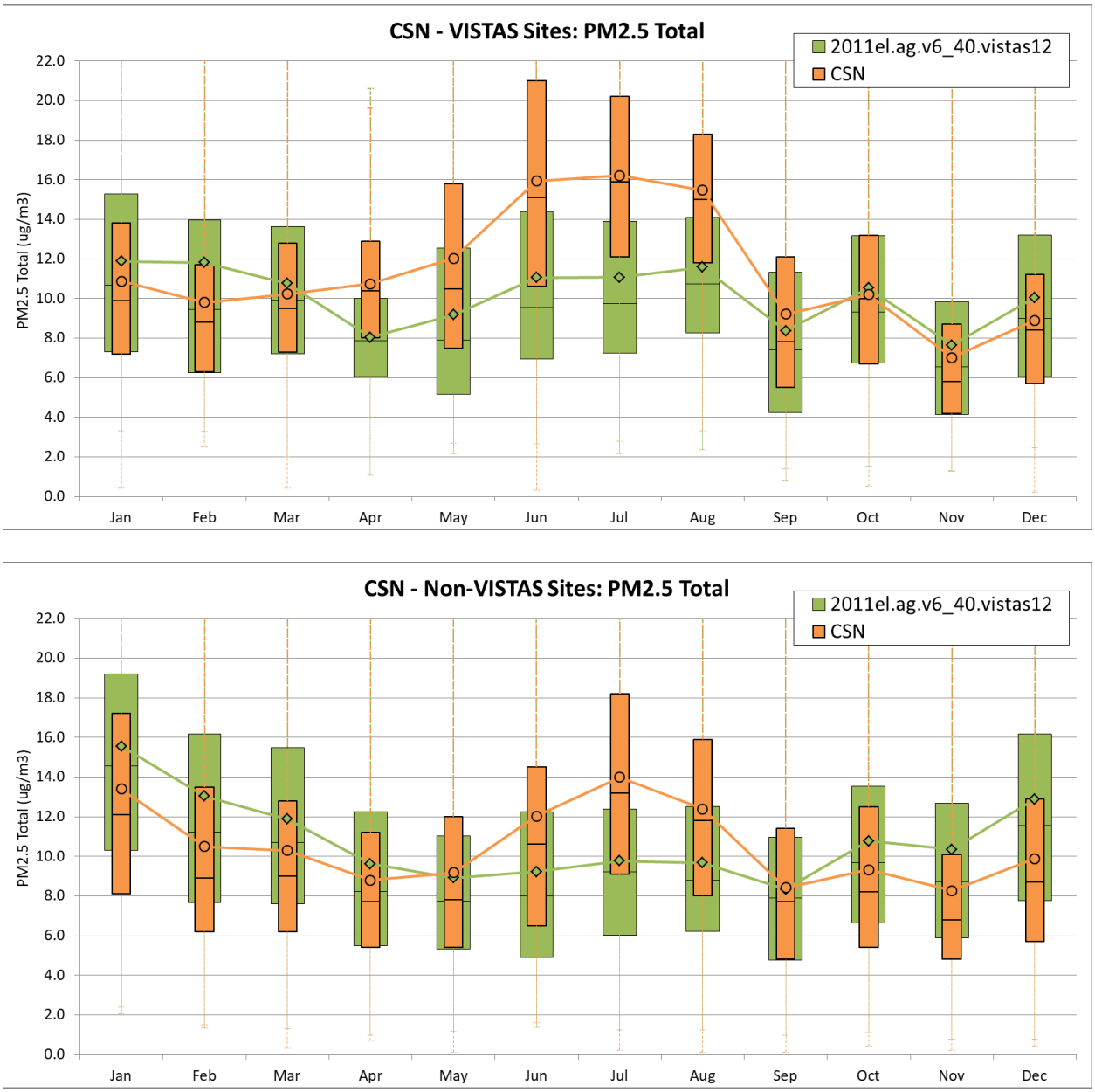


Figure 8-2. Boxplot Comparisons of Model Predictions and CSN Total $PM_{2.5}$ Observations for Each Climate Region by Month.

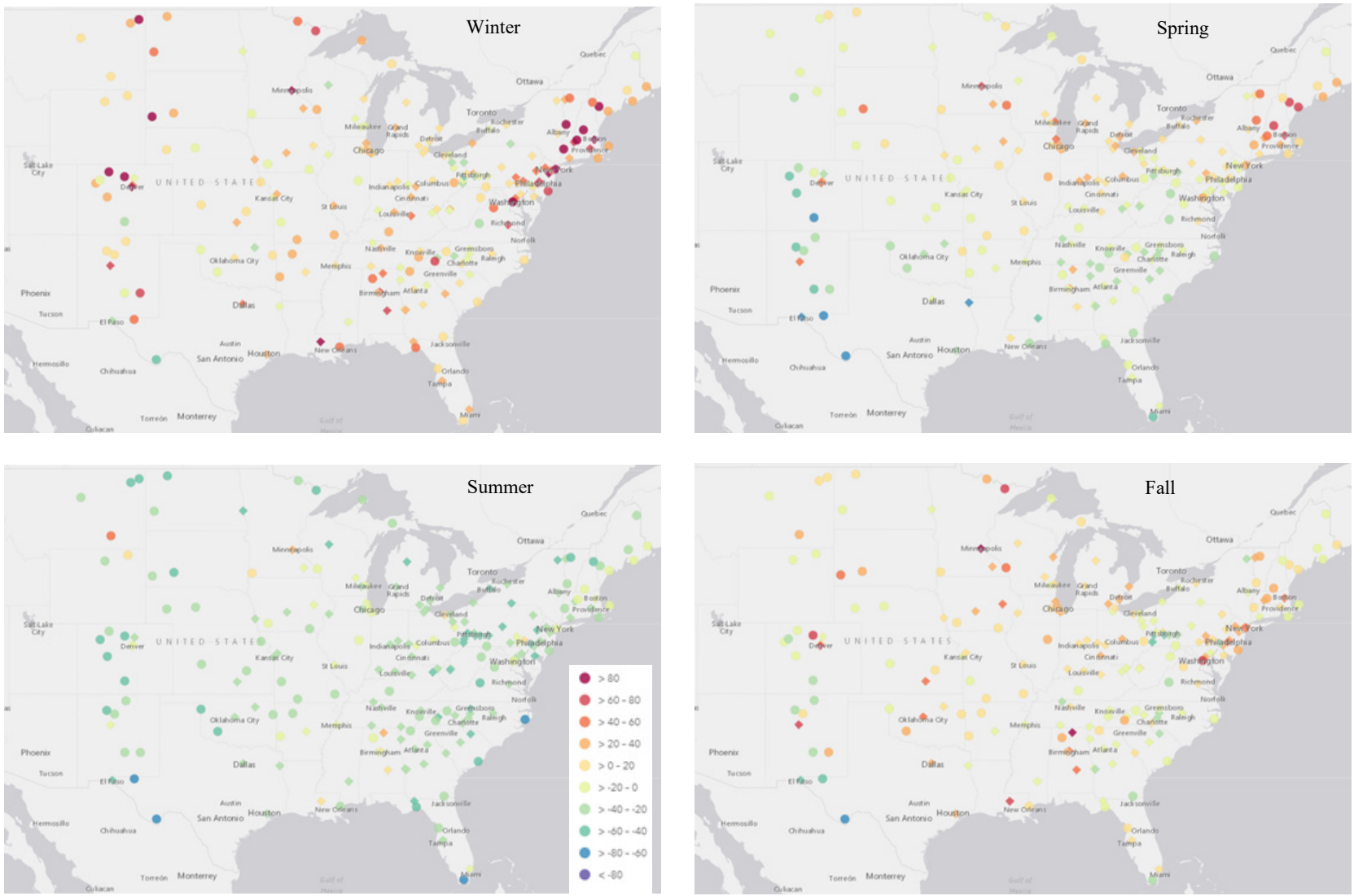


Figure 8-3. Spatial plots of total $PM_{2.5}$ NMB by season and network (Circle = IMPROVE, Diamond = CSN).

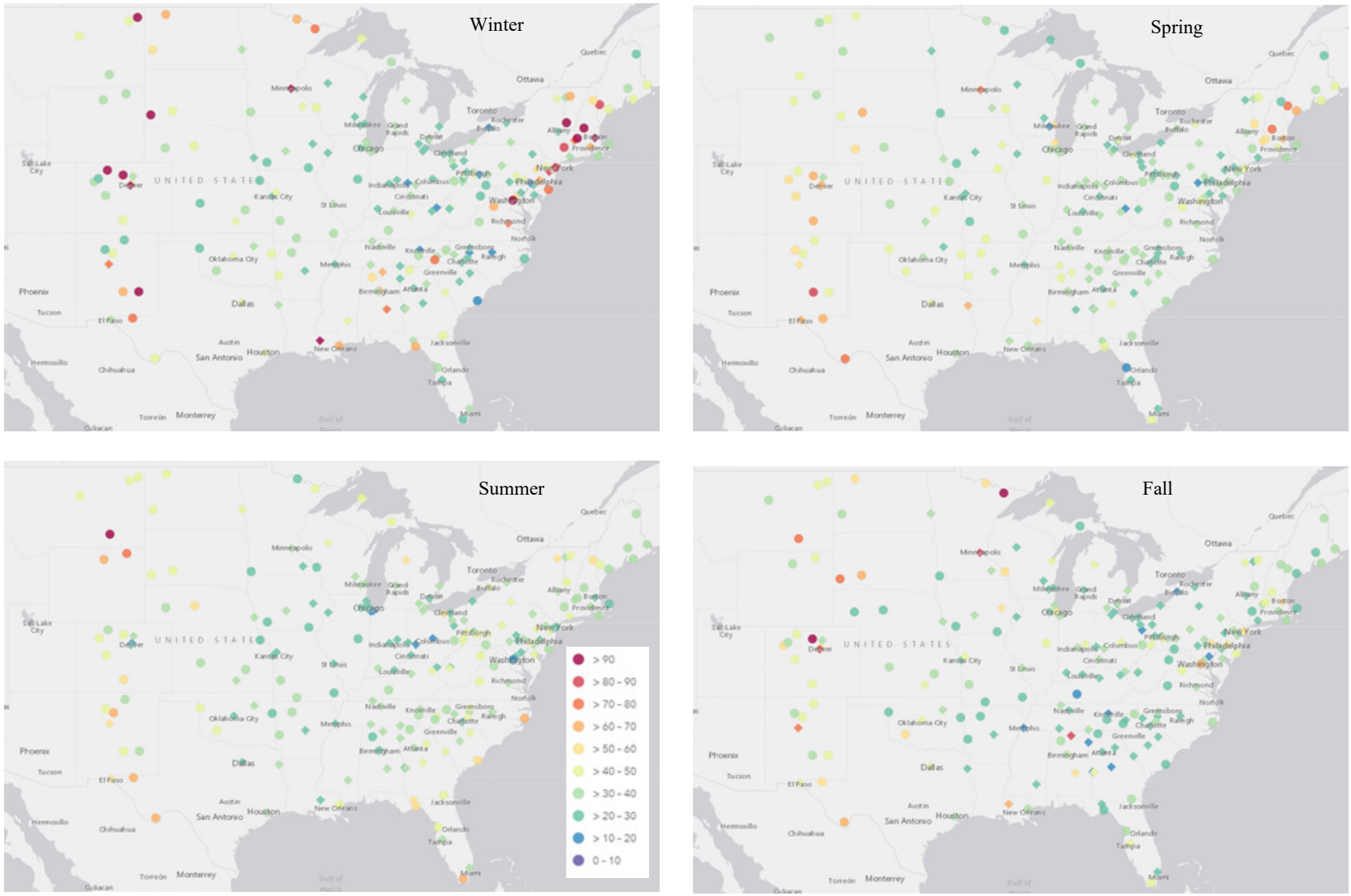


Figure 8-4. Spatial plots of total $PM_{2.5}$ NME by season and network (Circle = IMPROVE, Diamond = CSN).

9.0 PERFORMANCE ON 20% MOST-IMPAIRED DAYS

Spatial plots summarizing IMPROVE observations and model NMB on the 20% most-impaired days are shown in Figures 9-1 through 9-6. In each figure the top graphic presents the observed concentration and the bottom graphic presents the NMB.

For sulfate (Figure 9-1), predictions on the 20% most-impaired days are biased low across all regions, with the most significant percentage under predictions occurring in the southwest quarter of the VISTAS12 modeling domain. Some isolated over predictions are observed in a few Class I areas near the outer domain boundaries and in the northeast.

Predictions of nitrate (Figure 9-2) on the 20% most-impaired days in the VISTAS12 modeling domain are mixed with a high positive bias in the north and a mix of negative and positive bias in the southeast.

A general positive bias of OC (Figure 9-3) is observed across the region on the 20% most-impaired days. In the SESARM states the OC has approximately the same NMB at monitors with high observed concentrations as monitors with lower observed concentrations. For EC (Figure 9-4) the model shows a slight under prediction at monitors in the northern portion of the SESARM states and a positive bias at monitors in the southern SESARM region.

On the 20% most-impaired days, model performance for total $PM_{2.5}$ is overall biased low across most quadrants of the VISTAS12 modeling domain (corresponding closely to the sulfate performance). A slight over prediction of $PM_{2.5}$ on those days is observed in the Northern Plains and Upper Midwest, primarily along the Canadian border (corresponding closely to high nitrate concentrations and performance).

Sodium chloride (NACL) is generally over predicted along boundaries with ocean water bodies (Atlantic Ocean and Gulf of Mexico) and is expectedly under predicted across the rest of the VISTAS12 modeling domain.

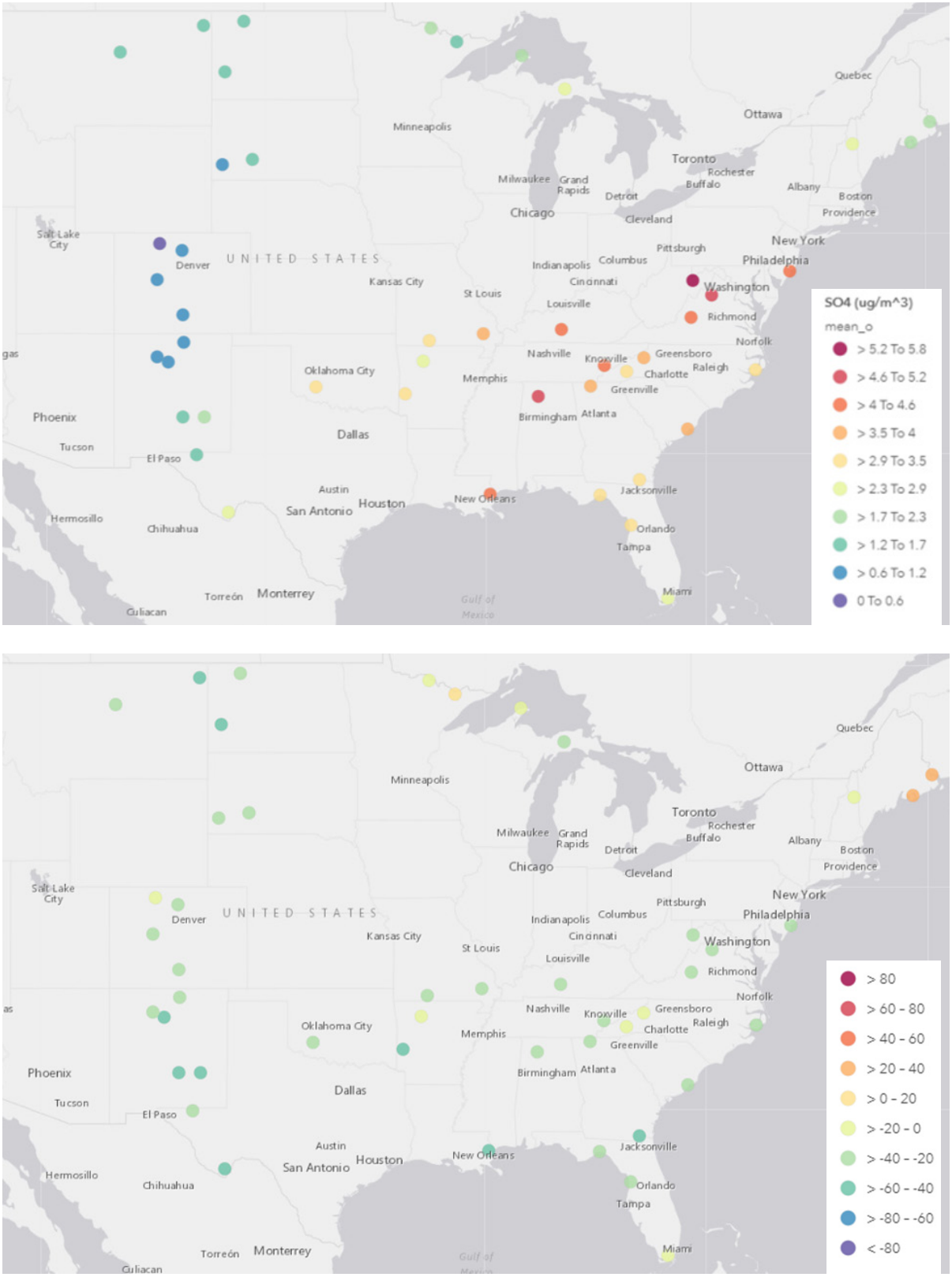


Figure 9-1. Observed Sulfate (Top) and Modeled NMB (Bottom) for Sulfate on the 20% Most-impaired Days at IMPROVE Monitor Locations.

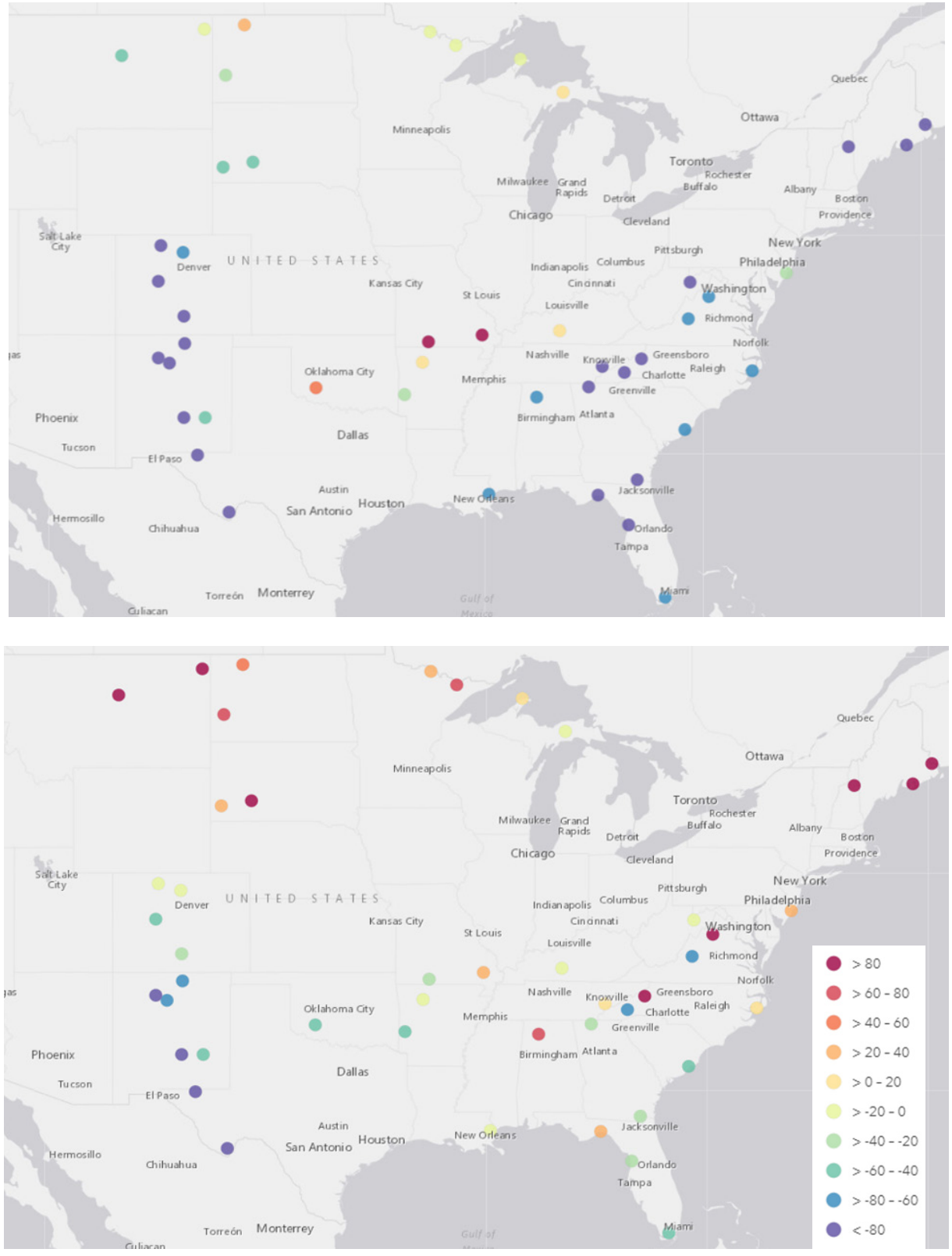


Figure 9-2. Observed Nitrate (Top) and Modeled NMB (Bottom) for Nitrate on the 20% Most-impaired Days at IMPROVE Monitor Locations.

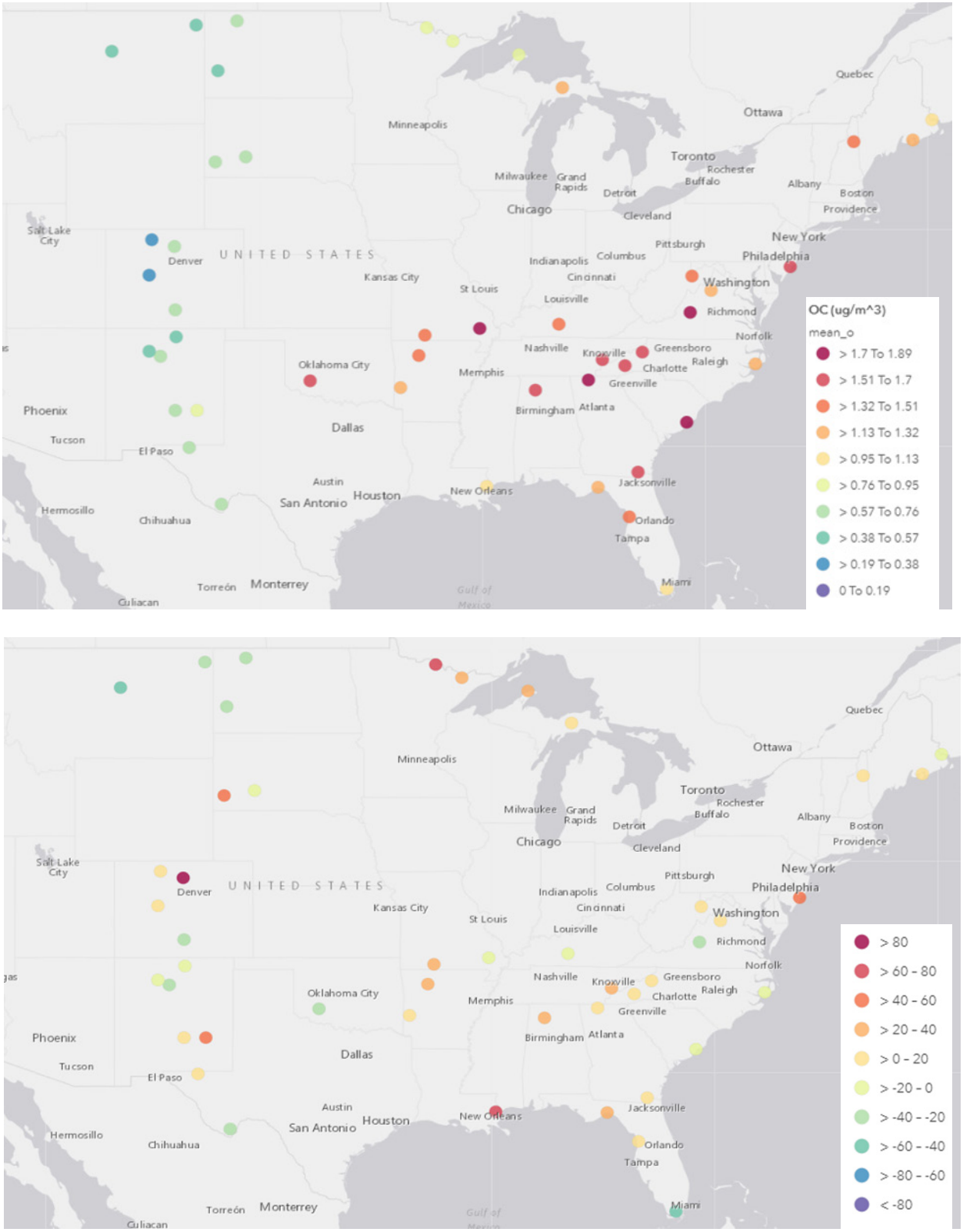


Figure 9-3. Observed OC (Top) and Modeled NMB (Bottom) for OC on the 20% Most-impaired Days at IMPROVE Monitor Locations.

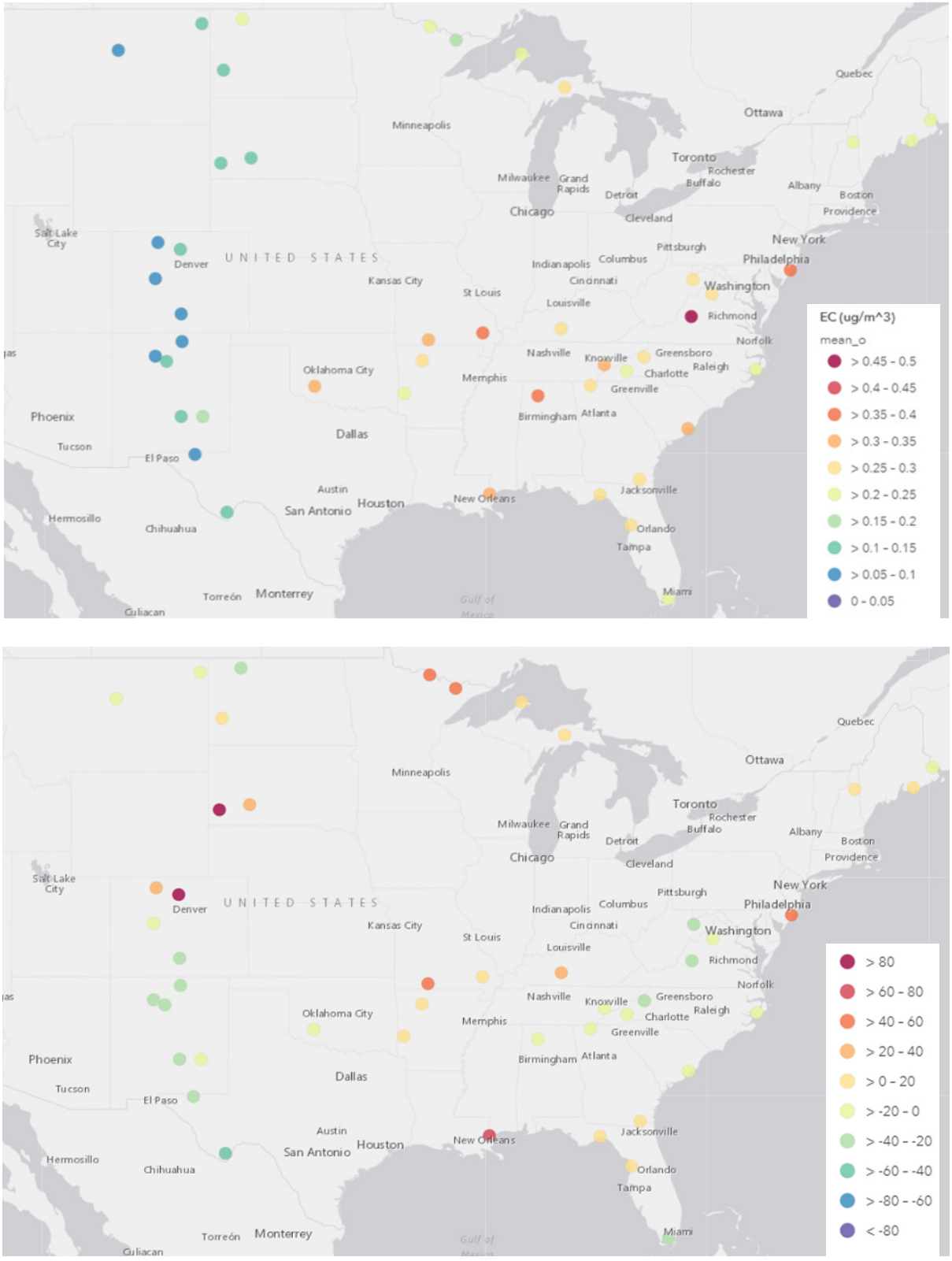


Figure 9-4. Observed EC (Top) and Modeled NMB (Bottom) for EC on the 20% Most-impaired Days at IMPROVE Monitor Locations.

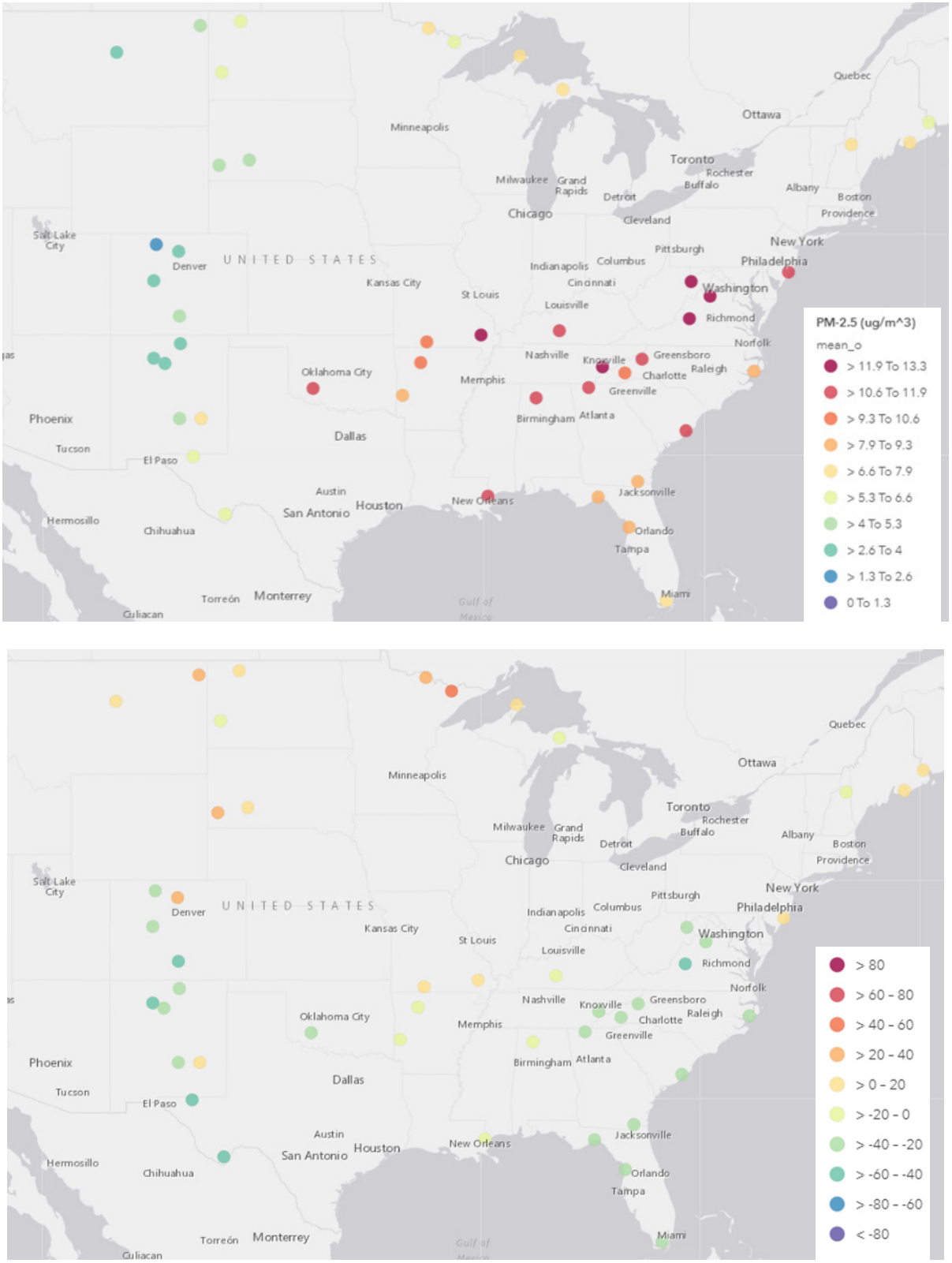


Figure 9-5. Observed Total $PM_{2.5}$ (Top) and Modeled NMB (Bottom) for Total $PM_{2.5}$ on the 20% Most-impaired Days at IMPROVE Monitor Locations.

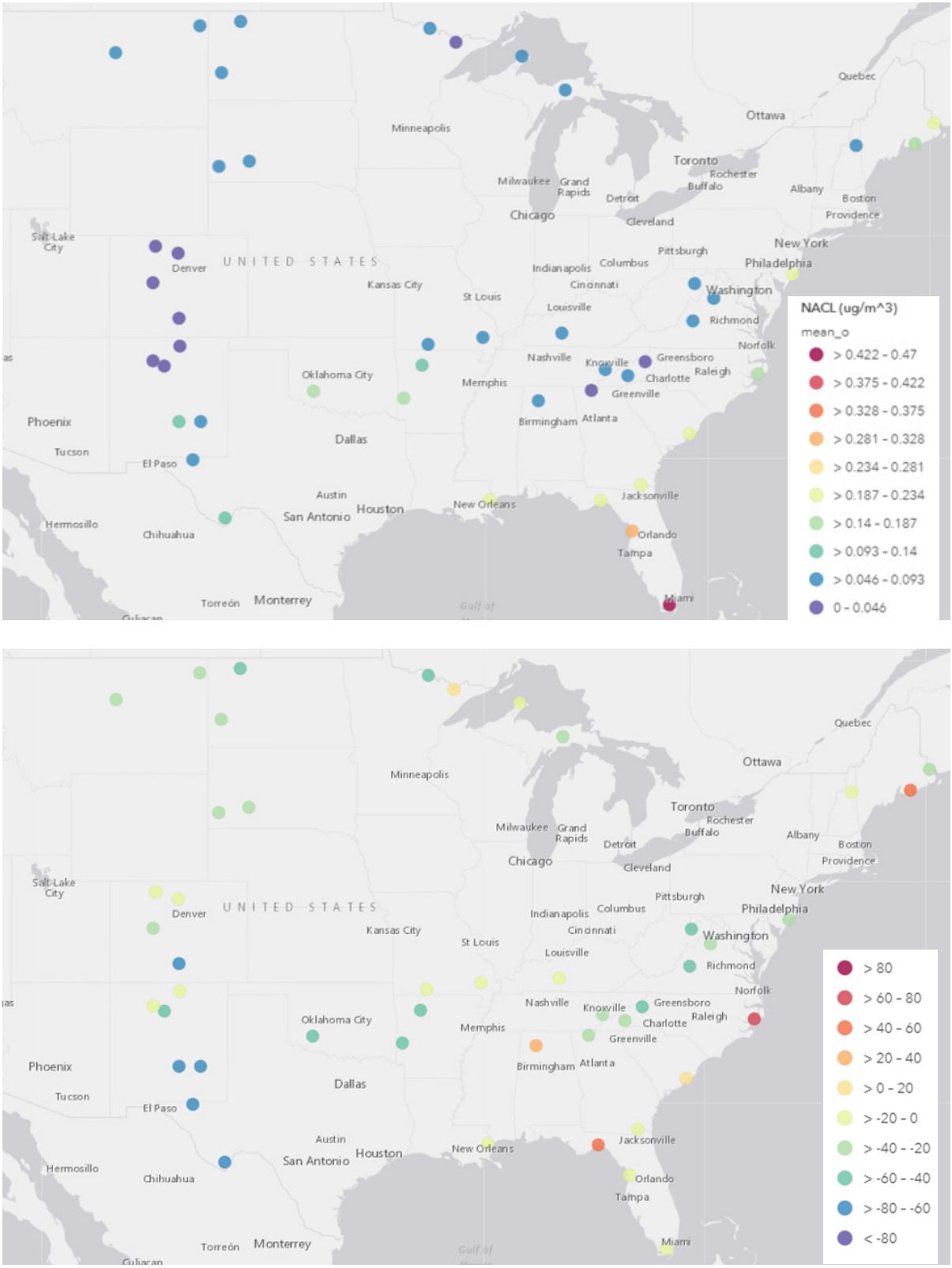


Figure 9-6. Observed NACL (Top) and Modeled NMB (Bottom) for NACL on the 20% Most-impaired Days at IMPROVE Monitor Locations.

10.0 $PM_{2.5}$ COMPOSITION AND CONTRIBUTIONS TO LIGHT EXTINCTION

Charts for each of the VISTAS_12 modeling domain's Class I areas can be generated using the provided Excel file titled "APP_F_PM_EXTINCTION_MPE.xlsx" in Appendix F. These stacked bar charts detail the daily and averaged composition of $PM_{2.5}$ on the 20% most impaired and clearest days for both modeled and observed concentration ($\mu g/m^3$) and light extinction ($bext^{-1}$) at each IMPROVE monitoring site located within the VISTAS12 modeling domain. Total mass plots display the amount of total particle mass using concentrations of coarse mass (CM), crustal (soil), ammonium nitrate (NO_3), ammonium sulfate (SO_4), EC, organic mass carbon (OMC), and sea salt.

Daily concentration values by day are presented for SAMA's 20% clearest days on the top of Figure 10-1 below. The amount of light extinction due to each aforementioned species by day is displayed in the daily light extinction tab of Appendix F and is presented on the bottom of Figure 10-1. An example of the averaged concentration across all days is presented for SAMA's 20% clearest days on the left of Figure 10-2 below. The average amount of light extinction due to each species is displayed in the average light extinction tab of Appendix F and is presented on the right of Figure 10-2.

Predicted (modeled) results for all locations are based on across all daily results for each Class I area's impairment classification (20% clearest or 20% most anthropogenically impaired) using CAMx v6.40 and calculated using the new IMPROVE equation. Observations, clearest, and most impaired days and associated observational concentrations and light extinction data by IMPROVE receptor were identified and provided by EPA in their Preliminary Regional Haze Modeling.[5]

[5] https://www.epa.gov/visibility/regional-haze-guidance-technical-support-document-and-data-file

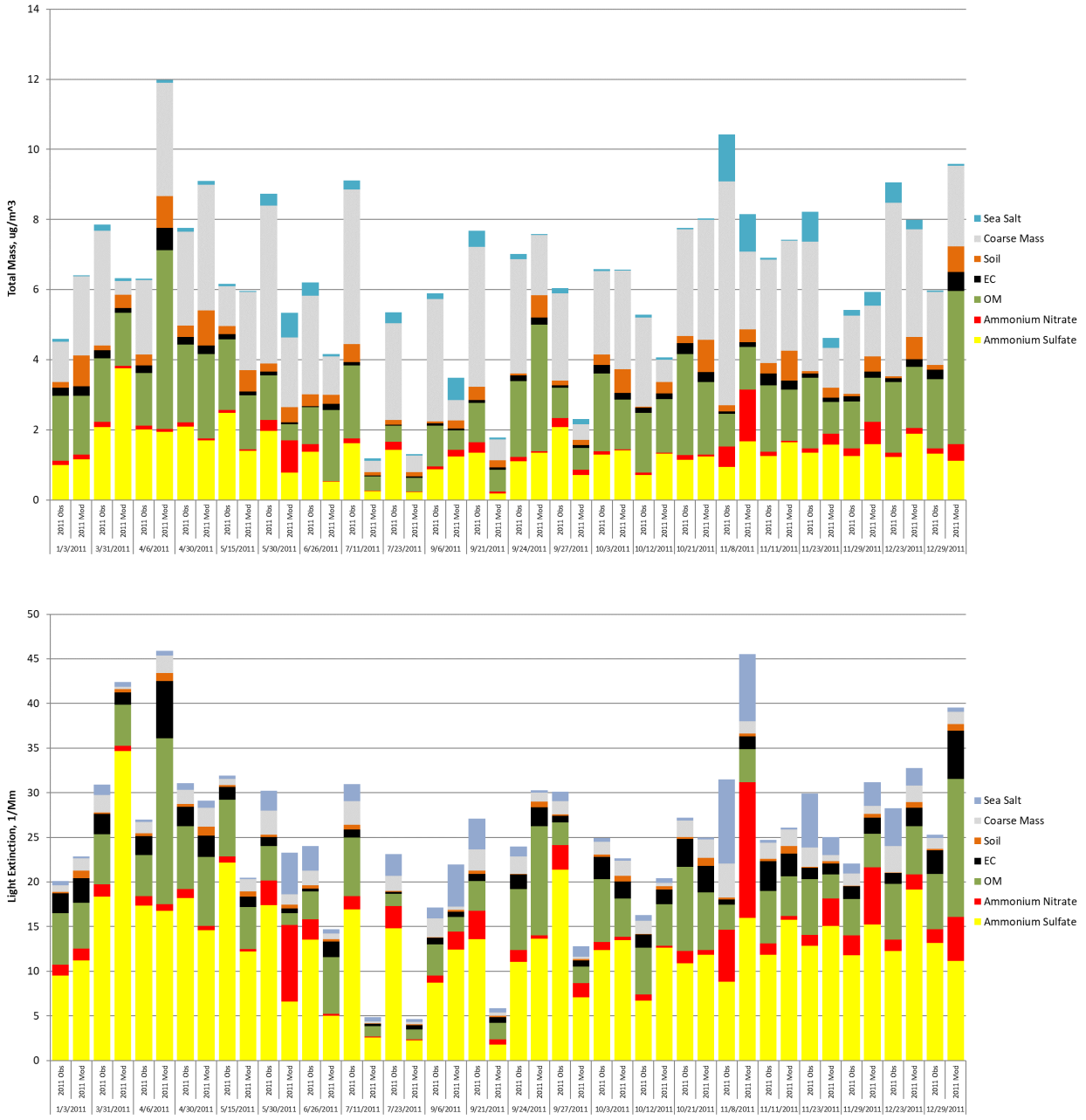


Figure 10-1. Example Daily Observed (Obs) and Predicted (Mod) Total Mass Concentrations (Top) and Light Extinctions (Bottom) at the St. Mark's Wildlife Refuge on the Observed 20% Clearest Days.

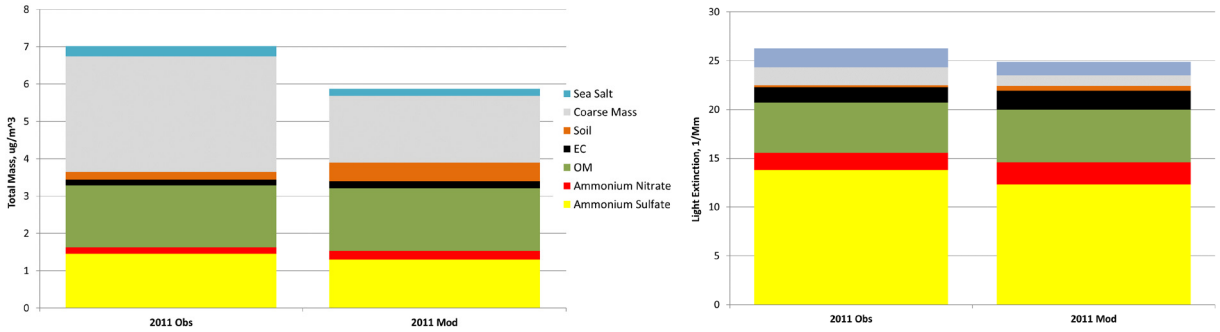


Figure 10-2. Example Averaged Observed (Obs) and Predicted (Mod) Total Mass Concentrations (Left) and Light Extinctions (Right) at the St. Mark's Wildlife Refuge on the Observed 20% Clearest Days.

Appendix A

VISTAS12 Modeling Domain
Model Performance Metrics by Network, Station, Pollutant, and Season

This page is intentionally left blank.

Appendix A-1

VISTAS12 Modeling Domain
CASTNET Model Performance Metrics by Station, Pollutant, and Season

(see MPE by Station and Season-1.pdf)

This page is intentionally left blank.

Appendix A-2

VISTAS12 Modeling Domain
CSN Model Performance Metrics by Station, Pollutant, and Season

(see MPE by Station and Season-2.pdf)

This page is intentionally left blank.

Appendix A-3

VISTAS12 Modeling Domain
IMPROVE Model Performance Metrics by Station, Pollutant, and Season

(see MPE by Station and Season-3.pdf)

This page is intentionally left blank.

Appendix B

VISTAS12 Modeling Domain
Scatter Plots of $PM_{2.5}$ Species by Network, Pollutant, and Month

This page is intentionally left blank.

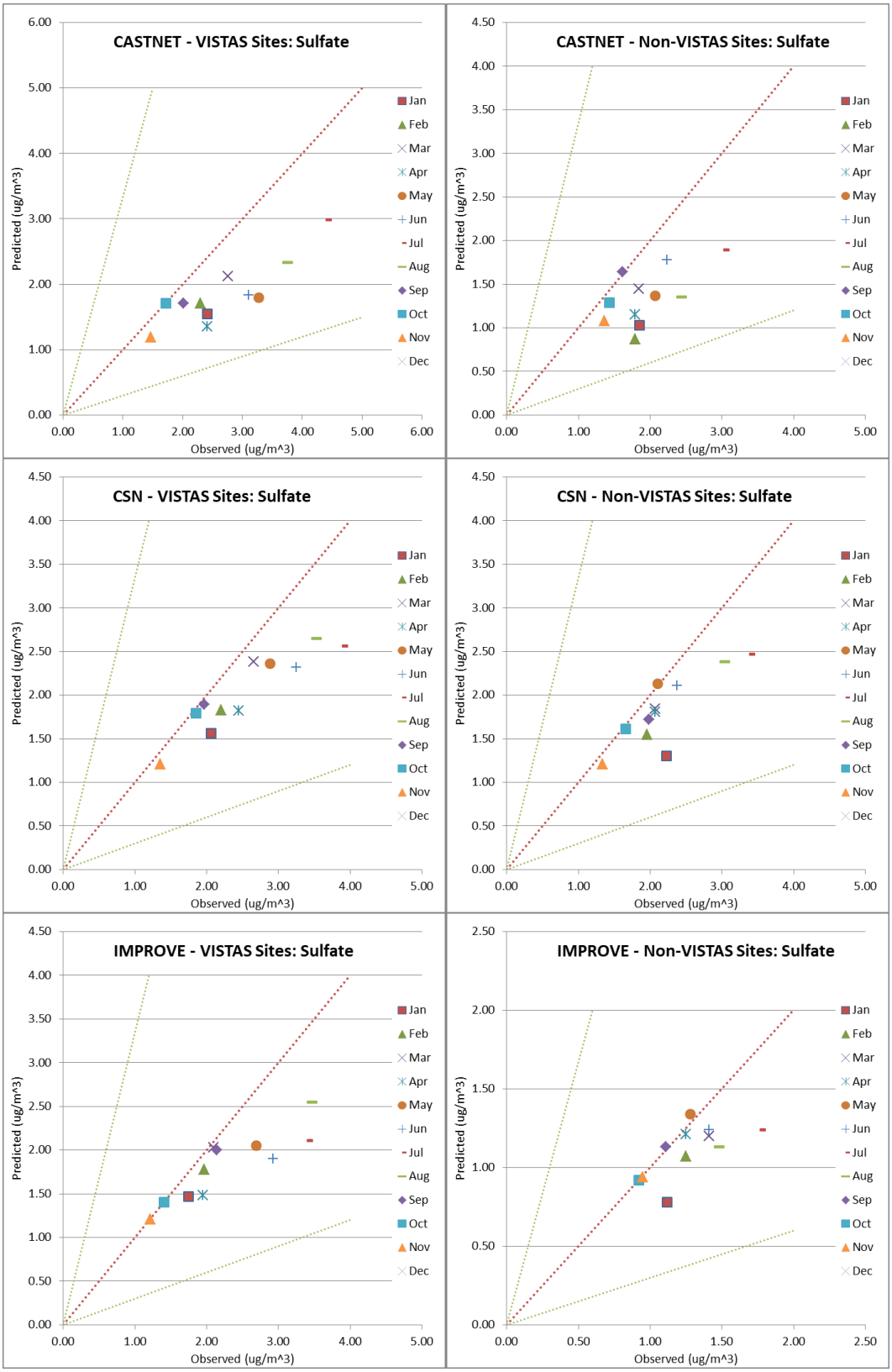


Figure B-1. Scatter Plots of Sulfate by Network and Month for VISTAS and Non-VISTAS Sites.

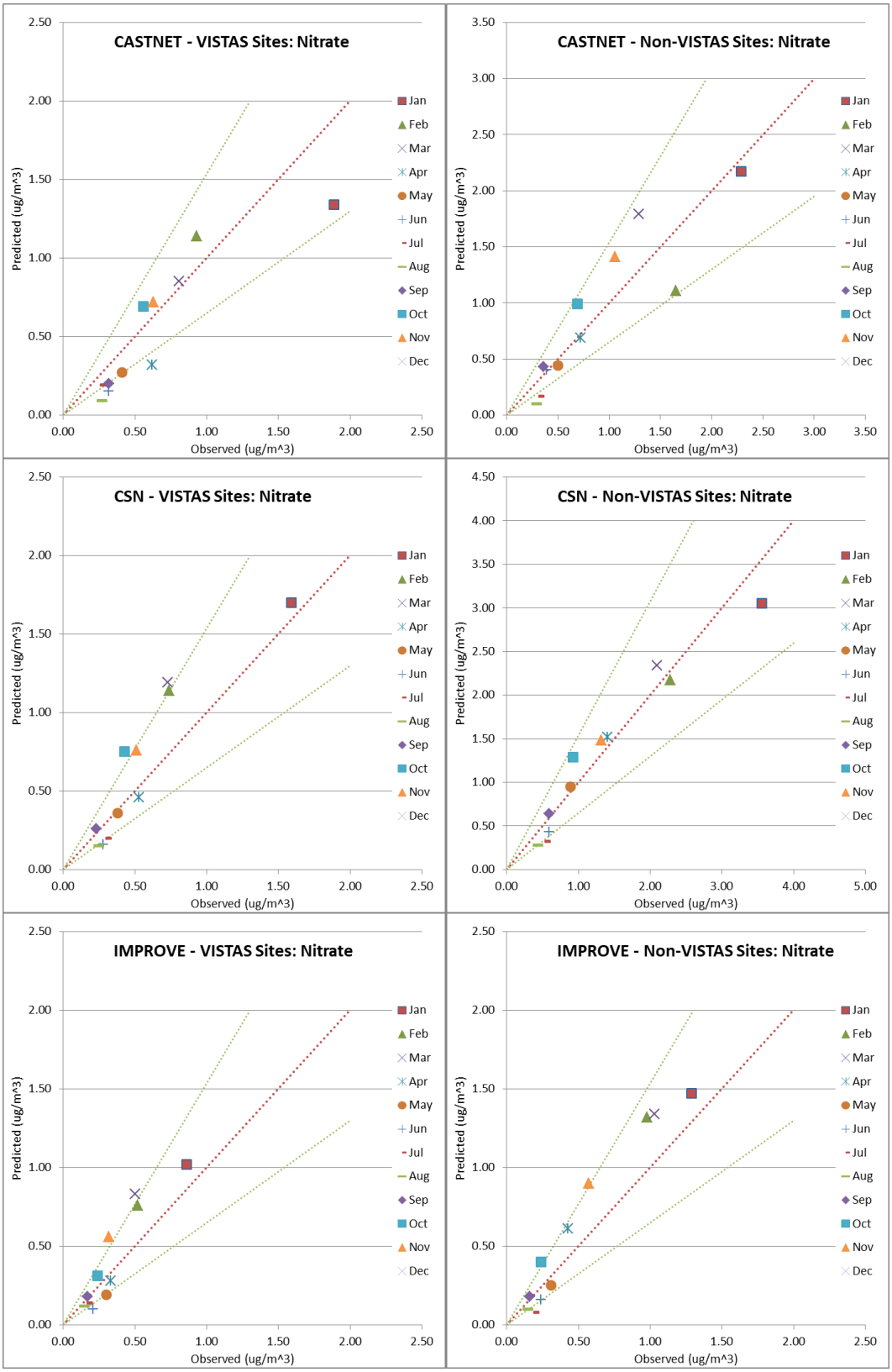


Figure B-2. Scatter Plots of Nitrate by Network and Month for VISTAS and Non-VISTAS Sites.

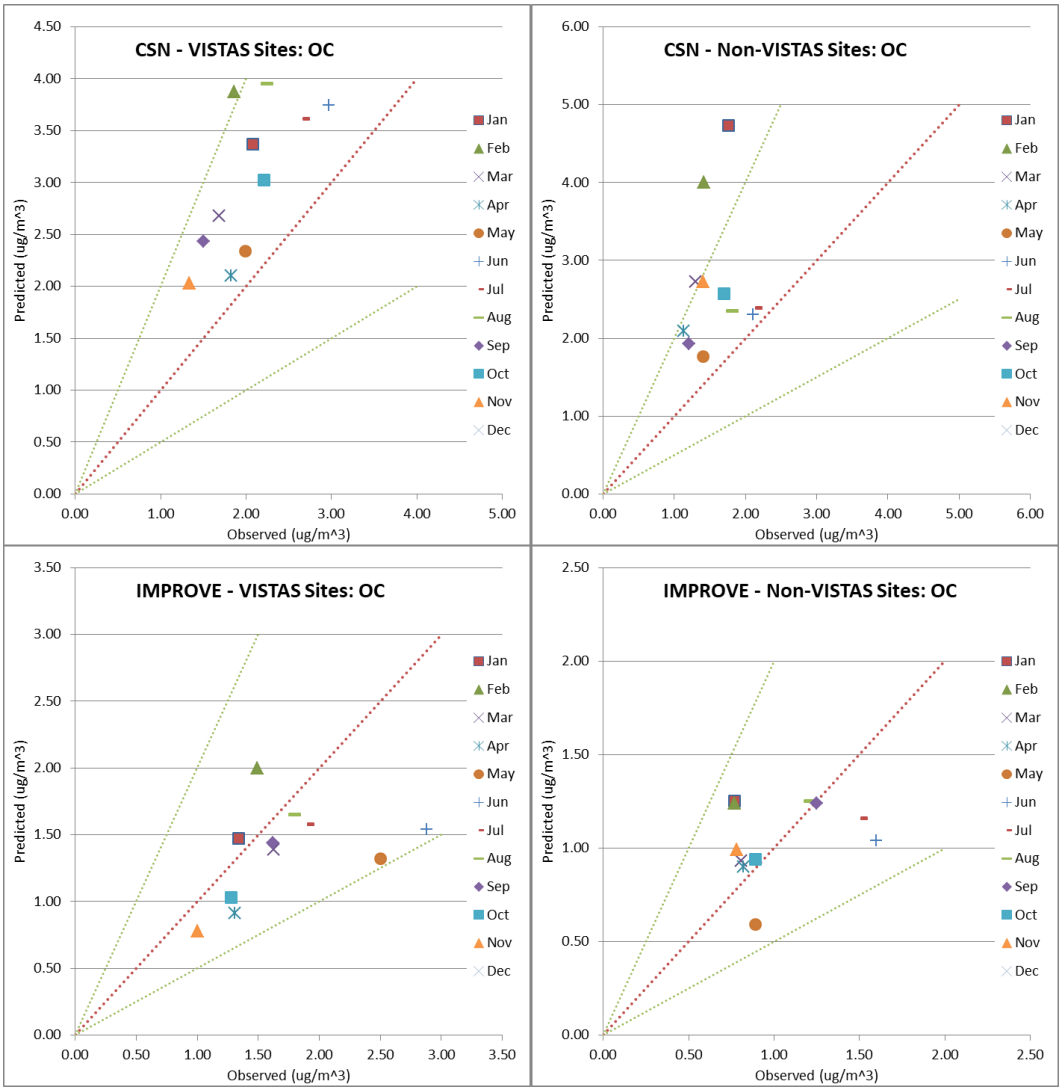


Figure B-3. Scatter Plots of OC by Network and Month for VISTAS and Non-VISTAS Sites.

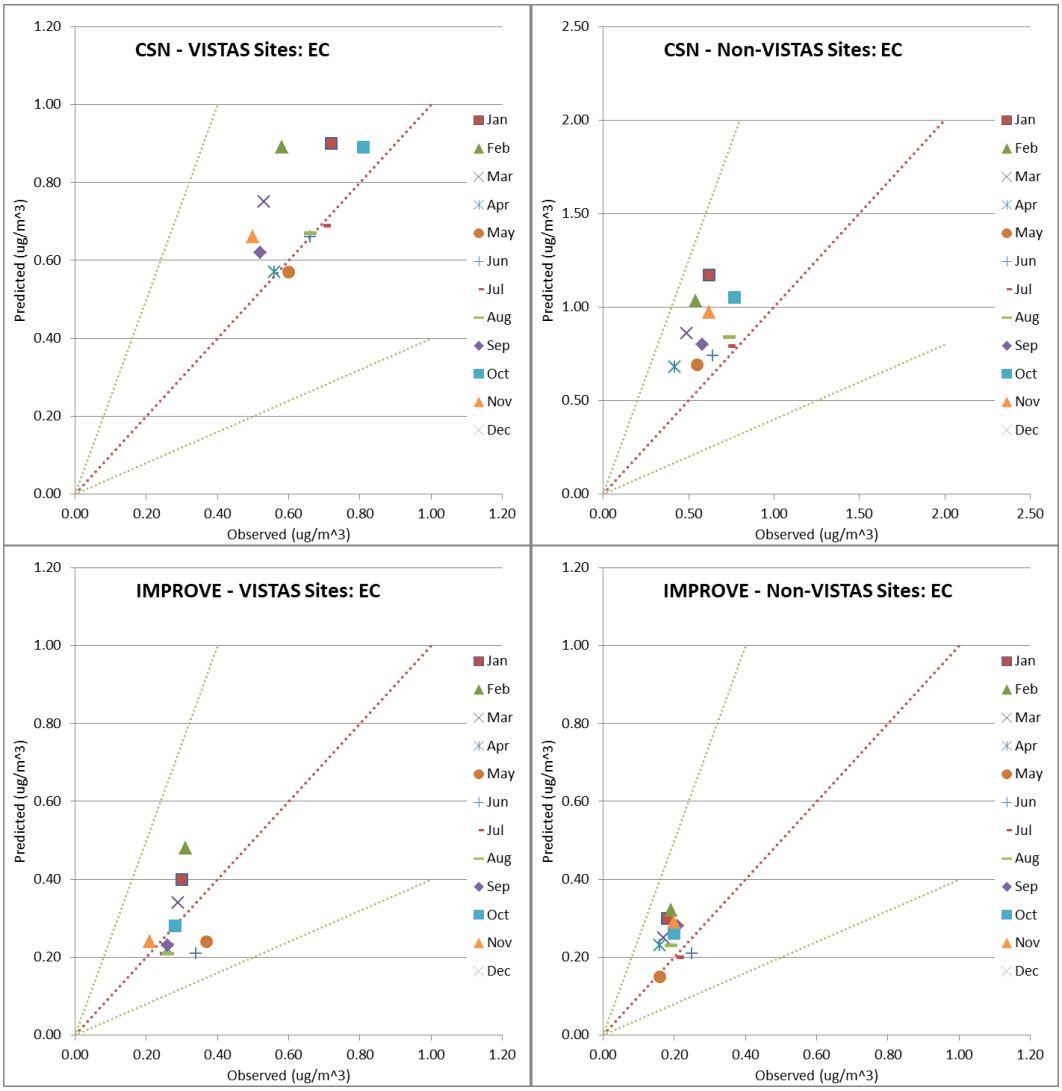


Figure B-4. Scatter Plots of EC by Network and Month for VISTAS and Non-VISTAS Sites.

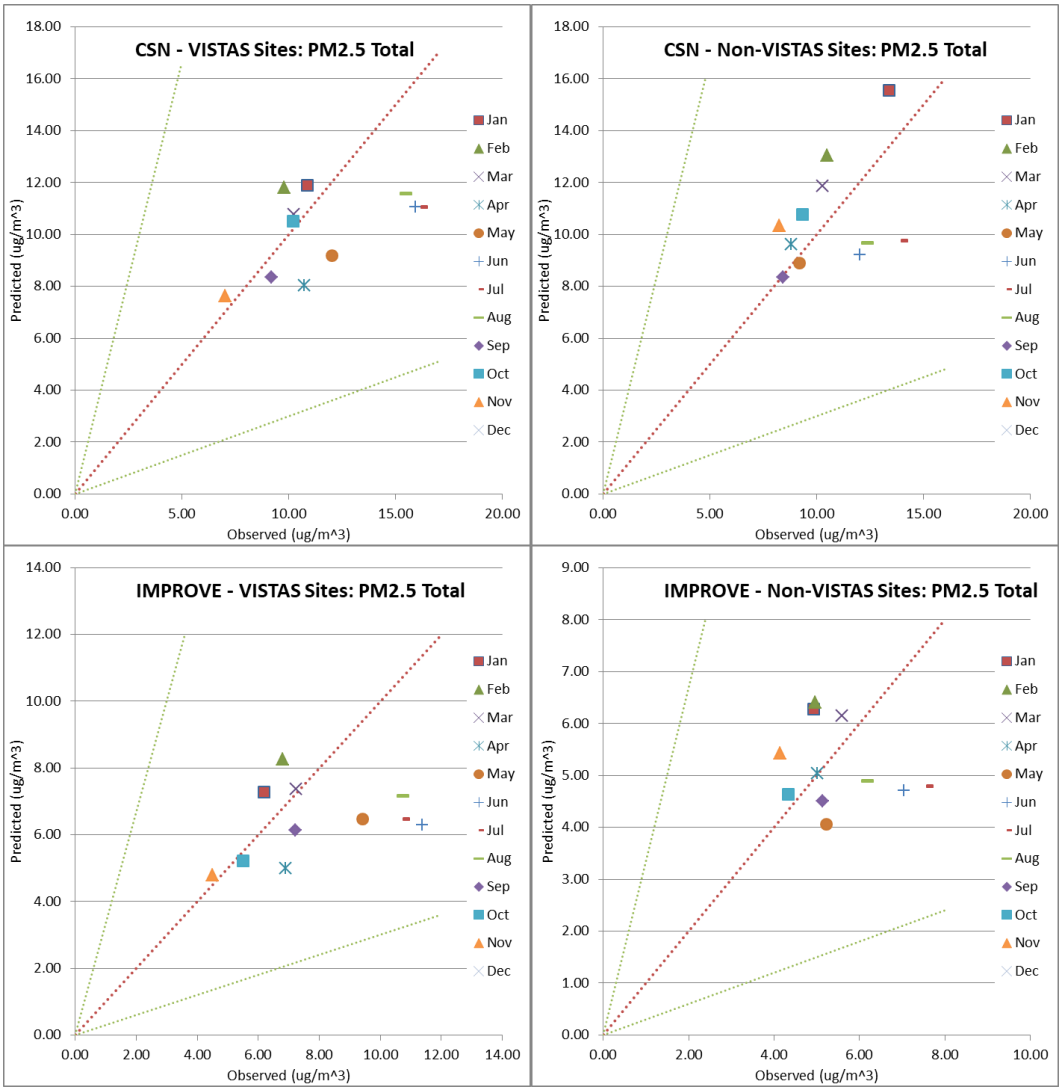


Figure B-5. Scatter Plots of Total $PM_{2.5}$ by Network and Month for VISTAS and Non-VISTAS sites.

This page is intentionally left blank.

Appendix C

VISTAS12 Modeling Domain
Scatter, Soccer, and Bugle Plots by Site for the 20% Most Impaired Days and 20% Clearest Days
(see "APP_C_maps_pred_obs_mpe_results_station_all_dates_improve.xlsx")

This page is intentionally left blank.

Appendix D

VISTAS12 Modeling Domain
Soccer Plots of $PM_{2.5}$ Species by Network, Pollutant, and Month

This page is intentionally left blank.

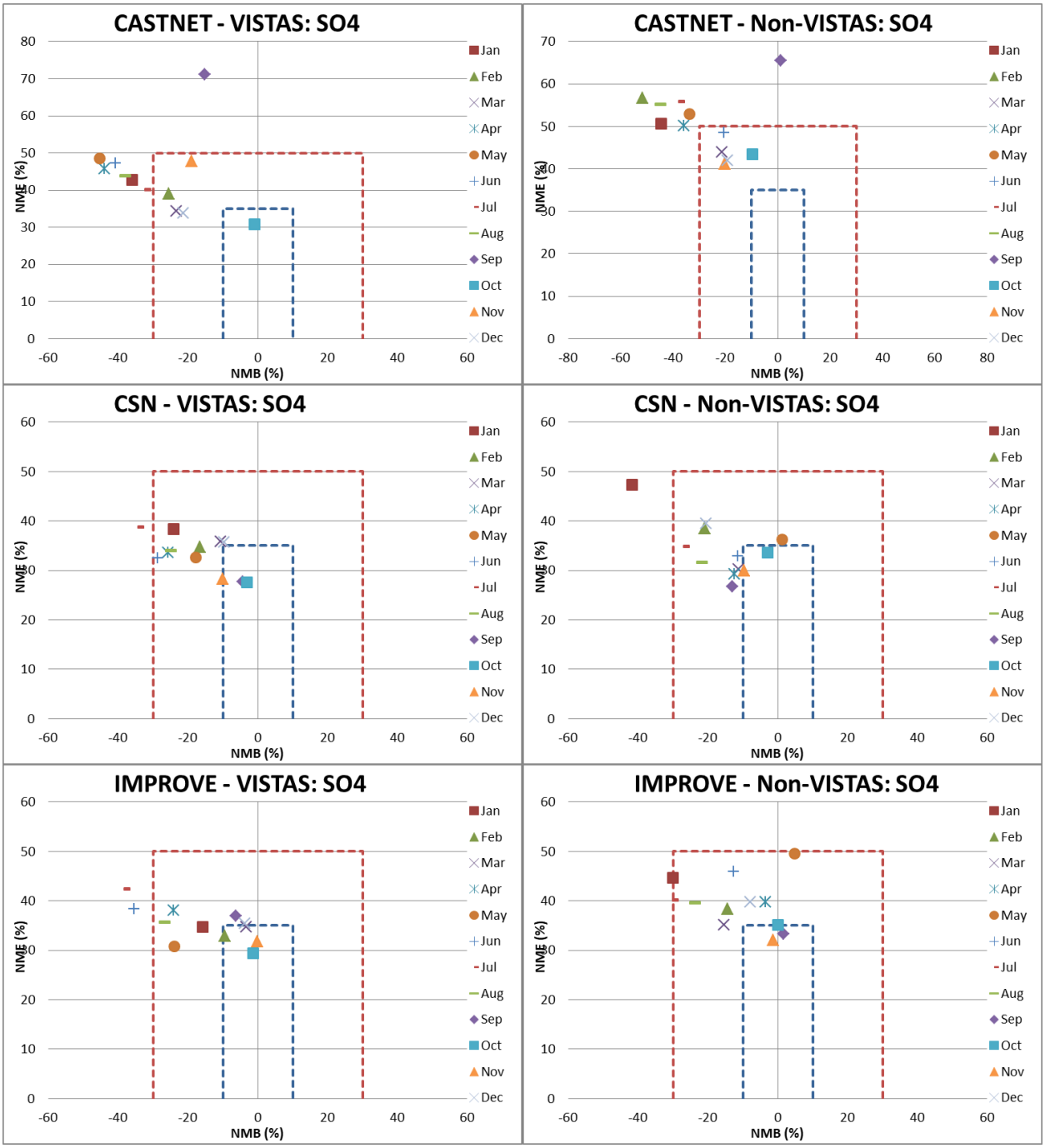


Figure D-1. Soccer Plot of Sulfate by Network and Month for VISTAS and Non-VISTAS Sites.

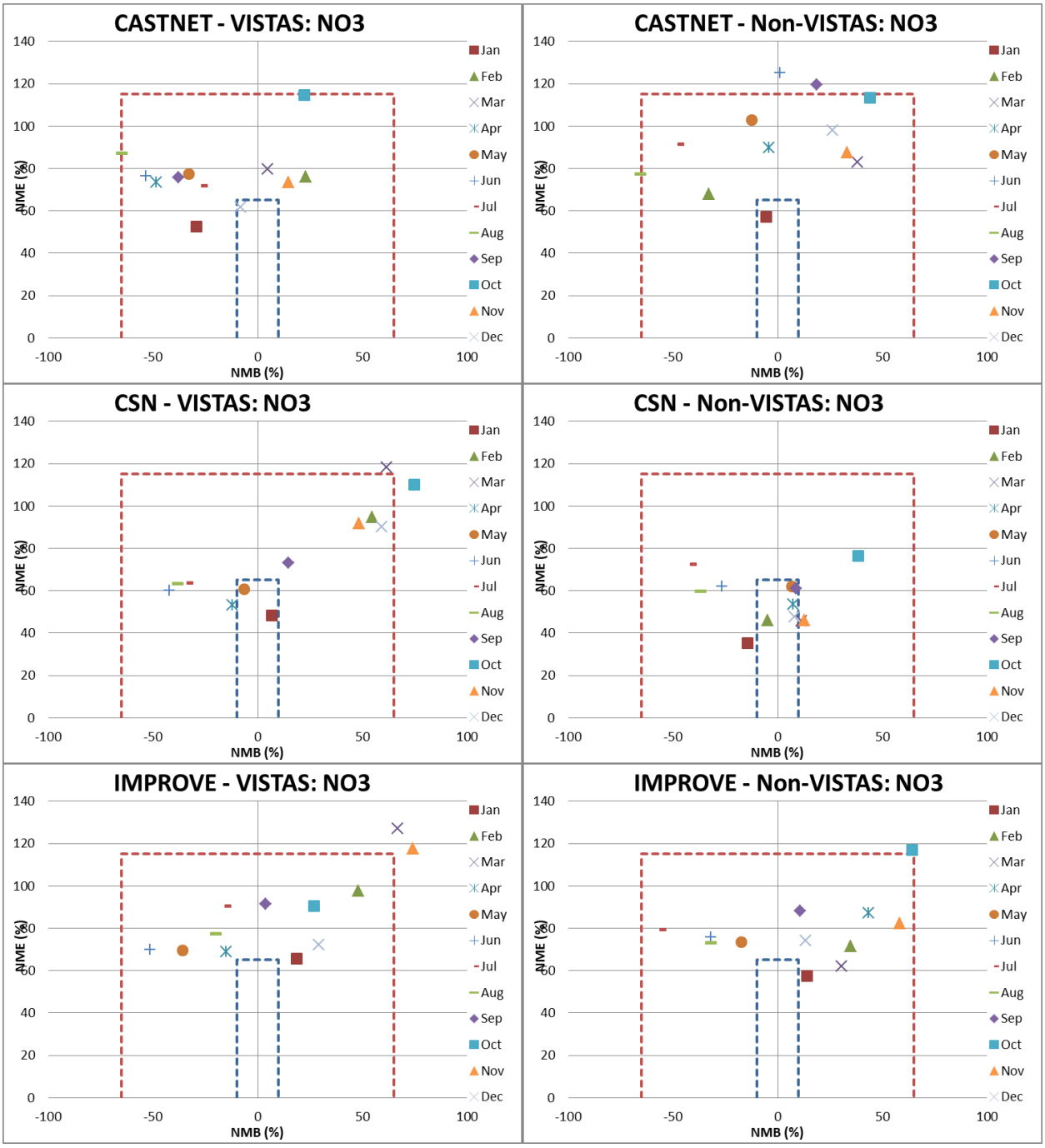


Figure D-2. Soccer Plot of Nitrate by Network and Month for VISTAS and Non-VISTAS Sites.

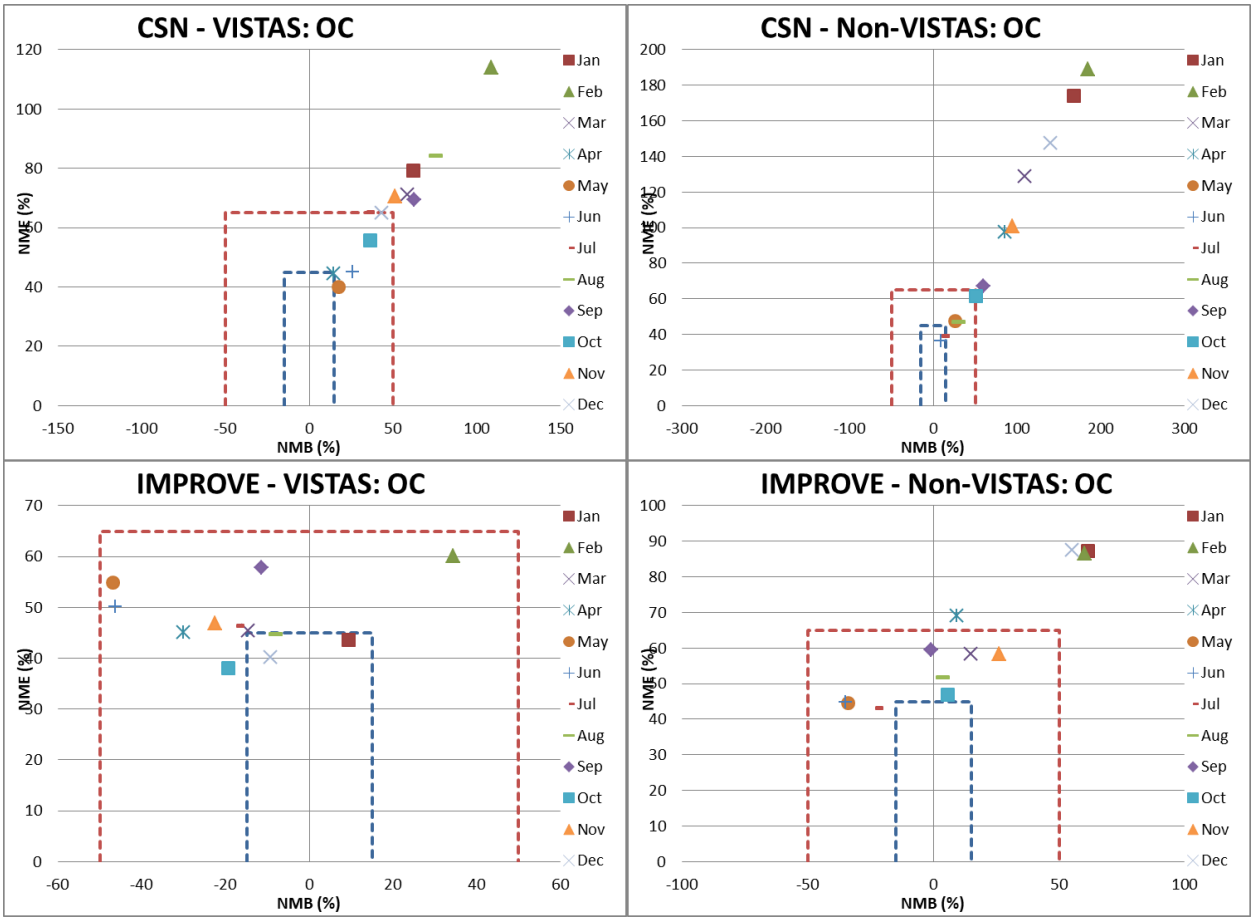


Figure D-3. Soccer Plot of OC by Network and Month for VISTAS and Non-VISTAS Sites.

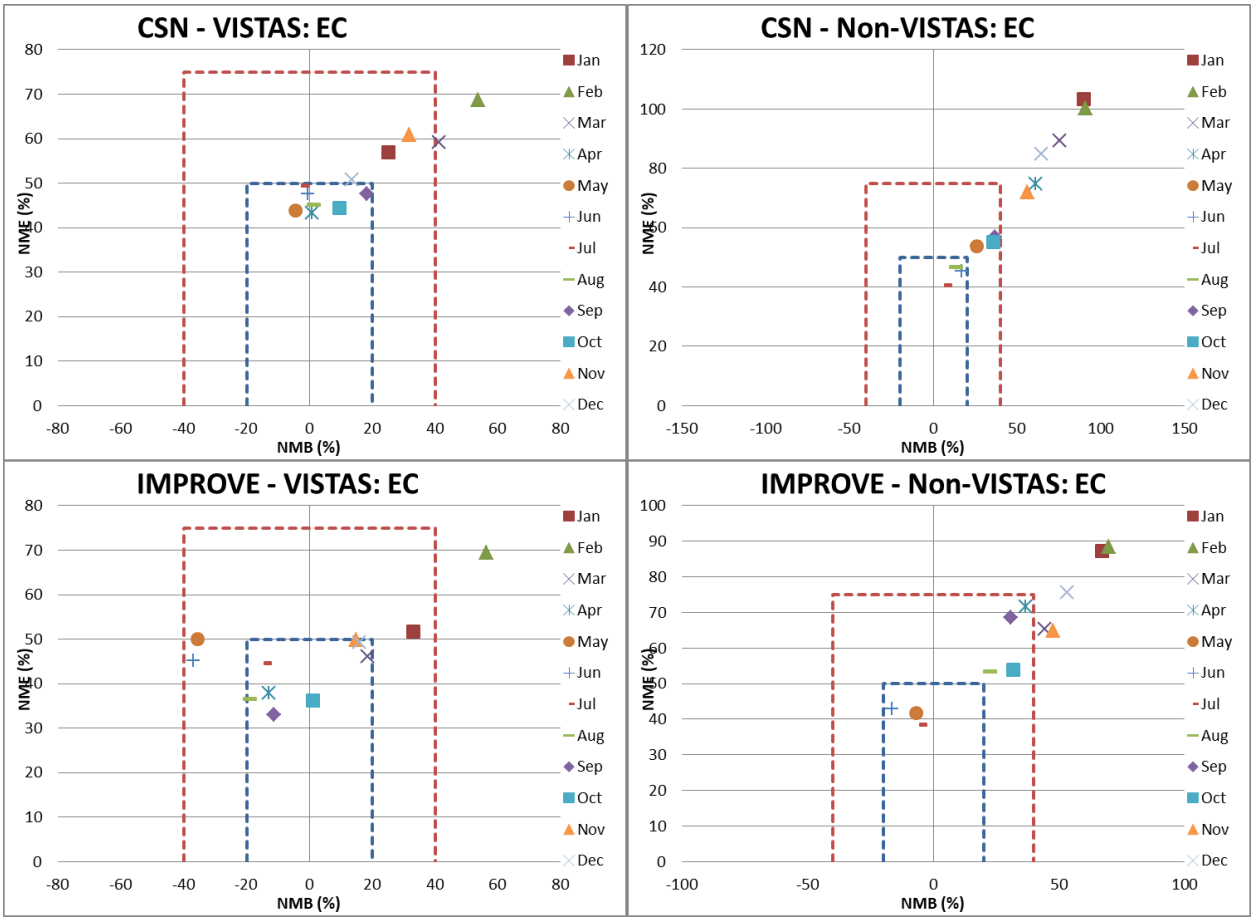


Figure D-4. Soccer Plot of EC by Network and Month for VISTAS and Non-VISTAS Sites.

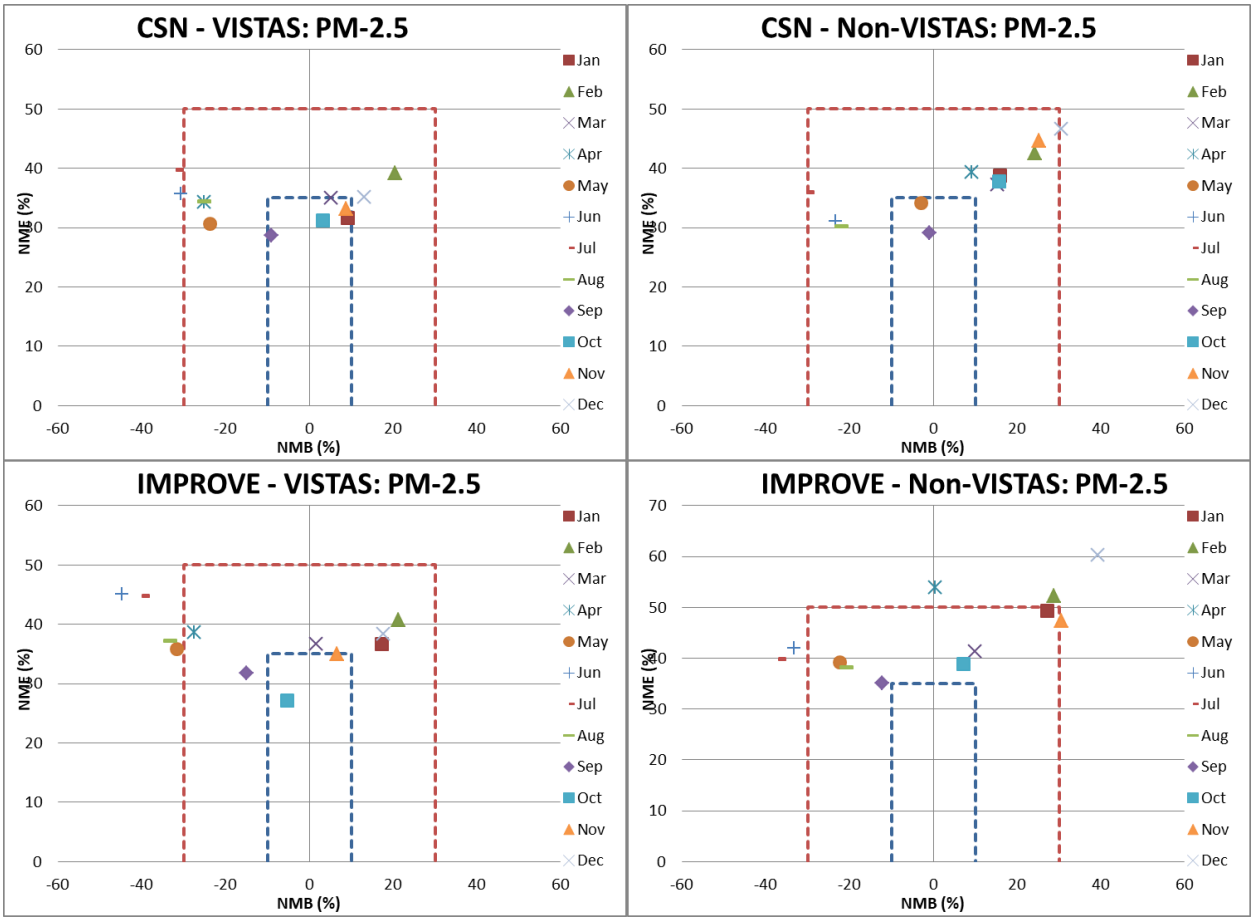


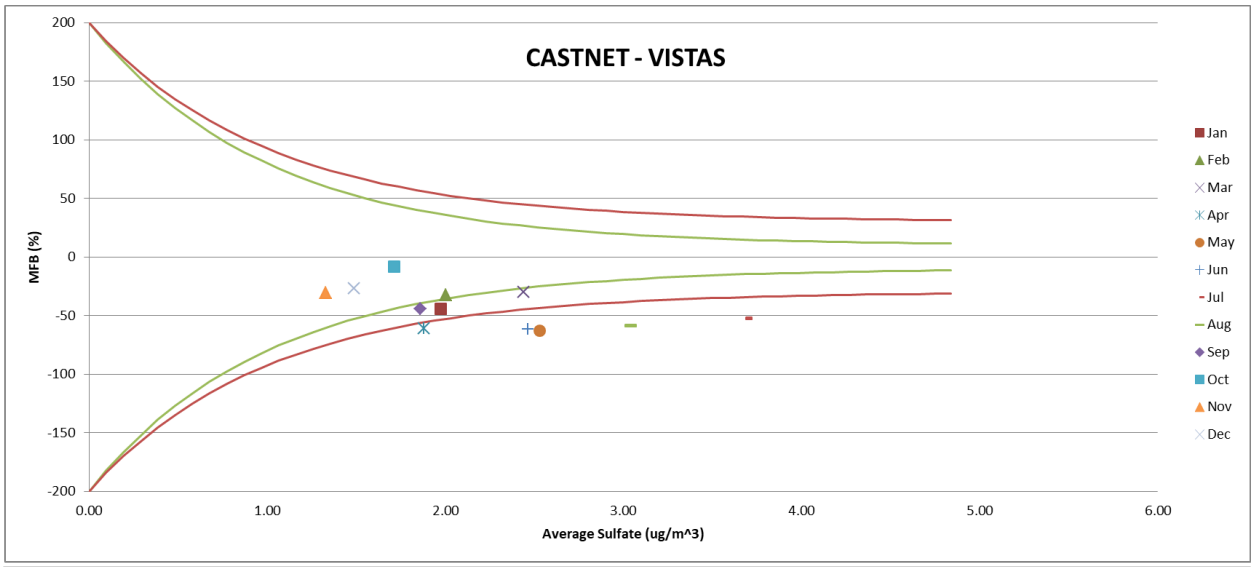
Figure D-5. Soccer Plot of Total $PM_{2.5}$ by Network and Month for VISTAS and Non-VISTAS Sites.

This page is intentionally left blank.

Appendix E

VISTAS12 Modeling Domain
Bugle Plots of $PM_{2.5}$ Species by Network, Pollutant, and Month

This page is intentionally left blank.



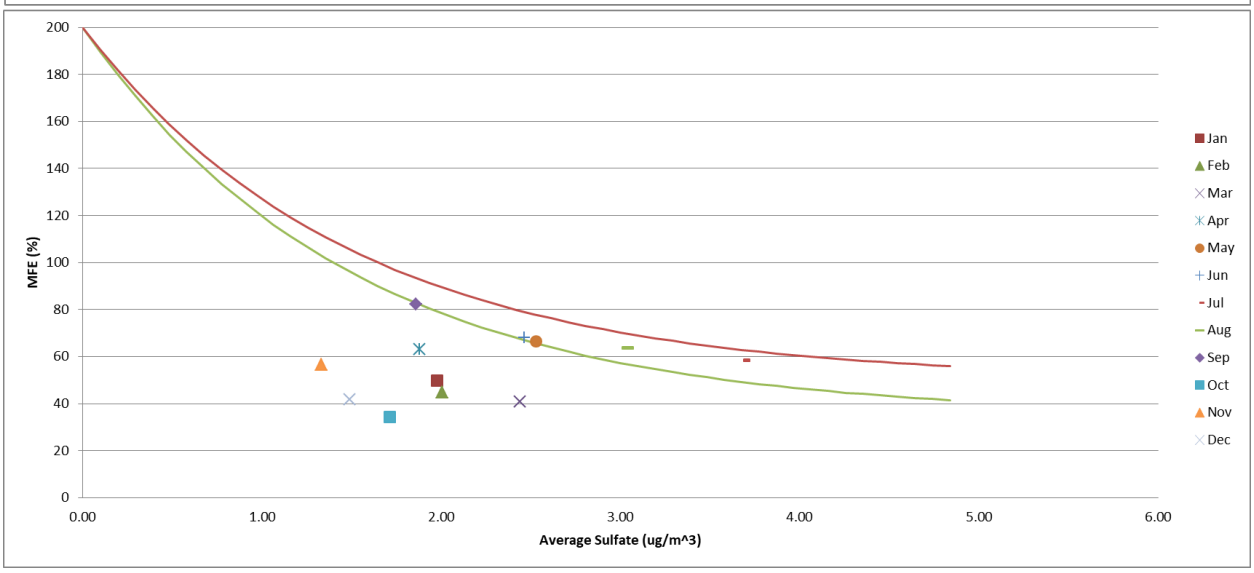
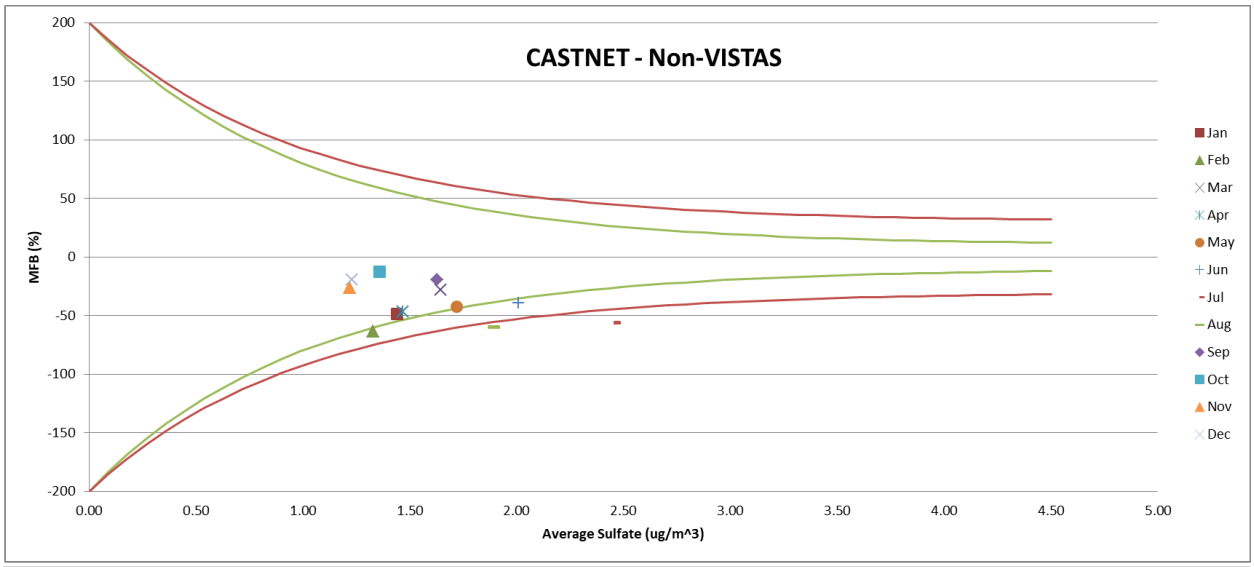


Figure E-1. Bugle Plot of Monthly Sulfate at VISTAS State CASTNET Sites.



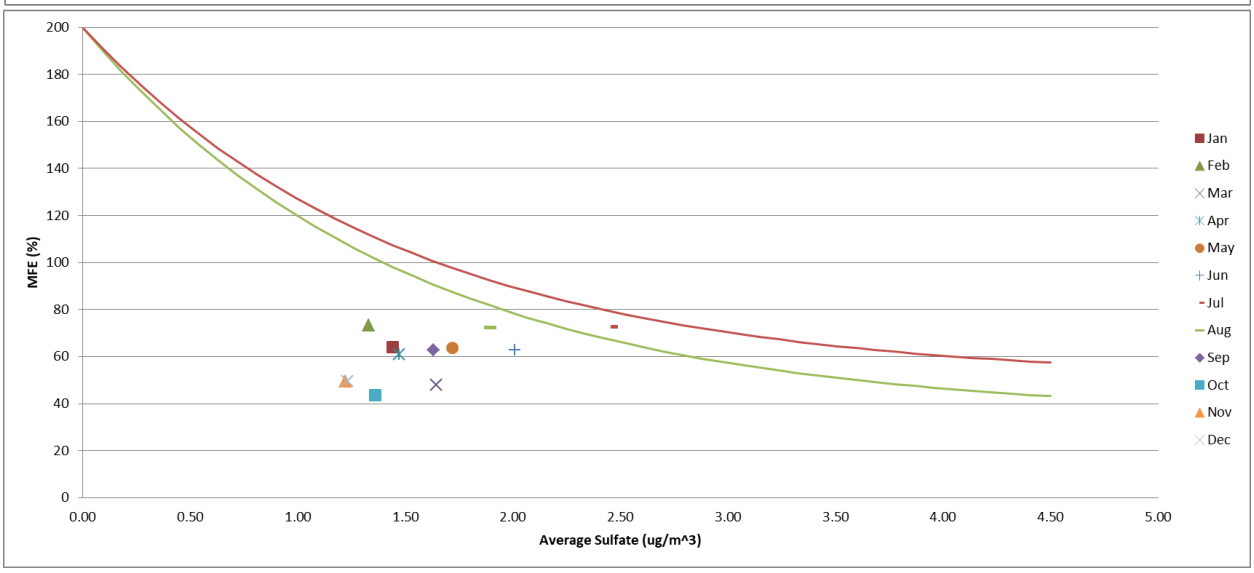


Figure E-2. Bugle Plot of Monthly Sulfate at Non-VISTAS State CASTNET Sites.

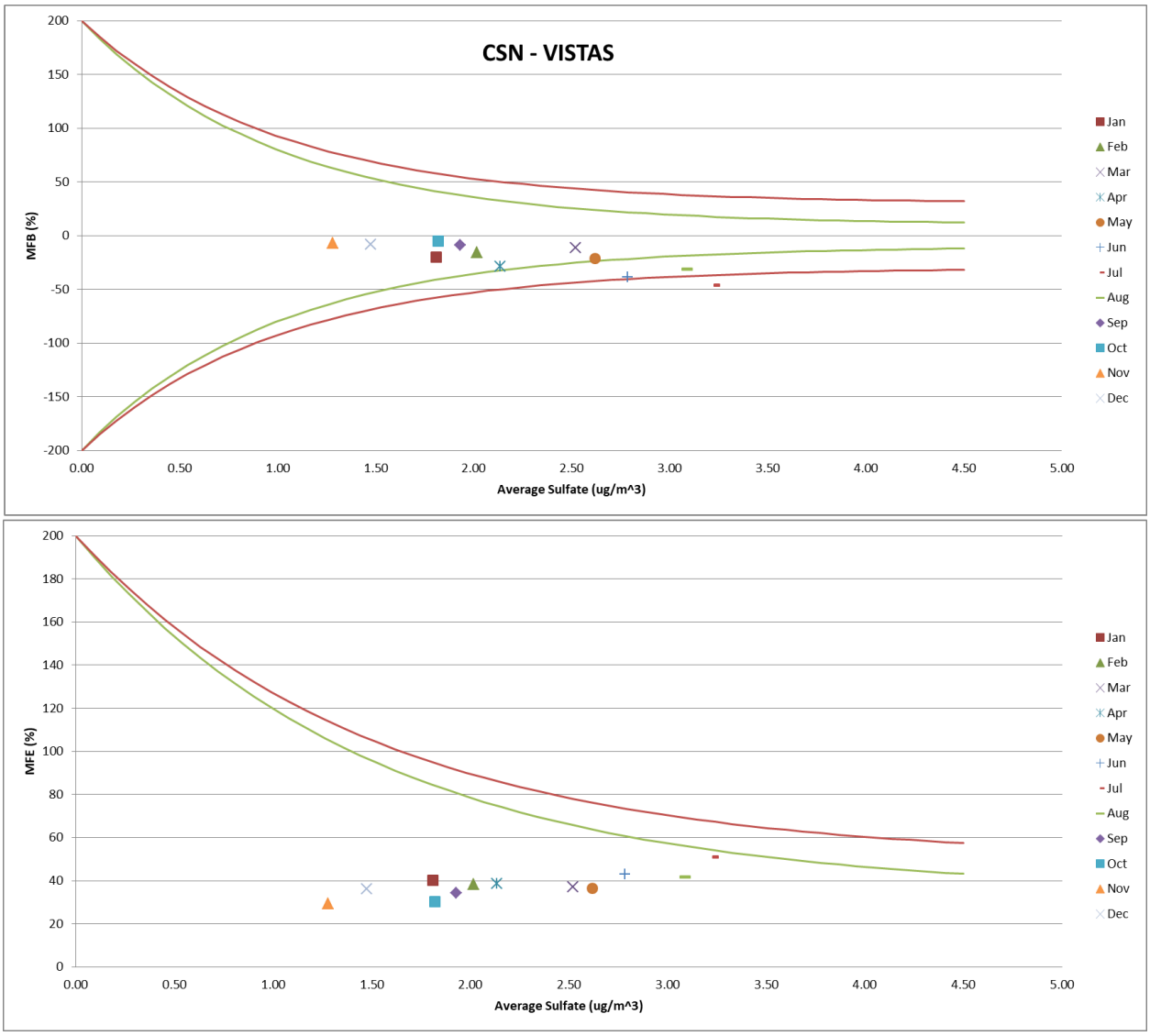


Figure E-3. Bugle Plot of Monthly Sulfate at VISTAS State CSN Sites.

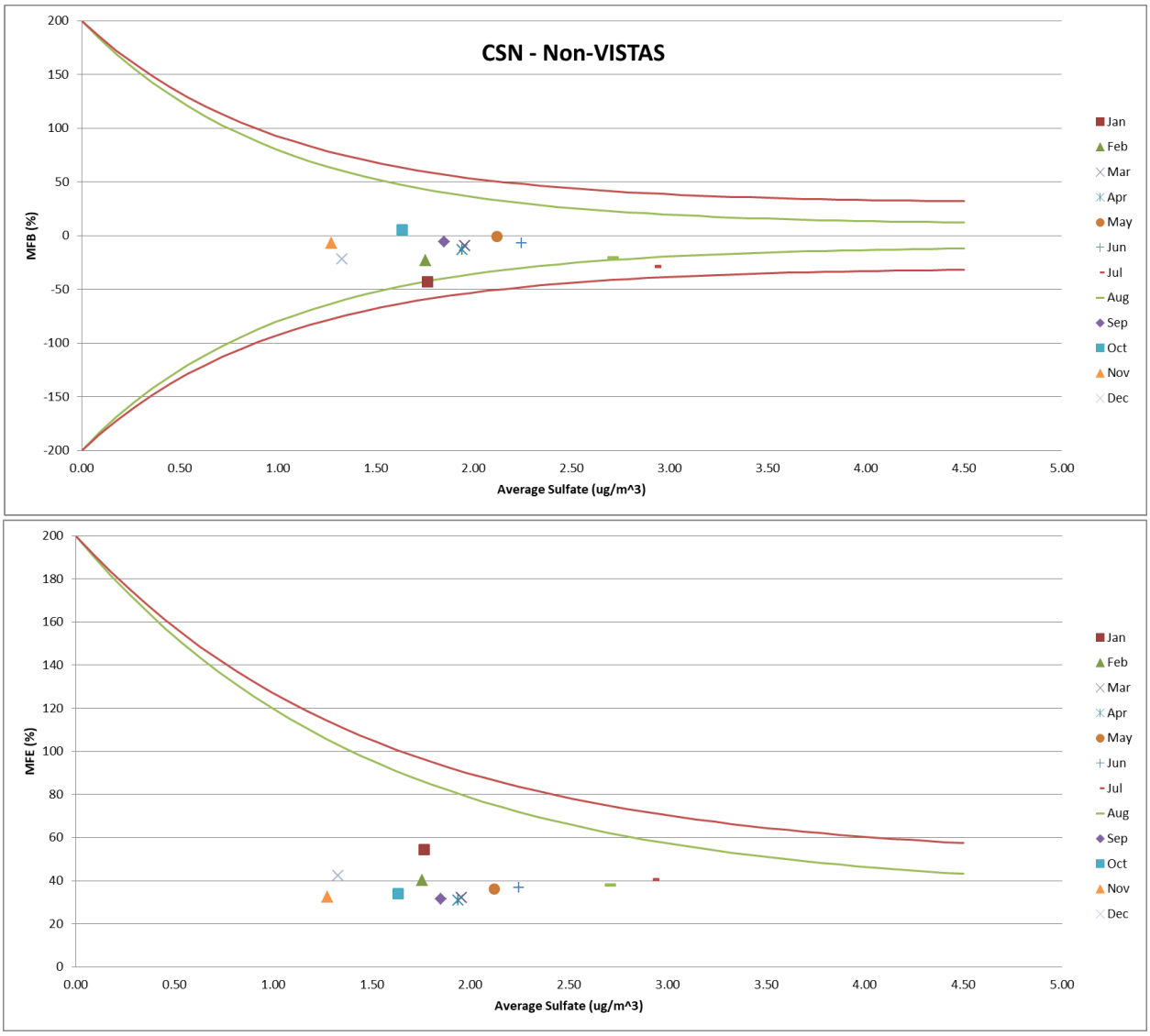


Figure E-4. Bugle Plot of Monthly Sulfate at Non-VISTAS State CSN Sites.

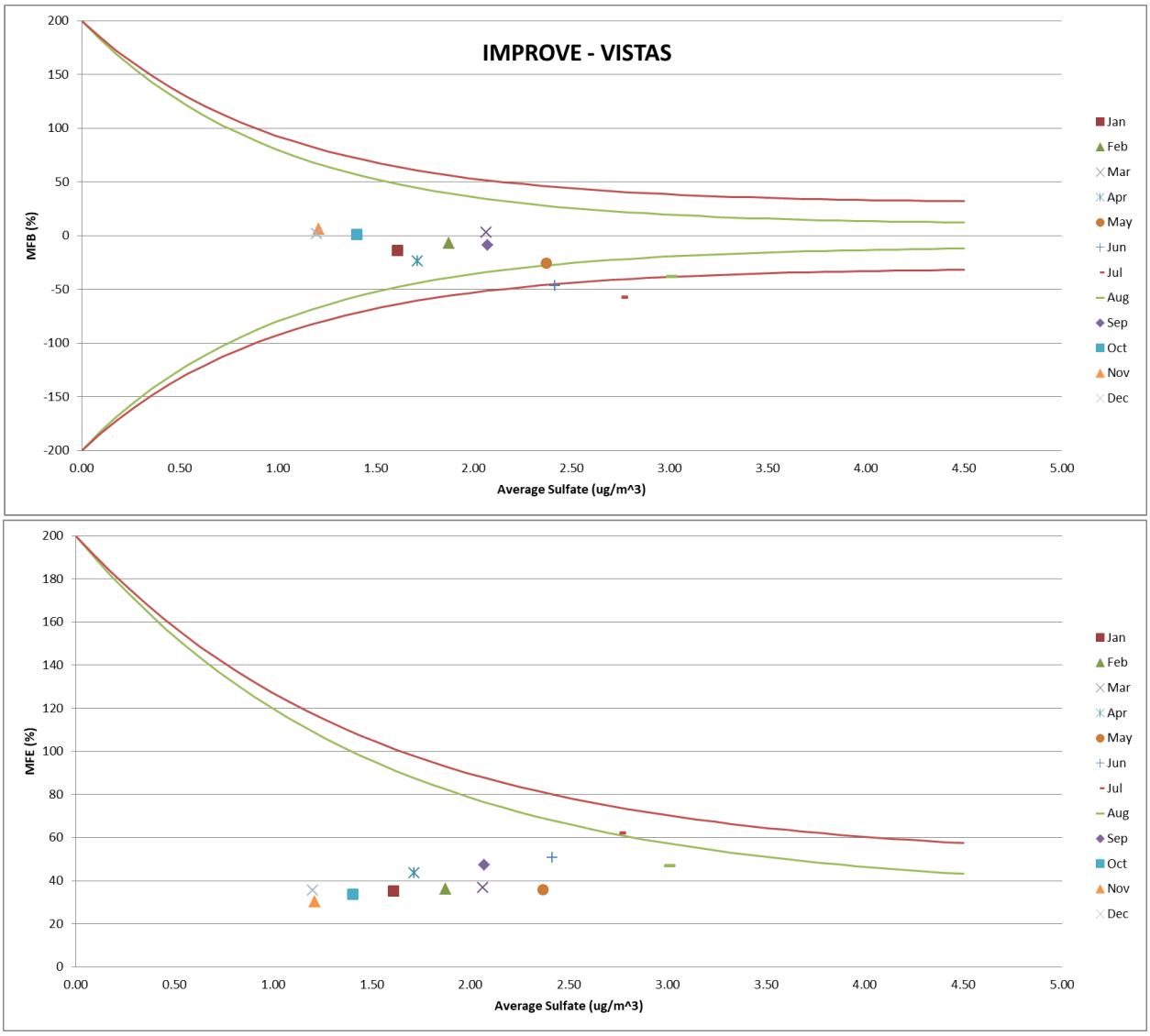


Figure E-5. Bugle Plot of Monthly Sulfate at VISTAS State IMPROVE Sites.

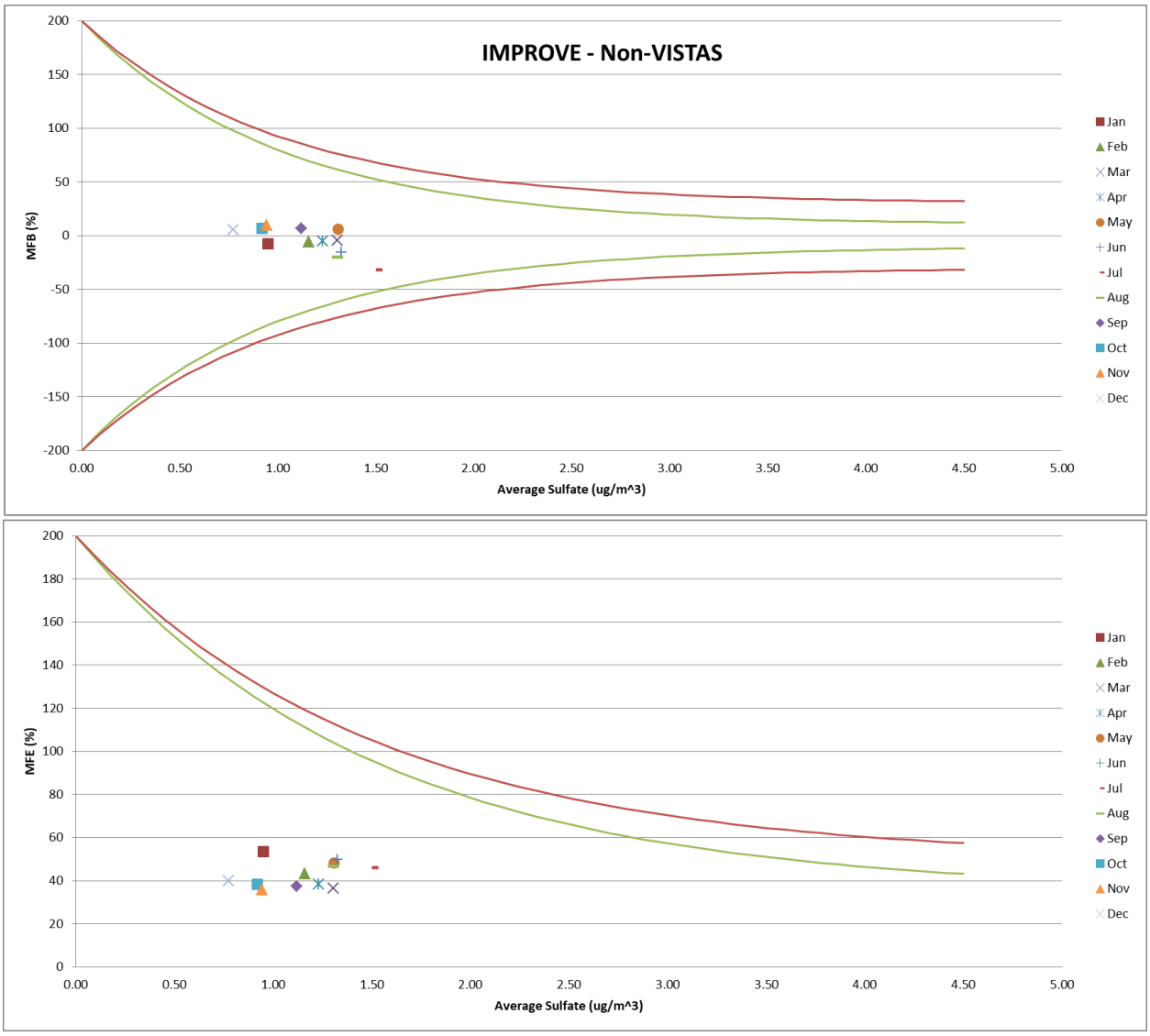


Figure E-6. Bugle Plot of Monthly Sulfate at Non-VISTAS State IMPROVE Sites.

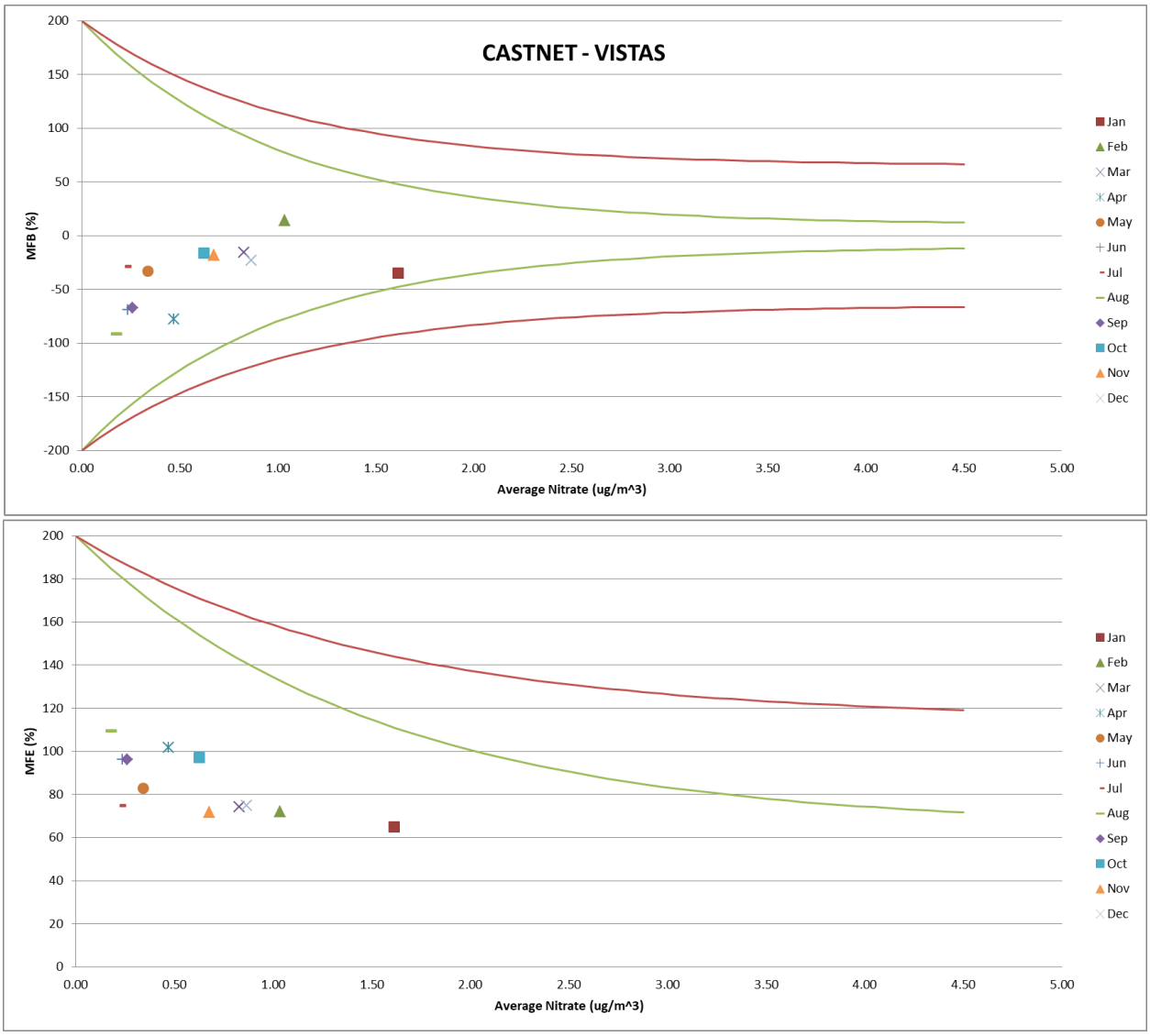


Figure E-7. Bugle Plot of Monthly Nitrate at VISTAS State CASTNET Sites.

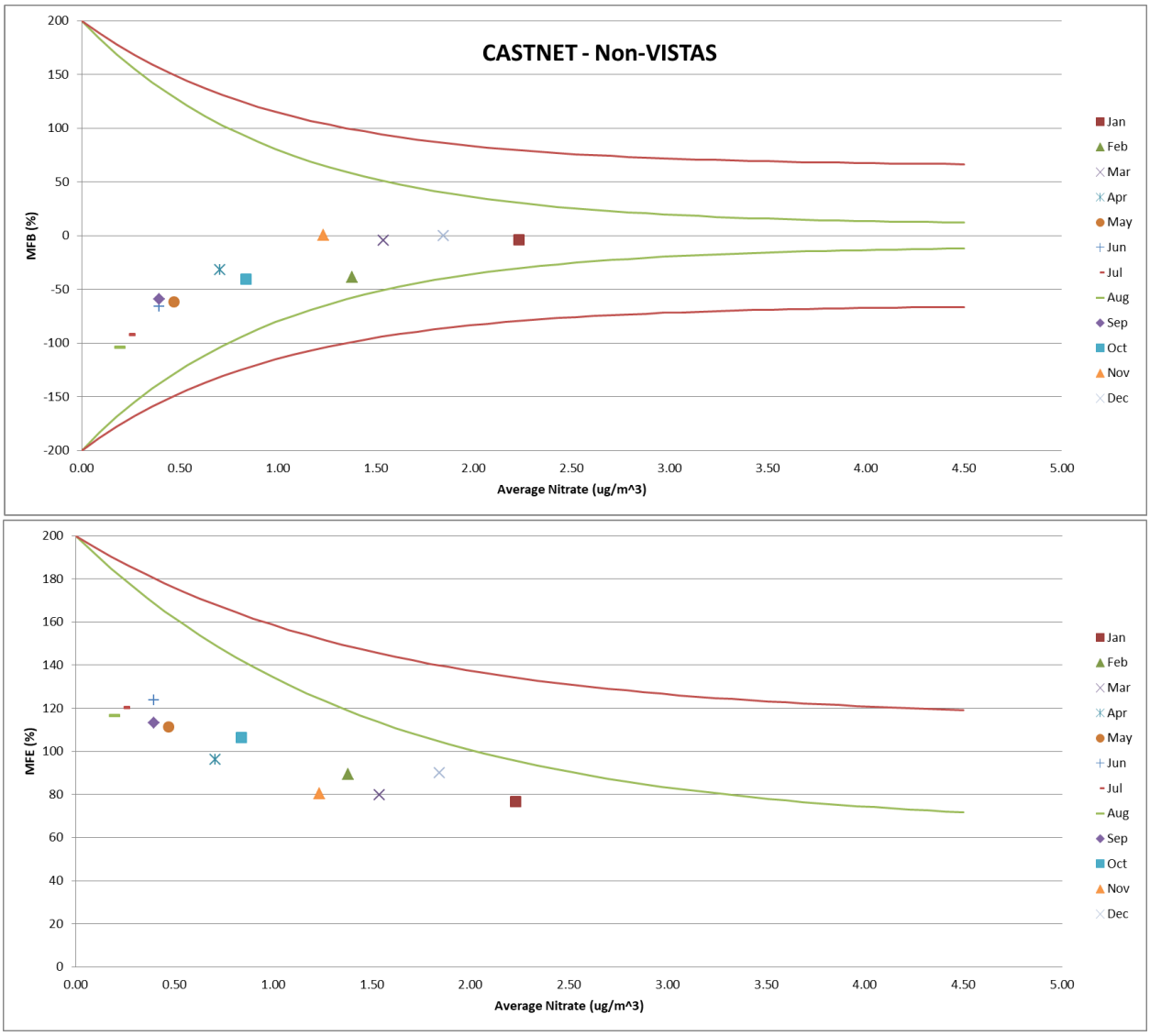
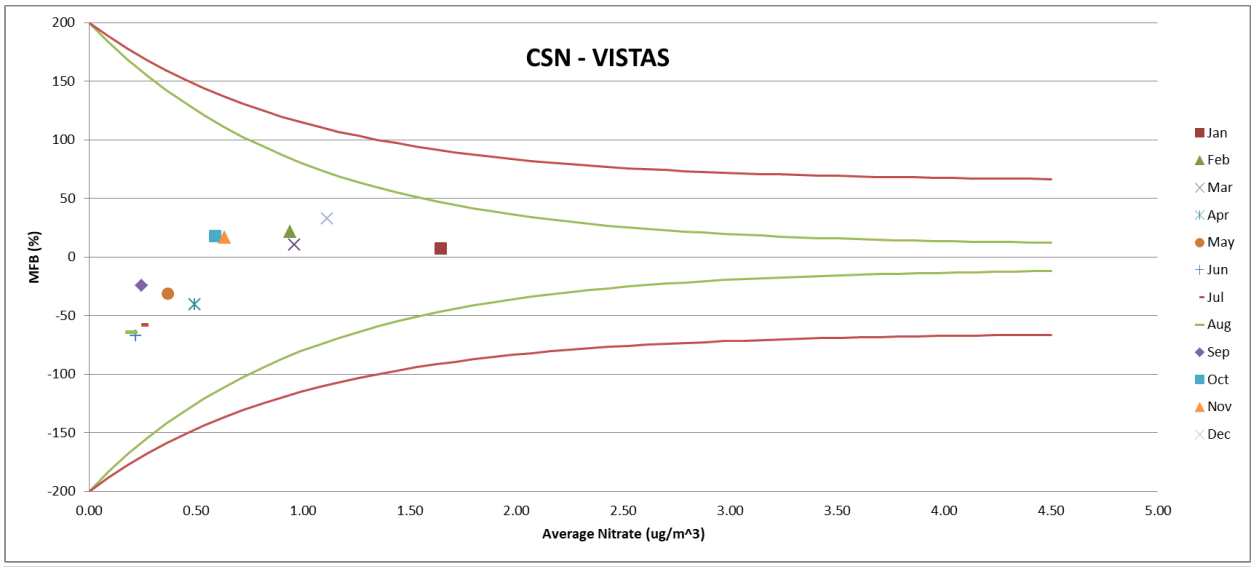


Figure E-8. Bugle Plot of Monthly Nitrate at Non-VISTAS State CASTNET Sites.



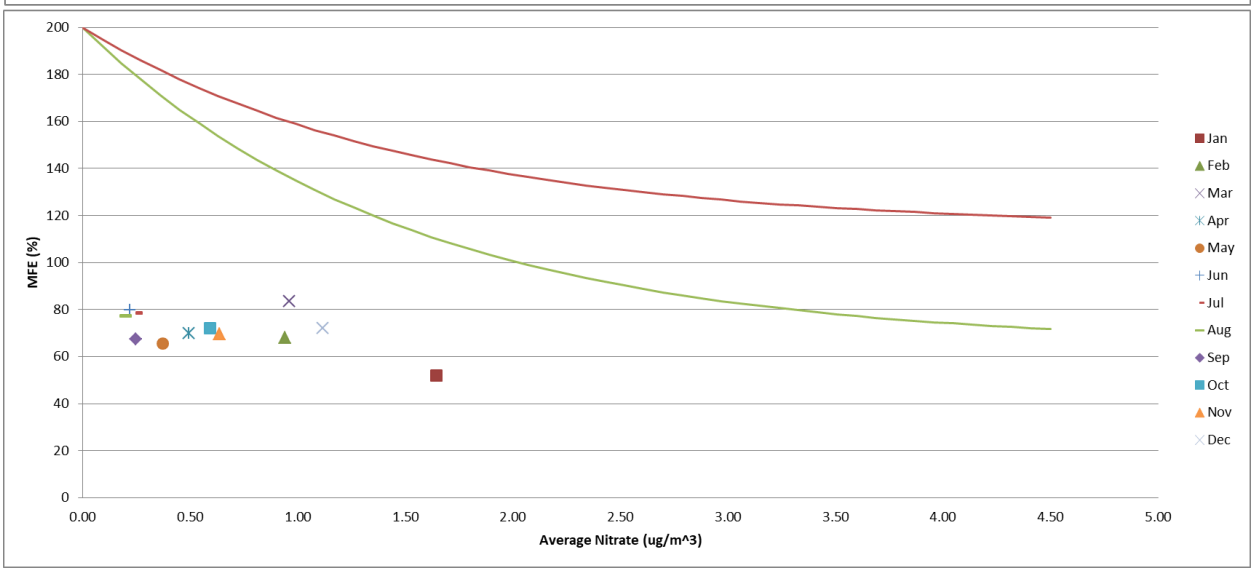
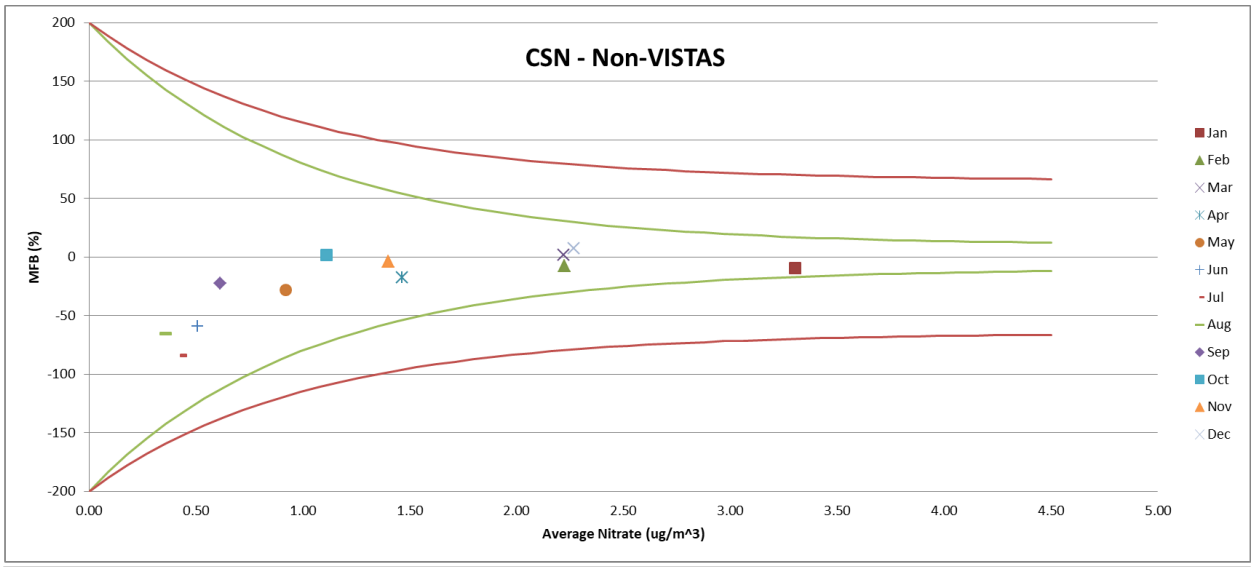


Figure E-9. Bugle Plot of Monthly Nitrate at VISTAS State CSN Sites.



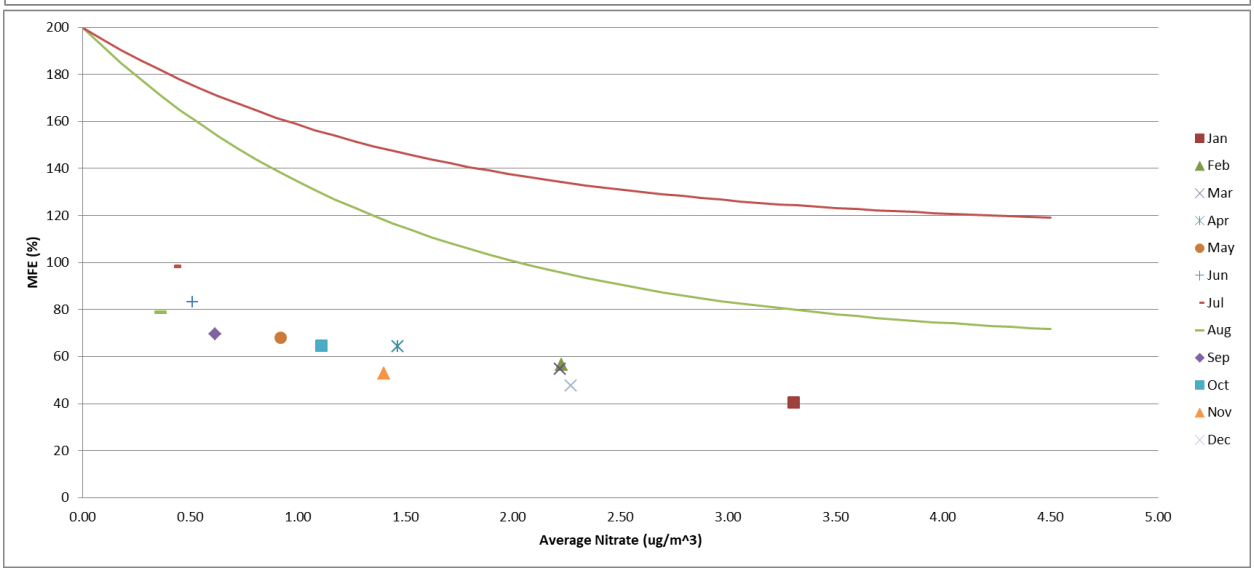


Figure E-10. Bugle Plot of Monthly Nitrate at Non-VISTAS State CSN Sites.

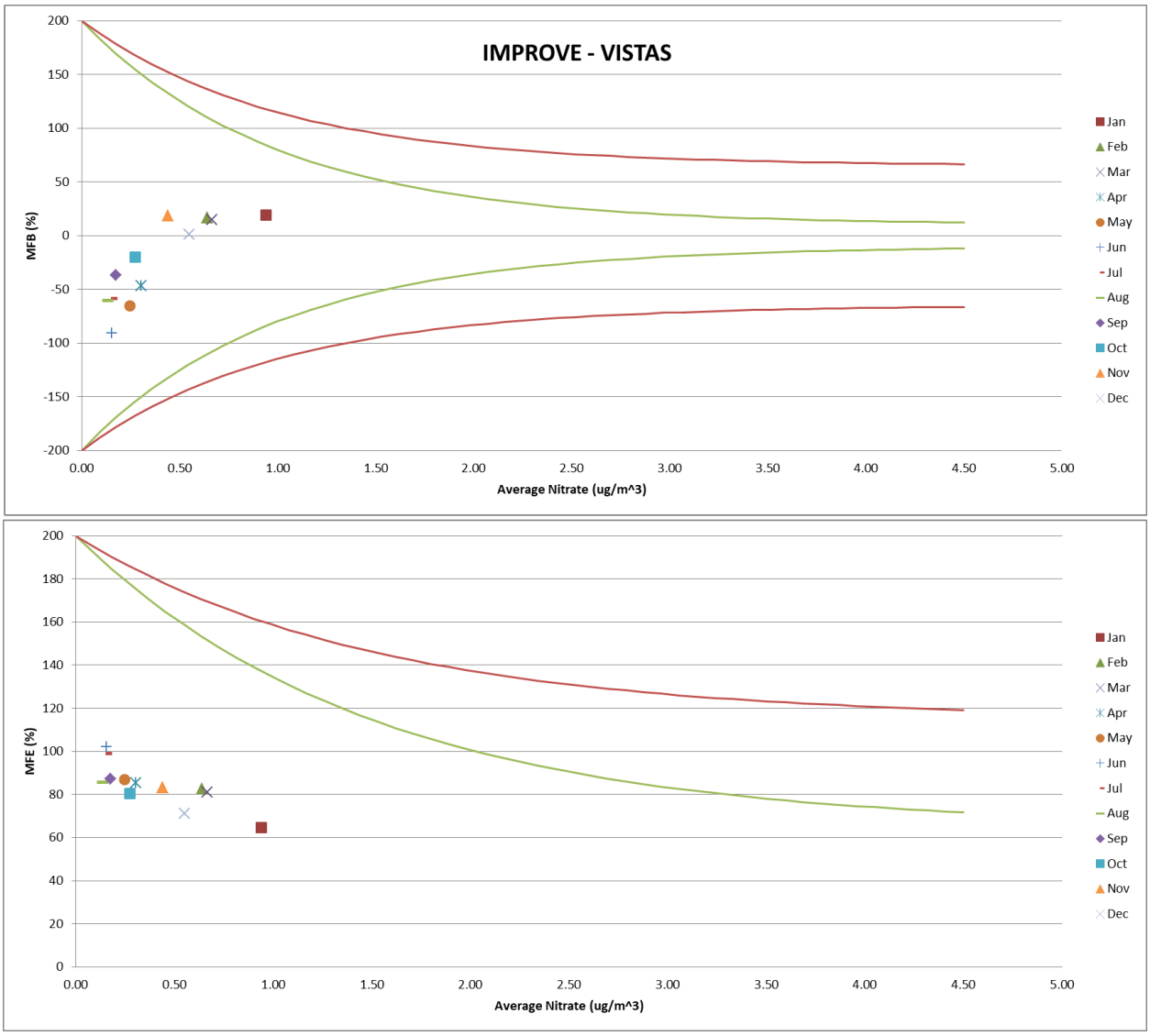


Figure E-11. Bugle Plot of Monthly Nitrate at VISTAS State IMPROVE Sites.

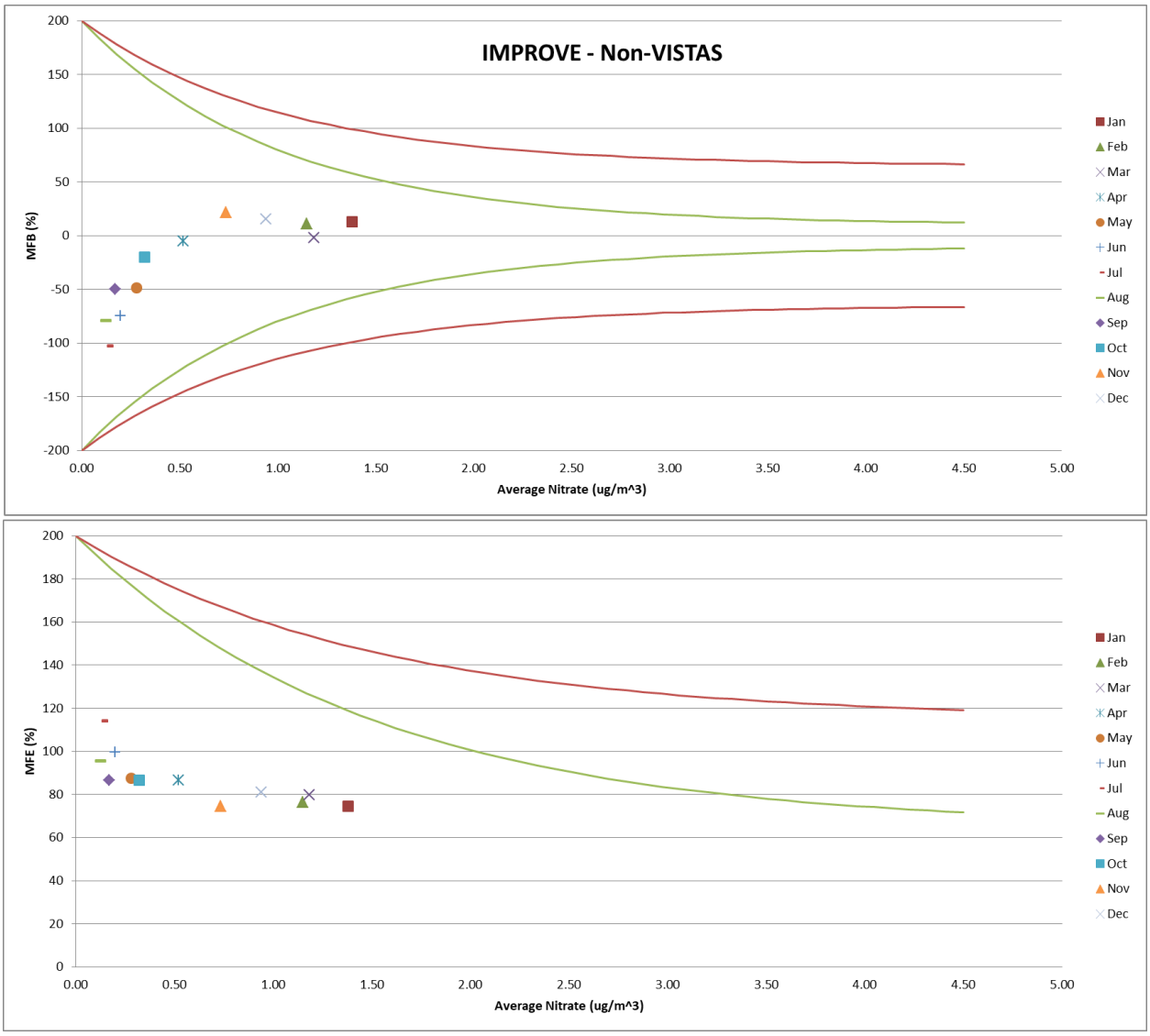


Figure E-12. Bugle Plot of Monthly Nitrate at Non-VISTAS State IMPROVE Sites.

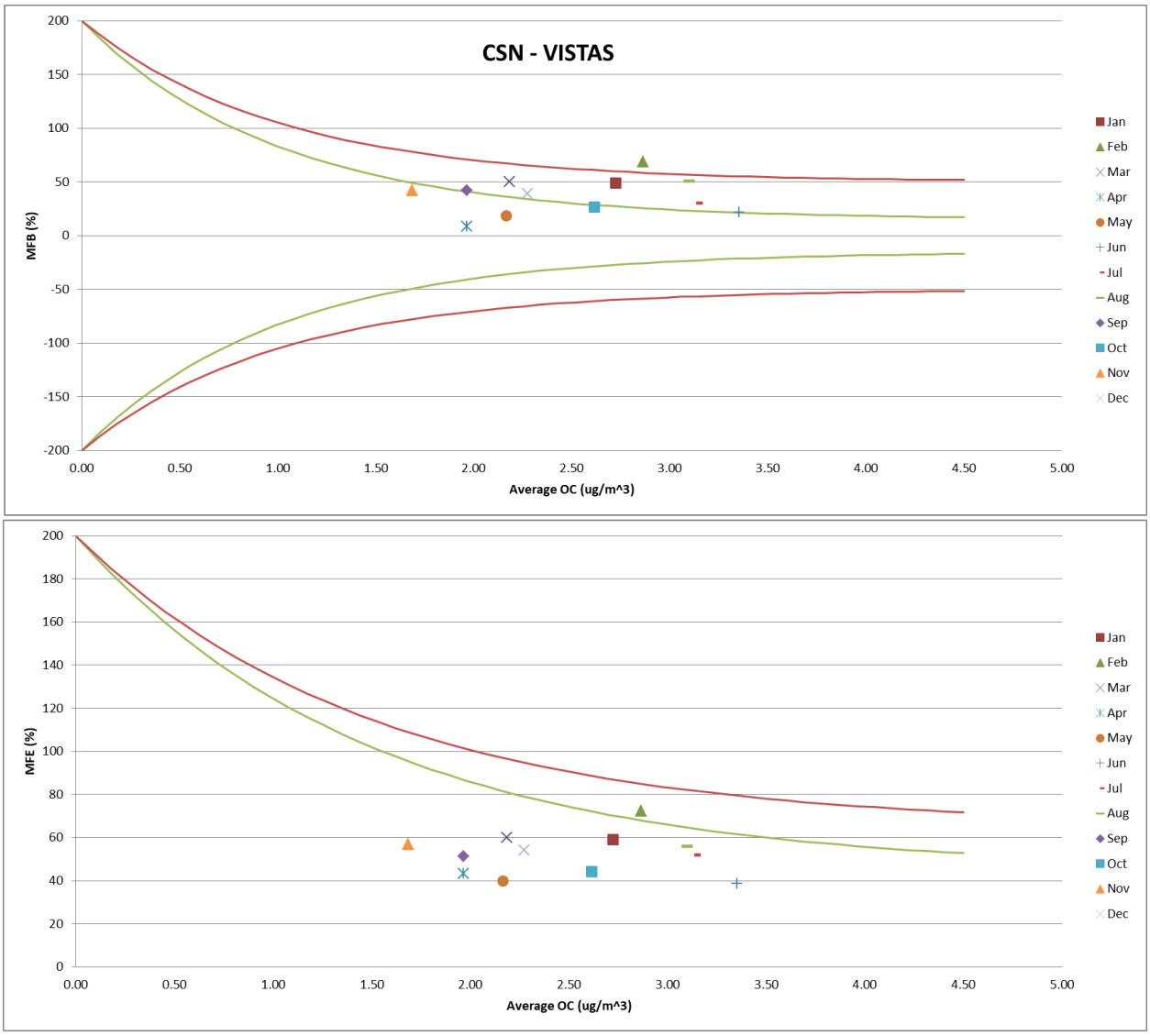
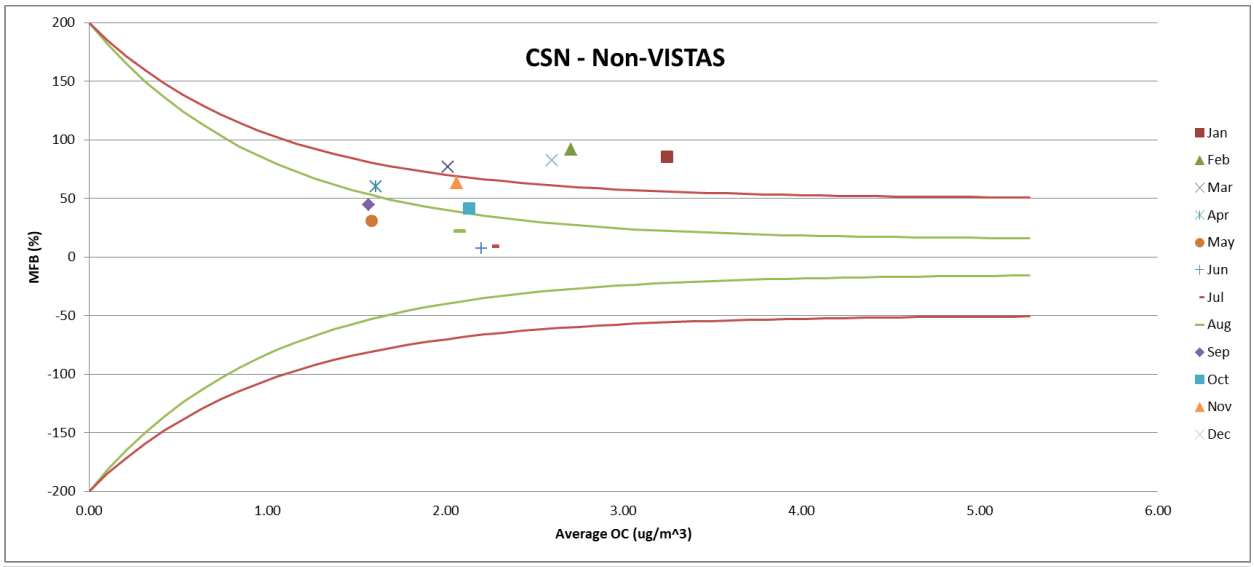


Figure E-13. Bugle Plot of Monthly OC at VISTAS State CSN Sites.



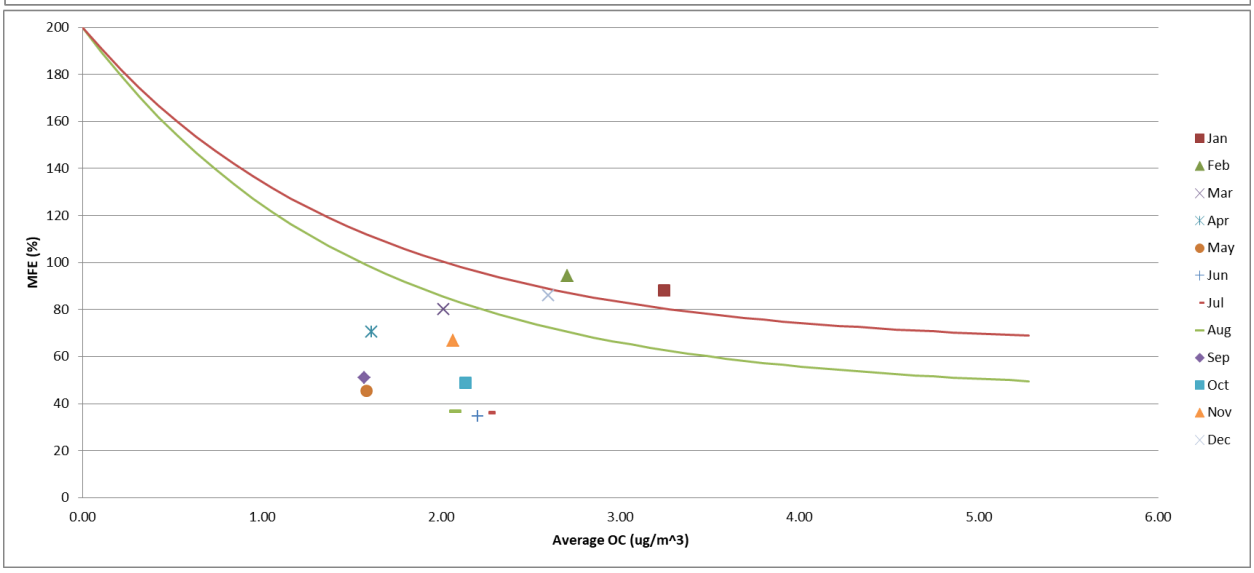


Figure E-14. Bugle Plot of Monthly OC at Non-VISTAS State CSN Sites.

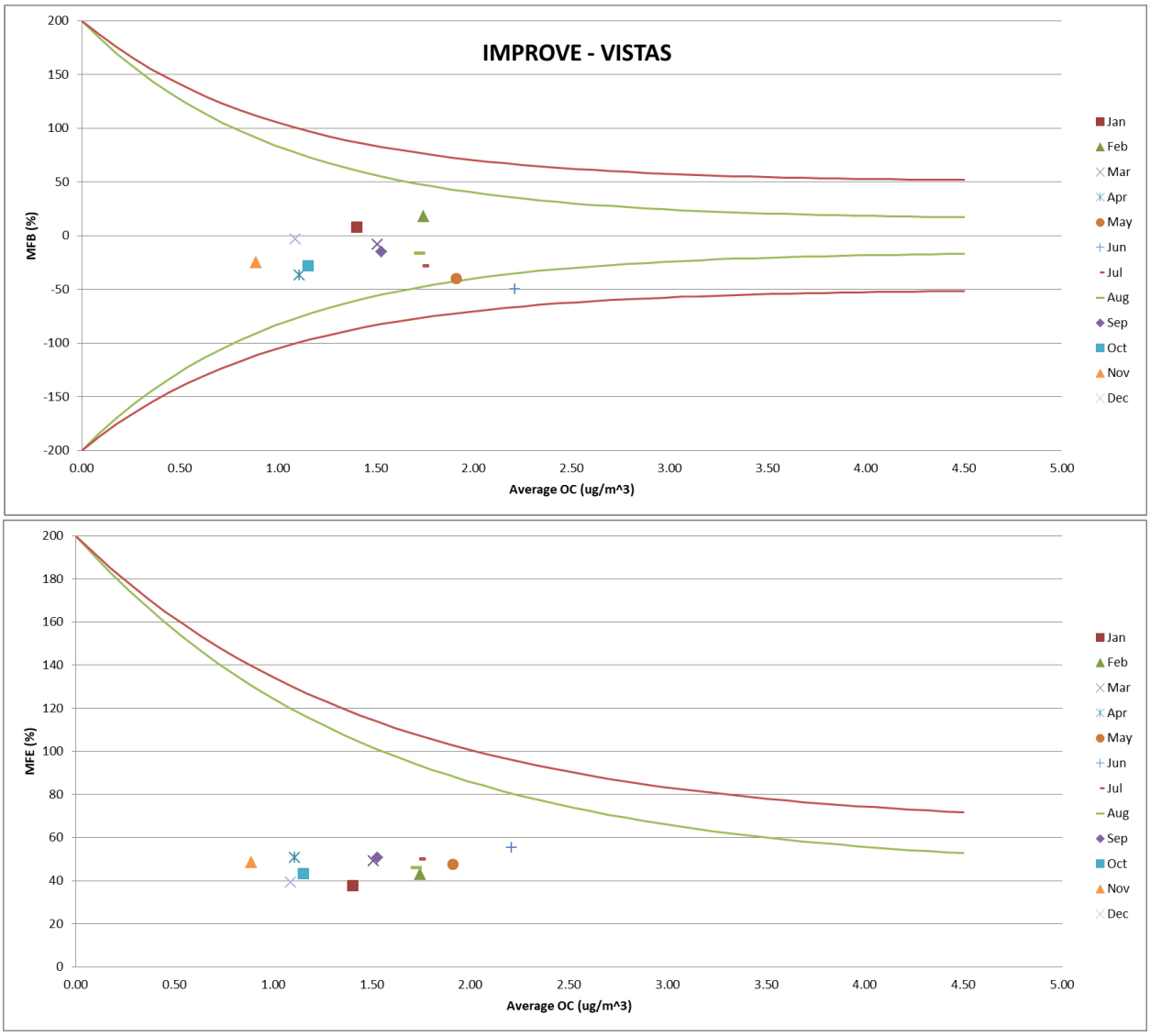


Figure E-15. Bugle Plot of Monthly OC at VISTAS State IMPROVE Sites.

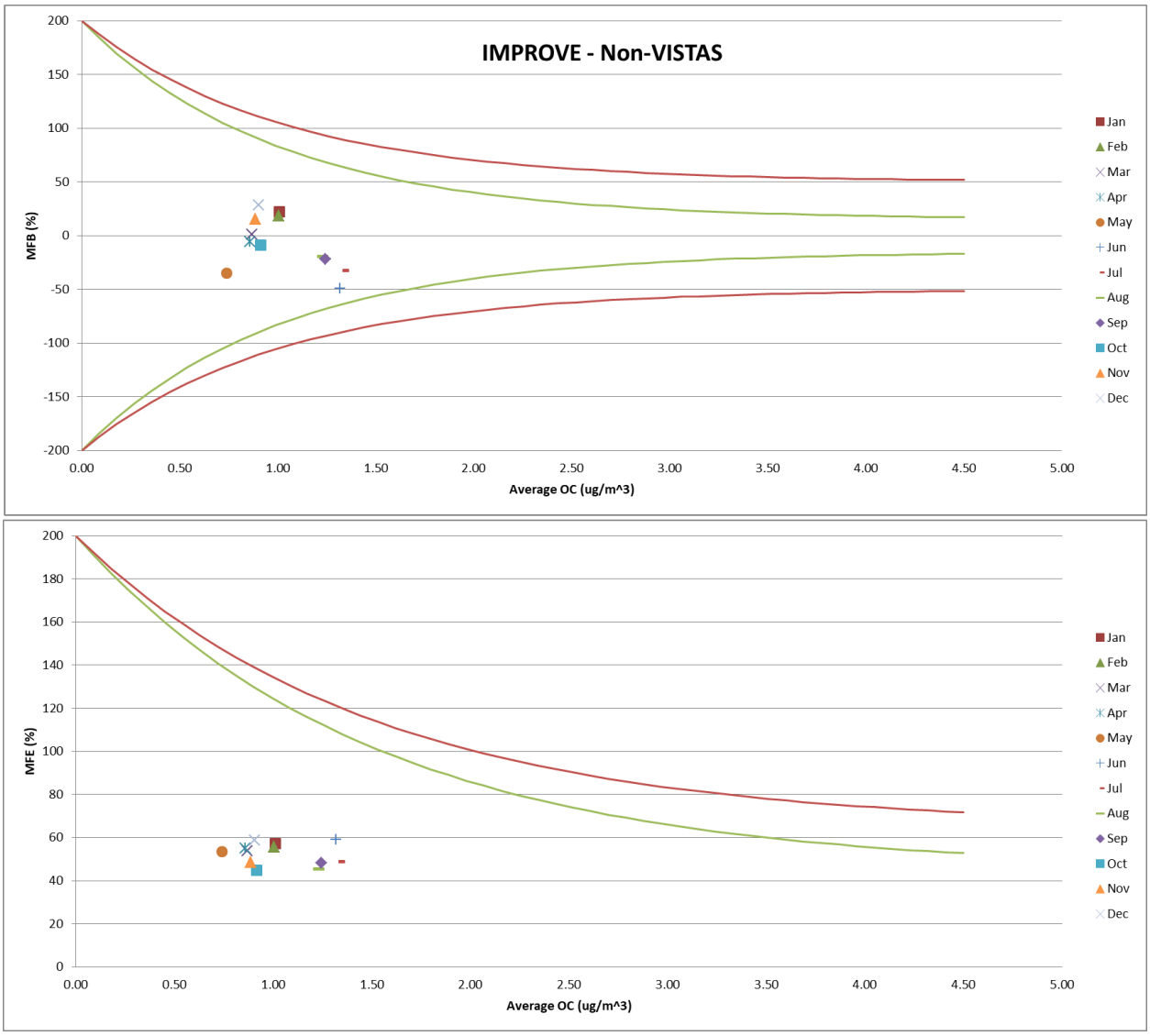


Figure E-16. Bugle Plot of Monthly OC at Non-VISTAS State IMPROVE Sites.

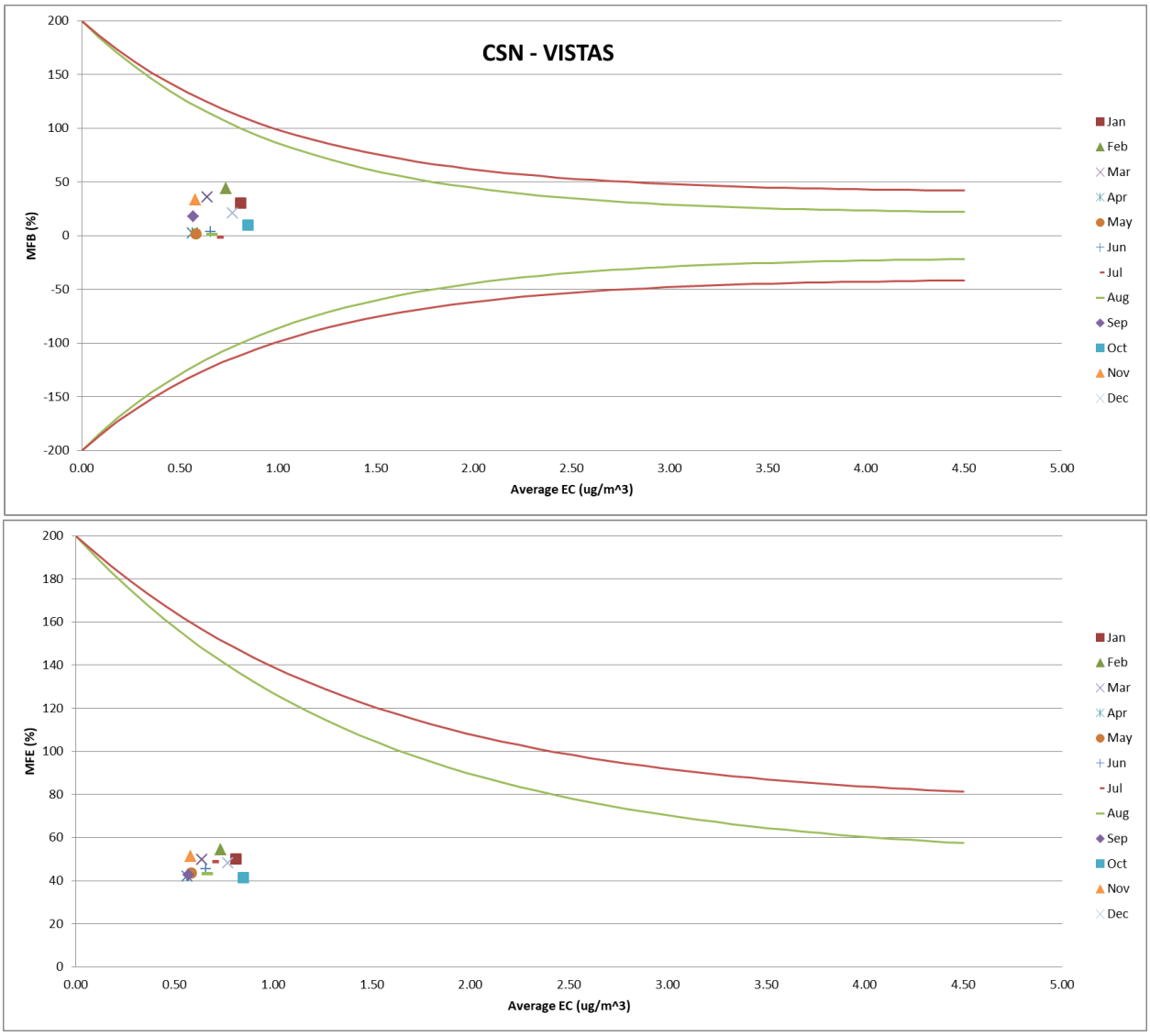


Figure E-17. Bugle Plot of Monthly EC at VISTAS State CSN Sites.

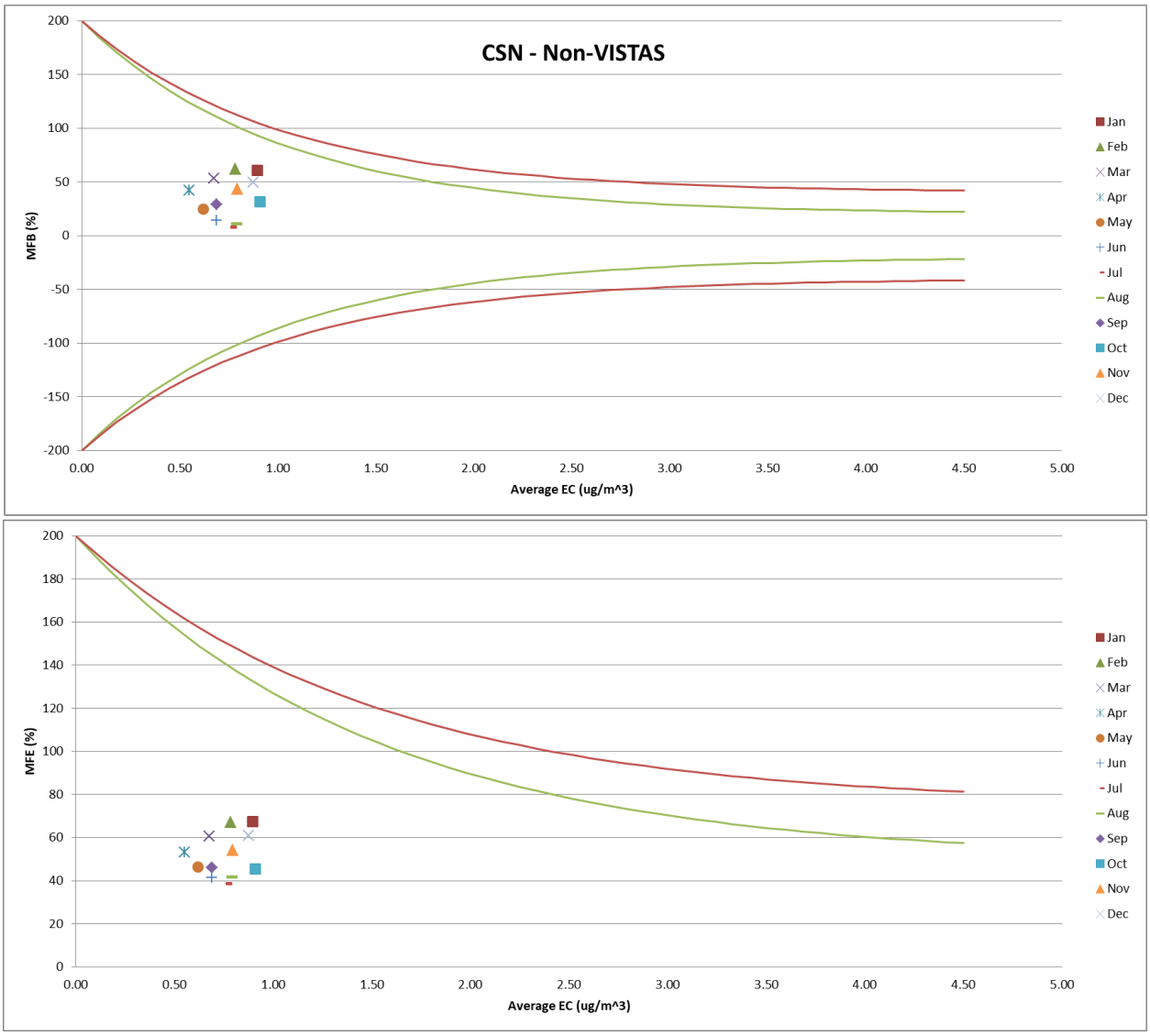


Figure E-18. Bugle Plot of Monthly EC at Non-VISTAS State CSN Sites.

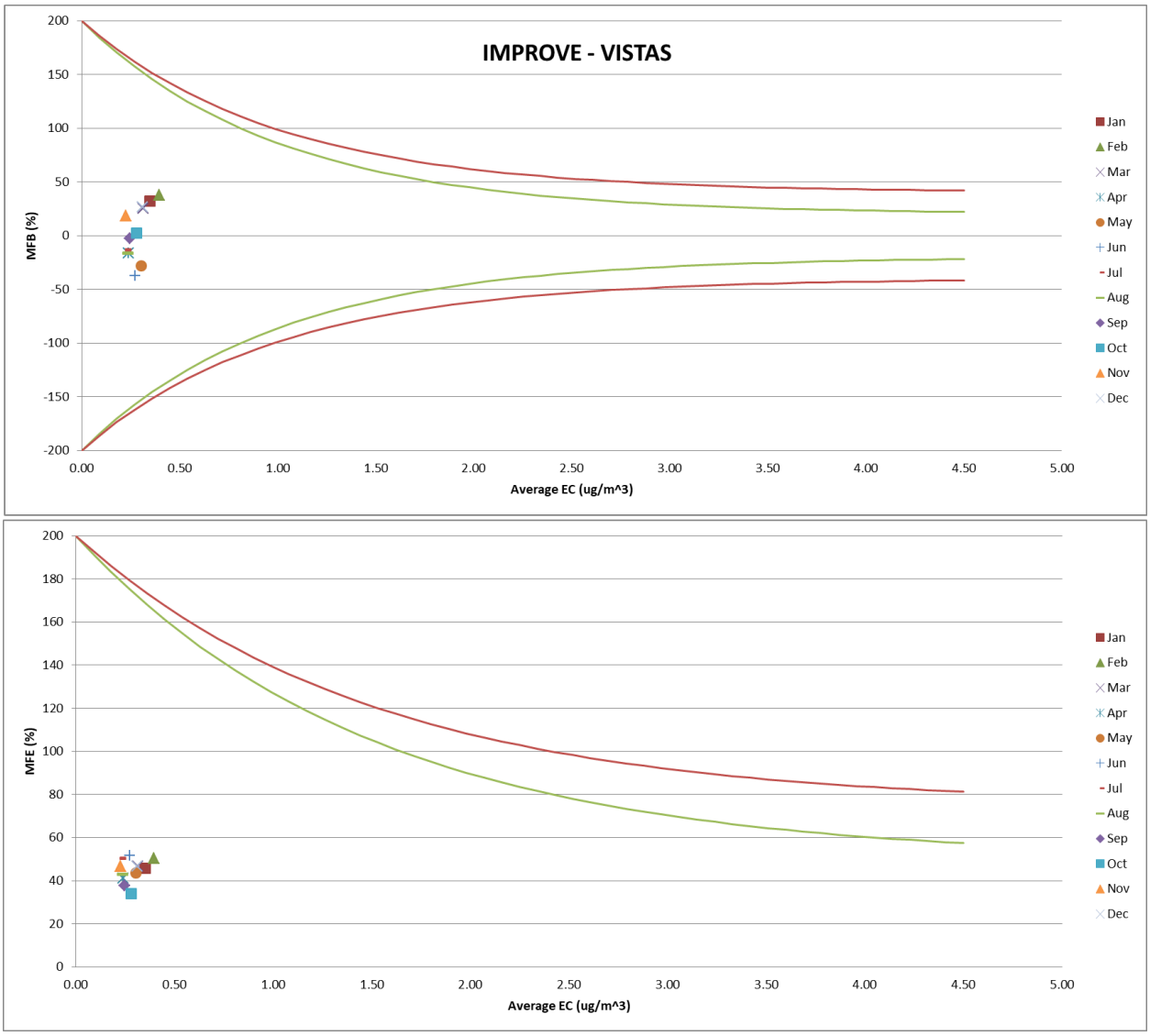


Figure E-19. Bugle Plot of Monthly EC at VISTAS State IMPROVE Sites.

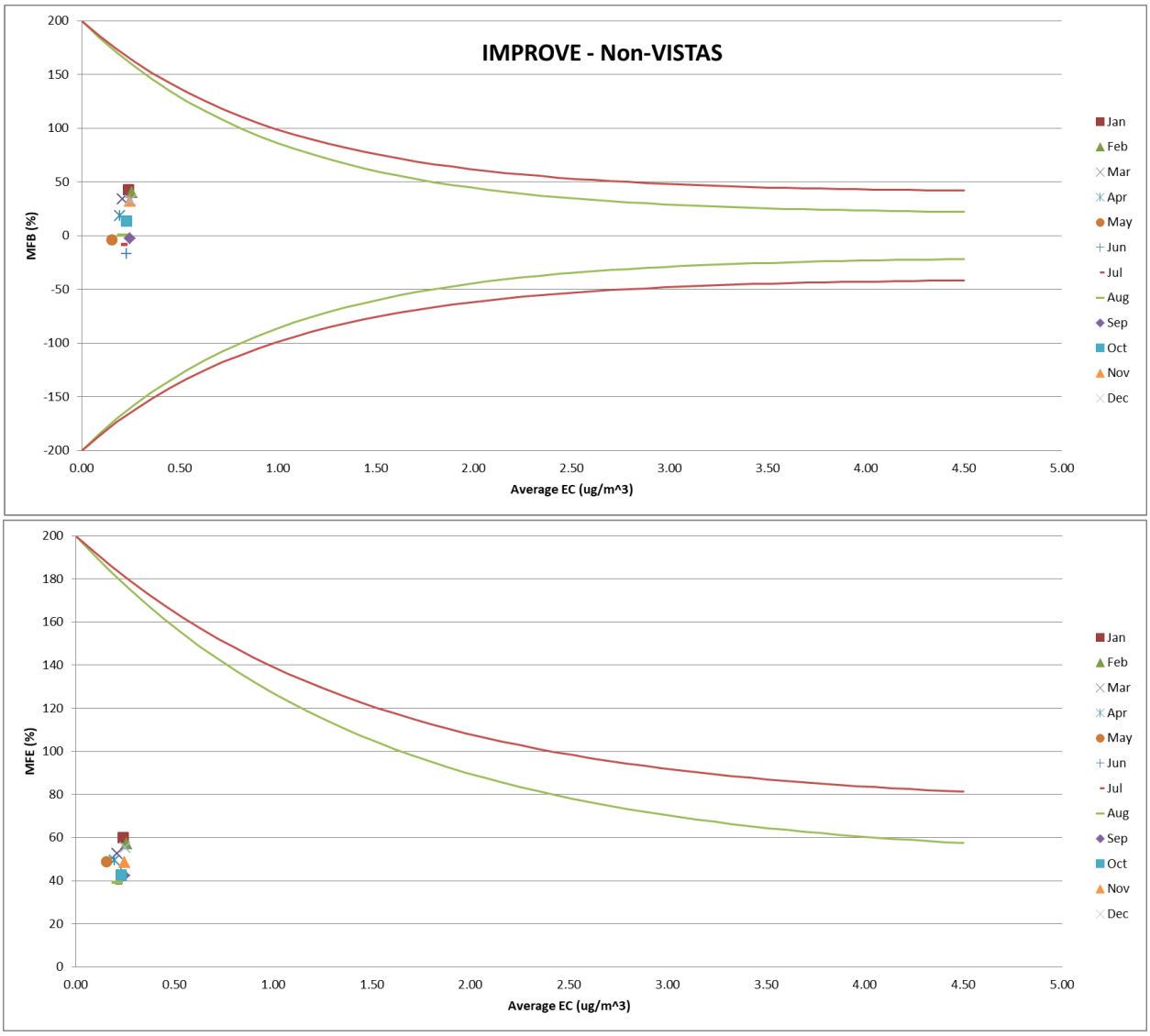


Figure E-20. Bugle Plot of Monthly EC at Non-VISTAS State IMPROVE Sites.

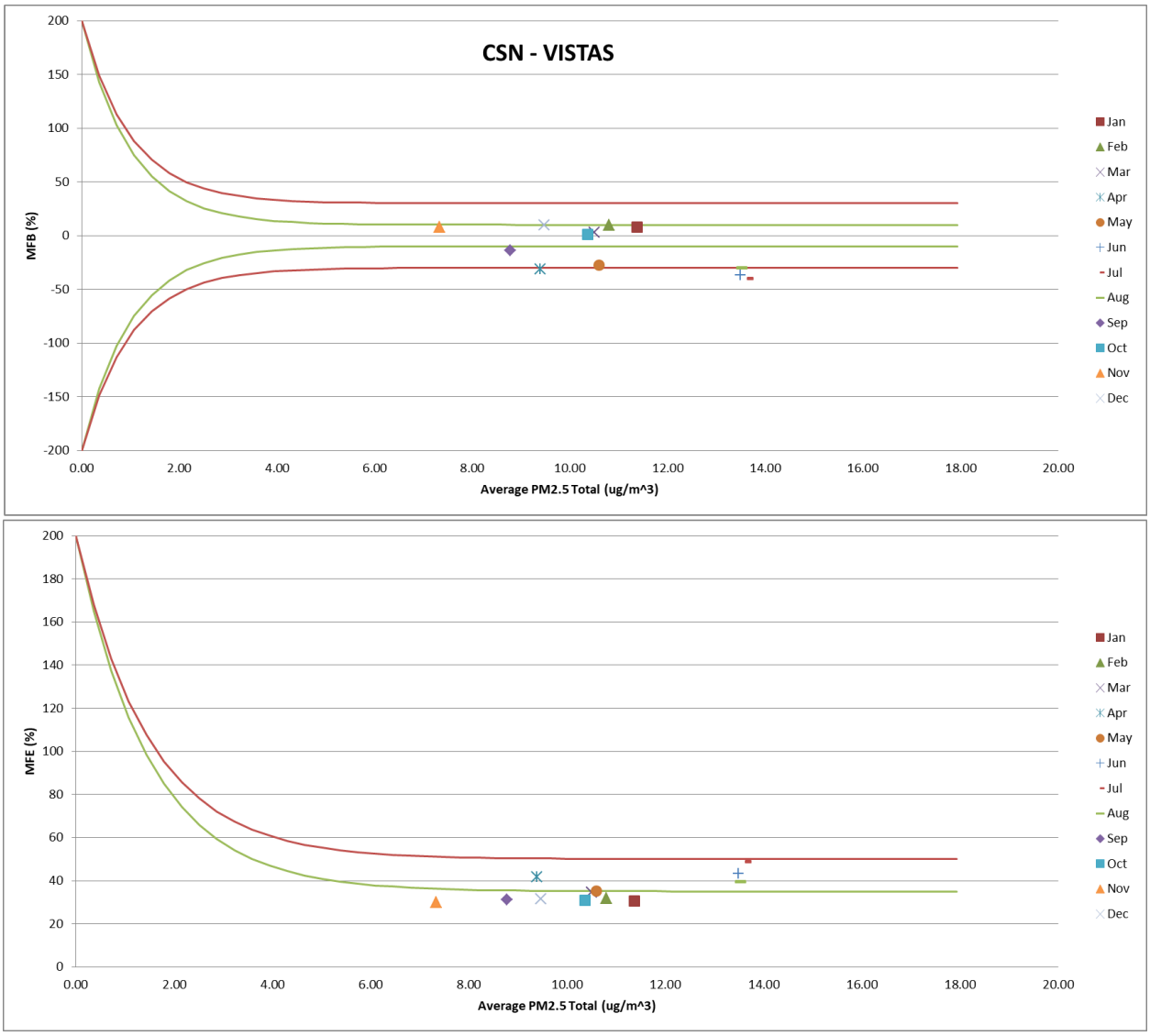
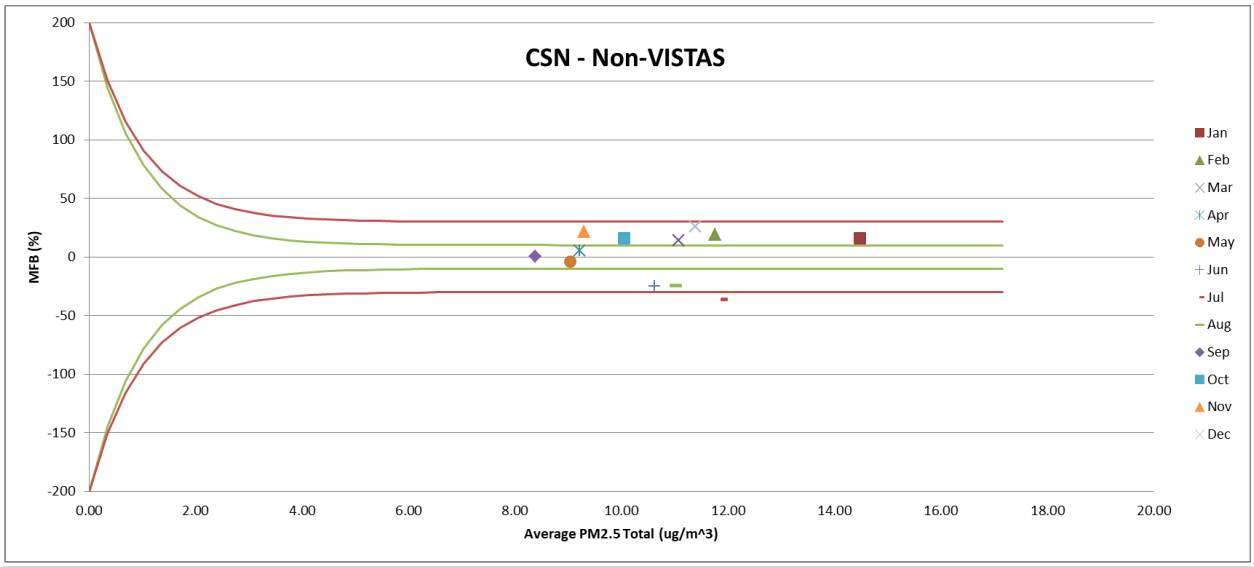


Figure E-21. Bugle Plot of Monthly Total $PM_{2.5}$ at VISTAS State CSN Sites.



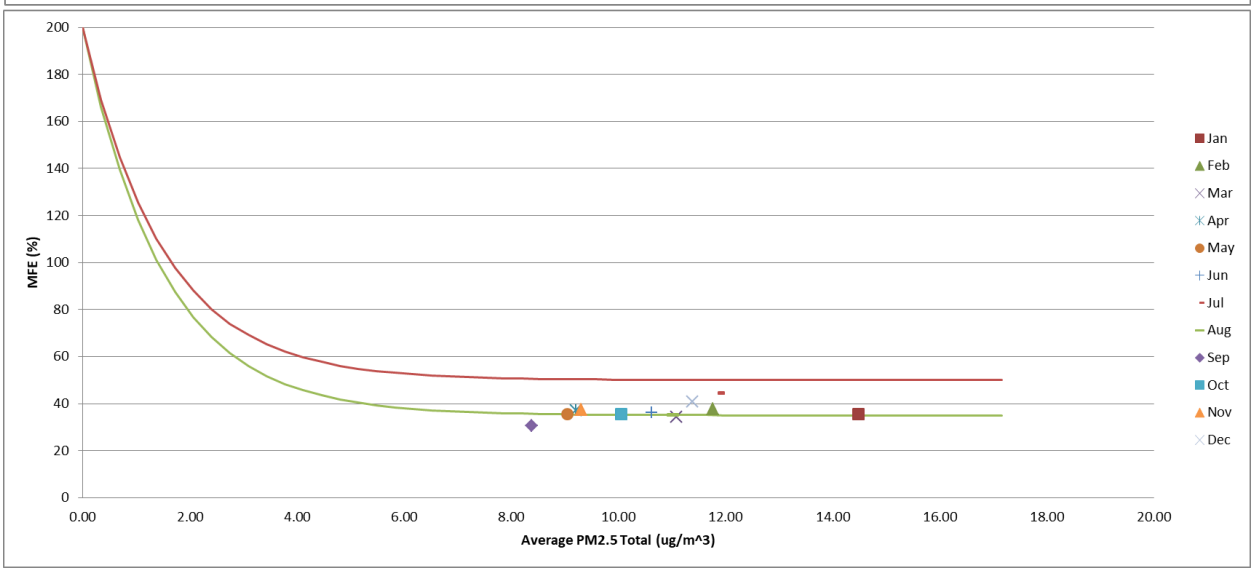
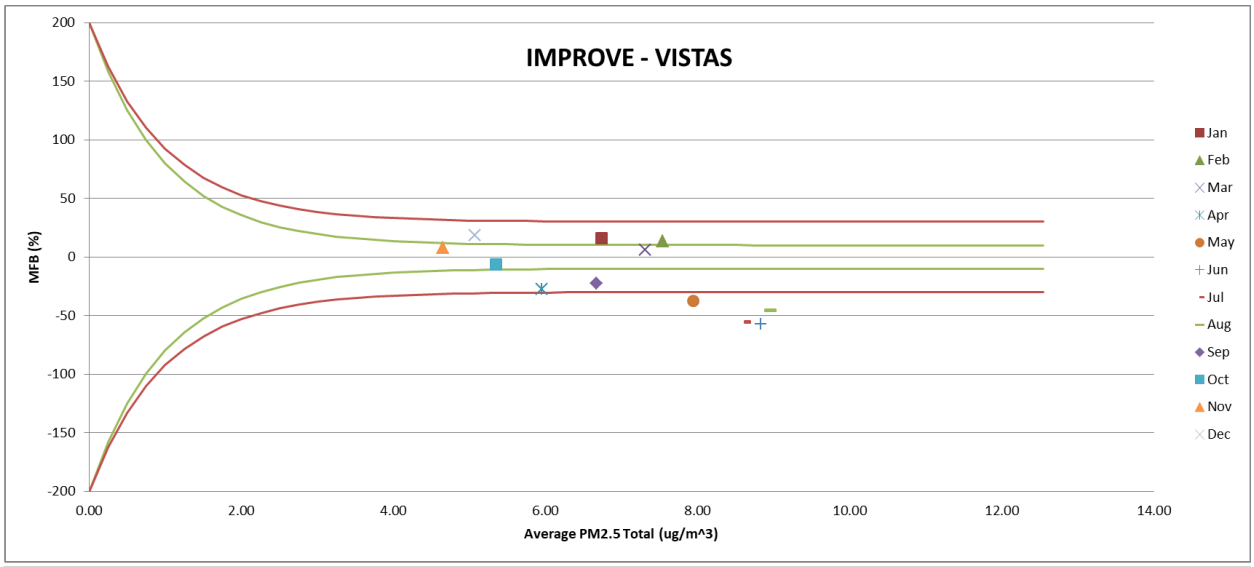


Figure E-22. Bugle Plot of Monthly Total $PM_{2.5}$ at Non-VISTAS State CSN Sites.



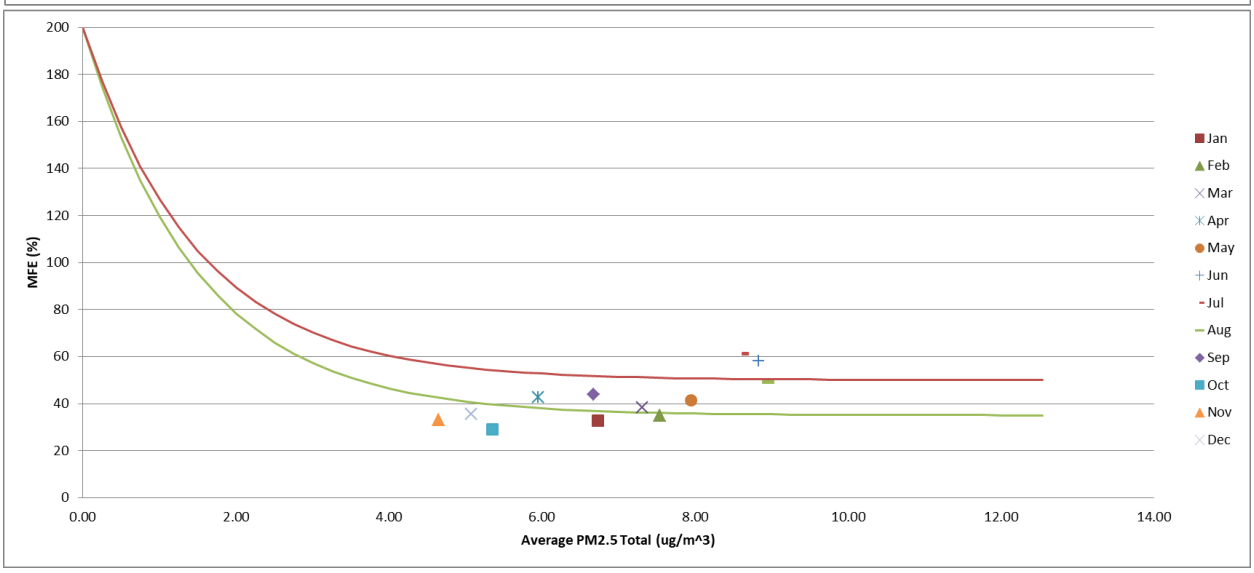
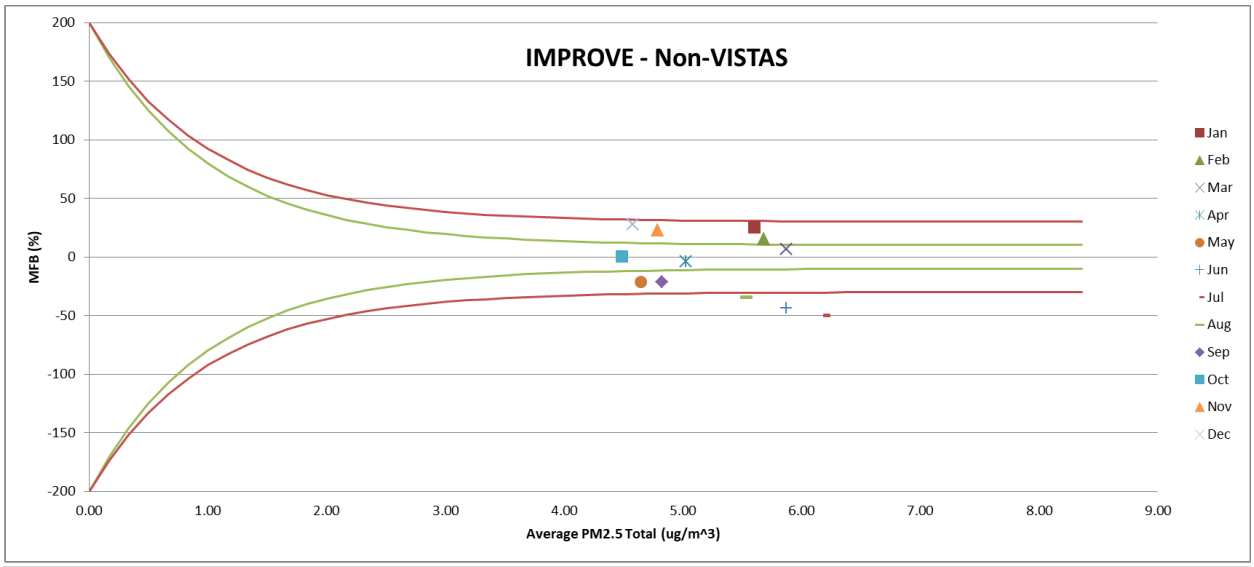


Figure E-23. Bugle Plot of Monthly Total $PM_{2.5}$ at VISTAS State IMPROVE Sites.



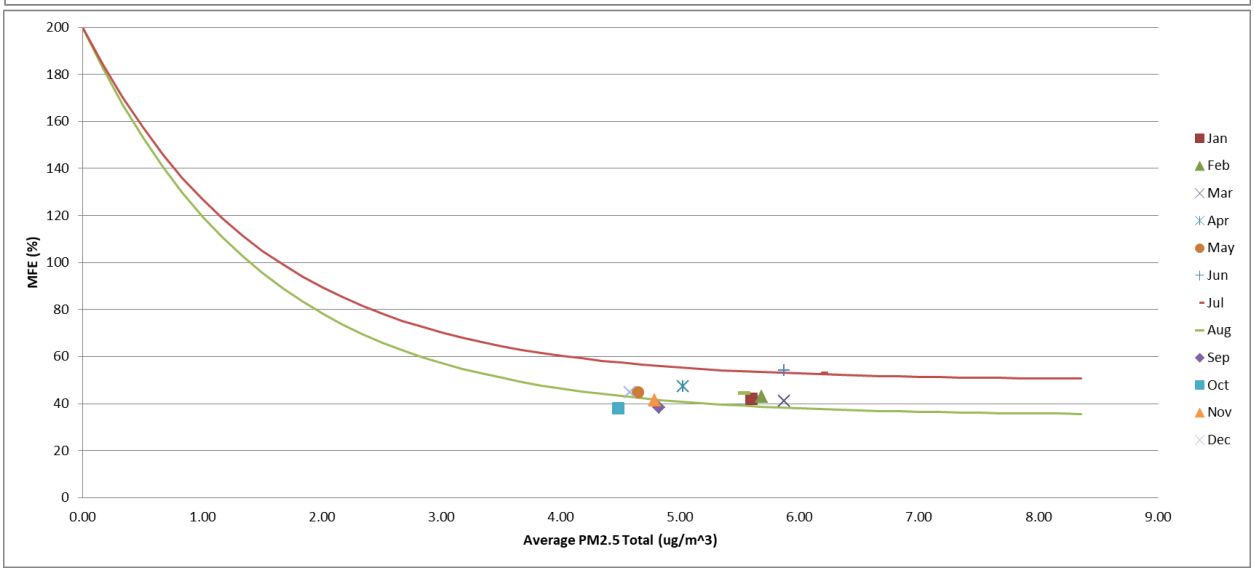


Figure E-24. Bugle Plot of Monthly Total $PM_{2.5}$ at Non-VISTAS State IMPROVE Sites.

Appendix F

VISTAS12 Modeling Domain
Observed and Modeled Concentration and Light Extinction Comparisons
(see "APP_F_PM_EXTINCTION_MPE.xlsx")

This page is intentionally left blank.

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: ABT147																		
NH4	WIN	11	0.78	0.8	0.63	2.73	30.14	0.02	0.23	0.08	3.99	-3.12	0.03	32.76	32.03	0.3	0.29	0.39
NH4	SPR	13	0.52	0.64	0.6	23.08	32.24	0.12	0.17	0.04	35.75	19.83	0.23	44.36	30.14	0.32	0.24	0.36
NH4	SUM	7	0.86	0.79	0.12	-8.41	59.7	-0.07	0.51	0.4	-2.49	-24.81	-0.09	54.4	63.17	0.65	0.64	0.01
NH4	FAL	13	0.55	0.63	0.73	14.79	47.9	0.08	0.26	0.09	11.01	-6.94	0.15	49.22	51.1	0.48	0.32	0.53
NH4	ALL	44	0.65	0.7	0.45	8.24	41.33	0.05	0.27	0.13	14.42	-0.92	0.08	44.49	42.06	0.41	0.36	0.2
NO3	WIN	11	1.35	1.8	0	33.36	74.7	0.45	1.01	1.24	45.44	16.91	0.33	78.46	60.26	0.75	1.2	0
NO3	SPR	13	0.55	0.79	0.06	44.06	94.38	0.24	0.52	0.31	95.9	12.57	0.44	142.46	90.6	0.94	0.61	0
NO3	SUM	7	0.25	0.29	0.63	18.34	128.98	0.05	0.32	0.13	100.26	-33.54	0.18	192.55	125.39	1.29	0.37	0.4
NO3	FAL	13	0.75	0.83	0.66	10.01	63.96	0.08	0.48	0.41	36.7	-18.57	0.1	96.28	75.14	0.64	0.65	0.44
NO3	ALL	44	0.76	0.97	0.55	28.01	78.56	0.21	0.6	0.57	66.49	-2.88	0.28	120.79	83.98	0.79	0.78	0.3
SO4	WIN	11	1.6	0.96	0.51	-39.63	39.63	-0.63	0.63	0.23	-37.19	-49.65	-0.66	37.19	49.65	0.66	0.79	0.26
SO4	SPR	13	1.58	1.54	0.54	-2.14	32.4	-0.03	0.51	0.54	1.82	-8.44	-0.02	33.6	31.53	0.33	0.74	0.29
SO4	SUM	7	2.39	2.45	0.1	2.8	71.75	0.07	1.71	4.61	9.3	-18.67	0.03	64.99	66.57	0.72	2.15	0.01
SO4	FAL	13	1.37	1.37	0.79	0.2	39.31	0	0.54	0.43	-2.15	-16.12	0	41.63	46.21	0.39	0.65	0.63
SO4	ALL	44	1.65	1.49	0.41	-9.5	44.91	-0.16	0.74	1.15	-7.92	-22.64	-0.11	41.86	45.97	0.5	1.09	0.17
CASTNET Monitoring Station: ACA416																		
NH4	WIN	11	0.37	0.38	0.22	1.62	45.63	0.01	0.17	0.05	9.97	-5.05	0.02	47.37	43.96	0.46	0.22	0.05
NH4	SPR	14	0.25	0.32	0.08	28.25	57.12	0.07	0.14	0.03	62.24	23.9	0.28	82.14	49.92	0.57	0.19	0.01
NH4	SUM	13	0.39	0.43	0.62	9.03	48.99	0.04	0.19	0.08	9.97	-3.26	0.09	43.03	43.92	0.49	0.28	0.39
NH4	FAL	12	0.36	0.37	0.18	2.98	57.41	0.01	0.21	0.05	12.4	-13.53	0.03	63.35	68.68	0.57	0.23	0.03
NH4	ALL	50	0.34	0.37	0.41	9.66	52	0.03	0.18	0.05	25.19	1.49	0.1	59.81	51.55	0.52	0.23	0.17
NO3	WIN	11	0.64	0.67	0.33	6.06	69.54	0.04	0.44	0.27	34.25	-6.33	0.06	84.96	71.49	0.7	0.52	0.11
NO3	SPR	14	0.28	0.34	0.38	22.6	107.19	0.06	0.3	0.16	69.97	-34.8	0.23	153.65	105.26	1.07	0.4	0.14
NO3	SUM	13	0.2	0.07	0.24	-65.49	85.97	-0.13	0.17	0.04	-40.9	-97.83	-1.9	81.7	124.82	2.49	0.23	0.06
NO3	FAL	12	0.59	0.37	0.42	-37.43	78.21	-0.22	0.46	0.26	-37.73	-94.17	-0.6	84.57	122.51	1.25	0.56	0.18
NO3	ALL	50	0.41	0.35	0.46	-14.97	81.69	-0.06	0.34	0.19	7.44	-59.17	-0.18	103.25	107.06	0.96	0.44	0.21
SO4	WIN	11	1.15	0.76	0.08	-34.41	45.86	-0.4	0.53	0.27	-27.89	-41.43	-0.52	41.63	52.77	0.7	0.66	0.01
SO4	SPR	14	1.03	1.45	0.23	40.59	71.49	0.42	0.74	0.91	54.88	16.64	0.41	83.71	52.74	0.71	1.04	0.05
SO4	SUM	13	1.39	1.88	0.39	35.16	89.69	0.49	1.25	2.53	33.47	-1.69	0.35	81.95	68.75	0.9	1.66	0.15
SO4	FAL	12	1.22	1.34	0.67	9.88	51.27	0.12	0.62	0.7	7	-11.9	0.1	51.44	54	0.51	0.85	0.45
SO4	ALL	50	1.2	1.38	0.4	15.57	66.63	0.19	0.8	1.25	19.61	-7.75	0.16	66.25	57.21	0.67	1.14	0.16

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: ALC188																		
NH4	WIN	5	0.51	0.94	0.66	83.49	86.47	0.43	0.44	0.09	83.05	50.77	0.83	86.75	54.64	0.86	0.53	0.43
NH4	SPR	10	0.65	0.37	0.57	-42.84	48.62	-0.28	0.32	0.04	-44.91	-67.86	-0.75	50.06	72.43	0.85	0.35	0.32
NH4	SUM	12	0.57	0.25	0.37	-56.12	65.99	-0.32	0.38	0.1	-55.27	-91.01	-1.28	62.57	97	1.5	0.45	0.14
NH4	FAL	4	0.56	0.65	0.73	15.4	43.72	0.09	0.25	0.09	29.98	11.47	0.15	53.98	40.72	0.44	0.31	0.54
NH4	ALL	31	0.59	0.45	0.18	-22.75	59.88	-0.13	0.35	0.16	-18.62	-47.45	-0.29	61.32	74.98	0.78	0.42	0.03
NO3	WIN	5	0.92	1.15	0.72	25.39	100.57	0.23	0.92	1.03	74.11	-0.29	0.25	132.34	93.69	1.01	1.04	0.52
NO3	SPR	10	1.16	0.23	0.66	-80.04	98.01	-0.93	1.14	0.56	53.11	-131.41	-4.01	213.17	166.18	4.91	1.19	0.44
NO3	SUM	12	0.97	0.04	0.38	-95.51	95.51	-0.93	0.93	0.11	-93.1	-176.24	-21.29	93.1	176.24	21.29	0.98	0.14
NO3	FAL	4	0.71	0.15	0.84	-78.66	78.66	-0.56	0.56	0.16	-69.65	-114.12	-3.69	69.65	114.12	3.69	0.68	0.71
NO3	ALL	31	0.99	0.3	0.3	-70	95.66	-0.69	0.95	0.59	-15.94	-125.38	-2.33	135.14	151.67	3.19	1.03	0.09
SO4	WIN	5	2.48	2.43	0.88	-1.8	21.31	-0.04	0.53	0.38	-5.66	-10.28	-0.02	22.2	25.19	0.22	0.62	0.78
SO4	SPR	10	3.76	1.66	0.42	-55.85	55.85	-2.1	2.1	0.87	-55.66	-82.16	-1.26	55.66	82.16	1.26	2.3	0.17
SO4	SUM	12	2.7	1.03	0.01	-61.82	71.8	-1.67	1.94	1.29	-59.52	-100.41	-1.62	72.01	109.5	1.88	2.02	0
SO4	FAL	4	2.68	2.05	0.16	-23.44	33.52	-0.63	0.9	1.07	-15.67	-23.39	-0.31	30.56	36.35	0.44	1.21	0.03
SO4	ALL	31	3.01	1.59	0.25	-47.02	54.25	-1.41	1.63	1.54	-43.93	-70.05	-0.89	53.35	77.64	1.02	1.88	0.06
CASTNET Monitoring Station: ALH157																		
NH4	WIN	11	1.83	1.39	0.19	-24.22	50.32	-0.44	0.92	1.09	-5.82	-27.7	-0.32	55.75	53.98	0.66	1.13	0.04
NH4	SPR	14	1.15	1.11	0.63	-4.07	35.94	-0.05	0.41	0.27	-6.57	-20.27	-0.04	38.1	45.77	0.37	0.52	0.4
NH4	SUM	12	1.13	0.92	0.02	-18.22	54.43	-0.21	0.61	0.49	-4.93	-24.75	-0.22	55.72	60.3	0.67	0.73	0
NH4	FAL	13	0.85	1.09	0.28	27.64	79.16	0.24	0.67	0.83	59.63	10.99	0.28	93.17	57.86	0.79	0.94	0.08
NH4	ALL	50	1.22	1.12	0.19	-8.12	52.65	-0.1	0.64	0.71	11.2	-14.85	-0.09	60.53	54.21	0.57	0.85	0.04
NO3	WIN	11	4.13	3.45	0.18	-16.46	57.24	-0.68	2.36	7.61	7.87	-21.43	-0.2	69.31	61.44	0.69	2.84	0.03
NO3	SPR	14	1.54	1.86	0.61	20.93	71.24	0.32	1.09	2.12	13.8	-21.45	0.21	73.07	74.67	0.71	1.49	0.38
NO3	SUM	12	0.53	0.22	0.6	-59.57	59.57	-0.32	0.32	0.03	-58.75	-88.96	-1.47	58.75	88.96	1.47	0.36	0.36
NO3	FAL	13	1.42	1.84	0.2	29.21	80.62	0.42	1.15	2.3	40.45	-6.53	0.29	94.24	72.42	0.81	1.57	0.04
NO3	ALL	50	1.84	1.81	0.55	-1.51	65.39	-0.03	1.2	3.07	2.01	-33.77	-0.02	74.31	74.6	0.66	1.75	0.3
SO4	WIN	11	2.16	1.33	0.39	-38.67	51.95	-0.84	1.12	0.8	-28.27	-48.85	-0.63	57.04	64.91	0.85	1.22	0.15
SO4	SPR	14	2.6	1.67	0.1	-35.66	45	-0.93	1.17	0.95	-33.66	-49.99	-0.55	43.6	58.47	0.7	1.35	0.01
SO4	SUM	12	3.62	2.6	0.06	-28.28	57.33	-1.02	2.08	5.05	-18.54	-39.65	-0.39	55.76	68.45	0.8	2.47	0
SO4	FAL	13	1.97	1.63	0.12	-17.17	57.19	-0.34	1.13	1.88	-7.61	-27.99	-0.21	54.45	61.98	0.69	1.41	0.01
SO4	ALL	50	2.58	1.81	0.18	-30.06	52.84	-0.78	1.37	2.21	-22.07	-41.54	-0.43	52.3	63.2	0.76	1.68	0.03

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: ANA115																		
NH4	WIN	11	1.56	1.1	0.23	-29.43	53.43	-0.46	0.83	0.81	-29.56	-52.51	-0.42	51.51	67.21	0.76	1.01	0.05
NH4	SPR	12	0.97	0.83	0.21	-15.16	42.24	-0.15	0.41	0.24	-6.32	-23.9	-0.18	46.82	49.64	0.5	0.51	0.04
NH4	SUM	13	0.96	0.83	0.28	-14.21	56.39	-0.14	0.54	0.44	-3	-27.56	-0.17	55.48	63.74	0.66	0.68	0.08
NH4	FAL	13	0.8	1.11	0.01	38.55	90.82	0.31	0.73	0.58	51.34	6.19	0.39	97.11	80.41	0.91	0.82	0
NH4	ALL	49	1.06	0.96	0.08	-8.82	59.16	-0.09	0.63	0.58	4.64	-23.31	-0.1	63.51	65.49	0.65	0.77	0.01
NO3	WIN	11	3.22	2.6	0.13	-19.23	72.15	-0.62	2.33	8.06	-13.47	-46.38	-0.24	68.09	79.39	0.89	2.91	0.02
NO3	SPR	12	1.2	1.26	0.76	5.06	52.68	0.06	0.63	0.63	7.76	-22.81	0.05	67.56	68.89	0.53	0.8	0.58
NO3	SUM	13	0.25	0.52	0.3	113.74	167	0.28	0.41	0.37	107.57	13.37	1.14	147.62	75.02	1.67	0.67	0.09
NO3	FAL	13	1.09	1.82	0.53	67.31	112.12	0.73	1.22	2.23	83.4	14.36	0.67	124.5	88.1	1.12	1.66	0.28
NO3	ALL	49	1.37	1.51	0.45	10.48	80.9	0.14	1.11	2.88	49.54	-8.64	0.1	104.03	77.97	0.81	1.7	0.2
SO4	WIN	11	2.1	0.97	0.3	-53.62	54.1	-1.12	1.13	0.49	-52.23	-75.65	-1.16	52.72	76.13	1.17	1.32	0.09
SO4	SPR	12	2.2	1.28	0.24	-41.94	48.67	-0.92	1.07	0.74	-33.19	-50.44	-0.72	47.03	60.22	0.84	1.26	0.06
SO4	SUM	13	2.85	1.93	0.19	-32.27	52.59	-0.92	1.5	2.43	-24.16	-46.6	-0.48	49.77	66.09	0.78	1.81	0.04
SO4	FAL	13	1.82	1.76	0.1	-3.78	60.01	-0.07	1.09	2.06	8	-21.19	-0.04	61.12	66.09	0.62	1.44	0.01
SO4	ALL	49	2.25	1.51	0.05	-32.93	53.56	-0.74	1.21	1.65	-24.14	-47.32	-0.49	52.77	66.91	0.8	1.48	0
CASTNET Monitoring Station: ARE128																		
NH4	WIN	8	1.35	1.09	0.4	-18.87	38.86	-0.25	0.52	0.27	-19.28	-32.7	-0.23	42.05	50.23	0.48	0.58	0.16
NH4	SPR	12	1.17	1.08	0.3	-7.81	64.69	-0.09	0.76	0.78	11.76	-16.33	-0.08	69.09	66.89	0.7	0.89	0.09
NH4	SUM	9	1.36	0.91	0.45	-33.34	58.02	-0.45	0.79	0.57	-36.96	-62.31	-0.5	58.11	76.65	0.87	0.88	0.2
NH4	FAL	12	0.87	1.11	0.31	26.9	77.67	0.23	0.68	0.56	48.34	6.39	0.27	92.13	72	0.78	0.78	0.1
NH4	ALL	41	1.16	1.05	0.01	-9.24	59.98	-0.11	0.7	0.63	5.71	-22.97	-0.1	68.15	67.28	0.66	0.8	0
NO3	WIN	8	2.5	2.42	0.18	-3.05	52.4	-0.08	1.31	2.37	2.74	-21.9	-0.03	58.96	61.82	0.54	1.54	0.03
NO3	SPR	12	1.2	1.9	0.25	58.11	124.03	0.7	1.49	5.41	199.05	5.43	0.58	246.34	78.94	1.24	2.43	0.06
NO3	SUM	9	0.26	0.64	0.17	148.95	246.77	0.38	0.63	2	217.87	-44.31	1.49	308.65	95.14	2.47	1.47	0.03
NO3	FAL	12	1.16	1.63	0.28	40.87	84.97	0.47	0.99	1.47	128.68	15.35	0.41	168.31	68.03	0.85	1.3	0.08
NO3	ALL	41	1.24	1.65	0.24	33.39	90.65	0.41	1.12	2.99	144.28	-7.92	0.33	200.62	75.96	0.91	1.78	0.06
SO4	WIN	8	2.1	1.2	0.29	-43.18	46.8	-0.91	0.98	0.24	-43.1	-60.15	-0.76	47.15	63.9	0.82	1.03	0.08
SO4	SPR	12	2.69	1.53	0.06	-43.04	55.01	-1.16	1.48	1.52	-33.02	-54.86	-0.76	54.74	68.15	0.97	1.69	0
SO4	SUM	9	3.77	1.99	0.61	-47.08	49.25	-1.77	1.86	1.22	-48.69	-72.05	-0.89	50.53	73.81	0.93	2.09	0.37
SO4	FAL	12	1.86	1.85	0.07	-0.61	59.36	-0.01	1.1	2.52	8.13	-17.12	-0.01	57.96	57.71	0.6	1.59	0
SO4	ALL	41	2.57	1.66	0.24	-35.38	52.77	-0.91	1.36	1.91	-26.38	-48.62	-0.55	53.28	65.51	0.82	1.66	0.06

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: ASH135																		
NH4	WIN	11	0.4	0.4	0.09	-2.12	56.5	-0.01	0.23	0.15	16.01	-18.83	-0.02	66.95	49.39	0.58	0.38	0.01
NH4	SPR	14	0.28	0.36	0.1	28.75	51.11	0.08	0.14	0.03	39.78	17.92	0.29	59.55	42	0.51	0.2	0.01
NH4	SUM	13	0.29	0.24	0.14	-18.76	60.04	-0.05	0.18	0.04	-11.23	-33.8	-0.23	57.54	63.76	0.74	0.21	0.02
NH4	FAL	13	0.37	0.34	0.26	-8.03	53.59	-0.03	0.2	0.06	-2.37	-23.49	-0.09	56.25	61.63	0.58	0.24	0.07
NH4	ALL	51	0.33	0.33	0.15	-0.51	55.23	0	0.18	0.07	10.9	-13.75	-0.01	59.79	54.14	0.56	0.26	0.02
NO3	WIN	11	0.37	0.65	0.07	78.74	118.61	0.29	0.43	0.8	138.24	-0.64	0.79	183.41	67.11	1.19	0.94	0.01
NO3	SPR	14	0.16	0.19	0.56	15.8	56.68	0.03	0.09	0.01	18.75	-17.21	0.16	69.61	68.04	0.57	0.12	0.31
NO3	SUM	13	0.08	0.02	0.34	-78.77	78.77	-0.06	0.06	0	-80.05	-142.83	-3.71	80.05	142.83	3.71	0.07	0.12
NO3	FAL	13	0.23	0.24	0.77	0.38	86.48	0	0.2	0.06	-12.99	-68.19	0	88.37	113.52	0.86	0.25	0.59
NO3	ALL	51	0.2	0.26	0.42	26.08	91.53	0.05	0.19	0.21	11.25	-58.65	0.26	101.6	98.5	0.92	0.46	0.18
SO4	WIN	11	1.04	0.65	0.04	-37.33	50.02	-0.39	0.52	0.28	-26.84	-43.01	-0.6	44.01	54.68	0.8	0.66	0
SO4	SPR	14	0.86	1	0.09	17.02	40.81	0.15	0.35	0.22	27.01	11.41	0.17	47.49	37.52	0.41	0.49	0.01
SO4	SUM	13	0.82	0.74	0.06	-9.96	64.43	-0.08	0.53	0.38	-2.99	-25.96	-0.11	60.71	64.03	0.72	0.62	0
SO4	FAL	13	0.98	0.97	0.1	-1.58	54.6	-0.02	0.54	0.55	10.24	-14.45	-0.02	60.3	54.49	0.55	0.74	0.01
SO4	ALL	51	0.92	0.85	0	-7.44	52.2	-0.07	0.48	0.39	3.47	-16.45	-0.08	53.38	52.3	0.56	0.63	0
CASTNET Monitoring Station: BBE401																		
NH4	WIN	11	0.49	0.24	0.16	-50.9	58.94	-0.25	0.29	0.08	-43.14	-67.45	-1.04	50.58	73.85	1.2	0.37	0.02
NH4	SPR	14	0.65	0.27	0.35	-58.91	60.01	-0.39	0.39	0.05	-57.39	-85.73	-1.43	58.5	86.8	1.46	0.44	0.12
NH4	SUM	13	0.62	0.27	0.3	-56.68	56.68	-0.35	0.35	0.03	-55.85	-82.2	-1.31	55.85	82.2	1.31	0.39	0.09
NH4	FAL	13	0.6	0.26	0.42	-56.91	58.16	-0.34	0.35	0.03	-58.07	-90.12	-1.32	59.28	91.28	1.35	0.39	0.17
NH4	ALL	51	0.6	0.26	0.29	-56.39	58.46	-0.34	0.35	0.05	-54.1	-82	-1.29	56.32	83.98	1.34	0.4	0.09
NO3	WIN	11	0.48	0.02	0.25	-95.22	95.22	-0.46	0.46	0.11	-92.87	-176.63	-19.94	92.87	176.63	19.94	0.56	0.06
NO3	SPR	14	0.8	0.02	0.07	-97.04	97.04	-0.77	0.77	0.06	-96.82	-187.76	-32.73	96.82	187.76	32.73	0.81	0.01
NO3	SUM	13	0.63	0.01	0.22	-98.98	98.98	-0.63	0.63	0.04	-98.97	-195.93	-97.4	98.97	195.93	97.4	0.66	0.05
NO3	FAL	13	0.57	0.01	0.54	-97.93	97.93	-0.56	0.56	0.06	-97.87	-191.7	-47.35	97.87	191.7	47.35	0.61	0.3
NO3	ALL	51	0.63	0.02	0.01	-97.45	97.45	-0.61	0.61	0.08	-96.78	-188.45	-38.14	96.78	188.45	38.14	0.67	0
SO4	WIN	11	1.39	0.94	0.11	-31.85	70.78	-0.44	0.98	1.87	-22.62	-49.26	-0.47	57.92	69.05	1.04	1.44	0.01
SO4	SPR	14	2.04	1.08	0.54	-47.02	50.11	-0.96	1.02	0.54	-45.38	-65.91	-0.89	48.59	68.8	0.95	1.21	0.29
SO4	SUM	13	1.87	0.89	0.04	-52.31	53.64	-0.98	1.01	0.31	-50.98	-75.65	-1.1	52.48	77.08	1.12	1.13	0
SO4	FAL	13	1.66	0.84	0.43	-49.24	51.78	-0.81	0.86	0.27	-50.14	-75.23	-0.97	52.35	77.37	1.02	0.97	0.19
SO4	ALL	51	1.76	0.94	0.29	-46.41	54.98	-0.82	0.97	0.75	-43.11	-67.18	-0.87	52.56	73.15	1.03	1.19	0.08

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: BEL116																		
NH4	WIN	9	1.05	1.34	0.46	28.36	48.69	0.3	0.51	0.29	31.81	15.42	0.28	54.56	45.07	0.49	0.62	0.22
NH4	SPR	13	0.89	0.79	0.31	-11.13	53.58	-0.1	0.48	0.29	-4.33	-27.29	-0.13	56.89	60.97	0.6	0.54	0.1
NH4	SUM	9	1.24	1.01	0.36	-18.34	41.54	-0.23	0.51	0.24	-17.36	-32.13	-0.22	44.23	54.11	0.51	0.54	0.13
NH4	FAL	13	0.64	0.88	0.18	38.69	89.48	0.25	0.57	0.39	52.09	11.02	0.39	95.85	74.28	0.89	0.67	0.03
NH4	ALL	44	0.92	0.98	0.29	6.32	56.49	0.06	0.52	0.36	17.07	-8.23	0.06	65.33	60.25	0.56	0.6	0.09
NO3	WIN	9	1.57	2.95	0.21	87.51	118.1	1.37	1.85	3.5	221.28	49.16	0.88	247.78	88.34	1.18	2.32	0.05
NO3	SPR	13	0.76	0.79	0.39	4.42	71.12	0.03	0.54	0.54	14.78	-16.36	0.04	67.59	65.79	0.71	0.74	0.16
NO3	SUM	9	0.24	0.14	0.3	-41.36	77.95	-0.1	0.19	0.06	-16.11	-51.61	-0.71	72	85.42	1.33	0.26	0.09
NO3	FAL	13	0.62	1.37	0.06	121.16	167.74	0.75	1.04	1.92	167.05	49.21	1.21	189.88	81.62	1.68	1.57	0
NO3	ALL	44	0.78	1.27	0.37	63.29	113.69	0.49	0.88	1.77	95.69	9.21	0.63	141.48	79.09	1.14	1.42	0.14
SO4	WIN	9	2.1	1.68	0.72	-19.88	24.73	-0.42	0.52	0.29	-20.08	-27.34	-0.25	25.32	32.32	0.31	0.68	0.52
SO4	SPR	13	2.63	1.75	0.27	-33.63	53.1	-0.88	1.4	1.7	-29.1	-49.43	-0.51	52.43	66.61	0.8	1.58	0.07
SO4	SUM	9	3.75	2.87	0.42	-23.59	41.25	-0.89	1.55	1.83	-23.68	-38.72	-0.31	43.46	55.92	0.54	1.62	0.17
SO4	FAL	13	1.73	1.66	0.22	-3.89	49.48	-0.07	0.86	1.33	-2.23	-18.91	-0.04	47.41	49.92	0.51	1.16	0.05
SO4	ALL	44	2.49	1.94	0.47	-22.03	43.79	-0.55	1.09	1.46	-18.21	-33.7	-0.28	43.57	52.48	0.56	1.33	0.22
CASTNET Monitoring Station: BFT142																		
NH4	WIN	10	0.7	0.47	0.21	-32.21	46.53	-0.23	0.33	0.12	-22.61	-45.57	-0.48	45.93	63.26	0.69	0.41	0.04
NH4	SPR	13	0.7	0.51	0.28	-26.13	55.51	-0.18	0.39	0.17	-11.98	-46.13	-0.35	66.61	81.16	0.75	0.45	0.08
NH4	SUM	11	0.55	0.5	0.33	-8.54	56.15	-0.05	0.31	0.15	-5.51	-38.15	-0.09	63	77.32	0.61	0.4	0.11
NH4	FAL	10	0.41	0.48	0.2	16.78	105.69	0.07	0.43	0.33	23.97	-46.41	0.17	110.73	110.89	1.06	0.58	0.04
NH4	ALL	44	0.6	0.49	0.22	-16.99	61.09	-0.1	0.36	0.2	-4.61	-44.07	-0.2	71.04	82.89	0.74	0.46	0.05
NO3	WIN	10	1.27	0.62	0.07	-51.36	51.36	-0.65	0.65	0.2	-50.41	-80.11	-1.06	50.41	80.11	1.06	0.79	0.01
NO3	SPR	13	1.22	0.56	0.58	-53.76	54.68	-0.65	0.66	0.15	-54.68	-85.87	-1.16	55.9	87.04	1.18	0.76	0.34
NO3	SUM	11	0.76	0.26	0.48	-65.94	81.89	-0.5	0.62	0.23	-45.18	-102.3	-1.94	83.83	127.32	2.4	0.69	0.23
NO3	FAL	10	0.78	0.44	0.43	-43.81	64.73	-0.34	0.51	0.22	-23.63	-56.73	-0.78	66.7	87.15	1.15	0.59	0.18
NO3	ALL	44	1.02	0.47	0.3	-53.62	60.6	-0.55	0.62	0.21	-44.28	-82.05	-1.16	64.09	95.56	1.31	0.71	0.09
SO4	WIN	10	2.08	1.23	0.29	-41.09	41.09	-0.86	0.86	0.31	-40.23	-54.65	-0.7	40.23	54.65	0.7	1.02	0.09
SO4	SPR	13	2.82	1.91	0.41	-32.16	37.94	-0.91	1.07	0.73	-31.32	-46.08	-0.47	38.06	51.87	0.56	1.24	0.17
SO4	SUM	11	3.28	1.93	0.29	-41.24	46.53	-1.35	1.53	1.35	-40.82	-62.28	-0.7	46.65	67.62	0.79	1.79	0.08
SO4	FAL	10	1.57	1.58	0.41	0.56	61.08	0.01	0.96	1.61	-2.25	-26.28	0.01	57.46	62.35	0.61	1.27	0.17
SO4	ALL	44	2.48	1.68	0.36	-32.17	44.7	-0.8	1.11	1.22	-29.11	-47.58	-0.47	45.11	58.82	0.66	1.36	0.13

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: BVL130																		
NH4	WIN	11	2.04	1.33	0.39	-34.63	45.03	-0.71	0.92	0.69	-23.91	-38.91	-0.53	45.99	52.65	0.69	1.09	0.15
NH4	SPR	12	1.14	1.6	0.21	41.22	69.08	0.47	0.78	1.3	43.98	9.5	0.41	73.17	51.11	0.69	1.23	0.04
NH4	SUM	12	1.24	0.79	0.05	-36.61	52.35	-0.45	0.65	0.4	-28.14	-49	-0.58	51.26	64.63	0.83	0.78	0
NH4	FAL	13	0.94	1.15	0.26	22.42	76.75	0.21	0.72	0.75	52.48	11.58	0.22	89.02	67.14	0.77	0.89	0.07
NH4	ALL	48	1.32	1.21	0.1	-7.72	58.07	-0.1	0.76	1.01	12.69	-15.66	-0.08	65.76	59.18	0.63	1.01	0.01
NO3	WIN	11	4.68	3.48	0.11	-25.6	41.82	-1.2	1.96	7.12	-5.96	-25.93	-0.34	46.84	45.18	0.56	2.93	0.01
NO3	SPR	12	1.67	2.84	0.46	69.93	105.6	1.17	1.76	5.85	71.43	8.23	0.7	112.46	73.92	1.06	2.69	0.21
NO3	SUM	12	0.71	0.2	0.48	-71.66	71.66	-0.51	0.51	0.06	-70.14	-111.04	-2.53	70.14	111.04	2.53	0.56	0.23
NO3	FAL	13	1.63	2.11	0.21	29.49	77.94	0.48	1.27	2	54.16	3.31	0.29	101.69	80.19	0.78	1.5	0.04
NO3	ALL	48	2.11	2.13	0.44	1	64.52	0.02	1.36	4.45	13.62	-30.75	0.01	83.93	78.31	0.65	2.11	0.2
SO4	WIN	11	2.47	1.13	0.76	-54.14	54.61	-1.34	1.35	0.6	-50.74	-72.09	-1.18	51.69	73.03	1.19	1.55	0.57
SO4	SPR	12	2.43	2.2	0.06	-9.57	54.39	-0.23	1.32	2.66	-3.43	-25.41	-0.11	57.42	55.82	0.6	1.65	0
SO4	SUM	12	3.91	2.25	0.01	-42.5	54.83	-1.66	2.14	3.76	-36.51	-59.41	-0.74	52.42	71.87	0.95	2.55	0
SO4	FAL	13	2.04	1.62	0.02	-20.7	59.91	-0.42	1.22	2.68	-14.09	-38.07	-0.26	55.47	61.28	0.76	1.69	0
SO4	ALL	48	2.7	1.81	0.15	-33.09	55.72	-0.9	1.51	2.83	-25.43	-48.04	-0.49	54.33	65.26	0.83	1.91	0.02
CASTNET Monitoring Station: BWR139																		
NH4	WIN	9	1.2	1.13	0.18	-5.72	41.84	-0.07	0.5	0.33	7.25	-8.4	-0.06	47.85	49.77	0.44	0.57	0.03
NH4	SPR	13	0.85	0.97	0.27	14.08	52.61	0.12	0.45	0.26	23.55	-0.29	0.14	63.28	52.47	0.53	0.53	0.07
NH4	SUM	12	1.24	0.92	0.71	-26.1	38.61	-0.32	0.48	0.2	-21.85	-34.5	-0.35	42.35	48.93	0.52	0.55	0.5
NH4	FAL	11	0.66	0.95	0.03	44.49	81.7	0.29	0.54	0.57	57.05	5.19	0.44	96.08	70.08	0.82	0.81	0
NH4	ALL	45	0.98	0.98	0.29	0.61	50.01	0.01	0.49	0.39	16.37	-9.7	0.01	62.63	55.29	0.5	0.62	0.08
NO3	WIN	9	1.88	2.44	0.33	29.67	78.68	0.56	1.48	2.97	92.57	14.59	0.3	133.87	70.22	0.79	1.81	0.11
NO3	SPR	13	1.03	1.3	0.24	25.9	73.47	0.27	0.76	0.86	39.96	-1.81	0.26	86.51	70.96	0.73	0.97	0.06
NO3	SUM	12	0.42	0.1	0.25	-75.99	87.66	-0.32	0.37	0.08	-11.73	-101.94	-3.16	120.74	136.53	3.65	0.43	0.06
NO3	FAL	11	0.89	1.95	0	119.95	166.05	1.06	1.47	4.44	141.15	21.88	1.2	186.53	82.79	1.66	2.36	0
NO3	ALL	45	1	1.37	0.31	36.16	97	0.36	0.97	2.2	61.43	-19.44	0.36	129.56	91.19	0.97	1.53	0.1
SO4	WIN	9	2.19	1.38	0.59	-36.97	39.03	-0.81	0.85	0.38	-33.03	-42.43	-0.59	35.9	45.12	0.62	1.02	0.35
SO4	SPR	13	2.54	1.97	0.21	-22.31	46.61	-0.57	1.18	1.29	-17.74	-33.14	-0.29	47.66	56.07	0.6	1.27	0.04
SO4	SUM	12	3.79	2.87	0.73	-24.38	39.66	-0.92	1.5	1.82	-23.68	-37.75	-0.32	45	52.89	0.52	1.63	0.54
SO4	FAL	11	1.82	1.7	0.35	-6.46	33.19	-0.12	0.6	0.43	-4.25	-11.58	-0.07	33.61	36.19	0.35	0.67	0.13
SO4	ALL	45	2.63	2.03	0.67	-22.86	40.39	-0.6	1.06	1.13	-19.08	-30.96	-0.3	41.16	48.17	0.52	1.22	0.45

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: CAD150																		
NH4	WIN	10	1.02	0.9	0.61	-11.54	35.84	-0.12	0.37	0.17	-5.82	-16.16	-0.13	39.62	43.02	0.41	0.43	0.37
NH4	SPR	13	0.79	0.55	0.41	-30.57	40.8	-0.24	0.32	0.09	-24.68	-39.77	-0.44	40.13	53.39	0.59	0.39	0.17
NH4	SUM	13	0.84	0.47	0.72	-43.77	43.77	-0.37	0.37	0.03	-45.23	-63.16	-0.78	45.23	63.16	0.78	0.41	0.51
NH4	FAL	13	0.52	0.51	0.59	-2.87	41.04	-0.02	0.22	0.07	-4.14	-16.9	-0.03	40.08	46.46	0.42	0.26	0.35
NH4	ALL	49	0.78	0.59	0.58	-24.32	40.37	-0.19	0.31	0.1	-20.83	-35.09	-0.32	41.36	52.03	0.53	0.37	0.34
NO3	WIN	10	1.25	1.59	0.65	27.05	57.68	0.34	0.72	0.63	80.32	21.59	0.27	109.65	56.8	0.58	0.86	0.43
NO3	SPR	13	0.59	0.28	0.34	-52.71	75.77	-0.31	0.44	0.28	-38.45	-85.18	-1.11	75.93	107.65	1.6	0.62	0.11
NO3	SUM	13	0.22	0.04	0.27	-82.36	84.21	-0.18	0.18	0.05	-63.74	-109.88	-4.67	69.72	114.89	4.77	0.29	0.07
NO3	FAL	13	0.41	0.37	0.67	-9.15	58.84	-0.04	0.24	0.09	-14.08	-42.63	-0.1	62.58	72.91	0.65	0.31	0.45
NO3	ALL	49	0.58	0.51	0.73	-12.19	65.42	-0.07	0.38	0.3	-14.46	-58.65	-0.14	77.62	89.98	0.74	0.55	0.53
SO4	WIN	10	2.08	1.37	0.33	-34.34	41.16	-0.71	0.86	0.61	-32.54	-46.33	-0.52	38.23	51.6	0.63	1.06	0.11
SO4	SPR	13	2.87	1.5	0.02	-47.75	47.95	-1.37	1.38	0.59	-45.8	-64.76	-0.91	46.07	65.03	0.92	1.57	0
SO4	SUM	13	2.87	1.38	0.67	-51.98	51.98	-1.49	1.49	0.29	-52.73	-76.15	-1.08	52.73	76.15	1.08	1.59	0.44
SO4	FAL	13	1.68	1.4	0.66	-16.41	36.22	-0.28	0.61	0.38	-18.63	-27.88	-0.2	35.95	42.72	0.43	0.67	0.44
SO4	ALL	49	2.39	1.41	0.33	-40.89	45.85	-0.98	1.1	0.71	-37.72	-54.24	-0.69	43.55	59.32	0.78	1.29	0.11
CASTNET Monitoring Station: CAT175																		
NH4	WIN	2	0.73	0.73	1	0.68	66.79	0	0.49	0.24	-1.64	-27.49	0.01	66.85	76.66	0.67	0.49	1
NH4	SPR	9	0.57	0.57	0.16	-0.33	47.55	0	0.27	0.13	5.17	-13	0	47.68	49.39	0.48	0.36	0.03
NH4	SUM	13	0.87	0.41	0.05	-52.6	64.46	-0.46	0.56	0.2	-49.14	-84.41	-1.11	61.5	94.73	1.36	0.64	0
NH4	FAL	12	0.6	0.53	0.47	-10.93	42.67	-0.07	0.25	0.11	-13.47	-29.15	-0.12	40.81	49.84	0.48	0.34	0.22
NH4	ALL	36	0.7	0.51	0.06	-26.94	54.92	-0.19	0.38	0.2	-21.03	-44.98	-0.37	51.44	67.43	0.75	0.48	0
NO3	WIN	2	1.06	1.42	1	33.41	87.78	0.36	0.93	0.87	29.12	-3.47	0.33	86.33	76.67	0.88	1	1
NO3	SPR	9	0.49	0.39	0.36	-19.84	59.54	-0.1	0.29	0.14	-15.83	-46.16	-0.25	57.76	79.95	0.74	0.39	0.13
NO3	SUM	13	0.13	0.02	0.24	-81.31	81.44	-0.1	0.1	0	-78.15	-137.68	-4.35	78.37	137.91	4.36	0.12	0.06
NO3	FAL	12	0.6	0.4	0.5	-32.32	59.67	-0.19	0.36	0.18	-26.12	-59.61	-0.48	60.98	84.2	0.88	0.46	0.25
NO3	ALL	36	0.42	0.32	0.63	-24.83	65.86	-0.11	0.28	0.16	-39.26	-81.32	-0.33	67.86	102.11	0.88	0.41	0.4
SO4	WIN	2	1.33	1.45	1	9.34	91.23	0.12	1.21	1.46	15.99	-26.66	0.09	92.38	96.94	0.91	1.22	1
SO4	SPR	9	1.54	1.67	0.06	7.85	51.39	0.12	0.79	1.29	17.28	-0.69	0.08	48.19	42.64	0.51	1.14	0
SO4	SUM	13	2.36	1.39	0.08	-41.11	66.56	-0.97	1.57	2.29	-35.75	-69.41	-0.7	62.81	89.97	1.13	1.8	0.01
SO4	FAL	12	1.42	1.72	0.36	21.22	64.23	0.3	0.91	1.54	18.87	-4.26	0.21	59.1	52.2	0.64	1.28	0.13
SO4	ALL	36	1.78	1.57	0.04	-11.92	63.68	-0.21	1.14	2.07	-1.41	-28.14	-0.14	59.56	65.93	0.72	1.46	0

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: CDR119																		
NH4	WIN	8	0.83	0.4	0.28	-51.27	51.27	-0.42	0.42	0.08	-45.73	-69.03	-1.05	45.73	69.03	1.05	0.51	0.08
NH4	SPR	13	0.86	0.44	0.46	-48.92	48.92	-0.42	0.42	0.06	-47.37	-69.04	-0.96	47.37	69.04	0.96	0.49	0.21
NH4	SUM	13	1.6	0.69	0.41	-57.03	57.03	-0.91	0.91	0.19	-55.76	-80.66	-1.33	55.76	80.66	1.33	1.01	0.17
NH4	FAL	13	0.6	0.52	0.09	-12.73	56.02	-0.08	0.34	0.19	-5.74	-26.24	-0.15	51.78	60.11	0.64	0.44	0.01
NH4	ALL	47	0.99	0.53	0.38	-46.8	54.09	-0.46	0.53	0.23	-37.9	-60.41	-0.88	50.63	69.78	1.02	0.67	0.14
NO3	WIN	8	0.7	0.33	0.71	-52.92	58.43	-0.37	0.41	0.13	-33.44	-60.51	-1.12	52.42	74.27	1.24	0.52	0.5
NO3	SPR	13	0.18	0.17	0.53	-9.49	62.93	-0.02	0.12	0.04	-16.91	-40.93	-0.1	54.06	61.77	0.7	0.2	0.28
NO3	SUM	13	0.06	0.06	0.15	3.03	57.46	0	0.04	0	6.56	-15.57	0.03	55.67	53.68	0.57	0.05	0.02
NO3	FAL	13	0.2	0.29	0.12	47.83	151.99	0.09	0.3	0.4	133.4	-55.32	0.48	232.66	104.88	1.52	0.64	0.01
NO3	ALL	47	0.24	0.2	0.28	-17.09	80.36	-0.04	0.19	0.17	28.34	-41.23	-0.21	103.63	73.58	0.97	0.41	0.08
SO4	WIN	8	2.1	1.15	0.14	-45.18	45.43	-0.95	0.96	0.88	-40.04	-59.47	-0.82	40.28	59.71	0.83	1.33	0.02
SO4	SPR	13	2.57	1.42	0.71	-44.58	44.58	-1.15	1.15	0.31	-45.09	-63.47	-0.8	45.09	63.47	0.8	1.27	0.51
SO4	SUM	13	4.98	3.39	0.36	-31.89	48.4	-1.59	2.41	5.15	-31.92	-48.15	-0.47	47.29	60.1	0.71	2.77	0.13
SO4	FAL	13	1.73	1.79	0	3.73	51.46	0.06	0.89	1.73	10.86	-6.52	0.04	46.03	46.58	0.51	1.32	0
SO4	ALL	47	2.92	2.02	0.54	-30.79	47.61	-0.9	1.39	2.54	-25.11	-42.8	-0.44	45.14	57.22	0.69	1.83	0.3
CASTNET Monitoring Station: CDZ171																		
NH4	WIN	11	1.53	1	0.67	-34.55	36.47	-0.53	0.56	0.25	-29.91	-41.36	-0.53	33.03	44.3	0.56	0.73	0.45
NH4	SPR	13	1.14	0.9	0.17	-20.64	59.59	-0.23	0.68	0.61	-16.69	-39.77	-0.26	58.16	68.96	0.75	0.81	0.03
NH4	SUM	8	1.33	0.97	0.6	-27.47	49.11	-0.37	0.66	0.39	-21.22	-52.08	-0.38	66.16	76.07	0.68	0.72	0.36
NH4	FAL	9	0.54	0.5	0.6	-6.62	38.56	-0.04	0.21	0.07	-5.77	-15.19	-0.07	35.93	39.03	0.41	0.27	0.36
NH4	ALL	41	1.15	0.85	0.51	-25.71	46.81	-0.3	0.54	0.38	-18.72	-37.2	-0.35	48.1	57.16	0.63	0.68	0.26
NO3	WIN	11	2.61	1.85	0.55	-29.15	45.12	-0.76	1.18	1.93	-11.92	-28.39	-0.41	47.76	54.88	0.64	1.58	0.31
NO3	SPR	13	0.84	1.21	0.01	43.77	154.6	0.37	1.3	4.16	64.17	-38.46	0.44	150.11	108.69	1.55	2.07	0
NO3	SUM	8	0.3	0.16	0.13	-46.27	70.51	-0.14	0.21	0.06	-17.06	-60.34	-0.86	70.53	94.87	1.31	0.27	0.02
NO3	FAL	9	0.65	0.55	0.45	-15.47	50.35	-0.1	0.33	0.16	-4.17	-29.5	-0.18	52.25	68.87	0.6	0.41	0.2
NO3	ALL	41	1.17	1.03	0.43	-11.63	72.08	-0.14	0.84	2.07	12.9	-38.06	-0.13	85.64	82.82	0.82	1.44	0.18
SO4	WIN	11	2.48	1.53	0.5	-38.42	44.17	-0.95	1.1	0.48	-34.76	-49.79	-0.62	45.41	58.02	0.72	1.18	0.25
SO4	SPR	13	3.01	1.67	0.43	-44.52	45.86	-1.34	1.38	0.8	-43.28	-60.3	-0.8	45.03	61.96	0.83	1.61	0.18
SO4	SUM	8	4.04	2.84	0.65	-29.82	48.72	-1.21	1.97	3.02	-27.52	-54.56	-0.42	59.94	75.52	0.69	2.11	0.42
SO4	FAL	9	1.5	1.08	0.48	-27.9	40.1	-0.42	0.6	0.42	-24.25	-40.81	-0.39	43.98	55.87	0.56	0.77	0.23
SO4	ALL	41	2.74	1.73	0.65	-36.8	45.58	-1.01	1.25	1.18	-33.74	-52.08	-0.58	47.81	62.21	0.72	1.48	0.43

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: CHE185																		
NH4	WIN	11	1.6	1.38	0.48	-13.49	42.28	-0.22	0.68	0.67	-4.07	-20.58	-0.16	45.55	51.4	0.49	0.84	0.23
NH4	SPR	13	1.08	0.81	0.52	-24.83	33.9	-0.27	0.37	0.16	-17.91	-29.29	-0.33	34.22	43.24	0.45	0.48	0.27
NH4	SUM	12	0.9	0.46	0.61	-48.43	48.43	-0.44	0.44	0.05	-49.29	-71.96	-0.94	49.29	71.96	0.94	0.49	0.37
NH4	FAL	13	0.62	0.58	0.45	-7.43	37	-0.05	0.23	0.07	-0.61	-10.41	-0.08	37.76	40.07	0.4	0.27	0.2
NH4	ALL	49	1.03	0.79	0.64	-23.14	40.42	-0.24	0.42	0.24	-17.9	-32.78	-0.3	41.39	51.26	0.53	0.55	0.41
NO3	WIN	11	3.35	2.83	0.59	-15.44	41.38	-0.52	1.39	2.59	-4.94	-21.95	-0.18	48.33	52.82	0.49	1.69	0.35
NO3	SPR	13	1.16	0.89	0.25	-23.86	64.39	-0.28	0.75	1.11	17.69	-41.32	-0.31	91.21	80.4	0.85	1.09	0.06
NO3	SUM	12	0.49	0.04	0.28	-90.89	90.89	-0.45	0.45	0.06	-88.72	-160.65	-9.98	88.72	160.65	9.98	0.51	0.08
NO3	FAL	13	0.91	0.51	0.89	-44.44	44.44	-0.41	0.41	0.07	-51.72	-81.25	-0.8	51.72	81.25	0.8	0.48	0.79
NO3	ALL	49	1.42	1.02	0.78	-28.56	51.07	-0.41	0.73	0.92	-31.86	-76.79	-0.4	70.5	94.09	0.71	1.04	0.61
SO4	WIN	11	2.28	1.63	0.36	-28.31	47.36	-0.65	1.08	1.68	-26.84	-46.72	-0.39	45.44	59.03	0.66	1.45	0.13
SO4	SPR	13	3.02	1.69	0.01	-43.94	50.6	-1.33	1.53	1.2	-39.21	-58.46	-0.78	48.31	66.35	0.9	1.72	0
SO4	SUM	12	2.66	1.32	0.61	-50.34	50.34	-1.34	1.34	0.35	-50.81	-73.99	-1.01	50.81	73.99	1.01	1.47	0.38
SO4	FAL	13	1.62	1.31	0.18	-19.33	41.34	-0.31	0.67	0.48	-16.33	-29.43	-0.24	41.16	50.52	0.51	0.76	0.03
SO4	ALL	49	2.39	1.49	0.29	-37.92	48.18	-0.91	1.15	1.11	-33.2	-51.92	-0.61	46.38	62.38	0.78	1.39	0.09
CASTNET Monitoring Station: CKT136																		
NH4	WIN	10	1.14	0.63	0.43	-45.02	47.43	-0.51	0.54	0.23	-38.15	-56.56	-0.82	42.64	60.6	0.86	0.7	0.19
NH4	SPR	10	0.88	0.59	0.19	-33.28	44.53	-0.29	0.39	0.11	-27.8	-43.57	-0.5	42.56	55.47	0.67	0.45	0.04
NH4	SUM	10	1.44	0.87	0.73	-39.64	39.64	-0.57	0.57	0.1	-40.33	-53.79	-0.66	40.33	53.79	0.66	0.65	0.53
NH4	FAL	10	0.56	0.54	0.48	-4.37	44.74	-0.02	0.25	0.08	-4.34	-18.53	-0.05	42.16	49.37	0.47	0.29	0.23
NH4	ALL	40	1.01	0.65	0.55	-34.87	43.63	-0.35	0.44	0.18	-27.65	-43.11	-0.54	41.92	54.8	0.67	0.55	0.3
NO3	WIN	10	0.97	0.55	0.65	-43.17	48.94	-0.42	0.47	0.25	-38.54	-57.68	-0.76	46.41	64.72	0.86	0.65	0.42
NO3	SPR	10	0.3	0.36	0.47	20.22	91.96	0.06	0.27	0.12	20.29	-31.69	0.2	97.77	91.7	0.92	0.36	0.22
NO3	SUM	10	0.15	0.06	0.68	-56.4	70.86	-0.08	0.1	0.01	-25.98	-60.4	-1.29	63.65	85.33	1.63	0.14	0.46
NO3	FAL	10	0.5	0.45	0.41	-10.05	84.19	-0.05	0.42	0.28	-22.08	-70.7	-0.11	83.63	106.29	0.94	0.53	0.16
NO3	ALL	40	0.48	0.35	0.52	-25.77	66.45	-0.12	0.32	0.2	-16.58	-55.12	-0.35	72.86	87.01	0.9	0.46	0.27
SO4	WIN	10	2.72	1.58	0.41	-42.02	44.88	-1.14	1.22	1.24	-37.65	-54.52	-0.72	40.16	56.88	0.77	1.59	0.17
SO4	SPR	10	2.82	1.53	0.11	-45.98	48.02	-1.3	1.36	0.96	-40.35	-59.63	-0.85	43.61	62.75	0.89	1.63	0.01
SO4	SUM	10	4.96	3.58	0.79	-27.85	32.77	-1.38	1.63	1.66	-30.26	-39.48	-0.39	33.74	42.69	0.45	1.89	0.62
SO4	FAL	10	1.64	1.35	0.25	-18.04	38.76	-0.3	0.64	0.62	-17.54	-32.42	-0.22	38.03	47.81	0.47	0.84	0.06
SO4	ALL	40	3.04	2.01	0.74	-33.91	39.83	-1.03	1.21	1.31	-31.45	-46.51	-0.51	38.89	52.53	0.6	1.54	0.55

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: CND125																		
NH4	WIN	11	1.06	1.02	0.51	-3.99	30.08	-0.04	0.32	0.17	2.31	-4.1	-0.04	31.24	31.11	0.31	0.42	0.26
NH4	SPR	14	0.9	0.64	0.23	-28.43	45.91	-0.26	0.41	0.18	-23.32	-39.69	-0.4	43.7	56.47	0.64	0.49	0.05
NH4	SUM	12	1.27	0.89	0.26	-30.2	32.69	-0.38	0.42	0.16	-25.98	-36.36	-0.43	29.84	39.97	0.47	0.56	0.07
NH4	FAL	12	0.61	0.84	0.32	39.54	85.75	0.24	0.52	0.41	60.37	9.23	0.4	100.16	69.95	0.86	0.68	0.1
NH4	ALL	49	0.95	0.84	0.21	-12.35	43.84	-0.12	0.42	0.28	2.28	-18.9	-0.14	51.33	50.04	0.5	0.55	0.05
NO3	WIN	11	1.45	1.93	0.27	33.24	71.39	0.48	1.04	1.34	50.71	21.06	0.33	78.83	57.19	0.71	1.25	0.07
NO3	SPR	14	0.46	0.29	0.34	-35.49	58.39	-0.16	0.27	0.09	-11.36	-37.55	-0.55	57.78	64.4	0.91	0.34	0.12
NO3	SUM	12	0.17	0.09	0.08	-47.17	64.93	-0.08	0.11	0.03	-6	-30.2	-0.89	51.5	61.85	1.23	0.2	0.01
NO3	FAL	12	0.49	1.15	0.11	133.85	183.24	0.66	0.9	1.69	188.32	26.8	1.34	232.02	88.34	1.83	1.46	0.01
NO3	ALL	49	0.62	0.82	0.54	32.95	90.04	0.2	0.56	0.87	52.79	-6.83	0.33	103.64	68.02	0.9	0.96	0.29
SO4	WIN	11	2.16	1.79	0.17	-17.1	32.82	-0.37	0.71	0.67	-13.15	-20.04	-0.21	30.54	34.28	0.4	0.9	0.03
SO4	SPR	14	2.83	1.83	0.2	-35.3	42.14	-1	1.19	1	-32.43	-46.82	-0.55	39.87	53.41	0.65	1.42	0.04
SO4	SUM	12	3.82	2.42	0.39	-36.71	38.27	-1.4	1.46	1.06	-34.24	-46.69	-0.58	36.69	48.97	0.6	1.74	0.15
SO4	FAL	12	1.76	1.82	0.36	3.83	55.39	0.07	0.97	1.42	13.39	-10.71	0.04	59.5	56.29	0.55	1.2	0.13
SO4	ALL	49	2.66	1.96	0.29	-26.15	41.23	-0.7	1.1	1.36	-17.32	-31.93	-0.35	41.81	48.73	0.56	1.36	0.08
CASTNET Monitoring Station: CNT169																		
NH4	WIN	7	0.08	0.12	0.73	56.29	56.29	0.04	0.04	0	72.69	43.95	0.56	72.69	43.95	0.56	0.06	0.53
NH4	SPR	11	0.17	0.11	0.24	-34.25	37.23	-0.06	0.06	0.01	-28.75	-39.66	-0.52	32.55	43.26	0.57	0.09	0.06
NH4	SUM	12	0.22	0.1	0.27	-53.28	53.54	-0.12	0.12	0	-51.94	-77.41	-1.14	52.23	77.7	1.15	0.13	0.07
NH4	FAL	11	0.15	0.13	0.14	-14.46	42.73	-0.02	0.07	0.01	5.75	-8.38	-0.17	47.07	45.05	0.5	0.08	0.02
NH4	ALL	41	0.17	0.12	0.13	-29.4	46.49	-0.05	0.08	0.01	-8.96	-28.04	-0.42	49.06	53.94	0.66	0.1	0.02
NO3	WIN	7	0.04	0.05	0.36	49.3	144.84	0.02	0.05	0.01	112.94	-41.52	0.49	197.96	89.79	1.45	0.1	0.13
NO3	SPR	11	0.16	0.04	0.22	-74.23	79.74	-0.12	0.13	0.01	-64.51	-116.25	-2.88	74.64	124.17	3.09	0.15	0.05
NO3	SUM	12	0.14	0.01	0.5	-92.35	92.35	-0.13	0.13	0	-91.4	-169.21	-12.08	91.4	169.21	12.08	0.13	0.25
NO3	FAL	11	0.1	0.04	0.38	-61.03	91.17	-0.06	0.1	0.01	-21.68	-79.02	-1.57	88.24	112.55	2.34	0.13	0.14
NO3	ALL	41	0.12	0.03	0.27	-70.61	90.22	-0.08	0.11	0.01	-30.59	-109	-2.4	104.25	128.36	3.07	0.13	0.07
SO4	WIN	7	0.21	0.41	0.35	97.79	97.79	0.2	0.2	0.01	116.56	66.52	0.98	116.56	66.52	0.98	0.22	0.13
SO4	SPR	11	0.52	0.37	0.47	-30.04	32.26	-0.16	0.17	0.04	-25.42	-34.59	-0.43	28.74	37.7	0.46	0.25	0.22
SO4	SUM	12	0.53	0.3	0.11	-43.07	44.73	-0.23	0.24	0.02	-42.59	-60.79	-0.76	44.33	62.48	0.79	0.27	0.01
SO4	FAL	11	0.37	0.39	0.38	5.69	43.25	0.02	0.16	0.04	29.31	8.65	0.06	56.86	43.09	0.43	0.2	0.15
SO4	ALL	41	0.43	0.36	0.05	-16.12	44.68	-0.07	0.19	0.05	8.48	-13.39	-0.19	55.84	51.32	0.53	0.24	0

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: COW137																		
NH4	WIN	10	0.47	0.45	0.33	-3.79	33.82	-0.02	0.16	0.04	-1.82	-10.48	-0.04	35.77	36.47	0.35	0.19	0.11
NH4	SPR	14	0.76	0.55	0	-27.75	41.81	-0.21	0.32	0.11	-19.61	-34.19	-0.38	39.81	49.83	0.58	0.4	0
NH4	SUM	13	1.09	0.69	0.19	-36.53	39.14	-0.4	0.43	0.12	-33	-46.16	-0.58	36.56	49.52	0.62	0.53	0.04
NH4	FAL	13	0.5	0.52	0.41	4.31	39.27	0.02	0.19	0.05	11.07	-3.04	0.04	45.3	40.16	0.39	0.23	0.17
NH4	ALL	50	0.72	0.56	0.36	-22.34	39.26	-0.16	0.28	0.11	-11.56	-24.46	-0.29	39.59	44.56	0.51	0.37	0.13
NO3	WIN	10	0.21	0.47	0.15	123.16	152.13	0.26	0.32	0.13	237.25	48.62	1.23	264.76	91.03	1.52	0.45	0.02
NO3	SPR	14	0.26	0.2	0.4	-23.59	72.66	-0.06	0.19	0.05	36.22	-31.1	-0.31	116.45	93.5	0.95	0.22	0.16
NO3	SUM	13	0.07	0.05	0.54	-35.05	51.39	-0.02	0.04	0	-33.93	-56.41	-0.54	54.23	72.04	0.79	0.04	0.29
NO3	FAL	13	0.24	0.33	0.76	33.97	67.42	0.08	0.16	0.04	23.81	-11.49	0.34	78.64	71.99	0.67	0.22	0.57
NO3	ALL	50	0.2	0.25	0.46	25.82	86.24	0.05	0.17	0.06	54.96	-16.64	0.26	120.11	81.84	0.86	0.26	0.22
SO4	WIN	10	1.28	1.43	0.05	11.2	44.9	0.14	0.58	0.77	24.21	6.73	0.11	47.24	34.49	0.45	0.89	0
SO4	SPR	14	2.31	1.76	0.05	-23.91	45.75	-0.55	1.06	1.12	-14.96	-28.86	-0.31	45.65	51.28	0.6	1.19	0
SO4	SUM	13	3.33	2.34	0.53	-29.61	32.68	-0.99	1.09	0.72	-28.05	-37.62	-0.42	32.8	41.86	0.46	1.3	0.28
SO4	FAL	13	1.43	1.51	0.31	5.73	47.88	0.08	0.69	0.66	10.83	-6.22	0.06	52.72	47.72	0.48	0.82	0.1
SO4	ALL	50	2.14	1.78	0.44	-16.86	40.74	-0.36	0.87	1.04	-3.82	-18.13	-0.2	44.47	44.55	0.49	1.08	0.2
CASTNET Monitoring Station: CTH110																		
NH4	WIN	11	0.91	0.72	0.8	-20.37	24.13	-0.18	0.22	0.05	-22.49	-29.57	-0.26	25.15	32.15	0.3	0.29	0.64
NH4	SPR	14	0.78	0.82	0.33	5.07	33.95	0.04	0.26	0.15	8.68	-0.21	0.05	33.17	30	0.34	0.39	0.11
NH4	SUM	12	1.07	0.82	0.05	-23.88	54.22	-0.26	0.58	0.41	-17.56	-42.73	-0.31	54.6	69.83	0.71	0.69	0
NH4	FAL	13	0.64	0.81	0.31	27.1	60.53	0.17	0.39	0.21	38.03	12.51	0.27	67.78	51.02	0.61	0.49	0.09
NH4	ALL	50	0.84	0.8	0.12	-5.46	43.1	-0.05	0.36	0.24	3.16	-13.57	-0.06	45.55	45.5	0.46	0.49	0.02
NO3	WIN	11	1.29	1.48	0.47	14.85	46.42	0.19	0.6	0.58	30.66	4.28	0.15	61.97	50.23	0.46	0.78	0.22
NO3	SPR	14	0.66	0.96	0.19	47.18	100.95	0.31	0.66	0.71	158.32	26.49	0.47	193.46	74.01	1.01	0.9	0.04
NO3	SUM	12	0.2	0.23	0.4	14.07	72.53	0.03	0.15	0.03	31.4	-19.81	0.14	96.89	81.83	0.73	0.19	0.16
NO3	FAL	13	0.58	0.95	0.42	62.77	79.84	0.37	0.47	0.46	95.66	12.27	0.63	129.54	62.94	0.8	0.77	0.18
NO3	ALL	50	0.67	0.9	0.51	34.55	70.9	0.23	0.47	0.47	83.48	6.79	0.35	124.74	67.78	0.71	0.72	0.26
SO4	WIN	11	1.83	0.99	0.52	-46.1	46.1	-0.85	0.85	0.28	-44.84	-61.89	-0.86	44.84	61.89	0.86	1	0.27
SO4	SPR	14	1.93	1.59	0.45	-17.28	42.23	-0.33	0.81	1.1	-16.72	-27.38	-0.21	36.95	42.22	0.51	1.1	0.21
SO4	SUM	12	2.92	2.29	0.02	-21.62	55.68	-0.63	1.62	3.24	-14.45	-39	-0.28	56.05	68.87	0.71	1.91	0
SO4	FAL	13	1.51	1.65	0.03	9.74	50.83	0.15	0.77	1.05	16.74	-1.62	0.1	53.14	45.72	0.51	1.03	0
SO4	ALL	50	2.03	1.64	0.29	-19.28	49.28	-0.39	1	1.56	-13.66	-31.06	-0.24	47.48	53.85	0.61	1.31	0.08

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: CVL151																		
NH4	WIN	10	0.77	0.68	0.74	-12.18	25.05	-0.09	0.19	0.04	-13.07	-18.79	-0.14	25.91	29.96	0.29	0.23	0.54
NH4	SPR	14	0.91	0.65	0.01	-28.54	41.55	-0.26	0.38	0.17	-21.03	-36.63	-0.4	41.18	52.32	0.58	0.49	0
NH4	SUM	12	0.79	0.49	0.71	-38.46	44.75	-0.31	0.35	0.08	-45.04	-73.92	-0.62	50.11	78.4	0.73	0.41	0.51
NH4	FAL	13	0.6	0.56	0.48	-7.66	40.9	-0.05	0.25	0.07	-7.69	-23.17	-0.08	44.55	51.13	0.44	0.27	0.23
NH4	ALL	49	0.77	0.59	0.39	-23.37	38.85	-0.18	0.3	0.11	-21.75	-38.55	-0.3	41.14	53.83	0.51	0.38	0.15
NO3	WIN	10	0.66	1.04	0.59	57.35	81.39	0.38	0.54	0.3	68.31	31.81	0.57	89.89	59.26	0.81	0.67	0.35
NO3	SPR	14	0.68	0.28	0.32	-58.11	61.87	-0.39	0.42	0.09	-56.38	-95.44	-1.39	61.16	99.84	1.48	0.5	0.1
NO3	SUM	12	0.24	0.04	0.06	-83.42	83.42	-0.2	0.2	0.05	-65.64	-111.83	-5.03	65.64	111.83	5.03	0.31	0
NO3	FAL	13	0.45	0.41	0.43	-10.1	64.24	-0.05	0.29	0.12	-12.67	-44.92	-0.11	67.66	80.07	0.71	0.35	0.18
NO3	ALL	49	0.51	0.41	0.49	-19.1	70.14	-0.1	0.36	0.21	-21.6	-60.08	-0.24	69.84	89.25	0.87	0.47	0.24
SO4	WIN	10	1.99	1.33	0.16	-33.37	37.3	-0.67	0.74	0.42	-31.9	-44.72	-0.5	35.69	48.18	0.56	0.93	0.02
SO4	SPR	14	2.96	1.95	0.12	-34.18	41.59	-1.01	1.23	1.34	-31.7	-47.56	-0.52	39.97	55.16	0.63	1.54	0.02
SO4	SUM	12	2.68	1.58	0.6	-41.29	52.15	-1.11	1.4	1.21	-46.69	-77.47	-0.7	55.67	84.54	0.89	1.56	0.36
SO4	FAL	13	1.76	1.44	0.5	-18.13	37.63	-0.32	0.66	0.45	-17.03	-28.34	-0.22	39.92	45.54	0.46	0.74	0.25
SO4	ALL	49	2.38	1.6	0.41	-32.86	43	-0.78	1.02	0.99	-31.52	-49.21	-0.49	42.93	58.38	0.64	1.26	0.17
CASTNET Monitoring Station: DCP114																		
NH4	WIN	11	1.84	1.34	0.21	-27.14	53.89	-0.5	0.99	1.17	-24.08	-45.22	-0.37	54.06	61.65	0.74	1.19	0.04
NH4	SPR	14	1.19	1.55	0.3	30.04	50.94	0.36	0.61	0.51	39.16	17.84	0.3	59.33	42.47	0.51	0.8	0.09
NH4	SUM	13	1.79	0.99	0.01	-44.82	48.78	-0.8	0.87	0.44	-38.61	-57.25	-0.81	44.76	62.98	0.88	1.04	0
NH4	FAL	13	0.93	1.1	0.36	17.72	67.6	0.17	0.63	0.47	30.22	4.31	0.18	69.71	64.26	0.68	0.7	0.13
NH4	ALL	51	1.42	1.24	0.04	-12.12	53.87	-0.17	0.76	0.85	3.42	-18.35	-0.14	57.13	57.39	0.61	0.94	0
NO3	WIN	11	3.42	3.12	0.03	-8.53	63.5	-0.29	2.17	11.96	4.89	-29.55	-0.09	66.45	56.32	0.69	3.47	0
NO3	SPR	14	1.1	2.6	0.64	136.89	140.31	1.5	1.54	1.26	218.89	81.69	1.37	224.23	88	1.4	1.88	0.41
NO3	SUM	13	0.42	0.61	0.32	44.34	83.6	0.19	0.35	0.18	62.18	25.22	0.44	90.61	64.16	0.84	0.46	0.1
NO3	FAL	13	1.05	1.82	0.07	73.09	134.81	0.77	1.42	2.58	130.69	27.07	0.73	169.83	90.73	1.35	1.78	0
NO3	ALL	51	1.41	2.01	0.36	41.94	94.92	0.59	1.34	4.07	110.31	29.38	0.42	142.27	75.79	0.95	2.1	0.13
SO4	WIN	11	2.81	1.26	0.57	-55.04	55.04	-1.55	1.55	0.83	-53.53	-77.02	-1.22	53.53	77.02	1.22	1.79	0.32
SO4	SPR	14	2.74	2.23	0.12	-18.48	44.46	-0.51	1.22	1.65	-13.3	-29.71	-0.23	47.82	52.38	0.55	1.38	0.02
SO4	SUM	13	4.92	2.38	0.03	-51.54	53.78	-2.53	2.64	3.55	-45.44	-68.66	-1.06	48.39	71.48	1.11	3.16	0
SO4	FAL	13	2.14	1.76	0.13	-17.94	48.56	-0.38	1.04	1.47	-14.22	-30.55	-0.22	46.7	55.56	0.59	1.27	0.02
SO4	ALL	51	3.16	1.94	0.24	-38.53	50.9	-1.22	1.61	2.69	-30.4	-50.06	-0.63	48.91	63.37	0.83	2.04	0.06

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: EGB181																		
NH4	WIN	11	1.46	1.24	0.25	-14.62	54.84	-0.21	0.8	0.88	-7.2	-28.17	-0.17	56.11	61.31	0.64	0.96	0.06
NH4	SPR	13	0.7	0.88	0	25.5	81.71	0.18	0.57	1	47.92	-2.19	0.25	90.2	57.85	0.82	1.02	0
NH4	SUM	13	0.71	0.64	0.03	-10.91	83.35	-0.08	0.59	0.49	-2.27	-47.41	-0.12	87.5	91.77	0.94	0.7	0
NH4	FAL	13	0.82	1.5	0.24	83.36	149.15	0.68	1.22	2.14	94.3	1.47	0.83	158.25	105.08	1.49	1.61	0.06
NH4	ALL	50	0.9	1.06	0.19	17.36	88.37	0.16	0.8	1.25	34.8	-18.71	0.17	99.69	79.71	0.88	1.13	0.03
NO3	WIN	11	3.43	2.97	0.23	-13.47	61.33	-0.46	2.1	6.14	-4.49	-34.99	-0.16	66.97	74.35	0.71	2.52	0.05
NO3	SPR	13	1.01	1.47	0.03	44.6	125.72	0.45	1.28	4.97	146.42	-28.71	0.45	226.48	99.44	1.26	2.28	0
NO3	SUM	13	0.36	0.53	0.09	46.12	142.89	0.17	0.51	0.6	57.69	-42.97	0.46	153.79	105.73	1.43	0.79	0.01
NO3	FAL	13	1.47	3.24	0.42	121.11	185.88	1.78	2.73	11.89	160.31	4.36	1.21	226.77	123.01	1.86	3.88	0.18
NO3	ALL	50	1.49	2.01	0.37	34.89	109.62	0.52	1.64	6.55	93.76	-25.2	0.35	172.56	101.69	1.1	2.61	0.14
SO4	WIN	11	1.8	1.09	0.13	-39.55	51.39	-0.71	0.93	0.77	-32.72	-50.84	-0.65	46.52	60.84	0.85	1.13	0.02
SO4	SPR	13	1.6	1.35	0.11	-15.79	45.73	-0.25	0.73	1.22	-10.78	-26.72	-0.19	40.77	43.37	0.54	1.14	0.01
SO4	SUM	13	1.97	1.41	0.12	-28.29	64.97	-0.56	1.28	1.79	-23.66	-55.9	-0.39	67.22	84.45	0.91	1.45	0.01
SO4	FAL	13	1.54	1.64	0.12	6.52	76.75	0.1	1.18	1.94	12.53	-22.64	0.07	77.13	79.93	0.77	1.4	0.01
SO4	ALL	50	1.72	1.38	0.09	-19.79	59.93	-0.34	1.03	1.55	-12.89	-38.55	-0.25	58.36	67.4	0.75	1.29	0.01
CASTNET Monitoring Station: ESP127																		
NH4	WIN	10	0.92	0.83	0.24	-9.53	24.37	-0.09	0.22	0.1	-7.14	-14.15	-0.11	22.87	27.87	0.27	0.32	0.06
NH4	SPR	13	1.03	0.74	0.32	-28.72	38.93	-0.3	0.4	0.14	-22.96	-34.09	-0.4	37.47	45.42	0.55	0.48	0.1
NH4	SUM	13	1.13	0.87	0.48	-23.52	34.98	-0.27	0.4	0.13	-20.29	-31.96	-0.31	38.95	44.7	0.46	0.45	0.23
NH4	FAL	13	0.53	0.63	0.11	18.97	72.99	0.1	0.38	0.17	33.57	-2.01	0.19	80.57	73.79	0.73	0.43	0.01
NH4	ALL	49	0.9	0.76	0.37	-15.62	39.84	-0.14	0.36	0.16	-4.02	-20.94	-0.19	46.32	49.18	0.47	0.43	0.14
NO3	WIN	10	1	1.24	0.3	23.94	64.47	0.24	0.64	0.49	66.94	24.14	0.24	94.99	66.19	0.64	0.74	0.09
NO3	SPR	13	0.36	0.53	0.23	44.88	97.75	0.16	0.35	0.19	101.1	30.6	0.45	134.76	83.2	0.98	0.47	0.05
NO3	SUM	13	0.1	0.1	0.54	-0.26	82.61	0	0.08	0.01	34.22	-15.31	0	98.66	77.52	0.83	0.1	0.29
NO3	FAL	13	0.31	0.54	0.63	75.38	104.56	0.23	0.32	0.12	85.85	24.54	0.75	119.36	68.08	1.05	0.42	0.39
NO3	ALL	49	0.41	0.56	0.63	37.54	81.51	0.15	0.33	0.2	72.34	15.49	0.38	112.98	74.21	0.82	0.47	0.4
SO4	WIN	10	2.14	1.55	0.18	-27.34	30.54	-0.58	0.65	0.43	-24.87	-33.75	-0.38	28.12	36.85	0.42	0.88	0.03
SO4	SPR	13	3.24	1.92	0.44	-40.75	41.94	-1.32	1.36	0.87	-35.69	-48.98	-0.69	37.87	51.08	0.71	1.61	0.19
SO4	SUM	13	3.49	2.96	0.62	-15.34	38.2	-0.54	1.33	2.08	-16.89	-27.56	-0.18	39.31	44.18	0.45	1.54	0.39
SO4	FAL	13	1.72	1.67	0.15	-3.04	59.2	-0.05	1.02	1.72	0.08	-26.86	-0.03	59.34	66.52	0.61	1.31	0.02
SO4	ALL	49	2.68	2.05	0.5	-23.34	41.73	-0.63	1.12	1.54	-19	-34.32	-0.3	41.96	50.44	0.54	1.39	0.25

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: EVE419																		
NH4	WIN	11	0.31	0.24	0.11	-21.29	81.37	-0.07	0.25	0.08	-13.21	-73.01	-0.27	91.18	115.42	1.03	0.3	0.01
NH4	SPR	14	0.39	0.24	0.01	-37.14	57.47	-0.14	0.22	0.05	-30.8	-67.01	-0.59	60.98	88.53	0.91	0.26	0
NH4	SUM	13	0.23	0.03	0.06	-87.95	87.95	-0.2	0.2	0	-87.93	-162.07	-7.3	87.93	162.07	7.3	0.22	0
NH4	FAL	12	0.27	0.09	0.46	-64.71	64.71	-0.17	0.17	0.01	-67.49	-114.56	-1.83	67.49	114.56	1.83	0.2	0.21
NH4	ALL	50	0.3	0.15	0.29	-49.56	70.56	-0.15	0.21	0.04	-50.59	-104.46	-0.98	76.19	119.81	1.4	0.25	0.09
NO3	WIN	11	1.33	0.62	0.07	-53.08	58.32	-0.71	0.77	0.47	-48.55	-90.42	-1.13	58.52	98.49	1.24	0.98	0
NO3	SPR	14	1.37	0.29	0.05	-78.68	78.68	-1.08	1.08	0.26	-78.13	-137.73	-3.69	78.13	137.73	3.69	1.19	0
NO3	SUM	13	0.71	0.31	0.2	-55.88	74.97	-0.4	0.53	0.15	-56.23	-107.64	-1.27	76.16	122.51	1.7	0.56	0.04
NO3	FAL	12	0.89	0.52	0.44	-41.28	62.37	-0.37	0.56	0.29	-39.51	-89.13	-0.7	68.48	111.31	1.06	0.66	0.19
NO3	ALL	50	1.07	0.43	0.17	-60.38	69.26	-0.65	0.74	0.37	-56.66	-107.83	-1.52	70.99	118.8	1.75	0.89	0.03
SO4	WIN	11	2.12	2.01	0.32	-5.02	39.44	-0.11	0.84	1.23	-4.03	-15.72	-0.05	38.46	40.92	0.42	1.12	0.1
SO4	SPR	14	2.8	1.69	0.12	-39.51	42.83	-1.11	1.2	0.67	-38.1	-54.31	-0.65	42.37	58.08	0.71	1.37	0.01
SO4	SUM	13	1.65	0.43	0.81	-73.7	73.7	-1.22	1.22	0.06	-75.43	-123.99	-2.8	75.43	123.99	2.8	1.24	0.65
SO4	FAL	12	1.71	0.72	0.25	-57.59	57.59	-0.98	0.98	0.14	-57.04	-84.21	-1.36	57.04	84.21	1.36	1.05	0.06
SO4	ALL	50	2.09	1.2	0.52	-42.39	51.31	-0.89	1.07	0.69	-44.86	-71.11	-0.74	53.63	77.71	0.89	1.21	0.27
CASTNET Monitoring Station: GAS153																		
NH4	WIN	10	0.78	0.78	0.39	1.26	33.19	0.01	0.26	0.14	0.92	-9.22	0.01	33.37	33.87	0.33	0.37	0.15
NH4	SPR	14	0.98	0.66	0.1	-32.31	40.02	-0.32	0.39	0.19	-26.82	-42.99	-0.48	36.79	51.41	0.59	0.54	0.01
NH4	SUM	13	1.2	0.74	0.36	-38.41	43.6	-0.46	0.53	0.14	-37.91	-55.83	-0.62	45.09	61.64	0.71	0.6	0.13
NH4	FAL	13	0.61	0.55	0.27	-9.16	47	-0.06	0.29	0.12	-2.41	-17.36	-0.1	45.73	48.73	0.52	0.36	0.07
NH4	ALL	50	0.9	0.68	0.24	-24.59	41.32	-0.22	0.37	0.19	-17.81	-32.91	-0.33	40.59	49.87	0.55	0.49	0.06
NO3	WIN	10	0.67	1.06	0.38	59.2	106.8	0.39	0.71	0.91	170.72	24.42	0.59	205.75	81.8	1.07	1.03	0.14
NO3	SPR	14	0.5	0.35	0.44	-30.26	50.67	-0.15	0.25	0.08	-2.24	-38.79	-0.43	72	67.89	0.73	0.32	0.2
NO3	SUM	13	0.18	0.05	0.01	-74.14	78.49	-0.13	0.14	0.02	-50.92	-89.26	-2.87	63.17	98.39	3.03	0.2	0
NO3	FAL	13	0.49	0.43	0.6	-12.78	47.79	-0.06	0.23	0.08	-8.31	-23.3	-0.15	45.99	53.2	0.55	0.29	0.35
NO3	ALL	50	0.45	0.43	0.33	-3.31	69.45	-0.01	0.31	0.27	18.12	-35.24	-0.03	89.69	74.78	0.72	0.52	0.11
SO4	WIN	10	2.15	1.69	0.4	-21.77	35.68	-0.47	0.77	0.66	-20.63	-28.55	-0.28	33.4	39.36	0.46	0.94	0.16
SO4	SPR	14	3.16	1.96	0	-37.79	40.28	-1.19	1.27	1.2	-34.14	-47.86	-0.61	37.31	50.91	0.65	1.62	0
SO4	SUM	13	3.9	2.33	0.55	-40.12	41.58	-1.56	1.62	0.84	-41.39	-58.36	-0.67	43.22	60.09	0.69	1.81	0.3
SO4	FAL	13	1.84	1.46	0.3	-20.23	34.54	-0.37	0.63	0.58	-17.03	-27.28	-0.25	32.08	39.98	0.43	0.85	0.09
SO4	ALL	50	2.8	1.87	0.47	-33.18	39.07	-0.93	1.1	1.09	-28.87	-41.38	-0.5	36.71	48.15	0.58	1.4	0.22

