Air Quality Modeling Technical Support Document for the Regulatory Impact Analysis for the Revisions to the National Ambient Air Quality Standards for Particulate Matter

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1. INTRODUCTION

In this technical support document (TSD), we describe the air quality modeling performed to support the regulatory impact analysis (RIA) for the revisions to the National Ambient Air Quality Standards (NAAQS) for particulate matter (PM). The purpose of the RIA was to conduct an illustrative analysis to estimate the health and environmental impacts of trying to reach the revised and alternative annual $PM_{2.5}$ primary standards. To conduct such an analysis, it was necessary to use air quality modeling to predict $PM_{2.5}$ concentrations in the future. Modeling was also used in the process of estimating the emissions reductions that might be required to meet a standard level in areas projected to exceed that level.

This TSD includes information on the following analytical aspects of the air quality modeling for the $PM_{2.5}$ NAAQS RIA:

- a description of the emissions and air quality modeling platform,
- an evaluation of model predictions compared to measured $PM_{2.5}$ concentrations,
- the procedures and results of projecting $PM_{2.5}$ concentrations for future year scenarios,
- the procedures and results of adjusting of future year air quality projections to account for the impact of existing episodic wood burning curtailment programs and atypical events such as wildfires,
- the procedures and results of adjusting future year air quality projections to develop an analytical baseline for the purpose of estimating the incremental costs and benefits for the revised and alternative standard levels,
- the procedures and results of adjusting air quality levels from the analytical baseline to meet the revised and alternative standard levels and associated estimates of emissions reductions,
- the procedures used for estimating annual average $PM_{2.5}$ concentrations for benefits inputs, and
- the procedures used for estimating changes in visibility for analyzing welfare benefits.

2. MODELING $PM_{2.5}$ LEVELS IN THE FUTURE

A national scale air quality modeling analysis was performed to estimate $PM_{2.5}$ concentrations for the annual and 24-hour primary standards for the future year of 2020[1]. As described in Section 3, air quality modeling was used in a relative sense to project future concentrations of $PM_{2.5}$. As part of this approach, air quality model predictions from a base year simulation are coupled with predictions from the future case to calculate the relative change (between base year and future case) in each species component of $PM_{2.5}$. These species-specific relative response factors (RRFs) are applied to the corresponding measured concentrations to estimate future species concentrations. The future case $PM_{2.5}$ annual and daily design values are then calculated using the projected species concentrations. We used 2007 as the base year and 2020 as the future year for air quality-related analyses for the RIA. For 2020 we modeled two emissions scenarios, a 2020 base case and a 2020 control case. The 2007 and 2020 scenarios were modeled as annual model simulations.

In addition to these emissions scenarios, we also performed several emissions sensitivity model runs to quantify the response of $PM_{2.5}$ to precursor emissions. Air quality ratios were then developed using model responsiveness to emissions changes based on the sensitivity air quality modeling that was designed to determine the response of $PM_{2.5}$ concentrations to reductions in emissions of SO_2, NO_x, and directly emitted $PM_{2.5}$. The air quality ratios were used in combination with results of the 2020 base case and 2020 control case to estimate the amount of emissions reductions needed to attain the existing standards, the revised annual standard of 12 $\mu g/m^3$ and two alternative annual standards. The resulting data were used as inputs to the calculation of expected costs and benefits associated with the emissions and air quality changes resulting from just attaining the revised and alternative annual standards after meeting a future baseline level that reflects attainment of the existing standards. In this way, the modeling for the 2020 base case, the 2020 control case, and sensitivity scenarios were used to inform the development of design values for the baseline which provides for attainment of the 15/35 NAAQS and the incremental emissions reductions needed to attain the revised 12 $\mu g/m^3$ annual standard and two alternative annual standards, 13 $\mu g/m^3$ and 11 $\mu g/m^3$.

Details on the 2007-based air quality modeling platform, the 2007 base year and 2020 base case scenarios, and the methods and results for attaining these NAAQS levels are provided below. Information on the 2020 control case can be found in Chapter 4 of the RIA.

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[1] In addition, we used air quality modeling to estimate light extinction in 2020 to support the analysis of the welfare benefits of this rule.

2.1 Air Quality Modeling Platform

The 2007-based Community Multi-scale Air Quality (CMAQ) modeling platform was used as the basis to project future-year air quality for 2020 and thereby estimate the costs and benefits for attaining the current and proposed alternative NAAQS considered in this assessment. This platform provides the most recent, complete set of base year emissions information currently available for national scale air quality modeling. In addition to the CMAQ model and the emissions data, the modeling platform includes the meteorology, and the initial and boundary condition data for 2007 which are inputs to this model[2]. The CMAQ model is a three-dimensional grid-based Eulerian air quality model designed to estimate the formation and fate of oxidant precursors, primary and secondary particulate matter concentrations and deposition over regional and urban spatial scales (e.g., over the contiguous U.S.) (Appel et al., 2008; Appel et al., 2007; Byun and Schere, 2006). Consideration of the different atmospheric processes (e.g., transport and deposition) that affect primary (directly emitted) and secondary (formed by atmospheric processes) $PM_{2.5}$ concentrations at the regional scale in different locations is fundamental to understanding and assessing the effects of pollution control measures that affect PM, ozone and deposition of pollutants to the surface. Because it accounts for spatial and temporal variations as well as differences in the reactivity of emissions, CMAQ is useful for evaluating the impacts of the control strategies on $PM_{2.5}$ concentrations. Version 4.7.1 of CMAQ was employed for the RIA modeling[3]. CMAQ is applied with the AERO5 aerosol module, which includes the ISORROPIA inorganic chemistry (Nenes et al., 1998) and a secondary organic aerosol module (Carlton et al., 2010). The CMAQ model is applied with sulfur and organic oxidation aqueous phase chemistry (Carlton et al., 2008) and the carbon-bond 2005 (CB05) gas-phase chemistry module (Yarwood et al., 2005).

2.1.1 Air Quality Modeling Domain

Figure 2-1 shows the geographic extent of the modeling domain that was used for air quality modeling in this analysis. The domain covers the 48 contiguous states along with the

[2] The boundary conditions provide pollutant concentrations along the perimeter of the modeling domain and enable treatment of the impact of pollution from outside the model domain on processes simulated within the domain.

[3] More information is available online at: www.cmaq-model.org

southern portions of Canada and the northern portions of Mexico[4]. This modeling domain contains 24 vertical layers with a top at about 17,600 meters, or 50 millibars (mb). A horizontal resolution of 12 x 12 km was used for modeling the 2007 base year and the 2020 base and control strategy scenarios. The model simulations produce gridded air quality concentrations on an hourly basis for the entire modeling domain. Results from the lowest layer of the model were used for the purposes of projecting air quality levels and informing costs and benefits analyses.

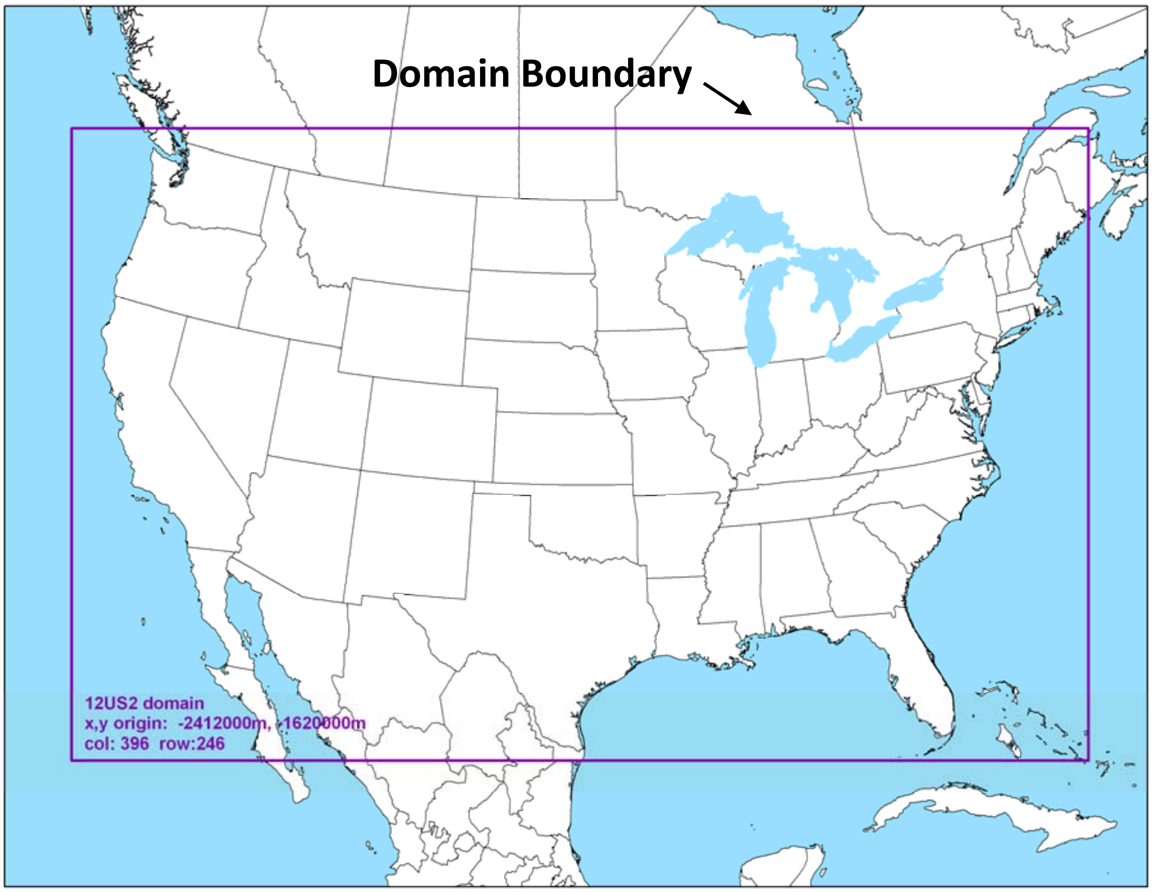

Figure 2-1. Map of the CMAQ Modeling Domain Used for PM NAAQS RIA

[4] Note that our 2007 modeling platform has a single modeling domain, whereas our previous 2005 platform had separate East and West domains. The single-domain approach reduces the amount of necessary post-processing.

2.1.2 Air Quality Model Inputs

CMAQ requires a variety of input files that contain information pertaining to the modeling domain and simulation period. These include gridded, hourly emissions estimates and meteorological data, and initial and boundary conditions. Separate emissions inventories were prepared for the 2007 base year and the future year of 2020 base case and control strategy scenarios. All other inputs were specified for the 2007 base year model application and remained unchanged for each future-year modeling scenario.

CMAQ requires detailed emissions inventories containing temporally allocated (i.e., hourly) emissions for each grid-cell in the modeling domain for a large number of chemical species that act as primary pollutants or precursors to secondary pollutants. The annual emission inventories, described in Section 2.1.4, were preprocessed into CMAQ-ready inputs using the SMOKE emissions preprocessing system[5]. Meteorological inputs reflecting 2007 conditions across the contiguous U.S. were derived from Version 3.1 of the Weather Research Forecasting Model (WRF). These inputs included hourly-varying horizontal wind components (i.e., speed and direction), temperature, moisture, vertical diffusion rates, and rainfall rates for each grid cell in each vertical layer. Details of the annual 2007 meteorological model simulation and evaluation are provided in a separate technical support document (EPA, 2011a).

The lateral boundary and initial species concentrations are provided by a three-dimensional global atmospheric chemistry model, the GEOS-CHEM model version 8-02-03 (Yantosca, 2004)[6]. The global GEOS-CHEM model simulates atmospheric chemical and physical processes driven by assimilated meteorological observations from the NASA's Goddard Earth Observing System (GEOS). This model was run for 2007 with a grid resolution of 2.0 degrees x 2.5 degrees (latitude-longitude) and 47 vertical layers. The predictions were used to provide one-way dynamic boundary conditions at three-hour intervals and an initial concentration field for the CMAQ simulations. A GEOS-Chem evaluation was conducted for the purpose of validating the 2007 GEOS-Chem simulation for predicting selected measurements relevant to their use as boundary conditions for CMAQ. This evaluation included reproducing GEOS-Chem evaluation plots reported in the literature for previous versions of the model (Lam, 2010).

2.1.3 Air Quality Model Evaluation

An operational model performance evaluation for $PM_{2.5}$ component species (e.g., sulfate, nitrate, elemental carbon, organic carbon) was performed to estimate the ability of the

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[5]More information is available online at: www.smoke-model.org
[6] More information is available online at: http://www-as.harvard.edu/chemistry/trop/geos.

CMAQ modeling system to replicate 2007 measured concentrations[7]. This evaluation principally comprises statistical assessments of model predictions versus observations paired in time and space consistent with the sampling period of measured data. Details on the evaluation methodology and the calculation of performance statistics are provided in Appendix A. Overall, the model performance statistics for sulfate, nitrate, organic carbon, and elemental carbon from the CMAQ 2007 simulation are within or close to the ranges found in other recent modeling applications. These model performance results give us confidence that our applications of CMAQ using this 2007 modeling platform provide a scientifically credible approach for assessing $PM_{2.5}$ concentrations for the purposes of the RIA.

2.1.4 Emissions Inventory

The 2007 emissions inventory and the 2020 base case emissions inventory were developed using the 2007 Version 5.0 emissions modeling platform (documentation and data files available from http://www.epa.gov/ttn/chief/emch/index.html). The starting point for the 2007v5 platform was Version 2 of the 2008 National Emissions Inventory (http://www.epa.gov/ttn/chief/net/2008inventory.html). The 2008 NEI is the most recently available inventory of anthropogenic emissions across the U.S. Some data in the 2008 NEI v2 were adjusted to better represent 2007 for this analysis. The 2020 base case inventory is the starting point for the baseline and control strategy modeling performed for this assessment. The Technical Support Document: Preparation of Emissions Inventories for the Version 5.0, 2007 Emissions Modeling Platform (EITSD, EPA, 2012) describes the development of the 2007 base year inventory in detail for all emissions sectors, along with the projection methodology applied to develop the 2020 base case inventory.

The 2020 EGU projected inventory represents demand growth, fuel resource availability, generating technology cost and performance, and other economic factors affecting power sector behavior. It also reflects the expected 2020 emissions effects due to environmental rules and regulations, consent decrees and settlements, plant closures, units built or with control devices updated since 2007, and forecast unit construction through the calendar year 2020. In this analysis, the projected EGU emissions include the Final Mercury and Air Toxics (MATS) rule

[7] This operational evaluation for CMAQ included statistical and graphical comparisons of model predictions for select $PM_{2.5}$ component species to the corresponding measured data from monitoring sites in the Continuous Speciation Network (CSN), the Interagency Monitoring of PROtected Visual Environments (IMPROVE) network, and the Clean Air Status and Trends Network (CASTNet).

announced on December 21, 2011 and the Final Cross-State Air Pollution Rule (CSAPR) issued on July 6, 2011.

On August 21, 2012, the D.C. Circuit Court of Appeals released an opinion that would vacate CSAPR. However, pending a petition to rehear the case, the Court has not issued a mandate making that opinion legally effective. As such, CSAPR is still a final rule but remains subject to a stay imposed by the Court on December 30, 2011. In the interim, the Clean Air Interstate Rule (CAIR) continues to be implemented to address regional transport of air pollution, as directed by the Court. In light of the still-pending litigation proceeding on CSAPR and its current status as a final rule (albeit stayed), EPA does not believe it would be appropriate or possible at this time to adjust emission projections on the basis of speculative alternative emission reduction requirements in 2020.

The EGU base case used in modeling this rule also represents a conservative approach to emission projections in this context, given that more recent trends in power sector economics suggest a likelihood of lower future EGU emissions. In fact, a sensitivity analysis using a more recent electricity demand forecast from EIA's AEO 2012 shows slightly lower EGU emissions, and it is reasonable to expect that recent reductions in gas prices and increases in coal prices would yield yet lower estimations of future EGU emissions in the context of this rule's analysis.

The EGU emissions were developed using version the Integrated Planning Model (IPM) version 4.10 Final MATS and are documented in detail at http://www.epa.gov/airmarkt/progsregs/epa-ipm/toxics.html. IPM is a multiregional, dynamic, deterministic linear programming model of the U.S. electric power sector. Note that for this analysis, no further EGU control measures were selected for illustrating attainment of the current and proposed alternative standard levels discussed in Chapter 4 of the RIA. Thus, the EGU emissions are unchanged between the future-year base-case and the control strategies.

Table 2-1 provides a comprehensive list of all the control programs, growth assumptions, and facility and unit closures information in the future year base case. The future-year base non-EGU stationary source emissions inventory includes all enforceable national rules and programs including the Reciprocating Internal Combustion Engines (RICE) and cement manufacturing National Emissions Standards for Hazardous Air Pollutants (NESHAPs) and Boiler Maximum Achievable Control Technology (MACT) reconsideration reductions. Many state and local control programs are also applied where those programs were finalized and enough details were available to apply reductions to the 2007 emissions data.

The 2007 and 2020 onroad mobile source emissions were developed using emissions factors derived from the MOtor Vehicle Emission Simulator (MOVES)[8] Version 2010b. The emissions were computed by using the Sparse Matrix Operator Kernel Emissions system (SMOKE) to combine the county-, vehicle type-, and temperature-specific emission factors and vehicle miles traveled and vehicle population activity data while taking into account hourly gridded temperature data. For California we received onroad emissions directly from the California Air Resources Board (CARB) in July 2012. These emissions were based on the latest available data and models from their SIP development process. We allocated the California onroad emissions down to the hourly, grid-cell, and CMAQ model-species level using ratios derived from the MOVES-based emissions data output from SMOKE.

The MOVES-based 2020 onroad emissions account for changes in activity data and the impact of on-the-books national rules including: the Light-Duty Vehicle Tier 2 Rule, the Heavy Duty Diesel Rule, the Mobile Source Air Toxics Rule, the Renewable Fuel Standard, the Light Duty Green House Gas/Corporate Average Fuel Efficiency (CAFE) standards for 2012-2016, and the Heavy-Duty Vehicle Greenhouse Gas Rule. The emissions do not account for the 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule (LD GHG), published October 15, 2012. The LD GHG rule was not included in this analysis because the rule was not signed at the time the modeling was performed, and it is expected to have little impact on particulate matter emissions. The RIA for the LD GHG (EPA, 2012c) shows that in 2030 counties are showing decreases in $PM_{2.5}$ design values of up to 0.16 $\mu g/m^3$. The modeling indicates that the majority of the modeled counties will experience small changes (< 0.05 $\mu g/m^3$) in their annual $PM_{2.5}$ design values in 2030 due to the vehicle standards. The impacts of the rule in 2020 should be even less than the 2030 impacts. The MOVES-based 2020 emissions include state rules related to the adoption of LEV standards, inspection and maintenance programs, Stage II refueling controls, and local fuel restrictions. For California, the provided future year emissions included most on-the-books regulations such as those for idling of heavy-duty vehicles, chip reflash, public fleets, track trucks, drayage trucks, and heavy duty trucks and buses. The California emissions do not reflect the impacts of the GHG/Smartway regulation.

Table 2-1 provides details on the national rules included to develop all categories of mobile source emissions. The nonroad mobile 2020 base emissions, including railroads and commercial marine vessel emissions also include all national control programs. These control programs include the Locomotive-Marine Engine rule, the Nonroad Spark Ignition rule and the

[8]More information is available online at: http://www.epa.gov/otaq/models/moves/index.htm.

Class 3 commercial marine vessel "ECA-IMO" program. The nonroad, locomotive, and class 1 and 2 commercial marine emissions used for California were obtained from CARB, and include nonroad rules reflected in the December 2010 Rulemaking Inventory (http://www.arb.ca.gov/regact/2010/offroadlsi10/offroadisor.pdf), those in the March 2011 Rule Inventory, the Off-Road Construction Rule Inventory for "In-Use Diesel", cargo handling equipment rules in place as of 2011 (see http://www.arb.ca.gov/ports/cargo/cargo.htm), rules through 2011 related to Transportation Refrigeration Units, the Spark-Ignition Marine Engine and Boat Regulations adopted July 24, 2008 for pleasure craft, and the 2007 and 2010 regulations to reduce emissions from commercial harbor craft. For ocean-going vessels, the data represents the 2005 voluntary Vessel Speed Reduction (VSR) within 20 nautical miles, the 2007 and 2008 auxiliary engine rules, the 40 nautical mile VSR program, the 2009 Low Sulfur Fuel regulation, the 2009-2018 cold ironing regulation, the use of 1% sulfur fuel in the ECA zone, the 2012-2015 Tier 2 NOx controls, the 2016 0.1% sulfur fuel regulation in ECA zone, and the 2016 IMO Tier 3 NOx controls. Control and growth-related assumptions in the 2020 base case are described in more detail in the EITSD.

All modeled 2007 and 2020 scenarios use the same year 2006 Canada emissions data for Canadian sources within the modeling domain. Note that 2006 is the latest year for which Canada provided data, and no accompanying future-year projected inventories were provided in a form suitable for this study. For Mexico, different emissions were used for 2008 and 2018 for Mexican sources within the domain as described in the Development of Mexico National Emissions Inventory Projections for 2008, 2012, and 2030 (ERG, 2009) and the associated technical memorandum titled Mexico 2018 Emissions Projections for Point, Area, On-Road Motor Vehicle and Nonroad Mobile Sources (ERG, 2009). All base year and projected emissions inventories are available on the EPA's Emissions Modeling Clearinghouse website at http://www.epa.gov/ttn/chief/emch/index.html.

Table 2-1(a). Control Strategies and Growth Assumptions for Creating 2020 Base Case Emissions Inventories from the 2007 Base Case for Non-EGU Point Sources.

Control Strategies and/or Growth Assumptions (Grouped by Affected Pollutants or Standard and Approach)	Pollutants Affected
Non-EGU Point (ptnonipm) Controls and Growth Assumptions	
Boat Manufacturing MACT rule, national, VOC: national applied by SCC	VOC
Consent decrees on companies (based on information from the Office of Enforcement and Compliance Assurance—OECA) apportioned to plants owned/operated by the companies	VOC, CO, NO_x, PM, SO_2
Refinery Consent Decrees: plant/SCC controls	NO_x, PM, SO_2
Commercial/Institutional/Hospital/Medical/Infectious Waste Incinerator Regulations	NO_X, PM, SO_2
NESHAP: Portland Cement (09/09/10)—plant level based on **Industrial Sector Integrated Solutions (ISIS)** policy emissions in 2013. The ISIS results are from the ISIS-Cement model runs for the NESHAP and NSPS analysis of July 28, 2010 and include closures.	Hg, NO_X, SO_2, PM, HCl
New York ozone SIP controls	VOC, NO_X, HAP VOC
Additional plant and unit closures provided by state, regional, and the EPA agencies and additional consent decrees. Includes updates from CSAPR comments.	All
Reciprocating Internal Combustion Engines (RICE) NESHAP with reconsideration	NO_X, CO, PM, SO_2
Ethanol plants that account for increased ethanol production due to RFS2 mandate	All
State fuel sulfur content rules for fuel oil—as of July, 2012, effective only in Maine, Massachusetts, New Jersey, New York and Vermont.	SO_2
Emission reductions resulting from controls put on specific boiler units (not due to MACT) after 2005, identified through analysis of the control data gathered from the Information Collection Request (ICR) from the Industrial/Commercial/Institutional Boiler NESHAP.	NO_X, SO_2, HCl
Emissions reductions resulting from Boiler MACT controls to specific boiler units	NO_X, CO, PM, SO_2, VOC, HCl
Plant and unit closures resulting from state submissions and industry and web postings effective prior to January 2012	All
Aircraft growth via Itinerant (ITN) operations at airports to 2020	All
Livestock Emissions Growth from year 2008 to year 2020 (some farms in the point inventory)	NH_3, PM
Upstream adjustments to year 2020 for refineries and gasoline distribution via the Energy Information and Security Act/Renewable Fuel Standards 2 (EISA/RFS2) impacts	All

Table 2-1(b). Control Strategies and Growth Assumptions for Creating 2020 Base Case Emissions Inventories from the 2007 Base Case for Nonpoint and Onroad Mobile Sources.

Control Strategies and/or Growth Assumptions (Grouped by Affected Pollutants or Standard and Approach Used to Apply to the Inventory)	Pollutants Affected
Nonpoint (nonpt sector) Controls and Growth Assumptions	
Residential Wood Combustion Growth and Change-outs from year 2008 to 2020	All
State fuel sulfur content rules for fuel oil—as of July, 2012, effective only in Maine, Massachusetts, New Jersey, New York and Vermont.	SO_2
Reciprocating Internal Combustion Engines (RICE) NESHAP with reconsideration	NO_X, CO, PM, SO_2
New York, Connecticut, and Virginia ozone SIP controls	VOC
Livestock Emissions Growth from year 2008 to year 2020 (some farms in the point inventory)	NH_3, PM
Upstream adjustments to year 2020 for refineries and gasoline distribution via the Energy Information and Security Act/Renewable Fuel Standards 2 (EISA/RFS2) impacts	All
Portable Fuel Container Mobile Source Air Toxics Rule 2 (MSAT2) inventory growth and control from year 2007 to 2020	VOC
Texas oil and gas projections to year 2020	VOC, SO_2, NO_X, CO, PM
Onroad Mobile Controls (list includes all key mobile control strategies but is not exhaustive)	
National Onroad Rules:	All
Tier 2 Rule: Signature date February 2000	
2007 Onroad Heavy-Duty Rule: February 2009	
Final Mobile Source Air Toxics Rule (MSAT2): February 2007	
Renewable Fuel Standard: March 2010	
Light Duty Greenhouse Gas Rule: May 2010	
Heavy (and Medium)-Duty Greenhouse Gas Rule: August 2011	
Corporate Average Fuel Economy standards for 2008–2011	
Local Onroad Programs:	VOC
National Low Emission Vehicle Program (NLEV): March 1998	
Ozone Transport Commission (OTC) LEV Program: January 1995	

Table 2-1(c). Control Strategies and Growth Assumptions for Creating 2020 Base Case Emissions Inventories from the 2007 Base Case for Nonroad Mobile Sources.

Control Strategies and/or Growth Assumptions (Grouped by Affected Pollutants or Standard and Approach Used to Apply to the Inventory)	Pollutants Affected
Nonroad Mobile Controls (list includes all key mobile control strategies but is not exhaustive) (continued)	
National Nonroad Controls:	All
Clean Air Nonroad Diesel Final Rule—Tier 4: June 2004	
Control of Emissions from Nonroad Large-Spark Ignition Engines and Recreational Engines (Marine and Land Based): "Pentathalon Rule": November 2002	
Clean Bus USA Program: October 2007	
Control of Emissions of Air Pollution from Locomotives and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder: October 2008	
Locomotive and marine rule (May 6, 2008)	
Marine SI rule (October 4, 1996)	
Nonroad large SI and recreational engine rule (November 8, 2002)	
Nonroad SI rule (October 8, 2008)	
Phase 1 nonroad SI rule (July 3, 1995)	
Tier 1 nonroad diesel rule (June 17, 2004)	
Locomotives:	All
Energy Information Administration (EIA) fuel consumption projections for freight rail	
Clean Air Nonroad Diesel Final Rule—Tier 4: June 2004	
Locomotive Emissions Final Rulemaking, December 17, 1997	
Locomotive rule: April 16, 2008	
Control of Emissions of Air Pollution from Locomotives and Marine: May 2008	
Commercial Marine:	All
Category 3 marine diesel engines Clean Air Act and International Maritime Organization standards (April 30, 2010)—*also includes CSAPR comments.*	
EIA fuel consumption projections for diesel-fueled vessels	
Clean Air Nonroad Diesel Final Rule—Tier 4	
Emissions Standards for Commercial Marine Diesel Engines, December 29, 1999	
Locomotive and marine rule (May 6, 2008)	
Tier 1 Marine Diesel Engines, February 28, 2003	

3. $PM_{2.5}$ MODELING RESULTS AND ANALYSES

The air quality modeling results were used in the RIA to estimate future $PM_{2.5}$ concentrations for the 2020 base case and 2020 control case as well as to calculate the air quality ratios that were used in determining the emissions reductions to attain the existing standards of 15/35, the revised annual standard of 12 µg/m^3 and the two alternative annual standards. These data are then used to estimate the costs and benefits of attaining these existing and revised NAAQS levels. Consistent with EPA guidance (EPA, 2007) and (EPA, 2011b), the air quality modeling results are applied in a relative sense to estimate 2020 future design values for $PM_{2.5}$ for the 2020 base case and 2020 control case. Air quality response ratios (hereafter referred to as air quality ratios) are calculated and used to estimate the tons of emissions reductions beyond the 2020 control case needed to show attainment of the existing, revised, and alternative NAAQS levels. Based on the tons of emissions needed in each county, design values are calculated for attaining the revised and alternative annual standard levels for input into the benefits assessment.

The flow diagram shown in Figure 3-1 summarizes our approach for calculating future-year design values for meeting the existing standards, the revised annual standard, and alternative annual standard levels[9]. Table 3-1 describes the specific air quality modeling simulations that informed this approach. The 2020 base case simulation (Box 1) was performed to estimate which monitor locations would exceed the current and alternative standard levels in 2020 based on emissions reductions expected from existing (i.e., "on-the-books") state and federal control programs. The 2020 control case simulation (Box 3) was performed to estimate the impact of emission reductions from additional controls beyond those of the 2020 base case in areas with design values above the revised and alternative standard levels. As discussed below, the 2020 base case and 2020 control case design values were adjusted to reflect reductions in $PM_{2.5}$ concentrations expected from the implementation of existing burn ban programs in certain counties and to remove the effects of atypical events (Boxes 2 and 4). To calculate future-year design values at the different standard levels, and the associated emissions reductions, these 2020 base and control case design values were adjusted downward using air quality response ratios, which give the change $PM_{2.5}$ design value ($\mu g/m^3$) per change in emissions by species (Boxes 5 through 9).

The remainder of this section is organized as follows. Section 3.1 describes the sensitivity simulations used in estimating the impact of emissions reductions on design values

[9] Design values for the cases shown in Box 1-9 of Figure 3-1 are available in the PM NAAQS Final Rule docket.

at those monitors estimated to exceed future air quality targets. Section 3.2 describes the procedures and the results from the 2020 base case modeling and the development of the adjusted 2020 base and controls cases (Boxes 1 through 4, respectively in Figure 3-1). Section 3.3 describes the identification of the emissions reductions estimated to be needed beyond those of the 2020 control case to attain the 15/35 standard and annual standards of 13, 12, and 11 μg/m^3 (Boxes 5 through 9 in Figure 3-1). Section 3.4 describes the procedures used for estimate annual average PM2.5 for benefits inputs. Section 3.5 discusses some of the limitations associated with using adjusted air quality data. Section 3.6 discusses the weight-of-evidence approach used in evaluating future year exceedances for Lincoln County, MT and Santa Cruz, AZ. Section 3.7 describes the procedures used for estimating changes in visibility for analyzing welfare benefits.

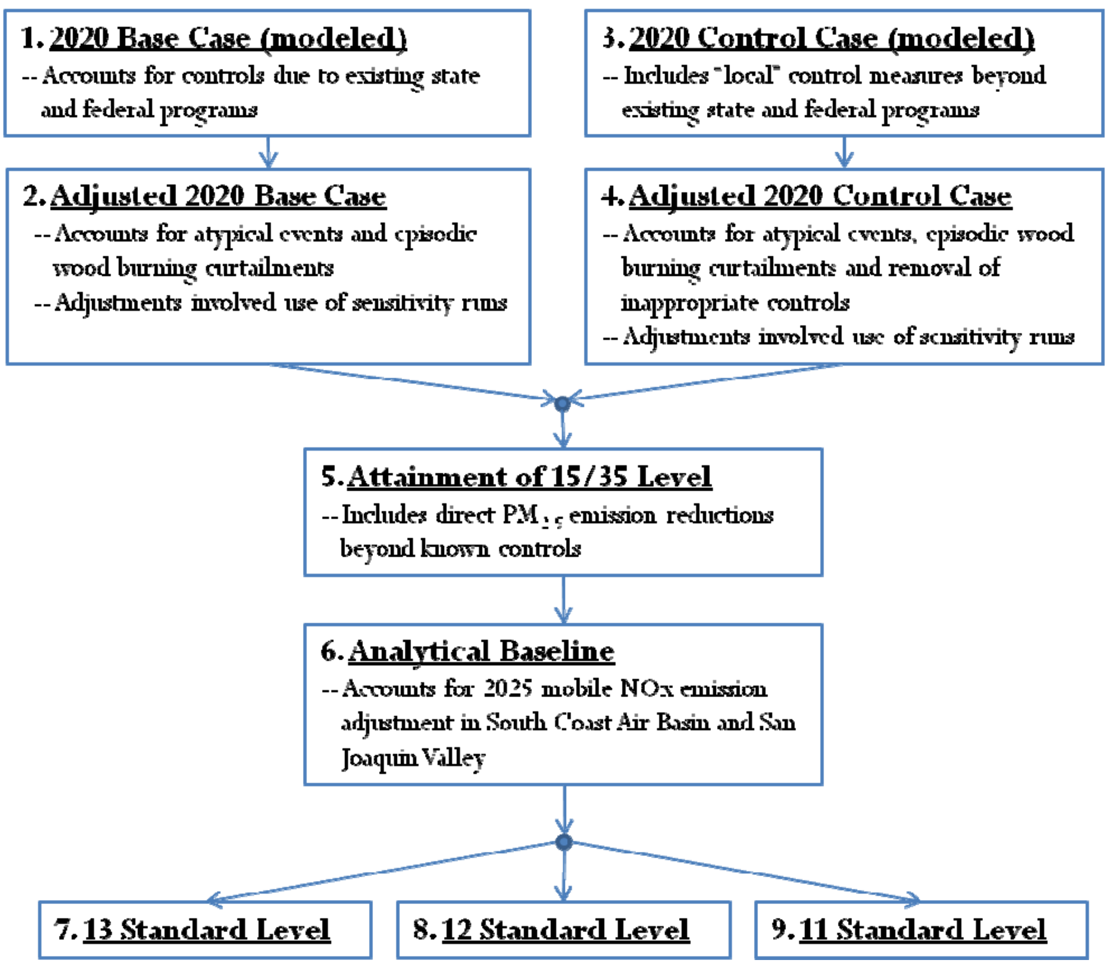

Figure 3-1. Flow Diagram of Process Used to Determine Future-Year Design Values and Associated Emission Reductions for Meeting the Current, Revised and Alternative Standard Levels

Table 3-1. Air Quality Model Simulations Used in the Regulatory Impact Analysis.

Simulation	Description	Purpose
2020 base case	Simulation of 2020 that accounts for expected controls due to existing state and federal programs.	Provides estimate of future-year design values based on existing controls
2020 control case	Simulation of 2020 that includes emissions controls beyond the controls of the 2020 base case in areas with design values above the alternative standard levels in the 2020 base case.	Provides impact of additional known controls on design values in target areas; provides basis for meeting standard levels with emission controls beyond known controls
2020 NO_x_$PM_{2.5}$ sensitivity	Simulation of 2020 where anthropogenic NO_x and $PM_{2.5}$ emissions are decreased by 25% and 50%, respectively, relative to the 2020 base case in selected counties.	Used in estimating the response of air quality to changes in emissions of NO_x and direct $PM_{2.5}$
2020 SO_2_RWC sensitivity	Simulation of 2020 where anthropogenic SO2 and residential wood combustion emissions are decreased by 25% and 100%, respectively, relative to the 2020 base case in selected counties.	Used in estimating the response of air quality to changes in emissions of SO_2 and residential wood combustion
2020 SJV sensitivity	Nine simulations of January 2020. Each simulation has emission reductions relative to the 2020 base case in a one- or two-county group in California's Central Valley. The emission reductions in each county group are the same as those in the 2020 NO_x_$PM_{2.5}$ sensitivity case.	This series of simulations is used to estimate the contributions of emissions from counties in the California's Central Valley on air quality in other counties in the Central Valley

3.1 Sensitivity Simulations

As mentioned above, results of the 2020 base case and 2020 control case model simulations were adjusted to account for the impact of existing burn ban programs as well as to meet the revised and alternative standard levels under consideration. The adjustment procedure involved use of results of the sensitivity simulations described in Table 3-1. The sensitivity simulations were defined to isolate the changes in ammonium sulfate ($(NH_4)_2SO_4$), ammonium nitrate (NH_4NO_3) and direct $PM_{2.5}$ associated with changes in emissions of SO_2, NO_x and direct $PM_{2.5}$, respectively[10]. These $PM_{2.5}$ component species were selected for reduction to

[10] Ammonium sulfate and ammonium nitrate are commonly referred to simply as $PM_{2.5}$ sulfate and $PM_{2.5}$ nitrate, respectively. These $PM_{2.5}$ components are largely secondary pollutants that form due to the oxidation of SO_2 and NOx in the atmosphere and the subsequent association with NH_3.

meet the standard levels because they dominate the mass of $PM_{2.5}$ in the areas of concern in the 2020 cases.

The sensitivity simulations are defined as follows:

- "2020 NO_x_$PM_{2.5}$" was used in calculating the air quality ratios associated with changes in NO_x and direct $PM_{2.5}$ emissions. This simulation was based on anthropogenic NO_x and direct $PM_{2.5}$ emission reductions from non-EGU sources of 25% and 50%, respectively, relative to the 2020 base case[11].
- "2020 SO_2_RWC" was used in calculating the air quality ratios associated with changes in SO_2 emissions and in quantifying the impacts on design values of existing burn ban programs. This simulation was based on anthropogenic SO_2 and residential wood combustion emissions reductions from non-EGU sources of 25% and 100%, respectively, relative to the 2020 base case[11].

In the sensitivity simulations, emissions reductions for direct $PM_{2.5}$ were generally applied to counties with monitors having design values above the 11/35 level in the 2020 base case, while emission reductions for NO_x and SO_2 were generally applied in those counties as well as their adjacent counties[12]. This approach reflects the local impacts of direct $PM_{2.5}$ emissions on air quality and the broader geographic impacts on $PM_{2.5}$ of SO_2 and NO_x emissions reductions. The list of counties where emissions reductions were applied, and the percentage of emissions reduction in these counties, is provided in Table 3-2.

Table 3-2. Percentage of Emissions Reductions Relative to the 2020 Base Case for the 2020 NOx_$PM_{2.5}$ and 2020 SO_2_RWC Air Quality Simulations

				2020 SO_2_RWC		**2020 NOx_$PM_{2.5}$**	
FIPS	**Group**	**County**[13]	**State**	**SO_2 Emission Reduction**	**RWC Emission Reduction**	**NOx Emission Reduction**	**Direct $PM_{2.5}$ Emission Reduction**
01073	01073	**Jefferson**	Alabama	25%	100%	25%	50%

[11] The anthropogenic non-EGU emissions sectors to which emissions reductions were applied are c1c2rail, c3marine, onroad mobile, nonroad mobile, ptnonipm, and nonpt. For the 2020_SO_2_RWC simulation, all residential wood combustion emissions in the nonpt sector were zeroed out.

[12] Emissions reductions were applied to gridded emissions fields. For grid cells that crossed county borders, emissions reductions were scaled by the fraction of the grid cell area contained within the county.

[13] Counties shown in bold exceeded the 11/35 standard level in the 2020 base case.

				2020 SO_2_RWC		2020 NOx_$PM_{2.5}$	
FIPS	Group	County[13]	State	SO_2 Emission Reduction	RWC Emission Reduction	NOx Emission Reduction	Direct $PM_{2.5}$ Emission Reduction
01007	01073	Bibb	Alabama	25%		25%	
01009	01073	Blount	Alabama	25%		25%	
01115	01073	St. Clair	Alabama	25%		25%	
01117	01073	Shelby	Alabama	25%		25%	
01125	01073	Tuscaloosa	Alabama	25%		25%	
01127	01073	Walker	Alabama	25%		25%	
17031	17031	**Cook**	Illinois	25%	100%	25%	50%
17043	17031	DuPage	Illinois	25%		25%	
17089	17031	Kane	Illinois	25%		25%	
17097	17031	Lake	Illinois	25%		25%	
17111	17031	McHenry	Illinois	25%		25%	
17197	17031	Will	Illinois	25%		25%	
18089	18089	**Lake**	Indiana	25%	100%	25%	50%
17091	18089	Kankakee	Illinois	25%		25%	
18073	18089	Jasper	Indiana	25%		25%	
18111	18089	Newton	Indiana	25%		25%	
18127	18089	Porter	Indiana	25%		25%	
26163	26163	**Wayne**	Michigan	25%	100%	25%	50%
26099	26163	Macomb	Michigan	25%		25%	
26115	26163	Monroe	Michigan	25%		25%	
26125	26163	Oakland	Michigan	25%		25%	
26161	26163	Washtenaw	Michigan	25%		25%	
48201	48201	**Harris**	Texas	25%	100%	25%	50%
48039	48201	Brazoria	Texas	25%		25%	
48071	48201	Chambers	Texas	25%		25%	
48157	48201	Fort Bend	Texas	25%		25%	
48167	48201	Galveston	Texas	25%		25%	
48291	48201	Liberty	Texas	25%		25%	
48339	48201	Montgomery	Texas	25%		25%	
48473	48201	Waller	Texas	25%		25%	
17119	17119	**Madison**	Illinois	25%	100%	25%	50%
17005	17119	Bond	Illinois	25%		25%	
17027	17119	Clinton	Illinois	25%		25%	
17083	17119	Jersey	Illinois	25%		25%	

				2020 SO_2_RWC		2020 NOx_$PM_{2.5}$	
FIPS	Group	County[13]	State	SO_2 Emission Reduction	RWC Emission Reduction	NOx Emission Reduction	Direct $PM_{2.5}$ Emission Reduction
17117	17119	Macoupin	Illinois	25%		25%	
17135	17119	Montgomery	Illinois	25%		25%	
17163	17119	St. Clair	Illinois	25%		25%	
29183	17119	St. Charles	Missouri	25%		25%	
29189	17119	St. Louis	Missouri	25%		25%	
29510	17119	St. Louis City	Missouri	25%		25%	
06001	06001	**Alameda**	California	25%	100%	25%	50%
06019	SJV	**Fresno**	California	25%	100%	25%	50%
06025	06025	**Imperial**	California	25%	100%	25%	50%
06029	SJV	**Kern**	California	25%	100%	25%	50%
06031	SJV	**Kings**	California	25%	100%	25%	50%
06037	SC	**Los Angeles**	California	25%	100%	25%	50%
06039	SJV	Madera	California	25%	100%	25%	50%
06047	SJV	**Merced**	California	25%	100%	25%	50%
06059	SC	Orange	California	25%	100%	25%	50%
06065	SC	**Riverside**	California	25%	100%	25%	50%
06067	06067	**Sacramento**	California	25%	100%	25%	50%
06071	SC	**San Bernardino**	California	25%	100%	25%	50%
06077	SJV	**San Joaquin**	California	25%	100%	25%	50%
06099	SJV	**Stanislaus**	California	25%	100%	25%	50%
06107	SJV	**Tulare**	California	25%	100%	25%	50%
06007	06007	**Butte**	California		100%		50%
04023	04023	Santa Cruz[14]	Arizona	25%	100%	25%	50%
49035	49035	**Salt Lake**	Utah	25%	100%	25%	50%
49049	49035	**Utah**	Utah	25%	100%	25%	50%
53053	53053	**Pierce**	Washington		100%		50%
41035	41035	**Klamath**	Oregon		100%		50%
16079	16079	**Shoshone**	Idaho		100%		50%
30053	30053	Lincoln[14]	Montana	25%	100%	25%	50%
42003	42003	**Allegheny**	Pennsylvania	25%	100%	25%	50%
42005	42003	Armstrong	Pennsylvania	25%		25%	
42007	42003	Beaver	Pennsylvania	25%		25%	

[14] Santa Cruz, AZ and Lincoln, MT were estimated to attain the alternative standard levels by weight-of-evidence considerations

				2020 SO_2_RWC		2020 NOx_$PM_{2.5}$	
FIPS	Group	County[13]	State	SO_2 Emission Reduction	RWC Emission Reduction	NOx Emission Reduction	Direct $PM_{2.5}$ Emission Reduction
42019	42003	Butler	Pennsylvania	25%		25%	
42125	42003	Washington	Pennsylvania	25%		25%	
42129	42003	Westmoreland	Pennsylvania	25%		25%	
19163	19163	**Scott**	Iowa	25%	100%	25%	50%
17161	19163	Rock Island	Illinois	25%		25%	
19031	19163	Cedar	Iowa	25%		25%	
19045	19163	Clinton	Iowa	25%		25%	
19139	19163	Muscatine	Iowa	25%		25%	
55079	55079	**Milwaukee**	Wisconsin	25%	100%	25%	50%
55089	55079	Ozaukee	Wisconsin	25%		25%	
55101	55079	Racine	Wisconsin	25%		25%	
55131	55079	Washington	Wisconsin	25%		25%	
55133	55133	**Waukesha**	Wisconsin	25%	100%	25%	50%
55027	55133	Dodge	Wisconsin	25%		25%	
55055	55133	Jefferson	Wisconsin	25%		25%	
55127	55133	Walworth	Wisconsin	25%		25%	
06063	06063	**Plumas**	California		100%		50%
06085	06085	**Santa Clara**	California		100%		50%
06101	06101	**Sutter**	California		100%		50%
06095	06095	**Solano**	California		100%		50%
41037	41037	**Lake**	Oregon		100%		50%
41039	41039	**Lane**	Oregon		100%		50%
48141	48141	**El Paso**	Texas	25%	100%	25%	50%

Spatial differences in the monthly average concentration of nitrate between the 2020 NOx_$PM_{2.5}$ case and the 2020 base case are shown in Figure 3-2 for the month of January. The largest decreases in nitrate between the 2020 NOx_$PM_{2.5}$ case and the 2020 base case occur in the San Joaquin Valley of California, with smaller decreases noticeable in the South Coast Air Basin, central Utah and other areas where NOx emissions reductions were applied. The differences in average primary organic aerosol between the 2020 NOx_$PM_{2.5}$ case and the 2020 base case for January (Figure 3-3) indicate decreases in concentrations in the local regions where the emissions reductions occurred.

Spatial differences in the monthly average concentration of sulfate between the 2020 SO_2_RWC case and the 2020 base case are shown in Figure 3-4 for the month of August. Small decreases in sulfate occur in the broad regions surrounding counties with SO_2 emissions reductions. Spatial differences for monthly average primary organic aerosol concentration associated with the 2020 SO_2_RWC case are shown in Figure 3-5 for January and indicate decreases in concentrations in the local regions where the emissions reductions occurred.

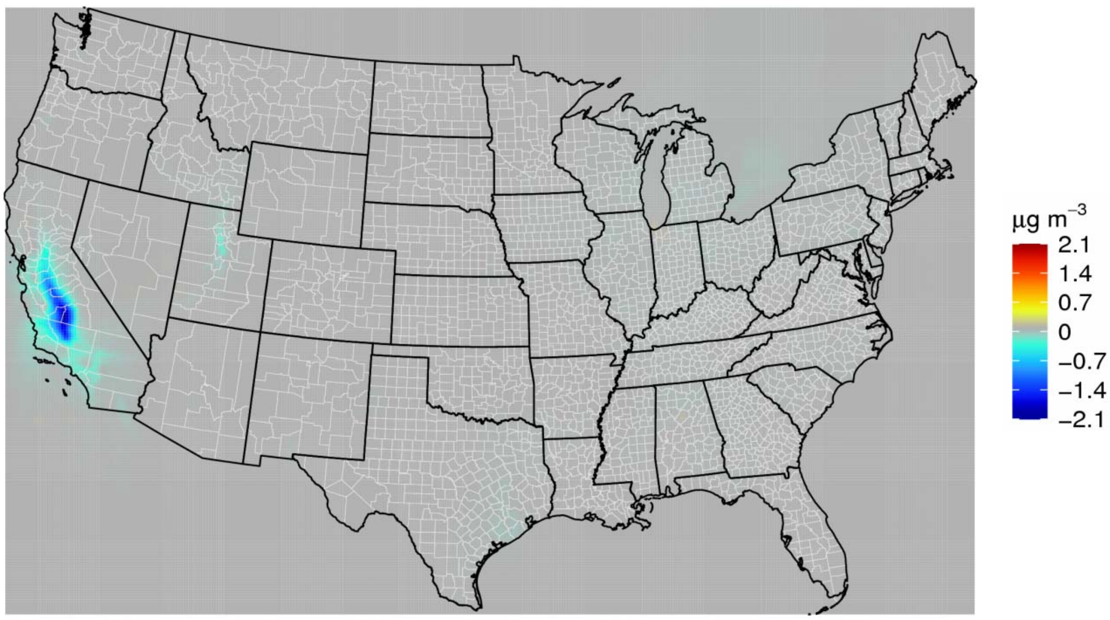

Figure 3-2. Difference in monthly average nitrate between 2020 NOx_$PM_{2.5}$ sensitivity run and 2020 base case (2020 NOx_$PM_{2.5}$ – 2020 base case) for January

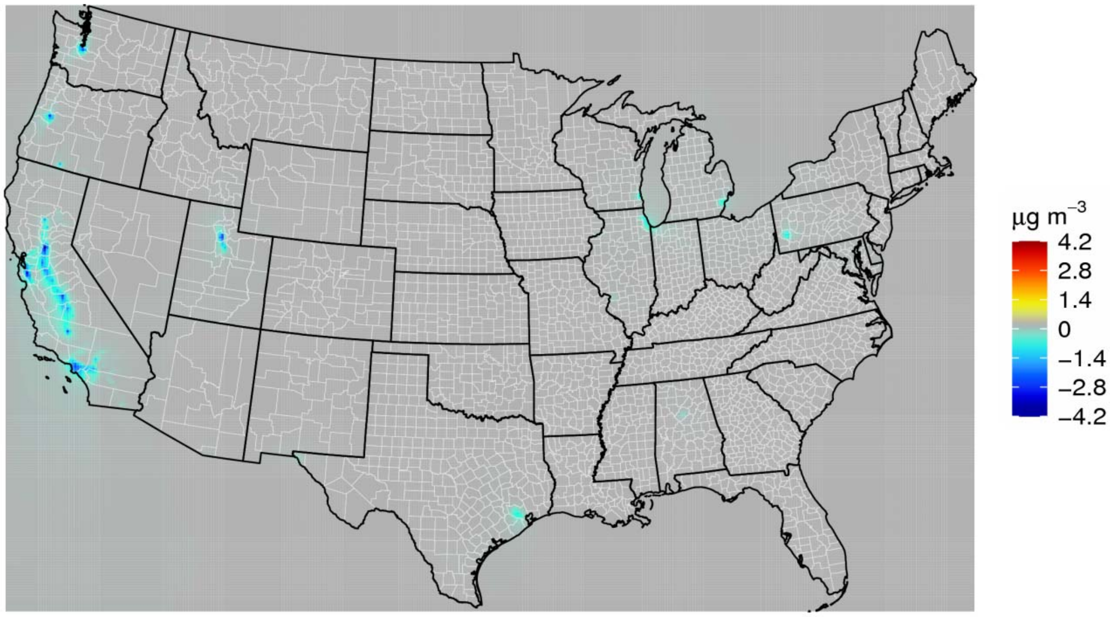

Figure 3-3. Difference in monthly average primary organic aerosol between 2020 NOx_$PM_{2.5}$ sensitivity run and 2020 base case (2020 NOx_$PM_{2.5}$ – 2020 base case) for January

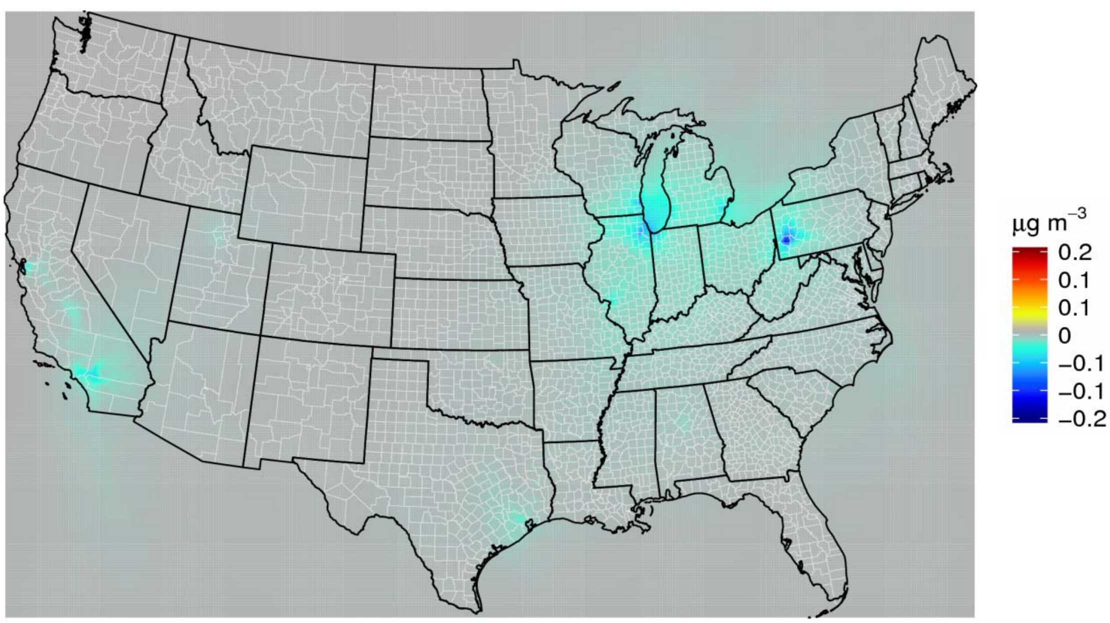

Figure 3-4. Difference in monthly average sulfate between 2020 SO_2_RWC sensitivity run and 2020 base case (2020 SO_2_RWC – 2020 base case) for August

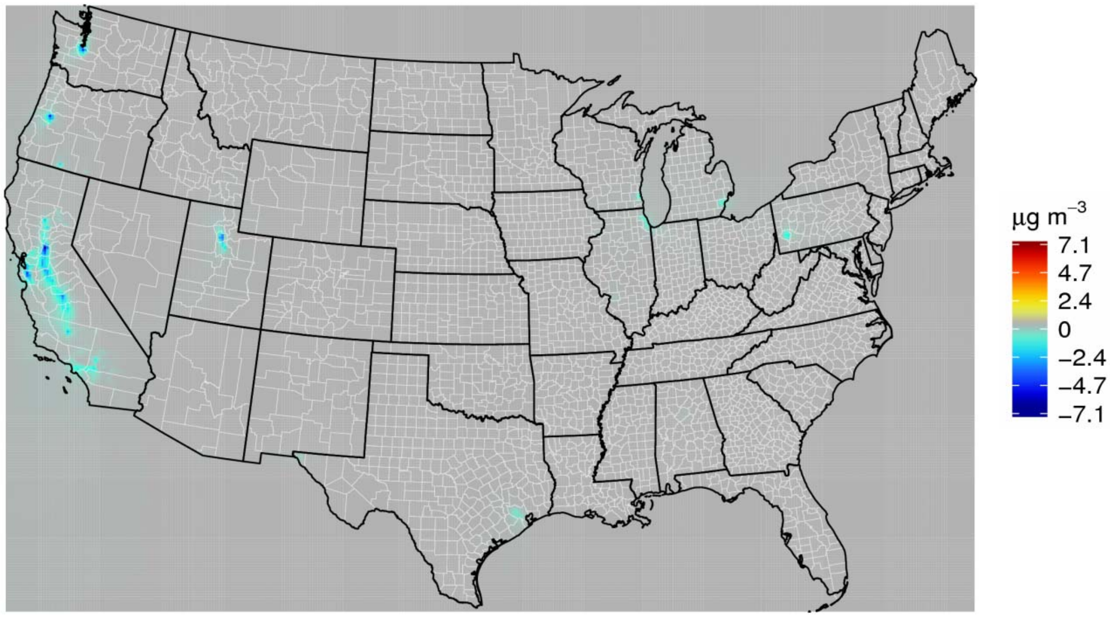

Figure 3-5. Difference in monthly average primary organic aerosol between 2020 SO_2_RWC sensitivity run and 2020 base case (2020 SO_2_RWC – 2020 base case) for January

As discussed in Section 3.3.1, a "county group" associated with each monitor was defined for estimating the change in emissions associated with a given change in design value in calculating air quality ratios. Due to the complex meteorological conditions and terrain features that affect the relationships between emissions and pollutant concentrations in the San Joaquin Valley, a detailed approach was developed to estimate the change in NOx emissions associated with a change in design value in this region. For San Joaquin Valley counties, the total NO_x emission change that contributed to $PM_{2.5}$ changes at a monitor was estimated using the weighted contribution of emissions changes in area counties as derived from nine "2020 SJV" sensitivity simulations.

