Appendix A

A-1. VISTAS II Quality Assurance Project Plan

A-2. VISTAS II Work Plan

A-3. VISTAS II Final Project Report for Contract

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Appendix A-1

Revised Quality Assurance Project Plan Southeastern VISTAS II Regional Haze Analysis Project

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Revised Quality Assurance Project Plan Southeastern VISTAS II Regional Haze Analysis Project

Prepared for:

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ERG Contract No. V-2018-03-01
SESARM Grant No. XA-00D53517

Prepared by:

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April 3, 2018

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TITLE and APPROVAL SHEET (A1)

Quality Assurance Project Plan for Southeastern VISTAS II Regional Haze Analysis Project for SESARM (Revision No. 3)

This QAPP 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).

April 3, 2018
Regi Oommen – ERG Program Manager and Technical Project Coordinator — Date

April 3, 2018
Darcy Wilson – ERG Deputy Program Manager and Project QA Coordinator — Date

April 3, 2018
Gregory Stella – Alpine Subcontract Manager — Date

April 3, 2018
John E. Hornback, SESARM Executive Director — Date

April 4 2018
Rick Gillam – U.S. EPA, Region 4 APTMD, Senior Modeler — Date

APRIL 4, 2018
Gregg Worley – U.S. EPA, Region 4 APTMD, Branch Chief — Date

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Abbreviations / Acronym List

Alpine	Alpine Geophysics, LLC
AMET	Atmospheric Evaluation Tool
APC	Administrative Project Coordinator
AQS	Air Quality System
ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing System
BNDEXTR	Program used to extract boundary conditions
CAMx	Comprehensive Air Quality Model with Extensions
CASTNET	Clean Air Status and Trends Network
CC	Coordinating Committee
CEM	Continuous Emissions Monitoring
CONUS	Continental United States
DIAG/DIAG2	Diagnostic output files from the boundary condition extraction program
DQOs	Data Quality Objectives
EGU	Electric generating unit
EPA	United States Environmental Protection Agency
ERG	Eastern Research Group, Inc.
FAA	Federal Aviation Administration
FLM	Federal Land Manager
FR	Federal Register
FTP	File Transfer Protocol
GB	Gigabtye
GIS	Geographic Information System
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory
IC/BC	Initial conditions and boundary conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
MAR	Marine/aircraft/rail
MB	Mean Bias
MDA8	Daily maximum 8-hour average
ME	Mean Error
MFB	Mean Fractional Bias
MFE	Mean Fractional Error
Modeled	Mean Modeled value
MPE	Model performance evaluation
NAAQS	National Ambient Air Quality Standards
NADP	National Acid Deposition Program
NAM-12	North American Mesoscale forecast data at the 12-km level
NCEI	National Centers for Environmental Information
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NO_x	Oxides of Nitrogen
NWS	National Weather Service
Observed	Mean Observed value
PM	Particulate matter

$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PSAT	Particulate Matter Source Apportionment Technology
PSD	Prevention of Significant Deterioration
QA	Quality Assurance
QA/G-5	Guidance for Quality Assurance Project Plans
QA/G-5M	Guidance for Quality Assurance Project Plans for Modeling
QA/QC	Quality assurance/quality control
QA/R-5	EPA Requirements for Quality Assurance Project Plans
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
R^2	Coefficient of Determination
RAID	Redundant Array of Independent Disks
RHR	Regional Haze Rule
RMSE	Root Mean Squared Error
RRFs	Relative response factors
SESARM	Southeastern States Air Resources Managers, Inc.
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOP	Standard Operating Procedure
SOW	Scope of Work
TAWG	Technical Analysis Work Group
VISTAS	Visibility Improvement - State and Tribal Association of the Southeast
VISTAS_12	12-km modeling domain for the VISTAS study area
WBAN	Weather Bureau Army-Navy

Document Control Table

Revision No.	Date	Comments
0	March 15, 2018	Draft QAPP submitted to SESARM
1	March 16, 2018	Revised QAPP submitted to SESARM
2	March 27, 2018	Revised QAPP submitted to SESARM based on SESARM comments
3	April 3, 2018	Revised QAPP submitted to SESARM based on EPA comments

DISTRIBUTION LIST (A3)

The approved version of this Quality Assurance Project Plan (QAPP) will be distributed to the staff listed in Table 1. The approved QAPP will be provided to all ERG and Alpine staff involved in the project, including those who join the project after initial distribution of the QAPP. SESARM will distribute the QAPP to the appropriate contacts on the Coordinating Committee and Technical Analysis Work Group.

Table 1. QAPP Distribution to Staff

Name Title	Contact Information	Mailing Address
SESARM		
John Hornback SESARM Executive Director	404.361.4000 hornback@metro4-sesarm.org	Southeastern States Air Resource Managers, Inc. 205 Corporate Center Drive, Suite D Stockbridge, GA 30281-7383
ERG		
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1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) addresses quality requirements for modeling projects and is responsive to all applicable elements specified by the United States Environmental Protection Agency (EPA)[1,2,3] in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5), EPA's *Guidance for Quality Assurance Project Plans* (EPA QA/G-5), and EPA's *Guidance for Quality Assurance Project Plans for Modeling* (EPA QA/G-5M). In development of this QAPP, ERG also reviewed SESARM's Quality Management Plan (QMP)[4] to ensure this QAPP meets the specifications in the QMP.

QAPP Approval and Distribution. This QAPP is approved and effective on the latest date the Approval Sheet is signed by any party. The ERG Program Manager or Alpine Subcontract Manager will provide the approved QAPP to all staff listed in the Distribution List and any other staff who work on the project. During the course of the project, the ERG Program Manager will also circulate any revision of the approved QAPP to all staff listed in the Distribution List. ERG will document the circulation of the original approved QAPP and any revised QAPP to project staff by maintaining the transmittal email message(s).

QAPP Organization. This QAPP is structured according to the outline in EPA document QA/G-5M. The remaining organization of this QAPP is:

- Section 2 Project Organization (A4);
- Section 3 Problem Definition and Background (A5);
- Section 4 Project Description and Schedule (A6);
- Section 5 Quality Objectives and Criteria for Model Inputs/Outputs (A7);
- Section 6 Special Training Requirements/Certifications (A8);
- Section 7 Documentation and Records (A9);
- Section 8 Measurement and Data Acquisition (Group B);
- Section 9 Assessments and Oversight (Group C); and
- Section 10 Data Validation and Usability (Group D).

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1 U.S. Environmental Protection Agency, "EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5", Office of Environmental Information, Washington, DC, EPA/240/B-01/003, March 2001. Reissued May 2006.

2 U.S. Environmental Protection Agency, "Guidance for Quality Assurance Project Plans, EPA QA/G-5", Office of Environmental Information, Washington, DC, EPA/240/R-02/009, December 2002.

3 U.S. Environmental Protection Agency, "Guidance for Quality Assurance Project Plans for Modeling, EPA QA/G-5M", Office of Environmental Information, Washington, DC, EPA/240/R-02/007, December 2002.

4 Southeastern States Air Resource Managers, Inc., "Quality Management Plan", March 2014.

1.1 Assessment of QAPP Implementation

ERG will conduct several stages of review during the planning and execution of this project to assure that the procedures outlined in this QAPP are followed. All tasks conducted and products generated receive (1) a conceptual review, (2) a developmental review, and (3) a final technical product review.

A **conceptual review** is performed during the initial stages of work development and ensures that the final product and associated documentation address the needs set forth by the SESARM Administrative Project Coordinator (APC), the Contract, and this QAPP.

The quality of intermediate deliverables and final products is also evaluated as these work products evolve. This **developmental review** includes, for example, (1) checks on calculations and data quality and (2) reviews of draft deliverables to ensure that the direction of work is consistent with the conceptual review outline.

Final product technical review is conducted on all deliverables prior to submittal to SESARM. Technical review is a documented critical review of work that has been performed. All deliverables will subsequently be reviewed by the SESARM APC, which may then be distributed to the Coordinating Committee (CC) and the Technical Analysis Work Group (TAWG). Reviewer comments in tracked changes will be stored on ERG's network in the same directory as the final document with the reviewer's initials and date in the file name. This provides a review history of the deliverable and documents reviewer comments. In addition, as specified in our contract-level QMP, we will employ our *Email Review Tracking System*. Our project team will maintain an internal quality assurance (QA) email mailbox to track team correspondence pertaining to deliverable reviews. This mailbox provides an auditable trail of the sequence and nature of deliverable reviews. The document author emails a review request to the reviewer and copies the QA email mailbox. The review request includes information to identify the document reviewed and the level of review (e.g., calculation review, technical review, senior review). Upon completion of the review, the reviewer responds to the author's email request and copies the QA email mailbox, adding "COMPLETED" to the subject heading.

Ms. Darcy Wilson, ERG's Project QA Coordinator, will assess the implementation of quality assurance/quality control (QA/QC) procedures on this project as follows:

- Review the QAPP (this document) for completeness and applicability, and
- Audit project files to ensure and verify the following:
  - That project staff have developed QC procedures and that these procedures are used; and
  - That project staff are documenting their use of these QC procedures by completing checklists, review spreadsheets, workflows, and other project-specific tracking methods.

Any quality deficiencies detected by technical reviewers or the Project QA Coordinator will be communicated, in writing, to the ERG Program Manager. The ERG Program Manager is responsible for ensuring that appropriate corrective action is taken. The Project QA Coordinator will notify the ERG Program Manager if, at any time, she considers the project to have quality deficiencies and they are not being remedied in a timely manner. Upon notification, the ERG Program Manager will conduct a project review. If he concurs that the work is deficient, he may issue a stop work order until the deficiencies are remedied. ERG will provide notifications to the SESARM APC when any significant quality deficiencies are identified that would potentially impact the acceptability of deliverables, the project schedule, project costs, and/or any other significant project criteria.

ERG will include any reports of corrective actions in the project QA files. At any time or at the end of the project, the Program Manager or the Project QA Coordinator may inspect the project QA files.

2 PROJECT ORGANIZATION (A4)

This section identifies project personnel and defines the project organization, roles, and responsibilities. The project organization structure is depicted in Figure 2-1 for staff with program management, technical support, or QA/QC roles. It shows the relationship and lines of authority, reporting, and communication among key ERG and Alpine project participants.

Mr. Regi Oommen, the ERG Program Manager and Technical Project Coordinator, will be the principal contact for SESARM on project issues, deliverables, and schedule. As Program Manager, Mr. Oommen has overall responsibility for planning and executing all work performed by ERG and Alpine under the contract and will:

- Ensure that the quality of work, schedule, and budget meet the requirements of the project;
- Provide technical direction to ERG staff and manage the daily activities on the project;
- Maintain the official, approved QAPP;
- Obtain appropriate technical review of all deliverables and ensure deliverables conform to ERG technical review requirements; and
- Keep the Project QA Coordinator advised of any quality problems that arise.

Mr. Oommen has the support of Ms. Darcy Wilson, the ERG Deputy Program Manager, for any issues that warrant elevation to develop strategies for mitigation and resolution. Ms. Wilson will provide senior level review, as needed. Ms. Wilson will also serve as ERG Project QA Coordinator. She is responsible for ensuring that the requirements of this QAPP are implemented and documented and may conduct an audit at any time to ensure quality review has occurred and been documented.

Mr. Oommen will be a principal investigator, leading Tasks 1 (Project Management), 2 (Emission Inventory Development), and 11 (Other Potential Tasks). Ms. Bebhinn Do, the ERG Data Librarian, will lead Tasks 4 (Data Acquisition and Preparation) and 5 (Area of Influence). Mr. Adam Langmaid, the ERG Digital Solutions Manager, will lead Task 10 (Data Handling and Sharing).

Mr. Gregory Stella, the Alpine Subcontract Manager, will be the principal contact for ERG on project deliverables and schedule. In addition, Mr. Stella will be a principal investigator, leading Tasks 3 (Emissions Processing), 8 (Model Performance Evaluation), and 9 (Future Year Model Projections). Mr. Stella will be supported by Mr. Dennis McNally of Alpine, who will lead Tasks 6 (Air Quality Modeling) and 7 (Source Apportionment Tagging).

Each Task Leader will draw upon all qualified personnel and equipment resources available at ERG and Alpine, to assemble the optimum skill sets for achieving each of the Tasks.

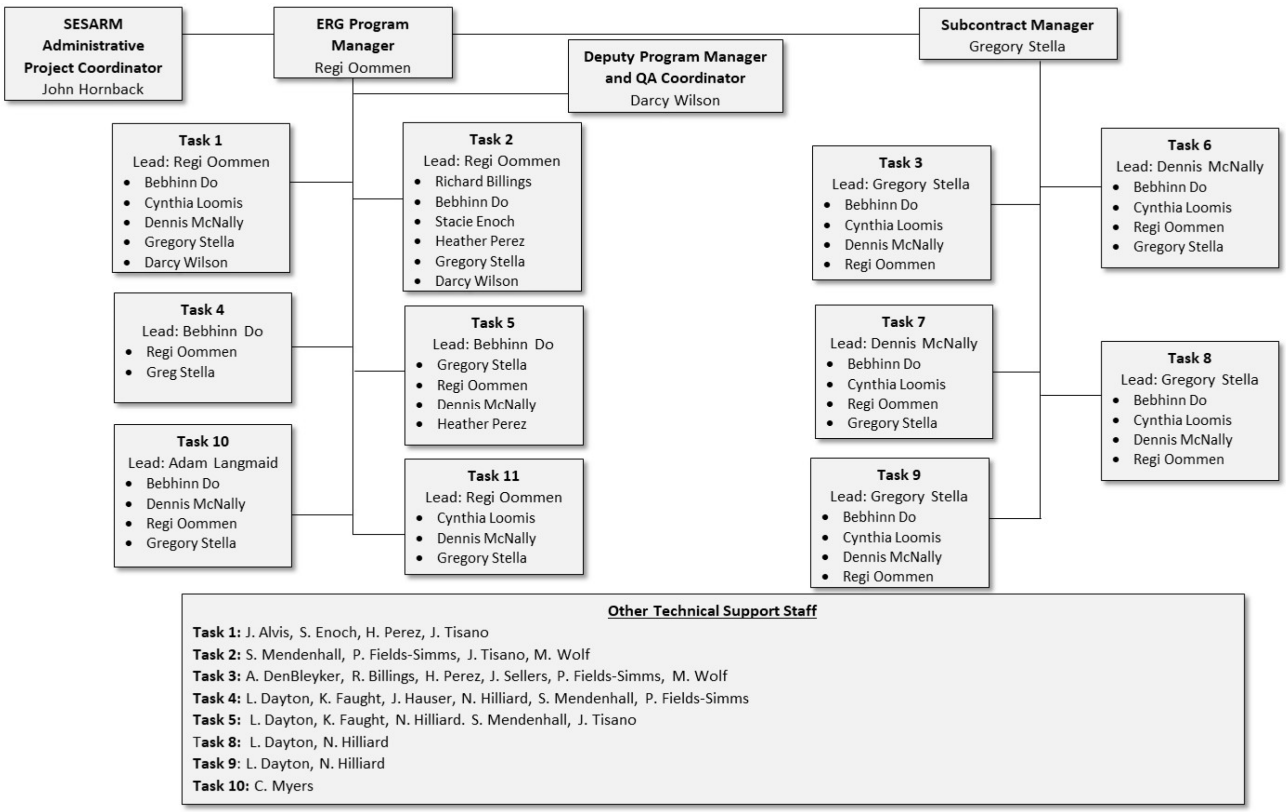

Figure 2-1. Project Organization Structure

The ERG Program Manager will be in regular communication with the SESARM APC (and/or the CC or TAWG) through periodic e-mails and telephone calls. The purpose of these communications will be to provide updates on progress, identify areas of technical concern, propose solutions to challenges where applicable, and discuss any preliminary results and/or data. ERG will provide a bulleted agenda to SESARM via email prior to each status meeting that will facilitate the discussion of progress and related issues. After each meeting, ERG will summarize the discussion for SESARM, including issue resolutions, action items, and responsible team members.

The ERG Program Manager and Alpine Subcontract Manager will prepare Project Instructions for the ERG/Alpine team, describing in detail the tasks and subtasks that are to be accomplished, milestone and deliverable schedules, and allocated resources per staff member. After the work plan and this QAPP are approved and notice to proceed is issued, ERG and Alpine Task Leaders will meet weekly or bi-weekly to monitor the technical activities of the team and ensure adherence to project budget, schedule, and quality specifications for deliverables.

3 PROBLEM DEFINITION AND BACKGROUND (A5)

The purpose of this project is to assist SESARM in evaluating current and projected future visibility in ten southeastern states: 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 Project analyses will support the states in their responsibilities to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The Clean Air Act 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 1999 Regional Haze Rule (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. There are 18 Class I areas located 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 improve visibility systematically to reach natural visibility conditions by 2064. The original RHR required states to improve visibility on the 20% worst days and protect visibility on the 20% least impaired 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 original RHR required 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 emission reduction measures that should be achieved by 2028, as was required by the original RHR. This extension will allow states to incorporate planning for other federal programs while conducting their regional haze planning. These other federal programs include: the Mercury and Air Toxics Standards, the 2010 1-hour 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 regional haze rule as amended defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview 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.

The SESARM member agencies 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 development, adoption, and implementation of strategies controlling and managing all air pollutants including fine particles, ozone, and 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 objectives of the VISTAS II Project include updating the Environmental Protection Agency's (EPA's) emission inventories for 2028, conducting a model performance evaluation (MPE) and air quality modeling, projecting potential 2028 visibility impacts in mandatory Class I Federal areas, conducting source apportionment analyses of results, providing presentations of results, producing project reports, and archiving support information and final conclusions. This project will mainly focus on emissions inventory development and emissions/air quality modeling. The work products resulting from this project will be used by the states to develop SIPs that are due to EPA by July 31, 2021.

This project is being funded under SESARM Grant # XA-00D53517. A project contract has been executed between SESARM and ERG, designated as Contract # V-2018-03-01.

This QAPP is one of several important project documents including the December 21, 2017 Request for Proposals, ERG's January 26, 2018 proposal, the referenced project contract executed on March 1, 2018, the project work plan, and numerous EPA quality assurance guidance and policy documents described in Section 1. Introduction of this QAPP. The content of this QAPP should be considered with other supporting, companion, and guidance documents in mind. Together, they constitute a comprehensive plan to produce necessary deliverables that are of acceptably high quality.

4 PROJECT DESCRIPTION AND SCHEDULE (A6)

4.1 Project Deliverables and Milestones

4.1.1 Task 1: Project Management

ERG will work closely with the SESARM APC to determine the number and size of the interim draft and interim final reports, which may be as frequent as the completion of each task or subtask. Each interim report will document the methodologies, data, and QA activities, and will act as stand-alone documents for their respective tasks. The interim reports from each task will serve as the basis of the final report. In preparation of the final report, ERG will prepare a detailed outline that will be provided to SESARM for review and comment. The final report will contain, at a minimum:

- An executive summary that provides a brief overview and summary of the modeling effort, emissions and air quality models used, model configuration, MPE overview and results, and rationale for the selected configuration;
- Summaries of QA procedures completed for the project;
- Technical details for all technical work performed as part of this project including:
  - Area of influence analysis,
  - Emissions inventory updates,
  - Emissions and air quality models used,
  - Model configuration and rationale, and
  - Model performance evaluation;
- Summaries and conclusions;
- A list of all final work products being delivered; and
- A discussion of data accessibility and availability for review by SESARM, stakeholders, and the public.

ERG will prepare a draft final report for SESARM review, and a final report will be prepared after receiving final comments from SESARM. ERG will submit two hard copies of the final report to SESARM for its files and for transmittal to EPA. An electronic copy of the report in Microsoft Word (.docx) format will be submitted to SESARM and will be made available in Adobe (.pdf) format on the Technical Website developed in Task 10 (Section 4.1.10).

Finally, ERG will provide project summaries in the form of slide presentations that can be distributed to VISTAS agencies and stakeholders to inform them of progress and findings. Each slide deck will contain the appropriate SESARM/VISTAS logo as prescribed by SESARM.

ERG will participate in up to two face-to-face meetings with the VISTAS agencies and any other invited guests.

4.1.2 Task 2: Emission Inventory Development

ERG will prepare EPA's 2011v6.3el base year and EPA's 2028v6.3el[5] and VISTAS' 2028 projected emission inventory files and ensure the data are in the proper formats for emissions modeling. Upon completion of the updates to the 2028 emissions as agreed upon, ERG will prepare state-specific final 2011 and 2028 emissions summaries for electric generating unit (EGU), non-EGU point, area, onroad, nonroad, fire, and marine/aircraft/rail (MAR) source categories. ERG will work with SESARM to determine the final format of the emission summaries which shall be compiled in separate Excel files for each SESARM state. The draft emission inventory comparisons will be prepared for VISTAS states review and finalized after comments are received.

4.1.3 Task 3: Emissions Processing

Alpine will prepare SMOKE-ready input files from the mass emissions data prepared in Task 2 (Section 4.1.2 of the QAPP).

4.1.4 Task 4: Data Acquisition and Preparation

The ERG/Alpine team will develop a database with Interagency Monitoring of Protected Visual Environments (IMPROVE), EPA's Air Quality System (AQS), National Atmospheric Deposition Program (NADP) deposition data, and meteorological data for use on this project. This database will provide a permanent record of the data used to support the MPE and the regional haze calculations. A final Microsoft Access Database (.accdb) will be provided that contains the observed data, station metadata, and data definitions table that documents each field in the database.

4.1.5 Task 5: Area of Influence

The ERG/Alpine team will use the IMPROVE data to identify upwind source regions contributing to the 20% most impaired days for each Class I area over the 2011-2016 period. The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model will be run for each of these days to identify areas most likely influencing visibility. The NAM-12 hybrid meteorology file will be used to run HYSPLIT. The ERG/Alpine team will use a combination of geographic information system (GIS) and *R* to analyze the trajectories and develop the gridded residence time plots and pollutant weight residence time plots. The ERG/Alpine team will include any *R* code, with documentation, as part of the project deliverables to provide a transparent analysis process, as well as the final shapefiles of the trajectories and gridded residence time analysis. The GIS or *R* generated gridded pollutant weighted residence time will then be linked with the 2011 and 2028 point source inventories to calculate the emission contribution from each source. This information will be summarized in separate Microsoft Excel

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5 The 2011v6.3el base year and 2028v6.3el data files are posted at: ftp://newftp.epa.gov/air/emismod/2011/v3platform/.

(.xlsx) format spreadsheets for each Class I area. A technical memorandum/interim report describing the area of influence calculations, and the results, will be prepared for SESARM.

4.1.6 Task 6: Air Quality Modeling

Alpine will use Version 6.40 of the Comprehensive Air Quality Model with Extensions (CAMx) and Particulate Matter Source Apportionment Technology (PSAT) to generate files and concentration data necessary to support air quality modeling to project visibility levels at individual Class I areas to 2028 and to estimate emissions sector contributions to 2028 PM concentrations and visibility. The ERG/Alpine team will document the modeling procedure in a draft protocol document and submit to SESARM for EPA review. Upon receipt of comments and revision requests by EPA and approved by SESARM, the ERG/Alpine team will make appropriate revisions to the document with plans to incorporate any revised direction into the air quality modeling itself.

4.1.7 Task 7: Source Apportionment Tagging

Alpine will tag 2028 emissions using CAMx PSAT modeling and using SESARM identified combinations of regions, facilities, and/or source categories. For this task, only sulfate and nitrate will be tracked using PSAT. During analysis for the initial regional haze SIPs, analysis found that in the southeast ammonium sulfate ($(NH_4)_2SO_4$), predominantly from sulfur dioxide (SO_2) emissions from EGUs and industrial sources, contributes 60 –70% of the light extinction on the 20% haziest days.[6] Current analysis of IMPROVE measurements continue to confirm the important of sulfate to visibility impairment on the 20% worst days though the southeast.[7] In addition to sulfate, nitrate is relatively high contributor at sites from Oklahoma thru Kentucky and is generally of concern with respect to transport from VISTAS states Class I areas outside VISTAS. The initial VISTAS analysis showed that the impacts from elemental carbon are minimal on the 20% worst days, and higher impacts from organic carbon. However, the impacts from organic carbon are dominated by biogenic emissions, not anthropogenic emissions, which can be controlled. Tracking of these and other PM species (i.e., elemental carbon, organic carbon, etc.) that contribute to visibility impairment may of some use, but has not been requested in this analysis.

4.1.8 Task 8: Model Performance Evaluation

Alpine will review EPA’s current operational MPE for particulate matter ($PM_{2.5}$ species components and coarse PM) and regional haze to compare the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. Alpine will prepare comprehensive MPE statistics and graphics from the 2011 CAMx simulation using data from the IMPROVE

6 Patricia Brewer & Tom Moore (2009) Source Contributions to Visibility Impairment in the Southeastern and Western United States, Journal of the Air & Waste Management Association, 59:9, 1070-1081, DOI: 10.3155/1047-3289.59.9.1070.

7 U.S. Environmental Protection Agency. 2016. Technical Support Document (TSD) Revised Recommendations for Visibility Progress Tracking Metrics for the Regional Haze Program U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Air Quality Assessment Division Research Triangle Park, NC 27711. July 2016.

network. A technical document describing the performance evaluation and results will be prepared for SESARM.

The ERG/Alpine team include MPE for weekly wet deposition and weekly dry deposition species. For the model performance evaluation, VISTAS CAMx results will be aggregated to appropriate time periods to match the various NADP monitoring network's collection times. To prevent confounding the MPE, the networks with different collection time (i.e., biweekly versus weekly) will be examined separately. Annual mean MPE statistics, similar to the statistics for the base year MPE, will be developed for wet deposition and dry deposition species available. Analysis will also include scatter plots of NADP observations versus CAMx predictions, and their correlation (r), both annually and by season. Statistics and scatter plots will also be examined by VISTAS state to provide more refined MPE information to facilitate further use by the states.

4.1.9 Task 9: Future Year Model Projections

The ERG/Alpine team will calculate relative response factors (RRFs) for each IMPROVE monitor in the VISTAS_12 modeling domain and prepare/update related graphics and charts. A technical memorandum/interim report describing the projections, methods, and results will be prepared for SESARM. Upon completion of this task, Alpine will work with ERG to develop procedures necessary to upload all future year regional haze visibility projections and supporting data on the website or dedicated file transfer protocol (FTP) site to be developed in Task 10 (Section 4.1.10 of the QAPP).

The ERG/Alpine team will also calculate the RRFs and future year projections of weekly wet deposition and weekly dry deposition species. RRFs for each deposition site will be calculated consistent with EPA guidance for calculating RRFs Ozone and $PM_{2.5}$ species. Future year projections will be developed for each site by multiplying the RRF by monitored values. The ERG/Alpine team will consult with SESARM on the averaging time used for the development of the RRFs. At a minimum, we would produce annual and maximum weekly RRFs and future projections to provide an estimate of annual and short-term loading changes.

4.1.10 Task 10: Data Handling and Sharing

The ERG/Alpine team will develop and implement a solution for the distribution and archival of project assets (emissions and air quality modeling output, summaries, and other project documentation). The ERG/Alpine team will work with SESARM to develop an effective data handling and sharing scheme.

The ERG/Alpine team will also develop a Standard Operating Procedure (SOP) for uploading files to sites such as SharePoint and the Metro 4/SESARM Drupal website. The SOP will address:

- File formats for all project asset types (e.g., model outputs);
- The review/approval process for publishing files and updates to either or both of the websites;

- Routines for publishing the model outputs after each run is complete, allowing SESARM to review the results in a timely manner; and
- Instructions for downloading content for offline access.

4.1.11 Task 11: Other Potential Tasks

ERG will provide support to SESARM for additional work not included in the original Scope of Work (SOW) in the Request for Proposals. Such support may involve assisting the member states in developing regional haze SIPs. Prior to contract execution, SESARM determined that subtasks would be required for data extractions of initial conditions and boundary conditions (IC/BC) and state-specific meteorological data files for up to five states. An additional five states may be requested by SESARM for each of the subtasks.

4.1.12 Task Deliverable Summary and Schedule

The ERG Program Manager and Alpine Subcontract Manager will work with each of the Task Leaders to ensure that the deliverables listed in Table 4-1 are met.

Table 4-1. Task Deliverable Summary and Schedule

Task/Subtask	Deliverable to SESARM or Internal Project Milestone	Deliverable or Milestone Date
Contract Award	Notification of award	February 20, 2018
Task 1: Project Management [Responsible Person: Regi Oommen]		
Contract Management	Project Milestone	Ongoing
Contract Development	Completed March 1, 2018	March 1, 2018
Work Plan Development	Draft delivered March 13, 2018	March 16, 2018
QAPP Development	Draft delivered March 15, 2018	March 16, 2018
Communications and Presentations		Ongoing
Reporting – Progress Reports	Deliverable	Monthly, within two weeks after the end of the month.
Reporting – Draft Interim Reports	Deliverable	Completion of tasks or subtasks
Reporting – Final Interim Reports	Deliverable	Within 2 weeks of receiving comments
Reporting – Draft Final Report	Milestone	May 8, 2019
Reporting – Final Report	Deliverable	July 1, 2019

Table 4-1. Task Deliverable Summary and Schedule

Task/Subtask	Deliverable to SESARM or Internal Project Milestone	Deliverable or Milestone Date
Reporting – Presentation Slides	Deliverable	Ongoing, as-needed
Invoicing	Deliverable	Monthly, within two weeks after the end of the month.
Task 2: Emission Inventory Development [Responsible Person: Regi Oommen]		
2011 Base Year Emissions Inventories	Deliverable	June 1, 2018
Projection Year Emissions Inventory Comparisons, draft	Draft Deliverable	May 18, 2018
Projection Year Emissions Inventory Comparisons, final	Deliverable	Within one week of receiving comments
Revisions to 2028 Projection Year Emissions Inventories, draft	Draft Deliverable	May 18, 2018
Revisions to 2028 Projection Year Emissions Inventories, final	Deliverable	Within one week of receiving comments
2028 EGU Point Source Emissions, draft	Draft Deliverable	May 18, 2018
2028 EGU Point Source Emissions, final	Deliverable	Within one week of receiving comments
2028 Non-EGU Point Source Emissions, draft	Draft Deliverable	May 18, 2018
2028 Non-EGU Point Source Emissions, final	Deliverable	Within one week of receiving comments
2028 Emissions for Other Categories, draft	Draft Deliverable	May 18, 2018
2028 Emissions for Other Categories, final	Deliverable	Within one week of receiving comments
Emission Comparisons from 2028v6.3el and 2023v6.3en, draft	Draft Deliverable	May 18, 2018
Emission Comparisons from 2028v6.3el and 2023v6.3en, final	Deliverable	Within one week of receiving comments
Documentation for Emission Comparisons from 2028v6.3el and 2023v6.3en, draft	Draft Deliverable	May 18, 2018
Documentation for Emission Comparisons from 2028v6.3el and 2023v6.3en, final	Deliverable	Within one week of receiving comments
2028 Documentation, draft	Draft Deliverable	May 18, 2018

Table 4-1. Task Deliverable Summary and Schedule

Task/Subtask	Deliverable to SESARM or Internal Project Milestone	Deliverable or Milestone Date
2028 Documentation, final	Deliverable	Within one week of receiving comments
Emission Summaries and QA	Deliverable	June 1, 2018
Task 3: Emissions Processing [Responsible Person: Gregory Stella]		
Create Photochemical Model Ready-EGU Emission Files for 2028	Deliverable	July 1, 2018
Full EGU Emissions Replacement	Not applicable	Task not funded
Scale Hourly EGU SMOKE to Match Annual 2028 Emissions	Deliverable	July 1, 2018
Create photochemical Model-Ready Non-EGU Emission Files for 2028	Deliverable	July 1, 2018
Merge EGU and non-EGU Data from Subtasks 3.1 and 3.2 for CAMx Modeling	Deliverable	July 1, 2018
Merge area/MAR data from Subtasks 3.1 and 3.2 for CAMx Model	Deliverable	July 1, 2018
Task 4: Data Acquisition and Preparation [Responsible Person: Bebhinn Do]		
Data Acquisition and Preparation	Deliverable	June 1, 2018
Collecting Additional Data (weekly wet deposition and weekly dry deposition)	Deliverable	Not specified, but would have to be completed by June 1, 2018.
Task 5: Area of Influence [Responsible Person: Bebhinn Do]		
Area of Influence Analysis	Deliverable	September 1, 2018
SO_2 and NO_x Emissions Contributions Rankings	Deliverable	Not specified, but would have to be completed by September 1, 2018.
Task 6: Air Quality Modeling [Responsible Person: Dennis McNally]		
Modeling Protocol, draft	Draft Deliverable	May 2, 2018
Modeling Protocol, final	Deliverable	Within 2 weeks of receiving comments
2011 Base Year Air Quality Modeling	Deliverable	September 1, 2018
2028 Projection Year Air Quality Modeling	Deliverable	December 1, 2018

Table 4-1. Task Deliverable Summary and Schedule

Task/Subtask	Deliverable to SESARM or Internal Project Milestone	Deliverable or Milestone Date
Task 7: Source Apportionment Tagging [Responsible Person: Dennis McNally]		
Source Apportionment Tagging*	Deliverable	April 1, 2019
Task 8: Model Performance Evaluation [Responsible Person: Gregory Stella]		
Model Performance Evaluation of 2011 Modeling	Deliverable	October 1, 2018
Model Performance Evaluation Related to Optional Subtask 4.1	Deliverable	October 1, 2018
Task 9: Future Year Projections [Responsible Person: Gregory Stella]		
Future Year Model Projections (minus PSAT runs)	Deliverable	December 31, 2018
Future Year Model Projection (with PSAT runs)	Deliverable	April 19, 2019
Calculate Relative Response Factors related to Optional Subtask 4.1	Deliverable	May 3, 2019
Task 10: Data Handling and Sharing [Responsible Person: Adam Langmaid]		
Website/FTP Site Development; Data Transfer and Archival	Deliverable	Ongoing, but to be completed by July 1, 2019
Task 11: Other Potential Tasks [Responsible Person: Regi Oommen]		
Other Potential Tasks (Not Defined)	Deliverable	Not specified, but to be completed by July 1, 2019
Other Potential Tasks (Defined): Extraction – IC/BC Data	Deliverable	Within 1 week after completion of Task 6.1 and 6.2 activities
Other Potential Tasks (Defined): Extraction – Meteorological Data	Deliverable	Within 1 week after regions are defined by the time the meteorological data is windowed for the VISTAS_12 domain

*250 tags – final number to be determined.

5 QUALITY OBJECTIVES AND CRITERIA FOR MODEL INPUTS/OUTPUTS (A7)

5.1 Data Quality Objectives, Performance Criteria, and Acceptance Criteria

This QAPP was prepared to ensure that (1) modeling input data are valid and defensible, (2) CAMx model set up is adequately documented in the protocol and final report, (3) model output data are reviewed and evaluated in a consistent manner and (4) that any analysis based on any of the modeling (e.g., RRFs) is reviewed and evaluated in a consistent manner.

The Data Quality Objectives (DQOs) specify the acceptance criteria for existing model input, and validation of data. DQOs identify the (1) type and quality of data that will be appropriate for use in the modeling project, (2) spatial and temporal input data coverage requirements, (3) data quality, and (4) technical soundness of the collection methodology. A list of related requirements is shown below.

- All input data for the model will be of known and documented quality.
- Meteorological and ambient monitoring data will be collected from as many sources as available and provide the maximum temporal and spatial coverage of the modeling domain.
- Modeling data will be representative of the parameters being measured with respect to time, location, and the conditions from which the data are obtained.

DQOs for the air quality modeling specifically include the ability to:

- Replicate base case air quality conditions.
- Estimate future air quality conditions, both spatially and temporally.
- Evaluate relative contributions of various pollutants to visibility impairment in the Class I areas.
- Identify the source(s) most likely influencing visibility in the Class I areas.

This project primarily uses data that were previously collected for a different intended use. For example, the emissions inventories for the base case modeling were developed by EPA for NAAQS regulatory purposes. The main objective is to evaluate the data quality to ensure that it meets the project's needs to generate reproducible and defensible modeling results to support VISTAS states' Regional Haze SIP submittals. Data used for this objective will be screened for the following:

- Completeness – All publicly-available data available will be collected and catalogued. At the onset of collection, the datasets will be assessed for missing data, including full documentation of collection and QA procedures. Datasets falling below certain completion thresholds will not be used in the analysis, and those completion thresholds are dependent upon the type of data used. For example:

- Time-period averaging. If annual average concentrations are to be developed, then ERG will require temporal completeness of 75% completeness for an entire year. This is consistent with averaging schemes used for criteria pollutants.[8]

- Meteorological measurements. For any observed data collected for the study, each measure will be subjected to the same completeness criteria as the Prevention of Significant Deterioration (PSD) program.[9] Any measurement failing to meet this criterion will be flagged. All meteorology modeling files used in this project were generated by EPA and will be checked to ensure all files needed have been obtained and contain all hours and parameters need for modeling.

- Emissions. Completeness checks for emissions include evaluating PM species, such as complete reporting of the filterable and condensable portions, as well as expected pollutants from source categories. Additionally, emission totals for 2011 will be compared to EPA-published Tier-level emissions.[10] Finally, ERG will check for stack parameter completeness for point sources that are necessary for emissions modeling.

Datasets below the prescribed completeness will not be used in any analysis, but will be retained and flagged as failing to meet completeness criteria. If analysis is performed for smaller time intervals (e.g., seasonal), completeness criteria will be reevaluated and data meeting completeness criteria for the smaller time intervals may be used.

- Representativeness – Collected data will be assessed for representativeness against similar datasets. For example, data distribution statistics will be calculated once the data has been collected, and those statistics will be compared to similar datasets. Statistics include minimum value, maximum value, and percentiles (5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th}). ERG will only compare datasets that are representative to one another, such as $PM_{2.5}$ measurements from the IMPROVE network being compared to other rural $PM_{2.5}$ monitoring sites. Representativeness is also evaluated for identifying data from other sources that can be used as surrogates. For example, if meteorological observations may be incomplete or not taken at a particular monitoring site, ERG would identify the closest, most representative meteorological station and use the data as a surrogate.

8 40 CFR Part 50.

9 Bailey, D. T., 2000: Meteorological monitoring guidance for regulatory modeling applications. Environmental Protection Agency Rep. EPA-454/R-99-005, 168 pp. [available at http://www.epa.gov/scram001/guidance/met/mmgrma.pdf.]

10 US Environmental Protection Agency. 2011el_cb6v2v6_11g_state_sector_totals. ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/reports/2011el_and_2023el/2011el_cb6v2_v6_11g_state_sector_totals.xlsx (accessed on March 29,2018).

- Compatibility – Compare compatible versions of emission inventory data—for example, base year emissions compared to the projected emissions—to characterize differences and evaluate significant differences, if found. This include keeping records of how the future year emission estimates have been adjusted and the justification for those adjustments.

- Accuracy – Verify all calculations and revisions based on the data received. This includes verifying and changes to emissions based on a percent reduction, and assuring any values transcribed from one data source to another were not erroneously copied. These verifications will be performed by a staff member who was not involved in the initial identification and collection of the data.

5.2 Task Description and Intended Uses of Output

The project will utilize previously collected meteorological, ambient monitoring data, meteorological modeling, and emission inventories. As recommended in current EPA regional haze modeling guidance, the use of monitoring data will help ensure that the modeling effort yields accurate predictions with an acceptable level of model uncertainty as compared to other, similar modeling exercises.[11] Calculation to this end will only use monitoring data sources with a QAPP in place. That is, only data from reputable sources that follow standardized and quality-controlled data collection procedures will be used. Data with unknown quality (i.e., collected without a documented QAPP or using unapproved SOPs) will not be acceptable for use.

For the existing emission inventories, ERG will verify the emission totals in the files received match the total emissions in EPA published summaries for the 2011 and 2028v6.3el model platform. ERG will independently check each data point to verify the correct value and units.

The existing EPA 2011 WRF meteorological modeling files will be used without modification. EPA has already conducted a thorough review of the modeling, including quantitative review of the 2-meter temperature and mixing ratio, 10-meter wind speed and direction, and shortwave radiation and a qualitative evaluation of precipitation. The quantitative metrics used in model performance included: mean bias, mean (gross) error, fractional bias, and fractional error.[12] Overall, the WRF modeling was deemed acceptable for use by EPA.

For the modeling platform, Alpine will replicate EPA base year modeling to ensure that all modeling options have been applied correctly, thus ensuring the ability to compare SESARM future year estimates to EPA's efforts. The modeling output will be evaluated against the collected ambient monitoring data, to ensure replication of the base year conditions. The comparison will be performed using the Atmospheric Evaluation Tool (AMET) and custom

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[11] Wayland, R. 2014. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. Memorandum. http://www3.epa.gov/scram001/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance2014.pdf

[12] U.S. Environmental Protection Agency. 2014. Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation. (available at: https://www3.epa.gov/scram001/reports/MET_TSD_2011_final_11-26-14.pdf)

scripts developed by Alpine, which have been thoroughly vetted on previous projects. The modeling protocol developed under Task 6.1 will outline the graphics and statistics to be used in evaluating model performance, as does Section 10.2 of this QAPP.

5.3 Requirements for Hardware/Software Configuration

For hardware, ERG and Alpine periodically review their equipment inventory to ensure that they are adequate for the needs of the project. For example, ERG rotates computer resources to each staff member every three years, and high-end users receive the more powerful computers in terms of processing speed and storage. All computers and laptops are currently equipped with the Windows10 operating software and the Microsoft Office Professional 2016 Suite. Recently, ERG built a state-of-the-art server farm at its Corporate headquarters that will house the meteorological, ambient, and emissions data to be used for this project. Similarly for software, ERG and Alpine often customize their networks to optimize performance and speed for data-intensive projects. Specific details on Alpine's high-performance computing cluster is in Section 8.10.2 of this QAPP. All software is licensed such that the latest security patches and updates are automatically updated by the vendor. In terms of modeling, Alpine has configured its powerful computing system using the latest modeling software versions prior to project initiation.

6 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION (A8)

As the tasks evolve and new technologies are deployed, we will ensure that staff members are trained internally on software upgrades, new packages that are being applied, and other areas requiring proficiency.

6.1 Types of Required Training and Certification

No additional training or certification is required for this project.

6.2 Plan for Obtaining Training and Certification

No additional training or certification is required for this project.

6.3 Documentation of Training and Certification

All personnel working on any element of this project have had their qualifications reviewed and have been determined by the Program Manager to have sufficient experience and knowledge to participate on this project. The only requirement is that project personnel are expected to read and observe the QAPP and the project instructions developed by the Program Manager/Technical Project Coordinator and task leads. The Project QA Coordinator will collect a written acknowledgement, via email, from each staff member that they have received and read the QAPP. The emails will be retained as part of the project record.

The Program Manager is responsible for overseeing internal training, should it become necessary. If any training or certifications are deemed necessary for any staff member working on this project to for the advancement of this project, it will be recorded in the company-wide training log. The log will note the name of the training course or certification, when it was taken, the name of entity that provided the training, short course description, and which staff completed the training or certification. Proof of satisfactory training completion and certification numbers will also be logged, with scanned copies of any certificates or course completion certificates retained with the project files.

7 DOCUMENTATION AND RECORDS (A9)

All project team members will have the approved work plan and approved QAPP for use during the project. It is the responsibility of the Program Manager and Subcontract Manager to ensure that each staff member receives each document, including any amended versions.

This project will generate the reports noted in Table 4-1 in Section 4.1 of the QAPP. All reports will either be emailed directly to SESARM, posted to the project website as described in Section 4.1.10 of the QAPP, or by both means. Reports that use or develop specific data sets will include descriptions of data source(s) and methodologies used in their preparations, and any other information that might be critical to their use in the project. To the extent possible, the documentation of the data will also include references that may have further information on the data validity and usability. Copies of all project reports will be retained in electronic format through the duration of the project and archived following its completion. Additional information on project retention and backup policies is noted in Section 8.10.1 of the QAPP.

8 MEASUREMENT AND DATA ACQUISITION (GROUP B)

This section of the QAPP describes the data generation and acquisition management activities of the project team. The QAPP elements in this group are intended to address all aspects of data generation and acquisition to ensure that appropriate methods for sampling, measurements and analysis, and QC activities are employed and documented. Data generation and acquisition group elements that are not applicable to specific project tasks are not discussed. Because the SESARM project does not involve the sampling, handling, or analysis of primary data, the first eight elements of Group B described in EPA document QA/R-5 are not applicable for QA/G-5M to this project.

8.1 Sampling Process Design (Experimental Design) (B1)

This element is not applicable to this project.

8.2 Sampling Methods (B2)

This element is not applicable to this project.

8.3 Sample Handling and Custody (B3)

This element is not applicable to this project.

8.4 Analytical Methods (B4)

This element is not applicable to this project.

8.5 Quality Control (B5)

This element is not applicable to this project.

8.6 Instrument/Equipment Testing, Inspection, and Maintenance (B6)

This element is not applicable to this project.

8.7 Calibration (B7)

This element is not applicable to this project.

8.8 Inspection/Acceptance of Supplies and Consumables (B8)

This element is not applicable to this project.

8.9 Non-direct Measurements (Data Acquisition Requirements) (B9)

The proposed modeling and data analysis study will utilize data from emissions inventories and models, meteorological models, and air quality models as well as data from air quality monitoring networks and meteorological observations in the Southeastern United States.

8.9.1 Emissions inventories, and ancillary data for emissions processing including chemical speciation profiles, temporal profiles and spatial surrogates

Base year 2011 and projected 2028 emissions inventory data will be obtained from EPA's Air Emissions Modeling website. The 2011 emissions inventory has undergone thorough review by EPA and state/local/tribal air agencies. The 2028 projected emissions inventory is projected from the base year 2011 emissions inventory, with growth and control packets applied, as well as incorporation of emissions from new sources, and retirements of other sources. To facilitate ERG and SESARM review, county-level emissions density plots and/or tables will be developed to show the 2011 emissions, 2028 emissions, absolute difference, and percent difference. Significant differences that are identified will be documented and checked for reasonableness against what future changes that may occur by 2028. Data entered for these two emissions inventories have passed QA/QC procedures employed by EPA and documented in the technical support document.[13] If revisions are directed for the 2028 emissions inventories by the states, then those changes will be documented, and double-checked to ensure that they were processed correctly. As part of this QA, ERG would prepare a tabular revisions summary for 2028, comparing the original 2028 vs. the revised 2028 that can be shared with SESARM. Comparisons would include absolute differences and percentage differences, along with comments about sizable changes.

[13] U.S. Environmental Protection Agency. 2016. Technical Support Document (TSD), Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform. https://www.epa.gov/sites/production/files/2016-09/documents/2011v6_3_2017_emismod_tsd_aug2016_final.pdf

8.9.2 *Initial and boundary conditions*

Alpine will extract the initial and boundary conditions for the VISTAS_12 domain from the EPA CONUS 12km domain simulation. This simulation will be performed using the EPA platform and CAMx v6.40 on the Alpine computer cluster. The most recently released version of the standard CAMx BNDEXTR processor will be used and the DIAG and DIAG2 BNDEXTR outputs will be examined for reasonableness as compared to similar data from the EPA CONUS 12km domain simulation. If any major differences are noted between the modeling results from this study's 2011 and EPA's 2011 modeling runs, a call will be convened between ERG, Alpine, SESARM, and the appropriate EPA staff to identify any inconsistencies in model data input, output, and/or model options procedures and come to consensus on appropriate corrective actions.

8.9.3 *Ambient air quality data*

ERG will obtain ambient air quality monitoring data from the IMPROVE website and EPA's AQS for all IMPROVE pollutants for 2011 through 2016. These data will be a mix of sub-daily (e.g., hourly) and daily measurements. Each data record has primary keys assigned to ensure that no duplication of data is permissible or that record growth occurs when running queries. Data entered into these systems have passed QA/QC procedures employed by EPA and the data owners. For AQS data, most monitors are run by state and local agencies that operate under monitoring plans,[14] which include QA/QC procedures, and are approved by their respective EPA Regional Offices. Other monitoring networks, like IMPROVE[15] and the Clean Air Status and Trends Network (CASTNET),[16] have quality assurance and standard operating procedures that are produced by the EPA contractor.

Wet and dry deposition data will be collected from the various NADP networks to supplement the project ambient air quality database. Monitor observation and station metadata will be obtained and preserved in the project database. Just like the ambient data obtained from EPA, each data record has primary keys assigned to ensure that no duplication of data is permissible or that record growth occurs when running queries. NADP[17] data have passed QA/QC procedures, all data flags added by NADP will be retained in the dataset.

8.9.4 *Meteorological data*

ERG will obtain observed meteorological data from three primary data sources:

- The National Centers for Environmental Information (NCEI)[18] for the Weather Bureau Army-Navy (WBAN) sites, which includes:

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14 State monitoring plans are available at: https://www.epa.gov/amtic/state-and-local-monitoring-plans

15 IMPROVE quality assurance documents (QAPP and QMP) are available at: http://vista.cira.colostate.edu/Improve/quality-assurance/

16 CASTNET Quality Assurance Project Plan is available at: https://www3.epa.gov/castnet/docs/qapp_v9-0_Main_body.pdf

17 NADP quality documentation is available at: http://nadp.slh.wisc.edu/lib/qaPlans.aspx

18 NCEI quality documentation is available at: http://www.cio.noaa.gov/services_programs/info_quality.html

- o National Weather Service (NWS) Automated Weather Observing System (ASOS),[19] and
- o Federal Aviation Administration (FAA) Automated Surface Observing System (AWOS),[20] and

- Ambient meteorological measurements from EPA's AQS; and
- Ambient meteorological measurements from the IMPROVE website.

Data entered into these systems have passed QA/QC procedures employed by EPA and the data owners. Data will be collected for 2011 through 2016 for all parameters available to facilitate any additional analysis state may want to conduct. Documentation of the database will note the varying quality of the meteorological data sets, and make suggestion as to appropriate site substitutions, when possible.

For the modeling, EPA's 2011 WRF runs will be obtained from EPA. These modeling files have already had their mode performance scrutinized and accepted for as sufficient.[21] To assure that the meteorological data are accurately converted (windowed) from the EPA CONUS domain to the VISTAS 12km domains, the meteorological fields all the domains will be compared both graphically and by examining specific grid values.

8.9.5 Air quality modeling and analysis

Each step of the air quality modeling will include verification of model configurations, confirmation that the correct data were used and were processed correctly, and other procedures. Alpine will compare al l configuration and processing streams with EPA obtained files and protocol to ensure consistent modeling with EPA's 2011 platform methods. A comprehensive MPE of the predicted output concentrations will be conducted and compared with observational data to ensure representativeness, and to calculate bias and error margins, temporal accuracy, and dynamic response to emissions and meteorology ensuring that the modeled predictions demonstrate adequate confidence in the application of the model for this analysis. Consistent with most current EPA modeling guidance,[22,23] these results will be compared to other peer-reviewed applications of a similar nature to determine adequate representation of observed

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[19] Quality control procedures for ASOS sites are laid out in the ASOS User's Guide (https://www.weather.gov/media/asos/aum-toc.pdf), standard operating procedure documents (https://www.weather.gov/asos/ASOSImplementation), and Observation quality control document (http://www.nws.noaa.gov/directives/sym/pd01013005curr.pdf)

[20] For non-federal AWOS are subject to certification and review by the FAA as outlined in: (https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_150_5220-16E.pdf)

[21] U.S. Environmental Protection Agency. 2014. Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation. (available at: https://www3.epa.gov/scram001/reports/MET_TSD_2011_final_11-26-14.pdf)

[22] Simon, H., Baker, K.R., Phillips, S., 2012. Compilation and interpretation of photochemical model performance statistics published between 2006 and 2012. Atmospheric Environment 61, 124-139.

[23] Wayland, R. 2014. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. Memorandum. http://www3.epa.gov/scram001/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance2014.pdf

conditions. Additionally, the simulations of the EPA platform performed on the Alpine cluster will be compared with the simulation results supplied by EPA with the original platform release (see Section 8.9.5.2 for more information). If significant differences between the SESARM 2028 run and EPA run that cannot be explained due to emission changes are found, the deltas will be explored with ERG, SESARM, and EPA.

8.9.5.1 SMOKE Emissions Processing QA/QC and Emissions Merging

EPA processed the emissions by major source category in several different "streams", including area sources, on-road mobile sources, non-road mobile sources, biogenic sources, non-CEM point sources, CEM point sources using day-specific hourly emissions, and emissions from fires. Separate QA/QC will be performed for each stream of emissions processing and in each step following the procedures utilized by EPA in their recent regional haze modeling. SMOKE includes advanced quality assurance features that include error logs when emissions are dropped or added. In addition, we will generate visual displays that include:

- Spatial plots of the hourly emissions for each major species.
- Summary tables of emissions for major species for each grid and by major source category.
- This QA information will be examined against the original source data and summarized in an overall QA/QC assessment.

Scripts to perform the emissions merging of the appropriate biogenic, on-road, non-road, area, low-level release point sources, fire, and elevated release 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.

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.

Similar QA/QC will be conducted on both the base year and projection year modeling platform.

8.9.5.2 CAMx Model Confirmation

To insure the data transfer integrity of the EPA CAMx platform being used in this study, the results of the EPA 2028el and 2011el CONUS 12km CAMx 6.32 model simulations will be compared to the simulations performed on the Alpine Geophysics computer system.

For the 2028el simulation EPA has provided the hourly average model outputs for all species. Model comparisons will be performed for ozone, sulfate, nitrate, organic carbon, and $PM_{2.5}$. Comparisons products will include tables of the hourly maximum positive and negative differences, and production of animations of hourly spatial difference plots.

For 2011el EPA has supplied daily maximum 8-hour average (MDA8) ozone results. These values will be compared with the Alpine simulation by producing tables of the maximum and minimum daily differences and production of an animation of the daily spatial differences. Should EPA be able to supply the daily "average" model outputs, the additional comparisons for the 2028el simulation will be performed.

The numerics of the CAMx model are quite complex, and it is typical to get small differences between simulations on different computer systems. The maximum ozone differences are typically less than 0.01 ppb. For PM species the differences can be larger do to different paths in the PM chemistry that are concentration dependent, so a small difference can lead to a different path through the chemistry that can increase the difference. In general, should a difference of 2% be seen in the replication of the 2011 base year photochemical modeling 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.

8.9.5.3 PSAT Tagging QA

The tagged modeling results will be qualitatively evaluated to better understand the individual source sector and species contributions and spatial distributions relative to regional haze at Class I areas. We will examine the tagged results by looking at spatial maps of the raw source apportionment outputs in modeled concentration units.

8.9.5.4 Area of Influence Analysis

For the area of influence analysis, all model execution code will be reviewed for accuracy by a second modeler. HYSPLIT output will be reviewed and all trajectories will be plotted to verify proper HYSPLIT model execution. Reviewer will ensure the proper origin of the trajectories, all levels are present, all trajectories are for the 72-hour timeframe. As possible, modelers will assess the reasonableness of the trajectories, noting any particularly long or short trajectories or divergent patterns that would need further review. Residency time plots will be compared back to the trajectory plots to qualitatively verify the highest regency corresponds to the highest density of trajectories. Final spreadsheets of ranked emission sources will be reviewed by a second analyst to ensure proper data transfer and calculation of facility specific values.

8.10 Data Management and Hardware/Software Configuration (B10)

The proper management of all data associated with this project is critical to assuring the quality and usability of the modeling results. As such, procedures will be implemented to ensure adequate data acquisition, validation, transmission, and storage of electronic and hard copy data.

8.10.1 Data Management

All original files (i.e., data obtained from external sources) will be kept separate from project working files. The data librarian will preserve backup copies of these files for record keeping and dissemination purposes.

All final project documentation, records, data, and reports will be maintained at ERG for a period of at least five years from the completion of the project. Data will be backed up periodically to alternate storage locations to prevent data loss. ERG's current back up practice is to perform a full back up every week, with daily backups of files alternated that day. After five years, the project documentation, records, data, and reports will be archived to tape storage and retained for another five years. Modeling files will be retained by ERG and duplicate copies of the modeling files will be retained by Alpine. All files will be retained in readily-accessible format for at least five years after project completion, and as an archive copy (i.e., tape storage) for five years after that. Original data files and final files, particularly input files, will be restricted to read-only access to order to avoid possible overwriting the files and unintentional editing.

Data will not be released without the expressed approval of the SESARM APC or previously identified surrogate. All outside requests for the data will go through the data librarian. The data librarian will arrange the dissemination of copies of the requested files. As part of the project deliverables, the data librarian will arrange to send hard drives with copies of the project files (e.g., modeling inputs, modeling outputs) to designated state and federal representatives. A list of all SESARM stakeholders and approved federal entities will be developed for disk dissemination two weeks prior to shipping the drives to ensure correct contact information. The data librarian will send the drives to the first representative, who will copy the contents of the drive to their own system and then forward the drive to the representative on the list. SESARM may elect to have two separate copies of the files developed, to expedite the process (i.e., two distinct copies sent to different representatives at a time). After the final representative copies the data, the drive will be returned to the data librarian. At that time, the drive's integrity will be checked, and after finding no errors, will be sent on the SESARM headquarters where it will remain.

8.10.2 Hardware/Software Configuration

In all tasks, the latest versions of the models and analysis software will be used, unless otherwise explicitly requested by SESARM. Alpine will use CAMx v6.40 with PSAT to generate the files and concentration data necessary to support this and additional tasks. All software version numbers and special configuration settings will be documented in the task protocols and reports.

A high-performance computing cluster is required to accomplish photochemical modeling in a reasonable timeframe. Alpine's computing facilities consist of a very powerful array of 32 multiprocessor Linux-based workstations. The aggregate network has 192 Processor Cores; 4688 gigabyte (GB) of memory and 96,000 GB of aggregate disk space with over 70,000 GB of RAID protected space. Alpine scientists have been using Linux and Unix for emissions, meteorological, and air quality modeling and data analysis for over twenty years. Alpine's computing system and knowledge base, in conjunction with existing relationships with hardware vendors, software vendors, and system specialists, enable Alpine to meet the computational requirements of this projects.

All databases developed to disseminate data will include a data dictionary that provides the field name, a clear description of the field contents, unit information, and data source for all tables included. For the data collected under Task 4, Data Acquisition and Preparation, databases will include the metadata for each monitoring/observation site, including locational information, site duration, site identifier, and network identifier. Any code generated to analyze data for the project will be provided to SESARM with adequate inline documentation to facilitate execution of the code by any member state.

9 ASSESSMENTS AND OVERSIGHT (GROUP C)

The purpose of this section is to describe the internal and external checks and activities necessary to assess the effectiveness of the modeling project implementation and associated QA/QC activities.

9.1 Assessment and Response Actions (C1)

Although the primary stakeholder providing oversight is SESARM, several other stakeholders will also provide some level oversight, including:

- The CC;
- The TAWG; and
- Representatives of EPA and EPA Regional Offices (3 and/or 4).

While some stakeholders may have more oversight than others, all of the above have oversight in the approval of this QAPP. As such, no technical work is to be authorized or commence until this QAPP is approved by the above-mentioned parties and formally authorized by the SESARM APC.

ERG's Program Manager will have oversight on all technical and administrative aspects for this contract. He will receive substantial support from the Deputy Program Manager, as well as contracts and clerical staff at ERG. For financial information, ERG uses the Deltek Timesheet program for accurate tracking of project charges and IBM Cognos Connection, which provides weekly financial information to be monitored by the ERG Program Manager.

Along with the ERG Program Manager, the ERG Project QA Coordinator will review all deliverables, and ensure that the required elements are met. Additionally, ERG and Alpine staff will employ the QA/QC checks that are described in this document and that have been developed and scripted over decades of experience, in reviewing the data for this project. As such, ERG and Alpine staff will serve as an extra level of review for each other within the tasks and subtasks.

9.1.1 Hardware/Software Assessments and Configurations

As part of its business practice, ERG and Alpine regularly evaluate their software and hardware needs for complex air quality projects. Such evaluations include: installation of the most recent versions of software such as Microsoft Office's Professional Suite; updates of vendor security patches and software updates; computer and hard drives upgrades; and increased network capacity for performance improvements and data archival backups.

ERG and Alpine also ensure that staff have redundant capabilities, such that code and scripts developed can be evaluated by another team member. When a new code or script is developed for the project, it will be tested, and quality assured by others on the team.

9.1.2 Plans for Science and Product Peer Review

There are no plans for science and product peer review for this project.

9.2 Reports to Management (C2)

Reports from ERG to SESARM will be frequent, through the use of Monthly Progress Reports, regular phone calls, e-mails, and interim project deliverables. The assessment reports described in Section 4.1 of the QAPP will describe our reporting procedures on the status of various elements of the project, including results, QA procedures, and any QA problems and suggested remedies. ERG is committed to the schedule, as described in Table 4-1.

Monthly Progress Reports will be submitted within two weeks of the end of each calendar month and will be electronically submitted to the SESARM APC. The monthly progress report will contain information about:

- Administrative items;
- Technical progress achieved by task and subtask;
- Any significant QA efforts and progress, as described in the QAPP;
- Work and deliverables to be accomplished the next month;
- Meetings and deliverables that took place;
- Problems that need to be addressed; and
- Financial information about resources spent and remaining.

If problems arise during the course of the project, then ERG will inform SESARM immediately describing the problem, and providing recommendations for corrective action. If such actions require updates in the approved QAPP, then ERG will initiate those discussions with SESARM, and make adjustments accordingly.

10 DATA VALIDATION AND USABILITY (GROUP D)

The primary purpose of this group of elements is to describe the process to assess the usability of the modeling results. Many of these procedures will occur during and/or near the end of each Task.

10.1 Departures from Validation Criteria (D1)

All data received or created during the project will undergo a verification procedure to ensure that the data are identical to their original sources (for example, checking on file names, format, and file sizes). Further, it is important to validate the names of parameters included and the units of such parameters.

10.2 Validation Methods (D2)

The AMET Tool and other statistical and graphical tools will be used to verify the meteorological and air quality modeling inputs/outputs. Graphical plots for variables will include:

- Overlaying observational and model data
- Graphical statistical plots for various meteorological and air quality variables including:
  - Time series of ambient and modeled concentrations
  - Stacked bar charts
  - Scatter plots
  - Bugle plots
  - Soccer plots
- Tabular statistical parameters

Calculated model performance statistics will be include to the following values:

- Mean Observed monitored concentration (Observed)
- Mean Modeled concentration (Modeled)
- Mean Bias (MB)

$$MB = \frac{1}{N}\sum_{1}^{N}(Modeled - Observed)$$

- Mean Error (ME)

$$ME = \frac{1}{N}\sum_{1}^{N}|Modeled - Observed|$$

- Normalized Mean Bias (NMB)

$$NMB = \frac{\sum_{1}^{N}(Modeled - Observed)}{\sum_{1}^{N} Observed} \times 100\%$$

- Normalized Mean Error (NME)

$$NME = \frac{\sum_{1}^{N}(|Modeled - Observed|)}{\sum_{1}^{N} Observed} \times 100$$

- Mean Fractional Bias (MFB)

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

- Mean Fractional Error (MFE)

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

- Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{\frac{\sum_{1}^{N}(Modeled - Observed)^2}{N}}$$

- Pearson Correlation Coefficient (r)

$$r = \frac{\sum_1^N \left((Modeled - \overline{Modeled}) \times (Observed - \overline{Observed}) \right)}{\sqrt{\sum_1^N (Modeled - \overline{Modeled})^2 \sum_1^N (Observed - \overline{Observed})^2}}$$

Additional statistical analysis may also be performed, as determined necessary. All statistics will be calculated consistent with the respective pollutants NAAQS averaging time. EPA has recently moved away from numeric "acceptable ranges" in lieu of using comparisons to other similar, modeling studies. This is outlined in the most current modeling guidance and will be the methods utilized here.[24] Additional studies[25,26] have suggested, at a minimum, the following performance criteria:

- Total $PM_{2.5}$ and SO_4: NMB <±30% and NME <50%
- NO_3: NMB <±65% and NME <115%.
- Major component species (i.e., ≥30% of total $PM_{2.5}$): MFE ≤75% and MFB ≤ ±60%.

ERG/Alpine expects the model performance of the replicated 2011 CAMx run to the be slightly different from EPA published MPE metrics[27] due to the differences in the version of CAMx being used and 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.

10.3 Reconciliation with User Requirements (D3)

The results of this project are intended to provide SESARM scientific-based information for its member states to update their Regional Haze SIPs. Representatives from each member state will be important stakeholders throughout the project reviewing emissions data, ambient monitoring data, and modeling results prior to the completion of interim and final reports. Should any concerns about quality of products arise, a call will be convened between contractors and stakeholders to determine the most appropriate corrective action. The ERG Program Manager will document all action and assure their completion.

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[24] Wayland, R. 2014. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. Memorandum. Available at: http://www3.epa.gov/scram001/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance2014.pdf

[25] Emery, C., Liu, Z., Russell, A. G., Odman, M. T., Yarwood, G., & Kumar, N. (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

[26] Boylan, J.W. and Russell, A.G. (2006). PM and Light Extinction Model Performance Metrics, Goals, and Criteria for Three-Dimensional Air Quality Models; Atmos. Environ., Volume 40, pp. 4946-4959.

[27] US Environmental Protection Agency. 2017. Documentation for the EPA's Preliminary 2028 Regional Haze Modeling. October 2017. Available at: https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

ERG will report to SESARM any departures from the assumptions set in the planning phase of the project, should they arise. Such departures will be documented in the Monthly Progress Reports and the interim and final reports.

All output data used by the member states will also contain the applicable data limitations to help inform decision makers about the appropriateness of using the data. Such limitations include the facts that all data was generated for this project for the explicit use in regional haze analysis and evaluation. As such, model performance, at all levels, has been tuned to the needs of regional haze evaluation and generally do not extend beyond regional haze pollutants. Any use outside of this purpose does so at their own risk. It is solely the data user's responsibility to ensure the data is applied appropriately. Detailed Metadata files and documentation will accompany all data outputs to encourage the appropriate use of the files.

Appendix A-2

Work Plan

Southeastern VISTAS II Regional Haze Analysis Project

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ERG

Work Plan

Southeastern VISTAS II Regional Haze Analysis Project

Prepared for:

Southeastern States Air Resource Managers, Inc. (SESARM)

205 Corporate Center Drive, Suite D
Stockbridge, GA 30281-7383

Prepared by:

Eastern Research Group, Inc.
1600 Perimeter Park Drive
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Morrisville, NC 27560

April 18, 2018

SESARM Contract No. V-2018-03-01

TITLE and APPROVAL SHEET

Work Plan for

Southeastern VISTAS II Regional Haze Analysis Project for

SESARM (Final)

This Work Plan 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).

April 18, 2018

Regi Oommen – ERG Program Manager and Technical Project Coordinator Date

April 19, 2018

John Hornback – SESARM Executive Director Date

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Abbreviations/Acronym List

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Alpine	Alpine Geophysics, LLC
AMET	Atmospheric Model Evaluation Tool
AMNet	Atmospheric Mercury Network
AMoN	Ammonia Monitoring Network
APC	Administrative Project Coordinator
AQS	Air Quality System
ARL	Air Resources Laboratory
ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing System
BNDEXTR	Program used to extract boundary conditions
bext	Beta extinction
Ca^{2+}	Calcium
CAMx	Comprehensive Air Quality Model with Extensions
CASTNET	Clean Air Status and Trends Network
CC	Coordinating Committee
CCRS	Coarse PM species (CAMx PM species)
CIRA	Cooperative Institute for Research in the Atmosphere
Cl^-	Chloride
CMAQ	Community Multiscale Air Quality
CO	Carbon monoxide
CONUS	Continental United States
CPRM	Coarse PM
CWRT	Concentration weighted residence time
CWT	Concentration weighted trajectory
d	Distance
DVB	Design value for base year
DVF	Design value for future year
EGU	Electricity Generating Unit
EIS	Emission Inventory System
EPA	United States Environmental Protection Agency
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee
ESRI	Environmental Systems Research Institute
EWRT	Extinction-weighted residency time
f(RH)	Monthly relative humidity function
f_s(RH)	Monthly relative humidity function associated with small size distribution
f_L(RH)	Monthly relative humidity function associated with large size distributions
f_{ss}(RH)	Monthly relative humidity function associated with sea salt
FAA	Federal Aviation Administration
FAT32	File Allocation Table, 32-bit
FCRS	Crustal fraction of PM
FF10	Flat File 2010
FIPS	Federal Information Processing Standard

FLM	Federal Land Manager
FPRM	Fine Other Primary (diameter ≤2.5 µm)
FR	Federal Register
g	Gram
GB	Gigabyte
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/BC	Initial conditions and boundary conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
K^+	Potassium
km	Kilometers
L	Liter
m	Meters
m^2	Square meters
m^3	Cubic meters
MAR	Marine, aircraft, and rail
MDL	Method Detection Level
MDN	Mercury Deposition Network
mg	Milligram
Mg^{2+}	Magnesium
MLM	Multi-Layer Model
MPE	Model performance evaluation
Na^+	Sodium
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
NCEI	National Centers for Environmental Information
NH_3	Ammonia
NH_4^+	Ammonium
NO_2	Nitrogen dioxide
NO_3^-	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NO_x	Oxides of nitrogen
NTN	National Trends Network
NWS	National Weather Service
ORIS	Plant identifier issued by U.S. Department of Energy
PEC	Primary elemental carbon
PGMs	Photochemical grid models
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
PSO4	Sulfate
Q	Emissions
Q/d	Emissions over distance
Q/d^2	Emissions over distance squared
QA	Quality assurance
QA/G-5M	Guidance for Quality Assurance Project Plans for Modeling
QA/QC	Quality assurance/quality control
QA/R-2	EPA Requirements for Quality Management Plans
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
r	Pearson correlation coefficient
RFP	Request for Proposal
RH	Relative humidity
RHR	Regional Haze Rule
RRF	Relative response factor
SATA	Serial AT Attachment
SCC	Source Classification Code
SEARCH	SouthEastern Aerosol Research and Characterization
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
SO_4^{2-}	Sulfate
SOA	Secondary organic aerosol
SOP	Standard Operating Procedure
SOW	Scope of Work
TAWG	Technical Analysis Work Group
TB	Terabytes
TDEP	Total Deposition
TSD	Technical Support Document
VISTAS	Visibility Improvement - State and Tribal Association of the Southeast
VOC	Volatile organic compounds
WBAN	Weather Bureau Army-Navy

1. INTRODUCTION

This work plan was prepared by Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine) in response to Southeastern States Air Resource Managers, Inc. (SESARM) Contract Number V-2018-03-01 (VISTAS Contract). SESARM initiated a Request for Proposals (RFP) on December 21, 2017, entitled "Southeastern VISTAS II Regional Haze Analysis Project." On February 20, 2018, ERG was selected by SESARM to provide technical support to this project. ERG and SESARM executed the VISTAS Contract on March 1, 2018.

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.

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

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 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 regional haze rule defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview 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 work plan describes the ERG Team's approach for supporting SESARM to help the VISTAS states meet the above deadlines and requirements. The project activities will include the following:

- Review and update of EPA emissions inventories for the 2028 base year;
- Air quality modeling and evaluation of modeling results;
- Ambient air monitoring data analysis; and
- Website activities, including data transfer.

Confidential Business Information. ERG does not anticipate that collecting, handling, and storing confidential business information will be necessary in conducting this work assignment.

Subcontracting. This work plan includes the use of subcontractor support (Alpine).

Travel. ERG and Alpine will attend two VISTAS project meetings/workshops, if scheduled.

Meetings. ERG and Alpine employees will clearly identify themselves as such during any meetings or telephone conversations.

Limitation of Contractor Activities. ERG will submit drafts of all deliverables to the SESARM Administrative Project Coordinator (APC) for review prior to submission of the final product. ERG will incorporate all SESARM APC comments into all final deliverables, unless otherwise agreed upon by the SESARM APC. ERG will adhere to all applicable management control procedures as implemented by the SESARM APC.

2. TECHNICAL APPROACH

The work assignments prescribed in the VISTAS Contract will be performed within the eleven tasks described below.

2.1 Task 1 – Project Management

Under this task, ERG will conduct all management activities, as described below in the following subtasks:

2.1.1 Subtask 1.1 – Contract Management

Under this subtask, the ERG Project Manager and the contractor staff will work closely together and with SESARM to ensure that they are familiar with and conform to all terms and conditions of the VISTAS Contract, and will ensure that no technical work related to Tasks 2 through 11 (Sections 2.2 through 2.11) will be initiated until EPA has approved the Quality Assurance Project Plan (QAPP) and SESARM has authorized in writing that the work on a technical task, or subtask as applicable, may begin. The ERG Project Manager will manage project activities to produce required deliverables that meet all administrative, technical, quality, schedule, and cost requirements. If any problems are identified which affect compliance with the VISTAS Contract, ERG will inform SESARM immediately at the earliest possible date and will work with SESARM to rectify any compliance issues as soon as practicable. Additionally, ERG will develop the Subcontract with Alpine.

2.1.2 Subtask 1.2 – Contract Development

Under this subtask, ERG worked with SESARM to develop and execute a project contract and to comply with all terms and conditions upon execution. Most of the contract development activities between ERG and SESARM took place prior to the execution of the VISTAS Contract on March 1, 2018. No additional work is planned for this subtask.

2.1.3 Subtask 1.3 – Work Plan Development

Under this subtask, ERG produced and delivered to SESARM on March 13, 2018 a draft work plan (this document) consistent with the Scope of Work (SOW) in the RFP, the executed VISTAS Contract, applicable Federal guidance, and any other requirements provided by SESARM. ERG will provide a final work plan to SESARM within 7 days of receipt of comments from SESARM. The work plan will incorporate appropriate methodologies and techniques for thoroughly and efficiently completing the prescribed tasks. The work plan will provide details of methods and approaches that will be used in the project including evaluation of products and software tools. The work plan will contain:

- Task and subtask descriptions and procedures for completion;
- A detailed list of deliverables and milestones associated with each task and subtask;
- Staff assignments and allocated hours for each task and subtask; and
- Other pertinent information for each task.

2.1.4 Subtask 1.4 – QAPP Development

Under this subtask, ERG will develop the project-specific QAPP, which SESARM is obligated to provide to EPA for review and approval prior to initiation of technical work.

Because the results of this project will be evaluated by the VISTAS states and EPA for establishing policy initiatives, reproducible and transparent procedures and methodologies will be of highest priority in the QAPP. To ensure the technical quality of work products, ERG will follow the procedures of its Corporate *Quality Management Plan*, following the requirements in EPA QA G-5M.[2] The QAPP will address all applicable project tasks and will describe data collection and evaluation, model performance evaluation (MPE), and modeling procedures and processes. The QAPP will include appropriate policies, procedures, specifications, standards, documentation, communications, and other activities necessary to ensure the accuracy and dependability of all data collected, used, and produced during the project. ERG will incorporate necessary standards and procedures to minimize costs, time required to complete the project, and repetitive work.

ERG submitted the draft QAPP to SESARM on March 15, 2018, within the prescribed VISTAS Contract timeframe. ERG will prepare a final QAPP for SESARM's review within one week of receipt of final comments from SESARM and EPA.

2.1.5 Subtask 1.5 – Communications

Under this subtask, ERG and Alpine's Task Leaders will meet weekly or bi-weekly to monitor the technical activities of the team and ensure adherence to project budget, schedule, and quality specifications for deliverables. To ensure close communication with SESARM, ERG will additionally hold bi-weekly to monthly status meetings with SESARM, which may include members of the Coordinating Committee (CC) and the Technical Analysis Work Group (TAWG) to provide updates on progress, identify areas of technical concern, propose solutions to challenges where applicable, and discuss any preliminary results and/or data. ERG will provide a bulleted agenda to SESARM via email prior to each status meeting that will facilitate the discussion of progress and related issues. After each meeting, ERG will summarize for SESARM the discussion including issue resolutions, action items, and responsible team members.

2.1.6 Subtask 1.6 – Reports

Under this subtask, ERG will prepare and submit a monthly progress report within two weeks of the end of each calendar month. Monthly progress reports will be electronically submitted to the SESARM APC. The monthly progress report will contain information about:

- Administrative items;
- Technical progress achieved by task and subtask;
- Any significant quality assurance (QA) efforts and progress, as described in the QAPP;
- Work and deliverables to be accomplished the next month;
- Meetings and deliverables that took place;
- Problems that need to be addressed and solutions; and
- Financial information about resources spent and remaining.

[2] EPA QA/G-5M, Guidance for Quality Assurance Project Plans for Modeling, December 2002.

For reports, ERG will work closely with the SESARM APC to determine the number and size of the interim draft and interim final reports, which may be as frequent as the completion of each task or subtask. Each interim report will document the methodologies, data, and QA activities, and will act as stand-alone documents for their respective tasks. The interim reports from each task will serve as the basis of the final report. In preparation of the final report, ERG will prepare a detailed outline that will be provided to SESARM for review and comment. The final report will contain, at a minimum:

- An executive summary that provides a brief overview and summary of the modeling effort, emissions and air quality models used, model configuration, MPE overview and results, and rationale for the selected configuration;
- Summaries of QA procedures completed for the project;
- Technical details for all technical work performed as part of this project including:
    - Area of influence analysis,
    - Emission inventory updates,
    - Emissions and air quality models used,
    - Model configuration and rationale, and
    - MPE
- Summaries and conclusions;
- A list of all final work products being delivered; and
- A discussion of data accessibility and availability for review by SESARM, stakeholders, and the public.

ERG will prepare a draft final report for SESARM review, and a final report will be prepared within four weeks of receiving comments from SESARM. ERG will submit two hard copies of the final report to SESARM for its files and for transmittal to EPA. Electronic copies of the report in Microsoft Word (.docx) and Adobe (.pdf) formats will be submitted to SESARM and will be made available on the Technical Web Site, to be developed in Task 10 (Section 2.10).

Finally, ERG will provide project summaries in the form of slide presentations that can be distributed to VISTAS agencies and stakeholders to inform them of progress and findings. Each slide deck will contain the appropriate SESARM/VISTAS logo.

2.1.7 Subtask 1.7 – Invoicing

Under this subtask, ERG will prepare and submit a monthly invoice within two weeks of the end of each calendar month. Invoices will be itemized and contain information about unpaid services that are billable and payable at the end of the previous calendar month, including invoice billing period, current and cumulative expenditures by personnel, other direct costs, indirect costs, and subcontractor charges. Monthly invoices will be electronically submitted to the SESARM APC with the monthly progress reports that are described in Subtask 1.6 (Section 2.1.6).

2.2 <u>Task 2 – Emissions Inventory Development</u>

In Task 2, ERG will prepare emission inventory files and ensure the data are in the proper formats for emissions modeling.

2.2.1 Subtask 2.1 – 2011 Base Year Emissions Inventory

Under this subtask, ERG will retrieve EPA's 2011v6.3el modeling platform emissions and prepare it for emissions modeling. ERG anticipates only minor processing of the data (i.e., reformatting for state review), as the Team is familiar with this inventory.

2.2.2 Subtask 2.2 – Projection Year Emissions Inventory

Under this subtask, 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).

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 (.xlsx) 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.

Additionally, 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 Eastern Regional Technical Advisory Committee (ERTAC) EGU projection tool from the most recent Continental United States (CONUS) 2.7 run available at the time of subtask authorization. The team will prepare state-specific summary comparisons of EPA's 2028v6.3el 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 (.xlsx) 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.

2.2.3 Subtask 2.3 – Revisions to 2028 Projection Year Emissions Inventory

Under this subtask, with direction from SESARM, ERG will update the 2028 EGU and non-EGU point source projection year mass emissions inventories in Flat File 2010 (FF10) format based on the information collected from Subtask 2.2. 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.

For the other source categories, ERG will use the 2028 emissions projections for:

- Onroad and nonroad mobile sources
- Marine, aircraft, and rail (MAR) sources
- Fires
- Area (non-point) sources
- Biogenic and international sources

When final, ERG will prepare Sparse Matrix Operator Kernel Emissions (SMOKE)-ready files for emissions processing. Each emissions record will have primary keys assigned to ensure no duplication occurs, as well as conform to EPA's format and content checks. Data files will then be transferred to Alpine for Task 3 SMOKE processing (the Task 3 SMOKE processing is described in Section 2.3.) A technical memorandum/interim report describing the changes, and their source origins, will be prepared for SESARM based on the "Reports" requirement in Subtask 1.6 (Section 2.1.6).

2.2.4 Optional Subtask 2.3.1 – Preparing Emission Summary Comparisons of the 2028v6.3el and 2023v6.3en Emissions Modeling Platforms

If directed by SESARM, ERG will generate state-specific summary comparisons of EPA's 2028v6.3el modeling platform mass emissions to the 2023v6.3en modeling platform emissions for stationary area sources and MAR sources to facilitate review by the VISTAS states. The summaries will be grouped by county and SCC for annual emissions of NO_x, VOC, $PM_{2.5}$-PRI, PM_{10}-PRI, SO_2, CO, 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: SCC descriptions and percentage differences between the two emissions inventories.