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: GRS420																		
NH4	WIN	11	0.64	0.53	0.25	-17.43	28.5	-0.11	0.18	0.04	-13.07	-21.3	-0.21	28.26	34.12	0.35	0.24	0.06
NH4	SPR	13	0.86	0.68	0.25	-20.89	52.93	-0.18	0.45	0.27	-7.63	-27.44	-0.26	50.64	59.16	0.67	0.55	0.06
NH4	SUM	7	1.04	0.84	0.59	-19.65	35.32	-0.2	0.37	0.12	-18.1	-27.76	-0.24	36.88	43.78	0.44	0.4	0.35
NH4	FAL	5	0.31	0.36	0.5	13.33	38.92	0.04	0.12	0.02	19.52	5.99	0.13	47.12	41.86	0.39	0.14	0.25
NH4	ALL	36	0.75	0.62	0.39	-17.67	41.02	-0.13	0.31	0.14	-7.56	-20.98	-0.21	40.63	46.11	0.5	0.4	0.15
NO3	WIN	11	0.54	0.45	0.6	-15.34	46.84	-0.08	0.25	0.11	6.09	-16.6	-0.18	60.02	59.58	0.55	0.34	0.36
NO3	SPR	13	0.33	0.31	0.11	-4.52	88.52	-0.01	0.29	0.13	77.48	-37.93	-0.05	167.88	102.3	0.93	0.36	0.01
NO3	SUM	7	0.09	0.04	0.53	-56.1	58.93	-0.05	0.05	0	-39.22	-61.91	-1.28	48.78	70.09	1.34	0.07	0.28
NO3	FAL	5	0.34	0.12	0.54	-64.23	64.23	-0.22	0.22	0.01	-61.93	-97.98	-1.8	61.93	97.98	1.8	0.24	0.3
NO3	ALL	36	0.35	0.28	0.52	-20.38	64.06	-0.07	0.22	0.09	13.61	-44.42	-0.26	97.05	82.38	0.8	0.3	0.27
SO4	WIN	11	1.77	1.43	0.03	-19.35	39.14	-0.34	0.69	0.62	-14.24	-23.89	-0.24	36.17	40.83	0.49	0.86	0
SO4	SPR	13	2.84	1.87	0.04	-34.25	50.08	-0.97	1.42	1.63	-26.3	-43.33	-0.52	48.15	61.74	0.76	1.61	0
SO4	SUM	7	3.56	2.67	0.72	-24.92	34.44	-0.89	1.23	0.98	-26.75	-38.55	-0.33	36.99	47.81	0.46	1.33	0.51
SO4	FAL	5	1.37	1.25	0.03	-8.24	49.74	-0.11	0.68	0.53	1.79	-18.55	-0.09	58.03	57.52	0.54	0.73	0
SO4	ALL	36	2.45	1.81	0.5	-26.3	43.21	-0.64	1.06	1.16	-18.8	-33.02	-0.36	43.69	52.05	0.59	1.26	0.25
CASTNET Monitoring Station: GTH161																		
NH4	WIN	10	0.09	0.13	0.41	42.69	50.63	0.04	0.04	0	52.11	36.93	0.43	57.31	42.92	0.51	0.05	0.17
NH4	SPR	12	0.17	0.07	0.11	-58	58	-0.1	0.1	0.01	-52.81	-78.08	-1.38	52.81	78.08	1.38	0.12	0.01
NH4	SUM	13	0.22	0.08	0.44	-62.15	62.15	-0.13	0.13	0	-62.49	-96.51	-1.64	62.49	96.51	1.64	0.14	0.19
NH4	FAL	12	0.17	0.13	0.26	-24.26	48.95	-0.04	0.08	0.01	-22.32	-38.27	-0.32	46.89	54.53	0.65	0.1	0.07
NH4	ALL	47	0.16	0.1	0	-39.18	56.28	-0.06	0.09	0.01	-25.38	-48.54	-0.64	54.93	69.68	0.93	0.11	0
NO3	WIN	10	0.06	0.06	0.28	-5.1	125.7	0	0.08	0.01	93.78	-61.88	-0.05	206.96	134.75	1.32	0.1	0.08
NO3	SPR	12	0.17	0.03	0.5	-83.07	83.07	-0.15	0.15	0	-83.9	-147.51	-4.91	83.9	147.51	4.91	0.16	0.25
NO3	SUM	13	0.13	0.01	0.43	-95.09	95.09	-0.12	0.12	0	-94.95	-181.2	-19.35	94.95	181.2	19.35	0.13	0.18
NO3	FAL	12	0.09	0.07	0.08	-16.41	123.98	-0.01	0.11	0.03	-10.05	-119.66	-0.2	137.92	150.06	1.48	0.16	0.01
NO3	ALL	47	0.12	0.04	0.09	-65	99.49	-0.07	0.11	0.01	-30.3	-131.5	-1.86	126.93	154.76	2.84	0.14	0.01
SO4	WIN	10	0.22	0.4	0.16	78.76	84.98	0.17	0.19	0.02	106.92	56.28	0.79	111.07	60.91	0.85	0.23	0.02
SO4	SPR	12	0.47	0.24	0.32	-48.69	51.33	-0.23	0.24	0.04	-42.4	-62.48	-0.95	46.32	65.99	1	0.3	0.1
SO4	SUM	13	0.54	0.25	0.52	-53.64	53.64	-0.29	0.29	0.01	-54.22	-80.66	-1.16	54.22	80.66	1.16	0.31	0.28
SO4	FAL	12	0.43	0.34	0.39	-19.44	36.21	-0.08	0.15	0.03	-13.88	-22.31	-0.24	34.12	38.87	0.45	0.19	0.15
SO4	ALL	47	0.43	0.3	0.03	-28.82	52	-0.12	0.22	0.06	-6.62	-31.98	-0.4	59.16	62.04	0.73	0.27	0

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: HOW132																		
NH4	WIN	11	0.38	0.39	0.15	3.22	54.63	0.01	0.2	0.08	11.25	-7.83	0.03	55.92	48.56	0.55	0.28	0.02
NH4	SPR	11	0.28	0.37	0.5	35.64	54.23	0.1	0.15	0.02	72.52	41.56	0.36	82.29	52.92	0.54	0.18	0.25
NH4	SUM	9	0.41	0.28	0.34	-31.83	40.38	-0.13	0.17	0.04	-29.35	-43.25	-0.47	37.3	50.55	0.59	0.23	0.12
NH4	FAL	13	0.36	0.37	0.45	4.18	49.47	0.01	0.18	0.04	4.55	-15.85	0.04	52.41	59.03	0.49	0.2	0.21
NH4	ALL	44	0.35	0.36	0.26	1.44	49.59	0.01	0.17	0.05	16.28	-5.1	0.01	57.66	53.15	0.5	0.22	0.07
NO3	WIN	11	0.31	0.66	0.04	114.12	149.72	0.35	0.46	0.33	142.25	35.69	1.14	175.26	82.53	1.5	0.68	0
NO3	SPR	11	0.19	0.26	0.41	35.92	105.84	0.07	0.2	0.07	44.15	-17.62	0.36	105.77	95.39	1.06	0.27	0.17
NO3	SUM	9	0.07	0.01	0.11	-82.92	82.92	-0.06	0.06	0	-81.87	-145.78	-4.85	81.87	145.78	4.85	0.07	0.01
NO3	FAL	13	0.25	0.26	0.58	3.08	82.61	0.01	0.21	0.1	-6.18	-66.76	0.03	90.67	109.49	0.83	0.31	0.33
NO3	ALL	44	0.21	0.31	0.47	44.12	111.87	0.09	0.24	0.15	28.03	-45.03	0.44	113.79	106.65	1.12	0.4	0.22
SO4	WIN	11	1.05	0.7	0.08	-33.39	50.39	-0.35	0.53	0.27	-24.03	-38.36	-0.5	44.99	54.58	0.76	0.63	0.01
SO4	SPR	11	0.98	1.24	0.54	27	46.75	0.26	0.46	0.19	45.43	28.94	0.27	58.68	43.67	0.47	0.51	0.29
SO4	SUM	9	1.13	1.04	0.18	-8.17	52.45	-0.09	0.59	0.68	-3.13	-21.46	-0.09	47.77	50.95	0.57	0.83	0.03
SO4	FAL	13	0.97	1.13	0.52	15.71	51.58	0.15	0.5	0.65	13.18	-7.44	0.16	51.42	48.59	0.52	0.82	0.27
SO4	ALL	44	1.03	1.03	0.29	0.48	50.32	0	0.52	0.51	8.6	-8.94	0	50.88	49.34	0.5	0.71	0.08
CASTNET Monitoring Station: HOW191																		
NH4	WIN	3	0.34	0.68	0.85	101.62	101.62	0.34	0.34	0.08	94.85	56.16	1.02	94.85	56.16	1.02	0.44	0.72
NH4	FAL	7	0.37	0.47	0.2	25.43	50.79	0.1	0.19	0.04	36.68	18.81	0.25	56.17	48.4	0.51	0.22	0.04
NH4	ALL	10	0.36	0.53	0.17	46.69	64.97	0.17	0.24	0.06	54.13	30.01	0.47	67.78	50.72	0.65	0.3	0.03
NO3	WIN	3	0.27	1.31	0.46	390.49	390.49	1.04	1.04	0.35	384.73	122.71	3.9	384.73	122.71	3.9	1.2	0.21
NO3	FAL	7	0.35	0.45	0.43	29.24	78.28	0.1	0.27	0.15	35.64	-29.08	0.29	105.4	84.81	0.78	0.41	0.19
NO3	ALL	10	0.32	0.71	0.16	118.41	155.35	0.38	0.5	0.4	140.37	16.46	1.18	189.2	96.18	1.55	0.74	0.03
SO4	WIN	3	0.86	1.09	0.77	26.66	42.65	0.23	0.37	0.09	24.22	16.06	0.27	42.38	37.08	0.43	0.38	0.6
SO4	FAL	7	1.01	1.08	0.26	7.52	38.46	0.08	0.39	0.18	20.74	8.45	0.08	45.09	40.19	0.38	0.43	0.07
SO4	ALL	10	0.96	1.08	0.3	12.63	39.58	0.12	0.38	0.16	21.78	10.73	0.13	44.28	39.25	0.4	0.42	0.09

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: HOX148																		
NH4	WIN	11	0.9	0.61	0.09	-32.13	72.35	-0.29	0.65	0.41	-27.21	-64.15	-0.47	69.95	96.56	1.07	0.7	0.01
NH4	SPR	14	0.67	0.52	0.14	-21.64	43.24	-0.14	0.29	0.13	-16.47	-32.79	-0.28	37.61	50.08	0.55	0.39	0.02
NH4	SUM	13	0.71	0.66	0.18	-6.94	70.37	-0.05	0.5	0.31	5.71	-26.11	-0.07	76.77	74.08	0.76	0.56	0.03
NH4	FAL	13	0.6	0.69	0.05	14.96	81.56	0.09	0.49	0.35	23.24	-12.11	0.15	82.87	75.53	0.82	0.6	0
NH4	ALL	51	0.71	0.62	0.03	-12.89	66.36	-0.09	0.47	0.31	-3.01	-32.58	-0.15	66.11	72.71	0.76	0.56	0
NO3	WIN	11	1.64	1.45	0.29	-11.65	118.91	-0.19	1.95	4.73	20.15	-60.04	-0.13	127.9	132.65	1.35	2.18	0.09
NO3	SPR	14	0.53	0.61	0.68	15.58	87.99	0.08	0.46	0.46	0.59	-59.09	0.16	93.67	104.73	0.88	0.68	0.46
NO3	SUM	13	0.14	0.17	0.3	22.18	101.39	0.03	0.14	0.05	12.81	-36.48	0.22	87.03	85.71	1.01	0.23	0.09
NO3	FAL	13	0.65	0.93	0.37	43.68	108.1	0.28	0.7	1.37	58.49	-22.74	0.44	131.63	100.79	1.08	1.21	0.14
NO3	ALL	51	0.7	0.76	0.31	8.76	109.09	0.06	0.76	1.54	22.68	-44.26	0.09	109.04	104.9	1.09	1.24	0.1
SO4	WIN	11	1.43	0.8	0.19	-44.01	53.29	-0.63	0.76	0.31	-42.56	-63.47	-0.79	52.12	71.03	0.95	0.84	0.04
SO4	SPR	14	1.62	1.07	0.25	-34.09	36.7	-0.55	0.59	0.44	-26.84	-39.32	-0.52	31.4	43.25	0.56	0.86	0.06
SO4	SUM	13	2.01	1.82	0.14	-9.52	70.53	-0.19	1.42	2.35	2.14	-28.36	-0.11	75.23	75.24	0.78	1.54	0.02
SO4	FAL	13	1.36	1.38	0.02	1.63	78.88	0.02	1.07	1.66	8.92	-20.94	0.02	73.01	73.69	0.79	1.29	0
SO4	ALL	51	1.61	1.28	0.06	-20.48	59.71	-0.33	0.96	1.28	-13.73	-37.05	-0.26	57.65	65.16	0.75	1.18	0
CASTNET Monitoring Station: HWF187																		
NH4	WIN	10	0.51	0.38	0.28	-25.81	54.78	-0.13	0.28	0.09	-22.76	-44.13	-0.35	55.89	65.09	0.74	0.32	0.08
NH4	SPR	12	0.43	0.37	0.3	-15.57	37.66	-0.07	0.16	0.04	-11.55	-20.71	-0.18	33.75	39.14	0.45	0.2	0.09
NH4	SUM	13	0.52	0.41	0.26	-21.35	69.94	-0.11	0.36	0.17	-20.62	-47.52	-0.27	65.2	76.94	0.89	0.43	0.07
NH4	FAL	13	0.43	0.48	0.24	11.44	48.82	0.05	0.21	0.09	21.04	-4.22	0.11	57.04	42.8	0.49	0.31	0.06
NH4	ALL	48	0.47	0.41	0.24	-12.96	53.88	-0.06	0.25	0.1	-7.52	-28.38	-0.15	53.19	55.78	0.62	0.33	0.06
NO3	WIN	10	0.36	0.59	0.2	64.63	128.31	0.23	0.46	0.59	129.65	-6.99	0.65	187.95	71.8	1.28	0.8	0.04
NO3	SPR	12	0.17	0.22	0.29	29.59	92.2	0.05	0.16	0.03	59.68	0.71	0.3	112.87	83.33	0.92	0.19	0.09
NO3	SUM	13	0.06	0.03	0.39	-58.38	75.57	-0.04	0.05	0	-59.98	-108.59	-1.4	78.28	120.07	1.82	0.05	0.15
NO3	FAL	13	0.19	0.42	0.54	120.57	184.56	0.23	0.35	0.4	77.24	-22.38	1.21	153.09	104.38	1.85	0.67	0.29
NO3	ALL	48	0.19	0.3	0.32	61.25	130.95	0.11	0.24	0.25	46.6	-36.75	0.61	130.04	96.58	1.31	0.52	0.1
SO4	WIN	10	1.31	0.69	0.48	-47.65	47.65	-0.63	0.63	0.23	-44.02	-61.16	-0.91	44.02	61.16	0.91	0.79	0.23
SO4	SPR	12	1.22	0.99	0.4	-18.78	36.58	-0.23	0.45	0.25	-16.04	-24.35	-0.23	33.43	38.6	0.45	0.55	0.16
SO4	SUM	13	1.51	1.36	0.2	-10.26	78.41	-0.16	1.18	2.5	-7.76	-39.28	-0.11	70.78	75.57	0.87	1.59	0.04
SO4	FAL	13	1.13	1.25	0.11	10.7	48.96	0.12	0.55	0.7	25.49	-2.87	0.11	61.18	41.76	0.49	0.85	0.01
SO4	ALL	48	1.29	1.1	0.21	-15.21	55.07	-0.2	0.71	1.04	-8.38	-30.25	-0.18	53.27	54.17	0.65	1.04	0.05

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: IRL141																		
NH4	WIN	10	0.52	0.5	0.6	-3.5	61.32	-0.02	0.32	0.14	-17.2	-60.25	-0.04	67.26	97.75	0.64	0.37	0.36
NH4	SPR	14	0.68	0.25	0.2	-63.19	69.8	-0.43	0.47	0.07	-60.52	-110.07	-1.72	72.39	118.46	1.9	0.51	0.04
NH4	SUM	13	0.48	0.1	0.07	-79.62	79.62	-0.38	0.38	0.03	-78.42	-139.55	-3.91	78.42	139.55	3.91	0.42	0.01
NH4	FAL	12	0.36	0.13	0.3	-63.7	71.28	-0.23	0.26	0.03	-63.41	-117	-1.75	73.35	124.66	1.96	0.28	0.09
NH4	ALL	49	0.52	0.23	0.35	-55.07	70.74	-0.28	0.37	0.09	-57.14	-109.42	-1.23	73.18	121.35	1.57	0.41	0.12
NO3	WIN	10	1.87	0.78	0.04	-58.56	60.57	-1.1	1.13	0.42	-54.25	-84.62	-1.41	57.64	87.75	1.46	1.27	0
NO3	SPR	14	1.89	0.39	0.15	-79.34	79.34	-1.5	1.5	0.32	-77.8	-132.24	-3.84	77.8	132.24	3.84	1.6	0.02
NO3	SUM	13	1.26	0.37	0.17	-71.02	71.02	-0.89	0.89	0.19	-70.73	-121.54	-2.45	70.73	121.54	2.45	0.99	0.03
NO3	FAL	12	1.22	0.52	0.03	-57.9	69.62	-0.71	0.85	0.48	-55.52	-104.41	-1.38	66.48	113.32	1.65	0.99	0
NO3	ALL	49	1.56	0.49	0.1	-68.33	71.08	-1.06	1.11	0.44	-65.66	-112.87	-2.16	69.04	115.69	2.24	1.25	0.01
SO4	WIN	10	2.68	1.78	0.34	-33.61	44.14	-0.9	1.18	0.8	-33.4	-47.02	-0.51	43.44	55.05	0.66	1.27	0.11
SO4	SPR	14	3.23	1.57	0.48	-51.37	51.37	-1.66	1.66	0.48	-51.97	-76.89	-1.06	51.97	76.89	1.06	1.8	0.23
SO4	SUM	13	2.13	0.64	0.72	-69.77	69.77	-1.48	1.48	0.14	-70.38	-111.29	-2.31	70.38	111.29	2.31	1.53	0.51
SO4	FAL	12	2.18	0.85	0.43	-60.92	62.67	-1.33	1.37	0.37	-62.2	-99.25	-1.56	63.98	100.95	1.6	1.46	0.18
SO4	ALL	49	2.57	1.19	0.58	-53.61	56.22	-1.38	1.44	0.5	-55.57	-85.4	-1.16	58.06	87.45	1.21	1.55	0.34
CASTNET Monitoring Station: KEF112																		
NH4	WIN	11	0.89	0.64	0.71	-28.23	29.88	-0.25	0.27	0.05	-29.32	-40.33	-0.39	30.82	41.77	0.42	0.34	0.51
NH4	SPR	14	0.76	0.59	0.2	-22.63	41	-0.17	0.31	0.1	-18.17	-28.73	-0.29	38.78	45.66	0.53	0.37	0.04
NH4	SUM	13	1.16	0.66	0.18	-43.13	51.51	-0.5	0.6	0.22	-41.47	-62.49	-0.76	49.5	69.7	0.91	0.68	0.03
NH4	FAL	13	0.66	0.59	0.07	-10.05	54.75	-0.07	0.36	0.15	-6.01	-25.7	-0.11	55.56	62.48	0.61	0.39	0
NH4	ALL	51	0.86	0.62	0.25	-28.46	44.77	-0.25	0.39	0.16	-23.42	-39.06	-0.4	44.07	55.24	0.63	0.47	0.06
NO3	WIN	11	0.82	1.27	0.21	54.51	106.76	0.45	0.88	1.44	135.76	27.92	0.55	167.69	73.27	1.07	1.28	0.05
NO3	SPR	14	0.37	0.56	0.05	49.73	98.29	0.19	0.37	0.2	136.72	31.61	0.5	169.06	79.45	0.98	0.48	0
NO3	SUM	13	0.1	0.11	0.35	7.31	59.65	0.01	0.06	0.01	17.15	-8.12	0.07	61.71	55.71	0.6	0.08	0.12
NO3	FAL	13	0.49	0.45	0.46	-6.84	56.72	-0.03	0.28	0.14	15.39	-22.08	-0.07	76.47	72.03	0.61	0.37	0.21
NO3	ALL	51	0.43	0.57	0.33	32.83	87.46	0.14	0.38	0.44	75.11	7	0.33	117.8	70.17	0.87	0.67	0.11
SO4	WIN	11	2.24	1.06	0.55	-52.8	52.8	-1.18	1.18	0.51	-51.25	-72.57	-1.12	51.25	72.57	1.12	1.38	0.3
SO4	SPR	14	2.12	1.41	0.15	-33.33	52.62	-0.71	1.11	1.06	-28.11	-45.62	-0.5	50.08	62.88	0.79	1.25	0.02
SO4	SUM	13	3.73	2.23	0.18	-40.01	47.51	-1.49	1.77	2.67	-37.32	-57.21	-0.67	44.44	63.5	0.79	2.21	0.03
SO4	FAL	13	1.77	1.65	0.19	-7	48.44	-0.12	0.86	1.16	-5.43	-22.03	-0.08	47.92	50.86	0.52	1.08	0.04
SO4	ALL	51	2.47	1.61	0.33	-34.9	49.92	-0.86	1.23	1.65	-29.67	-48.37	-0.54	48.34	62.06	0.77	1.55	0.11

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: KNZ184																		
NH4	WIN	9	1.37	0.92	0.13	-32.38	60.6	-0.44	0.83	0.74	-14.18	-41.31	-0.48	64	70.57	0.9	0.97	0.02
NH4	SPR	14	0.85	0.86	0.29	0.56	55.31	0	0.47	0.38	22.58	-8.08	0.01	68.06	58.11	0.55	0.61	0.08
NH4	SUM	12	0.57	0.46	0.27	-18.97	37.76	-0.11	0.22	0.08	-16.44	-32.76	-0.23	36.3	49.54	0.47	0.3	0.07
NH4	FAL	7	0.33	0.41	0.43	24.67	69.46	0.08	0.23	0.06	25.39	4.01	0.25	67.96	60.75	0.69	0.26	0.19
NH4	ALL	42	0.8	0.69	0.34	-13.91	54.63	-0.11	0.43	0.35	4.02	-20.24	-0.16	58.1	58.77	0.63	0.6	0.12
NO3	WIN	9	3.71	2.15	0.02	-41.97	58.25	-1.56	2.16	4.12	-28.06	-55.17	-0.72	57.35	76.26	1	2.56	0
NO3	SPR	14	1.91	1.5	0.46	-21.39	62.51	-0.41	1.19	2.28	-20.69	-61.36	-0.27	69.76	95.3	0.8	1.56	0.21
NO3	SUM	12	0.89	0.07	0.18	-91.89	91.89	-0.82	0.82	0.08	-90.69	-167.8	-11.33	90.69	167.8	11.33	0.87	0.03
NO3	FAL	7	0.69	0.3	0.49	-56.88	82.95	-0.39	0.58	0.22	-45.41	-104.03	-1.32	83.12	131.19	1.92	0.61	0.24
NO3	ALL	42	1.8	1.03	0.56	-42.73	66.1	-0.77	1.19	1.9	-46.39	-97.56	-0.75	75.31	117.92	1.15	1.58	0.31
SO4	WIN	9	1.63	0.86	0.41	-47.28	57.99	-0.77	0.94	0.55	-47.21	-70.93	-0.9	54.98	77.54	1.1	1.07	0.17
SO4	SPR	14	2.27	1.27	0.09	-43.93	46.61	-1	1.06	0.55	-39.55	-57.78	-0.78	43.52	61.45	0.83	1.24	0.01
SO4	SUM	12	2.31	1.26	0.47	-45.47	46.68	-1.05	1.08	0.48	-45.91	-69.96	-0.83	47.38	71.37	0.86	1.26	0.22
SO4	FAL	7	1.12	0.94	0.63	-16.07	36.52	-0.18	0.41	0.21	-19.1	-29.61	-0.19	37.76	43.68	0.44	0.49	0.39
SO4	ALL	42	1.95	1.12	0.41	-42.4	47.7	-0.83	0.93	0.57	-39.6	-59.38	-0.74	46.12	64.77	0.83	1.12	0.17
CASTNET Monitoring Station: LRL117																		
NH4	WIN	11	1.01	0.6	0.36	-40.74	44.51	-0.41	0.45	0.1	-37.28	-52.66	-0.69	42.22	57.28	0.75	0.52	0.13
NH4	SPR	13	0.91	0.61	0.2	-33.23	45.58	-0.3	0.41	0.16	-29.2	-48.26	-0.5	44.56	59.88	0.68	0.5	0.04
NH4	SUM	13	1.61	0.79	0.55	-50.77	52.46	-0.82	0.84	0.13	-50.21	-71.72	-1.03	52.52	73.87	1.07	0.89	0.31
NH4	FAL	13	0.75	0.67	0.19	-10.54	66.25	-0.08	0.49	0.35	-0.96	-30.24	-0.12	62.85	72.83	0.74	0.59	0.04
NH4	ALL	50	1.07	0.67	0.26	-37.53	51.79	-0.4	0.55	0.26	-29.1	-50.64	-0.6	50.87	66.31	0.83	0.65	0.07
NO3	WIN	11	0.9	0.9	0.34	0.99	90.21	0.01	0.81	0.96	122.32	3	0.01	183.25	90.84	0.9	0.98	0.11
NO3	SPR	13	0.41	0.58	0.68	42.4	69.52	0.17	0.28	0.15	64.15	7.63	0.42	102.36	65.97	0.7	0.42	0.46
NO3	SUM	13	0.09	0.13	0.13	52.15	93.04	0.05	0.08	0.01	81.98	18.67	0.52	118.46	71.12	0.93	0.11	0.02
NO3	FAL	13	0.36	0.61	0.22	69.07	162.66	0.25	0.59	0.72	212.95	-12.24	0.69	287.36	103.57	1.63	0.89	0.05
NO3	ALL	50	0.42	0.54	0.22	29.49	101.42	0.12	0.43	0.45	120.27	4.32	0.29	172.44	82.56	1.01	0.68	0.05
SO4	WIN	11	2.5	1.23	0.59	-50.95	50.95	-1.28	1.28	0.54	-48.57	-67.73	-1.04	48.57	67.73	1.04	1.47	0.35
SO4	SPR	13	2.56	1.45	0.23	-43.13	53.31	-1.1	1.36	1.04	-39.13	-62.14	-0.76	54.4	72.34	0.94	1.5	0.05
SO4	SUM	13	5.02	3.04	0.59	-39.53	41.68	-1.98	2.09	1.79	-40.07	-56.3	-0.65	42.32	58.46	0.69	2.39	0.35
SO4	FAL	13	2.08	1.7	0.04	-18.5	55.96	-0.39	1.17	2.3	-11.94	-35.91	-0.23	52.84	63.58	0.69	1.57	0
SO4	ALL	50	3.06	1.88	0.58	-38.64	48.4	-1.18	1.48	1.79	-34.38	-55.03	-0.63	49.57	65.44	0.79	1.79	0.34

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: MAC426																		
NH4	WIN	11	1.71	1.07	0.21	-37.05	44.26	-0.63	0.76	0.53	-30	-43.43	-0.59	39.87	51.93	0.7	0.96	0.04
NH4	SPR	14	1.11	0.87	0.26	-22.05	40.68	-0.25	0.45	0.21	-18.95	-31.03	-0.28	40.45	47.6	0.52	0.52	0.07
NH4	SUM	13	1.38	0.94	0.69	-31.74	32.48	-0.44	0.45	0.12	-31.19	-41.75	-0.46	31.99	42.52	0.48	0.56	0.47
NH4	FAL	13	0.7	0.71	0.04	0.59	60.3	0	0.42	0.23	4.22	-16.32	0.01	58.85	61.94	0.6	0.48	0
NH4	ALL	51	1.2	0.89	0.41	-26.1	42.28	-0.31	0.51	0.31	-18.55	-32.69	-0.35	42.86	50.9	0.57	0.64	0.16
NO3	WIN	11	2.9	1.94	0.14	-32.99	53.26	-0.96	1.54	2.98	-11.96	-34.44	-0.49	53.66	60.55	0.79	1.97	0.02
NO3	SPR	14	0.63	0.91	0.35	44.94	86.13	0.28	0.54	0.81	48.57	5.14	0.45	84.68	55.24	0.86	0.94	0.12
NO3	SUM	13	0.26	0.13	0.19	-49.31	75.32	-0.13	0.19	0.04	-24.57	-70.22	-0.97	78.78	98.21	1.49	0.23	0.03
NO3	FAL	13	0.59	0.68	0.1	15.24	80.88	0.09	0.48	0.4	29.74	-12.72	0.15	86.26	68.27	0.81	0.64	0.01
NO3	ALL	51	1.01	0.88	0.56	-13.6	64.39	-0.14	0.65	1.18	12.07	-27.16	-0.16	76.89	70.66	0.75	1.1	0.31
SO4	WIN	11	2.61	1.57	0.39	-40.04	40.04	-1.05	1.05	0.57	-36.85	-49.68	-0.67	36.85	49.68	0.67	1.29	0.15
SO4	SPR	14	3.06	1.81	0.42	-40.93	42.09	-1.25	1.29	0.58	-40.06	-54.34	-0.69	41.43	55.65	0.71	1.47	0.17
SO4	SUM	13	4.07	2.62	0.74	-35.62	36	-1.45	1.47	0.9	-35.13	-46.78	-0.55	35.58	47.22	0.56	1.73	0.55
SO4	FAL	13	1.86	1.51	0.07	-18.5	53.84	-0.34	1	1.38	-16.02	-38.31	-0.23	52.83	64.88	0.66	1.22	0
SO4	ALL	51	2.92	1.89	0.59	-35.23	41.43	-1.03	1.21	1.04	-31.98	-47.32	-0.54	41.86	54.57	0.64	1.45	0.35
CASTNET Monitoring Station: MCK131																		
NH4	WIN	11	1.6	1.06	0.48	-33.68	39.44	-0.54	0.63	0.45	-26.24	-36.92	-0.51	34.16	44.25	0.59	0.86	0.23
NH4	SPR	14	1.06	0.88	0.26	-17.41	38.15	-0.19	0.41	0.2	-10.55	-23.12	-0.21	39.87	45.28	0.46	0.48	0.07
NH4	SUM	12	1.5	0.89	0.3	-40.53	45.37	-0.61	0.68	0.27	-38.57	-55.79	-0.68	43.2	59.85	0.76	0.8	0.09
NH4	FAL	13	0.68	0.69	0.23	1.54	57.43	0.01	0.39	0.22	1.92	-17.76	0.02	55.04	59.01	0.57	0.47	0.05
NH4	ALL	50	1.19	0.87	0.39	-26.43	43.6	-0.31	0.52	0.34	-17.48	-32.6	-0.36	43.36	52.12	0.59	0.66	0.15
NO3	WIN	11	2.59	1.93	0.42	-25.45	44.47	-0.66	1.15	1.88	-10.15	-24.56	-0.34	44.26	52.17	0.6	1.52	0.18
NO3	SPR	14	0.62	0.96	0.4	54.32	96.28	0.34	0.6	0.63	67.21	9.99	0.54	108.06	70.09	0.96	0.86	0.16
NO3	SUM	12	0.34	0.13	0.63	-62.58	79.36	-0.21	0.27	0.04	-47.11	-99.24	-1.67	79.45	119.11	2.12	0.29	0.4
NO3	FAL	13	0.58	0.62	0.07	7.1	91.37	0.04	0.53	0.51	19.38	-33.79	0.07	98.87	85.72	0.91	0.72	0
NO3	ALL	50	0.97	0.88	0.62	-9.2	63.86	-0.09	0.62	0.86	10.32	-35.21	-0.1	84.77	81.98	0.7	0.93	0.38
SO4	WIN	11	2.63	1.52	0.42	-42.17	43.78	-1.11	1.15	0.8	-38.21	-52.39	-0.73	39.92	54.02	0.76	1.42	0.17
SO4	SPR	14	2.88	1.76	0.33	-38.86	39.98	-1.12	1.15	0.64	-35.67	-48.79	-0.64	37.85	50.81	0.65	1.38	0.11
SO4	SUM	12	4.18	2.52	0.22	-39.7	46.67	-1.66	1.95	2.62	-36.8	-54.63	-0.66	44.09	60.61	0.77	2.32	0.05
SO4	FAL	13	1.78	1.52	0.15	-14.19	51.75	-0.25	0.92	1.41	-13.57	-34.95	-0.17	49.57	61.09	0.6	1.21	0.02
SO4	ALL	50	2.85	1.83	0.4	-35.83	45.01	-1.02	1.28	1.61	-30.75	-47.38	-0.56	42.85	56.54	0.7	1.63	0.16

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: MCK231																		
NH4	WIN	11	1.63	1.06	0.47	-34.64	39.55	-0.56	0.64	0.48	-26.84	-37.84	-0.53	33.45	44.02	0.61	0.89	0.22
NH4	SPR	14	1.1	0.88	0.31	-20.41	34.5	-0.23	0.38	0.17	-17.6	-28.27	-0.26	33.69	41.68	0.43	0.47	0.1
NH4	SUM	12	1.55	0.89	0.28	-42.23	46.68	-0.65	0.72	0.3	-40.08	-58.1	-0.73	44.39	61.91	0.81	0.85	0.08
NH4	FAL	13	0.69	0.69	0.22	0.7	57.29	0	0.39	0.23	2.73	-16.12	0.01	53.12	56.81	0.57	0.48	0.05
NH4	ALL	50	1.22	0.87	0.39	-28.15	43.05	-0.34	0.52	0.35	-19.74	-34.37	-0.39	41.26	50.99	0.6	0.68	0.15
NO3	WIN	11	2.65	1.93	0.42	-27.15	44.49	-0.72	1.18	2.06	-11.91	-26.11	-0.37	42.78	51.57	0.61	1.61	0.18
NO3	SPR	14	0.67	0.96	0.43	43.65	86.35	0.29	0.58	0.61	54.19	3.93	0.44	97.24	67.45	0.86	0.83	0.19
NO3	SUM	12	0.38	0.13	0.52	-66.58	78.25	-0.25	0.29	0.04	-55.46	-106.83	-1.99	76.01	121.11	2.34	0.33	0.27
NO3	FAL	13	0.59	0.62	0.07	4.44	88.96	0.03	0.53	0.54	19.22	-34.23	0.04	97.34	83.51	0.89	0.73	0.01
NO3	ALL	50	1.01	0.88	0.61	-12.76	61.98	-0.13	0.63	0.91	4.24	-39.18	-0.15	80.19	81.01	0.71	0.96	0.37
SO4	WIN	11	2.68	1.52	0.41	-43.23	44.93	-1.16	1.21	0.87	-38.8	-53.63	-0.76	40.95	55.72	0.79	1.49	0.16
SO4	SPR	14	3.01	1.76	0.31	-41.41	41.41	-1.24	1.24	0.58	-39.76	-53.91	-0.71	39.76	53.91	0.71	1.46	0.1
SO4	SUM	12	4.32	2.52	0.21	-41.7	47.68	-1.8	2.06	2.8	-38.87	-57.37	-0.72	45.03	62.58	0.82	2.46	0.04
SO4	FAL	13	1.79	1.52	0.19	-14.93	51.06	-0.27	0.91	1.4	-14.32	-34.36	-0.18	48.18	59.44	0.6	1.21	0.03
SO4	ALL	50	2.93	1.83	0.4	-37.68	45.87	-1.11	1.35	1.69	-32.72	-49.6	-0.6	43.48	57.83	0.74	1.71	0.16
CASTNET Monitoring Station: MKG113																		
NH4	WIN	10	1.34	1.07	0.48	-20.28	44.81	-0.27	0.6	0.55	-22.1	-41.37	-0.25	45.35	56.43	0.56	0.79	0.23
NH4	SPR	13	0.9	0.72	0.14	-19.53	37.64	-0.18	0.34	0.14	-12.89	-24.12	-0.24	37.68	43.62	0.47	0.41	0.02
NH4	SUM	13	1.28	1.03	0.05	-19.63	49.53	-0.25	0.64	0.49	-10.06	-28.33	-0.24	48.18	60.25	0.62	0.74	0
NH4	FAL	13	0.78	0.98	0.13	25.33	55.61	0.2	0.43	0.21	28.23	9.67	0.25	59.22	51.48	0.56	0.5	0.02
NH4	ALL	49	1.06	0.94	0.27	-11	46.82	-0.12	0.5	0.37	-3.11	-19.79	-0.12	47.75	52.73	0.53	0.62	0.07
NO3	WIN	10	1.93	2.33	0.29	20.63	77.57	0.4	1.5	4.71	17.28	-16.21	0.21	71.05	67.11	0.78	2.21	0.08
NO3	SPR	13	0.62	0.82	0.17	31.58	90.69	0.2	0.56	0.38	124.39	18.31	0.32	167.75	90.84	0.91	0.65	0.03
NO3	SUM	13	0.19	0.36	0.52	96.32	132.21	0.18	0.24	0.07	125.2	33.04	0.96	159.53	81.17	1.32	0.32	0.27
NO3	FAL	13	0.73	1.26	0.37	71.92	104.93	0.53	0.77	0.7	117.72	25.59	0.72	154.63	83.43	1.05	0.99	0.14
NO3	ALL	49	0.8	1.12	0.55	39.91	90.23	0.32	0.72	1.29	100.98	17.1	0.4	142.35	81.47	0.9	1.18	0.3
SO4	WIN	10	2.71	1.27	0.41	-53	53.51	-1.44	1.45	1.05	-50.33	-73.05	-1.13	50.93	73.64	1.14	1.76	0.17
SO4	SPR	13	2.33	1.46	0.35	-37.6	46.93	-0.88	1.09	0.65	-33.37	-48.31	-0.6	46.38	58.96	0.75	1.19	0.12
SO4	SUM	13	3.95	3.01	0.06	-23.97	47.53	-0.95	1.88	4.5	-18.75	-37.92	-0.32	43.47	58.52	0.63	2.32	0
SO4	FAL	13	2.01	1.91	0.07	-4.74	47.18	-0.1	0.95	1.22	-1.28	-16.68	-0.05	48.94	49.13	0.5	1.11	0
SO4	ALL	49	2.75	1.95	0.34	-29.14	48.53	-0.8	1.34	2.13	-24.44	-42.21	-0.41	47.22	59.23	0.68	1.66	0.12

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: OXF122																		
NH4	WIN	5	1.7	1.48	0.27	-12.73	68.94	-0.22	1.17	1.7	-4.14	-30.05	-0.15	66.62	71.37	0.79	1.32	0.07
NH4	SPR	6	1.11	1.06	0.82	-4.04	20.99	-0.04	0.23	0.07	-6.77	-9.88	-0.04	21.06	22.29	0.22	0.27	0.67
NH4	SUM	7	1.73	1.24	0.17	-28.34	46.9	-0.49	0.81	0.86	-21.34	-39.13	-0.4	42.32	55.39	0.65	1.05	0.03
NH4	FAL	13	0.88	0.98	0.17	11.17	54.17	0.1	0.48	0.3	21.99	3.23	0.11	54.91	53.09	0.54	0.56	0.03
NH4	ALL	31	1.25	1.14	0.1	-9.02	49.44	-0.11	0.62	0.66	2.42	-14.24	-0.1	47.4	50.6	0.54	0.82	0.01
NO3	WIN	5	3.13	3.41	0.36	8.94	85.59	0.28	2.68	9.84	28.48	-9.96	0.09	90.85	76.22	0.86	3.15	0.13
NO3	SPR	6	1	1.89	0.79	88.7	88.7	0.89	0.89	0.43	98.45	54.27	0.89	98.45	54.27	0.89	1.1	0.63
NO3	SUM	7	0.38	0.72	0.51	88.47	156.77	0.34	0.6	0.69	64.68	-15.05	0.88	140.15	87.94	1.57	0.9	0.26
NO3	FAL	13	1.02	1.42	0.09	39.05	91.76	0.4	0.93	1.16	71.78	21.36	0.39	105.45	73.94	0.92	1.15	0.01
NO3	ALL	31	1.21	1.67	0.4	37.96	93.33	0.46	1.13	2.36	68.36	14.46	0.38	109.58	73.66	0.93	1.6	0.16
SO4	WIN	5	2.46	1.27	0.17	-48.31	52.17	-1.19	1.28	1.66	-42.43	-64.1	-0.93	46.34	67.83	1.01	1.75	0.03
SO4	SPR	6	2.7	1.44	0.19	-46.77	46.77	-1.26	1.26	0.56	-44.7	-61.89	-0.88	44.7	61.89	0.88	1.47	0.04
SO4	SUM	7	4.91	3.15	0.01	-35.85	43.81	-1.76	2.15	5.04	-31.24	-47.94	-0.56	40.96	56.25	0.68	2.85	0
SO4	FAL	13	2.18	1.64	0.05	-24.74	41.67	-0.54	0.91	1.28	-19.86	-37.1	-0.33	39.94	52.48	0.55	1.25	0
SO4	ALL	31	2.94	1.88	0.38	-36.02	44.8	-1.06	1.32	2.29	-30.88	-48.7	-0.56	42.12	57.63	0.7	1.85	0.15
CASTNET Monitoring Station: PAL190																		
NH4	WIN	10	0.73	0.44	0.27	-39.27	58.43	-0.29	0.43	0.26	-7.99	-33.33	-0.65	59.06	62.63	0.96	0.58	0.07
NH4	SPR	13	0.48	0.5	0.18	4.02	61.32	0.02	0.29	0.16	7.88	-18.3	0.04	61.7	58.52	0.61	0.4	0.03
NH4	SUM	12	0.58	0.36	0.51	-37.53	45.35	-0.22	0.26	0.04	95.22	-33.29	-0.6	168.82	62.89	0.73	0.29	0.26
NH4	FAL	13	0.43	0.41	0.28	-5.52	47.88	-0.02	0.21	0.06	52.17	-2.76	-0.06	98.13	57.39	0.51	0.26	0.08
NH4	ALL	48	0.54	0.43	0.06	-21.15	53.37	-0.11	0.29	0.14	38.4	-20.97	-0.27	97.8	60.16	0.68	0.39	0
NO3	WIN	10	1.63	0.93	0.03	-43.12	52.63	-0.7	0.86	0.77	-32.45	-48.64	-0.76	45.85	58.68	0.93	1.12	0
NO3	SPR	13	1.04	0.47	0.06	-55	79.99	-0.57	0.83	0.49	-44.46	-99.88	-1.22	84.68	125.7	1.78	0.91	0
NO3	SUM	12	0.78	0.03	0.13	-95.66	95.89	-0.74	0.74	0.07	-84.1	-165.9	-22.05	91.76	172.13	22.1	0.79	0.02
NO3	FAL	13	0.86	0.32	0.62	-62.29	68.65	-0.54	0.59	0.18	-51.32	-103.76	-1.65	76.83	121.76	1.82	0.68	0.39
NO3	ALL	48	1.05	0.42	0.43	-60.31	71.56	-0.63	0.75	0.37	-53.73	-106.76	-1.52	76.23	122.28	1.8	0.88	0.19
SO4	WIN	10	1.19	0.58	0.18	-51.14	61.3	-0.61	0.73	0.52	-39.63	-63.66	-1.05	51.56	72.85	1.25	0.94	0.03
SO4	SPR	13	1.72	1.11	0.02	-35.69	56.8	-0.61	0.98	0.94	-28.5	-51.34	-0.56	53.69	69.29	0.88	1.15	0
SO4	SUM	12	1.7	0.99	0.39	-41.44	48.9	-0.7	0.83	0.31	197.33	-39.17	-0.71	278.99	70.32	0.84	0.9	0.15
SO4	FAL	13	1.16	0.94	0.61	-19.44	31.41	-0.23	0.37	0.15	77.31	-17.54	-0.24	127.57	48.71	0.39	0.45	0.37
SO4	ALL	48	1.45	0.92	0.22	-36.47	49.75	-0.53	0.72	0.52	54.3	-41.71	-0.57	129.58	64.72	0.78	0.89	0.05

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: PAR107																		
NH4	WIN	11	0.82	0.45	0.59	-45.34	45.34	-0.37	0.37	0.07	-44.22	-62.7	-0.83	44.22	62.7	0.83	0.45	0.35
NH4	SPR	13	0.76	0.49	0.58	-34.73	42.83	-0.26	0.32	0.08	-34.91	-52.86	-0.53	42.05	58.94	0.66	0.39	0.33
NH4	SUM	13	1.45	0.59	0.35	-59.18	60.52	-0.86	0.88	0.21	-56.69	-85.76	-1.45	58.72	87.66	1.48	0.97	0.12
NH4	FAL	12	0.44	0.42	0.12	-3.74	73.04	-0.02	0.32	0.17	24.32	-15.08	-0.04	78.31	70.23	0.76	0.41	0.01
NH4	ALL	49	0.88	0.49	0.37	-43.87	54.84	-0.38	0.48	0.23	-28.27	-54.54	-0.78	55.84	70.17	0.98	0.61	0.14
NO3	WIN	11	0.97	0.36	0.08	-63.35	63.35	-0.62	0.62	0.24	-57.41	-91.5	-1.73	57.41	91.5	1.73	0.79	0.01
NO3	SPR	13	0.45	0.31	0.9	-31.79	41.98	-0.14	0.19	0.03	-49	-79.87	-0.47	53.87	84.26	0.62	0.23	0.8
NO3	SUM	13	0.12	0.08	0.26	-35.02	66.29	-0.04	0.08	0.01	-16.85	-53.11	-0.54	64.39	83.7	1.02	0.1	0.07
NO3	FAL	12	0.33	0.22	0.11	-31.09	91.08	-0.1	0.3	0.1	-12.93	-76.61	-0.45	104.46	119.96	1.32	0.34	0.01
NO3	ALL	49	0.45	0.24	0.48	-47.22	62.8	-0.21	0.28	0.14	-33.53	-74.58	-0.89	69.85	94.48	1.19	0.43	0.23
SO4	WIN	11	2.31	1.34	0.39	-41.83	42.37	-0.97	0.98	0.72	-40.51	-57.83	-0.72	41.05	58.36	0.73	1.29	0.15
SO4	SPR	13	2.58	1.53	0.52	-40.68	45.7	-1.05	1.18	0.78	-41.39	-60.45	-0.69	46.28	64.67	0.77	1.37	0.27
SO4	SUM	13	4.65	3.03	0.58	-34.75	43.79	-1.62	2.04	2.73	-36.19	-52.66	-0.53	43.92	59.6	0.67	2.31	0.34
SO4	FAL	12	1.62	1.4	0.07	-13.31	49.7	-0.21	0.8	0.99	-7.57	-26.34	-0.15	47.99	57.33	0.57	1.02	0
SO4	ALL	49	2.83	1.86	0.64	-34.49	44.82	-0.98	1.27	1.59	-31.53	-49.44	-0.53	44.9	60.11	0.68	1.6	0.41
CASTNET Monitoring Station: PED108																		
NH4	WIN	11	0.91	0.68	0.69	-25.16	26.85	-0.23	0.24	0.05	-22.01	-27.19	-0.34	24.57	29.59	0.36	0.32	0.47
NH4	SPR	14	0.91	0.68	0.58	-25.12	35.65	-0.23	0.33	0.1	-23.52	-37.59	-0.34	37.91	49.26	0.48	0.39	0.33
NH4	SUM	11	1.32	0.86	0.64	-34.96	38.18	-0.46	0.5	0.11	-31.74	-43.91	-0.54	38.17	49.38	0.59	0.57	0.41
NH4	FAL	13	0.57	0.66	0.15	15.72	59.76	0.09	0.34	0.23	22.61	-1.72	0.16	61.92	50.82	0.6	0.49	0.02
NH4	ALL	49	0.91	0.71	0.44	-21.53	38.52	-0.2	0.35	0.16	-12.79	-27.16	-0.27	41.34	45.29	0.49	0.45	0.2
NO3	WIN	11	0.82	1.13	0.14	36.53	84.37	0.3	0.7	0.51	149.64	34.45	0.37	180.35	74.43	0.84	0.78	0.02
NO3	SPR	14	0.42	0.45	0.46	7.39	65.76	0.03	0.28	0.11	72.27	6.06	0.07	120.76	81.35	0.66	0.34	0.21
NO3	SUM	11	0.11	0.06	0.05	-48.51	76.85	-0.05	0.08	0.01	-22.16	-61.07	-0.94	74.23	90.41	1.49	0.11	0
NO3	FAL	13	0.32	0.78	0.16	140.64	181.43	0.45	0.58	0.92	203.56	27.52	1.41	241.06	87.45	1.81	1.06	0.03
NO3	ALL	49	0.41	0.6	0.4	44.65	98.59	0.18	0.41	0.44	103.27	3.06	0.45	155.61	83.45	0.99	0.69	0.16
SO4	WIN	11	2.04	1.36	0.34	-33.64	36.59	-0.69	0.75	0.33	-30.66	-40.68	-0.51	34.84	44.43	0.55	0.9	0.12
SO4	SPR	14	2.76	1.79	0.55	-35.06	40.88	-0.97	1.13	0.7	-34.86	-49.64	-0.54	40.49	54.38	0.63	1.28	0.31
SO4	SUM	11	4.01	2.64	0.83	-34.18	34.18	-1.37	1.37	0.68	-34.87	-46.83	-0.52	34.87	46.83	0.52	1.6	0.69
SO4	FAL	13	1.64	1.5	0.22	-8.76	38.94	-0.14	0.64	0.57	-4.11	-15.41	-0.1	39.02	42.57	0.43	0.77	0.05
SO4	ALL	49	2.58	1.8	0.71	-30.07	37.45	-0.78	0.97	0.78	-25.76	-37.92	-0.43	37.57	47.32	0.54	1.17	0.5

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: PNF126																		
NH4	WIN	10	0.5	0.47	0.39	-6.34	38.68	-0.03	0.2	0.05	-2.9	-13.08	-0.07	38.14	40.78	0.41	0.22	0.16
NH4	SPR	12	0.77	0.48	0.41	-37.04	46.61	-0.28	0.36	0.13	-31.38	-50.99	-0.59	42.36	60.73	0.74	0.46	0.17
NH4	SUM	12	1.37	0.66	0.57	-51.6	51.6	-0.71	0.71	0.09	-52.31	-75.11	-1.07	52.31	75.11	1.07	0.77	0.32
NH4	FAL	13	0.51	0.45	0.11	-11.02	40.69	-0.06	0.21	0.06	-3.24	-17.94	-0.12	41.8	47.04	0.46	0.26	0.01
NH4	ALL	47	0.79	0.52	0.39	-34.71	46.69	-0.28	0.37	0.16	-22.88	-39.94	-0.53	43.85	56.37	0.72	0.48	0.15
NO3	WIN	10	0.33	0.57	0.3	73.53	138.37	0.24	0.45	0.24	132.31	2.59	0.74	197.59	105.05	1.38	0.55	0.09
NO3	SPR	12	0.33	0.21	0.25	-35.17	70.32	-0.12	0.23	0.07	-27.22	-65.93	-0.54	68.35	91.6	1.08	0.29	0.06
NO3	SUM	12	0.09	0.05	0.17	-49.45	54.43	-0.05	0.05	0	-32.93	-56.66	-0.98	41.46	64.35	1.08	0.08	0.03
NO3	FAL	13	0.38	0.17	0.53	-54.98	60.44	-0.21	0.23	0.03	-59.25	-97.48	-1.22	63.9	101.51	1.34	0.27	0.28
NO3	ALL	47	0.28	0.24	0.36	-16.97	82.07	-0.05	0.23	0.1	-3.59	-57.71	-0.2	87.75	90.25	0.99	0.33	0.13
SO4	WIN	10	1.32	1.58	0.1	19.49	51.57	0.26	0.68	1.01	34.8	12.65	0.19	57.88	40.18	0.52	1.04	0.01
SO4	SPR	12	2.33	1.65	0.2	-29.29	46.44	-0.68	1.08	1.08	-25.45	-43.5	-0.41	46.28	60.19	0.66	1.24	0.04
SO4	SUM	12	4.11	2.62	0.55	-36.28	40.45	-1.49	1.66	1.24	-36.96	-50.36	-0.57	40.75	53.76	0.63	1.86	0.31
SO4	FAL	13	1.34	1.58	0.18	17.55	56.02	0.24	0.75	0.95	24.81	2.91	0.18	58.99	49.51	0.56	1.01	0.03
SO4	ALL	47	2.3	1.86	0.46	-18.92	45.88	-0.43	1.05	1.6	-1.67	-20.47	-0.23	50.85	51.34	0.57	1.34	0.21
CASTNET Monitoring Station: PRK134																		
NH4	WIN	8	1.28	0.88	0.24	-31.12	64.6	-0.4	0.83	0.61	-31.81	-65.09	-0.45	63.94	91.19	0.94	0.88	0.06
NH4	SPR	14	0.85	0.91	0.6	7.23	65.03	0.06	0.55	0.46	7.49	-16.99	0.07	64.95	66.85	0.65	0.68	0.36
NH4	SUM	13	0.57	0.46	0.25	-18.26	56.46	-0.1	0.32	0.16	-3	-26.54	-0.22	55.03	62.52	0.69	0.42	0.06
NH4	FAL	10	0.55	0.65	0.55	17.8	67.37	0.1	0.37	0.21	17.11	-9.05	0.18	69.74	58.57	0.67	0.47	0.3
NH4	ALL	45	0.78	0.72	0.46	-7.73	63.46	-0.06	0.49	0.38	-0.39	-26.54	-0.08	62.97	68.08	0.69	0.62	0.21
NO3	WIN	8	2.75	2.08	0.46	-24.31	89.79	-0.67	2.47	6.48	-9.25	-69.24	-0.32	96.78	117.84	1.19	2.63	0.21
NO3	SPR	14	1.11	1.55	0.59	40.32	105.24	0.45	1.16	3.03	66.92	-22.17	0.4	140.08	106.48	1.05	1.8	0.35
NO3	SUM	13	0.27	0.24	0.13	-12.39	102.02	-0.03	0.28	0.1	14.22	-67.55	-0.14	121.49	121.37	1.16	0.32	0.02
NO3	FAL	10	0.77	0.94	0.54	22.14	104.94	0.17	0.81	1.05	95.79	-58.84	0.22	199.98	134.27	1.05	1.04	0.29
NO3	ALL	45	1.08	1.13	0.47	4.47	97.99	0.05	1.06	2.5	44.57	-51.8	0.04	140.32	118.98	0.98	1.58	0.22
SO4	WIN	8	1.53	0.87	0.35	-43.18	53.26	-0.66	0.82	0.36	-42.44	-62.99	-0.76	51.13	70.39	0.94	0.9	0.12
SO4	SPR	14	1.59	1.35	0.52	-14.71	41.5	-0.23	0.66	0.53	-9.08	-22.41	-0.17	43.39	49.71	0.49	0.77	0.27
SO4	SUM	13	1.48	1.13	0.26	-23.46	57.29	-0.35	0.85	1.11	-5.16	-27.49	-0.31	54.91	63.13	0.75	1.11	0.07
SO4	FAL	10	1.1	1.13	0.33	2.89	50.76	0.03	0.56	0.56	17.93	3.41	0.03	49.94	44.83	0.51	0.75	0.11
SO4	ALL	45	1.44	1.15	0.22	-19.73	50	-0.28	0.72	0.73	-7.88	-25.36	-0.25	49.55	56.18	0.62	0.9	0.05

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: PSU106																		
NH4	WIN	10	1.66	0.95	0.43	-42.93	47.84	-0.71	0.79	0.32	-39.13	-58.69	-0.75	47.56	65.96	0.84	0.91	0.18
NH4	SPR	14	1.04	0.76	0.21	-27.58	45.17	-0.29	0.47	0.26	-20.03	-36.12	-0.38	40.75	54.29	0.62	0.59	0.04
NH4	SUM	13	1.66	0.82	0.2	-50.92	56.33	-0.85	0.94	0.48	-49.19	-76.96	-1.04	54.95	82.21	1.15	1.09	0.04
NH4	FAL	11	0.84	0.75	0.1	-10.58	48.89	-0.09	0.41	0.25	-3.47	-21.99	-0.12	45.22	54.12	0.55	0.51	0.01
NH4	ALL	48	1.29	0.81	0.2	-37.26	50.33	-0.48	0.65	0.43	-28.11	-48.65	-0.59	47.04	64.24	0.8	0.81	0.04
NO3	WIN	10	2.69	2.12	0.01	-21.12	60.63	-0.57	1.63	3.3	13.82	-35.98	-0.27	90.14	80.35	0.77	1.9	0
NO3	SPR	14	0.97	1	0.28	2.36	108.1	0.02	1.05	1.75	96.58	-21.67	0.02	173.1	97.74	1.08	1.32	0.08
NO3	SUM	13	0.3	0.19	0.2	-34.49	118.99	-0.1	0.35	0.22	-9.55	-104.32	-0.53	131.77	140.48	1.82	0.48	0.04
NO3	FAL	11	0.8	0.7	0.41	-12.77	61.45	-0.1	0.49	0.33	-4.74	-37.39	-0.15	69.65	79.7	0.7	0.58	0.17
NO3	ALL	48	1.11	0.94	0.44	-14.68	77.17	-0.16	0.85	1.38	27.38	-50.64	-0.17	120.92	101.56	0.9	1.19	0.19
SO4	WIN	10	2.63	1.23	0.74	-53.35	53.35	-1.41	1.41	0.39	-52.47	-73.85	-1.14	52.47	73.85	1.14	1.54	0.54
SO4	SPR	14	2.39	1.48	0.04	-38.39	52.92	-0.92	1.27	1.21	-31.08	-52.76	-0.62	53.19	67.43	0.86	1.43	0
SO4	SUM	13	4.49	2.51	0.22	-44.15	52.23	-1.98	2.34	4.41	-42.07	-67.02	-0.79	49.8	73.87	0.94	2.89	0.05
SO4	FAL	11	1.98	1.69	0.22	-14.36	48.57	-0.28	0.96	1.51	-11.1	-29.35	-0.17	44.98	54.87	0.57	1.26	0.05
SO4	ALL	48	2.92	1.75	0.37	-39.88	52.04	-1.16	1.52	2.36	-33.93	-55.65	-0.66	50.24	67.63	0.87	1.93	0.14
CASTNET Monitoring Station: QAK172																		
NH4	WIN	10	1.25	0.78	0.56	-37.81	41.71	-0.47	0.52	0.16	-35.06	-50.58	-0.61	40.65	55.74	0.67	0.62	0.32
NH4	SPR	11	1.12	0.59	0.45	-47.51	47.51	-0.53	0.53	0.12	-42.38	-57.73	-0.91	42.38	57.73	0.91	0.63	0.2
NH4	SUM	13	1.72	0.81	0.2	-52.78	52.78	-0.91	0.91	0.27	-50.68	-72.83	-1.12	50.68	72.83	1.12	1.05	0.04
NH4	FAL	13	0.93	0.74	0.12	-19.67	43.76	-0.18	0.41	0.23	-15.35	-31.34	-0.24	42.64	54.22	0.54	0.51	0.01
NH4	ALL	47	1.26	0.73	0.3	-41.79	47.51	-0.53	0.6	0.27	-35.64	-53.09	-0.72	44.38	60.51	0.82	0.74	0.09
NO3	WIN	10	1.73	1.3	0.07	-24.9	63.24	-0.43	1.09	1.96	1.04	-30.74	-0.33	72.03	71.33	0.84	1.47	0
NO3	SPR	11	0.76	0.43	0.13	-42.65	66.87	-0.32	0.51	0.56	-16.35	-54.25	-0.74	69.64	78.51	1.17	0.82	0.02
NO3	SUM	13	0.31	0.14	0.46	-56.09	72.8	-0.17	0.23	0.04	-40.99	-82.04	-1.28	69.41	98.77	1.66	0.27	0.21
NO3	FAL	13	0.67	0.57	0.45	-15.45	66.42	-0.1	0.45	0.33	-20.68	-49.77	-0.18	60.63	76.72	0.79	0.58	0.2
NO3	ALL	47	0.82	0.57	0.44	-29.87	65.75	-0.24	0.54	0.67	-20.66	-55.7	-0.43	67.59	82.09	0.94	0.85	0.19
SO4	WIN	10	2.79	1.33	0.34	-52.17	54.39	-1.45	1.52	1.37	-48.68	-71.56	-1.09	51.14	73.88	1.14	1.87	0.12
SO4	SPR	11	3.08	1.42	0.52	-54.02	54.02	-1.66	1.66	0.62	-51.43	-73.67	-1.17	51.43	73.67	1.17	1.84	0.27
SO4	SUM	13	5.37	2.46	0.02	-54.3	54.3	-2.92	2.92	3.34	-50.6	-74.78	-1.19	50.6	74.78	1.19	3.44	0
SO4	FAL	13	2.56	2.29	0.08	-10.79	54.01	-0.28	1.38	3.11	-5.35	-26.77	-0.12	53.06	59.26	0.61	1.79	0.01
SO4	ALL	47	3.51	1.93	0.24	-45.09	54.2	-1.58	1.9	3.19	-37.87	-60.55	-0.82	51.59	70.03	0.99	2.39	0.06

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: ROM206																		
NH4	WIN	11	0.12	0.22	0.25	79.05	111.06	0.1	0.13	0.02	134.54	47.02	0.79	153.69	70.42	1.11	0.17	0.06
NH4	SPR	14	0.22	0.14	0.09	-35.62	62.37	-0.08	0.14	0.02	-26.15	-55.92	-0.55	63.23	72.4	0.97	0.17	0.01
NH4	SUM	13	0.26	0.1	0.35	-62.92	62.92	-0.16	0.16	0	-61.57	-93.36	-1.7	61.57	93.36	1.7	0.17	0.12
NH4	FAL	12	0.19	0.19	0.2	1.72	51.45	0	0.1	0.01	19.04	-2.13	0.02	60.08	50.06	0.51	0.12	0.04
NH4	ALL	50	0.2	0.16	0.37	-21.18	66.5	-0.04	0.13	0.02	10.84	-30.1	-0.27	81.94	72.05	0.84	0.16	0.13
NO3	WIN	11	0.11	0.31	0.36	180.73	295.73	0.2	0.32	0.15	618	21.09	1.81	690.2	144.76	2.96	0.44	0.13
NO3	SPR	14	0.25	0.14	0.09	-45.9	97.14	-0.12	0.24	0.09	-41.25	-108.82	-0.85	96.69	131.21	1.8	0.32	0.01
NO3	SUM	13	0.14	0.01	0.52	-91.78	91.78	-0.13	0.13	0	-89.75	-164.84	-11.17	89.75	164.84	11.17	0.14	0.28
NO3	FAL	12	0.12	0.19	0.08	59.68	150.34	0.07	0.18	0.05	122.94	-37.23	0.6	213.72	121.67	1.5	0.23	0.01
NO3	ALL	50	0.16	0.15	0.12	-3.6	135.31	-0.01	0.22	0.09	130.58	-77.62	-0.04	253.55	140.64	1.4	0.3	0.01
SO4	WIN	11	0.28	0.44	0.25	54.29	67.68	0.15	0.19	0.02	76.17	45.5	0.54	84.08	55.1	0.68	0.21	0.06
SO4	SPR	14	0.61	0.37	0.23	-39.32	49.11	-0.24	0.3	0.07	-30.55	-47.15	-0.65	46.48	59.95	0.81	0.36	0.05
SO4	SUM	13	0.63	0.28	0.17	-55.79	55.79	-0.35	0.35	0.02	-54.51	-79.7	-1.26	54.51	79.7	1.26	0.39	0.03
SO4	FAL	12	0.44	0.43	0.19	-3.24	35.57	-0.01	0.16	0.05	13.78	0.9	-0.03	41.13	35.42	0.37	0.22	0.03
SO4	ALL	50	0.5	0.37	0.21	-25.61	50.74	-0.13	0.26	0.08	-2.66	-23.7	-0.34	55.55	58.13	0.68	0.31	0.04
CASTNET Monitoring Station: ROM406																		
NH4	WIN	11	0.12	0.22	0.18	74.24	107.69	0.09	0.13	0.02	129.54	45.39	0.74	149.66	70.11	1.08	0.17	0.03
NH4	SPR	14	0.23	0.14	0.05	-37.92	62.13	-0.09	0.14	0.02	-30.51	-58.76	-0.61	61.08	73.53	1	0.18	0
NH4	SUM	13	0.27	0.1	0.41	-64.14	64.14	-0.17	0.17	0	-62.88	-95.93	-1.79	62.88	95.93	1.79	0.18	0.17
NH4	FAL	12	0.2	0.19	0.17	-1.5	49.36	0	0.1	0.01	13.74	-5.1	-0.02	55.43	48.38	0.5	0.12	0.03
NH4	ALL	50	0.21	0.16	0.34	-23.75	65.89	-0.05	0.14	0.02	6.91	-32.63	-0.31	79.68	72.57	0.86	0.16	0.11
NO3	WIN	11	0.11	0.31	0.31	174.31	290.13	0.2	0.33	0.15	563.51	22.87	1.74	633.74	143.49	2.9	0.44	0.1
NO3	SPR	14	0.27	0.14	0.12	-49.54	94.96	-0.13	0.26	0.09	-47.56	-114.15	-0.98	93.11	132.71	1.88	0.32	0.01
NO3	SUM	13	0.15	0.01	0.61	-92.25	92.25	-0.14	0.14	0	-90.42	-166.81	-11.9	90.42	166.81	11.9	0.15	0.37
NO3	FAL	12	0.12	0.19	0.14	61.75	152	0.07	0.18	0.05	106.31	-37.2	0.62	199.22	124.17	1.52	0.23	0.02
NO3	ALL	50	0.17	0.15	0.1	-7.92	132.65	-0.01	0.22	0.09	112.66	-79.23	-0.09	236.82	141.9	1.44	0.3	0.01
SO4	WIN	11	0.28	0.44	0.17	54.89	67.98	0.15	0.19	0.02	75.92	45.74	0.55	84.15	55.28	0.68	0.21	0.03
SO4	SPR	14	0.63	0.37	0.26	-40.8	49.51	-0.26	0.31	0.07	-32.07	-48.99	-0.69	46.66	60.76	0.84	0.37	0.07
SO4	SUM	13	0.65	0.28	0.2	-56.97	56.97	-0.37	0.37	0.02	-55.71	-81.92	-1.32	55.71	81.92	1.32	0.4	0.04
SO4	FAL	12	0.45	0.43	0.15	-6.32	35.3	-0.03	0.16	0.05	8.49	-2.25	-0.07	37.89	35	0.38	0.22	0.02
SO4	ALL	50	0.52	0.37	0.19	-27.35	51.17	-0.14	0.26	0.08	-4.72	-25.49	-0.38	55.15	58.87	0.7	0.32	0.03

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: SAL133																		
NH4	WIN	10	2.06	1.24	0.13	-40.12	54.44	-0.83	1.12	0.94	-36.86	-55.52	-0.67	50.7	65.81	0.91	1.27	0.02
NH4	SPR	14	1.26	1.55	0.45	22.73	55.27	0.29	0.7	0.79	20.37	0.88	0.23	55.43	48.99	0.55	0.93	0.21
NH4	SUM	13	1.43	1.13	0.06	-21.06	32.97	-0.3	0.47	0.31	-12.02	-23.2	-0.27	32.94	39.15	0.42	0.63	0
NH4	FAL	10	0.87	1.23	0.26	41.23	69.25	0.36	0.6	0.42	53.62	20.49	0.41	77.31	61.07	0.69	0.74	0.07
NH4	ALL	47	1.39	1.3	0.1	-7.01	50.55	-0.1	0.7	0.82	6.31	-13.61	-0.08	52.86	52.42	0.54	0.91	0.01
NO3	WIN	10	4.78	3.1	0.01	-35.13	57.46	-1.68	2.75	7.44	-28.6	-49.97	-0.54	53.09	65.16	0.89	3.2	0
NO3	SPR	14	1.62	2.69	0.61	65.78	100.5	1.07	1.63	2.75	223.4	40.76	0.66	250.79	82.15	1	1.97	0.37
NO3	SUM	13	0.48	0.85	0.28	79.16	98.58	0.38	0.47	0.52	99.28	31.1	0.79	119.39	56.69	0.99	0.81	0.08
NO3	FAL	10	1.3	2.46	0.67	89.19	103.05	1.16	1.34	1.51	74.69	30.08	0.89	102.69	73.87	1.03	1.69	0.44
NO3	ALL	47	1.91	2.22	0.44	16.3	77.8	0.31	1.49	4.03	103.81	16.51	0.16	140.87	69.73	0.78	2.03	0.19
SO4	WIN	10	2.4	0.92	0.13	-61.59	61.59	-1.48	1.48	0.84	-58.37	-86.89	-1.6	58.37	86.89	1.6	1.74	0.02
SO4	SPR	14	2.58	2.1	0.05	-18.61	51.9	-0.48	1.34	2.71	-13.62	-37.46	-0.23	56.8	59.53	0.64	1.72	0
SO4	SUM	13	3.87	2.45	0.08	-36.65	42.92	-1.42	1.66	2.32	-28.9	-44.52	-0.58	40.68	53.46	0.68	2.08	0.01
SO4	FAL	10	1.97	1.48	0.43	-24.62	53.73	-0.48	1.06	1.55	-12.79	-33.27	-0.33	49.89	60.93	0.71	1.34	0.19
SO4	ALL	47	2.77	1.82	0.22	-34.42	50.49	-0.95	1.4	2.19	-27.19	-49.04	-0.52	51.2	63.97	0.77	1.76	0.05
CASTNET Monitoring Station: SAN189																		
NH4	WIN	9	0.92	0.88	0.23	-4.25	66.15	-0.04	0.61	0.71	23.96	-13.75	-0.04	81.29	61.64	0.69	0.84	0.05
NH4	SPR	13	1.01	1.24	0.68	23.63	77.62	0.24	0.78	1.08	20.74	-8.4	0.24	70.12	68.57	0.78	1.07	0.46
NH4	SUM	13	0.57	0.51	0.07	-10.99	67.67	-0.06	0.39	0.28	3.47	-32.18	-0.12	73.4	71.42	0.76	0.54	0.01
NH4	FAL	13	0.4	0.6	0.26	47.98	85.14	0.19	0.34	0.28	45.98	8.96	0.48	81.68	57.91	0.85	0.56	0.07
NH4	ALL	48	0.71	0.8	0.54	13.04	73.81	0.09	0.52	0.6	23.5	-11.14	0.13	76.23	65.16	0.74	0.78	0.29
NO3	WIN	9	2.02	2.16	0.23	6.7	68.95	0.14	1.39	3.98	45.05	-6.35	0.07	96.17	62.22	0.69	2	0.06
NO3	SPR	13	1.9	2.35	0.46	23.39	91.91	0.44	1.75	6.45	74.48	-19.09	0.23	139.05	87.51	0.92	2.58	0.21
NO3	SUM	13	0.68	0.26	0.17	-61.33	82.58	-0.42	0.56	0.26	-51.11	-105.74	-1.59	78.47	123.55	2.14	0.66	0.03
NO3	FAL	13	0.83	1.22	0.23	48.2	139	0.4	1.15	3.16	51.58	-37.23	0.48	138.46	112.61	1.39	1.82	0.05
NO3	ALL	48	1.3	1.44	0.47	10.75	91.99	0.14	1.2	3.55	28.75	-45.08	0.11	114.44	99.33	0.92	1.89	0.22
SO4	WIN	9	1.07	0.74	0.3	-31.18	62.39	-0.33	0.67	0.54	-30.37	-51.1	-0.45	55.83	67.29	0.91	0.81	0.09
SO4	SPR	13	1.72	1.55	0.63	-9.66	57.6	-0.17	0.99	1.53	-15	-36.85	-0.11	52.69	64.61	0.64	1.25	0.39
SO4	SUM	13	1.7	1.22	0.11	-28.46	57.46	-0.48	0.98	1.46	-20.13	-50.47	-0.4	60.19	69.27	0.8	1.3	0.01
SO4	FAL	13	0.91	0.75	0.5	-18.27	32.16	-0.17	0.29	0.12	-16.02	-24.18	-0.22	30.4	36.45	0.39	0.38	0.25
SO4	ALL	48	1.37	1.09	0.42	-20.66	53.68	-0.28	0.74	0.96	-19.55	-39.78	-0.26	49.27	58.75	0.68	1.02	0.17

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: SHN418																		
NH4	WIN	10	0.75	0.87	0.63	16.88	36.52	0.13	0.27	0.1	17.37	9.56	0.17	37.26	32.97	0.37	0.35	0.4
NH4	SPR	14	0.8	0.65	0.42	-19.5	41.59	-0.16	0.33	0.19	-13.32	-30.26	-0.24	39.83	50.62	0.52	0.46	0.18
NH4	SUM	12	1.44	1.14	0.67	-20.84	33.42	-0.3	0.48	0.25	-21.71	-33.88	-0.26	35.74	45.11	0.42	0.58	0.45
NH4	FAL	13	0.59	1.03	0.12	75.81	109.71	0.44	0.64	0.59	97.11	34.3	0.76	121.53	68.59	1.1	0.89	0.01
NH4	ALL	49	0.89	0.91	0.39	2.87	49.39	0.03	0.44	0.38	20.19	-5.89	0.03	59.98	50.44	0.49	0.61	0.15
NO3	WIN	10	0.84	1.68	0.34	100.3	117.55	0.84	0.99	0.89	200.61	59.25	1	216.32	78.3	1.18	1.26	0.12
NO3	SPR	14	0.46	0.69	0.67	48.45	84.1	0.22	0.39	0.27	43.61	5.24	0.48	83.74	65.28	0.84	0.57	0.44
NO3	SUM	12	0.21	0.4	0.16	87	129.85	0.19	0.28	0.08	168.54	45.77	0.87	198.69	86.65	1.3	0.34	0.03
NO3	FAL	13	0.49	1.46	0.12	195.57	203.34	0.96	1	1.41	281.23	78.68	1.96	288.55	87.05	2.03	1.53	0.01
NO3	ALL	49	0.49	1.02	0.46	110.33	132.81	0.54	0.65	0.78	169.29	45.67	1.1	193.28	78.95	1.33	1.03	0.21
SO4	WIN	10	1.55	1.32	0.24	-14.86	31.7	-0.23	0.49	0.36	-11.16	-20.52	-0.17	30.73	37.1	0.37	0.64	0.06
SO4	SPR	14	2.14	1.41	0.52	-34.2	39.74	-0.73	0.85	0.62	-32.79	-47.57	-0.52	38.15	52.35	0.6	1.08	0.27
SO4	SUM	12	4.22	2.79	0.76	-33.88	36.01	-1.43	1.52	1.19	-35.45	-49.63	-0.51	37.89	51.91	0.54	1.8	0.58
SO4	FAL	13	1.52	1.74	0.18	14.85	65.42	0.23	0.99	2.63	22.6	-2.3	0.15	60.92	51.75	0.65	1.64	0.03
SO4	ALL	49	2.36	1.82	0.59	-23.12	41.41	-0.55	0.98	1.62	-14.33	-30.54	-0.3	42.61	48.97	0.54	1.38	0.35
CASTNET Monitoring Station: SND152																		
NH4	WIN	11	1.38	1.13	0.5	-17.68	29.66	-0.24	0.41	0.18	-17.76	-24.52	-0.21	28.22	33.85	0.36	0.49	0.25
NH4	SPR	11	1.27	1.1	0.22	-13.06	32.73	-0.17	0.41	0.25	-9.54	-18.42	-0.15	33.31	37.04	0.38	0.53	0.05
NH4	SUM	13	1.43	1	0.46	-29.81	38.12	-0.43	0.54	0.19	-29.43	-42.6	-0.42	40.51	51.39	0.54	0.61	0.21
NH4	FAL	13	0.8	0.85	0.09	5.44	50.8	0.04	0.41	0.26	13.8	-10.42	0.05	57.42	55.06	0.51	0.51	0.01
NH4	ALL	48	1.21	1.01	0.37	-16.29	36.9	-0.2	0.45	0.25	-10.49	-24.2	-0.19	40.62	45.08	0.44	0.54	0.14
NO3	WIN	11	2.18	2.08	0.47	-4.86	36.05	-0.11	0.79	0.96	-2.21	-10.53	-0.05	33.87	34.85	0.38	0.99	0.22
NO3	SPR	11	0.86	0.85	0.67	-2.11	39.64	-0.02	0.34	0.16	10.35	-5.87	-0.02	49.44	43.59	0.4	0.4	0.44
NO3	SUM	13	0.32	0.26	0.04	-18.2	68.65	-0.06	0.22	0.06	-0.05	-32.54	-0.22	74.3	78.6	0.84	0.25	0
NO3	FAL	13	0.78	0.99	0.09	26.91	70.67	0.21	0.55	0.38	43.72	5.79	0.27	88.05	65.04	0.71	0.65	0.01
NO3	ALL	48	1	1.01	0.75	1.29	46.94	0.01	0.47	0.39	13.69	-11	0.01	63.06	56.88	0.47	0.63	0.56
SO4	WIN	11	2.31	1.7	0.31	-26.55	35.79	-0.61	0.83	0.58	-25.44	-34.13	-0.36	34.26	41.23	0.49	0.98	0.1
SO4	SPR	11	3.43	2.67	0.05	-22.11	34.65	-0.76	1.19	1.75	-19.06	-29.29	-0.28	33.54	40.92	0.44	1.52	0
SO4	SUM	13	3.82	2.61	0.5	-31.75	40.22	-1.21	1.54	1.15	-32.1	-45.85	-0.47	42.53	54.64	0.59	1.62	0.25
SO4	FAL	13	1.96	1.73	0.02	-11.46	52.48	-0.22	1.03	1.46	-4.82	-29.61	-0.13	56.05	64	0.59	1.23	0
SO4	ALL	48	2.88	2.18	0.43	-24.43	40.14	-0.7	1.16	1.38	-20.19	-34.97	-0.32	42.24	50.96	0.53	1.37	0.19

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: SPD111																		
NH4	WIN	11	1.02	0.72	0.19	-28.97	34.28	-0.29	0.35	0.14	-24.5	-33.81	-0.41	30.11	39.02	0.48	0.48	0.04
NH4	SPR	14	0.96	0.69	0.2	-27.98	38.8	-0.27	0.37	0.13	-25.19	-39.2	-0.39	38.36	50.6	0.54	0.45	0.04
NH4	SUM	13	1.22	0.77	0.72	-36.76	38.92	-0.45	0.47	0.06	-35.38	-46.38	-0.58	39.41	49.94	0.62	0.51	0.51
NH4	FAL	13	0.54	0.7	0.21	28.99	60.45	0.16	0.33	0.12	33.38	11.49	0.29	61.55	55.7	0.6	0.38	0.05
NH4	ALL	51	0.93	0.72	0.28	-22.68	40.99	-0.21	0.38	0.16	-12.71	-26.94	-0.29	42.76	49.23	0.53	0.45	0.08
NO3	WIN	11	1.02	0.84	0.25	-17.85	45.01	-0.18	0.46	0.37	3.12	-11.63	-0.22	44.48	48.21	0.55	0.64	0.06
NO3	SPR	14	0.32	0.41	0.53	30.82	78.44	0.1	0.25	0.12	56.85	0.33	0.31	105.66	72.91	0.78	0.36	0.28
NO3	SUM	13	0.09	0.06	0.13	-37.62	65.04	-0.04	0.06	0	-36.6	-62.88	-0.6	60.55	79.01	1.04	0.07	0.02
NO3	FAL	13	0.36	0.57	0.57	56.46	106.03	0.2	0.38	0.22	47.28	-5.54	0.56	103.49	86.27	1.06	0.51	0.33
NO3	ALL	51	0.42	0.45	0.56	7.23	66.32	0.03	0.28	0.19	19	-19.86	0.07	80.41	72.54	0.66	0.44	0.31
SO4	WIN	11	2.25	1.61	0.21	-28.3	38.29	-0.64	0.86	0.78	-23.52	-32.45	-0.39	33.38	40.88	0.53	1.09	0.04
SO4	SPR	14	3	1.81	0.36	-39.8	42.54	-1.19	1.28	0.69	-38.26	-53.02	-0.66	41.67	56.18	0.71	1.46	0.13
SO4	SUM	13	3.87	2.83	0.47	-27	39.41	-1.05	1.53	1.5	-26.47	-38.31	-0.37	40.49	50.47	0.54	1.61	0.22
SO4	FAL	13	1.63	1.88	0.38	15.12	58.98	0.25	0.96	1.51	16.62	-5.53	0.15	58.96	55.9	0.59	1.25	0.15
SO4	ALL	51	2.71	2.04	0.45	-24.65	43.16	-0.67	1.17	1.45	-18.09	-32.73	-0.33	43.99	51.35	0.57	1.38	0.2
CASTNET Monitoring Station: STK138																		
NH4	WIN	10	2.17	1.49	0.18	-31.51	49.13	-0.68	1.07	1.26	-24.38	-46.01	-0.46	46.21	62.22	0.72	1.31	0.03
NH4	SPR	14	1.26	1.35	0.64	7.21	53.38	0.09	0.67	0.64	10.76	-14.57	0.07	60.19	61.5	0.53	0.8	0.4
NH4	SUM	11	0.84	0.67	0.25	-19.82	52.86	-0.17	0.44	0.27	-6.46	-28.02	-0.25	51.07	60.45	0.66	0.54	0.06
NH4	FAL	13	0.88	1.05	0.38	19.35	62	0.17	0.55	0.46	36.7	1.72	0.19	77.15	56.2	0.62	0.7	0.15
NH4	ALL	48	1.25	1.14	0.45	-8.65	53.41	-0.11	0.67	0.74	6.52	-19.79	-0.09	59.78	59.97	0.58	0.86	0.2
NO3	WIN	10	5.29	3.65	0.24	-30.98	52.6	-1.64	2.78	9.7	-18.25	-45.21	-0.45	51.75	65.67	0.76	3.52	0.06
NO3	SPR	14	2.26	2.7	0.74	19.68	66.24	0.44	1.5	4.45	18.42	-19.97	0.2	72.02	71.88	0.66	2.15	0.54
NO3	SUM	11	0.66	0.31	0.43	-53.36	78.57	-0.35	0.52	0.2	-37.65	-88.89	-1.14	82.75	112.95	1.68	0.57	0.19
NO3	FAL	13	1.68	2.1	0.45	25.12	81.22	0.42	1.36	2.42	35.26	-16.29	0.25	101.47	87.9	0.81	1.61	0.21
NO3	ALL	48	2.37	2.19	0.53	-7.54	63.54	-0.18	1.5	4.68	2.49	-40.03	-0.08	78.23	84.33	0.69	2.17	0.28
SO4	WIN	10	2.13	1.23	0.57	-42.53	50.82	-0.91	1.08	0.91	-44.18	-66.77	-0.74	49.13	71.17	0.88	1.31	0.33
SO4	SPR	14	2.06	1.58	0.17	-23.46	52.06	-0.48	1.07	1.26	-14.36	-34.7	-0.31	53.19	61.3	0.68	1.22	0.03
SO4	SUM	11	2.44	1.66	0.01	-32.09	47.87	-0.78	1.17	1.95	-22.26	-40.92	-0.47	43.78	58.46	0.7	1.6	0
SO4	FAL	13	1.55	1.3	0	-16.28	57.05	-0.25	0.89	1.16	-5.11	-25.99	-0.19	55.6	58.9	0.68	1.11	0
SO4	ALL	48	2.03	1.45	0.15	-28.54	51.66	-0.58	1.05	1.38	-19.88	-40.45	-0.4	50.84	62.05	0.72	1.31	0.02

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: SUM156																		
NH4	WIN	11	0.55	0.65	0.33	18.45	65.86	0.1	0.36	0.36	19.38	-7.34	0.18	61.98	51.99	0.66	0.61	0.11
NH4	SPR	14	0.52	0.37	0.03	-28.42	54.69	-0.15	0.29	0.09	-19.31	-47.03	-0.4	54.51	74.56	0.76	0.34	0
NH4	SUM	13	0.6	0.34	0.22	-43.7	65.89	-0.26	0.39	0.14	-40.38	-84.96	-0.78	72.91	102.59	1.17	0.46	0.05
NH4	FAL	13	0.44	0.35	0.66	-20.88	56.29	-0.09	0.25	0.08	-25.12	-56.25	-0.26	60.81	82.15	0.71	0.3	0.44
NH4	ALL	51	0.53	0.42	0.31	-20.66	60.78	-0.11	0.32	0.18	-17.82	-50.49	-0.26	62.42	78.77	0.77	0.43	0.1
NO3	WIN	11	0.44	1.37	0	212.5	249.5	0.93	1.09	2.38	389.35	49.69	2.13	420.09	95.92	2.49	1.8	0
NO3	SPR	14	0.39	0.28	0.09	-27.39	82.56	-0.11	0.32	0.18	-9.17	-69.62	-0.38	98.28	105.82	1.14	0.44	0.01
NO3	SUM	13	0.16	0.28	0.13	79.64	182.39	0.13	0.29	0.19	162.24	-23.69	0.8	244.35	110.61	1.82	0.46	0.02
NO3	FAL	13	0.43	0.37	0.57	-13.4	57.36	-0.06	0.25	0.11	-14.35	-40.47	-0.15	51.89	67.67	0.66	0.34	0.33
NO3	ALL	51	0.35	0.54	0.17	53.48	130.84	0.19	0.46	0.8	119.16	-24.75	0.53	193.1	95.18	1.31	0.91	0.03
SO4	WIN	11	2.16	1.62	0.8	-24.75	30.06	-0.53	0.65	0.26	-26.92	-36.59	-0.33	32.79	41.86	0.4	0.74	0.64
SO4	SPR	14	2.82	1.92	0.11	-32.09	43.46	-0.91	1.23	1.2	-30.98	-48.06	-0.47	42.8	57.85	0.64	1.42	0.01
SO4	SUM	13	2.7	1.62	0.53	-40.07	49.56	-1.08	1.34	1.15	-41.48	-69.47	-0.67	52.62	77.8	0.83	1.52	0.28
SO4	FAL	13	1.87	1.26	0.85	-32.39	35.73	-0.6	0.67	0.27	-35.14	-50.82	-0.48	38.06	53.49	0.53	0.8	0.71
SO4	ALL	51	2.4	1.61	0.58	-33.02	41.09	-0.79	0.99	0.8	-33.84	-51.75	-0.49	41.94	58.37	0.61	1.19	0.34
CASTNET Monitoring Station: THR422																		
NH4	WIN	11	0.35	0.52	0.33	46.84	81.09	0.17	0.29	0.13	58.58	22.93	0.47	87.13	60.46	0.81	0.4	0.11
NH4	SPR	12	0.6	0.45	0.28	-24.08	67.7	-0.14	0.41	0.28	-17.85	-59.66	-0.32	76.58	82.05	0.89	0.55	0.08
NH4	SUM	13	0.31	0.21	0.25	-32.38	39.83	-0.1	0.12	0.01	-29.23	-42.75	-0.48	38.08	50.81	0.59	0.15	0.06
NH4	FAL	13	0.25	0.39	0.13	54.48	85.08	0.14	0.22	0.07	69.58	25.07	0.54	97.3	61.31	0.85	0.3	0.02
NH4	ALL	49	0.38	0.39	0.26	3.16	67.53	0.01	0.25	0.14	19.48	-14.16	0.03	74.23	63.41	0.68	0.37	0.07
NO3	WIN	11	0.58	1.21	0.08	108.88	171.01	0.63	0.99	1.34	180.48	41.56	1.09	217.45	97.02	1.71	1.32	0.01
NO3	SPR	12	0.85	0.74	0.19	-13.74	99.14	-0.12	0.85	1.42	-0.5	-83.25	-0.16	115.76	121.99	1.15	1.2	0.04
NO3	SUM	13	0.27	0.08	0.07	-70.55	70.55	-0.19	0.19	0.02	-67.83	-116.84	-2.4	67.83	116.84	2.4	0.23	0.01
NO3	FAL	13	0.42	0.65	0.05	52.73	114.53	0.22	0.49	0.36	92.26	-7.69	0.53	151.96	95.21	1.15	0.64	0
NO3	ALL	49	0.52	0.65	0.23	23.22	116.38	0.12	0.61	0.85	46.87	-44.1	0.23	135.48	107.91	1.16	0.93	0.05
SO4	WIN	11	0.82	0.52	0.18	-37.43	56.38	-0.31	0.46	0.23	-24.43	-43.64	-0.6	51.77	61.7	0.9	0.57	0.03
SO4	SPR	12	1.34	0.69	0	-48.29	65.54	-0.65	0.88	0.6	-38.99	-74.98	-0.93	69.44	90.89	1.27	1.01	0
SO4	SUM	13	0.93	0.54	0.3	-42.32	44.21	-0.4	0.41	0.13	-37.35	-53.09	-0.73	39.84	55.46	0.77	0.53	0.09
SO4	FAL	13	0.77	0.6	0.33	-21.63	32.16	-0.17	0.25	0.09	-16.91	-27.25	-0.28	31.55	39.61	0.41	0.34	0.11
SO4	ALL	49	0.96	0.59	0.07	-39.06	51.28	-0.38	0.49	0.29	-29.43	-49.47	-0.64	47.57	61.33	0.84	0.66	0

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: UVL124																		
NH4	WIN	11	1.36	1.07	0.28	-21.4	75.19	-0.29	1.02	1.1	-15.21	-51.26	-0.27	74.75	91.94	0.96	1.09	0.08
NH4	SPR	13	0.92	0.82	0.42	-11.36	49.52	-0.1	0.46	0.28	-4.53	-27.05	-0.13	52.24	61.1	0.56	0.54	0.18
NH4	SUM	12	0.82	0.89	0.28	8.4	94.43	0.07	0.77	0.98	23.66	-27.17	0.08	97.79	85.29	0.94	0.99	0.08
NH4	FAL	13	0.86	1.19	0	38.09	95.44	0.33	0.82	0.87	53.57	2.31	0.38	104.65	83.17	0.95	0.99	0
NH4	ALL	49	0.98	0.99	0.01	1.12	77.43	0.01	0.76	0.84	15.39	-24.72	0.01	82.35	79.8	0.77	0.92	0
NO3	WIN	11	2.97	2.59	0.61	-12.84	104.31	-0.38	3.1	11.16	8.14	-55.32	-0.15	108.99	118.18	1.2	3.36	0.37
NO3	SPR	13	1.2	1.52	0.67	26.51	84.99	0.32	1.02	1.6	36.23	-20.76	0.27	105.44	91.91	0.85	1.3	0.45
NO3	SUM	12	0.36	1.01	0.28	178.65	253.96	0.65	0.92	2.02	169.02	-2.8	1.79	237.88	108.71	2.54	1.56	0.08
NO3	FAL	13	1.3	2.18	0.41	67.48	120.02	0.88	1.56	2.95	135.98	9.23	0.67	188.92	103.2	1.2	1.93	0.16
NO3	ALL	49	1.42	1.81	0.25	27.52	113.17	0.39	1.61	4.42	88.91	-16.16	0.28	160.82	104.92	1.13	2.14	0.06
SO4	WIN	11	1.75	0.87	0.21	-50.45	52.06	-0.88	0.91	0.33	-48.89	-71.56	-1.02	50.74	73.32	1.05	1.06	0.04
SO4	SPR	13	1.85	1.08	0.01	-41.76	47.72	-0.77	0.88	0.54	-34.13	-53.11	-0.72	45.19	61.25	0.82	1.07	0
SO4	SUM	12	2.23	1.67	0.31	-25.03	66.89	-0.56	1.49	2.61	-15.1	-46.53	-0.33	67.94	78.43	0.89	1.71	0.09
SO4	FAL	13	1.71	1.62	0.09	-5.68	70.75	-0.1	1.21	2.56	0.83	-28.04	-0.06	66.25	69.99	0.75	1.6	0.01
SO4	ALL	49	1.89	1.32	0.02	-30.04	59.73	-0.57	1.13	1.63	-23.51	-48.99	-0.43	57.59	70.48	0.85	1.4	0
CASTNET Monitoring Station: VIN140																		
NH4	WIN	11	2.25	1.52	0.5	-32.5	45.32	-0.73	1.02	0.8	-24.87	-39.57	-0.48	45.13	55.74	0.67	1.15	0.25
NH4	SPR	13	1.3	1.12	0.45	-13.6	36.22	-0.18	0.47	0.3	-14.74	-24.89	-0.16	35.8	41.25	0.42	0.57	0.2
NH4	SUM	13	1.41	1.14	0.01	-19.46	49.12	-0.27	0.69	0.58	-7.48	-27.39	-0.24	53.24	59.21	0.61	0.81	0
NH4	FAL	13	0.84	1.07	0.27	27.51	86.36	0.23	0.72	0.89	49.25	3.98	0.28	91.02	66.5	0.86	0.97	0.07
NH4	ALL	50	1.42	1.2	0.3	-15.42	50.44	-0.22	0.72	0.74	1.55	-21.26	-0.18	56.74	55.67	0.6	0.89	0.09
NO3	WIN	11	4.61	3.65	0.26	-20.7	50.17	-0.95	2.31	6.53	-5.11	-27.99	-0.26	58.58	62.23	0.63	2.73	0.07
NO3	SPR	13	1.49	1.74	0.55	16.48	58.85	0.25	0.88	1.84	12.56	-6.72	0.16	51.89	49.91	0.59	1.38	0.3
NO3	SUM	13	0.75	0.46	0.22	-39.36	71.61	-0.3	0.54	0.34	-26.54	-71.75	-0.65	78.52	91.75	1.18	0.66	0.05
NO3	FAL	13	1.23	1.8	0.09	46.51	106.66	0.57	1.31	4.16	84.63	-11.26	0.47	142.98	75.62	1.07	2.12	0.01
NO3	ALL	50	1.92	1.84	0.53	-3.86	63.54	-0.07	1.22	3.4	17.24	-29.49	-0.04	83.97	70.18	0.66	1.85	0.28
SO4	WIN	11	3.07	1.52	0.91	-50.52	50.52	-1.55	1.55	0.38	-50.97	-70.4	-1.02	50.97	70.4	1.02	1.67	0.83
SO4	SPR	13	3.29	1.76	0.08	-46.65	49.22	-1.54	1.62	1.07	-44.07	-62.52	-0.87	46.84	65.1	0.92	1.85	0.01
SO4	SUM	13	5.05	2.94	0.18	-41.76	57.5	-2.11	2.9	6.55	-32.43	-57.32	-0.72	56.66	76.26	0.99	3.32	0.03
SO4	FAL	13	2.14	1.57	0.14	-26.58	50.56	-0.57	1.08	1.57	-22.69	-41.15	-0.36	47.4	62.01	0.69	1.38	0.02
SO4	ALL	50	3.4	1.97	0.33	-42.24	52.89	-1.44	1.8	2.79	-37	-57.34	-0.73	50.45	68.37	0.92	2.2	0.11

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: VOY413																		
NH4	WIN	11	0.4	0.64	0.26	57.59	114.75	0.23	0.46	0.43	60.99	0.81	0.58	115.62	78.12	1.15	0.7	0.07
NH4	SPR	14	0.41	0.46	0.15	11.18	67.18	0.05	0.28	0.14	15.82	-6.33	0.11	62.61	57	0.67	0.38	0.02
NH4	SUM	13	0.32	0.26	0.29	-19.43	63.5	-0.06	0.21	0.08	2.51	-32.92	-0.24	68.95	66.64	0.79	0.29	0.09
NH4	FAL	13	0.45	0.57	0.91	26.61	47.59	0.12	0.21	0.06	28.35	9.66	0.27	57.66	48.99	0.48	0.26	0.83
NH4	ALL	51	0.4	0.47	0.48	19.43	71.23	0.08	0.28	0.18	25.36	-7.49	0.19	74.4	61.97	0.71	0.43	0.23
NO3	WIN	11	0.66	1.33	0.09	102.49	176.98	0.68	1.17	2.57	386.27	-6.24	1.02	454.09	108.62	1.77	1.74	0.01
NO3	SPR	14	0.33	0.42	0.52	28.39	120.54	0.09	0.4	0.57	15.3	-50.68	0.28	104.24	107.87	1.21	0.76	0.27
NO3	SUM	13	0.12	0.06	0.06	-51.58	86.39	-0.06	0.1	0.02	-51.87	-110.05	-1.07	83.21	125.57	1.78	0.14	0
NO3	FAL	13	0.68	1	0.94	47.84	88.3	0.32	0.6	0.74	39.39	-29.97	0.48	116.2	108.44	0.88	0.92	0.89
NO3	ALL	51	0.44	0.67	0.66	54.63	123.81	0.24	0.54	0.97	84.33	-50.95	0.55	177.39	112.69	1.24	1.02	0.44
SO4	WIN	11	0.88	0.78	0.34	-11.43	59.64	-0.1	0.52	0.49	-13.21	-32.15	-0.13	53.31	56.05	0.67	0.71	0.12
SO4	SPR	14	1.05	1.14	0.06	8.63	37.75	0.09	0.4	0.32	16.1	3.11	0.09	41.84	34.42	0.38	0.57	0
SO4	SUM	13	0.87	0.71	0.25	-18.76	59.89	-0.16	0.52	0.48	8.11	-26.77	-0.23	70.54	62.41	0.74	0.71	0.06
SO4	FAL	13	0.91	1.03	0.37	12.19	46.7	0.11	0.43	0.43	24.62	3.12	0.12	55.99	41.43	0.47	0.67	0.14
SO4	ALL	51	0.93	0.92	0.2	-1.08	49.7	-0.01	0.46	0.44	9.91	-12.11	-0.01	55.23	48.01	0.5	0.66	0.04
CASTNET Monitoring Station: VPI120																		
NH4	WIN	11	0.74	0.56	0.09	-24.22	32.17	-0.18	0.24	0.07	-18.97	-27.84	-0.32	28.31	36.11	0.42	0.32	0.01
NH4	SPR	9	0.84	0.47	0.67	-43.66	43.66	-0.37	0.37	0.04	-43.63	-59.56	-0.77	43.63	59.56	0.77	0.41	0.45
NH4	SUM	12	1.49	0.54	0.46	-63.9	63.9	-0.95	0.95	0.13	-62.82	-94.81	-1.77	62.82	94.81	1.77	1.02	0.21
NH4	FAL	13	0.62	0.55	0.08	-10.93	46.41	-0.07	0.29	0.12	0.59	-16.27	-0.12	47.26	51.91	0.52	0.35	0.01
NH4	ALL	45	0.93	0.54	0.16	-42.19	50.62	-0.39	0.47	0.22	-29.95	-48.7	-0.73	46.05	61.02	0.88	0.61	0.03
NO3	WIN	11	0.58	0.63	0.24	8.3	57.97	0.05	0.34	0.2	22.92	-8.34	0.08	68.48	58	0.58	0.45	0.06
NO3	SPR	9	0.31	0.16	0.07	-49.32	71.68	-0.16	0.23	0.04	-19.96	-69.38	-0.97	90.51	96.65	1.41	0.25	0
NO3	SUM	12	0.2	0.03	0.17	-83.9	83.9	-0.17	0.17	0.01	-78.06	-132.61	-5.21	78.06	132.61	5.21	0.2	0.03
NO3	FAL	13	0.58	0.33	0.1	-42.86	69.85	-0.25	0.4	0.19	-36.72	-77.27	-0.75	66.62	97.96	1.22	0.5	0.01
NO3	ALL	45	0.43	0.29	0.42	-31.97	67.94	-0.14	0.29	0.12	-29.81	-73.6	-0.47	74.9	97.17	1	0.38	0.18
SO4	WIN	11	1.95	1.63	0.29	-16.51	28.39	-0.32	0.55	0.37	-12.28	-18.37	-0.2	27.16	30.75	0.34	0.69	0.08
SO4	SPR	9	2.6	1.6	0.85	-38.57	38.57	-1	1	0.15	-39.9	-52.32	-0.63	39.9	52.32	0.63	1.08	0.72
SO4	SUM	12	4.86	2.35	0.62	-51.72	51.72	-2.51	2.51	1.54	-50.35	-72.3	-1.07	50.35	72.3	1.07	2.8	0.38
SO4	FAL	13	1.68	1.82	0.26	7.79	50.46	0.13	0.85	1.2	12.14	-4.9	0.08	51.1	50.48	0.5	1.1	0.07
SO4	ALL	45	2.78	1.87	0.5	-32.8	45.04	-0.91	1.25	1.96	-20.9	-35.65	-0.49	42.81	51.84	0.67	1.67	0.25

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: WNC429																		
NH4	WIN	11	0.26	0.37	0.18	43.7	74.71	0.11	0.19	0.06	64.58	21.89	0.44	90.57	53.81	0.75	0.27	0.03
NH4	SPR	14	0.29	0.39	0.22	34.36	80.71	0.1	0.24	0.12	54.69	-7.75	0.34	106.09	67.49	0.81	0.36	0.05
NH4	SUM	13	0.3	0.17	0.01	-44.21	44.21	-0.13	0.13	0.01	-42.43	-59.06	-0.79	42.43	59.06	0.79	0.15	0
NH4	FAL	13	0.23	0.37	0.44	57.41	95.26	0.13	0.22	0.25	118.39	5.55	0.57	151.08	48.91	0.95	0.52	0.19
NH4	ALL	51	0.27	0.32	0.03	19.32	72.45	0.05	0.2	0.12	48.3	-11.05	0.19	97.98	57.65	0.72	0.36	0
NO3	WIN	11	0.28	0.7	0.18	145.01	225.05	0.41	0.64	0.6	319.01	31.77	1.45	373.31	117.4	2.25	0.88	0.03
NO3	SPR	14	0.33	0.61	0.14	85.65	156.25	0.28	0.52	0.54	349.28	-18.71	0.86	427.88	116.36	1.56	0.79	0.02
NO3	SUM	13	0.18	0.03	0.24	-84.99	86.95	-0.15	0.16	0.01	-79.5	-145.71	-5.66	83.77	149.45	5.79	0.17	0.06
NO3	FAL	13	0.18	0.21	0.46	15.45	146.55	0.03	0.27	0.12	106.76	-62.83	0.15	218.42	142.25	1.47	0.35	0.21
NO3	ALL	51	0.24	0.38	0.14	55.02	158.57	0.13	0.39	0.36	171.63	-51.44	0.55	275	131.62	1.59	0.61	0.02
SO4	WIN	11	0.62	0.48	0.28	-22.2	41.58	-0.14	0.26	0.09	-5.46	-17.61	-0.29	40.07	44.01	0.53	0.33	0.08
SO4	SPR	14	0.72	0.62	0.04	-13.4	58.08	-0.1	0.42	0.24	-1.91	-31.75	-0.15	66.15	67.72	0.67	0.5	0
SO4	SUM	13	0.77	0.49	0.23	-36.4	37.45	-0.28	0.29	0.06	-33.4	-45.83	-0.57	34.57	46.98	0.59	0.37	0.05
SO4	FAL	13	0.56	0.64	0.17	14.42	48	0.08	0.27	0.15	33.6	4.07	0.14	64.33	41.38	0.48	0.4	0.03
SO4	ALL	51	0.67	0.56	0.13	-15.99	46.6	-0.11	0.31	0.16	-1.65	-23.16	-0.19	52.01	50.6	0.55	0.41	0.02
CASTNET Monitoring Station: WSP144																		
NH4	WIN	10	1.2	0.98	0.68	-18.11	36.41	-0.22	0.44	0.17	-20.3	-32.01	-0.22	39.24	47.29	0.44	0.47	0.46
NH4	SPR	14	0.72	0.8	0.33	11.04	50.67	0.08	0.37	0.22	15.2	-4.62	0.11	51.56	51.34	0.51	0.48	0.11
NH4	SUM	11	1.24	1.07	0.47	-13.83	51.02	-0.17	0.63	0.47	-14.41	-35.77	-0.16	53.5	65.02	0.59	0.71	0.22
NH4	FAL	12	0.69	0.76	0.58	10.74	49.87	0.07	0.34	0.24	5.64	-9.87	0.11	46.71	44.36	0.5	0.49	0.33
NH4	ALL	47	0.94	0.89	0.5	-4.65	46.76	-0.04	0.44	0.29	-1.72	-19.08	-0.05	48.15	51.9	0.49	0.54	0.25
NO3	WIN	10	2.23	2.18	0.36	-1.84	54.18	-0.04	1.21	1.97	4.86	-22.32	-0.02	63.66	64.4	0.55	1.4	0.13
NO3	SPR	14	0.8	1.03	0.32	27.47	109	0.22	0.88	1.66	105.63	-6.5	0.27	165.66	87.7	1.09	1.31	0.1
NO3	SUM	11	0.25	0.57	0.05	128.6	218.57	0.32	0.54	0.67	221.31	-8.15	1.29	292.09	95.63	2.19	0.88	0
NO3	FAL	12	0.9	1.11	0.34	23.59	75.93	0.21	0.68	1.01	26.93	-7.86	0.24	78.8	65.77	0.76	1.03	0.11
NO3	ALL	47	1	1.19	0.44	18.6	81.85	0.19	0.82	1.34	91.17	-10.6	0.19	151.37	79	0.82	1.17	0.2
SO4	WIN	10	2.14	1.15	0.36	-46.09	46.09	-0.99	0.99	0.34	-45	-63.5	-0.86	45	63.5	0.86	1.15	0.13
SO4	SPR	14	2.18	1.58	0.41	-27.48	45.61	-0.6	1	1	-25.13	-41.72	-0.38	43.76	55.96	0.63	1.17	0.16
SO4	SUM	11	3.66	2.74	0.51	-25.3	40.94	-0.93	1.5	2.6	-24.58	-43.9	-0.34	43.69	59.34	0.55	1.86	0.26
SO4	FAL	12	1.78	1.55	0.69	-13	38.48	-0.23	0.69	0.6	-16.23	-27.1	-0.15	37.23	44.59	0.44	0.81	0.48
SO4	ALL	47	2.42	1.75	0.59	-27.49	42.71	-0.66	1.03	1.22	-26.96	-43.13	-0.38	42.34	55.45	0.59	1.29	0.35

2011 Model Performance Results by Pollutant and Quarter - CASTNET Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CASTNET Monitoring Station: WST109																		
NH4	WIN	11	0.44	0.53	0.33	20.95	54.19	0.09	0.24	0.07	28.88	9.29	0.21	59.16	50.03	0.54	0.28	0.11
NH4	SPR	13	0.38	0.39	0.5	1.2	36.07	0	0.14	0.03	8.99	0.91	0.01	36.81	35.44	0.36	0.17	0.25
NH4	SUM	13	0.49	0.37	0.38	-23.7	61.79	-0.12	0.3	0.14	-24.8	-46.61	-0.31	54.97	67.09	0.81	0.39	0.14
NH4	FAL	11	0.41	0.38	0.21	-6.29	51.02	-0.03	0.21	0.07	-5.1	-23.91	-0.07	47.95	55.72	0.54	0.27	0.05
NH4	ALL	48	0.43	0.41	0.33	-3.49	51.47	-0.02	0.22	0.08	1.17	-15.73	-0.04	49.4	52	0.53	0.29	0.11
NO3	WIN	11	0.34	1.01	0.35	197.6	226.69	0.67	0.77	0.49	240.54	60.04	1.98	270.23	102.98	2.27	0.97	0.12
NO3	SPR	13	0.17	0.28	0.17	63.45	132.46	0.11	0.23	0.12	71.21	-16.92	0.63	137.73	89.05	1.32	0.37	0.03
NO3	SUM	13	0.06	0.02	0.2	-69.87	69.87	-0.04	0.04	0	-69.1	-112.16	-2.32	69.1	112.16	2.32	0.05	0.04
NO3	FAL	11	0.15	0.21	0.33	36.05	121.4	0.06	0.19	0.06	55.51	-46.6	0.36	148.06	117.09	1.21	0.24	0.11
NO3	ALL	48	0.18	0.36	0.64	104.15	165.67	0.18	0.29	0.23	68.42	-31.88	1.04	151.87	104.93	1.66	0.52	0.41
SO4	WIN	11	1.16	0.88	0.18	-24.27	45.52	-0.28	0.53	0.32	-15.01	-31.39	-0.32	47.31	51.45	0.6	0.63	0.03
SO4	SPR	13	1.11	1.11	0.6	-0.03	28.17	0	0.31	0.18	11.43	2.03	0	33.78	27.46	0.28	0.43	0.35
SO4	SUM	13	1.41	1.31	0.32	-6.83	74.91	-0.1	1.06	2.57	-8.85	-35.24	-0.07	62.63	66.07	0.8	1.61	0.1
SO4	FAL	11	1.1	1.14	0.48	3.59	46.93	0.04	0.52	0.62	-1.23	-16.51	0.04	43.95	44.73	0.47	0.79	0.23
SO4	ALL	48	1.2	1.12	0.33	-6.81	50.8	-0.08	0.61	0.98	-3.02	-19.97	-0.07	47.03	47.37	0.55	0.99	0.11

N: Number of observations
MEAN_O: Average of the observed values
MEAN_P: Average of the modeled values
r: Pearson correlation coefficient
NMB: Normalized Mean Bias
NME: Normalized Mean Error

MB: Mean Bias
ME: Mean Error
VAR: Variance
MNB: Mean Normalized Bias
MFB: Mean Fractional Bias

NMBF: Normalized Mean Bias Fraction
MNGE: Mean Normalized Gross Factor
MFE: Mean Fractional Error
NMEF: Normalized Mean Error Fraction
RMSE: Root Mean Squared Error
RSQR: r-squared

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 010730023																		
EC	WIN	23	0.69	1.68	0.82	141.85	141.85	0.99	0.99	0.14	256.36	98.91	1.42	256.36	98.91	1.42	1.05	0.67
EC	SPR	29	0.67	1.28	0.56	90.45	96.52	0.61	0.65	0.15	140.72	69.91	0.9	144.03	73.55	0.97	0.72	0.32
EC	SUM	26	0.74	1.38	0.63	86.13	94.5	0.64	0.7	0.15	120.61	68.3	0.86	123.39	71.69	0.95	0.75	0.4
EC	FAL	21	0.71	1.45	0.6	105.16	105.16	0.74	0.74	0.25	187.75	78.88	1.05	187.75	78.88	1.05	0.9	0.36
EC	ALL	99	0.7	1.44	0.65	104.18	108.2	0.73	0.76	0.19	172.28	78.13	1.04	173.98	80.08	1.08	0.85	0.42
NACL	WIN	26	0.12	0.26	0.82	116.99	126.48	0.14	0.15	0.04	197.3	79.72	1.17	201.27	85.05	1.26	0.24	0.68
NACL	SPR	29	0.13	0.22	0.89	61.03	67.41	0.08	0.09	0.02	256.21	57.05	0.61	259.92	61.25	0.67	0.15	0.79
NACL	SUM	28	0.09	0.11	0.68	28.58	45.27	0.02	0.04	0	50.21	29.12	0.29	61.06	42.81	0.45	0.05	0.46
NACL	FAL	23	0.12	0.19	0.85	56.41	70.25	0.07	0.08	0.01	128.47	56.97	0.56	135.26	65.77	0.7	0.12	0.72
NACL	ALL	106	0.11	0.19	0.82	67.56	78.48	0.08	0.09	0.02	159.63	55.21	0.68	165.96	63.2	0.78	0.16	0.67
NH4	WIN	26	0.97	1.13	0.31	16.33	42.1	0.16	0.41	0.27	34.78	13.68	0.16	57.2	40.33	0.42	0.54	0.1
NH4	SPR	30	1.03	0.99	0.51	-4.2	42.64	-0.04	0.44	0.36	5.31	-10.03	-0.04	45.45	43.9	0.45	0.6	0.26
NH4	SUM	28	1.06	0.95	0.79	-10.9	25.62	-0.12	0.27	0.13	7.13	-4.95	-0.12	35.61	29.49	0.29	0.37	0.62
NH4	FAL	23	0.6	0.85	0.66	40.14	56.23	0.24	0.34	0.1	77.31	41.61	0.4	87.47	53.55	0.56	0.4	0.43
NH4	ALL	107	0.93	0.98	0.55	5.16	39.33	0.05	0.37	0.24	28.42	8.16	0.05	54.76	41.34	0.39	0.5	0.3
NO3	WIN	26	1.21	1.48	0.13	22.73	66.75	0.27	0.81	1.07	66.93	17.43	0.23	97.6	58.03	0.67	1.07	0.02
NO3	SPR	30	0.56	0.62	0.11	12.26	76.75	0.07	0.43	0.81	15.98	-28.59	0.12	79.09	60.82	0.77	0.9	0.01
NO3	SUM	28	0.33	0.23	0.39	-31.62	32.49	-0.1	0.11	0.02	-27.49	-37.2	-0.46	28.53	38.21	0.48	0.17	0.15
NO3	FAL	23	0.53	0.65	0.45	22.48	55.26	0.12	0.29	0.16	24.09	1.73	0.22	56.8	46.11	0.55	0.42	0.2
NO3	ALL	107	0.65	0.73	0.45	12.95	62.59	0.08	0.41	0.55	18.73	-13.14	0.13	65.57	51.06	0.63	0.74	0.2
OC	WIN	23	1.77	6.01	0.86	240.03	240.03	4.24	4.24	2.32	421.18	120.61	2.4	421.18	120.61	2.4	4.51	0.73
OC	SPR	29	1.49	4.79	0.68	221.4	221.4	3.3	3.3	1.66	301.66	109.04	2.21	301.66	109.04	2.21	3.54	0.47
OC	SUM	26	2.08	7.39	0.77	255.26	255.26	5.31	5.31	6.62	279.9	111.86	2.55	279.9	111.86	2.55	5.9	0.6
OC	FAL	21	1.71	5.42	0.76	217.96	217.96	3.72	3.72	4.28	360.13	109.73	2.18	360.13	109.73	2.18	4.25	0.58
OC	ALL	99	1.75	5.89	0.77	235.59	235.59	4.13	4.13	4.28	336.11	112.62	2.36	336.11	112.62	2.36	4.62	0.59
PM-2.5	WIN	26	13.09	21.23	0.75	62.17	63.12	8.14	8.26	27.95	75.25	49.85	0.62	76.01	50.63	0.63	9.7	0.56
PM-2.5	SPR	30	13.53	17.5	0.48	29.33	39.63	3.97	5.36	31.24	38.61	26.09	0.29	46.07	34.57	0.4	6.85	0.23
PM-2.5	SUM	28	18.83	21.12	0.8	12.13	22.73	2.28	4.28	21.99	18.71	13.31	0.12	27.18	22.83	0.23	5.22	0.65
PM-2.5	FAL	23	11.72	18.68	0.8	59.44	59.63	6.97	6.99	15.14	74.61	49.09	0.59	74.86	49.34	0.6	7.98	0.64
PM-2.5	ALL	107	14.42	19.61	0.69	35.95	42.53	5.18	6.13	29.98	50.04	33.46	0.36	54.59	38.57	0.43	7.54	0.47
SO4	WIN	26	2.19	2.43	0.4	11.02	33.15	0.24	0.73	0.86	16.19	6.88	0.11	36.35	31.43	0.33	0.96	0.16
SO4	SPR	30	3.18	3.02	0.44	-4.93	39.01	-0.16	1.24	2.91	6.1	-4.5	-0.05	38.64	36.32	0.41	1.71	0.19
SO4	SUM	28	3.87	2.98	0.78	-22.81	27.67	-0.88	1.07	0.88	-20.02	-26.54	-0.3	29.46	34.23	0.36	1.29	0.61
SO4	FAL	23	2.12	2.36	0.69	11.06	29.96	0.23	0.64	0.54	23.29	15.54	0.11	35.27	29.64	0.3	0.77	0.47
SO4	ALL	107	2.89	2.73	0.59	-5.73	32.54	-0.17	0.94	1.58	5.41	-3.19	-0.06	34.96	33.15	0.35	1.27	0.35

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 010732003																		
EC	WIN	15	0.74	1.01	0.72	36.82	48.97	0.27	0.36	0.17	67.56	42.34	0.37	72.54	48.03	0.49	0.5	0.52
EC	SPR	13	0.68	0.69	0.66	1.91	31.64	0.01	0.21	0.07	13.46	6.35	0.02	33.17	30.03	0.32	0.26	0.44
EC	SUM	16	0.86	0.84	0.74	-2.87	21.56	-0.02	0.19	0.05	0.91	-3.22	-0.03	24.35	23.76	0.22	0.23	0.55
EC	FAL	14	0.67	0.95	0.84	42.38	49.27	0.28	0.33	0.09	58.39	37.36	0.42	64.32	43.96	0.49	0.41	0.7
EC	ALL	58	0.74	0.88	0.7	18.19	36.72	0.13	0.27	0.12	34.83	20.5	0.18	48.44	36.32	0.37	0.37	0.5
NACL	WIN	15	0.12	0.25	0.94	106.44	106.44	0.13	0.13	0.06	135.92	68.09	1.06	135.92	68.09	1.06	0.28	0.88
NACL	SPR	14	0.21	0.26	0.79	22.12	60.03	0.05	0.13	0.04	122.26	38.4	0.22	143.09	67.6	0.6	0.2	0.62
NACL	SUM	16	0.1	0.12	0.1	16.74	57.22	0.02	0.06	0.01	58.96	30.18	0.17	74.8	52.34	0.57	0.08	0.01
NACL	FAL	14	0.06	0.12	0.66	107.51	109.95	0.06	0.06	0	162.5	76.01	1.08	163.66	77.21	1.1	0.08	0.43
NACL	ALL	59	0.12	0.19	0.78	51.96	76.81	0.06	0.09	0.03	118.12	52.64	0.52	127.63	65.87	0.77	0.18	0.6
NH4	WIN	15	0.8	0.92	0.13	14.8	54.51	0.12	0.44	0.33	72.52	13.3	0.15	104.63	52.97	0.55	0.59	0.02
NH4	SPR	14	0.79	0.8	0.34	1.02	55.04	0.01	0.43	0.32	17.68	-7.35	0.01	62.95	55.46	0.55	0.56	0.12
NH4	SUM	16	1.01	0.95	0.67	-6.18	25.37	-0.06	0.26	0.13	5	-1.82	-0.07	28.64	27.16	0.27	0.37	0.45
NH4	FAL	14	0.49	0.84	0.62	71.99	84.07	0.35	0.41	0.13	119.57	60.19	0.72	124.75	65.78	0.84	0.51	0.39
NH4	ALL	59	0.78	0.88	0.38	12.67	48.84	0.1	0.38	0.25	52.36	15.42	0.13	78.91	49.6	0.49	0.51	0.15
NO3	WIN	15	1.08	1.09	0.21	1.38	73.08	0.01	0.79	1.2	54.86	-7.42	0.01	105.74	64.63	0.73	1.09	0.04
NO3	SPR	14	0.54	0.61	0.03	11.97	110.2	0.07	0.6	1.44	79.1	-41.4	0.12	162.17	80.65	1.1	1.2	0
NO3	SUM	16	0.29	0.15	0.23	-48.04	48.04	-0.14	0.14	0.01	-45.19	-63.48	-0.92	45.19	63.48	0.92	0.17	0.05
NO3	FAL	14	0.51	0.61	0.3	18.78	75.65	0.1	0.39	0.28	35.7	-9.89	0.19	89.99	66.8	0.76	0.54	0.09
NO3	ALL	59	0.6	0.61	0.2	0.78	78.34	0	0.47	0.72	28.93	-31.27	0.01	98.97	68.63	0.78	0.85	0.04
OC	WIN	15	2.21	3.97	0.79	79.37	79.37	1.76	1.76	3.94	90.98	56.33	0.79	90.98	56.33	0.79	2.65	0.63
OC	SPR	13	2.32	2.91	0.76	25.14	35.89	0.58	0.83	0.68	36.15	23.53	0.25	46.69	35.3	0.36	1.01	0.57
OC	SUM	16	4.29	6.4	0.4	48.93	69.56	2.1	2.99	8.78	70.28	44.18	0.49	78.53	54.98	0.7	3.63	0.16
OC	FAL	14	1.97	3.71	0.9	87.9	89.4	1.74	1.77	2.33	86.25	53.26	0.88	88.45	55.6	0.89	2.31	0.8
OC	ALL	58	2.75	4.34	0.66	57.51	68.67	1.58	1.89	4.47	71.84	44.89	0.58	77.01	51.07	0.69	2.64	0.44
PM-2.5	WIN	15	10.91	14.17	0.84	29.96	33.99	3.27	3.71	23.32	24.05	17.36	0.3	30.02	23.69	0.34	5.83	0.71
PM-2.5	SPR	14	13.3	11.8	0.52	-11.26	36.93	-1.5	4.91	30.48	0.86	-9.23	-0.13	39.6	39.15	0.42	5.72	0.27
PM-2.5	SUM	16	20.43	17.21	0.69	-15.76	23.49	-3.22	4.8	24.02	-14.8	-18.86	-0.19	22.97	25.96	0.28	5.86	0.48
PM-2.5	FAL	14	10.26	13.26	0.82	29.27	35.9	3	3.68	16.59	27.87	18.4	0.29	39.95	32.96	0.36	5.06	0.68
PM-2.5	ALL	59	13.9	14.22	0.65	2.26	30.81	0.31	4.28	31.71	8.92	1.47	0.02	32.74	30.18	0.31	5.64	0.42
SO4	WIN	15	1.96	2.14	0.02	9.13	45.71	0.18	0.9	1.13	21.46	4.63	0.09	52.63	44.37	0.46	1.08	0
SO4	SPR	14	2.9	2.77	0.47	-4.29	37.56	-0.12	1.09	1.89	8.85	-6.55	-0.04	46.37	40.37	0.39	1.38	0.23
SO4	SUM	16	3.97	3.09	0.61	-22.15	29.48	-0.88	1.17	1.23	-20.17	-27.46	-0.28	29.12	35.19	0.38	1.42	0.37
SO4	FAL	14	1.98	2.23	0.71	12.35	33.91	0.25	0.67	0.61	19.39	11.47	0.12	35.99	31.65	0.34	0.82	0.5
SO4	ALL	59	2.73	2.57	0.58	-6.01	35.24	-0.16	0.96	1.42	6.69	-5.1	-0.06	40.82	37.91	0.37	1.2	0.34

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 010890014																		
EC	WIN	14	0.52	0.91	0.61	75.78	77.64	0.39	0.4	0.11	119.86	64.2	0.76	120.55	64.91	0.78	0.51	0.38
EC	SPR	13	0.44	0.71	0.56	62.06	62.2	0.27	0.27	0.04	83.33	51.43	0.62	83.41	51.52	0.62	0.34	0.32
EC	SUM	16	0.57	0.93	0.74	64.95	64.95	0.37	0.37	0.02	68.85	49.34	0.65	68.85	49.34	0.65	0.39	0.55
EC	FAL	15	0.48	0.89	0.82	85.5	85.5	0.41	0.41	0.05	113.64	65.32	0.86	113.64	65.32	0.86	0.47	0.67
EC	ALL	58	0.5	0.87	0.69	72.13	72.61	0.36	0.37	0.06	95.99	57.53	0.72	96.18	57.72	0.73	0.43	0.47
NACL	WIN	14	0.06	0.22	0.88	247.83	256.4	0.16	0.16	0.04	340.63	95.55	2.48	346.64	103.17	2.56	0.26	0.78
NACL	SPR	12	0.11	0.22	0.8	90.86	115.05	0.1	0.13	0.03	128.26	55.16	0.91	144.58	76.8	1.15	0.21	0.64
NACL	SUM	16	0.07	0.08	0.38	24.21	52.85	0.02	0.04	0	52.75	19.16	0.24	72.16	46.56	0.53	0.05	0.14
NACL	FAL	15	0.05	0.11	0.33	131.86	142.84	0.06	0.07	0	173.58	70.96	1.32	181.71	80.8	1.43	0.09	0.11
NACL	ALL	57	0.07	0.15	0.75	114.82	134.46	0.08	0.1	0.02	171.15	59.13	1.15	183.65	75.84	1.34	0.17	0.56
NH4	WIN	15	0.93	1.17	0.22	26.46	49.12	0.25	0.45	0.31	77.41	23.11	0.26	95.09	44.45	0.49	0.61	0.05
NH4	SPR	13	1.02	1.29	0.49	26.79	56.65	0.27	0.58	0.45	51.16	23.27	0.27	73.88	54.5	0.57	0.72	0.24
NH4	SUM	16	0.99	1.27	0.4	27.91	50.26	0.28	0.5	0.33	56.54	27.46	0.28	72.12	45.9	0.5	0.64	0.16
NH4	FAL	15	0.52	1.06	0.48	105.53	115.05	0.55	0.59	0.27	188.22	75.37	1.06	190.97	78.44	1.15	0.75	0.23
NH4	ALL	59	0.86	1.2	0.43	39.08	61.51	0.34	0.53	0.35	94.14	37.61	0.39	108.56	55.7	0.62	0.68	0.18
NO3	WIN	15	1.32	1.89	0.3	42.75	74.31	0.57	0.98	1	93.46	38.35	0.43	113.68	63.46	0.74	1.15	0.09
NO3	SPR	13	0.54	1.41	0.46	163.69	174.3	0.88	0.93	2.33	144.4	47.88	1.64	160.46	69.88	1.74	1.76	0.22
NO3	SUM	16	0.26	0.57	0.28	124.43	131.2	0.32	0.34	0.24	119.73	49.73	1.24	127.14	58.04	1.31	0.59	0.08
NO3	FAL	15	0.57	1.38	0.37	142.65	153.96	0.81	0.87	0.74	170.17	65.36	1.43	178.73	76.45	1.54	1.18	0.13
NO3	ALL	59	0.67	1.3	0.45	94.21	115.12	0.63	0.77	1.07	131.31	50.4	0.94	144.17	66.71	1.15	1.21	0.2
OC	WIN	14	1.69	4.43	0.7	162.39	162.39	2.74	2.74	2.71	239.64	96.71	1.62	239.64	96.71	1.62	3.2	0.49
OC	SPR	13	1.96	4	0.59	104.48	110.59	2.04	2.16	1.57	245.13	84.11	1.04	248.36	87.73	1.11	2.4	0.35
OC	SUM	16	2.84	6.96	0.45	145.07	145.07	4.12	4.12	2.55	171.85	86.66	1.45	171.85	86.66	1.45	4.42	0.2
OC	FAL	15	1.58	4.34	0.87	174.33	174.33	2.76	2.76	2.2	458.43	103.5	1.74	458.43	103.5	1.74	3.13	0.76
OC	ALL	58	2.04	5.01	0.68	145.67	146.99	2.97	3	2.86	278.75	92.87	1.46	279.48	93.68	1.47	3.42	0.46
PM-2.5	WIN	15	10.23	15.65	0.51	53.01	61.94	5.42	6.33	30.36	60.8	39.91	0.53	65.31	44.94	0.62	7.73	0.26
PM-2.5	SPR	13	12.15	15.12	0.28	24.39	41.07	2.96	4.99	35.08	42.86	22.63	0.24	54.72	36.09	0.41	6.62	0.08
PM-2.5	SUM	16	17.11	20.7	0.39	21	34.18	3.59	5.85	32.12	28.33	21.04	0.21	37.26	31.26	0.34	6.71	0.16
PM-2.5	FAL	15	8.32	15.44	0.71	85.56	85.56	7.12	7.12	25.88	99.99	57.99	0.86	99.99	57.99	0.86	8.75	0.51
PM-2.5	ALL	59	12.03	16.85	0.56	40.02	50.74	4.82	6.11	33.34	58	35.58	0.4	64.19	42.6	0.51	7.52	0.31
SO4	WIN	15	2.07	1.94	0.19	-6.34	39.82	-0.13	0.82	0.95	15.59	-5.02	-0.07	55.52	45.88	0.43	0.98	0.04
SO4	SPR	13	3.05	2.85	0.29	-6.33	38.22	-0.19	1.16	1.78	7.08	-2.9	-0.07	41.46	38.51	0.41	1.35	0.09
SO4	SUM	16	3.61	3.35	0.46	-7.36	34.37	-0.27	1.24	2.46	-0.29	-9.19	-0.08	35.53	34.98	0.37	1.59	0.21
SO4	FAL	15	1.81	1.97	0.57	9.01	41.18	0.16	0.75	0.97	29.9	9.75	0.09	55.99	42.1	0.41	1	0.33
SO4	ALL	59	2.64	2.53	0.56	-4.03	37.63	-0.11	0.99	1.57	13.04	-1.93	-0.04	47.12	40.34	0.39	1.26	0.32

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 011011002																		
EC	WIN	15	0.8	1.22	0.65	52.54	61.39	0.42	0.49	0.29	105.82	52.6	0.53	111.8	59.15	0.61	0.69	0.43
EC	SPR	15	0.48	0.79	0.75	65.78	69.24	0.31	0.33	0.04	80.28	51.56	0.66	82.81	54.35	0.69	0.37	0.57
EC	SUM	16	0.53	1	0.39	88.84	88.84	0.47	0.47	0.08	116.15	63.58	0.89	116.15	63.58	0.89	0.54	0.15
EC	FAL	14	0.54	1.09	0.79	102.11	102.11	0.55	0.55	0.2	103.03	63.63	1.02	103.03	63.63	1.02	0.71	0.63
EC	ALL	60	0.59	1.02	0.67	74.57	78.3	0.44	0.46	0.16	101.54	57.84	0.75	103.67	60.18	0.78	0.59	0.45
NACL	WIN	14	0.08	0.26	0.98	236.48	236.48	0.18	0.18	0.08	371.03	98.65	2.36	371.03	98.65	2.36	0.34	0.96
NACL	SPR	13	0.24	0.33	0.6	39.47	87.81	0.09	0.21	0.12	1122.11	54.73	0.39	1136.4	77.46	0.88	0.36	0.35
NACL	SUM	15	0.09	0.17	0.23	92.73	110.08	0.08	0.1	0.01	125.34	60.06	0.93	135.29	72	1.1	0.12	0.05
NACL	FAL	14	0.04	0.11	0.6	207.95	207.95	0.07	0.07	0	237.53	103.05	2.08	237.53	103.05	2.08	0.08	0.36
NACL	ALL	56	0.11	0.22	0.68	100.54	129.28	0.11	0.14	0.05	446.2	79.22	1.01	452.18	87.69	1.29	0.26	0.46
NH4	WIN	14	0.73	0.91	0.28	24.9	67.51	0.18	0.49	0.46	61.61	14.35	0.25	96.63	57.54	0.68	0.7	0.08
NH4	SPR	13	0.89	0.69	0.72	-22.1	36.54	-0.2	0.32	0.1	-14.88	-30.55	-0.28	43.62	52.84	0.47	0.37	0.52
NH4	SUM	15	0.82	0.83	0.14	1.24	46.21	0.01	0.38	0.23	19.34	-1.21	0.01	56.31	44.68	0.46	0.48	0.02
NH4	FAL	14	0.46	0.81	0.78	75.14	75.14	0.35	0.35	0.07	86.92	53.87	0.75	86.92	53.87	0.75	0.43	0.6
NH4	ALL	56	0.72	0.81	0.34	12.32	53.44	0.09	0.39	0.25	38.86	9.64	0.12	71.1	52.09	0.53	0.51	0.11
NO3	WIN	14	0.64	1.32	0.35	106.85	144.37	0.68	0.92	2.8	102.76	27.38	1.07	134.32	72.01	1.44	1.81	0.12
NO3	SPR	13	0.4	0.4	0.68	0	58.83	0	0.23	0.13	-12.46	-33.13	0	50.43	58.12	0.59	0.36	0.46
NO3	SUM	16	0.21	0.18	0.31	-12.95	56.67	-0.03	0.12	0.02	21.43	-17.58	-0.15	80.53	62.38	0.65	0.14	0.1
NO3	FAL	14	0.29	0.46	0.22	57.56	99.31	0.17	0.29	0.17	64.55	12.18	0.58	103.91	64.66	0.99	0.44	0.05
NO3	ALL	57	0.38	0.58	0.51	53.32	101.75	0.2	0.38	0.84	44.27	-2.77	0.53	92.62	64.33	1.02	0.94	0.26
OC	WIN	15	2.12	5.18	0.56	144.32	144.32	3.06	3.06	11.11	191.28	82.35	1.44	191.28	82.35	1.44	4.52	0.31
OC	SPR	15	1.96	3.45	0.62	75.67	87.08	1.48	1.71	1.59	116.62	53.73	0.76	127.62	68	0.87	1.95	0.38
OC	SUM	16	2.98	7.6	0.31	154.86	154.86	4.62	4.62	11.73	201.95	84.9	1.55	201.95	84.9	1.55	5.75	0.1
OC	FAL	14	1.87	4.65	0.89	148.33	148.33	2.78	2.78	5.92	148.29	78.61	1.48	148.29	78.61	1.48	3.69	0.8
OC	ALL	60	2.25	5.27	0.57	133.87	136.36	3.02	3.07	8.97	165.43	75	1.34	168.18	78.57	1.36	4.25	0.33
PM-2.5	WIN	14	9.2	15.3	0.55	66.29	73.46	6.1	6.76	69.04	66.87	39.81	0.66	72.44	46.52	0.73	10.31	0.3
PM-2.5	SPR	14	11.71	12.16	0.62	3.87	23.7	0.45	2.77	15.85	8.42	0.72	0.04	27.43	26.38	0.24	4.01	0.38
PM-2.5	SUM	16	16.17	18.73	0.29	15.81	38.65	2.56	6.25	71.22	469.76	15.47	0.16	487.49	37.04	0.39	8.82	0.08
PM-2.5	FAL	14	9.93	14.35	0.74	44.48	55.65	4.42	5.52	29.7	51.05	35.66	0.44	57.28	42.84	0.56	7.01	0.54
PM-2.5	ALL	58	11.9	15.26	0.5	28.17	45.02	3.35	5.36	51.61	160.09	22.66	0.28	172.41	38.16	0.45	7.93	0.25
SO4	WIN	14	1.97	1.91	0.13	-2.89	42.73	-0.06	0.84	0.96	11.38	-1.62	-0.03	46.11	42.78	0.44	0.98	0.02
SO4	SPR	13	3.11	2.57	0.71	-17.37	32.26	-0.54	1	1.04	-11.59	-18.84	-0.21	32.9	36.65	0.39	1.16	0.51
SO4	SUM	15	3.53	2.63	0.07	-25.52	44.49	-0.9	1.57	2.63	-15.59	-29.69	-0.34	45.12	51.08	0.6	1.86	0
SO4	FAL	14	1.88	2.14	0.82	13.59	23.22	0.26	0.44	0.25	18.71	11.36	0.14	29.9	23.77	0.23	0.56	0.68
SO4	ALL	56	2.63	2.31	0.48	-12.06	37	-0.32	0.97	1.45	0.66	-9.89	-0.14	38.72	38.83	0.42	1.25	0.23

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 011130001																		
EC	WIN	14	1.06	0.97	0.63	-8	40.31	-0.08	0.43	0.43	18.1	4.91	-0.09	45.08	39.58	0.44	0.66	0.39
EC	SPR	6	0.62	0.77	0.93	23.38	38.03	0.15	0.24	0.04	67.2	40.01	0.23	75.08	48.4	0.38	0.25	0.87
EC	SUM	12	0.57	0.56	0.35	-1.49	24.18	-0.01	0.14	0.04	6.84	1.88	-0.02	24.94	24.67	0.25	0.19	0.13
EC	FAL	5	0.35	0.48	0.94	37.4	37.4	0.13	0.13	0.01	51.21	36.59	0.37	51.21	36.59	0.37	0.16	0.89
EC	ALL	37	0.73	0.74	0.71	0.87	35.73	0.01	0.26	0.19	26.89	13.9	0.01	44.24	35.77	0.36	0.44	0.5
NACL	WIN	13	0.09	0.25	0.99	172.53	173.75	0.16	0.16	0.1	162.82	73.57	1.73	165.54	76.56	1.74	0.35	0.98
NACL	SPR	15	0.22	0.33	0.7	46.32	97.83	0.1	0.22	0.18	92.83	42.26	0.46	114.25	73.92	0.98	0.44	0.49
NACL	SUM	16	0.08	0.09	0.75	14.7	35.41	0.01	0.03	0	25.57	15.89	0.15	40.66	33.44	0.35	0.03	0.57
NACL	FAL	15	0.05	0.06	0.27	18.23	51.87	0.01	0.03	0	69.22	22.09	0.18	88.96	44.62	0.52	0.04	0.07
NACL	ALL	59	0.11	0.18	0.77	60.45	94.76	0.07	0.11	0.07	84.01	36.88	0.6	99.17	56.07	0.95	0.28	0.59
NH4	WIN	14	0.78	0.89	0.48	14.1	48.78	0.11	0.38	0.3	49.27	8.6	0.14	79.92	46.53	0.49	0.56	0.23
NH4	SPR	15	0.85	0.64	0.5	-23.9	43.26	-0.2	0.37	0.17	-20.77	-38.5	-0.31	47.27	55.41	0.57	0.46	0.25
NH4	SUM	16	0.98	0.74	0.42	-24.7	32.94	-0.24	0.32	0.12	-18.64	-28.04	-0.33	31.75	39.07	0.44	0.42	0.18
NH4	FAL	15	0.51	0.63	0.76	24.53	42.67	0.12	0.22	0.06	67.18	35.24	0.25	76.41	45.47	0.43	0.28	0.58
NH4	ALL	60	0.78	0.72	0.49	-7.47	41	-0.06	0.32	0.19	18.13	-6.29	-0.08	58.04	46.49	0.44	0.44	0.24
NO3	WIN	14	0.72	1.23	0.18	71.48	116.84	0.51	0.84	2.12	72.73	5.13	0.71	116.32	71.56	1.17	1.54	0.03
NO3	SPR	15	0.4	0.44	0.4	8.36	81.86	0.03	0.33	0.27	27.52	-37.54	0.08	103.8	74.29	0.82	0.52	0.16
NO3	SUM	16	0.22	0.1	0.09	-56.85	56.85	-0.13	0.13	0.01	-51.67	-75.04	-1.32	51.67	75.04	1.32	0.15	0.01
NO3	FAL	15	0.3	0.28	0.59	-9.54	46.43	-0.03	0.14	0.03	-10.27	-25.13	-0.11	45.72	51.43	0.51	0.18	0.35
NO3	ALL	60	0.4	0.49	0.46	21.6	86.01	0.09	0.35	0.63	7.5	-34.48	0.22	78.3	68.14	0.86	0.8	0.21
OC	WIN	14	3.5	4.72	0.67	34.82	51.35	1.22	1.8	9.97	63.87	37.59	0.35	70.65	46.07	0.51	3.38	0.44
OC	SPR	6	2.23	4.01	0.92	79.62	79.62	1.78	1.78	0.95	151.28	70.97	0.8	151.28	70.97	0.8	2.03	0.84
OC	SUM	12	3.74	5.46	0.18	45.98	73.44	1.72	2.75	7.77	80.05	44.14	0.46	92.31	60.48	0.73	3.28	0.03
OC	FAL	5	1.42	2.77	0.97	94.97	94.97	1.35	1.35	1.62	88.82	56.1	0.95	88.82	56.1	0.95	1.85	0.95
OC	ALL	37	3.09	4.58	0.63	48.18	66.03	1.49	2.04	6.73	86.66	47.63	0.48	93.21	56.14	0.66	2.99	0.39
PM-2.5	WIN	14	12.21	14.2	0.72	16.33	30.17	1.99	3.68	45.39	16.36	9.2	0.16	29.84	24.75	0.3	7.03	0.52
PM-2.5	SPR	15	12.56	11.03	0.63	-12.2	27.26	-1.53	3.42	17.02	-4.72	-12.92	-0.14	30.93	31.58	0.31	4.4	0.4
PM-2.5	SUM	16	18.06	14.18	0.06	-21.49	29.49	-3.88	5.33	45.77	-16.22	-23.06	-0.27	26.26	31.98	0.38	7.8	0
PM-2.5	FAL	15	10.57	10.03	0.92	-5.09	18.52	-0.54	1.96	6.22	4.79	0.78	-0.05	22.26	20.44	0.2	2.55	0.85
PM-2.5	ALL	60	13.45	12.36	0.6	-8.09	26.96	-1.09	3.62	33.03	-0.49	-7.04	-0.09	27.27	27.31	0.29	5.85	0.36
SO4	WIN	14	1.97	1.81	0.75	-7.98	27.48	-0.16	0.54	0.43	-1.29	-7.83	-0.09	29.7	29.84	0.3	0.67	0.56
SO4	SPR	15	2.76	2.24	0.36	-18.92	38	-0.52	1.05	1.59	-9.3	-23.27	-0.23	42.62	43.66	0.47	1.36	0.13
SO4	SUM	16	3.67	2.28	0.22	-37.79	38.22	-1.39	1.4	1.47	-33.65	-45.45	-0.61	34.56	46.34	0.61	1.84	0.05
SO4	FAL	15	1.9	1.68	0.77	-11.5	30.24	-0.22	0.58	0.47	-4.24	-10.52	-0.13	31.82	32.44	0.34	0.72	0.59
SO4	ALL	60	2.6	2.01	0.54	-22.73	34.81	-0.59	0.91	1.26	-12.66	-22.4	-0.29	34.76	38.34	0.45	1.27	0.29

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 051190007																		
EC	WIN	20	0.59	1.26	0.83	114.35	114.35	0.67	0.67	0.1	121.19	71.59	1.14	121.19	71.59	1.14	0.74	0.68
EC	SPR	26	0.41	0.83	0.55	104.37	104.37	0.42	0.42	0.08	121.1	66.1	1.04	121.1	66.1	1.04	0.51	0.31
EC	SUM	29	0.36	1.09	0.47	205.43	205.43	0.74	0.74	0.13	253.63	100.87	2.05	253.63	100.87	2.05	0.82	0.23
EC	FAL	24	0.47	1.19	0.62	152.01	152.01	0.72	0.72	0.12	196.61	88.65	1.52	196.61	88.65	1.52	0.8	0.38
EC	ALL	99	0.44	1.08	0.62	143.17	143.17	0.64	0.64	0.13	178.25	82.86	1.43	178.25	82.86	1.43	0.73	0.38
NACL	WIN	22	0.07	0.1	0.6	42.23	69.49	0.03	0.05	0	79.75	29.94	0.42	97.08	54.04	0.69	0.08	0.36
NACL	SPR	27	0.13	0.15	0.76	8.94	59.31	0.01	0.08	0.03	19.58	1.33	0.09	54.23	46.55	0.59	0.17	0.58
NACL	SUM	28	0.13	0.05	0.01	-59.1	65.71	-0.08	0.08	0.03	-40.41	-64.49	-1.44	51.35	73.63	1.61	0.18	0
NACL	FAL	23	0.07	0.14	0.84	114.78	132.28	0.08	0.09	0.04	72.89	29.23	1.15	90.93	51.6	1.32	0.22	0.7
NACL	ALL	100	0.1	0.11	0.51	6.11	74.07	0.01	0.08	0.03	28.28	-4.39	0.06	71.29	56.94	0.74	0.17	0.26
NH4	WIN	22	0.91	0.99	0.39	8.91	51.38	0.08	0.47	0.34	66.61	19.93	0.09	92.65	52.6	0.51	0.59	0.15
NH4	SPR	27	0.79	0.8	0.61	0.91	40.15	0.01	0.32	0.25	12.35	0.4	0.01	41.88	39.42	0.4	0.5	0.38
NH4	SUM	28	0.72	0.58	0.53	-19.33	39.38	-0.14	0.28	0.15	9.13	-10.96	-0.24	51.96	44.68	0.49	0.42	0.28
NH4	FAL	24	0.61	0.65	0.81	7.08	33.35	0.04	0.2	0.08	22.51	8.54	0.07	44.3	34.53	0.33	0.29	0.66
NH4	ALL	101	0.75	0.75	0.58	-1.14	41.59	-0.01	0.31	0.21	25.69	3.44	-0.01	56.31	42.59	0.42	0.46	0.34
NO3	WIN	22	1.71	1.78	0.14	4.13	56.61	0.07	0.97	1.79	38.07	5.8	0.04	72.27	52.25	0.57	1.34	0.02
NO3	SPR	27	0.77	0.81	0.41	6.21	80.15	0.05	0.61	1.13	1.71	-43.17	0.06	80.03	84.7	0.8	1.06	0.16
NO3	SUM	28	0.3	0.11	0.29	-63.52	65.23	-0.19	0.19	0.02	-59.55	-95.16	-1.74	62.43	97.75	1.79	0.23	0.08
NO3	FAL	24	0.58	0.65	0.63	11.03	69.08	0.06	0.4	0.27	16.47	-24.89	0.11	84.93	75.16	0.69	0.52	0.4
NO3	ALL	101	0.8	0.79	0.55	-1.09	65.72	-0.01	0.52	0.77	-3.84	-42.57	-0.01	74.62	78.98	0.66	0.88	0.3
OC	WIN	20	1.79	3.45	0.81	93.11	93.11	1.66	1.66	1.15	109.3	61.94	0.93	109.3	61.95	0.93	1.98	0.66
OC	SPR	26	1.52	1.99	0.59	30.9	43.67	0.47	0.67	0.64	39.31	23.72	0.31	51.45	38.31	0.44	0.93	0.34
OC	SUM	29	1.74	5.29	0.31	204.11	204.11	3.55	3.55	8.11	256.68	92.01	2.04	256.68	92.01	2.04	4.55	0.1
OC	FAL	24	1.58	3.24	0.74	104.34	104.46	1.65	1.66	1.98	121.78	63.95	1.04	121.86	64.03	1.04	2.17	0.55
OC	ALL	99	1.65	3.56	0.49	114.86	117.98	1.9	1.95	4.62	137.11	61.2	1.15	140.32	65.06	1.18	2.87	0.24
PM-2.5	WIN	22	11.37	11.97	0.58	5.22	23.66	0.59	2.69	10.58	8.93	2.86	0.05	27.55	25.78	0.24	3.31	0.33
PM-2.5	SPR	27	10.46	8.6	0.54	-17.76	33.29	-1.86	3.48	12.07	-14.45	-22.86	-0.22	33.54	38.9	0.4	3.94	0.29
PM-2.5	SUM	29	14.74	12.71	0.79	-13.8	24.09	-2.03	3.55	12.64	-12.31	-18.54	-0.16	27.83	30.55	0.28	4.1	0.62
PM-2.5	FAL	24	10.95	10.56	0.78	-3.63	23.2	-0.4	2.54	9.49	2.28	-3.61	-0.04	27.48	26.1	0.24	3.11	0.61
PM-2.5	ALL	102	11.99	10.96	0.72	-8.64	25.94	-1.04	3.11	12.43	-4.86	-11.56	-0.09	29.2	30.68	0.28	3.68	0.52
SO4	WIN	22	1.83	1.52	0.78	-17.26	31.71	-0.32	0.58	0.47	-13.73	-21.63	-0.21	31.94	37.02	0.38	0.76	0.61
SO4	SPR	27	2.35	1.83	0.75	-22.41	27.93	-0.53	0.66	0.51	-18.57	-25.64	-0.29	26.51	32.55	0.36	0.89	0.57
SO4	SUM	28	2.88	1.66	0.46	-42.48	45.06	-1.22	1.3	1.27	-35.33	-50.87	-0.74	42.36	56.5	0.78	1.66	0.21
SO4	FAL	24	1.96	1.54	0.85	-21.34	29.56	-0.42	0.58	0.49	-10.63	-18.63	-0.27	31.22	33.02	0.38	0.82	0.72
SO4	ALL	101	2.29	1.65	0.67	-28.28	34.88	-0.65	0.8	0.84	-20.27	-30.09	-0.39	33.21	40.28	0.49	1.12	0.45

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 080010006																		
EC	WIN	15	1.26	2.13	0.63	69.01	75.45	0.87	0.95	0.58	143.58	64.57	0.69	146.99	68.16	0.75	1.15	0.39
EC	SPR	15	0.51	1.15	0.71	126.55	126.55	0.65	0.65	0.07	186.66	86.14	1.27	186.66	86.14	1.27	0.7	0.5
EC	SUM	16	0.95	1.25	0.35	31.18	42.9	0.3	0.41	0.17	48.02	31.33	0.31	53.89	38.4	0.43	0.51	0.12
EC	FAL	15	1.27	1.82	0.82	42.68	43.31	0.54	0.55	0.15	58.71	39.21	0.43	59.37	39.89	0.43	0.67	0.68
EC	ALL	61	1	1.58	0.71	58.51	63.64	0.58	0.64	0.28	108.24	54.92	0.59	110.78	57.82	0.64	0.79	0.5
NACL	WIN	15	0.16	0.11	0.31	-28.56	50.39	-0.05	0.08	0.01	-1.63	-20.02	-0.4	46.8	48.97	0.71	0.12	0.1
NACL	SPR	15	0.09	0.07	0.12	-19.66	72.91	-0.02	0.06	0.01	64.69	21.54	-0.24	92.85	66.23	0.91	0.11	0.02
NACL	SUM	16	0.06	0.04	0.21	-37.36	47.01	-0.02	0.03	0	-7.67	-34.59	-0.6	56.43	51.12	0.75	0.04	0.04
NACL	FAL	13	0.07	0.05	0.56	-33.21	50.28	-0.02	0.04	0	-8.63	-25.05	-0.5	49.53	53.21	0.75	0.05	0.31
NACL	ALL	59	0.09	0.07	0.46	-28.73	55.06	-0.03	0.05	0.01	12.05	-14.51	-0.4	61.72	54.87	0.77	0.09	0.21
NH4	WIN	15	0.7	0.54	0.68	-22.44	39.45	-0.16	0.28	0.09	13.83	-11.34	-0.29	60.89	49.87	0.51	0.34	0.46
NH4	SPR	15	0.43	0.33	0.36	-23.21	58.71	-0.1	0.26	0.13	37.96	-1.04	-0.3	84.81	64.65	0.76	0.37	0.13
NH4	SUM	16	0.25	0.24	0.35	-6.07	39.33	-0.02	0.1	0.01	18.46	1.53	-0.06	51.3	43.43	0.42	0.12	0.12
NH4	FAL	13	0.3	0.28	0.81	-5.14	25.08	-0.02	0.08	0.01	5.68	0.29	-0.05	26.03	24.05	0.26	0.1	0.65
NH4	ALL	59	0.42	0.35	0.67	-17.28	42.22	-0.07	0.18	0.06	19.43	-2.67	-0.21	56.69	46.19	0.51	0.26	0.44
NO3	WIN	15	2.11	1.02	0.7	-51.9	53	-1.1	1.12	1.1	-36.96	-61.64	-1.08	52.22	72.54	1.1	1.52	0.48
NO3	SPR	15	0.83	0.37	0.47	-55.3	64.77	-0.46	0.54	0.53	-46.58	-76.49	-1.24	57.33	85.34	1.45	0.86	0.22
NO3	SUM	16	0.32	0.1	0.27	-68.69	68.69	-0.22	0.22	0.02	-62.92	-95.14	-2.19	62.92	95.14	2.19	0.27	0.07
NO3	FAL	13	0.63	0.25	0.96	-59.68	59.68	-0.37	0.37	0.11	-57.73	-83.79	-1.48	57.73	83.79	1.48	0.5	0.93
NO3	ALL	59	0.97	0.44	0.77	-55.22	57.89	-0.54	0.56	0.56	-51.02	-79.38	-1.23	57.64	84.4	1.29	0.92	0.6
OC	WIN	15	1.92	8.2	0.74	327.37	327.37	6.28	6.28	6.89	584.58	128.79	3.27	584.58	128.79	3.27	6.81	0.54
OC	SPR	15	0.73	3.13	0.57	328.02	328.02	2.4	2.4	0.96	403.05	125.43	3.28	403.05	125.43	3.28	2.59	0.32
OC	SUM	16	1.73	2.21	0.23	27.88	43.46	0.48	0.75	0.52	40.51	28.46	0.28	48.3	37.86	0.43	0.87	0.06
OC	FAL	15	1.6	4.64	0.5	189.78	189.78	3.04	3.04	4.72	209.43	87.45	1.9	209.43	87.45	1.9	3.73	0.25
OC	ALL	61	1.5	4.51	0.54	200.73	205.44	3.01	3.08	7.63	304.99	91.48	2.01	307.03	93.95	2.05	4.08	0.29
PM-2.5	WIN	15	11.99	19.01	0.67	58.61	59.08	7.03	7.08	29.27	91.7	47.18	0.59	92.26	47.76	0.59	8.87	0.46
PM-2.5	SPR	15	7.62	9.72	0.02	27.56	62.25	2.1	4.74	36.16	75.6	34.92	0.28	88.1	52.55	0.62	6.37	0
PM-2.5	SUM	16	8.69	8.16	0.56	-6.17	19.72	-0.54	1.71	5.56	-0.55	-3.15	-0.07	18.23	18.74	0.21	2.42	0.32
PM-2.5	FAL	13	11.23	12.54	0.06	11.65	58.31	1.31	6.55	85.82	43.27	19.07	0.12	63.91	51.82	0.58	9.36	0
PM-2.5	ALL	59	9.82	12.28	0.38	25.09	50.06	2.46	4.91	45.11	51.92	24.22	0.25	64.88	42	0.5	7.15	0.15
SO4	WIN	15	0.66	0.77	0.48	16.71	40.29	0.11	0.27	0.08	43.39	23.97	0.17	58.01	41.17	0.4	0.31	0.23
SO4	SPR	15	0.78	0.81	0.32	3.94	41.3	0.03	0.32	0.21	29.18	11.62	0.04	50.98	39.45	0.41	0.45	0.1
SO4	SUM	16	0.93	0.72	0.52	-23.2	29.03	-0.22	0.27	0.09	-17.58	-23.24	-0.3	25.29	30.31	0.38	0.36	0.27
SO4	FAL	13	0.69	0.75	0.33	8.55	24.35	0.06	0.17	0.04	11.69	7.57	0.09	24.3	21.91	0.24	0.21	0.11
SO4	ALL	59	0.77	0.76	0.35	-1.26	33.72	-0.01	0.26	0.12	16.26	4.41	-0.01	39.92	33.54	0.34	0.35	0.12

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 080310025																		
EC	WIN	21	0.97	2.04	0.67	109.39	109.39	1.07	1.07	0.41	147.17	73	1.09	147.17	73	1.09	1.24	0.44
EC	SPR	25	0.52	1.05	0.69	103.13	104.54	0.53	0.54	0.08	153.71	74.54	1.03	154.3	75.15	1.05	0.6	0.47
EC	SUM	25	0.67	1.06	0.27	58.32	58.63	0.39	0.39	0.08	79.26	47.52	0.58	79.44	47.7	0.59	0.48	0.07
EC	FAL	25	0.88	1.49	0.58	69.02	71.03	0.61	0.63	0.23	100.3	53.92	0.69	102.08	55.79	0.71	0.78	0.33
EC	ALL	96	0.75	1.38	0.67	84.11	85.05	0.63	0.64	0.25	118.98	61.8	0.84	119.65	62.49	0.85	0.81	0.44
NACL	WIN	19	0.08	0.1	0.3	23.46	59.91	0.02	0.05	0	65.92	26.25	0.23	86.23	53.62	0.6	0.07	0.09
NACL	SPR	22	0.06	0.06	0.13	6.91	77.15	0	0.04	0	69.66	19.72	0.07	99.91	63	0.77	0.07	0.02
NACL	SUM	23	0.06	0.03	0.02	-53.98	62.21	-0.03	0.04	0	-20.68	-55.07	-1.17	68.72	77.34	1.35	0.06	0
NACL	FAL	24	0.06	0.05	0.09	-17.59	55.56	-0.01	0.03	0	2.26	-20.06	-0.21	56.17	56.76	0.67	0.04	0.01
NACL	ALL	88	0.06	0.06	0.21	-10.19	63.44	-0.01	0.04	0	26.86	-9.27	-0.11	76.88	63.02	0.71	0.06	0.05
NH4	WIN	21	0.91	0.51	0.63	-44.32	57.63	-0.4	0.52	0.69	10.84	-20.39	-0.8	71.17	68.11	1.04	0.93	0.39
NH4	SPR	23	0.47	0.32	0.45	-31.96	43.45	-0.15	0.2	0.09	-2.81	-22.46	-0.47	49.32	51.09	0.64	0.33	0.2
NH4	SUM	22	0.32	0.22	0.55	-30.69	42.83	-0.1	0.14	0.02	-13.75	-28.84	-0.44	45.42	50.27	0.62	0.16	0.31
NH4	FAL	24	0.38	0.3	0.8	-20.01	40.08	-0.08	0.15	0.05	2.44	-12.47	-0.25	44.89	43.87	0.5	0.23	0.63
NH4	ALL	90	0.51	0.34	0.65	-34.53	48.57	-0.18	0.25	0.22	-0.9	-20.88	-0.53	52.28	52.94	0.74	0.5	0.43
NO3	WIN	21	2.64	1	0.67	-62.24	63.55	-1.64	1.68	5.15	-44.37	-70.18	-1.65	52.16	76.54	1.68	2.8	0.44
NO3	SPR	23	1.02	0.41	0.6	-59.53	59.53	-0.61	0.61	0.32	-59.87	-94.97	-1.47	59.87	94.97	1.47	0.83	0.36
NO3	SUM	24	0.3	0.08	0.35	-73.01	74.27	-0.22	0.22	0.02	-63.65	-103.68	-2.71	70.31	108.43	2.75	0.27	0.12
NO3	FAL	24	0.98	0.43	0.85	-56.66	56.66	-0.56	0.56	0.49	-60.56	-91.7	-1.31	60.56	91.7	1.31	0.89	0.73
NO3	ALL	92	1.19	0.46	0.74	-61.17	61.92	-0.73	0.74	1.66	-57.5	-90.73	-1.58	61.01	93.42	1.59	1.48	0.55
OC	WIN	21	1.7	8.9	0.74	422.5	422.5	7.2	7.2	8.82	554.59	137.63	4.23	554.59	137.63	4.23	7.79	0.55
OC	SPR	25	0.68	3.31	0.54	386.55	386.55	2.63	2.63	1.62	2300.68	131.28	3.87	2300.7	131.28	3.87	2.92	0.29
OC	SUM	25	1.67	2.17	0.75	29.93	38.99	0.5	0.65	0.36	47.73	31.49	0.3	53.43	38.04	0.39	0.78	0.56
OC	FAL	25	1.37	4.7	0.42	243.72	243.72	3.33	3.33	6.21	301.2	99.67	2.44	301.2	99.67	2.44	4.16	0.18
OC	ALL	96	1.34	4.6	0.47	242.89	245.83	3.26	3.3	9.54	811.32	98.45	2.43	812.8	100.16	2.46	4.49	0.22
PM-2.5	WIN	19	8.93	17.65	0.63	97.68	98.18	8.72	8.76	25.09	144.54	70.31	0.98	145.09	70.87	0.98	10.06	0.4
PM-2.5	SPR	23	6.4	9.11	0.11	42.48	60.76	2.72	3.89	17.09	59.46	34.46	0.42	69.62	48.18	0.61	4.95	0.01
PM-2.5	SUM	24	8.49	7.28	0.5	-14.26	26.35	-1.21	2.24	6.17	-6.35	-12.25	-0.17	27.89	28.39	0.31	2.76	0.25
PM-2.5	FAL	24	7.11	11.52	0.37	62.12	81.3	4.42	5.78	29.74	222.48	43.85	0.62	236.83	61.87	0.81	7.02	0.14
PM-2.5	ALL	90	7.68	11.07	0.38	44.14	64.87	3.39	4.98	31.28	103.35	32.08	0.44	119.01	51.34	0.65	6.54	0.15
SO4	WIN	21	0.7	0.63	0.55	-9.9	45.44	-0.07	0.32	0.18	28.95	9.7	-0.11	58.47	49.11	0.5	0.43	0.3
SO4	SPR	23	0.83	0.68	0.44	-19.04	34.55	-0.16	0.29	0.17	-3.86	-13.04	-0.24	32.88	34.62	0.43	0.44	0.19
SO4	SUM	25	0.92	0.63	0.66	-31.82	40.19	-0.29	0.37	0.09	32.88	-26.99	-0.47	95.38	53.93	0.59	0.42	0.43
SO4	FAL	24	0.71	0.59	0.44	-16.51	29.31	-0.12	0.21	0.06	-4.68	-15.02	-0.2	34.21	34.49	0.35	0.27	0.19
SO4	ALL	93	0.79	0.63	0.51	-20.62	37.26	-0.16	0.3	0.13	13.21	-12.17	-0.26	55.8	43.05	0.47	0.4	0.26

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 081230008																		
EC	WIN	14	0.93	0.84	0.48	-9.78	55.88	-0.09	0.52	0.5	111.68	3.76	-0.11	151.58	57.97	0.62	0.71	0.23
EC	SPR	15	0.28	0.33	0.87	21.17	34.03	0.06	0.09	0.01	45.01	29.87	0.21	50.99	36.63	0.34	0.11	0.76
EC	SUM	16	0.48	0.4	0.48	-17.02	28.83	-0.08	0.14	0.04	-5.58	-10.99	-0.21	24.82	27.56	0.35	0.21	0.23
EC	FAL	15	0.7	0.64	0.73	-8.7	27.19	-0.06	0.19	0.05	-2.34	-7.32	-0.1	27.61	28.32	0.3	0.23	0.54
EC	ALL	60	0.59	0.54	0.65	-7.41	38.89	-0.04	0.23	0.14	35.24	3.58	-0.08	61.64	37.12	0.42	0.38	0.42
NACL	WIN	15	0.06	0.07	0.37	17.02	72.07	0.01	0.04	0	131.9	35.56	0.17	160.96	75.73	0.72	0.05	0.13
NACL	SPR	14	0.04	0.05	0.4	29.3	64.25	0.01	0.02	0	56.78	31.81	0.29	71.04	52.12	0.64	0.03	0.16
NACL	SUM	16	0.04	0.02	0.24	-46.96	55.96	-0.02	0.02	0	-20.65	-40.9	-0.89	50.99	61.95	1.06	0.04	0.06
NACL	FAL	15	0.04	0.04	0.32	-6.26	34.33	0	0.01	0	3.57	-6.54	-0.07	39.07	36.49	0.37	0.02	0.1
NACL	ALL	60	0.05	0.04	0.37	-2.06	58.17	0	0.03	0	41.61	3.77	-0.02	80.18	56.74	0.59	0.04	0.14
NH4	WIN	15	1	0.67	0.81	-32.84	44.97	-0.33	0.45	0.27	92.12	-11.9	-0.49	139.24	50.59	0.67	0.61	0.65
NH4	SPR	14	0.44	0.37	0.67	-15.29	46.44	-0.07	0.2	0.06	9.1	-9.61	-0.18	56.18	52.25	0.55	0.25	0.45
NH4	SUM	16	0.28	0.21	0.72	-24.25	38.62	-0.07	0.11	0.01	-2.07	-18.73	-0.32	50.17	48	0.51	0.13	0.52
NH4	FAL	15	0.35	0.33	0.53	-5.72	47.32	-0.02	0.16	0.1	15.42	3.24	-0.06	39.19	34.04	0.5	0.31	0.28
NH4	ALL	60	0.51	0.39	0.79	-23.56	44.73	-0.12	0.23	0.12	28.46	-9.4	-0.31	71.09	46.15	0.59	0.37	0.63
NO3	WIN	15	3.02	1.64	0.77	-45.5	51.26	-1.37	1.55	2.94	-5.85	-34.2	-0.84	63.41	62.88	0.94	2.2	0.6
NO3	SPR	14	1.02	0.57	0.66	-44.1	57.5	-0.45	0.59	0.3	-48.77	-78.01	-0.79	60.89	86.53	1.03	0.71	0.44
NO3	SUM	16	0.65	0.15	0.89	-77.14	77.14	-0.5	0.5	0.08	-79.09	-132.49	-3.37	79.09	132.49	3.37	0.58	0.79
NO3	FAL	15	1.25	0.57	0.67	-54.73	54.73	-0.69	0.69	0.96	-56.63	-86.93	-1.21	56.63	86.93	1.21	1.2	0.44
NO3	ALL	60	1.48	0.73	0.81	-50.95	56.04	-0.75	0.83	1.2	-48.09	-83.81	-1.04	65.31	92.97	1.14	1.33	0.66
OC	WIN	14	1.59	3.26	0.41	105.05	108.11	1.67	1.72	4.89	61639.4	65.84	1.05	61643	70.07	1.08	2.77	0.17
OC	SPR	13	0.58	1.04	0.58	77.63	78.85	0.45	0.46	0.16	116.99	62.42	0.78	117.85	63.31	0.79	0.61	0.34
OC	SUM	16	1.15	1.06	0.62	-7.92	24.45	-0.09	0.28	0.1	-6.7	-10.5	-0.09	23.42	25.19	0.27	0.33	0.38
OC	FAL	15	1.17	1.84	0.77	57.85	59.54	0.68	0.7	0.48	55.45	38.33	0.58	57.29	40.28	0.6	0.97	0.59
OC	ALL	58	1.13	1.79	0.54	57.75	68.42	0.65	0.78	1.78	14917.2	36.9	0.58	14927	48.47	0.68	1.49	0.29
PM-2.5	WIN	15	10.7	10.18	0.64	-4.9	36.32	-0.52	3.89	31.35	95.62	1	-0.05	126.83	37.54	0.38	5.62	0.41
PM-2.5	SPR	13	6.6	5.23	0.19	-20.78	35.94	-1.37	2.37	7.87	-12.09	-22.05	-0.26	33.02	39.35	0.45	3.12	0.04
PM-2.5	SUM	16	7.16	4.57	0.42	-36.19	36.19	-2.59	2.59	6.36	-31.15	-39.79	-0.57	31.15	39.79	0.57	3.62	0.17
PM-2.5	FAL	15	8.04	7.26	0.6	-9.67	31.22	-0.78	2.51	7.6	-7.81	-13.56	-0.11	30.1	32.58	0.35	2.86	0.36
PM-2.5	ALL	59	8.16	6.82	0.63	-16.37	34.94	-1.34	2.85	14.03	11.21	-18.84	-0.2	55.62	37.28	0.42	3.98	0.39
SO4	WIN	15	0.69	0.61	0.64	-11.38	33.13	-0.08	0.23	0.07	11.87	-1.29	-0.13	45.24	38.66	0.37	0.27	0.41
SO4	SPR	14	0.74	0.68	0.47	-8.29	38.15	-0.06	0.28	0.17	7.52	-4.62	-0.09	42.06	40.25	0.42	0.42	0.22
SO4	SUM	16	0.85	0.55	0.86	-35.57	35.57	-0.3	0.3	0.03	-33.65	-42.29	-0.55	33.65	42.29	0.55	0.35	0.74
SO4	FAL	15	0.56	0.55	0.18	-1.11	25.93	-0.01	0.15	0.04	4.69	-0.93	-0.01	27.2	25.79	0.26	0.19	0.03
SO4	ALL	60	0.71	0.6	0.53	-16.3	33.71	-0.12	0.24	0.09	-3.08	-12.91	-0.19	36.9	36.78	0.4	0.32	0.28

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 090090027																		
EC	WIN	23	1.3	1.15	0.78	-11.06	35.67	-0.14	0.46	0.34	10.87	-3.53	-0.12	46.53	41	0.4	0.6	0.61
EC	SPR	23	0.69	0.58	0.52	-16.22	35.62	-0.11	0.25	0.09	-3.53	-12.99	-0.19	36.36	37.99	0.43	0.33	0.27
EC	SUM	24	0.93	0.57	0.84	-37.97	40.42	-0.35	0.37	0.13	-27.61	-37.16	-0.61	34.48	43.2	0.65	0.5	0.7
EC	FAL	25	1.26	0.8	0.72	-36.49	43.29	-0.46	0.55	0.41	-27.67	-39.58	-0.57	36.9	47.78	0.68	0.79	0.51
EC	ALL	95	1.05	0.77	0.73	-25.96	39.14	-0.27	0.41	0.27	-12.48	-23.8	-0.35	38.49	42.61	0.53	0.58	0.53
NACL	WIN	22	0.12	0.12	0.1	0.56	69.47	0	0.08	0.02	38.32	7.53	0.01	69.46	53.3	0.69	0.15	0.01
NACL	SPR	22	0.27	0.49	0.98	84	107.49	0.23	0.29	0.55	91.46	32.96	0.84	113.16	61.47	1.07	0.77	0.95
NACL	SUM	24	0.12	0.19	0.08	58.71	122.91	0.07	0.15	0.07	110.2	3.24	0.59	159.32	80.54	1.23	0.27	0.01
NACL	FAL	25	0.11	0.14	0.56	22.29	71.67	0.02	0.08	0.02	57.55	3	0.22	94.26	57.5	0.72	0.15	0.32
NACL	ALL	93	0.15	0.23	0.92	51.56	96.73	0.08	0.15	0.16	74.61	11.22	0.52	109.65	63.39	0.97	0.41	0.84
NH4	WIN	22	1.06	1.1	0.76	3.7	29.2	0.04	0.31	0.32	21.81	10.86	0.04	35.84	27.79	0.29	0.57	0.57
NH4	SPR	24	0.67	0.71	0.88	5.35	30.92	0.04	0.21	0.06	34.39	11.48	0.05	56.72	44.19	0.31	0.25	0.77
NH4	SUM	23	0.61	0.52	0.75	-15.42	51.73	-0.09	0.32	0.19	58.3	5.6	-0.18	98.15	61.84	0.61	0.44	0.56
NH4	FAL	25	0.62	0.73	0.8	17.74	43.41	0.11	0.27	0.09	171.95	39.23	0.18	187.09	61.2	0.43	0.32	0.64
NH4	ALL	94	0.74	0.76	0.79	3.33	37.37	0.02	0.27	0.17	73.88	17.27	0.03	96.64	49.19	0.37	0.41	0.62
NO3	WIN	22	1.85	2.36	0.67	27.18	53.52	0.5	0.99	2.18	51.5	22.01	0.27	70.49	47.06	0.54	1.56	0.45
NO3	SPR	24	0.93	0.86	0.61	-7.67	45.71	-0.07	0.42	0.39	13.99	-4.4	-0.08	52.98	46.49	0.5	0.63	0.38
NO3	SUM	24	0.53	0.23	0.39	-57.23	70.61	-0.3	0.37	0.13	-42.96	-84.36	-1.34	72.49	104.18	1.65	0.47	0.15
NO3	FAL	25	0.93	0.87	0.74	-6.36	50.51	-0.06	0.47	0.38	-0.14	-26.49	-0.07	61.36	65.34	0.54	0.62	0.55
NO3	ALL	95	1.04	1.05	0.74	0.67	53.24	0.01	0.55	0.82	4.57	-24.3	0.01	64.17	66.16	0.53	0.9	0.55
OC	WIN	23	1.9	5.93	0.86	212.43	212.43	4.03	4.03	6.54	261.25	105.56	2.12	261.25	105.56	2.12	4.77	0.74
OC	SPR	23	1.1	2.36	0.31	115.36	134.35	1.27	1.48	1.94	179.93	71.49	1.15	187.78	80.45	1.34	1.88	0.09
OC	SUM	24	1.79	1.76	0.87	-1.83	19.95	-0.03	0.36	0.2	4.7	-0.81	-0.02	25.69	23.95	0.2	0.45	0.75
OC	FAL	25	1.98	2.49	0.81	25.84	46.15	0.51	0.91	1	62.34	28.86	0.26	78.81	51.14	0.46	1.12	0.65
OC	ALL	95	1.7	3.11	0.58	82.98	97.98	1.41	1.66	4.78	124.4	50.25	0.83	135.94	64.54	0.98	2.6	0.33
PM-2.5	WIN	22	11.91	15.18	0.85	27.44	38.49	3.27	4.58	24.46	36.36	25.33	0.27	44.16	35.12	0.38	5.93	0.72
PM-2.5	SPR	23	8.15	8.2	0.66	0.58	29.06	0.05	2.37	9.68	8.13	0.61	0.01	30.69	29.01	0.29	3.11	0.44
PM-2.5	SUM	25	10.84	6.5	0.78	-40.02	42.57	-4.34	4.61	11.58	-35.62	-48.61	-0.67	41.55	53.36	0.71	5.51	0.61
PM-2.5	FAL	25	10.67	8.74	0.79	-18.09	26.57	-1.93	2.84	11.69	-13.88	-20.52	-0.22	25.37	30.75	0.32	3.93	0.63
PM-2.5	ALL	95	10.39	9.51	0.71	-8.48	34.6	-0.88	3.6	21.76	-2.64	-12.18	-0.09	35.27	37.29	0.38	4.75	0.51
SO4	WIN	22	1.93	1.3	0.63	-32.73	41.01	-0.63	0.79	0.65	-27.72	-38.73	-0.49	38.12	47.49	0.61	1.02	0.4
SO4	SPR	24	1.75	1.76	0.88	0.6	23.95	0.01	0.42	0.28	4.13	0.4	0.01	24.44	23.44	0.24	0.53	0.77
SO4	SUM	24	2.17	1.76	0.7	-18.93	40.13	-0.41	0.87	1.45	1.31	-15.47	-0.23	44.04	42.24	0.49	1.27	0.49
SO4	FAL	25	1.8	1.62	0.79	-10.3	24.5	-0.19	0.44	0.51	9.79	-3.47	-0.11	34.65	29.96	0.27	0.74	0.62
SO4	ALL	95	1.91	1.62	0.73	-15.5	32.72	-0.3	0.63	0.78	-2.47	-13.69	-0.18	35.25	35.47	0.39	0.93	0.53

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 100010003																		
EC	WIN	14	0.38	0.49	0.76	27.97	36.47	0.11	0.14	0.02	41.01	29.25	0.28	45.48	34.38	0.36	0.17	0.58
EC	SPR	14	0.3	0.33	0.59	9.09	37.3	0.03	0.11	0.02	8.83	-0.4	0.09	38.02	38.29	0.37	0.13	0.34
EC	SUM	16	0.43	0.37	0.7	-13.43	23.96	-0.06	0.1	0.01	-11.93	-16.33	-0.16	23.55	26.11	0.28	0.13	0.49
EC	FAL	15	0.34	0.37	0.87	9.53	22.49	0.03	0.08	0.01	16.66	10.89	0.1	28.85	24.46	0.22	0.09	0.76
EC	ALL	59	0.37	0.39	0.71	6.67	29.35	0.02	0.11	0.02	12.83	5.19	0.07	33.54	30.54	0.29	0.13	0.5
NACL	WIN	13	0.04	0.15	0.45	248.87	254.88	0.11	0.11	0.04	280.62	74.54	2.49	285.29	79.63	2.55	0.22	0.2
NACL	SPR	14	0.14	0.6	0.16	326.32	342.54	0.46	0.48	0.74	1411.22	56.82	3.26	1430.8	86.76	3.43	0.98	0.03
NACL	SUM	1	0.02	0.04	0	102.83	102.83	0.02	0.02	0	102.83	67.91	1.03	102.83	67.91	1.03	0.02	0
NACL	FAL	14	0.11	0.41	0.98	288.46	305.29	0.31	0.32	0.39	151.42	41.62	2.88	176.22	76.46	3.05	0.69	0.95
NACL	ALL	42	0.1	0.39	0.57	300.38	315.29	0.29	0.3	0.41	610.19	57.5	3	626.43	80.67	3.15	0.7	0.33
NH4	WIN	13	1.28	1.06	0.81	-17.15	27.11	-0.22	0.35	0.26	-4.78	-10.56	-0.21	27.6	29.08	0.33	0.55	0.66
NH4	SPR	14	0.99	0.83	0.85	-16.87	30.69	-0.17	0.3	0.1	-10.66	-24.3	-0.2	37.89	46.41	0.37	0.35	0.72
NH4	SUM	1	0.45	0.36	0	-19.34	19.34	-0.09	0.09	0	-19.34	-21.41	-0.24	19.34	21.41	0.24	0.09	0
NH4	FAL	14	0.43	0.65	0.85	52.42	72.05	0.22	0.31	0.07	397.54	84.11	0.52	403.55	90.83	0.72	0.35	0.72
NH4	ALL	42	0.88	0.83	0.83	-5.78	35.65	-0.05	0.31	0.17	127.02	16.16	-0.06	156.15	55.26	0.38	0.42	0.69
NO3	WIN	13	2.1	2.28	0.61	8.49	48.71	0.18	1.03	1.53	36.54	10.17	0.08	69.03	54.43	0.49	1.25	0.38
NO3	SPR	14	1.27	1.26	0.82	-0.96	36.4	-0.01	0.46	0.31	7.68	-5.31	-0.01	43.05	41.94	0.37	0.56	0.68
NO3	SUM	1	0.16	0.05	0	-69.63	69.63	-0.11	0.11	0	-69.63	-106.83	-2.29	69.63	106.83	2.29	0.11	0
NO3	FAL	14	0.83	0.9	0.54	8.56	58.7	0.07	0.49	0.38	86.05	19.24	0.09	120.12	68.46	0.59	0.62	0.3
NO3	ALL	42	1.36	1.43	0.74	5.32	46.96	0.07	0.64	0.71	40.89	5.25	0.05	77.42	56.19	0.47	0.85	0.55
OC	WIN	14	1.14	2.28	0.82	99.89	99.89	1.14	1.14	0.35	134.99	71.93	1	134.99	71.93	1	1.28	0.68
OC	SPR	14	1.16	1.24	0.22	6.82	51.81	0.08	0.6	0.64	28.3	11.28	0.07	52.05	44.83	0.52	0.81	0.05
OC	SUM	16	2	1.71	0.74	-14.48	25.08	-0.29	0.5	0.4	-11.33	-17.05	-0.17	25.06	28.28	0.29	0.7	0.55
OC	FAL	15	0.87	1.1	0.84	26.45	31.61	0.23	0.28	0.09	44.12	23.38	0.26	48.89	28.54	0.32	0.37	0.71
OC	ALL	59	1.31	1.58	0.57	20.53	47.24	0.27	0.62	0.64	46.89	21.06	0.21	63.61	42.63	0.47	0.84	0.33
PM-2.5	WIN	14	8.41	9.15	0.82	8.89	26.08	0.75	2.19	7.05	64.95	18.1	0.09	75.65	29.92	0.26	2.76	0.68
PM-2.5	SPR	14	8.73	7.23	0.21	-17.2	29.35	-1.5	2.56	12.06	-10.91	-17.57	-0.21	24.54	29.95	0.35	3.78	0.04
PM-2.5	SUM	1	7.4	3.98	0	-46.18	46.18	-3.42	3.42	0	-46.18	-60.05	-0.86	46.18	60.05	0.86	3.42	0
PM-2.5	FAL	15	5.69	6.04	0.48	6.13	31.62	0.35	1.8	7.36	41.14	7.94	0.06	61.8	32.33	0.32	2.74	0.23
PM-2.5	ALL	44	7.56	7.36	0.62	-2.63	29.15	-0.2	2.2	9.75	30.17	1.51	-0.03	54	31.44	0.3	3.13	0.38
SO4	WIN	13	2.14	1.38	0.69	-35.51	39.21	-0.76	0.84	0.42	-30.83	-41.31	-0.55	36.3	45.96	0.61	1	0.48
SO4	SPR	14	2.2	1.75	0.8	-20.49	27	-0.45	0.59	0.33	-11.51	-18.51	-0.26	30.07	32.85	0.34	0.73	0.64
SO4	SUM	1	1.27	1.05	0	-17.01	17.01	-0.22	0.22	0	-17.01	-18.59	-0.2	17.01	18.59	0.2	0.22	0
SO4	FAL	14	1.54	1.52	0.75	-1.13	33.13	-0.02	0.51	0.56	22.42	6.5	-0.01	47.03	36.64	0.34	0.75	0.56
SO4	ALL	42	1.94	1.54	0.71	-20.46	32.64	-0.4	0.63	0.52	-6.31	-17.23	-0.26	37.34	37.83	0.41	0.82	0.51

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 100032004																		
EC	WIN	19	0.78	1.12	0.92	43.83	45.63	0.34	0.35	0.03	64.3	43.92	0.44	65.54	45.24	0.46	0.39	0.84
EC	SPR	28	0.47	0.61	0.29	30.39	50.41	0.14	0.24	0.09	182.02	27.72	0.3	194.51	43.32	0.5	0.33	0.08
EC	SUM	27	0.7	0.67	0.71	-4.2	21.3	-0.03	0.15	0.03	-0.25	-2.95	-0.04	20.85	20.68	0.22	0.18	0.5
EC	FAL	25	0.8	0.96	0.87	19.14	26.51	0.15	0.21	0.06	33.04	20.63	0.19	39.69	28.92	0.27	0.29	0.75
EC	ALL	99	0.68	0.81	0.78	20.18	33.94	0.14	0.23	0.07	72.1	20.67	0.2	83.3	33.88	0.34	0.3	0.61
NACL	WIN	20	0.12	0.15	0.55	27.44	77.71	0.03	0.09	0.02	87.7	38.32	0.27	109.34	66.62	0.78	0.13	0.3
NACL	SPR	29	0.18	0.23	0.65	26.06	84.27	0.05	0.15	0.08	393.48	43.31	0.26	411.09	67.61	0.84	0.29	0.42
NACL	SUM	27	0.06	0.08	0.45	33.97	76.58	0.02	0.05	0.01	34.85	-4.59	0.34	79.38	54.59	0.77	0.08	0.21
NACL	FAL	27	0.08	0.21	0.83	167.29	175.15	0.13	0.14	0.11	101.91	45.93	1.67	114.09	59.91	1.75	0.36	0.69
NACL	ALL	103	0.11	0.17	0.51	53.71	98.65	0.06	0.11	0.06	163.66	30.47	0.54	187.69	61.98	0.99	0.25	0.26
NH4	WIN	20	1.75	1.38	0.66	-20.76	40.18	-0.36	0.7	0.73	282.06	-7.29	-0.26	326.62	48.62	0.51	0.93	0.44
NH4	SPR	29	0.98	0.91	0.85	-7.76	26.4	-0.08	0.26	0.1	-0.61	-11.04	-0.08	34.22	34.83	0.29	0.33	0.72
NH4	SUM	26	1.14	0.99	0.9	-12.96	30.75	-0.15	0.35	0.19	7.77	-2.1	-0.15	38.77	35.08	0.35	0.46	0.81
NH4	FAL	27	0.65	0.94	0.76	45.48	51.41	0.3	0.33	0.17	71.83	42.26	0.45	74.88	45.55	0.51	0.5	0.58
NH4	ALL	102	1.08	1.03	0.76	-4.82	35.88	-0.05	0.39	0.32	76.12	6.08	-0.05	103.47	40.44	0.38	0.56	0.58
NO3	WIN	20	3.43	3.13	0.44	-8.66	45.21	-0.3	1.55	4.3	164.73	-3.79	-0.09	208.74	55.5	0.49	2.09	0.19
NO3	SPR	30	1.19	1.23	0.73	3.22	45.88	0.04	0.55	0.58	120.37	-11.42	0.03	170.26	58.15	0.46	0.76	0.53
NO3	SUM	27	0.61	0.34	0.59	-43.47	60.19	-0.26	0.37	0.15	-41.25	-70.86	-0.77	62.63	86.43	1.06	0.47	0.34
NO3	FAL	28	1.1	1.5	0.7	35.91	63.22	0.4	0.7	1.26	36.88	9.27	0.36	69.98	54.45	0.63	1.19	0.49
NO3	ALL	105	1.44	1.44	0.7	-0.56	50.66	-0.01	0.73	1.44	65	-19.73	-0.01	123.17	63.93	0.51	1.2	0.49
OC	WIN	19	1.75	4.96	0.86	183.69	183.69	3.21	3.21	2.21	216.58	99.33	1.84	216.58	99.33	1.84	3.54	0.73
OC	SPR	27	1.2	1.98	0.2	64.81	82.6	0.78	0.99	1.04	95.79	42.09	0.65	110.17	59.25	0.83	1.28	0.04
OC	SUM	27	2.36	2.14	0.86	-9.06	17.06	-0.21	0.4	0.24	-8.74	-11.41	-0.1	18.13	19.55	0.19	0.53	0.74
OC	FAL	25	1.6	2.44	0.82	52.14	57.55	0.83	0.92	0.97	72.59	42.43	0.52	75.54	45.72	0.58	1.29	0.68
OC	ALL	98	1.73	2.72	0.54	57.35	71.86	0.99	1.24	2.4	84.49	38.53	0.57	96.61	52.63	0.72	1.84	0.29
PM-2.5	WIN	20	14.78	15.68	0.8	6.13	25.38	0.91	3.75	19.93	50.75	14.6	0.06	63.5	29.33	0.25	4.56	0.64
PM-2.5	SPR	30	8.67	8.61	0.33	-0.64	35.94	-0.06	3.12	17.49	331.65	-0.11	-0.01	360.33	38.94	0.36	4.18	0.11
PM-2.5	SUM	27	12.9	9.11	0.81	-29.33	35.69	-3.78	4.6	17.25	-7.43	-29.18	-0.42	50.69	42.85	0.51	5.62	0.66
PM-2.5	FAL	27	8.37	10.07	0.84	20.3	28.19	1.7	2.36	9.28	29.54	19.33	0.2	36.01	26.35	0.28	3.49	0.71
PM-2.5	ALL	104	10.86	10.48	0.71	-3.52	31.55	-0.38	3.43	20.25	111.17	0.22	-0.04	138.66	34.84	0.33	4.52	0.5
SO4	WIN	20	2.4	1.48	0.74	-38.25	42.45	-0.92	1.02	0.99	73.57	-31.79	-0.62	138.27	52.85	0.69	1.35	0.55
SO4	SPR	30	2.11	1.75	0.62	-17.21	32.87	-0.36	0.69	0.65	157.91	-16.04	-0.21	201.63	39.13	0.4	0.89	0.38
SO4	SUM	27	3.39	2.69	0.89	-20.54	32.17	-0.7	1.09	1.47	389.69	-15.93	-0.26	435.8	41.27	0.4	1.4	0.79
SO4	FAL	28	1.63	1.62	0.67	-0.88	30.47	-0.01	0.5	0.42	10.91	2.74	-0.01	34.85	31.24	0.31	0.65	0.45
SO4	ALL	105	2.37	1.91	0.82	-19.5	34.02	-0.46	0.81	0.98	162.24	-14	-0.24	205.3	40.19	0.42	1.09	0.67

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 110010043																		
EC	WIN	23	0.62	1.95	0.71	213.76	213.76	1.33	1.33	0.37	245.67	105.42	2.14	245.67	105.42	2.14	1.46	0.5
EC	SPR	24	0.4	1.04	0.03	158.39	158.39	0.64	0.64	0.17	185.22	84.2	1.58	185.22	84.2	1.58	0.76	0
EC	SUM	23	0.59	1.15	0.62	94.86	94.86	0.56	0.56	0.08	111.57	64.97	0.95	111.57	64.97	0.95	0.63	0.38
EC	FAL	24	0.81	1.74	0.91	113.12	113.12	0.92	0.92	0.18	141.53	76.68	1.13	141.53	76.68	1.13	1.01	0.83
EC	ALL	94	0.61	1.47	0.73	141.68	141.68	0.86	0.86	0.29	170.84	82.76	1.42	170.84	82.76	1.42	1.02	0.53
NACL	WIN	22	0.06	0.16	0.58	163.77	176.12	0.1	0.11	0.01	250.55	92.39	1.64	255.24	97.79	1.76	0.14	0.33
NACL	SPR	25	0.1	0.17	0.49	74.08	112.69	0.07	0.11	0.02	381.89	67.87	0.74	396.27	87.32	1.13	0.17	0.24
NACL	SUM	23	0.05	0.06	0.62	20.97	69.5	0.01	0.03	0	18.96	-8.9	0.21	63.81	54.54	0.7	0.06	0.38
NACL	FAL	24	0.08	0.16	0.5	100.67	140.04	0.08	0.11	0.06	110.92	35.51	1.01	134.03	71.02	1.4	0.26	0.25
NACL	ALL	94	0.07	0.14	0.48	90.64	125.91	0.07	0.09	0.03	193.17	46.56	0.91	214.96	77.59	1.26	0.18	0.23
NH4	WIN	24	1.28	1.53	0.79	19.94	29.04	0.26	0.37	0.24	27.95	16.8	0.2	37.7	28.33	0.29	0.55	0.63
NH4	SPR	24	0.88	0.85	0.77	-3.13	25.74	-0.03	0.23	0.11	-6.26	-15.19	-0.03	29.65	32.53	0.27	0.33	0.59
NH4	SUM	23	1	0.86	0.79	-13.84	30.44	-0.14	0.31	0.17	-1.19	-8.95	-0.16	32.66	33.28	0.35	0.44	0.63
NH4	FAL	24	0.59	0.84	0.71	43.39	55.64	0.25	0.33	0.15	77.87	41.14	0.43	84.83	49.5	0.56	0.46	0.5
NH4	ALL	95	0.94	1.02	0.76	9.44	32.84	0.09	0.31	0.2	24.86	8.63	0.09	46.35	35.94	0.33	0.45	0.58
NO3	WIN	24	2.27	3.21	0.63	41.74	59.19	0.95	1.34	2.35	66.16	31.37	0.42	80.71	53.49	0.59	1.8	0.4
NO3	SPR	25	0.97	1.02	0.55	5.45	60.93	0.05	0.59	0.66	102.93	-19.97	0.05	164.49	71.74	0.61	0.81	0.3
NO3	SUM	23	0.46	0.13	0.2	-72.18	77.57	-0.33	0.36	0.1	-67.46	-114.43	-2.6	71.98	118.02	2.79	0.46	0.04
NO3	FAL	24	0.88	1.34	0.77	52.92	72.47	0.46	0.63	0.91	48.51	21.45	0.53	72.05	52.79	0.72	1.06	0.6
NO3	ALL	96	1.15	1.44	0.75	24.97	63.86	0.29	0.73	1.23	39.31	-19.41	0.25	98.27	73.53	0.64	1.15	0.57
OC	WIN	23	1.53	7.17	0.65	368.98	368.98	5.64	5.64	5.21	432.45	131.16	3.69	432.45	131.16	3.69	6.09	0.43
OC	SPR	24	1.18	2.7	0.21	129.33	145.83	1.52	1.71	3.25	213.36	68.38	1.29	222.33	78.77	1.46	2.36	0.04
OC	SUM	23	2.5	2.75	0.82	10.04	23.57	0.25	0.59	0.47	15.23	11.12	0.1	25.47	22.65	0.24	0.73	0.68
OC	FAL	24	1.9	3.93	0.75	107.15	108.97	2.03	2.07	3.97	119.65	63.48	1.07	120.65	64.54	1.09	2.85	0.56
OC	ALL	94	1.77	4.12	0.32	132.77	140.74	2.35	2.49	7.16	194.56	68.48	1.33	199.61	74.22	1.41	3.56	0.1
PM-2.5	WIN	22	11.38	21	0.83	84.62	84.62	9.63	9.63	21.81	93.16	59.63	0.85	93.16	59.63	0.85	10.7	0.69
PM-2.5	SPR	25	8.19	9.76	0.06	19.22	50.24	1.57	4.11	22.5	28.77	12.18	0.19	54.04	44.81	0.5	5	0
PM-2.5	SUM	23	13.13	10.05	0.88	-23.42	24.74	-3.07	3.25	7.14	-20.89	-25.44	-0.31	23.18	27.53	0.32	4.07	0.78
PM-2.5	FAL	25	8.78	12.31	0.81	40.17	44.21	3.53	3.88	19.17	44.62	30.12	0.4	47.93	33.82	0.44	5.62	0.65
PM-2.5	ALL	95	10.28	13.11	0.57	27.51	49.81	2.83	5.12	37.43	35.83	18.78	0.28	54.02	41.17	0.5	6.74	0.32
SO4	WIN	24	2.13	1.75	0.51	-18.13	38.21	-0.39	0.81	0.89	-12.44	-21.27	-0.22	35.64	39.39	0.47	1.02	0.26
SO4	SPR	25	2.06	1.74	0.56	-15.3	32.23	-0.32	0.66	0.6	78.03	-14.08	-0.18	120.83	41.06	0.38	0.84	0.31
SO4	SUM	23	3.4	2.66	0.81	-21.61	29.85	-0.73	1.01	1.72	-15.48	-22.17	-0.28	26.98	32.4	0.38	1.5	0.65
SO4	FAL	24	1.66	1.5	0.74	-9.95	25.56	-0.17	0.42	0.33	-1.32	-7.08	-0.11	25.78	26.94	0.28	0.6	0.55
SO4	ALL	96	2.3	1.9	0.76	-17.22	31.57	-0.4	0.73	0.92	13.17	-16.06	-0.21	53.29	35.04	0.38	1.04	0.58

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 120111002																		
EC	WIN	27	0.44	1.01	0.5	127.14	127.14	0.56	0.56	0.07	166.95	81.13	1.27	166.95	81.13	1.27	0.62	0.26
EC	SPR	29	0.4	0.8	0.6	99.54	101.33	0.4	0.41	0.06	119.76	67.8	1	121.14	69.33	1.01	0.47	0.36
EC	SUM	31	0.31	0.95	0.52	211.06	211.06	0.65	0.65	0.11	278.68	102.54	2.11	278.68	102.54	2.11	0.73	0.27
EC	FAL	28	0.36	1	0.68	174.63	174.79	0.64	0.64	0.07	231.14	99.95	1.75	231.18	99.99	1.75	0.68	0.47
EC	ALL	115	0.38	0.94	0.54	149.24	149.76	0.56	0.56	0.09	200.8	88.12	1.49	201.16	88.52	1.5	0.63	0.29
NACL	WIN	28	0.51	0.77	0.64	50.46	79.01	0.26	0.41	0.28	117.81	28.46	0.5	151.65	77.1	0.79	0.59	0.41
NACL	SPR	28	0.5	0.67	0.79	33.19	69.19	0.17	0.35	0.34	59.36	21.99	0.33	84.13	57.74	0.69	0.61	0.62
NACL	SUM	30	0.51	0.54	0.4	5.21	72.4	0.03	0.37	0.27	13.12	-27.27	0.05	82.37	75.17	0.72	0.52	0.16
NACL	FAL	29	0.82	0.78	0.8	-5.13	39.33	-0.04	0.32	0.26	-13.66	-26.97	-0.05	38.84	47.36	0.41	0.51	0.64
NACL	ALL	115	0.59	0.69	0.68	17.03	61.53	0.1	0.36	0.3	43.12	-1.63	0.17	88.69	64.38	0.62	0.56	0.47
NH4	WIN	26	0.46	0.43	0.54	-5.93	48.39	-0.03	0.22	0.08	33.35	-12.91	-0.06	86.62	68.13	0.51	0.29	0.29
NH4	SPR	28	0.58	0.36	0.56	-38.03	47.55	-0.22	0.27	0.07	-39.7	-67.96	-0.61	52.18	77.81	0.77	0.34	0.31
NH4	SUM	30	0.16	0.1	0.34	-33.55	74.45	-0.05	0.12	0.03	24.92	-41.69	-0.5	107.3	96.81	1.12	0.18	0.12
NH4	FAL	26	0.13	0.19	0.72	46.23	72.8	0.06	0.09	0.01	107.81	-3.47	0.46	156.6	78.33	0.73	0.13	0.51
NH4	ALL	110	0.33	0.27	0.64	-19.14	53.66	-0.06	0.18	0.06	30.06	-32.54	-0.24	100.03	80.83	0.66	0.25	0.41
NO3	WIN	28	0.55	0.54	0.08	-0.46	75.41	0	0.41	0.23	21.59	-17.9	0	84.46	78.82	0.76	0.48	0.01
NO3	SPR	28	0.55	0.28	0.01	-49.87	71.52	-0.28	0.4	0.1	-42.01	-85.01	-0.99	76.48	105.12	1.43	0.42	0
NO3	SUM	31	0.4	0.36	0.3	-9.56	84.38	-0.04	0.34	0.16	5.39	-42.87	-0.11	90.61	93.08	0.93	0.4	0.09
NO3	FAL	29	0.33	0.44	0.16	32.45	105.55	0.11	0.35	0.23	33.68	-25.73	0.32	110.73	90.39	1.06	0.49	0.02
NO3	ALL	116	0.46	0.41	0.05	-11.14	81.86	-0.05	0.37	0.2	4.93	-42.73	-0.13	90.75	91.87	0.92	0.45	0
OC	WIN	26	0.99	2.76	0.53	179.35	179.35	1.77	1.77	0.8	366.54	102.51	1.79	366.54	102.51	1.79	1.99	0.28
OC	SPR	29	1.21	1.95	0.78	61.27	85.83	0.74	1.04	0.74	151.91	68.14	0.61	159.47	77.02	0.86	1.14	0.61
OC	SUM	30	0.59	2.08	0.31	249.59	255.34	1.48	1.52	0.62	440.01	114.08	2.5	442.21	116.7	2.55	1.68	0.09
OC	FAL	26	0.53	2.19	0.52	310.99	310.99	1.65	1.65	0.24	1973.99	127.97	3.11	1974	127.97	3.11	1.73	0.27
OC	ALL	111	0.83	2.23	0.49	167.71	178.15	1.4	1.48	0.77	706.84	102.62	1.68	709.41	105.65	1.78	1.65	0.24
PM-2.5	WIN	27	7.92	9.79	0.32	23.58	38.88	1.87	3.08	9.47	34.73	23.6	0.24	44.56	35.22	0.39	3.6	0.1
PM-2.5	SPR	29	9.41	8.23	0.64	-12.56	20.68	-1.18	1.95	5.62	-8.68	-12.09	-0.14	18.78	20.8	0.24	2.65	0.41
PM-2.5	SUM	30	7.93	7.13	0.02	-9.99	33.78	-0.79	2.68	15.71	5.82	-3	-0.11	34.21	33.34	0.38	4.04	0
PM-2.5	FAL	29	6.53	7.64	0.43	17.01	29.67	1.11	1.94	4.68	28.23	19.05	0.17	36.67	28.64	0.3	2.43	0.18
PM-2.5	ALL	115	7.95	8.16	0.31	2.69	30.21	0.21	2.4	10.52	14.6	6.51	0.03	33.37	29.43	0.3	3.25	0.1
SO4	WIN	28	1.7	1.93	0.55	13.58	32.08	0.23	0.54	0.46	24.51	15.61	0.14	36.27	29.43	0.32	0.71	0.3
SO4	SPR	28	2.47	1.86	0.51	-24.9	33.26	-0.62	0.82	0.64	-19.8	-28.06	-0.33	32.64	37.87	0.44	1.01	0.26
SO4	SUM	31	1.48	0.74	0.58	-50.22	50.71	-0.74	0.75	0.29	-46.12	-64.45	-1.01	46.99	65.27	1.02	0.92	0.34
SO4	FAL	29	1.26	1.01	0.61	-19.97	28.5	-0.25	0.36	0.15	-14.91	-22.38	-0.25	29.18	33.82	0.36	0.46	0.37
SO4	ALL	116	1.72	1.36	0.59	-20.64	36.13	-0.35	0.62	0.52	-14.92	-25.82	-0.26	36.49	42.14	0.46	0.8	0.35

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 120573002																		
EC	WIN	29	0.54	0.88	0.71	61.32	62.19	0.33	0.34	0.08	78.94	48.31	0.61	79.58	48.97	0.62	0.44	0.51
EC	SPR	30	0.48	0.73	0.61	50.41	61.43	0.24	0.3	0.06	73.35	43.85	0.5	79.87	51.82	0.61	0.34	0.37
EC	SUM	31	0.35	0.81	0.32	127.88	131.57	0.45	0.47	0.07	188.19	78.37	1.28	190.48	80.9	1.32	0.52	0.1
EC	FAL	30	0.42	0.73	0.46	73.61	85.26	0.31	0.36	0.1	103.69	53.84	0.74	109.88	61.17	0.85	0.44	0.21
EC	ALL	120	0.45	0.79	0.54	74.82	81.53	0.34	0.37	0.08	111.95	56.34	0.75	115.88	60.98	0.82	0.44	0.3
NACL	WIN	29	0.23	0.5	0.7	117.76	128.61	0.27	0.3	0.11	197.69	60.72	1.18	209.48	75.32	1.29	0.43	0.49
NACL	SPR	28	0.26	0.56	0.57	115.31	150.62	0.3	0.39	0.32	159.67	64.21	1.15	173.99	85.3	1.51	0.64	0.32
NACL	SUM	30	0.21	0.32	0.4	51.44	113.94	0.11	0.24	0.1	63.94	3.99	0.51	113.58	82.24	1.14	0.33	0.16
NACL	FAL	27	0.29	0.54	0.6	84.76	113.24	0.25	0.33	0.4	78.52	8.64	0.85	118.02	63.82	1.13	0.68	0.36
NACL	ALL	114	0.25	0.48	0.59	93.02	126.65	0.23	0.31	0.23	124.93	34.31	0.93	153.86	76.87	1.27	0.54	0.34
NH4	WIN	27	0.64	0.75	0.53	18.01	52.55	0.12	0.34	0.19	78.4	27.32	0.18	98.34	53.14	0.53	0.45	0.28
NH4	SPR	28	0.64	0.6	0.54	-5.91	47.15	-0.04	0.3	0.18	-11.3	-32.9	-0.06	47.03	56.3	0.5	0.43	0.29
NH4	SUM	30	0.36	0.2	0.27	-43.72	68.05	-0.16	0.25	0.09	11.69	-35.87	-0.78	87.8	83.12	1.21	0.35	0.07
NH4	FAL	25	0.24	0.42	0.51	74.47	99.02	0.18	0.24	0.09	218.49	34.65	0.74	242.47	72.04	0.99	0.35	0.26
NH4	ALL	110	0.47	0.49	0.53	3.43	59.29	0.02	0.28	0.16	69.21	-3.57	0.03	115.16	66.42	0.59	0.4	0.28
NO3	WIN	29	0.58	1.13	0.56	95.18	121.24	0.55	0.7	0.74	96.3	35.76	0.95	121.51	71.9	1.21	1.02	0.31
NO3	SPR	28	0.48	0.74	0.35	52.87	97.02	0.26	0.47	0.6	51.39	-1.55	0.53	98.03	66.16	0.97	0.81	0.12
NO3	SUM	30	0.31	0.32	0.03	3.32	82.68	0.01	0.26	0.1	8.03	-29.48	0.03	82.51	79.72	0.83	0.32	0
NO3	FAL	27	0.32	0.55	0.03	70.72	127.18	0.23	0.41	0.42	83.2	-0.43	0.71	137.12	79.09	1.27	0.69	0
NO3	ALL	114	0.42	0.68	0.49	61.24	108.1	0.26	0.46	0.5	58.94	0.86	0.61	109.18	74.25	1.08	0.75	0.24
OC	WIN	29	1.65	3.02	0.78	82.5	82.74	1.36	1.37	1.81	93.94	56.14	0.82	94.16	56.37	0.83	1.91	0.61
OC	SPR	30	1.83	2.35	0.84	28.94	37.72	0.53	0.69	0.44	38.02	26.14	0.29	45.49	34.8	0.38	0.85	0.7
OC	SUM	31	1.31	2.29	0.6	75.14	82.76	0.98	1.08	0.72	125.28	58.72	0.75	129.77	63.84	0.83	1.3	0.36
OC	FAL	30	1.23	2.24	0.65	82.89	92.16	1.02	1.13	1.3	107.16	53.75	0.83	114.59	63.79	0.92	1.53	0.42
OC	ALL	120	1.5	2.47	0.7	64.63	70.97	0.97	1.06	1.14	91.36	48.71	0.65	96.3	54.76	0.71	1.44	0.49
PM-2.5	WIN	29	9.33	11.42	0.79	22.42	30.05	2.09	2.8	12.55	22.02	16.28	0.22	29.17	24.54	0.3	4.11	0.62
PM-2.5	SPR	29	11.22	9.74	0.42	-13.18	29.83	-1.48	3.35	18.49	-9.07	-15.28	-0.15	28.71	31.49	0.34	4.55	0.17
PM-2.5	SUM	31	10.77	7.26	0.5	-32.55	39.1	-3.51	4.21	19.68	-22.25	-31.28	-0.48	33.39	40.83	0.58	5.65	0.25
PM-2.5	FAL	27	6.95	8.01	0.34	15.32	42.15	1.06	2.93	12.67	69.99	9.91	0.15	95.44	43.86	0.42	3.72	0.12
PM-2.5	ALL	116	9.63	9.1	0.41	-5.57	34.72	-0.54	3.34	20.87	13.58	-5.8	-0.06	45.61	35.13	0.37	4.6	0.17
SO4	WIN	29	1.94	2.09	0.42	7.74	39.23	0.15	0.76	1.09	241.19	12.61	0.08	262.01	37.85	0.39	1.06	0.17
SO4	SPR	28	2.53	1.94	0.25	-23.51	34.09	-0.59	0.86	1.14	-17.31	-25.99	-0.31	30.73	36.22	0.45	1.22	0.06
SO4	SUM	30	2.19	0.89	0.56	-59.56	61.03	-1.31	1.34	0.85	-55.68	-83.13	-1.47	57.35	84.61	1.51	1.6	0.31
SO4	FAL	27	1.46	1.34	0.56	-8.11	35.67	-0.12	0.52	0.45	-7.06	-20.07	-0.09	36.88	43.16	0.39	0.68	0.31
SO4	ALL	114	2.04	1.56	0.34	-23.55	43.24	-0.48	0.88	1.2	40.78	-29.81	-0.31	98.03	51.02	0.57	1.2	0.12

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 120730012																		
EC	WIN	15	1.04	1.11	0.67	6.46	44.53	0.07	0.46	0.45	21.2	9.27	0.06	43.55	37.19	0.45	0.68	0.45
EC	SPR	15	0.53	0.64	0.63	21.29	46.56	0.11	0.25	0.12	35.26	21.86	0.21	47.21	35.93	0.47	0.36	0.4
EC	SUM	15	0.48	0.44	0.6	-9.2	26.75	-0.04	0.13	0.03	-0.72	-5.28	-0.1	25.45	26.46	0.29	0.18	0.36
EC	FAL	15	0.64	0.63	0.84	-1.4	28.05	-0.01	0.18	0.06	17.85	7.71	-0.01	36.97	31.47	0.28	0.24	0.7
EC	ALL	60	0.67	0.7	0.73	4.69	37.83	0.03	0.25	0.17	18.4	8.39	0.05	38.3	32.76	0.38	0.41	0.54
NACL	WIN	15	0.17	0.33	0.85	101.33	151.78	0.17	0.25	0.16	196.46	49.78	1.01	227.72	99.29	1.52	0.43	0.72
NACL	SPR	15	0.31	0.47	0.84	49	92.65	0.15	0.29	0.18	61.55	17.64	0.49	96.7	69.51	0.93	0.46	0.71
NACL	SUM	16	0.13	0.19	0.4	48.69	70.68	0.06	0.09	0.01	64.48	31.08	0.49	82.43	53.59	0.71	0.12	0.16
NACL	FAL	15	0.07	0.14	0.32	103.38	132.37	0.07	0.09	0.02	213.68	32.96	1.03	239.23	66.27	1.32	0.14	0.1
NACL	ALL	61	0.17	0.28	0.83	66.98	106.45	0.11	0.18	0.09	132.9	32.84	0.67	160.22	71.86	1.06	0.32	0.69
NH4	WIN	15	0.51	0.87	0.76	71.51	89.95	0.36	0.46	0.18	354.99	70.4	0.72	367.07	84.7	0.9	0.56	0.57
NH4	SPR	15	0.53	0.54	0.27	2.13	57.08	0.01	0.3	0.14	7.52	-22.7	0.02	66	64.13	0.57	0.37	0.08
NH4	SUM	16	0.4	0.28	0.64	-29.91	52.55	-0.12	0.21	0.06	-24.58	-52.25	-0.43	52.74	72.81	0.75	0.27	0.41
NH4	FAL	15	0.28	0.59	0.83	112.57	112.57	0.31	0.31	0.05	443.99	83.2	1.13	443.99	83.2	1.13	0.38	0.69
NH4	ALL	61	0.43	0.57	0.61	32.05	74.38	0.14	0.32	0.15	191.88	18.48	0.32	229.51	76.15	0.74	0.41	0.37
NO3	WIN	15	0.44	1.3	0.44	198.22	217.29	0.86	0.95	0.87	230.65	73.02	1.98	247.79	101.43	2.17	1.27	0.19
NO3	SPR	15	0.32	0.54	0.55	68.11	126.8	0.22	0.41	0.29	63.1	-5.33	0.68	124.05	89.59	1.27	0.58	0.31
NO3	SUM	16	0.19	0.1	0.33	-45.06	64.92	-0.09	0.12	0.02	-27.41	-58.82	-0.82	62.19	79.77	1.18	0.16	0.11
NO3	FAL	15	0.2	0.3	0.59	50.98	84.74	0.1	0.17	0.1	33.55	-3.15	0.51	70.93	52.63	0.85	0.34	0.35
NO3	ALL	61	0.28	0.55	0.59	94.47	142.94	0.27	0.41	0.44	73.29	0.44	0.94	125.19	80.84	1.43	0.72	0.35
OC	WIN	15	3.23	5.3	0.7	64.2	69.66	2.07	2.25	13.5	68.83	36.15	0.64	75.01	43.04	0.7	4.22	0.5
OC	SPR	15	1.79	2.92	0.76	63.32	77.16	1.13	1.38	3.13	55.54	28.11	0.63	71.19	49.4	0.77	2.1	0.57
OC	SUM	15	3.2	2.39	0.52	-25.27	40.18	-0.81	1.29	4.16	-9.36	-19.52	-0.34	33.21	38.92	0.54	2.19	0.27
OC	FAL	15	2.06	2.93	0.9	42.2	50.14	0.87	1.03	1.26	44.99	28.37	0.42	52.33	36.54	0.5	1.42	0.81
OC	ALL	60	2.57	3.39	0.61	31.76	57.87	0.82	1.49	6.59	40	18.28	0.32	57.94	41.98	0.58	2.69	0.38
PM-2.5	WIN	15	11.76	14.24	0.78	21.12	39.11	2.48	4.6	46.29	19.17	9.07	0.21	37.37	30.47	0.39	7.24	0.61
PM-2.5	SPR	15	10.63	9.15	0.61	-13.86	36.79	-1.47	3.91	19.04	-16.1	-26.54	-0.16	36.1	42.22	0.43	4.61	0.37
PM-2.5	SUM	16	13.02	6.2	0.69	-52.37	52.37	-6.82	6.82	14.61	-52.15	-74.3	-1.1	52.15	74.3	1.1	7.82	0.47
PM-2.5	FAL	14	9.6	8.78	0.91	-8.57	20.56	-0.82	1.97	5.01	-10.76	-14.33	-0.09	21.07	23.32	0.22	2.39	0.83
PM-2.5	ALL	60	11.31	9.55	0.62	-15.54	38.96	-1.76	4.41	32.95	-15.65	-27.52	-0.18	37.19	43.43	0.46	6	0.38
SO4	WIN	15	1.98	1.88	0.57	-4.94	37.17	-0.1	0.74	1.53	12.03	0.9	-0.05	37.01	34.97	0.39	1.24	0.32
SO4	SPR	15	2.63	1.88	0.17	-28.56	49.1	-0.75	1.29	1.51	-20.43	-37.91	-0.4	50.05	59.01	0.69	1.44	0.03
SO4	SUM	16	2.46	1.19	0.58	-51.71	55.36	-1.27	1.36	0.73	-53.27	-82.92	-1.07	57.1	86.45	1.15	1.54	0.33
SO4	FAL	15	1.46	1.66	0.76	13.61	34.43	0.2	0.5	0.36	47.24	15.39	0.14	66.99	41.43	0.34	0.64	0.58
SO4	ALL	61	2.14	1.65	0.4	-23.09	45.81	-0.49	0.98	1.36	-4.42	-27.07	-0.3	52.86	55.97	0.6	1.27	0.16

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 130210007																		
EC	WIN	14	0.8	0.85	0.62	7.19	48.64	0.06	0.39	0.32	10600.2	24.97	0.07	10618	47.19	0.49	0.57	0.39
EC	SPR	15	0.62	0.54	0.71	-12.58	30.52	-0.08	0.19	0.08	7.49	-2.07	-0.14	34.28	31.19	0.35	0.3	0.51
EC	SUM	16	0.61	0.45	0.64	-25.84	29.12	-0.16	0.18	0.02	-21.79	-27.1	-0.35	27.15	31.78	0.39	0.21	0.41
EC	FAL	14	0.77	0.59	0.92	-23.19	32.62	-0.18	0.25	0.12	-4.72	-9.91	-0.3	26.43	28.81	0.42	0.39	0.84
EC	ALL	59	0.69	0.6	0.66	-13.15	35.68	-0.09	0.25	0.14	2510.17	-4.3	-0.15	2541.9	34.58	0.41	0.38	0.43
NACL	WIN	14	0.04	0.22	0.75	399.42	399.42	0.18	0.18	0	514.13	135.69	3.99	514.13	135.69	3.99	0.19	0.57
NACL	SPR	15	0.15	0.45	0.53	195.85	221.97	0.3	0.33	0.18	3011.66	98.06	1.96	3020	110.14	2.22	0.52	0.28
NACL	SUM	16	0.1	0.2	0.76	107.74	107.74	0.1	0.1	0	159.5	75.87	1.08	159.5	75.87	1.08	0.11	0.58
NACL	FAL	12	0.08	0.22	0.39	188.89	205.37	0.15	0.16	0.01	383.09	111.49	1.89	386.35	115.11	2.05	0.17	0.15
NACL	ALL	57	0.09	0.27	0.53	192.82	206.7	0.18	0.19	0.06	1044.24	103.9	1.93	1047.1	107.84	2.07	0.3	0.28
NH4	WIN	14	0.59	0.86	0.64	44.96	57.04	0.27	0.34	0.1	125.62	47.19	0.45	133.43	56.13	0.57	0.42	0.41
NH4	SPR	13	0.65	0.65	0.84	0.82	33.17	0.01	0.22	0.08	-2.33	-15.75	0.01	42.39	43.93	0.33	0.28	0.7
NH4	SUM	16	0.83	0.7	0.34	-15.7	36.22	-0.13	0.3	0.14	-0.14	-12.64	-0.19	41.16	42.08	0.43	0.4	0.12
NH4	FAL	12	0.43	0.8	0.51	88.59	91.81	0.38	0.39	0.13	348.53	64.03	0.89	350.33	65.94	0.92	0.52	0.26
NH4	ALL	55	0.64	0.75	0.49	17.77	48.49	0.11	0.31	0.15	107.43	18.58	0.18	132.39	51.3	0.48	0.41	0.24
NO3	WIN	14	0.56	1.4	0.52	147.55	157.86	0.83	0.89	0.67	175.49	74.87	1.48	184.64	88.33	1.58	1.17	0.27
NO3	SPR	15	0.36	0.74	0.11	104.74	140.01	0.38	0.5	0.32	544.6	36.07	1.05	578.06	88	1.4	0.68	0.01
NO3	SUM	16	0.23	0.15	0.07	-33.57	56.12	-0.08	0.13	0.02	-25.67	-47.54	-0.51	53.33	69.04	0.84	0.15	0.01
NO3	FAL	12	0.28	0.86	0.65	205.27	213.43	0.58	0.6	0.43	191.84	67.55	2.05	199.24	75.71	2.13	0.87	0.42
NO3	ALL	57	0.36	0.76	0.53	113.36	144.16	0.4	0.51	0.46	219.6	28.76	1.13	254.39	80.17	1.44	0.79	0.28
OC	WIN	13	2.71	3.55	0.78	31.05	49.85	0.84	1.35	6.17	34.94	18.78	0.31	51.84	39.39	0.5	2.62	0.61
OC	SPR	15	2.96	2.67	0.89	-9.87	24.94	-0.29	0.74	0.74	-1.58	-11.45	-0.11	36.54	34.86	0.28	0.91	0.78
OC	SUM	16	3.9	3.88	0.37	-0.59	35.14	-0.02	1.37	3.45	9.55	0.18	-0.01	35.95	32.98	0.35	1.86	0.13
OC	FAL	14	2.28	2.32	0.91	1.76	21.32	0.04	0.49	0.29	4.85	-0.51	0.02	27.11	26.15	0.21	0.54	0.83
OC	ALL	58	3	3.12	0.71	3.87	32.97	0.12	0.99	2.77	11.23	1.17	0.04	37.53	33.25	0.33	1.67	0.51
PM-2.5	WIN	14	9.69	11.38	0.81	17.36	28.27	1.68	2.74	21.49	18.62	11.14	0.17	28.36	23.13	0.28	4.93	0.66
PM-2.5	SPR	15	12.08	10.01	0.49	-17.14	45.49	-2.07	5.5	39.36	281.97	-10.38	-0.21	337.52	61.63	0.55	6.61	0.24
PM-2.5	SUM	16	17.48	10.42	0.38	-40.35	42.26	-7.05	7.38	29.33	-36.28	-49.26	-0.68	38.63	51.51	0.71	8.89	0.14
PM-2.5	FAL	14	9.71	9.13	0.83	-5.99	17.64	-0.58	1.71	6.06	-4.47	-6.37	-0.06	15.92	16.99	0.19	2.53	0.68
PM-2.5	ALL	59	12.42	10.24	0.51	-17.54	35.9	-2.18	4.46	35.08	65.21	-14.87	-0.21	106.79	39.15	0.44	6.31	0.26
SO4	WIN	14	1.63	1.57	0.44	-3.75	27.7	-0.06	0.45	0.46	7.16	1.5	-0.04	26.64	26.15	0.29	0.68	0.19
SO4	SPR	15	2.18	2.36	0.19	8.4	53.88	0.18	1.17	2.91	1443.69	7.26	0.08	1483.2	59.72	0.54	1.72	0.04
SO4	SUM	16	3.5	2.23	0.26	-36.34	39.57	-1.27	1.38	1.6	-30.32	-42.06	-0.57	34.53	45.75	0.62	1.79	0.07
SO4	FAL	12	1.97	1.98	0.7	0.89	22.27	0.02	0.44	0.34	2.66	-1.7	0.01	23.62	22.74	0.22	0.58	0.48
SO4	ALL	57	2.37	2.05	0.33	-13.51	38.01	-0.32	0.9	1.76	373.73	-9.88	-0.16	411.51	39.77	0.44	1.37	0.11

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 130590001																		
EC	WIN	15	0.41	0.54	0.58	31.54	48.61	0.13	0.2	0.07	49.76	29.63	0.32	59.61	40.68	0.49	0.29	0.34
EC	SPR	15	0.44	0.46	0.69	4.14	34.86	0.02	0.15	0.04	23.59	7.73	0.04	47.69	35.86	0.35	0.2	0.47
EC	SUM	16	0.52	0.42	0.53	-19.86	28.3	-0.1	0.15	0.02	-13.66	-19.33	-0.25	28.76	31.5	0.35	0.18	0.29
EC	FAL	15	0.43	0.44	0.86	1.74	23.51	0.01	0.1	0.01	15.08	7.94	0.02	33.36	29.07	0.24	0.12	0.73
EC	ALL	61	0.45	0.47	0.6	2.4	33.26	0.01	0.15	0.04	18.16	6.07	0.02	42.13	34.23	0.33	0.2	0.36
NACL	WIN	13	0.07	0.12	0.99	67.4	75.64	0.05	0.06	0.01	801.35	66.96	0.67	812.09	80.58	0.76	0.1	0.98
NACL	SPR	14	0.13	0.21	0.31	64.62	131.08	0.08	0.17	0.05	152.61	45.72	0.65	178.91	83.85	1.31	0.25	0.1
NACL	SUM	16	0.09	0.05	0.85	-40.56	42.34	-0.04	0.04	0	-41.77	-58.47	-0.68	43.32	59.97	0.71	0.05	0.72
NACL	FAL	14	0.05	0.05	0.24	-15.16	46.76	-0.01	0.03	0	15.19	-4.12	-0.18	48.64	42.49	0.55	0.05	0.06
NACL	ALL	57	0.09	0.11	0.67	22.45	81.78	0.02	0.07	0.02	212.26	9.08	0.22	253.26	66.24	0.82	0.14	0.45
NH4	WIN	14	0.63	0.72	0.74	13.85	36.94	0.09	0.23	0.07	38.87	22.02	0.14	52.82	38.47	0.37	0.27	0.55
NH4	SPR	15	0.82	0.82	0.75	0.04	39.21	0	0.32	0.14	12.63	-6.99	0	54.98	52.55	0.39	0.38	0.57
NH4	SUM	16	1.23	0.98	0.46	-20.23	32.01	-0.25	0.39	0.16	-14.08	-22.33	-0.25	32.78	35.87	0.4	0.47	0.21
NH4	FAL	15	0.39	0.67	0.77	70.87	70.87	0.28	0.28	0.03	152.24	59.32	0.71	152.24	59.32	0.71	0.33	0.6
NH4	ALL	60	0.78	0.8	0.68	3	39.72	0.02	0.31	0.14	46.53	12.27	0.03	72.87	46.51	0.4	0.37	0.46
NO3	WIN	14	0.77	1.06	0.53	38.43	70.69	0.29	0.54	0.35	50.06	14.01	0.38	85.88	65.39	0.71	0.66	0.28
NO3	SPR	15	0.7	0.76	0.72	9.14	47.57	0.06	0.33	0.31	21.93	-14.63	0.09	66.17	56.51	0.48	0.56	0.52
NO3	SUM	16	0.38	0.1	0.29	-72.46	72.46	-0.27	0.27	0.02	-67.94	-109.58	-2.63	67.94	109.58	2.63	0.31	0.08
NO3	FAL	15	0.39	0.62	0.3	59.04	87.66	0.23	0.34	0.22	65.94	14.17	0.59	103.77	65.93	0.88	0.52	0.09
NO3	ALL	60	0.55	0.62	0.63	12.56	66.67	0.07	0.37	0.27	15.53	-26.06	0.13	80.64	75.09	0.67	0.53	0.4
OC	WIN	15	1.71	2.1	0.57	22.74	55.75	0.39	0.95	1.66	49.08	25.65	0.23	65.98	46.15	0.56	1.35	0.33
OC	SPR	15	2.37	2.31	0.78	-2.39	27.81	-0.06	0.66	0.78	20	2.43	-0.02	47.57	36.52	0.28	0.88	0.62
OC	SUM	16	3.31	4.38	0.49	32.33	49.34	1.07	1.63	2.74	47.38	30.53	0.32	56.8	41.61	0.49	1.97	0.24
OC	FAL	15	1.76	1.78	0.9	0.94	20.06	0.02	0.35	0.23	6.85	3.56	0.01	21.44	20.45	0.2	0.48	0.82
OC	ALL	61	2.3	2.67	0.71	15.91	39.57	0.37	0.91	1.58	31.1	15.79	0.16	48.09	36.27	0.4	1.31	0.51
PM-2.5	WIN	14	9.69	7.75	0.41	-20.05	39.94	-1.94	3.87	66.47	-0.71	-8.69	-0.25	31.59	34.02	0.5	8.38	0.17
PM-2.5	SPR	15	11.55	8.41	0.64	-27.2	39.4	-3.14	4.55	17.19	-19.21	-32.12	-0.37	42.41	48.28	0.54	5.2	0.41
PM-2.5	SUM	16	18.74	11.34	0.55	-39.48	40.61	-7.4	7.61	23.31	-36.58	-47.93	-0.65	38.32	49.55	0.67	8.84	0.3
PM-2.5	FAL	15	7.6	6.55	0.85	-13.77	21.05	-1.05	1.6	3.43	-8.42	-13.39	-0.16	24.05	25.14	0.24	2.13	0.73
PM-2.5	ALL	60	12.05	8.57	0.65	-28.83	37.11	-3.47	4.47	33.04	-16.83	-26.19	-0.41	34.2	39.51	0.52	6.72	0.42
SO4	WIN	14	1.49	1.28	0.7	-14.19	27.78	-0.21	0.41	0.29	-6.06	-11.95	-0.17	26.95	28.88	0.32	0.57	0.49
SO4	SPR	15	2.34	2.02	0.68	-13.5	29.34	-0.32	0.69	0.87	-5.38	-14.55	-0.16	30.64	33.31	0.34	0.99	0.46
SO4	SUM	16	4.12	2.71	0.32	-34.37	39.21	-1.42	1.62	1.56	-30.62	-42.22	-0.52	38.37	48.35	0.6	1.89	0.1
SO4	FAL	15	1.49	1.4	0.9	-5.93	16.89	-0.09	0.25	0.08	-4.12	-6.95	-0.06	19.4	20.55	0.18	0.3	0.81
SO4	ALL	60	2.4	1.88	0.73	-21.98	31.71	-0.53	0.76	1.02	-11.95	-19.42	-0.28	29.03	33.1	0.41	1.14	0.53

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 130890002																		
EC	WIN	16	1.36	1.21	0.89	-10.98	31.96	-0.15	0.43	0.43	23.19	9.47	-0.12	42.96	33.74	0.36	0.67	0.79
EC	SPR	24	1.17	0.92	0.67	-21.48	43.52	-0.25	0.51	0.4	17.31	-1.09	-0.27	53.65	47.11	0.55	0.68	0.45
EC	SUM	24	1.22	0.86	0.65	-29.79	37.28	-0.36	0.45	0.31	-15.47	-23.52	-0.42	32.75	37.96	0.53	0.67	0.43
EC	FAL	19	1.31	0.91	0.9	-30.69	39.06	-0.4	0.51	0.27	-10.06	-19.92	-0.44	38.55	41.49	0.56	0.65	0.8
EC	ALL	83	1.25	0.95	0.78	-23.84	38.28	-0.3	0.48	0.36	2.7	-9.85	-0.31	42.09	40.6	0.5	0.67	0.6
NACL	WIN	20	0.06	0.18	0.87	210.67	210.83	0.12	0.12	0.05	1019.45	85.71	2.11	1019.8	86.03	2.11	0.25	0.75
NACL	SPR	23	0.09	0.17	0.47	91.51	126.72	0.08	0.11	0.04	121.87	50.24	0.92	133.57	66.34	1.27	0.21	0.22
NACL	SUM	23	0.07	0.07	0.89	13.28	60.42	0.01	0.04	0	9.17	-15.4	0.13	62.88	60.76	0.6	0.05	0.79
NACL	FAL	23	0.07	0.09	0.18	23.7	95.89	0.02	0.07	0.02	63.69	22.94	0.24	88.8	60.2	0.96	0.13	0.03
NACL	ALL	89	0.07	0.13	0.54	76.58	118.08	0.05	0.08	0.03	279.41	34.19	0.77	302.88	67.73	1.18	0.17	0.29
NH4	WIN	20	0.68	1.05	0.5	53.81	74.07	0.37	0.51	0.33	185.02	51.85	0.54	193.58	62.18	0.74	0.68	0.25
NH4	SPR	24	0.73	0.94	0.64	28.61	49.35	0.21	0.36	0.15	37.47	17.29	0.29	60.86	47.96	0.49	0.44	0.41
NH4	SUM	23	0.77	0.87	0.49	13.65	41.75	0.1	0.32	0.15	33.49	10.3	0.14	61.21	46.2	0.42	0.4	0.24
NH4	FAL	23	0.33	0.77	0.74	131.07	134.93	0.44	0.45	0.09	171.13	77.72	1.31	175.04	82.75	1.35	0.52	0.55
NH4	ALL	90	0.63	0.9	0.54	43.88	64.52	0.28	0.41	0.19	103.4	38.63	0.44	119.62	59.56	0.65	0.52	0.29
NO3	WIN	20	1.08	1.94	0.39	78.55	111.71	0.85	1.21	2.36	197.81	53.52	0.79	215.96	78.17	1.12	1.76	0.15
NO3	SPR	24	0.43	0.82	0.32	89.01	115.98	0.39	0.5	0.47	114.83	30.51	0.89	143.66	70.67	1.16	0.78	0.1
NO3	SUM	23	0.19	0.12	0.43	-37.27	57.47	-0.07	0.11	0.01	-39.25	-64.52	-0.59	57.02	77.72	0.92	0.12	0.18
NO3	FAL	23	0.26	0.74	0.65	188.36	197.27	0.49	0.51	0.37	167.14	57.98	1.88	183.96	80.14	1.97	0.78	0.42
NO3	ALL	90	0.47	0.87	0.54	84.31	119.02	0.4	0.56	0.85	107.26	18.36	0.84	147.89	76.56	1.19	1	0.29
OC	WIN	16	2.76	4.02	0.76	45.67	57.63	1.26	1.59	6.21	59.83	30.25	0.46	68.55	39.97	0.58	2.79	0.58
OC	SPR	24	2.14	2.77	0.84	28.98	37.61	0.62	0.81	0.53	52.92	31.26	0.29	60.51	39.97	0.38	0.96	0.7
OC	SUM	24	2.75	4.19	0.58	52.39	64.81	1.44	1.78	2.7	65.51	39.05	0.52	74.68	49.68	0.65	2.18	0.34
OC	FAL	19	1.94	2.76	0.65	42.26	56.87	0.82	1.1	1.59	55.53	34.64	0.42	63.82	44.04	0.57	1.5	0.43
OC	ALL	83	2.39	3.42	0.71	42.94	54.68	1.03	1.31	2.61	58.49	34.09	0.43	66.92	43.71	0.55	1.91	0.5
PM-2.5	WIN	22	11.47	11.74	0.84	2.36	24.12	0.27	2.77	15.53	5.33	-0.69	0.02	26.74	22.97	0.24	3.95	0.71
PM-2.5	SPR	24	11.05	10.46	0.65	-5.33	28.12	-0.59	3.11	14.55	6.2	-2.97	-0.06	34.35	31.03	0.3	3.86	0.43
PM-2.5	SUM	25	17.01	11.73	0.58	-31.07	36.3	-5.28	6.18	22.25	-28.86	-38.62	-0.45	36.02	44.76	0.53	7.08	0.33
PM-2.5	FAL	23	9.6	9.21	0.81	-4.03	21.21	-0.39	2.04	7.09	-2.02	-5.94	-0.04	22.24	22.83	0.22	2.69	0.66
PM-2.5	ALL	94	12.38	10.79	0.68	-12.82	28.93	-1.59	3.58	20.05	-5.34	-12.65	-0.15	30.05	30.79	0.33	4.75	0.46
SO4	WIN	20	1.69	1.6	0.52	-5.21	35.98	-0.09	0.61	0.64	8.29	-0.43	-0.05	37.45	36.31	0.38	0.81	0.27
SO4	SPR	24	2.63	2.36	0.8	-10.34	24.76	-0.27	0.65	0.55	-4.97	-10.53	-0.12	27.43	28.5	0.28	0.79	0.64
SO4	SUM	23	3.33	2.63	0.29	-21.02	38.04	-0.7	1.27	2.03	-14.29	-26.3	-0.27	38.32	43.45	0.48	1.59	0.09
SO4	FAL	23	1.61	1.68	0.84	4.26	23.7	0.07	0.38	0.24	5.41	0.32	0.04	25.26	25.83	0.24	0.5	0.71
SO4	ALL	90	2.34	2.09	0.66	-10.83	31.2	-0.25	0.73	0.95	-1.75	-9.54	-0.12	31.89	33.38	0.35	1.01	0.44

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 131150003																		
EC	WIN	15	1.31	0.46	0.24	-64.99	64.99	-0.85	0.85	0.71	-58.35	-87.02	-1.86	58.35	87.02	1.86	1.2	0.06
EC	SPR	14	1.2	0.42	0.84	-65.36	65.36	-0.78	0.78	0.22	-62.65	-93.79	-1.89	62.65	93.79	1.89	0.92	0.7
EC	SUM	15	1.78	0.32	0.33	-81.83	81.83	-1.46	1.46	0.39	-79.59	-133.58	-4.5	79.59	133.58	4.5	1.59	0.11
EC	FAL	14	1.11	0.42	0.68	-61.78	61.78	-0.69	0.69	0.21	-57.45	-84.27	-1.62	57.45	84.27	1.62	0.82	0.46
EC	ALL	58	1.36	0.4	0.38	-70.16	70.16	-0.95	0.95	0.48	-64.66	-100.03	-2.35	64.66	100.03	2.35	1.18	0.14
NACL	WIN	14	0.06	0.22	0.96	253.34	253.34	0.16	0.16	0.06	315.62	104.84	2.53	315.62	104.84	2.53	0.29	0.92
NACL	SPR	13	0.15	0.28	0.62	91.6	111.05	0.13	0.16	0.03	212.97	69.16	0.92	222.25	81.98	1.11	0.22	0.39
NACL	SUM	16	0.08	0.12	0.61	43.36	43.58	0.03	0.03	0	50.06	35.3	0.43	50.23	35.47	0.44	0.04	0.37
NACL	FAL	15	0.11	0.11	0.81	5.39	79.93	0.01	0.09	0.02	117.81	51.96	0.05	131.44	70.77	0.8	0.16	0.66
NACL	ALL	58	0.1	0.18	0.46	81.43	109.05	0.08	0.11	0.03	168.2	63.98	0.81	173.85	71.77	1.09	0.2	0.21
NH4	WIN	14	0.73	0.84	0.51	14.93	41.69	0.11	0.3	0.12	121.34	21.64	0.15	142.73	46.31	0.42	0.37	0.26
NH4	SPR	14	0.83	1.09	0.65	30.21	53.2	0.25	0.44	0.24	50.84	23.76	0.3	70.75	51.34	0.53	0.56	0.42
NH4	SUM	16	1.08	0.93	0.14	-13.6	35.01	-0.15	0.38	0.19	-5.09	-14.45	-0.16	36.27	39.36	0.41	0.46	0.02
NH4	FAL	14	0.36	0.69	0.69	90.78	102.24	0.33	0.37	0.06	145.73	74.57	0.91	149.36	78.73	1.02	0.41	0.48
NH4	ALL	58	0.76	0.89	0.55	16.55	49.08	0.13	0.37	0.19	75.33	24.97	0.17	97.59	53.43	0.49	0.45	0.3
NO3	WIN	14	0.75	1.25	0.4	67.16	87.11	0.5	0.65	0.5	114.84	50.85	0.67	127.67	67.3	0.87	0.87	0.16
NO3	SPR	14	0.42	0.96	0.05	125.48	141.45	0.53	0.6	1.18	175.44	39.19	1.25	192.52	60.99	1.41	1.21	0
NO3	SUM	16	0.22	0.16	0.23	-28.29	45.1	-0.06	0.1	0.01	-27.64	-46.93	-0.39	46.36	62.26	0.63	0.11	0.05
NO3	FAL	15	0.3	0.6	0.35	99.64	121.58	0.3	0.36	0.25	101.45	30.39	1	126.36	61.61	1.22	0.59	0.12
NO3	ALL	59	0.41	0.72	0.42	73.72	100.7	0.3	0.42	0.52	87.18	16.36	0.74	120.67	62.99	1.01	0.78	0.18
OC	WIN	15	2.42	2.2	0.15	-9.23	61.6	-0.22	1.49	6.68	43.72	8.69	-0.1	71.9	53.82	0.68	2.59	0.02
OC	SPR	14	2.23	2.86	0.82	28.34	44.54	0.63	0.99	1.42	96.5	33.42	0.28	111.18	50.62	0.45	1.35	0.68
OC	SUM	15	2.79	4.54	0.34	62.8	66.82	1.75	1.86	2.69	67.46	43.24	0.63	70.88	47.09	0.67	2.4	0.12
OC	FAL	14	1.93	2.32	0.86	20.52	34.66	0.39	0.67	0.85	38.49	18.55	0.21	49.76	30.85	0.35	1	0.73
OC	ALL	58	2.35	2.99	0.49	27.35	53.97	0.64	1.27	3.5	61.34	25.98	0.27	75.77	45.76	0.54	1.98	0.24
PM-2.5	WIN	14	10.09	8.84	0.69	-12.34	28.27	-1.24	2.85	10.43	-13.73	-18.94	-0.14	26.98	30.24	0.32	3.46	0.48
PM-2.5	SPR	14	13.66	10.7	0.78	-21.7	30.82	-2.97	4.21	16.3	-16.84	-24.02	-0.28	30.29	35.13	0.39	5.01	0.6
PM-2.5	SUM	16	19.51	11.79	0.31	-39.54	39.54	-7.71	7.71	24.81	-37.45	-48.58	-0.65	37.45	48.58	0.65	9.18	0.1
PM-2.5	FAL	15	9.27	7.5	0.92	-19.04	19.69	-1.76	1.82	3.89	-17.92	-22.58	-0.24	19.36	23.98	0.24	2.65	0.85
PM-2.5	ALL	59	13.28	9.74	0.71	-26.65	31.86	-3.54	4.23	20.91	-21.96	-29.11	-0.36	28.67	34.78	0.43	5.78	0.5
SO4	WIN	14	1.94	1.6	0.4	-17.55	34.83	-0.34	0.68	0.59	-8.11	-16.46	-0.21	35.66	39.28	0.42	0.84	0.16
SO4	SPR	14	2.79	2.77	0.68	-0.54	28.85	-0.01	0.8	1.34	6.84	0.78	-0.01	29.52	27.43	0.29	1.16	0.46
SO4	SUM	16	4.11	2.72	0.27	-33.81	35.93	-1.39	1.48	1.62	-30.86	-42.06	-0.51	34.01	44.95	0.54	1.88	0.07
SO4	FAL	15	1.56	1.48	0.8	-5	20.81	-0.08	0.32	0.33	6.75	2.99	-0.05	21.36	20.7	0.22	0.58	0.64
SO4	ALL	59	2.63	2.15	0.66	-18.26	31.68	-0.48	0.83	1.3	-6.96	-14.37	-0.22	30.12	33.28	0.39	1.24	0.43

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 132150011																		
EC	WIN	15	0.7	0.82	0.55	17.57	46.25	0.12	0.32	0.38	29.11	16.92	0.18	41.44	32.24	0.46	0.63	0.3
EC	SPR	15	0.65	0.53	0.59	-17.66	37.17	-0.11	0.24	0.14	3.74	-9.41	-0.21	39.81	37.31	0.45	0.4	0.34
EC	SUM	16	0.53	0.48	0.46	-10.48	25.72	-0.06	0.14	0.04	-2.27	-7.14	-0.12	24.15	25.67	0.29	0.2	0.21
EC	FAL	15	0.58	0.53	0.57	-8.56	32.98	-0.05	0.19	0.08	9.11	-0.14	-0.09	34.12	34.09	0.36	0.28	0.33
EC	ALL	61	0.61	0.59	0.53	-4.06	36.11	-0.02	0.22	0.17	9.72	-0.06	-0.04	34.71	32.22	0.38	0.41	0.28
NACL	WIN	14	0.08	0.21	0.99	175.18	177.55	0.13	0.13	0.09	134.64	64.61	1.75	138.03	68.42	1.78	0.33	0.98
NACL	SPR	15	0.22	0.3	0.83	35.51	76.41	0.08	0.17	0.14	1373.83	26.98	0.36	1391.9	53.64	0.76	0.38	0.69
NACL	SUM	15	0.1	0.07	0.83	-21.6	34.26	-0.02	0.03	0	-13.92	-21.52	-0.28	33.81	37.79	0.44	0.05	0.69
NACL	FAL	14	0.04	0.05	0.05	7.64	59.43	0	0.03	0	42.4	14.26	0.08	65.06	46.44	0.59	0.04	0
NACL	ALL	58	0.11	0.16	0.83	43.27	82.15	0.05	0.09	0.06	394.43	20.45	0.43	417.74	51.37	0.82	0.26	0.69
NH4	WIN	15	0.62	0.82	0.57	31.86	56.51	0.2	0.35	0.24	107.52	32.43	0.32	126.7	57.09	0.57	0.53	0.33
NH4	SPR	15	0.7	0.61	0.51	-12.21	44.88	-0.09	0.31	0.14	-7.89	-27.74	-0.14	51.81	56.21	0.51	0.39	0.26
NH4	SUM	15	0.81	0.68	0.42	-16.18	32.78	-0.13	0.26	0.11	-10.05	-19.31	-0.19	32.02	36.64	0.39	0.35	0.18
NH4	FAL	15	0.4	0.58	0.69	45.51	56.32	0.18	0.22	0.06	113.59	50.27	0.46	120.66	58.49	0.56	0.3	0.47
NH4	ALL	60	0.63	0.67	0.52	6.51	45.69	0.04	0.29	0.16	50.79	8.91	0.07	82.8	52.11	0.46	0.4	0.27
NO3	WIN	15	0.59	1.16	0.23	95.78	133.05	0.57	0.79	1.93	112.49	15.02	0.96	151.71	73.72	1.33	1.5	0.05
NO3	SPR	15	0.4	0.43	0.5	8.41	80.04	0.03	0.32	0.25	15.41	-45.13	0.08	96.42	80.17	0.8	0.5	0.25
NO3	SUM	15	0.2	0.06	0.14	-68.38	68.38	-0.14	0.14	0.01	-63.07	-98.53	-2.16	63.07	98.53	2.16	0.16	0.02
NO3	FAL	15	0.26	0.24	0.18	-10.33	60.89	-0.03	0.16	0.05	-3.73	-31.65	-0.12	62.27	63.98	0.68	0.22	0.03
NO3	ALL	60	0.36	0.47	0.45	30.24	96.66	0.11	0.35	0.63	15.27	-40.07	0.3	93.37	79.1	0.97	0.8	0.2
OC	WIN	15	2.64	3.74	0.63	41.91	57.62	1.1	1.52	10.05	53.07	32.25	0.42	59.4	39.04	0.58	3.36	0.4
OC	SPR	15	3.03	2.86	0.77	-5.42	38.38	-0.16	1.16	1.97	17.43	-2.04	-0.06	55.38	46.86	0.41	1.41	0.59
OC	SUM	16	3.68	4.98	0.23	35.34	65.53	1.3	2.41	5.7	53.72	30.92	0.35	71.97	54.28	0.66	2.72	0.05
OC	FAL	15	2.53	2.4	0.55	-5.17	40.74	-0.13	1.03	2.27	6.13	-2.63	-0.05	33.82	35.29	0.43	1.51	0.3
OC	ALL	61	2.98	3.52	0.57	18.12	51.85	0.54	1.55	5.47	32.93	14.89	0.18	55.42	44.04	0.52	2.4	0.32
PM-2.5	WIN	15	9.31	11.25	0.68	20.9	38.32	1.94	3.57	47.82	45.75	17.68	0.21	58.45	31.86	0.38	7.18	0.46
PM-2.5	SPR	15	12.78	9.11	0.63	-28.73	39.53	-3.67	5.05	24.35	-20.95	-34.48	-0.4	40.97	49.33	0.55	6.15	0.4
PM-2.5	SUM	15	17.08	11.4	0.3	-33.27	35.99	-5.68	6.15	28.25	-30.72	-41.45	-0.5	34.36	44.66	0.54	7.78	0.09
PM-2.5	FAL	15	11.7	7.49	0.34	-35.95	42.5	-4.21	4.97	79.39	-20.9	-30.41	-0.56	29.33	37.9	0.66	9.85	0.12
PM-2.5	ALL	60	12.72	9.81	0.46	-22.84	38.8	-2.9	4.93	53.33	-6.7	-22.16	-0.3	40.78	40.94	0.5	7.86	0.21
SO4	WIN	15	1.8	1.63	0.71	-9.83	30.98	-0.18	0.56	0.55	7.78	-3.54	-0.11	38	35.24	0.34	0.76	0.51
SO4	SPR	15	2.72	2.07	0.35	-23.91	42.5	-0.65	1.15	1.55	-14.82	-31.45	-0.31	46.68	51.05	0.56	1.4	0.12
SO4	SUM	15	3.7	2.08	0.26	-43.9	44.18	-1.63	1.64	1.36	-40.94	-56.35	-0.78	41.23	56.64	0.79	2	0.07
SO4	FAL	15	1.85	1.54	0.75	-16.96	30.91	-0.31	0.57	0.37	-12.44	-19.58	-0.2	32.1	35.58	0.37	0.69	0.57
SO4	ALL	60	2.52	1.83	0.52	-27.46	38.93	-0.69	0.98	1.28	-15.1	-27.73	-0.38	39.5	44.63	0.54	1.32	0.27

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 132450091																		
EC	WIN	14	0.68	0.78	0.46	13.78	55.28	0.09	0.38	0.25	52.35	26.53	0.14	70.86	50.13	0.55	0.51	0.22
EC	SPR	13	0.53	0.52	0.58	-3.16	35.89	-0.02	0.19	0.06	5.25	-4.67	-0.03	39.93	38.04	0.37	0.24	0.34
EC	SUM	16	0.54	0.43	0.18	-21.05	31.78	-0.11	0.17	0.04	-14.18	-22.25	-0.27	30.6	36.15	0.4	0.23	0.03
EC	FAL	14	0.47	0.55	0.87	17.45	30.61	0.08	0.14	0.02	40.71	24.32	0.17	51.97	36.94	0.31	0.16	0.76
EC	ALL	57	0.56	0.57	0.55	1.32	39.5	0.01	0.22	0.1	20.08	5.18	0.01	47.87	40.21	0.4	0.31	0.3
NACL	WIN	12	0.05	0.42	0.96	665.24	665.24	0.36	0.36	0.12	2128.22	156.01	6.65	2128.2	156.01	6.65	0.5	0.91
NACL	SPR	14	0.13	0.56	0.46	332.78	336.92	0.43	0.44	0.18	563.16	125.63	3.33	564.41	126.93	3.37	0.6	0.21
NACL	SUM	16	0.1	0.19	0.71	97.87	97.87	0.09	0.09	0	150.07	71.64	0.98	150.07	71.64	0.98	0.11	0.5
NACL	FAL	14	0.06	0.25	0.04	359.33	362.26	0.2	0.2	0.01	672.27	130.15	3.59	673.17	131.08	3.62	0.23	0
NACL	ALL	56	0.09	0.35	0.5	306.5	308.54	0.26	0.26	0.09	807.78	117.84	3.06	808.32	118.4	3.09	0.4	0.25
NH4	WIN	14	0.53	0.91	0.8	71.19	71.48	0.38	0.38	0.06	862.5	78	0.71	862.77	78.27	0.71	0.45	0.65
NH4	SPR	14	0.74	0.76	0.65	2.78	50.8	0.02	0.38	0.23	7.23	-13.15	0.03	57.41	56.61	0.51	0.48	0.42
NH4	SUM	16	0.88	0.8	0.57	-9.3	40.08	-0.08	0.35	0.17	31.37	-0.91	-0.1	71.25	55.56	0.44	0.42	0.32
NH4	FAL	12	0.23	0.82	0.61	259.55	259.55	0.59	0.59	0.16	533.2	117.43	2.6	533.2	117.43	2.6	0.71	0.37
NH4	ALL	56	0.62	0.82	0.48	32.75	67.32	0.2	0.42	0.22	340.65	41.12	0.33	364.66	74.76	0.67	0.52	0.23
NO3	WIN	14	0.61	1.37	0.63	123.57	123.57	0.76	0.76	0.28	562.43	87.2	1.24	562.43	87.2	1.24	0.93	0.4
NO3	SPR	14	0.52	0.8	0.71	54.48	79.09	0.28	0.41	0.24	53.05	16.09	0.54	82.6	57.66	0.79	0.56	0.51
NO3	SUM	16	0.35	0.16	0.28	-55.93	66.23	-0.2	0.23	0.03	-42.84	-76.09	-1.27	61.72	90.52	1.5	0.27	0.08
NO3	FAL	13	0.26	0.77	0.65	197.89	206.35	0.51	0.54	0.35	186.89	72.45	1.98	199.12	92.75	2.06	0.79	0.42
NO3	ALL	57	0.44	0.75	0.55	72.7	108.85	0.32	0.47	0.35	181.77	20.54	0.73	221.17	82.14	1.09	0.67	0.3
OC	WIN	14	2.18	3.18	0.71	45.68	61.97	1	1.35	2.77	70.68	41.32	0.46	78.94	50.76	0.62	1.94	0.5
OC	SPR	13	2.41	2.74	0.76	13.54	37.76	0.33	0.91	1.54	21.68	6.74	0.14	46.03	36.68	0.38	1.28	0.58
OC	SUM	16	4.07	4.29	0.22	5.43	81.5	0.22	3.32	30.1	59.32	25	0.05	81.96	60.2	0.82	5.49	0.05
OC	FAL	14	1.95	2.44	0.72	25.25	38.14	0.49	0.74	1.24	32.03	17.73	0.25	45	33.61	0.38	1.22	0.51
OC	ALL	57	2.71	3.21	0.23	18.55	61.1	0.5	1.65	9.87	46.82	23.06	0.19	63.94	45.99	0.61	3.18	0.05
PM-2.5	WIN	14	8.42	11.45	0.75	35.95	41.68	3.03	3.51	10.88	155.64	39.78	0.36	158.94	43.23	0.42	4.48	0.56
PM-2.5	SPR	14	11	10.07	0.71	-8.44	29.37	-0.93	3.23	18.3	-1.14	-11.3	-0.09	34.85	33.77	0.32	4.38	0.5
PM-2.5	SUM	16	18.67	11.59	0.39	-37.92	45.03	-7.08	8.41	104.22	-27.65	-43.18	-0.61	38.47	52.24	0.73	12.42	0.16
PM-2.5	FAL	14	8.09	9.33	0.8	15.24	27.05	1.23	2.19	7.55	17.77	11.99	0.15	28.33	23.93	0.27	3.01	0.63
PM-2.5	ALL	58	11.79	10.64	0.31	-9.74	37.95	-1.15	4.47	52.91	33.95	-2.15	-0.11	64.23	38.78	0.42	7.36	0.1
SO4	WIN	14	1.49	1.69	0.69	13.4	34.76	0.2	0.52	0.32	334.58	28.08	0.13	348.32	44.25	0.35	0.6	0.47
SO4	SPR	14	2.36	2.19	0.61	-7.32	32.47	-0.17	0.77	1.01	0.09	-9.04	-0.08	34.06	35.45	0.35	1.02	0.37
SO4	SUM	16	3.36	2.47	0.63	-26.71	35.19	-0.9	1.18	1.4	-16.84	-27	-0.36	34.01	42	0.48	1.49	0.4
SO4	FAL	14	1.06	1.9	0.42	78.96	87.15	0.84	0.93	0.65	369.19	64.63	0.79	375.52	72.33	0.87	1.16	0.18
SO4	ALL	58	2.11	2.08	0.6	-1.82	40.7	-0.04	0.86	1.27	165.25	12.75	-0.02	192.32	48.28	0.41	1.13	0.37

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 170310057																		
EC	WIN	10	0.48	1.96	0.62	308.9	308.9	1.48	1.48	0.27	313.75	119.14	3.09	313.75	119.14	3.09	1.57	0.38
EC	SPR	11	0.76	1.6	0.69	111.1	111.1	0.84	0.84	0.19	136.06	73.36	1.11	136.06	73.36	1.11	0.95	0.47
EC	SUM	15	1.01	1.5	0.83	48.48	49.21	0.49	0.5	0.07	54.4	40.29	0.48	54.91	40.82	0.49	0.56	0.7
EC	FAL	11	0.98	1.75	0.86	78.99	79.18	0.77	0.77	0.18	93.8	58.16	0.79	94.08	58.44	0.79	0.88	0.73
EC	ALL	47	0.83	1.68	0.55	102.22	102.55	0.85	0.85	0.29	137.91	68.99	1.02	138.14	69.22	1.03	1.01	0.3
NACL	WIN	9	0.33	0.19	0.32	-41.71	76.47	-0.14	0.25	0.17	50.68	11.13	-0.72	89.9	72.28	1.31	0.43	0.1
NACL	SPR	14	0.1	0.16	0.64	62.18	76.75	0.06	0.08	0.01	76.05	41.87	0.62	85.99	53.97	0.77	0.1	0.41
NACL	SUM	14	0.08	0.05	0.37	-39.79	52.77	-0.03	0.04	0	-21.26	-39.43	-0.66	48.5	60.99	0.88	0.06	0.14
NACL	FAL	12	0.06	0.08	0.29	32.09	69.1	0.02	0.04	0	58.3	29.04	0.32	74.87	54.08	0.69	0.06	0.09
NACL	ALL	49	0.13	0.11	0.38	-9.67	71.24	-0.01	0.09	0.04	39.24	9.85	-0.11	73.28	59.37	0.79	0.2	0.15
NH4	WIN	9	1.86	1.5	0.88	-19.23	35.87	-0.36	0.67	0.83	7.21	-3.36	-0.24	39.96	38.33	0.44	0.98	0.78
NH4	SPR	14	1.64	1.93	0.96	17.64	22.33	0.29	0.37	0.18	20.79	15.63	0.18	26.68	22.02	0.22	0.51	0.92
NH4	SUM	14	0.89	0.96	0.87	7.15	23.51	0.06	0.21	0.08	38.84	19.89	0.07	50.53	33.08	0.24	0.28	0.75
NH4	FAL	12	0.71	0.92	0.89	29.48	44.89	0.21	0.32	0.14	161.74	50.86	0.29	172.92	64.32	0.45	0.43	0.79
NH4	ALL	49	1.24	1.33	0.87	6.98	29.47	0.09	0.37	0.31	57.97	21.99	0.07	71.75	38.53	0.29	0.57	0.76
NO3	WIN	9	4.3	3.57	0.91	-16.89	27.18	-0.73	1.17	2.23	-2.79	-14.01	-0.2	35.24	35.94	0.33	1.66	0.82
NO3	SPR	14	2.99	3.56	0.97	19.04	26.95	0.57	0.81	0.89	14.44	8.73	0.19	29.71	27.28	0.27	1.1	0.95
NO3	SUM	14	0.88	0.36	0.44	-58.91	60.33	-0.52	0.53	0.15	-58.8	-91.19	-1.43	60	92.34	1.47	0.65	0.19
NO3	FAL	12	1.08	1.4	0.66	29.58	71.79	0.32	0.78	1.65	10.7	-16.41	0.3	69.3	63.34	0.72	1.33	0.43
NO3	ALL	49	2.16	2.12	0.89	-1.85	36.41	-0.04	0.79	1.4	-10.57	-30.15	-0.02	49.08	56.29	0.37	1.19	0.79
OC	WIN	10	1.55	4.17	0.88	168.74	168.74	2.62	2.62	1.29	168.81	89.38	1.69	168.81	89.38	1.69	2.86	0.77
OC	SPR	11	1.94	3.09	0.93	59.46	59.46	1.15	1.15	0.18	73.56	50.74	0.59	73.56	50.74	0.59	1.23	0.87
OC	SUM	15	2.58	3.03	0.21	17.5	40.33	0.45	1.04	2.74	24.17	10.91	0.18	39.98	30.08	0.4	1.71	0.04
OC	FAL	11	2	2.38	0.83	18.64	27.86	0.37	0.56	0.36	27.39	19.88	0.19	34.82	27.96	0.28	0.71	0.68
OC	ALL	47	2.08	3.14	0.39	50.98	62.12	1.06	1.29	2.02	67.26	39.02	0.51	74.04	47.03	0.62	1.77	0.15
PM-2.5	WIN	9	13.42	16.11	0.73	20.05	32.14	2.69	4.31	24.3	30.62	21.3	0.2	37.06	28.29	0.32	5.62	0.53
PM-2.5	SPR	14	13.39	16.59	0.88	23.87	30.72	3.2	4.11	17.71	30.5	21.71	0.24	37.65	29.57	0.31	5.28	0.77
PM-2.5	SUM	14	15.36	14.03	0.66	-8.68	22.22	-1.33	3.41	14.83	-3.17	-8.27	-0.1	25.43	25.91	0.24	4.08	0.43
PM-2.5	FAL	12	9.43	13.06	0.69	38.42	58.36	3.62	5.5	26.64	54.17	31.48	0.38	68.64	53.32	0.58	6.31	0.48
PM-2.5	ALL	49	12.99	14.91	0.74	14.73	33.03	1.91	4.29	24.59	26.7	15.46	0.15	41.64	34.11	0.33	5.32	0.54
SO4	WIN	9	2	1.24	0.62	-38.12	48.24	-0.76	0.96	1.79	-20.23	-31.93	-0.62	38.69	47.85	0.78	1.54	0.39
SO4	SPR	14	2.61	2.54	0.92	-2.7	19.3	-0.07	0.5	0.45	-2.99	-6.84	-0.03	21.37	22.31	0.2	0.68	0.84
SO4	SUM	14	2.84	2.56	0.83	-9.77	25.43	-0.28	0.72	0.78	3.61	-3.3	-0.11	29.84	29.44	0.28	0.92	0.69
SO4	FAL	12	1.67	1.57	0.86	-6.12	36.69	-0.1	0.61	0.73	16.64	8	-0.07	37.48	33.61	0.39	0.86	0.73
SO4	ALL	49	2.33	2.07	0.81	-11.33	29.03	-0.26	0.68	0.92	0.54	-6.8	-0.13	30.92	31.81	0.33	1	0.65