The nine 2020 SJV model simulations were conducted for January 2020 for a domain centered on California (Figure 3-6) that is a subset of the continental U.S. domain used for the 2020 base case modeling. This series of simulations was used to estimate the contributions of emissions from counties in California's Central Valley on air quality in other counties in the Central Valley, which includes the San Joaquin Valley. The month of January was selected for this analysis because high $PM_{2.5}$ nitrate episodes occur during winter months in the Central Valley. One of the 9 sensitivity simulations reflected the 2020 base case emission scenario, and the other 8 simulations had NOx and direct $PM_{2.5}$ emissions reductions relative to the 2020 base case of 25% and 50%, respectively, from non-EGU anthropogenic sources in a one- or two-county group. The emissions reductions for these simulations matched those of the 2020 NOx_$PM_{2.5}$ sensitivity run but were applied in a subset of counties in each of the 8 sensitivity simulations. The counties where emissions reductions relative to the 2020 base case were applied are as follows: (1) Kern, (2) Kings and Tulare, (3) Fresno and Madera, (4), Merced, (5) Stanislaus, (6) San Joaquin, (7) Sacramento, and (8) Alameda.

The difference in average nitrate concentration for each simulation relative to the base case is shown in Figure 3-7 and 3-8. The impact of NOx emissions reductions on nitrate concentrations tended to be greater to the south of the county(s) where the emissions reductions occurred than to the north. This trend suggests transport of NOy from north to south during pollution episodes as well as the prevalence of NH_3 emissions in agricultural areas in the southern part of the Central Valley.

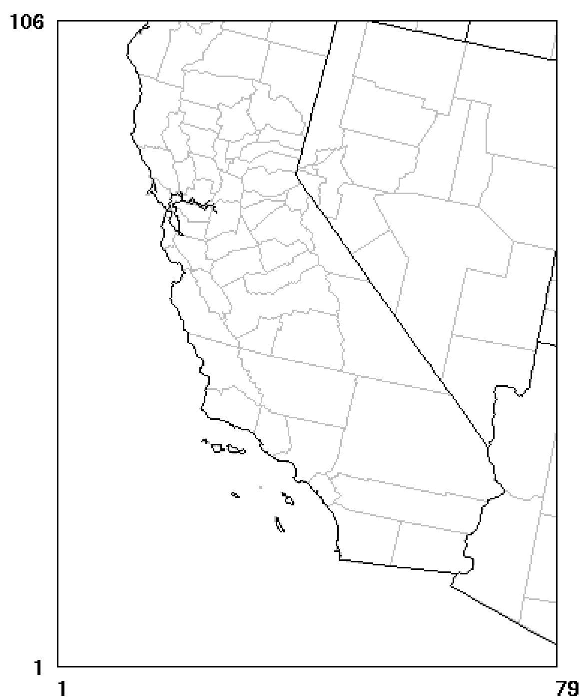

Figure 3-6. California Modeling Domain for 12-km Simulations

To estimate the contribution of NOx emissions in one area of the Central Valley on nitrate in another area, emissions weighting factors ($W_{igrp,jgrp}$) were developed from results of the 2020 SJV simulations according to Equation 3-1:

$$W_{igrp,jgrp} = \frac{\Delta C_{NO3,igrp}/\Delta Emiss_{NOx,jgrp}}{max(\Delta C_{NO3,igrp}/\Delta Emiss_{NOx,jgrp})} \qquad (3\text{-}1)$$

where $\Delta C_{NO3,igrp}$ is the change in average nitrate $PM_{2.5}$ concentration at a given monitor in the *igrp* county group between the 2020 base case simulation and the simulation with NO_x emissions reductions in the *jgrp* county group, and $\Delta Emiss_{NOx,jgrp}$ is the change in NO_x emissions in the *jgrp* county group between the simulations with 2020 base case emissions and the simulation with NO_x emissions reductions in the *jgrp* county group. Note that Equation 3-1 normalizes each Δconcentration-to-Δemission ratio for a given county group (numerator) by the maximum Δconcentration-to-Δemission ratio associated with that county group (denominator). The fraction of NO_x emissions from a given county or county group that impacts $PM_{2.5}$ nitrate in another county or county group as estimated according to Equation 3-1 is given in Table 3-3.

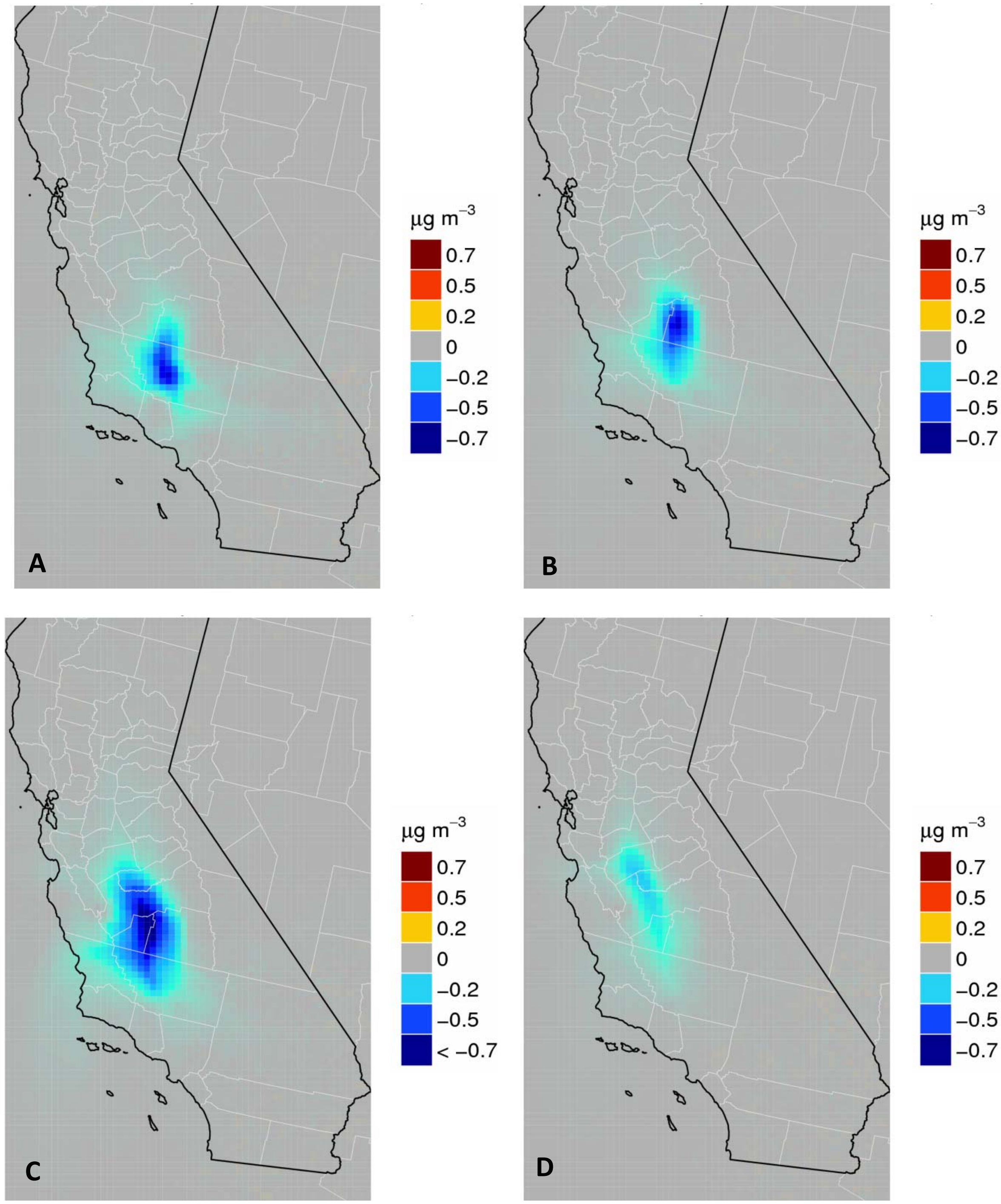

Figure 3-7. Change in monthly average nitrate concentration for January associated with NOx emissions reductions in (A) Kern, (B) Kings/Tulare, (C) Fresno/Madera and (D) Merced

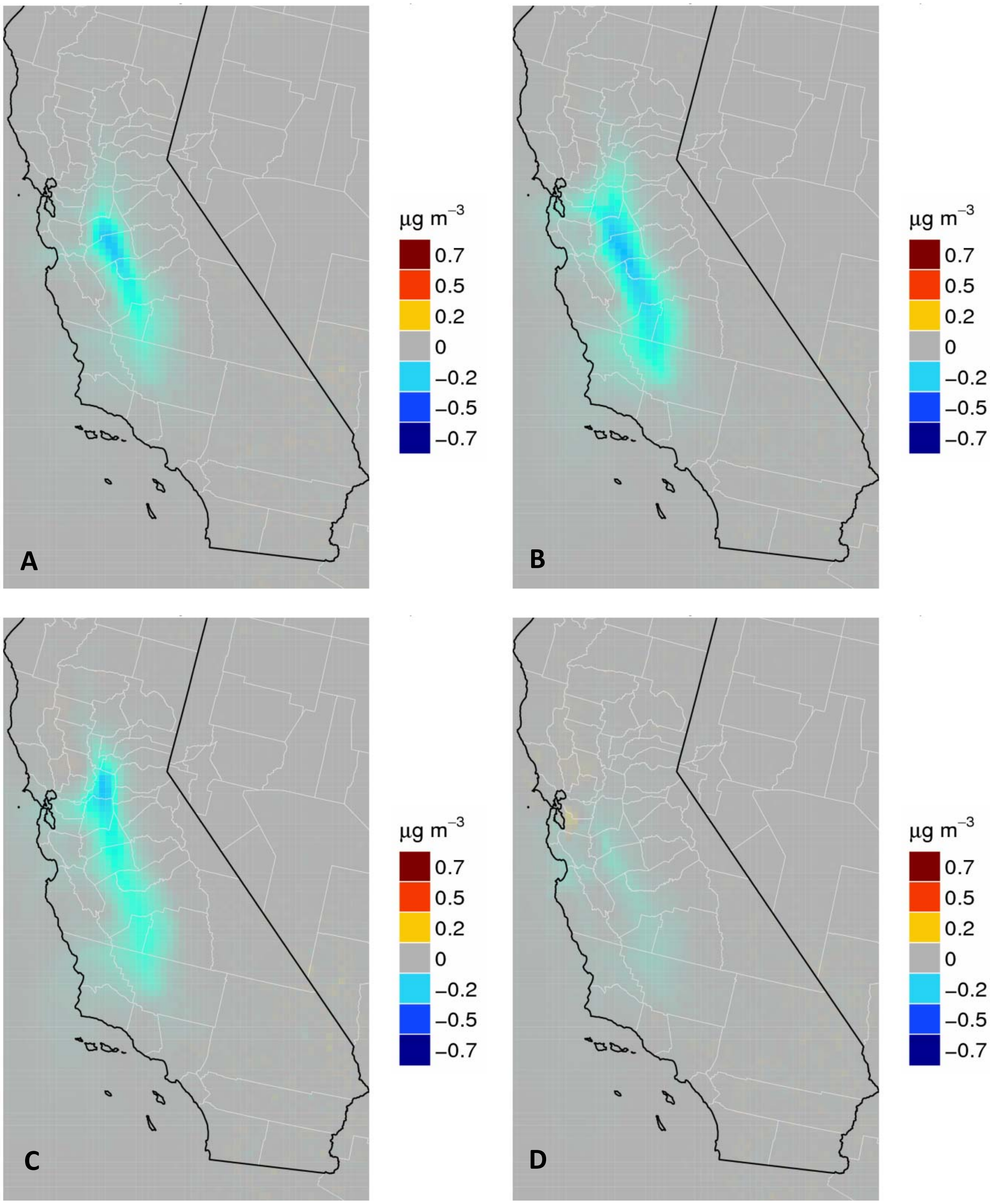

Figure 3-8. Change in monthly average nitrate concentration for January associated with NOx emissions reductions in (A) Stanislaus, (B) San Joaquin, (C) Sacramento and (D) Alameda

Table 3-3. Contribution Weighting Factors for NO_x Emissions in Counties or County Groups in California's Central Valley as Calculated According to Equation 3-1

County or County Group	Weight of Kern Emissions	Weight of Kings/ Tulare Emissions	Weight of Fresno/ Madera Emissions	Weight of Merced Emissions	Weight of Stanislaus Emissions	Weight of San Joaquin Emissions	Weight of Sacramento Emissions	Weight of Alameda Emissions
Kern	1	0.94	0.6	0.47	0.4	0.35	0.29	0.07
Kings/Tulare	0.11	1	0.89	0.56	0.4	0.31	0.24	0.05
Fresno/ Madera	0.06	0.41	1	0.65	0.48	0.38	0.35	0.04
Merced	0.02	0.07	0.23	1	0.92	0.51	0.4	0.04
Stanislaus	0.01	0.03	0.05	0.37	1	0.56	0.39	0.06
San Joaquin	0.02	0.04	0.08	0.39	0.7	0.66	1	0.09
Sacramento	0.01	0.03	0.04	0.12	0.22	0.25	1	0.01
Alameda	0.04	0.14	0.13	0.24	0.59	1	0.66	0.03

3.2 Calculating Future-year Design Values for 2020 Base and Control Cases

To predict the impact of the control strategies on future-year attainment, the air quality model results are used in a relative sense by estimating future-year $PM_{2.5}$ relative response factors (RRFs; US EPA, 2007). RRFs are ratios that are calculated from the change in $PM_{2.5}$ species concentrations between the base year (2007) and future-year (2020 base case and 2020 control case) air quality modeling results. The RRFs are calculated for each $PM_{2.5}$ component. Future-year estimates of the $PM_{2.5}$ annual and 24-hour standard design values at monitor locations are calculated by applying the species-specific RRFs to ambient $PM_{2.5}$ concentrations from the Federal Reference Method (FRM) Network, which are disaggregated into species concentrations through processing and interpolation of $PM_{2.5}$ species data from the Chemical Speciation Network (CSN) and Interagency Monitoring of PROtected Visual Environments (IMPROVE) monitoring networks. Species specific RRFs are calculated for sulfates, nitrates, organic carbon, elemental carbon, and crustal $PM_{2.5}$. In addition, ammonium and particle bound water RRFs are calculated based on the future year concentrations of sulfate, nitrate.

To more easily apply this methodology, EPA has created software, called Modeled Attainment Test Software (MATS) (Abt, 2012) to calculate future-year $PM_{2.5}$ annual and 24-hour standard design values. For the RIA, design values are projected from ambient FRM measurements during the period 2005-2009[15] coupled with $PM_{2.5}$ species data from IMPROVE and CSN sites for the 2006–2008 time period. In addition to calculating projected future-year annual and 24-hour standard design values, the MATS tool provides the amounts of sulfate, nitrate, ammonium, elemental carbon, organic carbon and crustal matter that comprise the annual and 24-hour standard design values for each site. These data are essential for understanding the PM species contributing to high $PM_{2.5}$ concentrations which is informative for designing control strategies to reduce the future-year design values to the proposed standard levels.

In order to derive 2020 design values for the purposes of the RIA, we made two adjustments to the design value calculations at those monitoring sites that 1) had observed ambient data in the base year period that reflects atypical events or highly variable events that are difficult to predict in the future year, and 2) would be impacted by existing local episodic residential wood burning curtailment programs (e.g. "burn ban" programs) that we were not able to simulate in the 2020 base case and control case air quality modeling. These adjustments are described below in Section 3.2.1 and 3.2.2. The set of design values based on the 2020 base case that have been adjusted to account for the impact of episodic wood burning curtailments and atypical events are referred to as the "adjusted 2020 base case" (Box 2, Figure 3-1). $PM_{2.5}$ design values are provided in Table B-1, Appendix B along with ambient design values from the 2005-2009 period. Counties with at least one monitor having an annual design value above the existing annual standard level, the revised standard level, or the alternative standard levels in the adjusted 2020 base case are shown in Figure 3-10.

[15] The 2005 -2007 period includes design values 2005-2007, 2006-2008, and 2007-2009.

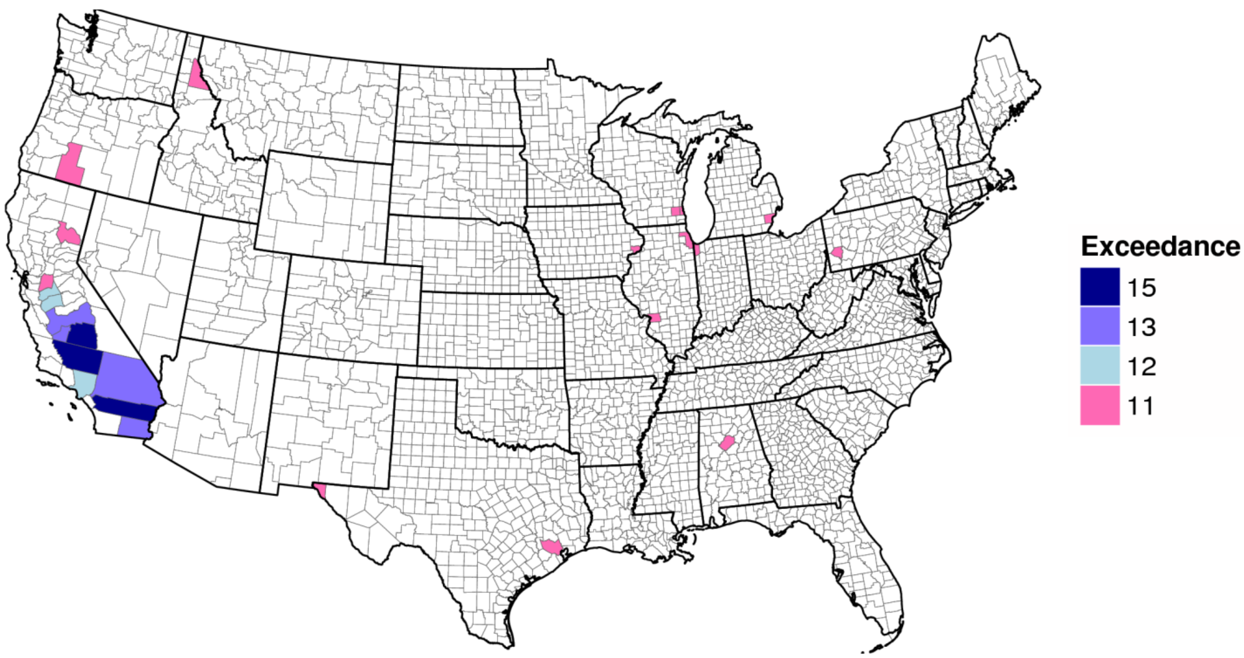

Figure 3-10. Counties with monitors that exceed the existing annual standard level of 15 μg/m³, the revised standard level of 12 μg/m³, and/or the alternative standard levels of 13 and 11 μg/m³ in the adjusted 2020 base case.

3.2.1 Future-year Design Values Adjustments for Episodic Residential Wood Curtailment Programs

A number of Western nonattainment areas have existing rules in place that require the curtailment of residential wood burning (from fireplaces and woodstoves) on an episodic basis. The burning curtailment programs ("burn bans") are implemented at the local level based on local air quality forecasts of high $PM_{2.5}$ days. The burn ban programs vary by area, but are similar in many ways. They generally have "stage 1" (lower concentration $PM_{2.5}$ days) and "stage 2" (higher concentration $PM_{2.5}$ days) level "burn ban" days with mandatory compliance on stage 2 days. The forecast trigger level also varies by area. When the daily $PM_{2.5}$ NAAQS was lowered to 35 μg/m³ in 2006, most areas implemented a trigger level at or below 35 μg/m³ for a mandatory burn ban[16]. There are also a number of exemptions in each area for residents who use firewood as their sole source of heat. Many of these programs have been strengthened in the last few years to become mandatory and also to address compliance with the daily $PM_{2.5}$ NAAQS. Since all of the identified areas have implemented or significantly strengthened their

[16] Some areas previously (before 2007) had voluntary burn ban programs with relatively high trigger levels based on the 1997 daily $PM_{2.5}$ NAAQs (65 μg/m³).

burn ban programs since 2007, we are assuming little or no reductions from a burn ban program in our 2007 base case and large reductions (on an episodic basis) in the 2020 future year cases.

Due to the complexity of accounting for "burn bans" on specific days in the future year modeling, we were not able to simulate the effects of "burn bans" in the 2020 base case modeling. In this regard, using the best available information, we applied a post-modeling adjustment to the 2020 model-based design values to reflect the expected effects on design values of the episodic residential wood burning curtailment programs. Episodic residential wood burning adjustments were made for the areas identified in Table 3-4[17]:

Table 3-4. Nonattainment Areas Where Episodic Residential Wood Burning Curtailment was Applied.

Nonattainment Areas Where Episodic Residential Wood Burning Adjustments Were Applied	State
Chico	CA
Los Angeles- South Coast Air Basin	CA
Sacramento	CA
San Francisco Bay Area	CA
San Joaquin Valley	CA
Yuba City-Marysville	CA
Klamath Falls	OR
Oakridge	OR
Provo	UT
Salt Lake City	UT
Seattle-Tacoma	WA

We applied two slightly different methodologies to adjust the annual average design values and the daily average design values for burn bans. For both NAAQS, the adjustments

[17] These areas were all predicted to violate the daily NAAQS in the 2020 base case and are known to have mandatory episodic curtailment programs. Adjustments were not applied to areas that solely violated the annual NAAQS or did not have an existing curtailment program. The specific counties in which episodic residential wood burning curtailment programs were applied are listed in Table 3-5.

were based on the "2020 SO2_RWC" model sensitivity run that eliminated or "zeroed-out" all emissions from the residential wood combustion category on all days of the year. Since the vast majority of residential wood combustion emissions impacts are from primary $PM_{2.5}$ emissions, we calculated the total change in primary organic carbon, elemental carbon, and crustal $PM_{2.5}$ species between the 2020 base and 2020 residential wood zero-out cases to estimate the impact on $PM_{2.5}$ from residential wood combustion burn ban controls[18].

Since the zero-out model run reduced all residential wood combustion emissions, we scaled the results of the sensitivity run to provide a realistic estimate of emissions reduction from a burn ban program. To quantify the compliance rate of wood burning curtailment programs we relied upon information from the Sacramento and South Coast Air Quality Management Districts. The South Coast Air Quality Management District (SCAQMD, 2012) estimated a75% rule effectiveness for their residential wood curtailment rule and the Sacramento Metropolitan Air Quality Management District (SCMAQMD, 2009) estimated a 70% reduction in residential wood combustion emissions on burn ban days in their area. Based on this information, we assumed a 70% reduction in residential wood combustion emissions on episodic burn ban days in all areas[19] with a mandatory burn ban program. This implies a relatively high level of compliance, but recognizes that the program will provide less than a 100% reduction due to non-compliance and exemptions from the rule.

For the annual NAAQS, we assumed that the burn ban programs provide reductions in $PM_{2.5}$ concentrations that are commensurate with the reduction in primary $PM_{2.5}$ emissions[20]. We also assumed that burn bans are applicable on certain days in the 1^{st} and 4^{th} quarters of the year (i.e., during the residential wood combustion season). The number of days for which we applied the burn ban was based on the observed fraction[21] of measured days above 35 $\mu g/m^3$ in the 1^{st} and 4^{th} quarters in the 2005-2009 base period in each affected county. For multi-county

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[18] The sensitivity run also included SO_2 emissions reductions. The SO_2 reductions have no impact on the organic carbon, elemental carbon, and crustal primary $PM_{2.5}$ species concentrations.

[19] For this modeling, it was necessary to make an assumption for all areas which may have a burn ban program. We did not have enough detailed information to develop area-specific percent reduction estimates. Therefore we used the 70% reduction for all areas. For State Implementation Plan (SIP) modeling of individual areas, we would expect local information to be used to appropriately account for the effects of an area specific burn ban program across the local nonattainment area.

[20] Since all of the adjustments are for primary $PM_{2.5}$, it is assumed that emissions reductions and the change in concentration are linear (i.e. a 50% reduction in residential wood combustion $PM_{2.5}$ emissions leads to a 50% reduction in the primary $PM_{2.5}$ concentrations from residential wood combustion.)

[21] FRM monitoring sites operate on different schedules (1 in 3 day, 1 in 6 day, or every day). The calculation was based on the fraction of exceedence days during the 1^{st} and 4^{th} quarters. This proportionality approach normalizes the number of high days between monitoring sites and allows a percentage of days to be applied to the modeled days (which include all days of the year).

areas, it was assumed that the burn ban control program would be applied by county (i.e. there may be a forecasted burn ban in only a portion of a large nonattainment area). The number of burn ban days applied per year by county is provided in Table 3-5[22].

Table 3-5. Estimated Number of Burn Ban Days by County Based on 2005-2009 FRM Data.

State	Nonattainment Area	County	Total Number of Burn Ban Days in 1st plus 4th Quarters
California	Chico	Butte	18
California	Los Angeles- South Coast Air Basin	Los Angeles	16
California	Los Angeles- South Coast Air Basin	Riverside	20
California	Los Angeles- South Coast Air Basin	San Bernardino	16
California	Sacramento	Sacramento	20
California	San Francisco Bay Area	Alameda	4
California	San Francisco Bay Area	Santa Clara	8
California	San Francisco Bay Area	Solano	8
California	San Joaquin Valley	Fresno	42
California	San Joaquin Valley	Kern	48
California	San Joaquin Valley	Kings	40
California	San Joaquin Valley	Merced	30
California	San Joaquin Valley	San Joaquin	20
California	San Joaquin Valley	Stanislaus	30
California	San Joaquin Valley	Tulare	38
California	Yuba City-Marysville	Sutter	4
Oregon	Klamath Falls	Klamath	16
Oregon	Oakridge	Lane	20
Utah	Salt Lake City	Salt Lake	16
Utah	Provo	Utah	10
Washington	Seattle-Tacoma	Pierce	16

[22] The number of burn ban days was based on the monitoring site in the county with the maximum percentage of exceedence days (days > 35 μg/m^3).

The 2020 base case model output files were modified to replace the base case modeled concentrations with the burn ban day concentrations on the identified number of days per year (from Table 3-5) at each monitoring site in the 21 counties. The burn ban adjustment was applied to an equal number of high days per quarter in the 1st and 4th quarters (i.e., half of the burn ban days were applied to the high modeled days in the 1st quarter and half to the high modeled days in the 4th quarter). The high days were based on the highest modeled $PM_{2.5}$ days in the 2007 base case for each quarter. This approach provided burn ban RRFs for the 1st and 4th quarters. For each burn ban day in the 1st and 4th quarters, the following calculation was performed for each component of primary $PM_{2.5}$ (organic carbon, elemental carbon, and crustal). The example equation below shows the calculation for organic carbon:

Daily Burn Ban Organic Carbon = 2020 base case organic carbon – 0.7*(2020 base case organic carbon – 2020_SO_2_RWC organic carbon)

The same calculation is repeated for elemental carbon and crustal PM2.5. This results in an adjusted set of modeled $PM_{2.5}$ species which account for the burn ban program on specific 1st and 4th quarter days. The modified 2020 base case predictions were then re-run through the MATS tool to calculate adjusted annual average design values which account for the episodic residential wood burning curtailment programs.

A similarly representative burn ban RRF was calculated to adjust the daily design values to account for episodic residential wood burning curtailment programs. Due to the nature of the future year daily design value calculations, the methodology differed slightly from the annual average design value calculations. The daily design value RRFs are calculated from the change in modeled $PM_{2.5}$ species on the 10% highest modeled $PM_{2.5}$ days in each quarter (i.e., the 9 highest modeled days per quarter). In this approach we assume that a burn ban will apply to **all** high observed $PM_{2.5}$ days (days > 35 $\mu g/m^3$) in the 1st and 4th quarters at each site. Therefore, we performed the calculation by applying the 70% burn ban adjustment on all of the 10% highest modeled days in the 1st and 4th quarters (which are the days used to calculate the RRFs). The revised model data were then re-run through the MATS tool to calculate a set of 2020 base case daily design values which account for the episodic residential wood burning curtailment programs. The impact of applying the burn ban adjustments on the 2020 base case annual average and daily design values is provided in Table C-1, Appendix C. The procedures for calculating 2020 control case design values that reflect the effects of the burn ban programs are described in Section 3.3.

3.2.2 Future-year Design Values Adjustments for Atypical or Unpredictable Events

Concentrations of $PM_{2.5}$ at a number of monitoring sites may be influenced by atypical or unpredictable events such as wildfires or fireworks. In the "official" base year 2005-2009 FRM data, all design value calculations at all sites reflect adjustments to data that EPA officially determined have met the criteria for exclusion under the Exceptional Events Rule (EPA, 2007) during that base year period. However, under a future year scenario it is possible that some atypical events would qualify as official exceptional events under the Exceptional Events Rule, even though they did not qualify in the base 2005-2009 period. This is due to the nature of the "but for" test in the Exceptional Events Rule. The rule states that exceptional events cannot be removed from the design value calculations unless the monitor would not have violated the NAAQS, "but for" the exceptional events. There are a number of monitoring sites that are above the current (35 $\mu g/m^3$) daily $PM_{2.5}$ NAAQS in the 2005-2009 period and would also **continue to violate the current NAAQS** even if certain atypical event days were removed. Therefore, those days cannot be removed from the official design value calculations for 2005-2009 period because they do not meet the "but for" test during this time period. However, at a certain point in our modeling analysis for the RIA, the design value at each violating site is reduced to a value that is slightly above the NAAQS level. At some point, before attainment is reached, the site would attain the NAAQS "but for" the atypical events days. Therefore, in the future year 2020 projections, we assume for purposes of the RIA that the impact of certain atypical or highly variable events would meet the "but for" test.

The identification of atypical event data that could affect future design value calculations could involve an extensive data analysis exercise. It would be difficult to identify every potentially important past event for each monitoring site in the country and completely characterize the exact nature of those days as part of the RIA. Therefore, we limited the analysis to a small group of monitoring sites where a few atypical event days may have an important impact on the future year design value calculations. In our analysis of potentially important atypical events, we included only monitoring sites that have 24-hour design values predicted to violate the 35 $\mu g/m^3$ daily NAAQS in the 2020 base case. At these sites we examined the ambient $PM_{2.5}$ concentrations on days with daily average measurements greater than 35 $\mu g/m^3$. There were several categories of potentially important atypical event days that we identified:

1) Wildfires - Summer days with high concentrations at sites in the West which normally do not exceed the NAAQS in the summer[23] [62 site-days];

2) Fireworks - High $PM_{2.5}$ concentrations predominantly on July 4th or 5th [37 site-days];

3) Other unusual high data – Other site-days with very high measured $PM_{2.5}$ concentrations that were much higher than concentrations on the same days at co-located and/or surrounding sites [2 site-days].

Based on this assessment, we identified 101 site-days in the above categories at 25 monitoring sites (23 of them in California) in the period 2005-2009[24,25]. In all of the subsequent future year design value calculations (for both the annual and daily NAAQS), the design values have been adjusted to reflect the removal of these days. The impact on the 2005-2009 annual design values at these 25 sites ranged from a reduction of 0.08 to 0.97 $\mu g/m^3$. The impact on the daily design values ranged from 0 to a reduction of 12.9 $\mu g/m^3$. The full list of 101 site-days can be found in Table D-1, Appendix D.

We recalculated the 2020 base case and 2020 control case annual and daily $PM_{2.5}$ design values to reflect the removal of potential future atypical event days from the starting point 2005-2009 ambient measured data. The impact of the removal of atypical event days on the 2020 base case annual average and daily design values is provided in Table D-2, Appendix D.

3.3 Calculating Future-year Design Values for Meeting the Existing Standards, the Revised Annual Standard, and Alternative Annual Standard Levels

The direct $PM_{2.5}$ emissions reductions beyond the emissions of the 2020 control case that are required to meet the existing, revised and alternative standard levels was estimated using air quality ratios. The development of the air quality ratios from results of the sensitivity simulations described above is discussed in Section 3.3.1. The procedures for estimating emissions reductions needed to meet the standard levels are described in Section 3.3.2.

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[23] The vast majority of the wildfires days occurred during a well documented summer 2008 wildfire period in Central California. Most of the high California wildfire days from 2008 are documented here: http://www.arb.ca.gov/desig/excevents/2008wildfires.htm

[24] These were site days that were not already identified and removed from the ambient data as EPA-concurred exceptional events.

[25] The adjustments are made to the base year design values for the sole purpose of projecting ambient data to the future year (2020). It is not appropriate to adjust the base year 2005-2009 data for the purpose of examining current or past attainment of the NAAQS.

3.3.1 Development of Air Quality Ratios

The air quality response ratios used in adjusting the 2020 design values were calculated based on results of the sensitivity simulations discussed above. The 2020 NO_x_$PM_{2.5}$ sensitivity simulation was used in calculating the air quality ratios associated with changes in NO_x and direct $PM_{2.5}$ emissions, and the 2020 SO_2_RWC sensitivity simulation was used in calculating the air quality ratios associated with changes in SO_2 emissions.

A county group was defined for each monitor in estimating the change in emissions associated with a given change in design value at the monitor in the sensitivity runs. For the development of direct $PM_{2.5}$ air quality ratios, the county group included just the county containing the monitor because of the relatively local nature of the impacts of direct $PM_{2.5}$ emissions on ambient $PM_{2.5}$ concentrations. For the development of NO_x and SO_2 air quality ratios, the county group was generally defined as the county containing the nonattainment monitor plus the adjacent counties (i.e., counties that border the county with the nonattainment monitor). This multi-county group approach was used for NOx and SO_2 in view of the more widespread impacts on $PM_{2.5}$ sulfate and nitrate of local emissions reductions of NOx and SO_2 compared to direct $PM_{2.5.}$ Note that this same general approach was used in the design of the 2020 sensitivity simulations (discussed above) and in the 2020 control case (see Chapter 4 of RIA). However, there were exceptions to this approach in certain areas in California where meteorological conditions affect the relationships between emissions and pollutant concentrations on a broader geographic scale within the South Coast Air Basin and within the San Joaquin Valley Air Basin. In the South Coast Air Basin, the county group for NO_x emission reductions was defined to include all counties in the air basin (i.e., Orange, Los Angeles, Riverside, and San Bernardino). For counties in the San Joaquin Valley Air Basin, the total NO_x emission change that contributed to $PM_{2.5}$ changes at a monitor in a given county was estimated using the weighted contribution of emissions changes in area counties as derived from the 2020 SJV simulations as discussed above.

In adjusting design values of the 2020 control case to meet different standard levels, Kings County and Tulare County in California were considered as a single area[26]. These counties share an east-west border and experience similar air quality due to their relative positions in the San Joaquin Valley. Also, direct $PM_{2.5}$ emissions are much smaller in Kings than in Tulare,

[26] To group these counties into a single area, the emission reductions needed for the Kings and Tulare monitors to meet the standard individually was first determined. Then the maximum of the individual emission reductions was selected and was used to adjust the design values at monitors in both counties using the air quality ratios.

and the Kings County monitor is close to the Tulare border (Figure 3-10) such that Tulare emissions have a large impact on design values in Kings County.

Figure 3-10. Location of Kings County Monitor Relative to Tulare County Border (Image taken from Google Earth).

Air quality ratios for emissions of direct $PM_{2.5}$, SO_2 and NO_x were calculated using information from the sensitivity simulations on the response of air quality at monitors to emission changes within the county groups. Below are the steps we followed in calculating the air quality ratios:

Step 1: *Calculate the fractional change in speciated annual and 24-hr design values for the 2020 sensitivity cases relative to the 2020 base case.* Speciated annual and quarterly 24-hr RRFs were calculated for the 2020 NO_x_$PM_{2.5}$ and 2020 SO_2_RWC sensitivity simulations relative to the 2020 base case using the MATS tool (Abt, 2010) for configurations where the 2020 base case was used as the reference case and the 2020 sensitivity cases were used as the control cases. The fractional change in the direct $PM_{2.5}$, sulfate and nitrate[27] components of the

[27]The $PM_{2.5}$ sulfate and nitrate components are computed using the SO_4, NO_3, NH_4 and water fraction from MATS as described in EPA guidance (EPA, 2007). The direct $PM_{2.5}$ design value component is computed by summing the elemental carbon, organic carbon and crustal portions of the design value.

design value for the 2020 sensitivity cases relative to the 2020 base case was then calculated as (RRF-1)[28] for a given monitoring site.

Step 2: *Calculate the fractional change in emissions in the relevant county group for the 2020 sensitivity cases relative to the 2020 base case.* The fractional changes in emissions of direct $PM_{2.5}$[29], SO_2 and NO_x between the 2020 base case and 2020 sensitivity cases were determined for the county group relevant to a given monitor. County emission groups for NO_x and SO_2 for the monitors considered are listed in Tables E-1 and E-2, Appendix E.

Step 3: *Calculate the ratio of fractional change in speciated design value to fractional change in emissions for the sensitivity cases.* The ratio of the fractional change in speciated design values (Step 1) to fractional change in county group emissions (Step 2) was calculated. Specifically, we calculated the fractional change in the direct $PM_{2.5}$, sulfate and nitrate components of the annual and daily standard design values per fractional change in direct $PM_{2.5}$, SO_2 and NO_x emissions, respectively, in the county group between the 2020 sensitivity cases and the 2020 base case.

Step 4: *Calculate the ratio of the speciated design values to emissions for the 2020 control case.* Using air quality and emission data from the 2020 control case, we calculated the ratio of direct $PM_{2.5}$, sulfate and nitrate to the emissions of direct $PM_{2.5}$, SO_2 and NO_x, respectively, in the relevant county group for the 2020 control case.

Step 5: *Calculate air quality ratios using results of Steps 3 and 4.* Air quality ratios were calculated by multiplying the ratios from Step 3 by the ratios from Step 4 for each 2020 sensitivity case, individually. The overall calculation of air quality ratios for $PM_{2.5}$ component specie i and emission specie j is given by Equation 3-2, where DV_i indicates the $PM_{2.5}$ component design value.

$$\text{Air Quality Ratio} = \left(\frac{RRF_i - 1}{\Delta Emission_j / Emission_j} \right)_{SensitivityCase} \left(\frac{DV_i}{Emission_j} \right)_{ControlCase} \times 1000 \qquad (3\text{-}2)$$

Air quality ratios give an estimate of how $PM_{2.5}$ design value components (μg/m^3) would change if 1000 tons of direct $PM_{2.5}$, SO_2 and/or NO_x emissions were reduced in the county group

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[28] For daily air quality ratios, a representative RRF was calculated as a weighted average of the quarterly 24-hr RRFs, where the weighting factors were the fractions of high 24-hr concentration days that occurred in the quarter in the 2020 control case.

[29] Direct $PM_{2.5}$ emissions are computed as the sum of emissions of elemental carbon, primary organic carbon, and unspeciated $PM_{2.5}$ mass.

in which the monitor is located. The air quality ratios used in the RIA and the associated county groups are provided in Appendix E.

3.3.2 Use of Air Quality Ratios to Calculate Design Values to Meet Existing, Revised, and Alternative Standard Levels

The air quality ratios were used in the process of adjusting the air quality modeling results to meet the current and alternative standard levels. The 2020 base case modeling and the development of the adjusted 2020 base case (Box 1 and Box 2, Figure 3-1) were described above. The procedures for determining the emissions reductions estimated to be needed to attain the 15/35 standard and annual standards of 13, 12, and 11 µg/m^3 are identified in boxes 4 through 9 in Figure 3-1. These procedures and the results are described below.

Adjusted 2020 Control Case (Box 4). *Adjust design values of 2020 control case to account for episodic wood burning curtailments and to account for atypical events and inappropriate emissions controls.* The impact of atypical events on design values was removed from 2020 control case design values by removing these days from the ambient data used in the future-year design value calculations in the MATS tool, as described above. To account for the impacts of wood burning curtailments in the 2020 control case, we started with the fractional change (i.e., RRF) in speciated design values between the 2020 base case and the 2020 control case (both cases without the effects of wood burning curtailment programs). We then applied these species-specific RRFs to adjust the corresponding speciated design values in the 2020 base case that had been adjusted to reflect the application of wood burning curtailments.

We also had to adjust the 2020 control case design values in certain counties to remove the impacts from a subset of modeled control measures. These control measures were deemed to be inappropriate for the purposes of the 2020 control case after a review of the results of the 2020 base case air quality modeling. The impact of a small amount unnecessary SO_2 emission controls included in the 2020 control simulation was removed from the 2020 control case results by adjusting the design values affected by the controls as follows. First, the total change in the sulfate component of the annual design values between the 2020 base case and the 2020 control case was calculated. Next, this change in sulfate was multiplied by the ratio of SO_2 emissions to "total sulfur" emissions[30] to estimate the fraction of the sulfate

[30] In this context "total sulfur" emissions include the sum of emissions of SO2 and directly emitted particulate sulfate.

reduction associated with SO_2 emissions reductions. This amount of sulfate was then multiplied by the ratio of the SO_2 emissions to be removed to the total tons of SO_2 emissions reductions to yield an estimate of the amount of sulfate associated with the inappropriate controls. The resulting amount of sulfate was then converted to ammonium sulfate and was added to the 2020 control case annual design value to remove the impact of the inappropriate controls. For monitors in counties impacted by the simulation of inappropriate controls that have at least one design value above the 24-hr standard level in the 2020 base case, the impact of the controls on daily design values was estimated from the impact on the annual design value by using the ratio of the air quality ratios for the annual and 24-hr design values. Since the emissions removed by this process were relatively small (Table 3-6), the adjustments had a minor impact on the design values (Table 3-7).

Table 3-6. SO_2 Emissions Control Amounts whose Impact was Removed from the 2020 Control Case Design Values through Post-Modeling Adjustments

FIPS Code	State Name	County Name	SO_2 Emissions (tons)
01073	Alabama	Jefferson	122
06037	California	Los Angeles	94
06071	California	San Bernardino	228
06077	California	San Joaquin	297
17119	Illinois	Madison	111
18089	Indiana	Lake	765
19045	Iowa	Clinton	207
26163	Michigan	Wayne	637
42003	Pennsylvania	Allegheny	207
48201	Texas	Harris	150

Table 3-7. Change in Annual Design Values Associated with Removing the Impact of SO_2 Emission Controls and Associated Change in Daily Design Values for Counties with at Least One Monitor above the 24-hr Level in the Adjusted 2020 Base Case

Monitor ID	FIPS Code	State Name	County Name	Increase in Annual DV with removal of SO_2 controls	Increase in Daily DV with removal of SO_2 controls
10735003	1073	Alabama	Jefferson	0.01	N/A
10730023	1073	Alabama	Jefferson	0.01	N/A
10731005	1073	Alabama	Jefferson	0.01	N/A
10732003	1073	Alabama	Jefferson	0.02	N/A
10732006	1073	Alabama	Jefferson	0.01	N/A
11170006	1117	Alabama	Shelby	0.01	N/A
60771002	6077	California	San Joaquin	0.04	N/A
60990005	6099	California	Stanislaus	0.06	0.2
170314201	17031	Illinois	Cook	0.02	N/A
170310057	17031	Illinois	Cook	0.04	N/A
170313301	17031	Illinois	Cook	0.06	N/A
170310050	17031	Illinois	Cook	0.16	N/A
170314007	17031	Illinois	Cook	0.02	N/A
170312001	17031	Illinois	Cook	0.06	N/A
170316005	17031	Illinois	Cook	0.04	N/A
170310022	17031	Illinois	Cook	0.19	N/A
170310076	17031	Illinois	Cook	0.06	N/A
170310052	17031	Illinois	Cook	0.03	N/A
171971011	17197	Illinois	Will	0.02	N/A
171971002	17197	Illinois	Will	0.03	N/A
180890006	18089	Indiana	Lake	0.19	N/A
180890027	18089	Indiana	Lake	0.16	N/A
180892010	18089	Indiana	Lake	0.18	N/A
180891003	18089	Indiana	Lake	0.19	N/A
180892004	18089	Indiana	Lake	0.19	N/A
180890031	18089	Indiana	Lake	0.18	N/A
181270020	18127	Indiana	Porter	0.06	N/A
181270024	18127	Indiana	Porter	0.12	N/A
190450021	19045	Iowa	Clinton	0.01	N/A
261630025	26163	Michigan	Wayne	0.01	N/A
261630019	26163	Michigan	Wayne	0.01	N/A
261630016	26163	Michigan	Wayne	0.01	N/A
261630039	26163	Michigan	Wayne	0.01	N/A
261630015	26163	Michigan	Wayne	0.01	N/A
261630036	26163	Michigan	Wayne	0.01	N/A
261630033	26163	Michigan	Wayne	0.01	N/A

Monitor ID	FIPS Code	State Name	County Name	Increase in Annual DV with removal of SO_2 controls	Increase in Daily DV with removal of SO_2 controls
261630001	26163	Michigan	Wayne	0.01	N/A
261630038	26163	Michigan	Wayne	0.01	N/A
261610008	26161	Michigan	Washtenaw	0.01	N/A
260990009	26099	Michigan	Macomb	0.01	N/A
261250001	26125	Michigan	Oakland	0.01	N/A
420030095	42003	Pennsylvania	Allegheny	0.01	0.0
420033007	42003	Pennsylvania	Allegheny	0.01	0.0
420030008	42003	Pennsylvania	Allegheny	0.01	0.0
420030067	42003	Pennsylvania	Allegheny	0.01	0.0
420030064	42003	Pennsylvania	Allegheny	0.02	0.1
420031301	42003	Pennsylvania	Allegheny	0.02	0.0
420031008	42003	Pennsylvania	Allegheny	0.02	0.0
421250200	42125	Pennsylvania	Washington	0.01	N/A
421250005	42125	Pennsylvania	Washington	0.01	N/A
421290008	42129	Pennsylvania	Westmoreland	0.01	N/A
482011035	48201	Texas	Harris	0.01	N/A
482010058	48201	Texas	Harris	0.01	N/A

In addition to adjustments to remove the impact of a subset of SO_2 emissions controls, the 2020 control case was adjusted to remove the impact of a subset of direct $PM_{2.5}$ emissions controls in counties that did not exceed the standard levels in the adjusted 2020 base case or over-shot the target standard level in the 2020 control case. The impacts of these direct $PM_{2.5}$ emission reductions on design values were removed from the 2020 control case in the following manner. Direct $PM_{2.5}$ emission amounts associated with the unnecessary controls were converted to incremental design value amounts ($\mu g/m^3$) using the air quality ratios for direct $PM_{2.5}$ emissions. These incremental design value amounts were then added to the 2020 control case design values. In counties where the unnecessary direct $PM_{2.5}$ controls dominated the change in the design value between the 2020 base case and 2020 control case, the impact of the controls was accounted for by using the corresponding design values from the adjusted 2020 base case in the set of design values for the 15/35 level discussed below. No adjustments were necessary for counties that did not have a valid design value. The direct $PM_{2.5}$ emission control amounts are listed in Table 3-8 along with an indication of the approach used. The associated design value adjustments are listed in Table 3-9 for counties where the air quality ratio approach was used.

Table 3-8. Direct $PM_{2.5}$ Emissions Control Amounts whose Impacts were Removed from the Analysis and Approach Used in Accounting for the Impacts

				Approach		
FIPS Code	**State**	**County**	**Direct $PM_{2.5}$ (tons)**	**AQ ratio**	**Use Adjusted 2020 base case DVs in 15/35 Case**	**N/A: No valid DV**
18089	Indiana	Lake	2412	x		
06001	California	Alameda	128	x		
06037	California	Los Angeles	873	x		
06065	California	Riverside	53	x		
06077	California	San Joaquin	123	x		
19045	Iowa	Clinton	264		x	
06007	California	Butte	223		x	
17161	Illinois	Rock Island	27		x	
19139	Iowa	Muscatine	209		x	
49049	Utah	Utah	23		x	
53053	Washington	Pierce	19		x	
48167	Texas	Galveston	267			x
06039	California	Madera	169			x
48039	Texas	Brazoria	943			x
48071	Texas	Chambers	68			x
48157	Texas	Fort Bend	26			x
48291	Texas	Liberty	97			x
48339	Texas	Montgomery	882			x
06059	California	Orange[31]	89			

Table 3-9. Change in Design Values Associated with Removing the Impact of the Direct $PM_{2.5}$ Emission Control Amounts from the 2020 Control Case Using Air Quality Ratios

Monitor ID	FIPS Code	State Name	County Name	Annual DV Increase	Daily DV Increase
60010007	6001	California	Alameda	0.07	N/A
60011001	6001	California	Alameda	0.05	N/A
60370002	6037	California	Los Angeles	0.32	N/A
60371002	6037	California	Los Angeles	0.35	N/A
60371103	6037	California	Los Angeles	0.35	N/A

[31] Adjustment was not performed to remove impact of the small amount of direct $PM_{2.5}$ emissions controls in Orange County. These controls had no impact incremental cost and benefit calculations because the annual design value for the revised and alternative standard levels equaled that in the analytical baseline.