If directed by the state agency, ERG will update the 2028 projection year mass emissions inventory files in FF10 format to reflect changes, and include in the documentation.[3] When final, ERG will prepare SMOKE-ready files for emissions processing. Each emissions record will have primary keys assigned to ensure no duplication occurs, as well as conform to EPA's format and content checks. The Task 3 SMOKE processing is described in Section 2.3. A technical memorandum/interim report describing the changes, and their source origins, will be prepared for SESARM based on the "Reports" requirement in Subtask 1.6 (Section 2.1.6).

2.2.5 Subtask 2.4 – Emission Summaries and Quality Assurance

Upon completion of the updates to the 2028 emissions as agreed upon, ERG will prepare state-specific final 2011 and 2028 emission summaries for EGU, non-EGU point, area, onroad, nonroad, fire, MAR source categories, and all sectors. Summaries and quality assurance will follow procedures laid out in EPA guidance[4] and described in the project QAPP. Per such guidance, ERG will develop county-level emissions density plots and/or tables that show the 2011 emissions, 2028 emissions, absolute difference, and percent difference to facilitate review. Summaries will include aggregations at the state-county, EPA Tier Levels (Tier 1, 2, and 3) and descriptions, and SCC (with description) levels, and for state/sector combinations. Significant differences that are identified will be documented and checked for reasonableness against what future changes that may occur by 2028. The summaries will be produced in Microsoft Excel (.xlsx) 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.

Data entered for these two emissions inventories have passed QA/QC procedures employed by EPA and documented in the technical support document (TSD).[5] If revisions are directed for the 2028 emissions inventories by the states, then those changes will be documented, and double-checked to ensure that they were processed correctly. As part of this QA, ERG would prepare a tabular revisions summary for 2028, comparing the original 2028 vs. the revised 2028 that can be shared with SESARM. Comparisons would include absolute differences and percentage differences, along with comments about sizable changes.

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3 As noted in the RFP, ERG prepared a cost estimate for developing summaries for one state (assume North Carolina). ERG notes that the cost estimate presented for this example location will be marginal for additional states due to economies of scale for preparing, processing, and presenting the data.

4 Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter NAAQS and Regional Haze Regulations" available at https://www.epa.gov/sites/production/files/2017-07/documents/ei_guidance_may_2017_final_rev.pdf

5 U.S. Environmental Protection Agency. 2016. Technical Support Document (TSD), Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform. https://www.epa.gov/sites/production/files/2016-09/documents/2011v6_3_2017_emismod_tsd_aug2016_final.pdf

2.3 Task 3 – Emissions Processing

In Task 3, ERG will direct Alpine to prepare SMOKE-ready input files from the mass emissions data prepared in Task 2 (Section 2.2). In this task, Alpine will ensure that annual emission changes are carried through to any relevant daily and hourly input files (as necessary) 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 Comprehensive Air Quality Model with Extensions (CAMx) photochemical model version 6.40-ready inputs using the SMOKE Modeling System.

2.3.1 Subtask 3.1 – Create Photochemical Model Ready EGU Emission Files for 2028

In this subtask, Alpine will create photochemical model ready EGU emissions files for 2028 using a set of scripts that have been used for many recent ozone and PM analyses that utilize existing temporal distribution ratios and create updated SMOKE-ready modeling files from annual emissions input data. These scripts contain both conversion and QA procedures allowing for a single step processing of the data. The generated output and QA files are used to ensure that no mass is lost in the conversion from annual to episodic file preparation and that the new files can be used as valid replacements for the older inputs to the model run.

As directed by SESARM, for states located outside of the VISTAS domain, Alpine will use EGU emissions as generated from the ERTAC EGU model version 2.7 simulation as discussed in Task 2 above.

When completed, the output and QA files will be made available to the VISTAS states for review through the file share procedures outlined in Task 10 (Section 2.10).

2.3.2 Optional Subtask 3.1.1 – Full EGU Emissions Replacement

SESARM has not chosen to fund this Subtask, but rather Subtask 3.1.2, Scale Hourly SMOKE Emissions.

2.3.3 Subtask 3.1.2 – Scale Hourly SMOKE Emissions for EGUs

Under this subtask, emissions from the SESARM-modified EGU review and the 2028 ERTAC run (for non-VISTAS states) will further be processed using hourly distribution ratios as generated from the EPA 2028el modeling platform to prepare SMOKE input files consistent with the base year modeling inputs.

This step is necessary to ensure that the new emissions from the future year platform run will match the hourly temporal distribution as modeled by EPA in the 2011el and 2028el regional haze modeling platforms. These ratios and the updated emissions will be used to prepare PTHOUR files necessary for this temporal replication. Alpine will use scripts identified above to apply SESARM approved scaling factors generated from EPA's 2011el modeling platform to create annual, daily, and/or hourly emission input files necessary to model this category in SMOKE. As part of this process, Alpine will generate state-level monthly emission charts to represent the before and after application of these scaled emissions.

2.3.4 Subtask 3.2 – Create Photochemical Model Ready Non-EGU Point Source Emission Files for 2028

Under this subtask, Alpine will utilize a previously developed set of scripts to create updated non-EGU point source SMOKE-ready files from the SESARM-modified annual emissions data. These scripts contain both conversion and QA procedures allowing for a single step processing of the data. The generated output and QA files are used to ensure that no mass is lost in the conversion from annual mass to model input file preparation and that the new files can be used as valid replacements for the older inputs to the model run.

When completed, output and QA files will be made available to the VISTAS states for review through the file share procedures outlined in Task 10 (Section 2.10).

2.3.5 Subtask 3.3 – Merge Data Files

Under this subtask, Alpine will merge the data from Subtask 3.1 and 3.2 (Sections 2.3.1 and 2.3.4) and EPA-supplied data for unmodified segments. EPA performed the emissions processing for the 2011v6.3el and 2028v6.3el platforms using SMOKE to output CMAQ format files. These emissions were merged in CMAQ format and the elevated and low level files were further merged in CAMx format.

The study team has had extensive experience and have developed the windowing, merging, QA tools and source tagging tools to work on CAMx format files. Alpine has previously applied these tools to the 2023v6.3el platform. To apply these tools the study team will convert the individual sectors that are supplied by EPA, and unchanged by SESARM, into CAMx format and window them onto the VISTAS 12km domain. The SMOKE processing for the changed segments will configure SMOKE to directly output CAMx format files.

2.4 Task 4 – Data Acquisition and Preparation

Under this task, ERG will develop a database with the Interagency Monitoring of Protected Visual Environments (IMPROVE), EPA's Air Quality System (AQS), and meteorological data for use on this project. This database will provide a permanent record of the set of data used to support the MPE and the regional haze calculations.

ERG is familiar with the IMPROVE data through our work developing large ambient air quality monitoring databases for various EPA programs. These data are housed in a SQL server database linked to facility, meteorological, and compliance data and are readily available for use for source analysis, as well as inputs and for quality assurance of our air quality modeling projects. This database includes:

- Hourly meteorological measurements obtained from the National Centers for Environmental Information (NCEI) for the Weather Bureau Army-Navy (WBAN) sites, which include:
    - National Weather Service (NWS) Automated Surface Observing Systems (ASOS); and
    - Federal Aviation Administration (FAA) Automated Weather Observing System (AWOS);

- Total and speciated light extinction (in inverse megameters) and meteorological measurements from the IMPROVE monitoring location via the IMPROVE website; and
- Ambient air pollutant and meteorological measurements from EPA's AQS.

The ERG database is complete for 1996 through 2017. All data is kept at the finest temporal resolution possible. The database includes automated routines to quality ensure data uploads, including filling in missing information (i.e., MDL levels, POC) and calculating concentrations to standard units.

ERG will develop a subset of this database with the IMPROVE, AQS, and meteorological data for use on this project. ERG will poll AQS to ensure the VISTAS II database has the latest version, to account for any corrections since ERG's last update. ERG is aware that the Cooperative Institute for Research in the Atmosphere (CIRA) may not have the most recent IMPROVE data uploaded to AQS. As such, ERG will download the latest information from CIRA's IMPROVE website to ensure a complete database. The database will include a data definitions table that states in plain language the contents of each field and unit, where applicable. ERG will also provide files of station metadata including location information (e.g., latitude, longitude, elevation), site duration, and type. All data retrieval will follow data acquisition and handling procedures outlined in the project QAPP.

ERG anticipates providing the project data in both Microsoft Excel files (.xlsx) and an Access database (.accdb) format. This will provide a permanent record of the set of data used to support the MPE and the regional haze calculations. The databases will include forms to facilitate the extraction of data for those stakeholders not familiar with Access.

The database will be uploaded to the files sharing platform, as designed in Task 10 (Section 2.10). SESARM will be notified when the database is available and ready for use.

2.4.1 Subtask 4.1 – Collecting Additional Data (weekly wet deposition and weekly dry deposition)

Under this subtask, ERG will aggregate deposition information from the various National Atmospheric Deposition Program (NADP) networks. Wet deposition values will be obtained from the National Trends Network (NTN) and the Atmospheric Integrated Research Monitoring Network (AIRMon) sites, which collects 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^-), and ammonium (NH_4^+) on a weekly basis. The SouthEastern Aerosol Research and Characterization (SEARCH) monitoring sites have largely been incorporated into the NTN network and are available through the NADP's site.

The Mercury Deposition Network (MDN) provides weekly dry and wet deposition measurement of mercury. The Atmospheric Mercury Network (AMNet) provides concentrations of atmospheric mercury species from automated, continuous measuring systems, concentrations of total mercury in precipitation, and meteorological measurements.

The Clean Air Status and Trends Network (CASTNET), provides weekly measurements of SO_2, nitric acid (HNO_3), particulate sulfate (SO_4^{-2}) and nitrate (NO_3^-), ammonium (NH_4^+), base cations (Mg^{+2}, Ca^{+2}, K^+, and Na^+), and chloride ion (Cl^-). NADP deployed Ammonia Monitoring Network (AMoN) sites at most CASNET sites, which record biweekly concentrations of ambient NH_3^-. Table 2-1 summarizes the measurements available from each deposition monitoring network.

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				✓		

These networks combine to provide substantial coverage across the VISTAS 12-km domain, as well as the continental US. The database will include a data definitions table that states in plain language the contents of each field and unit, where applicable. ERG will also provide files of station metadata including location information (e.g., latitude, longitude, elevation), site duration, and type. All data retrieval will follow data acquisition and handling procedures outlined in the project QAPP. ERG anticipates providing the project data in both Microsoft Excel files (.xlsx) and an Access database (.accdb) format. This will provide a permanent record of the set of data used to support the project. The databases will include forms to facilitate the extraction of data for those stakeholders not familiar with Access. The database will be uploaded to the files sharing platform, as designed in Task 10 (Section 2.10). SESARM will be notified when the database is available and ready for use.

In addition to observational data, the NADP's Total Deposition (TDEP) hybrid data can be downloaded for future use by the VISTAS states. The hybrid approach combines measurements from CASTNET; NADP's NTN, AIRMoN, and AMoN networks; and the SEARCH network with model output from CAMx to produce nationwide maps of deposition values. The data is available as map images and as gridded data in ESRI ArcGRID export files.[6] The ERG/Alpine team can also download this data for reference and review by the VISTAS states. These images and gridded data files will be uploaded to the files sharing platform, as

6 ftp://ftp.epa.gov/castnet/tdep/Total_Deposition_Documentation_current.pdf

designed in Task 10 (Section 2.10). SESARM will be notified when the data is available and ready for use.

2.5 Task 5 – 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.

The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model[7] developed by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL) will then be run for each of these days using NAM-12 hybrid meteorology and starting trajectory heights of 100 meters (m), 500 m, 1,000 m, and 1,500 m to identify areas most likely influencing visibility. Trajectories will be run 72 hours backwards in time.

Note: The RFP originally requested the NAM-12 (pressure) meteorological data to be used for the trajectories. However, in discussions with SESARM at contract execution, it was decided that ERG would use the NAMS-12 hybrid meteorology, as it provides better vertical and temporal resolution.

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 the IMPROVE monitor in each Class I area in the VISTAS_12 domain (Table 2-2 and Figure 2-1). Table 2-3 and Figure 2-2 indicates the representative monitor for each location that will be used in the analysis. For the three VISTAS region Class I areas (i.e., Wolf Island, Joyce Kilmer-Slickrock and Otter Creek) that do not have an IMPROVE monitor, the centroid of each Class I area will be used as the origin of the trajectories.

Table 2-2. IMPROVE Monitors in the VISTAS_12 Domain

IMPROVE Site	IMPROVE Site Code	State	County FIPS Code	Latitude	Longitude	Start Date	End Date
North Birmingham	BIRM1	AL	01073	33.5531	-86.8148	03/01/2004	04/28/2017
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
Flat Tops	FLTO1	CO	08103	39.9200	-107.6300	10/27/2011	04/28/2017
Great Sand Dunes NM	GRSA1	CO	08003	37.7249	-105.5185	03/02/1988	04/28/2017
Mount Zirkel Wilderness	MOZI1	CO	08057	40.5383	-106.6766	06/01/1994	04/28/2017
Ripple Creek	RICR1	CO	08103	40.0865	-107.3141	03/02/2009	10/30/2011
Rocky Mountain NP	ROMO1	CO	08069	40.2783	-105.5457	09/01/1990	04/28/2017
White River NF	WHRI1	CO	08097	39.1536	-106.8209	06/02/1993	04/28/2017
Mohawk Mt.	MOMO1	CT	09005	41.8214	-73.2973	09/13/2001	04/28/2017
Washington D.C.	WASH1	DC	11001	38.8762	-77.0344	03/02/1988	06/08/2015

[7] 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 2-2. IMPROVE Monitors in the VISTAS_12 Domain

IMPROVE Site	IMPROVE Site Code	State	County FIPS Code	Latitude	Longitude	Start Date	End Date
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
South Dekalb	ATLA1	GA	13089	33.6880	-84.2903	03/01/2004	04/28/2017
Lake Sugema	LASU2	IA	-999	40.6932	-92.0059	12/02/2004	04/28/2017
Viking Lake	VILA1	IA	19137	40.9690	-95.0450	05/08/2002	04/28/2017
Bondville	BOND1	IL	17019	40.0520	-88.3733	03/08/2001	04/28/2017
Cedar Bluff	CEBL1	KS	20195	38.7701	-99.7634	06/01/2002	04/28/2017
Sac and Fox	SAFO1	KS	20013	39.9791	-95.5682	06/01/2002	06/29/2011
Tallgrass	TALL1	KS	20017	38.4341	-96.5602	09/02/2002	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
Cape Cod	CACO1	MA	25001	41.9758	-70.0242	04/04/2001	04/28/2017
Martha's Vineyard	MAVI1	MA	25007	41.3309	-70.7846	12/01/2002	04/28/2017
Quabbin Summit	QURE1	MA	25015	42.2985	-72.3346	04/04/2001	12/29/2015
Frostburg Reservoir (Big Piney Run)	FRRE1	MD	24023	39.7058	-79.0122	03/01/2004	04/28/2017
Acadia NP	ACAD1	ME	23009	44.3771	-68.2610	03/02/1988	04/28/2017
Bridgton	BRMA1	ME	23005	44.1074	-70.7292	03/14/2001	12/29/2015
Casco Bay	CABA1	ME	23005	43.8325	-70.0644	03/14/2001	04/28/2017
Moosehorn NWR	MOOS1	ME	23029	45.1259	-67.2661	12/03/1994	04/28/2017
Penobscot	PENO1	ME	23019	44.9480	-68.6479	01/11/2006	04/28/2017
Presque Isle	PRIS1	ME	23003	46.6964	-68.0333	03/08/2001	04/28/2017
Detroit	DETR1	MI	26163	42.2286	-83.2085	09/03/2003	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
Blue Mounds	BLMO1	MN	27133	43.7158	-96.1913	06/01/2002	12/29/2015
Boundary Waters Canoe Area	BOWA1	MN	27075	47.9466	-91.4955	06/01/1991	04/28/2017
Great River Bluffs	GRRI1	MN	27169	43.9373	-91.4052	06/01/2002	04/28/2017
Voyageurs NP #2	VOYA2	MN	27137	48.4126	-92.8286	03/02/1988	04/28/2017
El Dorado Springs	ELDO1	MO	29039	37.7009	-94.0348	03/03/2002	12/29/2015
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
Fort Peck	FOPE1	MT	30085	48.3080	-105.1022	06/01/2002	04/28/2017

Table 2-2. IMPROVE Monitors in the VISTAS_12 Domain

IMPROVE Site	IMPROVE Site Code	State	County FIPS Code	Latitude	Longitude	Start Date	End Date
Medicine Lake	MELA1	MT	30091	48.4871	-104.4757	12/15/1999	04/28/2017
Northern Cheyenne	NOCH1	MT	30087	45.6495	-106.5574	06/01/2002	04/28/2017
UL Bend	ULBE1	MT	30027	47.5823	-108.7196	01/26/2000	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
Lostwood	LOST1	ND	38013	48.6419	-102.4022	12/15/1999	04/28/2017
Theodore Roosevelt	THRO1	ND	38007	46.8948	-103.3777	12/15/1999	04/28/2017
Crescent Lake	CRES1	NE	31069	41.7627	-102.4336	06/01/2002	12/29/2015
Nebraska NF	NEBR1	NE	31171	41.8888	-100.3387	06/01/2002	04/28/2017
Great Gulf Wilderness	GRGU1	NH	33007	44.3082	-71.2177	06/03/1995	04/28/2017
Londonderry	LOND1	NH	33015	42.8624	-71.3801	01/03/2011	04/28/2017
Pack Monadnock Summit	PACK1	NH	33011	42.8619	-71.8786	10/03/2007	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
Quaker City	QUCI1	OH	39121	39.9428	-81.3378	04/04/2001	04/28/2017
Ellis	ELLI1	OK	40045	36.0853	-99.9354	03/03/2002	10/18/2015
Stilwell	STIL1	OK	40071	35.7508	-94.6696	04/23/2010	04/28/2017
Wichita Mountains	WIMO1	OK	40031	34.7323	-98.7130	03/02/2001	04/28/2017
Egbert	EGBE1	ON	Canada	44.2312	-79.7832	09/01/2005	04/28/2017
Lawrenceville	PITT1	PA	42003	40.4654	-79.9607	03/01/2004	04/28/2017
Cape Romain NWR	ROMA1	SC	45019	32.9410	-79.6572	09/03/1994	04/28/2017
Badlands NP	BADL1	SD	46071	43.7435	-101.9412	03/02/1988	04/28/2017
Wind Cave	WICA1	SD	46033	43.5576	-103.4838	12/15/1999	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

Table 2-2. IMPROVE Monitors in the VISTAS_12 Domain

IMPROVE Site	IMPROVE Site Code	State	County FIPS Code	Latitude	Longitude	Start Date	End Date
Proctor Maple R. F.	PMRF1	VT	50007	44.5284	-72.8688	12/01/1993	04/28/2017
Forest County Potawatomi Community	FCPC1	WI	55041	45.5650	-88.8084	11/17/2016	04/28/2017
Dolly Sods Wilderness	DOSO1	WV	54093	39.1053	-79.4261	09/04/1991	04/28/2017
Cloud Peak	CLPE1	WY	56019	44.3335	-106.9565	06/01/2002	07/29/2015
Thunder Basin	THBA1	WY	56005	44.6634	-105.2874	06/01/2002	04/28/2017

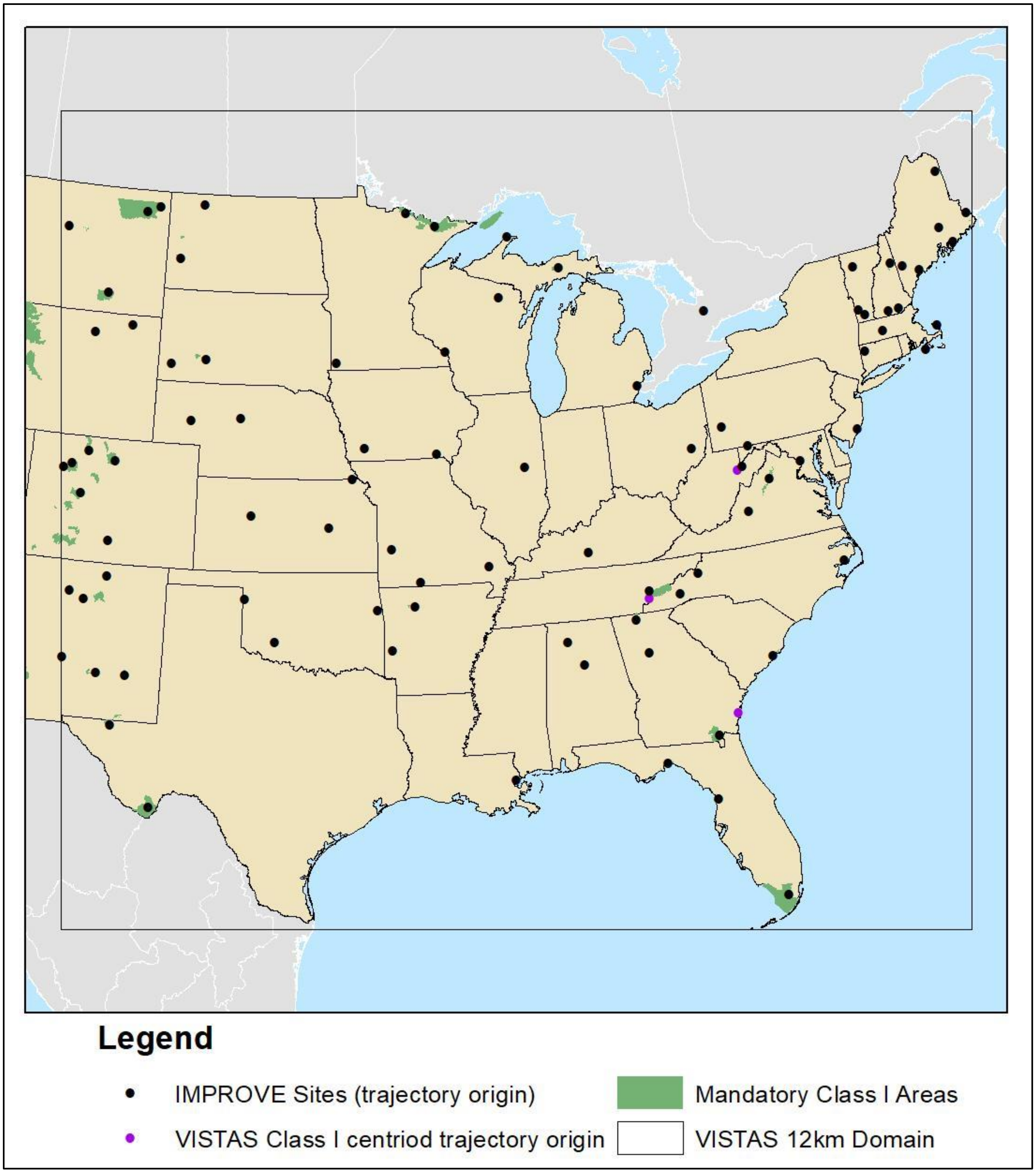

Figure 2-1. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS 12km Domain

Table 2-3. 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

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

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 plots via the openair[8] package for *R*. The residency time plots define the geographic areas with the highest probability of influencing the monitor on the 20% most impaired visibility days. The residency time is calculated as the frequency the trajectory is seen in a grid cell, as a percentage of the total. The grid used would align with the photochemical modeling 12km grid. For further analysis, *R* allows the residence time plots to be split by time increments (i.e., year, season), if that level of analysis is of interest. Images of the residency time 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. This can be accomplished in *R* using a Concentration Weighted Trajectory (CWT)[9] approach to the trajectory analysis, but substituting the extinction 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:

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

where i and j are the indices of grid, k the index of trajectory, N the total number of trajectories used in analysis, $bext_k$ is the extinction attributed to the pollutant measured upon arrival of trajectory k, and τ_{ijk} the residence time of trajectory k in grid cell (i, j).[10] The higher the value of $\bar{E}_{ij}$, 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. The results be normalized by the domain total to present the results as a percentage in images. Images of the extinction weighted residency time 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 next step is to 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 are calculated using ArcGIS and will be calculated from the

[8] 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.

[9] 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

[10] 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

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) divided by the distance (d) 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 extinction weighted residency time plot values (i.e., EWRT *(Q/d)). Similar to the EWRT plots, these values 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)). 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 (.xlsx) for each Class I area in the VISTAS_12 domain for further review by the states.

The Q/d values will be calculated by dividing emissions (tons per year) by distance (km).

All images (.png), shapefiles, and spreadsheets (.xlsx) will be uploaded to the files sharing platform, as designed in Task 10 (Section 2.10), 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 based on the “Reports” requirement in Subtask 1.6 (Section 2.1.6).

2.5.1 Optional Subtask 5.1 – SO_2 and NO_x Emissions Contribution Rankings

If directed by SESARM for this optional subtask, ERG will provide additional Excel spreadsheets ranking SO_2 and NO_2 emissions contributions for the point, onroad, nonroad, fires, and area source sectors from each county. The process will be similar to the process for point sources previously described in Section 2.5, 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 cell. The length of the trajectory within the cell would be used as a proxy for time, so that trajectories that only cross a small corner of the cell are not weight as much as trajectories passing through the more of the cell. This will be done in GIS using the same calculation as in *R*. The calculation of d would then be from the centroid of the county to the trajectory origin, in kilometers. 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.

This information can also be provided in an aggregated form to provide ranking of NO_x and SO_2 contribution for all source sectors on a county basis. The ERG/Alpine team would consult with the VISTAS states on the levels to which they would like to see the sources divided, and if desired, subdivided to allow the contributions to be viewed at several levels of aggregation and disaggregation. A database will be developed that facilitates the aggregation to multiple levels, so VISTAS states can see a source category, and then drill down into several subcategories to examine the highest contributors. For example, it may be of benefit to see the contribution of light duty versus heavy duty vehicles in addition to total onroad sources contribution at the county level. At a minimum, VISTAS will be able to aggregate at any of the four levels of the SCCs provided in the inventory.

All spreadsheets will be uploaded to the files sharing platform, as designed in Task 10 (Section 2.10), in separate folders for each Class I area in the VISTAS_12 domain. SESARM will be notified when the database is available and ready for use.

2.6 Task 6 – Air Quality Modeling

Under this task, ERG will direct Alpine to use Version 6.40 of CAMx, with Particulate Matter Source Apportionment Technology (PSAT) to generate the files and concentration data necessary to support this and additional tasks. The choice of running the model as quarterly simulations was made in consultation with SESARM to optimize the modeling to fit the computing capabilities of the VISTAS states. ERG will use the CONUS_12 and VISTAS_12 modeling domains for 2011 and 2028 modeling and the VISTAS_12 domain for PSAT work.

2.6.1 Subtask 6.1 – Modeling Protocol

Under this subtask, ERG will direct Alpine to prepare the modeling protocol, which is the "roadmap" for the entire study, laying out how the modeling will be conducted, and providing an opportunity for comment by SESARM and other stakeholders. The protocol will include all elements identified in the SOW to ensure a comprehensive and transparent path forward for the modeling project. The protocol will be developed following EPA's emissions and air quality modeling guidance and define air quality and meteorological model performance tests to ensure replicable and reliable modeling results.

To be consistent with EPA's recent regional haze modeling,[11] Alpine will utilize consistent configurations, chemistry, meteorology, and other ancillary data to perform this analysis. As specified in the RFP, the model version will be updated to the most recent available, currently CAMx version 6.40.

Once a final draft of the protocol has been completed, SESARM will submit the document for EPA to review. Upon receipt of comments and revision requests by EPA and approved by SESARM, the ERG/Alpine team will make appropriate revisions to the document with plans to incorporate any revised direction into the air quality modeling itself.

2.6.2 Subtask 6.2 – 2011 Base Year Air Quality Modeling

Under this subtask, ERG will direct Alpine to begin 2011 Base Year Air Quality modeling activities. The EPA 2011v6.3el modeling platform will form the foundation for the VISTAS II modeling. The study team already has EPA's 2011v6.3el modeling platform installed

[11] https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-Transmittal_Memo.pdf

on our computer cluster. EPA will be consulted, and any updated platform files will be acquired, developed, or utilized should it be available and requested by SESARM.

The numerics in photochemical grid models (PGMs) 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. Should a difference of 2% be seen in the replication of significantly contributing species of the 2011 base year photochemical modeling 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.

Development of the VISTAS_12 domain will require the EPA CONUS_12 simulation to be run using the most recent version of the CAMx modeling saving 3-dimensional concentration fields for extraction using the CAMx BNDEXTR program. The outputs of this simulation will be very large, approximately 10.5 Terabytes (TB). The study team has extensive experience with such large datasets and does not anticipate any issues.

Alpine has already processed EPA's 2011v6.3el platform on its internal modeling systems, using version 6.32 of CAMx that EPA used in its preliminary 2028 regional haze modeling. A comparison of the ozone results between the model run on Alpine's and EPA's computer clusters showed very small differences. The maximum ozone differences demonstrated were typically less than 0.01 ppb. Our experience has shown that changing CAMx versions often leads to larger differences than computer differences.

The VISTAS_12 domain will be a subset of the CONUS_12 domain, with the dimension specified in Table 2-4. After the VISTAS_12 simulation is complete, the results will be compared against the simulation over the CONUS_12 domain results and any differences noted. It is expected that the differences will be minor.

Table 2-4. Modeling Domain Specifications

Domain	Columns	Rows	Vertical Layers
CONUS_12	396	246	25
VISTAS_12	269	242	25

2.6.3 Subtask 6.3 – 2028 Projection Year Air Quality Modeling

Under this subtask, ERG will direct Alpine to begin 2028 modeling activities using the CAMx v6.40 model. The input emissions file will be the 2028 emissions inventory file developed in Task 2 (Section 2.2). The specific work elements in Subtask 6.3 (Section 2.6.3) follow those described in Subtask 6.2 (Section 2.6.2).

2.7 <u>Task 7 – Source Apportionment Tagging</u>

Under this task, ERG will direct Alpine to begin Source Apportionment Tagging activities. At this time, SESARM has planned for 250 source tags, but may increase or decrease the number of source tags during the course of the project. To gain a better understanding of the source contributions to modeled visibility, CAMx PSAT modeling will be utilized with the revised 2028 modeling platform. PSAT uses multiple tracer families to track the fate of both primary and secondary PM.[12] 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 or facility). For this application, 2028 emissions will be tagged 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 through SMOKE and tracked in PSAT as individual source tags. Receptors, identified as all the Class I areas in the VISTAS_12 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. During analysis for the initial regional haze SIPs, analysis found that in the southeast ammonium sulfate ($(NH_4)_2SO_4$), predominantly SO_2 emissions from EGUs and industrial sources, contributes 60 – 70% of the light extinction on the 20% haziest days.[13] Current analysis of IMPROVE measurements continues to confirm the importance of sulfate to visibility impairment on the 20% worst days through the Southeast.[14] In addition to sulfate, the VISTAS states may be interested in the contribution of nitrate from their states to visibility impairment at sites in the north central and eastern United States, as nitrate is generally of concern with respect to transport from VISTAS states to Class I areas outside the VISTAS region. The initial VISTAS analysis showed that the impacts from elemental carbon are minimal on the 20% worst days, with higher impacts from organic carbon. However, the impacts from organic carbon are dominated by biogenic emissions, not anthropogenic emissions, which can be controlled. Tracking of these and other PM species (i.e., elemental carbon, organic carbon, etc.) that contribute to visibility impairment may be of some use, but has not been requested in this analysis.

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[12] http://camx.com/publ/pdfs/yarwood_itm_paper.pdf

[13] Patricia Brewer & Tom Moore (2009) Source Contributions to Visibility Impairment in the Southeastern and Western United States, Journal of the Air & Waste Management Association, 59:9, 1070-1081, DOI: 10.3155/1047-3289.59.9.1070

[14] U.S. Environmental Protection Agency. 2016. Technical Support Document (TSD) Revised Recommendations for Visibility Progress Tracking Metrics for the Regional Haze Program U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Air Quality Assessment Division Research Triangle Park, NC 27711. July 2016

2.8 Task 8 – Model Performance Evaluation

Under this task, ERG will direct Alpine to begin MPE activities. Alpine will review EPA's current operational MPE[15] for particulate matter ($PM_{2.5}$ species components and coarse PM) and regional haze 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 (e.g., .csv, Excel). Alpine will use the current IMPROVE equation[16] (below) 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.

$$\begin{aligned} b_{ext} \approx\ & 2.2 \times f_s(RH) \times [Small\ Sulfate] + 4.8 \times f_L(RH) \times [Large\ Sulfate] \\ & + 2.4 \times f_s(RH) \times [Small\ Nitrate] + 5.1 \times f_L(RH) \times [Large\ Nitrate] \\ & + 2.8 \times [Small\ Organic\ Mass] + 6.1 \times [Large\ Organic\ Mass] \\ & + 10 \times [\text{Elemental Carbon}] + 1 \times [\text{Fine Soil}] \\ & + 1.7 \times f_{SS}(RH) \times [Sea\ Salt] + 0.6 \times [\text{Coarse Mass}] \\ & + \text{Rayleigh Scattering (Site Specific)} + 0.33 \times [\text{NO}_2\ \text{(ppb)}] \end{aligned}$$

Tables and plots will be prepared for VISTAS and 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 (and further include 2028 modeled data in Task 9 (Section 2.9)) the individual day-by-day and site-by-site stacked bar plots of total *beta* extinction (bext) and speciated components of bext for these most impaired and clearest days.[17] To confirm, 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.

Tables of the above-noted MPE statistics will be provided in Excel (.xlsx) or .csv file format and will include the same suite of metrics included in EPA's modeling TSD and this project's QAPP. Additional details will be provided in the modeling protocol. A technical document describing the performance evaluation and results will be prepared for SESARM under the "Reports" requirement in Subtask 1.6 (Section 2.1.6).

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15 https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf

16 Pitchford, M.; Malm, W.; Schichtel, B.; Kumar, N.; Lowenthal, D.; Hand, J. Revised algorithm for estimating light extinction from IMPROVE particle speciation data; J. Air & Waste Manage. Assoc. 2007, 57, 1326-1336; doi: 3155/1047-3289.57.11.1326.

17 MPE statistics can be calculated for all IMPROVE days (annual and by season of the year), but was not identified in the original SOW. Additional funds will be needed to accomplish this request.

2.8.1 *Subtask 8.1 – Model Performance Evaluation for Weekly Wet and Weekly Dry Deposition Species*

Under this subtask, ERG will direct Alpine to perform MPE for weekly wet deposition and weekly dry deposition species collected in Subtask 4.1 (Section 2.4.1). For the 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.[18] Dry deposition values from CASTNET can be developed from the observed concentration multiplied by a deposition velocity generated by the Multi-Layer Model (MLM)[19] for the site. The MLM generated deposition velocities are available for download with the CASTNET observations.[20]

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.

2.9 Task 9 – Future Year Model Projections

Under this task, ERG will direct Alpine to calculate relative response factors (RRFs) for each IMPROVE monitor in the VISTAS_12 modeling domain. RRFs are a ratio of the air quality

[18] 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.

[19] 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.

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

concentration in the future year to the air quality concentration in the base year.[21] In its simplest form, RRF is defined as:

$$RRF = \frac{Modeled\ Concentration_{FutureYear}}{Modeled\ Concentration_{BaseYear}}$$

This yields an average percent change in pollutant or species concentrations due to emission changes between the base and future years. For regional haze modeling the RRF is based on the measured 20% most impaired and 20% clearest days from the base year. Ultimately, the RRF is multiplied by a base design values (DVB), which is based on monitored data, to produce a design value for the future year (DVF). For regional haze modeling, RRFs for each component of light extinction are calculated and multiplied by their corresponding speciated DVBs to get speciated DVFs for each component of light extinction. Then, the speciated DVFs for each component are summed to give the total future year light extinction (Mm^{-1}) which will be converted to haze index (dV). The haze index DVF is the future year projection that will ultimately be used to determine the 2028 reasonable progress goals (RPGs) at each Class I area. Using the DVB keeps the future projection rooted in observed data, and not just modeling. The advantage to using RRFs is that the modeling is used in a relative sense, which can account for any factor causing bias in the modeling results. That is, any bias seen in the base year will likely be present in the future year and by taking the ratio of the two years that bias is effectively canceled out.

Alpine will use EPA's Software for Model Attainment Test – Community Edition (SMAT-CE) tool to calculate 2028 deciview values and visibility on the 20% most impaired and 20% clearest days at each Class I area in the VISTAS_12 domain. This tool implements the procedures from EPA's modeling guidance to project visibility to a modeled projection year using RRFs. With the results of each SMAT-CE run, executed for each simulation identified in Task 6 (Section 2.6), the ERG/Alpine team will prepare glide slope graphics, demonstrating the progress in visibility improvement for the 20% most impaired and 20% clearest days relative to baseline visibility conditions at each Class I area in the VISTAS_12 domain.

Additionally, using IMPROVE site observations and model concentration projections, Alpine will create day-by-day stacked bar charts of total, sulfate, and speciated component bext for the 20% most impaired and 20% clearest days per site for each IMPROVE monitor in the VISTAS_12 modeling domain. This step requires special processing of the SMAT-CE runs using available advanced options in the tool to generate the contribution calculations for each tagged species from Task 7 (Section 2.7) and for each simulation to be compared back to the baseline run. Details of these methods proposed to be used can be found in EPA's most recent Regional Haze Modeling TSD.[22]

Alpine will also modify the 2011 site-by-site average stacked bar charts of total, sulfate, and speciated component bext for the 20% most impaired and 20% clearest days per site for all IMPROVE monitors in the VISTAS_12 modeling domain from Task 8 (Section 2.8) to include

[21] Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze (PDF)(214 pp, 3.25 M) - December 2014. Available at: https://www3.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf

[22] https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf

2028 modeled data. At the direction of SESARM, these may be documented separately by VISTAS and non-VISTAS locations.

A technical memorandum/interim report describing the projections, methods, and results will be prepared for SESARM using the "Reports" requirement in Subtask 1.6 (Section 2.1.6).

Upon completion of this task, Alpine will work with ERG to develop procedures necessary to upload all future year regional haze visibility projections and supporting data on the website or dedicated FTP site to be developed in Task 10 (Section 2.10).

2.9.1 Subtask 9.1 – Calculating Relative Response Factors and Future Year Projections of Weekly Wet and Weekly Dry Deposition Species

Under this subtask, ERG will direct Alpine to calculate the RRFs and future year projections of weekly wet deposition and weekly dry deposition species. RRFs have become an integral part of the SIP process, as they are a useful tool in estimating the future year impacts of emission changes, while considering model performance. RRFs for each deposition site will be calculated consistent with EPA guidance for calculating RRFs for ozone and $PM_{2.5}$ species. Future year projections will be developed for each site by multiplying the RRF by monitored values. ERG and Alpine will consult with SESARM on the averaging time used for the development of the RRFs. At a minimum, Alpine will produce annual and maximum weekly RRFs and future projections to provide an estimate of annual and short-term loading changes.

2.10 Task 10 – Data Handling and Sharing

For Task 10, the ERG/Alpine team will develop and implement a solution for the distribution and archival of project assets (emissions and air quality modeling output, summaries, and other project documentation). ERG and Alpine will work with the SESARM to develop an effective data handling and sharing scheme. Alpine acted as the data librarian in the first VISTAS study, and ERG will do so for this study. At that time the most practical data sharing was conducted by mailing 300 gigabyte (GB) external hard drives to groups requesting large datasets. While the computer communications are much faster than they were in 2004, the size of the datasets has expanded.

While some groups have attempted to have fully internet-based transfer schemes, the study team's experience is that for sharing the full CAMx model inputs and outputs it is still best to continue to ship external USB3 hard drives formatted with FAT32 or exFAT. A typical transfer of an annual CAMx platform takes approximately 18 terabytes (TB) of data. This can be facilitated by sending two 10 TB drives. If SESARM was to purchase 2 sets of drives for distribution, a set could be sent to the requesting group. After the group reads the drives, they are sent back to the librarian. Alternatively, the requesting group can send drives to the librarian, the librarian can copy the data onto the drive and send it back. The study team has had good success with low-cost dedicated Serial AT Attachment (SATA) duplication "docks" that can copy 10 TB drives in approximately 12 hours. External USB3 hard drives will be distributed by the data librarian per the procedure outlined in the QAPP.

The ERG/Alpine team will also consult with SESARM on using SharePoint to manage project asset distribution files among project stakeholders and the Metro 4/SESARM Drupal web site to publish project assets for public use. ERG has extensive experience using SharePoint for project collaboration across agencies and stakeholders. ERG has had a lot of success using

SharePoint, as it allows for collaborative editing, parallel review, and file exchange for multiple users. SharePoint will allow for the following project functions:

- A central web site to provide quick access to project assets and news for stakeholders.
- File exchange and storage. The Team will use folders within SharePoint to organize project assets.
- Access control. Using SharePoint user groups, ERG will customize permissions so only the right people have access to specific files and folders.
- Project asset distribution. SharePoint can be configured to send out notifications related to file publishing.
- Project asset archives. SharePoint uses version control and a recycle bin for file retention. Version control allows keeping previous versions of files as needed and the recycle bin provides a mechanism for restoring files when an entire site collection is deleted.

SharePoint can also provide additional features not specified in the RFP, such as:

- Collaboration in Word and Excel. SharePoint allows simultaneous editing of Word documents and Excel spreadsheets (including data summary files), and enables tracking of response to comments.
- A central tracking location. ERG can adapt the project schedules into a dashboard editable by SESARM and ERG, as appropriate.
- Responsively designed interface to allow access and collaboration regardless of device and operating system and a downloadable app for stakeholder review.

ERG can update the existing Metro 4/SESARM Drupal site (http://www.metro4-sesarm.org/) to distribute project asset files intended for public use. ERG will publish the public data to the emissions, modeling, and reports web pages leveraging the site's Drupal template to create a simple and intuitive mechanism for accessing project assets. ERG will work with SESARM to determine if an interim "shadow" website is to be developed first and then transferred to the existing SESARM website, or if ERG is to work with the existing website and SESARM webmaster.

ERG and Alpine will develop a Standard Operating Procedure (SOP) for uploading files to the SharePoint and Metro 4/SESARM Drupal sites. The SOP will address:

- File formats for all project asset types (e.g., model outputs).
- The review/approval process for publishing files and updates to the two sites.
- Routines for publishing the model outputs after each run is complete, allowing SESARM to review the results in a timely manner.
- Instructions for downloading the SharePoint content locally for offline access.

2.11 Task 11 – Other Potential Tasks (Currently Funded)

In Task 11, ERG will provide support to SESARM for additional work not included in the original RFP. Such support may include assisting the VISTAS states in developing regional haze SIPs. ERG and Alpine have supported a number of states in supporting SIP and similar-type efforts. Prior to the execution of the VISTAS Contract, SESARM requested two additional subtasks under Task 11.

2.11.1 Subtask 11.1 – Extract IC/BC for up to 5 States

Under this subtask, ERG will direct Alpine to extract initial conditions and boundary conditions (IC/BC) from the 2011 and 2028 VISTAS_12 CAMx simulations. Initially, up to 5 roughly state-sized CAMx domains will be extracted. SESARM may request extractions for up to an additional 5 states.

2.11.2 Subtask 11.2 – Extract of Meteorological Data for up to 5 States

Under this subtask, ERG will direct Alpine to extract meteorological data from the CAMx simulations. Initially, up to 5 roughly state-sized CAMx domains will be extracted. SESARM may request extractions for up to an additional 5 states. To assure that the meteorological data are accurately converted (windowed) from the EPA CONUS domain to the VISTAS 12km domains, the meteorological fields all the domains will be compared both graphically and by examining specific grid values.

3. SCHEDULE OF DELIVERABLES

Table 3-1 presents the schedule of deliverables under the VISTAS Contract. The project end-date is July 1, 2019. The contract between ERG and SESARM allows for amendments when determined to be necessary and with agreement between the parties. The due dates specified in Table 3-1 are subject to this amendment process if needed.

Table 3-1. Project Deliverable Schedule

Task	Subtask	Deliverable	Due Date
1	1.3	Contract Management	Ongoing
	1.2	Contract Development	3/1/2018
	1.3	Draft Work Plan to SESARM	3/13/2018
	1.4	Draft QAPP to SESARM	3/15/2018
	1.5	Communications	Ongoing
	1.6a	Reporting – Progress Reports	Monthly, within 2 weeks after the end of the month
	1.6b	Reporting – Draft Interim Reports	Completion of subtasks or group of subtasks
	1.6c	Reporting – Final Interim Reports	Within 2 weeks of receiving comments
	1.6d	Reporting – Draft Final Report	5/8/2019
	1.6e	Reporting – Final Report	7/1/2019
	1.6f	Reporting – Presentation slides	Ongoing, as needed
	1.7	Invoicing	Monthly, within 2 weeks after the end of the month

Table 3-1. Project Deliverable Schedule

Task	Subtask	Deliverable	Due Date
2	2.1	2011 Base year emissions inventories	6/1/2018
	2.2a	Projection Year Emissions Inventory Comparisons, draft	5/18/2018
	2.2b	Projection Year Emissions Inventories, final	Within one week of receiving comments
	2.3a1	2028 EGU Point Source Emissions, draft	5/18/2018
	2.3a2	2028 EGU Point Source Emissions, final	Within one week of receiving comments
	2.3b1	2028 Non-EGU Point Source Emissions, draft	5/18/2018
	2.3b2	2028 Non-EGU Point Source Emissions, final	Within one week of receiving comments
	2.3c1	2028 Emissions for Other Categories, draft	5/18/2018
	2.3c2	2028 Emissions for Other Categories, final	Within one week of receiving comments
	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	Within one week of receiving comments
	2.3e1	2028 Documentation, draft	5/18/2018
	2.3e2	2028 Documentation, final	Within one week of receiving comments
	2.4	Emissions summaries and Quality Assurance	6/1/2018
3	3.1	Create Photochemical Model-Ready EGU emissions files for 2028	7/1/2018
	3.1.1*	Full EGU emissions replacement (will not be done)	Not Applicable
	3.1.2	Scale Hourly EGU SMOKE emissions to match annual 2028 (selected)	7/1/2018
	3.2	Create Photochemical Model-Ready Non-EGU emissions files for 2028	7/1/2018
	3.3a	Merge EGU/non-EGU data from Subtasks 3.1 and 3.2 for CAMx Model	7/1/2018
	3.3b*	Merge area/MAR data from Subtasks 3.1 and 3.2 for CAMx Model	7/1/2018
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	Within 2 weeks of receiving comments
	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)	4/1/2019
8	8	Model performance evaluation	10/1/2018
	8.1	Model performance evaluation (related to Subtask 4.1)	10/1/2018

Table 3-1. Project Deliverable Schedule

Task	Subtask	Deliverable	Due Date
9	9a	Future-year model projections – 250 tags (final number to be determined)	4/19/2019 [23]
	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
	11.1a	Extraction of state-specific modeling initial conditions/boundary conditions (5 states)	Within 1 week after completion of Task 6.1 and 6.2 activities
11	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

* Optional Task, No decision yet whether to perform it.

4. TASK ORGANIZATION OF KEY PERSONNEL

Table 4-1 presents the distribution of personnel by task.

Mr. Regi Oommen will serve as the ERG Program Manager and Technical Project Coordinator for this work ensuring that ERG's contractual obligations are met. He will be responsible for all management and administrative aspects of the work, including ensuring that the quality of the work, schedule, and budget meet the requirements of the VISTAS Contract. Regi will be supported by **Ms. Darcy Wilson**, who will serve as the Deputy Program Manager and QA Coordinator. Regi will also lead the work conducted under Tasks 1 (Section 2.1), 2 (Section 2.2), and 11 (Section 2.11) and will work in coordination with **Ms. Bebhinn Do** to support Tasks 4 (Section 2.4) and 5 (Section 2.5), and with **Mr. Adam Langmaid** to support Task 10 (Section 2.10). The ERG task managers will be supported by Jeanette Alvis, Richard Billings, Lindsay Dayton, Allison DenBleyker, Stacie Enoch, Karla Faught, Jaime Hauser, Noel Hilliard, Steve Mendenhall, Courtney Myers, Heather Perez, Jennifer Sellers, Paula Fields-Simms, Jody Tisano, and Marty Wolf.

[23] Please note that this date conflicts with Table 3 of the VISTAS Contract as executed but is consistent with ERG's proposal. SESARM and ERG affirm that 4/19/2019 is the correct date and commit to correct the error formally via an amendment or other means consistent with the VISTAS Contract at a later date but before 4/1/2019.

Mr. Gregory Stella will serve as the Alpine Project Manager for this work ensuring that Alpine's contractual obligations are met. He will be responsible for all management and administrative aspects of the subcontracted work, including ensuring that the quality of the work, schedule, and budget meets the requirements of the subcontract. Greg will also lead Tasks 3 (Section 2.3), 8 (Section 2.8), and 9 (Section 2.9), and will work in coordination with **Mr. Dennis McNally** to support Tasks 6 (Section 2.6) and 7 (Section 2.7). Greg and Dennis will be supported by Cynthia Loomis.

Table 4-1. Distribution of Personnel by Task for SESARM Contract V-2018-03-01

Personnel	Role	P-Level	Task											
			1	2	3	4	5	6	7	8	9	10	11	Total Hours
ERG Hours														
Regi Oommen	Program Manager/Task Lead	4	109	37	8	8	10	6	2	7	6	15	0	208
Darcy Wilson	Deputy Program Manager/QA	4	34	8	0	0	0	0	0	0	0	0	0	42
Jeanette Alvis	QAPP Support	4	16	0	0	0	0	0	0	0	0	0	0	16
Richard Billings	Emission Inventory Support	4	0	8	6	0	0	0	0	0	0	0	0	14
Lindsay Dayton	GIS Support	1	0	0	0	6	19	0	0	10	10	0	0	45
Allison DenBleyker	Emission Inventory Support	2	0	0	2	0	0	0	0	0	0	0	0	2
Bebhinn Do	Task Lead	3	84	52	12	19	36	6	2	14	12	15	0	252
Stacie Enoch	Emission Inventory Support	3	6	39	0	0	0	0	0	0	0	0	0	45
Karla Faught	Ambient Monitoring Support	2	0	0	0	24	56	0	0	0	0	0	0	80
Paula Fields-Simms	Emission Inventory Support	4	0	8	10	1	0	0	0	0	0	0	0	19
Jaime Hauser	Ambient Monitoring Support	3	0	0	0	7	0	0	0	0	0	0	0	7
Noel Hilliard	GIS Support	1	0	0	0	6	18	0	0	10	10	0	0	44
Adam Langmaid	Task 10 Lead	3	0	0	0	0	0	0	0	0	0	55	0	55
Steve Mendenhall	Database Support	4	0	20	0	4	6	0	0	0	0	0	0	30
Courtney Myers	Website Support	3	0	0	0	0	0	0	0	0	0	45	0	45
Heather Perez	GIS Support	4	25	2	2	0	8	0	0	0	0	0	0	37
Jennifer Sellers	Emission Inventory Support	2	0	0	2	0	0	0	0	0	0	0	0	2
Jody Tisano	Clerical Support	1	44	8	0	0	4	0	0	0	0	0	0	56
Marty Wolf	Emission Inventory Support	4	0	14	8	0	0	0	0	0	0	0	0	22
Alpine Hours														
Gregory Stella	Subcontract Manager/Task Lead	4	50	18	66	2	10	20	82	70	84	6	2	410
Cynthia Loomis	Modeling Support	4	4	0	68	0	0	0	0	2	0	0	2	76
Dennis McNally	Task Lead	4	12	0	8	2	4	120	220	10	24	6	20	426
Total Hours			**384**	**214**	**192**	**79**	**171**	**152**	**306**	**123**	**146**	**142**	**24**	**1,933**

Task 1 – Project Management
Task 2 – Emission Inventory Development
Task 3 – Emissions Processing
Task 4 – Data Acquisition and Preparation
Task 5 – Area of Influence Analysis
Task 6 – Air Quality Modeling
Task 7 – Source Apportionment Tagging
Task 8 – Model Performance Evaluation
Task 9 – Future Year Model Projections
Task 10 – Data Handling and Sharing
Task 11 – Other Potential Tasks

5. QUALITY CONTROL

ERG's corporate quality management system is detailed in the *Quality Management Plan*, dated December 2015. This QMP was prepared in accordance with *EPA Requirements for Quality Management Plans (QA/R-2)* [dated 03/20/01]. It details the responsibilities of the QA coordinators and Project Management Team and describes procedures used to plan, implement, and assess project quality. These procedures, tailored to the needs of the tasked activities, will be used on this project. An overview of the procedures ERG will use to ensure the quality of work on this project is set out in this section.

ERG has an established internal quality control review procedure for project deliverables (technical memoranda, calculations, etc.). The levels of review required for various types of deliverables anticipated on this project. All tasks conducted and products generated receive (1) a conceptual review, (2) a developmental review, and (3) a final product review.

A *conceptual review* is performed during the initial stages of work development and ensures that the final product and associated documentation address the needs set forth by the SESARM APC and the Tasks. Conceptual review will be provided by the ERG Program Manager and Technical Project Coordinator as well as senior engineers knowledgeable in the technical aspects of the work, but not directly involved in the task work under the Contract. The quality of intermediate deliverables and final products is also evaluated as these work products evolve. This *developmental review* includes (1) a check on calculations and data and (2) a review of draft documents to ensure that the direction of work is consistent with the conceptual review outline. *Final product review* is conducted on all deliverables prior to delivery to SESARM.

The draft QAPP was submitted to SESARM on March 15, 2018. Work on Tasks 2 (Section 2.2) through 11 (Section 2.11) will commence upon approval of the QAPP, subject to written authorization on a task-by-task basis from SESARM to ERG.

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Appendix A-3

Vistas II Regional Haze Air Quality Report

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VISTAS II Regional Haze Air Quality Report (Final)

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:
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1600 Perimeter Park Dr., Suite 200
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and

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February 10, 2021

Alpine Project Number: TS-527
ERG Project Number: 4133.00.001

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Executive Summary

This report documents SESARM's VISTAS II Regional Haze Air Quality project, which is a multi-state, multi-jurisdictional effort to develop air quality work products to support member states in their development of State Implementation Plans (SIPs). As required in the 2017 Regional Haze Rule, states must develop strategies to control anthropogenic emissions affecting visibility in Mandatory Class I Federal areas. Within SESARM, there are eighteen Mandatory Class I Federal Areas across the ten member states. Specifically, this report coalesces eleven defined task areas designed to provide technical work products that can be tailored for each SESARM member state's Regional Haze SIP development.

Emissions (Sections 2 and 9). Across the ten VISTAS member states, criteria pollutant emissions from 2011 to 2028 will significantly decreased. Of particular note:

- Oxides of Nitrogen (NO_X) total anthropogenic emissions are project to decrease from approximately 3.34 million tons per year (tpy) to approximately 1.53 million tpy, which is a 54% reduction. For point sources, the emissions from electricity generating units (EGUs) are projected to decrease from approximately 498,000 tpy to approximately 214,000 tpy (57% reduction). Emissions from non-EGUs are expected to decrease from approximately 388,000 tpy to approximately 349,000 tpy (10% reduction).

- Sulfur Dioxide (SO_2) total anthropogenic emissions are projected to decrease from 1.63 million tpy to approximately 0.45 million tpy, which is a 73% reduction. For point sources, the emissions from EGUs are projected to decrease from approximately 1.20 million tpy to approximately 183,000 tpy (85% reduction). Emissions from non-EGUs are projected to decrease from approximately 286,000 tpy to approximately 187,000 tpy (35% reduction).

Monitoring Data (Section 4). Within the VISTAS modeling domain, ambient air monitoring, meteorological observations, and deposition fluxes were obtained, standardized, and prepared for the years 2011 through 2016. These datasets were used for the model performance evaluations.

Modeling (Section 6). Seven benchmark comparisons were conducted to evaluate the CAMx modeling system and protocols implemented, and to demonstrate satisfactory confidence when projecting visibility metrics.

- Benchmark Confirmation Run #1 – compares EPA 2011 with CAMx 6.32 (CONUS)[1] vs. Alpine 2011 with CAMx 6.32 (CONUS);
- Benchmark Confirmation Run #2 – compares EPA 2028 with CAMx 6.32 (CONUS) vs. Alpine 2028 with CAMx 6.32 (CONUS);

[1] CONUS: Continental U.S.

- Benchmark Confirmation Run #3 – compares Alpine 2011 with CAMx 6.32 (CONUS) vs. Alpine 2011 with CAMx 6.40 (CONUS);
- Benchmark Confirmation Run #4 – compares Alpine 2028 with CAMx 6.32 (CONUS) vs. Alpine 2028 with CAMx 6.40 (CONUS);
- Benchmark Confirmation Run #5 – compares Alpine 2011 with CAMx 6.40 (CONUS) vs. Alpine 2011 with CAMx 6.40 (VISTAS modeling domain);
- Benchmark Confirmation Run #6 – compares Alpine 2028 with CAMx 6.40 (CONUS) vs. Alpine 2028 with CAMx 6.40 (VISTAS modeling domain);
- Benchmark Confirmation Run #7 – compares Alpine 2028elv3 with CAMx 6.40 (VISTAS modeling domain) vs. Alpine 2028elv5 with CAMx 6.40 (VISTAS modeling domain).

Model Performance Evaluations (Section 7). Modeled 2011 ozone and PM concentrations and wet and dry deposition fluxes were compared to observed concentrations and deposition fluxes. The statistical metrics presented suggest satisfactory model performance for regulatory applications.

Area Of Influence and PSAT[2] Analysis (Sections 5 and 8). At each Class I area in the VISTAS domain, 72-hour back trajectories for multiple time segments and vertical layers were generated for the six-year base period from 2011 through 2016. Extinction-weighted residence times were then applied to stationary source NO_x and SO_2 emissions and paired with distance from the Class I area to source locations to select facilities for PSAT modeling. Based on this analysis, a total of 209 individual source, geographic region, and boundary condition tags were created for evaluation of sulfate and nitrate source contributions. Sulfate and nitrate contributions were assessed for 87 individual sources. This information was used to help identify facilities that might need to perform a four-factor analysis.

Visibility Projections Metrics (Section 10). The EPA SMAT-CE[3] tool was used to calculate 2028 deciview values on the 20% most anthropogenically impaired and 20% clearest days at each Class I area in the VISTAS domain. At all Class I sites, the deciview values are projected to decrease from 2011 to 2028 on the 20% clearest and 20% most anthropogenically impaired days. Within the SESARM states, the expected visibility improvement is generally large. Additionally, with the exception of the Everglades, the projected visibility is below the modeled unadjusted glidepath. Visibility in 2028 at the Everglades National Park, the southernmost Mandatory Class I Federal area within VISTAS, is projected to be below the modeled adjusted glidepath when taking into account international emission visibility impacts.

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2 PSAT: Particulate Source Apportionment Technology
3 SMAT-CE: Software for the Modeled Attainment Test – Community Edition

Contents

TABLES

FIGURES

Abbreviations/Acronym List

AIRMoN	Atmospheric Integrated Research Monitoring Network
Alpine	Alpine Geophysics, LLC
AL	Alabama
AMoN	Ammonia Monitoring Network
AMNet	Atmospheric Mercury Network
AoI	Area of Influence
AQS	Air Quality System
ARL	Air Resources Laboratory
ASOS	Automated Surface Observing Systems
AWOS	Automated Weather Observing Systems
BC	Boundary conditions
BEIS	Biogenic Emissions Inventory System
Ca^{2+}	Calcium ion
CAA	Clean Air Act
CAL	Central Analytical Laboratory
CAMx	Comprehensive Air quality Model with eXtensions
CART	Classification And Regression Tree
CASTNET	Clean Air Status and Trends Network
CB6	Carbon Bond, version 6
CBSA	Core-Based Statistical Area
CC	Coordinating Committee
CCRS	Coarse PM species
CEM	Continuous Emissions Monitoring
CenRAP	Central Regional Air Partnership
CFR	Code of Federal Regulations
CIRA	Cooperative Institute for Research in the Atmosphere
Cl^{-}	Chloride ion
CM	Coarse mass
CMAQ	Community Multiscale Air Quality
CMV	Commercial Marine Vessels
CO	Carbon Monoxide
CONUS	Continental U.S.
CPP	Clean Power Plan
CPRM	Coarse PM
CSAPR	Cross-State Air Pollution Rule
CSN	Chemical Speciation Network
CWT	Concentration Weighted Trajectory
d	Distance in km
dv	Deciview
EC	Elemental Carbon
EGU	Electricity Generating Unit
EIS	Emission Inventory System
EPA	United States Environmental Protection Agency
EPIC	Environmental Policy Integrated Climate
ERG	Eastern Research Group, Inc.
ERTAC	Eastern Regional Technical Advisory Committee

EWRT	Extinction-weighted residence time
F	Degrees Fahrenheit
FAA	Federal Aviation Administration
FCRS	Crustal fraction of PM
FF10	Flat File 2010
FIPS	Federal Information Processing System
FL	Florida
FLM	Federal Land Manager
FPRM	Fine other particulate
FR	Federal Register
FRM	Federal Reference Method
FTP	File Transfer Protocol
g	Gram
GA	Georgia
GADNR	Georgia Department of Natural Resources
GB	Gigabyte
GIS	Geographic Information System
GUI	Graphical User Interface
ha	Hectare
HAL	Mercury Analytical Laboratory
HNO_3^-	Nitric acid
Hg	Mercury
HgP	Particulate Bound Mercury
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
IC	Initial conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
in	Inches
IPM	Integrated Planning Model
ISWS	Illinois State Water Survey
K^+	Potassium ion
kg	Kilogram
km	Kilometer
kts	Knots
KY	Kentucky
L	Liter
LADCO	Lake Michigan Air Directors Consortium (LADCO)
LC	Local Conditions
m	Meter
MANE-VU	Mid-Atlantic and Northeast Visibility Union
MAPS	Model Performance Evaluation, Analysis, and Plotting Software
MARAMA	Mid-Atlantic Regional Air Management Association, Inc.
mb	Millibar
MB	Mean bias
ME	Mean Error
mg	Milligram
Mg^{2+}	Magnesium ion
$\mu g/m^3$	micrograms per cubic meter
MDA	Maximum daily

MDN	Mercury Deposition Network
MLM	Multi-Layer Model
Mm^{-1}	Inverse Megameters
MMBTU/hr	Million British thermal units per hour
MOVES	Motor Vehicle Emissions Simulator
MPEs	Model performance evaluations
mph	Miles per hour
MS	Mississippi
MW	Megawatts
Na^{+}	Sodium ion
NaCl	Sodium chloride
NAAQS	National Ambient Air Quality Standard
NADP	National Atmospheric Deposition Program
NAICS	North American Industry Classification System
NAM	North American Mesoscale
NC	North Carolina
NCDAQ	North Carolina Division of Air Quality
NCDEQ	North Carolina Department of Environmental Quality
NCEI	National Centers for Environmental Information
NEG	Non-EGU
NEI	National Emissions Inventory
NH_3	Ammonia
NH_4^{+}	Ammonium ion
NMB	Normalized mean bias
NME	Normalized mean error
NO_3^{-}	Nitrate ion
NOAA	National Oceanic and Atmospheric Administration
NODA	Notice of data availability
NO_x	Oxides of nitrogen
NRC	National Research Council
NTN	National Trends Network
NWS	National Weather Service
OC	Organic Carbon
OM	Organic Matter
OMC	Organic Mass Carbon
ORIS	Plant identifier issued by U.S. Department of Energy
PCL	Chlorine
PEC	Primary elemental carbon
pH	Scale used to specify the acidity or basicity of an aqueous solution
PM	Particulate matter
PM_{10}	Particulate matter less than or equal to 10 microns in aerodynamic diameter (for concentrations)
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns in aerodynamic diameter (for concentrations)
PM10-PRI	Primary particulate matter (PM) less than 10 microns (for emissions)
PM25-PRI	Primary particulate matter (PM) less than 2.5 microns (for emissions)
PNH4	Ammonium
PNO3	Particulate nitrate

POA/POC	Primary organic carbon
ppb	Parts per billion
PSAT	Particulate Source Apportionment Technology
PSO4	Sulfate
Q	Facility emissions in tpy
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RADM-AQ	Regional Acid Deposition Model – aqueous chemistry
RFP	Request for Proposal
RH	Relative Humidity
RHR	Regional Haze Rule
RHWG	Regional Haze Work Group
RPO	Regional Planning Organization
RRFs	Relative Response Factors
RT	Residence time
RPG	Reasonable progress goal
SATA	Serial Advanced Technology Attachment
SIA	Second Improve Algorithm
SC	South Carolina
SCC	Source Classification Code
SCR	Selective catalytic reduction
SESARM	Southeastern States Air Resource Managers, Inc.
SIP	State Implementation Plans
SMAT	Software for the Modeled Attainment Test
SMAT-CE	SMAT – 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
SOP	Standard Operating Procedure
SOW	Scope of Work
SQL	Structured Query Language
TAMIS	Texas Air Monitoring Information System
TAWG	Technical Analysis Work Group
TB	Terabyte
TN	Tennessee
TPC	Technical Project Coordinator
tpy	Tons per year
TSD	Technical Support Document
URP	Uniform rate of progress
USB	Universal serial bus
USCRN	U.S. Climate Reference Network
USHCN	U.S. Historical Climatology Network
USRCRN	U.S. Regional Climate Reference Network
UTC	Universal Time Coordinated
Vd	Deposition velocity
VA	Virginia

VADEQ	Virginia Department of Environmental Quality
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast
VOC	Volatile organic compounds
WBAN	Weather Bureau Army Navy
WESTAR	Western States Air Resources Council
WRAP	Western Regional Air Partnership (WRAP)
WRF	Weather Research Forecast
WV	West Virginia

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Acknowledgements

A number of environmental professionals contributed to the completion of the report and project. SESARM relies on its member states to provide technical expertise, coordination, and review of work products and documentation. For this report, three succinct groups were involved: the Regional Haze Work Group (RHWG); the Coordinating Committee (CC), and the Technical Analysis Work Group (TAWG).

- The RHWG consists of the Metro4/SESARM Executive Directors and the CC and TAWG co-chairs. This group met regularly to coordinate review of reports, memoranda, work products, and this final report. Members of this group are presented below:
  - Chad LaFontaine/Metro4/SESARM, Executive Director and Technical Project Coordinator (TPC)
  - John Hornback/Metro4/SESARM, Executive Director and TPC (retired)
  - James Boylan/Georgia APB, CC co-chair and TAWG member
  - James Johnston/Tennessee DAPC, CC co-chair member
  - Doris McLeod/Virginia ARED, CC member and TAWG co-chair
  - Randy Strait/North Carolina DAQ, CC member and TAWG co-chair

- The primary and alternate leads for the CC and TAWG provided review of all reports and memoranda, and this group consisted of:
  - Haidar Al-Rawi/Tennessee DAPC, TAWG
  - Leigh Bacon/Alabama Air Division, CC and TAWG
  - Josh Bartlett/North Carolina DAQ, TAWG
  - Carla Bedenbaugh/South Carolina BAQ, TAWG
  - Elliott Bickerstaff/Mississippi Air Division, CC
  - Ben Cordes/Kentucky DAQ (formerly), TAWG
  - Rodney Cuevas/Mississippi Air Division, TAWG
  - Dave Fewell, West Virginia DAQ, CC and TAWG
  - Keith Head/Mississippi Air Division, CC
  - Alanna Keller/West Virginia DAQ (formerly), TAWG
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  - Paul LaRock/Tennessee DAPC, CC
  - Tammy Manning/North Carolina DAQ, CC
  - Tim Martin/Alabama Air Division, CC and TAWG
  - Jon McClung/West Virginia DAQ, CC
  - Leslie Poff/Kentucky Division of Air Quality, CC
  - Hastings Read/Florida DARM, CC

- Mark Reynolds/Tennessee DAPC, TAWG
- Todd Shrewsbury/West Virginia DAQ, TAWG
- Kristen Stumpf/Virginia ARED, TAWG
- Elliot Tardif/North Carolina DAQ, TAWG
- Katie Tiger/Eastern Band of Cherokee Indians, CC and TAWG
- Mary Peyton Wall/South Carolina BAQ, CC
- Heather Walsh/Florida DARM, TAWG
- Cody Webster/Knox County, Tennessee, CC and TAWG
- Chad Wilbanks/South Carolina BAQ, TAWG

Finally, the environmental consulting team of ERG and Alpine that supported this project:

- Stacie Enoch/ERG
- Karla Faught/ERG
- Steve Mendenhall/ERG
- Regi Oommen/ERG (Contract Lead)
- Heather Perez/ERG
- Tyler Richman/ERG
- Jennifer Sellers/ERG
- Jody Tisano/ERG
- Robin Weyl/ERG
- Darcy Wilson/ERG
- Lindsay Dayton/ERG (now with EPA)
- Bebhinn Do/ERG (now with EPA)
- Noel Hilliard/ERG (now with EPA)
- Cindy Loomis/Alpine
- Dennis McNally/Alpine
- Gregory Stella/Alpine (Subcontract Lead)

1.0 Introduction and Overview

This report documents SESARM's Regional Haze Air Quality Project, which was a multi-year, multi-jurisdictional effort evaluating emissions, monitoring, and modeling data for the ten southeastern states. This project was funded under SESARM Grant No. XA-00D53517.

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.

As authorized under the Clean Air Act (CAA) and each state's body of law and regulation, 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 certain criteria pollutants as well.

The 1999 Regional Haze Rule (RHR) identified 18 Mandatory Class I Federal areas (national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres) in the VISTAS region and required states to define long-term strategies to improve visibility in these Federal Class I national 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.[4] The 1999 rule defines these values as the average of the 20% of the monitored days with the highest or lowest light extinction values, expressed in deciviews (dv). 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 CAA. 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 Standard (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 2017 RHR defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview 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. Previous rule requirements used haziest days defined as the 20% of monitoring days in a calendar year with the worst visibility. The change to "most impaired" days allows states to focus on controlling anthropogenic emissions that impact visibility rather than natural episodic events such as wildfires and dust storms that impair visibility but are not controllable. The long-term strategy and the reasonable progress goals must

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

provide for an improvement in visibility for the most impaired days and ensure no degradation in visibility for the clearest days since the baseline period.

Under SESARM Contract No. V-2018-03-01 to support the "Regional Haze Analysis Project," Eastern Research Group, Inc. (ERG) and its subcontractor, Alpine Geophysics, LLC (Alpine), completed eleven umbrella tasks, as specified by the original Request for Proposal (RFP). These tasks are summarized throughout the remainder of this report.

1.1 Project Motivation

To adhere to the SIP requirements of the RHR, SESARM was authorized by the southeastern states to develop applicable data products to support the states. At project inception (March 2018), SESARM chose to use EPA's 2011 base year emissions inventory and the corresponding projected 2028 base year emissions inventory (projected off the 2011 emissions inventory) as the basis for emissions modeling, as at the time this was the latest emissions inventory and modeling platform available to support regional haze modeling. However, the full use of the projected EPA 2028 base year emissions inventory without adjustments were problematic for several reasons, including:

1. The electricity-generating unit (EGU) emissions for the projected EPA 2028 base year assumed control requirement benefits (e.g., fuel switching from coal to natural gas) of the Clean Power Plan, thereby resulting in lower EGU NO_x and SO_2 emissions.
2. Significant new sources of NO_x and SO_2 emissions were not included in the projected EPA 2028 base year emissions inventory.
3. Significant emission sources that were shutdown or projected to shutdown prior to 2028 were still present in the projected EPA 2028 base year emissions inventory.
4. One state, North Carolina, submitted projected 2028 emissions inventory data adjustments for non-EGU sources to EPA, which were not included in the projected EPA 2028 base year emissions inventory.

SESARM concluded that developing an updated projected 2028 base year emissions inventory was necessary to support its member states in meeting SIP requirements for the RHR.

1.2 Project Timeline

SESARM released an RFP for this project in December 2017, and an award was made in February 2018 to the ERG contracting team. The initial contract began on March 1, 2018 authorizing Task 1 activities related to project management, work plan development, and the quality assurance project plan

(QAPP) development. Table 1-1 presents each task/subtask, including authorization dates. As the project continued, additional tasks were authorized.

Table 1-1. SESARM Tasks and Authorizations

Task	Subtask Description	Authorized
Task 1 – Management	Develop Work Plan, QAPP, monthly progress reports, and contract items.	3/1/2018
Task 2 – Emissions Inventory	Develop the 2028 point source EGU and non-EGU emissions inventories.	4/20/2018
Task 3 – Emissions Processing	Convert the Task 2 emissions inventory into SMOKE format, integrate with other 2028 emissions data in the VISTAS domain.	6/29/2018
Task 4 – Data Gathering and Acquisition	Retrieve and standardize pollutant, meteorological, and deposition data within the VISTAS domain.	4/20/2018
Task 5 – Area Of Influence	Identify sources of interest using back trajectories, source locations, and emissions.	6/29/2018
Task 6 – Modeling	Develop the Modeling Protocol.	4/10/2018
	Prepare Benchmark Comparison Runs.	6/29/2018
Task 7 – PSAT Tagging	Assign sources/categories of interest for tagging.	3/14/2019
Task 8 – Model Performance Evaluations	Compare modeled output results to ambient monitoring and deposition data.	4/20/2018
Task 9 – Future Year Modeling	Run future year modeling to evaluate glidepath and estimate future year deposition.	10/23/2019
Task 10 – Data Storage	Provide a mechanism for data storage and transfer of work products between the contracting team, SESARM, and the state/local stakeholders.	4/20/2018
Task 11 – Additional requests	Prepare Initial Condition and Boundary Condition files.	4/20/2018
	Review, prepare, and update the 2028 point sources emissions inventory for re-modeling.	11/21/2019
	Prepare Day-by-Day results for PSAT analysis.	2/18/2020

1.3 Organization of the Report

This report is divided into 13 sections and one appendix.

- Section 1 introduces the Regional Haze Air Quality project and provides a description of management activities, and the developments of the Work Plan and QAPP.

- Section 2 presents an overview of the emissions inventory development, including differences between EPA's original 2028 emissions inventory and the revised 2028 emissions inventory, called "elv3".
- Section 3 chronicles the conversion of the 2028 point sources emissions inventory to Sparse Modeling Operator Kernal Emissions (SMOKE) format for both SESARM and non-SESARM states.
- Section 4 summarizes the information on the data acquisition and gathering of ambient monitoring and deposition datasets to support model performance evaluations (MPEs).
- Section 5 discusses the Area of Influence (AoI) Analysis, and how SESARM used these results for key stakeholder discussions.
- Section 6 documents the Comprehensive Air quality Model with eXtensions (CAMx) modeling benchmarking activities, demonstrating confidence in the modeling framework.
- Section 7 presents an overview of the MPEs for ozone, particulate matter less than or equal to 2.5 microns in aerodynamic diameter ($PM_{2.5}$), and the deposition data.
- Section 8 provides an overview of the Particulate Source Apportionment Technology (PSAT) tagging activities, results, and uses of the data results.
- Section 9 discusses the rationale for updating the original 2028 point sources emissions inventory for remodeling activities, as well conversion of the 2028 point sources remodeled emissions inventory for SESARM and non-SESARM states in the VISTAS domain.
- Section 10 presents an overview of the future year modeling activities, including methodology and a summary of the guideslope calculations.
- Section 11 summarizes activities related to development of dry and wet deposition calculations.
- Section 12 presents overview of additional requests authorized under this contract.
- Section 13 summarizes the project's data archiving and retention.
- Appendix A supports this report by providing a comprehensive list of deliverables generated under this contract.

As tasks and subtasks were completed, ERG and Alpine prepared stand-alone reports documenting the procedures, approaches, and assumptions for generation of the applicable datasets. In total, 23 technical reports and memoranda were prepared, along with several thousand Excel, Access, .pdf, and image files.

1.4 Work Plan

Under Task 1, ERG prepared the project work plan (approved April 18, 2018), outlining the technical steps, schedule of deliverables, and proposed staffing hours for each task.[5] Elements of the Work Plan, include: technical overview of the tasks and subtasks; project schedule; and project staffing.

As the project progressed, the Work Plan was not updated in technical procedures nor project calendar updates.

1.5 QAPP

Prior to initiation of technical work, approval of the QAPP by SESARM and EPA was required. The QAPP addresses quality requirements for modeling projects and is responsive to all applicable elements specified by EPA.[6,7,8] Under Task 1, ERG and Alpine prepared the QAPP which was approved on April 4, 2018.[9] Elements of the QAPP include: technical overview of the tasks and subtasks; project schedule; quality objectives; documentation and records; air quality modeling information; data management; and assessments and oversight.

The QAPP was developed to accommodate changes in the project scope (e.g., additional remodeling). Therefore, it was not necessary to update the QAPP during the project.

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5 ERG. "Work Plan: Southeastern VISTAS II Regional Haze Analysis Project." April 18, 2018. File located at: https://www.metro4-sesarm.org/sites/default/files/VISTAS%20Work%20Plan%20Final%20180419.pdf

6 U.S. Environmental Protection Agency, "EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5", Office of Environmental Information, Washington, DC, EPA/240/B-01/003, March 2001. Reissued May 2006.

7 U.S. Environmental Protection Agency, "Guidance for Quality Assurance Project Plans, EPA QA/G-5", Office of Environmental Information, Washington, DC, EPA/240/R-02/009, December 2002.

8 U.S. Environmental Protection Agency, "Guidance for Quality Assurance Project Plans for Modeling, EPA QA/G-5M", Office of Environmental Information, Washington, DC, EPA/240/R-02/007, December 2002.

9 ERG. "Revised Quality Assurance Project Plan: Southeastern VISTAS II Regional Haze Analysis Project." April 4, 2018. File located at: https://www.metro4-sesarm.org/sites/default/files/VISTAS%20QAPP%20Final%20180404.pdf

2.0 VISTAS II Emissions Inventory Development

This section summarizes the development of the projected 2028 emissions inventory for the ten SESARM states. Activities related to Task 2 are presented at: https://www.metro4-sesarm.org/content/task-2-emission-inventories

ERG was 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 EPA's TSD entitled "Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform", dated August 2016.[10] EPA projected the 2011 base year emissions to a 2028 future year base case scenario described in EPA's Technical Support Document (TSD) entitled, "Documentation for the EPA's Preliminary 20208 Regional Haze Modeling", October 2017.[11] This 2028 inventory (called "elv3") was used as the foundation for review and revising the 2028 emissions used for the AoI analysis and PSAT modeling. As noted in EPA's TSD, 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[12] and the subsequent notice of data availability (NODA)[13] to support ozone transport modeling for the 2015 8-hour ozone NAAQS.

2.1 Study Area of Interest

The area of interest for this study is the VISTAS_12 domain. As presented in Figure 2-1, the U.S. EPA continental U.S. (CONUS) modeling domain is divided into three sections:

- VISTAS_12 Domain, VISTAS states: Alabama (AL), Florida (FL), Georgia (GA), Kentucky (KY), Mississippi (MS), North Carolina (NC), South Carolina (SC), Tennessee (TN), Virginia (VA), and West Virginia (WV).
- Non-VISTAS States/Areas in VISTAS_12 Domain
    - States – Arkansas, Colorado (partial), Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana (partial), Nebraska, New Hampshire, New Jersey, New Mexico (partial), New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota, Texas, Vermont, Wisconsin, Wyoming (partial).
    - Areas – District of Columbia, Gulf of Mexico (U.S.), Northeastern Mexico, Southern Canada (Manitoba province through New Brunswick), and international offshore areas off the Atlantic Ocean.

10 https://www.epa.gov/air-emissions-modeling/2011-version-63-technical-support-document
11 https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf
12 https://www.epa.gov/airmarkets/final-cross-state-air-pollution-rule-update
13 https://www.epa.gov/airmarkets/notice-data-availability-preliminary-interstate-ozone-transport-modeling-data-2015-ozone

- States/Areas Outside of VISTAS_12 Domain:
  - States – Arizona, California, Colorado (partial), Idaho, Montana (partial), Nevada, New Mexico (partial), Oregon, Utah, Washington, and Wyoming (partial).
  - Areas – Northwestern and Southern Mexico, Southwestern Canada (Alberta through Saskatchewan), and international offshore areas off the Pacific Ocean.