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 170310076																		
EC	WIN	23	0.53	1.52	0.51	185.88	185.88	0.99	0.99	0.16	201.57	93.35	1.86	201.57	93.35	1.86	1.07	0.26
EC	SPR	25	0.68	1.23	0.54	82.85	84.15	0.56	0.57	0.18	99.07	59.48	0.83	99.69	60.13	0.84	0.7	0.29
EC	SUM	26	0.93	1.23	0.77	32.4	33.41	0.3	0.31	0.05	42.49	31.11	0.32	43.48	32.16	0.33	0.38	0.59
EC	FAL	23	0.67	1.39	0.81	108.64	108.64	0.72	0.72	0.13	130.21	74.63	1.09	130.21	74.63	1.09	0.81	0.65
EC	ALL	97	0.71	1.34	0.5	89.13	89.81	0.63	0.64	0.19	115.59	63.5	0.89	116.02	63.95	0.9	0.77	0.25
NACL	WIN	22	0.08	0.18	0	115.04	135.76	0.1	0.11	0.01	499.41	80.94	1.15	506.67	89.51	1.36	0.13	0
NACL	SPR	25	0.09	0.14	0.25	64.64	107.37	0.06	0.09	0.01	134.84	57.54	0.65	147.71	75.1	1.07	0.12	0.06
NACL	SUM	25	0.06	0.05	0.4	-16.31	37.38	-0.01	0.02	0	-4.67	-18.95	-0.19	41.95	42.57	0.45	0.03	0.16
NACL	FAL	23	0.06	0.08	0.3	43.96	81.54	0.03	0.05	0	220.07	39.42	0.44	240.68	66.48	0.82	0.07	0.09
NACL	ALL	95	0.07	0.11	0.27	56.54	94.73	0.04	0.07	0.01	203.19	38.44	0.57	225.52	67.79	0.95	0.09	0.07
NH4	WIN	21	1.55	1.44	0.73	-7.52	40.6	-0.12	0.63	0.71	24.71	6.93	-0.08	52.41	41.83	0.44	0.85	0.54
NH4	SPR	25	1.47	1.58	0.9	7.52	24.71	0.11	0.36	0.23	29.63	16.86	0.08	41.93	31.72	0.25	0.49	0.8
NH4	SUM	26	0.91	0.87	0.85	-4.51	32.2	-0.04	0.29	0.19	44.64	19.76	-0.05	62.97	41.98	0.34	0.44	0.73
NH4	FAL	23	0.74	0.94	0.95	26.6	33.77	0.2	0.25	0.06	74.98	35.89	0.27	81.49	43.38	0.34	0.31	0.9
NH4	ALL	95	1.16	1.2	0.84	3.41	32.43	0.04	0.38	0.3	43.63	20.07	0.03	59.58	39.58	0.32	0.55	0.71
NO3	WIN	22	3.3	3.15	0.79	-4.68	32.23	-0.15	1.06	2.08	105.62	7.61	-0.05	131.52	40.43	0.34	1.45	0.62
NO3	SPR	25	2.77	2.85	0.91	2.63	27.4	0.07	0.76	1.1	12.96	-3.8	0.03	43.06	34.04	0.27	1.05	0.83
NO3	SUM	26	0.87	0.36	0.77	-59.08	59.57	-0.52	0.52	0.31	-55.7	-82.66	-1.44	56.28	83.22	1.46	0.76	0.59
NO3	FAL	23	1.33	1.5	0.76	12.9	47.46	0.17	0.63	1.2	6.58	-18.8	0.13	58.34	54.48	0.47	1.11	0.58
NO3	ALL	96	2.03	1.92	0.86	-5.65	36.08	-0.11	0.73	1.21	14.07	-26.13	-0.06	70.57	53.72	0.38	1.1	0.74
OC	WIN	23	1.41	3.54	0.71	151.69	151.69	2.13	2.13	0.96	164.13	84.17	1.52	164.13	84.17	1.52	2.35	0.5
OC	SPR	25	1.48	2.62	0.62	76.84	79.33	1.14	1.17	0.89	92.3	55.91	0.77	93.51	57.22	0.79	1.48	0.38
OC	SUM	26	2.2	2.67	0.45	21.46	40.61	0.47	0.89	1.51	31.18	20.12	0.21	42.1	33.13	0.41	1.32	0.2
OC	FAL	23	1.35	2.25	0.69	66.23	68.52	0.9	0.93	0.6	81.26	51.3	0.66	82.68	52.85	0.69	1.19	0.47
OC	ALL	97	1.62	2.76	0.47	70	77.98	1.14	1.27	1.37	90.33	51.92	0.7	93.91	56.12	0.78	1.63	0.22
PM-2.5	WIN	23	11.45	15.38	0.76	34.33	39.1	3.93	4.48	13.11	54.82	34.71	0.34	57.38	37.47	0.39	5.34	0.57
PM-2.5	SPR	25	11.58	15.2	0.89	31.22	33.69	3.62	3.9	9.01	40.01	29.24	0.31	42.78	32.15	0.34	4.7	0.78
PM-2.5	SUM	26	13.07	12.98	0.79	-0.69	22.89	-0.09	2.99	14.48	11.06	6.2	-0.01	26.72	24.23	0.23	3.81	0.63
PM-2.5	FAL	23	8.72	12.12	0.85	39.02	43.19	3.4	3.76	9.75	47.35	32.98	0.39	51.37	37.29	0.43	4.62	0.73
PM-2.5	ALL	97	11.27	13.92	0.77	23.48	33.38	2.65	3.76	14.4	37.5	25.25	0.23	43.97	32.51	0.33	4.63	0.6
SO4	WIN	22	1.8	1.37	0.5	-23.93	48.8	-0.43	0.88	1.39	196.4	-18	-0.31	251.13	55.69	0.64	1.26	0.25
SO4	SPR	25	2.2	2.2	0.82	0.17	24.67	0	0.54	0.51	8.51	1.96	0	29.85	28.19	0.25	0.71	0.67
SO4	SUM	26	2.77	2.41	0.87	-12.75	29.05	-0.35	0.8	1.46	6.29	0.31	-0.15	28.57	27.46	0.33	1.26	0.75
SO4	FAL	24	1.62	1.51	0.85	-7.02	31.51	-0.11	0.51	0.52	125.99	3.35	-0.08	153.15	36.42	0.34	0.73	0.73
SO4	ALL	97	2.12	1.9	0.79	-10.36	32.14	-0.22	0.68	1	79.6	-2.66	-0.12	110.2	36.27	0.36	1.02	0.62

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 170314201																		
EC	WIN	20	0.44	1.44	0.55	224.09	224.09	0.99	0.99	0.16	270.73	106.9	2.24	270.73	106.9	2.24	1.07	0.31
EC	SPR	17	0.36	0.97	0.65	170.36	170.36	0.61	0.61	0.23	185.7	87.64	1.7	185.7	87.64	1.7	0.78	0.43
EC	SUM	30	0.68	1.12	0.73	63.92	65.39	0.44	0.45	0.19	71.61	47.08	0.64	72.84	48.34	0.65	0.61	0.53
EC	FAL	29	0.62	1.38	0.91	124.22	124.22	0.76	0.76	0.25	142.29	78.02	1.24	142.29	78.02	1.24	0.91	0.83
EC	ALL	96	0.55	1.24	0.73	122.94	123.5	0.68	0.69	0.25	154.65	76.07	1.23	155.03	76.47	1.24	0.85	0.53
NACL	WIN	28	0.07	0.16	0.3	111.46	124.73	0.08	0.09	0	197.95	80.75	1.11	202.3	86.14	1.25	0.1	0.09
NACL	SPR	30	0.1	0.11	0.54	11.6	91.74	0.01	0.09	0.04	122.09	46.75	0.12	140.74	74.33	0.92	0.2	0.29
NACL	SUM	28	0.07	0.04	0.18	-39.35	53.51	-0.03	0.04	0	-15.88	-34.52	-0.65	45.16	55.43	0.88	0.06	0.03
NACL	FAL	26	0.07	0.07	0.37	0.4	51.77	0	0.04	0	18.13	-2.52	0	59.12	50.05	0.52	0.05	0.14
NACL	ALL	112	0.08	0.1	0.36	21.69	82.81	0.02	0.07	0.01	82.43	23.5	0.22	113.29	66.92	0.83	0.12	0.13
NH4	WIN	28	1.69	1.43	0.73	-15.34	41.19	-0.26	0.7	0.9	19.17	1.61	-0.18	50.74	42.5	0.49	0.98	0.53
NH4	SPR	29	1.18	1.5	0.83	27.86	40.02	0.33	0.47	0.34	102.29	33.47	0.28	111.07	43.32	0.4	0.67	0.69
NH4	SUM	27	0.81	0.89	0.81	9.56	35.16	0.08	0.28	0.14	51.73	26.42	0.1	65.03	42.99	0.35	0.39	0.65
NH4	FAL	26	0.65	0.85	0.94	31.31	41.2	0.2	0.27	0.06	229.74	54.3	0.31	238.25	64.09	0.41	0.32	0.88
NH4	ALL	110	1.09	1.18	0.78	8	39.76	0.09	0.43	0.42	98.85	28.55	0.08	114.47	47.94	0.4	0.65	0.61
NO3	WIN	28	3.92	3.48	0.77	-11.2	33.61	-0.44	1.32	3.29	9.02	-2.67	-0.13	38.84	35.46	0.38	1.87	0.6
NO3	SPR	30	2.11	2.68	0.81	26.63	48.91	0.56	1.03	2.16	150.66	18.09	0.27	176.83	51.98	0.49	1.57	0.65
NO3	SUM	28	0.72	0.34	0.76	-53.27	55.97	-0.39	0.41	0.19	-57.18	-93.68	-1.14	60.02	96.36	1.2	0.59	0.58
NO3	FAL	27	1.13	1.24	0.73	9.77	47.81	0.11	0.54	1.17	1.95	-26.93	0.1	62.63	63.51	0.48	1.09	0.54
NO3	ALL	113	1.98	1.95	0.8	-1.44	41.91	-0.03	0.83	1.89	28.53	-25.51	-0.01	86.41	61.64	0.43	1.37	0.65
OC	WIN	20	1.31	3.63	0.67	176.55	176.55	2.32	2.32	0.82	250.01	96.31	1.77	250.01	96.31	1.77	2.49	0.44
OC	SPR	17	0.87	1.97	0.78	127.66	127.66	1.11	1.11	0.58	186.23	83.61	1.28	186.23	83.61	1.28	1.34	0.61
OC	SUM	30	1.83	2.35	0.57	27.98	50.46	0.51	0.93	1.23	41.87	25.45	0.28	56.31	42.56	0.5	1.22	0.33
OC	FAL	29	1.32	2.24	0.66	69.43	69.9	0.92	0.92	0.97	93.19	49.95	0.69	94.36	51.23	0.7	1.35	0.44
OC	ALL	96	1.4	2.52	0.54	79.77	89.12	1.12	1.25	1.38	126.3	57.91	0.8	131.17	63.65	0.89	1.62	0.3
PM-2.5	WIN	28	11.74	14.64	0.67	24.68	40.1	2.9	4.71	20.27	41.41	27.4	0.25	51.14	38.36	0.4	5.35	0.46
PM-2.5	SPR	30	8.68	12.66	0.84	45.95	51.38	3.99	4.46	16.31	165.4	38.74	0.46	171	45.15	0.51	5.68	0.71
PM-2.5	SUM	28	11.84	10.36	0.72	-12.49	25.94	-1.48	3.07	15.71	-6.68	-11.78	-0.14	25.66	27.86	0.3	4.23	0.52
PM-2.5	FAL	27	8.6	10.57	0.88	22.97	31.44	1.97	2.7	11.27	27.62	17.95	0.23	37.15	28.95	0.31	3.89	0.78
PM-2.5	ALL	113	10.2	12.08	0.73	18.45	36.83	1.88	3.76	20.17	59.12	18.44	0.18	73.3	35.31	0.37	4.87	0.53
SO4	WIN	28	1.85	1.19	0.51	-35.88	49.29	-0.66	0.91	1.38	-25.47	-38.66	-0.56	42.13	51.42	0.77	1.35	0.26
SO4	SPR	30	1.84	2.07	0.82	12.51	29.82	0.23	0.55	0.53	123.62	14.79	0.13	139.37	33.49	0.3	0.76	0.67
SO4	SUM	28	2.64	2.33	0.74	-11.79	34.73	-0.31	0.92	1.74	7.86	-2.62	-0.13	36.87	34.43	0.39	1.35	0.55
SO4	FAL	27	1.7	1.38	0.89	-19.11	36.66	-0.33	0.62	0.66	47.75	-6.06	-0.24	86.15	42.02	0.45	0.87	0.79
SO4	ALL	113	2.01	1.75	0.72	-12.87	37.26	-0.26	0.75	1.17	39.87	-7.75	-0.15	77.16	40.2	0.43	1.11	0.52

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 170434002																		
EC	WIN	11	0.46	1.03	0.85	125.11	125.11	0.57	0.57	0.02	142.88	79.84	1.25	142.88	79.84	1.25	0.59	0.72
EC	SPR	15	0.53	0.89	0.75	68.76	73.04	0.36	0.39	0.05	84.47	54.4	0.69	86.67	56.8	0.73	0.42	0.56
EC	SUM	16	0.83	1.04	0.7	25.75	27.2	0.21	0.22	0.04	31.38	23.94	0.26	32.47	25.05	0.27	0.29	0.49
EC	FAL	15	0.57	1.14	0.78	98.41	98.41	0.56	0.56	0.09	110.06	65.57	0.98	110.06	65.57	0.98	0.64	0.61
EC	ALL	57	0.61	1.02	0.65	67.85	69.38	0.41	0.42	0.07	87.58	53.7	0.68	88.46	54.64	0.69	0.49	0.42
NACL	WIN	14	0.13	0.1	0.05	-22.05	81.84	-0.03	0.11	0.02	74.39	22.21	-0.28	110.23	78.14	1.05	0.16	0
NACL	SPR	15	0.05	0.09	0.78	84.02	85.49	0.04	0.04	0	93.37	53.59	0.84	95.32	55.69	0.85	0.05	0.6
NACL	SUM	14	0.06	0.04	0.02	-38.59	50.8	-0.02	0.03	0	-30.46	-48.74	-0.63	45.05	61.52	0.83	0.04	0
NACL	FAL	15	0.04	0.05	0.54	45.82	56.19	0.02	0.02	0	46.51	29.24	0.46	56.27	40.6	0.56	0.03	0.29
NACL	ALL	58	0.07	0.07	0.25	2.8	72.21	0	0.05	0.01	46.78	15.02	0.03	76.68	58.61	0.72	0.08	0.06
NH4	WIN	14	1.72	1.27	0.82	-26.17	41.85	-0.45	0.72	1.31	1.12	-10.86	-0.35	39.26	39.17	0.57	1.23	0.67
NH4	SPR	15	1.59	1.62	0.9	1.82	22.85	0.03	0.36	0.24	11.53	2.74	0.02	31.62	26	0.23	0.49	0.8
NH4	SUM	14	0.87	0.88	0.71	1.34	30.94	0.01	0.27	0.14	22.19	11.52	0.01	38.85	31.72	0.31	0.37	0.51
NH4	FAL	14	0.79	1.05	0.43	33.45	58.11	0.26	0.46	0.73	102.23	30.53	0.33	119.61	50.1	0.58	0.89	0.19
NH4	ALL	57	1.25	1.21	0.69	-2.84	36.13	-0.04	0.45	0.66	33.87	8.38	-0.03	56.88	36.56	0.37	0.82	0.47
NO3	WIN	14	3.94	3.16	0.87	-19.76	29.55	-0.78	1.17	2.62	-8.09	-15.79	-0.25	29.36	32.59	0.37	1.8	0.76
NO3	SPR	15	2.6	2.93	0.89	12.63	42.88	0.33	1.11	1.97	3.86	-14.95	0.13	52.82	52.64	0.43	1.44	0.8
NO3	SUM	14	0.63	0.37	0.21	-42.31	51.75	-0.27	0.33	0.11	-41.99	-67.29	-0.73	51.29	75.5	0.9	0.43	0.04
NO3	FAL	15	1.34	1.86	0.57	39.01	56.88	0.52	0.76	2.84	133.99	-2.17	0.39	173.47	53.57	0.57	1.77	0.33
NO3	ALL	58	2.12	2.09	0.78	-1.55	39.83	-0.03	0.85	2.16	23.56	-24.48	-0.02	77.99	53.56	0.4	1.47	0.61
OC	WIN	11	1.32	2.88	0.89	117.77	117.77	1.56	1.56	0.32	139.92	77.23	1.18	139.92	77.23	1.18	1.66	0.79
OC	SPR	15	1.46	2.18	0.74	48.87	54.6	0.71	0.8	0.54	60.4	41.16	0.49	62.88	43.9	0.55	1.02	0.54
OC	SUM	16	2.48	2.43	0.57	-1.85	34.06	-0.05	0.84	1.47	1.23	-4.86	-0.02	29.65	29.87	0.35	1.21	0.33
OC	FAL	15	1.38	1.78	0.5	29.37	43.44	0.4	0.6	0.41	47.81	29.97	0.29	56.46	39.88	0.43	0.76	0.25
OC	ALL	57	1.7	2.28	0.57	34.32	53.32	0.58	0.91	1.03	55.82	32.26	0.34	66.73	45.34	0.53	1.17	0.32
PM-2.5	WIN	14	11.97	12.15	0.79	1.47	25.76	0.18	3.08	18.03	15.91	8.97	0.01	30.18	25.53	0.26	4.25	0.62
PM-2.5	SPR	15	10.82	12.54	0.76	15.87	32.1	1.72	3.47	18.67	20.14	11	0.16	35.86	30.51	0.32	4.65	0.58
PM-2.5	SUM	16	14.11	10.65	0.84	-24.55	25.01	-3.46	3.53	7.91	-21.8	-25.92	-0.33	22.77	26.86	0.33	4.46	0.7
PM-2.5	FAL	15	8.71	10.1	0.81	15.97	29.7	1.39	2.59	11.32	22.02	13.82	0.16	32.32	25.64	0.3	3.64	0.65
PM-2.5	ALL	60	11.44	11.33	0.69	-0.93	27.76	-0.11	3.18	18.23	8.44	1.39	-0.01	30.16	27.16	0.28	4.27	0.48
SO4	WIN	14	1.84	1	0.57	-45.55	53.84	-0.84	0.99	1.45	-30.07	-46.45	-0.84	46.13	58.96	0.99	1.47	0.32
SO4	SPR	15	2.52	2.21	0.89	-12.6	22.99	-0.32	0.58	0.46	-6.32	-11.85	-0.14	26.7	27.71	0.26	0.75	0.79
SO4	SUM	14	2.79	2.26	0.68	-18.84	29.53	-0.53	0.82	1.43	-6.51	-11.4	-0.23	23.23	26.48	0.36	1.31	0.46
SO4	FAL	15	1.57	1.32	0.38	-15.66	49.87	-0.25	0.78	1.22	6.85	-9.96	-0.19	50.37	45.31	0.59	1.13	0.15
SO4	ALL	58	2.18	1.7	0.68	-21.84	36.34	-0.48	0.79	1.18	-8.69	-19.6	-0.28	36.67	39.51	0.46	1.19	0.46

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 180190006																		
EC	WIN	15	0.59	0.98	0.85	65.23	67.3	0.39	0.4	0.05	72.14	49	0.65	74.78	51.93	0.67	0.44	0.73
EC	SPR	14	0.61	0.7	0.85	14.82	24.29	0.09	0.15	0.03	35.69	23.38	0.15	41.87	29.95	0.24	0.2	0.73
EC	SUM	16	0.91	0.87	0.83	-3.92	16.56	-0.04	0.15	0.04	1.24	-1.54	-0.04	18.08	17.81	0.17	0.2	0.69
EC	FAL	14	0.79	0.9	0.94	12.88	18.09	0.1	0.14	0.02	24.74	18.67	0.13	27.65	21.74	0.18	0.18	0.88
EC	ALL	59	0.73	0.86	0.77	18.38	28.94	0.13	0.21	0.06	33.02	22.02	0.18	40.41	30.3	0.29	0.28	0.6
NACL	WIN	15	0.09	0.12	0.21	33.38	66.76	0.03	0.06	0	77.06	35.73	0.33	93.78	55.87	0.67	0.07	0.04
NACL	SPR	15	0.11	0.1	0.43	-5.19	60.34	-0.01	0.06	0.01	21.89	-3.14	-0.05	63.13	61.11	0.64	0.1	0.18
NACL	SUM	16	0.08	0.04	0.27	-53.54	59.61	-0.05	0.05	0	-33.2	-54.28	-1.15	52.19	69.37	1.28	0.07	0.07
NACL	FAL	15	0.1	0.05	0.13	-51.59	60.14	-0.05	0.06	0.01	-16.16	-36.98	-1.07	48.81	59.61	1.24	0.11	0.02
NACL	ALL	61	0.1	0.08	0.24	-20.22	61.56	-0.02	0.06	0.01	11.65	-15.32	-0.25	64.27	61.62	0.77	0.09	0.06
NH4	WIN	15	1.58	1.27	0.82	-19.58	32.8	-0.31	0.52	0.39	-7.03	-13.57	-0.24	29.46	32.04	0.41	0.7	0.67
NH4	SPR	15	1.11	1.14	0.9	2.84	25.38	0.03	0.28	0.13	-0.32	-4.69	0.03	24.04	25.26	0.25	0.36	0.81
NH4	SUM	16	1.57	1.26	0.84	-19.55	27.64	-0.31	0.43	0.21	-11.08	-17.93	-0.24	30.01	32.18	0.34	0.55	0.71
NH4	FAL	15	0.71	0.77	0.61	7.77	43.65	0.06	0.31	0.25	37.78	19.78	0.08	52.23	38.31	0.44	0.5	0.37
NH4	ALL	61	1.25	1.11	0.79	-10.81	31	-0.13	0.39	0.27	4.57	-4.33	-0.12	33.87	31.95	0.35	0.54	0.63
NO3	WIN	15	2.83	2.62	0.65	-7.54	40.25	-0.21	1.14	1.89	9.06	-8.45	-0.08	51.26	50.53	0.44	1.39	0.42
NO3	SPR	15	0.92	1.33	0.74	44.53	88.6	0.41	0.82	1.82	23.48	-14.05	0.45	81.12	71.33	0.89	1.41	0.55
NO3	SUM	16	0.51	0.24	0.77	-54.14	54.14	-0.28	0.28	0.05	-52.69	-77.69	-1.18	52.69	77.69	1.18	0.36	0.6
NO3	FAL	15	0.94	0.69	0.75	-26.98	44.99	-0.25	0.42	0.26	-23.44	-43.49	-0.37	49.92	61.61	0.62	0.57	0.57
NO3	ALL	61	1.29	1.2	0.74	-6.74	51.06	-0.09	0.66	1.07	-11.58	-36.61	-0.07	58.65	65.49	0.55	1.04	0.54
OC	WIN	15	1.74	4.83	0.85	177.43	177.43	3.09	3.09	2.87	188.82	92.05	1.77	188.82	92.05	1.77	3.52	0.72
OC	SPR	14	1.83	2.46	0.71	34.35	42.34	0.63	0.77	0.68	62.26	37.22	0.34	66.9	42.29	0.42	1.04	0.51
OC	SUM	16	2.58	3.26	0.81	26.75	36.41	0.69	0.94	0.75	39.32	25.99	0.27	47.6	35.75	0.36	1.11	0.66
OC	FAL	14	1.81	2.99	0.84	65.35	65.35	1.18	1.18	0.9	92.87	53.59	0.65	92.87	53.59	0.65	1.51	0.71
OC	ALL	59	2	3.41	0.64	69.92	75.01	1.4	1.5	2.32	95.48	52	0.7	98.83	55.85	0.75	2.07	0.4
PM-2.5	WIN	15	11.98	15.38	0.82	28.35	32.39	3.4	3.88	12.28	38.54	27.58	0.28	42.41	31.72	0.32	4.88	0.67
PM-2.5	SPR	15	10.97	10.79	0.71	-1.61	23.42	-0.18	2.57	12.55	-1.95	-6.9	-0.02	25.31	24.94	0.24	3.55	0.5
PM-2.5	SUM	16	18.31	13.41	0.86	-26.78	28.19	-4.9	5.16	16.19	-24.91	-30.04	-0.37	26.34	31.39	0.39	6.34	0.74
PM-2.5	FAL	15	9.76	10.35	0.83	6.04	24.72	0.59	2.41	7.41	12.24	5.53	0.06	32.05	28.21	0.25	2.79	0.68
PM-2.5	ALL	61	12.85	12.5	0.72	-2.72	27.51	-0.35	3.53	21.29	5.47	-1.43	-0.03	31.44	29.1	0.28	4.63	0.51
SO4	WIN	15	2.5	1.46	0.87	-41.58	42.31	-1.04	1.06	0.96	-36.81	-49.53	-0.71	38.13	50.79	0.72	1.43	0.75
SO4	SPR	15	3.02	2.39	0.78	-20.93	34.12	-0.63	1.03	1.06	-24.24	-33.96	-0.26	34.68	42.98	0.43	1.21	0.6
SO4	SUM	16	5.45	3.6	0.82	-33.81	37.28	-1.84	2.03	2.57	-31.36	-41.43	-0.51	35.43	45.19	0.56	2.44	0.68
SO4	FAL	15	2.03	1.69	0.73	-17.04	30.22	-0.35	0.61	0.86	-12.51	-18.81	-0.21	24.31	27.74	0.36	0.99	0.53
SO4	ALL	61	3.28	2.31	0.82	-29.8	36.43	-0.98	1.2	1.71	-26.32	-36.02	-0.42	33.17	41.73	0.52	1.63	0.68

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 180372001																		
EC	WIN	14	0.5	0.51	0.65	1.89	30.64	0.01	0.15	0.03	4.87	-2.14	0.02	34.19	33.82	0.31	0.17	0.42
EC	SPR	14	0.46	0.37	0.7	-18.11	31.47	-0.08	0.14	0.03	-9.45	-15.61	-0.22	29.32	31.96	0.38	0.19	0.49
EC	SUM	16	0.7	0.43	0.87	-38.52	40.23	-0.27	0.28	0.03	-32.06	-42.15	-0.63	39.12	47.66	0.65	0.31	0.75
EC	FAL	15	0.44	0.44	0.78	-1.53	22.87	-0.01	0.1	0.02	-0.26	-3.66	-0.02	22.74	22.8	0.23	0.13	0.6
EC	ALL	59	0.53	0.44	0.62	-17.34	32.57	-0.09	0.17	0.04	-9.85	-16.57	-0.21	31.46	34.33	0.39	0.22	0.38
NACL	WIN	15	0.16	0.13	0.07	-16.12	83.7	-0.03	0.13	0.05	67.98	18.99	-0.19	101.17	76.03	1	0.23	0
NACL	SPR	15	0.12	0.13	0.31	10.48	79.97	0.01	0.09	0.02	191.89	6.66	0.1	234.44	71.65	0.8	0.14	0.09
NACL	SUM	15	0.09	0.05	0.26	-46.67	51.57	-0.04	0.05	0	-33.27	-52.79	-0.88	45.28	61.86	0.97	0.07	0.07
NACL	FAL	15	0.08	0.07	0.07	-16.1	68.86	-0.01	0.06	0.01	37.48	-2.85	-0.19	81.99	63.96	0.82	0.08	0
NACL	ALL	60	0.11	0.1	0.16	-15.4	73.45	-0.02	0.08	0.02	66.02	-7.5	-0.18	115.72	68.38	0.87	0.14	0.02
NH4	WIN	15	1.94	1.47	0.85	-24.22	32.13	-0.47	0.62	0.55	-11.43	-19.17	-0.32	29.89	32.64	0.42	0.88	0.73
NH4	SPR	15	1.32	1.61	0.83	21.75	32.09	0.29	0.42	0.67	12.89	6.81	0.22	26.12	21.75	0.32	0.87	0.69
NH4	SUM	15	1.67	1.62	0.94	-3.23	20.43	-0.05	0.34	0.19	20.37	5.45	-0.03	41.9	29.56	0.21	0.44	0.87
NH4	FAL	15	0.81	1.08	0.72	33.67	51.68	0.27	0.42	0.34	69.52	36.45	0.34	81.63	50.42	0.52	0.64	0.51
NH4	ALL	60	1.44	1.44	0.77	0.65	31.47	0.01	0.45	0.53	22.84	7.38	0.01	44.88	33.59	0.31	0.73	0.59
NO3	WIN	15	3.69	3.31	0.74	-10.33	36.91	-0.38	1.36	2.71	5.12	-10.39	-0.12	47.84	47.68	0.41	1.69	0.55
NO3	SPR	15	1.22	2.61	0.84	113.93	127.17	1.39	1.55	4.3	89.34	43.49	1.14	105.08	63.17	1.27	2.5	0.71
NO3	SUM	15	0.58	0.85	0.52	45.9	75.67	0.27	0.44	0.42	54.16	25.45	0.46	74.55	50.14	0.76	0.7	0.27
NO3	FAL	15	1.1	1.66	0.87	50	63.79	0.55	0.7	0.65	61.16	19.1	0.5	93.22	64.68	0.64	0.98	0.76
NO3	ALL	60	1.65	2.11	0.71	27.71	61.52	0.46	1.01	2.42	52.45	19.41	0.28	80.17	56.42	0.62	1.62	0.5
OC	WIN	14	1.65	2.64	0.64	59.89	63.65	0.99	1.05	0.74	73.68	44.64	0.6	76.45	47.64	0.64	1.31	0.41
OC	SPR	14	1.86	1.74	0.77	-6.24	36.12	-0.12	0.67	0.63	9.79	-0.65	-0.07	39.14	35.81	0.39	0.8	0.6
OC	SUM	16	2.24	2.57	0.86	14.99	28.21	0.34	0.63	0.49	23.6	13.47	0.15	37.4	30.52	0.28	0.78	0.74
OC	FAL	15	1.19	1.57	0.82	31.93	39.34	0.38	0.47	0.21	40.91	25.45	0.32	50.47	36.38	0.39	0.6	0.68
OC	ALL	59	1.74	2.14	0.74	22.68	40.13	0.4	0.7	0.66	36.61	20.56	0.23	50.4	37.33	0.4	0.9	0.55
PM-2.5	WIN	15	12.61	12.07	0.78	-4.34	25.07	-0.55	3.16	16.02	6.06	-4.03	-0.05	34.69	32.45	0.26	4.04	0.61
PM-2.5	SPR	14	10.92	10.55	0.61	-3.37	31.39	-0.37	3.43	25.1	-7.23	-16.37	-0.03	31.66	34.44	0.32	5.02	0.37
PM-2.5	SUM	15	17.77	12.34	0.93	-30.6	32.19	-5.44	5.72	12.89	-29.18	-35.95	-0.44	31.37	37.97	0.46	6.52	0.87
PM-2.5	FAL	15	7.81	8.77	0.77	12.19	29.74	0.95	2.32	8.18	12.75	7.54	0.12	29.42	26.59	0.3	3.01	0.6
PM-2.5	ALL	59	12.3	10.94	0.76	-11.11	29.77	-1.37	3.66	21.37	-4.35	-12.13	-0.12	31.79	32.84	0.33	4.82	0.57
SO4	WIN	15	2.58	1.41	0.88	-45.5	45.5	-1.17	1.17	0.5	-46.09	-64.2	-0.83	46.09	64.2	0.83	1.37	0.78
SO4	SPR	15	3.27	2.43	0.78	-25.54	35.09	-0.83	1.15	0.99	-28.72	-39.86	-0.34	37.72	47.51	0.47	1.3	0.61
SO4	SUM	15	5.26	3.8	0.94	-27.66	32.94	-1.45	1.73	2.09	-22.55	-30.7	-0.38	34.59	40.51	0.46	2.05	0.88
SO4	FAL	15	2.14	1.69	0.63	-21.13	40.03	-0.45	0.86	1.33	-13.83	-24.2	-0.27	36.98	41.73	0.51	1.24	0.4
SO4	ALL	60	3.31	2.33	0.9	-29.55	37.06	-0.98	1.23	1.37	-27.8	-39.74	-0.42	38.85	48.49	0.53	1.53	0.8

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 180650003																		
EC	WIN	13	0.31	0.53	0.55	71.08	76.09	0.22	0.24	0.02	83.63	52.41	0.71	85.95	54.93	0.76	0.27	0.3
EC	SPR	13	0.35	0.34	0.78	-4.02	25.73	-0.01	0.09	0.01	11.89	4.22	-0.04	32.76	29.07	0.27	0.12	0.6
EC	SUM	15	0.54	0.49	0.83	-10.41	17.31	-0.06	0.09	0.01	-6.96	-9.44	-0.12	18.67	19.1	0.19	0.11	0.68
EC	FAL	14	0.38	0.49	0.7	30.26	45.8	0.11	0.17	0.05	42.67	24.88	0.3	51.96	36.63	0.46	0.25	0.48
EC	ALL	55	0.4	0.46	0.58	15.63	36.69	0.06	0.15	0.03	31.54	17.15	0.16	46.38	34.39	0.37	0.2	0.34
NACL	WIN	15	0.05	0.1	0.15	106.34	115.8	0.05	0.06	0	228.39	62.51	1.06	239.31	78.53	1.16	0.07	0.02
NACL	SPR	14	0.04	0.09	0.87	109.76	110.46	0.05	0.05	0	126.5	67.6	1.1	127.96	69.15	1.1	0.06	0.76
NACL	SUM	16	0.05	0.03	0.17	-42.03	47.21	-0.02	0.03	0	-31.61	-47.67	-0.72	43.67	56.99	0.81	0.03	0.03
NACL	FAL	14	0.03	0.04	0.27	28.78	60.35	0.01	0.02	0	45.86	28.15	0.29	61.12	47.89	0.6	0.02	0.08
NACL	ALL	59	0.04	0.06	0.29	45.08	82.54	0.02	0.04	0	90.39	25.68	0.45	117.55	63.19	0.83	0.05	0.08
NH4	WIN	15	1.43	1.41	0.82	-1.59	33.67	-0.02	0.48	0.36	14.85	5.87	-0.02	39.1	35.28	0.34	0.6	0.67
NH4	SPR	14	1.42	2.01	0.84	41.99	46.3	0.59	0.66	0.59	43.36	27.86	0.42	48.22	33.11	0.46	0.97	0.7
NH4	SUM	16	1.3	1.39	0.79	6.76	30.92	0.09	0.4	0.24	38.82	16.07	0.07	54.97	34.6	0.31	0.5	0.63
NH4	FAL	12	0.94	1.16	0.71	24.43	45.9	0.23	0.43	0.23	37.99	22.23	0.24	54.71	42.39	0.46	0.53	0.5
NH4	ALL	57	1.29	1.5	0.73	16.54	38.17	0.21	0.49	0.41	33.45	17.58	0.17	49.08	36.06	0.38	0.68	0.53
NO3	WIN	15	3.35	3.53	0.68	5.47	46.58	0.18	1.56	3.57	27.35	10.24	0.05	56.98	48.42	0.47	1.9	0.47
NO3	SPR	14	2.07	3.84	0.75	85.35	92.65	1.77	1.92	3.49	110.52	56.61	0.85	116.61	63.62	0.93	2.57	0.56
NO3	SUM	16	0.69	0.68	0.64	-2.06	42.84	-0.01	0.3	0.14	4.06	-17.33	-0.02	54.58	57.01	0.44	0.38	0.4
NO3	FAL	14	1.14	1.74	0.66	52.11	65.22	0.6	0.74	1.53	59.65	21.04	0.52	84.61	56.4	0.65	1.37	0.44
NO3	ALL	59	1.8	2.41	0.7	33.47	61.55	0.6	1.11	2.61	48.43	16.33	0.33	77.04	56.25	0.62	1.72	0.5
OC	WIN	13	0.94	2.36	0.83	152.37	152.37	1.43	1.43	0.41	174.28	86.3	1.52	174.28	86.3	1.52	1.56	0.69
OC	SPR	13	1.03	1.3	0.76	25.72	46.97	0.27	0.49	0.23	89.73	38.37	0.26	104.4	56.13	0.47	0.55	0.58
OC	SUM	15	1.91	1.98	0.86	4.13	26.42	0.08	0.5	0.31	7.19	1.18	0.04	30.24	29.5	0.26	0.57	0.73
OC	FAL	14	0.92	1.45	0.91	58.41	58.41	0.54	0.54	0.17	196.79	58.99	0.58	196.79	58.99	0.58	0.67	0.83
OC	ALL	55	1.22	1.78	0.69	45.78	59.55	0.56	0.73	0.54	114.45	44.8	0.46	124.21	56.73	0.6	0.92	0.47
PM-2.5	WIN	14	10.18	11.21	0.82	10.09	30.23	1.03	3.08	10.82	19.28	10.48	0.1	37.84	33.77	0.3	3.45	0.68
PM-2.5	SPR	14	9.87	11.94	0.73	20.94	33.81	2.07	3.34	16.67	22.08	12.87	0.21	37.13	31.56	0.34	4.58	0.54
PM-2.5	SUM	16	15.03	11.43	0.77	-23.93	26.97	-3.6	4.05	17.61	-21.21	-26.11	-0.31	24.43	29.13	0.35	5.53	0.59
PM-2.5	FAL	14	7.3	8.53	0.65	16.86	45.11	1.23	3.29	15.32	23.9	6.86	0.17	52.24	44.6	0.45	4.1	0.42
PM-2.5	ALL	58	10.75	10.8	0.69	0.48	32.21	0.05	3.46	20.41	9.9	0.09	0	37.44	34.57	0.32	4.52	0.47
SO4	WIN	15	1.97	1.1	0.75	-43.99	44.61	-0.86	0.88	1.04	-35.98	-51.08	-0.79	37	52.06	0.8	1.34	0.57
SO4	SPR	14	2.72	2.48	0.84	-8.88	24.39	-0.24	0.66	0.65	-12.64	-18	-0.1	25.57	28.49	0.27	0.84	0.7
SO4	SUM	16	4.12	3.6	0.84	-12.53	25.81	-0.52	1.06	1.55	-7.56	-12.01	-0.14	24.37	26.44	0.3	1.35	0.71
SO4	FAL	14	2	1.49	0.87	-25.2	29.48	-0.5	0.59	0.53	-15.66	-24.43	-0.34	29.63	35.17	0.39	0.88	0.76
SO4	ALL	59	2.74	2.2	0.85	-19.61	29.55	-0.54	0.81	1.01	-17.91	-26.31	-0.24	29.11	35.51	0.37	1.14	0.72

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 180890022																		
EC	WIN	15	0.98	1.27	0.09	29.35	58.43	0.29	0.57	0.36	58.08	28.87	0.29	77.13	52.54	0.58	0.67	0.01
EC	SPR	15	0.81	0.99	0.6	21.26	44.17	0.17	0.36	0.14	36.15	23.55	0.21	50.18	40.67	0.44	0.42	0.36
EC	SUM	16	1.26	1.2	0.16	-5.12	27.77	-0.06	0.35	0.3	9.05	0.51	-0.05	30.99	30.31	0.29	0.55	0.03
EC	FAL	14	0.95	1.13	0.71	18.65	41.23	0.18	0.39	0.18	24.26	12.14	0.19	43.36	41.68	0.41	0.45	0.51
EC	ALL	60	1.01	1.15	0.41	13.84	41.52	0.14	0.42	0.26	31.63	16.07	0.14	50.21	41.11	0.42	0.53	0.17
NACL	WIN	14	0.37	0.41	0.37	10.82	90.92	0.04	0.34	0.15	273.52	60.65	0.11	305.79	106.41	0.91	0.39	0.13
NACL	SPR	13	0.09	0.31	0.13	255.56	267.85	0.22	0.23	0.03	432.62	114.94	2.56	435.49	118.1	2.68	0.28	0.02
NACL	SUM	16	0.06	0.15	0.31	145.76	145.76	0.09	0.09	0	220.8	89.94	1.46	220.8	89.94	1.46	0.1	0.09
NACL	FAL	15	0.07	0.2	0.51	185.73	185.73	0.13	0.13	0.01	286	95.6	1.86	286	95.6	1.86	0.17	0.26
NACL	ALL	58	0.14	0.26	0.48	81.63	133.08	0.12	0.19	0.05	297.87	89.94	0.82	306.3	101.69	1.33	0.25	0.23
NH4	WIN	14	2.23	1.5	0.7	-32.45	43.4	-0.72	0.97	1.97	-11.17	-23.76	-0.48	38.04	43.06	0.64	1.58	0.48
NH4	SPR	13	1.69	2.05	0.7	21.29	40.12	0.36	0.68	1.17	61	17.92	0.21	76.43	36.72	0.4	1.14	0.49
NH4	SUM	16	0.94	1	0.9	6.43	25.28	0.06	0.24	0.07	63.67	25.21	0.06	76.54	39.9	0.25	0.28	0.81
NH4	FAL	15	0.91	1.04	0.75	13.74	46.36	0.13	0.42	0.42	24.56	13.06	0.14	44.64	37.78	0.46	0.66	0.56
NH4	ALL	58	1.41	1.37	0.63	-3.18	39.69	-0.04	0.56	1.02	34.89	8.61	-0.03	58.97	39.4	0.41	1.01	0.4
NO3	WIN	14	3.89	3.18	0.84	-18.27	31.82	-0.71	1.24	2.83	-5.1	-14.1	-0.22	33.5	34.43	0.39	1.83	0.7
NO3	SPR	13	2.75	3.76	0.8	36.93	52.13	1.02	1.43	5.41	31.42	9.7	0.37	59.59	46.88	0.52	2.54	0.64
NO3	SUM	16	0.71	0.44	0.37	-37.99	46.97	-0.27	0.33	0.14	-31.75	-50.55	-0.61	43.1	59.79	0.76	0.46	0.13
NO3	FAL	15	1.42	1.77	0.51	24.45	61.07	0.35	0.87	3.74	38.99	-15.56	0.24	89.96	57.13	0.61	1.96	0.26
NO3	ALL	58	2.12	2.19	0.72	3.39	44.21	0.07	0.94	3.3	7.14	-19.2	0.03	56.6	50.09	0.44	1.82	0.52
OC	WIN	15	1.72	2.81	0.69	63.27	67.31	1.09	1.16	0.63	77.8	48.62	0.63	81.17	52.48	0.67	1.35	0.47
OC	SPR	15	1.47	2.05	0.85	39.76	41.24	0.58	0.61	0.24	48.13	33.6	0.4	50.91	36.66	0.41	0.76	0.73
OC	SUM	16	2.52	2.63	0.65	4.59	31.07	0.12	0.78	1.05	6.13	-0.6	0.05	29.05	27.77	0.31	1.03	0.42
OC	FAL	14	1.42	1.82	0.76	27.9	37.17	0.4	0.53	0.31	31.78	21.54	0.28	42.35	34.74	0.37	0.68	0.58
OC	ALL	60	1.8	2.34	0.69	30.1	42.94	0.54	0.77	0.7	40.53	25.42	0.3	50.65	37.8	0.43	0.99	0.48
PM-2.5	WIN	14	15.09	14.63	0.67	-3.08	31.86	-0.47	4.81	35.73	10.18	1.83	-0.03	34.06	30.78	0.33	6	0.45
PM-2.5	SPR	13	12.88	15.85	0.71	23.09	35.34	2.97	4.55	32.92	26.47	17.71	0.23	35.58	28.45	0.35	6.46	0.51
PM-2.5	SUM	16	15.02	13.08	0.78	-12.92	18.78	-1.94	2.82	10.32	-9.35	-12.68	-0.15	17.86	20.39	0.22	3.75	0.61
PM-2.5	FAL	15	9.85	11.83	0.84	20.12	33.98	1.98	3.35	13.73	18.65	8.84	0.2	38.9	35.71	0.34	4.2	0.71
PM-2.5	ALL	58	13.22	13.75	0.68	4.02	28.93	0.53	3.82	26.2	10.63	3.2	0.04	31.19	28.67	0.29	5.15	0.46
SO4	WIN	14	2.64	1.62	0.37	-38.55	48.69	-1.02	1.29	1.78	-24.62	-39.38	-0.63	45.36	54.52	0.79	1.68	0.14
SO4	SPR	13	2.72	2.8	0.64	3.14	31.55	0.09	0.86	1.39	18.31	7.1	0.03	37.91	33.37	0.32	1.18	0.41
SO4	SUM	16	3.21	2.86	0.9	-11.11	20.79	-0.36	0.67	0.67	-1.45	-4.56	-0.12	21.03	21.17	0.23	0.89	0.82
SO4	FAL	15	2.06	1.7	0.79	-17.42	30	-0.36	0.62	0.58	-6.73	-13.96	-0.21	29.89	33.42	0.36	0.84	0.63
SO4	ALL	58	2.66	2.25	0.7	-15.67	31.76	-0.42	0.85	1.22	-3.98	-12.78	-0.19	32.98	35.12	0.38	1.18	0.49

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 180892004																		
EC	WIN	9	0.52	1.56	0.58	201.5	201.5	1.04	1.04	0.16	211.44	98.45	2.02	211.44	98.45	2.02	1.12	0.34
EC	SPR	15	0.64	0.99	0.76	56.02	58.98	0.36	0.38	0.07	68.29	46.22	0.56	70.13	48.13	0.59	0.45	0.58
EC	SUM	16	1.01	1.24	0.53	23.71	34.73	0.24	0.35	0.11	34.48	24.2	0.24	41.85	33.31	0.35	0.4	0.29
EC	FAL	5	0.55	0.94	0.85	69.18	69.18	0.38	0.38	0.08	77.44	53.3	0.69	77.44	53.3	0.69	0.48	0.72
EC	ALL	45	0.74	1.19	0.45	61.89	68.11	0.45	0.5	0.19	85.91	49.62	0.62	89.15	53.5	0.68	0.63	0.21
NACL	WIN	9	0.19	0.49	0.07	164.21	198.54	0.31	0.37	0.06	342.8	105.11	1.64	352.03	116.76	1.99	0.39	0.01
NACL	SPR	15	0.09	0.34	0.15	281.95	289.48	0.25	0.26	0.04	373.71	104.15	2.82	378.97	110.02	2.89	0.32	0.02
NACL	SUM	16	0.07	0.16	0.16	114.39	114.39	0.09	0.09	0	159.54	73.44	1.14	159.54	73.44	1.14	0.1	0.02
NACL	FAL	5	0.04	0.17	0.24	289.11	289.11	0.13	0.13	0.01	287.48	98.82	2.89	287.48	98.82	2.89	0.16	0.06
NACL	ALL	45	0.1	0.29	0.29	192.83	208.09	0.19	0.21	0.03	281.8	92.83	1.93	285.4	97.12	2.08	0.27	0.08
NH4	WIN	10	2.03	1.74	0.75	-13.94	41.67	-0.28	0.84	1.44	24.87	6.87	-0.16	53.15	42.45	0.48	1.23	0.56
NH4	SPR	15	1.52	1.92	0.92	26.31	31.94	0.4	0.49	0.41	27.18	19.82	0.26	33.52	26.62	0.32	0.75	0.84
NH4	SUM	16	1.01	1.1	0.9	8.74	26.88	0.09	0.27	0.09	52.51	27.24	0.09	64.12	40.35	0.27	0.32	0.81
NH4	FAL	5	0.59	0.76	0.9	28.79	38.71	0.17	0.23	0.05	85.8	36.71	0.29	95.39	46.91	0.39	0.28	0.8
NH4	ALL	46	1.35	1.47	0.77	8.75	34.12	0.12	0.46	0.55	41.86	21.42	0.09	55.16	37.04	0.34	0.75	0.6
NO3	WIN	10	4.3	3.36	0.83	-21.85	35.28	-0.94	1.52	3.52	-8.91	-19.96	-0.28	38.23	41.28	0.45	2.1	0.69
NO3	SPR	15	2.58	3.12	0.88	20.84	42.5	0.54	1.1	3.03	4.52	-12.57	0.21	49.69	51.29	0.42	1.82	0.77
NO3	SUM	16	0.79	0.42	0.28	-46.34	50.03	-0.36	0.39	0.17	-38.06	-59.81	-0.86	45.63	66.2	0.93	0.55	0.08
NO3	FAL	5	0.72	0.66	0.93	-8.08	25.08	-0.06	0.18	0.05	-25.24	-38.33	-0.09	36.31	48.54	0.27	0.23	0.86
NO3	ALL	46	2.13	1.97	0.82	-7.63	39.65	-0.16	0.84	2.13	-16.44	-33.41	-0.08	44.33	54	0.43	1.47	0.67
OC	WIN	9	1.5	3.75	0.87	150.66	150.66	2.25	2.25	1.03	151.83	83.4	1.51	151.83	83.4	1.51	2.47	0.75
OC	SPR	15	1.48	2.27	0.9	53.46	53.46	0.79	0.79	0.18	61.9	44.84	0.53	61.9	44.84	0.53	0.9	0.82
OC	SUM	16	2.42	2.9	0.48	19.88	39.26	0.48	0.95	1.53	26.43	17.29	0.2	37.03	31.19	0.39	1.33	0.23
OC	FAL	5	1.12	1.65	0.86	47.47	47.47	0.53	0.53	0.19	54.03	38.44	0.47	54.03	38.44	0.47	0.69	0.74
OC	ALL	45	1.78	2.72	0.57	53.14	62.52	0.94	1.11	1.28	66.4	42.05	0.53	70.17	46.99	0.63	1.47	0.33
PM-2.5	WIN	9	13.07	16.37	0.89	25.27	36.45	3.3	4.76	15.05	47.2	32.93	0.25	52.88	38.99	0.36	5.09	0.79
PM-2.5	SPR	13	12.55	16.41	0.83	30.8	33.34	3.86	4.18	25.53	31.41	20.28	0.31	37.05	27.16	0.33	6.36	0.68
PM-2.5	SUM	16	14.98	14.63	0.78	-2.34	14.35	-0.35	2.15	9.69	2.31	0.3	-0.02	14.84	14.95	0.15	3.13	0.61
PM-2.5	FAL	5	8.1	9.97	0.74	23.05	37.46	1.87	3.03	13.43	18.38	8.05	0.23	39.38	32.91	0.37	4.11	0.56
PM-2.5	ALL	43	13.04	14.99	0.74	14.92	26.17	1.95	3.41	19.5	22.37	14.07	0.15	32.37	25.76	0.26	4.83	0.55
SO4	WIN	10	2.15	1.91	0.32	-11.16	49.35	-0.24	1.06	2.32	19.21	1.49	-0.13	52.05	43.43	0.56	1.54	0.1
SO4	SPR	15	2.55	2.97	0.88	16.64	28.41	0.42	0.72	0.56	18.3	12.71	0.17	31.05	27.73	0.28	0.86	0.77
SO4	SUM	16	3.28	3.19	0.89	-2.77	24	-0.09	0.79	0.86	13.44	8.21	-0.03	30	27.04	0.25	0.93	0.8
SO4	FAL	5	1.91	1.84	0.76	-3.66	29.76	-0.07	0.57	0.4	3.25	-2.32	-0.04	31.93	32.64	0.31	0.64	0.58
SO4	ALL	46	2.65	2.69	0.75	1.77	30.32	0.05	0.8	1.1	15.17	7.07	0.02	35.35	31.44	0.3	1.05	0.56

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 180970078																		
EC	WIN	23	0.58	1.26	0.5	117.44	118.63	0.68	0.69	0.1	150.66	77.75	1.17	151.21	78.32	1.19	0.75	0.25
EC	SPR	24	0.55	0.96	0.7	75.42	79.8	0.41	0.44	0.07	110.21	61.96	0.75	112.23	64.26	0.8	0.49	0.49
EC	SUM	24	0.92	1.21	0.81	31.32	34.93	0.29	0.32	0.09	36.67	27.05	0.31	39.61	30.28	0.35	0.42	0.65
EC	FAL	22	0.58	1.04	0.81	79.95	82.49	0.46	0.48	0.08	126.24	66.62	0.8	127.31	67.75	0.82	0.55	0.66
EC	ALL	93	0.66	1.12	0.7	69.59	72.62	0.46	0.48	0.11	105.03	57.96	0.7	106.7	59.79	0.73	0.56	0.49
NACL	WIN	19	0.08	0.18	0.48	117.66	129.47	0.1	0.11	0.01	179.34	79.52	1.18	183.3	83.95	1.29	0.13	0.23
NACL	SPR	22	0.05	0.14	0.82	163.25	164.08	0.09	0.09	0.01	191.13	80.69	1.63	192.64	82.34	1.64	0.12	0.67
NACL	SUM	25	0.05	0.04	0.75	-17.96	34.37	-0.01	0.02	0	-20.5	-31.68	-0.22	34.93	43.64	0.42	0.02	0.56
NACL	FAL	25	0.06	0.09	0.6	38.3	64.02	0.02	0.04	0	73.7	29.34	0.38	93.9	56.66	0.64	0.07	0.36
NACL	ALL	91	0.06	0.11	0.58	74.7	97.13	0.05	0.06	0.01	98.27	35.47	0.75	120.24	64.99	0.97	0.09	0.33
NH4	WIN	20	1.72	1.6	0.48	-7.13	36.45	-0.12	0.63	0.55	3.91	-7.17	-0.08	41.13	40.68	0.39	0.75	0.23
NH4	SPR	23	1.51	1.97	0.87	29.89	31.4	0.45	0.48	0.32	33.27	24.21	0.3	35.77	26.91	0.31	0.72	0.75
NH4	SUM	25	1.34	1.38	0.74	2.81	36.26	0.04	0.49	0.54	35.42	16.65	0.03	56.07	41.07	0.36	0.74	0.55
NH4	FAL	25	0.76	1.09	0.8	43.4	50.85	0.33	0.39	0.22	93.83	43.28	0.43	98.35	48.27	0.51	0.57	0.64
NH4	ALL	93	1.31	1.5	0.74	14.07	37.2	0.18	0.49	0.45	43.81	20.55	0.14	59.2	39.42	0.37	0.69	0.55
NO3	WIN	20	3.65	3.44	0.45	-5.82	37.66	-0.21	1.37	2.74	6.43	-7.44	-0.06	44.8	42.33	0.4	1.67	0.21
NO3	SPR	23	2.22	3.53	0.82	58.81	64.33	1.31	1.43	2.02	100.48	43.69	0.59	109.77	54.77	0.64	1.93	0.67
NO3	SUM	25	0.55	0.78	0.35	41.19	95.02	0.23	0.52	0.86	38.92	-7.21	0.41	94.45	72.85	0.95	0.96	0.12
NO3	FAL	25	1.14	1.82	0.58	60.47	80.3	0.69	0.91	2.32	62.32	13.7	0.6	94.97	60.64	0.8	1.67	0.33
NO3	ALL	93	1.79	2.31	0.72	29.26	57.89	0.52	1.03	2.24	53.45	10.95	0.29	87.7	58.53	0.58	1.59	0.52
OC	WIN	23	1.87	3.87	0.59	107.19	107.19	2	2	1.27	137.99	73.28	1.07	137.99	73.28	1.07	2.3	0.35
OC	SPR	24	1.56	2.36	0.68	51.17	59.12	0.8	0.92	0.65	103.32	50.78	0.51	107.7	55.74	0.59	1.13	0.46
OC	SUM	24	2.62	2.9	0.76	10.71	25.5	0.28	0.67	0.73	13.32	7.86	0.11	27.85	24.38	0.26	0.9	0.58
OC	FAL	22	1.54	2.18	0.77	42.21	55.7	0.65	0.86	0.6	350.67	43.07	0.42	358.42	52.19	0.56	1.01	0.6
OC	ALL	93	1.9	2.83	0.63	48.69	58.2	0.93	1.11	1.23	147.18	43.44	0.49	153.89	51.14	0.58	1.44	0.4
PM-2.5	WIN	19	12.55	14.91	0.74	18.83	26.2	2.36	3.29	9.36	23.3	17.76	0.19	29.66	24.65	0.26	3.87	0.54
PM-2.5	SPR	21	11.94	14.96	0.79	25.26	32.41	3.02	3.87	13.57	31.45	23.47	0.25	36.34	28.73	0.32	4.76	0.62
PM-2.5	SUM	23	16.97	12.67	0.93	-25.33	26.44	-4.3	4.49	20.79	-19.46	-23.33	-0.34	22.1	25.8	0.35	6.27	0.86
PM-2.5	FAL	25	9.31	11.07	0.77	18.91	31.52	1.76	2.94	13.79	23.15	14.94	0.19	35.89	30.19	0.32	4.11	0.6
PM-2.5	ALL	88	12.64	13.25	0.71	4.8	28.8	0.61	3.64	23.33	14.03	7.58	0.05	31.05	27.5	0.29	4.87	0.5
SO4	WIN	20	2.24	1.6	0.72	-28.48	37.04	-0.64	0.83	0.54	-24.33	-37.36	-0.4	39.61	48.4	0.52	0.97	0.52
SO4	SPR	23	2.87	2.59	0.86	-9.92	21.45	-0.28	0.62	0.56	-10.59	-15.06	-0.11	22.8	25.44	0.24	0.8	0.74
SO4	SUM	25	4.59	3.43	0.8	-25.13	34.56	-1.15	1.59	4.01	-14.46	-20.86	-0.34	28.31	33.19	0.46	2.31	0.64
SO4	FAL	25	2.06	1.65	0.9	-20.02	24.18	-0.41	0.5	0.45	-12.66	-16.9	-0.25	20.9	24.32	0.3	0.79	0.8
SO4	ALL	93	2.98	2.35	0.84	-21.09	29.91	-0.63	0.89	1.57	-15.14	-21.91	-0.27	27.39	32.16	0.38	1.4	0.7

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 191130037																		
EC	WIN	14	0.3	0.74	0.41	144.9	144.9	0.44	0.44	0.04	173.14	84.95	1.45	173.14	84.95	1.45	0.48	0.17
EC	SPR	12	0.35	0.46	0.52	33.09	47.52	0.11	0.16	0.04	73.57	33.11	0.33	81.71	42.06	0.48	0.23	0.28
EC	SUM	16	0.49	0.54	0.69	10.28	24.67	0.05	0.12	0.02	16.51	11.05	0.1	28.86	24.58	0.25	0.15	0.48
EC	FAL	15	0.42	0.65	0.79	55.96	56.42	0.23	0.23	0.03	68.28	45.04	0.56	68.63	45.41	0.56	0.29	0.63
EC	ALL	57	0.39	0.6	0.46	52.38	60.22	0.21	0.24	0.05	80.62	42.79	0.52	85.89	48.57	0.6	0.31	0.21
NACL	WIN	15	0.09	0.12	0.47	33.76	91.7	0.03	0.08	0.01	367.68	66.32	0.34	379.22	83.44	0.92	0.12	0.22
NACL	SPR	15	0.05	0.09	0.88	82.62	83.9	0.04	0.04	0	92.82	55.75	0.83	94.34	57.36	0.84	0.05	0.78
NACL	SUM	16	0.08	0.03	0.16	-61.33	70.77	-0.05	0.05	0.01	-17.88	-38.91	-1.59	47.12	61.57	1.83	0.12	0.03
NACL	FAL	14	0.04	0.08	0.9	115.22	115.88	0.04	0.05	0	93.75	55.27	1.15	94.61	56.15	1.16	0.07	0.82
NACL	ALL	60	0.06	0.08	0.26	24.1	87	0.02	0.06	0.01	132.23	33.04	0.24	153.03	64.72	0.87	0.09	0.07
NH4	WIN	15	1.67	1.26	0.86	-24.39	36.81	-0.41	0.61	0.4	-3.06	-17.34	-0.32	43.58	42.71	0.49	0.75	0.75
NH4	SPR	15	1.68	1.81	0.75	7.81	39.8	0.13	0.67	1.17	38.47	21.07	0.08	51.92	37.34	0.4	1.09	0.56
NH4	SUM	16	0.63	0.84	0.8	34.16	44.76	0.21	0.28	0.07	84.62	42.29	0.34	90.74	49.25	0.45	0.35	0.64
NH4	FAL	15	0.85	1.27	0.89	49.85	54.64	0.42	0.46	0.23	95.39	52.81	0.5	97.31	54.8	0.55	0.64	0.79
NH4	ALL	61	1.2	1.29	0.78	7.76	42.05	0.09	0.5	0.55	54.36	24.99	0.08	71.21	46.08	0.42	0.75	0.61
NO3	WIN	15	4.13	3.04	0.86	-26.52	35.16	-1.1	1.45	1.94	-19.48	-29.74	-0.36	36.21	43.57	0.48	1.77	0.73
NO3	SPR	15	2.96	3.49	0.76	17.86	47.97	0.53	1.42	5.06	33.08	4.77	0.18	69.46	56.7	0.48	2.31	0.57
NO3	SUM	16	0.51	0.49	0.4	-4.49	49.97	-0.02	0.25	0.12	20.81	-2.71	-0.05	57.75	49.13	0.52	0.34	0.16
NO3	FAL	15	1.6	2.53	0.92	57.88	63.07	0.93	1.01	1.61	72.36	36.02	0.58	80.44	44.83	0.63	1.57	0.86
NO3	ALL	61	2.27	2.36	0.8	3.63	44.97	0.08	1.02	2.72	26.6	2.01	0.04	60.91	48.57	0.45	1.65	0.63
OC	WIN	14	1.05	3.61	0.64	243.39	243.39	2.56	2.56	0.71	292.84	111.58	2.43	292.84	111.58	2.43	2.69	0.41
OC	SPR	12	1.08	1.85	0.41	71.77	86.27	0.77	0.93	0.97	240.65	53.93	0.72	247.46	62.49	0.86	1.25	0.17
OC	SUM	16	1.83	1.92	0.74	5.05	37.12	0.09	0.68	0.7	8.1	0.06	0.05	36.94	34.49	0.37	0.84	0.54
OC	FAL	15	1.16	2.22	0.27	91.47	100.57	1.06	1.17	1.2	118.32	54.47	0.91	125.87	62.85	1.01	1.52	0.07
OC	ALL	57	1.3	2.4	0.28	84.09	101.37	1.1	1.32	1.72	156	53.11	0.84	167.52	66.78	1.01	1.71	0.08
PM-2.5	WIN	15	11.96	13.26	0.65	10.89	29.1	1.3	3.48	17.86	25.23	14.14	0.11	40.27	30.68	0.29	4.42	0.42
PM-2.5	SPR	15	10.69	13.68	0.75	28.01	41.55	2.99	4.44	25.68	52.11	28.69	0.28	61.85	39.67	0.42	5.89	0.56
PM-2.5	SUM	16	11.67	9.64	0.8	-17.39	22.58	-2.03	2.63	6.35	-14.3	-18.25	-0.21	22.14	25.45	0.27	3.24	0.64
PM-2.5	FAL	15	8.39	12.31	0.83	46.82	50.88	3.93	4.27	14.48	68.11	39.23	0.47	71.75	43.08	0.51	5.47	0.69
PM-2.5	ALL	61	10.69	12.18	0.68	13.93	34.49	1.49	3.69	21.2	32.02	15.39	0.14	48.56	34.57	0.34	4.84	0.46
SO4	WIN	15	1.8	1.05	0.74	-41.82	48.38	-0.75	0.87	0.7	-24.75	-42.15	-0.72	44.79	55.76	0.83	1.13	0.55
SO4	SPR	15	2.21	2.26	0.89	1.95	25.03	0.04	0.55	0.48	13.61	7.85	0.02	30.21	27.57	0.25	0.7	0.8
SO4	SUM	16	2.33	2.02	0.82	-13.45	24.4	-0.31	0.57	0.48	-3.02	-9.42	-0.16	28.55	29.2	0.28	0.76	0.67
SO4	FAL	15	1.64	1.54	0.85	-6.19	29.21	-0.1	0.48	0.52	15.29	7.58	-0.07	32.77	29.63	0.31	0.73	0.72
SO4	ALL	61	2	1.72	0.81	-14.07	30.84	-0.28	0.62	0.63	0.23	-9.04	-0.16	33.99	35.43	0.36	0.84	0.65

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 191530030																		
EC	WIN	15	0.27	0.92	0.18	241.06	241.06	0.65	0.65	0.09	283.78	106.24	2.41	283.78	106.24	2.41	0.71	0.03
EC	SPR	12	0.41	0.66	0.74	62.15	66.27	0.25	0.27	0.05	62.52	41.2	0.62	67.76	47.42	0.66	0.34	0.55
EC	SUM	16	0.51	0.61	0.8	18.54	23.2	0.1	0.12	0.02	26.07	19.03	0.19	29.5	22.7	0.23	0.16	0.64
EC	FAL	15	0.46	0.77	0.24	65.95	71.5	0.31	0.33	0.1	79.55	45.81	0.66	83.96	50.59	0.71	0.44	0.06
EC	ALL	58	0.42	0.74	0.19	78.31	82.33	0.33	0.34	0.11	114.09	53.1	0.78	117.26	56.63	0.82	0.46	0.04
NACL	WIN	15	0.11	0.1	0.08	-14.94	79.34	-0.02	0.09	0.02	92.1	23.51	-0.18	122.2	71.08	0.93	0.14	0.01
NACL	SPR	15	0.08	0.07	0.61	-11.54	49.41	-0.01	0.04	0	24.85	6.97	-0.13	56.68	49.97	0.56	0.05	0.37
NACL	SUM	15	0.04	0.03	0.55	-32.25	53.27	-0.01	0.02	0	-29.54	-48.66	-0.48	52.33	66.18	0.79	0.02	0.3
NACL	FAL	13	0.03	0.04	0.69	57.87	68.5	0.02	0.02	0	59.93	34.63	0.58	70.68	47.22	0.69	0.03	0.47
NACL	ALL	58	0.07	0.06	0.42	-9.63	65.02	-0.01	0.04	0.01	36.04	3.06	-0.11	75.64	59.01	0.72	0.08	0.17
NH4	WIN	15	1.52	1.07	0.75	-29.68	42.12	-0.45	0.64	0.52	3.82	-20.77	-0.42	58.47	51.84	0.6	0.85	0.56
NH4	SPR	15	1.78	1.86	0.91	4.6	25.49	0.08	0.45	0.49	12.23	7.27	0.05	25.58	22.29	0.25	0.7	0.83
NH4	SUM	15	0.66	0.66	0.93	-0.26	26.37	0	0.17	0.05	56.66	20.81	0	74.67	41.77	0.26	0.22	0.87
NH4	FAL	14	0.71	0.91	0.97	29.64	32.72	0.21	0.23	0.05	85.82	45.36	0.3	89.12	48.85	0.33	0.3	0.95
NH4	ALL	59	1.17	1.13	0.88	-3.78	32.11	-0.04	0.38	0.34	38.85	12.62	-0.04	61.5	41.06	0.33	0.59	0.78
NO3	WIN	15	3.63	2.43	0.76	-33.09	43.68	-1.2	1.58	2.61	-24.77	-38.69	-0.49	44.68	53.17	0.65	2.01	0.58
NO3	SPR	15	3.49	3.4	0.97	-2.75	20.36	-0.1	0.71	0.94	-6.7	-21.88	-0.03	39.09	45.78	0.21	0.97	0.93
NO3	SUM	15	0.45	0.22	0.52	-50.09	62.24	-0.23	0.28	0.11	-42.21	-66.92	-1	57.38	78.73	1.25	0.4	0.27
NO3	FAL	14	1.27	1.74	0.99	37.23	43.54	0.47	0.55	0.48	41.23	21.49	0.37	62.69	49.36	0.44	0.84	0.98
NO3	ALL	59	2.23	1.95	0.91	-12.36	35.31	-0.27	0.79	1.4	-8.95	-27.31	-0.14	50.76	56.89	0.4	1.22	0.82
OC	WIN	15	0.85	4.32	0.19	409.76	409.76	3.47	3.47	1.95	466.87	130.14	4.1	466.87	130.14	4.1	3.74	0.04
OC	SPR	12	1.37	2.63	0.59	92.67	101.13	1.27	1.38	1.29	189.4	63.59	0.93	196.23	72.18	1.01	1.7	0.35
OC	SUM	16	1.74	2.28	0.87	30.47	35.16	0.53	0.61	0.6	26.86	19.88	0.3	32.14	25.61	0.35	0.94	0.76
OC	FAL	15	1.37	2.53	0.13	84.94	89.82	1.16	1.23	1.73	109.57	51.18	0.85	114.64	57.43	0.9	1.76	0.02
OC	ALL	58	1.34	2.94	0.13	120.17	124.94	1.61	1.67	2.67	195.67	65.53	1.2	199.86	70.51	1.25	2.29	0.02
PM-2.5	WIN	15	10.69	13.17	0.61	23.25	33.32	2.48	3.56	15.17	42.33	26.82	0.23	48.05	32.92	0.33	4.62	0.38
PM-2.5	SPR	15	11.99	13.76	0.9	14.8	23.53	1.77	2.82	12.86	18.5	12.06	0.15	30.22	25.8	0.24	4	0.82
PM-2.5	SUM	14	11.19	8.7	0.75	-22.3	31.41	-2.5	3.52	10.25	-12.84	-23.34	-0.29	37.21	37.67	0.4	4.06	0.56
PM-2.5	FAL	14	7.99	10.33	0.87	29.3	39.88	2.34	3.19	10.63	42.7	26.69	0.29	52.12	37.18	0.4	4.01	0.76
PM-2.5	ALL	58	10.49	11.56	0.78	10.14	31.14	1.06	3.27	16.4	22.94	10.86	0.1	41.8	33.25	0.31	4.19	0.61
SO4	WIN	15	1.51	1.01	0.39	-32.81	51.99	-0.49	0.78	0.79	-19.67	-36.79	-0.49	48.28	58.85	0.77	1.02	0.15
SO4	SPR	15	2.44	2.47	0.91	1.34	22.28	0.03	0.54	0.68	0.56	-2.69	0.01	21.45	21.81	0.22	0.83	0.83
SO4	SUM	15	2.32	1.72	0.89	-25.92	29.12	-0.6	0.67	0.35	-20.22	-27.95	-0.35	31.06	36.62	0.39	0.84	0.8
SO4	FAL	14	1.43	1.21	0.79	-15.56	31.55	-0.22	0.45	0.52	7.21	-2.35	-0.18	36.21	35.2	0.37	0.76	0.63
SO4	ALL	59	1.93	1.61	0.83	-16.72	31.89	-0.32	0.62	0.65	-8.29	-17.7	-0.2	34.22	38.17	0.38	0.87	0.69

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 191630015																		
EC	WIN	27	0.38	0.79	0.38	111.21	111.21	0.42	0.42	0.05	137.3	72.4	1.11	137.3	72.4	1.11	0.47	0.15
EC	SPR	31	0.42	0.63	0.64	49.65	52.74	0.21	0.22	0.04	64.73	39.54	0.5	67.54	42.52	0.53	0.29	0.41
EC	SUM	29	0.58	0.59	0.68	1.72	26	0.01	0.15	0.03	18.19	6.69	0.02	37.75	29.35	0.26	0.17	0.46
EC	FAL	29	0.48	0.69	0.63	43.72	49.53	0.21	0.24	0.05	55.62	36.65	0.44	60.77	42.78	0.5	0.3	0.4
EC	ALL	116	0.46	0.67	0.44	44.73	54.57	0.21	0.25	0.06	67.71	38.25	0.45	74.64	46.25	0.55	0.32	0.19
NACL	WIN	29	0.12	0.21	0.44	76.49	102.54	0.09	0.12	0.02	202.65	74.89	0.76	207.72	81.56	1.03	0.16	0.2
NACL	SPR	30	0.09	0.14	0.01	61.37	125.72	0.05	0.11	0.03	351.55	70.05	0.61	361.11	85.61	1.26	0.18	0
NACL	SUM	30	0.06	0.06	0.13	2.88	50.82	0	0.03	0	79.02	16.01	0.03	104.86	53.94	0.51	0.04	0.02
NACL	FAL	30	0.04	0.11	0.41	138.65	145.81	0.06	0.06	0.01	259.08	75.21	1.39	261.63	78	1.46	0.1	0.17
NACL	ALL	119	0.08	0.13	0.3	66.76	105.17	0.05	0.08	0.01	223.25	58.91	0.67	234.05	74.72	1.05	0.13	0.09
NH4	WIN	29	2.08	1.48	0.66	-29.22	45.27	-0.61	0.94	1.22	7.34	-18.46	-0.41	62.45	53.5	0.64	1.26	0.43
NH4	SPR	30	1.47	1.52	0.78	3.57	32.48	0.05	0.48	0.47	26.38	9.22	0.04	45.71	31.61	0.32	0.69	0.6
NH4	SUM	31	0.75	0.84	0.84	11.99	37.4	0.09	0.28	0.1	81.03	32.43	0.12	95.16	49.01	0.37	0.33	0.7
NH4	FAL	30	0.7	0.96	0.73	37.85	59.99	0.26	0.42	0.33	92.32	48.17	0.38	98.28	54.95	0.6	0.64	0.53
NH4	ALL	120	1.24	1.19	0.73	-3.6	42.33	-0.04	0.52	0.63	52.38	18.26	-0.04	75.68	47.23	0.44	0.8	0.54
NO3	WIN	29	4.7	3.46	0.8	-26.41	35.74	-1.24	1.68	3.39	-11.97	-24.08	-0.36	38.26	41.22	0.49	2.22	0.64
NO3	SPR	30	2.59	2.87	0.74	10.96	44.47	0.28	1.15	2.86	35.46	-0.43	0.11	73.53	52.18	0.44	1.71	0.55
NO3	SUM	31	0.53	0.31	0.4	-42.41	59.2	-0.23	0.32	0.15	-33.42	-55.65	-0.74	54.25	69.93	1.03	0.44	0.16
NO3	FAL	30	1.31	1.64	0.75	25.03	56.94	0.33	0.75	1.5	47.84	6.87	0.25	81.69	51.83	0.57	1.27	0.56
NO3	ALL	120	2.25	2.04	0.8	-9.13	42.79	-0.21	0.96	2.34	9.3	-18.59	-0.1	62.07	54.03	0.47	1.54	0.64
OC	WIN	27	1.24	3.35	0.56	171.11	171.11	2.11	2.11	0.81	196.04	91.01	1.71	196.04	91.01	1.71	2.3	0.32
OC	SPR	31	1.37	2.12	0.58	55.46	68.08	0.76	0.93	0.83	95.71	44.44	0.55	104.79	54.88	0.68	1.18	0.33
OC	SUM	29	2.01	2.06	0.57	2.12	34.35	0.04	0.69	1.08	11.76	2.56	0.02	35.36	31.11	0.34	1.04	0.33
OC	FAL	29	1.47	2.02	0.46	37.27	53.15	0.55	0.78	0.91	51.39	29.72	0.37	62.81	43.06	0.53	1.1	0.21
OC	ALL	116	1.52	2.37	0.36	55.25	72.76	0.84	1.11	1.47	87	41.13	0.55	98.18	54.39	0.73	1.48	0.13
PM-2.5	WIN	29	14.14	13.82	0.7	-2.26	25	-0.32	3.53	17.75	6.96	1.1	-0.02	29.09	26.22	0.26	4.23	0.49
PM-2.5	SPR	30	10.83	12.16	0.76	12.33	25.49	1.34	2.76	13.68	20.75	11.25	0.12	32.46	24.78	0.25	3.93	0.57
PM-2.5	SUM	30	12.02	9.5	0.81	-20.97	25.92	-2.52	3.11	10.78	-13.88	-18.35	-0.27	24.25	27.36	0.33	4.14	0.66
PM-2.5	FAL	30	8.73	9.95	0.78	13.98	27.95	1.22	2.44	10.29	18.88	13.09	0.14	28.83	24.24	0.28	3.43	0.61
PM-2.5	ALL	119	11.41	11.34	0.73	-0.6	25.93	-0.07	2.96	15.53	8.19	1.78	-0.01	28.65	25.65	0.26	3.94	0.53
SO4	WIN	29	2.04	1.26	0.47	-38.21	52.38	-0.78	1.07	1.44	-29.84	-45.87	-0.62	45.47	58.03	0.85	1.43	0.22
SO4	SPR	30	2.17	1.94	0.71	-10.44	28.47	-0.23	0.62	0.82	2.43	-5.17	-0.12	28.77	27.6	0.32	0.93	0.5
SO4	SUM	31	2.61	2.22	0.87	-15.03	26.98	-0.39	0.71	0.79	-3.16	-8.16	-0.18	26	27.2	0.32	0.97	0.75
SO4	FAL	30	1.55	1.41	0.82	-8.66	29.05	-0.13	0.45	0.39	6.28	0.56	-0.09	29.03	27.76	0.32	0.64	0.68
SO4	ALL	120	2.1	1.72	0.73	-18.13	33.73	-0.38	0.71	0.92	-5.85	-14.34	-0.22	32.15	34.89	0.41	1.03	0.53

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 201730010																		
EC	WIN	15	0.43	0.96	0.59	122.78	122.78	0.53	0.53	0.09	169.66	78.8	1.23	169.66	78.8	1.23	0.61	0.35
EC	SPR	15	0.35	0.63	0.69	80.52	90.19	0.28	0.32	0.09	87.96	50.6	0.81	95.63	59.14	0.9	0.42	0.47
EC	SUM	16	0.36	0.5	0.4	38.94	55.7	0.14	0.2	0.03	62.75	37.97	0.39	72.63	49.38	0.56	0.23	0.16
EC	FAL	15	0.41	0.74	0.91	79.68	79.68	0.33	0.33	0.02	88.76	58.16	0.8	88.76	58.16	0.8	0.35	0.83
EC	ALL	61	0.39	0.7	0.62	81.83	88.04	0.32	0.34	0.08	101.63	56.08	0.82	106.11	61.17	0.88	0.42	0.39
NACL	WIN	15	0.11	0.08	0.11	-27.2	65.44	-0.03	0.07	0.01	27.58	-0.12	-0.37	70.5	62.46	0.9	0.1	0.01
NACL	SPR	15	0.13	0.07	0.65	-48.67	62.05	-0.06	0.08	0.01	-10.1	-33.23	-0.95	56.66	64.57	1.21	0.13	0.43
NACL	SUM	16	0.12	0.04	0.3	-65.73	67.29	-0.08	0.08	0.01	-59.54	-93.2	-1.92	60.52	94.15	1.96	0.12	0.09
NACL	FAL	15	0.04	0.04	0.43	-0.52	46.7	0	0.02	0	9.91	-1.13	-0.01	40.05	39.29	0.47	0.03	0.18
NACL	ALL	61	0.1	0.06	0.39	-43.5	62.97	-0.04	0.06	0.01	-8.88	-32.93	-0.77	56.99	65.59	1.11	0.1	0.15
NH4	WIN	15	1.27	0.9	0.95	-29.1	36.7	-0.37	0.47	0.49	-1.97	-10.73	-0.41	34.86	35.34	0.52	0.79	0.9
NH4	SPR	15	1.13	1.1	0.94	-2.43	24.68	-0.03	0.28	0.14	8.86	3.63	-0.02	27.83	26.24	0.25	0.38	0.89
NH4	SUM	16	0.5	0.43	0.86	-13.9	31.92	-0.07	0.16	0.03	6.35	-5.94	-0.16	42.35	38.56	0.37	0.19	0.74
NH4	FAL	15	0.48	0.56	0.8	16.27	39.06	0.08	0.19	0.05	38.91	24.27	0.16	50.7	38.38	0.39	0.23	0.65
NH4	ALL	61	0.84	0.74	0.91	-11.53	32.31	-0.1	0.27	0.2	12.93	2.66	-0.13	38.99	34.69	0.37	0.46	0.82
NO3	WIN	15	3.21	2.12	0.89	-33.89	34.24	-1.09	1.1	1.85	-30.2	-39.48	-0.51	31.22	40.47	0.52	1.74	0.8
NO3	SPR	15	1.71	1.95	0.95	13.86	37.14	0.24	0.64	1.09	-9.47	-30.11	0.14	47.94	55.6	0.37	1.07	0.9
NO3	SUM	16	0.33	0.1	0.16	-69.84	69.84	-0.23	0.23	0.03	-62.69	-96.89	-2.32	62.69	96.89	2.32	0.28	0.02
NO3	FAL	15	0.74	0.75	0.99	2.21	15.54	0.02	0.11	0.02	-4.18	-9.11	0.02	23.32	25.76	0.16	0.14	0.98
NO3	ALL	61	1.48	1.21	0.88	-17.93	34.83	-0.26	0.51	0.98	-27.22	-44.77	-0.22	41.64	55.37	0.42	1.03	0.78
OC	WIN	15	1.33	4.34	0.54	225.94	225.94	3.01	3.01	1.99	315.21	108.5	2.26	315.21	108.5	2.26	3.32	0.29
OC	SPR	15	1.54	2.27	0.55	47.38	73.82	0.73	1.14	2.16	89.84	37.32	0.47	108.94	61.34	0.74	1.64	0.3
OC	SUM	16	1.66	2.14	0.86	28.77	32.03	0.48	0.53	0.26	35.08	25.25	0.29	38.32	28.68	0.32	0.7	0.73
OC	FAL	15	1.24	2.22	0.82	79.01	79.01	0.98	0.98	0.48	81.26	52.78	0.79	81.26	52.78	0.79	1.2	0.67
OC	ALL	61	1.45	2.73	0.46	88.82	96.72	1.29	1.4	2.21	128.79	55.46	0.89	134.33	62.27	0.97	1.96	0.22
PM-2.5	WIN	15	11.22	14.21	0.6	26.64	44.44	2.99	4.99	27.26	51.18	28.61	0.27	62.52	41.72	0.44	6.02	0.36
PM-2.5	SPR	15	11.74	11.18	0.79	-4.81	38.22	-0.56	4.49	25.55	-5.4	-14.39	-0.05	38.34	41.8	0.4	5.09	0.63
PM-2.5	SUM	16	11.19	8.09	0.69	-27.7	30.42	-3.1	3.4	8.04	-23.26	-30.37	-0.38	28.18	34.54	0.42	4.2	0.48
PM-2.5	FAL	15	6.71	9.93	0.75	48.09	48.09	3.22	3.22	8.8	52.01	36.51	0.48	52.01	36.51	0.48	4.38	0.57
PM-2.5	ALL	61	10.23	10.81	0.61	5.64	39.25	0.58	4.02	24.28	17.95	4.51	0.06	44.98	38.58	0.39	4.96	0.38
SO4	WIN	15	1.31	0.89	0.82	-32.13	39.53	-0.42	0.52	0.36	-15.01	-26.41	-0.47	37.3	44.52	0.58	0.73	0.67
SO4	SPR	15	2.18	1.59	0.92	-27.22	28.51	-0.59	0.62	0.5	-20.5	-26.12	-0.37	23.28	28.76	0.39	0.92	0.84
SO4	SUM	16	2.01	1.24	0.84	-38.15	39.14	-0.77	0.78	0.19	-36.06	-49.19	-0.62	39.07	51.91	0.63	0.88	0.71
SO4	FAL	15	1.12	1.06	0.82	-5.49	23.41	-0.06	0.26	0.13	0.36	-3.24	-0.06	22.38	22.79	0.25	0.36	0.68
SO4	ALL	61	1.66	1.19	0.85	-28.02	33.16	-0.47	0.55	0.36	-18.1	-26.62	-0.39	30.65	37.24	0.46	0.76	0.73

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 202090021																		
EC	WIN	20	0.54	0.94	0.46	75.62	86.04	0.4	0.46	0.25	103.38	53.65	0.76	110.31	61.3	0.86	0.64	0.21
EC	SPR	25	0.56	0.9	0.84	59.48	61.99	0.33	0.35	0.08	59.39	39.95	0.59	62.76	43.67	0.62	0.43	0.71
EC	SUM	24	0.57	0.79	0.7	39.37	45.48	0.22	0.26	0.05	49.66	33.94	0.39	54.09	38.93	0.45	0.31	0.49
EC	FAL	23	0.54	0.76	0.58	42.56	48.63	0.23	0.26	0.13	42.63	27.85	0.43	48.08	34.04	0.49	0.42	0.34
EC	ALL	92	0.55	0.85	0.61	53.37	59.38	0.29	0.33	0.12	62.22	38.34	0.53	67.17	43.86	0.59	0.46	0.37
NACL	WIN	19	0.13	0.1	0.02	-29.25	58.62	-0.04	0.08	0.01	-6.24	-27.51	-0.41	55.28	62.27	0.83	0.11	0
NACL	SPR	24	0.12	0.07	0.51	-41.29	56.98	-0.05	0.07	0.01	-13.3	-35.65	-0.7	54.86	62.79	0.97	0.1	0.26
NACL	SUM	24	0.09	0.04	0.58	-55.89	60.06	-0.05	0.06	0	-57.35	-89.65	-1.27	60.06	91.98	1.36	0.07	0.34
NACL	FAL	20	0.07	0.04	0.52	-40.28	55	-0.03	0.04	0	69.53	-37.89	-0.67	143.06	68.1	0.92	0.06	0.27
NACL	ALL	87	0.11	0.06	0.42	-41.35	57.89	-0.04	0.06	0.01	-4.87	-49.28	-0.71	76.66	71.95	0.99	0.08	0.18
NH4	WIN	20	1.38	1.21	0.83	-12.15	30.08	-0.17	0.41	0.39	-0.59	-9.09	-0.14	31.46	32.23	0.34	0.65	0.69
NH4	SPR	25	1.18	1.11	0.9	-5.95	25.47	-0.07	0.3	0.22	14.24	-2.54	-0.06	43.24	32.74	0.27	0.47	0.82
NH4	SUM	24	0.54	0.66	0.69	20.95	42.47	0.11	0.23	0.07	165.74	31.99	0.21	181.15	50.99	0.42	0.29	0.47
NH4	FAL	21	0.37	0.55	0.67	47.44	64.68	0.18	0.24	0.06	97.8	48.84	0.47	107.5	61.18	0.65	0.3	0.45
NH4	ALL	90	0.87	0.88	0.87	1.72	33.87	0.01	0.29	0.2	70.84	17.2	0.02	92.39	44.13	0.34	0.44	0.76
NO3	WIN	20	3.37	2.64	0.87	-21.43	33.38	-0.72	1.12	1.84	-13.54	-24.97	-0.27	37.1	41.99	0.42	1.54	0.75
NO3	SPR	25	1.89	1.74	0.95	-8.34	37.39	-0.16	0.71	0.81	-26.18	-48.18	-0.09	50.27	66.21	0.41	0.91	0.9
NO3	SUM	24	0.35	0.14	0.53	-59.66	59.66	-0.21	0.21	0.01	-58.36	-86.11	-1.48	58.36	86.11	1.48	0.23	0.28
NO3	FAL	21	0.55	0.44	0.68	-20.47	44.91	-0.11	0.25	0.1	-17.54	-38.82	-0.26	52.26	60.41	0.56	0.34	0.46
NO3	ALL	90	1.49	1.21	0.91	-19.09	37.4	-0.29	0.56	0.72	-29.94	-50.95	-0.24	49.97	64.78	0.46	0.89	0.83
OC	WIN	20	2.69	4.21	0.25	56.78	93.44	1.52	2.51	10.07	147.73	48.26	0.57	166.89	75.5	0.93	3.52	0.06
OC	SPR	25	2.23	2.86	0.57	27.9	56.94	0.62	1.27	2.93	38.18	14.79	0.28	61.65	45.88	0.57	1.82	0.32
OC	SUM	24	2.36	2.56	0.75	8.83	29.9	0.21	0.7	0.82	14.96	7.65	0.09	32.22	28.47	0.3	0.93	0.57
OC	FAL	23	1.88	2.04	0.51	8.58	39.57	0.16	0.75	1.59	10.56	-1.32	0.09	37.45	32.43	0.4	1.27	0.26
OC	ALL	92	2.28	2.87	0.46	26.16	55.41	0.6	1.26	3.87	49.03	16.17	0.26	70.8	44.42	0.55	2.06	0.21
PM-2.5	WIN	20	13.54	13.06	0.73	-3.54	27.28	-0.48	3.69	23.02	-0.18	-5.25	-0.04	26.04	26.96	0.28	4.82	0.53
PM-2.5	SPR	25	12.2	11.5	0.82	-5.71	28.53	-0.7	3.48	18.43	-5.17	-10.78	-0.06	27.43	29.32	0.3	4.35	0.68
PM-2.5	SUM	25	12.2	9.29	0.75	-23.83	28.2	-2.91	3.44	9.41	-20.05	-25.88	-0.31	27.18	31.62	0.37	4.23	0.56
PM-2.5	FAL	21	7.75	7.65	0.71	-1.23	24.86	-0.1	1.93	4.87	-1.67	-5.43	-0.01	24.97	25	0.25	2.21	0.5
PM-2.5	ALL	91	11.47	10.35	0.78	-9.75	27.54	-1.12	3.16	15.09	-7.35	-12.48	-0.11	26.49	28.44	0.31	4.04	0.6
SO4	WIN	20	1.53	1.27	0.61	-16.94	46.13	-0.26	0.7	0.9	-15.7	-28.52	-0.2	40.39	46.01	0.56	0.98	0.37
SO4	SPR	25	2.33	1.78	0.77	-23.61	27.82	-0.55	0.65	0.88	-16.68	-22.82	-0.31	25.32	29.95	0.36	1.09	0.59
SO4	SUM	24	2.3	1.85	0.77	-19.23	29.31	-0.44	0.67	0.51	-7.43	-18.75	-0.24	35.75	35.45	0.36	0.84	0.59
SO4	FAL	21	1.23	1.26	0.76	2.32	29.57	0.03	0.36	0.24	16.6	8.91	0.02	33.43	29.28	0.3	0.49	0.57
SO4	ALL	90	1.88	1.56	0.73	-17.04	31.87	-0.32	0.6	0.68	-6.23	-15.6	-0.21	33.34	34.83	0.38	0.89	0.53

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 210190017																		
EC	WIN	15	0.55	0.8	0.52	45.64	57.81	0.25	0.32	0.07	79.33	44.6	0.46	85.14	51.43	0.58	0.37	0.27
EC	SPR	14	0.61	0.64	0.64	5.3	41.61	0.03	0.25	0.1	31.05	18.58	0.05	48.55	39.83	0.42	0.31	0.41
EC	SUM	16	0.68	0.72	0.82	7.06	19.21	0.05	0.13	0.02	14.08	9.84	0.07	24.19	21.24	0.19	0.16	0.68
EC	FAL	13	0.63	0.73	0.8	16.45	31.57	0.1	0.2	0.05	46.12	27.2	0.16	54.95	37.52	0.32	0.24	0.64
EC	ALL	58	0.62	0.73	0.65	17.68	36.28	0.11	0.22	0.07	42.23	24.83	0.18	52.73	37.18	0.36	0.28	0.42
NACL	WIN	15	0.06	0.11	0.59	97.01	109.41	0.06	0.06	0	158.62	70.44	0.97	162.98	75.43	1.09	0.08	0.35
NACL	SPR	13	0.05	0.08	0.49	48.53	72.02	0.03	0.04	0	83.12	30.84	0.49	100.93	56.4	0.72	0.05	0.24
NACL	SUM	16	0.04	0.03	0.62	-11.56	29.7	0	0.01	0	-1.32	-9.98	-0.13	33.14	32.17	0.34	0.02	0.38
NACL	FAL	14	0.03	0.04	0.04	22.19	51.93	0.01	0.02	0	42.35	25.28	0.22	56.18	44.25	0.52	0.02	0
NACL	ALL	58	0.05	0.07	0.57	45.12	70.39	0.02	0.03	0	69.51	28.48	0.45	87.47	51.7	0.7	0.05	0.32
NH4	WIN	15	1.06	0.93	0.76	-12.6	34.9	-0.13	0.37	0.21	14.61	1.54	-0.14	45.54	39.61	0.4	0.48	0.58
NH4	SPR	14	1.1	0.92	0.55	-16.44	37.98	-0.18	0.42	0.36	4.61	-7.83	-0.2	41.19	41.49	0.45	0.63	0.31
NH4	SUM	16	1.04	0.94	0.87	-9.97	22.75	-0.1	0.24	0.1	-2.51	-6.7	-0.11	22.56	23.9	0.25	0.33	0.75
NH4	FAL	15	0.5	0.61	0.92	21.08	33.28	0.11	0.17	0.03	167.34	47.62	0.21	174.04	55.14	0.33	0.2	0.84
NH4	ALL	60	0.93	0.85	0.77	-8.3	31.89	-0.08	0.3	0.18	45.89	8.68	-0.09	70.52	39.74	0.35	0.43	0.59
NO3	WIN	15	1.53	1.59	0.57	3.9	45.08	0.06	0.69	0.71	19.57	2.23	0.04	53.16	48.98	0.45	0.85	0.32
NO3	SPR	14	0.62	0.7	0.22	12.5	81.81	0.08	0.51	0.69	31.48	-29.59	0.12	99.61	76	0.82	0.83	0.05
NO3	SUM	16	0.28	0.15	0.68	-44.75	48.08	-0.12	0.13	0.01	-43.68	-62.59	-0.81	46.99	65.67	0.87	0.16	0.47
NO3	FAL	15	0.39	0.33	0.7	-13.96	45.37	-0.05	0.18	0.05	-16.34	-30.37	-0.16	40.38	49.79	0.53	0.23	0.5
NO3	ALL	60	0.7	0.69	0.71	-1.91	53.09	-0.01	0.37	0.36	-3.49	-30.63	-0.02	59.16	59.94	0.54	0.6	0.5
OC	WIN	15	1.97	3.07	0.66	56.13	65.23	1.1	1.28	1.09	92.01	50.5	0.56	97.25	57.02	0.65	1.52	0.43
OC	SPR	14	1.7	2.14	0.68	25.6	36.62	0.44	0.62	0.57	37.99	22.16	0.26	47.69	33.84	0.37	0.87	0.47
OC	SUM	16	2.5	2.94	0.73	17.4	27.83	0.44	0.7	0.73	21.68	13.35	0.17	31.79	25.01	0.28	0.96	0.53
OC	FAL	13	1.7	2.18	0.89	28.06	32.74	0.48	0.56	0.22	39.05	29.43	0.28	41.62	32.22	0.33	0.67	0.79
OC	ALL	58	1.99	2.61	0.72	31.03	40.14	0.62	0.8	0.75	47.7	28.69	0.31	54.76	37.03	0.4	1.07	0.52
PM-2.5	WIN	15	9.91	10.77	0.79	8.76	18.25	0.87	1.81	4.95	15.53	9.43	0.09	25.97	21.38	0.18	2.39	0.63
PM-2.5	SPR	13	10.52	9.35	0.79	-11.09	19.27	-1.17	2.03	6.8	-9.31	-12.57	-0.12	17.9	20.53	0.22	2.86	0.63
PM-2.5	SUM	16	16.19	11.57	0.9	-28.51	29.15	-4.62	4.72	6.5	-28.57	-34.83	-0.4	29.29	35.53	0.41	5.27	0.8
PM-2.5	FAL	15	10.13	8.1	0.24	-19.98	32.02	-2.02	3.24	57.29	8.94	-7.48	-0.25	36.13	30.69	0.4	7.84	0.06
PM-2.5	ALL	59	11.8	10	0.62	-15.27	25.51	-1.8	3.01	23.14	-3.58	-11.72	-0.18	27.68	27.4	0.3	5.14	0.38
SO4	WIN	15	2.36	1.42	0.77	-39.86	40.81	-0.94	0.96	1.29	-29.14	-38.84	-0.66	31.75	41.21	0.68	1.47	0.59
SO4	SPR	14	3.33	2.48	0.72	-25.39	34.96	-0.85	1.16	1.77	-21.88	-29.06	-0.34	30.23	35.82	0.47	1.58	0.52
SO4	SUM	16	4.24	3.38	0.75	-20.22	28.37	-0.86	1.2	1.72	-19.86	-26.54	-0.25	28.3	33.68	0.36	1.57	0.56
SO4	FAL	15	2.1	1.83	0.94	-13.06	21.11	-0.27	0.44	0.19	-9.57	-13.79	-0.15	24.65	26.8	0.24	0.52	0.89
SO4	ALL	60	3.02	2.29	0.79	-24.14	31.23	-0.73	0.94	1.31	-20.08	-27.02	-0.32	28.7	34.34	0.41	1.36	0.63

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 210430500																		
EC	WIN	13	0.3	0.39	0.28	33.16	47.98	0.1	0.14	0.02	46.65	30.65	0.33	54.32	40.86	0.48	0.18	0.08
EC	SPR	15	0.33	0.32	0.31	-2.95	38.63	-0.01	0.13	0.04	9.62	-3.8	-0.03	39.54	37.91	0.4	0.19	0.1
EC	SUM	16	0.42	0.28	0.77	-33.31	33.31	-0.14	0.14	0.01	-33.31	-41.82	-0.5	33.31	41.82	0.5	0.16	0.59
EC	FAL	14	0.25	0.28	0.71	11.32	32.94	0.03	0.08	0.01	29.56	16.28	0.11	41.51	31.33	0.33	0.12	0.51
EC	ALL	58	0.33	0.31	0.39	-3.62	37.61	-0.01	0.12	0.03	10.89	-1.72	-0.04	41.61	38.06	0.39	0.16	0.15
NACL	WIN	15	0.04	0.07	0.32	62.23	102.54	0.03	0.04	0.01	72.21	29.69	0.62	95.1	60.63	1.03	0.08	0.1
NACL	SPR	15	0.07	0.06	0.04	-8.08	86.98	-0.01	0.06	0.01	126.7	19.9	-0.09	166.72	84.04	0.95	0.11	0
NACL	SUM	16	0.04	0.02	0.46	-48.81	54.15	-0.02	0.02	0	-35.41	-57.06	-0.95	48.76	67.59	1.06	0.03	0.21
NACL	FAL	14	0.04	0.02	0.03	-45.82	58.79	-0.02	0.03	0	-29.03	-51.54	-0.85	54.76	71.38	1.09	0.03	0
NACL	ALL	60	0.05	0.04	0.13	-10.88	76.66	-0.01	0.04	0	33.51	-14.85	-0.12	91.23	70.85	0.86	0.07	0.02
NH4	WIN	15	0.79	0.79	0.77	-0.55	40.38	0	0.32	0.14	76.25	21.15	-0.01	100.78	50.09	0.41	0.37	0.6
NH4	SPR	14	0.81	0.84	0.48	3.56	43.55	0.03	0.35	0.17	19.71	4.68	0.04	52.44	45.94	0.44	0.41	0.23
NH4	SUM	16	0.68	0.82	0.82	21.05	37.65	0.14	0.26	0.07	78.94	31.49	0.21	92.08	46.75	0.38	0.29	0.67
NH4	FAL	15	0.28	0.5	0.84	76.8	81.27	0.22	0.23	0.02	253.68	78.39	0.77	256.58	81.65	0.81	0.26	0.71
NH4	ALL	60	0.64	0.74	0.73	15.35	45.05	0.1	0.29	0.1	108.13	34.37	0.15	126.13	56.12	0.45	0.34	0.54
NO3	WIN	15	0.91	1.21	0.6	32.39	65.24	0.3	0.6	0.42	67.68	29.67	0.32	93.65	61.47	0.65	0.71	0.35
NO3	SPR	14	0.31	0.66	0.25	114.01	187.97	0.35	0.58	0.75	308.51	23.11	1.14	354.81	96.96	1.88	0.93	0.06
NO3	SUM	16	0.11	0.06	0.1	-40.57	54.94	-0.04	0.06	0	-36.65	-60.52	-0.68	52.66	73.08	0.92	0.07	0.01
NO3	FAL	14	0.23	0.21	0.57	-7.23	57.35	-0.02	0.13	0.03	-3.61	-27.99	-0.08	60.68	62.85	0.62	0.18	0.32
NO3	ALL	59	0.39	0.53	0.6	36.65	86.43	0.14	0.34	0.33	79.62	-10.03	0.37	136.68	73.37	0.86	0.59	0.36
OC	WIN	13	0.93	1.7	0.54	81.95	88.29	0.77	0.82	0.34	99.57	58.46	0.82	103.83	63.4	0.88	0.96	0.29
OC	SPR	15	1.05	1.5	0.44	42.72	62.1	0.45	0.65	0.81	76.05	33.81	0.43	90.14	52.5	0.62	1.01	0.2
OC	SUM	16	1.91	2.24	0.88	17.21	30.23	0.33	0.58	0.36	14.41	9.38	0.17	29.18	26.24	0.3	0.69	0.77
OC	FAL	14	0.73	1.21	0.89	64.68	64.68	0.47	0.47	0.16	91.13	54.73	0.65	91.13	54.73	0.65	0.62	0.78
OC	ALL	58	1.19	1.68	0.73	41.56	52.92	0.49	0.63	0.45	67.96	37.64	0.42	76.63	48.24	0.53	0.83	0.53
PM-2.5	WIN	15	7.89	7.15	0.5	-9.29	24.31	-0.73	1.92	6.26	-4.18	-8.65	-0.1	22.43	24.71	0.27	2.61	0.25
PM-2.5	SPR	15	9.96	7.09	0.47	-28.79	36.47	-2.87	3.63	15.56	-23.09	-34.22	-0.4	34.84	43.69	0.51	4.88	0.22
PM-2.5	SUM	16	16.84	8.42	0.48	-49.97	49.97	-8.41	8.41	138.71	-43.54	-58.41	-1	43.54	58.41	1	14.47	0.23
PM-2.5	FAL	15	6.13	5.5	0.78	-10.18	23.06	-0.62	1.41	4.15	-8.81	-12.95	-0.11	20.3	22.88	0.26	2.13	0.6
PM-2.5	ALL	61	10.31	7.07	0.51	-31.48	38.01	-3.25	3.92	53.05	-20.29	-29.05	-0.46	30.49	37.76	0.55	7.97	0.26
SO4	WIN	15	2.37	1.33	0.76	-44.07	45.88	-1.05	1.09	1.49	-32.99	-44.98	-0.79	38.98	49.86	0.82	1.61	0.58
SO4	SPR	14	3.06	2.39	0.95	-21.84	24.06	-0.67	0.74	0.27	-24.55	-29.89	-0.28	25.87	31.16	0.31	0.84	0.9
SO4	SUM	16	3.57	3.06	0.8	-14.37	24.79	-0.51	0.89	1.08	-12.98	-19.13	-0.17	26.23	30.94	0.29	1.16	0.65
SO4	FAL	15	1.73	1.74	0.85	0.43	26.63	0.01	0.46	0.47	-0.37	-7.39	0	27.65	28.78	0.27	0.69	0.72
SO4	ALL	60	2.69	2.14	0.8	-20.51	29.54	-0.55	0.8	0.98	-17.53	-25.17	-0.26	29.69	35.18	0.37	1.13	0.65

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 210670012																		
EC	WIN	14	0.47	0.98	0.88	106.76	106.76	0.51	0.51	0.03	111.34	70.09	1.07	111.34	70.09	1.07	0.53	0.77
EC	SPR	15	0.45	0.6	0.56	31.57	40.2	0.14	0.18	0.03	49.69	31.74	0.32	56.32	38.93	0.4	0.23	0.31
EC	SUM	15	0.71	0.77	0.65	8.72	31.54	0.06	0.22	0.06	21.67	14.78	0.09	35.43	30.95	0.32	0.26	0.42
EC	FAL	14	0.46	0.7	0.82	51.34	51.34	0.24	0.24	0.02	62.97	43.63	0.51	62.97	43.63	0.51	0.28	0.68
EC	ALL	58	0.53	0.76	0.56	44.08	53.98	0.23	0.28	0.06	60.53	39.48	0.44	65.8	45.52	0.54	0.34	0.31
NACL	WIN	15	0.07	0.13	0.76	74.29	89.2	0.06	0.07	0.01	97.72	52.3	0.74	105.83	62.09	0.89	0.09	0.57
NACL	SPR	15	0.07	0.09	0.65	31.93	61.65	0.02	0.04	0	1469.7	33.65	0.32	1494.1	68.75	0.62	0.06	0.42
NACL	SUM	15	0.05	0.03	0.03	-38.46	50.16	-0.02	0.03	0	-25.87	-41.99	-0.62	43.66	55.07	0.81	0.04	0
NACL	FAL	13	0.05	0.04	0.27	-24.98	52.32	-0.01	0.03	0	4.19	-10.01	-0.33	42.59	47.27	0.7	0.05	0.07
NACL	ALL	58	0.06	0.07	0.6	19.87	66.16	0.01	0.04	0	399.62	9.13	0.2	434.62	58.67	0.66	0.06	0.36
NH4	WIN	15	1.46	1.22	0.7	-16.32	35.8	-0.24	0.52	0.4	0.21	-8.3	-0.19	35.32	34.91	0.43	0.68	0.49
NH4	SPR	15	1.18	1.15	0.85	-2.18	24.8	-0.03	0.29	0.15	-4.65	-10.5	-0.02	25.39	27.15	0.25	0.39	0.73
NH4	SUM	15	1.46	1.21	0.87	-17.21	25.41	-0.25	0.37	0.16	-7.49	-12.8	-0.21	27.5	28.58	0.31	0.48	0.76
NH4	FAL	13	0.59	0.68	0.9	16.74	23.93	0.1	0.14	0.03	35.12	23.34	0.17	39.26	27.91	0.24	0.21	0.8
NH4	ALL	58	1.19	1.08	0.81	-9.34	28.38	-0.11	0.34	0.22	4.79	-2.94	-0.1	31.61	29.7	0.31	0.48	0.66
NO3	WIN	15	2.47	2.57	0.6	4.1	36.96	0.1	0.91	1.26	26.44	12.39	0.04	47.64	38.57	0.37	1.13	0.36
NO3	SPR	15	1	1.49	0.7	49.18	84.99	0.49	0.85	1.95	27.37	-8.49	0.49	77.43	65.27	0.85	1.48	0.48
NO3	SUM	15	0.51	0.3	0.62	-41.12	51.28	-0.21	0.26	0.07	-36.01	-54.51	-0.7	45.83	62.57	0.87	0.34	0.38
NO3	FAL	13	0.7	0.68	0.73	-2.58	40.74	-0.02	0.29	0.12	11.36	-7.1	-0.03	55.81	49.82	0.42	0.35	0.53
NO3	ALL	58	1.19	1.28	0.72	7.95	49.49	0.09	0.59	0.94	7.15	-14.68	0.08	56.71	54.2	0.49	0.98	0.53
OC	WIN	14	1.25	4.64	0.8	271.21	271.21	3.39	3.39	2.66	279.18	112.02	2.71	279.18	112.02	2.71	3.76	0.64
OC	SPR	15	1.25	2	0.55	60.1	74.23	0.75	0.93	0.7	110.15	52.45	0.6	120.91	65.44	0.74	1.13	0.3
OC	SUM	15	2.53	2.68	0.84	5.88	20.44	0.15	0.52	0.37	10.23	7.29	0.06	21.4	19.51	0.2	0.62	0.7
OC	FAL	14	1.13	2.22	0.75	95.95	96.98	1.09	1.1	0.82	286.3	61.87	0.96	288.26	63.9	0.97	1.41	0.56
OC	ALL	58	1.55	2.87	0.37	84.5	93.76	1.31	1.46	2.6	167.63	57.42	0.85	173.77	64.44	0.94	2.08	0.14
PM-2.5	WIN	15	10.19	14.4	0.65	41.38	41.38	4.21	4.21	12.32	44.68	32.77	0.41	44.68	32.77	0.41	5.49	0.43
PM-2.5	SPR	15	9.29	9.57	0.66	3.05	30.49	0.28	2.83	10.84	7.82	-0.48	0.03	35.15	34.07	0.3	3.31	0.43
PM-2.5	SUM	15	17.11	11.43	0.83	-33.17	33.17	-5.67	5.67	14	-31.74	-39.25	-0.5	31.74	39.25	0.5	6.8	0.68
PM-2.5	FAL	13	7.91	8.24	0.81	4.21	26.13	0.33	2.07	5.4	7.53	-0.63	0.04	32.13	31.05	0.26	2.35	0.66
PM-2.5	ALL	58	11.23	11	0.58	-2.04	33.41	-0.23	3.75	23.74	7.06	-1.94	-0.02	36.06	34.4	0.34	4.88	0.33
SO4	WIN	15	2.49	1.36	0.75	-45.35	45.83	-1.13	1.14	1.1	-39.53	-53.29	-0.83	40.65	54.36	0.84	1.54	0.57
SO4	SPR	15	2.97	2.28	0.92	-23.08	28.34	-0.68	0.84	0.42	-27.46	-36.95	-0.3	32.94	41.98	0.37	0.94	0.85
SO4	SUM	15	4.9	3.26	0.91	-33.49	33.49	-1.64	1.64	1.1	-32.51	-40.54	-0.5	32.51	40.54	0.5	1.95	0.82
SO4	FAL	13	1.83	1.5	0.87	-18.26	29.02	-0.33	0.53	0.37	-19.66	-26.41	-0.22	27	32.94	0.36	0.7	0.76
SO4	ALL	58	3.09	2.12	0.87	-31.35	34.19	-0.97	1.06	1	-30.14	-39.74	-0.46	33.49	42.78	0.5	1.39	0.76

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 220330009																		
EC	WIN	25	0.81	1.87	0.47	131.14	133.73	1.06	1.08	0.46	168.2	81.66	1.31	169.19	82.72	1.34	1.26	0.22
EC	SPR	30	0.63	1.3	0.37	104.71	106.28	0.66	0.67	0.15	134.16	70.48	1.05	134.68	71.02	1.06	0.77	0.14
EC	SUM	31	0.67	1.52	0.55	126.38	126.38	0.85	0.85	0.15	171.77	80.62	1.26	171.77	80.62	1.26	0.93	0.31
EC	FAL	30	0.82	1.78	0.76	116.15	116.15	0.96	0.96	0.17	162.38	79.2	1.16	162.38	79.2	1.16	1.04	0.57
EC	ALL	116	0.73	1.6	0.58	119.67	120.64	0.87	0.88	0.24	158.84	77.85	1.2	159.19	78.22	1.21	1	0.34
NACL	WIN	27	0.17	0.4	0.68	139.59	168.46	0.23	0.28	0.16	271.7	74.14	1.4	287.04	94.75	1.68	0.46	0.46
NACL	SPR	29	0.35	0.35	0.44	-1.35	73.54	0	0.26	0.25	72.46	18.35	-0.01	108.4	68.74	0.75	0.5	0.19
NACL	SUM	28	0.16	0.12	0.1	-23.81	69.19	-0.04	0.11	0.04	20.08	-22.28	-0.31	74.43	58.59	0.91	0.2	0.01
NACL	FAL	30	0.17	0.41	0.67	134.07	145.87	0.23	0.25	0.24	246.88	51.8	1.34	253.79	61.39	1.46	0.54	0.45
NACL	ALL	114	0.21	0.32	0.47	49.16	105.56	0.11	0.23	0.19	152.68	30.39	0.49	180.63	70.47	1.06	0.45	0.22
NH4	WIN	27	0.92	1.51	0.19	64.25	90.42	0.59	0.83	0.88	133.67	39.48	0.64	155.67	67.75	0.9	1.11	0.04
NH4	SPR	28	0.95	1.17	0.43	24.02	54.74	0.23	0.52	0.49	30.67	11.65	0.24	54.99	42.46	0.55	0.74	0.18
NH4	SUM	27	0.84	0.89	0.78	6.59	46.66	0.06	0.39	0.27	142.27	30.93	0.07	162.86	57.04	0.47	0.52	0.62
NH4	FAL	28	0.61	1.24	0.44	102.82	110.79	0.63	0.68	0.32	283.08	68.71	1.03	290.56	79.84	1.11	0.84	0.19
NH4	ALL	110	0.83	1.21	0.4	45.5	73.02	0.38	0.61	0.54	147.59	37.74	0.46	166.14	61.76	0.73	0.83	0.16
NO3	WIN	27	1.23	2.32	0.16	89.09	132.02	1.09	1.62	4.21	112.76	22.13	0.89	152.67	81.47	1.32	2.33	0.03
NO3	SPR	29	0.64	1.03	0.72	61.02	94.76	0.39	0.61	0.75	66.69	13.04	0.61	103.46	68.46	0.95	0.95	0.52
NO3	SUM	27	0.39	0.45	0.52	14.73	76.7	0.06	0.3	0.27	13.19	-25.67	0.15	72.05	57.07	0.77	0.52	0.27
NO3	FAL	30	0.57	1.25	0.35	118.72	144.55	0.68	0.83	1.21	151.1	46.97	1.19	170.72	73.13	1.45	1.29	0.12
NO3	ALL	113	0.7	1.26	0.47	79.08	118.69	0.56	0.83	1.73	87.32	14.97	0.79	125.57	70.09	1.19	1.43	0.22
OC	WIN	25	2.07	4.91	0.27	137.22	146.1	2.84	3.03	5.74	184.53	78.21	1.37	187.71	82.07	1.46	3.72	0.07
OC	SPR	30	1.9	2.81	0.59	47.7	63.07	0.91	1.2	1.03	81.66	46.73	0.48	88.68	55.15	0.63	1.36	0.35
OC	SUM	31	1.88	4.3	0.67	129.47	135.4	2.43	2.54	2.84	219.67	90.75	1.29	220.92	92.14	1.35	2.95	0.44
OC	FAL	30	2.06	4.89	0.63	137.31	137.31	2.83	2.83	2.03	174.22	81.81	1.37	174.22	81.81	1.37	3.17	0.4
OC	ALL	116	1.97	4.2	0.49	112.92	120.27	2.23	2.37	3.42	164.65	74.35	1.13	167.48	77.73	1.2	2.9	0.24
PM-2.5	WIN	27	10.59	20.4	0.18	92.61	102.37	9.81	10.84	101.96	106.9	53.56	0.93	113.87	61.78	1.02	14.08	0.03
PM-2.5	SPR	29	12.37	14.36	0.16	16.12	35.44	1.99	4.38	35.11	51.28	15.58	0.16	65.87	32.8	0.35	6.25	0.03
PM-2.5	SUM	28	14.3	15.76	0.75	10.23	28.25	1.46	4.04	27.16	26.48	14.32	0.1	39.43	29.03	0.28	5.41	0.57
PM-2.5	FAL	29	11.34	19.21	0.62	69.45	69.47	7.87	7.88	28.6	209.12	53.62	0.69	209.15	53.64	0.69	9.52	0.39
PM-2.5	ALL	113	12.16	17.4	0.34	43.09	55.42	5.24	6.74	60.46	98.93	34.1	0.43	107.56	44.14	0.55	9.38	0.11
SO4	WIN	27	2.44	2.9	0.5	18.96	49.34	0.46	1.2	1.85	32.79	14.56	0.19	57.27	47	0.49	1.44	0.25
SO4	SPR	29	3.19	3.08	0.53	-3.27	35.65	-0.1	1.14	2.13	429.16	-2.73	-0.03	463.79	40	0.37	1.46	0.28
SO4	SUM	28	3.46	2.53	0.74	-26.9	35.71	-0.93	1.24	2.18	64.34	-18.64	-0.37	113.07	44.26	0.49	1.75	0.54
SO4	FAL	30	2.26	2.98	0.54	31.73	40.42	0.72	0.92	1.49	208.95	32.36	0.32	215.65	39.98	0.4	1.42	0.29
SO4	ALL	114	2.83	2.88	0.5	1.54	39.46	0.04	1.12	2.31	187.73	6.69	0.02	216.07	42.7	0.39	1.52	0.25

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 240053001																		
EC	WIN	22	1.05	1.07	0.7	2.11	42.63	0.02	0.45	0.31	1685.39	19.8	0.02	1708.2	47.53	0.43	0.56	0.49
EC	SPR	25	0.48	0.53	0.26	10.32	43.12	0.05	0.21	0.07	30.25	12.77	0.1	51.7	39.04	0.43	0.27	0.07
EC	SUM	25	0.75	0.65	0.7	-12.93	25.4	-0.1	0.19	0.07	-4.16	-10.06	-0.15	24.69	24.95	0.29	0.28	0.5
EC	FAL	23	0.96	0.85	0.91	-10.88	30.85	-0.1	0.29	0.14	13.42	3.71	-0.12	37.81	33.7	0.35	0.38	0.82
EC	ALL	95	0.8	0.76	0.78	-4.06	35.05	-0.03	0.28	0.15	400.42	6.2	-0.04	424.85	36	0.37	0.38	0.61
NACL	WIN	18	0.12	0.2	0.15	64.87	126.65	0.08	0.15	0.07	152.04	58.22	0.65	166.08	78.21	1.27	0.27	0.02
NACL	SPR	24	0.12	0.21	0.69	76.51	112.14	0.09	0.13	0.03	136.65	58.63	0.77	150.02	75.75	1.12	0.2	0.47
NACL	SUM	25	0.06	0.09	0.7	64.23	87.16	0.04	0.05	0.01	51.35	20.77	0.64	74.94	50.42	0.87	0.08	0.49
NACL	FAL	24	0.08	0.2	0.49	144.05	155.95	0.12	0.13	0.1	141.22	46.76	1.44	151.51	60.28	1.56	0.33	0.24
NACL	ALL	91	0.09	0.17	0.41	87.43	121.95	0.08	0.11	0.05	117.47	45.02	0.87	132.96	65.2	1.22	0.24	0.17
NH4	WIN	19	1.41	1.45	0.59	2.92	38.22	0.04	0.54	0.53	443.34	12.17	0.03	467.5	40.71	0.38	0.73	0.35
NH4	SPR	25	0.93	0.83	0.73	-10.2	30.22	-0.09	0.28	0.12	1.92	-7.44	-0.11	35.51	33.4	0.34	0.36	0.53
NH4	SUM	26	1.05	0.91	0.87	-12.79	32.25	-0.13	0.34	0.16	7.52	-4.39	-0.15	41.5	37.87	0.37	0.42	0.75
NH4	FAL	24	0.57	0.8	0.74	42.2	50.15	0.24	0.28	0.13	150.72	51.87	0.42	155.26	56.9	0.5	0.43	0.54
NH4	ALL	94	0.97	0.97	0.74	0.72	36.17	0.01	0.35	0.24	130.68	12.51	0.01	155.06	42.12	0.36	0.49	0.55
NO3	WIN	19	2.69	3.11	0.37	15.7	49.47	0.42	1.33	3.37	121.56	19.27	0.16	145.13	47.75	0.49	1.88	0.14
NO3	SPR	25	1.14	0.95	0.57	-16.43	51.08	-0.19	0.58	0.59	-2.91	-32.06	-0.2	63.19	61.64	0.61	0.79	0.33
NO3	SUM	26	0.56	0.14	0.66	-74.08	74.08	-0.41	0.41	0.15	-72.13	-116.45	-2.86	72.13	116.45	2.86	0.56	0.43
NO3	FAL	24	0.96	1.12	0.8	16.6	49.4	0.16	0.47	0.47	21	-3.72	0.17	60.61	54.98	0.49	0.7	0.64
NO3	ALL	94	1.25	1.21	0.7	-3.07	52.9	-0.04	0.66	1.1	9.21	-37.79	-0.03	81.57	72.29	0.55	1.05	0.49
OC	WIN	21	2.49	4.26	0.64	70.65	72.92	1.76	1.82	2.26	109.64	58.82	0.71	110.83	60.06	0.73	2.32	0.41
OC	SPR	25	1.25	1.68	0.41	33.94	50.86	0.42	0.64	0.51	56.26	30.19	0.34	66.96	42.79	0.51	0.83	0.17
OC	SUM	25	2.41	2.31	0.67	-4.02	26.7	-0.1	0.64	1	-2.67	-7.56	-0.04	24.02	25.56	0.28	1	0.45
OC	FAL	23	2.01	2.19	0.87	9.05	31.14	0.18	0.63	0.6	34.13	20.3	0.09	46.71	35.69	0.31	0.8	0.75
OC	ALL	94	2.02	2.55	0.67	25.98	44.49	0.53	0.9	1.53	47.1	24.13	0.26	60.38	40.33	0.44	1.34	0.46
PM-2.5	WIN	18	14.99	15.78	0.74	5.23	25.91	0.78	3.89	22.09	11.9	5.87	0.05	30.16	26.65	0.26	4.76	0.55
PM-2.5	SPR	25	8.5	7.81	0.52	-8.14	25.42	-0.69	2.16	7.79	-2.74	-7.99	-0.09	25.25	26.61	0.28	2.88	0.27
PM-2.5	SUM	26	13.58	9.51	0.89	-29.96	29.96	-4.07	4.07	7.24	-29.91	-36.61	-0.43	29.91	36.61	0.43	4.88	0.8
PM-2.5	FAL	24	9.72	9.33	0.91	-4.01	17.52	-0.39	1.7	4.23	-0.47	-3.4	-0.04	19.39	19.64	0.18	2.09	0.84
PM-2.5	ALL	93	11.49	10.22	0.8	-11.07	25.32	-1.27	2.91	12.78	-6.92	-12.12	-0.12	25.99	27.61	0.28	3.79	0.64
SO4	WIN	19	2.27	1.74	0.54	-23.58	41.32	-0.54	0.94	1.05	38.57	-20.9	-0.31	94.09	48.86	0.54	1.16	0.29
SO4	SPR	25	2.2	1.81	0.62	-18.06	28.63	-0.4	0.63	0.52	-11.69	-18.24	-0.22	28.89	31.23	0.35	0.82	0.38
SO4	SUM	26	3.43	2.8	0.85	-18.23	25.83	-0.62	0.88	1.22	-12.03	-19.52	-0.22	27.12	30.87	0.32	1.27	0.72
SO4	FAL	24	1.76	1.65	0.81	-6.18	24.11	-0.11	0.42	0.34	2.89	-2.86	-0.07	26.37	24.99	0.26	0.59	0.66
SO4	ALL	94	2.44	2.03	0.81	-16.98	29.1	-0.41	0.71	0.81	2.1	-15.21	-0.2	40.93	33.1	0.35	0.99	0.66

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 240330030																		
EC	WIN	19	0.54	1.12	0.83	106.69	106.69	0.58	0.58	0.14	117.74	67.61	1.07	117.74	67.61	1.07	0.68	0.7
EC	SPR	25	0.38	0.62	0.15	63	76.08	0.24	0.29	0.1	96.32	47.69	0.63	103.86	56.29	0.76	0.39	0.02
EC	SUM	24	0.6	0.74	0.59	23.79	33.15	0.14	0.2	0.06	28.33	19.13	0.24	37.07	28.99	0.33	0.28	0.35
EC	FAL	21	0.61	0.98	0.86	61.87	66.86	0.37	0.41	0.09	87.49	54.89	0.62	89.32	56.92	0.67	0.48	0.75
EC	ALL	89	0.53	0.84	0.71	60.26	67.13	0.32	0.35	0.12	80.48	45.94	0.6	85.38	51.49	0.67	0.47	0.5
NACL	WIN	17	0.07	0.12	0.29	84.71	115.42	0.06	0.08	0.02	171.06	41.62	0.85	189.84	66.27	1.15	0.14	0.09
NACL	SPR	25	0.08	0.16	0.52	87.98	125.41	0.07	0.11	0.02	243.33	62.06	0.88	255.31	78.32	1.25	0.17	0.27
NACL	SUM	24	0.09	0.06	0.23	-35.34	69.94	-0.03	0.06	0.01	-20.46	-56.94	-0.55	69	79.44	1.08	0.09	0.05
NACL	FAL	22	0.09	0.09	0.8	-2.95	47.16	0	0.04	0	-2.95	-21.77	-0.03	53.4	54.43	0.49	0.06	0.64
NACL	ALL	88	0.08	0.11	0.45	27.39	86.65	0.02	0.07	0.01	95.86	4.7	0.27	141.37	70.33	0.87	0.12	0.2
NH4	WIN	18	0.84	1.13	0.33	35.78	49.96	0.3	0.42	0.34	82.08	33.14	0.36	93.07	45.72	0.5	0.66	0.11
NH4	SPR	25	0.74	0.78	0.75	6.74	30.49	0.05	0.22	0.09	12.25	0.28	0.07	39.94	36.25	0.3	0.31	0.56
NH4	SUM	24	0.82	0.92	0.84	12.16	33.4	0.1	0.27	0.08	31.62	18.12	0.12	47.48	36.52	0.33	0.31	0.71
NH4	FAL	22	0.35	0.78	0.64	122.5	126.38	0.43	0.45	0.15	262.07	84.65	1.23	264.18	87.05	1.26	0.58	0.41
NH4	ALL	89	0.68	0.89	0.62	30.45	48.48	0.21	0.33	0.18	93.35	32.59	0.3	108.15	50.8	0.48	0.47	0.39
NO3	WIN	18	1.6	2.4	0.37	49.86	70.91	0.8	1.14	2.37	122.43	35.27	0.5	141.27	64.86	0.71	1.73	0.14
NO3	SPR	25	0.8	0.91	0.62	12.98	49.93	0.1	0.4	0.42	40.64	-6.06	0.13	83.82	57.68	0.5	0.65	0.38
NO3	SUM	24	0.32	0.15	0.59	-52.7	62.23	-0.17	0.2	0.03	-56.38	-90.81	-1.11	62.05	95.56	1.32	0.25	0.35
NO3	FAL	22	0.51	1.11	0.66	118.02	135.42	0.6	0.69	0.91	136.7	50.05	1.18	154.45	73.21	1.35	1.13	0.44
NO3	ALL	89	0.76	1.06	0.61	38.52	74.37	0.29	0.57	0.97	54.76	-6.69	0.39	107.03	73.18	0.74	1.03	0.37
OC	WIN	19	1.35	4.07	0.75	200.92	200.92	2.72	2.72	1.78	237.12	99.86	2.01	237.12	99.86	2.01	3.03	0.57
OC	SPR	25	1.05	1.88	0.05	78.3	91.72	0.82	0.96	1.35	132.48	52.79	0.78	139.99	61.54	0.92	1.42	0
OC	SUM	24	2.24	2.56	0.69	14.23	34.22	0.32	0.77	0.85	21.15	11.5	0.14	38.38	31.83	0.34	0.97	0.47
OC	FAL	21	1.28	2.57	0.71	99.72	99.72	1.28	1.28	1.58	115.86	63.76	1	115.86	63.76	1	1.8	0.51
OC	ALL	89	1.49	2.69	0.48	80.45	91.2	1.2	1.36	2.1	120.88	54.3	0.8	127.63	62.23	0.91	1.88	0.23
PM-2.5	WIN	17	8.84	13.12	0.66	48.47	55.04	4.28	4.86	16.97	53.66	35.88	0.48	58.87	42	0.55	5.94	0.44
PM-2.5	SPR	25	7.82	7.69	0.32	-1.56	33.24	-0.12	2.6	11.46	3.44	-5	-0.02	33.71	33.85	0.34	3.39	0.1
PM-2.5	SUM	24	13.46	9.49	0.84	-29.47	29.65	-3.97	3.99	6.52	-29.47	-36.65	-0.42	29.69	36.87	0.42	4.72	0.7
PM-2.5	FAL	22	7.44	9.24	0.81	24.23	35.43	1.8	2.64	9.81	31.39	21.33	0.24	39.35	30.31	0.35	3.61	0.66
PM-2.5	ALL	88	9.46	9.62	0.55	1.71	36.21	0.16	3.42	19.39	11.15	0.85	0.02	38.89	35.36	0.36	4.41	0.31
SO4	WIN	18	1.76	1.36	0.34	-22.66	34.24	-0.4	0.6	0.39	-20.1	-28.02	-0.29	31.97	37.39	0.44	0.74	0.11
SO4	SPR	25	2.08	1.66	0.5	-20.25	34.02	-0.42	0.71	0.61	-16.04	-25.14	-0.25	33.15	38.69	0.43	0.89	0.25
SO4	SUM	24	3.16	2.8	0.83	-11.34	22.06	-0.36	0.7	0.87	-8.75	-13.19	-0.13	21.48	24.19	0.25	1	0.7
SO4	FAL	22	1.5	1.42	0.82	-5.02	23.11	-0.08	0.35	0.2	1.72	-2.74	-0.05	24.8	25.28	0.24	0.45	0.68
SO4	ALL	89	2.16	1.85	0.81	-14.54	27.48	-0.31	0.59	0.55	-10.5	-16.96	-0.17	27.7	31.2	0.32	0.81	0.65

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 250130008																		
EC	WIN	22	0.9	1.35	0.63	50.11	77.17	0.45	0.69	0.53	134.79	65.01	0.5	140.3	72.92	0.77	0.85	0.4
EC	SPR	21	0.31	0.75	0.39	141.99	142.57	0.44	0.44	0.08	199.51	85.67	1.42	199.77	85.93	1.43	0.53	0.15
EC	SUM	13	0.58	0.61	0.74	4.95	34.41	0.03	0.2	0.05	28.8	16.16	0.05	46.05	36.9	0.34	0.23	0.55
EC	ALL	56	0.6	0.95	0.63	57.76	80.25	0.35	0.48	0.28	134.45	61.42	0.58	140.72	69.44	0.8	0.63	0.4
NACL	WIN	27	0.13	0.27	0.04	100.73	170.27	0.13	0.23	0.06	480.81	96.96	1.01	492.92	117.74	1.7	0.27	0
NACL	SPR	31	0.11	0.23	0.76	108.81	133.25	0.12	0.15	0.04	650.13	88.57	1.09	658.55	99.13	1.33	0.23	0.57
NACL	SUM	26	0.05	0.11	0.06	136.97	166.78	0.06	0.08	0.02	246.24	48.69	1.37	269.7	79.48	1.67	0.14	0
NACL	FAL	26	0.06	0.15	0.52	176.31	187	0.1	0.1	0.01	238.73	85.41	1.76	243.82	91.52	1.87	0.14	0.27
NACL	ALL	110	0.09	0.19	0.55	119.42	159.15	0.11	0.14	0.03	415.86	80.45	1.19	427.96	97.25	1.59	0.21	0.31
NH4	WIN	27	0.81	1.21	0.86	48.52	54.26	0.39	0.44	0.14	84.74	49.64	0.49	87.09	52.35	0.54	0.55	0.74
NH4	SPR	30	0.48	0.72	0.71	49.31	56.55	0.24	0.27	0.09	207.02	48.73	0.49	210.36	52.38	0.57	0.39	0.51
NH4	SUM	26	0.4	0.55	0.7	37.63	59.49	0.15	0.24	0.08	153.09	51.45	0.38	164.04	66.22	0.59	0.33	0.48
NH4	FAL	26	0.43	0.72	0.86	67.47	70.49	0.29	0.3	0.05	415.19	81.31	0.67	416.82	83.13	0.7	0.37	0.73
NH4	ALL	109	0.53	0.8	0.83	50.44	58.91	0.27	0.31	0.1	213.52	57.38	0.5	218.02	63.01	0.59	0.42	0.69
NO3	WIN	27	1.6	2.49	0.75	55.76	68.52	0.89	1.1	1.53	83.1	43.14	0.56	95.19	58.5	0.69	1.53	0.56
NO3	SPR	31	0.54	0.79	0.49	45.32	86.73	0.25	0.47	0.64	64.25	14.52	0.45	101.54	67.19	0.87	0.84	0.24
NO3	SUM	29	0.29	0.17	0.56	-42.11	65.14	-0.12	0.19	0.04	-32.6	-70.53	-0.73	69.12	87.05	1.13	0.24	0.31
NO3	FAL	27	0.57	0.85	0.83	48.3	68.7	0.28	0.39	0.25	43.38	13.8	0.48	74.4	56	0.69	0.57	0.69
NO3	ALL	114	0.74	1.05	0.81	42.58	71.88	0.31	0.53	0.74	39.13	-0.51	0.43	85.36	67.53	0.72	0.91	0.65
OC	WIN	22	2.28	7.21	0.81	216.54	216.54	4.93	4.93	4.95	313.28	111.6	2.17	313.28	111.6	2.17	5.41	0.66
OC	SPR	21	0.97	3.1	0.43	218.76	220.9	2.13	2.15	2.81	338.18	103.77	2.19	338.86	104.47	2.21	2.71	0.19
OC	SUM	13	1.96	2	0.75	1.63	27.29	0.03	0.54	0.56	9.89	0.16	0.02	33.65	30.6	0.27	0.75	0.57
OC	ALL	56	1.72	4.46	0.66	159.92	167.19	2.74	2.87	6.87	252.19	82.79	1.6	257.96	90.12	1.67	3.79	0.44
PM-2.5	WIN	27	10.13	17.92	0.79	76.99	78.94	7.8	7.99	24.64	94.47	58.31	0.77	95.21	59.08	0.79	9.24	0.63
PM-2.5	SPR	31	6.43	8.75	0.52	36.05	54.41	2.32	3.5	14.42	54.61	31.85	0.36	65.37	44.08	0.54	4.45	0.27
PM-2.5	SUM	30	8.68	6.79	0.8	-21.73	30.76	-1.89	2.67	7.55	-14.13	-20.87	-0.28	31.05	34.87	0.39	3.33	0.64
PM-2.5	FAL	26	8	9.86	0.81	23.35	34.16	1.87	2.73	8.88	88.37	28.6	0.23	97.08	38.54	0.34	3.52	0.66
PM-2.5	ALL	114	8.26	10.66	0.67	29.15	50.52	2.41	4.17	25.57	53.66	23.5	0.29	70.64	43.95	0.51	5.6	0.44
SO4	WIN	27	1.68	1.26	0.72	-24.94	31.83	-0.42	0.54	0.36	-20.52	-27.23	-0.33	28.28	34.11	0.42	0.73	0.51
SO4	SPR	31	1.43	1.64	0.84	14.8	25.98	0.21	0.37	0.31	23.97	13.2	0.15	34.52	24.72	0.26	0.6	0.7
SO4	SUM	30	1.6	1.48	0.66	-7.55	41.72	-0.12	0.67	0.9	69.74	0.79	-0.08	104.89	47.72	0.45	0.96	0.44
SO4	FAL	27	1.47	1.46	0.86	-0.8	25.58	-0.01	0.38	0.25	15.68	7.08	-0.01	35.32	29.88	0.26	0.5	0.74
SO4	ALL	115	1.54	1.47	0.73	-4.91	31.64	-0.08	0.49	0.51	23.52	-0.97	-0.05	51.6	34.14	0.33	0.72	0.53

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 250250042																		
EC	WIN	29	0.71	1.95	0.78	172.61	172.61	1.23	1.23	0.31	195.74	93.22	1.73	195.74	93.22	1.73	1.35	0.61
EC	SPR	31	0.47	1.2	0.4	154.37	154.37	0.73	0.73	0.18	172.04	85.6	1.54	172.04	85.6	1.54	0.84	0.16
EC	SUM	30	0.66	1.11	0.87	68.91	69.25	0.45	0.45	0.05	86.27	55.9	0.69	86.44	56.08	0.69	0.5	0.75
EC	FAL	30	0.66	1.42	0.78	115.97	115.97	0.76	0.76	0.23	131.17	72.76	1.16	131.17	72.76	1.16	0.9	0.61
EC	ALL	120	0.62	1.41	0.7	126.78	126.87	0.79	0.79	0.27	146.11	76.81	1.27	146.15	76.85	1.27	0.95	0.49
NACL	WIN	28	0.17	0.21	0.24	25.29	95.96	0.04	0.16	0.09	93.97	41.42	0.25	110.2	68.09	0.96	0.3	0.06
NACL	SPR	31	0.19	0.43	0.68	126.5	141.37	0.24	0.27	0.47	330.83	63.36	1.26	342.54	78.96	1.41	0.73	0.46
NACL	SUM	31	0.13	0.36	0.31	176.98	204.38	0.23	0.27	0.84	355.18	30.85	1.77	378.44	59.91	2.04	0.94	0.1
NACL	FAL	30	0.1	0.22	0.62	109.91	118.14	0.11	0.12	0.04	135.27	43.84	1.1	149.22	61.42	1.18	0.22	0.38
NACL	ALL	120	0.15	0.31	0.49	107.92	139.43	0.16	0.21	0.37	232.96	44.96	1.08	249.27	67.12	1.39	0.63	0.24
NH4	WIN	28	0.94	1.38	0.83	46.8	52.17	0.44	0.49	0.22	76.29	44.39	0.47	80.03	48.52	0.52	0.64	0.69
NH4	SPR	31	0.63	0.85	0.8	35.18	43.27	0.22	0.27	0.07	69.35	32.88	0.35	78.86	45.58	0.43	0.35	0.63
NH4	SUM	30	0.47	0.55	0.84	16.34	39.36	0.08	0.18	0.05	108.35	33.02	0.16	124.73	53.86	0.39	0.24	0.71
NH4	FAL	30	0.47	0.72	0.74	53.35	60.56	0.25	0.29	0.11	186.85	59.84	0.53	190.71	64	0.61	0.41	0.55
NH4	ALL	119	0.62	0.86	0.83	39.2	49	0.24	0.3	0.13	110.44	42.42	0.39	118.9	53	0.49	0.43	0.69
NO3	WIN	28	1.49	2.72	0.73	82.49	87.51	1.23	1.31	2.01	114.07	55.31	0.82	119.42	61.31	0.88	1.88	0.53
NO3	SPR	31	0.69	0.87	0.53	25.47	67.56	0.18	0.47	0.58	36.19	4.84	0.25	74.49	59.83	0.68	0.78	0.28
NO3	SUM	30	0.4	0.19	0.39	-52.83	74.53	-0.21	0.29	0.11	-38.25	-86.05	-1.12	81.27	107.4	1.58	0.39	0.15
NO3	FAL	30	0.55	0.79	0.59	43.25	83.72	0.24	0.46	0.48	40.63	5.78	0.43	79.12	61.84	0.84	0.73	0.35
NO3	ALL	119	0.77	1.11	0.77	44.54	80.47	0.34	0.62	1.04	36.87	-5.96	0.45	87.94	72.68	0.8	1.08	0.59
OC	WIN	29	1.75	7.72	0.79	341.78	341.78	5.97	5.97	8.4	362.85	123.77	3.42	362.85	123.77	3.42	6.64	0.63
OC	SPR	31	1.18	3.48	0.24	195.85	197.36	2.3	2.32	3.51	258.33	97.23	1.96	258.86	97.78	1.97	2.97	0.06
OC	SUM	30	2.11	2.63	0.85	24.31	33.65	0.51	0.71	0.47	36.54	25.93	0.24	43.38	33.71	0.34	0.86	0.73
OC	FAL	30	1.67	3.39	0.74	103.11	104.96	1.72	1.75	1.92	130.16	67.87	1.03	131.25	69.06	1.05	2.21	0.55
OC	ALL	120	1.67	4.27	0.43	155.33	159.02	2.6	2.66	7.58	196.1	78.48	1.55	198.22	80.86	1.59	3.79	0.18
PM-2.5	WIN	28	9.76	21.1	0.89	116.27	116.27	11.34	11.34	26.37	126.07	74.14	1.16	126.07	74.14	1.16	12.45	0.78
PM-2.5	SPR	31	7.2	11.79	0.58	63.72	69.5	4.59	5.01	13.44	75.77	49.58	0.64	79.15	53.22	0.69	5.87	0.34
PM-2.5	SUM	31	10.24	9.21	0.74	-10.03	25.06	-1.03	2.57	10.26	-1.59	-8	-0.11	27.35	26.52	0.28	3.36	0.55
PM-2.5	FAL	30	7.75	11.42	0.68	47.42	53.48	3.67	4.14	18.28	57.22	37.59	0.47	61.05	41.92	0.53	5.64	0.46
PM-2.5	ALL	120	8.72	13.2	0.6	51.45	64.68	4.49	5.64	35.84	62.89	37.44	0.51	72.19	48.38	0.65	7.48	0.36
SO4	WIN	28	1.72	1.81	0.75	5.06	25.38	0.09	0.44	0.32	14.33	7.94	0.05	29.75	25.82	0.25	0.58	0.57
SO4	SPR	31	1.69	2.26	0.73	33.83	40.39	0.57	0.68	0.82	41.04	25.93	0.34	47.68	33.22	0.4	1.07	0.53
SO4	SUM	31	1.73	1.97	0.81	14.22	36.3	0.25	0.63	0.63	120.83	21.12	0.14	138.68	42.07	0.36	0.83	0.65
SO4	FAL	30	1.56	1.83	0.83	16.99	30.08	0.27	0.47	0.36	36.66	21.83	0.17	45.51	31.54	0.3	0.65	0.69
SO4	ALL	120	1.68	1.97	0.77	17.79	33.3	0.3	0.56	0.57	54.33	19.46	0.18	66.46	33.36	0.33	0.81	0.59

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 260810020																		
EC	WIN	23	0.5	0.95	0.56	88.58	90.01	0.45	0.45	0.09	110.49	61.81	0.89	112.35	63.89	0.9	0.54	0.32
EC	SPR	25	0.45	0.6	0.75	33.53	41.87	0.15	0.19	0.06	32.57	21.03	0.34	41.64	31.69	0.42	0.29	0.56
EC	SUM	26	0.63	0.57	0.67	-9.05	24.53	-0.06	0.15	0.04	-1.43	-7.37	-0.1	25.69	25.89	0.27	0.22	0.44
EC	FAL	23	0.66	0.81	0.71	23.25	39.19	0.15	0.26	0.08	34.44	23.02	0.23	44.95	35.28	0.39	0.32	0.5
EC	ALL	97	0.56	0.73	0.55	29.62	46.18	0.17	0.26	0.1	42.38	23.56	0.3	54.92	38.62	0.46	0.35	0.3
NACL	WIN	23	0.13	0.12	0.23	-12.91	70.76	-0.02	0.09	0.04	62.37	25.7	-0.15	83.38	56.6	0.81	0.21	0.05
NACL	SPR	25	0.06	0.07	0.66	19.91	55.51	0.01	0.03	0	614.48	27.97	0.2	642.06	63.05	0.56	0.04	0.44
NACL	SUM	25	0.03	0.03	0.35	-21.89	57.31	-0.01	0.02	0	96.2	-10.35	-0.28	148.6	64.23	0.73	0.03	0.12
NACL	FAL	20	0.06	0.05	0.15	-10.81	45.17	-0.01	0.02	0	18.63	-2.88	-0.12	52.14	41.93	0.51	0.04	0.02
NACL	ALL	93	0.07	0.07	0.39	-6.33	61.21	0	0.04	0.01	210.47	10.47	-0.07	244.38	57.23	0.65	0.11	0.15
NH4	WIN	24	1.68	1.19	0.84	-29	39.97	-0.49	0.67	0.7	14.57	-11.81	-0.41	62.25	48.18	0.56	0.97	0.7
NH4	SPR	25	1.12	1.17	0.84	4.42	34.31	0.05	0.38	0.26	17.41	7.45	0.04	40.21	34.85	0.34	0.51	0.7
NH4	SUM	25	0.8	0.74	0.75	-6.49	47.66	-0.05	0.38	0.28	69.73	22.46	-0.07	97.31	59.35	0.51	0.53	0.57
NH4	FAL	21	0.71	0.91	0.84	28.72	35.81	0.2	0.25	0.12	75.04	30.26	0.29	81.43	37.26	0.36	0.4	0.71
NH4	ALL	95	1.08	1.01	0.79	-7.24	39.32	-0.08	0.43	0.41	43.2	11.58	-0.08	69.92	45.2	0.42	0.64	0.62
NO3	WIN	24	3.71	2.85	0.88	-23.05	33.47	-0.86	1.24	2.17	-11.02	-20.45	-0.3	37.68	40.05	0.43	1.7	0.77
NO3	SPR	25	2.07	2.04	0.91	-1.56	35.82	-0.03	0.74	0.92	-5.66	-29.09	-0.02	53.92	61.09	0.36	0.96	0.82
NO3	SUM	25	0.7	0.49	0.28	-29.96	59.16	-0.21	0.41	0.62	-29.5	-59.25	-0.43	58.08	80.79	0.84	0.82	0.08
NO3	FAL	21	1.22	1.58	0.73	29.61	58.4	0.36	0.71	0.97	16.51	-16.19	0.3	68.31	63.32	0.58	1.05	0.53
NO3	ALL	95	1.94	1.74	0.85	-10.31	40.03	-0.2	0.77	1.35	-8.39	-31.99	-0.12	54.09	61.45	0.45	1.18	0.72
OC	WIN	23	1.56	5.42	0.63	246.25	246.25	3.85	3.85	4.08	313.07	109.5	2.46	313.07	109.5	2.46	4.35	0.39
OC	SPR	25	1.28	2.87	0.7	124.4	124.4	1.59	1.59	1.84	128.98	68.12	1.24	128.98	68.12	1.24	2.09	0.49
OC	SUM	26	2.14	2.28	0.71	6.4	32.97	0.14	0.7	0.88	14.11	5.23	0.06	35.72	31.09	0.33	0.95	0.51
OC	FAL	23	1.88	2.82	0.67	49.51	57.61	0.93	1.09	1.08	80.14	47.01	0.5	83.2	50.4	0.58	1.4	0.44
OC	ALL	97	1.72	3.3	0.4	91.91	102.86	1.58	1.77	3.81	130.26	56.07	0.92	136.78	63.8	1.03	2.51	0.16
PM-2.5	WIN	23	11.47	14.75	0.86	28.56	36.54	3.28	4.19	12.98	54.06	34.67	0.29	58.88	40.31	0.37	4.87	0.74
PM-2.5	SPR	25	8.82	10.78	0.85	22.31	34.68	1.97	3.06	11.44	22.98	16.26	0.22	33.52	28.15	0.35	3.91	0.73
PM-2.5	SUM	25	11.47	8.18	0.83	-28.71	32.64	-3.29	3.74	11.03	-26.11	-34.44	-0.4	31.56	38.86	0.46	4.68	0.69
PM-2.5	FAL	21	8.77	10.11	0.85	15.24	27.82	1.34	2.44	8.58	19.4	12.31	0.15	32.12	26.61	0.28	3.22	0.71
PM-2.5	ALL	94	10.16	10.91	0.77	7.35	33.26	0.75	3.38	17.45	16.73	6.4	0.07	38.89	33.63	0.33	4.24	0.59
SO4	WIN	24	1.74	1.01	0.58	-42.02	47.71	-0.73	0.83	1.03	-29.33	-43.24	-0.72	42.52	54.27	0.82	1.25	0.34
SO4	SPR	25	1.67	1.66	0.87	-1.12	25.16	-0.02	0.42	0.32	0.36	-4.1	-0.01	23.45	24.85	0.25	0.57	0.76
SO4	SUM	25	2.27	1.7	0.83	-25.12	38.58	-0.57	0.88	1.56	1.24	-12.52	-0.34	43.94	43	0.52	1.37	0.69
SO4	FAL	21	1.58	1.3	0.8	-17.71	34.74	-0.28	0.55	0.45	-3.07	-11.41	-0.22	34.79	36.25	0.42	0.73	0.64
SO4	ALL	95	1.83	1.43	0.75	-21.98	36.8	-0.4	0.67	0.93	-7.66	-17.82	-0.28	36.17	39.58	0.47	1.05	0.56

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 260910007																		
EC	WIN	13	0.27	0.47	0.82	74.79	74.79	0.2	0.2	0.01	99.36	60.66	0.75	99.36	60.66	0.75	0.23	0.67
EC	SPR	13	0.33	0.43	0.66	29.5	41.46	0.1	0.14	0.02	47.16	30.79	0.3	55.89	40.26	0.41	0.16	0.44
EC	SUM	15	0.47	0.39	0.81	-17.05	23.06	-0.08	0.11	0.01	-11.76	-16.01	-0.21	23.45	26.16	0.28	0.13	0.66
EC	FAL	15	0.4	0.56	0.89	40.35	43.76	0.16	0.17	0.03	77.3	41.35	0.4	79.95	44.3	0.44	0.23	0.8
EC	ALL	56	0.37	0.46	0.69	24.69	41.61	0.09	0.15	0.03	51.57	28.02	0.25	63.74	42.3	0.42	0.19	0.48
NACL	WIN	15	0.04	0.1	0.51	134.99	138.87	0.06	0.06	0	274.77	79.97	1.35	278.37	84.13	1.39	0.07	0.26
NACL	SPR	14	0.04	0.09	0.36	110.11	127.93	0.05	0.05	0	146.38	60.02	1.1	160.15	80.02	1.28	0.07	0.13
NACL	SUM	16	0.05	0.03	0.47	-31.07	58.7	-0.02	0.03	0	-2.56	-20.85	-0.45	52.21	55.31	0.85	0.05	0.22
NACL	FAL	15	0.04	0.06	0.8	58.26	73.52	0.02	0.03	0	63.63	34.2	0.58	78.94	56.4	0.74	0.04	0.64
NACL	ALL	60	0.04	0.07	0.32	62.58	97.58	0.03	0.04	0	118.07	36.99	0.63	140.62	68.55	0.98	0.06	0.11
NH4	WIN	15	1.2	1.14	0.86	-5.11	39.17	-0.06	0.47	0.41	44.05	18.01	-0.05	64.39	42.42	0.41	0.64	0.75
NH4	SPR	14	1.18	1.61	0.72	36.04	48.49	0.43	0.57	0.7	80.85	38.21	0.36	87.94	46.05	0.48	0.94	0.51
NH4	SUM	15	1.03	1.12	0.61	8.99	46.41	0.09	0.48	0.44	59.2	25.19	0.09	78.37	49.81	0.46	0.67	0.38
NH4	FAL	14	0.66	1.05	0.77	59.09	63.6	0.39	0.42	0.23	101.54	44.95	0.59	105.99	50.22	0.64	0.62	0.6
NH4	ALL	58	1.02	1.23	0.68	20.1	47.48	0.21	0.48	0.49	70.73	31.25	0.2	83.73	47.09	0.47	0.73	0.47
NO3	WIN	15	2.73	2.85	0.91	4.53	29.21	0.12	0.8	0.89	24.16	11.26	0.05	42.66	33.97	0.29	0.95	0.82
NO3	SPR	14	1.99	2.66	0.72	33.78	59.71	0.67	1.19	2.47	61.1	20.59	0.34	90.29	60.24	0.6	1.71	0.51
NO3	SUM	16	0.65	0.64	0.56	-2.1	67.27	-0.01	0.44	0.42	-12.34	-39.66	-0.02	63.56	75.71	0.69	0.65	0.31
NO3	FAL	15	1.38	1.85	0.69	34.41	64.75	0.47	0.89	1.57	57.3	2.74	0.34	99.97	61.73	0.65	1.34	0.47
NO3	ALL	60	1.66	1.96	0.8	18.18	49.04	0.3	0.82	1.38	31.33	-2.27	0.18	73.67	58.17	0.49	1.21	0.64
OC	WIN	13	1.06	2.72	0.94	155.98	155.98	1.66	1.66	0.25	251.85	99.53	1.56	251.85	99.53	1.56	1.73	0.88
OC	SPR	13	0.95	1.67	0.75	76.3	76.3	0.72	0.72	0.2	109.22	59.89	0.76	109.22	59.89	0.76	0.85	0.56
OC	SUM	15	1.8	1.84	0.79	2.07	26.1	0.04	0.47	0.39	1.37	-4.15	0.02	27.45	27.09	0.26	0.62	0.63
OC	FAL	13	1.36	2	0.71	47.08	52.33	0.64	0.71	0.29	76.77	44.7	0.47	80.7	48.93	0.52	0.84	0.51
OC	ALL	54	1.31	2.05	0.62	56.22	66.7	0.74	0.88	0.63	105.78	47.99	0.56	113.98	57.68	0.67	1.08	0.39
PM-2.5	WIN	15	9.04	9.95	0.95	10.04	23.59	0.91	2.13	4.37	27.4	20.18	0.1	35.06	28.46	0.24	2.28	0.9
PM-2.5	SPR	14	8.68	10.33	0.78	18.97	27.41	1.65	2.38	13.95	24.2	13.65	0.19	33.57	23.81	0.27	4.08	0.61
PM-2.5	SUM	16	12.29	8.9	0.81	-27.58	33.12	-3.39	4.07	11.54	-26.16	-34.64	-0.38	34.18	40.71	0.46	4.8	0.65
PM-2.5	FAL	15	7.38	9.1	0.77	23.27	39.8	1.72	2.94	15.41	20.65	7.38	0.23	42.45	36.7	0.4	4.28	0.59
PM-2.5	ALL	60	9.41	9.54	0.71	1.45	30.91	0.14	2.91	15.9	10.68	0.84	0.01	36.32	32.7	0.31	3.99	0.51
SO4	WIN	15	1.54	0.86	0.71	-44.28	49.75	-0.68	0.77	0.86	-30.66	-43.53	-0.79	41.22	52.01	0.89	1.15	0.5
SO4	SPR	14	2.23	2.39	0.85	7	24.55	0.16	0.55	0.96	10.38	0.72	0.07	31.08	24.34	0.25	0.99	0.73
SO4	SUM	16	3.11	2.51	0.71	-19.55	35	-0.61	1.09	2.25	-4.16	-12.12	-0.24	31.93	34.03	0.44	1.62	0.5
SO4	FAL	15	1.53	1.46	0.84	-4.35	29.67	-0.07	0.45	0.38	0.36	-10.14	-0.05	36.84	38.39	0.31	0.62	0.71
SO4	ALL	60	2.12	1.8	0.76	-14.8	34.16	-0.31	0.72	1.26	-6.26	-16.48	-0.17	35.28	37.35	0.4	1.17	0.57

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 261130001																		
EC	WIN	15	0.16	0.27	0.83	65.71	67.54	0.11	0.11	0.01	94.39	59.67	0.66	94.96	60.25	0.68	0.13	0.69
EC	SPR	15	0.16	0.21	0.71	32.1	53.8	0.05	0.09	0.01	51.22	21.52	0.32	70.83	44.53	0.54	0.11	0.51
EC	SUM	15	0.26	0.17	0.89	-35.93	37.76	-0.09	0.1	0	-35.12	-46.51	-0.56	36.96	48.26	0.59	0.12	0.79
EC	FAL	14	0.2	0.3	0.85	48.39	52.03	0.1	0.1	0.01	208.13	36.42	0.48	215.05	44.99	0.52	0.15	0.71
EC	ALL	59	0.2	0.24	0.68	20.05	50.81	0.04	0.1	0.01	77.48	17.46	0.2	102.58	49.58	0.51	0.13	0.47
NACL	WIN	15	0.04	0.06	0.48	39.34	50.74	0.02	0.02	0	162.35	34.74	0.39	173	47.06	0.51	0.03	0.23
NACL	SPR	14	0.03	0.05	0.37	34.76	63.65	0.01	0.02	0	50.57	30.62	0.35	62.92	48.67	0.64	0.03	0.14
NACL	SUM	15	0.03	0.02	0.52	-39.12	52.41	-0.01	0.02	0	-36.19	-59.78	-0.64	50.52	71.76	0.86	0.02	0.27
NACL	FAL	13	0.04	0.04	0.28	-5.69	45.41	0	0.02	0	23.32	-3.48	-0.06	61.56	47.78	0.48	0.02	0.08
NACL	ALL	57	0.04	0.04	0.37	7.93	52.75	0	0.02	0	50.94	0.14	0.08	88.32	54.12	0.53	0.03	0.14
NH4	WIN	15	0.69	0.61	0.78	-12.26	53.59	-0.08	0.37	0.23	96.2	22.4	-0.14	129.98	67.35	0.61	0.49	0.6
NH4	SPR	14	0.63	0.76	0.82	20.31	38.43	0.13	0.24	0.16	62.8	15.21	0.2	80.33	35.32	0.38	0.43	0.68
NH4	SUM	14	0.36	0.59	0.9	62	63.04	0.22	0.23	0.04	213.97	75.37	0.62	214.71	76.13	0.63	0.3	0.82
NH4	FAL	12	0.44	0.82	0.63	85.4	87.08	0.38	0.38	0.14	162.48	61.28	0.85	164.05	62.92	0.87	0.53	0.4
NH4	ALL	55	0.54	0.69	0.67	27.68	56.68	0.15	0.3	0.17	132.14	42.54	0.28	146.34	60.47	0.57	0.44	0.45
NO3	WIN	15	1.66	1.34	0.81	-19.46	43.91	-0.32	0.73	1.31	34.17	-6.23	-0.24	76.63	51.69	0.55	1.19	0.65
NO3	SPR	14	0.76	1.22	0.78	61.91	84.23	0.47	0.64	1.26	48.51	-4.79	0.62	96.95	78.54	0.84	1.21	0.61
NO3	SUM	15	0.17	0.21	0.48	24.51	97.42	0.04	0.16	0.04	32.42	-36.77	0.25	117.26	100.89	0.97	0.21	0.23
NO3	FAL	14	0.53	0.96	0.67	81.24	99.67	0.43	0.53	0.41	102.97	17.07	0.81	144.78	81.44	1	0.78	0.45
NO3	ALL	58	0.78	0.93	0.71	18.41	65.39	0.14	0.51	0.86	53.79	-8.16	0.18	108.49	78.08	0.65	0.94	0.5
OC	WIN	14	0.57	2.05	0.67	262.79	262.79	1.49	1.49	0.39	1821.64	128.39	2.63	1821.6	128.39	2.63	1.61	0.44
OC	SPR	15	0.52	1.5	0.69	188.64	188.64	0.98	0.98	0.42	736.16	101.36	1.89	736.16	101.36	1.89	1.17	0.47
OC	SUM	15	1.7	1.5	0.84	-11.63	30.91	-0.2	0.52	0.47	-8.34	-16.03	-0.13	31.09	34.97	0.35	0.71	0.71
OC	FAL	13	0.67	1.7	0.85	152.86	152.86	1.03	1.03	0.43	210.56	94.76	1.53	210.56	94.76	1.53	1.22	0.72
OC	ALL	57	0.88	1.68	0.56	92.02	113.71	0.81	1	0.83	686.97	75.6	0.92	697.35	89.02	1.14	1.21	0.31
PM-2.5	WIN	15	5.78	6.15	0.78	6.46	36.41	0.37	2.1	6.89	31.78	18.11	0.06	48.65	38.91	0.36	2.65	0.61
PM-2.5	SPR	14	5.69	6.26	0.73	10.03	32.96	0.57	1.87	8.68	6.17	-2.56	0.1	31.97	29.65	0.33	3	0.54
PM-2.5	SUM	15	10.93	5.22	0.61	-52.22	52.22	-5.71	5.71	17.7	-52	-76.1	-1.09	52	76.1	1.09	7.09	0.37
PM-2.5	FAL	14	6.16	6.57	0.67	6.64	42.76	0.41	2.64	10.86	9.34	-2.92	0.07	44.04	41.66	0.43	3.32	0.45
PM-2.5	ALL	58	7.18	6.04	0.51	-15.91	43.29	-1.14	3.11	18.34	-1.49	-16.32	-0.19	44.37	46.96	0.51	4.43	0.26
SO4	WIN	15	1.21	0.69	0.6	-43.29	51.44	-0.53	0.62	0.49	-25.74	-40.1	-0.76	43.55	55.08	0.91	0.87	0.36
SO4	SPR	14	1.57	1.24	0.83	-20.94	26.28	-0.33	0.41	0.28	-13.35	-19.84	-0.26	23.64	28.75	0.33	0.62	0.69
SO4	SUM	15	1.63	1.43	0.97	-12.12	18.78	-0.2	0.31	0.12	-3.38	-6.75	-0.14	22.62	23.45	0.21	0.4	0.94
SO4	FAL	14	1.4	1.33	0.75	-4.43	35.24	-0.06	0.49	0.52	5.22	-3.28	-0.05	35.79	34.71	0.37	0.73	0.57
SO4	ALL	58	1.45	1.17	0.8	-19.39	31.63	-0.28	0.46	0.38	-9.5	-17.7	-0.24	31.45	35.63	0.39	0.68	0.65

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 261150005																		
EC	WIN	15	0.39	0.64	0.82	64.9	68.44	0.25	0.26	0.02	77.74	52.78	0.65	79.68	54.86	0.68	0.28	0.68
EC	SPR	13	0.34	0.54	0.9	58.44	58.44	0.2	0.2	0.01	68.04	48.28	0.58	68.04	48.28	0.58	0.22	0.82
EC	SUM	15	0.73	0.56	0.73	-22.25	30.25	-0.16	0.22	0.06	-11.97	-18.32	-0.29	27.6	30.96	0.39	0.29	0.54
EC	FAL	15	0.59	0.71	0.88	20.23	27.95	0.12	0.16	0.04	32.53	23.19	0.2	38.6	29.7	0.28	0.23	0.78
EC	ALL	58	0.52	0.61	0.69	19.11	41.15	0.1	0.21	0.06	40.67	25.73	0.19	52.98	40.7	0.41	0.26	0.47
NACL	WIN	14	0.08	0.17	0.38	107.56	110.13	0.09	0.09	0.01	140.4	65.32	1.08	142.15	67.18	1.1	0.11	0.14
NACL	SPR	15	0.05	0.14	0.38	181.49	182.41	0.09	0.09	0	224.93	88.53	1.81	226.01	89.65	1.82	0.11	0.15
NACL	SUM	16	0.05	0.05	0.72	0.32	38.45	0	0.02	0	-1.27	-12.87	0	39.55	40.56	0.38	0.02	0.52
NACL	FAL	15	0.06	0.08	0.59	28.12	58.83	0.02	0.04	0	50.72	20.26	0.28	73.17	52.95	0.59	0.05	0.34
NACL	ALL	60	0.06	0.11	0.48	79.09	96.3	0.05	0.06	0	101.33	39.01	0.79	118.51	62.14	0.96	0.08	0.23
NH4	WIN	15	1.26	1.19	0.88	-5.92	33.65	-0.07	0.43	0.36	28.04	9.16	-0.06	50.11	35.35	0.36	0.6	0.77
NH4	SPR	15	1.23	1.62	0.7	31.75	43.23	0.39	0.53	0.67	45.77	25.23	0.32	54.48	35.12	0.43	0.91	0.49
NH4	SUM	16	1.03	1.04	0.7	1.23	43.33	0.01	0.45	0.31	55.01	20.77	0.01	79.7	52.53	0.43	0.55	0.49
NH4	FAL	15	0.78	0.97	0.86	24.9	33.18	0.19	0.26	0.13	226.35	34.91	0.25	234.8	44.54	0.33	0.41	0.74
NH4	ALL	61	1.07	1.2	0.74	11.97	38.69	0.13	0.42	0.4	88.24	22.49	0.12	104.36	42.06	0.39	0.64	0.54
NO3	WIN	15	2.79	2.85	0.86	2.16	31.57	0.06	0.88	1.17	12.82	-1.04	0.02	43.04	38.44	0.32	1.08	0.74
NO3	SPR	15	1.87	2.49	0.81	32.86	51.13	0.62	0.96	1.65	57.49	17.97	0.33	84.45	53.44	0.51	1.42	0.66
NO3	SUM	16	0.65	0.49	0.58	-23.73	66.72	-0.15	0.43	0.27	-36.96	-68.04	-0.31	64.46	88	0.87	0.54	0.34
NO3	FAL	15	1.58	1.52	0.81	-3.62	42.26	-0.06	0.67	0.83	8.16	-25.97	-0.04	71.12	62.69	0.44	0.91	0.66
NO3	ALL	61	1.7	1.82	0.85	6.57	42.78	0.11	0.73	1.06	9.6	-20.07	0.07	65.74	61.09	0.43	1.03	0.72
OC	WIN	15	1.16	2.56	0.85	121.18	121.18	1.4	1.4	0.36	174.96	83.64	1.21	174.96	83.64	1.21	1.53	0.73
OC	SPR	13	0.83	1.52	0.92	84.02	84.02	0.7	0.7	0.1	92.57	61.56	0.84	92.57	61.56	0.84	0.77	0.84
OC	SUM	15	1.94	1.86	0.81	-4.19	24.92	-0.08	0.48	0.45	0.31	-5.77	-0.04	27.98	28.08	0.26	0.67	0.66
OC	FAL	14	1.28	1.78	0.87	39.23	39.77	0.5	0.51	0.17	141.95	47	0.39	142.46	47.52	0.4	0.65	0.76
OC	ALL	57	1.32	1.95	0.7	47.78	59.18	0.63	0.78	0.58	102.1	46.08	0.48	109.51	55.11	0.59	0.99	0.48
PM-2.5	WIN	15	9.75	10.43	0.89	6.93	23.62	0.68	2.3	6.45	18.62	12	0.07	31.89	27.33	0.24	2.63	0.79
PM-2.5	SPR	15	8.83	10.93	0.73	23.73	28.56	2.1	2.52	14.9	29.14	17.32	0.24	36.13	25.54	0.29	4.39	0.54
PM-2.5	SUM	16	13.37	9.48	0.78	-29.09	32.57	-3.89	4.35	13.2	-27.19	-35.73	-0.41	31.89	39.69	0.46	5.32	0.61
PM-2.5	FAL	15	9.1	9.17	0.83	0.76	28.66	0.07	2.61	11.21	7.11	-1.09	0.01	33.52	32.17	0.29	3.35	0.69
PM-2.5	ALL	61	10.31	9.99	0.73	-3.12	28.8	-0.32	2.97	16.52	6.36	-2.43	-0.03	33.33	31.32	0.3	4.08	0.53
SO4	WIN	15	1.73	0.98	0.76	-43.39	46.87	-0.75	0.81	1.13	-31.14	-41.82	-0.77	36.86	46.53	0.83	1.3	0.58
SO4	SPR	15	2.48	2.64	0.81	6.45	26.51	0.16	0.66	1.44	10.39	-1.21	0.06	33.31	25.95	0.27	1.21	0.66
SO4	SUM	16	3.37	2.73	0.68	-19	34.01	-0.64	1.15	2.21	-3.88	-12.85	-0.23	33.27	35.41	0.42	1.62	0.47
SO4	FAL	15	1.76	1.69	0.89	-3.9	26.06	-0.07	0.46	0.35	-3.22	-10.93	-0.04	31.75	33.64	0.27	0.59	0.8
SO4	ALL	61	2.35	2.02	0.74	-14.03	32.93	-0.33	0.77	1.44	-6.91	-16.64	-0.16	33.79	35.38	0.38	1.24	0.55

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 261470005																		
EC	WIN	15	0.3	0.54	0.61	79.17	80.56	0.24	0.24	0.08	86.5	49.72	0.79	87.67	50.96	0.81	0.37	0.37
EC	SPR	15	0.38	0.42	0.7	13.21	32.62	0.05	0.12	0.03	22.14	15.4	0.13	32.59	28.26	0.33	0.17	0.49
EC	SUM	15	0.56	0.49	0.57	-11.29	28.28	-0.06	0.16	0.05	-6.08	-11.92	-0.13	25.9	28.6	0.32	0.23	0.32
EC	FAL	15	0.39	0.54	0.64	37.62	47.99	0.15	0.19	0.06	409.2	35.86	0.38	415.78	43.29	0.48	0.29	0.41
EC	ALL	60	0.41	0.5	0.53	22.95	43.75	0.09	0.18	0.07	127.94	22.27	0.23	140.49	37.78	0.44	0.28	0.28
NACL	WIN	14	0.07	0.17	0.47	160.87	161.33	0.11	0.11	0.02	195.38	68.74	1.61	195.86	69.22	1.61	0.17	0.22
NACL	SPR	15	0.06	0.09	0.19	42.92	103.86	0.03	0.06	0.01	188.14	37.51	0.43	218.69	81.2	1.04	0.08	0.04
NACL	SUM	16	0.05	0.03	0.35	-25.49	51.2	-0.01	0.02	0	-10.63	-30.13	-0.34	49.96	57.61	0.69	0.03	0.12
NACL	FAL	15	0.03	0.06	0.64	107.81	115.98	0.03	0.04	0	272.76	60.72	1.08	282.92	75.56	1.16	0.04	0.41
NACL	ALL	60	0.05	0.09	0.33	71.55	110.18	0.04	0.06	0.01	157.98	32.56	0.72	184.43	70.7	1.1	0.09	0.11
NH4	WIN	14	1.07	0.98	0.84	-8.24	42.23	-0.09	0.45	0.42	43.15	19.7	-0.09	66.24	48.55	0.46	0.66	0.71
NH4	SPR	15	0.81	1.25	0.54	54.32	76.16	0.44	0.62	0.59	148.51	34.38	0.54	167.56	57.4	0.76	0.89	0.29
NH4	SUM	16	0.8	0.82	0.94	2.32	21.24	0.02	0.17	0.07	87.37	33.18	0.02	99.89	48.12	0.21	0.26	0.88
NH4	FAL	14	0.6	1.02	0.85	71.93	75.73	0.43	0.45	0.23	249.99	63.7	0.72	254.21	68.65	0.76	0.64	0.72
NH4	ALL	59	0.82	1.02	0.67	24.18	50.98	0.2	0.42	0.38	131.01	37.53	0.24	145.73	55.46	0.51	0.65	0.44
NO3	WIN	14	2.33	2.19	0.89	-6.16	31.04	-0.14	0.72	1.02	16.59	4.8	-0.07	43.6	37.4	0.33	1.02	0.8
NO3	SPR	15	1.36	2.06	0.58	51.25	79.35	0.7	1.08	2.54	74.03	20.09	0.51	105.85	69.63	0.79	1.74	0.34
NO3	SUM	16	0.58	0.47	0.41	-18.58	71.25	-0.11	0.41	0.37	-20.5	-49.85	-0.23	60.59	76.52	0.88	0.62	0.17
NO3	FAL	14	1.04	1.72	0.76	65.74	86.95	0.68	0.9	1.46	75.53	21.12	0.66	107.18	65.19	0.87	1.39	0.57
NO3	ALL	59	1.3	1.58	0.69	21.2	59.31	0.28	0.77	1.5	35.12	-2.26	0.21	79.12	62.8	0.59	1.25	0.47
OC	WIN	15	1.03	2.09	0.76	104.09	104.09	1.07	1.07	0.48	147.36	73.93	1.04	147.36	73.93	1.04	1.27	0.58
OC	SPR	15	1.16	1.47	0.74	27.05	41.28	0.31	0.48	0.25	48.49	26.81	0.27	60.19	39.71	0.41	0.59	0.55
OC	SUM	15	2.06	1.84	0.71	-10.84	28.81	-0.22	0.59	0.51	-9.58	-16.86	-0.12	29.56	33.8	0.32	0.75	0.51
OC	FAL	15	1.2	1.5	0.77	25.44	37.13	0.3	0.44	0.23	153.39	34.67	0.25	159.65	41.73	0.37	0.57	0.59
OC	ALL	60	1.36	1.73	0.62	26.88	47.49	0.37	0.65	0.58	84.91	29.64	0.27	99.19	47.29	0.47	0.84	0.39
PM-2.5	WIN	14	8.41	8.56	0.89	1.8	22.63	0.15	1.9	5.43	7.84	3.96	0.02	25.58	24.02	0.23	2.33	0.78
PM-2.5	SPR	15	8.03	9.24	0.77	15.16	31.71	1.22	2.55	13.94	13.26	4.99	0.15	32.22	28.25	0.32	3.93	0.6
PM-2.5	SUM	16	12.55	8.3	0.69	-33.9	34.35	-4.25	4.31	21.22	-31.59	-42.46	-0.51	31.91	42.78	0.52	6.27	0.47
PM-2.5	FAL	15	6.81	8.52	0.87	25.01	35.43	1.7	2.41	7.03	178.11	28.67	0.25	189.22	41.39	0.35	3.15	0.75
PM-2.5	ALL	60	9.02	8.65	0.68	-4.09	31.41	-0.37	2.83	17.96	41.25	-1.98	-0.04	69.84	34.42	0.33	4.25	0.46
SO4	WIN	14	1.46	0.9	0.78	-38.63	43.62	-0.57	0.64	0.47	-27.28	-37.64	-0.63	36.06	45.32	0.71	0.89	0.61
SO4	SPR	15	1.69	2.06	0.5	21.94	50.01	0.37	0.84	3.19	19.42	0.06	0.22	48.2	34.91	0.5	1.82	0.25
SO4	SUM	16	2.76	2.03	0.92	-26.49	28.46	-0.73	0.79	0.9	-17.29	-24.84	-0.36	29.81	34.39	0.39	1.2	0.84
SO4	FAL	14	1.69	1.55	0.86	-8.56	27.91	-0.15	0.47	0.35	-1.05	-11.51	-0.09	34.92	38.2	0.31	0.61	0.74
SO4	ALL	59	1.93	1.65	0.68	-14.15	35.88	-0.27	0.69	1.43	-6.47	-18.38	-0.16	37.18	38.02	0.42	1.23	0.46

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 261630001																		
EC	WIN	27	0.63	1.07	0.76	69.93	72.51	0.44	0.46	0.04	91.39	57.71	0.7	92.69	59.1	0.73	0.49	0.58
EC	SPR	30	0.63	0.93	0.7	47.86	51.38	0.3	0.32	0.07	58.23	40.07	0.48	60.25	42.35	0.51	0.4	0.49
EC	SUM	31	0.98	0.91	0.63	-7.2	24.19	-0.07	0.24	0.09	2.75	-2.97	-0.08	26.24	24.33	0.26	0.31	0.4
EC	FAL	29	0.8	1.12	0.77	40.35	43.65	0.32	0.35	0.09	45.31	33.13	0.4	48.23	36.29	0.44	0.44	0.59
EC	ALL	117	0.77	1.01	0.57	31.39	44.15	0.24	0.34	0.11	47.98	31.02	0.31	55.75	39.94	0.44	0.41	0.32
NACL	WIN	28	0.12	0.26	0.24	114.04	140.8	0.14	0.17	0.03	220.73	66.68	1.14	234.26	85.5	1.41	0.23	0.06
NACL	SPR	31	0.07	0.19	0.47	159.65	171.58	0.12	0.12	0.01	228.28	75.15	1.6	237.66	89.4	1.72	0.16	0.22
NACL	SUM	29	0.06	0.04	0.19	-36.17	51.06	-0.02	0.03	0	-22.41	-42.8	-0.57	49.69	60.03	0.8	0.04	0.04
NACL	FAL	29	0.08	0.13	0.37	53.34	86.83	0.04	0.07	0.01	72.88	27.23	0.53	95.48	58.15	0.87	0.12	0.14
NACL	ALL	117	0.08	0.15	0.41	84.02	119.35	0.07	0.1	0.02	125.82	32.01	0.84	155.01	73.44	1.19	0.15	0.17
NH4	WIN	28	1.69	1.35	0.79	-19.94	45.28	-0.34	0.76	0.87	48.06	9.42	-0.25	84.69	55.96	0.57	0.99	0.63
NH4	SPR	31	1.22	1.44	0.49	17.81	47.4	0.22	0.58	0.73	34.28	14.1	0.18	55.76	39.59	0.47	0.88	0.24
NH4	SUM	31	0.97	0.95	0.82	-2.73	35.05	-0.03	0.34	0.2	49.36	15.89	-0.03	74.14	46.13	0.36	0.45	0.67
NH4	FAL	29	0.85	1.07	0.76	25.63	49.52	0.22	0.42	0.31	159.66	47.3	0.26	169.66	59.24	0.5	0.6	0.58
NH4	ALL	119	1.18	1.2	0.67	2.03	44.39	0.02	0.52	0.57	72.01	21.56	0.02	95.11	49.93	0.44	0.76	0.44
NO3	WIN	28	3.82	3.21	0.86	-15.84	30.87	-0.6	1.18	2.27	8.73	-3.72	-0.19	40.33	35.29	0.37	1.62	0.73
NO3	SPR	31	2.16	2.07	0.62	-3.89	48.72	-0.08	1.05	2.1	14.68	-14.08	-0.04	64.76	54.32	0.51	1.45	0.39
NO3	SUM	31	0.76	0.27	0.32	-64.26	73.66	-0.49	0.56	0.29	-58.97	-103.2	-1.8	72.82	113.13	2.06	0.73	0.1
NO3	FAL	29	1.34	1.59	0.81	18.61	43.51	0.25	0.58	0.62	28.78	1.32	0.19	62.02	47.4	0.44	0.82	0.66
NO3	ALL	119	1.98	1.75	0.81	-11.61	42.27	-0.23	0.84	1.42	-2.47	-31.11	-0.13	60.45	63.48	0.48	1.21	0.66
OC	WIN	27	1.69	2.97	0.56	75.35	83.89	1.28	1.42	0.86	118.53	63.54	0.75	121.26	66.88	0.84	1.58	0.32
OC	SPR	30	1.25	2.15	0.67	71.69	74.17	0.9	0.93	0.44	87.59	53.89	0.72	89.04	55.42	0.74	1.11	0.46
OC	SUM	31	1.87	2.16	0.63	15.57	36.33	0.29	0.68	0.64	22.12	13.62	0.16	37.69	31.86	0.36	0.85	0.39
OC	FAL	29	1.45	2.23	0.67	54.61	60.34	0.79	0.87	1.06	85.83	49.96	0.55	88.14	52.49	0.6	1.3	0.45
OC	ALL	117	1.57	2.36	0.6	50.95	61.47	0.8	0.96	0.87	76.94	44.47	0.51	82.65	51.1	0.61	1.23	0.36
PM-2.5	WIN	28	12.97	12.53	0.83	-3.39	25.13	-0.44	3.26	15.3	13.41	4.64	-0.04	35.08	29.84	0.26	3.94	0.69
PM-2.5	SPR	31	10.52	11.29	0.62	7.3	27.04	0.77	2.85	18.47	9.86	2.3	0.07	29.01	24.78	0.27	4.37	0.39
PM-2.5	SUM	31	13.92	9.55	0.64	-31.38	33.43	-4.37	4.65	25.29	-27.12	-36.11	-0.46	30.04	38.84	0.49	6.66	0.41
PM-2.5	FAL	29	10.06	10.63	0.87	5.61	21.7	0.56	2.18	8.15	6.2	2.31	0.06	23.43	21.67	0.22	2.91	0.76
PM-2.5	ALL	119	11.87	10.97	0.67	-7.61	27.4	-0.9	3.25	21.41	0.17	-7.15	-0.08	29.35	28.87	0.3	4.71	0.45
SO4	WIN	28	1.81	1.12	0.78	-37.84	41.57	-0.68	0.75	0.6	-25.79	-36	-0.61	35.48	44.2	0.67	1.04	0.61
SO4	SPR	31	2.21	2.36	0.54	6.85	42.57	0.15	0.94	2.19	7.84	-4.57	0.07	40.71	35.75	0.43	1.49	0.3
SO4	SUM	31	3.13	2.73	0.81	-12.75	33.22	-0.4	1.04	1.71	-3.31	-13.8	-0.15	37.9	38.34	0.38	1.37	0.66
SO4	FAL	29	2.09	1.84	0.81	-12.13	30.81	-0.25	0.65	1.07	2.85	-8.34	-0.14	35.98	33.6	0.35	1.07	0.65
SO4	ALL	119	2.32	2.04	0.72	-12.36	36.53	-0.29	0.85	1.51	-4.19	-15.29	-0.14	37.59	37.89	0.42	1.26	0.52

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 261630015																		
EC	WIN	15	0.53	1.27	0.48	139.28	139.28	0.74	0.74	0.05	162.94	84.31	1.39	162.94	84.31	1.39	0.77	0.23
EC	SPR	15	0.59	1.21	0.76	106.5	106.5	0.63	0.63	0.09	118.69	70.55	1.06	118.69	70.55	1.06	0.69	0.58
EC	SUM	14	1.07	1.16	0.69	8.91	27.92	0.09	0.3	0.12	23.16	15.13	0.09	35.68	30	0.28	0.35	0.48
EC	FAL	14	0.75	1.28	0.88	71.54	71.54	0.53	0.53	0.09	79.44	53.88	0.72	79.44	53.88	0.72	0.61	0.77
EC	ALL	58	0.73	1.23	0.52	69.44	76.17	0.5	0.55	0.14	97.6	56.71	0.69	100.63	60.3	0.76	0.63	0.27
NACL	WIN	15	0.16	0.48	0.21	198.96	217.36	0.32	0.35	0.06	491.46	102.81	1.99	497.41	110.48	2.17	0.41	0.04
NACL	SPR	15	0.09	0.34	0.26	277.67	277.67	0.25	0.25	0.05	546.39	111.65	2.78	546.39	111.65	2.78	0.33	0.07
NACL	SUM	12	0.07	0.05	0.55	-30.59	43.93	-0.02	0.03	0	60.63	-10.8	-0.44	107.37	54.77	0.63	0.05	0.3
NACL	FAL	15	0.07	0.16	0.31	126.4	142.5	0.09	0.1	0.01	180.61	74.72	1.26	186.89	82.3	1.42	0.12	0.09
NACL	ALL	57	0.1	0.27	0.27	168.42	190.76	0.17	0.19	0.05	333.41	73.83	1.68	346.47	91.64	1.91	0.28	0.07
NH4	WIN	15	1.28	1.37	0.91	7.67	40.27	0.1	0.51	0.41	74.86	32.15	0.08	87.07	46.52	0.4	0.65	0.83
NH4	SPR	15	1.27	1.66	0.3	30.23	63.83	0.39	0.81	1.3	63.22	25.65	0.3	83.61	49.81	0.64	1.2	0.09
NH4	SUM	12	1.18	0.92	0.89	-22.09	34.56	-0.26	0.41	0.24	17.35	-0.02	-0.28	51.79	42.52	0.44	0.56	0.8
NH4	FAL	15	0.75	1.1	0.9	48.12	54.22	0.36	0.4	0.11	130.77	52.52	0.48	136.13	58.61	0.54	0.49	0.81
NH4	ALL	57	1.12	1.28	0.62	14.96	48.54	0.17	0.54	0.59	74.4	29.03	0.15	91.64	49.72	0.49	0.79	0.38
NO3	WIN	15	2.75	2.79	0.94	1.46	21.23	0.04	0.58	0.62	19.59	9.37	0.01	35.1	27.47	0.21	0.79	0.89
NO3	SPR	15	2.1	2.13	0.66	1.7	51.73	0.04	1.08	2.1	22.23	-7.74	0.02	69.16	59.44	0.52	1.45	0.44
NO3	SUM	12	0.8	0.26	0.19	-67.34	75.23	-0.54	0.6	0.43	-61.18	-101.94	-2.06	69.44	108.56	2.3	0.85	0.04
NO3	FAL	15	1.38	1.66	0.85	20.32	46.32	0.28	0.64	0.71	28.72	-1.54	0.2	69.27	52.6	0.46	0.89	0.72
NO3	ALL	57	1.81	1.79	0.82	-1.08	40.62	-0.02	0.73	1.08	5.68	-21.44	-0.01	60.28	59.57	0.41	1.04	0.67
OC	WIN	15	1.34	3.37	0.91	151.35	151.35	2.03	2.03	0.23	178.79	90.59	1.51	178.79	90.59	1.51	2.09	0.83
OC	SPR	15	1.22	2.42	0.58	98.07	98.07	1.2	1.2	0.58	111.6	65.22	0.98	111.6	65.22	0.98	1.42	0.34
OC	SUM	14	2.3	2.38	0.81	3.85	22.6	0.09	0.52	0.44	11.39	6.47	0.04	26.11	24.29	0.23	0.67	0.65
OC	FAL	14	1.39	2.36	0.92	70.53	70.53	0.98	0.98	0.17	117.93	62.6	0.71	117.93	62.6	0.71	1.06	0.84
OC	ALL	58	1.55	2.64	0.57	70.41	77.1	1.09	1.2	0.84	106.32	56.97	0.7	109.87	61.27	0.77	1.43	0.33
PM-2.5	WIN	14	10.08	14.12	0.93	40.08	42.39	4.04	4.27	8.39	93.51	47.6	0.4	94.59	48.73	0.42	4.97	0.87
PM-2.5	SPR	15	9.46	13.6	0.46	43.72	50.78	4.14	4.8	34.08	59.45	36.26	0.44	63.36	40.46	0.51	7.15	0.21
PM-2.5	SUM	12	17.14	10.99	0.68	-35.9	36.4	-6.15	6.24	29.09	-30.22	-39.27	-0.56	31.9	40.87	0.57	8.18	0.46
PM-2.5	FAL	15	8.53	12.04	0.89	41.14	44.74	3.51	3.82	8.41	52.1	37.36	0.41	54.26	39.71	0.45	4.55	0.8
PM-2.5	ALL	56	11.01	12.75	0.51	15.79	42.81	1.74	4.71	36.76	46.78	23.2	0.16	61.99	42.41	0.43	6.31	0.26
SO4	WIN	15	1.59	1.24	0.9	-21.68	33.19	-0.34	0.53	0.51	-4.71	-10.97	-0.28	29.2	31.03	0.42	0.79	0.81
SO4	SPR	15	2.29	2.79	0.39	21.59	51.72	0.5	1.19	4.01	26.17	7.15	0.22	49.96	36.02	0.52	2.06	0.15
SO4	SUM	12	3.61	2.61	0.91	-27.8	35.06	-1	1.27	1.38	-12.48	-21.67	-0.39	37.44	39.97	0.49	1.54	0.83
SO4	FAL	15	1.79	1.78	0.92	-0.96	18.2	-0.02	0.33	0.2	2.02	-1.09	-0.01	20.15	20.45	0.18	0.45	0.84
SO4	ALL	57	2.25	2.08	0.65	-7.81	35.65	-0.18	0.8	1.81	3.55	-5.85	-0.08	34.01	31.45	0.39	1.36	0.43

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 261630033																		
EC	WIN	15	0.61	1.27	0.28	108.14	114.21	0.66	0.7	0.11	145.9	75.03	1.08	148.49	77.9	1.14	0.73	0.08
EC	SPR	14	0.64	1.23	0.68	90.1	90.1	0.58	0.58	0.11	96.88	60.38	0.9	96.88	60.38	0.9	0.67	0.47
EC	SUM	14	0.99	1.15	0.6	16.55	29.39	0.16	0.29	0.09	30.1	19.29	0.17	40.66	31.36	0.29	0.34	0.35
EC	FAL	15	0.86	1.36	0.86	58.9	59.83	0.51	0.51	0.1	79.33	50.2	0.59	79.97	50.86	0.6	0.59	0.74
EC	ALL	58	0.77	1.25	0.6	62.13	67.6	0.48	0.52	0.13	88.9	51.62	0.62	92.28	55.44	0.68	0.6	0.36
NACL	WIN	15	0.28	0.48	0.25	70.84	114.32	0.2	0.32	0.12	621.39	63.38	0.71	641.68	88.87	1.14	0.4	0.06
NACL	SPR	14	0.08	0.32	0.05	309.83	309.83	0.24	0.24	0.05	503.89	102.29	3.1	503.89	102.29	3.1	0.33	0
NACL	SUM	16	0.09	0.05	0.91	-40.58	46.03	-0.03	0.04	0	-23.48	-34.59	-0.68	38.67	47.76	0.77	0.06	0.83
NACL	FAL	15	0.09	0.16	0.05	80.49	105.69	0.07	0.09	0.01	181.73	53.46	0.8	198.49	73.77	1.06	0.13	0
NACL	ALL	60	0.13	0.25	0.24	86.1	128	0.12	0.17	0.06	312.09	43.85	0.86	337.93	77.26	1.28	0.27	0.06
NH4	WIN	14	1.46	1.35	0.87	-7.23	49.3	-0.11	0.72	0.97	82.76	26.54	-0.08	106.65	55.93	0.53	0.99	0.76
NH4	SPR	14	1.31	1.68	0.34	28.55	68.12	0.37	0.89	1.48	62.41	26	0.29	82.76	50.18	0.68	1.27	0.12
NH4	SUM	16	1.09	0.94	0.9	-13.52	31.64	-0.15	0.35	0.15	27.86	5.24	-0.16	59.18	42.39	0.37	0.42	0.81
NH4	FAL	14	0.84	1.17	0.86	39.03	49.54	0.33	0.42	0.14	110.8	41.26	0.39	118.99	50.84	0.5	0.5	0.75
NH4	ALL	58	1.17	1.28	0.61	8.82	49.87	0.1	0.58	0.73	69.47	24.09	0.09	90.77	49.58	0.5	0.86	0.37
NO3	WIN	15	2.65	2.79	0.84	5.15	35.38	0.14	0.94	1.85	793.78	19.04	0.05	812.28	41.06	0.35	1.37	0.71
NO3	SPR	14	2.18	2.11	0.67	-3.06	55.32	-0.07	1.2	2.45	13.88	-10.44	-0.03	64.32	61.32	0.57	1.57	0.45
NO3	SUM	16	0.81	0.27	0.38	-66.88	68.72	-0.54	0.56	0.26	-64.54	-103.7	-2.02	66.01	105.08	2.08	0.75	0.14
NO3	FAL	15	1.46	1.66	0.86	14.07	42.49	0.2	0.62	0.65	18.47	-7.46	0.14	62.42	51.14	0.42	0.83	0.74
NO3	ALL	60	1.75	1.68	0.79	-4.29	46.77	-0.08	0.82	1.36	189.09	-27.19	-0.04	251.28	65.38	0.49	1.17	0.62
OC	WIN	15	1.67	3.37	0.73	102.14	102.14	1.71	1.71	0.44	130.37	72.94	1.02	130.37	72.94	1.02	1.83	0.54
OC	SPR	14	1.32	2.39	0.66	81.1	81.1	1.07	1.07	0.53	92.09	56.72	0.81	92.09	56.72	0.81	1.29	0.44
OC	SUM	14	2.45	2.34	0.59	-4.66	25.14	-0.11	0.62	0.66	-1.04	-4.79	-0.05	23.37	23.99	0.26	0.82	0.35
OC	FAL	15	1.63	2.43	0.89	48.69	49.41	0.79	0.81	0.2	102.13	49.69	0.49	102.6	50.17	0.49	0.91	0.79
OC	ALL	58	1.76	2.64	0.54	49.74	59.91	0.88	1.06	0.88	82.11	44.25	0.5	88.12	51.32	0.6	1.28	0.29
PM-2.5	WIN	15	11.67	13.67	0.75	17.09	36.26	1.99	4.23	30.06	289.55	31.34	0.17	299.93	42.92	0.36	5.83	0.57
PM-2.5	SPR	14	10.03	13.58	0.49	35.41	44.24	3.55	4.44	34.29	43.23	26.48	0.35	49.92	33.72	0.44	6.85	0.24
PM-2.5	SUM	16	15.53	11.39	0.83	-26.68	28.36	-4.14	4.4	25.09	-19.6	-24.96	-0.36	25.52	29.75	0.39	6.5	0.69
PM-2.5	FAL	15	9.87	12.04	0.85	21.99	31.97	2.17	3.16	10.94	22.62	16.21	0.22	32.81	27.84	0.32	3.96	0.73
PM-2.5	ALL	60	11.87	12.63	0.59	6.45	34.18	0.77	4.06	34.05	82.9	11.41	0.06	101.64	33.49	0.34	5.89	0.35
SO4	WIN	14	1.84	1.24	0.79	-32.77	42.05	-0.6	0.77	1.16	-12.66	-21.69	-0.49	34.97	40.26	0.63	1.24	0.62
SO4	SPR	14	2.16	2.88	0.37	33.13	57.02	0.72	1.23	4.32	40.34	16.58	0.33	57.28	35.69	0.57	2.2	0.14
SO4	SUM	16	3.36	2.74	0.88	-18.42	30.25	-0.62	1.02	1.3	-3.99	-11.2	-0.23	33.33	34.89	0.37	1.3	0.77
SO4	FAL	15	1.76	1.78	0.88	0.63	19.95	0.01	0.35	0.28	4.62	1.14	0.01	20.76	20.73	0.2	0.53	0.78
SO4	ALL	59	2.31	2.17	0.63	-5.99	36.43	-0.14	0.84	2.02	6.66	-3.96	-0.06	36.21	32.75	0.39	1.43	0.4

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 270530963																		
EC	WIN	28	0.48	2.3	0.62	375.21	375.21	1.82	1.82	0.68	447.81	129.57	3.75	447.81	129.57	3.75	1.99	0.39
EC	SPR	30	0.38	1.52	0.65	297.47	297.47	1.14	1.14	0.34	322.52	116.16	2.97	322.52	116.16	2.97	1.28	0.43
EC	SUM	22	0.54	1.27	0.55	136.69	136.69	0.73	0.73	0.12	161.71	81.73	1.37	161.71	81.73	1.37	0.81	0.3
EC	FAL	30	0.57	1.56	0.74	174.67	174.67	0.99	0.99	0.28	188.07	91.96	1.75	188.07	91.96	1.75	1.12	0.55
EC	ALL	110	0.49	1.68	0.53	242.93	242.93	1.19	1.19	0.52	285.58	106.09	2.43	285.58	106.09	2.43	1.39	0.28
NACL	WIN	28	0.21	0.43	0.61	107.19	129.33	0.22	0.27	0.04	393.2	91.92	1.07	400.03	99.7	1.29	0.31	0.38
NACL	SPR	29	0.12	0.23	0.66	87.42	104.85	0.11	0.13	0.02	276.16	77.24	0.87	280.47	82.09	1.05	0.16	0.43
NACL	SUM	22	0.04	0.04	0.52	-7.94	35.22	0	0.01	0	15.2	1.24	-0.09	43.17	37.47	0.38	0.02	0.27
NACL	FAL	29	0.05	0.14	0.02	192.18	226.21	0.09	0.11	0.02	480.65	76.63	1.92	493.64	93.57	2.26	0.17	0
NACL	ALL	108	0.11	0.22	0.63	102.82	126.5	0.11	0.14	0.03	308.25	65.4	1.03	320.37	80.65	1.26	0.2	0.39
NH4	WIN	28	1.53	1.78	0.52	16.1	55.04	0.25	0.84	1.53	70.97	29.23	0.16	91.08	54.49	0.55	1.26	0.27
NH4	SPR	29	1.11	1.34	0.9	21.37	33.38	0.24	0.37	0.17	64.13	34.31	0.21	71.26	42.29	0.33	0.48	0.81
NH4	SUM	21	0.3	0.56	0.94	85.92	89.62	0.26	0.27	0.05	127	65.89	0.86	129.86	69.25	0.9	0.34	0.88
NH4	FAL	27	0.62	1.1	0.85	77.27	77.27	0.48	0.48	0.38	142.71	66.49	0.77	142.71	66.49	0.77	0.78	0.73
NH4	ALL	105	0.93	1.24	0.75	32.76	53.96	0.31	0.5	0.57	98.73	47.55	0.33	106.64	57.16	0.54	0.82	0.56
NO3	WIN	28	3.84	3.55	0.61	-7.65	44.3	-0.29	1.7	6.03	10.7	-4.21	-0.08	46.09	40.96	0.48	2.47	0.38
NO3	SPR	29	2.24	2.14	0.92	-4.36	26.59	-0.1	0.6	0.64	5.88	-9.25	-0.05	44.9	42.65	0.28	0.8	0.86
NO3	SUM	22	0.39	0.23	0.91	-39.93	41.26	-0.15	0.16	0.01	-45.07	-65.7	-0.66	46.41	66.99	0.69	0.19	0.83
NO3	FAL	29	1.26	1.77	0.94	40.94	56.07	0.51	0.7	1.45	36.86	5.51	0.41	69.25	49.2	0.56	1.31	0.89
NO3	ALL	108	2.01	2.02	0.81	0.21	40.86	0	0.82	2.23	5.07	-15.48	0	52.05	48.93	0.41	1.49	0.65
OC	WIN	28	1.59	7.6	0.82	378.61	378.61	6.01	6.01	6.2	475.69	133.62	3.79	475.69	133.62	3.79	6.51	0.67
OC	SPR	30	1.18	4.55	0.53	284.17	284.17	3.37	3.37	3.31	328.78	115.77	2.84	328.78	115.77	2.84	3.83	0.29
OC	SUM	22	1.8	3.64	0.55	102.16	103.63	1.84	1.87	1.5	118.11	67.33	1.02	118.73	67.97	1.04	2.21	0.31
OC	FAL	30	1.6	4.71	0.53	195.13	195.13	3.11	3.11	3.02	231.6	98.64	1.95	231.6	98.64	1.95	3.57	0.28
OC	ALL	110	1.52	5.19	0.56	240.68	241.03	3.67	3.67	5.77	297.54	105.95	2.41	297.66	106.08	2.41	4.38	0.31
PM-2.5	WIN	28	12.63	24.41	0.72	93.36	95.78	11.79	12.09	46.09	123.17	67.72	0.93	124.37	69.03	0.96	13.6	0.52
PM-2.5	SPR	29	9.66	16.6	0.85	71.75	72.04	6.93	6.96	15.09	89.1	56.52	0.72	89.34	56.77	0.72	7.95	0.73
PM-2.5	SUM	22	8.85	11.38	0.42	28.56	38.49	2.53	3.41	12.89	38.35	26.1	0.29	45.47	34.14	0.38	4.39	0.18
PM-2.5	FAL	29	8.58	16.03	0.68	86.83	88.44	7.45	7.59	35.46	101.75	58.73	0.87	103	60.11	0.88	9.54	0.47
PM-2.5	ALL	108	9.98	17.41	0.73	74.52	77.55	7.43	7.74	38.03	90.99	53.82	0.75	93.16	56.24	0.78	9.66	0.54
SO4	WIN	28	1.45	1.78	0.51	22.7	49.53	0.33	0.72	1.73	33.13	15.97	0.23	50.55	37.24	0.5	1.35	0.26
SO4	SPR	29	1.53	1.95	0.73	27.86	39.15	0.43	0.6	0.53	44.33	28.85	0.28	49.53	34.85	0.39	0.84	0.54
SO4	SUM	22	1.12	1.42	0.88	26.43	34.78	0.3	0.39	0.27	43.9	26.81	0.26	51.5	35.32	0.35	0.59	0.77
SO4	FAL	29	1.11	1.56	0.67	40.62	49.95	0.45	0.55	0.65	94.07	43.05	0.41	99.61	49.25	0.5	0.92	0.45
SO4	ALL	108	1.31	1.69	0.65	29.02	43.81	0.38	0.58	0.82	54.7	28.91	0.29	63.64	39.43	0.44	0.98	0.42

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 271095008																		
EC	WIN	14	0.35	0.93	0.84	163.72	163.72	0.58	0.58	0.13	179.09	87.99	1.64	179.09	87.99	1.64	0.68	0.71
EC	SPR	15	0.37	0.53	0.35	44.65	61.13	0.16	0.22	0.08	81.06	37.82	0.45	91.48	49.84	0.61	0.32	0.12
EC	SUM	11	0.46	0.46	0.02	-1.41	27.71	-0.01	0.13	0.03	5.24	-1.25	-0.01	28.79	26.45	0.28	0.17	0
EC	FAL	15	0.44	0.68	0.44	53.23	62.7	0.24	0.28	0.07	64.76	41.4	0.53	69.11	46.6	0.63	0.36	0.2
EC	ALL	55	0.4	0.66	0.36	63.2	76.81	0.26	0.31	0.12	86.4	43.75	0.63	95.14	53.99	0.77	0.43	0.13
NACL	WIN	15	0.19	0.32	0.77	71.09	115.49	0.13	0.22	0.05	654.61	91.97	0.71	661.15	100.64	1.15	0.26	0.59
NACL	SPR	14	0.04	0.15	0.77	274.72	274.72	0.11	0.11	0.01	352.24	116.2	2.75	352.24	116.2	2.75	0.13	0.6
NACL	SUM	12	0.03	0.05	0.73	55.6	63.13	0.02	0.02	0	61.41	40.08	0.56	69.06	50.01	0.63	0.03	0.53
NACL	FAL	15	0.04	0.12	0.56	222.66	229.36	0.08	0.08	0	916.03	93.28	2.23	920.47	98.61	2.29	0.1	0.31
NACL	ALL	56	0.08	0.17	0.66	114.81	145.49	0.09	0.11	0.02	521.93	87.26	1.15	526.51	93.14	1.45	0.16	0.43
NH4	WIN	15	1.67	1.46	0.57	-12.8	43.42	-0.21	0.72	0.83	21.41	-3.67	-0.15	61.16	47.73	0.5	0.94	0.32
NH4	SPR	14	1.12	1.34	0.96	19.79	26.52	0.22	0.3	0.1	50.03	28.1	0.2	54.83	33.33	0.27	0.38	0.93
NH4	SUM	12	0.66	0.83	0.89	25.84	38.33	0.17	0.25	0.08	50.84	32.23	0.26	59.28	41.58	0.38	0.33	0.79
NH4	FAL	15	0.91	1.14	0.97	25.56	32.2	0.23	0.29	0.1	217.71	60.01	0.26	220.79	63.26	0.32	0.39	0.94
NH4	ALL	56	1.11	1.21	0.86	8.72	36.06	0.1	0.4	0.33	87.45	29.02	0.09	101.93	46.97	0.36	0.58	0.74
NO3	WIN	15	4.09	3.28	0.57	-19.81	43.03	-0.81	1.76	4.03	-9.54	-23.16	-0.25	45.03	48.1	0.54	2.16	0.33
NO3	SPR	14	2.17	2.31	0.94	6.29	28.63	0.14	0.62	0.74	3.25	-12.44	0.06	45.46	46.92	0.29	0.87	0.89
NO3	SUM	12	0.61	0.6	0.86	-1.57	37.44	-0.01	0.23	0.08	-8.12	-24.27	-0.02	43.3	49.9	0.38	0.28	0.75
NO3	FAL	15	1.69	2.32	0.98	37.21	45.53	0.63	0.77	1.29	32.49	19.06	0.37	48.3	38.76	0.46	1.3	0.96
NO3	ALL	56	2.22	2.2	0.84	-0.76	39.69	-0.02	0.88	1.91	5.22	-9.41	-0.01	45.64	45.69	0.4	1.38	0.71
OC	WIN	14	1.28	6.18	0.96	383.67	383.67	4.9	4.9	8.27	420.82	131.76	3.84	420.82	131.76	3.84	5.68	0.93
OC	SPR	15	1.03	3.06	0.4	198.51	198.51	2.04	2.04	2.94	376.97	92.61	1.99	376.97	92.61	1.99	2.66	0.16
OC	SUM	11	1.65	2.28	0.43	38.77	46.3	0.64	0.76	0.38	49.45	33.75	0.39	55.71	40.73	0.46	0.89	0.18
OC	FAL	15	1.32	3.44	0.47	159.72	159.72	2.12	2.12	1.96	181.04	86.26	1.6	181.04	86.26	1.6	2.54	0.22
OC	ALL	55	1.3	3.8	0.5	193.58	195.49	2.51	2.53	5.78	269.19	89.07	1.94	270.44	90.47	1.95	3.47	0.25
PM-2.5	WIN	15	12.83	17.35	0.61	35.25	46.29	4.52	5.94	39.82	44.09	29.46	0.35	51.73	38.41	0.46	7.76	0.37
PM-2.5	SPR	14	8.69	11.07	0.87	27.39	31.68	2.38	2.75	10.63	47.28	28.65	0.27	51.32	32.87	0.32	4.04	0.75
PM-2.5	SUM	12	10.25	8.35	0.54	-18.5	26.8	-1.9	2.75	6.51	-17.34	-22.34	-0.23	25.9	30.23	0.33	3.18	0.3
PM-2.5	FAL	15	8.91	12.28	0.87	37.92	40.39	3.38	3.6	13.96	49.11	32.42	0.38	51.59	35.15	0.4	5.04	0.77
PM-2.5	ALL	56	10.19	12.5	0.75	22.61	37.6	2.3	3.83	23.87	33.07	18.95	0.23	46.06	34.4	0.38	5.4	0.56
SO4	WIN	15	1.72	1.11	0.64	-35.59	47.39	-0.61	0.82	0.61	-29.57	-45.44	-0.55	45.87	56.82	0.74	0.99	0.41
SO4	SPR	14	1.63	1.77	0.94	8.16	26.12	0.13	0.43	0.29	23.09	15.13	0.08	34.67	27.65	0.26	0.55	0.88
SO4	SUM	12	2.1	1.82	0.88	-13.23	22.06	-0.28	0.46	0.37	-11.51	-14.55	-0.15	19.33	21.88	0.25	0.67	0.77
SO4	FAL	15	1.51	1.28	0.87	-15.48	30.49	-0.23	0.46	0.34	4.91	-4.34	-0.18	37.84	37.01	0.36	0.63	0.75
SO4	ALL	56	1.72	1.47	0.83	-14.68	31.78	-0.25	0.55	0.48	-3.3	-12.67	-0.17	35.23	36.73	0.37	0.74	0.69

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 280670002																		
EC	WIN	12	0.85	0.67	0.42	-21.19	66.69	-0.18	0.57	0.71	-5.96	-24.89	-0.27	50.96	55.55	0.85	0.86	0.18
EC	SPR	15	0.48	0.26	0.56	-45.56	47.21	-0.22	0.22	0.03	-41	-57.85	-0.84	43.85	60.43	0.87	0.27	0.32
EC	SUM	16	0.69	0.38	0.69	-45.03	46.49	-0.31	0.32	0.03	-38.96	-52.4	-0.82	43.4	56.17	0.85	0.36	0.48
EC	FAL	15	0.73	0.46	0.56	-37.03	39.76	-0.27	0.29	0.1	-27.39	-37.29	-0.59	33	42.51	0.63	0.42	0.31
EC	ALL	58	0.68	0.43	0.47	-36.71	49.96	-0.25	0.34	0.19	-29.66	-44.21	-0.58	42.39	53.61	0.79	0.5	0.22
NACL	WIN	12	0.15	0.43	0.94	193.43	199.94	0.28	0.29	0.18	685.03	100.87	1.93	691.96	108.66	2	0.51	0.88
NACL	SPR	15	0.39	0.59	0.59	52.52	120.42	0.2	0.46	0.89	179.55	52.35	0.53	200.91	85.08	1.2	0.96	0.35
NACL	SUM	16	0.1	0.22	0.4	122.96	135.86	0.12	0.13	0.01	182.76	83.53	1.23	186.8	88.35	1.36	0.14	0.16
NACL	FAL	14	0.04	0.2	0.54	373.12	373.12	0.16	0.16	0.01	916.59	128.74	3.73	916.59	128.74	3.73	0.18	0.29
NACL	ALL	57	0.17	0.35	0.65	108.89	152.72	0.18	0.26	0.28	467.9	90.08	1.09	476.11	101.69	1.53	0.56	0.43
NH4	WIN	12	0.73	0.77	0.53	6.43	48.24	0.05	0.35	0.31	15.6	-4.6	0.06	56.37	48.01	0.48	0.56	0.28
NH4	SPR	15	0.99	0.7	0.64	-29.95	41.6	-0.3	0.41	0.16	-25.15	-41.28	-0.43	42.37	55.62	0.59	0.5	0.41
NH4	SUM	16	0.86	0.66	0.74	-23.71	33.57	-0.2	0.29	0.08	-18.65	-31.68	-0.31	39.92	47.52	0.44	0.34	0.54
NH4	FAL	14	0.64	0.8	0.84	25.37	32.63	0.16	0.21	0.05	50.98	31.99	0.25	54.37	35.81	0.33	0.28	0.71
NH4	ALL	57	0.81	0.73	0.56	-10.58	38.72	-0.09	0.32	0.18	3.95	-12.87	-0.12	47.58	46.88	0.43	0.43	0.32
NO3	WIN	12	0.93	1.31	0.52	40.37	99.13	0.38	0.93	2.98	36.98	-31.03	0.4	107.79	79.28	0.99	1.77	0.27
NO3	SPR	15	0.49	0.51	0.43	4.81	88.23	0.02	0.43	0.38	-2.11	-45.7	0.05	82.52	87.28	0.88	0.62	0.18
NO3	SUM	16	0.31	0.14	0.17	-54.73	64.15	-0.17	0.2	0.02	-52.31	-82.54	-1.21	60.12	88.49	1.42	0.23	0.03
NO3	FAL	14	0.47	0.57	0.45	21.53	72.51	0.1	0.34	0.18	33.58	0.95	0.22	79.44	63.42	0.73	0.43	0.2
NO3	ALL	57	0.53	0.59	0.57	11.85	84.89	0.06	0.45	0.81	0.8	-41.49	0.12	80.79	80.07	0.85	0.9	0.32
OC	WIN	12	2.32	3.14	0.63	35.17	78.11	0.82	1.81	16.24	23.9	0.9	0.35	58.61	45.6	0.78	4.11	0.39
OC	SPR	15	2.03	1.33	0.4	-34.49	42.65	-0.7	0.87	0.77	-26.73	-44.15	-0.53	43.61	56.54	0.65	1.12	0.16
OC	SUM	16	3.39	5.36	0.74	57.91	62.2	1.96	2.11	2.73	68.66	41.14	0.58	74.3	47.17	0.62	2.57	0.55
OC	FAL	15	2.52	2.99	0.67	18.81	46.22	0.47	1.17	2.25	17.2	5.16	0.19	44.03	37.75	0.46	1.57	0.45
OC	ALL	58	2.59	3.24	0.67	25.15	57.17	0.65	1.48	5.86	21.42	1.45	0.25	55.29	46.83	0.57	2.51	0.45
PM-2.5	WIN	12	11.1	10.36	0.6	-6.67	49.48	-0.74	5.49	76.7	-14.12	-26.44	-0.07	42.76	43.8	0.53	8.79	0.36
PM-2.5	SPR	15	13.87	7.12	0.09	-48.67	51.26	-6.75	7.11	34.12	-40.82	-61.02	-0.95	45.28	64.89	1	8.93	0.01
PM-2.5	SUM	16	15.59	12.03	0.61	-22.88	33.66	-3.57	5.25	23.23	-17.81	-28.31	-0.3	37.52	41.88	0.44	6	0.38
PM-2.5	FAL	14	11.65	9.91	0.71	-14.95	25	-1.74	2.91	15.3	-11.67	-16.49	-0.18	23.76	26.44	0.29	4.28	0.5
PM-2.5	ALL	57	13.22	9.86	0.47	-25.42	39.44	-3.36	5.22	40.53	-21.58	-33.62	-0.34	37.28	44.55	0.53	7.2	0.22
SO4	WIN	12	1.82	1.83	0.63	0.35	40.88	0.01	0.74	0.89	2.75	-9.03	0	41.98	42.05	0.41	0.94	0.4
SO4	SPR	15	3.11	2.42	0.51	-21.91	37.09	-0.68	1.15	1.69	-14.25	-25.05	-0.28	37.12	41.98	0.47	1.47	0.26
SO4	SUM	16	3.04	2.15	0.59	-29.41	34.53	-0.89	1.05	0.87	-27.63	-39.75	-0.42	34.19	45.5	0.49	1.29	0.35
SO4	FAL	14	2.13	2.16	0.95	1.03	14.77	0.02	0.32	0.15	9.09	5.28	0.01	20.6	17.65	0.15	0.39	0.91
SO4	ALL	57	2.58	2.16	0.62	-16.42	32.27	-0.42	0.83	1.08	-8.69	-18.35	-0.2	33.26	37.01	0.39	1.12	0.39

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 290470005																		
EC	WIN	27	0.35	0.9	0.75	159.55	159.55	0.55	0.55	0.15	159.1	80.03	1.6	159.1	80.03	1.6	0.68	0.57
EC	SPR	31	0.37	0.62	0.87	69.53	72.38	0.26	0.27	0.09	61.47	40.66	0.7	64.96	44.5	0.72	0.39	0.75
EC	SUM	30	0.41	0.57	0.45	38.97	48.96	0.16	0.2	0.04	47.67	31.17	0.39	54.71	39.33	0.49	0.25	0.2
EC	FAL	30	0.38	0.68	0.74	77.06	79.73	0.29	0.31	0.11	72.16	45.31	0.77	74.7	48.07	0.8	0.44	0.55
EC	ALL	118	0.38	0.69	0.64	81.92	86.09	0.31	0.32	0.11	83.02	48.44	0.82	86.37	52.22	0.86	0.46	0.41
NACL	WIN	26	0.07	0.09	0.24	21.6	59.2	0.02	0.04	0	59.42	22.46	0.22	84.89	57.15	0.59	0.05	0.06
NACL	SPR	28	0.08	0.07	0.68	-20.29	51.36	-0.02	0.04	0	203.55	1.85	-0.25	244.71	58.93	0.64	0.06	0.47
NACL	SUM	27	0.07	0.04	0.46	-49.9	58.51	-0.04	0.04	0	-16.81	-60.06	-1	74.9	86.07	1.17	0.06	0.21
NACL	FAL	29	0.05	0.04	0.15	-26.45	63.74	-0.01	0.03	0	31.97	-10.67	-0.36	76.92	58.45	0.87	0.06	0.02
NACL	ALL	110	0.07	0.06	0.42	-18.65	57.55	-0.01	0.04	0	70.16	-11.78	-0.23	121.02	65.05	0.71	0.06	0.17
NH4	WIN	27	1.45	1.19	0.79	-17.89	35.81	-0.26	0.52	0.43	2.06	-7.82	-0.22	39.26	39.2	0.44	0.71	0.62
NH4	SPR	30	1.29	1.09	0.84	-15.75	33.9	-0.2	0.44	0.36	16.55	-8.28	-0.19	57.29	42.99	0.4	0.63	0.71
NH4	SUM	30	0.63	0.63	0.81	0.31	29.92	0	0.19	0.06	58.37	16.44	0	80.11	42	0.3	0.24	0.66
NH4	FAL	30	0.52	0.64	0.92	22.32	44.72	0.12	0.23	0.06	92.34	42.33	0.22	103.55	55.22	0.45	0.28	0.84
NH4	ALL	117	0.96	0.88	0.86	-8.53	35.4	-0.08	0.34	0.25	43.36	11.14	-0.09	70.84	45	0.39	0.5	0.74
NO3	WIN	27	3.71	2.77	0.86	-25.16	34.49	-0.93	1.28	2.07	-15.13	-24.8	-0.34	35.51	41.16	0.46	1.71	0.73
NO3	SPR	31	1.95	1.63	0.9	-16.61	38.22	-0.32	0.75	1	61.53	-38.09	-0.2	132.99	67.65	0.46	1.05	0.81
NO3	SUM	30	0.32	0.12	0.51	-61.29	61.29	-0.2	0.2	0.01	-59.01	-89.28	-1.58	59.01	89.28	1.58	0.23	0.26
NO3	FAL	30	0.85	0.81	0.94	-5.11	35.4	-0.04	0.3	0.18	4.43	-21.47	-0.05	60.79	59.46	0.37	0.42	0.89
NO3	ALL	118	1.66	1.3	0.91	-21.66	37.07	-0.36	0.61	0.89	-1.17	-43.84	-0.28	73.52	65.01	0.47	1.01	0.82
OC	WIN	27	1.2	3.96	0.69	229.88	230.47	2.76	2.76	4.47	1547.95	100.19	2.3	1548.6	100.82	2.3	3.47	0.47
OC	SPR	31	1.6	2.22	0.77	38.73	57.47	0.62	0.92	1.48	61.08	29.17	0.39	77.18	48.38	0.57	1.36	0.59
OC	SUM	30	1.87	2.34	0.87	25.17	31.48	0.47	0.59	0.4	28.66	18.81	0.25	36.79	28.12	0.31	0.79	0.76
OC	FAL	30	1.2	2.06	0.78	72.29	73.91	0.87	0.88	0.91	68.1	42.58	0.72	70.13	44.83	0.74	1.29	0.6
OC	ALL	118	1.47	2.61	0.57	76.89	84.7	1.13	1.25	2.55	394.84	46.2	0.77	401.79	54.33	0.85	1.96	0.33
PM-2.5	WIN	27	11.04	13.7	0.56	24.12	43.08	2.66	4.75	27.37	39.76	20.2	0.24	55.65	39.99	0.43	5.87	0.32
PM-2.5	SPR	31	10.89	9.91	0.84	-9	29.26	-0.98	3.19	14.14	5.77	-9.58	-0.1	43.06	36.73	0.32	3.89	0.7
PM-2.5	SUM	30	11.11	8.23	0.73	-25.94	30.15	-2.88	3.35	10.58	-19.87	-27.17	-0.35	29.32	33.41	0.41	4.35	0.54
PM-2.5	FAL	30	7.16	8.43	0.64	17.71	42.23	1.27	3.02	13.55	56.4	16.58	0.18	76.47	40.54	0.42	3.89	0.4
PM-2.5	ALL	118	10.03	9.97	0.67	-0.59	35.34	-0.06	3.55	20.51	19.9	-0.59	-0.01	50.94	37.6	0.36	4.53	0.45
SO4	WIN	27	1.65	1.15	0.52	-30.61	45.93	-0.51	0.76	0.78	-18.25	-32.13	-0.44	40.27	49.12	0.66	1.02	0.27
SO4	SPR	31	2.37	1.75	0.68	-26.04	38.61	-0.62	0.91	1.25	215.1	-18.41	-0.35	264.18	45.93	0.52	1.28	0.46
SO4	SUM	30	2.45	1.76	0.78	-28.12	33.56	-0.69	0.82	0.57	-21.53	-30.59	-0.39	33.53	39.55	0.47	1.02	0.6
SO4	FAL	30	1.39	1.2	0.79	-13.98	32.38	-0.19	0.45	0.39	5.23	-2.57	-0.16	33.1	32.91	0.38	0.65	0.62
SO4	ALL	118	1.98	1.47	0.72	-25.4	37.3	-0.5	0.74	0.79	48.19	-20.62	-0.34	95.56	41.73	0.5	1.02	0.52

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 295100085																		
EC	WIN	28	0.74	1.71	0.7	130.73	130.73	0.97	0.97	0.22	144.28	78.16	1.31	144.28	78.16	1.31	1.08	0.49
EC	SPR	28	0.84	1.28	0.83	53.35	53.35	0.45	0.45	0.11	3119.93	45.3	0.53	3119.9	45.3	0.53	0.56	0.69
EC	SUM	31	0.98	1.25	0.51	27.67	36.14	0.27	0.35	0.2	38	24.7	0.28	44.53	32.14	0.36	0.52	0.26
EC	FAL	30	0.87	1.31	0.62	51.09	56.56	0.44	0.49	0.2	71.96	42.78	0.51	74.95	46	0.57	0.63	0.38
EC	ALL	117	0.86	1.38	0.54	61.01	64.98	0.52	0.56	0.25	809.7	47.06	0.61	812.19	49.86	0.65	0.73	0.3
NACL	WIN	28	0.13	0.17	0.53	31.18	63.42	0.04	0.08	0.01	82.83	40.25	0.31	96.48	56.94	0.63	0.11	0.28
NACL	SPR	30	0.07	0.15	0.82	121.2	128.19	0.08	0.09	0.01	172.73	71.71	1.21	179.55	80.89	1.28	0.13	0.67
NACL	SUM	30	0.06	0.06	0.23	-5.63	54.19	0	0.03	0	25.65	1.28	-0.06	63.45	50.62	0.57	0.06	0.05
NACL	FAL	30	0.06	0.11	0.64	77.68	111	0.05	0.07	0.01	80.12	27.75	0.78	106.98	65.29	1.11	0.12	0.42
NACL	ALL	118	0.08	0.12	0.55	52.74	85.18	0.04	0.07	0.01	90.46	35.16	0.53	111.87	63.54	0.85	0.11	0.3
NH4	WIN	28	2	1.68	0.82	-16.16	38.52	-0.32	0.77	0.94	24.44	-1.38	-0.19	60.53	43.18	0.46	1.02	0.67
NH4	SPR	30	1.35	1.43	0.74	5.29	41.15	0.07	0.56	0.55	45.68	17.66	0.05	67.6	44.84	0.41	0.74	0.55
NH4	SUM	31	0.89	0.95	0.66	6.18	34.23	0.06	0.3	0.17	27.87	12.39	0.06	46.81	34.5	0.34	0.42	0.44
NH4	FAL	30	0.73	0.91	0.81	25.25	45.33	0.18	0.33	0.21	67.92	32.06	0.25	81.46	48.03	0.45	0.49	0.66
NH4	ALL	119	1.23	1.23	0.79	0.21	39.46	0	0.48	0.49	41.65	15.44	0	64.01	42.56	0.39	0.7	0.63
NO3	WIN	28	4.12	3.56	0.86	-13.59	32.6	-0.56	1.34	3.07	15.64	-3.71	-0.16	50.63	39.05	0.38	1.84	0.74
NO3	SPR	30	1.81	2.22	0.78	22.5	55.43	0.41	1.01	1.94	69.55	26.69	0.23	92.53	55.88	0.55	1.45	0.61
NO3	SUM	31	0.41	0.29	0.39	-28.42	53.38	-0.12	0.22	0.07	-22.68	-44.17	-0.4	54.31	63.13	0.75	0.29	0.15
NO3	FAL	30	0.93	1.33	0.8	43.17	80.54	0.4	0.75	1.92	29.3	-5.08	0.43	78.19	61.94	0.81	1.44	0.64
NO3	ALL	119	1.77	1.81	0.83	2.37	46.1	0.04	0.81	1.87	22.69	-6.93	0.02	69.1	55.34	0.46	1.37	0.68
OC	WIN	28	2.03	5.98	0.5	194.97	195.77	3.95	3.97	4.17	218.41	93.7	1.95	219.17	94.51	1.96	4.45	0.25
OC	SPR	27	1.87	3.42	0.64	82.83	83.74	1.55	1.56	3.06	88.33	50.75	0.83	89.22	51.66	0.84	2.34	0.41
OC	SUM	31	2.55	3.18	0.69	24.56	37.92	0.63	0.97	1.08	30.24	20.24	0.25	40.98	32.89	0.38	1.21	0.48
OC	FAL	30	1.7	2.7	0.6	58.39	61.69	1	1.05	1.14	79.13	43.12	0.58	81.13	45.28	0.62	1.46	0.36
OC	ALL	116	2.05	3.79	0.45	84.95	90.5	1.74	1.85	3.97	101.83	50.99	0.85	105.6	55.34	0.9	2.64	0.2
PM-2.5	WIN	28	15.53	19.97	0.67	28.62	38.77	4.44	6.02	33.03	46.28	30.29	0.29	53.03	38.61	0.39	7.26	0.45
PM-2.5	SPR	31	12.23	14.44	0.71	18.08	33.02	2.21	4.04	25.03	25.02	15.57	0.18	36.53	29.31	0.33	5.47	0.51
PM-2.5	SUM	31	14.59	12.8	0.66	-12.29	23.76	-1.79	3.47	15.26	-7.47	-11.47	-0.14	23.46	24.61	0.27	4.3	0.43
PM-2.5	FAL	30	9.9	11.75	0.6	18.68	34.51	1.85	3.42	21.15	27.65	16.16	0.19	39.03	29.27	0.35	4.96	0.36
PM-2.5	ALL	120	13.03	14.64	0.65	12.34	32.22	1.61	4.2	28.38	22.25	12.17	0.12	37.63	30.26	0.32	5.56	0.43
SO4	WIN	28	2.27	1.83	0.7	-19.55	34.38	-0.44	0.78	0.93	-13.34	-21.44	-0.24	31.26	35.8	0.43	1.06	0.49
SO4	SPR	30	2.71	2.31	0.55	-14.47	36.38	-0.39	0.98	1.92	-1.77	-11.56	-0.17	35.52	35.4	0.43	1.44	0.3
SO4	SUM	31	3.17	2.58	0.69	-18.6	32.71	-0.59	1.04	1.48	-10.44	-18.28	-0.23	31.81	34.8	0.4	1.35	0.48
SO4	FAL	30	1.89	1.62	0.84	-14.69	29.33	-0.28	0.56	0.58	1.01	-5.79	-0.17	30.57	29.94	0.34	0.81	0.71
SO4	ALL	119	2.52	2.09	0.7	-16.94	33.42	-0.43	0.84	1.25	-6.05	-14.18	-0.2	32.3	33.96	0.4	1.2	0.49

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 310550019																		
EC	WIN	20	0.37	1.28	0.63	243.08	243.08	0.9	0.9	0.16	262.02	108.64	2.43	262.02	108.64	2.43	0.99	0.4
EC	SPR	16	0.42	0.9	0.71	115.38	115.38	0.48	0.48	0.13	145.46	76.37	1.15	145.46	76.37	1.15	0.6	0.5
EC	SUM	24	0.51	0.83	0.71	62.93	64.01	0.32	0.33	0.05	73.67	48.2	0.63	74.69	49.27	0.64	0.4	0.5
EC	FAL	24	0.39	1	0.55	153.53	153.53	0.61	0.61	0.1	168.21	86.04	1.54	168.21	86.04	1.54	0.69	0.3
EC	ALL	84	0.43	1	0.47	134.08	134.45	0.57	0.57	0.15	159.2	78.77	1.34	159.49	79.07	1.34	0.69	0.22
NACL	WIN	23	0.08	0.1	0.14	25.72	64.31	0.02	0.05	0	66.99	28.05	0.26	89.09	57.71	0.64	0.06	0.02
NACL	SPR	24	0.07	0.06	0.84	-5.45	45.12	0	0.03	0	105.48	22.21	-0.06	131.45	55.42	0.48	0.04	0.71
NACL	SUM	25	0.06	0.03	0.5	-47.22	59.3	-0.03	0.03	0	-46.62	-73.01	-0.89	54.55	79.16	1.12	0.04	0.25
NACL	FAL	24	0.04	0.04	0.63	22.98	49.75	0.01	0.02	0	151.68	19.84	0.23	173.75	47.94	0.5	0.03	0.39
NACL	ALL	96	0.06	0.06	0.53	-1.7	55.42	0	0.03	0	68.2	-1.78	-0.02	111.85	60.28	0.56	0.04	0.29
NH4	WIN	23	1.31	1.12	0.73	-14.73	34.54	-0.19	0.45	0.27	3.66	-9.64	-0.17	42.87	40.56	0.41	0.55	0.54
NH4	SPR	25	1.35	1.26	0.81	-6.76	36.74	-0.09	0.5	0.57	0.05	-9.02	-0.07	35.94	36.15	0.39	0.76	0.66
NH4	SUM	26	0.59	0.71	0.88	21.12	37.23	0.12	0.22	0.06	103.64	36.95	0.21	113.57	48.62	0.37	0.27	0.77
NH4	FAL	24	0.45	0.73	0.82	63.4	74.1	0.28	0.33	0.17	110.32	53.98	0.63	115.06	59.16	0.74	0.5	0.67
NH4	ALL	98	0.92	0.95	0.8	3.64	40.52	0.03	0.37	0.3	55.39	18.46	0.04	77.54	46.13	0.41	0.55	0.65
NO3	WIN	23	3.32	2.49	0.8	-24.92	34.11	-0.83	1.13	1.3	-19.42	-29.62	-0.33	36.13	42.95	0.45	1.41	0.64
NO3	SPR	25	2.41	2.18	0.9	-9.6	36.52	-0.23	0.88	1.25	-7.76	-30.15	-0.11	50.03	58.64	0.4	1.14	0.81
NO3	SUM	26	0.47	0.27	0.88	-42.29	46.92	-0.2	0.22	0.04	-42.82	-63.34	-0.73	50.26	68.81	0.81	0.28	0.78
NO3	FAL	24	0.93	1.1	0.94	17.76	44.17	0.17	0.41	0.56	0.21	-17.14	0.18	49.94	52.11	0.44	0.76	0.89
NO3	ALL	98	1.75	1.48	0.89	-15.2	37.19	-0.27	0.65	0.89	-17.85	-35.64	-0.18	46.81	56.06	0.44	0.98	0.78
OC	WIN	20	1.08	3.68	0.46	240.87	240.87	2.6	2.6	2.23	283.19	105.63	2.41	283.19	105.63	2.41	3	0.21
OC	SPR	16	1.47	2.32	0.77	57.22	68.2	0.84	1.01	4.03	87.84	42.16	0.57	95.55	50.84	0.68	2.18	0.59
OC	SUM	24	1.53	2.01	0.71	31.22	37.15	0.48	0.57	0.49	32.31	21.06	0.31	39.52	29.47	0.37	0.84	0.5
OC	FAL	24	1.14	2.01	0.55	75.99	77.15	0.87	0.88	0.61	90.44	54.06	0.76	91.08	54.72	0.77	1.17	0.3
OC	ALL	84	1.3	2.47	0.53	89.48	94.13	1.17	1.23	2.28	119.23	54.64	0.89	122.94	58.89	0.94	1.91	0.28
PM-2.5	WIN	24	10.58	12.82	0.68	21.16	29.93	2.24	3.17	10.45	27.22	19.98	0.21	33.63	27.22	0.3	3.93	0.46
PM-2.5	SPR	24	10.9	11.6	0.72	6.42	36.58	0.7	3.99	35.07	11.91	2.3	0.06	36.63	33.91	0.37	5.96	0.52
PM-2.5	SUM	26	11.49	8.58	0.74	-25.33	30.49	-2.91	3.5	10.18	-20.57	-27.11	-0.34	28.6	34.29	0.41	4.32	0.54
PM-2.5	FAL	24	8.03	9.35	0.53	16.52	38.15	1.33	3.06	19.87	26.09	14.36	0.17	41.06	31.52	0.38	4.65	0.28
PM-2.5	ALL	98	10.27	10.54	0.63	2.65	33.39	0.27	3.43	22.67	10.51	1.78	0.03	34.85	31.79	0.33	4.77	0.39
SO4	WIN	23	1.39	1.1	0.47	-20.77	45.33	-0.29	0.63	0.6	-13.83	-26.13	-0.26	40.7	46.94	0.57	0.83	0.22
SO4	SPR	25	2.1	1.8	0.73	-14.26	34.57	-0.3	0.73	1.41	-14.28	-20.83	-0.17	27.19	30.41	0.4	1.22	0.53
SO4	SUM	26	2.2	1.84	0.78	-16.47	30.93	-0.36	0.68	0.68	-4.98	-15.58	-0.2	37.68	38.03	0.37	0.9	0.62
SO4	FAL	24	1.05	1.21	0.8	14.89	36.78	0.16	0.39	0.24	31.58	18.29	0.15	44.44	33.45	0.37	0.52	0.64
SO4	ALL	98	1.7	1.5	0.74	-11.86	35.72	-0.2	0.61	0.78	-0.47	-11.1	-0.13	37.37	37.06	0.41	0.91	0.54

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 340230006																		
EC	WIN	24	0.61	1.38	0.9	124.1	124.1	0.76	0.76	0.18	140.77	78.89	1.24	140.77	78.89	1.24	0.87	0.82
EC	SPR	25	0.4	0.77	0.59	91.57	93.09	0.37	0.37	0.08	112.29	63.8	0.92	113.56	65.18	0.93	0.47	0.35
EC	SUM	23	0.68	0.94	0.6	37.89	51.25	0.26	0.35	0.09	56.96	36.62	0.38	64.41	45.11	0.51	0.4	0.36
EC	FAL	23	0.71	1.37	0.89	91.9	91.9	0.66	0.66	0.18	97.06	61.63	0.92	97.06	61.63	0.92	0.78	0.8
EC	ALL	95	0.6	1.11	0.77	85.31	89.26	0.51	0.53	0.18	102.4	60.5	0.85	104.54	62.92	0.89	0.66	0.59
NACL	WIN	23	0.1	0.13	0.23	26.18	92.2	0.03	0.09	0.02	77.26	19.48	0.26	108.25	63.92	0.92	0.15	0.05
NACL	SPR	24	0.26	0.36	0.83	41.89	84.28	0.11	0.22	0.18	103.18	37.08	0.42	120.87	61.95	0.84	0.44	0.69
NACL	SUM	23	0.09	0.19	0.42	122.49	163.93	0.11	0.14	0.07	103.26	18.18	1.22	142.31	74.67	1.64	0.29	0.17
NACL	FAL	21	0.09	0.14	0.12	63.59	101.92	0.05	0.09	0.07	122.1	-5.14	0.64	160.35	47.52	1.02	0.28	0.01
NACL	ALL	91	0.14	0.21	0.75	55.03	101.19	0.07	0.14	0.09	101.01	18.11	0.55	132.21	62.33	1.01	0.31	0.56
NH4	WIN	23	0.92	1.18	0.68	28.06	36.58	0.26	0.34	0.34	59.41	26.32	0.28	62.71	29.91	0.37	0.64	0.46
NH4	SPR	24	0.73	0.74	0.78	1.03	31.21	0.01	0.23	0.09	14.5	-5.28	0.01	48.01	41.24	0.31	0.3	0.6
NH4	SUM	23	0.83	0.77	0.74	-6.62	40.18	-0.05	0.33	0.21	58.44	11.85	-0.07	88.89	50.51	0.43	0.47	0.54
NH4	FAL	21	0.48	1.06	0.83	119.2	119.31	0.57	0.57	0.16	334.89	91.33	1.19	334.99	91.43	1.19	0.7	0.7
NH4	ALL	91	0.75	0.93	0.66	24.89	48.52	0.19	0.36	0.26	110.89	29.33	0.25	128.28	52.3	0.49	0.54	0.44
NO3	WIN	23	1.72	2.68	0.73	55.62	60.2	0.96	1.04	2.35	63.22	32.3	0.56	73.71	47.79	0.6	1.81	0.54
NO3	SPR	25	0.96	1.04	0.58	8.47	60.92	0.08	0.59	0.61	568.39	11.89	0.08	606.97	69.61	0.61	0.78	0.33
NO3	SUM	23	0.49	0.49	0.68	0.92	53.69	0	0.26	0.21	-3.4	-36.8	0.01	64.65	63.94	0.54	0.45	0.46
NO3	FAL	21	0.82	1.83	0.77	123.13	141.77	1.01	1.16	1.74	112.87	38.47	1.23	139.36	74.42	1.42	1.66	0.59
NO3	ALL	92	1	1.49	0.71	49.32	74.88	0.49	0.75	1.42	195.17	10.89	0.49	231.34	63.83	0.75	1.29	0.51
OC	WIN	24	1.36	4.83	0.84	254.1	254.1	3.47	3.47	3.14	300.26	114.58	2.54	300.26	114.58	2.54	3.89	0.71
OC	SPR	25	0.89	1.91	0.35	114.2	126.61	1.02	1.13	0.88	230.66	79.03	1.14	235.65	84.86	1.27	1.39	0.13
OC	SUM	23	1.92	2.26	0.69	17.97	36.36	0.34	0.7	0.62	29.94	20.45	0.18	40.73	32.69	0.36	0.86	0.48
OC	FAL	23	1.38	2.94	0.88	113.17	113.17	1.56	1.56	1.37	137.11	74.54	1.13	137.11	74.54	1.13	1.95	0.77
OC	ALL	95	1.38	2.98	0.55	116.53	124.85	1.6	1.72	2.86	177	72.74	1.17	180.92	77.24	1.25	2.33	0.3
PM-2.5	WIN	23	8.14	15.04	0.69	84.74	84.74	6.9	6.9	32.37	127.2	56.7	0.85	127.2	56.7	0.85	8.94	0.48
PM-2.5	SPR	25	8.54	7.96	0.33	-6.72	39.85	-0.57	3.4	16.15	9.93	-5.48	-0.07	46.35	43.56	0.43	4.06	0.11
PM-2.5	SUM	24	13.29	8.82	0.59	-33.63	40.42	-4.47	5.37	25.25	-8.69	-35.39	-0.51	55.64	49.97	0.61	6.72	0.35
PM-2.5	FAL	21	9.6	11.65	0.77	21.42	33.24	2.06	3.19	15.37	27.51	17.18	0.21	38.11	29.43	0.33	4.43	0.59
PM-2.5	ALL	93	9.9	10.77	0.39	8.71	47.72	0.86	4.73	39.55	38.1	7.29	0.09	66.88	45.27	0.48	6.35	0.15
SO4	WIN	24	1.57	1.3	0.7	-17.65	31.98	-0.28	0.5	0.39	99.95	-12.34	-0.21	142.05	38.68	0.39	0.68	0.49
SO4	SPR	25	1.85	1.49	0.73	-19.24	29.82	-0.36	0.55	0.38	69.06	-15.39	-0.24	111.06	38.08	0.37	0.71	0.53
SO4	SUM	24	2.91	2.21	0.71	-23.94	38.85	-0.7	1.13	2.05	230.05	-17.76	-0.31	278.44	45.62	0.51	1.59	0.51
SO4	FAL	21	1.67	1.68	0.9	0.46	19.15	0.01	0.32	0.19	10.13	5.35	0	25.47	23.23	0.19	0.43	0.81
SO4	ALL	94	2.01	1.67	0.76	-17	31.61	-0.34	0.63	0.83	104.88	-10.58	-0.2	142.59	36.84	0.38	0.97	0.58

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 340273001																		
EC	WIN	11	0.38	0.72	0.87	91.08	96.88	0.34	0.36	0.12	90.62	53.69	0.91	95.67	59.55	0.97	0.49	0.76
EC	SPR	25	0.25	0.45	0.72	79.9	82.85	0.2	0.21	0.05	90.58	52.83	0.8	92.11	54.53	0.83	0.29	0.51
EC	SUM	25	0.44	0.58	0.65	30.48	44.4	0.13	0.2	0.06	66.02	26.96	0.3	75.04	37.72	0.44	0.28	0.42
EC	FAL	22	0.41	0.68	0.54	67.26	78.15	0.27	0.32	0.09	87.07	48.92	0.67	92.71	55.48	0.78	0.4	0.29
EC	ALL	83	0.37	0.59	0.66	59.72	69.39	0.22	0.25	0.07	82.26	44.12	0.6	87.6	50.38	0.69	0.35	0.44
NACL	WIN	23	0.04	0.1	0.14	122.08	166.03	0.05	0.07	0.01	1142.49	63.79	1.22	1161	90.2	1.66	0.11	0.02
NACL	SPR	21	0.07	0.22	0.32	198.04	235.97	0.15	0.18	0.11	234.39	53.89	1.98	259.01	90.98	2.36	0.36	0.1
NACL	SUM	22	0.04	0.16	0.66	285.02	317.58	0.12	0.14	0.11	225.01	30.1	2.85	263.8	85.97	3.18	0.35	0.44
NACL	FAL	25	0.04	0.12	0.48	171.92	197.09	0.08	0.09	0.03	914.99	46.63	1.72	935.77	75.4	1.97	0.19	0.23
NACL	ALL	91	0.05	0.15	0.42	192.85	227.97	0.1	0.12	0.06	648.62	48.65	1.93	674.06	85.29	2.28	0.27	0.17
NH4	WIN	24	0.8	0.96	0.75	19.82	34.3	0.16	0.28	0.17	38.37	23.06	0.2	47.21	32.82	0.34	0.44	0.57
NH4	SPR	24	0.56	0.67	0.67	19.14	40.58	0.11	0.23	0.1	53.79	18.31	0.19	73.64	44.61	0.41	0.34	0.44
NH4	SUM	23	0.72	0.69	0.73	-3.9	41.91	-0.03	0.3	0.18	59.59	16.03	-0.04	85.31	49.26	0.44	0.42	0.53
NH4	FAL	24	0.5	0.82	0.66	63.48	86.25	0.32	0.43	0.15	201.5	72.68	0.63	207.46	79.94	0.86	0.5	0.44
NH4	ALL	95	0.65	0.79	0.68	21.89	47.94	0.14	0.31	0.16	88.61	32.7	0.22	103.59	51.69	0.48	0.43	0.47
NO3	WIN	24	1.36	2.08	0.66	52.73	65.01	0.72	0.88	1.32	80.47	31.03	0.53	98.86	60.17	0.65	1.35	0.44
NO3	SPR	24	0.71	0.75	0.44	5.23	66.67	0.04	0.47	0.4	41.92	5.78	0.05	81.47	61.2	0.67	0.63	0.2
NO3	SUM	24	0.38	0.28	0.66	-26.67	63.91	-0.1	0.24	0.09	-20.97	-68.31	-0.36	82.09	94.26	0.87	0.32	0.44
NO3	FAL	25	0.7	1.04	0.67	48.35	78.15	0.34	0.55	0.37	69.4	15.38	0.48	107.07	69.81	0.78	0.69	0.45
NO3	ALL	97	0.79	1.04	0.71	31.65	68.27	0.25	0.54	0.64	42.98	-3.83	0.32	92.53	71.34	0.68	0.84	0.51
OC	WIN	11	0.92	2.59	0.77	180.29	180.29	1.66	1.66	1.31	186.93	91.21	1.8	186.93	91.21	1.8	2.02	0.59
OC	SPR	25	0.64	1.4	0.68	116.82	117.45	0.75	0.76	0.36	2851.64	79.36	1.17	2852.6	80.35	1.17	0.96	0.46
OC	SUM	25	1.6	1.77	0.71	10.83	31.68	0.17	0.51	0.35	17.1	10.42	0.11	34.03	30.2	0.32	0.62	0.51
OC	FAL	21	1.07	1.88	0.52	75.09	86.78	0.81	0.93	0.63	137.91	63.54	0.75	142.46	68.71	0.87	1.13	0.27
OC	ALL	82	1.08	1.8	0.54	65.77	78.24	0.71	0.85	0.77	935.01	55.88	0.66	941.62	63.54	0.78	1.13	0.29
PM-2.5	WIN	24	7.59	10.7	0.78	41.05	47.17	3.11	3.58	16.12	42.91	28.52	0.41	49.95	36.66	0.47	5.08	0.62
PM-2.5	SPR	24	6.93	6.17	0.62	-10.9	29.54	-0.75	2.05	7.96	-3.74	-13.23	-0.12	31.28	32.37	0.33	2.92	0.38
PM-2.5	SUM	22	9.89	6.45	0.6	-34.75	38	-3.44	3.76	10.13	-32.88	-42.97	-0.53	35.6	45.36	0.58	4.68	0.36
PM-2.5	FAL	24	6.46	8.06	0.7	24.85	38.39	1.6	2.48	8.2	87.81	24.04	0.25	97.9	35.29	0.38	3.28	0.49
PM-2.5	ALL	94	7.67	7.88	0.55	2.72	38.45	0.21	2.95	16.61	24.73	-0.01	0.03	54.07	37.25	0.38	4.08	0.3
SO4	WIN	24	1.71	1.22	0.68	-28.84	35.2	-0.49	0.6	0.43	-25.02	-33.04	-0.41	32.1	39.15	0.49	0.82	0.46
SO4	SPR	24	1.64	1.53	0.71	-6.59	27.89	-0.11	0.46	0.41	-4.24	-9.95	-0.07	26.59	27.62	0.3	0.65	0.51
SO4	SUM	24	2.64	2.07	0.66	-21.69	40.87	-0.57	1.08	2.13	-8.65	-19.27	-0.28	38.57	41.65	0.52	1.57	0.43
SO4	FAL	25	1.54	1.62	0.75	5.05	37.71	0.08	0.58	0.73	26.95	12.96	0.05	48.31	38.75	0.38	0.86	0.56
SO4	ALL	97	1.88	1.61	0.69	-14.39	36.13	-0.27	0.68	0.99	-2.43	-12.06	-0.17	36.52	36.81	0.42	1.03	0.48

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 340390004																		
EC	WIN	22	1.43	2.04	0.71	42.69	56.16	0.61	0.8	0.56	76.24	44.56	0.43	82.04	52.37	0.56	0.97	0.51
EC	SPR	25	1.3	1.31	0.47	0.73	44.41	0.01	0.58	0.51	24.51	7.44	0.01	54.24	45.6	0.44	0.71	0.22
EC	SUM	23	2	1.5	0.72	-25.3	35.73	-0.51	0.72	0.58	-12.79	-21.6	-0.34	34.58	38	0.48	0.91	0.51
EC	FAL	20	2.1	1.97	0.82	-6.14	26.34	-0.13	0.55	0.46	7.95	0.59	-0.07	32.25	30.64	0.28	0.69	0.67
EC	ALL	90	1.69	1.68	0.64	-0.35	39.23	-0.01	0.66	0.69	23.94	7.57	0	51.12	41.99	0.39	0.83	0.41
NACL	WIN	22	0.12	0.17	0.31	46.04	72.02	0.05	0.09	0.02	67.22	25.01	0.46	83.81	47.58	0.72	0.15	0.09
NACL	SPR	25	0.27	0.47	0.94	75.51	106.8	0.2	0.28	0.52	99.57	40.51	0.76	113.22	59.71	1.07	0.75	0.88
NACL	SUM	22	0.07	0.25	0.54	259.8	277.67	0.18	0.19	0.2	175.08	38.14	2.6	200.73	70	2.78	0.48	0.29
NACL	FAL	21	0.11	0.17	0.95	48.62	66.42	0.06	0.08	0.02	22.14	3.46	0.49	56.12	46.87	0.66	0.14	0.9
NACL	ALL	90	0.15	0.27	0.88	86.24	112.48	0.13	0.16	0.21	92.05	27.5	0.86	114.1	56.27	1.12	0.47	0.78
NH4	WIN	22	1.39	1.31	0.81	-5.31	27.5	-0.07	0.38	0.28	2.95	-2.17	-0.06	27.31	25.94	0.29	0.54	0.66
NH4	SPR	25	0.92	0.8	0.79	-13.15	33.27	-0.12	0.31	0.17	-2.27	-16.12	-0.15	38.75	41.82	0.38	0.44	0.63
NH4	SUM	22	1.07	0.79	0.64	-26.55	38.3	-0.28	0.41	0.53	-2.58	-12.74	-0.36	33.97	36.6	0.52	0.78	0.41
NH4	FAL	21	0.81	1.03	0.91	27.62	33.71	0.22	0.27	0.07	99.99	43.31	0.28	104.19	47.76	0.34	0.34	0.83
NH4	ALL	90	1.05	0.98	0.75	-6.63	32.74	-0.07	0.34	0.29	22.79	1.98	-0.07	50.05	38.05	0.35	0.55	0.56
NO3	WIN	22	2.41	2.8	0.73	16.39	38.13	0.39	0.92	2.05	28.21	7.69	0.16	53.9	44.46	0.38	1.48	0.53
NO3	SPR	25	1.35	1.05	0.74	-22.29	52.1	-0.3	0.7	1.12	11.9	-14.41	-0.29	62.93	57.91	0.67	1.1	0.54
NO3	SUM	22	0.82	0.46	0.47	-44.7	65.11	-0.37	0.54	0.84	-26.67	-62.02	-0.81	68.96	84.04	1.18	0.99	0.22
NO3	FAL	21	1.32	1.6	0.91	21.49	52.28	0.28	0.69	0.62	12.11	-9.95	0.21	61.49	59.53	0.52	0.84	0.84
NO3	ALL	90	1.47	1.46	0.74	-0.75	48.33	-0.01	0.71	1.28	6.51	-19.6	-0.01	61.86	61.39	0.49	1.13	0.54
OC	WIN	22	2.01	6.52	0.77	224.62	224.62	4.51	4.51	5.99	268.15	107.43	2.25	268.15	107.43	2.25	5.13	0.59
OC	SPR	25	1.58	2.74	0.36	72.75	86.64	1.15	1.37	1.85	126.22	54.87	0.73	135.85	66.11	0.87	1.78	0.13
OC	SUM	23	2.41	2.77	0.83	14.86	26.75	0.36	0.64	0.46	25.19	17.95	0.15	32.96	26.7	0.27	0.77	0.69
OC	FAL	20	2.2	3.88	0.87	76.02	76.86	1.68	1.69	1.72	84.15	53.45	0.76	85.25	54.62	0.77	2.13	0.76
OC	ALL	90	2.04	3.92	0.53	92.65	99.45	1.89	2.02	4.92	125.75	57.97	0.93	130.65	63.59	0.99	2.91	0.28
PM-2.5	WIN	22	12.71	19.56	0.93	53.88	53.93	6.85	6.86	17.96	57.43	42.71	0.54	57.49	42.77	0.54	8.06	0.87
PM-2.5	SPR	25	10.67	10.57	0.6	-1	31.58	-0.11	3.37	17.75	9.27	1.21	-0.01	33.42	32.2	0.32	4.21	0.36
PM-2.5	SUM	23	15.65	10.81	0.66	-30.91	35.34	-4.84	5.53	35.62	-23.17	-31.66	-0.45	31.84	38.59	0.51	7.68	0.43
PM-2.5	FAL	21	12.62	14.23	0.83	12.7	25.47	1.6	3.22	14.62	17.65	12.02	0.13	28.94	25.26	0.25	4.15	0.68
PM-2.5	ALL	91	12.87	13.65	0.61	6.01	36.69	0.77	4.72	38.85	14.65	5.43	0.06	37.81	34.77	0.37	6.28	0.37
SO4	WIN	22	2.17	1.54	0.79	-28.99	33.97	-0.63	0.74	0.44	-23.22	-30.32	-0.41	31.5	37.5	0.48	0.92	0.62
SO4	SPR	25	2.08	1.75	0.78	-15.94	25.16	-0.33	0.52	0.43	-9.48	-15.14	-0.19	24.66	27.9	0.3	0.74	0.61
SO4	SUM	22	3.09	2.41	0.68	-21.9	32.75	-0.68	1.01	2.56	-10.3	-16.77	-0.28	27.36	31.4	0.42	1.74	0.47
SO4	FAL	21	1.93	1.85	0.81	-4.24	25.46	-0.08	0.49	0.42	13.37	5.23	-0.04	33.53	29.43	0.27	0.65	0.65
SO4	ALL	90	2.31	1.88	0.74	-18.6	29.72	-0.43	0.69	1.01	-7.71	-14.5	-0.23	29.06	31.46	0.37	1.09	0.55

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 350010023																		
EC	WIN	24	1.09	1.03	0.81	-5.31	36.95	-0.06	0.4	0.33	28.31	14.69	-0.06	48.96	39.84	0.39	0.58	0.66
EC	SPR	25	0.28	0.6	0.87	112.89	112.89	0.32	0.32	0.02	140.46	77.18	1.13	140.46	77.18	1.13	0.34	0.76
EC	SUM	26	0.51	0.61	0.42	18.84	62.44	0.1	0.32	0.21	61.18	36.82	0.19	71.92	52.98	0.62	0.47	0.17
EC	FAL	23	0.52	0.75	0.83	44.7	52.01	0.23	0.27	0.03	65.15	43.8	0.45	68.45	47.33	0.52	0.3	0.69
EC	ALL	98	0.6	0.74	0.76	24.72	55.04	0.15	0.33	0.17	74.29	43.34	0.25	82.96	54.61	0.55	0.44	0.58
NACL	WIN	25	0.05	0.05	0.5	15.19	58.77	0.01	0.03	0	66.19	28.82	0.15	89.16	57.95	0.59	0.03	0.25
NACL	SPR	24	0.05	0.06	0.88	23.48	34.71	0.01	0.02	0	38.12	22.9	0.23	49.81	36.68	0.35	0.02	0.78
NACL	SUM	24	0.06	0.02	0.29	-61.69	64.09	-0.04	0.04	0	-55.78	-87.31	-1.61	59.3	90.49	1.67	0.05	0.09
NACL	FAL	24	0.03	0.02	0.15	-24.59	43.7	-0.01	0.01	0	-13.69	-28.49	-0.33	43.73	48.06	0.58	0.02	0.02
NACL	ALL	97	0.05	0.04	0.47	-14.11	51.68	-0.01	0.03	0	9.3	-15.56	-0.16	60.8	58.29	0.6	0.03	0.23
NH4	WIN	25	0.33	0.37	0.86	10.92	36.49	0.04	0.12	0.02	97.86	26.04	0.11	114.44	45.02	0.36	0.15	0.74
NH4	SPR	25	0.23	0.18	0.34	-24.42	43.47	-0.06	0.1	0.03	-3.38	-13	-0.32	34.94	38.75	0.58	0.17	0.11
NH4	SUM	24	0.31	0.18	0.42	-41.79	50.01	-0.13	0.16	0.02	-25.36	-44.61	-0.72	51.52	61.44	0.86	0.2	0.18
NH4	FAL	24	0.24	0.19	0.18	-20.19	42.55	-0.05	0.1	0.02	0.65	-13.22	-0.25	45.23	44.69	0.53	0.15	0.03
NH4	ALL	98	0.28	0.23	0.59	-17.57	42.94	-0.05	0.12	0.03	18.05	-10.83	-0.21	61.8	47.36	0.52	0.17	0.35
NO3	WIN	25	1.17	0.7	0.93	-40.46	44.13	-0.47	0.52	0.35	-24.2	-37.75	-0.68	40.65	49.33	0.74	0.76	0.86
NO3	SPR	25	0.29	0.15	0.66	-47.74	50.92	-0.14	0.15	0.03	-38.28	-54.99	-0.91	42.33	58.6	0.97	0.23	0.43
NO3	SUM	24	0.24	0.12	0.26	-50.88	54.77	-0.12	0.13	0.03	-32.69	-50.72	-1.04	40.35	56.95	1.11	0.22	0.07
NO3	FAL	24	0.34	0.19	0.79	-42.05	51.34	-0.14	0.17	0.05	-23.7	-41.07	-0.73	47.63	59.55	0.89	0.26	0.62
NO3	ALL	98	0.51	0.29	0.93	-42.94	47.47	-0.22	0.24	0.14	-29.75	-46.14	-0.75	42.71	56.06	0.83	0.43	0.86
OC	WIN	24	2.31	4.75	0.87	105.74	107.77	2.44	2.49	1.06	183.99	85.63	1.06	184.49	86.15	1.08	2.65	0.75
OC	SPR	25	0.62	1.98	0.65	216.93	216.93	1.35	1.35	0.64	278.27	104.27	2.17	278.27	104.27	2.17	1.57	0.43
OC	SUM	26	2.48	2	0.38	-19.4	67.73	-0.48	1.68	12.01	47.15	22.44	-0.24	69.68	56.33	0.84	3.5	0.14
OC	FAL	23	1.05	2.34	0.73	122.24	122.24	1.29	1.29	0.51	144.82	76.81	1.22	144.82	76.81	1.22	1.47	0.54
OC	ALL	98	1.63	2.75	0.45	68.49	104.42	1.12	1.7	4.86	162.54	71.55	0.68	168.64	80.67	1.04	2.47	0.2
PM-2.5	WIN	25	8.25	13.72	0.81	66.3	74.26	5.47	6.13	12.19	102.4	58.48	0.66	106.94	63.91	0.74	6.49	0.66
PM-2.5	SPR	24	5.6	7.89	0.34	40.86	55.66	2.29	3.12	9.77	60.45	34.42	0.41	71.32	47.29	0.56	3.87	0.11
PM-2.5	SUM	24	8.73	7.41	0.25	-15.09	55.63	-1.32	4.86	71.27	40.68	10.67	-0.18	69.19	50.65	0.66	8.54	0.06
PM-2.5	FAL	24	5.55	9.4	0.54	69.44	76.18	3.85	4.23	9.21	79.93	50.31	0.69	83.71	55.21	0.76	4.91	0.29
PM-2.5	ALL	97	7.05	9.65	0.41	36.96	65.27	2.6	4.6	31.8	71.19	38.68	0.37	83.04	54.37	0.65	6.21	0.17
SO4	WIN	25	0.4	0.6	0.38	51.93	60.48	0.21	0.24	0.03	69.93	44.89	0.52	74.57	50.28	0.6	0.27	0.14
SO4	SPR	25	0.66	0.59	0.58	-10.92	37.87	-0.07	0.25	0.16	8.44	0.86	-0.12	33.46	32.47	0.43	0.41	0.34
SO4	SUM	24	0.9	0.54	0.53	-40.67	40.67	-0.37	0.37	0.1	-38.13	-50.84	-0.69	38.13	50.84	0.69	0.49	0.28
SO4	FAL	24	0.65	0.54	0.11	-17.59	39.52	-0.11	0.26	0.12	-2.16	-11.89	-0.21	37.89	40.27	0.48	0.36	0.01
SO4	ALL	98	0.65	0.57	0.33	-12.91	42.74	-0.08	0.28	0.14	10.13	-3.69	-0.15	46.17	43.42	0.49	0.39	0.11

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 360010005																		
EC	WIN	27	0.93	0.98	0.77	5.12	45.39	0.05	0.42	0.25	66.49	28.72	0.05	86.21	52.45	0.45	0.5	0.6
EC	SPR	28	0.44	0.56	0.56	26.88	50	0.12	0.22	0.06	55.69	29.54	0.27	72.52	50.67	0.5	0.26	0.32
EC	SUM	28	0.84	0.54	0.74	-35.25	37.34	-0.3	0.31	0.07	-26.98	-35.47	-0.54	32.19	40.14	0.58	0.4	0.55
EC	FAL	30	0.83	0.68	0.6	-18.03	37.13	-0.15	0.31	0.15	8.43	-5.47	-0.22	42.3	39.12	0.45	0.42	0.36
EC	ALL	113	0.76	0.69	0.65	-9.53	41.46	-0.07	0.31	0.16	25.24	3.94	-0.11	57.78	45.42	0.46	0.4	0.42
NACL	WIN	28	0.22	0.12	0.17	-44.93	81.91	-0.1	0.18	0.1	67.19	4.18	-0.82	113.27	76.57	1.49	0.34	0.03
NACL	SPR	28	0.09	0.11	0.8	28.78	55.44	0.02	0.05	0	65.15	25.38	0.29	85.06	50.53	0.55	0.07	0.64
NACL	SUM	26	0.04	0.05	0.65	3.82	64.29	0	0.03	0	5.59	-20.66	0.04	62.28	57.51	0.64	0.04	0.42
NACL	FAL	28	0.06	0.08	0.56	47.42	69.27	0.03	0.04	0	64.09	25.24	0.47	83.76	50.43	0.69	0.06	0.32
NACL	ALL	110	0.1	0.09	0.33	-11.58	72.76	-0.01	0.07	0.03	51.32	9.06	-0.13	86.53	58.78	0.82	0.18	0.11
NH4	WIN	28	1.17	0.96	0.74	-17.79	34.45	-0.21	0.4	0.26	3.38	-9.04	-0.22	40.47	38.83	0.42	0.55	0.54
NH4	SPR	28	0.52	0.68	0.68	31.23	47.01	0.16	0.24	0.1	74.22	28.51	0.31	85.88	42.54	0.47	0.35	0.46
NH4	SUM	28	0.52	0.55	0.76	6.52	44.68	0.03	0.23	0.09	68.37	23.19	0.07	90.66	51.82	0.45	0.3	0.58
NH4	FAL	27	0.45	0.67	0.77	49.3	62.07	0.22	0.28	0.09	177.89	58.03	0.49	184.82	65.95	0.62	0.38	0.59
NH4	ALL	111	0.66	0.72	0.74	7.6	43.45	0.05	0.29	0.16	80.09	24.88	0.08	99.7	49.64	0.43	0.41	0.55
NO3	WIN	28	2.42	2.02	0.69	-16.64	39.21	-0.4	0.95	1.48	-1.57	-16.75	-0.2	46.78	46.67	0.47	1.28	0.48
NO3	SPR	29	0.65	0.61	0.66	-5.43	55.21	-0.04	0.36	0.29	-5.69	-30.57	-0.06	55.97	62.99	0.58	0.54	0.44
NO3	SUM	28	0.32	0.11	0.4	-66.22	67.1	-0.21	0.22	0.02	-64.22	-105.65	-1.96	65.2	106.57	1.99	0.26	0.16
NO3	FAL	28	0.55	0.68	0.44	21.91	84.74	0.12	0.47	0.49	18.68	-28.75	0.22	88.54	81.38	0.85	0.71	0.2
NO3	ALL	113	0.98	0.85	0.78	-13.41	50.55	-0.13	0.5	0.6	-13.13	-45.3	-0.15	64.05	74.3	0.58	0.79	0.61
OC	WIN	27	2.3	4.86	0.79	111.1	111.1	2.56	2.56	1.57	192.78	83.79	1.11	192.78	83.79	1.11	2.85	0.63
OC	SPR	28	1.13	2.27	0.68	102.05	108.82	1.15	1.22	1.12	136.71	63.68	1.02	142.22	69.95	1.09	1.56	0.46
OC	SUM	28	2.19	1.87	0.64	-14.69	25.88	-0.32	0.57	0.57	-9.66	-14.17	-0.17	23.02	25.43	0.3	0.82	0.41
OC	FAL	30	1.6	2.37	0.63	48.3	54.89	0.77	0.88	0.65	69.87	42.18	0.48	73.97	46.75	0.55	1.12	0.4
OC	ALL	113	1.8	2.82	0.62	56.81	71.69	1.02	1.29	2	96.1	43.49	0.57	106.64	56.06	0.72	1.74	0.38
PM-2.5	WIN	28	12.42	13.09	0.8	5.43	27.75	0.67	3.45	19.21	22.13	13.82	0.05	35.96	29.57	0.28	4.43	0.63
PM-2.5	SPR	29	6.41	7.47	0.72	16.41	35.62	1.05	2.28	6.89	21.82	13.42	0.16	38.38	33.81	0.36	2.83	0.52
PM-2.5	SUM	28	9.01	6.1	0.68	-32.27	35.45	-2.91	3.19	9.87	-26.2	-35.12	-0.48	30.35	39.02	0.52	4.28	0.46
PM-2.5	FAL	28	8.28	7.65	0.8	-7.61	26.51	-0.63	2.19	7.4	2.29	-4.19	-0.08	29.63	28.9	0.29	2.79	0.64
PM-2.5	ALL	113	9.01	8.57	0.76	-4.87	30.81	-0.44	2.77	13.2	5.16	-2.87	-0.05	33.62	32.84	0.32	3.66	0.57
SO4	WIN	28	1.7	1.17	0.61	-31.5	39.26	-0.54	0.67	0.38	-25.5	-36.19	-0.46	36.83	44.41	0.57	0.82	0.37
SO4	SPR	29	1.3	1.56	0.67	19.98	37.56	0.26	0.49	0.64	26.29	13.64	0.2	41.31	31.18	0.38	0.84	0.44
SO4	SUM	28	1.98	1.56	0.75	-21.13	32.5	-0.42	0.64	0.95	-7.03	-18.25	-0.27	33.31	37.08	0.41	1.06	0.56
SO4	FAL	28	1.5	1.44	0.9	-3.81	28.07	-0.06	0.42	0.41	13.22	4.31	-0.04	36.85	33.21	0.29	0.64	0.8
SO4	ALL	113	1.62	1.43	0.71	-11.36	34.29	-0.18	0.55	0.69	1.96	-8.92	-0.13	37.11	36.42	0.39	0.85	0.5