Monitor ID	FIPS Code	State Name	County Name	Annual DV Increase	Daily DV Increase
60371201	6037	California	Los Angeles	0.24	N/A
60371301	6037	California	Los Angeles	0.37	N/A
60371602	6037	California	Los Angeles	0.35	N/A
60372005	6037	California	Los Angeles	0.28	N/A
60374002	6037	California	Los Angeles	0.28	N/A
60374004	6037	California	Los Angeles	0.26	N/A
60379033	6037	California	Los Angeles	0.1	N/A
60651003	6065	California	Riverside	0.09	0.2
60652002	6065	California	Riverside	0.05	0.1
60655001	6065	California	Riverside	0.04	0.1
60658001	6065	California	Riverside	0.11	0.2
60658005	6065	California	Riverside	0.13	0.3
60771002	6077	California	San Joaquin	0.13	N/A
180890006	18089	Indiana	Lake	1.01	N/A
180890027	18089	Indiana	Lake	0.77	N/A
180890031	18089	Indiana	Lake	0.88	N/A
180891003	18089	Indiana	Lake	0.97	N/A
180892004	18089	Indiana	Lake	0.97	N/A
180892010	18089	Indiana	Lake	0.96	N/A

Attainment of the 15/35 Level (Box 5). *Estimate future-year design values and emission reductions beyond the adjusted 2020 control case to meet the existing standard level (15/35).* For monitors with design values greater than 15/35 in the adjusted 2020 control case (Box 4, Figure 3-1), additional direct $PM_{2.5}$ emission reductions were applied to meet this level. The additional direct $PM_{2.5}$ emission reduction amounts were estimated using air quality ratios. The direct $PM_{2.5}$ emissions reductions needed to attain the 15/35 standard were also applied to reduce $PM_{2.5}$ design values at all attaining monitoring sites in the same county as the nonattainment monitor. For example, the highest 24-hr design value in San Bernardino County in the adjusted 2020 control case was 36.4 μg/m^3 at monitor 60719004. Additional emissions reductions of 585 tons of direct $PM_{2.5}$ were estimated to be required for this monitor to meet the 24-hr standard level[32] as follows: (36.4 − 35.4) / 1.710 × 1000 = 585 tons, where 1.710 is the 24-hr direct $PM_{2.5}$ air quality ratio for the monitor 60719004. The 585 tons of direct $PM_{2.5}$ emissions reductions in this county were estimated to reduce the highest annual design value in San Bernardino at monitor 60710025 from 13.41 to 12.99 μg/m^3 as follows: 13.41 – (585 ×

[32] A 24-hour design value of 35.4 μg/m^3 is the highest value that meets the 24-hour standard.

0.710 / 1000) = 12.99 µg/m^3, where 0.710 is the annual direct $PM_{2.5}$ air quality ratio for the 60710025 monitor. The direct $PM_{2.5}$ emission reduction amounts beyond the adjusted 2020 control case that are necessary to meet the current standard level for individual counties are listed in Table 3-10.

Table 3-10. Tons of Direct $PM_{2.5}$ Emission Reductions beyond the Adjusted 2020 Control Case to Meet the Current Standard Level for Counties that Exceed the Revised or Alternative Annual Standard Levels in the Adjusted 2020 Base Case.

FIPS Code	State Name	County Name	Direct $PM_{2.5}$ Emissions (tons)
6019	California	Fresno	497
6025	California	Imperial	288
6029	California	Kern	1,496
6031/6107	California	Kings/Tulare	610
6071	California	San Bernardino	585
6099	California	Stanislaus	346
42003	Pennsylvania	Allegheny	764

Emissions were controlled in certain counties in the 2020 control case that exceeded the alternative annual standard of 11 µg/m^3 but that did not exceed the existing standard level. These emissions controls are relevant for meeting the 11 µg/m^3 level (Box 9) but are not relevant for meeting the existing standard level. Therefore annual design values in the 15/35 case are set to those of the adjusted 2020 base case for monitors in the following counties: Jefferson, AL; Shoshone, ID; Cook, IL; Madison, IL; Klamath, OR; Lake, IN; Scott, IA; Wayne, MI; Milwaukee, WI; and Harris, TX. Although not used in meeting the existing standard level, design values from the adjusted 2020 control case for these counties are considered below in meeting the alternative standard level of 11 µg/m^3. Annual design values were also set to the corresponding adjusted 2020 base case values for monitors in Clinton, IA; Butte, CA; Rock Island, IL; Muscatine, IA; Utah, UT; and Pierce, WA to remove the impact of inappropriate controls included in the control run for these counties as discussed above.

Analytical Baseline (Box 6). *Create analytical baseline for meeting alternative standards that accounts for 2025 mobile NOx emission adjustment in San Joaquin Valley and South Coast*

Air Basin. The goal of the RIA is to provide the best estimates of the costs and benefits of an illustrative attainment strategy to just meet the revised annual 12 µg/m^3 standards, as well as two alternative annual standards of 13 µg/m^3 and 11 µg/m^3, ***that are incremental to just meeting the current standards of 15/35***, and reflect emissions projections that account for the impact of economic growth and implementation of state and federal emissions controls. Most areas of the U.S. will be required to demonstrate attainment with the new standards by 2020. As a result, for these areas, the correct baseline for estimating the incremental emissions reductions that would be needed to attain the more protective standards is a baseline with emissions projected to 2020 and adjusted to reflect the additional emissions reductions that would be needed to attain the current 15/35 standards. For two areas in Southern California (South Coast Air Basin and San Joaquin Valley), the degree of projected non-attainment with the revised annual standard of 12 µg/m^3 is high enough that those counties are not expected to be able to demonstrate attainment with the new standard by 2020. Instead, those two areas are likely to qualify for an (up to) five year extension of their attainment date. If the areas are granted an attainment date extension, they will have until 2025 to attain the revised annual standard. As a result, for these two areas, the correct baseline for estimating the incremental emissions reductions that would be needed to attain the more protective standards is a baseline with emissions projected to 2025 adjusted to reflect the additional emissions reductions that would be needed to attain the current 15/35 standards. This difference in attainment year is important because between 2020 and 2025, emissions from mobile sources in California are expected to be reduced due to continued fleet turn over from older, higher emitting vehicles to newer, lower emitting vehicles. These reductions in emissions will occur as a result of previous state rules for which costs and benefits have already been counted, and thus will not be appropriate to attribute these costs and benefits to meeting the revised annual standard.

Modeling of two separate years is time prohibitive, and would result in two separate years of benefits and costs which would not provide a complete picture of the nationwide costs and benefits of just meeting the new standards in either 2020 or 2025 because of differences in the baselines between the two years. To provide the most reasonable and reliable estimates of costs and benefits of full attainment for the nation, we constructed an analytical baseline for estimating the incremental costs and benefits of attaining the revised standard of 12 µg/m^3 and alternative annual standards of 13 µg/m^3 and 11 µg/m^3 with the following characteristics. The analytical baseline was developed by applying a mobile NOx emission adjustment to design values at a level of attaining 15/35 that corresponds to Box 5 in Figure 3-1. This approach allows us to generate costs and benefits of full attainment without overstating the costs and benefits in those two areas, which would occur if we forced costly emissions reductions in 2020 in areas that would not have to be incurred until 2025, and which will be offset because of the expected reductions in mobile source emissions due to other programs[33].

The impact of expected mobile NOx emission reductions between 2020 and 2025 on air quality was accounted for by adjusting the set of 15/35 annual design values that reflect attainment of the existing standards using the air quality ratios listed in Table E-1, Appendix E. The total mobile NOx emissions adjustment was 27,467 tons for the South Coast Air Basin and 14,410 tons for the San Joaquin Valley[34]. The expected mobile NOx emissions reductions for individual counties in the South Coast and San Joaquin Valley between 2020 and 2025 are listed in Table 3-11. For counties in the San Joaquin Valley, the amount of emissions that impact a monitor in a given county was estimated as the weighted contribution of emissions from all counties in the San Joaquin Valley as discussed above. The estimates of annual design value reductions associated with the 2025 mobile NOx emission adjustment are listed in Table 3-12.

Table 3-11. Mobile NOx Emissions Reductions between 2020 and 2025 for Counties in the San Joaquin Valley and South Coast Air Basin

FIPS Code	State Name	County Name	NOx Reductions (tons)	Air Basin
6037	California	Los Angeles	13,999	SC
6059	California	Orange	3,581	SC
6065	California	Riverside	4,691	SC
6071	California	San Bernardino	5,196	SC
6019	California	Fresno	2,777	SJV
6029	California	Kern	3,553	SJV
6031	California	Kings	723	SJV
6039	California	Madera	681	SJV
6047	California	Merced	1,325	SJV
6077	California	San Joaquin	2,489	SJV
6099	California	Stanislaus	1,408	SJV
6107	California	Tulare	1,455	SJV

[33] Benefits for all areas are estimated using 2020 population data for consistency, recognizing that full attainment costs and benefits will not actually be realized until 2025 for a portion of the costs and benefits. The 2020 estimates of full attainment costs and benefits will be an underestimate of benefits in 2025 because of population growth and changes in the age distribution of the population between 2020 and 2025.

[34] The total mobile NOx emissions reductions are the sum of emissions reductions for the onroad, nonroad and c1c2rail sectors.

Table 3-12. Estimated Decrease in Annual DV at Monitors in the San Joaquin Valley and South Coast Air Basin Due to Expected Mobile NOx Emissions Reductions between 2020 and 2025

FIPS Code	Monitor ID	County Name	Decrease in Annual DV ($\mu g/m^3$)
6037	60370002	Los Angeles	0.27
6037	60371002	Los Angeles	0.23
6037	60371103	Los Angeles	0.24
6037	60371201	Los Angeles	0.11
6037	60371301	Los Angeles	0.22
6037	60371602	Los Angeles	0.26
6037	60372005	Los Angeles	0.21
6037	60374002	Los Angeles	0.17
6037	60374004	Los Angeles	0.16
6037	60379033	Los Angeles	0.13
6059	60590007	Orange	0.24
6059	60592022	Orange	0.20
6065	60651003	Riverside	0.47
6065	60652002	Riverside	0.02
6065	60655001	Riverside	0.01
6065	60658001	Riverside	0.48
6065	60658005	Riverside	0.45
6071	60710025	San Bernardino	0.35
6071	60710306	San Bernardino	0.18
6071	60712002	San Bernardino	0.44
6071	60718001	San Bernardino	0.02
6071	60719004	San Bernardino	0.36
6019	60190008	Fresno	0.48
6019	60195001	Fresno	0.47
6019	60195025	Fresno	0.46
6029	60290010	Kern	0.61
6029	60290014	Kern	0.60
6029	60290016	Kern	0.60
6031	60310004	Kings	0.54
6047	60472510	Merced	0.21
6077	60771002	San Joaquin	0.09
6099	60990005	Stanislaus	0.21
6107	61072002	Tulare	0.62

Incremental costs and benefits of the revised and alternative standards are assessed in the RIA relative to the set of analytic baseline design values. Annual design values and exceedance categories are provided for the analytic baseline in Figure 3-11 and Table 3-13 for counties with at least one monitor that exceeds a level[35]. The full list of annual design values for the analytical baseline is provided in Appendix F.

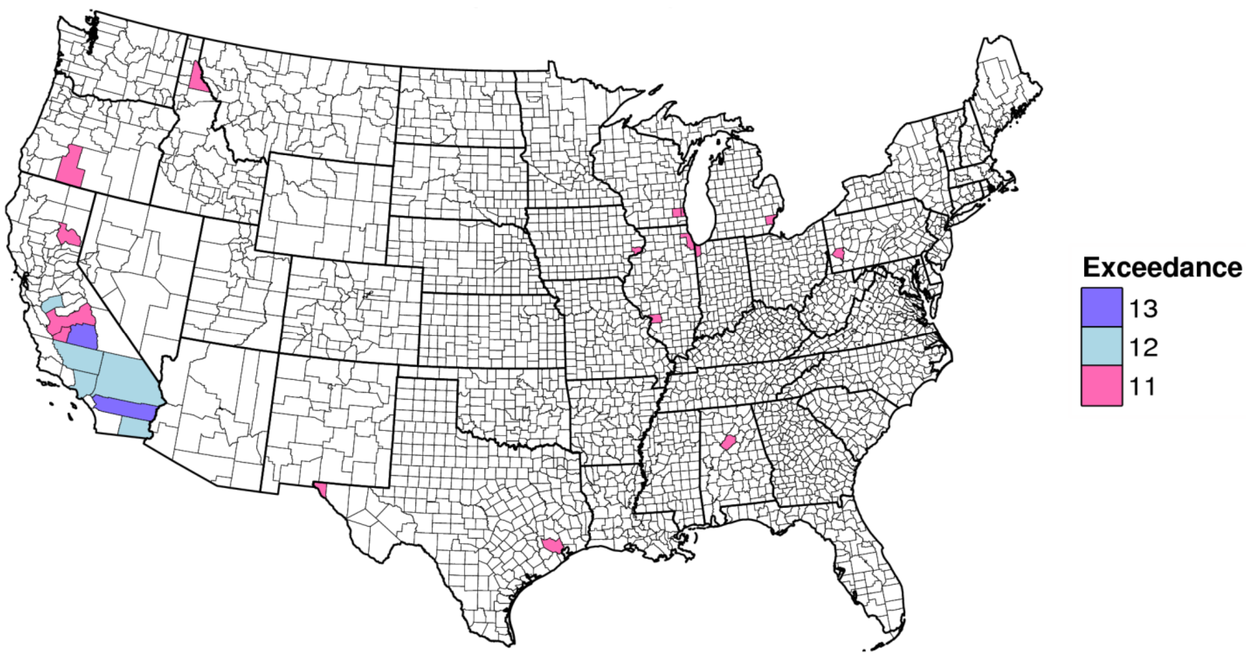

Figure 3-11. Counties that Exceed the Revised and/or Alternative Annual Standard Levels of 13, 12 and 11 μg/m³ in the Analytical Baseline.

[35] There were two counties (Lincoln County, MT and Santa Cruz County, AZ) that exceeded alternative standard levels in the 2020 base case for which we used a weight-of-evidence approach to determine how they would attain these levels, as described in section 3.3.5.

Table 3-13. Annual Design Values and Exceedance Category for the Highest County Monitor in the Analytical Baseline for Counties with at Least one Monitor Above the Revised and/or Alternative Standard Levels.

FIPS Code	Monitor ID	State Name	County Name	Annual DV	13/35	12/35	11/35
6065	60658005	California	Riverside	14.58	x	x	x
6107	61072002	California	Tulare	13.23	x	x	x
6029	60290016	California	Kern	12.7		x	x
6071	60710025	California	San Bernardino	12.64		x	x
6025	60250005	California	Imperial	12.57		x	x
6037	60371002	California	Los Angeles	12.34		x	x
6047	60472510	California	Merced	12.12		x	x
55079	550790059	Wisconsin	Milwaukee	12.02			x
6031	60310004	California	Kings	11.79			x
17119	171191007	Illinois	Madison	11.7			x
6019	60190008	California	Fresno	11.61			x
26163	261630033	Michigan	Wayne	11.58			x
1073	10730023	Alabama	Jefferson	11.56			x
17031	170316005	Illinois	Cook	11.52			x
16079	160790017	Idaho	Shoshone	11.52			x
19163	191630019	Iowa	Scott	11.51			x
48201	482011035	Texas	Harris	11.43			x
48141	481410044	Texas	El Paso	11.39			x
41035	410350004	Oregon	Klamath	11.3			x
55133	551330027	Wisconsin	Waukesha	11.22			x
18089	180891003	Indiana	Lake	11.17			x
6063	60631009	California	Plumas	11.15			x
42003	420030064	Pennsylvania	Allegheny	11.12			x

13 Standard Level (Box 7). *Estimate future-year design values and emission reductions beyond the analytical baseline to meet the alternative annual standard level of 13* µg/m^3*.* Annual $PM_{2.5}$ design values at monitors in Tulare and Riverside Counties in California exceeded the alternative standard level of 13 μg/m^3 in the analytical baseline (Table 3-13 and Figure 3-11). The additional direct $PM_{2.5}$ emission reductions required for these counties to meet this standard level were estimated using air quality ratios. For example, the highest annual design value in Riverside County in the analytical baseline case was 14.58 µg/m^3. Emission reductions of 626 tons of direct $PM_{2.5}$ were estimated to be required for this monitor to meet the annual standard level of 13.04 µg/m^3 as follows: (14.58 − 13.04) / 2.459 × 1000 = 626 tons, where

2.459 is the annual direct $PM_{2.5}$ air quality ratio for monitor 60658005. The emissions reductions by county to attain a 13/35 standard are provided in Table 3.14. These reductions were applied to lower the annual $PM_{2.5}$ design values at all sites in the given county[36].

Table 3-14. Tons of Direct $PM_{2.5}$ Emission Reductions Beyond the Analytical Baseline to Meet the 13 $\mu g/m^3$ Level.

FIPS Code	State Name	County Name	Direct $PM_{2.5}$ Emissions Reductions (tons)
6065	California	Riverside	626
6107	California	Tulare	101

12 Standard Level (Box 8). *Estimate future-year design values and emission reductions beyond the analytical baseline to meet the revised annual standard level of 12* $\mu g/m^3$. Annual $PM_{2.5}$ design values at monitors in the following 7 counties in California exceeded the revised standard level of 12 $\mu g/m^3$ in the analytical baseline (Table 3-13 and Figure 3-11): Los Angeles, Riverside, San Bernardino, Kern, Tulare, Merced, and Imperial. The additional direct $PM_{2.5}$ emission reductions required for these counties to meet the standard level of 12 $\mu g/m^3$ were estimated using air quality ratios. For example, the highest annual design value in Riverside County in the analytical baseline case was 14.58 $\mu g/m^3$. Emission reductions of 1,033 tons of direct $PM_{2.5}$ were estimated to be required for this monitor to meet the annual standard level of 12.04 $\mu g/m^3$ as follows: $(14.58 - 12.04) / 2.459 \times 1000 = 1033$ tons, where 2.459 is the annual direct $PM_{2.5}$ air quality ratio for monitor 60658005. The emissions reductions by county to attain a 13/35 standard are provided in Table 3.15. These reductions were applied to lower the annual $PM_{2.5}$ design values at all sites in the given county[37]. The full list of annual design values for the case where the revised standard level of 12 $\mu g/m^3$ is met is provided in Appendix F.

[36] Emissions reductions needed in Tulare County were also applied to reduce the annual $PM_{2.5}$ design value at the monitor in Kings County, which is combined with Tulare in our analysis.
[37] For Kings and Tulare Counties, the maximum of the emission reductions required for the individual counties was applied to monitors in both counties using the air quality ratios since these counties are combined in our analysis.

Table 3-15. **Tons of Direct $PM_{2.5}$ Emission Reductions Beyond the Analytical Baseline to Meet the 12 $\mu g/m^3$ Level.**

FIPS Code	State Name	County Name	Direct $PM_{2.5}$ Emissions Reductions (tons)
6037	California	Los Angeles	743
6065	California	Riverside	1,033
6025	California	Imperial	294
6029	California	Kern	418
6107	California	Tulare	635
6047	California	Merced	19
6071	California	San Bernardino	844

11 Standard Level (Box 9). *Estimate future-year design values and emission reductions beyond the analytical baseline to meet the alternative annual standard level of 11* $\mu g/m^3$ *.* Annual $PM_{2.5}$ design values at monitors in 23 counties exceeded the alternative standard level of 11 $\mu g/m^3$ in the analytical baseline (Table 3-13 and Figure 3-11). As discussed above, annual design values in the analytical baseline do not reflect the emission controls of the 2020 control case for counties with monitors that did not exceed the current standard level in the 2020 base case. To estimate the emission reductions beyond the known controls needed to meet the alternative standard level of 11 $\mu g/m^3$ in these counties, we started with annual design values for the adjusted 2020 control case (Box 4 of Figure 3-1). The additional direct $PM_{2.5}$ emission reductions required for these counties to meet the alternative standard level were then estimated using air quality ratios. For example, the annual design value at the high monitor in Jefferson, AL was 11.56 $\mu g/m^3$ in the adjusted 2020 base case and 11.11 $\mu g/m^3$ in the adjusted 2020 control case. The additional direct $PM_{2.5}$ emission reductions needed beyond the emission reductions of the 2020 control case for this monitor to meet the 11 $\mu g/m^3$ level were estimated using air quality ratios as follows: $(11.11 - 11.04) / 0.561 \times 1000 = 125$ tons, where 0.561 is the direct $PM_{2.5}$ air quality ratio for monitor 10730023. Annual $PM_{2.5}$ design values associated with emission reductions estimated in this way in (Table 3-16) were calculated for the counties with exceedance monitors.

Table 3-16. Tons of Direct $PM_{2.5}$ Emission Reductions Beyond the Analytical Baseline to Meet the Alternative Standard 11 $\mu g/m^3$ Level[a].

FIPS Code	State Name	County Name	Tons of Direct $PM_{2.5}$
6037	California	Los Angeles	3,222
6065	California	Riverside	1,440
1073	Alabama	Jefferson	125
6019	California	Fresno	325
6025	California	Imperial	850
6029	California	Kern	1,051
6031/6107	California	Kings/Tulare	1,168
6071	California	San Bernardino	2,252
6047	California	Merced	255
6063	California	Plumas	44
17031	Illinois	Cook	427
17119	Illinois	Madison	1,687
18089	Indiana	Lake	0
16079	Idaho	Shoshone	61
41035	Oregon	Klamath	25
42003	Pennsylvania	Allegheny	154
19163	Iowa	Scott	188
26163	Michigan	Wayne	870
55079	Wisconsin	Milwaukee	455
55133	Wisconsin	Waukesha	55
48141	Texas	El Paso	158
48201	Texas	Harris	123

[a]For the following counties, the emission reductions listed are relative to the adjusted 2020 control case design values rather than the analytical baseline: Jefferson, AL; Shoshone, ID; Cook, IL; Madison, IL; Klamath, OR; Lake, IN; Scott, IA; Wayne, MI; Milwaukee, WI; and Harris, TX.

3.4 Estimating Changes in Annual Average $PM_{2.5}$ Concentrations for Benefits Inputs

The calculation of health benefits for the revised annual standard of 12 µg/m^3 and the two alternative annual standards uses spatial surfaces of gridded annual average $PM_{2.5}$ concentrations for the analytical baseline and spatial surface reflecting attainment of each different standard. The spatial surface for each case covers the U.S. portion of the air quality modeling domain. To create the spatial field for analytical baseline we started with a spatial surface for the 2020 control case reflecting the removal of atypical events.   The 2020 control case spatial surface was adjusted using the projected annual design values for the analytical baseline to create the spatial surface for the baseline. The spatial surface for the 2020 control case was also adjusted to reflect attainment of the different standards using the annual design values for each standard. Details of this process are described below.

The spatial surface for the 2020 control case (with removal of potential future atypical events) was developed using the MATS tool by calculating species-specific RRFs at every grid cell within the modeling domain for the 2020 control case and applying these RRFs to ambient data that have been interpolated to cover all grid cells in the modeling domain. The basic spatial interpolation technique, called Voronoi Neighbor Averaging (VNA), was applied for annual design values for the 2020 control case and each standard to create spatial fields of annual $PM_{2.5}$ for each of these cases. As part of this technique, VNA uses the inverse distance squared weighted average of the annual design values at monitoring sites that are nearest to the center of each model grid cell. We then calculate the ratio of annual $PM_{2.5}$ for each standard level to annual $PM_{2.5}$ for the 2020 control case for each grid cell in the VNA fields. These gridded ratios are then multiplied by the gridded annual concentrations from the MATS outputs for the 2020 control case. That is, a spatial surface was calculated by adjusting the 2020 control case using a multiplicative factor calculated as the ratio of the gridded design values for attainment of each standard to the gridded design values of the 2020 control case where the design value gridded spatial fields are based on the nearest neighbor monitor locations (weighted by distance). This approach is shown mathematically in the equation below.

$$\textit{Adjusted } AQ_{ij} = \frac{\textit{VNA Interpolated } AQ_{ij} \textit{ from Alternative Standard}}{\textit{VNA Interpolated } AQ_{ij} \textit{ from 2020 Base}} \; \textit{x MATS } AQ_{ij}$$

where *ij* refers to column *i* and row *j* of the modeling domain. This approach aims to estimate the change in population exposure associated with attaining an alternate NAAQS, relying on data from the existing monitoring network and the inverse distance squared variant of the VNA interpolation method to adjust the gridded concentrations from the MATS tool such that each area attains the standard alternatives. Using the VNA spatial averaging technique, the annual average $PM_{2.5}$ spatial surfaces are smoothed to minimize sharp gradients in $PM_{2.5}$ concentrations in the spatial fields due to changes in the monitor concentrations[38]. Because the VNA approach interpolates monitor values, it is most reliable in areas with a denser monitoring network. In areas with a sparser monitoring network, there is less observed monitoring data to support the VNA interpolation and we have less confidence in the air quality values further away from the location of monitoring sites. To the extent that any bias in the interpolated values is present, the ratio of the interpolated values should be relatively insensitive to this bias and the adjusted air quality values should be unaffected.

3.5 Limitations of Using Adjusted Air Quality Data

Due to time constraints, design values and $PM_{2.5}$ surfaces at the analytical baseline level and the alternative standard levels were based on adjusted fields derived from the modeled 2020 base case and 2020 control case, rather than directly on air quality simulation results. While a credible technical basis exists for the adjustment procedures used in this analysis, there are important limitations to the approaches used to estimate the response of air quality to emissions changes. For instance, air quality ratios are calculated with results from a limited number of model sensitivity runs and are based on the assumption that the monitor design values would decrease with additional emissions reductions of SO_2, NO_x and direct $PM_{2.5}$ similar to how the model sensitivity runs predicted changes in air quality concentrations. The uncertainty of this assumption will increase with increasing emissions reductions needed to estimate attainment. In addition, the model response to emissions changes are analyzed at a county-level or within a small group of counties, and we assume that air quality concentrations at a monitor will decrease linearly with emissions reductions in a county (e.g., direct $PM_{2.5}$ emission reductions) or a group of counties (e.g., SO_2 and NO_x emissions reductions). Because of the more local influence of changes in directly emitted $PM_{2.5}$ emissions on air quality, it is also particularly difficult for the air quality ratio approach to estimate well how the design value at a monitor in a county would respond to changes in direct $PM_{2.5}$ emissions in a county without knowing the location of the source (e.g., extrapolated emissions reductions) relative to the location of the monitor.

The exact impact of using this methodology to estimate the emissions reductions needed for attainment and the associated effect on the cost and benefits is uncertain and may vary from monitor-to-monitor. We do not believe that this methodology tends towards any

[38] For the purposes of estimating benefits, this smoothed surface was then clipped to grid cells within 50 km of monitors whose design values were changed as a result of the standard level.

general trend and does not always result in either an underestimation or overestimation of the costs and benefits of attaining the proposed alternative standards.

3.6 Weight-of-Evidence Approach for Lincoln County, MT and Santa Cruz, NM

There were two counties that exceeded alternative standard levels in the 2020 base case for which we used a weight-of-evidence approach to determine how they would attain these levels. These counties are Lincoln County, MT and Santa Cruz County, AZ.

Lincoln County's $PM_{2.5}$ air quality problem is dominated by residential wood combustion emissions of primary $PM_{2.5}$, and the County has few additional emissions sources to control. The Lincoln County monitor is situated in the City of Libby in a valley that is subject to wintertime temperature inversions (Figure 3-12). These temperature inversions, which suppress air mixing and dilution of $PM_{2.5}$, combined with resident's reliance on wood burning for home heating can produce poor $PM_{2.5}$ air quality. However, since 2005, Libby has successfully implemented a woodstove change-out program that has resulted in consistent improvements in $PM_{2.5}$ air quality in recent years (Figure 3-13). The success of this program and the downward trend in annual design values at the Libby monitor suggests that Libby will meet the revised and alternative standard levels in 2020. Since residential wood combustion emissions in Libby and the emission reductions due to the wood-stove change-out program are not fully captured in our emission inventory, our modeled estimates of future-year design values are not reliable at this site. However, our weight-of-evidence considerations suggest that Lincoln County would likely attain the alternative standard levels in 2020 based on on-the-books control programs.

Figure 3-12. City of Libby in Lincoln County, Montana. (Image taken from Google Earth.)

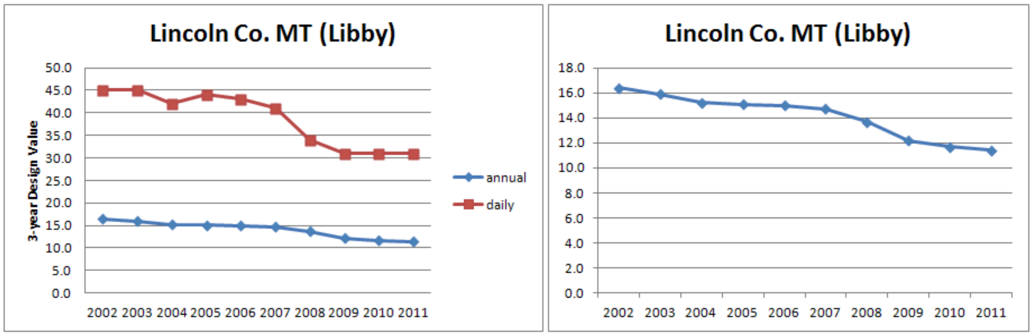

Figure 3-13. Three-year annual and 24-hr design values for the monitor in Libby, MT.

Santa Cruz, AZ had a 24-hr design value of 29.7 $\mu g/m^3$ and an annual design value of 12.65 $\mu g/m^3$ in the 2020 base case. However, Santa Cruz has few local emissions sources and therefore relatively low emissions available for control. Total emissions in Santa Cruz County of SO_2, NOx and direct $PM_{2.5}$ were 65, 688, and 542 tons, respectively, in the 2020 base case. Total emissions of SO_2, NOx and direct $PM_{2.5}$ for the Mexican State of Sonora, which borders Santa Cruz, were much greater at 100,089, 53,518 and 27,641 tons, respectively. The lack of substantial local controllable emissions in Santa Cruz and the large impact of emissions from Sonora, Mexico on air quality in Santa Cruz suggest that emissions from Mexico make meeting the alternative standards for this county impractical in our analysis. Cross-border impacts of Mexican emissions on Santa Cruz County have been recognized previously. On September 25, 2012, in a Federal Register Notice, EPA Region IX approved a State Implementation Plan (SIP) revision submitted by the Arizona Department of Environmental Quality. As indicated in the Notice, EPA Region IX reviewed three years of air quality data from Arizona and determined that the Nogales nonattainment area in Santa Cruz County is attaining the National Ambient Air Quality Standard for PM_{10}, but for international emissions sources in Nogales, Sonora, Mexico. Our weight-of-evidence considerations suggest that Santa Cruz would likely not require emissions reductions in addition to those of on on-the-books control programs to attain the alternative standard levels.

3.7 Estimating Changes in Visibility for Analyzing Welfare Benefits

Changes in visibility were calculated in order to assess both recreational and residential visibility welfare benefits. The visibility calculations for the welfare benefits assessment are based on annual average light extinction (bext) values, converted to units of visual range (km).

Since we are interested in providing visibility estimates throughout the US, we utilize gridded, speciated $PM_{2.5}$ data that is produced by the MATS tool (Abt, 2012) along with future-year design values for the annual NAAQS.

The gridded species data used to calculate the visibility values is somewhat different than the gridded data used to calculate health benefits. The gridded $PM_{2.5}$ data used as input to BenMAP for health benefits is based on adjusted species data using the SANDWICH technique (Frank, 2006). The $PM_{2.5}$ species data is adjusted to match the nature of the $PM_{2.5}$ FRM filter data that is used as the basis for determining attainment of the $PM_{2.5}$ NAAQS. For example, in the spatial fields used in BenMAP, the nitrate data has been adjusted to account for volatilization, a particle bound water component is added to the sulfate and nitrate concentrations, and the organic carbon is calculated as the difference between the measured FRM $PM_{2.5}$ mass and the sum of the rest of the $PM_{2.5}$ species. For visibility calculations, we use the "raw" $PM_{2.5}$ species data, as measured by IMPROVE and CSN monitors. The equation below shows the "old" IMPROVE equation which is used to calculate visibility in Mm^{-1}. Note that the coarse PM component of the "old" IMPROVE equation was excluded here because this term is not used in calculating visibility spatial fields.

$$b\text{ext} = 3 \text{ x } f(\text{RH})\text{x } [Sulfate] + 3 \text{ x } f(\text{RH})\text{x } [Nitrate] + 4 \text{ x } [Organic\ Mass] + 10 \text{ x } [Elemental\ Carbon] + 1 \text{ x } [Fine\ Soil] + 10$$

The mass concentrations of the components indicated in brackets are in units of $\mu g/m^3$, and f(RH) is the unitless water growth term that depends on relative humidity. The final term in the equation is known as the Rayleigh scattering term and accounts for light scattering by the natural gases in unpolluted air. Since IMPROVE does not include ammonium ion monitoring, the assumption is made that all sulfate is fully neutralized ammonium sulfate and all nitrate is assumed to be ammonium nitrate.

The visibility values are calculated from observed concentrations for each of the PM species for each calendar quarter. Using the "old" IMPROVE equation (without the coarse mass component), and with quarterly averaged climatological average relative humidity [f(RH)] values, we calculate a quarterly average light extinction (bext) value from the IMPROVE and CSN data for the 2006-2008 base period which has been interpolated to the modeling grid using gradient adjusted spatial fields (eVNA). The observed sulfate and nitrate concentrations are assumed to be fully neutralized by ammonium and the organic carbon is multiplied by 1.4 to derive organic carbon mass. The interpolated gridded 2006-2008 ambient data is projected to 2020 using modeled RRFs. The model-derived quarterly average RRFs for sulfate, nitrate, elemental carbon, organic carbon, and crustal components are multiplied by the gridded light extinction components to get future year quarterly average visibility. The four quarterly average total light extinction values (for each grid cell) are then averaged together to get annual average visibility. The procedure was repeated for both the 2020 base case and 2020 control case scenarios.

The gridded field of 2020 base case and control case annual average visibility is used to calculate residential visibility benefits in the following manner. The visibility data at Class I areas is extracted from the gridded data to calculate recreational visibility benefits. The Class I area visibility is based on the visibility calculated at the grid cell which contains the centroid of each of the 149 Class I areas in the continental U.S.

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Appendix A
Model Performance Evaluation for the 2007-Based $PM_{2.5}$ NAAQS Final Rule Air Quality Modeling Platform

A.1. Introduction

An operational model performance evaluation for $PM_{2.5}$ speciated components was conducted using 2007 State/local monitoring sites data in order to estimate the ability of the CMAQ modeling system to replicate the base year concentrations for the 12-km Continental United States domain[1]. Included in this evaluation are statistical measures of model versus observed pairs that were paired in space and time on a daily or weekly basis, depending on the sampling frequency of each network (measured data). For certain time periods with missing $PM_{2.5}$ species observations, we excluded the CMAQ predictions from those time periods in our calculations. It should be noted when pairing model and observed data that each CMAQ concentration represents a grid-cell volume-averaged value, while the ambient network measurements are made at specific locations.

Model performance statistics were calculated for several spatial scales and temporal periods. Statistics were generated for six large subregions[2]: Midwest, Northeast, Southeast, Central U.S., Western U.S. excluding California, and California separately. The statistics for each site and subregion were calculated by season (e.g., "winter" is defined as December-January-February). In addition to the performance statistics, we prepared several graphical presentations of model performance. These graphical presentations include:

(1) regional maps which show the normalized mean bias and error calculated for each season at individual monitoring sites,

(2) bar and whisker plots which show the distribution of the predicted and observed data by month by subregion, and

(3) time series plots of observed and predicted concentrations at selected speciation monitoring sites where future-year exceedances of the 11/35 alternative standard level for $PM_{2.5}$ were estimated based on results for the 2020 base case.

A.1.1 Monitoring Networks

The model evaluation for $PM_{2.5}$ focuses on the key $PM_{2.5}$ components including sulfate (SO_4), nitrate (NO_3), total nitrate ($TNO_3=NO_3+HNO_3$), ammonium (NH_4), elemental carbon (EC), organic carbon (OC), and crustal material. The $PM_{2.5}$ performance statistics were calculated for each season. $PM_{2.5}$ ambient measurements for 2007 were obtained from the following networks: Chemical Speciation Network (CSN), Interagency Monitoring of PROtected Visual Environments (IMPROVE), and the Clean Air Status and Trends Network (CASTNet). The pollutant species included in the evaluation for each network are listed in Table A-1. For $PM_{2.5}$ species that are measured by more than one network, we calculated separate sets of statistics for each network. The CSN and IMPROVE networks provide 24-hour average concentrations on

[1]See Section 2.1.1 and Figure 2-1 for the description and map of the CMAQ modeling domain.

[2] The subregions are defined by States where: Midwest is IL, IN, MI, OH, and WI; Northeast is CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, and VT; Southeast is AL, FL, GA, KY, MS, NC, SC, TN, VA, and WV; Central is AR, IA, KS, LA, MN, MO, NE, OK, and TX; West without California is AK, OR, WA, AZ, NM, CO, UT, WY, SD, ND, MT, ID, and NV.

a 1 in every 3 day, or 1 in every 6 day sampling cycle. The $PM_{2.5}$ species data at CASTNet sites are weekly integrated samples. In this analysis we use the term "urban sites" to refer to CSN sites; "suburban/rural sites" to refer to CASTNet sites; and "rural sites" to refer to IMPROVE sites.

Table A-1. $PM_{2.5}$ monitoring networks and pollutants species included in the CMAQ performance evaluation.

Ambient Monitoring Networks	Particulate Species						
	SO_4	NO_3	TNO_3[a]	NH_4	EC	OC	Crustal
IMPROVE	X	X			X	X	X
CASTNet	X		X	X			
CSN	X	X		X	X	X	X

[a] $TNO_3 = (NO_3 + HNO_3)$

A.1.2 Model Performance Statistics

The Atmospheric Model Evaluation Tool (AMET) was used to conduct the evaluation described in this document.[3] There are various statistical metrics available and used by the science community for model performance evaluation. For this analysis, we have selected normalized mean bias, normalized mean error, fractional bias and fractional error to characterize model performance (Table A-2). As noted above, we calculated the performance statistics by season. In this analysis "winter" includes the months of December-January-February; "spring" includes the months of March-April-May; "summer" includes the months of June-July-August; and "fall" includes the months of September-October-November.

Table A-2. AMET model performance statistics calculated for this analysis.

Percent Normalized Mean Bias
Percent Normalized Mean Error
Fractional Bias
Fractional Error

Normalized mean bias (NMB) is used as a normalization to facilitate a range of concentration magnitudes. This statistic averages the difference (model - observed) over the sum of observed values. NMB is a useful model performance indicator because it avoids over

[3] Appel, K.W., Gilliam, R.C., Davis, N., Zubrow, A., and Howard, S.C.: Overview of the Atmospheric Model Evaluation Tool (AMET) v1.1 for evaluating meteorological and air quality models, *Environ. Modell. Softw.*,26, 4, 434-443, 2011. (http://www.cmascenter.org/)

inflating the observed range of values, especially at low concentrations.

Normalized mean bias is defined as:

$$\text{NMB} = \frac{\sum_{1}^{n}(P-O)}{\sum_{1}^{n}(O)} * 100$$

Normalized mean error (NME) is also similar to NMB, where the performance statistic is used as a normalization of the mean error. NME calculates the absolute value of the difference (model - observed) over the sum of observed values.

Normalized mean error is defined as:

$$\text{NME} = \frac{\sum_{1}^{n}|P-O|}{\sum_{1}^{n}(O)} * 100$$

Fractional bias is defined as:

$$\text{FB} = \frac{1}{n}\left(\frac{\sum_{1}^{n}(P-O)}{\sum_{1}^{n}\left(\frac{(P+O)}{2}\right)}\right) * 100$$

, where P = predicted and O = observed concentrations.

FB is a useful model performance indicator because it has the advantage of equally weighting positive and negative bias estimates. The single largest disadvantage in this estimate of model performance is that the estimated concentration (i.e., prediction, P) is found in both the numerator and denominator. Fractional error (FE) is similar to fractional bias except the absolute value of the difference is used so that the error is always positive.

Fractional error is defined as:

$$\text{FE} = \frac{1}{n}\left(\frac{\sum_{1}^{n}|P-O|}{\sum_{1}^{n}\left(\frac{(P+O)}{2}\right)}\right) * 100$$

The "acceptability" of model performance was judged by comparing our CMAQ 2007 performance results to the range of performance found in recent regional $PM_{2.5}$ model applications.[4,5,6,7,8,9,10,11,12, 13,14] These other modeling studies represent a wide range of modeling analyses which cover various models, model configurations, domains, years and/or episodes, chemical mechanisms, and aerosol modules. Overall, the $PM_{2.5}$ concentrations and model performance results for the 2007 CMAQ simulations performed for the PM NAAQS final rule are within the range or close to that found in other recent applications. The model performance results, as described in this document, demonstrate that the predictions from the PM NAAQS Rule modeling platform generally replicate the corresponding observed concentrations in terms of the magnitude, temporal fluctuations, and spatial differences for sulfate and nitrate. In addition, the modeling platform captures the general magnitude and seasonal variations in ammonium and organic carbon, two other components of $PM_{2.5}$. As noted below, model predictions of elemental carbon and crustal material are over predicted, most likely due to problems in the emissions for these pollutants.

Consistent with EPA's guidance for attainment demonstration modeling, we have applied the model predictions performed as part of the PM NAAQS Rule in a relative manner

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[4] Appel, K.W., Bhave, P.V., Gilliland, A.B., Sarwar, G., and Roselle, S.J.: evaluation of the community multiscale air quality (CMAQ) model version 4.5: sensitivities impacting model performance: Part II – particulate matter. Atmospheric Environment 42, 6057-6066, 2008.

[5] Appel, K.W., Gilliland, A.B., Sarwar, G., Gilliam, R.C., 2007. Evaluation of the community multiscale air quality (CMAQ) model version 4.5: sensitivities impacting model performance: Part I – ozone. Atmospheric Environment 41, 9603-9615.

[6] Appel, K.W., Roselle, S.J., Gilliam, R.C., and Pleim, J.E.,: Sensitivity of the Community Multiscale Air Quality (CMAQ) model v4.7 results for the eastern United States to MM5 and WRF meteorological drivers. Geoscientific Model Development, 3, 169-188, 2010.

[7] Foley, K.M., Roselle, S.J., Appel, K.W., Bhave, P.V., Pleim, J.E., Otte, T.L., Mathur, R., Sarwar, G., Young, J.O., Gilliam, R.C., Nolte, C.G., Kelly, J.T., Gilliland, A.B., and Bash, J.O.,: Incremental testing of the Community multiscale air quality (CMAQ) modeling system version 4.7. Geoscientific Model Development, 3, 205-226, 2010.

[8] Hogrefe, G., Civeroio, K.L., Hao, W., Ku, J-Y., Zalewsky, E.E., and Sistla, G., Rethinking the Assessment of Photochemical Modeling Systems in Air Quality Planning Applications. Air & Waste Management Assoc., 58:1086-1099, 2008.

[9] 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. (http://www.cmascenter.org/conference/2008/agenda.cfm).

[10] Simon, H., Baker, K.R., and Phillips, S., 2012. Compilation and interpretation of photochemical model performance statistics published between 2006 and 2012. Atmospheric Environment 61, 124-139. http://dx.doi.org/10.1016/j.atmosenv.2012.07.012

[11] Tesche, T.W., Morris, R., Tonnesen, G., McNally, D., Boylan, J., Brewer, P., 2006. CMAQ/CAMx annual 2002 performance evaluation over the eastern United States. Atmospheric Environment 40, 4906-4919.

[12] U.S. Environmental Protection Agency; Technical Support Document for the Final Clean Air Interstate Rule: Air Quality Modeling; Office of Air Quality Planning and Standards; RTP, NC; March 2005 (CAIR Docket OAR-2005-0053-2149).

[13] 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, 329pp., 2009. (http://www.epa.gov/otaq/regs/nonroad/marine/ci/420r09007.pdf)

[14] 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. (http://www.epa.gov/oms/renewablefuels/420r10006.pdf)

for projecting future concentrations of $PM_{2.5}$. The National Research Council[15] states that using air quality modeling in a relative manner “may help reduce the bias introduced by modeling errors and, therefore, may be more accurate than using model results directly (absolute values) to estimate future pollutant levels”. Thus, the results of this evaluation together with the manner in which we are applying model predictions gives us confidence that our air quality model applications using the CMAQ 2007 modeling platform provides a scientifically credible approach for assessing $PM_{2.5}$ concentrations for the Final PM NAAQS Rule.

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

A.2. Evaluation of $PM_{2.5}$ Component Species

The evaluation of 2007 model predictions for $PM_{2.5}$ covers the performance for the individual $PM_{2.5}$ component species (i.e., sulfate, nitrate, ammonium, organic carbon, elemental carbon, and crustal). Performance results are provided for each $PM_{2.5}$ species. As indicated above, for each species we present tabular summaries of bias and error statistics by subregion for each season. These statistics are based on the set of observed-predicted pairs of data for the particular season at monitoring sites within the subregion. Separate statistics are provided for each monitoring network, as applicable for the particular species measured. For sulfate, nitrate, ammonium, elemental carbon, and organic carbon we also provide a more refined temporal and spatial analysis of model performance including (1) graphics of the distribution of 24-hour average concentrations and predictions by month for each subregion, (2) spatial maps which show the normalized mean bias and error by site, aggregated by season, and (3) time series plots of observed and predicted concentrations for CSN sites in counties projected to exceed the 11/35 alternative standard level in the 2020 base case[16]. The counties and CSN sites considered in the time series analysis are listed in Table A-3.

Table A-3. CSN sites used for the sulfate, nitrate, ammonium, elemental carbon, and organic carbon time series analysis

County	State	CSN Sites Used for Time Series Analysis
Jefferson	Alabama	10730023 10732003
Fresno	California	60190008
Imperial	California	60250005
Kern	California	60290014
Los Angeles	California	60371103
Plumas	California	60631009
Riverside	California	60658001
Sacramento	California	60670006
San Bernardino	California	60712002
Stanislaus	California	60990005
Tulare	California	61072002
Wayne	Michigan	26163003
Klamath	Oregon	410350004
Allegheny	Pennsylvania	420030064
El Paso	Texas	481410044
Salt Lake	Utah	490353006
Waukesha	Wisconsin	551330027

[16] We have included time series for all CSN sites (with data available in AMET for 2007) in the counties projected to exceed the 11/35 alternative standard level in the 2020 base case because some of the projected exceedance sites do not have co-located $PM_{2.5}$ speciation monitors.

A.2.1. Model Evaluation for Sulfate

The model performance bias and error statistics for sulfate for each subregion and each season are provided in Table A-4. The distributions of observed and predicted sulfate by month for each subregion are shown in Figures A-1 through A-6. Spatial plots of the normalized mean bias and error by season for individual monitors are shown in Figures A-7 through A-10. Time series plots of observed and predicted 24-hour average sulfate at selected CSN monitoring sites are provided in Figure A-11a-r. As seen in Table A-4, model predictions for sulfate are generally biased low compared with observations in the five U.S. subregions. The median NMB for sulfate over the different seasons, networks and subregions in Table A-4 is -25% with a range of -49.9% to 26.1%. In general, the NMB for sulfate does not vary greatly across seasons suggesting that the model is capturing the temporal trends in sulfate concentration at the seasonal time scale. This behavior is evident in Figures A-1 through A-6 where both modeled and observed sulfate concentrations are seen to increase during the summer months when photochemistry is more active and ambient SO_2 is readily converted to sulfate. Further investigation is needed to identify the causes of low biases in sulfate predictions but underestimation of SO_2 emissions and uncertainty the conversion rates of SO_2 to sulfate in clouds could play a role.

Table A-4. Sulfate performance statistics by subregion, by season for the 2007 CMAQ model simulation.

Subregion	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
Central U.S.	CSN	Winter	576	-17.1	46.4	-26.3	45.4
		Spring	664	-31.4	37.6	-34.3	42.2
		Summer	622	-32.6	39.1	-38.8	48.7
		Fall	656	-22.8	32.2	-21.7	36.6
	IMPROVE	Winter	536	-24.5	40.4	-22.6	42.2
		Spring	642	-35.9	39.3	-39.0	45.0
		Summer	675	-35.7	40.2	-39.7	48.9
		Fall	637	-24.2	32.8	-19.5	35.7
	CASTNet	Winter	81	-40.6	41.7	-47.5	48.3
		Spring	90	-40.3	40.4	-49.1	49.4
		Summer	97	-45.4	45.7	-57.1	57.6
		Fall	102	-32.5	32.7	-38.3	38.8
Midwest	CSN	Winter	567	-20.1	38.1	-28.7	41.4
		Spring	640	-19.3	28.5	-17.8	30.5
		Summer	604	-11.8	31.7	-10.8	34.6
		Fall	610	-19.1	31.1	-15.3	33.7
	IMPROVE	Winter	145	-22.1	36.7	-23.3	35.2
		Spring	147	-19.3	28.5	-17.8	30.5

Subregion	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
		Summer	152	-14.9	30.9	-9.4	35.5
		Fall	144	-25.0	31.4	-18.2	33.7
	CASTNet	Winter	152	-25.8	31.0	-32.7	37.1
		Spring	157	-27.0	28.8	-30.2	33.3
		Summer	162	-24.4	26.5	-26.2	28.9
		Fall	160	-24.9	27.2	-28.7	31.1
Southeast	CSN	Winter	711	-23.9	34.3	-24.2	36.4
		Spring	782	-29.2	32.9	-31.8	36.8
		Summer	731	-32.3	36.6	-38.6	44.9
		Fall	728	-21.7	32.4	-24.9	37.4
	IMPROVE	Winter	434	-15.4	31.1	-12.0	32.5
		Spring	482	-28.2	32.2	-28.8	36.1
		Summer	454	-31.9	36.8	-37.3	45.6
		Fall	460	-21.3	33.0	-20.0	37.2
	CASTNet	Winter	262	-32.6	33.0	-37.9	38.5
		Spring	288	-30.2	30.4	-36.1	36.5
		Summer	266	-32.9	33.4	-39.3	40.1
		Fall	289	-29.4	29.7	-34.8	35.7
Northeast	CSN	Winter	833	-14.1	33.1	-18.2	33.9
		Spring	897	-23.9	31.4	-21.4	33.7
		Summer	860	-24.9	31.2	-23.0	34.0
		Fall	883	-15.5	30.2	-11.0	32.0
	IMPROVE	Winter	551	-6.3	31.3	-10.5	29.6
		Spring	597	-17.3	28.8	-14.2	31.5
		Summer	589	-24.3	32.6	-19.8	36.6
		Fall	569	-9.5	30.9	-1.2	32.1
	CASTNet	Winter	179	-24.6	27.6	-29.4	32.9
		Spring	194	-27.4	29.2	-28.3	31.3
		Summer	191	-26.7	28.1	-30.8	33.1
		Fall	191	-19.4	21.1	-21.9	24.5
West without California	CSN	Winter	517	-9.2	52.1	-1.5	47.0
		Spring	594	-25.3	40.2	-21.2	42.8
		Summer	563	-29.1	42.2	-31.7	46.1
		Fall	570	-16.1	40.1	-14.1	40.4
	IMPROVE	Winter	1,712	8.6	53.2	27.3	50.8
		Spring	2,018	-24.7	42.8	-14.5	45.8
		Summer	2,017	-25.6	43.0	-29.7	47.6
		Fall	2,000	-19.1	43.1	-8.6	41.9

Subregion	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
	CASTNet	Winter	196	-10.7	30.4	0.1	27.3
		Spring	214	-36.8	42.6	-33.8	46.6
		Summer	213	-40.7	43.5	-51.8	55.1
		Fall	212	-33.1	37.1	-33.3	40.0
California	CSN	Winter	313	-14.1	50.8	3.0	45.2
		Spring	356	-37.8	44.6	-31.4	47.8
		Summer	335	-46.5	53.5	-48.9	55.6
		Fall	335	-42.4	49.6	-39.8	54.2
	IMPROVE	Winter	500	26.1	61.4	39.0	56.3
		Spring	564	-33.4	46.4	-26.7	50.1
		Summer	557	-39.2	49.8	-38.8	53.1
		Fall	514	-29.5	46.8	-18.1	48.6
	CASTNet	Winter	75	6.3	32.6	12.8	32.4
		Spring	78	-41.5	44.1	-43.5	48.7
		Summer	76	-49.9	50.3	-61.9	62.9
		Fall	75	-40.9	43.3	-44.1	48.2

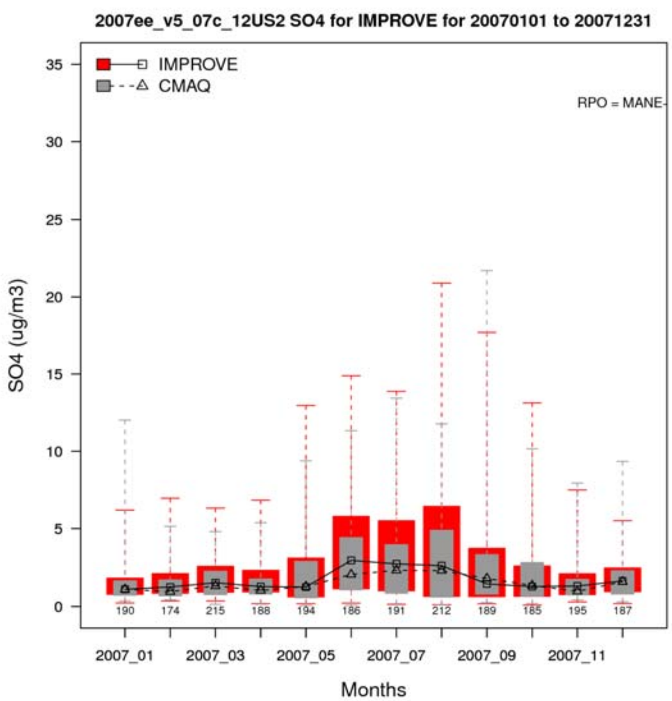

Figure A-1a. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at IMPROVE sites in the Northeast subregion. [symbol = median; top/bottom of box = 75th/25th percentiles; top/bottom line = max/min values]

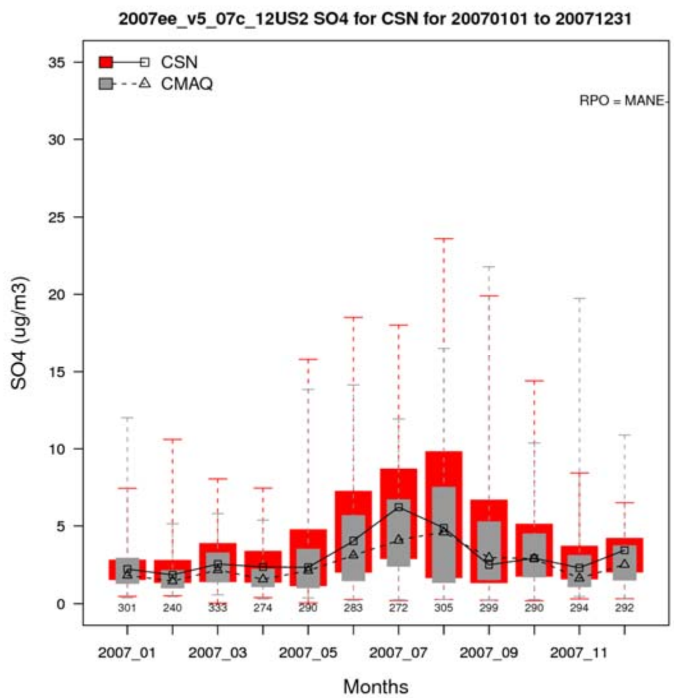

Figure A-1b. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at CSN sites in the Northeast subregion.