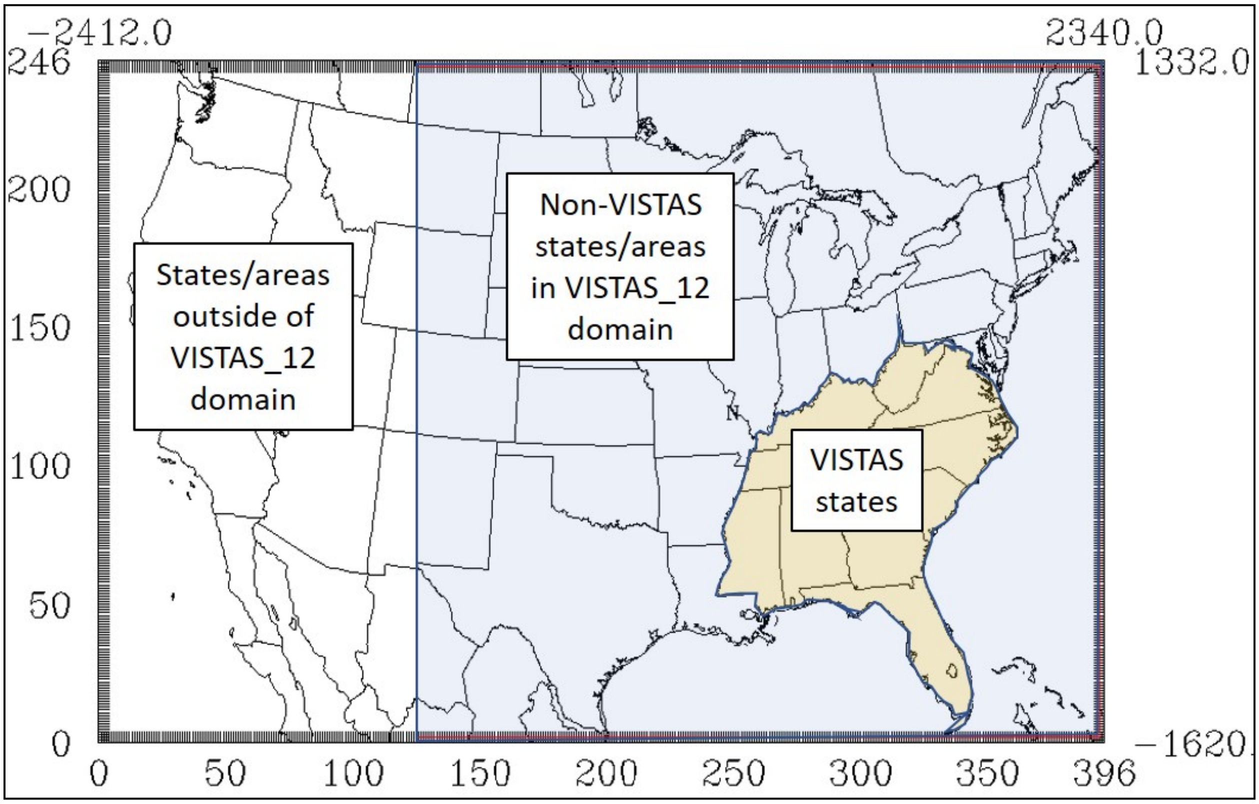

Figure 2-1. Geographic Areas for the VISTAS II Regional Haze Analysis Project

2.2 Pollutants of Interest

The pollutants of interest are the following criteria pollutants: carbon monoxide (CO); oxides of nitrogen (NO_x); particulate matter (PM) less than 10 microns (PM_{10}-PRI); PM less than 2.5 microns ($PM_{2.5}$-PRI); sulfur dioxide (SO_2); and volatile organic compounds (VOCs). Additionally, ammonia (NH_3) was of interest as a precursor pollutant for PM.

2.3 Sectors and Years of Interest

For emissions modeling, all sectors were compiled for base year 2011 and projected year 2028. These include:

- Point Sources: EGU, non-EGU sources, railyards, and aircrafts activities (e.g., landing/takeoffs; ground-support equipment, and idling);
- Point-Fires: Fires data with emission release point locations;

- Nonpoint Sources: Nonpoint area sources, locomotives (outside the railyards), and commercial marine vessels (CMVs);
- Onroad Sources: Cars, trucks, buses, motorcycles, and Stage 2 refueling;
- Nonroad Sources: Off-road engines, such as for construction, lawn and garden, and recreational marine vessels; and
- Biogenics: Biogenic emissions from vegetation and soils using EPA's Biogenic Emissions Inventory System (BEIS) software.

2.4 Data Processing

After consultation with the SESARM states, it was decided that only point sources emissions were to be reviewed and updated for this project; thus, there were no emissions updates for the other sectors, and the projected 2028 EPA emissions would be used without exception. To facilitate state-review of the point sources data, ERG obtained the following emissions inventory data:

- 2011 "el" emissions inventory datasets (includes some "ek" files) retrieved from EPA's FTP site;[14]
- 2023 "en" emissions inventory datasets retrieved from EPA's FTP site;[14]
- 2028 "el" emissions inventory datasets retrieved from EPA's FTP site;[14] and
- 2028 emissions inventory data for EGUs generated by the Eastern Regional Technical Advisory Committee (ERTAC) EGU projection tool[15] from the CONUS 2.7 run

All 2011, 2023, and 2028 emissions data were uploaded into Microsoft SQL Server and Microsoft Access. The data were then extracted for the ten VISTAS states for the pollutants of interest. ERG reviewed the data fields for completeness. The datasets were then merged to provide side-by-side analysis of emissions. ERG matched the emissions summaries published by EPA[16] to the extracted emissions for the ten VISTAS states.

2011 Base Year Emissions

The emissions data in the 2011 platform are primarily based on Version 2 of the 2011 National Emissions Inventory (NEI) for point sources, nonpoint sources, CMVs, 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

14 Data obtained from: ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/2011emissions

15 Data obtained with permission from J. McDill, Mid-Atlantic Regional Air Management Association (MARAMA). More information on this data is presented at: http://www.marama.org/2013-ertac-egu-forecasting-tool-documentation

16 State-level pollutant emissions by SCC were retrieved from: ftp://newftp.epa.gov/air/emismod/2011/v3platform/reports/2011el_and_2023el/2011el_2011ek_2017ek_2023el_state_fullSCC_summary.xlsx

nonpoint sector of the inventory, but wind-blown dust from natural sources is not accounted for in the inventory.[17]

CAMx-ready emission inputs for 2011 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.

To conserve resources, EPA's 2011el emission platform in CAMx-ready format was used without exception.[18]

2028 Projection Year Emissions

For traditional county-level source emissions, EPA projected 2011 emissions 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 regulations anticipated to be fully implemented by calendar year 2028.

For projected year 2028 EGU point sources, states considered the EPA 2028el, the EPA 2023en, or 2028 emissions from the ERTAC EGU projection tool from the most recent CONUS 2.7 run. The EPA 2028el emissions inventory for EGUs considered the impacts of the Clean Power Plan (CPP), which was

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17 Wind-blown dust emissions are included as part of the CAMx model.

18 VA Department of Environmental Quality (VADEQ) noted via e-mail and attachments to ERG on 6/7/2018 that four sources in the 2011 NEI did not match their internal emissions inventory. Due to time and resource constraints, these updates were not made for the 2011 modeling:
1) Meadwestvaco Covington (EIS Facility ID = 5798711): EPA's 2011 NEI facility summary spreadsheet shows 356.2 tons of SO_2 from this facility in 2011. Emissions reported to VA DEQ for 2011 are 7,850 tons of SO_2.
2) Chemical Lime Company (EIS Facility ID 4184511): The 2011 NEI data reflect values submitted by the facility (514.9 tons NO_X, 896.8 tons SO_2). The facility has since submitted updated emissions factors such that 2011 emissions for this facility are estimated to be 1,395 tons NO_X and 5,710 tons SO_2.
3) Old Virginia Brick Company (EIS Facility ID = 8517811): EPA's 2011 NEI facility data show 1,178 tons of NO_X emitted from this facility. Virginia's internal database shows 5.8 tons of NO_X in 2011 from this facility. The facility has since permanently shut down.
4) Celanese (EIS Facility ID = 4004311)/Duke Energy of Narrows (EIS Facility ID 10698711): VADEQ noted that SO_2 and NO_X emissions from the steam plant at Celanese Acetate (EIS Facility ID = 4004311) were not included in the EPA 2011 modeling inventory. These emissions are included in the 2011 NEI under EIS Facility ID = 10698711 since at that time the steam plant was under separate ownership and therefore was considered a separate, support facility. In 2012 ownership of the steam plant reverted to Celanese, and from 2012 on, emissions from the steam plant were included with Celanese's emissions. The 2011 modeling inventory for VA does not appear to account for 3,540 tons of NO_X and 6,540 tons of SO_2 from EIS facility # 10698711.

later vacated. Impacts of the CPP assumed that coal-fired EGUs would be shutdown and replaced by natural gas-fired EGUs. Thus, the EPA 2028el projected emissions for EGU emissions are not reflective of probable emissions for 2028. The ERTAC EGU emissions did not consider the impacts of the CPP. Details on state decisions are presented in the Task 2A report.

For projected year 2028 non-EGU point sources, most states considered the EPA 2023en and EPA 2028el emissions, as well as providing their own emissions. For example, the North Carolina Department of Environmental Quality (NCDEQ) developed its own 2028 non-EGU point source emissions inventory by applying growth and control factors and facility closures to the data in EPA's 2016 modeling platform. Georgia used 2016 emissions (or 2014 emissions if 2016 was not available) to represent 2028 emissions for the 33 non-EGU facilities with over 100 tons per year (tpy) of SO_2 in 2011 (does not include Hartsfield-Jackson Atlanta International Airport). Details on state decisions are presented in the Task 2A report.

2.5 Comparison of Revised EGU and Non-EGU Inventories to the EPA 2028 el Inventory

Tables 2-1 through 2-10 present state-level emissions comparisons by pollutant of the original projected EPA 2028 base year emissions and the revised SESARM 2028 base year emissions (called “elv3”).

Table 2-1 summarizes the revised 2028 point EGU and non-EGU emissions for Alabama.

Table 2-1. Alabama 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	11,845	27,988	-57.7%	65,588	63,285	3.6%
NH_3	862	2,007	-57.0%	1,522	1,399	8.8%
NO_x	27,964	23,699	18.0%	52,426	53,438	-1.9%
PM_{10}-PRI	3,836	6,495	-40.9%	18,496	18,336	0.9%
$PM_{2.5}$-PRI	2,679	4,999	-46.4%	15,246	15,104	0.9%
SO_2	17,031	28,892	-41.1%	70,670	72,276	-2.2%
VOC	1,266	2,422	-47.7%	24,976	23,958	4.2%

Table 2-2 summarizes the revised 2028 point EGU and non-EGU emissions for Florida.

Table 2-2. Florida 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	26,658	65,259	-59.2%	100,250	94,837	5.7%
NH_3	3,520	4,129	-14.8%	1,177	2,440	-51.8%
NO_x	27,659	44,775	-38.2%	40,347	38,233	5.5%
PM_{10}-PRI	9,716	10,231	-5.0%	13,646	12,585	8.4%
$PM_{2.5}$-PRI	8,478	7,917	7.1%	11,802	10,777	9.5%
SO_2	29,220	54,015	-45.9%	34,281	35,648	-3.8%
VOC	1,406	2,811	-50.0%	26,536	25,669	3.4%

Table 2-3 summarizes the revised 2028 point EGU and non-EGU emissions for Georgia.

Table 2-3. Georgia 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	9,986	25,058	-60.1%	57,245	67,860	-15.6%
NH_3	1,178	1,508	-21.9%	5,595	5,678	-1.5%
NO_x	25,927	13,163	97.0%	41,270	45,540	-9.4%
PM_{10}-PRI	5,227	3,876	34.8%	12,382	15,695	-21.1%
$PM_{2.5}$-PRI	4,340	3,374	28.6%	9,653	12,502	-22.8%
SO_2	18,474	27,533	-32.9%	18,591	23,519	-21.0%
VOC	1,062	885	19.9%	24,524	27,198	-9.8%

Table 2-4 summarizes the revised 2028 point EGU and non-EGU emissions for Kentucky.

Table 2-4. Kentucky 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	11,851	24,801	-52.2%	85,720	86,082	-0.4%
NH_3	681	705	-3.4%	449	508	-11.5%
NO_x	37,019	43,411	-14.7%	29,221	31,048	-5.9%
PM_{10}-PRI	8,293	12,180	-31.9%	15,902	16,253	-2.2%
$PM_{2.5}$-PRI	6,475	9,409	-31.2%	10,458	10,619	-1.5%
SO_2	56,319	81,304	-30.7%	18,821	19,083	-1.4%
VOC	1,271	1,212	4.9%	43,373	46,814	-7.4%

Table 2-5 summarizes the revised 2028 point EGU and non-EGU emissions for Mississippi.

Table 2-5. Mississippi 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	4,939	18,160	-72.8%	36,787	34,061	8.0%
NH_3	614	1,288	-52.3%	1,925	1,784	7.9%
NO_x	18,735	11,210	67.1%	33,880	32,503	4.2%
PM_{10}-PRI	1,483	1,923	-22.9%	9,169	9,184	-0.2%
$PM_{2.5}$-PRI	1,181	1,777	-33.5%	7,749	7,765	-0.2%
SO_2	6,530	6,253	4.4%	14,250	19,255	-26.0%
VOC	473	2,183	-78.3%	27,102	25,389	6.7%

Table 2-6 summarizes the revised 2028 point EGU and non-EGU emissions for North Carolina.

Table 2-6. North Carolina 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	12,053	22,086	-45.4%	46,358	33,823	37.1%
NH_3	105	1,284	-91.8%	1,356	1,271	6.7%
NO_x	27,811	18,528	50.1%	38,053	30,418	25.1%
PM_{10}-PRI	4,127	3,203	28.9%	12,838	8,590	49.4%
$PM_{2.5}$-PRI	3,568	2,763	29.1%	8,875	5,866	51.3%
SO_2	19,734	11,548	70.9%	15,498	21,407	-27.6%
VOC	640	1,075	-40.4%	47,066	29,129	61.6%

Table 2-7 summarizes the revised 2028 point EGU and non-EGU emissions for South Carolina.

Table 2-7. South Carolina 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	13,676	11,181	22.3%	89,997	89,363	0.7%
NH_3	913	657	38.9%	1,704	1,657	2.8%
NO_x	11,458	12,303	-6.9%	24,594	22,613	8.8%
PM_{10}-PRI	3,486	6,611	-47.3%	6,441	6,322	1.9%
$PM_{2.5}$-PRI	2,751	4,159	-33.9%	4,638	4,530	2.4%
SO_2	10,774	18,231	-40.9%	18,827	17,885	5.3%
VOC	1,864	1,847	0.9%	20,763	22,387	-7.3%

Table 2-8 summarizes the revised 2028 point EGU and non-EGU emissions for Tennessee.

Table 2-8. Tennessee 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	4,403	5,837	-24.6%	48,950	45,967	6.5%
NH_3	189	419	-54.8%	991	1,019	-2.7%
NO_x	10,086	10,025	0.6%	35,793	36,007	-0.6%
PM_{10}-PRI	3,860	5,608	-31.2%	11,074	10,755	3.0%
$PM_{2.5}$-PRI	3,398	3,919	-13.3%	8,171	7,892	3.5%
SO_2	12,114	28,429	-57.4%	11,333	8,781	29.1%
VOC	635	416	52.6%	33,238	33,717	-1.4%

Table 2-9 summarizes the revised 2028 point EGU and non-EGU emissions for Virginia.

Table 2-9. Virginia 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	5,949	31,807	-81.3%	33,899	32,019	5.9%
NH_3	444	1,379	-67.8%	1,396	1,400	-0.3%
NO_x	13,338	10,207	30.7%	29,872	31,321	-4.6%
PM_{10}-PRI	2,979	853	249.2%	5,764	5,849	-1.5%
$PM_{2.5}$-PRI	1,568	747	109.7%	4,571	4,607	-0.8%
SO_2	3,389	2,335	45.2%	16,450	16,967	-3.0%
VOC	1,016	650	56.2%	17,400	17,498	-0.6%

Table 2-10 summarizes the revised 2028 point EGU and non-EGU emissions for West Virginia.

Table 2-1. West Virginia 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	12,968	11,894	9.0%	33,399	33,581	-0.5%
NH_3	70	840	-91.7%	187	215	-12.9%
NO_x	46,722	27,315	71.0%	18,332	22,530	-18.6%
PM_{10}-PRI	11,499	11,311	1.7%	3,214	4,292	-25.1%
$PM_{2.5}$-PRI	9,574	7,604	25.9%	2,217	2,963	-25.2%
SO_2	57,829	46,075	25.5%	5,575	15,151	-63.2%
VOC	1,100	779	41.3%	7,596	8,046	-5.6%

Pollutant emission bubble maps highlighting emission changes for the point EGU and non-EGU sector from the EPA 2028el inventory to the revised VISTAS 2028 inventory are presented in the Task 2A report.

2.6 Revisions to the Non-VISTAS States in the VISTAS_12 Domain

Under the direction of SESARM, ERG replaced the EPA 2028el EGU emission with the 2028 ERTAC EGU emissions from the CONUS 2.7 run for the non-VISTAS states in the VISTAS_12 domain. No other emission changes were considered for this part of the VISTAS_12 domain. Summary emissions for the Non-VISTAS states in the VISTAS_12 domain are presented in Chapter 3 of this report, as well as the Task 3A report for Emissions Processing.

2.7 Tier 1 Emissions Comparison

Table 2-11 summarizes the Base Year 2011 Tier 1 emissions by pollutant for the ten VISTAS states, while Table 2-12 summarizes the revised 2028 Tier 1 emissions by pollutant. Table 2-13 presents the percent change by pollutant from the 2011 Tier 1 emissions to the revised 2028 Tier 1 emissions. State-level summaries are presented in the Task 2A report.

Table 2-11. 2011 Tier 1 Pollutant Emissions (except Biogenic) for the Ten VISTAS States[19]

Tier 1 Description	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
Chemical & Allied Product Mfg	34,883	6,762	17,238	5,022	3,837	39,482	20,714
Fuel Comb. Elec. Util.	151,802	6,471	488,453	85,656	61,846	1,191,386	10,576
Fuel Comb. Industrial	264,348	2,696	250,349	120,862	97,403	177,103	19,668
Fuel Comb. Other	277,771	7,390	70,985	39,401	38,003	27,359	47,920
Highway Vehicles	7,549,047	32,263	1,574,943	88,017	47,390	8,027	791,993
Metals Processing	163,506	123	12,501	15,160	12,650	33,405	9,833
Miscellaneous[17]	3,953,133	633,365	106,762	3,732,801	827,631	41,197	740,642
Off-Highway	3,710,940	604	626,217	49,059	46,279	34,422	541,514
Other Industrial Processes[17]	105,113	8,737	98,400	194,381	78,734	44,820	148,394
Petroleum & Related Industries	95,162	120	73,588	2,963	2,459	33,046	145,163
Solvent Utilization	318	190	367	910	796	48	668,718
Storage & Transport	2,886	284	497	7,448	3,462	89	323,577
Waste Disposal & Recycling	576,851	2,177	22,864	85,381	75,021	3,971	48,995
Totals	**16,885,761**	**701,183**	**3,343,164**	**4,427,062**	**1,295,512**	**1,634,354**	**3,517,706**

19 Totals for PM_{10}-PRI and $PM_{2.5}$-PRI include the unadjusted PM_{10}-PRI and $PM_{2.5}$-PRI emissions for source categories included in the "afdust" sector. See Appendix C for the list of source categories and comparison of adjusted and unadjusted emissions by state.

Table 2-12. 2028 Tier 1 Pollutant Emissions (except Biogenic) for the Ten VISTAS States, elv3[20]

Tier 1 Description	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
Chemical & Allied Product Mfg	28,357	4,987	10,592	5,300	3,708	35,496	20,707
Fuel Comb. Elec. Util.	115,627	7,608	244,706	49,625	40,397	229,708	9,434
Fuel Comb. Industrial	274,608	3,075	207,420	127,056	107,579	79,113	18,126
Fuel Comb. Other	262,447	7,318	67,126	36,710	35,651	16,893	43,053
Highway Vehicles	2,371,974	21,976	341,421	63,604	16,147	3,117	192,413
Metals Processing	162,305	143	12,403	14,572	12,095	32,729	9,245
Miscellaneous[18]	3,778,975	675,213	99,091	4,362,444	890,359	37,923	727,086
Off-Highway	3,676,988	742	349,374	23,899	22,227	7,646	301,285
Other Industrial Processes[18]	104,406	8,478	97,274	192,736	76,665	41,408	149,490
Petroleum & Related Industries	144,989	122	101,783	6,207	5,864	46,286	233,019
Solvent Utilization	337	165	379	919	819	25	687,863
Storage & Transport	990	219	509	6,711	3,275	91	219,387
Waste Disposal & Recycling	577,013	2,107	22,922	85,386	75,052	3,828	49,596
Totals	**11,499,015**	**732,154**	**1,555,000**	**4,975,169**	**1,289,838**	**534,264**	**2,660,703**

20 Totals for PM_{10}-PRI and $PM_{2.5}$-PRI include the unadjusted PM_{10}-PRI and $PM_{2.5}$-PRI emissions for source categories included in the "afdust" sector. See Appendix C for the list of source categories and comparison of adjusted and unadjusted emissions by state.

Table 2-13. Percent Change in Emissions by Tier 1 Level, All Sectors Combined (except Biogenic) for the Ten VISTAS States [21]

Tier 1 Description	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	% Difference						
Chemical & Allied Product Mfg	-19%	-26%	-39%	6%	-3%	-10%	-0.04%
Fuel Comb. Elec. Util.	-24%	18%	-50%	-42%	-35%	-81%	-11%
Fuel Comb. Industrial	4%	14%	-17%	5%	10%	-55%	-8%
Fuel Comb. Other	-6%	-1%	-5%	-7%	-6%	-38%	-10%
Highway Vehicles	-69%	-32%	-78%	-28%	-66%	-61%	-76%
Metals Processing	-1%	16%	-1%	-4%	-4%	-2%	-6%
Miscellaneous[19]	-4%	7%	-7%	17%	8%	-8%	-2%
Off-Highway	-1%	23%	-44%	-51%	-52%	-78%	-44%
Other Industrial Processes[19]	-1%	-3%	-1%	-1%	-3%	-8%	1%
Petroleum & Related Industries	52%	1%	38%	109%	138%	40%	61%
Solvent Utilization	6%	-13%	3%	1%	3%	-48%	3%
Storage & Transport	-66%	-23%	2%	-10%	-5%	2%	-32%
Waste Disposal & Recycling	0.03%	-3%	0.25%	0.01%	0.04%	-4%	1%
Totals	**-32%**	**4%**	**-53%**	**12%**	**-0.4%**	**-67%**	**-24%**

[21] Totals for PM_{10}-PRI and $PM_{2.5}$-PRI include the unadjusted PM_{10}-PRI and $PM_{2.5}$-PRI emissions for source categories included in the "afdust" sector. See Appendix C for the list of source categories and comparison of adjusted and unadjusted emissions by state.

3.0 VISTAS II EMISSIONS PROCESSING

This section summarizes the procedures to prepare the 2028 point sources inventory into CAMx-ready files, and to integrate with other emission sources within the VISTAS domain. Activities related to Task 3 are presented at: https://www.metro4-sesarm.org/content/task-3-emissions-processing

ERG tasked Alpine with preparing SMOKE-ready input files for processing point source emissions to support the 2028 regional haze base case. For these tasks, Alpine created SESARM state inputs (based on ERG provided data), as well as non-SESARM state files to generate national modeling inventories for these categories consistent with the 2011 meteorology associated with the base year modeling platform.

On June 30, 2018, ERG provided Alpine, via project File Transfer Protocol (FTP), with two emissions inventory files for use in this task:

- VISTAS_2028_FF10_EGU.zip – EGU emissions estimates for the 2028 regional base case.
- VISTAS_2028_FF10_NON_EGU.zip – Non-EGU emissions estimates for the 2028 regional base case.

These files represent the SESARM state EGU and non-EGU point source emissions, respectively, and replace the EGU and non-EGU source files for the SESARM states from the EPA 2028el modeling platform. No 2028 adjustments were made to the other sector files (e.g., nonpoint, nonroad, onroad, biogenic, etc.) used in modeling the future year.

Upon receipt of these files, Alpine first confirmed that the files were in the documented Flat File 2010 (FF10) format and that all states in the SESARM region were represented in each file. As a second step, Alpine compared the emission files with the summary files by Federal Information Processing System (FIPS) code, source classification code (SCC), and pollutant that were provided by ERG and confirmed that the annual emission totals of both files matched the summary file totals. A final pre-use quality assurance/quality control (QA/QC) step was to confirm that all required fields for modeling were populated and that all sources had latitude and longitude data within the boundaries of the SESARM state domain.

Additionally, Alpine obtained the ERTAC EGU forecast tool, version 2.7, emission projections to 2028 that were prepared by the ERTAC EGU workgroup[22] and made available through a FTP transfer to Alpine from ERG on May 1, 2018. These EGU projections were used for non-SESARM states.

3.1 File Preparation: Non-EGU Point Sources

Since no issues were identified in Alpine's cursory QA/QC review of the "VISTAS_2028_FF10_NON_EGU" file provided by ERG, Alpine prepared a new FF10-formatted file with new header information indicating what emissions were included in the file and that it was to be used in the SESARM 2028 regional haze modeling analysis. The resulting file was prepared and was named "ff10_point_nonegu_sesarm_2028.csv". Alpine confirmed that emissions totals matched the provided emissions totals.

As a second step, to complete the 2028 inventory for the remainder of the VISTAS modeling domain, Alpine developed non-SESARM state non-EGU point source emissions files consistent with the formatting of the SESARM-only file prepared by ERG. For this purpose, Alpine reviewed the EPA list of non-EGU point source emissions for SMOKE processing[23] to determine which files were necessary for us to review and extract non-SESARM state data. From these files, Alpine determined that the following files were needed to extract non-SESARM state data to fully represent non-EGU point sources consistent with EPA's 2028el modeling platform:

- 2023el_from_refueling_2011NEIv2_POINT_20140913_20sep2016_v1.csv
- 2023_MARAMA_Point_Offsets_2016_08_24_04oct2016_v1.csv
- Biodiesel_Plants_2018_ff10_11apr2013_v0.csv
- 2023el_from_ethanol_plants_2011NEIv2_POINT_20141123_20sep2016_v0.csv
- Illinois_WV_new_sources_NODA_29aug2016_v2.csv
- MARAMA_2028_ptnonipm_2011NEIv2_POINT_20140913_revised_20150115_mar_18nov2016_v3.csv
- MARAMA_2028el_refueling_2011NEIv2_POINT_20140913_18nov2016_v1.csv
- MARAMA_2028el_pt_oilgas_2011NEIv2_POINT_20140913_mar_21nov2016_v1.csv
- 2028el_pt_oilgas_2011NEIv2_POINT_20140913_02dec2016_v1.csv

[22] SESARM received permission from J. McDill of MARAMA on April 27, 2018 to allow SESARM to use the ERTAC EGU forecast tool, version 2.7 emission projections for year 2028 for this project. As such, ERG downloaded this data from a North Carolina Division of Air Quality (NCDAQ) secure FTP site (ftp.daq.ncdenr.org) for Task 2 activities and provided the data to Alpine for Task 3 activities.

[23] The "ptinv_ptnonipm_2028el_cb6v2_v6_11g.lst" and "ptinv_pt_oilgas_2028el_cb6v2_v6_11g.lst" were extracted from: ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/2028emissions/ 2028el_cb6v2_v6_11g_inputs_point.zip

These files were concatenated to develop a single non-EGU point source file of national coverage and to be consistent with the ERG-provided SESARM-only non-EGU point source files. From this single file, Alpine removed all records associated with SESARM state sources. The remaining file was reconfigured as a new FF10 formatted input file and is named "ff10_point_nonegu_nonsesarm_2028el.csv". Since these emissions inventory files were confirmed for use by EPA in their modeling platform, no additional QA/QC beyond removal of SESARM state records was conducted by Alpine.

Both non-EGU point source files were prepared with annual emissions and no additional temporal file preparation (daily or hourly input format) was conducted consistent with EPA's 2011el modeling configuration.

3.2 File Preparation: EGU Point Sources

Alpine obtained the ERTAC EGU forecast tool, version 2.7, emission projections to 2028 that were prepared by the ERTAC EGU workgroup[24] and made available through an FTP transfer to Alpine from ERG on May 1, 2018. As a first step, Alpine concatenated the individual region input files and created a single, national file of EGU emissions as included in each of the following ERTAC v.2.7 files:

- FsS_WESTAR_WAORWYIDMTNDSDCANVAZUTNMCO_ff10_future.csv
- FsS_CENSARA_ARIAKSLAMOOKNETX_ff10_future.csv
- FsS_SESARM_ALFLGAKYMSNCSCTNWV_ff10_future.csv
- FsS_LADCO_INILMIMNOHWI_ff10_future.csv
- FsS_MANE-VUVA_CTDEDCMEMDMANHNJNYPARIVTVA_ff10_future.csv

From this single file, Alpine removed all records associated with SESARM state sources (no matching to EPA's Integrated Planning Model (IPM) data for the same 2023 scenario was conducted on these files to determine if there were units missing in the non-SESARM states).[25] The remaining file was reconfigured as a new FF10 formatted input file and used as a working file for non-SESARM state EGU file development. Similar to the non-EGU cursory QA/QC, Alpine confirmed that all required fields for modeling were populated and that all sources had latitude and longitude data within the boundaries of the modeling domain and outside of SESARM states.

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[24] SESARM received permission from J. McDill of MARAMA on April 27, 2018 to allow SESARM to use the ERTAC EGU forecast tool, version 2.7 emission projections for year 2028 for this project. As such, ERG downloaded this data from a NCDAQ secure FTP site (ftp.daq.ncdenr.org) for Task 2 activities and provided the data to Alpine for Task 3 activities.

[25] Since we did not prepare the original ERTAC files, we included all obtained files in the case that the ERTAC group may have included/excluded SESARM sources in any one of the other files.

For ease of data management, processing, and resulting QA/QC, Alpine then concatenated the SESARM-only EGU file provided by ERG to the working file to create a single, national, annual emissions file for all EGU emission sources (both SESARM and non-SESARM states). The file is called "ptegu_2028_12july2018.csv".

This file was then configured with new header information to indicate the national coverage of the inputs and documented to note the file's use in SESARM's 2028 regional haze modeling.

3.3 Additional Data for Small EGUs

The ERTAC tool includes EGUs that burn fossil fuel with ≥25 megawatts (MW) of generation capacity or ≥250 million British thermal units per hour (MMBtu/hr) of heat input and generate electricity for the power grid. EPA's IPM forecast includes the same fossil fuel units as those included in ERTAC, plus small EGUs with <25 MW of generation capacity or <250 MMBtu/hr of heat input and may or may not produce electricity for the power grid. Therefore, it was necessary to develop a 2028 projection year inventory for the small EGUs that are included in IPM but not in ERTAC to include in the VISTAS II modeling platform to ensure complete accounting of emissions from small EGUs. The documentation for developing the small EGU inventory and the QA/QC steps conducted to develop the small EGU inventory are included in the Task 3A Report.[26]

The small EGU FF10 files were finalized in early-November,[27] and sent to ALPINE for emissions processing. Processing concluded on December 9, 2018.

3.4 Hourly Scaling for EGU Point Sources

The next step was to create hourly emission files consistent with the temporal distribution of EPA's 2011el modeling platform for EGUs that report continuous emissions monitoring (CEM) data to EPA. The purpose of this step was to ensure that emissions simulated in 2028 occur in the same timelines as the emissions were simulated in the 2011 modeling, preventing fabricated emissions increases or decreases between the two years simply as a result of the temporal profile. For example, Alpine ensured that a unit operating during hour 14 of June 12th in the 2011 simulation was also operating at a comparable level on hour 14 of June 12th in the 2028 simulation with the only difference being in the absolute level of emissions between the two years.

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[26] Memorandum: "Southeastern VISTAS II Regional Haze Project: Documentation of 2028 Mass Emissions Inventory for Small Electricity Generating Units (EGUs) for States not included in the VISTAS II Region." Prepared by the North Carolina Division of Air Quality (NCDAQ). December 7, 2018.

[27] Final data files submitted to SESARM by NCDAQ on November 12, 2018.

In order to accomplish this step, Alpine first obtained EPA's hourly distribution files of CEM-based EGU emissions from the 2011/2028el modeling platforms. These files present hourly emissions of NO_x and SO_2 emissions, as well as provide an hourly distribution of heat input for the annual episode simulated (e.g., the 2011 calendar year).

Using these files, Alpine generated an hourly-to-annual ratio of NO_x, SO_2, and heat input for each unit identified by EPA within the VISTAS_12 domain. Alpine used ratio preparation methods originally identified and applied for VISTAS in past regional haze studies.[28] These ratios were then matched to the new annual EGU file "ptegu_2028_12july2018.csv" where the NO_x ratios were used to scale annual NO_x emissions, the SO_2 ratios were used to scale SO_2 emissions, and heat input was used to scale all other pollutant emissions from annual to hourly distribution. When the "EPA HOUR" files did not have associated NO_x or SO_2 ratios (because of missing or incomplete data), Alpine used heat input as the scalar for all pollutants.

For cases where ORIS facility and unit ID were not provided in either the SESARM EGU file or the non-SESARM ERTAC EGU file, no hourly emission distribution was calculated, and default temporal profiles will be used in the emissions processing of these sources.

The sole exception to this procedure was the Power Plant Scherer facility in Georgia (GA). In 2011-2014, Plant Scherer installed selective catalytic reduction (SCR) NO_x controls on Units 1-4. These SCR controls are only required to be run from May 1 to September 30. GA Department of Natural Resources (GA DNR) provided episodic (January-March, April-September, and October-December) emission aggregates for each of four boilers at this facility.

3.5 Addendum to the elv3 Emissions Processing

Since the completion of the elv3 emissions processing and subsequent modeling efforts (October 2019), SESARM concluded that the 2028 point 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 AoI report;
- Updated 2028 EGU emissions projections developed by ERTAC;
- EPA's 2028 point source emissions based on the 2016 modeling platform; and
- Additional facility emission updates after PSAT analysis from other regional planning organizations with states in the VISTAS modeling domain, such as the Central Regional Air Partnership (CenRAP); the Lake Michigan Air Directors Consortium (LADCO); the Mid-

[28] ftp://ftp.epa.gov/EmisInventory/ei_conference/EI14/session11/stella.pdf

Atlantic and Northeast Visibility Union (MANE-VU); and the Western Regional Air Partnership (WRAP).

Specific updates related to development of the 2028 emissions inventory updates for re-modeling are documented in the Task 2B report for SESARM states and Task 3B for non-SESARM states. The remodeled emissions are referred to as "elv5".[29]

When comparing emissions processing results from the elv3 modeling and the subsequent modeling (elv5), several problems were identified within the elv3 modeling framework, including differences in modeled emissions being significantly different than expected emissions (i.e., the mass emissions ERG provided to Alpine for processing through the SMOKE emissions processor vs. after processing.) Table 3-1 presents these differences for states in the VISTAS domain. Appendix B of the Task 3A report is a memorandum summarizing the problems with the elv3 modeling, which include:

- Differences in model spin-up days
- Molecular weight differences in CAMx Reporting
- Stack characteristic changes
- Temporal variability configuration and processing of small boiler files
- EGU boiler unit double count in 2028

Table 3-1. Comparison of Modeled Emissions vs. Expected Emissions in the elv3 Inventory.

State	Modeled NOx Emissions (tpy)	Modeled SO_2 Emissions (tpy)	Expected NOx Emissions (tpy)	Expected SO_2 Emissions (tpy)	Percent Difference, NOx (%)	Percent Difference, SO_2 (%)
SESARM States						
Alabama	84,809	89,233	80,528	87,896	4%	2%
Florida	71,763	63,344	68,110	63,596	5%	1%
Georgia	84,069	89,233	80,528	87,896	1%	<1%
Kentucky	71,763	64,344	68,110	63,596	1%	<1%
Mississippi	67,854	37,270	67,309	37,121	1%	<1%
North Carolina	67,070	75,281	66,321	75,197	7%	3%
South Carolina	52,978	20,831	52,709	20,815	5%	2%
Tennessee	70,746	36,441	65,949	35,270	1%	<1%
Virginia	37,834	30,119	36,117	29,652	8%	2%
West Virginia	46,470	23,524	45,976	23,480	<1%	<1%
SESARM Totals	**46,940**	**20,260**	**43,283**	**19,883**	**3%**	**1%**

[29] An "elv4" modeling platform was developed for SESARM modeling, but was later not used due to technical issues. Specific details are presented in the Tasks 3A and 3B final reports.

Table 3-1. Comparison of Modeled Emissions vs. Expected Emissions in the elv3 Inventory.

State	Modeled NOx Emissions (tpy)	Modeled SO_2 Emissions (tpy)	Expected NOx Emissions (tpy)	Expected SO_2 Emissions (tpy)	Percent Difference, NOx (%)	Percent Difference, SO_2 (%)
Non-SESARM States in the VISTAS Domain						
Arkansas	75,165	89,284	74,454	87,557	1%	2%
Colorado	87,539	17,040	88,107	17,742	-1%	-4%
Connecticut	4,337	463	5,032	504	-14%	-8%
Delaware	4,787	4,757	4,152	3,531	15%	35%
District of Columbia	556	21	556	21	0%	0%
Illinois	112,950	169,260	106,617	144,967	6%	17%
Indiana	151,208	195,574	138,970	188,159	9%	4%
Iowa	44,962	54,514	43,846	51,396	3%	6%
Kansas	43,991	30,445	43,299	30,429	2%	<1%
Louisiana	167,539	137,710	160,058	141,305	5%	-3%
Maine	14,000	2,845	11,711	2,504	20%	14%
Maryland	27,710	44,692	27,481	44,667	1%	<1%
Massachusetts	18,213	2,706	13,421	1,930	36%	40%
Michigan	99,760	86,580	93,486	80,950	7%	7%
Minnesota	64,221	32,872	55,909	28,319	15%	16%
Missouri	67,880	180,622	65,162	171,837	4%	5%
Montana	22,796	17,468	23,639	19,588	-4%	-11%
Nebraska	46,813	76,573	46,829	76,569	<-1%	<1%
New Hampshire	3,876	2,402	3,693	2,383	5%	1%
New Jersey	17,688	4,305	17,081	4,131	4%	4%
New Mexico	70,497	26,630	70,476	26,628	<1%	<1%
New York	60,432	39,786	52,641	32,272	15%	23%
North Dakota	51,689	55,279	51,268	55,007	1%	<1%
Ohio	110,479	189,262	107,788	172,265	2%	10%
Oklahoma	120,411	53,571	116,468	49,591	3%	8%
Pennsylvania	124,445	190,614	111,502	180,793	12%	5%
Rhode Island	1,667	895	1,666	895	<1%	0%
South Dakota	13,462	1,199	13,426	1,195	<1%	<1%
Texas	364,551	413,170	359,997	411,482	1%	<1%
Vermont	1,079	130	731	128	48%	2%
Wisconsin	48,486	47,217	47,295	46,153	3%	2%
Wyoming	118,851	60,990	115,810	60,985	3%	<1%
Non-SESARM Totals	**2,159,040**	**2,228,876**	**2,072,571**	**2,135,883**	**4%**	**4%**
Totals	**2,769,877**	**2,689,607**	**2,663,981**	**2,592,218**	**4%**	**4%**

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4.0 VISTAS II Data Acquisition

This section summarizes the ambient monitoring and deposition data collected for model performance evaluations and wet/dry deposition. Activities related to Task 3 are presented at: https://www.metro4-sesarm.org/content/task-4-data-acquisition-and-analysis

ERG used existing data sets to develop databases containing the air quality, deposition, and meteorological data for use in the study. The air quality, deposition, and meteorological data are provided in three separate Microsoft Access databases. A data dictionary containing descriptions of the fields in each Access table is provided in Excel format.

These databases cover the VISTAS II study period of 2009-2016 for concentrations and deposition data, and 2011-2016 for wind information (wind speed and wind direction). At a minimum, databases include data all the states that fall within the VISTAS 12-kilometer (km) modeling domain (Figure 4-1). When not inhibited by file size limitations, additional states have been included in the database. These databases provide a permanent record of the set of data used to support the model performance evaluation (MPE) and the regional haze calculations conducted throughout the study.

These databases also have a use beyond this study, as the ambient air quality, meteorological and deposition data can fulfill the data gathering phase of any additional studies the SESARM partners might wish to conduct. For example, the weekly wet deposition and weekly dry deposition data were collected under Subtask 4.1 for potential use by SESARM's partners to support other projects that evaluate acid deposition in watersheds. Having this data set in hand will facilitate any other evaluation, saving time and resources. Additionally, states could use the meteorology and air quality database for a multivariate regression model or Classification And Regression Tree (CART) analysis to examine the meteorological conditions that lead to impair visibility and high concentrations of PM or other pollutants.

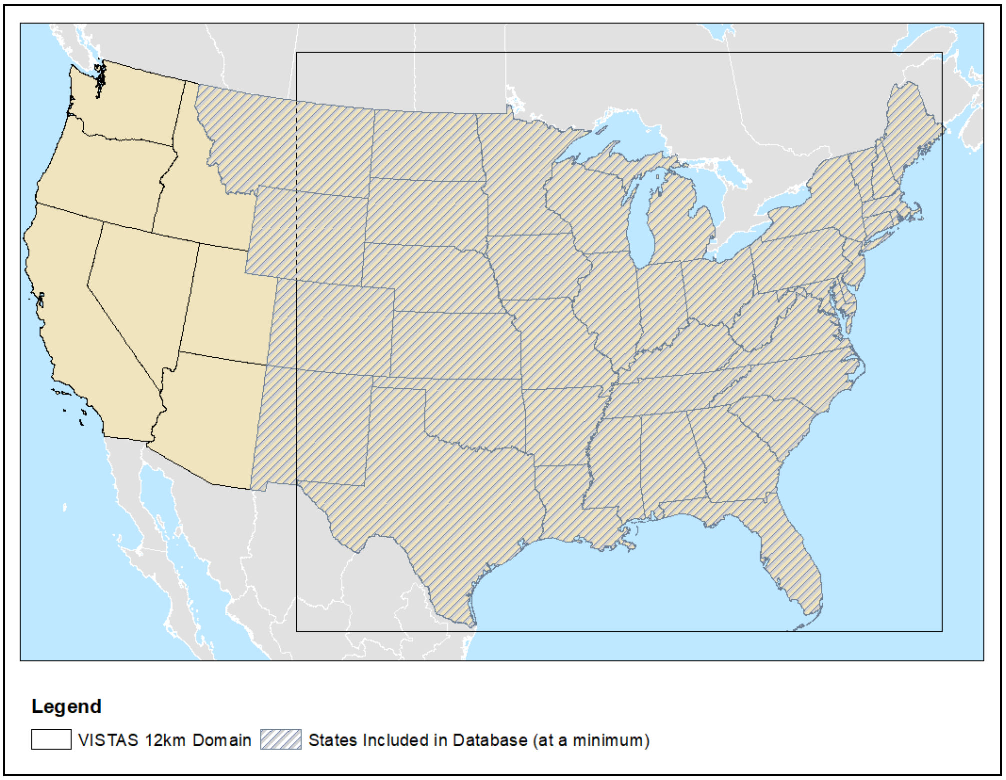

Figure 4-1. States Included in Task 4 Databases

The primary goal of Task 4 was to collect ambient air quality information for use across the VISTAS II projects and other analyses associated with the SESARM partners regional haze SIP submittals. ERG developed a comprehensive ambient air quality database to serve as a master database of available ambient data for the 2011 to 2016 study period. Additionally, concentration data from 2009 and 2010 were obtained for calculation of Relative Response Factors (RRFs) for Task 9. The database includes data from the following monitoring networks:

- Interagency Monitoring of Protected Visual Environments (IMPROVE),
- U.S. EPA's Air Quality System (AQS)

These networks are discussed in the following sections. The data was retrieved from the Cooperative Institute for Research in the Atmosphere (CIRA) IMPROVE website and EPA's AQS. Figure 4-2 presents monitoring site locations gathered for this task.

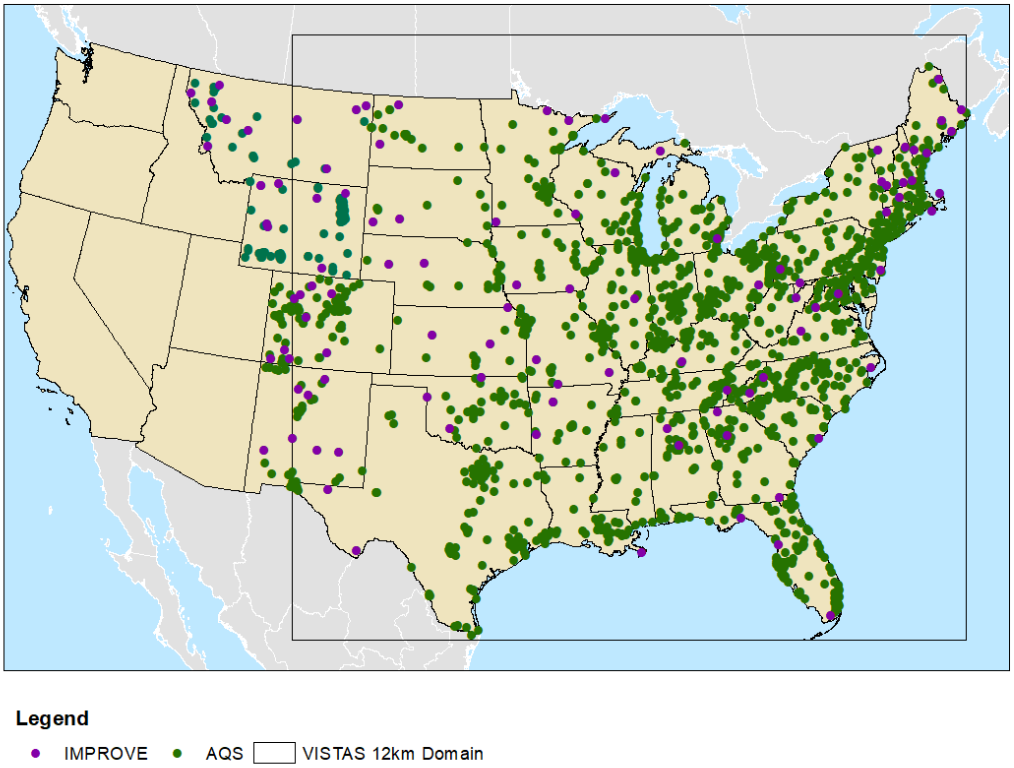

Figure 4-2. Air Quality Monitoring Sites Included in the Database

4.1 Monitoring Networks

4.1.1 IMPROVE

The IMPROVE network is overseen by a collaborative association of state, tribal, and federal agencies, and international partners. EPA is the primary funding source, with contracting and research support from the National Park Service. Collectively, this group is known as CIRA. The Air Quality Group at the University of California, Davis is the central analytical laboratory, with ion analysis provided by Research Triangle Institute, and carbon analysis provided by Desert Research Institute.

During the implementation of the RHR, IMPROVE was designated as the visibility network to fulfill the monitoring requirements of the RHR. The existing network expanded to 110 monitoring sites representative of 155 of the 156 mandatory Class I areas. The IMPROVE network also includes protocol sites to expand the spatial coverage of the network. The IMPROVE monitoring network has a rigorous quality assurance (QA) program and extensive quality control (QC) and assessment procedures. This includes requiring adherence to the network QAPP[30] and standard operating procedures (SOPs)[31] for monitoring equipment. Each member of the analytics team submits quality assurance reports[32] annually to affirm adherence to the quality documentation, compliance with the Quality Assurance Plans and Data Quality Objects.

IMPROVE monitors collect 24-hour samples every three days. Filters from the monitoring sites are analyzed for total $PM_{2.5}$ mass, mass of individual $PM_{2.5}$ species (e.g., organic carbon, elemental carbon (EC), sulfate ion, nitrate ion), light absorption, and PM_{10} mass. Select sites also include a nephelometer for optical monitoring. Table 4-1 provides a detailed list of IMPROVE monitoring network measurements included in the database for the VISTAS II project.

Table 4-2. IMPROVE Monitoring Network Measurements

AQS Parameter Code	Parameter Description	Units[a]
42401	Sulfur Dioxide	$\mu g/m^3$ LC
81103	Mass, $PM_{2.5}$ - PM_{10} (Coarse)	$\mu g/m^3$ LC
85101	Mass, PM_{10} (Total)	$\mu g/m^3$ LC
88101	Mass, $PM_{2.5}$ (Fine)	$\mu g/m^3$ LC
88103	Arsenic (Fine)	$\mu g/m^3$ LC
88104	Aluminum (Fine)	$\mu g/m^3$ LC
88109	Bromine (Fine)	$\mu g/m^3$ LC
88111	Calcium (Fine)	$\mu g/m^3$ LC
88112	Chromium (Fine)	$\mu g/m^3$ LC
88114	Copper (Fine)	$\mu g/m^3$ LC
88115	Chlorine (Fine)	$\mu g/m^3$ LC
88126	Iron (Fine)	$\mu g/m^3$ LC
88128	Lead (Fine)	$\mu g/m^3$ LC
88132	Manganese (Fine)	$\mu g/m^3$ LC
88136	Nickel (Fine)	$\mu g/m^3$ LC
88140	Magnesium (Fine)	$\mu g/m^3$ LC
88152	Phosphorus (Fine)	$\mu g/m^3$ LC
88154	Selenium (Fine)	$\mu g/m^3$ LC
88161	Titanium (Fine)	$\mu g/m^3$ LC
88164	Vanadium (Fine)	$\mu g/m^3$ LC
88165	Silicon (Fine)	$\mu g/m^3$ LC
88167	Zinc (Fine)	$\mu g/m^3$ LC
88168	Strontium (Fine)	$\mu g/m^3$ LC
88169	Sulfur (Fine)	$\mu g/m^3$ LC

30 http://vista.cira.colostate.edu/improve/wp-content/uploads/2017/01/IMPROVE-QAPP-Signed_3_2016.pdf
31 Available at: http://vista.cira.colostate.edu/Improve/sops/
32 IMPROVE quality assurance documentation can be found at: http://vista.cira.colostate.edu/Improve/quality-assurance/

Table 4-2. IMPROVE Monitoring Network Measurements

AQS Parameter Code	Parameter Description	Units[a]
88176	Rubidium (Fine)	μg/m³ LC
88180	Potassium (Fine)	μg/m³ LC
88184	Sodium (Fine)	μg/m³ LC
88185	Zirconium (Fine)	μg/m³ LC
88203	Chloride (Fine)	μg/m³ LC
88301	Ammonium Ion (Fine)	μg/m³ LC
88306	Total Nitrate (Fine)	μg/m³ LC
88307	Carbon, Elemental Total (Fine)	μg/m³ LC
88320	Carbon, Organic Total (Fine)	μg/m³ LC
88329	Carbon, Elemental Fraction 1 (Fine)	μg/m³ LC
88330	Carbon, Elemental Fraction 2 (Fine)	μg/m³ LC
88331	Carbon, Elemental Fraction 3 (Fine)	μg/m³ LC
88332	Carbon, Organic Fraction 1 (Fine)	μg/m³ LC
88333	Carbon, Organic Fraction 2 (Fine)	μg/m³ LC
88334	Carbon, Organic Fraction 3 (Fine)	μg/m³ LC
88335	Carbon, Organic Fraction 4 (Fine)	μg/m³ LC
88336	Carbon, Organic Pyrolized (Fine), by Reflectance	μg/m³ LC
88337	Hydrogen (Fine)	μg/m³ LC
88338	Nitrite (Fine)	μg/m³ LC
88339	Ammonium Sulfate (Fine)	μg/m³ LC
88344	Ammonium Nitrate (Fine)	μg/m³ LC
88348	Soil (Fine)	μg/m³ LC
88350	Carbon, Organic Mass (Fine) (1.8*OC)	μg/m³ LC
88395	Sea Salt (Fine)	μg/m³ LC
88401	Mass, $PM_{2.5}$ Reconstructed (Fine)	μg/m³ LC
88403	Sulfate (Fine)	μg/m³ LC

[a] LC: local conditions

For the database, total and speciated light extinction (in inverse megameters (Mm^{-1})) and meteorological measurements from the IMPROVE monitoring location were collected via the IMPROVE website.[33] The initial measurements are made in micrograms per cubic meter and converted to local conditions (LC), meaning the volumetric measurements are adjusted based on the temperature and humidity conditions at the observation site. These measurements are then used in the "IMPROVE Equation"[34] to estimate light extinction at each site.

33 IMPROVE data is available at: http://views.cira.colostate.edu/fed/DataWizard/Default.aspx
34 http://vista.cira.colostate.edu/Improve/the-improve-algorithm/; retrieved on May 1, 2018. Filename = SIA_daily_budgets_04_18_2.zip, archived at: http://vista.cira.colostate.edu/DataWarehouse/IMPROVE/Data/SummaryData/RHR_2016/)

4.1.2 EPA's Air Quality System (AQS)

The AQS[35] contains ambient air pollution data collected by EPA, state, local, and tribal air pollution control agencies from thousands of monitors across the United States. ERG pulled ambient concentrations for all the criteria pollutants (e.g., CO, NH_3, NO_x, PM_{10}, $PM_{2.5}$, O_3, and SO_2), as well as the $PM_{2.5}$ component species information from these sites, which were aggregated into the air quality databases.

Overall, nearly 1,800 monitors throughout the United States were active during the VISTAS II study period of 2009-2016 and are include in the ambient monitoring database. Figure 4-2 shows the location of these within the VISTAS 12-km domain collected from the AQS system and included in the database. Data were collected from the AQS system.

4.2 Database Development

Due to its size, the ambient air quality data are split between several databases based on monitor type. The databases are further divided by whether the monitor was in one of the SESARM partner's jurisdictions (SESARM) or outside (Non-SESARM).

The primary data source for the database was from AQS, which contains data from multiple programs, including IMPROVE and Clean Air Status and Trends Network (CASTNET). As such, the IMPROVE and CASTNET data were subsequently removed from the AQS data and placed into their own separate databases.

The SESARM AQS data were split into six zipped Access databases:

- TASK_4_0_AMBIENT_DATABASE_SESARM_2009.zip
- TASK_4_0_AMBIENT_DATABASE_SESARM_2010.zip
- TASK_4_0_AMBIENT_DATABASE_SESARM_2011.zip
- TASK_4_0_AMBIENT_DATABASE_SESARM_2012.zip
- TASK_4_0_AMBIENT_DATABASE_SESARM_2013.zip
- TASK_4_0_AMBIENT_DATABASE_SESARM_2014.zip
- TASK_4_0_AMBIENT_DATABASE_SESARM_2015.zip
- TASK_4_0_AMBIENT_DATABASE_SESARM_2016.zip

Each database includes a single table, AMBIENT_DATABASE_SESARM_STATES, that include all the AQS ambient monitoring data for the year. For AQS data for NONSESARM states, there are eighteen zipped Access databases, which is made up of three files for each year:

[35] https://www.epa.gov/aqs

- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2009_1.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2009_2.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2009_3.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2010_1.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2010_2.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2010_3.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2011_1.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2011_2.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2011_3.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2012_1.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2012_2.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2012_3.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2013_1.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2013_2.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2013_3.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2014_1.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2014_2.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2014_3.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2015_1.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2015_2.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2015_3.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2016_1.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2016_2.zip
- TASK_4_0_AMBIENT_DATABASE_NON_SESARM_2016_3.zip

File #1 include the data for January 1 through April 30. File #2 include data for May 1 through August 31. File #3 includes data for September 1 through December 31. Each database includes a single table, AMBIENT_DATABASE_NON_SESARM_STATES, which include all the AQS ambient monitoring data for the calendar period.

The supplemental databases include:

- CASTNET databases (2 zipped database)
  - TASK_4_0_AMBIENT_DATABASE_CASTNET_NON_SESARM_SUPP.zip
  - TASK_4_0_AMBIENT_DATABASE_CASTNET_SESARM_SUPP.zip

- IMPROVE Data (2 zipped databases)
  - TASK_4_0_AMBIENT_DATABASE_IMPROVE_SESARM_SUPP.zip
  - TASK_4_0_AMBIENT_DATABASE_IMPROVE_NON_SESARM_SUPP.zip

The CASTNET databases contain one table, which holds all the data for the specified area for the entire study period. Similarly, the IMPROVE databases contain one table, which holds all the data for the specified area for the entire study period.

Consistent with the project QAPP, a data definitions tables that describes the contents of each field and unit, where applicable has been provided (AQ_Data_Dictionary.xlsx). ERG also provided a site list, (Air_Quality_Monitoring_Site_Descriptions.xlsx), which includes station metadata such as location information (e.g., latitude, longitude, elevation), site duration, and type. The site list includes also information on the nearest National Weather Service (NWS) site for coupling meteorological and air quality data. The field names and descriptions of the site list are detailed in Table 4-2.

4.3 Database Quality Assurance

Since CIRA may not have the most recent IMPROVE data uploaded to AQS, ERG download the latest information from CIRA's IMPROVE website to ensure a complete database. The ambient database was screened to ensure no duplicative IMPROVE values were included in the database. Furthermore, each data record has primary keys assigned to ensure that no duplication of data is permissible or that record growth occurs when running queries and assure that there are no duplicate entries. That is, the primary keys prevent erroneous one-to-many pairs that could create extra rows in the data table that are not actual observations. Data entered into these systems have passed QA/QC procedures employed by EPA and the data owners.

All data retrieval will follow data acquisition and handling procedures outlined in the project QAPP.

Table 4-2. Field Names and Descriptions for "Air_Quality_Monitoring_Site_Descriptions"

Field Name	Description
AMA_SITE_CODE	Unique site identifier consisting of 5-digit Federal Information Processing System (FIPS) code and 4-digit site identifier (ID)
STATE_FIPS	2-digit FIPS code for the state
COUNTY_FIPS	3-digit FIPS code for the county
STATE_COUNTY_FIPS	Combined 5-digit FIPS code for State and County
COUNTY_NAME	Name of the county where the monitor is located
LOCAL_SITE_ID	Site ID designated by the agency maintaining the monitor
SITE_NAME	Site name
ADDRESS	Street address for the site
CITY	City where the site is located
STATE_ABBR	State postal abbreviation
ZIP_CODE	Zip Code where the site is located
EPA_REGION	EPA region (1 through 10) where the monitor is located
SUPPORT_AGENCY_CODE	Code for the Support Agency
SUPPORT_AGENCY	Name of the agency maintaining the monitor
MONITOR_LATITUDE	Site latitude (decimal degrees)
MONITOR_LONGITUDE	Site Longitude (decimal degrees)
DATUM	Coordinate data system
ELEVATION	Elevation of the monitoring site, in meters
LOCATION_TYPE	Type of location
LAND_USE	Land Use Type
DATE_SITE_ESTABLISHED	Date in which the site began operation
DATE_SITE_CLOSED	Date in which the site ceased operations
CBSA_NAME	Core-Based Statistical Area (CBSA) name
CBSA_TYPE	CBSA type (metropolitan or micropolitan)
CLOSEST_NWS_STATION	Name of closest National Weather Service (NWS) meteorological station
CLOSEST_NWS_STATION_WBAN	Weather Bureau Army Navy (WBAN) ID of closest NWS meteorological station

Table 4-2. Field Names and Descriptions for "Air_Quality_Monitoring_Site_Descriptions"

Field Name	Description
CLOSEST_NWS_STATION_DISTANCE_MILES	Distance to closest NWS station in miles
CLOSEST_NWS_STATION_BEARING_FROM_EAST	Bearing angle from the east of the monitoring site and the closest NWS station
SECOND_CLOSEST_NWS_STATION	Name of second closest NWS meteorological station
SECOND_CLOSEST_NWS_STATION_WBAN	Second closest NWS station identifier
SECOND_CLOSEST_NWS_STATION_DISTANCE_MILES	Distance to second closest NWS station in miles
SECOND_CLOSEST_NWS_STATION_BEARING_FROM_EAST	Bearing angle from the east of the monitoring site and the second closest NWS station
COMMENT	General comment

4.4 Deposition Database

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., FLMs) to support other projects such as evaluation of acid deposition in watersheds. This following section provides a summary of the monitoring networks and data included in the database.

4.4.1 Monitoring Networks

ERG aggregated deposition information from the various monitoring networks into a single database for SESARM states. This data can be used to assess the deposition of various pollutants on land and waterways. The primary source for deposition data is the National Atmospheric Deposition Program (NADP).[36] 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)

Additional dry deposition information is available from CASTNET. This data was also collected and is available in the deposition database. Figure 4-3 shows the spatial distribution of these deposition networks across the United States. All the NADP sites in Figure 4-3 were included in the VISTAS II database. Table 4-3 summarizes the measurements available from each deposition monitoring network. Each network is discussed separately in the following sections.

[36] 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/

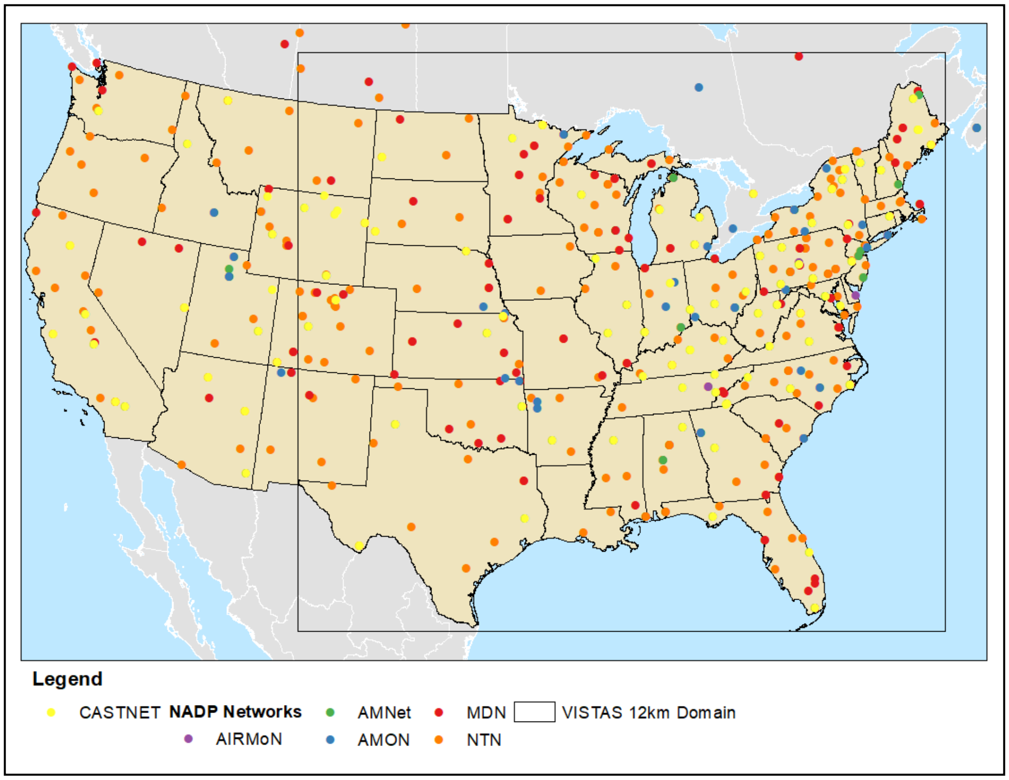

Figure 4-3. Deposition Monitors Included in the VISTAS II Database

Table 4-3. Wet and Dry Deposition Monitoring Network Measurements

	Wet Deposition			Dry Deposition		
Measurement	**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 (HgP) concentration				✓		
Average Gaseous Oxidized Mercury				✓		

4.4.1.1 National Atmospheric Deposition Program (NADP)

The NADP is a clearing house for national deposition data. All networks have quality assurance plans[37] and SOPs[38] in place to help ensure data comparability and representativeness. Each network is reviewed annually to note operation and equipment changes, as well as perform a QA/QC review to ensure compliance with the Quality Assurance Plans and Data Quality Objects laid out for each network. These QA reports are published on NADP website.[39]

National Trends Network (NTN)

The NTN[40] provides a long-term record of wet deposition across the United States. The earliest NTN monitors were brought online in the summer of 1978, with new monitors installed almost every year since. There were 285 active monitors throughout the United States and Canada for at least part of the VISTAS II study period of 2011-2016. All 285 of the monitors were included in the VISTAS II database. Data were collected from the NADP's NTN website.[41]

NTN sites are located away from urban areas and point sources of pollution. Each site has an automated precipitation chemistry collector, which ensures that the sample is exposed only during precipitation (wet-only-sampling). Samples are collected on Tuesday mornings and are sent to the Central Analytical Laboratory (CAL) at the Illinois State Water Survey (ISWS) for analysis, data entry, verification, and screening. Measurements collected include 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^-), and ammonium (NH_4^+). The CAL conducts additional review of field and lab notes, and flags samples that were mishandled, compromised, or contaminated. Once the data is delivered to NADP, a final review is conducted before data are made available.

Atmospheric Integrated Research Monitoring Network (AIRMoN)

AIRMoN[42] was incorporated into NADP in 1992. The AIRMoN sites have the same equipment used at NTN sites. Samples are analyzed by CAL and follow similar handling procedures. The main difference is low volume AIRMoN samples are not diluted to accommodate complete analysis like NTN.

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[37] QAPP is available at: http://nadp.slh.wisc.edu/lib/qaPlans.aspx
[38] SOPs are available at: http://nadp.slh.wisc.edu/lib/manualsSOPs.aspx
[39] Quality assurance reports are available at: http://nadp.slh.wisc.edu/lib/qaReports.aspx
[40] http://nadp.slh.wisc.edu/NTN/
[41] Data is available for download at: http://nadp.slh.wisc.edu/data/NTN/
[42] http://nadp.slh.wisc.edu/AIRMoN/

The AIRMoN sites collects weekly wet deposition data, include 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^-), and ammonium (NH_4^+). Data were downloaded from the AIRMoN page on the NADP website.[43] There were 7 active monitors throughout the United States and Canada during the study period, which are included in the deposition database.

Mercury Deposition Network (MDN)

The MDN[44] provides weekly dry and wet deposition measurement of mercury. MDN site utilize an automated collector similar to the NTN sites, but that has been modified to preserve Mercury. Samples are collected on Tuesdays, or within 24-hours of the start of a precipitation event. Samples are analyzed by the Mercury Analytical Laboratory (HAL) at Eurofins Frontier Global Sciences, Inc., Seattle, Washington. MDN sites follow stringent sampling protocols that enable sites to report mercury concentrations below 1 part per trillion (<1 nanogram/liter). The analysis includes all forms of mercury, which is reported as total mercury concentration.

After analyzing the samples, the HAL conducts additional review of field and lab notes, and flags samples that were mishandled, compromised, or contaminated. Once the data is delivered to NADP, a final review is conducted before data are made available on the NADP website.[45]

Atmospheric Mercury Network (AMNet)

AMNet[46] collects atmospheric mercury fraction data to estimate dry and total deposition of mercury. Automated continuous measuring system collect concentrations of atmospheric mercury species, total mercury in precipitation, and meteorological measurements. Data are collected using standardized instrumentation, methods, and QA procedures.[47] Data are made available on the NADP website.[48]

There were 33 active monitors throughout the United States and Canada for at least part of the VISTAS II study period of 2011-2016.

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43 Data are available for download at: http://nadp.slh.wisc.edu/data/AIRMoN/
44 http://nadp.slh.wisc.edu/MDN/
45 Data are available for download at: http://nadp.slh.wisc.edu/data/MDN/
46 http://nadp.slh.wisc.edu/AMNet/
47 Quality documents and SOPs are available at: http://nadp.slh.wisc.edu/AMNet/docs.aspx
48 Data are available at: http://nadp.slh.wisc.edu/data/AMNet/

Ammonia Monitoring Network (AMoN)

NADP deployed AMoN.[49] sites at most CASNET sites, which record biweekly concentrations of ambient ammonia gas (NH_3^-). With monitoring sites established in 2007, AMoN provides long-term ammonia gas. AMoN utilizes passive samplers, which are deployed for two weeks at a time. AMoN samples are prepared, extracted and analyzed at the NADP's CAL following strict SOPs.[50] Data are made available on the NADP website.[51] AMoN site collect multiple, or replicate, samples for each sampling period. The database includes the individual replicate values and the NADP processed average of the samples.

There were 105 active monitors throughout the United States and Canada between 2011-2016.

4.4.1.2 Clean Air Status and Trends Network (CASTNET)

CASTNET[52] is a long-term rural monitoring network with 95 sites located throughout the United States and Canada. The network was established under the 1991 CAA Amendments to assess the trends in acidic deposition due to emission reduction programs. The CASTNET provides weekly measurements of sulfur dioxide (SO_2), nitric acid (HNO_3), particulate sulfate (SO_4^{-2}), nitrate (NO_3^-), ammonium (NH_4^+), base cations (magnesium [Mg^{+2}], calcium [Ca^{+2}], potassium (K^+), and sodium [Na^+]), and chloride ion (Cl^-) for deposition analysis, as well as several ambient concentrations on an hourly basis. Data collection and analysis follow QAPP and SOPs, which are available on the CASTNET website.[53] Data are available through AQS and the CASTNET website.[54]

There were 98 active monitors throughout the United States and Canada for at least part of the VISTAS II study period of 2011-2016, which are all included in the database.

4.4.2 Database Development

The deposition database (DepositionData_2011-2016.accdb) consists of eight tables:

- AIRMoN_2011-2016: Weekly AIRMoN data collected between 2011 and 2016
- AMNet_2011-2016: Weekly AMNet data collected between 2011 and 2016
- 2016AMoN_AVE_2011-2016: Weekly average of replicate sample from AMoN sites collected between 2011 and 2016

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49 http://nadp.slh.wisc.edu/AMoN/
50 Available at: http://nadp.slh.wisc.edu/AMoN/amon-standardoperatingprocedures.pdf
51 Data available at: http://nadp.slh.wisc.edu/data/AMoN/
52 https://www.epa.gov/castnet
53 Quality documents are available on: https://java.epa.gov/castnet/documents.do
54 Data are available at: https://java.epa.gov/castnet/clearsession.do

- AMoN_REP_2011-2016: Weekly individual replicate samples collected at AMoN sites between 2011 and 2016
- MDN_2011-2016: Weekly MDN data collected between 2011 and 2016
- NTN_2011-2016: Weekly NTN data collected between 2011 and 2016
- CASTNET_2011-2016: data collected between 2011 and 2016
- Deposition_Sites: comprehensive list of the sites in each monitoring network.

All data were downloaded directly from the NADP and CASTNET website and uploaded into an Access database. The "start" and "stop" dates of the samples were used to filter the table to the 2011 to 2016 VISTAS II study period.

Consistent with the project QAPP, a data dictionary containing descriptions of the fields in each table is provided (Deposition_Data_Dictionary.xlsx). The field names and descriptions of the site list are detailed in Table 4-4.

Table 4-4. Field Names and Descriptions for Table "Deposition_Sites"

Field Name	Description
network	Monitoring network name. (e.g., NTN, MDN)
siteid	4-digit site ID (first two digits are the state abbreviation, followed by a two-digit number).
siteName	Site name
county	County name
state	State postal abbreviation
latitude	Site latitude (decimal degrees)
longitude	Site Longitude (decimal degrees)
elevation	site elevation (in meters)
status	Operational Status (A= Active, I = inactive)
startdate	Start date for the site, reported in Greenwich Mean Time (GMT); YYYY-MM-DD hh:mm format
stopdate	End date for the site, reported in Greenwich Mean Time (GMT); YYYY-MM-DD hh:mm format
start	Start date, without time
stop	End date, without time

4.4.3 Database Quality Assurance

Consistent with the QAPP, all original files (i.e., data downloaded from network websites) were sequestered from the project working files to preserve the original data. Data sheet were imported into Access for filtering. When additional fields were added (i.e., start, stop), the working database preserved the queries used to generate the fields for QA/QC review. Review was conducted by a second analyst, not part of the deposition field gathering and database development.

Fields from the original source were preserved throughout the process and are present in the final data table. Additionally, each data record has primary keys assigned to ensure that no duplication of data is permissible or that record growth occurs when running queries.

4.5 Meteorological Database

Hourly meteorological measurements obtained from the National Centers for Environmental Information (NCEI) for the WBAN sites, which include NWS Automated Surface Observing Systems (ASOS) and Federal Aviation Administration (FAA) Automated Weather Observing System (AWOS) sites. Hourly data from EPA's AQS sites are also included in the database.

Meteorological data are provided to support additional analysis by states that may arise when developing regional haze SIPs. Figure 4-4 shows the spatial distribution of the meteorological networks across the United States. Table 4-5 summarizes the measurements provided from each meteorological monitoring network. Each network is discussed separately in the following sections.

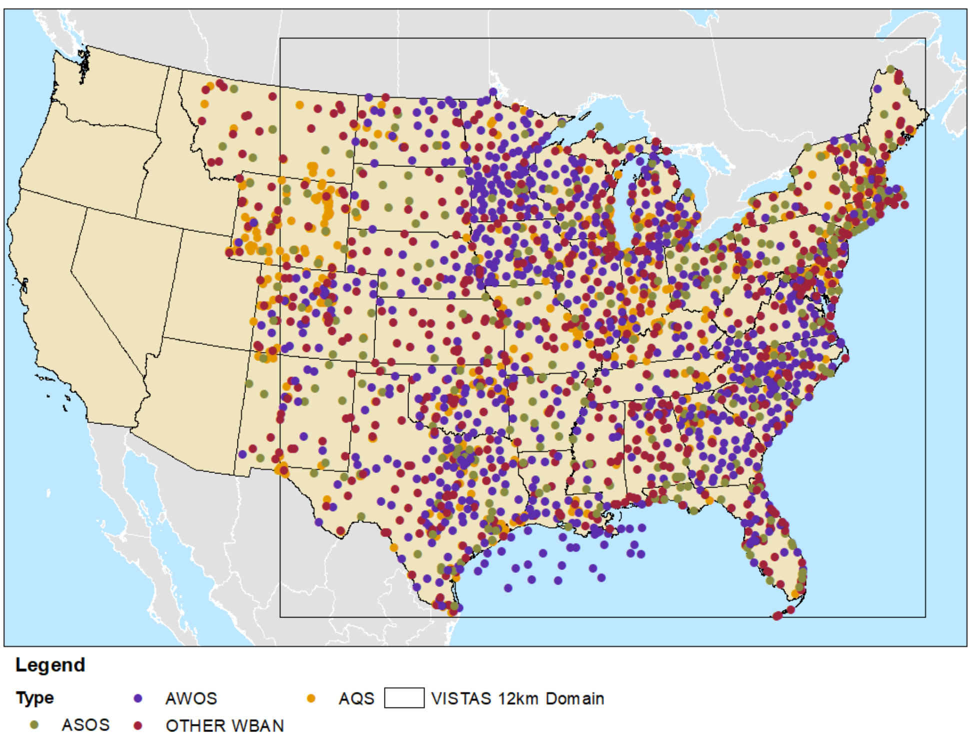

Figure 4-4. Meteorological Monitoring Sites Included in the VISTAS II Database

Table 4-5. Meteorological Monitoring Network Measurements Included

Observation	Parameter Code	AQS*	NWS*	TAMIS*
Wind Speed (mph or kts)	61101	✓	✓	✓
Wind Direction (degrees)	61102	✓	✓	✓
Resultant Speed (mph or kts)	61103	✓		
Resultant Direction (degrees)	61104	✓		
Sky Condition	--		✓	
Visibility	--		✓	
Weather Type	--		✓	
Temperature (F)	--		✓	
Dew Point (F)	--		✓	
Station Pressure (in Hg)	--		✓	
Sea Level Pressure (mb)	--		✓	
Hourly precipitation (in)	--		✓	

* Air Quality System (AQS), National Weather Service (NWS), Texas Air Monitoring Information System (TAMIS)

4.5.1 Monitoring Networks

4.5.1.1 Air Quality System (AQS)

In addition to ambient concentrations, EPA's AQS contains meteorological data from collocated towers. These data are reported by the agency operating the monitor to AQS. Operators adhere to collection and quality standards established by EPA. There were 681 active AQS meteorological monitors throughout the United States during the study period.

4.5.1.2 Weather Bureau Army-Navy (WBAN) Sites

The WBAN numbering system was the first attempt at a standardized station numbering system across various weather reporting agencies. The WBAN site list is comprised of ASOS, AWOS, and various other observation sites. For the database, only hourly data was included form the various WBAN networks. For summary purposes, the ASOS and AWOS sites were identified separately from the other networks and are described below.

Automated Surface Observing Systems (ASOS)

ASOS sites are managed by the National Weather Service and serve meteorological and aviation observing needs. Sites are typically collocated with airports but can be sited at other strategic locations. ASOS sites report hourly observations and special observations during rapid shifts in weather and for changing aviation needs. There were 309 active monitors throughout the United States during the study period. Hourly data was obtained from NCEI.[55]

Automated Weather Observing System (AWOS)

AWOS sites are operated by the FAA, and generally fulfill observational needs for aviation. AWOS provides a similar suite of measurements as the ASOS sites, but report at 20-minute intervals. There were 777 active monitors throughout the United States during the study period. Hourly data was obtained from NCEI.[56]

Additional Weather Bureau Army-Navy (WBAN)

The additional WBAN sites include the U.S. Historical Climatology Network (USHCN), U.S. Climate Reference Network (USCRN), U.S. Regional Climate Reference Network (USRCRN), and other various Military, Weather Service, Airways sites.[57] In all, there were 660 additional WBAN active monitors throughout the United States during the study period. Hourly data was obtained from NCEI.[58]

4.5.2 Database Development

Due to its size, the meteorological data is split between several databases. Similar to the ambient databases, the meteorological databases are divided by network (i.e., NWS, AQS, the Texas Air Monitoring Information System [TAMIS]) and then further divided by whether the monitor was in one of the SESARM partner's jurisdictions (SESARM) or outside (Non-SESARM).

For the NWS data, the data within the SESARM states are presented in six zipped Access databases:

- NWS_SESARM_10_States_2011.zip
- NWS_SESARM_10_States_2012.zip
- NWS_SESARM_10_States_2013.zip
- NWS_SESARM_10_States_2014.zip
- NWS_SESARM_10_States_2015.zip
- NWS_SESARM_10_States_2016.zip

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55 Data available at: https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/automated-surface-observing-system-asos

56 Data are available at: https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/automated-weather-observing-system-awos

57 https://www.ncdc.noaa.gov/homr/

58 https://www.ncdc.noaa.gov/homr/reports/platforms

Each database includes one table, NWS_SESARM_10_STATES**,** which holds all the meteorological data for the year. For NWS data for NONSESARM states, there are eighteen zipped Access databases, which is made up of three files for each year:

- NWS_VISTAS_NON_SESARM_2011_1.zip
- NWS_VISTAS_NON_SESARM_2011_2.zip
- NWS_VISTAS_NON_SESARM_2011_3.zip
- NWS_VISTAS_NON_SESARM_2012_1.zip
- NWS_VISTAS_NON_SESARM_2012_2.zip
- NWS_VISTAS_NON_SESARM_2012_3.zip
- NWS_VISTAS_NON_SESARM_2013_1.zip
- NWS_VISTAS_NON_SESARM_2013_2.zip
- NWS_VISTAS_NON_SESARM_2013_3.zip
- NWS_VISTAS_NON_SESARM_2014_1.zip
- NWS_VISTAS_NON_SESARM_2014_2.zip
- NWS_VISTAS_NON_SESARM_2014_3.zip
- NWS_VISTAS_NON_SESARM_2015_1.zip
- NWS_VISTAS_NON_SESARM_2015_2.zip
- NWS_VISTAS_NON_SESARM_2015_3.zip
- NWS_VISTAS_NON_SESARM_2016_1.zip
- NWS_VISTAS_NON_SESARM_2016_2.zip
- NWS_VISTAS_NON_SESARM_2016_3.zip

Each database includes a single table, NWS_NON_SESARM_VISTAS_DOMAIN, which include all the meteorology data for the calendar period. File #1 include the data for January 1 through April 30. File #2 include data for May 1 through August 31. File #3 includes data for September 1 through December 31. For the AQS Data, all states, that is SESARM and NONSESARM, are contained in separate zipped Access databases for each year:

- TASK_4_0_MET_DATABASE_AQS_2011.zip
- TASK_4_0_MET_DATABASE_AQS_2012.zip
- TASK_4_0_MET_DATABASE_AQS_2013.zip
- TASK_4_0_MET_DATABASE_AQS_2014.zip
- TASK_4_0_MET_DATABASE_AQS_2015.zip
- TASK_4_0_MET_DATABASE_AQS_2016.zip

All database contains a single table, MET_DATABASE_AQS_VISTAS_DOMAIN, with all the data for the year.

The TAMIS dataset provides additional meteorological data for the state of Texas. This additional Texan data is provided in a separate zipped Access database file, TASK_4_0_MET_DATABASE_TAMIS_2011_2016.zip. The database has a single table, MET_DATABASE_TAMIS_2011_2016, which holds all the data for the 2011-2016 for all the TAMIS sites. Lastly, Florida DEP provided relative humidity (RH) data at the St. Marks, FL IMPROVE site (SAMA1.txt).

Consistent with the project QAPP, a data dictionary containing description of the fields in each table is provided (METEOROLOGY_Data_Dictionary.xlsx). Additionally, the spreadsheet (Meteorological_Site_list.xlsx) contains information on all the meteorological sites included in the databases. The field names and descriptions are the same as those presented in Table 4-2.

4.5.3 Database Quality Assurance

Consistent with the QAPP, all original files (i.e., data downloaded from original sources) were sequestered from the project working files to preserve the original data. When additional fields were added (i.e., alternate units), ERG's comprehensive environmental database retains the original fields for QA/QC review. Review was conducted by a second analyst who was not part of the deposition field gathering and database development. Each data record has primary keys assigned to ensure that no duplication of data is permissible or that record growth occurs when running queries.