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 360290005																		
EC	WIN	15	0.43	0.79	0.38	81.63	83.09	0.35	0.36	0.05	96.47	59.12	0.82	97.21	59.88	0.83	0.42	0.14
EC	SPR	14	0.52	0.64	0.36	22.75	50.42	0.12	0.26	0.07	46.14	27.46	0.23	61.33	45.94	0.5	0.3	0.13
EC	SUM	16	0.84	0.62	0.43	-25.73	42.07	-0.22	0.35	0.13	1486.11	-15.48	-0.35	1537.8	51.17	0.57	0.42	0.18
EC	FAL	14	0.74	0.6	0.83	-17.75	29.49	-0.13	0.22	0.05	-2.64	-9.44	-0.22	32.02	32.26	0.36	0.26	0.69
EC	ALL	59	0.64	0.66	0.25	4.53	47.36	0.03	0.3	0.13	437.86	15.11	0.05	463.88	47.66	0.47	0.36	0.06
NACL	WIN	15	0.41	0.09	0.03	-78.82	78.85	-0.32	0.32	0.06	-66.18	-108.14	-3.72	66.32	108.27	3.72	0.41	0
NACL	SPR	12	0.1	0.06	0.38	-40.52	57.7	-0.04	0.06	0.01	0.26	-24.51	-0.68	59.21	63.24	0.97	0.09	0.15
NACL	SUM	15	0.05	0.02	0.5	-51.61	52	-0.02	0.02	0	-48.66	-69.68	-1.07	48.9	69.91	1.07	0.03	0.25
NACL	FAL	15	0.04	0.05	0.86	5.47	37.38	0	0.02	0	10.9	-0.11	0.05	41.21	36.49	0.37	0.03	0.75
NACL	ALL	57	0.15	0.05	0.48	-65	70.64	-0.1	0.11	0.04	-27.3	-51.98	-1.86	53.63	69.81	2.02	0.21	0.23
NH4	WIN	15	1.16	0.92	0.94	-20.81	28.24	-0.24	0.33	0.16	-3.75	-12	-0.26	30.76	30.44	0.36	0.47	0.88
NH4	SPR	11	0.82	0.81	0.64	-1.16	41.48	-0.01	0.34	0.26	65.83	19.83	-0.01	86.32	46.16	0.42	0.51	0.41
NH4	SUM	14	1.23	0.98	0.94	-20.44	36.13	-0.25	0.45	0.4	63.31	8.74	-0.26	92.4	43.84	0.45	0.68	0.88
NH4	FAL	15	0.45	0.55	0.78	22.19	48.7	0.1	0.22	0.08	95.19	41.24	0.22	103.46	51.26	0.49	0.3	0.61
NH4	ALL	55	0.92	0.81	0.89	-11.39	36.05	-0.1	0.33	0.25	54.22	14.16	-0.13	77.39	42.67	0.41	0.51	0.79
NO3	WIN	15	2.77	1.99	0.92	-28.2	32.25	-0.78	0.89	0.51	-26.9	-35.67	-0.39	32.96	41.1	0.45	1.06	0.84
NO3	SPR	12	1.44	1.22	0.52	-14.72	59.55	-0.21	0.86	1.73	12.41	-25.22	-0.17	75.91	60.95	0.7	1.33	0.27
NO3	SUM	14	0.61	0.14	0.91	-76.31	76.31	-0.46	0.46	0.11	-78	-129.45	-3.22	78	129.45	3.22	0.57	0.83
NO3	FAL	15	0.77	0.49	0.76	-36.1	43.95	-0.28	0.34	0.1	-34.65	-63.38	-0.56	53.66	76.28	0.69	0.42	0.58
NO3	ALL	56	1.41	0.96	0.84	-31.58	44.68	-0.44	0.63	0.61	-33.33	-64.3	-0.46	58.97	76.87	0.65	0.9	0.71
OC	WIN	15	1.05	3.13	0.7	196.91	196.91	2.07	2.07	0.71	211.58	98.09	1.97	211.58	98.09	1.97	2.24	0.49
OC	SPR	14	0.93	1.93	0.52	107.84	109.04	1	1.01	0.4	138.24	70.97	1.08	139.15	71.9	1.09	1.18	0.27
OC	SUM	15	1.92	1.75	0.8	-9.09	25.12	-0.17	0.48	0.33	-0.88	-6.03	-0.1	27	27.57	0.28	0.6	0.63
OC	FAL	14	1.3	1.58	0.87	21.55	31.33	0.28	0.41	0.11	40.38	27.79	0.22	46.84	34.85	0.31	0.43	0.75
OC	ALL	58	1.31	2.11	0.28	61.25	76.81	0.8	1	1.13	97.61	47.65	0.61	106.59	58.27	0.77	1.33	0.08
PM-2.5	WIN	15	11.65	10.23	0.85	-12.12	19.95	-1.41	2.32	5.56	-8.86	-12.36	-0.14	21.37	23.33	0.23	2.75	0.72
PM-2.5	SPR	12	7.23	7.6	0.65	5.2	37.86	0.38	2.74	11.23	31.04	17.69	0.05	49.69	40.9	0.38	3.37	0.42
PM-2.5	SUM	16	15.53	8.87	0.64	-42.88	49.13	-6.66	7.63	54.6	354.89	-32.4	-0.75	425.27	64.63	0.86	9.95	0.41
PM-2.5	FAL	15	7.22	6.17	0.8	-14.56	18.94	-1.05	1.37	3.11	-10.96	-14.08	-0.17	17.5	19.94	0.22	2.05	0.64
PM-2.5	ALL	58	10.66	8.26	0.67	-22.48	34.01	-2.4	3.63	26.95	99.2	-12.12	-0.29	137.65	37.48	0.44	5.72	0.45
SO4	WIN	15	1.72	1.06	0.85	-38.56	39.37	-0.66	0.68	0.31	-32.76	-43	-0.63	34.84	44.95	0.64	0.87	0.72
SO4	SPR	12	1.37	1.2	0.85	-12.21	26.2	-0.17	0.36	0.22	43.18	1.01	-0.14	73.2	36.17	0.3	0.49	0.71
SO4	SUM	15	3.61	3.17	0.93	-11.95	24.02	-0.43	0.87	1.48	216.59	1.93	-0.14	244.75	34.68	0.27	1.29	0.87
SO4	FAL	15	1.48	1.31	0.96	-11.59	25.11	-0.17	0.37	0.35	4.92	-0.05	-0.13	26.71	26.12	0.28	0.62	0.91
SO4	ALL	57	2.08	1.71	0.93	-17.71	27.87	-0.37	0.58	0.65	58.76	-10.61	-0.22	96.01	35.44	0.34	0.89	0.87

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 360310003																		
EC	WIN	15	0.12	0.2	0.72	70.67	74.62	0.08	0.09	0.01	82.63	52.45	0.71	84.23	54.15	0.75	0.13	0.52
EC	SPR	15	0.09	0.1	0.74	9.77	38.44	0.01	0.04	0	43.04	10.34	0.1	70.68	50.04	0.38	0.05	0.55
EC	SUM	15	0.18	0.11	0.52	-41.45	49.6	-0.07	0.09	0.01	-32.59	-49.18	-0.71	47.63	61.2	0.85	0.13	0.27
EC	FAL	15	0.11	0.13	0.39	15.53	45.19	0.02	0.05	0	56.75	21.16	0.16	78.18	45.37	0.45	0.06	0.15
EC	ALL	60	0.12	0.13	0.45	6.99	52.43	0.01	0.07	0.01	37.45	8.69	0.07	70.18	52.69	0.52	0.1	0.2
NACL	WIN	14	0.08	0.04	0.04	-48.43	71.03	-0.04	0.06	0.02	9.61	-6.77	-0.94	44.03	46.94	1.38	0.16	0
NACL	SPR	11	0.05	0.07	0.07	35.74	112.22	0.02	0.06	0.01	75.65	-10.08	0.36	126.51	65.2	1.12	0.12	0.01
NACL	SUM	12	0.04	0.01	0.04	-63.84	70.52	-0.03	0.03	0	-13.16	-53.7	-1.77	76.58	86.08	1.95	0.06	0
NACL	FAL	15	0.04	0.03	0.3	-23.48	76.93	-0.01	0.03	0	637.79	-26.77	-0.31	705.62	79.92	1.01	0.05	0.09
NACL	ALL	52	0.05	0.04	0.03	-28.14	80.79	-0.02	0.04	0.01	199.53	-24.07	-0.39	259.83	69.35	1.12	0.1	0
NH4	WIN	15	0.38	0.49	0.87	29.72	42.35	0.11	0.16	0.03	107	36.58	0.3	115.45	46	0.42	0.22	0.76
NH4	SPR	11	0.29	0.36	0.77	25.25	32.63	0.07	0.09	0.01	62.48	30.28	0.25	68.7	37.06	0.33	0.12	0.59
NH4	SUM	13	0.25	0.43	0.87	69.29	82.59	0.18	0.21	0.07	287.76	84.11	0.69	290.45	87.05	0.83	0.31	0.76
NH4	FAL	14	0.21	0.37	0.67	73.52	82.37	0.16	0.17	0.03	790	77.2	0.74	794.2	81.8	0.82	0.24	0.45
NH4	ALL	53	0.29	0.42	0.83	45.95	56.88	0.13	0.16	0.04	322.52	57.66	0.46	327.96	63.67	0.57	0.23	0.69
NO3	WIN	15	0.48	0.9	0.69	89.9	118.37	0.43	0.56	0.74	90.34	24.1	0.9	128.16	79.4	1.18	0.96	0.47
NO3	SPR	12	0.27	0.27	0.15	-2.41	91.73	-0.01	0.25	0.08	22.33	-36.2	-0.02	106.86	105.34	0.94	0.28	0.02
NO3	SUM	12	0.08	0.05	0.95	-43.11	49.54	-0.04	0.04	0	-57.43	-91.95	-0.76	59.52	93.92	0.87	0.05	0.91
NO3	FAL	15	0.21	0.14	0.28	-31.9	75.84	-0.07	0.16	0.04	-19.18	-52.34	-0.47	70.23	86.27	1.11	0.21	0.08
NO3	ALL	54	0.27	0.36	0.69	33.69	98.43	0.09	0.27	0.28	11.97	-36.32	0.34	92.08	90.3	0.98	0.53	0.47
OC	WIN	12	0.47	1.4	0.79	198.16	198.16	0.93	0.93	0.36	348.31	106.89	1.98	348.31	106.89	1.98	1.11	0.62
OC	SPR	13	0.3	0.64	0.69	110.36	121.23	0.34	0.37	0.07	260.01	82.67	1.1	269.08	95.53	1.21	0.42	0.47
OC	SUM	15	1.71	1	0.45	-41.39	52.02	-0.71	0.89	3.91	-23.57	-35.21	-0.71	36.6	46.52	0.89	2.1	0.2
OC	FAL	14	0.42	0.75	0.69	78.37	78.82	0.33	0.33	0.05	301.37	74.04	0.78	301.58	74.26	0.79	0.4	0.48
OC	ALL	54	0.76	0.94	0.36	23.12	82.53	0.18	0.63	1.55	211.58	53.07	0.23	230.54	78.93	0.83	1.26	0.13
PM-2.5	WIN	15	4.03	4.51	0.68	11.95	42.94	0.48	1.73	5.8	27.92	9.16	0.12	53.23	40.5	0.43	2.46	0.46
PM-2.5	SPR	12	3.49	2.99	0.48	-14.27	26.58	-0.5	0.93	1.37	-2.38	-11.68	-0.17	31.67	32.13	0.31	1.27	0.23
PM-2.5	SUM	15	8.49	3.88	0.51	-54.28	59.22	-4.61	5.03	24.19	-54.84	-81.91	-1.19	57.94	84.7	1.3	6.74	0.26
PM-2.5	FAL	15	4.41	3.17	0.71	-28.06	40.52	-1.24	1.79	4.82	-7.38	-18.18	-0.39	39.3	42.61	0.56	2.52	0.5
PM-2.5	ALL	57	5.19	3.67	0.48	-29.22	47.09	-1.52	2.44	13.25	-9.53	-26.39	-0.41	46.27	50.92	0.67	3.94	0.23
SO4	WIN	15	1.13	0.81	0.91	-28.26	33.01	-0.32	0.37	0.12	-15.98	-22.75	-0.39	30.48	34.97	0.46	0.47	0.83
SO4	SPR	12	0.92	1.02	0.39	10.6	34.55	0.1	0.32	0.16	41.9	14.22	0.11	61.36	37.94	0.35	0.41	0.15
SO4	SUM	14	1.28	1.49	0.79	16.11	52.03	0.21	0.67	1.35	374.19	16.91	0.16	398.36	46.55	0.52	1.18	0.62
SO4	FAL	15	0.95	1.14	0.91	19.66	30.58	0.19	0.29	0.14	50.08	28.57	0.2	58.79	38.19	0.31	0.42	0.84
SO4	ALL	56	1.08	1.11	0.78	3.44	38.38	0.04	0.41	0.49	111.66	8.83	0.03	136.65	39.37	0.38	0.7	0.61

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 360551007																		
EC	WIN	23	0.46	0.8	0.81	75.08	79.96	0.34	0.37	0.05	110.89	65.79	0.75	112.12	67.1	0.8	0.41	0.65
EC	SPR	29	0.3	0.5	0.52	64.34	69.83	0.2	0.21	0.04	85.64	48.1	0.64	89.45	52.84	0.7	0.27	0.27
EC	SUM	26	0.53	0.5	0.72	-5.39	23.5	-0.03	0.12	0.02	2.55	-1.24	-0.06	24.08	24.08	0.25	0.15	0.52
EC	FAL	28	0.56	0.61	0.72	8.75	34.54	0.05	0.19	0.05	40.08	20.27	0.09	57.02	40.03	0.35	0.22	0.52
EC	ALL	106	0.46	0.59	0.63	29.15	47.62	0.13	0.22	0.06	58.7	32.49	0.29	69.77	45.5	0.48	0.28	0.4
NACL	WIN	25	0.15	0.1	0.14	-35.06	60.74	-0.05	0.09	0.03	19.52	-4.66	-0.54	60	54.54	0.94	0.17	0.02
NACL	SPR	29	0.05	0.06	0.19	29.69	70.49	0.01	0.04	0	73.88	23.97	0.3	102.94	62.83	0.7	0.04	0.03
NACL	SUM	29	0.04	0.02	0.05	-47.69	61.27	-0.02	0.02	0	-13.61	-63.27	-0.91	82.37	74.83	1.17	0.03	0
NACL	FAL	27	0.06	0.06	0.33	-2.51	70.25	0	0.04	0	20.34	-9.92	-0.03	68.6	61.46	0.72	0.07	0.11
NACL	ALL	110	0.07	0.06	0.31	-18.07	64.6	-0.01	0.05	0.01	25.32	-13.86	-0.22	79.33	63.78	0.79	0.09	0.09
NH4	WIN	25	1.16	1	0.77	-14.01	36.63	-0.16	0.43	0.4	15.88	3.74	-0.16	42.42	36.98	0.43	0.65	0.59
NH4	SPR	28	0.65	1	0.45	53.83	77.32	0.35	0.5	0.49	191.15	43.59	0.54	209.35	65.32	0.77	0.78	0.2
NH4	SUM	29	0.71	0.81	0.65	14.98	49.99	0.11	0.35	0.36	113.66	37.17	0.15	126.94	56.59	0.5	0.61	0.42
NH4	FAL	25	0.59	0.85	0.85	45.39	57.46	0.27	0.34	0.11	189.87	63.01	0.45	194.96	68.68	0.57	0.42	0.71
NH4	ALL	107	0.77	0.91	0.62	18.73	52.63	0.14	0.41	0.38	128.9	37.08	0.19	144.65	57.12	0.53	0.63	0.39
NO3	WIN	25	2.52	2.1	0.72	-16.45	37.04	-0.41	0.93	1.77	-2.56	-12.99	-0.2	38.07	39.32	0.44	1.39	0.51
NO3	SPR	29	1	1.29	0.47	29.37	72.67	0.29	0.73	1.69	71.7	-1.62	0.29	116.8	64.42	0.73	1.33	0.22
NO3	SUM	29	0.39	0.19	0.36	-50.87	70.19	-0.2	0.28	0.13	-12.02	-75.94	-1.04	98.18	94.51	1.43	0.42	0.13
NO3	FAL	27	0.78	0.88	0.7	12.89	57.33	0.1	0.45	0.4	34.87	2.03	0.13	73.78	57.38	0.57	0.64	0.5
NO3	ALL	110	1.13	1.09	0.7	-3.97	51.83	-0.04	0.59	1.05	23.71	-22.9	-0.04	83.44	64.92	0.54	1.03	0.48
OC	WIN	23	1.24	3.95	0.83	217.86	217.86	2.71	2.71	1.09	285.27	110.67	2.18	285.27	110.67	2.18	2.9	0.69
OC	SPR	29	0.77	2.01	0.47	161.21	163.18	1.24	1.25	0.75	221.34	87.04	1.61	222.62	88.45	1.63	1.51	0.23
OC	SUM	26	1.72	1.68	0.74	-2.09	24.22	-0.04	0.42	0.3	4.61	0.31	-0.02	24.38	24	0.25	0.55	0.54
OC	FAL	28	1.14	2.07	0.72	82.56	85.16	0.94	0.97	0.52	157.91	67.27	0.83	159.01	68.46	0.85	1.18	0.52
OC	ALL	106	1.2	2.37	0.49	97.01	107.23	1.17	1.29	1.54	165.3	65.67	0.97	170.79	72.18	1.07	1.7	0.24
PM-2.5	WIN	25	10.38	11.59	0.84	11.65	26.61	1.21	2.76	11.25	24.36	17.85	0.12	31.56	26.16	0.27	3.56	0.71
PM-2.5	SPR	28	6.47	8.52	0.62	31.61	43.11	2.05	2.79	12.38	37.72	22.38	0.32	47.28	33.82	0.43	4.07	0.39
PM-2.5	SUM	28	11.28	7.55	0.47	-33.01	40.1	-3.72	4.52	26.85	-23.82	-39	-0.49	42	47.39	0.6	6.38	0.22
PM-2.5	FAL	27	7.94	8.25	0.88	3.89	27.29	0.31	2.17	6.69	21.26	12.45	0.04	36.94	30.89	0.27	2.6	0.77
PM-2.5	ALL	108	8.99	8.91	0.63	-0.86	34.23	-0.08	3.08	19.48	14.56	2.94	-0.01	39.68	34.83	0.35	4.41	0.4
SO4	WIN	25	1.61	1.17	0.84	-27.42	32.23	-0.44	0.52	0.28	-21.6	-27.68	-0.38	28.01	33.58	0.44	0.69	0.7
SO4	SPR	29	1.42	1.73	0.73	22.03	48.19	0.31	0.68	0.92	30.51	9.58	0.22	55.84	39.93	0.48	1.01	0.53
SO4	SUM	29	2.37	2.25	0.68	-5.18	35.48	-0.12	0.84	2.58	21.86	-5.35	-0.05	52.03	34.5	0.37	1.61	0.46
SO4	FAL	27	1.61	1.66	0.94	3.55	24.49	0.06	0.39	0.31	18.99	11.35	0.04	32.89	28.24	0.24	0.56	0.88
SO4	ALL	110	1.76	1.72	0.75	-2.06	35.04	-0.04	0.62	1.14	13.56	-2.39	-0.02	42.88	34.19	0.36	1.07	0.56

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 360610134																		
EC	WIN	20	1.28	3.74	0.76	191.37	191.37	2.45	2.45	1.2	210.86	97.79	1.91	210.86	97.79	1.91	2.69	0.57
EC	SPR	26	1.07	2.17	0.51	103.79	103.79	1.11	1.11	0.68	121.9	64.25	1.04	121.9	64.25	1.04	1.38	0.26
EC	SUM	26	1.47	2.32	0.56	57.99	61.08	0.85	0.9	0.78	81.53	46.31	0.58	83.54	48.51	0.61	1.23	0.31
EC	FAL	18	1.47	3.21	0.89	118.72	118.72	1.74	1.74	1.15	126.2	73.47	1.19	126.2	73.47	1.19	2.04	0.78
EC	ALL	90	1.31	2.77	0.62	111.35	112.35	1.46	1.47	1.3	130.86	68.36	1.11	131.44	69	1.12	1.85	0.38
NACL	WIN	26	0.2	0.34	0.09	71.47	143.1	0.14	0.28	0.14	252.08	82.5	0.71	267.01	105.49	1.43	0.41	0.01
NACL	SPR	31	0.23	0.53	0.98	127.41	134.84	0.3	0.31	0.87	141.62	59.89	1.27	146.03	65.14	1.35	0.98	0.95
NACL	SUM	30	0.12	0.24	0.19	105.06	134.45	0.12	0.16	0.13	112.22	23.35	1.05	136.37	53.43	1.34	0.38	0.03
NACL	FAL	22	0.1	0.22	0.71	123.35	131.28	0.12	0.13	0.03	120.57	56.92	1.23	128.96	66.7	1.31	0.22	0.51
NACL	ALL	109	0.17	0.34	0.8	106.6	136.69	0.18	0.23	0.33	155.63	54.63	1.07	168.78	71.86	1.37	0.6	0.63
NH4	WIN	26	1.46	1.53	0.79	4.53	28.69	0.07	0.42	0.26	20.51	11.51	0.05	37.32	30.94	0.29	0.52	0.63
NH4	SPR	31	1.02	0.93	0.76	-8.74	32.78	-0.09	0.34	0.25	3.46	-7.77	-0.1	35.49	36.61	0.36	0.51	0.58
NH4	SUM	29	1.1	0.78	0.67	-28.64	41.82	-0.31	0.46	0.48	3.34	-16.52	-0.4	52.15	48.48	0.59	0.76	0.45
NH4	FAL	22	1.01	1.13	0.83	12.02	34.88	0.12	0.35	0.16	56.27	24.55	0.12	70.08	40.66	0.35	0.41	0.69
NH4	ALL	108	1.15	1.08	0.73	-6.06	34.23	-0.07	0.39	0.32	18.29	1.1	-0.06	47.45	39.26	0.36	0.57	0.54
NO3	WIN	26	2.72	2.84	0.74	4.43	28.64	0.12	0.78	1.42	14.32	2.18	0.04	37.48	31.93	0.29	1.2	0.54
NO3	SPR	31	1.61	1.2	0.68	-25.66	51.22	-0.41	0.83	1.79	-0.13	-19.43	-0.35	51.22	51.07	0.69	1.4	0.46
NO3	SUM	30	0.91	0.43	0.46	-52.74	63.31	-0.48	0.57	0.62	-44.55	-74.45	-1.12	58.76	85.31	1.34	0.92	0.22
NO3	FAL	22	1.55	1.59	0.9	2.09	42.81	0.03	0.67	0.64	-3.34	-22.31	0.02	51.4	56.57	0.43	0.8	0.81
NO3	ALL	109	1.67	1.46	0.74	-12.81	42.68	-0.21	0.71	1.22	-9.56	-30	-0.15	50.05	57.04	0.49	1.12	0.55
OC	WIN	20	2.56	10.36	0.78	304.86	304.86	7.8	7.8	12.15	309.68	118.13	3.05	309.68	118.13	3.05	8.54	0.61
OC	SPR	26	2.2	4.42	0.48	101.29	103.04	2.22	2.26	2.65	125.15	64.29	1.01	126.2	65.4	1.03	2.76	0.23
OC	SUM	26	2.76	4.23	0.66	53.64	55.67	1.48	1.53	1.51	60.7	40.83	0.54	62.74	42.97	0.56	1.92	0.43
OC	FAL	18	2.76	6.12	0.83	121.98	121.98	3.36	3.36	3.83	129.92	73.99	1.22	129.92	73.99	1.22	3.89	0.69
OC	ALL	90	2.55	6.03	0.5	136.27	137.34	3.48	3.5	10.43	148.49	71.42	1.36	149.38	72.36	1.37	4.74	0.25
PM-2.5	WIN	26	14.22	27.89	0.84	96.17	96.17	13.67	13.67	44.38	104.7	64.45	0.96	104.7	64.45	0.96	15.21	0.7
PM-2.5	SPR	31	11.6	14.82	0.58	27.83	44.24	3.23	5.13	26.47	40.62	24.97	0.28	52.83	39.66	0.44	6.07	0.33
PM-2.5	SUM	30	14.39	14.15	0.66	-1.68	22.02	-0.24	3.17	23.76	6.33	0.32	-0.02	24.24	21.55	0.22	4.88	0.43
PM-2.5	FAL	22	12.39	19.03	0.78	53.55	56.99	6.63	7.06	31.44	74.03	44.96	0.54	76.4	47.51	0.57	8.69	0.6
PM-2.5	ALL	109	13.15	18.6	0.6	41.46	53.37	5.45	7.02	57.73	53.21	31.64	0.41	62.09	42.17	0.53	9.35	0.36
SO4	WIN	26	2.4	2.3	0.63	-4.29	28.13	-0.1	0.68	0.96	7.1	1.55	-0.04	29.42	29.07	0.29	0.99	0.4
SO4	SPR	31	2.15	2.15	0.81	0.01	21.42	0	0.46	0.41	3.99	0.04	0	23.02	21.85	0.21	0.64	0.66
SO4	SUM	30	3.02	2.35	0.77	-22.14	32.31	-0.67	0.98	1.92	-9.93	-17.86	-0.28	30.78	33.97	0.42	1.54	0.59
SO4	FAL	22	2.39	2.28	0.81	-4.4	22.78	-0.1	0.54	0.61	11.65	3.46	-0.05	31.1	26.52	0.24	0.79	0.66
SO4	ALL	109	2.5	2.27	0.75	-9.2	26.85	-0.23	0.67	1.07	2.45	-3.84	-0.1	28.31	27.85	0.3	1.06	0.56

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 360810124																		
EC	WIN	29	0.99	2.93	0.77	195.73	195.73	1.94	1.94	0.94	214.96	97.8	1.96	214.96	97.8	1.96	2.17	0.59
EC	SPR	29	0.59	1.45	0.69	144.95	144.95	0.86	0.86	0.28	164.36	83.7	1.45	164.36	83.7	1.45	1.01	0.47
EC	SUM	31	0.93	1.67	0.66	79.9	88.2	0.74	0.82	0.31	116.39	60.41	0.8	120.5	65.34	0.88	0.93	0.44
EC	FAL	29	0.93	2.23	0.81	138.73	138.73	1.29	1.29	0.49	155.24	81.92	1.39	155.24	81.92	1.39	1.47	0.65
EC	ALL	118	0.86	2.06	0.71	139.24	141.59	1.2	1.22	0.72	161.95	80.61	1.39	163.03	81.91	1.42	1.47	0.51
NACL	WIN	26	0.15	0.24	0.46	58.93	87.81	0.09	0.13	0.02	137.14	51.2	0.59	151.55	71.38	0.88	0.17	0.21
NACL	SPR	30	0.24	0.46	0.97	89.81	104.46	0.22	0.25	0.76	94.98	33.35	0.9	108.57	51.08	1.04	0.9	0.95
NACL	SUM	29	0.1	0.2	0.14	99.89	150.26	0.1	0.15	0.1	144.35	30.9	1	168.12	60.77	1.5	0.33	0.02
NACL	FAL	29	0.12	0.19	0.79	61.62	80.83	0.07	0.1	0.02	70.11	35.64	0.62	84.23	52.78	0.81	0.17	0.63
NACL	ALL	114	0.15	0.28	0.91	79.16	103.83	0.12	0.16	0.24	110.82	37.38	0.79	127.33	58.61	1.04	0.5	0.83
NH4	WIN	27	1.38	1.46	0.57	5.81	31.66	0.08	0.44	0.49	113.84	10.47	0.06	132.65	32.22	0.32	0.7	0.33
NH4	SPR	30	0.83	0.85	0.87	1.95	28.51	0.02	0.24	0.09	13.55	-0.93	0.02	42.37	37.52	0.29	0.29	0.75
NH4	SUM	29	0.85	0.71	0.73	-16.07	36.46	-0.14	0.31	0.26	23.53	-2.1	-0.19	61.79	48.41	0.43	0.52	0.54
NH4	FAL	29	0.77	0.92	0.85	18.73	36.33	0.14	0.28	0.12	83.41	33.75	0.19	89.92	41.31	0.36	0.38	0.72
NH4	ALL	115	0.95	0.98	0.76	2.63	32.98	0.03	0.31	0.24	57.23	10.2	0.03	80.45	39.98	0.33	0.49	0.57
NO3	WIN	27	2.53	2.79	0.52	10.4	39.66	0.26	1	2.54	91.14	7.71	0.1	117.6	43.47	0.4	1.62	0.27
NO3	SPR	30	1.2	1.03	0.67	-14.17	50.09	-0.17	0.6	0.8	5.67	-18.97	-0.17	58.8	56.53	0.58	0.91	0.45
NO3	SUM	30	0.67	0.32	0.43	-51.39	64.27	-0.34	0.43	0.37	-41.26	-74.55	-1.06	61.37	87.03	1.32	0.7	0.18
NO3	FAL	29	1.24	1.16	0.85	-6.17	40.22	-0.08	0.5	0.45	-7.89	-28.32	-0.07	49.7	53.25	0.43	0.68	0.73
NO3	ALL	116	1.38	1.29	0.73	-6.56	45.2	-0.09	0.62	1.06	10.04	-29.47	-0.07	70.88	60.56	0.48	1.03	0.53
OC	WIN	29	1.66	8.23	0.79	396.46	396.46	6.57	6.57	7.96	438.16	133.16	3.96	438.16	133.16	3.96	7.15	0.63
OC	SPR	29	1.21	3.25	0.67	169.49	169.49	2.04	2.04	1.27	226.42	97.23	1.69	226.42	97.23	1.69	2.33	0.45
OC	SUM	31	2.06	3.4	0.8	64.71	65.6	1.33	1.35	0.75	82.81	51.23	0.65	83.95	52.43	0.66	1.59	0.64
OC	FAL	29	1.75	4.31	0.83	146.74	146.74	2.56	2.56	1.88	179.84	88.77	1.47	179.84	88.77	1.47	2.91	0.69
OC	ALL	118	1.68	4.77	0.52	184.95	185.24	3.1	3.1	7.05	229.28	91.9	1.85	229.58	92.21	1.85	4.08	0.28
PM-2.5	WIN	26	12.6	23.4	0.91	85.75	85.75	10.8	10.8	27.76	92.3	60.45	0.86	92.3	60.45	0.86	12.02	0.82
PM-2.5	SPR	30	8.72	11.62	0.71	33.3	43.54	2.9	3.8	14.46	45.11	28.38	0.33	54.23	38.99	0.44	4.78	0.5
PM-2.5	SUM	29	12.06	11.15	0.78	-7.47	23.04	-0.9	2.78	14.7	3.09	-3.28	-0.08	28.22	27.68	0.25	3.94	0.61
PM-2.5	FAL	28	10.25	14.84	0.72	44.72	52.87	4.59	5.42	22.92	56.99	39.27	0.45	61.55	45.76	0.53	6.63	0.52
PM-2.5	ALL	113	10.85	15.01	0.7	38.36	51.16	4.16	5.55	36.87	48.13	30.33	0.38	58.13	42.7	0.51	7.36	0.48
SO4	WIN	27	2.15	2	0.55	-6.97	24.08	-0.15	0.52	0.61	29.44	-5.17	-0.07	55.54	25.84	0.26	0.79	0.31
SO4	SPR	30	1.99	1.98	0.86	-0.4	20.45	-0.01	0.41	0.29	2.09	-2.7	0	23.62	23.16	0.21	0.53	0.73
SO4	SUM	31	2.54	2.2	0.72	-13.42	34.14	-0.34	0.87	1.9	177.72	-6.52	-0.16	211.68	36.87	0.39	1.42	0.52
SO4	FAL	29	1.89	1.93	0.86	2.22	20.34	0.04	0.38	0.3	12.65	7.18	0.02	25.4	21.74	0.2	0.55	0.74
SO4	ALL	117	2.15	2.03	0.75	-5.43	25.56	-0.12	0.55	0.82	57.55	-1.83	-0.06	81.26	27.06	0.27	0.91	0.56

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 361010003																		
EC	WIN	19	0.21	0.3	0.8	39.93	44.43	0.09	0.1	0.01	52.04	35.62	0.4	53.95	37.62	0.44	0.12	0.64
EC	SPR	25	0.16	0.19	0.78	16.57	37.95	0.03	0.06	0	29.85	16.17	0.17	49.35	39.41	0.38	0.07	0.6
EC	SUM	27	0.25	0.18	0.64	-28.82	36.64	-0.07	0.09	0.01	-15.68	-26.9	-0.4	37.53	41.57	0.51	0.12	0.4
EC	FAL	22	0.24	0.23	0.85	-6.21	26.61	-0.01	0.06	0.01	9.38	2.46	-0.07	32.77	29.94	0.28	0.08	0.73
EC	ALL	93	0.22	0.22	0.67	0.22	35.85	0	0.08	0.01	16.32	4.39	0	42.94	37.43	0.36	0.1	0.45
NACL	WIN	28	0.04	0.06	0.57	41.49	67.25	0.02	0.03	0	81.54	37.99	0.41	98.05	57.45	0.67	0.03	0.33
NACL	SPR	29	0.04	0.06	0.32	48.78	74.95	0.02	0.03	0	110.35	38.93	0.49	130.1	63.77	0.75	0.04	0.1
NACL	SUM	28	0.04	0.02	0.56	-56.29	60.75	-0.02	0.03	0	-28.63	-64.99	-1.29	63.7	79.48	1.39	0.04	0.32
NACL	FAL	25	0.04	0.06	0.66	53.59	86.31	0.02	0.03	0	303.98	15.15	0.54	335.73	54.37	0.86	0.06	0.43
NACL	ALL	110	0.04	0.05	0.44	19.78	71.69	0.01	0.03	0	111.65	6.84	0.2	151.77	64.02	0.72	0.04	0.19
NH4	WIN	29	0.8	0.79	0.76	-0.79	28.39	-0.01	0.23	0.1	39.61	11.14	-0.01	59.65	35.16	0.29	0.31	0.57
NH4	SPR	26	0.58	0.88	0.22	52.21	71.26	0.3	0.41	0.4	73.75	35.41	0.52	84.64	48.79	0.71	0.7	0.05
NH4	SUM	29	0.66	0.75	0.82	13.81	42.31	0.09	0.28	0.12	77.58	34.24	0.14	90.69	49.85	0.42	0.36	0.68
NH4	FAL	26	0.43	0.71	0.84	64.63	79.49	0.28	0.34	0.09	422.54	85.12	0.65	425.65	88.54	0.79	0.42	0.7
NH4	ALL	110	0.62	0.78	0.63	25.65	50.06	0.16	0.31	0.19	148.2	40.45	0.26	160.25	54.87	0.5	0.46	0.4
NO3	WIN	29	1.32	1.54	0.24	16.21	59.59	0.21	0.79	0.95	71.04	18.67	0.16	100.49	60.51	0.6	1	0.06
NO3	SPR	29	0.67	1.13	0.33	68.78	99.58	0.46	0.67	1.82	116.13	35.57	0.69	135.56	59.8	1	1.43	0.11
NO3	SUM	29	0.2	0.14	0.27	-30	66.96	-0.06	0.13	0.02	-13.81	-46.32	-0.43	67.63	82.67	0.96	0.17	0.07
NO3	FAL	28	0.36	0.63	0.45	75.72	105.67	0.27	0.38	0.31	94.02	21.67	0.76	126.6	65.04	1.06	0.62	0.2
NO3	ALL	115	0.64	0.86	0.49	34.71	77.04	0.22	0.49	0.81	66.61	7.28	0.35	107.41	67.03	0.77	0.93	0.24
OC	WIN	19	0.81	1.41	0.71	74.25	82.73	0.6	0.67	0.22	160.23	69.24	0.74	163.66	73.19	0.83	0.76	0.5
OC	SPR	24	0.52	0.91	0.63	76.04	84.75	0.39	0.44	0.16	116.1	58.79	0.76	121.43	64.78	0.85	0.56	0.4
OC	SUM	27	1.31	1.22	0.68	-7.28	31.57	-0.1	0.41	0.31	-2.46	-9.3	-0.08	30.69	31.63	0.34	0.57	0.46
OC	FAL	22	0.74	1.05	0.55	41.71	62.89	0.31	0.46	0.45	68.75	35.49	0.42	81.92	51.47	0.63	0.74	0.31
OC	ALL	92	0.86	1.14	0.6	31.54	56.18	0.27	0.49	0.35	79.1	35.39	0.32	94.08	53.6	0.56	0.65	0.36
PM-2.5	WIN	29	9.44	6.76	0.27	-28.41	39.15	-2.68	3.7	123.9	-9.17	-15.03	-0.4	25.08	29.04	0.55	11.45	0.07
PM-2.5	SPR	28	5.55	5.63	0.48	1.4	34.54	0.08	1.92	9.46	4.41	-4.69	0.01	34.72	31.64	0.35	3.08	0.23
PM-2.5	SUM	29	10.25	5.66	0.8	-44.76	45.09	-4.59	4.62	11.73	-41.63	-56.94	-0.81	42.33	57.61	0.82	5.73	0.64
PM-2.5	FAL	28	6.3	5.24	0.9	-16.81	28.24	-1.06	1.78	7.75	-2.5	-8.95	-0.2	30.33	31.3	0.34	2.98	0.8
PM-2.5	ALL	114	7.92	5.83	0.46	-26.4	38.18	-2.09	3.02	41.82	-12.45	-21.66	-0.36	33.12	37.5	0.52	6.8	0.21
SO4	WIN	29	1.76	1.05	0.84	-40.24	40.87	-0.71	0.72	0.2	-38.5	-50.63	-0.67	40.48	52.37	0.68	0.83	0.71
SO4	SPR	29	1.45	1.43	0.58	-1.81	37.89	-0.03	0.55	0.58	149.99	-3.52	-0.02	183.32	39.31	0.39	0.76	0.33
SO4	SUM	29	2.77	2.23	0.87	-19.54	31.71	-0.54	0.88	1.16	-11.96	-21.52	-0.24	34.88	38.26	0.39	1.2	0.75
SO4	FAL	28	1.73	1.53	0.92	-11.95	31.62	-0.21	0.55	1.14	11.19	3.1	-0.14	33.68	30.86	0.36	1.09	0.85
SO4	ALL	115	1.93	1.56	0.84	-19.26	34.96	-0.37	0.68	0.84	27.82	-18.33	-0.24	73.43	40.28	0.43	0.99	0.7

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 370210034																		
EC	WIN	15	0.48	0.46	0.74	-3.95	34.61	-0.02	0.17	0.05	22.86	11.79	-0.04	41.82	35.28	0.36	0.23	0.55
EC	SPR	15	0.41	0.41	0.41	0.27	47.07	0	0.19	0.05	22.97	7.78	0	54.25	45.28	0.47	0.22	0.17
EC	SUM	16	0.59	0.45	0.49	-23.25	25.47	-0.14	0.15	0.02	-20.39	-25.51	-0.3	23.27	28.22	0.33	0.2	0.24
EC	FAL	12	0.45	0.41	0.95	-9.71	32.74	-0.04	0.15	0.04	18.21	9.61	-0.11	37.68	33.16	0.36	0.21	0.9
EC	ALL	58	0.49	0.44	0.68	-10.55	33.94	-0.05	0.17	0.04	9.99	0.01	-0.12	39.06	35.48	0.38	0.21	0.47
NACL	WIN	14	0.04	0.09	0.7	136.32	157.43	0.05	0.06	0.01	1470.46	72.12	1.36	1485.9	90.47	1.57	0.12	0.49
NACL	SPR	14	0.09	0.1	0.1	12.55	87.67	0.01	0.07	0.01	75.67	25.28	0.13	110.26	79.54	0.88	0.09	0.01
NACL	SUM	15	0.06	0.05	0.15	-26.79	54.2	-0.02	0.03	0	0.31	-18.55	-0.37	49.86	55.13	0.74	0.05	0.02
NACL	FAL	14	0.03	0.05	0.13	46.48	75.74	0.01	0.02	0	91.53	33.83	0.46	109.75	56.41	0.76	0.03	0.02
NACL	ALL	57	0.05	0.07	0.29	26.45	87.61	0.01	0.05	0.01	402.31	27.35	0.26	432.11	70.12	0.88	0.08	0.09
NH4	WIN	14	0.61	0.58	0.81	-4.19	26.19	-0.03	0.16	0.04	13.26	4.31	-0.04	35.65	30.48	0.27	0.2	0.65
NH4	SPR	14	0.69	0.69	0.67	0.67	32.29	0	0.22	0.07	24.91	4.74	0.01	51.15	40.23	0.32	0.27	0.44
NH4	SUM	15	1.04	0.91	0.47	-12.28	26.34	-0.13	0.27	0.15	-2.36	-7.87	-0.14	24.52	26.19	0.3	0.41	0.22
NH4	FAL	15	0.38	0.56	0.79	48.9	59.4	0.18	0.22	0.03	87.29	49.88	0.49	92.98	57.12	0.59	0.25	0.62
NH4	ALL	58	0.68	0.69	0.7	1.42	32.52	0.01	0.22	0.09	31.18	13.05	0.01	51.34	38.61	0.33	0.3	0.49
NO3	WIN	14	0.56	0.69	0.32	23.05	72.54	0.13	0.41	0.23	49.72	11.96	0.23	87.4	66.46	0.73	0.5	0.11
NO3	SPR	14	0.44	0.31	0.22	-28.4	68.55	-0.12	0.3	0.13	-15.53	-53.63	-0.4	76.76	85.31	0.96	0.38	0.05
NO3	SUM	15	0.27	0.1	0.2	-64.42	67.35	-0.17	0.18	0.01	-63.62	-102.63	-1.81	66.34	105.09	1.89	0.21	0.04
NO3	FAL	15	0.31	0.32	0.3	1.69	65.28	0.01	0.2	0.06	34.05	-16.45	0.02	92.09	76.74	0.65	0.25	0.09
NO3	ALL	58	0.39	0.35	0.43	-10.79	69.05	-0.04	0.27	0.12	0.61	-40.85	-0.12	80.6	83.66	0.77	0.35	0.19
OC	WIN	15	1.77	1.75	0.6	-0.97	48.15	-0.02	0.85	1.23	42.36	21.56	-0.01	62.98	48.97	0.49	1.11	0.36
OC	SPR	15	1.51	1.8	0.67	18.73	43.3	0.28	0.66	0.49	58.41	27.23	0.19	76.18	48.76	0.43	0.76	0.45
OC	SUM	16	2.22	2.92	0.57	31.67	38.61	0.7	0.86	0.8	38.11	25.38	0.32	44.87	32.85	0.39	1.14	0.32
OC	FAL	12	1.24	1.6	0.73	29.08	45.58	0.36	0.57	0.46	77.45	35.5	0.29	87.22	46.92	0.46	0.77	0.53
OC	ALL	58	1.72	2.06	0.63	19.65	43.26	0.34	0.74	0.83	52.6	26.96	0.2	66.41	44.04	0.43	0.97	0.4
PM-2.5	WIN	14	8.05	6.12	0.61	-23.96	32.24	-1.93	2.6	11.09	-14.52	-20.47	-0.32	27.25	31.79	0.42	3.85	0.37
PM-2.5	SPR	14	9.59	6.86	0.65	-28.5	32.36	-2.73	3.1	9.65	-23.6	-32.15	-0.4	28.67	36.7	0.45	4.14	0.43
PM-2.5	SUM	15	16.69	9.04	0.68	-45.85	45.85	-7.65	7.65	8.12	-45.59	-60.76	-0.85	45.59	60.76	0.85	8.16	0.46
PM-2.5	FAL	15	7.23	5.81	0.91	-19.55	26.12	-1.41	1.89	5.33	-9.43	-13.41	-0.24	23.63	26.06	0.32	2.71	0.84
PM-2.5	ALL	58	10.44	6.97	0.77	-33.22	36.79	-3.47	3.84	14.8	-23.43	-31.88	-0.5	31.4	38.98	0.55	5.18	0.59
SO4	WIN	14	1.74	1.18	0.68	-32.08	39.77	-0.56	0.69	0.64	-16.18	-27.35	-0.47	38.43	43.87	0.59	0.98	0.46
SO4	SPR	14	2.36	2	0.68	-15	26.68	-0.35	0.63	0.76	-12.66	-19.43	-0.18	24.94	29.44	0.31	0.94	0.46
SO4	SUM	15	4.3	2.72	0.61	-36.68	36.68	-1.58	1.58	1.84	-33.3	-42.96	-0.58	33.3	42.96	0.58	2.08	0.37
SO4	FAL	15	1.59	1.48	0.81	-7.12	23.77	-0.11	0.38	0.28	-7.97	-12.78	-0.08	22.79	25.83	0.26	0.54	0.65
SO4	ALL	58	2.51	1.86	0.73	-26.16	32.82	-0.66	0.82	1.21	-17.64	-25.71	-0.35	29.8	35.49	0.44	1.28	0.54

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 370350004																		
EC	WIN	15	0.83	0.63	0.78	-24.28	39.72	-0.2	0.33	0.19	-1.89	-11.16	-0.32	36.72	37.37	0.52	0.48	0.61
EC	SPR	15	0.74	0.5	0.66	-32.6	37.48	-0.24	0.28	0.14	-21.62	-29.4	-0.48	29.56	36.18	0.56	0.44	0.43
EC	SUM	16	0.74	0.55	0.64	-25.94	26.61	-0.19	0.2	0.03	-22.28	-27.15	-0.35	23.05	27.9	0.36	0.26	0.41
EC	FAL	15	0.63	0.5	0.8	-20.33	32.67	-0.13	0.21	0.14	-0.41	-5.75	-0.26	24.31	26.35	0.41	0.4	0.64
EC	ALL	61	0.74	0.55	0.74	-25.95	34.23	-0.19	0.25	0.13	-11.73	-18.51	-0.35	28.32	31.88	0.46	0.4	0.55
NACL	WIN	15	0.06	0.09	0.59	41.01	99.6	0.03	0.06	0.01	158.2	29.47	0.41	189.26	73.35	1	0.12	0.35
NACL	SPR	15	0.1	0.16	0.55	55.12	78.42	0.06	0.08	0.01	72.07	27.14	0.55	95.75	60.03	0.78	0.13	0.31
NACL	SUM	16	0.06	0.05	0.6	-16.46	45.77	-0.01	0.03	0	-13.82	-25.55	-0.2	41.4	46.03	0.55	0.04	0.36
NACL	FAL	15	0.04	0.04	0.35	-1.68	38.1	0	0.02	0	17.52	4.97	-0.02	41.74	34.77	0.39	0.02	0.12
NACL	ALL	61	0.07	0.08	0.61	25.63	68.94	0.02	0.05	0.01	57.31	8.44	0.26	91.21	53.42	0.69	0.09	0.38
NH4	WIN	15	0.73	0.66	0.67	-9.36	40.53	-0.07	0.29	0.19	16.9	6	-0.1	42.67	38.92	0.45	0.44	0.44
NH4	SPR	15	0.93	0.8	0.7	-13.95	34.26	-0.13	0.32	0.16	15.32	-6.14	-0.16	53.43	43.88	0.4	0.42	0.5
NH4	SUM	16	0.86	0.98	0.16	13.24	40.26	0.11	0.35	0.23	37.89	19.1	0.13	52.27	37.21	0.4	0.49	0.03
NH4	FAL	15	0.36	0.6	0.84	63.33	63.33	0.23	0.23	0.02	147.33	55.21	0.63	147.33	55.21	0.63	0.27	0.7
NH4	ALL	61	0.72	0.76	0.61	5.28	41.29	0.04	0.3	0.17	54.09	18.55	0.05	73.57	43.7	0.41	0.41	0.37
NO3	WIN	15	1.14	0.98	0.4	-14.3	61.33	-0.16	0.7	1.06	8.42	-16.97	-0.17	62.85	59.31	0.72	1.04	0.16
NO3	SPR	15	0.81	0.44	0.52	-45.73	57.22	-0.37	0.46	0.31	-40.29	-66.21	-0.84	50.53	73.6	1.05	0.67	0.27
NO3	SUM	16	0.29	0.14	0.41	-51.6	51.6	-0.15	0.15	0.01	-49.19	-72.9	-1.07	49.19	72.9	1.07	0.19	0.17
NO3	FAL	15	0.37	0.4	0.65	8.88	49.54	0.03	0.18	0.05	2.31	-17.12	0.09	53.33	53.49	0.5	0.23	0.42
NO3	ALL	61	0.65	0.48	0.56	-25.12	57.28	-0.16	0.37	0.37	-20.17	-43.79	-0.34	53.89	64.96	0.76	0.63	0.31
OC	WIN	15	2.39	2.15	0.65	-10.12	39.16	-0.24	0.94	1.69	15.01	4.52	-0.11	41.75	38.3	0.44	1.32	0.43
OC	SPR	15	2.24	1.99	0.88	-11.39	19.92	-0.26	0.45	0.2	-7.33	-11.24	-0.13	23.27	23.71	0.22	0.51	0.78
OC	SUM	16	2.69	3.1	0.35	15.32	37.35	0.41	1	1.31	22.66	12.11	0.15	41.65	34.07	0.37	1.22	0.12
OC	FAL	15	1.66	1.84	0.85	10.66	28.08	0.18	0.47	0.3	27.29	16.19	0.11	39.96	30.59	0.28	0.58	0.72
OC	ALL	61	2.25	2.28	0.64	1.29	31.88	0.03	0.72	0.96	14.54	5.51	0.01	36.74	31.71	0.32	0.98	0.41
PM-2.5	WIN	15	10.36	7.43	0.63	-28.25	33.55	-2.93	3.48	18.16	-19.63	-27.06	-0.39	27.12	33.86	0.47	5.17	0.4
PM-2.5	SPR	15	11.25	7.8	0.84	-30.64	32.65	-3.45	3.67	5.31	-28.34	-36.07	-0.44	31.43	38.84	0.47	4.15	0.71
PM-2.5	SUM	16	15.56	9.69	0.27	-37.69	39.06	-5.86	6.08	17.06	-34.95	-45.79	-0.6	36.64	47.38	0.63	7.17	0.07
PM-2.5	FAL	15	7.33	6.27	0.85	-14.49	22.53	-1.06	1.65	3.82	-9.77	-14.06	-0.17	21.77	24.63	0.26	2.22	0.73
PM-2.5	ALL	61	11.2	7.83	0.71	-30.06	33.56	-3.37	3.76	14.17	-23.37	-30.99	-0.43	29.36	36.36	0.48	5.05	0.5
SO4	WIN	15	1.66	1.15	0.89	-30.48	36.11	-0.51	0.6	0.35	-19.25	-26.52	-0.44	32.59	38.24	0.52	0.78	0.8
SO4	SPR	15	2.62	2.18	0.77	-16.78	27.59	-0.44	0.72	0.68	-11.56	-17.2	-0.2	26.22	29.41	0.33	0.93	0.6
SO4	SUM	16	3.32	2.71	0.04	-18.29	35.99	-0.61	1.2	2.71	-6.46	-15.04	-0.22	33.86	36.16	0.44	1.76	0
SO4	FAL	15	1.43	1.37	0.87	-4.03	18.77	-0.06	0.27	0.11	-3.72	-6.88	-0.04	20.39	20.99	0.2	0.34	0.76
SO4	ALL	61	2.27	1.87	0.68	-17.85	30.97	-0.41	0.7	1.04	-10.18	-16.39	-0.22	28.36	31.28	0.38	1.1	0.46

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 370570002																		
EC	WIN	13	0.64	0.63	0.74	-0.84	30.31	-0.01	0.19	0.08	10.69	3.84	-0.01	30.81	28.31	0.31	0.28	0.55
EC	SPR	15	0.57	0.43	0.58	-23.59	30.23	-0.13	0.17	0.04	-17.95	-25.31	-0.31	28.57	34.65	0.4	0.24	0.34
EC	SUM	16	0.63	0.47	0.81	-24.19	25.52	-0.15	0.16	0.01	-23.54	-28.21	-0.32	25.54	30.11	0.34	0.18	0.65
EC	FAL	14	0.55	0.49	0.89	-10.4	23.07	-0.06	0.13	0.03	-4.72	-8.41	-0.12	22.49	24.13	0.26	0.17	0.78
EC	ALL	58	0.59	0.5	0.75	-15.37	27.28	-0.09	0.16	0.04	-9.88	-15.5	-0.18	26.77	29.43	0.32	0.22	0.56
NACL	WIN	15	0.15	0.12	0.05	-22.14	97.37	-0.03	0.14	0.09	47.97	3.7	-0.28	94.93	75.13	1.25	0.3	0
NACL	SPR	15	0.1	0.17	0.53	70.73	94.94	0.07	0.09	0.02	117.67	54.67	0.71	130.88	69.76	0.95	0.15	0.28
NACL	SUM	16	0.05	0.06	0.53	31.42	62.28	0.01	0.03	0	40.72	12.69	0.31	68.26	46.29	0.62	0.04	0.28
NACL	FAL	15	0.09	0.06	0.13	-36.33	72.69	-0.03	0.07	0.02	22.72	-0.75	-0.57	61.84	60.22	1.14	0.14	0.02
NACL	ALL	61	0.1	0.1	0.18	5.26	86.63	0.01	0.08	0.03	57	17.5	0.05	88.64	62.58	0.87	0.18	0.03
NH4	WIN	15	0.82	0.77	0.77	-5.85	38.48	-0.05	0.31	0.15	20.7	6.13	-0.06	49.87	42.09	0.41	0.39	0.6
NH4	SPR	15	0.9	0.82	0.64	-8.82	35.91	-0.08	0.32	0.17	11.61	-9.01	-0.1	51.57	45.2	0.39	0.42	0.41
NH4	SUM	16	0.86	0.87	0.33	1.51	40.63	0.01	0.35	0.2	15.3	2.96	0.02	43.42	40.2	0.41	0.44	0.11
NH4	FAL	15	0.39	0.6	0.66	55.05	67.7	0.21	0.26	0.09	107.48	50.65	0.55	114.02	57.65	0.68	0.37	0.43
NH4	ALL	61	0.74	0.77	0.63	3.31	42.11	0.02	0.31	0.17	38.39	12.52	0.03	64.37	46.18	0.42	0.41	0.4
NO3	WIN	15	1	1.26	0.71	26.35	53.13	0.26	0.53	0.53	24.6	5	0.26	56.12	49.47	0.53	0.77	0.51
NO3	SPR	15	0.73	0.6	0.66	-18.54	40.32	-0.14	0.3	0.14	-15.63	-31.94	-0.23	40.26	53.18	0.49	0.4	0.43
NO3	SUM	16	0.27	0.19	0.49	-28.03	41.81	-0.07	0.11	0.01	-30.3	-47.35	-0.39	44.13	58.19	0.58	0.13	0.24
NO3	FAL	15	0.36	0.56	0.48	57.3	95.67	0.2	0.34	0.29	52.72	13.07	0.57	90.6	68.48	0.96	0.57	0.23
NO3	ALL	61	0.58	0.64	0.72	10.61	54.19	0.06	0.32	0.27	7.22	-15.83	0.11	57.55	57.34	0.54	0.52	0.52
OC	WIN	13	2.21	2.21	0.64	-0.13	34.69	0	0.77	0.88	3.54	-3.68	0	33.07	34.03	0.35	0.94	0.41
OC	SPR	15	1.94	1.82	0.75	-6.21	26.45	-0.12	0.51	0.33	-5.6	-11.14	-0.07	28.55	30.77	0.28	0.59	0.56
OC	SUM	16	2.5	2.87	0.45	14.81	39.87	0.37	1	1.69	20.54	10.65	0.15	38.25	33.42	0.4	1.35	0.2
OC	FAL	14	1.72	1.68	0.97	-2.24	14.33	-0.04	0.25	0.09	0.52	-2.89	-0.02	20.33	19.97	0.15	0.3	0.93
OC	ALL	58	2.1	2.16	0.7	2.9	30.4	0.06	0.64	0.81	5.14	-1.46	0.03	30.25	29.62	0.3	0.9	0.49
PM-2.5	WIN	15	9.96	8.23	0.92	-17.39	19.97	-1.73	1.99	2.49	-18.01	-21.4	-0.21	20.4	23.68	0.24	2.34	0.85
PM-2.5	SPR	15	10.48	7.57	0.82	-27.75	28.5	-2.91	2.99	4.07	-27.68	-36.27	-0.38	30.21	38.57	0.39	3.54	0.67
PM-2.5	SUM	16	14.39	8.99	0.57	-37.48	37.75	-5.39	5.43	11.87	-37.65	-49.69	-0.6	37.84	49.88	0.6	6.4	0.33
PM-2.5	FAL	15	7.73	6.12	0.89	-20.89	23.89	-1.62	1.85	3.42	-19.08	-25.31	-0.26	24.88	30.37	0.3	2.46	0.8
PM-2.5	ALL	61	10.7	7.75	0.78	-27.59	28.99	-2.95	3.1	7.94	-25.8	-33.44	-0.38	28.49	35.86	0.4	4.08	0.6
SO4	WIN	15	1.76	1.25	0.82	-28.96	33.39	-0.51	0.59	0.46	-18.3	-25.17	-0.41	28.47	33.99	0.47	0.85	0.68
SO4	SPR	15	2.48	2.13	0.7	-14.24	30.86	-0.35	0.76	0.98	-12.49	-19.12	-0.17	27.16	31.41	0.36	1.05	0.49
SO4	SUM	16	3.2	2.39	0.21	-25.34	38.09	-0.81	1.22	1.96	-20.91	-30.71	-0.34	33.05	40.75	0.51	1.62	0.05
SO4	FAL	15	1.53	1.27	0.67	-17.23	31.21	-0.26	0.48	0.38	-14.54	-23.74	-0.21	28.71	36.13	0.38	0.67	0.45
SO4	ALL	61	2.26	1.77	0.63	-21.69	34.09	-0.49	0.77	1.01	-16.63	-24.78	-0.28	29.41	35.65	0.44	1.12	0.4

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 370670022																		
EC	WIN	10	0.56	0.65	0.82	16.04	32.49	0.09	0.18	0.04	28.46	20.1	0.16	37.95	30.92	0.32	0.22	0.67
EC	SPR	7	0.42	0.47	0.66	10.75	28.4	0.05	0.12	0.02	22.13	15.91	0.11	31.7	27.4	0.28	0.14	0.44
EC	SUM	5	0.48	0.5	0.94	3.2	11.68	0.02	0.06	0.01	4.84	3.56	0.03	12.43	11.47	0.12	0.08	0.87
EC	FAL	14	0.47	0.54	0.95	13.86	19.23	0.07	0.09	0.01	21.84	16.61	0.14	26.88	21.97	0.19	0.11	0.89
EC	ALL	36	0.49	0.55	0.87	12.58	23.96	0.06	0.12	0.02	21.37	15.63	0.13	28.89	24.05	0.24	0.15	0.75
NACL	WIN	12	0.04	0.11	0.81	150.92	178.24	0.07	0.08	0.02	656.7	64.57	1.51	668.63	83.08	1.78	0.16	0.66
NACL	SPR	11	0.06	0.14	0.79	157.59	157.59	0.09	0.09	0.02	137.57	69.54	1.58	137.57	69.54	1.58	0.16	0.63
NACL	SUM	13	0.07	0.05	0.4	-28.89	63.23	-0.02	0.05	0	-9.34	-32.85	-0.41	55.29	61.78	0.89	0.07	0.16
NACL	FAL	14	0.04	0.05	0.1	21	60.1	0.01	0.03	0	45.11	18.46	0.21	64.64	45.99	0.6	0.04	0.01
NACL	ALL	50	0.05	0.09	0.48	60.32	106.91	0.03	0.06	0.01	198.07	27.42	0.6	223.21	64.18	1.07	0.12	0.23
NH4	WIN	12	0.93	0.84	0.73	-9.04	38.8	-0.08	0.36	0.2	13.13	-0.93	-0.1	47.64	43.04	0.43	0.46	0.53
NH4	SPR	11	0.83	0.91	0.77	9.04	33.84	0.08	0.28	0.11	46.48	20.4	0.09	64.04	40.8	0.34	0.34	0.59
NH4	SUM	13	0.91	0.8	0.05	-11.77	39.76	-0.11	0.36	0.22	4.53	-5.65	-0.13	38.43	39.13	0.45	0.48	0
NH4	FAL	14	0.4	0.58	0.72	45.69	54.37	0.18	0.22	0.08	63.82	34.8	0.46	69.19	40.5	0.54	0.33	0.52
NH4	ALL	50	0.75	0.77	0.65	2.59	40.2	0.02	0.3	0.17	32.42	12.54	0.03	54.89	40.82	0.4	0.41	0.42
NO3	WIN	12	1.12	1.46	0.52	29.78	73.4	0.33	0.82	1.49	39.95	3.66	0.3	82.36	63.03	0.73	1.27	0.27
NO3	SPR	11	0.6	0.62	0.73	3.45	40.23	0.02	0.24	0.09	2.46	-10.55	0.03	46.05	45.59	0.4	0.3	0.54
NO3	SUM	13	0.26	0.14	0.29	-48.16	57.21	-0.13	0.15	0.01	-46.66	-73.63	-0.93	55.73	81.53	1.1	0.17	0.09
NO3	FAL	14	0.34	0.57	0.44	67.73	116.56	0.23	0.4	0.39	50.02	-2.26	0.68	100.98	75.37	1.17	0.66	0.19
NO3	ALL	50	0.57	0.68	0.63	20.53	70.94	0.12	0.4	0.52	12	-21.22	0.21	72.66	67.46	0.71	0.73	0.39
OC	WIN	10	1.77	2.08	0.78	17.18	38.36	0.3	0.68	0.56	34.27	23.17	0.17	45.84	36.7	0.38	0.81	0.61
OC	SPR	7	1.5	1.67	0.83	10.81	19.9	0.16	0.3	0.11	14.85	11.22	0.11	23.45	20.53	0.2	0.37	0.69
OC	SUM	5	2.19	3.06	0.73	39.69	52.08	0.87	1.14	0.89	50.06	30.2	0.4	63.49	46.34	0.52	1.28	0.53
OC	FAL	14	1.57	1.62	0.83	2.95	28.37	0.05	0.45	0.38	3.03	-2.75	0.03	30.19	29	0.28	0.62	0.68
OC	ALL	36	1.7	1.95	0.78	15	34.05	0.25	0.58	0.52	20.54	11.74	0.15	37.85	31.9	0.34	0.77	0.61
PM-2.5	WIN	12	8.87	8.34	0.82	-5.92	25.24	-0.52	2.24	7.17	-6.7	-10.72	-0.06	24.6	25.72	0.27	2.73	0.67
PM-2.5	SPR	12	10.22	8.23	0.89	-19.46	21.96	-1.99	2.24	2.13	-21.19	-25.51	-0.24	23.6	27.84	0.27	2.47	0.79
PM-2.5	SUM	13	15.05	8.26	0.18	-45.1	45.56	-6.79	6.86	14.09	-42.73	-57.75	-0.82	43.32	58.32	0.83	7.76	0.03
PM-2.5	FAL	14	7.11	6.07	0.84	-14.53	31.34	-1.03	2.23	5.36	-8.67	-16.18	-0.17	35.66	37.62	0.37	2.54	0.7
PM-2.5	ALL	51	10.28	7.67	0.63	-25.34	33.21	-2.6	3.41	13.49	-19.83	-27.69	-0.34	32.17	37.79	0.44	4.5	0.4
SO4	WIN	12	2.01	1.33	0.78	-33.84	38.58	-0.68	0.77	0.56	-22.2	-31.55	-0.51	35.36	42.81	0.58	1.01	0.61
SO4	SPR	11	2.52	2.42	0.75	-3.88	32.41	-0.1	0.82	1.05	-0.23	-5.64	-0.04	30.48	30.24	0.34	1.03	0.57
SO4	SUM	13	3.49	2.31	0.17	-33.98	38.01	-1.19	1.33	2.21	-26.55	-36.47	-0.51	31.54	40.88	0.58	1.9	0.03
SO4	FAL	14	1.63	1.21	0.72	-25.74	32.43	-0.42	0.53	0.28	-24.4	-35.05	-0.35	32.64	42.54	0.44	0.68	0.52
SO4	ALL	50	2.4	1.79	0.6	-25.43	35.77	-0.61	0.86	1.18	-19.11	-28.11	-0.34	32.53	39.47	0.48	1.24	0.36

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 371190041																		
EC	WIN	23	0.72	1.23	0.79	70.9	70.9	0.51	0.51	0.09	97.94	59.01	0.71	97.94	59.01	0.71	0.59	0.63
EC	SPR	24	0.53	0.89	0.45	68	70.19	0.36	0.37	0.07	85.71	52.16	0.68	87.13	53.64	0.7	0.45	0.2
EC	SUM	26	0.62	0.95	0.56	53.43	58.24	0.33	0.36	0.07	62.8	42.66	0.53	65.41	45.8	0.58	0.42	0.31
EC	FAL	24	0.59	1.1	0.74	86.96	91.29	0.51	0.54	0.16	112.17	61.68	0.87	114.49	64.38	0.91	0.65	0.55
EC	ALL	97	0.61	1.04	0.7	69.38	72.18	0.43	0.44	0.1	89.02	53.59	0.69	90.64	55.47	0.72	0.53	0.48
NACL	WIN	27	0.06	0.16	0.84	162	172.39	0.1	0.1	0.03	336.59	80.44	1.62	343.53	88.39	1.72	0.19	0.7
NACL	SPR	30	0.08	0.15	0.62	73.99	94.51	0.06	0.08	0.01	102.14	47.73	0.74	112.74	61.98	0.95	0.13	0.38
NACL	SUM	30	0.08	0.07	0.2	-12.15	73.53	-0.01	0.06	0.02	1.25	-20.56	-0.14	58.64	59.14	0.84	0.12	0.04
NACL	FAL	29	0.07	0.1	0.59	40.37	84.25	0.03	0.06	0.01	44.91	10.61	0.4	79.94	56.44	0.84	0.11	0.34
NACL	ALL	116	0.07	0.12	0.48	58.83	100.92	0.04	0.08	0.02	116.31	28.4	0.59	144.27	66	1.01	0.14	0.23
NH4	WIN	27	0.91	0.99	0.66	8.39	49.44	0.08	0.45	0.33	61.7	26.46	0.08	81.94	51.41	0.49	0.58	0.43
NH4	SPR	31	0.79	0.84	0.64	6.07	36.67	0.05	0.29	0.16	37.16	8.24	0.06	64.3	44.15	0.37	0.4	0.41
NH4	SUM	31	0.95	0.87	0.44	-7.82	35.55	-0.07	0.34	0.21	7.8	-4.76	-0.08	41.41	40.18	0.39	0.47	0.19
NH4	FAL	29	0.31	0.75	0.52	143.33	144.28	0.44	0.45	0.18	251.94	84	1.43	252.48	84.55	1.44	0.61	0.27
NH4	ALL	118	0.74	0.86	0.54	16.14	50.93	0.12	0.38	0.25	87.85	27.61	0.16	108.57	54.7	0.51	0.52	0.29
NO3	WIN	27	1.5	1.75	0.61	16.19	59.45	0.24	0.89	1.35	59.42	20.31	0.16	89.26	60.53	0.59	1.19	0.38
NO3	SPR	31	0.58	0.59	0.81	2.18	46.88	0.01	0.27	0.12	9.34	-11.95	0.02	59.06	56.12	0.47	0.35	0.66
NO3	SUM	31	0.27	0.18	0.29	-32.29	50.19	-0.09	0.13	0.04	-25.02	-41.07	-0.48	44.19	57.13	0.74	0.22	0.08
NO3	FAL	29	0.38	0.9	0.57	140.24	168.79	0.53	0.64	1.48	101	19.16	1.4	138.49	72.31	1.69	1.33	0.33
NO3	ALL	118	0.66	0.82	0.62	25.29	70.96	0.17	0.47	0.77	34.3	-4.57	0.25	81.59	61.37	0.71	0.89	0.38
OC	WIN	23	2.27	3.42	0.88	50.83	51.5	1.15	1.17	0.45	71.57	47.63	0.51	72.23	48.31	0.52	1.33	0.78
OC	SPR	24	2.03	2.61	0.68	28.4	39.26	0.58	0.8	0.66	39.66	25.47	0.28	48.56	35.74	0.39	1	0.47
OC	SUM	26	2.68	3.54	0.43	31.93	47.62	0.86	1.28	2.68	48.66	29.31	0.32	56.53	40.32	0.48	1.85	0.19
OC	FAL	24	1.92	2.75	0.79	43.69	51.98	0.84	1	0.74	67.55	41.29	0.44	72.1	46.39	0.52	1.2	0.63
OC	ALL	97	2.23	3.09	0.68	38.18	47.6	0.85	1.06	1.21	56.54	35.67	0.38	62.13	42.58	0.48	1.39	0.46
PM-2.5	WIN	28	11.57	12.82	0.84	10.75	24.99	1.24	2.89	12.2	21.24	15.98	0.11	28.79	24.66	0.25	3.71	0.7
PM-2.5	SPR	30	10.54	9.72	0.53	-7.81	25.79	-0.82	2.72	12.26	-2.41	-8.13	-0.08	26.4	27.75	0.28	3.6	0.28
PM-2.5	SUM	31	16.15	11.48	0.46	-28.91	30.3	-4.67	4.89	23.19	-25.35	-32.34	-0.41	26.85	33.77	0.43	6.71	0.22
PM-2.5	FAL	29	8.82	10.07	0.74	14.13	28.41	1.25	2.51	10.99	18.54	12.13	0.14	30.25	25.03	0.28	3.54	0.55
PM-2.5	ALL	118	11.84	11	0.61	-7.05	27.7	-0.83	3.28	20.76	2.32	-3.79	-0.08	28.03	27.93	0.3	4.63	0.38
SO4	WIN	27	1.74	1.52	0.79	-12.81	27.41	-0.22	0.48	0.37	-1.63	-6.05	-0.15	25.22	26.12	0.31	0.65	0.63
SO4	SPR	31	2.41	2.13	0.63	-11.7	29.42	-0.28	0.71	0.86	-7.33	-13.97	-0.13	27.74	30.85	0.33	0.97	0.4
SO4	SUM	31	3.66	2.48	0.4	-32.13	34.47	-1.18	1.26	2.26	-26.94	-36.28	-0.47	29.87	39.09	0.51	1.91	0.16
SO4	FAL	29	1.47	1.54	0.74	5.34	26.06	0.08	0.38	0.28	8.82	3.51	0.05	27.27	25.82	0.26	0.53	0.55
SO4	ALL	118	2.35	1.94	0.64	-17.62	30.63	-0.41	0.72	1.2	-7.21	-13.72	-0.21	27.61	30.7	0.37	1.17	0.4

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 371590021																		
EC	WIN	14	0.54	0.47	0.37	-13.74	47.2	-0.07	0.26	0.13	7.61	-5.53	-0.16	44.46	43.61	0.55	0.37	0.14
EC	SPR	14	0.42	0.32	0.64	-23.35	31.52	-0.1	0.13	0.02	-19.88	-28.38	-0.3	30.52	38.02	0.41	0.17	0.41
EC	SUM	15	0.51	0.31	0.68	-39.79	39.79	-0.2	0.2	0.01	-38.69	-50.15	-0.66	38.69	50.15	0.66	0.23	0.46
EC	FAL	15	0.49	0.33	0.72	-33.65	40.86	-0.17	0.2	0.05	-15.48	-28.6	-0.51	40.63	45.56	0.62	0.28	0.52
EC	ALL	58	0.49	0.35	0.53	-27.88	40.35	-0.14	0.2	0.06	-16.97	-28.55	-0.39	38.61	44.45	0.56	0.27	0.28
NACL	WIN	15	0.04	0.09	0.89	122.91	145.38	0.05	0.06	0.02	189.32	47.91	1.23	206.7	70.34	1.45	0.14	0.8
NACL	SPR	15	0.1	0.17	0.6	69.12	90.02	0.07	0.09	0.02	100.25	47.44	0.69	113.19	63.73	0.9	0.15	0.36
NACL	SUM	14	0.05	0.05	0.59	9.39	64.98	0	0.03	0	1.51	-19.58	0.09	58.52	59.01	0.65	0.04	0.34
NACL	FAL	15	0.05	0.04	0.08	-19.14	62.57	-0.01	0.03	0	91.2	-10.92	-0.24	145.07	67.58	0.77	0.05	0.01
NACL	ALL	59	0.06	0.09	0.61	47.9	89.05	0.03	0.05	0.01	97.16	16.82	0.48	132.1	65.27	0.89	0.11	0.37
NH4	WIN	15	0.71	0.68	0.84	-4.63	34.56	-0.03	0.25	0.1	29.03	11.07	-0.05	53.92	41.53	0.36	0.32	0.7
NH4	SPR	15	0.9	0.82	0.67	-9.04	37.73	-0.08	0.34	0.19	11.89	-7.44	-0.1	51.87	45.68	0.41	0.44	0.45
NH4	SUM	14	0.85	0.88	0.5	3.89	40.53	0.03	0.34	0.17	19.41	5.8	0.04	46.75	42.25	0.41	0.41	0.25
NH4	FAL	14	0.3	0.59	0.69	95.48	96.95	0.29	0.29	0.08	128.55	65.32	0.95	131.61	68.75	0.97	0.41	0.48
NH4	ALL	58	0.7	0.74	0.67	6.92	43.93	0.05	0.31	0.16	46.3	18.11	0.07	70.41	49.35	0.44	0.4	0.45
NO3	WIN	15	0.87	0.98	0.72	12.61	48.72	0.11	0.42	0.34	15.93	-4.87	0.13	54.88	51.78	0.49	0.6	0.52
NO3	SPR	15	0.72	0.53	0.76	-26.88	39.53	-0.19	0.29	0.13	-14.77	-30.36	-0.37	40.26	50.08	0.54	0.42	0.57
NO3	SUM	14	0.24	0.17	0.03	-29.92	50.54	-0.07	0.12	0.02	-26.49	-46.14	-0.43	47.52	60.79	0.72	0.15	0
NO3	FAL	15	0.28	0.46	0.24	61.69	106.08	0.17	0.3	0.27	64.59	10.74	0.62	100.78	66.64	1.06	0.55	0.06
NO3	ALL	59	0.53	0.54	0.68	1.03	53.46	0.01	0.29	0.22	10.43	-17.18	0.01	61.09	57.27	0.53	0.46	0.46
OC	WIN	14	2.1	1.92	0.55	-8.33	40.91	-0.17	0.86	1.6	15.38	2.18	-0.09	44.95	40.4	0.45	1.28	0.3
OC	SPR	14	1.8	1.71	0.78	-4.92	28.57	-0.09	0.51	0.36	-5.11	-12.52	-0.05	30.64	35.03	0.3	0.61	0.61
OC	SUM	15	2.55	2.51	0.04	-1.33	40.15	-0.03	1.02	2.71	8.16	-4.63	-0.01	38.03	37.24	0.41	1.65	0
OC	FAL	15	1.62	1.39	0.86	-13.85	27.25	-0.22	0.44	0.32	-1.93	-11.51	-0.16	35.8	36.01	0.32	0.61	0.74
OC	ALL	58	2.02	1.89	0.52	-6.46	35.17	-0.13	0.71	1.26	4.09	-6.67	-0.07	37.34	37.15	0.38	1.13	0.27
PM-2.5	WIN	15	8.29	6.92	0.86	-16.5	21.83	-1.37	1.81	4.35	-11.16	-14.91	-0.2	21.43	24.09	0.26	2.49	0.74
PM-2.5	SPR	15	10.23	7.25	0.87	-29.11	29.11	-2.98	2.98	3.27	-29.94	-38.98	-0.41	29.94	38.98	0.41	3.48	0.75
PM-2.5	SUM	14	14.71	8.87	0.4	-39.72	43.36	-5.84	6.38	21.66	-37.72	-52.65	-0.66	42.46	56.72	0.72	7.47	0.16
PM-2.5	FAL	15	7.1	5.26	0.77	-25.93	33.92	-1.84	2.41	7.34	-17.24	-26.1	-0.35	31.27	38.34	0.46	3.27	0.6
PM-2.5	ALL	59	10	7.04	0.72	-29.58	33.42	-2.96	3.34	11.88	-23.78	-32.83	-0.42	31.09	39.24	0.47	4.54	0.51
SO4	WIN	15	1.67	1.25	0.85	-25.33	33.68	-0.42	0.56	0.46	-12.68	-18.74	-0.34	29.58	33.54	0.45	0.8	0.73
SO4	SPR	15	2.57	2.19	0.7	-14.67	30.71	-0.38	0.79	1.01	-11.95	-18.94	-0.17	28.36	32.76	0.36	1.07	0.49
SO4	SUM	14	3.38	2.42	0.44	-28.29	32.63	-0.95	1.1	1.55	-25.56	-35.61	-0.39	29.89	39.62	0.45	1.57	0.2
SO4	FAL	15	1.36	1.25	0.72	-8.17	31.46	-0.11	0.43	0.31	-6.94	-14.82	-0.09	29.92	34.68	0.34	0.56	0.52
SO4	ALL	59	2.23	1.77	0.7	-20.59	32.08	-0.46	0.71	0.91	-14.09	-21.8	-0.26	29.43	35.07	0.4	1.06	0.5

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 371830014																		
EC	WIN	26	0.74	1.14	0.87	52.66	53.95	0.39	0.4	0.07	81.86	51.82	0.53	82.33	52.31	0.54	0.47	0.76
EC	SPR	30	0.41	0.75	0.4	82.03	84.19	0.34	0.35	0.06	100.39	57	0.82	101.58	58.3	0.84	0.42	0.16
EC	SUM	30	0.5	0.87	0.69	72.74	74	0.37	0.37	0.03	81.38	54.21	0.73	82.28	55.17	0.74	0.41	0.48
EC	FAL	28	0.55	1	0.65	81.74	84.26	0.45	0.47	0.09	102.91	60.32	0.82	104.2	61.73	0.84	0.54	0.42
EC	ALL	114	0.55	0.93	0.77	70.6	72.36	0.39	0.4	0.06	91.78	55.9	0.71	92.75	56.95	0.72	0.46	0.6
NACL	WIN	27	0.06	0.15	0.77	149.78	166.34	0.09	0.1	0.03	584.52	71.55	1.5	595.33	86.72	1.66	0.21	0.6
NACL	SPR	30	0.12	0.16	0.51	34.81	73.85	0.04	0.09	0.02	124.54	46.24	0.35	136.99	62.18	0.74	0.16	0.26
NACL	SUM	27	0.08	0.08	0.15	-7.17	94.47	-0.01	0.08	0.03	53.46	-21.27	-0.08	119.09	74.48	1.02	0.18	0.02
NACL	FAL	28	0.1	0.18	0.51	87.58	122.86	0.08	0.12	0.04	92.74	32.47	0.88	114.37	61.61	1.23	0.23	0.26
NACL	ALL	112	0.09	0.14	0.4	58.17	106.31	0.05	0.1	0.03	210.34	32.62	0.58	237.51	70.92	1.06	0.19	0.16
NH4	WIN	27	0.8	0.87	0.66	8.7	39.87	0.07	0.32	0.15	33.9	17.69	0.09	51.86	39.47	0.4	0.4	0.44
NH4	SPR	31	0.7	0.71	0.7	1.89	30.73	0.01	0.22	0.07	3.45	-4.85	0.02	32.33	34.19	0.31	0.26	0.49
NH4	SUM	27	0.98	0.83	0.63	-14.98	31.28	-0.15	0.31	0.15	-8.44	-17.1	-0.18	31.86	36.42	0.37	0.42	0.4
NH4	FAL	28	0.44	0.71	0.73	61.15	68.92	0.27	0.3	0.09	98.48	45.37	0.61	107.71	56.34	0.69	0.4	0.54
NH4	ALL	113	0.73	0.78	0.64	7.16	39.05	0.05	0.28	0.14	31.43	10.05	0.07	55.56	41.47	0.39	0.37	0.41
NO3	WIN	27	1.1	1.52	0.54	38.81	60.73	0.43	0.67	0.74	69.72	31.38	0.39	85.55	54	0.61	0.96	0.29
NO3	SPR	31	0.5	0.53	0.51	6.87	50.46	0.03	0.25	0.13	17.49	-4.43	0.07	57.04	52.21	0.5	0.36	0.26
NO3	SUM	27	0.25	0.16	0.3	-35.09	59.64	-0.09	0.15	0.03	-33.91	-62.68	-0.54	57.93	75.75	0.92	0.2	0.09
NO3	FAL	28	0.36	0.71	0.77	95.04	114.97	0.35	0.42	0.27	82.33	34.32	0.95	105.87	66.1	1.15	0.63	0.6
NO3	ALL	113	0.55	0.72	0.68	32.13	66.98	0.18	0.37	0.33	33.76	-0.19	0.32	76.17	61.71	0.67	0.6	0.46
OC	WIN	26	2.33	3.06	0.86	31.25	37.91	0.73	0.88	0.53	55.25	37.19	0.31	58.41	40.62	0.38	1.03	0.75
OC	SPR	30	1.71	2.18	0.7	27.26	40.86	0.47	0.7	0.59	46.07	26.39	0.27	54.79	36.96	0.41	0.9	0.49
OC	SUM	30	2.87	3.61	0.66	25.73	37.82	0.74	1.09	1.49	34.08	22.13	0.26	43.24	33	0.38	1.43	0.44
OC	FAL	28	1.86	2.73	0.7	46.96	52.58	0.87	0.98	1.12	55.16	36.16	0.47	58.95	40.42	0.53	1.37	0.49
OC	ALL	114	2.19	2.89	0.75	31.8	41.54	0.7	0.91	0.96	47.24	30.13	0.32	53.6	37.61	0.42	1.2	0.56
PM-2.5	WIN	27	9.28	10.38	0.87	11.78	20	1.09	1.86	4.21	18.47	13.59	0.12	25.57	21.31	0.2	2.32	0.76
PM-2.5	SPR	31	9.3	8.26	0.68	-11.2	24.74	-1.04	2.3	6	-6.5	-12.05	-0.13	27.45	29.39	0.28	2.66	0.46
PM-2.5	SUM	27	15.34	10.66	0.75	-30.49	31.72	-4.68	4.86	10.31	-28.54	-36.23	-0.44	30.66	38.22	0.46	5.67	0.56
PM-2.5	FAL	28	9.24	9.17	0.86	-0.74	21.56	-0.07	1.99	5.4	1.93	-1.68	-0.01	23.01	22.99	0.22	2.32	0.73
PM-2.5	ALL	113	10.72	9.56	0.74	-10.8	25.46	-1.16	2.73	10.92	-3.71	-9.13	-0.12	26.67	27.98	0.29	3.5	0.54
SO4	WIN	27	1.72	1.37	0.68	-20.44	29.48	-0.35	0.51	0.34	-11.67	-17.73	-0.26	27.99	31.27	0.37	0.68	0.46
SO4	SPR	31	2.16	1.86	0.77	-13.73	24.51	-0.3	0.53	0.34	-13.93	-19.7	-0.16	24.33	29.07	0.28	0.65	0.59
SO4	SUM	27	3.65	2.5	0.57	-31.37	33.92	-1.14	1.24	1.64	-28.62	-38.19	-0.46	31.51	40.94	0.49	1.72	0.33
SO4	FAL	28	1.8	1.64	0.78	-8.94	26.33	-0.16	0.47	0.35	-8.6	-15.62	-0.1	26.57	30.93	0.29	0.62	0.61
SO4	ALL	113	2.32	1.84	0.71	-20.62	29.27	-0.48	0.68	0.8	-15.58	-22.64	-0.26	27.47	32.89	0.37	1.01	0.51

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 380171004																		
EC	WIN	28	0.24	0.28	0.68	14.28	42.25	0.03	0.1	0.03	35.68	22.45	0.14	45.78	34.97	0.42	0.18	0.47
EC	SPR	29	0.22	0.3	0.8	37.74	48.13	0.08	0.1	0.01	53.26	34.95	0.38	60.01	43.06	0.48	0.13	0.63
EC	SUM	30	0.35	0.32	0.24	-9.83	41.22	-0.03	0.15	0.05	11.27	-1.7	-0.11	41.68	40.23	0.46	0.23	0.06
EC	FAL	30	0.35	0.46	0.67	31.11	40.44	0.11	0.14	0.05	53.26	28.86	0.31	59.58	36.79	0.4	0.25	0.45
EC	ALL	117	0.29	0.34	0.57	16.31	42.44	0.05	0.12	0.04	38.28	21	0.16	51.8	38.79	0.42	0.2	0.32
NACL	WIN	28	0.13	0.07	0.19	-48.73	59.87	-0.06	0.08	0.03	13.52	-19.28	-0.95	64.78	55.93	1.17	0.19	0.04
NACL	SPR	29	0.07	0.07	0.62	13.89	64.39	0.01	0.04	0	94.03	32.23	0.14	118.73	64.37	0.64	0.05	0.38
NACL	SUM	29	0.06	0.02	0.06	-69.85	76.59	-0.04	0.05	0.03	21.88	-40.11	-2.32	99	72.06	2.54	0.16	0
NACL	FAL	30	0.06	0.06	0.12	0.9	68.19	0	0.04	0	64.37	13.92	0.01	98	62.29	0.68	0.06	0.01
NACL	ALL	116	0.08	0.06	0.18	-30.3	65.8	-0.02	0.05	0.02	48.89	-3.02	-0.43	95.41	63.71	0.94	0.13	0.03
NH4	WIN	28	0.8	0.98	0.54	22.91	64.09	0.18	0.51	0.64	55.36	20.99	0.23	82.34	54.33	0.64	0.82	0.29
NH4	SPR	30	0.91	1	0.94	9.81	27.7	0.09	0.25	0.09	58.98	25.47	0.1	72.59	40.93	0.28	0.32	0.89
NH4	SUM	29	0.24	0.41	0.69	66.35	82.87	0.16	0.2	0.04	148.48	58.3	0.66	156.08	67.1	0.83	0.27	0.48
NH4	FAL	30	0.34	0.73	0.64	115.88	121.1	0.39	0.41	0.14	272.35	84.69	1.16	274.28	86.95	1.21	0.54	0.41
NH4	ALL	117	0.57	0.78	0.76	36.22	59.83	0.21	0.34	0.24	135.01	47.72	0.36	147.33	62.43	0.6	0.53	0.57
NO3	WIN	28	2.2	2.38	0.71	8.46	49	0.19	1.08	2.21	35.2	4.02	0.08	72.48	54.01	0.49	1.5	0.5
NO3	SPR	30	1.85	1.83	0.86	-1.38	35.67	-0.03	0.66	1.08	30.91	-9.12	-0.01	77.01	59.6	0.36	1.04	0.74
NO3	SUM	30	0.28	0.21	0.73	-24.38	56.5	-0.07	0.16	0.04	-22.39	-50.48	-0.32	58.92	71.27	0.75	0.21	0.53
NO3	FAL	30	0.76	1.47	0.71	93.15	98.79	0.71	0.75	1.03	114.64	53.7	0.93	121.83	62.11	0.99	1.24	0.51
NO3	ALL	118	1.26	1.46	0.8	15.91	52.08	0.2	0.66	1.17	39.66	-0.55	0.16	82.73	61.88	0.52	1.1	0.63
OC	WIN	28	1.28	0.9	0.58	-29.18	72.71	-0.37	0.93	5.64	102.01	39.23	-0.41	118.73	64.68	1.03	2.4	0.33
OC	SPR	27	0.49	0.92	0.72	85.42	87.11	0.42	0.43	0.1	325.65	69.1	0.85	326.36	69.84	0.87	0.53	0.52
OC	SUM	30	1.36	1.11	0.22	-18.27	47.23	-0.25	0.64	1.12	9.28	-5.62	-0.22	44.31	42.14	0.58	1.09	0.05
OC	FAL	30	1.23	1.7	0.4	38.73	61.33	0.48	0.75	1.8	157.85	39.85	0.39	169.25	54.65	0.61	1.42	0.16
OC	ALL	115	1.1	1.17	0.3	6.17	62.74	0.07	0.69	2.31	144.9	34.7	0.06	161.24	57.4	0.63	1.52	0.09
PM-2.5	WIN	28	7.12	6.53	0.79	-8.27	34.16	-0.59	2.43	9.69	-10.39	-18.21	-0.09	33.41	37	0.37	3.17	0.62
PM-2.5	SPR	29	7.65	6.44	0.9	-15.82	22.88	-1.21	1.75	4.88	-8.87	-14.12	-0.19	24.96	27.48	0.27	2.52	0.81
PM-2.5	SUM	30	8.92	4.94	0.14	-44.6	47.22	-3.98	4.21	9.11	-40.26	-56.49	-0.81	43.59	59.16	0.85	4.99	0.02
PM-2.5	FAL	29	8.93	8	0.53	-10.44	37.53	-0.93	3.35	20.41	3.61	-5.47	-0.12	36.33	36.24	0.42	4.61	0.28
PM-2.5	ALL	116	8.17	6.46	0.63	-20.89	36.12	-1.71	2.95	12.86	-14.23	-23.9	-0.26	34.66	40.16	0.46	3.97	0.4
SO4	WIN	28	0.99	0.82	0.56	-16.58	55.12	-0.16	0.54	0.75	-17.67	-33.26	-0.2	45.64	50.68	0.66	0.88	0.31
SO4	SPR	30	1.47	1.3	0.74	-11.57	38.21	-0.17	0.56	0.63	6.01	-5.33	-0.13	41.8	39.02	0.43	0.81	0.55
SO4	SUM	30	1.04	0.98	0.57	-6.16	37.22	-0.06	0.39	0.34	3.18	-4.74	-0.07	32.39	31.4	0.4	0.59	0.33
SO4	FAL	30	0.86	0.88	0.78	2.29	26.85	0.02	0.23	0.11	20.6	7.68	0.02	39.69	29.27	0.27	0.33	0.61
SO4	ALL	118	1.09	1	0.63	-8.56	39.32	-0.09	0.43	0.46	3.38	-8.5	-0.09	39.78	37.37	0.43	0.68	0.4

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 390350038																		
EC	WIN	14	0.44	1	0.65	127.17	127.17	0.56	0.56	0.05	611.78	82.61	1.27	611.78	82.61	1.27	0.6	0.43
EC	SPR	14	0.67	1.04	0.81	55.56	55.99	0.37	0.38	0.05	85.52	52.35	0.56	85.69	52.53	0.56	0.44	0.65
EC	SUM	15	1.04	1.06	0.82	2.12	19.88	0.02	0.21	0.1	14.05	9.45	0.02	23.37	20.63	0.2	0.32	0.67
EC	FAL	15	0.85	1.05	0.83	23.97	29.62	0.2	0.25	0.06	37.85	27.24	0.24	41.03	30.63	0.3	0.32	0.69
EC	ALL	58	0.76	1.04	0.72	37.44	45.49	0.28	0.34	0.1	181.74	42.07	0.37	185.01	45.87	0.45	0.43	0.51
NACL	WIN	14	0.13	0.18	0.71	43.66	52.34	0.06	0.07	0	61.58	41.14	0.44	66.71	47.09	0.52	0.07	0.5
NACL	SPR	13	0.09	0.14	0.42	52.55	65.87	0.05	0.06	0	77.15	42.53	0.53	84.37	51.1	0.66	0.07	0.18
NACL	SUM	16	0.09	0.04	0.33	-48.88	50.57	-0.04	0.04	0	-40.66	-58.93	-0.96	46.29	63.53	0.99	0.05	0.11
NACL	FAL	12	0.08	0.08	0.25	-6.44	57.18	-0.01	0.05	0.01	67.96	17.49	-0.07	94.3	55.9	0.61	0.07	0.06
NACL	ALL	55	0.1	0.11	0.47	11.99	55.74	0.01	0.05	0	36.91	7.2	0.12	70.96	54.74	0.56	0.07	0.22
NH4	WIN	15	1.44	1.17	0.92	-18.78	35.69	-0.27	0.51	0.49	14.57	-1.05	-0.23	45	35.16	0.44	0.75	0.85
NH4	SPR	14	1.41	1.52	0.94	8.01	19.2	0.11	0.27	0.12	12.8	7.69	0.08	25.49	22.46	0.19	0.37	0.88
NH4	SUM	16	1.36	1.12	0.88	-18.19	36.85	-0.25	0.5	0.39	25.79	4.23	-0.22	58.52	43.76	0.45	0.67	0.78
NH4	FAL	12	0.87	0.86	0.78	-0.68	38.44	-0.01	0.33	0.16	154.3	23.79	-0.01	178.13	51.54	0.39	0.4	0.61
NH4	ALL	57	1.29	1.18	0.86	-8.86	32	-0.11	0.41	0.33	46.7	7.81	-0.1	72.03	37.9	0.35	0.59	0.73
NO3	WIN	15	3.02	2.54	0.89	-15.83	30.55	-0.48	0.92	1.1	-3.08	-15.05	-0.19	39.74	38.65	0.36	1.15	0.79
NO3	SPR	14	2.13	2.1	0.67	-1.43	49.45	-0.03	1.05	2.48	10.46	-6.93	-0.01	51.07	49.92	0.5	1.58	0.45
NO3	SUM	16	0.83	0.25	0.45	-69.16	69.98	-0.57	0.58	0.51	-63.2	-102.28	-2.24	64.32	103.35	2.27	0.91	0.21
NO3	FAL	12	1.25	0.97	0.57	-22.18	50.42	-0.28	0.63	0.69	12.01	-24.82	-0.29	76.11	66.13	0.65	0.87	0.32
NO3	ALL	57	1.81	1.46	0.8	-19.42	43.94	-0.35	0.8	1.23	-13.45	-39.6	-0.24	57.08	65.37	0.55	1.16	0.64
OC	WIN	13	1.39	3.15	0.82	125.75	125.75	1.75	1.75	0.58	143.71	78.99	1.26	143.71	78.99	1.26	1.91	0.67
OC	SPR	14	1.5	2.5	0.74	66.44	66.44	1	1	0.43	95.77	57.07	0.66	95.77	57.07	0.66	1.19	0.55
OC	SUM	15	2.43	2.63	0.8	8.22	23.24	0.2	0.56	0.47	18.49	12.59	0.08	29.22	25.06	0.23	0.71	0.64
OC	FAL	15	1.56	2.15	0.83	37.27	46.18	0.58	0.72	0.33	74.2	45.39	0.37	77.69	49.4	0.46	0.82	0.69
OC	ALL	57	1.74	2.59	0.64	48.96	56.6	0.85	0.98	0.77	80.69	47.29	0.49	84.43	51.62	0.57	1.22	0.41
PM-2.5	WIN	14	10.61	11.33	0.93	6.81	17.76	0.72	1.88	4.53	15.82	11.54	0.07	24.55	20.75	0.18	2.25	0.86
PM-2.5	SPR	13	10.8	12	0.54	11.15	33.94	1.2	3.67	19.74	17.65	10	0.11	34.57	31.31	0.34	4.6	0.3
PM-2.5	SUM	16	16.49	12.05	0.92	-26.91	27.83	-4.44	4.59	11.98	-22	-26.74	-0.37	25.36	29.73	0.38	5.63	0.85
PM-2.5	FAL	12	11.88	9.98	0.83	-15.92	25.81	-1.89	3.06	12.43	-4.54	-9.43	-0.19	26.02	26.16	0.31	4	0.68
PM-2.5	ALL	55	12.64	11.41	0.76	-9.77	26.5	-1.23	3.35	17.47	0.81	-4.54	-0.11	27.47	27.04	0.29	4.36	0.57
SO4	WIN	15	1.84	1.2	0.79	-34.64	38.52	-0.64	0.71	0.74	-25.71	-33.85	-0.53	30.82	38.26	0.59	1.07	0.63
SO4	SPR	14	2.83	2.71	0.72	-4.37	33.76	-0.12	0.96	1.72	0.74	-7.39	-0.05	32.85	35.81	0.35	1.32	0.52
SO4	SUM	16	4.18	3.48	0.91	-16.7	28.56	-0.7	1.19	1.86	2.42	-5.39	-0.2	33.01	30.33	0.34	1.53	0.83
SO4	FAL	12	2.35	1.72	0.87	-26.78	35.04	-0.63	0.82	0.65	-10.15	-18.58	-0.37	36.3	38.31	0.48	1.02	0.75
SO4	ALL	57	2.85	2.32	0.84	-18.49	32.65	-0.53	0.93	1.33	-8.04	-16.15	-0.23	33.09	35.44	0.4	1.27	0.7

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 390350060																		
EC	WIN	11	1.08	1.25	0.85	15.66	28.65	0.17	0.31	0.11	29.09	20.21	0.16	37.47	29.44	0.29	0.37	0.73
EC	SPR	21	0.99	1.06	0.66	6.18	26.18	0.06	0.26	0.12	20.77	11.89	0.06	33.14	26.76	0.26	0.35	0.44
EC	SUM	26	1.25	1.01	0.79	-19.21	26.19	-0.24	0.33	0.13	-10.66	-16	-0.24	25.89	27.71	0.32	0.43	0.63
EC	FAL	21	1.18	1.06	0.72	-9.91	30.23	-0.12	0.36	0.22	0.61	-5.86	-0.11	30.14	31.06	0.34	0.48	0.52
EC	ALL	79	1.14	1.07	0.71	-6.16	27.62	-0.07	0.31	0.17	6.23	-0.85	-0.07	30.56	28.59	0.29	0.42	0.5
NACL	WIN	22	0.31	0.21	0.7	-31.45	59.51	-0.1	0.18	0.1	39.74	2.3	-0.46	77.19	55.77	0.87	0.33	0.49
NACL	SPR	22	0.18	0.12	0.61	-30.79	49.6	-0.05	0.09	0.01	6.97	-16.98	-0.44	59.61	53.09	0.72	0.13	0.37
NACL	SUM	26	0.08	0.04	0.58	-49.33	50.59	-0.04	0.04	0	-42.58	-59.42	-0.97	45.65	62.2	1	0.05	0.34
NACL	FAL	24	0.13	0.09	0.45	-29.72	57.29	-0.04	0.08	0.01	-5.27	-29.05	-0.42	57.39	59.42	0.82	0.11	0.2
NACL	ALL	94	0.17	0.11	0.64	-33.34	55.48	-0.06	0.09	0.03	-2.19	-27.29	-0.5	59.3	57.85	0.83	0.18	0.41
NH4	WIN	23	2.1	1.46	0.85	-30.15	36.26	-0.63	0.76	0.62	-8.32	-25.05	-0.43	45.9	45.29	0.52	1.01	0.72
NH4	SPR	22	1.57	1.38	0.82	-12.05	29.75	-0.19	0.47	0.34	-0.35	-8.99	-0.14	34.15	34.65	0.34	0.61	0.67
NH4	SUM	26	1.25	1.02	0.89	-18.97	36.55	-0.24	0.46	0.32	20.98	2.69	-0.23	51.69	40.68	0.45	0.62	0.79
NH4	FAL	25	0.86	0.89	0.82	4.13	34.4	0.04	0.3	0.12	63.65	22.73	0.04	82.54	45.21	0.34	0.35	0.68
NH4	ALL	96	1.42	1.17	0.84	-17.54	34.39	-0.25	0.49	0.4	20.18	-1.42	-0.21	54.32	41.58	0.42	0.68	0.71
NO3	WIN	23	3.73	3.12	0.76	-16.39	36.17	-0.61	1.35	2.84	-1.48	-13.91	-0.2	41.65	42.29	0.43	1.79	0.58
NO3	SPR	22	2.36	1.83	0.76	-22.7	37.37	-0.54	0.88	1.55	-20.82	-33	-0.29	37	46.67	0.48	1.36	0.58
NO3	SUM	26	0.79	0.22	0.49	-72.19	72.19	-0.57	0.57	0.43	-65.2	-104.69	-2.6	65.2	104.69	2.6	0.87	0.24
NO3	FAL	25	1.2	0.95	0.59	-20.87	49.21	-0.25	0.59	0.52	0.95	-28.77	-0.26	66.99	64.31	0.62	0.76	0.35
NO3	ALL	96	1.96	1.47	0.82	-24.95	42.52	-0.49	0.83	1.31	-22.54	-46.74	-0.33	53.56	65.93	0.57	1.24	0.68
OC	WIN	11	3.14	3.88	0.89	23.33	31.73	0.73	1	0.86	39.52	28.03	0.23	44.58	33.92	0.32	1.18	0.8
OC	SPR	21	1.54	2.45	0.79	59.79	59.79	0.92	0.92	0.39	79.13	50.98	0.6	79.13	50.98	0.6	1.11	0.62
OC	SUM	26	2.07	2.51	0.78	20.99	28.16	0.44	0.58	0.38	32.36	21.49	0.21	37.12	26.67	0.28	0.75	0.61
OC	FAL	21	1.87	2.33	0.89	24.22	33.94	0.45	0.64	0.28	47.09	31.62	0.24	52.27	37.33	0.34	0.69	0.79
OC	ALL	79	2.03	2.64	0.86	30.1	36.72	0.61	0.74	0.46	49.71	32.93	0.3	53.36	36.98	0.37	0.91	0.74
PM-2.5	WIN	22	15.59	14.15	0.79	-9.21	23.83	-1.43	3.71	24.61	-0.88	-6.68	-0.1	27.28	28.15	0.26	5.16	0.62
PM-2.5	SPR	22	12.65	12.36	0.75	-2.31	24.1	-0.29	3.05	16.49	3.57	-0.64	-0.02	23.59	23.6	0.25	4.07	0.56
PM-2.5	SUM	26	15.15	11.06	0.89	-26.99	28.3	-4.09	4.29	13.01	-23.48	-28.23	-0.37	24.98	29.6	0.39	5.45	0.8
PM-2.5	FAL	25	12.32	9.91	0.79	-19.55	28.99	-2.41	3.57	20	-7.59	-13.42	-0.24	26.87	29.67	0.36	5.08	0.62
PM-2.5	ALL	95	13.93	11.78	0.78	-15.46	26.42	-2.15	3.68	20.3	-7.8	-12.95	-0.18	25.69	27.89	0.31	4.99	0.6
SO4	WIN	23	3.05	1.56	0.47	-48.77	49.84	-1.49	1.52	1.91	-40.9	-58.31	-0.95	41.84	59.21	0.97	2.03	0.22
SO4	SPR	22	2.82	2.5	0.66	-11.16	34.22	-0.31	0.96	1.82	-4.25	-12.65	-0.13	33.74	37.29	0.39	1.38	0.43
SO4	SUM	26	3.86	3.17	0.9	-17.78	27.25	-0.69	1.05	1.62	-0.07	-7.88	-0.22	30.93	28.64	0.33	1.45	0.8
SO4	FAL	25	2.26	1.87	0.88	-17.33	25.25	-0.39	0.57	0.45	-6.96	-12.37	-0.21	26.01	27.89	0.31	0.78	0.78
SO4	ALL	96	3.01	2.29	0.75	-23.79	33.84	-0.72	1.02	1.64	-12.6	-22.22	-0.31	32.91	37.75	0.44	1.47	0.57

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 390490081																		
EC	WIN	14	0.67	1.29	0.42	94.65	107.21	0.63	0.71	0.24	143.23	71.98	0.95	146.85	76.12	1.07	0.8	0.17
EC	SPR	15	0.43	0.9	0.55	109.27	109.27	0.47	0.47	0.08	132.26	72.81	1.09	132.26	72.81	1.09	0.55	0.3
EC	SUM	16	0.84	1.33	0.84	57.42	57.42	0.48	0.48	0.07	57.81	42.85	0.57	57.81	42.85	0.57	0.55	0.71
EC	FAL	15	0.8	1.33	0.68	65.46	71.24	0.52	0.57	0.23	90.63	50.97	0.65	94.31	55.04	0.71	0.71	0.46
EC	ALL	60	0.69	1.21	0.64	76.22	80.75	0.52	0.56	0.16	104.56	59.16	0.76	106.32	61.15	0.81	0.66	0.41
NACL	WIN	15	0.08	0.15	0.2	86.93	113.55	0.07	0.09	0.01	140.41	68.03	0.87	147.59	77.47	1.14	0.11	0.04
NACL	SPR	15	0.04	0.1	0.3	139.86	139.86	0.06	0.06	0	182.41	76.65	1.4	182.41	76.65	1.4	0.07	0.09
NACL	SUM	16	0.05	0.04	0.82	-21.73	28.85	-0.01	0.01	0	-18.3	-25.63	-0.28	28.46	34.12	0.37	0.02	0.67
NACL	FAL	15	0.03	0.07	0.52	99.48	99.48	0.03	0.03	0	120.39	64.42	0.99	120.39	64.42	0.99	0.04	0.28
NACL	ALL	61	0.05	0.09	0.4	72.18	95.15	0.04	0.05	0	104.19	44.7	0.72	118.22	62.69	0.95	0.07	0.16
NH4	WIN	15	1.61	1.48	0.87	-7.77	30.45	-0.13	0.49	0.33	7.86	0.38	-0.08	35.7	33.04	0.33	0.59	0.76
NH4	SPR	15	1.36	1.74	0.7	27.71	48.39	0.38	0.66	0.59	46.13	24.97	0.28	61.99	43.21	0.48	0.86	0.49
NH4	SUM	16	1.53	1.52	0.78	-0.74	31.77	-0.01	0.49	0.36	18.27	7.8	-0.01	41.4	34.93	0.32	0.6	0.62
NH4	FAL	15	0.8	1.09	0.94	36.54	39.55	0.29	0.32	0.09	146.54	40.15	0.37	152.11	46.81	0.4	0.42	0.88
NH4	ALL	61	1.33	1.46	0.78	9.87	36.72	0.13	0.49	0.38	54.1	18.15	0.1	72.29	39.42	0.37	0.63	0.61
NO3	WIN	15	3.43	3.64	0.73	5.98	35.87	0.21	1.23	2.26	14.11	4.49	0.06	38.6	34.97	0.36	1.52	0.54
NO3	SPR	15	2.01	2.87	0.64	42.81	71.17	0.86	1.43	2.71	81.84	34.2	0.43	102.41	59.24	0.71	1.86	0.41
NO3	SUM	16	0.87	0.91	0.76	5.54	42.98	0.05	0.37	0.42	6.07	-10.74	0.06	47.74	43.24	0.43	0.65	0.57
NO3	FAL	15	1.29	1.83	0.54	42.26	65.1	0.55	0.84	1.65	53.4	17.21	0.42	79.99	52.47	0.65	1.4	0.29
NO3	ALL	61	1.88	2.29	0.75	21.71	50.92	0.41	0.96	1.84	38.32	10.93	0.22	66.87	47.41	0.51	1.42	0.56
OC	WIN	14	1.99	4.63	0.62	132.71	132.71	2.64	2.64	1.93	176.59	84.05	1.33	176.59	84.05	1.33	2.98	0.38
OC	SPR	15	1.18	2.33	0.68	97.93	97.93	1.15	1.15	0.6	125.13	66.78	0.98	125.13	66.78	0.98	1.39	0.47
OC	SUM	16	2.18	2.96	0.79	35.36	36.52	0.77	0.8	0.48	42.44	30.45	0.35	43.18	31.21	0.37	1.04	0.62
OC	FAL	15	1.3	2.73	0.92	109.54	109.54	1.43	1.43	0.38	155.33	79.62	1.1	155.33	79.62	1.1	1.55	0.85
OC	ALL	60	1.67	3.13	0.69	88.02	88.42	1.47	1.47	1.3	122.64	64.33	0.88	122.83	64.53	0.88	1.86	0.47
PM-2.5	WIN	15	12.76	15.33	0.89	20.14	23.18	2.57	2.96	7.76	24.69	19.83	0.2	27.25	22.49	0.23	3.79	0.79
PM-2.5	SPR	15	9.76	12.68	0.74	29.96	36.19	2.92	3.53	13.3	33.92	24.21	0.3	40.52	31.39	0.36	4.67	0.55
PM-2.5	SUM	16	15.29	14.13	0.86	-7.61	17.68	-1.16	2.7	10.02	-5.76	-7.69	-0.08	16.22	17.27	0.19	3.37	0.73
PM-2.5	FAL	14	8.59	11.65	0.86	35.66	42.86	3.06	3.68	11.36	44.97	32.6	0.36	47.91	35.81	0.43	4.55	0.73
PM-2.5	ALL	60	11.71	13.49	0.81	15.18	27.34	1.78	3.2	13.76	23.61	16.56	0.15	32.45	26.43	0.27	4.11	0.66
SO4	WIN	15	1.99	1.16	0.87	-41.88	43.41	-0.83	0.86	0.81	-34.67	-45.86	-0.72	36.51	47.58	0.75	1.23	0.75
SO4	SPR	15	2.62	2.52	0.86	-3.86	21.43	-0.1	0.56	0.52	-3.18	-6.68	-0.04	22.92	22.99	0.22	0.73	0.75
SO4	SUM	16	4.42	3.68	0.81	-16.85	26.06	-0.74	1.15	1.79	-12.11	-16.5	-0.2	22.5	25.87	0.31	1.53	0.66
SO4	FAL	15	1.91	1.65	0.97	-13.33	19.42	-0.25	0.37	0.15	-8.57	-12.68	-0.15	24.44	25.6	0.22	0.46	0.94
SO4	ALL	61	2.76	2.28	0.87	-17.65	26.92	-0.49	0.74	0.93	-14.59	-20.37	-0.21	26.53	30.43	0.33	1.08	0.76

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 390610040																		
EC	WIN	29	0.6	1.41	0.68	134.11	134.11	0.81	0.81	0.1	175.57	86.14	1.34	175.57	86.14	1.34	0.87	0.47
EC	SPR	30	0.49	0.94	0.55	90.89	97.32	0.45	0.48	0.1	131.01	68.71	0.91	133.37	71.58	0.97	0.55	0.3
EC	SUM	31	0.75	1.26	0.63	69.17	69.17	0.52	0.52	0.14	76.19	49.94	0.69	76.19	49.94	0.69	0.64	0.39
EC	FAL	30	0.62	1.17	0.68	90.26	91.46	0.56	0.56	0.1	121.32	67.82	0.9	121.79	68.31	0.91	0.64	0.47
EC	ALL	120	0.62	1.2	0.63	94.12	95.71	0.58	0.59	0.13	125.19	67.85	0.94	125.9	68.69	0.96	0.68	0.39
NACL	WIN	29	0.07	0.28	0.37	303.45	303.45	0.21	0.21	0.01	439.77	120.8	3.03	439.77	120.8	3.03	0.24	0.13
NACL	SPR	30	0.06	0.13	0.41	118.9	120.78	0.07	0.07	0.01	211.78	65.77	1.19	214.15	68.41	1.21	0.11	0.16
NACL	SUM	26	0.06	0.04	0.13	-31.11	52.24	-0.02	0.03	0	17.71	-26.71	-0.45	77.5	59.05	0.76	0.05	0.02
NACL	FAL	30	0.09	0.11	0.53	28.43	76.19	0.02	0.07	0.01	83.81	30.04	0.28	106.34	60.29	0.76	0.11	0.28
NACL	ALL	115	0.07	0.14	0.28	104.42	137.41	0.07	0.1	0.02	192.01	49.42	1.04	212.03	77.39	1.37	0.14	0.08
NH4	WIN	29	1.81	1.67	0.67	-7.73	31.45	-0.14	0.57	0.52	12.79	0.06	-0.08	40.82	34.77	0.34	0.73	0.45
NH4	SPR	30	1.37	1.32	0.69	-3.52	32.81	-0.05	0.45	0.36	11.18	0.59	-0.04	39.35	34.23	0.34	0.6	0.48
NH4	SUM	26	1.44	1.23	0.78	-14.64	25.41	-0.21	0.37	0.29	-6.47	-11.16	-0.17	22.33	24.95	0.3	0.58	0.61
NH4	FAL	30	0.69	0.91	0.78	31.4	47.21	0.22	0.33	0.13	134.82	41.92	0.31	143.39	52.47	0.47	0.42	0.61
NH4	ALL	115	1.32	1.28	0.76	-2.96	32.47	-0.04	0.43	0.35	39.85	8.58	-0.03	63.01	37.03	0.33	0.59	0.57
NO3	WIN	29	3.27	3.38	0.7	3.32	37.96	0.11	1.24	1.98	23.14	7.9	0.03	51.1	42.38	0.38	1.41	0.49
NO3	SPR	30	1.7	1.97	0.55	15.99	62.3	0.27	1.06	2.36	39.58	8.89	0.16	73.71	54.89	0.62	1.56	0.3
NO3	SUM	26	0.49	0.37	0.53	-24.37	51.23	-0.12	0.25	0.1	-24.27	-44.95	-0.32	51.87	62.77	0.68	0.33	0.28
NO3	FAL	30	0.79	0.93	0.6	18.27	53.57	0.14	0.42	0.34	27.97	0.17	0.18	66.51	55.79	0.54	0.6	0.36
NO3	ALL	115	1.58	1.69	0.78	6.88	47.74	0.11	0.76	1.24	17.97	-5.81	0.07	61.19	53.75	0.48	1.12	0.61
OC	WIN	29	1.65	4.51	0.57	173.09	173.09	2.86	2.86	1.66	208.16	93.44	1.73	208.16	93.44	1.73	3.13	0.32
OC	SPR	30	1.25	2.35	0.71	87.37	88.22	1.09	1.11	0.44	155.48	70.31	0.87	156.29	71.15	0.88	1.28	0.51
OC	SUM	31	1.94	3.02	0.73	55.98	58.38	1.08	1.13	0.55	61.97	43.12	0.56	63.78	45.08	0.58	1.31	0.53
OC	FAL	30	1.34	2.58	0.81	93.03	93.85	1.24	1.26	1.02	122.33	65.01	0.93	123.25	66.01	0.94	1.6	0.66
OC	ALL	120	1.55	3.1	0.63	100.54	101.67	1.56	1.57	1.45	135.76	67.55	1.01	136.67	68.51	1.02	1.97	0.39
PM-2.5	WIN	29	13.61	16.87	0.71	23.94	32.27	3.26	4.39	15.83	32.66	22.99	0.24	39.6	30.91	0.32	5.14	0.5
PM-2.5	SPR	30	10.94	11.49	0.68	5.04	29.3	0.55	3.2	16.51	17.33	10.23	0.05	33.6	29.27	0.29	4.1	0.46
PM-2.5	SUM	26	17.06	13.19	0.83	-22.68	24.25	-3.87	4.14	17.07	-19.18	-23.32	-0.29	21.33	25.33	0.31	5.66	0.68
PM-2.5	FAL	30	8.43	10.59	0.83	25.52	33.65	2.15	2.84	8.55	35.82	25.37	0.26	41.68	31.94	0.34	3.63	0.7
PM-2.5	ALL	115	12.34	12.99	0.72	5.28	29.32	0.65	3.62	21.31	17.76	9.81	0.05	34.45	29.49	0.29	4.66	0.52
SO4	WIN	29	2.64	1.77	0.71	-32.73	37.2	-0.86	0.98	0.97	-27.06	-36.76	-0.49	33.37	42.13	0.55	1.31	0.51
SO4	SPR	30	2.83	2.17	0.82	-23.25	28.36	-0.66	0.8	0.71	-17.1	-23.16	-0.3	27.2	31.18	0.37	1.07	0.67
SO4	SUM	26	5.13	3.68	0.75	-28.28	32.7	-1.45	1.68	3.69	-25.02	-32.79	-0.39	29.48	36.9	0.46	2.41	0.57
SO4	FAL	30	2.06	1.91	0.86	-7.09	27.35	-0.15	0.56	0.62	1.41	-4.95	-0.08	27.12	28.23	0.29	0.8	0.74
SO4	ALL	115	3.1	2.34	0.82	-24.37	31.7	-0.75	0.98	1.64	-16.57	-24.02	-0.32	29.25	34.47	0.42	1.49	0.67

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 390811001																		
EC	WIN	15	0.73	0.59	0.25	-19.81	56.3	-0.15	0.41	0.42	20.94	1.41	-0.25	60.16	55.22	0.7	0.67	0.06
EC	SPR	15	0.82	0.45	0.39	-45.08	50.29	-0.37	0.41	0.21	-33.13	-48.16	-0.82	41.1	55.28	0.92	0.59	0.15
EC	SUM	16	1.13	0.49	0.65	-56.16	56.16	-0.63	0.63	0.1	-53.19	-74.15	-1.28	53.19	74.15	1.28	0.71	0.43
EC	FAL	15	0.86	0.47	0.82	-45.79	49.19	-0.39	0.42	0.13	-31.79	-46.21	-0.84	42.93	54.89	0.91	0.54	0.67
EC	ALL	61	0.89	0.5	0.39	-43.8	53.19	-0.39	0.47	0.25	-24.77	-42.31	-0.78	49.41	60.12	0.95	0.63	0.15
NACL	WIN	13	0.1	0.11	0.42	8.16	45.89	0.01	0.05	0	21.98	9.17	0.08	47.19	41.7	0.46	0.06	0.18
NACL	SPR	15	0.06	0.08	0.12	27.1	74.62	0.02	0.04	0	80.79	31.56	0.27	109.92	70.51	0.75	0.05	0.01
NACL	SUM	16	0.04	0.04	0.42	-13.13	31.5	-0.01	0.01	0	-5.02	-12.12	-0.15	31.78	33.76	0.36	0.02	0.18
NACL	FAL	12	0.05	0.06	0.73	38.75	58.88	0.02	0.03	0	37.09	21.91	0.39	55.44	44.47	0.59	0.04	0.53
NACL	ALL	56	0.06	0.07	0.54	13.84	52.63	0.01	0.03	0	33.26	11.82	0.14	61.36	47.74	0.53	0.04	0.29
NH4	WIN	13	2.28	0.91	0.75	-59.86	59.86	-1.36	1.36	1.09	-53.46	-77.2	-1.49	53.46	77.2	1.49	1.72	0.56
NH4	SPR	15	1.34	0.96	0.8	-28.29	32.85	-0.38	0.44	0.21	-31.42	-43.07	-0.39	34.69	46.08	0.46	0.59	0.65
NH4	SUM	16	1.62	1.01	0.83	-37.53	41.5	-0.61	0.67	0.29	-17.73	-35.11	-0.6	48.48	53.73	0.66	0.81	0.69
NH4	FAL	13	1.03	0.58	0.79	-43.93	54.97	-0.45	0.56	0.34	-6.75	-34.83	-0.78	67.55	66.58	0.98	0.74	0.62
NH4	ALL	57	1.56	0.88	0.68	-43.84	47.68	-0.68	0.74	0.6	-26.98	-46.74	-0.78	50.34	60	0.85	1.04	0.47
NO3	WIN	13	3.59	1.84	0.63	-48.79	54.63	-1.75	1.96	3.61	-34.54	-58.25	-0.95	53.76	70.08	1.07	2.58	0.39
NO3	SPR	15	0.97	1.03	0.57	6.92	66.13	0.07	0.64	1.02	-3.65	-42.27	0.07	73.03	78.91	0.66	1.01	0.32
NO3	SUM	16	0.36	0.15	0.46	-59.42	60.66	-0.22	0.22	0.02	-57.6	-87.39	-1.46	58.85	88.58	1.49	0.26	0.21
NO3	FAL	13	0.77	0.49	0.61	-36.83	55.29	-0.28	0.43	0.2	-18.23	-44.34	-0.58	60.14	73.09	0.88	0.53	0.37
NO3	ALL	57	1.35	0.84	0.68	-37.54	57.34	-0.51	0.77	1.62	-29.16	-59.05	-0.6	61.72	78.28	0.92	1.37	0.46
OC	WIN	15	1.87	2.55	0.28	36.85	65.78	0.69	1.23	1.91	74.47	38.4	0.37	87.85	56.17	0.66	1.54	0.08
OC	SPR	15	1.39	1.54	0.59	10.66	40.41	0.15	0.56	0.46	21.19	10.49	0.11	42.4	36.64	0.4	0.7	0.34
OC	SUM	16	2.39	2.04	0.38	-14.82	40.57	-0.35	0.97	1.36	4.21	-15	-0.17	51.23	44.83	0.48	1.22	0.15
OC	FAL	15	1.74	1.43	0.83	-17.78	28.79	-0.31	0.5	0.49	-1.56	-8.01	-0.22	29.42	29.19	0.35	0.76	0.69
OC	ALL	61	1.86	1.89	0.43	1.96	44.05	0.04	0.82	1.24	24.24	6.12	0.02	52.7	41.76	0.44	1.11	0.18
PM-2.5	WIN	13	18.89	9.41	0.72	-50.21	50.21	-9.49	9.49	41.54	-46.35	-63.29	-1.01	46.35	63.29	1.01	11.47	0.52
PM-2.5	SPR	15	11.24	7.98	0.82	-29.01	29.01	-3.26	3.26	7.31	-29.83	-39.14	-0.41	29.83	39.14	0.41	4.24	0.67
PM-2.5	SUM	16	18.83	10.21	0.59	-45.75	45.75	-8.61	8.61	39.53	-42.5	-57.38	-0.84	42.5	57.38	0.84	10.66	0.35
PM-2.5	FAL	13	10.76	6.22	0.77	-42.22	43.86	-4.54	4.72	15.73	-34.27	-45.99	-0.73	38.7	49.86	0.76	6.03	0.6
PM-2.5	ALL	57	15.01	8.53	0.7	-43.15	43.42	-6.47	6.52	33	-38.17	-51.33	-0.76	39.18	52.22	0.76	8.66	0.49
SO4	WIN	13	3.63	1.21	0.63	-66.64	66.64	-2.42	2.42	1.01	-65.74	-99.77	-2	65.74	99.77	2	2.62	0.39
SO4	SPR	15	3.54	2.02	0.89	-42.9	44.04	-1.52	1.56	1.14	-44.73	-62.01	-0.75	45.88	63.11	0.77	1.86	0.79
SO4	SUM	16	5.52	3.94	0.89	-28.57	29.71	-1.58	1.64	1.66	-27.13	-37.05	-0.4	30.93	40.45	0.42	2.04	0.8
SO4	FAL	13	2.99	1.51	0.77	-49.37	50.12	-1.47	1.5	1.52	-44.59	-62.89	-0.98	46.74	64.9	0.99	1.92	0.59
SO4	ALL	57	3.99	2.26	0.86	-43.37	44.2	-1.73	1.76	1.48	-44.55	-63.82	-0.77	46.41	65.52	0.78	2.12	0.73

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 390933002																		
EC	WIN	9	0.42	0.63	0.66	49.13	52.67	0.21	0.22	0.02	75.28	44.63	0.49	77.36	46.8	0.53	0.25	0.44
EC	SPR	12	0.36	0.59	0.68	65.26	80.78	0.23	0.29	0.05	113.54	62.61	0.65	117.92	67.66	0.81	0.33	0.47
EC	SUM	15	0.74	0.71	0.74	-4.16	26.81	-0.03	0.2	0.06	14.67	5.81	-0.04	36.2	31.58	0.28	0.25	0.54
EC	FAL	12	0.55	0.74	0.9	34.03	38.95	0.19	0.22	0.03	59.64	39.57	0.34	62.95	43.09	0.39	0.25	0.81
EC	ALL	48	0.54	0.67	0.75	24.98	42.66	0.13	0.23	0.05	61.99	35.73	0.25	71.03	46.33	0.43	0.27	0.57
NACL	WIN	11	0.06	0.11	0.11	82.11	95.79	0.05	0.06	0	2656.62	60.62	0.82	2665.2	70.56	0.96	0.07	0.01
NACL	SPR	14	0.05	0.08	0.61	51.32	64.62	0.03	0.03	0	56.05	23.13	0.51	76.74	50.94	0.65	0.05	0.37
NACL	SUM	15	0.05	0.03	0.69	-43.09	49.47	-0.02	0.03	0	-25.9	-39.92	-0.76	39.44	51.36	0.87	0.04	0.48
NACL	FAL	10	0.04	0.05	0.2	8.78	39.52	0	0.02	0	16.93	5.05	0.09	41.52	36.47	0.4	0.02	0.04
NACL	ALL	50	0.05	0.06	0.32	22.45	63.41	0.01	0.03	0	595.77	8.85	0.22	627.97	52.49	0.63	0.05	0.1
NH4	WIN	11	1.21	1.07	0.86	-11.49	36.04	-0.14	0.44	0.4	16.1	3.91	-0.13	42.32	34.38	0.41	0.65	0.74
NH4	SPR	14	0.92	1.43	0.79	55.94	66.49	0.51	0.61	0.43	71.7	36.84	0.56	80.93	47.72	0.66	0.83	0.62
NH4	SUM	15	0.94	1.06	0.94	12.64	27.17	0.12	0.26	0.08	217.25	43.02	0.13	224.07	50.54	0.27	0.31	0.89
NH4	FAL	11	0.57	0.95	0.83	67.68	68.57	0.38	0.39	0.07	306.75	69.31	0.68	307.37	69.94	0.69	0.47	0.69
NH4	ALL	51	0.91	1.14	0.74	25.05	46.11	0.23	0.42	0.31	153.21	38.56	0.25	163.54	50.46	0.46	0.6	0.54
NO3	WIN	11	2.42	2.44	0.82	1.07	34.15	0.03	0.82	0.97	10.45	-5.07	0.01	45.78	39.91	0.34	0.98	0.67
NO3	SPR	14	1.42	2.13	0.81	49.4	71.9	0.7	1.02	2.11	45.97	21.48	0.49	65.84	45.55	0.72	1.61	0.65
NO3	SUM	15	0.5	0.38	0.89	-22.86	33.89	-0.11	0.17	0.04	-30.05	-44.19	-0.3	38.59	51.87	0.44	0.23	0.79
NO3	FAL	11	0.97	1.25	0.74	28.92	53.59	0.28	0.52	0.44	70.01	20.09	0.29	97.06	56.43	0.54	0.72	0.55
NO3	ALL	51	1.27	1.49	0.81	17.79	48.96	0.23	0.62	1	21.14	-3.86	0.18	60.23	48.54	0.49	1.02	0.66
OC	WIN	9	1.38	2.25	0.87	63.41	63.41	0.87	0.87	0.22	100.7	57.08	0.63	100.7	57.08	0.63	0.99	0.75
OC	SPR	12	0.95	1.63	0.77	71.73	75.28	0.68	0.71	0.29	101.46	60.33	0.72	102.52	61.42	0.75	0.87	0.59
OC	SUM	15	2.44	2	0.54	-18.28	28.59	-0.45	0.7	1.18	-8.84	-15.72	-0.22	23.97	27.94	0.35	1.17	0.29
OC	FAL	12	1.35	1.65	0.84	21.93	34.01	0.3	0.46	0.18	36.28	27.56	0.22	42.59	34.62	0.34	0.52	0.71
OC	ALL	48	1.6	1.86	0.62	16.82	42.3	0.27	0.68	0.8	50.55	27.76	0.17	62.65	43.44	0.42	0.93	0.38
PM-2.5	WIN	11	9.15	9.53	0.78	4.13	23.2	0.38	2.12	8.71	15.7	8.37	0.04	29.67	25.13	0.23	2.98	0.61
PM-2.5	SPR	14	8.35	10.49	0.74	25.6	42.29	2.14	3.53	15.2	27.44	14.96	0.26	46.05	38.52	0.42	4.45	0.54
PM-2.5	SUM	16	10.29	10.62	0.38	3.2	54.35	0.33	5.59	55.9	870.38	25.23	0.03	903.29	64.46	0.54	7.48	0.14
PM-2.5	FAL	12	9.34	9.37	0.78	0.34	27.12	0.03	2.53	9.6	48.07	11.25	0	67.94	34.31	0.27	3.1	0.6
PM-2.5	ALL	53	9.33	10.08	0.54	8.04	38.98	0.75	3.64	25.58	284.15	15.85	0.08	306.4	42.62	0.39	5.11	0.29
SO4	WIN	11	1.72	1.06	0.73	-38.14	43.92	-0.66	0.76	0.96	-26.32	-35.95	-0.62	33.62	42.03	0.71	1.18	0.54
SO4	SPR	14	2.16	2.48	0.78	15.08	43.4	0.33	0.94	1.46	21.79	3.37	0.15	53.6	44.56	0.43	1.25	0.61
SO4	SUM	15	3.47	3.26	0.78	-5.93	30.09	-0.21	1.04	2.04	19.54	4.86	-0.06	44.76	33.39	0.32	1.44	0.61
SO4	FAL	11	1.69	1.74	0.96	2.92	13.79	0.05	0.23	0.08	12.81	9.13	0.03	20.6	17.35	0.14	0.29	0.92
SO4	ALL	51	2.35	2.25	0.77	-4.35	33.1	-0.1	0.78	1.35	8.82	-3.43	-0.05	39.57	34.86	0.35	1.17	0.6

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 390950026																		
EC	WIN	15	0.42	0.69	0.61	63.71	65.64	0.27	0.28	0.02	85.79	53.52	0.64	86.89	54.67	0.66	0.31	0.37
EC	SPR	15	0.44	0.71	0.35	59.25	69.35	0.26	0.31	0.07	92.08	51.27	0.59	96.31	56.28	0.69	0.37	0.12
EC	SUM	14	0.74	0.62	0.25	-16.03	35.16	-0.12	0.26	0.07	-2.28	-11.38	-0.19	38.73	39.11	0.42	0.29	0.06
EC	FAL	14	0.78	0.87	0.83	12.13	33.66	0.09	0.26	0.09	38.45	22.84	0.12	52.44	39.65	0.34	0.32	0.69
EC	ALL	58	0.59	0.72	0.63	22.33	46.98	0.13	0.28	0.09	54.73	29.87	0.22	69.39	47.71	0.47	0.32	0.39
NACL	WIN	15	0.09	0.15	0.45	59.74	69.81	0.06	0.07	0	93.65	44.57	0.6	99.08	50.73	0.7	0.08	0.21
NACL	SPR	15	0.08	0.16	0.57	111.67	120.19	0.09	0.09	0	201.55	68.67	1.12	209.69	78.09	1.2	0.11	0.32
NACL	SUM	12	0.07	0.05	0.1	-22.17	66.38	-0.02	0.05	0	-6.86	-39.53	-0.28	72.72	73.9	0.85	0.06	0.01
NACL	FAL	9	0.07	0.1	0.22	45.3	85.93	0.03	0.06	0.01	73.78	30	0.45	98.05	60.95	0.86	0.08	0.05
NACL	ALL	51	0.08	0.12	0.4	55.13	85.9	0.04	0.07	0.01	98.23	29.3	0.55	125.23	66.03	0.86	0.09	0.16
NH4	WIN	15	1.42	1.25	0.8	-12.05	49.31	-0.17	0.7	0.8	40.59	10.02	-0.14	74.23	52.96	0.56	0.91	0.64
NH4	SPR	15	1.49	1.79	0.72	19.92	40.86	0.3	0.61	0.8	38.73	17.99	0.2	56.66	39.37	0.41	0.94	0.52
NH4	SUM	12	1.24	1.27	0.81	2.03	31.9	0.03	0.4	0.28	20.11	10.57	0.02	38.11	32.69	0.32	0.53	0.65
NH4	FAL	9	0.59	0.93	0.67	57.64	65.8	0.34	0.39	0.17	156.76	54	0.58	163.99	62.63	0.66	0.54	0.45
NH4	ALL	51	1.25	1.35	0.71	8.23	43.65	0.1	0.55	0.61	55.72	20.26	0.08	76.4	45.9	0.44	0.79	0.51
NO3	WIN	15	3.14	3.09	0.85	-1.6	30.6	-0.05	0.96	1.39	14.31	-0.86	-0.02	44.6	38.25	0.31	1.18	0.72
NO3	SPR	15	2.22	3.01	0.81	35.87	55.89	0.8	1.24	2.27	68.65	25	0.36	91.29	54.1	0.56	1.7	0.65
NO3	SUM	12	0.74	0.84	0.86	13.14	62.14	0.1	0.46	0.42	-10.97	-40.61	0.13	63.87	72.12	0.62	0.66	0.74
NO3	FAL	9	1.63	1.94	0.4	18.47	54.51	0.3	0.89	1.43	32.95	-4.31	0.18	76.97	53.75	0.55	1.23	0.16
NO3	ALL	51	2.04	2.33	0.82	14.48	44.76	0.3	0.91	1.55	27.64	-3.22	0.14	68.58	53.62	0.45	1.28	0.67
OC	WIN	15	1.23	2.99	0.82	142.78	142.78	1.76	1.76	0.36	173.98	88.15	1.43	173.98	88.15	1.43	1.86	0.67
OC	SPR	15	1.03	2.01	0.65	95.32	95.32	0.98	0.98	0.35	135.65	66.32	0.95	135.65	66.32	0.95	1.15	0.42
OC	SUM	14	2.01	2.01	0.71	-0.34	28.7	-0.01	0.58	0.49	0.02	-5.29	0	28.28	28.58	0.29	0.7	0.5
OC	FAL	14	1.52	2.11	0.77	38.88	47.64	0.59	0.72	0.42	81.15	46.64	0.39	86.14	52.18	0.48	0.87	0.59
OC	ALL	58	1.44	2.29	0.54	59.09	71.14	0.85	1.02	0.81	99.67	49.93	0.59	107.7	59.44	0.71	1.24	0.29
PM-2.5	WIN	15	10.06	11.3	0.85	12.35	21.94	1.24	2.21	8.53	30.39	19.73	0.12	35.61	25.28	0.22	3.17	0.73
PM-2.5	SPR	15	10.42	12.28	0.8	17.84	30.63	1.86	3.19	13.19	20.43	12.27	0.18	35.72	29.67	0.31	4.08	0.64
PM-2.5	SUM	12	14.17	10.62	0.68	-25.07	32.53	-3.55	4.61	27.11	-21.84	-29.26	-0.33	30.19	36.54	0.43	6.3	0.46
PM-2.5	FAL	9	9.92	9.61	0.62	-3.15	29.11	-0.31	2.89	25.55	11.1	5.21	-0.03	25.55	24.39	0.3	5.06	0.38
PM-2.5	ALL	51	11.11	11.13	0.67	0.2	28.64	0.02	3.18	21.73	11.77	3.45	0	32.59	29.06	0.29	4.66	0.45
SO4	WIN	15	1.74	0.92	0.71	-46.96	51.5	-0.82	0.9	1.37	-33.89	-47.28	-0.89	42.24	53.64	0.97	1.43	0.5
SO4	SPR	15	2.66	2.51	0.64	-5.65	33.12	-0.15	0.88	2.05	1.16	-10.68	-0.06	35.34	31.78	0.35	1.44	0.41
SO4	SUM	12	3.75	2.97	0.76	-20.63	26.93	-0.77	1.01	1.77	-16.36	-21.99	-0.26	24.43	29.48	0.34	1.54	0.58
SO4	FAL	9	1.26	1.06	0.86	-16.47	23.5	-0.21	0.3	0.11	-17.83	-23.93	-0.2	24.83	30.21	0.28	0.39	0.75
SO4	ALL	51	2.4	1.89	0.73	-20.99	33.88	-0.5	0.81	1.54	-16.62	-26.44	-0.27	32.95	37.39	0.43	1.34	0.54

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 390990014																		
EC	WIN	15	0.55	0.74	0.52	33.99	67.82	0.19	0.38	0.15	80.01	44.64	0.34	92.94	60.67	0.68	0.43	0.27
EC	SPR	14	0.62	0.57	0.75	-7.69	28.42	-0.05	0.18	0.04	6.72	-0.68	-0.08	34.53	31.85	0.31	0.2	0.57
EC	SUM	15	0.94	0.67	0.73	-28.29	33.52	-0.26	0.31	0.14	-17.52	-23.68	-0.39	27.88	32.93	0.47	0.46	0.53
EC	FAL	15	0.68	0.65	0.63	-3.9	38.9	-0.03	0.26	0.1	27.64	9.31	-0.04	55.53	42.16	0.4	0.31	0.4
EC	ALL	59	0.7	0.66	0.57	-5.36	40.71	-0.04	0.28	0.13	24.51	7.53	-0.06	53.03	42.07	0.43	0.37	0.32
NACL	WIN	13	0.16	0.15	0.27	-2.59	44.25	0	0.07	0.01	20.13	1.81	-0.03	50.78	40.17	0.45	0.1	0.07
NACL	SPR	14	0.07	0.1	0.47	54.53	65.02	0.04	0.04	0	68.76	36.58	0.55	77.06	46.17	0.65	0.06	0.22
NACL	SUM	16	0.04	0.04	0.21	1.07	44.21	0	0.02	0	26.59	-4.95	0.01	61.72	37.34	0.44	0.03	0.04
NACL	FAL	14	0.04	0.06	0.41	61.16	73.19	0.02	0.03	0	82.64	44.67	0.61	91.66	55.37	0.73	0.04	0.17
NACL	ALL	57	0.07	0.09	0.58	19.37	52.79	0.01	0.04	0	49.24	18.98	0.19	70.35	44.58	0.53	0.06	0.34
NH4	WIN	13	1.3	1	0.85	-22.78	36.37	-0.3	0.47	0.21	-8.26	-16.9	-0.3	38.56	40.16	0.47	0.54	0.72
NH4	SPR	14	0.94	1.1	0.73	16.68	45.37	0.16	0.43	0.51	9.52	-2.08	0.17	35.53	29.07	0.45	0.73	0.53
NH4	SUM	15	1.15	1.12	0.79	-2.72	36.06	-0.03	0.42	0.26	28.66	14.55	-0.03	51.91	41.97	0.37	0.51	0.62
NH4	FAL	14	0.76	0.77	0.64	0.95	40.68	0.01	0.31	0.17	89.22	15.51	0.01	113.56	47.26	0.41	0.42	0.41
NH4	ALL	56	1.03	1	0.68	-3.47	39.12	-0.04	0.4	0.31	30.44	3.33	-0.04	60.13	39.65	0.41	0.56	0.46
NO3	WIN	13	2.7	2.14	0.82	-20.81	31.82	-0.56	0.86	0.93	-12.67	-22.24	-0.26	34.97	39.02	0.4	1.12	0.67
NO3	SPR	14	1.15	1.57	0.51	36.16	93.1	0.42	1.07	2.93	26.55	-8.62	0.36	78.91	63.99	0.93	1.76	0.26
NO3	SUM	15	0.49	0.31	0.66	-37.1	54.4	-0.18	0.27	0.06	-44.09	-72.75	-0.59	59.36	82.88	0.86	0.31	0.43
NO3	FAL	14	0.96	0.89	0.3	-7.49	58.87	-0.07	0.57	0.55	26.7	-18.12	-0.08	86.23	71.11	0.64	0.75	0.09
NO3	ALL	56	1.29	1.2	0.66	-7.23	52.9	-0.09	0.68	1.22	-1.44	-31.33	-0.08	65.3	65.03	0.57	1.11	0.43
OC	WIN	15	1.44	2.53	0.48	75.4	84.88	1.09	1.22	0.92	120.66	62	0.75	124.12	65.93	0.85	1.45	0.23
OC	SPR	14	1.15	1.54	0.77	34.02	38.7	0.39	0.44	0.2	48.07	31.28	0.34	52.41	36.09	0.39	0.6	0.59
OC	SUM	15	2.07	1.91	0.65	-7.88	28.66	-0.16	0.59	0.52	1.76	-3	-0.09	27.01	27.04	0.31	0.74	0.42
OC	FAL	15	1.31	1.53	0.79	16.79	34.82	0.22	0.46	0.25	57.97	31.84	0.17	67.63	43.11	0.35	0.55	0.62
OC	ALL	59	1.5	1.88	0.54	25.59	45.61	0.38	0.68	0.69	57.27	30.52	0.26	68.05	43.16	0.46	0.91	0.29
PM-2.5	WIN	13	12.31	9.61	0.83	-21.93	28.89	-2.7	3.56	11.67	-15.05	-20.72	-0.28	27.71	31.03	0.37	4.35	0.68
PM-2.5	SPR	14	8.82	8.46	0.74	-4.12	36.35	-0.36	3.21	15.51	-9.61	-16.97	-0.04	34.17	35.85	0.38	3.96	0.55
PM-2.5	SUM	16	15.63	10.24	0.82	-34.52	34.98	-5.4	5.47	14.64	-32.94	-41.52	-0.53	33.41	41.98	0.53	6.61	0.67
PM-2.5	FAL	14	8.33	7.47	0.82	-10.27	25.98	-0.86	2.16	6.18	3.32	-2.67	-0.11	30.25	28.67	0.29	2.63	0.68
PM-2.5	ALL	57	11.41	8.98	0.73	-21.3	32.13	-2.43	3.66	16.24	-14.22	-21.2	-0.27	31.52	34.71	0.41	4.71	0.53
SO4	WIN	13	2.12	1.1	0.7	-48.3	50.85	-1.02	1.08	0.58	-44.23	-60.76	-0.93	47.69	63.87	0.98	1.27	0.49
SO4	SPR	14	2.14	1.87	0.52	-12.73	45.49	-0.27	0.97	2.05	-17.91	-32.67	-0.15	44.57	48.19	0.52	1.46	0.27
SO4	SUM	15	3.85	3.36	0.9	-12.86	22.45	-0.5	0.87	1.18	-5.31	-8.91	-0.15	22.39	23.46	0.26	1.2	0.81
SO4	FAL	14	2.09	1.59	0.92	-23.7	28.73	-0.5	0.6	0.28	-16.13	-23.33	-0.31	31.55	35.83	0.38	0.73	0.84
SO4	ALL	56	2.58	2.02	0.81	-21.78	33.91	-0.56	0.88	1.11	-20.2	-30.49	-0.28	36.1	42.12	0.43	1.19	0.66

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 391130032																		
EC	WIN	7	0.55	1.02	0.85	86.76	86.76	0.48	0.48	0.03	108.39	66.23	0.87	108.39	66.23	0.87	0.51	0.72
EC	SPR	15	0.54	0.78	0.33	46.26	64.39	0.25	0.34	0.11	85.8	47.74	0.46	93.04	56.97	0.64	0.41	0.11
EC	SUM	16	0.8	1.08	0.71	34.1	40	0.27	0.32	0.06	36.8	28.43	0.34	40.91	33.14	0.4	0.37	0.51
EC	FAL	15	0.69	1	0.75	44.38	57.75	0.31	0.4	0.12	81.53	47.87	0.44	88.45	55.85	0.58	0.46	0.56
EC	ALL	53	0.66	0.97	0.68	45.68	55.94	0.3	0.37	0.09	72.78	44.39	0.46	78.03	50.68	0.56	0.43	0.46
NACL	WIN	7	0.05	0.2	0.62	260.58	260.58	0.14	0.14	0.01	330.91	104.88	2.61	330.91	104.88	2.61	0.17	0.38
NACL	SPR	15	0.06	0.12	0.06	104.12	114.89	0.06	0.07	0	162.2	63.7	1.04	169.34	71.84	1.15	0.09	0
NACL	SUM	16	0.06	0.05	0.21	-23.87	48.11	-0.01	0.03	0	-8.8	-27.9	-0.31	48.31	56.02	0.63	0.04	0.05
NACL	FAL	15	0.05	0.07	0.73	50.01	54	0.02	0.03	0	80.37	44.72	0.5	82.67	47.16	0.54	0.03	0.53
NACL	ALL	53	0.06	0.09	0.26	69.55	97.36	0.04	0.05	0.01	109.7	36.11	0.7	129.61	64.44	0.97	0.08	0.07
NH4	WIN	7	1.1	1.39	0.91	25.61	27.76	0.28	0.31	0.08	79.81	38.16	0.26	80.8	39.17	0.28	0.41	0.82
NH4	SPR	15	1.57	1.71	0.53	8.66	40.28	0.14	0.63	1.04	31.8	11	0.09	49.46	32.41	0.4	1.03	0.28
NH4	SUM	16	1.47	1.59	0.85	8.34	27.73	0.12	0.41	0.23	26.77	17.12	0.08	38.6	30.59	0.28	0.5	0.72
NH4	FAL	15	0.76	1.08	0.88	42.42	47.06	0.32	0.36	0.19	114.58	40.84	0.42	118.58	45.22	0.47	0.54	0.78
NH4	ALL	53	1.25	1.45	0.73	16.33	35.53	0.2	0.44	0.44	60.05	24.88	0.16	69.88	36.38	0.36	0.69	0.53
NO3	WIN	7	2.28	3.12	0.89	37.1	42.97	0.84	0.98	0.79	28.28	18.46	0.37	42.86	35.22	0.43	1.23	0.78
NO3	SPR	15	2.38	2.95	0.7	24.15	50.95	0.57	1.21	2.78	60.79	26.03	0.24	77.62	45.03	0.51	1.76	0.49
NO3	SUM	16	0.73	0.89	0.56	21.64	61.62	0.16	0.45	0.59	14.55	-5.36	0.22	55.72	48.64	0.62	0.78	0.31
NO3	FAL	15	1.19	1.52	0.57	27.79	52.51	0.33	0.63	1.19	30.56	2.99	0.28	63.3	47.81	0.53	1.14	0.32
NO3	ALL	53	1.53	1.95	0.74	27.13	51.26	0.42	0.78	1.46	33.98	9.04	0.27	62.37	45.61	0.51	1.28	0.55
OC	WIN	7	1.49	3.37	0.81	126.38	126.38	1.88	1.88	0.95	155.5	81.21	1.26	155.5	81.21	1.26	2.12	0.66
OC	SPR	15	1.39	2.15	0.64	54.91	59.06	0.76	0.82	0.48	95.45	50.64	0.55	97.86	53.16	0.59	1.03	0.41
OC	SUM	16	2.36	2.71	0.82	14.93	28.82	0.35	0.68	0.46	20.18	14.73	0.15	30.98	27.58	0.29	0.76	0.68
OC	FAL	15	1.55	2.24	0.85	44.16	52.5	0.69	0.81	0.33	84.13	50.28	0.44	87.98	54.48	0.52	0.9	0.73
OC	ALL	53	1.74	2.5	0.74	43.92	52.65	0.76	0.92	0.71	77.46	43.73	0.44	82.49	49.51	0.53	1.14	0.54
PM-2.5	WIN	7	9.93	13.13	0.96	32.29	32.29	3.21	3.21	6.5	28.57	23.56	0.32	28.57	23.56	0.32	4.1	0.92
PM-2.5	SPR	14	11.6	12.2	0.53	5.18	34.57	0.6	4.01	30.73	20.42	9.29	0.05	39.42	32.03	0.35	5.58	0.28
PM-2.5	SUM	16	15.53	13.78	0.83	-11.24	17.56	-1.74	2.73	13.01	-9.83	-11.7	-0.13	14.95	16.4	0.2	4.01	0.7
PM-2.5	FAL	15	9.51	10.51	0.56	10.45	39.97	0.99	3.8	29.6	24.26	14.13	0.1	40.56	36.19	0.4	5.53	0.32
PM-2.5	ALL	52	11.98	12.32	0.67	2.86	28.77	0.34	3.45	24.27	13.32	6.15	0.03	30.76	27.28	0.29	4.94	0.45
SO4	WIN	7	1.75	1.22	0.92	-30.63	31.18	-0.54	0.55	0.43	-25.02	-30.57	-0.44	25.89	31.43	0.45	0.85	0.85
SO4	SPR	15	2.83	2.35	0.34	-16.65	33.76	-0.47	0.95	2.46	-8.63	-18.32	-0.2	31.68	33.57	0.41	1.64	0.12
SO4	SUM	16	4.47	4.01	0.75	-10.47	29.19	-0.47	1.31	2.96	-1.77	-6.12	-0.12	24.27	25.95	0.33	1.78	0.56
SO4	FAL	15	1.84	1.83	0.96	-0.42	17.18	-0.01	0.32	0.18	-0.92	-4.41	0	20.21	21.23	0.17	0.43	0.93
SO4	ALL	53	2.9	2.55	0.79	-11.98	28.46	-0.35	0.83	1.75	-6.54	-12.32	-0.14	25.43	27.49	0.32	1.37	0.62

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 391351001																		
EC	WIN	28	0.52	0.61	0.8	17.54	26.77	0.09	0.14	0.03	29.19	18.97	0.18	37.52	28.7	0.27	0.18	0.63
EC	SPR	31	0.59	0.4	0.68	-32.37	41.79	-0.19	0.25	0.09	-11.09	-22.94	-0.48	40.23	44.08	0.62	0.36	0.46
EC	SUM	26	0.81	0.43	0.76	-46.51	47.28	-0.38	0.38	0.06	-40.41	-54.65	-0.87	42.98	56.86	0.88	0.45	0.57
EC	FAL	28	0.67	0.54	0.72	-18.99	39.75	-0.13	0.26	0.12	6.29	-6.92	-0.23	43.91	41.26	0.49	0.37	0.51
EC	ALL	113	0.64	0.49	0.57	-23.08	39.86	-0.15	0.26	0.1	-3.55	-15.88	-0.3	41.1	42.51	0.52	0.36	0.32
NACL	WIN	27	0.09	0.12	0.34	32.72	71.46	0.03	0.07	0.01	322.44	39.09	0.33	343.04	66.08	0.71	0.08	0.12
NACL	SPR	31	0.05	0.11	0.41	108.19	115.79	0.06	0.06	0	170.72	70.57	1.08	173.99	74.32	1.16	0.09	0.17
NACL	SUM	29	0.05	0.04	0.1	-21.89	50.81	-0.01	0.02	0	12.8	-18.06	-0.28	61.67	51.87	0.65	0.04	0.01
NACL	FAL	28	0.06	0.08	0.7	43.86	82.55	0.02	0.05	0.01	103.96	26.18	0.44	132.02	66.11	0.83	0.08	0.5
NACL	ALL	115	0.06	0.09	0.46	42.22	80.28	0.03	0.05	0.01	150.26	30.02	0.42	175.14	64.73	0.8	0.08	0.21
NH4	WIN	28	1.87	1.55	0.72	-17.21	30.57	-0.32	0.57	0.57	-5.38	-13.91	-0.21	32.6	34.81	0.37	0.82	0.52
NH4	SPR	31	1.4	1.83	0.49	30.58	44.47	0.43	0.62	0.82	81.16	27.8	0.31	91.96	39.6	0.44	1	0.24
NH4	SUM	30	1.29	1.32	0.81	2.43	30.66	0.03	0.39	0.25	21.95	11.1	0.02	40.49	34.42	0.31	0.5	0.66
NH4	FAL	28	0.73	1.06	0.79	44.82	51.62	0.33	0.38	0.18	191.25	49.91	0.45	195.02	53.99	0.52	0.53	0.62
NH4	ALL	117	1.32	1.45	0.66	9.31	37.28	0.12	0.49	0.54	71.61	18.83	0.09	89.22	40.57	0.37	0.75	0.44
NO3	WIN	28	3.68	3.58	0.72	-2.66	37.69	-0.1	1.39	2.63	12.82	-2.49	-0.03	49.48	45.42	0.39	1.62	0.52
NO3	SPR	31	2.1	3.53	0.68	68.65	73.07	1.44	1.53	2.58	117.45	51.01	0.69	123.1	57.31	0.73	2.16	0.47
NO3	SUM	30	0.78	0.91	0.77	16.89	42.35	0.13	0.33	0.25	9.56	-4.76	0.17	43.64	39.97	0.42	0.52	0.6
NO3	FAL	28	0.9	1.51	0.64	66.76	85.78	0.6	0.78	1.33	74.77	27.51	0.67	98.3	59.47	0.86	1.3	0.41
NO3	ALL	117	1.85	2.39	0.74	28.93	54.41	0.54	1.01	2.05	54.53	18.28	0.29	79.17	50.54	0.54	1.53	0.55
OC	WIN	27	1.44	2.62	0.81	82.18	82.18	1.18	1.18	0.36	99	60.26	0.82	99	60.26	0.82	1.32	0.66
OC	SPR	31	1.17	1.54	0.72	31.89	43.87	0.37	0.51	0.29	66.22	36.49	0.32	73.56	45	0.44	0.66	0.51
OC	SUM	26	1.69	1.93	0.71	13.96	35.28	0.24	0.6	0.51	22.77	12.83	0.14	39.25	32.53	0.35	0.75	0.51
OC	FAL	27	1.14	1.83	0.85	61.1	65	0.69	0.74	0.58	103.69	50.03	0.61	108.82	56.36	0.65	1.03	0.72
OC	ALL	111	1.35	1.97	0.72	45.66	55.62	0.62	0.75	0.56	73.13	40.02	0.46	80.29	48.55	0.56	0.97	0.51
PM-2.5	WIN	27	12.94	12.07	0.83	-6.75	19.54	-0.87	2.53	9.46	-4.74	-9.37	-0.07	21.66	24.21	0.21	3.2	0.7
PM-2.5	SPR	31	10.74	11.37	0.46	5.88	32.28	0.63	3.47	24.5	21.84	8.55	0.06	40.55	32.71	0.32	4.99	0.21
PM-2.5	SUM	29	13.24	9.86	0.8	-25.57	27.31	-3.39	3.62	16.15	-20.49	-25.45	-0.34	23.13	27.99	0.37	5.25	0.65
PM-2.5	FAL	28	8.37	9	0.81	7.51	30.19	0.63	2.53	9.73	83.34	10.88	0.08	102.02	33.33	0.3	3.18	0.66
PM-2.5	ALL	115	11.31	10.57	0.7	-6.5	27.01	-0.74	3.06	18	19.9	-3.66	-0.07	46.69	29.67	0.29	4.31	0.49
SO4	WIN	28	2.46	1.5	0.79	-38.87	38.93	-0.95	0.96	0.52	-39.18	-53.45	-0.64	39.28	53.55	0.64	1.2	0.63
SO4	SPR	31	2.62	2.22	0.43	-15.4	35.79	-0.4	0.94	1.69	-3.59	-16.86	-0.18	39.76	37.12	0.42	1.36	0.19
SO4	SUM	30	3.79	3.01	0.77	-20.7	32.48	-0.78	1.23	2.58	-11.68	-18.94	-0.26	28.69	33.97	0.41	1.79	0.59
SO4	FAL	28	2.08	1.81	0.92	-13.09	21.5	-0.27	0.45	0.35	-6.56	-10.83	-0.15	21.67	23.14	0.25	0.65	0.84
SO4	ALL	117	2.75	2.15	0.76	-21.86	32.7	-0.6	0.9	1.39	-14.89	-24.71	-0.28	32.48	36.9	0.42	1.32	0.58

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 391510017																		
EC	WIN	12	0.53	0.77	0.46	44.12	50.42	0.24	0.27	0.05	60.2	39.99	0.44	63.51	43.59	0.5	0.32	0.21
EC	SPR	15	0.56	0.63	0.41	11.87	47.03	0.07	0.27	0.14	35.03	21.15	0.12	50.16	40.33	0.47	0.38	0.17
EC	SUM	16	0.97	0.81	0.61	-16.84	24.53	-0.16	0.24	0.08	-9.74	-13.66	-0.2	21.76	24.35	0.29	0.33	0.37
EC	FAL	15	0.77	0.71	0.74	-8.09	31.14	-0.06	0.24	0.14	10.28	3.23	-0.09	32.65	30.41	0.34	0.38	0.55
EC	ALL	58	0.72	0.73	0.59	0.69	34.85	0.01	0.25	0.13	21.49	10.81	0.01	40.56	34.03	0.35	0.36	0.35
NACL	WIN	13	0.2	0.17	0.22	-16.19	58.63	-0.03	0.12	0.02	34.51	4.82	-0.19	74.7	60.37	0.7	0.16	0.05
NACL	SPR	13	0.1	0.1	0.13	-1.99	58.32	0	0.06	0.01	40.24	6.37	-0.02	73.51	51.56	0.6	0.08	0.02
NACL	SUM	7	0.08	0.07	0.7	-17.72	30.99	-0.01	0.02	0	-3.09	-13.4	-0.22	36.74	38.53	0.38	0.04	0.48
NACL	FAL	15	0.16	0.08	0.11	-49.89	72.98	-0.08	0.12	0.06	23.08	-13.69	-1	72.54	63.22	1.46	0.25	0.01
NACL	ALL	48	0.14	0.11	0.23	-25.59	61.44	-0.04	0.09	0.03	27.01	-3.2	-0.34	68.17	55.69	0.83	0.17	0.05
NH4	WIN	13	1.57	1.29	0.86	-17.48	35.65	-0.27	0.56	0.37	0.09	-8.82	-0.21	38.21	38.72	0.43	0.66	0.74
NH4	SPR	13	1.08	1.37	0.86	27.27	35.08	0.29	0.38	0.36	25.4	16.89	0.27	35	27.46	0.35	0.67	0.74
NH4	SUM	8	1.05	1.6	0.84	51.53	55.98	0.54	0.59	0.42	96.08	51.9	0.52	100.15	56.34	0.56	0.84	0.71
NH4	FAL	15	0.82	0.97	0.71	18.12	45.21	0.15	0.37	0.2	319.13	30.68	0.18	337.72	53.63	0.45	0.47	0.5
NH4	ALL	49	1.13	1.26	0.74	12.39	40.75	0.14	0.46	0.4	120.14	20.01	0.12	139.16	43.17	0.41	0.65	0.55
NO3	WIN	13	3.09	2.85	0.77	-7.63	36.5	-0.24	1.13	1.7	6.75	-5.9	-0.08	44.86	43.05	0.4	1.33	0.59
NO3	SPR	13	1.52	1.97	0.75	29.36	60.79	0.45	0.93	3.17	9.41	-4.18	0.29	43.25	37.58	0.61	1.84	0.56
NO3	SUM	8	0.68	0.97	0.89	42.11	72.88	0.29	0.5	0.4	23.62	-8.1	0.42	74.46	69.02	0.73	0.7	0.79
NO3	FAL	15	1.21	1.44	0.58	19.72	50.54	0.24	0.61	0.61	36.31	5.44	0.2	72.18	53.36	0.51	0.82	0.33
NO3	ALL	49	1.7	1.88	0.72	10.33	47.69	0.18	0.81	1.61	19.26	-2.33	0.1	57.63	48.99	0.48	1.28	0.52
OC	WIN	12	1.66	2.58	0.67	55.29	56.35	0.92	0.94	0.45	72.56	46.06	0.55	73.11	46.61	0.56	1.14	0.44
OC	SPR	15	1.44	1.76	0.54	22.27	56.02	0.32	0.8	1.15	57.7	34.53	0.22	69.21	49.13	0.56	1.12	0.29
OC	SUM	16	2.38	2.35	0.57	-1.32	28.93	-0.03	0.69	0.71	4.12	-2.03	-0.01	30.21	28.94	0.29	0.84	0.33
OC	FAL	15	1.73	1.69	0.72	-2.1	27.87	-0.04	0.48	0.74	13.04	7.32	-0.02	28.15	26	0.28	0.86	0.52
OC	ALL	58	1.82	2.08	0.56	14	39.38	0.25	0.72	0.91	34.44	19.79	0.14	48.64	37.06	0.39	0.99	0.31
PM-2.5	WIN	13	12.29	11.8	0.84	-3.99	20.92	-0.49	2.57	8.36	3.58	-0.25	-0.04	24.28	23.51	0.22	2.93	0.71
PM-2.5	SPR	14	9.39	10.39	0.8	10.7	22.08	1	2.07	11.73	10.26	6.96	0.11	18.84	16.3	0.22	3.57	0.64
PM-2.5	SUM	7	15.77	13.54	0.81	-14.17	28.04	-2.23	4.42	23.4	-7.65	-14.49	-0.17	31.3	32.61	0.33	5.33	0.65
PM-2.5	FAL	15	10.1	8.94	0.85	-11.5	19.23	-1.16	1.94	7.94	-6.94	-9.2	-0.13	17.64	18.83	0.22	3.05	0.73
PM-2.5	ALL	49	11.29	10.77	0.81	-4.59	22.15	-0.52	2.5	12.55	0.66	-2.96	-0.05	21.7	21.32	0.23	3.58	0.65
SO4	WIN	13	2.11	1.31	0.82	-38.15	40.75	-0.81	0.86	0.71	-32.48	-42.15	-0.62	35.33	44.75	0.66	1.17	0.68
SO4	SPR	13	2.24	2.5	0.81	11.76	31.07	0.26	0.7	1.36	5.55	-1.19	0.12	29.82	27.91	0.31	1.19	0.65
SO4	SUM	8	3.25	3.82	0.76	17.36	43.03	0.56	1.4	3.79	43.54	21.47	0.17	58.24	38.71	0.43	2.03	0.58
SO4	FAL	15	2.16	1.66	0.96	-23.09	26.93	-0.5	0.58	0.24	-16.74	-21.97	-0.3	27.27	31.2	0.35	0.7	0.92
SO4	ALL	49	2.35	2.14	0.76	-8.72	34.92	-0.2	0.82	1.52	-5.16	-14.72	-0.1	35.14	35.15	0.38	1.25	0.57

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 391530023																		
EC	WIN	15	0.39	0.66	0.77	69.3	69.3	0.27	0.27	0.01	89.44	55.58	0.69	89.44	55.58	0.69	0.29	0.59
EC	SPR	14	0.45	0.59	0.78	32.53	42.74	0.14	0.19	0.02	47.68	34.68	0.33	51.59	39.22	0.43	0.21	0.61
EC	SUM	15	0.79	0.72	0.53	-8.68	24.58	-0.07	0.19	0.12	1.16	-3.36	-0.1	21.48	22.51	0.27	0.35	0.28
EC	FAL	13	0.64	0.68	0.83	6.63	24.93	0.04	0.16	0.04	17.37	11.19	0.07	29.08	25.27	0.25	0.21	0.69
EC	ALL	57	0.56	0.66	0.68	17.39	36.3	0.1	0.2	0.07	39.52	24.81	0.17	48.49	35.95	0.36	0.27	0.46
NACL	WIN	13	0.13	0.15	0.13	15.59	65.46	0.02	0.09	0.01	81.65	27.96	0.16	108.3	63.95	0.65	0.1	0.02
NACL	SPR	7	0.18	0.07	0.6	-59.51	60.01	-0.11	0.11	0.02	-39.82	-59.33	-1.47	41.02	60.5	1.48	0.19	0.35
NACL	SUM	13	0.06	0.04	0.4	-33.14	50.32	-0.02	0.03	0	-18.87	-33.82	-0.5	44.05	51.46	0.75	0.04	0.16
NACL	FAL	15	0.07	0.07	0.05	0.88	70.97	0	0.05	0.01	52.93	21.33	0.01	77.32	58.06	0.71	0.07	0
NACL	ALL	48	0.1	0.08	0.36	-15.54	62.74	-0.02	0.06	0.01	27.74	-3.57	-0.18	71.41	58.22	0.74	0.1	0.13
NH4	WIN	13	1.85	1.17	0.73	-36.67	41.25	-0.68	0.76	0.58	-31.29	-42.66	-0.58	38.46	48.61	0.65	1.02	0.53
NH4	SPR	7	1.48	1.57	0.89	5.91	26	0.09	0.38	0.39	-1.44	-6.74	0.06	25.51	25.72	0.26	0.63	0.79
NH4	SUM	13	1.59	1.38	0.82	-13.25	31.99	-0.21	0.51	0.39	6.42	-4.32	-0.15	38.93	35.29	0.37	0.66	0.67
NH4	FAL	15	1.12	0.89	0.79	-19.95	33.84	-0.22	0.38	0.21	22.44	-9.23	-0.25	61.07	41.4	0.42	0.51	0.63
NH4	ALL	48	1.5	1.2	0.74	-19.88	34.66	-0.3	0.52	0.45	0.07	-16.59	-0.25	43.76	39.41	0.43	0.73	0.55
NO3	WIN	13	3.8	2.67	0.73	-29.75	42.93	-1.13	1.63	2.49	-24.46	-38.55	-0.42	44.85	53.55	0.61	1.94	0.53
NO3	SPR	7	1.91	1.79	0.84	-6.14	66.86	-0.12	1.28	3.12	-22.43	-42.43	-0.07	54.08	65.04	0.71	1.77	0.71
NO3	SUM	13	0.61	0.55	0.71	-11.04	68.76	-0.07	0.42	0.28	-26.02	-56.13	-0.12	65.33	83.02	0.77	0.54	0.51
NO3	FAL	15	1.58	1.26	0.71	-20.56	39.42	-0.33	0.62	0.45	-11.62	-33.29	-0.26	53.13	58.59	0.5	0.75	0.5
NO3	ALL	48	1.97	1.53	0.76	-22.52	47.61	-0.44	0.94	1.53	-20.58	-42.24	-0.29	54.33	64.78	0.61	1.32	0.57
OC	WIN	15	1.34	2.49	0.8	86.62	86.62	1.16	1.16	0.25	113.79	64.75	0.87	113.79	64.75	0.87	1.26	0.64
OC	SPR	14	1.31	1.7	0.78	30.45	38.42	0.4	0.5	0.25	49.44	32.46	0.3	54.26	37.64	0.38	0.64	0.6
OC	SUM	15	2.48	2.13	0.65	-14.03	23.92	-0.35	0.59	0.55	-11.44	-16.26	-0.16	24.04	26.66	0.28	0.82	0.42
OC	FAL	13	1.41	1.53	0.94	8.67	21.29	0.12	0.3	0.09	24.94	18.22	0.09	33.41	27.61	0.21	0.32	0.89
OC	ALL	57	1.65	1.99	0.63	20.56	39.62	0.34	0.65	0.6	44.77	24.89	0.21	57.22	39.6	0.4	0.85	0.4
PM-2.5	WIN	13	13.82	10.45	0.68	-24.38	34.4	-3.37	4.76	18.26	-17.9	-25.87	-0.32	35.02	39.28	0.45	5.44	0.47
PM-2.5	SPR	14	10.59	9.62	0.78	-9.08	25.71	-0.96	2.72	12.91	-11.24	-17.01	-0.1	24.14	28.04	0.28	3.72	0.61
PM-2.5	SUM	16	16.44	10.99	0.81	-33.12	35.03	-5.44	5.76	19.04	-30.52	-39.18	-0.5	32.36	40.96	0.52	6.98	0.65
PM-2.5	FAL	15	9.31	7.9	0.88	-15.19	22.33	-1.41	2.08	4.6	-10.11	-14.88	-0.18	25.46	27.49	0.26	2.57	0.78
PM-2.5	ALL	58	12.6	9.74	0.76	-22.67	30.56	-2.86	3.85	16.96	-17.76	-24.56	-0.29	29.19	33.98	0.4	5.01	0.58
SO4	WIN	13	2.73	1.15	0.68	-57.92	57.92	-1.58	1.58	0.73	-55.53	-81.36	-1.38	55.53	81.36	1.38	1.8	0.46
SO4	SPR	7	3.37	3.32	0.91	-1.5	23.49	-0.05	0.79	1.07	-6.3	-11.5	-0.02	23.04	26.74	0.24	1.04	0.83
SO4	SUM	13	5.02	3.94	0.78	-21.61	34.11	-1.08	1.71	3.49	-14.4	-21.9	-0.28	33.45	38.3	0.44	2.16	0.61
SO4	FAL	15	2.64	1.51	0.88	-42.98	43.85	-1.14	1.16	0.7	-37.66	-52.23	-0.75	40.73	55.13	0.77	1.41	0.78
SO4	ALL	48	3.42	2.33	0.81	-31.74	40.09	-1.08	1.37	1.74	-31.63	-45.97	-0.47	40.19	53.53	0.59	1.71	0.66

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 401091037																		
EC	WIN	15	0.48	0.71	0.62	46.82	56.33	0.23	0.27	0.06	71.44	43.68	0.47	74.97	47.74	0.56	0.34	0.39
EC	SPR	15	0.35	0.55	0.43	58.68	74.15	0.2	0.26	0.14	82.7	40.22	0.59	93.76	52.67	0.74	0.43	0.19
EC	SUM	16	0.34	0.48	0.57	42.65	48.14	0.14	0.16	0.03	53.95	36.26	0.43	57.46	40.2	0.48	0.22	0.33
EC	FAL	12	0.36	0.67	0.89	89.96	89.96	0.32	0.32	0.03	96.62	62.98	0.9	96.62	62.98	0.9	0.36	0.8
EC	ALL	58	0.38	0.6	0.58	56.89	65	0.22	0.25	0.07	74.74	44.73	0.57	79.48	50.09	0.65	0.34	0.34
NACL	WIN	12	0.05	0.05	0.18	5.36	75.44	0	0.04	0	62.81	27.2	0.05	85.58	63.13	0.75	0.06	0.03
NACL	SPR	13	0.17	0.08	0.58	-56.16	64.35	-0.1	0.11	0.02	-23.88	-44.48	-1.28	50.59	65.8	1.47	0.18	0.34
NACL	SUM	16	0.14	0.05	0.1	-66.77	76.26	-0.1	0.11	0.01	-46.18	-89.22	-2.01	73.61	104.81	2.3	0.15	0.01
NACL	FAL	11	0.03	0.05	0.7	62.49	86.47	0.02	0.03	0	64.61	34.3	0.62	79.61	53.75	0.86	0.04	0.48
NACL	ALL	52	0.1	0.06	0.33	-46.7	71.9	-0.05	0.08	0.01	7.98	-25.04	-0.88	71.89	74.64	1.35	0.13	0.11
NH4	WIN	12	1.12	0.8	0.88	-28.9	42.76	-0.32	0.48	0.36	4.75	-12.08	-0.41	51.38	48.64	0.6	0.68	0.78
NH4	SPR	14	1.23	0.86	0.98	-30.33	32.35	-0.37	0.4	0.16	-0.31	-23.55	-0.44	53.79	42.55	0.46	0.55	0.96
NH4	SUM	16	0.57	0.43	0.74	-23.69	39.8	-0.13	0.23	0.05	-15.76	-29.43	-0.31	46.26	49.37	0.52	0.26	0.54
NH4	FAL	12	0.43	0.54	0.67	25.34	45.22	0.11	0.2	0.06	40.13	25.9	0.25	49.99	37.69	0.45	0.26	0.45
NH4	ALL	54	0.83	0.65	0.9	-22.15	38.45	-0.18	0.32	0.18	5.22	-11.75	-0.28	50.18	44.85	0.49	0.47	0.8
NO3	WIN	12	2.91	1.72	0.84	-40.66	46.06	-1.18	1.34	1.55	-23.4	-41.34	-0.69	47.1	55.2	0.78	1.72	0.7
NO3	SPR	14	1.44	0.78	0.88	-45.65	47.73	-0.66	0.69	0.77	-63.31	-104.4	-0.84	66.5	107.27	0.88	1.1	0.78
NO3	SUM	16	0.32	0.08	0.17	-74.55	74.55	-0.24	0.24	0.03	-68.74	-108.78	-2.93	68.74	108.78	2.93	0.29	0.03
NO3	FAL	12	0.64	0.61	0.94	-5.3	41.42	-0.03	0.27	0.2	-26.96	-39.85	-0.06	41.09	51.49	0.44	0.45	0.89
NO3	ALL	54	1.26	0.75	0.87	-40.66	48.17	-0.51	0.61	0.77	-47.97	-77.34	-0.69	57.21	83.75	0.81	1.02	0.75
OC	WIN	15	1.37	2.3	0.58	68.08	71.47	0.93	0.98	0.72	100.53	53.87	0.68	102.45	55.86	0.71	1.26	0.34
OC	SPR	15	1.46	1.93	0.4	32.26	66.21	0.47	0.96	3.17	59.2	23.95	0.32	80.06	48.76	0.66	1.84	0.16
OC	SUM	16	1.62	2.35	0.7	44.91	51.11	0.73	0.83	0.87	44.93	29.58	0.45	51.88	37.4	0.51	1.18	0.5
OC	FAL	12	0.94	1.83	0.72	94.64	94.64	0.89	0.89	0.23	103.89	63.55	0.95	103.89	63.55	0.95	1.01	0.52
OC	ALL	58	1.37	2.12	0.52	54.47	66.67	0.75	0.92	1.33	75.2	41.44	0.54	83.01	50.52	0.67	1.37	0.27
PM-2.5	WIN	12	10.88	11.23	0.49	3.19	41.15	0.35	4.48	30.6	31.44	10.02	0.03	59.63	46.49	0.41	5.54	0.24
PM-2.5	SPR	14	11.44	8.93	0.71	-21.89	39.8	-2.5	4.55	24.91	-21.34	-31.18	-0.28	37.98	44.57	0.51	5.58	0.5
PM-2.5	SUM	16	10.74	7.83	0.56	-27.12	29.47	-2.91	3.17	10.6	-24.53	-33.1	-0.37	27.06	35.51	0.4	4.37	0.31
PM-2.5	FAL	13	5.88	8.75	0.55	48.63	49.59	2.86	2.92	7.38	53.43	37.84	0.49	54.44	38.88	0.5	3.95	0.3
PM-2.5	ALL	55	9.8	9.07	0.53	-7.48	38.22	-0.73	3.75	23.34	6.92	-6.44	-0.08	43.42	41.01	0.41	4.89	0.28
SO4	WIN	12	1.38	0.98	0.89	-29.06	39.15	-0.4	0.54	0.67	-4.75	-14.95	-0.41	36.24	38.88	0.55	0.91	0.78
SO4	SPR	14	2.74	1.92	0.91	-29.78	30.68	-0.82	0.84	0.57	-22.82	-30.18	-0.42	30.21	36.05	0.44	1.11	0.83
SO4	SUM	16	2.16	1.25	0.79	-41.91	45.11	-0.9	0.97	0.26	-43.7	-61.34	-0.72	47.05	64.29	0.78	1.04	0.62
SO4	FAL	12	1.16	1.16	0.83	0.16	23.51	0	0.27	0.15	14.69	8.48	0	28.45	24.49	0.24	0.39	0.69
SO4	ALL	54	1.91	1.34	0.85	-29.69	35.89	-0.57	0.69	0.53	-16.66	-27.44	-0.42	36.15	42.48	0.51	0.92	0.72

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 401431127																		
EC	WIN	22	0.52	0.62	0.73	18.4	37.74	0.1	0.2	0.07	21.84	12.48	0.18	38.37	32.74	0.38	0.28	0.53
EC	SPR	24	0.51	0.67	0.85	31.87	41.18	0.16	0.21	0.09	22.85	14.02	0.32	35.13	28.04	0.41	0.35	0.71
EC	SUM	25	0.39	0.47	0.63	18.59	34.66	0.07	0.14	0.02	23.67	14.99	0.19	38.53	32.42	0.35	0.17	0.4
EC	FAL	24	0.4	0.54	0.69	32.51	52.16	0.13	0.21	0.05	38.56	23.02	0.33	54.11	42.1	0.52	0.26	0.47
EC	ALL	95	0.46	0.57	0.76	25.44	41.25	0.12	0.19	0.06	26.8	16.19	0.25	41.57	33.83	0.41	0.27	0.58
NACL	WIN	22	0.1	0.08	0.56	-20.8	47.11	-0.02	0.05	0	18.38	-11.79	-0.26	63.69	52.8	0.59	0.07	0.32
NACL	SPR	19	0.13	0.09	0.6	-32.57	55.97	-0.04	0.07	0.01	3.03	-19.3	-0.48	61.28	60.91	0.83	0.11	0.36
NACL	SUM	26	0.12	0.05	0.23	-60.5	66.16	-0.07	0.08	0.01	-33.66	-80.52	-1.53	76.53	94.58	1.67	0.12	0.05
NACL	FAL	24	0.04	0.05	0.84	26.7	51.94	0.01	0.02	0	32.5	12.12	0.27	59.55	48.02	0.52	0.03	0.7
NACL	ALL	91	0.1	0.07	0.47	-32.81	56.9	-0.03	0.06	0.01	4.03	-26.69	-0.49	65.77	65.17	0.85	0.09	0.22
NH4	WIN	23	1.5	1.03	0.66	-31.39	46.27	-0.47	0.7	1.92	-3.7	-18.38	-0.46	41.82	45.07	0.67	1.47	0.44
NH4	SPR	22	1.03	0.86	0.92	-16.13	35.79	-0.17	0.37	0.36	28.88	1.97	-0.19	60.65	41.61	0.43	0.62	0.84
NH4	SUM	26	0.55	0.48	0.82	-13.02	29.39	-0.07	0.16	0.04	14.52	-2.72	-0.15	47.64	38.2	0.34	0.2	0.67
NH4	FAL	24	0.56	0.63	0.73	13.46	49.26	0.08	0.27	0.2	108.77	33.96	0.13	125.36	56.6	0.49	0.45	0.53
NH4	ALL	95	0.89	0.74	0.76	-17.17	41.11	-0.15	0.37	0.65	37.24	3.84	-0.21	68.88	45.3	0.5	0.82	0.57
NO3	WIN	23	2.78	1.88	0.75	-32.32	42.7	-0.9	1.19	2.5	-16.53	-33.43	-0.48	42.75	53.15	0.63	1.82	0.56
NO3	SPR	22	1.21	0.77	0.81	-36.27	55.69	-0.44	0.67	1.03	-39.22	-75.34	-0.57	65.48	93.39	0.87	1.11	0.66
NO3	SUM	26	0.28	0.09	0.04	-67.67	67.75	-0.19	0.19	0.02	-63.98	-99.59	-2.09	64.09	99.7	2.1	0.23	0
NO3	FAL	24	0.78	0.61	0.86	-21.83	46.35	-0.17	0.36	0.42	-26.28	-47.5	-0.28	50.15	65.77	0.59	0.67	0.73
NO3	ALL	95	1.23	0.81	0.83	-33.79	47.84	-0.41	0.59	1.04	-37.23	-64.8	-0.51	55.72	78.4	0.72	1.1	0.69
OC	WIN	22	1.78	2.42	0.77	35.98	46.53	0.64	0.83	0.87	45.88	30.45	0.36	52.43	38.27	0.47	1.13	0.59
OC	SPR	24	2.57	2.9	0.83	12.88	31.38	0.33	0.81	1.89	30.92	13.63	0.13	47.76	32.51	0.31	1.42	0.69
OC	SUM	25	1.98	2.77	0.7	40.15	49.07	0.79	0.97	1.47	38.07	23.27	0.4	48.36	34.53	0.49	1.45	0.49
OC	FAL	24	1.29	2.04	0.7	57.97	66.14	0.75	0.85	1.01	69.37	36.79	0.58	78.81	48.29	0.66	1.25	0.49
OC	ALL	95	1.91	2.54	0.77	33.01	45.41	0.63	0.87	1.36	45.98	25.91	0.33	56.84	38.36	0.45	1.32	0.59
PM-2.5	WIN	23	13.43	10.67	0.51	-20.51	37.73	-2.75	5.07	42.47	-10.51	-20.94	-0.26	35.94	41.39	0.47	7.07	0.26
PM-2.5	SPR	22	12.26	9.47	0.89	-22.74	29.41	-2.79	3.61	11.39	-17.11	-23.35	-0.29	29.52	33.51	0.38	4.38	0.79
PM-2.5	SUM	26	11.86	8.44	0.69	-28.88	31.47	-3.43	3.73	8.93	-28.1	-37.2	-0.41	31.3	40.19	0.44	4.55	0.47
PM-2.5	FAL	24	7.29	8.36	0.75	14.65	31.95	1.07	2.33	9.61	19.01	10.94	0.15	33.63	28.19	0.32	3.28	0.56
PM-2.5	ALL	95	11.18	9.2	0.67	-17.71	32.85	-1.98	3.67	21	-9.4	-17.89	-0.22	32.6	35.91	0.4	4.99	0.45
SO4	WIN	23	2.49	1.48	0.56	-40.68	47.03	-1.01	1.17	5.17	-26.65	-39.9	-0.69	39.24	49.86	0.79	2.49	0.32
SO4	SPR	22	2.6	1.94	0.82	-25.41	29.6	-0.66	0.77	1.49	-14.65	-20	-0.34	25.03	29.12	0.4	1.39	0.67
SO4	SUM	26	2.36	1.38	0.78	-41.5	42.36	-0.98	1	0.35	-39.17	-52.88	-0.71	41.22	54.77	0.72	1.14	0.6
SO4	FAL	24	1.58	1.44	0.71	-8.61	27.42	-0.14	0.43	0.53	1.16	-5.83	-0.09	27.59	26.98	0.3	0.74	0.5
SO4	ALL	95	2.25	1.55	0.65	-31.15	37.55	-0.7	0.84	1.95	-20.27	-30.24	-0.45	33.55	40.62	0.55	1.56	0.42

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420010001																		
EC	WIN	15	0.35	0.49	0.94	42.63	43.76	0.15	0.15	0.01	48.61	36.28	0.43	50.19	37.9	0.44	0.17	0.87
EC	SPR	14	0.24	0.3	0.83	28.43	31.6	0.07	0.07	0.01	27.87	22.11	0.28	31.39	25.86	0.32	0.11	0.7
EC	SUM	16	0.39	0.38	0.78	-3.19	22.02	-0.01	0.09	0.01	-5.57	-10.02	-0.03	23.31	25.14	0.23	0.11	0.61
EC	FAL	14	0.3	0.39	0.81	30.12	35.34	0.09	0.11	0.01	35.17	25.97	0.3	38.75	29.73	0.35	0.14	0.66
EC	ALL	59	0.32	0.39	0.82	22.27	32.6	0.07	0.1	0.01	25.81	17.91	0.22	35.72	29.64	0.33	0.13	0.67
NACL	WIN	13	0.04	0.09	0.57	120.92	138	0.05	0.06	0.01	486.19	66.07	1.21	493.63	75.9	1.38	0.09	0.33
NACL	SPR	13	0.08	0.15	0.58	100.48	114.87	0.08	0.09	0.01	164.96	66.61	1	170.85	73.45	1.15	0.11	0.34
NACL	SUM	15	0.05	0.04	0.47	-24.57	45.82	-0.01	0.02	0	37.86	-7.37	-0.33	78.61	48.86	0.61	0.04	0.22
NACL	FAL	14	0.05	0.15	0.43	209.91	233.03	0.1	0.12	0.08	155.48	36.21	2.1	170.72	56.29	2.33	0.31	0.18
NACL	ALL	55	0.06	0.11	0.35	95.69	127.53	0.05	0.07	0.03	203.81	38.57	0.96	221.96	62.95	1.28	0.17	0.12
NH4	WIN	13	1.18	1.08	0.68	-8.36	31.32	-0.1	0.37	0.22	3.73	-4.64	-0.09	33.18	31.2	0.34	0.47	0.46
NH4	SPR	14	0.94	0.91	0.72	-2.89	38.16	-0.03	0.36	0.16	11.22	-3.38	-0.03	49.48	43.22	0.39	0.4	0.51
NH4	SUM	16	1.24	1.19	0.86	-3.9	23.77	-0.05	0.29	0.22	25.2	12.3	-0.04	40.11	30.12	0.25	0.47	0.75
NH4	FAL	14	0.55	0.82	0.77	49.02	51.22	0.27	0.28	0.09	211.19	60.63	0.49	212.7	62.19	0.51	0.4	0.59
NH4	ALL	57	0.98	1	0.79	2.37	32.98	0.02	0.32	0.19	62.55	16.46	0.02	83.22	41.46	0.33	0.44	0.62
NO3	WIN	14	1.71	2.19	0.54	28.4	49.01	0.49	0.84	1.3	330.24	24.46	0.28	351.46	52.09	0.49	1.24	0.29
NO3	SPR	14	1.16	1.2	0.63	2.96	54.76	0.03	0.64	0.77	43.65	4.42	0.03	85.37	57.1	0.55	0.88	0.39
NO3	SUM	16	0.53	0.61	0.77	15.28	55.99	0.08	0.3	0.23	4.8	-20.85	0.15	60.61	59.45	0.56	0.49	0.59
NO3	FAL	14	0.78	1.15	0.67	47.21	68.09	0.37	0.53	0.42	87.65	44.25	0.47	99.3	61.18	0.68	0.75	0.44
NO3	ALL	58	1.03	1.27	0.7	23.02	55.07	0.24	0.57	0.7	112.73	11.9	0.23	146.13	57.52	0.55	0.87	0.48
OC	WIN	15	1.14	2.4	0.88	110.2	110.2	1.26	1.26	0.28	139.48	76.91	1.1	139.48	76.91	1.1	1.37	0.77
OC	SPR	14	0.92	1.39	0.58	49.87	67.71	0.46	0.63	0.34	80.07	43.64	0.5	93.36	59.65	0.68	0.74	0.34
OC	SUM	16	2.12	2.02	0.75	-4.73	26.3	-0.1	0.56	0.47	-3.53	-8.84	-0.05	27.3	27.66	0.28	0.69	0.56
OC	FAL	14	0.88	1.38	0.67	55.81	57.97	0.49	0.51	0.39	109.37	53.24	0.56	111.08	55.06	0.58	0.8	0.45
OC	ALL	59	1.29	1.81	0.66	40.16	57.3	0.52	0.74	0.62	79.45	40.14	0.4	91.38	54.27	0.57	0.94	0.44
PM-2.5	WIN	14	8.44	9.37	0.8	11.1	23.55	0.94	1.99	6.49	14.28	9.2	0.11	26.44	23.39	0.24	2.71	0.64
PM-2.5	SPR	14	7.46	6.93	0.86	-7.15	18.15	-0.53	1.35	2.44	-8.15	-10.88	-0.08	18.19	19.78	0.2	1.65	0.74
PM-2.5	SUM	16	13.73	8.9	0.89	-35.16	35.16	-4.83	4.83	6.64	-35.1	-44.52	-0.54	35.1	44.52	0.54	5.47	0.79
PM-2.5	FAL	14	6.2	6.52	0.78	5.1	26.49	0.32	1.64	4.25	16.45	7.07	0.05	35.31	29.95	0.26	2.09	0.61
PM-2.5	ALL	58	9.12	7.96	0.76	-12.7	27.79	-1.16	2.53	10.4	-4.23	-10.98	-0.15	28.98	29.93	0.32	3.43	0.57
SO4	WIN	13	2.18	1.3	0.72	-40.35	41.68	-0.88	0.91	0.41	-35.95	-47.71	-0.68	37.87	49.52	0.7	1.09	0.52
SO4	SPR	14	1.93	1.72	0.78	-11.04	25.28	-0.21	0.49	0.36	-4.56	-10.42	-0.12	27.83	29.9	0.28	0.63	0.61
SO4	SUM	16	3.84	2.81	0.84	-26.82	28.29	-1.03	1.09	1.88	-16.24	-20.94	-0.37	22.01	26.25	0.39	1.72	0.71
SO4	FAL	14	1.65	1.47	0.86	-10.99	29.67	-0.18	0.49	0.36	2.44	-7.3	-0.12	38.05	37.36	0.33	0.62	0.74
SO4	ALL	57	2.45	1.87	0.85	-23.89	30.65	-0.59	0.75	0.95	-13.28	-21.11	-0.31	30.99	35.18	0.4	1.14	0.72

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420030008																		
EC	WIN	24	0.87	1.49	0.81	71.89	72.99	0.62	0.63	0.13	115.62	62.42	0.72	116.34	63.18	0.73	0.72	0.65
EC	SPR	25	0.61	1.01	0.55	64.79	70.13	0.4	0.43	0.13	85.32	51.02	0.65	87.43	53.43	0.7	0.53	0.3
EC	SUM	26	0.86	0.95	0.81	10.04	24.12	0.09	0.21	0.06	18.75	14.1	0.1	27.44	24.08	0.24	0.26	0.66
EC	FAL	25	0.84	1.16	0.9	37.86	42	0.32	0.35	0.05	59.07	40.2	0.38	61.35	42.87	0.42	0.39	0.81
EC	ALL	100	0.8	1.15	0.74	44.12	50.49	0.35	0.4	0.13	68.72	41.45	0.44	72.25	45.5	0.5	0.5	0.55
NACL	WIN	24	0.1	0.24	0.43	130.86	134.5	0.13	0.14	0.01	253.8	86.41	1.31	255.85	88.7	1.35	0.16	0.18
NACL	SPR	22	0.06	0.11	0.11	98.84	138.32	0.06	0.08	0.01	230.05	62.46	0.99	243.62	80.98	1.38	0.1	0.01
NACL	SUM	26	0.04	0.04	0.61	2.76	31.19	0	0.01	0	10.81	1.96	0.03	34.78	31.88	0.31	0.02	0.37
NACL	FAL	25	0.07	0.09	0.66	28.1	60.91	0.02	0.04	0	143.1	30.32	0.28	168.33	63.26	0.61	0.06	0.43
NACL	ALL	97	0.07	0.12	0.5	75.5	98	0.05	0.07	0.01	154.75	43.89	0.75	171.26	65.16	0.98	0.1	0.25
NH4	WIN	24	1.52	1.51	0.76	-0.52	27.93	-0.01	0.42	0.3	16.17	3.41	-0.01	40.08	31.64	0.28	0.55	0.58
NH4	SPR	23	1	1.06	0.74	6.23	35.48	0.06	0.35	0.24	11.95	2.39	0.06	39.45	35.38	0.35	0.5	0.55
NH4	SUM	26	1.27	1.04	0.85	-18.05	34.23	-0.23	0.43	0.27	10.15	-3.6	-0.22	45.32	39.57	0.42	0.57	0.72
NH4	FAL	25	0.71	0.84	0.67	17.66	48.69	0.13	0.35	0.18	73.36	31.78	0.18	90.98	53.53	0.49	0.44	0.45
NH4	ALL	98	1.12	1.11	0.76	-1.4	34.75	-0.02	0.39	0.27	28.17	8.55	-0.01	54.31	40.21	0.35	0.52	0.58
NO3	WIN	24	2.65	3.17	0.6	19.7	44.95	0.52	1.19	2.27	34.99	16.16	0.2	54.94	42.51	0.45	1.6	0.36
NO3	SPR	23	1.08	1.31	0.68	20.96	62.49	0.23	0.67	1.06	3.7	-20.19	0.21	60.22	60.49	0.62	1.05	0.46
NO3	SUM	26	0.44	0.23	0.58	-48.09	53.16	-0.21	0.23	0.04	-46.46	-70.46	-0.93	53.68	76.67	1.02	0.29	0.34
NO3	FAL	25	0.84	0.92	0.68	9.33	53.15	0.08	0.45	0.3	22.46	-0.73	0.09	63.4	55.39	0.53	0.55	0.47
NO3	ALL	98	1.23	1.38	0.79	11.77	50.76	0.15	0.63	0.96	2.84	-19.66	0.12	58	59.08	0.51	0.99	0.63
OC	WIN	24	2.12	5.17	0.67	143.97	143.97	3.05	3.05	2.4	221.7	91.19	1.44	221.7	91.19	1.44	3.42	0.45
OC	SPR	25	1.25	2.72	0.4	117.59	117.59	1.47	1.47	1.43	156.33	72.38	1.18	156.33	72.38	1.18	1.89	0.16
OC	SUM	26	1.97	2.66	0.58	34.8	39.47	0.69	0.78	0.8	43.3	28.31	0.35	46.8	32.01	0.39	1.13	0.34
OC	FAL	25	1.66	2.86	0.75	72.65	77.6	1.2	1.29	0.99	107.71	58.2	0.73	110.75	61.69	0.78	1.56	0.56
OC	ALL	100	1.75	3.33	0.6	90.36	92.9	1.58	1.62	2.15	130.48	61.89	0.9	132.15	63.73	0.93	2.16	0.36
PM-2.5	WIN	24	13.29	17.78	0.87	33.74	35.19	4.48	4.68	11.72	42.08	31.13	0.34	43.15	32.27	0.35	5.64	0.76
PM-2.5	SPR	23	9.42	10.84	0.56	15	37.79	1.41	3.56	17.44	21.71	11.63	0.15	40.06	34.48	0.38	4.41	0.31
PM-2.5	SUM	26	15.03	11.82	0.83	-21.37	25.53	-3.21	3.84	14.82	-17.89	-22.67	-0.27	23.95	27.73	0.32	5.01	0.69
PM-2.5	FAL	25	9.98	10.82	0.81	8.47	26.16	0.84	2.61	9.7	23.38	13.25	0.08	36.23	28.16	0.26	3.23	0.66
PM-2.5	ALL	98	12	12.79	0.72	6.61	30.55	0.79	3.66	21.05	16.62	7.72	0.07	35.57	30.54	0.31	4.66	0.52
SO4	WIN	24	2.54	1.68	0.78	-34.08	37.71	-0.87	0.96	0.64	-31.6	-40.43	-0.52	34.89	43.36	0.57	1.18	0.61
SO4	SPR	23	2.42	2	0.61	-17.25	36.49	-0.42	0.88	1.19	-12.79	-21.12	-0.21	32.42	37.34	0.44	1.17	0.37
SO4	SUM	26	4.53	3.8	0.86	-16.16	26.19	-0.73	1.19	2.21	-9.94	-16.01	-0.19	26.42	28.93	0.31	1.66	0.74
SO4	FAL	25	2.22	1.81	0.72	-18.37	32.34	-0.41	0.72	0.97	-8.41	-15.8	-0.22	30.95	33.96	0.4	1.06	0.52
SO4	ALL	98	2.96	2.35	0.84	-20.57	31.77	-0.61	0.94	1.31	-15.52	-23.14	-0.26	31.06	35.72	0.4	1.29	0.7

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420030064																		
EC	WIN	14	1.08	1.1	0.37	2.04	83.1	0.02	0.89	1.26	114.63	37.42	0.02	147.66	82.39	0.83	1.12	0.14
EC	SPR	15	1.21	0.73	0.47	-39.87	65.24	-0.48	0.79	3.19	28.17	3.33	-0.66	64.34	56.43	1.09	1.85	0.23
EC	SUM	16	2.22	0.83	0.48	-62.58	65.39	-1.39	1.45	2.53	-41.53	-65	-1.67	52.75	73.98	1.75	2.11	0.23
EC	FAL	11	1.45	0.87	0.65	-39.94	53.98	-0.58	0.78	0.89	0.45	-20.94	-0.67	55.07	55.99	0.9	1.11	0.42
EC	ALL	56	1.51	0.88	0.33	-41.96	66.36	-0.64	1	2.35	24.43	-12.44	-0.72	80.04	67.85	1.14	1.66	0.11
NACL	WIN	13	0.62	0.26	0.27	-57.02	87.73	-0.35	0.54	0.37	122.24	-11.93	-1.33	203.99	120.93	2.04	0.7	0.07
NACL	SPR	15	0.1	0.14	0.24	39.34	94.87	0.04	0.09	0.01	186.81	43.07	0.39	214.79	80.37	0.95	0.12	0.06
NACL	SUM	16	0.08	0.07	0.68	-14.28	36.64	-0.01	0.03	0	11.03	0.21	-0.17	38.7	35.45	0.43	0.04	0.47
NACL	FAL	14	0.07	0.12	0.27	68.59	104.72	0.05	0.08	0.01	162.07	60.35	0.69	171.03	73.39	1.05	0.1	0.08
NACL	ALL	58	0.2	0.14	0.51	-29.65	84.79	-0.06	0.17	0.11	117.88	23.09	-0.42	153.23	75.38	1.21	0.34	0.26
NH4	WIN	14	2.82	1.29	0.38	-54.47	58.64	-1.54	1.66	3.36	-33.07	-56.12	-1.2	52.76	71.04	1.29	2.39	0.15
NH4	SPR	15	1.31	1.1	0.9	-15.75	27.17	-0.21	0.36	0.14	1.17	-17.15	-0.19	46.37	42.55	0.32	0.42	0.81
NH4	SUM	16	2.02	1.16	0.89	-42.57	46.86	-0.86	0.95	0.92	-11.35	-30.43	-0.74	51.77	53.98	0.82	1.29	0.79
NH4	FAL	14	0.97	0.83	0.88	-14.13	42.11	-0.14	0.41	0.27	46.52	15.46	-0.16	76.89	52.16	0.49	0.54	0.78
NH4	ALL	59	1.78	1.1	0.65	-38.37	47	-0.68	0.84	1.46	0.41	-22.26	-0.62	56.59	54.69	0.76	1.39	0.42
NO3	WIN	14	3.45	2.59	0.27	-25.08	64.12	-0.87	2.21	9.11	10.31	-16.26	-0.33	64.87	67.32	0.86	3.14	0.07
NO3	SPR	15	1.07	1.34	0.62	25	69.56	0.27	0.74	1.09	16.38	-12.17	0.25	68.8	62.61	0.7	1.08	0.39
NO3	SUM	16	0.72	0.3	0.54	-58.85	60.41	-0.43	0.44	0.14	-56.99	-86.8	-1.43	58.74	88.44	1.47	0.56	0.29
NO3	FAL	14	0.87	1.01	0.54	15.36	55.85	0.13	0.49	0.45	52.74	12.82	0.15	82.03	48.6	0.56	0.68	0.3
NO3	ALL	59	1.49	1.27	0.52	-14.78	63.48	-0.22	0.95	2.78	3.67	-27.45	-0.17	68.28	67.41	0.74	1.68	0.27
OC	WIN	14	1.82	4.6	0.4	152.22	152.22	2.78	2.78	3.6	260.77	89.38	1.52	260.77	89.38	1.52	3.36	0.16
OC	SPR	15	1.57	1.96	0.39	25.34	67.87	0.4	1.06	1.46	96.12	39.04	0.25	114.82	63.47	0.68	1.27	0.15
OC	SUM	16	3.06	2.26	0.47	-26.21	36.67	-0.8	1.12	2.01	-13.22	-22.37	-0.36	34.29	38.89	0.5	1.63	0.22
OC	FAL	11	2.08	2.27	0.27	9.34	53.9	0.19	1.12	2.1	49.82	21.07	0.09	71.2	48.84	0.54	1.46	0.07
OC	ALL	56	2.16	2.77	0.19	28.25	70.42	0.61	1.52	4.07	96.95	30.55	0.28	119.73	60.05	0.7	2.11	0.04
PM-2.5	WIN	13	22.16	15.51	0.41	-30	48.41	-6.65	10.73	150.33	-6.64	-21.59	-0.43	47.92	53.16	0.69	13.95	0.17
PM-2.5	SPR	14	12.42	9.99	0.64	-19.55	34.12	-2.43	4.24	17.28	-14.6	-23.72	-0.24	35.17	40.5	0.42	4.81	0.4
PM-2.5	SUM	16	21.11	11.59	0.77	-45.11	45.13	-9.52	9.53	48.71	-39.4	-52.64	-0.82	39.5	52.74	0.82	11.8	0.59
PM-2.5	FAL	14	16.81	8.9	0.31	-47.06	60.53	-7.91	10.17	604.95	6.04	-10.24	-0.89	44.69	45.37	1.14	25.84	0.1
PM-2.5	ALL	57	18.16	11.43	0.42	-37.05	47.7	-6.73	8.66	207.86	-14.68	-28.04	-0.59	41.63	48.02	0.76	15.91	0.17
SO4	WIN	14	4.49	1.46	0.47	-67.39	67.39	-3.02	3.02	5.03	-59.71	-89.87	-2.07	59.71	89.87	2.07	3.77	0.22
SO4	SPR	15	2.89	2.05	0.74	-29.03	34.01	-0.84	0.98	1.17	-26.47	-35.61	-0.41	32.46	41.02	0.48	1.37	0.55
SO4	SUM	16	6	4.08	0.85	-32.01	35.64	-1.92	2.14	4.34	-19.99	-30.85	-0.47	36.78	43.14	0.52	2.83	0.73
SO4	FAL	14	2.66	1.78	0.81	-33.08	38.64	-0.88	1.03	1.5	-22.21	-32.61	-0.49	35.85	44.16	0.58	1.51	0.66
SO4	ALL	59	4.06	2.4	0.76	-40.92	44.14	-1.66	1.79	3.8	-31.59	-46.48	-0.69	40.9	53.93	0.75	2.56	0.58

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420210011																		
EC	WIN	15	0.83	0.59	0.36	-29.33	58.74	-0.24	0.49	0.57	19.64	-2.9	-0.41	57.64	51.86	0.83	0.8	0.13
EC	SPR	12	0.53	0.35	0.46	-34.6	40.91	-0.18	0.22	0.05	-23.45	-34.93	-0.53	33.95	43.91	0.63	0.29	0.22
EC	SUM	16	0.71	0.44	0.77	-38.46	38.46	-0.27	0.27	0.03	-35.55	-44.81	-0.62	35.55	44.81	0.62	0.32	0.59
EC	FAL	14	0.69	0.42	0.4	-38.92	45.21	-0.27	0.31	0.1	-28.27	-41.22	-0.64	40.3	51.72	0.74	0.42	0.16
EC	ALL	57	0.7	0.45	0.44	-35.1	46.83	-0.25	0.33	0.2	-16.69	-30.82	-0.54	42.19	48.17	0.72	0.51	0.2
NACL	WIN	15	0.08	0.11	0.59	37.37	50.55	0.03	0.04	0	83.28	36.52	0.37	89.39	44.17	0.51	0.06	0.35
NACL	SPR	14	0.05	0.09	0.14	68.43	90.91	0.04	0.05	0	99.2	35.64	0.68	117.27	57.08	0.91	0.07	0.02
NACL	SUM	16	0.05	0.03	0.42	-37.44	42.75	-0.02	0.02	0	-31.82	-44.74	-0.6	38.01	50.47	0.68	0.02	0.17
NACL	FAL	14	0.04	0.06	0.04	38.67	75.3	0.02	0.03	0	54.47	12.84	0.39	83.52	54.28	0.75	0.05	0
NACL	ALL	59	0.05	0.07	0.46	27.96	62.35	0.02	0.03	0	49.01	8.66	0.28	80.68	51.34	0.62	0.05	0.21
NH4	WIN	15	1.2	0.9	0.48	-25.12	36.92	-0.3	0.44	0.46	-10.94	-20.2	-0.34	33.03	37.71	0.49	0.74	0.23
NH4	SPR	14	0.86	0.81	0.79	-6.39	35.28	-0.06	0.3	0.14	35.49	-8.57	-0.07	78.37	44.32	0.38	0.38	0.62
NH4	SUM	16	1.46	0.91	0.82	-37.81	41.07	-0.55	0.6	0.45	-18.97	-27.88	-0.61	32.85	39.96	0.66	0.87	0.67
NH4	FAL	14	0.72	0.6	0.62	-15.57	42	-0.11	0.3	0.16	47.17	7.95	-0.18	82.17	54.12	0.5	0.41	0.39
NH4	ALL	59	1.08	0.81	0.66	-24.72	38.94	-0.27	0.42	0.35	11.69	-12.84	-0.33	55.4	43.78	0.52	0.65	0.44
NO3	WIN	15	1.68	1.6	0.32	-4.54	50.99	-0.08	0.86	1.73	16.99	-9.42	-0.05	61.39	52.56	0.53	1.32	0.1
NO3	SPR	14	0.79	0.76	0.62	-3.89	61.15	-0.03	0.48	0.48	-4.02	-31.76	-0.04	63.42	64.85	0.64	0.69	0.39
NO3	SUM	16	0.38	0.16	0.52	-56.57	59.4	-0.21	0.22	0.02	-56.1	-86.98	-1.3	59.23	89.76	1.37	0.26	0.27
NO3	FAL	14	0.58	0.53	0.61	-8.59	56.37	-0.05	0.32	0.18	13.25	-31.92	-0.09	82.92	78.54	0.62	0.43	0.37
NO3	ALL	59	0.85	0.76	0.62	-11.28	55.09	-0.1	0.47	0.61	-8.71	-41.09	-0.13	66.4	71.73	0.62	0.79	0.39
OC	WIN	15	1.89	2.7	0.18	42.99	91.06	0.81	1.72	4.93	127.34	59.05	0.43	137.43	75.27	0.91	2.36	0.03
OC	SPR	12	1.25	1.45	0.41	15.85	45.98	0.2	0.58	0.42	43.44	20.12	0.16	64.11	44.08	0.46	0.68	0.17
OC	SUM	16	2.2	1.88	0.68	-14.44	31.01	-0.32	0.68	0.73	-5.06	-11.44	-0.17	28.99	31.03	0.36	0.91	0.46
OC	FAL	14	1.43	1.45	0.6	1.49	36.63	0.02	0.52	0.45	15.76	6.76	0.01	38.61	34.97	0.37	0.67	0.36
OC	ALL	57	1.73	1.9	0.37	9.93	51.7	0.17	0.89	1.88	45.11	18.22	0.1	67.28	46.39	0.52	1.38	0.14
PM-2.5	WIN	15	11.95	9.79	0.35	-18.1	37.96	-2.16	4.54	53.59	-2.33	-10.58	-0.22	29.49	32.07	0.46	7.63	0.12
PM-2.5	SPR	14	9.15	7.1	0.63	-22.43	28.7	-2.05	2.63	9.72	-22.16	-30.47	-0.29	27.93	35.81	0.37	3.73	0.39
PM-2.5	SUM	16	17.2	9.26	0.91	-46.18	46.18	-7.94	7.94	11.99	-46.25	-61.01	-0.86	46.25	61.01	0.86	8.66	0.82
PM-2.5	FAL	14	9.49	6.46	0.72	-31.98	32.42	-3.04	3.08	8.46	-29.37	-38.65	-0.47	29.86	39.13	0.48	4.2	0.53
PM-2.5	ALL	59	12.13	8.22	0.62	-32.25	38.43	-3.91	4.66	27.37	-25.36	-35.64	-0.48	33.75	42.48	0.57	6.53	0.39
SO4	WIN	15	2.6	1.37	0.69	-47.27	47.27	-1.23	1.23	1.68	-40.23	-53.21	-0.9	40.23	53.21	0.9	1.79	0.47
SO4	SPR	14	2.38	2	0.89	-15.95	25.14	-0.38	0.6	0.4	-17.74	-24.07	-0.19	28.95	33.05	0.3	0.73	0.79
SO4	SUM	16	5.04	3.52	0.96	-30.15	31.11	-1.52	1.57	1.32	-27.85	-34.77	-0.43	31.05	37.76	0.45	1.91	0.92
SO4	FAL	14	2.42	1.61	0.82	-33.57	37.45	-0.81	0.91	0.97	-27.98	-38.12	-0.51	35.18	44.21	0.56	1.28	0.67
SO4	ALL	59	3.17	2.16	0.89	-31.81	34.57	-1.01	1.1	1.29	-28.63	-37.71	-0.47	33.86	42.1	0.51	1.52	0.8

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420270100																		
EC	WIN	15	0.41	0.59	0.6	43.04	62.26	0.18	0.26	0.08	91.78	51.03	0.43	97.56	58.17	0.62	0.33	0.36
EC	SPR	15	0.26	0.33	0.63	26.25	45.17	0.07	0.12	0.02	47.49	31.79	0.26	55.74	41.64	0.45	0.14	0.4
EC	SUM	16	0.48	0.45	0.84	-6.49	18.87	-0.03	0.09	0.01	-3.63	-5.78	-0.07	18.68	19.46	0.2	0.1	0.71
EC	FAL	15	0.35	0.47	0.78	34.16	41.08	0.12	0.14	0.01	52.02	34.68	0.34	56.57	39.51	0.41	0.16	0.61
EC	ALL	61	0.38	0.46	0.66	21.69	40.08	0.08	0.15	0.03	46.09	27.38	0.22	56.51	39.36	0.4	0.2	0.43
NACL	WIN	14	0.04	0.12	0.54	217.81	217.81	0.08	0.08	0	517.12	103.53	2.18	517.12	103.53	2.18	0.09	0.29
NACL	SPR	13	0.04	0.1	0.6	143.37	143.44	0.06	0.06	0	190.12	83.47	1.43	190.22	83.57	1.43	0.07	0.36
NACL	SUM	16	0.04	0.04	0.55	9.13	33.87	0	0.01	0	25.91	11.4	0.09	42.87	33.99	0.34	0.02	0.3
NACL	FAL	14	0.04	0.09	0.5	156.51	168.57	0.06	0.06	0.01	299.22	63.18	1.57	307.96	75.78	1.69	0.11	0.25
NACL	ALL	57	0.04	0.09	0.44	128.34	137.86	0.05	0.05	0	251.14	63.18	1.28	258.07	72.64	1.38	0.08	0.2
NH4	WIN	15	1	0.88	0.82	-11.48	26.66	-0.11	0.27	0.17	17.11	1.03	-0.13	38.6	27.68	0.3	0.43	0.67
NH4	SPR	15	0.85	0.87	0.33	1.59	60.77	0.01	0.52	0.44	150.97	18.32	0.02	188.16	65.8	0.61	0.66	0.11
NH4	SUM	16	1.33	0.85	0.78	-36.3	40.57	-0.48	0.54	0.4	-7.14	-21.66	-0.57	44.97	46.58	0.64	0.8	0.6
NH4	FAL	15	0.5	0.67	0.39	35.24	98.58	0.17	0.49	0.49	287.32	68.55	0.35	299.83	86.38	0.99	0.72	0.15
NH4	ALL	61	0.93	0.82	0.6	-11.72	49.12	-0.11	0.45	0.44	110.11	15.93	-0.13	141.29	56.45	0.56	0.67	0.36
NO3	WIN	15	1.43	1.64	0.54	14.57	59.89	0.21	0.86	1.15	71.13	25.23	0.15	99.07	61.79	0.6	1.09	0.29
NO3	SPR	15	1.13	1.05	0.63	-6.93	53.43	-0.08	0.6	0.79	29.01	0.56	-0.07	65.01	49.93	0.57	0.89	0.4
NO3	SUM	16	0.37	0.19	0.8	-49.97	49.97	-0.19	0.19	0.02	-52.16	-78.93	-1	52.16	78.93	1	0.23	0.64
NO3	FAL	15	0.55	0.79	0.35	43.09	90.25	0.24	0.5	0.48	72.11	1.89	0.43	121.28	73.34	0.9	0.73	0.13
NO3	ALL	61	0.86	0.9	0.64	4.9	61.5	0.04	0.53	0.63	28.67	-13.89	0.05	83.85	66.21	0.61	0.8	0.41
OC	WIN	15	1.26	3.05	0.65	142.94	142.94	1.8	1.8	1.06	334.99	100.38	1.43	334.99	100.38	1.43	2.07	0.42
OC	SPR	14	0.83	1.59	0.55	90.71	90.71	0.76	0.76	0.29	677.4	68.59	0.91	677.4	68.59	0.91	0.93	0.31
OC	SUM	16	1.82	1.83	0.75	0.11	24.93	0	0.45	0.42	11.84	5.13	0	29.51	25.63	0.25	0.65	0.57
OC	FAL	14	1.05	1.77	0.84	67.68	67.68	0.71	0.71	0.16	116.55	59.82	0.68	116.55	59.82	0.68	0.82	0.7
OC	ALL	59	1.26	2.07	0.56	63.84	73.57	0.81	0.93	0.92	276.77	57.38	0.64	281.56	62.94	0.74	1.25	0.31
PM-2.5	WIN	15	8.02	9.61	0.7	19.77	35.55	1.59	2.85	12.32	40.27	26.11	0.2	48.71	35.56	0.36	3.85	0.5
PM-2.5	SPR	14	6.48	7.01	0.54	8.22	30.65	0.53	1.99	7.53	11.59	4.28	0.08	31.6	27.23	0.31	2.79	0.29
PM-2.5	SUM	16	14.51	7.68	0.82	-47.08	47.08	-6.83	6.83	15.44	-45.14	-60.17	-0.89	45.14	60.17	0.89	7.88	0.67
PM-2.5	FAL	15	6.97	6.6	0.67	-5.31	33.54	-0.37	2.34	11.59	19.13	3.63	-0.06	43.76	37.15	0.35	3.42	0.45
PM-2.5	ALL	60	9.13	7.73	0.57	-15.27	39.24	-1.39	3.58	23.08	5.52	-7.61	-0.18	42.53	40.58	0.46	5	0.32
SO4	WIN	15	2.04	1.18	0.92	-42.04	42.04	-0.86	0.86	0.39	-38.03	-48.54	-0.73	38.03	48.54	0.73	1.06	0.85
SO4	SPR	15	1.83	1.72	0.26	-6.06	47.81	-0.11	0.88	1.16	10.2	-6.68	-0.06	53.45	49.49	0.51	1.08	0.07
SO4	SUM	16	4.44	2.64	0.93	-40.5	40.95	-1.8	1.82	1.99	-33.48	-43.99	-0.68	36.32	46.57	0.69	2.28	0.86
SO4	FAL	15	1.82	1.4	0.84	-23.12	34.22	-0.42	0.62	2.13	-4.59	-12.76	-0.3	29.78	33.56	0.45	1.52	0.7
SO4	ALL	61	2.56	1.75	0.84	-31.71	41.2	-0.81	1.06	1.84	-16.75	-28.26	-0.46	39.35	44.57	0.6	1.58	0.7

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420290100																		
EC	WIN	14	0.53	0.59	0.93	11.35	23.06	0.06	0.12	0.02	22.45	17.94	0.11	26.95	23.06	0.23	0.15	0.86
EC	SPR	14	0.39	0.37	0.39	-5.84	28.98	-0.02	0.11	0.02	0.16	-7.29	-0.06	31.04	32.4	0.31	0.14	0.15
EC	SUM	16	0.61	0.43	0.69	-29.98	32.41	-0.18	0.2	0.04	-26.61	-33.9	-0.43	28.87	35.98	0.46	0.27	0.48
EC	FAL	14	0.44	0.51	0.83	17.09	26.59	0.07	0.12	0.01	31.61	19.42	0.17	41.2	29.93	0.27	0.14	0.69
EC	ALL	58	0.5	0.47	0.7	-4.82	28.12	-0.02	0.14	0.03	5.75	-2.09	-0.05	31.91	30.54	0.3	0.19	0.49
NACL	WIN	14	0.05	0.12	0.3	128.4	161.46	0.07	0.09	0.01	551.82	75.45	1.28	561.95	88.41	1.61	0.14	0.09
NACL	SPR	14	0.1	0.18	0.22	75.31	135.83	0.08	0.14	0.03	129.98	57.57	0.75	141.61	76.65	1.36	0.2	0.05
NACL	SUM	16	0.07	0.07	0.61	4.28	57.87	0	0.04	0	22.01	-5.06	0.04	67.82	53.02	0.58	0.05	0.37
NACL	FAL	14	0.04	0.13	0.86	186.43	191.94	0.08	0.08	0.02	152.24	60.82	1.86	158.37	68.63	1.92	0.17	0.74
NACL	ALL	58	0.07	0.12	0.32	84.23	128.54	0.06	0.08	0.02	207.39	45.39	0.84	226.76	71.03	1.29	0.15	0.1
NH4	WIN	14	1.39	1.14	0.79	-17.82	26.18	-0.25	0.36	0.23	-8.66	-13.87	-0.22	26.25	28.01	0.32	0.54	0.62
NH4	SPR	14	1.17	1.02	0.82	-12.91	30.16	-0.15	0.35	0.16	-12.41	-21.4	-0.15	32.23	37.62	0.35	0.42	0.67
NH4	SUM	16	1.52	1.02	0.91	-32.73	40.44	-0.5	0.61	0.5	-13.3	-24.92	-0.49	43.05	46.6	0.6	0.86	0.82
NH4	FAL	13	0.85	0.92	0.92	8.57	28.07	0.07	0.24	0.09	52.61	28.27	0.09	62.1	39.52	0.28	0.31	0.84
NH4	ALL	57	1.25	1.03	0.83	-17.67	32.25	-0.22	0.4	0.3	3.09	-9.21	-0.21	40.61	38.21	0.39	0.59	0.7
NO3	WIN	14	2.77	2.6	0.62	-6.29	33.4	-0.17	0.93	1.61	8.82	-2.65	-0.07	38.71	37.89	0.36	1.28	0.38
NO3	SPR	14	1.65	1.6	0.78	-2.59	41.9	-0.04	0.69	0.81	-8.1	-22.21	-0.03	43.26	49.73	0.43	0.9	0.62
NO3	SUM	16	1.29	0.58	0.63	-55.26	59.93	-0.71	0.77	0.61	-59.12	-96.13	-1.24	63.8	100.07	1.34	1.06	0.4
NO3	FAL	14	1.54	1.49	0.62	-3.43	50.05	-0.05	0.77	0.97	10.37	-12.92	-0.04	61.38	60.45	0.52	0.99	0.39
NO3	ALL	58	1.79	1.53	0.71	-14.59	44	-0.26	0.79	1.06	-13.63	-35.64	-0.17	52.2	63.35	0.52	1.06	0.5
OC	WIN	14	1.59	2.89	0.94	81.05	81.05	1.29	1.29	0.19	108.61	65.85	0.81	108.61	65.85	0.81	1.36	0.88
OC	SPR	14	1.22	1.52	0.26	25.17	55.38	0.31	0.67	0.57	61.64	24.36	0.25	83.74	53.24	0.55	0.82	0.07
OC	SUM	16	2.28	1.71	0.83	-24.77	26.49	-0.56	0.6	0.34	-24.08	-29.48	-0.33	25.79	31.08	0.35	0.81	0.69
OC	FAL	14	1.05	1.44	0.71	37.96	39.09	0.4	0.41	0.21	69.22	37.22	0.38	69.88	37.89	0.39	0.6	0.51
OC	ALL	58	1.56	1.88	0.63	20.92	47.44	0.33	0.74	0.77	51.16	22.63	0.21	70.41	46.47	0.47	0.94	0.4
PM-2.5	WIN	14	10.9	10.73	0.91	-1.54	13.98	-0.17	1.52	7.93	5.55	3.64	-0.02	13.71	13.15	0.14	2.82	0.83
PM-2.5	SPR	14	9.48	7.8	0.51	-17.68	31.64	-1.68	3	11.6	-14.81	-23.4	-0.21	30.02	36.57	0.38	3.8	0.26
PM-2.5	SUM	16	14.31	8.07	0.9	-43.58	43.58	-6.23	6.23	14.03	-42.86	-56.87	-0.77	42.86	56.87	0.77	7.27	0.8
PM-2.5	FAL	14	9.71	7.34	0.66	-24.42	34.21	-2.37	3.32	25.13	-3.2	-11.94	-0.32	31.33	33.74	0.45	5.55	0.43
PM-2.5	ALL	58	11.21	8.47	0.71	-24.42	32.24	-2.74	3.61	19.92	-14.83	-23.34	-0.32	29.94	35.84	0.43	5.24	0.5
SO4	WIN	14	1.93	1.3	0.52	-32.63	38.3	-0.63	0.74	0.5	-30.66	-40.61	-0.48	35.91	45.25	0.57	0.95	0.27
SO4	SPR	14	2.25	1.75	0.85	-22.16	23.92	-0.5	0.54	0.19	-20.82	-27.25	-0.28	24.28	30.45	0.31	0.66	0.73
SO4	SUM	16	3.71	2.53	0.97	-31.88	35.23	-1.18	1.31	1.34	-23.25	-30.64	-0.47	32.68	38.44	0.52	1.66	0.95
SO4	FAL	14	1.74	1.36	0.96	-21.83	27.58	-0.38	0.48	0.39	-7.41	-11.99	-0.28	24.95	27.04	0.35	0.73	0.92
SO4	ALL	58	2.45	1.76	0.94	-28.15	32	-0.69	0.78	0.73	-20.63	-27.73	-0.39	29.57	35.4	0.45	1.1	0.88

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420430401																		
EC	WIN	15	0.64	1.07	0.88	67.13	71.97	0.43	0.46	0.06	104.82	62.7	0.67	106.18	64.13	0.72	0.5	0.77
EC	SPR	15	0.46	0.69	0.38	49.79	59.37	0.23	0.28	0.17	61.15	36.28	0.5	67.58	43.28	0.59	0.47	0.14
EC	SUM	16	0.81	0.85	0.71	4.92	28.48	0.04	0.23	0.09	15.88	8.79	0.05	33.25	28.28	0.28	0.3	0.51
EC	FAL	15	0.66	0.83	0.8	26.83	43.45	0.18	0.29	0.07	50.37	33.39	0.27	58.93	43.11	0.43	0.31	0.63
EC	ALL	61	0.65	0.86	0.67	33.44	48.25	0.22	0.31	0.12	57.37	34.86	0.33	65.94	44.43	0.48	0.4	0.44
NACL	WIN	15	0.14	0.17	0.43	21.98	99.93	0.03	0.14	0.06	162.75	69.93	0.22	173.45	87.8	1	0.24	0.18
NACL	SPR	15	0.05	0.16	0.29	200.51	200.51	0.11	0.11	0.01	257.17	85.25	2.01	257.17	85.25	2.01	0.15	0.08
NACL	SUM	15	0.04	0.06	0.59	68.92	70.22	0.02	0.03	0	119.36	49.8	0.69	121.11	51.67	0.7	0.03	0.35
NACL	FAL	15	0.06	0.17	0.39	197.65	213.19	0.11	0.12	0.07	183.76	54.38	1.98	192.2	64.19	2.13	0.29	0.16
NACL	ALL	60	0.07	0.14	0.28	96.45	137.74	0.07	0.1	0.04	180.76	64.84	0.96	185.98	72.23	1.38	0.21	0.08
NH4	WIN	15	1.4	1.27	0.83	-9.36	21.52	-0.13	0.3	0.18	-2.04	-5.9	-0.1	21.6	22.67	0.24	0.45	0.69
NH4	SPR	15	1.01	1.08	0.71	6.23	37.33	0.06	0.38	0.38	16.14	5.68	0.06	36.16	29.93	0.37	0.62	0.5
NH4	SUM	16	0.94	1.32	0.7	39.95	50.77	0.38	0.48	0.37	96.53	42.83	0.4	103.73	51.41	0.51	0.71	0.48
NH4	FAL	14	0.64	0.91	0.84	41.86	52.85	0.27	0.34	0.11	304.75	57.5	0.42	309.03	62.02	0.53	0.43	0.7
NH4	ALL	60	1	1.15	0.73	14.53	37.49	0.15	0.38	0.3	100.37	24.78	0.15	114.21	41.33	0.37	0.57	0.53
NO3	WIN	15	2.54	2.75	0.68	8.44	38.25	0.21	0.97	1.8	28.66	9.49	0.08	52.69	41.25	0.38	1.36	0.46
NO3	SPR	15	1.65	1.65	0.79	-0.3	40.78	-0.01	0.67	1.12	8.27	-9.89	0	51.45	44.77	0.41	1.06	0.63
NO3	SUM	16	0.52	0.93	0.74	77.83	110.86	0.41	0.58	0.62	51.93	-0.76	0.78	103.35	74.17	1.11	0.89	0.55
NO3	FAL	15	1.14	1.36	0.75	19.12	48.64	0.22	0.55	0.56	45.37	22.58	0.19	64.6	48.41	0.49	0.78	0.56
NO3	ALL	61	1.45	1.66	0.77	14.64	47.86	0.21	0.69	1.04	33.86	5.25	0.15	68.6	52.51	0.48	1.04	0.6
OC	WIN	15	1.4	5.46	0.89	288.87	288.87	4.06	4.06	1.8	368.79	124.09	2.89	368.79	124.09	2.89	4.27	0.79
OC	SPR	15	1.03	2.54	0.21	147.41	152.1	1.51	1.56	3.51	234.32	77.82	1.47	238.48	82.75	1.52	2.41	0.05
OC	SUM	16	1.95	2.66	0.6	36.67	50.61	0.71	0.98	1.09	51.43	33.63	0.37	57.56	41.18	0.51	1.26	0.36
OC	FAL	15	1.1	2.38	0.69	116.55	116.55	1.28	1.28	0.87	139.03	73.65	1.17	139.03	73.65	1.17	1.58	0.48
OC	ALL	61	1.38	3.25	0.46	135.81	141.84	1.87	1.95	3.45	195.98	76.58	1.36	198.61	79.77	1.42	2.64	0.21
PM-2.5	WIN	15	10.74	15.66	0.89	45.77	45.77	4.92	4.92	8.6	54.22	40.06	0.46	54.22	40.06	0.46	5.72	0.8
PM-2.5	SPR	15	8.23	9.9	0.53	20.28	39.01	1.67	3.21	32.35	24.21	10.82	0.2	42.42	32.44	0.39	5.93	0.28
PM-2.5	SUM	16	12.63	11.36	0.74	-10.1	26.03	-1.28	3.29	15.78	-7.54	-12.91	-0.11	25.59	27.19	0.29	4.17	0.54
PM-2.5	FAL	15	7.23	9.24	0.84	27.7	36.78	2	2.66	5.56	38.3	27.81	0.28	44.58	34.75	0.37	3.09	0.7
PM-2.5	ALL	61	9.76	11.53	0.7	18.22	36.03	1.78	3.52	20.46	26.72	15.97	0.18	41.44	33.51	0.36	4.86	0.49
SO4	WIN	15	2.2	1.41	0.79	-35.99	35.99	-0.79	0.79	0.31	-34.63	-44.5	-0.56	34.63	44.5	0.56	0.97	0.62
SO4	SPR	15	1.96	1.78	0.7	-9.06	29.11	-0.18	0.57	0.74	-9.73	-15.5	-0.1	25.57	28.42	0.32	0.88	0.49
SO4	SUM	16	3	2.94	0.68	-2.16	34.22	-0.06	1.03	1.91	14.32	4.15	-0.02	39.21	34.09	0.35	1.38	0.46
SO4	FAL	15	1.5	1.41	0.81	-5.68	30.61	-0.09	0.46	0.44	13.15	0.48	-0.06	41.08	35.94	0.32	0.67	0.66
SO4	ALL	61	2.18	1.9	0.74	-12.69	32.92	-0.28	0.72	0.95	-3.92	-13.55	-0.15	35.19	35.71	0.38	1.02	0.54

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420490003																		
EC	WIN	15	0.31	0.69	0.73	126.92	126.92	0.39	0.39	0.06	138.49	76.39	1.27	138.49	76.39	1.27	0.46	0.54
EC	SPR	15	0.34	0.46	0.74	35.79	51.03	0.12	0.17	0.03	61.37	41.4	0.36	66.51	47.68	0.51	0.2	0.55
EC	SUM	16	0.57	0.51	0.81	-11.4	22.32	-0.07	0.13	0.02	-4.63	-8.01	-0.13	22.92	23.75	0.25	0.15	0.65
EC	FAL	15	0.42	0.45	0.55	7	30.04	0.03	0.13	0.03	22.86	13.94	0.07	36.49	31.25	0.3	0.18	0.31
EC	ALL	61	0.41	0.53	0.43	27.96	49.11	0.12	0.2	0.06	53.56	30.29	0.28	65.4	44.42	0.49	0.28	0.18
NACL	WIN	14	0.1	0.11	0.12	1.84	81.65	0	0.08	0.02	98.69	37.63	0.02	117.14	66.95	0.82	0.16	0.02
NACL	SPR	15	0.06	0.07	0.14	1.06	59.7	0	0.04	0	58.17	6.83	0.01	96.93	62.67	0.6	0.05	0.02
NACL	SUM	16	0.04	0.03	0.31	-26.42	50.16	-0.01	0.02	0	24.57	-9.01	-0.36	70.98	54.96	0.68	0.04	0.09
NACL	FAL	15	0.04	0.05	0.55	49.76	76.14	0.02	0.03	0	61.14	30.07	0.5	80.98	55.14	0.76	0.04	0.3
NACL	ALL	60	0.06	0.06	0.16	3.06	68.95	0	0.04	0.01	59.41	15.6	0.03	90.74	59.73	0.69	0.08	0.03
NH4	WIN	15	1.01	0.86	0.49	-14.28	43.39	-0.14	0.44	0.59	25.14	9.3	-0.17	48.2	40.8	0.51	0.78	0.24
NH4	SPR	15	0.79	0.93	0.68	16.94	44.82	0.13	0.36	0.27	47.72	25.29	0.17	61.72	41.36	0.45	0.54	0.46
NH4	SUM	16	0.98	0.91	0.93	-7.03	35.43	-0.07	0.35	0.17	94.68	29.08	-0.08	115.95	54.3	0.38	0.42	0.86
NH4	FAL	15	0.42	0.56	0.77	32.64	55.57	0.14	0.23	0.06	123.32	46.91	0.33	135.55	61.32	0.56	0.29	0.59
NH4	ALL	61	0.8	0.82	0.72	1.68	42.78	0.01	0.34	0.29	73.08	27.67	0.02	90.77	49.53	0.43	0.54	0.51
NO3	WIN	15	2.06	1.76	0.51	-14.37	39.13	-0.3	0.8	2.06	19.34	4.23	-0.17	45.42	40.05	0.46	1.46	0.26
NO3	SPR	15	1.29	1.44	0.82	11.69	41.19	0.15	0.53	0.55	4.27	-9.36	0.12	44.44	44.53	0.41	0.75	0.67
NO3	SUM	16	0.27	0.16	0.52	-41.35	67.37	-0.11	0.18	0.04	-46.16	-78.26	-0.71	62.05	88.3	1.15	0.23	0.27
NO3	FAL	15	0.54	0.45	0.26	-16.54	51.09	-0.09	0.27	0.1	8.63	-31.31	-0.2	76.67	69.2	0.61	0.33	0.07
NO3	ALL	61	1.03	0.94	0.73	-8.48	43.28	-0.09	0.44	0.7	-4.18	-29.49	-0.09	57.22	60.97	0.47	0.84	0.53
OC	WIN	15	0.89	3.17	0.7	256.84	256.84	2.28	2.28	1.83	440.14	114.52	2.57	440.14	114.52	2.57	2.65	0.48
OC	SPR	15	0.87	1.7	0.65	96.29	96.29	0.83	0.83	0.28	162.95	72.19	0.96	162.95	72.19	0.96	0.99	0.42
OC	SUM	16	1.87	1.85	0.7	-1.35	26.97	-0.03	0.5	0.5	7.15	1.05	-0.01	28.23	27.44	0.27	0.71	0.49
OC	FAL	15	1.14	1.41	0.66	24.53	43.12	0.28	0.49	0.26	55.3	33.66	0.25	64.26	44.22	0.43	0.58	0.43
OC	ALL	61	1.2	2.03	0.33	68.93	84.82	0.83	1.02	1.5	163.78	54.46	0.69	171.51	63.98	0.85	1.48	0.11
PM-2.5	WIN	14	8.39	10.24	0.7	22.01	39.69	1.85	3.33	14.09	41.24	28.39	0.22	49.3	37.99	0.4	4.18	0.48
PM-2.5	SPR	15	7.15	7.95	0.81	11.29	28.25	0.81	2.02	5.52	12.37	5.74	0.11	30.52	29.22	0.28	2.48	0.66
PM-2.5	SUM	16	12.8	9.14	0.93	-28.6	28.61	-3.66	3.66	7.98	-25.43	-31.08	-0.4	25.46	31.11	0.4	4.62	0.87
PM-2.5	FAL	15	6.39	5.91	0.78	-7.53	26.61	-0.48	1.7	4.32	4.08	-2.88	-0.08	31.49	29.73	0.29	2.13	0.61
PM-2.5	ALL	60	8.76	8.29	0.77	-5.3	30.65	-0.46	2.68	12.25	6.95	-0.95	-0.06	33.8	31.9	0.32	3.53	0.59
SO4	WIN	15	1.6	1.03	0.54	-35.59	43.68	-0.57	0.7	0.84	-20.76	-31.11	-0.55	35.12	42.59	0.68	1.08	0.29
SO4	SPR	15	1.63	1.54	0.71	-5.74	29.9	-0.09	0.49	0.5	-7.97	-14.44	-0.06	27.89	30.14	0.32	0.72	0.5
SO4	SUM	16	3.59	3.22	0.92	-10.38	26.15	-0.37	0.94	1.26	5.95	-3.29	-0.12	36.77	33.2	0.29	1.18	0.84
SO4	FAL	15	1.55	1.31	0.89	-15.51	29.73	-0.24	0.46	0.42	-1.58	-9.38	-0.18	29.6	29.44	0.35	0.69	0.79
SO4	ALL	61	2.12	1.8	0.88	-15.12	30.77	-0.32	0.65	0.79	-5.89	-14.37	-0.18	32.42	33.83	0.36	0.95	0.78

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420692006																		
EC	WIN	15	0.49	0.6	0.7	23.04	36.31	0.11	0.18	0.05	42.71	27.93	0.23	48.36	34.27	0.36	0.25	0.49
EC	SPR	14	0.34	0.38	0.65	12.17	28.27	0.04	0.1	0.02	15.27	8.31	0.12	30.29	25.33	0.28	0.16	0.42
EC	SUM	15	0.69	0.51	0.78	-26.55	32.2	-0.18	0.22	0.03	-23.7	-31.38	-0.36	33.37	39.5	0.44	0.26	0.61
EC	FAL	13	0.45	0.43	0.84	-4.81	24.28	-0.02	0.11	0.02	9.68	3.35	-0.05	30.24	26.92	0.26	0.13	0.7
EC	ALL	57	0.5	0.48	0.68	-2.66	30.97	-0.01	0.15	0.04	10.96	1.9	-0.03	35.84	31.77	0.32	0.21	0.47
NACL	WIN	14	0.21	0.08	0.02	-61.29	78.08	-0.13	0.16	0.03	-30.88	-69.87	-1.58	70.07	94.25	2.02	0.22	0
NACL	SPR	14	0.08	0.12	0.05	52.94	114.85	0.04	0.09	0.02	93.55	24.08	0.53	129.11	78.23	1.15	0.14	0
NACL	SUM	15	0.04	0.03	0.4	-10.17	51.05	0	0.02	0	143.38	0.56	-0.11	186.95	63.13	0.57	0.03	0.16
NACL	FAL	13	0.04	0.06	0.65	49.42	96.59	0.02	0.04	0	31.91	-6.25	0.49	77.61	60.35	0.97	0.07	0.42
NACL	ALL	56	0.09	0.07	0.13	-19.38	85.18	-0.02	0.08	0.02	61.48	-12.75	-0.24	117.89	74.04	1.06	0.14	0.02
NH4	WIN	14	0.93	0.8	0.9	-13.63	24.19	-0.13	0.22	0.2	11.77	1.66	-0.16	31.24	24.97	0.28	0.47	0.82
NH4	SPR	15	0.67	0.72	0.8	7.43	28.63	0.05	0.19	0.06	19.38	5.08	0.07	43.19	32.84	0.29	0.26	0.64
NH4	SUM	15	0.86	0.86	0.88	0.09	24.66	0	0.21	0.1	46.77	15.72	0	60.95	33.43	0.25	0.32	0.77
NH4	FAL	12	0.35	0.48	0.83	36.31	68.97	0.13	0.24	0.07	383.8	74.62	0.36	390.96	83.73	0.69	0.3	0.69
NH4	ALL	56	0.72	0.73	0.84	1.29	30.14	0.01	0.22	0.12	102.9	21.98	0.01	119.48	41.94	0.3	0.34	0.71
NO3	WIN	14	1.58	1.6	0.86	1.38	31.58	0.02	0.5	0.41	13.89	1.26	0.01	40.8	40.54	0.32	0.64	0.75
NO3	SPR	15	0.9	0.94	0.89	5.18	40.65	0.05	0.36	0.2	18.48	-7.1	0.05	59.49	55.91	0.41	0.45	0.8
NO3	SUM	15	0.37	0.32	0.6	-13.44	51.31	-0.05	0.19	0.05	-15.99	-37.69	-0.16	56.14	64.96	0.59	0.22	0.36
NO3	FAL	13	0.47	0.39	0.78	-15.85	32.25	-0.07	0.15	0.04	-11.71	-24.71	-0.19	39.73	45.42	0.38	0.2	0.61
NO3	ALL	57	0.83	0.82	0.88	-1.49	36.56	-0.01	0.3	0.18	1.39	-17.11	-0.02	49.51	52.12	0.37	0.42	0.78
OC	WIN	15	1.15	3.22	0.72	179.32	179.32	2.07	2.07	1.35	231.97	97.92	1.79	231.97	97.92	1.79	2.37	0.52
OC	SPR	14	0.87	1.67	0.72	91.74	96.81	0.8	0.84	0.53	160.96	64.16	0.92	166.6	71.07	0.97	1.08	0.52
OC	SUM	15	1.83	2.05	0.74	12.25	31.76	0.22	0.58	0.59	12.97	6.48	0.12	31.25	28.39	0.32	0.8	0.55
OC	FAL	13	0.87	1.54	0.64	76.4	77.91	0.67	0.68	0.43	176.39	57.05	0.76	177.3	57.99	0.78	0.94	0.42
OC	ALL	57	1.2	2.15	0.58	79.41	88.41	0.95	1.06	1.23	144.22	56.24	0.79	150.62	63.92	0.88	1.46	0.34
PM-2.5	WIN	15	10.19	10.44	0.73	2.52	23.57	0.26	2.4	13.41	6.57	1.93	0.03	22.87	20.65	0.24	3.67	0.53
PM-2.5	SPR	14	7.31	7.78	0.83	6.4	21.79	0.47	1.59	5.2	4.22	0.12	0.06	20.25	20.55	0.22	2.33	0.68
PM-2.5	SUM	15	13.74	8.88	0.8	-35.37	38.55	-4.86	5.3	24.39	-31.3	-41.42	-0.55	36.27	45.61	0.6	6.93	0.64
PM-2.5	FAL	13	5.93	6.08	0.63	2.47	31.04	0.15	1.84	6.74	21.44	10.14	0.02	39.45	31.78	0.31	2.6	0.4
PM-2.5	ALL	57	9.45	8.38	0.7	-11.25	30.04	-1.06	2.84	17.92	-0.58	-8.05	-0.13	29.53	29.73	0.34	4.36	0.49
SO4	WIN	14	1.87	1.06	0.69	-43.44	43.44	-0.81	0.81	0.27	-40.44	-53.23	-0.77	40.44	53.23	0.77	0.96	0.47
SO4	SPR	15	1.71	1.54	0.69	-9.95	25.91	-0.17	0.44	0.29	-7.26	-13.26	-0.11	27.35	28.94	0.29	0.56	0.47
SO4	SUM	15	3.31	2.37	0.86	-28.43	33.32	-0.94	1.1	1.71	-15.57	-22.88	-0.4	32.28	35.86	0.47	1.61	0.75
SO4	FAL	13	1.28	1.11	0.86	-13.5	33.62	-0.17	0.43	0.64	6.09	-3.3	-0.16	35.52	35.12	0.39	0.82	0.74
SO4	ALL	57	2.07	1.54	0.85	-25.65	34	-0.53	0.7	0.86	-14.55	-23.34	-0.34	33.72	38.13	0.46	1.07	0.72

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420710007																		
EC	WIN	15	0.57	1.09	0.89	92.84	92.84	0.53	0.53	0.06	115.14	67.76	0.93	115.14	67.76	0.93	0.58	0.79
EC	SPR	15	0.39	0.58	0.35	46.87	56.57	0.18	0.22	0.07	68.03	37.87	0.47	74.41	45.09	0.57	0.32	0.12
EC	SUM	16	0.75	0.74	0.59	-1.19	33.49	-0.01	0.25	0.09	7.78	1.11	-0.01	33.37	31.58	0.34	0.31	0.35
EC	FAL	14	0.61	0.76	0.82	24.96	38.51	0.15	0.24	0.06	55.34	33.86	0.25	62.15	41.37	0.39	0.28	0.68
EC	ALL	60	0.58	0.79	0.62	36.25	53.08	0.21	0.31	0.11	60.78	34.61	0.36	70.79	46.29	0.53	0.39	0.38
NACL	WIN	14	0.09	0.31	0.56	252.46	252.46	0.22	0.22	0.03	685.59	124.04	2.52	685.59	124.04	2.52	0.28	0.31
NACL	SPR	15	0.1	0.26	0.48	160.76	186.58	0.16	0.18	0.02	234.15	96.6	1.61	241.23	106.24	1.87	0.21	0.23
NACL	SUM	14	0.05	0.13	0.4	166.69	168.17	0.08	0.08	0.01	221.63	84.46	1.67	222.25	85.1	1.68	0.11	0.16
NACL	FAL	15	0.04	0.28	0.51	591.18	591.18	0.24	0.24	0.12	526.8	128.37	5.91	526.8	128.37	5.91	0.42	0.26
NACL	ALL	58	0.07	0.24	0.37	254.44	264.22	0.17	0.18	0.05	415.78	108.51	2.54	417.76	111.16	2.64	0.28	0.14
NH4	WIN	14	1.52	1.66	0.61	9.51	36.28	0.14	0.55	0.67	27.36	9.13	0.1	50.43	36.4	0.36	0.83	0.38
NH4	SPR	15	1.32	1.24	0.84	-6.2	26.15	-0.08	0.35	0.19	-6.12	-10.06	-0.07	25	25.65	0.28	0.45	0.71
NH4	SUM	14	1.43	1.71	0.82	19.51	41.01	0.28	0.59	0.58	82.79	21.42	0.2	103.07	46.24	0.41	0.81	0.67
NH4	FAL	14	0.75	1.2	0.82	59.39	68.76	0.45	0.52	0.25	263.59	68.82	0.59	267.78	73.35	0.69	0.67	0.67
NH4	ALL	57	1.26	1.45	0.77	15.27	39.56	0.19	0.5	0.46	90.19	21.76	0.15	110.05	45.06	0.4	0.7	0.59
NO3	WIN	14	2.87	3.53	0.51	22.94	47.24	0.66	1.36	4.42	45.09	12.89	0.23	68	42.39	0.47	2.2	0.26
NO3	SPR	15	2.05	2.11	0.86	2.84	24.21	0.06	0.5	0.71	0.46	-7.02	0.03	28.89	28.81	0.24	0.84	0.73
NO3	SUM	14	1.23	2.1	0.61	70.9	109.52	0.87	1.34	3.25	79.65	12.41	0.71	122.27	74.7	1.1	2	0.38
NO3	FAL	15	1.43	2.25	0.62	58.18	75.28	0.83	1.07	1.99	106.32	40.65	0.58	122.22	60.9	0.75	1.64	0.39
NO3	ALL	58	1.89	2.49	0.64	31.7	56.02	0.6	1.06	2.66	57.73	14.8	0.32	85	51.46	0.56	1.74	0.41
OC	WIN	15	1.8	6.23	0.86	246.84	246.84	4.43	4.43	4.88	300.25	112.29	2.47	300.25	112.29	2.47	4.95	0.73
OC	SPR	15	1.26	2.45	0.36	94.27	96.3	1.19	1.22	1.55	194.03	63.72	0.94	196.59	66.52	0.96	1.72	0.13
OC	SUM	16	2.26	2.8	0.51	23.51	42.76	0.53	0.97	1.38	31.29	19.06	0.24	43.4	33.57	0.43	1.29	0.26
OC	FAL	14	1.35	2.49	0.81	84.67	88.14	1.14	1.19	0.51	129.84	70.43	0.85	131.17	71.82	0.88	1.35	0.66
OC	ALL	60	1.68	3.5	0.55	107.81	115.74	1.81	1.95	4.45	162.21	65.52	1.08	166.39	70.41	1.16	2.78	0.3
PM-2.5	WIN	15	13.14	18.91	0.7	43.93	48.92	5.77	6.43	36.9	59.4	37.99	0.44	62.51	41.51	0.49	8.38	0.49
PM-2.5	SPR	15	9.49	10.91	0.78	14.99	23.96	1.42	2.27	12	11.51	6.96	0.15	23.01	19.99	0.24	3.74	0.6
PM-2.5	SUM	14	13.66	14.26	0.73	4.41	31.35	0.6	4.28	31.06	11.15	1.56	0.04	35.62	30.29	0.31	5.61	0.54
PM-2.5	FAL	15	10.79	11.54	0.44	6.87	50.66	0.74	5.47	88.59	49.64	29.82	0.07	61.22	47.22	0.51	9.44	0.19
PM-2.5	ALL	59	11.74	13.9	0.59	18.41	39.35	2.16	4.62	46.86	33.3	19.38	0.18	45.76	34.83	0.39	7.18	0.35
SO4	WIN	14	2.15	1.68	0.53	-22.07	40.4	-0.48	0.87	1	-17.25	-27.51	-0.28	36.64	43.11	0.52	1.11	0.28
SO4	SPR	15	2.34	1.87	0.86	-20.13	26.24	-0.47	0.61	0.29	-21.11	-27.19	-0.25	27.44	33.03	0.33	0.72	0.74
SO4	SUM	14	3.55	3.05	0.84	-14.03	29.58	-0.5	1.05	1.62	12.48	-7.01	-0.16	48.82	36.78	0.34	1.37	0.71
SO4	FAL	15	1.53	1.47	0.74	-3.98	35.81	-0.06	0.55	0.75	23.68	1.42	-0.04	53.82	40.55	0.37	0.87	0.55
SO4	ALL	58	2.38	2	0.82	-15.67	32.13	-0.37	0.76	0.94	-0.49	-15	-0.19	41.64	38.31	0.38	1.04	0.67

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 420950025																		
EC	WIN	15	0.75	1.07	0.76	43.25	59.14	0.32	0.44	0.15	90.24	49.7	0.43	98.94	60.1	0.59	0.51	0.58
EC	SPR	15	0.37	0.51	0.62	38.53	47.62	0.14	0.18	0.04	54.25	30.96	0.39	63.09	40.96	0.48	0.24	0.39
EC	SUM	16	0.75	0.62	0.62	-17.63	31.97	-0.13	0.24	0.07	-9.08	-15.54	-0.21	30.7	32.99	0.39	0.3	0.39
EC	FAL	15	0.73	0.72	0.75	-0.34	34.8	0	0.25	0.08	27.02	12.78	0	49.97	40.31	0.35	0.29	0.57
EC	ALL	61	0.65	0.73	0.68	12.19	42.62	0.08	0.28	0.11	39.79	18.9	0.12	60.18	43.42	0.43	0.35	0.46
NACL	WIN	15	0.07	0.14	0.41	103.23	132.35	0.07	0.09	0.01	267.33	62.06	1.03	281.11	80.24	1.32	0.13	0.17
NACL	SPR	15	0.09	0.2	0.29	131.52	180.02	0.12	0.16	0.05	165.77	69.7	1.32	175.73	85.6	1.8	0.25	0.08
NACL	SUM	15	0.05	0.08	0.28	58.46	88.89	0.03	0.04	0	74.74	19.21	0.58	102.7	53.85	0.89	0.08	0.08
NACL	FAL	15	0.05	0.14	0.79	206.57	225.71	0.09	0.1	0.03	161.69	47.81	2.07	179.46	71.46	2.26	0.2	0.62
NACL	ALL	60	0.06	0.14	0.38	123.14	157.5	0.08	0.1	0.03	167.38	49.7	1.23	184.75	72.79	1.57	0.18	0.15
NH4	WIN	15	1.16	1.16	0.82	-0.07	21.09	0	0.25	0.15	3.43	-0.78	0	23.09	21	0.21	0.39	0.67
NH4	SPR	15	0.74	0.8	0.9	8.35	23.06	0.06	0.17	0.04	8.97	-4.31	0.08	37.43	37.07	0.23	0.22	0.81
NH4	SUM	15	1.11	0.87	0.87	-20.86	34.41	-0.23	0.38	0.22	9.43	-5.07	-0.26	47.69	41.93	0.43	0.52	0.76
NH4	FAL	14	0.61	0.74	0.94	20.31	43.37	0.12	0.27	0.09	156.2	58.85	0.2	164.95	68.55	0.43	0.32	0.88
NH4	ALL	59	0.91	0.9	0.84	-1.49	29.16	-0.01	0.27	0.14	42.62	11.38	-0.02	66.65	41.69	0.3	0.38	0.71
NO3	WIN	15	1.95	2.52	0.66	28.89	48.81	0.56	0.95	1.67	35.2	15.1	0.29	56.82	46.06	0.49	1.41	0.43
NO3	SPR	15	0.99	1.16	0.86	17.13	41.72	0.17	0.41	0.26	20.94	7.07	0.17	45.64	41.38	0.42	0.54	0.75
NO3	SUM	15	0.56	0.42	0.56	-26.08	50.75	-0.15	0.29	0.14	-29.4	-53.22	-0.35	51.76	69.87	0.69	0.4	0.32
NO3	FAL	15	0.87	0.89	0.79	1.66	39.6	0.01	0.35	0.22	9.2	-6.62	0.02	49	41.27	0.4	0.47	0.62
NO3	ALL	60	1.09	1.24	0.8	13.74	45.62	0.15	0.5	0.64	8.98	-9.42	0.14	50.8	49.65	0.46	0.82	0.64
OC	WIN	15	1.76	6.4	0.61	263.86	263.86	4.64	4.64	6.14	353.65	117.86	2.64	353.65	117.86	2.64	5.26	0.37
OC	SPR	15	1.04	2.19	0.34	111.72	121.06	1.16	1.25	1.58	167.44	62.78	1.12	176.99	74.24	1.21	1.71	0.12
OC	SUM	16	2.14	2.06	0.82	-3.74	19.66	-0.08	0.42	0.35	2.69	-2.34	-0.04	23.22	21.11	0.2	0.6	0.68
OC	FAL	15	1.5	2.38	0.75	58.55	62.64	0.88	0.94	0.96	110.21	53.09	0.59	113.66	56.86	0.63	1.32	0.56
OC	ALL	61	1.62	3.24	0.44	100.13	110.66	1.62	1.79	5.41	155.94	56.86	1	164.53	66.76	1.11	2.84	0.2
PM-2.5	WIN	15	10.7	16.88	0.92	57.77	59.16	6.18	6.33	12.02	68.48	47.42	0.58	69.76	48.76	0.59	7.09	0.85
PM-2.5	SPR	15	7.86	8.37	0.61	6.45	28.87	0.51	2.27	9.82	6.47	-1.8	0.06	29.52	29.85	0.29	3.17	0.38
PM-2.5	SUM	15	15.31	8.79	0.96	-42.59	42.59	-6.52	6.52	23.76	-38.49	-49.24	-0.74	38.49	49.24	0.74	8.14	0.91
PM-2.5	FAL	15	7.92	8.65	0.87	9.17	26.09	0.73	2.07	5.34	25.85	16.92	0.09	37.38	29.94	0.26	2.42	0.76
PM-2.5	ALL	60	10.45	10.67	0.6	2.13	41.13	0.22	4.3	33.07	15.58	3.32	0.02	43.79	39.45	0.41	5.75	0.36
SO4	WIN	15	2.12	1.45	0.63	-31.66	42.43	-0.67	0.9	0.61	-31.21	-41.62	-0.46	38.72	47.7	0.62	1.03	0.4
SO4	SPR	15	1.8	1.53	0.83	-15.01	19.55	-0.27	0.35	0.15	-15.02	-19.62	-0.18	19.53	23.92	0.23	0.47	0.69
SO4	SUM	15	3.49	2.35	0.85	-32.67	34.88	-1.14	1.22	2.19	-20.91	-28.03	-0.49	27.13	33.51	0.52	1.87	0.72
SO4	FAL	15	1.59	1.46	0.89	-8.15	32.94	-0.13	0.52	0.49	15.82	4.03	-0.09	43.65	38.36	0.36	0.71	0.79
SO4	ALL	60	2.25	1.7	0.82	-24.58	33.25	-0.55	0.75	1.02	-12.83	-21.31	-0.33	32.26	35.87	0.44	1.15	0.68

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 421010004																		
EC	WIN	15	0.62	1.43	0.85	130.15	130.15	0.81	0.81	0.13	161.68	83.91	1.3	161.68	83.91	1.3	0.89	0.72
EC	SPR	14	0.38	0.74	0.47	96.02	96.02	0.36	0.36	0.08	178.75	64.19	0.96	178.75	64.19	0.96	0.45	0.22
EC	SUM	15	0.67	1.08	0.85	62.13	62.13	0.41	0.41	0.06	68.74	47.78	0.62	68.74	47.78	0.62	0.48	0.72
EC	FAL	14	0.53	1.11	0.72	107.81	112.64	0.57	0.6	0.1	127.8	72.24	1.08	130.59	75.33	1.13	0.66	0.52
EC	ALL	58	0.55	1.1	0.78	98.16	99.28	0.54	0.55	0.12	133.59	66.99	0.98	134.26	67.73	0.99	0.65	0.61
NACL	WIN	15	0.09	0.17	0.43	81.98	121.41	0.08	0.11	0.03	116.05	51.66	0.82	132.56	73.32	1.21	0.19	0.18
NACL	SPR	15	0.28	0.34	0.8	24.32	69.25	0.07	0.19	0.1	120.35	42.11	0.24	134.94	65.18	0.69	0.33	0.64
NACL	SUM	16	0.07	0.1	0.74	37.9	73.26	0.03	0.05	0.01	29.52	7.07	0.38	61.54	51.48	0.73	0.08	0.55
NACL	FAL	15	0.08	0.29	0.83	266.98	278.53	0.21	0.22	0.23	168.5	52.01	2.67	182.3	68.51	2.79	0.53	0.69
NACL	ALL	61	0.13	0.23	0.61	73.21	110.71	0.1	0.14	0.1	107.31	37.7	0.73	126.75	64.41	1.11	0.32	0.38
NH4	WIN	15	1.35	1.47	0.67	9.29	31.75	0.13	0.43	0.5	12.54	6.52	0.09	27.79	23.89	0.32	0.72	0.45
NH4	SPR	15	0.89	0.75	0.79	-16.11	31.64	-0.14	0.28	0.1	-18.06	-31.67	-0.19	37.26	46.85	0.38	0.35	0.63
NH4	SUM	16	1.15	0.9	0.77	-21.59	33.41	-0.25	0.38	0.38	5.17	-9.43	-0.28	44.16	40.12	0.43	0.67	0.59
NH4	FAL	15	0.67	0.75	0.97	12.36	27.79	0.08	0.19	0.04	158.59	41.24	0.12	165.08	48.19	0.28	0.21	0.94
NH4	ALL	61	1.02	0.97	0.76	-4.83	31.58	-0.05	0.32	0.28	39	1.48	-0.05	68.17	39.77	0.33	0.53	0.58
NO3	WIN	15	2.43	2.95	0.6	21.67	44.25	0.53	1.07	2.58	24.81	8.4	0.22	48.45	39.85	0.44	1.69	0.36
NO3	SPR	15	1.28	1.02	0.7	-20.48	45.99	-0.26	0.59	0.59	-23.52	-43.1	-0.26	48.24	59.88	0.58	0.81	0.49
NO3	SUM	16	0.63	0.29	0.53	-53.49	65.64	-0.34	0.41	0.17	-59.92	-100.71	-1.15	66.83	106.43	1.41	0.53	0.28
NO3	FAL	15	1.13	1.01	0.81	-10.33	35.52	-0.12	0.4	0.23	11.73	-8.05	-0.12	52.56	48.09	0.4	0.5	0.65
NO3	ALL	61	1.35	1.3	0.76	-3.86	45.48	-0.05	0.62	0.99	-12.51	-36.93	-0.04	54.23	64.27	0.47	1	0.58
OC	WIN	15	1.31	5.74	0.68	338.39	338.39	4.43	4.43	4.87	420.13	125.72	3.38	420.13	125.72	3.38	4.95	0.46
OC	SPR	14	1.07	2.35	0.41	120.48	128.45	1.28	1.37	1.47	430.13	72.58	1.2	436.46	79.6	1.28	1.77	0.17
OC	SUM	15	1.93	2.77	0.89	44.07	45.14	0.85	0.87	0.45	42.2	32.11	0.44	44.02	34.07	0.45	1.08	0.79
OC	FAL	14	1.11	2.63	0.75	136.65	136.65	1.52	1.52	0.67	150.28	79.24	1.37	150.28	79.24	1.37	1.73	0.56
OC	ALL	58	1.36	3.4	0.45	149.86	151.76	2.04	2.07	3.94	259.67	77.46	1.5	261.67	79.66	1.52	2.85	0.2
PM-2.5	WIN	15	10.81	18.03	0.88	66.86	66.86	7.23	7.23	23.21	70.75	49.06	0.67	70.75	49.06	0.67	8.68	0.77
PM-2.5	SPR	15	8.35	8.98	0.44	7.46	32.96	0.62	2.75	12.28	10.12	2.47	0.07	32.78	30.39	0.33	3.56	0.2
PM-2.5	SUM	16	13.88	10.89	0.76	-21.55	25.88	-2.99	3.59	22.02	-17.7	-22.63	-0.27	23.85	27.92	0.33	5.57	0.58
PM-2.5	FAL	15	7.51	10.52	0.93	40.08	41.96	3.01	3.15	3.27	47.87	34.83	0.4	50.39	37.62	0.42	3.51	0.87
PM-2.5	ALL	61	10.2	12.09	0.64	18.49	40.89	1.89	4.17	29.26	27.01	15.3	0.18	44.1	36.11	0.41	5.73	0.4
SO4	WIN	15	2.08	1.84	0.67	-11.68	36.7	-0.24	0.76	0.92	-12.91	-20.44	-0.13	33.99	36.72	0.42	0.99	0.45
SO4	SPR	15	1.92	1.63	0.85	-15.41	18.7	-0.3	0.36	0.13	-13.99	-18.19	-0.18	19.39	23.27	0.22	0.47	0.73
SO4	SUM	16	3.54	2.64	0.78	-25.3	34.4	-0.89	1.22	3.08	-12.13	-18.95	-0.34	29.23	33.27	0.46	1.97	0.61
SO4	FAL	15	1.62	1.69	0.89	4.35	30.36	0.07	0.49	0.46	42	20.14	0.04	56.83	37.19	0.3	0.68	0.8
SO4	ALL	61	2.31	1.96	0.78	-15.14	31	-0.35	0.72	1.31	0.53	-9.52	-0.18	34.77	32.62	0.37	1.19	0.61