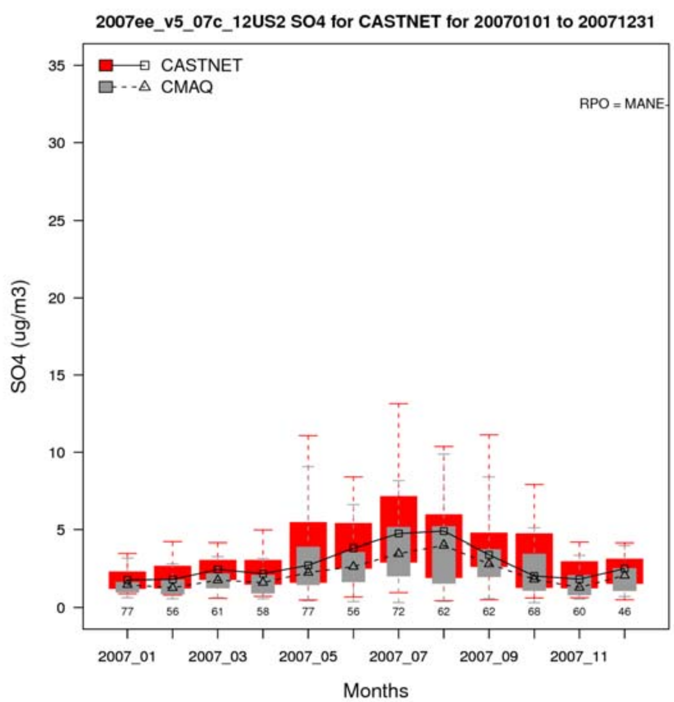

Figure A-1c. Distribution of observed and predicted weekly average sulfate by month for 2007 at CASTNet sites in the Northeast subregion.

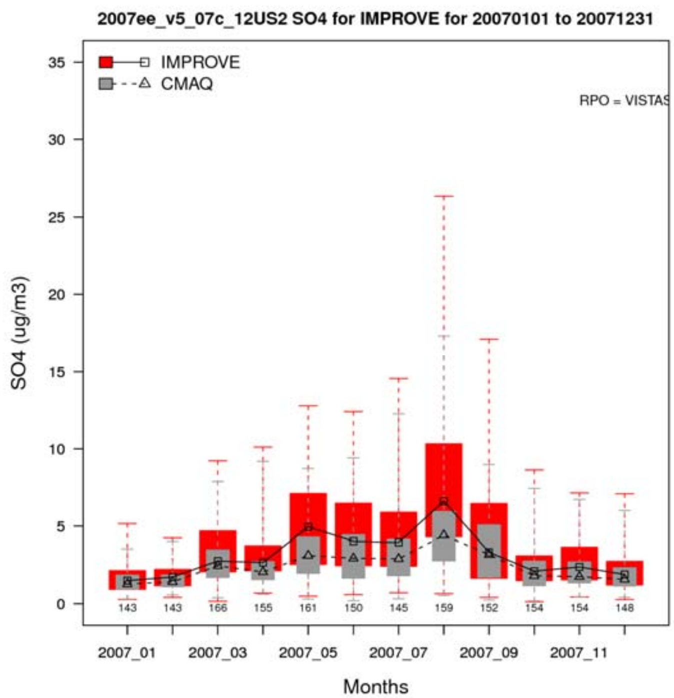

Figure A-2a. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at IMPROVE sites in the Southeast subregion.

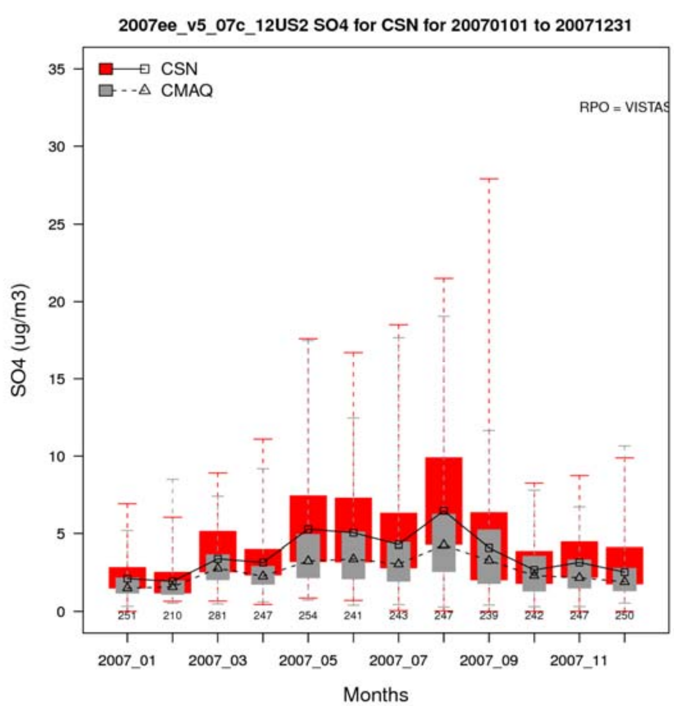

Figure A-2b. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at CSN sites in the Southeast subregion.

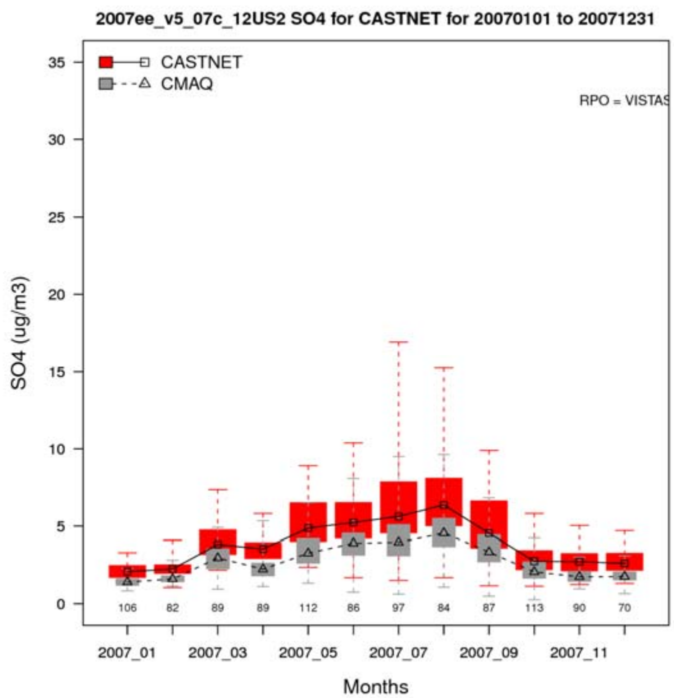

Figure A-2c. Distribution of observed and predicted weekly average sulfate by month for 2007 at CASTNet sites in the Southeast subregion.

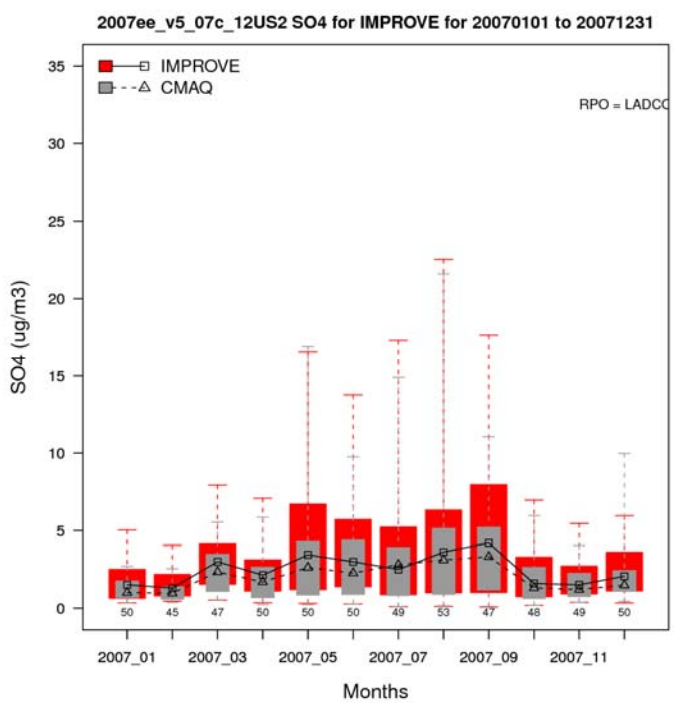

Figure A-3a. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at IMPROVE sites in the Midwest subregion.

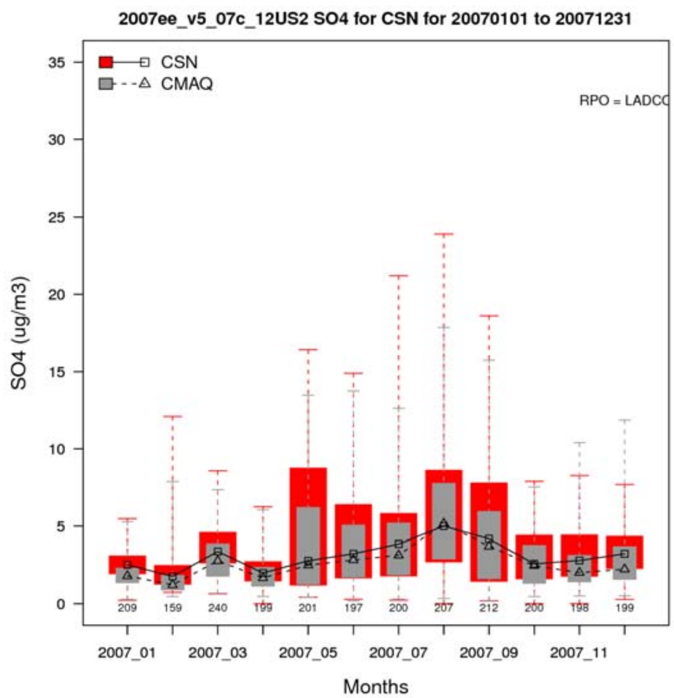

Figure A-3b. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at CSN sites in the Midwest subregion.

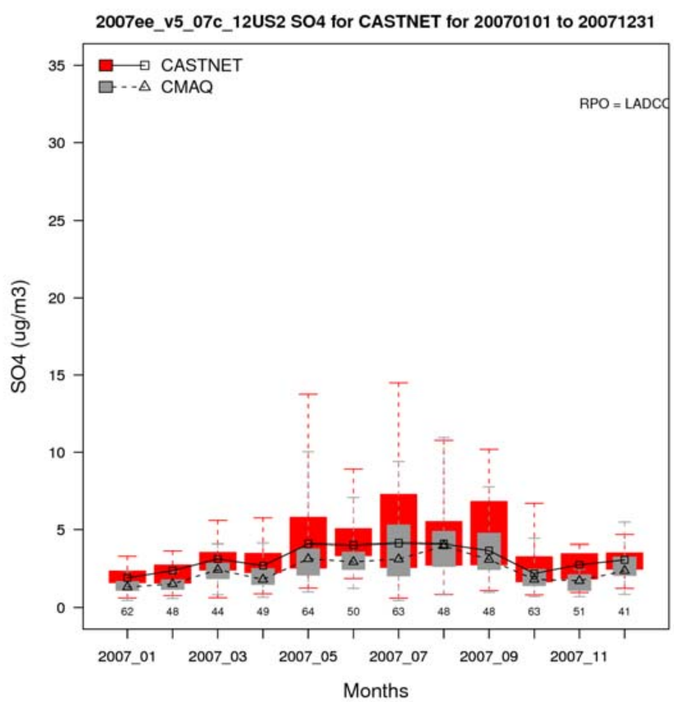

Figure A-3c. Distribution of observed and predicted weekly average sulfate by month for 2007 at CASTNet sites in the Midwest subregion.

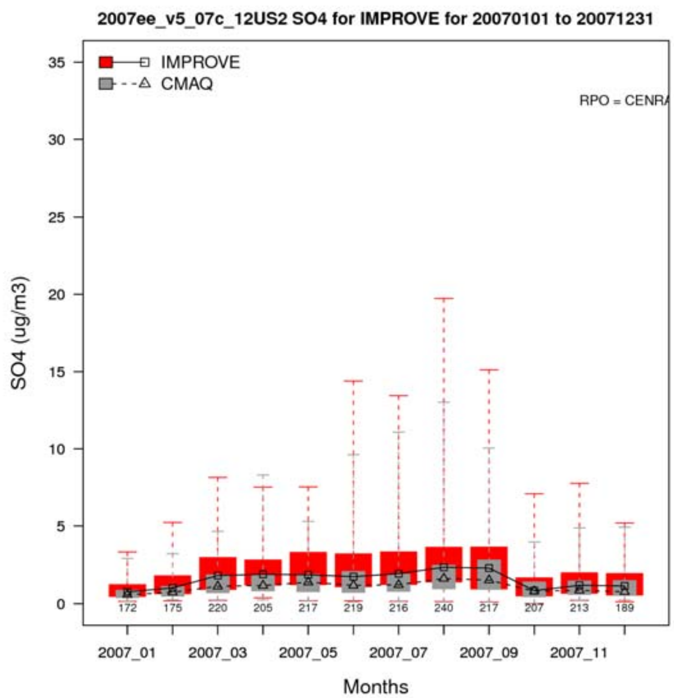

Figure A-4a. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at IMPROVE sites in the Central states subregion.

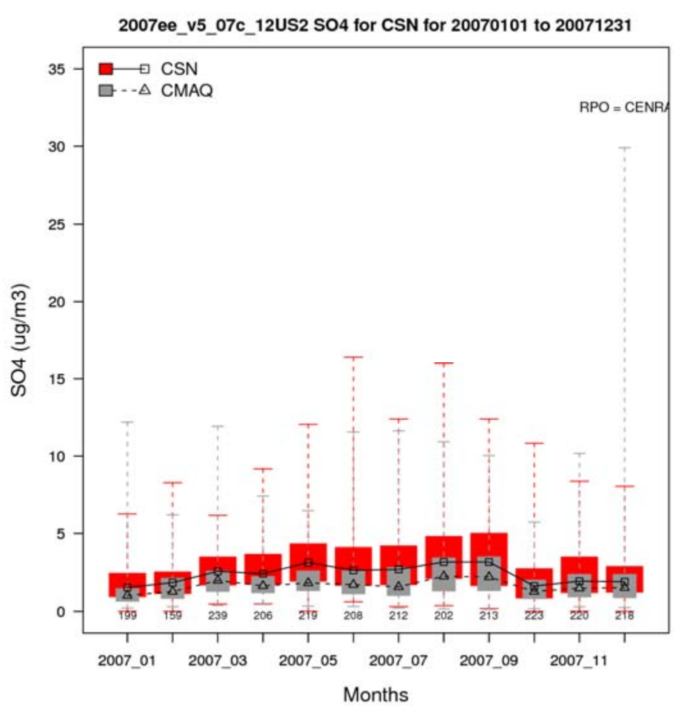

Figure A-4b. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at CSN sites in the Central states subregion.

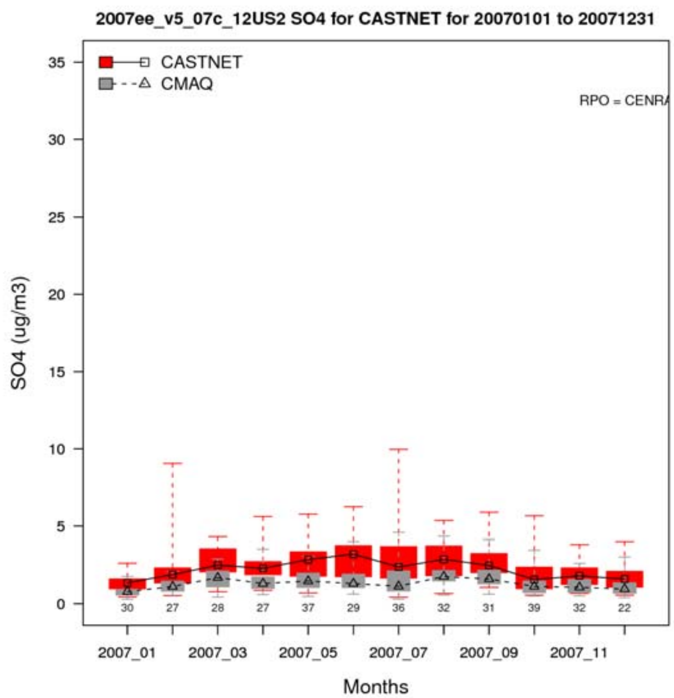

Figure A-4c. Distribution of observed and predicted weekly average sulfate by month for 2007 at CASTNet sites in the Central states subregion.

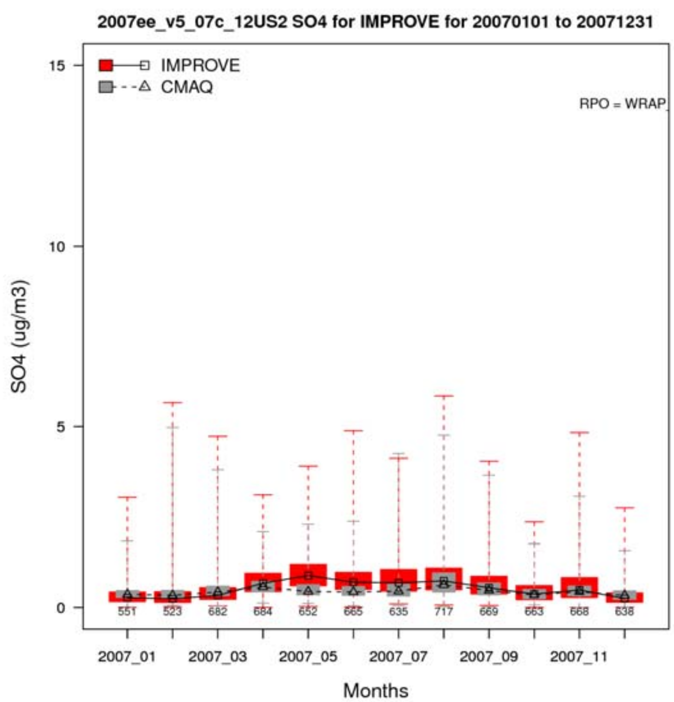

Figure A-5a. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at IMPROVE sites in the Western states excluding California subregion. [Note the change in scale for sulfate concentration from the previous sub-regional boxplots.]

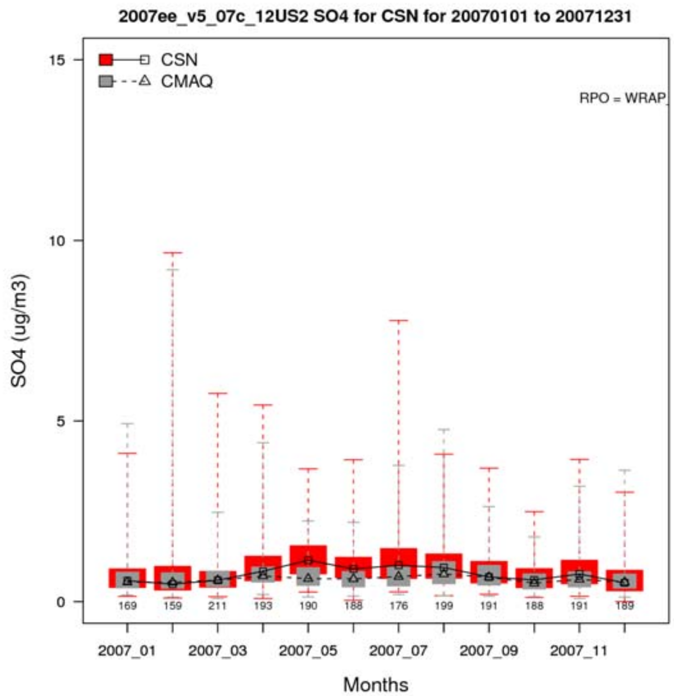

Figure A-5b. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at CSN sites in the Western states excluding California subregion. [Note the change in scale for sulfate concentration from the previous sub-regional boxplots.]

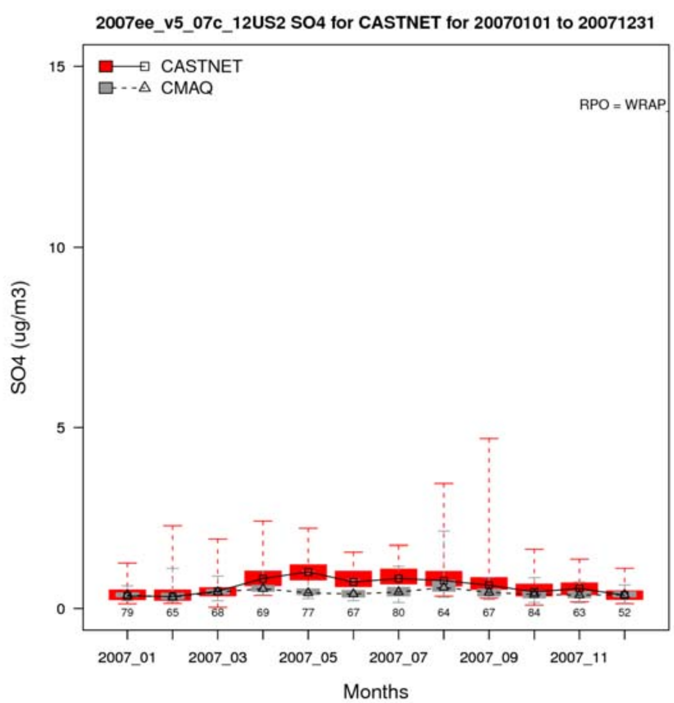

Figure A-5c. Distribution of observed and predicted weekly average sulfate by month for 2007 at CASTNet sites in the Western states excluding California subregion. [Note the change in scale for sulfate concentration from the previous sub-regional boxplots.]

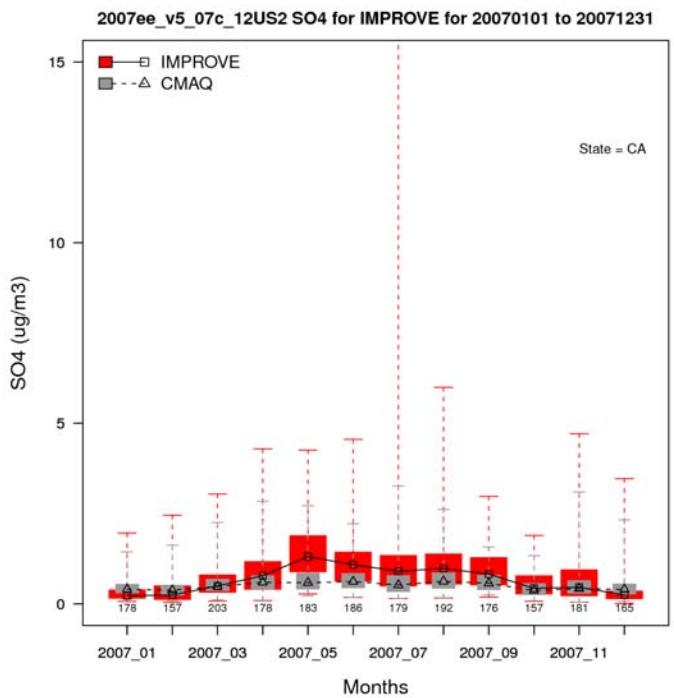

Figure A-6a. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at IMPROVE sites in the California subregion. [Note the change in scale for sulfate concentration from the previous Eastern sub-regional boxplots.]

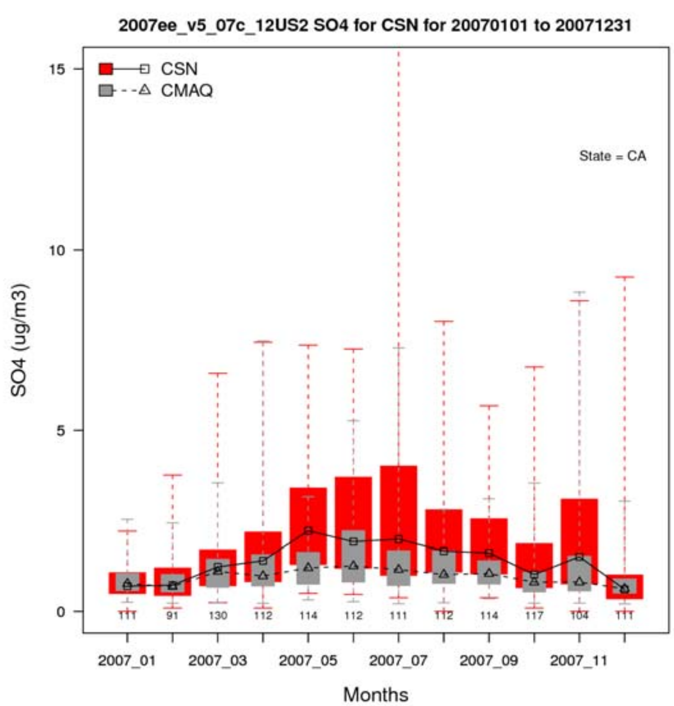

Figure A-6b. Distribution of observed and predicted 24-hour average sulfate by month for 2007 at CSN sites in the California subregion. [Note the change in scale for sulfate concentration from the previous Eastern sub-regional boxplots.]

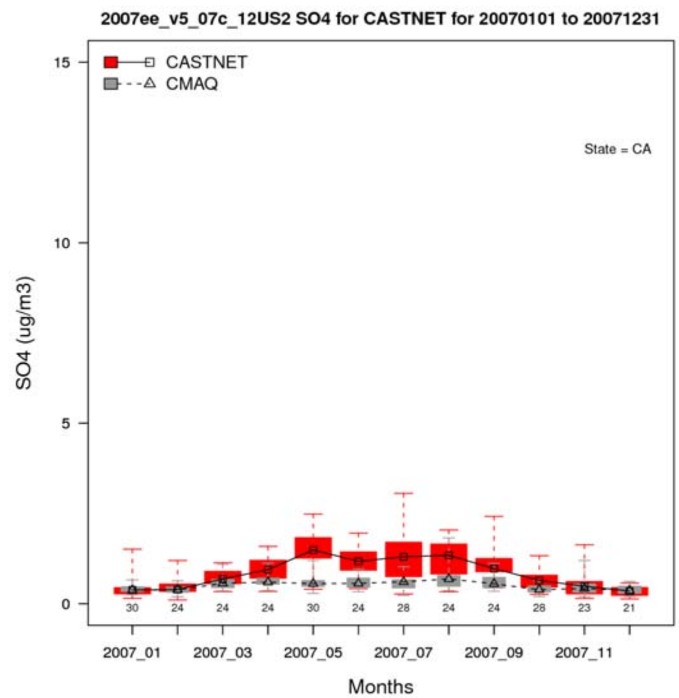

Figure A-6c. Distribution of observed and predicted weekly average sulfate by month for 2007 at CASTNet sites in the California subregion. [Note the change in scale for sulfate concentration from the previous Eastern sub-regional boxplots.]

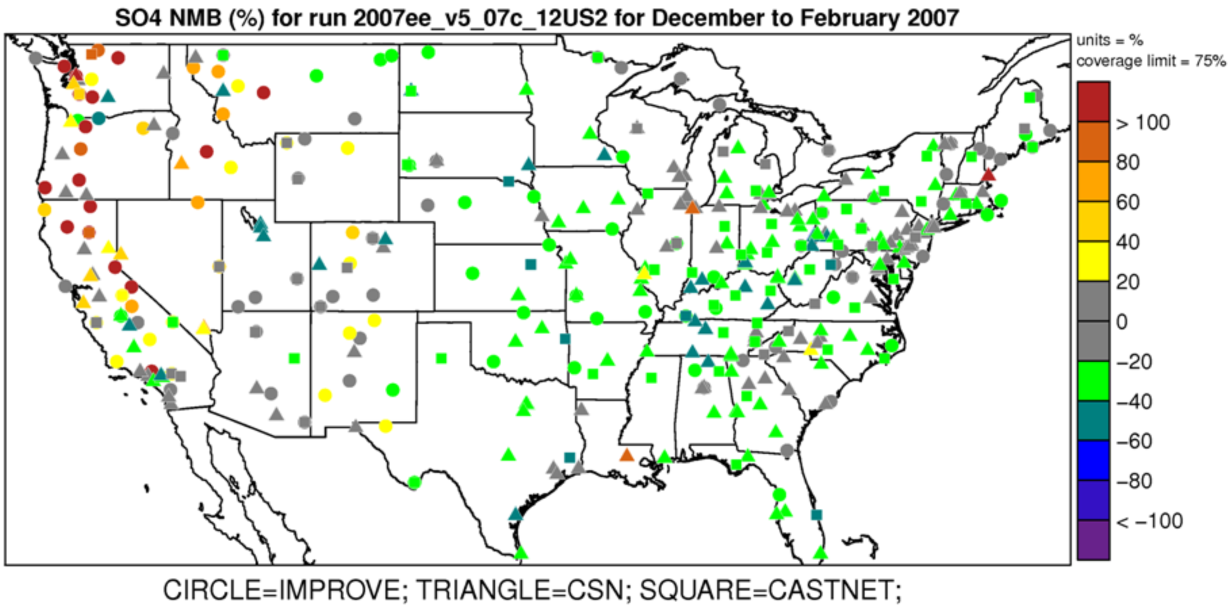

Figure A-7a. Normalized Mean Bias (%) of sulfate during winter 2007 at monitoring sites in Continental U.S. modeling domain.

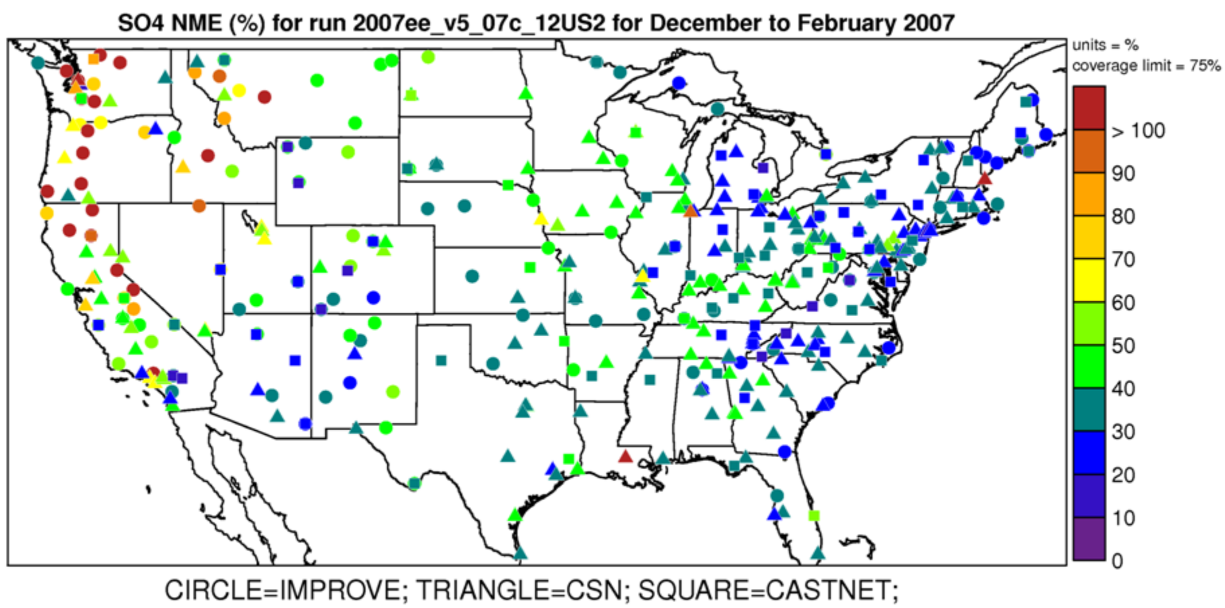

Figure A-7b. Normalized Mean Error (%) of sulfate during winter 2007 at monitoring sites in Continental U.S. modeling domain.

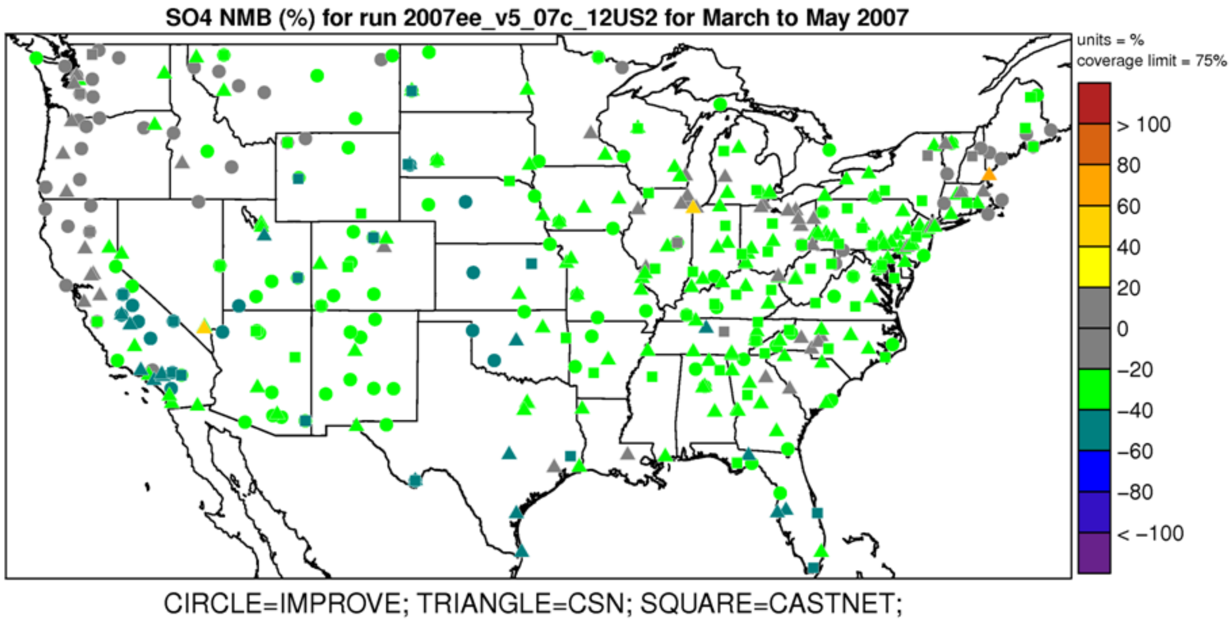

Figure A-8a. Normalized Mean Bias (%) of sulfate during spring 2007 at monitoring sites in Continental U.S. modeling domain.

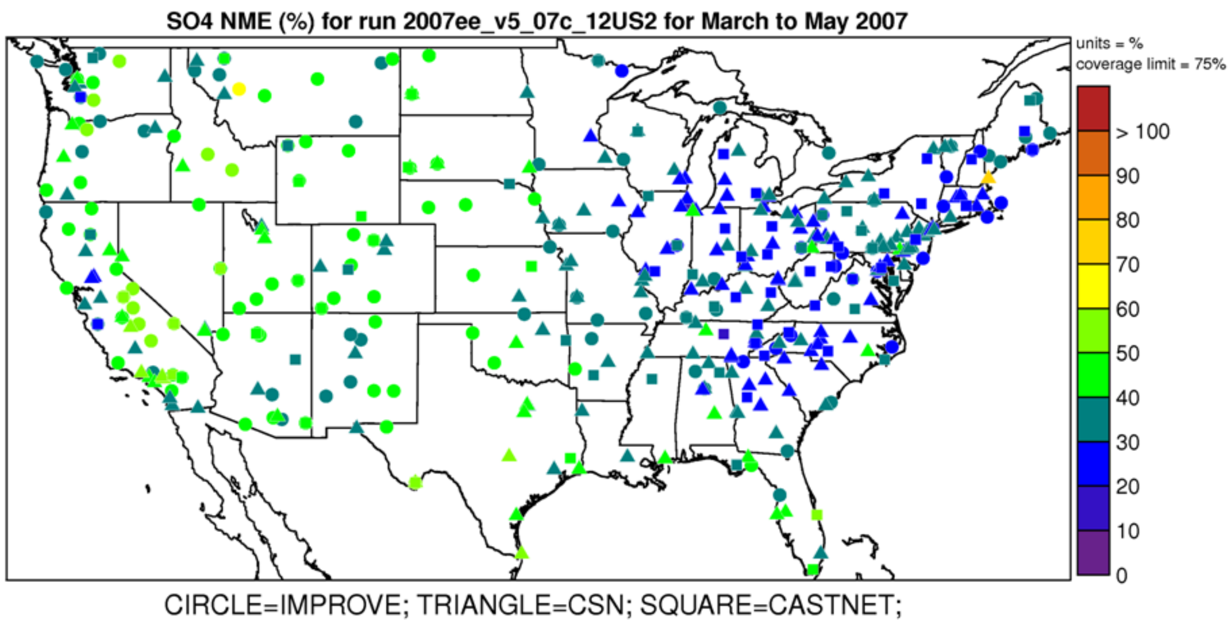

Figure A-8b. Normalized Mean Error (%) of sulfate during spring 2007 at monitoring sites in Continental U.S. modeling domain.

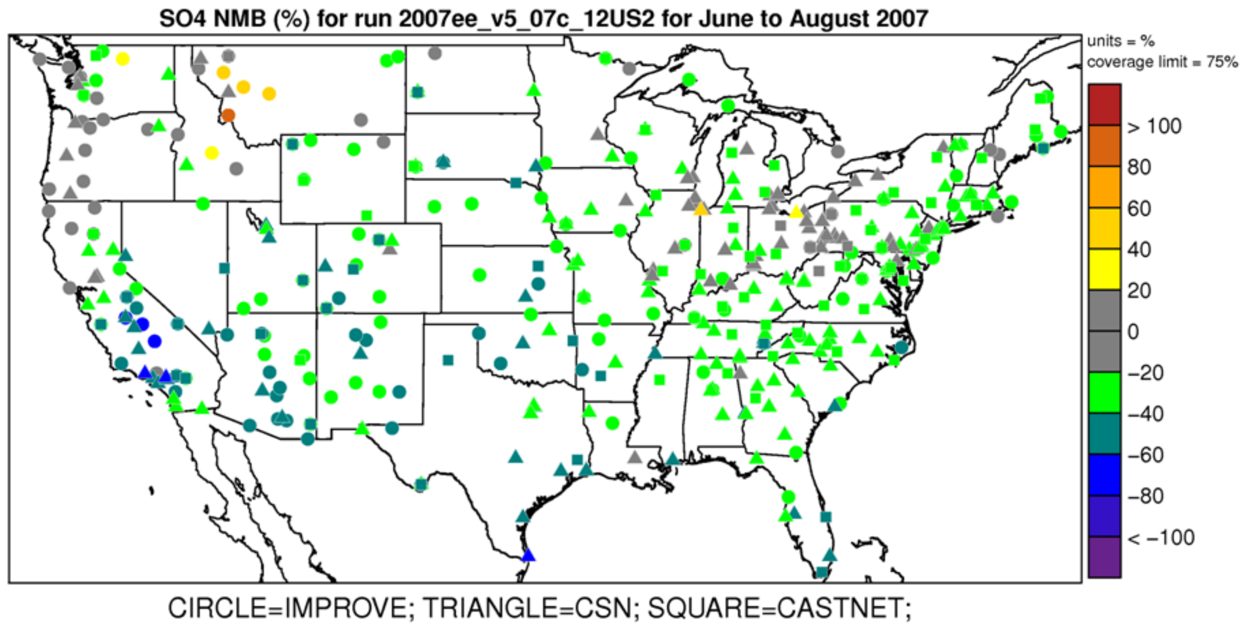

Figure A-9a. Normalized Mean Bias (%) of sulfate during summer 2007 at monitoring sites in Continental U.S. modeling domain.

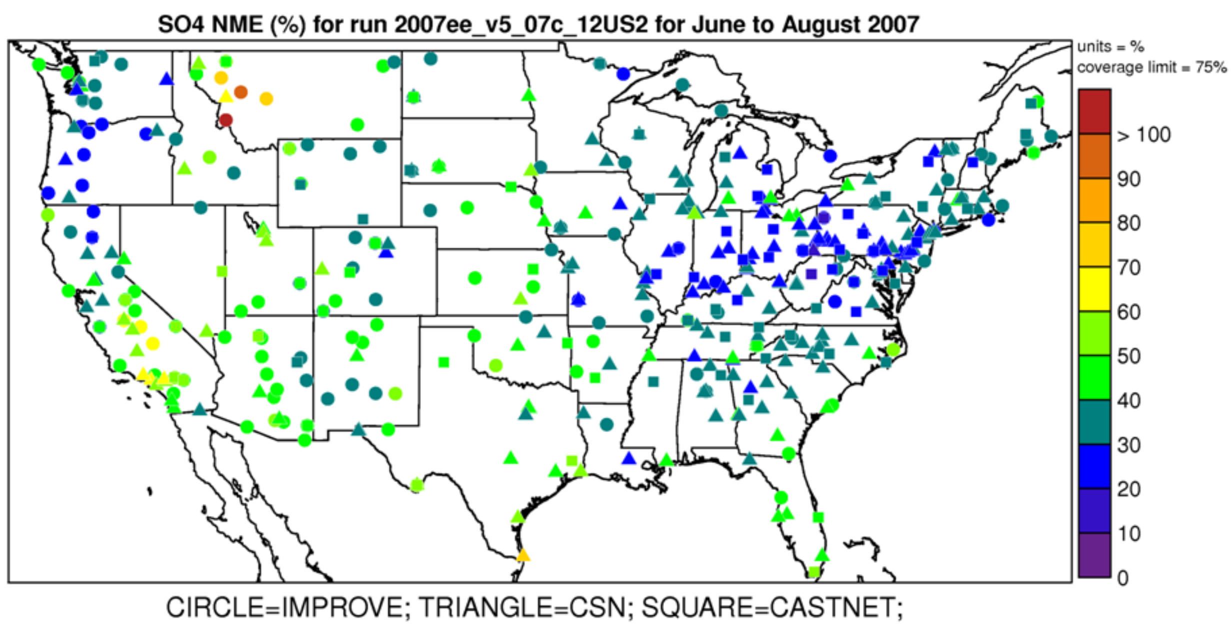

Figure A-9b. Normalized Mean Error (%) of sulfate during summer 2007 at monitoring sites in Continental U.S. modeling domain.

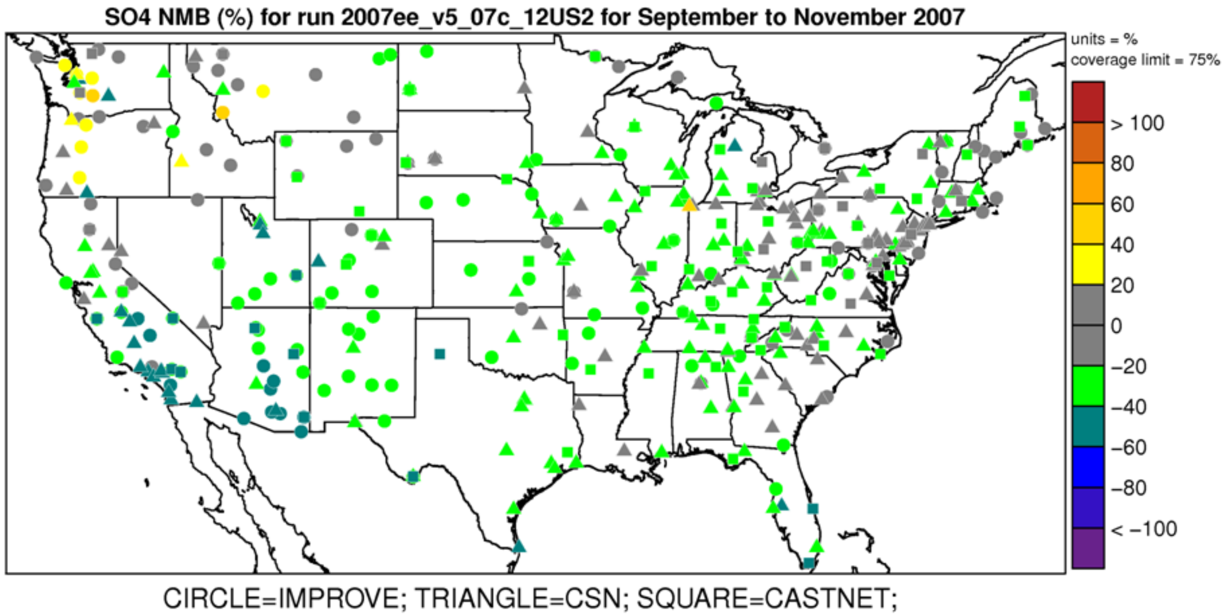

Figure A-10a. Normalized Mean Bias (%) of sulfate during fall 2007 at monitoring sites in Continental U.S. modeling domain.

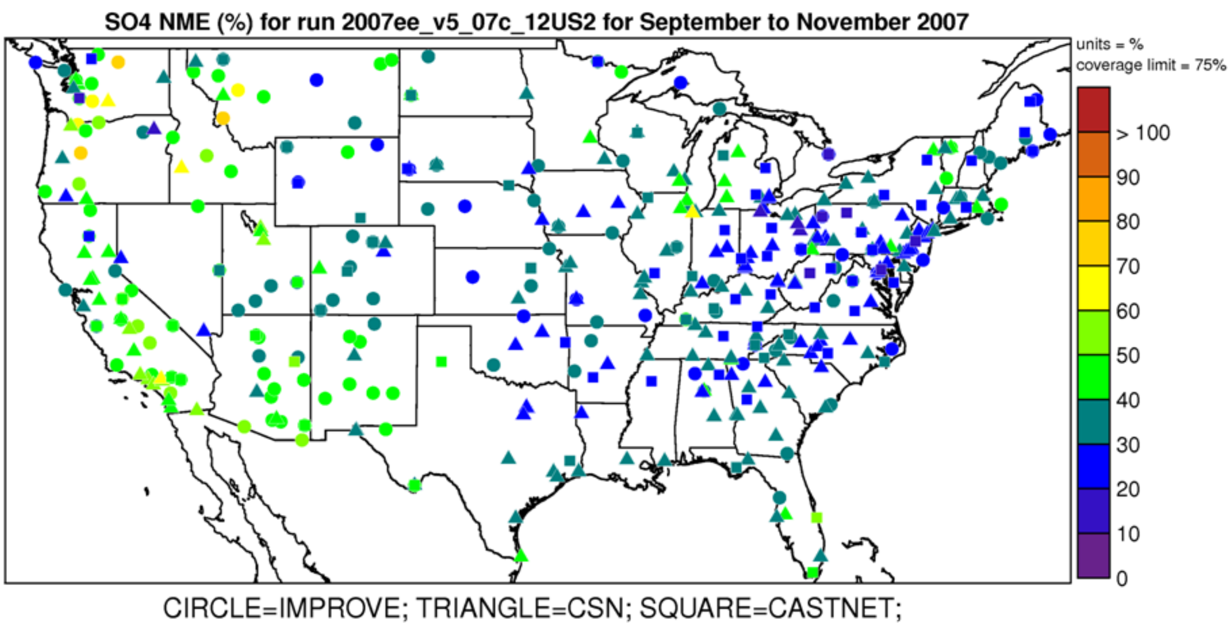

Figure A-10b. Normalized Mean Error (%) of sulfate during fall 2007 at monitoring sites in Continental U.S. modeling domain.

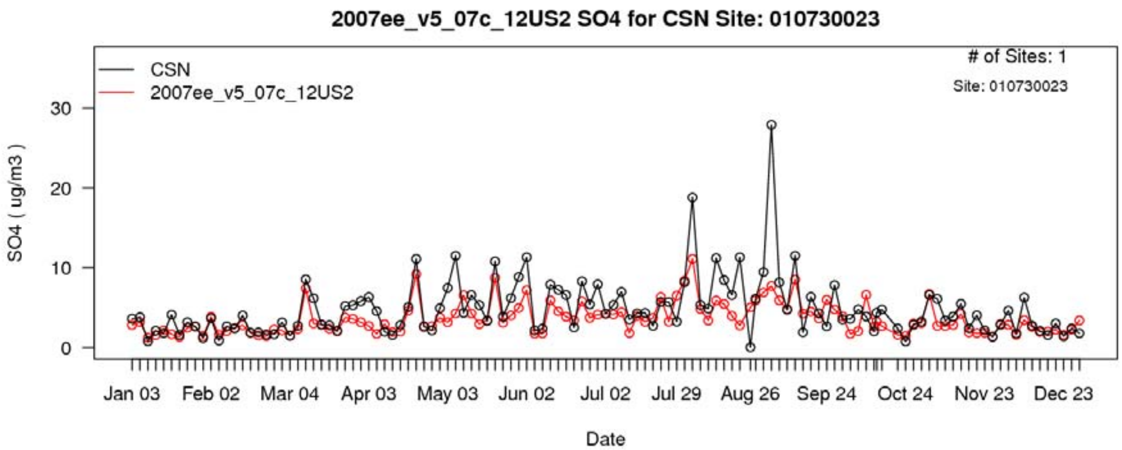

Figure A-11a. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 010730023 in Jefferson County, AL.