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5.0 VISTAS II AREA OF INFLUENCE

This section summarizes the development of the Area of Influence analysis. The results of this analysis helped identify specific sources/source categories for PSAT Analysis. Activities related to Task 5 are presented at: https://www.metro4-sesarm.org/content/task-5-area-influence-analysis

Under this task, ERG identified 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.[59] Due to the presence of large SO_2 emission reductions during this six-year period, the AoI analysis was set up to look at: 1) each year individually (2011, 2012, 2013, 2014, 2015, and 2016); 2) two separate periods of 2011-2013 and 2014-2016; and 3) for all years combined (2011-2016). Final results for the AoI analysis relied upon data from 2011 through 2016.

5.1 Identification of Sites

In addition to identifying the areas influencing visibility in Class I areas inside SESARM states, this analysis identifies areas from SESARM states that might have an influence on visibility in Class I areas outside the SESARM states. Analysis started by examining the eighty-three (83) Interagency Monitoring of Protected Visual Environments (IMPROVE) monitor positions in Class I areas within the VISTAS 12-km modeling domain. The final number of Class I areas was reduced from 83 to 45 due to:

Exclusion of Central and Western States IMPROVE monitors. To simplify the potential number of trajectories to be generated, SESARM approved a North Carolina Division of Air Quality recommendation which demonstrated that trajectories originating in Class I areas in several western states do not pass over a SESARM state and could be excluded from further analysis. These states are: Kansas; Nebraska; North Dakota; South Dakota; Colorado; Wyoming; and Montana. With the exclusion of these states, the number of IMPROVE monitors in the VISTAS 12-km domain reduces to thirty-eight (38).

Class I Areas With No IMPROVE Monitor. There are six (6) Class I areas in the VISTAS 12-km modeling domain that do not have an IMPROVE monitor. Of the six, three are located in the SESARM states (Wolf Island, GA; Joyce Kilmer-Slickrock, NC/TN; and Otter Creek, WV) and three are located

[59] http://vista.cira.colostate.edu/Improve/the-improve-algorithm/; retrieved on May 1, 2018. Filename = SIA_daily_budgets_04_18_2.zip, archived at: http://vista.cira.colostate.edu/DataWarehouse/IMPROVE/Data/SummaryData/RHR_2016/)

outside the SESARM states (Carlsbad Caverns, NM; Pecos Wilderness Area, NM; and Presidential Range-Dry River Wilderness, NH). For these Class I areas, the trajectory origin will be the centroid of the Class I area. Visibility data will be based on an appropriate IMPROVE monitor, as previously determined by the FLMs. This increased the number of trajectory origins to forty-four (44).

IMPROVE Monitor Relocation. Additionally, the IMPROVE monitor for the Lye Brook Wilderness, VT area moved in 2012. Separate trajectory analysis was completed for each monitoring location. This increased the number of trajectory origins to forty-five (45).

One final adjustment was made to the origin of trajectories for three Class I areas (Breton Island, LA; Guadalupe Mountains National Park, TX; and Isle Royale National Park, MI). For these areas, the IMPROVE monitor lies just outside the Class I area. Thus, the origins of the trajectories were moved to the centroid of the Class I area to better represent the area. This resulted in 36 trajectories originating from the Class I Area IMPROVE monitor (including both of the Lye Brook Wilderness monitors) and nine (9) originating from the Class I area centroids (6 with no monitor, plus three relocated for monitors outside the Class I areas).

Table 5-1 presents the trajectory origins for each Class I area, noting whether the origin is the centroid or IMPROVE monitor location. Figure 5-1 presents the location of the trajectory origins, while Figure 5-2 presents a closer view of the SESARM states. Both figures also denote which Class I areas have trajectories originating from IMROVE monitors or centroids.

5.2 Identification of Dates for Analysis

To identify the 20% most impaired days for analysis, ERG downloaded the RHR Summary, "Daily Impairment Values Including Patched Values" (December 2018 version) dataset from the IMPROVE website.[60] IMPROVE is a collaborative association of state, tribal, and federal agencies, and international partners. The EPA is the primary funding source, with contracting and research support from the National Park Service. The Air Quality Group at the University of California, Davis is the central analytical laboratory, with ion analysis provided by Research Triangle Institute, and carbon analysis provided by Desert Research Institute. The RHR Summary data provides the means for the best, middle, and worst 20% visibility days. The data also provide the 20% most impaired day values. From this

[60] "Daily Impairment Values Including Patched Values" under the "Regional Haze Rule Summary data through 1988-2017 (posted December 2018)" section (Filename = sia_impairment_daily_budgets_5_19.csv.) Internet address: http://vista.cira.colostate.edu/DataWarehouse/IMPROVE/Data/SummaryData/RHR_2017/

dataset, ERG was able to identify the 20% most impaired days for each Class I area in the VISTAS 12-km modeling domain over the 2011-2016 period for AoI analysis. The RHR data set contains flags on the data to indicate which group (i.e., best, worst, clearest, most impaired). For consistency with the revised EPA guidance on tracking visibility[61], days were ranked based on the anthropogenic contribution only to determine those that most impaired. The RHR Summary provides this ranking in the "Impairment_Group" column. Similarly, the anthropogenic portion of nitrate (anthro_eamm_no3) and sulfate (anthro_eamm_so4) were used for trajectory weighting described in Section 2.5.

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

Table 5-1. IMPROVE Monitors in the VISTAS_12 Domain

Class I Area	State	FIPS Code	IMPROVE Site Code	Trajectory Origin		
				Latitude	Longitude	Description
Acadia National Park	ME	23009	ACAD1	44.3771	-68.2610	IMPROVE Monitor
Bandelier Wilderness Area	NM	35028	BAND1	35.7797	-106.2664	IMPROVE Monitor
Big Bend NP	TX	48043	BIBE1	29.3027	-103.1780	IMPROVE Monitor
Bosque del Apache Wilderness Area	NM	35053	BOAP1	33.8695	-106.8520	IMPROVE Monitor
Boundary Waters Canoe Area Wilderness Area	MN	27075	BOWA1	47.9466	-91.4955	IMPROVE Monitor
Breton Wilderness	LA	22075	BRIS1	29.8895	-88.8524	Class I Centroid [b]
Brigantine Wilderness Area	NJ	34001	BRIG1	39.4650	-74.4492	IMPROVE Monitor
Caney Creek Wilderness Area	AR	05113	CACR1	34.4544	-94.1429	IMPROVE Monitor
Cape Romain Wilderness	SC	45019	ROMA1	32.9410	-79.6572	IMPROVE Monitor
Carlsbad Caverns NP	NM	48109	GUMO1[a]	32.1409	-104.5529	Class I Centroid
Chassahowitzka Wilderness Area	FL	12017	CHAS1	28.7484	-82.5549	IMPROVE Monitor
Cohotta Wilderness Area	GA	13213	COHU1	34.7852	-84.6265	IMPROVE Monitor
Dolly Sods Wilderness	WV	54093	DOSO1	39.1053	-79.4261	IMPROVE Monitor
Everglades NP	FL	12086	EVER1	25.3910	-80.6806	IMPROVE Monitor
Great Gulf Wilderness Area	NH	33007	GRGU1	44.3082	-71.2177	IMPROVE Monitor
Great Smoky Mountains NP	NC/TN	47009	GRSM1	35.6334	-83.9416	IMPROVE Monitor
Guadalupe Mountain NP	TX	48109	GUMO1	31.9236	-104.8846	Class I Centroid [b]
Hercules-Glades Wilderness Area	MO	29213	HEGL1	36.6138	-92.9221	IMPROVE Monitor
Isle Royale NP	MI	26083	ISLE1	48.0109	-88.8284	Class I Centroid [b]
James River Face Wilderness	VA	51163	JARI1	37.6266	-79.5125	IMPROVE Monitor
Joyce Kilmer-Slickrock Wilderness	NC/TN	47009	GRSM1[a]	35.4047	-83.9762	Class I Centroid
Linville Gorge Wilderness Area	NC	37011	LIGO1	35.9723	-81.9331	IMPROVE Monitor
Lye Brook Wilderness	VT	50003	LYBR1	43.1482	-73.1268	IMPROVE Monitor
		50025	LYEB1	42.9561	-72.9098	IMPROVE Monitor

[61] US EPA, 2018. Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program. EPA-454/R-18-010. December 2018 available at: https://www.epa.gov/sites/production/files/2018-12/documents/technical_guidance_tracking_visibility_progress.pdf

Table 5-1. IMPROVE Monitors in the VISTAS_12 Domain

Class I Area	State	FIPS Code	IMPROVE Site Code	Trajectory Origin		
				Latitude	Longitude	Description
Mammoth Cave NP	KY	21061	MACA1	37.1318	-86.1479	IMPROVE Monitor
Mingo Wilderness Area	MO	29207	MING1	36.9717	-90.1432	IMPROVE Monitor
Moosehorn Wilderness EDM	ME	23029	MOOS1	44.8362	-67.2276	IMPROVE Monitor
Okefenokee Wilderness Area	GA	13049	OKEF1	30.7405	-82.1283	IMPROVE Monitor
Otter Creek Wilderness	WV	54093	DOSO1[a]	38.9969	-79.6460	Class I Centroid
Pecos Wilderness Area	NM	35055	WHPE1 [a]	35.8944	-105.6453	Class I Centroid
Presidential Range-Dry River Wilderness	NH	33007	GRGU1[a]	44.1775	-71.3226	Class I Centroid
Salt Creek Wilderness Area	NM	35005	SACR1	33.4598	-104.4042	IMPROVE Monitor
San Pedro Parks Wilderness Area	NM	35039	SAPE1	36.0139	-106.8447	IMPROVE Monitor
Seney Wilderness Area	MI	26153	SENE1	46.2889	-85.9503	IMPROVE Monitor
Shenandoah NP	VA	51113	SHEN1	38.5229	-78.4348	IMPROVE Monitor
Shining Rock Wilderness Area	NC	37087	SHRO1	35.3937	-82.7744	IMPROVE Monitor
Sipsey Wilderness Area	AL	01079	SIPS1	34.3433	-87.3388	IMPROVE Monitor
St Marks Wilderness Area	FL	12129	SAMA1	30.0926	-84.1614	IMPROVE Monitor
Swanquarter Wilderness Area	NC	37095	SWAN1	35.4510	-76.2075	IMPROVE Monitor
Upper Buffalo Wilderness Area	AR	05101	UPBU1	35.8258	-93.2030	IMPROVE Monitor
Voyageurs National Park	MN	27137	VOYA2	48.4126	-92.8286	IMPROVE Monitor
Wheeler Peak Wilderness	NM	35055	WHPE1	36.5854	-105.452	IMPROVE Monitor
White Mountain Wilderness Area	NM	35027	WHIT1	33.4687	-105.5349	IMPROVE Monitor
Wichita Mountains Wilderness	OK	40031	WIMO1	34.7323	-98.7130	IMPROVE Monitor
Wolf Island Wilderness	GA	13049	OKEF1[a]	31.3451	-81.3058	Class I Centroid

[a] No IMPROVE Monitor is located at this Class I Area. As such, the nearby IMPROVE monitor was used as a surrogate.

[b] This Class I Area does have a dedicated IMPROVE Monitor. However, it is located outside the Class I Area boundary. The trajectory origin was altered to the Class I Area centroid.

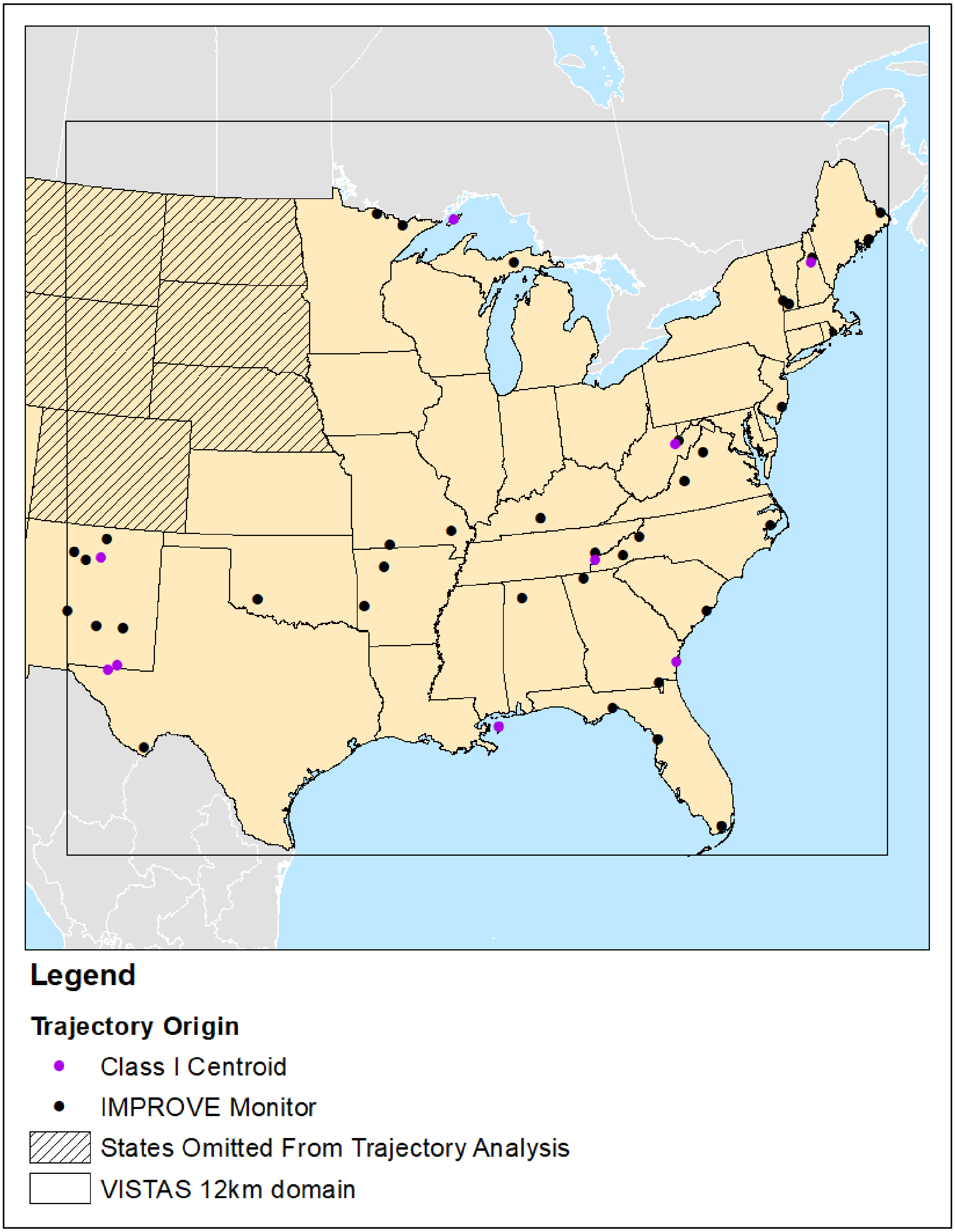

Figure 5-1. IMPROVE Monitor Locations and Starting Points for Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) Trajectories in the VISTAS 12-km Domain

Figure 5-2. IMPROVE Monitor Locations and Starting Points for HYSPLIT Trajectories in the VISTAS States

5.3 Emissions Data Collection

The 2028 emissions data used in the AoI analysis came from the Task 2A emissions inventory, which was prepared in August 2018 and was used for the PSAT tagging. Emissions were split into two distinct groups, by source category: Point and county-level (e.g., nonpoint, onroad, nonroad, prescribed fires, and total point emissions).

NO_x and SO_2 point source emissions were aggregated at the facility level. The aggregated emissions also included facility latitude and longitude,[62] which was used to calculate the distance between the point source and Class I area. The file also included additional information including state and county FIPS code, Emission Inventory System (EIS) Facility ID, Facility Name, primary North American Industry Classification System (NAICS) code, Tier 1 description, and SCCs (i.e., all SCCs present at the facility). After initial review of the data, the SESARM partners provided a list of revised facility emissions based on updated information. This included facilities that are scheduled to cease operations (in whole or part) before 2028, or other emissions adjustments that were not included in the original emissions inventory effort. Table 5-2 lists the facilities whose emissions were revised for the AoI analysis.

For source categories within the nonpoint, onroad, nonroad, and prescribed fire sectors,[63] the emissions were calculated at the county-level by summing the emission inventory databases by the state and county FIPS code. Similarly, the point emissions were summed by the state and county FIPS code reported for each facility. The point source files included airport and other nonroad emission sources reported to a specific latitude and longitude. These sources were separated into two distinct point source categories: 1) NONROAD_MAR for marine, air, and railroad source, and 2) NONROAD_OTHER for those sources with traditional nonroad SCC descriptions (e.g., construction). This was done to better separate the nonroad sources, in which NONROAD_MAR might require different federal actions for controls, as opposed to NONROAD_OTHER.

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[62] Emission estimates are often provided at the facility-level (often a facility-centroid), but can also be reported for separate emission release points. In cases where the facility-level coordinates are not reported, the latitude and longitude coordinates by facility emission release points are averaged.

[63] Note that agricultural fires are included in the nonpoint inventory. Additionally, wildfires are not included in this analysis to be consistent with the Second Improve Algorithm (SIA) Impairment data, which excludes the impact of wildfires.

Table 5-2. Revised Facility Emissions for the AoI Analysis

FIPS Code	State	EIS Facility ID	Facility Name	Reason for 2028 Emissions Adjustment	NO_x 2028 (tpy)	NO_x 2028 Revised (tpy)	SO_2 2028 (tpy)	SO_2 2028 Revised (tpy)
01053	AL	7440211	Escambia Operating Company LLC	Permit Limit	349.3	349.3[a]	18,974.4	7,963.0
01053	AL	985111	Escambia Operating Company LLC	Facility Shutdown	149.6	0.0	8,589.6	0.0
01127	AL	7917311	Alabama Power - Gorgas	Facility Shutdown	3,976.4	0.0	1,410.9	0.0
01129	AL	1028611	PowerSouth Energy Coop - Lowman	Partial Shutdown	2,910.8	300.0	3,805.2	0.0
05059	AR	658911	Lake Catherine	Facility Shutdown	125.0	0.0	0.4	0.0
05069	AR	893911	White Bluff	Facility Shutdown	16,179.2	0.0	31,997.1	0.0
12047	FL	769711	White Springs Agricultural Chemicals, Inc	Permit Limit	112.4	112.4[a]	3,197.8	2,745.0
12057	FL	716411	Mosaic Fertilizer, LLC	Permit Limit	159.7	159.7[a]	3,034.1	1,890.0
12105	FL	717711	Mosaic Fertilizer LLC	Permit Limit	310.4	310.4[a]	7,900.7	3,581.0
12105	FL	919811	Mosaic Fertilizer, LLC	Permit Limit	141.0	141.0[a]	4,425.6	3,614.0
13103	GA	3711211	GA Power Co PLT McIntosh	Facility Shutdown	447.1	0.0	127.3	0.0
13115	GA	3713211	GA Power Company - Plant Hammond	Facility Shutdown	864.9	0.0	772.5	0.0
21059	KY	5891711	Owensboro Municipal Utilities - Elmer Smith Station	Facility Shutdown	23.4	0.0	6.7	0.0
21177	KY	5196711	Tennessee Valley Authority - Paradise Fossil Plant	Facility Shutdown	2,927.4	0.0	2,990.2	0.0
24001	MD	7763811	Luke Paper Company	Permit Limit	3,607.0	3,607.0[a]	22,660.0	9,876.0
28059	MS	8232011	Mississippi Phosphates Corporation	Facility Shutdown	325.7	0.0	1,330.6	0.0
28073	MS	7154411	South Mississippi Electric Power Association, R D Morrow Plant	Fuel Switch	4,219.3	652.6	3,827.5	101.4
28121	MS	7288911	Pursue Energy Corporation Thomasville Gas Plant	Facility Shutdown	3.9	0.0	8,933.5	0.0
28141	MS	17942211	Mississippi Silicon[b]	New Source	0.0	836.0	0.0	648.0
31055	NE	6732411	Omaha Public Power District - North Omaha Power Station	Units Shutdown	6,961.2	50.0	14,530.0	5.0
39081	OH	8190811	W. H. Sammis Plant (0641160017)	Facility Shutdown	3,740.0	0.0	3,184.0	0.0
42007	PA	3853711	FIRSTENERGY GEN LLC/Bruce Mansfield PLT	Facility Shutdown	10,707.0	0.0	19,074.0	0.0
47001	TN	6196011	TVA Bull Run Fossil Plant	Facility Shutdown	964.2	0.0	622.5	0.0
47105	TN	4129211	Tate & Lyle, Loudon	Fuel Switch	883.3	252.5	472.8	110.2
48161	TX	Full_3497	Big Brown	Facility Shutdown	4,407.0	0.0	52,307.0	0.0

Table 5-2. Revised Facility Emissions for the AoI Analysis

FIPS Code	State	EIS Facility ID	Facility Name	Reason for 2028 Emissions Adjustment	NO_x 2028 (tpy)	NO_x 2028 Revised (tpy)	SO_2 2028 (tpy)	SO_2 2028 Revised (tpy)
48331	TX	13408411	Sandow 5 Generating Plant	Facility Shutdown	0.8	0.0	0.0	0.0
48331	TX	4204811	Sandow Steam Electric Station	Facility Shutdown	1,055.0	0.0	20,013.0	0.0
48331	TX	Full_52071	Sandow 5	Facility Shutdown	1,042.0	0.0	1,255.0	0.0
48449	TX	Full_6147	Monticello	Facility Shutdown	7,199.0	0.0	44,287.0	0.0
48487	TX	7927311	Oklaunion Power Station	Facility Shutdown	5,513.0	0.0	1,679.0	0.0
Revised Totals					**79,305.0**	**6,771.0**	**281,408.4**	**30,533.6**

[a] No emission changes.

[b] New facility added for this analysis, and not included in the final Task 2A point source emissions inventory.

5.4 Trajectories

For this study, the HYSPLIT model[64] developed by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL) was used to identify areas most likely influencing visibility.

5.4.1 Meteorological Data

The analysis started by collecting the meteorological and air quality data needed to complete the task. For the meteorology data, ERG downloaded the North American Mesoscale forecast data at the 12-km level (NAM-12) hybrid sigma-pressure data from NOAA ARL FTP Server (ftp://arlftp.arlhq.noaa.gov/nams). The extent of the domain is presented in Figure 5-3.

The meteorological files include 40 pressure levels in the vertical, and output for every hour of the day. The files available from NOAA ARL are in a HYSPLIT ready format for individual dates starting in March 2010. ERG downloaded December 29, 2010 through December 31, 2016 for use in the back trajectories. Due to the total size of all the meteorology files (2.23 TB), these data were provided to the SESARM states via hard drive transfer.

[64] 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

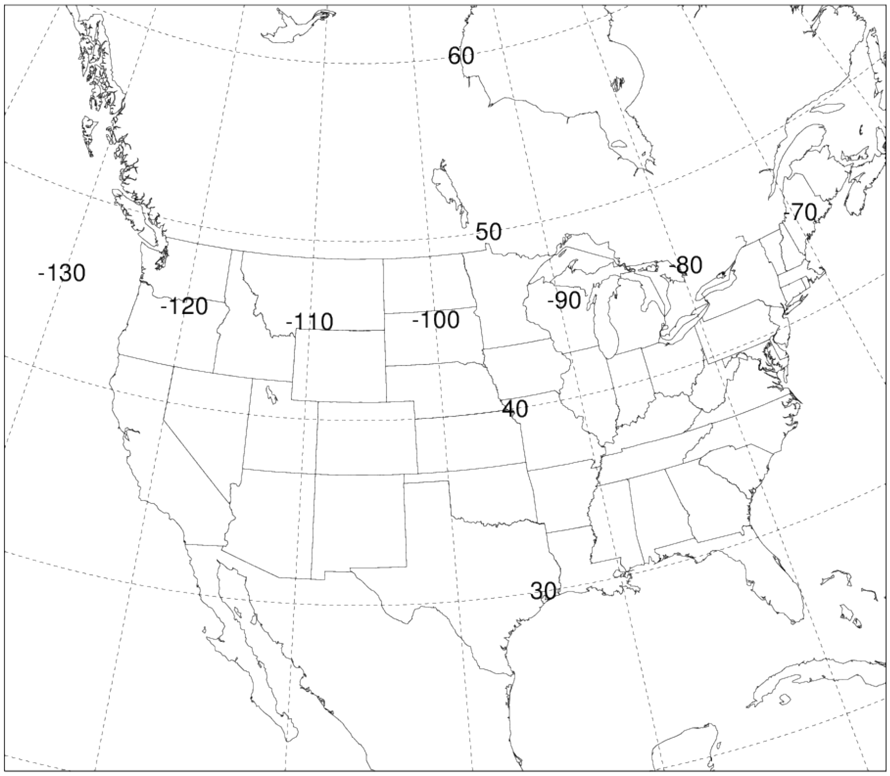


Figure 5-3. NAM 12-km (Sigma-Pressure Hybrid) Modeling Domain

5.4.2 Trajectory Set up

The HYSPLIT runs included starting heights of 100 meters (m), 500 m, 1,000 m, and 1,500 m. Trajectories were run 72 hours backwards in time for each height at each location from 2011 through 2016. Trajectories were 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. ERG converted these times from local time of the Class I area to Universal Time Coordinated (UTC), adjusting the data as necessary, and accounting for the shift from daylight saving time to standard time.

While several packages exist to run HYSPLIT from *R* (e.g., SplitR, opentraj), all were designed to work with reanalysis data[65] and not daily meteorological data files, and the daily NAM 12-km hybrid was not an option for the meteorological files in any of the packages available. In lieu of running HYSPLIT with *R*, ERG developed a python script that created all the necessary control files to run HYSPLIT. HYSPLIT was then run outside its Graphical User Interface (GUI) via a batch script. The python code and batch script used to run HYSPLIT are available in the Task 5 Report (Appendices A and B, respectively),

[65] The reanalysis data is the NOAA data reformatted for HYSPLIT.

and include instruction on how to run them. This scripted method was necessary for running the 148,468 (37,117 start times modeled, at 4 different heights) trajectories for each site for the AoI analysis.

R was used to combine the HYSPLIT output files (tdump files) into a single file. Plots of the trajectories by height by year (Figure 5-4) and height by season (Figure 5-5) were generated using *R* (via the openair[66] package).

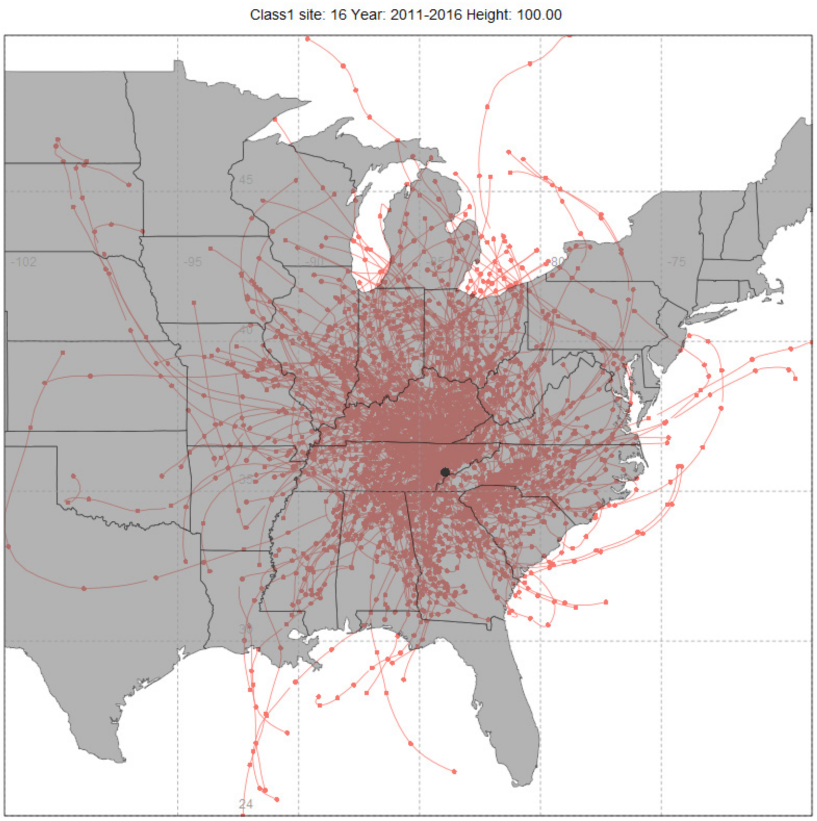


Figure 5-4. Example Trajectory Plot, 100m Trajectories by Year, for Great Smoky Mountain National Park. (Created with *R*)

[66] Carslaw, D.C. 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.

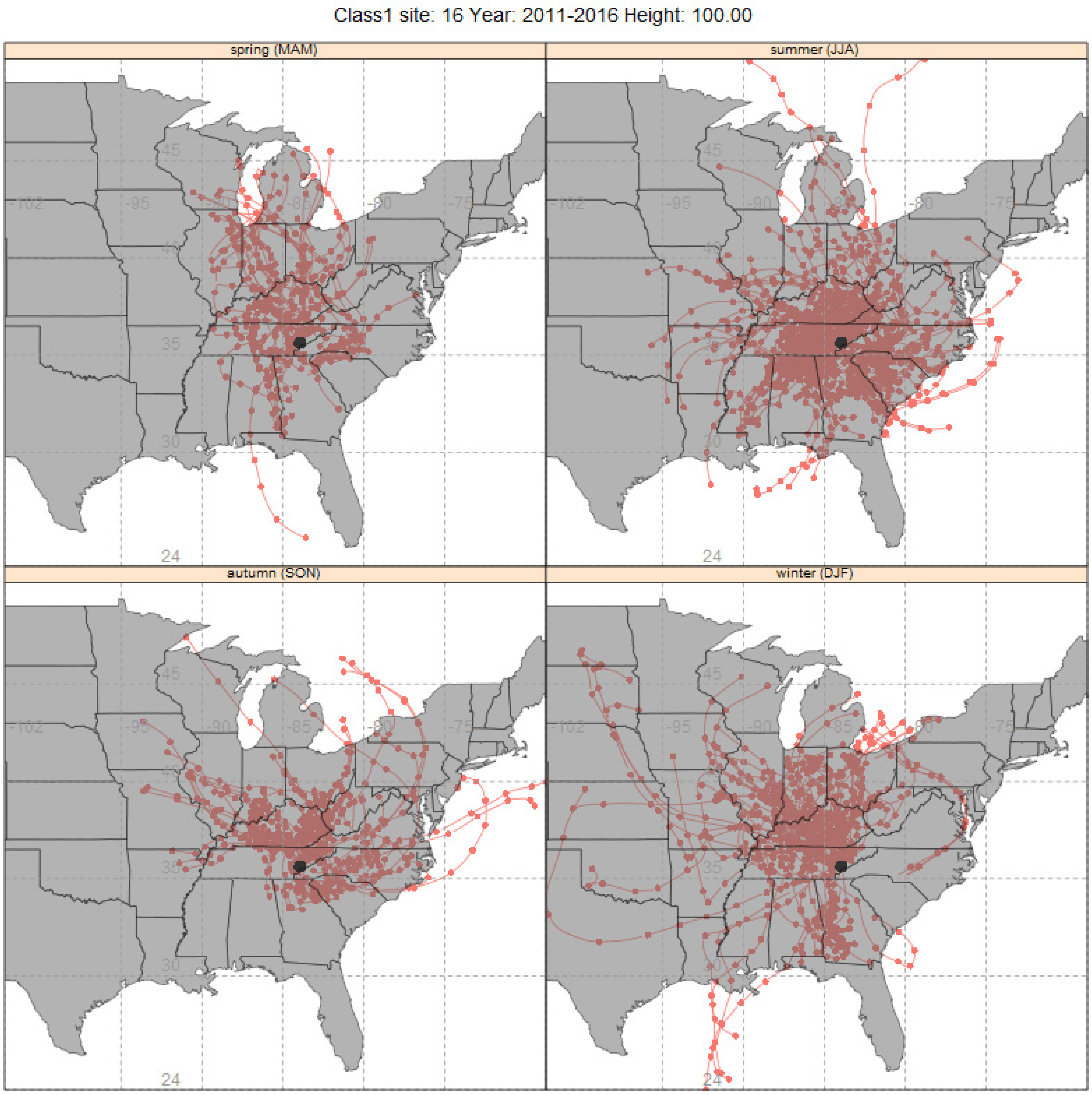


Figure 5-5. Example Trajectory Plot, 100m Trajectories by Season, for Great Smoky Mountain National Park. (Created with *R*)

The files of the trajectory endpoints for each starting height were also converted to ArcGIS and plotted using ArcGIS (Figure 5-6), and all shapefile and base layers were delivered to SESARM. These back trajectories for the 20% most impaired days were then used to develop residence time (RT) plots for multiple time segments (annual [2011, 2012, 2013, 2014, 2015, and 2016], specific time period [2011-2013 and 2014-2016], and entire period [2011-2016]).

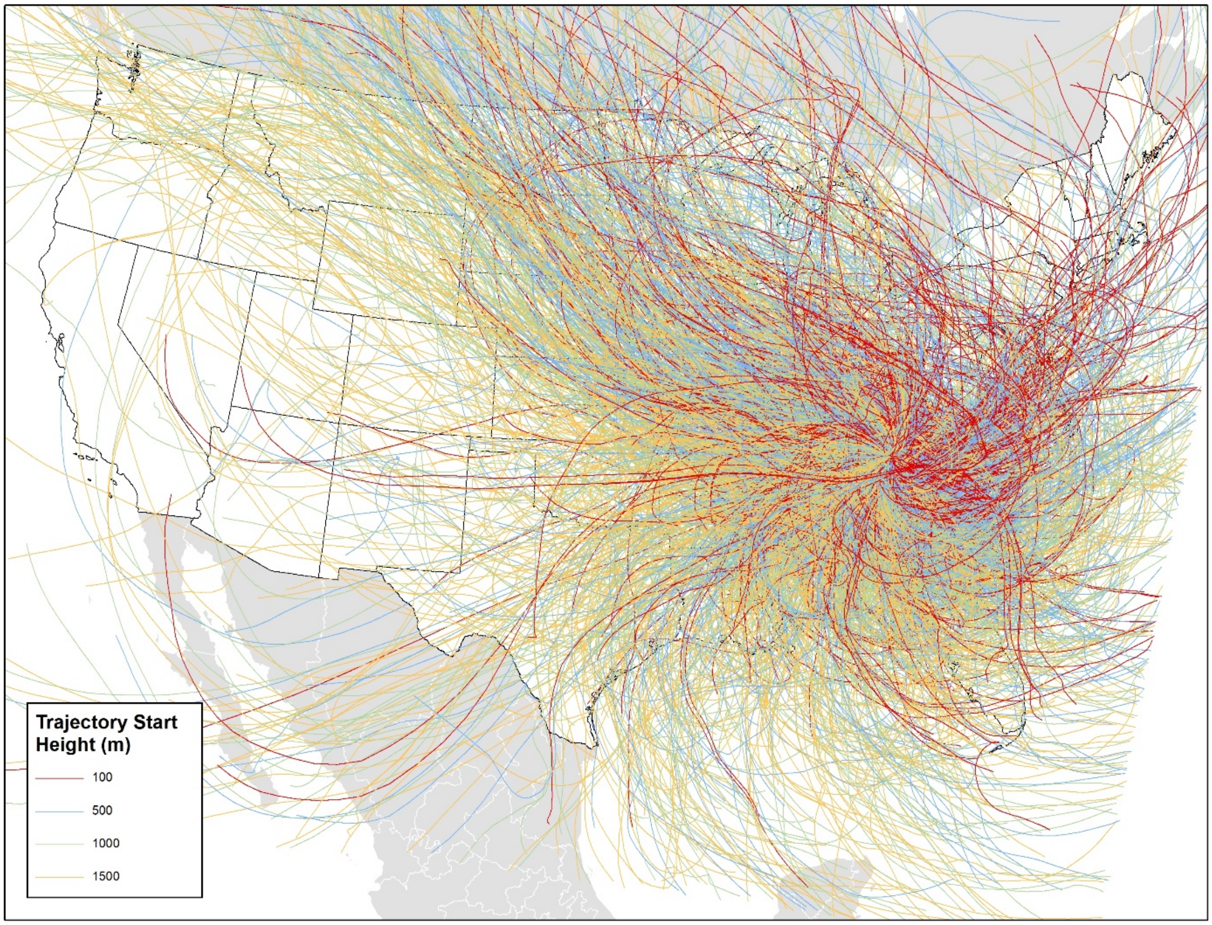


Figure 5-6. Example Trajectory Plot for Great Smoky Mountain National Park. Plot was Created with GIS, for the 20% Most Impaired Days.

5.5 Residence Time

The RT plots define the geographic areas with the highest probability of influencing the monitor on the 20% most impaired visibility days. The RTs for point sources were calculated as the number of trajectory hours that pass through each of the 12-km modeling domain grid cell (i.e., the number of hourly trajectory end points in each cell) using *R* and custom geographic information system (GIS) scripts. The analysis was expanded to the EPA's 12US2 domain, which cover the entire continental United States, from the VISTAS 12-km domain. This ensured the analysis for western Class I areas took into account their entire source region and did not artificially weight results on sources within the VISTAS 12-km domain only.

The *R* script was used to look at the various breaks of the data to review for any outlying years, or if emission controls installed midway through the review period affected, extinction-weighted residence time (EWRT), as discussed in Section 5.6). Figure 5-7 shows an example RT plot (number of trajectory counts) produced by the *R* code.

ArcGIS was used to develop final RT and EWRT values that were exported to shapefiles and joined with the emissions data for the AoI analysis spreadsheets. Figure 5-8 shows a similar residence time plot as the R files, as plotted in GIS version, with a wide view of the modeling domain at the top, and a close up of the Class I area at the bottom (as “percents of total”).

The RTs for county-level source sectors were calculated as the number of trajectory hours that passed through the county, as opposed to grid cells. This was completed in GIS using a custom script.

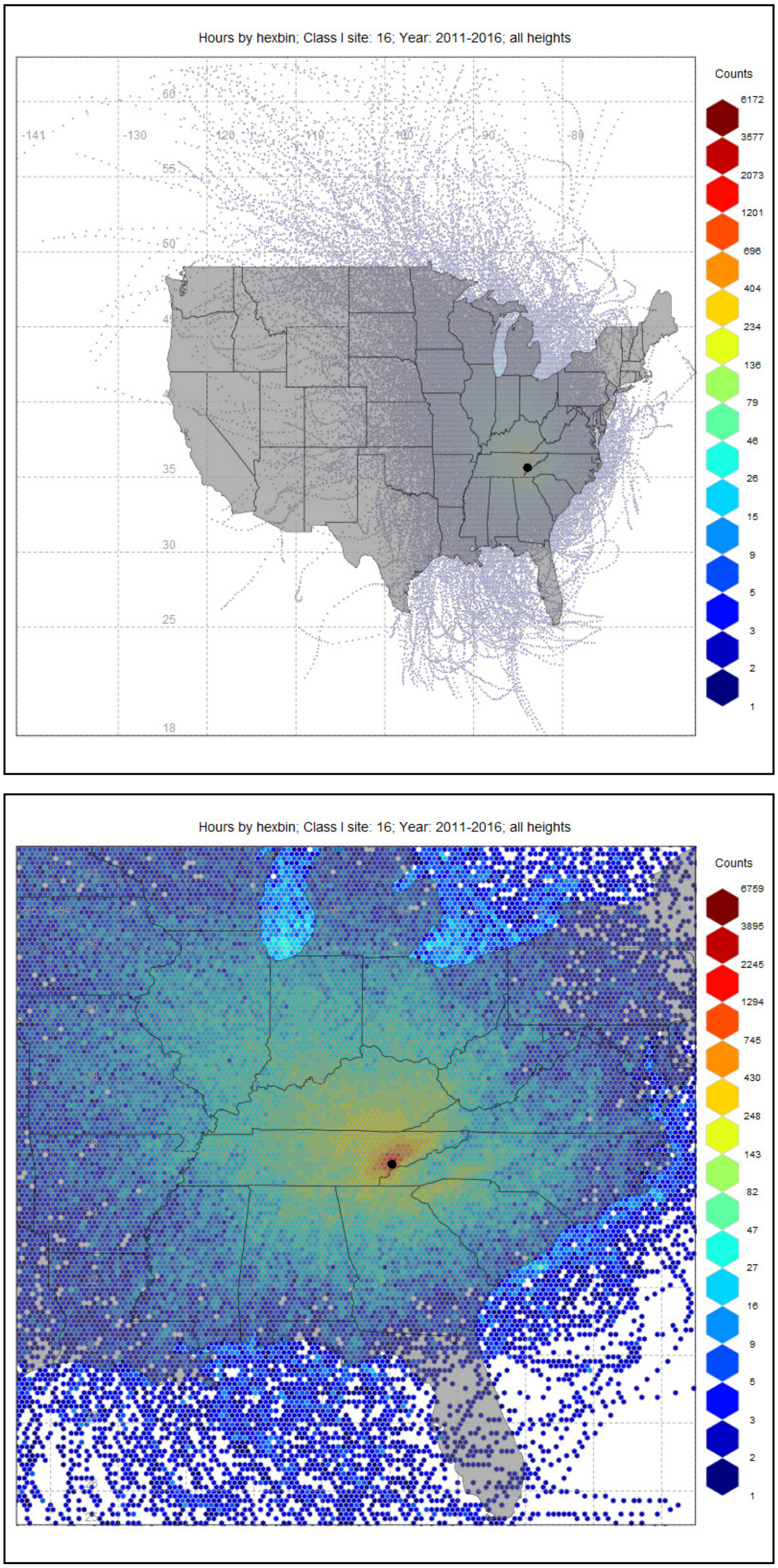
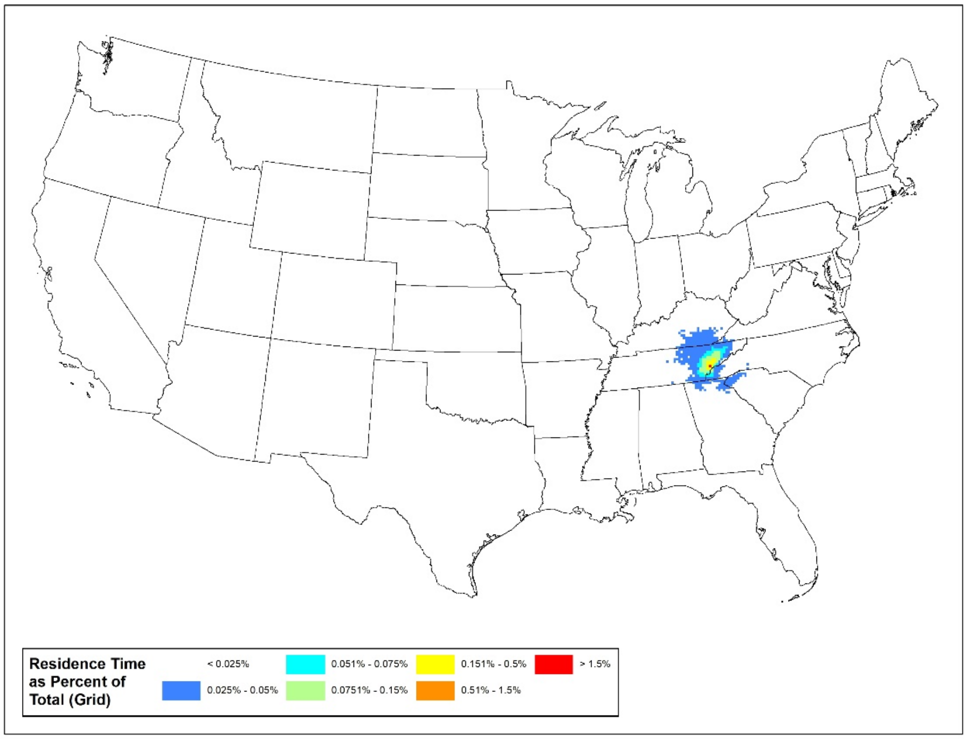


Figure 5-7. Example Residence Time, Per 12-km Modeling Grid Cell, Plot for Great Smoky Mountain National Park. (Full view (top), Class I zoom (bottom); Plot was Created with R)



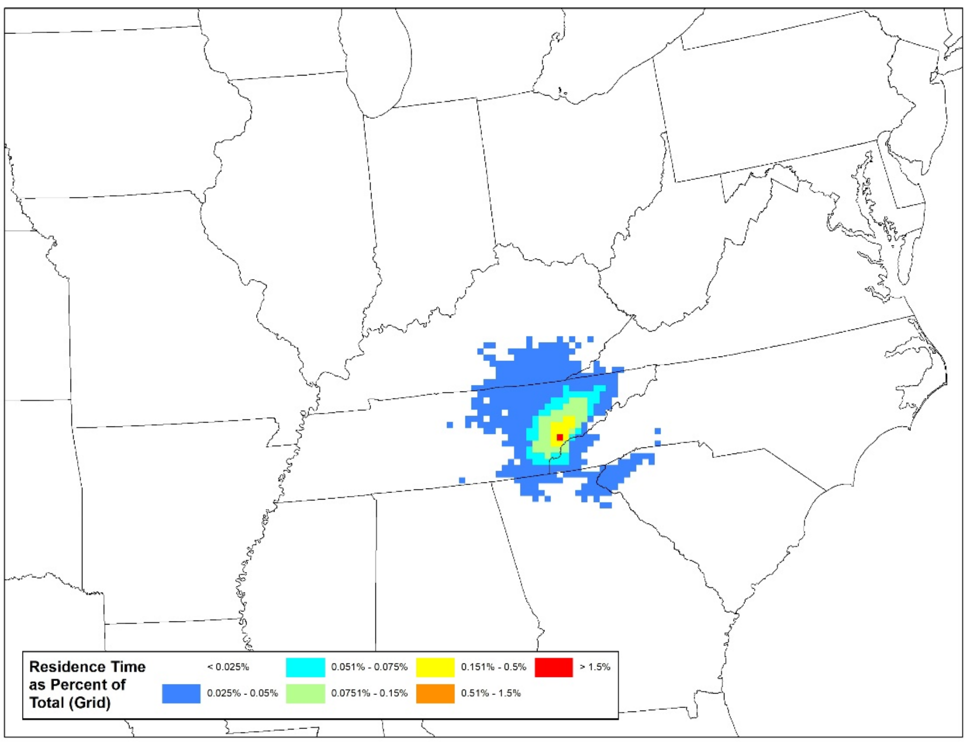


Figure 5-8. Example Residence Time, Per 12-km Modeling Grid Cell, Plot for Great Smoky Mountain National Park, zoomed in on Class I area. (Full view (top), Class I zoom (bottom); Plot was Created with GIS)

5.6 Extinction-Weighted Residence Time

The trajectory residence time was also weighted by extinction attributable to ammonium sulfate and ammonium nitrate on the arrival date of each trajectory and used to produce separate sulfate and nitrate 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)[67] approach was used to develop the EWRT, substituting the extinction values for the concentration. The extinction attributable to each pollutant is paired with the trajectory for that day. The mean weighted extinction of the pollutant species for each grid cell is calculated according to:

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

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).[68]

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.

[67] 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

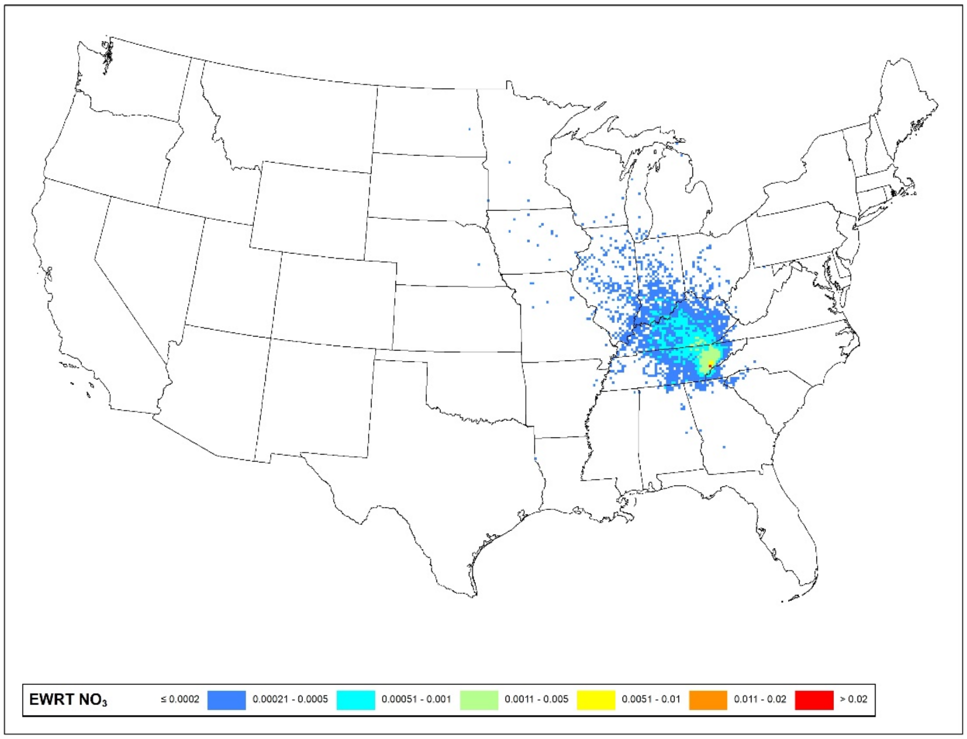
[68] Carslaw, D.C. (2015). The openair manual — open-source tools for analyzing air pollution data. Manual for Version 1.1-4, King's College London. http://www.openair-project.org/PDF/OpenAir_Manual.pdf

Figure 5-9 presents the EWRT for ammonium nitrate extinction for the Great Smoky Mountain National Park for the 20% most impaired days from 2011 to 2016. The figure provides a view of the full modeling domain (top) and an image focused on the Class I Area (bottom). Figure 5-10 show the EWRT for ammonium nitrate extinction as a percentage of the total ammonium nitrate, with a full domain view and Class I area view. Figure 5-11 shows the weighted ammonium sulfate EWRT, and Figure 5-12 shows the weighted ammonium sulfate EWRT as a percent of the total ammonium sulfate.

5.7 Contributor Identification

The final phase of the analysis combined the EWRT values with the emission data to determine the sources most likely contributing to elevated extinction levels. ArcGIS was used to spatially join the emissions data with the gridded EWRT data to obtain the EWRT value corresponding to each point source. This new layer was extracted from ArcGIS and brought into an Access database to be paired with other data elements.

In the database, the data were further joined with the distance (d) from the point source (average of all emission release points) to the trajectory origin in kilometers, which was calculated using R. The facility emissions (Q, in tons per year) were then divided by the distance (d, in kilometers) to the trajectory origin; for a final value (Q/d). This was then multiplied by the facility's sulfate or nitrate EWRT grid values (i.e., EWRT *(Q/d)). Next, the sulfate and nitrate EWRT *(Q/d) values were summed for all point sources at each Class I area and used to normalize the sulfate and nitrate contributions from each individual source. This information allows the individual facilities to be ranked from highest to lowest based on sulfate and/or nitrate contributions.



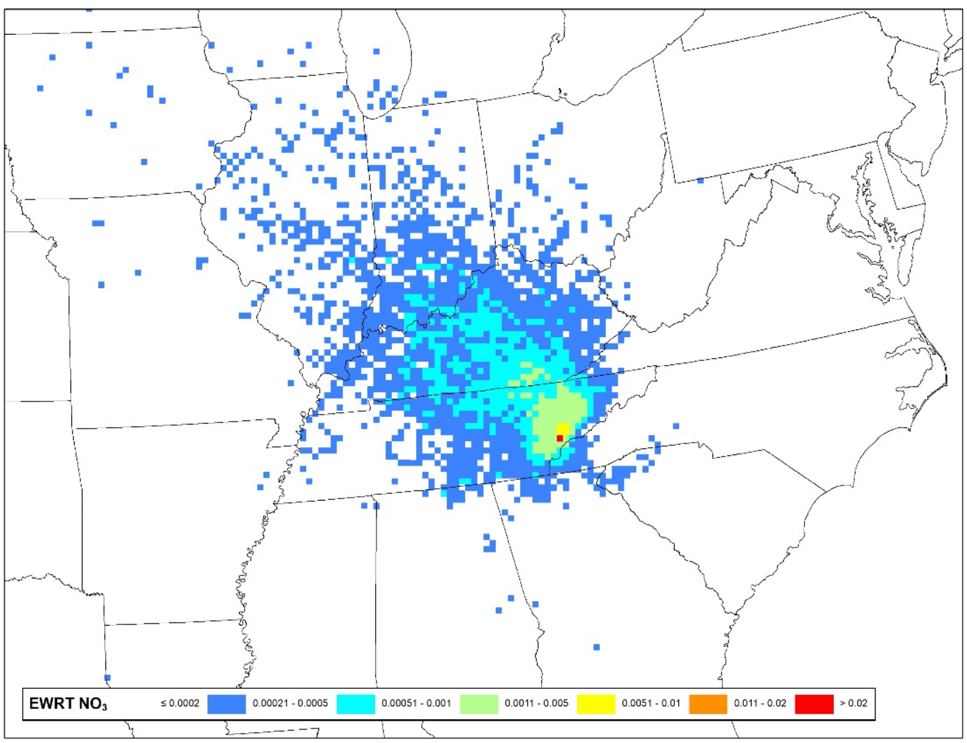
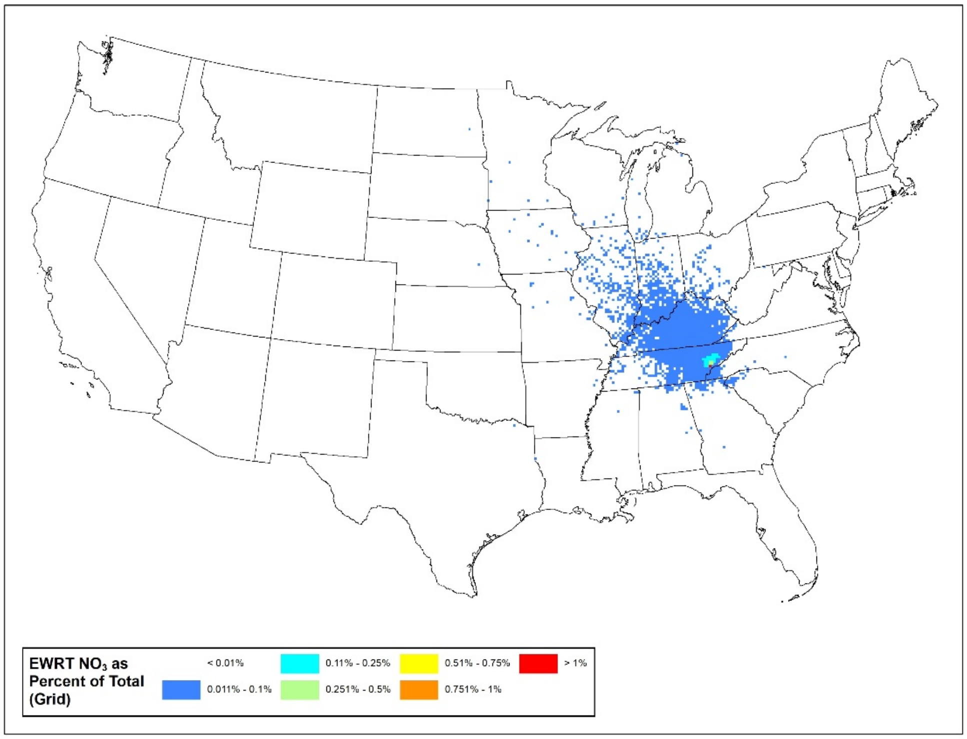


Figure 5-9. Example EWRT for Ammonium Nitrate Extinction, Per 12-km Modeling Grid Cell, Plot for Great Smoky Mountain National Park. Based on All Years. (Full view (top), Class I zoom (bottom); Plot was Created with GIS)



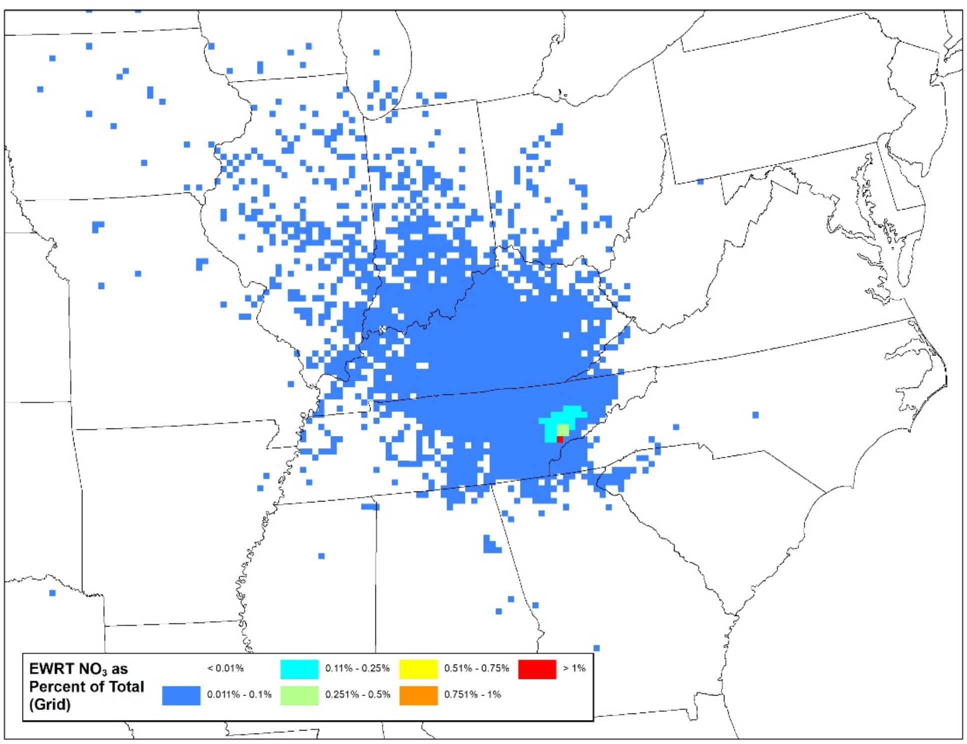
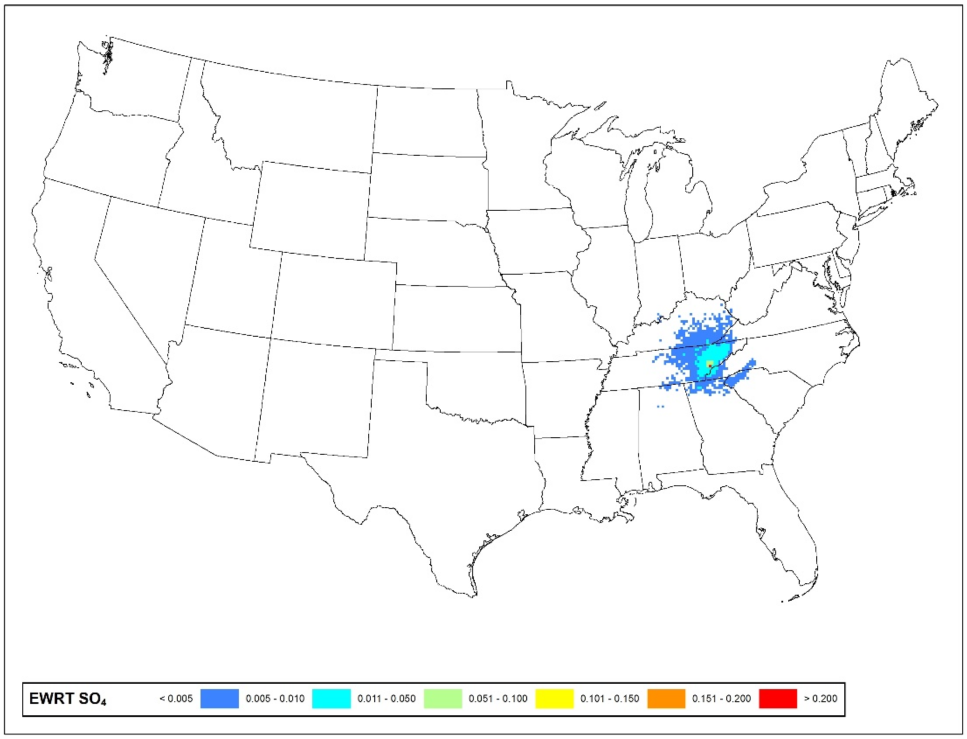


Figure 5-10. Example EWRT, as a percentage of the total, for Ammonium Nitrate Extinction, Per 12-km Modeling Grid Cell, Plot for Great Smoky Mountain National Park. Based on All Years. (Full view (top), Class I zoom (bottom); Plot was Created with GIS)



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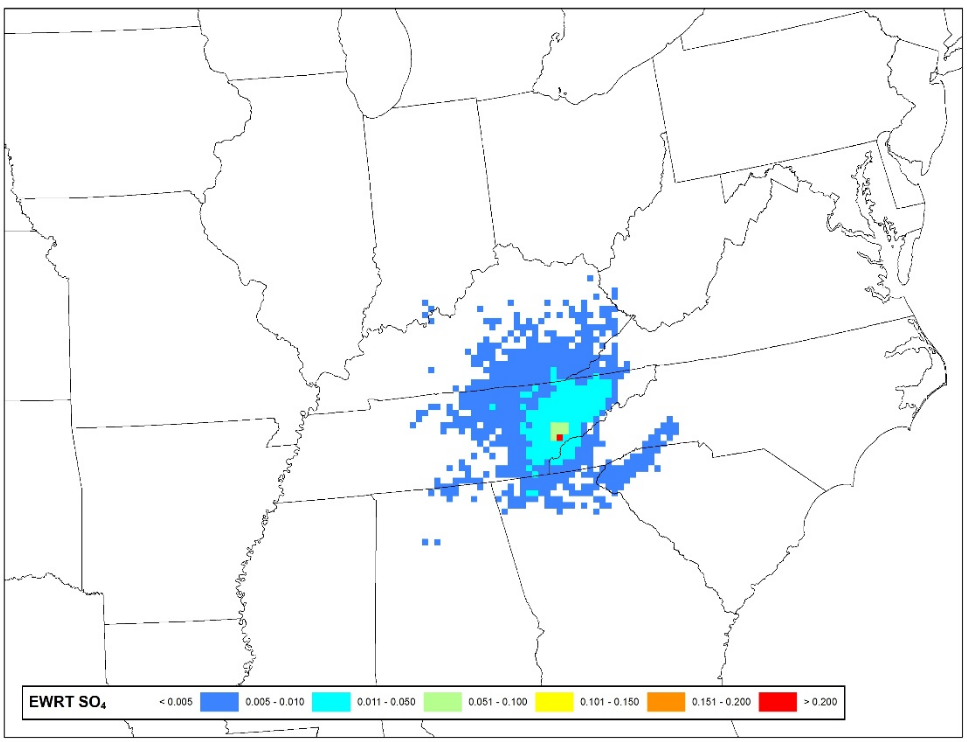


Figure 5-11. Example EWRT for Ammonium Sulfate Extinction, Per 12-km Modeling Grid Cell, Plot for Great Smoky Mountain National Park. Based on All Years. (Full view (top), Class I zoom (bottom); Plot was Created with GIS)

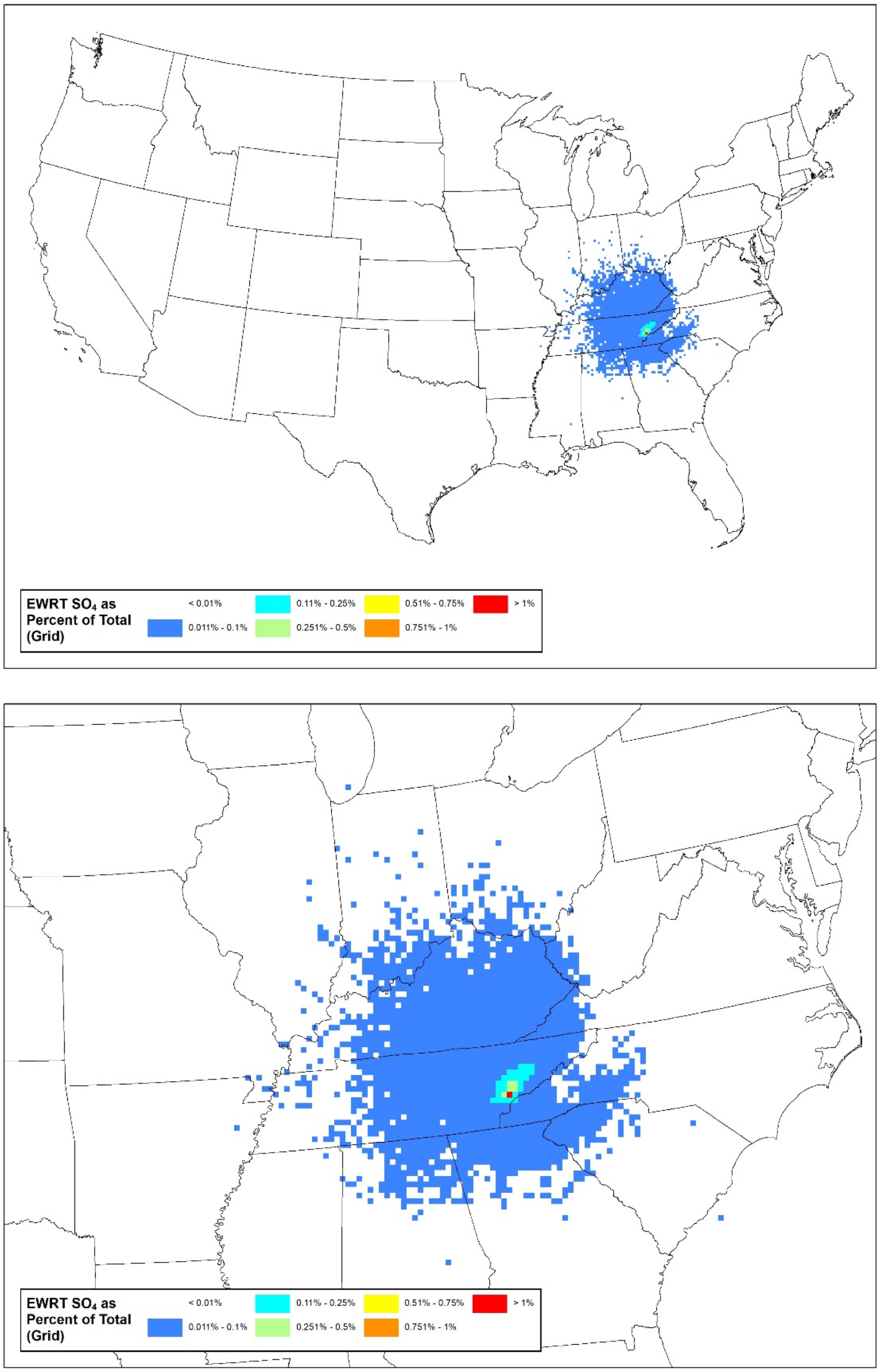


Figure 5-12. Example EWRT, as a percentage of the total, for Ammonium Sulfate Extinction, Per 12-km Modeling Grid Cell, Plot for Great Smoky Mountain National Park. Based on All Years. (Full view (top), Class I zoom (bottom); Plot was Created with GIS)

This data was further paired with additional point source metadata that defined the facility (i.e., Facility ID, Facility Name, State Name, County Name, FIPS code, NAICS, and industry description). Spreadsheets[69] for individual Class I areas were then exported from the database for further analysis by the states. Plots of the EWRT *(Q/d), as a percentage of the total, were generated based on the grid total emissions and distance to the class I area. Figures 5-13 (ammonium nitrate) and 5-14 (ammonium sulfate) show examples of these plots for the Great Smoky Mountain National Park. The figure includes a wide view of the entire continental United States, and a closer view in the vicinity of the Class I area.

Users of the data should note that while point sources account for most of the sulfate extinction, these sources only account for a portion of the nitrate extinction. Much of the nitrate extinction can be attributable to the onroad and nonpoint sectors. As such, a similar analysis for county level data was conducted, that included county total point source contributions. This allows the point source contribution to be directly compared to the other source categories.

Similar analysis was conducted to rank SO_2 and NO_x emissions contributions for the county-level sources (nonpoint, onroad, nonroad, fires, and total point source sectors). The process was similar to the process for point sources previously described, except calculations of RT and EWRT were completed at the county-level as opposed to grids.

The analysis also added new columns to normalize the EWRT*(Q/d) by the area of each county to develop a metric to compare the contributions from counties on a relative basis. The existing calculation had a propensity to attribute higher contributions to larger counties simply because they typically contained more emission sources and more hourly trajectory end points. Normalizing the contribution by the area of the county (i.e., EWRT*(Q/d) per square kilometer) provides a sense of the source emission density within the county. This allows county contributions to be directly compared, without large counties being weighted more heavily by simply having more emission sources and more hourly trajectory end points.

This analysis was completed in GIS using the same calculation method as the point sources. The calculation of "d" was from the centroid of the county to the trajectory origin, in km. Similar to point sources, the final spatial join was made between the county-level EWRT, emissions, and source

[69] Spreadsheets containing the results and field descriptions are posted on the Metro 4/SESARM website (https://www.metro4-sesarm.org/content/task-5-area-influence-analysis), and are also catalogued in Appendix A of this Final Report.

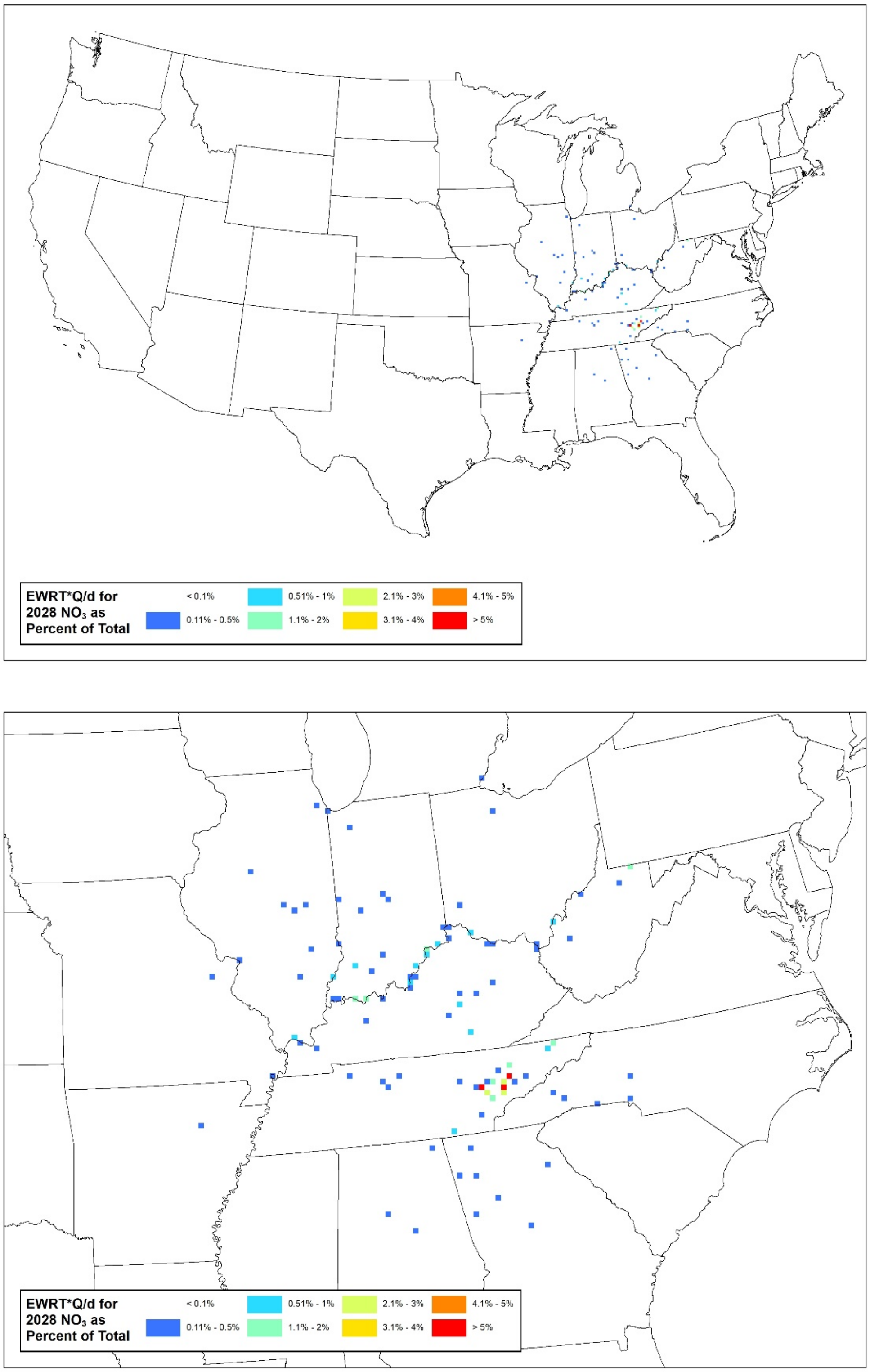
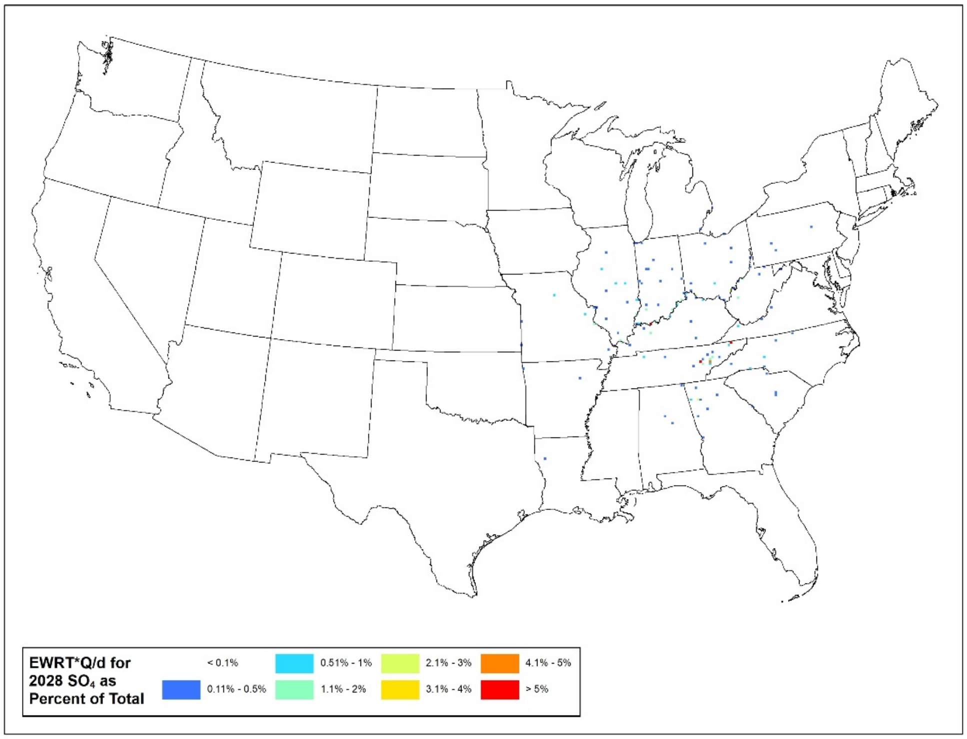


Figure 5-13. Example EWRT*(Q/d) for Ammonium Nitrate Extinction for 2028, Per 12-km Modeling Grid Cell, Plot for Great Smoky Mountain National Park. Based on All Years. (Full view (top), Class I zoom (bottom); Plot was Created with GIS)



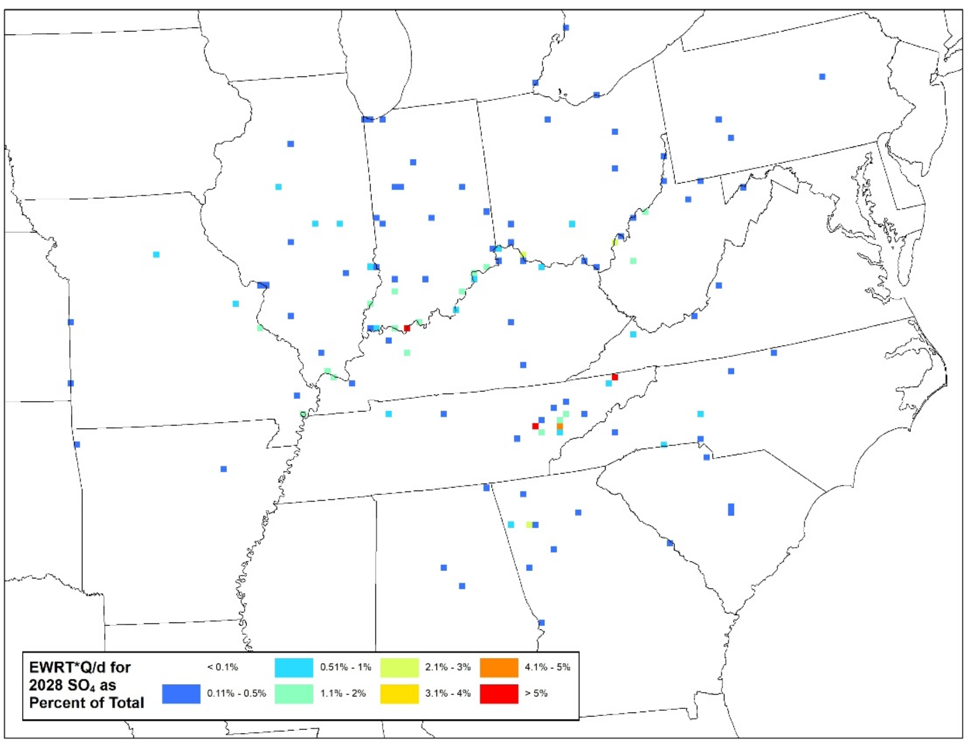


Figure 5-14. Example EWRT*(Q/d) for Ammonium Sulfate Extinction for 2028, Per 12-km Modeling Grid Cell, Plot for Great Smoky Mountain National Park. Based on All Years. (Full view (top), Class I zoom (bottom); Plot was Created with GIS)

information for each sector. All county and emissions source identifying information was joined in an Access database with calculations of Q/d and Q/d^2 values, EWRT, EWRT*(Q/d), fraction and sum contributions, and any other source information. The database was then used to generate individual spreadsheets (referenced above) for each Class I area.

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6.0 VISTAS II AIR QUALITY MODELING

This section summarizes the development of the Modeling Protocol, the 2011 benchmark conformation runs, and the 2028 benchmark confirmation runs. Activities related to Task 6 are presented at: https://www.metro4-sesarm.org/content/task-6-air-quality-modeling

Under this task, ERG authorized Alpine to initiate modeling activities. One of the first project deliverables was the Modeling Protocol (Subtask 6.1), which underwent SESARM, TAWG, CC, and EPA Region 4 review. A final version of the QAPP was approved in June 2018.

The next two Subtasks consisted of evaluating confidence in the air quality modeling through benchmark conformations of the 2011 base year air quality modeling (Subtask 6.2) and the 2028 base year air quality modeling (Subtask 6.3).

6.1 Modeling Protocol

The Air Quality Modeling Protocol for the VISTAS II Regional Haze modeling analysis was developed by ERG and Alpine with the purpose of estimating regional haze and progress at southeastern state Class I areas in projection year 2028.[70] This information was used by SESARM-participating states in the regional haze SIP development process.

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

6.1.1 Episode Selection

Episode selection is an important component of any modeling analysis. EPA guidance recommends choosing time periods reflective of 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. This is best accomplished by modeling a full year. For this analysis, the full 2011 calendar year was modeled with 10 days of model spin-up in 2010.

[70] "Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project. Final Modeling Protocol." Final Report. 6/27/2018.

6.1.2 Model Selection

The Weather Research Forecast (WRF) prognostic meteorological model was selected for the VISTAS II modeling. Emissions processing was completed using the SMOKE model for most source categories. The exceptions are that the BEIS model was used for biogenic emissions and there are special processors for fires, windblown dust, lightning and sea salt emissions. The MOVES2014a 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 was also used. The setup is based on the same WRF/SMOKE/BEIS/CAMx modeling system used in the EPA 2011/2028el platform modeling.

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 to ensure confidence in modelling results.

6.1.3 Base and Future Year Emissions Data

A 2011 base year and a 2028 future year were 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 from EPA's "el" modeling platform were used as the starting point. No adjustments were made to 2011 emissions. For "elv3", updates were made to EGU and non-EGU point source data within the VISTAS states for 2028; and the ERTAC EGU v.2.7 outputs were used for non-VISTAS EGUs in the projection year.