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 421010055																		
EC	WIN	14	0.83	1.6	0.92	92.51	92.51	0.77	0.77	0.12	102.95	65.12	0.93	102.95	65.12	0.93	0.85	0.85
EC	SPR	11	0.65	1.02	0.35	57	64.31	0.37	0.42	0.1	66.12	43.92	0.57	70.4	48.77	0.64	0.49	0.12
EC	SUM	16	0.99	1.32	0.7	33.43	39.07	0.33	0.39	0.13	43.77	31.01	0.33	47.23	34.72	0.39	0.48	0.5
EC	FAL	15	0.84	1.53	0.8	80.88	83.09	0.68	0.7	0.16	110.99	60.51	0.81	112.84	62.5	0.83	0.79	0.65
EC	ALL	56	0.84	1.39	0.75	64.29	67.87	0.54	0.57	0.17	80.96	49.98	0.64	83.29	52.52	0.68	0.68	0.56
NACL	WIN	14	0.09	0.17	0.5	84.8	102.73	0.08	0.1	0.03	103.33	49.1	0.85	113	60.18	1.03	0.19	0.25
NACL	SPR	13	0.33	0.33	0.79	-0.33	61.28	0	0.2	0.11	88.56	31.69	0	109.32	63.26	0.61	0.33	0.63
NACL	SUM	16	0.09	0.1	0.26	5.07	69.96	0	0.06	0.01	21.67	-15.91	0.05	76.9	60.21	0.7	0.1	0.07
NACL	FAL	15	0.11	0.29	0.57	161.88	177.37	0.18	0.2	0.21	139	39.14	1.62	157.71	63.82	1.77	0.49	0.32
NACL	ALL	58	0.15	0.22	0.58	43.91	90.84	0.07	0.14	0.09	86.72	24.69	0.44	113.78	61.82	0.91	0.31	0.34
NH4	WIN	15	1.31	1.63	0.59	24.43	31.46	0.32	0.41	0.78	27.51	16.47	0.24	32.7	21.89	0.31	0.94	0.35
NH4	SPR	13	0.89	0.81	0.72	-9.19	34.83	-0.08	0.31	0.16	-7.05	-18.1	-0.1	38.82	41.21	0.38	0.41	0.51
NH4	SUM	16	1.65	1.01	0.87	-39.03	46.5	-0.64	0.77	1.36	-2.66	-21.91	-0.64	48.28	46.56	0.76	1.33	0.77
NH4	FAL	15	0.65	0.88	0.96	34.97	38.62	0.23	0.25	0.04	244.14	59.38	0.35	245.39	60.67	0.39	0.3	0.92
NH4	ALL	59	1.14	1.09	0.63	-4.68	38.96	-0.05	0.45	0.76	66.79	9.36	-0.05	92.35	42.7	0.41	0.87	0.4
NO3	WIN	15	2.44	3.13	0.56	28.31	44.11	0.69	1.08	3.07	32.39	12.5	0.28	51.81	38.9	0.44	1.88	0.31
NO3	SPR	13	1.22	1.02	0.65	-16.43	50.7	-0.2	0.62	0.82	-18.5	-34.78	-0.2	47.07	54.33	0.61	0.93	0.43
NO3	SUM	16	0.84	0.32	0.89	-61.34	62.84	-0.51	0.53	0.21	-65.96	-107.56	-1.59	67.7	109.19	1.63	0.69	0.8
NO3	FAL	15	1.1	1.14	0.84	3.39	36.43	0.04	0.4	0.2	19.8	-0.68	0.03	57.91	51.15	0.36	0.44	0.71
NO3	ALL	59	1.4	1.4	0.73	0.1	46.89	0	0.65	1.27	-8.69	-33.83	0	56.63	64.47	0.47	1.13	0.54
OC	WIN	14	1.61	5.03	0.89	212.92	212.92	3.42	3.42	2.33	235.43	104.02	2.13	235.43	104.02	2.13	3.75	0.79
OC	SPR	11	1.55	2.55	0.06	64.61	78.28	1	1.21	1.2	95.5	48.52	0.65	104.2	58.41	0.78	1.48	0
OC	SUM	16	2.56	2.96	0.74	15.73	25.37	0.4	0.65	0.66	19.84	13.44	0.16	29.76	24.12	0.25	0.91	0.55
OC	FAL	15	1.52	2.92	0.82	92.58	92.58	1.4	1.4	0.42	111.12	65.55	0.93	111.12	65.55	0.93	1.55	0.68
OC	ALL	56	1.84	3.39	0.44	83.72	89.8	1.54	1.66	2.44	113.05	56.93	0.84	117.59	61.92	0.9	2.2	0.19
PM-2.5	WIN	15	10.63	17.55	0.82	65.07	65.07	6.92	6.92	30.88	70.06	47.6	0.65	70.06	47.6	0.65	8.87	0.67
PM-2.5	SPR	13	8.76	9.15	0.24	4.46	39.99	0.39	3.5	17.64	15.39	3.06	0.04	44.59	40.56	0.4	4.22	0.06
PM-2.5	SUM	16	17.11	11.74	0.85	-31.4	34.27	-5.37	5.86	52.93	-24.15	-30.74	-0.46	28.1	34.33	0.5	9.05	0.73
PM-2.5	FAL	15	7.61	11.83	0.86	55.42	55.65	4.22	4.24	5.74	76.54	48.84	0.55	76.8	49.11	0.56	4.85	0.74
PM-2.5	ALL	59	11.21	12.67	0.53	13.03	46.37	1.46	5.2	49.98	34.11	16.86	0.13	54.78	42.83	0.46	7.22	0.28
SO4	WIN	15	2.07	2.15	0.58	3.89	35.71	0.08	0.74	1.79	2.46	-5.81	0.04	31.89	28.22	0.36	1.34	0.34
SO4	SPR	13	1.99	1.82	0.78	-8.54	21.96	-0.17	0.44	0.21	-4.96	-9.77	-0.09	25.57	27.6	0.24	0.49	0.61
SO4	SUM	16	4.52	2.94	0.9	-34.82	38.27	-1.57	1.73	5.72	-19.33	-27.08	-0.53	29.73	35.24	0.59	2.86	0.81
SO4	FAL	15	1.62	1.97	0.89	21.91	35.55	0.35	0.57	0.4	61.81	35.17	0.22	69.67	44	0.36	0.73	0.79
SO4	ALL	59	2.6	2.25	0.77	-13.59	34.57	-0.35	0.9	2.74	10.01	-2.03	-0.16	39.52	34	0.4	1.69	0.6

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 421255001																		
EC	WIN	14	0.32	0.44	0.55	36.5	44.75	0.12	0.14	0.02	43.66	28.9	0.37	51.13	37.2	0.45	0.18	0.31
EC	SPR	11	0.31	0.35	0.84	11.62	28.67	0.04	0.09	0.01	10.53	4.57	0.12	29.66	26.71	0.29	0.11	0.7
EC	SUM	15	0.61	0.36	0.41	-40.61	40.61	-0.25	0.25	0.06	-33.4	-44.45	-0.68	33.4	44.45	0.68	0.34	0.17
EC	FAL	15	0.38	0.37	0.72	-2.74	30.26	-0.01	0.12	0.02	13.05	5.82	-0.03	34.35	31.55	0.31	0.14	0.52
EC	ALL	55	0.41	0.38	0.37	-7.97	37.01	-0.03	0.15	0.05	7.67	-2.27	-0.09	37.43	35.54	0.4	0.22	0.14
NACL	WIN	15	0.05	0.1	0.73	84.09	96.72	0.04	0.05	0	141.7	62.47	0.84	148.13	70.92	0.97	0.06	0.53
NACL	SPR	11	0.04	0.08	0.58	110.54	110.54	0.04	0.04	0	143.28	73.64	1.11	143.28	73.64	1.11	0.05	0.33
NACL	SUM	15	0.06	0.04	0.09	-35.28	57.44	-0.02	0.04	0.01	-1	-15.17	-0.55	43.23	46.43	0.89	0.08	0.01
NACL	FAL	15	0.05	0.05	0.04	8.73	84.93	0	0.04	0	49.84	7.84	0.09	93.44	71.21	0.85	0.06	0
NACL	ALL	56	0.05	0.07	0.19	29.97	83.09	0.02	0.04	0	79.18	29.24	0.3	104.43	64.97	0.83	0.06	0.04
NH4	WIN	15	0.98	0.91	0.83	-7.42	28.47	-0.07	0.28	0.12	3.1	-3.75	-0.08	31.44	30.91	0.31	0.35	0.68
NH4	SPR	11	0.79	0.89	0.78	12.5	34.73	0.1	0.28	0.19	9.46	1.45	0.13	33.45	29.59	0.35	0.45	0.61
NH4	SUM	15	1.15	0.98	0.85	-15.02	26.25	-0.17	0.3	0.13	43.27	0.35	-0.18	74.9	38.79	0.31	0.4	0.73
NH4	FAL	15	0.5	0.58	0.83	16.8	41.27	0.08	0.21	0.05	246.75	43.9	0.17	262.12	61.9	0.41	0.24	0.68
NH4	ALL	56	0.86	0.84	0.8	-2.79	30.79	-0.02	0.27	0.13	80.37	11.13	-0.03	105.27	41.06	0.32	0.36	0.65
NO3	WIN	15	1.49	1.79	0.49	19.73	52.67	0.29	0.79	1.4	37.02	12	0.2	59.8	45.76	0.53	1.22	0.24
NO3	SPR	11	0.75	1.2	0.23	60.15	111.7	0.45	0.84	1.93	100.62	-16.93	0.6	167.57	82.49	1.12	1.46	0.05
NO3	SUM	15	0.23	0.14	0.07	-40.18	59.32	-0.09	0.14	0.02	-32.57	-61.76	-0.67	62.75	75.92	0.99	0.17	0
NO3	FAL	15	0.58	0.54	0.74	-6.01	42.84	-0.03	0.25	0.1	17.6	-11.76	-0.06	68.78	57.19	0.46	0.32	0.55
NO3	ALL	56	0.76	0.9	0.61	17.45	62.61	0.13	0.48	0.83	25.67	-19.8	0.17	84.17	64.12	0.63	0.92	0.37
OC	WIN	14	0.99	1.94	0.76	95.4	95.4	0.95	0.95	0.34	120.05	65.36	0.95	120.05	65.36	0.95	1.12	0.58
OC	SPR	11	0.88	1.3	0.73	48.67	52.8	0.43	0.46	0.26	49.81	32.25	0.49	55.27	38.04	0.53	0.66	0.54
OC	SUM	15	1.85	1.68	0.33	-9.22	34.99	-0.17	0.65	0.69	-3.57	-11.23	-0.1	33.64	33.64	0.39	0.85	0.11
OC	FAL	15	0.96	1.18	0.72	23.39	39.15	0.22	0.37	0.13	51.61	31.47	0.23	61.02	41.76	0.39	0.43	0.52
OC	ALL	55	1.19	1.53	0.48	28.6	51.33	0.34	0.61	0.53	53.62	28.61	0.29	67.43	44.81	0.51	0.81	0.23
PM-2.5	WIN	15	8.11	8.39	0.84	3.41	21.25	0.28	1.72	4.22	4.72	1.28	0.03	22.78	22.31	0.21	2.07	0.7
PM-2.5	SPR	11	7.42	7.06	0.8	-4.76	28.38	-0.35	2.11	6.41	-9.73	-17.41	-0.05	31	34.82	0.3	2.56	0.64
PM-2.5	SUM	15	15.82	9.38	0.81	-40.69	40.69	-6.44	6.44	10.42	-40.52	-52.61	-0.69	40.52	52.61	0.69	7.2	0.65
PM-2.5	FAL	15	6.86	5.77	0.76	-15.86	30.3	-1.09	2.08	6.18	-3.49	-8.62	-0.19	27.93	29.21	0.36	2.71	0.58
PM-2.5	ALL	56	9.71	7.69	0.71	-20.72	32.52	-2.01	3.16	14.26	-12.44	-19.48	-0.26	30.52	34.73	0.41	4.28	0.51
SO4	WIN	15	2.24	1.26	0.91	-43.55	43.55	-0.97	0.97	0.44	-41.79	-54.87	-0.77	41.79	54.87	0.77	1.18	0.82
SO4	SPR	11	2.26	1.71	0.72	-24.47	31.55	-0.55	0.71	1.09	-22.43	-32.04	-0.32	28.6	37.56	0.42	1.18	0.51
SO4	SUM	15	5.15	4.05	0.96	-21.43	23.01	-1.1	1.19	0.78	-16.45	-22.75	-0.27	28.78	31.18	0.29	1.41	0.91
SO4	FAL	15	1.98	1.49	0.81	-24.44	34.83	-0.48	0.69	0.5	-16.01	-23.31	-0.32	31.84	37.35	0.46	0.86	0.65
SO4	ALL	56	2.95	2.16	0.93	-26.92	30.58	-0.8	0.9	0.74	-24.29	-33.33	-0.37	33.05	40.43	0.42	1.17	0.87

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 421290008																		
EC	WIN	15	0.67	0.61	0.16	-8.02	48.35	-0.05	0.32	0.2	17.41	-0.15	-0.09	52.8	48.41	0.53	0.45	0.02
EC	SPR	15	0.54	0.34	0.63	-37.14	39.67	-0.2	0.21	0.05	-31.19	-42.61	-0.59	34.52	45.72	0.63	0.3	0.39
EC	SUM	9	0.88	0.38	0.63	-56.79	56.79	-0.5	0.5	0.06	-53.7	-75.52	-1.31	53.7	75.52	1.31	0.56	0.4
EC	FAL	6	0.49	0.41	0.72	-17.08	23.85	-0.08	0.12	0.03	-8.86	-12.14	-0.21	18.7	21.2	0.29	0.19	0.52
EC	ALL	45	0.64	0.45	0.29	-30.46	45.76	-0.2	0.29	0.13	-16.52	-30.97	-0.44	42.34	49.31	0.66	0.41	0.08
NACL	WIN	15	0.11	0.15	0.67	32.44	57.36	0.04	0.06	0	70.91	37.75	0.32	84.57	54.45	0.57	0.08	0.44
NACL	SPR	14	0.04	0.08	0.1	93.05	116.07	0.04	0.05	0	183.04	56.1	0.93	194.15	69.03	1.16	0.07	0.01
NACL	SUM	15	0.04	0.03	0.23	-33.61	41.64	-0.02	0.02	0	-24.32	-35.69	-0.51	35.09	44.74	0.63	0.03	0.05
NACL	FAL	14	0.06	0.07	0.49	4.47	65.53	0	0.04	0	42.38	11	0.04	77.69	55.92	0.66	0.06	0.24
NACL	ALL	58	0.07	0.08	0.59	23.74	65.68	0.02	0.04	0	66.46	16.73	0.24	96.56	55.81	0.66	0.06	0.35
NH4	WIN	15	1.16	1.02	0.92	-11.57	21.51	-0.13	0.25	0.07	-1.32	-9.62	-0.13	30.93	29.12	0.24	0.3	0.84
NH4	SPR	13	1.04	1.04	0.8	-0.51	29.42	-0.01	0.31	0.19	-3.38	-9.43	-0.01	27.67	29.85	0.3	0.43	0.64
NH4	SUM	15	1.5	1.01	0.84	-32.36	38.87	-0.48	0.58	0.41	10.97	-13.91	-0.48	58.94	47.24	0.57	0.8	0.71
NH4	FAL	14	0.72	0.66	0.85	-7.9	38.5	-0.06	0.28	0.1	96.97	14.27	-0.09	127.41	50.13	0.42	0.32	0.73
NH4	ALL	57	1.11	0.93	0.77	-15.99	32.04	-0.18	0.36	0.23	25.58	-4.84	-0.19	61.25	39.21	0.38	0.51	0.6
NO3	WIN	15	1.89	1.98	0.76	4.74	35.37	0.09	0.67	0.77	9.31	-5.5	0.05	42.41	42.46	0.35	0.88	0.58
NO3	SPR	14	0.87	1.03	0.68	18.7	67.41	0.16	0.59	0.78	7.03	-31.55	0.19	77.06	76.11	0.67	0.9	0.46
NO3	SUM	15	0.45	0.17	0.37	-61.69	65.25	-0.28	0.29	0.05	-60.84	-98.47	-1.61	64.94	102.02	1.7	0.36	0.14
NO3	FAL	14	0.77	0.61	0.61	-20.91	51.75	-0.16	0.4	0.19	7.43	-27.1	-0.26	75.73	67.46	0.65	0.47	0.37
NO3	ALL	58	1	0.95	0.8	-4.85	48.61	-0.05	0.49	0.48	-9.84	-41.04	-0.05	64.65	72.02	0.51	0.69	0.64
OC	WIN	15	1.45	2.74	0.64	88.7	93.53	1.29	1.36	0.96	109.65	57.84	0.89	114.07	62.66	0.94	1.62	0.41
OC	SPR	15	1.29	1.34	0.68	3.55	29.13	0.05	0.38	0.31	17.69	8.4	0.04	33.32	26.88	0.29	0.56	0.46
OC	SUM	9	2.7	1.9	0.52	-29.52	39.63	-0.8	1.07	1.49	-17.73	-28.5	-0.42	36.3	43.06	0.56	1.46	0.27
OC	FAL	6	1.11	1.57	0.9	41.62	41.62	0.46	0.46	0.07	65.54	44.15	0.42	65.54	44.15	0.42	0.53	0.81
OC	ALL	45	1.6	1.95	0.41	21.68	53.28	0.35	0.85	1.32	47.64	22.27	0.22	65.13	44.35	0.53	1.2	0.17
PM-2.5	WIN	15	11.21	10.21	0.84	-8.95	19.84	-1	2.22	6.08	-8.77	-12.59	-0.1	21.77	23.46	0.22	2.66	0.7
PM-2.5	SPR	14	8.89	7.27	0.68	-18.29	31.31	-1.63	2.78	10.01	-17.45	-25.06	-0.22	29.24	35.35	0.38	3.56	0.46
PM-2.5	SUM	15	16.45	8.9	0.88	-45.91	46.99	-7.55	7.73	18.82	-39.21	-53.52	-0.85	46.27	59.11	0.87	8.71	0.77
PM-2.5	FAL	14	10.29	6.56	0.66	-36.3	40.12	-3.74	4.13	54.57	-18.64	-26.52	-0.57	27.99	34.95	0.63	8.28	0.43
PM-2.5	ALL	58	11.79	8.28	0.62	-29.76	36	-3.51	4.24	28.75	-21.12	-29.55	-0.42	31.41	38.32	0.51	6.41	0.39
SO4	WIN	15	2.21	1.3	0.9	-41.02	41.1	-0.91	0.91	0.43	-37.63	-48.12	-0.7	37.73	48.22	0.7	1.12	0.8
SO4	SPR	14	2.36	2.06	0.83	-12.96	27.65	-0.31	0.65	0.61	-11.68	-18.44	-0.15	28.95	32.9	0.32	0.84	0.68
SO4	SUM	15	5.06	3.35	0.9	-33.71	35.61	-1.71	1.8	2.34	-22.34	-30.49	-0.51	34.1	40.11	0.54	2.29	0.81
SO4	FAL	14	2.22	1.73	0.93	-21.88	27.25	-0.49	0.61	0.33	-16.56	-22.34	-0.28	27.39	31.81	0.35	0.75	0.86
SO4	ALL	58	2.99	2.12	0.9	-29.02	33.64	-0.87	1	1.24	-22.33	-30.17	-0.41	32.17	38.46	0.47	1.41	0.81

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 421330008																		
EC	WIN	15	0.65	1.02	0.93	56.28	56.28	0.37	0.37	0.02	75.34	50.38	0.56	75.34	50.38	0.56	0.39	0.87
EC	SPR	11	0.42	0.6	0.55	44.63	47.72	0.19	0.2	0.05	43.4	28.67	0.45	47.43	32.84	0.48	0.3	0.3
EC	SUM	15	0.78	0.79	0.61	0.19	26.91	0	0.21	0.07	2.56	-2.73	0	27.57	25.77	0.27	0.27	0.37
EC	FAL	14	0.77	0.8	0.78	4.58	27.43	0.04	0.21	0.08	20.88	12.22	0.05	35.31	29.09	0.27	0.28	0.61
EC	ALL	55	0.67	0.82	0.68	21.84	37.42	0.15	0.25	0.08	35.24	21.84	0.22	46.54	34.74	0.37	0.31	0.47
NACL	WIN	15	0.11	0.21	0.91	90.86	91.29	0.1	0.1	0	153.78	73.76	0.91	154.14	74.13	0.91	0.12	0.83
NACL	SPR	14	0.09	0.19	0.12	109.82	145.89	0.1	0.13	0.02	186.29	67.13	1.1	197.93	83.13	1.46	0.17	0.02
NACL	SUM	16	0.05	0.09	0.57	78.18	85.59	0.04	0.04	0	97.43	49.78	0.78	105.07	59.78	0.86	0.05	0.33
NACL	FAL	15	0.07	0.23	0.71	232.39	242.64	0.16	0.17	0.12	181.04	68.56	2.32	188.61	79.15	2.43	0.38	0.5
NACL	ALL	60	0.08	0.18	0.46	125.27	138.43	0.1	0.11	0.04	153.15	64.52	1.25	159.89	73.66	1.38	0.22	0.22
NH4	WIN	15	1.36	1.31	0.82	-3.19	22.47	-0.04	0.3	0.14	1.31	-2.41	-0.03	23.54	22.87	0.23	0.38	0.67
NH4	SPR	14	1.15	1.05	0.7	-9.02	38.8	-0.1	0.45	0.32	-4.57	-15.42	-0.1	41.52	41.27	0.43	0.57	0.49
NH4	SUM	16	1.25	1.36	0.79	9.25	31.64	0.12	0.39	0.31	21.22	10.51	0.09	38.29	30.9	0.32	0.57	0.62
NH4	FAL	14	0.6	0.93	0.8	55.82	58.14	0.33	0.35	0.09	168.26	60.47	0.56	169.31	61.55	0.58	0.45	0.64
NH4	ALL	59	1.1	1.17	0.77	6.81	33.97	0.07	0.37	0.24	44.93	12.93	0.07	66.39	38.59	0.34	0.5	0.59
NO3	WIN	15	2.62	2.79	0.63	6.55	34.45	0.17	0.9	1.65	19.92	4.73	0.07	44.51	35.48	0.34	1.3	0.4
NO3	SPR	14	1.78	1.63	0.81	-8.44	37.43	-0.15	0.67	0.84	-2.63	-19.07	-0.09	48.5	49.04	0.41	0.93	0.66
NO3	SUM	16	0.69	0.94	0.34	36.26	92.01	0.25	0.64	0.82	37.63	-7.11	0.36	88.86	66.33	0.92	0.94	0.12
NO3	FAL	15	1.06	1.45	0.55	36.86	61.75	0.39	0.65	0.51	70.35	31.87	0.37	88.53	56	0.62	0.82	0.3
NO3	ALL	60	1.52	1.69	0.74	11.33	47.01	0.17	0.71	0.99	31.99	2.81	0.11	68.28	52	0.47	1.01	0.54
OC	WIN	15	1.6	5.39	0.78	236.87	236.87	3.79	3.79	2.33	277.66	110.16	2.37	277.66	110.16	2.37	4.08	0.61
OC	SPR	11	0.92	2.41	0.64	161.3	166.6	1.49	1.53	1.33	158.1	76.18	1.61	163.08	81.96	1.67	1.88	0.41
OC	SUM	15	2.54	2.91	0.45	14.56	35.67	0.37	0.91	1.99	23.17	13.19	0.15	33.37	26.63	0.36	1.46	0.2
OC	FAL	14	1.4	2.59	0.8	85.33	85.33	1.19	1.19	0.68	110.51	63.54	0.85	110.51	63.54	0.85	1.45	0.64
OC	ALL	55	1.67	3.4	0.41	103.97	113.32	1.73	1.89	3.36	141.79	65.05	1.04	145.57	69.87	1.13	2.52	0.17
PM-2.5	WIN	15	11.58	15.87	0.83	37.08	37.67	4.29	4.36	10.52	46.81	33.73	0.37	47.38	34.3	0.38	5.38	0.7
PM-2.5	SPR	14	8.66	9.63	0.68	11.28	29.27	0.98	2.53	13.43	9.19	0.88	0.11	31.39	29.61	0.29	3.79	0.47
PM-2.5	SUM	16	14.71	12.15	0.77	-17.4	27.53	-2.56	4.05	16.06	-17.45	-22.37	-0.21	26.97	30.87	0.33	4.76	0.59
PM-2.5	FAL	15	7.54	9.89	0.82	31.14	38.45	2.35	2.9	6	50.1	34.93	0.31	53.62	38.71	0.38	3.39	0.67
PM-2.5	ALL	60	10.72	11.93	0.71	11.24	32.52	1.21	3.49	18.05	21.72	11.4	0.11	39.76	33.4	0.33	4.42	0.51
SO4	WIN	15	2.11	1.52	0.67	-28.19	34.93	-0.6	0.74	0.4	-26.2	-34.01	-0.39	32.61	39.72	0.49	0.87	0.45
SO4	SPR	14	2.07	1.74	0.72	-16.1	30.27	-0.33	0.63	0.55	-15.29	-22.51	-0.19	28.76	33.81	0.36	0.81	0.51
SO4	SUM	16	3.68	3.11	0.86	-15.51	27.42	-0.57	1.01	1.15	-9.78	-15.55	-0.18	29.23	31.13	0.32	1.22	0.73
SO4	FAL	15	1.54	1.48	0.77	-4.22	31.32	-0.07	0.48	0.56	12.19	-0.62	-0.04	38.79	33.64	0.33	0.75	0.6
SO4	ALL	60	2.38	1.98	0.85	-16.61	30.3	-0.4	0.72	0.72	-9.68	-18.06	-0.2	32.35	34.53	0.36	0.94	0.71

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 440071010																		
EC	WIN	23	0.63	1.28	0.83	102.92	102.92	0.65	0.65	0.1	137.12	74.01	1.03	137.12	74.01	1.03	0.72	0.69
EC	SPR	24	0.29	0.69	0.53	137.01	137.01	0.4	0.4	0.05	197.38	85.21	1.37	197.38	85.21	1.37	0.45	0.29
EC	SUM	24	0.47	0.59	0.64	25.13	41.03	0.12	0.19	0.04	58.39	32.04	0.25	68.49	43.67	0.41	0.23	0.41
EC	FAL	23	0.55	0.86	0.74	55.39	61.97	0.31	0.34	0.08	102.91	51.4	0.55	106.34	55.17	0.62	0.41	0.55
EC	ALL	94	0.49	0.85	0.72	75.48	81.28	0.37	0.39	0.1	124.03	60.62	0.75	127.45	64.51	0.81	0.49	0.51
NACL	WIN	28	0.15	0.15	0.02	3.21	89.66	0	0.13	0.05	81.7	22.29	0.03	111.46	66.02	0.9	0.23	0
NACL	SPR	29	0.18	0.3	0.84	71.41	87.3	0.13	0.16	0.06	216.79	54.25	0.71	227.55	68.59	0.87	0.28	0.71
NACL	SUM	29	0.11	0.16	0.31	49.86	95.19	0.05	0.1	0.03	124.96	25.57	0.5	156.39	71.62	0.95	0.19	0.09
NACL	FAL	30	0.15	0.2	0.72	31.53	75.59	0.05	0.12	0.03	102.76	32	0.32	128.69	64.39	0.76	0.19	0.52
NACL	ALL	116	0.15	0.21	0.66	40.05	86.16	0.06	0.13	0.05	131.73	33.61	0.4	156.17	67.64	0.86	0.23	0.44
NH4	WIN	28	0.85	1.13	0.74	33.55	50.13	0.28	0.43	0.25	89.99	44.63	0.34	96.73	52.55	0.5	0.58	0.54
NH4	SPR	30	0.53	0.77	0.76	46.26	54.25	0.24	0.29	0.09	128	48.24	0.46	131.49	52.25	0.54	0.38	0.57
NH4	SUM	29	0.42	0.52	0.74	24.27	51.72	0.1	0.22	0.09	154.62	37.88	0.24	171.29	58.74	0.52	0.31	0.55
NH4	FAL	29	0.4	0.66	0.74	66.57	75.47	0.27	0.3	0.08	259.99	73.78	0.67	263.36	77.71	0.75	0.39	0.55
NH4	ALL	116	0.55	0.77	0.77	40.98	56.09	0.22	0.31	0.13	158.48	51.16	0.41	166.02	60.31	0.56	0.42	0.59
NO3	WIN	28	1.42	2.39	0.78	68.29	73.49	0.97	1.04	0.96	109.12	53.93	0.68	114.3	60.45	0.73	1.38	0.6
NO3	SPR	30	0.59	0.87	0.48	48.51	81.11	0.28	0.47	0.5	58.37	20.45	0.49	86.25	59.37	0.81	0.76	0.23
NO3	SUM	30	0.34	0.15	0.24	-56	73.49	-0.19	0.25	0.05	-45.57	-95.69	-1.27	80.81	107.54	1.67	0.3	0.06
NO3	FAL	30	0.53	0.82	0.82	56.14	77.7	0.3	0.41	0.31	36.93	13.16	0.56	66.01	53.35	0.78	0.63	0.67
NO3	ALL	118	0.71	1.03	0.8	46.44	75.89	0.33	0.54	0.62	38.54	-2.99	0.46	86.38	70.34	0.76	0.85	0.64
OC	WIN	23	1.63	6.01	0.74	269.28	269.28	4.38	4.38	4.37	348.14	116.8	2.69	348.14	116.8	2.69	4.86	0.55
OC	SPR	24	0.9	2.58	0.48	188.72	188.9	1.69	1.69	1.21	374.61	100.21	1.89	374.69	100.29	1.89	2.02	0.23
OC	SUM	24	1.64	1.79	0.85	9.14	22.27	0.15	0.37	0.26	24.24	14.68	0.09	33.54	25.33	0.22	0.53	0.72
OC	FAL	23	1.35	2.53	0.83	87.7	88.13	1.18	1.19	0.83	118.51	64.4	0.88	118.97	64.86	0.88	1.49	0.69
OC	ALL	94	1.38	3.21	0.53	133.06	137.2	1.83	1.89	4.07	216.01	73.67	1.33	218.52	76.52	1.37	2.73	0.29
PM-2.5	WIN	29	10.08	16.56	0.86	64.28	64.28	6.48	6.48	12.99	78.27	52.43	0.64	78.27	52.43	0.64	7.41	0.75
PM-2.5	SPR	30	6.63	9.01	0.6	35.98	47.21	2.38	3.13	9.56	47.64	32.21	0.36	53.62	39.11	0.47	3.9	0.36
PM-2.5	SUM	29	9.66	6.58	0.74	-31.84	35.89	-3.07	3.47	8.92	-23.95	-33.59	-0.47	36.19	43.06	0.53	4.29	0.55
PM-2.5	FAL	30	7.92	8.54	0.69	7.89	34.66	0.62	2.75	11.8	29.39	14.48	0.08	47.38	36.53	0.35	3.49	0.47
PM-2.5	ALL	118	8.55	10.15	0.63	18.74	46.06	1.6	3.94	22.43	32.94	16.5	0.19	53.81	42.7	0.46	5	0.4
SO4	WIN	28	1.79	1.37	0.57	-23.38	33.51	-0.42	0.6	0.69	-14.53	-21.57	-0.31	27.45	31.69	0.44	0.93	0.33
SO4	SPR	30	1.61	1.91	0.81	18.5	32.15	0.3	0.52	0.48	22.25	14.84	0.18	34.09	28.16	0.32	0.75	0.66
SO4	SUM	30	1.76	1.8	0.76	2.56	37.28	0.05	0.66	0.81	19.41	1.88	0.03	49.51	39.77	0.37	0.9	0.57
SO4	FAL	30	1.57	1.53	0.87	-2.87	21.72	-0.05	0.34	0.27	10.93	2.76	-0.03	30.57	25.11	0.22	0.52	0.76
SO4	ALL	118	1.68	1.66	0.72	-1.39	31.38	-0.02	0.53	0.63	9.92	-0.16	-0.01	35.54	31.18	0.32	0.79	0.52

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 450250001																		
EC	WIN	15	0.37	0.37	0.5	1.57	35.73	0.01	0.13	0.03	7.4	0.65	0.02	31.85	31.39	0.36	0.18	0.25
EC	SPR	15	0.39	0.31	0.86	-21.2	28.8	-0.08	0.11	0.01	-26.11	-33.55	-0.27	31.6	38.11	0.37	0.13	0.74
EC	SUM	16	0.49	0.22	0.78	-55.38	55.85	-0.27	0.27	0.02	-49.66	-70.13	-1.24	52.15	72.39	1.25	0.3	0.61
EC	FAL	15	0.39	0.23	0.77	-40.57	43.07	-0.16	0.17	0.04	-30.37	-40.61	-0.68	34.92	44.82	0.72	0.25	0.6
EC	ALL	61	0.41	0.28	0.48	-31.43	42.12	-0.13	0.17	0.03	-25.1	-36.47	-0.46	37.87	47.1	0.61	0.23	0.23
NACL	WIN	14	0.13	0.14	0.13	9.05	120.37	0.01	0.15	0.11	231.73	36.82	0.09	252.63	71.13	1.2	0.33	0.02
NACL	SPR	15	0.14	0.22	0.57	61.72	96.77	0.08	0.13	0.03	183.71	52.14	0.62	196.1	66.99	0.97	0.19	0.32
NACL	SUM	16	0.07	0.08	0.72	10.53	57.78	0.01	0.04	0	3.2	-14.51	0.11	52.91	52.76	0.58	0.06	0.52
NACL	FAL	14	0.06	0.08	0.38	23.97	74.38	0.02	0.05	0.01	55.37	22.38	0.24	75.85	49.75	0.74	0.07	0.15
NACL	ALL	59	0.1	0.13	0.35	29.76	92.63	0.03	0.09	0.04	115.7	23.37	0.3	142.15	60.02	0.93	0.19	0.12
NH4	WIN	14	0.61	0.66	0.85	8.03	29.96	0.05	0.18	0.05	48.05	22.59	0.08	61.86	39.68	0.3	0.23	0.71
NH4	SPR	14	0.78	0.84	0.68	8.14	51.87	0.06	0.4	0.24	36.66	3.39	0.08	77.84	66.47	0.52	0.49	0.46
NH4	SUM	16	0.75	0.76	0.68	1.95	27.91	0.01	0.21	0.11	12.35	4.41	0.02	30.25	26.65	0.28	0.33	0.46
NH4	FAL	14	0.29	0.52	0.74	80.25	86.35	0.23	0.25	0.03	218.8	70.71	0.8	220.93	73.02	0.86	0.3	0.54
NH4	ALL	58	0.61	0.7	0.73	14.21	42.39	0.09	0.26	0.11	76.67	24.56	0.14	95.4	50.6	0.42	0.35	0.53
NO3	WIN	15	0.59	0.81	0.44	37.55	78.8	0.22	0.46	0.41	208.1	16.36	0.38	245.21	70.25	0.79	0.68	0.19
NO3	SPR	15	0.58	0.62	0.8	6.6	53.64	0.04	0.31	0.21	42.71	-2.77	0.07	87.53	60.77	0.54	0.46	0.65
NO3	SUM	16	0.19	0.1	0.49	-46.54	49.74	-0.09	0.09	0	-46.09	-68.04	-0.87	48.54	70.27	0.93	0.11	0.24
NO3	FAL	14	0.23	0.34	0.35	49.42	85.72	0.11	0.2	0.07	62.58	12.24	0.49	97.44	65.1	0.86	0.28	0.12
NO3	ALL	60	0.4	0.46	0.7	17.08	66.81	0.07	0.26	0.18	65.01	-11.89	0.17	118.87	66.68	0.67	0.43	0.49
OC	WIN	15	1.26	1.76	0.51	39.69	60.87	0.5	0.77	0.79	45.63	27.74	0.4	58.49	43.51	0.61	1.02	0.26
OC	SPR	15	1.73	2	0.82	15.73	36.17	0.27	0.63	0.7	7.62	-1.25	0.16	34.11	31.84	0.36	0.88	0.67
OC	SUM	16	2.8	3.31	0.39	18.32	50.9	0.51	1.42	3.46	25.12	8.78	0.18	49.4	41.86	0.51	1.93	0.15
OC	FAL	15	1.43	1.45	0.68	0.96	42.88	0.01	0.61	0.76	9.83	-0.54	0.01	43.2	41.74	0.43	0.87	0.46
OC	ALL	61	1.82	2.15	0.62	17.99	47.6	0.33	0.87	1.5	22.1	8.68	0.18	46.35	39.77	0.48	1.27	0.38
PM-2.5	WIN	15	6.84	6.66	0.69	-2.68	26.43	-0.18	1.81	5.53	22.63	1.22	-0.03	47.63	32.34	0.27	2.36	0.47
PM-2.5	SPR	15	10.57	7.9	0.79	-25.22	32.83	-2.67	3.47	7.78	-28.18	-37.79	-0.34	34.51	43.42	0.44	3.86	0.63
PM-2.5	SUM	16	14.97	8.74	0.67	-41.63	44.17	-6.23	6.61	19.53	-40.83	-55.88	-0.71	44	58.69	0.76	7.64	0.45
PM-2.5	FAL	15	7.13	5.34	0.86	-25.12	25.64	-1.79	1.83	4.79	-22.16	-27.63	-0.34	23.08	28.54	0.34	2.83	0.75
PM-2.5	ALL	61	9.96	7.19	0.71	-27.87	34.96	-2.78	3.48	14.6	-17.52	-30.45	-0.39	37.41	41.04	0.48	4.72	0.51
SO4	WIN	15	1.54	1.33	0.89	-13.91	29.62	-0.21	0.46	0.32	211.44	2.46	-0.16	241.39	38.16	0.34	0.61	0.8
SO4	SPR	15	2.38	2.27	0.56	-4.43	31.14	-0.11	0.74	1.34	380.9	-1.9	-0.05	409.81	38.81	0.33	1.16	0.31
SO4	SUM	16	3.33	2.15	0.63	-35.62	39.86	-1.19	1.33	1.55	-32.83	-44.96	-0.55	38.2	49.38	0.62	1.72	0.39
SO4	FAL	14	1.52	1.3	0.75	-14.61	25.62	-0.22	0.39	0.26	-9.31	-15.91	-0.17	24.39	29.63	0.3	0.55	0.57
SO4	ALL	60	2.22	1.77	0.68	-20.17	33.48	-0.45	0.74	1.09	137.16	-15.56	-0.25	178.68	39.33	0.42	1.14	0.46

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 450790007																		
EC	WIN	23	0.77	0.91	0.76	18.08	39.58	0.14	0.31	0.13	41.36	26.48	0.18	52.72	39.73	0.4	0.39	0.57
EC	SPR	24	0.48	0.55	0.63	15.17	31.16	0.07	0.15	0.04	23.46	15.04	0.15	36.05	29.32	0.31	0.21	0.39
EC	SUM	29	0.55	0.62	0.73	13.2	24.77	0.07	0.14	0.02	13.84	9.12	0.13	26.3	24.16	0.25	0.16	0.54
EC	FAL	30	0.6	0.69	0.72	15.69	28.77	0.09	0.17	0.05	26.49	16.51	0.16	35.28	26.57	0.29	0.24	0.52
EC	ALL	106	0.6	0.69	0.75	15.64	31.24	0.09	0.19	0.06	25.57	16.32	0.16	36.78	29.39	0.31	0.26	0.56
NACL	WIN	28	0.07	0.15	0.74	123.68	144.61	0.08	0.1	0.04	126.97	53.65	1.24	139.43	68.24	1.45	0.21	0.54
NACL	SPR	29	0.13	0.19	0.7	42.46	65.4	0.06	0.09	0.02	104.38	31.32	0.42	124.1	56.83	0.65	0.15	0.49
NACL	SUM	29	0.09	0.11	0.65	22.62	77.15	0.02	0.07	0.02	-0.53	-26.55	0.23	60.71	60.2	0.77	0.15	0.43
NACL	FAL	29	0.09	0.14	0.54	44.58	87.72	0.04	0.08	0.02	43.82	7.7	0.45	79.72	55.87	0.88	0.15	0.29
NACL	ALL	115	0.1	0.15	0.61	52.16	87.23	0.05	0.08	0.03	68.15	16.2	0.52	100.66	60.22	0.87	0.17	0.38
NH4	WIN	28	0.77	0.86	0.73	12.25	51.41	0.09	0.4	0.27	138.77	34.36	0.12	156.6	56.15	0.51	0.53	0.54
NH4	SPR	29	0.78	0.69	0.4	-11.69	45.08	-0.09	0.35	0.19	10.62	-10.83	-0.13	55.64	55.55	0.51	0.45	0.16
NH4	SUM	29	0.75	0.73	0.67	-1.83	33.54	-0.01	0.25	0.1	6.92	-6.27	-0.02	40.78	40.89	0.34	0.32	0.45
NH4	FAL	29	0.36	0.66	0.75	83.54	83.73	0.3	0.3	0.06	145.58	63.08	0.84	145.79	63.29	0.84	0.38	0.56
NH4	ALL	115	0.66	0.73	0.63	10.9	48.86	0.07	0.32	0.18	74.92	19.96	0.11	99.21	53.95	0.49	0.43	0.4
NO3	WIN	28	0.96	1.25	0.78	30.24	59.15	0.29	0.57	0.68	53.01	13.43	0.3	81.57	55.86	0.59	0.87	0.6
NO3	SPR	29	0.48	0.3	0.25	-37.69	66.99	-0.18	0.32	0.22	-24.86	-56.42	-0.6	65	79.62	1.08	0.5	0.06
NO3	SUM	29	0.22	0.12	0.07	-42.73	65.67	-0.09	0.14	0.03	-36.69	-70.2	-0.75	64.2	85.28	1.15	0.19	0
NO3	FAL	29	0.3	0.48	0.68	58.97	95.01	0.18	0.29	0.17	39.59	-2.94	0.59	87.58	68.32	0.95	0.45	0.46
NO3	ALL	115	0.49	0.53	0.74	9.73	67.49	0.05	0.33	0.31	7.37	-29.4	0.1	74.53	72.41	0.67	0.55	0.55
OC	WIN	23	2.24	3.11	0.84	38.99	45.06	0.87	1.01	1.44	49.82	33.92	0.39	54.44	39.07	0.45	1.48	0.7
OC	SPR	24	2.08	2.36	0.87	13.49	32.14	0.28	0.67	0.62	19.06	11.51	0.13	35.44	32.3	0.32	0.83	0.75
OC	SUM	30	2.86	4.09	0.31	43.13	67.15	1.23	1.92	4.87	59.43	31.98	0.43	73.74	49.98	0.67	2.53	0.09
OC	FAL	30	2	2.55	0.63	27.55	46.82	0.55	0.94	1.31	35.43	20.8	0.28	49.85	38.41	0.47	1.27	0.4
OC	ALL	107	2.31	3.06	0.63	32.5	50.54	0.75	1.17	2.31	41.58	24.67	0.32	54.3	40.43	0.51	1.69	0.4
PM-2.5	WIN	28	10.02	10.7	0.86	6.8	26.06	0.68	2.61	9.81	7.04	2.86	0.07	25.45	24.5	0.26	3.21	0.73
PM-2.5	SPR	30	13.58	8.92	0.45	-34.28	38.78	-4.66	5.27	41.93	-27.11	-37.65	-0.52	32.03	42.07	0.59	7.97	0.21
PM-2.5	SUM	29	15.58	10.5	0.29	-32.58	38.97	-5.08	6.07	39.81	-28.18	-40.14	-0.48	36.89	47.76	0.58	8.1	0.09
PM-2.5	FAL	29	9.72	8.69	0.78	-10.65	23.5	-1.04	2.29	7.91	-8.38	-13.38	-0.12	25.17	26.75	0.26	3	0.62
PM-2.5	ALL	116	12.26	9.69	0.51	-20.95	33.3	-2.57	4.08	30.97	-14.45	-22.43	-0.27	29.94	35.42	0.42	6.13	0.26
SO4	WIN	28	1.77	1.62	0.62	-8.47	34.68	-0.15	0.61	0.73	8.64	-1.6	-0.09	37.97	33.57	0.38	0.87	0.39
SO4	SPR	29	2.8	2.05	0.3	-26.88	40.01	-0.75	1.12	2.3	-12.19	-22.69	-0.37	33.35	40.8	0.55	1.69	0.09
SO4	SUM	29	3.43	2.15	0.63	-37.1	39.5	-1.27	1.35	1.24	-35.31	-47.64	-0.59	38.45	50.27	0.63	1.69	0.4
SO4	FAL	29	1.79	1.7	0.81	-4.97	23.96	-0.09	0.43	0.33	-1.73	-7.35	-0.05	25.39	26.25	0.25	0.58	0.65
SO4	ALL	115	2.45	1.88	0.59	-23.22	35.94	-0.57	0.88	1.39	-10.31	-19.98	-0.3	33.75	37.76	0.47	1.31	0.34

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 470370023																		
EC	WIN	13	0.61	1.09	0.74	78.28	79.4	0.48	0.49	0.13	93.35	57.02	0.78	93.94	57.62	0.79	0.6	0.55
EC	SPR	15	0.55	0.78	0.74	41.98	45.32	0.23	0.25	0.04	56.14	38.95	0.42	57.84	40.75	0.45	0.31	0.54
EC	SUM	14	0.89	0.95	0.53	6.35	17.06	0.06	0.15	0.04	9.19	6.28	0.06	18.24	16.32	0.17	0.21	0.28
EC	FAL	15	0.9	1.14	0.76	27.62	39.54	0.25	0.35	0.13	54.83	33.25	0.28	62.5	42.09	0.4	0.44	0.58
EC	ALL	57	0.74	0.99	0.69	33.72	41.55	0.25	0.31	0.11	52.75	33.55	0.34	57.57	38.95	0.42	0.41	0.47
NACL	WIN	12	0.05	0.08	0.43	52.18	64.22	0.03	0.03	0	87.22	46.96	0.52	92.61	53.39	0.64	0.04	0.18
NACL	SPR	15	0.11	0.12	0.72	10.63	67.93	0.01	0.07	0.01	32.8	-2.38	0.11	79.3	63.26	0.68	0.11	0.52
NACL	SUM	16	0.08	0.05	0.66	-38.86	45.31	-0.03	0.04	0	-33.52	-49.61	-0.64	45.11	59.06	0.74	0.05	0.44
NACL	FAL	14	0.05	0.05	0.6	0.54	29.81	0	0.01	0	4.65	-2.06	0.01	30.08	29.96	0.3	0.02	0.36
NACL	ALL	57	0.07	0.07	0.69	0.49	54.56	0	0.04	0	18.73	-5.17	0	60.41	51.82	0.55	0.07	0.48
NH4	WIN	12	1.28	1.06	0.61	-17.26	28.53	-0.22	0.36	0.16	-6.88	-15.27	-0.21	32.07	31.46	0.34	0.46	0.37
NH4	SPR	15	0.93	0.84	0.76	-10.32	34.41	-0.1	0.32	0.17	0.7	-8.48	-0.12	35.44	36.57	0.38	0.42	0.57
NH4	SUM	16	1.07	1.01	0.8	-5.85	28.67	-0.06	0.31	0.16	25.04	4.07	-0.06	51.67	37.16	0.3	0.4	0.64
NH4	FAL	15	0.62	0.78	0.75	26.09	40.08	0.16	0.25	0.09	48.46	27.59	0.26	56.27	36.41	0.4	0.34	0.57
NH4	ALL	58	0.96	0.92	0.75	-4.77	31.98	-0.05	0.31	0.16	18.2	2.91	-0.05	44.61	35.63	0.34	0.4	0.56
NO3	WIN	12	2.03	1.65	0.76	-18.87	33.61	-0.38	0.68	0.8	4.81	-8.55	-0.23	43.19	40.43	0.41	0.97	0.57
NO3	SPR	15	0.65	0.82	0.56	27.61	94.52	0.18	0.61	1.71	2.92	-38.33	0.28	74.03	72.97	0.95	1.32	0.32
NO3	SUM	16	0.37	0.14	0.44	-61.5	65	-0.23	0.24	0.03	-63.14	-100.76	-1.6	65.35	102.79	1.69	0.28	0.19
NO3	FAL	15	0.74	0.72	0.69	-2.87	45.68	-0.02	0.34	0.2	-7.11	-28.83	-0.03	52.94	62.47	0.47	0.45	0.48
NO3	ALL	58	0.88	0.78	0.63	-11.52	51.45	-0.1	0.45	0.71	-17.51	-46.93	-0.13	59.8	71.75	0.58	0.85	0.4
OC	WIN	13	1.92	4.29	0.75	122.79	122.79	2.36	2.36	2.42	140.74	74.61	1.23	140.74	74.61	1.23	2.83	0.56
OC	SPR	15	1.82	2.16	0.74	18.91	41.73	0.34	0.76	0.67	46.3	24.1	0.19	62.99	44.82	0.42	0.89	0.54
OC	SUM	14	2.23	3.42	0.32	53.72	60.1	1.2	1.34	0.83	65.97	44.32	0.54	69.01	47.72	0.6	1.5	0.1
OC	FAL	15	2.09	2.82	0.87	35.16	39.98	0.73	0.83	0.51	56.89	33.49	0.35	64.06	42.73	0.4	1.02	0.75
OC	ALL	57	2.01	3.13	0.62	55.44	63.91	1.12	1.29	1.62	75.45	43.06	0.55	82.48	51.78	0.64	1.69	0.38
PM-2.5	WIN	13	9.81	12.57	0.55	28.13	33.77	2.76	3.31	13.88	30.32	20.74	0.28	36.42	27.71	0.34	4.64	0.3
PM-2.5	SPR	15	11.01	8.8	0.64	-20.08	31.18	-2.21	3.43	13.61	-17.54	-24.32	-0.25	29.6	34.44	0.39	4.3	0.41
PM-2.5	SUM	16	16.74	11.69	0.73	-30.14	32.78	-5.04	5.49	16.61	-24.96	-31.74	-0.43	30.22	36.5	0.47	6.49	0.53
PM-2.5	FAL	14	9.16	10.14	0.86	10.7	25.52	0.98	2.34	6.03	16.83	10.3	0.11	32.39	28.39	0.26	2.64	0.74
PM-2.5	ALL	58	11.87	10.76	0.58	-9.34	31.23	-1.11	3.71	21.66	-0.56	-7.91	-0.1	31.97	32.04	0.34	4.78	0.33
SO4	WIN	12	2.39	1.74	0.68	-27.46	32.01	-0.66	0.77	0.3	-26.19	-33.85	-0.38	31.67	38.65	0.44	0.86	0.46
SO4	SPR	15	2.78	1.94	0.86	-30.36	31.21	-0.84	0.87	0.45	-27.81	-34.56	-0.44	29.24	35.92	0.45	1.08	0.74
SO4	SUM	16	3.92	2.98	0.83	-23.93	30.78	-0.94	1.21	1.5	-18.01	-25.76	-0.31	30.69	36.26	0.4	1.54	0.68
SO4	FAL	15	2	1.79	0.65	-10.23	40.1	-0.2	0.8	0.86	-0.54	-12.81	-0.11	44.95	46.9	0.45	0.95	0.42
SO4	ALL	58	2.81	2.15	0.81	-23.68	32.82	-0.67	0.92	0.9	-17.72	-26.36	-0.31	34.2	39.42	0.43	1.16	0.66

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 470654002																		
EC	WIN	15	0.57	0.78	0.8	35.44	44.68	0.2	0.26	0.07	74.32	44.31	0.35	78.11	48.42	0.45	0.33	0.64
EC	SPR	13	0.66	0.64	0.68	-3.47	33.89	-0.02	0.22	0.09	19	8.35	-0.04	39.71	33.75	0.35	0.31	0.46
EC	SUM	16	0.91	0.65	0.29	-28.01	36.78	-0.25	0.33	0.1	-20.71	-29.52	-0.39	35.33	41.57	0.51	0.41	0.08
EC	FAL	15	0.68	0.69	0.85	1.11	27.51	0.01	0.19	0.05	14.12	7.59	0.01	33.38	29.6	0.28	0.22	0.73
EC	ALL	59	0.71	0.69	0.64	-2.85	35.55	-0.02	0.25	0.11	21.05	7.03	-0.03	46.68	38.54	0.37	0.33	0.41
NACL	WIN	8	0.06	0.18	0.99	184.87	187.87	0.11	0.12	0.05	130.39	57.66	1.85	137.62	66.1	1.88	0.24	0.97
NACL	SPR	14	0.1	0.15	0.56	51.78	94.5	0.05	0.09	0.02	67.77	29.48	0.52	93.18	64.47	0.95	0.14	0.31
NACL	SUM	15	0.06	0.05	0.67	-17.12	37.23	-0.01	0.02	0	-8.98	-19.81	-0.21	37.06	42.8	0.45	0.03	0.44
NACL	FAL	15	0.04	0.04	0.44	-5.53	48.79	0	0.02	0	-5.48	-20.61	-0.06	42.47	44.79	0.52	0.03	0.2
NACL	ALL	52	0.06	0.09	0.68	43.27	85.22	0.03	0.05	0.01	34.13	5.15	0.43	69.2	52.79	0.85	0.12	0.46
NH4	WIN	8	0.76	0.83	0.28	9.51	36	0.07	0.27	0.14	36.49	12.15	0.1	56	36.03	0.36	0.38	0.08
NH4	SPR	15	0.95	0.84	0.28	-11.76	48.04	-0.11	0.46	0.51	4.62	-10.95	-0.13	45.68	49.7	0.54	0.72	0.08
NH4	SUM	15	1.09	0.88	0.38	-19.5	36.13	-0.21	0.39	0.22	0.06	-13.58	-0.24	43.38	41.33	0.45	0.52	0.14
NH4	FAL	14	0.52	0.65	0.71	24.12	49.15	0.13	0.26	0.11	66.61	38.4	0.24	73.59	47.62	0.49	0.35	0.51
NH4	ALL	52	0.85	0.8	0.44	-5.75	42.15	-0.05	0.36	0.28	24.9	5.13	-0.06	54.12	44.62	0.45	0.53	0.19
NO3	WIN	8	0.83	1.15	0.28	39.12	74.76	0.32	0.62	0.77	59.25	19.19	0.39	87.44	53.42	0.75	0.94	0.08
NO3	SPR	15	0.53	0.63	0.02	20.36	96.55	0.11	0.51	1.04	42.03	-42.17	0.2	121.03	77.65	0.97	1.03	0
NO3	SUM	15	0.29	0.1	0.54	-65.58	65.58	-0.19	0.19	0.01	-65.82	-101.54	-1.91	65.82	101.54	1.91	0.21	0.29
NO3	FAL	15	0.5	0.37	0.37	-26.4	68.91	-0.13	0.35	0.16	-19.71	-57.96	-0.36	72.35	91.77	0.94	0.42	0.14
NO3	ALL	53	0.5	0.49	0.36	-2.28	78.12	-0.01	0.39	0.49	-3.37	-54.18	-0.02	86.56	84.75	0.8	0.7	0.13
OC	WIN	15	1.53	2.63	0.68	71.87	71.87	1.1	1.1	1.11	124.27	63.87	0.72	124.27	63.87	0.72	1.52	0.46
OC	SPR	13	2.33	2.22	0.71	-4.66	41.87	-0.11	0.97	1.3	43.94	9.9	-0.05	77.41	50.59	0.44	1.15	0.5
OC	SUM	16	3.16	3.55	0.62	12.19	31.3	0.39	0.99	1.56	22.98	16.15	0.12	33.32	28.25	0.31	1.31	0.39
OC	FAL	15	2.05	2.17	0.84	5.55	35.06	0.11	0.72	0.83	93.25	18.21	0.06	116.53	45.72	0.35	0.92	0.7
OC	ALL	59	2.28	2.67	0.7	17.08	41.46	0.39	0.95	1.41	71.21	27.43	0.17	87.31	46.67	0.41	1.25	0.49
PM-2.5	WIN	8	10.7	10.41	0.71	-2.68	21.25	-0.29	2.27	7.32	-1.32	-4.06	-0.03	20.68	20.26	0.22	2.72	0.5
PM-2.5	SPR	15	12.03	8.91	0.54	-26	38.11	-3.13	4.59	22.62	-17.2	-27.76	-0.35	37.69	42.69	0.51	5.69	0.29
PM-2.5	SUM	15	17.25	10.62	0.66	-38.45	39.79	-6.63	6.86	19.66	-33.23	-42.99	-0.62	36.78	46.12	0.65	7.98	0.43
PM-2.5	FAL	15	7.71	7.32	0.81	-5.03	30.82	-0.39	2.38	11.16	17.34	4.72	-0.05	41.97	35.19	0.32	3.36	0.66
PM-2.5	ALL	53	12.08	9.17	0.67	-24.13	35.22	-2.92	4.26	23	-9.57	-19.3	-0.32	36.07	38.15	0.46	5.61	0.46
SO4	WIN	8	2.03	1.63	0.76	-19.59	24.17	-0.4	0.49	0.22	-14.31	-19.84	-0.24	25.46	29.22	0.3	0.62	0.58
SO4	SPR	15	2.96	2.29	0.59	-22.52	33.8	-0.67	1	2.23	-11.99	-19.46	-0.29	29.01	33.52	0.44	1.64	0.35
SO4	SUM	15	4.05	2.71	0.59	-33.08	38.8	-1.34	1.57	1.69	-26.52	-36.87	-0.49	36.74	46.01	0.58	1.87	0.34
SO4	FAL	15	1.68	1.47	0.78	-12.71	24.54	-0.21	0.41	0.64	-5.47	-9.04	-0.15	19.39	21.61	0.28	0.83	0.61
SO4	ALL	53	2.77	2.08	0.73	-24.89	33.22	-0.69	0.92	1.52	-14.61	-21.49	-0.33	27.94	33.04	0.44	1.41	0.54

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 470931020																		
EC	WIN	15	0.57	0.79	0.85	38.45	47.71	0.22	0.27	0.05	77.21	45.37	0.38	81.39	49.93	0.48	0.31	0.72
EC	SPR	12	0.66	0.77	0.9	16.89	33.04	0.11	0.22	0.05	49.95	31.61	0.17	58.03	40.32	0.33	0.24	0.81
EC	SUM	14	0.89	0.84	0.61	-6.18	21.17	-0.06	0.19	0.07	4.33	-4.94	-0.07	28.65	22.95	0.23	0.27	0.37
EC	FAL	13	0.61	0.79	0.84	29.72	42.1	0.18	0.26	0.06	74.7	42.32	0.3	81.16	49.81	0.42	0.3	0.71
EC	ALL	54	0.68	0.8	0.8	16.85	34.38	0.12	0.23	0.07	51.65	28.53	0.17	62.47	40.77	0.34	0.29	0.64
NACL	WIN	15	0.07	0.12	0.45	73.39	136.12	0.05	0.09	0.03	266.34	62.67	0.73	278.35	83.65	1.36	0.19	0.2
NACL	SPR	6	0.06	0.1	0.79	54.07	96.53	0.03	0.06	0	40.79	6.1	0.54	85.54	70.42	0.97	0.07	0.62
NACL	SUM	14	0.05	0.06	0.92	20.64	29.48	0.01	0.01	0	21.57	14.12	0.21	32.2	26.35	0.29	0.02	0.84
NACL	FAL	14	0.03	0.05	0.38	59.64	83.37	0.02	0.03	0	97.24	43.27	0.6	112.94	62.72	0.83	0.04	0.14
NACL	ALL	49	0.05	0.08	0.5	53.92	92.25	0.03	0.05	0.01	120.47	36.33	0.54	137.15	59.68	0.92	0.11	0.25
NH4	WIN	15	0.69	0.77	0.82	10.6	29.88	0.07	0.21	0.06	41.86	19.32	0.11	55.45	34.41	0.3	0.26	0.67
NH4	SPR	7	0.65	0.91	0.48	38.7	63.43	0.25	0.41	0.17	66.83	30.94	0.39	86.63	55.68	0.63	0.48	0.23
NH4	SUM	15	1.08	1.02	0.6	-4.77	22.87	-0.05	0.25	0.09	3.56	-1.12	-0.05	25.44	23.88	0.24	0.31	0.36
NH4	FAL	14	0.37	0.67	0.87	80.96	82.69	0.3	0.31	0.05	114.6	62.51	0.81	116.64	64.7	0.83	0.37	0.75
NH4	ALL	51	0.71	0.84	0.71	17.37	38.54	0.12	0.27	0.1	53.99	26.76	0.17	67.7	42.55	0.39	0.34	0.51
NO3	WIN	15	0.67	1.14	0.67	71.15	82.14	0.47	0.55	0.28	87.52	47.13	0.71	100.15	62.44	0.82	0.71	0.45
NO3	SPR	7	0.29	0.62	0.27	115.93	172.41	0.33	0.49	0.68	211.76	19.77	1.16	252.74	76.39	1.72	0.89	0.07
NO3	SUM	15	0.25	0.15	0.56	-40.64	54.96	-0.1	0.14	0.02	-32.21	-57.46	-0.68	59.66	70.99	0.93	0.17	0.31
NO3	FAL	14	0.34	0.62	0.66	83.3	93.04	0.28	0.31	0.21	69.79	25.7	0.83	91.72	57.43	0.93	0.54	0.43
NO3	ALL	51	0.4	0.63	0.63	57.93	88.54	0.23	0.36	0.29	64.49	6.73	0.58	106.87	65.49	0.89	0.59	0.4
OC	WIN	15	1.64	2.37	0.8	44.91	47.61	0.74	0.78	0.52	94.49	50.59	0.45	96.82	53.15	0.48	1.03	0.65
OC	SPR	12	2.1	2.05	0.97	-2.3	21.96	-0.05	0.46	0.35	62.75	22.48	-0.02	77.41	38.71	0.22	0.59	0.95
OC	SUM	14	2.41	3.38	0.77	40.49	46.09	0.97	1.11	0.64	54.03	36.9	0.4	57.91	40.97	0.46	1.26	0.59
OC	FAL	13	1.45	1.9	0.88	31.18	42.63	0.45	0.62	0.48	66.87	35.76	0.31	74.41	44.17	0.43	0.82	0.77
OC	ALL	54	1.89	2.45	0.82	29.29	39.87	0.55	0.75	0.64	70.3	37.23	0.29	77.02	44.62	0.4	0.97	0.67
PM-2.5	WIN	15	8.72	8.73	0.79	0.1	18.71	0.01	1.63	4.15	1.21	-1.66	0	20.09	19.31	0.19	2.04	0.63
PM-2.5	SPR	7	9.39	8.47	0.82	-9.74	31.28	-0.91	2.94	12.65	8.21	-0.93	-0.11	37.6	33.09	0.35	3.67	0.68
PM-2.5	SUM	15	17.15	11.31	0.72	-34.04	35.06	-5.84	6.01	13.8	-30.56	-38.38	-0.52	32.91	40.54	0.53	6.92	0.52
PM-2.5	FAL	14	8.18	7.81	0.88	-4.51	20.14	-0.37	1.65	5.98	8.17	1.15	-0.05	26.15	22.07	0.21	2.47	0.77
PM-2.5	ALL	51	11.14	9.2	0.8	-17.42	27.85	-1.94	3.1	15.07	-5.26	-11.59	-0.21	27.93	28.2	0.34	4.34	0.64
SO4	WIN	15	1.97	1.39	0.7	-29.5	36.41	-0.58	0.72	0.75	-17.59	-26.23	-0.42	32.87	38.55	0.52	1.04	0.49
SO4	SPR	7	2.3	2.47	0.6	7.5	34.15	0.17	0.79	1.14	16.74	5.69	0.07	39.03	31.38	0.34	1.08	0.35
SO4	SUM	15	4.29	3.2	0.92	-25.41	25.41	-1.09	1.09	0.29	-25.78	-30.42	-0.34	25.78	30.42	0.34	1.21	0.84
SO4	FAL	14	1.57	1.48	0.89	-5.27	20.4	-0.08	0.32	0.17	-3.41	-7.69	-0.06	22.12	24.17	0.22	0.42	0.79
SO4	ALL	51	2.59	2.1	0.85	-18.97	28.11	-0.49	0.73	0.72	-11.39	-17.99	-0.23	28.68	31.23	0.35	0.98	0.72

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 470990002																		
EC	WIN	13	0.3	0.41	0.67	35.73	49.71	0.11	0.15	0.04	41.56	27.51	0.36	49.96	37.45	0.5	0.22	0.45
EC	SPR	15	0.33	0.29	0.77	-12.99	29.74	-0.04	0.1	0.01	-4.05	-14.08	-0.15	37.84	37.49	0.34	0.12	0.59
EC	SUM	15	0.36	0.27	0.58	-23.48	31.71	-0.08	0.11	0.01	-15.43	-22.44	-0.31	29.9	34.74	0.41	0.14	0.34
EC	FAL	15	0.31	0.34	0.82	12.22	27.99	0.04	0.09	0.01	30.28	16.23	0.12	43.58	31.07	0.28	0.1	0.68
EC	ALL	58	0.33	0.33	0.61	0.34	34.04	0	0.11	0.02	12.11	0.92	0	39.99	35.11	0.34	0.15	0.38
NACL	WIN	15	0.06	0.11	0.75	75.65	101	0.05	0.06	0	119.44	50.16	0.76	137.47	74.31	1.01	0.08	0.56
NACL	SPR	15	0.11	0.16	0.9	47.89	84.3	0.05	0.09	0.02	46.69	5.09	0.48	93	69.01	0.84	0.15	0.8
NACL	SUM	12	0.06	0.06	0.64	12.89	57.64	0.01	0.03	0	21.08	-3.15	0.13	64.48	54.51	0.58	0.04	0.4
NACL	FAL	12	0.03	0.06	0.42	140.16	152.69	0.04	0.04	0	147.59	66.96	1.4	156.13	76.86	1.53	0.05	0.18
NACL	ALL	54	0.07	0.1	0.86	56.26	89.37	0.04	0.06	0.01	83.63	29.53	0.56	113.05	69.01	0.89	0.1	0.74
NH4	WIN	15	0.86	0.76	0.71	-11.06	29.48	-0.09	0.25	0.1	13.65	-4.7	-0.12	45.68	35.25	0.33	0.33	0.5
NH4	SPR	15	0.8	0.86	0.62	7.3	52.84	0.06	0.42	0.4	51.56	8.38	0.07	83.6	52.32	0.53	0.64	0.38
NH4	SUM	12	0.76	0.85	0.82	10.83	30.91	0.08	0.24	0.09	54.96	23.86	0.11	69.57	41.41	0.31	0.31	0.67
NH4	FAL	14	0.46	0.7	0.79	54.23	61.34	0.25	0.28	0.05	140.43	58.99	0.54	142.64	61.39	0.61	0.34	0.63
NH4	ALL	56	0.72	0.79	0.66	9.67	41.78	0.07	0.3	0.18	64.35	20.85	0.1	85.2	47.67	0.42	0.43	0.44
NO3	WIN	15	1.2	1.11	0.46	-6.92	57.24	-0.08	0.68	0.7	39.66	3.62	-0.07	80.8	60.72	0.61	0.84	0.21
NO3	SPR	15	0.41	1.07	0.44	161.1	196.39	0.66	0.8	3.65	115.04	-5.16	1.61	169.63	79.01	1.96	2.02	0.19
NO3	SUM	12	0.15	0.08	0.17	-46.62	55.17	-0.07	0.08	0.01	-41.97	-66.16	-0.87	51.49	74.44	1.03	0.1	0.03
NO3	FAL	15	0.25	0.55	0.4	125.74	167.72	0.31	0.41	0.19	271.15	37.19	1.26	310.22	101.18	1.68	0.54	0.16
NO3	ALL	57	0.52	0.74	0.34	42.18	99.83	0.22	0.52	1.29	103.23	-4.55	0.42	158.38	79.07	1	1.16	0.12
OC	WIN	13	1.1	1.93	0.64	74.96	81.17	0.83	0.9	1.69	86.58	48.7	0.75	91.18	54.11	0.81	1.54	0.41
OC	SPR	15	1.46	1.71	0.89	17.4	28.6	0.25	0.42	0.25	44.09	18.6	0.17	58.33	39.59	0.29	0.56	0.78
OC	SUM	15	2.36	3.61	0.55	53	62.31	1.25	1.47	1.57	67.8	44.98	0.53	70.98	48.6	0.62	1.77	0.3
OC	FAL	15	1.34	1.82	0.88	35.83	39.38	0.48	0.53	0.42	67.55	30.85	0.36	75.19	39.48	0.39	0.81	0.78
OC	ALL	58	1.58	2.28	0.72	44.2	52.21	0.7	0.83	1.11	65.81	35.34	0.44	73.32	45.14	0.52	1.26	0.53
PM-2.5	WIN	15	7.71	7.9	0.68	2.39	33.81	0.18	2.61	10.19	53.18	0.69	0.02	86.15	39.98	0.34	3.2	0.46
PM-2.5	SPR	15	10.95	7.64	0.52	-30.2	44.71	-3.31	4.89	19.21	-25.05	-40	-0.43	45.24	55.93	0.64	5.49	0.27
PM-2.5	SUM	12	15.91	10.09	0.64	-36.58	38.81	-5.82	6.17	17.47	-34.02	-44.05	-0.58	36.9	46.7	0.61	7.17	0.42
PM-2.5	FAL	15	8.13	7.08	0.62	-12.94	26.59	-1.05	2.16	11.73	2.29	-7.41	-0.15	31.42	32.53	0.31	3.58	0.39
PM-2.5	ALL	57	10.4	8.08	0.6	-22.34	36.95	-2.32	3.84	19.41	0.84	-21.57	-0.29	50.61	43.63	0.48	4.98	0.36
SO4	WIN	15	1.96	1.42	0.69	-27.88	32.96	-0.55	0.65	0.39	-21.11	-30.62	-0.39	32.38	40.33	0.46	0.83	0.47
SO4	SPR	15	2.68	1.98	0.79	-25.99	33.98	-0.7	0.91	1.13	-18.99	-25.73	-0.35	29.88	35.31	0.46	1.27	0.62
SO4	SUM	12	3.34	2.57	0.9	-22.88	28.89	-0.76	0.96	0.66	-21.56	-29.09	-0.3	30.34	36.98	0.37	1.12	0.8
SO4	FAL	15	1.77	1.59	0.86	-10.06	27.27	-0.18	0.48	0.37	13.48	2.39	-0.11	38.49	32.37	0.3	0.63	0.75
SO4	ALL	57	2.39	1.86	0.84	-22.38	30.95	-0.53	0.74	0.69	-11.54	-20.33	-0.29	32.9	36.21	0.4	0.99	0.71

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 471251009																		
EC	WIN	15	0.33	0.53	0.33	62.94	65.19	0.21	0.21	0.04	2639.09	47.83	0.63	2641.2	50.05	0.65	0.29	0.11
EC	SPR	15	0.33	0.37	0.64	10.2	34.28	0.03	0.11	0.02	37.23	17.86	0.1	53.33	36.34	0.34	0.13	0.41
EC	SUM	16	0.53	0.46	0.68	-11.47	23.54	-0.06	0.12	0.02	-7.79	-11.41	-0.13	23.02	24.37	0.27	0.15	0.46
EC	FAL	15	0.46	0.53	0.7	13.43	25.74	0.06	0.12	0.03	23.68	13.55	0.13	34.82	25.72	0.26	0.18	0.5
EC	ALL	61	0.41	0.47	0.53	14.14	34.37	0.06	0.14	0.04	661.89	16.49	0.14	677.19	33.96	0.34	0.2	0.28
NACL	WIN	14	0.05	0.08	0.13	68.58	93.33	0.03	0.04	0	121.42	55.07	0.69	130.83	67.66	0.93	0.05	0.02
NACL	SPR	15	0.08	0.12	0.75	48.83	90.1	0.04	0.07	0.01	82.47	30.05	0.49	110.46	69.47	0.9	0.12	0.57
NACL	SUM	15	0.06	0.05	0.57	-14.75	38.55	-0.01	0.02	0	-8.26	-19.75	-0.17	39.07	41.31	0.45	0.03	0.33
NACL	FAL	15	0.03	0.04	0.17	15.39	49.69	0.01	0.02	0	38.52	20.31	0.15	59.46	45.81	0.5	0.02	0.03
NACL	ALL	59	0.05	0.07	0.71	30.74	70.89	0.02	0.04	0	57.47	20.85	0.31	84.18	55.87	0.71	0.07	0.51
NH4	WIN	14	1.07	0.92	0.89	-14.18	24.27	-0.15	0.26	0.1	10.52	-0.93	-0.17	37.88	31.4	0.28	0.35	0.79
NH4	SPR	15	0.91	0.92	0.82	1.21	35.73	0.01	0.32	0.18	24.28	5.49	0.01	52.89	42.74	0.36	0.42	0.67
NH4	SUM	15	1.18	1.1	0.74	-6.58	34.35	-0.08	0.4	0.28	48.28	4.48	-0.07	78.11	41.1	0.37	0.53	0.55
NH4	FAL	15	0.69	0.77	0.86	11.01	30.59	0.08	0.21	0.08	47.12	21.13	0.11	60.84	36.17	0.31	0.29	0.74
NH4	ALL	59	0.96	0.93	0.8	-3.49	31.33	-0.03	0.3	0.17	32.92	7.69	-0.04	57.76	37.96	0.32	0.41	0.63
NO3	WIN	14	1.75	1.63	0.74	-6.41	39.27	-0.11	0.69	0.8	33.35	6.18	-0.07	67.01	49.94	0.42	0.9	0.54
NO3	SPR	15	0.66	1.06	0.32	59.99	131.21	0.4	0.87	2.79	60.63	-26.65	0.6	134.07	78.97	1.31	1.72	0.1
NO3	SUM	15	0.34	0.2	0.55	-40.62	61.84	-0.14	0.21	0.04	-47.02	-79.98	-0.68	63.92	93.72	1.04	0.23	0.3
NO3	FAL	15	0.71	0.8	0.88	12.52	63.47	0.09	0.45	0.38	-7.19	-33.53	0.13	58.64	70.86	0.63	0.62	0.77
NO3	ALL	59	0.85	0.91	0.59	7.36	64.95	0.06	0.55	1.05	9.55	-34.17	0.07	81.14	73.77	0.65	1.03	0.35
OC	WIN	14	1.23	2.2	0.64	79.45	81.65	0.97	1	0.7	95.81	55.74	0.79	97.61	57.67	0.82	1.29	0.41
OC	SPR	14	1.77	1.71	0.78	-3.23	36.25	-0.06	0.64	0.55	17.97	3.7	-0.03	49.21	42.63	0.37	0.74	0.61
OC	SUM	16	2.53	3.01	0.69	19.14	33.38	0.48	0.84	1.01	35.77	22.09	0.19	46.42	34.13	0.33	1.12	0.48
OC	FAL	15	2.18	1.86	0.64	-14.68	38.38	-0.32	0.84	0.99	16.38	-5.6	-0.17	57.1	46.88	0.45	1.05	0.41
OC	ALL	59	1.95	2.22	0.63	13.73	42.63	0.27	0.83	1.07	40.86	18.67	0.14	61.94	44.97	0.43	1.07	0.39
PM-2.5	WIN	14	8.9	8.85	0.14	-0.58	33.96	-0.05	3.02	22.62	343.08	5.19	-0.01	366.67	38.62	0.34	4.76	0.02
PM-2.5	SPR	15	10.07	7.53	0.5	-25.24	38.9	-2.54	3.92	17.96	-21.42	-32.65	-0.34	36.27	44.57	0.52	4.94	0.25
PM-2.5	SUM	16	16.46	10.48	0.7	-36.31	37.98	-5.97	6.25	19.3	-33.08	-43.39	-0.57	35.54	45.63	0.6	7.42	0.48
PM-2.5	FAL	15	10.23	7.72	0.7	-24.58	31.23	-2.51	3.2	11.12	-18.63	-25.84	-0.33	29.94	35.08	0.41	4.18	0.49
PM-2.5	ALL	60	11.54	8.67	0.58	-24.86	35.96	-2.87	4.15	22.18	61.22	-24.98	-0.33	111.59	41.09	0.48	5.51	0.34
SO4	WIN	14	2.04	1.35	0.91	-33.61	34.47	-0.69	0.7	0.24	-31.28	-40.26	-0.51	34.06	42.79	0.52	0.84	0.83
SO4	SPR	15	2.72	1.89	0.68	-30.43	34.98	-0.83	0.95	0.89	-25.26	-33.7	-0.44	32.48	40.28	0.5	1.25	0.47
SO4	SUM	15	4.15	3.06	0.76	-26.15	31.67	-1.08	1.31	2.13	-22.51	-30.55	-0.35	29.01	36.43	0.43	1.82	0.58
SO4	FAL	15	2.16	1.67	0.86	-22.67	31.02	-0.49	0.67	0.44	-13.53	-23.22	-0.29	35.61	39.64	0.4	0.82	0.75
SO4	ALL	59	2.78	2	0.83	-27.82	32.85	-0.77	0.91	0.98	-23.01	-31.79	-0.39	32.77	39.73	0.46	1.26	0.69

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 471570024																		
EC	WIN	15	0.76	0.93	0.77	22.77	33.38	0.17	0.25	0.09	20.77	12.02	0.23	35.6	30.13	0.33	0.34	0.59
EC	SPR	15	0.72	0.72	0.84	-0.25	18.99	0	0.14	0.03	1.03	-3.09	0	22.69	22.51	0.19	0.16	0.7
EC	SUM	16	1.19	1.11	0.65	-7.36	28.53	-0.09	0.34	0.24	131.66	2.45	-0.08	158.12	33.96	0.31	0.5	0.42
EC	FAL	15	1.05	1.11	0.74	5.7	28.21	0.06	0.3	0.15	13.17	5.62	0.06	33.44	30.39	0.28	0.39	0.55
EC	ALL	61	0.94	0.97	0.71	3.61	27.6	0.03	0.26	0.14	43.13	4.22	0.04	64.03	29.33	0.28	0.37	0.51
NACL	WIN	15	0.06	0.09	0.64	51.53	64.3	0.03	0.04	0	78.96	40.31	0.52	87.95	51.62	0.64	0.05	0.41
NACL	SPR	14	0.12	0.2	0.85	64.39	100.26	0.08	0.12	0.07	68.43	19.2	0.64	97.25	58.69	1	0.28	0.73
NACL	SUM	16	0.08	0.06	0.47	-21.2	42.75	-0.02	0.03	0	-12.48	-23.84	-0.27	36.46	42.86	0.54	0.05	0.22
NACL	FAL	14	0.03	0.06	0.53	72.81	76.2	0.02	0.03	0	75.2	48.19	0.73	77.33	50.5	0.76	0.04	0.28
NACL	ALL	59	0.07	0.1	0.81	37.98	73.57	0.03	0.05	0.02	50.77	19.78	0.38	73.67	50.65	0.74	0.14	0.65
NH4	WIN	15	1.12	1.01	0.69	-10.06	34.98	-0.11	0.39	0.26	8.69	-0.93	-0.11	36.47	33.56	0.39	0.52	0.47
NH4	SPR	15	0.9	0.88	0.84	-2.26	31.08	-0.02	0.28	0.13	13.23	-8.92	-0.02	49.64	37.23	0.32	0.37	0.71
NH4	SUM	16	0.73	0.77	0.62	5.6	38.62	0.04	0.28	0.11	35.62	7.94	0.06	63.31	40.32	0.39	0.34	0.39
NH4	FAL	14	0.81	0.93	0.95	15.33	26.22	0.12	0.21	0.04	34.68	22.51	0.15	42.05	30.99	0.26	0.24	0.9
NH4	ALL	60	0.89	0.89	0.78	0.72	32.93	0.01	0.29	0.14	23.07	4.91	0.01	48.22	35.68	0.33	0.38	0.61
NO3	WIN	15	2.19	2.04	0.61	-6.7	44	-0.15	0.96	1.78	20.47	0.78	-0.07	54.56	45.98	0.47	1.34	0.37
NO3	SPR	15	0.83	0.95	0.83	13.81	69.45	0.12	0.58	0.82	-17.47	-54.33	0.14	70.46	85.54	0.69	0.91	0.7
NO3	SUM	16	0.37	0.17	0.41	-53.6	75.35	-0.2	0.28	0.06	-58.1	-98.94	-1.15	73.64	108.52	1.62	0.31	0.17
NO3	FAL	14	0.9	1.05	0.82	16.96	58.73	0.15	0.53	0.5	-2.71	-28.55	0.17	62.65	65.39	0.59	0.72	0.68
NO3	ALL	60	1.06	1.04	0.73	-2.33	54.79	-0.02	0.58	0.8	-15.38	-46.43	-0.02	65.51	77.07	0.56	0.9	0.54
OC	WIN	15	1.66	2.54	0.81	52.88	54.39	0.88	0.9	0.72	53.04	36.57	0.53	56.55	40.36	0.54	1.22	0.65
OC	SPR	15	1.61	1.62	0.55	1.05	35.21	0.02	0.57	0.43	13.38	3.28	0.01	41.46	38.03	0.35	0.66	0.3
OC	SUM	16	2.38	4.3	0.24	80.43	80.43	1.92	1.92	4.05	532.3	51.41	0.8	532.3	51.41	0.8	2.78	0.06
OC	FAL	15	1.98	2.62	0.91	31.92	37.46	0.63	0.74	0.34	32.32	23.72	0.32	40.95	34.03	0.37	0.86	0.83
OC	ALL	61	1.92	2.79	0.58	45.85	54.62	0.88	1.05	1.91	163.9	29.12	0.46	173.79	41.13	0.55	1.64	0.34
PM-2.5	WIN	15	10.03	10.38	0.7	3.49	21.62	0.35	2.17	9.33	5.66	1.51	0.03	22.25	20.49	0.22	3.07	0.49
PM-2.5	SPR	15	10.22	8.37	0.67	-18.09	28.68	-1.85	2.93	8.55	-20.18	-27.87	-0.22	29.58	36.06	0.35	3.46	0.46
PM-2.5	SUM	16	14.54	12.33	0.6	-15.21	28.98	-2.21	4.21	17.42	-10.36	-18.62	-0.18	33.07	35.99	0.34	4.72	0.36
PM-2.5	FAL	14	10.46	10.43	0.86	-0.37	18.48	-0.04	1.93	6.96	0.44	-2.01	0	18.36	19	0.19	2.64	0.74
PM-2.5	ALL	60	11.38	10.41	0.72	-8.56	25.04	-0.97	2.85	11.98	-6.29	-12.02	-0.09	26.06	28.17	0.27	3.6	0.51
SO4	WIN	15	1.89	1.24	0.79	-34.48	35.97	-0.65	0.68	0.45	-28.77	-39.7	-0.53	33.92	44.02	0.55	0.93	0.62
SO4	SPR	15	2.49	2.03	0.78	-18.5	30.58	-0.46	0.76	0.57	-12.04	-21.97	-0.23	37.38	38.33	0.38	0.88	0.61
SO4	SUM	16	2.69	2.23	0.54	-16.83	35.75	-0.45	0.96	1.06	-9.18	-22.96	-0.2	41.8	45.12	0.43	1.12	0.29
SO4	FAL	14	2.2	1.84	0.9	-16.32	25.17	-0.36	0.55	0.44	-6.8	-13.34	-0.2	28.83	31	0.3	0.75	0.82
SO4	ALL	60	2.33	1.84	0.77	-20.75	32.07	-0.48	0.75	0.65	-14.24	-24.65	-0.26	35.7	39.85	0.4	0.94	0.59

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 481130069																		
EC	WIN	23	0.77	1.33	0.86	72.79	72.79	0.56	0.56	0.12	86.25	55.64	0.73	86.25	55.64	0.73	0.66	0.73
EC	SPR	24	0.6	0.89	0.62	47.04	60.62	0.28	0.37	0.14	63.8	37.27	0.47	74.34	49.9	0.61	0.47	0.39
EC	SUM	24	0.51	0.73	0.69	43.83	45.86	0.22	0.23	0.04	60.09	39.61	0.44	61.3	40.91	0.46	0.3	0.48
EC	FAL	24	0.81	1.18	0.79	44.78	54.68	0.36	0.44	0.18	71.18	43.78	0.45	76.81	50.07	0.55	0.56	0.63
EC	ALL	95	0.67	1.03	0.79	52.85	59.34	0.36	0.4	0.14	70.16	43.95	0.53	74.55	49.06	0.59	0.51	0.62
NACL	WIN	22	0.1	0.13	0.52	36.52	68.77	0.04	0.07	0.02	98.46	31.61	0.37	116.45	52.9	0.69	0.13	0.27
NACL	SPR	24	0.26	0.14	0.68	-45.56	55.07	-0.12	0.14	0.03	-4.99	-29.41	-0.84	61.01	66.49	1.01	0.21	0.47
NACL	SUM	26	0.24	0.08	0.06	-67.97	74.75	-0.16	0.18	0.04	-48.66	-89.11	-2.12	69.52	102.22	2.33	0.26	0
NACL	FAL	24	0.11	0.1	0.3	-9.52	78.86	-0.01	0.09	0.02	-2.91	-32.67	-0.11	68.76	72.08	0.87	0.14	0.09
NACL	ALL	96	0.18	0.11	0.34	-37.61	67.64	-0.07	0.12	0.03	7.41	-32.41	-0.6	77.96	74.45	1.08	0.2	0.12
NH4	WIN	22	1.1	1.03	0.68	-5.58	29.34	-0.06	0.32	0.2	8.48	-4.31	-0.06	37.09	32.32	0.31	0.45	0.46
NH4	SPR	24	1.02	0.81	0.83	-20.84	28.75	-0.21	0.29	0.13	-9.96	-18.51	-0.26	31.88	34.08	0.36	0.42	0.68
NH4	SUM	26	0.68	0.42	0.88	-38.66	38.9	-0.26	0.27	0.03	-38.56	-52.29	-0.63	40.03	53.63	0.63	0.32	0.78
NH4	FAL	24	0.62	0.81	0.56	31.43	62.55	0.19	0.39	0.57	38.86	15.53	0.31	60.72	42.47	0.63	0.78	0.31
NH4	ALL	96	0.85	0.76	0.63	-10.7	37.3	-0.09	0.32	0.26	-1.28	-15.89	-0.12	42.49	41.07	0.42	0.52	0.4
NO3	WIN	22	2	1.68	0.54	-16.13	41.31	-0.32	0.83	1.16	-2.24	-20.29	-0.19	49.45	46.52	0.49	1.12	0.29
NO3	SPR	24	0.91	0.35	0.89	-61.12	61.12	-0.56	0.56	0.21	-64.56	-101.57	-1.57	64.56	101.57	1.57	0.72	0.79
NO3	SUM	26	0.43	0.1	0.1	-76.19	76.19	-0.33	0.33	0.04	-71.26	-115.57	-3.2	71.26	115.57	3.2	0.38	0.01
NO3	FAL	24	0.8	0.88	0.76	9.86	79.46	0.08	0.63	1.75	-26.12	-61.64	0.1	69.22	83.83	0.79	1.32	0.57
NO3	ALL	96	1	0.72	0.68	-28.2	57.48	-0.28	0.58	0.82	-42.48	-76.76	-0.39	64.08	88.31	0.8	0.95	0.46
OC	WIN	23	1.86	3.79	0.74	104.26	105.77	1.94	1.97	2.22	112.99	64.52	1.04	114.06	65.63	1.06	2.44	0.54
OC	SPR	24	1.95	2.12	0.12	8.55	52.22	0.17	1.02	1.8	35.17	11.89	0.09	61.53	45.79	0.52	1.35	0.01
OC	SUM	24	1.62	2.27	0.78	40.61	45.81	0.66	0.74	0.7	48.76	31.71	0.41	52.8	36.38	0.46	1.06	0.61
OC	FAL	24	1.65	2.83	0.65	71.02	78.39	1.17	1.3	1.55	84.01	49.83	0.71	88.38	55.74	0.78	1.71	0.43
OC	ALL	95	1.77	2.74	0.53	55.02	70.53	0.97	1.25	1.98	69.78	39.22	0.55	78.83	50.73	0.71	1.71	0.28
PM-2.5	WIN	23	10.13	14.44	0.61	42.45	46.33	4.3	4.7	22.03	45.76	30.96	0.42	50.84	36.68	0.46	6.37	0.38
PM-2.5	SPR	24	11.49	10.08	0.02	-12.25	49.65	-1.41	5.7	46.63	7.35	-9.37	-0.14	52.05	50.37	0.57	6.97	0
PM-2.5	SUM	26	11.85	8.8	0.7	-25.8	28.7	-3.06	3.4	9.71	-24.64	-32.76	-0.35	28.57	36.41	0.39	4.37	0.49
PM-2.5	FAL	24	9.33	12.23	0.58	30.99	45.83	2.89	4.28	46.07	30.89	17.4	0.31	43.97	33.1	0.46	7.38	0.34
PM-2.5	ALL	97	10.73	11.3	0.31	5.29	41.88	0.57	4.49	39.9	13.71	0.55	0.05	43.47	39.11	0.42	6.34	0.1
SO4	WIN	22	2.01	1.78	0.9	-11.52	25.66	-0.23	0.52	0.31	-8.59	-15.96	-0.13	30.24	33.94	0.29	0.61	0.8
SO4	SPR	24	3	2.33	0.73	-22.19	31.49	-0.66	0.94	1.29	-15.75	-22.61	-0.29	26.92	32.53	0.4	1.32	0.54
SO4	SUM	26	2.59	1.29	0.83	-50.13	50.13	-1.3	1.3	0.23	-52.95	-76.22	-1.01	52.95	76.22	1.01	1.38	0.69
SO4	FAL	24	1.85	1.81	0.61	-2.4	37.07	-0.04	0.69	1.16	5.48	-2.8	-0.02	35.51	34.36	0.38	1.08	0.37
SO4	ALL	96	2.37	1.79	0.7	-24.5	36.95	-0.58	0.88	0.99	-18.88	-30.65	-0.32	36.88	45.14	0.49	1.15	0.49

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 481410044																		
EC	WIN	25	1.07	0.78	0.71	-26.93	42.34	-0.29	0.45	0.31	2.32	-10.76	-0.37	43.67	44.39	0.58	0.63	0.51
EC	SPR	30	0.45	0.53	0.74	17.14	43.32	0.08	0.2	0.05	46.44	29.33	0.17	57.9	44.12	0.43	0.24	0.55
EC	SUM	29	0.52	0.49	0.44	-6.37	35.4	-0.03	0.18	0.07	7.98	-0.07	-0.07	34.25	33.38	0.38	0.26	0.19
EC	FAL	30	0.79	0.74	0.7	-6.36	31.53	-0.05	0.25	0.13	18.12	6.61	-0.07	39.06	33.46	0.34	0.36	0.5
EC	ALL	114	0.69	0.63	0.73	-9.26	37.95	-0.06	0.26	0.15	19.53	7.08	-0.1	43.8	38.64	0.42	0.39	0.53
NACL	WIN	25	0.17	0.04	0	-78.73	79.38	-0.14	0.14	0.07	-44.88	-71.04	-3.7	46.72	72.77	3.73	0.31	0
NACL	SPR	31	0.18	0.09	0.62	-51.17	54.38	-0.09	0.1	0.01	-42.55	-63.39	-1.05	48.27	68.05	1.11	0.14	0.39
NACL	SUM	27	0.11	0.03	0.65	-72.7	72.7	-0.08	0.08	0	-70.37	-113.3	-2.66	70.37	113.3	2.66	0.1	0.42
NACL	FAL	30	0.09	0.04	0	-62.03	72.18	-0.06	0.07	0.02	-42.44	-72.87	-1.63	60.59	85.66	1.9	0.14	0
NACL	ALL	113	0.14	0.05	0.29	-65.01	68.11	-0.09	0.09	0.03	-49.68	-79.53	-1.86	56.48	84.58	1.95	0.18	0.08
NH4	WIN	25	0.46	0.36	0.57	-20.85	39.89	-0.1	0.18	0.09	-0.38	-9.74	-0.26	32.46	35.68	0.5	0.31	0.32
NH4	SPR	31	0.29	0.18	0.43	-37.82	45.29	-0.11	0.13	0.02	-23.54	-38.86	-0.61	43.69	53.47	0.73	0.18	0.18
NH4	SUM	28	0.48	0.24	0.79	-49.19	49.19	-0.23	0.23	0.02	-48.16	-66.73	-0.97	48.16	66.73	0.97	0.27	0.63
NH4	FAL	29	0.38	0.28	0.72	-24.72	31.2	-0.09	0.12	0.02	-22.72	-31.52	-0.33	29.51	37.42	0.41	0.16	0.52
NH4	ALL	113	0.4	0.26	0.62	-33.68	41.63	-0.13	0.16	0.04	-24.3	-37.44	-0.51	38.68	48.7	0.63	0.23	0.38
NO3	WIN	25	1.2	0.39	0.66	-67.58	67.58	-0.81	0.81	0.7	-64.51	-100.03	-2.08	64.51	100.03	2.08	1.16	0.44
NO3	SPR	31	0.32	0.07	0.49	-79.19	79.19	-0.25	0.25	0.01	-76.51	-127.57	-3.81	76.51	127.57	3.81	0.28	0.24
NO3	SUM	28	0.27	0.05	0.19	-83.02	83.02	-0.22	0.22	0.01	-79.32	-135.48	-4.89	79.32	135.48	4.89	0.25	0.04
NO3	FAL	30	0.37	0.09	0.7	-75.26	75.58	-0.28	0.28	0.09	-65.84	-105.75	-3.04	68.11	107.69	3.05	0.4	0.49
NO3	ALL	114	0.51	0.14	0.78	-73	73.06	-0.37	0.37	0.24	-71.76	-117.73	-2.7	72.36	118.24	2.71	0.61	0.62
OC	WIN	25	2.01	1.46	0.53	-27.32	45.56	-0.55	0.92	1.76	3.47	-9.9	-0.38	41.54	42.99	0.63	1.43	0.28
OC	SPR	30	1.11	1.01	0.59	-8.99	41.83	-0.1	0.47	0.34	19.23	0.09	-0.1	54.89	46.84	0.46	0.59	0.34
OC	SUM	29	1.44	1.3	0.08	-9.58	68.34	-0.14	0.99	2.41	37.66	5.69	-0.11	76.02	60.47	0.76	1.56	0.01
OC	FAL	30	1.4	1.51	0.42	7.46	44.73	0.1	0.63	0.74	28.99	14.08	0.07	48.82	39.85	0.45	0.87	0.17
OC	ALL	114	1.47	1.32	0.35	-10.52	50.29	-0.15	0.74	1.33	23.03	3	-0.12	55.74	47.62	0.56	1.17	0.12
PM-2.5	WIN	25	9.62	6.39	0.42	-33.54	40.34	-3.22	3.88	18.46	-18.16	-31.5	-0.5	38.04	45.71	0.61	5.37	0.18
PM-2.5	SPR	31	12.35	4.63	0.11	-62.54	62.54	-7.72	7.72	53.47	-53.88	-80.07	-1.67	53.88	80.07	1.67	10.64	0.01
PM-2.5	SUM	26	10.46	4.75	0.02	-54.54	55.49	-5.7	5.8	17.26	-49.78	-74.34	-1.2	51.2	75.64	1.22	7.06	0
PM-2.5	FAL	30	10.63	5.96	0.42	-43.92	44.33	-4.67	4.71	21.82	-37.09	-51.93	-0.78	38.01	52.82	0.79	6.6	0.17
PM-2.5	ALL	112	10.84	5.41	0.12	-50.11	51.78	-5.43	5.61	31.48	-40.46	-60.36	-1	45.47	64.07	1.04	7.81	0.01
SO4	WIN	25	0.68	0.81	0.8	20.53	38.32	0.14	0.26	0.08	34.32	24.67	0.21	43.61	35.9	0.38	0.31	0.64
SO4	SPR	31	0.92	0.67	0.66	-27.03	33.46	-0.25	0.31	0.12	-18.16	-25	-0.37	29.18	34.61	0.46	0.43	0.43
SO4	SUM	28	1.35	0.73	0.77	-45.99	45.99	-0.62	0.62	0.1	-45.87	-62.25	-0.85	45.87	62.25	0.85	0.69	0.6
SO4	FAL	30	1.05	0.82	0.44	-21.52	33.01	-0.23	0.35	0.37	19	-19.12	-0.27	60.81	37.67	0.42	0.65	0.19
SO4	ALL	114	1.01	0.76	0.53	-24.76	38.18	-0.25	0.38	0.24	-3.68	-21.71	-0.33	44.77	42.49	0.51	0.55	0.28

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 482011039																		
EC	WIN	28	0.52	1.06	0.5	102.93	102.93	0.54	0.54	0.22	156.9	66.29	1.03	156.9	66.29	1.03	0.72	0.25
EC	SPR	31	0.43	0.6	0.85	39.3	42.86	0.17	0.18	0.05	48.99	31.95	0.39	51.77	34.95	0.43	0.29	0.72
EC	SUM	31	0.27	0.54	0.6	101.53	109.81	0.27	0.3	0.04	159.33	75.58	1.02	162.91	80.03	1.1	0.33	0.36
EC	FAL	28	0.53	0.88	0.85	67.32	69.44	0.36	0.37	0.07	81.55	53.28	0.67	82.65	54.47	0.69	0.45	0.72
EC	ALL	118	0.43	0.76	0.73	75.79	78.68	0.33	0.34	0.11	111.31	56.62	0.76	113.24	58.86	0.79	0.47	0.53
NACL	WIN	29	0.23	0.45	0.45	97.33	137.06	0.22	0.31	0.45	101.29	18.5	0.97	140.29	74.69	1.37	0.71	0.2
NACL	SPR	31	0.74	0.46	0.43	-38.44	67.11	-0.28	0.5	0.41	20.22	-33.19	-0.62	95.09	75.03	1.09	0.7	0.18
NACL	SUM	29	0.47	0.17	0.2	-64.15	75.33	-0.3	0.36	0.15	-32.18	-77.33	-1.79	78.85	102.14	2.1	0.5	0.04
NACL	FAL	30	0.25	0.39	0.64	57.38	99.53	0.14	0.25	0.3	76.66	23.37	0.57	107	64.01	1	0.56	0.42
NACL	ALL	119	0.43	0.37	0.34	-13.64	83.18	-0.06	0.35	0.39	41.43	-17.09	-0.16	105.15	78.78	0.96	0.62	0.11
NH4	WIN	29	0.84	0.92	0.22	9.2	63	0.08	0.53	0.56	86.08	13.83	0.09	121.72	60.83	0.63	0.75	0.05
NH4	SPR	31	1.02	0.66	0.76	-35.15	39.88	-0.36	0.41	0.13	-30.82	-47.29	-0.54	41.4	55.14	0.62	0.51	0.58
NH4	SUM	29	0.45	0.29	0.9	-36.01	43.52	-0.16	0.2	0.06	-3.73	-37.88	-0.56	67.13	69.51	0.68	0.29	0.81
NH4	FAL	30	0.52	0.65	0.72	24.77	46.45	0.13	0.24	0.07	42.69	16	0.25	66.31	50.82	0.46	0.29	0.52
NH4	ALL	119	0.71	0.63	0.56	-11.54	48.29	-0.08	0.34	0.24	22.8	-14.15	-0.13	73.52	58.94	0.55	0.5	0.32
NO3	WIN	29	1.25	1.67	0.23	33.98	88.18	0.42	1.1	2.43	78.24	10.79	0.34	117.72	66.21	0.88	1.62	0.05
NO3	SPR	31	0.75	0.44	0.48	-41.56	67.72	-0.31	0.51	0.44	-46.08	-76.93	-0.71	60.11	86.68	1.16	0.73	0.23
NO3	SUM	29	0.38	0.18	0.3	-52.67	69.17	-0.2	0.27	0.04	-53.96	-88.85	-1.11	68.16	97.81	1.46	0.29	0.09
NO3	FAL	30	0.45	0.56	0.29	23.74	68.44	0.11	0.31	0.26	33.65	-8.68	0.24	82.62	59.77	0.68	0.52	0.08
NO3	ALL	119	0.71	0.71	0.47	-0.09	76.81	0	0.54	0.87	2.39	-41.25	0	81.78	77.62	0.77	0.93	0.22
OC	WIN	28	1.58	3.13	0.54	98.33	100.13	1.55	1.58	5.18	108.3	54.39	0.98	109.44	55.57	1	2.76	0.29
OC	SPR	31	1.89	1.81	0.74	-4.26	50.79	-0.08	0.96	1.76	12.55	-7.05	-0.04	57.11	51.63	0.53	1.33	0.55
OC	SUM	31	0.86	1.42	0.79	65.16	84.61	0.56	0.73	0.51	203.28	70.76	0.65	209.81	79.89	0.85	0.9	0.63
OC	FAL	28	1.57	2.56	0.72	62.86	68.2	0.99	1.07	1.67	72.69	44.32	0.63	76.63	48.57	0.68	1.63	0.52
OC	ALL	118	1.47	2.2	0.62	49.55	72.96	0.73	1.07	2.58	99.65	40.16	0.5	114.27	59.26	0.73	1.76	0.39
PM-2.5	WIN	28	10.4	13.96	0.6	34.24	45.73	3.56	4.76	33.34	40.05	24.03	0.34	50.16	35.83	0.46	6.78	0.36
PM-2.5	SPR	31	12.72	9.8	0.51	-22.95	37.04	-2.92	4.71	21.36	-18.1	-28.03	-0.3	36.15	43.27	0.48	5.47	0.26
PM-2.5	SUM	29	10.19	7.09	0.65	-30.36	34.94	-3.09	3.56	13.45	-24.93	-36.7	-0.44	33.94	44.47	0.5	4.8	0.42
PM-2.5	FAL	30	9.67	11.77	0.54	21.72	31.84	2.1	3.08	16.96	24.19	15.8	0.22	33.69	26.39	0.32	4.62	0.3
PM-2.5	ALL	118	10.77	10.62	0.46	-1.38	37.36	-0.15	4.02	29.84	4.77	-6.67	-0.01	38.31	37.51	0.38	5.46	0.21
SO4	WIN	29	2.07	2.15	0.46	3.77	42.08	0.08	0.87	1.66	13.16	-2.6	0.04	45.69	38.34	0.42	1.29	0.21
SO4	SPR	31	3.42	2.67	0.58	-21.92	32.18	-0.75	1.1	1.3	-17.08	-25.11	-0.28	31.2	36.89	0.41	1.36	0.33
SO4	SUM	29	2.55	1.14	0.83	-55.39	55.39	-1.41	1.41	0.63	-55.84	-83.45	-1.24	55.84	83.45	1.24	1.62	0.69
SO4	FAL	30	2.33	2.05	0.76	-11.71	26.05	-0.27	0.61	0.54	-1.48	-10.66	-0.13	31.6	31.25	0.3	0.79	0.57
SO4	ALL	119	2.6	2.01	0.59	-22.63	38.25	-0.59	1	1.34	-15.22	-30.2	-0.29	40.84	47.17	0.49	1.3	0.35

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 482030002																		
EC	WIN	15	0.59	0.45	0.72	-23.25	36.49	-0.14	0.22	0.08	-19.43	-28.61	-0.3	30.85	38.09	0.48	0.31	0.52
EC	SPR	15	1.01	0.38	0.32	-62.17	69.6	-0.63	0.7	3.49	-31.86	-51.62	-1.64	44.87	61.48	1.84	1.97	0.1
EC	SUM	16	0.45	0.27	0.81	-39.32	41.69	-0.18	0.19	0.01	-32.39	-47.31	-0.65	45.34	56.09	0.69	0.21	0.66
EC	FAL	14	0.59	0.42	0.5	-29.25	32.25	-0.17	0.19	0.05	-26.07	-33.98	-0.41	29.28	36.98	0.46	0.28	0.25
EC	ALL	60	0.66	0.38	0.32	-42.37	49.25	-0.28	0.32	0.95	-27.54	-40.6	-0.74	37.85	48.48	0.85	1.01	0.1
NACL	WIN	15	0.08	0.08	0.87	0.42	45.16	0	0.03	0	102.65	10.56	0	137.03	56.13	0.45	0.05	0.76
NACL	SPR	15	0.21	0.24	0.56	15.24	85.57	0.03	0.18	0.1	16.16	-13	0.15	71.15	60.38	0.86	0.32	0.32
NACL	SUM	16	0.21	0.07	0.08	-67.1	71.62	-0.14	0.15	0.05	-46.89	-78.72	-2.04	61.4	89.74	2.18	0.26	0.01
NACL	FAL	14	0.04	0.09	0.62	97.45	108.77	0.04	0.05	0.01	88.21	36.73	0.97	98.95	49.08	1.09	0.1	0.38
NACL	ALL	60	0.14	0.12	0.4	-13.65	76.09	-0.02	0.1	0.05	37.78	-13.03	-0.16	91.51	64.51	0.88	0.21	0.16
NH4	WIN	15	0.5	0.65	0.46	31.72	55.48	0.16	0.28	0.14	101	33.9	0.32	119.4	55.9	0.55	0.4	0.21
NH4	SPR	15	0.65	0.71	0.91	9.45	20.82	0.06	0.14	0.03	33.39	17.99	0.09	42.93	29.5	0.21	0.17	0.82
NH4	SUM	16	0.5	0.45	0.83	-10.88	27.74	-0.05	0.14	0.03	-1.8	-10.19	-0.12	32.79	34.15	0.31	0.19	0.69
NH4	FAL	14	0.35	0.57	0.78	65.72	65.72	0.23	0.23	0.03	96.43	52.02	0.66	96.43	52.02	0.66	0.29	0.6
NH4	ALL	60	0.5	0.59	0.71	18.65	38.5	0.09	0.19	0.07	55.62	22.4	0.19	71.83	42.6	0.39	0.28	0.5
NO3	WIN	15	0.66	0.64	0.05	-2.25	69.93	-0.01	0.46	0.36	22.56	-19.73	-0.02	86.47	71.83	0.72	0.6	0
NO3	SPR	15	0.44	0.34	0.51	-22.23	89.4	-0.1	0.4	0.33	-39.17	-95.16	-0.29	85.02	118.88	1.15	0.58	0.26
NO3	SUM	16	0.31	0.03	0.29	-89.69	89.69	-0.28	0.28	0.01	-87.92	-158.58	-8.7	87.92	158.58	8.7	0.3	0.09
NO3	FAL	14	0.25	0.18	0.71	-29.19	60.15	-0.07	0.15	0.02	-35.16	-70.12	-0.41	66.99	93.13	0.85	0.16	0.5
NO3	ALL	60	0.42	0.3	0.43	-28.65	77.64	-0.12	0.32	0.19	-35.8	-87.37	-0.4	81.95	111.7	1.09	0.45	0.19
OC	WIN	15	1.92	2.09	0.51	8.65	49.43	0.17	0.95	2.38	23.39	4.18	0.09	51.68	44.05	0.49	1.55	0.26
OC	SPR	15	6.24	2.19	0.23	-64.85	79.55	-4.05	4.96	206.97	-15.12	-36.32	-1.85	49.74	57.28	2.26	14.94	0.05
OC	SUM	16	2.2	4.41	0.79	100.91	103.53	2.22	2.27	9.33	73.17	37.67	1.01	80.98	47.19	1.04	3.77	0.62
OC	FAL	14	2.31	2.94	0.44	27.28	53.67	0.63	1.24	2.88	29.37	15.82	0.27	46.26	37.44	0.54	1.81	0.19
OC	ALL	60	3.16	2.93	0.12	-7.35	75.01	-0.23	2.37	60.94	28.43	5.7	-0.08	57.74	46.65	0.81	7.81	0.01
PM-2.5	WIN	15	8.25	7.39	0.69	-10.42	31.87	-0.86	2.63	12.04	-9.02	-19.16	-0.12	34.47	36.06	0.36	3.57	0.48
PM-2.5	SPR	15	20.24	7.65	0.21	-62.23	65.45	-12.59	13.25	1002.55	-39.78	-58.56	-1.65	45	62.93	1.73	34.08	0.04
PM-2.5	SUM	16	13.58	9.16	0.79	-32.58	39.74	-4.42	5.4	19.27	-38.68	-58.55	-0.48	44.38	63.74	0.59	6.23	0.62
PM-2.5	FAL	14	8.44	8.29	0.57	-1.68	25.93	-0.14	2.19	10.07	-0.17	-5.38	-0.02	23.97	24.66	0.26	3.18	0.32
PM-2.5	ALL	60	12.71	8.13	0.21	-36	46.56	-4.58	5.92	285.26	-22.55	-36.3	-0.56	37.29	47.5	0.73	17.5	0.04
SO4	WIN	15	1.59	1.64	0.64	3.06	47.46	0.05	0.75	1.21	2.65	-11.4	0.03	46.68	44.49	0.47	1.1	0.41
SO4	SPR	15	2.66	2.22	0.83	-16.3	22.86	-0.43	0.61	0.58	-13.24	-18.17	-0.19	22.11	25.92	0.27	0.88	0.69
SO4	SUM	16	2.85	1.41	0.67	-50.55	50.55	-1.44	1.44	0.7	-52.06	-75.19	-1.02	52.06	75.19	1.02	1.67	0.45
SO4	FAL	14	1.62	1.79	0.83	10.66	24.14	0.17	0.39	0.25	13.83	8.94	0.11	26.95	23.71	0.24	0.53	0.7
SO4	ALL	60	2.2	1.76	0.61	-20.01	37.1	-0.44	0.82	1.11	-13.3	-25.36	-0.25	37.37	43.19	0.46	1.14	0.38

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 500070012																		
EC	WIN	22	0.4	0.7	0.91	73.44	73.44	0.3	0.3	0.02	108.87	62.89	0.73	108.87	62.89	0.73	0.32	0.83
EC	SPR	24	0.28	0.42	0.69	50.05	60.55	0.14	0.17	0.01	68.02	43.36	0.5	75.7	52.45	0.61	0.19	0.47
EC	SUM	21	0.4	0.41	0.58	3.38	22.59	0.01	0.09	0.02	14.17	7.74	0.03	27.47	22.88	0.23	0.13	0.34
EC	FAL	12	0.45	0.57	0.86	27.27	32.38	0.12	0.15	0.02	33.68	23.2	0.27	39.63	29.57	0.32	0.18	0.75
EC	ALL	79	0.37	0.52	0.77	39.59	48.42	0.15	0.18	0.03	59.87	36.27	0.4	66.64	44.02	0.48	0.22	0.59
NACL	WIN	24	0.17	0.11	0.06	-33.72	74.26	-0.06	0.12	0.06	55.77	9.92	-0.51	95.35	72.13	1.12	0.25	0
NACL	SPR	24	0.06	0.13	0.31	112.04	144.56	0.07	0.09	0.06	107.58	33.69	1.12	128.37	60.61	1.45	0.25	0.1
NACL	SUM	21	0.04	0.05	0.54	12.23	59.71	0.01	0.02	0	0.3	-17.86	0.12	45.89	38.94	0.6	0.06	0.29
NACL	FAL	11	0.08	0.08	0.37	-3.91	58.87	0	0.05	0.01	48.83	19.19	-0.04	69.54	48.41	0.61	0.08	0.14
NACL	ALL	80	0.09	0.09	0.11	4.99	84.9	0	0.08	0.04	55.8	11.04	0.05	88.72	56.7	0.85	0.2	0.01
NH4	WIN	24	0.94	1.01	0.9	7.24	36.3	0.07	0.34	0.2	52.34	26.52	0.07	69.16	48.19	0.36	0.46	0.81
NH4	SPR	23	0.36	0.62	0.64	71.15	76.46	0.26	0.28	0.05	129.89	54.77	0.71	134.62	60.02	0.76	0.35	0.42
NH4	SUM	21	0.19	0.38	0.84	100.17	106.01	0.19	0.2	0.07	178.7	66.92	1	182.61	71.5	1.06	0.33	0.7
NH4	FAL	10	0.47	0.71	0.82	52.03	57.49	0.24	0.27	0.07	116.69	57.76	0.52	120.32	61.56	0.57	0.36	0.67
NH4	ALL	78	0.51	0.69	0.87	35.29	54.24	0.18	0.28	0.11	117.48	49.73	0.35	125.57	59.67	0.54	0.38	0.76
NO3	WIN	24	2.03	2.17	0.86	6.71	44.32	0.14	0.9	1.77	87.63	20.65	0.07	110.75	52.24	0.44	1.34	0.74
NO3	SPR	24	0.58	0.65	0.84	13.24	50.05	0.08	0.29	0.14	6.01	-14.87	0.13	54.98	58.17	0.5	0.38	0.7
NO3	SUM	21	0.19	0.1	0.3	-46.9	67.35	-0.09	0.13	0.01	-41.61	-74.8	-0.88	66.26	93.38	1.27	0.15	0.09
NO3	FAL	11	0.72	0.9	0.77	23.93	57.18	0.17	0.41	0.24	156.68	29.6	0.24	186.21	66.73	0.57	0.52	0.6
NO3	ALL	80	0.93	1	0.88	6.85	48	0.06	0.45	0.62	38.71	-13.83	0.07	92.72	66.81	0.48	0.79	0.77
OC	WIN	22	1.49	3.62	0.84	142.44	142.44	2.13	2.13	0.82	200.52	91.67	1.42	200.52	91.67	1.42	2.31	0.7
OC	SPR	24	0.96	1.85	0.64	92.04	97.21	0.88	0.93	0.53	139.73	64.51	0.92	143.13	68.77	0.97	1.15	0.41
OC	SUM	21	2	1.68	0.59	-16.18	30.71	-0.32	0.61	1.03	-3.12	-9.94	-0.19	28.97	28.59	0.37	1.07	0.35
OC	FAL	12	1.42	2.32	0.9	63.01	63.01	0.9	0.9	0.23	91.65	56.72	0.63	91.65	56.72	0.63	1.02	0.8
OC	ALL	79	1.46	2.37	0.53	62.56	80.74	0.91	1.18	1.51	111.38	51.1	0.63	120.95	62.64	0.81	1.53	0.28
PM-2.5	WIN	24	9.01	11.92	0.94	32.21	38.66	2.9	3.48	6.64	49.58	34.7	0.32	54.55	40.56	0.39	3.88	0.89
PM-2.5	SPR	24	5.52	6.45	0.58	16.8	36.01	0.93	1.99	4.87	20.56	12.08	0.17	38.29	34.2	0.36	2.39	0.34
PM-2.5	SUM	21	8.1	5.39	0.72	-33.46	33.48	-2.71	2.71	6.33	-32.05	-40.87	-0.5	32.08	40.9	0.5	3.7	0.52
PM-2.5	FAL	10	7.26	8.8	0.86	21.23	26.49	1.54	1.92	3.6	27.29	19.98	0.21	33.17	26.3	0.26	2.44	0.74
PM-2.5	ALL	79	7.49	8.13	0.82	8.52	35.08	0.64	2.63	10.3	16.24	5.87	0.09	40.93	36.91	0.35	3.27	0.68
SO4	WIN	24	1.37	1.13	0.83	-17.18	26.51	-0.23	0.36	0.26	-7.5	-14.52	-0.21	25.89	27.1	0.32	0.56	0.69
SO4	SPR	24	0.97	1.25	0.36	28.59	45.46	0.28	0.44	0.28	41.81	18.68	0.29	58.57	40.68	0.45	0.6	0.13
SO4	SUM	21	0.97	1.07	0.8	10.4	46.16	0.1	0.45	0.53	12.99	-0.32	0.1	43.55	37.92	0.46	0.73	0.64
SO4	FAL	11	1.13	1.26	0.86	11.56	40.98	0.13	0.46	0.29	1104.62	35.79	0.12	1119.2	52.29	0.41	0.55	0.74
SO4	ALL	80	1.11	1.17	0.67	5.17	38.01	0.06	0.42	0.38	165.59	6.08	0.05	190.65	37.48	0.38	0.62	0.45

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 510870014																		
EC	WIN	22	0.63	1.18	0.76	87.09	87.97	0.55	0.56	0.1	103.07	62.81	0.87	103.52	63.27	0.88	0.63	0.57
EC	SPR	24	0.44	0.61	0.3	38.94	49.26	0.17	0.22	0.04	52.38	32.63	0.39	59.8	40.93	0.49	0.27	0.09
EC	SUM	23	0.61	0.58	0.69	-4.56	23.61	-0.03	0.14	0.03	1.21	-2.41	-0.05	23.59	23.27	0.25	0.18	0.48
EC	FAL	23	0.64	0.84	0.89	30.89	34.47	0.2	0.22	0.04	38.27	28.75	0.31	40.61	31.3	0.34	0.28	0.8
EC	ALL	92	0.58	0.8	0.68	37.79	48.5	0.22	0.28	0.09	48.18	30.11	0.38	56.4	39.45	0.49	0.38	0.46
NACL	WIN	19	0.06	0.22	0.59	294.42	296	0.17	0.17	0.04	706.34	115.23	2.94	707.51	116.46	2.96	0.25	0.35
NACL	SPR	25	0.12	0.26	0.17	123.71	168.98	0.14	0.2	0.1	447.22	78.23	1.24	455.54	90.19	1.69	0.35	0.03
NACL	SUM	23	0.07	0.07	0.18	14.87	77.79	0.01	0.05	0.01	28.5	-3.24	0.15	70.79	59.55	0.78	0.1	0.03
NACL	FAL	22	0.07	0.3	0.48	316.01	323.42	0.23	0.23	0.31	223.64	64.73	3.16	236.47	80.72	3.23	0.6	0.23
NACL	ALL	89	0.08	0.21	0.24	169.61	203.53	0.14	0.16	0.12	339.06	61.74	1.7	355.75	85.54	2.04	0.37	0.06
NH4	WIN	20	1.01	1.28	0.5	26.39	37.55	0.27	0.38	0.49	59.26	25.27	0.26	67.04	34.03	0.38	0.75	0.25
NH4	SPR	25	0.74	0.89	0.61	19.22	37.13	0.14	0.28	0.12	28.02	13.49	0.19	46.74	36.8	0.37	0.37	0.37
NH4	SUM	23	0.91	0.87	0.8	-4.79	23.36	-0.04	0.21	0.09	2.54	-6.24	-0.05	32.53	31.42	0.25	0.3	0.64
NH4	FAL	22	0.44	0.85	0.69	93.79	99.57	0.41	0.44	0.19	144.57	61.05	0.94	148.71	66.27	1	0.6	0.47
NH4	ALL	90	0.77	0.96	0.6	24.48	41.81	0.19	0.32	0.24	56.94	22.69	0.24	72.55	42.01	0.42	0.52	0.36
NO3	WIN	20	1.35	2.47	0.46	82.86	88.98	1.12	1.2	2.46	146.15	55.35	0.83	150.67	60.4	0.89	1.93	0.21
NO3	SPR	25	0.61	1	0.49	64.45	92.47	0.39	0.56	0.46	90.09	25.79	0.64	119.14	68.91	0.92	0.78	0.24
NO3	SUM	23	0.24	0.16	0.72	-32.98	52.44	-0.08	0.13	0.02	-40.77	-63.34	-0.49	50.99	70.11	0.78	0.17	0.51
NO3	FAL	22	0.47	1.33	0.73	180.92	195.82	0.86	0.93	1.11	169.89	57.48	1.81	193.11	92.62	1.96	1.36	0.53
NO3	ALL	90	0.65	1.2	0.64	84.45	105.5	0.55	0.68	1.16	88.61	17.33	0.84	126.81	73.12	1.05	1.21	0.41
OC	WIN	22	1.85	5.92	0.59	220.31	220.31	4.07	4.07	3.98	257.15	106.03	2.2	257.15	106.03	2.2	4.53	0.34
OC	SPR	24	1.39	2.22	0.13	60.52	76.3	0.84	1.06	1.34	91.76	38.75	0.61	106.52	56.3	0.76	1.43	0.02
OC	SUM	23	2.39	2.79	0.79	16.97	33.87	0.4	0.81	0.92	17.51	11.14	0.17	32.06	28.14	0.34	1.04	0.62
OC	FAL	23	1.96	3.2	0.65	63.43	71.54	1.24	1.4	3.03	69.45	40.95	0.63	72.96	44.83	0.72	2.14	0.42
OC	ALL	92	1.89	3.49	0.47	84.89	95.35	1.6	1.8	4.29	107.17	48.49	0.85	115.54	58.29	0.95	2.62	0.22
PM-2.5	WIN	20	9.76	16.65	0.7	70.58	74.56	6.89	7.28	25.97	77.81	51.43	0.71	79.89	53.76	0.75	8.57	0.49
PM-2.5	SPR	25	8.21	8.66	0.14	5.44	37.16	0.45	3.05	12.51	12.94	1.92	0.05	41.49	39.02	0.37	3.56	0.02
PM-2.5	SUM	23	13.85	9.2	0.85	-33.62	33.62	-4.66	4.66	6.41	-34.35	-43.46	-0.51	34.35	43.46	0.51	5.3	0.72
PM-2.5	FAL	21	9.57	11.01	0.62	15.11	34.15	1.45	3.27	21.43	16.93	9.17	0.15	32.68	27.93	0.34	4.85	0.38
PM-2.5	ALL	89	10.34	11.15	0.43	7.85	43.21	0.81	4.47	32.22	16.24	3.03	0.08	46.2	40.86	0.43	5.73	0.19
SO4	WIN	20	2.13	1.65	0.34	-22.44	40.39	-0.48	0.86	1.25	-11.25	-23.16	-0.29	38.35	39.6	0.52	1.22	0.11
SO4	SPR	25	2.24	1.89	0.59	-15.59	28.48	-0.35	0.64	0.54	-12.3	-21.98	-0.18	32.79	36.68	0.34	0.81	0.35
SO4	SUM	23	3.54	2.6	0.71	-26.58	31.44	-0.94	1.11	1.29	-26.81	-36.24	-0.36	31.53	40.44	0.43	1.48	0.5
SO4	FAL	22	1.72	1.6	0.76	-6.88	27.67	-0.12	0.48	0.38	-3.68	-10	-0.07	26.77	27.55	0.3	0.63	0.58
SO4	ALL	90	2.42	1.95	0.68	-19.52	31.77	-0.47	0.77	0.94	-13.67	-22.96	-0.24	32.23	36.06	0.39	1.08	0.46

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 540390011																		
EC	WIN	23	0.74	1.01	0.8	36.2	47.62	0.27	0.35	0.1	57.77	31.87	0.36	68.47	43.74	0.48	0.41	0.63
EC	SPR	10	0.71	0.66	0.63	-8.09	29.3	-0.06	0.21	0.05	-5.64	-11.36	-0.09	30.26	32.1	0.32	0.23	0.39
EC	SUM	20	0.93	0.62	0.3	-33.36	36.31	-0.31	0.34	0.13	-24.04	-33.42	-0.5	32.01	39.75	0.54	0.48	0.09
EC	FAL	22	0.89	0.75	0.39	-15.51	33.65	-0.14	0.3	0.32	6.27	-7.54	-0.18	38.97	37.3	0.4	0.58	0.15
EC	ALL	75	0.83	0.78	0.43	-5.88	37.76	-0.05	0.31	0.22	12.4	-2.86	-0.06	45	39.24	0.4	0.47	0.18
NACL	WIN	23	0.04	0.14	0.75	233.71	233.71	0.1	0.1	0.01	672.16	114.81	2.34	672.16	114.81	2.34	0.13	0.56
NACL	SPR	24	0.04	0.09	0.25	123.97	144.4	0.05	0.06	0	581.77	73.54	1.24	596.23	94.22	1.44	0.07	0.06
NACL	SUM	25	0.04	0.04	0.19	-2.46	60.87	0	0.02	0	64.2	-1.35	-0.03	106.74	56.12	0.62	0.04	0.03
NACL	FAL	22	0.06	0.09	0.52	41.17	80.59	0.03	0.05	0.01	76.82	25.96	0.41	102.17	62.31	0.81	0.1	0.27
NACL	ALL	94	0.05	0.09	0.5	93.7	125.35	0.04	0.06	0.01	348.05	52.58	0.94	368.99	81.65	1.25	0.09	0.25
NH4	WIN	23	0.92	1.03	0.74	11.38	37.25	0.11	0.34	0.21	45.07	17.69	0.11	61.63	37.24	0.37	0.47	0.54
NH4	SPR	24	0.8	0.81	0.33	1.52	49.8	0.01	0.4	0.3	41.07	6.15	0.02	75.5	51.04	0.5	0.55	0.11
NH4	SUM	25	0.85	0.84	0.81	-1.13	28.46	-0.01	0.24	0.08	13.95	5.1	-0.01	36.69	32.06	0.29	0.29	0.66
NH4	FAL	20	0.37	0.61	0.59	65.56	66.24	0.24	0.24	0.04	107.6	50.8	0.66	108.56	51.79	0.66	0.32	0.35
NH4	ALL	92	0.75	0.83	0.66	10.58	41.12	0.08	0.31	0.17	49.16	18.45	0.11	68.67	42.6	0.41	0.42	0.44
NO3	WIN	23	0.99	1.73	0.65	74.86	92.06	0.74	0.91	0.75	188.38	56.22	0.75	206.15	78.71	0.92	1.14	0.42
NO3	SPR	24	0.47	0.72	0.27	53.27	129.91	0.25	0.61	1.1	66.38	-18.84	0.53	133.65	84.22	1.3	1.08	0.07
NO3	SUM	25	0.19	0.1	0.28	-48	54.7	-0.09	0.11	0.01	-46.27	-72.78	-0.92	53.21	77.93	1.05	0.13	0.08
NO3	FAL	22	0.26	0.36	0.78	39.42	76.83	0.1	0.2	0.06	35.4	-3.26	0.39	82.64	68.35	0.77	0.27	0.61
NO3	ALL	94	0.47	0.72	0.65	51.47	95.57	0.24	0.45	0.58	59.02	-11.18	0.51	118.06	77.49	0.96	0.8	0.43
OC	WIN	23	1.06	3.97	0.89	273.8	273.8	2.91	2.91	4.08	372.54	116.26	2.74	372.54	116.26	2.74	3.54	0.78
OC	SPR	10	0.79	2.16	0.62	173.49	173.49	1.37	1.37	0.92	241.22	89.66	1.73	241.22	89.66	1.73	1.67	0.38
OC	SUM	20	2.25	2.59	0.79	15.18	25.49	0.34	0.57	0.45	21.93	14.71	0.15	31.78	25.5	0.25	0.75	0.62
OC	FAL	22	1.05	2.3	0.41	118.69	129.41	1.25	1.36	1.48	169.53	68.83	1.19	177.95	80.64	1.29	1.74	0.16
OC	ALL	75	1.34	2.87	0.52	114.32	121.4	1.53	1.63	2.91	201.99	71.72	1.14	207.08	78.06	1.21	2.29	0.27
PM-2.5	WIN	23	9.24	12.43	0.53	34.53	49.71	3.19	4.59	30.43	48.74	29.31	0.35	57.48	41.71	0.5	6.37	0.28
PM-2.5	SPR	24	9.54	8.21	0.5	-13.94	34.79	-1.33	3.32	19.67	-2.29	-10.59	-0.16	33.86	35.5	0.4	4.63	0.25
PM-2.5	SUM	25	14.11	9.92	0.88	-29.7	29.85	-4.19	4.21	5.36	-29.57	-36.06	-0.42	29.72	36.21	0.42	4.79	0.78
PM-2.5	FAL	22	7.54	7.82	0.64	3.74	32.66	0.28	2.46	9.41	61.05	7.12	0.04	84.96	36.59	0.33	3.08	0.41
PM-2.5	ALL	94	10.21	9.61	0.54	-5.95	35.91	-0.61	3.67	23.35	17.77	-3.46	-0.06	50.49	37.46	0.38	4.87	0.29
SO4	WIN	23	2.38	1.57	0.66	-34.03	40.78	-0.81	0.97	1.04	-25.55	-35.2	-0.52	34.12	42.58	0.62	1.3	0.43
SO4	SPR	24	2.93	2.01	0.38	-31.62	44.54	-0.93	1.31	2.41	-22.79	-34.63	-0.46	37.68	46.3	0.65	1.81	0.14
SO4	SUM	25	4.17	3.32	0.89	-20.29	24.48	-0.85	1.02	0.91	-21.21	-27.01	-0.25	25.62	30.98	0.31	1.27	0.78
SO4	FAL	22	1.59	1.58	0.81	-0.17	17.7	0	0.28	0.17	3.05	-2.5	0	21.92	22.15	0.18	0.42	0.66
SO4	ALL	94	2.81	2.15	0.77	-23.49	32.3	-0.66	0.91	1.29	-17	-25.22	-0.31	29.91	35.66	0.42	1.31	0.59

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 540391005																		
EC	WIN	15	0.82	0.77	0.34	-5.81	50.02	-0.05	0.41	0.31	43.12	13.17	-0.06	71.66	52.16	0.53	0.56	0.11
EC	SPR	15	0.8	0.61	0.54	-23.55	33.39	-0.19	0.27	0.08	-11.78	-19.74	-0.31	32.18	36.08	0.44	0.34	0.29
EC	SUM	16	1.07	0.69	0.78	-36.02	36.32	-0.39	0.39	0.08	-31.61	-39.94	-0.56	32.01	40.34	0.57	0.48	0.6
EC	FAL	15	0.73	0.69	0.89	-5.1	28.53	-0.04	0.21	0.06	15.79	8.81	-0.05	35.33	31.91	0.3	0.26	0.8
EC	ALL	61	0.86	0.69	0.59	-19.6	37.24	-0.17	0.32	0.15	3.3	-9.92	-0.24	42.62	40.13	0.46	0.43	0.34
NACL	WIN	14	0.09	0.12	0.74	33.17	52.25	0.03	0.05	0	52.16	27.41	0.33	67.18	45.94	0.52	0.06	0.54
NACL	SPR	15	0.07	0.08	0.12	30.3	90.61	0.02	0.06	0.01	349.33	31.63	0.3	380.8	76.53	0.91	0.08	0.01
NACL	SUM	14	0.05	0.03	0.04	-43.29	46.67	-0.02	0.03	0	-32.59	-48.21	-0.76	37.26	52.58	0.82	0.04	0
NACL	FAL	14	0.14	0.05	0.03	-61.83	81.7	-0.09	0.11	0.06	57.36	-14.04	-1.62	111.33	71.52	2.14	0.25	0
NACL	ALL	57	0.09	0.07	0.13	-16.91	70.63	-0.01	0.06	0.02	110.82	-0.23	-0.2	153.21	61.9	0.85	0.14	0.02
NH4	WIN	14	1.1	0.88	0.75	-19.46	34.54	-0.21	0.38	0.26	-3.9	-10.89	-0.24	30.65	32.89	0.43	0.55	0.57
NH4	SPR	15	1.03	0.8	0.52	-22.89	36.79	-0.24	0.38	0.29	-8.15	-18.49	-0.3	35.09	39.48	0.48	0.59	0.27
NH4	SUM	15	1.3	0.87	0.67	-33.12	37.04	-0.43	0.48	0.23	-25.83	-36.62	-0.5	33.42	43.13	0.55	0.64	0.45
NH4	FAL	13	0.49	0.62	0.58	26.71	53.97	0.13	0.26	0.08	89.57	38.49	0.27	103.41	56.13	0.54	0.31	0.33
NH4	ALL	57	0.99	0.8	0.66	-19.93	38.18	-0.2	0.38	0.26	10.53	-8.4	-0.25	49.14	42.62	0.48	0.55	0.44
NO3	WIN	14	1.43	1.46	0.69	1.99	43.14	0.03	0.62	0.54	8.47	-8.66	0.02	50.43	54.44	0.43	0.74	0.48
NO3	SPR	15	0.73	0.54	0.19	-25.92	80.62	-0.19	0.59	0.49	-19.42	-70.13	-0.35	84.57	107.14	1.09	0.73	0.04
NO3	SUM	15	0.41	0.08	0.85	-80.26	80.26	-0.33	0.33	0.02	-80.35	-135.31	-4.07	80.35	135.31	4.07	0.36	0.73
NO3	FAL	14	0.66	0.4	0.47	-38.94	51.88	-0.26	0.34	0.26	-34.47	-57.94	-0.64	47.16	68.48	0.85	0.57	0.22
NO3	ALL	58	0.8	0.61	0.7	-23.61	58.65	-0.19	0.47	0.35	-32.08	-69.21	-0.31	66.21	92.37	0.77	0.62	0.48
OC	WIN	15	1.91	3.15	0.49	64.98	79.73	1.24	1.52	1.8	101.04	51.89	0.65	110.65	64.01	0.8	1.83	0.24
OC	SPR	15	1.64	1.93	0.46	17.56	34.88	0.29	0.57	0.73	30.96	16.84	0.18	43.51	31.05	0.35	0.9	0.21
OC	SUM	16	2.42	2.89	0.57	19.35	31.58	0.47	0.76	0.86	26.74	16	0.19	37.62	29.08	0.32	1.04	0.32
OC	FAL	15	1.33	2.22	0.73	67.05	67.05	0.89	0.89	1.16	70.95	47.13	0.67	70.95	47.13	0.67	1.4	0.53
OC	ALL	61	1.83	2.55	0.57	39.14	50.95	0.72	0.93	1.27	56.92	32.69	0.39	65.22	42.59	0.51	1.34	0.32
PM-2.5	WIN	15	11.14	10.22	0.57	-8.28	22.93	-0.92	2.55	10.15	-6.89	-11.83	-0.09	23.34	26.03	0.25	3.32	0.33
PM-2.5	SPR	15	10.31	8	0.61	-22.42	27.31	-2.31	2.82	10.56	-17.04	-24.07	-0.29	27.13	32.04	0.35	3.99	0.37
PM-2.5	SUM	14	18.96	10.44	0.85	-44.94	44.94	-8.52	8.52	9.38	-45.08	-59.71	-0.82	45.08	59.71	0.82	9.05	0.71
PM-2.5	FAL	15	8.48	7.45	0.83	-12.18	23.53	-1.03	1.99	7.21	-8.09	-11.9	-0.14	22.19	24.68	0.27	2.88	0.69
PM-2.5	ALL	59	12.11	9	0.68	-25.65	32.16	-3.11	3.89	18.74	-18.84	-26.32	-0.35	29.17	35.21	0.43	5.33	0.46
SO4	WIN	14	2.33	1.37	0.87	-41.27	42.28	-0.96	0.99	0.88	-32.82	-43.13	-0.7	36.16	46.12	0.72	1.34	0.76
SO4	SPR	15	2.86	2.21	0.58	-22.64	35.54	-0.65	1.02	1.49	-19.96	-27.91	-0.29	32.08	37.57	0.46	1.38	0.34
SO4	SUM	15	4.5	3.47	0.74	-22.73	30.23	-1.02	1.36	1.54	-21.69	-29.97	-0.29	31.37	37.66	0.39	1.61	0.55
SO4	FAL	14	2.04	1.65	0.71	-19.29	25.42	-0.39	0.52	0.48	-8.92	-17.67	-0.24	29.43	32.82	0.32	0.8	0.5
SO4	ALL	58	2.96	2.2	0.77	-25.66	33.05	-0.76	0.98	1.17	-20.85	-29.65	-0.35	32.24	38.51	0.44	1.32	0.59

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 540511002																		
EC	WIN	5	1.03	0.5	0.42	-51.31	55.09	-0.53	0.57	0.45	-27.16	-44.39	-1.05	41.47	56.53	1.13	0.86	0.17
EC	SUM	3	0.64	0.33	0.98	-49.19	49.19	-0.32	0.32	0.03	-46.21	-63.28	-0.97	46.21	63.28	0.97	0.36	0.96
EC	FAL	15	0.58	0.34	0.59	-40.75	42.11	-0.24	0.24	0.08	-27.88	-38.18	-0.69	32.94	42.43	0.71	0.37	0.35
EC	ALL	23	0.69	0.38	0.55	-45.24	47.22	-0.31	0.32	0.17	-30.11	-42.8	-0.83	36.52	48.22	0.86	0.51	0.3
NACL	WIN	5	0.07	0.1	0.95	44.81	51.4	0.03	0.04	0	130.01	52.1	0.45	135.42	57.9	0.51	0.05	0.91
NACL	SUM	3	0.08	0.02	0.48	-73.04	73.04	-0.06	0.06	0	-70.02	-109.24	-2.71	70.02	109.24	2.71	0.07	0.23
NACL	FAL	15	0.05	0.05	0.34	-7.47	57.04	0	0.03	0	-3.33	-19.81	-0.08	53.77	54.83	0.62	0.04	0.12
NACL	ALL	23	0.06	0.06	0.64	-5.61	58.43	0	0.04	0	16.96	-15.84	-0.06	73.64	62.6	0.62	0.04	0.41
NH4	WIN	5	0.58	0.71	0.94	22.51	29.47	0.13	0.17	0.03	17.97	13.91	0.23	26.93	23.41	0.29	0.22	0.88
NH4	SUM	3	1.56	0.8	0.78	-48.82	54.21	-0.76	0.85	0.69	-30.69	-46.51	-0.95	43.48	58.17	1.06	1.13	0.61
NH4	FAL	15	0.55	0.57	0.75	4.36	41.81	0.02	0.23	0.12	54.26	23.73	0.04	69.33	42.74	0.42	0.34	0.57
NH4	ALL	23	0.68	0.63	0.63	-8.1	43.23	-0.06	0.3	0.25	35.29	12.43	-0.09	56.74	40.55	0.47	0.5	0.4
NO3	WIN	5	1.32	1.43	0.97	8.16	25.49	0.11	0.34	0.16	-4.53	-12.06	0.08	27.32	31.66	0.25	0.41	0.95
NO3	SUM	3	0.25	0.06	0.96	-75.77	75.77	-0.19	0.19	0	-76.55	-125.02	-3.13	76.55	125.02	3.13	0.19	0.92
NO3	FAL	15	0.48	0.45	0.75	-6.67	50.52	-0.03	0.24	0.09	-3.9	-26.29	-0.07	56.84	62.47	0.54	0.31	0.56
NO3	ALL	23	0.63	0.61	0.93	-3.46	40.45	-0.02	0.26	0.1	-13.52	-36.08	-0.04	52.99	63.93	0.42	0.32	0.86
OC	WIN	5	3	2.17	0.46	-27.45	44.59	-0.82	1.34	4.31	23.84	-5.82	-0.38	65.63	57.94	0.61	2.23	0.21
OC	SUM	3	1.65	2.07	0.48	25.32	35.87	0.42	0.59	0.28	31.36	23.11	0.25	39.57	31.87	0.36	0.67	0.23
OC	FAL	15	1.43	1.21	0.67	-15.49	33.27	-0.22	0.48	0.44	7.57	-2.21	-0.18	38.24	36.23	0.39	0.7	0.45
OC	ALL	23	1.8	1.53	0.57	-14.94	37.68	-0.27	0.68	1.39	14.21	0.31	-0.18	44.37	40.38	0.44	1.21	0.32
PM-2.5	WIN	5	12.18	7.68	0.49	-36.91	37.79	-4.5	4.6	36.02	-26.11	-36.51	-0.59	27.47	37.85	0.6	7.5	0.24
PM-2.5	SUM	3	19.07	9.68	0.93	-49.25	49.25	-9.39	9.39	2.82	-50.83	-69.49	-0.97	50.83	69.49	0.97	9.54	0.86
PM-2.5	FAL	15	9.85	5.8	0.73	-41.11	41.11	-4.05	4.05	9.29	-37.89	-49.77	-0.7	37.89	49.77	0.7	5.07	0.54
PM-2.5	ALL	23	11.56	6.72	0.72	-41.9	42.1	-4.84	4.87	17.39	-37.02	-49.46	-0.72	37.31	49.75	0.72	6.39	0.52
SO4	WIN	5	1.87	0.99	0.84	-46.98	46.98	-0.88	0.88	0.14	-44.97	-60.02	-0.89	44.97	60.02	0.89	0.96	0.7
SO4	SUM	3	6.25	4.43	0.99	-29.19	29.19	-1.82	1.82	0.31	-34.26	-43.02	-0.41	34.26	43.02	0.41	1.91	0.98
SO4	FAL	15	2.28	1.7	0.96	-25.73	26.72	-0.59	0.61	0.31	-26.04	-33.2	-0.35	27.71	34.82	0.36	0.81	0.92
SO4	ALL	23	2.71	1.9	0.97	-29.96	30.5	-0.81	0.83	0.44	-31.23	-40.31	-0.43	32.32	41.37	0.44	1.05	0.94

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 540690010																		
EC	WIN	10	0.5	0.52	0.07	3.55	40.39	0.02	0.2	0.06	17.43	1.41	0.04	48.38	41.91	0.4	0.25	0.01
EC	SPR	15	0.56	0.38	0.58	-32.07	36.88	-0.18	0.21	0.07	-24.01	-32.62	-0.47	32.26	40	0.54	0.32	0.34
EC	SUM	13	0.87	0.4	0.61	-54.33	55.76	-0.47	0.49	0.15	-43.01	-62.01	-1.19	47.25	65.94	1.22	0.61	0.37
EC	ALL	38	0.65	0.42	0.27	-35.06	46.22	-0.23	0.3	0.13	-19.61	-33.72	-0.54	41.63	49.38	0.71	0.43	0.07
NACL	WIN	10	0.09	0.08	0.17	-4.9	49.27	0	0.04	0	24.82	-3.74	-0.05	65.18	48.36	0.52	0.06	0.03
NACL	SPR	14	0.05	0.06	0.19	20.21	59.38	0.01	0.03	0	89.38	23.04	0.2	116.65	58.38	0.59	0.04	0.04
NACL	SUM	9	0.06	0.02	0.82	-56.57	56.57	-0.03	0.03	0	-54.76	-76.48	-1.3	54.76	76.48	1.3	0.03	0.68
NACL	ALL	33	0.06	0.06	0.31	-8.54	54.52	-0.01	0.03	0	30.51	-12.22	-0.09	84.18	60.28	0.6	0.04	0.09
NH4	WIN	10	1.36	1.08	0.79	-20.75	29.11	-0.28	0.4	0.16	-19.26	-25.35	-0.26	28.77	33.48	0.37	0.49	0.63
NH4	SPR	14	0.99	0.83	0.69	-16.44	32.8	-0.16	0.33	0.2	-16.32	-22.67	-0.2	27.43	31.96	0.39	0.47	0.48
NH4	SUM	9	1.49	1.1	0.86	-26.33	30.19	-0.39	0.45	0.21	-8.22	-18.56	-0.36	37.21	36.11	0.41	0.6	0.75
NH4	ALL	33	1.24	0.98	0.77	-21.11	30.72	-0.26	0.38	0.2	-15	-22.36	-0.27	30.5	33.55	0.39	0.52	0.59
NO3	WIN	10	2.07	2.12	0.33	2.56	54.86	0.05	1.14	2.24	22.71	-5.82	0.03	68.85	56.51	0.55	1.5	0.11
NO3	SPR	14	0.78	0.85	0.38	9.43	75.12	0.07	0.58	0.94	39.55	-41.78	0.09	121.66	89.07	0.75	0.97	0.14
NO3	SUM	9	0.39	0.13	0.57	-65.42	65.42	-0.25	0.25	0.03	-62.26	-93.81	-1.89	62.26	93.81	1.89	0.31	0.32
NO3	ALL	33	1.06	1.04	0.6	-2.08	62.2	-0.02	0.66	1.11	6.68	-45.07	-0.02	89.46	80.5	0.64	1.05	0.36
OC	WIN	10	1.67	2.47	0.14	47.61	63.51	0.8	1.06	1.01	66.42	33.64	0.48	81.54	50.98	0.64	1.28	0.02
OC	SPR	15	1.34	1.41	0.71	5.05	33.67	0.07	0.45	0.3	17.03	7.42	0.05	37.95	32.8	0.34	0.55	0.51
OC	SUM	13	2.08	1.89	0.73	-9.15	30.32	-0.19	0.63	0.52	-1.1	-9.33	-0.1	34.5	34.65	0.33	0.75	0.53
OC	ALL	38	1.68	1.85	0.57	10.19	40.07	0.17	0.67	0.72	23.83	8.59	0.1	48.24	38.22	0.4	0.86	0.32
PM-2.5	WIN	10	11.51	9.69	0.51	-15.79	28.83	-1.82	3.32	13.21	-15.98	-23.07	-0.19	28.9	34.1	0.34	4.06	0.26
PM-2.5	SPR	14	9.76	6.74	0.64	-30.9	36.73	-3.02	3.58	9.45	-28.66	-39.46	-0.45	35.93	46.01	0.53	4.31	0.41
PM-2.5	SUM	9	18.87	10.37	0.9	-45.04	45.04	-8.5	8.5	7.33	-46.23	-61.55	-0.82	46.23	61.55	0.82	8.92	0.8
PM-2.5	ALL	33	12.77	8.63	0.69	-32.47	37.92	-4.15	4.84	17.36	-29.61	-40.52	-0.48	36.61	46.64	0.56	5.88	0.47
SO4	WIN	10	2.66	1.42	0.86	-46.77	46.77	-1.24	1.24	0.65	-44.1	-60.47	-0.88	44.1	60.47	0.88	1.48	0.74
SO4	SPR	14	2.92	1.82	0.77	-37.79	37.79	-1.1	1.1	1.17	-38.01	-50.53	-0.61	38.01	50.53	0.61	1.54	0.59
SO4	SUM	9	5.86	4.66	0.94	-20.44	25.34	-1.2	1.48	1.14	-20.74	-25.75	-0.26	26.73	31.32	0.32	1.6	0.89
SO4	ALL	33	3.64	2.47	0.92	-32.16	34.31	-1.17	1.25	1	-35.15	-46.78	-0.47	36.78	48.3	0.51	1.54	0.84

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 550090005																		
EC	WIN	5	0.33	0.74	0.87	120.73	120.73	0.4	0.4	0.02	140.26	79.11	1.21	140.26	79.11	1.21	0.43	0.75
EC	FAL	9	0.33	0.79	0.82	135.99	135.99	0.45	0.45	0.05	1663.06	87.39	1.36	1663.1	87.39	1.36	0.51	0.68
EC	ALL	14	0.33	0.77	0.83	130.53	130.53	0.43	0.43	0.04	1119.21	84.43	1.31	1119.2	84.43	1.31	0.48	0.69
NACL	WIN	5	0.06	0.22	0.53	237.16	237.16	0.15	0.15	0	246.87	103.12	2.37	246.87	103.12	2.37	0.17	0.28
NACL	FAL	9	0.06	0.14	0.48	138.07	141.49	0.08	0.08	0	152.52	73.57	1.38	155.89	77.22	1.41	0.11	0.23
NACL	ALL	14	0.06	0.17	0.5	175.5	177.63	0.11	0.11	0.01	186.21	84.12	1.76	188.38	86.47	1.78	0.13	0.25
NH4	WIN	5	1.35	1.11	1	-17.38	25.87	-0.23	0.35	0.14	9.69	2.64	-0.21	35.2	31.51	0.31	0.44	1
NH4	FAL	9	0.91	1.11	0.9	21.67	30.3	0.2	0.28	0.12	79.39	37.38	0.22	83.44	41.64	0.3	0.4	0.81
NH4	ALL	14	1.07	1.11	0.9	4.11	28.31	0.04	0.3	0.17	54.5	24.98	0.04	66.21	38.02	0.28	0.41	0.81
NO3	WIN	5	3.13	2.66	0.98	-14.91	19.94	-0.47	0.62	0.56	2.89	-2.63	-0.18	29.92	28.5	0.23	0.88	0.97
NO3	FAL	9	1.95	2.27	0.78	16.53	40.91	0.32	0.8	1.22	27.44	0.87	0.17	60.93	46.98	0.41	1.15	0.61
NO3	ALL	14	2.37	2.41	0.87	1.72	31.03	0.04	0.74	1.13	18.67	-0.38	0.02	49.85	40.38	0.31	1.06	0.75
OC	WIN	5	1.14	3.26	0.89	186.62	186.62	2.13	2.13	0.12	268.67	104.63	1.87	268.67	104.63	1.87	2.15	0.79
OC	FAL	8	1.26	2.57	0.6	103.61	111.93	1.31	1.41	1.12	144.56	70.26	1.04	148.79	74.87	1.12	1.68	0.36
OC	ALL	13	1.21	2.83	0.6	133.57	138.88	1.62	1.69	0.9	192.29	83.48	1.34	194.89	86.32	1.39	1.88	0.36
PM-2.5	WIN	5	9.82	11.77	0.95	19.9	23.03	1.95	2.26	5.73	54.19	32.22	0.2	55.97	34.03	0.23	3.09	0.91
PM-2.5	FAL	9	8.86	10.92	0.69	23.35	40.54	2.07	3.59	19.66	224.02	38	0.23	238.61	54.78	0.41	4.89	0.48
PM-2.5	ALL	14	9.2	11.23	0.78	22.04	33.86	2.03	3.12	14.69	163.37	35.94	0.22	173.38	47.37	0.34	4.34	0.61
SO4	WIN	5	1.5	0.92	0.67	-39.13	40.86	-0.59	0.61	0.28	-28.32	-38.38	-0.64	32.54	42.38	0.67	0.79	0.45
SO4	FAL	9	1.38	1.31	0.96	-4.98	24.16	-0.07	0.33	0.17	28.38	11.49	-0.05	46.14	31.33	0.25	0.42	0.93
SO4	ALL	14	1.42	1.17	0.84	-17.87	30.46	-0.25	0.43	0.27	8.13	-6.32	-0.22	41.28	35.28	0.37	0.58	0.71

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 550270001																		
EC	WIN	29	0.3	0.49	0.8	60.31	61.07	0.18	0.19	0.01	69.89	47.53	0.6	70.45	48.1	0.61	0.21	0.64
EC	SPR	31	0.29	0.37	0.8	29.12	40.19	0.08	0.11	0.01	38.88	25.85	0.29	46.7	34.68	0.4	0.14	0.63
EC	SUM	31	0.39	0.32	0.64	-17.31	30.61	-0.07	0.12	0.02	-1.3	-11.66	-0.21	34.56	31.78	0.37	0.16	0.42
EC	FAL	30	0.33	0.47	0.83	40.69	45.89	0.14	0.15	0.03	53.02	33.67	0.41	57.61	38.71	0.46	0.22	0.7
EC	ALL	121	0.33	0.41	0.64	24.8	43.33	0.08	0.14	0.03	39.52	23.37	0.25	51.98	38.15	0.43	0.19	0.41
NACL	WIN	29	0.05	0.11	0.31	104.6	113.79	0.06	0.06	0	278.64	78.17	1.05	282.35	82.25	1.14	0.07	0.1
NACL	SPR	30	0.05	0.09	0.42	79.02	98.11	0.04	0.05	0	141.93	56.51	0.79	153.5	71.43	0.98	0.06	0.18
NACL	SUM	30	0.04	0.02	0.03	-45.51	66.22	-0.02	0.03	0	82.76	-37.82	-0.84	156.37	74.19	1.22	0.04	0
NACL	FAL	28	0.03	0.05	0.04	70.01	93.09	0.02	0.03	0	404.6	48.02	0.7	420.39	69.67	0.93	0.03	0
NACL	ALL	117	0.04	0.07	0.31	53.23	93.84	0.02	0.04	0	223.5	35.66	0.53	250.04	74.4	0.94	0.05	0.1
NH4	WIN	29	1.57	1.32	0.63	-16.09	41.87	-0.25	0.66	1.28	21.29	1.37	-0.19	53.19	41.98	0.5	1.16	0.4
NH4	SPR	31	1.2	1.42	0.79	18.09	36.89	0.22	0.44	0.44	56.54	25.12	0.18	68.47	38.14	0.37	0.7	0.63
NH4	SUM	31	0.66	0.88	0.69	32.29	68.44	0.21	0.45	0.33	195.73	54.83	0.32	210.29	73.74	0.68	0.61	0.47
NH4	FAL	29	0.52	0.9	0.92	74.4	75.38	0.39	0.39	0.11	169.88	71.91	0.74	170.71	72.79	0.75	0.51	0.84
NH4	ALL	120	0.99	1.13	0.72	14.59	49.18	0.14	0.49	0.59	111.37	38.37	0.15	126.12	56.64	0.49	0.78	0.52
NO3	WIN	29	3.61	3.1	0.79	-14.02	29.18	-0.51	1.05	3.49	0.61	-6.72	-0.16	30.19	30.38	0.34	1.93	0.62
NO3	SPR	31	2.41	2.63	0.86	9.17	32.12	0.22	0.77	1.5	32.35	-2.12	0.09	70.24	52.3	0.32	1.24	0.74
NO3	SUM	31	0.67	0.77	0.6	14.26	68.02	0.1	0.46	0.59	49.62	-22.03	0.14	114.07	78.64	0.68	0.77	0.36
NO3	FAL	29	1.02	1.62	0.65	58.5	76.12	0.6	0.78	1.62	66.23	15.85	0.58	97.06	60.78	0.76	1.41	0.42
NO3	ALL	120	1.92	2.02	0.8	5.45	39.72	0.1	0.76	1.93	37.33	-4.03	0.05	78.37	55.85	0.4	1.39	0.64
OC	WIN	29	1.12	2.53	0.76	125.44	125.44	1.41	1.41	0.37	169.27	81.63	1.25	169.27	81.63	1.25	1.53	0.58
OC	SPR	31	0.92	1.61	0.85	74.38	74.38	0.69	0.69	0.19	163.63	61.49	0.74	163.63	61.49	0.74	0.81	0.72
OC	SUM	31	1.57	1.58	0.68	0.5	35.63	0.01	0.56	0.55	13.91	3.65	0.01	39.19	35.2	0.36	0.74	0.47
OC	FAL	29	1.09	1.68	0.72	54.6	58.4	0.59	0.63	0.24	83.17	49.06	0.55	85.3	51.31	0.58	0.77	0.52
OC	ALL	120	1.18	1.84	0.6	56.33	69.26	0.66	0.82	0.58	106.87	48.41	0.56	113.92	57.1	0.69	1.01	0.36
PM-2.5	WIN	29	10.78	10.6	0.8	-1.69	23.66	-0.18	2.55	13.47	6.99	2.8	-0.02	24.17	22.55	0.24	3.67	0.64
PM-2.5	SPR	31	8.54	9.67	0.81	13.24	29.07	1.13	2.48	13.3	27.58	13.86	0.13	41.58	29.9	0.29	3.82	0.65
PM-2.5	SUM	31	8.73	7.35	0.72	-15.72	31.11	-1.37	2.71	10.19	-9.54	-17.61	-0.19	32.79	34.71	0.37	3.47	0.52
PM-2.5	FAL	29	7.32	8.1	0.85	10.55	25.61	0.77	1.88	6.93	15.28	7.88	0.11	31.6	26.9	0.26	2.74	0.73
PM-2.5	ALL	120	8.84	8.92	0.78	0.91	27.3	0.08	2.41	11.96	10.04	1.61	0.01	32.69	28.64	0.27	3.46	0.61
SO4	WIN	29	1.66	1.15	0.47	-30.62	55.66	-0.51	0.92	2.04	-26.89	-41.57	-0.44	42.88	51.75	0.8	1.51	0.22
SO4	SPR	31	1.69	1.87	0.74	10.85	34.69	0.18	0.58	0.93	17.43	6.02	0.11	36.74	28.5	0.35	0.98	0.55
SO4	SUM	31	1.97	1.82	0.72	-7.34	36.72	-0.14	0.72	1.26	10.04	0.1	-0.08	37.79	35.46	0.4	1.13	0.51
SO4	FAL	30	1.27	1.2	0.92	-4.88	29.65	-0.06	0.38	0.24	22.66	7.77	-0.05	45.63	34.78	0.31	0.49	0.85
SO4	ALL	121	1.65	1.52	0.67	-7.71	39.41	-0.13	0.65	1.17	6.21	-6.47	-0.08	40.69	37.41	0.43	1.09	0.45

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 550790026																		
EC	WIN	26	0.45	0.71	0.7	58.97	65.11	0.26	0.29	0.05	71.27	42.6	0.59	75.93	49.02	0.65	0.35	0.49
EC	SPR	29	0.43	0.87	0.71	104.77	112.88	0.45	0.48	0.12	172.29	71.86	1.05	179.19	80.34	1.13	0.57	0.5
EC	SUM	30	0.58	0.96	0.57	66.37	73	0.38	0.42	0.12	87.46	49.21	0.66	91.28	53.61	0.73	0.51	0.32
EC	FAL	28	0.61	0.71	0.87	14.94	36.19	0.09	0.22	0.07	21.63	10.46	0.15	41.18	34.06	0.36	0.29	0.76
EC	ALL	113	0.52	0.82	0.7	57.92	69.07	0.3	0.36	0.11	89.2	43.9	0.58	97.9	54.57	0.69	0.45	0.49
NACL	WIN	28	0.12	0.15	0.26	26.92	96.42	0.03	0.12	0.03	134.48	52.98	0.27	153.73	80.32	0.96	0.16	0.07
NACL	SPR	30	0.05	0.09	0.56	84.38	92.3	0.04	0.05	0	115.63	59.78	0.84	119.01	63.83	0.92	0.06	0.31
NACL	SUM	30	0.04	0.03	0.39	-30.88	48.79	-0.01	0.02	0	-13.54	-32.59	-0.45	48.54	54.56	0.71	0.03	0.15
NACL	FAL	29	0.05	0.04	0.08	-16.97	60.79	-0.01	0.03	0	20.53	-16.76	-0.2	74.29	62.3	0.73	0.05	0.01
NACL	ALL	117	0.07	0.08	0.39	20.08	80.72	0.01	0.05	0.01	63.45	15.5	0.2	98.17	65.02	0.81	0.09	0.16
NH4	WIN	28	1.59	1.31	0.81	-17.5	36.26	-0.28	0.58	0.57	11.86	-5.87	-0.21	48.57	39.67	0.44	0.81	0.66
NH4	SPR	30	1.13	1.49	0.71	31.67	56.6	0.36	0.64	0.65	109.16	31.7	0.32	129.14	56.75	0.57	0.88	0.5
NH4	SUM	31	0.66	0.88	0.63	32.95	64.02	0.22	0.42	0.28	128.57	52.25	0.33	139.78	67.44	0.64	0.57	0.4
NH4	FAL	30	0.62	0.74	0.95	18.5	30.6	0.12	0.19	0.05	77.95	36.97	0.18	87.11	47.52	0.31	0.25	0.9
NH4	ALL	119	0.99	1.1	0.77	11.24	46.09	0.11	0.46	0.44	83.46	29.54	0.11	102.36	53.19	0.46	0.67	0.59
NO3	WIN	28	3.51	2.88	0.9	-18.1	27.73	-0.64	0.97	1.31	-12.47	-21.72	-0.22	34.15	38.29	0.34	1.31	0.81
NO3	SPR	30	2.39	3.06	0.76	28.08	60.64	0.67	1.45	3.95	72.34	15.32	0.28	107.08	68.35	0.61	2.1	0.58
NO3	SUM	31	0.62	0.64	0.57	4.18	74.03	0.03	0.46	0.43	13.03	-33.94	0.04	87.9	81.82	0.74	0.66	0.33
NO3	FAL	30	1.19	1.08	0.88	-9.12	46.14	-0.11	0.55	0.5	-26.07	-59.34	-0.1	60.81	83.38	0.51	0.72	0.78
NO3	ALL	119	1.89	1.89	0.82	-0.04	45.09	0	0.85	1.76	12.13	-25.05	0	73.26	68.57	0.45	1.33	0.68
OC	WIN	26	1.36	2.35	0.48	72.21	82.7	0.99	1.13	0.61	91.33	54.1	0.72	97.24	62.06	0.83	1.26	0.23
OC	SPR	29	1.11	2.41	0.82	116.94	121.07	1.3	1.35	0.8	179.48	75.7	1.17	183.11	79.87	1.21	1.58	0.67
OC	SUM	30	1.87	2.53	0.66	35.33	49.29	0.66	0.92	0.94	47.89	29.22	0.35	57.17	40.54	0.49	1.17	0.43
OC	FAL	28	1.48	1.72	0.75	16.43	33.86	0.24	0.5	0.46	24.02	13.64	0.16	38.82	31.08	0.34	0.72	0.56
OC	ALL	113	1.46	2.26	0.64	54.46	66.62	0.8	0.97	0.86	85.74	43.01	0.54	94.16	53.24	0.67	1.22	0.4
PM-2.5	WIN	28	11.09	10.74	0.8	-3.2	25.28	-0.36	2.8	14.87	10.04	1.49	-0.03	33.54	28.99	0.26	3.87	0.64
PM-2.5	SPR	30	8.69	12.55	0.8	44.38	57.8	3.86	5.02	29.38	57.62	32.26	0.44	71.08	48.96	0.58	6.65	0.64
PM-2.5	SUM	31	10.88	10.23	0.63	-6.01	32.9	-0.65	3.58	20.85	4.9	-4.9	-0.06	37.21	35.61	0.35	4.61	0.39
PM-2.5	FAL	30	7.55	7.85	0.93	3.92	20.74	0.3	1.57	5.05	2.28	-1.46	0.04	21.32	21.59	0.21	2.27	0.87
PM-2.5	ALL	119	9.54	10.33	0.74	8.31	34.11	0.79	3.25	20.89	18.74	6.84	0.08	40.88	33.88	0.34	4.64	0.55
SO4	WIN	28	1.76	1.27	0.47	-28.19	50.2	-0.5	0.88	1.84	-21.05	-32.98	-0.39	38.11	44.51	0.7	1.44	0.22
SO4	SPR	30	1.65	2.13	0.7	29.53	52.27	0.49	0.86	2.16	33.55	14.62	0.3	51.55	35.66	0.52	1.55	0.49
SO4	SUM	31	2.16	2.18	0.56	0.9	39.55	0.02	0.85	2.57	20.75	6.33	0.01	41.21	33.73	0.4	1.6	0.32
SO4	FAL	30	1.45	1.26	0.92	-13.06	29.55	-0.19	0.43	0.3	5.69	-3.11	-0.15	34.48	32.03	0.34	0.58	0.84
SO4	ALL	119	1.76	1.72	0.58	-2.1	42.99	-0.04	0.76	1.85	10.35	-3.21	-0.02	41.39	36.32	0.44	1.36	0.34

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 551198001																		
EC	WIN	15	0.26	0.28	0.61	7.89	43.16	0.02	0.11	0.02	40.05	22.35	0.08	56.9	44.35	0.43	0.14	0.37
EC	SPR	15	0.19	0.17	0.39	-7.77	47.72	-0.01	0.09	0.03	39.33	9.09	-0.08	67.23	49.56	0.52	0.17	0.15
EC	SUM	16	0.24	0.14	0.64	-42.69	43.01	-0.1	0.1	0.01	-39.92	-53.41	-0.74	40.28	53.77	0.75	0.13	0.41
EC	FAL	15	0.26	0.29	0.88	10.91	26.14	0.03	0.07	0.01	28.76	12.74	0.11	44.84	31.29	0.26	0.1	0.77
EC	ALL	61	0.24	0.22	0.61	-7.96	39.43	-0.02	0.09	0.02	16.12	-3.15	-0.09	52.12	44.89	0.43	0.14	0.37
NACL	WIN	13	0.1	0.07	0.27	-32.2	64.74	-0.03	0.06	0.02	21.01	-9.34	-0.48	63.19	55.72	0.95	0.13	0.07
NACL	SPR	15	0.05	0.05	0.11	8.4	70.67	0	0.03	0	162.01	7.14	0.08	207.49	69.45	0.71	0.04	0.01
NACL	SUM	16	0.03	0.02	0.16	-53.65	67.25	-0.02	0.02	0	-8.59	-41.59	-1.16	64.02	75.24	1.45	0.04	0.02
NACL	FAL	15	0.04	0.04	0.06	5.22	82.54	0	0.03	0	707.81	14.96	0.05	748.97	77.71	0.83	0.05	0
NACL	ALL	59	0.05	0.04	0.1	-19.54	70.01	-0.01	0.04	0	223.44	-7.72	-0.24	274.46	70.1	0.87	0.07	0.01
NH4	WIN	14	0.99	0.87	0.83	-12.06	30.78	-0.12	0.3	0.22	8.26	-2.56	-0.14	35.67	35.41	0.35	0.48	0.69
NH4	SPR	15	1.07	0.96	0.88	-11.07	39.89	-0.12	0.43	0.39	90.03	24.84	-0.12	112.46	53.49	0.45	0.64	0.77
NH4	SUM	16	0.26	0.46	0.92	79.57	79.57	0.21	0.21	0.05	249.12	67.85	0.8	249.12	67.85	0.8	0.31	0.85
NH4	FAL	13	0.75	1.11	0.86	48.02	55.99	0.36	0.42	0.22	229.06	72.04	0.48	232.48	75.8	0.56	0.59	0.75
NH4	ALL	58	0.76	0.83	0.83	10.26	44.32	0.08	0.33	0.26	145.34	40.67	0.1	158.52	58.09	0.44	0.51	0.69
NO3	WIN	14	2.42	2.07	0.83	-14.3	32.98	-0.35	0.8	1.36	5.59	-10.64	-0.17	42.33	39.11	0.38	1.22	0.69
NO3	SPR	15	1.97	1.52	0.94	-23.05	31.53	-0.45	0.62	0.99	-24.83	-45.98	-0.3	49.54	63.53	0.41	1.09	0.88
NO3	SUM	16	0.22	0.2	0.86	-6.97	61.06	-0.02	0.13	0.03	-17.29	-51.45	-0.07	69.68	83.7	0.66	0.17	0.73
NO3	FAL	15	1.38	1.88	0.88	36.09	62.15	0.5	0.86	1.38	52.72	-8.21	0.36	109.2	83.8	0.62	1.28	0.77
NO3	ALL	60	1.46	1.39	0.87	-5.03	40.5	-0.07	0.59	1.05	3.67	-29.75	-0.05	68.15	68.28	0.43	1.03	0.76
OC	WIN	15	1.03	1.83	0.58	78.15	90.81	0.8	0.93	0.36	143.87	69.58	0.78	149.42	76.16	0.91	1	0.34
OC	SPR	15	0.53	1.1	0.47	108.45	130.02	0.57	0.69	0.36	336.34	79.09	1.08	344.16	90.16	1.3	0.83	0.22
OC	SUM	16	1.56	1.15	0.61	-26.56	39.39	-0.42	0.62	0.41	-18.59	-28.45	-0.36	36.41	43.11	0.54	0.76	0.37
OC	FAL	14	1.02	1.47	0.81	44.18	48.38	0.45	0.49	0.25	82.62	47.87	0.44	84.86	50.3	0.48	0.67	0.65
OC	ALL	60	1.04	1.38	0.5	32.42	65.58	0.34	0.68	0.57	134.37	40.75	0.32	152.91	64.81	0.66	0.83	0.25
PM-2.5	WIN	14	9.43	7.24	0.83	-23.25	26.62	-2.19	2.51	6.96	-18.57	-24.89	-0.3	25.73	31.22	0.35	3.43	0.69
PM-2.5	SPR	15	7.59	6.27	0.84	-17.37	29.57	-1.32	2.25	11.99	-4.24	-12.42	-0.21	31.91	33.9	0.36	3.71	0.71
PM-2.5	SUM	16	7.61	4.38	0.64	-42.41	45.67	-3.23	3.48	5.37	-43.17	-58.86	-0.74	45.63	61.1	0.79	3.97	0.41
PM-2.5	FAL	15	7.41	7.46	0.91	0.75	25.14	0.06	1.86	6.54	0.44	-5.7	0.01	27.44	28.89	0.25	2.56	0.82
PM-2.5	ALL	60	7.98	6.29	0.81	-21.16	31.82	-1.69	2.54	9.17	-16.8	-26.03	-0.27	33.01	39.28	0.4	3.47	0.65
SO4	WIN	14	1.46	0.81	0.81	-44.4	44.4	-0.65	0.65	0.27	-39.91	-53.8	-0.8	39.91	53.8	0.8	0.83	0.65
SO4	SPR	14	1.77	1.55	0.74	-12.62	35.71	-0.22	0.63	0.85	5.8	-2.76	-0.14	34.52	33.6	0.41	0.95	0.54
SO4	SUM	16	1.22	1.21	0.88	-0.55	30.1	-0.01	0.37	0.28	0.34	-4.96	-0.01	28.06	27.84	0.3	0.53	0.77
SO4	FAL	15	1.41	1.32	0.89	-6.47	28.81	-0.09	0.41	0.32	19.42	5.83	-0.07	43.95	34.82	0.31	0.57	0.79
SO4	ALL	59	1.46	1.23	0.78	-15.92	34.8	-0.23	0.51	0.48	-3.07	-13.28	-0.19	36.45	37.14	0.41	0.73	0.6

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
CSN Monitoring Station: 551330027																		
EC	WIN	14	0.42	0.68	0.57	63.17	63.17	0.26	0.26	0.02	74.06	49.01	0.63	74.06	49.01	0.63	0.31	0.33
EC	SPR	15	0.51	0.66	0.69	28.66	48.19	0.15	0.25	0.07	50.74	33.12	0.29	58.81	42.65	0.48	0.3	0.47
EC	SUM	16	0.85	0.67	0.66	-21.07	25.32	-0.18	0.21	0.09	-12.86	-17.25	-0.27	19.25	23.32	0.32	0.34	0.44
EC	FAL	14	0.57	0.72	0.75	26.3	34.5	0.15	0.2	0.04	31.74	23.55	0.26	37.21	29.73	0.34	0.24	0.56
EC	ALL	59	0.59	0.68	0.56	14.64	38.71	0.09	0.23	0.08	34.52	20.96	0.15	46.57	35.85	0.39	0.3	0.32
NACL	WIN	15	0.14	0.09	0.07	-36.64	60.35	-0.05	0.09	0.02	16.89	-9.11	-0.58	59.24	58.5	0.95	0.14	0
NACL	SPR	15	0.06	0.08	0.56	49.83	80.19	0.03	0.04	0	117.12	50.23	0.5	128.8	65.86	0.8	0.06	0.32
NACL	SUM	14	0.05	0.03	0.54	-50.2	51.79	-0.03	0.03	0	-46.4	-69.35	-1.01	49.61	72.24	1.04	0.03	0.29
NACL	FAL	14	0.06	0.04	0.36	-30.55	40.47	-0.02	0.03	0	-19.65	-31.05	-0.44	36.97	45.54	0.58	0.03	0.13
NACL	ALL	58	0.08	0.06	0.34	-22.1	58.75	-0.02	0.05	0.01	18.71	-13.6	-0.28	69.53	60.59	0.75	0.08	0.12
NH4	WIN	15	1.34	1.09	0.87	-19.05	35.67	-0.26	0.48	0.51	0.47	-6.45	-0.24	30.33	32.81	0.44	0.76	0.76
NH4	SPR	15	1.25	1.47	0.85	17.9	34.72	0.22	0.43	0.32	65.04	27.79	0.18	79.01	43.3	0.35	0.61	0.72
NH4	SUM	14	0.9	0.98	0.63	9.41	46.13	0.08	0.41	0.26	60.18	26.2	0.09	78.56	50.32	0.46	0.52	0.39
NH4	FAL	13	0.67	0.8	0.8	19.12	44.76	0.13	0.3	0.17	85.87	38.01	0.19	94.98	48.35	0.45	0.43	0.64
NH4	ALL	57	1.05	1.1	0.8	3.92	38.87	0.04	0.41	0.36	51.61	20.72	0.04	69.73	43.42	0.39	0.6	0.63
NO3	WIN	15	3.19	2.62	0.89	-17.85	27.55	-0.57	0.88	1.3	-11.13	-17.79	-0.22	27.79	32.21	0.34	1.28	0.8
NO3	SPR	15	2.49	2.74	0.89	9.92	36.43	0.25	0.91	1.11	19.04	-7.09	0.1	64.92	58.72	0.36	1.08	0.78
NO3	SUM	14	0.8	0.6	0.36	-25.86	62.18	-0.21	0.5	0.6	-7.52	-41.14	-0.35	67.4	76.83	0.84	0.8	0.13
NO3	FAL	14	1.35	1.38	0.85	1.73	33.74	0.02	0.46	0.47	-0.6	-22.67	0.02	51.72	49.65	0.34	0.69	0.73
NO3	ALL	58	1.99	1.86	0.87	-6.43	34.82	-0.13	0.69	0.98	0.09	-21.84	-0.07	52.73	54.05	0.37	1	0.76
OC	WIN	14	1.22	2.4	0.65	97.05	97.05	1.18	1.18	0.3	118.29	68.78	0.97	118.29	68.78	0.97	1.3	0.42
OC	SPR	15	1.03	1.89	0.77	84.63	84.63	0.87	0.87	0.36	107.8	62.34	0.85	107.8	62.34	0.85	1.05	0.59
OC	SUM	16	2.34	2.07	0.62	-11.54	30.95	-0.27	0.73	1.17	-4.3	-11.18	-0.13	26.97	29.17	0.35	1.12	0.38
OC	FAL	14	1.44	1.71	0.61	18.75	41.95	0.27	0.6	0.53	49.33	30.26	0.19	59.52	42.45	0.42	0.78	0.38
OC	ALL	59	1.53	2.02	0.53	32.23	55.1	0.49	0.84	0.92	66.01	36.32	0.32	76.91	50.15	0.55	1.08	0.29
PM-2.5	WIN	15	10.37	9.85	0.9	-5	22.04	-0.52	2.28	7.48	5.35	1.58	-0.05	24.26	23.16	0.23	2.78	0.81
PM-2.5	SPR	15	9.73	10.96	0.95	12.56	18.43	1.22	1.79	3.35	17.14	11.77	0.13	27.13	23.95	0.18	2.2	0.91
PM-2.5	SUM	14	14.06	9.4	0.87	-33.19	33.19	-4.67	4.67	7.1	-31.84	-39.37	-0.5	31.84	39.37	0.5	5.37	0.75
PM-2.5	FAL	14	8.02	7.82	0.78	-2.45	25.25	-0.2	2.03	7.09	20.34	6.4	-0.03	40.06	29.49	0.26	2.67	0.61
PM-2.5	ALL	58	10.53	9.54	0.81	-9.42	25.36	-0.99	2.67	10.97	3.04	-4.51	-0.1	30.65	28.8	0.28	3.46	0.66
SO4	WIN	15	1.56	0.92	0.76	-41.05	42.67	-0.64	0.67	0.61	-34.47	-45.81	-0.7	36.41	47.67	0.72	1.01	0.57
SO4	SPR	15	1.8	2.05	0.76	13.68	39.15	0.25	0.71	0.98	28.51	14.03	0.14	45.69	34.41	0.39	1.02	0.58
SO4	SUM	14	2.75	2.3	0.56	-16.3	27.45	-0.45	0.75	1.68	-0.76	-9.27	-0.19	27.63	29.82	0.33	1.37	0.31
SO4	FAL	14	1.37	1.03	0.87	-24.95	35.88	-0.34	0.49	0.37	-3.31	-12.45	-0.33	36.31	36.94	0.48	0.7	0.76
SO4	ALL	58	1.86	1.57	0.69	-15.71	35.17	-0.29	0.66	1.02	-2.52	-13.46	-0.19	36.67	37.34	0.42	1.05	0.47

2011 Model Performance Results by Pollutant and Quarter - CSN Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)

N: Number of observations
MEAN_O: Average of the observed values
MEAN_P: Average of the modeled values
r: Pearson correlation coefficient
NMB: Normalized Mean Bias
NME: Normalized Mean Error
MB: Mean Bias
ME: Mean Error
VAR: Variance
MNB: Mean Normalized Bias
MFB: Mean Fractional Bias
NMBF: Normalized Mean Bias Fraction
MNGE: Mean Normalized Gross Factor
MFE: Mean Fractional Error
NMEF: Normalized Mean Error Fraction
RMSE: Root Mean Squared Error
RSQR: r-squared

This page is intentionally left blank.

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: ACAD1																		
EC	WIN	29	0.13	0.24	0.85	87.47	91.82	0.11	0.12	0.01	108.89	59.88	0.87	113.41	66	0.92	0.15	0.72
EC	SPR	31	0.08	0.14	0.56	61.51	75.3	0.05	0.06	0	132.41	57.23	0.62	138.85	64.89	0.75	0.08	0.31
EC	SUM	27	0.14	0.15	0.81	0.9	33.13	0	0.05	0	34.21	12.56	0.01	56.72	38.73	0.33	0.06	0.66
EC	FAL	30	0.16	0.19	0.68	13.65	40.38	0.02	0.07	0.01	40.11	15.62	0.14	59	38.53	0.4	0.09	0.46
EC	ALL	117	0.13	0.18	0.66	36.58	57.05	0.05	0.07	0.01	80.25	36.91	0.37	93.11	52.37	0.57	0.1	0.43
NO3	WIN	29	0.31	0.77	0.88	149.44	154.76	0.46	0.48	0.26	195.18	70.27	1.49	206.82	86.63	1.55	0.69	0.77
NO3	SPR	31	0.15	0.29	0.36	93.35	138.96	0.14	0.21	0.07	222.54	34.14	0.93	264.61	101.51	1.39	0.29	0.13
NO3	SUM	31	0.13	0.08	0.55	-34.2	61.95	-0.04	0.08	0.01	-17.69	-57.34	-0.52	70.8	88.23	0.94	0.1	0.30
NO3	FAL	30	0.23	0.42	0.77	85.46	108.48	0.19	0.25	0.21	69.85	13.09	0.85	108.15	69.35	1.08	0.49	0.59
NO3	ALL	121	0.2	0.39	0.8	91.58	124.05	0.18	0.25	0.17	116.58	14.14	0.92	162.31	86.57	1.24	0.45	0.64
OC	WIN	29	0.64	1.08	0.84	69.99	71.9	0.45	0.46	0.16	79.98	49.8	0.7	82.11	52.11	0.72	0.6	0.70
OC	SPR	31	0.43	0.61	0.73	40.82	52.32	0.18	0.23	0.06	57.27	35.79	0.41	64.54	44.1	0.52	0.3	0.53
OC	SUM	27	1.14	0.75	0.82	-34.03	40.89	-0.39	0.46	0.3	-24.42	-37.05	-0.52	39.67	48.74	0.62	0.67	0.66
OC	FAL	30	0.8	0.77	0.72	-4.09	33.95	-0.03	0.27	0.12	6.33	-6.22	-0.04	41.05	37.31	0.35	0.35	0.52
OC	ALL	117	0.74	0.8	0.62	8.08	47.35	0.06	0.35	0.24	30.99	11.68	0.08	57.13	45.42	0.47	0.5	0.39
PM-2.5	WIN	29	3.48	4.77	0.83	37.12	44.98	1.29	1.57	2.83	44.03	29.55	0.37	49.99	37.52	0.45	2.12	0.69
PM-2.5	SPR	31	3.12	4.26	0.63	36.35	47.57	1.13	1.49	3.43	60.27	28.38	0.36	69.85	39.69	0.48	2.17	0.40
PM-2.5	SUM	31	5.28	4.26	0.69	-19.27	33.77	-1.02	1.78	5.49	-10.83	-18.97	-0.24	31.38	35.27	0.42	2.55	0.48
PM-2.5	FAL	29	4.16	4.12	0.74	-0.98	32.91	-0.04	1.37	3.64	12.08	0.69	-0.01	37.84	32.22	0.33	1.91	0.55
PM-2.5	ALL	120	4.02	4.35	0.65	8.29	38.67	0.33	1.55	4.76	26.33	9.74	0.08	47.38	36.22	0.39	2.21	0.43
SO4	WIN	29	1.03	0.87	0.86	-15.38	27.88	-0.16	0.29	0.11	-7.68	-12.66	-0.18	26.84	27.95	0.33	0.36	0.73
SO4	SPR	31	0.92	1.83	0.45	97.49	105.95	0.9	0.98	2.13	202.08	47.62	0.97	209.83	56.81	1.06	1.71	0.20
SO4	SUM	31	1.08	1.8	0.7	66.53	79.43	0.72	0.86	1.33	106.14	48.35	0.67	114.52	57.93	0.79	1.36	0.49
SO4	FAL	30	1.13	1.29	0.73	14.28	41.23	0.16	0.47	0.42	44.47	17.34	0.14	64.07	41.63	0.41	0.67	0.53
SO4	ALL	121	1.04	1.46	0.55	40.11	62.98	0.42	0.66	1.19	88.15	25.85	0.4	105.42	46.41	0.63	1.17	0.30

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BADL1																		
EC	WIN	29	0.07	0.11	0.42	55.91	77.49	0.04	0.05	0	78.58	37.67	0.56	93.53	55.67	0.77	0.08	0.17
EC	SPR	31	0.08	0.14	0.5	65.64	97.38	0.05	0.08	0.02	109.75	16.82	0.66	141.54	59.1	0.97	0.15	0.25
EC	SUM	31	0.12	0.11	0.75	-9.18	27.64	-0.01	0.03	0	-3.52	-10.98	-0.1	29.13	30.58	0.3	0.04	0.56
EC	FAL	30	0.09	0.24	0.06	154.75	170.9	0.14	0.16	0.18	212.51	45.89	1.55	222.84	59.41	1.71	0.44	0.00
EC	ALL	121	0.09	0.15	0.19	60.49	88.24	0.06	0.08	0.05	98.74	21.9	0.6	121.39	51.05	0.88	0.24	0.04
NO3	WIN	29	0.37	0.88	0.82	136.36	139.64	0.51	0.52	0.37	199.2	77.04	1.36	205.03	84.42	1.4	0.79	0.67
NO3	SPR	31	0.44	1.14	0.65	160.42	171.74	0.71	0.75	1.35	151.14	37.36	1.6	182.53	82.87	1.72	1.36	0.42
NO3	SUM	31	0.2	0.07	0.06	-65.35	87.28	-0.13	0.18	0.08	-27.27	-84.66	-1.89	91.74	108.29	2.52	0.31	0.00
NO3	FAL	30	0.11	0.24	0.77	124.47	166.31	0.13	0.18	0.14	85.71	-11.09	1.24	148.51	80.44	1.66	0.4	0.59
NO3	ALL	121	0.28	0.58	0.68	107.41	145.33	0.3	0.41	0.6	100.73	3.6	1.07	156.23	89.15	1.45	0.83	0.47
OC	WIN	29	0.29	0.38	0.3	27.85	71.35	0.08	0.21	0.09	46.29	11.79	0.28	77.92	54.33	0.71	0.31	0.09
OC	SPR	31	0.49	0.53	0.61	10.13	67.09	0.05	0.33	0.33	36.85	-23.38	0.1	100.21	68.91	0.67	0.57	0.38
OC	SUM	31	1.08	0.63	0.7	-41.63	43.41	-0.45	0.47	0.12	-40.92	-57.77	-0.71	43.76	60.32	0.74	0.56	0.49
OC	FAL	30	0.6	1.02	0.05	69.3	124.46	0.42	0.75	3.89	205.67	0.14	0.69	252.07	63.44	1.24	2.02	0.00
OC	ALL	121	0.62	0.64	0.2	3.26	70.79	0.02	0.44	1.2	61.05	-17.93	0.03	118.06	61.86	0.71	1.09	0.04
PM-2.5	WIN	29	2.17	2.84	0.61	30.66	47.98	0.67	1.04	1.51	51.97	30.08	0.31	62.58	42.42	0.48	1.4	0.37
PM-2.5	SPR	31	3.1	4.43	0.63	43.15	62.6	1.34	1.94	11.76	45.3	13.11	0.43	70.58	45.09	0.63	3.68	0.40
PM-2.5	SUM	31	4.73	2.78	0.67	-41.23	42.24	-1.95	2	1.47	-40.05	-54.99	-0.7	41.84	56.56	0.72	2.3	0.45
PM-2.5	FAL	30	3.05	3.83	0.02	25.36	68.28	0.77	2.08	22.87	74.34	3.78	0.25	106.43	45.21	0.68	4.84	0.00
PM-2.5	ALL	121	3.28	3.48	0.32	5.91	54.07	0.19	1.78	11.07	32.23	-2.58	0.06	70.19	47.42	0.54	3.33	0.10
SO4	WIN	29	0.74	0.48	0.58	-35.62	55.15	-0.26	0.41	0.36	16.07	-7.18	-0.55	59.12	54.1	0.86	0.66	0.34
SO4	SPR	31	0.87	0.98	0.57	12.06	45.09	0.11	0.39	0.74	32.85	6.06	0.12	61.6	41.21	0.45	0.87	0.33
SO4	SUM	31	0.83	0.64	0.52	-22.73	31.74	-0.19	0.26	0.08	-17.62	-25.87	-0.29	31.41	37.32	0.41	0.34	0.27
SO4	FAL	30	0.54	0.59	0.69	8.82	37.08	0.05	0.2	0.07	26.97	14.17	0.09	45.82	36.68	0.37	0.27	0.47
SO4	ALL	121	0.75	0.68	0.5	-9.74	42.22	-0.07	0.32	0.34	14.44	-3.28	-0.11	49.36	42.18	0.47	0.59	0.25

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BAND1																		
EC	WIN	29	0.14	0.09	0.3	-33.96	54.97	-0.05	0.07	0.01	1.47	-19.19	-0.51	54.36	54.28	0.83	0.11	0.09
EC	SPR	31	0.07	0.07	0.64	7.36	33.37	0	0.02	0	46.2	17.17	0.07	61.37	35.54	0.33	0.03	0.40
EC	SUM	25	0.39	0.31	0.51	-22.29	75.6	-0.09	0.3	0.48	5.11	-17.99	-0.29	49.74	44.32	0.97	0.7	0.26
EC	FAL	25	0.11	0.09	0.38	-10.25	35.32	-0.01	0.04	0	5.69	-6.08	-0.11	40.19	38.09	0.39	0.05	0.14
EC	ALL	110	0.17	0.13	0.55	-19.78	60.77	-0.03	0.1	0.11	15.86	-5.69	-0.25	52.07	43.06	0.76	0.34	0.30
NO3	WIN	28	0.23	0.07	0.29	-68.41	74.7	-0.16	0.17	0.05	-47.72	-89	-2.17	70	101.98	2.36	0.27	0.08
NO3	SPR	31	0.16	0.05	0.74	-70.81	70.81	-0.11	0.11	0.01	-65.71	-100.99	-2.43	65.71	100.99	2.43	0.15	0.54
NO3	SUM	23	0.16	0.04	0.47	-76.6	76.62	-0.12	0.12	0.03	-62.81	-98.85	-3.27	62.87	98.91	3.27	0.2	0.22
NO3	FAL	25	0.09	0.05	0.48	-45.96	52.78	-0.04	0.05	0.01	-23.57	-37.09	-0.85	36.03	47.26	0.98	0.12	0.23
NO3	ALL	107	0.16	0.05	0.4	-67.86	71.1	-0.11	0.12	0.03	-50.53	-82.46	-2.11	59.29	88.25	2.21	0.2	0.16
OC	WIN	29	0.5	0.33	0.29	-34.89	51.8	-0.18	0.26	0.09	-11.26	-29.17	-0.54	49.1	53.4	0.8	0.35	0.09
OC	SPR	31	0.35	0.25	0.7	-27.94	34.62	-0.1	0.12	0.01	-21.68	-30.35	-0.39	32.92	39.56	0.48	0.15	0.49
OC	SUM	25	2.72	1.65	0.51	-39.47	71.94	-1.07	1.96	14.98	-29.83	-50.29	-0.65	48.57	62.65	1.19	4.02	0.26
OC	FAL	25	0.51	0.41	0.47	-20.54	36.49	-0.11	0.19	0.05	-12.48	-22.18	-0.26	35.49	40.7	0.46	0.25	0.23
OC	ALL	110	0.97	0.62	0.58	-35.38	61.1	-0.34	0.59	3.6	-18.69	-32.71	-0.55	41.33	48.71	0.95	1.93	0.33
PM-2.5	WIN	29	1.9	1.95	0.17	2.9	41.45	0.06	0.79	0.88	13.48	2.15	0.03	43.44	39.58	0.41	0.94	0.03
PM-2.5	SPR	31	3.61	2.36	0.55	-34.47	41.02	-1.24	1.48	3.72	-21.69	-31.95	-0.53	33.91	42.37	0.63	2.3	0.30
PM-2.5	SUM	25	7.3	4.91	0.51	-32.82	61.65	-2.4	4.5	60.28	-28.79	-46.41	-0.49	46.49	57.19	0.92	8.13	0.26
PM-2.5	FAL	25	2.39	2.66	0.3	11.55	40.64	0.28	0.97	1.33	30.26	15.47	0.12	49.17	39.17	0.41	1.19	0.09
PM-2.5	ALL	110	3.72	2.9	0.55	-21.99	50.23	-0.82	1.87	16.38	-2.22	-15.47	-0.28	42.75	44.27	0.64	4.13	0.30
SO4	WIN	28	0.32	0.44	0.59	37.82	54.4	0.12	0.17	0.02	54.89	35.08	0.38	64.04	46.35	0.54	0.2	0.35
SO4	SPR	31	0.59	0.5	0.56	-14.66	35.07	-0.09	0.21	0.13	2.97	-5.26	-0.17	32.26	31.61	0.41	0.37	0.31
SO4	SUM	23	0.77	0.52	0.61	-32.61	36.08	-0.25	0.28	0.1	-31.96	-44.16	-0.48	36.19	47.88	0.54	0.4	0.37
SO4	FAL	25	0.51	0.39	0.24	-23.96	37.78	-0.12	0.19	0.12	-2.48	-15	-0.32	36.2	36.41	0.5	0.37	0.06
SO4	ALL	107	0.54	0.46	0.5	-14.11	38.97	-0.08	0.21	0.11	7.77	-5.34	-0.16	42.34	40.09	0.45	0.34	0.25

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BIBE1																		
EC	WIN	29	0.11	0.08	0.39	-28.57	43.23	-0.03	0.05	0	-7.23	-21.18	-0.4	40.08	46.37	0.61	0.07	0.16
EC	SPR	31	0.27	0.08	0.39	-68.48	71.12	-0.18	0.19	0.05	-52.07	-83.63	-2.17	61.42	90.02	2.26	0.28	0.15
EC	SUM	31	0.2	0.05	0.47	-73.68	77.06	-0.14	0.15	0.11	-8.73	-54.54	-2.8	76.74	77.4	2.93	0.36	0.22
EC	FAL	29	0.12	0.08	0.65	-33.81	40.76	-0.04	0.05	0	-21.96	-37.57	-0.51	41.64	52	0.62	0.07	0.42
EC	ALL	120	0.18	0.07	0.3	-58.26	63.62	-0.1	0.11	0.05	-22.76	-49.89	-1.4	55.44	67.02	1.52	0.24	0.09
NO3	WIN	28	0.25	0.05	0.48	-81.8	84.78	-0.21	0.21	0.1	-81.72	-149.65	-4.49	85.03	152.33	4.66	0.38	0.23
NO3	SPR	31	0.31	0.02	0.2	-92.17	92.17	-0.28	0.28	0.03	-90.03	-165.18	-11.78	90.03	165.18	11.78	0.34	0.04
NO3	SUM	31	0.27	0.02	0.32	-93.85	93.85	-0.26	0.26	0.02	-93.77	-179.21	-15.26	93.77	179.21	15.26	0.3	0.10
NO3	FAL	29	0.13	0.01	0.4	-89.54	89.54	-0.12	0.12	0	-88.34	-160.13	-8.56	88.34	160.13	8.56	0.13	0.16
NO3	ALL	119	0.24	0.02	0.41	-89.79	90.52	-0.22	0.22	0.04	-88.64	-163.95	-8.79	89.42	164.58	8.86	0.3	0.17
OC	WIN	29	0.41	0.26	0.54	-36.67	45.59	-0.15	0.19	0.06	-5.21	-27.03	-0.58	52.34	53.89	0.72	0.29	0.29
OC	SPR	31	1.88	0.39	0.44	-79.37	79.99	-1.49	1.5	2.78	-65.89	-108.3	-3.85	67.76	109.93	3.88	2.24	0.19
OC	SUM	31	1.17	0.44	0.47	-62.08	68.99	-0.72	0.8	2.57	-32.1	-55.07	-1.64	49.62	69.12	1.82	1.76	0.22
OC	FAL	29	0.57	0.44	0.67	-21.84	37.53	-0.12	0.21	0.09	30.11	-22.72	-0.28	81.27	50.07	0.48	0.33	0.45
OC	ALL	120	1.02	0.38	0.4	-62.42	67.72	-0.64	0.69	1.73	-19.3	-54.23	-1.66	62.61	71.38	1.8	1.46	0.16
PM-2.5	WIN	29	3.56	1.99	0.55	-44.24	46.4	-1.57	1.65	3.35	-33.82	-49.03	-0.79	38.91	53.53	0.83	2.42	0.30
PM-2.5	SPR	31	10	2.52	0.36	-74.86	74.86	-7.49	7.49	24.84	-70.47	-112.03	-2.98	70.47	112.03	2.98	9	0.13
PM-2.5	SUM	31	7.03	2.15	0.42	-69.38	69.38	-4.88	4.88	12.26	-66.53	-104.02	-2.27	66.53	104.02	2.27	6	0.18
PM-2.5	FAL	29	6.4	2.48	0.06	-61.24	61.26	-3.92	3.92	39.21	-51.1	-76.78	-1.58	51.11	76.8	1.58	7.39	0.00
PM-2.5	ALL	120	6.81	2.28	0.3	-66.43	66.71	-4.52	4.54	24.36	-55.91	-86.22	-1.98	57.15	87.31	1.99	6.69	0.09
SO4	WIN	28	1.04	0.88	0.64	-15.08	43.52	-0.16	0.45	0.5	27.37	3.83	-0.18	59.28	49.47	0.51	0.73	0.41
SO4	SPR	31	1.74	0.82	0.53	-52.95	53.16	-0.92	0.92	0.92	-44.41	-63.48	-1.13	44.63	63.69	1.13	1.33	0.28
SO4	SUM	31	1.63	0.85	0.42	-47.97	48.21	-0.78	0.79	0.32	-46.47	-67.17	-0.92	46.81	67.5	0.93	0.96	0.18
SO4	FAL	29	1.31	0.95	0.76	-27.46	31.46	-0.36	0.41	0.14	-27.04	-37.69	-0.38	31.98	42.13	0.43	0.52	0.58
SO4	ALL	119	1.44	0.87	0.51	-39.41	45.26	-0.57	0.65	0.57	-23.83	-42.32	-0.65	45.56	56.08	0.75	0.94	0.26

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BLMO1																		
EC	WIN	25	0.21	0.18	0.11	-15.58	47.48	-0.03	0.1	0.02	14.7	-0.68	-0.18	47.45	46.08	0.56	0.15	0.01
EC	SPR	21	0.18	0.21	0.7	12.84	30.56	0.02	0.06	0	23.98	13.24	0.13	37.69	29.79	0.31	0.07	0.49
EC	SUM	28	0.21	0.23	0.68	10.41	26.46	0.02	0.06	0	12.59	7.29	0.1	28.24	26.12	0.26	0.07	0.46
EC	FAL	26	0.27	0.34	0.83	28.28	35.68	0.08	0.09	0.01	30.71	22.13	0.28	37.76	30.59	0.36	0.14	0.69
EC	ALL	100	0.22	0.24	0.6	10.2	35.18	0.02	0.08	0.01	20.22	10.41	0.1	37.5	33.04	0.35	0.11	0.36
NO3	WIN	23	2.21	2.34	0.48	5.6	43.12	0.12	0.95	2.21	32.42	11.18	0.06	55.49	38.78	0.43	1.49	0.23
NO3	SPR	21	2.09	2.32	0.9	11.25	34.71	0.23	0.72	0.83	23.14	1.77	0.11	54.52	43.82	0.35	0.94	0.81
NO3	SUM	28	0.52	0.86	0.73	63.83	89.09	0.33	0.47	0.46	53.41	12.81	0.64	89.69	66.14	0.89	0.76	0.53
NO3	FAL	26	0.96	1.59	0.92	66.36	72.58	0.63	0.69	1.35	55.12	29.82	0.66	67.98	45.76	0.73	1.32	0.84
NO3	ALL	98	1.37	1.71	0.78	25.04	50.84	0.34	0.7	1.22	42.45	14.57	0.25	68.37	49.53	0.51	1.16	0.60
OC	WIN	25	0.69	0.59	0.31	-14.63	32.85	-0.1	0.23	0.09	-0.71	-9.99	-0.17	32.45	34.55	0.38	0.32	0.10
OC	SPR	21	0.69	0.68	0.43	-2.36	42.36	-0.02	0.29	0.23	17.12	3.52	-0.02	43.85	40.64	0.43	0.48	0.19
OC	SUM	28	1.07	0.85	0.52	-20.7	33.92	-0.22	0.36	0.14	-18.29	-26.26	-0.26	32.73	38.55	0.43	0.43	0.27
OC	FAL	26	1.03	0.94	0.64	-9.25	29.81	-0.1	0.31	0.22	-1.92	-10.35	-0.1	30.49	30.92	0.33	0.48	0.41
OC	ALL	100	0.88	0.77	0.58	-13.03	33.86	-0.12	0.3	0.17	-2.2	-11.8	-0.15	34.41	36	0.39	0.43	0.33
PM-2.5	WIN	25	6.78	6.16	0.3	-9.08	38.36	-0.62	2.6	17.51	5.19	-9.43	-0.1	41.93	36.79	0.42	4.23	0.09
PM-2.5	SPR	21	7.3	7.48	0.83	2.54	25.47	0.19	1.86	6.83	9.61	0.93	0.03	29.84	26.34	0.25	2.62	0.69
PM-2.5	SUM	28	6.04	6.08	0.72	0.73	28.69	0.04	1.73	6.04	-0.3	-6.26	0.01	27.7	27.8	0.29	2.46	0.51
PM-2.5	FAL	26	6.32	6.82	0.76	7.9	30.11	0.5	1.9	9.53	11.33	4.31	0.08	29.16	25.7	0.3	3.13	0.58
PM-2.5	ALL	100	6.56	6.59	0.66	0.41	30.79	0.03	2.02	10.14	6.18	-2.8	0	32.09	29.2	0.31	3.19	0.44
SO4	WIN	23	1.03	1.03	0.04	0.26	75.73	0	0.78	2.32	17.39	-23	0	73.31	51.84	0.76	1.52	0.00
SO4	SPR	21	1.45	1.53	0.86	6.04	32.07	0.09	0.46	0.49	9.54	0.61	0.06	31.92	28.63	0.32	0.71	0.73
SO4	SUM	28	1.44	1.38	0.72	-4.11	38.28	-0.06	0.55	0.56	10.4	-1.69	-0.04	43.52	40.39	0.4	0.75	0.51
SO4	FAL	26	0.97	0.89	0.68	-7.9	37.67	-0.08	0.37	0.45	18.65	7.33	-0.09	41.63	36.05	0.41	0.68	0.46
SO4	ALL	98	1.22	1.2	0.58	-1.46	44	-0.02	0.54	0.93	14.05	-3.81	-0.01	47.53	39.41	0.45	0.97	0.34

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BOND1																		
EC	WIN	29	0.3	0.42	0.63	39.69	45.07	0.12	0.14	0.01	42.71	31.84	0.4	46.38	35.85	0.45	0.16	0.39
EC	SPR	31	0.31	0.35	0.64	15.68	33.68	0.05	0.1	0.01	28.27	18.93	0.16	39.89	33.04	0.34	0.12	0.42
EC	SUM	31	0.42	0.35	0.7	-16.24	25.03	-0.07	0.1	0.01	-5.56	-13.08	-0.19	29.35	28.43	0.3	0.13	0.49
EC	FAL	30	0.35	0.45	0.78	29.65	38.42	0.1	0.13	0.02	38.54	26.84	0.3	44.04	34.21	0.38	0.18	0.61
EC	ALL	121	0.34	0.39	0.6	14.33	34.58	0.05	0.12	0.02	25.61	15.79	0.14	39.77	32.82	0.35	0.15	0.36
NO3	WIN	27	3.73	3.02	0.76	-19.13	30.27	-0.71	1.13	2.43	-5.43	-12.91	-0.24	28.66	30.63	0.37	1.71	0.57
NO3	SPR	31	1.73	3.17	0.8	83.46	95.53	1.44	1.65	3.18	126.76	43.01	0.83	143.26	64.99	0.96	2.29	0.64
NO3	SUM	31	0.44	0.29	0.32	-33.62	65.86	-0.15	0.29	0.12	-28.56	-55.34	-0.51	58.48	75.08	0.99	0.37	0.10
NO3	FAL	27	1.07	1.75	0.74	63.75	89.89	0.68	0.96	1.74	80.92	20.56	0.64	115.45	68.74	0.9	1.49	0.55
NO3	ALL	116	1.7	2.04	0.72	19.9	59.24	0.34	1.01	2.53	43.81	-1.51	0.2	87.46	60.56	0.59	1.62	0.52
OC	WIN	29	1.1	1.43	0.58	30.05	37.4	0.33	0.41	0.17	35.76	25.84	0.3	40.86	31.36	0.37	0.53	0.34
OC	SPR	31	1.25	1.13	0.71	-9.36	31.83	-0.12	0.4	0.27	1.7	-6.12	-0.1	32.65	33.21	0.35	0.53	0.50
OC	SUM	31	1.8	1.36	0.79	-24.58	31.93	-0.44	0.57	0.33	-20.52	-30.93	-0.33	35.48	41.71	0.42	0.72	0.62
OC	FAL	30	1.15	1.03	0.83	-10.91	27.64	-0.13	0.32	0.18	-9.58	-15.21	-0.12	26.73	29.45	0.31	0.44	0.69
OC	ALL	121	1.33	1.24	0.71	-7.16	32.06	-0.1	0.43	0.31	1.37	-7.07	-0.08	33.88	34.01	0.35	0.57	0.50
PM-2.5	WIN	29	10.23	9.87	0.66	-3.45	29.03	-0.35	2.97	13.87	12.41	2.99	-0.04	34.91	30.68	0.3	3.74	0.44
PM-2.5	SPR	31	8.2	11.04	0.65	34.64	49.82	2.84	4.09	18.72	44.66	26.91	0.35	56.61	42.17	0.5	5.18	0.42
PM-2.5	SUM	31	10.95	8.8	0.89	-19.58	23.85	-2.14	2.61	7.5	-13.23	-16.59	-0.24	21.9	24.16	0.3	3.48	0.79
PM-2.5	FAL	30	6.84	8.67	0.75	26.79	42.1	1.83	2.88	10.24	35.31	24.21	0.27	44.41	35.32	0.42	3.69	0.56
PM-2.5	ALL	121	9.05	9.6	0.62	6.06	34.7	0.55	3.14	16.38	19.78	9.36	0.06	39.49	33.1	0.35	4.08	0.38
SO4	WIN	27	2.17	1.28	0.66	-40.76	43.75	-0.88	0.95	0.8	-32.81	-46.38	-0.69	38.3	51.3	0.74	1.26	0.44
SO4	SPR	31	2.17	2.17	0.61	0.25	37.56	0.01	0.81	1.3	4.38	-4.59	0	35.16	34.37	0.38	1.14	0.38
SO4	SUM	31	3.26	2.3	0.89	-29.52	34.79	-0.96	1.13	1.89	-14.72	-22.81	-0.42	32.84	36.44	0.49	1.68	0.80
SO4	FAL	27	1.83	1.69	0.5	-7.77	39.24	-0.14	0.72	1.43	18.01	1.39	-0.08	44.88	36.69	0.43	1.21	0.25
SO4	ALL	116	2.38	1.89	0.66	-20.77	38.16	-0.49	0.91	1.56	-6.21	-17.79	-0.26	37.53	39.4	0.48	1.34	0.43

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BOWA1																		
EC	WIN	27	0.08	0.17	0.82	112.88	112.88	0.09	0.09	0.01	144.2	75.81	1.13	144.2	75.81	1.13	0.12	0.67
EC	SPR	28	0.07	0.08	0.53	20.99	53.89	0.01	0.04	0	40.61	14.91	0.21	66.16	47.11	0.54	0.06	0.28
EC	SUM	29	0.14	0.08	0.18	-39.51	56.66	-0.05	0.08	0.01	-10.84	-33.16	-0.65	50.61	57.83	0.94	0.12	0.03
EC	FAL	30	0.44	1.69	0.75	285.36	313.25	1.25	1.37	21.09	135.79	11.7	2.85	180.59	78.76	3.13	4.76	0.56
EC	ALL	114	0.19	0.53	0.76	183.56	221.84	0.34	0.41	5.86	77.1	16.26	1.84	110.8	64.96	2.22	2.44	0.57
NO3	WIN	28	0.75	1.45	0.67	92.56	111.93	0.7	0.84	2.24	190.8	30.96	0.93	219.39	79.59	1.12	1.65	0.45
NO3	SPR	26	0.19	0.29	0.92	52.65	89.34	0.1	0.17	0.08	33.77	-26.18	0.53	101.47	88.54	0.89	0.31	0.84
NO3	SUM	25	0.04	0.03	0.23	-12.05	87.06	0	0.03	0	-13.54	-61.57	-0.14	79.31	80.39	0.99	0.07	0.05
NO3	FAL	26	0.48	0.81	0.93	66.94	80.94	0.32	0.39	0.29	636.03	31.28	0.67	670.03	86	0.81	0.63	0.86
NO3	ALL	105	0.38	0.67	0.79	76.81	98.64	0.29	0.37	0.77	213.51	-5.14	0.77	268.43	83.59	0.99	0.92	0.62
OC	WIN	28	0.4	0.81	0.86	100.83	100.83	0.41	0.41	0.09	178.55	74.09	1.01	178.55	74.09	1.01	0.51	0.74
OC	SPR	28	0.4	0.45	0.5	11.45	44.97	0.05	0.18	0.07	43.46	19.67	0.11	63.16	44.47	0.45	0.26	0.25
OC	SUM	29	1.63	0.72	0.36	-55.67	57.74	-0.91	0.94	1.8	-38.87	-57.23	-1.26	42.92	60.85	1.3	1.62	0.13
OC	FAL	30	6.03	8.03	0.69	33.17	113.55	2	6.85	314.13	58.23	-6.23	0.33	110	76.8	1.14	17.84	0.47
OC	ALL	115	2.18	2.58	0.71	18.53	99.41	0.4	2.17	83.57	59.44	6.77	0.19	98.37	64.25	0.99	9.15	0.50
PM-2.5	WIN	27	2.99	5.15	0.65	72.31	76.33	2.16	2.28	15.39	72.64	41.16	0.72	78.26	47.82	0.76	4.48	0.43
PM-2.5	SPR	28	2.82	3.08	0.71	8.97	28.7	0.25	0.81	1.79	12.2	4.81	0.09	30.8	27.23	0.29	1.36	0.51
PM-2.5	SUM	28	4.94	2.94	0.3	-40.56	47.58	-2	2.35	8.75	-30.93	-45.39	-0.68	39.4	51.89	0.8	3.57	0.09
PM-2.5	FAL	27	5.77	10.05	0.76	74.24	126.98	4.28	7.32	272.18	98.43	21.51	0.74	132.67	70.54	1.27	17.04	0.58
PM-2.5	ALL	110	4.13	5.26	0.68	27.53	76.64	1.14	3.16	78.66	37.22	5.06	0.28	69.64	49.19	0.77	8.94	0.46
SO4	WIN	28	0.75	0.79	0.46	5.37	58.41	0.04	0.44	0.88	11.77	-5.38	0.05	49.35	42.21	0.58	0.94	0.21
SO4	SPR	26	0.88	1.08	0.81	21.79	30.63	0.19	0.27	0.11	55.08	27.32	0.22	60.18	32.86	0.31	0.38	0.66
SO4	SUM	25	0.51	0.61	0.47	20.28	44.38	0.1	0.22	0.09	51.88	24.1	0.2	66.1	40.74	0.44	0.32	0.22
SO4	FAL	26	0.83	1.16	0.65	39.91	55.39	0.33	0.46	0.46	133.7	43.56	0.4	143.58	55.67	0.55	0.75	0.42
SO4	ALL	105	0.75	0.91	0.59	22.09	47.15	0.16	0.35	0.41	62.24	21.85	0.22	79.35	42.88	0.47	0.66	0.35

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BRIG1																		
EC	WIN	28	0.36	0.78	0.9	115.68	115.68	0.42	0.42	0.04	124.29	73.13	1.16	124.29	73.13	1.16	0.47	0.81
EC	SPR	31	0.2	0.33	0.42	60.63	82.58	0.12	0.17	0.02	111.98	54.85	0.61	123.87	70.01	0.83	0.2	0.17
EC	SUM	29	0.35	0.37	0.34	5.69	39.29	0.02	0.14	0.03	24.36	7.68	0.06	49.04	37.68	0.39	0.18	0.11
EC	FAL	29	0.27	0.47	0.81	72.14	75.19	0.2	0.21	0.1	175.52	56.35	0.72	177.86	58.99	0.75	0.38	0.66
EC	ALL	117	0.29	0.48	0.67	63.44	77.98	0.19	0.23	0.07	108.96	47.9	0.63	118.8	60.01	0.78	0.33	0.44
NO3	WIN	28	1.5	2.13	0.67	41.58	57.13	0.62	0.86	0.99	91.26	37.39	0.42	104.92	55.54	0.57	1.18	0.45
NO3	SPR	31	0.7	0.81	0.38	15.37	61.52	0.11	0.43	0.33	40.49	5.01	0.15	78.38	57.22	0.62	0.59	0.14
NO3	SUM	29	0.34	0.2	0.52	-40.94	59.91	-0.14	0.2	0.04	-31.51	-63.96	-0.69	63.52	85.36	1.01	0.24	0.27
NO3	FAL	29	0.5	1.01	0.85	101.3	131.35	0.51	0.66	2.39	68.69	9.8	1.01	111	72.42	1.31	1.63	0.72
NO3	ALL	117	0.75	1.02	0.69	35.67	70.71	0.27	0.53	1.02	41.78	-3.15	0.36	89.13	67.56	0.71	1.05	0.48
OC	WIN	28	1.33	3.24	0.8	142.99	142.99	1.91	1.91	1.55	152.63	80.85	1.43	152.63	80.85	1.43	2.28	0.64
OC	SPR	31	1.07	1.16	0.24	8.01	62.35	0.09	0.67	1.02	48.16	18.39	0.08	72.12	53.3	0.62	1.01	0.06
OC	SUM	29	2.14	1.36	0.34	-36.64	47.87	-0.78	1.02	1.56	-20.92	-37.3	-0.58	43.31	52.63	0.76	1.48	0.12
OC	FAL	29	1.11	1.36	0.58	22.75	50.39	0.25	0.56	1.74	39.32	11.04	0.23	63.32	39.84	0.5	1.34	0.33
OC	ALL	117	1.41	1.76	0.31	24.69	72.84	0.35	1.03	2.38	53.85	17.71	0.25	82.06	56.39	0.73	1.58	0.09
PM-2.5	WIN	27	7.14	12.23	0.9	71.31	71.31	5.09	5.09	8.61	81.49	54.05	0.71	81.49	54.05	0.71	5.87	0.81
PM-2.5	SPR	31	7.2	6.8	0.35	-5.58	35.59	-0.4	2.56	11.85	8.07	-1.12	-0.06	35.9	36.56	0.38	3.47	0.12
PM-2.5	SUM	29	11.21	6.96	0.7	-37.92	40.23	-4.25	4.51	17.24	-30.31	-42.43	-0.61	35.54	46.92	0.65	5.94	0.49
PM-2.5	FAL	29	5.76	7.27	0.56	26.26	47.14	1.51	2.72	31.01	26.57	13.37	0.26	42.78	32.35	0.47	5.77	0.32
PM-2.5	ALL	116	7.83	8.22	0.42	5.01	46.96	0.39	3.68	28.24	20.19	5.02	0.05	48.14	42.17	0.47	5.33	0.18
SO4	WIN	28	1.72	1.3	0.81	-24.5	30.23	-0.42	0.52	0.26	-17.36	-25.02	-0.32	30.67	34.06	0.4	0.66	0.66
SO4	SPR	31	1.99	1.62	0.83	-18.59	24.96	-0.37	0.5	0.29	-11.92	-17.91	-0.23	25.82	28.5	0.31	0.65	0.68
SO4	SUM	29	3.46	2.35	0.83	-32.15	36.38	-1.11	1.26	1.78	-22.57	-34.46	-0.47	37.03	45.35	0.54	1.74	0.69
SO4	FAL	29	1.52	1.53	0.69	0.4	33.31	0.01	0.51	0.5	16.67	5.45	0	40.14	34.89	0.33	0.71	0.47
SO4	ALL	117	2.18	1.7	0.83	-21.76	31.91	-0.47	0.69	0.86	-8.78	-17.92	-0.28	33.31	35.59	0.41	1.04	0.68

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BRIS1																		
EC	WIN	28	0.38	0.82	0.06	117.17	151.32	0.44	0.57	1.11	35279.33	30.6	1.17	35304.94	64.38	1.51	1.14	0.00
EC	SPR	30	0.32	0.35	0.49	8.78	42.94	0.03	0.14	0.05	21.52	6.13	0.09	46.63	36.81	0.43	0.23	0.24
EC	SUM	31	0.33	0.47	0.16	41.82	73.56	0.14	0.24	0.07	78.47	35.82	0.42	97.36	59.54	0.74	0.3	0.03
EC	FAL	25	0.36	0.47	0.41	30.4	61.28	0.11	0.22	0.15	58.62	15.5	0.3	84.1	46.66	0.61	0.4	0.17
EC	ALL	114	0.35	0.53	0.18	51.37	84.15	0.18	0.29	0.36	8704.95	22.27	0.51	8728.58	51.92	0.84	0.63	0.03
NO3	WIN	29	0.75	1.14	0.41	52.3	112.65	0.39	0.85	2.37	52.61	-16.44	0.52	118.61	88.69	1.13	1.59	0.17
NO3	SPR	28	0.35	0.46	0.19	32.54	120.46	0.11	0.42	0.37	34.98	-36.39	0.33	119.21	100.9	1.2	0.62	0.04
NO3	SUM	31	0.26	0.13	0.11	-49.49	87.97	-0.13	0.23	0.07	-40.28	-97.86	-0.98	86.31	117.4	1.74	0.29	0.01
NO3	FAL	25	0.31	0.52	0.21	69.86	144.33	0.22	0.44	0.45	88.26	-12.39	0.7	156.67	95.2	1.44	0.71	0.04
NO3	ALL	113	0.42	0.56	0.47	33.76	115.22	0.14	0.48	0.86	30.64	-42.83	0.34	118.32	101.03	1.15	0.94	0.22
OC	WIN	29	1.23	2.68	0.11	118.5	162.66	1.46	2	17.55	3168.79	14.87	1.19	3206.83	65.95	1.63	4.43	0.01
OC	SPR	30	1.23	1.01	0.37	-18.45	52.55	-0.23	0.65	1	-7.81	-30.54	-0.23	54.36	56.33	0.64	1.02	0.14
OC	SUM	31	1.49	1.81	0.79	20.99	46.86	0.31	0.7	0.8	29.58	11.11	0.21	55.6	46.93	0.47	0.95	0.63
OC	FAL	25	1.39	1.56	0.45	11.99	60.1	0.17	0.84	2.76	11.16	-15.21	0.12	58.25	47.25	0.6	1.67	0.20
OC	ALL	115	1.34	1.77	0.28	32.04	78.05	0.43	1.04	5.9	807.45	-4.53	0.32	850.51	54.25	0.78	2.47	0.08
PM-2.5	WIN	28	6.45	9.21	0.47	42.76	69.47	2.76	4.48	76.82	36.74	7.14	0.43	64.75	40.72	0.69	9.19	0.22
PM-2.5	SPR	28	8.61	6.56	0.22	-23.77	39.75	-2.05	3.42	17.62	-17.45	-30.47	-0.31	38.31	44.55	0.52	4.67	0.05
PM-2.5	SUM	31	10.87	6.82	0.75	-37.29	40.51	-4.06	4.41	11.28	-37.49	-54.78	-0.59	41.5	58.45	0.65	5.26	0.57
PM-2.5	FAL	25	7.12	7.31	0.26	2.64	39.69	0.19	2.83	18.64	10.27	-2.63	0.03	40.21	35.57	0.4	4.32	0.07
PM-2.5	ALL	112	8.36	7.46	0.29	-10.79	45.74	-0.9	3.83	37.58	-3.26	-21.58	-0.12	46.23	45.44	0.51	6.2	0.09
SO4	WIN	29	1.99	1.67	0.64	-16.4	37.48	-0.33	0.75	0.63	-14.3	-24.73	-0.2	38.43	42.79	0.45	0.86	0.41
SO4	SPR	28	2.9	2.2	0.48	-24.04	39.23	-0.7	1.14	1.72	-19.41	-31.1	-0.32	37.52	45.65	0.52	1.49	0.23
SO4	SUM	31	3.42	1.56	0.71	-54.28	54.28	-1.86	1.86	1.16	-56.29	-85.03	-1.19	56.29	85.03	1.19	2.15	0.50
SO4	FAL	25	2.04	1.72	0.62	-15.43	32.42	-0.31	0.66	0.76	-5.08	-12.86	-0.18	31.17	33.84	0.38	0.93	0.38
SO4	ALL	113	2.62	1.78	0.52	-31.9	43.11	-0.84	1.13	1.49	-25.04	-40.23	-0.47	41.5	53.11	0.63	1.48	0.27

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: BRMA1																		
EC	WIN	25	0.21	0.39	0.79	83.88	83.88	0.18	0.18	0.02	105.23	62.06	0.84	105.23	62.06	0.84	0.22	0.63
EC	SPR	31	0.11	0.19	0.72	66.42	72.58	0.07	0.08	0	88.22	53.31	0.66	92.15	57.74	0.73	0.1	0.52
EC	SUM	31	0.22	0.17	0.7	-22.8	32.95	-0.05	0.07	0.01	-11.1	-19.01	-0.3	31.23	35.11	0.43	0.1	0.48
EC	FAL	30	0.22	0.23	0.81	3.35	28.06	0.01	0.06	0.01	16.78	8.9	0.03	33.27	29.05	0.28	0.08	0.66
EC	ALL	117	0.19	0.23	0.64	24.73	49.98	0.05	0.09	0.02	47.22	24.63	0.25	63.71	45.31	0.5	0.13	0.41
NO3	WIN	21	0.35	1.17	0.68	232.62	237.08	0.82	0.83	0.53	347.88	104.32	2.33	353.17	111.64	2.37	1.1	0.46
NO3	SPR	30	0.12	0.36	0.57	197.34	209.28	0.24	0.26	0.08	277.34	73.38	1.97	294.06	98.04	2.09	0.37	0.33
NO3	SUM	31	0.08	0.07	0.59	-19.95	66.75	-0.02	0.06	0.01	-23.72	-55.85	-0.25	67.45	80.43	0.83	0.08	0.35
NO3	FAL	30	0.15	0.32	0.73	113.95	139.1	0.17	0.21	0.21	81.92	15.35	1.14	117.29	67.96	1.39	0.49	0.53
NO3	ALL	112	0.16	0.42	0.74	159.99	182.8	0.26	0.3	0.26	154.9	27.87	1.6	195.07	87.66	1.83	0.57	0.55
OC	WIN	25	1	2.09	0.77	108.85	108.85	1.09	1.09	0.48	133.21	72.53	1.09	133.21	72.53	1.09	1.29	0.59
OC	SPR	31	0.6	0.96	0.81	58.73	62.01	0.35	0.37	0.12	66.12	43.05	0.59	69.66	46.96	0.62	0.5	0.65
OC	SUM	31	1.5	0.93	0.49	-38.16	44.51	-0.57	0.67	1.15	-29.58	-42.46	-0.62	38.05	49.62	0.72	1.22	0.24
OC	FAL	30	1.02	1.05	0.8	2.82	30.58	0.03	0.31	0.16	16.52	6.99	0.03	36.9	32.38	0.31	0.4	0.64
OC	ALL	117	1.03	1.22	0.42	17.56	56.96	0.18	0.59	0.82	42.38	17.45	0.18	66.47	49.39	0.57	0.92	0.17
PM-2.5	WIN	25	4.23	7.71	0.84	82.5	84.69	3.49	3.58	6.49	88.55	56.73	0.83	90.98	59.59	0.85	4.32	0.70
PM-2.5	SPR	31	2.89	4.96	0.78	71.87	71.87	2.08	2.08	3.08	92.72	52.34	0.72	92.72	52.34	0.72	2.72	0.60
PM-2.5	SUM	31	6.47	4.22	0.6	-34.89	41.46	-2.26	2.68	9.92	-28.89	-41.19	-0.54	38.27	49.02	0.64	3.88	0.36
PM-2.5	FAL	30	4.18	4.58	0.74	9.36	32.24	0.39	1.35	3.6	23.69	11.69	0.09	41.17	33.73	0.32	1.94	0.55
PM-2.5	ALL	117	4.46	5.25	0.49	17.89	53.22	0.8	2.37	10.25	41.91	18.07	0.18	64.7	48.24	0.53	3.3	0.24
SO4	WIN	21	1.04	0.92	0.83	-11.19	24.46	-0.12	0.25	0.1	-0.1	-4.69	-0.13	24.69	25.08	0.28	0.34	0.68
SO4	SPR	30	0.86	1.55	0.59	79.78	85.37	0.69	0.74	1.35	161.57	46.38	0.8	166.15	51.45	0.85	1.35	0.34
SO4	SUM	31	1.36	1.47	0.65	7.97	53.48	0.11	0.73	1.13	34.72	9.03	0.08	67.55	51.1	0.53	1.07	0.42
SO4	FAL	30	1.06	1.18	0.65	11.15	40.89	0.12	0.43	0.41	45.17	15.83	0.11	65.55	40.29	0.41	0.65	0.43
SO4	ALL	112	1.09	1.31	0.57	20.64	51.76	0.22	0.56	0.89	64.97	18.28	0.21	85.39	43.42	0.52	0.97	0.32

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: CABA1																		
EC	WIN	25	0.38	0.42	0.79	8.08	34.88	0.03	0.13	0.03	22.31	8.36	0.08	45.36	36.75	0.35	0.17	0.62
EC	SPR	31	0.16	0.28	0.51	77.74	87.77	0.12	0.14	0.02	120	59.4	0.78	124.41	64.64	0.88	0.17	0.26
EC	SUM	25	0.32	0.31	0.82	-0.53	25.17	0	0.08	0.01	18.46	8.21	-0.01	36.64	30.41	0.25	0.11	0.68
EC	FAL	23	0.37	0.38	0.78	1.26	28.25	0	0.11	0.02	19.79	5.6	0.01	40.07	30.49	0.28	0.15	0.61
EC	ALL	104	0.3	0.34	0.75	14.83	38.78	0.04	0.12	0.02	49.95	22.93	0.15	65.66	42.15	0.39	0.16	0.56
NO3	WIN	24	0.46	1.3	0.77	183.83	187.9	0.84	0.86	0.72	206.21	84.58	1.84	208.88	87.48	1.88	1.19	0.59
NO3	SPR	30	0.2	0.54	0.48	169.18	185.77	0.34	0.37	0.23	216.32	64.04	1.69	230.81	85.86	1.86	0.59	0.23
NO3	SUM	25	0.18	0.23	0.67	27.5	82.62	0.05	0.15	0.04	30.9	-12.04	0.28	86.07	70.88	0.83	0.22	0.45
NO3	FAL	26	0.21	0.44	0.34	105.25	140.24	0.23	0.3	0.22	132.96	28.6	1.05	167.28	80.31	1.4	0.52	0.11
NO3	ALL	105	0.26	0.61	0.72	138.62	160.27	0.36	0.41	0.38	149.22	41.85	1.39	175.6	81.29	1.6	0.71	0.52
OC	WIN	25	1.65	1.89	0.82	14.99	33.3	0.25	0.55	0.46	27.36	15.68	0.15	42.93	33.95	0.33	0.72	0.67
OC	SPR	31	0.73	1.13	0.51	54.92	76.27	0.4	0.56	0.39	72.81	40.5	0.55	84.4	55.54	0.76	0.74	0.26
OC	SUM	25	1.68	1.21	0.78	-27.56	36.02	-0.46	0.6	0.45	-26.77	-37.61	-0.38	36.22	45.03	0.5	0.82	0.60
OC	FAL	23	1.48	1.29	0.91	-12.5	20.8	-0.18	0.31	0.13	-7.14	-12.51	-0.14	25.18	27.04	0.24	0.41	0.83
OC	ALL	104	1.34	1.37	0.73	2	38.03	0.03	0.51	0.49	20.27	4.04	0.02	49.75	41.52	0.38	0.7	0.54
PM-2.5	WIN	21	5.63	7.82	0.86	38.75	44.55	2.18	2.51	7.76	38.4	27.08	0.39	44.19	33.37	0.45	3.54	0.74
PM-2.5	SPR	31	3.62	5.97	0.69	64.91	67.82	2.35	2.46	5.5	81.21	49.66	0.65	82.35	50.85	0.68	3.32	0.48
PM-2.5	SUM	24	6.98	5.61	0.77	-19.71	30.94	-1.38	2.16	6.79	-12.44	-18.98	-0.25	28.92	32.37	0.39	2.95	0.59
PM-2.5	FAL	26	5.6	5.77	0.88	3.04	24.49	0.17	1.37	2.69	14.02	6.63	0.03	33.31	29.22	0.24	1.65	0.77
PM-2.5	ALL	102	5.33	6.22	0.69	16.57	39.79	0.88	2.12	7.89	33.23	17.89	0.17	49.42	37.39	0.4	2.94	0.48
SO4	WIN	24	1.19	1.04	0.86	-12.94	25.03	-0.15	0.3	0.12	-3.94	-8.54	-0.15	26.18	27.06	0.29	0.37	0.74
SO4	SPR	30	1.09	1.71	0.67	57.57	60.66	0.63	0.66	1.09	89.09	37.39	0.58	92.53	41.16	0.61	1.22	0.45
SO4	SUM	25	1.17	1.53	0.65	30.12	55.65	0.35	0.65	1.06	51.78	22.69	0.3	73.23	48.05	0.56	1.09	0.42
SO4	FAL	26	1.18	1.34	0.69	13.28	43.95	0.16	0.52	0.49	34.45	14.77	0.13	56.8	42.26	0.44	0.72	0.48
SO4	ALL	105	1.16	1.42	0.63	23.06	46.8	0.27	0.54	0.79	45.41	17.79	0.23	63.92	39.85	0.47	0.93	0.40

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: CACO1																		
EC	WIN	27	0.16	0.28	0.91	78.21	78.9	0.12	0.12	0.03	89.05	53.99	0.78	89.89	54.86	0.79	0.2	0.83
EC	SPR	31	0.11	0.18	0.62	63.27	84.32	0.07	0.09	0.01	145.24	61.38	0.63	152.85	71.01	0.84	0.12	0.38
EC	SUM	26	0.23	0.27	0.91	20.44	31.23	0.05	0.07	0.01	33.18	25.05	0.2	39	31.35	0.31	0.09	0.83
EC	FAL	30	0.18	0.24	0.92	31.9	42.91	0.06	0.08	0.01	112.51	43.29	0.32	120.28	52.01	0.43	0.1	0.85
EC	ALL	114	0.17	0.24	0.83	44.24	54.73	0.07	0.09	0.01	97.76	46.58	0.44	103.4	53.14	0.55	0.13	0.69
NO3	WIN	23	0.6	1.08	0.84	80.75	98.32	0.48	0.59	0.44	130.02	44.92	0.81	153.82	82.81	0.98	0.82	0.71
NO3	SPR	31	0.31	0.64	0.48	101.9	142.44	0.32	0.45	0.52	122.9	18.52	1.02	166.46	82.38	1.42	0.79	0.23
NO3	SUM	25	0.26	0.21	0.56	-16.85	70.91	-0.04	0.18	0.05	-10.71	-52.89	-0.2	78.94	88.98	0.85	0.22	0.32
NO3	FAL	13	0.37	0.64	0.94	69.4	89.21	0.26	0.33	0.27	26.11	-6.32	0.69	73	72.57	0.89	0.58	0.88
NO3	ALL	92	0.38	0.63	0.76	67.14	104.38	0.25	0.39	0.37	74.7	2.2	0.67	126.31	82.89	1.04	0.66	0.58
OC	WIN	27	0.7	1.06	0.96	51.5	52.85	0.36	0.37	0.27	43.54	31.02	0.52	46.36	34.28	0.53	0.63	0.91
OC	SPR	31	0.62	0.69	0.72	10.03	41.89	0.06	0.26	0.18	30.72	18.09	0.1	43.95	34.42	0.42	0.43	0.52
OC	SUM	26	1.48	1.2	0.87	-18.96	29.68	-0.28	0.44	0.27	-25.95	-38.81	-0.23	37.21	47.99	0.37	0.59	0.75
OC	FAL	30	0.89	0.76	0.89	-14.9	28.85	-0.13	0.26	0.1	-22.06	-34.32	-0.18	35.27	43.46	0.34	0.35	0.79
OC	ALL	114	0.91	0.91	0.8	0.42	35.99	0	0.33	0.26	6.94	-5.62	0	40.7	39.86	0.36	0.51	0.64
PM-2.5	WIN	29	4.75	5.79	0.9	21.81	30.61	1.04	1.45	4.45	17.26	12.69	0.22	26.45	23.09	0.31	2.35	0.82
PM-2.5	SPR	31	5.03	5.7	0.66	13.42	35.9	0.67	1.81	6.45	28.24	9.65	0.13	48.25	34.22	0.36	2.63	0.43
PM-2.5	SUM	26	7.42	6.54	0.84	-11.87	25.44	-0.88	1.89	5.33	-9.15	-15.36	-0.13	27.01	30.52	0.29	2.47	0.70
PM-2.5	FAL	30	5.03	4.89	0.87	-2.88	24.15	-0.14	1.22	2.53	-5.87	-12.34	-0.03	25.84	29.32	0.25	1.6	0.75
PM-2.5	ALL	116	5.5	5.7	0.78	3.73	28.81	0.2	1.58	5.21	8.29	-0.88	0.04	32.24	29.34	0.29	2.29	0.60
SO4	WIN	23	1.22	0.97	0.82	-19.96	26.85	-0.24	0.33	0.14	-13.64	-18.43	-0.25	24.36	27.45	0.34	0.45	0.67
SO4	SPR	31	1.41	1.91	0.76	35.94	46.45	0.51	0.65	0.63	47.83	26.01	0.36	58.16	38.03	0.46	0.94	0.58
SO4	SUM	25	1.81	2.28	0.75	25.94	49.94	0.47	0.91	1.24	48.73	22.69	0.26	68.93	48.16	0.5	1.21	0.57
SO4	FAL	13	1.35	1.17	0.94	-13.15	23.59	-0.18	0.32	0.12	-4.25	-12.32	-0.15	31.47	31	0.27	0.39	0.88
SO4	ALL	92	1.46	1.67	0.76	14.52	40.56	0.21	0.59	0.72	25.35	8.59	0.15	48.86	37.14	0.41	0.87	0.58

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: CACR1																		
EC	WIN	29	0.23	0.38	0.69	65.38	71.91	0.15	0.16	0.03	93.51	48.72	0.65	99.46	55.45	0.72	0.22	0.47
EC	SPR	31	0.27	0.35	0.48	27.39	66.83	0.08	0.18	0.14	29.69	0.43	0.27	64.81	48.55	0.67	0.38	0.23
EC	SUM	30	0.23	0.22	0.25	-4.54	46.58	-0.01	0.11	0.02	18.28	-4.25	-0.05	54.63	41.23	0.49	0.16	0.06
EC	FAL	25	0.23	0.3	0.51	28.7	45.59	0.07	0.11	0.03	29.91	15.44	0.29	45.8	34.48	0.46	0.18	0.26
EC	ALL	115	0.24	0.31	0.46	28.56	58.52	0.07	0.14	0.06	42.86	14.65	0.29	66.76	45.32	0.59	0.25	0.21
NO3	WIN	14	1.37	0.89	0.56	-35.22	53.97	-0.48	0.74	1.37	174.37	-24.53	-0.54	242.21	70.66	0.83	1.27	0.31
NO3	SPR	13	0.35	0.24	0.31	-32.45	62.6	-0.11	0.22	0.06	-27.98	-63.31	-0.48	67.79	88.08	0.93	0.27	0.09
NO3	SUM	31	0.24	0.03	0.36	-87.97	87.97	-0.21	0.21	0.02	-83.15	-145.84	-7.31	83.15	145.84	7.31	0.26	0.13
NO3	FAL	27	0.42	0.37	0.63	-11.24	70.64	-0.05	0.3	0.24	-22.88	-66.78	-0.13	78.53	91.66	0.8	0.5	0.40
NO3	ALL	85	0.5	0.31	0.64	-37.64	65.22	-0.19	0.33	0.34	-13.15	-88.12	-0.6	105.53	107.41	1.05	0.61	0.41
OC	WIN	29	1.16	1.51	0.66	30.67	51.32	0.36	0.59	0.66	57.56	24.31	0.31	73.71	42.86	0.51	0.89	0.44
OC	SPR	31	1.7	1.69	0.56	-0.51	59.69	-0.01	1.01	2.63	7.27	-19.34	-0.01	63.09	58.2	0.6	1.62	0.32
OC	SUM	30	2.07	3.15	0.53	52.64	59.68	1.09	1.23	2.6	59.22	29.63	0.53	70.91	44.62	0.6	1.95	0.28
OC	FAL	25	1.38	1.47	0.76	6.84	31.14	0.09	0.43	0.45	5.96	-1.28	0.07	29.72	28.24	0.31	0.68	0.57
OC	ALL	115	1.59	1.98	0.62	24.63	52.76	0.39	0.84	1.84	33.22	8.37	0.25	60.55	44.28	0.53	1.41	0.38
PM-2.5	WIN	29	6.04	7.66	0.59	26.79	49.9	1.62	3.02	11.87	56.77	22.94	0.27	73.75	44.74	0.5	3.81	0.34
PM-2.5	SPR	31	8.3	7.83	0.51	-5.67	41.95	-0.47	3.48	23.5	-0.38	-12.23	-0.06	41.01	40.37	0.44	4.87	0.26
PM-2.5	SUM	29	10.21	8.72	0.65	-14.64	31.1	-1.5	3.18	12.56	-13.92	-23.92	-0.17	33.94	39.65	0.36	3.85	0.42
PM-2.5	FAL	27	6.11	6.63	0.78	8.55	25.65	0.52	1.57	3.92	12.66	5.65	0.09	30.04	26.3	0.26	2.05	0.61
PM-2.5	ALL	116	7.7	7.73	0.59	0.35	36.91	0.03	2.84	14.64	13.56	-2.2	0	44.88	38.01	0.37	3.83	0.34
SO4	WIN	14	1.07	0.97	0.21	-9.84	55.09	-0.11	0.59	0.71	78.72	-6.85	-0.11	124.07	54.47	0.61	0.85	0.05
SO4	SPR	13	2.03	1.88	0.78	-7.46	26.36	-0.15	0.54	0.54	7.59	0.77	-0.08	29.45	29.66	0.28	0.75	0.62
SO4	SUM	31	2.72	1.36	0.7	-50.21	50.21	-1.37	1.37	0.68	-47.85	-67.06	-1.01	47.85	67.06	1.01	1.6	0.49
SO4	FAL	27	1.59	1.57	0.93	-1.38	18.42	-0.02	0.29	0.16	9.89	1.7	-0.01	27.88	22.85	0.19	0.4	0.86
SO4	ALL	85	1.99	1.44	0.63	-27.5	38.82	-0.55	0.77	0.89	-0.18	-24.92	-0.38	51.25	45.22	0.54	1.09	0.40

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: CEBL1																		
EC	WIN	26	0.11	0.15	0.65	46.44	51.42	0.05	0.05	0.01	88.2	42.81	0.46	91.35	46.3	0.51	0.1	0.42
EC	SPR	29	0.17	0.21	0.82	24.17	46.28	0.04	0.08	0.02	23.4	8.07	0.24	47.63	37.97	0.46	0.13	0.67
EC	SUM	31	0.15	0.18	0.6	18.2	36.36	0.03	0.06	0	27.4	16.63	0.18	40.51	32.83	0.36	0.07	0.36
EC	FAL	30	0.14	0.15	0.37	9.67	35.88	0.01	0.05	0.01	24.65	10.84	0.1	40.34	31.42	0.36	0.09	0.14
EC	ALL	116	0.14	0.18	0.68	22.49	41.66	0.03	0.06	0.01	39.32	18.86	0.22	53.64	36.77	0.42	0.1	0.47
NO3	WIN	24	1.45	1.31	0.76	-9.2	40.62	-0.13	0.59	0.69	11.46	-4.64	-0.1	50.16	47.35	0.45	0.84	0.58
NO3	SPR	27	1	1.11	0.95	11.52	37.62	0.12	0.38	0.26	-11.33	-37.66	0.12	55.29	69.13	0.38	0.53	0.90
NO3	SUM	28	0.31	0.16	0.8	-47.01	57.9	-0.14	0.18	0.02	-56.73	-98.29	-0.89	67.46	105.33	1.09	0.2	0.63
NO3	FAL	30	0.37	0.33	0.74	-10.31	53.34	-0.04	0.2	0.06	-20.89	-46.33	-0.11	58.69	73.27	0.59	0.25	0.55
NO3	ALL	109	0.75	0.7	0.88	-6.47	43.17	-0.05	0.32	0.25	-20.61	-48.35	-0.07	58.22	74.77	0.46	0.5	0.78
OC	WIN	26	0.4	0.53	0.36	30.25	60.89	0.12	0.25	0.2	83.21	16.01	0.3	110.68	50.14	0.61	0.46	0.13
OC	SPR	29	1.02	0.77	0.7	-24.53	46.29	-0.25	0.47	0.52	-17.62	-34.5	-0.32	45.97	55.18	0.61	0.76	0.49
OC	SUM	31	1.3	1.17	0.68	-10.3	33.95	-0.13	0.44	0.25	-11.36	-20.08	-0.11	34.71	39.04	0.38	0.52	0.46
OC	FAL	30	0.71	0.5	0.42	-28.75	46.02	-0.2	0.32	0.29	-4.52	-29.05	-0.4	54.84	50.38	0.65	0.58	0.18
OC	ALL	116	0.88	0.75	0.65	-14.09	42.85	-0.12	0.38	0.34	10.04	-17.91	-0.16	59.76	48.5	0.5	0.59	0.42
PM-2.5	WIN	26	4.01	4.53	0.86	12.97	28.5	0.52	1.14	2.16	30.5	18.91	0.13	40.91	31.09	0.28	1.56	0.73
PM-2.5	SPR	29	5.86	5.21	0.71	-11.06	36.73	-0.65	2.15	10.19	-5.39	-18.9	-0.12	41.27	45.74	0.41	3.26	0.51
PM-2.5	SUM	31	7.02	5.07	0.61	-27.85	33.85	-1.96	2.38	4.33	-26.49	-35.34	-0.39	33.08	41.02	0.47	2.85	0.37
PM-2.5	FAL	30	3.72	3.59	0.49	-3.72	33.72	-0.14	1.26	3.78	8.26	-3.23	-0.04	37.31	33.95	0.35	1.95	0.24
PM-2.5	ALL	116	5.2	4.6	0.69	-11.6	33.71	-0.6	1.75	5.99	0.55	-10.77	-0.13	37.97	38.15	0.38	2.52	0.48
SO4	WIN	24	0.86	0.75	0.83	-12.12	34.47	-0.1	0.3	0.21	19.46	1.97	-0.14	49.56	40.71	0.39	0.47	0.68
SO4	SPR	27	1.19	0.92	0.74	-22.71	31.2	-0.27	0.37	0.27	-15.83	-24.92	-0.29	30.51	36.66	0.4	0.59	0.55
SO4	SUM	28	1.53	1.03	0.66	-32.83	36.88	-0.5	0.57	0.28	-30.41	-41.15	-0.49	35.68	45.59	0.55	0.73	0.43
SO4	FAL	30	0.74	0.72	0.83	-2.84	29.87	-0.02	0.22	0.09	13.13	4.09	-0.03	37.52	34.94	0.31	0.3	0.69
SO4	ALL	109	1.08	0.86	0.76	-20.8	33.59	-0.22	0.36	0.25	-3.84	-15.18	-0.26	37.96	39.37	0.42	0.54	0.58

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: CHAS1																		
EC	WIN	29	0.48	0.51	0.61	7.56	39.22	0.04	0.19	0.09	25.04	11.8	0.08	42.95	36.45	0.39	0.31	0.37
EC	SPR	31	0.33	0.36	0.78	8.53	25.79	0.03	0.08	0.01	21.1	11.65	0.09	36.01	29.33	0.26	0.11	0.60
EC	SUM	26	0.21	0.29	0.12	38.39	69.36	0.08	0.14	0.04	60.54	25.45	0.38	80.48	51.51	0.69	0.22	0.01
EC	FAL	30	0.37	0.31	0.43	-14.55	42.83	-0.05	0.16	0.06	7.71	-3.34	-0.17	37.9	36.91	0.5	0.25	0.18
EC	ALL	116	0.35	0.37	0.57	5.92	40.86	0.02	0.14	0.05	27.46	10.9	0.06	48.2	38.04	0.41	0.23	0.33
NO3	WIN	29	0.4	0.72	0.51	80.24	124.2	0.32	0.49	0.53	76.81	8.86	0.8	124.46	81.95	1.24	0.8	0.26
NO3	SPR	31	0.32	0.36	0.55	13.28	79.35	0.04	0.25	0.13	17.9	-21.31	0.13	80.8	71.82	0.79	0.36	0.30
NO3	SUM	26	0.22	0.24	0.23	8.94	101.41	0.02	0.23	0.09	22.47	-46.36	0.09	112.52	96.86	1.01	0.31	0.05
NO3	FAL	30	0.25	0.43	0.66	69.89	138.25	0.18	0.35	0.28	42.84	-18.3	0.7	113.31	91.72	1.38	0.56	0.43
NO3	ALL	116	0.3	0.44	0.56	47.16	110.82	0.14	0.33	0.27	40.1	-18.6	0.47	107.23	85.11	1.11	0.54	0.31
OC	WIN	29	1.95	1.95	0.83	-0.07	35.92	0	0.7	1.51	12.55	1.45	0	37.41	33.1	0.36	1.23	0.70
OC	SPR	31	1.5	1.36	0.74	-9.37	31.8	-0.14	0.48	0.31	-7.66	-16.27	-0.1	35.49	35.93	0.35	0.58	0.55
OC	SUM	26	1.3	1.22	0.17	-6.43	56.13	-0.08	0.73	1.35	-0.36	-22.35	-0.07	53.49	50.65	0.6	1.16	0.03
OC	FAL	30	1.5	1.2	0.53	-19.51	46.46	-0.29	0.69	0.77	-17.75	-31.97	-0.24	42.04	49.93	0.58	0.92	0.28
OC	ALL	116	1.57	1.43	0.69	-8.43	41.24	-0.13	0.65	0.97	-3.58	-17.26	-0.09	41.7	42.14	0.45	0.99	0.47
PM-2.5	WIN	29	7.71	8.98	0.81	16.56	32.67	1.28	2.52	9.36	24.11	13.97	0.17	38.82	31.2	0.33	3.32	0.66
PM-2.5	SPR	31	7.65	7.26	0.78	-5.11	18.94	-0.39	1.45	2.9	-4.27	-7.32	-0.05	20.15	21.03	0.2	1.75	0.60
PM-2.5	SUM	26	7.8	4.91	0.12	-37.05	47.02	-2.89	3.67	16.91	-30.16	-47.02	-0.59	42.97	54.24	0.75	5.03	0.02
PM-2.5	FAL	28	6.27	6.28	0.61	0.21	34.54	0.01	2.16	7.6	3.46	-6.78	0	37.78	36.7	0.35	2.76	0.38
PM-2.5	ALL	114	7.36	6.92	0.6	-5.95	32.65	-0.44	2.4	11.06	-1.06	-10.83	-0.06	34.44	35.04	0.35	3.35	0.36
SO4	WIN	29	2.07	2.04	0.58	-1.47	35.64	-0.03	0.74	0.96	14.13	1.75	-0.01	40.24	34.08	0.36	0.98	0.34
SO4	SPR	31	2.18	1.97	0.47	-9.7	30.64	-0.21	0.67	0.66	-4.85	-12.01	-0.11	30.94	31.79	0.34	0.84	0.22
SO4	SUM	26	2.06	0.85	0.56	-58.51	61.36	-1.2	1.26	1.3	-54.99	-83.5	-1.41	58.67	86.47	1.48	1.66	0.31
SO4	FAL	30	1.48	1.38	0.69	-7.2	36.42	-0.11	0.54	0.55	-3.79	-15	-0.08	36.65	40.98	0.39	0.75	0.47
SO4	ALL	116	1.95	1.58	0.51	-18.59	40.39	-0.36	0.79	1.06	-11.07	-25.37	-0.23	40.96	47	0.5	1.09	0.26

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: CLPE1																		
EC	WIN	21	0.02	0.03	0.76	48.69	70.31	0.01	0.02	0	336.37	63.69	0.49	341.55	69.93	0.7	0.02	0.57
EC	SPR	29	0.03	0.03	0.53	10.93	58.24	0	0.02	0	338.39	37.5	0.11	360.18	66.09	0.58	0.02	0.28
EC	SUM	23	0.12	0.19	0.13	51.76	112.26	0.06	0.14	0.22	50.93	-25.9	0.52	107.05	49.01	1.12	0.47	0.02
EC	FAL	26	0.1	0.14	0.79	41.72	60.38	0.04	0.06	0.01	54.57	14.59	0.42	84.34	52.99	0.6	0.11	0.62
EC	ALL	99	0.07	0.1	0.37	42.8	83.29	0.03	0.06	0.05	196.64	22.31	0.43	224.98	59.5	0.83	0.23	0.14
NO3	WIN	24	0.07	0.13	0.66	86.11	122.96	0.06	0.09	0.06	111.83	-14.63	0.86	181.99	97.79	1.23	0.25	0.43
NO3	SPR	29	0.13	0.11	0.13	-11.56	109.72	-0.01	0.14	0.05	173.86	-43.35	-0.13	267.27	104.75	1.24	0.22	0.02
NO3	SUM	21	0.07	0.02	0.05	-73.54	77.85	-0.05	0.06	0	-66.82	-110.59	-2.78	72.63	115.04	2.94	0.07	0.00
NO3	FAL	25	0.07	0.03	0.69	-50.52	68.42	-0.03	0.05	0	-52.18	-86.04	-1.02	62.89	94.62	1.38	0.06	0.48
NO3	ALL	99	0.09	0.08	0.35	-10.7	98.64	-0.01	0.09	0.03	50.69	-61.43	-0.12	153.7	102.69	1.1	0.18	0.13
OC	WIN	21	0.12	0.11	0.55	-3.54	61.43	0	0.07	0.01	143.91	24.5	-0.04	180.52	74.76	0.64	0.09	0.30
OC	SPR	29	0.14	0.11	0.57	-19.34	46.05	-0.03	0.06	0.01	43.96	-0.9	-0.24	81.92	50.53	0.57	0.1	0.33
OC	SUM	23	1.12	1.08	0.35	-2.81	82.15	-0.03	0.92	4.89	-17.35	-52.52	-0.03	66.83	65.45	0.85	2.21	0.12
OC	FAL	25	0.75	0.71	0.75	-5.97	53.54	-0.04	0.4	0.35	14.52	-12.82	-0.06	69.01	64.14	0.57	0.59	0.56
OC	ALL	98	0.52	0.49	0.49	-5.3	67.78	-0.03	0.35	1.24	43.48	-10.61	-0.06	96.21	62.7	0.72	1.11	0.24
PM-2.5	WIN	26	0.88	0.97	0.71	10.07	38.1	0.09	0.34	0.28	30.52	17.8	0.1	44.13	34.55	0.38	0.53	0.50
PM-2.5	SPR	30	1.94	1.38	0.63	-28.71	46.47	-0.56	0.9	3.13	0.13	-14.29	-0.4	42.11	42.73	0.65	1.85	0.40
PM-2.5	SUM	23	3.95	3.1	0.41	-21.64	68.27	-0.86	2.7	22.78	-29.64	-56.53	-0.28	61.48	67.78	0.87	4.85	0.17
PM-2.5	FAL	26	2.66	2.37	0.8	-11.15	36.25	-0.3	0.97	1.58	-3.29	-13.65	-0.13	39.49	39.94	0.41	1.29	0.64
PM-2.5	ALL	105	2.3	1.9	0.47	-17.33	50.96	-0.4	1.17	6.46	0.29	-15.44	-0.21	46.21	45.5	0.62	2.57	0.22
SO4	WIN	24	0.23	0.34	0.42	47.96	87.02	0.11	0.2	0.06	141.69	62	0.48	150.33	73.75	0.87	0.27	0.17
SO4	SPR	30	0.47	0.49	0.67	3.18	45.12	0.02	0.21	0.1	81.71	17.26	0.03	105.91	48.2	0.45	0.32	0.45
SO4	SUM	21	0.51	0.34	0.57	-33.38	34.72	-0.17	0.18	0.01	-33.28	-42.28	-0.5	34.33	43.28	0.52	0.2	0.33
SO4	FAL	25	0.4	0.44	0.59	8.97	31.91	0.04	0.13	0.03	19.33	6.83	0.09	41.16	32.22	0.32	0.16	0.34
SO4	ALL	100	0.4	0.41	0.58	1.21	44.91	0	0.18	0.06	56.36	12.89	0.01	85.35	49.3	0.45	0.25	0.33

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: COHU1																		
EC	WIN	23	0.25	0.39	0.93	54.36	56.91	0.14	0.14	0.02	68.47	45.21	0.54	70.42	47.29	0.57	0.2	0.86
EC	SPR	23	0.34	0.34	0.91	-0.3	23.46	0	0.08	0.01	13.81	5.67	0	33.04	28.65	0.24	0.1	0.82
EC	SUM	26	0.27	0.22	0.59	-18.95	28.17	-0.05	0.08	0.01	-12.06	-18.23	-0.23	28.27	30.11	0.35	0.1	0.35
EC	FAL	25	0.23	0.26	0.59	11.94	33.05	0.03	0.08	0.01	59.26	16.21	0.12	73.37	33.02	0.33	0.1	0.34
EC	ALL	97	0.27	0.3	0.8	9.44	34.21	0.03	0.09	0.02	31.55	11.36	0.09	51.02	34.59	0.34	0.13	0.65
NO3	WIN	23	0.59	0.79	0.56	34.52	62.49	0.2	0.37	0.26	48.14	16.78	0.35	72.7	50.43	0.62	0.55	0.31
NO3	SPR	20	0.4	0.52	0.19	30.27	83.3	0.12	0.33	0.57	36.9	-22.89	0.3	95.94	57.66	0.83	0.77	0.04
NO3	SUM	26	0.12	0.11	0.28	-7.47	62.01	-0.01	0.08	0.02	-4.46	-36.79	-0.08	65.14	63.18	0.67	0.14	0.08
NO3	FAL	25	0.22	0.37	0.38	71.26	109.48	0.16	0.24	0.15	102.39	21.68	0.71	137.31	72.27	1.09	0.42	0.14
NO3	ALL	94	0.32	0.44	0.54	35.55	76.41	0.11	0.25	0.24	45.63	-5.17	0.36	92.74	61.31	0.76	0.5	0.29
OC	WIN	23	1.18	1.37	0.91	16.29	36.62	0.19	0.43	0.55	15.26	7.97	0.16	31.78	27.5	0.37	0.77	0.84
OC	SPR	23	2.28	1.6	0.81	-29.56	36.53	-0.67	0.83	1.21	-6.52	-18.12	-0.42	38.99	40.12	0.52	1.29	0.65
OC	SUM	26	2.23	2.11	0.75	-5.32	25.8	-0.12	0.57	0.6	-5.52	-10.86	-0.06	26.55	27.84	0.27	0.78	0.57
OC	FAL	25	1.19	1.16	0.73	-3.06	39.41	-0.04	0.47	0.7	-5.86	-15.21	-0.03	34.39	36.21	0.41	0.84	0.53
OC	ALL	97	1.72	1.57	0.75	-9	33.35	-0.16	0.58	0.85	-0.92	-9.24	-0.1	32.76	32.83	0.37	0.94	0.56
PM-2.5	WIN	23	4.79	6.47	0.88	35.1	42.62	1.68	2.04	5.81	50.97	30.2	0.35	56.74	36.7	0.43	2.94	0.77
PM-2.5	SPR	23	10.05	7.83	0.64	-22.14	34.27	-2.23	3.44	16.51	-3.83	-16.09	-0.28	38.24	37.59	0.44	4.63	0.40
PM-2.5	SUM	26	11.12	8.08	0.72	-27.35	30.86	-3.04	3.43	8.04	-26.26	-33.32	-0.38	30.07	36.55	0.42	4.16	0.52
PM-2.5	FAL	25	5.48	5.7	0.83	4.01	25.5	0.22	1.4	3.73	15.55	7.26	0.04	33.2	28.86	0.26	1.94	0.69
PM-2.5	ALL	97	7.91	7.02	0.72	-11.22	32.61	-0.89	2.58	11.95	8.15	-3.72	-0.13	39.14	34.85	0.37	3.57	0.51
SO4	WIN	23	1.35	1.32	0.62	-2.59	37.12	-0.04	0.5	0.38	18.65	4.07	-0.03	47.41	39.93	0.38	0.61	0.38
SO4	SPR	20	2.47	2.24	0.51	-9.4	33.92	-0.23	0.84	0.97	3.63	-5.93	-0.1	37.73	37.85	0.37	1.01	0.26
SO4	SUM	26	3.49	2.35	0.62	-32.64	36.01	-1.14	1.26	1.11	-30.3	-40.4	-0.48	34.18	43.97	0.53	1.55	0.39
SO4	FAL	25	1.52	1.58	0.78	3.57	29.32	0.05	0.45	0.47	19.15	9.26	0.04	34.49	28.57	0.29	0.69	0.60
SO4	ALL	94	2.23	1.87	0.71	-16.12	34.47	-0.36	0.77	0.97	2.05	-8.98	-0.19	38.26	37.59	0.41	1.05	0.50

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: CRES1																		
EC	WIN	26	0.07	0.13	0.59	94.31	98.46	0.06	0.06	0	139.66	63.91	0.94	142.39	67.24	0.98	0.09	0.35
EC	SPR	31	0.14	0.14	0.79	0.23	47.19	0	0.07	0.01	26.3	7.93	0	53.4	44.5	0.47	0.11	0.62
EC	SUM	31	0.12	0.14	0.62	14.34	34.7	0.02	0.04	0	23.24	11.3	0.14	40.25	32.75	0.35	0.06	0.38
EC	FAL	30	0.09	0.14	0.77	54.37	58.55	0.05	0.05	0	71.68	44.23	0.54	76.01	49.17	0.59	0.06	0.60
EC	ALL	118	0.11	0.14	0.71	28.81	52.68	0.03	0.06	0.01	62.01	30.38	0.29	75.3	47.61	0.53	0.08	0.50
NO3	WIN	26	0.78	0.71	0.88	-8.1	35.87	-0.06	0.28	0.17	23.12	-2.22	-0.09	62.73	48.18	0.39	0.41	0.77
NO3	SPR	31	0.85	1.01	0.68	18.19	67.45	0.16	0.58	1.37	31.61	-4.67	0.18	78.6	62.4	0.67	1.18	0.46
NO3	SUM	31	0.2	0.13	0.26	-31.7	96.66	-0.06	0.19	0.1	-16.12	-92.67	-0.46	108.31	112.05	1.42	0.32	0.07
NO3	FAL	30	0.21	0.29	0.92	39.29	71.54	0.08	0.15	0.05	30.63	-14.36	0.39	88.45	68.36	0.72	0.23	0.85
NO3	ALL	118	0.5	0.53	0.74	6.33	60.1	0.03	0.3	0.44	16.95	-29.71	0.06	85.41	73.83	0.6	0.67	0.54
OC	WIN	26	0.27	0.29	0.23	8	54.65	0.02	0.15	0.06	16.78	-6.13	0.08	53.73	43.42	0.55	0.25	0.05
OC	SPR	31	0.76	0.46	0.71	-38.84	53.88	-0.3	0.41	0.5	-31.29	-53.07	-0.64	52	67.61	0.88	0.77	0.50
OC	SUM	31	1.03	0.72	0.54	-30.44	36.48	-0.31	0.38	0.19	-30.39	-42.95	-0.44	36.27	47.92	0.52	0.54	0.29
OC	FAL	30	0.5	0.43	0.74	-14.6	34.46	-0.07	0.17	0.04	-0.12	-15.12	-0.17	44.84	44.62	0.4	0.22	0.55
OC	ALL	118	0.66	0.48	0.69	-26.45	43	-0.17	0.28	0.23	-12.54	-30.42	-0.36	46.43	51.26	0.58	0.51	0.47
PM-2.5	WIN	26	2.59	2.64	0.67	1.89	36.19	0.05	0.94	1.62	20.44	5.1	0.02	45.61	36.77	0.36	1.27	0.45
PM-2.5	SPR	31	4.56	4.07	0.56	-10.88	52.6	-0.5	2.4	19.57	-5.88	-22.35	-0.12	47.05	51.09	0.59	4.45	0.32
PM-2.5	SUM	31	4.82	3.33	0.57	-30.83	38.83	-1.49	1.87	2.75	-30.74	-43	-0.45	38.74	49.61	0.56	2.23	0.32
PM-2.5	FAL	29	3.08	2.67	0.6	-13.29	29.84	-0.41	0.92	1.76	-0.08	-8.55	-0.15	32.26	32.28	0.34	1.39	0.36
PM-2.5	ALL	117	3.83	3.21	0.58	-16.1	40.99	-0.62	1.57	7.02	-5.18	-18.3	-0.19	40.86	42.85	0.49	2.72	0.34
SO4	WIN	26	0.57	0.48	0.48	-15.41	40.47	-0.09	0.23	0.13	14.93	1.09	-0.18	43.65	40.7	0.48	0.37	0.23
SO4	SPR	31	0.88	0.85	0.5	-3.12	51.18	-0.03	0.45	0.81	7.77	-11.97	-0.03	48.64	45.7	0.53	0.9	0.25
SO4	SUM	31	0.93	0.74	0.54	-20.36	39.04	-0.19	0.36	0.17	-19.16	-28.8	-0.26	36.86	42.91	0.49	0.45	0.29
SO4	FAL	30	0.54	0.54	0.75	0.13	29.75	0	0.16	0.04	15.33	5.42	0	37.89	32.92	0.3	0.21	0.56
SO4	ALL	118	0.74	0.66	0.53	-10.31	41.38	-0.08	0.31	0.3	4.19	-9.09	-0.12	41.71	40.62	0.46	0.56	0.28