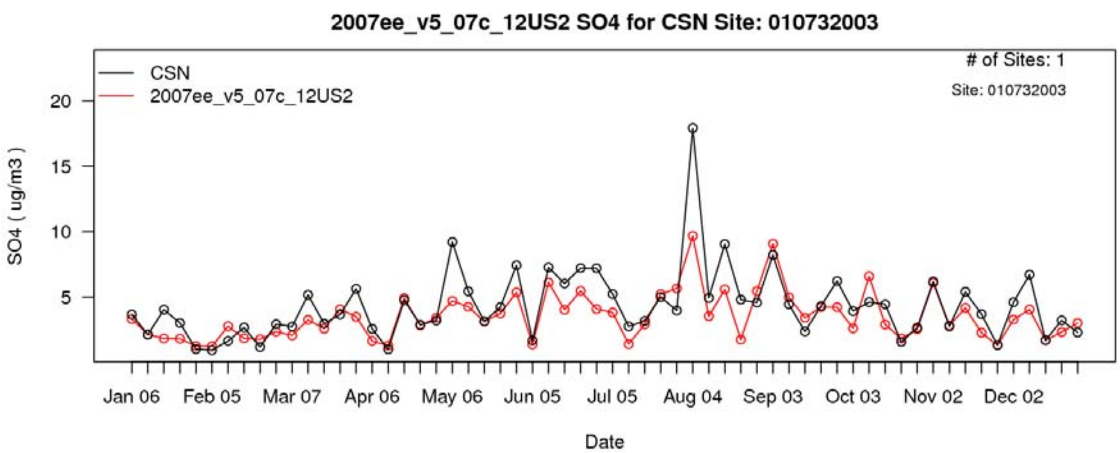

Figure A-11b. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 010732003 in Jefferson County, AL.

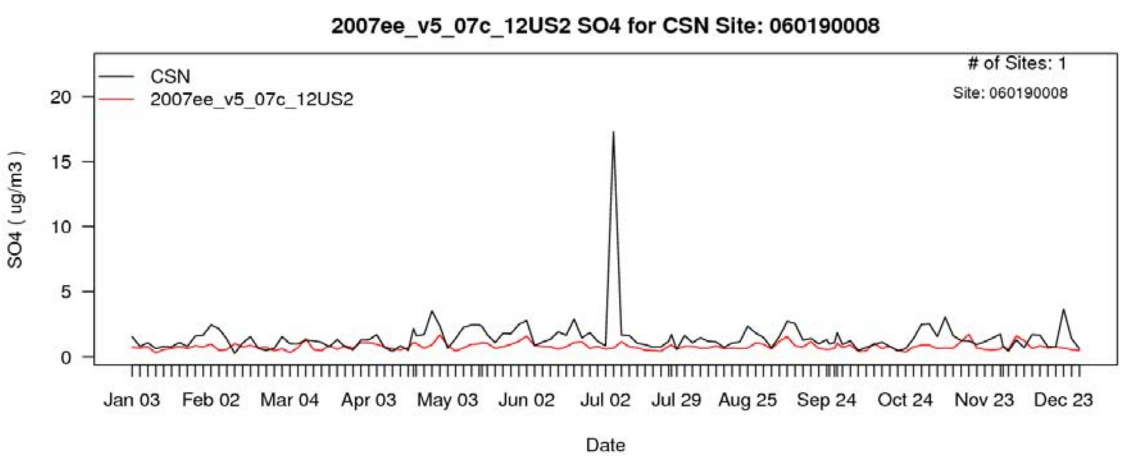

Figure A-11c. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060190008 in Fresno County, CA.

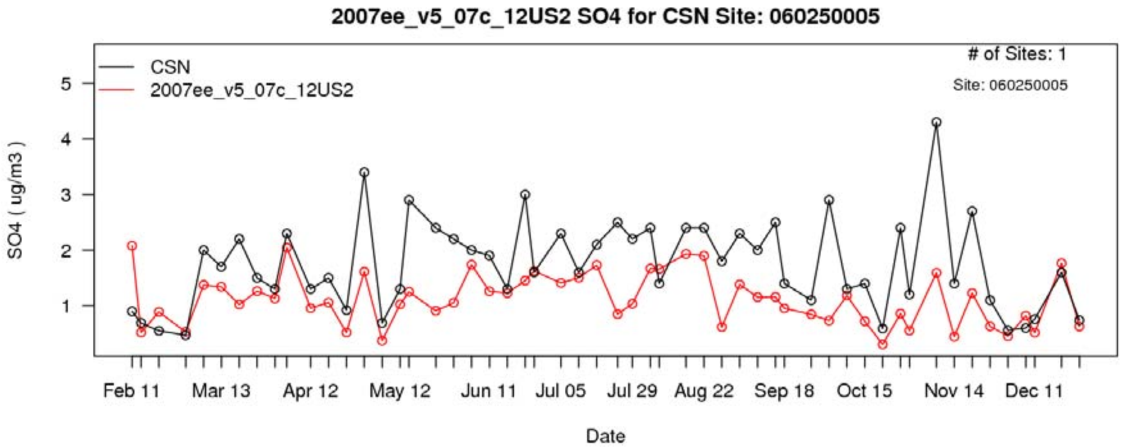

Figure A-11d. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060250005 in Imperial County, CA.

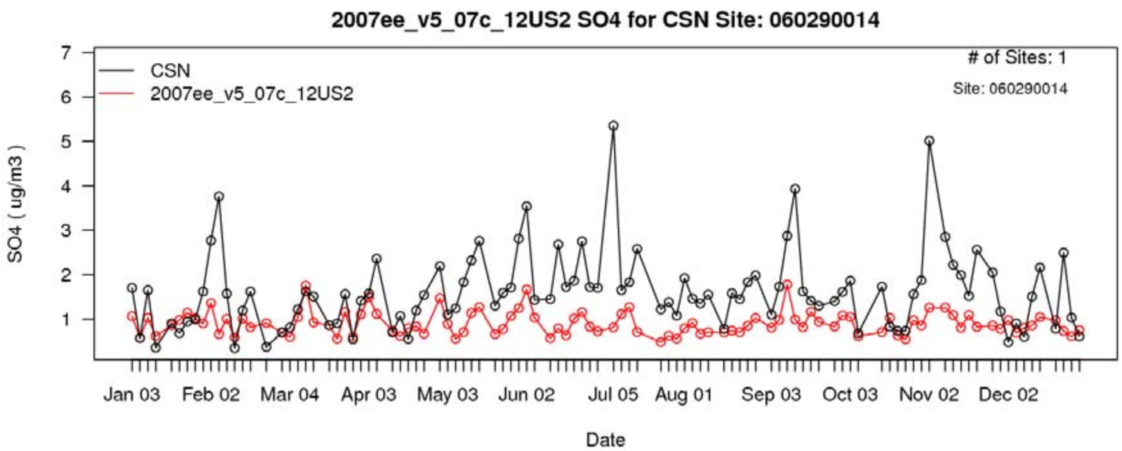

Figure A-11e. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060290014 in Kern County, CA.

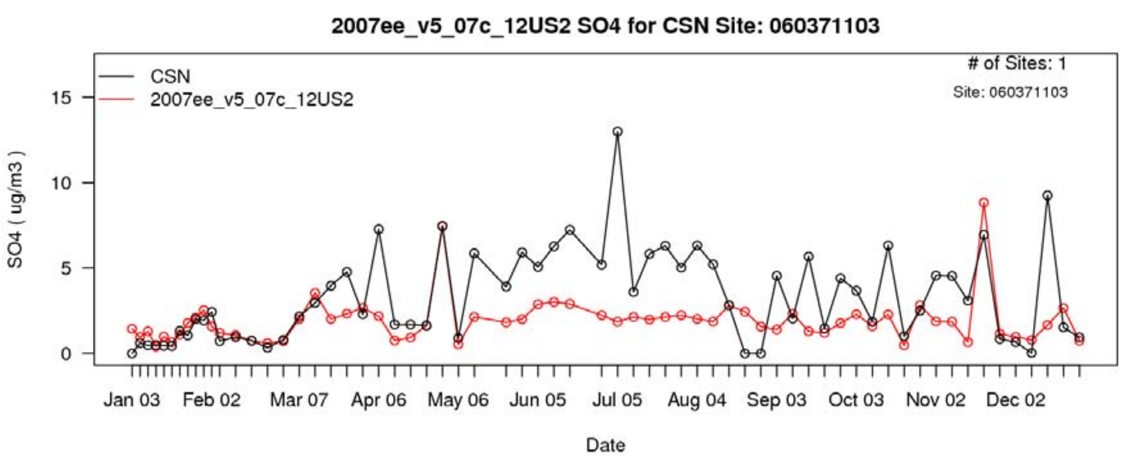

Figure A-11f. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060371103 in Los Angeles County, CA.

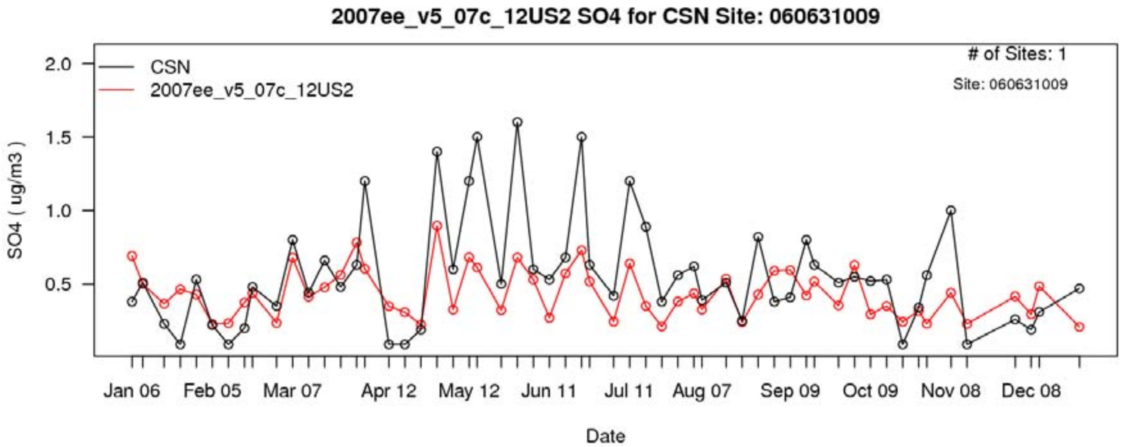

Figure A-11g. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060631009 in Plumas County, CA.

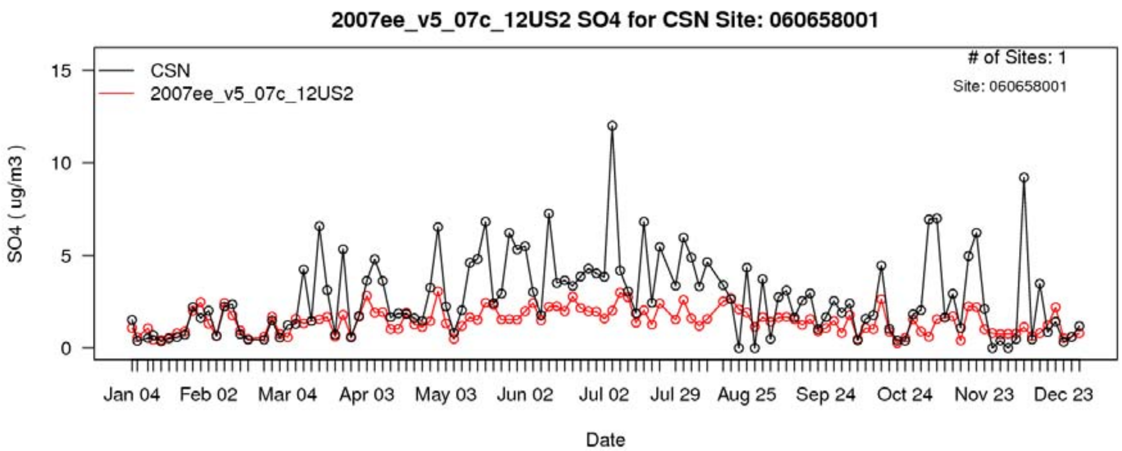

Figure A-11h. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060658001 in Riverside County, CA.

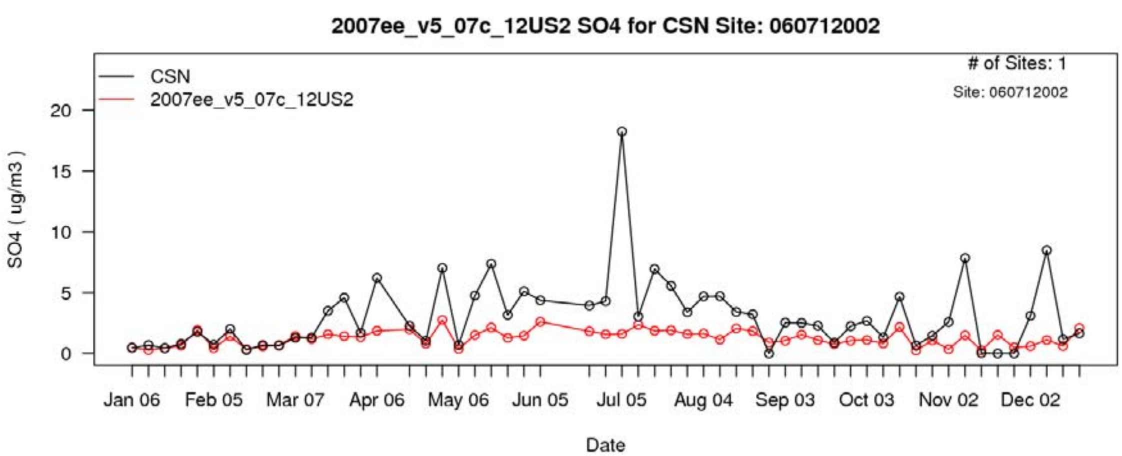

Figure A-11i. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060712002 in San Bernardino County, CA.

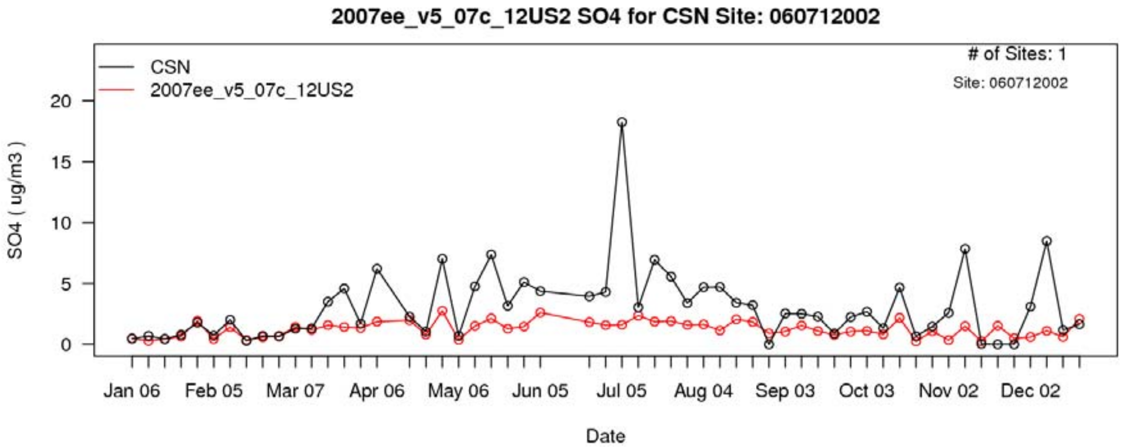

Figure A-11j. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060990005 in Stanislaus County, CA.

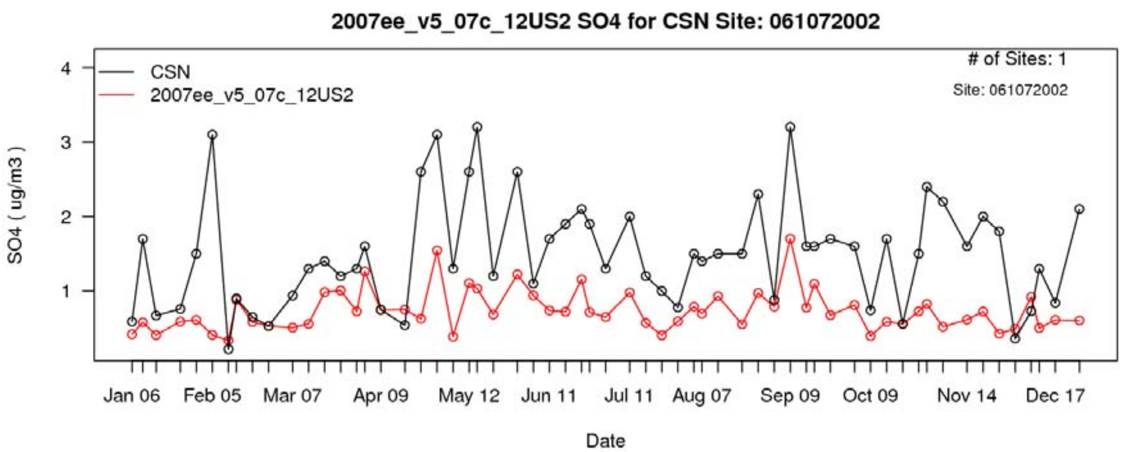

Figure A-11k. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 061072002 in Tulare County, CA.

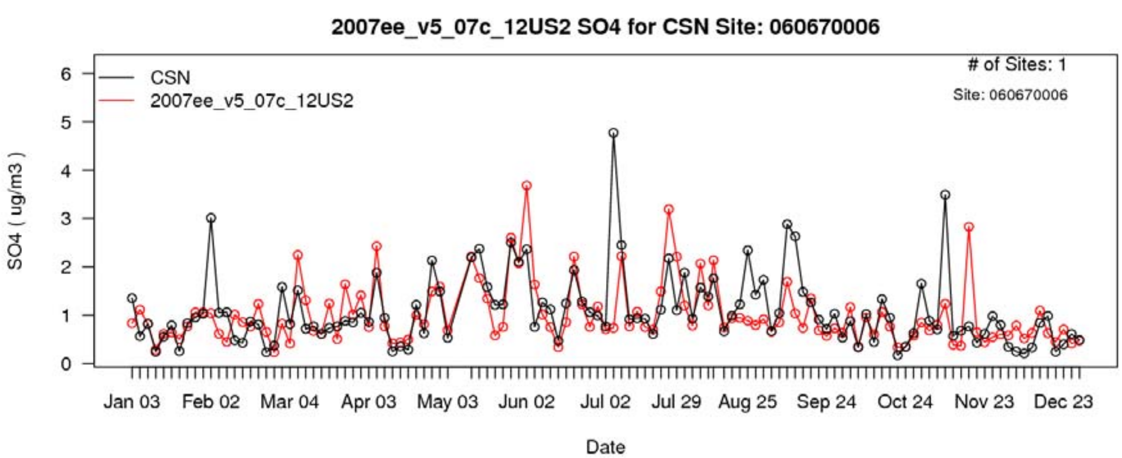

Figure A-11l. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 060670006 in Sacramento County, CA.

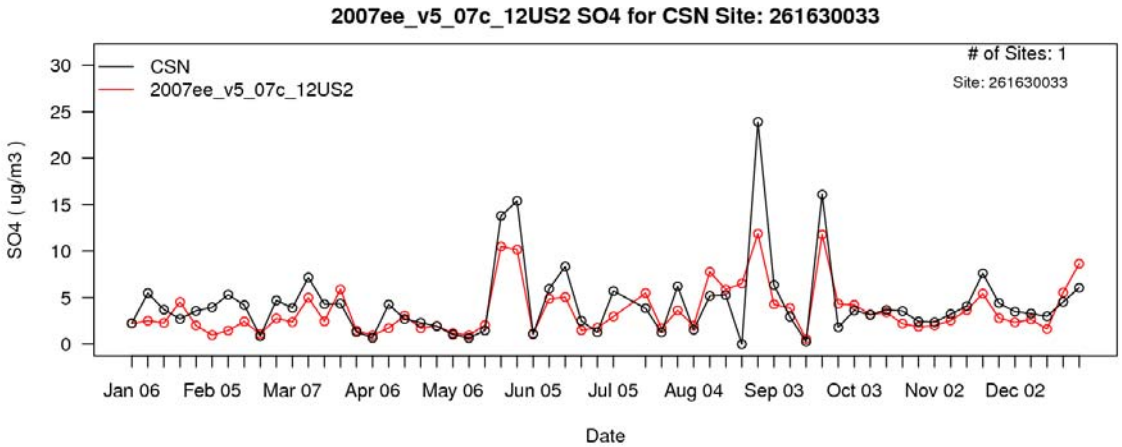

Figure A-11m. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 261630033 in Wayne County, MI.

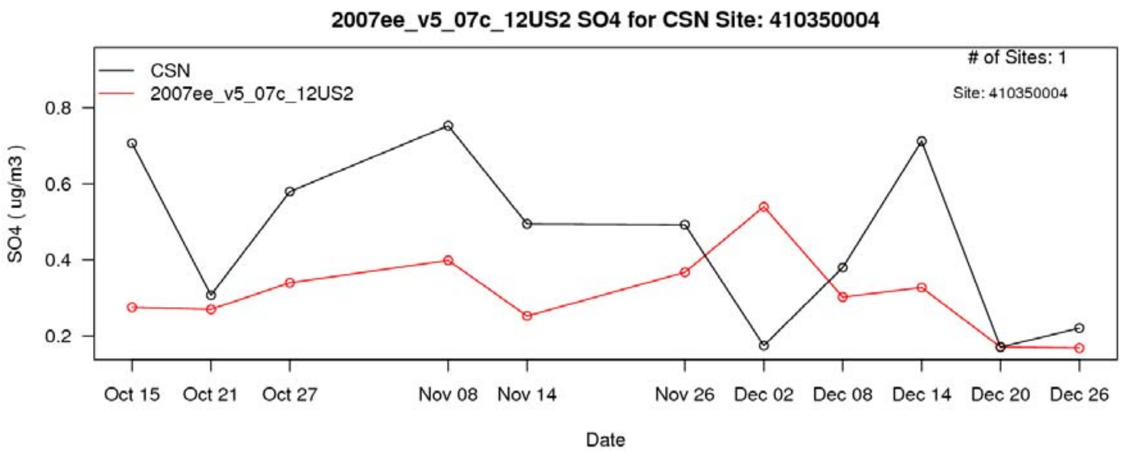

Figure A-11n. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 410350004 in Klamath County, OR.

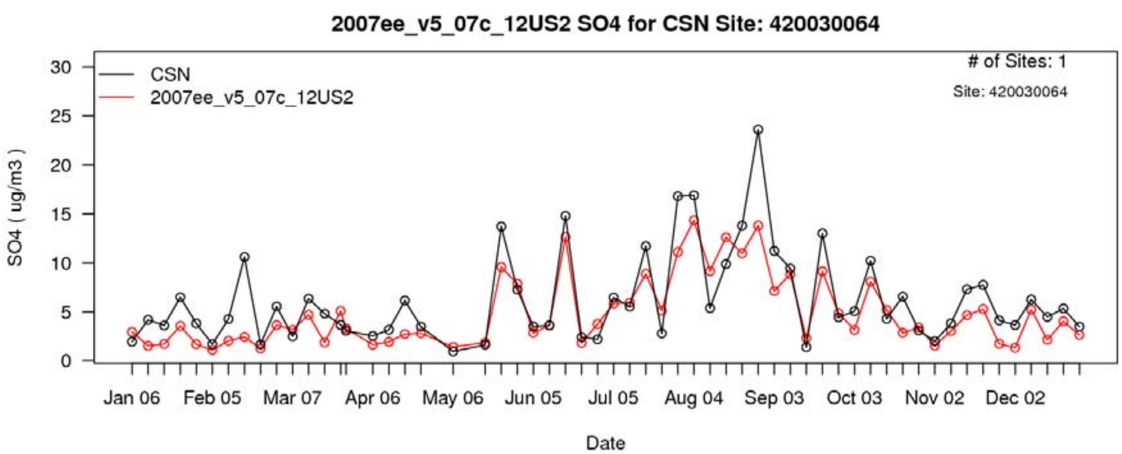

Figure A-11o. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 420030064 in Allegheny County, PA.

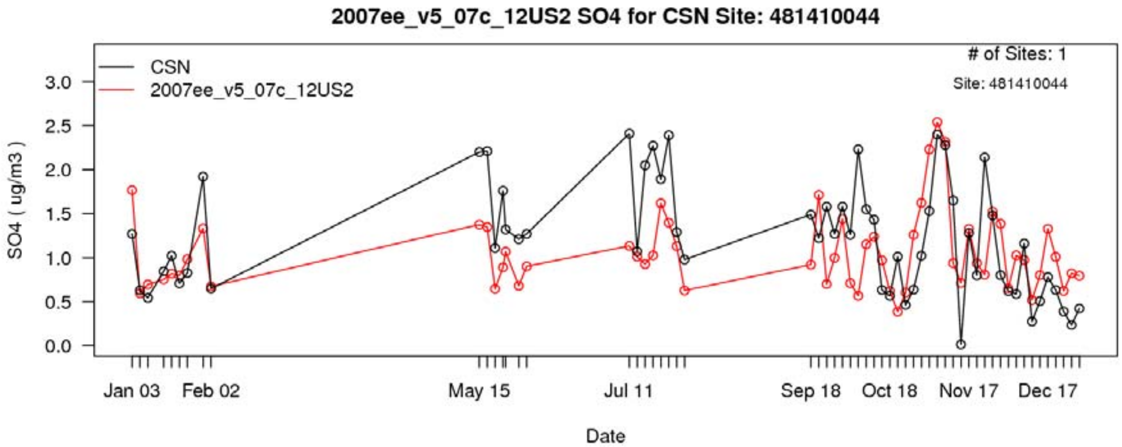

Figure A-11p. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 481410044 in El Paso County, TX.

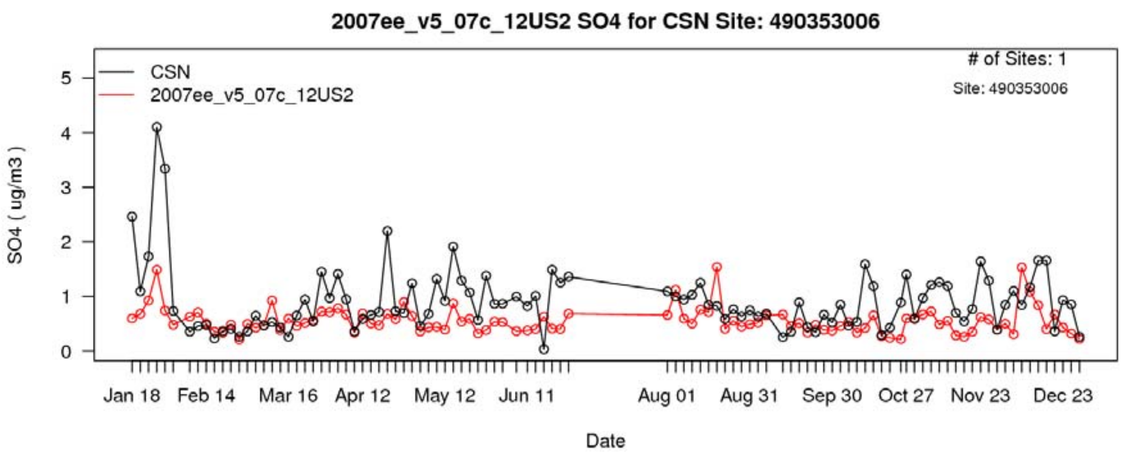

Figure A-11q. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 490353006 in Salt Lake County, UT.

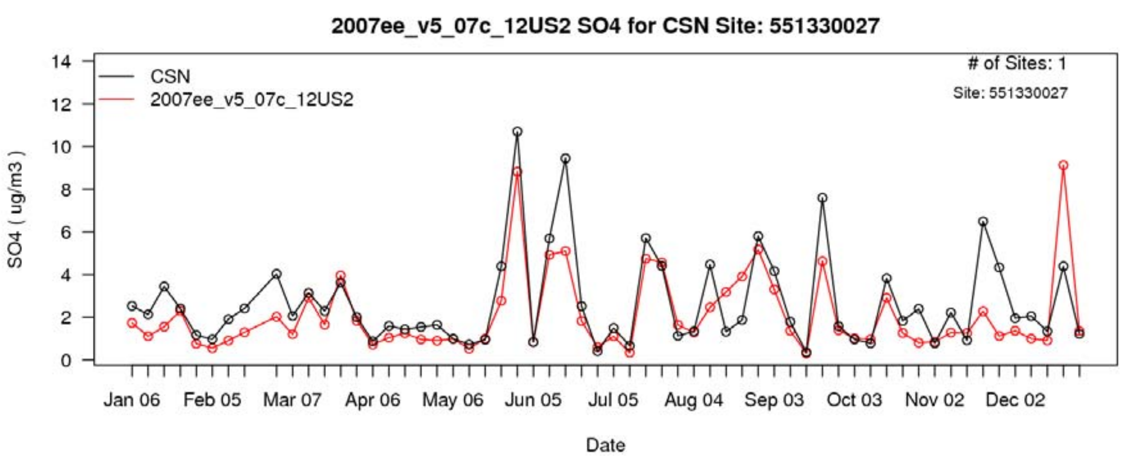

Figure A-11r. Time series of observed (black) and predicted (red) 24-hour average sulfate for 2007 at site 551330027 in Waukesha County, WI.

A.2.2 Model Evaluation for Nitrate

The model performance bias and error statistics for nitrate for each subregion and each season are provided in Table A-5. This table includes statistics for particulate nitrate, as measured at CSN and IMPROVE sites, and statistics for total nitrate, as measured at CASTNet sites. The distributions of observed and predicted nitrate by month for each subregion are shown in Figures A-12 through A-17. Spatial plots of the normalized mean bias and error by season for individual monitors are shown in Figures A-18 through A-21. Time series plots of observed and predicted 24-hour average nitrate concentration at selected CSN monitoring sites are provided in Figure A-22a-q. As seen in Table A-5, model predictions for nitrate are generally biased high compared with observations in Northeast, Midwest, Southeast and Central U.S; with exceptions of under-predictions in summer at urban monitors in the Southeast and Northeast and at rural monitors in the Southeast. Over-predictions of nitrate in the east could be due in part to the under-predictions of sulfate[17] discussed above as well as possible over-estimates of NOx emissions. In the West, the model under-predicts nitrate concentrations in many cases. These under-predictions could be related to uncertainty in NOx and ammonia emissions as well as due to challenges in simulating the meteorological stagnation episodes that can lead to high nitrate concentrations in wintertime. For instance, the under-predictions of nitrate concentration in January in Tulare, CA (Figure A22j) and Salt Lake City, UT (Figure A22p) are likely due to the inability of the meteorological model to fully capture a wintertime meteorological stagnation event.

Table A-5. Nitrate performance statistics by subregion, by season for the 2007 CMAQ model simulation.

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
Central U.S.	CSN	Winter	432	-0.1	42.9	10.6	49.4
		Spring	502	13.9	57.0	-11.4	70.3
		Summer	469	25.9	92.9	-28.6	85.9
		Fall	503	101.0	124.0	26.8	85.7
	IMPROVE	Winter	536	2.4	49.4	4.5	64.0
		Spring	642	19.7	62.9	-27.9	85.8
		Summer	674	28.8	103.0	-55.2	104
		Fall	637	144.0	161.0	19.9	98.9
	CASTNet	Winter	81	14.3	35.5	19.3	33.3
		Spring	90	7.1	32.1	-1.1	33.8
		Summer	97	13.4	27.5	7.0	24.8
		Fall	102	50.2	52.9	33.5	37.8

[17] Increases in sulfate concentration enhance particle acidity under ammonia-limited conditions which can result in greater partitioning of the total nitrate to the gas phase and therefore a reduction in $PM_{2.5}$ nitrate.

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
Midwest	CSN	Winter	567	5.3	42.2	12.5	40.0
		Spring	640	11.1	60.7	-0.1	65.2
		Summer	604	23.9	89.3	-49.1	100.0
		Fall	610	43.2	73.7	12.7	68.1
	IMPROVE	Winter	145	17.0	57.4	11.3	72.2
		Spring	147	30.6	86.0	-37.4	99.5
		Summer	152	9.6	76.6	-27.8	82.4
		Fall	144	69.9	106.0	-8.9	94.8
	CASTNet	Winter	152	8.8	21.9	10.9	21.3
		Spring	157	16.4	24.8	13.8	22.6
		Summer	162	54.0	55.9	41.2	43.3
		Fall	159	70.7	70.8	51.9	52.1
Southeast	CSN	Winter	711	35.5	85.1	-12.4	84.4
		Spring	782	35.2	102.0	-31.1	97.0
		Summer	731	-44.5	74.8	-93.5	112.0
		Fall	728	72.8	126.0	-25.5	97.1
	IMPROVE	Winter	434	31.5	69.3	3.4	69.7
		Spring	482	26.6	113.0	-52.4	114.0
		Summer	454	-24.7	115.0	-104.0	138.0
		Fall	460	103.0	164.0	-35.7	115.0
	CASTNet	Winter	262	29.2	36.0	26.1	34.6
		Spring	288	17.1	38.5	10.7	37.9
		Summer	266	21.9	37.8	17.3	35.9
		Fall	289	66.6	73.1	43.2	53.2
Northeast	CSN	Winter	862	15.8	47.0	22.3	52.5
		Spring	925	33.6	72.1	13.6	68.2
		Summer	891	-16.2	74.9	-56.5	93.7
		Fall	913	19.6	66.5	-7.1	73.1
	IMPROVE	Winter	551	82.6	103.0	56.6	81.5
		Spring	597	64.1	106.0	4.8	84.5
		Summer	589	6.7	106.0	-68.7	113.0
		Fall	569	68.7	110.0	-10.8	95.0
	CASTNet	Winter	179	32.5	37.4	37.4	40.3
		Spring	194	31.3	36.6	24.6	33.8

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
		Summer	191	57.3	64.6	31.9	49.2
		Fall	191	87.5	90.9	51.0	60.0
West without California	CSN	Winter	517	-38.0	66.8	-28.7	72.9
		Spring	594	-3.0	68.2	-39.9	80.4
		Summer	563	-52.8	79.7	-121.0	133.0
		Fall	570	9.0	81.7	-27.0	86.5
	IMPROVE	Winter	1,706	5.7	82.9	-31.7	96.6
		Spring	2,018	-14.7	84.7	-73.3	111.0
		Summer	2,016	-64.9	86.9	139.0	149.0
		Fall	1,999	57.1	129.0	-34.1	114.0
	CASTNet	Winter	196	17.9	45.0	31.9	48.7
		Spring	214	21.8	38.8	25.0	38.4
		Summer	213	10.9	45.7	10.9	41.3
		Fall	212	23.6	53.6	30.7	48.3
California	CSN	Winter	313	-34.4	52.2	-32.7	64.4
		Spring	356	-19.9	45.6	-31.3	59.3
		Summer	335	24.6	73.5	-37.5	78.7
		Fall	335	-21.3	52.3	-36.2	72.5
	IMPROVE	Winter	500	-22.4	67.5	-29.8	101.0
		Spring	564	-23.0	74.3	-78.3	108.0
		Summer	557	-57.6	82.5	-127.0	138.0
		Fall	514	-33.7	81.1	-60.6	116.0
	CASTNet	Winter	75	5.4	49.8	12.7	51.9
		Spring	78	-5.6	28.0	3.6	35.0
		Summer	76	-15.0	23.3	-21.1	31.2
		Fall	75	-6.2	38.6	-6.3	42.9

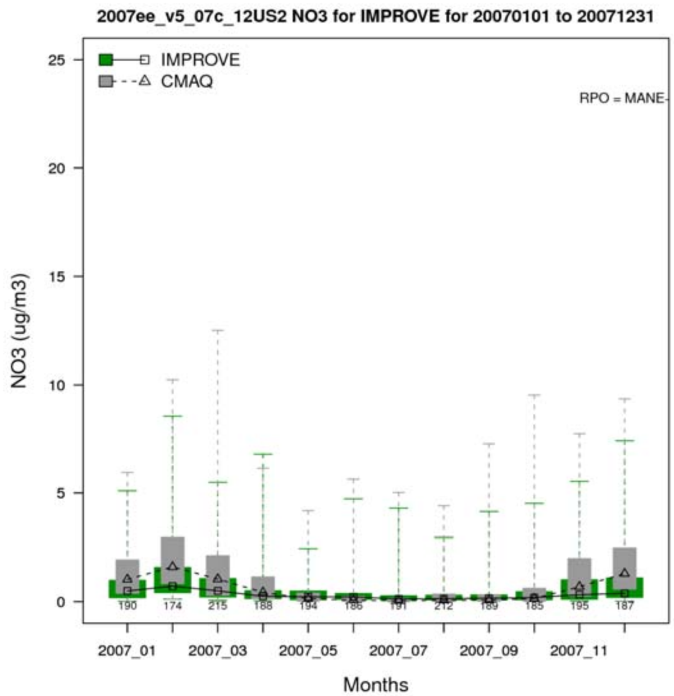

Figure A-12a. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at IMPROVE sites in the Northeast subregion. [symbol = median; top/bottom of box = 75th/25th percentiles; top/bottom line = max/min values]

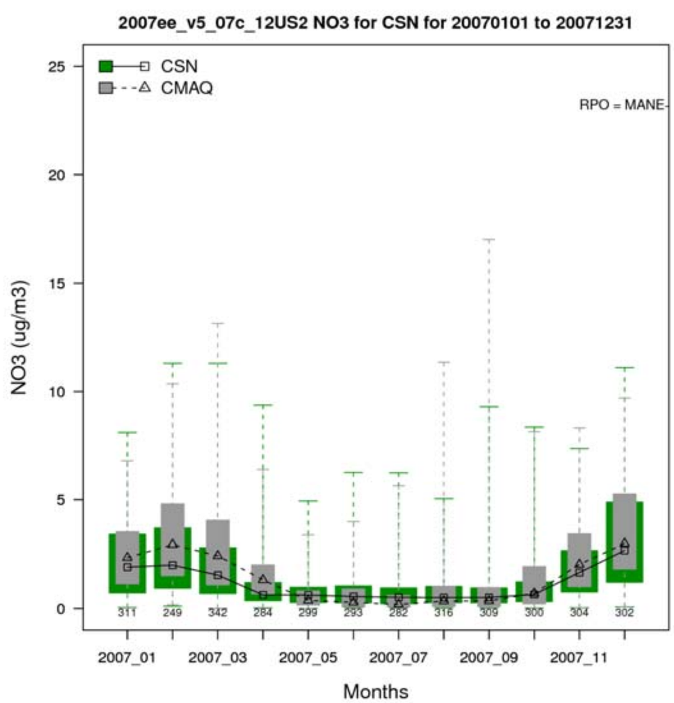

Figure A-12b. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at CSN sites in the Northeast subregion.

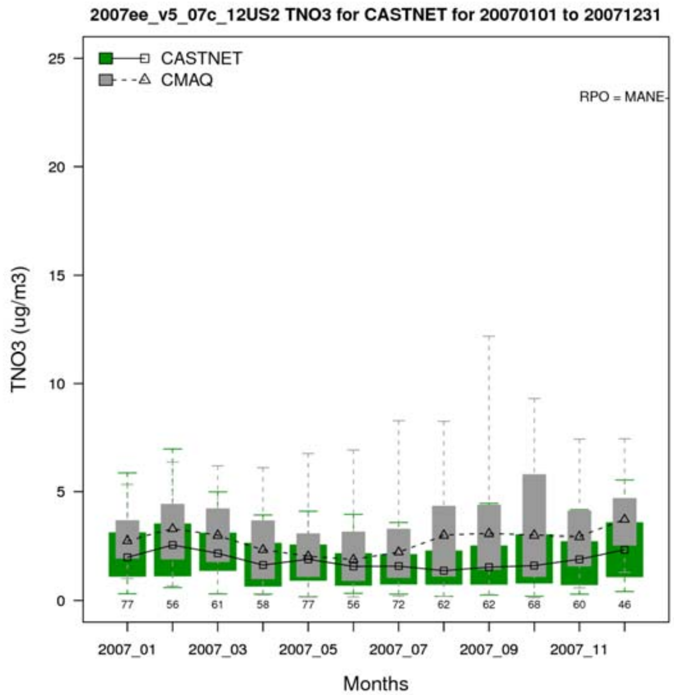

Figure A-12c. Distribution of observed and predicted weekly average total nitrate by month for 2007 at CASTNet sites in the Northeast subregion.

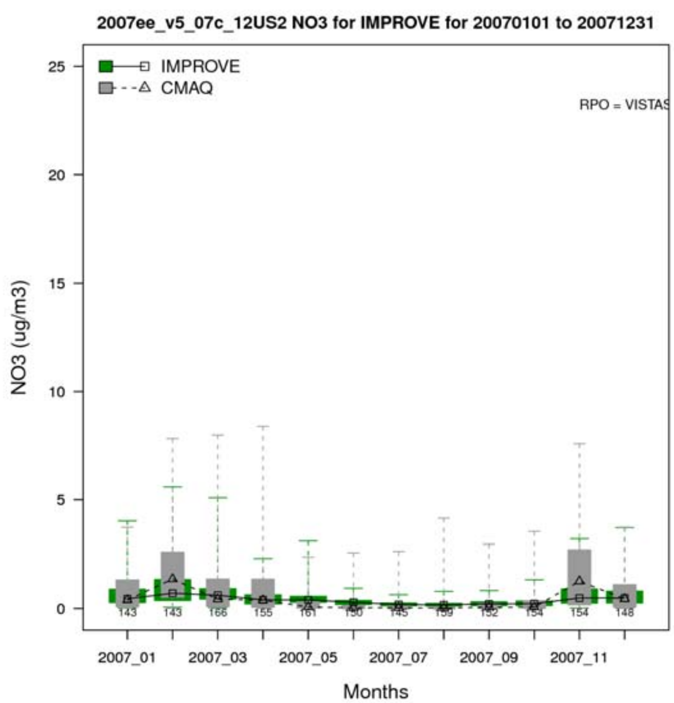

Figure A-13a. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at IMPROVE sites in the Southeast subregion.

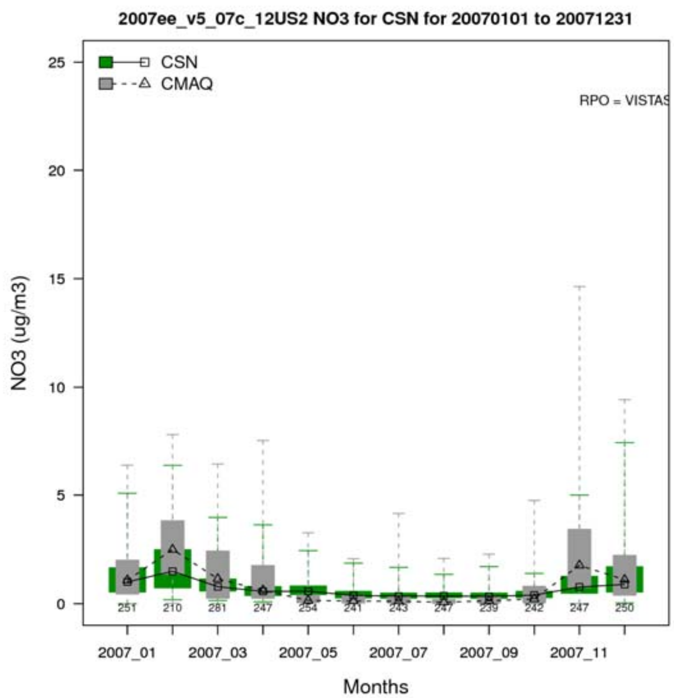

Figure A-13b. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at CSN sites in the Southeast subregion.

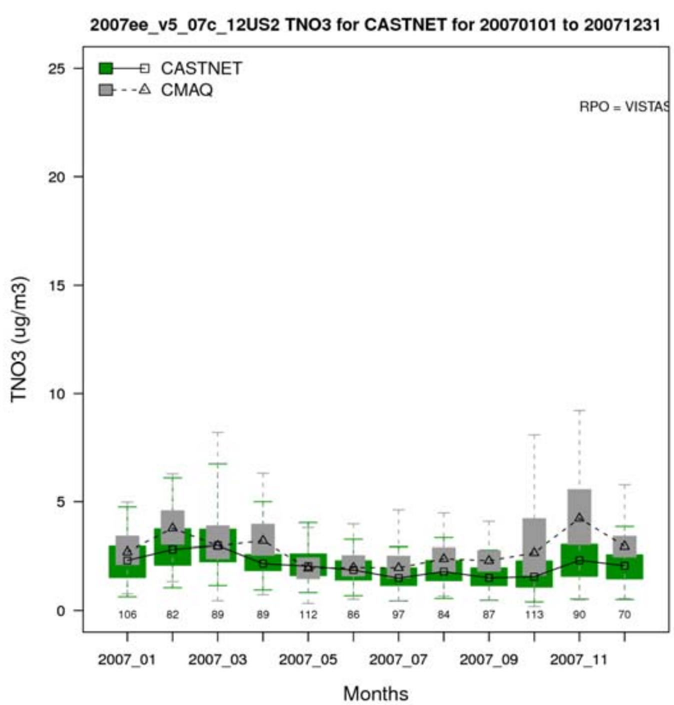

Figure A-13c. Distribution of observed and predicted weekly average total nitrate by month for 2007 at CASTNet sites in the Southeast subregion.

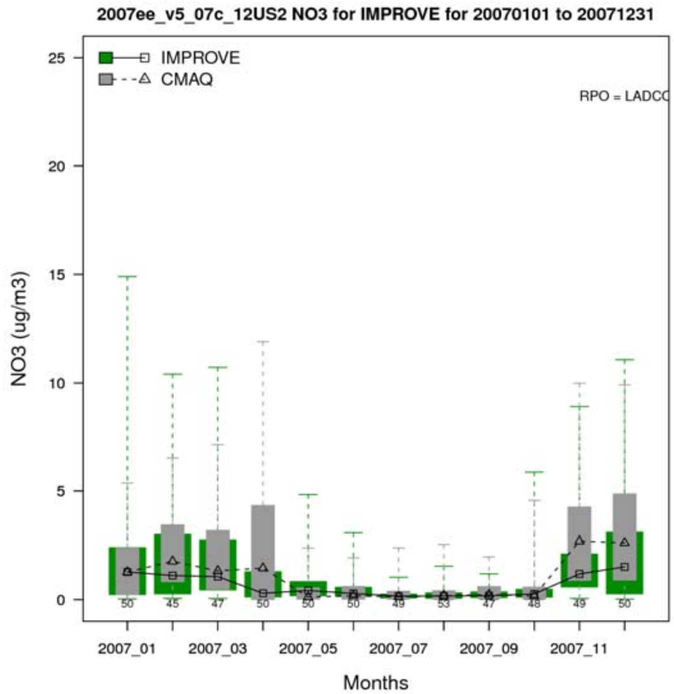

Figure A-14a. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at IMPROVE sites in the Midwest subregion.

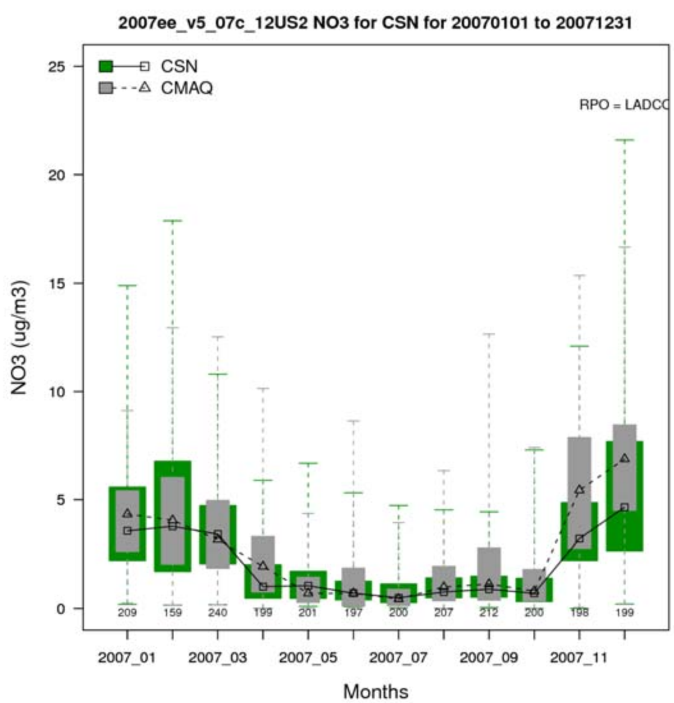

Figure A-14b. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at CSN sites in the Midwest subregion.

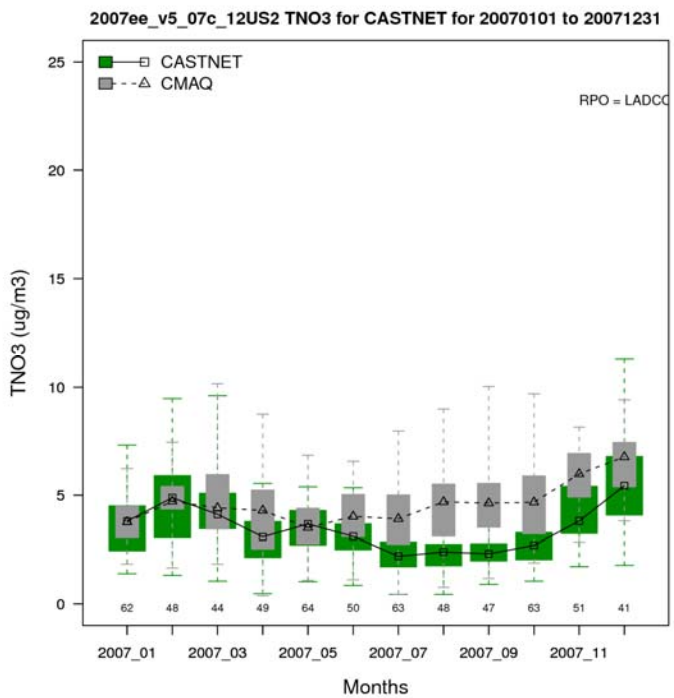

Figure A-14c. Distribution of observed and predicted weekly average total nitrate by month for 2007 at CASTNet sites in the Midwest subregion.

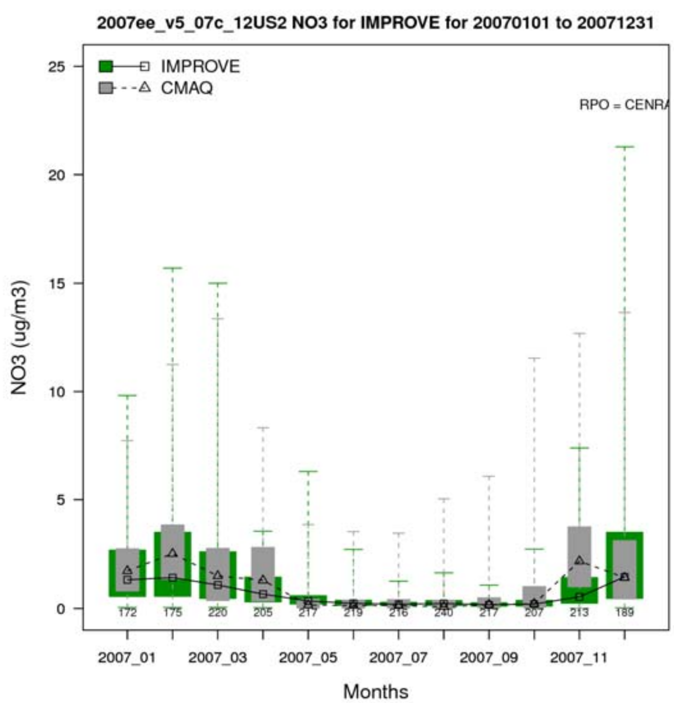

Figure A-15a. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at IMPROVE sites in the Central states subregion.

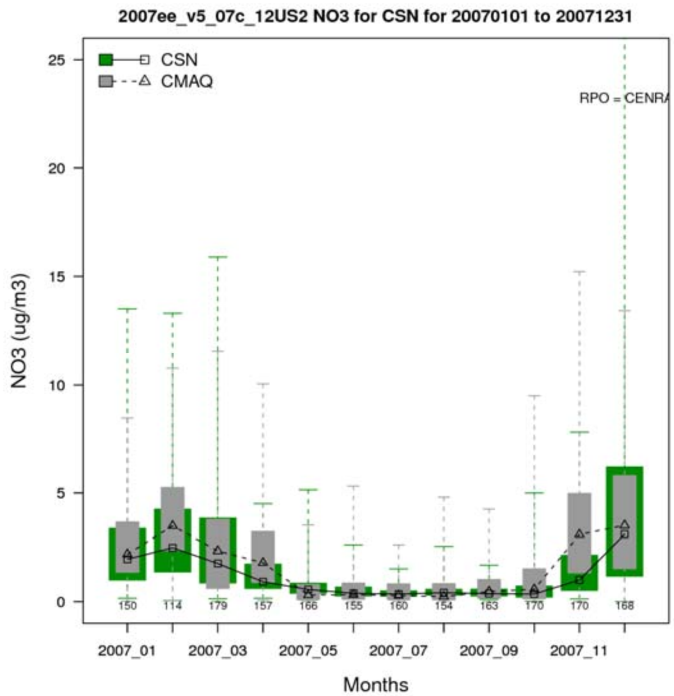

Figure A-15b. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at CSN sites in the Central states subregion.