6.1.4 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 utilized methods applied to the emissions platform that follows a multistep emissions QA/QC approach, including:

- Visualizing the model-ready emissions with the scale of the plots set to a very low value, Alpine determined 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 were 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 the Version 6 Carbon Bond (CB6) species, Alpine compared reports generated with SMOKE to target these specific areas of the processing. For speciation, the inventory state import totals were compared against the same state totals with the speciation matrix applied.

6.1.5 Meteorology Input Preparation and QA/QC

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

6.1.6 Initial and Boundary Conditions Development

Initial Conditions (IC) and Boundary Conditions (BCs) are important inputs to the CAMx model. Alpine ran 10 days of model spin-up before the first days occurred 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.

6.1.7 Air Quality Modeling Input Preparation and QA/QC

Each step of the air quality modeling was subjected to QA/QC procedures. These procedures included verification of model configurations and confirmation that the correct data used were processed correctly.

6.1.8 Model Performance Evaluation

An operational model performance evaluation was performed for PM ($PM_{2.5}$ 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 focused on graphical analyses and statistical metrics of model predictions versus observations and are described in detail in Section 7 of this report.

6.1.9 Future Year Significant Contribution Modeling

PM predictions from 2011 and 2028 CAMx model simulations were 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.[71] The guidance describes the recommended modeling analysis used to help set reasonable progress goals (RPGs) that reflect emissions controls in a regional haze SIP. The CAMx PSAT method will be utilized for this effort.

6.2 Benchmark Confirmation Runs

The simulations on the Alpine computer cluster and the EPA computer were based on hourly differences in ozone, $PM_{2.5}$, primary organic carbon (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 was done both graphically (e.g., scatter density plots) and quantitatively (e.g., residual distributions) for reviewed concentrations. Analysis products were hourly spatial plots of the absolute differences. Should significant differences be noted between the confirmation runs and EPA's original simulations, spatial plots were generated and discussed with SESARM and others as requested.

For this study, six benchmark confirmation runs were initially approved. The following confirmation runs were performed:

- Benchmark Conformation Run #1 - EPA 2011 with CAMx_6.32 (CONUS) vs. Alpine 2011 with CAMx_6.32 (CONUS)
- Benchmark Conformation Run #2 - EPA 2028 with CAMx_6.32 (CONUS) vs. Alpine 2028 with CAMx_6.32 (CONUS)
- Benchmark Conformation Run #3 - Alpine 2011 with CAMx_6.32 (CONUS) vs. Alpine 2011 with CAMx_6.40 (CONUS)
- Benchmark Conformation Run #4 - Alpine 2028 with CAMx_6.32 (CONUS) vs. Alpine 2028 with CAMx_6.40 (CONUS)

[71] "Modeling Guidance for Demonstrating Air Quality Goals for Ozone, PM2.5, and Regional Haze", Final Report. November 2018. Internet address: https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf

- Benchmark Conformation Run #5 - Alpine 2011 with CAMx_6.40 (CONUS) vs. Alpine 2011 with CAMx_6.40 (VISTAS)
- Benchmark Conformation Run #6 - Alpine 2028 with CAMx_6.40 (CONUS) vs. Alpine 2028 with CAMx_6.40 (VISTAS)

Unlike the Work Plan or the QAPP, the Modeling Protocol underwent revisions and updates throughout the study, on an as-needed basis. This included the decision to re-model the emissions inventory (discussed in Section 9 of this report). As a result, a 7th benchmark confirmation run was included to compare the original modeled emissions to the revised modeled emissions:

- Benchmark Conformation Run #7 - Alpine 2028elv3 with CAMx_6.40 (VISTAS) vs. Alpine 2028elv5 with CAMx_6.40 (VISTAS)

6.2.1 Benchmark Confirmation Run #1

The first benchmark confirmation run compares the EPA 2011 modeling results for the continental U.S. using the CAMx 6.32 modeling platform. Details on this comparison are presented in the technical report.[72] The purpose of this comparison run was to demonstrate the Alpine's ability to replicate EPA's results for the 2011 "el" base year. This replication effort also ensures that the EPA data, models, and scripts operated in a consistent manner as EPA's procedures.

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. Observations were made for the following modeled pollutants:

- Ozone: The maximum positive difference is 3.13 parts per billion (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%.
- $PM_{2.5}$: The maximum positive difference is 6.73 $\mu g/m^3$ falling to 2.21 $\mu g/m^3$ for the 10th high. The maximum negative difference is -5.41 $\mu g/m^3$ falling to -1.97 $\mu g/m^3$ for the 10th high. The maximum positive percent difference from these days is 44.5%. The negative percent difference from these days is -31.7%. Both maximum percentages occur on low $PM_{2.5}$ concentration days.
- Sulfate: The maximum positive difference is 0.31 $\mu g/m^3$ falling to 0.19 $\mu g/m^3$ for the 10th high. The maximum negative difference is -0.40 $\mu g/m^3$ falling to -0.14 $\mu g/m^3$ for the 10th high. The maximum positive percent difference from these days is 15.1%, and the maximum negative percent difference from these days is -18.5%.

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[72] "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." Final Report. 8/17/2020.

- Nitrate: 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 the maximum negative percent difference from these days is -54.5%, both on low nitrate concentration days.
- Organic Carbon: The maximum positive difference is 0.18 μg/m^3 falling to 0.09 μg/m^3 for the 10th highest value. The maximum negative difference is -0.33 μg/m^3, falling to -0.08 μg/m^3 for the 10th highest value. The maximum positive percent difference from these days is 2.0%, and the maximum negative percent difference from these days is -2.89%.

6.2.2 Benchmark Confirmation Run #2

The second benchmark confirmation run compares the EPA 2018 modeling results for the continental U.S. using the CAMx 6.32 modeling platform. Details on this comparison are presented in the technical report. [73] The purpose of this comparison run was to demonstrate the Alpine's ability to replicate EPA's results for the 2028 "el" base year. This replication effort also ensures that the EPA data, models, and scripts operated in a consistent manner as EPA's procedures.

Similar to Benchmark Confirmation Run #1, 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. Observations were made for the following modeled pollutants:

- Ozone: 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 -7.5%.
- $PM_{2.5}$: The maximum positive difference is 5.15 μg/m^3, falling to 2.84 μg/m^3 for the 10th high. The maximum negative difference is -4.61 μg/m^3, falling to -2.45 μg/m^3 for the 10th high. The maximum positive percent difference from these days is 48.4%, and the maximum negative percent difference is -32.9%, both on low $PM_{2.5}$ concentration days.
- Sulfate: 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 the maximum negative percent difference is -6.8%.
- Nitrate: 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 116.7%, and the maximum negative percent difference is -52.6%, both on low nitrate concentration days.

[73] "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." Final Report. 8/17/2020.

- Organic Carbon: 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 the maximum negative percent difference of -2.86%.

6.2.3 Benchmark Confirmation Run #3

EPA 2011el and 2028el platform simulations were performed with CAMx version 6.32. Since that time the CAMx model was updated to version 6.40 which include better physical treatment and corrects model flaws that were discovered after the release of 6.32. The third benchmark confirmation run compares the Alpine 2011 modeling results for the continental U.S. using the CAMx 6.32 modeling platform versus the modeling results using the CAMx 6.40 modeling report. Details on this comparison are presented in the technical report.[74] It is noted that while CAMx 6.50 was released during this study, it had not been tested sufficiently for use in this project.

The purpose of this comparison run was to note differences between the two modeling systems, which include:

- *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:
  - 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;
  - Inclusion of in-line inorganic iodine emissions to support halogen chemical mechanisms;
  - A major revision to the secondary organic aerosol portioning (SOAP) chemistry/ partitioning algorithm;
  - Updates to the Regional Acid Deposition Model – aqueous chemistry (RADM-AQ) algorithm; and
  - A major revision to the wet deposition algorithm to identify assumptions or processes that were unintentionally or otherwise unreasonably limiting gas and PM updates into precipitation. The wet deposition algorithm was simplified and improved in several ways, resulting in the increased scavenging of gases and PM.
- *Configuration Differences*. 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:

[74] "Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project. 2011el CAMx Version 6.32 and 6.40 Benchmarking Report, Task 6 Benchmark Report #2 Covering Benchmark Run #3." Final Report. 8/17/2020.

- o 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;
- o 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.

The results are presented for the hours with the largest difference between the EPA and VISTAS simulations. Observations were made for the following modeled pollutants:

- Ozone: The maximum positive difference is 14.48 ppb falling to 10.47 ppb for the 10th highest. The maximum negative difference is -13.74 ppb falling to -9.61 for the 10th highest. 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%.
- $PM_{2.5}$: 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 highest. The maximum negative difference is -35.09 $\mu g/m^3$, falling to -18.42 $\mu g/m^3$ for the 10th highest. The maximum positive percent difference from these days is 1445%, and the maximum negative percent difference is -59.4%. On the day of the maximum positive difference (September 24 at 0400), the maximum difference in $PM_{2.5}$ concentration was 64.76 $\mu g/m^3$ $\mu g/m^3$. At this hour the difference in the sulfate, nitrate, and OM concentrations were 10.26 $\mu g/m^{3,}$ 28.08 $\mu g/m^3$, and 9.28 $\mu g/m^3$, respectively, with the difference dominated by the differences in the nitrate estimates.
- Sulfate: The maximum positive difference is 23.32 $\mu g/m^3$, falling to 14.77 $\mu g/m^3$ for the 10th highest. The maximum negative difference is -17.77 $\mu g/m^3$, falling to -5.76 $\mu g/m^3$ for the 10th highest. The maximum positive percent difference from these days is 171%, and the maximum negative percent difference is -26.9%.
- Nitrate: The maximum positive difference is 28.08 $\mu g/m^3$, falling to 21.00 $\mu g/m^3$ for the 10th highest. The maximum negative difference is -7.05 $\mu g/m^3$, falling to -6.16 $\mu g/m^3$ for the 10th highest. The maximum positive percent difference from these days is 2512%, and the maximum negative percent difference is -80.7%.
- Organic Carbon: The maximum positive difference is 30.29 $\mu g/m^3$, falling to 25.25 $\mu g/m^3$ for the 10th highest. The maximum negative difference is -28.67 $\mu g/m^3$, falling to -16.60 $\mu g/m^3$ for the 10th highest. The maximum positive percent difference from these days is 801%, and the maximum negative percent difference is -80.3%.

6.2.4 Benchmark Confirmation Run #4

Similar to Benchmark Confirmation #3, the fourth benchmark confirmation run compares the Alpine 2028 modeling results for the continental U.S. using the CAMx 6.32 modeling platform versus the modeling results using the CAMx 6.40 modeling report. Details on this comparison are presented in the technical report.[75]

In addition to the model and configuration differences noted in Section 6.2.3, there are notable emissions inventory differences used in the modeling by SESARM compared to EPA's 2028el modeling platform. Observations were made for modeled $PM_{2.5}$ Design Values:

- Annual $PM_{2.5}$ Design Value: The maximum calculated increase is 0.51 µg/m^3 at monitor 510590030 in Fairfax, Virginia (7% increase between 6.32 and 6.40) and maximum decrease is 0.43 µg/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 µg/m^3, with an average annual percent increase of 3% at these same locations.
- 24-Hour (daily) $PM_{2.5}$ Design Value: The maximum calculated increase is 1.1 µg/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 µg/m^3 at monitor 130210007 in Bibb County, 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 µg/m^3, with an average daily percent difference of 2% at these same locations.

6.2.5 Benchmark Confirmation Run #5

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. The fifth benchmark confirmation run compares the EPA 2011 modeling results for the continental U.S. vs. the EPA 12-km continental grid using the CAMx 6.40 modeling platform. Details on this comparison are presented in the technical report.[76] Observations were made for the following pollutants:

- Ozone: The maximum positive difference is 17.75 parts per billion (ppb) falling to 9.16 ppb for the 10th highest. The maximum negative difference is -17.41 ppb falling to -12.19 for the 10th highest. Generally the highest positive and negative differences are occurring on relatively

75 "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." Final Report. 8/17/2020.

76 "Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project. 2011el CAMx Version 6.40 12-km VISTAS and EPA 12-km Continental Grid Comparison Report, Task 6 Benchmark Report #3 Covering Benchmark Run #5." Final Report. 8/17/2020.

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.

- PM$_{2.5}$: The maximum positive difference is 383.55 micrograms per cubic meter (µg/m^3) falling to 211.10 µg/m^3 for the 10th highest. The maximum negative difference is -297.25 µg/m^3 falling to -174.08 µg/m^3 for the 10th highest. The maximum positive percent difference from these days is 101.8% and negative percent difference of -33.4%.
- Sulfate: The maximum positive difference is 5.76 µg/m^3 falling to 3.39 µg/m^3 for the 10th highest. The maximum negative difference is -4.58 µg/m^3 falling to -2.34 µg/m^3 for the 10th highest. The maximum positive percent difference on these days is 89.3% and negative percent difference of -32.6%.
- Nitrate: The maximum positive difference is 7.62 µg/m^3 falling to 5.55 µg/m^3 for the 10th highest. The maximum negative difference is -5.37 µg/m^3 falling to -3.14 µg/m^3 for the 10th highest. The maximum positive percent difference from these days is 129.2% and negative percent difference of -49.16%.
- Organic Carbon: The maximum positive difference is 296.08 µg/m^3 falling to 161.79 µg/m^3 for the 10th highest. The maximum negative difference is -288.20 µg/m^3 falling to -134.56 µg/m^3 for the 10th highest. The maximum positive percent difference from these days is 97.4% and negative percent difference of -33.7%.

6.2.6 Benchmark Confirmation Run #6

Benchmark comparison run #6 compare the modeling results using CAMx 6.40 performed on the Alpine computer system using the SESARM 2028elv3 modeling platform over the VISTAS12 and 12US2 domains. Details on this comparison are presented in the technical report.[77] Observations were made for the following modeled pollutants:

- Ozone: 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.
- PM$_{2.5}$: 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%.
- Sulfate: 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%.

77 "Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project. 2028elv3 CAMx Version 6.40 12-km VISTAS and EPA 12-km Continental Grid Comparison Report, Task 6 Benchmark Report #5 Covering Benchmark Run #6." Final Report. 8/17/2020.

- Nitrate: 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%.
- Organic Carbon: 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%.

6.2.7 Benchmark Confirmation Run #7

Since the completion of the original round of emissions inventory development, emissions processing, modeling, and PSAT, SESARM concluded that the 2028 point EGU and non-EGU emissions needed to be reviewed and updated for selected sources. Specific updates related to development of the 2028 emissions inventory updates (identified as "elv5") are presented in the Task 2B and Task 3B updated reports.

This seventh benchmark documents the differences in model estimates between CAMx 6.40 2028elv3 and 2028elv5. Details on this comparison are presented in the technical report.[78] Observations were made for modeled $PM_{2.5}$ Design Values:

- Annual $PM_{2.5}$ Design Value: The maximum calculated decrease is 0.67 μg/m^3 at monitor 211010014 in Henderson County, 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 μg/m^3, with an average annual percent decrease of 4% at these same locations.
- 24-Hour (daily) $PM_{2.5}$ Design Value: The maximum calculated decrease is 2.4 μg/m^3 at monitor 010732003 in Jefferson County, 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 μg/m^3, with an average annual percent decrease of 4% at these same locations.

[78] "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." Final Report. 9/22/2020.

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7.0 VISTAS II Model Performance Evaluations

This section summarizes the [insert]. Activities related to Task 7 are presented at: https://www.metro4-sesarm.org/content/model-performance-evaluations.

Model performance evaluations (MPEs), which compare modeled concentrations to observed concentrations, are important for demonstrating confidence in the air quality modeling system. Under this task, ERG directed Alpine to perform MPE activities for ozone concentrations, particulate matter concentrations, and regional haze values (e.g., light extinction). The deposition MPE was conducted by ERG.

MPE metrics for the above were developed from the Model Performance Evaluation, Analysis, and Plotting Software (MAPS) tool.[79] For this evaluation, the mean bias, mean error, normalized mean bias, and normalized mean error were selected to characterize model performance; these statistics are consistent with the recommendations in Simon et al. (2012),[80] the photochemical modeling guidance (U.S. EPA, 2018),[81] 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:

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79 McNally, D. and T. W. Tesche. 1993. Model Performance Evaluation, Analysis, and Plotting Software (MAPS). Alpine Geophysics, LLC. Arvada, CO.

80 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.

81 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

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

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:

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

These data are presented as:

- Tables and plots;
- Scatter (with linear regression and r^2 value), bugle, and soccer plots;
- the individual day-by-day and site-by-site stacked bar plots of total *beta* extinction (bext) and speciated components of bext for these most impaired and clearest days

7.1 Ozone MPE

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 model applications.[5,82,83,84,85,86,87,88] 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.

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[82] NRC, 2002. National Research Council (NRC), 2002. Estimating the Public Health Benefits of Proposed Air Pollution Regulations, Washington, DC: National Academies Press.

[83] 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.

[84] 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.

[85] 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.

[86] 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.

[87] 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.

[88] 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, 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.

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 7-1 and 7-2, respectively. The statistics shown in Tables 7-1 and 7-2 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 7-1 through 7-4. Time series plots of observed and predicted maximum daily (MDA) 8-hour ozone during the period May through September at select sites listed in Table 7-5 are provided in Figures 7-5 through 7-14.

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.

7.1.1 Performance Statistics by States and Month

As indicated by the statistics in Table 7-1, bias and error for 8-hour daily maximum ozone are relatively low in the region. Generally, 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 ME is less than 10 ppb in all months. 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 NME is less than 15 percent in the region across all months.

Table 7-1. 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 7-2) 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 7-2. 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

Table 7-2. 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	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
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

7.1.2 Spatial Performance Evaluation

Figures 7-1 through 7-4 show the spatial variability in bias and error at monitor locations. Mean bias, as seen from Figure 7-1, 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 of these sites have 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.

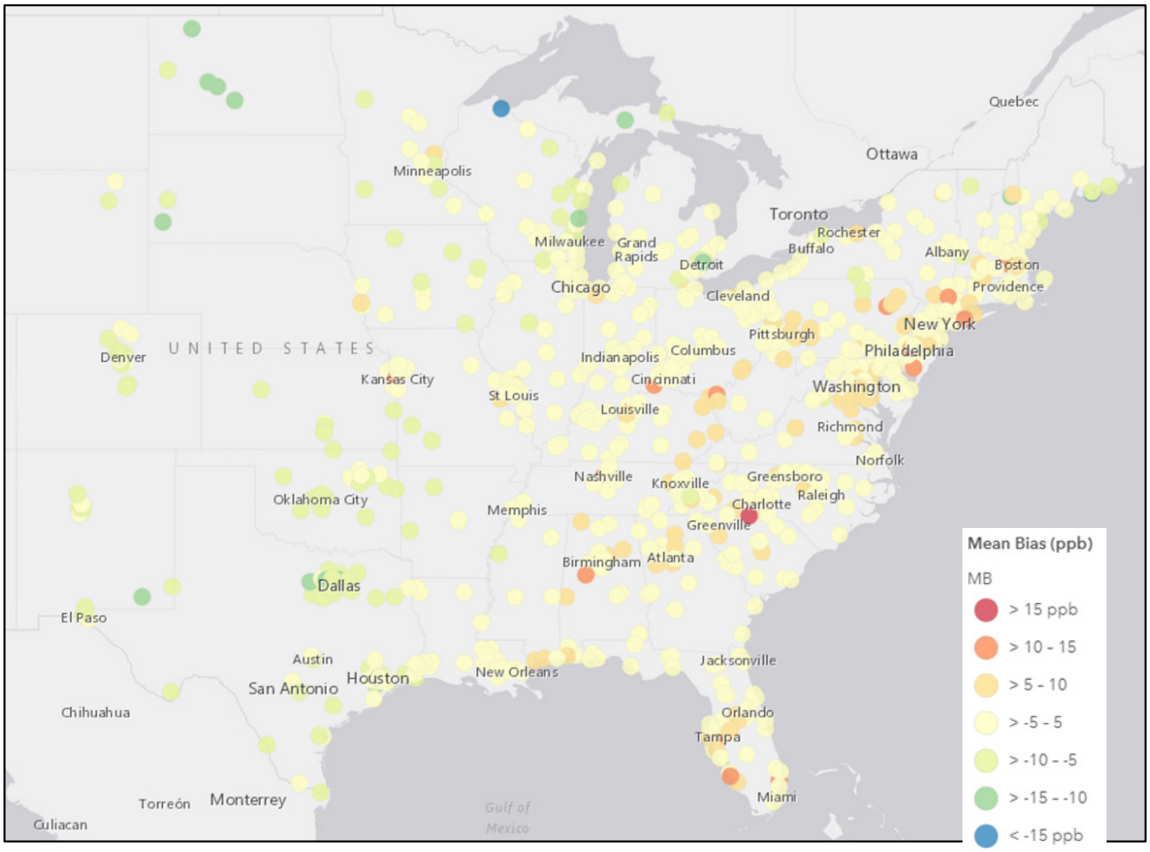


Figure 7-1. Mean Bias (ppb) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.

Figure 7-2 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 VISTAS12 domain and generally underpredict at sites in and around the western and north western borders of the domain.

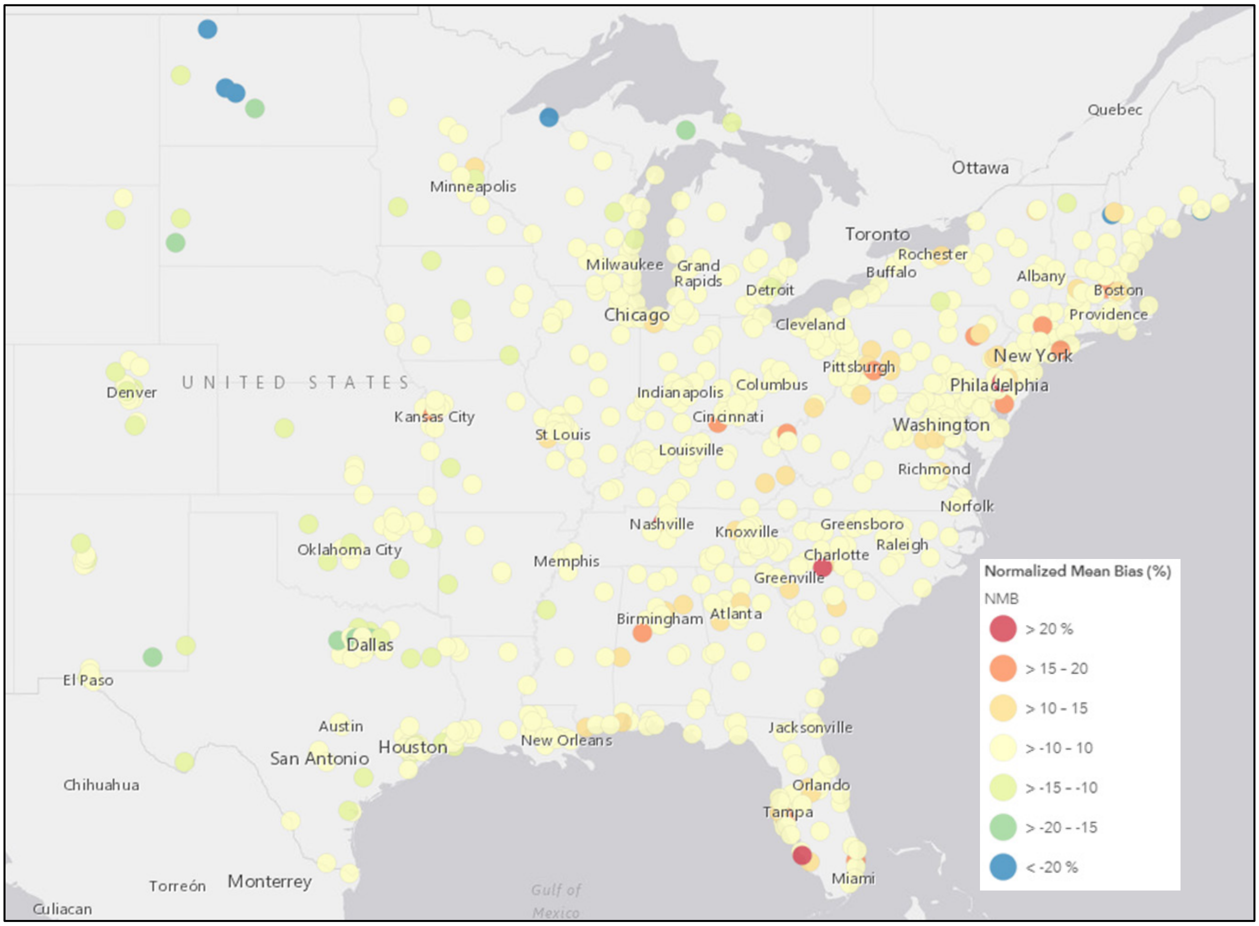


Figure 7-2. Normalized Mean Bias (%) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.

Mean error (ME), as seen from Figure 7-3, 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 10% of their monitors above 10 ppb model error, with the majority of those within this value. Figure 7-4 indicates that the normalized mean error (NME) for days with observed 8-hour daily maximum ozone ≥ 60 ppb is less than 15% 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.

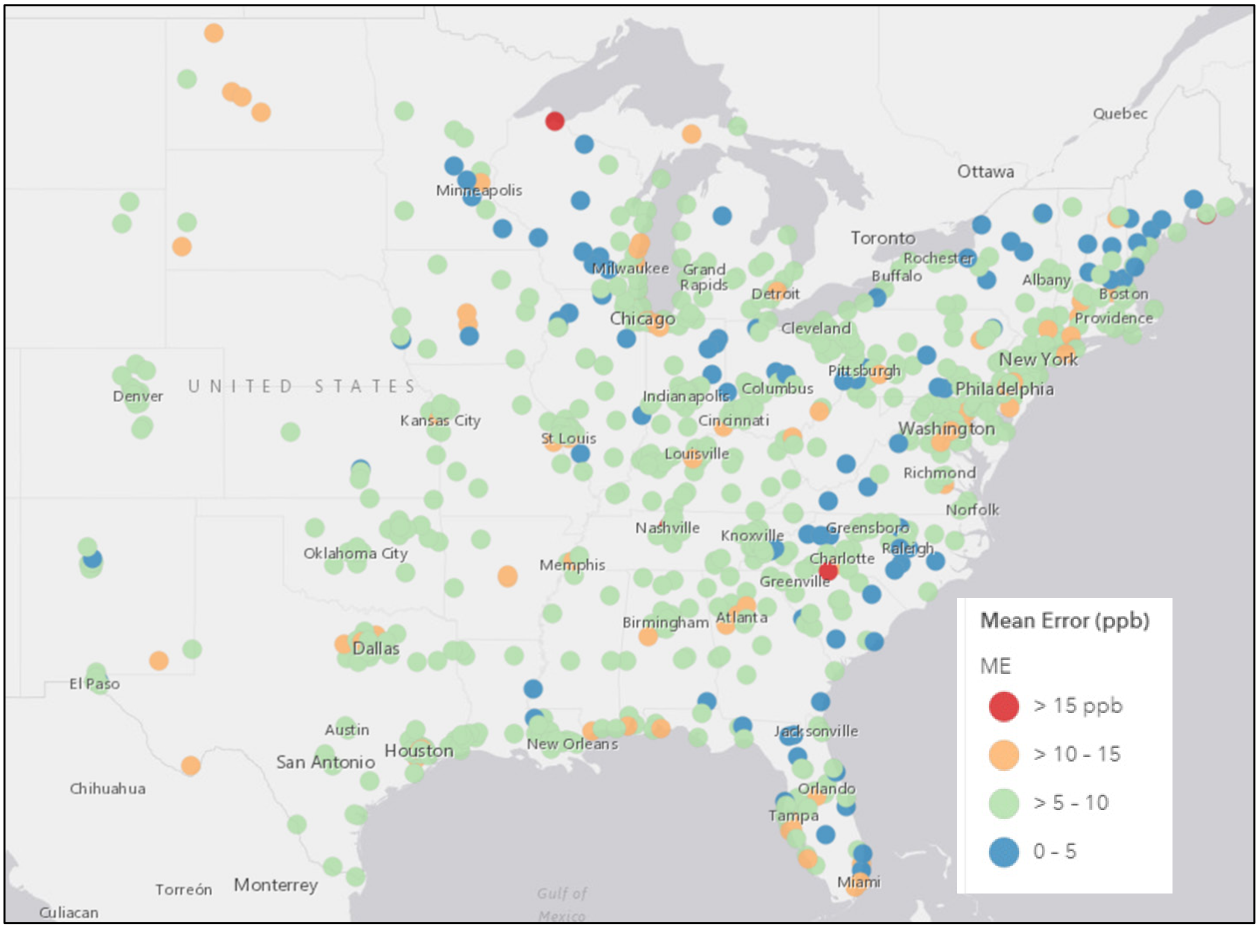


Figure 7-3. Mean Error (ppb) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.

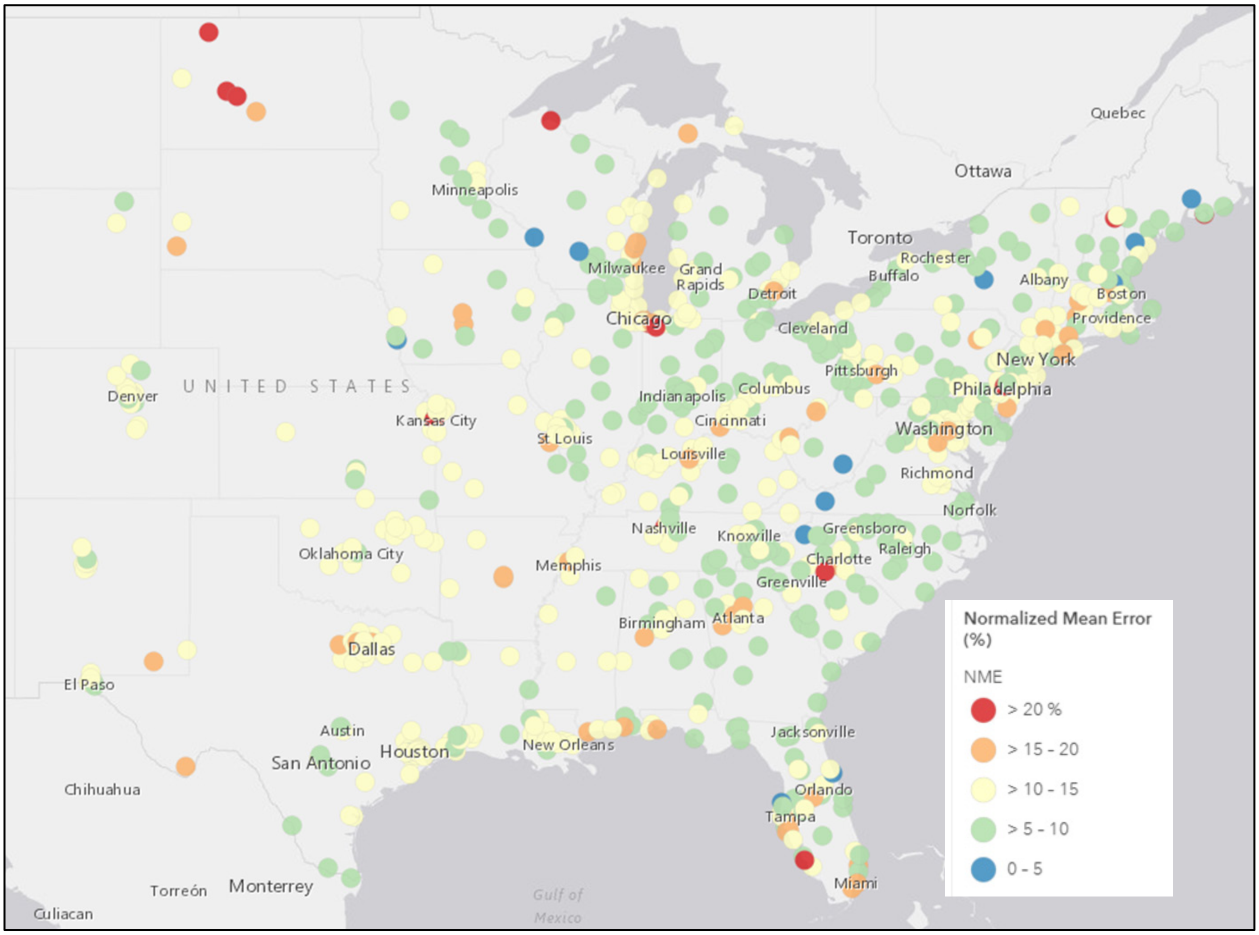


Figure 7-4. Normalized Mean Error (%) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.

7.1.3 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 7-3 presents data for the highest 2011 3-year design value sites in each VISTAS state.

Table 7-3. 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 7-5 through 7-14, 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. Conversely, there are underpredictions 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.

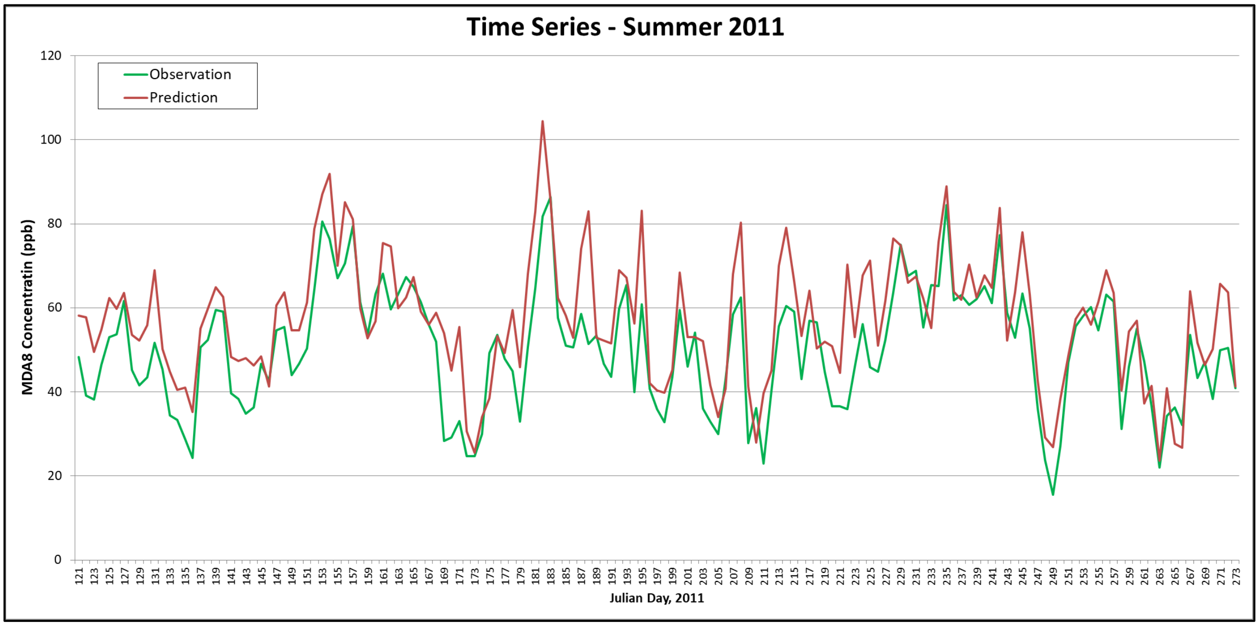


Figure 7-5. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 010731005 in Alabama.

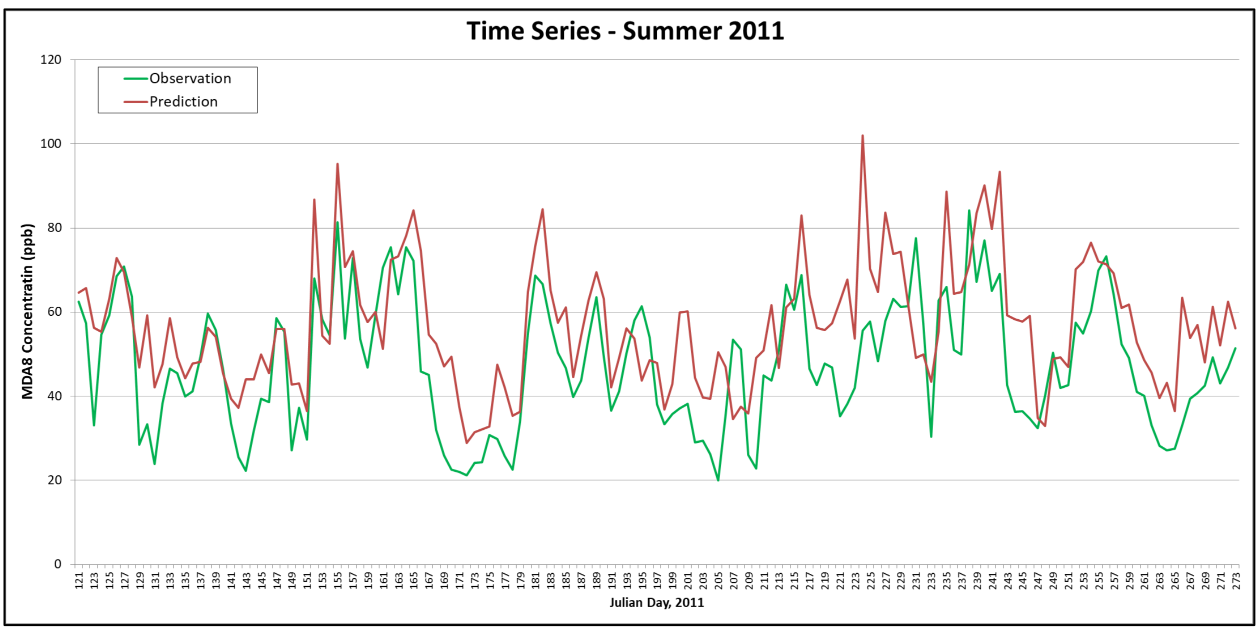


Figure 7-6. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 121130015 in Florida.

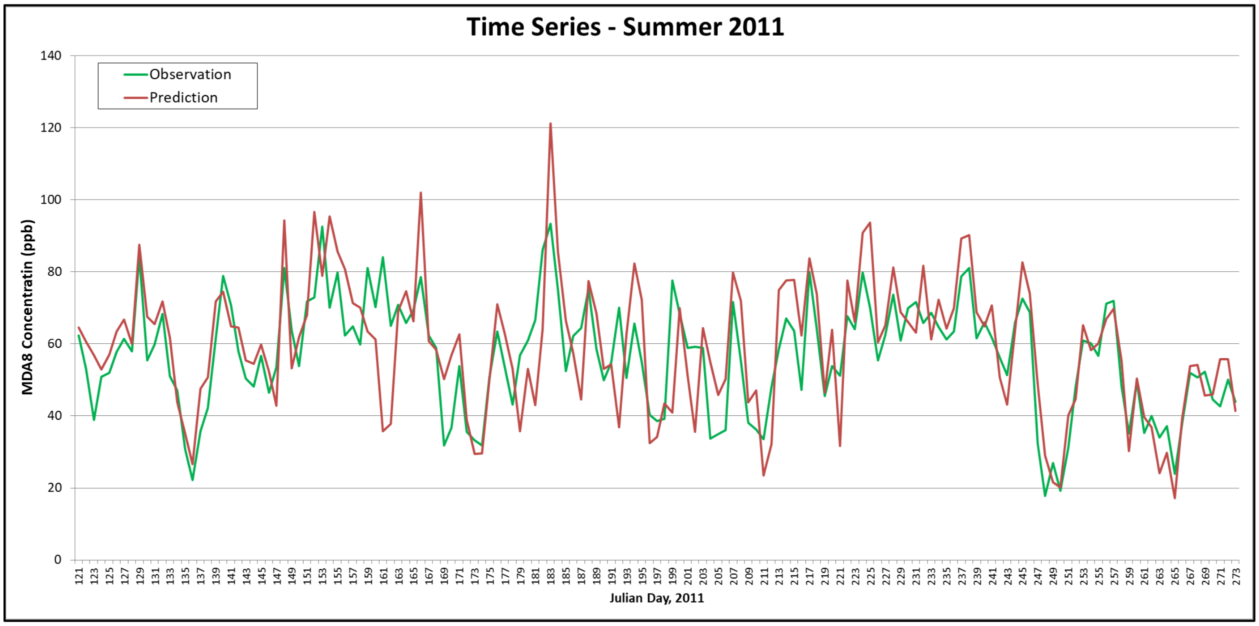


Figure 7-7. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 131210055 in Georgia.

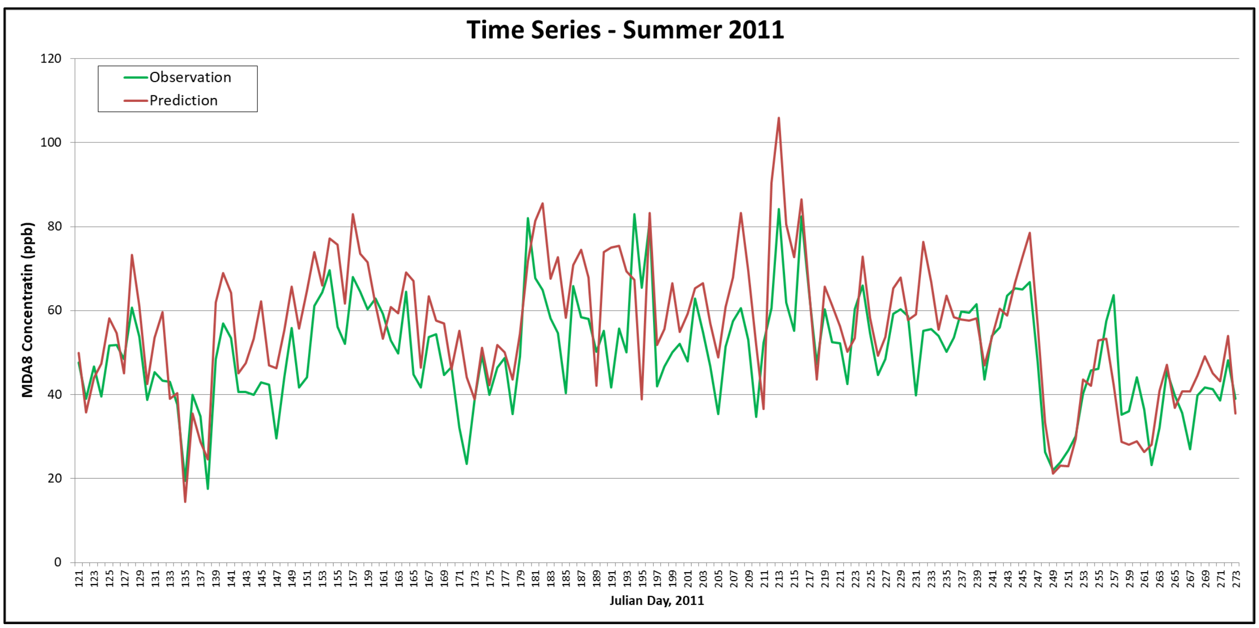


Figure 7-8. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 211110051 in Kentucky.

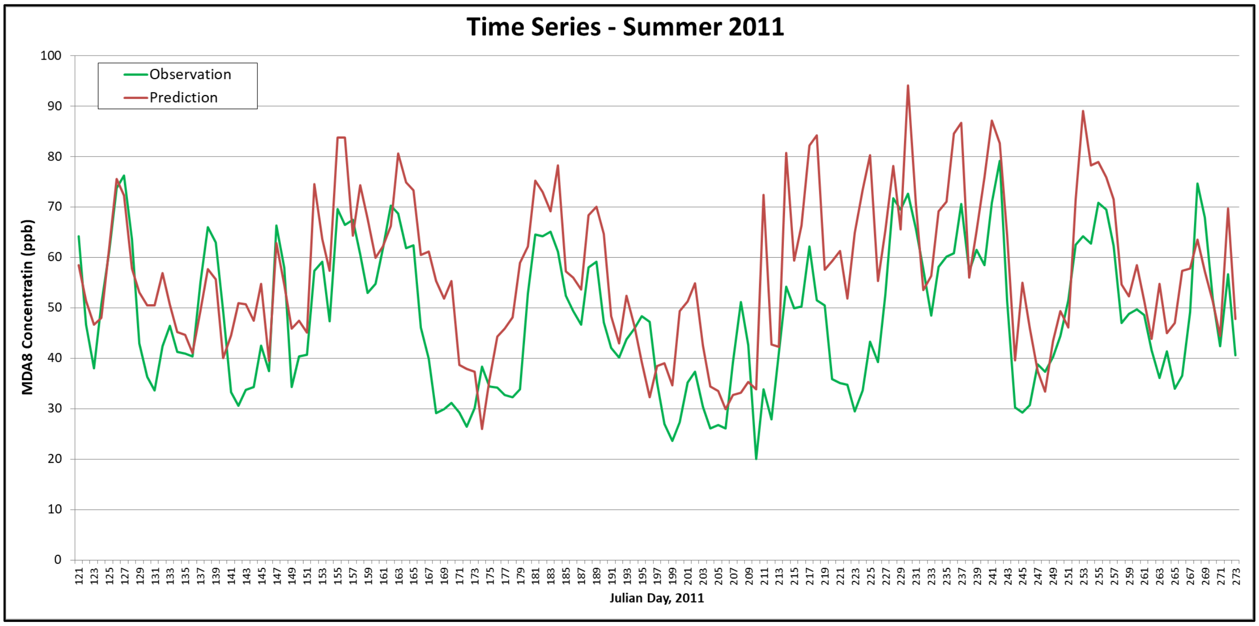


Figure 7-9. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 280470008 in Mississippi.

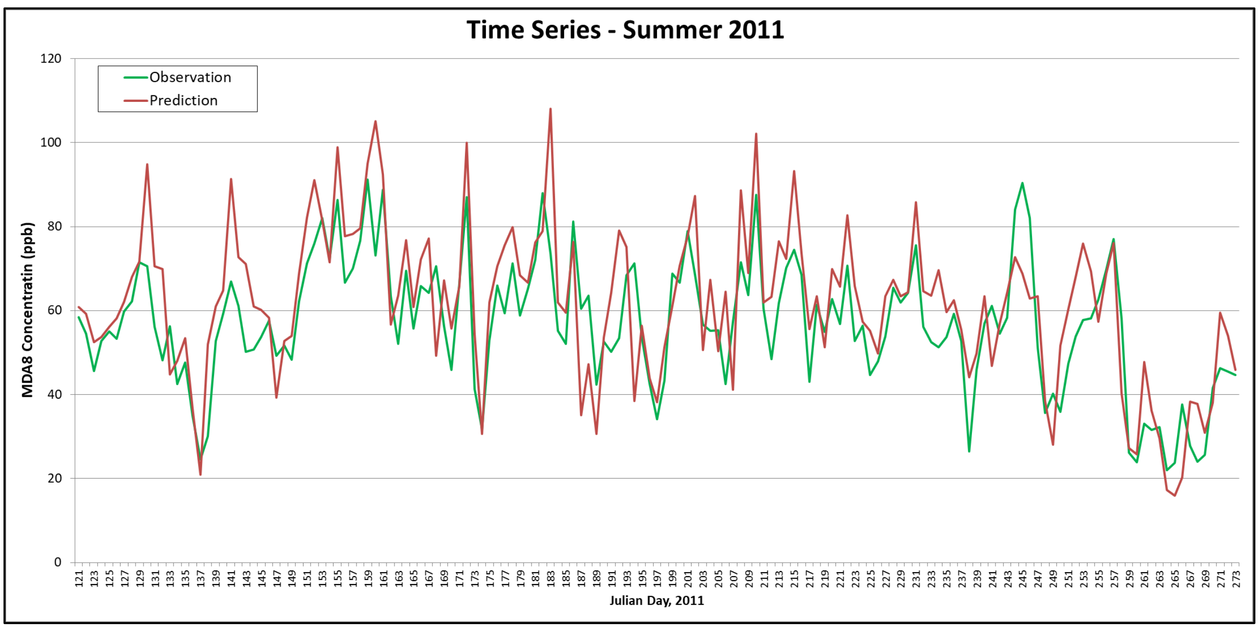


Figure 7-10. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 371190041 in North Carolina.

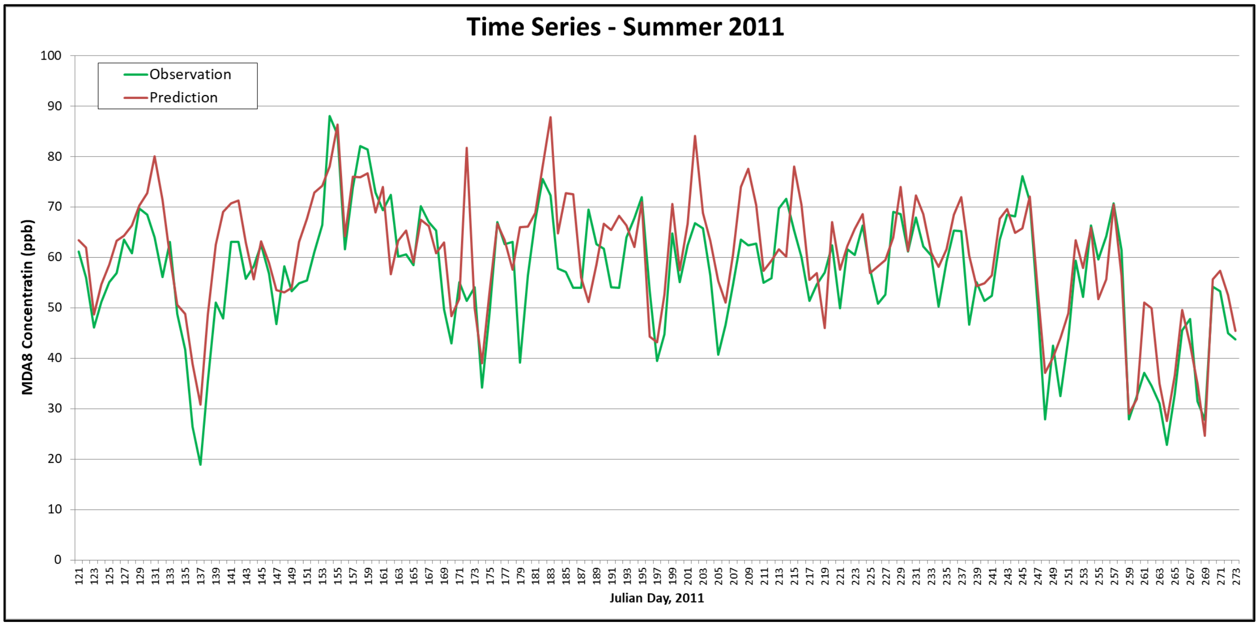


Figure 7-11. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 450830009 in South Carolina.

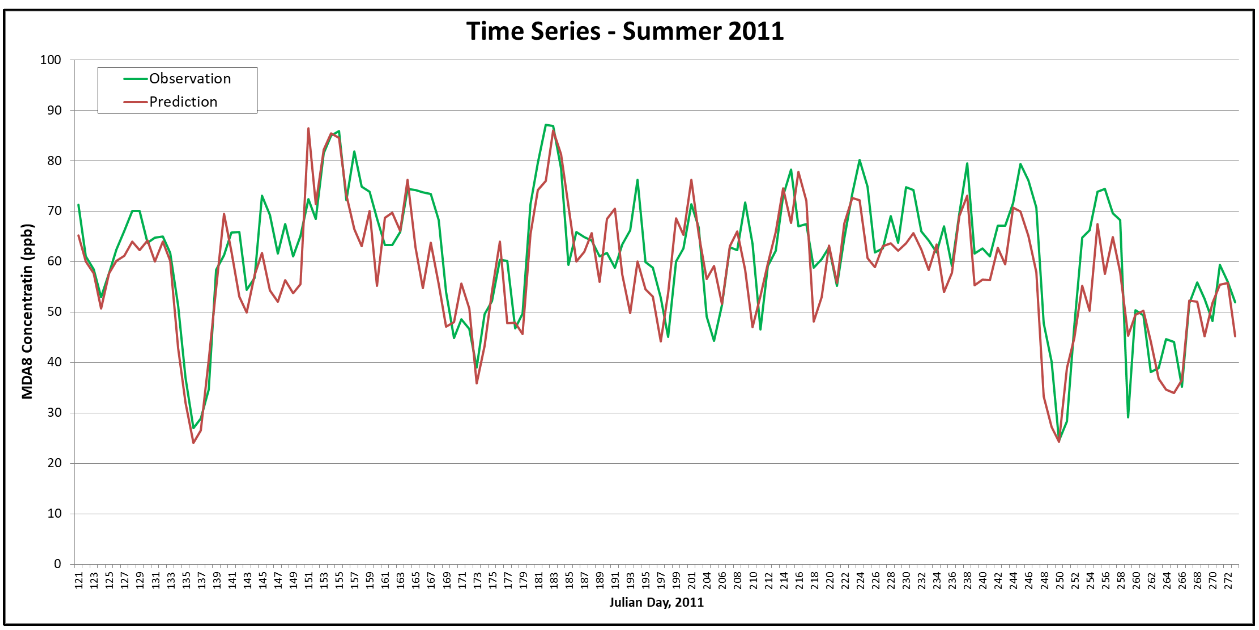


Figure 7-12. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 470090101 in Tennessee.

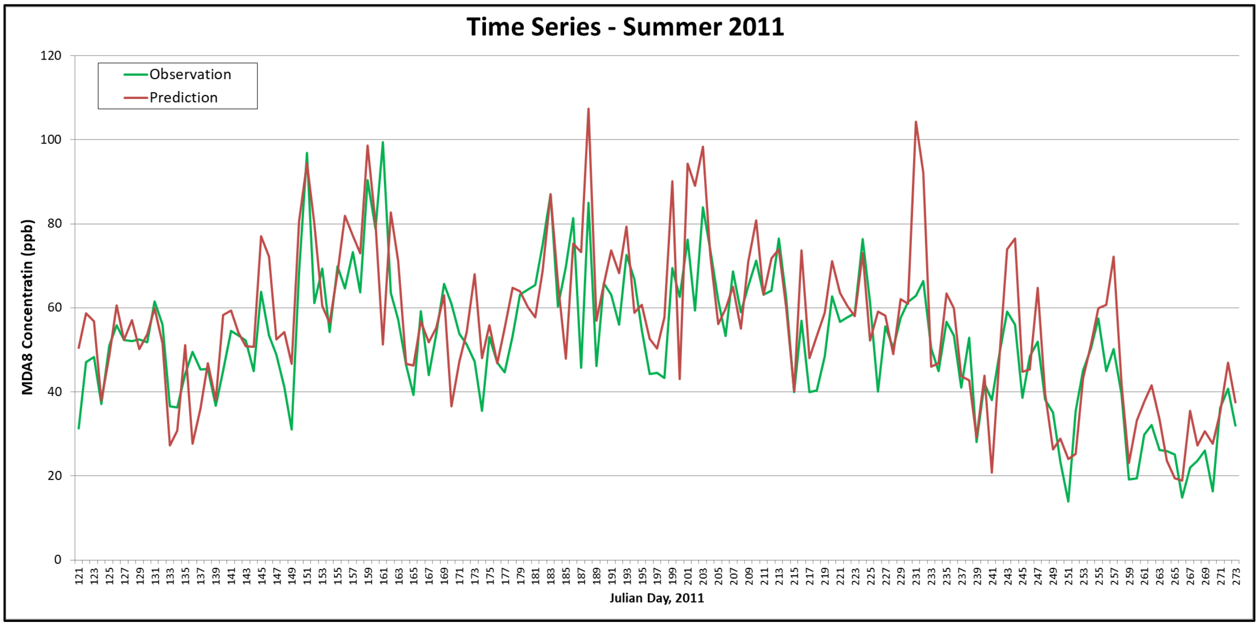


Figure 7-13. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 510590030 in Virginia.

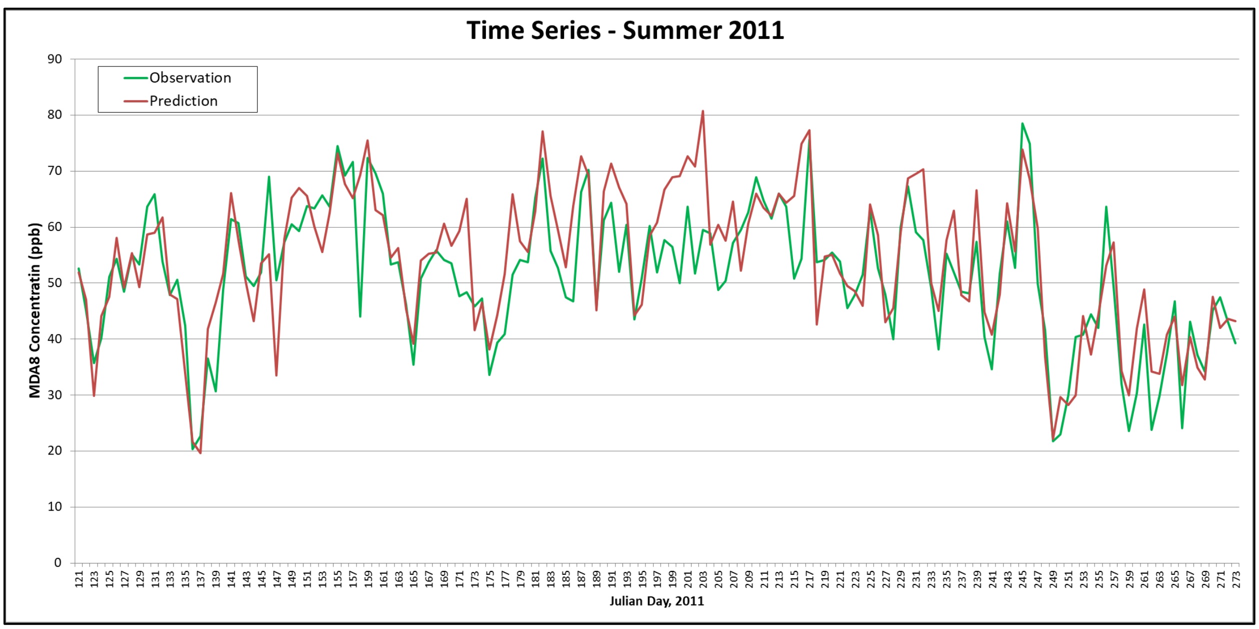


Figure 7-14. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 540690010 in West Virginia.

7.1.4 Summary

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.

7.2 PM MPEs

Comparing PM and PM species model performance statistics of EPA's CAMx 6.32 and VISTAS CAMx 6.40 simulations using EPA's 2011el modeling platform showed that each set of outputs were relatively similar. The VISTAS results had slightly improved performance for all $PM_{2.5}$ species except sulfate and organic carbon (OC) at IMPROVE, Chemical Speciation Network (CSN), and CASTNET monitors in the southeastern state region.

For sulfate and OC, VISTAS CAMx 6.40 concentrations were lower than EPA CAMx 6.32 concentrations, 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 EPA CAMx 6.32 and VISTAS 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 EPA CAMx 6.32 concentrations compared to VISTAS CAMx 6.40 at lower concentration levels, with consistent performance at higher concentrations. VISTAS CAMx 6.40 concentrations were generally slightly higher than EPA CAMx 6.32 concentrations during dry periods, and EPA CAMx 6.32 concentrations were generally slightly higher than VISTAS CAMx 6.40 concentrations 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 the EPA CAMx 6.32 and VISTAS 6.40 results 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. No features in the modeling were identified that would preclude the use of the more up-to-date science in CAMx 6.40 for use in the VISTAS air quality planning.

7.2.1 $PM_{2.5}$ Sulfate

Table 7-4 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 7-15 through 7-17.

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 showed the highest average sulfate concentrations in the summer. However, the model performance is showing the largest underestimation in the summer. This under prediction is also noticeable during all other seasons even 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 7-4. Model Performance Statistics for $PM_{2.5}$ Sulfate by Region, Network, and Season.

Region	Network	Season	N	Avg. Obs. (µg/m^3)	Avg. Pre. (µg/m^3)	r	NMB (%)	NME (%)	MB (µg/m^3)	ME (µg/m^3)
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

Table 7-4. 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)
		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

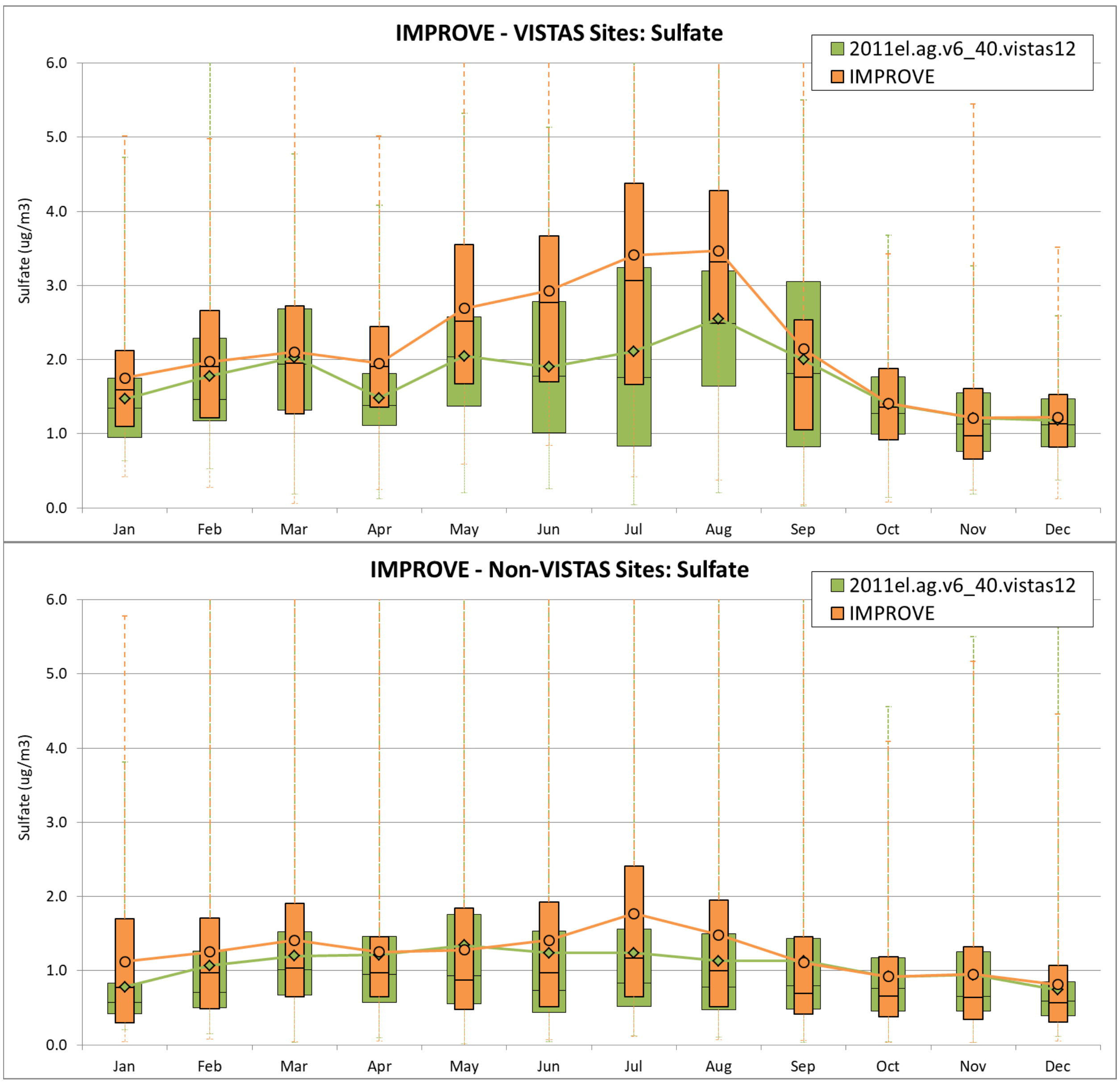


Figure 7-15. Boxplot Comparisons of Model Predictions and IMRPOVE Sulfate Observations for Each Climate Region by Month.

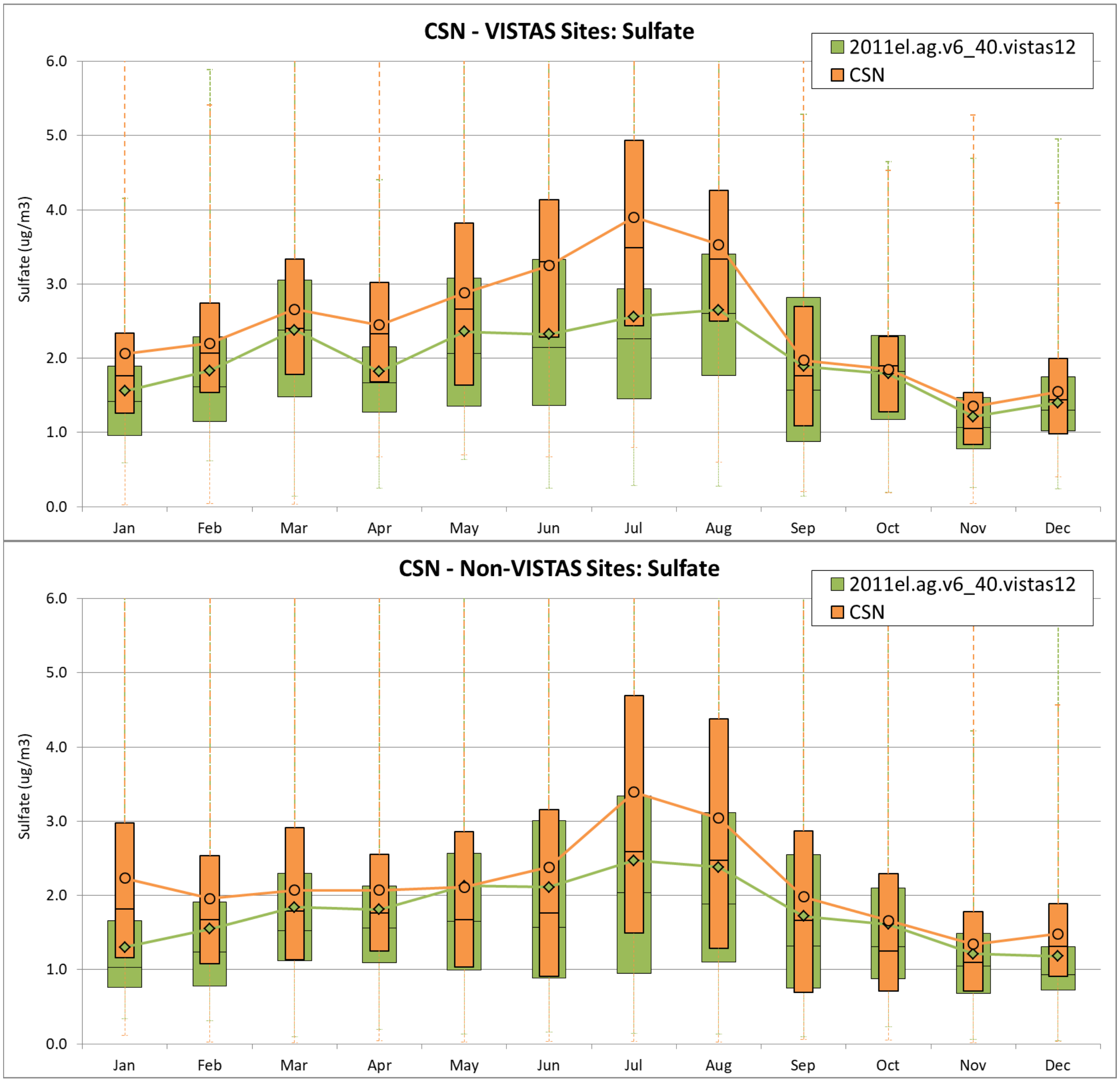


Figure 7-16. Boxplot Comparisons of Model Predictions and CSN Sulfate Observations for Each Climate Region by Month.

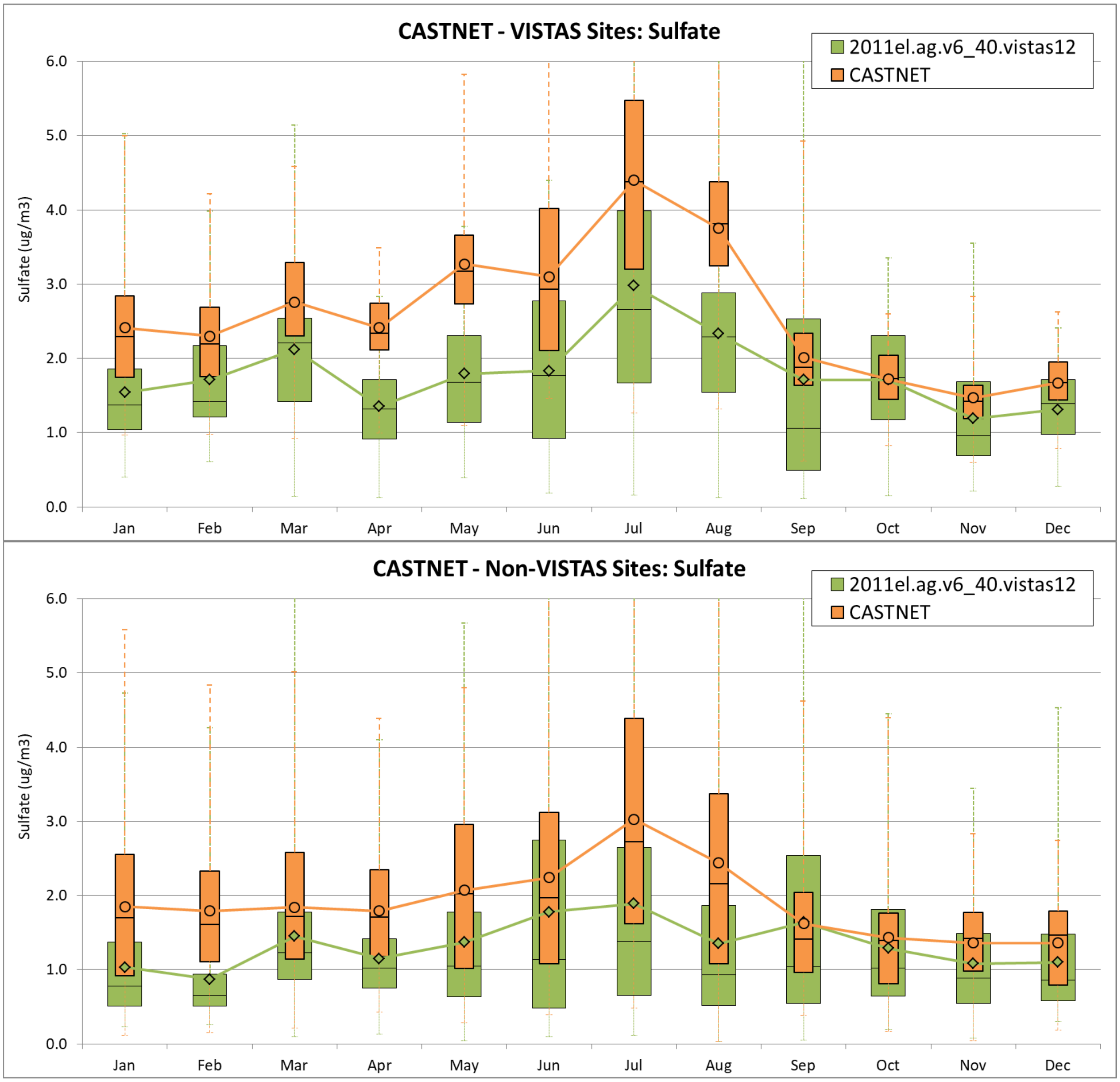


Figure 7-17. Boxplot Comparisons of Model Predictions and CASTNET Sulfate Observations for Each Climate Region by Month.

7.2.2 $PM_{2.5}$ Nitrate

Table 7-5 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 7-18 through 7-20.

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 significant 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 7-5. 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

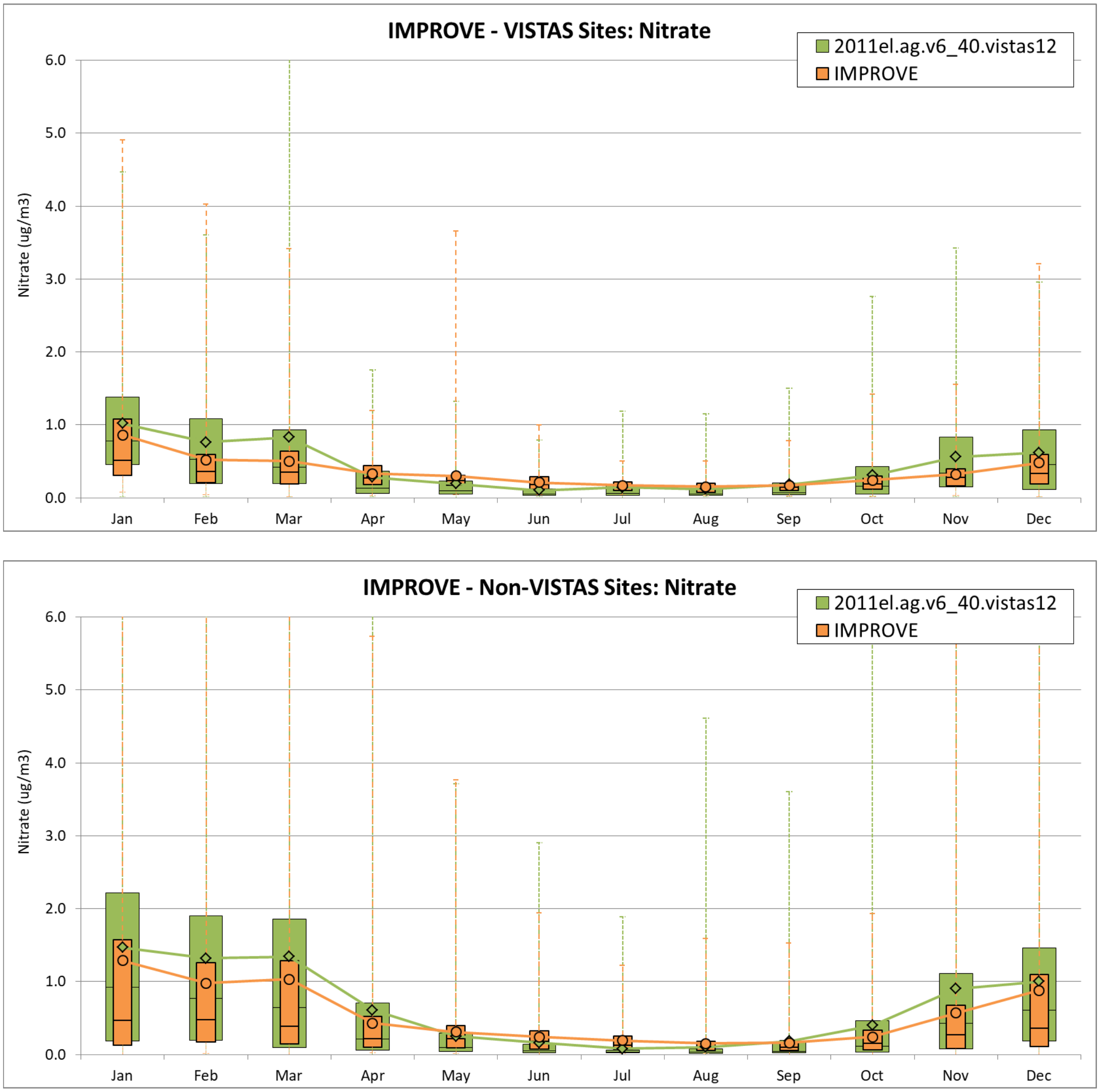
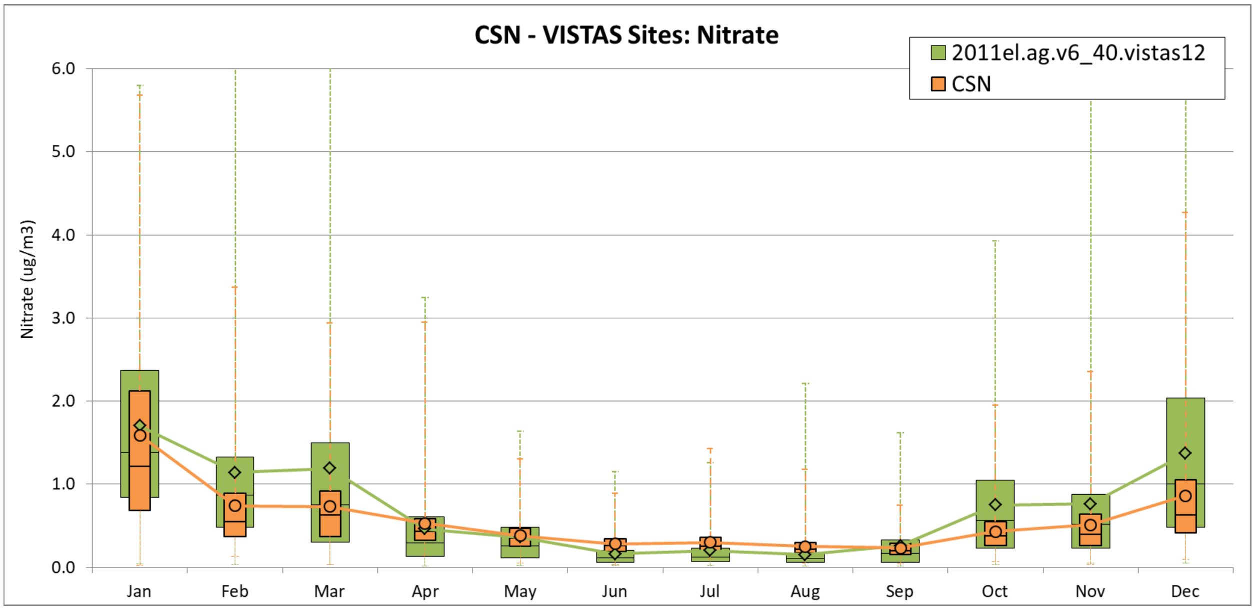


Figure 7-18. Boxplot Comparisons of Model Predictions and IMPROVE Nitrate Observations for Each Climate Region by Month.



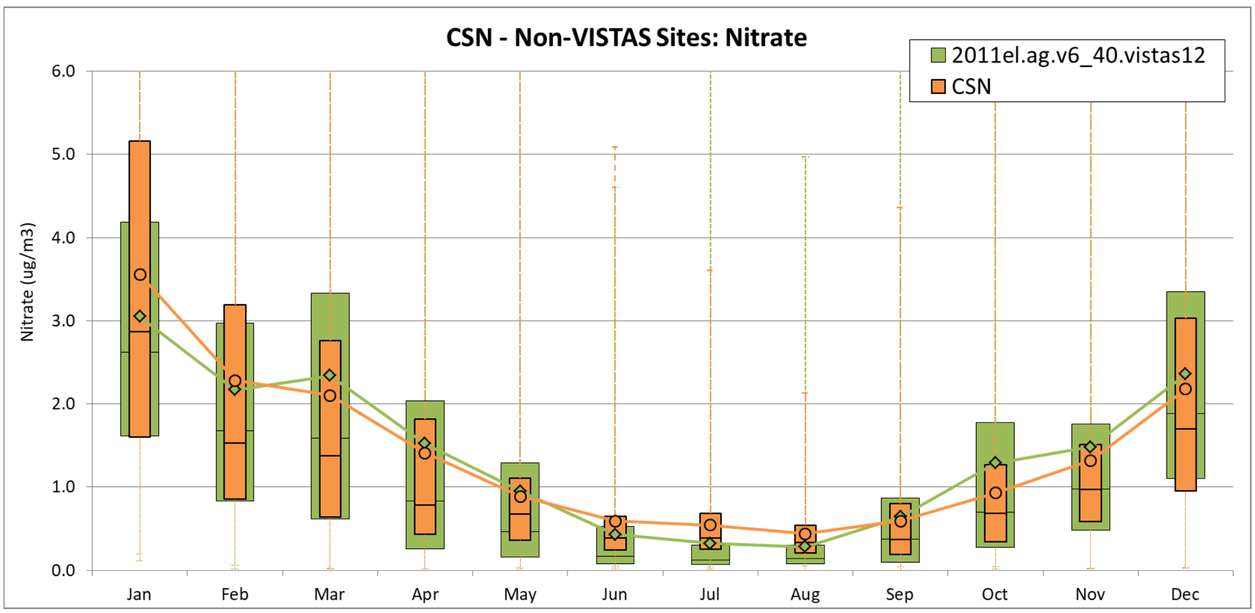


Figure 7-19. Boxplot Comparisons of Model Predictions and CSN Nitrate Observations for Each Climate Region by Month.