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: DOSO1																		
EC	WIN	29	0.23	0.27	0.63	18.65	37.17	0.04	0.09	0.02	37.17	15.77	0.19	51.79	32.59	0.37	0.14	0.40
EC	SPR	31	0.2	0.16	0.46	-23.35	38.74	-0.05	0.08	0.01	-14.28	-27.76	-0.3	39.21	46.15	0.51	0.11	0.21
EC	SUM	30	0.23	0.15	0.62	-32.66	36.17	-0.07	0.08	0	-28.81	-38.66	-0.49	34.75	43.27	0.54	0.1	0.38
EC	FAL	29	0.22	0.17	0.69	-20.55	32.12	-0.04	0.07	0.01	-12.31	-21.91	-0.26	32.71	37.59	0.4	0.1	0.47
EC	ALL	119	0.22	0.19	0.55	-14.39	36.07	-0.03	0.08	0.01	-4.92	-18.47	-0.17	39.57	40.03	0.42	0.12	0.30
NO3	WIN	29	0.56	0.8	0.62	41.08	85.52	0.23	0.48	0.34	154.84	27.65	0.41	195.04	88.06	0.86	0.62	0.38
NO3	SPR	31	0.4	0.43	0.71	7.39	76.74	0.03	0.3	0.25	16.81	-42.28	0.07	98.08	91.95	0.77	0.5	0.51
NO3	SUM	30	0.13	0.07	0.55	-49.19	52.94	-0.06	0.07	0	-47.08	-70.91	-0.97	50.43	73.99	1.04	0.09	0.30
NO3	FAL	29	0.3	0.25	0.44	-19.22	71.66	-0.06	0.22	0.11	97.38	-24.73	-0.24	164.86	83.21	0.89	0.34	0.20
NO3	ALL	119	0.35	0.38	0.67	9.73	76.9	0.03	0.27	0.19	53.98	-28.18	0.1	125.97	84.34	0.77	0.43	0.45
OC	WIN	29	1.09	0.96	0.61	-11.88	40.22	-0.13	0.44	0.4	9.36	-14.12	-0.13	54.9	43.79	0.46	0.65	0.37
OC	SPR	31	1.22	0.72	0.64	-41.08	43.88	-0.5	0.54	0.33	-34.89	-52.81	-0.7	42.12	57.74	0.74	0.76	0.42
OC	SUM	30	1.42	1.19	0.46	-16.57	34.15	-0.24	0.49	0.6	-5.15	-16.13	-0.2	35.42	35.94	0.41	0.81	0.21
OC	FAL	29	0.91	0.74	0.77	-18.71	40.66	-0.17	0.37	0.26	-22.18	-35.52	-0.23	37.05	47.78	0.5	0.54	0.60
OC	ALL	119	1.16	0.9	0.58	-22.61	39.43	-0.26	0.46	0.42	-13.51	-29.92	-0.29	42.31	46.42	0.51	0.7	0.34
PM-2.5	WIN	28	5.17	5.22	0.72	0.83	28.61	0.04	1.48	3.48	10.94	0.87	0.01	37.06	31.01	0.29	1.87	0.52
PM-2.5	SPR	31	6.54	4.8	0.72	-26.6	33.74	-1.74	2.21	6.46	-16.24	-27.32	-0.36	34.46	41.02	0.46	3.08	0.52
PM-2.5	SUM	30	11.4	7.12	0.7	-37.58	40.55	-4.28	4.62	14.34	-34.45	-45.54	-0.6	37.96	48.67	0.65	5.72	0.49
PM-2.5	FAL	29	5.3	4.34	0.89	-17.98	29.82	-0.95	1.58	5.54	-3.17	-12.13	-0.22	33.07	34.09	0.36	2.54	0.79
PM-2.5	ALL	118	7.15	5.38	0.77	-24.77	34.91	-1.77	2.49	10.08	-11.21	-21.53	-0.33	35.63	38.88	0.46	3.63	0.59
SO4	WIN	29	1.63	1.27	0.7	-22.1	33.57	-0.36	0.55	0.38	-12.24	-20.99	-0.28	33.96	36.86	0.43	0.71	0.50
SO4	SPR	31	1.97	1.67	0.77	-15.56	31.84	-0.31	0.63	0.72	1.32	-10.19	-0.18	38.44	37.49	0.38	0.9	0.59
SO4	SUM	30	4.5	3.36	0.77	-25.36	33.27	-1.14	1.5	3.16	-21.17	-28.02	-0.34	28.9	34.8	0.45	2.11	0.60
SO4	FAL	29	1.72	1.5	0.83	-12.62	41.18	-0.22	0.71	1.52	35.12	5.42	-0.14	66.53	46.06	0.47	1.25	0.69
SO4	ALL	119	2.46	1.96	0.84	-20.62	34.36	-0.51	0.85	1.58	0.58	-13.51	-0.26	41.79	38.75	0.43	1.36	0.70

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: ELDO1																		
EC	WIN	22	0.35	0.42	0.47	20.35	47.6	0.07	0.16	0.07	26.17	11.62	0.2	46.87	36.7	0.48	0.26	0.22
EC	SPR	29	0.28	0.36	0.79	31.55	53.2	0.09	0.15	0.05	28.03	11.63	0.32	52.13	41.56	0.53	0.23	0.63
EC	SUM	27	0.25	0.25	0.48	0.01	25.71	0	0.06	0.01	10.83	3.57	0	29.91	26.57	0.26	0.09	0.23
EC	FAL	30	0.31	0.32	0.67	4.01	31.49	0.01	0.1	0.02	6.38	-0.68	0.04	31.58	30.51	0.31	0.14	0.44
EC	ALL	108	0.29	0.33	0.64	14.04	39.62	0.04	0.12	0.03	17.34	6.19	0.14	39.8	33.75	0.4	0.19	0.41
NO3	WIN	23	3.6	2.82	0.79	-21.72	42.48	-0.78	1.53	3.47	13.3	-8.96	-0.28	57.94	50.44	0.54	2.02	0.63
NO3	SPR	25	1.06	1.15	0.94	8.44	43.67	0.09	0.46	0.37	-4.61	-24.46	0.08	53.22	58.05	0.44	0.62	0.89
NO3	SUM	27	0.22	0.06	0.16	-71.37	71.37	-0.16	0.16	0.01	-67.12	-106.93	-2.49	67.12	106.93	2.49	0.19	0.02
NO3	FAL	30	0.75	0.84	0.86	11.3	52.39	0.08	0.39	0.45	13.51	-17.29	0.11	67.33	64.65	0.52	0.68	0.75
NO3	ALL	105	1.31	1.15	0.85	-12.69	45.58	-0.17	0.6	1.1	-11.58	-40.22	-0.15	61.86	70.83	0.52	1.06	0.72
OC	WIN	22	1.46	1.46	0.5	0.39	43.26	0.01	0.63	1.19	0.1	-11.58	0	39.26	37.37	0.43	1.09	0.25
OC	SPR	29	1.69	1.48	0.78	-12.47	40.08	-0.21	0.68	0.82	-14.46	-26.6	-0.14	39.14	46.12	0.46	0.93	0.61
OC	SUM	27	1.76	1.82	0.77	3.58	27.82	0.06	0.49	0.4	9.43	1.67	0.04	33.24	29.66	0.28	0.63	0.59
OC	FAL	30	1.32	1.23	0.74	-6.78	35.63	-0.09	0.47	0.43	-9.17	-18.41	-0.07	33.52	37.57	0.38	0.66	0.55
OC	ALL	108	1.56	1.49	0.72	-4.15	36.17	-0.06	0.56	0.69	-4.05	-14.2	-0.04	36.13	37.85	0.38	0.83	0.51
PM-2.5	WIN	22	9.95	9.91	0.62	-0.43	33.36	-0.04	3.32	18.78	15.11	3.96	0	40.47	33.57	0.34	4.33	0.39
PM-2.5	SPR	29	8.12	7.94	0.83	-2.26	28.18	-0.18	2.29	8.24	-1.47	-8.08	-0.02	30.9	32.34	0.29	2.88	0.69
PM-2.5	SUM	27	9.51	6.61	0.64	-30.53	36.06	-2.9	3.43	8.32	-25.41	-34.52	-0.44	34.59	42.35	0.52	4.09	0.41
PM-2.5	FAL	30	6.79	6.78	0.56	-0.09	33.4	-0.01	2.27	11.05	5.11	-2.07	0	31.01	29.41	0.33	3.32	0.31
PM-2.5	ALL	108	8.47	7.69	0.66	-9.27	32.79	-0.79	2.78	12.69	-2.25	-10.57	-0.1	33.8	34.28	0.36	3.65	0.44
SO4	WIN	23	2	1.45	0.73	-27.89	40.08	-0.56	0.8	0.97	-18.38	-28.67	-0.39	35.51	43.25	0.56	1.13	0.53
SO4	SPR	25	2.23	1.77	0.78	-20.46	30.21	-0.46	0.67	0.59	-14.86	-22.07	-0.26	30.69	35.34	0.38	0.89	0.61
SO4	SUM	27	2.39	1.47	0.61	-38.61	44.16	-0.92	1.06	0.89	-30.88	-46.28	-0.63	43.65	56.07	0.72	1.32	0.37
SO4	FAL	30	1.39	1.34	0.6	-3.28	33.27	-0.05	0.46	0.61	15.6	4.64	-0.03	36.77	31.27	0.34	0.78	0.36
SO4	ALL	105	1.98	1.5	0.67	-24.31	37.34	-0.48	0.74	0.86	-11.04	-22.11	-0.32	36.81	41.24	0.49	1.04	0.45

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: ELLI1																		
EC	WIN	29	0.16	0.18	0.86	8.4	21.05	0.01	0.03	0	13.19	7.66	0.08	24.48	20.95	0.21	0.05	0.74
EC	SPR	31	0.27	0.23	0.7	-16.44	33.57	-0.04	0.09	0.03	-1.47	-8.71	-0.2	31.73	33.62	0.4	0.18	0.49
EC	SUM	28	0.17	0.14	0.77	-17.34	29.72	-0.03	0.05	0	0	-19.05	-0.21	46.28	37.29	0.36	0.06	0.60
EC	FAL	30	0.17	0.16	0.74	-3.98	24.03	-0.01	0.04	0	-2.03	-6.33	-0.04	24.78	24.46	0.25	0.05	0.55
EC	ALL	118	0.2	0.18	0.72	-8.77	28.08	-0.02	0.05	0.01	2.34	-6.53	-0.1	31.63	29.05	0.31	0.1	0.52
NO3	WIN	28	1.65	0.98	0.58	-40.91	49.67	-0.68	0.82	1.02	-25.8	-47.44	-0.69	48.75	64.07	0.84	1.22	0.34
NO3	SPR	31	0.87	0.56	0.86	-35.48	52.11	-0.31	0.45	0.32	-53.67	-89.92	-0.55	61.5	96.61	0.81	0.65	0.74
NO3	SUM	28	0.24	0.03	0.01	-86.83	86.83	-0.21	0.21	0.02	-82.87	-144.8	-6.59	82.87	144.8	6.59	0.24	0.00
NO3	FAL	30	0.36	0.25	0.78	-30.94	59.5	-0.11	0.21	0.08	-31.24	-59.36	-0.45	60.9	81.39	0.86	0.31	0.61
NO3	ALL	117	0.78	0.45	0.77	-41.5	54.31	-0.32	0.42	0.4	-48.24	-85.05	-0.71	63.41	96.45	0.93	0.71	0.60
OC	WIN	29	0.55	0.51	0.69	-7.11	38.65	-0.04	0.21	0.08	-2.69	-16.15	-0.08	42.28	42.41	0.42	0.29	0.47
OC	SPR	31	1.74	0.86	0.73	-50.34	54.25	-0.87	0.94	1.78	-40.82	-60.49	-1.01	48.56	66.32	1.09	1.6	0.53
OC	SUM	28	1.32	1.19	0.77	-9.9	27.79	-0.13	0.37	0.18	-10.52	-16.31	-0.11	28.2	31.14	0.31	0.44	0.60
OC	FAL	30	0.71	0.53	0.79	-24.87	31.91	-0.18	0.23	0.04	-27.3	-38.79	-0.33	34.19	45	0.42	0.27	0.63
OC	ALL	118	1.08	0.77	0.66	-29.05	40.95	-0.32	0.44	0.65	-20.82	-33.59	-0.41	38.53	46.67	0.58	0.87	0.44
PM-2.5	WIN	29	4.87	4.2	0.83	-13.67	27.17	-0.67	1.32	2.63	-1.61	-7.14	-0.16	27.77	28.41	0.31	1.75	0.68
PM-2.5	SPR	31	8.07	4.91	0.53	-39.16	48.87	-3.16	3.94	24.53	-27.15	-42.96	-0.64	43.89	56.21	0.8	5.87	0.29
PM-2.5	SUM	28	8.35	4.51	0.56	-46.02	47.05	-3.84	3.93	4.98	-45.4	-62.79	-0.85	46.78	64.04	0.87	4.45	0.32
PM-2.5	FAL	30	4.1	3.49	0.65	-14.75	28.56	-0.6	1.17	2.01	-9.98	-18.79	-0.17	31.57	33.9	0.34	1.54	0.42
PM-2.5	ALL	118	6.34	4.28	0.6	-32.48	40.87	-2.06	2.59	10.87	-20.84	-32.72	-0.48	37.48	45.56	0.61	3.89	0.36
SO4	WIN	28	0.98	0.83	0.68	-14.98	39.22	-0.15	0.38	0.33	8.06	-7.12	-0.18	47.63	44.21	0.46	0.59	0.47
SO4	SPR	31	1.47	1.04	0.41	-29.23	44.73	-0.43	0.66	0.73	-19.55	-32.19	-0.41	38.63	45.42	0.63	0.96	0.17
SO4	SUM	28	1.79	1.05	0.67	-41.34	45.28	-0.74	0.81	0.23	-40.6	-56.57	-0.7	46.37	60.94	0.77	0.88	0.45
SO4	FAL	30	0.89	0.83	0.84	-6.66	23.24	-0.06	0.21	0.09	3.99	-2.6	-0.07	28.16	27.04	0.25	0.3	0.71
SO4	ALL	117	1.28	0.94	0.6	-26.65	40.08	-0.34	0.51	0.42	-11.94	-24.44	-0.36	39.95	44.13	0.55	0.73	0.36

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: EVER1																		
EC	WIN	29	0.22	0.24	0.66	8.35	43.99	0.02	0.1	0.01	25.59	9	0.08	53.97	45.87	0.44	0.12	0.43
EC	SPR	31	0.21	0.11	0.78	-46.64	47.31	-0.1	0.1	0.01	-41.82	-59.94	-0.87	45.41	62.88	0.89	0.13	0.61
EC	SUM	28	0.13	0.07	0.6	-48.83	79.13	-0.07	0.11	0.04	118.72	-3.98	-0.95	180.83	92.5	1.55	0.22	0.36
EC	FAL	21	0.11	0.13	0.61	27.46	65.71	0.03	0.07	0.01	47.65	4.93	0.27	88.74	63.47	0.66	0.09	0.37
EC	ALL	109	0.17	0.14	0.54	-19.88	54.61	-0.03	0.09	0.02	34.59	-14.73	-0.25	90.82	66.08	0.68	0.15	0.29
NO3	WIN	18	0.42	0.43	0.34	1.02	85.1	0	0.36	0.23	-6.27	-56.43	0.01	86.55	99.27	0.85	0.47	0.12
NO3	SPR	23	0.41	0.32	0.18	-22	78.45	-0.09	0.32	0.15	-20.24	-73.76	-0.28	79.78	107.28	1.01	0.4	0.03
NO3	FAL	2	0.32	0.58	1	84.06	162.25	0.27	0.51	0.26	72.87	-19.21	0.84	157.06	126.17	1.62	0.58	1.00
NO3	ALL	43	0.41	0.38	0.26	-8.32	84.3	-0.03	0.35	0.19	-10.06	-63.97	-0.09	86.21	104.81	0.92	0.44	0.07
OC	WIN	29	0.79	0.84	0.85	5.68	26.3	0.04	0.21	0.07	9.37	2.96	0.06	30.28	27.81	0.26	0.27	0.72
OC	SPR	31	1.23	0.5	0.83	-59.48	59.48	-0.73	0.73	0.56	-57.64	-83.78	-1.47	57.64	83.78	1.47	1.05	0.69
OC	SUM	29	1.14	0.32	0.55	-71.82	71.82	-0.82	0.82	0.21	-69.66	-111.73	-2.55	69.66	111.73	2.55	0.93	0.30
OC	FAL	22	0.78	0.47	0.32	-40.11	52.14	-0.31	0.41	0.16	-30.53	-58.7	-0.67	56.83	71.64	0.87	0.51	0.10
OC	ALL	111	1	0.53	0.53	-46.7	55.15	-0.47	0.55	0.39	-37.9	-63.45	-0.88	53.47	74.05	1.03	0.78	0.28
PM-2.5	WIN	29	4.87	5.73	0.64	17.63	25.54	0.86	1.24	1.85	22.3	16.67	0.18	29.11	24.14	0.26	1.61	0.41
PM-2.5	SPR	30	7.81	4.27	0.49	-45.39	46.96	-3.55	3.67	10.1	-40.62	-56.49	-0.83	43.02	58.7	0.86	4.76	0.24
PM-2.5	SUM	30	6.79	2.33	0.49	-65.7	65.88	-4.46	4.47	5.21	-63.5	-99.96	-1.92	63.84	100.29	1.92	5.01	0.24
PM-2.5	FAL	30	4.85	3.38	0.05	-30.23	42.66	-1.47	2.07	4.44	-25.4	-44.68	-0.43	43.96	57.12	0.61	2.57	0.00
PM-2.5	ALL	119	6.09	3.91	0.22	-35.78	47.24	-2.18	2.88	9.59	-27.22	-46.64	-0.56	45.12	60.36	0.74	3.79	0.05
SO4	WIN	18	1.81	2.21	0.44	22.1	33.75	0.4	0.61	0.63	27.32	17.1	0.22	37.61	28.8	0.34	0.89	0.20
SO4	SPR	23	2.29	1.58	0.6	-31.08	38.23	-0.71	0.88	0.47	-27.14	-39.15	-0.45	38.54	47.68	0.55	0.99	0.37
SO4	FAL	2	1.2	1.03	1	-14.44	14.44	-0.17	0.17	0.01	-12.43	-13.48	-0.17	12.43	13.48	0.17	0.21	1.00
SO4	ALL	43	2.04	1.82	0.37	-10.87	35.91	-0.22	0.73	0.81	-3.66	-14.41	-0.12	36.94	38.19	0.4	0.93	0.14

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: FLTO1																		
EC	WIN	10	0.04	0.06	0.53	37.26	63.61	0.02	0.03	0	89.76	34.83	0.37	108.61	56.24	0.64	0.04	0.28
EC	FAL	9	0.06	0.08	0.05	47.51	104.91	0.03	0.06	0.01	68.91	4.16	0.48	112.46	64.62	1.05	0.11	0.00
EC	ALL	19	0.05	0.07	0.17	43.02	86.82	0.02	0.04	0.01	79.88	20.3	0.43	110.43	60.21	0.87	0.08	0.03
NO3	WIN	10	0.09	0.05	0.61	-47.77	58.69	-0.04	0.05	0.01	-54.38	-91.73	-0.91	61.83	98.01	1.12	0.08	0.37
NO3	FAL	9	0.06	0.12	0.5	111.57	187.84	0.07	0.11	0.06	69.26	-24.79	1.12	141.59	81.58	1.88	0.26	0.25
NO3	ALL	19	0.08	0.08	0.25	10.55	105.96	0.01	0.08	0.03	4.18	-60.02	0.11	99.61	90.23	1.06	0.19	0.06
OC	WIN	9	0.19	0.21	0.47	6.49	53.68	0.01	0.1	0.02	22.29	2.86	0.06	58.17	47.9	0.54	0.15	0.22
OC	FAL	9	0.35	0.34	0.25	-0.85	77.74	0	0.27	0.19	-2.8	-36.41	-0.01	67.68	65.11	0.78	0.43	0.06
OC	ALL	18	0.27	0.27	0.34	1.8	69.07	0	0.19	0.1	9.74	-16.78	0.02	62.93	56.51	0.69	0.32	0.12
PM-2.5	WIN	10	0.97	1.24	0.71	27.7	36.95	0.27	0.36	0.27	29.96	19.46	0.28	39.29	31.17	0.37	0.58	0.50
PM-2.5	FAL	9	1.87	1.75	0.15	-6.44	52.17	-0.12	0.97	2.31	-0.45	-16.92	-0.07	43.36	41.97	0.56	1.53	0.02
PM-2.5	ALL	19	1.39	1.48	0.35	6.03	46.61	0.08	0.65	1.27	15.55	2.23	0.06	41.22	36.28	0.47	1.13	0.13
SO4	WIN	10	0.25	0.43	0.77	75.23	75.37	0.19	0.19	0.02	90.95	54.54	0.75	91.07	54.67	0.75	0.24	0.60
SO4	FAL	9	0.46	0.45	0.42	-3.32	34.64	-0.02	0.16	0.04	12.56	4.16	-0.03	35.34	35.34	0.36	0.21	0.18
SO4	ALL	19	0.35	0.44	0.51	25.91	49.8	0.09	0.17	0.04	53.82	30.68	0.26	64.67	45.52	0.5	0.23	0.26

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: FOPE1																		
EC	WIN	17	0.07	0.08	0.61	2.84	31.89	0	0.02	0	20.25	7.34	0.03	42.9	36.01	0.32	0.03	0.38
EC	SPR	27	0.11	0.08	0.64	-22.72	36.39	-0.02	0.04	0	-4.08	-18.2	-0.29	38.05	42.57	0.47	0.07	0.41
EC	SUM	29	0.11	0.12	0.25	3.24	50.2	0	0.06	0.01	36.63	14.8	0.03	57.47	43.81	0.5	0.09	0.06
EC	FAL	30	0.13	0.16	0.53	20.83	54.17	0.03	0.07	0.01	45.88	18.1	0.21	66.87	45.67	0.54	0.1	0.28
EC	ALL	103	0.11	0.11	0.49	2.75	46.1	0	0.05	0.01	25.95	5.88	0.03	52.71	42.74	0.46	0.08	0.24
NO3	WIN	17	0.63	1.47	0.71	135.9	149.4	0.85	0.93	1.21	195.24	71.93	1.36	205.19	86.23	1.49	1.39	0.50
NO3	SPR	27	0.89	1.2	0.75	33.81	71.09	0.3	0.64	0.94	57.78	8.33	0.34	97.89	73.4	0.71	1.01	0.56
NO3	SUM	29	0.11	0.08	0.59	-19.56	69.41	-0.02	0.07	0.01	-31.63	-66.97	-0.24	69.06	88	0.86	0.1	0.35
NO3	FAL	30	0.2	0.62	0.77	211.31	223.41	0.42	0.45	0.6	285.5	44.84	2.11	318.67	94.92	2.23	0.88	0.60
NO3	ALL	103	0.43	0.76	0.72	79.12	110.8	0.34	0.47	0.71	121.62	8.26	0.79	171.79	85.89	1.11	0.9	0.52
OC	WIN	17	0.4	0.25	0.26	-38.72	46.15	-0.16	0.19	0.03	-24.93	-42.34	-0.63	45.56	56.74	0.75	0.24	0.07
OC	SPR	27	0.47	0.22	0.42	-53.27	54.28	-0.25	0.25	0.04	-47.05	-70.29	-1.14	49.7	72.57	1.16	0.31	0.18
OC	SUM	29	1.1	0.46	0.4	-58.43	59.5	-0.64	0.66	0.29	-56.82	-84.96	-1.41	57.76	85.84	1.43	0.84	0.16
OC	FAL	30	0.8	0.69	0.44	-14.1	46.6	-0.11	0.37	0.29	-1.31	-18.16	-0.16	47.41	48.49	0.54	0.55	0.20
OC	ALL	103	0.73	0.43	0.47	-41.62	53.3	-0.31	0.39	0.23	-32.83	-54.62	-0.71	50.62	66.68	0.91	0.57	0.22
PM-2.5	WIN	17	2.67	3.27	0.74	22.24	41.29	0.59	1.1	2.2	28.15	16.43	0.22	43.46	34.92	0.41	1.6	0.55
PM-2.5	SPR	27	4.03	3.62	0.81	-10.09	35.61	-0.41	1.43	3.87	1.28	-13.08	-0.11	41.22	44.62	0.4	2.01	0.66
PM-2.5	SUM	29	4.29	2.35	0.56	-45.14	45.14	-1.94	1.94	1.84	-42.87	-57.77	-0.82	42.87	57.77	0.82	2.36	0.31
PM-2.5	FAL	30	3.44	3.65	0.64	5.98	42.97	0.21	1.48	4.08	26.58	9.57	0.06	53.03	43.61	0.43	2.03	0.41
PM-2.5	ALL	103	3.71	3.21	0.63	-13.31	41.38	-0.49	1.53	4.01	0.65	-14.19	-0.15	45.49	46.43	0.48	2.06	0.40
SO4	WIN	17	0.65	0.49	0.7	-23.61	45.03	-0.15	0.29	0.1	9.58	-10.96	-0.31	59.81	52.97	0.59	0.35	0.49
SO4	SPR	27	1.3	0.86	0.79	-33.4	40.83	-0.43	0.53	0.53	-19.09	-33.72	-0.5	39.87	49.4	0.61	0.85	0.63
SO4	SUM	29	0.72	0.61	0.56	-14.72	29.81	-0.11	0.21	0.06	-11.1	-18.33	-0.17	30.46	33.84	0.35	0.27	0.32
SO4	FAL	30	0.5	0.64	0.68	28.34	49.22	0.14	0.24	0.07	48.61	30.9	0.28	59.13	43.45	0.49	0.3	0.46
SO4	ALL	103	0.79	0.67	0.74	-16.09	40.11	-0.13	0.32	0.24	7.61	-6.81	-0.19	46.12	43.88	0.48	0.51	0.54

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: FRRE1																		
EC	WIN	29	0.32	0.35	0.64	10.45	36.41	0.03	0.12	0.02	26.79	15.36	0.1	43.42	35.5	0.36	0.15	0.41
EC	SPR	28	0.24	0.2	0.53	-17.94	32.93	-0.04	0.08	0.01	-12.89	-21.64	-0.22	32.66	38.3	0.4	0.1	0.28
EC	SUM	28	0.3	0.22	0.45	-26.57	33.22	-0.08	0.1	0.01	-22.05	-29.85	-0.36	31.76	38.08	0.45	0.12	0.20
EC	FAL	30	0.26	0.23	0.65	-11.11	37.82	-0.03	0.1	0.01	10.23	-4.87	-0.13	45.25	39.56	0.43	0.12	0.42
EC	ALL	115	0.28	0.25	0.59	-10.38	35.19	-0.03	0.1	0.01	0.92	-9.93	-0.12	38.44	37.87	0.39	0.12	0.35
NO3	WIN	28	0.9	1.08	0.34	20.15	68.91	0.18	0.62	0.77	68.23	7.31	0.2	109.83	65.29	0.69	0.9	0.12
NO3	SPR	28	0.52	0.64	0.5	22.61	77.65	0.12	0.4	0.38	34.29	-3.42	0.23	84.42	72.57	0.78	0.63	0.25
NO3	SUM	15	0.13	0.11	0.16	-17.27	51.03	-0.02	0.07	0.01	-11.85	-30.69	-0.21	50.38	59.17	0.62	0.08	0.02
NO3	FAL	24	0.33	0.39	0.55	21.39	82.78	0.07	0.27	0.12	160.89	16.18	0.21	207.47	83.82	0.83	0.35	0.31
NO3	ALL	95	0.52	0.62	0.56	19.57	72.96	0.1	0.38	0.37	68.99	0.39	0.2	117.62	71.15	0.73	0.62	0.31
OC	WIN	29	1.15	1.12	0.65	-2.43	37.2	-0.03	0.43	0.32	12.76	1.62	-0.02	40.3	37.01	0.38	0.57	0.42
OC	SPR	28	0.93	0.73	0.66	-21.58	30.1	-0.2	0.28	0.11	-17.52	-26.04	-0.28	29.78	36.34	0.38	0.39	0.43
OC	SUM	28	1.66	1.22	0.48	-26.6	33.86	-0.44	0.56	0.56	-19.93	-30.58	-0.36	33.08	38.14	0.46	0.87	0.23
OC	FAL	30	0.81	0.81	0.66	-0.68	46.93	-0.01	0.38	0.39	5.84	-8.96	-0.01	46.28	42.93	0.47	0.63	0.43
OC	ALL	115	1.13	0.97	0.6	-14.58	36.41	-0.16	0.41	0.38	-4.38	-15.71	-0.17	37.54	38.67	0.43	0.64	0.35
PM-2.5	WIN	29	6.06	6.43	0.72	6.09	26.45	0.37	1.6	4.26	10.96	5.85	0.06	27.35	25.38	0.26	2.1	0.52
PM-2.5	SPR	28	5.68	5.2	0.63	-8.44	28.8	-0.48	1.63	4.27	-3.67	-11.88	-0.09	30.59	32.96	0.31	2.12	0.39
PM-2.5	SUM	28	11.89	7.58	0.71	-36.26	39.2	-4.31	4.66	15.99	-32.55	-42.28	-0.57	35.31	44.76	0.61	5.88	0.51
PM-2.5	FAL	30	5.46	4.96	0.92	-9.2	20.74	-0.5	1.13	2.14	-1.35	-9.87	-0.1	27.83	27.54	0.23	1.55	0.84
PM-2.5	ALL	115	7.23	6.03	0.74	-16.66	30.88	-1.2	2.23	9.8	-6.41	-14.29	-0.2	30.2	32.51	0.37	3.35	0.54
SO4	WIN	28	1.99	1.36	0.79	-31.58	34.23	-0.63	0.68	0.42	-27.81	-36.12	-0.46	30.94	39.03	0.5	0.9	0.62
SO4	SPR	28	1.88	1.68	0.76	-10.66	28.26	-0.2	0.53	0.4	-6.16	-14.93	-0.12	30.58	34.05	0.32	0.66	0.58
SO4	SUM	15	4.35	3.44	0.81	-20.83	32.14	-0.91	1.4	3.02	-15.74	-22.61	-0.26	30.58	34.55	0.41	1.96	0.66
SO4	FAL	24	1.85	1.66	0.92	-10.73	26.95	-0.2	0.5	0.47	1.23	-8.24	-0.12	34.1	33.03	0.3	0.71	0.84
SO4	ALL	95	2.3	1.86	0.85	-19.07	30.68	-0.44	0.7	0.91	-12.19	-20.7	-0.24	31.58	35.34	0.38	1.05	0.73

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: GRGU1																		
EC	WIN	28	0.12	0.22	0.88	86.07	86.07	0.1	0.1	0	112.56	64.9	0.86	112.56	64.9	0.86	0.12	0.78
EC	SPR	30	0.11	0.11	0.51	2.02	52.04	0	0.06	0.01	36.75	10.83	0.02	65.6	50.65	0.52	0.08	0.26
EC	SUM	22	0.21	0.1	0.6	-53.55	54.38	-0.11	0.11	0.01	-47.36	-67.37	-1.15	48.64	68.56	1.17	0.16	0.36
EC	FAL	26	0.16	0.13	0.73	-14.16	36.03	-0.02	0.06	0	-10.93	-21.13	-0.16	35.7	40.92	0.42	0.07	0.54
EC	ALL	106	0.14	0.14	0.43	-1.29	55.76	0	0.08	0.01	27.62	1.04	-0.01	67.15	55.75	0.56	0.11	0.19
NO3	WIN	28	0.25	0.86	0.55	248.82	264.99	0.61	0.65	0.53	367.33	95.57	2.49	373.89	103.38	2.65	0.95	0.30
NO3	SPR	30	0.1	0.28	0.2	186.88	203.38	0.18	0.2	0.07	328.95	52.2	1.87	354.75	93.06	2.03	0.32	0.04
NO3	SUM	22	0.04	0.03	0.2	-29.14	72.71	-0.01	0.03	0	-21.77	-58.69	-0.41	72.36	79.99	1.03	0.04	0.04
NO3	FAL	26	0.1	0.22	0.36	111.41	169.55	0.12	0.18	0.14	104.47	-3.7	1.11	166.25	90.16	1.7	0.39	0.13
NO3	ALL	106	0.13	0.37	0.61	189.48	219.78	0.24	0.28	0.25	211.24	26.93	1.89	254.96	92.36	2.2	0.55	0.37
OC	WIN	28	0.53	1.04	0.82	95.36	96.17	0.51	0.51	0.13	138.77	69.32	0.95	139.22	69.79	0.96	0.62	0.67
OC	SPR	30	0.58	0.59	0.88	0.23	37.71	0	0.22	0.13	24.33	11.66	0	45.19	38.44	0.38	0.36	0.78
OC	SUM	22	1.97	0.77	0.51	-61.04	61.04	-1.2	1.2	2.91	-50.18	-71.24	-1.57	50.18	71.24	1.57	2.09	0.26
OC	FAL	26	0.84	0.68	0.76	-18.36	32.43	-0.15	0.27	0.11	-12.21	-22.06	-0.22	34.03	39.64	0.4	0.37	0.58
OC	ALL	106	0.92	0.77	0.4	-16.62	55.83	-0.15	0.51	1.05	30.13	1.41	-0.2	68.33	53.82	0.67	1.04	0.16
PM-2.5	WIN	27	3.23	4.86	0.81	50.62	57.36	1.63	1.85	3.2	64.12	42.07	0.51	69.08	47.72	0.57	2.42	0.66
PM-2.5	SPR	30	3.07	3.63	0.88	18.59	25.98	0.57	0.8	0.98	30.4	18.97	0.19	36.98	26.09	0.26	1.14	0.78
PM-2.5	SUM	22	7.7	3.6	0.65	-53.23	54.32	-4.1	4.18	18.43	-44.62	-62.95	-1.14	47.11	65.14	1.16	5.93	0.42
PM-2.5	FAL	26	3.93	3.66	0.81	-6.94	30.57	-0.27	1.2	2.67	0.71	-10.47	-0.07	37.96	37.74	0.33	1.66	0.66
PM-2.5	ALL	105	4.29	3.95	0.53	-7.98	43.74	-0.34	1.88	9.82	16	0.45	-0.09	47.6	42.72	0.48	3.15	0.28
SO4	WIN	28	1.01	0.88	0.87	-13.44	30.06	-0.14	0.3	0.17	7.88	0.56	-0.16	32.37	31.28	0.35	0.43	0.75
SO4	SPR	30	0.96	1.34	0.8	38.99	46.49	0.37	0.45	0.32	103.61	32.79	0.39	110.81	40.68	0.46	0.68	0.64
SO4	SUM	22	1.47	1.38	0.89	-6.18	35.51	-0.09	0.52	0.5	28.97	8.67	-0.07	56.54	42.19	0.38	0.71	0.78
SO4	FAL	26	1.04	1.26	0.91	20.85	35.78	0.22	0.37	0.2	37.99	21.65	0.21	52.3	37.51	0.36	0.5	0.82
SO4	ALL	106	1.1	1.2	0.81	9.52	36.96	0.1	0.41	0.34	46.74	16.54	0.1	64.48	37.73	0.37	0.59	0.65

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: GRRI1																		
EC	WIN	29	0.22	0.47	0.47	118.67	118.67	0.26	0.26	0.03	133.82	73.24	1.19	133.82	73.24	1.19	0.3	0.22
EC	SPR	31	0.21	0.36	0.45	72.52	84.05	0.15	0.17	0.03	97.26	53.43	0.73	102.58	59.61	0.84	0.22	0.21
EC	SUM	31	0.25	0.28	0.64	11.87	23.67	0.03	0.06	0	20.67	14.68	0.12	29	24.28	0.24	0.08	0.40
EC	FAL	29	0.25	0.44	0.6	75.37	77.18	0.19	0.19	0.03	94.89	55.05	0.75	96.15	56.38	0.77	0.25	0.36
EC	ALL	120	0.23	0.39	0.43	66.65	73.1	0.15	0.17	0.03	85.74	48.6	0.67	89.57	53	0.73	0.23	0.19
NO3	WIN	29	3.36	3.24	0.68	-3.55	35.55	-0.12	1.19	3.09	17.05	3.98	-0.04	42.42	35.06	0.37	1.76	0.46
NO3	SPR	31	1.88	2.36	0.93	25.51	37.74	0.48	0.71	0.68	45.75	14.99	0.26	72.09	50.56	0.38	0.96	0.87
NO3	SUM	31	0.24	0.39	0.49	58.01	108.98	0.14	0.27	0.16	60.08	-2.79	0.58	112.14	72.32	1.09	0.43	0.24
NO3	FAL	24	1.21	1.8	0.94	48.88	54.87	0.59	0.66	0.89	95.88	28.54	0.49	114.32	54.34	0.55	1.11	0.88
NO3	ALL	115	1.67	1.93	0.86	15.6	42.03	0.26	0.7	1.27	52.84	10.25	0.16	84.22	53.3	0.42	1.16	0.75
OC	WIN	29	0.98	2.02	0.66	106.84	106.84	1.04	1.04	0.49	117.75	68.13	1.07	117.75	68.13	1.07	1.25	0.43
OC	SPR	31	0.96	1.39	0.44	44.67	66.15	0.43	0.64	0.54	76.81	37.38	0.45	89.64	52.69	0.66	0.85	0.19
OC	SUM	31	1.42	1.14	0.63	-19.58	32.63	-0.28	0.46	0.34	-10.04	-16.85	-0.24	30.88	34.09	0.41	0.64	0.40
OC	FAL	29	1.07	1.49	0.33	38.73	55.98	0.41	0.6	0.55	63.58	32.18	0.39	75.19	45.7	0.56	0.85	0.11
OC	ALL	120	1.11	1.5	0.3	35.22	61.32	0.39	0.68	0.69	61.07	29.54	0.35	77.76	49.93	0.61	0.92	0.09
PM-2.5	WIN	29	8.83	10.97	0.55	24.23	41.81	2.14	3.69	22.53	46.47	27.3	0.24	57.02	39.58	0.42	5.21	0.31
PM-2.5	SPR	31	6.17	8.82	0.86	42.86	45.87	2.65	2.83	6.89	58.35	37.34	0.43	62.34	41.85	0.46	3.73	0.73
PM-2.5	SUM	31	6.77	5.98	0.83	-11.68	23.92	-0.79	1.62	4.66	-3.97	-7.95	-0.13	22.56	23.55	0.27	2.3	0.68
PM-2.5	FAL	29	5.63	8.25	0.86	46.49	53.49	2.62	3.01	6.17	63.11	41.18	0.46	67.42	46.14	0.53	3.61	0.74
PM-2.5	ALL	120	6.84	8.47	0.73	23.82	40.51	1.63	2.77	12	40.53	24.14	0.24	52.01	37.61	0.41	3.83	0.53
SO4	WIN	29	1.47	1.24	0.53	-15.43	54.83	-0.23	0.81	1.74	-9.62	-24.73	-0.18	44.95	49.17	0.65	1.34	0.28
SO4	SPR	31	1.46	1.44	0.86	-1.05	27.83	-0.02	0.41	0.27	15.31	7.33	-0.01	34.31	29.77	0.28	0.52	0.74
SO4	SUM	31	1.71	1.48	0.87	-13.42	30.3	-0.23	0.52	0.66	4.48	-4.6	-0.16	33.94	31.52	0.35	0.85	0.75
SO4	FAL	24	1.15	1.16	0.84	1.1	35.45	0.01	0.41	0.31	30.75	15.33	0.01	51.41	40.18	0.35	0.55	0.70
SO4	ALL	115	1.46	1.34	0.73	-8.23	36.69	-0.12	0.54	0.77	9.33	-2.3	-0.09	40.46	37.31	0.4	0.88	0.53

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: GRSA1																		
EC	WIN	29	0.09	0.06	0	-31.34	79.31	-0.03	0.07	0.01	2.44	-46.38	-0.46	87.59	82.56	1.16	0.12	0.00
EC	SPR	28	0.05	0.04	0.13	-27.23	45.15	-0.01	0.02	0	34.88	-19.36	-0.37	85.42	49.35	0.62	0.03	0.02
EC	SUM	31	0.17	0.12	0.76	-32.56	45.88	-0.06	0.08	0.02	-24.84	-39.37	-0.48	43.24	54.29	0.68	0.16	0.58
EC	FAL	30	0.08	0.07	0.1	-3.82	55.89	0	0.04	0.01	4.78	-23.33	-0.04	56.16	49.8	0.58	0.08	0.01
EC	ALL	118	0.1	0.07	0.64	-26.13	55.34	-0.03	0.06	0.01	3.57	-32.26	-0.35	67.43	58.92	0.75	0.11	0.41
NO3	WIN	29	0.16	0.09	0.38	-44.74	76.2	-0.07	0.12	0.03	-40.26	-97.19	-0.81	84.11	118.02	1.38	0.18	0.15
NO3	SPR	16	0.11	0.03	0.27	-73.21	73.21	-0.08	0.08	0	-69.17	-112.07	-2.73	69.17	112.07	2.73	0.1	0.07
NO3	SUM	19	0.07	0.01	0.61	-87.1	87.1	-0.06	0.06	0	-84.5	-148.19	-6.75	84.5	148.19	6.75	0.08	0.37
NO3	FAL	30	0.08	0.05	0.85	-33.4	72.71	-0.03	0.06	0	-49.32	-101.57	-0.5	82.31	117.14	1.09	0.07	0.72
NO3	ALL	94	0.11	0.05	0.54	-52.81	76.35	-0.06	0.08	0.01	-57.01	-111.43	-1.12	81.07	122.82	1.62	0.12	0.29
OC	WIN	29	0.49	0.24	0.06	-49.6	80.81	-0.24	0.39	0.25	-34.08	-86.92	-0.98	84.35	100.47	1.6	0.56	0.00
OC	SPR	28	0.41	0.13	0.3	-67.18	67.18	-0.27	0.27	0.02	-63.83	-96.74	-2.05	63.83	96.74	2.05	0.31	0.09
OC	SUM	31	1.53	0.75	0.86	-50.54	51.34	-0.77	0.78	1.34	-42.64	-61.47	-1.02	44.83	63.45	1.04	1.39	0.74
OC	FAL	30	0.44	0.35	0.22	-21.05	53.38	-0.09	0.24	0.13	-15.17	-47.24	-0.27	60.03	64.03	0.68	0.37	0.05
OC	ALL	118	0.73	0.38	0.78	-48.05	58.58	-0.35	0.43	0.52	-38.58	-72.48	-0.93	62.92	80.6	1.13	0.8	0.61
PM-2.5	WIN	29	1.75	1.31	0.63	-25.04	44.11	-0.44	0.77	1.06	-21.6	-33.69	-0.33	37.06	46.18	0.59	1.12	0.39
PM-2.5	SPR	31	4.17	1.47	0.2	-64.69	66.19	-2.69	2.76	9.72	-53.45	-82.02	-1.83	57.88	85.79	1.87	4.12	0.04
PM-2.5	SUM	31	5.45	2.32	0.82	-57.4	57.4	-3.13	3.13	9.24	-54.93	-79.9	-1.35	54.93	79.9	1.35	4.36	0.67
PM-2.5	FAL	30	2.29	1.55	0.34	-32.38	48.53	-0.74	1.11	1.21	-28.45	-47.47	-0.48	48.51	61.11	0.72	1.33	0.12
PM-2.5	ALL	121	3.45	1.67	0.62	-51.61	57.04	-1.78	1.97	6.79	-40	-61.33	-1.07	49.81	68.67	1.18	3.16	0.39
SO4	WIN	29	0.25	0.39	0.53	53.4	76.13	0.14	0.19	0.03	89.07	50.45	0.53	97.8	61.53	0.76	0.22	0.28
SO4	SPR	16	0.36	0.41	0.35	15.08	43.91	0.05	0.16	0.05	30.25	15.35	0.15	49.48	40.51	0.44	0.22	0.13
SO4	SUM	19	0.56	0.33	0.54	-40.24	45.17	-0.22	0.25	0.06	-34.14	-49.27	-0.67	44.38	56.15	0.76	0.33	0.29
SO4	FAL	30	0.43	0.36	0.44	-15.66	32.98	-0.07	0.14	0.03	-8.09	-18.09	-0.19	33.03	37.7	0.39	0.2	0.20
SO4	ALL	94	0.39	0.37	0.34	-4.03	46.93	-0.02	0.18	0.06	23.15	2.45	-0.04	58.1	49.26	0.49	0.24	0.11

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: GRSM1																		
EC	WIN	29	0.22	0.39	0.87	73.3	74.16	0.16	0.17	0.02	90.84	53.47	0.73	91.5	54.16	0.74	0.21	0.76
EC	SPR	27	0.25	0.25	0.31	0.73	44.63	0	0.11	0.02	39.26	9.99	0.01	68.43	47.3	0.45	0.14	0.10
EC	SUM	31	0.32	0.25	0.41	-22.77	32.1	-0.07	0.1	0.01	-19.43	-26.58	-0.29	30.72	34.79	0.42	0.13	0.17
EC	FAL	29	0.26	0.28	0.44	11.1	43.95	0.03	0.11	0.02	40.94	17.83	0.11	61.49	44.14	0.44	0.14	0.19
EC	ALL	116	0.26	0.29	0.46	10.94	46.62	0.03	0.12	0.02	36.89	13.05	0.11	62.39	44.88	0.47	0.16	0.21
NO3	WIN	29	0.44	0.65	0.73	48.31	73.88	0.21	0.32	0.14	68.35	17.27	0.48	102.08	64.73	0.74	0.43	0.53
NO3	SPR	27	0.25	0.28	0.1	9.47	114.13	0.02	0.29	0.24	26.69	-51.12	0.09	120.63	99.39	1.14	0.49	0.01
NO3	SUM	31	0.11	0.04	0.33	-63.98	65.54	-0.07	0.07	0	-61.94	-94.13	-1.78	63.05	95.14	1.82	0.09	0.11
NO3	FAL	29	0.21	0.14	0.56	-32.66	65.42	-0.07	0.14	0.02	-29.2	-65.96	-0.48	71.61	89.06	0.97	0.17	0.32
NO3	ALL	116	0.25	0.27	0.66	9.22	80.61	0.02	0.2	0.11	-0.55	-49.23	0.09	88.35	87.01	0.81	0.33	0.43
OC	WIN	29	1.04	1.33	0.92	28.39	38.49	0.29	0.4	0.24	36.94	24.03	0.28	45.17	33.99	0.38	0.57	0.84
OC	SPR	27	1.44	1.14	0.76	-21.36	38.37	-0.31	0.55	0.62	12.38	-5.07	-0.27	50.54	43.11	0.49	0.84	0.58
OC	SUM	31	2.01	2.13	0.55	5.84	33.38	0.12	0.67	0.99	12.05	3.35	0.06	34.62	30.24	0.33	1	0.30
OC	FAL	29	1.22	1.18	0.8	-3.43	32.04	-0.04	0.39	0.28	8.82	-4.37	-0.04	41.26	35.54	0.33	0.53	0.63
OC	ALL	116	1.44	1.46	0.72	1.58	35.18	0.02	0.51	0.59	17.54	4.63	0.02	42.62	35.5	0.35	0.77	0.52
PM-2.5	WIN	28	5.21	6.28	0.86	20.69	31.72	1.08	1.65	3.16	30.72	20.73	0.21	39.82	30.92	0.32	2.08	0.73
PM-2.5	SPR	27	8.08	6.16	0.51	-23.72	39.79	-1.92	3.22	15.18	-0.89	-15.12	-0.31	43.51	42.93	0.52	4.34	0.26
PM-2.5	SUM	30	12	7.93	0.57	-33.91	36.89	-4.07	4.43	10.41	-32.42	-42.11	-0.51	35.44	44.72	0.56	5.19	0.32
PM-2.5	FAL	29	5.99	5.42	0.81	-9.52	26.11	-0.57	1.56	4.66	3.46	-3.99	-0.11	29.6	28.96	0.29	2.23	0.65
PM-2.5	ALL	114	7.87	6.47	0.67	-17.85	34.67	-1.41	2.73	11.92	-0.31	-10.59	-0.22	36.94	36.9	0.42	3.73	0.45
SO4	WIN	29	1.61	1.35	0.58	-16.28	33.78	-0.26	0.54	0.59	-4.5	-11.47	-0.19	30.55	32.99	0.4	0.81	0.34
SO4	SPR	27	2.36	2	0.56	-15.36	31.27	-0.36	0.74	0.81	-0.73	-11.4	-0.18	36.78	35.74	0.37	0.97	0.31
SO4	SUM	31	3.76	2.46	0.57	-34.46	38.27	-1.29	1.44	1.48	-31.8	-43.08	-0.53	36.51	47.35	0.58	1.78	0.32
SO4	FAL	29	1.68	1.58	0.72	-5.9	30.14	-0.1	0.51	0.71	3.68	-1.95	-0.06	25.77	26.58	0.32	0.85	0.52
SO4	ALL	116	2.38	1.86	0.7	-21.91	34.45	-0.52	0.82	1.14	-8.87	-17.52	-0.28	32.4	35.87	0.44	1.19	0.48

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: GUMO1																		
EC	WIN	28	0.09	0.08	0.24	-16.38	53.29	-0.01	0.05	0	68.17	-7.25	-0.2	111.83	52.07	0.64	0.07	0.06
EC	SPR	30	0.1	0.08	0.43	-21.45	52.24	-0.02	0.05	0.01	14.44	-5.84	-0.27	56.8	48.84	0.67	0.1	0.19
EC	SUM	30	0.11	0.07	0.25	-40.05	58.66	-0.04	0.06	0.01	-3.05	-38.34	-0.67	69.75	62.58	0.98	0.11	0.06
EC	FAL	24	0.14	0.08	0.58	-39.65	40.9	-0.06	0.06	0	-34.43	-49.2	-0.66	36.22	50.92	0.68	0.08	0.34
EC	ALL	112	0.11	0.08	0.36	-30.38	51.09	-0.03	0.06	0.01	12.72	-24.19	-0.44	69.62	53.77	0.73	0.09	0.13
NO3	WIN	27	0.36	0.13	0.03	-64.14	93	-0.23	0.33	0.16	-44.93	-129.93	-1.79	107.94	145.14	2.59	0.47	0.00
NO3	SPR	27	0.24	0.03	0.47	-87.17	87.17	-0.21	0.21	0.01	-85.81	-151.73	-6.79	85.81	151.73	6.79	0.23	0.22
NO3	SUM	31	0.22	0.01	0.61	-94.8	94.8	-0.21	0.21	0.02	-94.02	-178.13	-18.21	94.02	178.13	18.21	0.24	0.38
NO3	FAL	24	0.16	0.02	0.58	-86.39	86.39	-0.14	0.14	0.01	-85.73	-151.53	-6.35	85.73	151.53	6.35	0.18	0.34
NO3	ALL	109	0.25	0.05	0.15	-80.72	91.12	-0.2	0.22	0.05	-78	-153.8	-4.19	93.61	157.56	4.73	0.3	0.02
OC	WIN	27	0.32	0.23	0.16	-29.65	59.87	-0.1	0.19	0.05	34.75	-39.04	-0.42	111.08	66.04	0.85	0.25	0.03
OC	SPR	30	0.84	0.3	0.45	-64.69	69.15	-0.54	0.58	0.5	-50.68	-80.15	-1.83	61.05	87.44	1.96	0.89	0.20
OC	SUM	31	0.97	0.58	0.15	-40.16	57.75	-0.39	0.56	0.66	-26.87	-48.25	-0.67	50.97	67.05	0.97	0.9	0.02
OC	FAL	24	0.58	0.46	0.77	-20.43	41.71	-0.12	0.24	0.07	-25.4	-43.27	-0.26	46.33	59.81	0.52	0.3	0.59
OC	ALL	112	0.7	0.39	0.36	-43.41	58.81	-0.3	0.41	0.38	-18.07	-53.5	-0.77	67.17	70.72	1.04	0.69	0.13
PM-2.5	WIN	10	1.81	2.63	0.48	45.5	77.53	0.82	1.4	3.44	70.28	28.67	0.46	90.94	55.04	0.78	2.03	0.23
PM-2.5	SPR	7	8.06	2.8	0.49	-65.29	65.29	-5.27	5.27	9.18	-59.19	-90.11	-1.88	59.19	90.11	1.88	6.07	0.24
PM-2.5	SUM	31	7.09	2.33	0.26	-67.16	67.16	-4.76	4.76	7.92	-65.29	-101.98	-2.04	65.29	101.98	2.04	5.53	0.07
PM-2.5	FAL	22	4.73	2.26	0.56	-52.12	52.12	-2.46	2.46	4.93	-52.14	-75.93	-1.09	52.14	75.93	1.09	3.32	0.32
PM-2.5	ALL	70	5.69	2.4	0.29	-57.86	63.43	-3.29	3.61	10.44	-41.18	-73.94	-1.37	64.21	85.9	1.51	4.61	0.09
SO4	WIN	27	0.43	0.63	0.35	46.09	78.33	0.2	0.34	0.26	80.29	37.46	0.46	91.78	52.87	0.78	0.55	0.12
SO4	SPR	27	0.82	0.56	0.65	-31.86	35.1	-0.26	0.29	0.11	-24.39	-32.27	-0.47	29.55	36.95	0.52	0.43	0.42
SO4	SUM	31	1.36	0.75	0.56	-44.64	45.94	-0.61	0.62	0.16	-43.98	-62.52	-0.81	45.87	64.2	0.83	0.73	0.31
SO4	FAL	24	0.87	0.68	0.88	-21.57	27.47	-0.19	0.24	0.07	-18.03	-28.66	-0.28	32.33	40.38	0.35	0.32	0.78
SO4	ALL	109	0.89	0.66	0.54	-25.9	43.35	-0.23	0.38	0.24	-2.63	-22.81	-0.35	50.22	49.4	0.59	0.54	0.29

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: HEGL1																		
EC	WIN	28	0.32	0.5	0.66	57.48	69.34	0.18	0.22	0.06	57.34	32.02	0.57	68.45	45.43	0.69	0.3	0.43
EC	SPR	30	0.29	0.48	0.47	62.74	92.33	0.18	0.27	0.34	48.75	9.7	0.63	79.04	49.55	0.92	0.61	0.22
EC	SUM	26	0.26	0.23	0.52	-11.58	39.74	-0.03	0.1	0.02	10.82	-4.07	-0.13	48.65	43.64	0.45	0.13	0.27
EC	FAL	30	0.26	0.3	0.61	16.88	38.72	0.04	0.1	0.02	20.81	12.21	0.17	37.61	31.77	0.39	0.14	0.38
EC	ALL	114	0.28	0.38	0.47	34.67	62	0.1	0.18	0.12	34.86	12.7	0.35	58.61	42.51	0.62	0.36	0.22
NO3	WIN	27	2.47	1.88	0.8	-24.07	44.43	-0.59	1.1	2.05	13.89	-10.41	-0.32	61.94	54.98	0.59	1.55	0.65
NO3	SPR	30	0.63	0.68	0.47	7.61	76.94	0.05	0.48	0.61	7.09	-29.39	0.08	76.73	74.57	0.77	0.78	0.22
NO3	SUM	20	0.17	0.05	0.14	-67.64	67.64	-0.11	0.11	0.01	-61.85	-99.01	-2.09	61.85	99.01	2.09	0.15	0.02
NO3	FAL	30	0.46	0.52	0.8	12.31	60.26	0.06	0.28	0.18	50.74	-14.78	0.12	108.59	75.53	0.6	0.43	0.63
NO3	ALL	107	0.96	0.82	0.81	-14.78	53.31	-0.14	0.51	0.81	8.16	-33.52	-0.17	79.15	74.47	0.63	0.91	0.66
OC	WIN	28	1.43	1.97	0.68	38.24	59.5	0.55	0.85	0.96	39.39	19.61	0.38	59.83	45.01	0.59	1.12	0.46
OC	SPR	30	1.7	2.12	0.57	24.75	64.41	0.42	1.1	5.7	13.25	-9.94	0.25	54.59	46.1	0.64	2.42	0.32
OC	SUM	26	2.01	2.34	0.69	16.76	39.9	0.34	0.8	0.84	42.56	16.28	0.17	64.39	42.75	0.4	0.98	0.48
OC	FAL	30	1.21	1.29	0.68	7.01	39.69	0.08	0.48	0.58	14.55	3.37	0.07	39.34	35	0.4	0.77	0.46
OC	ALL	114	1.57	1.92	0.59	21.85	51.2	0.34	0.81	2.11	26.7	6.8	0.22	54.1	42.15	0.51	1.49	0.35
PM-2.5	WIN	28	7.64	9.29	0.76	21.55	39.32	1.65	3	10.15	30.61	17.17	0.22	48.42	38.38	0.39	3.59	0.58
PM-2.5	SPR	30	7.67	8.35	0.46	8.85	44.75	0.68	3.43	32.78	8.78	-6.58	0.09	45.34	39.22	0.45	5.77	0.21
PM-2.5	SUM	28	10.76	7.33	0.63	-31.87	38.07	-3.43	4.1	12.2	-25.95	-36.8	-0.47	37.46	46.54	0.56	4.9	0.40
PM-2.5	FAL	30	5.69	6.19	0.7	8.84	27.75	0.5	1.58	5.53	15.94	8.67	0.09	29.95	25.77	0.28	2.4	0.50
PM-2.5	ALL	116	7.9	7.77	0.53	-1.58	38.11	-0.12	3.01	18.97	7.52	-4.2	-0.02	40.2	37.31	0.39	4.36	0.28
SO4	WIN	27	1.75	1.38	0.76	-21.2	35.24	-0.37	0.62	0.7	-10.39	-19.59	-0.27	32.75	36.49	0.45	0.92	0.58
SO4	SPR	30	2.19	1.74	0.76	-20.83	29.08	-0.46	0.64	0.62	-16.96	-23.05	-0.26	26.76	31.76	0.37	0.91	0.58
SO4	SUM	20	2.49	1.66	0.81	-33.41	39.98	-0.83	0.99	0.57	-27.7	-39.29	-0.5	41.08	50.17	0.6	1.12	0.65
SO4	FAL	30	1.44	1.37	0.79	-5.17	30.94	-0.07	0.45	0.37	11.86	2.56	-0.05	34.42	30.11	0.33	0.62	0.62
SO4	ALL	107	1.93	1.53	0.77	-20.66	33.51	-0.4	0.65	0.63	-9.23	-18.03	-0.26	33.1	35.93	0.42	0.89	0.59

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: ISLE1																		
EC	WIN	27	0.08	0.14	0.97	74.54	74.54	0.06	0.06	0	145.85	71.05	0.75	145.85	71.05	0.75	0.08	0.94
EC	SPR	31	0.09	0.09	0.69	-4.94	37.68	0	0.03	0	15.77	1	-0.05	47.94	43.67	0.4	0.05	0.48
EC	SUM	31	0.14	0.07	0.63	-48.36	49.42	-0.07	0.07	0.01	-44.48	-64.67	-0.94	45.63	65.77	0.96	0.1	0.40
EC	FAL	27	0.18	0.17	0.8	-2.19	46.47	0	0.08	0.02	44.35	5.03	-0.02	77.73	50.33	0.48	0.16	0.64
EC	ALL	116	0.12	0.12	0.74	-4.85	50.01	-0.01	0.06	0.01	36.6	0.69	-0.05	77.05	57.5	0.53	0.1	0.54
NO3	WIN	26	0.64	0.92	0.79	44.63	78.42	0.28	0.5	1.18	81.5	3.87	0.45	132.17	89.2	0.78	1.12	0.62
NO3	SPR	31	0.41	0.27	0.98	-33.23	44.22	-0.14	0.18	0.17	-21.32	-70.31	-0.5	79.91	95.12	0.66	0.43	0.96
NO3	SUM	31	0.05	0.06	0.71	24.36	98.86	0.01	0.05	0.02	-28.3	-70.89	0.24	75	91.5	0.99	0.14	0.50
NO3	FAL	30	0.27	0.35	0.94	28.78	47.42	0.08	0.13	0.05	37.44	-16.12	0.29	99.08	82.23	0.47	0.23	0.89
NO3	ALL	118	0.33	0.38	0.8	15.08	61.61	0.05	0.2	0.34	14.44	-40.34	0.15	95.01	89.59	0.62	0.59	0.64
OC	WIN	27	0.36	0.72	0.94	101.79	102.57	0.37	0.37	0.11	318.06	83.87	1.02	318.81	84.66	1.03	0.49	0.88
OC	SPR	31	0.52	0.53	0.64	2.14	39.34	0.01	0.2	0.09	18.42	5.16	0.02	44	36.78	0.39	0.3	0.41
OC	SUM	31	1.55	0.78	0.41	-49.82	53.98	-0.77	0.84	0.91	-45.11	-65.37	-0.99	48.61	68.59	1.08	1.23	0.16
OC	FAL	27	1.21	0.85	0.8	-29.54	58.68	-0.36	0.71	3.22	33.58	1.85	-0.42	71.6	52.04	0.83	1.83	0.63
OC	ALL	116	0.92	0.72	0.62	-21.97	57.64	-0.2	0.53	1.22	74.72	3.86	-0.28	115.62	59.98	0.74	1.12	0.38
PM-2.5	WIN	29	3.02	3.94	0.89	30.49	44	0.92	1.33	8.24	29.03	17.34	0.3	43.02	34.34	0.44	3.01	0.79
PM-2.5	SPR	31	3.69	3.28	0.91	-11.03	21.38	-0.41	0.79	0.91	-6.94	-11.18	-0.12	23.18	24.63	0.24	1.04	0.82
PM-2.5	SUM	31	5.48	3.29	0.72	-39.93	46.2	-2.19	2.53	5.88	-41.2	-58.26	-0.66	45.36	61.87	0.77	3.27	0.52
PM-2.5	FAL	30	4.15	3.74	0.68	-10.01	46.04	-0.42	1.91	15.4	24.31	7.79	-0.11	51.78	43.37	0.51	3.95	0.46
PM-2.5	ALL	121	4.1	3.55	0.66	-13.34	40.05	-0.55	1.64	8.75	0.65	-11.7	-0.15	40.71	41.14	0.46	3.01	0.44
SO4	WIN	26	0.84	0.83	0.76	-0.63	45.49	-0.01	0.38	0.67	1.58	-5.77	-0.01	31.24	31.53	0.46	0.82	0.57
SO4	SPR	31	1.09	1.21	0.85	11.78	27.28	0.13	0.3	0.13	22.16	13.04	0.12	34.37	27.3	0.27	0.39	0.72
SO4	SUM	31	0.85	1.08	0.89	27.03	46.9	0.23	0.4	0.36	45.45	27.52	0.27	58.26	42.66	0.47	0.64	0.80
SO4	FAL	30	0.81	0.94	0.83	16.35	42.36	0.13	0.34	0.18	101.71	33.84	0.16	117.64	52.32	0.42	0.45	0.70
SO4	ALL	118	0.9	1.03	0.83	14.07	39.35	0.13	0.35	0.33	43.97	17.99	0.14	61.13	38.63	0.39	0.59	0.69

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: JARI1																		
EC	WIN	29	0.59	0.46	0.73	-22.02	36.29	-0.13	0.21	0.06	-2.99	-13.92	-0.28	39.61	39.29	0.47	0.27	0.54
EC	SPR	31	0.33	0.3	0.44	-9.58	34.97	-0.03	0.12	0.02	3.69	-4.9	-0.11	35.09	34.33	0.39	0.15	0.19
EC	SUM	31	0.45	0.3	0.53	-33.03	34.41	-0.15	0.15	0.02	-27.82	-35.82	-0.49	29.34	37.24	0.51	0.21	0.28
EC	FAL	25	0.43	0.36	0.59	-15.88	33.54	-0.07	0.14	0.04	-3.59	-11.63	-0.19	32.44	33.45	0.4	0.21	0.35
EC	ALL	116	0.45	0.35	0.65	-21.22	34.96	-0.09	0.16	0.04	-7.97	-16.87	-0.27	34.11	36.16	0.44	0.21	0.43
NO3	WIN	29	0.9	0.64	0.25	-28.75	63.58	-0.26	0.57	1.11	20.68	-11.63	-0.4	69.65	63.95	0.89	1.09	0.06
NO3	SPR	31	0.49	0.27	0.23	-44.5	77.43	-0.22	0.38	0.48	36.28	-40.52	-0.8	116.71	84.06	1.4	0.73	0.05
NO3	SUM	31	0.15	0.04	0.11	-70.77	70.77	-0.11	0.11	0.01	-64.86	-104.41	-2.42	64.86	104.41	2.42	0.15	0.01
NO3	FAL	25	0.25	0.22	0.64	-11.89	57.37	-0.03	0.14	0.03	12.65	-28.55	-0.13	77.23	70.65	0.65	0.18	0.42
NO3	ALL	116	0.45	0.29	0.43	-35.17	67.53	-0.16	0.3	0.43	0.26	-47.79	-0.54	82.58	81.58	1.04	0.67	0.18
OC	WIN	29	2.23	1.23	0.55	-44.99	51.6	-1	1.15	1.13	-32.44	-50.06	-0.82	48.09	61.31	0.94	1.46	0.30
OC	SPR	31	1.43	0.95	0.7	-33.85	39.31	-0.48	0.56	0.42	-28.54	-40.63	-0.51	37.06	47.16	0.59	0.81	0.48
OC	SUM	31	2.14	1.42	0.4	-33.56	38.48	-0.72	0.82	1.94	-26.02	-36.41	-0.51	32.89	42.28	0.58	1.57	0.16
OC	FAL	25	1.46	1.06	0.56	-26.96	43.91	-0.39	0.64	0.8	-23.86	-34.8	-0.37	34.79	43.76	0.6	0.98	0.32
OC	ALL	116	1.82	1.17	0.52	-35.98	43.6	-0.66	0.8	1.14	-27.83	-40.6	-0.56	38.21	48.66	0.68	1.25	0.28
PM-2.5	WIN	29	8.13	5.82	0.68	-28.36	33.66	-2.3	2.74	7.24	-21.66	-29.63	-0.4	30.9	37.04	0.47	3.54	0.47
PM-2.5	SPR	31	6.98	5.24	0.65	-24.98	31.99	-1.75	2.23	6.63	-16.08	-24.87	-0.33	30.78	35.88	0.43	3.11	0.42
PM-2.5	SUM	31	11.88	6.83	0.47	-42.5	44.76	-5.05	5.32	17.88	-39.09	-52.91	-0.74	41.98	55.45	0.78	6.59	0.22
PM-2.5	FAL	25	6.6	5	0.84	-24.2	29.32	-1.6	1.94	4.01	-17.51	-23.79	-0.32	26.88	32	0.39	2.56	0.70
PM-2.5	ALL	116	8.5	5.76	0.66	-32.2	36.71	-2.74	3.12	11.24	-23.93	-33.32	-0.48	32.96	40.57	0.54	4.33	0.44
SO4	WIN	29	1.86	1.2	0.73	-35.57	36.57	-0.66	0.68	0.37	-28.61	-38.17	-0.55	34.02	42.18	0.57	0.9	0.54
SO4	SPR	31	2	1.68	0.71	-16.33	27.99	-0.33	0.56	0.51	-8.04	-16.89	-0.2	31.69	34.44	0.33	0.79	0.51
SO4	SUM	31	3.73	2.61	0.39	-30.07	42.73	-1.12	1.59	3.1	-20.79	-35.58	-0.43	43.94	49.58	0.61	2.09	0.15
SO4	FAL	25	1.73	1.45	0.85	-15.89	29.99	-0.27	0.52	0.45	7.54	-9.62	-0.19	44.15	35.5	0.36	0.72	0.73
SO4	ALL	116	2.37	1.76	0.67	-25.82	36.19	-0.61	0.86	1.27	-13.23	-25.64	-0.35	38.23	40.65	0.49	1.28	0.45

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: LASU2																		
EC	WIN	29	0.26	0.3	0.54	16.56	37.95	0.04	0.1	0.01	25.87	14.76	0.17	42.09	35.46	0.38	0.12	0.29
EC	SPR	31	0.29	0.4	0.63	39.7	65.23	0.11	0.19	0.13	34.51	6.68	0.4	60.62	38.54	0.65	0.38	0.40
EC	SUM	29	0.32	0.27	0.72	-15.24	24.41	-0.05	0.08	0.01	-6.01	-10.32	-0.18	22.64	24.24	0.29	0.12	0.52
EC	FAL	27	0.27	0.26	0.68	-3.29	26.94	-0.01	0.07	0.01	-1.58	-6.75	-0.03	25.42	25.21	0.28	0.1	0.46
EC	ALL	116	0.28	0.31	0.52	9.54	39.13	0.03	0.11	0.05	13.82	1.32	0.1	38.3	31.09	0.39	0.22	0.27
NO3	WIN	28	3.68	3.16	0.77	-14.23	35.7	-0.52	1.31	2.61	15.09	-6.48	-0.17	53.41	43.24	0.42	1.7	0.59
NO3	SPR	30	1.61	2.17	0.89	34.78	48.61	0.56	0.78	0.8	53.71	21.8	0.35	74.35	50.06	0.49	1.06	0.79
NO3	SUM	31	0.28	0.25	0.53	-10.57	60.58	-0.03	0.17	0.06	-0.66	-23.58	-0.12	59.47	63.14	0.68	0.24	0.28
NO3	FAL	27	0.8	1.42	0.89	77.33	93.15	0.62	0.75	1.6	85.67	26.05	0.77	117.29	67.2	0.93	1.41	0.80
NO3	ALL	116	1.57	1.72	0.82	9.89	47.18	0.15	0.74	1.44	37.3	3.84	0.1	75.31	55.9	0.47	1.21	0.67
OC	WIN	29	1.01	1.06	0.68	4.8	29.32	0.05	0.3	0.11	7.9	0.05	0.05	32.91	32.81	0.29	0.34	0.46
OC	SPR	31	1.32	1.6	0.67	21.08	58.22	0.28	0.77	2.1	15.27	-12.01	0.21	59.38	44.46	0.58	1.48	0.45
OC	SUM	29	1.7	1.45	0.81	-14.65	29.14	-0.25	0.5	0.37	-14.64	-21.67	-0.17	28.97	33.89	0.34	0.65	0.66
OC	FAL	27	1.06	0.91	0.61	-14.66	40.7	-0.16	0.43	0.32	-14.33	-27.03	-0.17	39.69	45.52	0.48	0.58	0.37
OC	ALL	116	1.28	1.27	0.67	-0.94	39.45	-0.01	0.5	0.8	-0.94	-14.91	-0.01	40.58	39.15	0.4	0.89	0.46
PM-2.5	WIN	29	10.1	8.9	0.71	-11.86	29.89	-1.2	3.02	14.68	1.77	-7.58	-0.13	35.55	32.98	0.34	4.01	0.50
PM-2.5	SPR	31	8.37	9.89	0.64	18.22	42.01	1.52	3.51	21.87	32.54	9.37	0.18	57.58	39.72	0.42	4.92	0.41
PM-2.5	SUM	31	8.98	6.93	0.87	-22.84	28.34	-2.05	2.54	5.1	-17.32	-22.82	-0.3	28.65	32.15	0.37	3.05	0.76
PM-2.5	FAL	27	6.21	6.62	0.75	6.67	28.99	0.41	1.8	9.06	8.69	2.47	0.07	25.83	23.15	0.29	3.04	0.56
PM-2.5	ALL	118	8.46	8.12	0.67	-3.99	32.46	-0.34	2.75	14.76	6.42	-4.83	-0.04	37.3	32.28	0.34	3.86	0.44
SO4	WIN	28	1.78	1.19	0.51	-33.4	52.06	-0.59	0.93	1.25	-21.67	-37.99	-0.5	46.32	56.99	0.78	1.27	0.26
SO4	SPR	30	1.84	1.85	0.71	0.33	31.97	0.01	0.59	0.75	11.03	1.35	0	33.44	29.05	0.32	0.87	0.51
SO4	SUM	31	2.36	1.75	0.81	-25.81	35.63	-0.61	0.84	0.98	-11.58	-20.24	-0.35	33.82	37.32	0.48	1.16	0.65
SO4	FAL	27	1.41	1.21	0.89	-13.97	30.98	-0.2	0.44	0.33	11.22	2.54	-0.16	36.87	34.53	0.36	0.6	0.79
SO4	ALL	116	1.87	1.51	0.69	-18.8	37.66	-0.35	0.7	0.91	-2.86	-13.64	-0.23	37.45	39.28	0.46	1.01	0.48

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: LIGO1																		
EC	WIN	29	0.22	0.26	0.72	20.19	47.83	0.04	0.11	0.02	57.52	29.3	0.2	74.24	50.47	0.48	0.13	0.52
EC	SPR	30	0.26	0.22	0.43	-16.78	44.98	-0.04	0.12	0.02	3.31	-10.38	-0.2	46.58	45.84	0.54	0.16	0.18
EC	SUM	22	0.31	0.16	0.4	-46.68	47.3	-0.14	0.15	0.01	-43.81	-59.93	-0.88	44.82	60.91	0.89	0.17	0.16
EC	FAL	30	0.23	0.2	0.54	-14.06	37.42	-0.03	0.09	0.01	3.54	-11.78	-0.16	44.91	41.9	0.44	0.11	0.29
EC	ALL	111	0.25	0.21	0.48	-14.88	44.34	-0.04	0.11	0.02	8.19	-10.21	-0.17	53.01	48.97	0.52	0.14	0.23
NO3	WIN	29	0.25	0.42	0.4	66.58	117.87	0.17	0.29	0.19	123.07	19.67	0.67	162.99	80.78	1.18	0.46	0.16
NO3	SPR	30	0.2	0.18	0.41	-9.17	70.66	-0.02	0.14	0.04	50.98	-25.64	-0.1	116.79	74.31	0.78	0.2	0.17
NO3	SUM	22	0.07	0.05	0.15	-31.84	81.17	-0.02	0.06	0.01	-30.81	-70.91	-0.47	73.37	86.89	1.19	0.09	0.02
NO3	FAL	30	0.14	0.17	0.45	21.35	76.29	0.03	0.11	0.02	85.53	-20.33	0.21	149.66	81.83	0.76	0.15	0.20
NO3	ALL	111	0.17	0.21	0.48	24.61	90.73	0.04	0.16	0.07	62.94	-21.34	0.25	129.14	80.53	0.91	0.27	0.23
OC	WIN	29	1.14	0.93	0.77	-18.19	42.56	-0.21	0.48	0.42	2.79	-10.13	-0.22	41.27	43.09	0.52	0.68	0.59
OC	SPR	30	1.43	1.09	0.76	-23.99	36.58	-0.34	0.52	0.34	-13.58	-23.29	-0.32	37.08	41.51	0.48	0.68	0.58
OC	SUM	22	1.93	1.66	0.5	-13.79	37.06	-0.27	0.71	0.7	-7.26	-19.3	-0.16	38.68	42.06	0.43	0.88	0.25
OC	FAL	30	1.16	0.98	0.57	-15.36	52.59	-0.18	0.61	0.61	-6.04	-26.38	-0.18	53.42	56.53	0.62	0.8	0.32
OC	ALL	111	1.38	1.13	0.67	-17.96	41.63	-0.25	0.57	0.51	-6.01	-19.9	-0.22	42.91	46.09	0.51	0.76	0.45
PM-2.5	WIN	29	4.41	4.62	0.8	4.84	33.58	0.21	1.48	3.22	22.27	8.85	0.05	44.44	35.26	0.34	1.81	0.64
PM-2.5	SPR	30	6.82	5.68	0.74	-16.65	31.72	-1.13	2.16	6.81	-1.77	-11.52	-0.2	36.35	36.25	0.38	2.85	0.55
PM-2.5	SUM	22	11.27	7.38	0.61	-34.53	36.53	-3.89	4.12	6.09	-34.38	-45.43	-0.53	36.79	47.56	0.56	4.61	0.37
PM-2.5	FAL	30	5.33	4.78	0.83	-10.37	30.37	-0.55	1.62	3.85	-2.9	-11.84	-0.12	33.77	35.64	0.34	2.04	0.70
PM-2.5	ALL	111	6.67	5.5	0.77	-17.57	33.36	-1.17	2.22	7	-2.26	-13.01	-0.21	37.85	38.07	0.4	2.89	0.60
SO4	WIN	29	1.16	1.19	0.73	2.73	36.29	0.03	0.42	0.25	33.01	13.59	0.03	56.01	40.89	0.36	0.5	0.53
SO4	SPR	30	1.9	1.96	0.68	3.1	31.42	0.06	0.6	0.68	21.51	5.77	0.03	43.73	33.62	0.31	0.83	0.46
SO4	SUM	22	3.31	2.86	0.42	-13.82	30.08	-0.46	1	1.33	-8.77	-15.79	-0.16	30.49	33.57	0.35	1.24	0.18
SO4	FAL	30	1.35	1.58	0.78	16.52	38.16	0.22	0.52	0.55	42.85	16.63	0.17	59.42	37.32	0.38	0.77	0.61
SO4	ALL	111	1.84	1.83	0.76	-0.33	33.08	-0.01	0.61	0.72	24.28	6.47	0	48.56	36.51	0.33	0.85	0.57

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: LOST1																		
EC	WIN	29	0.15	0.09	0.56	-35.74	39.89	-0.05	0.06	0	-27.72	-38.3	-0.56	34.96	44.92	0.62	0.08	0.31
EC	SPR	19	0.16	0.11	0.58	-31.61	44.75	-0.05	0.07	0.01	5.37	-14.33	-0.46	50.5	47.02	0.65	0.13	0.34
EC	SUM	29	0.21	0.14	0.24	-36.18	44.69	-0.08	0.09	0.01	-27.57	-41.74	-0.57	40.54	52.09	0.7	0.12	0.06
EC	FAL	29	0.29	0.23	0.28	-21.74	56.62	-0.06	0.17	0.05	-17.43	-39.35	-0.28	53.97	62.33	0.72	0.23	0.08
EC	ALL	106	0.21	0.15	0.43	-29.86	48.39	-0.06	0.1	0.02	-18.93	-35.23	-0.43	44.47	52.02	0.69	0.15	0.18
NO3	WIN	29	0.98	2.11	0.4	115.72	143.03	1.13	1.4	3.58	180.08	54.77	1.16	198.77	79.92	1.43	2.2	0.16
NO3	SPR	19	1.2	1.58	0.55	31.87	76.88	0.38	0.92	1.36	161.99	35.04	0.32	191.31	76.26	0.77	1.23	0.30
NO3	SUM	29	0.31	0.08	0.72	-72.6	72.6	-0.22	0.22	0.07	-67.68	-108.27	-2.65	67.68	108.27	2.65	0.35	0.52
NO3	FAL	26	0.42	1.21	0.61	187.51	193.61	0.79	0.81	0.83	284.18	75.35	1.88	295.83	90.91	1.94	1.2	0.37
NO3	ALL	103	0.69	1.21	0.53	76.12	120.73	0.52	0.83	1.77	133.26	10.42	0.76	184.99	90	1.21	1.43	0.28
OC	WIN	29	0.35	0.25	0.58	-30.2	35.4	-0.11	0.13	0.02	-21.02	-29.83	-0.43	31.86	38.31	0.51	0.17	0.33
OC	SPR	19	0.48	0.27	0.61	-42.72	49.35	-0.2	0.24	0.05	-20.41	-37.91	-0.75	48.4	57.94	0.86	0.3	0.37
OC	SUM	29	1.03	0.52	0.17	-49.23	56.32	-0.51	0.58	0.24	-43.67	-66.33	-0.97	52.34	73.2	1.11	0.7	0.03
OC	FAL	29	0.9	0.95	0.35	5.64	65.21	0.05	0.59	0.9	22.14	-3.56	0.06	63.69	56.08	0.65	0.95	0.12
OC	ALL	106	0.71	0.52	0.42	-26.88	55.71	-0.19	0.4	0.37	-15.3	-34.08	-0.37	49.14	56.23	0.76	0.64	0.18
PM-2.5	WIN	29	3.29	4.21	0.46	27.92	65.04	0.92	2.14	7.36	37.62	15.39	0.28	66.11	52.16	0.65	2.86	0.21
PM-2.5	SPR	19	4.23	4.42	0.55	4.59	43.93	0.19	1.86	5.69	26.01	10.01	0.05	51.81	42.46	0.44	2.39	0.30
PM-2.5	SUM	28	5.67	3.18	0.75	-43.89	43.89	-2.49	2.49	1.44	-43.51	-58.44	-0.78	43.51	58.44	0.78	2.76	0.56
PM-2.5	FAL	29	4.65	5.28	0.45	13.51	53.23	0.63	2.48	9.81	43.15	14.77	0.14	70.46	51.23	0.53	3.19	0.20
PM-2.5	ALL	105	4.47	4.27	0.39	-4.51	50.88	-0.2	2.27	8.12	15.41	-5.44	-0.05	58.7	51.82	0.53	2.86	0.15
SO4	WIN	29	0.86	0.56	0.59	-35.23	43.77	-0.3	0.38	0.29	-13.05	-25.57	-0.54	38.59	43.76	0.68	0.62	0.35
SO4	SPR	19	0.97	1.03	0.48	6.46	45.96	0.06	0.45	0.49	26.06	10.38	0.06	47.97	38.02	0.46	0.7	0.23
SO4	SUM	29	1.1	0.96	0.74	-12.48	38.84	-0.14	0.43	0.27	4.62	-8.84	-0.14	45.72	43.96	0.44	0.53	0.55
SO4	FAL	26	0.57	0.74	0.45	29.85	57.83	0.17	0.33	0.15	61.5	32.58	0.3	75.23	48.88	0.58	0.42	0.20
SO4	ALL	103	0.88	0.81	0.58	-7.9	44.8	-0.07	0.39	0.32	17.95	0.45	-0.09	51.58	44.05	0.49	0.57	0.33

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: LYBR1																		
EC	WIN	21	0.11	0.32	0.6	199.61	200.41	0.22	0.22	0.02	345.38	103.11	2	345.83	103.56	2	0.26	0.36
EC	SPR	28	0.1	0.17	0.62	63.97	81.24	0.07	0.08	0.01	138.55	57.28	0.64	146.9	67.83	0.81	0.11	0.38
EC	SUM	22	0.18	0.15	0.72	-16.52	40.36	-0.03	0.07	0.01	2.97	-11.09	-0.2	45.39	41.97	0.48	0.09	0.52
EC	FAL	30	0.17	0.22	0.8	29.55	45.26	0.05	0.08	0.01	125.68	40.6	0.3	133.29	50.16	0.45	0.09	0.63
EC	ALL	101	0.14	0.21	0.5	51.43	76.44	0.07	0.11	0.02	148.2	46.96	0.51	162.11	64.38	0.76	0.15	0.25
NO3	WIN	22	0.45	1.18	0.67	161.87	171.74	0.73	0.77	0.71	251.33	84.77	1.62	258.21	92.81	1.72	1.11	0.45
NO3	SPR	27	0.25	0.36	0.31	43.38	116.14	0.11	0.29	0.25	101.11	-18.69	0.43	171.56	91.32	1.16	0.51	0.10
NO3	SUM	23	0.19	0.06	0.11	-70.12	81.7	-0.14	0.16	0.06	-46.25	-93.58	-2.35	78.09	111.38	2.73	0.27	0.01
NO3	FAL	30	0.27	0.24	0.72	-10.03	51.58	-0.03	0.14	0.03	16.63	-31.87	-0.11	89.27	75.28	0.57	0.17	0.52
NO3	ALL	102	0.29	0.43	0.58	51.37	111.8	0.15	0.32	0.34	75.43	-17.14	0.51	144.97	91.45	1.12	0.6	0.33
OC	WIN	20	0.48	1.72	0.6	256.98	256.98	1.24	1.24	0.67	351.67	111.68	2.57	351.67	111.68	2.57	1.48	0.36
OC	SPR	27	0.51	0.9	0.6	77.31	94.73	0.39	0.48	0.24	232.7	69.89	0.77	241.04	79.74	0.95	0.63	0.36
OC	SUM	22	1.25	0.82	0.67	-34.17	45.75	-0.43	0.57	1.1	3.43	-15.42	-0.52	52.07	48.36	0.69	1.13	0.45
OC	FAL	29	0.67	0.98	0.76	45.78	58.76	0.31	0.4	0.15	167.79	47.39	0.46	175.7	56.32	0.59	0.49	0.57
OC	ALL	98	0.72	1.07	0.32	49.63	87.84	0.36	0.63	0.79	186.3	52.61	0.5	201.86	72.28	0.88	0.96	0.10
PM-2.5	WIN	22	2.61	6.53	0.78	150.19	150.19	3.92	3.92	8.53	177.61	85.56	1.5	177.61	85.56	1.5	4.89	0.61
PM-2.5	SPR	28	3.18	4.5	0.62	41.39	55.29	1.32	1.76	4.5	72.43	35.83	0.41	81.13	46.57	0.55	2.5	0.38
PM-2.5	SUM	23	6.09	4.08	0.65	-32.95	44.6	-2.01	2.72	12.82	-7.56	-28.59	-0.49	51.86	53.63	0.67	4.1	0.42
PM-2.5	FAL	30	3.93	4.49	0.92	14.27	30.57	0.56	1.2	1.79	78.86	29.16	0.14	90.8	43.23	0.31	1.45	0.84
PM-2.5	ALL	103	3.93	4.84	0.51	23.19	57.85	0.91	2.27	10.34	78.91	30.12	0.23	98.02	55.5	0.58	3.34	0.26
SO4	WIN	22	0.85	0.87	0.82	2.77	28.1	0.02	0.24	0.09	15.51	7.23	0.03	34.64	30.02	0.28	0.31	0.68
SO4	SPR	27	0.93	1.29	0.84	38.24	43.86	0.36	0.41	0.22	66.77	36.6	0.38	70.68	40.94	0.44	0.59	0.70
SO4	SUM	23	1.64	1.49	0.61	-9.11	59.09	-0.15	0.97	1.69	85.07	3.76	-0.1	129.86	66.9	0.65	1.31	0.37
SO4	FAL	30	1.27	1.33	0.96	4.45	22.98	0.06	0.29	0.14	62.79	24.49	0.04	73.61	36.36	0.23	0.38	0.93
SO4	ALL	102	1.17	1.25	0.78	7.01	39.56	0.08	0.46	0.53	58.67	19.3	0.07	77.11	43.09	0.4	0.73	0.61

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: MACA1																		
EC	WIN	29	0.34	0.52	0.74	52.12	56.6	0.18	0.19	0.03	54.27	37.47	0.52	58.87	42.52	0.57	0.25	0.55
EC	SPR	31	0.29	0.31	0.66	5.95	29.4	0.02	0.09	0.01	16.94	8.95	0.06	35.14	30.6	0.29	0.1	0.43
EC	SUM	31	0.34	0.33	0.43	-1.01	26.76	0	0.09	0.01	4.95	-0.78	-0.01	28.82	27.02	0.27	0.11	0.19
EC	FAL	30	0.31	0.36	0.73	16.04	27.12	0.05	0.09	0.01	26.65	18.62	0.16	33.75	26.74	0.27	0.11	0.53
EC	ALL	121	0.32	0.38	0.6	18.35	35.1	0.06	0.11	0.02	25.22	15.69	0.18	38.86	31.59	0.35	0.15	0.36
NO3	WIN	28	2.08	2.02	0.58	-2.61	39.99	-0.05	0.83	1.22	34.34	10.89	-0.03	62.34	47.06	0.41	1.11	0.33
NO3	SPR	31	0.68	1.22	0.2	80.79	141.48	0.55	0.96	2.89	147.23	26.44	0.81	179.85	71.9	1.41	1.78	0.04
NO3	SUM	26	0.2	0.12	0	-40.05	58.79	-0.08	0.12	0.01	-32.42	-62.9	-0.67	59.59	79.85	0.98	0.14	0.00
NO3	FAL	30	0.39	0.55	0.57	41.51	79.74	0.16	0.31	0.15	62.4	10.75	0.42	103.1	69.61	0.8	0.42	0.33
NO3	ALL	115	0.83	0.99	0.57	18.97	68.03	0.16	0.57	1.18	57	-1.64	0.19	104.03	67.05	0.68	1.1	0.32
OC	WIN	29	1.46	1.7	0.81	16.41	33.15	0.24	0.48	0.31	18.98	11.04	0.16	35.58	31.91	0.33	0.6	0.66
OC	SPR	31	1.44	1.04	0.82	-28.33	37.67	-0.41	0.54	0.37	-17.58	-27.05	-0.4	33.93	40.3	0.53	0.73	0.67
OC	SUM	31	2.26	1.72	0.77	-23.89	31.69	-0.54	0.72	0.43	-24.26	-32.17	-0.31	31.61	38.22	0.42	0.85	0.59
OC	FAL	30	1.3	1.12	0.82	-13.71	30.71	-0.18	0.4	0.23	-14.53	-20.83	-0.16	28.94	33.32	0.36	0.51	0.68
OC	ALL	121	1.62	1.39	0.74	-14.19	33.18	-0.23	0.54	0.42	-9.77	-17.69	-0.17	32.49	36.03	0.39	0.69	0.55
PM-2.5	WIN	29	7.68	9.36	0.67	21.83	31.35	1.68	2.41	6.5	29.44	19.69	0.22	37.93	29.5	0.31	3.05	0.45
PM-2.5	SPR	31	8.34	7.24	0.41	-13.2	36.93	-1.1	3.08	13.97	-2.71	-14.41	-0.15	39.14	38.44	0.43	3.9	0.17
PM-2.5	SUM	31	11.69	7.66	0.74	-34.46	35.57	-4.03	4.16	8.05	-32.8	-42.22	-0.53	34.41	43.72	0.54	4.93	0.54
PM-2.5	FAL	30	6.49	6.44	0.86	-0.76	19.68	-0.05	1.28	2.42	2.76	-0.72	-0.01	21.88	21.67	0.2	1.56	0.74
PM-2.5	ALL	121	8.58	7.66	0.56	-10.77	32.02	-0.92	2.75	12.09	-1.36	-9.97	-0.12	33.36	33.49	0.36	3.6	0.31
SO4	WIN	28	2.11	1.5	0.8	-28.91	33.84	-0.61	0.71	0.43	-22.02	-29.92	-0.41	33.35	39.5	0.48	0.89	0.64
SO4	SPR	31	2.74	1.84	0.78	-32.73	36.58	-0.9	1	0.84	-23.06	-31.95	-0.49	34.37	41.12	0.54	1.28	0.61
SO4	SUM	26	3.32	2.1	0.73	-36.94	40.31	-1.23	1.34	0.97	-33.7	-45.53	-0.59	38.01	49.43	0.64	1.57	0.53
SO4	FAL	30	1.85	1.67	0.72	-9.67	31.65	-0.18	0.59	0.6	-2.36	-9.15	-0.11	29.93	32.07	0.35	0.8	0.53
SO4	ALL	115	2.49	1.77	0.74	-28.73	36.18	-0.71	0.9	0.85	-19.81	-28.58	-0.4	33.79	40.25	0.51	1.17	0.55

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: MAVI1																		
EC	WIN	28	0.17	0.34	0.79	96.69	97.29	0.17	0.17	0.02	114.61	65.42	0.97	115.01	65.83	0.97	0.21	0.62
EC	SPR	31	0.1	0.21	0.4	100.15	120.09	0.1	0.12	0.01	184.54	74.48	1	192.1	84.99	1.2	0.15	0.16
EC	SUM	28	0.21	0.24	0.74	15.38	42.62	0.03	0.09	0.01	50.14	21.42	0.15	69.49	45.1	0.43	0.12	0.54
EC	FAL	28	0.16	0.25	0.86	54.97	67.86	0.09	0.11	0.02	98.41	51.63	0.55	103.71	57.59	0.68	0.17	0.74
EC	ALL	115	0.16	0.26	0.74	61.04	76.49	0.1	0.12	0.02	113.82	53.79	0.61	121.96	63.94	0.76	0.17	0.55
NO3	WIN	23	0.68	1.23	0.82	81.88	93.53	0.55	0.63	0.65	94.93	35.75	0.82	118.41	71.19	0.94	0.98	0.68
NO3	SPR	31	0.41	0.92	0.51	123.33	140.61	0.51	0.58	0.8	140.88	36.22	1.23	164.8	72.56	1.41	1.03	0.26
NO3	SUM	27	0.35	0.53	0.84	53.32	94.59	0.19	0.33	0.25	31.05	-14.65	0.53	92.07	81.35	0.95	0.54	0.70
NO3	FAL	19	0.42	0.8	0.72	90.45	118.28	0.38	0.5	0.74	41.26	-7.5	0.9	94.87	73.2	1.18	0.94	0.52
NO3	ALL	100	0.46	0.86	0.72	89.02	111.18	0.41	0.51	0.63	81.73	14.07	0.89	121.2	74.74	1.11	0.89	0.52
OC	WIN	28	0.89	1.39	0.72	56.99	61.01	0.5	0.54	0.41	60.28	37.64	0.57	65.4	43.9	0.61	0.82	0.52
OC	SPR	31	0.59	0.84	0.38	43.45	76.17	0.25	0.45	0.32	73.28	38.17	0.43	86.69	55.19	0.76	0.62	0.15
OC	SUM	28	1.33	0.99	0.74	-25.37	40.39	-0.34	0.54	0.38	-18.76	-34.93	-0.34	44.06	51.73	0.54	0.7	0.54
OC	FAL	28	1.21	0.81	0.76	-33.41	46.11	-0.4	0.56	0.38	-40.09	-59.52	-0.5	47.49	65.65	0.69	0.74	0.58
OC	ALL	115	0.99	1	0.57	1.11	52.27	0.01	0.52	0.52	20.1	-3.54	0.01	61.58	54.14	0.52	0.72	0.32
PM-2.5	WIN	27	5.19	6.62	0.85	27.57	37.79	1.43	1.96	5.64	28.47	18.43	0.28	38.7	30.51	0.38	2.77	0.72
PM-2.5	SPR	30	5.59	6.37	0.54	13.8	37.51	0.77	2.1	9.2	19.34	9.65	0.14	37.3	31.14	0.38	3.13	0.29
PM-2.5	SUM	30	8.44	6.14	0.76	-27.25	38.76	-2.3	3.27	12.49	-19.5	-31.02	-0.37	36.83	44.87	0.53	4.22	0.58
PM-2.5	FAL	28	6.16	5.13	0.64	-16.66	39.51	-1.03	2.43	27.99	-4.3	-13.79	-0.2	32.05	36.99	0.47	5.39	0.41
PM-2.5	ALL	115	6.38	6.07	0.61	-4.89	38.47	-0.31	2.45	15.97	5.6	-4.61	-0.05	36.23	36	0.4	4.01	0.37
SO4	WIN	23	1.32	0.93	0.68	-29.21	35.42	-0.38	0.47	0.36	-16.67	-25.2	-0.41	32.31	37.42	0.5	0.71	0.47
SO4	SPR	31	1.49	1.82	0.64	22.34	38.73	0.33	0.58	0.93	29.95	16.09	0.22	44.73	33.09	0.39	1.02	0.41
SO4	SUM	27	2.36	2.29	0.52	-2.88	54.01	-0.07	1.28	3.54	36.82	4	-0.03	72.77	52.31	0.56	1.88	0.27
SO4	FAL	19	1.19	1.08	0.86	-9.28	27.79	-0.11	0.33	0.14	4.76	-6.75	-0.1	38.94	39.27	0.31	0.39	0.74
SO4	ALL	100	1.63	1.6	0.6	-1.51	42.58	-0.02	0.69	1.43	16.3	-1.01	-0.02	48.34	40.45	0.43	1.19	0.35

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: MELA1																		
EC	WIN	27	0.07	0.09	0.65	30.88	46.75	0.02	0.03	0	51.56	30.64	0.31	63.11	44.48	0.47	0.04	0.43
EC	SPR	31	0.1	0.11	0.43	5.67	52.44	0.01	0.05	0	48.86	8.2	0.06	85.11	57.39	0.52	0.07	0.18
EC	SUM	29	0.13	0.14	0.54	4.79	31.29	0.01	0.04	0	22.47	10.68	0.05	38.57	30.66	0.31	0.07	0.29
EC	FAL	27	0.17	0.21	0.51	27.37	63	0.05	0.11	0.03	33.38	14.07	0.27	57.54	44.05	0.63	0.17	0.26
EC	ALL	114	0.12	0.14	0.57	16.34	49.06	0.02	0.06	0.01	39.12	15.54	0.16	61.53	44.38	0.49	0.1	0.33
NO3	WIN	27	0.62	1.94	0.6	210.87	220.82	1.32	1.38	3.07	258.48	82.39	2.11	266.04	92.55	2.21	2.19	0.36
NO3	SPR	31	0.8	1.22	0.77	52.15	78.88	0.42	0.63	0.81	98.92	25.93	0.52	132.07	80.95	0.79	1	0.60
NO3	SUM	30	0.17	0.11	0.59	-32.01	67.26	-0.05	0.11	0.02	-44.58	-82.5	-0.47	68.51	98.44	0.99	0.15	0.35
NO3	FAL	27	0.28	0.72	0.72	157.5	173.26	0.44	0.48	0.52	248.1	40.22	1.58	281.82	92.32	1.73	0.84	0.51
NO3	ALL	115	0.47	0.98	0.66	108.36	135.02	0.51	0.64	1.31	133.97	14.26	1.08	182.1	90.9	1.35	1.25	0.44
OC	WIN	27	0.33	0.26	0.67	-22.39	32.05	-0.07	0.11	0.01	-15.68	-22.19	-0.29	28.51	32.86	0.41	0.14	0.44
OC	SPR	31	0.38	0.27	0.06	-29.45	56.35	-0.11	0.21	0.07	-7.31	-33.59	-0.42	59.57	63.11	0.8	0.28	0.00
OC	SUM	29	0.93	0.44	0.35	-52.32	55.41	-0.49	0.51	0.19	-50.56	-73.89	-1.1	53.18	76.09	1.16	0.65	0.12
OC	FAL	27	0.78	0.88	0.46	13.39	67.13	0.1	0.52	0.61	21.87	-1.28	0.13	62.32	54.35	0.67	0.79	0.21
OC	ALL	114	0.6	0.46	0.46	-24.35	56.1	-0.15	0.34	0.26	-13.38	-33.49	-0.32	51.24	57.18	0.74	0.53	0.21
PM-2.5	WIN	27	2.06	3.88	0.64	88.09	99.81	1.82	2.06	5.53	100.19	48.87	0.88	109.5	59.79	1	2.97	0.41
PM-2.5	SPR	31	3.63	3.82	0.75	5.42	41.06	0.2	1.49	3.03	24.61	2.84	0.05	57.74	50.05	0.41	1.75	0.56
PM-2.5	SUM	30	4.5	2.51	0.59	-44.27	45.61	-1.99	2.05	1.76	-41.97	-56.58	-0.79	43.33	57.81	0.82	2.39	0.35
PM-2.5	FAL	27	4.04	4.35	0.68	7.56	41.57	0.31	1.68	4.9	22.42	6.07	0.08	51.02	44.09	0.42	2.24	0.46
PM-2.5	ALL	115	3.58	3.62	0.51	0.91	50.63	0.03	1.81	5.57	24.47	-1.09	0.01	64.56	52.96	0.51	2.36	0.26
SO4	WIN	27	0.6	0.47	0.57	-21.77	44.67	-0.13	0.27	0.11	10.54	-8.33	-0.28	54.33	48.94	0.57	0.35	0.32
SO4	SPR	31	1.15	0.89	0.75	-22.73	41.2	-0.26	0.48	0.37	-1.83	-16.74	-0.29	45	47.89	0.53	0.66	0.56
SO4	SUM	30	0.8	0.64	0.43	-19.94	36.53	-0.16	0.29	0.13	-11.48	-22.06	-0.25	36.6	38.82	0.46	0.39	0.18
SO4	FAL	27	0.52	0.68	0.51	31.14	55.29	0.16	0.28	0.11	57.12	32.95	0.31	68.56	47.09	0.55	0.37	0.26
SO4	ALL	115	0.78	0.68	0.67	-13.46	42.76	-0.11	0.33	0.21	12.4	-4.49	-0.16	50.53	45.58	0.49	0.47	0.45

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: MING1																		
EC	WIN	27	0.44	0.45	0.52	2.69	35.56	0.01	0.16	0.05	16.7	5.86	0.03	38.25	32.9	0.36	0.22	0.27
EC	SPR	29	0.32	0.27	0.76	-14.81	26.49	-0.05	0.08	0.01	-10.43	-15.84	-0.17	27.56	30.44	0.31	0.1	0.57
EC	SUM	18	0.43	0.39	0.74	-9.94	26.13	-0.04	0.11	0.02	-3.86	-9.28	-0.11	26.19	27.02	0.29	0.15	0.54
EC	FAL	30	0.34	0.4	0.85	17.58	30.82	0.06	0.11	0.02	21.38	13.84	0.18	34.56	28.9	0.31	0.14	0.71
EC	ALL	104	0.38	0.38	0.68	-0.05	30.31	0	0.11	0.03	6.93	-0.51	0	32.12	30.04	0.3	0.16	0.47
NO3	WIN	21	2.13	2.75	0.56	28.93	62.54	0.62	1.33	2.86	107.29	38.16	0.29	124.61	59.71	0.63	1.8	0.31
NO3	SPR	29	0.96	1.94	0.79	102.29	113.09	0.98	1.09	2.23	203.78	54.1	1.02	218.5	77.39	1.13	1.79	0.63
NO3	SUM	18	0.36	0.35	0.73	-2.79	63.18	-0.01	0.23	0.09	17.47	-24.44	-0.03	82.05	74.46	0.65	0.31	0.53
NO3	FAL	24	0.42	1.39	0.77	229.28	235.4	0.97	0.99	1.58	299.6	78.45	2.29	313.14	96.07	2.35	1.59	0.59
NO3	ALL	92	0.97	1.67	0.68	72.28	97.99	0.7	0.95	1.93	170.3	41.45	0.72	195.06	77.65	0.98	1.56	0.46
OC	WIN	27	2.03	1.6	0.4	-21.31	42.69	-0.43	0.87	1.23	-7.71	-18.15	-0.27	37.56	42.2	0.54	1.19	0.16
OC	SPR	29	1.52	0.93	0.77	-38.88	40.09	-0.59	0.61	0.25	-36.94	-49.83	-0.64	38.49	51.27	0.66	0.78	0.59
OC	SUM	18	2.65	2.31	0.82	-12.85	24.74	-0.34	0.65	0.52	-12.41	-19.16	-0.15	28.71	32.25	0.28	0.8	0.67
OC	FAL	30	1.62	1.5	0.76	-7.28	36.8	-0.12	0.6	0.69	-9	-18.53	-0.08	36.71	39.19	0.4	0.84	0.58
OC	ALL	104	1.88	1.51	0.7	-19.73	36.26	-0.37	0.68	0.71	-17.04	-27.27	-0.25	36.04	42.14	0.45	0.92	0.49
PM-2.5	WIN	27	8.92	10.79	0.58	20.97	35.18	1.87	3.14	16.63	28.01	15.68	0.21	40.99	30.3	0.35	4.49	0.33
PM-2.5	SPR	27	8.62	8.63	0.5	0.03	39.58	0	3.41	19.27	7.17	-6.05	0	41.82	39.01	0.4	4.39	0.25
PM-2.5	SUM	18	12.65	9.71	0.8	-23.25	30.05	-2.94	3.8	10.47	-20.94	-28.63	-0.3	31.56	37.85	0.39	4.37	0.64
PM-2.5	FAL	30	7.55	8.72	0.81	15.5	27.69	1.17	2.09	9.53	16.9	9.88	0.16	28.91	23.64	0.28	3.3	0.66
PM-2.5	ALL	102	9.1	9.42	0.63	3.53	33.2	0.32	3.02	16.91	10.59	0.4	0.04	35.99	31.98	0.33	4.12	0.40
SO4	WIN	21	1.88	1.43	0.92	-23.71	26.74	-0.45	0.5	0.2	-19.15	-25.18	-0.31	26.1	31.55	0.35	0.63	0.84
SO4	SPR	29	2.45	1.86	0.66	-24.35	34.36	-0.6	0.84	1.12	-15.99	-24.55	-0.32	31.79	37.85	0.45	1.21	0.44
SO4	SUM	18	2.98	1.93	0.75	-35.39	38.85	-1.06	1.16	0.97	-33.7	-46.26	-0.55	37.29	49.5	0.6	1.44	0.57
SO4	FAL	24	1.71	1.59	0.89	-6.82	24.35	-0.12	0.42	0.36	12	3.22	-0.07	33.37	29.08	0.26	0.61	0.80
SO4	ALL	92	2.23	1.7	0.79	-23.61	32.07	-0.53	0.72	0.78	-12.88	-21.7	-0.31	31.98	36.4	0.42	1.03	0.62

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: MOMO1																		
EC	WIN	29	0.21	0.47	0.92	128.32	128.32	0.27	0.27	0.03	138.71	77.03	1.28	138.71	77.03	1.28	0.32	0.84
EC	SPR	31	0.16	0.24	0.71	49.48	58.81	0.08	0.1	0.01	80.14	45.72	0.49	84.04	50.33	0.59	0.13	0.50
EC	SUM	29	0.25	0.24	0.9	-2.31	21.16	-0.01	0.05	0.01	1.45	-1.55	-0.02	19.79	20.04	0.22	0.07	0.82
EC	FAL	26	0.28	0.36	0.8	29.72	41.36	0.08	0.11	0.02	53.2	34.07	0.3	59.72	41.97	0.41	0.15	0.63
EC	ALL	115	0.22	0.33	0.72	47.95	59.71	0.11	0.13	0.03	68.97	39.06	0.48	76.12	47.53	0.6	0.19	0.51
NO3	WIN	29	0.73	1.54	0.69	109.64	112.87	0.81	0.83	0.47	187.02	66.88	1.1	194.21	80.58	1.13	1.06	0.48
NO3	SPR	31	0.4	0.64	0.56	61.17	102.75	0.24	0.41	0.34	112.07	33.49	0.61	142.64	77.14	1.03	0.63	0.32
NO3	SUM	29	0.21	0.1	0.55	-53.04	63.46	-0.11	0.14	0.03	-51.33	-86.57	-1.13	61.54	94.43	1.35	0.2	0.31
NO3	FAL	26	0.43	0.49	0.38	14.27	80.42	0.06	0.34	0.21	82.58	0.56	0.14	133.02	75.93	0.8	0.46	0.14
NO3	ALL	115	0.44	0.7	0.67	57.39	97.36	0.25	0.43	0.38	83.1	4.19	0.57	133.02	82.09	0.97	0.67	0.45
OC	WIN	29	0.88	2.11	0.85	138.71	139.36	1.22	1.23	0.51	162.76	81.98	1.39	163.8	83.1	1.39	1.42	0.72
OC	SPR	31	0.74	0.98	0.65	32.68	54.93	0.24	0.4	0.27	68.79	36.12	0.33	78.46	47.63	0.55	0.57	0.42
OC	SUM	29	1.54	1.02	0.76	-33.8	37.75	-0.52	0.58	0.47	-28.59	-38.66	-0.51	34.91	44.27	0.57	0.86	0.58
OC	FAL	26	0.95	1.1	0.87	15.61	26.15	0.15	0.25	0.1	29.25	18.64	0.16	37.93	28.56	0.26	0.35	0.75
OC	ALL	115	1.02	1.3	0.5	26.97	60.74	0.28	0.62	0.73	58.99	24.87	0.27	79.84	51.42	0.61	0.9	0.25
PM-2.5	WIN	29	4.46	8.34	0.85	87.17	89.02	3.88	3.97	7.57	93.57	57.36	0.87	96.18	60.58	0.89	4.76	0.73
PM-2.5	SPR	31	4.25	5.41	0.74	27.33	39.59	1.16	1.68	4.5	51.34	27.9	0.27	58.35	35.72	0.4	2.42	0.55
PM-2.5	SUM	29	7.54	4.73	0.87	-37.17	39.44	-2.8	2.97	6.69	-33.11	-43.96	-0.59	37.44	47.84	0.63	3.81	0.76
PM-2.5	FAL	26	5.03	5.52	0.88	9.73	27.65	0.49	1.39	3.04	29.97	18.43	0.1	42.41	33.33	0.28	1.81	0.77
PM-2.5	ALL	115	5.31	6	0.59	13.13	47.44	0.7	2.52	11.21	35.86	15.07	0.13	59.01	44.5	0.47	3.42	0.35
SO4	WIN	29	1.38	1.07	0.79	-22.87	28.86	-0.32	0.4	0.23	-17.89	-24.28	-0.3	28.39	32.9	0.37	0.57	0.63
SO4	SPR	31	1.32	1.54	0.84	16.53	30.3	0.22	0.4	0.31	91.19	17.09	0.17	103.62	31.8	0.3	0.6	0.71
SO4	SUM	29	1.95	1.56	0.8	-19.91	36.79	-0.39	0.72	0.86	-1.47	-17.14	-0.25	45.16	42.66	0.46	1	0.64
SO4	FAL	26	1.52	1.47	0.84	-3.08	33.43	-0.05	0.51	0.5	28.78	9.04	-0.03	53.38	40.02	0.34	0.71	0.71
SO4	ALL	115	1.54	1.41	0.78	-8.41	32.74	-0.13	0.5	0.53	26.21	-3.79	-0.09	58.55	36.67	0.36	0.74	0.62

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: MOOS1																		
EC	WIN	29	0.18	0.18	0.04	-1.24	64.59	0	0.12	0.03	49.61	17.68	-0.01	77.65	58.91	0.65	0.19	0.00
EC	SPR	25	0.08	0.1	0.46	22.05	50.01	0.02	0.04	0	66.59	28.13	0.22	82.28	47.9	0.5	0.06	0.22
EC	SUM	27	0.13	0.12	0.66	-6.61	35.32	-0.01	0.04	0	0.69	-7.31	-0.07	35.83	34.65	0.38	0.06	0.43
EC	FAL	30	0.13	0.15	0.67	13.53	44.01	0.02	0.06	0.01	47.84	7.92	0.14	75.3	41.3	0.44	0.08	0.45
EC	ALL	111	0.13	0.14	0.37	4.79	50.19	0.01	0.07	0.01	41.06	11.32	0.05	67.89	45.77	0.5	0.11	0.14
NO3	WIN	28	0.25	0.73	0.76	187.07	194.39	0.47	0.49	0.29	249.66	71.84	1.87	261.14	88.99	1.94	0.72	0.58
NO3	SPR	28	0.12	0.19	0.18	58.61	129.36	0.07	0.16	0.05	201.55	10.98	0.59	256.51	98.87	1.29	0.23	0.03
NO3	SUM	28	0.09	0.03	0.5	-71.03	74.69	-0.07	0.07	0	-54.22	-97.81	-2.45	72.13	105.76	2.58	0.1	0.25
NO3	FAL	30	0.18	0.41	0.77	129.85	164.39	0.23	0.29	0.26	318.71	10.12	1.3	368.9	88.76	1.64	0.55	0.59
NO3	ALL	114	0.16	0.34	0.75	109.74	156.52	0.18	0.25	0.19	181.38	-1.02	1.1	241.94	95.48	1.57	0.47	0.56
OC	WIN	29	0.72	0.81	0.33	12.32	47.49	0.09	0.34	0.26	33.17	16.64	0.12	51.6	41.57	0.47	0.51	0.11
OC	SPR	25	0.49	0.51	0.78	4.78	25.86	0.02	0.13	0.03	13.87	6.9	0.05	31.12	26.82	0.26	0.16	0.60
OC	SUM	27	1.1	0.72	0.86	-34.81	36.26	-0.38	0.4	0.1	-34.9	-45.41	-0.53	37.27	47.55	0.56	0.5	0.74
OC	FAL	30	0.83	0.68	0.82	-17.6	28.57	-0.15	0.24	0.07	-13.95	-21.68	-0.21	31.2	34.26	0.35	0.29	0.67
OC	ALL	111	0.79	0.69	0.67	-13.21	35.33	-0.1	0.28	0.15	-0.47	-11.01	-0.15	37.99	37.73	0.41	0.4	0.45
PM-2.5	WIN	29	3.25	4.18	0.71	28.79	42.74	0.94	1.39	2.45	37.96	24.1	0.29	48.66	37.77	0.43	1.82	0.51
PM-2.5	SPR	25	2.91	4.05	0.55	39.11	50.09	1.14	1.46	3.85	59.27	29.13	0.39	68.8	40.04	0.5	2.27	0.30
PM-2.5	SUM	28	4.77	3.83	0.67	-19.85	33.56	-0.95	1.6	3.52	-10.83	-19.22	-0.25	33.09	35.82	0.42	2.1	0.45
PM-2.5	FAL	30	3.79	4.01	0.79	5.7	30.53	0.22	1.16	2.65	19.86	6.18	0.06	40.86	30.57	0.31	1.64	0.62
PM-2.5	ALL	112	3.7	4.02	0.62	8.57	37.72	0.32	1.4	3.74	25.67	9.59	0.09	47.18	35.86	0.38	1.96	0.39
SO4	WIN	28	1.01	0.87	0.75	-13.36	31.36	-0.13	0.32	0.16	-1.67	-9.11	-0.15	32.12	31.65	0.36	0.42	0.57
SO4	SPR	28	0.84	1.81	0.41	114.99	122.79	0.97	1.03	2.36	168.67	55.53	1.15	174.93	62.57	1.23	1.82	0.17
SO4	SUM	28	0.99	1.67	0.48	68.37	88	0.68	0.87	1.35	134.09	52.77	0.68	144.1	65.37	0.88	1.34	0.24
SO4	FAL	30	0.94	1.29	0.82	37.33	48.82	0.35	0.46	0.28	97.36	35.18	0.37	105.38	44.41	0.49	0.63	0.67
SO4	ALL	114	0.94	1.41	0.46	49.05	70.54	0.46	0.67	1.19	99.57	33.62	0.49	113.98	50.88	0.71	1.18	0.22

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: MOZI1																		
EC	WIN	25	0.02	0.08	0.29	259.44	259.44	0.06	0.06	0	350.85	101.83	2.59	350.85	101.83	2.59	0.09	0.09
EC	SPR	26	0.03	0.04	0.52	29.1	58.62	0.01	0.02	0	95.05	42.82	0.29	106.36	57.22	0.59	0.02	0.27
EC	SUM	26	0.06	0.08	0.89	26.75	39.51	0.02	0.03	0	18.59	10.71	0.27	29.62	24.58	0.4	0.07	0.79
EC	FAL	27	0.06	0.08	0.4	32.58	65.44	0.02	0.04	0	60.53	26.67	0.33	83.32	56.65	0.65	0.05	0.16
EC	ALL	104	0.05	0.07	0.52	58.16	79.19	0.03	0.04	0	128.46	44.79	0.58	139.96	59.64	0.79	0.06	0.27
NO3	WIN	27	0.1	0.17	0.21	66.18	133.85	0.07	0.13	0.04	228.09	19.83	0.66	269.71	84.93	1.34	0.21	0.05
NO3	SPR	28	0.13	0.07	0.45	-50.89	71.22	-0.07	0.09	0.01	-16.37	-61.54	-1.04	81.96	94.42	1.45	0.13	0.20
NO3	SUM	25	0.07	0.01	0.57	-82.2	82.2	-0.06	0.06	0	-80.26	-135.96	-4.62	80.26	135.96	4.62	0.07	0.32
NO3	FAL	27	0.08	0.07	0.27	-7.31	96.58	-0.01	0.08	0.02	-0.56	-56.98	-0.08	93.86	90.65	1.04	0.14	0.07
NO3	ALL	107	0.1	0.08	0.24	-16.41	94.82	-0.02	0.09	0.02	34.38	-57.25	-0.2	131.94	100.78	1.13	0.15	0.06
OC	WIN	26	0.11	0.29	0.25	169.21	174.91	0.18	0.19	0.08	283.92	72.49	1.69	288.31	77.43	1.75	0.34	0.06
OC	SPR	28	0.16	0.14	0.59	-15.48	42.49	-0.03	0.07	0.01	14.81	-1.6	-0.18	49.91	44.68	0.5	0.1	0.35
OC	SUM	26	0.59	0.55	0.91	-5.39	29.37	-0.03	0.17	0.05	-4.89	-11.54	-0.06	30.15	31.44	0.31	0.22	0.82
OC	FAL	27	0.33	0.34	0.36	3.49	54.68	0.01	0.18	0.06	37.43	6.75	0.03	72.31	53.18	0.55	0.25	0.13
OC	ALL	107	0.29	0.33	0.73	11.23	51.36	0.03	0.15	0.06	81.12	16.09	0.11	108.69	51.56	0.51	0.24	0.54
PM-2.5	WIN	27	0.79	1.62	0.38	105.52	111.93	0.83	0.88	0.72	146.64	65.08	1.06	149.72	68.85	1.12	1.19	0.15
PM-2.5	SPR	27	1.91	1.41	0.56	-26.56	45.22	-0.51	0.87	2.17	18.61	-6.2	-0.36	53.38	42.39	0.62	1.56	0.31
PM-2.5	SUM	26	2.64	1.87	0.88	-29.18	32.6	-0.77	0.86	0.34	-30.08	-38.58	-0.41	33.72	41.58	0.46	0.97	0.77
PM-2.5	FAL	27	1.81	1.63	0.29	-9.97	42.32	-0.18	0.77	0.9	3.6	-9.46	-0.11	45.45	44.82	0.47	0.96	0.09
PM-2.5	ALL	107	1.78	1.63	0.47	-8.52	47.36	-0.15	0.84	1.41	35.3	3.1	-0.09	70.91	49.48	0.52	1.2	0.22
SO4	WIN	27	0.22	0.45	0.33	101.25	115.02	0.23	0.26	0.03	153.31	72.32	1.01	158.58	78.78	1.15	0.29	0.11
SO4	SPR	28	0.41	0.48	0.54	15.76	47.93	0.06	0.2	0.1	53.81	27.71	0.16	66.32	43.8	0.48	0.32	0.29
SO4	SUM	25	0.46	0.35	0.54	-23.61	28.21	-0.11	0.13	0.01	-22.31	-28.94	-0.31	26.97	32.73	0.37	0.16	0.29
SO4	FAL	27	0.38	0.4	0.39	3.89	35.03	0.01	0.13	0.03	19.2	6.22	0.04	43.19	35.62	0.35	0.17	0.15
SO4	ALL	107	0.37	0.42	0.37	14.18	49.03	0.05	0.18	0.06	52.4	20.31	0.14	74.57	47.97	0.49	0.25	0.13

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: NEBR1																		
EC	WIN	28	0.08	0.17	0.34	106.17	110.51	0.09	0.09	0.02	183.07	68.72	1.06	185.03	70.84	1.11	0.15	0.12
EC	SPR	29	0.13	0.24	0.91	86.8	92.18	0.11	0.12	0.04	90.94	55.77	0.87	93.9	58.99	0.92	0.23	0.83
EC	SUM	29	0.14	0.19	0.73	33.54	41.86	0.05	0.06	0	41.55	26.41	0.34	51.63	38.26	0.42	0.08	0.53
EC	FAL	27	0.11	0.2	0.62	85.48	85.48	0.09	0.09	0	110.72	62.33	0.85	110.72	62.33	0.85	0.12	0.39
EC	ALL	113	0.12	0.2	0.77	73.49	78.4	0.09	0.09	0.02	105.82	53.01	0.73	109.65	57.41	0.78	0.16	0.59
NO3	WIN	29	1.08	0.96	0.58	-10.39	65.61	-0.11	0.71	2.66	110.87	28.3	-0.12	141.61	70.16	0.73	1.64	0.33
NO3	SPR	29	1.13	1.71	0.76	51.44	69.48	0.58	0.78	2.6	47.37	15.86	0.51	76.16	55.98	0.69	1.71	0.58
NO3	SUM	29	0.26	0.31	0.54	20.8	93.05	0.05	0.24	0.1	64.44	-41.51	0.21	151.48	102.19	0.93	0.32	0.29
NO3	FAL	27	0.22	0.23	0.8	8.35	56.85	0.02	0.12	0.04	-0.39	-25.51	0.08	58.97	60.18	0.57	0.21	0.64
NO3	ALL	114	0.68	0.81	0.61	20.22	69.23	0.14	0.47	1.45	56.55	-5.37	0.2	107.9	72.34	0.69	1.21	0.38
OC	WIN	28	0.37	0.4	0.18	7.08	77.66	0.03	0.29	0.28	50.28	-16.66	0.07	108.33	60.98	0.78	0.53	0.03
OC	SPR	29	0.83	0.79	0.87	-5.36	52.97	-0.04	0.44	0.69	-25.07	-38.72	-0.06	42.61	51.59	0.56	0.83	0.76
OC	SUM	29	1.08	0.84	0.3	-22.17	50.88	-0.24	0.55	0.35	-19.49	-43.39	-0.28	55.56	66.34	0.65	0.63	0.09
OC	FAL	27	0.61	0.5	0.59	-17.42	41.86	-0.11	0.25	0.09	-1.05	-16.3	-0.21	47.21	48.46	0.51	0.32	0.35
OC	ALL	113	0.73	0.64	0.74	-12.59	53.09	-0.09	0.39	0.37	0.77	-29.09	-0.14	63.32	56.95	0.61	0.61	0.54
PM-2.5	WIN	29	3.38	3.27	0.6	-3.09	50.21	-0.1	1.7	7.72	40.75	14.3	-0.03	66.15	46.62	0.52	2.78	0.36
PM-2.5	SPR	29	5.44	6.33	0.73	16.22	40.21	0.88	2.19	30.5	11.32	-1.23	0.16	40.79	34.91	0.4	5.59	0.53
PM-2.5	SUM	29	5.58	4.43	0.27	-20.67	50.7	-1.15	2.83	9.54	-15.18	-39.8	-0.26	57.15	63.86	0.64	3.3	0.07
PM-2.5	FAL	27	3.37	3	0.7	-11.04	26.23	-0.37	0.88	1.4	-4.47	-10.56	-0.12	26.9	28.28	0.29	1.24	0.50
PM-2.5	ALL	114	4.46	4.28	0.64	-4.11	42.97	-0.18	1.92	13.02	8.33	-9.3	-0.04	48.11	43.68	0.45	3.61	0.41
SO4	WIN	29	0.92	0.56	0.37	-39.63	58.74	-0.37	0.54	0.84	11.99	-12.31	-0.66	56.08	52.83	0.97	0.99	0.14
SO4	SPR	29	1.2	1.28	0.63	6.77	43.61	0.08	0.52	1.33	2.52	-10.07	0.07	39.1	36.93	0.44	1.16	0.40
SO4	SUM	29	1.24	1.1	0.23	-11.23	55.29	-0.14	0.68	0.85	-2.74	-28.75	-0.13	58.3	57.53	0.62	0.93	0.05
SO4	FAL	27	0.63	0.66	0.76	5.26	27.16	0.03	0.17	0.07	17.43	7.89	0.05	35.31	30.17	0.27	0.26	0.58
SO4	ALL	114	1	0.9	0.44	-9.95	48.37	-0.1	0.49	0.82	7.12	-11.14	-0.11	47.41	44.61	0.54	0.91	0.20

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: NOCH1																		
EC	WIN	26	0.04	0.06	0.61	47.55	75.6	0.02	0.03	0	210.74	64.36	0.48	218.44	73.95	0.76	0.04	0.37
EC	SPR	31	0.05	0.05	0.61	7.78	48.18	0	0.02	0	25.2	2.79	0.08	60.47	51.76	0.48	0.03	0.37
EC	SUM	29	0.17	0.51	0.32	198.74	226.61	0.34	0.39	1.44	213.27	0.68	1.99	250.59	50.24	2.27	1.25	0.10
EC	FAL	21	0.1	0.25	0.04	157.72	182.28	0.15	0.18	0.28	319.37	41.76	1.58	330.3	54.82	1.82	0.55	0.00
EC	ALL	107	0.09	0.22	0.35	144.36	173.44	0.13	0.15	0.46	178.99	24.83	1.44	203.34	57.34	1.73	0.69	0.12
NO3	WIN	26	0.19	0.5	0.69	162.43	176.66	0.31	0.33	0.34	174.07	41.67	1.62	200.46	78.09	1.77	0.66	0.48
NO3	SPR	31	0.21	0.4	0.73	89.22	127.81	0.19	0.27	0.25	143.43	8.15	0.89	192.25	78.88	1.28	0.53	0.53
NO3	SUM	28	0.08	0.03	0.4	-58.9	70.74	-0.05	0.06	0.01	-33.29	-65.24	-1.43	61.54	77.01	1.72	0.13	0.16
NO3	FAL	21	0.06	0.06	0.3	17.38	94.51	0.01	0.05	0.01	103.84	-22.99	0.17	166.28	61.59	0.95	0.11	0.09
NO3	ALL	106	0.14	0.26	0.69	84.55	132.36	0.12	0.19	0.18	96.42	-9.18	0.85	154.59	74.77	1.32	0.44	0.48
OC	WIN	26	0.2	0.18	0.35	-11.41	53.97	-0.02	0.11	0.02	66.11	5.27	-0.13	106.43	58.23	0.61	0.14	0.13
OC	SPR	31	0.21	0.16	0.39	-23.49	50.6	-0.05	0.11	0.02	19.83	-22.94	-0.31	78.23	60.03	0.66	0.15	0.15
OC	SUM	29	1.47	2.58	0.35	75.69	140.99	1.11	2.07	33.35	75.07	-49	0.76	163.96	79.32	1.41	5.88	0.12
OC	FAL	21	0.79	1.16	0.04	46.57	122.17	0.37	0.97	6.27	563.21	10.4	0.47	599.04	58.9	1.22	2.53	0.00
OC	ALL	107	0.66	1.02	0.39	53.31	121.84	0.35	0.81	10.52	152.69	-16.6	0.53	210.53	64.6	1.22	3.26	0.15
PM-2.5	WIN	25	1.73	1.92	0.82	10.89	33.05	0.19	0.57	0.6	27.88	13.61	0.11	43.19	31.34	0.33	0.8	0.67
PM-2.5	SPR	31	2.32	2.27	0.54	-2.13	46.81	-0.05	1.08	4.37	24.06	2.52	-0.02	55.89	45.07	0.48	2.09	0.29
PM-2.5	SUM	28	4.78	6.87	0.35	43.56	103.22	2.08	4.94	162.55	36.37	-34.04	0.44	107.62	60.29	1.03	12.92	0.12
PM-2.5	FAL	21	3.03	3.79	0.02	25.19	74.76	0.76	2.26	30.12	133.62	15.93	0.25	156.87	46.22	0.75	5.54	0.00
PM-2.5	ALL	105	2.98	3.72	0.37	24.8	74.75	0.74	2.23	51.54	50.16	-1.91	0.25	86.86	46.09	0.75	7.22	0.14
SO4	WIN	26	0.51	0.45	0.67	-13.08	49.44	-0.07	0.25	0.14	43.49	15.36	-0.15	72.69	53.95	0.57	0.38	0.45
SO4	SPR	31	0.62	0.66	0.59	5.36	53.31	0.03	0.33	0.28	62.51	16.51	0.05	90.63	52.49	0.53	0.53	0.35
SO4	SUM	28	0.53	0.49	0.51	-6.68	27.99	-0.04	0.15	0.04	-2.3	-8.92	-0.07	28.11	27.48	0.3	0.21	0.26
SO4	FAL	21	0.41	0.52	0.59	25.88	40.49	0.11	0.17	0.04	46.8	25.98	0.26	56.87	37.07	0.4	0.22	0.35
SO4	ALL	106	0.53	0.54	0.58	0.98	43.72	0.01	0.23	0.14	37.61	11.39	0.01	63.03	43.19	0.44	0.37	0.34

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: OKEF1																		
EC	WIN	29	0.37	0.51	0.61	36.51	60.49	0.14	0.23	0.15	36.15	18.88	0.37	52.43	39.46	0.6	0.41	0.37
EC	SPR	31	0.75	0.43	0.2	-42.2	70.68	-0.32	0.53	1.76	6.31	-13.42	-0.73	48.6	47.11	1.22	1.36	0.04
EC	SUM	28	0.28	0.31	0.44	8.38	54.94	0.02	0.15	0.04	156.4	2.28	0.08	199.48	57.75	0.55	0.21	0.19
EC	FAL	30	0.33	0.22	0.47	-32.36	45.43	-0.11	0.15	0.06	-13.91	-24.96	-0.48	36.5	42	0.67	0.27	0.23
EC	ALL	118	0.44	0.37	0.23	-16.25	61.36	-0.07	0.27	0.55	44.12	-4.69	-0.19	82.27	46.46	0.73	0.75	0.05
NO3	WIN	29	0.34	0.57	0.52	67.7	108.99	0.23	0.37	0.28	67.62	6.33	0.68	113.91	78.36	1.09	0.57	0.27
NO3	SPR	31	0.34	0.22	0.12	-34.99	75.89	-0.12	0.26	0.11	-16.1	-57.12	-0.54	77.19	95.64	1.17	0.35	0.01
NO3	SUM	28	0.18	0.13	0.34	-27.21	74.81	-0.05	0.13	0.03	-29.82	-79.07	-0.37	80.68	104.79	1.03	0.18	0.12
NO3	FAL	29	0.24	0.23	0.46	-2.79	85.67	-0.01	0.2	0.08	-10.28	-52.84	-0.03	79.52	91.26	0.88	0.29	0.21
NO3	ALL	117	0.28	0.29	0.39	4.56	87.95	0.01	0.24	0.14	2.81	-45.59	0.05	87.7	92.46	0.88	0.38	0.15
OC	WIN	29	1.84	2.19	0.43	19.18	59.56	0.35	1.1	3.95	19.8	1.87	0.19	47.9	39.98	0.6	2.02	0.18
OC	SPR	31	5.5	2.28	0.19	-58.45	72.13	-3.21	3.97	133.26	-18.55	-36.14	-1.41	42.36	52.07	1.74	11.98	0.03
OC	SUM	28	3	2.46	0.46	-18.14	56.72	-0.54	1.7	6.03	8.2	-19.55	-0.22	68.55	63.31	0.69	2.51	0.22
OC	FAL	30	3.25	1.21	0.65	-62.64	66.85	-2.04	2.17	35.59	-28.71	-46.17	-1.68	43.54	58.27	1.79	6.3	0.42
OC	ALL	118	3.44	2.03	0.23	-40.88	66.01	-1.4	2.27	48.35	-5.36	-25.41	-0.69	50.23	53.34	1.12	7.09	0.05
PM-2.5	WIN	29	7.1	8.35	0.48	17.64	43.82	1.25	3.11	23.3	18.92	7.43	0.18	40	33.09	0.44	4.99	0.23
PM-2.5	SPR	29	9.84	7.81	0.48	-20.62	37.14	-2.03	3.66	33.06	-14.98	-23.72	-0.26	29.34	34.55	0.47	6.1	0.23
PM-2.5	SUM	28	10.95	7.31	0.53	-33.18	41.21	-3.63	4.51	24.5	-24.96	-40.6	-0.5	41.7	53.14	0.62	6.14	0.28
PM-2.5	FAL	29	7.34	5.24	0.85	-28.57	33.85	-2.1	2.48	10.53	-18.72	-25.35	-0.4	27.33	32.85	0.47	3.86	0.72
PM-2.5	ALL	115	8.79	7.18	0.48	-18.31	39.04	-1.61	3.43	26	-9.81	-20.38	-0.22	34.53	38.28	0.48	5.35	0.23
SO4	WIN	29	1.9	1.7	0.62	-10.31	27.22	-0.2	0.52	0.46	0.62	-6.06	-0.11	28.25	28.1	0.3	0.71	0.38
SO4	SPR	31	2.4	1.72	0.52	-28.29	35.56	-0.68	0.85	1.02	-18.24	-28.1	-0.39	33.89	40.29	0.5	1.22	0.27
SO4	SUM	28	2.36	1.35	0.68	-42.69	46.96	-1.01	1.11	0.81	-43.71	-65.67	-0.74	47.95	69.19	0.82	1.35	0.46
SO4	FAL	29	1.82	1.49	0.79	-17.96	31.44	-0.33	0.57	0.47	-13.9	-22.52	-0.22	31.27	37.91	0.38	0.76	0.62
SO4	ALL	117	2.12	1.57	0.62	-25.94	35.87	-0.55	0.76	0.79	-18.58	-30.25	-0.35	35.21	43.59	0.48	1.05	0.39

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: PACK1																		
EC	WIN	29	0.15	0.44	0.84	188.99	188.99	0.29	0.29	0.03	217.99	97.53	1.89	217.99	97.53	1.89	0.33	0.71
EC	SPR	31	0.1	0.23	0.58	130.83	133.44	0.13	0.13	0.01	205.5	81.27	1.31	206.46	82.31	1.33	0.18	0.34
EC	SUM	30	0.17	0.2	0.67	22.11	36.62	0.04	0.06	0.01	69.11	25.13	0.22	79.38	36.83	0.37	0.08	0.45
EC	FAL	29	0.19	0.31	0.74	59.28	62.87	0.11	0.12	0.01	93.87	52.58	0.59	95.68	54.48	0.63	0.17	0.55
EC	ALL	119	0.15	0.29	0.62	92.98	98.53	0.14	0.15	0.02	146.95	64.09	0.93	150.23	67.77	0.99	0.21	0.38
NO3	WIN	28	0.42	1.22	0.65	191.48	197.14	0.8	0.83	0.52	247.53	88.07	1.91	254.92	100.73	1.97	1.08	0.42
NO3	SPR	28	0.16	0.34	0.65	108.01	154.71	0.17	0.25	0.15	509.68	25.31	1.08	549.74	82.99	1.55	0.43	0.42
NO3	SUM	21	0.1	0.06	0.15	-37.49	98.2	-0.04	0.1	0.03	616.82	-85.74	-0.6	737.29	104.52	1.57	0.17	0.02
NO3	FAL	27	0.22	0.35	0.22	59.15	115.74	0.13	0.25	0.28	255.53	10.33	0.59	301.09	78.16	1.16	0.55	0.05
NO3	ALL	104	0.23	0.52	0.65	124.1	160.92	0.29	0.38	0.36	394.76	15.9	1.24	443.68	90.86	1.61	0.67	0.42
OC	WIN	29	0.69	2.27	0.79	228.37	228.37	1.58	1.58	0.71	259.91	105.34	2.28	259.91	105.34	2.28	1.79	0.63
OC	SPR	30	0.54	1.11	0.49	105.13	112.12	0.57	0.6	0.42	165.57	73.08	1.05	168.35	76.15	1.12	0.86	0.24
OC	SUM	29	1.34	1.12	0.68	-16.61	32.2	-0.22	0.43	0.48	-3.73	-12.01	-0.2	33.11	33.78	0.39	0.73	0.47
OC	FAL	29	0.79	1.28	0.65	61.35	68.79	0.49	0.55	0.28	114.64	52.73	0.61	118.37	56.91	0.69	0.72	0.42
OC	ALL	117	0.84	1.44	0.37	71.72	93.97	0.6	0.79	0.88	134.37	54.94	0.72	145.13	68.11	0.94	1.11	0.13
PM-2.5	WIN	29	3.44	8	0.85	132.43	133.71	4.56	4.6	7.62	153.01	78.25	1.32	154.38	79.77	1.34	5.33	0.72
PM-2.5	SPR	31	3.05	5.25	0.56	72.17	75.66	2.2	2.31	6.03	262.53	53.18	0.72	264.44	55.31	0.76	3.3	0.31
PM-2.5	SUM	30	5.75	4.6	0.66	-19.91	37.56	-1.14	2.16	7.39	37.97	-17.09	-0.25	86.13	44.44	0.47	2.95	0.44
PM-2.5	FAL	29	4.17	5.36	0.73	28.56	40.54	1.19	1.69	5.15	76.92	37.06	0.29	83.3	44.09	0.41	2.56	0.54
PM-2.5	ALL	119	4.1	5.78	0.49	41.15	65.38	1.69	2.68	10.71	134	37.65	0.41	148.52	55.79	0.65	3.68	0.24
SO4	WIN	28	1	1.01	0.87	0.77	23.5	0.01	0.24	0.09	11.9	5.04	0.01	30.48	27.34	0.24	0.3	0.76
SO4	SPR	29	0.92	1.55	0.65	67.4	70.13	0.62	0.65	0.68	1081.17	48.36	0.67	1083.93	51.32	0.7	1.03	0.42
SO4	SUM	21	1.44	1.5	0.73	3.69	35.5	0.05	0.51	0.55	141.3	5.13	0.04	170.16	42.59	0.35	0.75	0.53
SO4	FAL	27	1.23	1.37	0.85	11.2	34.28	0.14	0.42	0.34	69.19	29.58	0.11	82.65	44.86	0.34	0.6	0.73
SO4	ALL	105	1.13	1.35	0.72	19.53	40.16	0.22	0.45	0.47	347.84	23.33	0.2	362.78	41.52	0.4	0.72	0.52

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: PENO1																		
EC	WIN	28	0.47	0.37	0.82	-20.61	32.6	-0.1	0.15	0.06	7.98	-5.33	-0.26	39.03	34	0.41	0.26	0.67
EC	SPR	28	0.22	0.2	0.68	-11.11	45.35	-0.02	0.1	0.04	23.75	8.49	-0.12	46.93	39.1	0.51	0.2	0.46
EC	SUM	30	0.2	0.19	0.49	-7.96	31.85	-0.02	0.07	0.01	-0.17	-8.65	-0.09	30.87	31.97	0.35	0.12	0.24
EC	FAL	25	0.32	0.25	0.64	-24.12	36.58	-0.08	0.12	0.05	-15.47	-24.17	-0.32	30.61	37.11	0.48	0.23	0.41
EC	ALL	111	0.3	0.25	0.75	-17.36	35.81	-0.05	0.11	0.04	4.47	-6.99	-0.21	36.92	35.44	0.43	0.21	0.56
NO3	WIN	28	0.49	1.18	0.8	142.74	144.09	0.69	0.7	0.54	174.25	72.12	1.43	178.6	77.27	1.44	1.01	0.64
NO3	SPR	25	0.18	0.3	0.37	65.4	120.91	0.12	0.22	0.09	117.6	5.49	0.65	171.57	92.33	1.21	0.33	0.14
NO3	SUM	27	0.11	0.04	0.38	-69.06	76.74	-0.08	0.09	0.01	-62.28	-113.19	-2.23	75	122.18	2.48	0.12	0.14
NO3	FAL	25	0.25	0.43	0.89	72.68	97.94	0.18	0.25	0.15	45.14	-13.16	0.73	108.13	88.99	0.98	0.42	0.78
NO3	ALL	105	0.26	0.5	0.83	90.26	122.18	0.24	0.32	0.29	69.2	-11.7	0.9	133.51	95.19	1.22	0.59	0.68
OC	WIN	28	1.68	1.69	0.85	0.83	26.03	0.01	0.44	0.38	16.31	8.96	0.01	31.71	27.27	0.26	0.62	0.72
OC	SPR	28	0.92	0.83	0.82	-8.8	34.13	-0.08	0.31	0.22	7.08	-2.37	-0.1	37.38	35.01	0.37	0.47	0.67
OC	SUM	30	1.27	0.83	0.76	-34.45	40.93	-0.44	0.52	0.22	-34.51	-49.83	-0.53	42.67	55.69	0.62	0.64	0.58
OC	FAL	25	1.33	0.93	0.86	-30.47	34.57	-0.41	0.46	0.34	-26.33	-34.99	-0.44	32.49	40.37	0.5	0.71	0.74
OC	ALL	111	1.3	1.07	0.81	-17.45	33.39	-0.23	0.43	0.33	-9.36	-19.69	-0.21	36.28	39.86	0.4	0.61	0.66
PM-2.5	WIN	28	6.21	6.66	0.79	7.2	32.38	0.45	2.01	6.53	15.81	8.77	0.07	33.99	30.39	0.32	2.59	0.62
PM-2.5	SPR	27	3.88	4.51	0.66	16.21	36.54	0.63	1.42	4.32	28.64	14.69	0.16	42.13	30.49	0.37	2.17	0.44
PM-2.5	SUM	30	5.34	3.8	0.75	-28.99	38.96	-1.55	2.08	3.42	-25.57	-37.7	-0.41	39.98	48.55	0.55	2.41	0.57
PM-2.5	FAL	24	4.87	4.46	0.9	-8.53	23.52	-0.42	1.15	2.47	-3.52	-11.53	-0.09	29.63	30.45	0.26	1.63	0.81
PM-2.5	ALL	109	5.1	4.85	0.77	-4.85	33.2	-0.25	1.69	5.02	3.35	-7.03	-0.05	36.7	35.42	0.35	2.25	0.59
SO4	WIN	28	1.34	0.9	0.72	-32.76	34.82	-0.44	0.47	0.34	-23.74	-32.09	-0.49	29.56	37.22	0.52	0.73	0.52
SO4	SPR	25	1.03	1.55	0.45	51.3	70.66	0.53	0.72	1.29	65.89	29.28	0.51	79.68	45.86	0.71	1.25	0.20
SO4	SUM	27	1.07	1.42	0.71	32.86	57.81	0.35	0.62	0.9	63.33	23.09	0.33	85.33	51.97	0.58	1.01	0.51
SO4	FAL	25	1.06	1.13	0.71	6.78	38.76	0.07	0.41	0.37	34.41	10.77	0.07	58.19	41.28	0.39	0.62	0.51
SO4	ALL	105	1.13	1.24	0.53	10.28	49.07	0.12	0.55	0.86	33.84	6.92	0.1	62.65	44.03	0.49	0.93	0.28

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: PMRF1																		
EC	WIN	29	0.21	0.38	0.79	81.19	85.18	0.17	0.18	0.02	113.73	58.25	0.81	117.28	62.33	0.85	0.22	0.62
EC	SPR	31	0.11	0.15	0.44	35.75	58.25	0.04	0.07	0.01	69.52	26.17	0.36	87.66	48.32	0.58	0.09	0.19
EC	SUM	30	0.19	0.14	0.83	-28.71	30.73	-0.05	0.06	0	-22.07	-28.34	-0.4	25.86	31.81	0.43	0.09	0.69
EC	FAL	24	0.19	0.24	0.62	26.68	45.52	0.05	0.09	0.01	41.53	23.16	0.27	55.74	40.66	0.46	0.11	0.38
EC	ALL	114	0.17	0.22	0.64	28.9	55.55	0.05	0.1	0.02	50.77	19.35	0.29	72.21	45.93	0.56	0.14	0.41
NO3	WIN	29	0.93	1.54	0.86	65.3	83.26	0.61	0.78	0.63	176.73	67.21	0.65	185.9	78.1	0.83	1	0.73
NO3	SPR	31	0.18	0.48	0.64	165.78	185.61	0.3	0.34	0.18	185.45	41.9	1.66	212.32	85.65	1.86	0.52	0.41
NO3	SUM	27	0.06	0.04	0.12	-22.8	65.86	-0.01	0.04	0	12.99	-42.6	-0.3	95.98	77.35	0.85	0.05	0.02
NO3	FAL	24	0.25	0.46	0.45	84.02	106.92	0.21	0.27	0.21	174.45	38.32	0.84	192.2	60.63	1.07	0.51	0.20
NO3	ALL	111	0.36	0.65	0.84	78.84	100.46	0.29	0.36	0.31	138.84	27.18	0.79	172.77	76.25	1	0.63	0.70
OC	WIN	29	0.99	1.96	0.82	96.81	99.3	0.96	0.99	0.47	131.04	66.7	0.97	133.68	69.62	0.99	1.18	0.68
OC	SPR	31	0.59	0.8	0.52	35.15	54.71	0.21	0.32	0.19	45.95	24.43	0.35	61.11	42.87	0.55	0.48	0.27
OC	SUM	30	1.59	0.83	0.62	-48.24	48.24	-0.77	0.77	0.83	-43.69	-59.89	-0.93	43.69	59.89	0.93	1.19	0.39
OC	FAL	24	0.9	1.07	0.55	18.49	41.68	0.17	0.38	0.23	35.75	17.7	0.18	53.02	38.39	0.42	0.51	0.30
OC	ALL	114	1.02	1.16	0.41	13.11	60.65	0.13	0.62	0.83	41.86	11.58	0.13	73.28	53.21	0.61	0.92	0.17
PM-2.5	WIN	29	4.99	7.75	0.87	55.26	61.09	2.76	3.05	6.04	83.73	48.6	0.55	87.96	53.43	0.61	3.69	0.76
PM-2.5	SPR	31	3.01	4.24	0.69	40.83	47.48	1.23	1.43	2.26	46.06	28.64	0.41	53.59	38.53	0.47	1.94	0.48
PM-2.5	SUM	30	6.5	3.86	0.77	-40.55	44.9	-2.64	2.92	7.81	-36.1	-51.59	-0.68	44.49	58.08	0.76	3.84	0.59
PM-2.5	FAL	24	4.14	5.05	0.61	21.78	41.23	0.9	1.71	4.81	46.26	24.49	0.22	58.96	39.62	0.41	2.37	0.37
PM-2.5	ALL	114	4.67	5.2	0.66	11.39	49.07	0.53	2.29	9.28	34.06	11.73	0.11	61.07	47.69	0.49	3.09	0.43
SO4	WIN	29	1.21	0.93	0.92	-23.18	27.15	-0.28	0.33	0.16	-12.51	-18.39	-0.3	26.42	29.2	0.35	0.49	0.85
SO4	SPR	31	0.92	1.19	0.77	29.29	42.99	0.27	0.4	0.22	39.31	20.15	0.29	53.97	37.95	0.43	0.54	0.60
SO4	SUM	27	1.51	1.2	0.89	-20.61	36.88	-0.31	0.56	0.64	-0.58	-20.1	-0.26	47.85	44.45	0.46	0.86	0.79
SO4	FAL	24	1.19	1.2	0.83	0.73	33.85	0.01	0.4	0.3	34.93	14.37	0.01	55.47	38.65	0.34	0.55	0.68
SO4	ALL	111	1.2	1.13	0.82	-5.96	34.98	-0.07	0.42	0.38	15.12	-0.96	-0.06	45.61	37.4	0.37	0.62	0.67

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: PRIS1																		
EC	WIN	29	0.26	0.2	0.75	-23.36	29.72	-0.06	0.08	0.01	-7.51	-15.36	-0.3	28.51	31	0.39	0.13	0.56
EC	SPR	31	0.14	0.11	0.71	-23.12	38.42	-0.03	0.05	0	-6.09	-16.81	-0.3	38.86	41.69	0.5	0.08	0.51
EC	SUM	31	0.18	0.11	0.59	-37.67	40.43	-0.07	0.07	0	-30.13	-42.55	-0.6	38.83	49.53	0.65	0.09	0.35
EC	FAL	30	0.22	0.17	0.72	-25.24	34.07	-0.06	0.08	0.01	-20.94	-29.47	-0.34	32.56	39.22	0.46	0.1	0.52
EC	ALL	121	0.2	0.15	0.75	-27.16	34.96	-0.05	0.07	0.01	-16.27	-26.2	-0.37	34.81	40.53	0.48	0.1	0.56
NO3	WIN	29	0.36	0.79	0.74	116.29	121.8	0.42	0.44	0.24	126.82	55.77	1.16	136.44	69.5	1.22	0.64	0.54
NO3	SPR	31	0.16	0.3	0.42	88.1	112.14	0.14	0.18	0.05	187.19	53.07	0.88	204.97	77.6	1.12	0.26	0.18
NO3	SUM	31	0.06	0.05	0.16	-23.06	77.58	-0.01	0.05	0	4.5	-42.19	-0.3	86.4	88.36	1.01	0.07	0.02
NO3	FAL	30	0.14	0.4	0.5	184.17	205.58	0.26	0.29	0.29	310.35	17.11	1.84	355.31	85.9	2.06	0.59	0.25
NO3	ALL	121	0.18	0.37	0.7	110.95	132.06	0.2	0.23	0.17	156.45	20.4	1.11	195.44	80.47	1.32	0.45	0.48
OC	WIN	29	1.01	0.96	0.79	-4.91	22.81	-0.05	0.23	0.11	6.2	0.61	-0.05	26.11	23.88	0.24	0.33	0.62
OC	SPR	31	0.6	0.52	0.68	-13.58	30.89	-0.08	0.19	0.07	-0.12	-8.26	-0.16	31.42	32.65	0.36	0.27	0.46
OC	SUM	31	1.47	0.77	0.6	-47.41	49.13	-0.7	0.72	0.58	-43.93	-61.8	-0.9	45.64	63.41	0.93	1.03	0.36
OC	FAL	30	1.07	0.8	0.77	-24.58	32.46	-0.26	0.35	0.13	-21.27	-29.06	-0.33	30.93	36.67	0.43	0.45	0.60
OC	ALL	121	1.04	0.76	0.65	-26.62	36.01	-0.28	0.37	0.29	-15.07	-25.01	-0.36	33.67	39.42	0.49	0.61	0.43
PM-2.5	WIN	29	4.37	4.33	0.81	-0.85	21.63	-0.04	0.95	1.79	0.62	-3.45	-0.01	21.16	22.38	0.22	1.34	0.65
PM-2.5	SPR	31	3.39	3.22	0.61	-5.03	28.22	-0.17	0.96	1.69	7.42	-1.43	-0.05	34.14	30.38	0.3	1.31	0.38
PM-2.5	SUM	31	5.04	3.21	0.7	-36.34	37.61	-1.83	1.9	3.98	-31.84	-43.44	-0.57	34.97	46.28	0.59	2.71	0.50
PM-2.5	FAL	30	4.17	4.03	0.65	-3.36	35.3	-0.14	1.47	4.43	1.27	-9.48	-0.03	37.84	35.59	0.37	2.11	0.43
PM-2.5	ALL	121	4.24	3.69	0.64	-13.12	31.18	-0.56	1.32	3.54	-5.79	-14.67	-0.15	32.16	33.83	0.36	1.96	0.41
SO4	WIN	29	1.05	0.78	0.87	-26.09	29.68	-0.27	0.31	0.07	-25.03	-31.51	-0.35	28.68	34.63	0.4	0.38	0.76
SO4	SPR	31	0.86	1.13	0.05	31.86	57.47	0.27	0.49	0.35	59.29	26.71	0.32	76.24	47.94	0.57	0.65	0.00
SO4	SUM	31	0.82	0.98	0.67	20.4	50.54	0.17	0.41	0.34	49.94	22.72	0.2	67.64	46.6	0.51	0.61	0.45
SO4	FAL	30	0.93	1.08	0.66	16.86	44.97	0.16	0.42	0.34	38.33	19.51	0.17	56.92	41.41	0.45	0.61	0.43
SO4	ALL	121	0.91	1	0.57	9.4	45.03	0.09	0.41	0.32	31.49	9.95	0.09	57.85	42.79	0.45	0.57	0.33

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: QUCI1																		
EC	WIN	29	0.36	0.56	0.87	54.16	56.03	0.2	0.2	0.04	58.41	40.05	0.54	59.65	41.39	0.56	0.28	0.76
EC	SPR	30	0.29	0.27	0.52	-6.43	34.99	-0.02	0.1	0.02	5.86	-2.36	-0.07	33.8	32.78	0.37	0.14	0.27
EC	SUM	31	0.35	0.26	0.65	-25.8	28.96	-0.09	0.1	0.01	-21.9	-27.85	-0.35	26.51	32.04	0.39	0.13	0.43
EC	FAL	28	0.3	0.38	0.41	26.26	45.95	0.08	0.14	0.03	37.84	20.57	0.26	54.03	39.8	0.46	0.19	0.17
EC	ALL	118	0.33	0.36	0.59	11.76	41.42	0.04	0.13	0.03	19.07	6.81	0.12	43.04	36.37	0.41	0.19	0.35
NO3	WIN	23	1.33	1.82	0.57	36.48	70.58	0.49	0.94	1.29	124.85	31.07	0.36	153.03	69.45	0.71	1.23	0.33
NO3	SPR	31	0.65	0.91	0.38	38.6	92.74	0.25	0.61	1.08	116.99	2.34	0.39	164.46	70.74	0.93	1.07	0.15
NO3	SUM	28	0.18	0.15	0.71	-13.63	45.72	-0.02	0.08	0.01	-14.79	-28.6	-0.16	41.59	50.15	0.53	0.1	0.51
NO3	FAL	27	0.35	0.52	0.67	50.6	87.69	0.18	0.3	0.16	77.18	28.29	0.51	104.98	67.16	0.88	0.44	0.45
NO3	ALL	109	0.6	0.81	0.65	35.35	78.03	0.21	0.47	0.65	74.93	6.88	0.35	115.75	64.29	0.78	0.84	0.43
OC	WIN	29	1.36	2.43	0.9	78.36	78.36	1.07	1.07	0.67	86.78	54.99	0.78	86.78	54.99	0.78	1.34	0.82
OC	SPR	30	1.05	1.23	0.6	17.1	47.95	0.18	0.5	0.36	28.87	13.82	0.17	52.94	42.95	0.48	0.62	0.36
OC	SUM	31	1.5	1.42	0.52	-5.45	35.25	-0.08	0.53	0.47	0.8	-11.81	-0.06	40.67	38.46	0.37	0.69	0.27
OC	FAL	28	0.99	1.61	0.81	63.59	73.45	0.63	0.72	0.74	59.78	35.23	0.64	70.01	48.52	0.73	1.06	0.65
OC	ALL	118	1.23	1.66	0.68	35.4	57.01	0.44	0.7	0.75	43.06	22.29	0.35	62.08	46.05	0.57	0.97	0.46
PM-2.5	WIN	27	7.91	10.83	0.84	36.94	39.61	2.92	3.13	8.55	44.09	31.05	0.37	47.14	34.31	0.4	4.13	0.71
PM-2.5	SPR	31	7.37	7.09	0.58	-3.82	34.63	-0.28	2.55	11.26	6.23	-1.19	-0.04	33.01	32.17	0.36	3.37	0.34
PM-2.5	SUM	31	12.22	8.41	0.83	-31.19	31.42	-3.81	3.84	9.84	-28.83	-36.19	-0.45	29.68	36.99	0.46	4.94	0.69
PM-2.5	FAL	28	6.46	7.68	0.81	18.88	35.05	1.22	2.26	6.48	28.38	16.18	0.19	45.22	37.25	0.35	2.82	0.65
PM-2.5	ALL	117	8.56	8.44	0.65	-1.39	34.56	-0.12	2.96	15.29	10.98	1.13	-0.01	38.31	35.16	0.35	3.91	0.43
SO4	WIN	23	2.46	1.65	0.83	-32.83	35.11	-0.81	0.86	0.73	-29.18	-37.55	-0.49	31.43	39.7	0.52	1.18	0.68
SO4	SPR	31	2.68	1.94	0.76	-27.56	34.78	-0.74	0.93	1.27	-22.96	-31.14	-0.38	30.11	37.42	0.48	1.35	0.57
SO4	SUM	28	4.83	3.48	0.85	-27.97	30.03	-1.35	1.45	2.77	-21.16	-27.86	-0.39	26.34	32.56	0.42	2.14	0.73
SO4	FAL	27	2.14	2.06	0.9	-4.03	24.61	-0.09	0.53	0.49	-2.42	-9.83	-0.04	30.27	32.09	0.26	0.71	0.81
SO4	ALL	109	3.05	2.3	0.85	-24.53	31.14	-0.75	0.95	1.55	-18.72	-26.37	-0.33	29.46	35.33	0.41	1.45	0.72

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: QURE1																		
EC	WIN	28	0.29	0.69	0.9	135.22	135.22	0.4	0.4	0.05	161.88	83.84	1.35	161.88	83.84	1.35	0.46	0.81
EC	SPR	31	0.17	0.3	0.51	78.33	88.36	0.13	0.15	0.02	109	56.39	0.78	114.44	62.52	0.88	0.19	0.26
EC	SUM	31	0.25	0.3	0.74	18.62	34.36	0.05	0.09	0.01	46.81	27.24	0.19	55	37.04	0.34	0.11	0.55
EC	FAL	29	0.31	0.41	0.79	33.33	43.73	0.1	0.13	0.02	55.05	34.01	0.33	61.87	42.16	0.44	0.17	0.63
EC	ALL	119	0.25	0.42	0.71	65.17	74.05	0.17	0.19	0.04	92.09	49.8	0.65	97.31	55.94	0.74	0.26	0.51
NO3	WIN	28	0.69	1.88	0.78	170.8	173.53	1.18	1.2	0.83	267.93	91.6	1.71	273.49	100.7	1.74	1.49	0.62
NO3	SPR	31	0.33	0.67	0.48	105.31	144.05	0.34	0.47	0.55	137.69	32.99	1.05	169.95	79.15	1.44	0.82	0.23
NO3	SUM	31	0.14	0.12	0.32	-14.57	76.24	-0.02	0.11	0.03	1.69	-46.89	-0.17	86.08	75	0.89	0.17	0.10
NO3	FAL	29	0.3	0.55	0.66	84.62	106.45	0.25	0.32	0.16	97.6	31.6	0.85	124.48	69.14	1.06	0.47	0.44
NO3	ALL	119	0.36	0.78	0.78	118.58	142.85	0.42	0.51	0.58	123.14	25.63	1.19	161.38	80.7	1.43	0.87	0.61
OC	WIN	28	1.12	3.43	0.84	205.51	205.51	2.31	2.31	1.87	227.42	99.79	2.06	227.42	99.79	2.06	2.68	0.70
OC	SPR	31	0.77	1.34	0.41	74.27	92.52	0.57	0.71	0.61	113.97	53.43	0.74	123.52	64.32	0.93	0.97	0.17
OC	SUM	31	1.58	1.26	0.68	-20.27	32.54	-0.32	0.51	0.6	-12.99	-21.41	-0.25	32.5	35.96	0.41	0.84	0.46
OC	FAL	29	1.15	1.51	0.77	30.52	45.37	0.35	0.52	0.31	39.89	25.1	0.31	52.42	39.67	0.45	0.66	0.60
OC	ALL	119	1.16	1.85	0.43	60.05	85.57	0.69	0.99	1.74	89.54	37.94	0.6	106.93	59.27	0.86	1.49	0.18
PM-2.5	WIN	28	4.73	11.55	0.92	144.12	144.24	6.82	6.82	14.85	149.76	82.02	1.44	149.92	82.17	1.44	7.83	0.85
PM-2.5	SPR	31	4.27	6.3	0.6	47.47	60.58	2.03	2.59	7.54	66.48	39.49	0.47	73.26	47	0.61	3.41	0.36
PM-2.5	SUM	31	6.48	5.24	0.79	-19.11	31.02	-1.24	2.01	5.21	-9.26	-18.39	-0.24	34.2	36.38	0.38	2.6	0.62
PM-2.5	FAL	29	4.96	6.49	0.8	30.89	43.54	1.53	2.16	4.55	47.2	30.3	0.31	56.95	42	0.44	2.62	0.64
PM-2.5	ALL	119	5.12	7.3	0.54	42.61	64.99	2.18	3.33	16.13	61.65	32.18	0.43	77.15	51.29	0.65	4.57	0.30
SO4	WIN	28	1.2	1.03	0.83	-14.4	23.21	-0.17	0.28	0.13	-8.6	-12.53	-0.17	21.01	23.36	0.27	0.4	0.69
SO4	SPR	31	1.33	1.56	0.82	17.73	28.04	0.24	0.37	0.33	34.63	15.99	0.18	44.12	26.42	0.28	0.62	0.67
SO4	SUM	31	1.59	1.41	0.74	-11.17	35.78	-0.18	0.57	0.65	11.67	-6.58	-0.13	47.81	41.96	0.4	0.82	0.54
SO4	FAL	29	1.35	1.38	0.87	2.14	26.78	0.03	0.36	0.26	23.62	9.81	0.02	44.23	35.07	0.27	0.51	0.76
SO4	ALL	119	1.37	1.35	0.79	-1.36	29.08	-0.02	0.4	0.38	15.79	1.89	-0.01	39.67	31.86	0.29	0.62	0.62

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: RICR1																		
EC	WIN	5	0.02	0.03	0.08	41.16	61.41	0.01	0.01	0	76.71	41.98	0.41	88.97	56.46	0.61	0.02	0.01
EC	SPR	13	0.03	0.03	0.43	-12.33	52.7	0	0.02	0	30.05	8.76	-0.14	60.71	49.1	0.6	0.03	0.18
EC	SUM	20	0.07	0.08	0.75	22.12	69.38	0.01	0.05	0.01	11.85	-4.55	0.22	48.82	43.01	0.69	0.11	0.57
EC	FAL	6	0.07	0.07	0.55	4.5	41.33	0	0.03	0	27.63	3.25	0.05	63.52	47.43	0.41	0.03	0.31
EC	ALL	44	0.05	0.06	0.69	13.17	60.69	0.01	0.03	0.01	26.75	5.73	0.13	58.9	46.94	0.61	0.08	0.47
NO3	WIN	6	0.1	0.03	0.53	-69.63	69.63	-0.07	0.07	0	-64.76	-99.81	-2.29	64.76	99.81	2.29	0.09	0.28
NO3	SPR	13	0.14	0.05	0.67	-61.28	64.77	-0.09	0.09	0.01	-51.38	-86.99	-1.58	59.49	94.16	1.67	0.13	0.45
NO3	SUM	20	0.07	0.01	0.81	-83.03	83.03	-0.06	0.06	0	-83.58	-144.65	-4.89	83.58	144.65	4.89	0.07	0.65
NO3	FAL	6	0.05	0.01	0.59	-71.77	71.77	-0.04	0.04	0	-72.42	-115.41	-2.54	72.42	115.41	2.54	0.04	0.35
NO3	ALL	45	0.09	0.03	0.73	-70.61	72.17	-0.06	0.07	0	-70.28	-118.12	-2.4	72.62	120.19	2.46	0.09	0.54
OC	WIN	6	0.12	0.09	0.43	-21.34	48.32	-0.03	0.06	0.01	189.02	8.07	-0.27	230.88	63.65	0.61	0.08	0.18
OC	SPR	13	0.19	0.11	0.53	-39.6	50.1	-0.08	0.1	0.01	-14.02	-30.05	-0.66	45.84	52.91	0.83	0.14	0.28
OC	SUM	20	0.6	0.56	0.85	-6.35	35.28	-0.04	0.21	0.15	-9.81	-16.22	-0.07	27.12	30.33	0.38	0.39	0.73
OC	FAL	6	0.5	0.47	0.55	-7.25	32.11	-0.04	0.16	0.03	-4.49	-10.31	-0.08	30.26	31.61	0.35	0.19	0.30
OC	ALL	45	0.4	0.36	0.85	-11.6	37.27	-0.05	0.15	0.08	16.19	-16.19	-0.13	60.11	41.47	0.42	0.28	0.73
PM-2.5	WIN	6	1	0.94	0.1	-6.52	27.39	-0.07	0.27	0.11	1.63	-4.17	-0.07	28.21	28.48	0.29	0.34	0.01
PM-2.5	SPR	13	2.91	1.37	0.75	-52.83	55.96	-1.54	1.63	4.02	-33.16	-49.56	-1.12	43.34	57.2	1.19	2.53	0.57
PM-2.5	SUM	20	3.17	1.84	0.79	-42.07	46.74	-1.33	1.48	1.04	-45.08	-61.08	-0.73	47.1	62.92	0.81	1.68	0.62
PM-2.5	FAL	6	2.92	1.85	0.75	-36.66	36.66	-1.07	1.07	0.18	-36.07	-45.19	-0.58	36.07	45.19	0.58	1.15	0.57
PM-2.5	ALL	45	2.77	1.58	0.65	-42.86	47.19	-1.19	1.31	1.88	-34.21	-48.04	-0.75	42.02	54.31	0.83	1.81	0.42
SO4	WIN	6	0.21	0.37	0.01	81.03	81.03	0.17	0.17	0.01	108.6	59.53	0.81	108.6	59.53	0.81	0.21	0.00
SO4	SPR	13	0.51	0.42	0.61	-18.77	47.92	-0.1	0.25	0.17	10.93	-4.43	-0.23	47.39	43.61	0.59	0.42	0.37
SO4	SUM	20	0.51	0.35	0.74	-32.18	32.24	-0.16	0.16	0.01	-30.47	-38.3	-0.47	30.53	38.37	0.48	0.2	0.55
SO4	FAL	6	0.4	0.43	0.88	5.84	9.02	0.02	0.04	0	5.73	5.2	0.06	8.54	8.14	0.09	0.04	0.78
SO4	ALL	45	0.46	0.38	0.55	-16.55	37.54	-0.08	0.17	0.07	4.86	-9.67	-0.2	42.88	38.67	0.45	0.27	0.30

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: ROMA1																		
EC	WIN	29	0.34	0.4	0.75	19.08	39.94	0.06	0.13	0.04	31.17	20.66	0.19	43.16	36.96	0.4	0.21	0.57
EC	SPR	31	0.31	0.3	0.89	-1.71	31.69	-0.01	0.1	0.02	5.86	-7.56	-0.02	42.64	41.09	0.32	0.14	0.80
EC	SUM	30	0.24	0.17	0.64	-29.04	45.97	-0.07	0.11	0.02	-8.13	-20.87	-0.41	44.09	48.8	0.65	0.17	0.42
EC	FAL	30	0.2	0.22	0.79	11.67	36.29	0.02	0.07	0.01	39.79	18.15	0.12	57.5	39.43	0.36	0.1	0.62
EC	ALL	120	0.27	0.27	0.78	0.83	38.22	0	0.1	0.03	16.96	2.36	0.01	46.84	41.6	0.38	0.16	0.61
NO3	WIN	29	0.47	0.55	0.16	16.72	74.22	0.08	0.35	0.23	42.37	-5.68	0.17	92.86	66.74	0.74	0.49	0.02
NO3	SPR	15	0.36	0.35	0.19	-4.98	70.6	-0.02	0.26	0.1	7.58	-28.89	-0.05	76.52	81.44	0.74	0.32	0.03
NO3	SUM	31	0.25	0.15	0.11	-40.99	81.71	-0.1	0.21	0.06	-36.22	-90.27	-0.69	87.31	109.86	1.38	0.27	0.01
NO3	FAL	30	0.22	0.22	0.61	-0.78	71.58	0	0.16	0.04	-3.46	-41.55	-0.01	77	84.31	0.72	0.21	0.38
NO3	ALL	105	0.32	0.31	0.39	-3.76	74.86	-0.01	0.24	0.11	1.11	-44.22	-0.04	84.35	86.59	0.78	0.34	0.16
OC	WIN	29	1.47	1.43	0.9	-2.61	25.26	-0.04	0.37	0.39	-7.57	-12.87	-0.03	23.94	26.34	0.26	0.63	0.80
OC	SPR	31	1.85	1.38	0.87	-25.38	35.85	-0.47	0.66	0.94	-28.29	-41.01	-0.34	37.78	48.74	0.48	1.08	0.75
OC	SUM	31	2.7	1.33	0.33	-50.54	57.97	-1.36	1.56	10.59	-32.92	-54.39	-1.02	46.94	64.69	1.17	3.53	0.11
OC	FAL	30	1.05	0.94	0.75	-10.45	40.74	-0.11	0.43	0.29	-15.95	-29.64	-0.12	42.02	49.81	0.45	0.55	0.57
OC	ALL	121	1.78	1.27	0.51	-28.46	43.07	-0.51	0.77	3.4	-21.45	-34.87	-0.4	37.86	47.72	0.6	1.91	0.26
PM-2.5	WIN	28	6.68	6.9	0.82	3.18	18.38	0.21	1.23	3.16	5.68	2.28	0.03	20.44	19.57	0.18	1.79	0.68
PM-2.5	SPR	14	8.84	6.15	0.64	-30.49	36.62	-2.7	3.24	12.01	-23.53	-34.26	-0.44	34.97	44.25	0.53	4.39	0.41
PM-2.5	SUM	30	12.88	5.86	0.38	-54.48	55.79	-7.02	7.19	49.2	-49.92	-73.28	-1.2	51.83	75.05	1.23	9.92	0.14
PM-2.5	FAL	30	5.78	5.04	0.82	-12.71	23.03	-0.73	1.33	2.92	-13.52	-20.6	-0.15	24.69	30.13	0.26	1.86	0.68
PM-2.5	ALL	102	8.54	5.94	0.43	-30.36	38.5	-2.59	3.29	26.78	-20.33	-31.69	-0.44	32.92	42.38	0.55	5.79	0.18
SO4	WIN	29	1.79	1.49	0.75	-16.81	24.26	-0.3	0.43	0.31	-9.09	-13.61	-0.2	23.01	24.38	0.29	0.63	0.57
SO4	SPR	15	2.39	1.71	0.6	-28.34	33.47	-0.68	0.8	0.94	-19.22	-28.02	-0.4	29.93	36.63	0.47	1.18	0.36
SO4	SUM	31	3.2	1.83	0.8	-42.85	45.52	-1.37	1.46	0.97	-46	-67.75	-0.75	48.5	69.96	0.8	1.69	0.64
SO4	FAL	30	1.66	1.57	0.86	-5.56	23.54	-0.09	0.39	0.33	-6.63	-12.41	-0.06	23.44	26.95	0.25	0.58	0.74
SO4	ALL	105	2.25	1.64	0.72	-27.12	34.42	-0.61	0.78	0.87	-20.73	-31.31	-0.37	31.65	40.32	0.47	1.12	0.52

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: ROMO1																		
EC	WIN	26	0.05	0.8	0.33	1643.97	1643.97	0.75	0.75	1.95	2990.03	115.15	16.44	2990.03	115.15	16.44	1.59	0.11
EC	SPR	30	0.04	0.08	0.38	84.93	113.74	0.04	0.05	0.01	150.31	40.36	0.85	168.03	62.69	1.14	0.11	0.14
EC	SUM	31	0.13	0.11	0.9	-18.87	31.36	-0.03	0.04	0	-6.16	-23.97	-0.23	43.29	41.35	0.39	0.06	0.81
EC	FAL	30	0.07	0.23	0.16	229.23	252.74	0.16	0.18	0.14	327.45	51.16	2.29	343.8	71.54	2.53	0.41	0.02
EC	ALL	117	0.08	0.29	0.11	282.57	316.24	0.21	0.24	0.56	785.32	42.71	2.83	807.16	70.96	3.16	0.78	0.01
NO3	WIN	25	0.15	0.37	0.4	139.67	172.96	0.21	0.26	0.15	1198.06	49.53	1.4	1230.45	95.37	1.73	0.44	0.16
NO3	SPR	31	0.21	0.18	0.7	-17.15	96.56	-0.04	0.21	0.13	-34.79	-94.04	-0.21	89.54	113.59	1.17	0.36	0.49
NO3	SUM	31	0.1	0.02	0.35	-78.36	78.36	-0.08	0.08	0.01	-77.01	-132.12	-3.62	77.01	132.12	3.62	0.12	0.12
NO3	FAL	30	0.11	0.14	0.32	27.36	138.82	0.03	0.16	0.08	82.82	-46.68	0.27	179.32	107.68	1.39	0.29	0.10
NO3	ALL	117	0.14	0.17	0.5	15.85	118.87	0.02	0.17	0.1	247.61	-61.31	0.16	353.02	113.09	1.19	0.32	0.25
OC	WIN	26	0.23	3.43	0.3	1421.92	1421.92	3.21	3.21	37	4087.62	92.49	14.22	4087.62	92.49	14.22	6.88	0.09
OC	SPR	31	0.24	0.31	0.23	26.84	86.26	0.07	0.21	0.19	71.29	-7.24	0.27	117.87	56.36	0.86	0.44	0.05
OC	SUM	31	0.95	0.58	0.91	-38.71	43.06	-0.37	0.41	0.23	-33.29	-46.91	-0.63	39.29	51.44	0.7	0.61	0.84
OC	FAL	30	0.38	1.01	0.13	163.71	211.69	0.63	0.81	2.71	313.07	29.36	1.64	348.55	77.11	2.12	1.76	0.02
OC	ALL	118	0.46	1.25	0.07	170.35	233.08	0.79	1.08	10.74	990.24	13.62	1.7	1030.56	68.3	2.33	3.37	0.00
PM-2.5	WIN	26	1.39	8.31	0.32	497.69	501.52	6.92	6.97	162.49	788.89	71.7	4.98	793.21	77.14	5.02	14.5	0.10
PM-2.5	SPR	31	2.37	1.94	0.15	-18.14	64.92	-0.43	1.54	6.05	40.45	-16.89	-0.22	91.39	53.54	0.79	2.5	0.02
PM-2.5	SUM	31	3.87	2.05	0.9	-47.04	48.26	-1.82	1.87	1.33	-47.61	-66.28	-0.89	49.17	67.67	0.91	2.16	0.80
PM-2.5	FAL	28	1.98	3.2	0.12	61.44	108.18	1.22	2.14	16.22	85.8	5.28	0.61	127.1	59.45	1.08	4.21	0.01
PM-2.5	ALL	116	2.46	3.7	0.09	50.57	121.67	1.24	2.99	52.79	195.62	-4.88	0.51	246.03	64.03	1.22	7.37	0.01
SO4	WIN	25	0.31	0.44	0.27	40.51	106.74	0.13	0.34	0.24	163.35	68.43	0.41	175.44	85.87	1.07	0.51	0.07
SO4	SPR	31	0.44	0.48	0.37	9.46	49.55	0.04	0.22	0.13	46.6	12.39	0.09	70.24	42.37	0.5	0.37	0.14
SO4	SUM	31	0.6	0.38	0.74	-36.14	37.74	-0.22	0.23	0.02	-36.26	-48.23	-0.57	37.85	49.69	0.59	0.26	0.54
SO4	FAL	30	0.41	0.41	0.54	-0.32	34.24	0	0.14	0.03	12.24	1.29	0	40.64	36.16	0.34	0.18	0.29
SO4	ALL	117	0.45	0.43	0.33	-4.31	50.41	-0.02	0.22	0.12	40.78	5.46	-0.05	76.55	52.01	0.53	0.34	0.11

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SACR1																		
EC	WIN	26	0.15	0.18	0.57	24.78	41.33	0.04	0.06	0.01	36.42	20.37	0.25	47.23	32.52	0.41	0.11	0.32
EC	SPR	30	0.12	0.19	0.08	52.08	93.63	0.06	0.11	0.05	350.68	42.42	0.52	366.36	62.5	0.94	0.23	0.01
EC	SUM	30	0.14	0.13	0.72	-2.54	32.51	0	0.04	0.01	3.08	-8.1	-0.03	38	33.82	0.33	0.08	0.52
EC	FAL	26	0.15	0.17	0.71	18.08	31.42	0.03	0.05	0.01	22.77	13.13	0.18	35.24	27.1	0.31	0.09	0.50
EC	ALL	112	0.14	0.17	0.35	22.31	48.98	0.03	0.07	0.02	108.5	16.97	0.22	127.46	39.64	0.49	0.14	0.12
NO3	WIN	26	0.96	0.55	0.81	-42.94	47.02	-0.41	0.45	0.44	-23.2	-35.49	-0.75	36.36	46.53	0.82	0.78	0.65
NO3	SPR	28	0.32	0.15	0.49	-53.33	55.41	-0.17	0.18	0.03	-38.51	-57.29	-1.14	46.11	63.65	1.19	0.24	0.24
NO3	SUM	30	0.29	0.09	0.52	-69.4	70.06	-0.2	0.2	0.04	-56.18	-88.82	-2.27	57.97	90.4	2.29	0.28	0.27
NO3	FAL	26	0.3	0.17	0.17	-41.99	60.38	-0.12	0.18	0.04	-4.78	-36.25	-0.72	67.91	70.93	1.04	0.24	0.03
NO3	ALL	110	0.46	0.23	0.81	-49.24	54.56	-0.23	0.25	0.14	-31.74	-55.76	-0.97	52.19	68.62	1.07	0.44	0.66
OC	WIN	26	0.53	0.81	0.64	52.88	68.47	0.28	0.36	0.23	57.76	34.15	0.53	70.07	49.19	0.68	0.56	0.41
OC	SPR	30	1	0.86	0.33	-14.48	55.75	-0.15	0.56	1.08	-4.62	-19.11	-0.17	42.59	43.25	0.65	1.05	0.11
OC	SUM	30	1.1	1.1	0.55	-0.44	45.08	0	0.5	0.37	7.06	-7.68	0	48.95	48.2	0.45	0.6	0.30
OC	FAL	26	0.69	0.9	0.84	30.55	42.45	0.21	0.29	0.18	32.64	20.65	0.31	43.67	32.98	0.42	0.48	0.71
OC	ALL	112	0.85	0.92	0.46	8.67	51.37	0.07	0.44	0.51	21.64	5.55	0.09	50.93	43.57	0.51	0.72	0.22
PM-2.5	WIN	26	4.48	8.03	0.4	79.19	95.77	3.55	4.29	10.06	132.98	62.58	0.79	141.2	73.25	0.96	4.76	0.16
PM-2.5	SPR	28	10.25	6.84	0.45	-33.25	45.77	-3.41	4.69	38.18	-12.91	-25.59	-0.5	39.57	46.81	0.69	7.06	0.20
PM-2.5	SUM	30	7.99	5.97	0.21	-25.28	32.53	-2.02	2.6	9.14	-21.23	-29.71	-0.34	30.12	37.37	0.44	3.63	0.04
PM-2.5	FAL	26	5.08	6.89	0.56	35.71	48.17	1.81	2.45	5.58	51.11	30.7	0.36	60.79	41.72	0.48	2.98	0.31
PM-2.5	ALL	110	7.05	6.9	0.22	-2.13	49.61	-0.15	3.5	23.71	34.44	7.43	-0.02	66.03	49.28	0.51	4.87	0.05
SO4	WIN	26	0.81	0.62	0.74	-23.29	43.26	-0.19	0.35	0.51	14.21	1.2	-0.3	43.91	40.59	0.56	0.74	0.55
SO4	SPR	28	1.57	0.65	0.11	-58.5	59.37	-0.92	0.93	1.4	-44.45	-66.34	-1.41	46.25	67.97	1.43	1.5	0.01
SO4	SUM	30	1.64	0.84	0.49	-48.83	48.83	-0.8	0.8	0.2	-47.84	-66.88	-0.95	47.84	66.88	0.95	0.92	0.24
SO4	FAL	26	1.01	0.72	0.74	-28.7	33.14	-0.29	0.34	0.15	-17.75	-27.78	-0.4	31.88	38.53	0.46	0.49	0.55
SO4	ALL	110	1.28	0.71	0.48	-44.23	48.34	-0.56	0.62	0.67	-25.2	-41.41	-0.79	42.73	54.24	0.87	0.99	0.23

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SAFO1																		
EC	WIN	14	0.22	0.31	0.75	41.92	43.63	0.09	0.1	0.01	50.28	35.32	0.42	52.02	37.16	0.44	0.12	0.56
EC	SPR	31	0.31	0.39	0.68	25.98	49.86	0.08	0.16	0.09	20.07	7.34	0.26	41.13	32.59	0.5	0.32	0.46
EC	SUM	9	0.31	0.27	0.78	-12.64	20.21	-0.04	0.06	0	-8.5	-11.06	-0.14	17.73	19.6	0.23	0.08	0.60
EC	ALL	54	0.29	0.35	0.65	22.2	43.33	0.06	0.12	0.06	23.14	11.53	0.22	40.05	31.61	0.43	0.25	0.43
NO3	WIN	14	2.85	2.92	0.8	2.46	32.25	0.07	0.92	1.24	17.38	3.33	0.02	44.98	37.31	0.32	1.12	0.63
NO3	SPR	31	1.82	1.83	0.94	0.12	33.26	0	0.61	0.67	0.45	-18.81	0	51.38	54.03	0.33	0.82	0.88
NO3	SUM	9	0.45	0.29	0.76	-35.44	43.76	-0.16	0.2	0.06	-37.33	-55.26	-0.55	43.78	61.26	0.68	0.29	0.58
NO3	ALL	54	1.86	1.85	0.92	-0.37	33.28	-0.01	0.62	0.72	-1.46	-19.14	0	48.46	50.9	0.33	0.85	0.85
OC	WIN	14	0.91	0.93	0.76	3.01	26.26	0.03	0.24	0.08	4.14	-0.06	0.03	26.63	25.73	0.26	0.28	0.58
OC	SPR	31	1.6	1.34	0.62	-16.27	59.11	-0.26	0.95	2.02	-22.82	-40.51	-0.19	49.68	58.83	0.71	1.44	0.38
OC	SUM	9	1.9	1.58	0.91	-16.57	26.9	-0.31	0.51	0.29	-23.17	-30.38	-0.2	29.01	35.55	0.32	0.62	0.82
OC	ALL	54	1.47	1.27	0.65	-13.26	46.92	-0.19	0.69	1.25	-15.89	-28.34	-0.15	40.26	46.37	0.54	1.13	0.43
PM-2.5	WIN	14	7.61	8	0.72	5.11	28.76	0.39	2.19	7.06	17	7.49	0.05	37.43	32.89	0.29	2.69	0.52
PM-2.5	SPR	31	9.03	8.7	0.74	-3.73	37.14	-0.34	3.35	22.71	1.18	-8.02	-0.04	36.37	35.36	0.39	4.78	0.54
PM-2.5	SUM	9	9.76	7.28	0.96	-25.42	25.42	-2.48	2.48	1.28	-28.14	-34.04	-0.34	28.14	34.04	0.34	2.73	0.92
PM-2.5	ALL	54	8.78	8.28	0.74	-5.76	33.09	-0.51	2.91	15.96	0.4	-8.34	-0.06	35.27	34.5	0.35	4.03	0.55
SO4	WIN	14	1.32	1.02	0.65	-23.15	44.53	-0.31	0.59	0.56	-14.74	-27.6	-0.3	39.97	46.87	0.58	0.81	0.42
SO4	SPR	31	2.07	1.59	0.71	-23.43	36.68	-0.49	0.76	1.03	-13.53	-21.85	-0.31	30.17	34.96	0.48	1.13	0.50
SO4	SUM	9	2.54	1.78	0.93	-29.63	29.63	-0.75	0.75	0.23	-32.09	-40.55	-0.42	32.09	40.55	0.42	0.89	0.87
SO4	ALL	54	1.95	1.47	0.75	-24.72	36.53	-0.48	0.71	0.79	-16.94	-26.46	-0.33	33.03	38.98	0.49	1.01	0.56

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SAMA1																		
EC	WIN	26	0.37	0.67	0.81	83.76	96.36	0.31	0.35	0.16	76.59	40.91	0.84	88.89	56.41	0.96	0.51	0.65
EC	SPR	29	0.32	0.3	0.7	-7.81	43.66	-0.03	0.14	0.04	-0.62	-15.76	-0.08	46.86	45.38	0.47	0.21	0.49
EC	SUM	28	0.18	0.13	0.73	-26.22	42.39	-0.05	0.08	0.01	9.93	-19.53	-0.36	63.49	54.99	0.57	0.11	0.54
EC	FAL	30	0.23	0.22	0.79	-4.17	26.88	-0.01	0.06	0.01	6	-2.59	-0.04	31.96	28.64	0.28	0.09	0.62
EC	ALL	113	0.27	0.32	0.68	18.36	55.95	0.05	0.15	0.07	21.52	-0.16	0.18	56.7	45.86	0.56	0.27	0.46
NO3	WIN	21	0.37	0.82	0.19	119.48	161.34	0.45	0.6	0.56	160.22	36.52	1.19	190.96	84.31	1.61	0.87	0.03
NO3	SPR	28	0.29	0.26	0.58	-9.98	92.14	-0.03	0.27	0.15	-24.65	-69.23	-0.11	77.26	99.31	1.02	0.39	0.34
NO3	SUM	27	0.2	0.1	0.09	-50.91	88.9	-0.1	0.18	0.03	-32.82	-93.91	-1.04	92.25	123.01	1.81	0.21	0.01
NO3	FAL	23	0.19	0.27	0.62	41.43	117.83	0.08	0.22	0.13	19.49	-36.32	0.41	100.69	93.54	1.18	0.37	0.38
NO3	ALL	99	0.26	0.34	0.44	29.65	116.88	0.08	0.3	0.24	22.59	-45.88	0.3	110.91	101.25	1.17	0.5	0.20
OC	WIN	26	1.63	3.03	0.73	85.82	100.35	1.4	1.64	4.56	76.32	35.61	0.86	90.62	53.43	1	2.55	0.53
OC	SPR	29	2.16	1.57	0.42	-27.24	58.49	-0.59	1.26	5.92	-2.33	-24.83	-0.37	54.11	55.4	0.8	2.5	0.17
OC	SUM	28	1.85	1.22	0.68	-34.08	47.64	-0.63	0.88	1.19	-22.71	-38.66	-0.52	45.72	54.88	0.72	1.26	0.46
OC	FAL	30	1.31	1.26	0.65	-3.97	45.85	-0.05	0.6	0.74	-4.59	-18.82	-0.04	44	46.01	0.48	0.86	0.42
OC	ALL	113	1.74	1.74	0.39	0.03	62.13	0	1.08	3.7	10.12	-12.75	0	57.74	52.32	0.62	1.92	0.16
PM-2.5	WIN	26	6.98	10.69	0.73	53.25	70.14	3.71	4.89	38.97	47.77	24.43	0.53	65.16	44.85	0.7	7.26	0.54
PM-2.5	SPR	29	9.45	6.94	0.43	-26.58	42.72	-2.51	4.04	24.24	-19.08	-32.15	-0.36	41.18	48.65	0.58	5.53	0.18
PM-2.5	SUM	28	9.29	4.41	0.81	-52.54	52.54	-4.88	4.88	6.91	-55.17	-81.63	-1.11	55.17	81.63	1.11	5.54	0.66
PM-2.5	FAL	30	5.85	5.72	0.8	-2.27	27.98	-0.13	1.64	4.27	-0.46	-7.32	-0.02	29.56	32.21	0.29	2.07	0.64
PM-2.5	ALL	113	7.89	6.85	0.43	-13.12	48.26	-1.03	3.81	27.67	-7.7	-24.8	-0.15	47.08	51.58	0.56	5.36	0.19
SO4	WIN	21	2.1	2.23	0.48	6.47	46.83	0.14	0.98	2.2	9.29	-3.67	0.06	41.72	36.85	0.47	1.49	0.23
SO4	SPR	28	2.43	1.99	0.32	-18.07	39.44	-0.44	0.96	1.19	-10.83	-22.83	-0.22	39.68	44.43	0.48	1.18	0.10
SO4	SUM	27	2.37	1.17	0.8	-50.69	51.35	-1.2	1.22	0.62	-53.18	-79.68	-1.03	53.96	80.43	1.04	1.44	0.64
SO4	FAL	23	1.64	1.58	0.73	-3.25	37.75	-0.05	0.62	0.61	7	-7.41	-0.03	44.14	46.28	0.39	0.78	0.54
SO4	ALL	99	2.16	1.72	0.5	-20.17	44.24	-0.44	0.95	1.38	-13.97	-30.69	-0.25	45.04	53.07	0.55	1.25	0.25

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SAPE1																		
EC	WIN	28	0.03	0.05	0.82	44.23	52.28	0.01	0.02	0	94.82	49.06	0.44	100.12	54.91	0.52	0.02	0.67
EC	SPR	30	0.05	0.05	0.69	-4.86	44.7	0	0.02	0	24.19	7.95	-0.05	51.34	42.36	0.47	0.03	0.47
EC	SUM	30	0.29	0.19	0.81	-34.03	50.11	-0.1	0.14	0.11	2.31	-24.15	-0.52	58.45	50.16	0.76	0.34	0.66
EC	FAL	27	0.06	0.05	0.49	-12.37	50.12	-0.01	0.03	0	23.7	-1.17	-0.14	63.82	52.85	0.57	0.04	0.24
EC	ALL	115	0.11	0.09	0.84	-22.3	49.59	-0.02	0.05	0.03	35.56	7.45	-0.29	68	49.91	0.64	0.18	0.70
NO3	WIN	21	0.1	0.04	0.29	-60.83	78.42	-0.06	0.08	0.01	-30.5	-80.94	-1.55	83.27	108.97	2	0.13	0.08
NO3	SPR	24	0.18	0.03	0.67	-80.62	80.62	-0.14	0.14	0.01	-78.55	-131.44	-4.16	78.55	131.44	4.16	0.18	0.45
NO3	SUM	30	0.14	0.02	0.76	-85.74	85.74	-0.12	0.12	0.02	-77.34	-132.15	-6.01	77.34	132.15	6.01	0.17	0.57
NO3	FAL	23	0.06	0.02	0.3	-72.04	74.13	-0.04	0.05	0	-55.86	-94.01	-2.58	67.41	102.59	2.65	0.06	0.09
NO3	ALL	98	0.12	0.03	0.37	-78.03	81.29	-0.1	0.1	0.01	-62.56	-112.05	-3.55	76.58	120.07	3.7	0.15	0.13
OC	WIN	27	0.16	0.14	0.62	-12.88	38.3	-0.02	0.06	0.01	29.46	-0.93	-0.15	65.26	45.79	0.44	0.09	0.39
OC	SPR	30	0.35	0.18	0.66	-49.09	55.03	-0.17	0.19	0.09	-30.72	-46.93	-0.96	43.29	56.5	1.08	0.35	0.44
OC	SUM	30	2.07	1.17	0.84	-43.51	51.39	-0.9	1.06	4.54	-18.45	-36.31	-0.77	45.99	53.4	0.91	2.31	0.70
OC	FAL	27	0.3	0.28	0.69	-6.5	48.87	-0.02	0.15	0.03	186.03	-0.53	-0.07	231.97	63.01	0.52	0.18	0.48
OC	ALL	114	0.75	0.45	0.86	-39.1	50.93	-0.29	0.38	1.36	38.1	-22.25	-0.64	93.89	54.69	0.84	1.2	0.74
PM-2.5	WIN	27	1.16	1.22	0.85	5.73	24.7	0.07	0.29	0.12	14.72	8.74	0.06	29.12	24.76	0.25	0.35	0.72
PM-2.5	SPR	30	3.51	1.8	0.55	-48.77	52.36	-1.71	1.84	3.74	-35.85	-52.35	-0.95	44.15	59.4	1.02	2.58	0.31
PM-2.5	SUM	30	6.33	3.45	0.83	-45.55	47.14	-2.88	2.99	17.27	-38.46	-55.67	-0.84	42.98	59.25	0.87	5.06	0.69
PM-2.5	FAL	24	2.23	1.4	0.43	-37.18	38.23	-0.83	0.85	1	-30.45	-40.85	-0.59	32.28	42.59	0.61	1.3	0.18
PM-2.5	ALL	111	3.42	2.02	0.84	-41.05	45.49	-1.41	1.56	7.14	-23.09	-35.9	-0.7	37.61	47.3	0.77	3.02	0.70
SO4	WIN	22	0.23	0.44	0.83	95.56	95.56	0.22	0.22	0.01	130.61	71.39	0.96	130.61	71.39	0.96	0.24	0.69
SO4	SPR	24	0.55	0.47	0.63	-14.43	33.38	-0.08	0.18	0.11	1.3	-5	-0.17	28.29	28.84	0.39	0.34	0.40
SO4	SUM	30	0.68	0.47	0.67	-30.54	34.66	-0.21	0.24	0.06	-29.61	-39.63	-0.44	34.27	43.75	0.5	0.31	0.45
SO4	FAL	23	0.42	0.41	0.63	-2.99	28.86	-0.01	0.12	0.03	6.67	-0.81	-0.03	32.07	30.55	0.3	0.16	0.40
SO4	ALL	99	0.49	0.45	0.59	-7.52	39.44	-0.04	0.19	0.07	21.92	2.46	-0.08	53.72	43.21	0.43	0.28	0.35

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SENE1																		
EC	WIN	26	0.11	0.18	0.92	63.65	66.59	0.07	0.07	0	171.99	66.61	0.64	173.38	68.13	0.67	0.08	0.85
EC	SPR	30	0.1	0.12	0.82	18.1	41	0.02	0.04	0	29.18	15.18	0.18	50.76	42.47	0.41	0.05	0.68
EC	SUM	31	0.16	0.1	0.84	-39.7	43.98	-0.06	0.07	0	-28.35	-48.06	-0.66	48.76	58.4	0.73	0.09	0.71
EC	FAL	30	0.15	0.17	0.94	16.72	32.15	0.02	0.05	0	28.04	13.12	0.17	50.4	43.37	0.32	0.07	0.88
EC	ALL	117	0.13	0.14	0.81	7.55	44.11	0.01	0.06	0.01	45.38	9.32	0.08	77.38	52.62	0.44	0.08	0.65
NO3	WIN	29	1.08	1	0.73	-7.3	57.2	-0.08	0.62	1.19	50.07	-18.84	-0.08	110.46	72.45	0.62	1.09	0.53
NO3	SPR	31	0.4	0.42	0.79	5.43	61.35	0.02	0.24	0.28	38.25	-54.13	0.05	127.51	92.01	0.61	0.53	0.62
NO3	SUM	31	0.08	0.1	0.85	30.74	88.64	0.02	0.07	0.02	-33.98	-79.9	0.31	78.27	102.03	0.89	0.15	0.72
NO3	FAL	30	0.36	0.45	0.89	25.58	53.27	0.09	0.19	0.12	24.31	-30.73	0.26	92.16	82.19	0.53	0.36	0.80
NO3	ALL	121	0.47	0.49	0.79	3.33	58.7	0.02	0.28	0.4	19.12	-46.47	0.03	102.04	87.46	0.59	0.63	0.62
OC	WIN	26	0.53	0.9	0.84	68.94	74.17	0.37	0.39	0.07	146.9	66.33	0.69	149.14	68.96	0.74	0.45	0.71
OC	SPR	31	0.59	0.66	0.84	12.33	29.62	0.07	0.17	0.04	30.78	16.49	0.12	46.37	35.11	0.3	0.22	0.70
OC	SUM	31	1.54	0.82	0.76	-46.93	47.34	-0.72	0.73	0.36	-44.6	-61.86	-0.88	45.07	62.32	0.89	0.94	0.58
OC	FAL	30	0.79	0.86	0.93	8.89	28.74	0.07	0.23	0.07	155.91	22.96	0.09	173.09	43.79	0.29	0.28	0.87
OC	ALL	118	0.88	0.8	0.7	-8.2	43.55	-0.07	0.38	0.3	68.37	8.53	-0.09	100.89	51.92	0.47	0.56	0.49
PM-2.5	WIN	28	3.79	4.49	0.85	18.55	40.37	0.7	1.53	5.16	37.7	22.68	0.19	51.35	38.49	0.4	2.38	0.72
PM-2.5	SPR	31	3.53	3.95	0.83	11.87	29.09	0.42	1.03	2.34	19.32	8.01	0.12	36.08	27.15	0.29	1.59	0.70
PM-2.5	SUM	30	6.01	3.65	0.9	-39.32	42.08	-2.36	2.53	4.03	-40.7	-55.08	-0.65	43.71	57.53	0.69	3.1	0.82
PM-2.5	FAL	30	3.65	4.12	0.94	12.84	26.23	0.47	0.96	1.37	26	14.75	0.13	39.9	31.73	0.26	1.26	0.88
PM-2.5	ALL	119	4.25	4.05	0.8	-4.78	35.47	-0.2	1.51	4.77	10.2	-2.75	-0.05	42.56	38.63	0.37	2.19	0.64
SO4	WIN	29	0.99	0.77	0.76	-21.85	41.08	-0.22	0.41	0.29	-13.95	-22.96	-0.28	34.06	40.12	0.53	0.58	0.58
SO4	SPR	31	1.16	1.29	0.8	10.62	33.44	0.12	0.39	0.32	21.26	7.94	0.11	41.36	32.31	0.33	0.58	0.63
SO4	SUM	31	1.3	1.12	0.93	-13.81	28.99	-0.18	0.38	0.54	23.61	3.69	-0.16	52.6	39.93	0.34	0.75	0.87
SO4	FAL	30	0.97	1.02	0.92	4.9	35.14	0.05	0.34	0.18	64.32	27.44	0.05	81.24	47.51	0.35	0.43	0.84
SO4	ALL	121	1.11	1.06	0.84	-4.9	34.11	-0.05	0.38	0.35	24.1	4.28	-0.05	52.38	39.9	0.36	0.6	0.71

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SHEN1																		
EC	WIN	27	0.16	0.35	0.53	122.22	122.22	0.19	0.19	0.02	179.77	78.61	1.22	179.77	78.61	1.22	0.23	0.28
EC	SPR	31	0.18	0.2	0.38	8.6	52.43	0.02	0.1	0.01	365.47	22.47	0.09	389.84	53.89	0.52	0.12	0.14
EC	SUM	31	0.29	0.21	0.64	-26.09	31.92	-0.08	0.09	0.01	-18.82	-25.76	-0.35	28.94	34.06	0.43	0.12	0.41
EC	FAL	30	0.2	0.26	0.58	29.42	50.07	0.06	0.1	0.01	136.48	35.44	0.29	147.7	48.8	0.5	0.12	0.34
EC	ALL	119	0.21	0.25	0.3	20.31	56.28	0.04	0.12	0.02	165.5	25.91	0.2	187.11	53.05	0.56	0.15	0.09
NO3	WIN	27	0.7	1.45	0.31	105.99	111.11	0.75	0.78	0.65	333.27	71.15	1.06	337.16	75.76	1.11	1.1	0.09
NO3	SPR	31	0.48	0.78	0.37	62.66	109.63	0.3	0.53	0.48	168.2	16.43	0.63	211.94	82.24	1.1	0.76	0.13
NO3	SUM	31	0.19	0.35	0.13	87.36	122.22	0.16	0.23	0.06	154.46	42.55	0.87	179.34	79.63	1.22	0.3	0.02
NO3	FAL	30	0.33	0.98	0.27	192.9	193.57	0.64	0.65	0.42	334.41	93.52	1.93	335.01	94.16	1.94	0.91	0.08
NO3	ALL	119	0.42	0.87	0.45	108.32	128.55	0.45	0.54	0.45	243.98	55.08	1.08	262.89	83.09	1.29	0.81	0.20
OC	WIN	27	0.69	1.26	0.45	82.66	93.91	0.57	0.65	0.41	140.7	63.63	0.83	143.02	66.32	0.94	0.86	0.21
OC	SPR	31	0.93	0.81	0.7	-12.54	42.85	-0.12	0.4	0.33	27.98	3.51	-0.14	63.29	50.12	0.49	0.58	0.49
OC	SUM	31	1.57	1.37	0.52	-12.91	34.36	-0.2	0.54	0.62	2.02	-11.44	-0.15	39.14	34.9	0.39	0.81	0.27
OC	FAL	29	0.92	0.95	0.44	3.23	48.86	0.03	0.45	0.5	35.23	15.21	0.03	56	43.8	0.49	0.71	0.19
OC	ALL	118	1.04	1.1	0.52	5.2	48.54	0.05	0.51	0.55	48.73	16.21	0.05	73.4	48.27	0.49	0.75	0.27
PM-2.5	WIN	27	4.32	6.75	0.36	56.11	63.95	2.42	2.76	6.36	95.29	48.49	0.56	98.8	52.32	0.64	3.5	0.13
PM-2.5	SPR	31	5.48	5.41	0.6	-1.25	40.66	-0.07	2.23	7.61	47.6	8.5	-0.01	78.26	48.1	0.41	2.76	0.36
PM-2.5	SUM	31	11.52	7.98	0.8	-30.74	32.69	-3.54	3.77	6.81	-30.81	-38.42	-0.44	32.43	39.86	0.47	4.4	0.64
PM-2.5	FAL	30	5.29	5.84	0.68	10.37	43.16	0.55	2.28	9.2	54.33	24.3	0.1	70.48	44.41	0.43	3.08	0.46
PM-2.5	ALL	119	6.74	6.49	0.67	-3.74	40.99	-0.25	2.76	12.14	39.69	9.34	-0.04	69.02	45.98	0.43	3.49	0.44
SO4	WIN	27	1.33	1.12	0.28	-15.91	38.65	-0.21	0.51	0.42	6.18	-11.1	-0.19	48.02	40.72	0.46	0.68	0.08
SO4	SPR	31	1.65	1.53	0.79	-7.38	29.26	-0.12	0.48	0.31	20.77	-0.18	-0.08	51.15	38.04	0.32	0.57	0.62
SO4	SUM	31	3.83	3	0.85	-21.6	25.73	-0.83	0.99	0.99	-20.13	-25.39	-0.28	25.48	30.13	0.33	1.29	0.73
SO4	FAL	30	1.44	1.49	0.69	3.03	42.64	0.04	0.62	0.99	60.71	19.43	0.03	81.07	45.44	0.43	0.99	0.48
SO4	ALL	119	2.09	1.81	0.85	-13.57	31.25	-0.28	0.65	0.79	16.87	-4.28	-0.16	51.29	38.45	0.36	0.93	0.72

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SHRO1																		
EC	WIN	19	0.09	0.21	0.67	132	132	0.12	0.12	0.01	194.95	82.48	1.32	194.95	82.48	1.32	0.14	0.45
EC	SPR	21	0.18	0.22	0.59	21.71	48.87	0.04	0.09	0.01	70.69	30.83	0.22	88.56	53.76	0.49	0.11	0.35
EC	SUM	27	0.2	0.15	0.56	-23.2	31.91	-0.05	0.06	0	-17.92	-25.85	-0.3	30.51	36.69	0.42	0.08	0.31
EC	FAL	27	0.16	0.19	0.77	25.5	35.26	0.04	0.05	0	74.99	31.85	0.25	81.56	39.21	0.35	0.08	0.59
EC	ALL	94	0.16	0.19	0.49	19.47	48.61	0.03	0.08	0.01	71.59	25.28	0.19	91.38	50.48	0.49	0.1	0.24
NO3	WIN	19	0.21	0.31	0.23	49.59	105.33	0.1	0.22	0.07	137.84	5.89	0.5	189.54	84.37	1.05	0.28	0.05
NO3	SPR	21	0.23	0.23	0.29	-2.02	69.19	0	0.16	0.05	358.17	-11.82	-0.02	415.34	78.76	0.71	0.23	0.08
NO3	SUM	27	0.16	0.05	0.33	-68.01	74.9	-0.11	0.12	0.01	-67.58	-115.88	-2.13	73.73	120.54	2.34	0.14	0.11
NO3	FAL	23	0.2	0.16	0.36	-20.85	75.96	-0.04	0.15	0.05	35.06	-48.15	-0.26	121.62	87.77	0.96	0.22	0.13
NO3	ALL	90	0.2	0.17	0.32	-11.34	80.33	-0.02	0.16	0.05	101.36	-48.58	-0.13	190.13	94.78	0.91	0.22	0.10
OC	WIN	19	0.49	0.74	0.6	52.06	59.38	0.25	0.29	0.14	61.89	37.69	0.52	67.4	43.95	0.59	0.45	0.36
OC	SPR	21	1.11	1.05	0.86	-4.89	30.43	-0.05	0.34	0.17	35.34	10.85	-0.05	62.29	43.6	0.32	0.41	0.74
OC	SUM	27	1.9	1.61	0.76	-15.44	30.38	-0.29	0.58	0.42	-12.39	-19.59	-0.18	31.19	35.18	0.36	0.71	0.58
OC	FAL	26	0.87	1.06	0.78	21.6	52.2	0.19	0.45	0.5	18.78	0.92	0.22	51.15	41.44	0.52	0.73	0.61
OC	ALL	93	1.15	1.15	0.74	0.59	37.54	0.01	0.43	0.38	22.28	4.72	0.01	51.19	40.62	0.38	0.61	0.55
PM-2.5	WIN	19	2.29	3.89	0.54	70.16	73.65	1.6	1.68	1.86	116.66	52.39	0.7	118.51	54.41	0.74	2.1	0.29
PM-2.5	SPR	21	5.23	5.52	0.69	5.47	39.52	0.29	2.07	6.9	68.35	24.16	0.05	86.57	47.76	0.4	2.64	0.47
PM-2.5	SUM	27	9.94	6.81	0.73	-31.47	33.56	-3.13	3.34	8.28	-29.1	-38.1	-0.46	31.57	40.44	0.49	4.25	0.53
PM-2.5	FAL	22	4.26	5.28	0.93	23.77	29.59	1.01	1.26	1.83	74.54	32.76	0.24	79.84	38.8	0.3	1.69	0.86
PM-2.5	ALL	89	5.79	5.5	0.76	-4.99	37.48	-0.29	2.17	8.7	50.63	13.42	-0.05	75.04	44.74	0.39	2.96	0.58
SO4	WIN	19	0.71	1.09	0.25	53.79	59.65	0.38	0.42	0.19	127.9	45.06	0.54	131.27	48.65	0.6	0.58	0.06
SO4	SPR	21	1.5	1.89	0.45	25.32	55.22	0.38	0.83	0.87	91.38	35.56	0.25	106.92	55.3	0.55	1.01	0.20
SO4	SUM	27	3.04	2.45	0.64	-19.51	28.83	-0.59	0.88	0.96	-15.94	-23.22	-0.24	28.02	33.72	0.36	1.15	0.41
SO4	FAL	23	1.35	1.87	0.81	38.74	47.82	0.52	0.64	0.55	182.16	45.05	0.39	185.25	48.43	0.48	0.91	0.66
SO4	ALL	90	1.76	1.88	0.72	7.09	40.44	0.12	0.71	0.9	90.09	22.36	0.07	108.41	45.66	0.4	0.96	0.52

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SIPS1																		
EC	WIN	23	0.33	0.6	0.57	79.65	79.65	0.27	0.27	0.15	84.13	47.1	0.8	84.13	47.1	0.8	0.47	0.32
EC	SPR	26	0.4	0.42	0.23	2.95	61.81	0.01	0.25	0.19	13.37	-8.42	0.03	55.3	46.98	0.62	0.44	0.05
EC	SUM	27	0.37	0.26	0.61	-30.55	37.32	-0.11	0.14	0.02	-23.23	-32.41	-0.44	33.98	41.07	0.54	0.18	0.37
EC	FAL	19	0.37	0.5	0.58	34.35	53.44	0.13	0.2	0.09	32.84	17.57	0.34	48.87	35.8	0.53	0.32	0.34
EC	ALL	95	0.37	0.43	0.33	16.3	57.01	0.06	0.21	0.13	23.99	3.4	0.16	54.94	43.09	0.57	0.37	0.11
NO3	WIN	23	0.88	1.16	0.22	31.62	66.41	0.28	0.59	0.45	95.05	33.41	0.32	115.73	60.11	0.66	0.72	0.05
NO3	SPR	26	0.48	0.87	0.35	82.48	144.89	0.39	0.69	2.19	57.5	-18.39	0.82	121.19	79.23	1.45	1.53	0.12
NO3	SUM	27	0.16	0.09	0.03	-41.85	55.04	-0.07	0.09	0.01	-28.66	-55.66	-0.72	52.28	71.53	0.95	0.12	0.00
NO3	FAL	19	0.25	0.55	0.34	123.9	165.95	0.31	0.41	0.5	186.08	26.5	1.24	222.3	78.96	1.66	0.77	0.12
NO3	ALL	95	0.44	0.66	0.42	49.45	99.7	0.22	0.44	0.84	67.82	-7.46	0.49	120.5	72.36	1	0.94	0.17
OC	WIN	23	1.55	2.42	0.63	56.38	58.72	0.87	0.91	3	62.8	31.55	0.56	66.52	35.55	0.59	1.94	0.39
OC	SPR	26	2.24	2.1	0.2	-6.49	59.02	-0.15	1.32	7.14	16.78	-1.95	-0.07	50.31	43.78	0.63	2.68	0.04
OC	SUM	27	2.4	3.17	0.67	32.01	40.58	0.77	0.98	1.5	29.85	17.56	0.32	41.62	33.54	0.41	1.45	0.45
OC	FAL	19	1.85	2.84	0.85	53.24	63.69	0.99	1.18	2.14	40.49	25.34	0.53	54.22	42.12	0.64	1.76	0.73
OC	ALL	95	2.04	2.63	0.43	28.77	53.64	0.59	1.1	3.74	36.38	17.16	0.29	52.54	38.55	0.54	2.02	0.18
PM-2.5	WIN	23	6.44	9.91	0.58	54.02	57.08	3.48	3.67	20.68	60.94	36.48	0.54	64.41	40.37	0.57	5.72	0.34
PM-2.5	SPR	26	10.32	9.73	0.16	-5.7	47.84	-0.59	4.94	53.48	5.5	-10.18	-0.06	46.2	42.77	0.51	7.34	0.03
PM-2.5	SUM	27	11.98	10.48	0.77	-12.49	22.58	-1.5	2.71	9.43	-12.73	-18.21	-0.14	23.87	27.63	0.26	3.42	0.59
PM-2.5	FAL	19	7.95	10.57	0.79	32.98	39.89	2.62	3.17	13.88	32.06	22.08	0.33	40.71	31.97	0.4	4.56	0.62
PM-2.5	ALL	95	9.38	10.16	0.45	8.31	38.85	0.78	3.64	29.52	19.05	5.28	0.08	43.16	35.73	0.39	5.49	0.20
SO4	WIN	23	1.7	1.55	0.66	-9.04	28.86	-0.15	0.49	0.34	1.22	-6.85	-0.1	33.55	33.26	0.32	0.6	0.44
SO4	SPR	26	3.11	2.4	0.55	-22.62	39.18	-0.7	1.22	2.14	-11.92	-21.43	-0.29	36.21	41.09	0.51	1.62	0.31
SO4	SUM	27	3.61	2.41	0.8	-33.11	36.67	-1.2	1.32	1.05	-31.53	-44.05	-0.49	37.56	49.06	0.55	1.57	0.64
SO4	FAL	19	2.11	2.05	0.81	-2.94	22.71	-0.06	0.48	0.5	6.04	1.25	-0.03	24.94	24.58	0.23	0.71	0.66
SO4	ALL	95	2.71	2.13	0.73	-21.46	34.1	-0.58	0.92	1.28	-10.72	-19.79	-0.27	33.7	38.16	0.43	1.27	0.53

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: STIL1																		
EC	WIN	29	0.41	0.59	0.48	45.13	68.28	0.18	0.28	0.2	42.01	15.25	0.45	64.5	42.68	0.68	0.49	0.23
EC	SPR	28	0.38	0.6	0.72	56.85	77.99	0.22	0.3	0.26	40.86	13.89	0.57	64.67	42.02	0.78	0.56	0.52
EC	SUM	26	0.31	0.3	0.21	-0.95	36.88	0	0.11	0.02	8.95	-2.33	-0.01	38.34	34.75	0.37	0.16	0.04
EC	FAL	27	0.33	0.36	0.51	7.74	33.82	0.03	0.11	0.02	11.35	4.98	0.08	31.71	29.63	0.34	0.14	0.26
EC	ALL	110	0.36	0.47	0.59	30.55	56.77	0.11	0.2	0.14	26.37	8.23	0.31	50.31	37.43	0.57	0.39	0.34
NO3	WIN	29	2.45	2.32	0.76	-5.42	37.92	-0.13	0.93	1.57	33.59	1.34	-0.06	67.46	46.78	0.4	1.26	0.58
NO3	SPR	29	0.88	0.95	0.71	8.27	71.94	0.07	0.63	0.72	14.17	-23.24	0.08	81.51	79.52	0.72	0.85	0.50
NO3	SUM	26	0.2	0.06	0.13	-71.67	71.67	-0.15	0.15	0.01	-67.51	-106.19	-2.53	67.51	106.19	2.53	0.18	0.02
NO3	FAL	29	0.66	0.68	0.88	3.19	54.45	0.02	0.36	0.31	7.31	-23.27	0.03	67.53	64.74	0.54	0.56	0.78
NO3	ALL	113	1.07	1.03	0.84	-4.1	49.17	-0.04	0.53	0.68	-1.4	-36.02	-0.04	71.1	73.46	0.51	0.83	0.70
OC	WIN	29	2.01	2.21	0.25	9.87	72.29	0.2	1.45	5.09	22.26	-13.35	0.1	76.72	59.32	0.72	2.27	0.06
OC	SPR	28	2.46	2.63	0.64	6.95	53.72	0.17	1.32	4.69	-0.94	-18.83	0.07	51.19	47.09	0.54	2.17	0.41
OC	SUM	26	2.3	2.84	0.56	23.24	38.47	0.54	0.89	1.1	27.69	15.64	0.23	43.11	33.53	0.38	1.18	0.32
OC	FAL	27	1.51	1.53	0.5	1.4	38.75	0.02	0.58	0.88	8.01	-6.94	0.01	40.91	34.1	0.39	0.94	0.25
OC	ALL	110	2.07	2.3	0.53	10.99	51.78	0.23	1.07	3.04	14.14	-6.32	0.11	53.49	43.92	0.52	1.76	0.28
PM-2.5	WIN	29	9.33	10.92	0.45	17.13	44.69	1.6	4.17	38.1	31.8	8.64	0.17	54.02	36.91	0.45	6.38	0.20
PM-2.5	SPR	29	10.19	10.61	0.55	4.17	41.54	0.42	4.23	35.46	10.65	-2.51	0.04	44.53	38.51	0.42	5.97	0.30
PM-2.5	SUM	26	11.08	8.59	0.71	-22.47	25.5	-2.49	2.83	6.28	-21.48	-27.49	-0.29	25.03	30.81	0.33	3.53	0.50
PM-2.5	FAL	30	6.66	7.07	0.61	6.22	27	0.41	1.8	8.34	12.26	4.71	0.06	28.74	24.71	0.27	2.92	0.37
PM-2.5	ALL	114	9.24	9.3	0.54	0.6	35.21	0.06	3.25	24.49	9.13	-3.47	0.01	38.34	32.72	0.35	4.95	0.29
SO4	WIN	29	1.8	1.41	0.72	-21.73	33.76	-0.39	0.61	0.82	-10.7	-20.04	-0.28	29.7	34.44	0.43	0.99	0.52
SO4	SPR	29	2.61	2.21	0.85	-15.14	25.03	-0.4	0.65	0.63	-5.76	-11.01	-0.18	25.58	27.72	0.29	0.89	0.73
SO4	SUM	26	2.65	1.44	0.67	-45.52	45.94	-1.2	1.22	0.59	-42.82	-59.43	-0.84	43.59	60.18	0.84	1.43	0.44
SO4	FAL	29	1.46	1.42	0.56	-2.41	32.37	-0.04	0.47	0.7	15.68	-0.55	-0.02	41.05	30.64	0.33	0.84	0.31
SO4	ALL	113	2.11	1.63	0.71	-23.07	34.26	-0.49	0.72	0.86	-10.05	-21.78	-0.3	34.75	37.66	0.45	1.05	0.50

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: SWAN1																		
EC	WIN	27	0.2	0.26	0.84	29.72	37.87	0.06	0.08	0.01	54.4	29.87	0.3	62.6	39.03	0.38	0.1	0.71
EC	SPR	29	0.18	0.19	0.81	6.85	45.18	0.01	0.08	0.01	16.46	-0.52	0.07	51.57	47.31	0.45	0.12	0.66
EC	SUM	27	0.37	0.13	0.79	-65.32	66.08	-0.24	0.24	0.19	-20.37	-60.28	-1.88	73.42	78.25	1.91	0.49	0.62
EC	FAL	27	0.13	0.12	0.9	-9.99	30.23	-0.01	0.04	0	40.39	6.02	-0.11	70.57	42.72	0.34	0.05	0.82
EC	ALL	110	0.22	0.18	0.44	-20.17	49.88	-0.04	0.11	0.06	22.6	-6.12	-0.25	64.3	51.75	0.62	0.26	0.20
NO3	WIN	27	0.55	0.6	0.42	7.77	72.77	0.04	0.4	0.29	47.34	-7.16	0.08	102.02	73.88	0.73	0.54	0.18
NO3	SPR	29	0.39	0.52	0.3	34.39	96.15	0.13	0.37	0.36	39.52	-25.87	0.34	106.21	84.57	0.96	0.62	0.09
NO3	SUM	27	0.3	0.13	0.18	-56.59	76.72	-0.17	0.23	0.05	-49.96	-101.4	-1.3	76.68	118.37	1.77	0.28	0.03
NO3	FAL	27	0.18	0.23	0.05	26.55	89.01	0.05	0.16	0.06	56.59	-6.21	0.27	112	78.07	0.89	0.24	0.00
NO3	ALL	110	0.36	0.37	0.41	4.64	82.35	0.02	0.29	0.21	23.67	-34.99	0.05	99.35	88.65	0.82	0.45	0.17
OC	WIN	27	0.96	0.94	0.76	-2.18	33.58	-0.02	0.32	0.21	4.68	-3.03	-0.02	33.4	31.88	0.34	0.46	0.58
OC	SPR	29	1.25	0.91	0.6	-27.47	43.09	-0.34	0.54	1.27	-16.73	-30.69	-0.38	41.37	49.58	0.59	1.18	0.36
OC	SUM	27	5	1.16	0.4	-76.8	77.5	-3.84	3.87	39.19	-52.58	-86.51	-3.31	57.19	90.26	3.34	7.34	0.16
OC	FAL	27	0.81	0.6	0.82	-25.69	40.83	-0.21	0.33	0.15	-31.6	-49.55	-0.35	44.01	59.64	0.55	0.44	0.67
OC	ALL	110	1.99	0.9	0.37	-54.69	62.94	-1.09	1.25	12.52	-23.92	-42.23	-1.21	43.94	57.69	1.39	3.7	0.14
PM-2.5	WIN	27	4.66	5.06	0.76	8.47	26.73	0.39	1.25	2.67	17.52	8.71	0.08	32.93	26.36	0.27	1.68	0.58
PM-2.5	SPR	29	7.3	5.8	0.67	-20.54	31.61	-1.5	2.31	8.46	-18.22	-27.35	-0.26	29.73	36.77	0.4	3.27	0.44
PM-2.5	SUM	26	13.58	5.2	0.48	-61.72	61.72	-8.38	8.38	46.07	-55.98	-83.7	-1.61	55.99	83.72	1.61	10.78	0.23
PM-2.5	FAL	27	4.43	3.7	0.79	-16.6	33.64	-0.74	1.49	3.3	-11.41	-23.62	-0.2	37.09	43.65	0.4	1.96	0.63
PM-2.5	ALL	109	7.43	4.95	0.48	-33.39	44.27	-2.48	3.29	26.08	-16.69	-30.94	-0.5	38.61	47.1	0.66	5.68	0.23
SO4	WIN	27	1.42	1.23	0.72	-13.96	27.55	-0.2	0.39	0.24	-0.57	-9.39	-0.16	31.98	30.44	0.32	0.53	0.51
SO4	SPR	29	2.25	1.9	0.78	-15.51	25.32	-0.35	0.57	0.51	-15.46	-22.19	-0.18	24.43	30.08	0.3	0.79	0.62
SO4	SUM	27	2.98	1.85	0.65	-37.8	41.28	-1.12	1.23	1.04	-35.32	-55	-0.61	44.44	62.26	0.66	1.52	0.43
SO4	FAL	27	1.28	1.19	0.81	-7.09	32.92	-0.09	0.42	0.35	-8.48	-25.11	-0.08	39.34	47.63	0.35	0.6	0.65
SO4	ALL	110	1.99	1.55	0.73	-22.1	32.78	-0.44	0.65	0.7	-14.97	-27.82	-0.28	34.86	42.37	0.42	0.94	0.54

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: TALL1																		
EC	WIN	28	0.22	0.34	0.56	57.92	63.75	0.13	0.14	0.02	72.22	43.39	0.58	75.81	47.34	0.64	0.19	0.32
EC	SPR	28	0.4	0.59	0.79	47.73	74.39	0.19	0.3	0.45	35.93	14.71	0.48	59.78	44.85	0.74	0.7	0.62
EC	SUM	31	0.22	0.26	0.52	14.85	30	0.03	0.07	0.01	22.46	14.94	0.15	33.34	27.2	0.3	0.09	0.27
EC	FAL	30	0.21	0.27	0.43	32.3	44.04	0.07	0.09	0.01	42.82	26.87	0.32	48.54	33.98	0.44	0.14	0.19
EC	ALL	117	0.26	0.36	0.77	39.15	55.98	0.1	0.15	0.12	42.81	24.75	0.39	53.73	37.98	0.56	0.36	0.60
NO3	WIN	28	2.83	2.15	0.78	-24.04	37.06	-0.68	1.05	1.5	-13.29	-26.03	-0.32	40.78	44.85	0.49	1.4	0.60
NO3	SPR	28	1.83	1.66	0.95	-9.48	30.61	-0.17	0.56	0.51	-19.71	-37.92	-0.1	45.56	58.35	0.34	0.74	0.90
NO3	SUM	31	0.28	0.08	0.62	-70.13	70.13	-0.19	0.19	0.02	-65.02	-104.3	-2.35	65.02	104.3	2.35	0.24	0.38
NO3	FAL	29	0.49	0.58	0.8	18.69	58.19	0.09	0.28	0.19	33.36	-8.58	0.19	85.52	65.62	0.58	0.45	0.64
NO3	ALL	116	1.32	1.09	0.9	-17.82	38.71	-0.24	0.51	0.61	-17	-45.45	-0.22	59.6	69.19	0.47	0.82	0.81
OC	WIN	28	0.89	1.06	0.65	19.58	41.33	0.17	0.37	0.26	23.68	11.14	0.2	43	34.96	0.41	0.54	0.42
OC	SPR	28	2.15	2.27	0.75	5.55	67.56	0.12	1.45	8.86	-14.08	-36.7	0.06	56.06	62.72	0.68	2.98	0.56
OC	SUM	31	1.59	1.37	0.76	-13.94	30.43	-0.22	0.48	0.31	-15.05	-24.17	-0.16	32.16	38.29	0.35	0.6	0.58
OC	FAL	30	0.97	0.81	0.65	-16.51	34.74	-0.16	0.34	0.26	-11.53	-21.39	-0.2	33.58	34.13	0.42	0.53	0.43
OC	ALL	117	1.4	1.37	0.74	-2.13	46.53	-0.03	0.65	2.36	-4.65	-18	-0.02	40.84	42.27	0.48	1.54	0.55
PM-2.5	WIN	28	7.28	7.48	0.75	2.75	32.45	0.2	2.36	7.68	17.9	8.45	0.03	40.31	34.97	0.32	2.78	0.56
PM-2.5	SPR	28	10.34	9.99	0.75	-3.3	41.81	-0.34	4.32	52.35	-3.85	-16.31	-0.03	40.3	41.07	0.43	7.24	0.56
PM-2.5	SUM	31	8.42	5.71	0.71	-32.2	33.95	-2.71	2.86	4.48	-30.57	-40.66	-0.48	32.89	42.84	0.5	3.44	0.51
PM-2.5	FAL	30	4.83	5.25	0.67	8.71	32.23	0.42	1.56	4.62	19.6	11.13	0.09	35.78	29.54	0.32	2.19	0.44
PM-2.5	ALL	117	7.69	7.04	0.73	-8.38	35.86	-0.64	2.76	18.36	0.29	-9.8	-0.09	37.18	37.12	0.39	4.33	0.53
SO4	WIN	28	1.33	0.93	0.7	-29.69	42.8	-0.39	0.57	0.45	-20.22	-32.63	-0.42	38.29	47.73	0.61	0.78	0.49
SO4	SPR	28	2.17	1.42	0.79	-34.49	40.22	-0.75	0.87	1.25	-23.87	-33.24	-0.53	32.76	40.95	0.61	1.34	0.62
SO4	SUM	31	2.09	1.26	0.73	-39.89	41.92	-0.83	0.88	0.36	-36.43	-51.33	-0.66	42.6	56.15	0.7	1.03	0.53
SO4	FAL	29	1.01	0.96	0.81	-5.31	29.67	-0.05	0.3	0.18	10.63	2.61	-0.06	33.32	31.62	0.31	0.42	0.65
SO4	ALL	116	1.66	1.15	0.74	-30.92	39.68	-0.51	0.66	0.65	-17.72	-28.96	-0.45	36.87	44.32	0.57	0.95	0.54

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: THBA1																		
EC	WIN	15	0.12	0.08	0.5	-27.35	42.27	-0.03	0.05	0	14.24	-12.77	-0.38	60	46.92	0.58	0.07	0.25
EC	SPR	25	0.06	0.05	0.77	-15.37	34.72	-0.01	0.02	0	-3.41	-15.72	-0.18	41.01	43.01	0.41	0.03	0.59
EC	SUM	27	0.13	0.35	0.68	165.24	197.58	0.22	0.26	0.56	94.61	15.85	1.65	124.78	54.56	1.98	0.78	0.46
EC	FAL	24	0.16	0.19	0.39	13.77	53.48	0.02	0.09	0.02	26.69	3.89	0.14	56.13	43.09	0.53	0.14	0.15
EC	ALL	91	0.12	0.18	0.43	52.93	96.5	0.06	0.11	0.18	36.52	-0.69	0.53	72.98	47.1	0.97	0.43	0.19
NO3	WIN	15	0.21	0.29	0.61	41.11	90.4	0.09	0.19	0.06	115.38	56.92	0.41	127.48	72.66	0.9	0.26	0.37
NO3	SPR	25	0.28	0.38	0.78	34.98	74.12	0.1	0.21	0.12	89.16	10.35	0.35	127.6	65.71	0.74	0.36	0.61
NO3	SUM	27	0.07	0.06	0.46	-18.37	59.96	-0.01	0.04	0.01	-25.24	-46.35	-0.23	49.77	56.41	0.73	0.08	0.21
NO3	FAL	24	0.11	0.14	0.69	25.09	70.78	0.03	0.08	0.02	59.62	-21.33	0.25	122.55	69.02	0.71	0.14	0.47
NO3	ALL	91	0.16	0.2	0.76	27.55	75.14	0.04	0.12	0.05	51.75	-7.15	0.28	103.15	64.97	0.75	0.23	0.57
OC	WIN	15	0.31	0.21	0.33	-32.95	36.08	-0.1	0.11	0.01	-30.3	-39.55	-0.49	33.68	42.55	0.54	0.14	0.11
OC	SPR	25	0.35	0.15	0.33	-56.75	59.06	-0.2	0.21	0.04	-48.54	-73.68	-1.31	51.89	76.6	1.37	0.28	0.11
OC	SUM	27	1.1	1.76	0.65	60.45	126.23	0.66	1.38	13.36	18.61	-33.11	0.6	93.37	70.64	1.26	3.72	0.42
OC	FAL	24	0.86	0.79	0.49	-8.64	57.29	-0.07	0.49	0.51	25.67	-18.43	-0.09	82.22	60.48	0.63	0.72	0.24
OC	ALL	91	0.7	0.81	0.46	15.06	87.99	0.11	0.62	4.24	-6.04	-41.45	0.15	69.19	64.97	0.88	2.06	0.22
PM-2.5	WIN	15	1.77	2.09	0.61	18.05	33.39	0.32	0.59	0.44	31.03	20.62	0.18	41.39	32.7	0.33	0.73	0.37
PM-2.5	SPR	25	2.25	2.15	0.74	-4.33	35.05	-0.1	0.79	1.02	-2.44	-13.66	-0.05	38.03	41.79	0.37	1.01	0.55
PM-2.5	SUM	27	4.62	5.17	0.38	11.78	79.81	0.54	3.69	69.17	0.44	-32.67	0.12	70.44	59.41	0.8	8.33	0.14
PM-2.5	FAL	24	4.07	3.6	0.49	-11.56	42.97	-0.47	1.75	4.18	7.48	-14.48	-0.13	57.19	50.6	0.49	2.1	0.24
PM-2.5	ALL	91	3.35	3.42	0.38	1.89	55.75	0.06	1.87	22.14	6.55	-13.86	0.02	53.25	47.84	0.56	4.71	0.14
SO4	WIN	15	0.4	0.39	0.67	-1.29	48.5	-0.01	0.19	0.13	44.23	25.09	-0.01	58.7	44.82	0.49	0.36	0.45
SO4	SPR	25	0.62	0.59	0.61	-5.12	40.23	-0.03	0.25	0.12	5.62	-10.12	-0.05	46.22	43.51	0.42	0.35	0.37
SO4	SUM	27	0.58	0.49	0.46	-14.6	27.3	-0.08	0.16	0.03	-11.25	-16.06	-0.17	25.11	27.82	0.32	0.2	0.22
SO4	FAL	24	0.45	0.51	0.59	13.11	29.75	0.06	0.14	0.03	23.32	13.09	0.13	38.34	29.75	0.3	0.18	0.35
SO4	ALL	91	0.53	0.51	0.56	-3.6	34.67	-0.02	0.18	0.08	11.64	0.04	-0.04	39.94	35.44	0.36	0.28	0.32

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: THRO1																		
EC	WIN	29	0.09	0.12	0.75	30.01	43.24	0.03	0.04	0	51.21	29.75	0.3	61.02	41.48	0.43	0.05	0.56
EC	SPR	30	0.1	0.11	0.54	9.91	41.59	0.01	0.04	0	42.08	17.75	0.1	62.52	43.26	0.42	0.05	0.29
EC	SUM	31	0.18	0.21	0.2	15.29	50.98	0.03	0.09	0.05	15.79	-4.76	0.15	46.06	32.74	0.51	0.22	0.04
EC	FAL	28	0.19	0.21	0.39	11.76	48.21	0.02	0.09	0.03	20.22	5.12	0.12	44.88	37.18	0.48	0.17	0.15
EC	ALL	118	0.14	0.16	0.41	15.53	47.11	0.02	0.07	0.02	32.23	11.79	0.16	53.64	38.62	0.47	0.14	0.17
NO3	WIN	28	0.47	1.44	0.79	208.16	212.95	0.97	0.99	2.12	216.99	82.93	2.08	224.1	94.42	2.13	1.75	0.62
NO3	SPR	30	0.7	0.94	0.63	34.95	79.45	0.24	0.55	0.63	102.16	26.38	0.35	135.27	74.82	0.79	0.83	0.40
NO3	SUM	31	0.21	0.1	0.74	-53.71	60.51	-0.12	0.13	0.02	-38.82	-69.48	-1.16	62.98	85.41	1.31	0.19	0.55
NO3	FAL	30	0.16	0.51	0.83	213.18	223.87	0.34	0.36	0.18	240.87	61.67	2.13	268.46	99.75	2.24	0.55	0.69
NO3	ALL	119	0.38	0.73	0.64	90.73	130.42	0.35	0.5	0.86	127.42	23.61	0.91	170.92	88.47	1.3	0.99	0.41
OC	WIN	29	0.34	0.26	0.58	-22.66	39.01	-0.08	0.13	0.03	-6.27	-24.11	-0.29	45.47	42.37	0.5	0.18	0.34
OC	SPR	30	0.36	0.25	0.5	-30.35	41.23	-0.11	0.15	0.03	-16.98	-30.47	-0.44	40.55	47.5	0.59	0.2	0.25
OC	SUM	31	1.03	0.78	0.3	-24.43	70.5	-0.25	0.73	1.15	-26.57	-55.6	-0.32	64.02	75.74	0.93	1.1	0.09
OC	FAL	28	0.77	0.74	0.31	-4.35	61.08	-0.03	0.47	0.68	8.64	-19.4	-0.05	62.02	55.27	0.64	0.83	0.09
OC	ALL	118	0.63	0.51	0.42	-19.18	59.37	-0.12	0.37	0.49	-10.79	-32.88	-0.24	53.02	55.5	0.73	0.71	0.18
PM-2.5	WIN	29	2.35	3.4	0.85	44.39	54.19	1.04	1.28	2.84	44.68	26.7	0.44	55.14	38.76	0.54	1.98	0.72
PM-2.5	SPR	30	3.77	3.31	0.57	-12.31	34.81	-0.46	1.31	4.2	5.47	-6.66	-0.14	39.6	38.76	0.4	2.1	0.33
PM-2.5	SUM	31	4.64	3.2	0.54	-30.95	46.87	-1.44	2.17	4.94	-32.83	-48.46	-0.45	45.65	57.18	0.68	2.65	0.29
PM-2.5	FAL	30	3.83	3.75	0.78	-2.17	34.39	-0.08	1.32	2.64	4.94	-5.08	-0.02	39.16	38.43	0.35	1.63	0.61
PM-2.5	ALL	120	3.67	3.41	0.59	-6.96	41.64	-0.26	1.53	4.46	4.92	-9	-0.07	44.81	43.44	0.45	2.13	0.35
SO4	WIN	28	0.62	0.46	0.54	-25.98	46.66	-0.16	0.29	0.15	13.87	-6.97	-0.35	54.6	48.08	0.63	0.42	0.29
SO4	SPR	30	1.08	0.82	0.36	-23.84	47.57	-0.26	0.51	0.69	6.7	-8.04	-0.31	46.05	46.98	0.62	0.87	0.13
SO4	SUM	31	0.8	0.67	0.82	-16.33	33.02	-0.13	0.26	0.15	-5.11	-15	-0.2	36.08	36.6	0.39	0.41	0.68
SO4	FAL	30	0.54	0.63	0.76	17.04	38.7	0.09	0.21	0.06	36.97	24.28	0.17	48.04	37.04	0.39	0.27	0.58
SO4	ALL	119	0.76	0.65	0.59	-14.92	41.84	-0.11	0.32	0.28	12.94	-1.45	-0.18	45.97	42.03	0.49	0.54	0.35

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: ULBE1																		
EC	WIN	27	0.05	0.06	0.83	1.75	42.47	0	0.02	0	819.83	23.9	0.02	841.44	50.38	0.42	0.03	0.69
EC	SPR	31	0.05	0.05	0.41	-0.88	49.03	0	0.02	0	31.29	0.03	-0.01	66.93	55.46	0.49	0.03	0.17
EC	SUM	26	0.09	0.1	0.28	15.2	75.26	0.01	0.07	0.02	49.1	1.07	0.15	87.56	53.56	0.75	0.13	0.08
EC	FAL	28	0.11	0.13	0.63	11.24	51.54	0.01	0.06	0.01	79.82	25.09	0.11	101.35	52.89	0.52	0.08	0.39
EC	ALL	112	0.08	0.08	0.5	8.43	55.92	0.01	0.04	0.01	237.65	12.29	0.08	267.04	53.15	0.56	0.08	0.25
NO3	WIN	29	0.31	0.95	0.64	209	219.21	0.64	0.67	1.7	275.98	58.92	2.09	292.5	79.71	2.19	1.45	0.41
NO3	SPR	31	0.27	0.6	0.75	120.16	133.05	0.33	0.36	0.55	144.13	10.42	1.2	187.65	77.23	1.33	0.81	0.56
NO3	SUM	26	0.03	0.01	0.26	-58.66	58.66	-0.02	0.02	0	-55.39	-81.59	-1.42	55.39	81.59	1.42	0.02	0.07
NO3	FAL	28	0.14	0.21	0.99	55.7	79.19	0.08	0.11	0.07	22.9	-22.35	0.56	89.77	77.67	0.79	0.27	0.98
NO3	ALL	114	0.19	0.46	0.73	137.57	155.49	0.27	0.3	0.66	102.39	-6.27	1.38	160.12	78.96	1.55	0.86	0.53
OC	WIN	29	0.29	0.19	0.49	-32.62	52.78	-0.09	0.15	0.05	11.05	-11.85	-0.48	59.12	53.61	0.78	0.24	0.24
OC	SPR	31	0.29	0.17	0.28	-40.16	51.13	-0.12	0.15	0.03	-27.72	-46.81	-0.67	43.5	59.57	0.85	0.21	0.08
OC	SUM	26	0.86	0.55	0.48	-36.44	61.35	-0.31	0.53	0.46	-38.63	-64.85	-0.57	56.86	73.98	0.97	0.75	0.23
OC	FAL	28	0.72	0.61	0.53	-14.66	42.03	-0.11	0.3	0.24	18.09	-6.54	-0.17	60.37	51.1	0.49	0.51	0.28
OC	ALL	114	0.52	0.37	0.57	-29.14	52.13	-0.15	0.27	0.19	-9.09	-32.14	-0.41	54.66	59.26	0.74	0.46	0.32
PM-2.5	WIN	29	2	2.35	0.74	17.1	49.11	0.34	0.98	2.21	28.56	13.07	0.17	50.7	40.67	0.49	1.53	0.54
PM-2.5	SPR	31	2.51	2.35	0.8	-6.06	33.37	-0.15	0.84	1.39	-11.05	-24.05	-0.06	35.5	43.49	0.36	1.19	0.64
PM-2.5	SUM	26	3.07	1.94	0.52	-36.72	48.41	-1.13	1.48	2.28	-35.2	-51.12	-0.58	44.64	57.1	0.76	1.88	0.27
PM-2.5	FAL	28	3.2	2.56	0.7	-20.14	34.72	-0.65	1.11	2.38	-4.12	-14.92	-0.25	37.06	38.08	0.43	1.67	0.49
PM-2.5	ALL	114	2.68	2.31	0.65	-13.8	40.69	-0.37	1.09	2.34	-4.78	-18.54	-0.16	41.84	44.55	0.47	1.57	0.42
SO4	WIN	29	0.57	0.44	0.44	-22.48	61.72	-0.13	0.35	0.29	64.75	15.94	-0.29	100.17	66.29	0.8	0.56	0.19
SO4	SPR	31	0.75	0.66	0.63	-11.44	39.9	-0.09	0.3	0.22	-1.81	-15.13	-0.13	39.85	44.1	0.45	0.47	0.40
SO4	SUM	26	0.42	0.37	0.55	-11.43	28.37	-0.05	0.12	0.02	-4	-12.23	-0.13	31.48	32.66	0.32	0.16	0.30
SO4	FAL	28	0.43	0.51	0.41	20.6	54.19	0.09	0.23	0.13	47.38	24.51	0.21	61.02	41.16	0.54	0.37	0.17
SO4	ALL	114	0.55	0.5	0.53	-8.23	46.34	-0.05	0.25	0.18	26.7	3.17	-0.09	58.48	46.41	0.5	0.42	0.28

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: UPBU1																		
EC	WIN	28	0.25	0.37	0.72	45.94	57.63	0.12	0.14	0.02	60.07	30.93	0.46	72.73	46.11	0.58	0.19	0.51
EC	SPR	30	0.28	0.32	0.39	14.21	64.91	0.04	0.18	0.12	14.99	-14.74	0.14	63.03	47.62	0.65	0.34	0.16
EC	SUM	28	0.28	0.21	0.32	-24.59	45.2	-0.07	0.13	0.03	-13.77	-30.39	-0.33	43.27	44.56	0.6	0.19	0.11
EC	FAL	29	0.23	0.28	0.63	19.94	42.42	0.05	0.1	0.02	32.88	12.63	0.2	51.14	35.42	0.42	0.15	0.40
EC	ALL	115	0.26	0.29	0.44	12.9	53.08	0.03	0.14	0.05	23.48	-0.53	0.13	57.58	43.43	0.53	0.23	0.19
NO3	WIN	28	1.69	1.53	0.62	-9.36	52.23	-0.16	0.88	1.17	100.03	-4.09	-0.1	149.96	64.98	0.58	1.09	0.38
NO3	SPR	25	0.62	0.36	0.5	-41.87	68.13	-0.26	0.42	0.28	-23.42	-64.16	-0.72	77.75	94.89	1.17	0.59	0.25
NO3	SUM	28	0.23	0.04	0.18	-82.18	82.18	-0.19	0.19	0.02	-78.22	-133.45	-4.61	78.22	133.45	4.61	0.23	0.03
NO3	FAL	29	0.41	0.41	0.59	0.66	73.38	0	0.3	0.23	-14.01	-59.78	0.01	82.25	91.46	0.73	0.48	0.35
NO3	ALL	110	0.74	0.59	0.74	-19.92	60.77	-0.15	0.45	0.44	-3.46	-65.35	-0.25	97.44	96.19	0.76	0.68	0.55
OC	WIN	28	1.15	1.45	0.61	25.48	52.32	0.29	0.6	0.59	61.8	16.7	0.25	87.58	47.41	0.52	0.82	0.37
OC	SPR	30	1.62	1.53	0.43	-5.73	55.43	-0.09	0.9	2.34	6.01	-24.38	-0.06	59.99	47.69	0.59	1.53	0.19
OC	SUM	28	2.35	2.53	0.66	7.7	38.13	0.18	0.9	1.19	15.84	2.55	0.08	45.53	39.4	0.38	1.11	0.44
OC	FAL	29	1.15	1.33	0.82	16.06	40.34	0.18	0.46	0.41	18.9	3.98	0.16	46.52	38.6	0.4	0.67	0.67
OC	ALL	115	1.56	1.7	0.64	8.81	45.75	0.14	0.72	1.17	25.24	-0.67	0.09	59.79	43.31	0.46	1.09	0.41
PM-2.5	WIN	28	6.28	7.64	0.74	21.64	35.88	1.36	2.25	6.91	41.91	18.34	0.22	56.87	36.91	0.36	2.96	0.55
PM-2.5	SPR	30	8.28	7.09	0.4	-14.41	42.89	-1.19	3.55	20.13	-6.25	-22.54	-0.17	44.82	45.4	0.5	4.64	0.16
PM-2.5	SUM	28	11.53	7.45	0.64	-35.39	38.65	-4.08	4.46	12.16	-32.36	-44.95	-0.55	37.68	49.37	0.6	5.37	0.41
PM-2.5	FAL	29	5.96	5.98	0.7	0.28	26.13	0.02	1.56	5.45	13.62	-1.44	0	38.46	28.15	0.26	2.33	0.50
PM-2.5	ALL	115	8	7.03	0.53	-12.12	36.91	-0.97	2.95	15.21	4.13	-12.72	-0.14	44.41	39.95	0.42	4.02	0.29
SO4	WIN	28	1.43	1.4	0.83	-1.76	31.46	-0.03	0.45	0.44	33.92	-4.33	-0.02	65.48	35.37	0.32	0.66	0.68
SO4	SPR	25	2.21	1.84	0.79	-16.86	30.1	-0.37	0.67	0.68	-8.27	-15.41	-0.2	29.53	33.53	0.36	0.9	0.62
SO4	SUM	28	2.76	1.42	0.62	-48.72	49.48	-1.35	1.37	0.68	-46.61	-65.5	-0.95	47.51	66.34	0.96	1.58	0.39
SO4	FAL	29	1.45	1.4	0.77	-3.67	30.78	-0.05	0.45	0.37	17.13	1.74	-0.04	42.91	32.36	0.32	0.61	0.59
SO4	ALL	110	1.95	1.5	0.68	-22.95	37.47	-0.45	0.73	0.83	-0.59	-20.82	-0.3	46.79	42.04	0.49	1.02	0.46

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: VILA1																		
EC	WIN	28	0.21	0.33	0.35	53.84	68.36	0.12	0.15	0.03	73.63	41.37	0.54	82.09	51.67	0.68	0.2	0.12
EC	SPR	28	0.26	0.29	0.69	10.22	34.88	0.03	0.09	0.02	17.34	5.93	0.1	40.31	35.36	0.35	0.13	0.48
EC	SUM	29	0.31	0.31	0.56	-0.3	33.14	0	0.1	0.02	17.68	7.12	0	39.11	33.23	0.33	0.14	0.31
EC	FAL	30	0.29	0.31	0.65	6.96	27.54	0.02	0.08	0.01	12.07	5.66	0.07	28.21	24.92	0.28	0.12	0.43
EC	ALL	115	0.27	0.31	0.51	14.66	38.75	0.04	0.11	0.02	29.75	14.79	0.15	47.02	36.07	0.39	0.15	0.26
NO3	WIN	28	3.23	2.7	0.7	-16.61	30.54	-0.54	0.99	1.53	-7.16	-16.74	-0.2	32.94	35.64	0.37	1.35	0.49
NO3	SPR	30	2.05	2.17	0.9	5.89	35.51	0.12	0.73	1.08	5.56	-12.81	0.06	50.22	50.68	0.36	1.05	0.80
NO3	SUM	25	0.34	0.29	0.61	-16.63	49.84	-0.06	0.17	0.06	-11.34	-29.27	-0.2	50.94	59.09	0.6	0.26	0.37
NO3	FAL	30	0.88	1.42	0.97	60.96	65.69	0.54	0.58	0.42	78.68	37.88	0.61	93.36	56.68	0.66	0.84	0.94
NO3	ALL	113	1.66	1.69	0.87	1.76	38.03	0.03	0.63	0.94	18.08	-3.97	0.02	57.55	50.4	0.38	0.97	0.76
OC	WIN	28	0.81	0.95	0.33	18.13	43.8	0.15	0.35	0.39	20.5	6.23	0.18	42.9	34.66	0.44	0.64	0.11
OC	SPR	28	1.19	0.9	0.63	-24.17	41.78	-0.29	0.5	0.39	-18.68	-31.72	-0.32	38.52	47.76	0.55	0.69	0.39
OC	SUM	29	1.42	1.35	0.86	-4.65	26.97	-0.07	0.38	0.2	-5.48	-12.63	-0.05	30.09	33.36	0.28	0.46	0.74
OC	FAL	30	1.07	0.9	0.86	-15.35	27.19	-0.16	0.29	0.1	-17.58	-24.91	-0.18	29.84	35.15	0.32	0.35	0.74
OC	ALL	115	1.12	1.03	0.7	-8.34	33.8	-0.09	0.38	0.29	-5.53	-15.89	-0.09	35.2	37.65	0.37	0.55	0.50
PM-2.5	WIN	28	8.45	7.81	0.59	-7.53	28.83	-0.64	2.44	9.37	-0.67	-7.31	-0.08	29.17	28.52	0.31	3.13	0.35
PM-2.5	SPR	31	8.37	8.15	0.79	-2.59	29.71	-0.22	2.49	12.03	0.1	-6.96	-0.03	30.71	30.74	0.31	3.48	0.63
PM-2.5	SUM	29	8.33	6.83	0.88	-17.99	24.78	-1.5	2.06	3.71	-13.25	-18.34	-0.22	26.69	29.58	0.3	2.44	0.77
PM-2.5	FAL	30	6.33	6.88	0.9	8.62	23.4	0.55	1.48	3.52	11.98	6.03	0.09	27.89	24.14	0.23	1.95	0.81
PM-2.5	ALL	118	7.86	7.42	0.79	-5.57	26.91	-0.44	2.12	7.74	-0.34	-6.54	-0.06	28.64	28.25	0.28	2.82	0.62
SO4	WIN	28	1.42	0.95	0.48	-33.18	48.1	-0.47	0.68	0.6	-24.82	-39.25	-0.5	40.64	51.41	0.72	0.91	0.23
SO4	SPR	30	1.89	1.63	0.74	-14.06	31.47	-0.27	0.6	0.84	-11.47	-18	-0.16	26.47	30.19	0.37	0.95	0.55
SO4	SUM	25	1.97	1.53	0.78	-22.56	31.74	-0.44	0.63	0.51	-5.26	-19.47	-0.29	40.21	39.39	0.41	0.84	0.61
SO4	FAL	30	1.2	1.06	0.84	-11.93	32.04	-0.14	0.39	0.42	17.19	6.45	-0.14	39.28	33.74	0.36	0.67	0.71
SO4	ALL	113	1.61	1.29	0.72	-20.12	35.29	-0.32	0.57	0.61	-5.79	-17.1	-0.25	36.42	38.42	0.44	0.85	0.52

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: VOYA2																		
EC	WIN	29	0.1	0.21	0.63	108	113	0.11	0.11	0.06	235.75	54.32	1.08	241.95	62.2	1.13	0.27	0.39
EC	SPR	31	0.09	0.09	0.62	8.34	47.73	0.01	0.04	0	17.65	-0.54	0.08	51.3	44.85	0.48	0.06	0.39
EC	SUM	23	0.13	0.11	0.63	-14.23	32.46	-0.02	0.04	0	12.48	-14.5	-0.17	52.62	38.83	0.38	0.06	0.40
EC	FAL	29	0.16	0.23	0.57	48.18	68.75	0.08	0.11	0.06	53.8	26.35	0.48	66.05	42.08	0.69	0.26	0.32
EC	ALL	112	0.12	0.16	0.55	39.57	66.31	0.05	0.08	0.04	82.42	17.76	0.4	104.76	47.39	0.66	0.2	0.31
NO3	WIN	19	0.84	1.34	0.94	60.42	61.32	0.51	0.51	0.2	263.15	50.89	0.6	271	61.83	0.61	0.68	0.89
NO3	SPR	5	0.86	0.51	0.96	-40.3	40.45	-0.35	0.35	0.21	-33.58	-54.05	-0.67	42.23	61.86	0.68	0.58	0.91
NO3	SUM	19	0.05	0.06	0.81	33.36	95.3	0.02	0.04	0.01	-18.46	-53.72	0.33	70.22	78.59	0.95	0.11	0.66
NO3	FAL	29	0.32	0.7	0.96	121.28	126.08	0.39	0.4	0.4	155.42	45.46	1.21	180.29	81.77	1.26	0.74	0.92
NO3	ALL	72	0.42	0.69	0.9	63.88	79.05	0.27	0.33	0.3	124.84	13.81	0.64	165.59	74.29	0.79	0.61	0.80
OC	WIN	29	0.49	0.98	0.54	98.7	100.23	0.49	0.5	1.27	126.44	48.35	0.99	128.41	50.59	1	1.23	0.29
OC	SPR	31	0.51	0.45	0.48	-11.33	41.36	-0.06	0.21	0.09	5.19	-8.65	-0.13	43.71	40.85	0.47	0.31	0.23
OC	SUM	23	1.22	0.81	0.44	-33.87	42.29	-0.41	0.52	0.56	-26.64	-37.74	-0.51	35.97	45.8	0.64	0.85	0.20
OC	FAL	29	0.91	1.04	0.22	13.89	61.93	0.13	0.56	1.68	42.38	10.58	0.14	66.56	44.81	0.62	1.3	0.05
OC	ALL	112	0.76	0.81	0.27	7.66	58.03	0.06	0.44	1	39.68	5.11	0.08	69.97	45.42	0.58	1	0.07
PM-2.5	WIN	29	3.39	5.32	0.77	56.87	61.97	1.93	2.1	12.43	64.21	33.42	0.57	71.64	42.26	0.62	4.02	0.59
PM-2.5	SPR	31	3.27	3.24	0.75	-0.67	31.87	-0.02	1.04	2.25	6	-2.93	-0.01	33.55	31.73	0.32	1.5	0.57
PM-2.5	SUM	23	4.47	3.2	0.76	-28.36	28.51	-1.27	1.27	2.17	-26.53	-33.42	-0.4	26.6	33.49	0.4	1.94	0.57
PM-2.5	FAL	30	3.77	4.73	0.65	25.44	53.23	0.96	2.01	12.89	58.07	25.6	0.25	75.62	49.39	0.53	3.72	0.42
PM-2.5	ALL	113	3.68	4.16	0.66	13.2	43.97	0.49	1.62	8.96	28.14	7.77	0.13	53.08	39.48	0.44	3.03	0.43
SO4	WIN	19	0.86	0.64	0.74	-25.86	34.97	-0.22	0.3	0.26	-12.16	-19.19	-0.35	25.94	30.96	0.47	0.56	0.55
SO4	SPR	5	0.75	0.7	0.88	-6.81	42.52	-0.05	0.32	0.21	252.07	22.89	-0.07	276	54.1	0.46	0.46	0.77
SO4	SUM	19	0.89	0.95	0.88	6.34	37.36	0.06	0.33	0.21	43.88	22.07	0.06	59.7	41.78	0.37	0.46	0.77
SO4	FAL	30	0.72	0.9	0.79	25.36	44.11	0.18	0.32	0.15	124.84	33.07	0.25	138.35	49.48	0.44	0.43	0.63
SO4	ALL	73	0.8	0.83	0.77	3.47	39.5	0.03	0.32	0.22	76.82	15.91	0.03	98.05	42.97	0.39	0.47	0.59

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O (µg/m^3)	MEAN_P (µg/m^3)	r unitless	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)	VAR (µg/m^3)^2	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: WASH1																		
EC	WIN	27	0.88	2.05	0.69	132.77	132.77	1.17	1.17	0.42	142.45	76.48	1.33	142.45	76.48	1.33	1.33	0.48
EC	SPR	24	0.77	1.1	0.29	41.63	47.68	0.32	0.37	0.15	58.08	34.99	0.42	62.33	39.49	0.48	0.5	0.08
EC	SUM	26	1.01	1.21	0.44	19.15	40.14	0.19	0.41	0.2	31.76	20.57	0.19	44.99	36.52	0.4	0.49	0.19
EC	FAL	23	0.77	1.62	0.83	110.84	110.84	0.85	0.85	0.27	137.95	73.95	1.11	137.95	73.95	1.11	0.99	0.68
EC	ALL	100	0.86	1.5	0.5	73.96	81.68	0.64	0.7	0.42	92.39	51.4	0.74	96.85	56.63	0.82	0.91	0.25
NO3	WIN	27	1.83	2.81	0.63	53.84	63.69	0.98	1.16	1.43	98.35	44.19	0.54	107.62	58.83	0.64	1.55	0.39
NO3	SPR	24	0.72	0.95	0.65	31.48	56	0.23	0.4	0.41	51.98	9.1	0.31	82.28	52.01	0.56	0.68	0.42
NO3	SUM	26	0.37	0.14	0.33	-60.48	70.99	-0.22	0.26	0.06	-53.22	-90.2	-1.53	67.35	99.76	1.8	0.32	0.11
NO3	FAL	23	0.63	1.23	0.88	97.28	103.75	0.61	0.65	1.05	74.56	40.88	0.97	81.96	49.36	1.04	1.19	0.77
NO3	ALL	100	0.91	1.31	0.76	44.42	69.35	0.4	0.63	0.95	42.34	0.07	0.44	85.17	65.66	0.69	1.05	0.58
OC	WIN	27	1.81	5.89	0.55	224.52	224.52	4.07	4.07	4.36	265.75	106.85	2.25	265.75	106.85	2.25	4.58	0.30
OC	SPR	24	1.51	2.17	0.11	44.17	66.78	0.67	1.01	1.65	76.23	32.77	0.44	89.66	48.9	0.67	1.45	0.01
OC	SUM	26	2.3	2.23	0.8	-3.05	22.47	-0.07	0.52	0.36	1.26	-3.25	-0.03	25.69	24.77	0.23	0.6	0.65
OC	FAL	23	1.67	2.86	0.65	70.88	78.47	1.19	1.31	2.32	88.31	48.79	0.71	92.97	54.17	0.78	1.93	0.42
OC	ALL	100	1.83	3.35	0.36	82.58	96.94	1.51	1.78	4.82	110.69	47.09	0.83	121.33	59.49	0.97	2.67	0.13
PM-2.5	WIN	27	8.78	20.3	0.83	131.28	131.28	11.52	11.52	22.5	140.89	79.47	1.31	140.89	79.47	1.31	12.46	0.68
PM-2.5	SPR	24	8.44	10.21	0.16	20.98	46.12	1.77	3.89	22.48	37.44	19.45	0.21	53.95	39.96	0.46	5.06	0.02
PM-2.5	SUM	25	12.06	10.07	0.86	-16.51	19.68	-1.99	2.37	5.45	-14.66	-17.78	-0.2	18.83	21.66	0.24	3.07	0.74
PM-2.5	FAL	23	7.24	12.01	0.66	65.85	66.93	4.77	4.85	27.63	74.61	46.27	0.66	75.49	47.18	0.67	7.1	0.44
PM-2.5	ALL	99	9.17	13.34	0.39	45.56	63.39	4.18	5.81	45.2	61.14	32.65	0.46	73.8	47.79	0.63	7.91	0.15
SO4	WIN	27	1.69	1.59	0.38	-5.59	35.52	-0.09	0.6	0.54	-2.7	-10.41	-0.06	34.12	34.04	0.38	0.74	0.14
SO4	SPR	24	2.26	1.88	0.49	-16.94	31.48	-0.38	0.71	0.76	-11.5	-19.27	-0.2	30.19	33.64	0.38	0.95	0.24
SO4	SUM	26	3.35	2.61	0.81	-22.18	29.39	-0.74	0.98	1.33	-16.36	-23.07	-0.29	27.33	32.6	0.38	1.37	0.66
SO4	FAL	23	1.55	1.51	0.78	-2.55	24.12	-0.04	0.37	0.22	5.94	1.09	-0.03	26.71	26.01	0.25	0.47	0.62
SO4	ALL	100	2.22	1.9	0.76	-14.37	30.31	-0.32	0.67	0.81	-6.38	-13.18	-0.17	29.71	31.72	0.35	0.95	0.57

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: WHIT1																		
EC	WIN	26	0.05	0.07	0.44	41.11	70.05	0.02	0.04	0	169.46	46.95	0.41	179.66	59.39	0.7	0.06	0.19
EC	SPR	27	0.06	0.23	0.1	279.4	317.98	0.17	0.19	0.65	889.47	42.9	2.79	908.59	66.3	3.18	0.82	0.01
EC	SUM	25	0.18	0.23	0.92	25.78	71.86	0.05	0.13	0.07	43.04	-12.68	0.26	95.77	57.48	0.72	0.27	0.85
EC	FAL	27	0.09	0.08	0.66	-8.83	36.88	-0.01	0.03	0	94.68	-6.98	-0.1	130.96	40.65	0.4	0.04	0.43
EC	ALL	105	0.1	0.15	0.44	60.74	103.19	0.06	0.1	0.19	305.27	17.84	0.61	334.6	55.89	1.03	0.44	0.19
NO3	WIN	26	0.18	0.13	0.19	-28.68	99.72	-0.05	0.18	0.13	-25.16	-84.06	-0.4	90.91	101.38	1.4	0.37	0.04
NO3	SPR	28	0.2	0.04	0.52	-80.96	80.96	-0.16	0.16	0.01	-74.26	-123.32	-4.25	74.26	123.32	4.25	0.2	0.27
NO3	SUM	25	0.17	0.03	0.82	-84.34	84.34	-0.14	0.14	0.01	-82.69	-142.87	-5.39	82.69	142.87	5.39	0.18	0.66
NO3	FAL	27	0.1	0.03	0.91	-66.83	66.83	-0.07	0.07	0.01	-59.12	-89.06	-2.01	59.12	89.06	2.01	0.12	0.82
NO3	ALL	106	0.16	0.06	0.22	-65.33	84.6	-0.11	0.14	0.04	-60.35	-109.57	-1.88	76.48	113.82	2.44	0.24	0.05
OC	WIN	26	0.25	0.26	0.2	3.38	62.34	0.01	0.16	0.06	160.31	8.92	0.03	195.84	56.7	0.62	0.25	0.04
OC	SPR	28	0.59	1.02	0.06	71.63	169.35	0.42	1	13.94	173.43	-49.17	0.72	255.73	66.2	1.69	3.76	0.00
OC	SUM	25	1.39	1.43	0.79	2.64	69.15	0.04	0.96	2.46	9.99	-19.19	0.03	68.06	64.37	0.69	1.57	0.63
OC	FAL	27	0.42	0.46	0.74	10.46	42.75	0.04	0.18	0.06	11.31	-3.46	0.1	46.73	44.35	0.43	0.26	0.55
OC	ALL	106	0.65	0.79	0.41	20.48	88.15	0.13	0.58	4.32	90.37	-16.21	0.2	143.54	57.87	0.88	2.08	0.17
PM-2.5	WIN	26	2.4	1.94	0.02	-19.08	63.86	-0.46	1.53	10.71	43.56	9.75	-0.24	69.11	47.61	0.79	3.3	0.00
PM-2.5	SPR	28	8.33	3.88	0.06	-53.42	85.65	-4.45	7.13	94.69	-36.86	-80.4	-1.15	77.15	96.28	1.84	10.7	0.00
PM-2.5	SUM	24	6.7	4.42	0.79	-33.99	47.64	-2.28	3.19	11.86	-39.47	-58.17	-0.51	45.92	63.52	0.72	4.13	0.62
PM-2.5	FAL	27	3.38	2.43	0.49	-28.05	39.26	-0.95	1.33	2.51	-23.81	-35.09	-0.39	37.79	46.31	0.55	1.85	0.24
PM-2.5	ALL	105	5.22	3.15	0.29	-39.57	64.27	-2.06	3.35	33.74	-14.19	-41.34	-0.65	57.9	63.89	1.06	6.16	0.08
SO4	WIN	26	0.7	0.48	0.24	-31.41	78.81	-0.22	0.55	1.53	74.43	26.37	-0.46	101.12	65.9	1.15	1.26	0.06
SO4	SPR	28	1.8	0.54	0.33	-69.73	70.18	-1.25	1.26	1.68	-51.89	-80.71	-2.3	53.75	82.41	2.32	1.8	0.11
SO4	SUM	25	1.12	0.65	0.61	-41.67	44.9	-0.47	0.5	0.07	-42.84	-60.73	-0.71	46.83	63.92	0.77	0.54	0.38
SO4	FAL	27	0.73	0.58	0.52	-20.52	42.7	-0.15	0.31	0.19	-6.39	-21.64	-0.26	43.39	45.51	0.54	0.47	0.27
SO4	ALL	106	1.1	0.56	0.25	-48.62	60.78	-0.53	0.67	1.09	-7.18	-34.69	-0.95	61.1	64.6	1.18	1.17	0.06

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: WHPE1																		
EC	WIN	20	0.03	0.04	0.47	32	55.94	0.01	0.02	0	80.3	37.29	0.32	93.91	54.52	0.56	0.02	0.22
EC	SPR	28	0.06	0.04	0.42	-33.73	60.21	-0.02	0.04	0.01	28.72	-0.29	-0.51	66.73	52.72	0.91	0.09	0.18
EC	SUM	31	0.12	0.13	0.64	5.35	70.5	0.01	0.09	0.02	20.23	-11.52	0.05	69.52	54.43	0.7	0.15	0.41
EC	FAL	21	0.06	0.05	0.29	-20.67	39.31	-0.01	0.02	0	-4.99	-16.53	-0.26	37.51	40.54	0.5	0.03	0.08
EC	ALL	100	0.07	0.07	0.61	-5.75	61.62	0	0.05	0.01	29.32	0.34	-0.06	66.89	51.05	0.65	0.1	0.37
NO3	WIN	20	0.09	0.06	0.7	-33.27	52.89	-0.03	0.05	0	-44.03	-72.84	-0.5	55.73	81.84	0.79	0.07	0.49
NO3	SPR	28	0.16	0.04	0.6	-71.77	71.77	-0.11	0.11	0.01	-71.38	-117.25	-2.54	71.38	117.25	2.54	0.13	0.36
NO3	SUM	31	0.14	0.03	0.7	-79.87	79.87	-0.11	0.11	0.01	-78.63	-133.78	-3.97	78.63	133.78	3.97	0.14	0.49
NO3	FAL	21	0.07	0.03	0.26	-57.37	76.98	-0.04	0.06	0	-48.08	-89.45	-1.35	68.34	102.72	1.81	0.07	0.07
NO3	ALL	100	0.12	0.04	0.52	-67.44	72.74	-0.08	0.09	0.01	-63.27	-107.65	-2.07	69.86	112.24	2.23	0.12	0.27
OC	WIN	19	0.11	0.15	0.53	36.34	62.77	0.04	0.07	0	421.81	49.84	0.36	436.44	68.91	0.63	0.08	0.28
OC	SPR	28	0.24	0.16	0.52	-36.41	49.99	-0.09	0.12	0.02	59.73	-29.2	-0.57	123.49	58.06	0.79	0.16	0.27
OC	SUM	31	1.14	0.85	0.67	-25.64	43.7	-0.29	0.5	1.07	-10.38	-22.22	-0.34	35.84	42.88	0.59	1.08	0.45
OC	FAL	21	0.29	0.25	0.46	-13.82	57.24	-0.04	0.17	0.06	22.27	-2.55	-0.16	64.95	56.35	0.66	0.25	0.21
OC	ALL	99	0.51	0.39	0.74	-23.07	47	-0.12	0.24	0.37	99.32	-6.19	-0.3	143.69	55.03	0.61	0.62	0.55
PM-2.5	WIN	20	1.08	1.24	0.86	15.21	27.47	0.16	0.3	0.09	22.01	15.87	0.15	31.96	27.34	0.27	0.34	0.74
PM-2.5	SPR	28	2.8	1.76	0.71	-37.35	42.32	-1.05	1.19	1.58	-26.98	-37.82	-0.6	38.44	46.96	0.68	1.64	0.50
PM-2.5	SUM	31	4.29	2.75	0.78	-35.89	37.34	-1.54	1.6	4.41	-34.36	-47.02	-0.56	36.51	49.05	0.58	2.6	0.60
PM-2.5	FAL	21	1.9	1.45	0.42	-23.46	40.98	-0.45	0.78	1.17	-5.07	-18.14	-0.31	41.61	43.89	0.54	1.17	0.18
PM-2.5	ALL	100	2.73	1.9	0.78	-30.44	38.53	-0.83	1.05	2.47	-14.87	-25.8	-0.44	37.21	43.04	0.55	1.78	0.60
SO4	WIN	20	0.22	0.42	0.66	96.3	103.43	0.21	0.22	0.02	141.47	72.31	0.96	144.38	75.63	1.03	0.24	0.44
SO4	SPR	28	0.48	0.47	0.51	-2.62	38.44	-0.01	0.18	0.07	18.99	6.72	-0.03	42.95	36.16	0.39	0.27	0.26
SO4	SUM	31	0.61	0.43	0.77	-29.24	32.43	-0.18	0.2	0.04	-28.64	-38.59	-0.41	33.04	42.62	0.46	0.26	0.59
SO4	FAL	21	0.44	0.38	0.55	-15.08	32.48	-0.07	0.14	0.04	0.36	-9.89	-0.18	35.54	36.06	0.38	0.21	0.30
SO4	ALL	100	0.46	0.43	0.56	-6.9	40.82	-0.03	0.19	0.06	24.81	2.31	-0.07	58.61	46.03	0.44	0.25	0.32

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: WHRI1																		
EC	WIN	29	0.03	0.05	0.35	56.23	80.45	0.02	0.03	0	121.3	47.77	0.56	135.55	65.19	0.8	0.04	0.12
EC	SPR	30	0.05	0.04	0.13	-14.19	55.58	-0.01	0.03	0	22.45	-2.01	-0.17	61.39	50.95	0.65	0.04	0.02
EC	SUM	28	0.09	0.07	0.96	-21.39	30.45	-0.02	0.03	0	-8.61	-17.45	-0.27	32.41	35.26	0.39	0.04	0.92
EC	FAL	27	0.07	0.07	0.28	3.2	65.6	0	0.04	0.01	23.74	-4.07	0.03	65.66	53.24	0.66	0.08	0.08
EC	ALL	114	0.06	0.06	0.68	-1.48	52.89	0	0.03	0	40.27	6.37	-0.02	74.15	51.26	0.54	0.05	0.46
NO3	WIN	29	0.08	0.07	0.66	-11.59	62.91	-0.01	0.05	0.01	-9.23	-55.89	-0.13	79.03	81.28	0.71	0.07	0.44
NO3	SPR	31	0.15	0.04	0.42	-75.39	77.55	-0.11	0.11	0.01	-71.86	-121.7	-3.06	74.44	123.85	3.15	0.15	0.18
NO3	SUM	28	0.1	0.01	0.63	-90.44	90.44	-0.09	0.09	0	-89.18	-162.26	-9.46	89.18	162.26	9.46	0.1	0.39
NO3	FAL	30	0.06	0.05	0.33	-12.43	112.75	-0.01	0.07	0.02	-23.22	-94.06	-0.14	102.59	121.12	1.29	0.14	0.11
NO3	ALL	118	0.1	0.04	0.23	-56.65	83.53	-0.05	0.08	0.01	-48.21	-108.12	-1.31	86.22	121.81	1.93	0.12	0.05
OC	WIN	23	0.11	0.19	0.42	77.04	101.41	0.08	0.11	0.02	2948.58	55.96	0.77	2962.18	74.06	1.01	0.16	0.17
OC	SPR	29	0.16	0.15	0.15	-2.16	63.11	0	0.1	0.02	59.71	9.52	-0.02	98.65	62.12	0.64	0.15	0.02
OC	SUM	28	0.63	0.48	0.9	-23.97	38.18	-0.15	0.24	0.1	-8.04	-19.22	-0.32	38.25	40.65	0.5	0.36	0.80
OC	FAL	27	0.24	0.34	0.53	42.81	76.22	0.1	0.18	0.08	100.66	28.99	0.43	127.32	63.76	0.76	0.3	0.28
OC	ALL	107	0.29	0.29	0.77	1.2	54.81	0	0.16	0.07	673.29	16.89	0.01	705.6	59.48	0.55	0.26	0.60
PM-2.5	WIN	29	0.89	1.09	0.9	22.53	32.37	0.2	0.29	0.07	40.49	25.82	0.23	49.37	36.21	0.32	0.34	0.81
PM-2.5	SPR	31	2.65	1.3	0.61	-50.75	52.55	-1.34	1.39	3.63	-35.29	-50.66	-1.03	39.02	54.07	1.07	2.33	0.37
PM-2.5	SUM	24	3.22	1.63	0.87	-49.33	50.27	-1.59	1.62	1.29	-44.95	-63.01	-0.97	47.27	65.23	0.99	1.95	0.76
PM-2.5	FAL	30	1.58	1.39	0.43	-11.63	43.38	-0.18	0.68	1	0.78	-18.49	-0.13	49.46	47.08	0.49	1.02	0.18
PM-2.5	ALL	114	2.04	1.34	0.6	-34.2	47.69	-0.7	0.97	2.1	-8.55	-25.34	-0.52	46.14	50.03	0.72	1.61	0.36
SO4	WIN	29	0.17	0.37	0.36	112.41	128.67	0.19	0.22	0.03	168.02	78.19	1.12	173.28	84.62	1.29	0.25	0.13
SO4	SPR	31	0.38	0.4	0.48	4.9	48.24	0.02	0.18	0.09	36.16	14.89	0.05	57.87	42.16	0.48	0.31	0.23
SO4	SUM	28	0.48	0.31	0.59	-35.66	39.95	-0.17	0.19	0.02	-27.29	-40.88	-0.55	41.87	50.9	0.62	0.22	0.35
SO4	FAL	30	0.33	0.35	0.51	4.92	37.24	0.02	0.12	0.02	23.01	5.73	0.05	49.51	40.84	0.37	0.16	0.26
SO4	ALL	118	0.34	0.36	0.37	4.83	52.8	0.02	0.18	0.06	50.17	14.88	0.05	80.31	54.33	0.53	0.24	0.14

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: WICA1																		
EC	WIN	26	0.08	0.36	0.27	354.49	380.38	0.28	0.3	0.34	340.73	60.57	3.54	359.06	83.7	3.8	0.65	0.07
EC	SPR	31	0.06	0.1	0.3	61.91	93.79	0.04	0.06	0.03	68.13	7.77	0.62	97.35	45.87	0.94	0.19	0.09
EC	SUM	31	0.13	0.18	0.89	40.27	73	0.05	0.1	0.04	18.51	-3.37	0.4	53.61	41.65	0.73	0.21	0.78
EC	FAL	21	0.1	0.21	0.01	107.96	136.28	0.11	0.14	0.14	234.41	27.97	1.08	255.83	56.04	1.36	0.39	0.00
EC	ALL	109	0.09	0.21	0.3	121.81	152.07	0.12	0.14	0.14	151.08	21.09	1.22	177.87	55.65	1.52	0.39	0.09
NO3	WIN	26	0.23	0.46	0.56	105.48	144.25	0.24	0.33	0.16	187.16	41.19	1.05	225.57	96.55	1.44	0.46	0.31
NO3	SPR	31	0.44	0.53	0.72	19.42	62.32	0.09	0.28	0.2	121.44	3.72	0.19	165.51	70.77	0.62	0.45	0.51
NO3	SUM	31	0.11	0.06	0.56	-47.68	68.06	-0.05	0.07	0.01	-51.93	-94.01	-0.91	72.13	104.81	1.3	0.09	0.31
NO3	FAL	21	0.17	0.21	0.7	20.19	95.05	0.03	0.16	0.07	55.93	-36.58	0.2	143.78	96.71	0.95	0.27	0.49
NO3	ALL	109	0.24	0.32	0.7	30.28	85.62	0.07	0.21	0.12	75.19	-22.9	0.3	149.09	91.6	0.86	0.35	0.48
OC	WIN	26	0.33	1.52	0.21	356.98	400.86	1.19	1.33	6.48	382.64	57.37	3.57	404.84	87.16	4.01	2.81	0.05
OC	SPR	31	0.37	0.4	0.33	8	79.78	0.03	0.3	0.63	22.82	-29.39	0.08	89.72	61.33	0.8	0.79	0.11
OC	SUM	31	1.11	1.03	0.86	-7.68	54.33	-0.09	0.6	0.84	-21.87	-38.86	-0.08	47.72	57.06	0.59	0.92	0.74
OC	FAL	21	0.57	0.94	0.01	64.43	120.87	0.37	0.69	3.05	433.51	9.07	0.64	475.95	67.95	1.21	1.79	0.00
OC	ALL	109	0.61	0.95	0.28	55.29	115.64	0.34	0.71	2.8	175.06	-3.98	0.55	227.35	67.55	1.16	1.71	0.08
PM-2.5	WIN	26	1.83	4.65	0.2	154.65	173.64	2.83	3.17	31.62	192.18	52.39	1.55	203.25	65.43	1.74	6.29	0.04
PM-2.5	SPR	31	2.89	2.87	0.55	-0.58	46.41	-0.02	1.34	5.06	11.82	-12.12	-0.01	57.22	47.34	0.47	2.25	0.31
PM-2.5	SUM	27	4.22	3.26	0.65	-22.88	44.82	-0.97	1.89	5.28	-26.65	-40.15	-0.3	41.52	50.58	0.58	2.49	0.43
PM-2.5	FAL	19	2.46	3.57	0.04	45.12	79.43	1.11	1.95	18.45	86.81	11.8	0.45	116.35	48.96	0.79	4.44	0.00
PM-2.5	ALL	103	2.89	3.55	0.23	22.83	71.29	0.66	2.06	16.34	61.1	1.23	0.23	100.88	53.05	0.71	4.1	0.05
SO4	WIN	26	0.56	0.47	0.43	-15.15	51.86	-0.08	0.29	0.2	33.91	12.2	-0.18	62.29	51.73	0.61	0.46	0.19
SO4	SPR	31	0.72	0.67	0.66	-6.84	36.04	-0.05	0.26	0.14	24.93	0.93	-0.07	55.41	39.78	0.39	0.38	0.43
SO4	SUM	31	0.71	0.55	0.6	-22.71	26.94	-0.16	0.19	0.03	-18.27	-23.18	-0.29	25.14	29.06	0.35	0.24	0.36
SO4	FAL	21	0.5	0.54	0.78	7.48	27.4	0.04	0.14	0.03	18.05	9.51	0.07	33.87	28.14	0.27	0.18	0.61
SO4	ALL	109	0.64	0.56	0.59	-11.46	35.15	-0.07	0.22	0.11	13.46	-1.59	-0.13	44.29	37.34	0.4	0.34	0.35

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

Table A3. 2011 Model Performance Results by Pollutant and Season - IMPROVE Sites

Pollutant	Quarter	N	MEAN_O ($\mu g/m^3$)	MEAN_P ($\mu g/m^3$)	r unitless	NMB (%)	NME (%)	MB ($\mu g/m^3$)	ME ($\mu g/m^3$)	VAR $(\mu g/m^3)^2$	MNB (%)	MFB (%)	NMFB unitless	MNGE (%)	MFE (%)	NMFE unitless	RMSE unitless	RSQR (%)
IMPROVE Monitoring Station: WIMO1																		
EC	WIN	27	0.22	0.22	0.7	-0.69	31.46	0	0.07	0.01	17.98	1.86	-0.01	44.84	34.44	0.32	0.09	0.49
EC	SPR	28	0.28	0.32	0.66	11.05	52.33	0.03	0.15	0.07	10.04	-6.24	0.11	47.32	42.32	0.52	0.26	0.43
EC	SUM	30	0.17	0.15	0.65	-9.06	35.9	-0.02	0.06	0.01	7.33	-2.62	-0.1	38.75	36.11	0.39	0.08	0.42
EC	FAL	29	0.25	0.4	0.56	62.08	85.44	0.15	0.21	0.39	34.19	2.46	0.62	61.73	37.77	0.85	0.65	0.32
EC	ALL	114	0.23	0.27	0.54	18.36	53.36	0.04	0.12	0.12	17.35	-1.15	0.18	48.14	37.66	0.53	0.36	0.30
NO3	WIN	27	1.94	1	0.54	-48.18	61.62	-0.93	1.19	2.52	-20.98	-47.95	-0.93	59.16	67.03	1.19	1.84	0.29
NO3	SPR	28	0.89	0.59	0.89	-33.69	52.64	-0.3	0.47	0.33	-55.02	-94.41	-0.51	61.82	100.06	0.79	0.64	0.79
NO3	SUM	31	0.3	0.03	0.26	-88.48	88.48	-0.27	0.27	0.03	-84.25	-148.54	-7.68	84.25	148.54	7.68	0.31	0.07
NO3	FAL	29	0.42	0.2	0.67	-52.97	64.49	-0.22	0.27	0.25	-49.96	-80.91	-1.13	57.59	87.48	1.37	0.55	0.45
NO3	ALL	115	0.86	0.44	0.68	-48.94	62.25	-0.42	0.53	0.82	-53.63	-94.69	-0.96	66.17	102.2	1.22	1	0.47
OC	WIN	27	0.87	0.72	0.52	-18.06	42.7	-0.16	0.37	0.19	-3.87	-21.45	-0.22	48.47	47.29	0.52	0.46	0.27
OC	SPR	28	1.81	1.3	0.54	-28.08	56.98	-0.51	1.03	1.72	-25.46	-48.04	-0.39	54.35	65.22	0.79	1.41	0.29
OC	SUM	31	1.47	1.28	0.67	-12.63	35.67	-0.19	0.52	0.42	-8.09	-18.6	-0.14	37.29	39.74	0.41	0.67	0.45
OC	FAL	29	1.2	1.65	0.73	38.08	71.33	0.46	0.85	6.7	3.3	-21.06	0.38	52.26	49.03	0.71	2.63	0.54
OC	ALL	115	1.34	1.25	0.63	-7.13	51.74	-0.1	0.7	2.39	-8.45	-27.06	-0.08	47.84	50.06	0.56	1.55	0.40
PM-2.5	WIN	27	6.42	5.48	0.86	-14.73	34.28	-0.95	2.2	8.9	14.86	-0.66	-0.17	45.1	36.22	0.4	3.13	0.73
PM-2.5	SPR	28	9.27	6.6	0.51	-28.8	45.3	-2.67	4.2	22.19	-19.99	-36.51	-0.4	44.97	55.11	0.64	5.41	0.26
PM-2.5	SUM	31	8.56	4.85	0.65	-43.35	44.26	-3.71	3.79	4.98	-42.62	-58.99	-0.77	44.42	60.67	0.78	4.33	0.43
PM-2.5	FAL	29	5.35	6.43	0.57	20.36	51.52	1.09	2.75	41.72	15.42	-6.72	0.2	52.55	41.79	0.52	6.55	0.33
PM-2.5	ALL	115	7.42	5.82	0.48	-21.53	43.87	-1.6	3.26	22.76	-8.98	-26.64	-0.27	46.76	48.82	0.56	5.03	0.23
SO4	WIN	27	1.57	1.05	0.71	-33.16	39.66	-0.52	0.62	0.84	-13.64	-25.83	-0.5	36.82	44.2	0.59	1.05	0.50
SO4	SPR	28	2.1	1.42	0.72	-32.48	38.51	-0.68	0.81	0.83	-21.03	-31.46	-0.48	33.81	40.9	0.57	1.14	0.52
SO4	SUM	31	1.98	1.09	0.75	-45.07	46.28	-0.89	0.92	0.22	-44.97	-63.26	-0.82	47.77	65.61	0.84	1.01	0.56
SO4	FAL	29	1.12	1.04	0.84	-7.2	25.97	-0.08	0.29	0.14	3.12	-6.65	-0.08	34.41	33.22	0.28	0.38	0.70
SO4	ALL	115	1.7	1.15	0.72	-32.38	39.12	-0.55	0.66	0.59	-19.66	-32.45	-0.48	38.43	46.4	0.58	0.94	0.52

N: Number of observations
MEAN_O: Average of the observed values
MEAN_P: Average of the modeled values
r: Pearson correlation coefficient
NMB: Normalized Mean Bias
NME: Normalized Mean Error
MB: Mean Bias
ME: Mean Error
VAR: Variance
MNB: Mean Normalized Bias
MFB: Mean Fractional Bias
NMBF: Normalized Mean Bias Fraction
MNGE: Mean Normalized Gross Factor
MFE: Mean Fractional Error
NMEF: Normalized Mean Error Fraction
RMSE: Root Mean Squared Error
RSQR: r-squared

WIN = Winter; SPR = Spring; SUM = Summer; FAL = Fall; ALL = all days

This page is intentionally left blank.