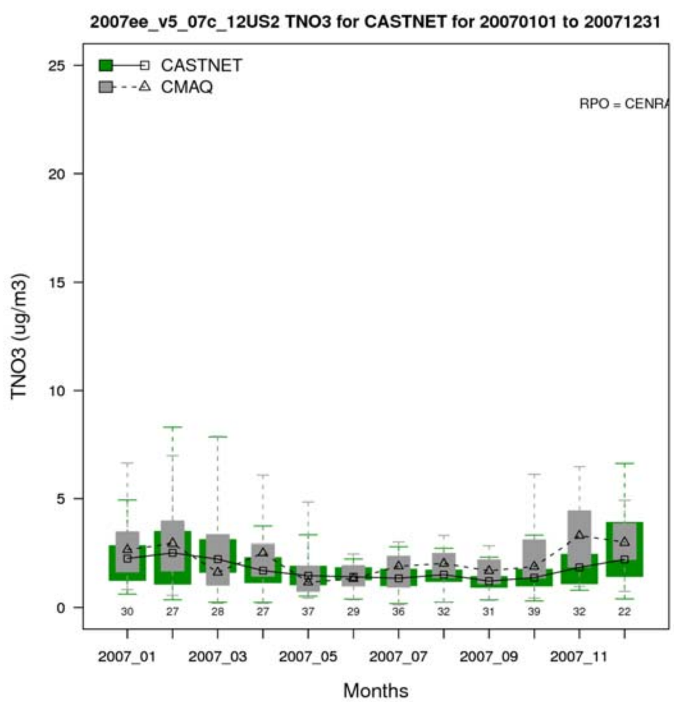

Figure A-15c. Distribution of observed and predicted weekly average total nitrate by month for 2007 at CASTNet sites in the Central states subregion.

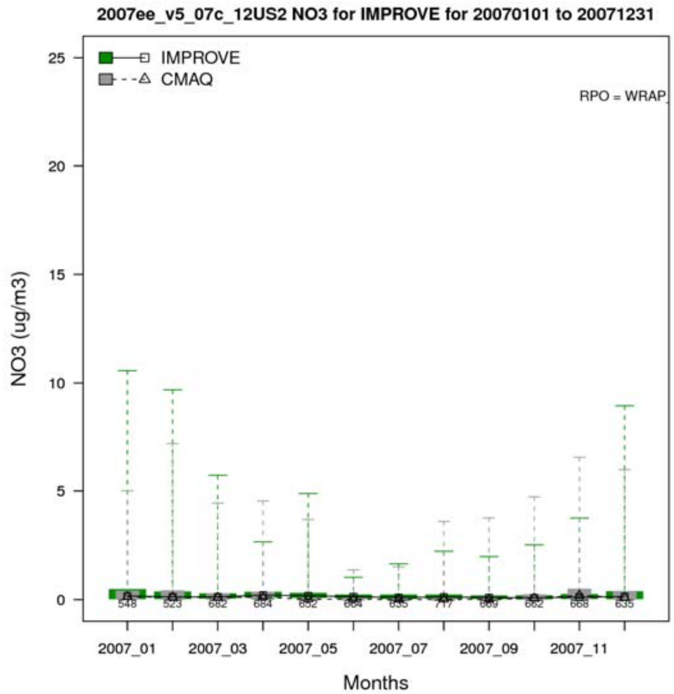

Figure A-16a. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at IMPROVE sites in the Western states excluding California subregion.

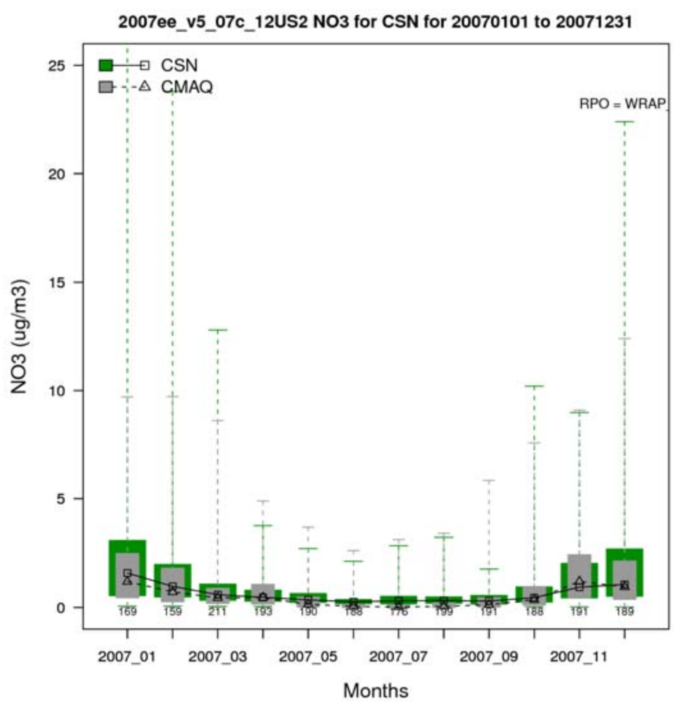

Figure A-16b. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at CSN sites in the Western states excluding California subregion.

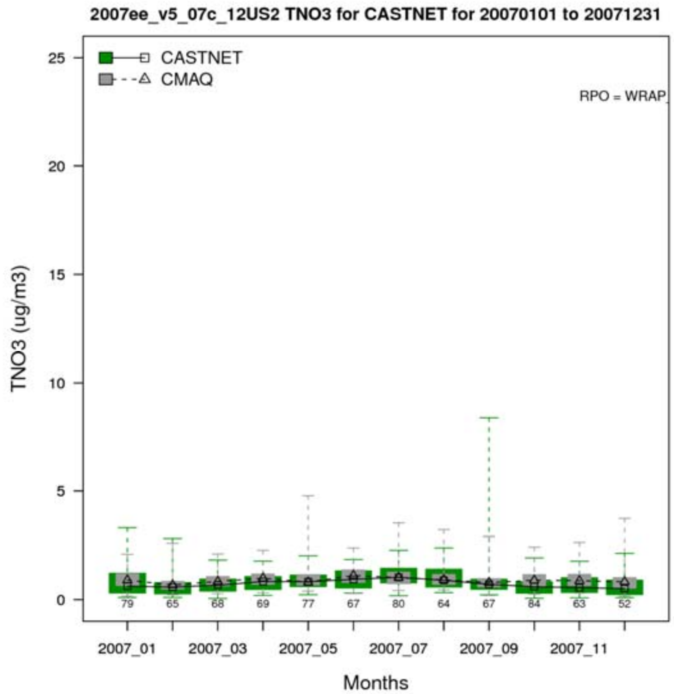

Figure A-16c. Distribution of observed and predicted weekly average total nitrate by month for 2007 at CASTNet sites in the Western excluding California subregion.

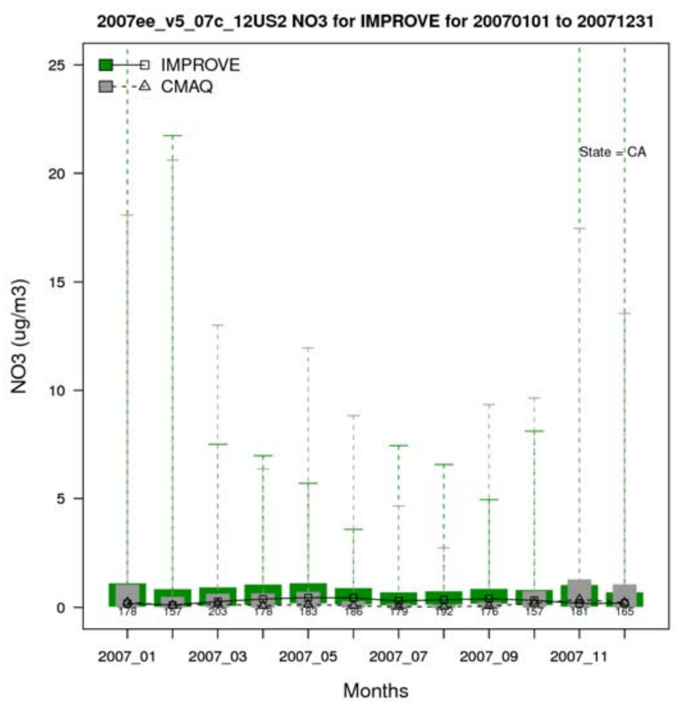

Figure A-17a. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at IMPROVE sites in the California subregion.

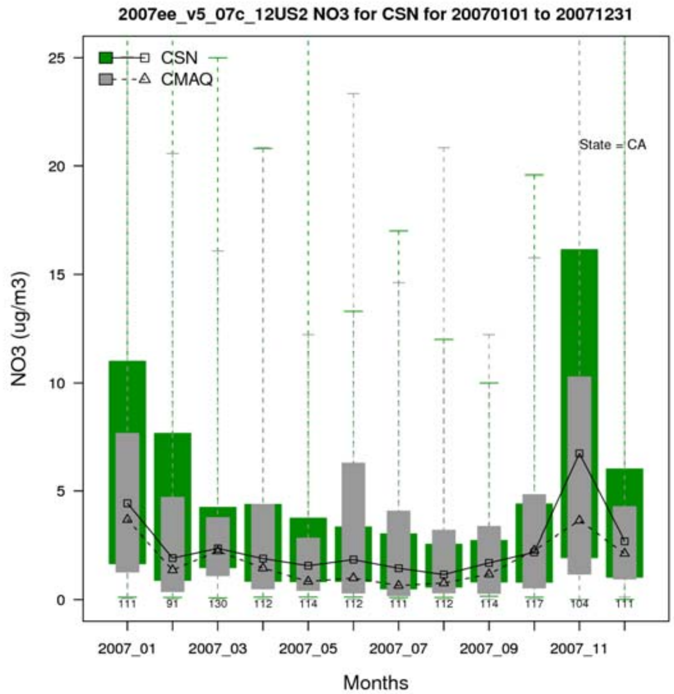

Figure A-17b. Distribution of observed and predicted 24-hour average nitrate by month for 2007 at CSN sites in the California subregion.

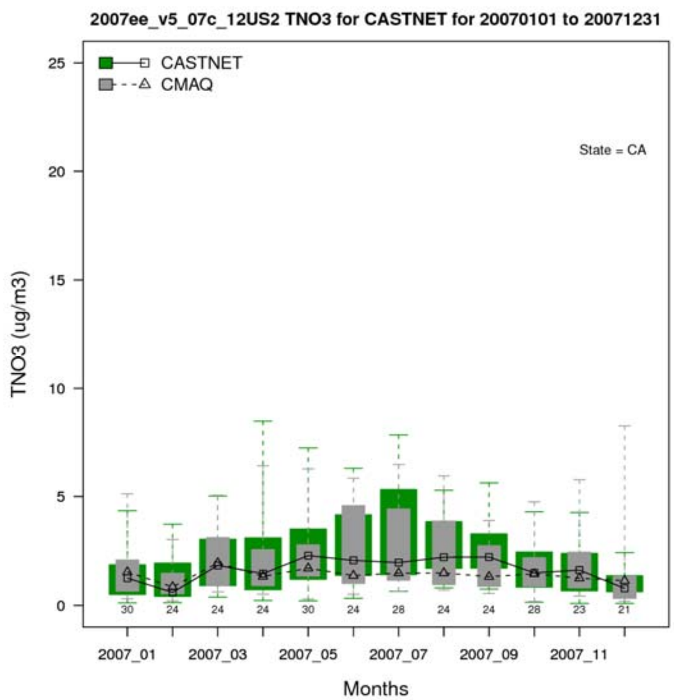

Figure A-17c. Distribution of observed and predicted weekly average total nitrate by month for 2007 at CASTNet sites in the California subregion.

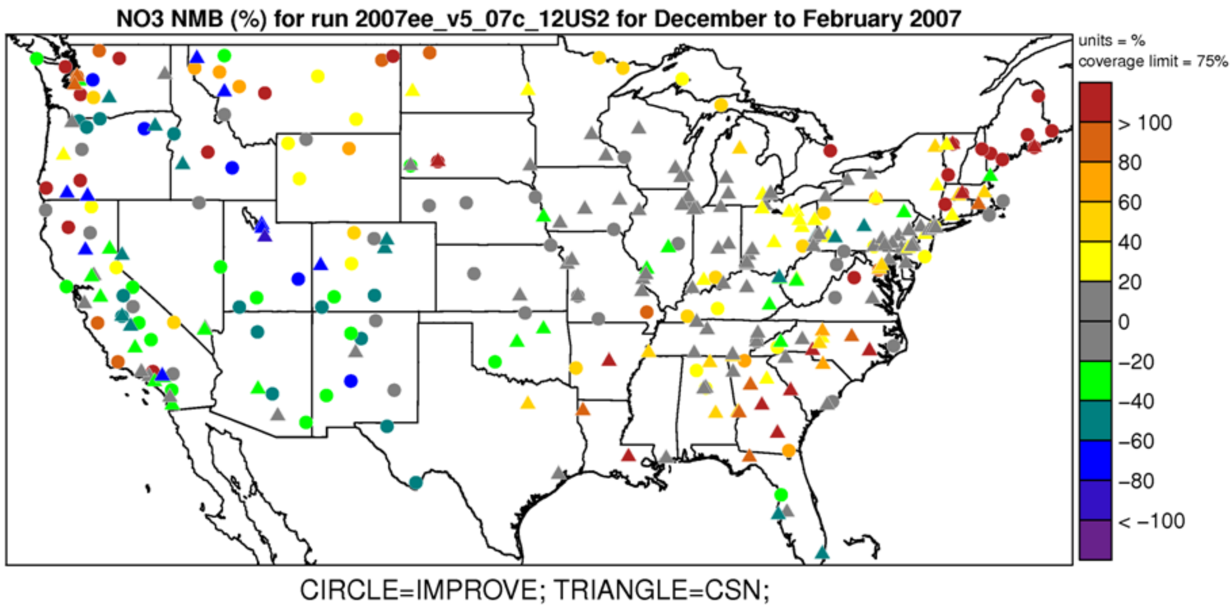

Figure A-18a. Normalized Mean Bias (%) for nitrate during winter 2007 at monitoring sites in the Continental U.S. modeling domain.

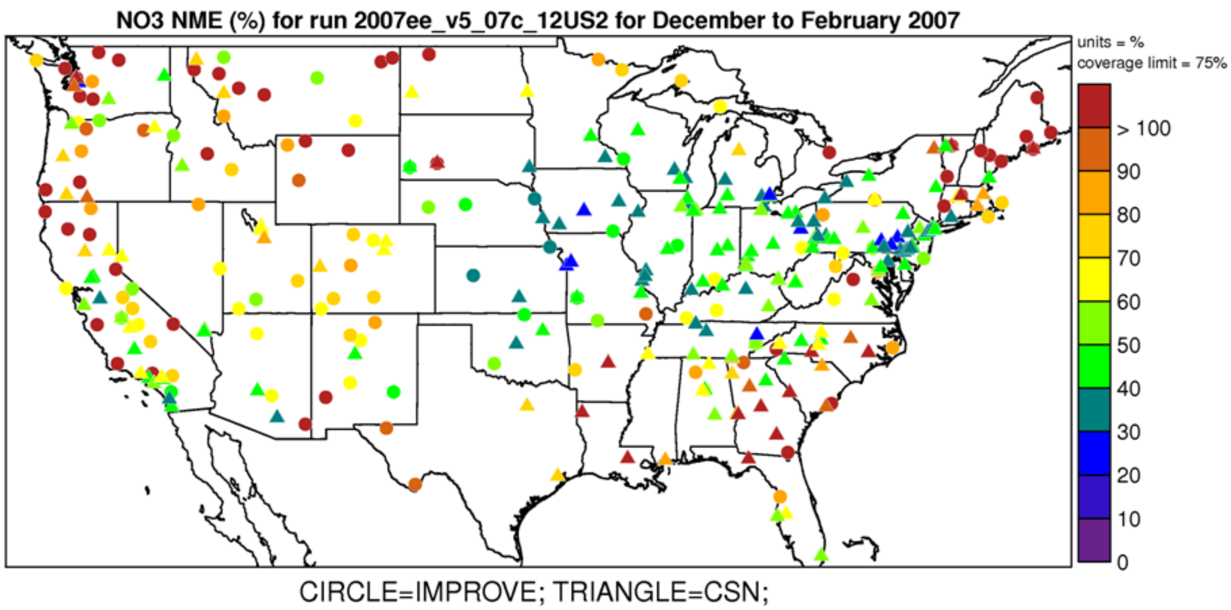

Figure A-18b. Normalized Mean Error (%) for nitrate during winter 2007 at monitoring sites in the Continental U.S. modeling domain.

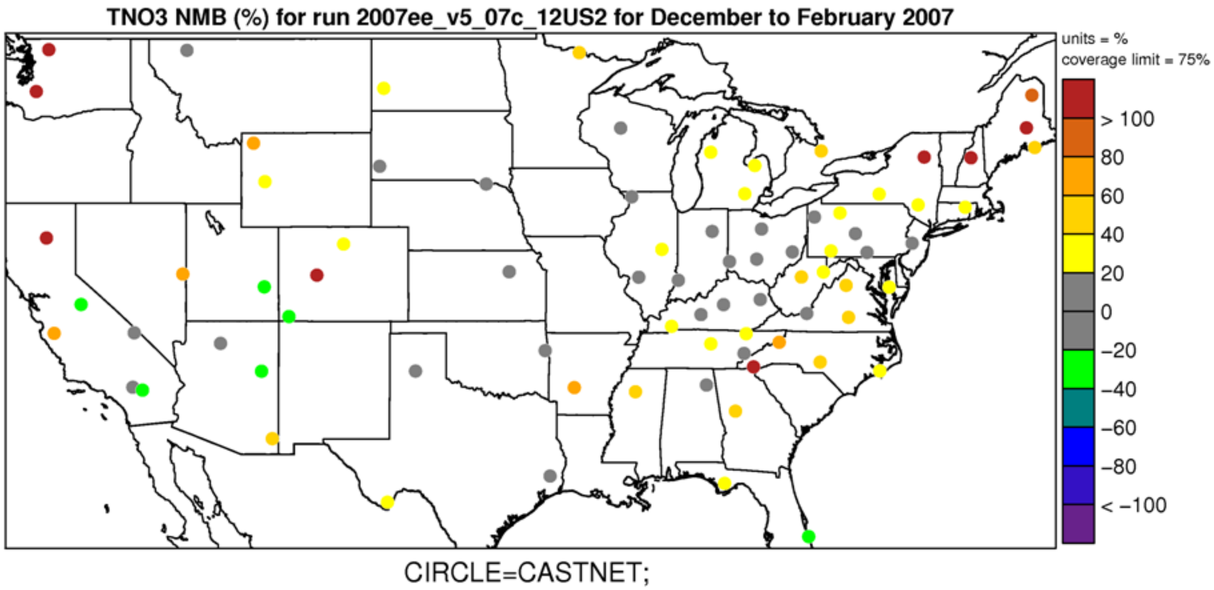

Figure A-18c. Normalized Mean Bias (%) for total nitrate during winter 2007 at monitoring sites in the Continental U.S. modeling domain.

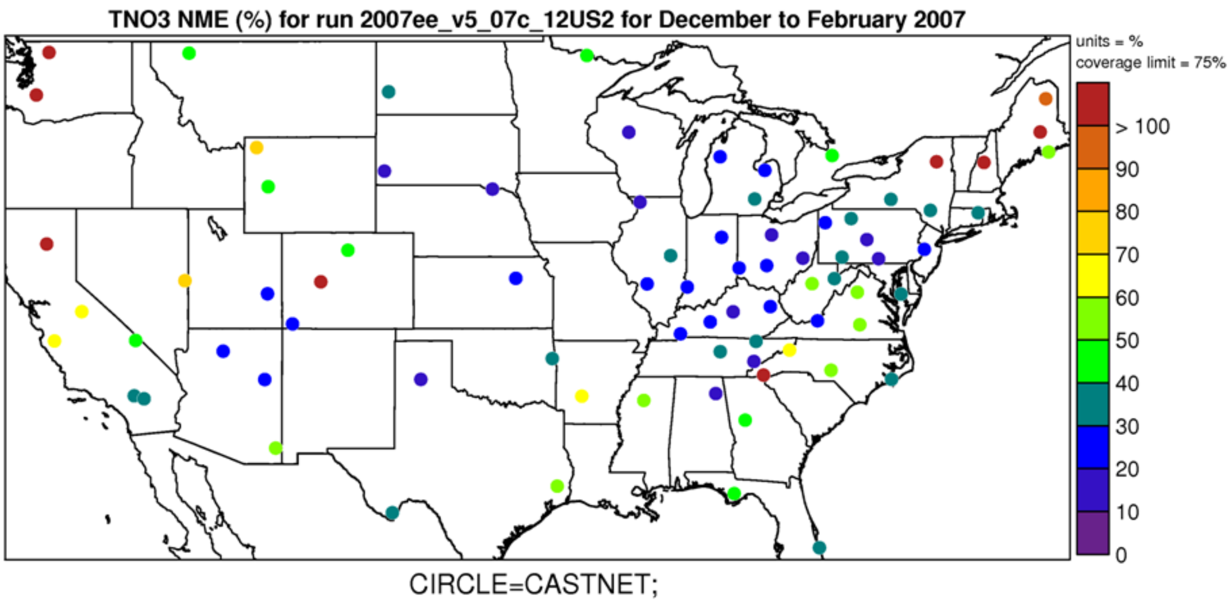

Figure A-18d. Normalized Mean Error (%) for total nitrate during winter 2007 at monitoring sites in the Continental U.S. modeling domain.

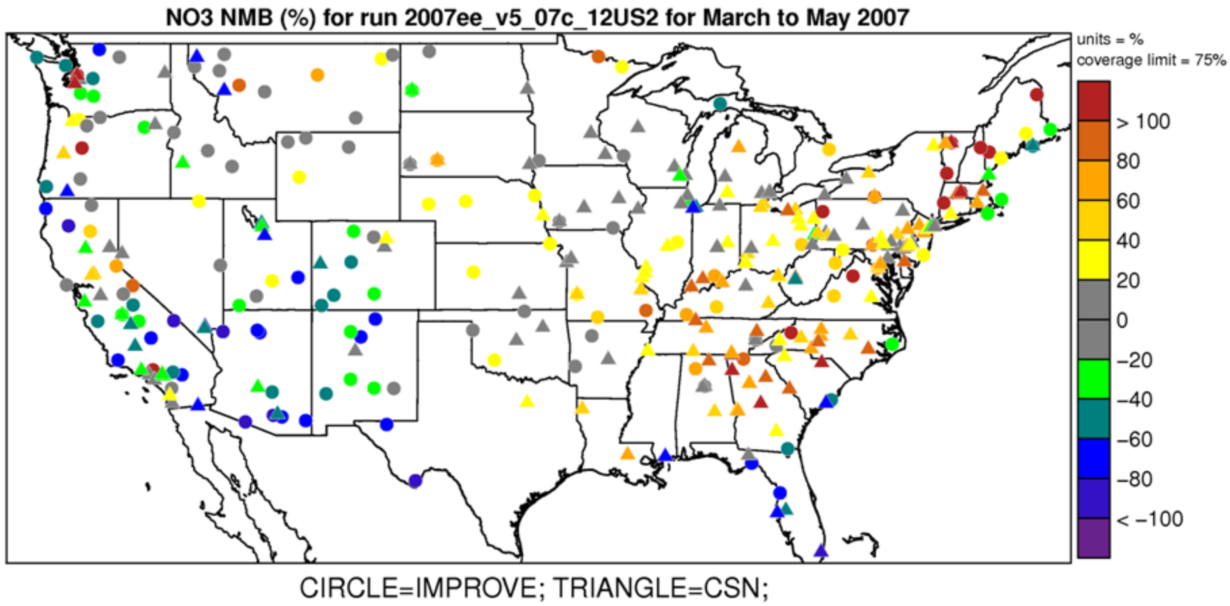

Figure A-19a. Normalized Mean Bias (%) for nitrate during spring 2007 at monitoring sites in the Continental U.S. modeling domain.

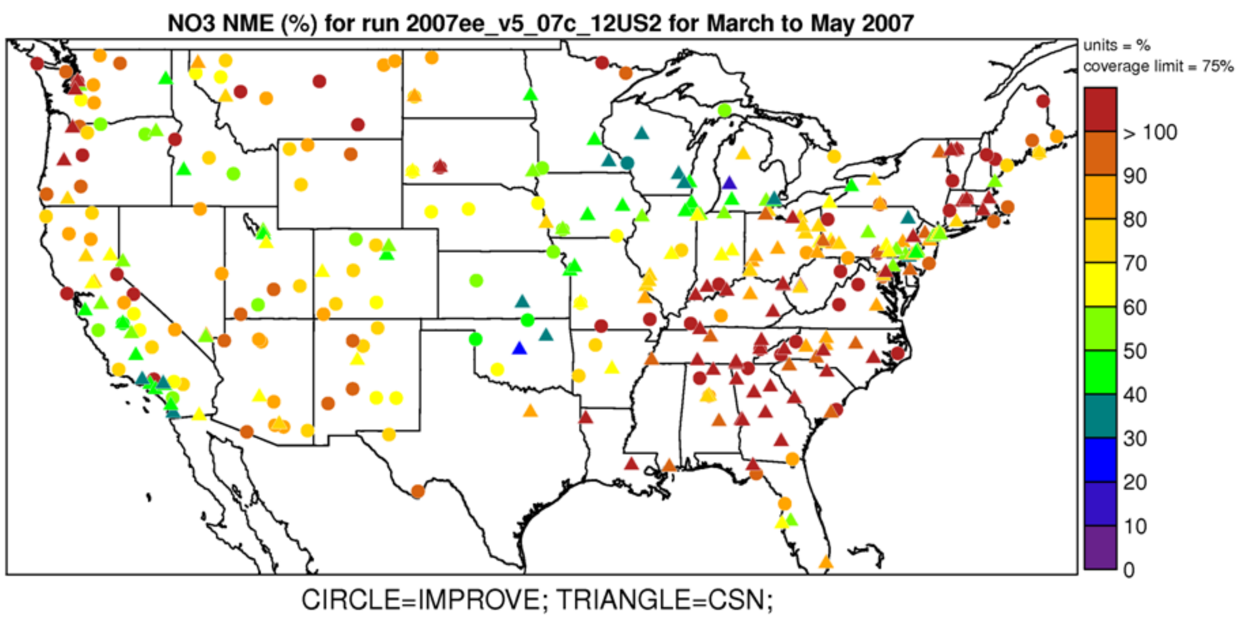

Figure A-19b. Normalized Mean Error (%) for nitrate during spring 2007 at monitoring sites in the Continental U.S. modeling domain.

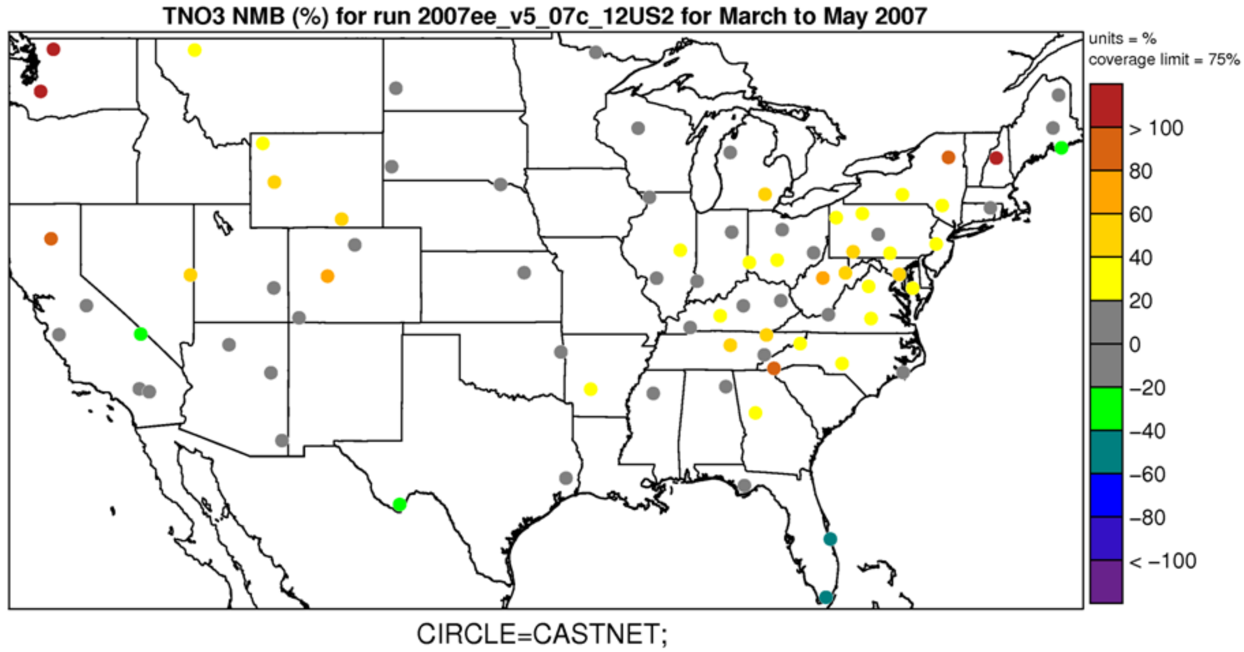

Figure A-19c. Normalized Mean Bias (%) for total nitrate during spring 2007 at monitoring sites in the Continental U.S. modeling domain.

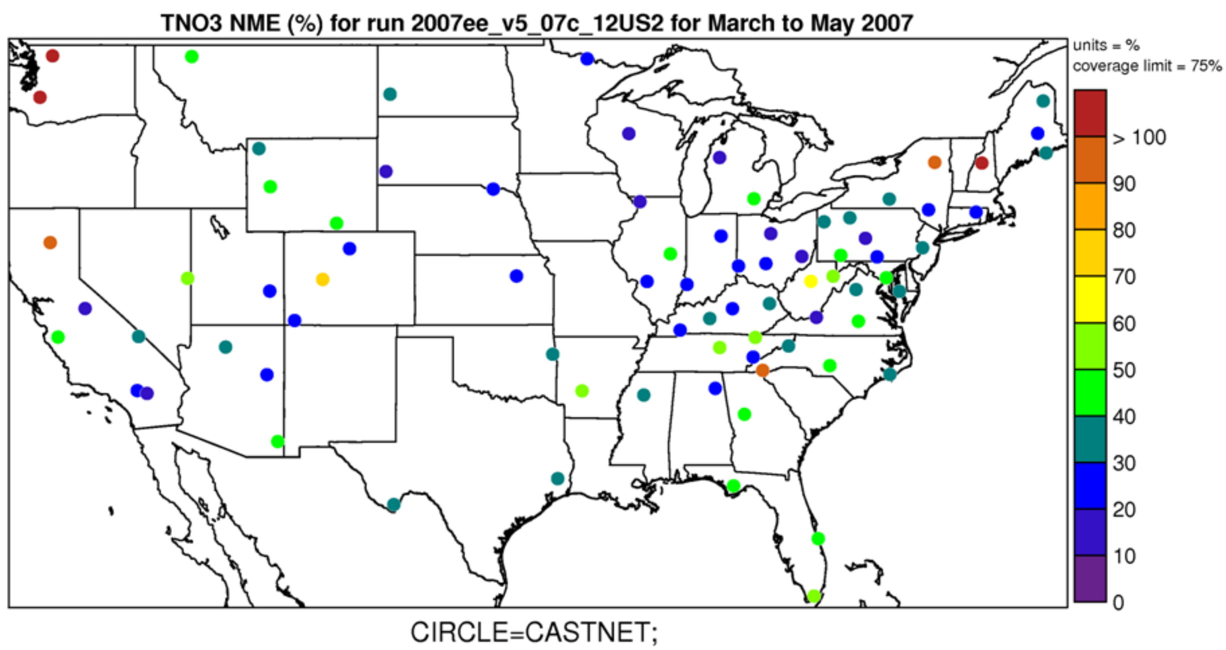

Figure A-19d. Normalized Mean Error (%) for total nitrate spring 2007 at monitoring sites in the Continental U.S. modeling domain.

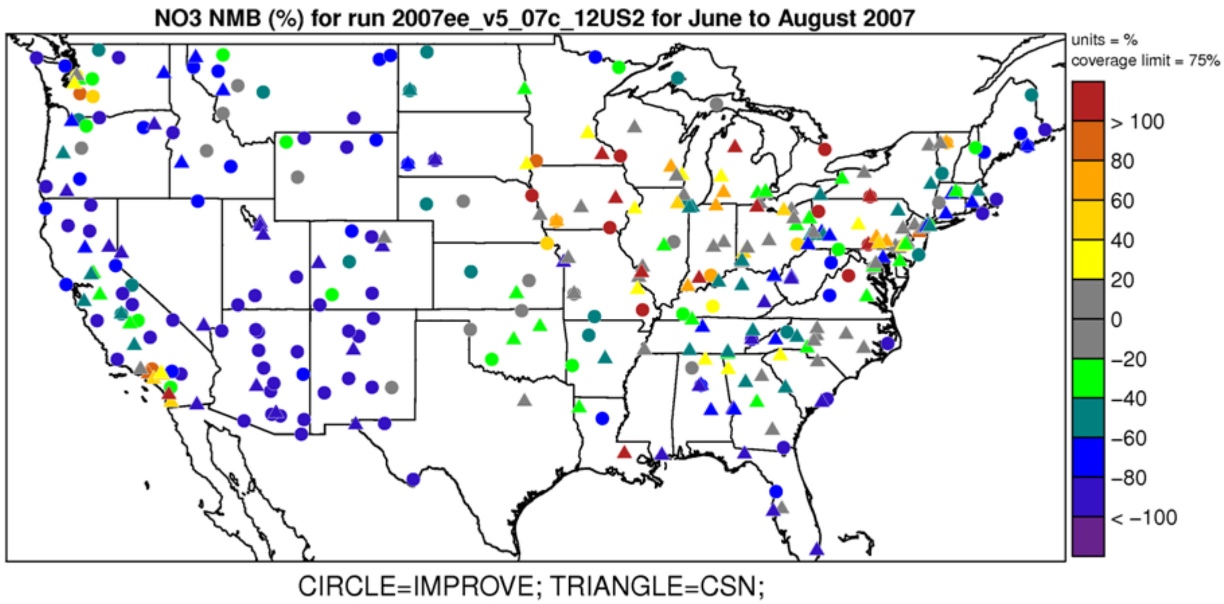

Figure A-20a. Normalized Mean Bias (%) for nitrate during summer 2007 at monitoring sites in the Continental U.S. modeling domain.

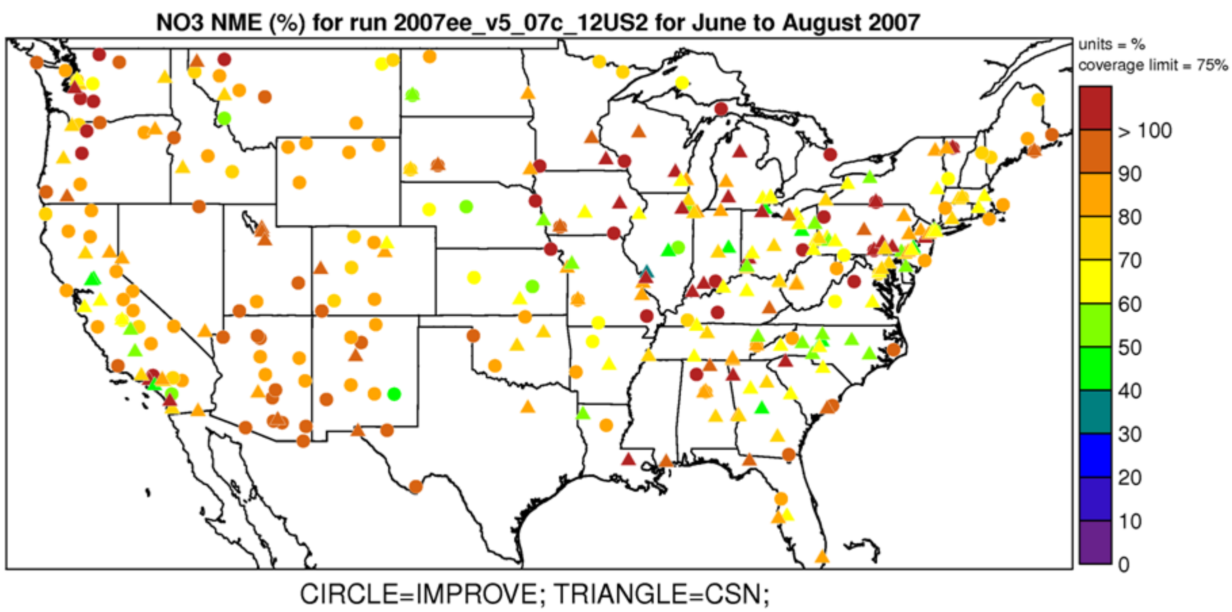

Figure A-20b. Normalized Mean Error (%) for nitrate during summer 2007 at monitoring sites in the Continental U.S. modeling domain.

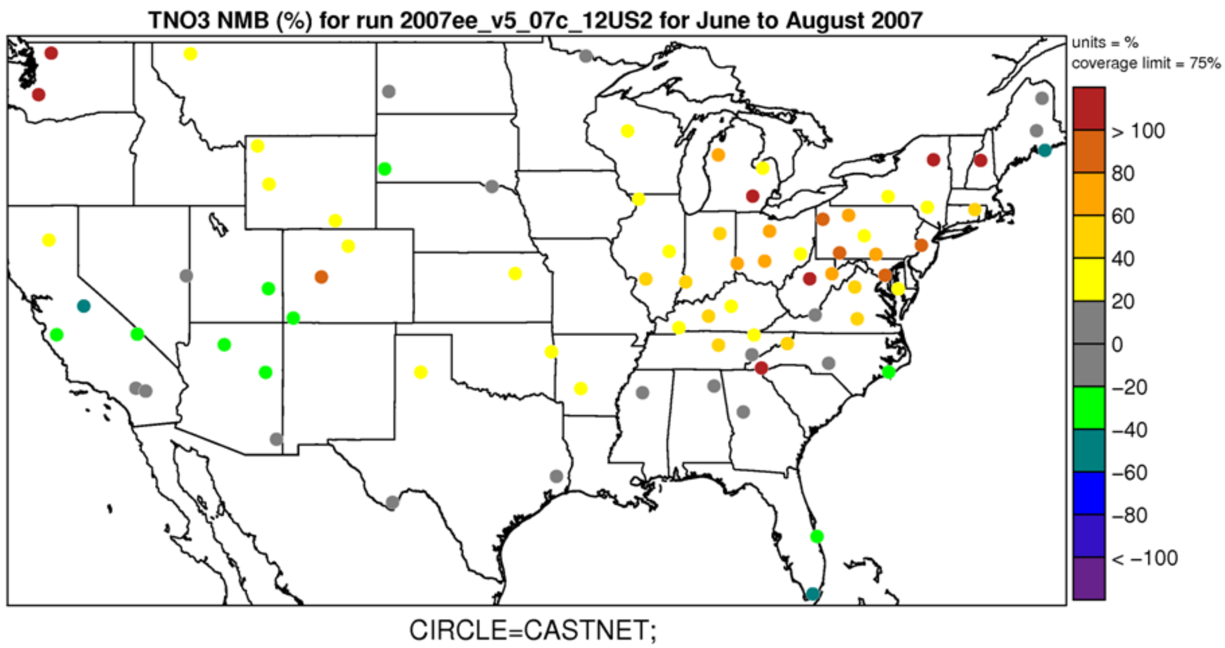

Figure A-20c. Normalized Mean Bias (%) for total nitrate during summer 2007 at monitoring sites in the Continental U.S. modeling domain.

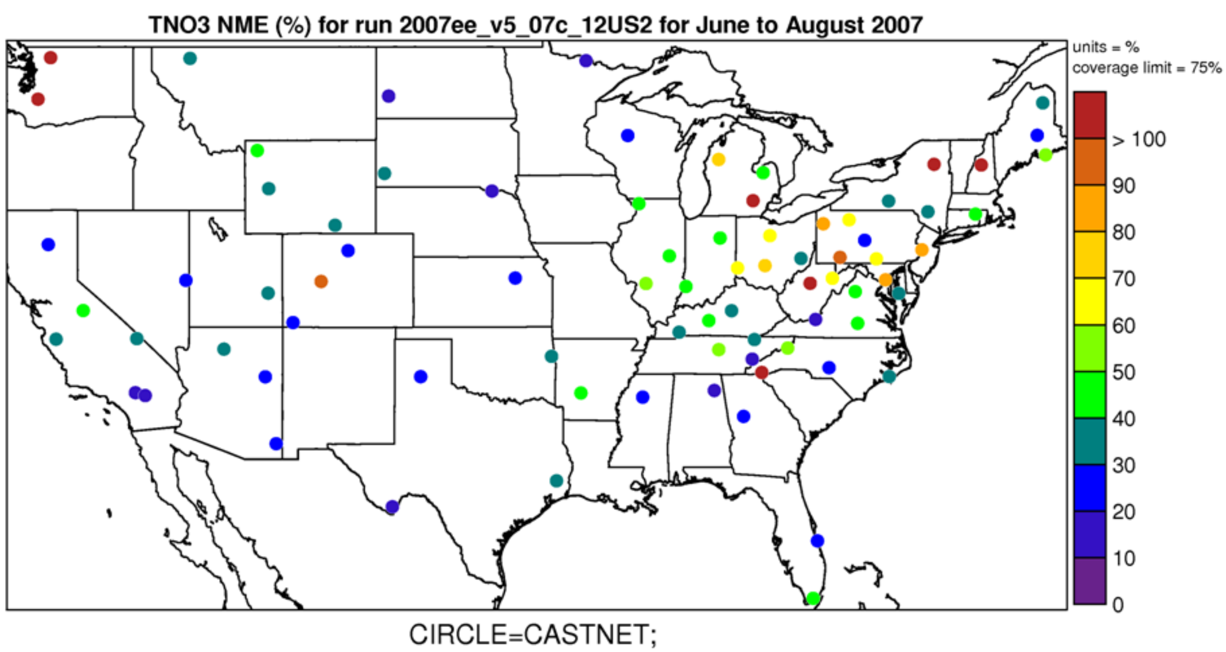

Figure A-20d. Normalized Mean Error (%) for total nitrate summer 2007 at monitoring sites in the Continental U.S. modeling domain.

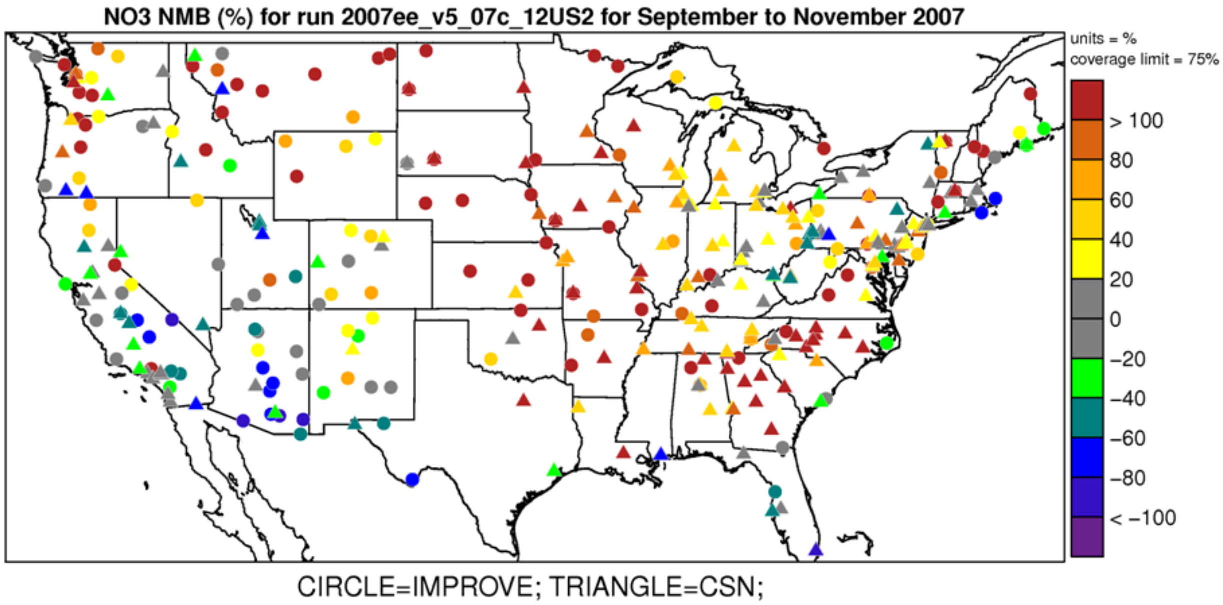

Figure A-21a. Normalized Mean Bias (%) for nitrate during fall 2007 at monitoring sites in the Continental U.S. modeling domain.

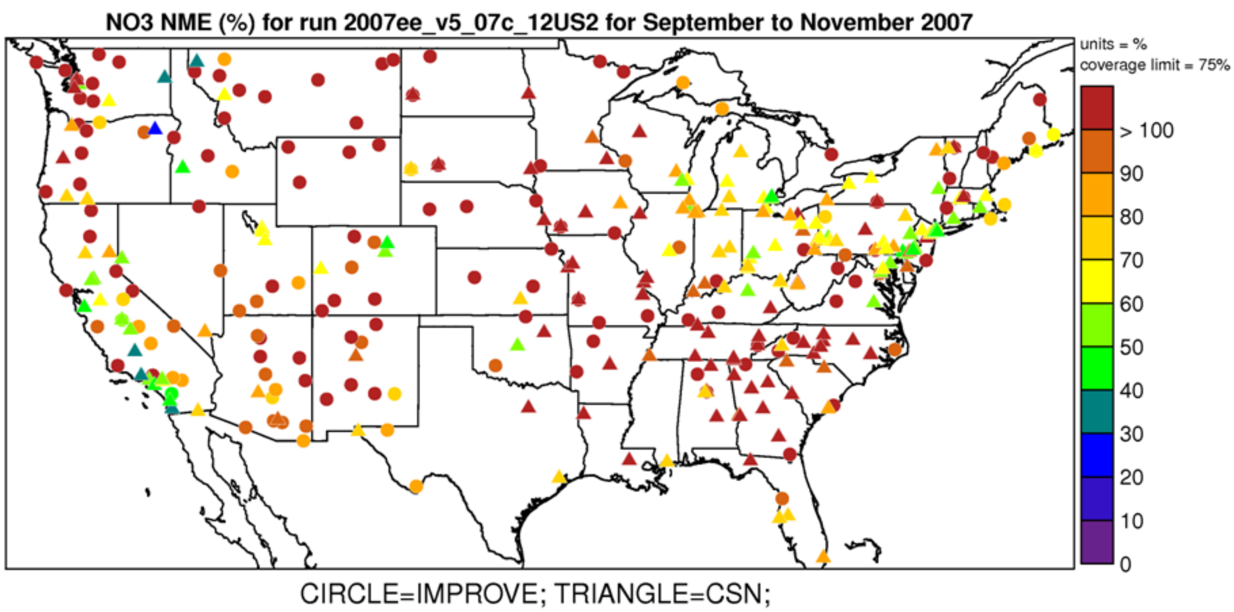

Figure A-21b. Normalized Mean Error (%) for nitrate during fall 2007 at monitoring sites in the Continental U.S. modeling domain.

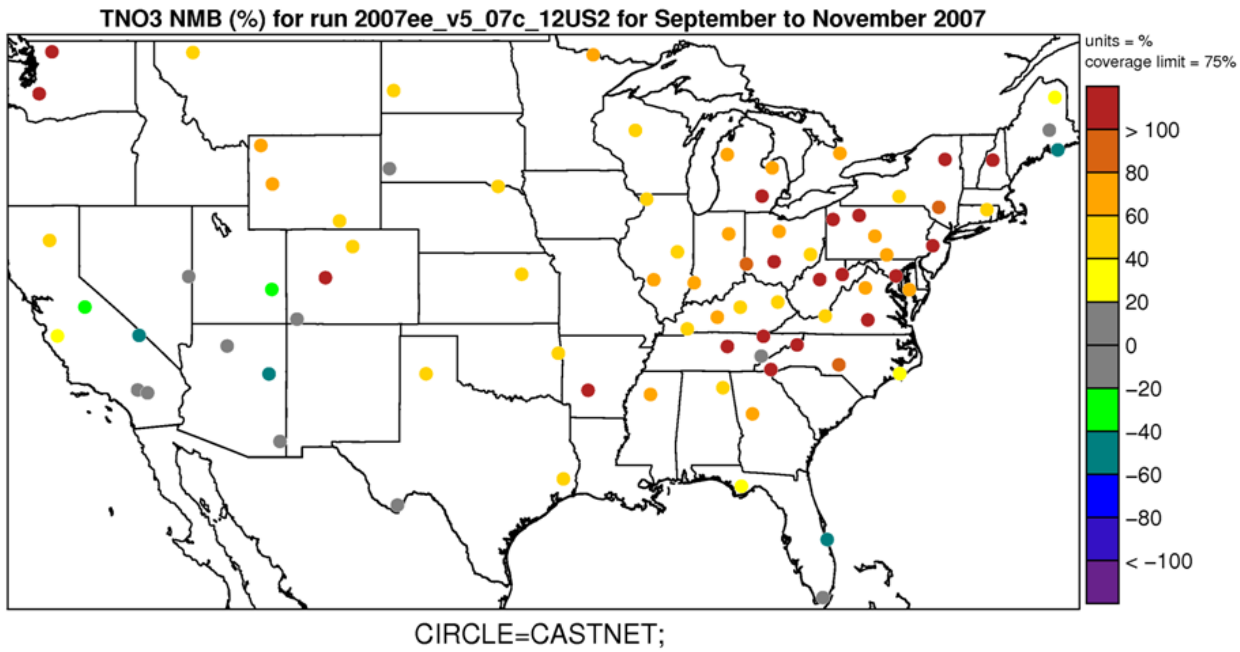

Figure A-21c. Normalized Mean Bias (%) for total nitrate during fall 2007 at monitoring sites in the Continental U.S. modeling domain.

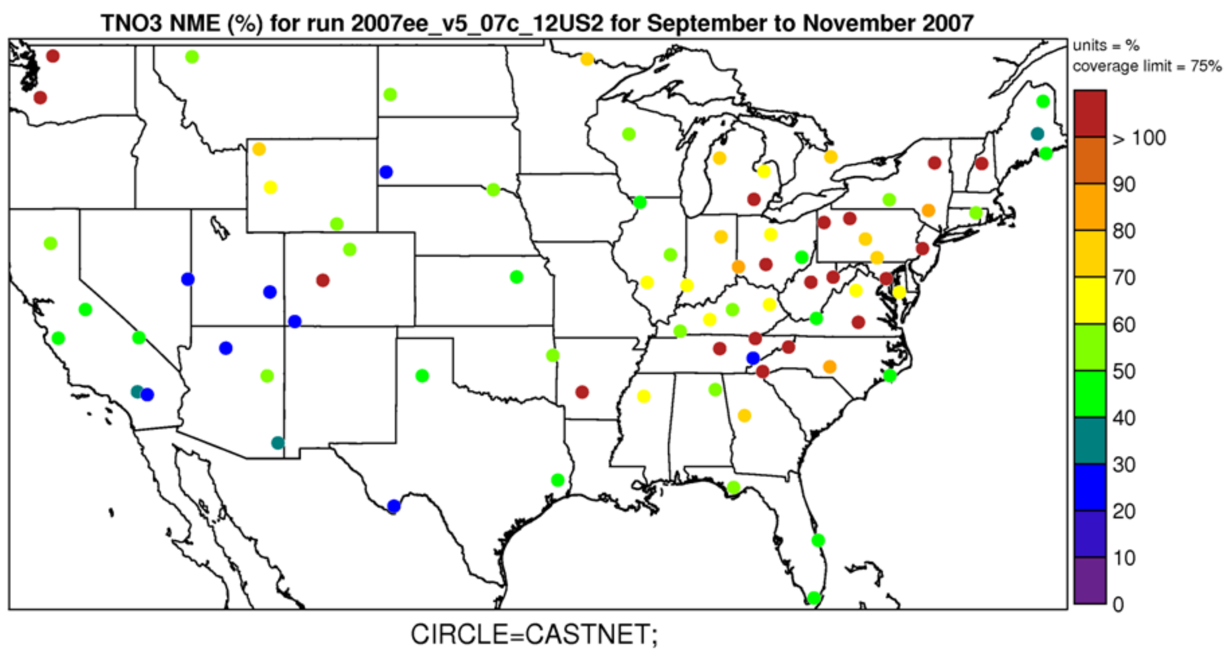

Figure A-21d. Normalized Mean Error (%) for total nitrate fall 2007 at monitoring sites in the Continental U.S. modeling domain.