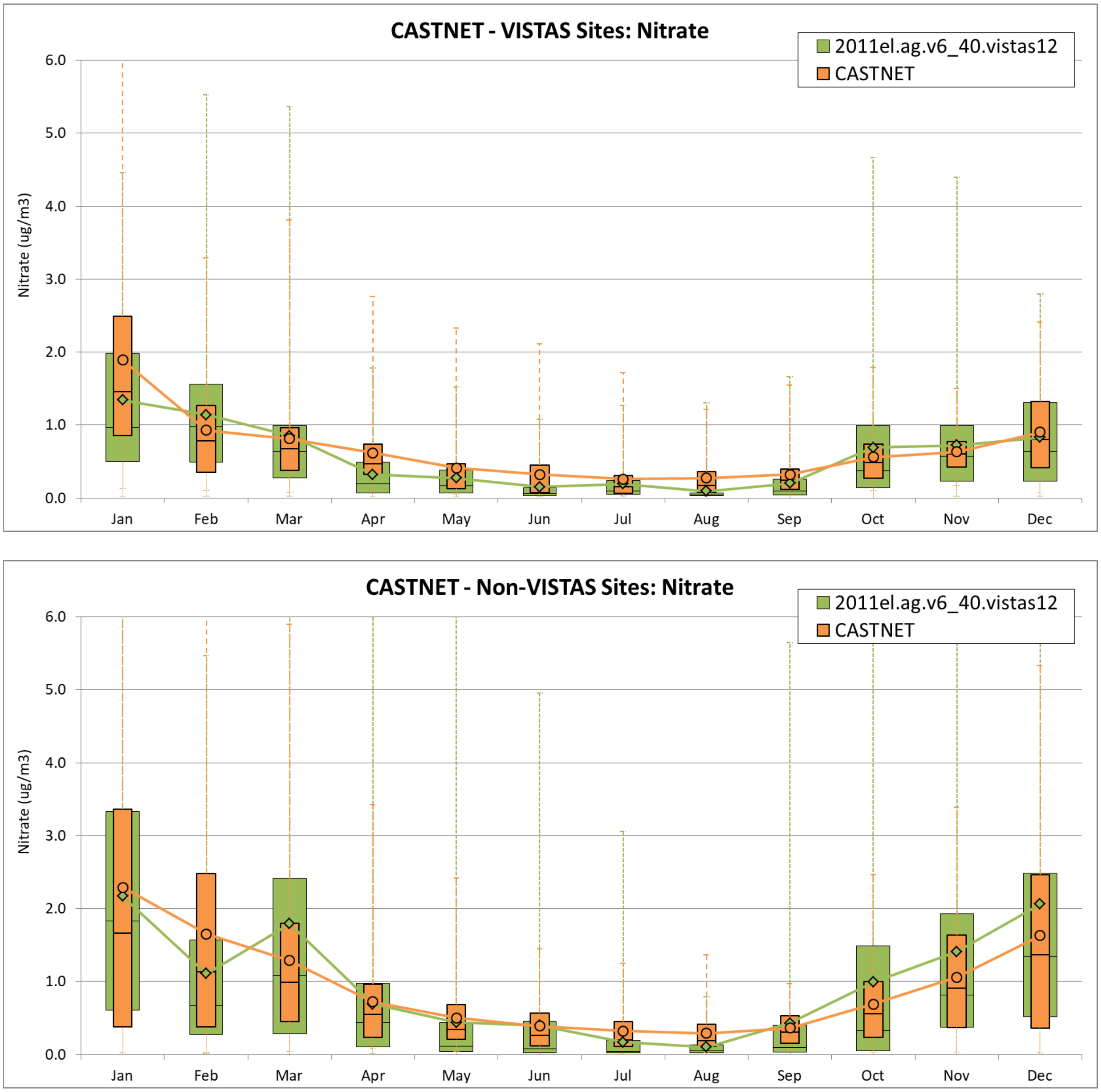


Figure 7-20. Boxplot Comparisons of Model Predictions and CASTNET Nitrate Observations for Each Climate Region by Month.

7.2.3 PM2.5 Ammonium

Table 7-6 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 7-21 and 7-22.

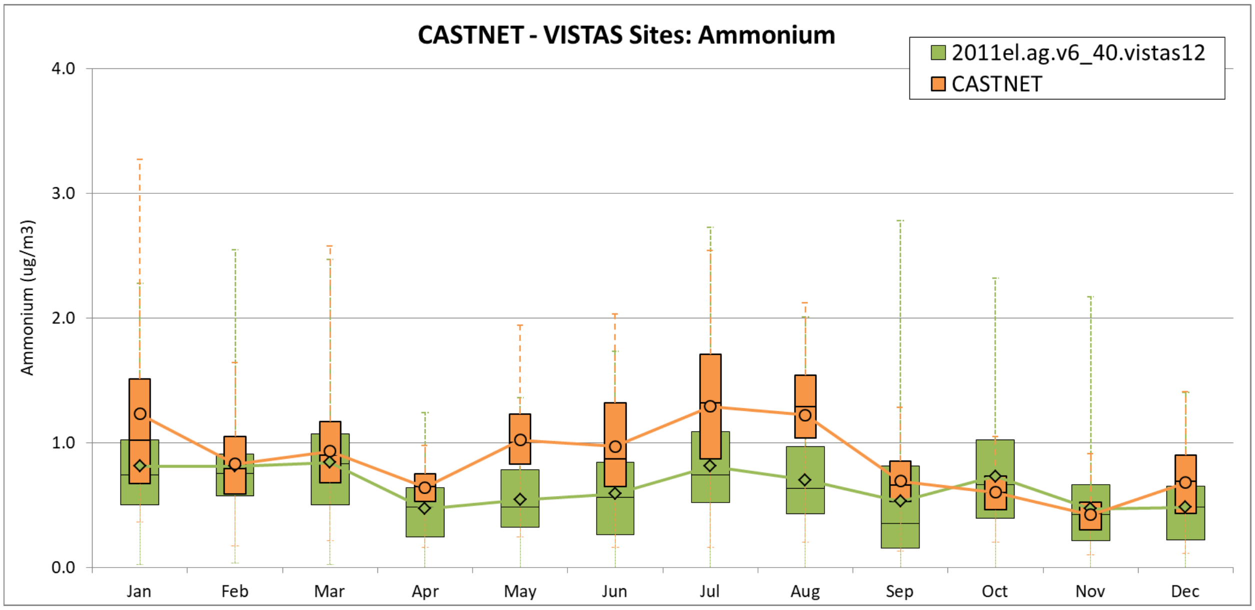
Ammonium is generally under predicted across the VISTAS12 domain in all seasons, with the exception of over prediction in the fall months. In the VISTAS state receptor networks, ammonium is generally under predicted with a significant over prediction observed during the lowest observed concentration 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 7-6. 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 7-21. Boxplot Comparisons of Model Predictions and CSN Ammonium Observations for Each Climate Region by Month.



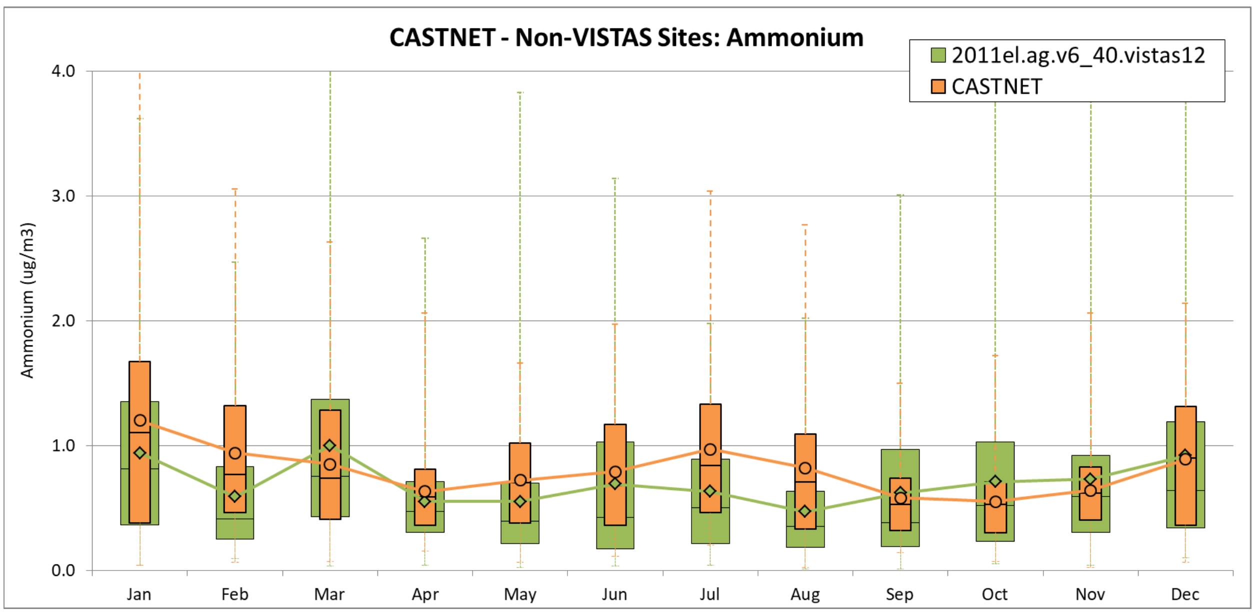


Figure 7-22. Boxplot Comparisons of Model Predictions and CASTNET Ammonium Observations for Each Climate Region by Month.

7.2.4 $PM_{2.5}$ OC

Table 7-7 summarizes model performance statistics for $PM_{2.5}$ OC. To provide a direct comparison to the observational data, CAMx's organic matter (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 presented in Figures 7-32 and 7-24.

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 7-7. 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

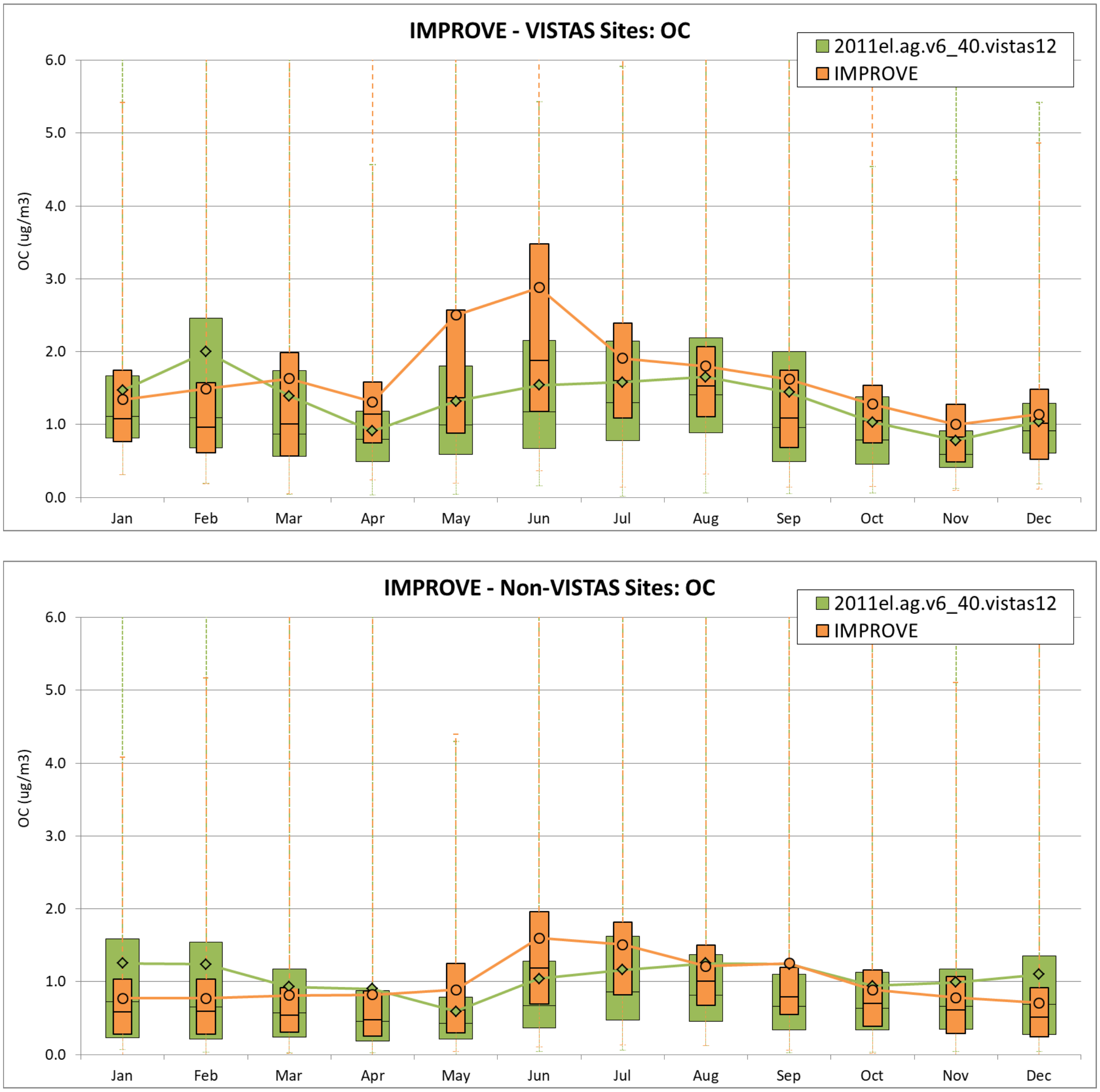


Figure 7-23. Boxplot Comparisons of Model Predictions and IMPROVE Organic Carbon (OC) Observations for Each Climate Region by Month.

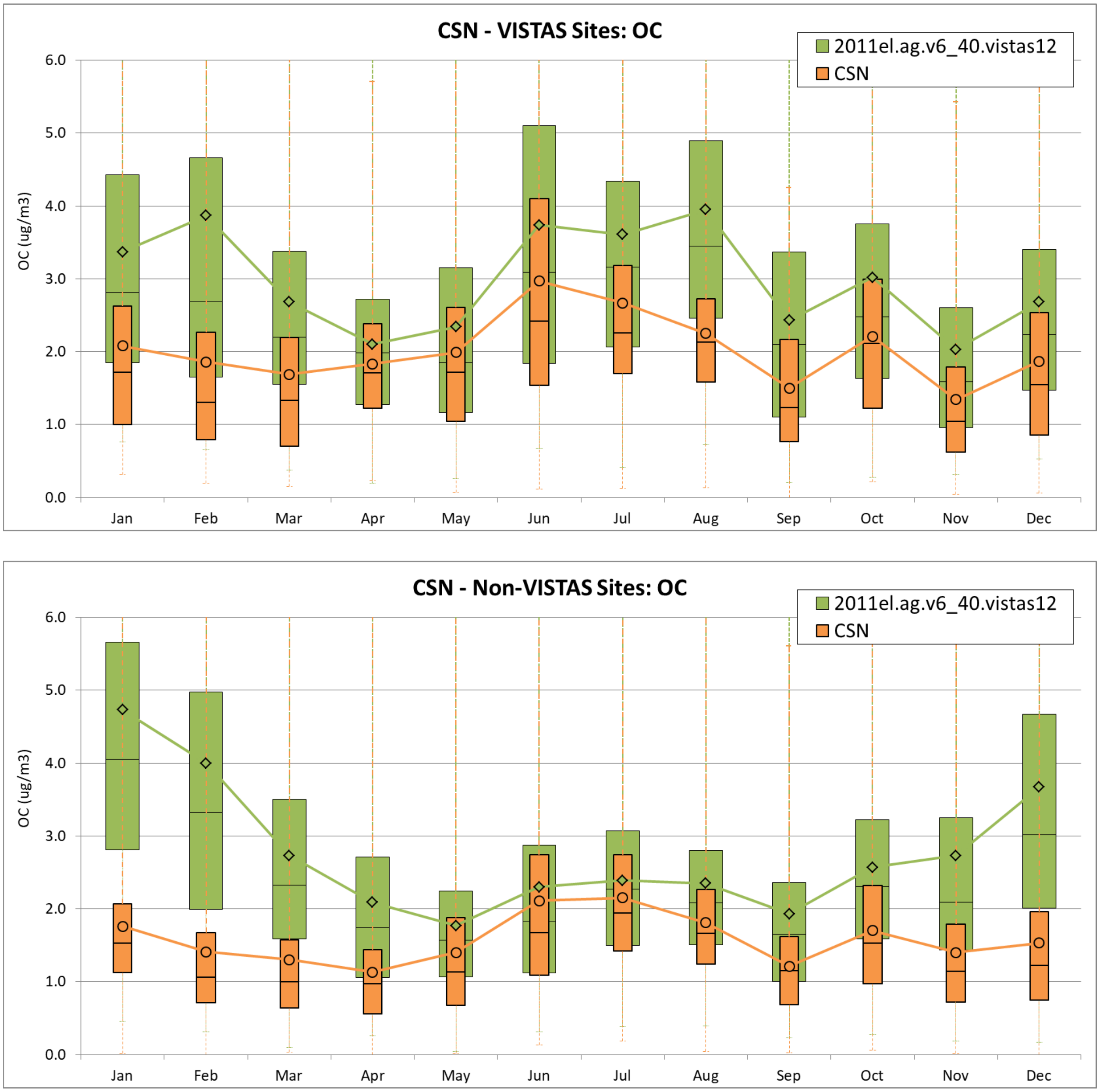


Figure 7-24. Boxplot Comparisons of Model Predictions and CSN Organic Carbon (OC) Observations for Each Climate Region by Month.

7.2.5 $PM_{2.5}$ EC

Table 7-8 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 7-25 and 7-26.

In the VISTAS states, EC concentrations averaged over the entire year show fairly close agreement with observations. The NMB is 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 7-8. 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

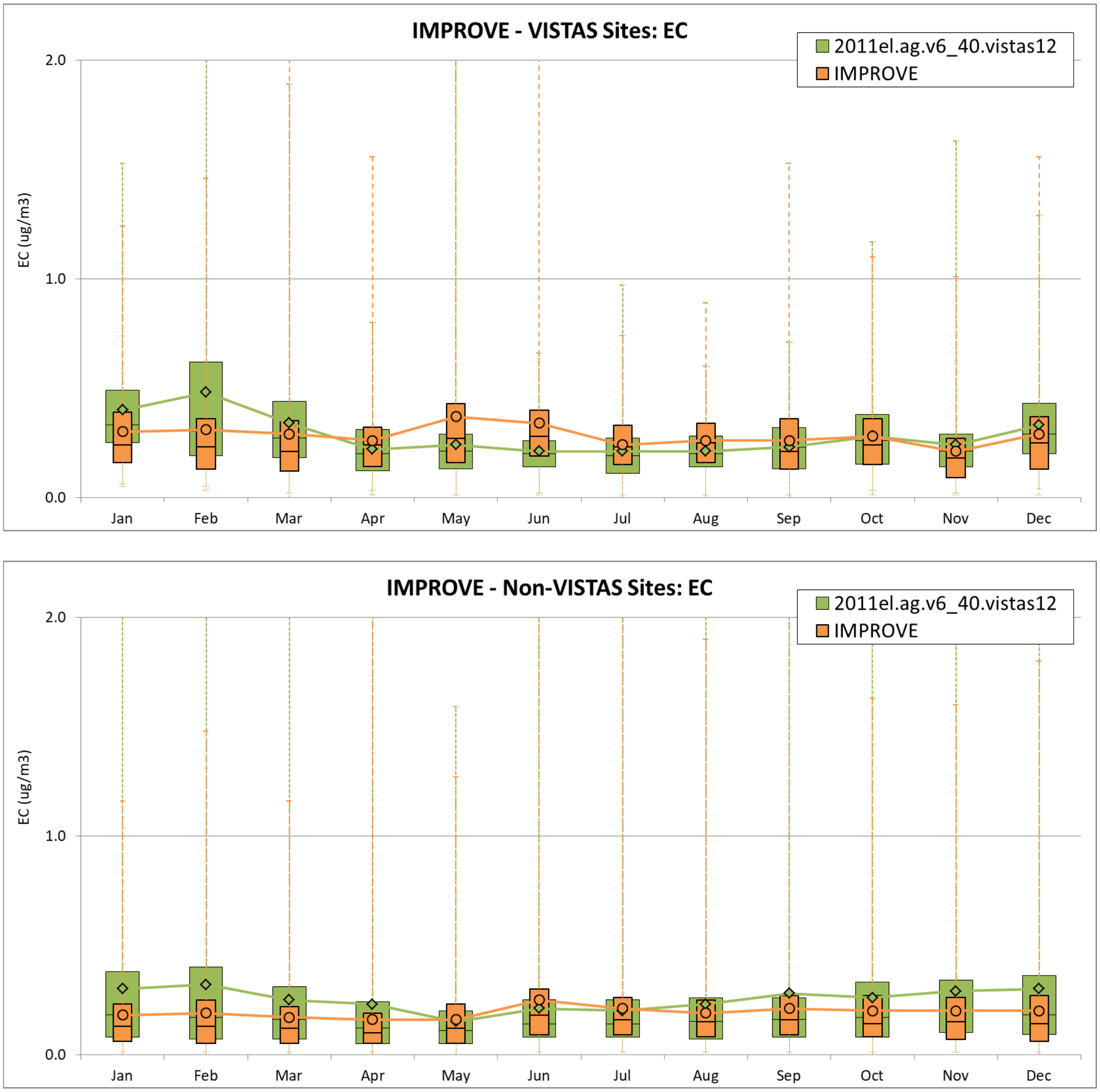
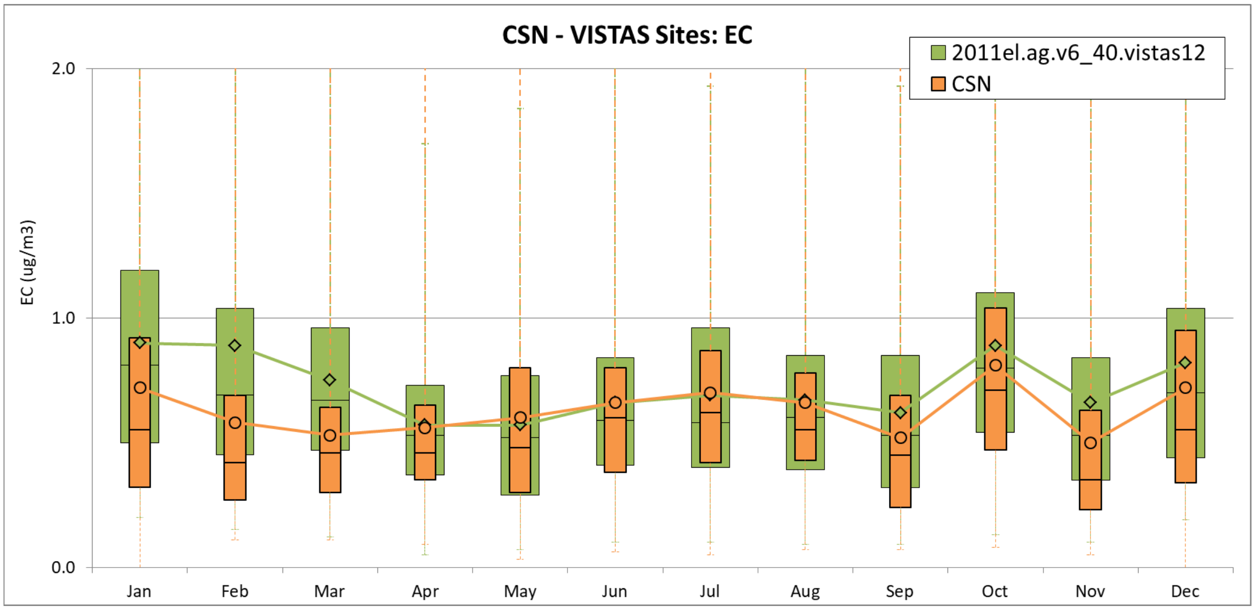


Figure 7-25. Boxplot Comparisons of Model Predictions and IMPROVE Elemental Carbon (EC) Observations for Each Climate Region by Month.



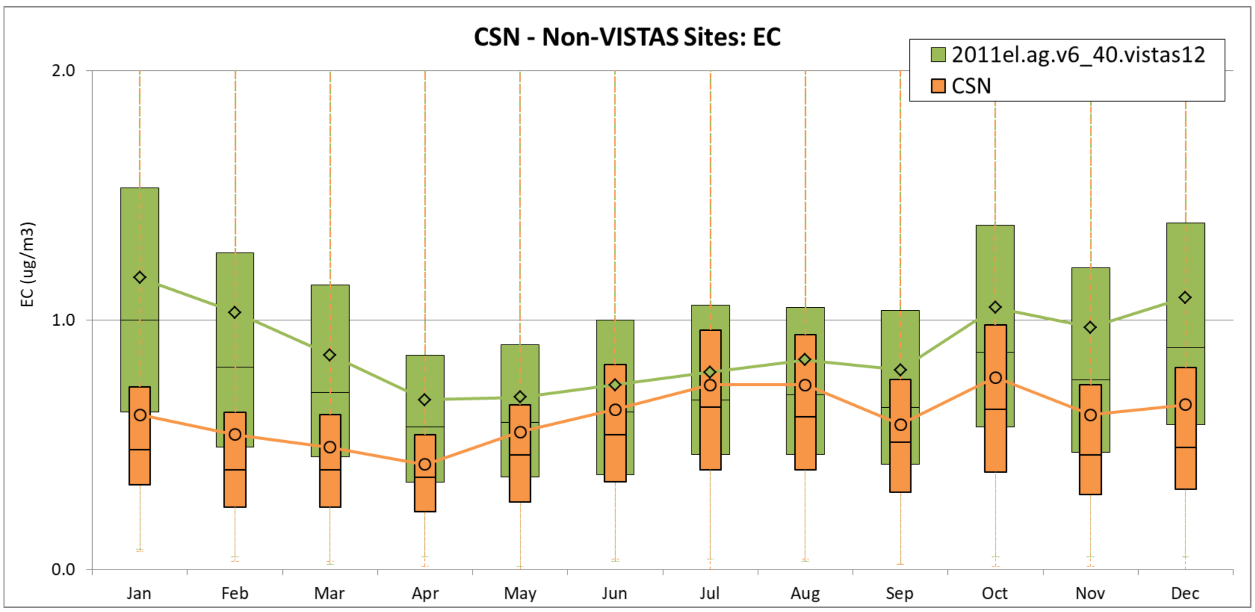


Figure 7-26. Boxplot Comparisons of Model Predictions and CSN Elemental Carbon (EC) Observations for Each Climate Region by Month.

7.2.6 Total $PM_{2.5}$

Table 7-9 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 presented in Figures 7-27 and 7-28.

$PM_{2.5}$ 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 7-9. 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

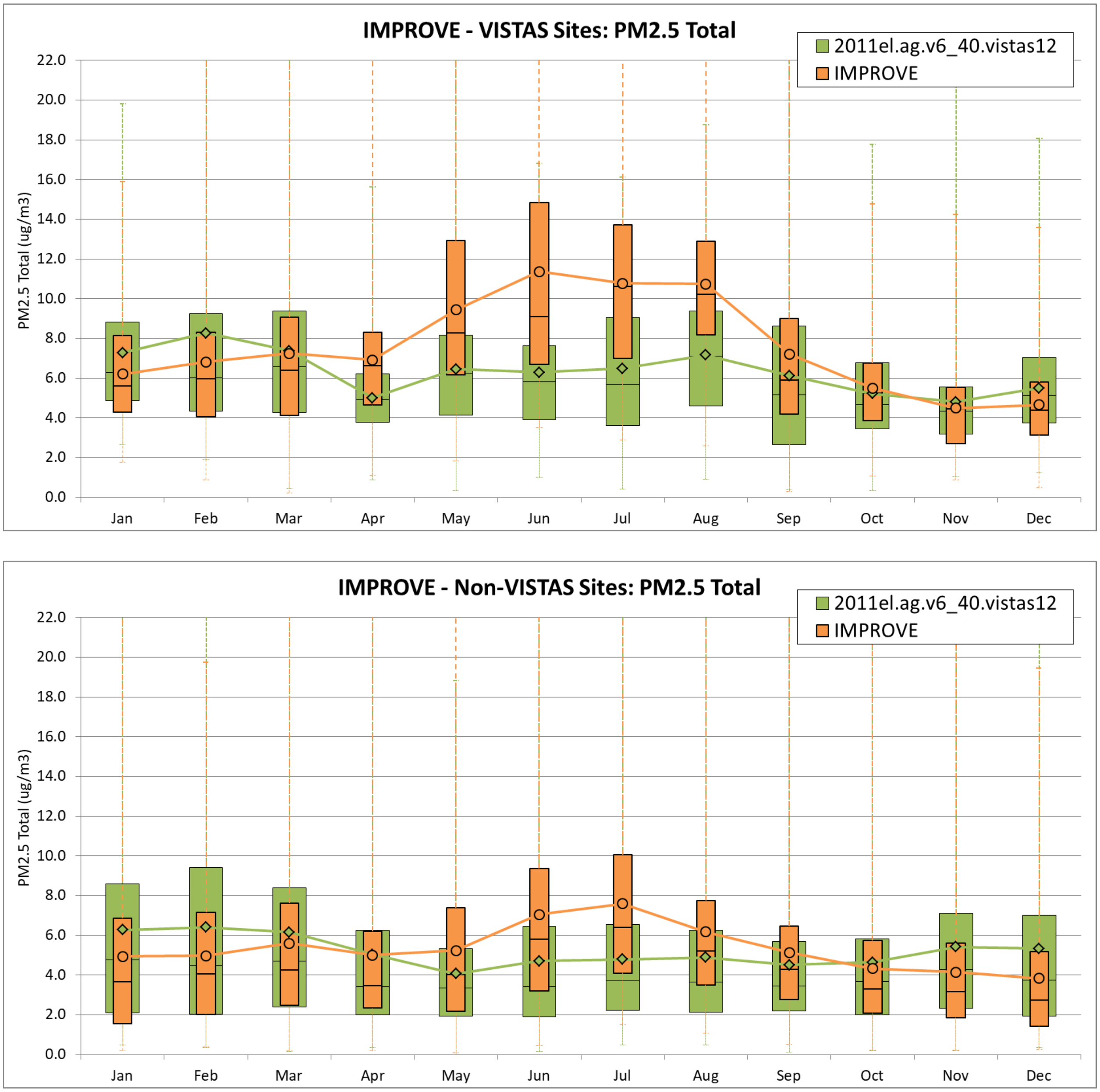
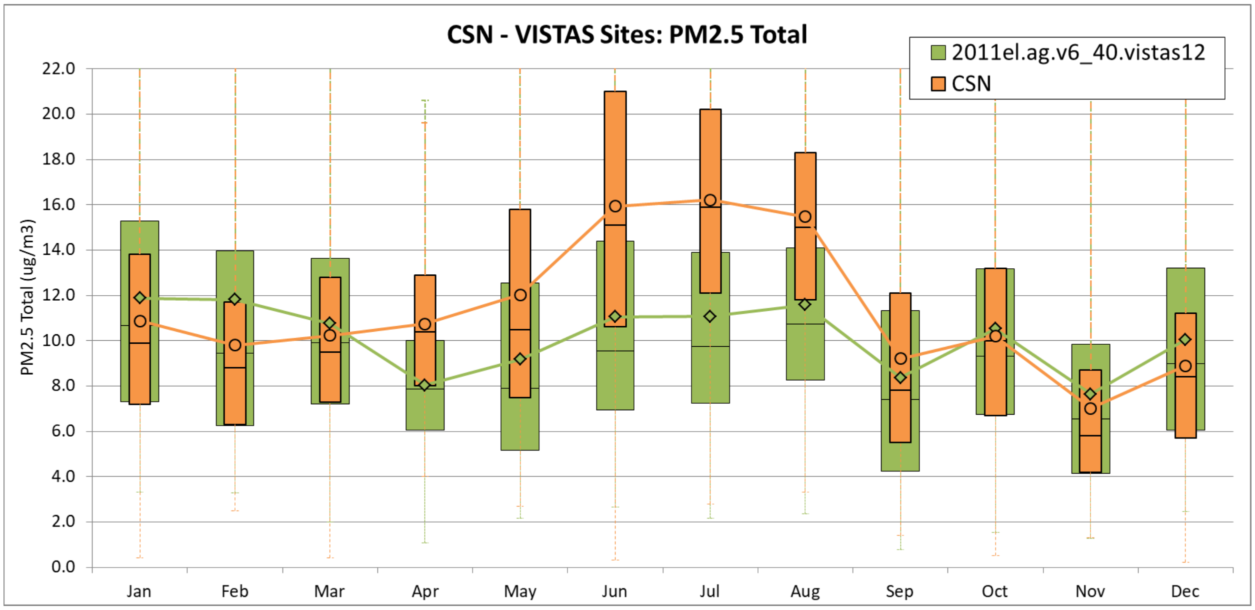


Figure 7-27. Boxplot Comparisons of Model Predictions and IMPROVE Total $PM_{2.5}$ Observations for Each Climate Region by Month.



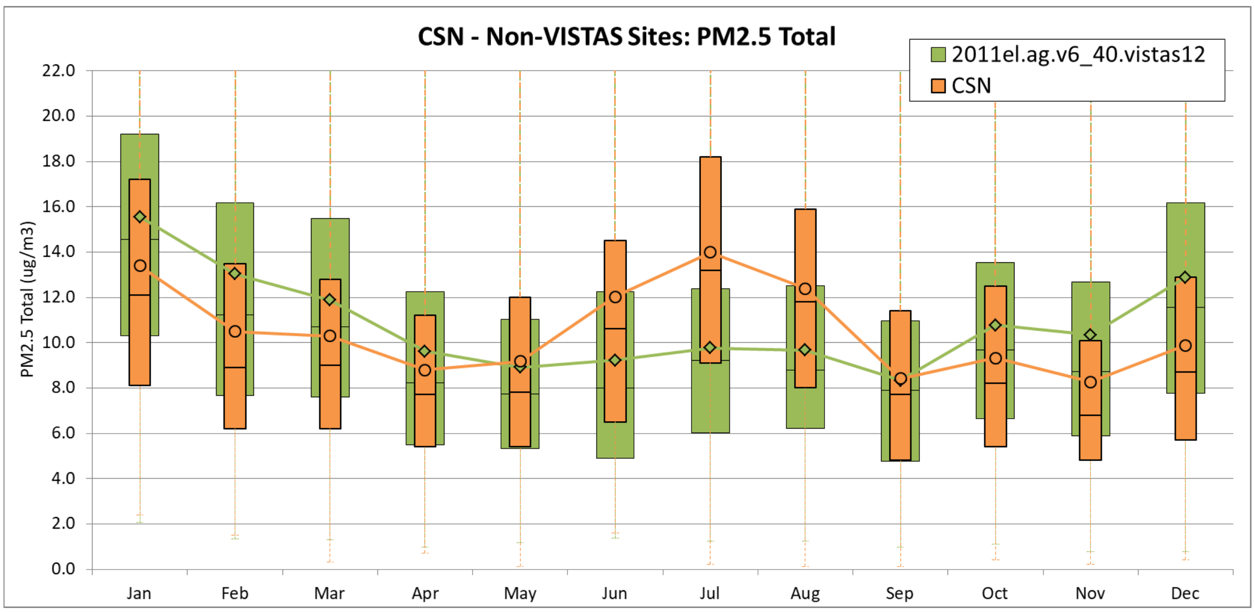


Figure 7-28. Boxplot Comparisons of Model Predictions and CSN Total $PM_{2.5}$ Observations for Each Climate Region by Month.

7.3 $PM_{2.5}$ Composition and Contribution to Light Extinction

As part of this deliverable, Alpine prepared an interactive Excel workbook in which each of the VISTAS_12 modeling domain's Class I areas for the $PM_{2.5}$ composition and contribution to light extinction can be generated. 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 (μg/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.

For example, daily concentration values by day are presented for SAMA's 20% clearest days on the top of Figure 7-29 below. The amount of light extinction due to each aforementioned species by day is displayed in the daily light extinction tab of the Excel workbook and an example is presented on the bottom of Figure 7-29. An example of the averaged concentration across all days is presented for SAMA's 20% clearest days on the left of Figure 7-30 below. The average amount of light extinction due to each species is displayed in the average light extinction tab of Excel workbook and an example is presented on the right of Figure 7-30.

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.[89]

[89] https://www.epa.gov/visibility/regional-haze-guidance-technical-support-document-and-data-file

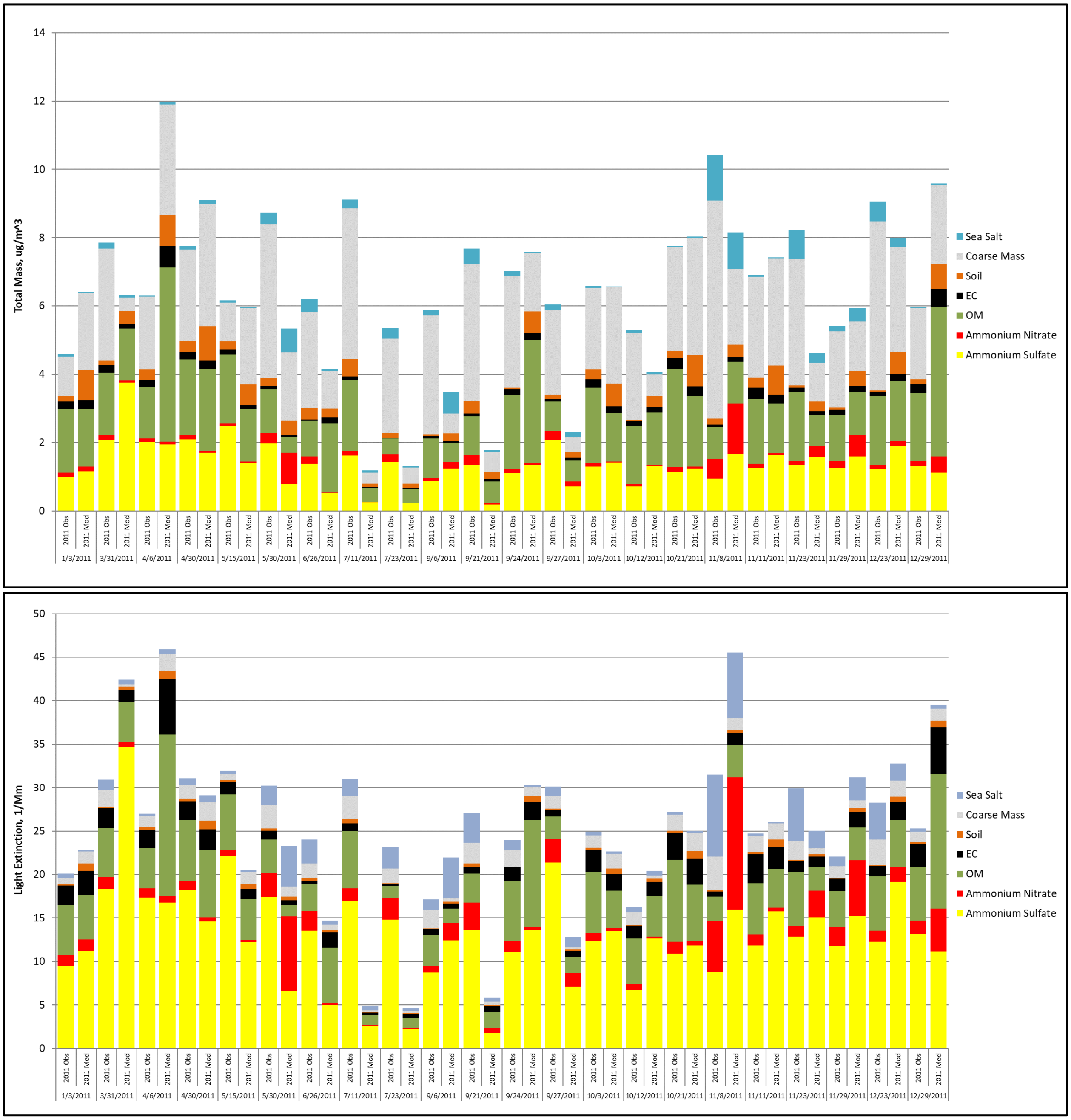


Figure 7-29. Example Daily Observed (Obs) and Predicted (Mod) Total Mass Concentrations (Top) and Light Extinctions (Bottom) at the St. Mark's Wildlife Refuge on the Observed 20% Clearest Days.

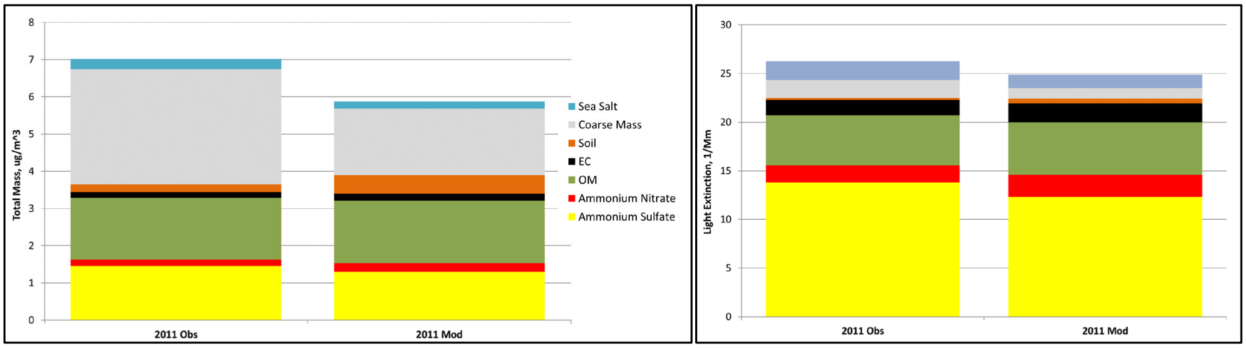


Figure 7-30. Example Averaged Observed (Obs) and Predicted (Mod) Total Mass Concentrations (Left) and Light Extinctions (Right) at the St. Mark's Wildlife Refuge on the Observed 20% Clearest Days.

7.4 Performance on 20% Most Impaired Days

Spatial plots summarizing IMPROVE observations and model NMB on the 20% most-impaired days are shown in Figures 7-31 through 7-36. In each figure the top graphic presents the observed concentration, and the bottom graphic presents the NMB.

For sulfate (Figure 7-31), 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 7-32) 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 7-33) 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 7-34) 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 $PM_{2.5}$ (Figure 7-35) 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 a mix of over- and under-predictions along boundaries with ocean water bodies (Atlantic Ocean and Gulf of Mexico) and is generally under predicted, as expected, across the rest of the VISTAS12 modeling domain (Figure 7-36).

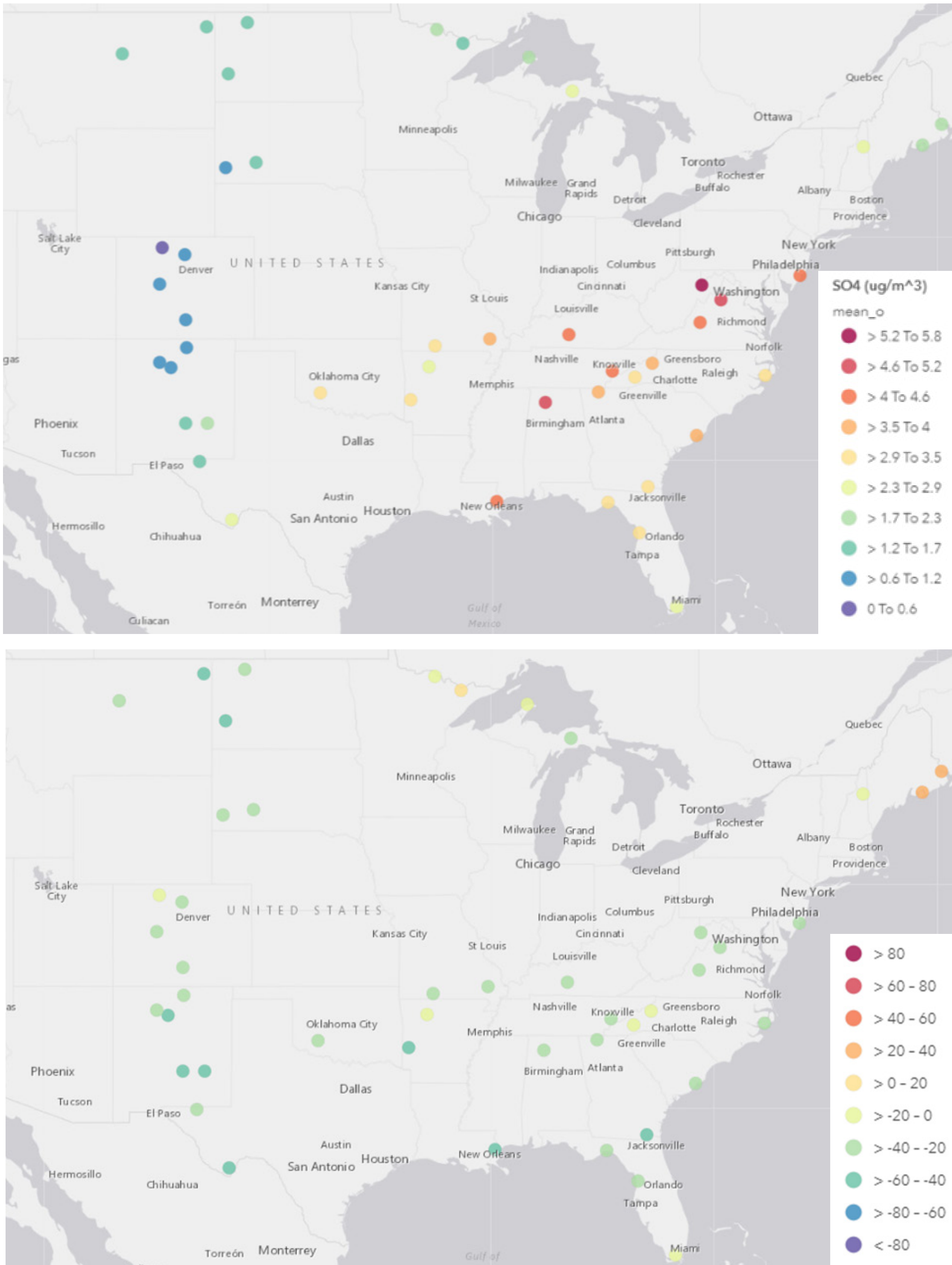


Figure 7-31. Observed Sulfate (Top) and Modeled NMB (Bottom) for Sulfate on the 20% Most-impaired Days at IMPROVE Monitor Locations.

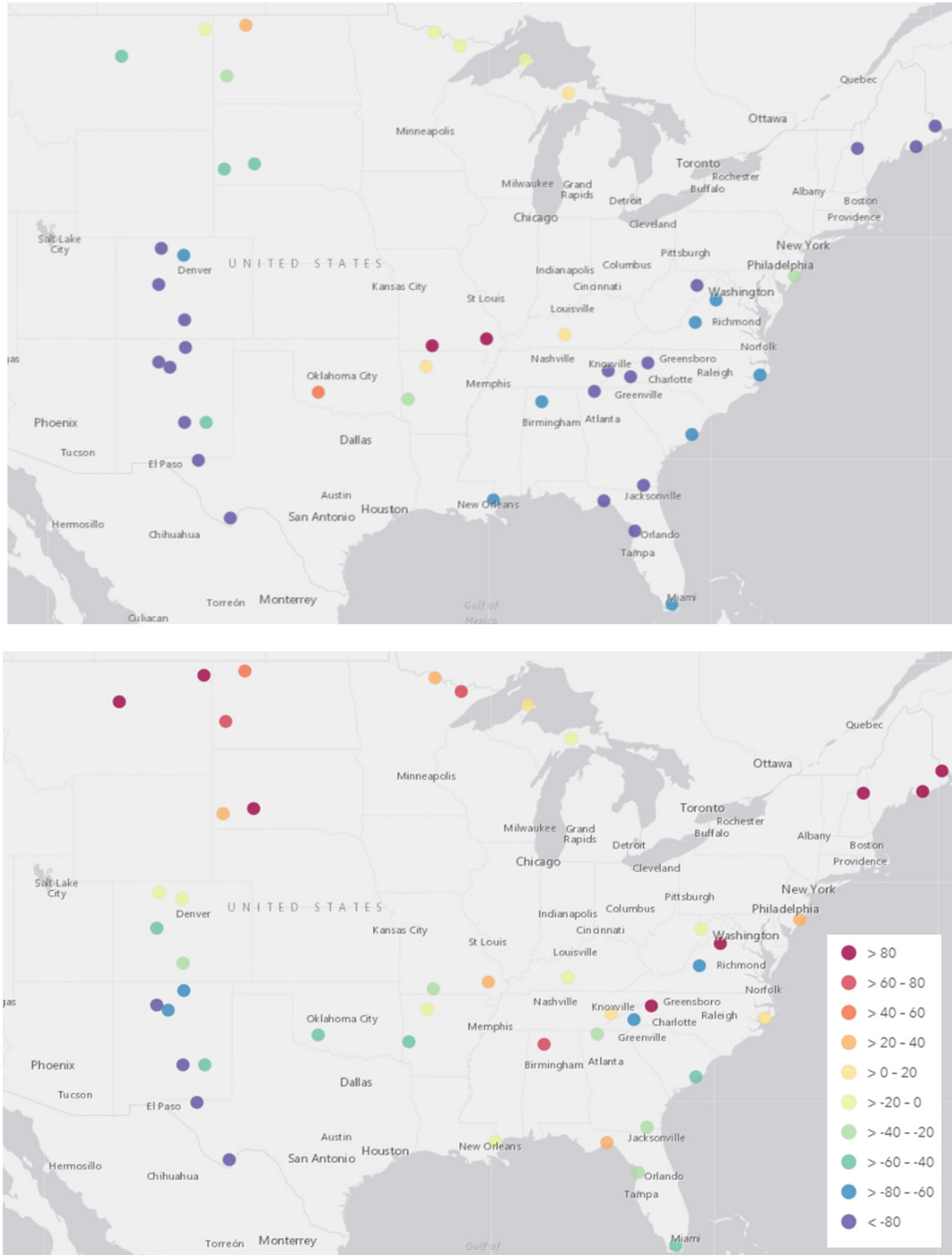


Figure 7-32. Observed Nitrate (Top) and Modeled NMB (Bottom) for Nitrate on the 20% Most-impaired Days at IMPROVE Monitor Locations.

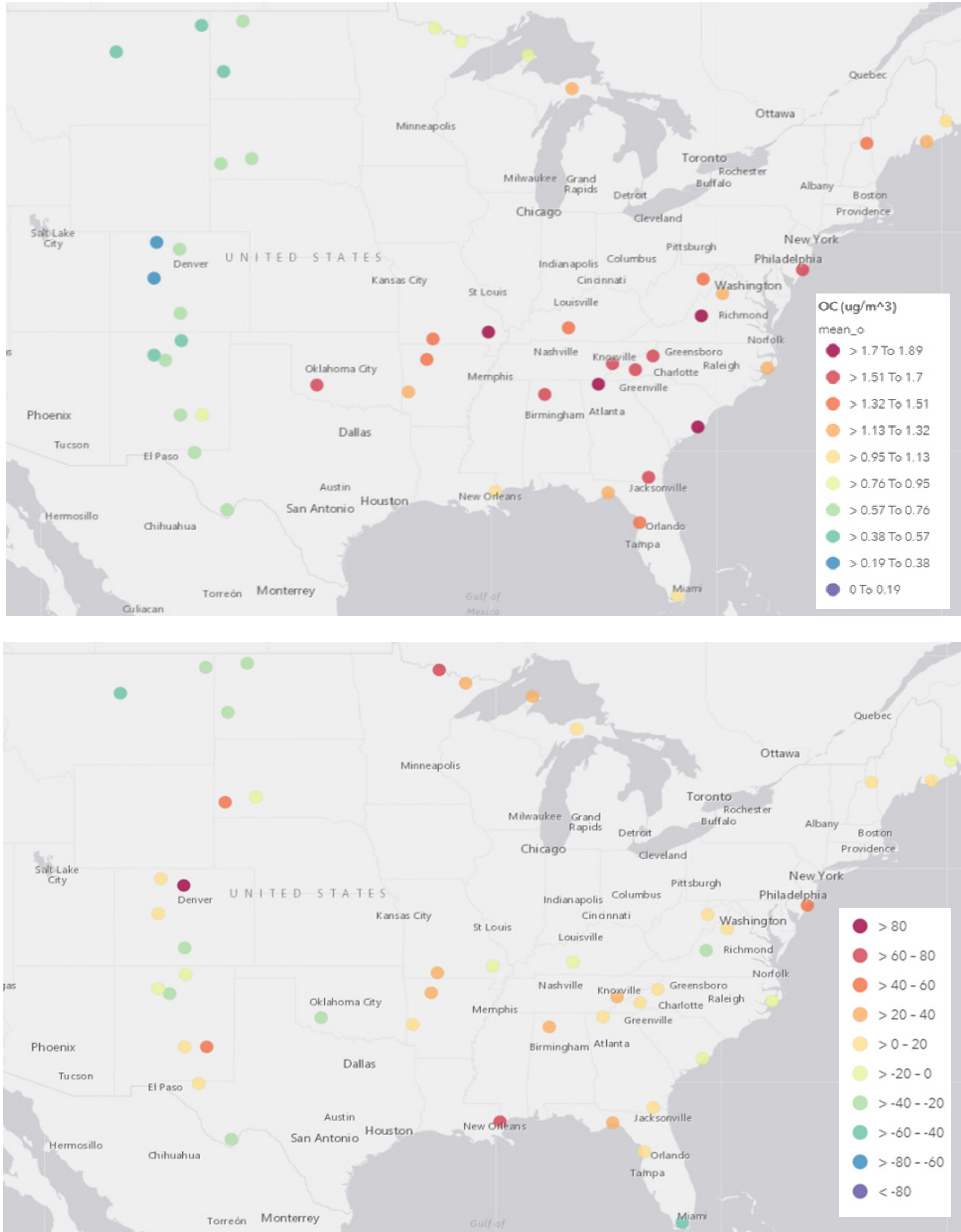


Figure 7-33. Observed OC (Top) and Modeled NMB (Bottom) for OC on the 20% Most-impaired Days at IMPROVE Monitor Locations.

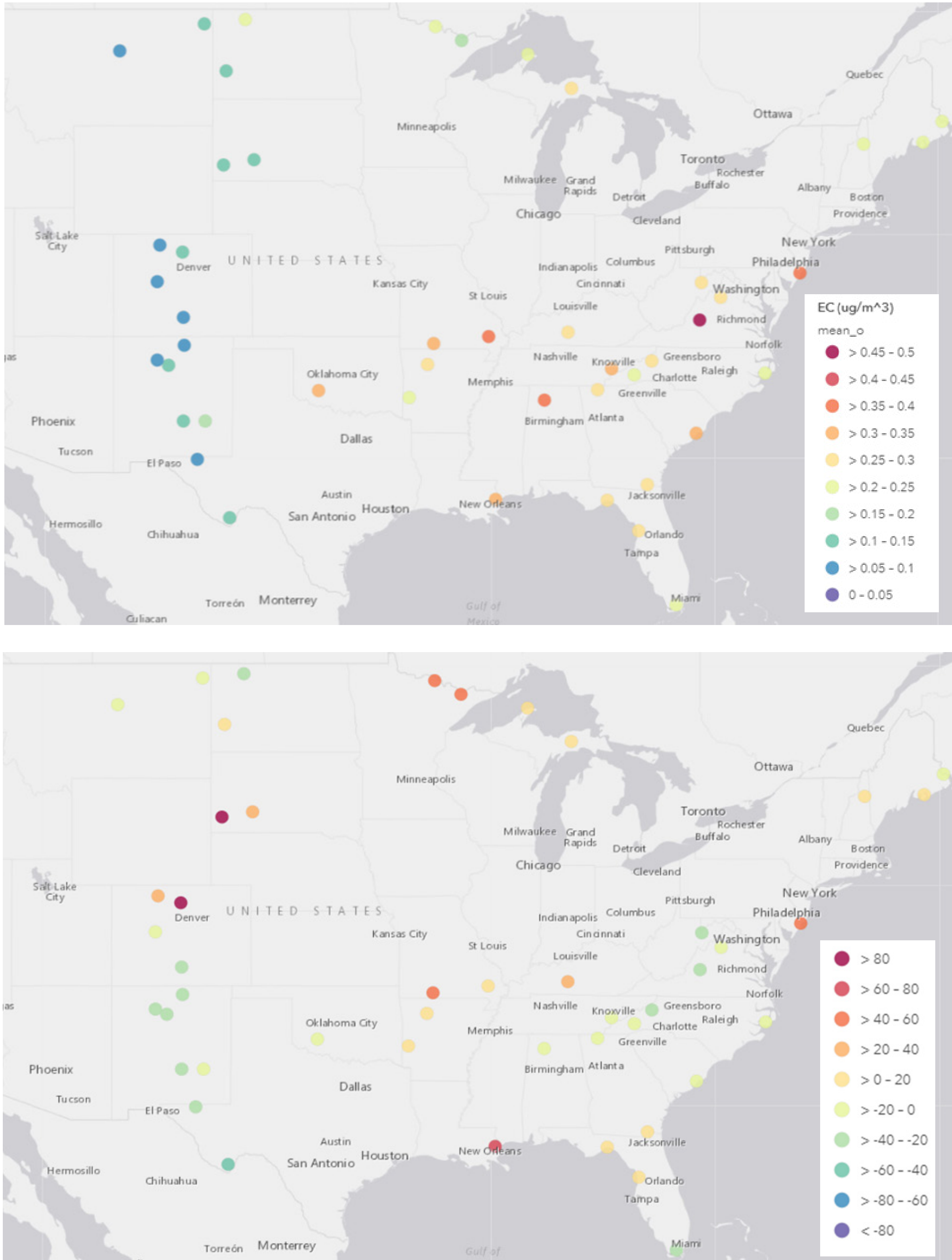
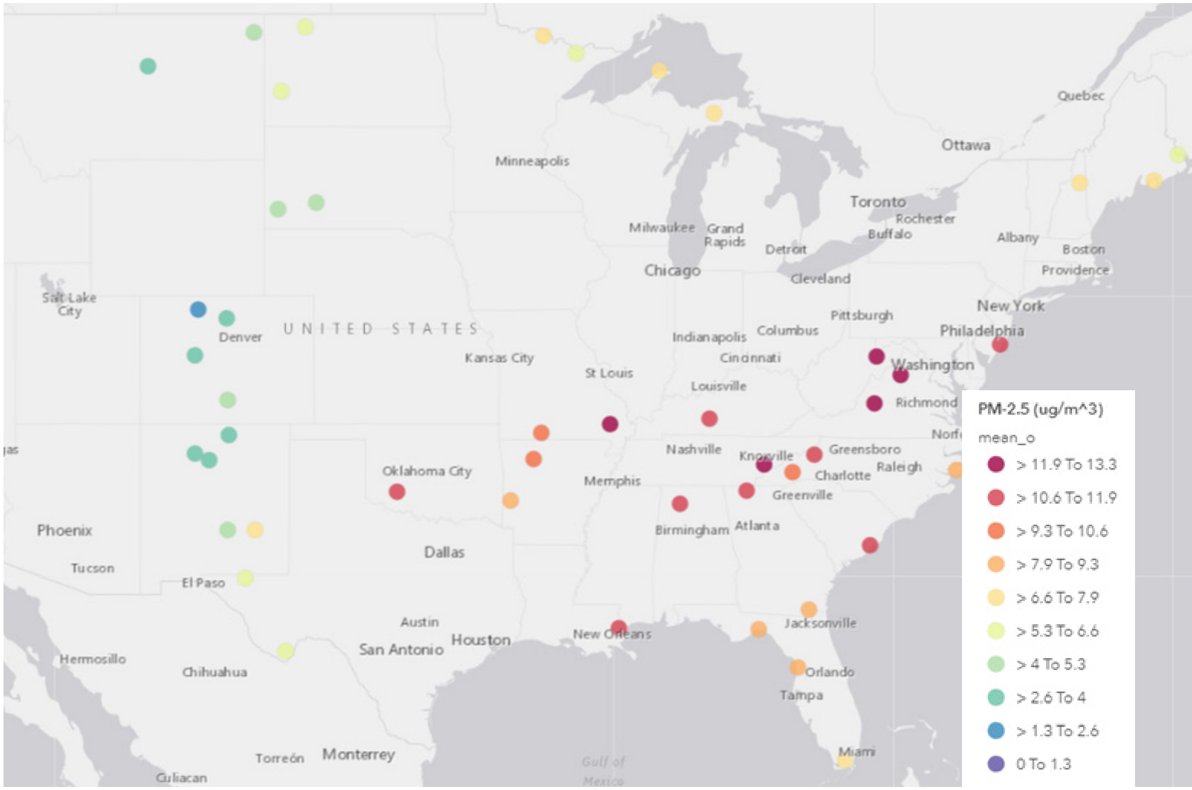


Figure 7-34. Observed EC (Top) and Modeled NMB (Bottom) for EC on the 20% Most-impaired Days at IMPROVE Monitor Locations.



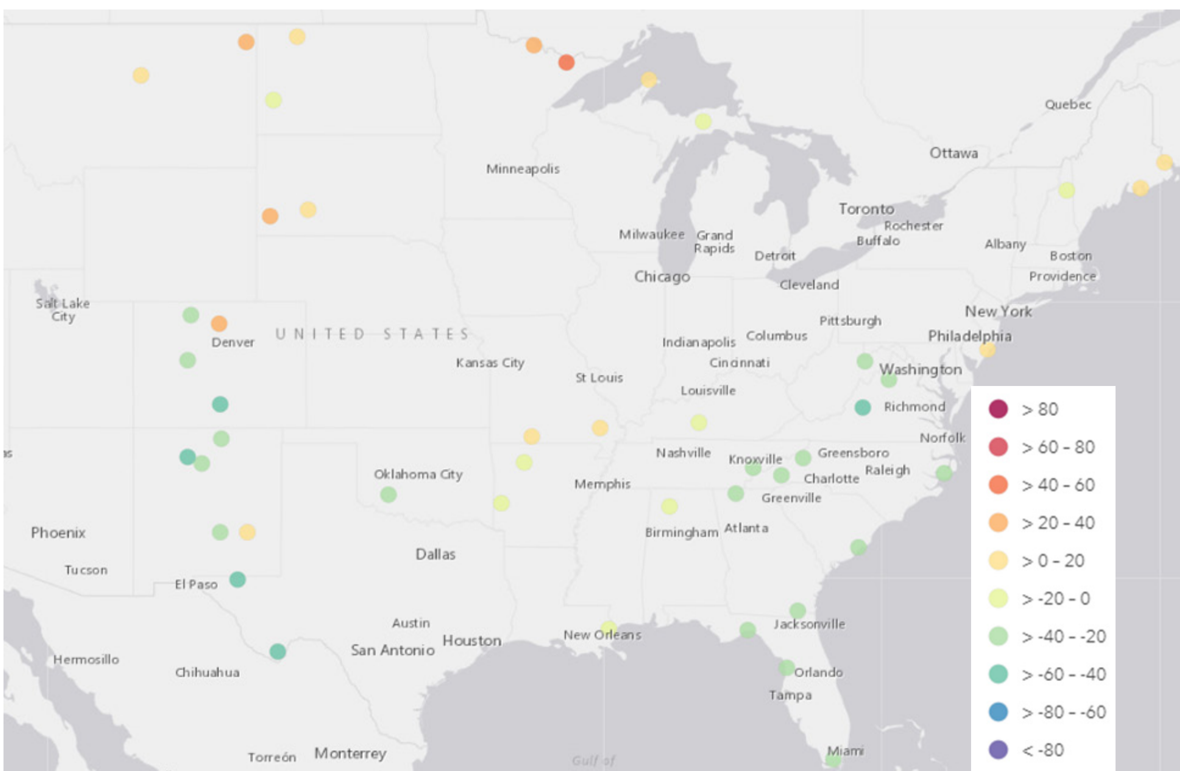
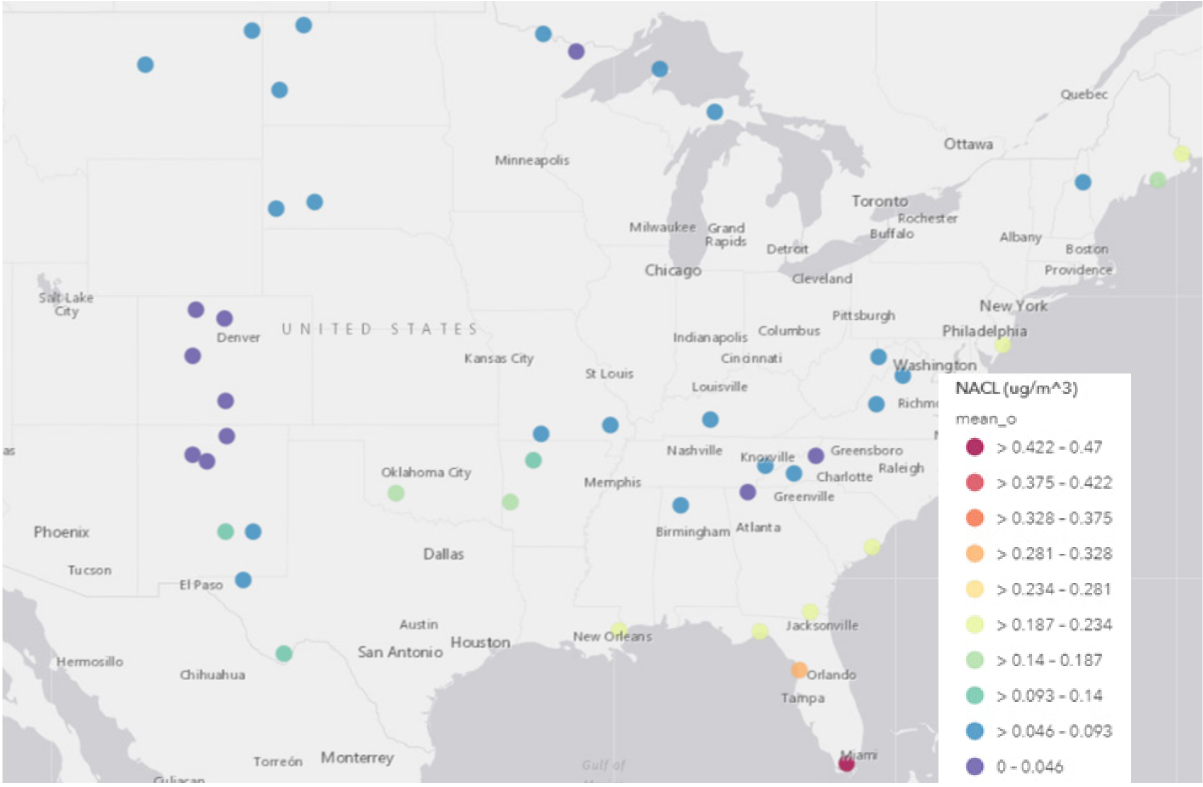


Figure 7-35. Observed Total $PM_{2.5}$ (Top) and Modeled NMB (Bottom) for Total $PM_{2.5}$ on the 20% Most-impaired Days at IMPROVE Monitor Locations.



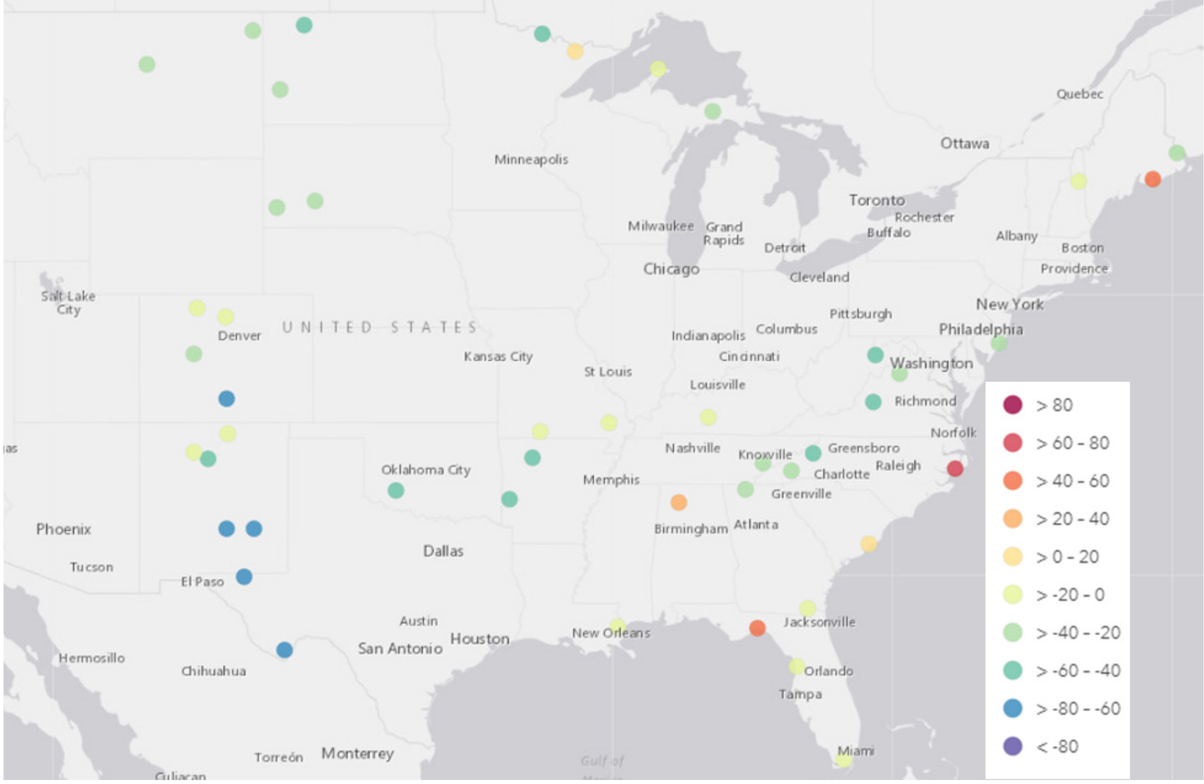


Figure 7-36. Observed NACL (Top) and Modeled NMB (Bottom) for NACL on the 20% Most-impaired Days at IMPROVE Monitor Locations.

7.5 Deposition MPE

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 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.

7.5.1 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 NADP,[90] which consists of the following monitoring networks:

- NTN
- AIRMoN
- MDN
- AMNet
- 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 CASTNET. These data were also collected and are 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 7-37 presents the spatial distribution of these deposition networks across the United States.

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90 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/

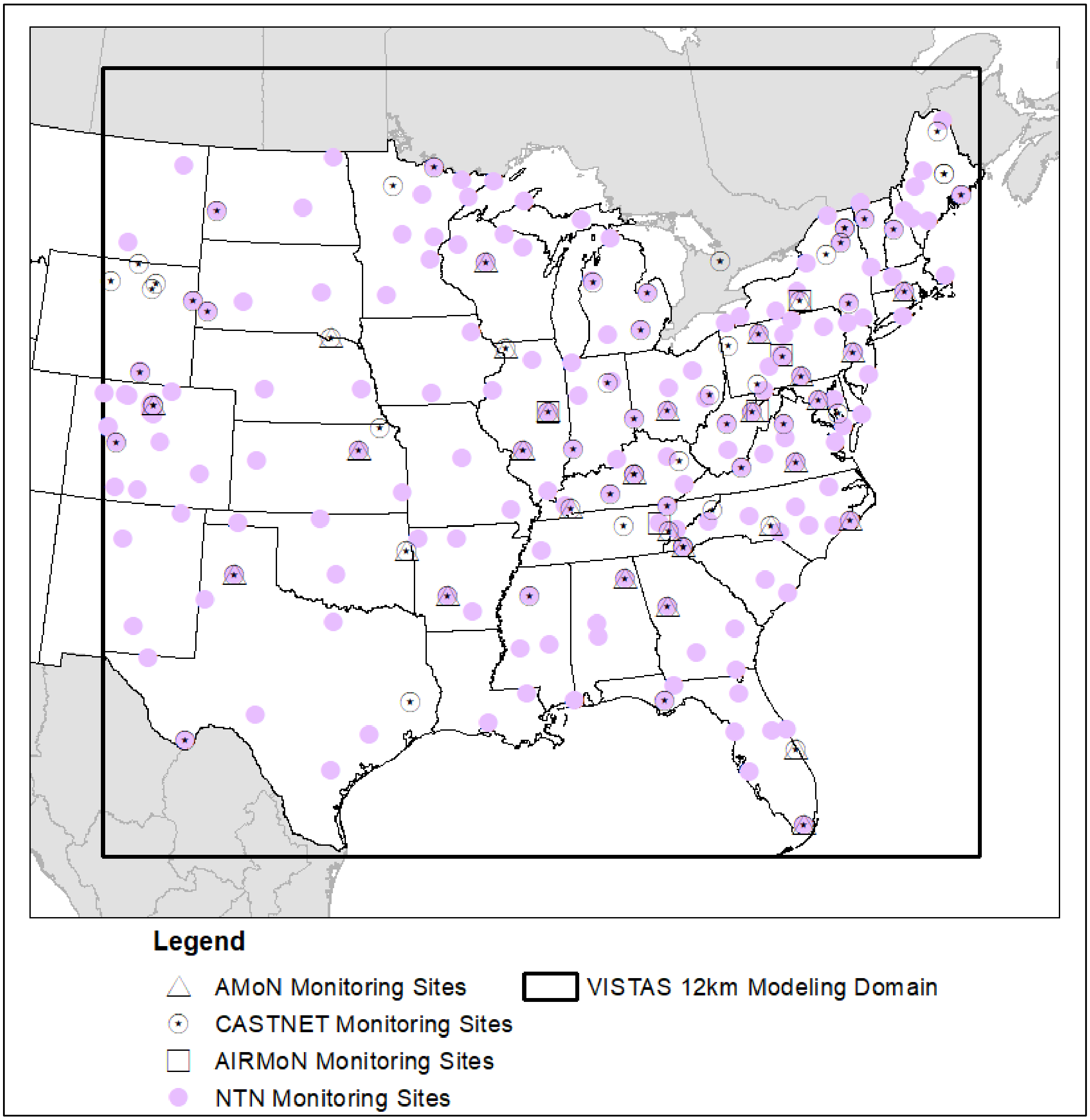

Figure 7-37. Deposition Monitors Included in the VISTAS II Database

Table 7-10 summarizes the measurements available from each deposition monitoring network. Each network is discussed separately in the following sections.

Table 7-10. 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)[91] for each site. The MLM generated deposition velocities are available for download with the CASTNET 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.[92]

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[91] 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.

[92] 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

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 a geographic area-weighted V_d over vegetation types within 1.0 km.[93] 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.

7.5.2 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 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 includes 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.

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[93] 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

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.[94] 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.[95]

7.5.3 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.

7.5.4 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.

7.5.5 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[96] 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[97]. While not entirely observed truth, these hybrid

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[94] 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.

[95] 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)

[96] http://nadp.slh.wisc.edu/committees/tdep/tdepmaps/

[97] 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

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 Community Multiscale Air Quality (CMAQ) model 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 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[98].

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 to the underlying NEI (including updates to point sources, nonpoint sources, and fires), the switch to MOVES2014a and updates to international emissions.[99] Given these differences in modeling platforms, it is not surprising that there are differences in between the two model outputs. However, there are some similarities.

Wet deposition of particulate NH_4^+ has a comparable spatial pattern between the two models. As Figure 7-38 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 7-39) 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-}.

98 ftp://ftp.epa.gov/castnet/tdep/grids/; ftp://ftp.epa.gov/castnet/tdep/images/

99 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

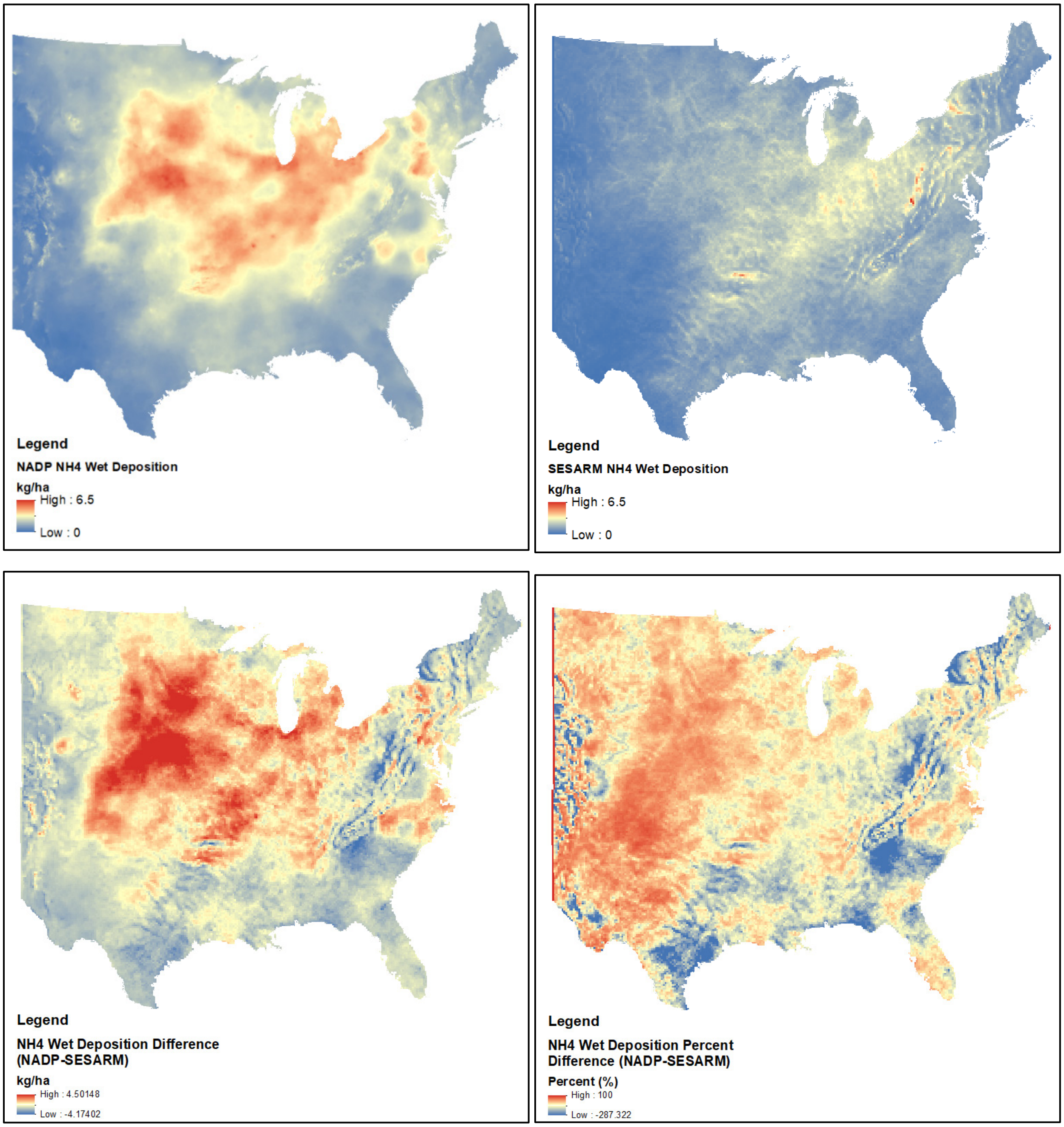

Figure 7-38. Plots of Total Annual Particulate NH_4^+ Wet Deposition. NADP Wet Deposition (top left), SESARM Wet Deposition (top right), Difference (bottom left), Percent Difference[100] (bottom right).