Appendix E-4

Deposition Model Performance Evaluation
Southeastern VISTAS II Regional Haze Analysis Project

Revised Final

January 22, 2021

This page intentionally left blank.

Deposition Model Performance Evaluation
Southeastern VISTAS II Regional Haze Analysis Project
(Task 8.1)

Prepared for:

Southeastern States Air Resource Managers, Inc. (SESARM)

1252 W. Government St., #1375

Brandon, MS 39043

Prepared by:

Eastern Research Group, Inc.

1600 Perimeter Park Drive

Suite 200

Morrisville, NC 27560

Final – January 22, 2021

SESARM Contract No. V-2018-03-01

This page is intentionally blank.

TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. APPROACH 2

2.1 Observed Data 3

2.2 Modeled Data 6

2.3 Metrics 7

3. 2011 MODEL PERFORMANCE EVALUATION RESULTS 9

3.1 Wet Deposition 9

3.1.1 Weekly Wet Deposition 9

3.1.2 Accumulated Seasonal Wet Deposition 13

3.1.3 Accumulated Annual Wet Deposition 15

3.2 Dry Deposition 15

3.2.1 Weekly Dry Deposition 17

3.2.2 Accumulated Seasonal Dry Deposition 19

3.2.3 Accumulated Annual Dry Deposition 22

4. COMPARISON TO NADP ANNUAL MAPS 24

Appendix A: Wet Deposition Results

Appendix B: Dry Deposition Results

LIST OF TABLES

Page

Table 2-1. Wet and Dry Deposition Monitoring Network Measurements 5

Table 3-1. Weekly Wet Deposition MPE Metrics for NADP Sites in the VISTAS 12 km Domain 10

Table 3-2. Accumulated Seasonal Wet Deposition MPE Metrics for NADP Sites in the VISTAS 12 km Domain.....13

Table 3-3. Accumulated Annual Wet Deposition MPE Metrics for NADP Sites in the VISTAS 12 km Domain.....15

Table 3-4. Weekly Deposition MPE Metrics for CASTNET Sites in the VISTAS 12 km Domain 17

Table 3-5. Accumulated Seasonal Dry Deposition MPE Metrics for CASTNET Sites in the VISTAS 12 km Domain.....20

Table 3-6. Accumulated Annual Dry Deposition MPE Metrics for CASTNET Sites in the VISTAS 12 km Domain.....22

LIST OF FIGURES

Page

Figure 2-1. Deposition Monitors Included in the VISTAS II Database 4

Figure 3-1. Scatter Plots of Weekly Wet Deposition for NTN Sites in the VISTAS 12 km Domain for NH_4^+ (top), NO_3^+ (bottom left), and SO_4^{2-} (bottom right).....11

Figure 3-2. Scatter Plots of Weekly Wet Deposition for AIRMon Sites in the VISTAS 12 km Domain for NH_4^+ (top), NO_3^+ (bottom left), and SO_4^{2-} (bottom right).....12

Figure 3-3. Scatter Plots of Seasonal Accumulated Wet Deposition for NADP Sites in the VISTAS 12 km Domain for NH_4^+ (top), NO_3^+ (bottom left), and SO_4^{2-} (bottom right)....14

Figure 3-4. Scatter Plots of Annual Accumulated Wet Deposition for NTN Sites in the VISTAS 12 km Domain for NH_4^+ (top), NO_3^+ (bottom left), and SO_4^{2-} (bottom right).....16

Figure 3-5. Scatter Plots of Weekly Dry Deposition for CASTNET Sites in the VISTAS 12 km Domain for Cl^- (top, left), HNO_3 (top middle), SO_2 (top right), NH_4^+ (bottom, left), NO_3^+ (bottom, middle), SO_4^{2-} (bottom right) 18

LIST OF FIGURES (Continued)

Page

Figure 3-6. Scatter Plots of Weekly Dry Deposition for AMoN Sites in the VISTAS 12 km Domain for NH_3 19

Figure 3-7. Scatter Plots of Seasonal Dry Deposition for CASTNET Sites in the VISTAS 12 km Domain for Cl (top, left), HNO_3 (top middle), SO_2 (top right), NH_4^+ (bottom, left), NO_3^+ (bottom, middle), SO_4^{2-} (bottom right) 21

Figure 3-8. Scatter Plots of Annual Accumulated Dry Deposition for CASTNET Sites in the VISTAS 12 km Domain for Cl^- (top, left), HNO_3 (top middle), SO_2 (top right), NH_4^+ (bottom, left), NO_3^+ (bottom, middle), SO_4^{2-} (bottom right) 23

Figure 4-1. Plots of Total Annual Particulate NH_4^+ Wet Deposition. NADP Wet Deposition (top left), SESARM Wet Deposition (top right), Difference (bottom left), Percent Difference (bottom right). 26

Figure 4-2. Plots of Total Annual Particulate NO_3^+ Wet Deposition. NADP Wet Deposition (top left), SESARM Wet Deposition (top right), Difference (bottom left), Percent Difference (bottom right). 27

Figure 4-3. Plots of Total Annual Particulate NH_4^+ Dry Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference (bottom right). 28

Figure 4-4. Plots of Total Annual Particulate NO_3^+ Dry Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference (bottom right). 29

Figure 4-5. Plots of Total Annual Particulate SO_4^{2-} Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference (bottom right). 30

Abbreviations/Acronym List

AIRMon	Atmospheric Integrated Research Monitoring Network
Alpine	Alpine Geophysics, LLC
AMNet	Atmospheric Mercury Network
AMoN	Ammonia Monitoring Network
Ca^{2+}	Calcium
CAMx	Comprehensive Air Quality Model with Extensions
CASTNET	Clean Air Status and Trends Network
CIRA	Cooperative Institute for Research in the Atmosphere
Cl^-	Chloride
CMAQ	Community Multiscale Air Quality Modeling
DJF	December, January, and February (i.e., Winter)
EGU	Electricity Generating Unit
EPA	United States Environmental Protection Agency
EPIC	Environmental Policy Integrated Climate
ERG	Eastern Research Group, Inc.
g	Gram
ha	hectare
Hg	Mercury
HNO_3	Nitric acid
IMPROVE	Interagency Monitoring of Protected Visual Environments
JJA	June, July, and August (i.e., Summer)
K^{2+}	Potassium
kg	Kilogram
km	Kilometer
L	liter
m^2	Square meters
m^3	Cubic meters
MAM	March, April, and May (i.e., Spring)
MB	Mean Bias
MDN	Mercury Deposition Network
ME	Mean Error
MFB	Mean Fractional Bias
MFE	Mean Fractional Error
mg	Milligram
Mg^{2+}	Magnesium
MLM	Multi-Layer Model
MOVES	Motor Vehicle Emissions Simulator
MPE	Model Performance Evaluation
n	Number of samples
Na^{2+}	Sodium
NADP	National Atmospheric Deposition Program
NH_3	Ammonia
NH_4^+	Ammonium
NME	Normalized Mean Error

NMB	Normalized Mean Bias
NO_3^-	Nitrate
NTN	National Trends Network
O	Observed
P	Predicted
PM	Particulate matter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
r	Pearson correlation coefficient
R	Programming software language called *R*
RHR	Regional Haze Rule
RMSE	Root Mean Squared Error
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SO_2	Sulfur dioxide
SO_4^{2-}	Sulfate
SON	September, October, and November (i.e., Fall)
V_d	Deposition velocity
VISTAS	Visibility Improvement - State and Tribal Association of the Southeast

State Abbreviations (used in Appendices A and B)

AL	Alabama
AR	Arkansas
CO	Colorado
FL	Florida
GA	Georgia
IL	Illinois
IN	Indiana
KS	Kansas
KY	Kentucky
LA	Louisiana
MA	Massachusetts
MD	Maryland
ME	Maine
MI	Michigan
MN	Minnesota
MO	Missouri
MS	Mississippi
NC	North Carolina
ND	North Dakota
NE	Nebraska
NH	New Hampshire
NJ	New Jersey
NM	New Mexico
NY	New York
OH	Ohio

OK	Oklahoma
PA	Pennsylvania
SD	South Dakota
TN	Tennessee
TX	Texas
VA	Virginia
VT	Vermont
WI	Wisconsin
WV	West Virginia
WY	Wyoming

1. INTRODUCTION

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

To demonstrate progress toward the improvement goals, the SESARM partners modeled visibility and air quality conditions for a base year of 2011 and future year of 2028. The SESARM VISTAS II Regional Haze modeling analysis was performed by the contractor team Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine). The preparation and modeling were conducted over several contract tasks, including emission inventory development, ambient data collection, Comprehensive Air quality Model with extensions (CAMx) modeling, and model performance evaluation of the base year. The VISTAS II modeling included particulate matter simulations and source apportionment studies using the 12-kilometer (km) grid based on EPA's 2011/2028el modeling platform and preliminary source contribution assessment,[2] updated to include a 12 km subdomain over the VISTAS region and augmented with revisions to electric generating unit (EGU) and non-EGU point source projections. The air quality modeling was conducted using CAMx. A detailed description of the modeling platform can be found in the Task 6 modeling report.

Under Task 8 of the Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project, a thorough model performance evaluation (MPE) was conducted for particulate matter less than or equal to 2.5 microns in aerodynamic diameter ($PM_{2.5}$) species components, coarse particulate matter (PM) and light extinction to examine the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. As part of the study, the modeling team also performed a MPE for weekly wet deposition and weekly dry deposition species collected in under Subtask 4.1. This report documents the MPE for the wet and dry deposition values produced from the base year CAMx modeling of the VISTAS 12 km modeling domain.

2. APPROACH

This task uses the data collected under Subtask 4.1, *Collecting Additional Data (weekly wet deposition and weekly dry deposition)*, to conduct a MPE of the deposition rates modeled

[2] EPA. 2017. Documentation for the EPA's Preliminary 2028 Regional Haze Modeling. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October. Available at: https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

under Subtask 6.2, *2011 Base Year Air Quality Modeling*. The following sections provide an overview of the observed and modeled data used in the analysis. These sections detail the sources of the data and how the data were prepared for the analysis. This includes conversions and aggregation.

2.1 Observed Data

Under Subtask 4.1 weekly wet deposition and weekly dry deposition data were organized into a database for potential use by SESARM states or other parties (e.g., Federal Land Managers) to support other projects such as evaluation of acid deposition in watersheds. These data were used in the deposition MPE.

The primary source for deposition data is the National Atmospheric Deposition Program (NADP).[3] The NADP consists of the following monitoring networks:

- National Trends Network (NTN)
- Atmospheric Integrated Research Monitoring Network (AIRMon)
- Mercury Deposition Network (MDN)
- Atmospheric Mercury Network (AMNet)
- Ammonia Monitoring Network (AMoN)

MDN and AMNet collect mercury data only. As the CAMx run did not utilize chemistry mechanisms for mercury, these sites were not used in the analysis. Dry deposition information is also available from the Clean Air Status and Trends Network (CASTNET). These data were also collected and is available in the Subtask 4.1 deposition database and was utilized for the MPE.

The data from NTN and AIRMon were used in the wet deposition MPE and CASTNET and AMoN were used for dry deposition MPE. The MPE focused on the monitors from these networks within the VISTAS 12 km modeling domain, as it is of the most value to the VISTAS partners for using this modeling for any other activities in their jurisdiction. Figure 2-1 presents the spatial distribution of these deposition networks across the United States.

[3] National Atmospheric Deposition Program (NRSP-3). 2018. NADP Program Office, Wisconsin State Laboratory of Hygiene, 465 Henry Mall, Madison, WI 53706. http://nadp.slh.wisc.edu/

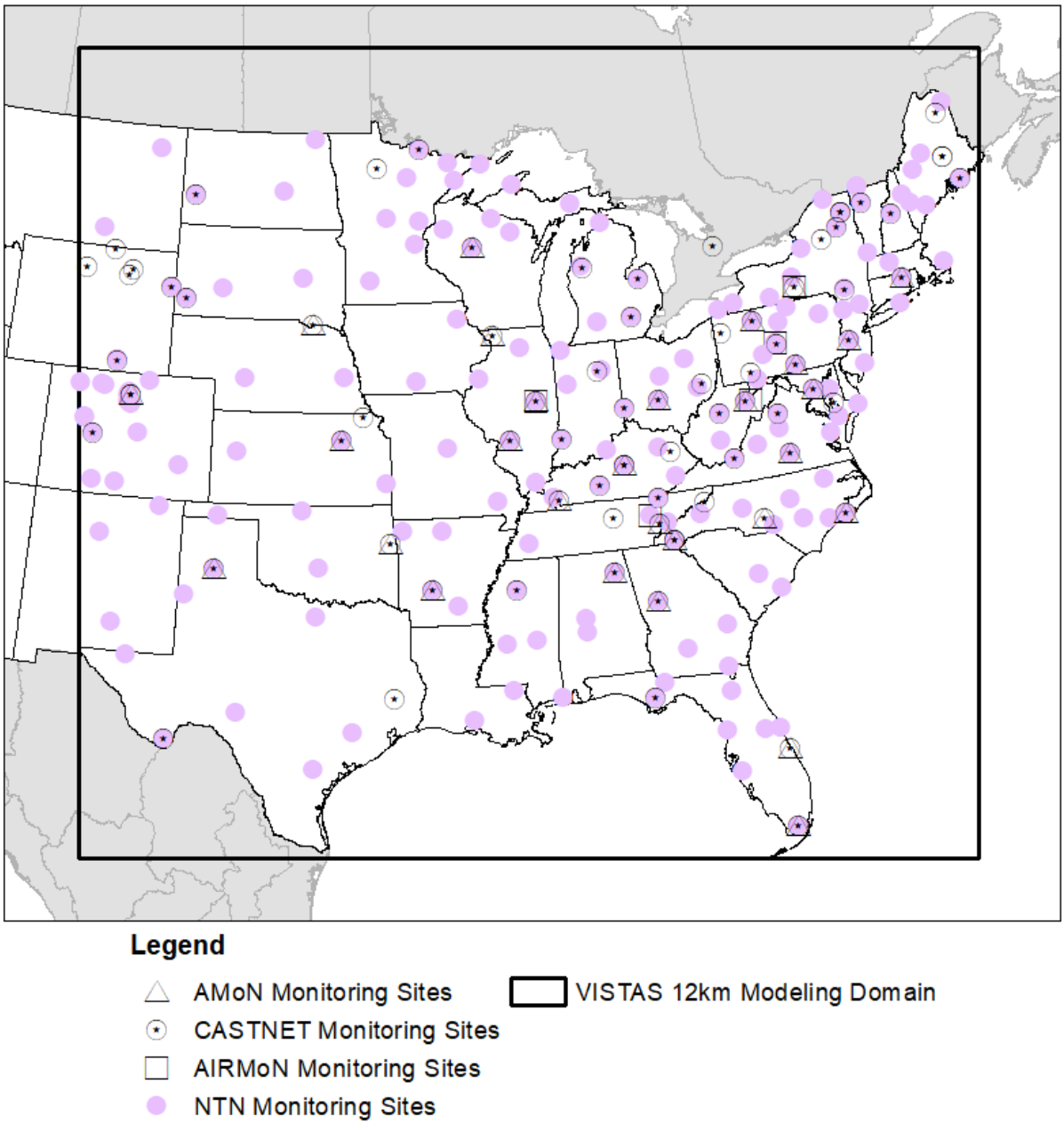


Figure 2-1. Deposition Monitors Included in the VISTAS II Database

Table 2-1 summarizes the measurements available from each deposition monitoring network. Each network is discussed separately in the following sections.

Table 2-1. Wet and Dry Deposition Monitoring Network Measurements

Measurement	Wet Deposition			Dry Deposition		
	NTN	MDN	AIRMon	AMNet	AMoN	CASTNET
Free acidity (H^+ as pH)	✓		✓			
Conductance	✓		✓			
Calcium (Ca^{2+})	✓		✓			✓
Magnesium (Mg^{2+})	✓		✓			✓
Sodium (Na^+)	✓		✓			✓
Potassium (K^+)	✓		✓			✓
Sulfate (SO_4^{2-})	✓		✓			✓
Nitrate (NO_3^-)	✓		✓			✓
Chloride (Cl^-)	✓		✓			✓
Ammonium (NH_4^+)	✓		✓			
Total mercury (Hg) total concentration		✓				✓
Total mercury (Hg) total deposition		✓				
Ammonia (NH_3)					✓	
Particulate Bound Mercury concentration				✓		
Average Gaseous Oxidized Mercury				✓		

Only observations that were flagged as valid in the NTN data file were used in the performance analysis. For the weekly measurements, NADP networks typically present measurements as concentration in milligram per liter (mg/L), which is equivalent to g/m^3. These concentrations are then multiplied by the precipitation in meters to yield wet deposition rates in units of g/m^2. These were further converted to kilograms per hectare (kg/ha), using the conversion of 1 ha = 10,000 m^2. The data were then filtered to remove any invalid measurements, per the data quality flags included in the database. The observations for the annual and seasonal analysis were based on the aggregate deposition data generated by NADP.

Dry deposition values from CASTNET were developed from the observed concentration multiplied by a deposition velocity (V_d) generated by the Multi-Layer Model (MLM)[4] for each site. The MLM generated deposition velocities are available for download with the CASTNET

[4] Meyers, T. P., Finkelstein, P., Clarke, J., Ellestad, T.G., and Sims, P.F. 1998. A Multilayer Model for Inferring Dry Deposition Using Standard Meteorological Measurements. J. Geophys. Res., 103(D17): 22,645-22,661, DOI: 10.1029/98jd01564.

observations. The observations for the annual and seasonal analysis were based on the aggregate deposition data generated and published by the EPA on the CASTNET website.[5]

Dry deposition data from the AMoN are measured as a concentration. Similar to CASTNET, the concentrations have to be multiplied by a deposition velocity to calculate the deposition per surface area. Deposition velocities for AMoN sites are not routinely calculated. However, the deposition velocities are calculated for CASTNET sites. These deposition velocities are calculated as an area-weighted V_d over vegetation types within 1.0 km.[6] Within the AMoN network, there are 29 sites within 1.0 km of a CASTNET site. Given the CASTNET deposition velocities are based on vegetation within 1km radius of the site, the CASTNET deposition velocities were applied to the AMoN sites within a 1 km radius to estimate the deposition at the AMoN sites. To calculate the deposition flux for the AMON sites, the hourly deposition velocities were averaged to match the collection periods for the AMoN sites. These average deposition velocities were then multiplied by the concentration to yield the deposition flux in Appendix B includes the list of AMoN sites and their paired CASTNET sites.

2.2 Modeled Data

Alpine extracted the daily wet and dry deposition values for the monitoring locations in the VISTAS 12 km domain. The available wet and dry deposition values were extracted for Cl^-, HNO_3, NH_3, NH_4^+, NO_3^-, SO_2 and SO_4^{2-} species. The CAMx deposition outputs are generated in grams per hectare (g/ha), which were converted to kg/ha, to have consistent units with the NADP monitoring networks and other studies. The data was then aggregated using the *R* software to match the monitoring network's concentration collection times.

Based on Appel et al. 2011, the CAMx wet deposition results were adjusted to account for chemical reactions that occur in the collected sample. For example, the SO_2 in rainwater is

[5] U.S. Environmental Protection Agency Clean Air Markets Division Clean Air Status and Trends Network (CASTNET) Dry – Deposition Weekly, Dry deposition- Annual, Dry Deposition – Seasonal, and Dry Deposition Velocity - Hourly. Available at www.epa.gov/castnet Date accessed: July 2018. https://java.epa.gov/castnet/clearsession.do

[6] U.S. Environmental Protection Agency. 2018. Clean Air Status and Trends Network (CASTNET) Quality Assurance Project Plan (QAPP) Revision 9.2, October 2018. Available at https://www3.epa.gov/castnet/docs/QAPP_v9-2_Main_body.pdf

oxidized to SO_4^{2-} by the time the samples are analyzed. To account for this, the CAMx estimates of SO_4^{2-} wet deposition include 150% (based on the ratio of the molecular weights of SO_2 and SO_4^{2-}) of the model estimated SO_2 wet deposition to account for the SO_2 captured in the observations. Similarly, for NH_4^+, the CAMx estimates of NH_4^+ wet deposition include 106% of the model estimated NH_3 wet deposition to account for reduced nitrogen (both NH_4^+ and NH_3) captured in the NTN observations. This is due to NH_4^+ being the favored phase at the pH of rainwater. Additionally, HNO_3 reacts with water and dissociates to NO_3^+. The CAMx estimates of NO_3^+ wet deposition were adjusted to include 98.4% of the model estimated nitric acid wet deposition to account for NO_3^+ captured as nitric acid, and thus converted to NO_3^+ in the measurements.

CAMx estimates of wet deposition were further adjusted to account for the error present in the model estimated precipitation using a ratio of the observed to estimated precipitation.[7] This is a linear adjustment using a ratio of the observed precipitation to the modeled precipitation. In instances where the observed precipitation is greater than the model estimated precipitation, the ratio is greater than one, and the model estimated wet deposition is increased. Similarly, if there is no measured precipitation at the site the modeled values are corrected to zero. In instances where the observed precipitation was indicated to be trace amounts (i.e., less than 0.01 mm), a value of 0.00001 was used for the adjustment.[8]

2.3 Metrics

Annual mean MPE statistics, like the statistics for the base year MPE, were developed for the wet deposition and dry deposition species available. Analysis included scatter plots of observations versus CAMx predictions, and their correlation (r), both annually and by season. Statistics and scatter plots can also be examined by VISTAS states to provide more refined MPE information to facilitate further use by the states.

---

[7] Appel, K. W., et al. 2011. "A multi-resolution assessment of the Community Multiscale Air Quality (CMAQ) model v4. 7 wet deposition estimates for 2002–2006." Geoscientific Model Development 4.2 (2011): 357-371.

[8] Akyüz, A., et al. 2013. "Procedure for Assigning A Value for Trace Precipitation Data Without Changing the Climatic History". Journal of Service Climatology. (https://www.stateclimate.org/sites/default/files/upload/pdf/journal-articles/2013_Adnan_et_al_2013.pdf)

For this MPE, mean bias (MB) and normalized mean bias (NMB), mean error (ME) and normalized mean error (NME), and Pearson's correlation coefficient (r), mean fractional bias (MFB), mean fractional error (MFE), and root mean squared error (RMSE) are defined and calculated, per the equations below.

Mean bias (MB) is the average difference between modeled, or predicted (P), and observed (O) concentrations for a given number of samples (n):

$$MB(kg/ha) = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

Normalized mean bias (NMB) is the sum of the difference between predicted and observed values divided by the sum of the observed values:

$$NMB(\%) = \frac{\sum_1^n(P-O)}{\sum_1^n(O)} * 100$$

Mean error (ME) is the average absolute value of the difference between predicted and observed concentrations for a given number of samples:

$$ME(kg/ha) = \frac{1}{n}\sum_{i=1}^{n}|P_i - O_i|$$

Normalized mean error (NME) is the sum of the absolute value of the difference between predicted and observed values divided by the sum of the observed values:

$$NME(\%) = \frac{\sum_1^n|P-O|}{\sum_1^n(O)} * 100$$

Pearson's correlation coefficient (r) is defined as:

$$r = \frac{\sum_{i=1}^{n}(P_i - \overline{P})(O_i - \overline{O})}{\sqrt{\sum_{i=1}^{n}(P_i - \overline{P})^2}\sqrt{\sum_{i=1}^{n}(O_i - \overline{O})^2}}$$

Mean Fractional Bias (MFB) is defined as:

$$MFB(\%) = \frac{2}{N}\sum_{1}^{N}\left(\frac{P-O}{P+O}\right) \times 100$$

Mean Fractional Error (MFE) is defined as:

$$MFE(\%) = \frac{2}{N}\sum_{1}^{N}\left(\frac{|P-O|}{P+O}\right) \times 100$$

Root Mean Squared Error (RMSE) is defined as:

$$RSME = \sqrt{\frac{\sum_{1}^{N}(P-O)^2}{N}}$$

Model predictions of deposition species are paired in space and time with observational data from the deposition monitoring networks. These results are presented based on the monitoring network's collection frequency and for annual and season (winter (DJF), spring (MAM), summer (JJA), and fall (SON)) accumulation. To prevent confounding the MPE results, the different deposition networks were examined separately. The MPE metrics were calculated based on the weekly collection periods, as well as the accumulated deposition for each season and year.

3. 2011 MODEL PERFORMANCE EVALUATION RESULTS

Visualization of observations and model estimates, and computation of model performance statistics were calculated using the *R* software, which utilized the *openair* package.

3.1 Wet Deposition

Wet deposition model performance was evaluated at the site's weekly collection frequency as well as for seasonal and annual accumulation. Overall, the MPE metrics show weak performance for replicating deposition at the monitoring site collection frequency. However, modeling performance improved for the accumulated seasonal and annual wet deposition. This suggests that season and total annual wet deposition are adequately captured while weekly trends are not captured well by the model. Metrics and plots by state are available in Appendix A.

3.1.1 Weekly Wet Deposition

Table 3-1 summarizes the aggregated weekly MPE metrics for wet deposition in the VISTAS 12-km domain. The model demonstrates a negative mean bias for NH_4^+ and SO_4^{2-} and a positive mean bias for NO_3^+ compared to the weekly NTN observations. The AIRMon sites have a larger positive mean bias for all pollutants.

Table 3-1. Weekly Wet Deposition MPE Metrics for NADP Sites in the VISTAS 12 km Domain

Network	Pollutant	n	MB (kg/ha)	ME (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
NTN	NH_4^+	3,404	-0.025	0.045	-32%	58%	0.629	-19%	34%	0.092
	NO_3^+	3,404	0.024	0.123	12%	62%	0.642	6%	29%	0.242
	SO_4^{2-}	3,404	-0.001	0.118	0%	57%	0.681	0%	29%	0.245
AIRMon	NH_4^+	158	-0.003	0.020	-13%	76%	0.534	-7%	41%	0.041
	NO_3^+	158	0.051	0.097	67%	127%	0.398	25%	47%	0.192
	SO_4^{2-}	158	0.018	0.091	20%	100%	0.352	9%	46%	0.197

The normalized and mean fraction bias suggest there is larger over/under prediction issue with the data, which is better visualized in the scatter plots in Figure 3-1 and Figure 3-2.

The Figure 3-1 and Figure 3-2 scatter plots present observed versus modeled deposition fluxes for the NTN and AIRMon sites respectively. The scatter plots include the 1:1 line (solid line), the line all the points would fall on for a perfect replication of observed conditions. The plot also includes the "2-to-1" (2:1) and "1-to-2" (1:2) lines as the two dashed lines on the plot. These lines help show how close the points are to a "1-to-1" (1:1) relationship. Points that fall within these two lines are within a "factor of 2" of the observed value. The plots show substantial spread differences in the observed and predicted, especially for lower flux values.

The number of points outside the dashed lines show many predictions are more than a "factor of 2" off from the observations. These plots suggest there is a mix of instances where the wet deposition in both over and under prediction, which have moderated the ME and MB metrics. The NMB and MFB metrics do hint at this larger spread in the data.

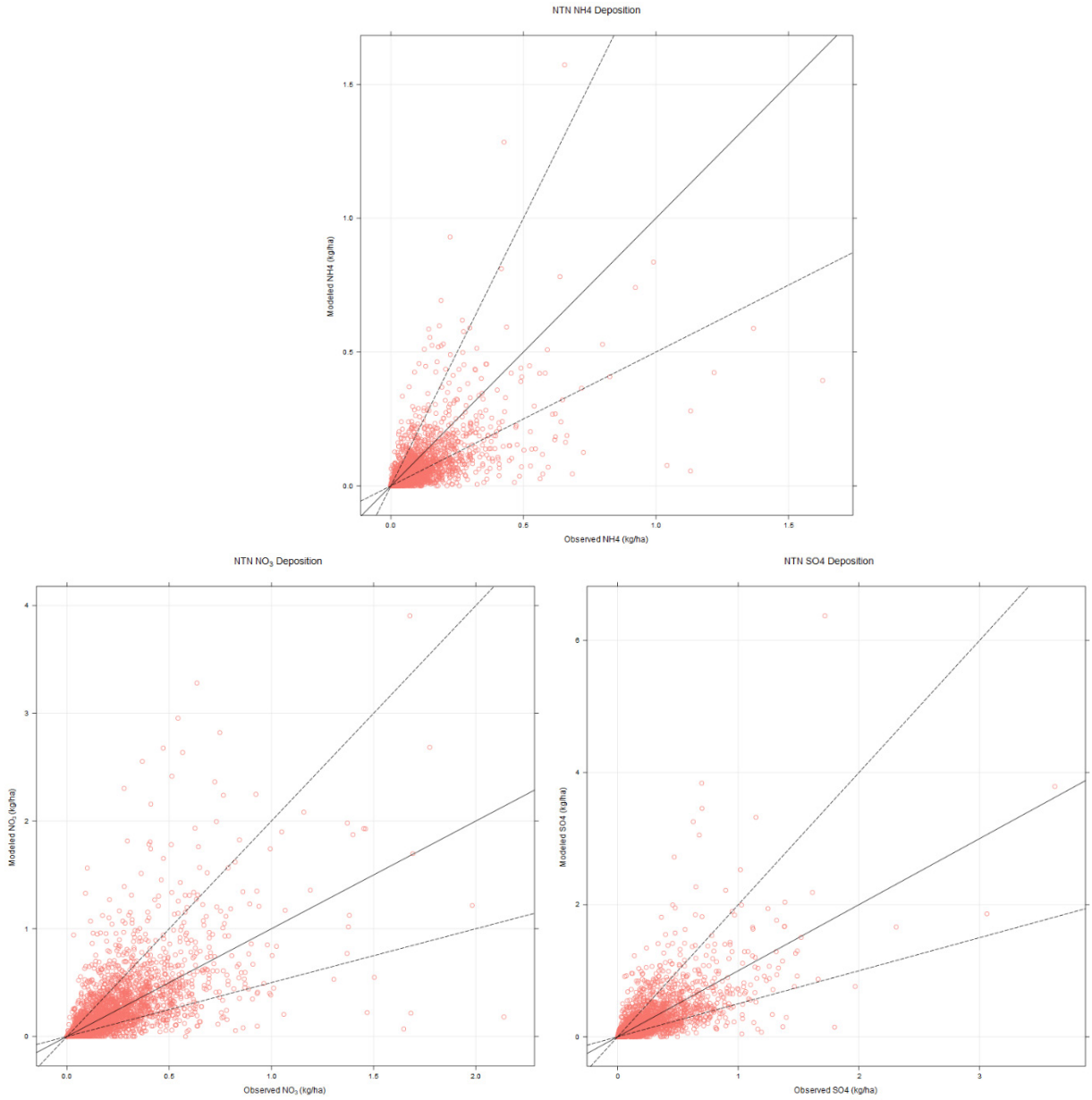


Figure 3-1. Scatter Plots of Weekly Wet Deposition for NTN Sites in the VISTAS 12 km Domain for NH_4^+ (top), NO_3^+ (bottom left), and SO_4^{2-} (bottom right)

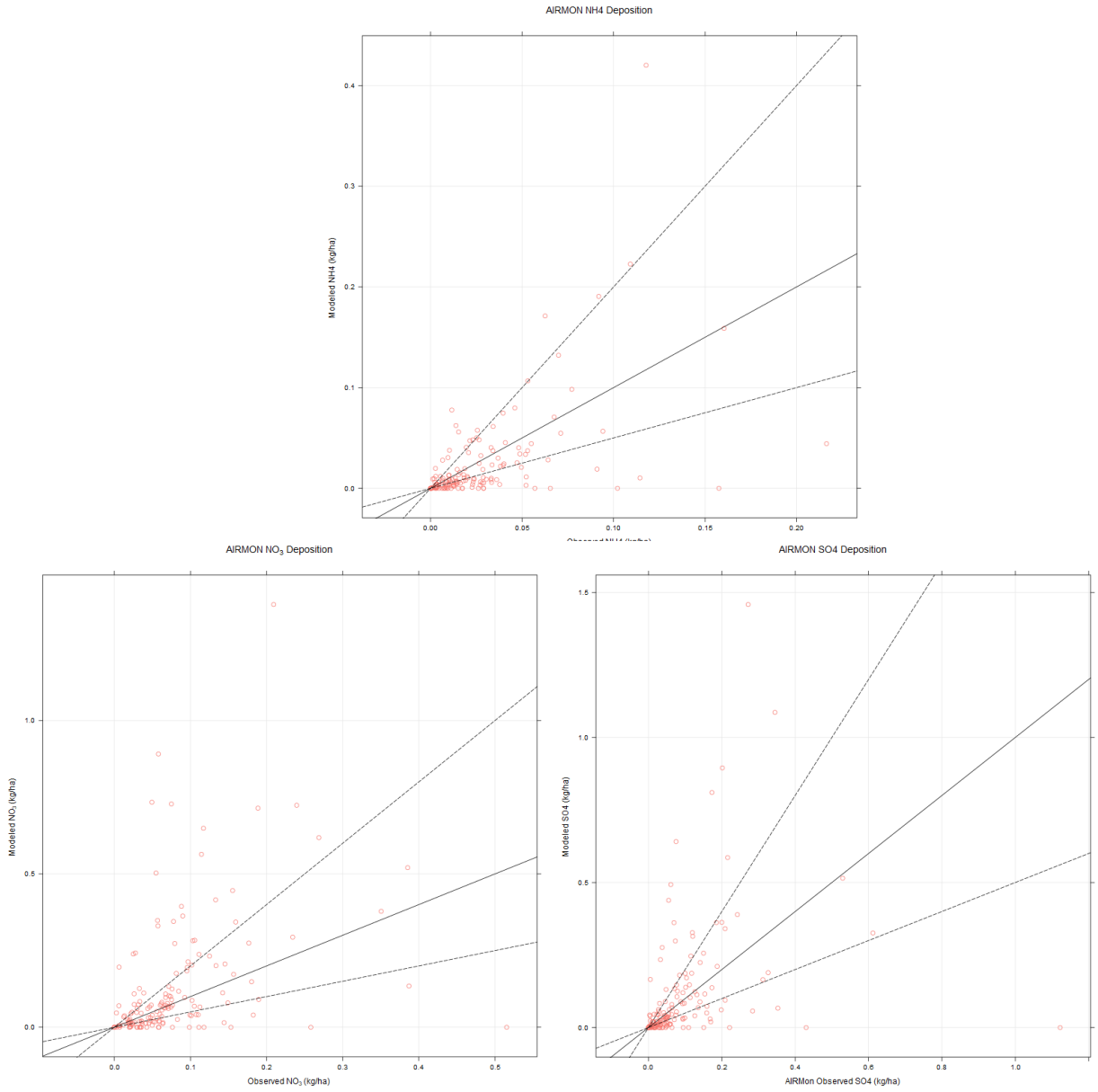


Figure 3-2. Scatter Plots of Weekly Wet Deposition for AIRMon Sites in the VISTAS 12 km Domain for NH_4^+ (top), NO_3^+ (bottom left), and SO_4^{2-} (bottom right)

3.1.2 Accumulated Seasonal Wet Deposition

When deposition values are aggregated to total accumulated wet deposition for a season there is still a negative bias for most pollutants as presented in Table 3-2. The exceptions are NO_3^+ for the summer and fall and SO_4^{2-} for the summer months. There is improvement from the weekly performance, as the NMEs are all below 50% and there is a substantial increase in the correlation coefficients. There is also more precision and accuracy seen in the scatter plots for each pollutant, as presented in Figure 3-3, as more of the sites fall within a factor of 2 of the 1:1 line than the weekly performance.

Table 3-2. Accumulated Seasonal Wet Deposition MPE Metrics for NADP Sites in the VISTAS 12 km Domain

Season	Pollutant	n	MB (kg/ha)	ME (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
Winter	NH_4^+	98	-0.150	0.163	-43%	47%	0.718	-28%	30%	0.215
Spring	NH_4^+	96	-0.542	0.545	-43%	44%	0.830	-28%	28%	0.717
Summer	NH_4^+	99	-0.363	0.407	-32%	36%	0.769	-19%	22%	0.571
Fall	NH_4^+	98	-0.193	0.232	-33%	40%	0.740	-20%	24%	0.302
Winter	NO_3^+	98	-0.176	0.501	-12%	34%	0.656	-6%	18%	0.823
Spring	NO_3^+	96	-0.237	0.569	-9%	21%	0.850	-5%	11%	0.810
Summer	NO_3^+	99	0.207	0.746	7%	27%	0.838	4%	13%	0.972
Fall	NO_3^+	98	0.325	0.543	21%	34%	0.838	9%	16%	0.785
Winter	SO_4^{2-}	98	-0.313	0.494	-25%	39%	0.720	-14%	22%	0.725
Spring	SO_4^{2-}	96	-0.441	0.690	-15%	23%	0.878	-8%	13%	0.961
Summer	SO_4^{2-}	99	0.235	0.726	8%	26%	0.887	4%	12%	1.066
Fall	SO_4^{2-}	98	-0.127	0.529	-7%	30%	0.781	-4%	15%	0.811

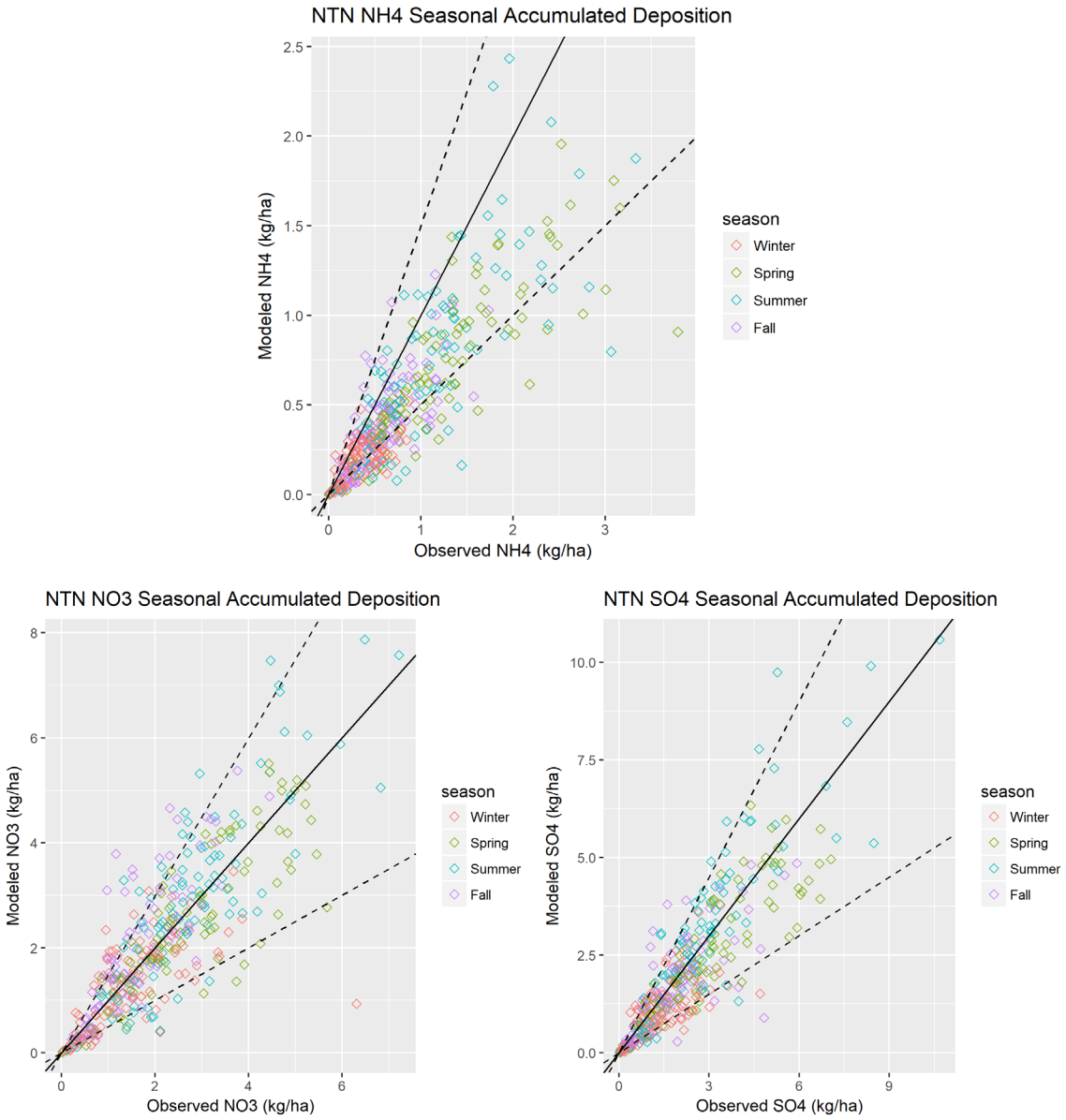


Figure 3-3. Scatter Plots of Seasonal Accumulated Wet Deposition for NADP Sites in the VISTAS 12 km Domain for NH_4^+ (top), NO_3^+ (bottom left), and SO_4^{2-} (bottom right)

3.1.3 Accumulated Annual Wet Deposition

When considering the total accumulated wet deposition for the calendar year, there is still under prediction of NH_4^+ and SO_4^{2-}, and a slight over prediction of NO_3^+. However, we see continued improvement from the seasonal accumulated performance with respect to the NME and r values, as presented in Table 3-3. More of the data fall within a factor of 2 of the 1:1 line, as presented in Figure 3-4, which suggests an overall decent prediction of the total annual wet deposition at the NADP sites.

Table 3-3. Accumulated Annual Wet Deposition MPE Metrics for NADP Sites in the VISTAS 12 km Domain

Pollutant	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
NH_4^+	99	-1.245	1.246	-38%	38%	0.861	-23%	23%	1.536
NO_3^+	99	0.134	1.453	2%	17%	0.901	1%	8%	1.933
SO_4^{2-}	99	-0.585	1.604	-7%	18%	0.916	-3%	9%	2.142

3.2 Dry Deposition

Similar to the wet deposition performance, comparing weekly modeled deposition to the weekly observations does not show good agreement. The comparisons of the accumulated seasonal dry deposition improve, but most species have at least one season with poor model performance. The seasons with poor performance usually affect the model performance with respect to the annual accumulated deposition rates. Metrics and plots by state are available in Appendix B.

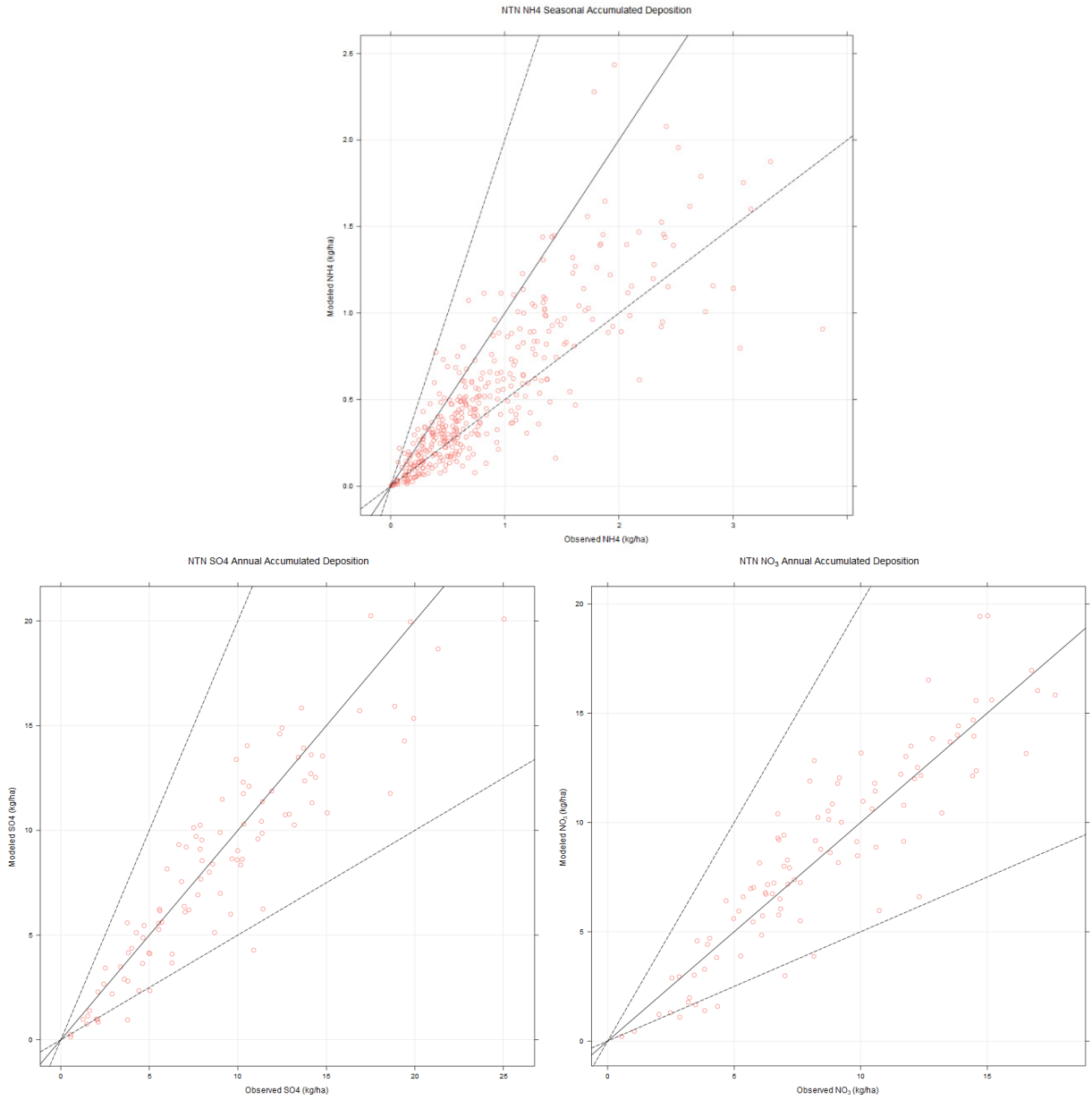


Figure 3-4. Scatter Plots of Annual Accumulated Wet Deposition for NTN Sites in the VISTAS 12 km Domain for NH_4^+ (top), NO_3^+ (bottom left), and SO_4^{2-} (bottom right)

3.2.1 Weekly Dry Deposition

The weekly dry deposition MB and ME presented in Table 3-4 would seem to suggest relatively good model performance for the CASTNET sites. However, these metric results are not consistent with other calculated metrics. The normalized mean and mean fraction bias and error values show that the weekly model performance is not particularly good, especially for Cl^-, SO_2, and HNO_3. The weekly dry deposition observations are quite small, so the small values presented in Table 3-4 are deceptive. In actuality, Cl^-, SO_2, and HNO_3 are grossly under predicted, which is presented clearly in Figure 3-5. The other pollutants fair better, but the performance is not optimal. Similar for NH_4^+ at AMoN sites, there is a large under prediction as shown in Figure 3-6.

Table 3-4. Weekly Deposition MPE Metrics for CASTNET Sites in the VISTAS 12 km Domain

Network	Pollutant	n	MB (kg/ha)	ME (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
CASTNET	Cl^-	965	-0.001	0.001	-87%	89%	0.796	-77%	79%	0.004
	NH_4^+	965	0.001	0.003	13%	51%	0.603	6%	24%	0.004
	SO_4^{2-}	965	0.0004	0.007	3%	43%	0.650	1%	21%	0.009
	SO_2	965	-0.031	0.031	-96%	96%	0.656	-93%	93%	0.052
	NO_3^+	965	0.001	0.004	12%	80%	0.601	6%	37%	0.006
	HNO_3	965	-0.062	0.062	-95%	95%	0.612	-90%	90%	0.077
AMoN	NH_3	355	-0.007	0.007	-95%	95%	0.463	-90%	91%	0.013

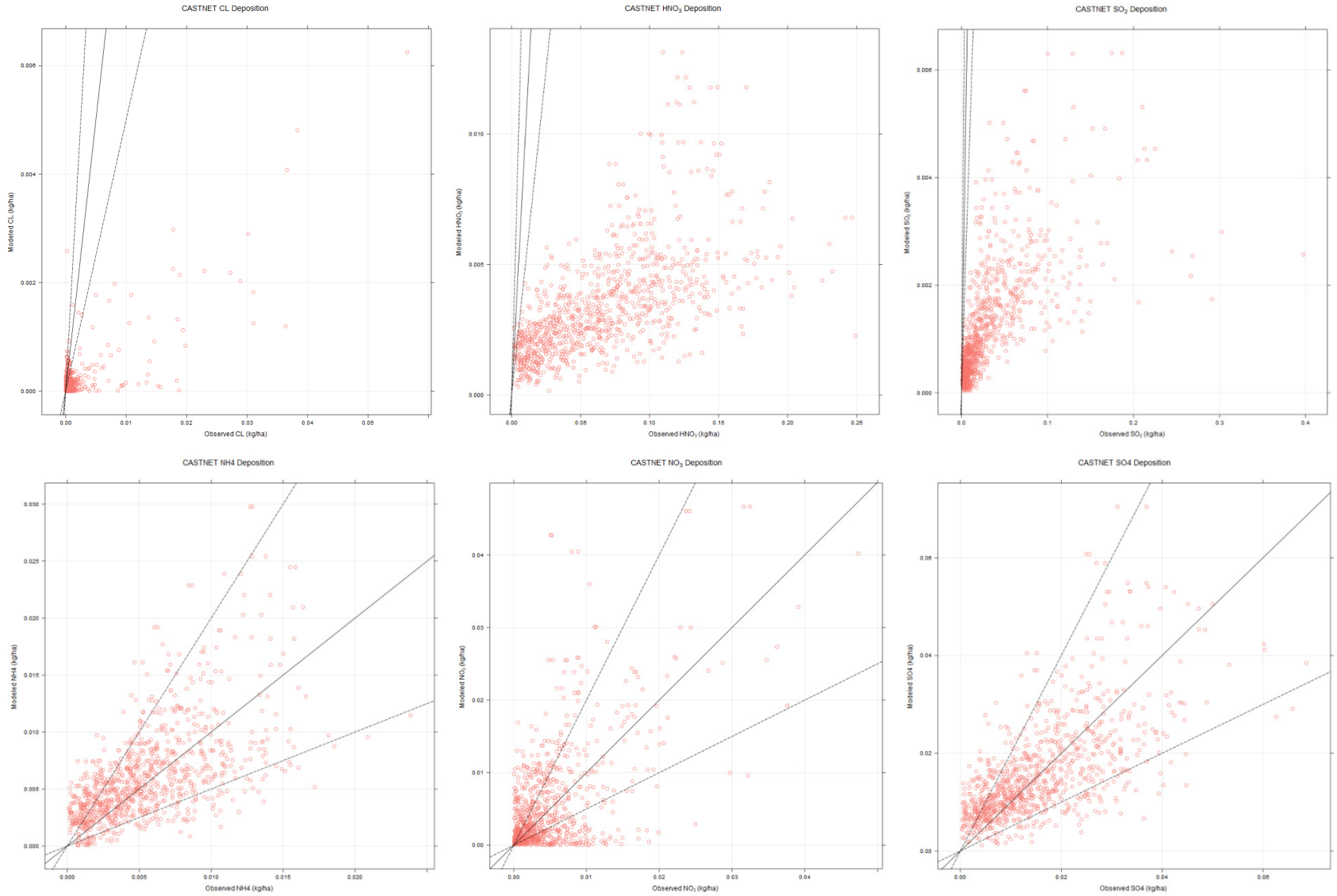


Figure 3-5. Scatter Plots of Weekly Dry Deposition for CASTNET Sites in the VISTAS 12 km Domain for Cl^- (top, left), HNO_3 (top middle), SO_2 (top right), NH_4^+ (bottom, left), NO_3^+ (bottom, middle), SO_4^{2-} (bottom right)

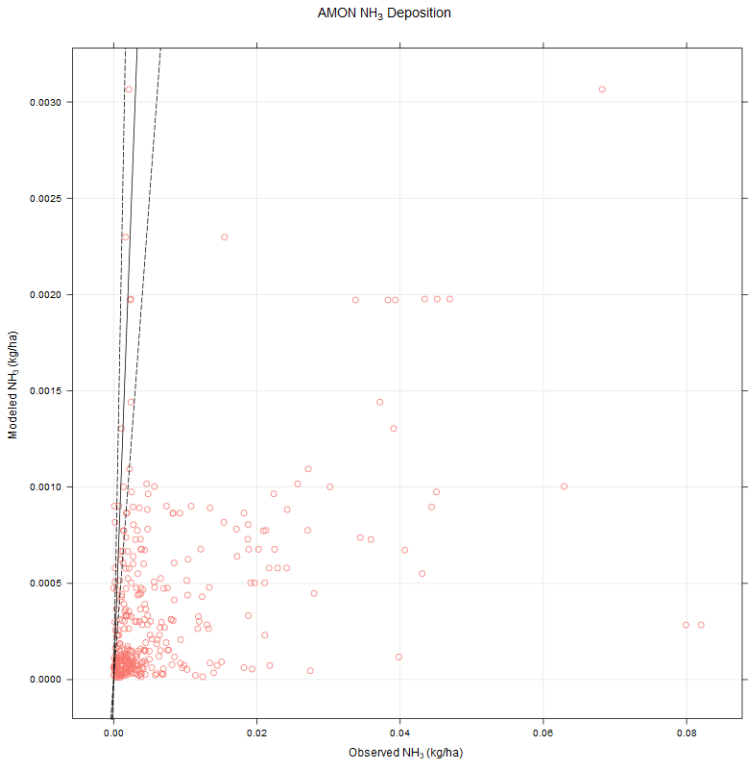


Figure 3-6. Scatter Plots of Weekly Dry Deposition for AMoN Sites in the VISTAS 12 km Domain for NH_3

3.2.2 Accumulated Seasonal Dry Deposition

As presented in Table 3-5, continued poor model performance is observed when comparing accumulated modeling results by season to accumulated seasonal observations, especially for Cl^-, SO_2, and HNO_3. The SO_4^{2-} and NO_3^+ pollutants exhibit seasonality in their predictions: that is, three of the four seasons are under predicted, with one season over predicted. Conversely, NH_4^+ is opposite in that three seasons are over predicted, and one is not (summer). The correlation for the accumulated seasonal predictions is mixed, with varying degrees of correlation across the seasons.

Figure 3-7 presents the various metrics, including color coding to help distinguish how each pollutant has at least one season that under performs.

Table 3-5. Accumulated Seasonal Dry Deposition MPE Metrics for CASTNET Sites in the VISTAS 12 km Domain

Season	Pollutant	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
Winter	Cl^-	18	-0.010	0.010	-80%	80%	0.981	-66%	66%	0.029
Spring	Cl^-	18	-0.017	0.017	-86%	87%	0.900	-76%	77%	0.048
Summer	Cl^-	19	-0.009	0.009	-92%	92%	0.960	-86%	86%	0.026
Fall	Cl^-	18	-0.016	0.016	-89%	90%	0.994	-81%	81%	0.045
Winter	NH_4^+	18	0.008	0.022	14%	35%	0.680	6%	17%	0.025
Spring	NH_4^+	18	0.005	0.023	6%	29%	0.599	3%	14%	0.030
Summer	NH_4^+	19	-0.027	0.034	-27%	35%	0.783	-16%	20%	0.042
Fall	NH_4^+	18	0.007	0.016	14%	34%	0.552	7%	16%	0.020
Winter	SO_4^{2-}	18	-0.008	0.036	-6%	27%	0.709	-3%	14%	0.043
Spring	SO_4^{2-}	18	-0.021	0.077	-9%	33%	0.261	-5%	17%	0.096
Summer	SO_4^{2-}	19	-0.063	0.096	-21%	32%	0.770	-12%	18%	0.110
Fall	SO_4^{2-}	18	0.016	0.050	12%	36%	0.258	5%	17%	0.057
Winter	SO_2	18	-0.825	0.825	-98%	98%	0.803	-96%	96%	1.201
Spring	SO_2	18	-0.318	0.318	-96%	96%	0.839	-93%	93%	0.431
Summer	SO_2	19	-0.336	0.336	-96%	96%	0.907	-93%	93%	0.465
Fall	SO_2	18	-0.295	0.295	-96%	96%	0.785	-92%	92%	0.405
Winter	NO_3^+	18	0.021	0.051	22%	54%	0.682	10%	24%	0.059
Spring	NO_3^+	18	-0.002	0.042	-2%	54%	0.539	-1%	27%	0.058
Summer	NO_3^+	19	-0.023	0.024	-68%	71%	0.223	-52%	54%	0.040
Fall	NO_3^+	18	-0.001	0.019	-1%	44%	0.543	-1%	22%	0.025
Winter	HNO_3	18	-0.647	0.647	-95%	95%	0.509	-91%	91%	0.751
Spring	HNO_3	18	-0.916	0.916	-96%	96%	0.507	-92%	92%	1.039
Summer	HNO_3	19	-1.068	1.068	-96%	96%	0.732	-92%	92%	1.212
Fall	HNO_3	18	-0.619	0.619	-94%	94%	0.631	-89%	89%	0.716

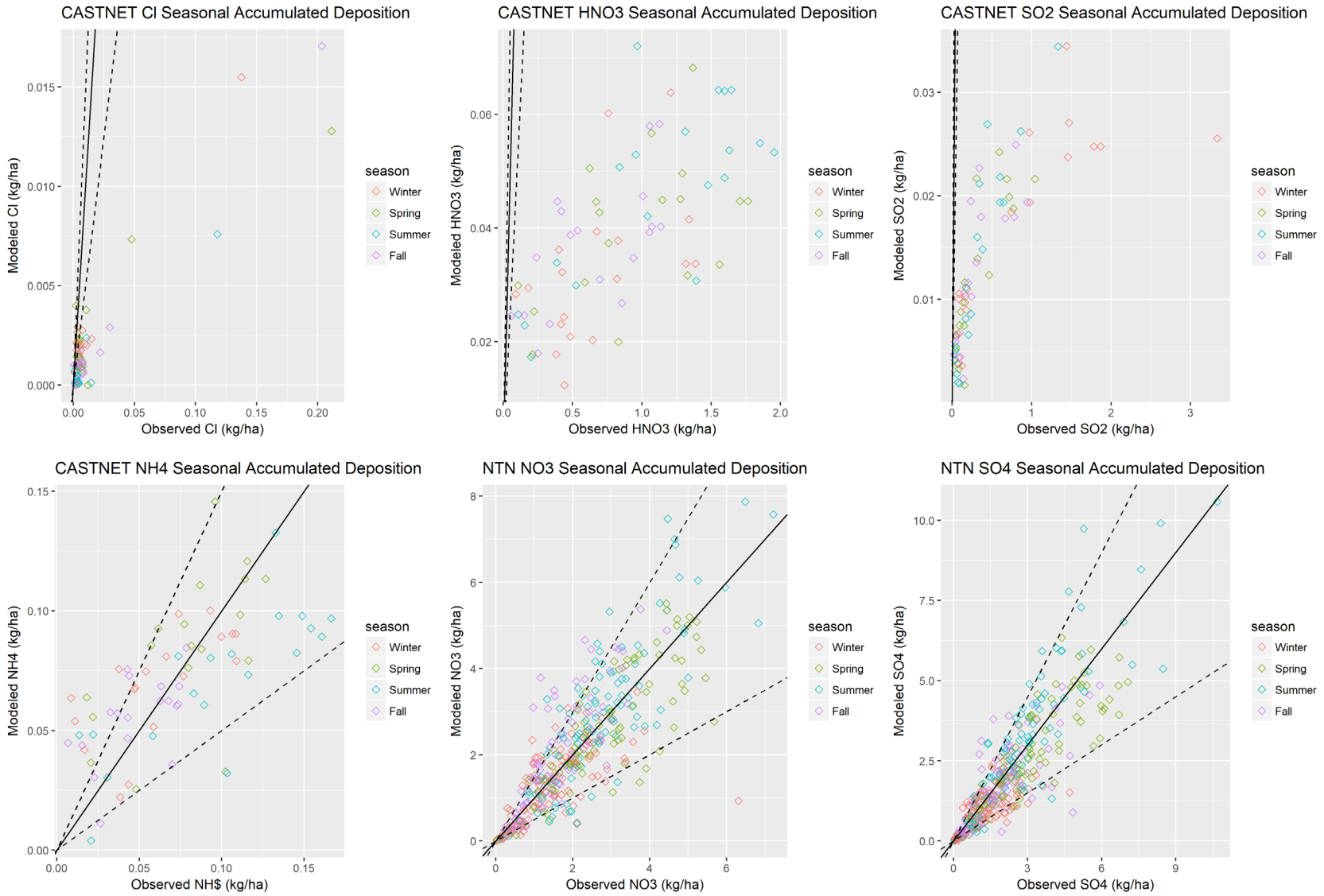


Figure 3-7. Scatter Plots of Seasonal Dry Deposition for CASTNET Sites in the VISTAS 12 km Domain for Cl (top, left), HNO_3 (top middle), SO_2 (top right), NH_4^+ (bottom, left), NO_3^+ (bottom, middle), SO_4^{2-} (bottom right)

3.2.3 Accumulated Annual Dry Deposition

As presented in Table 3-6, most pollutants, except for NO_3, are under predicted, based on the total accumulated dry deposition. SO_2 and HNO_3 have the worst under prediction of all the pollutants, followed by Cl^-.

Table 3-6. Accumulated Annual Dry Deposition MPE Metrics for CASTNET Sites in the VISTAS 12 km Domain

Pollutant	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
Cl^-	19	-0.054	0.054	-88%	88%	0.981	-78%	78%	0.156
NH_4^+	19	-0.002	0.077	-1%	27%	0.688	0%	14%	0.090
SO_4^{2-}	19	-0.067	0.219	-8%	27%	0.537	-4%	14%	0.268
SO_2	19	-1.616	1.616	-97%	97%	0.869	-94%	94%	2.221
NO_3^+	19	0.001	0.113	1%	46%	0.572	0%	23%	0.154
HNO_3	19	-3.272	3.272	-95%	95%	0.607	-91%	91%	3.688

Of particular note for Cl^- is that one site (EVE419, Everglades National Park) appears to be an outlier, thereby skewing model performance, which can easily be seen in Figure 3-8. This point seems to be a large driver for the error and bias performance metrics, as the correlation value suggests the annual accumulated dry deposition is captured fairly well by the model.

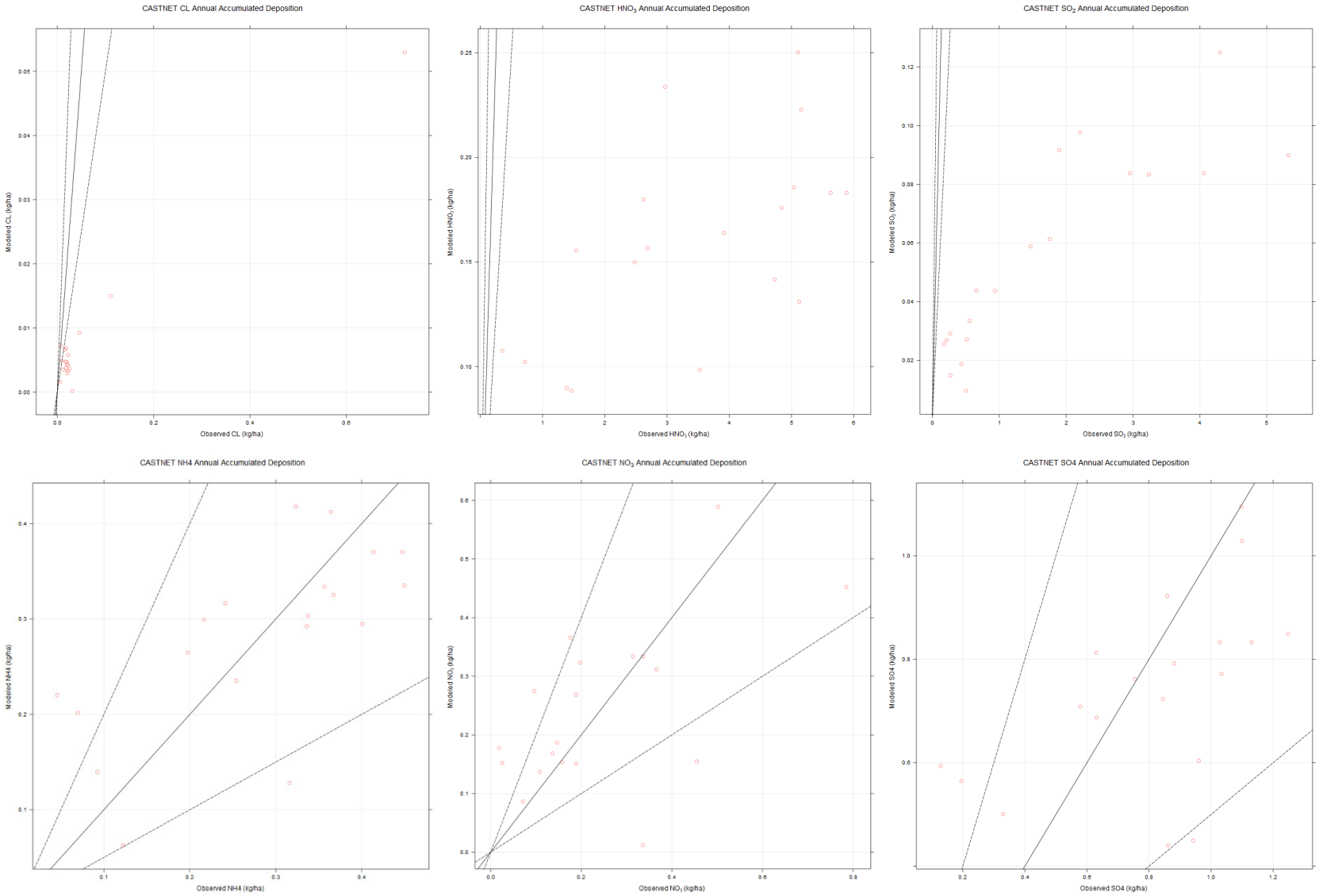


Figure 3-8. Scatter Plots of Annual Accumulated Dry Deposition for CASTNET Sites in the VISTAS 12 km Domain for Cl^- (top, left), HNO_3 (top middle), SO_2 (top right), NH_4^+ (bottom, left), NO_3^+ (bottom, middle), SO_4^{2-} (bottom right)

4. COMPARISON TO NADP ANNUAL MAPS

A final MPE step was to compare the annual deposition totals from the VISTAS II base year modeling to the annual Total Deposition Maps[9] developed by the NADP and EPA. These total deposition maps are produced via a hybrid approach that combines the monitored data with modeled data to produce a gridded map of total sulfate and nitrate depositions[10]. While not entirely observed truth, these hybrid estimates provide the ability to evaluate the model performance for the entire domain in areas where data availability is limited due to incomplete records from the monitoring sites.

The latest version (2018.02) of the NADP deposition modeling uses CMAQ version 5.0.2 at a 12 km resolution. Emission data is based on the 2011 Nation Emissions Inventory (NEI) version 1, with mobile sources information derived from Motor Vehicle Emissions Simulator (MOVES) 2010b (2011 emission factor and 2012 activity data) modeling runs, and Satellite Mapping Automated Reanalysis Tool for Fire v2 for fire data. The runs also utilized the bidirectional NH_3 module, fertilizer emissions from the Environmental Policy Integrated Climate (EPIC) model (http://epicapex.tamu.edu/), and inline biogenic emissions. Results are available as ESRI ArcGRID exported gridded deposition fields (.e00 format) and static maps via the EPA ftp site[11].

The SESARM modeling was completed with CAMx based on EPA's "el" platform, which is based on 2011 NEI version 2. This inventory includes several updates from the NADP modeling platform, including updates the underlying NEI (including updates to point sources, nonpoint sources, and fires), the switch to MOVES2014a and updates to international emissions[12]. Given these differences in modeling platforms, it is not surprising that there are differences in between the two models. However, there are some similarities.

---

[9] http://nadp.slh.wisc.edu/committees/tdep/tdepmaps/

[10] Schwede, Donna B. and Lear, Gary G., "A novel hybrid approach for estimating total deposition in the United States" (2014). U.S. Environmental Protection Agency Papers. 219. Available at: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1219&context=usepapapers

[11] ftp://ftp.epa.gov/castnet/tdep/grids/; ftp://ftp.epa.gov/castnet/tdep/images/

[12] Eyth, Alison. And Vukovich, Jeff, "Technical Support Document (TSD) Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2028". Available at: https://www.epa.gov/sites/production/files/2017-11/documents/2011v6.3_2028_update_emismod_tsd_oct2017.pdf

Wet deposition of particulate NH_4^+ has comparable spatial pattern between the two models. As Figure 4-1 shows higher values stretching from the Great Lake regions south and west into the central plains and Texas. The VISTAS12 modeling also contains the peaks in eastern North Carolina and in northern Georgia/Alabama that appear in the NADP modeling. The extent of the higher values into Texas and Oklahoma is greater in the VISTAS12 modeling and values are more varied in than the NADP modeling. The smoothed appearance of the NADP modeling is likely due to the inverse distance weighting used to nudge the model toward the monitored values. However, the VISTAS12 wet deposition pattern for particulate NO_3^+ (Figure 4-2) has some high deposition values in the Midwest but isn't as extensive as the area in the NADP modeling. NADP did not have a separate wet deposition layer for particulate SO_4^{2-}.

The dry deposition patterns for NH_4^+ (Figure 4-3) is not as well matched as the wet deposition pattern. The VISTAS12 modeling tends to highlight the urban areas, as areas like Chicago, Detroit, Cleveland, and other Midwestern population centers show up as hot spots on the map. This pattern holds for NO_3^+ (Figure 4-4) and SO_4^{2-} (Figure 4-5). Overall the differences seen in the patterns of deposition are to be expected, as the two sets of modeling did use different emissions inventories.

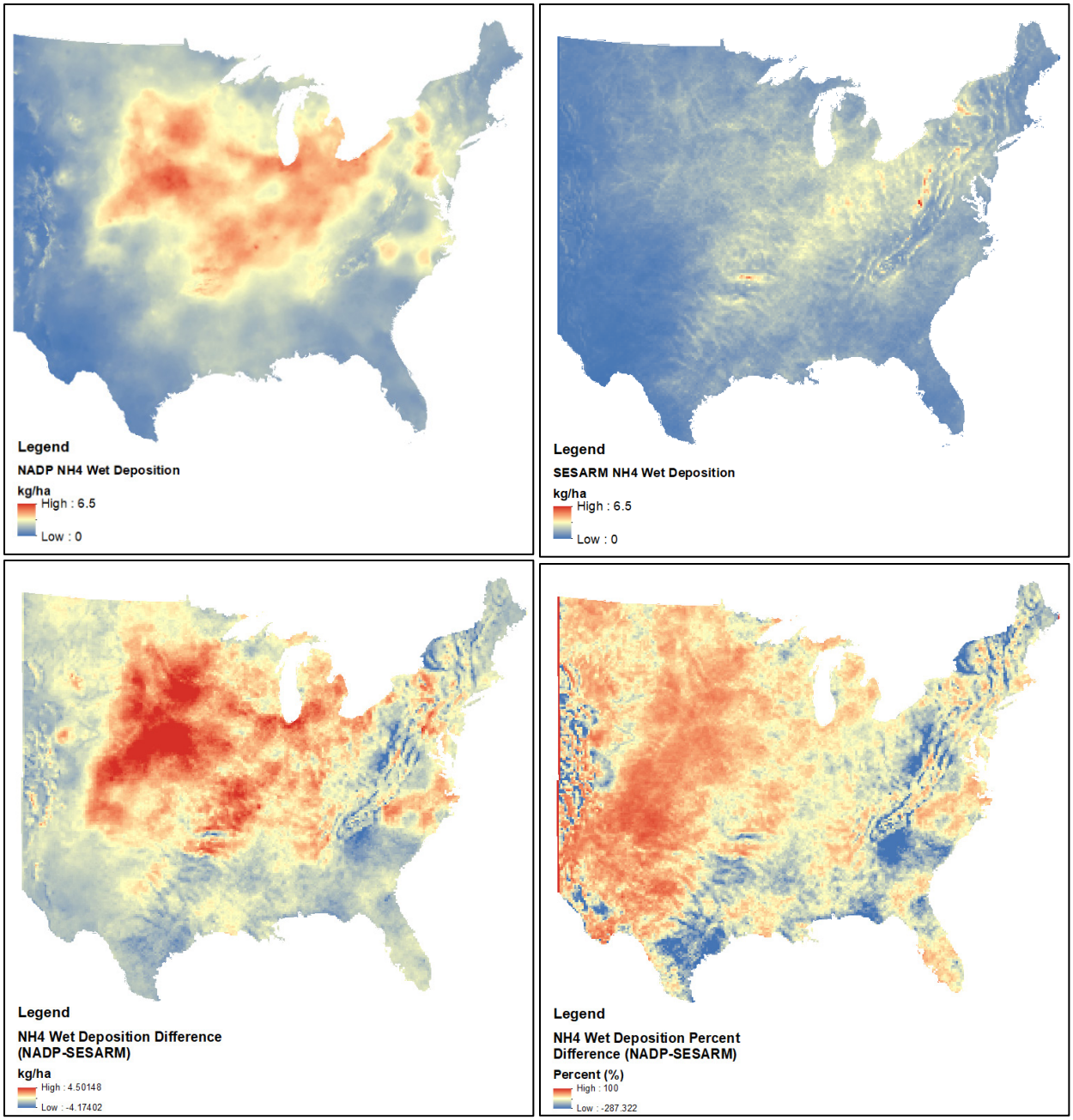


Figure 4-1. Plots of Total Annual Particulate NH_4^+ Wet Deposition. NADP Wet Deposition (top left), SESARM Wet Deposition (top right), Difference (bottom left), Percent Difference[13] (bottom right).

[13] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

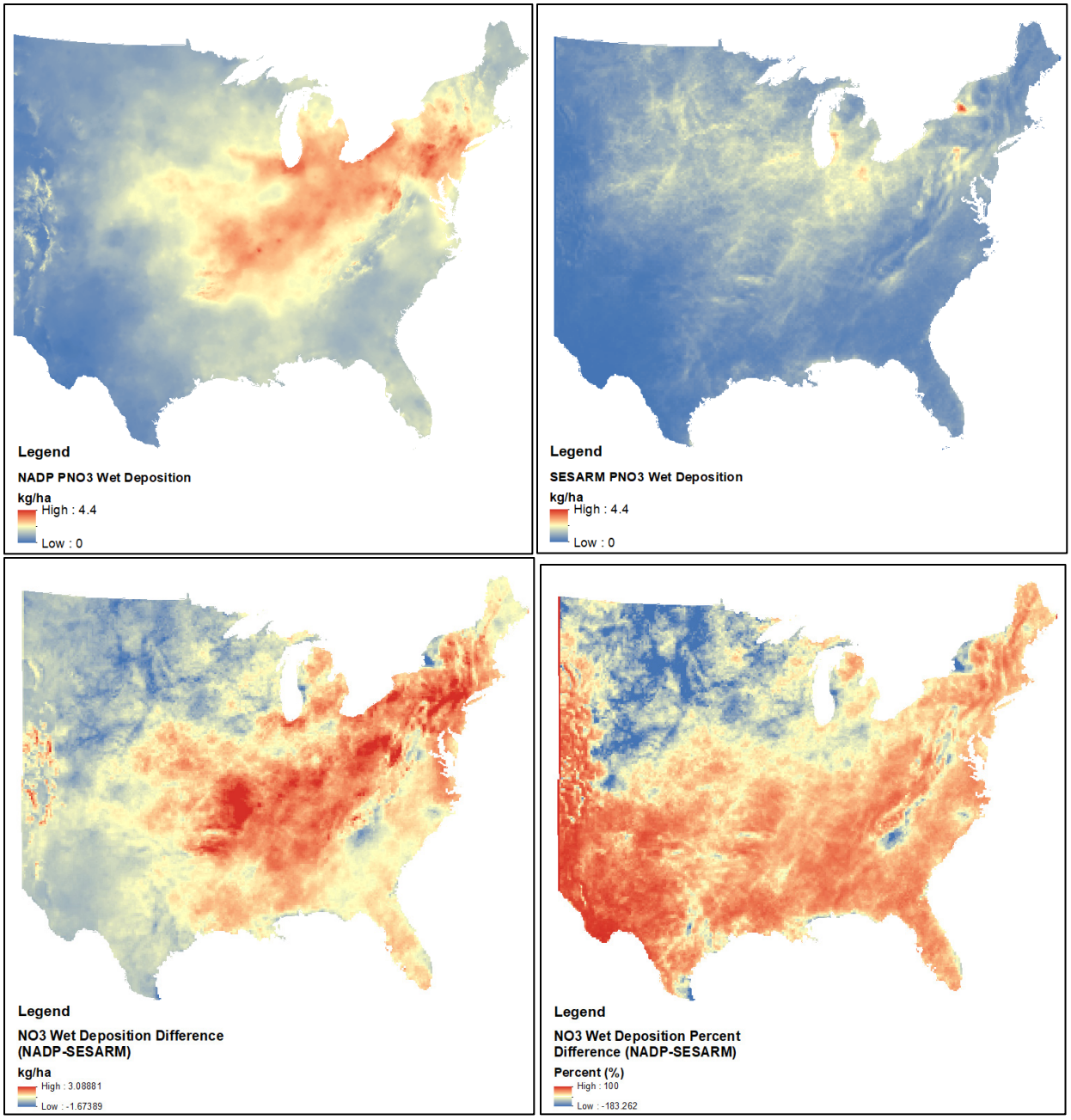


Figure 4-2. Plots of Total Annual Particulate NO_3^+ Wet Deposition. NADP Wet Deposition (top left), SESARM Wet Deposition (top right), Difference (bottom left), Percent Difference[14] (bottom right).

[14] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

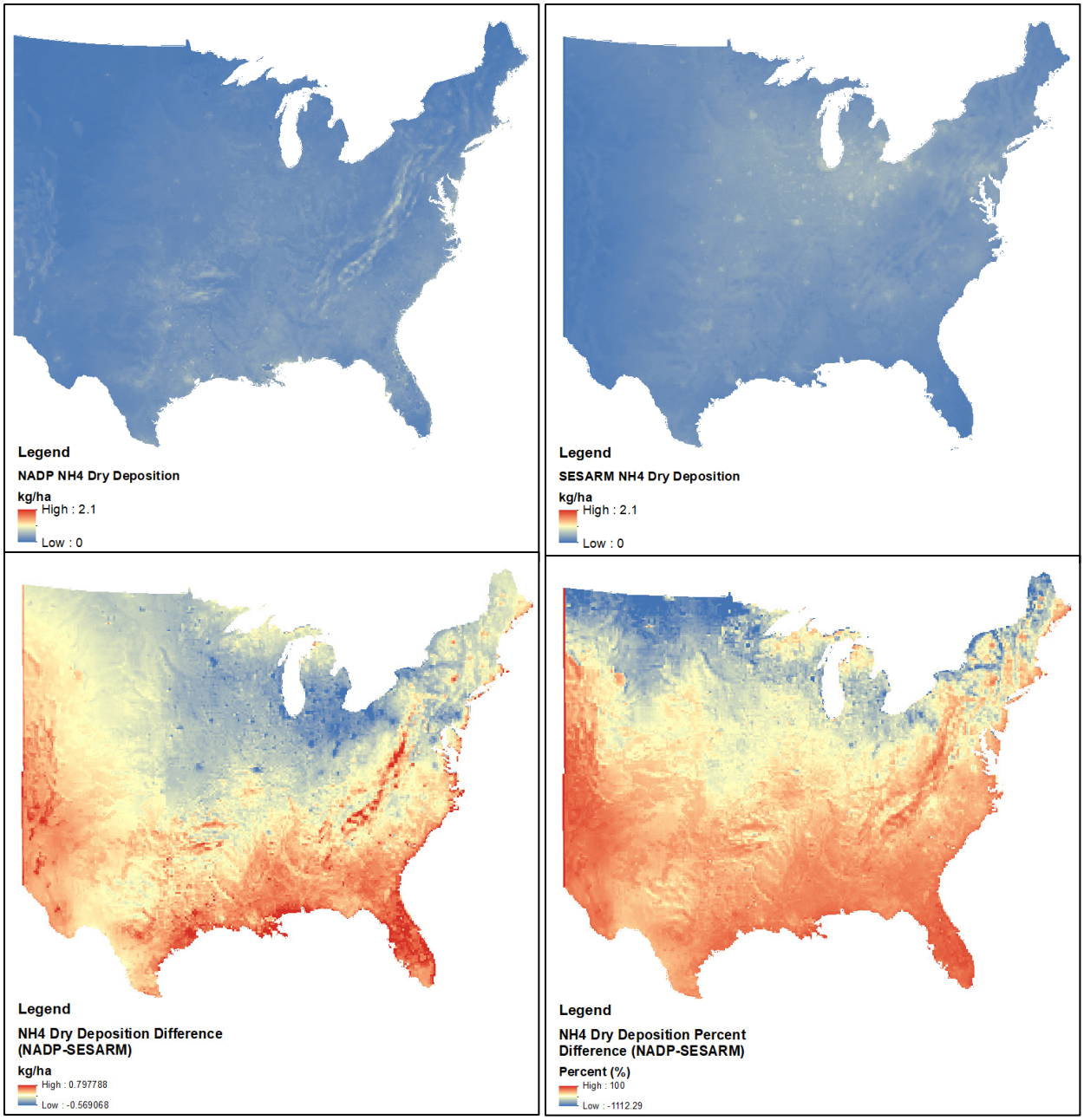


Figure 4-3. Plots of Total Annual Particulate NH_4^+ Dry Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference[15] (bottom right).

[15] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

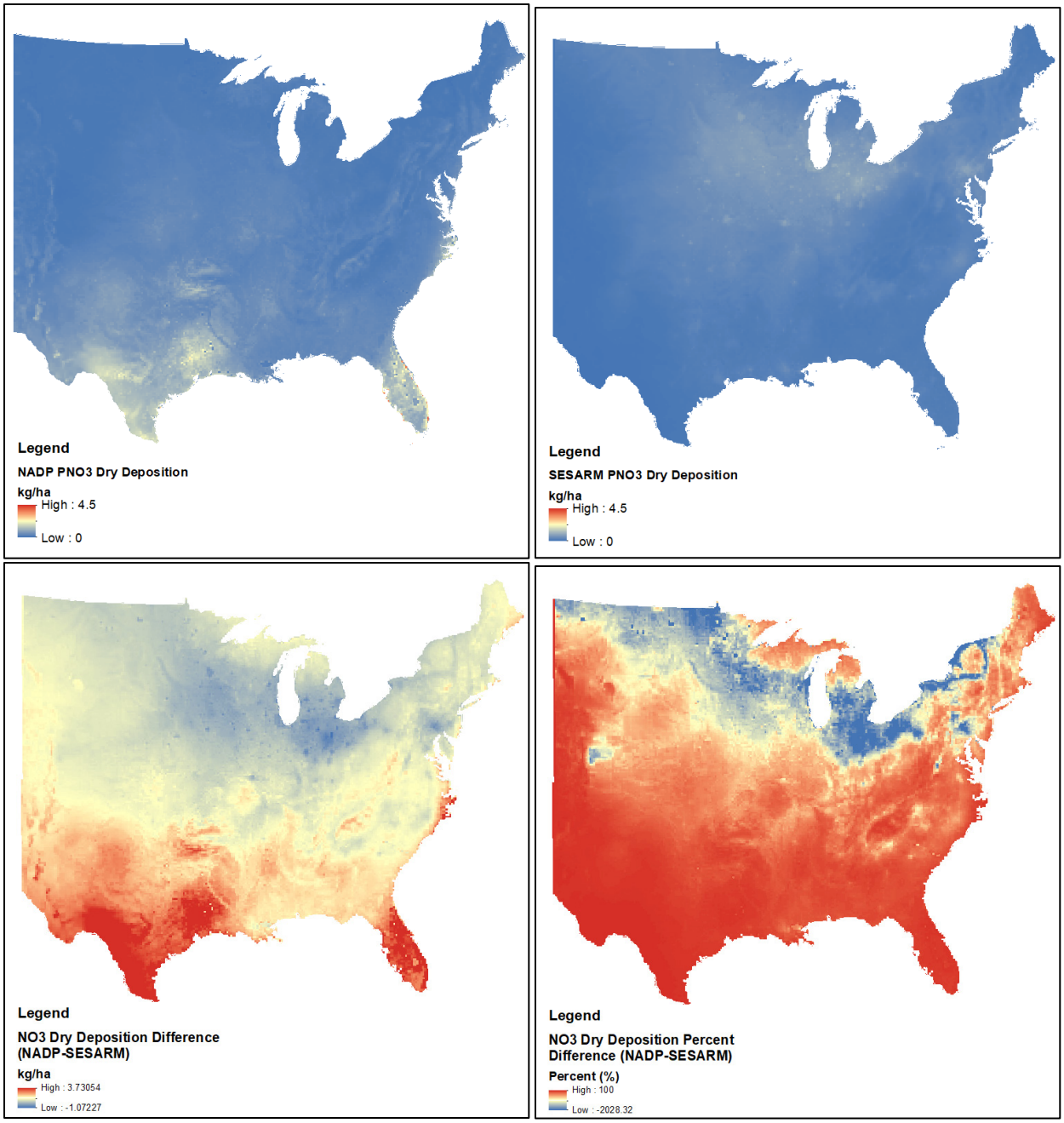


Figure 4-4. Plots of Total Annual Particulate NO_3^+ Dry Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference[16] (bottom right).

[16] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

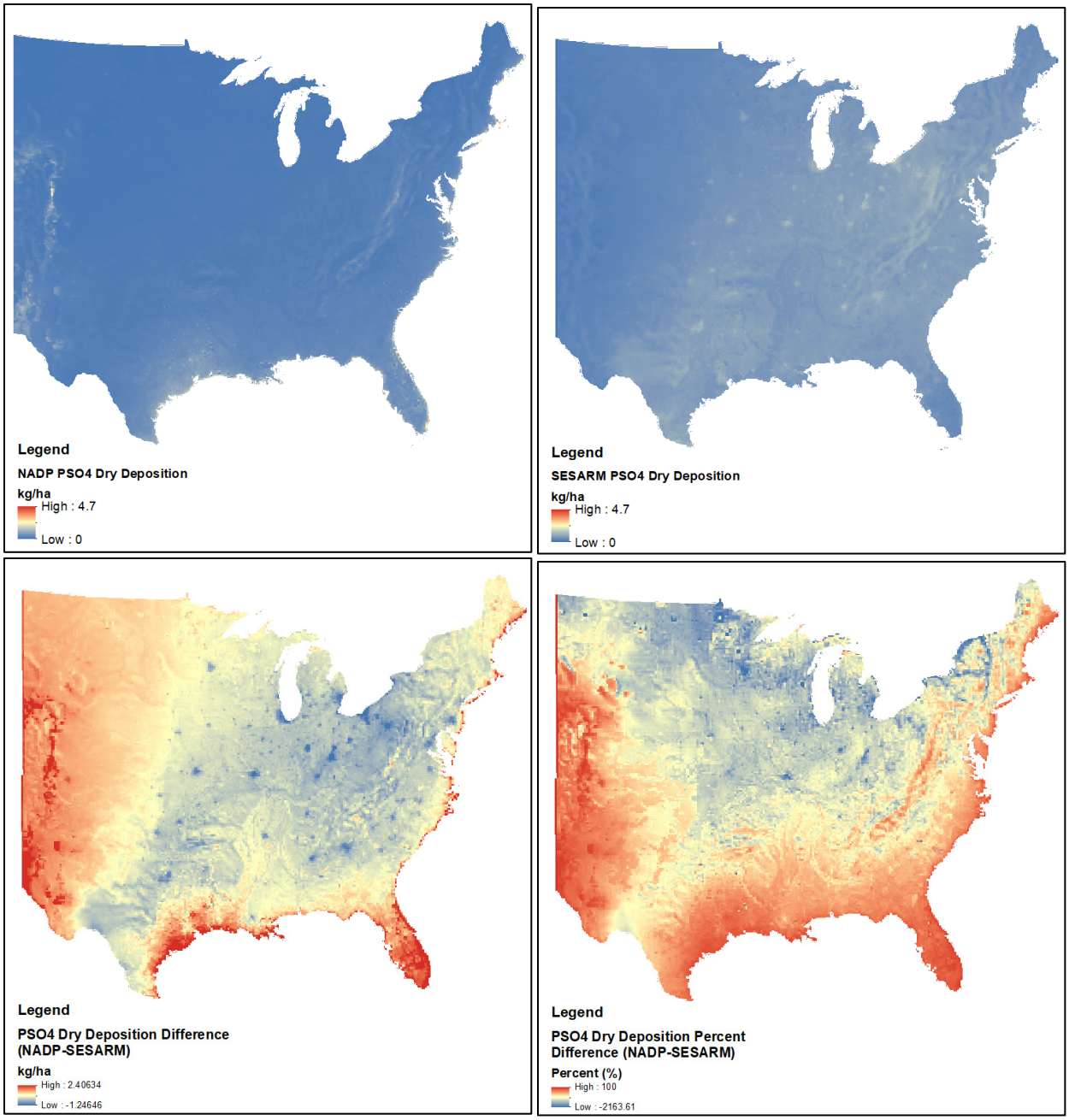


Figure 4-5. Plots of Total Annual Particulate SO_4^{2-} Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference[17] (bottom right).

[17] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

Appendix A
Wet Deposition MPE Results by State

Table A-1. Model Performance Metrics for NTN NH_4^+ Wet Deposition

Network	Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
NTN	NH_4^+	AL	38	-0.003	0.020	-8%	57%	0.585	-4%	30%	0.039
		AR	118	-0.022	0.054	-24%	60%	0.624	-14%	34%	0.123
		CO	290	-0.023	0.024	-64%	68%	0.696	-47%	50%	0.044
		FL	156	-0.018	0.034	-41%	75%	0.346	-26%	48%	0.077
		GA	42	-0.014	0.023	-29%	50%	0.669	-17%	29%	0.041
		IL	124	-0.046	0.067	-38%	55%	0.717	-24%	34%	0.126
		IN	130	-0.052	0.060	-41%	47%	0.863	-26%	30%	0.099
		KS	99	-0.050	0.080	-39%	63%	0.625	-24%	39%	0.148
		KY	109	-0.018	0.049	-21%	57%	0.574	-12%	32%	0.083
		LA	28	-0.031	0.055	-39%	70%	0.329	-24%	43%	0.135
		MA	80	-0.015	0.024	-37%	58%	0.613	-23%	36%	0.040
		MD	35	-0.017	0.040	-22%	53%	0.601	-13%	30%	0.052
		ME	157	-0.005	0.019	-14%	55%	0.742	-8%	29%	0.034
		MI	169	-0.018	0.055	-20%	62%	0.609	-11%	34%	0.108
		MN	140	-0.033	0.058	-37%	64%	0.558	-23%	39%	0.122
		MO	64	-0.038	0.058	-32%	49%	0.514	-19%	29%	0.141
		MS	35	-0.007	0.037	-13%	69%	0.548	-7%	37%	0.061
		NC	243	-0.010	0.051	-12%	62%	0.611	-6%	33%	0.096
		ND	42	-0.046	0.047	-65%	66%	0.804	-48%	49%	0.093
		NE	35	-0.123	0.132	-53%	57%	0.733	-36%	39%	0.257
		NH	40	-0.008	0.027	-18%	61%	0.554	-10%	34%	0.042
		NJ	31	-0.023	0.039	-29%	50%	0.633	-17%	29%	0.058
		NM	39	-0.015	0.015	-82%	83%	0.652	-70%	70%	0.032
		NY	239	-0.030	0.048	-38%	59%	0.552	-23%	37%	0.079
		OH	127	-0.029	0.054	-24%	45%	0.705	-14%	25%	0.093
		OK	50	-0.030	0.043	-37%	53%	0.715	-23%	32%	0.069
		PA	165	-0.028	0.042	-33%	49%	0.666	-19%	29%	0.065
		SD	59	-0.041	0.066	-37%	60%	0.678	-23%	37%	0.108
		TN	63	-0.011	0.033	-16%	48%	0.684	-8%	26%	0.058
		TX	124	-0.027	0.034	-49%	63%	0.714	-32%	42%	0.064
		VA	82	-0.007	0.036	-11%	55%	0.673	-6%	29%	0.062
		VT	69	-0.013	0.032	-26%	62%	0.603	-15%	36%	0.056
		WI	88	-0.006	0.034	-10%	57%	0.840	-5%	30%	0.064
		WV	64	-0.016	0.050	-20%	64%	0.425	-11%	36%	0.083
		WY	30	-0.056	0.058	-61%	62%	0.471	-43%	45%	0.200

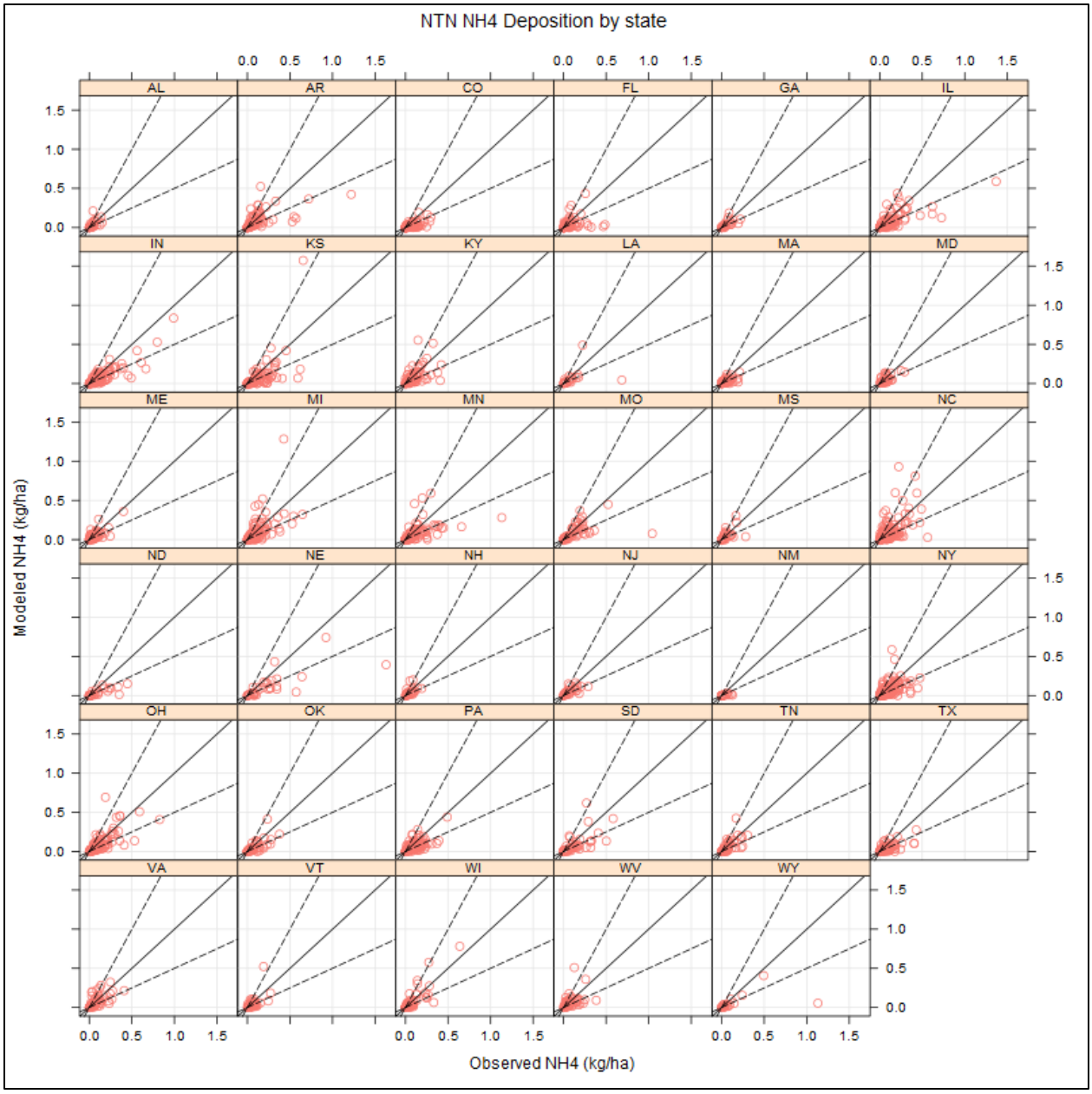


Figure A-1. Modeled NH_4^+ versus NTN Observed NH_4^+ Wet Deposition, by State

Table A-2. Model Performance Metrics for NTN NO_3^+ Wet Deposition

Network	Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
NTN	NO_3^+	AL	38	0.050	0.096	37%	70%	0.746	15%	30%	0.160
		AR	118	0.069	0.162	33%	76%	0.587	14%	33%	0.322
		CO	290	-0.068	0.076	-54%	60%	0.566	-37%	41%	0.155
		FL	156	0.039	0.123	25%	80%	0.618	11%	35%	0.289
		GA	42	0.037	0.077	30%	63%	0.643	13%	27%	0.143
		IL	124	0.015	0.141	5%	50%	0.748	3%	24%	0.248
		IN	130	0.008	0.139	3%	49%	0.796	1%	24%	0.269
		KS	99	-0.004	0.143	-2%	60%	0.652	-1%	30%	0.266
		KY	109	0.071	0.175	28%	70%	0.561	12%	31%	0.307
		LA	28	0.106	0.162	50%	76%	0.813	20%	30%	0.297
		MA	80	0.015	0.097	9%	54%	0.622	4%	26%	0.141
		MD	35	0.087	0.151	40%	69%	0.500	17%	29%	0.264
		ME	157	0.029	0.081	22%	62%	0.604	10%	28%	0.128
		MI	169	0.066	0.149	31%	70%	0.658	13%	30%	0.326
		MN	140	0.006	0.088	4%	62%	0.622	2%	30%	0.170
		MO	64	-0.006	0.150	-2%	51%	0.554	-1%	26%	0.309
		MS	35	0.055	0.151	34%	94%	0.442	15%	40%	0.234
		NC	243	0.046	0.106	29%	68%	0.626	13%	30%	0.220
		ND	42	-0.024	0.048	-25%	52%	0.772	-14%	29%	0.090
		NE	35	-0.005	0.193	-1%	59%	0.692	-1%	30%	0.317
		NH	40	0.037	0.133	19%	70%	0.478	9%	32%	0.228
		NJ	31	0.029	0.107	11%	40%	0.766	5%	19%	0.148
		NM	39	-0.029	0.031	-56%	59%	0.818	-39%	41%	0.074
		NY	239	0.018	0.154	7%	59%	0.592	3%	28%	0.263
		OH	127	0.076	0.172	24%	55%	0.688	11%	25%	0.314
		OK	50	0.059	0.117	34%	67%	0.644	15%	29%	0.334
		PA	165	0.019	0.155	6%	51%	0.565	3%	25%	0.231
		SD	59	0.012	0.092	8%	61%	0.691	4%	29%	0.171
		TN	63	0.041	0.141	19%	63%	0.520	8%	29%	0.249
		TX	124	0.018	0.092	14%	74%	0.571	7%	34%	0.186
		VA	82	0.046	0.109	27%	64%	0.534	12%	28%	0.238
		VT	69	0.020	0.105	10%	55%	0.573	5%	26%	0.202
		WI	88	0.049	0.096	40%	78%	0.828	17%	33%	0.217
		WV	64	0.044	0.189	16%	68%	0.408	7%	32%	0.341
		WY	30	0.006	0.067	5%	56%	0.904	2%	27%	0.121

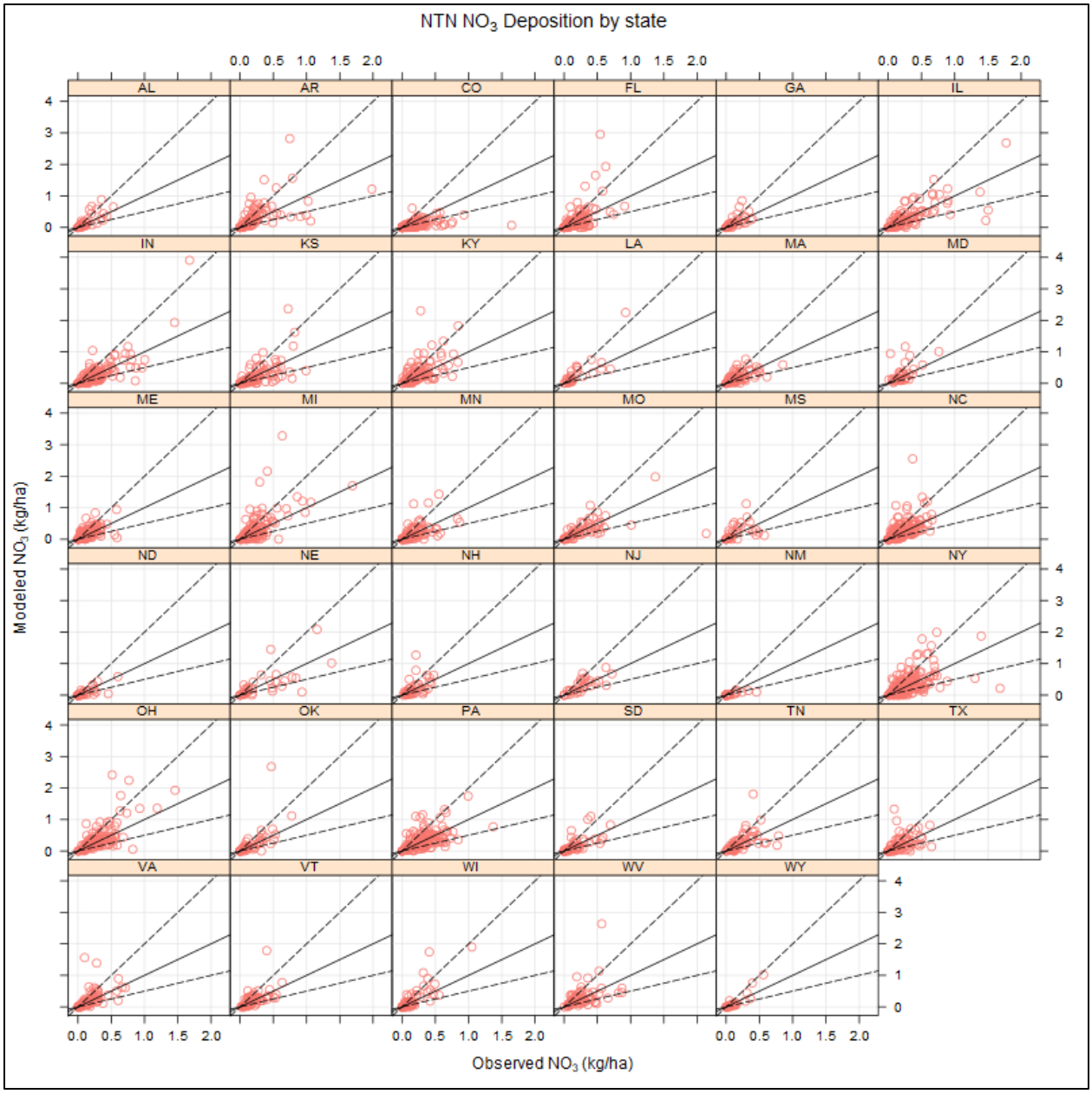


Figure A-2. Modeled NO_3^+ versus NTN Observed NO_3^+ Wet Deposition, by State

Table A-3. Model Performance Metrics for NTN SO_4^{2-} Wet Deposition

Network	Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
NTN	SO_4^{2-}	AL	38	0.021	0.105	11%	58%	0.747	5%	27%	0.180
		AR	118	0.035	0.166	14%	66%	0.633	7%	31%	0.364
		CO	290	-0.033	0.039	-48%	58%	0.721	-32%	38%	0.069
		FL	156	-0.037	0.121	-22%	71%	0.485	-12%	40%	0.216
		GA	42	0.017	0.094	10%	54%	0.681	5%	26%	0.176
		IL	124	-0.018	0.162	-6%	52%	0.721	-3%	27%	0.288
		IN	130	-0.075	0.142	-23%	44%	0.832	-13%	25%	0.197
		KS	99	-0.005	0.118	-3%	59%	0.592	-1%	30%	0.311
		KY	109	0.041	0.187	14%	65%	0.623	7%	30%	0.299
		LA	28	-0.017	0.144	-7%	55%	0.688	-3%	29%	0.300
		MA	80	-0.052	0.111	-27%	57%	0.456	-15%	33%	0.203
		MD	35	0.013	0.128	5%	53%	0.618	3%	26%	0.184
		ME	157	0.019	0.080	14%	60%	0.634	7%	28%	0.135
		MI	169	0.032	0.117	16%	61%	0.672	8%	28%	0.258
		MN	140	0.005	0.065	5%	67%	0.585	2%	33%	0.121
		MO	64	-0.036	0.145	-12%	48%	0.649	-6%	25%	0.286
		MS	35	0.026	0.125	15%	70%	0.494	7%	33%	0.235
		NC	243	0.023	0.116	13%	62%	0.631	6%	29%	0.238
		ND	42	-0.014	0.032	-23%	54%	0.758	-13%	30%	0.062
		NE	35	-0.034	0.146	-14%	58%	0.714	-7%	31%	0.229
		NH	40	0.031	0.105	19%	65%	0.602	9%	30%	0.187
		NJ	31	0.005	0.127	2%	50%	0.681	1%	25%	0.191
		NM	39	-0.017	0.021	-53%	66%	0.652	-36%	45%	0.048
		NY	239	0.013	0.150	5%	60%	0.617	3%	29%	0.310
		OH	127	-0.015	0.209	-3%	48%	0.764	-2%	24%	0.358
		OK	50	-0.014	0.097	-8%	54%	0.714	-4%	28%	0.162
		PA	165	-0.027	0.164	-8%	47%	0.679	-4%	25%	0.252
		SD	59	0.012	0.058	13%	61%	0.718	6%	29%	0.104
		TN	63	0.010	0.154	4%	58%	0.552	2%	28%	0.268
		TX	124	-0.012	0.092	-8%	62%	0.713	-4%	32%	0.156
		VA	82	0.005	0.106	2%	48%	0.739	1%	24%	0.185
		VT	69	0.000	0.101	0%	59%	0.603	0%	30%	0.200
		WI	88	0.032	0.064	36%	72%	0.811	15%	30%	0.128
		WV	64	0.114	0.269	32%	75%	0.687	14%	32%	0.652
		WY	30	-0.003	0.056	-3%	60%	0.761	-2%	31%	0.118

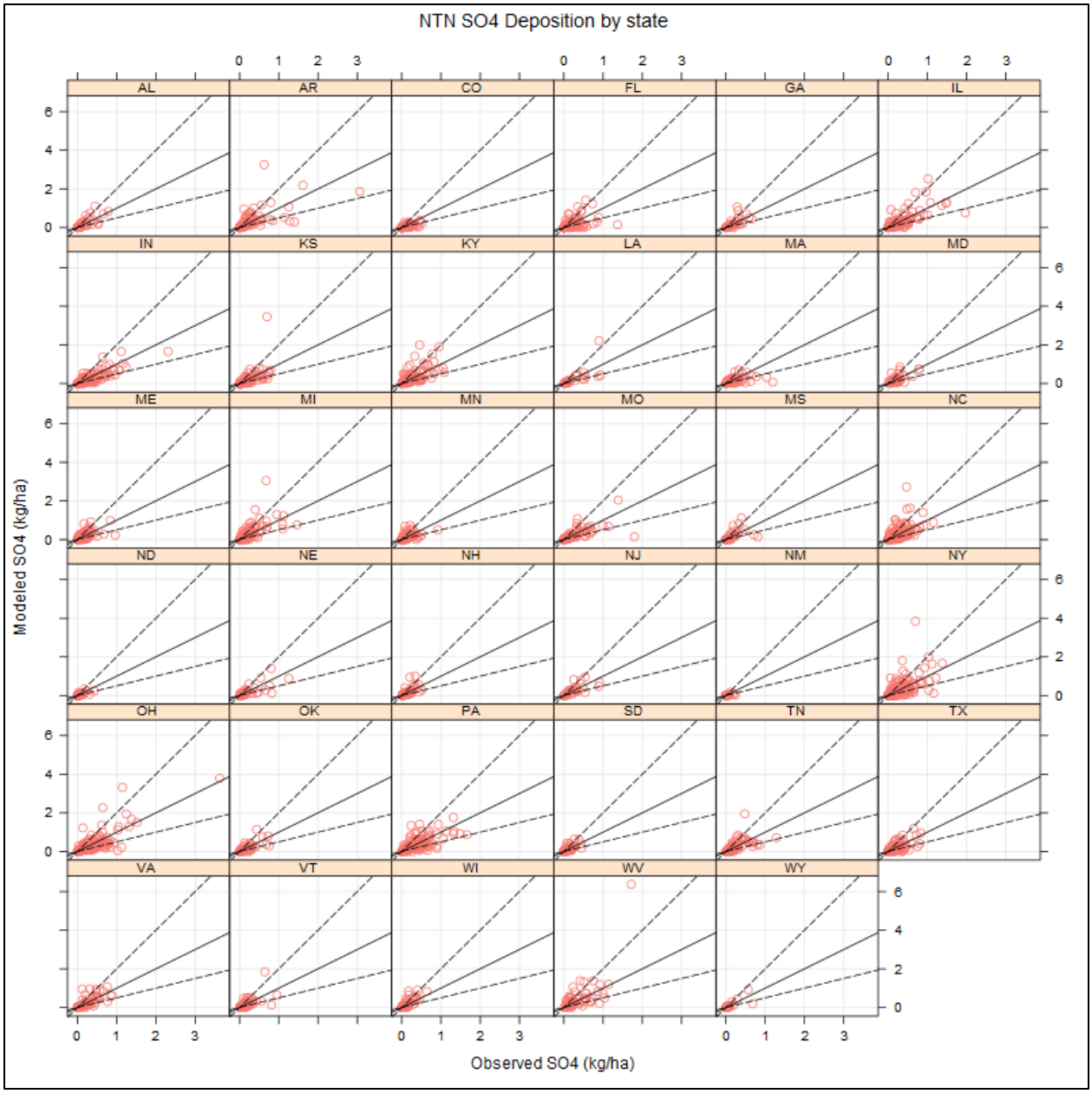


Figure A-3. Modeled SO_4^{2-} versus NTN Observed SO_4^{2-} Wet Deposition, by State

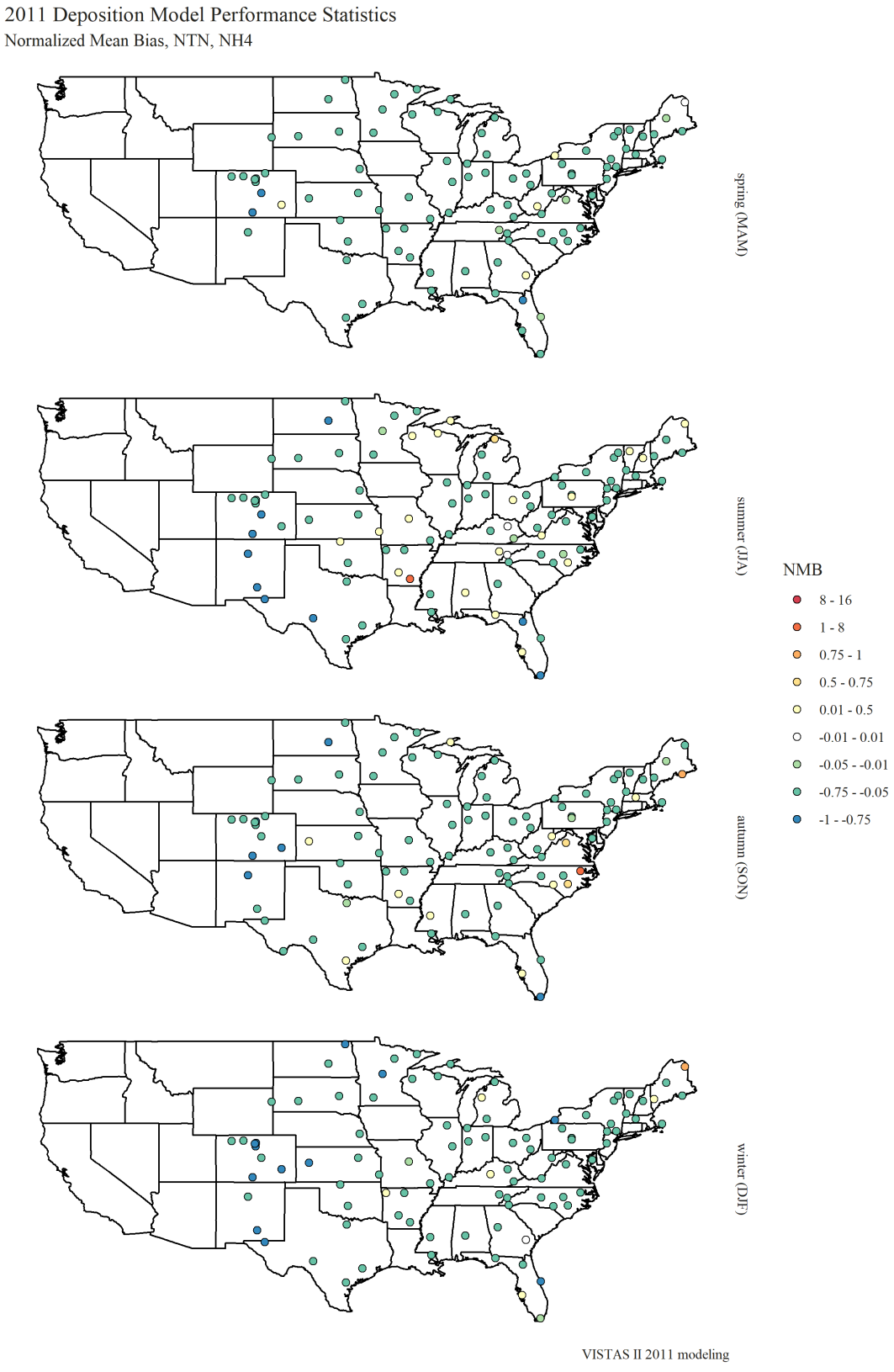


Figure A-4. Normalized Mean Bias for NTN NH_4^+ Wet Deposition, by Season

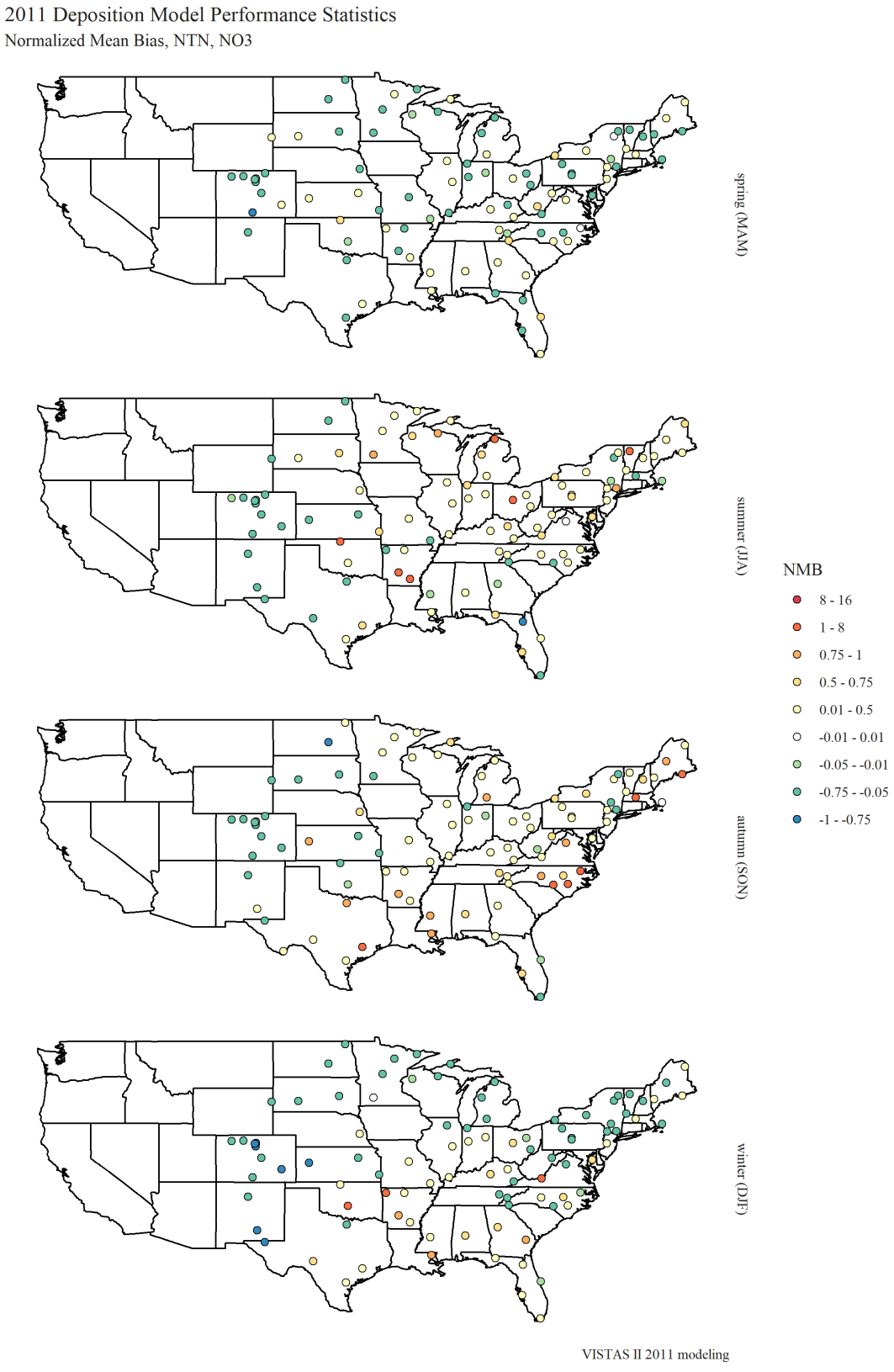


Figure A-5. Normalized Mean Bias for NTN NO_3^+ Wet Deposition, by Season

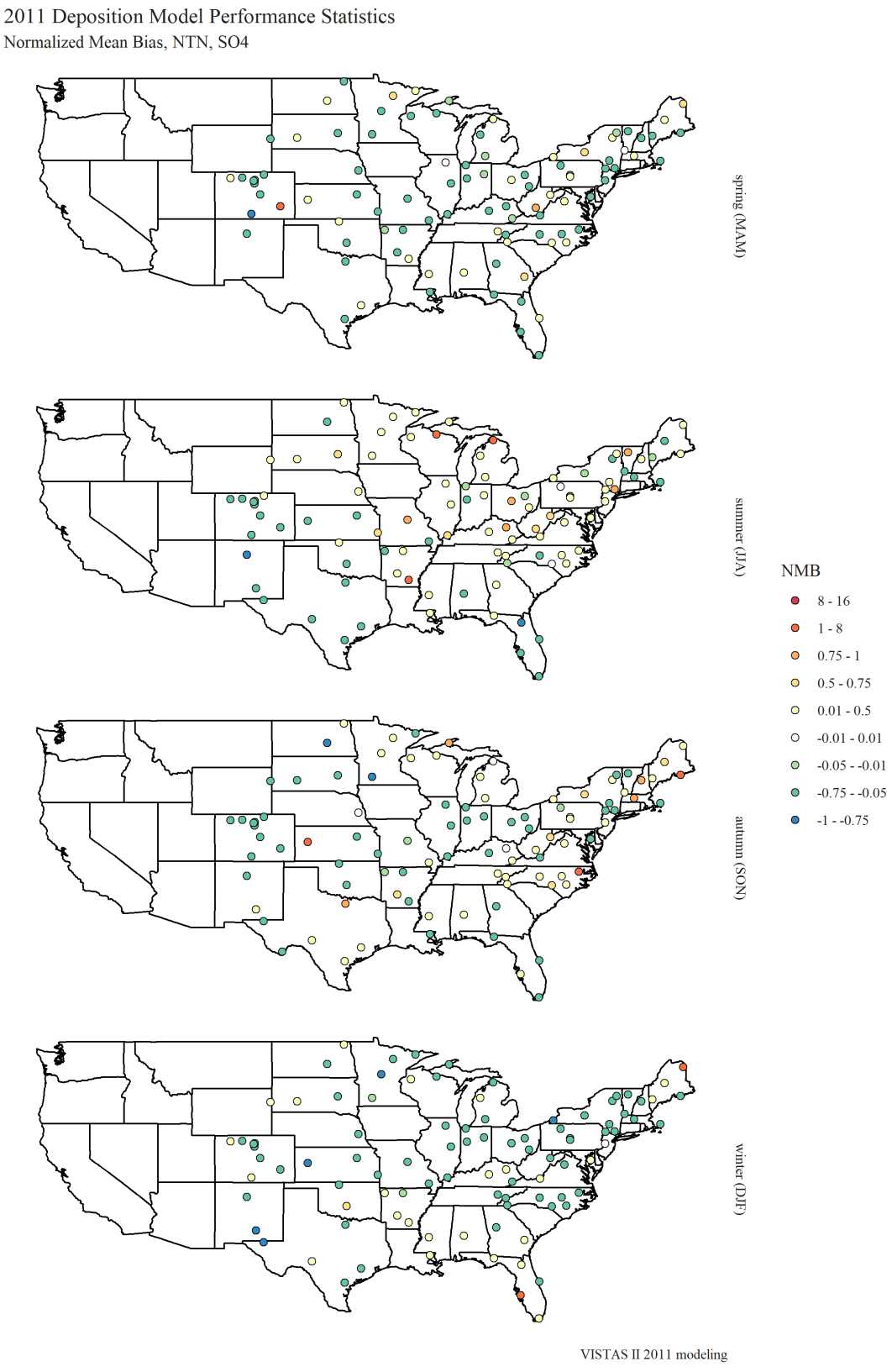


Figure A-6. Normalized Mean Bias for NTN SO_4^{2-} Wet Deposition, by Season

Table A-4. Model Performance Metrics for AIRMon NH_4^+ Wet Deposition

Network	Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
AIRMon	NH_4^+	IL	39	-0.007	0.019	-21%	57%	0.715	-12%	32%	0.033
		PA	40	-0.005	0.020	-20%	85%	0.281	-11%	47%	0.035
		TN	41	-0.002	0.021	-6%	75%	0.493	-3%	39%	0.039
		VT	38	0.000	0.021	-1%	100%	0.633	0%	50%	0.054

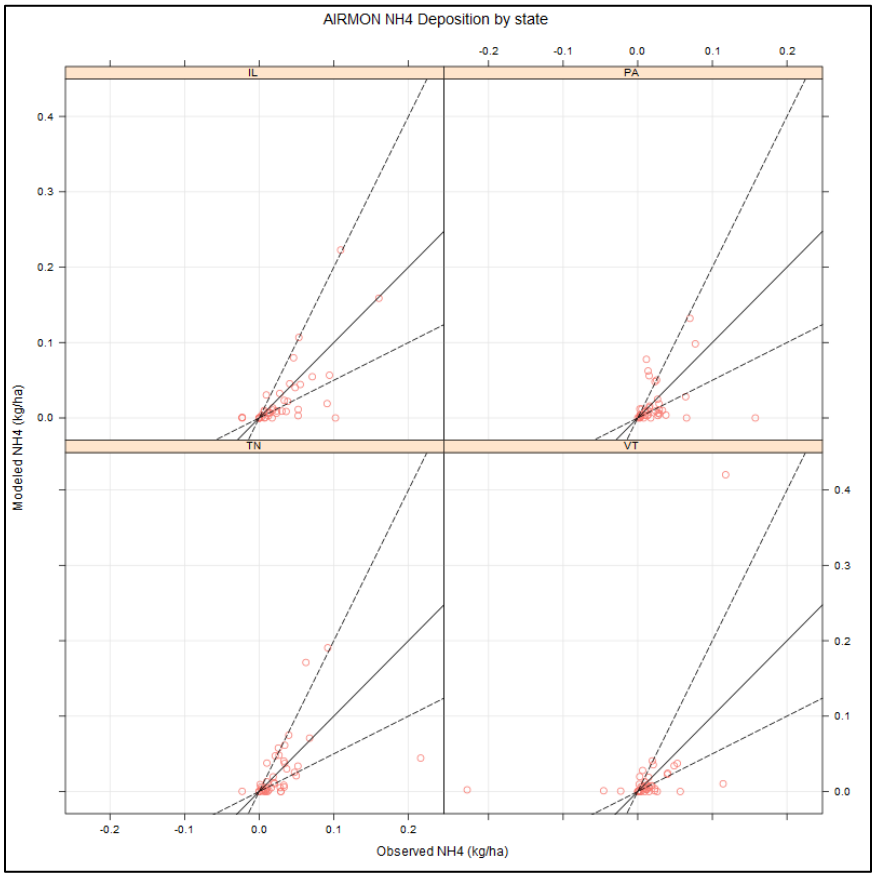


Figure A-7. Modeled NH_4^+ versus AIRMon Observed NH_4^+ Wet Deposition, by State

Table A-5. Model Performance Metrics for AIRMon NO_3^+ Wet Deposition

Network	Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
AIRMon	NO_3^+	IL	39	0.033	0.070	42%	89%	0.691	17%	37%	0.126
		PA	40	0.039	0.111	44%	125%	0.192	18%	51%	0.201
		TN	41	0.084	0.122	111%	162%	0.320	36%	52%	0.219
		VT	38	0.047	0.084	75%	132%	0.507	27%	48%	0.208

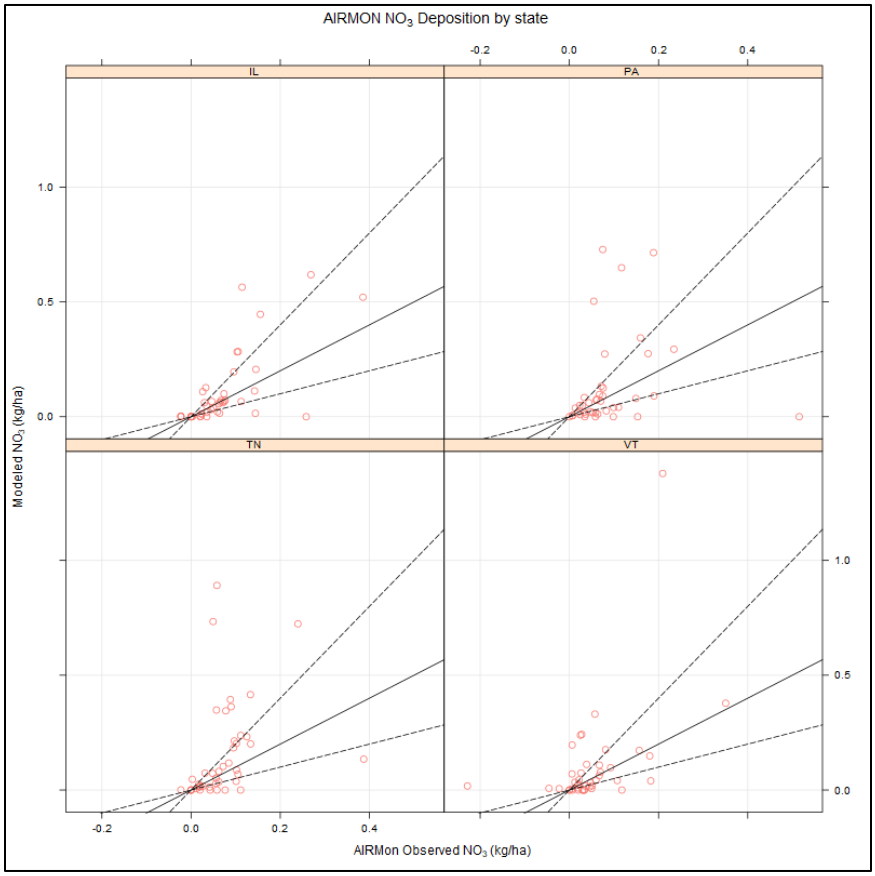


Figure A-8. Modeled NO_3^+ versus AIRMon Observed NO_3^+ Wet Deposition, by State

Table A-6. Model Performance Metrics for AIRMon SO_4^{2-} Wet Deposition

Network	Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
AIRMon	SO_4^{2-}	IL	39	0.008	0.079	9%	83%	0.558	4%	40%	0.175
		PA	40	-0.003	0.114	-2%	104%	0.054	-1%	53%	0.233
		TN	41	0.043	0.095	45%	100%	0.509	18%	41%	0.167
		VT	38	0.024	0.073	40%	122%	0.507	17%	51%	0.206

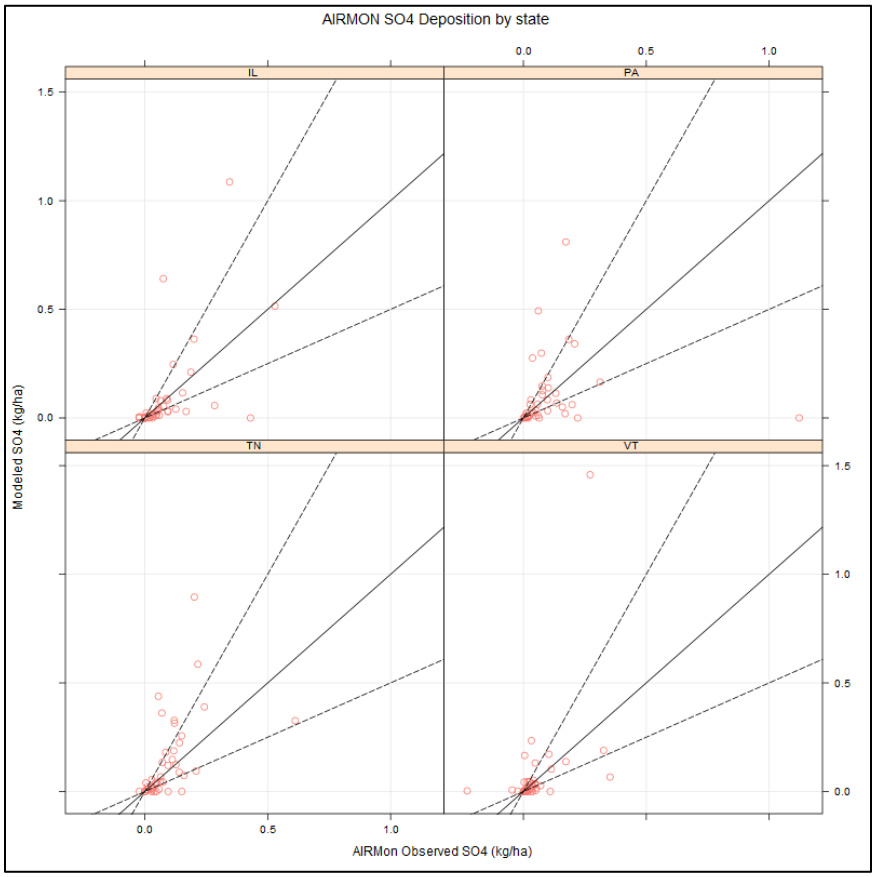


Figure A-9. Modeled SO_4^{2-} versus AIRMon Observed SO_4^{2-} Wet Deposition, by State

Figure A-10. Normalized Mean Bias for AIRMon NH_4^+ Wet Deposition, by Season

Figure A-11. Normalized Mean Bias for AIRMon NO_3^+ Wet Deposition, by Season

Figure A-12. Normalized Mean Bias for AIRMon SO_4^{2-} Wet Deposition, by Season

Appendix B
Dry Deposition MPE Results by State

Table B-1. Model Performance Metrics for CASTNET Cl^- Dry Deposition

Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFE (%)	MFB (%)	RMSE (unitless)
Cl^-	AR	52	-0.0003	0.0004	-86%	88%	0.043	77%	-75%	0.001
	FL	52	-0.013	0.013	-93%	93%	0.797	86%	-86%	0.017
	GA	52	-0.001	0.001	-80%	84%	0.254	70%	-67%	0.001
	IL	52	-0.0002	0.0002	-64%	69%	0.365	51%	-47%	0.0003
	KS	45	-0.0004	0.0004	-85%	85%	0.510	74%	-74%	0.001
	KY	104	-0.0002	0.0003	-60%	74%	0.227	53%	-43%	0.0004
	ME	52	-0.002	0.002	-87%	87%	0.724	77%	-76%	0.004
	MI	52	-0.0002	0.0002	-74%	77%	0.031	62%	-59%	0.0002
	NC	52	-0.0004	0.0004	-85%	85%	0.672	75%	-75%	0.001
	NH	52	0.0000	0.0002	-2%	115%	0.087	58%	-1%	0.0005
	NY	93	-0.0002	0.0002	-85%	86%	0.464	75%	-74%	0.0002
	PA	104	-0.0002	0.0002	-68%	77%	0.253	58%	-51%	0.0003
	TX	52	-0.001	0.001	-99%	99%	0.644	99%	-99%	0.001
	VA	100	-0.0002	0.0003	-70%	77%	0.468	59%	-54%	0.0004
	WV	51	-0.0002	0.0003	-73%	75%	0.308	59%	-57%	0.0004

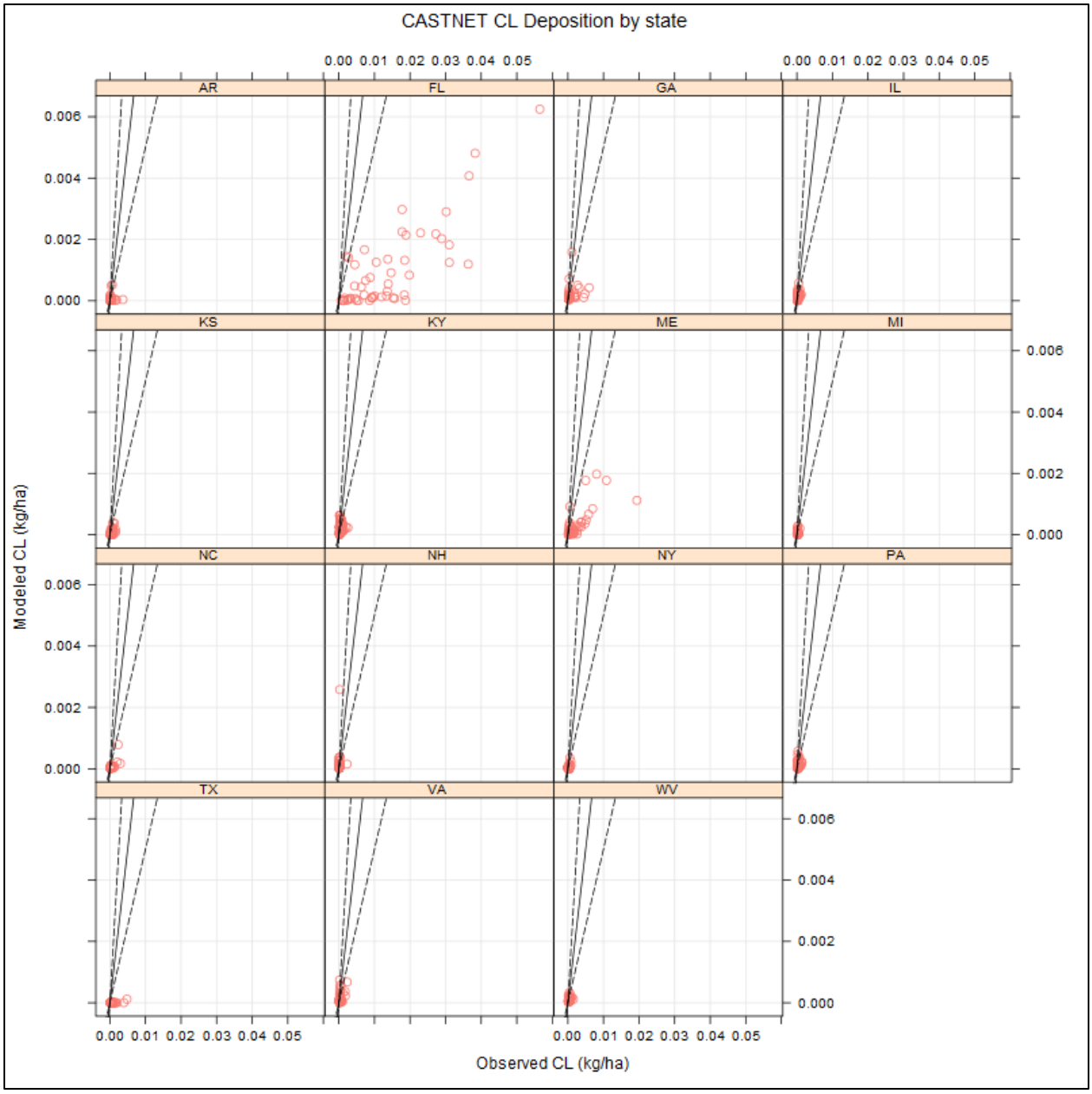


Figure B-1. Modeled Cl^- versus CASTNET Observed Cl^- Dry Deposition, by State

Table B-2. Model Performance Metrics for CASTNET NH_4^+ Dry Deposition

Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFE (%)	MFB (%)	RMSE (unitless)
NH_4^+	AR	52	0.001	0.002	33%	50%	0.475	21%	14%	0.002
	FL	52	-0.001	0.001	-49%	54%	0.685	36%	-33%	0.001
	GA	52	-0.002	0.003	-27%	34%	0.617	20%	-16%	0.004
	IL	52	0.001	0.002	12%	35%	0.439	17%	6%	0.003
	KS	45	-0.0003	0.002	-5%	34%	0.635	17%	-2%	0.003
	KY	104	0.006	0.006	71%	72%	0.730	26%	26%	0.007
	ME	52	0.001	0.001	47%	66%	0.373	27%	19%	0.001
	MI	52	0.001	0.002	29%	37%	0.727	16%	13%	0.002
	NC	52	-0.0004	0.001	-8%	31%	0.649	16%	-4%	0.002
	NH	52	0.003	0.003	373%	373%	0.654	65%	65%	0.004
	NY	93	0.001	0.002	25%	66%	0.549	29%	11%	0.003
	PA	104	0.000	0.003	-6%	43%	0.561	22%	-3%	0.003
	TX	52	-0.004	0.004	-60%	61%	0.420	43%	-42%	0.005
	VA	100	0.0005	0.003	7%	39%	0.534	19%	4%	0.003
	WV	51	-0.001	0.003	-10%	42%	0.639	22%	-5%	0.004

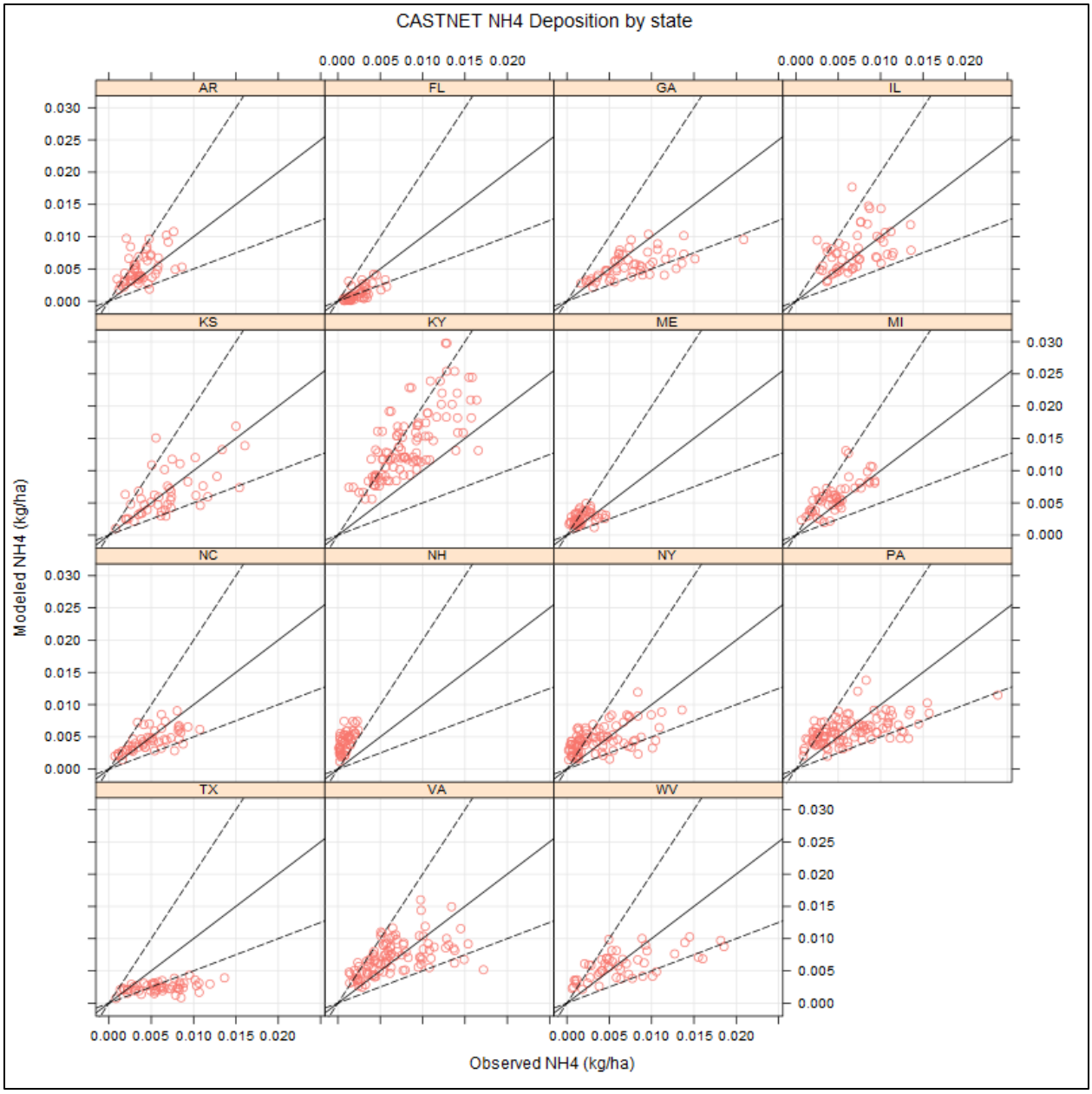


Figure B-2. Modeled NH_4^+ versus CASTNET Observed NH_4^+ Dry Deposition, by State

Table B-3. Model Performance Metrics for CASTNET NO_3^+ Dry Deposition

Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFE (%)	MFB (%)	RMSE (unitless)
NO_3^+	AR	52	0.001	0.002	22%	87%	0.587	39%	10%	0.003
	FL	52	-0.006	0.006	-66%	66%	0.223	49%	-49%	0.008
	GA	52	-0.001	0.002	-22%	60%	0.486	34%	-12%	0.003
	IL	52	0.001	0.005	15%	47%	0.740	22%	7%	0.006
	KS	45	-0.006	0.007	-41%	48%	0.830	30%	-26%	0.009
	KY	104	0.006	0.007	101%	113%	0.753	37%	34%	0.011
	ME	52	0.0004	0.001	17%	66%	0.651	31%	8%	0.002
	MI	52	0.002	0.003	59%	81%	0.711	31%	23%	0.005
	NC	52	0.0003	0.001	19%	73%	0.557	33%	9%	0.002
	NH	52	0.003	0.003	800%	803%	0.409	80%	80%	0.005
	NY	93	0.001	0.002	64%	120%	0.435	46%	24%	0.003
	PA	104	0.001	0.003	24%	74%	0.541	33%	11%	0.005
	TX	52	-0.006	0.006	-96%	96%	0.197	93%	-93%	0.007
	VA	100	0.002	0.003	53%	97%	0.622	38%	21%	0.004
	WV	51	0.001	0.002	27%	60%	0.711	27%	12%	0.003

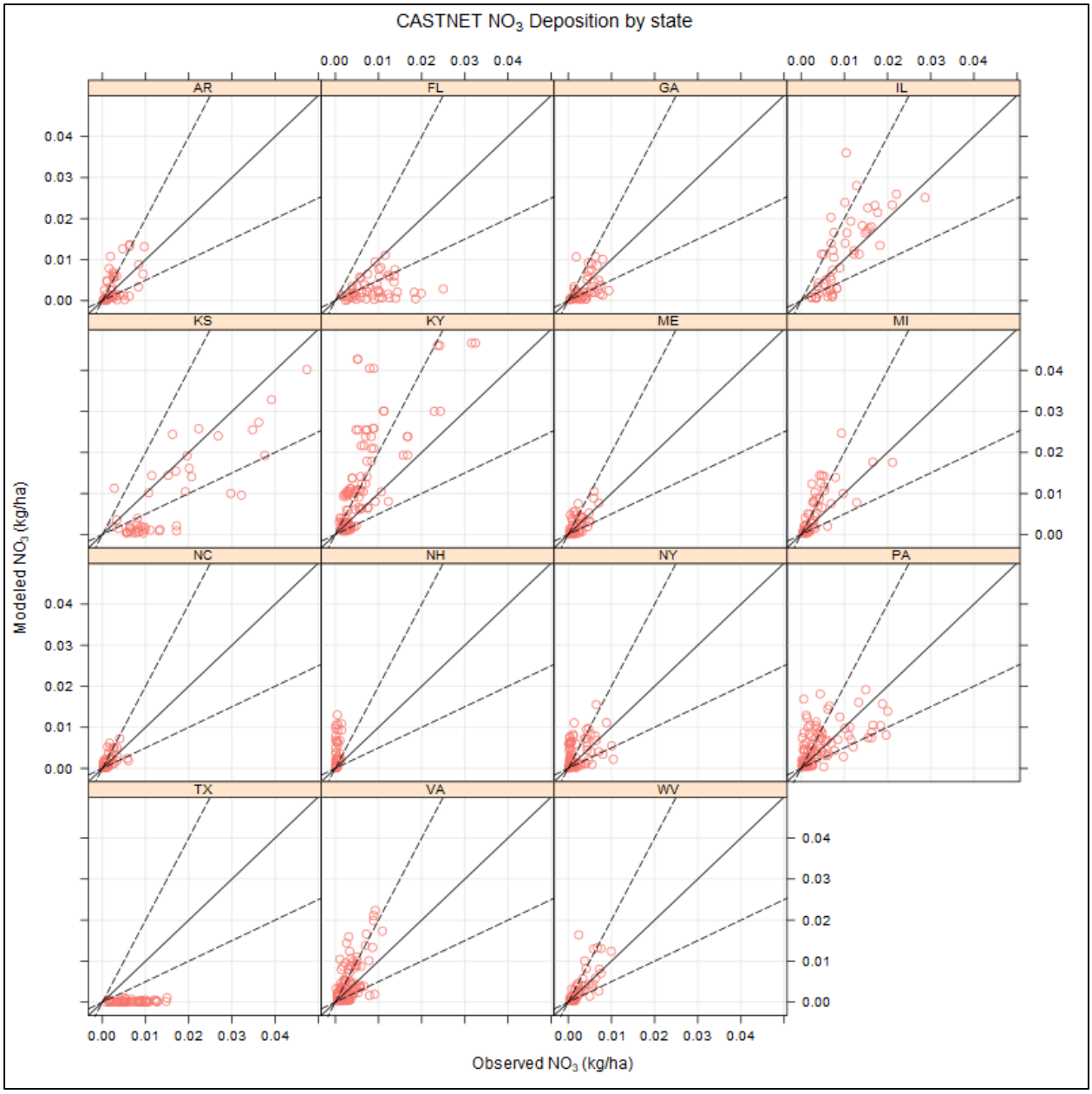


Figure B-3. Modeled NO_3^+ versus CASTNET Observed NO_3^+ Dry Deposition, by State

Table B-4. Model Performance Metrics for CASTNET HNO_3 Dry Deposition

Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFE (%)	MFB (%)	RMSE (unitless)
HNO_3	AR	52	-0.049	0.049	-94%	94%	0.471	89%	-89%	0.054
	FL	52	-0.025	0.025	-94%	94%	0.661	88%	-88%	0.033
	GA	52	-0.093	0.093	-96%	96%	0.581	93%	-93%	0.101
	IL	52	-0.088	0.088	-97%	97%	0.831	94%	-94%	0.103
	KS	45	-0.096	0.096	-97%	97%	0.740	95%	-95%	0.114
	KY	104	-0.104	0.104	-94%	94%	0.367	88%	-88%	0.109
	ME	52	-0.026	0.026	-94%	94%	0.721	89%	-89%	0.031
	MI	52	-0.045	0.045	-94%	94%	0.715	89%	-89%	0.052
	NC	52	-0.027	0.027	-90%	90%	0.629	82%	-82%	0.031
	NH	52	-0.005	0.005	-70%	70%	0.466	54%	-54%	0.006
	NY	93	-0.048	0.048	-94%	94%	0.802	89%	-89%	0.069
	PA	104	-0.068	0.068	-95%	95%	0.404	91%	-91%	0.079
	TX	52	-0.066	0.066	-97%	97%	0.507	95%	-95%	0.076
	VA	100	-0.082	0.082	-95%	95%	0.652	91%	-91%	0.088
	WV	51	-0.053	0.053	-92%	92%	0.581	85%	-85%	0.060

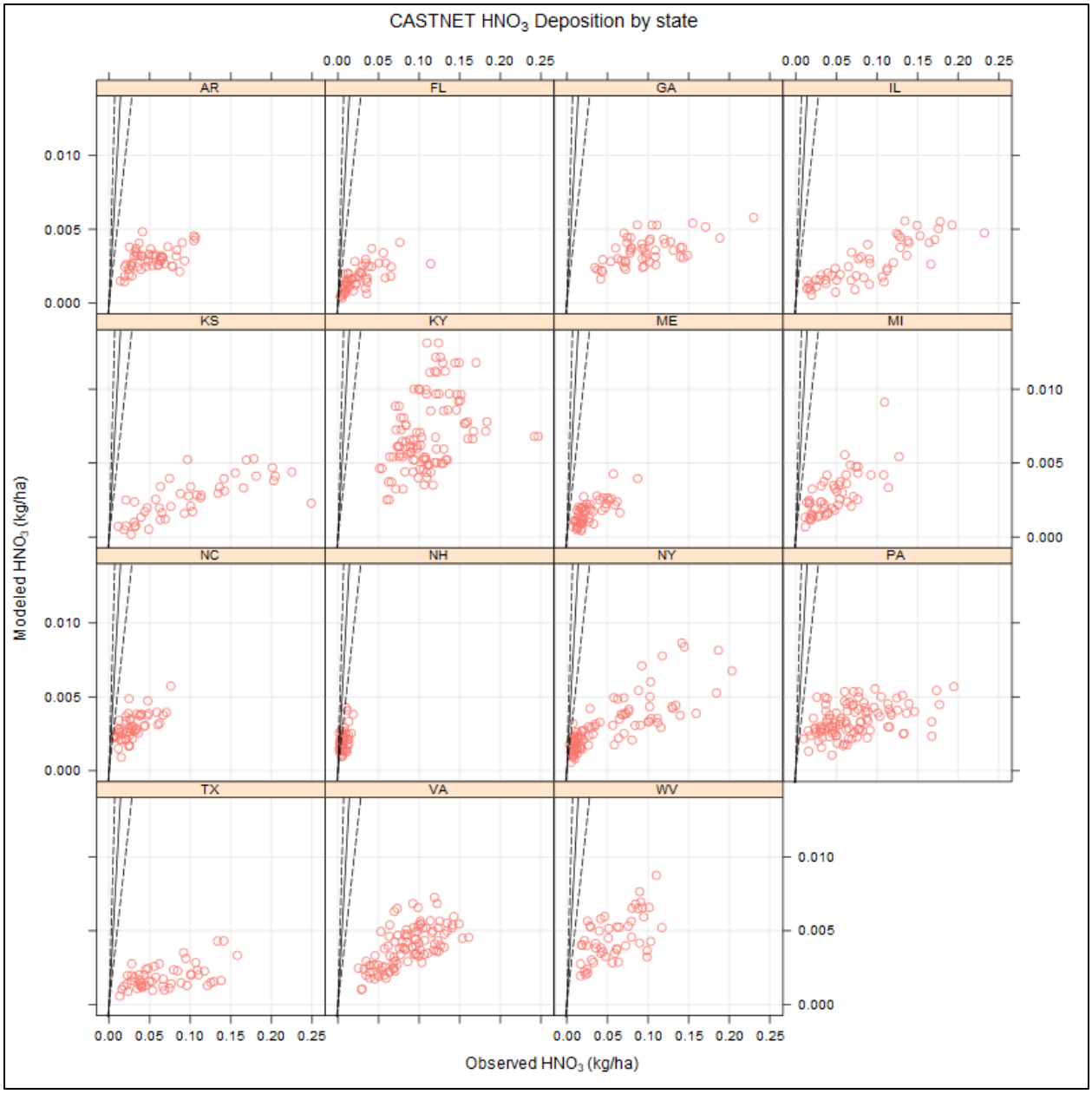


Figure B-4. Modeled HNO_3 versus CASTNET Observed HNO_3 Dry Deposition, by State

Table B-5. Model Performance Metrics for CASTNET SO_4^{2-} Dry Deposition

Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFE (%)	MFB (%)	RMSE (unitless)
SO_4^{2-}	AR	52	0.001	0.004	9%	36%	0.528	17%	4%	0.006
	FL	52	-0.008	0.008	-49%	49%	0.779	33%	-33%	0.010
	GA	52	-0.008	0.008	-32%	34%	0.710	20%	-19%	0.012
	IL	52	-0.002	0.005	-15%	30%	0.757	16%	-8%	0.007
	KS	45	-0.007	0.007	-36%	38%	0.817	23%	-22%	0.009
	KY	104	0.011	0.011	54%	54%	0.816	21%	21%	0.014
	ME	52	0.003	0.004	50%	60%	0.369	24%	20%	0.005
	MI	52	0.002	0.003	22%	28%	0.877	13%	10%	0.004
	NC	52	0.00005	0.004	0%	30%	0.704	15%	0%	0.006
	NH	52	0.009	0.009	357%	357%	0.756	64%	64%	0.010
	NY	93	0.004	0.006	37%	63%	0.706	27%	16%	0.007
	PA	104	-0.001	0.006	-5%	35%	0.765	18%	-3%	0.007
	TX	52	-0.010	0.010	-53%	56%	0.408	38%	-36%	0.013
	VA	100	0.0004	0.005	2%	28%	0.782	14%	1%	0.008
	WV	51	-0.001	0.005	-7%	25%	0.894	13%	-3%	0.007

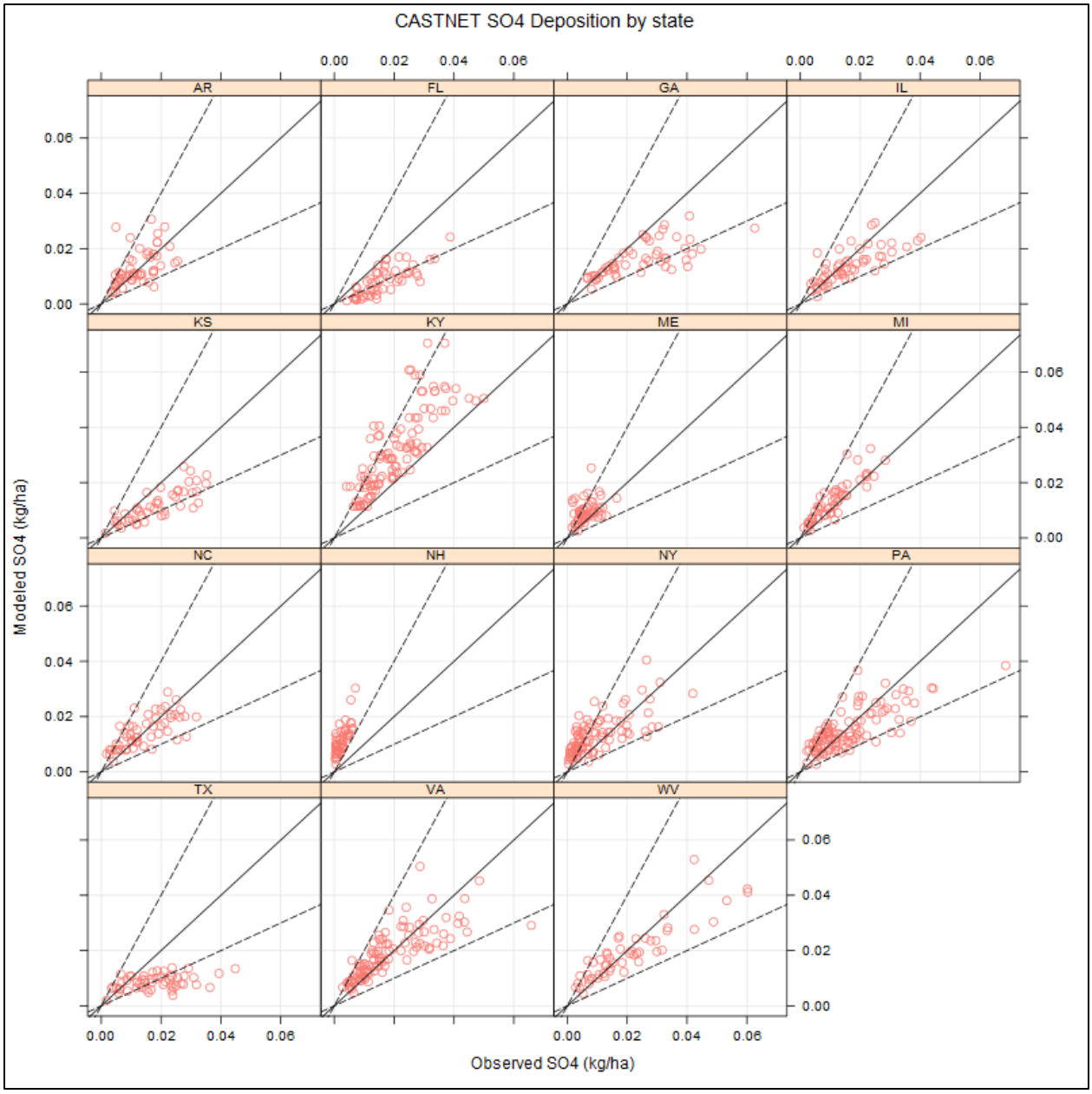


Figure B-5. Modeled SO_4^{2-} versus CASTNET Observed SO_4^{2-} Dry Deposition, by State

Table B-6. Model Performance Metrics for CASTNET SO_2 Dry Deposition

Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFE (%)	MFB (%)	RMSE (unitless)
SO_2	AR	52	-0.010	0.010	-94%	94%	0.484	89%	-89%	0.011
	FL	52	-0.005	0.005	-95%	95%	0.447	90%	-90%	0.005
	GA	52	-0.033	0.033	-97%	97%	0.678	93%	-93%	0.039
	IL	52	-0.061	0.061	-97%	97%	0.423	95%	-95%	0.070
	KS	45	-0.009	0.009	-95%	95%	0.194	90%	-90%	0.011
	KY	104	-0.064	0.064	-95%	95%	0.545	91%	-91%	0.081
	ME	52	-0.008	0.008	-96%	96%	0.801	92%	-92%	0.010
	MI	52	-0.012	0.012	-93%	93%	0.503	88%	-88%	0.014
	NC	52	-0.005	0.005	-89%	89%	0.555	81%	-81%	0.005
	NH	52	-0.003	0.003	-86%	86%	0.595	75%	-75%	0.004
	NY	93	-0.010	0.010	-94%	94%	0.562	89%	-89%	0.013
	PA	104	-0.068	0.068	-98%	98%	0.302	95%	-95%	0.096
	TX	52	-0.009	0.009	-98%	98%	0.262	96%	-96%	0.011
	VA	100	-0.053	0.053	-97%	97%	0.725	94%	-94%	0.066
	WV	51	-0.041	0.041	-96%	96%	0.421	92%	-92%	0.050

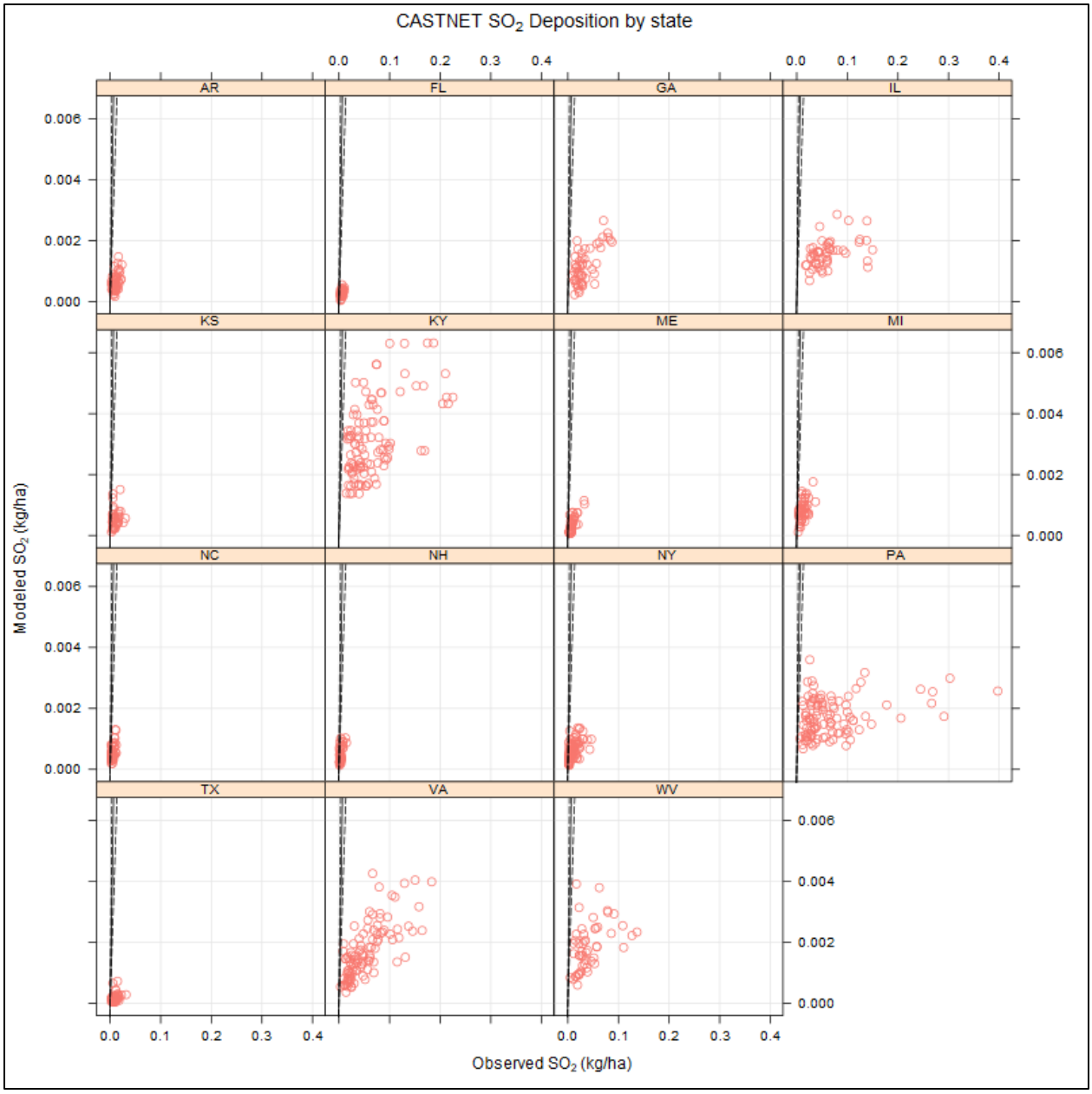


Figure B-6. Modeled SO_2 versus CASTNET Observed SO_2 Dry Deposition, by State

Figure B-7. Normalized Mean Bias for CASTNET Cl^- Dry Deposition, by Season

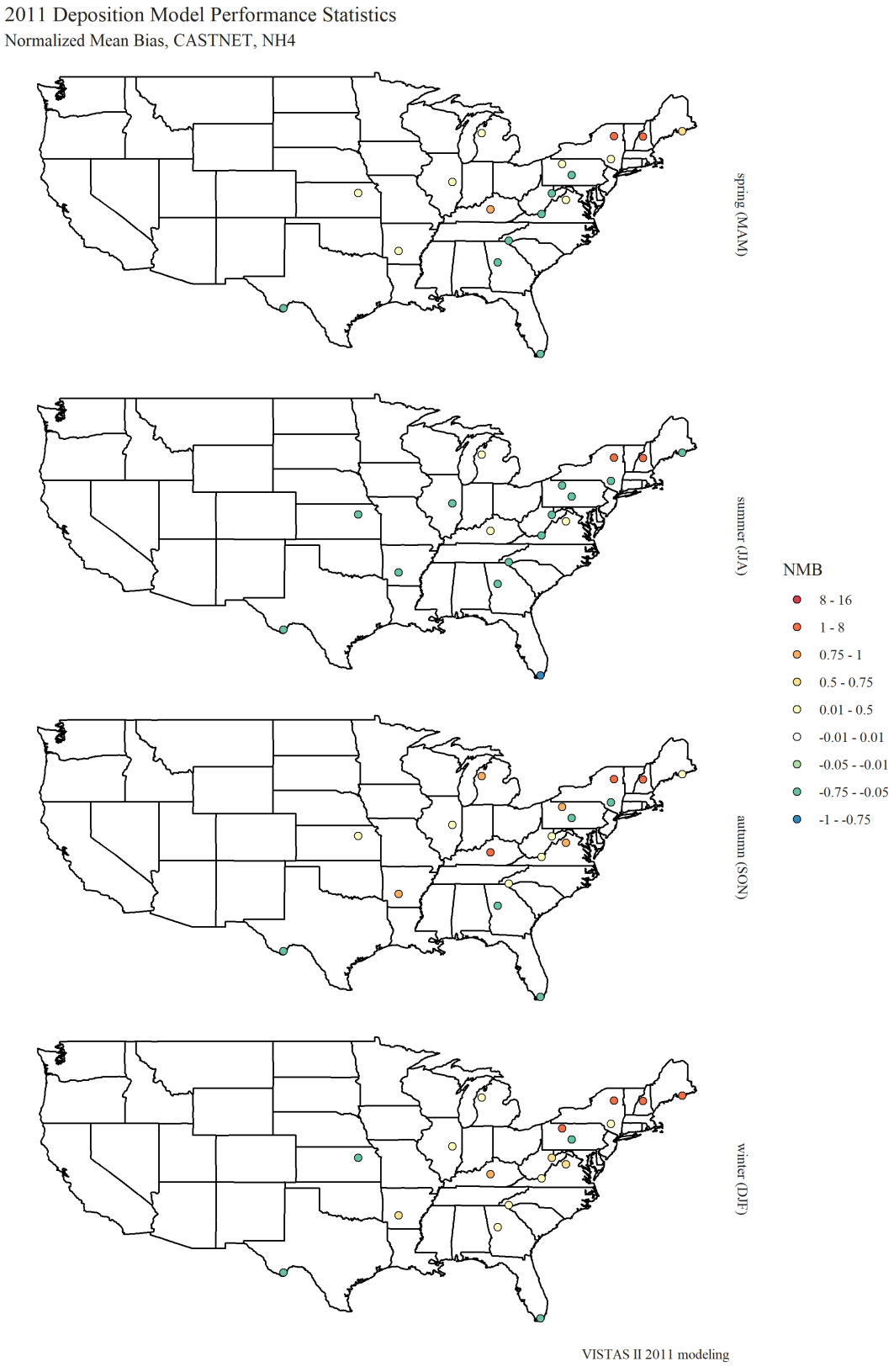


Figure B-8. Normalized Mean Bias for CASTNET NH_4^+ Dry Deposition, by Season

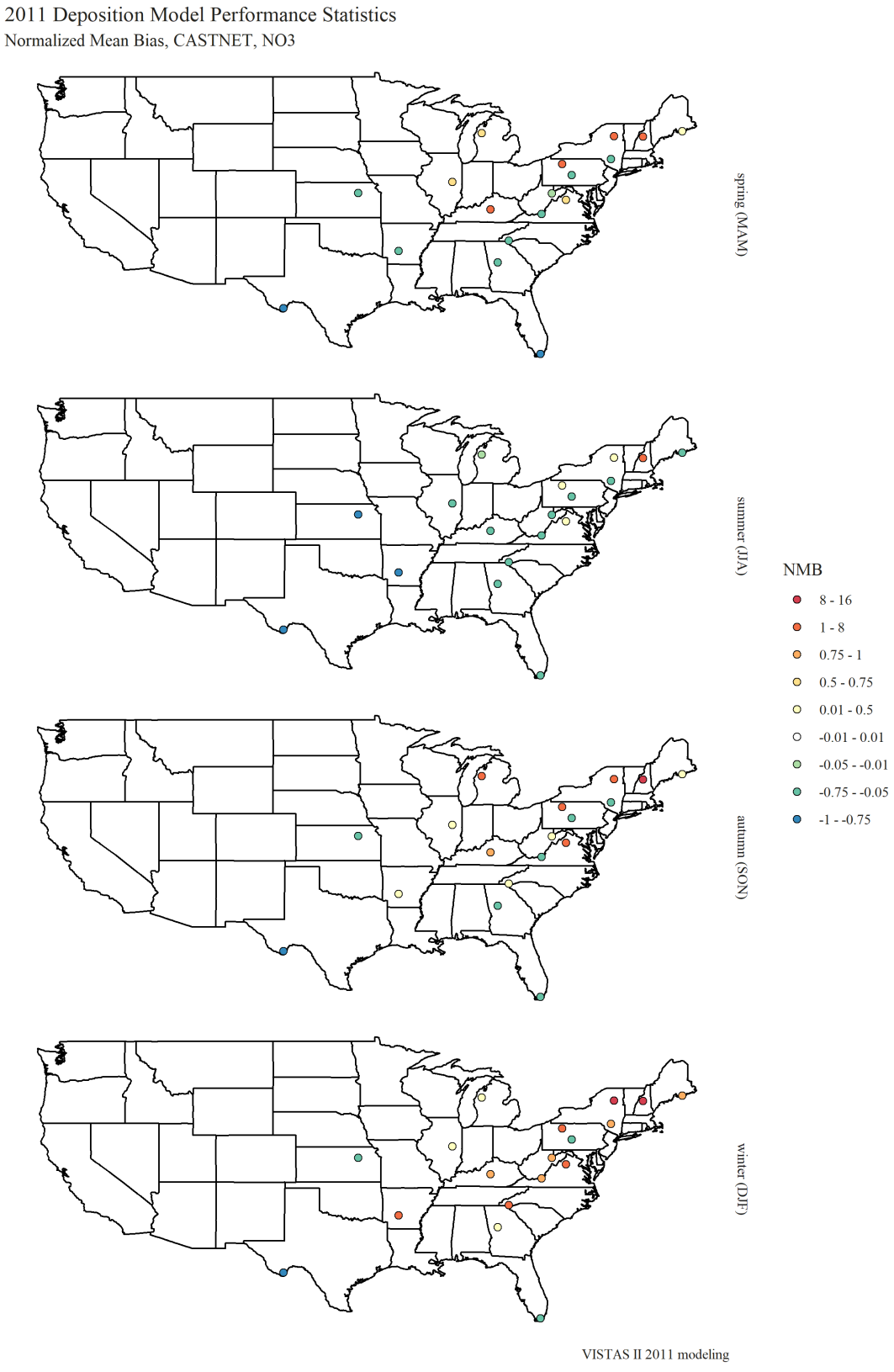


Figure B-9. Normalized Mean Bias for CASTNET NO_3^+ Dry Deposition, by Season

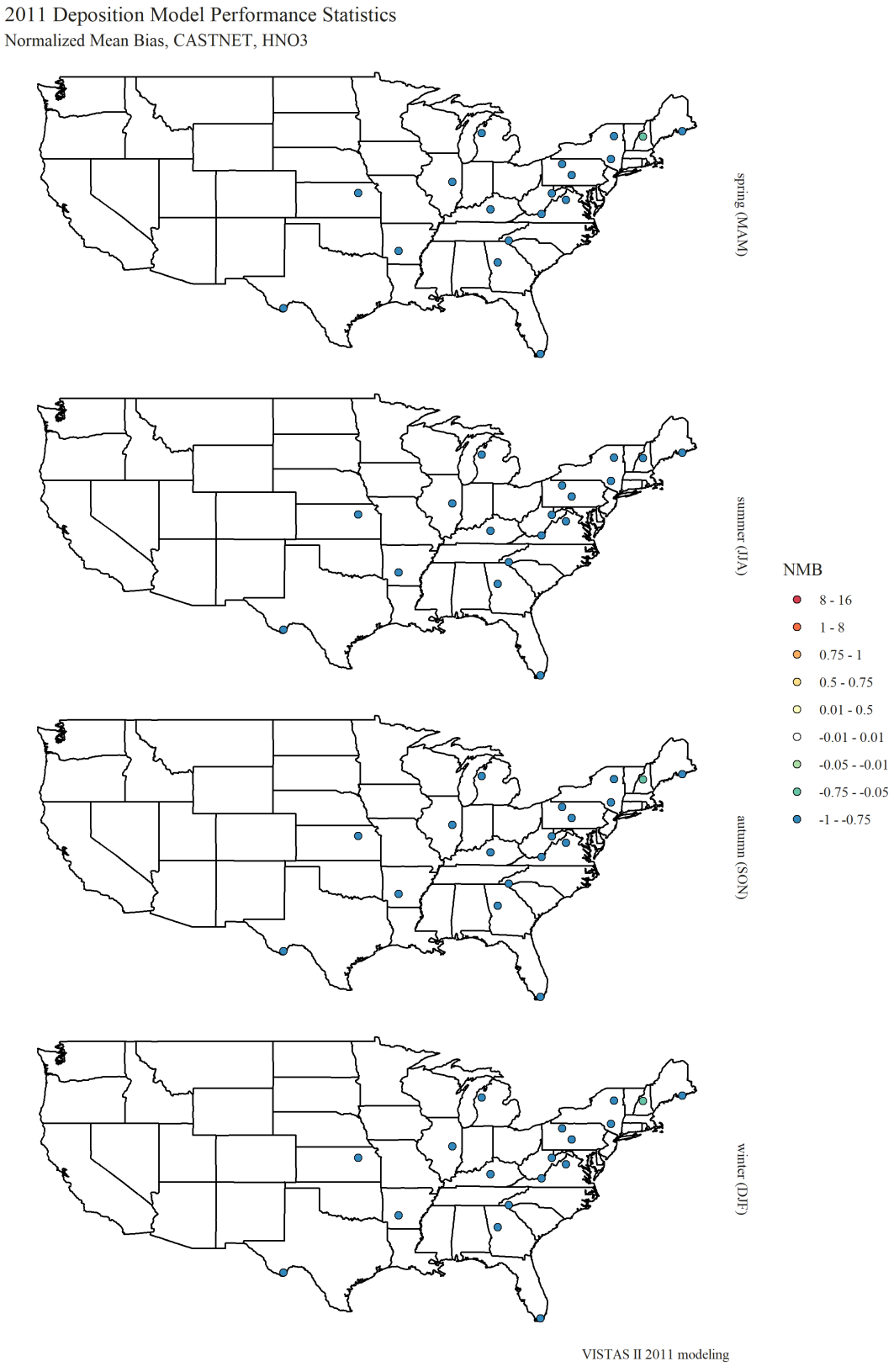


Figure B-10. Normalized Mean Bias for CASTNET HNO_3 Dry Deposition, by Season

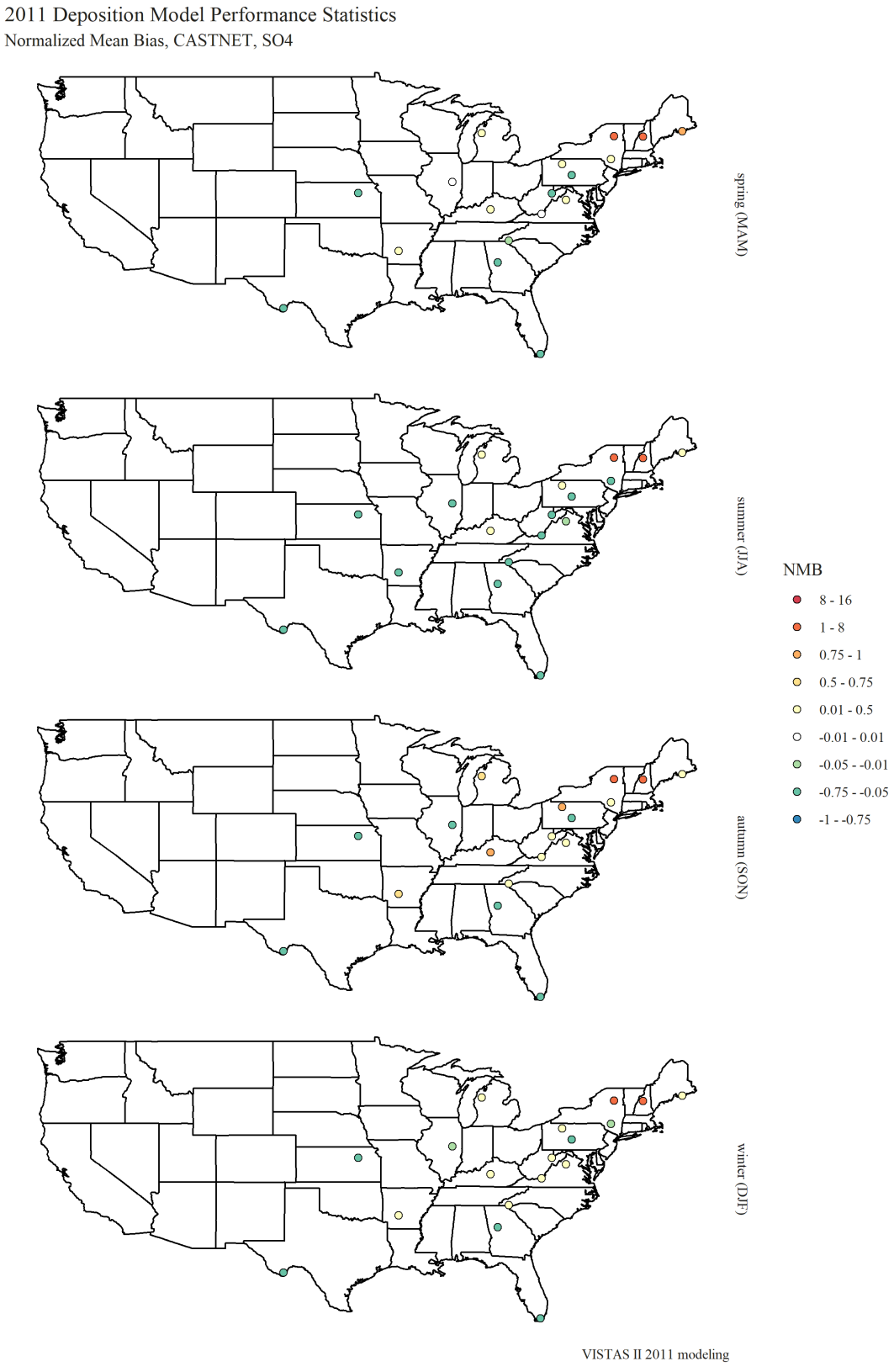


Figure B-11. Normalized Mean Bias for CASTNET SO_4^{2-} Dry Deposition, by Season

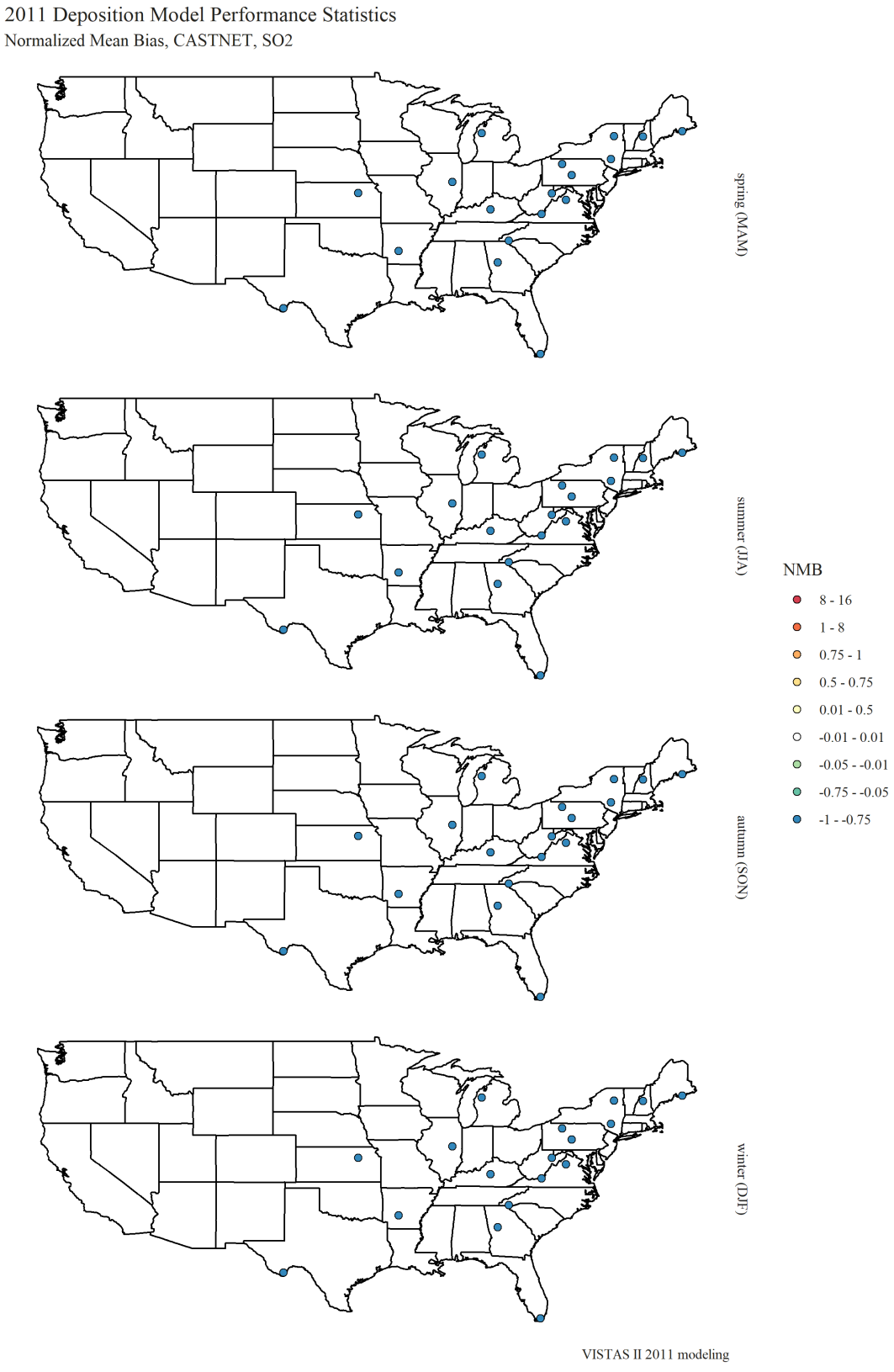


Figure B-12. Normalized Mean Bias for CASTNET SO_2 Dry Deposition, by Season

Table B-7. Model Performance Metrics for AMoN NH_3 Dry Deposition

Pollutant	State	n	MB (kg/ha)	MGE (kg/ha)	NMB (%)	NME (%)	r (unitless)	MFB (%)	MFE (%)	RMSE (unitless)
NH_3	AR	30	-0.003	0.003	-89%	90%	0.448	-80%	81%	0.004
	FL	40	-0.007	0.007	-99%	99%	0.329	-98%	98%	0.011
	GA	30	-0.004	0.004	-92%	92%	0.209	-85%	86%	0.006
	IL	77	-0.010	0.010	-95%	95%	0.440	-91%	91%	0.019
	KS	28	-0.019	0.019	-94%	95%	0.103	-89%	90%	0.028
	KY	44	-0.008	0.008	-93%	93%	0.408	-87%	87%	0.012
	NC	29	-0.002	0.002	-94%	94%	0.277	-89%	89%	0.002
	PA	45	-0.002	0.002	-96%	96%	0.737	-93%	93%	0.003
	WV	32	-0.003	0.003	-98%	98%	-0.097	-97%	97%	0.005

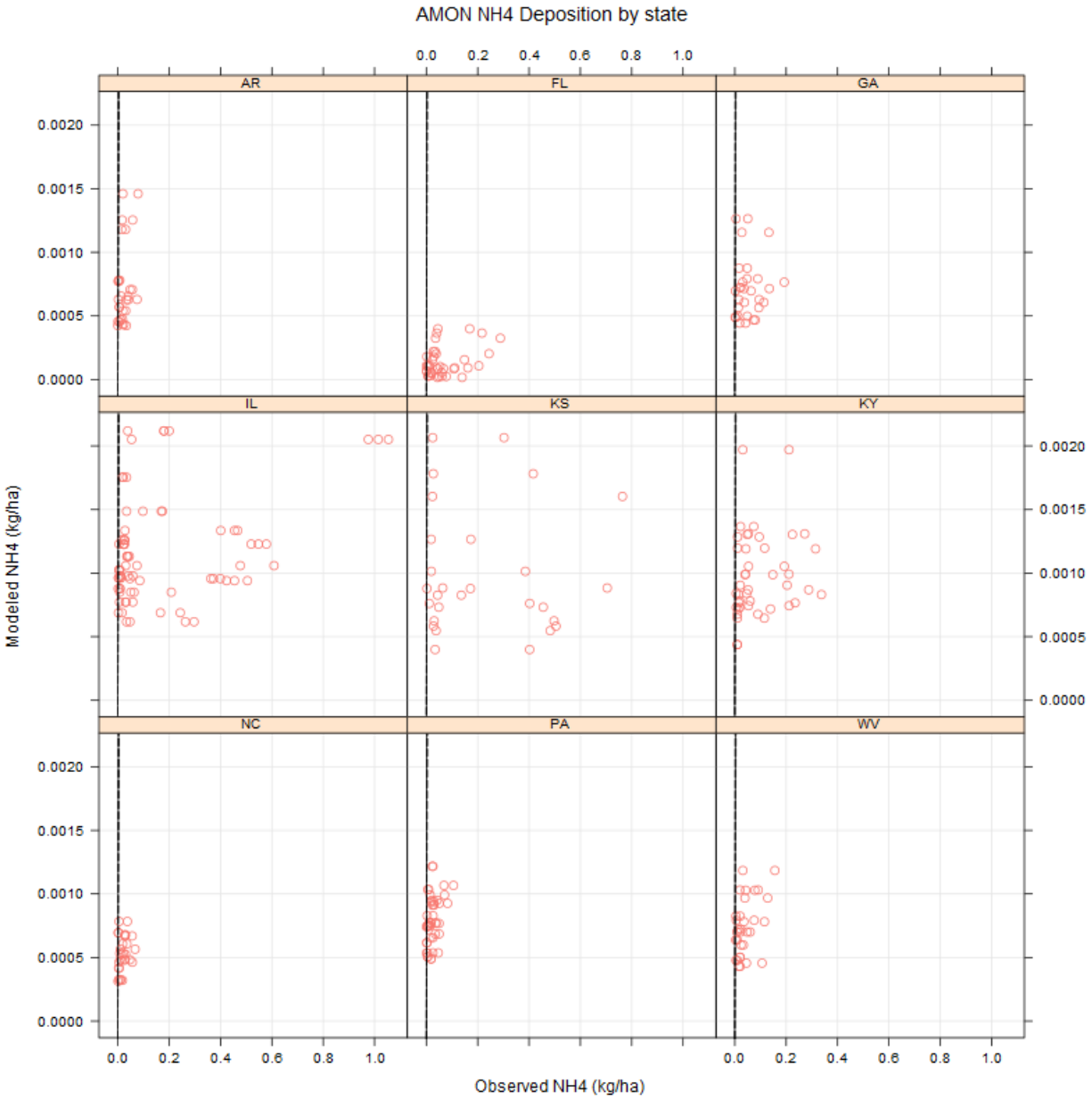


Figure B-13. Modeled NH_3 versus AMoN Observed NH_3 Dry Deposition, by State

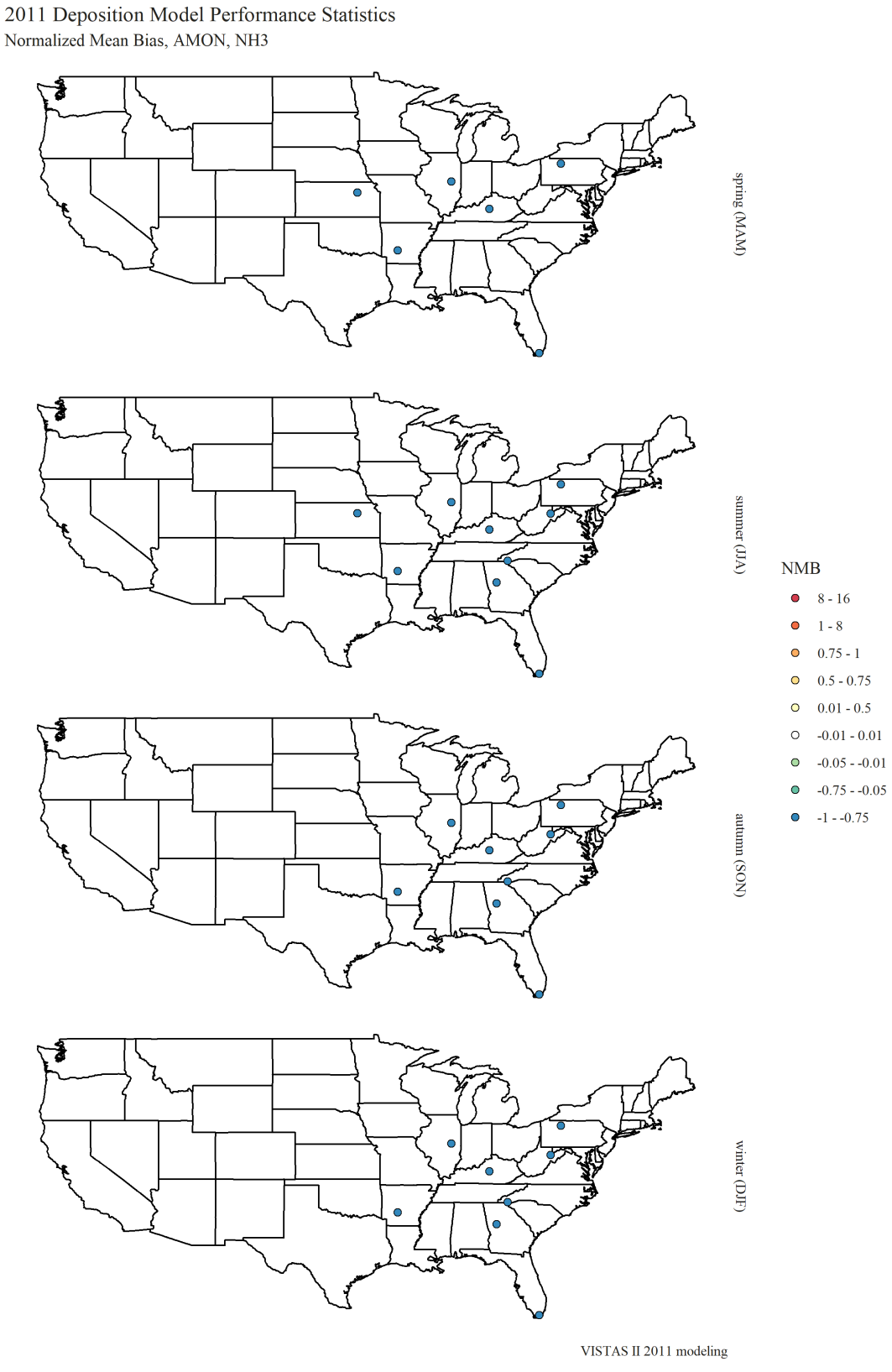


Figure B-14. Normalized Mean Bias for AMoN NH_3 Dry Deposition, by Season

Appendix E-5

Model Performance Evaluation for Ozone of the CAMx 6.40 Modeling System and the VISTAS II 2011 Updated Modeling Platform

August 17, 2020

This page intentionally left blank.

Model Performance Evaluation for Ozone of the CAMx 6.40 Modeling System and the VISTAS II 2011 Updated Modeling Platform (Task 8.0)

Prepared for:
Southeastern States Air Resource Managers, Inc. (SESARM)
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final – August 17, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 Introduction 1

2.0 Results 7
- 2.1 Performance Statistics by State and Month 8
- 2.2 Spatial Performance Evaluation 10
- 2.3 Time Series Plots by Monitor 14
- 2.4 Concentration Correlation Plots 20

3.0 Summary 27

Appendix A Model Performance Statistics for MDA8 Ozone at Individual Monitoring Sites Based on Days with Observed Values ≥ 60 ppb

This page is intentionally blank.

TABLES

Table 2-1. Performance Statistics for MDA8 Ozone ≥ 60 ppb by Month for VISTAS States Based on Data at AQS Network Sites....8

Table 2-2. Performance Statistics for MDA8 Ozone ≥ 60 ppb by Month and VISTAS State Within VISTAS12 Domain Based on Data at AQS Network Sites....9

Table 2-3. Monitoring Sites Included in the Ozone Time Series Analysis. 15

FIGURES

Figure 1-1. VISTAS12 Modeling Domain. Areas in green denote Class I Areas. 4

Figure 2-1. Mean Bias (ppb) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain....11

Figure 2-2. Normalized Mean Bias (%) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain....12

Figure 2-3. Mean Error (ppb) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain....13

Figure 2-4. Normalized Mean Error (%) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain....14

Figure 2-5. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 010731005 in Alabama. 16

Figure 2-6. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 121130015 in Florida. 16

Figure 2-7. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 131210055 in Georgia. 17

Figure 2-8. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 211110051 in Kentucky. 17

Figure 2-9. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 280470008 in Mississippi....18

Figure 2-10. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 371190041 in North Carolina....18

Figure 2-11. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 450830009 in South Carolina....19

Figure 2-12. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 470090101 in Tennessee. 19

Figure 2-13. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 510590030 in Virginia. 20

Figure 2-14. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 540690010 in West Virginia. 20

Figure 2-15. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 010731005 in Alabama. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 21

Figure 2-16. Correlation of Observed and Predicted MDA8 Ozone for May Through September 2011 at Site 121130015 in Florida. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 22

Figure 2-17. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 131210055 in Georgia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 22

Figure 2-18. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 211110051 in Kentucky. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 23

Figure 2-19. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 280470008 in Mississippi. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 23

Figure 2-20. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 371190041 in North Carolina. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 24

Figure 2-21. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 450830009 in South Carolina. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 24

Figure 2-22. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 470090101 in Tennessee. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 25

Figure 2-23. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 510590030 in Virginia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 25

Figure 2-24. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 540690010 in West Virginia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value. 26

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
AQS	Air Quality Subsystem
CAMx	Comprehensive Air quality Model with eXtensions
ERG	Eastern Research Group, Inc.
EGU	Electric Generating Unit
EPA	United States Environmental Protection Agency
FL	Florida
GA	Georgia
km	Kilometer
MAPS	Model Performance Evaluation, Analysis, and Plotting Software
MB	Mean Bias
MDA8	Maximum Daily 8-Hour
ME	Mean Error
MPE	Model Performance Evaluation
MS	Mississippi
n	Number of observations
NC	North Carolina
NMB	Normalized Mean Bias
NME	Normalized Mean Error
OSAT	Ozone Source Apportionment Technology
ppb	parts per billion
PSAT	Particulate Source Apportionment Technology
R^2	Pearson correlation coefficient, squared
RADM-AQ	Regional Acid Deposition Model – aqueous chemistry
SC	South Carolina
SESARM	Southeastern States Air Resource Managers, Inc.
SIPS	State Implementation Plans
SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
TN	Tennessee
VA	Virginia
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast
WI	Wisconsin
WV	West Virginia

This page is intentionally blank.

1.0 INTRODUCTION

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

To demonstrate progress toward the improvement goals, the SESARM partners modeled visibility and air quality conditions for a base year of 2011 and future year of 2028. The SESARM VISTAS II Regional Haze modeling analysis was performed by the contractor team Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine). The preparation and modeling were conducted over several contract tasks, including emission inventory development, ambient data collection, Comprehensive Air quality Model with extensions (CAMx) modeling, and model performance evaluation (MPE) of the base year. The VISTAS II modeling included particulate matter simulations and source apportionment studies using the 12-kilometer (km) grid based on EPA's 2011/2028el modeling platform and preliminary source contribution assessment,[2] updated to include a 12-km subdomain over the VISTAS region and augmented with revisions to electric generating unit (EGU) and non-EGU point source projections. The air quality modeling was conducted using CAMx. A detailed description of the modeling platform can be found in the Task 6 modeling report.

Under Task 8 of the Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project, a thorough MPE was conducted for Maximum Daily 8-Hour (MDA8) ozone concentrations to examine the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. This report documents the MPE for the base year CAMx modeling.

The VISTAS II modeling for 2011 is based on the EPA modeling conducted for Regional Haze Analysis, sometimes referred to as the "2011el" modeling. Updates to the EPA platform in the VISTAS II modeling include updating the version of CAMx from version 6.32 to 6.40. Many updates to the CAMx model were implemented between the 6.32 and 6.40 release. According to the CAMx 6.40 release notes, the significant changes included:

1. Updates to the chemistry to include a condensed halogen mechanism for ocean-borne inorganic reactive iodine, hydrolysis of isoprene-derived organic nitrate and SO_2

[2] EPA. 2017. Documentation for the EPA's Preliminary 2028 Regional Haze Modeling. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October. Available at: https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

oxidation on primary crustal fine PM. This update includes the changes to the Ozone and Particulate Source Apportionment Technology (OSAT/PSAT) algorithms;
2. Inclusion of in-line inorganic iodine emissions to support halogen chemical mechanisms;
3. A major revision to the Secondary organic aerosol partitioning (SOAP) and secondary organic aerosol (SOA) chemistry algorithm;
4. Updates to the Regional Acid Deposition Model aqueous chemistry (RADM-AQ) algorithm; and
5. A major revision to the wet deposition algorithm to identify assumptions or processes that were unintentionally or otherwise unreasonably limiting gas and PM update into precipitation. The wet deposition algorithm was simplified and improved in several ways, resulting in the increased scavenging of gases and PM.

In addition to the model version, the CAMx 6.32 and 6.40 simulations contained differences in the EPA modeling platform that had been made subsequent to the 2011el/2028el model release. In the most current 2023en simulation, EPA developed new photolysis rates and ozone column data. These updates were included in the updated modeling platform and resulting CAMx 6.40 simulation and were used in the VISTAS II 2011el (hereafter "VISTAS12") simulations.

Figure 1-1 presents the VISTAS12 modeling domain.

Figure 1-1. VISTAS12 Modeling Domain. Areas in green denote Class I Areas.

An operational model evaluation was conducted for the 2011 base year CAMx v6.40 simulation performed for the VISTAS12 modeling domain defined by SESARM and shown in Figure 1-1. The purpose of this evaluation is to examine the ability of this 2011 air quality modeling platform to represent the magnitude and spatial and temporal variability of measured (i.e., observed) ozone concentrations within the modeling domain. The evaluation presented here

is based on model simulations using the 2011 emissions platform (i.e., scenario name 2011el.ag.v6_40.vistas12). This model evaluation for ozone focuses on comparisons of model predicted 8-hour daily maximum concentrations to the corresponding observed data at monitoring sites in the EPA Air Quality System (AQS).

Included in the evaluation are statistical measures of model performance based upon model-predicted versus observed concentrations that were paired in space and time. Model performance statistics were calculated for several spatial scales and temporal periods. Statistics were calculated for individual monitoring sites, and in aggregate for monitoring sites within states of the 12-km modeling domain.

For MDA8 ozone, model performance statistics were created for the periods May through September. The aggregated statistics by state and VISTAS region as a whole are presented in this document. Model performance statistics for MDA8 ozone at individual monitoring sites based on days with observed values ≥ 60 ppb can be found as Appendix A to this document.

In addition to the above performance statistics, we prepared several graphical presentations of model performance for MDA8 ozone. These graphical presentations include:

1. spatial maps that show the mean bias and error as well as normalized mean bias and error calculated for MDA8 ≥ 60 ppb for May through September at individual AQS monitoring sites within the VISTAS12 modeling domain;
2. time series plots (May through September) of observed and predicted MDA8 ozone concentrations for select sites from each VISTAS state located within the VISTAS12 modeling domain; and
3. scatter plots (May through September) that show the correlation of the predicted and observed MDA8 ozone concentrations for select sites from each VISTAS state located within the VISTAS12 modeling domain.

The Model Performance Evaluation, Analysis, and Plotting Software (MAPS) tool was used to calculate the model performance statistics used in this document.[3] For this evaluation we have selected the mean bias, mean error, normalized mean bias, and normalized mean error to characterize model performance, statistics which are consistent with the recommendations in

[3] McNally, D. and T. W. Tesche. 1993. Model Performance Evaluation, Analysis, and Plotting Software (MAPS). Alpine Geophysics, LLC. Arvada, CO.

Simon et al. (2012),[4] the photochemical modeling guidance (U.S. EPA, 2018),[5] and EPA's recent performance evaluation of the 2011en platform (EPA, 2018).

Mean bias (MB) is the average difference between predicted (P) and observed (O) concentrations for a given number of samples (n):

$$MB(ppb) = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

Mean error (ME) is the average absolute value of the difference between predicted and observed concentrations for a given number of samples:

$$ME(ppb) = \frac{1}{n}\sum_{i=1}^{n}|P_i - O_i|$$

Normalized mean bias (NMB) is the sum of the difference between predicted and observed values divided by the sum of the observed values:

$$NMB(\%) = \frac{\sum_1^n(P-O)}{\sum_1^n(O)} * 100$$

Normalized mean error (NME) is the sum of the absolute value of the difference between predicted and observed values divided by the sum of the observed values:

$$NME(\%) = \frac{\sum_1^n|P-O|}{\sum_1^n(O)} * 100$$

As described in more detail below, the model performance statistics indicate that the 8-hour daily maximum ozone concentrations predicted by the VISTAS12 modeling platform closely reflect the corresponding 8-hour observed ozone concentrations in each region in the modeling domain. The acceptability of model performance was judged by considering the 2011 CAMx performance results in light of the range of performance found in recent regional ozone

[4] Simon, H., K. Baker and S. Phillips. 2012. Compilations and Interpretation of Photochemical Model Performance Statistics Published between 2006 and 2012. *Atmos. Env.* 61 (2012) 124-139. December.

[5] EPA, 2018. Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. Internet address: https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf

model applications.[5,6,7,8,9,10,11,12] These other modeling studies represent a wide range of modeling analyses that cover various models, model configurations, domains, years and/or episodes, chemical mechanisms, and aerosol modules.

Overall, the ozone model performance results for the VISTAS12 modeling are within the range found in other recent peer-reviewed and regulatory applications. The model performance results, as described in this document, demonstrate that the predictions from the VISTAS12 modeling domain using the EPA's 2011el modeling platform corresponds closely to observed concentrations in terms of the magnitude, temporal fluctuations, and geographic differences for 8-hour daily maximum ozone.

2.0 RESULTS

The 8-hour ozone model performance bias and error statistics for the months of May through September for the region and VISTAS states in the VISTAS12 modeling domain are provided in Tables 2-1 and 2-2, respectively. The statistics shown in Tables 2-1 and 2-2 were calculated using data pairs on days with observed 8-hour ozone of ≥ 60 ppb. Spatial plots of the mean bias and error as well as the normalized mean bias and error for individual monitors are shown in Figures 2-3 through 2-6. Time series plots of observed and predicted MDA 8-hour ozone during the period May through September at select sites listed in Table 5 are provided in Figures 2-1 through 2-16. The correlations of observed and predicted 8-hour ozone by month in the period of May through September for each region are shown in Figures 2-17 through 2-27.

6 NRC, 2002. National Research Council (NRC), 2002. Estimating the Public Health Benefits of Proposed Air Pollution Regulations, Washington, DC: National Academies Press.

7 Phillips et al., 2007. Phillips, S., K. Wang, C. Jang, N. Possiel, M. Strum, T. Fox, 2007. Evaluation of 2002 Multi-pollutant Platform: Air Toxics, Ozone, and Particulate Matter, 7th Annual CMAS Conference, Chapel Hill, NC, October 6-8, 2008.

8 EPA. 2005. Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hr Ozone NAAQS -- Final. U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C. October.

9 EPA. 2009. U.S. Environmental Protection Agency, Proposal to Designate an Emissions Control Area for Nitrogen Oxides, Sulfur Oxides, and Particulate Matter: Technical Support Document. EPA-420-R-007.

10 EPA. 2010. U.S. Environmental Protection Agency, 2010, Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis. EPA-420-R-10-006. February 2010. Sections 3.4.2.1.2 and 3.4.3.3. Docket EPA-HQ-OAR-2009-0472-11332.

11 EPA. 2016. Air Quality Modeling Technical Support Document for the 2015 Ozone NAAQS Preliminary Interstate Transport Assessment. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. December 2016.

12 EPA. 2018. Air Quality Modeling Technical Support Document for the Updated 2023 Projected Ozone Design Values. Office of Air Quality Planning and Standards, United States Environmental Protection Agency. June 2018.

Overall, model performance for MDA8 ozone concentrations for the VISTAS12 modeling is similar to what was found in EPA's model performance evaluation conducted for the EPA's 2011en CAMx v6.40 simulation performed in support of the 2008 and 2015 ozone NAAQS reviews.[11]

2.1 Performance Statistics by State and Month

As indicated by the statistics in Table 2-1, bias and error for 8-hour daily maximum ozone are relatively low in the region. Generally, mean bias (MB) for 8-hour ozone ≥ 60 ppb during each month of the May through September period, demonstrating within ±5 ppb at AQS sites in VISTAS states, ranging from -0.13 ppb (September) to 3.79 ppb (July). The mean error (ME) is less than 10 ppb in all months. Normalized mean bias (NMB) is within ±5 percent for AQS sites in all months except July (5.63%). The mean bias and normalized mean bias statistics indicate a tendency for the model to overpredict MDA8 ozone concentrations in month of May through August and slightly underpredict MDA8 ozone concentrations in September for AQS sites. The normalized mean error (NME) is less than 15 percent in the region across all months.

Table 2-1. Performance Statistics for MDA8 Ozone ≥ 60 ppb by Month for VISTAS States Based on Data at AQS Network Sites.

Region	Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
VISTAS	May	838	2.48	6.11	3.79	9.34
VISTAS	Jun	2028	1.73	7.11	2.57	10.55
VISTAS	Jul	1233	3.79	8.88	5.63	13.21
VISTAS	Aug	1531	2.38	6.94	3.59	10.48
VISTAS	Sep	681	-0.13	6.09	-0.19	9.08

Looking at 12-km model performance for individual states located within the VISTAS12 domain (Table 2-2) indicates that mean bias is within ± 5 ppb for the majority of the months and states for all but July in Alabama (6.18ppb), July in Florida (-5.32 ppb), August in Georgia (5.67 ppb), July in Kentucky (5.04 ppb), May in Virginia (5.57 ppb), and July in West Virginia (5.27 ppb). The mean error is less than 10 ppb for nearly all months and states, with exceptions occurring in July (Alabama, Florida, and Georgia) and August (Florida). The normalized mean bias is within ±10 percent in all months and states. The normalized mean error is within 15

percent for all months and states with again exceptions occurring in July (Alabama, Florida, and Georgia) and August (Florida).

Table 2-2. Performance Statistics for MDA8 Ozone ≥ 60 ppb by Month and VISTAS State Within VISTAS12 Domain Based on Data at AQS Network Sites.

Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
Alabama					
May	75	2.55	4.89	3.89	7.47
June	235	3.30	7.53	4.95	11.29
July	83	6.18	10.64	9.12	15.71
August	241	3.56	6.77	5.30	10.09
September	80	1.67	5.83	2.61	9.11
Florida					
May	241	2.47	6.44	3.72	9.72
June	137	1.23	7.59	1.83	11.30
July	20	-5.32	14.73	-8.21	22.74
August	62	3.17	10.49	4.74	15.67
September	78	0.98	7.52	1.48	11.40
Georgia					
May	130	3.91	5.87	5.85	8.78
June	251	2.07	8.43	3.05	12.41
July	111	2.89	11.09	4.19	16.06
August	218	5.67	7.95	8.44	11.84
September	97	1.22	5.03	1.81	7.48
Kentucky					
May	25	3.93	6.03	6.30	9.66
June	227	0.68	6.86	1.03	10.37
July	170	5.04	9.83	7.57	14.76
August	167	-0.32	7.30	-0.49	11.03
September	78	-0.82	6.60	-1.20	9.62
Mississippi					
May	33	-2.97	5.50	-4.49	8.30
June	64	1.38	8.80	2.07	13.23
July	24	2.42	8.18	3.74	12.64
August	74	2.25	9.02	3.39	13.60
September	37	2.19	8.12	3.35	12.39
North Carolina					
May	117	4.44	6.52	6.99	10.27
June	473	2.36	6.22	3.46	9.12
July	299	4.29	7.41	6.39	11.03
August	257	2.68	5.65	4.10	8.66

Table 2-2. Performance Statistics for MDA8 Ozone ≥ 60 ppb by Month and VISTAS State Within VISTAS12 Domain Based on Data at AQS Network Sites.

Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
September	129	-1.35	5.36	-2.00	7.96
South Carolina					
May	46	3.34	4.56	5.30	7.23
June	148	0.34	5.25	0.50	7.82
July	74	0.94	7.52	1.42	11.38
August	86	2.15	6.81	3.32	10.53
September	49	-0.44	4.34	-0.66	6.56
Tennessee					
May	108	-1.18	5.38	-1.82	8.32
June	237	1.98	7.96	2.93	11.77
July	158	4.28	9.39	6.41	14.08
August	295	-0.03	6.04	-0.04	9.09
September	99	-2.67	6.83	-3.87	9.91
Virginia					
May	41	5.57	9.47	8.01	13.62
June	200	0.55	7.40	0.82	10.99
July	225	2.82	8.63	4.12	12.59
August	90	2.93	7.27	4.50	11.18
September	17	1.32	6.53	2.07	10.25
West Virginia					
May	22	0.40	7.54	0.63	11.90
June	56	0.95	5.00	1.44	7.56
July	69	5.27	6.96	8.03	10.60
August	41	2.61	5.91	4.01	9.08
September	17	0.21	5.78	0.28	7.82

Monitor specific performance metrics for monitors in the VISTAS12 modeling domain are provided as Appendix A to this document.

2.2 Spatial Performance Evaluation

Figures 2-1 through 2-4 show the spatial variability in bias and error at monitor locations. Mean bias, as seen from Figure 2-1, is within ±5 ppb at most sites across the VISTAS12 domain with a maximum under-prediction of 23.44 ppb at one site (AQS monitor 550030010) in Ashland County, WI and a maximum over-prediction of 17.95 ppb in York County, SC (AQS monitor 450910006); both with small sample sizes (n=1 and n=7, respectively). A positive mean

bias is generally seen in the range of 5 to 10 ppb with regions of 10 to 15 ppb over-prediction seen scattered throughout the domain. The model has a tendency to underestimate in the western portion of the domain and overestimate in the eastern portion of the domain.

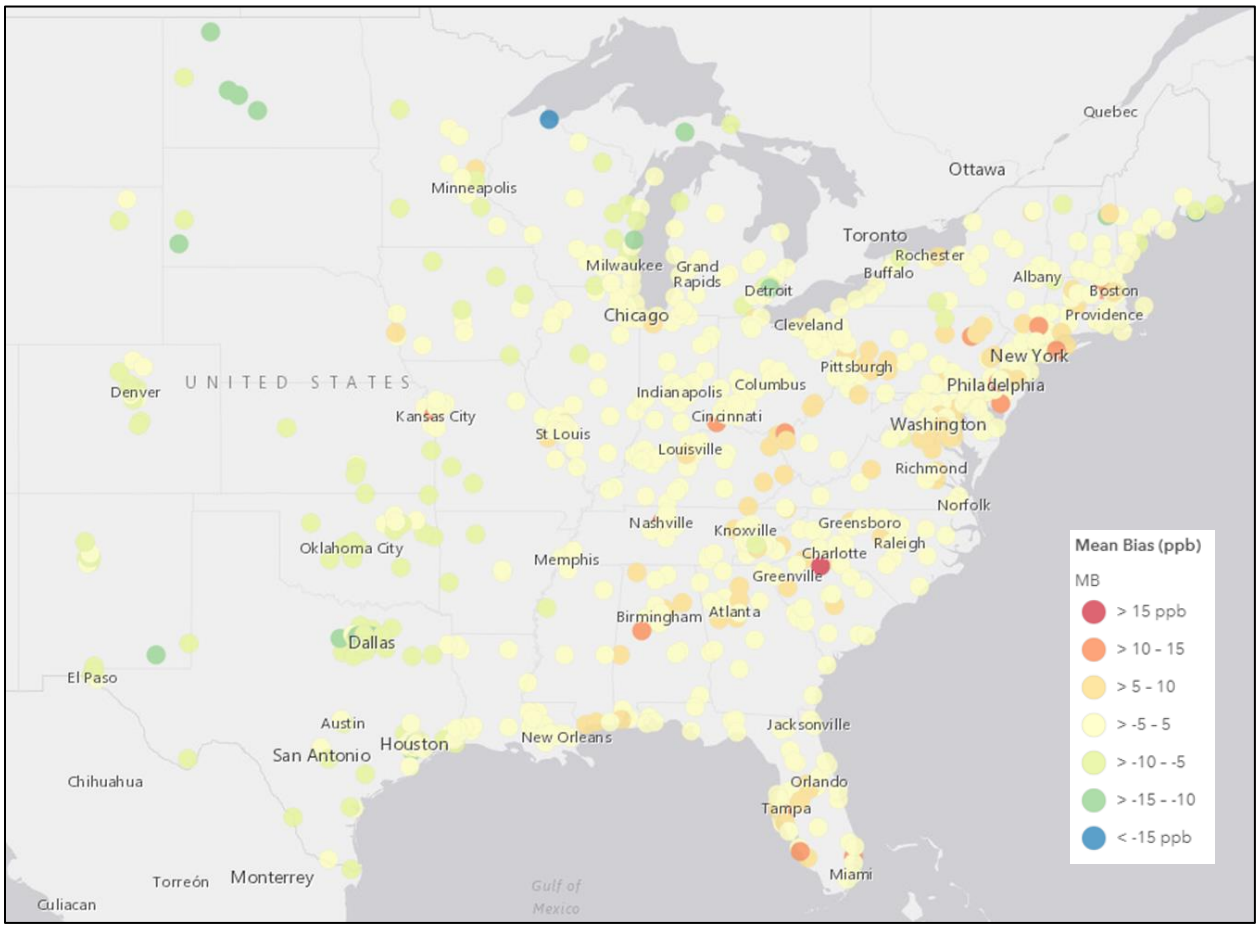


Figure 2-1. Mean Bias (ppb) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.[13]

Figure 2-2 indicates that the normalized mean bias for days with observed 8-hour daily maximum ozone ≥ 60 ppb is within ± 10 percent at the vast majority of monitoring sites across the VISTAS12 modeling domain. Monitors in Ashland County, WI and York County, SC again bookend the NMB range with 38.03% and 27.44%, respectively. There are regional differences in model performance, as the model tends to overpredict at most sites in eastern region of the

[13] Appendix A-2 presents the Mean Bias data in a Google Earth .kmz file to allow the user to zoom to specific geographic regions.

VISTAS12 domain and generally underpredict at sites in and around the western and north western borders of the domain.

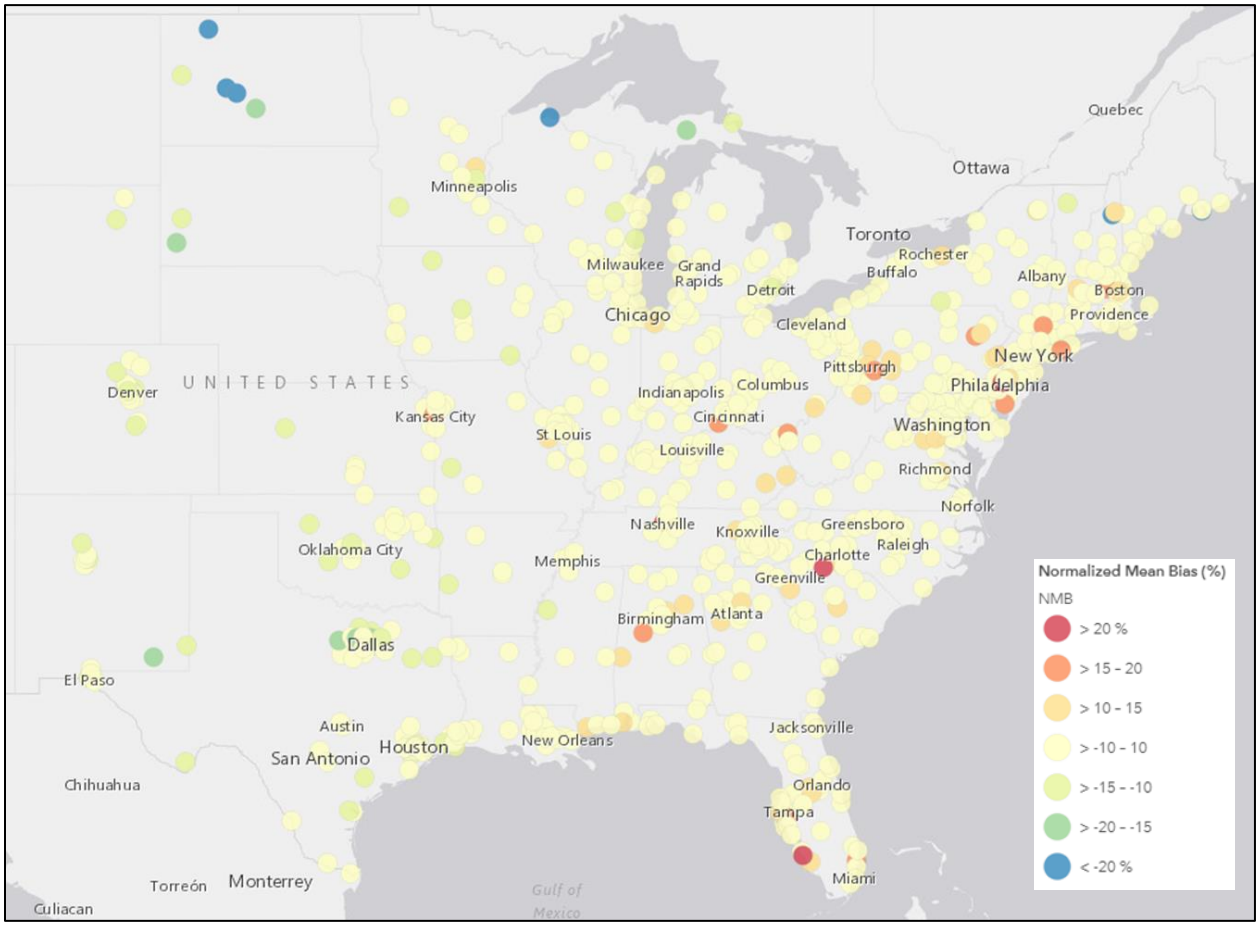


Figure 2-2. Normalized Mean Bias (%) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.[14]

Mean error (ME), as seen from Figure 2-3, is generally 10 ppb or less at most of the sites across the VISTAS12 modeling domain although the Ashland, WI and York, SC monitors show much higher ME of 23.44 and 17.95 ppb, respectively. VISTAS states show less than ten percent of their monitors above 10 ppb model error, with the majority of those within this value. Figure 2-4 indicates that the normalized mean error (NME) for days with observed 8-hour daily

[14] Appendix A-3 presents the Normalized Mean Bias data in a Google Earth .kmz file to allow the user to zoom to specific geographic regions.

maximum ozone ≥ 60 ppb is less than 15 percent at the vast majority of monitoring sites across the VISTAS12 modeling domain. Noted exceptions seen are monitors 450910006 (York County, SC), 470370011 (Davidson County, TN), and 120713002 (Lee County, FL) with NMEs of 27.44%, 25.4%, and 23.07%, respectively. Somewhat elevated NMEs (> 15%) are seen in and around many of the VISTAS state metro areas.

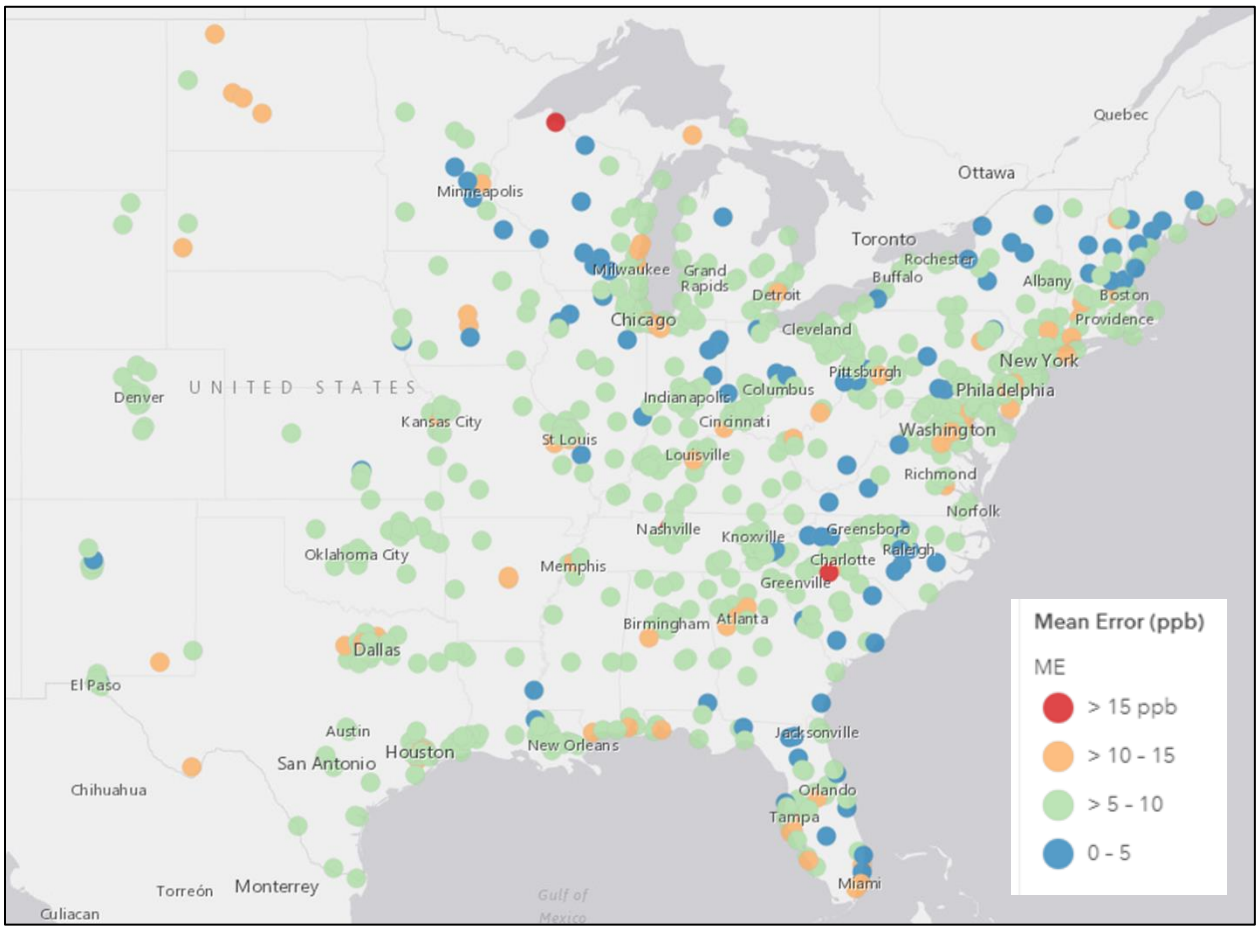


Figure 2-3. Mean Error (ppb) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain. [15]

[15] Appendix A-4 presents the Mean Error data in a Google Earth .kmz file to allow the user to zoom to specific geographic regions.

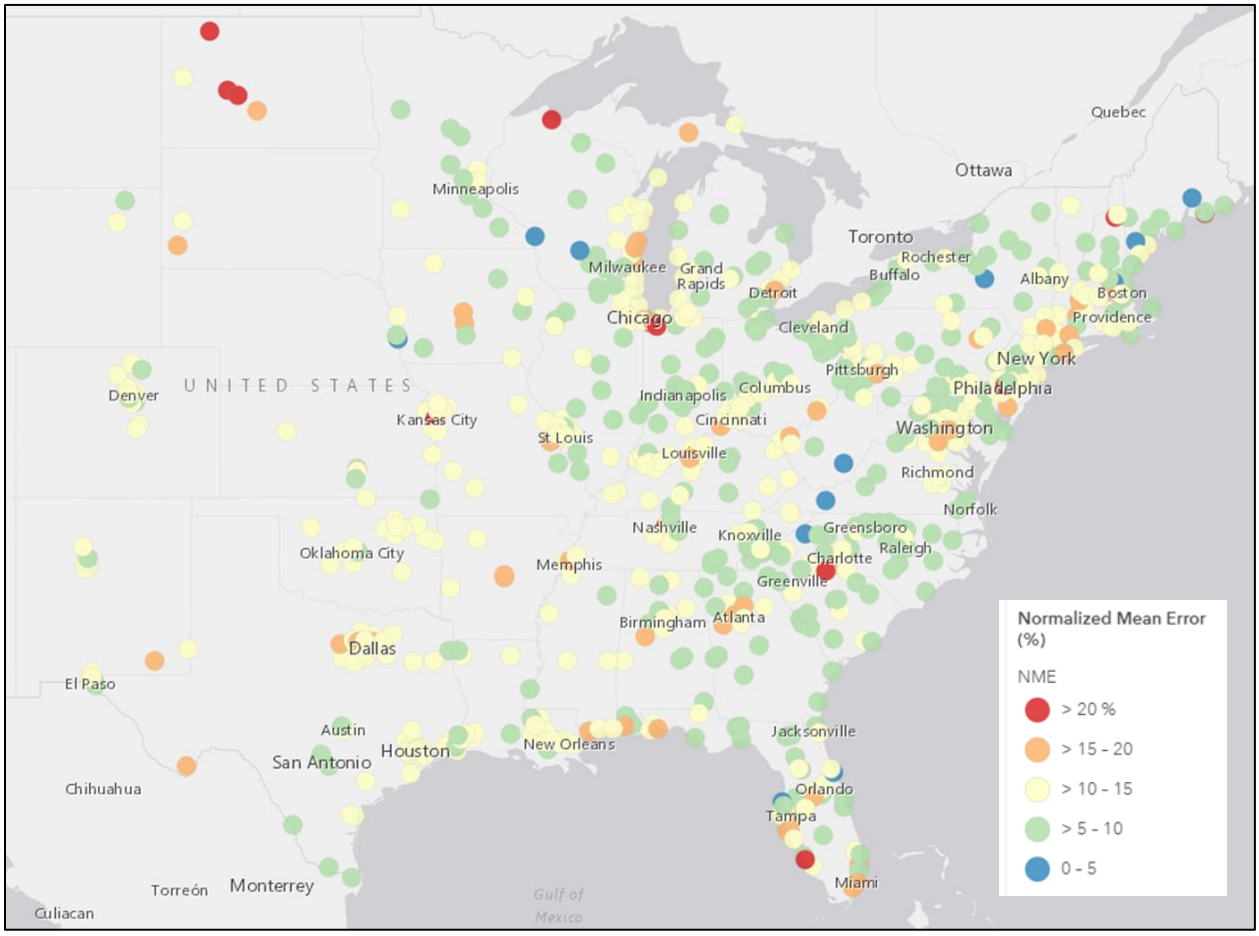


Figure 2-4. Normalized Mean Error (%) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.[16]

2.3 Time Series Plots by Monitor

In addition to the above analysis of overall model performance, we also examined how well the modeling platform replicates day to day fluctuations in observed 8-hour daily maximum concentrations. Table 2-3 presents data for the highest 2011 3-year design value site in each VISTAS state.

[16] Appendix A-5 presents the Normalized Mean Error data in a Google Earth .kmz file to allow the user to zoom to specific geographic regions.

Table 2-3. Monitoring Sites Included in the Ozone Time Series Analysis.

AQS Monitor ID	State	County	2009-2011 Ozone Design Value (ppb)
010731005	Alabama	Jefferson	75
121130015	Florida	Santa Rosa	74
131210055	Georgia	Fulton	80
211110051	Kentucky	Jefferson	78
280470008	Mississippi	Harrison	75
371190041	North Carolina	Mecklenburg	79
450830009	South Carolina	Spartanburg	74
470090101	Tennessee	Blount	76
510590030	Virginia	Fairfax	82
540690010	West Virginia	Ohio	73

For this site-specific analysis we present the time series of observed and predicted 8-hour daily maximum concentrations by site in the 12-km simulation over the period of May through September. The results, as shown in Figures 2-5 through 2-14, indicate that the modeling platform generally replicates the day-to-day variability in ozone during this time period at these sites. That is, days with high modeled concentrations are generally also days with high measured concentrations and, conversely, days with low modeled concentrations are also days with low measured concentrations in most cases.

For example, model predictions at several sites not only accurately capture the day-to-day variability in the observations, but also appear to have relatively low bias on individual days. Santa Rosa County, FL and Harrison County, MS each track closely with the observations, but there is a tendency to overpredict on several of the observed high ozone days at these coastal state locations. Of particular note are the overpredictions at the Mecklenburg County, NC monitor early in the ozone season, at the Fairfax County, VA monitor during a late season episode, and at the Ohio County, WV monitor mid-season and the underprediction of MDA8 at the Fulton County, GA monitor during an early ozone season episode and multiple days at the coastal monitors in Florida and Mississippi.

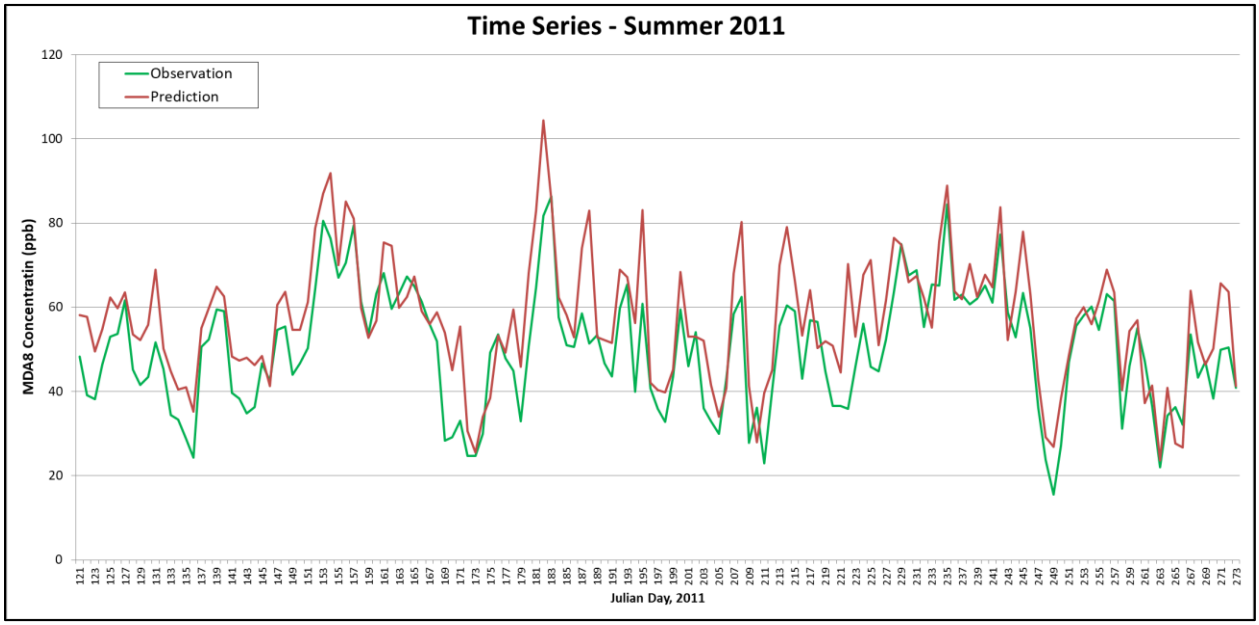


Figure 2-5. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 010731005 in Alabama.

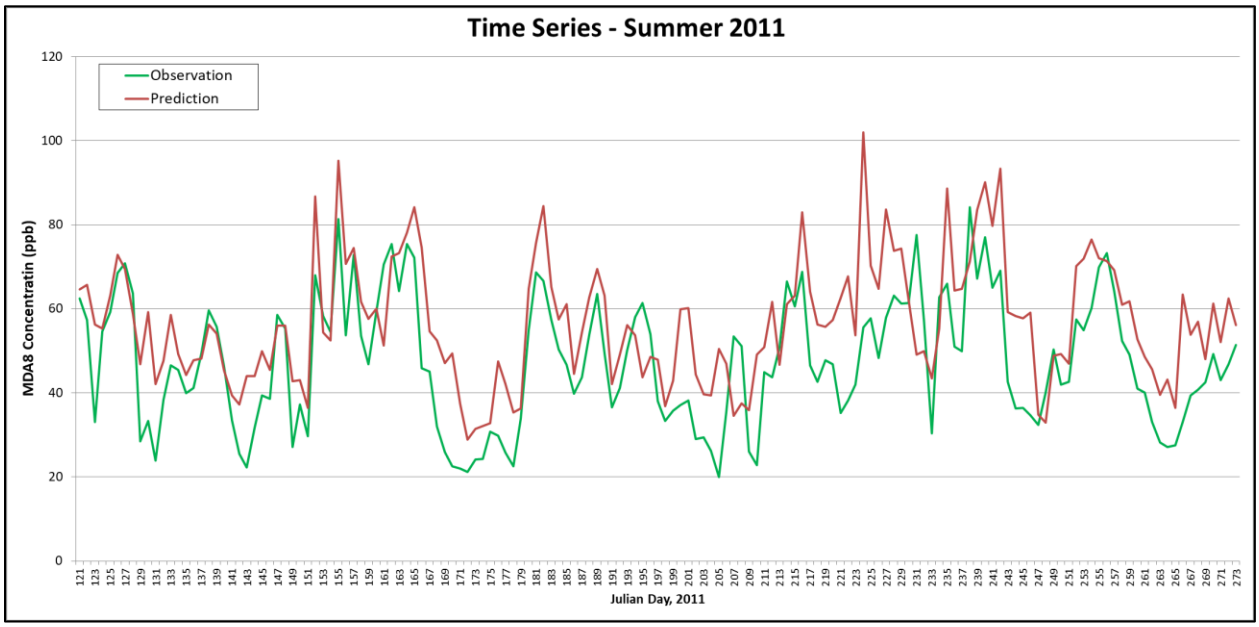


Figure 2-6. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 121130015 in Florida.

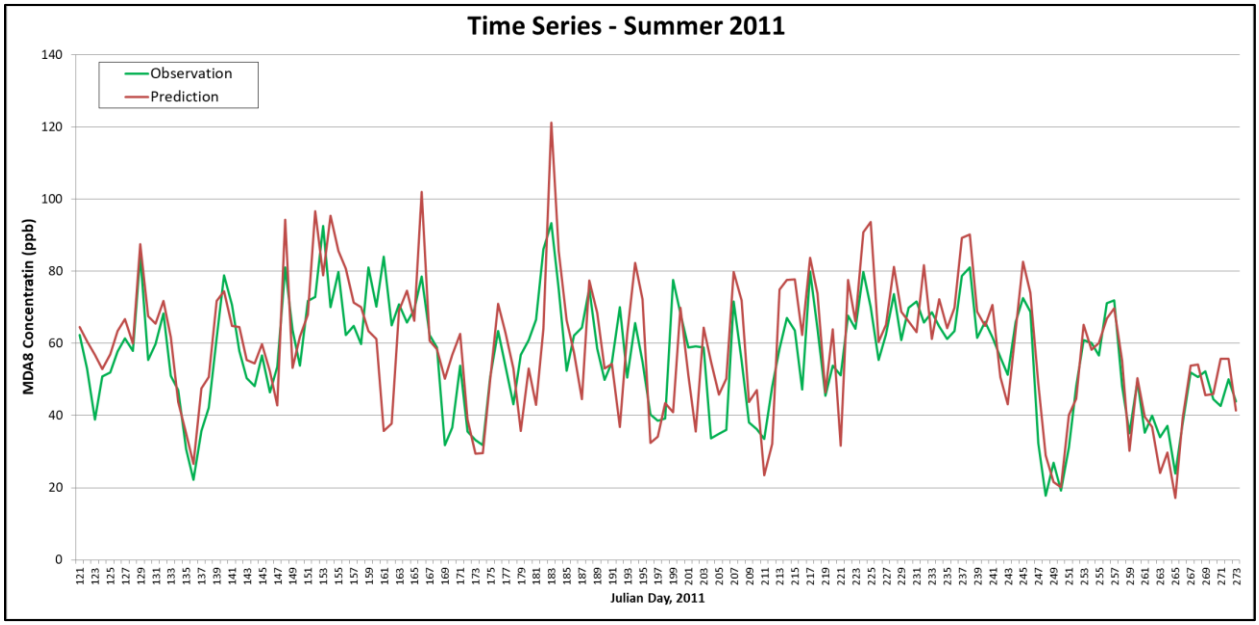


Figure 2-7. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 131210055 in Georgia.