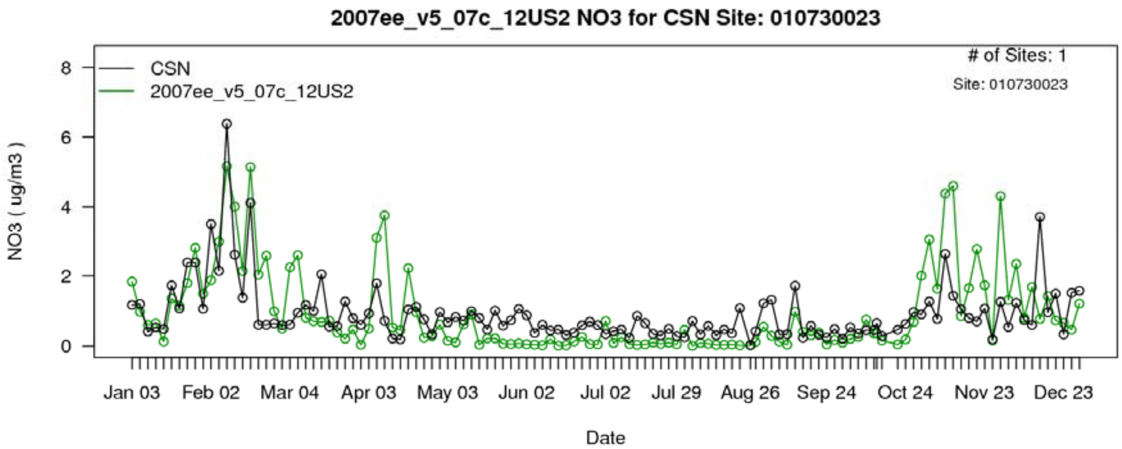

Figure A-22a. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 010730023 in Jefferson County, AL.

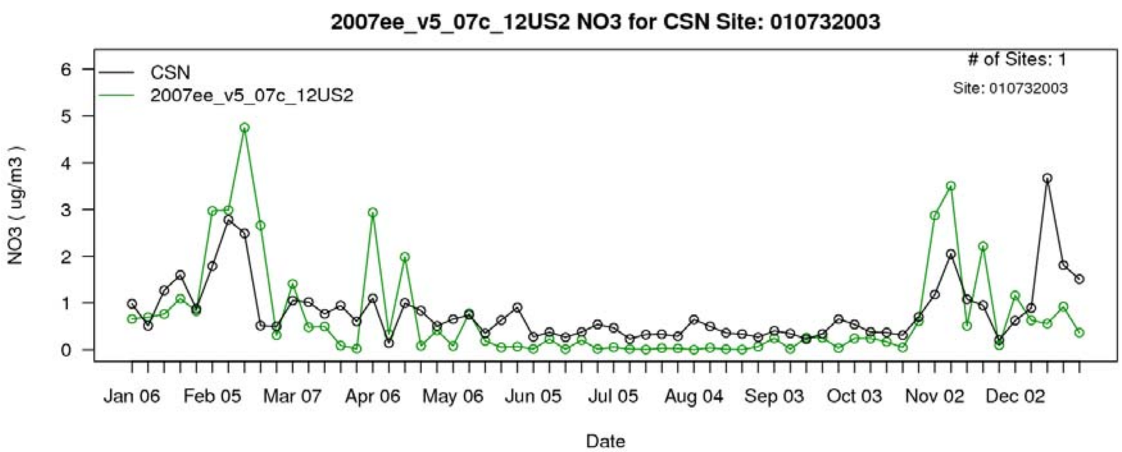

Figure A-22b. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 010732003 in Jefferson County, AL.

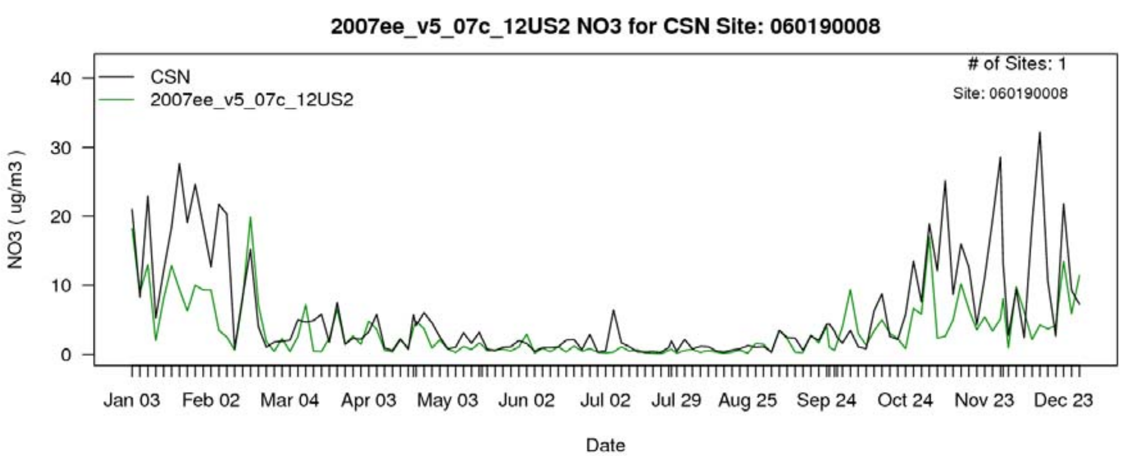

Figure A-22c. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 060190008 in Fresno County, CA.

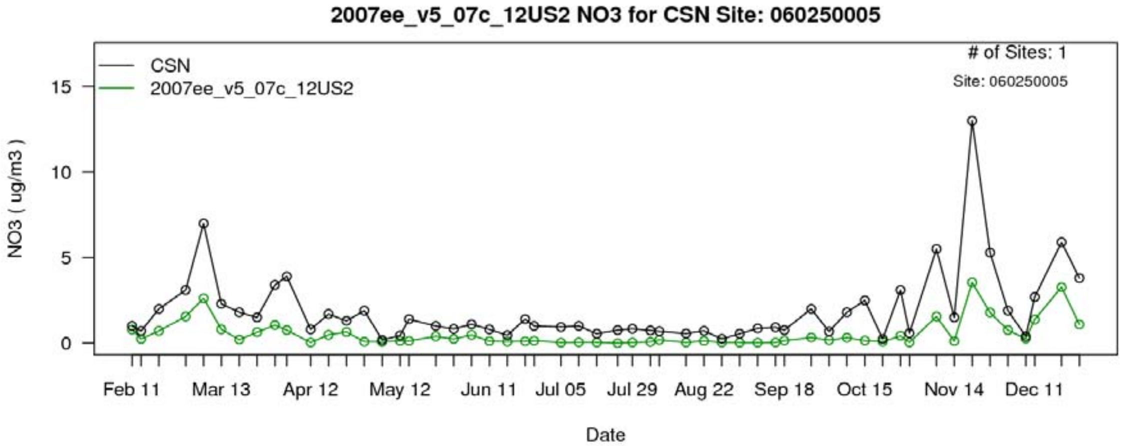

Figure A-22d. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 060250005 in Imperial County, CA.

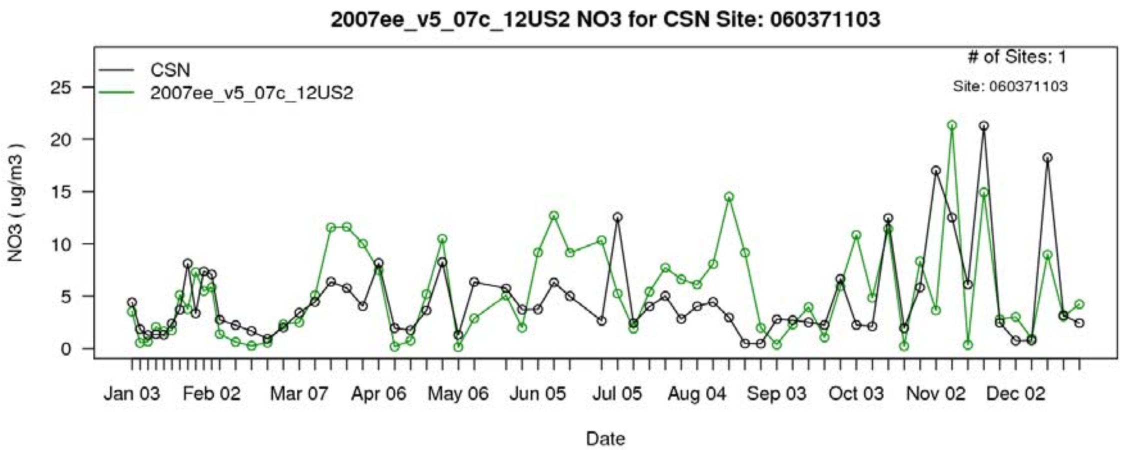

Figure A-22e. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 060371103 in Los Angeles County, CA.

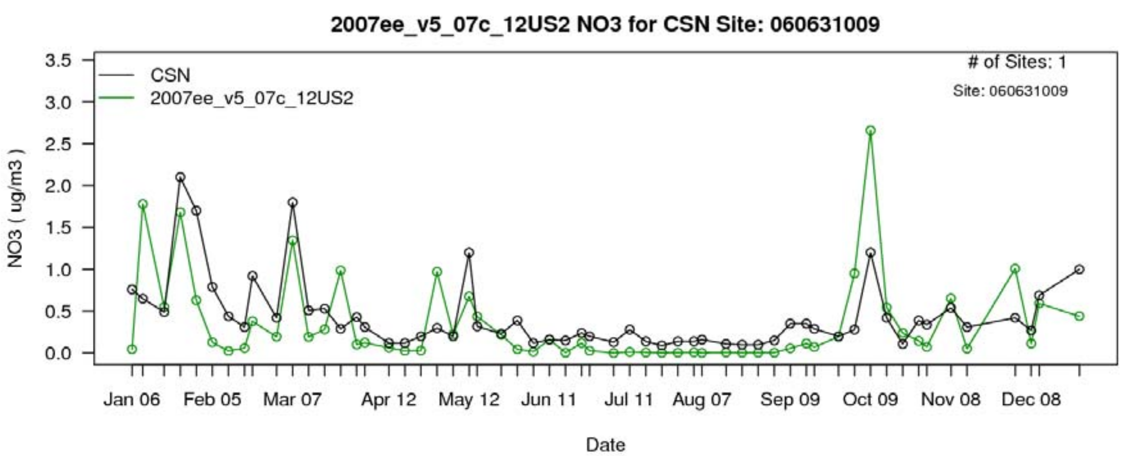

Figure A-22f. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 060631009 in Plumas County, CA.

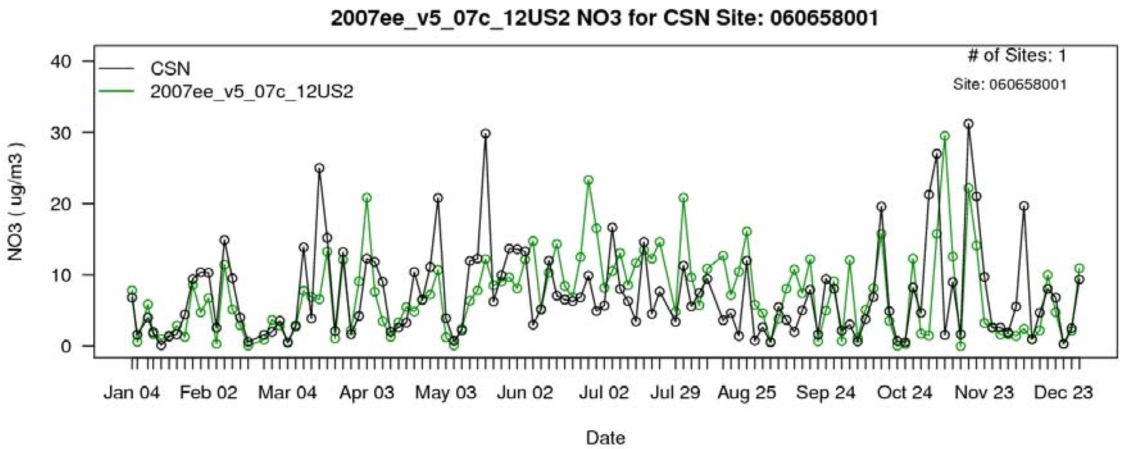

Figure A-22g. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 060658001 in Riverside County, CA.

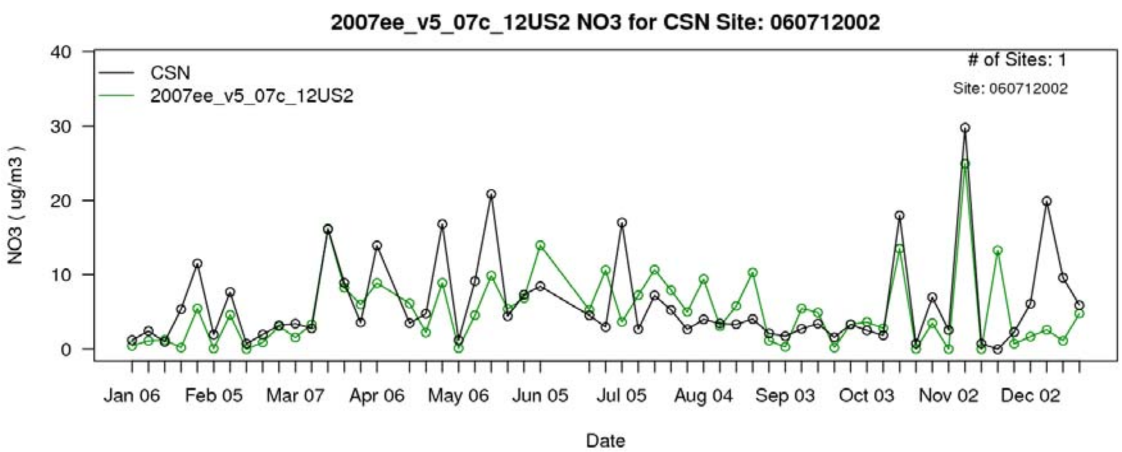

Figure A-22h. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 060712002 in San Bernardino County, CA.

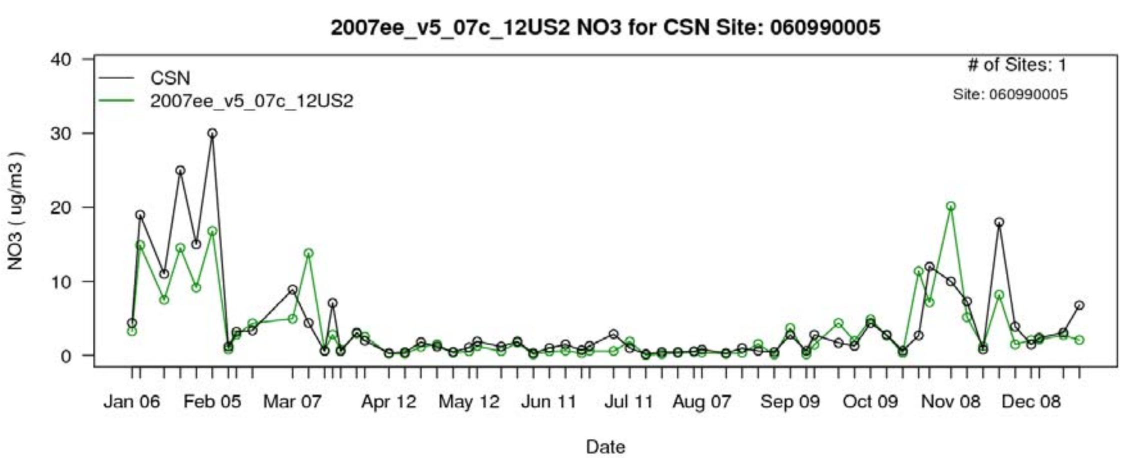

Figure A-22i. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 060990005 in Stanislaus County, CA.

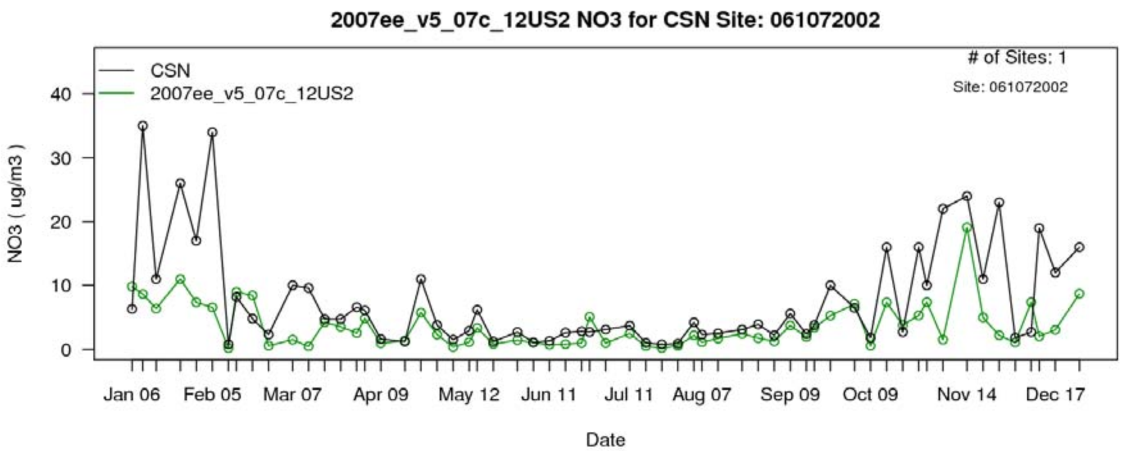

Figure A-22j. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 061072002 in Tulare County, CA.

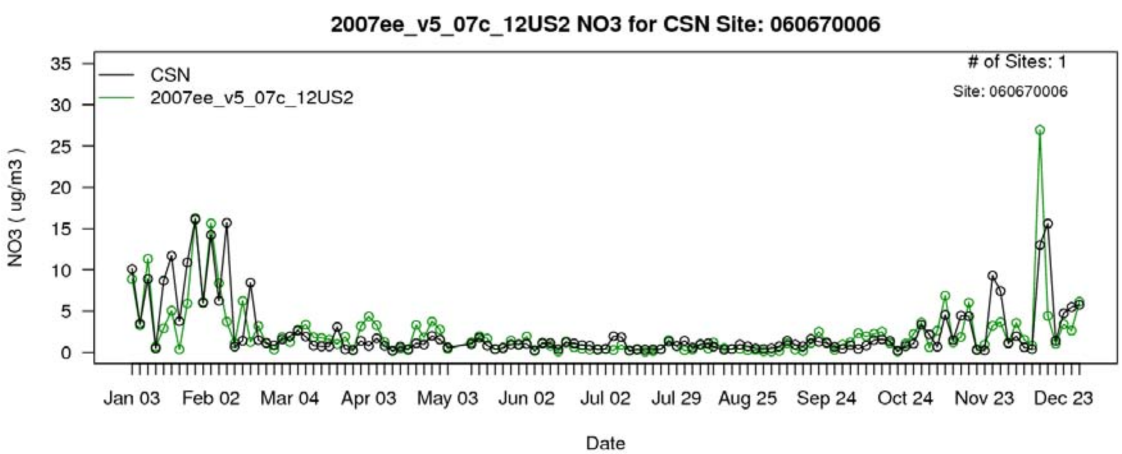

Figure A-22k. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 060670006 in Sacramento County, CA.

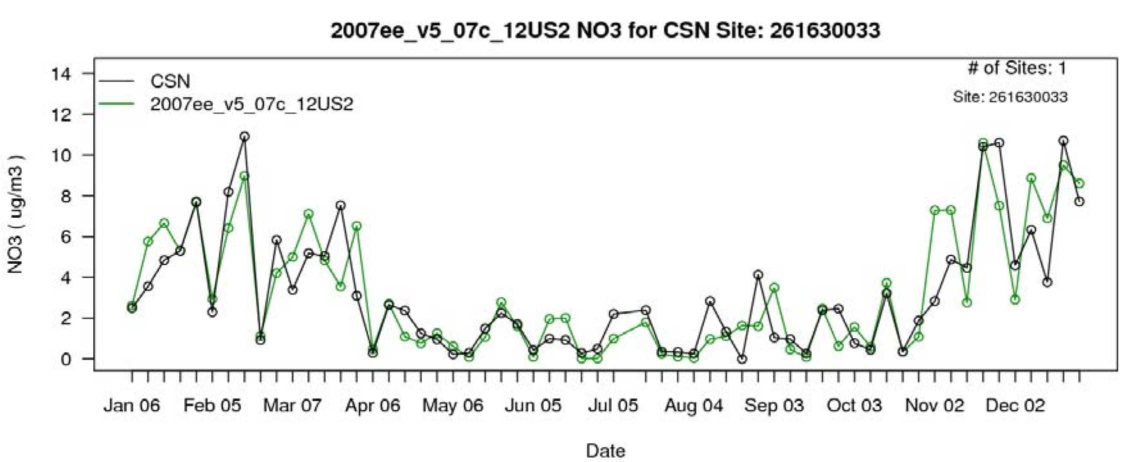

Figure A-22l. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 261630033 in Wayne County, MI.

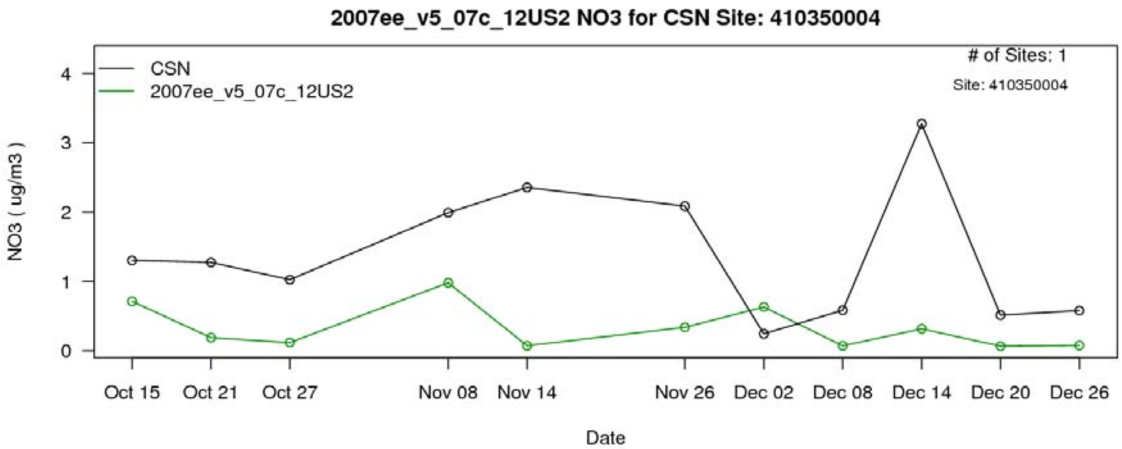

Figure A-22m. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 410350004 in Klamath County, OR.

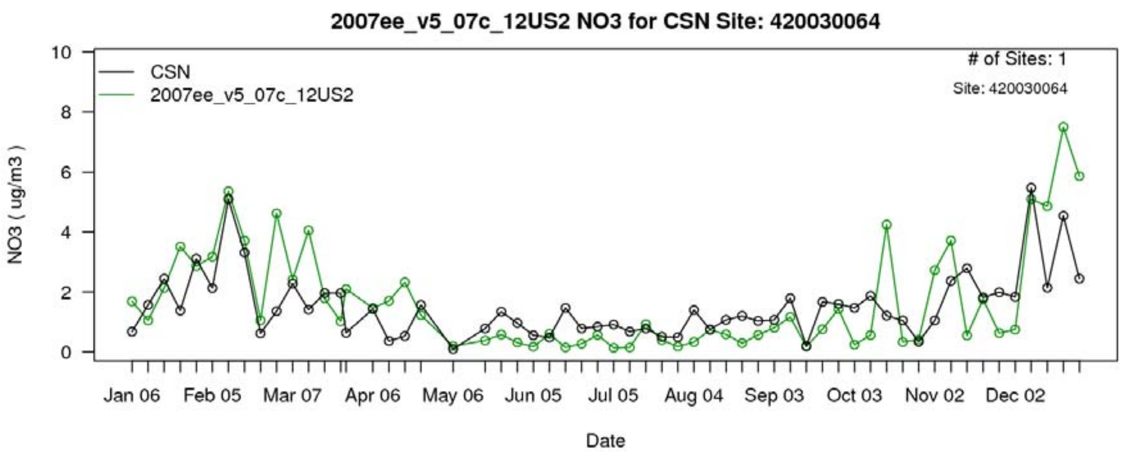

Figure A-22n. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 420030064 in Allegheny County, PA.

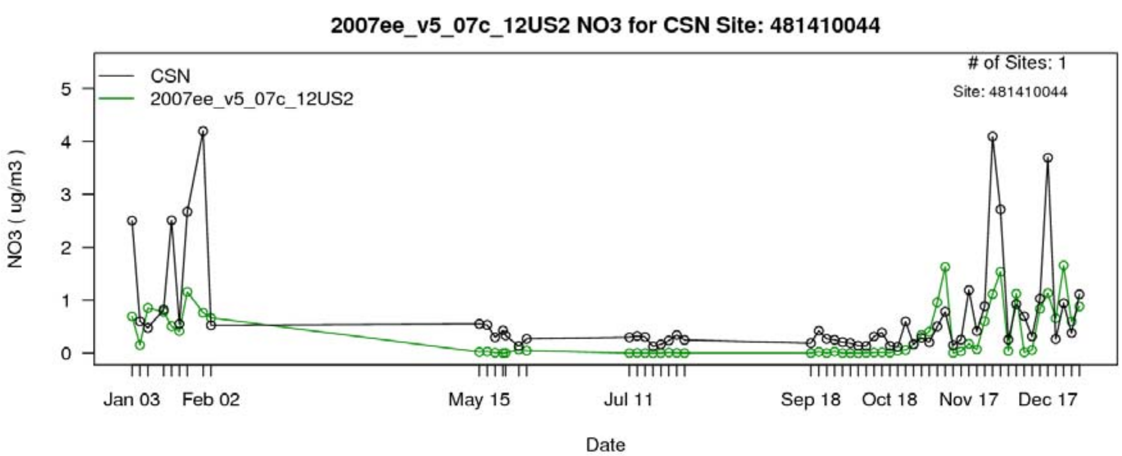

Figure A-22o. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 481410044 in El Paso County, TX.

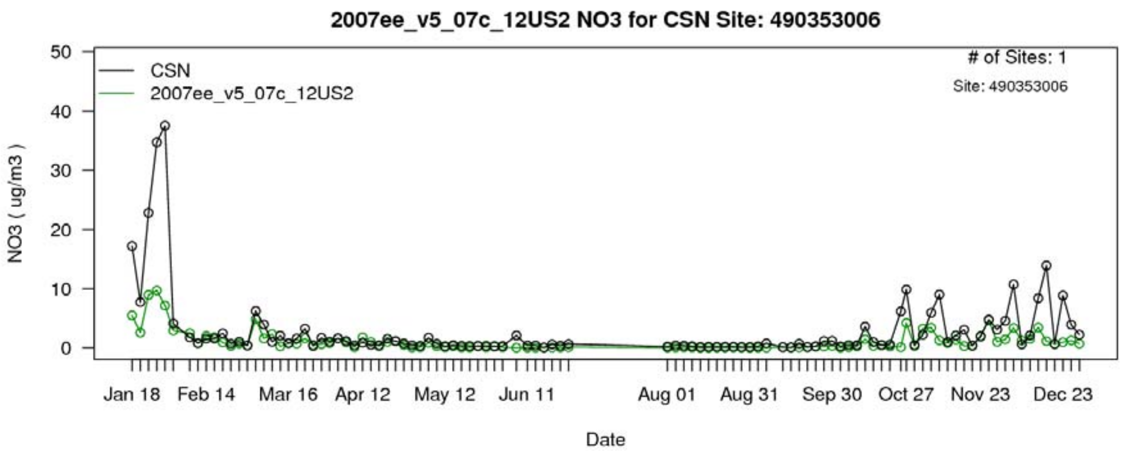

Figure A-22p. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 490353006 in Salt Lake County, UT.

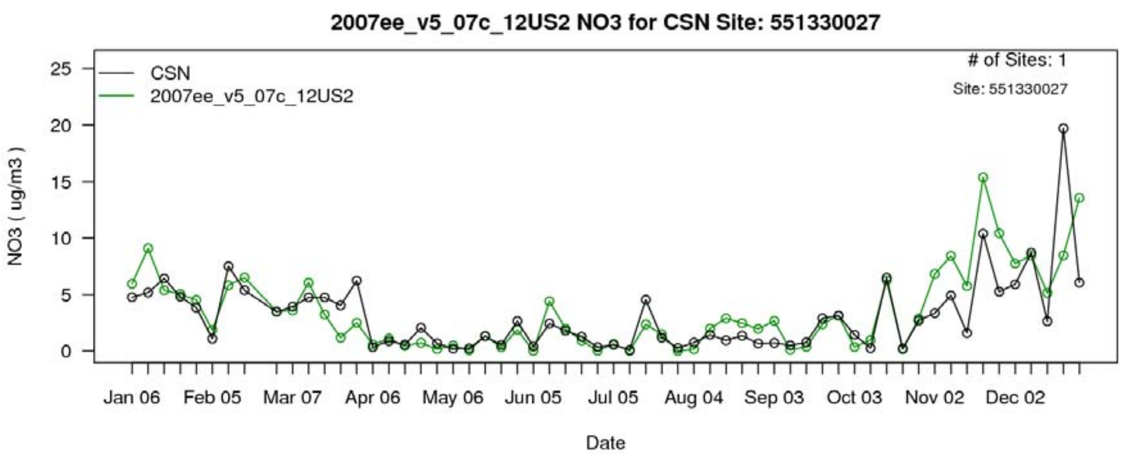

Figure A-22q. Time series of observed (black) and predicted (green) 24-hour average nitrate for 2007 at site 551330027 in Waukesha County, WI.

A.2.3. Model Evaluation for Ammonium

The model performance bias and error statistics for ammonium for each subregion and each season are provided in Table A-6. Spatial plots of the normalized mean bias and error by season for individual monitors are shown in Figures A-23 through A-26. Time series plots of observed and predicted 24-hour average ammonium concentration at selected CSN monitoring sites are provided in Figure A-27a-r. The statistics indicate that model bias for ammonium is generally ± 40 percent or less for all seasons in each subregion. For urban CSN sites, the median NMB across subregions and seasons is -6% with a range of -29.4% to 17.9%. The tendency for lower biases for ammonium than for sulfate and nitrate could be due in part to compensating effects of the under-predictions of sulfate and over-predictions of nitrate discussed above[18]. The model does a good job of capturing the changes in ammonium concentration between summer and winter months in some cases (e.g., Sacramento, Figure A-27j) but does not fully capture the wintertime peak concentrations in areas with complex terrain during strong wintertime stagnation episodes (e.g., Salt Lake City, Figure A-27q).

Table A-6. Ammonium performance statistics by subregion, by season for the 2007 CMAQ model simulation.

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
Central U.S.	CSN	Winter	532	-1.8	45.3	2.7	43.6
		Spring	607	-12.8	35.7	-13.3	39.3
		Summer	564	-19.4	38.2	-21.7	46.1
		Fall	602	5.9	43.3	6.9	47.1
	CASTNet	Winter	81	0.8	34.8	1.3	36.0
		Spring	90	1.7	30.6	-6.7	32.3
		Summer	97	-18.4	30.3	-20.6	35.9
		Fall	102	12.7	39.6	8.5	37.9
Midwest	CSN	Winter	567	-4.8	31.6	4.5	30.2
		Spring	640	-6.9	33.0	0.4	34.2
		Summer	604	-9.8	31.5	-1.5	35.2
		Fall	610	0.5	34.6	10.7	39.7
	CASTNet	Winter	152	7.3	24.4	8.8	24.2
		Spring	157	11.4	29.7	10.1	26.7
		Summer	162	-5.2	22.4	-2.2	22.4
		Fall	160	17.2	30.7	15.8	28.5
Southeast	CSN	Winter	681	3.4	40.8	7.7	40.9
		Spring	752	-12.8	34.1	-11.7	36.3
		Summer	701	-29.4	36.8	-27.8	40.8

[18] Model performance for ammonium is related to that for sulfate and nitrate because ammonium is associated with sulfate and nitrate in $PM_{2.5}$.

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
		Fall	697	0.5	37.3	2.4	38.5
	CASTNet	Winter	262	3.2	33.0	0.6	32.6
		Spring	288	-4.4	29.4	-4.6	30.8
		Summer	266	-32.0	34.1	-37.8	40.8
		Fall	289	-13.6	34.7	-14.5	36.3
Northeast	CSN	Winter	750	-0.1	31.7	9.1	33.6
		Spring	805	-4.2	34.8	3.5	34.8
		Summer	769	-26.9	35.7	-18.2	38.2
		Fall	793	-5.8	34.9	7.2	37.4
	CASTNet	Winter	179	23.8	35.7	29.5	37.2
		Spring	194	8.2	33.2	9.1	28.8
		Summer	191	-26.6	30.9	-35.9	40.0
		Fall	191	-7.1	27.1	-9.2	29.4
West without California	CSN	Winter	443	-27.7	68.2	7.5	63.9
		Spring	498	8.3	52.9	12.1	50.2
		Summer	471	-11.9	44.9	-10.4	46.3
		Fall	474	11.7	63.1	12.5	54.5
	CASTNet	Winter	196	14.6	42.5	22.3	39.8
		Spring	214	-13.2	35.6	-7.0	38.6
		Summer	213	-36.0	42.0	-44.8	51.8
		Fall	212	-16.2	41.8	-13.5	40.6
California	CSN	Winter	310	-19.7	55.9	16.7	65.3
		Spring	354	-8.8	51.7	6.8	57.4
		Summer	334	17.9	54.3	1.1	47.5
		Fall	333	-21.3	50.3	-0.1	59.2
	CASTNet	Winter	75	63.3	83.6	49.5	60.8
		Spring	78	-3.6	45.3	6.3	46.7
		Summer	76	-37.1	40.0	-43.8	48.3
		Fall	75	-8.2	41.9	-4.8	44.9

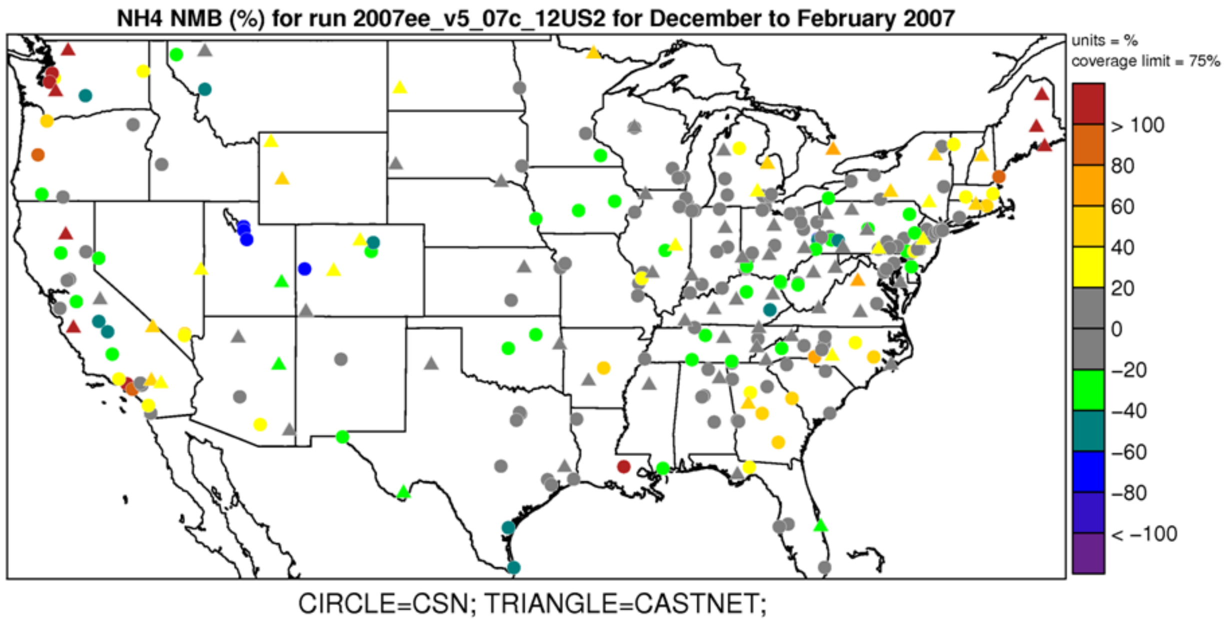

Figure A-23a. Normalized Mean Bias (%) of ammonium during winter 2007 at monitoring sites in Continental U.S. modeling domain.

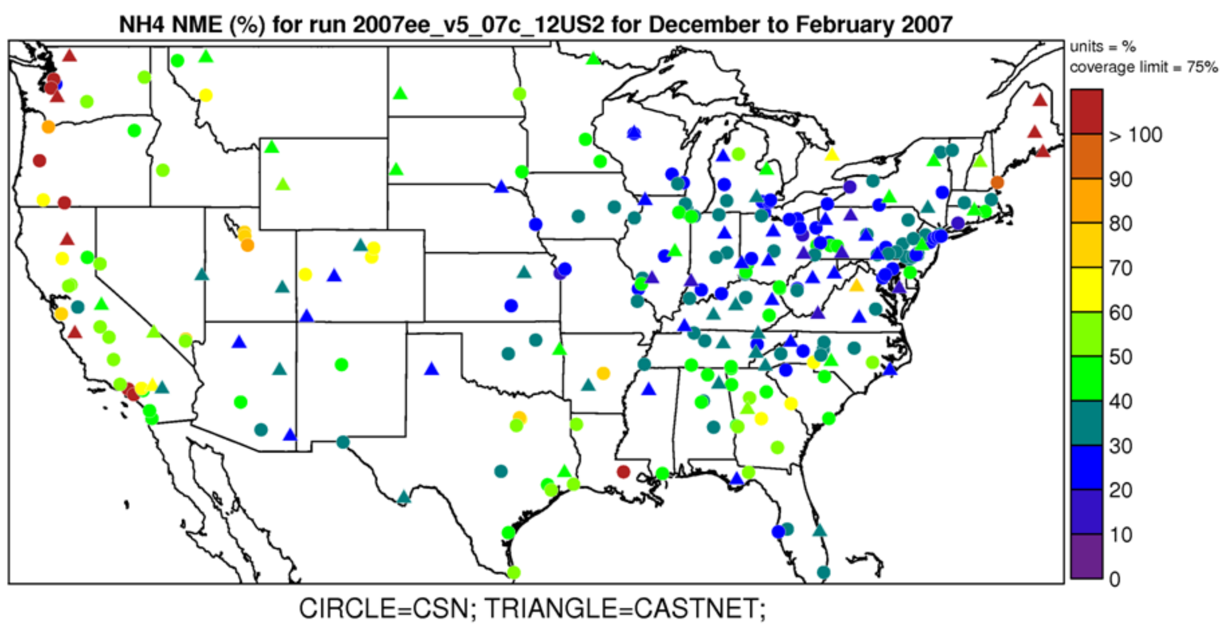

Figure A-23b. Normalized Mean Error (%) of ammonium during winter 2007 at monitoring sites in Continental U.S. modeling domain.

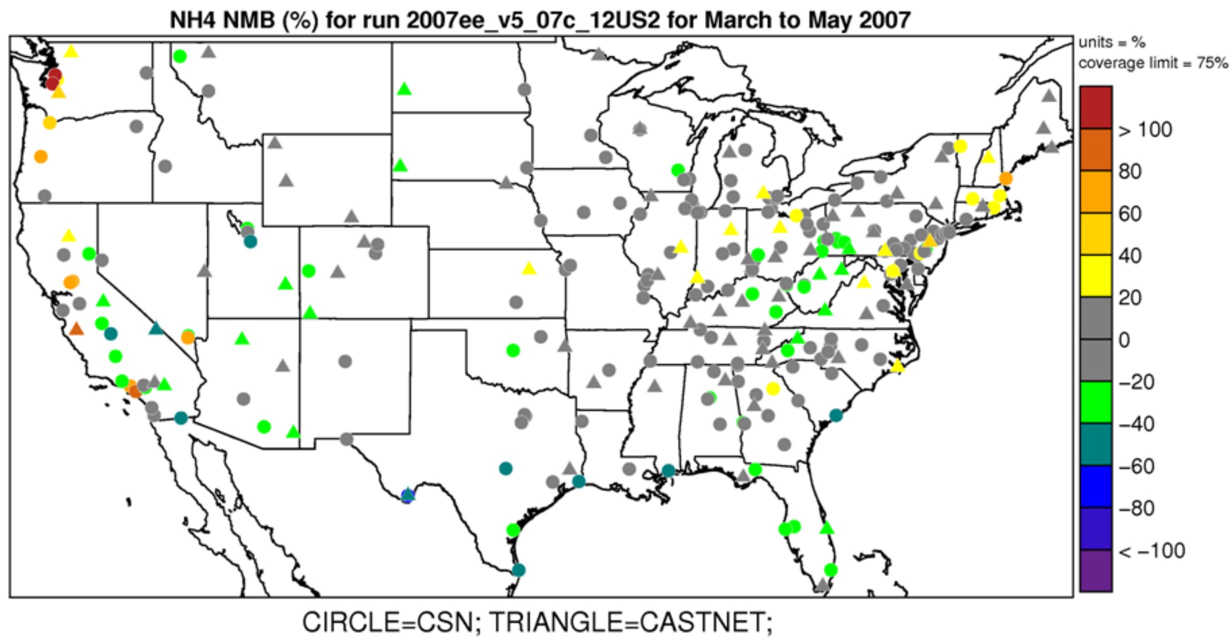

Figure A-24a. Normalized Mean Bias (%) of ammonium during spring 2007 at monitoring sites in Continental U.S. modeling domain.

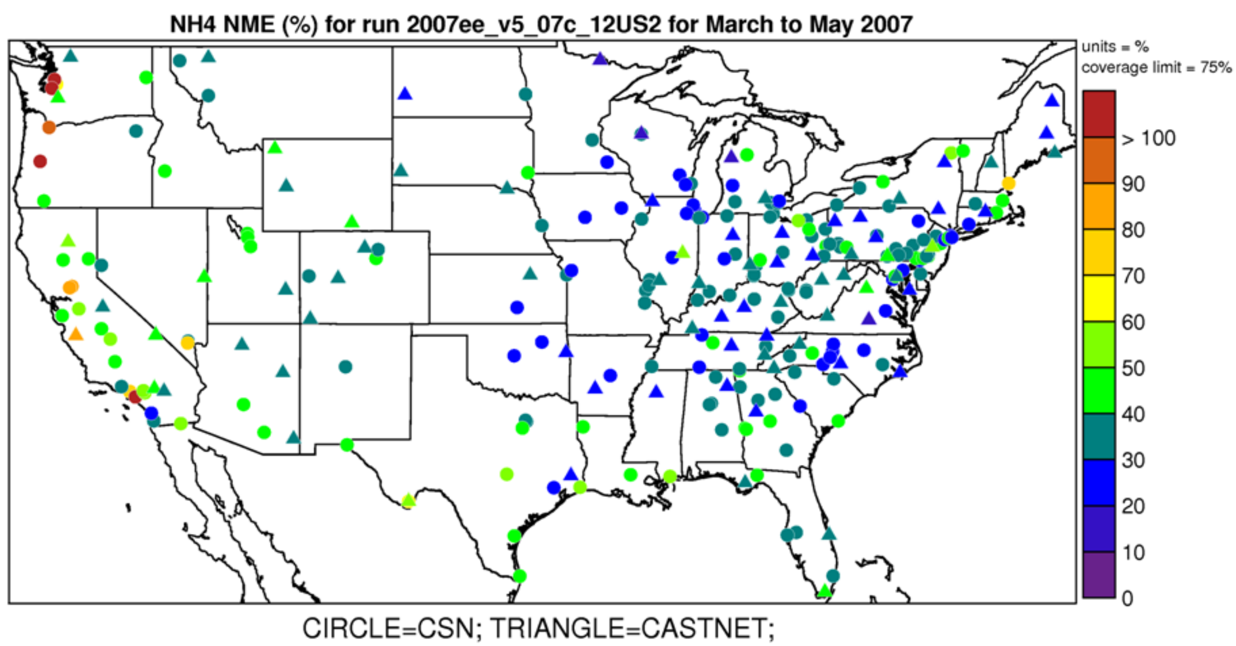

Figure A-24b. Normalized Mean Error (%) of ammonium during spring 2007 at monitoring sites in Continental U.S. modeling domain.

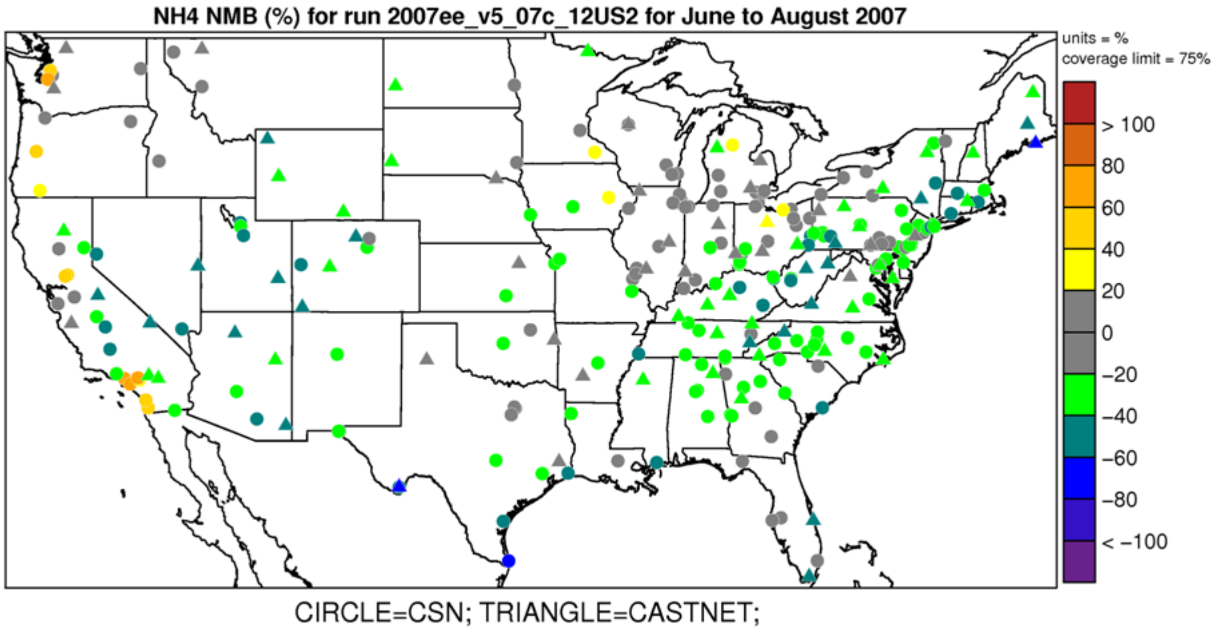

Figure A-25a. Normalized Mean Bias (%) of ammonium during summer 2007 at monitoring sites in Continental U.S. modeling domain.

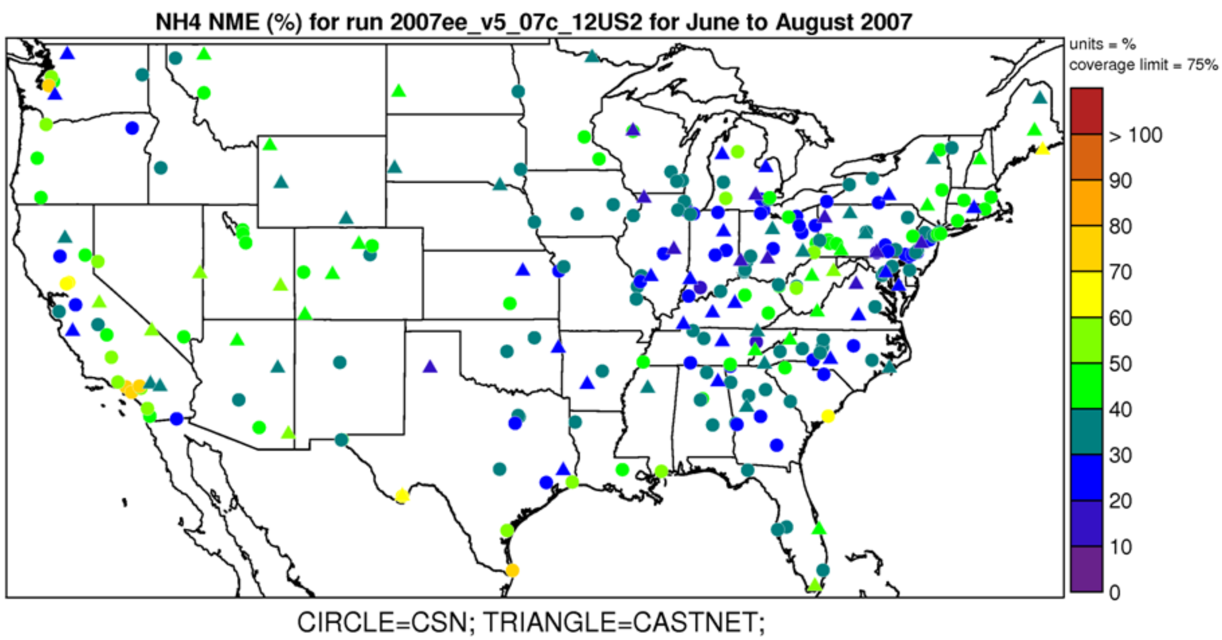

Figure A-25b. Normalized Mean Error (%) of ammonium during summer 2007 at monitoring sites in Continental U.S. modeling domain.

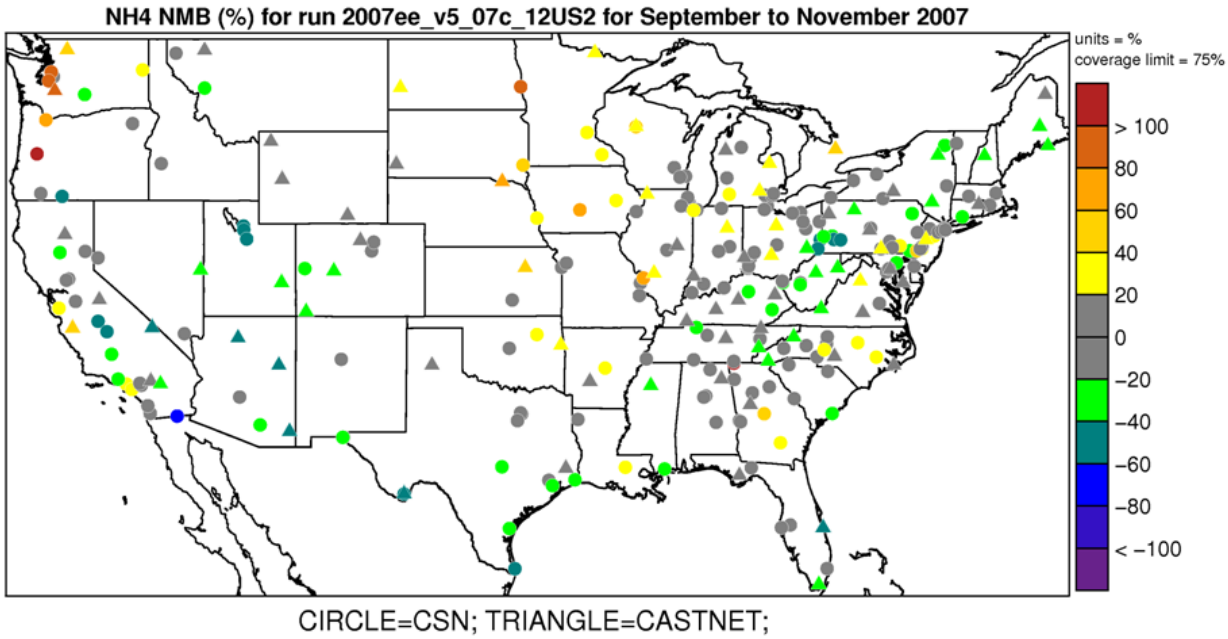

Figure A-26a. Normalized Mean Bias (%) of ammonium during fall 2007 at monitoring sites in Continental U.S. modeling domain.