[100] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

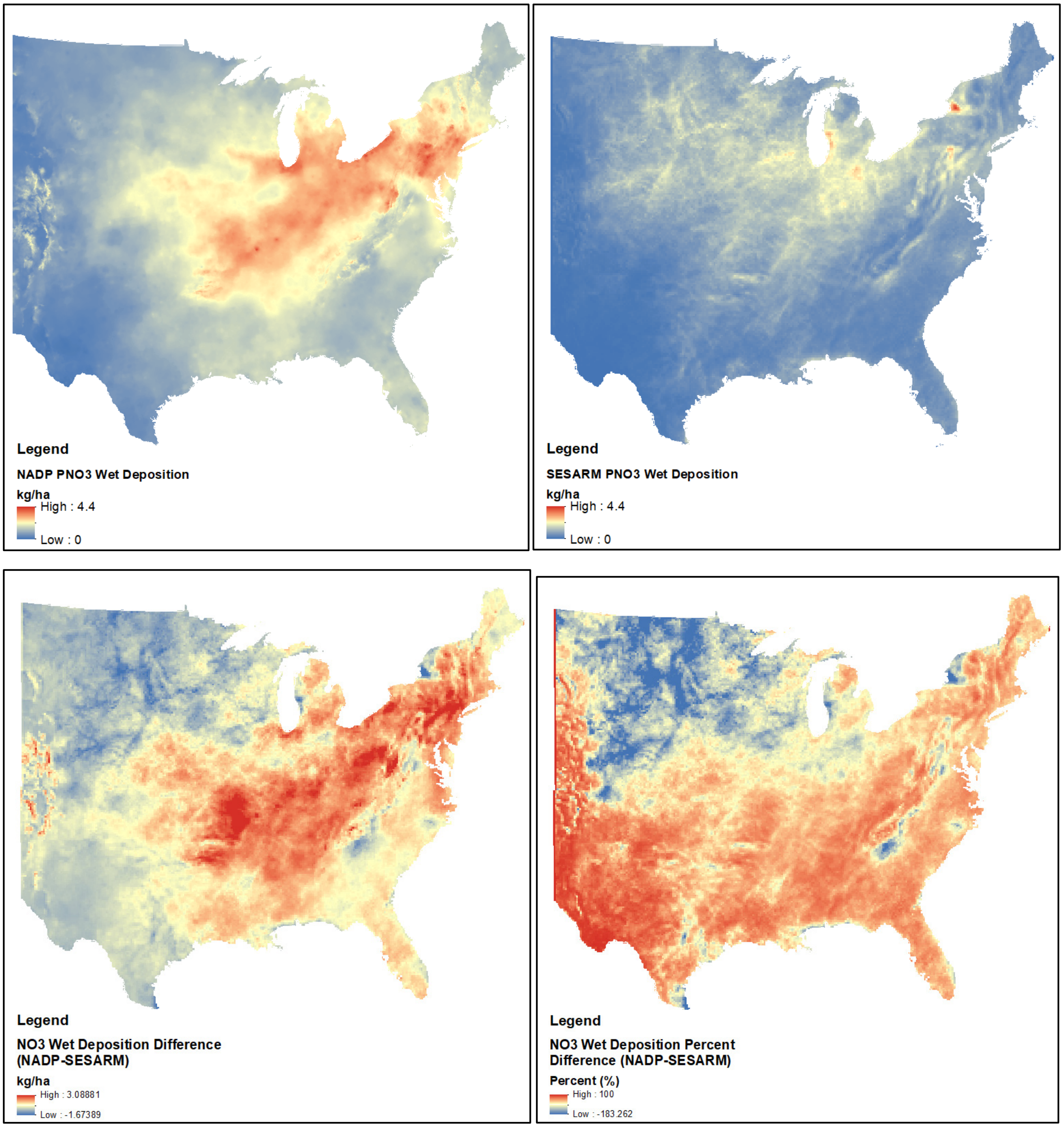

Figure 7-39. Plots of Total Annual Particulate NO_3^+ Wet Deposition. NADP Wet Deposition (top left), SESARM Wet Deposition (top right), Difference (bottom left), Percent Difference[101] (bottom right).

The dry deposition patterns for NH_4^+ (Figure 7-40) is not as well matched as the wet deposition pattern. The VISTAS12 modeling tends to highlight the urban areas, as areas like Chicago, Detroit,

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[101] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

Cleveland, and other Midwestern population centers show up as hot spots on the map. This pattern holds for NO_3^+ (Figure 7-41) and SO_4^{2-} (Figure 7-42). Overall, the differences seen in the patterns of deposition are to be expected, as the two sets of modeling did use different emissions inventories.

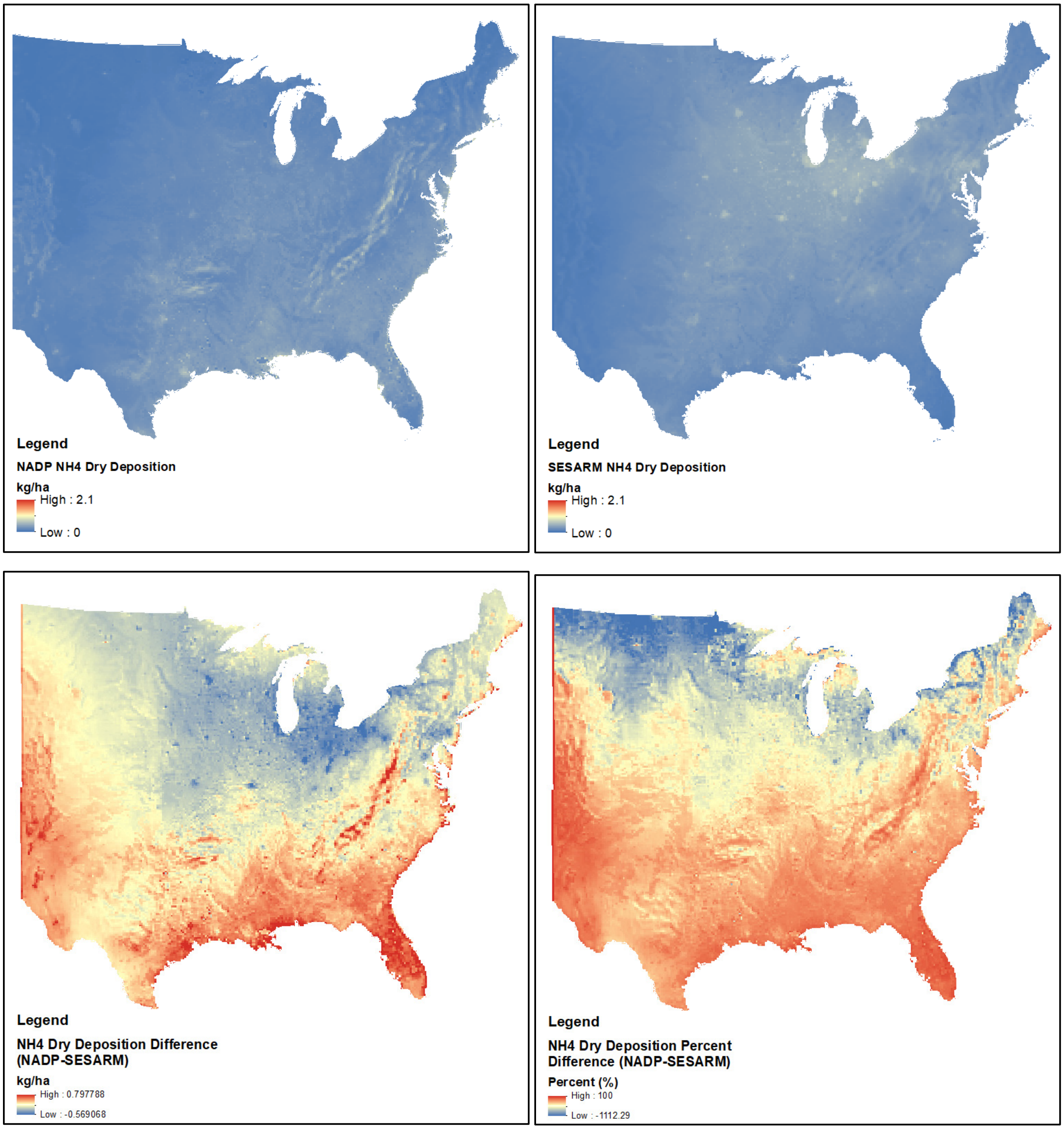

Figure 7-40. Plots of Total Annual Particulate NH_4^+ Dry Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference[102] (bottom right).

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[102] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

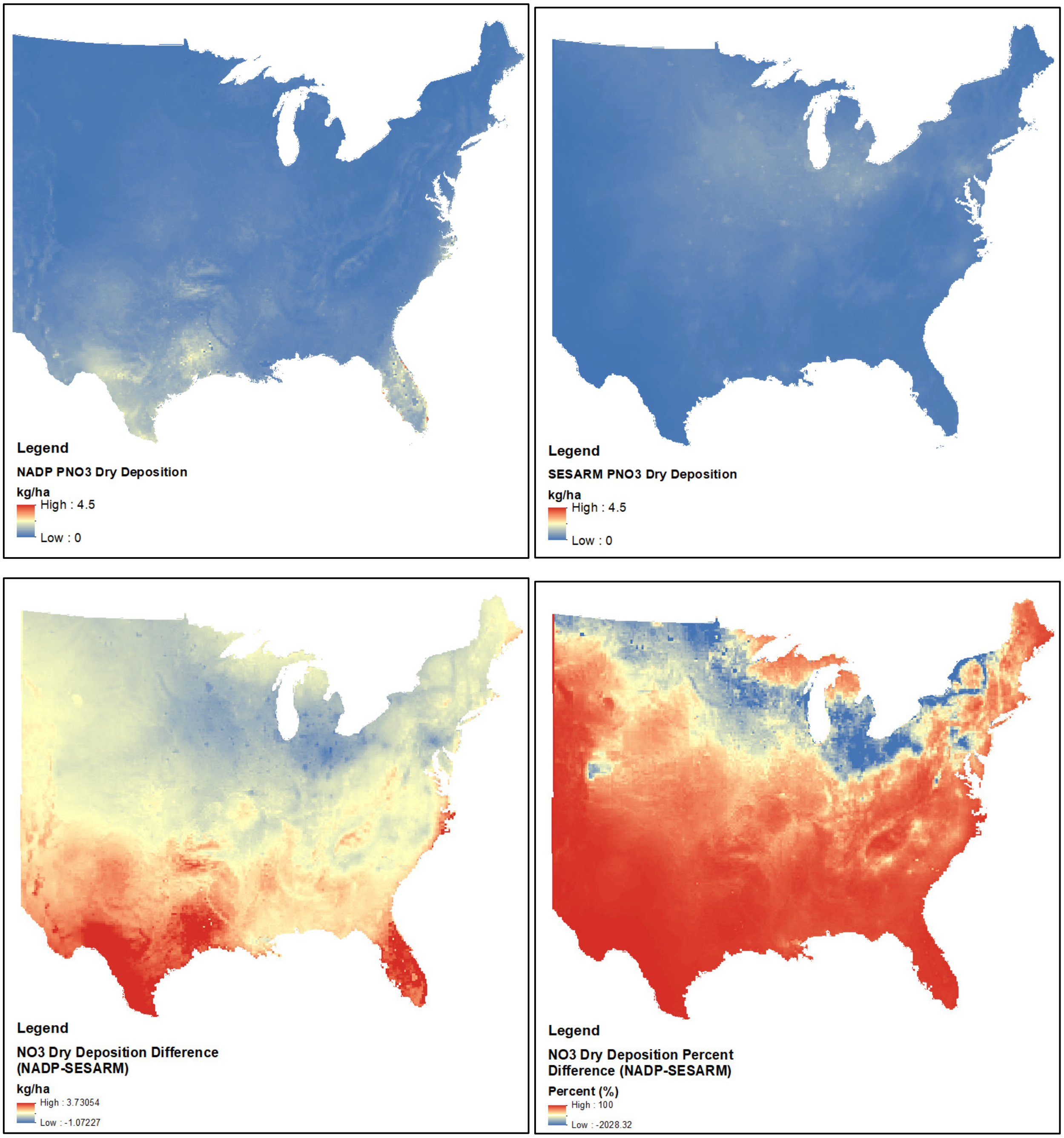

Figure 7-41. Plots of Total Annual Particulate NO_3^+ Dry Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference[103] (bottom right).

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103 Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

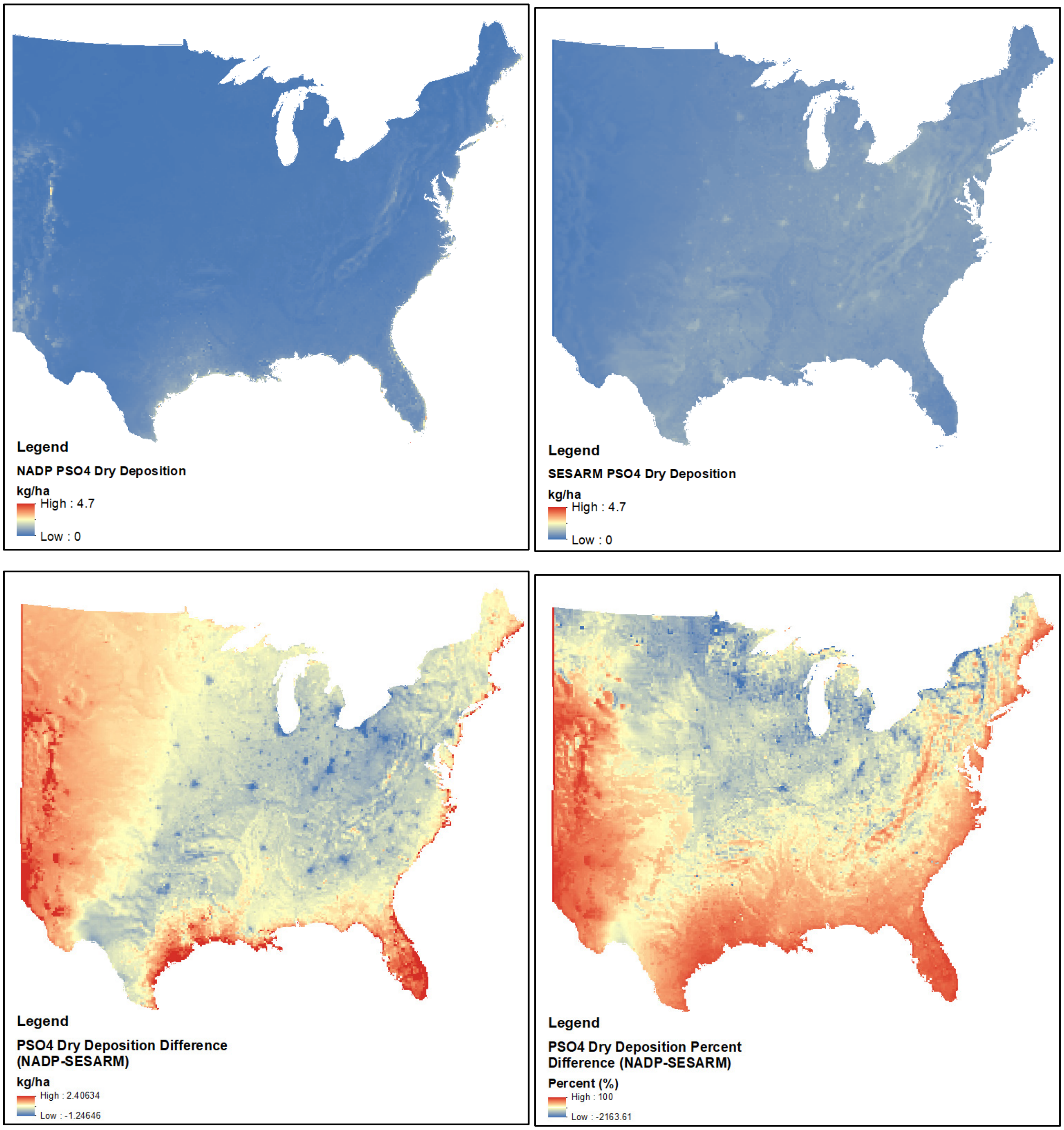


Figure 7-42. Plots of Total Annual Particulate SO_4^{2-} Deposition. NADP Dry Deposition (top left), SESARM Dry Deposition (top right), Difference (bottom left), Percent Difference[104] (bottom right).

[104] Percent Difference = 100*[(NADP Deposition) – (SESARM Deposition)]/(NADP Deposition)

8.0 VISTAS II PSAT MODELING

This section summarizes the PSAT modeling for select emissions sources or groups of sources]. Activities related to Task 8 are presented at: https://www.metro4-sesarm.org/content/source-apportionment-modelingtagging

Under Task 7, ERG authorized Alpine to developing PSAT modeling results by tagging select facilities and geographic areas. A "tag" can be identified as a specific source, or group of sources. Sources of interest are for those emitting SO_2 and/or NO_x.

8.1 PSAT Overview

In order to gain a better understanding of the source contributions to modeled visibility, Alpine used CAMx PSAT modeling.[105] 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)[106]
- 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.[107]

Although an update of the 2028 emissions was completed in March 2020, the PSAT modeling was not rerun.

8.2 PSAT Tags

SESARM worked with its stakeholders and surrounding regional planning organizations (RPOs) within the VISTAS modeling domain to compile a list of 209 tags for PSAT analysis. The starting point

105 More information on CAMx modeling can be found at: http://www.camx.com/home.aspx

106 PEC = primary elemental carbon; POA = primary organic carbon; FCRS = crustal fraction of PM; FPRM = fine other particulate (diameter ≤ 2.5 µm); CCRS = Coarse PM species (CAMx PM species); CPRM = Coarse PM

107 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."

for identifying tags were the results of Task 5, AOI Analysis.[108] Under Task 5, Class I-specific workbooks within the VISTAS modeling domain were created from combining HYSPLIT back trajectories, NO_x and SO_2 emissions inventories (facility-level and county-level),[109] and 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:

- CENRAP;
- MANE-VU;
- LADCO; and
- WRAP.

As a result of this consultation, two groups of PSAT tagging for SO_2 and NO_x emissions were conducted. Group 1 is presented in Table 8-1 for groups of sources (70 tags) and Group 2 is presented in Table 8-2 for individual facilities (209 tags). Each of these emissions sources or source sectors were processed through SMOKE software and tracked in PSAT as individual source tags. For this application, only sulfate and nitrate were tracked using PSAT.

Table 8-1. Regional-Category Combination Tags

Tag Name	Tagging Description
All NOx	Individual SESARM states, CENRAP, LADCO, MANE-VU
All SO_2	Individual SESARM states, CENRAP, LADCO, MANE-VU
Point EGU NOx	Individual SESARM states, CENRAP, LADCO, MANE-VU
Point EGU SO_2	Individual SESARM states, CENRAP, LADCO, MANE-VU
Point non-EGU NOx	Individual SESARM states, CENRAP, LADCO, MANE-VU
Point non-EGU SO_2	Individual SESARM states, CENRAP, LADCO, MANE-VU
All NOx Boundary Conditions	North, South, East, West
All SO_2 Boundary Conditions	North, South, East, West

108 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.

109 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.

Table 8-2. 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
AL	01129-1028711	American Midstream Chatom, LLC	073	AL	3,106	426
AL	05063-1083411	Entergy Arkansas Inc-Independence Plant	056	AR	32,050	14,133
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	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	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	020,074	FL	1,520	1,831
FL	12129-2731711	Tallahassee City Purdom Generating Sta.	078	FL	3	121
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

Table 8-2. 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)
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.	023,080	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
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
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
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
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	028,088	NC	4,846	496
NC	37023-8513011	SGL Carbon LLC	089	NC	262	22
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	029,085	NC	1,127	2,992
NC	37117-8049311	Domtar Paper Company, LLC	086	NC	687	1,796

Table 8-2. 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)
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
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
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	45015-4834911	Alumax of South Carolina	030	SC	3,752	108
SC	45015-8306711	SCE&G Williams	092	SC	392	993
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
SC	45043-6652811	Santee Cooper Winyah Generating Station	091	SC	2,247	1,773
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	040,095	VA	2,290	1,973
VA	51027-4034811	Jewell Coke Company LLP	041,093	VA	5,091	520
VA	51580-5798711	Meadwestvaco Packaging Resource Group	042,094	VA	2,115	1,986

Table 8-2. 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	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
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. However, as the emissions from this source were at an airport, and occurring in the first vertical layer, and thus not conducive for PSAT modeling. 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.

8.3 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 the Software for the Modeled Attainment Test (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 8-3.

Table 8-3. Matching of CAMx Raw Output Species to SMAT Input Variables

SMAT Species	Raw CAMx 6.40 Species
Sulfate (SO_4)[1]	PSO4
Nitrate (NO_3)[1]	PNO3
Ammonium (NH_4)[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 ($PM_{2.5}$)[2]	PSO4+PNO3+PNH4+POA+PEC+FCRS+FPRM+SOA1+SOA2+SOA3+ SOA4+SOPA+SOPB+NA[3]+PCL[3]

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.
3 NA = sodium; PCL = chlorine

8.4 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 8-4 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 8-4. 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-Community Edition (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 approach to prepare the SMAT input files, running the SMAT software, and analyzing the results are in the Task 7 final report.[110]

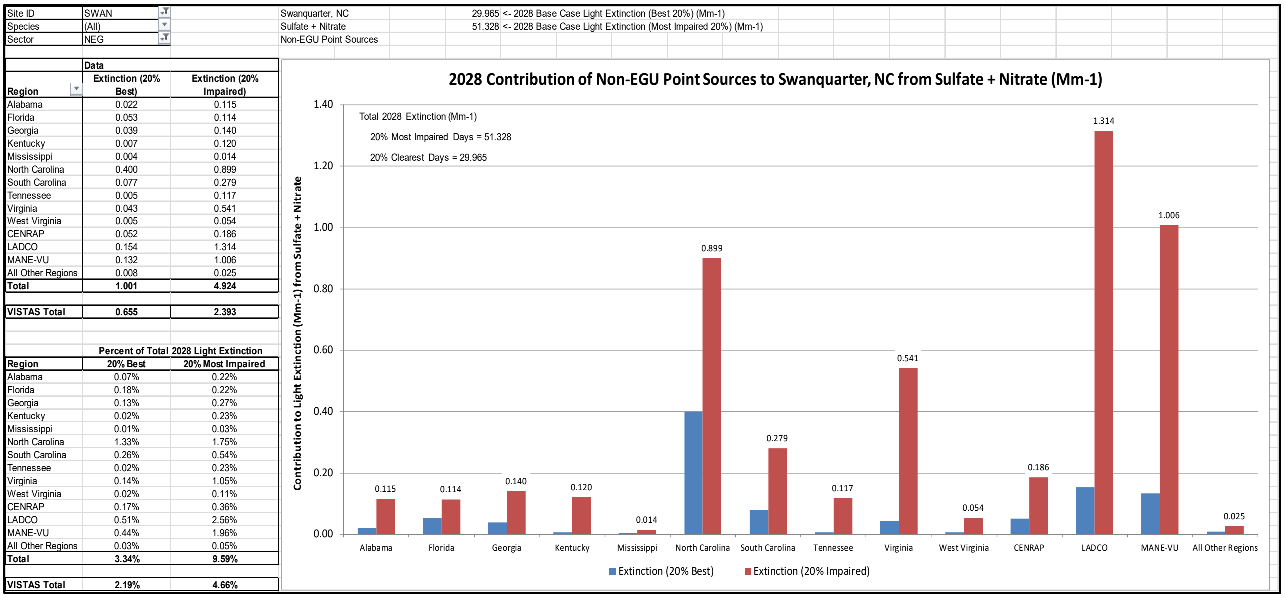
8.5 Sector Tag Result

The sector and facility tag modeling results were consolidated into an Excel workbook ("ATTACHMENT_A_PSAT_TAG_RESULTS.xlsm") which accompanied the final report. Examples for each type of product with dynamic features are presented below.

8.5.1 Area By Sector

The "Area By Sector" results present 2028 contributions from source regions-category combinations to light extinction on the 20% clearest and 20% most anthropogenically impaired days to a single Class I area. Figure 8-1 presents an example of this output.

110 "Particulate Source Apportionment Technology Modeling Results, Task 7." Final Report, 8/17/2020.



Site ID	SWAN	
Species	(All)	
Sector	NEG	

Swanquarter, NC 29.965 <- 2028 Base Case Light Extinction (Best 20%) (Mm-1)
Sulfate + Nitrate 51.328 <- 2028 Base Case Light Extinction (Most Impaired 20%) (Mm-1)
Non-EGU Point Sources

Region	Data: 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

Region	Percent of Total 2028 Light Extinction: 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 8-1. Area by Sector PivotChart and Table Example

Dynamic options for this product include:

- Choice of Class I areas to which regions-categorycombinations contribute.
- Choice of [S]ulfate, [N]itrate, or both [S] and [N] may be selected.
- Choice of 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.

8.5.2 Sector To Area

The “Sector To Area” results present 2028 contributions from source regions-category combinations to light extinction on the 20% clearest and 20% most anthropogenically impaired days to all Class I areas. Figure 8-2 presents an example of this output.

Region	Georgia		Georgia
Sector	ALL		All Anthro + Natural Sources
Species	(All)		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

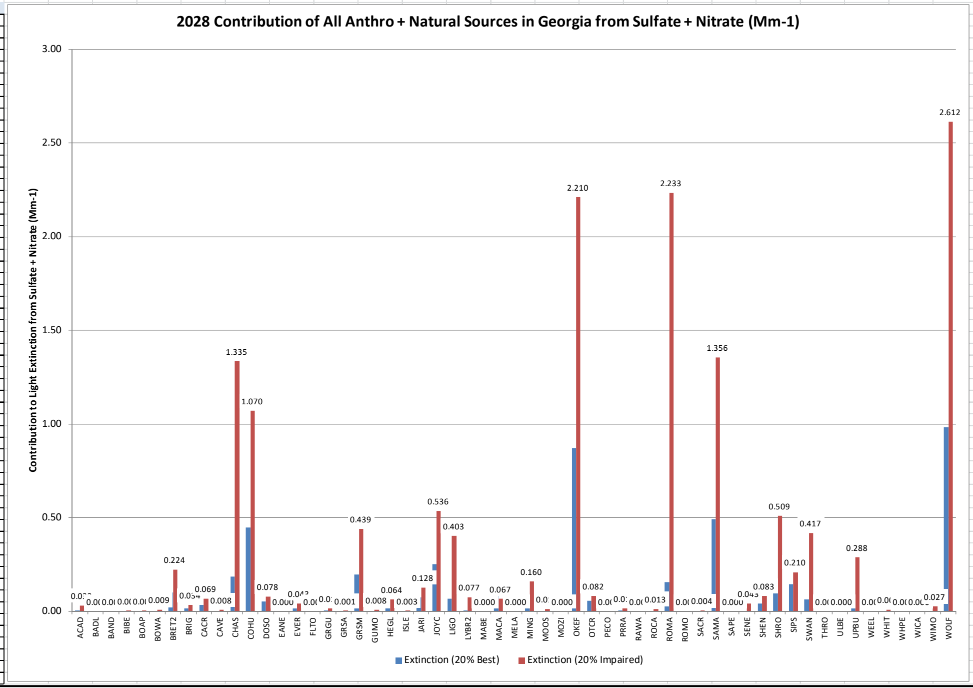


Figure 8-2. Sector to Area PivotChart and Table Example

Dynamic options for this product include:

- Choice of tagged regions (States, RPOs, Boundaries).
- Choice of 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. Certain boundary conditions are also shown
- Choice of [S]ulfate, [N]itrate, or both [S] and [N] may be selected.

8.5.3 Facility To Area

The "Facility To Area" results present 2028 contributions from individual facilities to light extinction on the 20% clearest and 20% most anthropogenically impaired days to all Class I areas. Figure 8-3 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

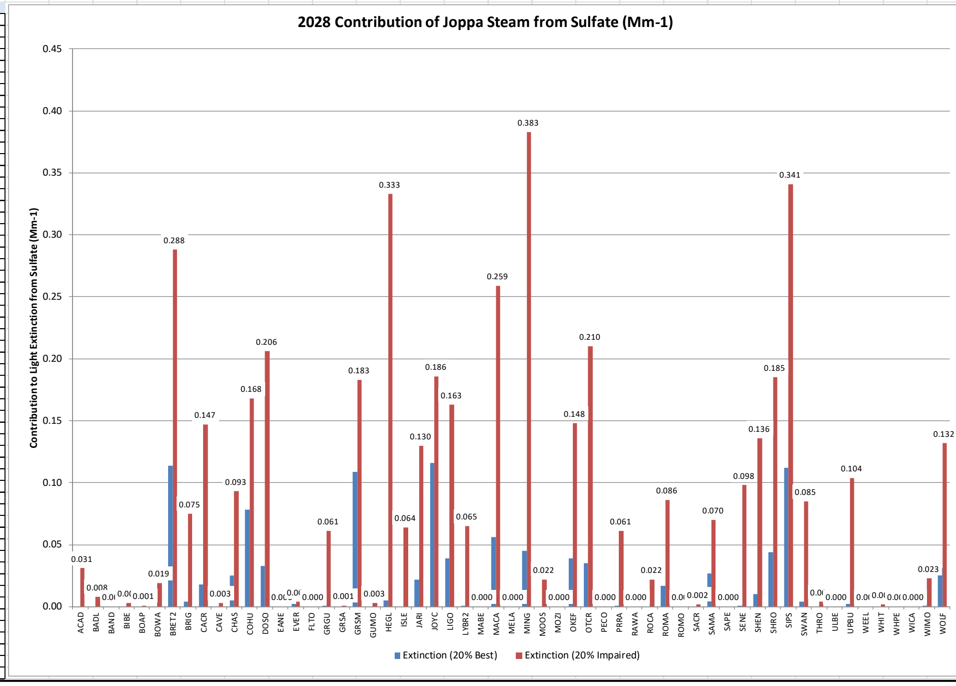


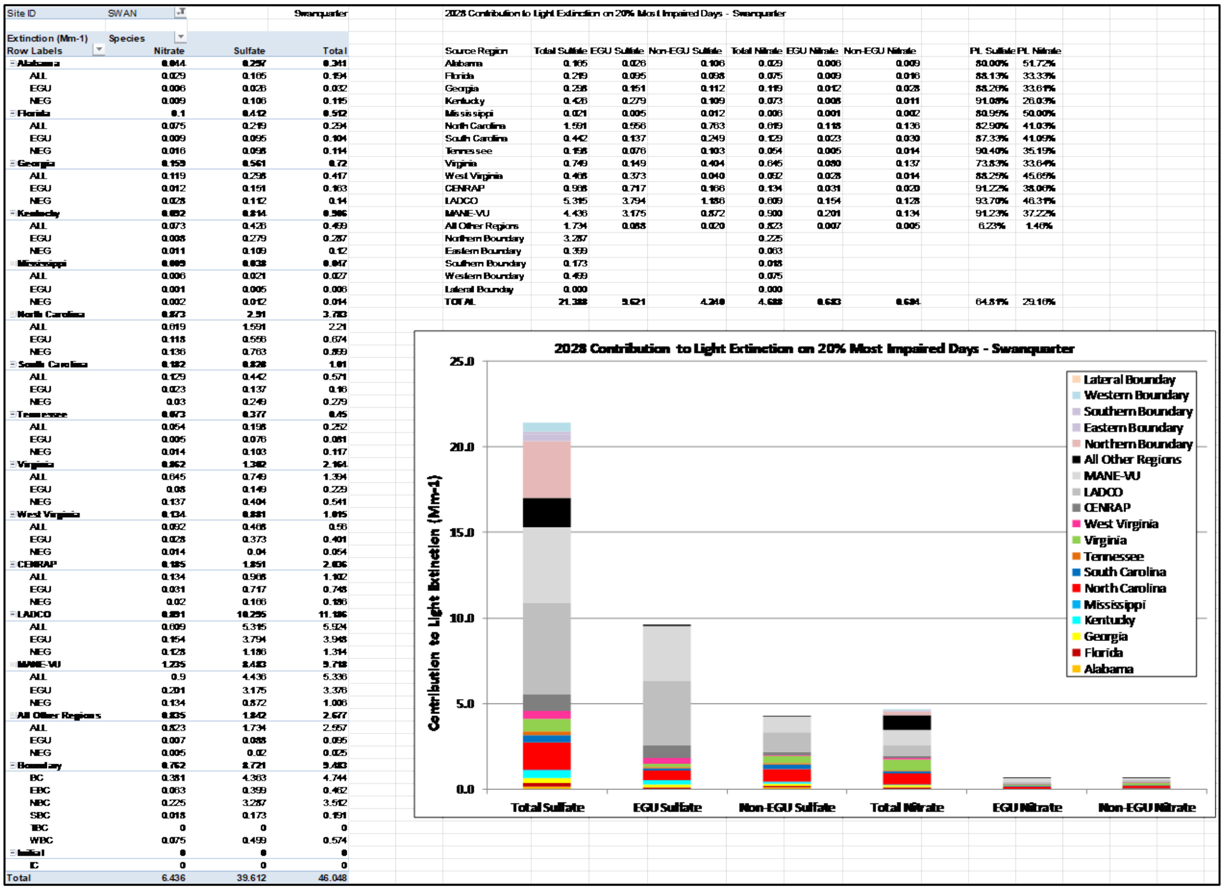
Figure 8-3. Facility to Area PivotChart and Table Example

Dynamic options for this product include:

- Choice of tagged facilities.
- Choice of [S]ulfate, [N]itrate, or both [S] and [N] may be selected.

8.5.4 Stacked Bar [S] and [N] by Area

The "Stacked Bar [S] and [N] by Area" results present 2028 contributions 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 8-4 presents an example of this output.



Site ID	SWAN		Swanquarter
Extinction (Mm-1)	Species		
Row Labels	Nitrate	Sulfate	Total
Alabama	**0.044**	**0.297**	**0.341**
ALL	0.029	0.165	0.194
EGU	0.006	0.026	0.032
NEG	0.009	0.106	0.115
Florida	**0.1**	**0.412**	**0.512**
ALL	0.075	0.219	0.294
EGU	0.009	0.095	0.104
NEG	0.016	0.098	0.114
Georgia	**0.159**	**0.561**	**0.72**
ALL	0.119	0.298	0.417
EGU	0.012	0.151	0.163
NEG	0.028	0.112	0.14
Kentucky	**0.092**	**0.814**	**0.906**
ALL	0.073	0.428	0.499
EGU	0.008	0.279	0.287
NEG	0.011	0.109	0.12
Mississippi	**0.009**	**0.038**	**0.047**
ALL	0.006	0.021	0.027
EGU	0.001	0.005	0.006
NEG	0.002	0.012	0.014
North Carolina	**0.873**	**2.91**	**3.783**
ALL	0.619	1.591	2.21
EGU	0.118	0.556	0.674
NEG	0.136	0.763	0.899
South Carolina	**0.182**	**0.828**	**1.01**
ALL	0.129	0.442	0.571
EGU	0.023	0.137	0.16
NEG	0.03	0.249	0.279
Tennessee	**0.073**	**0.377**	**0.45**
ALL	0.054	0.198	0.252
EGU	0.005	0.076	0.081
NEG	0.014	0.103	0.117
Virginia	**0.862**	**1.302**	**2.164**
ALL	0.645	0.749	1.394
EGU	0.08	0.149	0.229
NEG	0.137	0.404	0.541
West Virginia	**0.134**	**0.881**	**1.015**
ALL	0.092	0.468	0.56
EGU	0.028	0.373	0.401
NEG	0.014	0.04	0.054
CENRAP	**0.185**	**1.851**	**2.036**
ALL	0.134	0.968	1.102
EGU	0.031	0.717	0.748
NEG	0.02	0.166	0.186
LADCO	**0.891**	**10.295**	**11.186**
ALL	0.609	5.315	5.924
EGU	0.154	3.794	3.948
NEG	0.128	1.186	1.314
MANE-VU	**1.235**	**8.483**	**9.718**
ALL	0.9	4.436	5.336
EGU	0.201	3.175	3.376
NEG	0.134	0.872	1.006
All Other Regions	**0.835**	**1.842**	**2.677**
ALL	0.823	1.734	2.557
EGU	0.007	0.088	0.095
NEG	0.005	0.02	0.025
Boundary	**0.762**	**8.721**	**9.483**
BC	0.381	4.363	4.744
EBC	0.063	0.399	0.462
NBC	0.225	3.287	3.512
SBC	0.018	0.173	0.191
TBC	0	0	0
WBC	0.075	0.499	0.574
Initial	**0**	**0**	**0**
IC	0	0	0
Total	6.436	39.612	46.048

2028 Contribution to Light Extinction on 20% Most Impaired Days - Swanquarter

Source Region	Total Sulfate	EGU Sulfate	Non-EGU Sulfate	Total Nitrate	EGU Nitrate	Non-EGU Nitrate	PL Sulfate	PL Nitrate
Alabama	0.165	0.026	0.106	0.029	0.006	0.009	80.00%	51.72%
Florida	0.219	0.095	0.098	0.075	0.009	0.016	88.13%	33.33%
Georgia	0.298	0.151	0.112	0.119	0.012	0.028	88.26%	33.61%
Kentucky	0.428	0.279	0.109	0.073	0.008	0.011	91.08%	26.03%
Mississippi	0.021	0.005	0.012	0.006	0.001	0.002	80.95%	50.00%
North Carolina	1.591	0.556	0.763	0.619	0.118	0.136	82.90%	41.03%
South Carolina	0.442	0.137	0.249	0.129	0.023	0.030	87.33%	41.09%
Tennessee	0.198	0.076	0.103	0.054	0.005	0.014	90.40%	35.19%
Virginia	0.749	0.149	0.404	0.645	0.080	0.137	73.83%	33.64%
West Virginia	0.468	0.373	0.040	0.092	0.028	0.014	88.25%	45.65%
CENRAP	0.968	0.717	0.166	0.134	0.031	0.020	91.22%	38.06%
LADCO	5.315	3.794	1.186	0.609	0.154	0.128	93.70%	46.31%
MANE-VU	4.436	3.175	0.872	0.900	0.201	0.134	91.23%	37.22%
All Other Regions	1.734	0.088	0.020	0.823	0.007	0.005	6.23%	1.46%
Northern Boundary	3.287			0.225				
Eastern Boundary	0.399			0.063				
Southern Boundary	0.173			0.018				
Western Boundary	0.499			0.075				
Lateral Bounday	0.000			0.000				
TOTAL	21.388	9.621	4.240	4.688	0.683	0.694	64.81%	29.16%

Figure 8-4. Stacked Bar S and N by Area PivotChart and Table Example

Dynamic options for this product include the choice of Class I areas to which combinations contribute.

8.5.5 Region Sector to Area

The "Region Sector To Area" results present 2028 contributions from source regions to light extinction on the 20% most anthropogenically impaired days to all Class I areas. Figure 8-5 presents an example of this output.

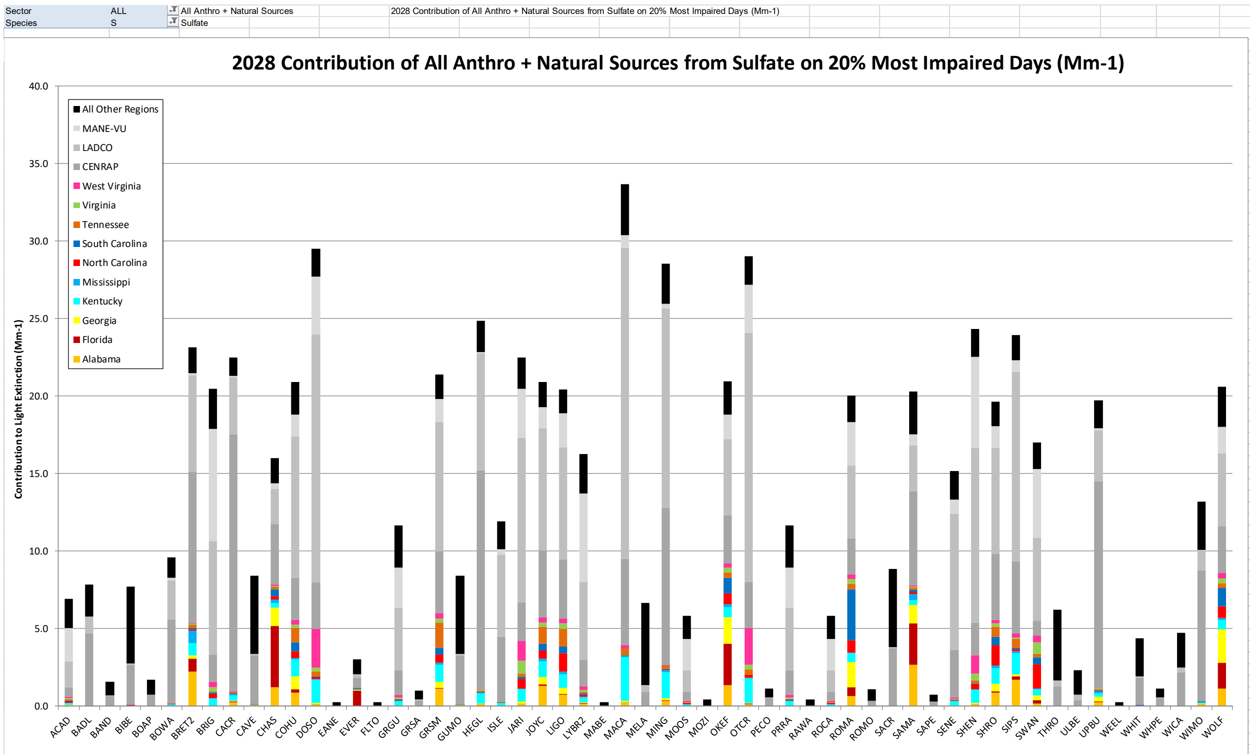


Figure 8-5. Region Sector to Area PivotChart Example

Dynamic options for this product include:

- Choice of 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.
- Choice of [S]ulfate, [N]itrate, or both S and N may be selected.

8.5.6 Boundary to Area

The "Boundary To Area" results present 2028 contributions 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.

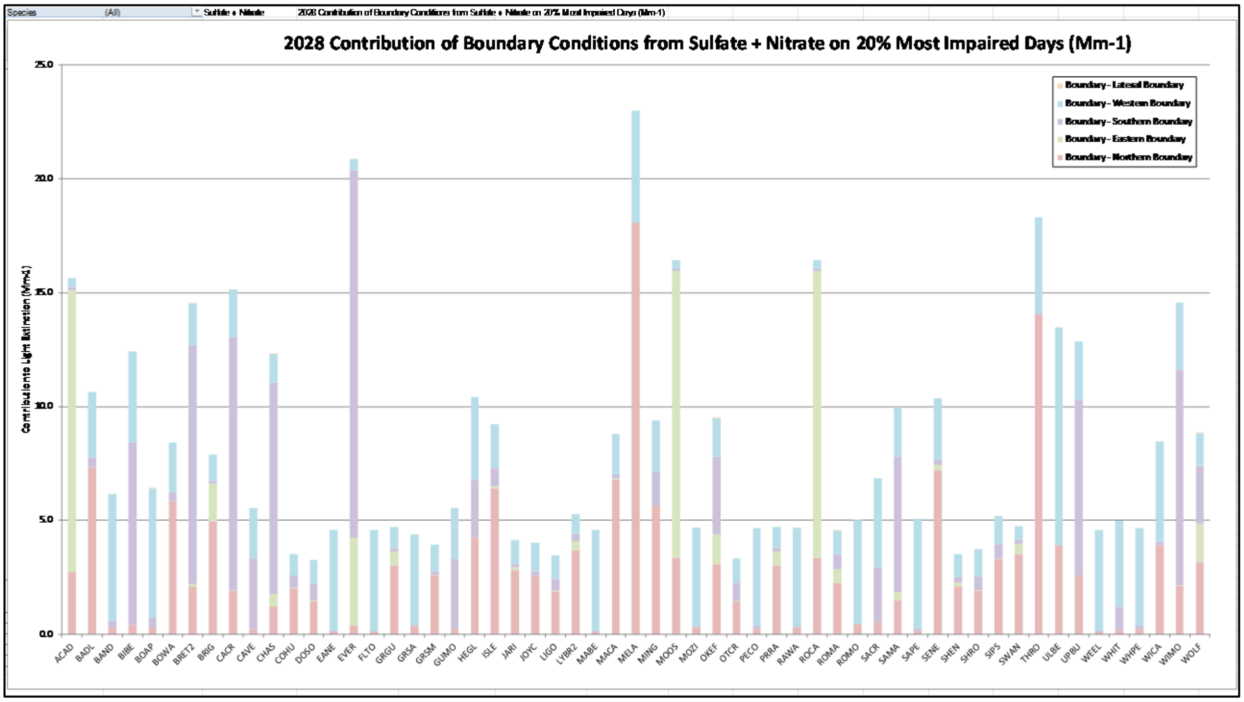


Figure 8-6. Boundary to Area PivotChart Example

Dynamic options for this product include the choice of Class I areas to which combinations contribute.

8.6 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 8-1 through 8-4. The sector and facility tag modeling results were consolidated into an Excel workbook ("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 area. These data are to be used to demonstrate relative contribution across days, not necessarily relative contribution to the overall visibility impairment metrics.

Figure 8-7 presents the Group 10 (20% clearest days) results for Wolf Island in Georgia.

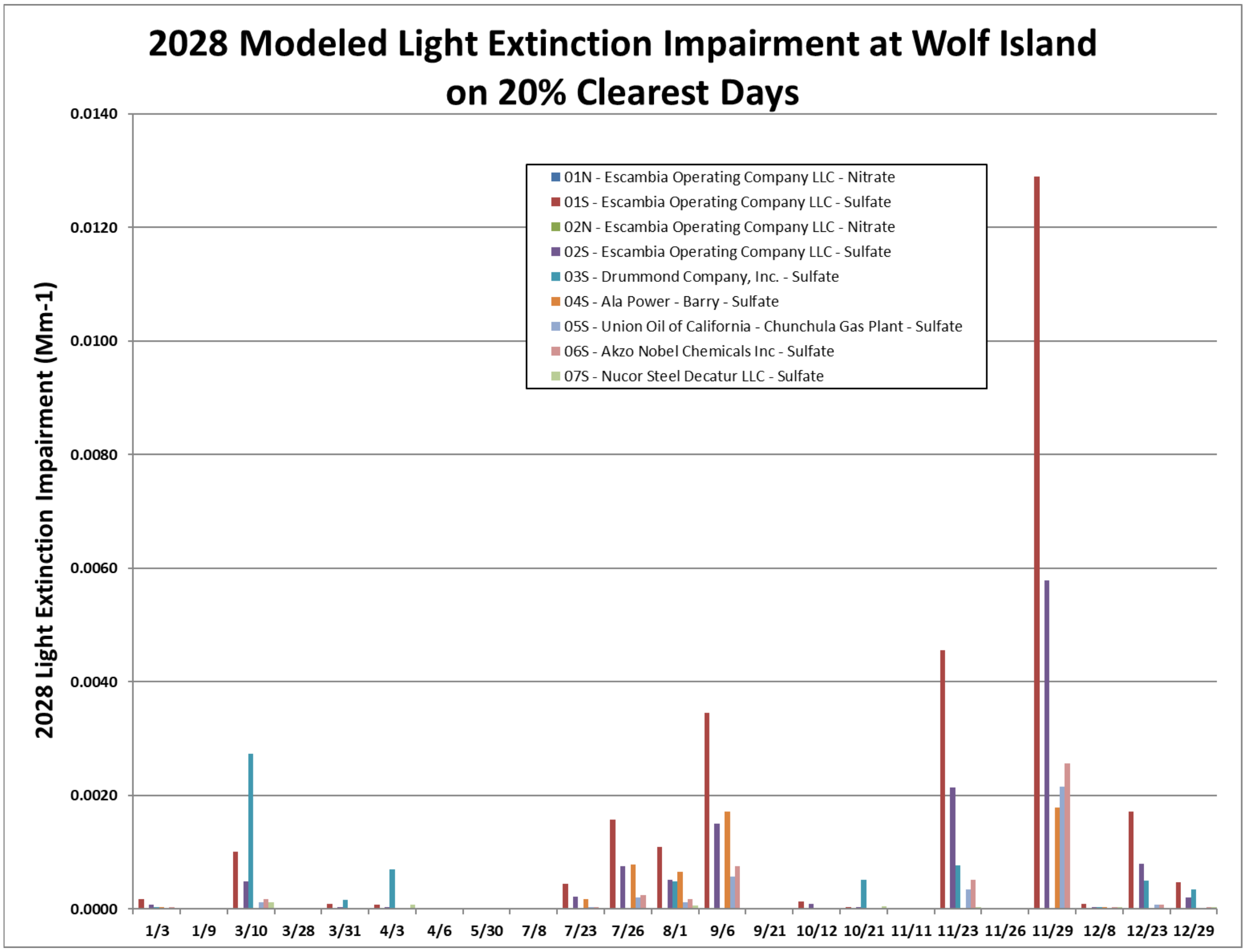


Figure 8-7. 2028 Modeled Light Extinction Impairment at Wolf Island on 20% Clearest Days

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 8-8 presents the Group 90 (20% most anthropogenically impaired) results for Wolf Island in Georgia.

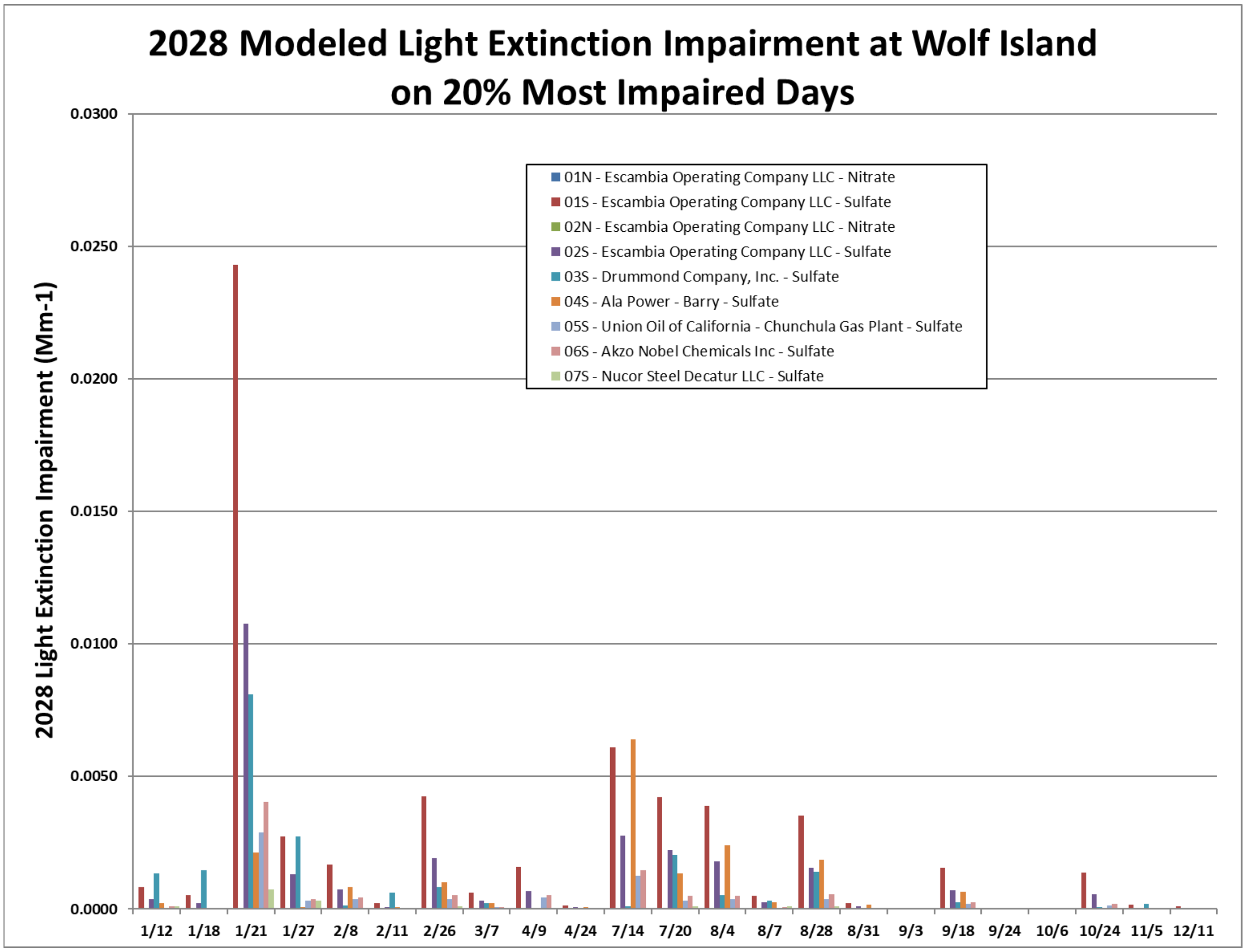


Figure 8-8. 2028 Modeled Light Extinction Impairment at Wolf Island on 20% Most Impaired Days

Similar to Figure 8-8, 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.

9.0 VISTAS II Remodeling: Emissions Inventory and Emissions Processing Updates

This section summarizes the rationale for remodeling the 2028 emissions based on updated data. Activities related to Task 9 are presented at: https://www.metro4-sesarm.org/content/future-year-projections

The original emissions inventory created under Task 2 (Summer 2018) was modeled in Fall 2018. The results were used to provide inputs and context for the AoI analysis, the PSAT modeling, and initial modeling of RPGs (based on the "elv3" emissions) for each Class I Federal area. The 2028 emissions in the "el" platform were projected from a 2011 base year.

In Fall 2019, EPA released a 2028 emissions inventory projected from its 2016 modeling platform for all source sectors (EPA2016v1). In addition, for EGUs, the ERTAC prepared a 2028 emissions inventory projected from the 2016 base year. SESARM initiated Task 11.3, which directed ERG to investigate differences and potential impacts of switching to these alternate emissions inventories. The differences between the VISTAS 2028 emissions inventory and the 2028 emissions inventory projected from EPA2016v1 were fairly significant for both NO_x (-20%) and SO_2 (-46%) for all states in the VISTAS domain.

Based on consultation with EPA, it was determined that VISTAS needed to update 2028 SO_2 and NO_x emissions for point sources to reflect emission changes associated with the addition of new facilities and changes at existing facilities (e.g., closures, emission controls, and fuel switching from coal to natural gas for combustion sources), as observed in the EPA 2016/2028 modeling platform and the ERTAC projections. At that time, there were insufficient resources and time to revise the AOI and PSAT modeling activities. Therefore, the VISTAS states updated 2028 criteria pollutant emissions for point sources to support re-modeling of reasonable progress goals (based on the elv5 inventory) for each Class I Federal area.

9.1 Emissions Updates for Remodeling

ERG prepared EGU and non-EGU emissions summary comparison tables for each VISTAS state. These tables compared the 2028 emissions used for the original modeling (elv3) to the following data sources:

- Point source emissions updates identified after completing the AoI[111] and PSAT modeling analyses;
- Updated EGU emissions for 2028 projected from 2016 base year emissions developed by the ERTAC;[112] and
- EPA's 2028 point source emissions projected from EPA's 2016 base year modeling platform.[113]

Each VISTAS state reviewed the above data sets for their state and identified revisions to 2028 EGU and non-EGU emissions needed to reflect more accurate emissions for modeling reasonable progress goals for each Class I Federal area.

For point sources in non-VISTAS states with a PSAT contribution of ≥1.00% for sulfate or ≥1.00% for nitrate, VISTAS consulted with the non-VISTAS states to review 2028 emissions for any adjustments based on newer information. As a result, the 2028 emissions for some of these point sources were revised based on comments provided by the non-VISTAS states. Specific updates related to development of the 2028 emissions inventory updates are presented in the Task 2B report.

For the elv5 remodeling effort, VISTAS states provided similar comments to the original modeling, including: deletion of process-specific emission records; inclusion of new facilities and units; adjustments to emissions; and, direction by states to replace emissions with updated emissions estimates, such as using ERTAC 16.0 emissions to replace ERTAC 2.7 emissions.

Once updates were made, ERG provided revised files for states to approve. Where updates to emissions and/or stack parameters were made, ERG documented these changes in the final report. In March 2020, SESARM, its member states, and surrounding states in the VISTAS domain reviewed updated 2028 emissions for select point sources. Table 9-1 provides a summary of emission changes by SESARM state.

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[111] Point source updates from the AoI analysis were documented in Section 5 of this report and the Task 5 Final Report.
[112] Point source emission from Version 16 of the 2028 ERTAC Projection Tool were provided to R. Oommen/ERG from D. McLeod/VDEQ on March 11, 2028.
[113] ftp://newftp.epa.gov/Air/emismod/2016/v1/2028emissions/2028fh_inventory_point_27sep2019.zip

Table 9-1. SESARM Point Source Adjustments for the Remodel

State	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
Alabama	-4,967	-77	-9,565	-2,525	-1,805	-28,644	-708
Florida	-2,504	-243	2,004	810	866	-10,519	67
Georgia	-157	-2	-1,312	-82	-74	-900	-16
Kentucky	-56	-7	-4,109	1,062	952	-9,503	-169
Mississippi	18	-266	-5,761	41	-2	-12,374	-8
North Carolina	-3,827	695	-6,899	-498	-337	-10,885	172
South Carolina	58	8	120	<-1	11	<1	-178
Tennessee	-938	-5	-2,925	-1,284	-989	-2,390	-108
Virginia	1,037	2,016	-1,538	1,033	3	-1,288	-502
West Virginia	-4,267	-20	3,147	-4,237	-3,711	-9,688	-540
Totals	**-15,604**	**2,098**	**-26,839**	**-5,681**	**-5,088**	**-86,192**	**-1,991**

Table 9-2 provides a summary of emission changes by Data Source/Reason for the SESARM states.

Table 9-2. SESARM Point Source Adjustments by Data Source/Reason

Data Source	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
AoI Analysis	-330	-267	-7,458	-1,251	-758	-15,793	-25
EPA 2016 Platform	572	-15	725	1,481	1,216	-264	71
ERTAC 16.0	-2,331	2,612	-7,211	1,388	219	-9,088	-259
PSAT inquiry[a]	-12,105	-175	-8,055	-5,913	-4,636	-67,432	-549
State Update	-1,410	-58	-4,841	-1,386	-1,128	6,386	-1,228
Totals	**-15,604**	**2,098**	**-26,839**	**-5,681**	**-5,088**	**-86,192**	**-1,991**

[a] "PSAT inquiry" refers to emission inventory updates received by SESARM after the results of PSAT analysis.

The Task 2B report presents point source-specific emissions updates for 2028 and the source for the updated emissions. Additionally, stack parameter updates for new sources were provided for Mississippi Silicon (EIS Facility ID = 17942211) and new units for Ascend Performance Materials (assigned as EIS Unit ID = 83267013b for EIS Facility ID = 985511), Georgia Pacific (assigned as EIS Unit ID = 83317013b for EIS Facility ID = 7442111), and National Cement of Alabama (assigned as EIS Unit ID = 103297113b for EIS Facility ID = 949611).

9.2 Point EGU and Non-EGU Emissions Comparison by State[114]

Table 9-3 summarizes the revised elv5 2028 point EGU and non-EGU emissions for Alabama.

Table 9-3. Alabama 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	10,747	27,988	-61.6%	61,719	63,285	-2.5%
NH_3	685	2,007	-65.8%	1,622	1,399	16.0%
NO_x	20,008	23,699	-15.6%	50,817	53,438	-4.9%
PM_{10}-PRI	2,742	6,495	-57.8%	17,065	18,336	-6.9%
$PM_{2.5}$-PRI	2,063	4,999	-58.7%	14,057	15,104	-6.9%
SO_2	8,366	28,892	-71.0%	50,691	72,276	-29.9%
VOC	1,787	2,422	-26.2%	23,747	23,958	-0.9%

Table 9-4 summarizes the revised elv5 2028 point EGU and non-EGU emissions for Florida.

Table 9-4. Florida 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	18,224	65,259	-72.1%	106,181	94,837	12.0%
NH_3	3,150	4,129	-23.7%	1,303	2,440	-46.6%
NO_x	25,050	44,775	-44.1%	44,960	38,233	17.6%
PM_{10}-PRI	10,303	10,231	0.7%	13,869	12,585	10.2%
$PM_{2.5}$-PRI	9,145	7,917	15.5%	12,001	10,777	11.4%
SO_2	24,005	54,015	-55.6%	28,978	35,648	-18.7%
VOC	1,298	2,811	-53.8%	26,711	25,669	4.1%

[114] The revised 2028 emissions and differences presented in Tables 9-5 through 9-14 are reflective of the emissions update finalized on 3/31/2020 that was used for the elv5 modeling. It is important to note that several EGU facilities that were in the May 2018 version of the 2028 SESARM emissions inventory (elv3) were reclassified as non-EGUs in the March 2020 version of the 2028 SESARM emissions inventory (elv5) based on updated emissions inventory information from EPA. As such, emissions and differences presented in these tables would also capture emissions changes due to these reclassifications, even if a state did not provide updated emission changes for elv5. This was observed for both Georgia and Virginia, who did not provide elv5 non-EGU sector emissions updates, yet the emissions and differences did not match the values for non-EGU presented in the Task 2A Report due to reclassifications.

Table 9-5 summarizes the revised elv5 2028 point EGU and non-EGU emissions for Georgia.

Table 9-5. Georgia 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	9,751	25,058	-61.1%	57,324	67,860	-15.5%
NH_3	1,176	1,508	-22.0%	5,595	5,678	-1.5%
NO_x	24,588	13,163	86.8%	41,298	45,540	-9.3%
PM_{10}-PRI	5,140	3,876	32.6%	12,387	15,695	-21.1%
$PM_{2.5}$-PRI	4,263	3,374	26.4%	9,655	12,502	-22.8%
SO_2	17,574	27,533	-36.2%	18,593	23,519	-20.9%
VOC	1,042	885	17.7%	24,528	27,198	-9.8%

Table 9-6 summarizes the revised elv5 2028 point EGU and non-EGU emissions for Kentucky.

Table 9-6. Kentucky 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	11,462	24,801	-53.8%	86,053	86,082	-0.03%
NH_3	669	705	-5.1%	454	508	-10.5%
NO_x	32,696	43,411	-24.7%	29,435	31,048	-5.2%
PM_{10}-PRI	9,326	12,180	-23.4%	15,931	16,253	-2.0%
$PM_{2.5}$-PRI	7,402	9,409	-21.3%	10,483	10,619	-1.3%
SO_2	49,586	81,304	-39.0%	16,051	19,083	-15.9%
VOC	887	1,212	-26.8%	43,588	46,814	-6.9%

Table 9-7 summarizes the revised elv5 2028 point EGU and non-EGU emissions for Mississippi.

Table 9-7. Mississippi 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	4,153	18,160	-77.1%	37,591	34,061	10.4%
NH_3	579	1,288	-55.0%	1,693	1,784	-5.1%
NO_x	12,209	11,210	8.9%	34,645	32,503	6.6%
PM_{10}-PRI	1,456	1,923	-24.3%	9,236	9,184	0.6%
$PM_{2.5}$-PRI	1,119	1,777	-37.0%	7,809	7,765	0.6%
SO_2	3,236	6,253	-48.2%	5,169	19,255	-73.2%
VOC	413	2,183	-81.1%	27,155	25,389	7.0%

Table 9-8 summarizes the revised elv5 2028 point EGU and non-EGU emissions for North Carolina.

Table 9-8. North Carolina 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	8,239	22,086	-62.7%	46,329	33,823	37.0%
NH_3	806	1,284	-37.2%	1,348	1,271	6.0%
NO_x	20,978	18,528	13.2%	37,956	30,418	24.8%
PM_{10}-PRI	3,644	3,203	13.8%	12,602	8,590	46.7%
$PM_{2.5}$-PRI	3,244	2,763	17.4%	8,653	5,866	47.5%
SO_2	9,571	11,548	-17.1%	14,776	21,407	-31.0%
VOC	812	1,075	-24.4%	47,061	29,129	61.6%

Table 9-9 summarizes the revised elv5 2028 point EGU and non-EGU emissions for South Carolina.

Table 9-9. South Carolina 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	12,711	11,181	13.7%	91,019	89,363	1.9%
NH_3	863	657	31.3%	1,762	1,657	6.3%
NO_x	10,707	12,303	-13.0%	25,463	22,613	12.6%
PM_{10}-PRI	3,432	6,611	-48.1%	6,495	6,322	2.7%
$PM_{2.5}$-PRI	2,730	4,159	-34.4%	4,670	4,530	3.1%
SO_2	10,695	18,231	-41.3%	18,906	17,885	5.7%
VOC	476	1,847	-74.2%	21,974	22,387	-1.8%

Table 9-10 summarizes the revised elv5 2028 point EGU and non-EGU emissions for Tennessee.

Table 9-10. Tennessee 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	3,614	5,837	-38.1%	48,801	45,967	6.2%
NH_3	174	419	-58.4%	1,001	1,019	-1.7%
NO_x	7,814	10,025	-22.1%	35,140	36,007	-2.4%
PM_{10}-PRI	2,629	5,608	-53.1%	11,020	10,755	2.5%
$PM_{2.5}$-PRI	2,430	3,919	-38.0%	8,150	7,892	3.3%
SO_2	10,030	28,429	-64.7%	11,027	8,781	25.6%
VOC	541	416	30.0%	33,224	33,717	-1.5%

Table 9-11 summarizes the revised elv5 2028 point EGU and non-EGU emissions for Virginia.

Table 9-11. Virginia 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	5,811	31,807	-81.7%	35,075	32,019	9.5%
NH_3	2,365	1,379	71.5%	1,490	1,400	6.5%
NO_x	10,436	10,207	2.2%	31,236	31,321	-0.3%
PM_{10}-PRI	3,942	853	362.0%	5,834	5,849	-0.2%
$PM_{2.5}$-PRI	1,509	747	101.9%	4,633	4,607	0.6%
SO_2	1,976	2,335	-15.4%	16,575	16,967	-2.3%
VOC	455	650	-30.0%	17,457	17,498	-0.2%

Table 9-12 summarizes the revised elv5 2028 point EGU and non-EGU emissions for West Virginia.

Table 9-12. West Virginia 2028 Point EGU and Non-EGU Emissions Comparison

Pollutant	Revised 2028 EGU Emissions (tpy)	EPA 2028el EGU Emissions (tpy)	% Diff for EGU	Revised 2028 Non-EGU Emissions (tpy)	EPA 2028el Non-EGU Emissions (tpy)	% Diff for Non-EGU
CO	8,661	11,894	-27.2%	33,439	33,581	-0.4%
NH_3	50	840	-94.1%	187	215	-12.8%
NO_x	49,874	27,315	82.6%	18,327	22,530	-18.7%
PM_{10}-PRI	6,877	11,311	-39.2%	3,600	4,292	-16.1%
$PM_{2.5}$-PRI	5,480	7,604	-27.9%	2,599	2,963	-12.3%
SO_2	47,744	46,075	3.6%	5,971	15,151	-60.6%
VOC	1,162	779	49.2%	6,994	8,046	-13.1%

Pollutant emission bubble maps highlighting emission changes for the point EGU and non-EGU sector from the EPA 2028el inventory to the revised VISTAS 2028 inventory are presented in the Task 2B report.

Table 9-13 summarizes the Base Year 2011 Tier 1 emissions by pollutant for the ten VISTAS states, while Table 9-14 summarizes the revised (elv5) 2028 Tier 1 emissions by pollutant. Table 9-15 presents the percent change by pollutant from the 2011 Tier 1 emissions to the revised (elv5) 2028 Tier 1 emissions. State-level summaries are presented in the Task 2B report.

Table 9-13. 2011 Tier 1 Pollutant Emissions (except Biogenic) for the Ten VISTAS States[115]

Tier 1 Description	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
Chemical & Allied Product Mfg	34,883	6,762	17,238	5,022	3,837	39,482	20,714
Fuel Comb. Elec. Util.	151,802	6,471	488,453	85,656	61,846	1,191,386	10,576
Fuel Comb. Industrial	264,348	2,696	250,349	120,862	97,403	177,103	19,668
Fuel Comb. Other	277,771	7,390	70,985	39,401	38,003	27,359	47,920
Highway Vehicles	7,549,047	32,263	1,574,943	88,017	47,390	8,027	791,993
Metals Processing	163,506	123	12,501	15,160	12,650	33,405	9,833
Miscellaneous[17]	3,953,133	633,365	106,762	3,732,801	827,631	41,197	740,642
Off-Highway	3,710,940	604	626,217	49,059	46,279	34,422	541,514
Other Industrial Processes[17]	105,113	8,737	98,400	194,381	78,734	44,820	148,394
Petroleum & Related Industries	95,162	120	73,588	2,963	2,459	33,046	145,163
Solvent Utilization	318	190	367	910	796	48	668,718
Storage & Transport	2,886	284	497	7,448	3,462	89	323,577
Waste Disposal & Recycling	576,851	2,177	22,864	85,381	75,021	3,971	48,995
Totals	**16,885,761**	**701,183**	**3,343,164**	**4,427,062**	**1,295,512**	**1,634,354**	**3,517,706**

[115] Totals for PM_{10}-PRI and $PM_{2.5}$-PRI include the unadjusted PM_{10}-PRI and $PM_{2.5}$-PRI emissions for source categories included in the "afdust" sector. See Appendix C for the list of source categories and comparison of adjusted and unadjusted emissions by state.

Table 9-14. 2028 Tier 1 Pollutant Emissions (except Biogenic) for the Ten VISTAS States, elv5[116]

Tier 1 Description	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
Chemical & Allied Product Mfg	28,334	4,930	10,561	5,279	3,700	28,198	20,184
Fuel Comb. Elec. Util.	101,793	9,941	216,451	44,188	35,209	183,351	8,770
Fuel Comb. Industrial	272,849	3,088	205,032	126,911	107,424	78,121	17,911
Fuel Comb. Other	262,468	7,319	67,184	36,711	35,652	16,898	43,049
Highway Vehicles	2,371,974	21,976	341,421	63,604	16,147	3,117	192,413
Metals Processing	163,152	144	13,297	13,997	11,740	31,211	9,046
Miscellaneous[18]	3,778,975	675,213	99,091	4,362,444	890,359	37,923	727,086
Off-Highway	3,676,987	742	349,374	23,899	22,227	7,646	301,285
Other Industrial Processes[18]	104,648	8,273	99,121	193,076	77,102	47,414	149,452
Petroleum & Related Industries	143,691	122	101,729	6,199	5,861	7,361	232,823
Solvent Utilization	337	165	379	919	819	25	687,749
Storage & Transport	990	219	509	6,616	3,215	2,857	219,347
Waste Disposal & Recycling	577,197	2,117	23,980	85,423	75,087	3,950	49,593
Totals	**11,483,395**	**734,250**	**1,528,129**	**4,969,267**	**1,284,542**	**448,072**	**2,658,708**

[116] Totals for PM_{10}-PRI and $PM_{2.5}$-PRI include the unadjusted PM_{10}-PRI and $PM_{2.5}$-PRI emissions for source categories included in the "afdust" sector. See Appendix C for the list of source categories and comparison of adjusted and unadjusted emissions by state.

Table 9-15. Percent Change in Emissions by Tier 1 Level, All Sectors Combined (except Biogenic) for the Ten VISTAS States [117]

Tier 1 Description	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	% Difference						
Chemical & Allied Product Mfg	-19%	-27%	-39%	5%	-4%	-29%	-3%
Fuel Comb. Elec. Util.	-33%	54%	-56%	-48%	-43%	-85%	-17%
Fuel Comb. Industrial	3%	15%	-18%	5%	10%	-56%	-9%
Fuel Comb. Other	-6%	-1%	-5%	-7%	-6%	-38%	-10%
Highway Vehicles	-69%	-32%	-78%	-28%	-66%	-61%	-76%
Metals Processing	0%	17%	6%	-8%	-7%	-7%	-8%
Miscellaneous[19]	-4%	7%	-7%	17%	8%	-8%	-2%
Off-Highway	-1%	23%	-44%	-51%	-52%	-78%	-44%
Other Industrial Processes[19]	<-0.5%	-5%	1%	-1%	-2%	6%	1%
Petroleum & Related Industries	51%	1%	38%	109%	138%	-78%	60%
Solvent Utilization	6%	-13%	3%	1%	3%	-48%	3%
Storage & Transport	-66%	-23%	2%	-11%	-7%	3099%	-32%
Waste Disposal & Recycling	<0.5%	-3%	5%	<0.5%	<0.5%	-1%	1%
Totals	**-32%**	**5%**	**-54%**	**12%**	**-0.8%**	**-73%**	**-24%**

[117] Totals for PM_{10}-PRI and $PM_{2.5}$-PRI include the unadjusted PM_{10}-PRI and $PM_{2.5}$-PRI emissions for source categories included in the "afdust" sector. See Appendix C for the list of source categories and comparison of adjusted and unadjusted emissions by state.

9.3 Emissions Processing Updates for Remodeling

As part of the emissions inventory update and for remodeling, SESARM directed ERG to develop the non-SESARM states point EGU and non-EGU emissions inventory files based on updated information. Specific updates include:

- Versions 16.0 and 16.1 of the ERTAC EGU emissions;[118]
- Select facility updates from the Area of Influence analysis;
- Select facility updates from the PSAT analysis; and the SESARM made the following decisions:
  - No point source changes to states outside the VISTAS modeling domain (e.g., Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington);
  - Replace the ERTACv2.7 EGU emissions for LADCO states (Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin) with ERTACv16.1 EGU emissions;
  - Replace the ERTACv2.7 EGU emissions for CenSARA, MANE-VU, and WRAP states in the VISTAS domain with ERTACv16.0 EGU emissions; and
  - Update select facilities following AOI and PSAT analysis.

For the non-SESARM states, Table 9-16 and Table 9-17 show the original modeled elv3 and remodeled elv5 2028 point source emissions, respectively, by RPO and state. Table 9-18 provides a summary of non-SESARM emission changes by RPO and state. Table 9-19 provides a summary of emission changes by Data Source/Reason.

118 Point source emission from Version 16 of the 2028 ERTAC Projection Tool were provided to R. Oommen/ERG from D. McLeod/VDEQ on March 11, 2028.

Table 9-16. Non-SESARM Original Modeled elv3 Point Sources Emissions

State	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
CENRAP RPO States							
Arkansas	49,574	1,284	74,310	11,138	7,236	87,523	22,725
Iowa	33,338	3,708	43,678	10,792	7,461	51,354	20,593
Kansas	35,809	1,953	42,974	9,678	6,153	30,410	16,010
Louisiana	124,663	6,726	159,627	54,385	46,204	141,044	57,861
Missouri	115,378	1,654	65,094	14,411	9,692	171,745	14,221
Nebraska	21,143	916	46,819	7,691	4,127	76,558	5,926
Oklahoma	81,621	6,385	116,107	11,745	8,048	49,539	47,308
Texas	289,440	7,715	355,488	54,951	41,141	404,777	119,950
CENRAP Total	**750,967**	**30,341**	**904,098**	**174,791**	**130,063**	**1,012,950**	**304,594**
LADCO RPO States							
Illinois	93,802	1,807	106,521	26,181	16,351	144,869	46,028
Indiana	316,427	1,278	138,482	30,952	19,686	187,959	36,681
Michigan	81,241	1,539	93,300	13,349	9,465	80,873	26,325
Minnesota	35,789	1,560	55,754	24,083	15,678	28,284	19,875
Ohio	266,094	4,240	107,621	38,210	31,442	172,147	30,894
Wisconsin	52,098	1,088	47,188	12,265	8,440	46,055	21,926
LADCO Total	**845,451**	**11,511**	**548,867**	**145,040**	**101,062**	**660,186**	**181,729**
MANE-VU RPO States (not including Virginia and West Virginia)							
Connecticut	3,649	399	4,864	442	351	497	938
Delaware	4,983	206	4,147	1,111	1,011	3,528	2,267
District of Columbia	465	0	554	39	38	21	71
Maine	14,568	570	11,688	2,899	2,248	2,499	3,409
Maryland	36,046	482	27,439	5,122	3,977	44,601	3,059
Massachusetts	14,136	545	13,399	1,639	1,391	1,928	3,623
New Hampshire	6,076	355	3,689	722	617	2,380	682
New Jersey	17,517	1,220	16,716	4,284	3,911	4,123	8,290
New York	75,736	2,102	52,537	8,409	6,188	29,915	11,168
Pennsylvania	110,660	2,056	107,212	31,666	23,507	180,371	26,036
Rhode Island	2,698	61	1,602	214	99	890	1,211
Vermont	2,511	21	730	235	163	127	492
MANE-VU Total	**289,045**	**8,017**	**244,576**	**56,782**	**43,499**	**270,880**	**61,247**
WRAP RPO States (in the VISTAS Domain)							
Colorado	73,644	468	88,225	18,969	9,339	18,236	92,210
Montana	11,492	90	23,782	8,670	4,006	20,170	5,084
New Mexico	30,231	455	70,477	4,828	3,102	26,597	7,025
North Dakota	17,758	6,102	51,241	5,815	4,254	54,978	3,913
South Dakota	4,648	76	13,427	871	825	1,194	3,253
Wyoming	72,505	576	115,668	35,046	15,646	60,946	28,254
WRAP Total	**210,278**	**7,767**	**362,820**	**74,199**	**37,173**	**182,122**	**139,739**
Totals	**2,095,741**	**57,636**	**2,060,360**	**450,813**	**311,797**	**2,126,139**	**687,309**

Table 9-17. Non-SESARM Remodeled elv5 Point Sources Emissions

State	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
CENRAP RPO States							
Arkansas	47,257	1,765	49,710	9,973	6,687	39,528	22,443
Iowa	33,509	3,833	39,573	9,868	6,110	42,524	20,554
Kansas	29,515	1,776	32,733	8,649	5,443	9,898	15,902
Louisiana	116,427	7,841	165,713	53,151	44,322	116,582	58,055
Missouri	103,442	1,660	62,692	12,533	7,752	137,402	14,036
Nebraska	24,435	1,047	28,911	6,359	2,842	52,637	5,805
Oklahoma	87,202	6,780	105,800	11,018	7,389	36,155	47,133
Texas	290,005	7,500	306,266	47,080	39,040	186,595	119,388
CENRAP Total	**731,792**	**32,202**	**791,398**	**158,630**	**119,586**	**621,321**	**303,315**
LADCO RPO States							
Illinois	91,480	2,663	104,208	22,866	14,177	116,578	46,287
Indiana	312,429	2,195	104,240	25,239	17,446	113,473	36,314
Michigan	80,716	1,737	85,269	13,760	9,819	67,781	26,258
Minnesota	34,480	1,845	56,167	22,992	15,546	28,636	19,887
Ohio	265,489	5,529	96,967	26,505	22,400	130,998	30,795
Wisconsin	54,199	2,576	44,494	11,100	6,043	40,705	22,090
LADCO Total	**838,794**	**16,545**	**491,345**	**122,463**	**85,431**	**498,172**	**181,631**
MANE-VU RPO States (not including Virginia and West Virginia)							
Connecticut	3,658	471	5,070	520	414	346	949
Delaware	4,779	148	3,401	763	665	2,472	2,233
District of Columbia	465	0	554	39	38	21	71
Maine	14,699	586	11,622	2,881	2,195	2,492	3,398
Maryland	37,901	584	25,141	5,674	4,049	27,168	3,076
Massachusetts	17,385	735	13,741	1,671	1,313	2,250	3,724
New Hampshire	5,836	340	2,827	637	608	1,373	692
New Jersey	17,563	2,056	16,703	4,888	4,095	3,618	8,189
New York	73,752	1,885	52,232	8,028	5,688	16,965	11,300
Pennsylvania	141,583	3,929	89,260	30,800	19,408	91,713	24,999
Rhode Island	3,367	28	1,712	249	138	895	1,220
Vermont	2,511	21	730	235	163	127	492
MANE-VU Total	**323,499**	**10,784**	**222,991**	**56,383**	**38,774**	**149,440**	**60,342**
WRAP RPO States (in the VISTAS Domain)							
Colorado	68,099	575	78,556	19,000	9,320	15,621	92,168
Montana	10,459	89	18,879	8,008	3,532	13,271	5,023
New Mexico	32,011	405	56,575	3,647	2,265	20,407	7,130
North Dakota	15,580	6,074	47,716	4,887	4,002	47,976	3,853
South Dakota	4,457	76	4,281	755	704	1,590	3,240
Wyoming	71,149	421	95,427	31,075	13,703	36,619	28,036
WRAP Total	**201,755**	**7,640**	**301,433**	**67,373**	**33,526**	**135,483**	**139,450**
Totals	**2,095,839**	**67,172**	**1,807,167**	**404,849**	**277,317**	**1,404,416**	**684,739**

Table 9-18. Non-SESARM Point Sources Emissions Adjustments for the elv5 Remodel

State	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
CENRAP RPO States							
Arkansas	-2,317	481	-24,601	-1,166	-549	-47,995	-282
Iowa	171	125	-4,105	-924	-1,351	-8,829	-40
Kansas	-6,294	-177	-10,241	-1,029	-711	-20,512	-109
Louisiana	-8,236	1,115	6,087	-1,235	-1,882	-24,461	194
Missouri	-11,936	6	-2,402	-1,878	-1,940	-34,343	-185
Nebraska	3,292	130	-17,909	-1,332	-1,285	-23,922	-121
Oklahoma	5,581	396	-10,306	-728	-659	-13,384	-175
Texas	564	-215	-49,222	-7,870	-2,100	-218,182	-562
CENRAP Total	**-19,175**	**1,861**	**-112,700**	**-16,161**	**-10,477**	**-391,629**	**-1,278**
LADCO RPO States							
Illinois	-2,321	856	-2,313	-3,316	-2,174	-28,291	259
Indiana	-3,998	918	-34,242	-5,713	-2,240	-74,486	-367
Michigan	-525	198	-8,031	411	354	-13,091	-66
Minnesota	-1,309	285	413	-1,091	-132	352	11
Ohio	-605	1,289	-10,655	-11,705	-9,043	-41,148	-99
Wisconsin	2,101	1,488	-2,694	-1,165	-2,397	-5,350	165
LADCO Total	**-6,657**	**5,034**	**-57,522**	**-22,578**	**-15,631**	**-162,015**	**-97**
MANE-VU RPO States (not including Virginia and West Virginia)							
Connecticut	10	72	206	78	63	-151	11
Delaware	-205	-57	-746	-348	-346	-1,057	-35
District of Columbia	0	0	0	0	0	0	0
Maine	131	16	-66	-18	-53	-8	-11
Maryland	1,855	102	-2,298	551	72	-17,433	16
Massachusetts	3,249	190	342	32	-77	323	101
New Hampshire	-240	-15	-862	-86	-8	-1,007	10
New Jersey	47	836	-13	603	185	-505	-101
New York	-1,984	-217	-305	-381	-500	-12,949	131
Pennsylvania	30,922	1,873	-17,952	-866	-4,099	-88,658	-1,038
Rhode Island	669	-33	110	36	39	6	9
Vermont	0	0	0	0	0	0	0
MANE-VU Total	**34,453**	**2,767**	**-21,585**	**-399**	**-4,725**	**-121,440**	**-905**
WRAP RPO States (in the VISTAS Domain)							
Colorado	-5,545	107	-9,668	31	-19	-2,615	-42
Montana	-1,032	-2	-4,904	-662	-474	-6,899	-61
New Mexico	1,780	-49	-13,903	-1,181	-837	-6,191	105
North Dakota	-2,178	-28	-3,525	-928	-252	-7,002	-60
South Dakota	-191	0	-9,146	-116	-121	396	-13
Wyoming	-1,356	-155	-20,241	-3,971	-1,943	-24,327	-218
WRAP Total	**-8,523**	**-127**	**-61,386**	**-6,826**	**-3,647**	**-46,639**	**-289**
Totals	**98**	**9,535**	**-253,193**	**-45,964**	**-34,479**	**-721,723**	**-2,570**

Table 9-19. Non-SESARM Point Source Adjustments by Data Source/Reason (elv3 to elv5)

Data Source / Reason	CO	NH_3	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
	tpy						
AOI Analysis	-168	2	-379	-4,954	-3,814	-13,250	-20
ERTAC 16.0	9,563	4,601	-173,595	-22,171	-18,616	-507,500	-2,175
ERTAC 16.1	-1,445	5,054	-22,764	-6,652	-4,764	-64,638	437
PSAT Inquiry[a]	-6,526	-74	-44,026	-11,671	-7,196	-115,318	-661
State Update	-1,327	-47	-12,428	-515	-90	-21,017	-151
Totals	**98**	**9,535**	**-253,193**	**-45,964**	**-34,479**	**-721,723**	**-2,570**

[a] "PSAT inquiry" refers to emission inventory updates received by SESARM after the results of PSAT analysis

After receipt of the emissions files, Alpine began processing the emissions data in a similar fashion, as presented in Section 3 of this report, following the same scripts and procedures as before. These include, but are not limited to:

- Using EGU CEM data (hourly heat input, hourly NO_x emissions, and hourly SO_2 emissions) to scale annual emissions for EGUs;
- Scaling the non-EGU annual emissions to hourly emissions using temporal allocation factor files;
- Splitting emissions releases into low-level and elevated-level based on stack parameters;
- Applying speciation profiles to the VOC and PM emissions; and
- Replacing specific emissions profiles for the GA Plant Scherer 2029 emissions based on information provided by the GADNR.