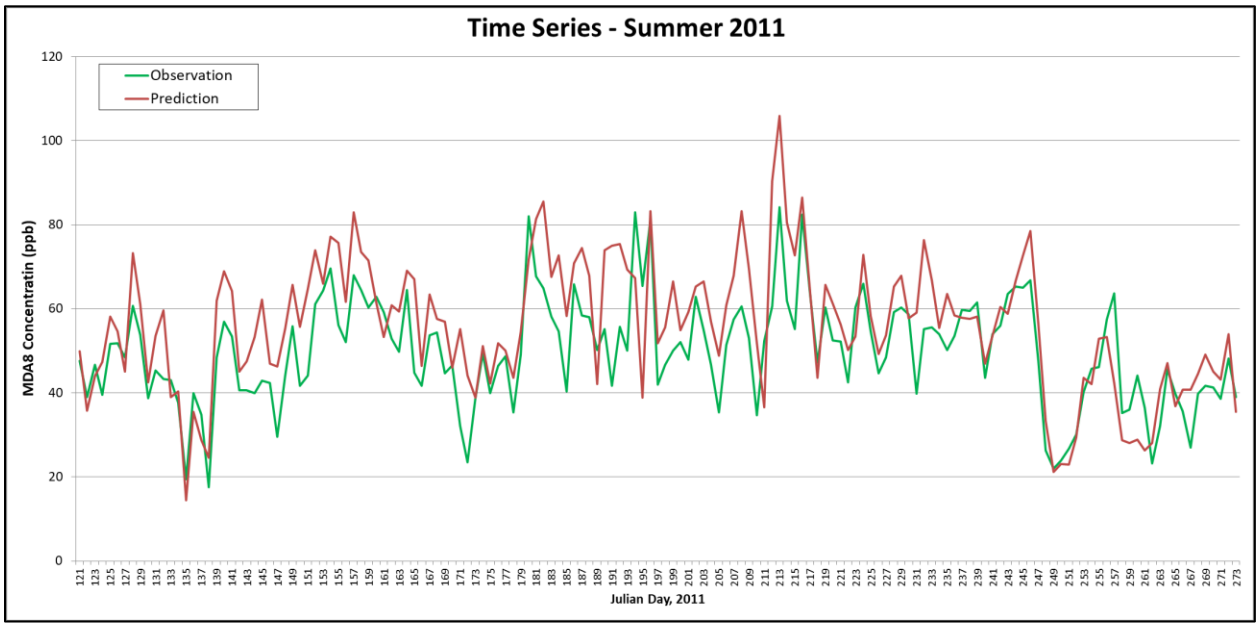


Figure 2-8. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 211110051 in Kentucky.

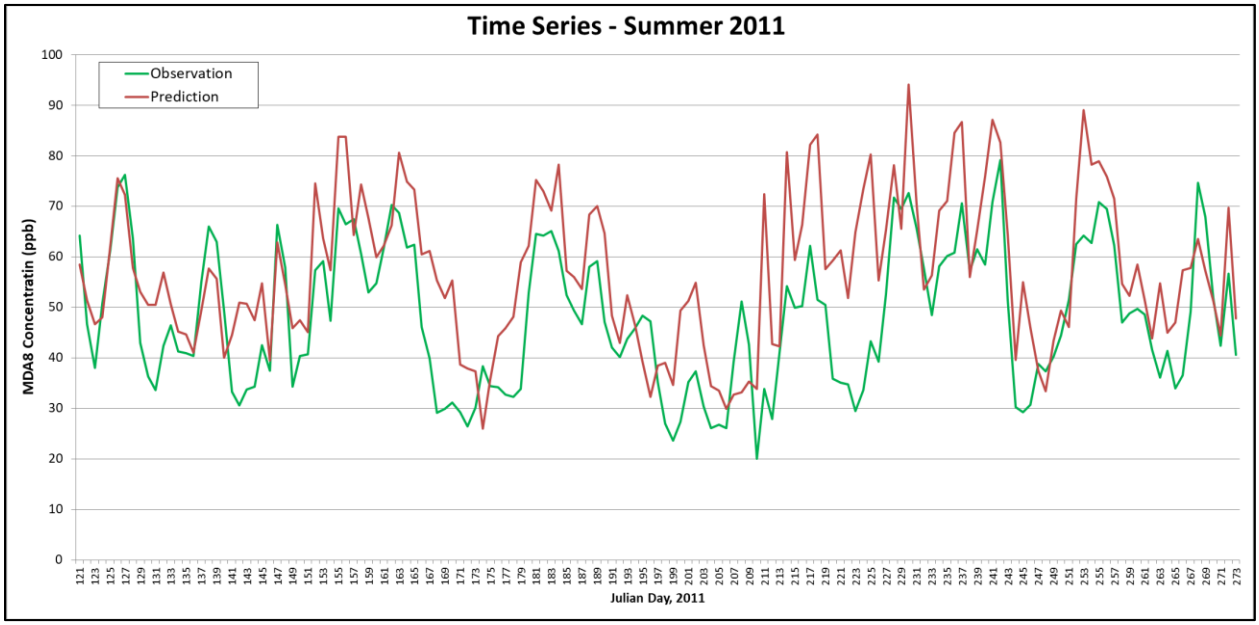


Figure 2-9. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 280470008 in Mississippi.

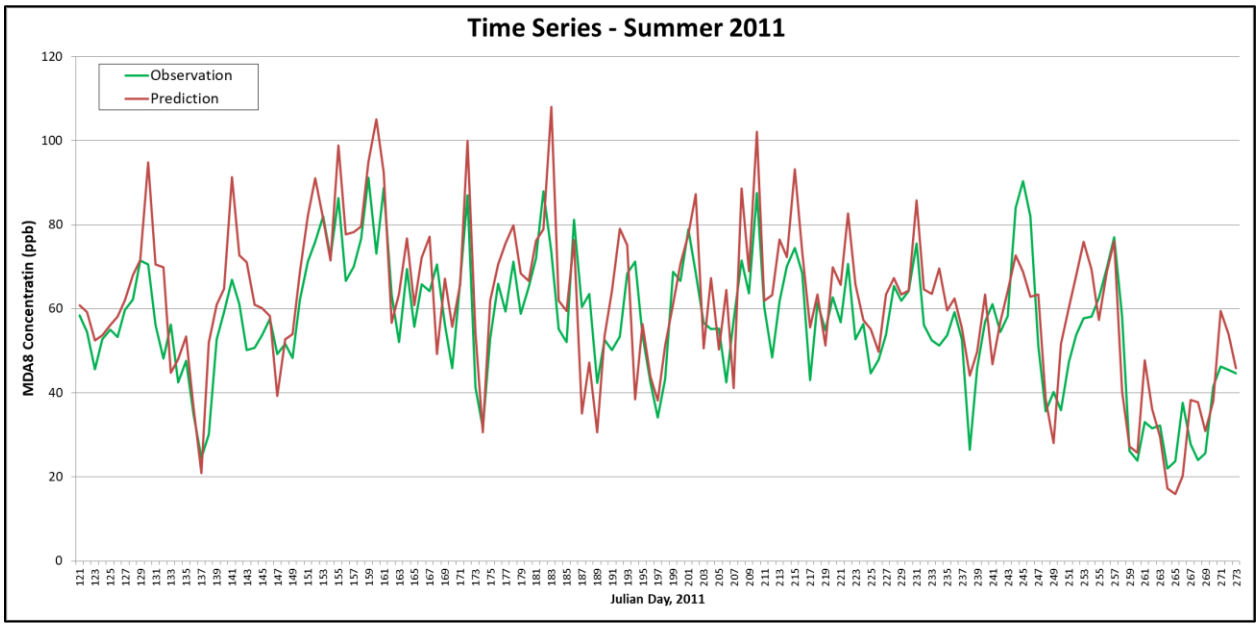


Figure 2-10. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 371190041 in North Carolina.

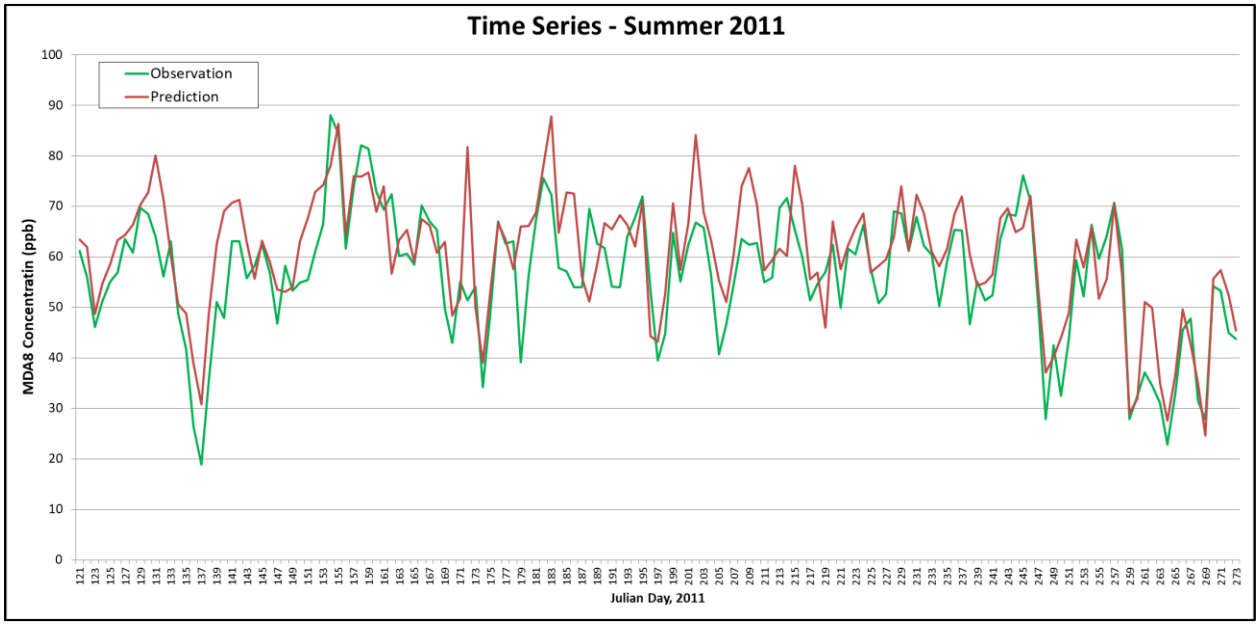


Figure 2-11. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 450830009 in South Carolina.

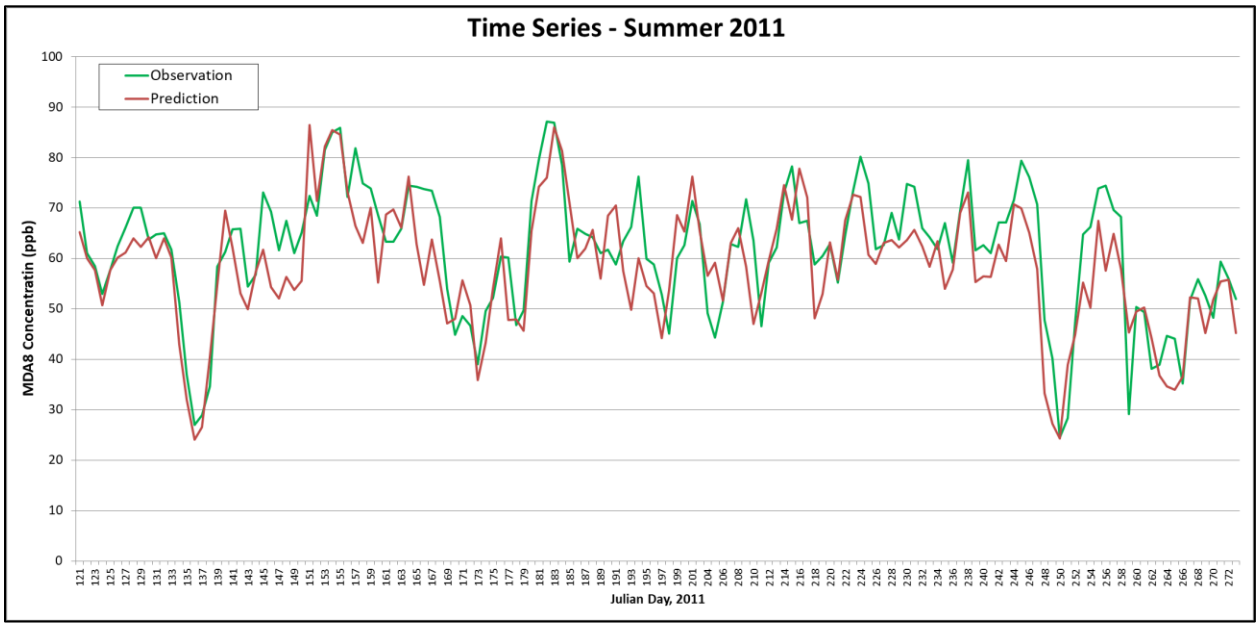


Figure 2-12. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 470090101 in Tennessee.

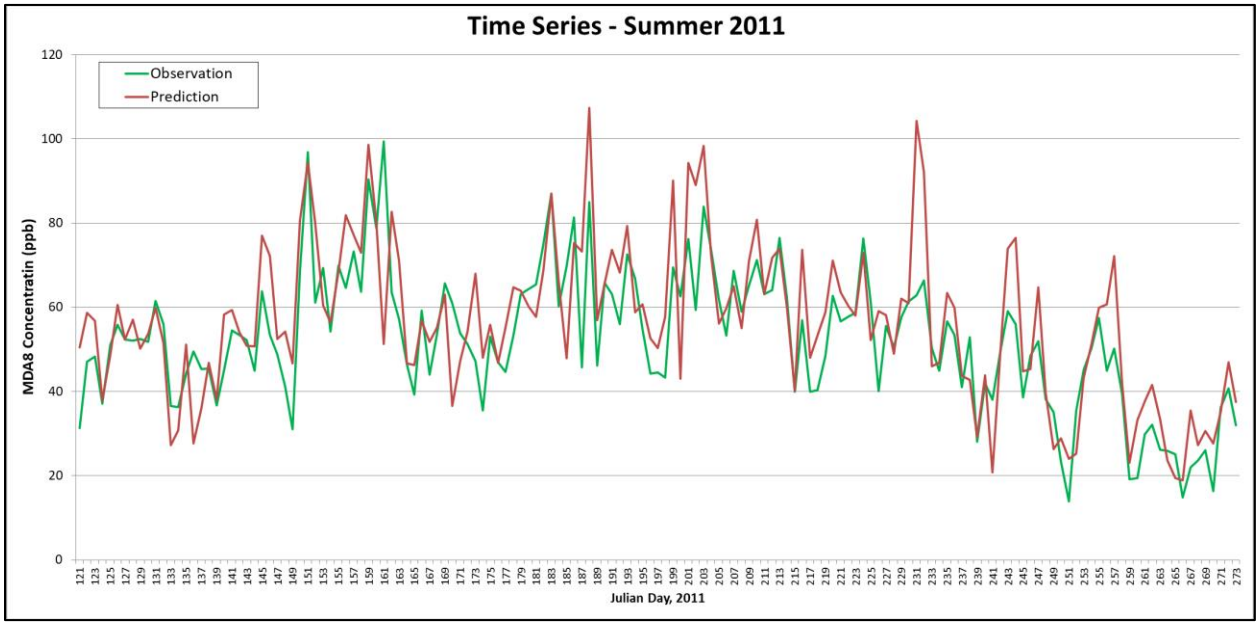


Figure 2-13. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 510590030 in Virginia.

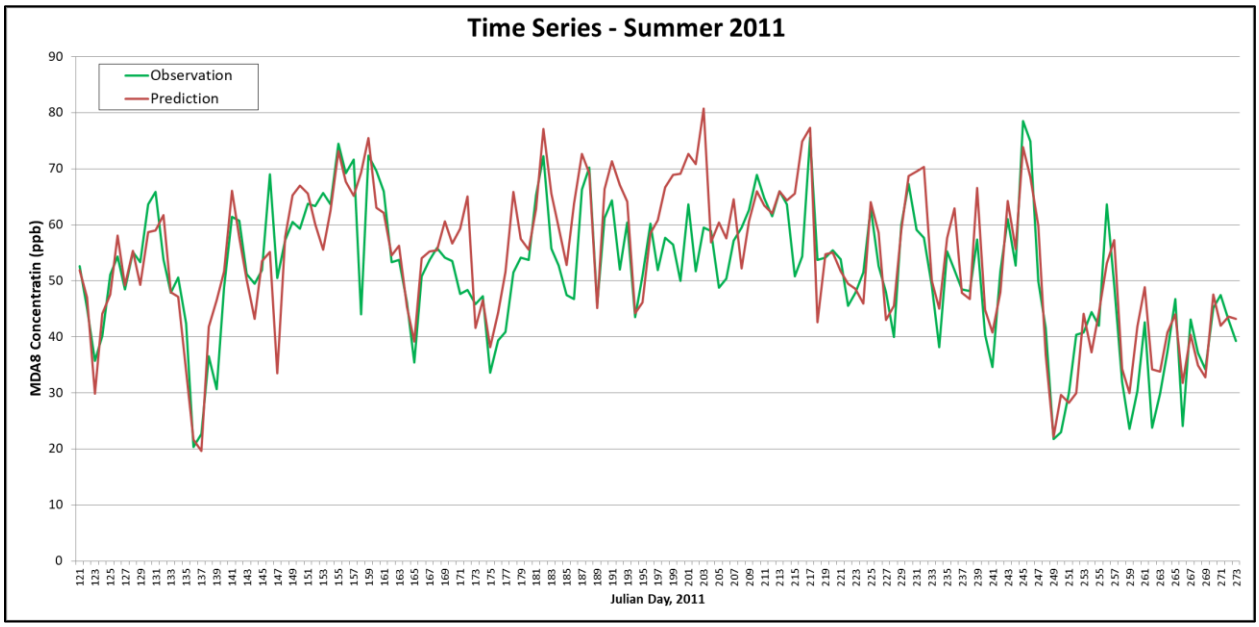


Figure 2-14. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 540690010 in West Virginia.

2.4 Concentration Correlation Plots

Under and overpredictions can also be reviewed through examination of correlation plots of observed vs. modeled MDA8 concentrations by location during the May through September

episode (Figures 2-15 through 2-24). On these graphics each daily MDA8 concentration at a monitor is plotted as a single ordered pair with the observed ozone on the horizontal axis and the corresponding model estimate on the vertical axis. A perfect model would show all points in a single line with a unit slope and a y-axis intercept of zero. In the figures the fourth highest observation is plotted with a red square and the fourth highest model estimate has a yellow diamond.

While many of the sites generally track well and capture day-to-day variability, the presented sites demonstrate a modeled over estimation of ozone on most days with medium range ozone concentrations (40-60 ppb). At all monitors presented here, except in Blount County, TN, the model has overpredicted the 4th high observed values (yellow diamond).

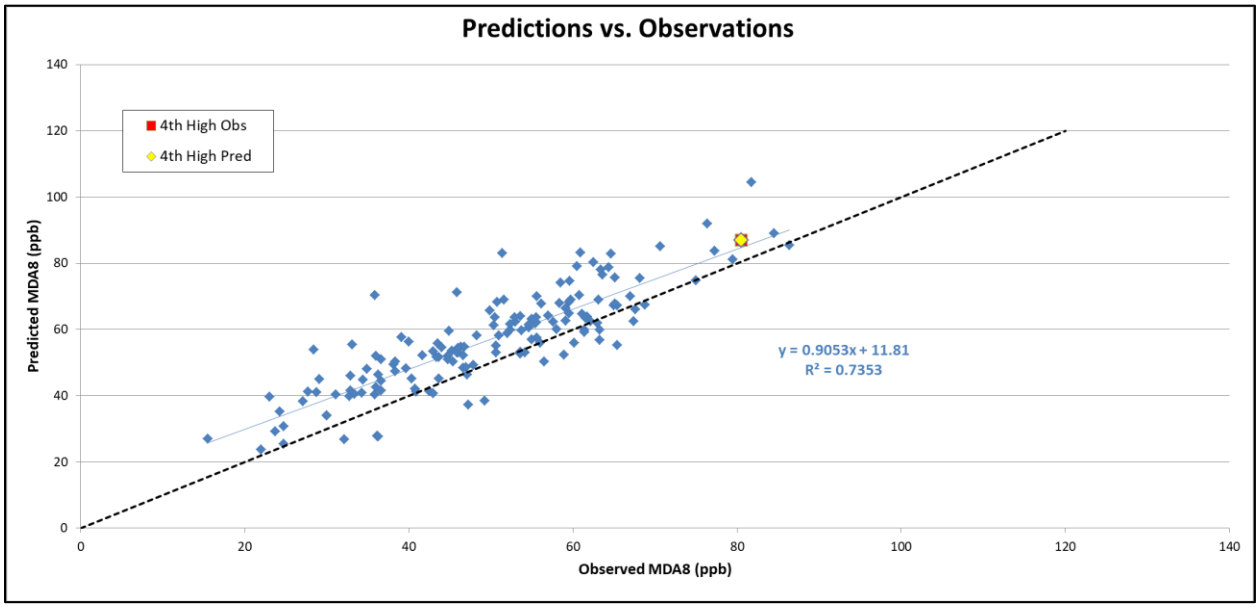


Figure 2-15. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 010731005 in Alabama. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

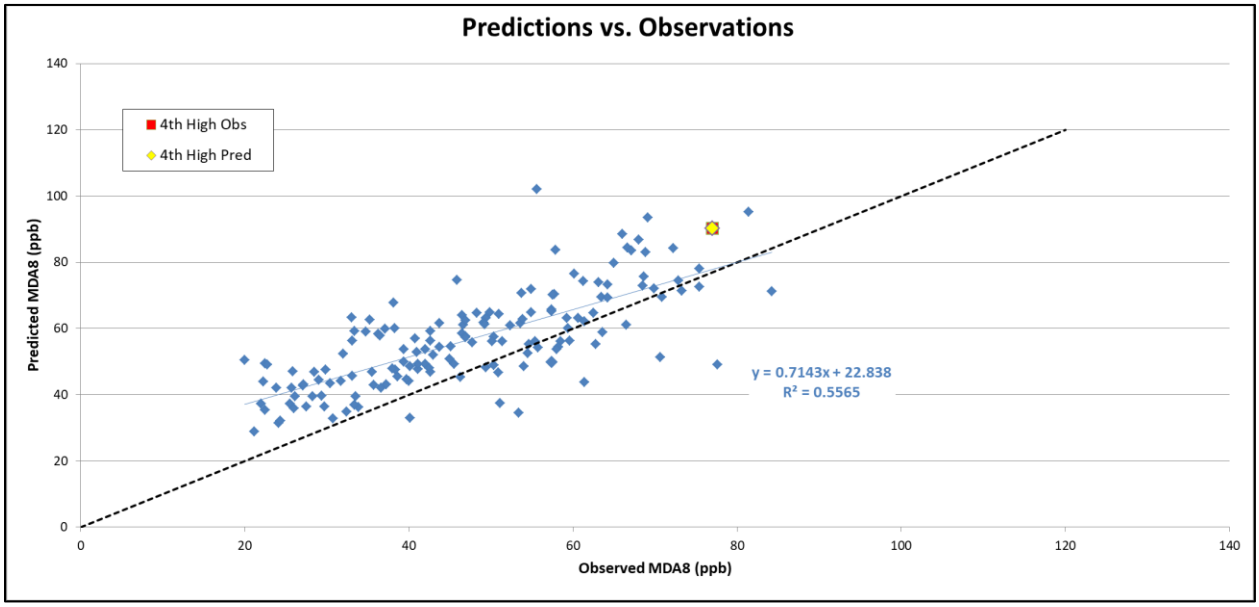


Figure 2-16. Correlation of Observed and Predicted MDA8 Ozone for May Through September 2011 at Site 121130015 in Florida. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

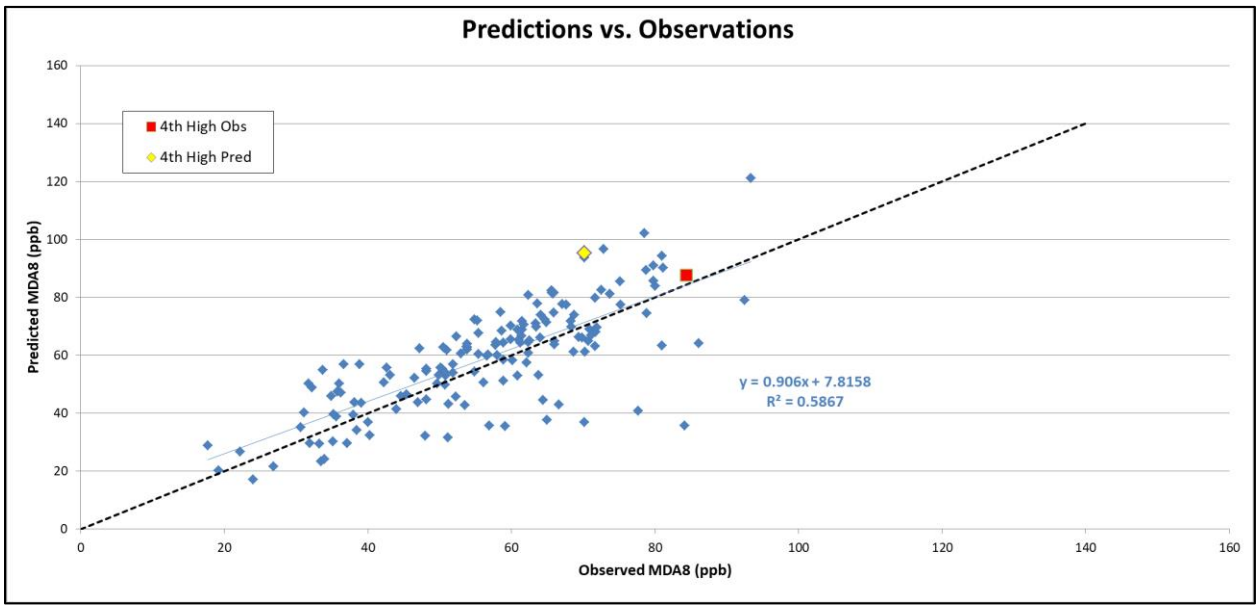


Figure 2-17. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 131210055 in Georgia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

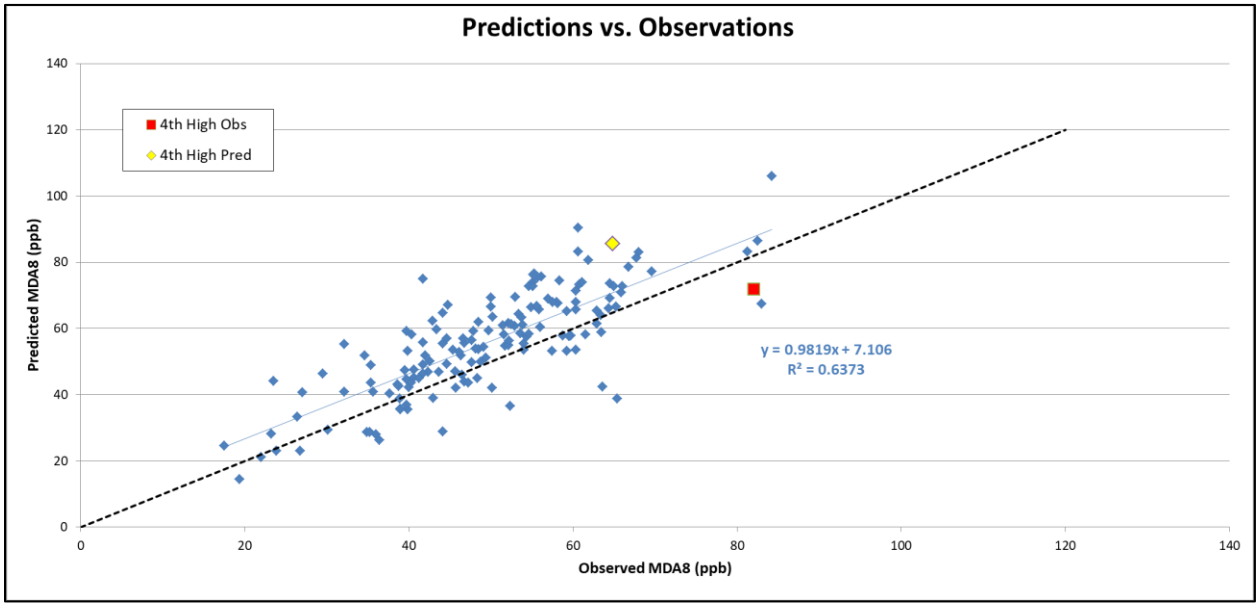


Figure 2-18. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 211110051 in Kentucky. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

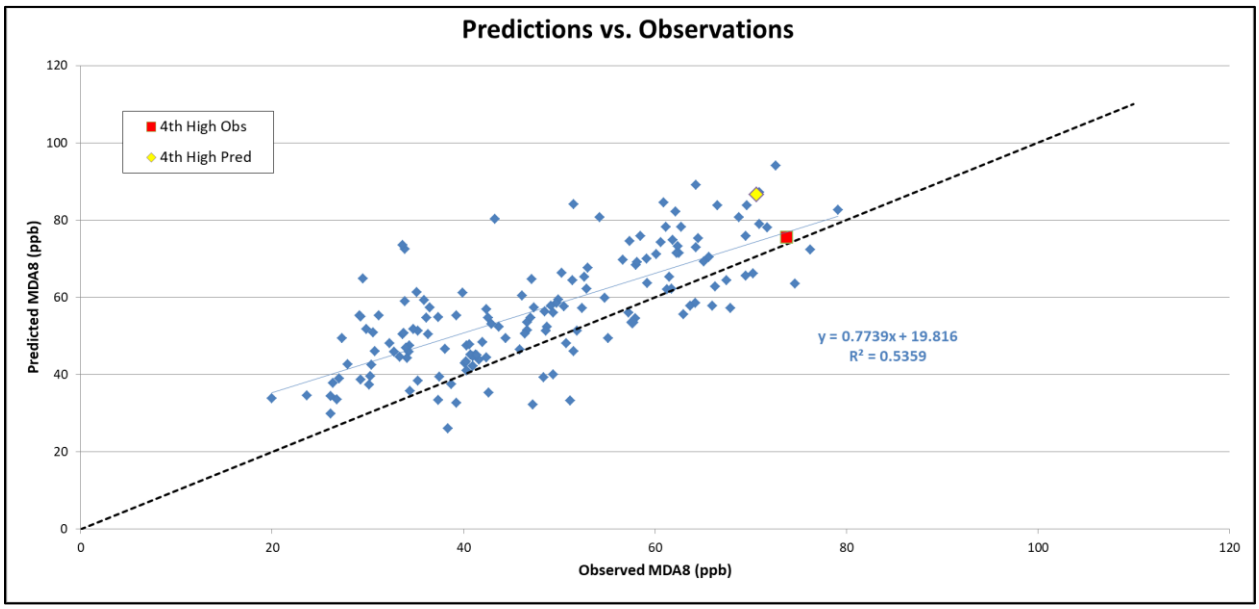


Figure 2-19. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 280470008 in Mississippi. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

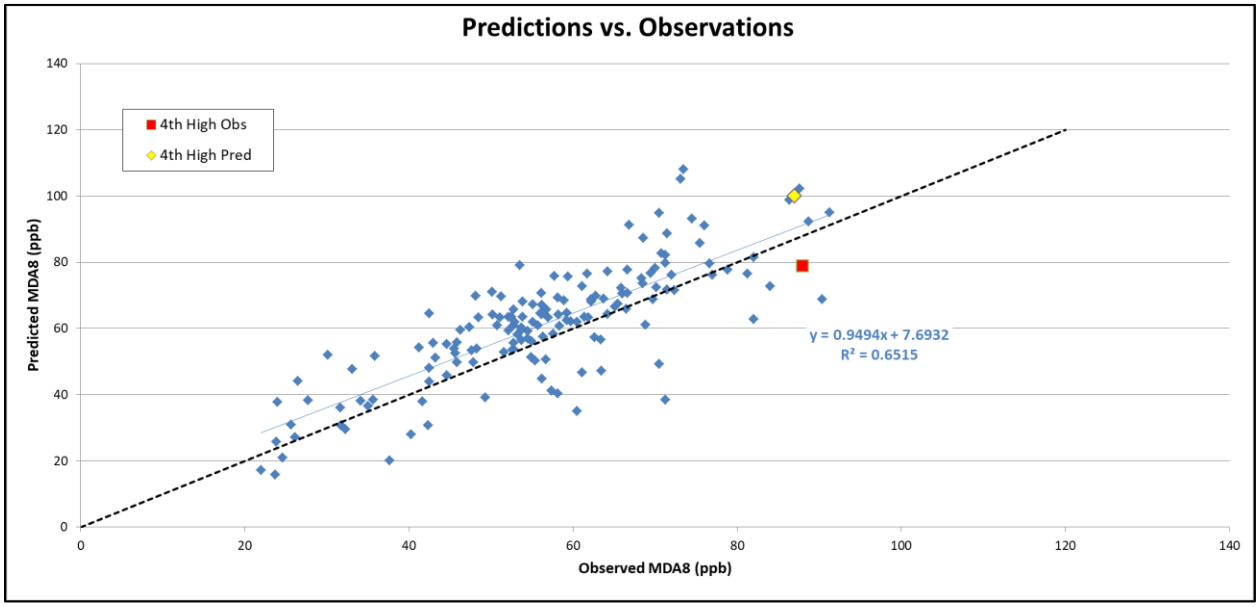


Figure 2-20. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 371190041 in North Carolina. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

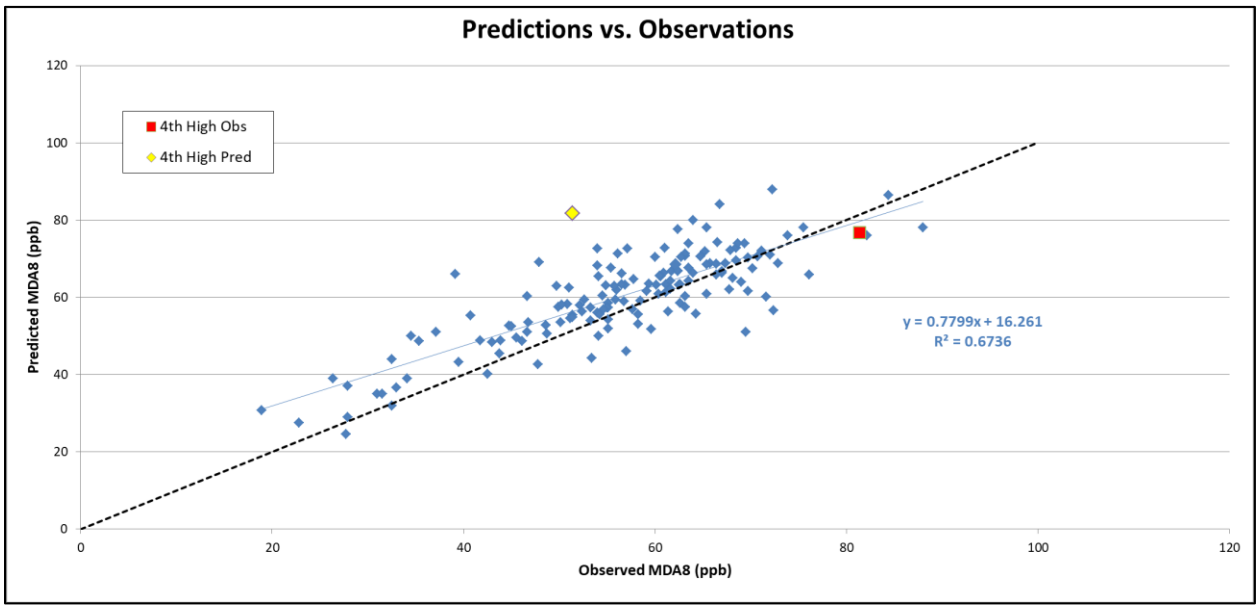


Figure 2-21. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 450830009 in South Carolina. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

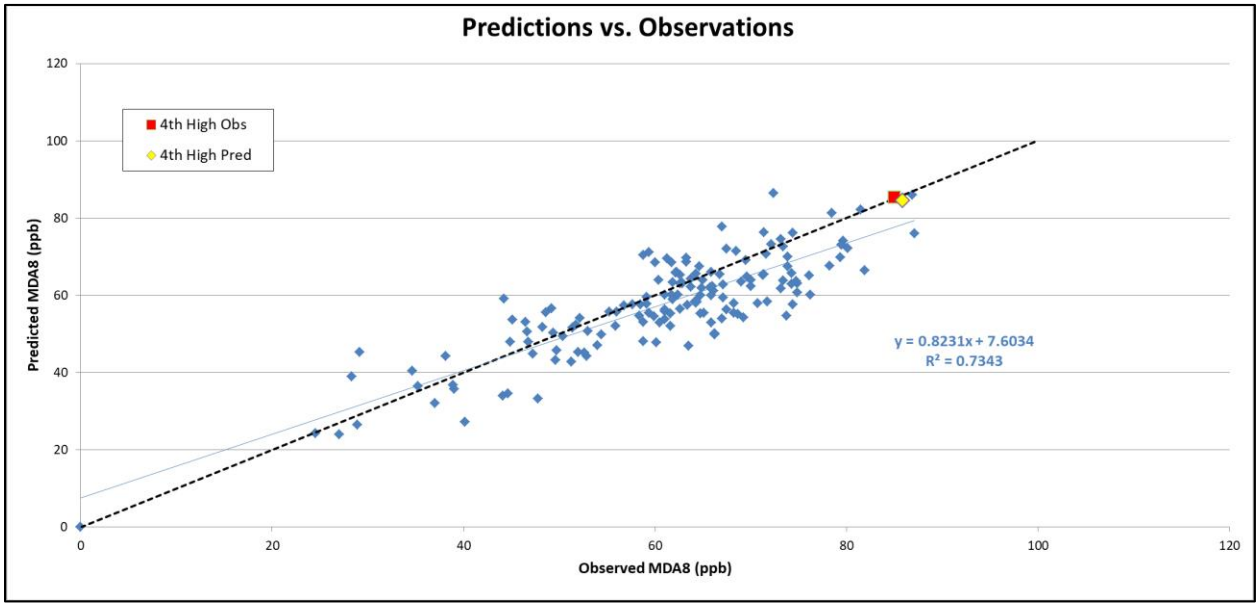


Figure 2-22. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 470090101 in Tennessee. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

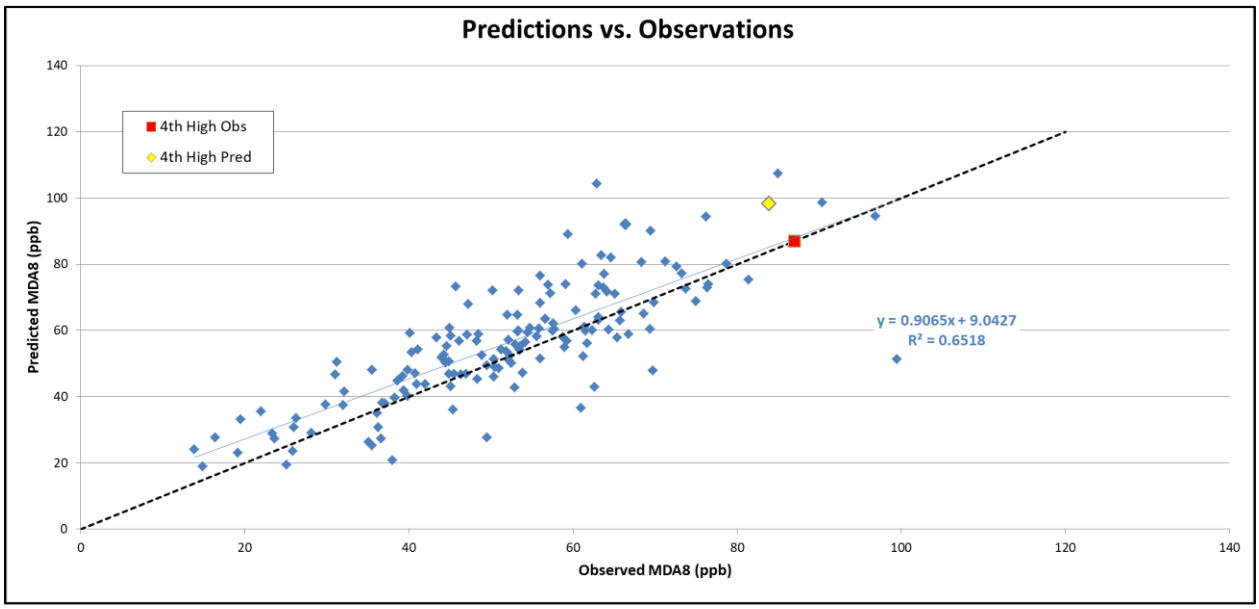


Figure 2-23. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 510590030 in Virginia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

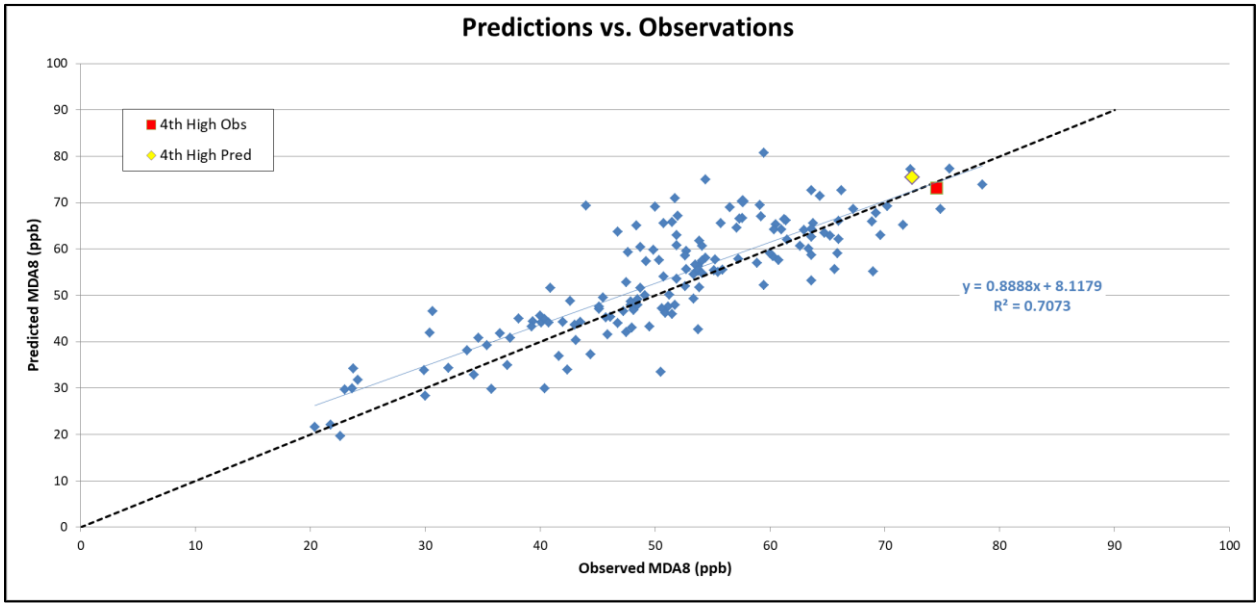


Figure 2-24. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 540690010 in West Virginia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

3.0 SUMMARY

As was seen with the 12-km evaluation conducted by EPA on the 2011en platform,[11] the VISTAS12 modeling has better skill at predicting ozone concentrations in the mid-range of 40 to 60 ppb than it does at the tail ends of the concentration curves. Additionally, as noted above and demonstrated with the statistics and figures of this analysis, the model tends to overestimate ozone concentrations across all ranges and at all presented monitors. It is also noted that compared to observed concentrations, the model overestimates less at high-end concentrations (greater than 60 ppb) than at low-end observed concentrations (less than 40 ppb).

Over the entire concentration range, the model tends to overpredict MDA8 ozone in the VISTAS12 domain. However, looking across all represented monitors in the domain, we note that the model is able to capture site-to-site differences in the short-term (i.e., day-to-day) variability and the general magnitude of the observed ozone concentrations for the May through September 2011 episode.

As a result, and compared to similar results from comparable studies, we find that the predictions from the 12-km domain using this configuration of the 2011el modeling platform correspond closely to observed concentrations in terms of the magnitude, temporal fluctuations, and geographic differences for 8-hour daily maximum ozone.

Thus, the model performance results demonstrate the scientific credibility of the VISTAS12 modeling. These results provide confidence in the ability of the modeling platform to be used for future year ozone concentration projections and contribution analyses.

This page is intentionally left blank.

Appendix A

Model Performance Statistics for MDA8 Ozone at Individual Monitoring Sites Based on Days with Observed Values ≥ 60 ppb

(see: AppendixA1-OzoneMPEbyStation.xlsx
AppendixA2-MeanBias.kmz
AppendixA3-NormalizedMeanBias.kmz
AppendixA4-MeanError.kmz
AppendixA5-NormalizedMeanError.kmz)

This page is intentionally left blank.

Appendix E-6

Future Year Model Projections

This page intentionally left blank.

Future Year Model Projections
Task 9a

Prepared for:
Southeastern States Air Resource Managers, Inc.
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final – September 23, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 Introduction....1
2.0 Rate of Progress Goals and Uniform Rate of Progress....2
3.0 Calculation of 2028 Visibility....4
4.0 Comparison to Regional Haze "Glidepath"....11
5.0 $PM_{2.5}$ Composition and Contributions to Light Extinction....19
6.0 Regional Haze Site Summaries....23

Appendix A Glideslope Stacked Bar Charts for Each Class I Area
Appendix B Visibility and Light Extinction Graphs for Each Class I Area
Appendix C Uniform Rate of Progress Graphs for Each Class I Area

TABLES

Table 3-1. SMAT Settings for 2028 Visibility Calculations. 6

Table 3-2. Base and Future Year Deciview Values on the 20% Clearest and 20% Most Anthropogenically Impaired Days at Each Class I Area for the Base Model Period (2009-2013) and Future Year (2028) in the VISTAS 12 Modeling Domain 7

Table 4-1. Natural and Default-Adjusted Natural Conditions, 2000-2004 Baseline Visibility, Observed 2009-2013 Visibility, 2028 Projected Visibility, 2028 Unadjusted and Default-Adjusted Glidepath Values for the 20% Most Anthropogenically Impaired Days. 14

FIGURES

Figure 2-1. Example Glidepath Plot. 3

Figure 3-1. Projected Change in Deciviews (dv) at IMPROVE Sites in VISTAS_12 Domain on the 20% Most Impaired Days Between 2011 and 2028 (2028 – 2011). 11

Figure 4-1. Map of Deviations from the 2028 Unadjusted Glidepath at IMPROVE Sites in the VISTAS 12 Domain. 18

Figure 5-1. Predicted (CAMx) Concentrations ($\mu g/m^3$) Great Smoky Mountains National Park on the Modeled 20% Clearest (Top) and 20% Most Anthropogenically Impaired (Bottom) Days. 20

Figure 5-2. Predicted (CAMx) Light Extinctions (Mm^{-1}) Great Smoky Mountains National Park on the Modeled 20% Clearest (Top) and 20% Most Anthropogenically Impaired (Bottom) Days. 21

Figure 5-3. SMAT Concentrations (µg/m^3) Great Smoky Mountains National Park on the Modeled 20% Clearest (Right) and 20% Most Anthropogenically Impaired (Left) Days. 22

Figure 5-4. SMAT Light Extinctions (Mm-1) Great Smoky Mountains National Park on the Modeled 20% Clearest (Right) and 20% Most Anthropogenically Impaired (Left) Days. 23

Figure 6-1. 2009-2017 IMPROVE Observations, 2011 and 2028 CAMx Model Predictions, and Unadjusted and Default-Adjusted Glidepaths for Visibility (Top) and Light Extinction (Bottom) at GRSM1. 24

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
B20%	20% Clearest Days
Bext	Beta (or light) extinction
CAMx	Comprehensive Air quality Model with eXtensions
CMAQ	Community Multiscale Air Quality
CFR	Code of Federal Register
dv	Deciview
EC	Elemental carbon
EPA	United States Environmental Protection Agency
ERG	Eastern Research Group, Inc.
$f_s(RH)$	Monthly relative humidity function associated with small size distribution
$f_{ss}(RH)$	Monthly relative humidity function associated with sea salt
$f_L(RH)$	Monthly relative humidity function associated with large size distributions
I20%	20% Most Anthropogenically Impaired Days
IMPROVE	Interagency Monitoring of Protected Visual Environments
µg	micrograms
$\mu g/m^3$	micrograms per cubic meter
Mm^{-1}	Inverse Megameters
OM	Organic mass carbon
PM	Particulate matter
PM_{10}-PRI	Primary particulate matter ≤ 10 microns in aerodynamic diameter
$PM_{2.5}$-PRI	Primary particulate matter ≤2.5 microns in aerodynamic diameter
RHR	Regional Haze Rule
RPGs	Reasonable Progress Goals
RRF	Relative Response Factor
SESARM	Southeastern States Air Resource Managers, Inc.
SIPs	State Implementation Plans
SMAT-CE	Software for Model Attainment Test - Community Edition
URP	Uniform Rate of Progress
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast

State Abbreviations

AL	Alabama
AR	Arkansas
CO	Colorado
FL	Florida
GA	Georgia
KY	Kentucky
LA	Louisiana
ME	Maine
MI	Michigan
MN	Minnesota
MO	Missouri
MT	Montana
NC	North Carolina
ND	North Dakota
NH	New Hampshire
NJ	New Jersey
NM	New Mexico
OK	Oklahoma
SC	South Carolina
SD	South Dakota
TN	Tennessee
TX	Texas
VA	Virginia
VT	Vermont
WV	West Virginia

1.0 INTRODUCTION

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

This report documents the steps taken by Alpine Geophysics, LLC (Alpine), under subcontract to Eastern Research Group, Inc. (ERG), in preparing the uniform rate of progress (URP) or "glidepath" visibility and light extinction values from the 2028elv5 modeling platform. Alpine prepared these datasets under ERG subcontract 4133.00.001/01.

2.0 RATE OF PROGRESS GOALS AND UNIFORM RATE OF PROGRESS

As required by the Regional Haze Rule (RHR), Reasonable Progress Goals (RPGs) must provide for an improvement in visibility for the 20 percent most anthropogenically impaired days (I20%) relative to baseline visibility conditions and ensure no degradation in visibility for the 20 percent clearest days (B20%) relative to baseline visibility conditions.[2] The baseline for each Class I area is the average visibility (in deciviews, dv) for the years 2000 through 2004. The visibility conditions in these years are the benchmark for the "provide for an improvement" and "no degradation" requirements. In addition, states are required to determine the rate of improvement in visibility needed to reach natural conditions by 2064 for the 20 percent most anthropogenically impaired days.[3]

A line drawn between the end of the 2000-2004 baseline period and 2064 is the uniform rate of progress (URP) or "glidepath" between these two points. The glidepath represents a linear or uniform rate of progress (dv/year)and can be used to determine visibility improvement needed in each implementation period to stay on target to reach natural conditions by 2064. The URP is a framework for consideration but there is no rule requirement to be on or below the glidepath. An example glidepath plot is shown in Figure 2-1.

[2] 40 CFR 51.308(f)(3)(i)-2
[3] 40 CFR 51.308(f)(1)

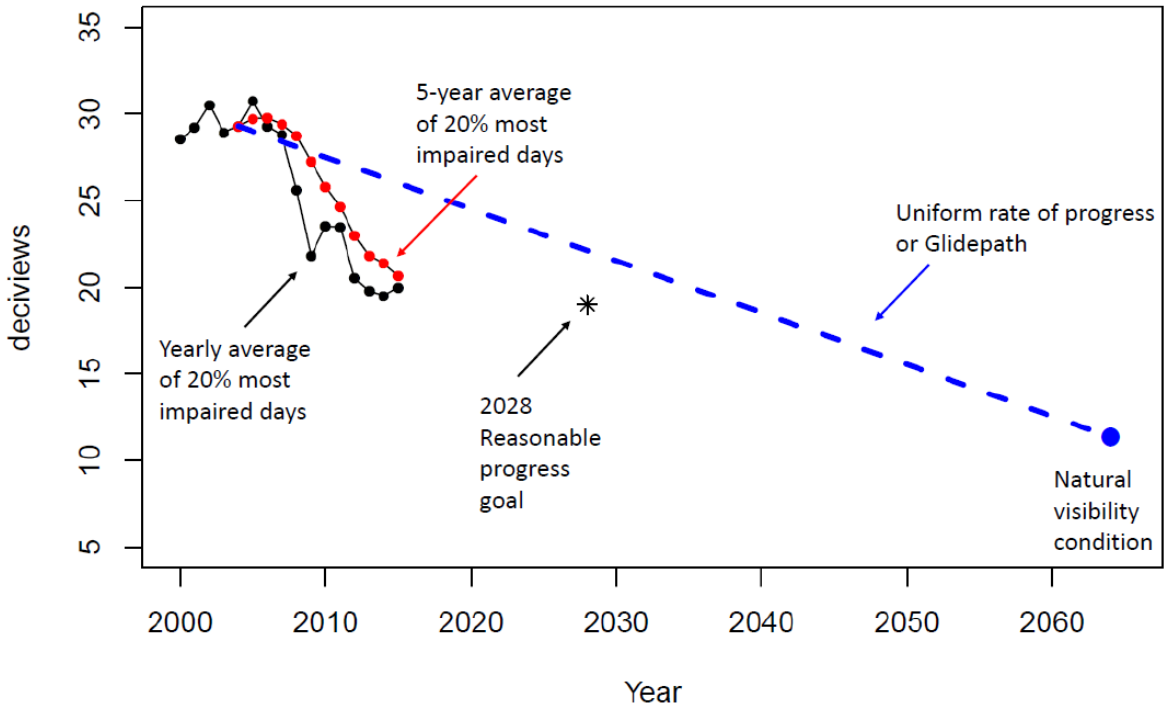


Figure 2-1. Example Glidepath Plot.

The RHR requires states to submit an implementation plan that evaluates and contains measures found necessary to make reasonable progress for implementation periods in approximately ten-year increments. The next regional haze SIP is due in July 2021, for the implementation period which ends in 2028. Therefore, modeling was used to project visibility to 2028 using a 2028 emissions inventory with "on-the-books" controls.[4] The EPA Software for Model Attainment Test - Community Edition (SMAT-CE) tool was used to calculate 2028 deciview values on the 20% most anthropogenically impaired and 20% clearest days at each Class I Area (IMPROVE site).[5] SMAT-CE[6] is an EPA software tool which implements the procedures in the SIP Modeling Guidance to project visibility to a future year.

[4] "Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project Final Modeling Protocol, Update and Addendum to the Approved Modeling Protocol for Task 6.1 (June 2018)." August 31, 2020.

[5] The base year (2009-2013) IMPROVE data for the 20% most impaired and 20% clearest days was calculated based on the EPA recommended method described in "Technical Guidance for the Second Implementation Period of the Regional Haze Rule." (December 2018).

[6] SMAT-CE is available here: https://www.epa.gov/scram/photochemical-modeling-tools

3.0 CALCULATION OF 2028 VISIBILITY

The visibility projections follow the procedures in section 5 of the SIP Modeling Guidance.[7] Based on the recommendation in the modeling guidance, the observed base period visibility data is linked to the base modeling year. This is the 5-year ambient data base period centered about the base modeling year. In this case, for a base modeling year of 2011, the ambient IMPROVE data should be from the 2009-2013 period.[8]

The visibility calculations use the "revised" IMPROVE equation, which has been used in most regional haze SIPs over the last 10 years. The IMPROVE equation (or algorithm) uses particulate matter (PM) species concentrations and relative humidity data to calculate visibility impairment or beta extinction (bext) in units of inverse megameters (Mm-1) as follows:

$$
\begin{aligned}
bext = {} & 2.2 \times f_s(RH) \times [\text{Small Sulfate}] + 4.8 \times f_L(RH) \times [\text{Large Sulfate}] \\
& + 2.4 \times f_s(RH) \times [\text{Small Nitrate}] + 5.1 \times f_L(RH) \times [\text{Large Nitrate}] \\
& + 2.8 \times \{\text{Small Organic Mass}] + 6.1 \times [\text{Large Organic Mass}] \\
& + 10 \times [\text{Elemental Carbon}] \\
& + 1 \times [\text{Fine Soil}] \\
& + 1.7 \times f_{ss}(RH) \times [\text{Sea Salt}] \\
& + 0.6 \times [\text{Coarse Mass}] \\
& + \text{Rayleigh Scattering (site specific)}
\end{aligned}
$$

The total sulfate, nitrate, and organic mass concentrations are each split into two fractions, representing small and large size distributions of those components. Site-specific Rayleigh scattering is calculated based on the elevation and annual average temperature of each IMPROVE monitoring site.

The 2028 future year visibility on the I20% and B20% days at each Class I area is estimated by using the observed IMPROVE data (2009-2013) and the relative percent modeled change in PM species between 2011 and 2028. The process is described in the following six steps (see the SIP Modeling Guidance for a more detailed description and examples).

---

7 https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf.

8 The baseline period for the regional haze program continues to be 2000-2004, and the uniform rate of progress is calculated using that historical data. However, the modeled visibility projections should use ambient data from a 5-year base period that corresponds to the modeled base year meteorological and emissions data. Also, unlike the ozone and $PM_{2.5}$ attainment tests, the ambient data averaging calculation is a 5-year mean, where each year counts equally (unlike the 5-year weighted average values recommended for the ozone and $PM_{2.5}$ attainment test).

- Step 1 - For each Class I area (i.e., IMPROVE site), estimate anthropogenic impairment (Mm^{-1}) on each day using observed speciated $PM_{2.5}$ data plus PM_{10} data (and other information) for each of the 5 years comprising the base period (2009-2013) and rank the days on this indicator.[9] This ranking will determine the 20 percent most anthropogenically impaired days. For each Class I area, also rank observed visibility (in deciviews) on each day using observed speciated $PM_{2.5}$ data plus PM_{10} data for each of the 5 years comprising the base period. This ranking will determine the 20 percent clearest days.
- Step 2 - For each of the 5 years comprising the base period, calculate the mean deciviews for the I20% and B20% days. For each Class I area, calculate the 5-year mean deciviews for most impaired and clearest days from the 5 year-specific values.
- Step 3 - Use an air quality model to simulate air quality with base period (2011) emissions and future year (2028) emissions. Use the resulting information to develop site-specific relative response factors (RRFs) for each component of PM[10] identified in the "revised" IMPROVE equation. The RRFs are an average percent change in species concentrations based on the measured I20% and B20% days from 2011 (the calendar days from 2011 identified from the IMPROVE data above are matched by day to the modeled days).
- Step 4 - Multiply the species-specific RRFs by the measured daily species concentration data during the 2009-2013 base period (for each day in the measured I20% day set and each day in the B20% day set), for each site. This results in daily future year 2028 PM species concentration data.
- Step 5 - Using the results in Step 4 and the IMPROVE algorithm, calculate the future daily extinction coefficients for the previously identified I20% days and B20% days in each of the five base years.
- Step 6 - Calculate daily deciview values (from total daily extinction) and then compute the future year (2028) average mean deciviews for the I20% days and B20% days for each year. Average the five years together to get the final future mean deciview values for the I20% and B20% days.

The SMAT-CE tool outputs individual year and 5-year average base year and future year deciview values on the I20% and B20% days. Additional SMAT output variables include the results of intermediate calculations such as species-specific extinction values (both base and future year) and species specific RRFs (on the I20% and B20% days). Table 3-1 details the settings used for the SMAT runs to generate the 2028 future year deciview projections.

[9] The EPA recommended methodology for determining the most anthropogenically impaired days (which includes the explanation of how anthropogenic vs. natural daily light extinction was determined) can be found in Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program.

[10] Relative response factors (RRFs) are calculated separately for sulfate, nitrate, organic carbon mass, elemental carbon, fine soil mass, and coarse mass. Since observed sea salt is primarily from natural sources which are not expected to be year-sensitive, and the modeled sea salt is uncertain, the sea salt RRF for all sites is assumed to be 1.0.

In cases within VISTAS states where an IMPROVE monitor is not located within a Class I area, surrogate IMPROVE monitors are assigned to establish baseline visibility values for modeling. When this occurs, the 5-year average base year visibility from the surrogate location is used with modeled concentrations from the actual Class I area modeled grid cell to calculate future year RRFs and visibility results. In Class I areas outside of the VISTAS states, surrogate monitor baseline data and RRFs are used to project future year visibility.

Table 3-1. SMAT Settings for 2028 Visibility Calculations.

SMAT Option	Setting or File Used
IMPROVE algorithm	Use new version
Grid cells at monitor or Class I area centroid?	Use grid cells at monitor
IMPROVE data file	ClassIareas_NEWIMPROVEALG_2000to2017_2019_feb 11_IMPAIRMENT.csv[11]
Baseline file	2011el_cb6r4_v6_11g.ag.vistas12.vistas12.PM.mats.tileFULL.csv
Forecast file	2028elv5_cb6r4_v6_11g.ag.vistas12.vistas12.PM.mats.tileFULL.csv
Temporal adjustment at monitor	3 x 3
Start monitor year	2009
End monitor year	2013
Base model year	2011
Minimum years required for a valid monitor	1

Table 3-2 shows the base and future year deciview values on the B20% and I20% days at each Class I area for the base model period (2009-2013) and future year (2028).[12]

[11] The IMPROVE ambient data file has the 20% most impaired days identified as "group 90" days and 20% clearest days identified as "group 10" days. The definition of the most impaired days uses the EPA recommended methodology from Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program. The IMPROVE data file used for this analysis included patched and/or substituted data.

[12] The 2028 results are calculated for Class I areas with the VISTAS_12 modeling domain which are represented by 45 IMPROVE sites. Results are not shown for Class I areas which are outside of this domain and for Class I areas which did not have complete IMPROVE data in 2011.

Table 3-2. Base and Future Year Deciview Values on the 20% Clearest and 20% Most Anthropogenically Impaired Days at Each Class I Area for the Base Model Period (2009-2013) and Future Year (2028) in the VISTAS 12 Modeling Domain

Class I Area Site ID	Class I Area Name	IMPROVE Site ID	Base Year (2009-2013) 20% Clearest Days (dv)	Future Year (2028) 20% Clearest Days (dv)	Base Year (2009-2013) 20% Most Anthropogenically Impaired Days (dv)	Future Year (2028) 20% Most Anthropogenically Impaired Days (dv)
SIPS	Sipsey Wilderness	SIPS1	12.84	11.11	21.67	16.62
CACR	Caney Creek Wilderness	CACR1	9.74	8.79	20.87	18.32
UPBU	Upper Buffalo Wilderness	UPBU1	9.95	8.93	20.52	17.82
GRSA	Great Sand Dunes NM	GRSA1	3.81	3.68	8.78	8.29
MOZI	Mount Zirkel Wilderness	MOZI1	0.44	0.23	6.05	5.49
RAWA	Rawah Wilderness	MOZI1	0.44	0.23	6.05	5.49
ROMO	Rocky Mountain NP	ROMO1	1.60	1.47	9.21	8.39
CHAS	Chassahowitzka	CHAS1	13.76	12.54	19.94	16.79
EVER	Everglades NP	EVER1	11.23	10.64	16.30	15.52
SAMA	St. Marks	SAMA1	13.33	11.59	20.11	16.43
COHU	Cohutta Wilderness	COHU1	10.94	9.15	21.19	14.90
OKEF	Okefenokee	OKEF1	13.34	11.58	20.70	16.90
WOLF	Wolf Island	OKEF1	13.34	11.55	20.70	16.75
MACA	Mammoth Cave NP	MACA1	13.69	11.66	24.04	19.27
BRET2	Breton Wilderness	BRIS1[13]	13.81	12.13	22.49	18.39

[13] The BRIS1 IMPROVE monitor is used for Breton Wilderness as the original monitor (BRET1) was decommissioned in 2005 after Hurricane Katrina.

Table 3-2. Base and Future Year Deciview Values on the 20% Clearest and 20% Most Anthropogenically Impaired Days at Each Class I Area for the Base Model Period (2009-2013) and Future Year (2028) in the VISTAS 12 Modeling Domain

Class I Area Site ID	Class I Area Name	IMPROVE Site ID	Base Year (2009-2013) 20% Clearest Days (dv)	Future Year (2028) 20% Clearest Days (dv)	Base Year (2009-2013) 20% Most Anthropogenically Impaired Days (dv)	Future Year (2028) 20% Most Anthropogenically Impaired Days (dv)
ACAD	Acadia NP	ACAD1	7.02	6.70	16.84	14.67
MOOS	Moosehorn	MOOS1	6.71	6.61	15.80	14.14
ROCA	Roosevelt Campobello International Park	MOOS1	6.71	6.61	15.80	14.14
ISLE	Isle Royale NP	ISLE1	5.40	5.25	17.63	15.12
SENE	Seney	SENE1	5.51	5.34	19.84	16.87
BOWA	Boundary Waters Canoe Area	BOWA1	4.86	4.76	16.43	13.99
HEGL	Hercules-Glades Wilderness	HEGL1	10.96	9.75	21.63	18.80
MING	Mingo	MING1	12.47	11.14	22.70	19.69
MELA	Medicine Lake	MELA1	6.56	6.30	16.59	15.79
ULBE	UL Bend	ULBE1	4.03	3.86	11.90	11.37
LIGO	Linville Gorge Wilderness	LIGO1	9.70	8.21	20.39	14.25
SHRO	Shining Rock	SHRO1[a]	5.36	4.54	19.05	13.31
SWAN	Swanquarter	SWAN1	11.76	10.77	19.76	15.27
THRO	Theodore Roosevelt NP	THRO1	6.38	6.11	15.71	14.67
GRGU	Great Gulf Wilderness	GRGU1	5.87	5.40	15.43	12.30

Table 3-2. Base and Future Year Deciview Values on the 20% Clearest and 20% Most Anthropogenically Impaired Days at Each Class I Area for the Base Model Period (2009-2013) and Future Year (2028) in the VISTAS 12 Modeling Domain

Class I Area Site ID	Class I Area Name	IMPROVE Site ID	Base Year (2009-2013) 20% Clearest Days (dv)	Future Year (2028) 20% Clearest Days (dv)	Base Year (2009-2013) 20% Most Anthropogenically Impaired Days (dv)	Future Year (2028) 20% Most Anthropogenically Impaired Days (dv)
PRRA	Presidential Range-Dry River Wilderness	GRGU1	5.87	5.40	15.43	12.30
BRIG	Brigantine	BRIG1	12.25	11.07	22.26	18.40
BAND	Bandelier NM	BAND1	3.99	3.99	9.17	8.96
BOAP	Bosque del Apache	BOAP1	5.72	5.71	11.19	10.96
PECO	Pecos Wilderness	WHPE1	0.57	0.57	6.96	6.57
SACR	Salt Creek	SACR1	7.37	7.73	15.31	15.00
SAPE	San Pedro Parks Wilderness	SAPE1	1.22	1.16	6.82	6.52
WHIT	White Mountain Wilderness	WHIT1	3.34	3.33	10.58	10.14
WHPE	Wheeler Peak Wilderness	WHPE1	0.57	0.57	6.96	6.57
WIMO	Wichita Mountains	WIMO1	9.22	8.56	20.32	18.10
ROMA	Cape Romain	ROMA1	13.59	12.11	21.48	16.64
BADL	Badlands NP	BADL1	5.78	5.54	14.33	12.95
WICA	Wind Cave NP	WICA1	3.99	3.78	12.31	11.20
GRSM	Great Smoky Mountains NP	GRSM1	10.63	8.96	21.39	15.03

Table 3-2. Base and Future Year Deciview Values on the 20% Clearest and 20% Most Anthropogenically Impaired Days at Each Class I Area for the Base Model Period (2009-2013) and Future Year (2028) in the VISTAS 12 Modeling Domain

Class I Area Site ID	Class I Area Name	IMPROVE Site ID	Base Year (2009-2013) 20% Clearest Days (dv)	Future Year (2028) 20% Clearest Days (dv)	Base Year (2009-2013) 20% Most Anthropogenically Impaired Days (dv)	Future Year (2028) 20% Most Anthropogenically Impaired Days (dv)
JOYC	Joyce-Kilmer-Slickrock Wilderness	GRSM1	10.63	8.97	21.39	14.88
BIBE	Big Bend NP	BIBE1	5.65	5.60	14.37	13.94
CAVE	Carlsbad Caverns NP	GUMO1	5.25	5.03	12.81	12.07
GUMO	Guadalupe Mountains NP	GUMO1	5.25	5.03	12.81	12.07
JARI	James River Face Wilderness	JARI1	11.79	9.80	21.37	15.87
SHEN	Shenandoah NP	SHEN1	8.60	7.27	20.72	14.47
LYBR2	Lye Brook Wilderness	LYEB1	4.89	4.22	18.06	14.14
DOSO	Dolly Sods Wilderness	DOSO1	9.03	7.55	21.59	15.29
OTCR	Otter Creek Wilderness	DOSO1	9.03	7.55	21.59	15.26

[a] The base year model period dv value for the 20% clearest and most impaired days at Shining Rock was calculated using a 3-year average of 2009, 2012, and 2013 (IMPROVE data) for both the 20% clearest and most impaired days. These values from the base year were then applied to the RRF from the LIGO site calculate the adjusted future year dvs.

Figure 3-1 shows the predicted change in deciviews at each Class I area (IMPROVE site) on the I20% days between 2011 and 2028 (2028 deciviews minus 2011 deciviews). The visibility improvement in the east is generally large, in the range of a 2-6 deciview improvement. Most sites in the west show a relatively small deciview improvement of less than 2 deciviews.

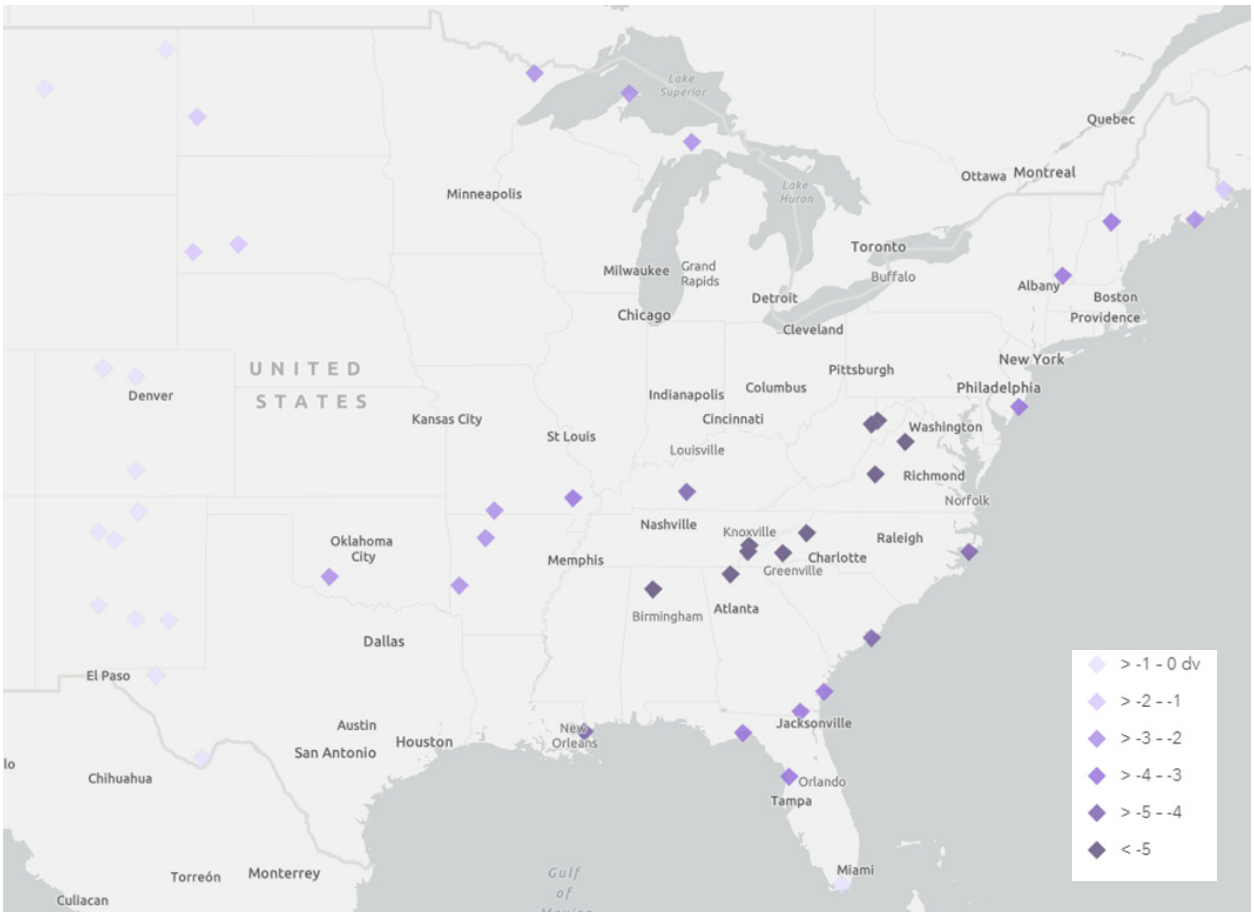


Figure 3-1. Projected Change in Deciviews (dv) at IMPROVE Sites in VISTAS_12 Domain on the 20% Most Impaired Days Between 2011 and 2028 (2028 – 2011).

4.0 COMPARISON TO REGIONAL HAZE "GLIDEPATH"

The future year 2028 deciview projections can be compared to the visibility "glidepaths" at each Class I area. The unadjusted "glidepath" represents the amount of visibility improvement needed in each implementation period, starting from the baseline 2000-2004 period, to stay on a linear path to natural visibility conditions by 2064. The adjusted "glidepath" accounts for international anthropogenic impacts on visibility at each Class I area.

Visibility on the I20% days is compared to the relevant value of the glidepath, in this case for a future year of 2028. Since the glidepath is a linear path between 2004 and 2064, a glidepath value (in deciviews) can be calculated for any future year, using a simple equation. The following formula was used to calculate the 2028 unadjusted glidepath value:

$$Glidepath2028 = Baseline\ Avg\ Deciview - \left(\frac{Baseline\ Avg\ Deciview - Natural\ Conditions}{60}\right) * 24$$

Where:

Baseline avg deciview = average observed deciview value on the I20% days for 2000-2004 (in dv)

Natural conditions = Natural conditions on the I20% days at the Class I area (in dv)

Visibility at Class I areas is impacted not only by natural and anthropogenic emissions from within the U.S., but also by natural and anthropogenic *international* emissions. Due to the fact that international anthropogenic emissions are beyond the control of states preparing regional haze SIPs, the Regional Haze Rule allows states to optionally propose an adjustment of the 2064 URP endpoint to account for international anthropogenic impacts, if the adjustment has been developed using scientifically valid data and methods.[14] The URP can be adjusted by adding an estimate of the visibility impact of international anthropogenic sources to the value of the natural visibility conditions to get an adjusted 2064 endpoint. See the Technical Guidance on Tracking Visibility Progress[15] for more details. This is referred to as the "Default Adjusted" glideslope and natural conditions calculation.

The regional haze rule also allows for an optional adjustment to the URP relating to certain prescribed fires. Specifically, the rule also allows states to optionally propose an adjustment of the 2064 URP endpoint to account for impacts from certain wildland prescribed fires.

[14] See 40 CFR 51.308(f)(1)(vi)
[15] https://www.epa.gov/visibility/technical-guidance-tracking-visibility-progress-second-implementation-period-regional

The EPA modeling calculates estimated Class I area (IMPROVE site) contributions from international anthropogenic and prescribed fire emissions using a combination of hemispheric scale CMAQ zero-out model runs and regional scale CAMx source apportionment modeling.

Table 4-1 shows the 2028 glidepath values (in dv) at each Class I area, including the data needed to calculate the glidepath (natural conditions and the 2000-2004 baseline deciview values).[16] The observed 2009-2013 values and projected 2028 values are also included, which are repeated from Table 3-2.

In cases where an IMPROVE monitor is not located within a Class I area, surrogate IMPROVE monitors are assigned to establish a glidepath.

[16] The values for the 20% most impaired and clearest days and natural conditions are calculated according to the draft recommended method in the draft EPA guidance document "Draft Guidance for the Second Implementation Period of the Regional Haze Rule" posted at https://www.epa.gov/visibility/regional-haze-guidance-technical-support-document-and-data-file.

Table 4-1. Natural and Default-Adjusted Natural Conditions, 2000-2004 Baseline Visibility, Observed 2009-2013 Visibility, 2028 Projected Visibility, 2028 Unadjusted and Default-Adjusted Glidepath Values for the 20% Most Anthropogenically Impaired Days.

Class I Area ID	Class I Area Name	State	IMPROVE Site ID	Natural Conditions 20% Most Impaired Days (dv)	Default Adjusted Natural Conditions 20% Most Impaired Days (dv)	Observed 00-04 Baseline 20% Most Impaired Days (dv)	Observed 09-13 Impairment 20% Most Impaired Days (dv)	Projected 2028 Impairment 20% Most Impaired Days (dv)	2028 Unadjusted Glidepath 20% Most Impaired Days (dv)	2028 Default Adjusted Glidepath 20% Most Impaired Days (dv)
SIPS	Sipsey Wilderness	AL	SIPS1	9.55	11.35	27.71	21.67	16.62	20.45	21.16
CACR	Caney Creek Wilderness	AR	CACR1	9.47	11.21	23.99	20.87	18.32	18.18	18.88
UPBU	Upper Buffalo Wilderness	AR	UPBU1	9.43	11.84	24.25	20.52	17.82	18.32	19.29
GRSA	Great Sand Dunes NM	CO	GRSA1	4.45	6.57	9.66	8.78	8.29	7.58	8.42
MOZI	Mount Zirkel Wilderness	CO	MOZI1	3.16	5.26	7.29	6.05	5.49	5.64	6.48
RAWA	Rawah Wilderness	CO	MOZI1	3.16	5.26	7.29	6.05	5.49	5.64	6.48
ROMO	Rocky Mountain NP	CO	ROMO1	4.93	6.87	11.12	9.21	8.39	8.64	9.42
CHAS	Chassahowitzka	FL	CHAS1	8.97	11.40	24.62	19.96	16.79	18.36	19.27
EVER	Everglades NP	FL	EVER1	8.34	11.25	19.54	16.30	15.52	15.06	16.22
SAMA	St. Marks	FL	SAMA1	9.19	11.49	24.30	20.11	16.43	18.26	19.36
COHU	Cohutta Wilderness	GA	COHU1	9.52	11.55	28.85	21.19	14.90	21.12	22.09
OKEF	Okefenokee	GA	OKEF1	9.47	12.41	25.34	20.70	16.90	18.99	20.17
WOLF	Wolf Island	GA	OKEF1	9.47	12.41	25.34	20.70	16.75	18.99	20.17
MACA	Mammoth Cave NP	KY	MACA1	9.79	12.11	29.83	24.04	19.27	21.81	22.74
BRET2	Breton Wilderness	LA	BRIS1	9.28	12.71			18.39		20.03
ACAD	Acadia NP	ME	ACAD1	10.39	13.10	22.01	16.84	14.67	17.36	18.45
MOOS	Moosehorn	ME	MOOS1	9.97	13.42	20.66	15.80	14.14	16.38	17.76

Table 4-1. Natural and Default-Adjusted Natural Conditions, 2000-2004 Baseline Visibility, Observed 2009-2013 Visibility, 2028 Projected Visibility, 2028 Unadjusted and Default-Adjusted Glidepath Values for the 20% Most Anthropogenically Impaired Days.

Class I Area ID	Class I Area Name	State	IMPROVE Site ID	Natural Conditions 20% Most Impaired Days (dv)	Default Adjusted Natural Conditions 20% Most Impaired Days (dv)	Observed 00-04 Baseline 20% Most Impaired Days (dv)	Observed 09-13 Impairment 20% Most Impaired Days (dv)	Projected 2028 Impairment 20% Most Impaired Days (dv)	2028 Unadjusted Glidepath 20% Most Impaired Days (dv)	2028 Default Adjusted Glidepath 20% Most Impaired Days (dv)
ROCA	Roosevelt Campobello International Park	ME	MOOS1	9.97	13.42	20.66	15.80	14.14	16.38	17.76
ISLE	Isle Royale NP	MI	ISLE1	10.15	12.99	19.53	17.63	15.12	15.78	16.91
SENE	Seney	MI	SENE1	11.11	14.07	23.62	19.84	16.87	18.62	19.80
BOWA	Boundary Waters Canoe Area	MN	BOWA1	9.11	12.12	18.95	16.43	13.99	15.01	15.83
HEGL	Hercules-Glades Wilderness	MO	HEGL1	9.30	11.32	25.17	21.63	18.80	18.82	19.63
MING	Mingo	MO	MING1	9.28	11.09	26.60	22.59	19.69	19.67	20.22
MELA	Medicine Lake	MT	MELA1	5.95	13.21	16.63	16.59	15.79	12.36	15.26
ULBE	UL Bend	MT	ULBE1	5.87	11.79	12.76	11.90	11.37	10.00	12.37
LIGO	Linville Gorge Wilderness	NC	LIGO1	9.70	11.14	28.05	20.39	14.25	20.71	21.29
SHRO	Shining Rock	NC	SHRO1	9.70	11.78	28.05	19.05	13.31	20.71	21.50
SWAN	Swanquarter	NC	SWAN1	9.79	11.44	24.40	19.76	15.27	18.56	18.80
THRO	Theodore Roosevelt NP	ND	THRO1	5.96	10.56	16.35	15.71	14.67	12.19	14.04
GRGU	Great Gulf Wilderness	NH	GRGU1	9.78	12.66	21.93	15.43	12.30	17.07	18.22
PRRA	Presidential Range-Dry River Wilderness	NH	GRGU1	9.78	12.66	21.93	15.43	12.30	17.07	18.22
BRIG	Brigantine	NJ	BRIG1	10.69	12.72	27.43	22.20	18.40	20.73	21.55
BAND	Bandelier NM	NM	BAND1	4.59	6.73	9.70	9.17	8.96	7.66	8.51
BOAP	Bosque del Apache	NM	BOAP1	5.36	7.52	11.61	11.19	10.96	9.11	9.97

Table 4-1. Natural and Default-Adjusted Natural Conditions, 2000-2004 Baseline Visibility, Observed 2009-2013 Visibility, 2028 Projected Visibility, 2028 Unadjusted and Default-Adjusted Glidepath Values for the 20% Most Anthropogenically Impaired Days.

Class I Area ID	Class I Area Name	State	IMPROVE Site ID	Natural Conditions 20% Most Impaired Days (dv)	Default Adjusted Natural Conditions 20% Most Impaired Days (dv)	Observed 00-04 Baseline 20% Most Impaired Days (dv)	Observed 09-13 Impairment 20% Most Impaired Days (dv)	Projected 2028 Impairment 20% Most Impaired Days (dv)	2028 Unadjusted Glidepath 20% Most Impaired Days (dv)	2028 Default Adjusted Glidepath 20% Most Impaired Days (dv)
PECO	Pecos Wilderness	NM	WHPE1	3.53		7.35	6.96	6.57	5.82	
SACR	Salt Creek	NM	SACR1	5.50	9.69	16.54	15.26	15.00	12.12	13.80
SAPE	San Pedro Parks Wilderness	NM	SAPE1	3.36	5.61	7.66	6.81	6.52	5.94	6.84
WHIT	White Mountain Wilderness	NM	WHIT1	4.89	8.53	11.31	10.58	10.14	8.74	10.20
WHPE	Wheeler Peak Wilderness	NM	WHPE1	3.53		7.35	6.96	6.57	5.82	
WIMO	Wichita Mountains	OK	WIMO1	6.92	10.19	22.15	20.32	18.10	16.06	17.36
ROMA	Cape Romain	SC	ROMA1	9.79	11.89	25.25	21.48	16.64	19.07	19.91
BADL	Badlands NP	SD	BADL1	6.09	9.67	14.98	14.33	12.95	11.42	12.86
WICA	Wind Cave NP	SD	WICA1	5.64	8.38	13.09	12.31	11.20	10.11	11.21
GRSM	Great Smoky Mountains NP	TN	GRSM1	10.05	11.68	29.16	21.39	15.03	21.52	22.17
JOYC	Joyce-Kilmer-Slickrock Wilderness	TN	GRSM1	10.05	11.68	29.16	21.39	14.88	21.52	22.17
BIBE	Big Bend NP	TX	BIBE1	5.33	12.34	15.57	14.37	13.94	11.47	14.28
CAVE	Carlsbad Caverns NP	TX	GUMO1	4.83	10.57	14.60	12.81	12.07	10.69	12.99
GUMO	Guadalupe Mountains NP	TX	GUMO1	4.83	10.57	14.60	12.81	12.07	10.69	12.99
JARI	James River Face Wilderness	VA	JARI1	9.48	11.25	28.08	21.37	15.87	20.64	21.35
SHEN	Shenandoah NP	VA	SHEN1	9.52	11.19	28.32	20.72	14.47	20.80	21.47

Table 4-1. Natural and Default-Adjusted Natural Conditions, 2000-2004 Baseline Visibility, Observed 2009-2013 Visibility, 2028 Projected Visibility, 2028 Unadjusted and Default-Adjusted Glidepath Values for the 20% Most Anthropogenically Impaired Days.

Class I Area ID	Class I Area Name	State	IMPROVE Site ID	Natural Conditions 20% Most Impaired Days (dv)	Default Adjusted Natural Conditions 20% Most Impaired Days (dv)	Observed 00-04 Baseline 20% Most Impaired Days (dv)	Observed 09-13 Impairment 20% Most Impaired Days (dv)	Projected 2028 Impairment 20% Most Impaired Days (dv)	2028 Unadjusted Glidepath 20% Most Impaired Days (dv)	2028 Default Adjusted Glidepath 20% Most Impaired Days (dv)
LYBR2	Lye Brook Wilderness	VT	LYEB1		12.78			14.14		19.25
DOSO	Dolly Sods Wilderness	WV	DOSO1	8.92	10.78	28.29	21.59	15.29	20.54	21.29
OTCR	Otter Creek Wilderness	WV	DOSO1	8.92	10.78	28.29	21.59	15.26	20.54	21.29

The 2028 future year projected deciview values can be compared to the unadjusted glidepath for 2028. While the RHR requires future year projected visibility impairment be compared to the glidepath, it does not require the RPGs be on or below the glidepath. However, the rule has different requirements depending on whether the projected value (RPG) is above or below the glidepath.[17]

Figure 4-1 shows the difference between the 2028 projected visibility impairment (in deciviews at each IMPROVE site on the I20% days) and the 2028 unadjusted glidepath (2028 projected minus 2028 unadjusted glidepath). Negative values are below the unadjusted glidepath and positive values are above the unadjusted glidepath.

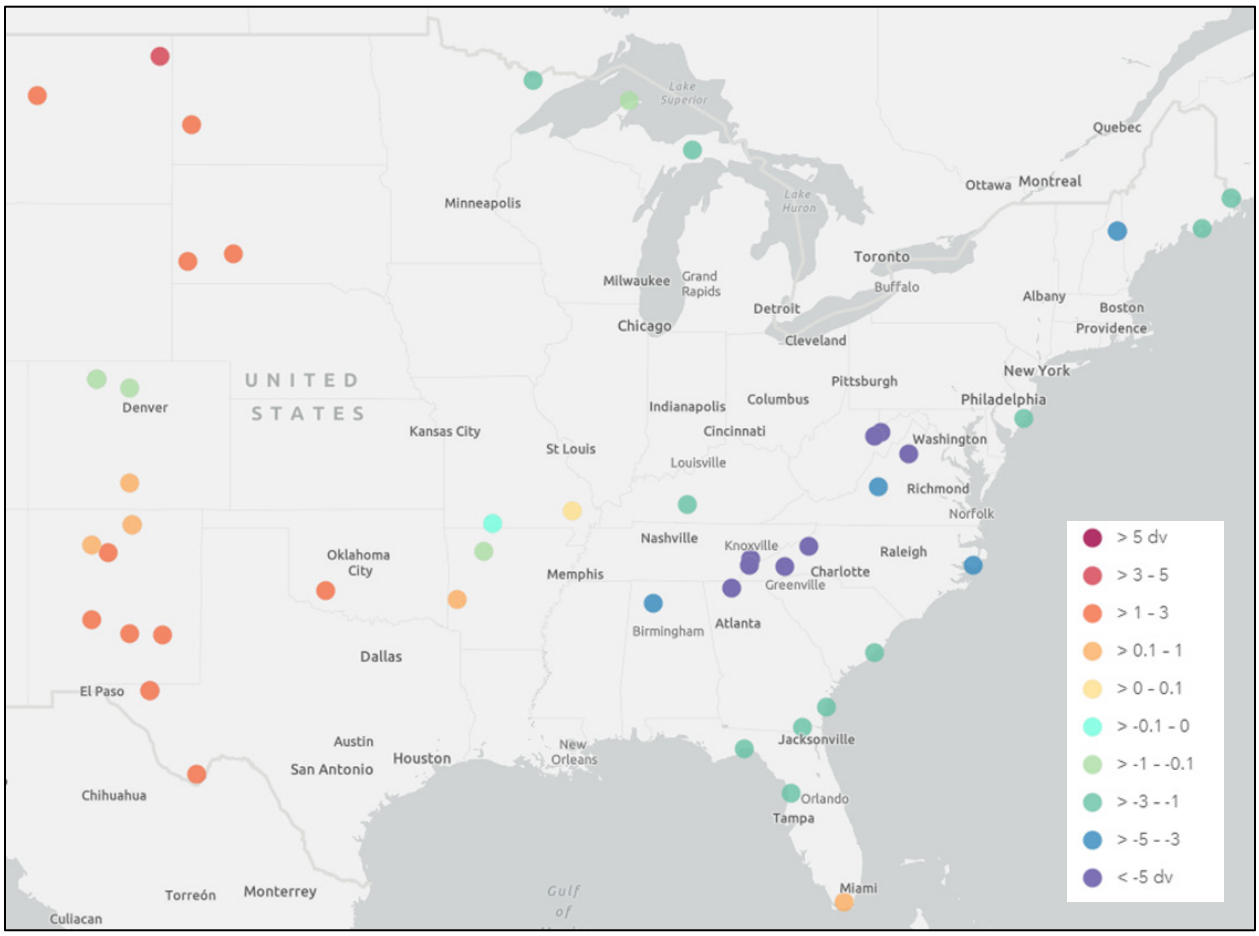


Figure 4-1. Map of Deviations from the 2028 Unadjusted Glidepath at IMPROVE Sites in the VISTAS 12 Domain.

[17] See 40 CFR 51.308(f)(3)(ii) and (iii)

There are two major features that can be seen in Figure 4-1. First, all Class I areas in the VISTAS states, except for Everglades, are significantly below the unadjusted glidepath. Second, the majority of Class I areas west of the Mississippi River are above the unadjusted glidepath.

5.0 $PM_{2.5}$ COMPOSITION AND CONTRIBUTIONS TO LIGHT EXTINCTION

Day-by-day stacked bar charts detailing the composition of $PM_{2.5}$ on each of the 20% clearest and 20% most impaired days for both 2011 and 2028 modeled concentration ($\mu g/m^3$) and light extinction (Mm^{-1}) were developed for each IMPROVE monitoring site in the VISTAS_12 modeling domain. These plots display the amount of total particle mass using concentrations of coarse mass, crustal (soil), ammonium nitrate, ammonium sulfate, elemental carbon (EC), organic mass carbon (OM), and sea salt. Charts for each of the VISTAS_12 modeling domain's Class I areas can be generated using the provided Excel file titled "APP_A_ag_v6_40.2028elv5.vistas_12_SESARM (4 Sept 2020).xlsx" in Appendix A.

Figure 5-1 below presents the daily mass budgets for each of the 20% clearest (top) and 20% most anthropogenically impaired (bottom) days at the Great Smoky Mountains National Park. Values identified as "2011 Mod" represent the 2011 modeled concentrations and values identified as "2028 Mod" represent the 2028 modeled concentrations. The amount of light extinction due to each species is displayed in Figure 5-2 below. Rayleigh scattering in the extinction plots is site specific Rayleigh scattering for that site, which does not vary by day (not modeled or observed).

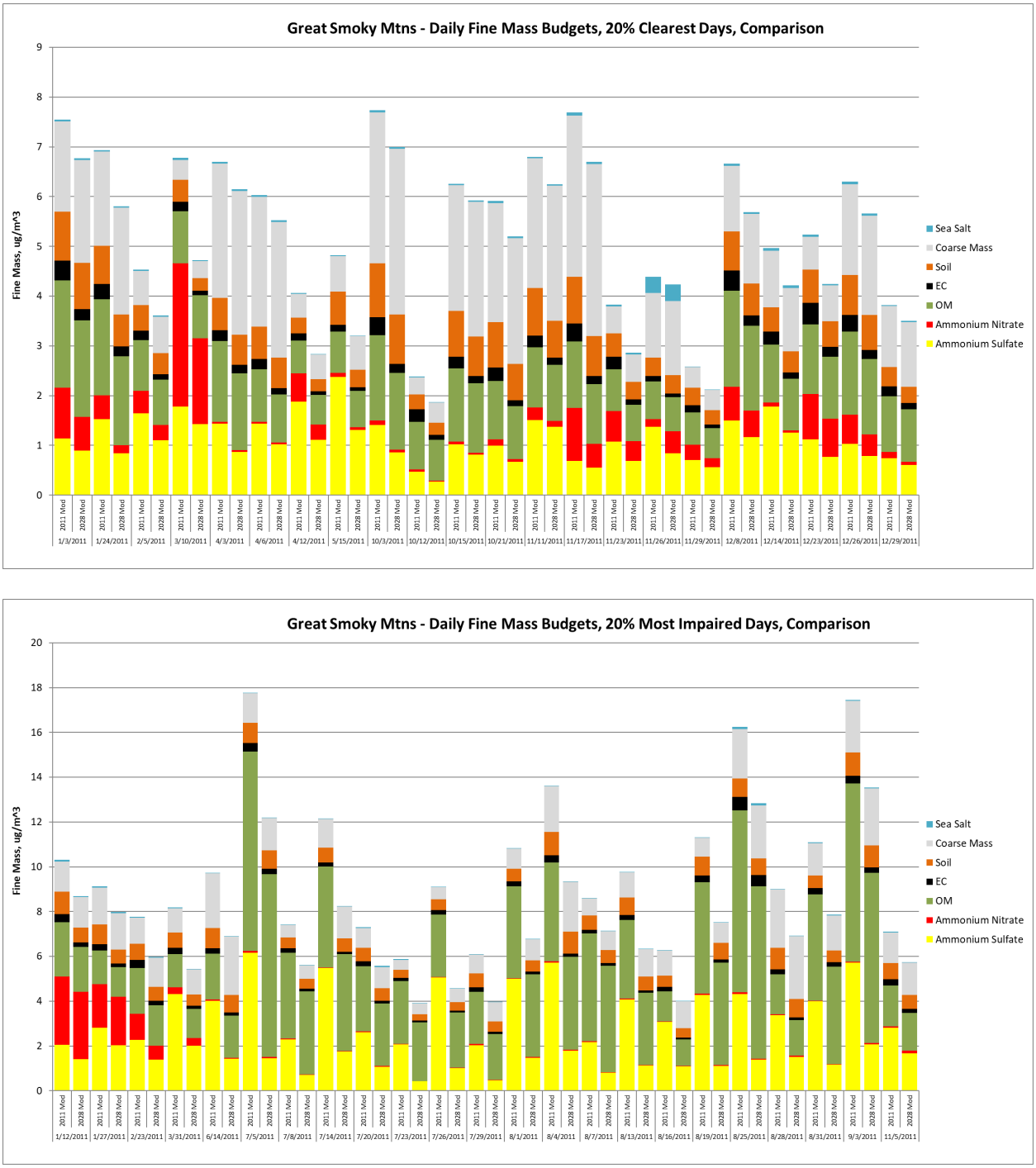


Figure 5-1. Predicted (CAMx) Concentrations (µg/m^3) Great Smoky Mountains National Park on the Modeled 20% Clearest (Top) and 20% Most Anthropogenically Impaired (Bottom) Days.

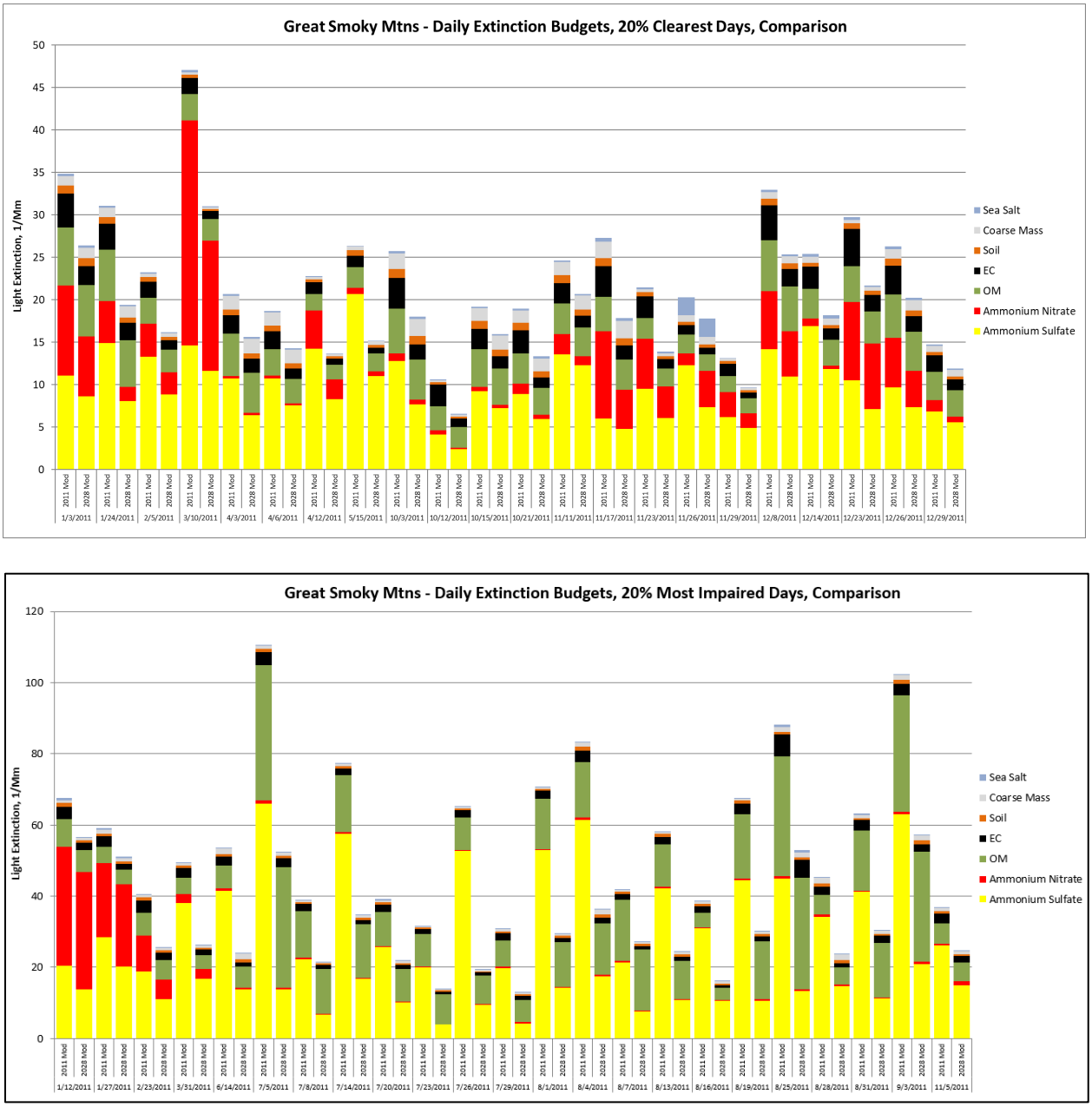


Figure 5-2. Predicted (CAMx) Light Extinctions (Mm^{-1}) Great Smoky Mountains National Park on the Modeled 20% Clearest (Top) and 20% Most Anthropogenically Impaired (Bottom) Days.

Average stacked bar charts detailing the composition of $PM_{2.5}$ on each of the 20% clearest and 20% most impaired days for both 2011 and 2028 SMAT concentration ($\mu g/m^3$) and light extinction (Mm^{-1}) were developed for each IMPROVE monitoring site in the VISTAS_12 modeling domain. These plots display the amount of total particle mass using concentrations of

coarse mass, crustal (soil), ammonium nitrate, ammonium sulfate, elemental carbon (EC), organic mass carbon (OM), and sea salt. Charts for each of the VISTAS_12 modeling domain's Class I areas can be generated using the provided Excel file titled "StackedBarCharts.xlsx" in Appendix B.

Figure 5-3 below presents the average mass budgets for the 20% clearest (right) and 20% most anthropogenically impaired (left) days at the Great Smoky Mountains National Park. Values identified as "2011 SMAT" represent the 2009-2013 average observed concentrations and values identified as "2028 SMAT" represent the 2028 SMAT output concentrations. The amount of light extinction due to each species is displayed in Figure 5-4 below. Rayleigh scattering in the extinction plots is site specific Rayleigh scattering for that site, which does not vary by day (not modeled or observed).

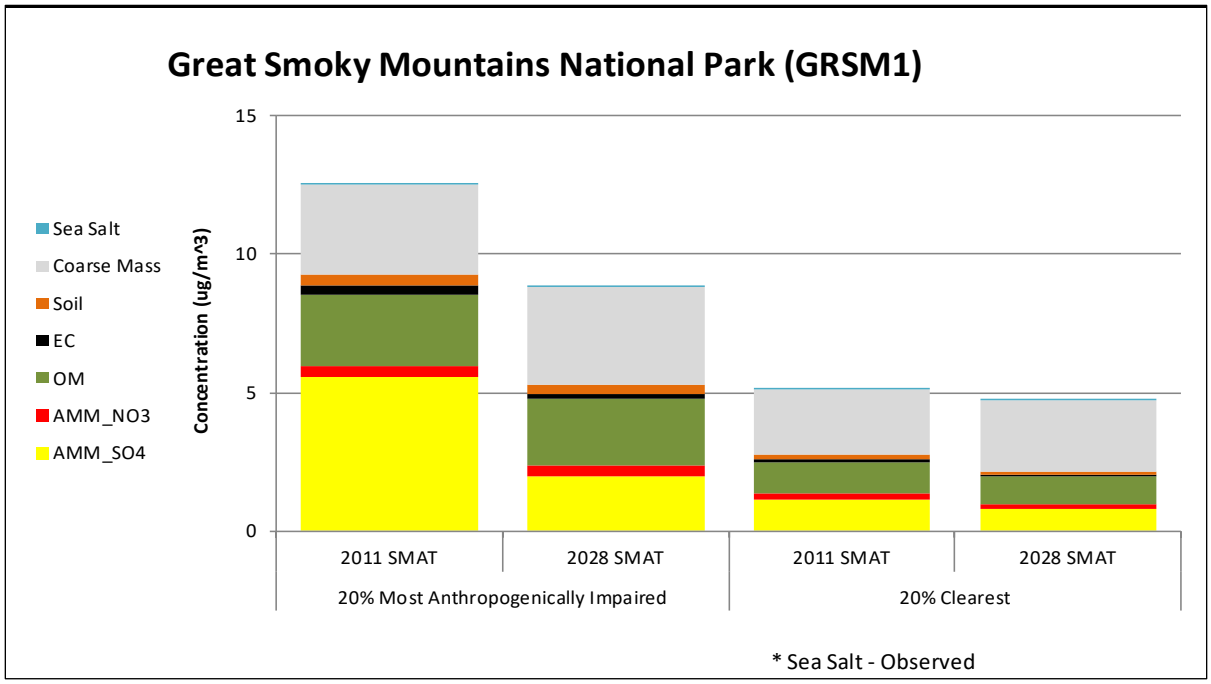


Figure 5-3. SMAT Concentrations (µg/m^3) Great Smoky Mountains National Park on the Modeled 20% Clearest (Right) and 20% Most Anthropogenically Impaired (Left) Days.

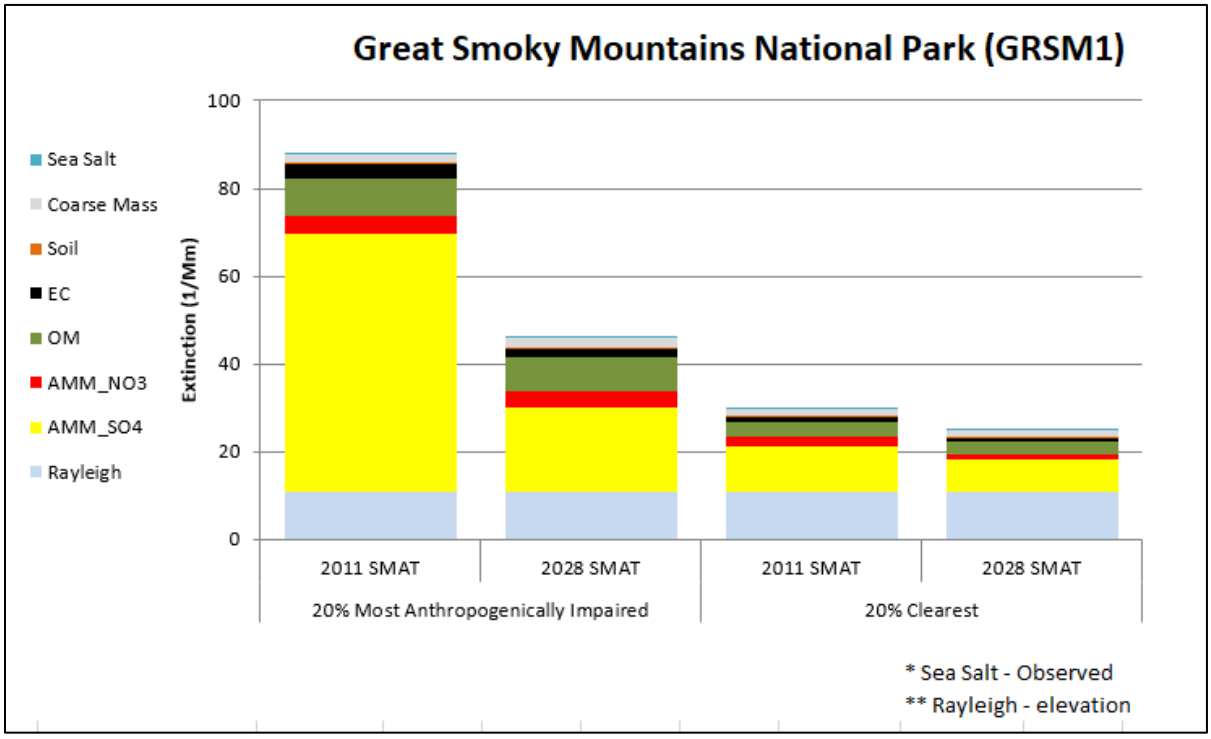


Figure 5-4. SMAT Light Extinctions (Mm-1) Great Smoky Mountains National Park on the Modeled 20% Clearest (Right) and 20% Most Anthropogenically Impaired (Left) Days.

6.0 REGIONAL HAZE SITE SUMMARIES

Figure 6-1 provides an example of relevant observational and modeling data available at each IMPROVE station in the VISTAS_12 modeling domain. Charts for each of the VISTAS_12 modeling domain's Class I areas can be generated by the provided Excel file titled "APP_C_SESARM_2028elv5_URP_20200903.xlsx" in Appendix C.

- The 2009-2013 observed annual average visibility (deciviews) and light extinction values (Mm^{-1}) on the 20% most impaired days are shown as (up to 5) black dots and (for comparison) additional recent observations for 2014-2017 are shown as green dots.
- The red diamonds represent the modeled 2011 (left) and 2028 (right) visibility or light extinction values on the 20% most anthropogenically impaired days.
- The dashed blue line and the dashed orange line represent different versions of the URP glidepath.
- The dashed blue line (Glidepath) is the unadjusted glidepath that runs from the 2000-2004 baseline value to natural conditions in 2064.
- The dashed orange line (Adj Glidepath) is the default adjusted glidepath that runs from the 2000-2004 baseline value to the default adjusted 2064 endpoint.
- The short solid blue line on the right side of the plot represents the unadjusted 2064 endpoint (ambient natural conditions).

- The short solid orange line on the right side of the plot represents the default adjusted 2064 endpoint.

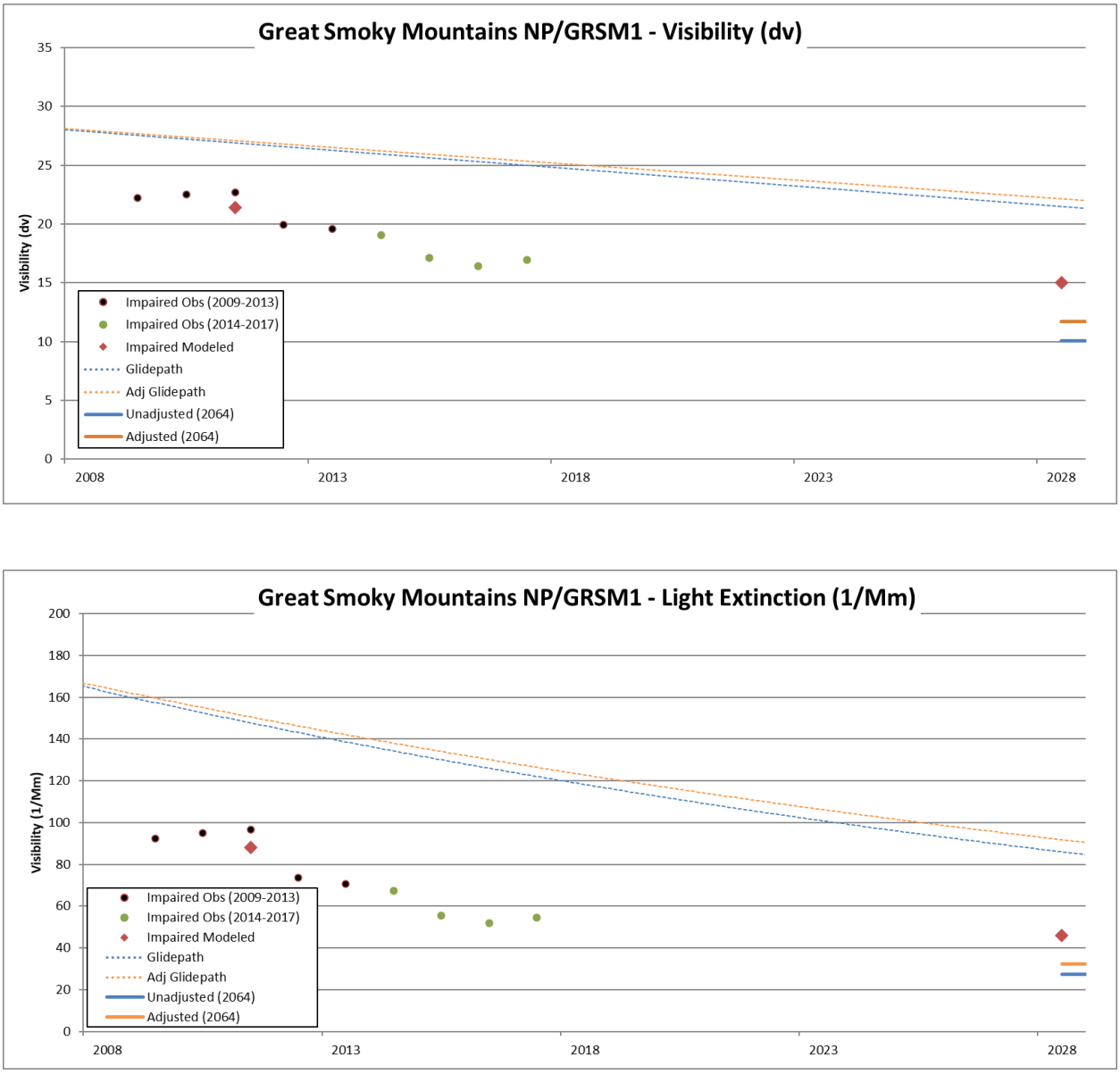


Figure 6-1. 2009-2017 IMPROVE Observations, 2011 and 2028 CAMx Model Predictions, and Unadjusted and Default-Adjusted Glidepaths for Visibility (Top) and Light Extinction (Bottom) at GRSM1.

Appendix A.

Daily Mass Concentration and Light Extinction Stacked Bar Charts for Each Class I Area

(see "APP_A_ag_v6_40.2028elv5.vistas_12_SESARM (4 Sept 2020).xlsx")

This page is intentionally left blank.

Appendix B.

Uniform Rate of Progress Graphs for Each Class I Area

(see "APP_B_StackedBarCharts.xlsx")

This page is intentionally left blank.

Appendix C.

Uniform Rate of Progress Graphs for Each Class I Area

(see "APP_C_SESARM_2028elv5_URP_20200903.xlsx")

This page is intentionally left blank.

Appendix E-7a

Particulate Source Apportionment Technology Modeling Results

This page intentionally left blank.

Particulate Source Apportionment Technology Modeling Results Task 7

Prepared for:
Southeastern States Air Resource Managers, Inc.
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

and

Eastern Research Group, Inc.
1600 Perimeter Park Dr., Suite 200
Morrisville, NC 27560

Final – August 31, 2020

Alpine Project Number: TS-527
ERG Project Number: 4133.00.006

This page is intentionally blank.

Contents

Page

1.0 Introduction 1

2.0 PSAT Overview 2

3.0 PSAT Tags 3

4.0 PSAT Post-Processing 13

5.0 Process for Creating PSAT Contributions for Class I Areas 13

6.0 Sector Tag Results 15
- 6.1 Area By Sector 15
- 6.2 Sector to Area 16
- 6.3 Facility to Area 17
- 6.4 Stacked Bar S and N by Area 17
- 6.5 Region Sector to Area 19
- 6.6 Boundary to Area 19

7.0 PSAT DAY-to-Day Analysis 20

Attachment A – PSAT Tagging Results
Attachment B – Day-By-Day Results

TABLES

Table 3-1. Round 1 SESARM Defined Regional-Category Combination Tags 4

Table 3-2. Round 1 SESARM-Defined Individual Facility Tags 6

Table 3-3. Round 2 SESARM Defined Regional-Category Combination Tags 9

Table 3-4. Round 2 SESARM-Defined Individual Facility Tags 11

Table 4-1. Matching of CAMx Raw Output Species to SMAT Input Variables 13

Table 5-1. Matching of "Bulk Raw Species", PSAT Output Species, and SMAT Input Variables 14

FIGURES

Figure 6-1. Area by Sector PivotChart and Table Example 15

Figure 6-2. Sector to Area PivotChart and Table Example 16

Figure 6-3. Facility to Area PivotChart and Table Example 17

Figure 6-4. Stacked Bar S and N by Area PivotChart and Table Example 18

Figure 6-5. Region Sector to Area PivotChart Example 19

Figure 6-6. Boundary to Area PivotChart Example.....20
Figure 7-1. 2028 Modeled Light Extinction Impairment at Wolf Island on 20% Clearest Days..21
Figure 7-2. 2028 Modeled Light Extinction Impairment at Wolf Island on 20% Most Impaired Days.....22

Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
AOI	Area of Influence
b_{ext}	Beta (or light) extinction
CAMx	Comprehensive Air Quality Model with Extensions
CCRS	Coarse PM species (CAMx PM species)
CenRAP	Central Regional Air Planning
CPRM	Coarse PM
EGU	Electric Generating Unit
EPA	United States Environmental Protection Agency
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee
EWRT	Extinction Weighted Residence Time
FCRS	Crustal fraction of PM
FPRM	Fine Other Primary (diameter ≤2.5 µm)
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
HgP	Particulate mercury
IMPROVE	Interagency
LADCO	Lake Michigan Air Directors Consortium
MANE-VU	Mid-Atlantic and Northeast Visibility Union
MARAMA	Mid-Atlantic Regional Air Management Association, Inc.
Mm-1	Inverse Megameters
Na^+	Sodium ion
NO_x	Oxides of nitrogen
PCL	Chorine
PEC	Primary elemental carbon
PM	Particulate Matter
$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PNH4	Ammonium
PNO3	Particulate nitrate
POA	Primary organic carbon
PSAT	Particulate Source Apportionment Technology
PSO4	Sulfate
RHR	Regional Haze Rule
RPO	Regional Planning Organization
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plan
SMAT	Software for Model Attainment Test
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOA	Secondary Organic Aerosol
tpy	Tons per year
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast
WRAP	Western Regional Air Partnership

This page is intentionally blank.

1.0 INTRODUCTION

Southeastern States Air Resource Managers, Inc. (SESARM) has been designated by the United States Environmental Protection Agency (EPA) as the entity responsible for coordinating regional haze evaluations for the ten Southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS analyses will support the VISTAS states in their responsibility to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The state and local air pollution control agencies in the Southeast are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including the evaluation, development, adoption, and implementation of strategies controlling and managing all criteria air pollutants including fine particles and ozone as well as regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region. The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and incrementally improve visibility to natural conditions by 2064. The original RHR required states to improve visibility on the 20% most impaired days and protect visibility on the 20% least impaired days.[1] The RHR

[1] RHR summary data is available at: http://vista.cira.colostate.edu/Improve/rhr-summary-data/

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

This report documents the steps taken by Alpine Geophysics, LLC (Alpine) in developing Particulate Source Apportionment Technology (PSAT) modeling results, which was completed under Task 7 of VISTAS Contract No. V-2018-03-01, entitled "Southeast VISTAS II Regional Haze Analysis Project". Under this contract, SESARM exercised the option of increasing PSAT tags from the base of 150 tags to up to 250 tags. A "tag" can be identified as a specific source, or group of sources. Sources of interest are for those emitting sulfur dioxide (SO_2) and/or oxides of nitrogen (NO_x).

2.0 PSAT OVERVIEW

In order to gain a better understanding of the source contributions to modeled visibility, Alpine used the CAMx PSAT modeling.[2] PSAT uses multiple tracer families to track the fate of both primary and secondary PM. PSAT is designed to apportion the following classes of CAMx PM species:

- Sulfate (PSO4)
- Particulate nitrate (PNO3)
- Ammonium (PNH4)
- Secondary organic aerosol (SOA)
- Primary PM (PEC, POA, FCRS, FPRM, CCRS, and CPRM)
- Particulate mercury (HgP)

PSAT allows emissions to be tracked (tagged) by various combinations of sectors and geographic areas (e.g., by state). For this application, 2028elv3 emissions were tagged per configuration provided by SESARM.[3]

Although an update of the 2028 emissions was completed in March 2020, the PSAT modeling was not rerun.

[2] More information on CAMx modeling can be found at: http://www.camx.com/home.aspx

[3] The 2028elv3 emissions were completed in August 2018, and is summarized in the Task 2 Report entitled "Southeastern VISTAS II Regional Haze Analysis Project – Task 2A: Emission Inventory Updates Report for Area Of Influence and Point Source Apportionment Tagging. August 2020."

3.0 PSAT TAGS

SESARM worked with its stakeholders and surrounding regional planning organizations (RPOs) within the VISTAS modeling domain to compile a list of tags for PSAT analysis. The starting point for identifying tags were the results of Task 5, Area of Influence (AOI) Analysis.[4] Under Task 5, Class I-specific workbooks within the VISTAS modeling domain were created from combining Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) back trajectories, NO_x and SO_2 emissions inventories (facility-level and county-level),[5] and extinction weighted residence time (EWRT) values of nitrate and sulfate to calculate relative contributions of facility-level sources and source category sectors (e.g., point, onroad, nonroad, nonpoint, and fires).

Each tag identified was chosen to inform SESARM and its stakeholders on sources or groups of sources that are likely affecting visibility in the SESARM states, warranting further understanding of their contributions.

Additionally, the following RPOs were asked to provide comment on potential tags for its member states within the VISTAS modeling domain:

- The Central States Regional Air Partnership (CENRAP);
- The Mid-Atlantic and Northeast Visibility Union (MANE-VU);
- The Lake Michigan Air Directors Consortium (LADCO); and
- The Western Regional Air Partnership (WRAP).

As a result of this consultation, two rounds of PSAT tagging for SO_2 and NO_x emissions were conducted. Round 1 is presented in Table 3-1 for groups of sources (70 tags) and Table 3-2 for individual facilities (55 tags).[6] Each of these emissions sources or source sectors were processed through Sparse Matrix Operating Kernal Emissions (SMOKE) software and tracked in

[4] The steps for developing the AOI analysis are documented in the report entitled "Area of Influence Analysis, Southeastern VISTAS II Regional Haze Analysis Project – Documentation Report for Task 5." December 2019.

[5] Due to additional state review and updates from sources within the VISTAS modeling domain, the AOI analyses included updated emissions and/or facility/unit-closures beyond what is described in Task 2. These updates are captured in the Task 5 report.

[6] Officially SESARM requested 54 PSAT facility tags for Round 1. However, PSAT facility tagged results were conducted for McGhee Tyson Airport (AOI Facility ID = 47009-9159211, PSAT Tag ID = 034) based on the initial list of PSAT tags for Round 1. This source was officially removed from the PSAT tagging list on a June 1, 2019 e-mail from Mr. John Hornback, SESARM to Mr. Regi Oommen, ERG.

PSAT as individual source tags. For this application, only sulfate and nitrate were tracked using PSAT.

Table 3-1. Round 1 SESARM Defined Regional-Category Combination Tags

Tag Name	Tagging Description
Alabama – All NOX	Total NO_x emissions from Alabama
Alabama – All SO2	Total SO_2 emissions from Alabama
Florida – All NOX	Total NO_x emissions from Florida
Florida – All SO2	Total SO_2 emissions from Florida
Georgia – All NOX	Total NO_x emissions from Georgia
Georgia – All SO2	Total SO_2 emissions from Georgia
Kentucky – All NOX	Total NO_x emissions from Kentucky
Kentucky – All SO2	Total SO_2 emissions from Kentucky
Mississippi – All NOX	Total NO_x emissions from Mississippi
Mississippi – All SO2	Total SO_2 emissions from Mississippi
North Carolina – All NOX	Total NO_x emissions from North Carolina
North Carolina – All SO2	Total SO_2 emissions from North Carolina
South Carolina – All NOX	Total NO_x emissions from South Carolina
South Carolina – All SO2	Total SO_2 emissions from South Carolina
Tennessee – All NOX	Total NO_x emissions from Tennessee
Tennessee – All SO2	Total SO_2 emissions from Tennessee
Virginia – All NOX	Total NO_x emissions from Virginia
Virginia – All SO2	Total SO_2 emissions from Virginia
West Virginia – All NOX	Total NO_x emissions from West Virginia
West Virginia – All SO2	Total SO_2 emissions from West Virginia
CENRAP – All NOX	Total NO_x emissions from the CENRAP region
CENRAP – All SO2	Total SO_2 emissions from the CENRAP region
MANE-VU – All NOX	Total NO_x emissions from the MANE-VU region
MANE-VU – All SO2	Total SO_2 emissions from the MANE-VU region
LADCO – All NOX	Total NO_x emissions from the LADCO region
LADCO – All SO2	Total SO_2 emissions from the LADCO region
Alabama – Point EGU NOX	Total Point NO_x EGU emissions from Alabama
Alabama – Point EGU SO2	Total Point SO_2 EGU emissions from Alabama
Florida – Point EGU NOX	Total Point NO_x EGU emissions from Florida
Florida – Point EGU SO2	Total Point SO_2 EGU emissions from Florida
Georgia – Point EGU NOX	Total Point NO_x EGU emissions from Georgia
Georgia – Point EGU SO2	Total Point SO_2 EGU emissions from Georgia
Kentucky – Point EGU NOX	Total Point NO_x EGU emissions from Kentucky
Kentucky – Point EGU SO2	Total Point SO_2 EGU emissions from Kentucky
Mississippi – Point EGU NOX	Total Point NO_x EGU emissions from Mississippi

Table 3-1. Round 1 SESARM Defined Regional-Category Combination Tags

Tag Name	Tagging Description
Mississippi – Point EGU SO2	Total Point SO_2 EGU emissions from Mississippi
North Carolina – Point EGU NOX	Total Point NO_x EGU emissions from North Carolina
North Carolina – Point EGU SO2	Total Point SO_2 EGU emissions from North Carolina
South Carolina – Point EGU NOX	Total Point NO_x EGU emissions from South Carolina
South Carolina – Point EGU SO2	Total Point SO_2 EGU emissions from South Carolina
Tennessee – Point EGU NOX	Total Point NO_x EGU emissions from Tennessee
Tennessee – Point EGU SO2	Total Point SO_2 EGU emissions from Tennessee
Virginia – Point EGU NOX	Total Point NO_x EGU emissions from Virginia
Virginia – Point EGU SO2	Total Point SO_2 EGU emissions from Virginia
West Virginia – Point EGU NOX	Total Point NO_x EGU emissions from West Virginia
West Virginia – Point EGU SO2	Total Point SO_2 EGU emissions from West Virginia
CENRAP – Point EGU NOX	Total Point NO_x EGU emissions from the CENRAP region
CENRAP – Point EGU SO2	Total Point SO_2 EGU emissions from the CENRAP region
MANE-VU – Point EGU NOX	Total Point NO_x EGU emissions from the MANE-VU region
MANE-VU – Point EGU SO2	Total Point SO_2 EGU emissions from the MANE-VU region
LADCO – Point EGU NOX	Total Point NO_x EGU emissions from the LADCO region
LADCO – Point EGU SO2	Total Point SO_2 EGU emissions from the LADCO region

Table 3-2. Round 1 SESARM-Defined Individual Facility Tags

Requesting State	Area of Influence Facility ID	Facility Name	PSAT Tag ID[a]	Facility State	SO_2 Emissions (tpy)	NOx Emissions (tpy)
AL/FL	01053-7440211	Escambia Operating Company LLC	001	AL	18,974	349
AL	01053-985111	Escambia Operating Company LLC	002	AL	8,590	150
AL	01073-1018711	Drummond Company, Inc.	003	AL	2,562	1,229
AL	01097-1056111	Ala Power – Barry	004	AL	6,026	2,182
AL	01097-1061611	Union Oil of California – Chunchula Gas Plant	005	AL	2,573	349
AL	01097-949811	Akzo Nobel Chemicals Inc.	006	AL	3,336	21
AL	01103-1000011	Nucor Steel Decatur LLC	007	AL	170	331
AL	01109-985711	Sanders Lead Co	008	AL	7,951	122
FL	12005-535411	Rocktenn CP LLC	009	FL	2,591	1,405
FL	12017-640611	Duke Energy Florida, Inc. (Def)	010	FL	5,306	2,490
FL	12031-640211	JEA	011	FL	2,094	652
FL/GA	12033-752711	Gulf Power – Crist	012	FL	2,616	2,998
FL	12047-769711	White Springs Agricultural Chemicals, Inc.	013	FL	3,198	112
FL/GA	12057-538611	Tampa Electric Company (Tec)	014	FL	6,085	2,665
FL	12057-716411	Mosaic Fertilizer, LLC	015	FL	3,034	160
FL	12089-753711	Rock Tenn CP, LLC	016	FL	2,607	2,317
FL	12089-845811	Rayonier Performance Fibers LLC	017	FL	2,327	562
FL	12105-717711	Mosaic Fertilizer LLC	018	FL	7,901	310
FL	12105-919811	Mosaic Fertilizer, LLC	019	FL	4,426	141
FL	12123-752411	Buckeye Florida, Limited Partnership	020	FL	1,520	1,831
GA/TN	13015-2813011	Ga Power Company – Plant Bowen	021	GA	10,453	6,643
GA	13051-3679811	International Paper – Savannah	022	GA	3,945	1,561
GA	13127-3721011	Brunswick Cellulose Inc.	023	GA	294	1,555
KY	21091-7352411	Century Aluminum of KY LLC	024	KY	5,044	198
AL	21145-6037011	Tennessee Valley Authority (TVA) – Shawnee Fossil Plant	025	KY	19,505	7,007

Table 3-2. Round 1 SESARM-Defined Individual Facility Tags

Requesting State	Area of Influence Facility ID	Facility Name	PSAT Tag ID[a]	Facility State	SO_2 Emissions (tpy)	NOx Emissions (tpy)
KY	21177-5196711	Tennessee Valley Authority – Paradise Fossil Plant	026	KY	2,990	2,927
AL/KY	21183-5561611	Big Rivers Electric Corp – Wilson Station	027	KY	6,934	1,152
NC	37013-8479311	PCS Phosphate Company, Inc. – Aurora	028	NC	4,846	496
NC	37087-7920511	Blue Ridge Paper Products – Canton Mill	029	NC	1,127	2,992
SC	45015-4834911	Alumax of South Carolina	030	SC	3,752	108
SC	45019-4973611	Kapstone Charleston Kraft LLC	031	SC	1,864	2,356
SC	45043-5698611	International Paper Georgetown Mill	032	SC	2,768	2,031
TN	47001-6196011	TVA Bull Run Fossil Plant	033	TN	623	964
TN	47009-9159211[b]	McGhee Tyson Airport	034	TN	79	595
TN	47093-4979911	Cemex – Knoxville Plant	035	TN	121	712
TN	47105-4129211	Tate & Lyle, Loudon	036	TN	473	883
TN	47145-4979111	TVA Kingston Fossil Plant	037	TN	1,886	1,687
AL/TN	47161-4979311	TVA Cumberland Fossil Plant	038	TN	8,427	4,917
TN	47163-3982311	Eastman Chemical Company	039	TN	6,420	6,900
VA	51023-5039811	Roanoke Cement Company	040	VA	2,290	1,973
VA	51027-4034811	Jewell Coke Company LLP	041	VA	5,091	520
VA	51580-5798711	Meadwestvaco Packaging Resource Group	042	VA	2,115	1,986
WV	54023-6257011	Dominion Resources, Inc. – Mount Storm Power Station	043	WV	2,124	1,984
WV	54033-6271711	Allegheny Energy Supply Co, LLC-Harrison	044	WV	10,083	11,831
WV	54041-6900311	Equitrans – Copley Run Cs 70	045	WV	<1	511
WV	54049-4864511	American Bituminous Power-Grant Town Plt.	046	WV	2,210	1,245
WV	54051-6902311	Mitchell Plant	047	WV	5,372	2,720
WV	54061-16320111	Longview Power	048	WV	2,314	1,557
WV	54061-6773611	Monongahela Power Co.- Fort Martin Power	049	WV	4,882	13,743
WV	54061-6773811	Morgantown Energy Associates	050	WV	829	656

Table 3-2. Round 1 SESARM-Defined Individual Facility Tags

Requesting State	Area of Influence Facility ID	Facility Name	PSAT Tag ID[a]	Facility State	SO_2 Emissions (tpy)	NOx Emissions (tpy)
WV	54073-4782811	Monongahela Power Co – Pleasants Power Station	051	WV	16,817	5,497
WV	54079-6789111	Appalachian Power Company – John E Amos Plant	052	WV	10,984	4,878
WV	54083-6790511	Glady 6c4350	053	WV	<1	343
WV	54083-6790711	Files Creek 6c4340	054	WV	<1	643
WV	54093-6327811	Kingsford Manufacturing Company	055	WV	17	141

[a] The PSAT ID tags match the "Facility to Area" spreadsheet tab in Attachment A.
[b] Please note that PSAT tagged results were conducted for McGhee Tysons Airport based on the initial list of PSAT tags for Round 1. This source was officially removed from the PSAT tagging list on a June 1, 2019 e-mail from Mr. John Hornback, SESARM to Mr. Regi Oommen, ERG.

For Round 2 of tagging, Table 3-3 presents tags for Regional Category combinations (34 tags) and Table 3-4 presents additional facilities (79 tags) for both SO_2 and NO_x emissions.

Table 3-3. Round 2 SESARM Defined Regional-Category Combination Tags

Tag Name	Tagging Description
East Boundary Conditions – All NOX	NO_x boundary conditions on the eastern boundary of the VISTAS modeling domain.
East Boundary Conditions – All SO2	SO_2 boundary conditions on the eastern boundary of the VISTAS modeling domain.
East Boundary Conditions – All NOX	NO_x boundary conditions on the eastern boundary of the VISTAS modeling domain.
East Boundary Conditions – All SO2	SO_2 boundary conditions on the eastern boundary of the VISTAS modeling domain.
East Boundary Conditions – All NOX	NO_x boundary conditions on the eastern boundary of the VISTAS modeling domain.
East Boundary Conditions – All SO2	SO_2 boundary conditions on the eastern boundary of the VISTAS modeling domain.
East Boundary Conditions – All NOX	NO_x boundary conditions on the eastern boundary of the VISTAS modeling domain.
East Boundary Conditions – All SO2	SO_2 boundary conditions on the eastern boundary of the VISTAS modeling domain.
Alabama – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from Alabama
Alabama – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from Alabama
Florida – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from Florida
Florida – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from Florida
Georgia – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from Georgia
Georgia – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from Georgia
Kentucky – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from Kentucky
Kentucky – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from Kentucky
Mississippi – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from Mississippi
Mississippi – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from Mississippi
North Carolina – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from North Carolina
North Carolina – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from North Carolina
South Carolina – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from South Carolina
South Carolina – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from South Carolina
Tennessee – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from Tennessee
Tennessee – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from Tennessee
Virginia – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from Virginia

Table 3-3. Round 2 SESARM Defined Regional-Category Combination Tags

Tag Name	Tagging Description
Virginia – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from Virginia
West Virginia – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from West Virginia
West Virginia – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from West Virginia
CENRAP – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from the CENRAP region
CENRAP – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from the CENRAP region
MANE-VU – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from the MANE-VU region
MANE-VU – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from the MANE-VU region
LADCO – Point Non-EGU NOX	Total Point NO_x Non-EGU emissions from the LADCO region
LADCO – Point Non-EGU SO2	Total Point SO_2 Non-EGU emissions from the LADCO region

Table 3-4. Round 2 SESARM-Defined Individual Facility Tags

Requesting State	Area of Influence Facility ID	Facility Name	PSAT Tag ID[a]	Facility State	SO_2 Emissions (tpy)	NOx Emissions (tpy)
AL	01129-1028711	American Midstream Chatom, LLC	073	AL	3,106	426
AL	05063-1083411	Entergy Arkansas Inc-Independence Plant	056	AR	32,050	1,4133
FL	12086-3532711	Homestead City Utilities	077	FL	0	97
FL	12086-899911	Tarmac America LLC	079	FL	9	880
FL	12086-900011	Florida Power & Light (PTF)	076	FL	13	171
FL	12086-900111	Cemex Construction Materials Fl. LLC.	075	FL	30	910
FL	12123-752411	Buckeye Florida, Limited Partnership	074	FL	1,520	1,831
FL	12129-2731711	Tallahassee City Purdom Generating Sta.	078	FL	3	121
GA	13103-536311	Georgia-Pacific Consumer Products LP (Savannah River Mill)	081	GA	1,860	352
GA	13115-539311	Temple Inland	082	GA	1,791	1,773
GA	13127-3721011	Brunswick Cellulose Inc.	080	GA	294	1,555
AL	17127-7808911	Joppa Steam	062	IL	20,509	4,706
AL/KY	18051-7363111	Gibson	064	IN	23,117	12,280
AL/KY	18125-7362411	Indianapolis Power & Light Petersburg	066	IN	18,142	10,665
KY	18129-8166111	Sigeco AB Brown South Indiana Gas & Ele	067	IN	7,645	1,579
KY, AL/KY/TN	18147-8017211	Indiana Michigan Power DBA AEP Rockport	065	IN	30,536	8,807
KY	18173-8183111	Alcoa Warrick Power Plt Agc Div of AL	063	IN	5,071	11,159
VA/WV	24001-7763811	Luke Paper Company	058	MD	9,876	3,607
MS	28059-6251011	Mississippi Power Company, Plant Victor J Daniel	084	MS	224	3,736
MS	28059-8384311	Chevron Products Company, Pascagoula Refinery	083	MS	742	1,534
AL	29143-5363811	New Madrid Power Plant-Marston	057	MO	16,784	4,394
NC	37013-8479311	PCS Phosphate Company, Inc. - Aurora	088	NC	4,846	496
NC	37023-8513011	SGL Carbon LLC	089	NC	262	22

Table 3-4. Round 2 SESARM-Defined Individual Facility Tags

Requesting State	Area of Influence Facility ID	Facility Name	PSAT Tag ID[a]	Facility State	SO_2 Emissions (tpy)	NOx Emissions (tpy)
NC	37035-8370411	Duke Energy Carolinas, LLC - Marshall Steam Station	087	NC	4,139	7,511
NC	37087-7920511	Blue Ridge Paper Products - Canton Mill	085	NC	1,127	2,992
NC	37117-8049311	Domtar Paper Company, LLC	086	NC	687	1,796
VA, TN	39025-8294311	Duke Energy Ohio, Wm. H. Zimmer Station (1413090154)	070	OH	22,134	7,150
VA	39031-8010811	Conesville Power Plant (0616000000)	069	OH	6,356	9,958
WV	39053-7983011	Ohio Valley Electric Corp., Kyger Creek Station (0627000003)	072	OH	3,400	9,144
WV, TN/VA/WV	39053-8148511	General James M. Gavin Power Plant (0627010056)	071	OH	41,596	8,123
WV	39081-8115711	Cardinal Power Plant (Cardinal Operating Company) (0641050002)	068	OH	7,461	2,467
VA	42005-3866111	Genon NE Mgmt Co/Keystone Sta	059	PA	56,939	6,578
VA	42063-3005111	NRG Wholesale Gen/Seward Gen Sta	061	PA	8,880	2,255
WV, VA/WV	42063-3005211	Homer City Gen LP/ Center Twp	060	PA	11,866	5,216
SC	45015-4120411	Santee Cooper Cross Generating Station	090	SC	4,281	3,723
SC	45015-8306711	SCE&G Williams	092	SC	392	993
SC	45043-6652811	Santee Cooper Winyah Generating Station	091	SC	2,247	1,773
VA	51023-5039811	Roanoke Cement Company	095	VA	2,290	1,973
VA	51027-4034811	Jewell Coke Company LLP	093	VA	5,091	520
VA	51580-5798711	Meadwestvaco Packaging Resource Group	094	VA	2,115	1,986

[a] The PSAT ID tags match the "Facility to Area" spreadsheet tab in Attachment A.

4.0 PSAT POST-PROCESSING

The CAMx 2011 and 2028 model output were post-processed using a "species definition file" that cross references raw CAMx output species names with PM species needed for SMAT. The results of the post-processing are 24-hour average PM species with the "combine file" output names. These are matched to the SMAT species as shown in Table 4-1.

Table 4-1. Matching of CAMx Raw Output Species to SMAT Input Variables

SMAT Species	Raw CAMx 6.40 Species
Sulfate (SO4)[1]	PSO4
Nitrate (NO3)[1]	PNO3
Ammonium (NH4)[1]	PNH4
Organic Matter (OM)	POA+SOA1+SOA2 +SOA3+SOA4+SOPA+SOPB
Elemental carbon (EC)	PEC
Crustal (CRUSTAL)	FPRM+FCRS
Coarse PM (CM)	CPRM+CCRS
PM2.5 (PM25)[2]	PSO4+PNO3+PNH4+POA+PEC+FCRS+FPRM+SOA1+SOA2+SOA3+SOA4+SOPA+SOPB+NA+PCL

[1] Modeled ammonium concentrations are not used in the post-processing of the 2028 visibility values because the IMPROVE network does not measure ammonium and there is not an ammonium term in the IMPROVE visibility equation.

[2] Note that total $PM_{2.5}$ concentration data is needed as a SMAT input variable, but it is not used in the visibility calculations for regional haze. Visibility calculations only use the species specific model outputs.

5.0 PROCESS FOR CREATING PSAT CONTRIBUTIONS FOR CLASS I AREAS

The CAMx hourly concentration data was post-processed to create SMAT input files. This involved processing both the 2028 "full model" and the specific source apportionment outputs. The "full model" results are the total PM species concentrations (e.g. sulfate, nitrate) and are identical to the total species concentrations from the non-source apportionment model run for 2028elv3 (e.g., future year base case). The source apportionment outputs contain the sulfate and/or nitrate contributions for each tagged source.

The PSAT source apportionment tracking uses slightly different variable names for the source apportionment variables. Table 5-1 below shows the SMAT species definition matching to be used for the 2028 full model and 2028 source apportionment results in the VISTAS II analysis.

Table 5-1. Matching of "Bulk Raw Species", PSAT Output Species, and SMAT Input Variables

SMAT Species	2028 Full Model Species	2028 PSAT Tag Raw Species
Sulfate	PSO4	PS4
Nitrate	PNO3	PN3
Ammonium	PHN4	PN4

This analysis uses a comparable method that was documented by EPA in the regional haze modeling for 2028. Slight differences do occur as in this study we are looking at the SMAT-CE generated visibility/extinction deltas whereas EPA's approach was designed for a different purpose than just to estimate emissions sector contributions to 2028 particulate matter concentrations and visibility. As a reminder, SESARM is only looking for individual facility or sector contributions to visibility impairment based on defined sulfate and nitrate tags and not looking to establish a full list of species-based contribution metrics.

The following approach was used in preparing the SMAT input files, running the SMAT software, and analysing the results:

1. Regional haze SMAT was run for the 2028 future case using "standard" 2011 and 2028 SMAT input files. In this SMAT run, the advanced option "Create forecast IMPROVE visibility file" was invoked to create an output file with future year (2028) daily species extinction values at each IMPROVE monitor for each of the 20% best and most impaired days (based on 2011 ambient data). These are the extinction values that are added and averaged to get the 2028 base case projected deciview values for each site. SMAT generates a new output file called "scenario_name Forecast IMPROVE Daily Data.csv" that was re-used to calculate the sector tag fractions.

2. Alpine then created future year, tag-specific SMAT input files by subtracting the 2028 hourly tags from the hourly full model concentration files. This simple arithmetic was implemented using standard IOAPI utility programs and generated files similar to EPA's source category-based tagged SMAT input files. Once the hourly files were created, the same processing stream as was used in Step 1 was used to create the tagged SMAT input files from the hourly model concentration files.

3. SMAT was then run again for each sector tag, using the "advanced options" accessing the "Forecast IMPROVE Daily Data" file (created as an output file from step 1 above) as the "advanced option" input file, the 2028 base case SMAT input file is used as the "Baseline file", and each 2028 sector tag SMAT input file is used as the "Forecast file".

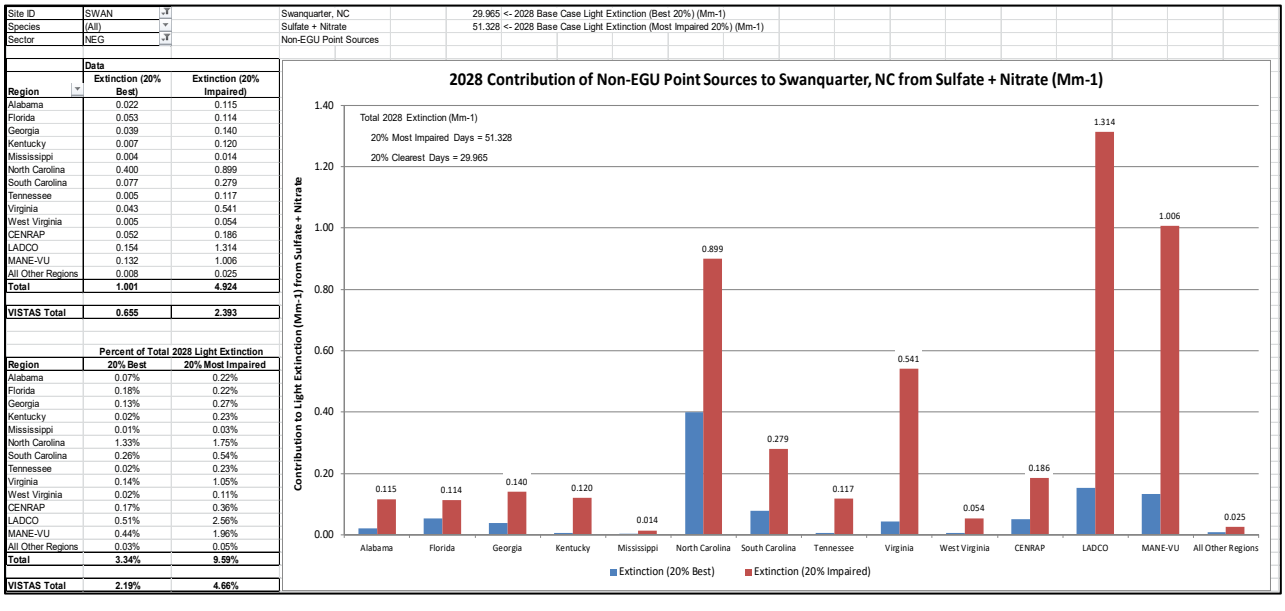
4. The total extinction (on the 20% most impaired days) for each tag was calculated from the SMAT bulk output file and each of the tag output files. The visibility impacts of each tag was computed by subtracting the SMAT output *absent* the tag (created in Step 3) from the full model SMAT output file (created in Step 1).

6.0 SECTOR TAG RESULTS

The sector and facility tag modeling results were consolidated into Attachment A, the Excel workbook "ATTACHMENT_A_PSAT_TAG_RESULTS.xlsm", with the following reports and charts prepared.

6.1 Area By Sector

This tab provides 2028 contribution from source regions-category combinations to light extinction on the 20% best and 20% most anthropogenically impaired days to a single Class I area. Figure 6-1 presents an example of this output.



Site ID	SWAN	Swanquarter, NC	29.965 <- 2028 Base Case Light Extinction (Best 20%) (Mm-1)
Species	(All)	Sulfate + Nitrate	51.328 <- 2028 Base Case Light Extinction (Most Impaired 20%) (Mm-1)
Sector	NEG	Non-EGU Point Sources	

	Data	
Region	Extinction (20% Best)	Extinction (20% Impaired)
Alabama	0.022	0.115
Florida	0.053	0.114
Georgia	0.039	0.140
Kentucky	0.007	0.120
Mississippi	0.004	0.014
North Carolina	0.400	0.899
South Carolina	0.077	0.279
Tennessee	0.005	0.117
Virginia	0.043	0.541
West Virginia	0.005	0.054
CENRAP	0.052	0.186
LADCO	0.154	1.314
MANE-VU	0.132	1.006
All Other Regions	0.008	0.025
Total	**1.001**	**4.924**
VISTAS Total	**0.655**	**2.393**

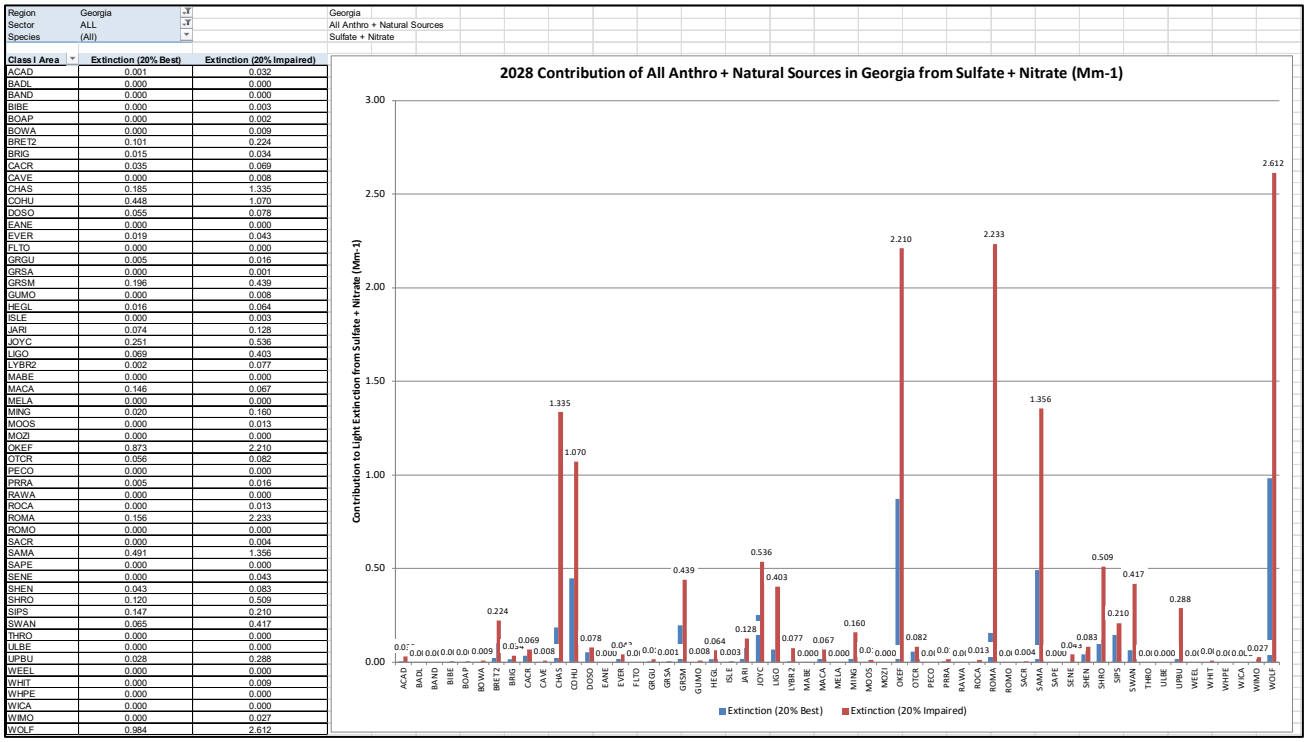
	Percent of Total 2028 Light Extinction	
Region	20% Best	20% Most Impaired
Alabama	0.07%	0.22%
Florida	0.18%	0.22%
Georgia	0.13%	0.27%
Kentucky	0.02%	0.23%
Mississippi	0.01%	0.03%
North Carolina	1.33%	1.75%
South Carolina	0.26%	0.54%
Tennessee	0.02%	0.23%
Virginia	0.14%	1.05%
West Virginia	0.02%	0.11%
CENRAP	0.17%	0.36%
LADCO	0.51%	2.56%
MANE-VU	0.44%	1.96%
All Other Regions	0.03%	0.05%
Total	**3.34%**	**9.59%**
VISTAS Total	**2.19%**	**4.66%**

Figure 6-1. Area by Sector PivotChart and Table Example

- Cell B1 provides options for Class I areas to which combinations contribute.
- Cell B2 provides option for [S]ulfate, [N]itrate, or (All) both.
- Cell B3 provides option for category. [ALL] being all anthro and natural emissions from region; [NEG] representing all non-EGU point source contribution, and [EGU] representing all EGU point source contribution.

6.2 Sector to Area

This tab provides 2028 contribution from source regions-category combinations to light extinction on the 20% best and 20% most anthropogenically impaired days to all Class I areas. Figure 6-2 presents an example of this output.



Region	Georgia
Sector	ALL
Species	(All)

Georgia
All Anthro + Natural Sources
Sulfate + Nitrate

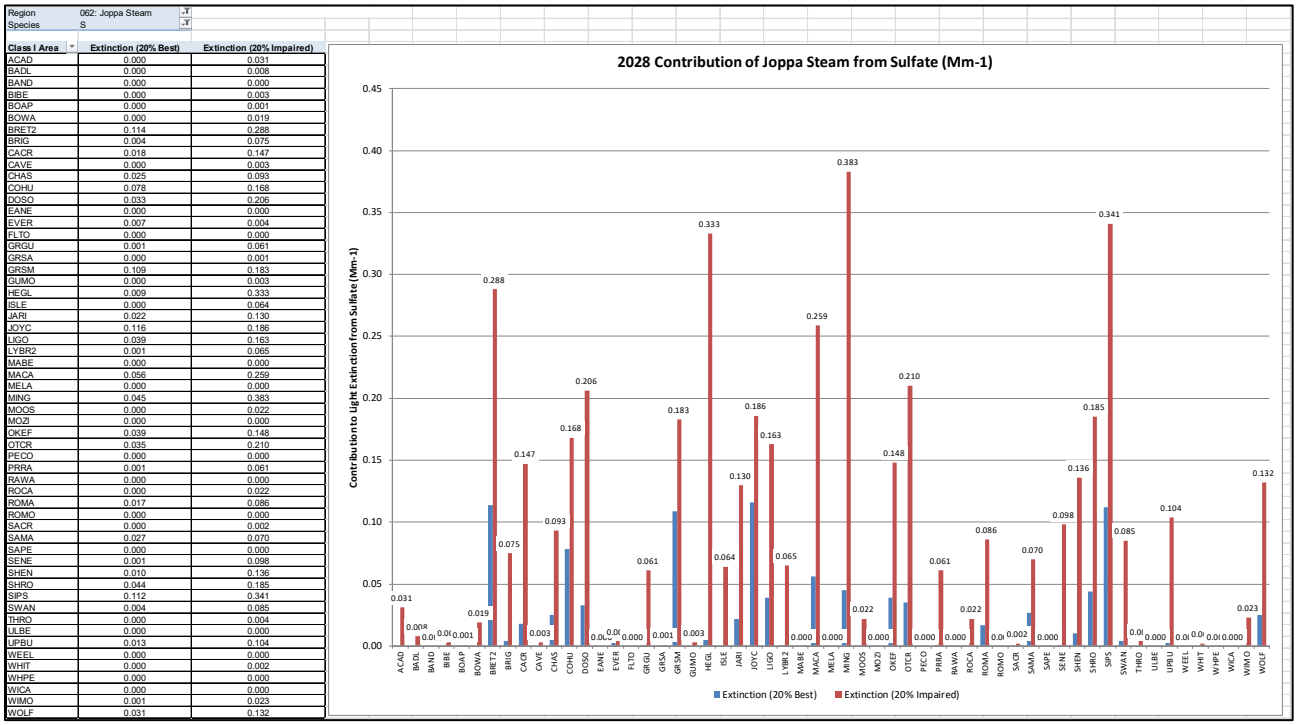
Class I Area	Extinction (20% Best)	Extinction (20% Impaired)
ACAD	0.001	0.032
BADL	0.000	0.000
BAND	0.000	0.000
BIBE	0.000	0.003
BOAP	0.000	0.002
BOWA	0.000	0.009
BRET2	0.101	0.224
BRIG	0.015	0.034
CACR	0.035	0.069
CAVE	0.000	0.008
CHAS	0.185	1.335
COHU	0.448	1.070
DOSO	0.055	0.078
EANE	0.000	0.000
EVER	0.019	0.043
FLTO	0.000	0.000
GRGU	0.005	0.016
GRSA	0.000	0.001
GRSM	0.196	0.439
GUMO	0.000	0.008
HEGL	0.016	0.064
ISLE	0.000	0.003
JARI	0.074	0.128
JOYC	0.251	0.536
LIGO	0.069	0.403
LYBR2	0.002	0.077
MABE	0.000	0.000
MACA	0.146	0.067
MELA	0.000	0.000
MING	0.020	0.160
MOOS	0.000	0.013
MOZI	0.000	0.000
OKEF	0.873	2.210
OTCR	0.056	0.082
PECO	0.000	0.000
PRRA	0.005	0.016
RAWA	0.000	0.000
ROCA	0.000	0.013
ROMA	0.156	2.233
ROMO	0.000	0.000
SACR	0.000	0.004
SAMA	0.491	1.356
SAPE	0.000	0.000
SENE	0.000	0.043
SHEN	0.043	0.083
SHRO	0.120	0.509
SIPS	0.147	0.210
SWAN	0.065	0.417
THRO	0.000	0.000
ULBE	0.000	0.000
UPBU	0.028	0.288
WEEL	0.000	0.000
WHIT	0.000	0.009
WHPE	0.000	0.000
WICA	0.000	0.000
WIMO	0.000	0.027
WOLF	0.984	2.612

Figure 6-2. Sector to Area PivotChart and Table Example

- Cell B1 provides options for tagged regions (States, RPOs).
- Cell B2 provides option for category. [ALL] being all anthro and natural emissions from region; [NEG] representing all non-EGU point source contribution, and [EGU] representing all EGU point source contribution.
- Cell B3 provides option for [S]ulfate, [N]itrate, or (All) both.

6.3 Facility to Area

This tab provides 2028 contribution from individual facilities to light extinction on the 20% best and 20% most anthropogenically impaired days to all Class I areas. Figure 6-3 presents an example of this output.



Region	062: Joppa Steam
Species	S

Class I Area	Extinction (20% Best)	Extinction (20% Impaired)
ACAD	0.000	0.031
BADL	0.000	0.008
BAND	0.000	0.000
BIBE	0.000	0.003
BOAP	0.000	0.001
BOWA	0.000	0.019
BRET2	0.114	0.288
BRIG	0.004	0.075
CACR	0.018	0.147
CAVE	0.000	0.003
CHAS	0.025	0.093
COHU	0.078	0.168
DOSO	0.033	0.206
EANE	0.000	0.000
EVER	0.007	0.004
FLTO	0.000	0.000
GRGU	0.001	0.061
GRSA	0.000	0.001
GRSM	0.109	0.183
GUMO	0.000	0.003
HEGL	0.009	0.333
ISLE	0.000	0.064
JARI	0.022	0.130
JOYC	0.116	0.186
LIGO	0.039	0.163
LYBR2	0.001	0.065
MABE	0.000	0.000
MACA	0.056	0.259
MELA	0.000	0.000
MING	0.045	0.383
MOOS	0.000	0.022
MOZI	0.000	0.000
OKEF	0.039	0.148
OTCR	0.035	0.210
PECO	0.000	0.000
PRRA	0.001	0.061
RAWA	0.000	0.000
ROCA	0.000	0.022
ROMA	0.017	0.086
ROMO	0.000	0.000
SACR	0.000	0.002
SAMA	0.027	0.070
SAPE	0.000	0.000
SENE	0.001	0.098
SHEN	0.010	0.136
SHRO	0.044	0.185
SIPS	0.112	0.341
SWAN	0.004	0.085
THRO	0.000	0.004
ULBE	0.000	0.000
UPBU	0.013	0.104
WEEL	0.000	0.000
WHIT	0.000	0.002
WHPE	0.000	0.000
WICA	0.000	0.000
WIMO	0.001	0.023
WOLF	0.031	0.132

Figure 6-3. Facility to Area PivotChart and Table Example

- Cell B1 provides options for tagged facilities.
- Cell B2 provides option for [S]ulfate, [N]itrate, or (All) both.

6.4 Stacked Bar S and N by Area

This tab provides 2028 contribution from source regions-category combinations (including boundary conditions) to light extinction on the 20% most anthropogenically impaired days to a single Class I area in multiple compared combinations. Figure 6-4 presents an example of this output.

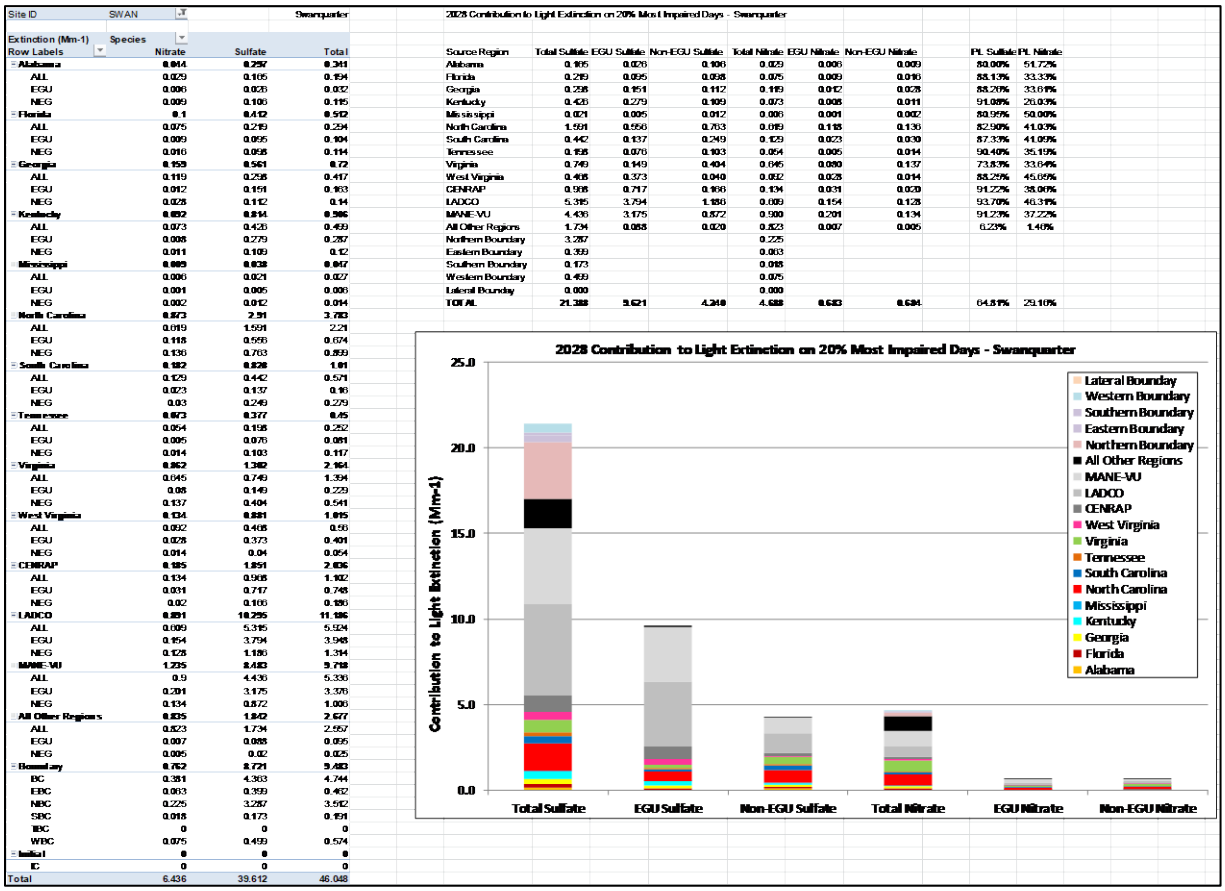


Figure 6-4. Stacked Bar S and N by Area PivotChart and Table Example

- Cell B1 provides options for Class I areas to which combinations contribute.

6.5 Region Sector to Area

This tab provides 2028 contribution from source regions to light extinction on the 20% most anthropogenically impaired days to all Class I areas. Figure 6-5 presents an example of this output.

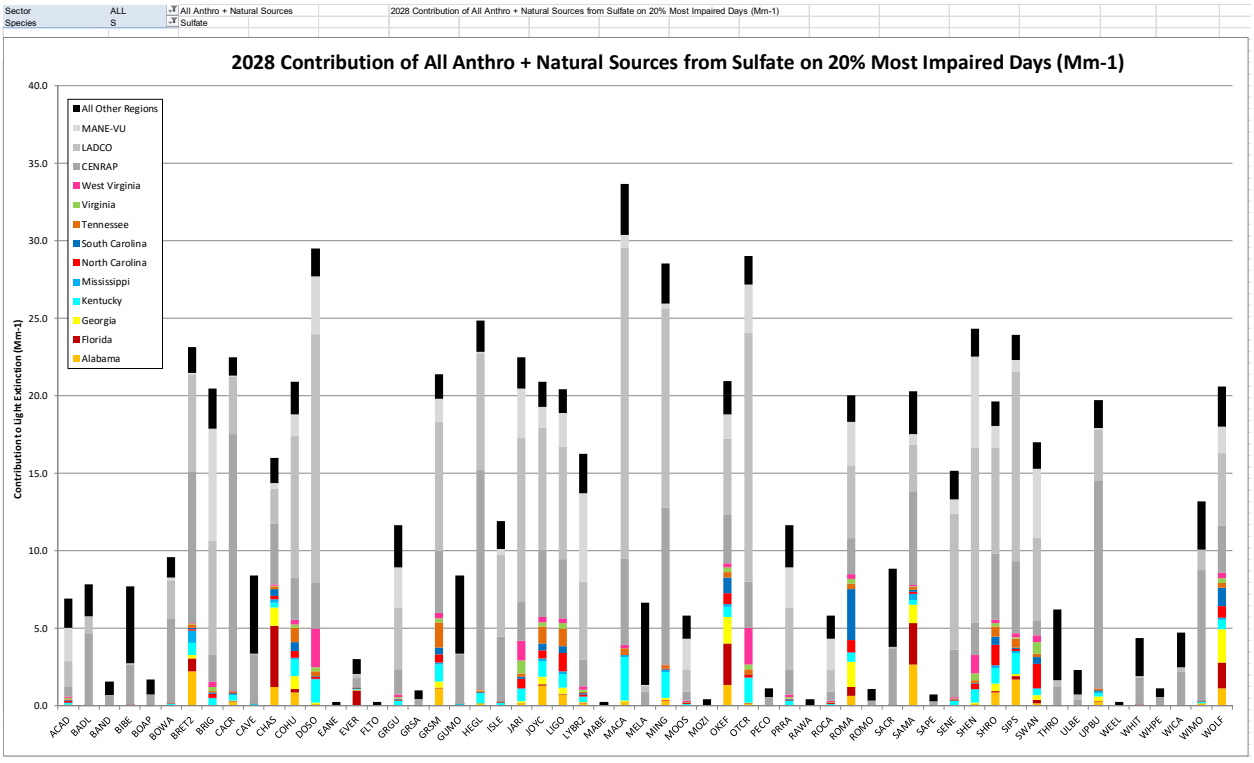


Figure 6-5. Region Sector to Area PivotChart Example

- Cell B1 provides option for category. [ALL] being all anthro and natural emissions from region; [NEG] representing all non-EGU point source contribution, and [EGU] representing all EGU point source contribution.
- Cell B2 provides option for [S]ulfate, [N]itrate, or (All) both.

6.6 Boundary to Area

This tab provides 2028 contribution from boundary condition direction to light extinction on the 20% most anthropogenically impaired days to all Class I areas. Figure 6-6 presents an example of this output.

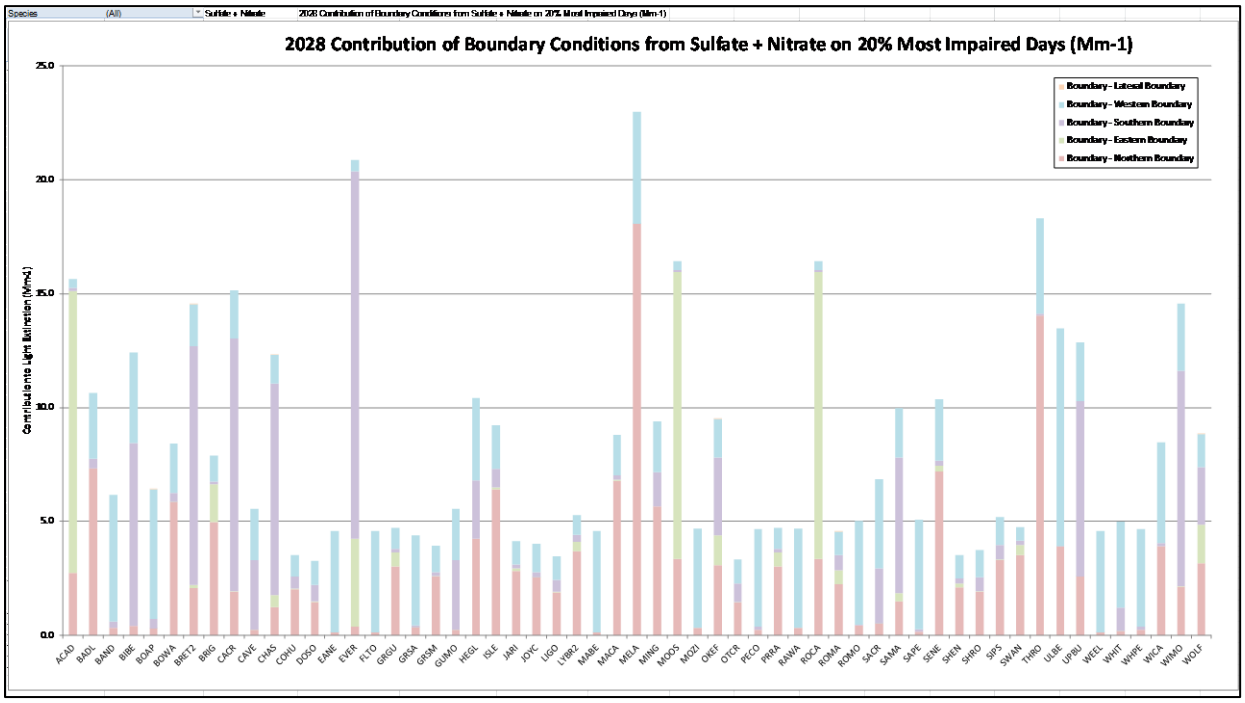


Figure 6-6. Boundary to Area PivotChart Example

- Cell B1 provides option for [S]ulfate, [N]itrate, or (All) both.

7.0 PSAT DAY-TO-DAY ANALYSIS

To further inform the Stakeholders, day-by-day modeled PSAT source apportionment results were prepared for each of the SESARM tagged scenarios relative to Class I areas presented in Tables 3-1 through 3-4. The full results are in Attachment B, as a Excel Workbook titled "ATTACHMENT_B_DAY_BY_DAY_GROUP_10_90.xlsx".

Results presented are in light extinction (b_{ext}) with units of inverse megameters (Mm^{-1}) for the 20% clearest days (Group 10) and the 20% most anthropogenically impaired days (Group 90). It should be noted that as the modeled extinction presented is the difference between the PSAT tag run and the base case run and does not utilize RRF calculations for visibility, these results cannot be directly correlated to the base case visibility at any Class I areas. These data are to be used to demonstrate relative contribution across days, not necessarily relative contribution to the overall visibility impairment metrics.

Figure 7-1 presents the Group 10 (20% clearest days) results for Wolf Island in Georgia.

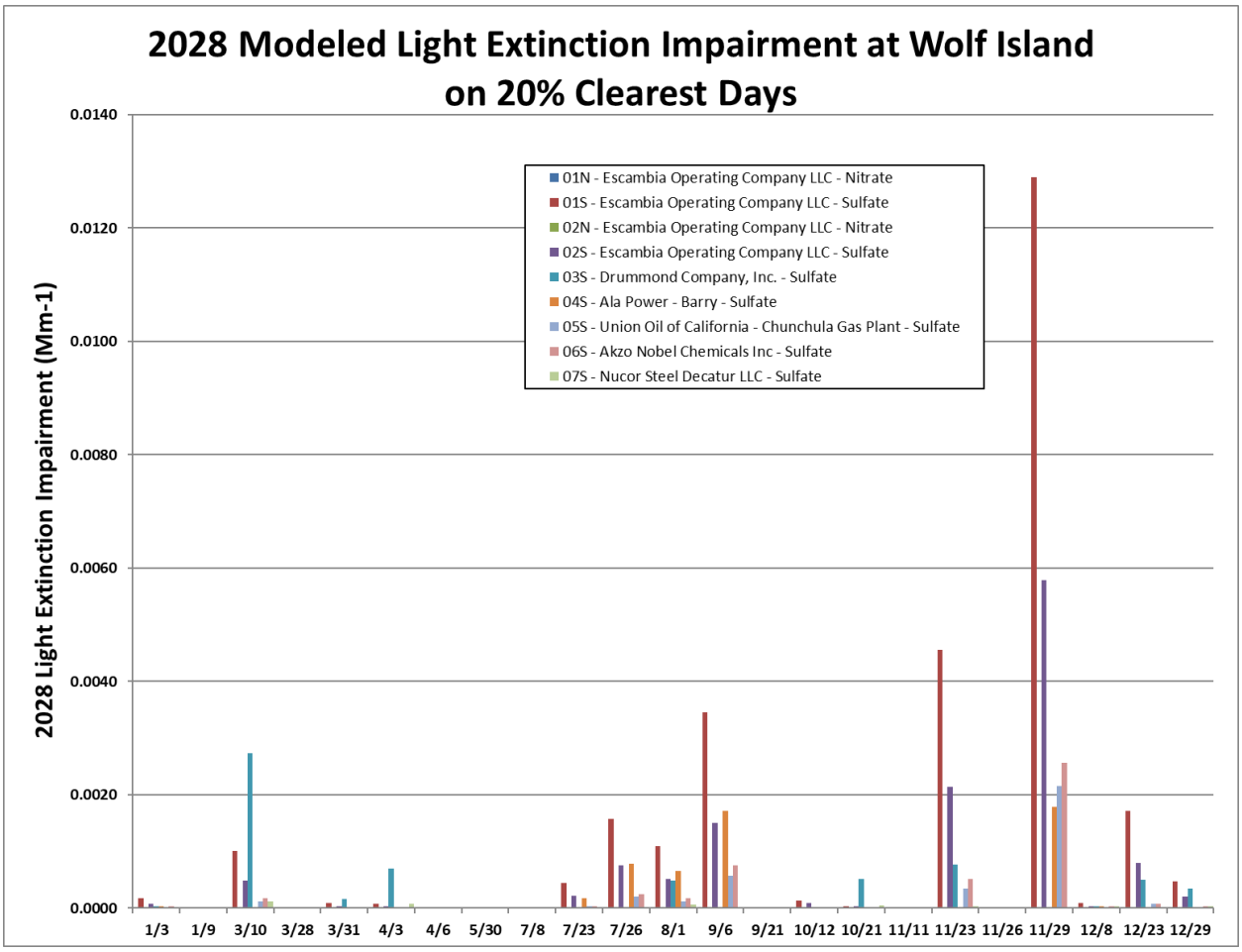


Figure 7-1. 2028 Modeled Light Extinction Impairment at Wolf Island on 20% Clearest Days

In this example, the stacked bar charts represent the relative contributions of tagged sources of interest, and their respective contributions to the light extinction values for each of the 20% clearest days.

Figure 7-2 presents the Group 90 (20% most anthropogenically impaired) results for Wolf Island in Georgia.

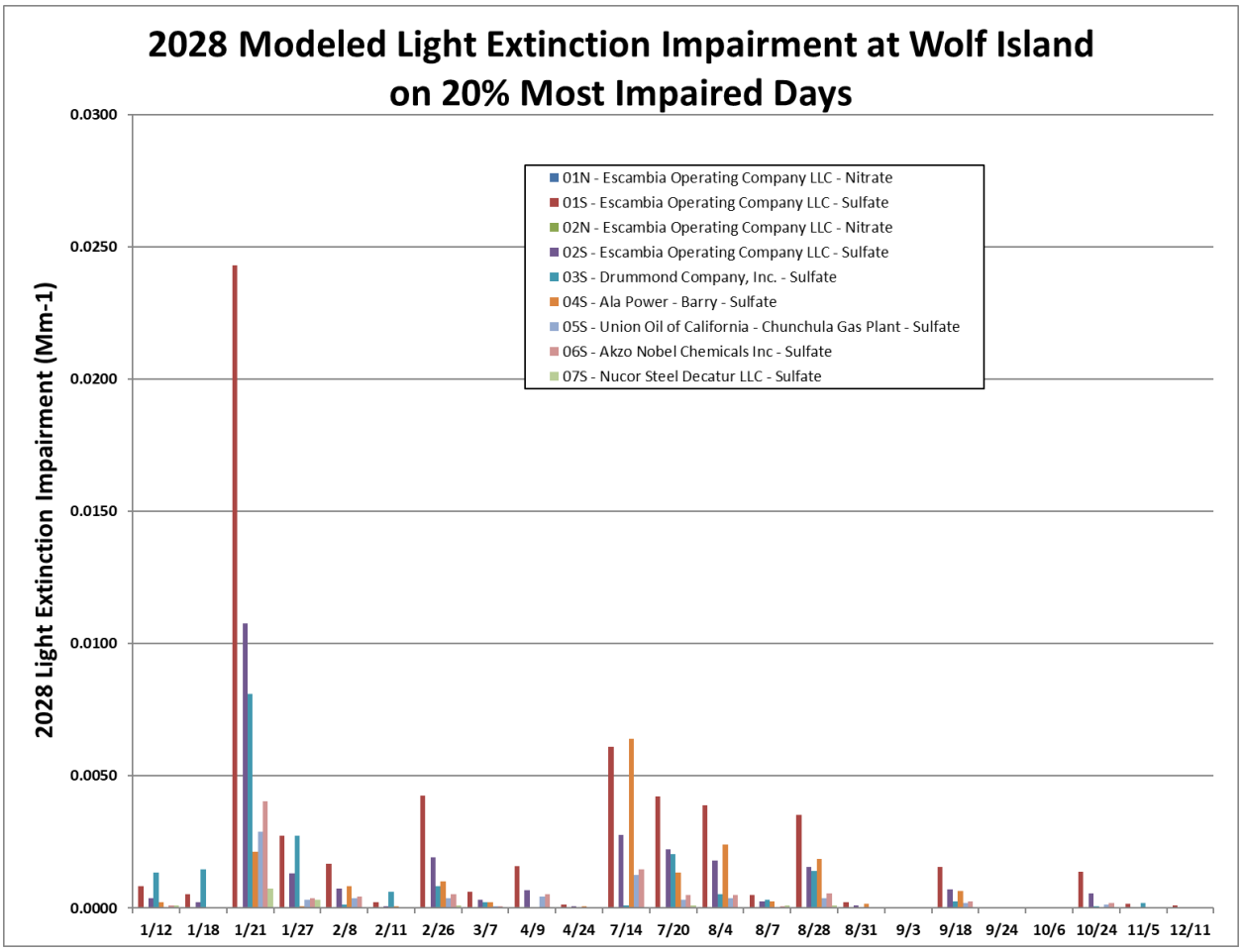


Figure 7-2. 2028 Modeled Light Extinction Impairment at Wolf Island on 20% Most Impaired Days

Similar to Figure 7-1, the stacked bar charts represent the relative contributions of tagged sources of interest, and their respective contributions to the light extinction values for each of the 20% most impaired days.

Attachment A – PSAT Tagging Results

(ATTACHMENT_A_PSAT_TAG_RESULTS.xlsm)

Attachment B – Day-By-Day Results

(ATTACHMENT_B_DAY_BY_DAY_GROUP_10_90.xls)

VISTAS Roadmap for Calculations Associated with the Initial Screening of Sources for Reasonable Progress (Four-Factor Analyses)

Prepared by:
VISTAS Technical Analysis Workgroup

August 9, 2022

Overview

This document describes the calculations associated with the initial screening of sources for reasonable progress (four-factor analyses). The original PSAT results were determined based on the modeled elv3 2028 SO_2 and NOx emissions. The 2028 EGU and non-EGU (NEGU) point emissions were updated for a new 2028 model run based on the elv5 emissions inventory, but the original PSAT runs were not redone. Therefore, the original PSAT results have been adjusted using the methodology described below to reflect the updated 2028 emissions.

Task 2: Emission Inventories

VISTAS Emissions 2028 Comparisons Remodeling 200902.xlsx

- The "STATE_LEVEL_COMPARISON" tab contains EGU and NEGU state-level comparisons for the original (elv3 modeled) and revised (elv5 inventory) SO_2 and NOx emissions inventory (Inv) and modeled emissions (Mod) in the VISTAS 12-km domain.

- The "FACILITY_COMPARISON" tab contains facility-by-facility comparisons for the original and revised SO_2 and NOx emissions in the VISTAS 12-km domain.

- The "PSAT_ANALYSIS" tab contains facility-by-facility comparisons for the original and revised SO_2 and NOx emissions for the 87 facilities with PSAT tags. The ratio of revised SO_2 to original SO_2 emissions is contained in Column Q. The ratio of revised NOx to original NOx emissions is contained in Column R. These ratios are used to adjust the original facility PSAT results under Task 7 in "ATTACHMENT_A_PSAT_TAG_RESULTS.xlsm" to account for emission increases/decreases associated with the revised SO_2 and NOx emissions. The file containing the adjusted impacts is called "ATTACHMENT_A_PSAT_TAG_RESULTS_adjusted_09-02-2020.xlsx." The facility ratios are shown in Table 1 at the end of this document.

- The "Ratios" tab contains the state level data for VISTAS states and the RPO level data for states outside of VISTAS states. This tab calculates the emissions ratio for NO_X and for SO_2 between the elv3 modeled values and the elv5 inventory values for each state within VISTAS. It also calculates the RPO level ratios for NO_X and SO_2 for CENSARA, MANE-VU, LADCO, and WRAP. These ratios are used to adjust estimated impacts from the EGU and NEGU sectors to each Class I area. Adjusted PSAT results are found in the spreadsheet called, "ATTACHMENT_A_PSAT_TAG_RESULTS_adjusted_09-02-2020.xlsx." The state and regional ratios are shown in Table 2 at the end of this document. Within the "Ratios" tab contained in the spreadsheet, "VISTAS Emissions 2028 Comparisons Remodeling 200902.xlsx":

    - The sulfate ratio for EGUs for each VISTAS state (Column E) is the value in column D (SO_2 EGUelv5 Inv) divided by the value in column C (SO_2 EGU elv3 Mod).
    - The sulfate ratio for NEGUs for each VISTAS state (Column H) is the value in column G (SO_2 NEGU elv5 inv) divided by the value in column F (SO_2 NEGU elv3 Mod).
    - The nitrate ratio for EGUs for each VISTAS state (Column K) is the value in column J (NO_X EGU elv5 Inv) divided by the value in column I (NOx EGU elv3 Mod).
    - The nitrate ratio for NEGUs for each VISTAS state (Column N) is the value in column M (NOx NEGU elv5 Inv) divided by the value in column L (NOx NEGU elv3 Mod).
    - The sulfate ratio for EGUs for each RPO other than VISTAS (Column E) is the sum of the SO_2 emissions for that RPO in column D (SO_2 EGUelv5 Inv) divided by the sum of SO_2 emissions for that RPO in column C (SO_2 EGUelv3 Mod).

- The nitrate ratio for EGUs for each RPO other than VISTAS (Column K) is the sum of the NO_X emissions for that RPO in column J (NO_X EGU elv5 Inv) divided by the sum of NO_X emissions for that RPO in column I (NO_X EGU elv3 Mod).
- The sulfate ratio for NEGUs for each RPO other than VISTAS (Column H) is the sum of the SO_2 emissions for that RPO in column G (SO_2 NEGU elv5 Inv) divided by the sum of SO_2 emissions for that RPO in column F (SO_2 NEGU elv3 Mod).
- The nitrate ratio for NEGUs for each RPO other than VISTAS (Column N) is the sum of the NO_X emissions for that RPO in column M (NO_X NEGU elv5 Inv) divided by the sum of NO_X emissions for that RPO in column L (NO_X NEGU elv3 Mod).

Task 5: Area of Influence Analysis

VISTAS AOI Data Summary.xlsx

This Excel file contains a summary of the facility information and AOI contributions from the "POINT" worksheet contained in in the AOI spreadsheets for each Class I area. Only facilities contributing more than 0.1% combination of sulfate + nitrate (Column AS) are included in this summary for each Class I area.

Each worksheet identifies one of the pertinent Class I areas. The AOI contributions for the following are identified in each sheet:

- (facility nitrate)/(total EGU+NEGU sulfate+nitrate) ➔ Column AQ (Combined_NO3_2028_fraction)
- (facility sulfate)/(total EGU+NEGU sulfate+nitrate) ➔ Column AR (Combined_SO4_2028_fraction)
- (facility sulfate + facility nitrate)/(total EGU+NEGU sulfate+nitrate) ➔ Column AS (Combined_SO4_NO3_2028_EWRT.Qd)

The individual VISTAS Class I Area and nearby non-VISTAS Class I Area Excel spreadsheets with all the detailed calculations are located at:
https://www.metro4-sesarm.org/content/task-5-area-influence-analysis

Task 7: Source Apportionment Modeling/Tagging

ATTACHMENT_A_PSAT_TAG_RESULTS_adjusted_09-02-2020.xlsx

The data tabs in this spreadsheet (rh_results_SEC_v4_adj, rh_results_SEC_BCv4_adj, rh_results_INDv3_adj) contain the original PSAT results in columns identified with the heading delta_extw (20% most impaired days) and delta_extb (20% clearest days). Scaled values using the ratios developed from the elv5 inventory are in columns designated delta_extb_adj and delta_extw_adj. The adjusted PSAT results are based on emission ratios calculated in "*VISTAS Emissions 2028 Comparisons Remodeling 200902.xlsx*" (see Table 2 at the end of this document)

- Revised Facility EGU Sulfate PSAT Results = Original EGU Sulfate PSAT Results * SO_2 EGU Ratio
  where, SO_2 EGU Ratio = (Revised EGU SO_2 emissions)/(Original EGU SO2 emissions)

- Revised Facility NEGU Sulfate PSAT Results = Original NEGU Sulfate PSAT Results * SO_2 NEGU Ratio *where, SO_2 NEGU Ratio = (Revised NEGU SO_2 emissions)/(Original NEGU SO_2 emissions)*

- Revised Facility EGU Nitrate PSAT Results = Original EGU Nitrate PSAT Results * NOx EGU Ratio *where, NOx EGU Ratio = (Revised EGU NOx emissions)/(Original EGU NOx emissions)*

- Revised Facility NEGU Nitrate PSAT Results = Original NEGU Nitrate PSAT Results * NOx NEGU Ratio *where, NOx NEGU Ratio = (Revised NEGU NOx emissions)/(Original NEGU NOx emissions)*

To adjust the total EGU+NEG, sulfate+nitrate contribution to visibility impairment at each Class I area, the EGU sulfate, EGU nitrate, NEGU sulfate, and NEGU nitrate contributions at each Class I area were adjusted by the respective ratio for that area (state or RPO), sector (EGU or NEG), and pollutant (sulfate or nitrate). These adjusted values were summed to determine the scaled EGU+NEG, sulfate+nitrate impact on each Class I area.

Since impacts of any facility are reviewed as a percentage of the total EGU+NEGU, sulfate+nitrate impact on a Class I area, revisions to the inventory affect both the numerator of the equation (the scaled PSAT estimate of sulfate or nitrate impact from a particular facility) and the denominator of the equation (the scaled PSAT estimate of sulfate + nitrate impact from all EGUs and NEGUs on a Class I area). Table 3 at the end of this document provides the original and adjusted EGU + NEGU impacts for each Class I area as well as the ratios developed from this information. To calculate the changes to the denominator, the Ratio_Class_I_Area was used:

- Ratio_Class_I_Area = (Original EGU sulfate + NEGU sulfate + EGU nitrate + NEGU nitrate)/
  (Revised EGU sulfate + NEGU sulfate + EGU nitrate + NEGU nitrate)

This methodology allows a user to calculate a singular value for a particular Class I area and sector impact. To make the wholesale updates to the PSAT estimated impacts at each Class I area, a pivot table approach was used to create the ATTACHMENT_A_PSAT_TAG_RESULTS_adjusted_09-02-2020.xlsx file.

Task 7: Source Apportionment Modeling/Tagging

VISTAS PSAT Percent Contribution Rankings 02-09-2021 calcs.xlsx

The VISTAS PSAT Percent Contribution Ranking 02-09-2021 calcs.xlsx, tab "comb SO4+NO3>0.0001-copy" worksheet combines AOI information from the database provided by the VISTAS contractor (AOI_SPREADSHEET_ANALYSIS_POINT.zip) for all facilities with a Combined_SO4_NO3_2028_EWRT.Qd of at least 0.01% (0.0001) with original and adjusted PSAT information from "ATTACHMENT_A_PSAT_TAG_RESULTS_adjusted_09-02-2020.xlsx".

Tab "Facility Ratios" shows the emissions estimate for each tagged facility from the AOI analysis, the elv3 modeling, and the elv5 modeling. It also shows the ratio applied to each facility. This information originates in the Excel file called, "VISTAS Emissions 2028 Comparisons Remodeling 200902.xlsx."

Tab "Facility Tagging Results" shows the original, elv3 PSAT tagging results and the adjusted PSAT tagging results based on the elv5 inventory for each facility. This information originates in the Excel file called, "ATTACHMENT_A_PSAT_TAG_RESULTS_adjusted_09-02-2020.xlsx," tab "rh_results_INDv3_adj."

Tab "Class I EGU+NEG, S+N" shows the original, elv3 PSAT tagging results for the impact of sulfate and nitrate from EGUs and NEGUs on each Class I area for 20% most impaired days and 20% clearest days. The tab also shows the adjusted values for each Class I area and the ratio of the original value to the

adjusted value. This information originates in the Excel file called, "ATTACHMENT_A_PSAT_TAG_RESULTS_adjusted_09-02-2020.xlsx", tab "rh_results_SEC+BECv4_adj". This information is provided in Table 3 at the end of this document.

Tab "Tagged Facilities Xwalk" shows the facility identification for each tagged facility, which allow comparison of tagged and AOI results. This information originates in the Excel file called, "ATTACHMENT_A_PSAT_TAG_RESULTS_adjusted_09-02-2020.xlsx", tab "Facility Name xwalk".

Certain facilities were tagged for NO_X and SO_2 twice. Since multiple tags for a facility produced identical PSAT results, such facilities are only listed once in tab "comb SO4+NO3>0.0001-copy." These facilities are shown in Table 4:

Table 4: Facilities Tagged Twice

State	Tag Numbers	Facility FIPS and EIS ID	Facility Name
FL	020/074	12123-752411	Buckeye Florida, Limited Partnership
GA	023/080	13127-3721011	Brunswick Cellulose Inc
NC	028/088	37013-8479311	PCS Phosphate Company, Inc - Aurora
NC	029/085	37087-7920511	Blue Ridge Paper Products – Canton Mill
VA	040/095	51023-5039811	Roanoke Cement Company
VA	041/093	51027-4034811	Jewell Coke Company LLP
VA	042/094	51580-5798711	Meadwestvaco Packaging Resource Group

Two facilities are scheduled to be shut down prior to 2028 but were tagged in the elv3 PSAT run. These facilities are listed in Table 5. Under the tab "Facility Ratios," each facility is listed as having zero NO_X and SO_2 emissions in 2028. State emissions totals were adjusted accordingly and are reflected in the scaled values for EGU+NEG, Sulfate+Nitrate impacts on Class I areas in the tab "Class I EGU+NEG S+N." These facilities are not shown in tab "comb SO4+NO3>0.0001-copy."

Table 5: Facilities with AoI of zero but included in the PSAT tagging

State	Tag Numbers	Facility FIPS and EIS ID	Facility Name
AL	002	01053-085111	Escambia Operating Company LLC
TN	033	47001-6196011	TVA Bull Run Fossil Plant

Table 1

This table provides the ratio of revised to original SO_2 and NOx emissions for the 87 facilities with PSAT tags. Green indicates emission reductions, and red indicates emission increases.

State	RPO	Facility FIPS - EIS ID	Facility Name	SO_2 ratio, remodeled/ original	NO_X ratio, remodeled/ original
AL	VISTAS	01053-7440211	Escambia Operating Company LLC	0.199	1.000
AL	VISTAS	01053-985111	Escambia Operating Company LLC	0.010	0.000
AL	VISTAS	01073-1018711	DRUMMOND COMPANY, INC.	1.000	1.000
AL	VISTAS	01097-1056111	Ala Power - Barry	0.499	1.000
AL	VISTAS	01097-1061611	Union Oil of California - Chunchula Gas Plant	0.000	0.000
AL	VISTAS	01097-949811	Akzo Nobel Chemicals Inc	1.000	1.000
AL	VISTAS	01103-1000011	Nucor Steel Decatur LLC	1.000	1.000
AL	VISTAS	01109-985711	Sanders Lead Co	1.000	1.000
AL	VISTAS	01129-1028711	American Midstream Chatom, LLC	0.000	0.000
FL	VISTAS	12005-535411	ROCKTENN CP LLC	1.000	1.000
FL	VISTAS	12017-640611	DUKE ENERGY FLORIDA, INC. (DEF)	0.493	0.421
FL	VISTAS	12031-640211	JEA	1.027	1.591
FL	VISTAS	12033-752711	GULF POWER - Crist	0.219	0.382
FL	VISTAS	12047-769711	WHITE SPRINGS AGRICULTURAL CHEMICALS,INC	0.487	0.909
FL	VISTAS	12057-538611	TAMPA ELECTRIC COMPANY (TEC)	1.000	1.000
FL	VISTAS	12057-716411	MOSAIC FERTILIZER, LLC	0.595	1.057
FL	VISTAS	12086-3532711	HOMESTEAD CITY UTILITIES	1.000	1.000
FL	VISTAS	12086-899911	TARMAC AMERICA LLC	1.000	2.701
FL	VISTAS	12086-900011	FLORIDA POWER & LIGHT (PTF)	1.000	1.000
FL	VISTAS	12086-900111	CEMEX CONSTRUCTION MATERIALS FL. LLC.	1.000	2.856
FL	VISTAS	12089-753711	ROCK TENN CP, LLC	1.000	1.000
FL	VISTAS	12089-845811	RAYONIER PERFORMANCE FIBERS LLC	1.000	1.000
FL	VISTAS	12105-717711	MOSAIC FERTILIZER LLC	0.568	1.000
FL	VISTAS	12105-919811	MOSAIC FERTILIZER, LLC	0.972	1.000
FL	VISTAS	12123-752411	BUCKEYE FLORIDA, LIMITED PARTNERSHIP	1.000	1.000
FL	VISTAS	12129-2731711	TALLAHASSEE CITY PURDOM GENERATING STA.	1.000	1.000
GA	VISTAS	13015-2813011	Ga Power Company - Plant Bowen	1.000	1.000
GA	VISTAS	13051-3679811	International Paper - Savannah	1.000	1.000
GA	VISTAS	13103-536311	Georgia-Pacific Consumer Products LP (Savannah River Mill)	1.000	1.000
GA	VISTAS	13115-539311	TEMPLE INLAND	1.000	1.000
GA	VISTAS	13127-3721011	Brunswick Cellulose Inc	1.000	1.000
KY	VISTAS	21091-7352411	Century Aluminum of KY LLC	0.441	1.000
KY	VISTAS	21145-6037011	Tennessee Valley Authority (TVA) - Shawnee Fossil Plant	1.000	1.000
KY	VISTAS	21177-5196711	Tennessee Valley Authority - Paradise Fossil Plant	0.004	0.238
KY	VISTAS	21183-5561611	Big Rivers Electric Corp - Wilson Station	1.000	1.000
MS	VISTAS	28059-6251011	Mississippi Power Company, Plant Victor J Daniel	1.000	1.000
MS	VISTAS	28059-8384311	Chevron Products Company, Pascagoula Refinery	1.000	1.000
NC	VISTAS	37013-8479311	PCS Phosphate Company, Inc. - Aurora	1.000	1.000
NC	VISTAS	37023-8513011	SGL Carbon LLC	1.000	1.000

State	RPO	Facility FIPS - EIS ID	Facility Name	SO_2 ratio, remodeled/ original	NO_X ratio, remodeled/ original
NC	VISTAS	37035-8370411	Duke Energy Carolinas, LLC - Marshall Steam Station	0.641	0.713
NC	VISTAS	37087-7920511	Blue Ridge Paper Products - Canton Mill	0.359	0.978
NC	VISTAS	37117-8049311	Domtar Paper Company, LLC	1.000	1.000
SC	VISTAS	45015-4120411	SANTEE COOPER CROSS GENERATING STATION	1.000	1.000
SC	VISTAS	45015-4834911	ALUMAX OF SOUTH CAROLINA	1.000	1.000
SC	VISTAS	45015-8306711	SCE&G WILLIAMS	1.000	1.000
SC	VISTAS	45019-4973611	KAPSTONE CHARLESTON KRAFT LLC	1.000	1.000
SC	VISTAS	45043-5698611	INTERNATIONAL PAPER GEORGETOWN MILL	1.000	1.000
SC	VISTAS	45043-6652811	SANTEE COOPER WINYAH GENERATING STATION	1.000	1.000
TN	VISTAS	47001-6196011	TVA BULL RUN FOSSIL PLANT	0.000	0.000
TN	VISTAS	47093-4979911	Cemex - Knoxville Plant	1.000	1.000
TN	VISTAS	47105-4129211	TATE & LYLE, Loudon	0.352	0.261
TN	VISTAS	47145-4979111	TVA KINGSTON FOSSIL PLANT	0.225	0.225
TN	VISTAS	47161-4979311	TVA CUMBERLAND FOSSIL PLANT	1.000	1.000
TN	VISTAS	47163-3982311	EASTMAN CHEMICAL COMPANY	1.000	1.000
VA	VISTAS	51023-5039811	Roanoke Cement Company	1.000	1.000
VA	VISTAS	51027-4034811	Jewell Coke Company LLP	1.000	1.000
VA	VISTAS	51580-5798711	Meadwestvaco Packaging Resource Group	1.000	1.000
WV	VISTAS	54023-6257011	Dominion Resources, Inc. - MOUNT STORM POWER STATION	0.449	0.487
WV	VISTAS	54033-6271711	ALLEGHENY ENERGY SUPPLY CO, LLC-HARRISON	1.027	0.847
WV	VISTAS	54041-6900311	EQUITRANS - COPLEY RUN CS 70	1.000	1.000
WV	VISTAS	54049-4864511	AMERICAN BITUMINOUS POWER-GRANT TOWN PLT	1.278	1.394
WV	VISTAS	54051-6902311	MITCHELL PLANT	0.787	1.459
WV	VISTAS	54061-16320111	LONGVIEW POWER	1.010	1.437
WV	VISTAS	54061-6773611	MONONGAHELA POWER CO.- FORT MARTIN POWER	0.626	0.873
WV	VISTAS	54061-6773811	MORGANTOWN ENERGY ASSOCIATES	0.004	0.330
WV	VISTAS	54073-4782811	MONONGAHELA POWER CO-PLEASANTS POWER STA	0.684	1.042
WV	VISTAS	54079-6789111	APPALACHIAN POWER COMPANY - JOHN E AMOS PLANT	0.555	1.495
WV	VISTAS	54083-6790511	GLADY 6C4350	1.000	1.000
WV	VISTAS	54083-6790711	FILES CREEK 6C4340	1.000	1.000
WV	VISTAS	54093-6327811	KINGSFORD MANUFACTURING COMPANY	1.000	1.000
IL	Midwest RPO	17127-7808911	Joppa Steam	0.392	0.424
IN	Midwest RPO	18051-7363111	Gibson	0.562	0.702
IN	Midwest RPO	18125-7362411	INDIANAPOLIS POWER & LIGHT PETERSBURG	0.519	0.502
IN	Midwest RPO	18129-8166111	Sigeco AB Brown South Indiana Gas & Ele	0.000	0.018
IN	Midwest RPO	18147-8017211	INDIANA MICHIGAN POWER DBA AEP ROCKPORT	0.353	0.962
IN	Midwest RPO	18173-8183111	Alcoa Warrick Power Plt Agc Div of AL	0.288	0.271
OH	Midwest RPO	39025-8294311	Duke Energy Ohio, Wm. H. Zimmer Station (1413090154)	0.467	0.820
OH	Midwest RPO	39031-8010811	Conesville Power Plant (0616000000)	0.000	0.000
OH	Midwest RPO	39053-7983011	Ohio Valley Electric Corp., Kyger Creek Station (0627000003)	1.258	0.685

State	RPO	Facility FIPS - EIS ID	Facility Name	SO_2 ratio, remodeled/ original	NO_X ratio, remodeled/ original
OH	Midwest RPO	39053-8148511	General James M. Gavin Power Plant (0627010056)	0.525	0.983
OH	Midwest RPO	39081-8115711	Cardinal Power Plant (Cardinal Operating Company) (0641050002)	1.326	1.639
MD	MANE-VU	24001-7763811	Luke Paper Company	0.436	1.000
PA	MANE-VU	42005-3866111	GENON NE MGMT CO/KEYSTONE STA	0.370	0.773
PA	MANE-VU	42063-3005111	NRG WHOLESALE GEN/SEWARD GEN STA	0.767	0.724
PA	MANE-VU	42063-3005211	HOMER CITY GEN LP/ CENTER TWP	0.782	0.951
AR	CENRAP	05063-1083411	ENTERGY ARKANSAS INC-INDEPENDENCE PLANT	0.426	0.317
MO	CENRAP	29143-5363811	NEW MADRID POWER PLANT-MARSTON	0.665	0.923

Table 2

The following table provides the ratio of revised emissions to original emissions for EGU SO_2, NEGU SO_2, EGU NOx, and NEGU NOx for each state and RPO. These calculations are contained in the spreadsheet called, "VISTAS Emissions 2028 Comparisons Remodeling 200902.xlsx." Green indicates emission reductions, and red indicates emission increases.

State/RPO	Sulfate EGU Ratio	Sulfate NEGU Ratio	Nitrate EGU Ratio	Nitrate NEGU Ratio
AL	0.455	0.715	0.635	0.967
FL	0.801	0.843	0.800	1.111
GA	0.944	0.997	0.929	0.998
KY	0.879	0.850	0.866	1.005
MS	0.494	0.362	0.642	1.020
NC	0.458	0.951	0.643	0.995
SC	0.951	1.001	0.813	1.033
TN	0.825	0.970	0.739	0.979
VA	0.525	1.005	0.614	1.043
WV	0.825	1.068	1.067	0.997
CENSARA	0.482	0.984	0.687	0.969
LADCO	0.571	0.956	0.687	0.966
MANE-VU	0.425	0.775	0.588	1.012

Table 3

The following table provides the original and adjusted, sulfate and nitrate, impacts of EGUs and NEGUs on various Class I areas for the 20% most impaired days.

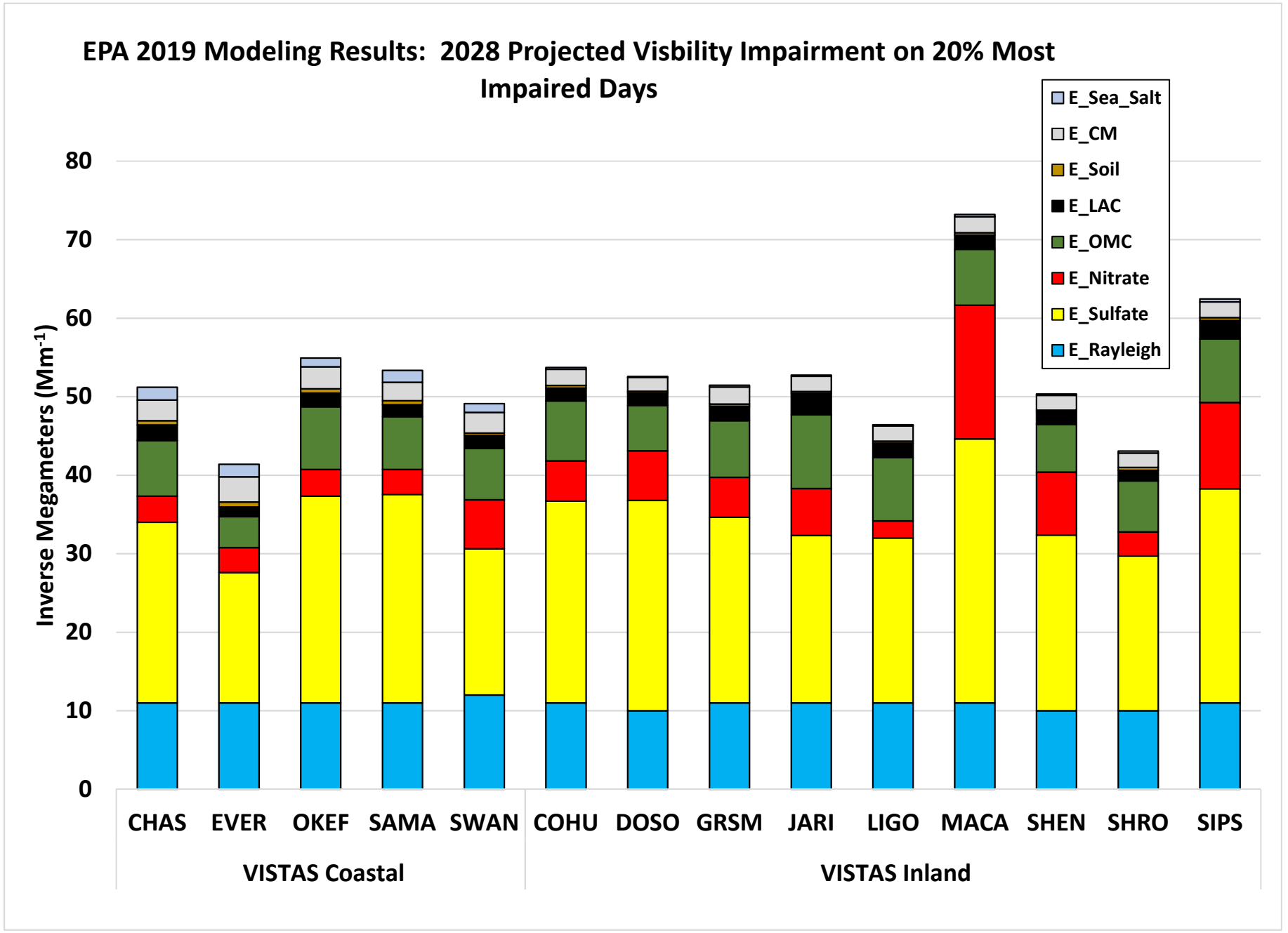
20% Most Impaired Days, 2028 Impacts, Inverse Megameters (Mm^{-1})															
Class I Area	EGU						NEGU						EGU + NEGU		
	Nitrate (N)		Sulfate (S)		N+S		Nitrate (N)		Sulfate (S)		N+S		N+S		
	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Total, delta_ extw	Total, delta_ extw_ adj	Ratio
ACAD	0.317	0.205	2.940	1.575	3.257	1.780	0.362	0.362	1.395	1.221	1.757	1.583	5.014	3.363	1.491
BADL	0.605	0.509	4.435	2.539	5.040	3.048	0.373	0.367	1.143	1.113	1.516	1.480	6.556	4.528	1.448
BAND	0.047	0.038	0.514	0.290	0.561	0.328	0.091	0.089	0.250	0.247	0.341	0.336	0.902	0.664	1.359
BIBE	0.034	0.024	1.913	0.961	1.947	0.985	0.051	0.050	0.562	0.541	0.613	0.591	2.560	1.576	1.625
BOAP	0.094	0.076	0.566	0.311	0.660	0.387	0.185	0.182	0.242	0.236	0.427	0.418	1.087	0.805	1.350
BOWA	1.565	1.155	5.451	2.941	7.016	4.096	1.794	1.742	2.486	2.402	4.280	4.144	11.296	8.239	1.371
BRET2	0.493	0.344	9.773	5.610	10.266	5.954	0.934	0.910	9.175	8.182	10.109	9.092	20.375	15.046	1.354
BRIG	1.970	1.291	11.498	6.103	13.468	7.394	1.933	1.917	4.755	4.214	6.688	6.130	20.156	13.524	1.490
CACR	2.090	1.474	15.985	8.159	18.075	9.634	1.623	1.576	4.222	4.042	5.845	5.618	23.920	15.252	1.568
CAVE	0.071	0.050	2.253	1.133	2.324	1.183	0.216	0.210	0.746	0.712	0.962	0.922	3.286	2.106	1.561
CHAS	0.518	0.377	8.058	5.107	8.576	5.484	0.514	0.515	4.287	3.761	4.801	4.276	13.377	9.760	1.371
COHU	0.370	0.267	12.271	7.306	12.641	7.573	0.442	0.435	4.946	4.550	5.388	4.986	18.029	12.558	1.436
DOSO	0.557	0.417	21.211	12.494	21.768	12.911	0.403	0.395	5.242	4.867	5.645	5.261	27.413	18.173	1.508
EANE	0.032	0.032	0.077	0.063	0.109	0.095	0.044	0.044	0.044	0.044	0.088	0.088	0.197	0.182	1.080
EVER	0.077	0.056	0.855	0.513	0.932	0.569	0.185	0.194	0.603	0.541	0.788	0.735	1.720	1.303	1.320
FLTO	0.032	0.032	0.077	0.063	0.109	0.095	0.044	0.044	0.044	0.044	0.088	0.088	0.197	0.182	1.080
GRGU	0.194	0.133	6.092	3.287	6.286	3.420	0.203	0.200	2.065	1.872	2.268	2.071	8.554	5.491	1.558
GRSA	0.114	0.107	0.401	0.262	0.515	0.369	0.183	0.182	0.183	0.180	0.366	0.362	0.881	0.731	1.205
GRSM	0.790	0.565	13.104	7.588	13.894	8.153	0.556	0.541	4.948	4.531	5.504	5.072	19.398	13.226	1.467
GUMO	0.071	0.050	2.253	1.133	2.324	1.183	0.216	0.210	0.746	0.712	0.962	0.922	3.286	2.106	1.561
HEGL	3.007	2.142	17.092	9.135	20.099	11.278	2.204	2.142	4.537	4.351	6.741	6.493	26.840	17.771	1.510
ISLE	1.530	1.121	6.691	3.723	8.221	4.844	1.777	1.723	3.006	2.876	4.783	4.599	13.004	9.443	1.377
JARI	0.595	0.417	14.824	8.467	15.419	8.883	0.553	0.549	4.420	4.124	4.973	4.673	20.392	13.557	1.504
JOYC	0.749	0.538	13.018	7.535	13.767	8.073	0.534	0.520	4.883	4.438	5.417	4.958	19.184	13.031	1.472
LIGO	0.317	0.226	12.462	7.058	12.779	7.284	0.295	0.288	5.107	4.695	5.402	4.983	18.181	12.266	1.482
LYBR2	0.601	0.405	9.020	4.681	9.621	5.086	0.723	0.715	3.308	2.908	4.031	3.623	13.652	8.708	1.568
MABE	0.032	0.032	0.077	0.063	0.109	0.095	0.044	0.044	0.044	0.044	0.088	0.088	0.197	0.182	1.080
MACA	2.887	2.060	20.613	12.017	23.500	14.077	2.411	2.346	7.905	7.412	10.316	9.758	33.816	23.835	1.419
MELA	0.979	0.914	2.897	2.510	3.876	3.424	0.545	0.541	1.120	1.105	1.665	1.646	5.541	5.070	1.093
MING	2.982	2.092	17.462	9.824	20.444	11.917	2.603	2.528	7.005	6.578	9.608	9.106	30.052	21.023	1.430
MOOS	0.182	0.121	2.473	1.316	2.655	1.438	0.206	0.204	1.382	1.179	1.588	1.383	4.243	2.821	1.504

20% Most Impaired Days, 2028 Impacts, Inverse Megameters (Mm^{-1})															
Class I Area	EGU						NEGU						EGU + NEGU		
	Nitrate (N)		Sulfate (S)		N+S		Nitrate (N)		Sulfate (S)		N+S		N+S		
	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Sum, delta_ extw	Sum, delta_ extw_ adj	Total, delta_ extw	Total, delta_ extw_ adj	Ratio
MOZI	0.137	0.136	0.229	0.215	0.366	0.351	0.063	0.063	0.079	0.079	0.142	0.142	0.508	0.492	1.032
OKEF	0.417	0.301	9.853	5.989	10.270	6.291	0.572	0.580	6.812	6.084	7.384	6.664	17.654	12.955	1.363
OTCR	0.581	0.436	20.759	12.249	21.340	12.685	0.420	0.411	5.169	4.824	5.589	5.235	26.929	17.919	1.503
PECO	0.049	0.042	0.424	0.242	0.473	0.284	0.076	0.075	0.188	0.185	0.264	0.259	0.737	0.543	1.356
PRRA	0.194	0.133	6.092	3.287	6.286	3.420	0.203	0.200	2.065	1.872	2.268	2.071	8.554	5.491	1.558
RAWA	0.137	0.136	0.229	0.215	0.366	0.351	0.063	0.063	0.079	0.079	0.142	0.142	0.508	0.492	1.032
ROCA	0.182	0.121	2.473	1.316	2.655	1.438	0.206	0.204	1.382	1.179	1.588	1.383	4.243	2.821	1.504
ROMA	0.838	0.616	10.570	6.363	11.408	6.980	0.954	0.963	5.904	5.541	6.858	6.503	18.266	13.483	1.355
ROMO	0.189	0.174	0.483	0.351	0.672	0.525	0.372	0.371	0.212	0.211	0.584	0.582	1.256	1.107	1.135
SACR	0.234	0.177	2.614	1.324	2.848	1.501	1.286	1.264	1.330	1.310	2.616	2.574	5.464	4.074	1.341
SAMA	0.388	0.279	8.394	4.880	8.782	5.159	0.549	0.545	6.656	5.686	7.205	6.231	15.987	11.390	1.404
SAPE	0.021	0.018	0.218	0.125	0.239	0.143	0.038	0.037	0.118	0.116	0.156	0.154	0.395	0.296	1.333
SENE	2.203	1.601	8.090	4.584	10.293	6.185	3.004	2.912	4.598	4.361	7.602	7.273	17.895	13.458	1.330
SHEN	0.707	0.522	16.874	9.342	17.581	9.864	0.481	0.474	4.438	4.048	4.919	4.522	22.500	14.387	1.564
SHRO	0.313	0.223	12.041	6.925	12.354	7.148	0.267	0.261	4.740	4.337	5.007	4.598	17.361	11.746	1.478
SIPS	1.243	0.873	14.948	8.635	16.191	9.507	1.137	1.106	5.300	4.857	6.437	5.963	22.628	15.470	1.463
SWAN	0.683	0.459	9.621	5.261	10.304	5.720	0.684	0.688	4.240	3.883	4.924	4.571	15.228	10.292	1.480
THRO	0.879	0.791	2.997	2.475	3.876	3.266	0.527	0.522	1.011	0.996	1.538	1.518	5.414	4.785	1.132
ULBE	0.260	0.245	1.023	0.808	1.283	1.052	0.095	0.093	0.389	0.379	0.484	0.472	1.767	1.525	1.159
UPBU	2.103	1.498	13.415	7.003	15.518	8.501	1.689	1.642	3.424	3.257	5.113	4.899	20.631	13.400	1.540
WEEL	0.032	0.032	0.077	0.063	0.109	0.095	0.044	0.044	0.044	0.044	0.088	0.088	0.197	0.182	1.080
WHIT	0.045	0.034	1.335	0.681	1.380	0.715	0.126	0.123	0.519	0.503	0.645	0.627	2.025	1.341	1.510
WHPE	0.049	0.042	0.424	0.242	0.473	0.284	0.076	0.075	0.188	0.185	0.264	0.259	0.737	0.543	1.356
WICA	0.590	0.541	2.547	1.726	3.137	2.268	0.476	0.473	0.660	0.651	1.136	1.123	4.273	3.391	1.260
WIMO	1.491	1.083	6.734	3.555	8.225	4.637	2.219	2.154	2.277	2.198	4.496	4.352	12.721	8.990	1.415
WOLF	0.379	0.275	9.712	5.899	10.091	6.174	0.522	0.528	6.374	5.806	6.896	6.334	16.987	12.508	1.358

Appendix E-8

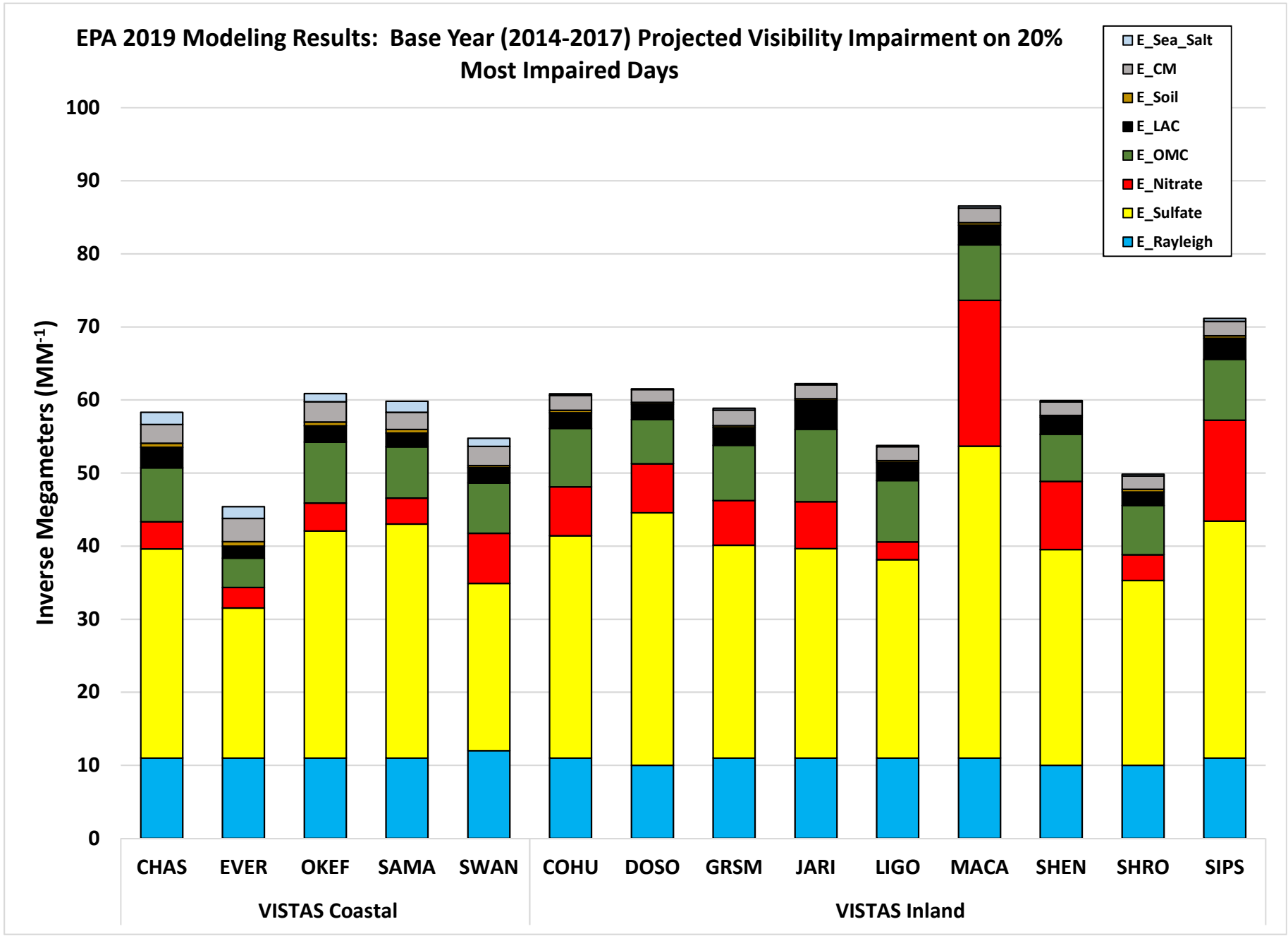
USEPA 2028 Model Projections of Visibility Impairing Species at VISTAS Class I Areas for 20% Most Impaired Days

This page intentionally left blank.



SMAT 2028 Bulk- EPA 2019 Modeling with graphics.xlsx-2028 20perMI

Row Labels	E_Rayleigh	E_Sulfate	E_Nitrate	E_OMC	E_LAC	E_Soil	E_CM	E_Sea_Salt
VISTAS Coastal								
CHAS	11	23.00	3.32	7.09	2.00	0.55	2.61	1.65
EVER	11	16.60	3.17	3.96	1.23	0.62	3.21	1.59
OKEF	11	26.34	3.40	7.99	1.75	0.53	2.81	1.12
SAMA	11	26.55	3.18	6.71	1.54	0.50	2.35	1.51
SWAN	12	18.64	6.24	6.55	1.65	0.29	2.65	1.12
VISTAS Inland								
COHU	11	25.69	5.13	7.64	1.62	0.35	2.07	0.21
DOSO	10	26.78	6.33	5.77	1.57	0.25	1.77	0.12
GRSM	11	23.64	5.08	7.22	1.81	0.29	2.18	0.23
JARI	11	21.33	5.98	9.40	2.71	0.25	1.94	0.14
LIGO	11	21.00	2.19	8.06	1.83	0.25	1.96	0.15
MACA	11	33.63	17.01	7.11	1.81	0.32	2.03	0.29
SHEN	10	22.38	8.00	6.10	1.59	0.22	1.87	0.19
SHRO	10	19.72	3.07	6.47	1.37	0.36	1.84	0.24
SIPS	11	27.26	10.99	8.11	2.34	0.36	2.01	0.37



SMAT 2028 Bulk- EPA 2019 Modeling with graphics.xlsx-2016 20per MI chart

Row Labels	E_Rayleigh	E_Sulfate	E_Nitrate	E_OMC	E_LAC	E_Soil	E_CM	E_Sea_Salt
VISTAS Coastal								
CHAS	11	28.63	3.69	7.39	2.83	0.54	2.59	1.65
EVER	11	20.54	2.80	4.01	1.66	0.59	3.20	1.59
OKEF	11	31.06	3.85	8.34	2.22	0.52	2.78	1.12
SAMA	11	32.04	3.54	7.00	1.91	0.49	2.33	1.51
SWAN	12	22.91	6.84	6.89	2.10	0.28	2.63	1.12
VISTAS Inland								
COHU	11	30.41	6.71	8.02	2.11	0.34	2.06	0.21
DOSO	10	34.58	6.70	6.04	2.12	0.25	1.73	0.12
GRSM	11	29.12	6.13	7.56	2.40	0.28	2.14	0.23
JARI	11	28.65	6.43	9.93	3.92	0.24	1.92	0.14
LIGO	11	27.15	2.43	8.40	2.46	0.24	1.93	0.15
MACA	11	42.69	19.94	7.59	2.70	0.33	2.01	0.29
SHEN	10	29.53	9.33	6.45	2.35	0.21	1.84	0.19
SHRO	10	25.31	3.52	6.74	1.85	0.36	1.82	0.24
SIPS	11	32.43	13.79	8.35	2.87	0.35	1.98	0.37

site_id	ss_Rayleigh	E_amm_so4_g90_b	E_amm_no3_g90_b	E_omc_g90_b	E_ec_g90_b	E_crustal_g90_b	E_cm_g90_b	E_sea_salt_g90_b	tbext_g90_b	E_amm_so4_g90_f	E_amm_no3_g90_f	E_omc_g90_f	E_ec_g90_f	E_crustal_g90_f	E_cm_g90_f	E_sea_salt_g90_f	tbext_g90_f
ACAD	12	16.72	5.13	6.45	1.81	0.18	1.99	1.42	45.69	13.57	5.22	5.97	1.34	0.18	2.03	1.42	41.73
AGTI	11	13.44	11.06	6.10	2.09	0.61	6.30	1.42	52.02	12.72	7.76	5.91	1.76	0.64	6.49	1.42	47.70
ALLA	11	9.12	7.45	6.06	1.75	0.19	1.09	0.38	37.05	8.87	5.94	5.87	1.37	0.20	1.11	0.38	34.75
ANAC	10	4.28	0.72	4.53	0.95	0.43	1.47	0.03	22.41	4.19	0.68	4.46	0.86	0.43	1.49	0.03	22.15
ANAD	9	6.81	4.17	5.98	1.20	0.79	3.04	0.21	31.20	6.68	3.23	5.85	1.10	0.79	3.06	0.21	29.93
ARCH	9	3.90	2.31	2.16	0.73	0.40	1.43	0.06	19.98	3.70	2.21	2.09	0.59	0.40	1.44	0.06	19.48
BADL	11	10.90	5.59	3.49	1.06	0.49	1.89	0.06	34.48	9.89	5.35	3.37	0.82	0.50	1.91	0.06	32.90
BALD	9	5.47	0.61	3.09	0.78	0.45	1.53	0.04	20.97	4.86	0.62	3.08	0.70	0.46	1.54	0.04	20.30
BAND	9	5.79	1.85	3.48	0.96	0.47	1.87	0.03	23.46	5.55	1.67	3.39	0.71	0.48	1.88	0.03	22.72
BIBE	10	20.57	1.10	4.63	1.46	0.90	3.68	0.10	42.45	19.58	1.14	4.71	1.42	0.93	3.74	0.10	41.63
BLCA	9	4.04	0.56	3.30	0.91	0.43	1.37	0.02	19.64	3.84	0.53	3.26	0.80	0.44	1.37	0.02	19.28
BOAP	10	5.90	2.45	4.74	1.53	0.63	3.19	0.14	28.57	5.82	2.09	4.70	1.36	0.64	3.20	0.14	27.95
BOMA	10	3.67	0.69	8.61	1.60	0.38	1.24	0.02	26.22	3.57	0.63	8.47	1.48	0.39	1.25	0.02	25.81
BOWA	11	12.72	13.16	4.07	1.36	0.20	1.54	0.16	44.21	11.59	10.67	3.83	1.13	0.20	1.55	0.16	40.13
BRET2	11	38.90	5.80	6.38	3.09	0.60	3.25	1.21	70.23	34.08	5.47	6.21	2.08	0.62	3.29	1.21	63.95
BRID	9	3.88	0.85	3.32	0.63	0.50	1.37	0.03	19.57	3.70	0.81	3.29	0.56	0.50	1.38	0.03	19.27
BRIG	12	26.00	20.73	9.76	3.95	0.29	5.18	1.17	79.08	19.79	18.42	9.13	2.61	0.30	5.26	1.17	68.67
CABI	10	4.44	1.13	8.20	1.50	0.43	1.37	0.06	27.12	4.33	1.05	8.09	1.43	0.44	1.38	0.06	26.78
CACR	11	31.23	8.94	8.36	2.23	0.55	2.88	0.47	65.66	23.53	7.56	8.10	1.80	0.59	2.92	0.47	55.96
CANY	9	3.90	2.31	2.16	0.73	0.40	1.43	0.06	19.98	3.70	2.21	2.09	0.59	0.40	1.44	0.06	19.48
CAPI	9	4.22	1.90	2.30	0.76	0.49	1.74	0.06	20.46	4.02	1.84	2.26	0.66	0.49	1.75	0.06	20.06
CARI	10	5.62	1.59	6.33	1.37	0.55	2.22	0.11	27.79	5.49	1.31	6.20	1.23	0.56	2.23	0.11	27.13
CAVE	9	14.87	1.59	3.57	1.01	1.53	4.38	0.09	36.03	14.33	1.56	3.58	0.91	1.56	4.42	0.09	35.46
CHAS	11	28.63	3.69	7.39	2.83	0.54	2.59	1.65	58.30	23.00	3.32	7.09	2.00	0.55	2.61	1.65	51.21
CHIR	10	7.69	0.81	2.59	0.81	0.65	3.26	0.05	25.86	6.55	0.80	2.60	0.73	0.67	3.29	0.05	24.69
CHIW	10	7.69	0.81	2.59	0.81	0.65	3.26	0.05	25.86	6.55	0.80	2.60	0.73	0.67	3.29	0.05	24.69
COHU	11	30.41	6.71	8.02	2.11	0.34	2.06	0.21	60.84	25.69	5.13	7.64	1.62	0.35	2.07	0.21	53.71
CRLA	9	6.40	1.18	4.01	1.23	0.48	1.00	0.16	23.47	6.31	1.09	3.94	1.13	0.48	1.01	0.16	23.12
CRMO	10	3.70	6.00	2.28	0.65	0.31	1.14	0.23	24.31	3.64	5.20	2.22	0.55	0.31	1.15	0.23	23.30
CUCA	9	7.85	11.50	4.72	1.38	0.58	3.77	0.61	39.41	7.74	8.09	4.66	1.10	0.58	3.81	0.61	35.59
DESO	9	4.86	1.14	6.78	1.36	0.57	2.02	0.07	25.80	4.76	0.97	6.61	1.26	0.57	2.03	0.07	25.28
DIPE	9	6.40	1.18	4.01	1.23	0.48	1.00	0.16	23.47	6.31	1.09	3.94	1.13	0.48	1.01	0.16	23.12
DOME	10	9.37	8.46	7.81	1.66	0.97	7.83	0.22	46.31	9.23	5.83	7.72	1.57	0.98	7.87	0.22	43.41

site_id	ss_Rayleigh	E_amm_so4_g90_b	E_amm_no3_g90_b	E_omc_g90_b	E_ec_g90_b	E_crustal_g90_b	E_cm_g90_b	E_sea_salt_g90_b	tbext_g90_b	E_amm_so4_g90_f	E_amm_no3_g90_f	E_omc_g90_f	E_ec_g90_f	E_crustal_g90_f	E_cm_g90_f	E_sea_salt_g90_f	tbext_g90_f
DOSO	10	34.58	6.70	6.04	2.12	0.25	1.73	0.12	61.54	26.78	6.33	5.77	1.57	0.25	1.77	0.12	52.59
EACA	10	6.35	8.66	4.73	1.28	0.30	1.17	0.15	32.64	6.20	7.47	4.61	1.12	0.30	1.18	0.15	31.03
EANE	8	3.54	0.87	1.88	0.63	0.59	1.00	0.05	16.57	3.35	0.86	1.86	0.55	0.60	1.01	0.05	16.27
EMIG	10	7.10	2.53	7.45	1.37	0.64	3.24	0.16	32.48	6.96	2.28	7.32	1.29	0.64	3.26	0.16	31.90
EVER	11	20.54	2.80	4.01	1.66	0.59	3.20	1.59	45.39	16.60	3.17	3.96	1.23	0.62	3.21	1.59	41.39
FITZ	9	3.88	0.85	3.32	0.63	0.50	1.37	0.03	19.57	3.70	0.81	3.29	0.56	0.50	1.38	0.03	19.27
FLTO	8	3.54	0.87	1.88	0.63	0.59	1.00	0.05	16.57	3.35	0.86	1.86	0.55	0.60	1.01	0.05	16.27
GALI	10	7.69	0.81	2.59	0.81	0.65	3.26	0.05	25.86	6.55	0.80	2.60	0.73	0.67	3.29	0.05	24.69
GAMO	9	3.93	1.07	4.65	0.87	0.43	1.18	0.03	21.15	3.83	1.14	4.59	0.78	0.44	1.19	0.03	20.99
GEMO	9	6.40	1.18	4.01	1.23	0.48	1.00	0.16	23.47	6.31	1.09	3.94	1.13	0.48	1.01	0.16	23.12
GICL	9	5.69	0.53	3.50	0.80	0.43	1.54	0.03	21.53	5.13	0.53	3.47	0.71	0.44	1.55	0.03	20.86
GLAC	11	5.62	6.17	12.29	3.21	0.31	1.59	0.14	40.32	5.39	5.96	12.03	2.87	0.31	1.60	0.14	39.30
GLPE	11	8.99	1.91	3.74	0.85	0.24	1.24	0.38	28.36	8.83	1.63	3.63	0.69	0.25	1.26	0.38	27.68
GORO	10	6.86	1.43	2.61	0.65	0.28	0.93	0.24	23.00	6.73	1.24	2.56	0.59	0.29	0.93	0.24	22.58
GRCA	9	4.71	0.97	2.42	0.69	0.73	1.39	0.07	19.98	4.28	0.94	2.40	0.65	0.72	1.39	0.07	19.45
GRGU	11	17.27	2.61	5.29	1.59	0.17	1.54	0.19	39.66	14.01	2.61	4.88	1.19	0.18	1.58	0.19	35.63
GRSA	9	4.27	1.14	4.62	1.22	0.54	1.56	0.02	22.37	4.04	1.12	4.56	1.06	0.55	1.57	0.02	21.91
GRSM	11	29.12	6.13	7.56	2.40	0.28	2.14	0.23	58.87	23.64	5.08	7.22	1.81	0.29	2.18	0.23	51.47
GRTE	9	3.51	0.98	5.18	0.99	0.42	1.37	0.07	21.52	3.41	0.92	5.12	0.91	0.43	1.38	0.07	21.24
GUMO	9	14.87	1.59	3.57	1.01	1.53	4.38	0.09	36.03	14.33	1.56	3.58	0.91	1.56	4.42	0.09	35.46
HECA	11	5.02	14.31	6.15	1.52	0.28	1.23	0.22	39.73	4.92	12.15	6.02	1.33	0.28	1.24	0.22	37.17
HEGL	11	26.50	16.05	8.07	2.60	0.38	2.84	0.30	67.75	21.37	13.36	7.73	2.17	0.38	2.86	0.30	59.18
HOOV	9	4.44	1.17	4.48	0.86	0.75	1.67	0.07	22.44	4.34	1.05	4.44	0.79	0.75	1.68	0.07	22.12
ISLE	12	16.49	16.50	4.54	1.67	0.18	1.84	0.21	53.43	14.73	13.99	4.27	1.33	0.19	1.85	0.21	48.56
JARB	10	3.98	0.67	3.56	0.69	1.02	2.51	0.03	22.47	3.91	0.64	3.53	0.62	1.02	2.52	0.03	22.27
JARI	11	28.65	6.43	9.93	3.92	0.24	1.92	0.14	62.22	21.33	5.98	9.40	2.71	0.25	1.94	0.14	52.75
JOMU	9	6.81	4.17	5.98	1.20	0.79	3.04	0.21	31.20	6.68	3.23	5.85	1.10	0.79	3.06	0.21	29.93
JOSH	10	7.65	7.24	4.37	1.34	0.90	5.21	0.41	37.14	7.43	5.92	4.32	1.18	0.93	5.32	0.41	35.50
JOYC	11	29.12	6.13	7.56	2.40	0.28	2.14	0.23	58.87	23.64	5.08	7.22	1.81	0.29	2.18	0.23	51.47
KAIS	9	6.81	4.17	5.98	1.20	0.79	3.04	0.21	31.20	6.68	3.23	5.85	1.10	0.79	3.06	0.21	29.93
KALM	12	7.12	1.86	7.58	1.39	0.25	1.54	1.71	33.46	6.91	1.75	7.41	1.26	0.25	1.54	1.71	32.83
KICA	11	12.91	21.27	13.51	2.53	0.69	5.30	0.39	67.59	12.74	12.39	13.21	2.21	0.69	5.34	0.39	57.97
LABE	10	5.60	1.73	6.41	1.19	0.52	1.76	0.09	27.30	5.47	1.50	6.30	1.10	0.52	1.76	0.09	26.75

site_id	ss_Rayleigh	E_amm_so4_g90_b	E_amm_no3_g90_b	E_omc_g90_b	E_ec_g90_b	E_crustal_g90_b	E_cm_g90_b	E_sea_salt_g90_b	tbext_g90_b	E_amm_so4_g90_f	E_amm_no3_g90_f	E_omc_g90_f	E_ec_g90_f	E_crustal_g90_f	E_cm_g90_f	E_sea_salt_g90_f	tbext_g90_f
LAGA	9	4.04	0.56	3.30	0.91	0.43	1.37	0.02	19.64	3.84	0.53	3.26	0.80	0.44	1.37	0.02	19.28
LAVO	10	5.62	1.59	6.33	1.37	0.55	2.22	0.11	27.79	5.49	1.31	6.20	1.23	0.56	2.23	0.11	27.13
LIGO	11	27.15	2.43	8.40	2.46	0.24	1.93	0.15	53.77	21.00	2.19	8.06	1.83	0.25	1.96	0.15	46.43
LOST	11	14.07	17.62	2.97	1.84	0.24	1.67	0.23	49.63	12.65	17.65	2.87	1.31	0.25	1.65	0.23	47.61
LYBR2	11	16.55	9.82	4.83	1.85	0.19	1.44	0.28	45.96	13.68	9.60	4.40	1.38	0.20	1.48	0.28	42.03
MABE	8	3.54	0.87	1.88	0.63	0.59	1.00	0.05	16.57	3.35	0.86	1.86	0.55	0.60	1.01	0.05	16.27
MACA	11	42.69	19.94	7.59	2.70	0.33	2.01	0.29	86.56	33.63	17.01	7.11	1.81	0.32	2.03	0.29	73.20
MAZA	10	5.65	1.94	3.29	1.05	0.73	2.94	0.15	25.75	5.06	1.90	3.24	0.86	0.74	2.97	0.15	24.91
MELA	11	13.29	14.93	2.62	1.33	0.29	2.00	0.11	45.57	13.24	13.87	2.57	1.01	0.30	2.01	0.11	44.12
MEVE	9	4.72	1.05	2.35	0.61	0.41	1.32	0.02	19.47	4.45	1.00	2.29	0.50	0.42	1.33	0.02	19.01
MIMO	10	3.67	0.69	8.61	1.60	0.38	1.24	0.02	26.22	3.57	0.63	8.47	1.48	0.39	1.25	0.02	25.81
MING	12	30.95	19.26	9.01	3.14	0.42	3.15	0.31	78.24	25.43	16.48	8.52	2.45	0.41	3.15	0.31	68.76
MOHO	10	7.05	2.54	3.34	0.86	0.33	1.27	0.44	25.84	6.81	2.11	3.29	0.80	0.33	1.28	0.44	25.05
MOJE	11	8.35	1.45	6.60	1.34	0.46	2.55	0.18	31.93	8.15	1.28	6.50	1.27	0.47	2.57	0.18	31.41
MOKE	9	4.86	1.14	6.78	1.36	0.57	2.02	0.07	25.80	4.76	0.97	6.61	1.26	0.57	2.03	0.07	25.28
MOLA	9	6.40	1.18	4.01	1.23	0.48	1.00	0.16	23.47	6.31	1.09	3.94	1.13	0.48	1.01	0.16	23.12
MOOS	12	15.10	3.38	4.97	1.46	0.16	1.33	0.95	39.34	13.31	3.48	4.55	1.12	0.16	1.38	0.95	36.95
MORA	11	10.65	2.34	7.43	2.16	0.23	1.81	0.28	35.91	10.18	1.95	7.19	1.71	0.23	1.85	0.28	34.40
MOWA	11	8.35	1.45	6.60	1.34	0.46	2.55	0.18	31.93	8.15	1.28	6.50	1.27	0.47	2.57	0.18	31.41
MOZI	8	4.01	1.14	2.15	0.55	0.47	1.04	0.02	17.37	3.82	1.09	2.11	0.46	0.49	1.04	0.02	17.04
NOAB	9	3.90	0.90	3.99	0.71	0.48	1.42	0.01	20.42	3.76	0.87	3.94	0.63	0.49	1.43	0.01	20.14
NOCA	11	8.99	1.91	3.74	0.85	0.24	1.24	0.38	28.36	8.83	1.63	3.63	0.69	0.25	1.26	0.38	27.68
OKEF	11	31.06	3.85	8.34	2.22	0.52	2.78	1.12	60.89	26.34	3.40	7.99	1.75	0.53	2.81	1.12	54.93
OLYM	11	10.48	4.29	4.34	1.08	0.17	1.27	0.81	33.44	10.38	3.59	4.30	0.91	0.17	1.31	0.81	32.48
OTCR	10	34.58	6.70	6.04	2.12	0.25	1.73	0.12	61.54	26.78	6.33	5.77	1.57	0.25	1.77	0.12	52.59
PASA	10	6.00	2.16	4.99	1.02	0.41	1.39	0.10	26.06	5.84	1.89	4.89	0.90	0.42	1.40	0.10	25.44
PEFO	9	5.03	1.07	3.19	1.41	0.69	2.65	0.05	23.10	4.67	1.00	3.13	1.18	0.70	2.68	0.05	22.41
PIMO	10	5.65	1.94	3.29	1.05	0.73	2.94	0.15	25.75	5.06	1.90	3.24	0.86	0.74	2.97	0.15	24.91
PINN	11	8.67	8.05	7.00	2.10	0.42	3.98	1.11	42.33	8.51	5.45	6.88	1.81	0.43	4.01	1.11	39.20
PRRA	11	17.27	2.61	5.29	1.59	0.17	1.54	0.19	39.66	14.01	2.61	4.88	1.19	0.18	1.58	0.19	35.63
RAFA	10	10.95	6.99	5.17	1.01	0.61	5.63	1.18	41.53	10.82	4.65	5.08	0.93	0.61	5.67	1.18	38.94
RAWA	8	4.01	1.14	2.15	0.55	0.47	1.04	0.02	17.37	3.82	1.09	2.11	0.46	0.49	1.04	0.02	17.04
REDR	9	3.51	0.98	5.18	0.99	0.42	1.37	0.07	21.52	3.41	0.92	5.12	0.91	0.43	1.38	0.07	21.24

site_id	ss_Rayleigh	E_amm_so4_g90_b	E_amm_no3_g90_b	E_omc_g90_b	E_ec_g90_b	E_crustal_g90_b	E_cm_g90_b	E_sea_salt_g90_b	tbext_g90_b	E_amm_so4_g90_f	E_amm_no3_g90_f	E_omc_g90_f	E_ec_g90_f	E_crustal_g90_f	E_cm_g90_f	E_sea_salt_g90_f	tbext_g90_f
REDW	11	11.14	2.63	2.83	0.43	0.11	2.23	6.65	37.02	10.88	2.26	2.80	0.38	0.12	2.24	6.65	36.32
ROCA	12	15.10	3.38	4.97	1.46	0.16	1.33	0.95	39.34	13.31	3.48	4.55	1.12	0.16	1.38	0.95	36.95
ROMA	12	29.33	3.87	8.56	2.34	0.50	3.44	1.28	61.33	24.38	3.69	8.30	1.75	0.52	3.50	1.28	55.42
ROMO	9	4.60	3.48	3.88	1.07	0.50	1.51	0.04	24.08	4.23	3.08	3.78	0.82	0.50	1.53	0.04	22.98
SACR	10	14.25	7.96	4.79	1.83	1.03	6.24	0.30	46.39	13.23	6.87	4.74	1.36	1.05	6.27	0.30	43.81
SAGA	9	7.85	11.50	4.72	1.38	0.58	3.77	0.61	39.41	7.74	8.09	4.66	1.10	0.58	3.81	0.61	35.59
SAGO	10	6.40	15.53	5.32	1.75	0.65	3.69	0.52	43.86	6.33	10.25	5.26	1.45	0.66	3.74	0.52	38.20
SAGU	10	6.93	1.97	3.47	1.41	1.25	4.68	0.18	29.90	5.98	1.82	3.38	1.06	1.26	4.70	0.18	28.38
SAJA	10	6.40	15.53	5.32	1.75	0.65	3.69	0.52	43.86	6.33	10.25	5.26	1.45	0.66	3.74	0.52	38.20
SAMA	11	32.04	3.54	7.00	1.91	0.49	2.33	1.51	59.82	26.55	3.18	6.71	1.54	0.50	2.35	1.51	53.35
SAPE	8	5.04	0.98	2.84	0.68	0.55	1.42	0.03	19.55	4.73	1.00	2.79	0.57	0.57	1.44	0.03	19.13
SAWT	10	3.01	0.44	7.32	1.24	0.49	1.10	0.02	23.61	2.93	0.41	7.22	1.10	0.49	1.11	0.02	23.29
SCAP	10	3.67	0.69	8.61	1.60	0.38	1.24	0.02	26.22	3.57	0.63	8.47	1.48	0.39	1.25	0.02	25.81
SELW	10	4.28	0.72	4.53	0.95	0.43	1.47	0.03	22.41	4.19	0.68	4.46	0.86	0.43	1.49	0.03	22.15
SENE	12	20.11	22.08	5.68	2.26	0.19	1.45	0.23	64.00	17.69	19.23	5.29	1.76	0.20	1.46	0.23	57.86
SEQU	11	12.91	21.27	13.51	2.53	0.69	5.30	0.39	67.59	12.74	12.39	13.21	2.21	0.69	5.34	0.39	57.97
SHEN	10	29.53	9.33	6.45	2.35	0.21	1.84	0.19	59.92	22.38	8.00	6.10	1.59	0.22	1.87	0.19	50.36
SHRO	10	25.31	3.52	6.74	1.85	0.36	1.82	0.24	49.84	19.72	3.07	6.47	1.37	0.36	1.84	0.24	43.07
SIPS	11	32.43	13.79	8.35	2.87	0.35	1.98	0.37	71.15	27.26	10.99	8.11	2.34	0.36	2.01	0.37	62.45
SOWA	10	5.60	1.73	6.41	1.19	0.52	1.76	0.09	27.30	5.47	1.50	6.30	1.10	0.52	1.76	0.09	26.75
STMO	10	6.35	8.66	4.73	1.28	0.30	1.17	0.15	32.64	6.20	7.47	4.61	1.12	0.30	1.18	0.15	31.03
SUPE	10	6.97	1.39	3.76	1.17	1.02	4.10	0.16	28.57	6.11	1.34	3.68	0.91	1.03	4.14	0.16	27.38
SWAN	12	22.91	6.84	6.89	2.10	0.28	2.63	1.12	54.77	18.64	6.24	6.55	1.65	0.29	2.65	1.12	49.13
SYCA2	9	4.32	0.91	6.17	2.40	3.49	7.13	0.11	33.52	4.04	0.89	6.08	2.16	3.51	7.17	0.11	32.96
TETO	9	3.51	0.98	5.18	0.99	0.42	1.37	0.07	21.52	3.41	0.92	5.12	0.91	0.43	1.38	0.07	21.24
THIS	11	8.35	1.45	6.60	1.34	0.46	2.55	0.18	31.93	8.15	1.28	6.50	1.27	0.47	2.57	0.18	31.41
THLA	10	5.62	1.59	6.33	1.37	0.55	2.22	0.11	27.79	5.49	1.31	6.20	1.23	0.56	2.23	0.11	27.13
THRO	11	11.91	9.88	2.47	1.13	0.28	2.24	0.14	39.04	11.29	8.75	2.38	0.83	0.28	2.26	0.14	36.93
ULBE	11	9.18	6.13	2.94	0.83	0.23	1.06	0.11	31.49	8.77	7.45	2.91	0.65	0.24	1.11	0.11	32.24
UPBU	11	27.14	11.95	8.08	2.22	0.53	2.36	0.39	63.68	21.61	10.32	7.83	1.89	0.55	2.38	0.39	55.97
VENT	11	8.67	8.05	7.00	2.10	0.42	3.98	1.11	42.33	8.51	5.45	6.88	1.81	0.43	4.01	1.11	39.20
VOYA	12	12.52	12.50	3.80	1.38	0.20	1.51	0.25	44.17	10.77	10.83	3.57	1.10	0.21	1.53	0.25	40.26
WASH	9	3.90	0.90	3.99	0.71	0.48	1.42	0.01	20.42	3.76	0.87	3.94	0.63	0.49	1.43	0.01	20.14

site_id	ss_Rayleigh	E_amm_so4_g90_b	E_amm_no3_g90_b	E_omc_g90_b	E_ec_g90_b	E_crustal_g90_b	E_cm_g90_b	E_sea_salt_g90_b	tbext_g90_b	E_amm_so4_g90_f	E_amm_no3_g90_f	E_omc_g90_f	E_ec_g90_f	E_crustal_g90_f	E_cm_g90_f	E_sea_salt_g90_f	tbext_g90_f
WEEL	8	3.54	0.87	1.88	0.63	0.59	1.00	0.05	16.57	3.35	0.86	1.86	0.55	0.60	1.01	0.05	16.27
WEMI	9	4.04	0.56	3.30	0.91	0.43	1.37	0.02	19.64	3.84	0.53	3.26	0.80	0.44	1.37	0.02	19.28
WHIT	9	8.44	2.07	3.70	0.98	0.76	3.03	0.14	28.12	8.14	1.95	3.68	0.81	0.78	3.05	0.14	27.56
WHPA	10	6.86	1.43	2.61	0.65	0.28	0.93	0.24	23.00	6.73	1.24	2.56	0.59	0.29	0.93	0.24	22.58
WICA	10	7.57	5.06	3.33	1.04	0.40	1.54	0.07	29.02	6.87	4.56	3.27	0.91	0.42	1.56	0.07	27.66
WIMO	11	22.85	14.95	6.93	2.40	0.58	4.21	0.33	63.26	18.41	12.88	6.79	1.81	0.60	4.24	0.33	56.07
WOLF	11	31.06	3.85	8.34	2.22	0.52	2.78	1.12	60.89	26.34	3.40	7.99	1.75	0.53	2.81	1.12	54.93
YELL	9	3.51	0.98	5.18	0.99	0.42	1.37	0.07	21.52	3.41	0.92	5.12	0.91	0.43	1.38	0.07	21.24
YOSE	10	7.10	2.53	7.45	1.37	0.64	3.24	0.16	32.48	6.96	2.28	7.32	1.29	0.64	3.26	0.16	31.90
ZION2	10	4.43	1.32	2.62	0.87	0.86	3.40	0.09	23.58	4.20	1.27	2.58	0.71	0.87	3.43	0.09	23.14

Column	Column Header	Column Description
A	site_id	Class I Area ID
B	type	unused
C	date	Base model year
D	monitor_gridcell	CAMx grid cell location of monitor
E	gridcell_lat	Latitude of grid cell centroid
F	gridcell_long	Longitude of grid cell centroid
G	monitor_lat	Latitude of IMPROVE monitor
H	monitor_long	Longitude of IMPROVE monitor
I	dv_best_b	2014-2017 IMPROVE deciviews 20% clearest days
J	dv_best_f	2028 projected deciviews 20% clearest days
K	dv_worst_b	2014-2017 IMPROVE deciviews 20% most impaired days
L	dv_worst_f	2028 projected deciviews 20% most impaired days
M	amm_so4_g10_b	2014-2017 observed total ammonium sulfate concentration- 20% clearest days (ug/m3)
N	s_amm_so4_g10_b	2014-2017 observed "small" ammonium sulfate concentration- 20% clearest days (ug/m3)
O	l_amm_so4_g10_b	2014-2017 observed "large" ammonium sulfate concentration- 20% clearest days (ug/m3)
P	amm_no3_g10_b	2014-2017 observed total ammonium nitrate concentration- 20% clearest days (ug/m3)
Q	s_amm_no3_g10_b	2014-2017 observed "small" ammonium nitrate concentration- 20% clearest days (ug/m3)
R	l_amm_no3_g10_b	2014-2017 observed "large" ammonium nitrate concentration- 20% clearest days (ug/m3)
S	omc_g10_b	2014-2017 observed total organic carbon mass concentration- 20% clearest days (ug/m3)
T	s_omc_g10_b	2014-2017 observed "small" organic carbon mass concentration- 20% clearest days (ug/m3)
U	l_omc_g10_b	2014-2017 observed "large" organic carbon mass concentration- 20% clearest days (ug/m3)
V	ec_g10_b	2014-2017 observed elemental carbon concentration- 20% clearest days (ug/m3)
W	crustal_g10_b	2014-2017 observed fine crustal mass concentration- 20% clearest days (ug/m3)
X	cm_g10_b	2014-2017 observed coarse mass concentration- 20% clearest days (ug/m3)
Y	sea_salt_g10_b	2014-2017 observed sea salt concentration- 20% clearest days (ug/m3)
Z	amm_so4_g90_b	2014-2017 observed total ammonium sulfate concentration- 20% most impaired days (ug/m3)
AA	s_amm_so4_g90_b	2014-2017 observed "small" ammonium sulfate concentration- 20% most impaired days (ug/m3)
AB	l_amm_so4_g90_b	2014-2017 observed "large" ammonium sulfate concentration- 20% most impaired days (ug/m3)
AC	amm_no3_g90_b	2014-2017 observed total ammonium nitrate concentration- 20% most impaired days (ug/m3)
AD	s_amm_no3_g90_b	2014-2017 observed "small" ammonium nitrate concentration- 20% most impaired days (ug/m3)
AE	l_amm_no3_g90_b	2014-2017 observed "large" ammonium nitrate concentration- 20% most impaired days (ug/m3)
AF	omc_g90_b	2014-2017 observed total organic carbon mass concentration- 20% most impaired days (ug/m3)
AG	s_omc_g90_b	2014-2017 observed "small" organic carbon mass concentration- 20% most impaired days (ug/m3)
AH	l_omc_g90_b	2014-2017 observed "large" organic carbon mass concentration- 20% most impaired days (ug/m3)
AI	ec_g90_b	2014-2017 observed elemental carbon concentration- 20% most impaired days (ug/m3)

Column	Column Header	Column Description
AJ	crustal_g90_b	2014-2017 observed fine crustal mass concentration- 20% most impaired days (ug/m3)
AK	cm_g90_b	2014-2017 observed coarse mass concentration- 20% most impaired days (ug/m3)
AL	sea_salt_g90_b	2014-2017 observed sea salt concentration- 20% most impaired days (ug/m3)
AM	ss_Rayleigh	Site specific Rayleigh scattering (Mm-1)
AN	E_amm_so4_g10_b	2014-2017 observed beta extinction (Mm-1) ammonium sulfate 20% clearest days
AO	E_amm_no3_g10_b	2014-2017 observed beta extinction (Mm-1) ammonium nitrate 20% clearest days
AP	E_omc_g10_b	2014-2017 observed beta extinction (Mm-1) organic carbon mass 20% clearest days
AQ	E_ec_g10_b	2014-2017 observed beta extinction (Mm-1) elemental carbon 20% clearest days
AR	E_crustal_g10_b	2014-2017 observed beta extinction (Mm-1) fine crustal 20% clearest days
AS	E_cm_g10_b	2014-2017 observed beta extinction (Mm-1) coarse mass 20% clearest days
AT	E_sea_salt_g10_b	2014-2017 observed beta extinction (Mm-1) sea salt 20% clearest days (observed IMPROVE data)
AU	tbext_g10_b	Total beta extinction (Mm-1) on the 20% clearest days (including Rayleigh)
AV	E_amm_so4_g90_b	2014-2017 observed beta extinction (Mm-1) ammonium sulfate 20% most impaired days
AW	E_amm_no3_g90_b	2014-2017 observed beta extinction (Mm-1) ammonium nitrate 20% most impaired days
AX	E_omc_g90_b	2014-2017 observed beta extinction (Mm-1) organic carbon mass 20% most impaired days
AY	E_ec_g90_b	2014-2017 observed beta extinction (Mm-1) elemental carbon 20% most impaired days
AZ	E_crustal_g90_b	2014-2017 observed beta extinction (Mm-1) fine crustal 20% most impaired days
BA	E_cm_g90_b	2014-2017 observed beta extinction (Mm-1) coarse mass 20% most impaired days
BB	E_sea_salt_g90_b	2014-2017 observed beta extinction (Mm-1) sea salt 20% most impaired days
BC	tbext_g90_b	2014-2017 observed total beta extinction (Mm-1) on the 20% most impaired days (including Rayleigh)
BC	amm_so4_g10_f	2028 total ammonium sulfate concentration- 20% clearest days (ug/m3)
BE	s_amm_so4_g10_f	2028 "small" ammonium sulfate concentration- 20% clearest days (ug/m3)
BF	l_amm_so4_g10_f	2028 "large" ammonium sulfate concentration- 20% clearest days (ug/m3)
BG	amm_no3_g10_f	2028 total ammonium nitrate concentration- 20% clearest days (ug/m3)
BH	s_amm_no3_g10_f	2028 "small" ammonium nitrate concentration- 20% clearest days (ug/m3)
BI	l_amm_no3_g10_f	2028 "large" ammonium nitrate concentration- 20% clearest days (ug/m3)
BJ	omc_g10_f	2028 total organic carbon mass concentration- 20% clearest days (ug/m3)
BK	s_omc_g10_f	2028 "small" organic carbon mass concentration- 20% clearest days (ug/m3)
BL	l_omc_g10_f	2028 "large" organic carbon mass concentration- 20% clearest days (ug/m3)
BM	ec_g10_f	2028 elemental carbon concentration- 20% clearest days (ug/m3)

Column	Column Header	Column Description
BN	crustal_g10_f	2028 fine crustal mass concentration- 20% clearest days (ug/m3)
BO	cm_g10_f	2028 coarse mass concentration- 20% clearest days (ug/m3)
BP	sea_salt_g10_f (from observed IMPROVE data)	2028 sea salt concentration- 20% clearest days (ug/m3) (from observed IMPROVE data)
BQ	amm_so4_g90_f	2028 total ammonium sulfate concentration- 20% most impaired days (ug/m3)
BR	s_amm_so4_g90_f	2028 "small" ammonium sulfate concentration- 20% most impaired days (ug/m3)
BS	l_amm_so4_g90_f	2028 "large" ammonium sulfate concentration- 20% most impaired days (ug/m3)
BT	amm_no3_g90_f	2028 total ammonium nitrate concentration- 20% most impaired days (ug/m3)
BU	s_amm_no3_g90_f	2028 "small" ammonium nitrate concentration- 20% most impaired days (ug/m3)
BV	l_amm_no3_g90_f	2028 "large" ammonium nitrate concentration- 20% most impaired days (ug/m3)
BW	omc_g90_f	2028 total organic carbon mass concentration- 20% most impaired days (ug/m3)
BX	s_omc_g90_f	2028 "small" organic carbon mass concentration- 20% most impaired days (ug/m3)
BY	l_omc_g90_f	2028 "large" organic carbon mass concentration- 20% most impaired days (ug/m3)
BZ	ec_g90_f	2028 elemental carbon concentration- 20% most impaired days (ug/m3)
CA	crustal_g90_f	2028 fine crustal mass concentration- 20% most impaired days (ug/m3)
CB	cm_g90_f	2028 coarse mass concentration- 20% most impaired days (ug/m3)
CC	sea_salt_g90_f	2028 sea salt concentration- 20% most impaired days (ug/m3) (from observed IMPROVE data)
CD	E_amm_so4_g10_f	2028 beta extinction (Mm-1) ammonium sulfate 20% clearest days
CE	E_amm_no3_g10_f	2028 beta extinction (Mm-1) ammonium nitrate 20% clearest days
CF	E_omc_g10_f	2028 beta extinction (Mm-1) organic carbon mass 20% clearest days
CG	E_ec_g10_f	2028 beta extinction (Mm-1) elemental carbon 20% clearest days
CH	E_crustal_g10_f	2028 beta extinction (Mm-1) fine crustal 20% clearest days
CI	E_cm_g10_f	2028 beta extinction (Mm-1) coarse mass 20% clearest days
CJ	E_sea_salt_g10_f	2028 beta extinction (Mm-1) sea salt 20% clearest days (observed IMPROVE data)
CK	tbext_g10_f	2028 Total beta extinction (Mm-1) on the 20% clearest days (including Rayleigh)
CL	E_amm_so4_g90_f	2028 beta extinction (Mm-1) ammonium sulfate 20% most impaired days
CM	E_amm_no3_g90_f	2028 beta extinction (Mm-1) ammonium nitrate 20% most impaired days
CN	E_omc_g90_f	2028 beta extinction (Mm-1) organic carbon mass 20% most impaired days
CO	E_ec_g90_f	2028 beta extinction (Mm-1) elemental carbon 20% most impaired days
CP	E_crustal_g90_f	2028 beta extinction (Mm-1) fine crustal 20% most impaired days
CQ	E_cm_g90_f	2028 beta extinction (Mm-1) coarse mass 20% most impaired days
CR	E_sea_salt_g90_f	2028 beta extinction (Mm-1) sea salt 20% most impaired days (from observed IMPROVE data)
CS	tbext_g90_f	2028 Total beta extinction (Mm-1) on the 20% most impaired days (including Rayleigh)
CT	rrf_g10_crustal	Modeled (2028/2016) fine crustal relative response factor (RRF) on 20% clearest days
CU	rrf_g10_no3	Modeled (2028/2016) nitrate relative response factor (RRF) on 20% clearest days

Column	Column Header	Column Description
CV	rrf_g10_oc	Modeled (2028/2016) organic carbon relative response factor (RRF) on 20% clearest days
CW	rrf_g10_ec	Modeled (2028/2016) elemental carbon relative response factor (RRF) on 20% clearest days
CX	rrf_g10_cm	Modeled (2028/2016) coarse mass relative response factor (RRF) on 20% clearest days
CY	rrf_g10_so4	Modeled (2028/2016) sulfate relative response factor (RRF) on 20% clearest days
CZ	rrf_g90_crustal	Modeled (2028/2016) fine crustal relative response factor (RRF) on 20% most impaired days
DA	rrf_g90_no3	Modeled (2028/2016) nitrate relative response factor (RRF) on 20% most impaired days
DB	rrf_g90_oc	Modeled (2028/2016) organic carbon relative response factor (RRF) on 20% most impaired days
DC	rrf_g90_ec	Modeled (2028/2016) elemental carbon relative response factor (RRF) on 20% most impaired days
DD	rrf_g90_cm	Modeled (2028/2016) coarse mass relative response factor (RRF) on 20% most impaired days
DE	rrf_g90_so4	Modeled (2028/2016) sulfate relative response factor (RRF) on 20% most impaired days