In June 2020, while reviewing the Benchmark #7 report associated with the remodeled 2028 inventories, it was discovered that the emissions associated with non-SESARM states, as well as limited emissions in Georgia, were not being passed from the emissions processing phase into the CAMx input files. Thorough investigation pointed in part to the inclusion of monthly emissions data in the ERTAC 16.0/16.1 derived emission files for non-SESARM sources and cross-reference (facility to boiler data) changes made between the ERTAC 2.7 data used in 2028v3 and the ERTAC 16.x data used in 2028v4. These differences in the files appeared to create a lookup conflict in the SMOKE emissions processor when CEM-based PTHOUR files were also associated with the annual and monthly emissions in the ERTAC input files.

Ultimately, work around processing steps were implemented that required the zeroing out of the monthly emissions from the EGU annual input file and further review and update to multiple unit-level cross-reference characteristics for non-SESARM facilities taken directly from the ERTAC model output. No annual emissions, stack characteristics, nor locational parameters were changed in this step, nor did any PTHOUR files generated for the modeling have to be modified for the 2028elv5 modeling.

This file was then configured with new header information to indicate the national coverage of the inputs and documented to note the file's use in SESARM's 2028elv5 regional haze modeling.

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10.0 VISTAS II FUTURE YEAR MODELING (ELV5)

This section summarizes the steps taken in preparing the uniform rate of progress (URP) or "glidepath" visibility and light extinction values from the 2028elv5 modeling platform. Activities related to Task 9 are presented at: https://www.metro4-sesarm.org/content/future-year-projections

As required by the RHR, 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.[119] The baseline for each Class I area is the average visibility (in "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.[120]

A line drawn between the end of the 2000-2004 baseline period visibility metric and 2064 natural condition metric 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 10-1.

[119] 40 CFR 51.308(f)(3)(i)-2
[120] 40 CFR 51.308(f)(1)

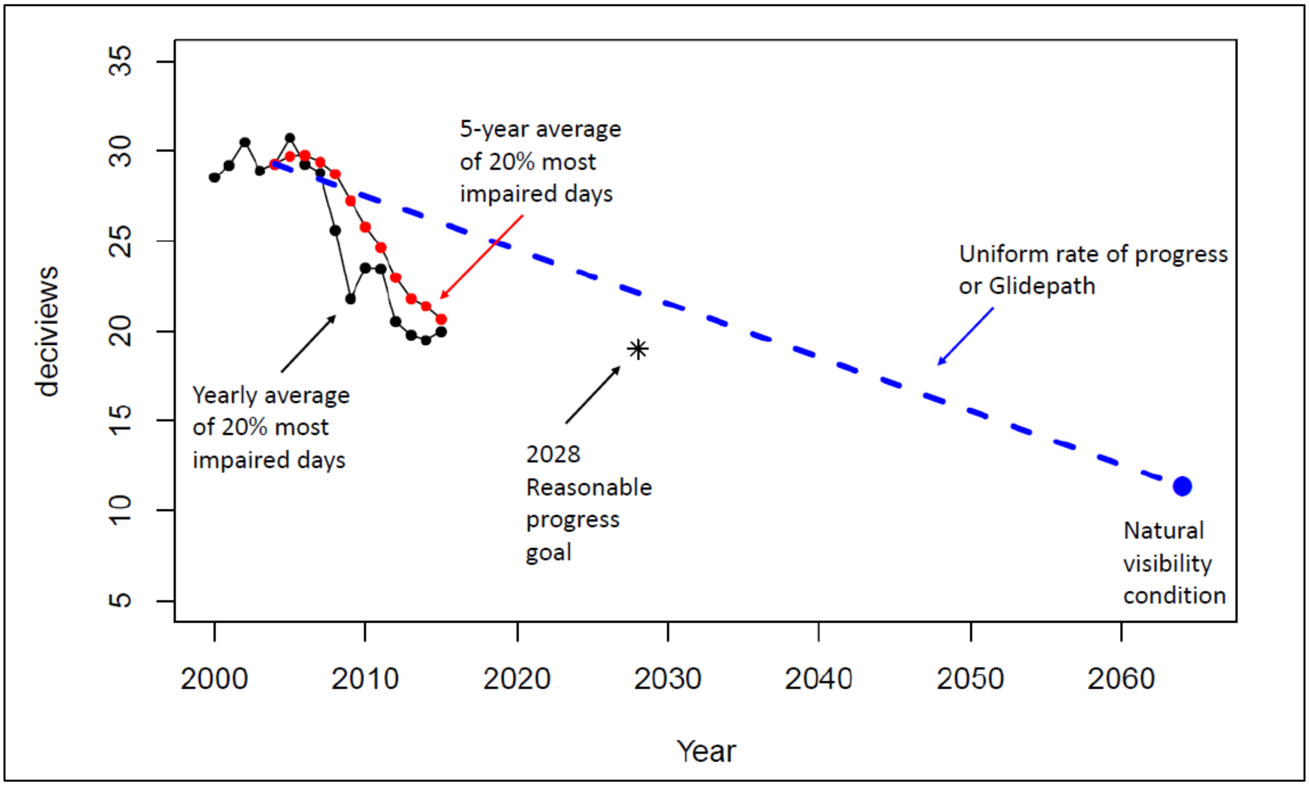

Figure 10-1. Example Glidepath Plot.

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 ending in 2028. Therefore, modeling was used to project visibility to 2028 using a 2028 emissions inventory.[121] The EPA Software for the Modeled Attainment Test (SMAT) – Community Edition (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).[122] SMAT-CE[123] is an EPA software tool which implements the procedures in the SIP Modeling Guidance to project visibility to a future year.

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121 "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.

122 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).

123 SMAT-CE is available here: https://www.epa.gov/scram/photochemical-modeling-tools

10.1 Calculation of 2028 Visibility

The visibility projections follow the procedures in section 5 of the SIP Modeling Guidance.[124] 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 are from the 2009-2013 period.[125]

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 PM species concentrations and relative humidity data to calculate visibility impairment or beta extinction (bext) in units of inverse megameters (Mm^{-1}) as follows:

bext = 2.2 x f_s(RH) x [Small Sulfate] + 4.8 x f_L(RH) x [Large Sulfate]
+ 2.4 x f_s(RH) x [Small Nitrate] + 5.1 x f_L(RH) x [Large Nitrate]
+ 2.8 x [Small Organic Mass] + 6.1 x [Large Organic Mass]
+ 10 x [Elemental Carbon]
+ 1 x [Fine Soil]
+ 1.7 x f_{ss}(RH) x [Sea Salt]
+ 0.6 x [Coarse Mass]
+ Rayleigh Scattering (site specific)

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).

- 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 five years comprising the base period (2009-2013) and rank the

124 https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf.

125 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).

days on this indicator.[126] 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 five years comprising the base period. This ranking will determine the 20 percent clearest days.

- Step 2 - For each of the five years comprising the base period, calculate the mean deciviews for the I20% and B20% days. For each Class I area, calculate the five-year mean deciviews for most impaired and clearest days from the five 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 RRFs for each component of PM[127] 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 five-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 10-1 details the settings used for the SMAT runs to generate the 2028 future year deciview projections.

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[126] 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.

[127] 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.

Table 10-1. 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[128]
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

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 five-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 10-2 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).[129]

[128] The IMPROVE ambient data file has the 20% most impaired days identified as “impairment 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.

[129] 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 10-2. 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[130]	13.81	12.13	22.49	18.39
ACAD	Acadia NP	ACAD1	7.02	6.70	16.84	14.67

[130] The BRIS1 IMPROVE monitor is used for Breton Wilderness as the original monitor (BRET1) was decommissioned in 2005 after Hurricane Katrina.

Table 10-2. 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)
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
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

Table 10-2. 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)
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
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

Table 10-2. 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)
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 10-2 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.

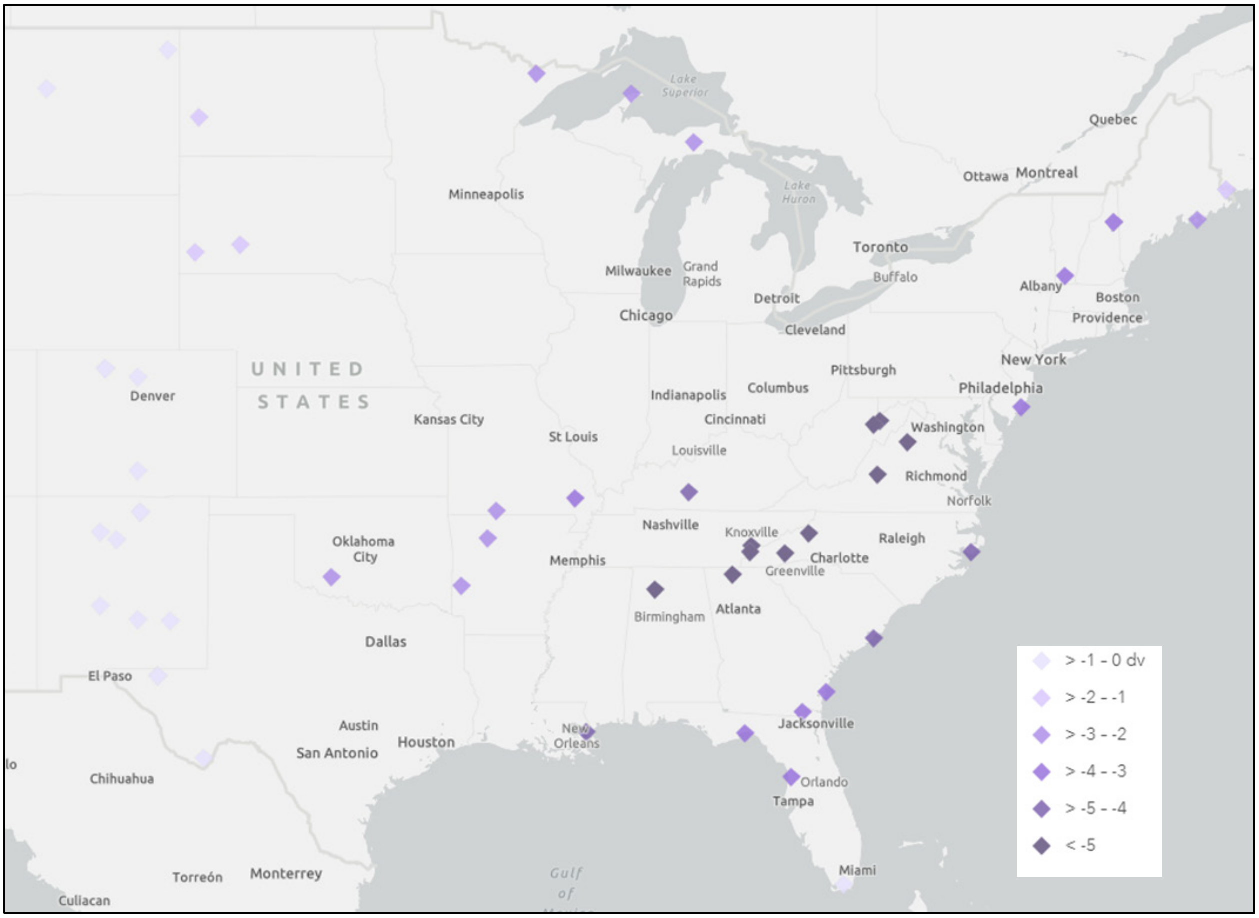

Figure 10-2. Projected Change in Deciviews (dv) at IMPROVE Sites in VISTAS_12 Domain on the 20% Most Impaired Days Between 2011 and 2028 (2028 – 2011).

10.2 Comparison of Modeled Visibility and 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.[131] 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. This is referred to as the "Default Adjusted" glidepath and natural conditions calculation. See the Technical Guidance on Tracking Visibility Progress for the Second Implementation Period of the Regional Haze Program[132] for more details.

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 fires.

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.

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131 See 40 CFR 51.308(f)(1)(vi)

132 EPA, 2018. "Technical Guidance on Tracking Visibility Progress for the Second Implementation Period for the Regional Haze Program." December 20, 2018. Internet Address: https://www.epa.gov/visibility/technical-guidance-tracking-visibility-progress-second-implementation-period-regional

Table 10-3 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).[133] The observed 2009-2013 values and projected 2028 values are also included, which are repeated from Table 10-2.

In cases where an IMPROVE monitor is not located within a Class I area, surrogate IMPROVE monitors are assigned to establish a glidepath.

[133] 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/draft-guidance-second-implementation-period-regional-haze-rule.

Table 10-3. 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
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

Table 10-3. 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)
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
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

Table 10-3. 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)
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
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.[134]

Figure 10-3 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.

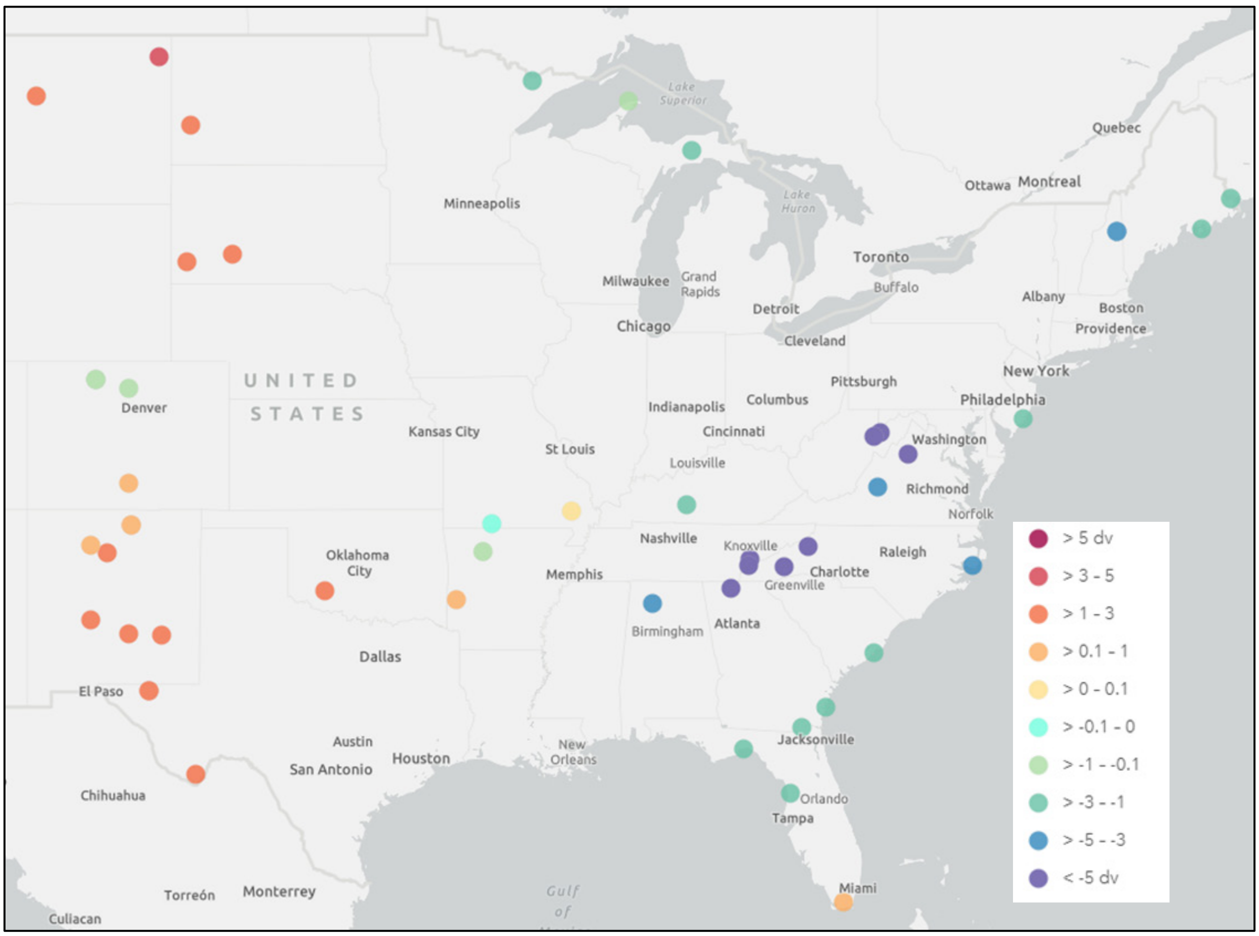


Figure 10-3. Map of Deviations from the 2028 Unadjusted Glidepath at IMPROVE Sites in the VISTAS 12 Domain.

[134] See 40 CFR 51.308(f)(3)(ii) and (iii)

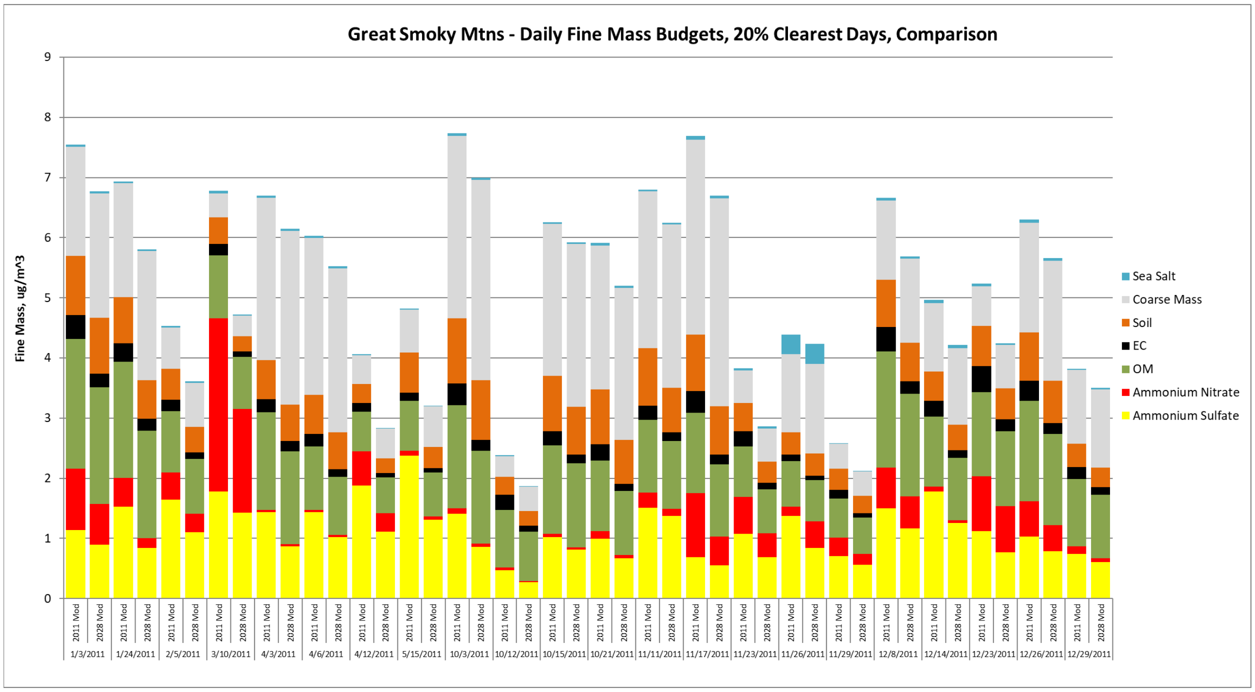
There are two major features that can be seen in Figure 10-3. First, all Class I areas in the VISTAS states, except for Everglades, are significantly below the unadjusted glidepath. Second, the majority of Class I areas west of the Mississippi River are above the unadjusted glidepath.

10.3 $PM_{2.5}$ 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, EC, 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[135] within the Final Report.

Figure 10-4 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 10-5 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).

[135] The Excel file, "APP_A_ag_v6_40.2028elv5.vistas_12_SESARM (4 Sept 2020).xlsx", is part of Appendix A of the Task 9a Report.



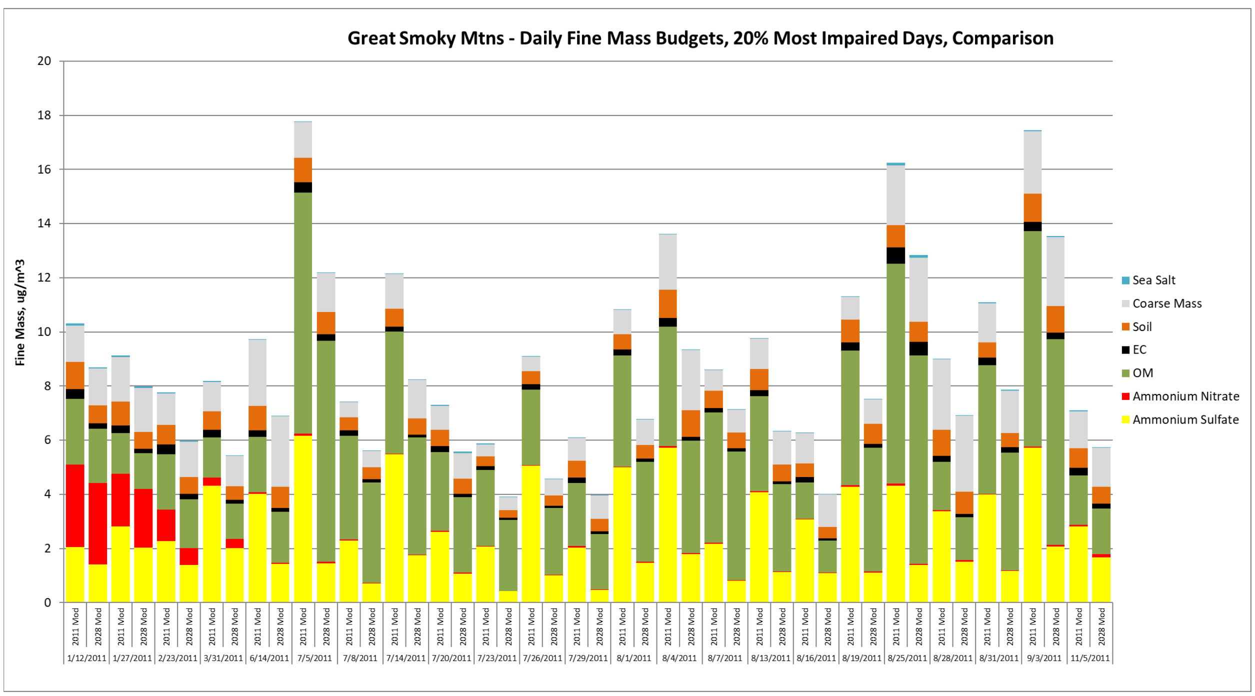
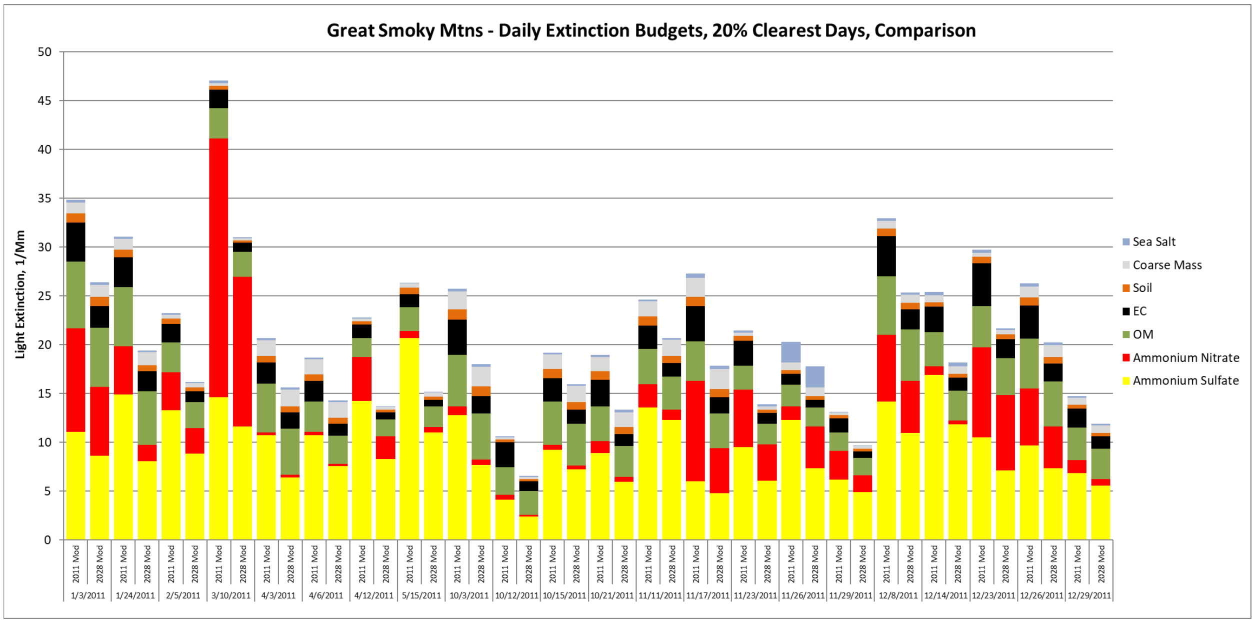


Figure 10-4. Predicted (CAMx) Concentrations (µg/m^3) Great Smoky Mountains National Park on the Modeled 20% Clearest (Top) and 20% Most Anthropogenically Impaired (Bottom) Days.



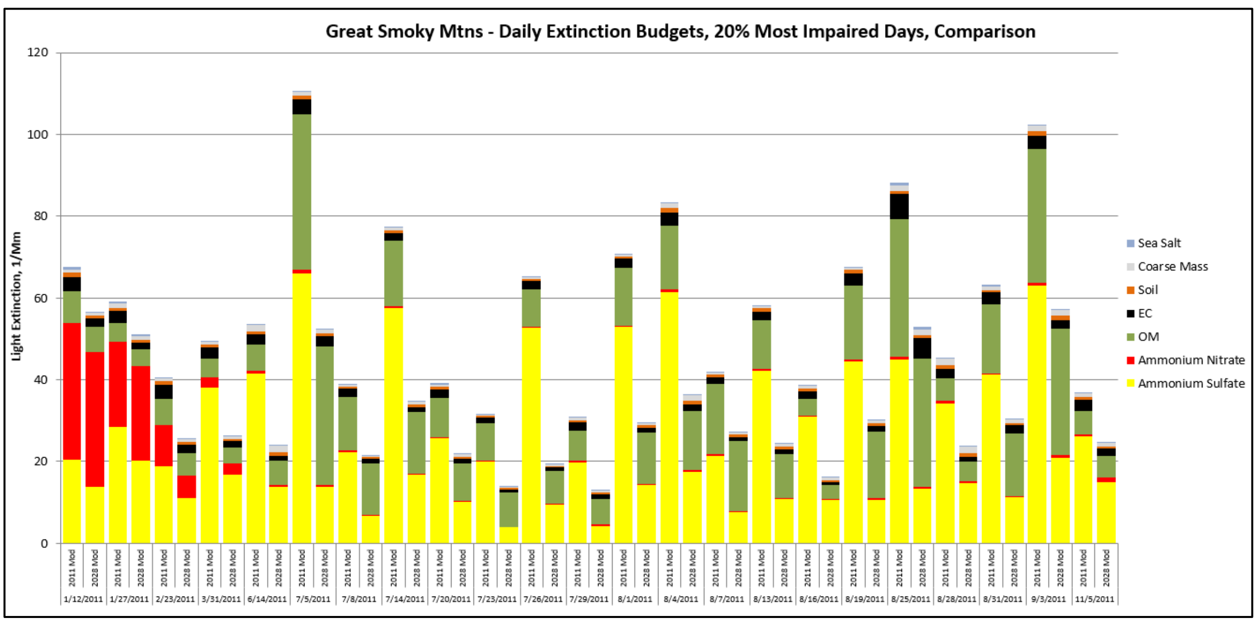


Figure 10-5. Predicted (CAMx) Light Extinctions (Mm^{-1}) Great Smoky Mountains National Park on the Modeled 20% Clearest (Top) and 20% Most Anthropogenically Impaired (Bottom) Days.

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 (µg/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, EC, 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[136] in the Final Report.

Figure 10-6 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 10-7 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).

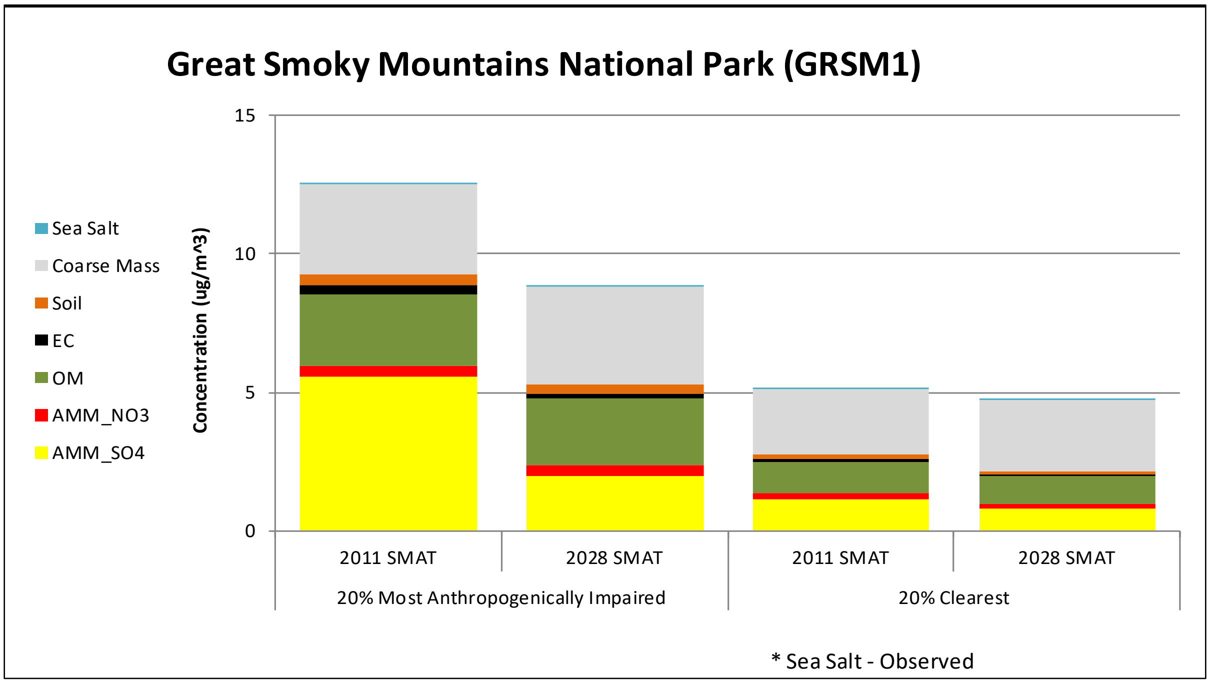


Figure 10-6. SMAT Concentrations (µg/m^3) Great Smoky Mountains National Park on the Modeled 20% Clearest (Right) and 20% Most Anthropogenically Impaired (Left) Days.

[136] The Excel file, "APP_B_StackedBarCharts.xlsx", is part of Appendix B of the Task 9a Final Report.

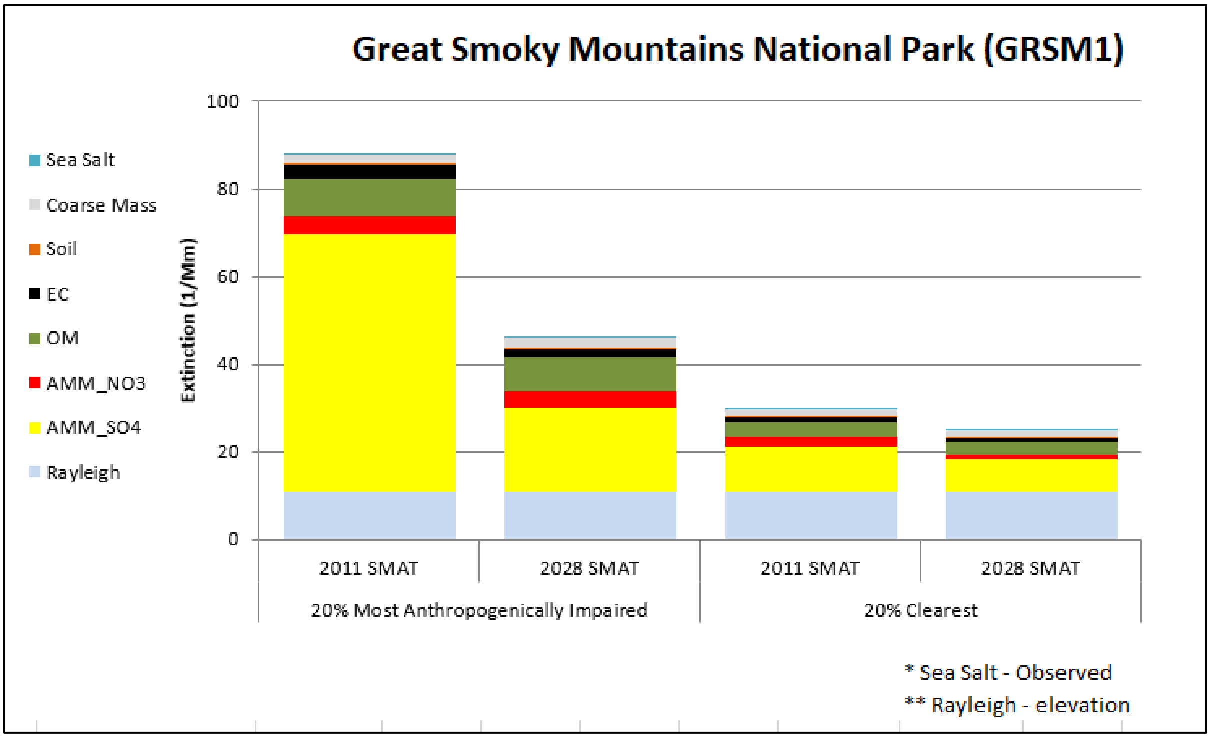


Figure 10-7. SMAT Light Extinctions (Mm^{-1}) Great Smoky Mountains National Park on the Modeled 20% Clearest (Right) and 20% Most Anthropogenically Impaired (Left) Days.

10.4 Regional Haze Site Summaries

Figure 10-8 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[137] in the Final Report.

- 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 (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. Adjustments account for anthropogenic international emissions using EPA modeling.

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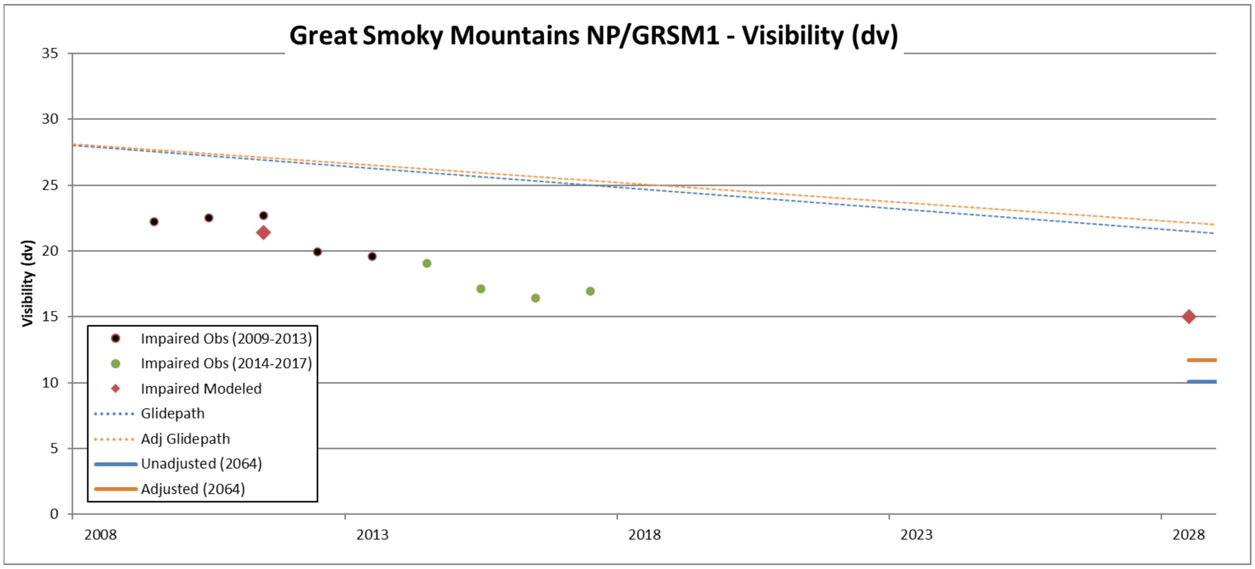
[137] The Excel file, "APP_C_SESARM_2028elv5_URP_20200903.xlsx", is part of Appendix C of the Task 9a Final Report.



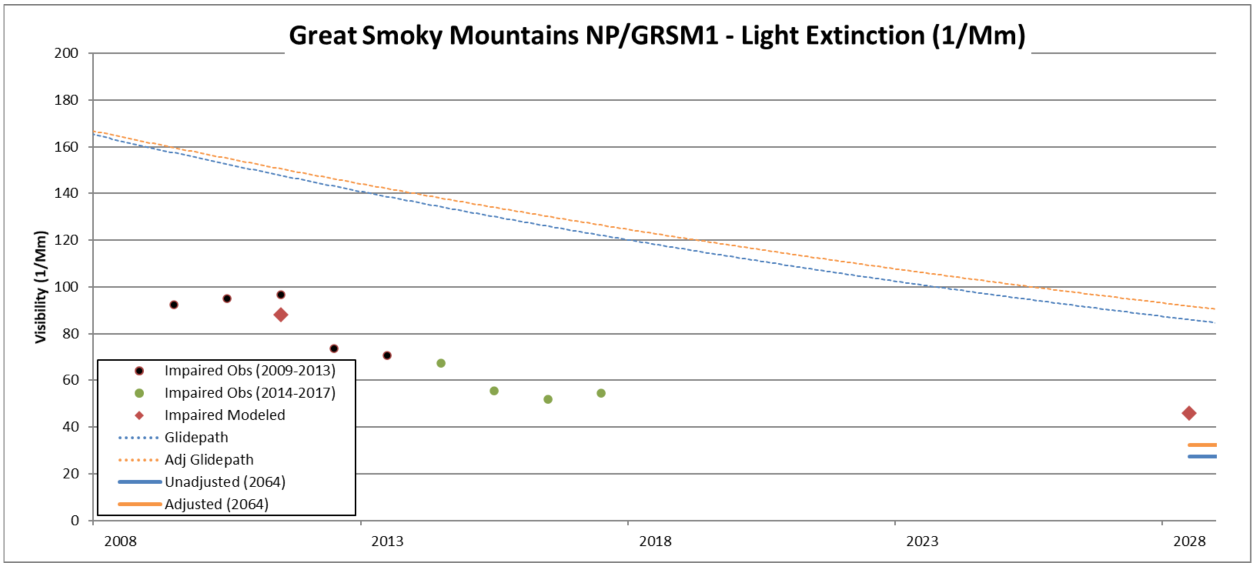


Figure 10-8. 2009-2017 IMPROVE Observations, 2011 and 2028 CAMx Model Predictions, and Unadjusted and Default-Adjusted Glidepaths for Visibility (Top) and Light Extinction (Bottom) at GRSM1.

11.0 VISTAS II Dry and Wet Deposition Calculations

This section serves as a placeholder for the development of relative response factors (RRFs) and their application to future year projections of wet and dry depositions. Activities related to Task 9.1 are presented at: https://www.metro4-sesarm.org/content/future-year-projections

Under Task 9.1, quarterly relative response factors (RRFs) and future year projections of wet and dry deposition species were developed. RRFs have become an integral part of the SIP process, as they are a useful tool in estimating the future year impacts of emission changes, while considering model performance. RRFs for each deposition site were calculated consistent with EPA guidance for calculating RRFs for $PM_{2.5}$ species. Future year projections were developed for each site by multiplying the quarterly RRF by applicable monitored values and then summing the total to an annual average.

The documentation and deliverables for this subtask are located at: https://www.metro4-sesarm.org/content/future-year-projections.

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12.0 VISTAS II ADDITIONAL DATA REQUESTS

This section summarizes the additional data requests authorized under this contract that was not originally in the Scope of Work. Activities related to Task 11 are presented at: https://www.metro4-sesarm.org/content/task-11-other-tasks

Under this contract, SESARM initiated Task 11 for additional requests not included in the original Scope of Work (SOW) in the Request for Proposal (RFP). Three sets of requests were satisfied under this task, and these requests are presented below.

12.1 Additional Request #1: Data extractions of Initial Conditions and Boundary Conditions (IC/BC)

Under this subtask, ERG directed Alpine to extract IC/BCs from the 2011 and 2028 VISTAS_12 CAMx simulations. Initially, up to five roughly state-sized CAMx domains were to be extracted, with an additional five domains that could be added by request.

In August 2018, SESARM states confirmed the five geographic domains for extraction, and they are presented in Table 12-1.

Table 12-1. Geographic Specifications for the IC/BC Extractions

State	Lower Left Coordinates	Upper Right Coordinates
Alabama	672, -1236	1236, -396
Florida	792, -1596	1920, -804
Georgia	816, -1068	1680, -300
North Carolina	1104, -852	1956, -96
Tennessee	540, -600	1452, -168

Figures 12-1 through 12-5 present the geographic boundaries for each state request.

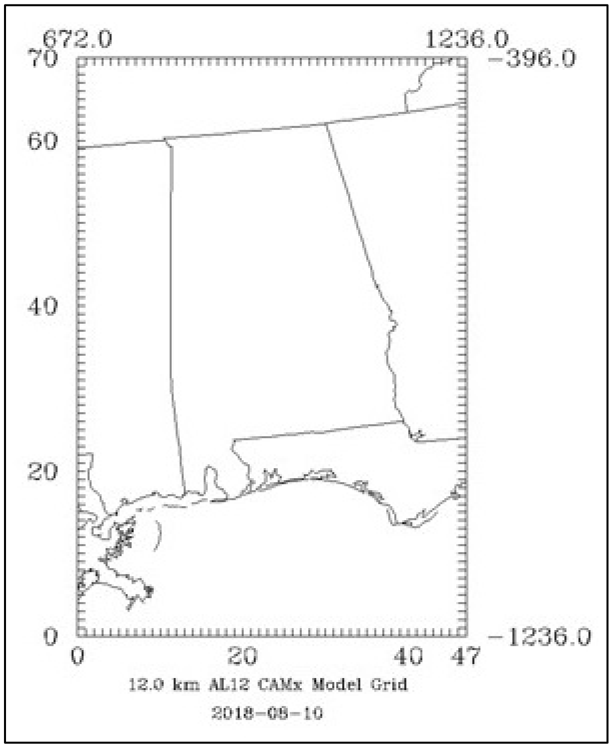

Figure 12-1. Geographic Boundary Map for IC/BC Extraction for Alabama

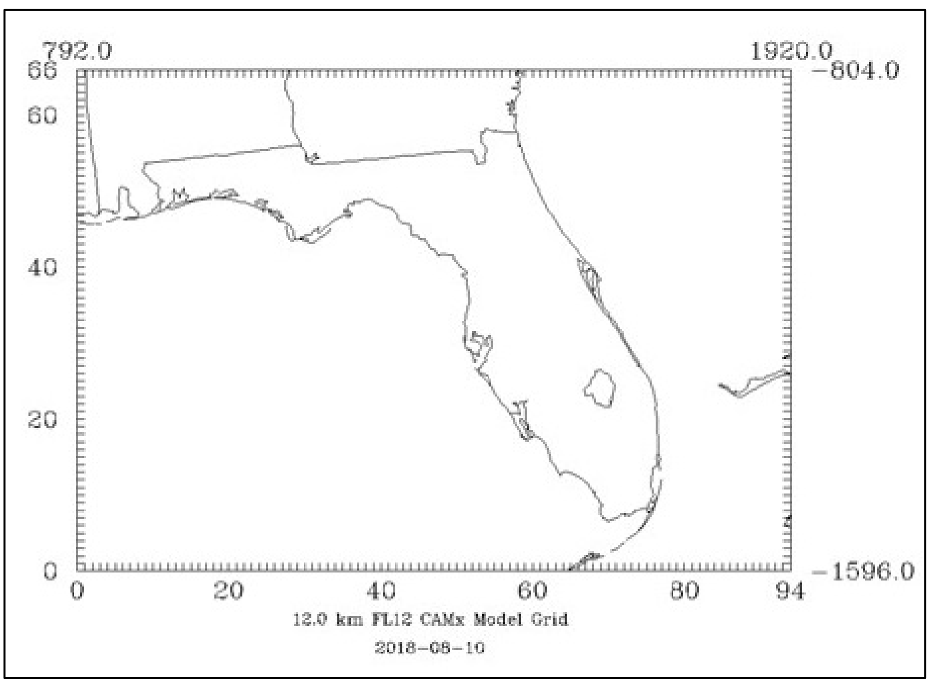

Figure 12-2. Geographic Boundary Map for IC/BC Extraction for Florida

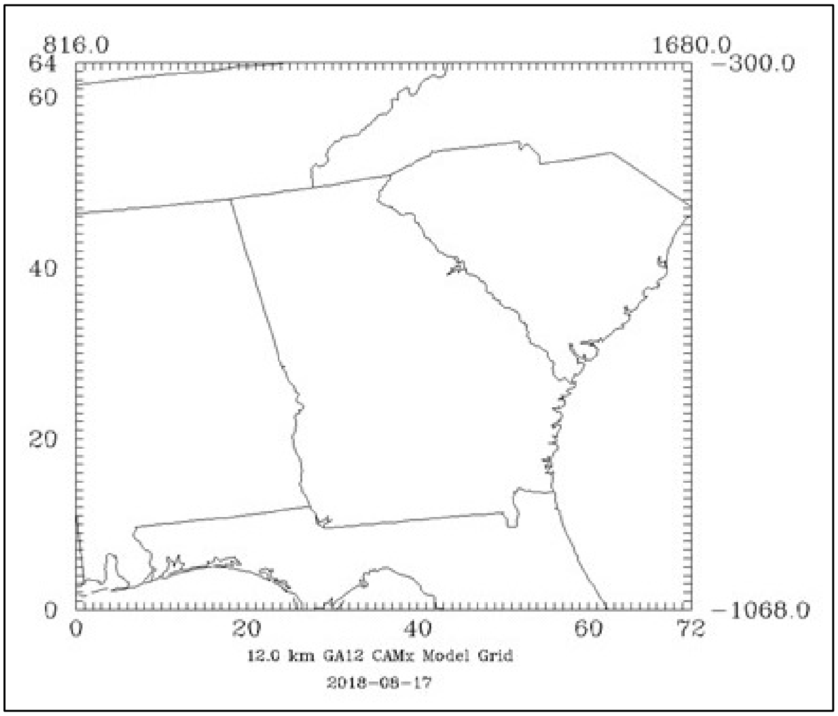

Figure 12-3. Geographic Boundary Map for IC/BC Extraction for Georgia

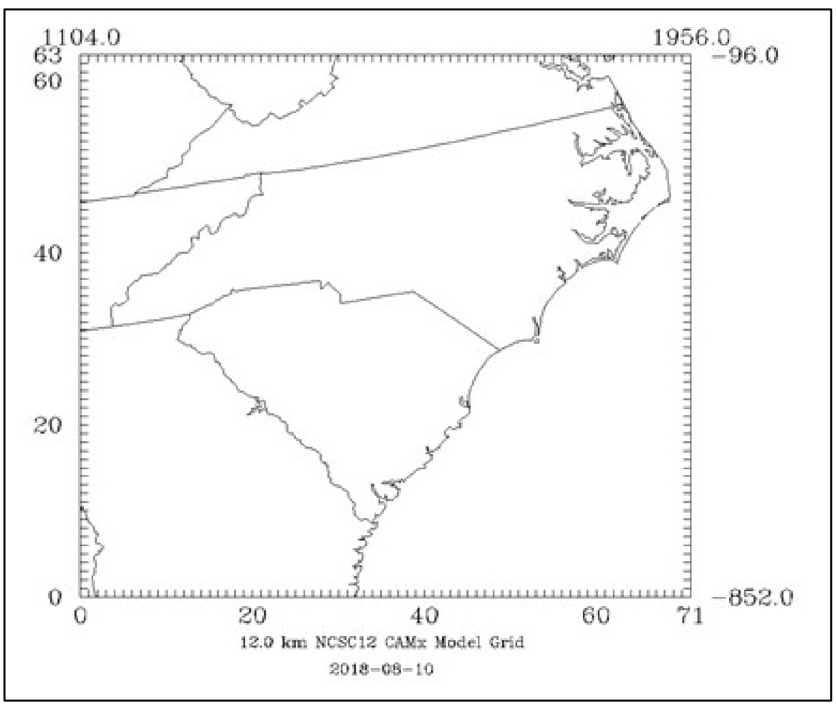

Figure 12-4. Geographic Boundary Map for IC/BC Extraction for North Carolina

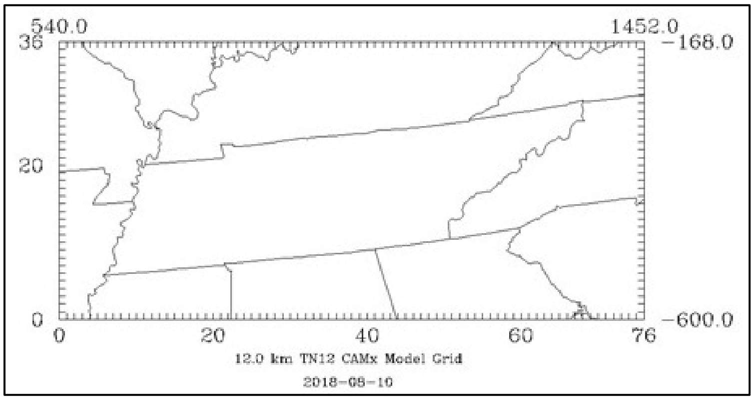

Figure 12-5. Geographic Boundary Map for IC/BC Extraction for Tennessee

The IC/BC data for each state are preserved on an external Serial Advanced Technology Attachment (SATA) disk that can be shared with each requesting state.

12.2 Additional Request #2: Developing Emissions for Remodeling

As documented in Section 9 of this report (as well as the Task 2B and Task 3B reports), SESARM directed ERG to review newer and updated 2028 emissions information from:

- Point sources 2028 emissions projected from the 2016 modeling platform developed by the EPA.
- Version 16.0 of the 2028 EGU emissions developed by the ERTAC.
- Specific emissions changes identified after the AoI review.

In December 2019, ERG prepared side-by-side emissions estimates for all point source facilities in the VISTAS_12 domain. As presented in Table 12-2, emissions (in tpy) from NO_x were approximately 20% lower and emissions from SO_2 were nearly 46% lower than emissions used for the original ("elv3") modeling.

Table 12-2. 2028 Point Emissions Comparison, elv3 vs. EPA 2028 based on 2016 Platform

VISTAS Domain States	Point NO_x Emissions (tpy)			Point SO_2 Emissions (tpy)		
	2028 elv3	**EPA 2028**	**% Diff.**	**2028 elv3**	**EPA 2028**	**% Diff.**
SESARM	590,052	542,524	-8.1%	455,577	300,585	-34.0%
Non-SESARM	2,051,412	1,565,591	-23.7%	2,118,965	1,099,702	-48.1%
Total	**2,641,464**	**2,108,116**	**-20.2%**	**2,574,542**	**1,400,287**	**-45.6%**

Table 12-3 compares just the ERTAC 16.0 version with the "elv3" modeling emissions for EGUs. Emissions from NO_x were approximately 24% lower and emissions from SO_2 were nearly 44% lower than emissions used for the original ("elv3") modeling.

Table 12-3. 2028 EGU Emissions Comparison, elv3 vs. ERTAC 2028, Version 16.0

VISTAS Domain States	NO_x Emissions (tpy)			SO_2 Emissions (tpy)		
	2028 elv3	ERTAC 2028	% Diff.	2028 elv3	ERTAC 2028	% Diff.
SESARM	246,719	200,791	-18.6%	231,414	161,503	-30.2%
Non-SESARM	637,195	467,244	-26.7%	1,337,078	712,388	-46.7%
Total	**883,914**	**668,035**	**-24.4%**	**1,568,492**	**873,890**	**-44.3%**

After consultation with EPA in January 2020, and in light of the significant decreases in emissions of these key pollutants within the VISTAS_12 domain, SESARM directed ERG to prepare emission comparison tables for each SESARM state consisting of:

- Facility, Unit, and Process-Level information;
- Stack parameters and locational coordinates;
- 2011v6.3el emissions;
- 2023v6.3en emissions;
- 2028v6.3el emissions;
- 2028 ERTACv2.7 emissions;
- Final 2028 VISTAS emissions (also called "elv3");
- 2028 EPA emissions from the 2016 platform;
- 2028 ERTACv16.0 emissions; and
- Revised 2028 emissions for VISTAS Remodel (filled in by VISTAS states and used for "elv5").

States compared the emissions used for the "elv3" modeling to the 2028 EPA emissions from the 2016 platform and the 2028 ERTACv16.0 emissions and decide whether to update emissions or keep as-is using the "Revised 2028 emissions for VISTAS Remodel" field.

In addition, for EGU emissions in non-VISTAS states, VISTAS agreed to replace the ERTACV2.7 2028 forecast (projected from a 2011 base year) in elv3 with the ERTAC16.0 forecast (projected from a 2016 base year) in elv5. After consultation with the other RPOs, LADCO requested that VISTAS use ERTAC16.1 in place of ERTAC16.0 for its states as the ERTAC16.1 forecast for 2028 corrected issues associated with $PM_{2.5}$ and PM_{10} emission factors that were unique to EGUs in some of the LADCO states.

Revisions were provided to ERG in February 2020, which were then reviewed, quality-assured, and ultimately placed in the master database. In March 2020, the revised emissions inventory was submitted to Alpine in FF10 format for the remodeling. As presented in Table 12-4, 2028 elv5 emissions (in tpy) from NO_x were approximately 10% lower and emissions from SO_2 were nearly 31% lower than emissions used for the 2028 elv3 modeling.

Table 12-4. 2028 Point Emissions Comparison, elv3 vs. elv5

VISTAS Domain States	Point NO_x Emissions (tpy)			Point SO_2 Emissions (tpy)		
	2028 elv3	2028 elv5	% Diff.	2028 elv3	2028 elv5	% Diff.
SESARM	590,052	563,637	-4.5%	455,577	369,520	-18.9%
Non-SESARM	2,051,412	1,807,167	-11.9%	2,118,965	1,404,416	-33.7%
Total	**2,641,464**	**2,370,804**	**-10.2%**	**2,574,542**	**1,773,936**	**-31.1%**

12.3 Additional Request #3: Day-By-Day Analysis

SESARM tasked Alpine with expanding the PSAT results by providing day-by-day results for each of the tagged scenarios relative to Class I areas in the VISTAS_12 domain for the 2028 elv3 base case simulation. The results are presented in light extinction (or "b_{ext}") with units of inverse megameters (Mm^{-1}) with underlying sulfate and nitrate concentration contributions. The day-by-day results are presented in the companion Excel workbook for the Task 7 report, which contains the tabular and graphical results of the 2028elv3 base case and the individual scenario contribution to light extinction for the selected Class I area. The scenarios are summarized in Section 8 of this report and the Task 7 Report on PSAT Tagging.

Figure 12-6 presents the Day-By-Day results for the Wolf Island Class I area for the 20% Clearest Days, and Figure 12-7 presents results for the 20% Most Impaired Days. The steps for preparing the results are presented in the Read Me tab of the Task 7 Excel workbook.

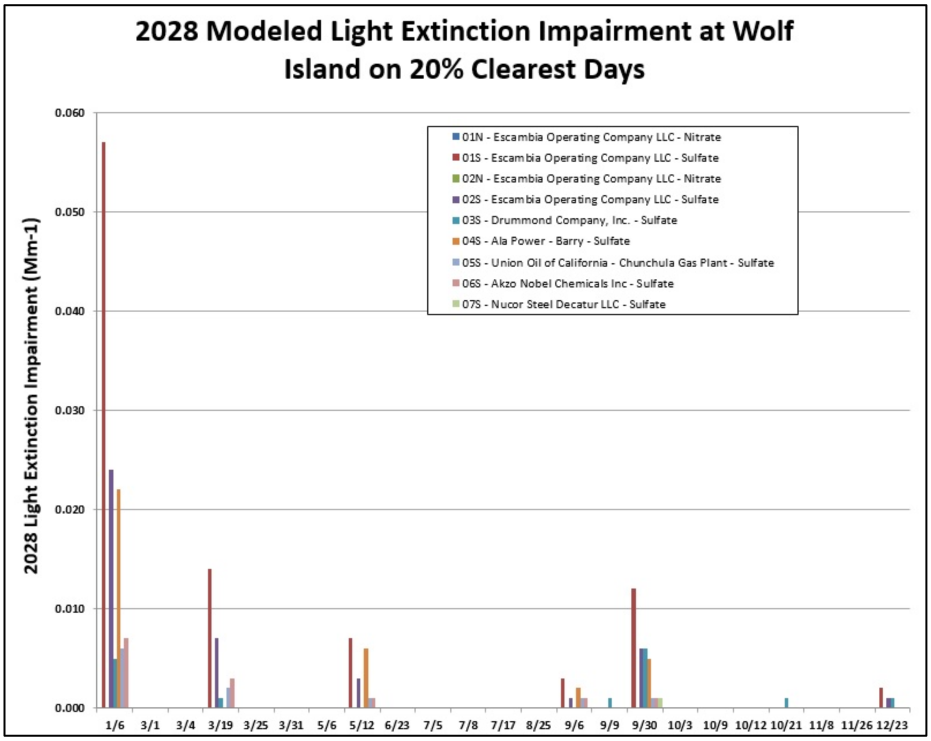

Figure 12-6. Day-By-Day Results for the 20% Clearest Days at the Wolf Island Class I Area.

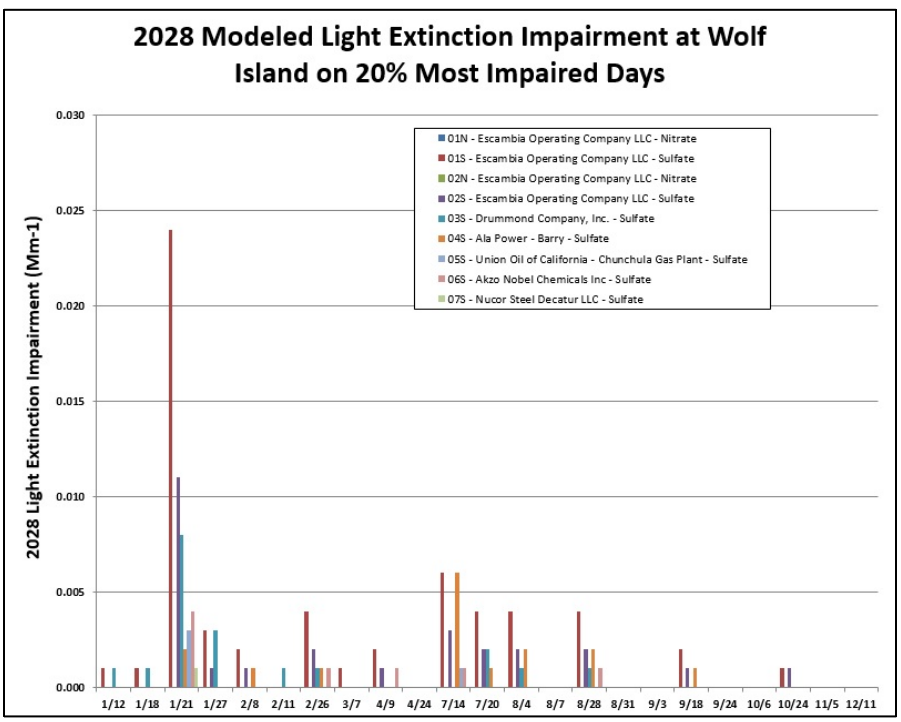

Figure 12-7. Day-By-Day Results for the 20% Most Impaired Days at the Wolf Island Class I Area.

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13.0 VISTAS II DATA ARCHIVING AND RETENTION

This section summarizes the data archiving and retention plan for the work products generated for this project. Activities related to Task 10 are presented at: https://www.metro4-sesarm.org/content/data-handling-and-sharing

For Task 10, the ERG/Alpine team consulted with SESARM to implement and utilize multiple solutions for the distribution and short-term and long-term archival of project assets (e.g., emissions and air quality modeling outputs, summaries, and other project documentation). Over the course of this project, tens of thousands of data products, images, files, and programming codes were developed to support Regional Haze SIP development for the SESARM member states, as well as to benefit other stakeholders.

For this project, ERG has acted as the data librarian, which was a role that Alpine served in the first VISTAS study. For the first VISTAS study, the most practical solution for data sharing of the data to the stakeholders was by mailing 300 gigabyte (GB) external hard drives to groups requesting large datasets. Since that time, computer communications have become much faster than they were in the mid-2000s, and the size of the datasets has expanded. One of the key challenges was distributing these pieces to the multiple stakeholders for review, comment, revision, and usage. ERG and Alpine worked with the SESARM to develop an effective data handling and sharing scheme. Essentially, five solutions were implemented throughout the life of the project and are described below.

13.1 File Transfer Protocol (FTP)

Early in the project, files were posted for storage, access, upload, and download on ERG's password-protected FTP site. The link and password were only distributed to the key stakeholders. This solution, while simple to execute and control, provided limitations of long-term storage, space, and accessibility for certain users. The organization of the FTP site consisted of placing files into folders specific to each task and subtask. This was beneficial in sharing and review of state-specific emissions files, which would often exceed size limitations of stakeholder e-mail servers. The FTP was also the solution for facilitating the transfer of large emissions and select modeling files between ERG and Alpine.

13.2 Contractor Network Storage

All interim and final data files developed by ERG and Alpine are retained on their respective networks, and will remain active for at least one year after project conclusion. As such, backups and maintenance are routinely applied to maintain the integrity and security of the data files. Access to these files is limited to only project staff at the respective companies, and the files are not publicly available. Alpine will retain project files for five years from the end of the project while ERG will indefinitely retain project files on tape drives and hard drives. Files can be retrieved with little effort in case the SESARM-retained project files are lost or corrupted.

13.3 External Hard Drives

Two sets of external drives that are used for this project. The first set contains all project-related files, excluding modeling input and output files, while the second set contains the modeling input and output files.

Project files (excluding modeling inputs and outputs)

The first set of external hard drives contain all the project files, excluding the modeling input and output files. One external drive is owned by SESARM (one TB) and the other was purchased by ERG specifically for this project (four TB). The files preserved on these drives will be exact copies and will contain all the files needed for transparency and any necessary reproducibility. At the end of the project, the SESARM drive will be sent back to SESARM archival according to federal grant records retention requirements and for provision to member states and other interested parties when no other source of the data is conveniently available.

Modeling files

The second set of external hard drives are a series of nine SATA hard drives of varying sizes containing the modeling input and output files for each of the final modeling runs. They include:

- Drive 1 – 2011/2028 CAMx and spatially and temporally merged emissions (10 TB drive);
- Drive 2 – 2028 elv5 CAMx 6.40 emissions and SMOKE processing files in the VISTAS 12-km domain (4 TB);
- Drive 3 – 2011 el outputs, VISTAS 12-km domain (8 TB drive);
- Drive 4 – 2011 el outputs, CONUS 12-km domain (10 TB drive);
- Drive 5 – 2011 CAMx 6.32 outputs for EPA and VISTAS modeling (8 TB);
- Drive 6 – 2028 elv3 CAMx 6.40 outputs for CONUS (12 TB);
- Drive 7 – 2028 elv3 CAMx 6.40 outputs in the VISTAS 12-km domain for PSAT tagging rounds 1 and 2 (12 TB);
- Drive 8 – 2028 elv3 CAMx 6.40 outputs in the VISTAS 12-km domain for PSAT tagging rounds 3 and 4 (12 TB); and

- Drive 9 – 2028 elv5 CAMx 6.40 outputs in the VISTAS 12-km domain (8 TB).

The files on these drives can be accessed using a Wavlink docking station, which can be plugged into the universal serial bus (USB) port, or the data can be more rapidly read by mounting the drive directly to a computer using the SATA interface. These files were prepared by Alpine and shipped to ERG for the duration of the project. At project end, these data files will be physically stored at the SESARM office location or offices of a VISTAS state if determined to be more appropriate, and available for duplication or shipping if a VISTAS state has a need for this level of detailed data. The drives and data are designed to be compatible with Linux EXT-3 filesystems that are easily accessible on the Linux computer systems which are required to run the CAMx model.

Only the first drive (2011/2028 CAMx and spatially and temporally merged emissions) is necessary for the states to run the model on either the VISTAS 12-km domain, or the smaller state-specific domains (as requested in Task 11.1). If the states wish to modify the emission files, then the second disk (2028 elv5 CAMx 6.40 emissions and SMOKE processing files in the VISTAS 12-km domain) will also be required. README files on each of these disks explain the organization of the modeling files.

13.4 SharePoint

North Carolina's Department of Environmental Quality (NCDEQ) offered supplemental VISTAS project data handling and storage services on a SharePoint platform. The SharePoint platform allows for collaborative editing, parallel review, and file exchange for multiple users. Its primary functions include:

- A central web site to provide quick access to project assets and news for stakeholders.
- File exchange and storage. Folders within the SharePoint platform have been used to organize project assets.
- Access control. The SharePoint site is not publicly available. Access to this site is granted by NCDEQ. Using SharePoint user groups, NCDEQ customizes permissions so only the properly credentialed individuals have access to specific files and folders.
- Project asset distribution. The SharePoint platform is configured to send out notifications related to file publishing.
- Project asset archives. The SharePoint platform uses version control and a recycle bin for file retention. Version control allows keeping previous versions of files as needed, and the recycle bin provides a mechanism for restoring files when an entire site collection is mistakenly deleted.

The information in the SharePoint platform is organized by task folder. In addition to the final reports, interim and draft reports are archived. The SharePoint platform also houses thousands of images and data files within Class I area folders for stakeholder use.

13.5 Metro 4/SESARM Website

The Metro 4/SESARM website hosts information about the project under the “Technical Center” location (https://www.metro4-sesarm.org/content/vistas-regional-haze-program). The “Technical Center” will ultimately contain task-level folders housing all task and final reports in .pdf format and for some tasks, data products. For example, the Area of Influence spreadsheets developed for each Class I area within the SESARM domain are posted in the Task 5 folder. Additionally, project materials such as presentations, handouts, and consultation letters are posted for public review.

SESARM staff are responsible for providing access to all data and reports critical to regional haze SIP development and approval. Maintenance of this website and retention of other supporting information in the various archival resources noted in this report will ensure the availability of information to the VISTAS states, Federal Land Managers, and other interested stakeholders for an adequate amount of time to serve the VISTAS states’ regional haze SIP needs and the requirements of the federal grant that funded this VISTAS project.

Appendix A

Regional Air Quality Project Deliverables

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Table A-1. Regional Haze Air Quality Project Deliverables (February 10, 2021)

Deliverable(s)	Type	Final Date	VISTAS Website[1]
Task 1 – Project Management			
Project Work Plan	.pdf	4/19/2018	Yes
Project Quality Assurance Project Plan (QAPP)	.pdf	4/3/2018	Yes
36 Monthly Progress Reports, March 2018-February 2021	.pdf	Monthly	--
Final Report	.pdf	1/27/2021	Yes
Task 2 – Emissions Inventory			
Task 2 Emissions Summary_EGU_DETAILED_AL	Excel	6/26/2018	--
Task 2 Emissions Summary_EGU_DETAILED_FL	Excel	6/26/2018	--
Task 2 Emissions Summary_EGU_DETAILED_GA	Excel	6/25/2018	--
Task 2 Emissions Summary_EGU_DETAILED_KY	Excel	6/27/2018	--
Task 2 Emissions Summary_EGU_DETAILED_MS	Excel	6/28/2018	--
Task 2 Emissions Summary_EGU_DETAILED_NC	Excel	6/26/2018	--
Task 2 Emissions Summary_EGU_DETAILED_SC	Excel	6/27/2018	--
Task 2 Emissions Summary_EGU_DETAILED_TN	Excel	7/13/2018	--
Task 2 Emissions Summary_EGU_DETAILED_VA	Excel	6/28/2018	--
Task 2 Emissions Summary_EGU_DETAILED_WV	Excel	6/28/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_AL	Excel	6/25/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_FL	Excel	6/25/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_GA	Excel	6/25/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_KY	Excel	6/27/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_MS	Excel	6/27/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_NC	Excel	6/27/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_SC	Excel	6/28/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_TN	Excel	6/28/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_VA	Excel	6/28/2018	--
Task 2 Emissions Summary_NON_EGU_DETAILED_WV	Excel	6/28/2018	--
Task 2A – VISTAS_2028_FF10_EGU.zip	.csv	5/8/2019	--
Task 2B – VISTAS_2028_FF10_EGU_20200331.zip	.csv	3/31/2020	--
Task 2A – VISTAS_2028_FF10_NON_EGU.zip	.csv	5/8/2019	--
Task 2B – VISTAS_2028_FF10_NON_EGU_20200331.zip	.csv	3/31/2020	--

Table A-1. Regional Haze Air Quality Project Deliverables (February 10, 2021)

Deliverable(s)	Type	Final Date	VISTAS Website[1]
Task 2A Emission Inventory Updates Report (AoI and PSAT)	.pdf	9/22/2020	Yes
Task 2B Emission Inventory Updates Report (2028 Visibility Estimates)	.pdf	9/22/2020	Yes
Task 3 – Emissions Processing			
pthour_2028_12july2018_01	.csv	7/12/2018	--
pthour_2028_12july2018_02	.csv	7/12/2018	--
pthour_2028_12july2018_03	.csv	7/12/2018	--
pthour_2028_12july2018_04	.csv	7/12/2018	--
pthour_2028_12july2018_05	.csv	7/12/2018	--
pthour_2028_12july2018_06	.csv	7/12/2018	--
pthour_2028_12july2018_07	.csv	7/12/2018	--
pthour_2028_12july2018_08	.csv	7/12/2018	--
pthour_2028_12july2018_09	.csv	7/12/2018	--
pthour_2028_12july2018_10	.csv	7/12/2018	--
pthour_2028_12july2018_11	.csv	7/12/2018	--
pthour_2028_12july2018_12	.csv	7/12/2018	--
pthour_remodel_2028_01	.csv	5/31/2020	--
pthour_remodel_2028_02	.csv	5/31/2020	--
pthour_remodel_2028_03	.csv	5/31/2020	--
pthour_remodel_2028_04	.csv	5/31/2020	--
pthour_remodel_2028_05	.csv	5/31/2020	--
pthour_remodel_2028_06	.csv	5/31/2020	--
pthour_remodel_2028_07	.csv	5/31/2020	--
pthour_remodel_2028_08	.csv	5/31/2020	--
pthour_remodel_2028_09	.csv	5/31/2020	--
pthour_remodel_2028_10	.csv	5/31/2020	--
pthour_remodel_2028_11	.csv	5/31/2020	--
pthour_remodel_2028_12	.csv	5/31/2020	--
Conversion of the Task 2A 2028 Point Source Modeling Files for Emissions Processing with SMOKE	.pdf/ Excel	10/12/2020	Yes

Table A-1. Regional Haze Air Quality Project Deliverables (February 10, 2021)

Deliverable(s)	Type	Final Date	VISTAS Website[1]
Conversion of the Task 2B 2028 Point Source Remodeling Files for Emissions Processing with SMOKE	.pdf/ Excel	10/12/2020	Yes
Task 4 – Data Acquisition and Preparation			
Task 4 Report	.pdf	10/17/2018	Yes
TASK_4_0_AMBIENT_DATABASE_SESARM (2009-2016)	Access	9/17/2018	--
TASK_4_0_AMBIENT_DATABASE_NON_SESARM (2009-2016)	Access	9/17/2018	--
TASK_4_0_AMBIENT_DATABASE_CASTNET_SESARM_SUPP	Access	9/17/2018	--
TASK_4_0_AMBIENT_DATABASE_CASTNET_NON_SESARM_SUPP	Access	9/17/2018	--
TASK_4_0_AMBIENT_DATABASE_IMPROVE_SESARM_SUPP	Access	9/17/2018	--
TASK_4_0_AMBIENT_DATABASE_IMPROVE_NON_SESARM_SUPP	Access	9/17/2018	--
TASK_4_0_MET_DATABASE_AQS (2011-2016)	Access	9/17/2018	--
NWS_SESARM_10_States (2011-2016)	Access	9/15/2018	--
NWS_VISTAS_NON_SESARM (2011-2016)	Access	9/15/2018	--
DepositionData_2011-2016	Access	1/10/2019	--
Task 5 – Area of Influence			
Task 5 – Area of Influence Analysis Documentation Report	.pdf	12/2/2020	Yes
AOI Spreadsheets (45 total, one for each Class I Area)	Excel	10/22/2020	Yes[2]
Combined point and county-level Access databases with NO_3 and SO_4 rankings	Access	10/23/2020	--
72-hour composite annual back trajectories for multiple vertical levels (100, 500, 1000, and 1500 meters) centered at each Class I area	.png	11/5/2020	--
72-hour composite seasonal back trajectories for multiple vertical levels (100, 500, 1000, and 1500 meters) centered at each Class I area	.png	11/5/2020	--
72-hour composite back trajectories at 100, 500, 1000, and 1500 meters layered together and centered at each Class I area	.png	11/5/2020	--
Residence time count plots centered at each Class I area	.png	11/5/2020	--
Residence time percent plots centered at each Class I area	.png	11/5/2020	--
Sulfate EWRT plots at each Class I area	.png	11/5/2020	--
Nitrate EWRT plots at each Class I area	.png	11/5/2020	--
Sulfate EWRT percent plots at each Class I area	.png	11/5/2020	--

Table A-1. Regional Haze Air Quality Project Deliverables (February 10, 2021)

Deliverable(s)	Type	Final Date	VISTAS Website[1]
Nitrate EWRT percent plots at each Class I area	.png	11/5/2020	--
Sulfate (Q/d)*EWRT percent plots at each Class I area	.png	11/5/2020	--
Nitrate (Q/d)*EWRT percent plots at each Class I area	.png	11/5/2020	--
Individual back trajectory maps every 6 hours for most impaired days for each Class I area	.jpg	11/5/2020	--
Task 6 – Air Quality Modeling			
Task 6.1 – Final Modeling Protocol	.pdf	6/27/2018	Yes
Task 6.1 – Final Modeling Protocol; Update and Addendum	.pdf	8/31/2020	Yes
Task 6 – Benchmark Confirmation Report#1 - Runs 1 and 2	.pdf	8/17/2020	Yes
Task 6 – Benchmark Confirmation Report#2 - Run 3	.pdf	8/17/2020	Yes
Task 6 – Benchmark Confirmation Report#3 - Run 4	.pdf	8/17/2020	Yes
Task 6 – Benchmark Confirmation Report#4 - Run 5	.pdf	8/17/2020	Yes
Task 6 – Benchmark Confirmation Report#5 - Run 6	.pdf	8/17/2020	Yes
Task 6 – Benchmark Confirmation Report#6 - Run 7	.pdf	9/22/2020	Yes
Drive 1 Modeling Files – 2011/2028 CAMx and spatially and temporally merged emissions	Linux	12/21/2020	--
Drive 2 Modeling Files – 2028 elv5 CAMx 6.40 emissions and SMOKE processing files in the VISTAS 12-km domain	Linux	12/21/2020	--
Drive 3 Modeling Files – 2011 el outputs, VISTAS 12-km domain	Linux	12/21/2020	--
Drive 4 Modeling Files – 2011 el outputs, continental U.S. (CONUS) 12-km domain	Linux	12/21/2020	--
Drive 5 Modeling Files – 2011 CAMx 6.32 outputs for EPA and VISTAS modeling	Linux	12/21/2020	--
Drive 6 Modeling Files – 2028 elv3 CAMx 6.40 outputs for CONUS	Linux	12/21/2020	--
Drive 7 Modeling Files – 2028 elv3 CAMx 6.40 outputs in the VISTAS 12-km domain for PSAT tagging rounds 1 and 2	Linux	12/21/2020	--
Drive 8 Modeling Files – 2028 elv3 CAMx 6.40 outputs in the VISTAS 12-km domain for PSAT tagging rounds 3 and 4	Linux	12/21/2020	--
Drive 9 Modeling Files – 2028 elv5 CAMx 6.40 outputs in the VISTAS 12-km domain	Linux	12/21/2020	--
Task 7 – PSAT Modeling			
Task 7 – Particulate Source Apportionment Technology Modeling Results final report	.pdf/ Excel	8/31/2020	Yes

Table A-1. Regional Haze Air Quality Project Deliverables (February 10, 2021)

Deliverable(s)	Type	Final Date	VISTAS Website[1]
Task 8 – Model Performance Evaluations			
Task 8.0 – Model Performance Evaluation for Ozone of the CAMx 6.40 Modeling System and the VISTAS II 2011 Updated Modeling Platform final report	.pdf/ Excel/ .kmz	8/17/2020	Yes
Task 8.0 – Model Performance Evaluation for Particulate Matter and Regional Haze of the CAMx 6.40 Modeling System and the VISTAS II 2011 Updated Modeling Platform final report	.pdf/ Excel	10/29/2020	Yes
Task 8.1 – Deposition Model Performance Evaluation final report	.pdf	1/22/2021	Yes
Task 9 – Future Year Modeling			
Task 9a – Future Year Model Projections final report	.pdf/ Excel	9/23/2020	Yes
Task 9.1 – Wet and Dry Deposition Calculations final report	.pdf/ Excel	1/20/2021	Yes
Task 10 – Data Archiving and Retention			
Task 10 – SESARM Data Handling and Sharing Summary memorandum	.pdf	12/21/2020	Yes
Task 11 – Additional Data Requests			
Task 11 – Additional Requests memorandum	.pdf/ Excel	12/21/2020	Yes
AL_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
FL_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
GA_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
KY_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
MS_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
NC_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
SC_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
TN_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
VA_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
WV_POINT_FACILITY_DETAILED_EGU	Excel	2/3/2020	--
AL_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--
FL_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--

Table A-1. Regional Haze Air Quality Project Deliverables (February 10, 2021)

Deliverable(s)	Type	Final Date	VISTAS Website[1]
GA_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--
KY_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--
MS_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--
NC_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--
SC_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--
TN_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--
VA_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--
WV_POINT_FACILITY_DETAILED_NON_EGU	Excel	2/3/2020	--

[1] For specific files not on the VISTAS website, please contact the state in which the Class I Area is located.

[2] On the VISTAS website, only the 18 Class I area spreadsheets in the VISTAS region plus 6 nearby Class I areas are posted.