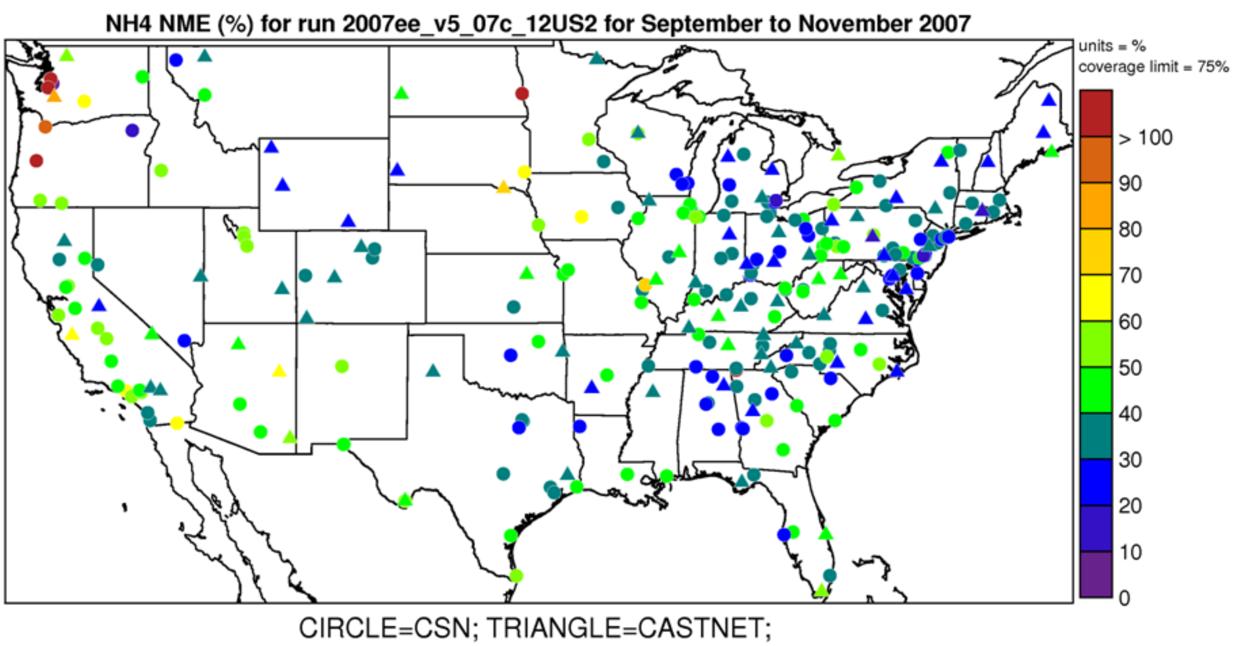

Figure A-26b. Normalized Mean Error (%) of ammonium during fall 2007 at monitoring sites in Continental U.S. modeling domain.

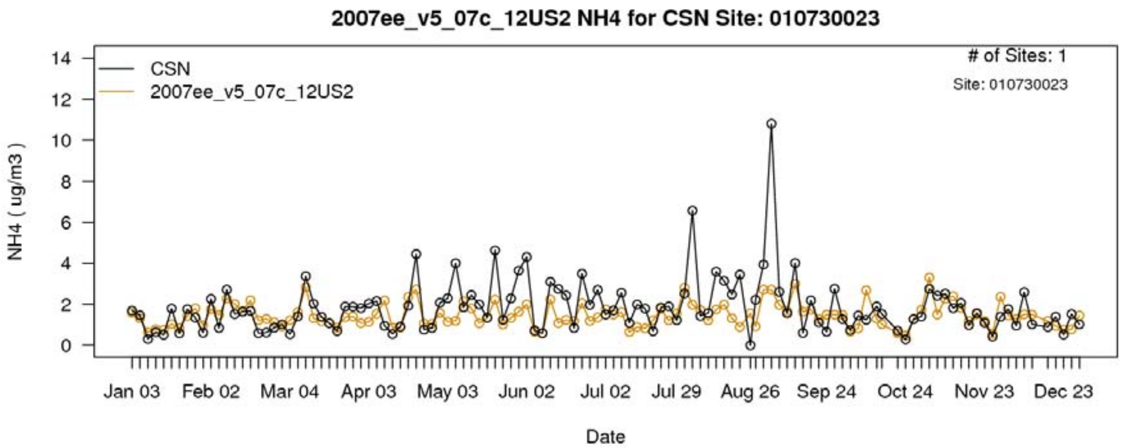

Figure A-27a. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 010730023 in Jefferson County, AL.

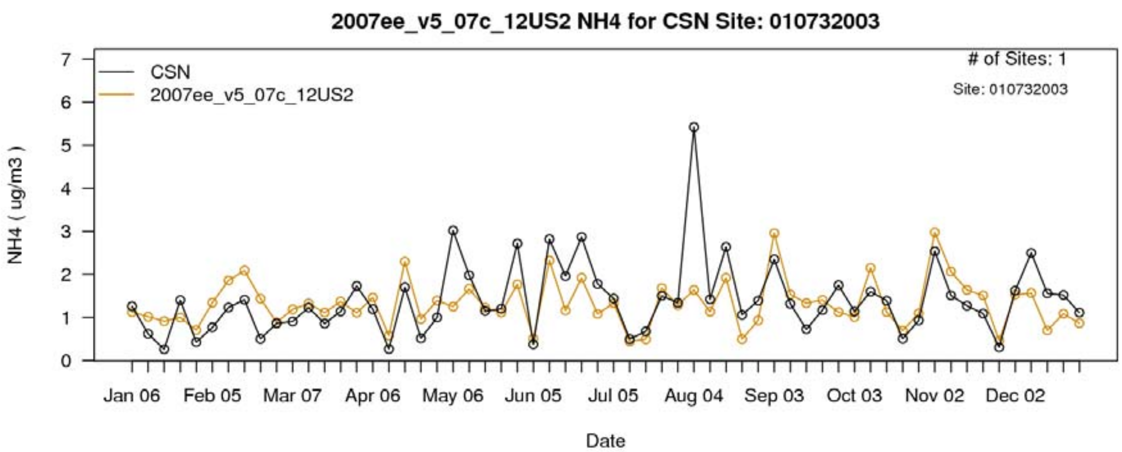

Figure A-27b. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 010732003 in Jefferson County, AL.

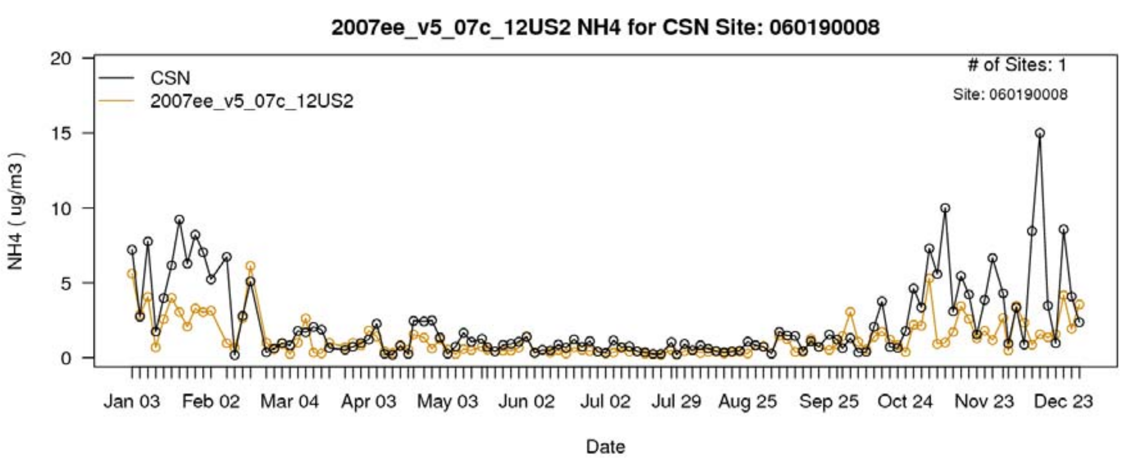

Figure A-27c. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060190008 in Fresno County, CA.

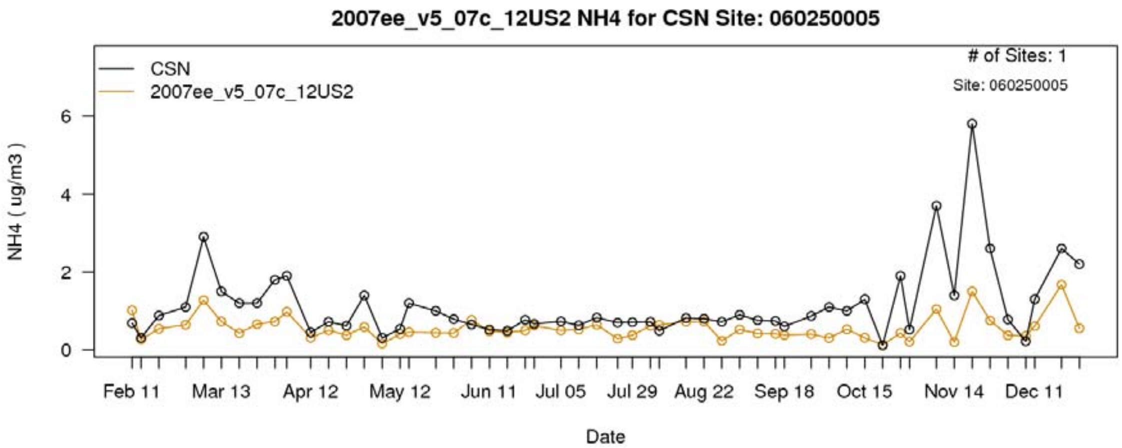

Figure A-27d. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060250005 in Imperial County, CA.

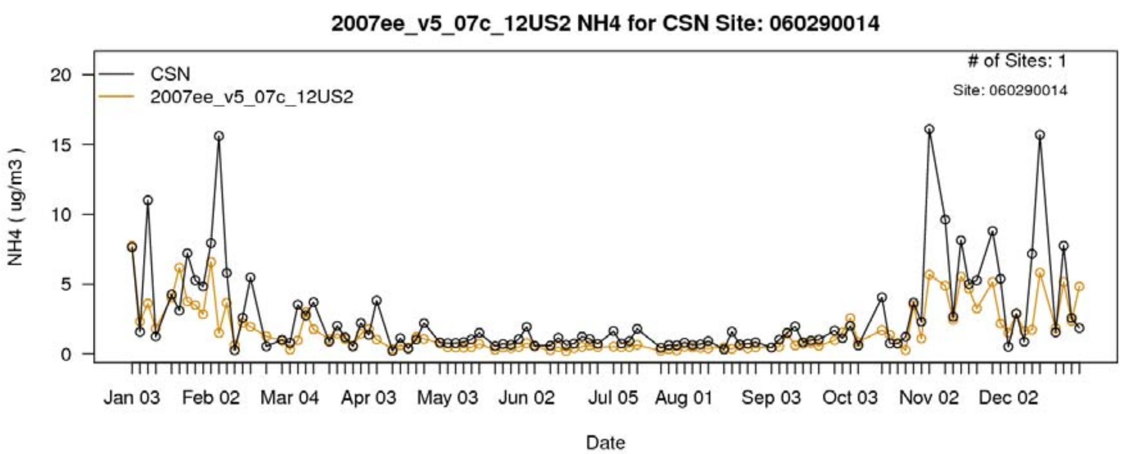

Figure A-27e. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060290014 in Kern County, CA.

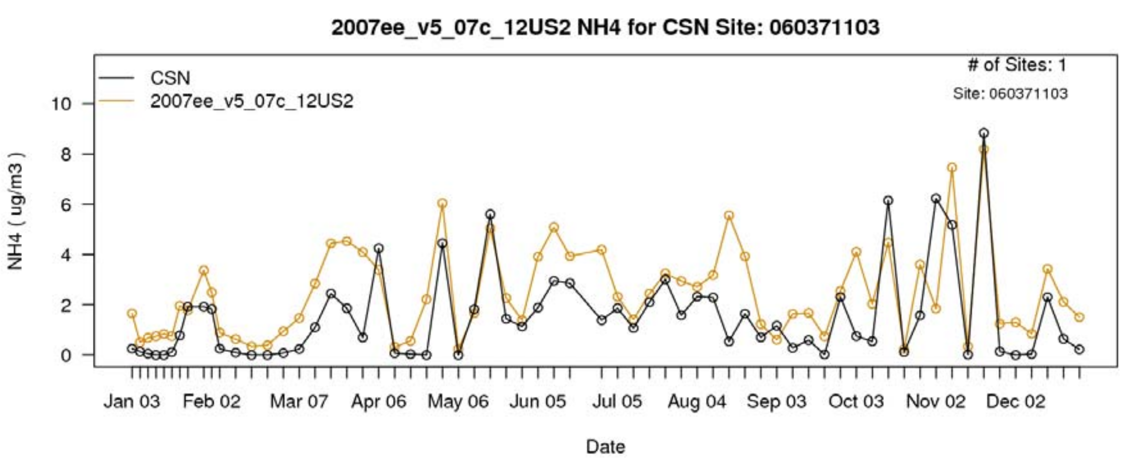

Figure A-27f. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060371103 in Los Angeles County, CA.

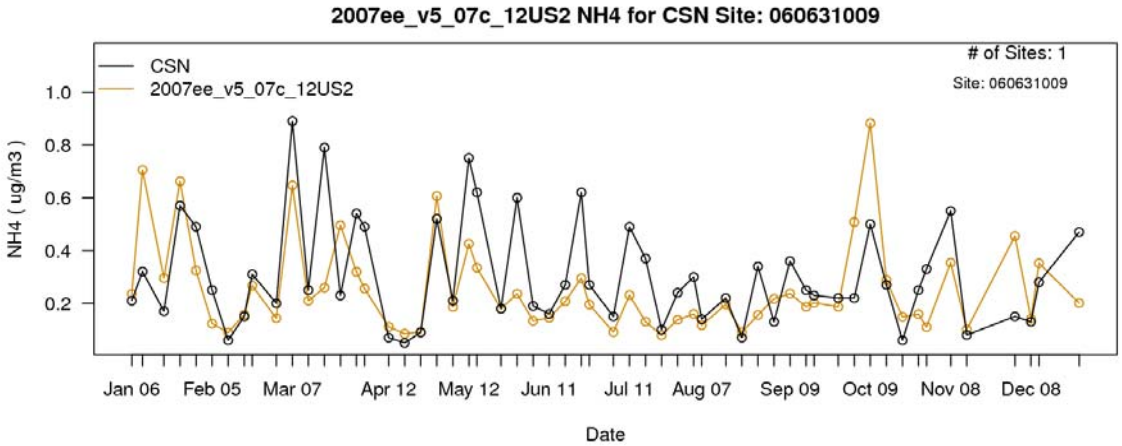

Figure A-27g. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060631009 in Plumas County, CA.

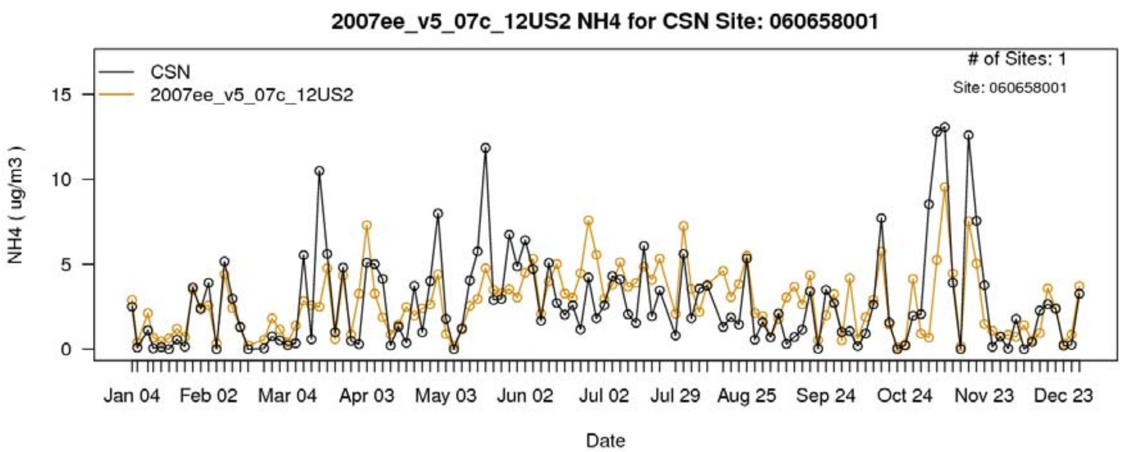

Figure A-27h. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060658001 in Riverside County, CA.

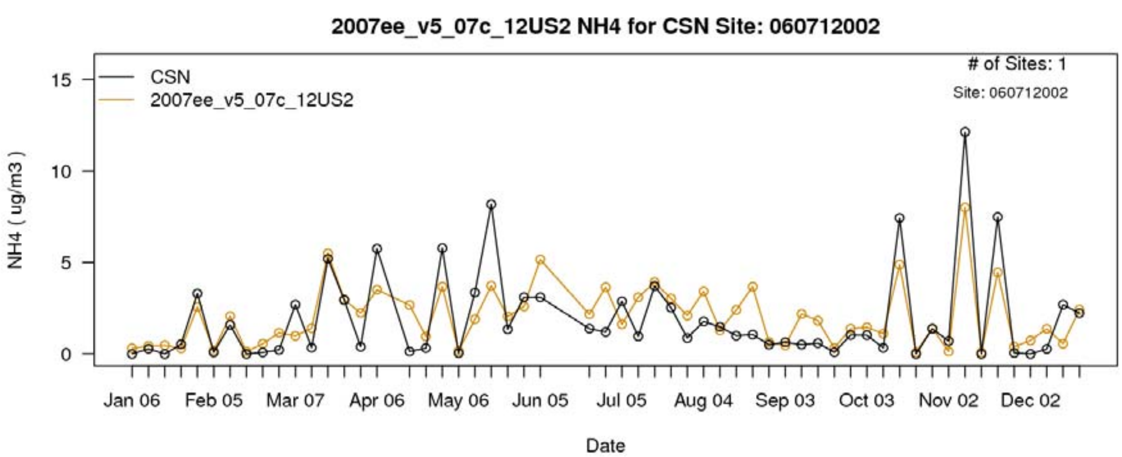

Figure A-27i. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060712002 in San Bernardino County, CA.

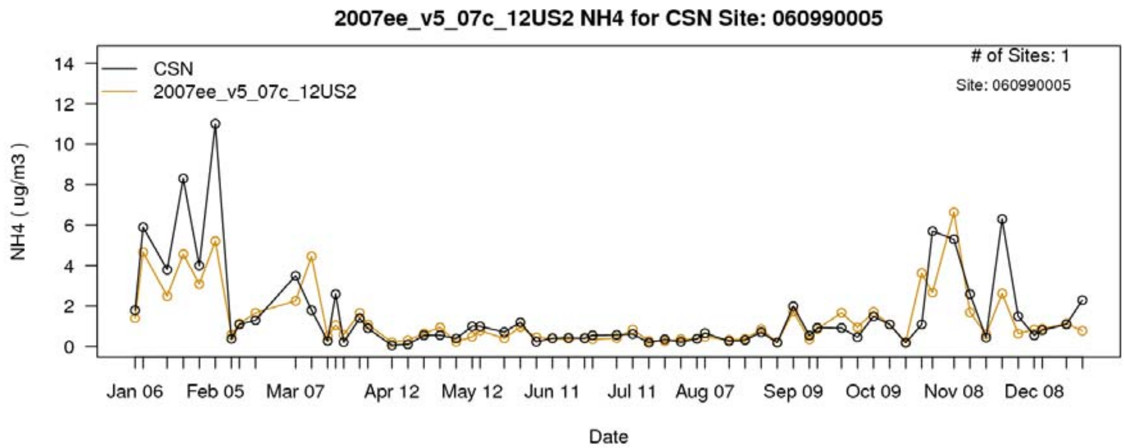

Figure A-27j. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060990005 in Stanislaus County, CA.

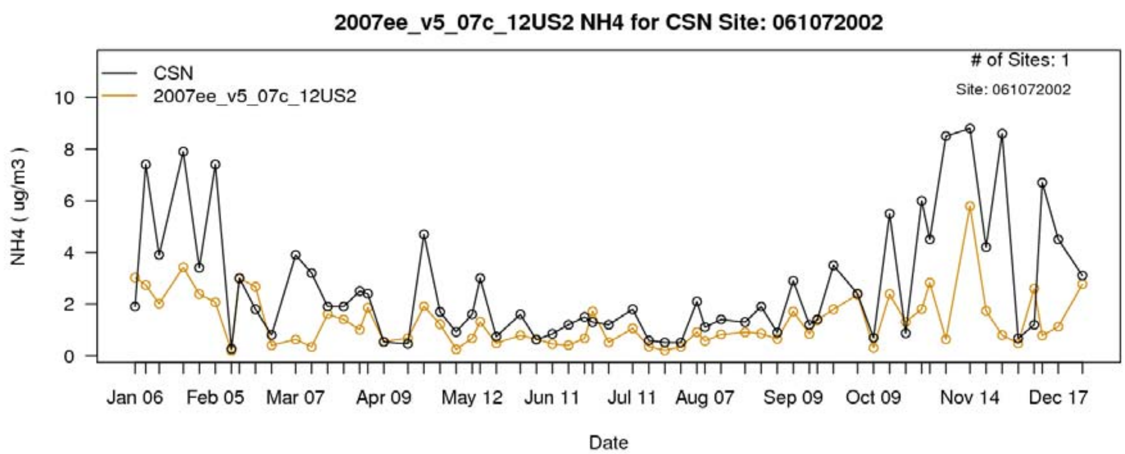

Figure A-27k. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 061072002 in Tulare County, CA.

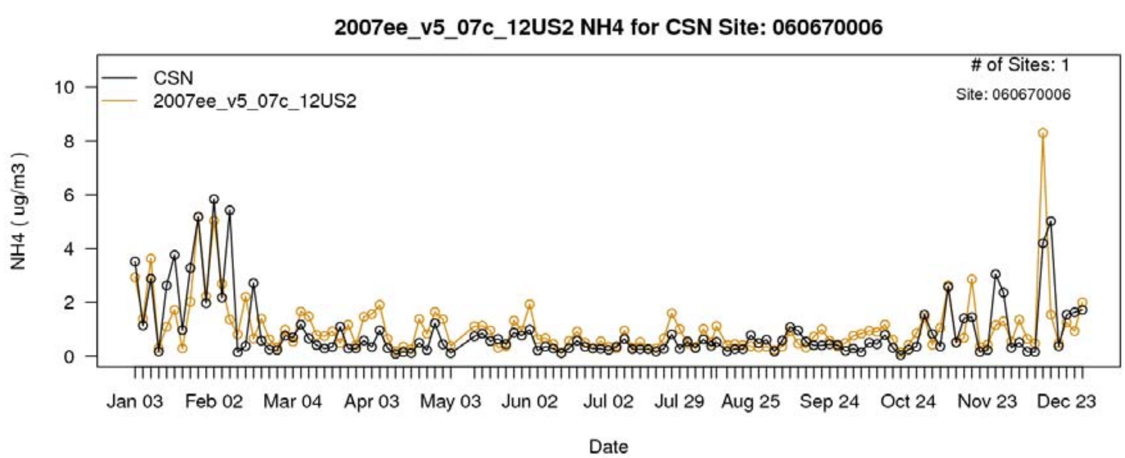

Figure A-27l. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 060670006 in Sacramento County, CA.

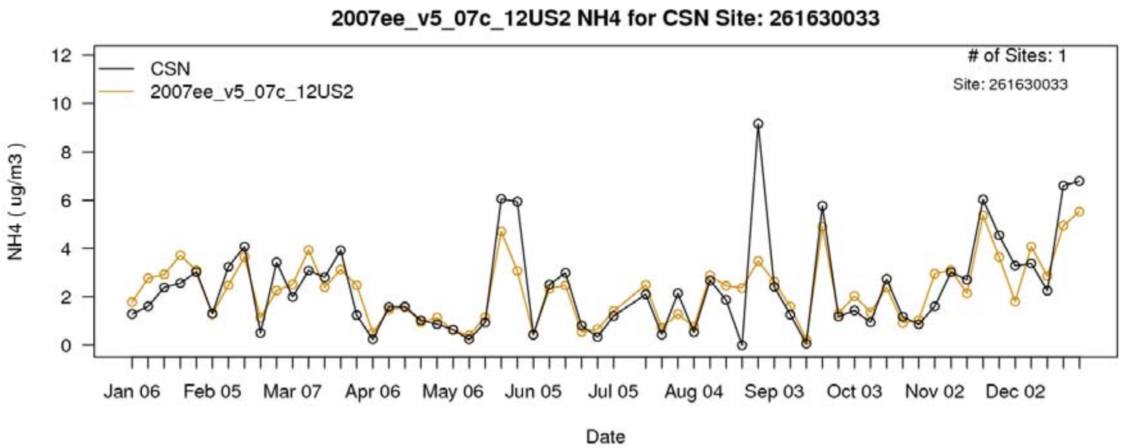

Figure A-27m. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 261630033 in Wayne County, MI.

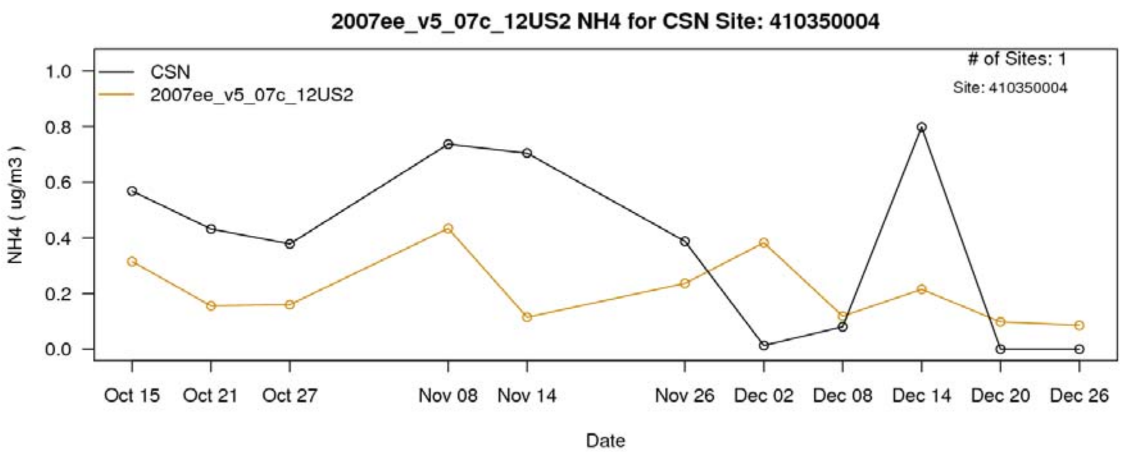

Figure A-27n. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 410350004 in Klamath County, OR.

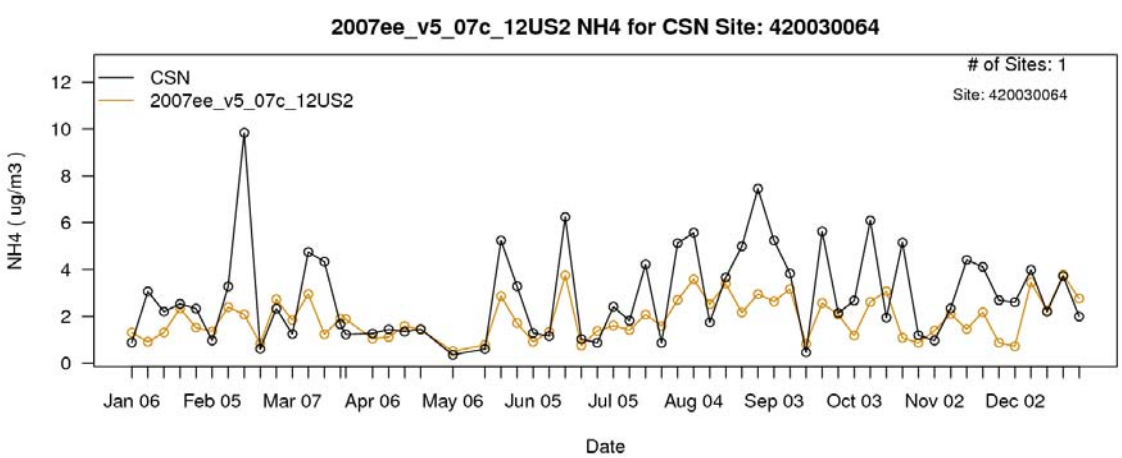

Figure A-27o. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 420030064 in Allegheny County, PA.

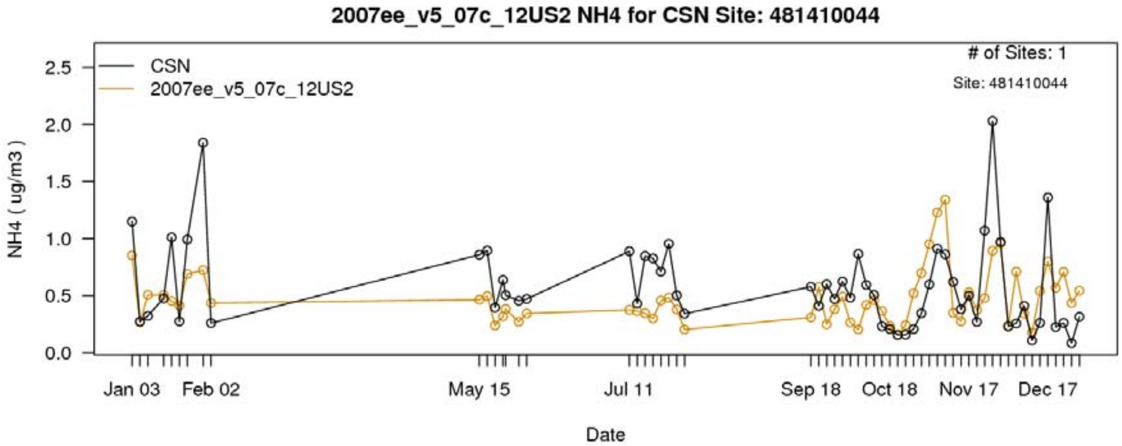

Figure A-27p. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 481410044 in El Paso County, TX.

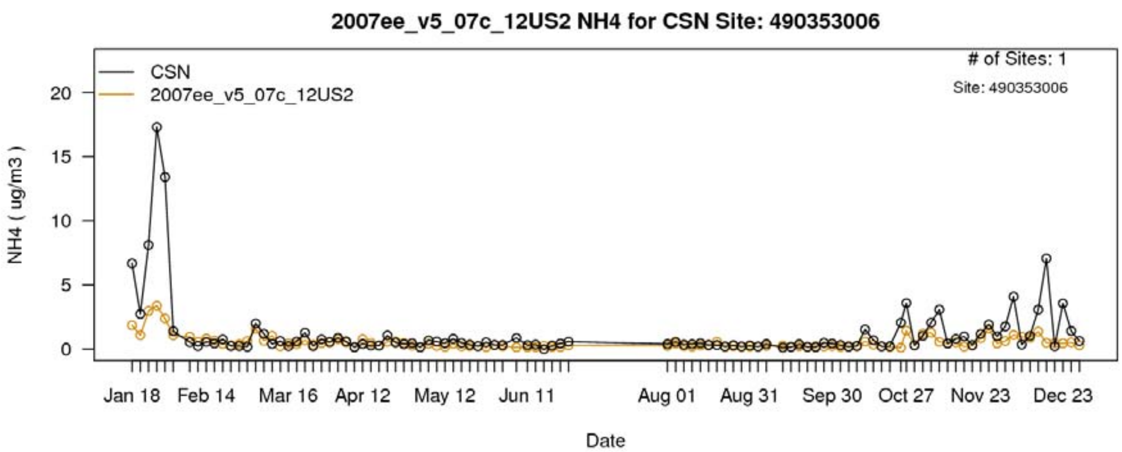

Figure A-27q. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 490353006 in Salt Lake County, UT.

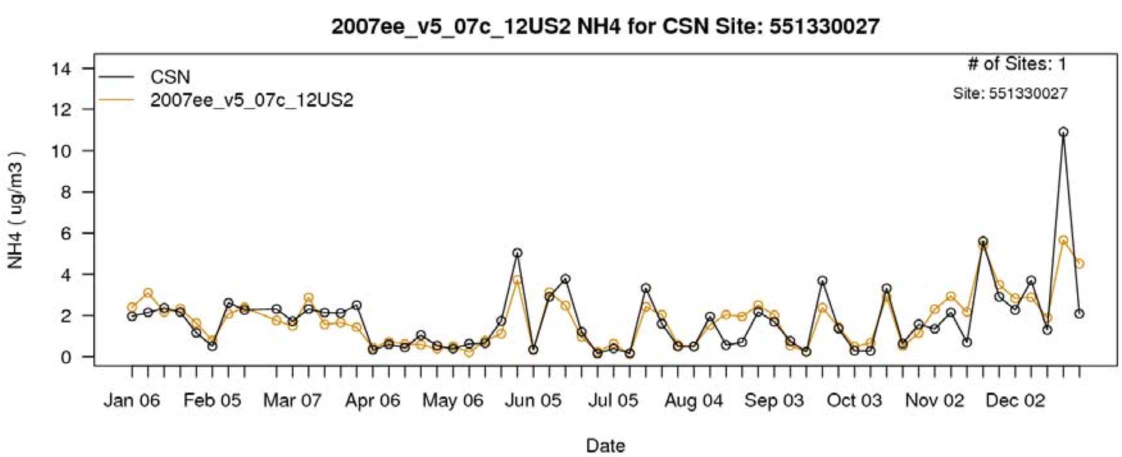

Figure A-27r. Time series of observed (black) and predicted (orange) 24-hour average ammonium for 2007 at site 551330027 in Waukesha County, WI.

A.2.4. Model Evaluation for Elemental Carbon

The model performance bias and error statistics for elemental carbon for each subregion and each season are provided in Table A-7. Spatial plots of the normalized mean bias and error by season for individual monitors are shown in Figures A-28 through A-31. Time series plots of observed and predicted 24-hour average elemental carbon concentration at selected CSN monitoring sites are provided in Figure A-32a-m. The statistics show clear over prediction at urban sites in all subregions. For example, the median NMB at CSN monitors over all subregions and seasons is 49% with a range of 20.1% to 120%. Rural sites show much less over-prediction than urban sites, with under-predictions occurring in the Central U.S. and Southeast subregions during spring and summer. The median NMB at rural (IMPROVE) monitors for the subregions and seasons is 26% with a range of -18.3% to 86.6%. In the West, the model tends to over-predict elemental carbon concentrations at both urban and rural sites during all seasons. The over-predictions for monitors in Fresno (Figure A-32c) and Kern (Figure A-32d) counties could be related to an over-estimate of diesel truck emissions. The meteorological mixing depth has a significant impact on elemental carbon concentrations, and so the biases in predictions could also be related to the estimates of mixing depth by the meteorological model.

Table A-7. Elemental Carbon performance statistics by subregion, by season for the 2007 CMAQ model simulation.

Subregion	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
Central U.S.	CSN	Winter	537	120.0	153.0	66.8	85.4
		Spring	630	81.6	101.0	47.1	65.6
		Summer	559	113.0	123.0	60.1	74.5
		Fall	595	84.2	113.0	51.4	69.4
	IMPROVE	Winter	556	26.1	52.4	15.0	41.9
		Spring	661	-18.3	49.8	-25.0	47.4
		Summer	658	-12.2	41.1	-23.4	47.9
		Fall	645	26.4	47.4	10.8	39.5
Midwest	CSN	Winter	566	113.0	124.0	68.4	76.0
		Spring	641	39.1	59.3	27.9	49.9
		Summer	601	51.4	65.2	34.1	49.1
		Fall	600	42.7	69.1	31.0	53.2
	IMPROVE	Winter	162	55.1	71.1	31.8	49.1
		Spring	182	2.2	45.1	-14.4	47.2
		Summer	174	-0.1	41.0	-22.2	44.5
		Fall	144	10.1	42.1	6.3	44.6
Southeast	CSN	Winter	671	56.0	72.6	42.4	56.2
		Spring	753	25.6	50.1	18.2	44.7

Subregion	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
		Summer	703	47.1	70.3	36.1	55.5
		Fall	697	20.1	58.5	24.1	49.8
	IMPROVE	Winter	479	23.1	54.4	7.2	45.8
		Spring	512	-17.5	43.6	-22.7	44.8
		Summer	480	-16.9	45.9	-31.5	55.3
		Fall	492	13.2	40.3	11.0	42.4
Northeast	CSN	Winter	753	91.2	102.0	56.2	65.8
		Spring	806	38.1	66.6	13.9	52.3
		Summer	757	52.6	71.0	36.9	52.9
		Fall	774	29.3	71.1	24.0	55.7
	IMPROVE	Winter	565	70.0	85.4	31.3	52.1
		Spring	624	38.1	66.6	13.9	52.3
		Summer	614	17.8	56.7	-13.2	49.6
		Fall	569	63.6	82.0	22.2	48.5
West without California	CSN	Winter	454	27.2	77.9	14.1	65.1
		Spring	499	69.7	105.0	23.5	67.5
		Summer	476	96.7	125.0	39.5	69.4
		Fall	504	26.3	86.0	7.9	67.5
	IMPROVE	Winter	1,774	32.6	83.9	0.1	61.2
		Spring	1,985	31.6	94.9	-14.8	58.0
		Summer	1,969	66.7	118.0	-10.3	62.2
		Fall	1,894	74.2	119.0	8.7	59.4
California	CSN	Winter	191	27.8	59.1	20.2	53.9
		Spring	188	70.7	80.5	51.2	58.9
		Summer	519	33.3	78.3	17.8	60.1
		Fall	214	36.3	62.5	33.7	51.7
	IMPROVE	Winter	465	33.9	73.7	19.8	67.3
		Spring	512	26.5	68.9	11.5	59.5
		Summer	519	86.6	90.6	60.0	63.2
		Fall	494	60.2	93.0	29.6	65.3

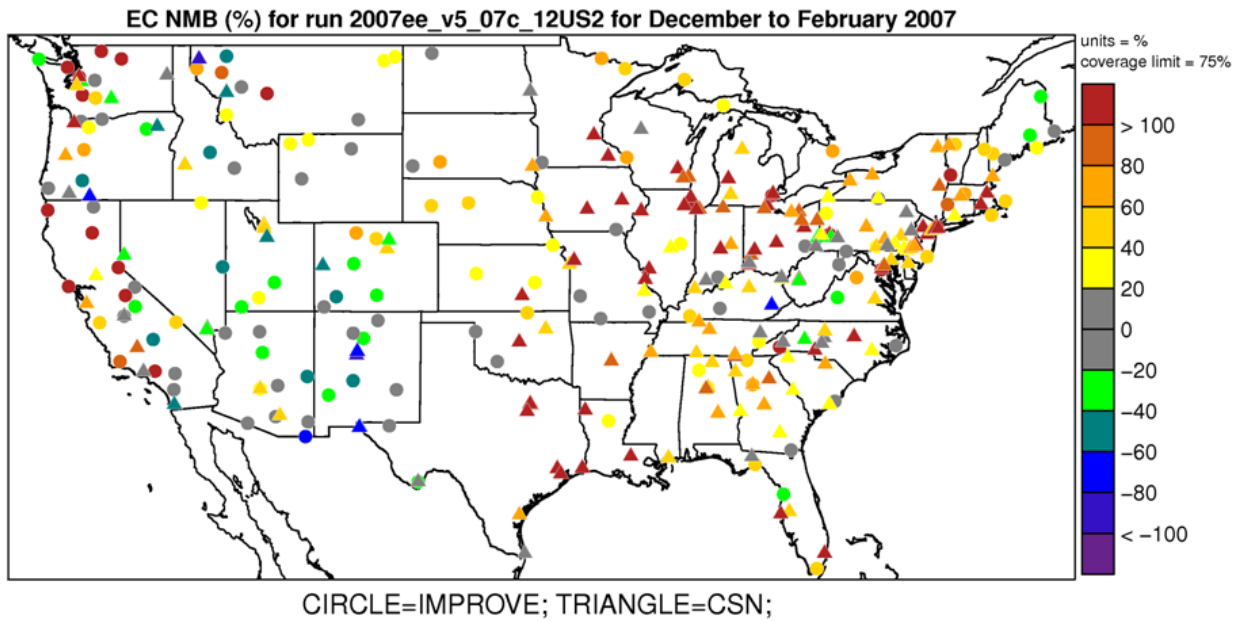

Figure A-28a. Normalized Mean Bias (%) of elemental carbon during winter 2007 at monitoring sites in Continental U.S. modeling domain.

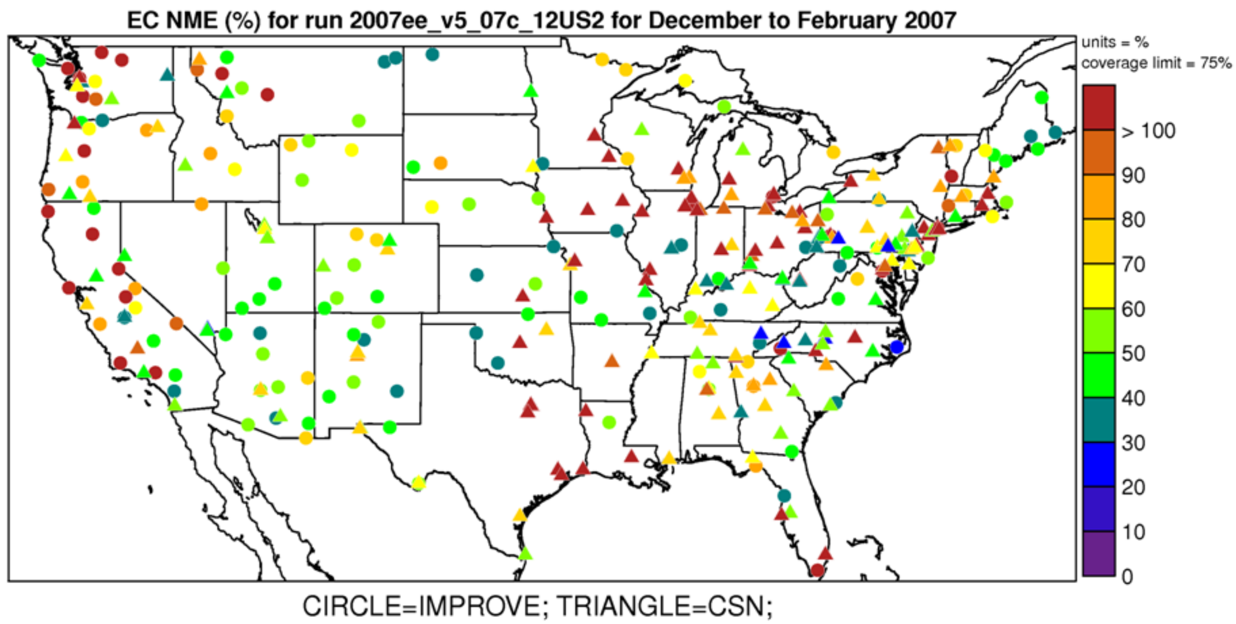

Figure A-28b. Normalized Mean Error (%) of elemental carbon during winter 2007 at monitoring sites in Continental U.S. modeling domain.

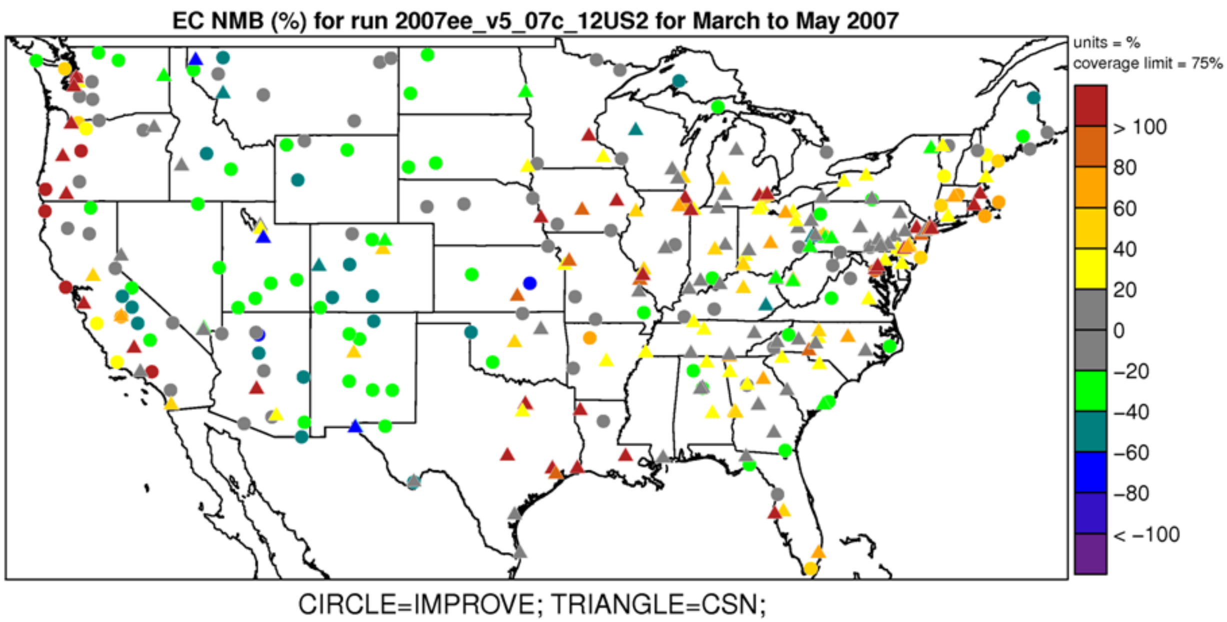

Figure A-29a. Normalized Mean Bias (%) of elemental carbon during spring 2007 at monitoring sites in Continental U.S. modeling domain.

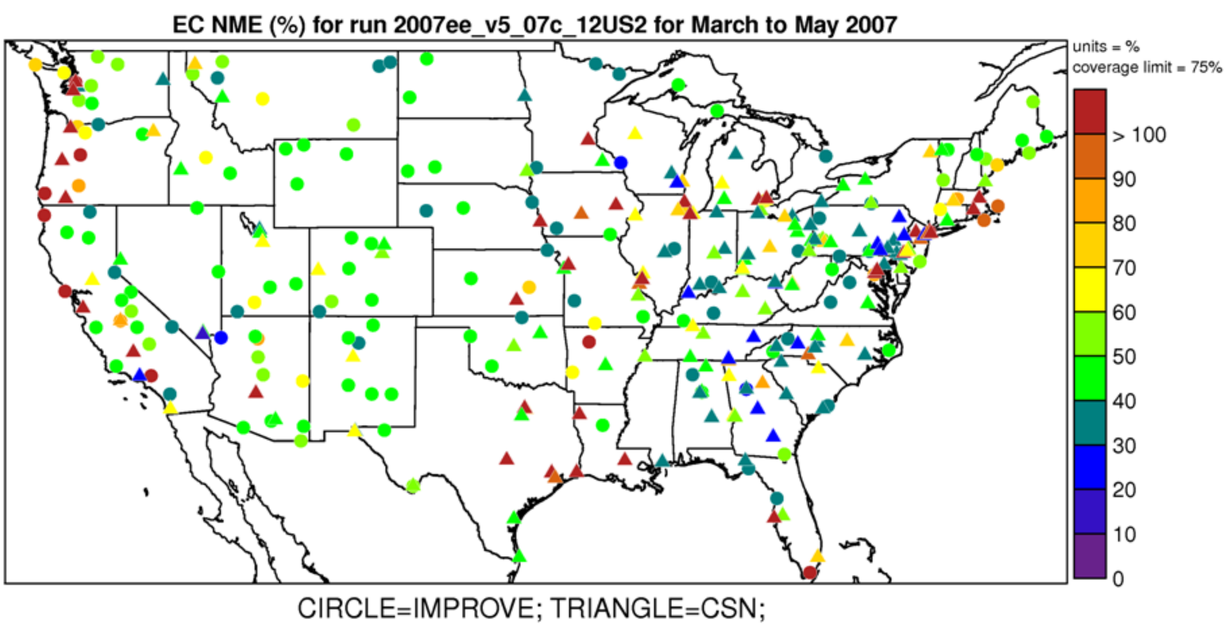

Figure A-29b. Normalized Mean Error (%) of elemental carbon during spring 2007 at monitoring sites in Continental U.S. modeling domain.

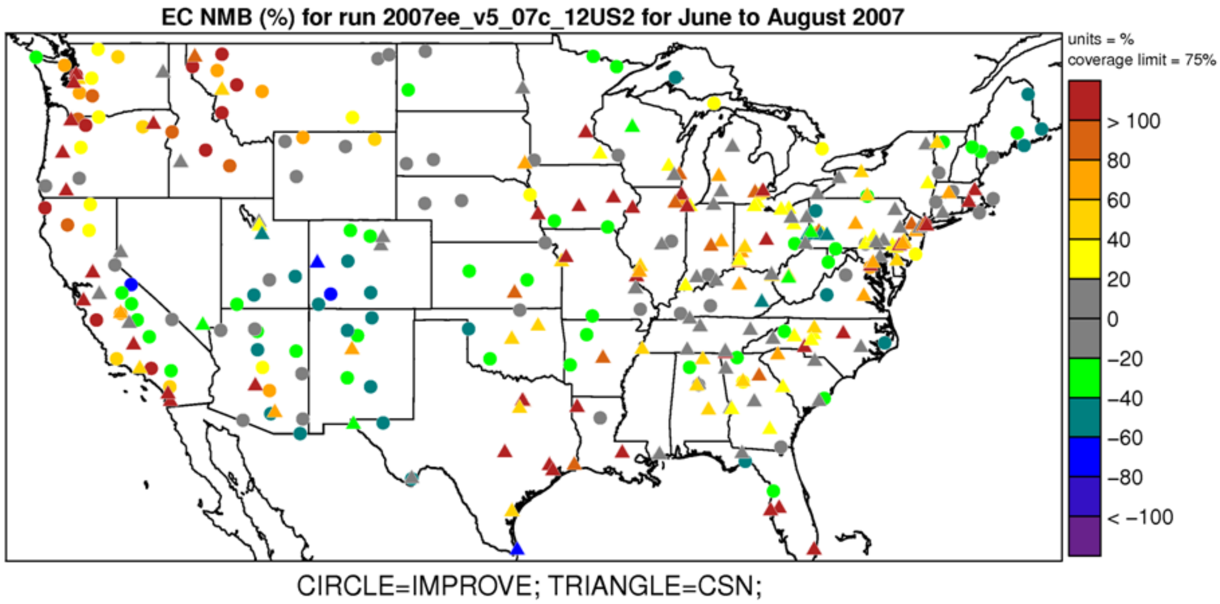

Figure A-30a. Normalized Mean Bias (%) of elemental carbon during summer 2007 at monitoring sites in Continental U.S. modeling domain.

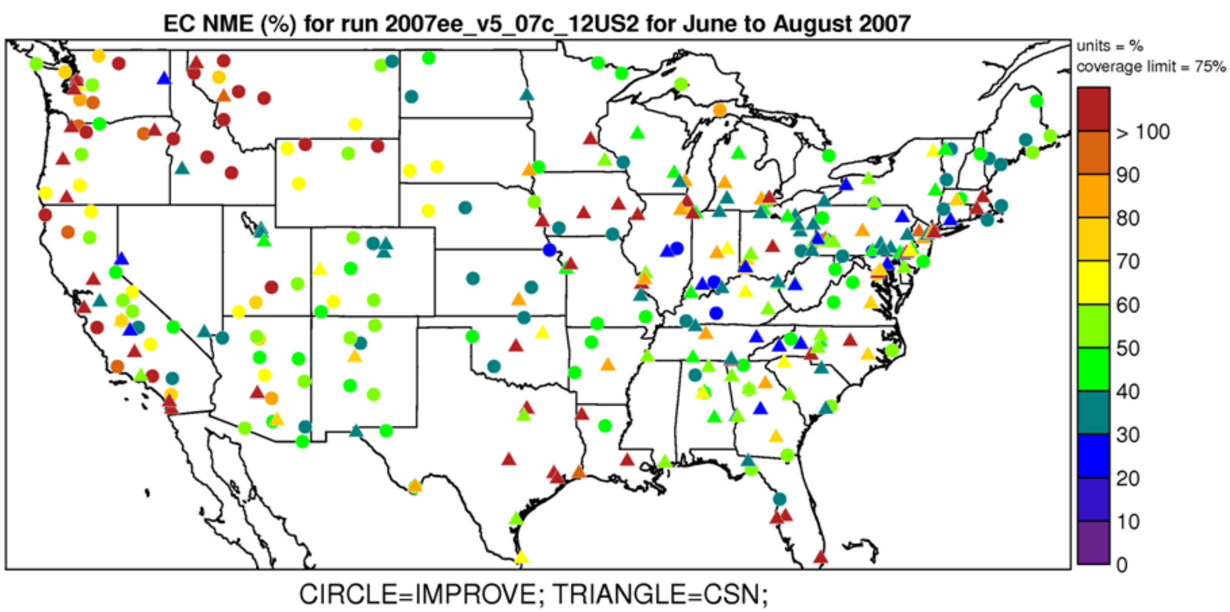

Figure A-30b. Normalized Mean Error (%) of elemental carbon during summer 2007 at monitoring sites in Continental U.S. modeling domain.

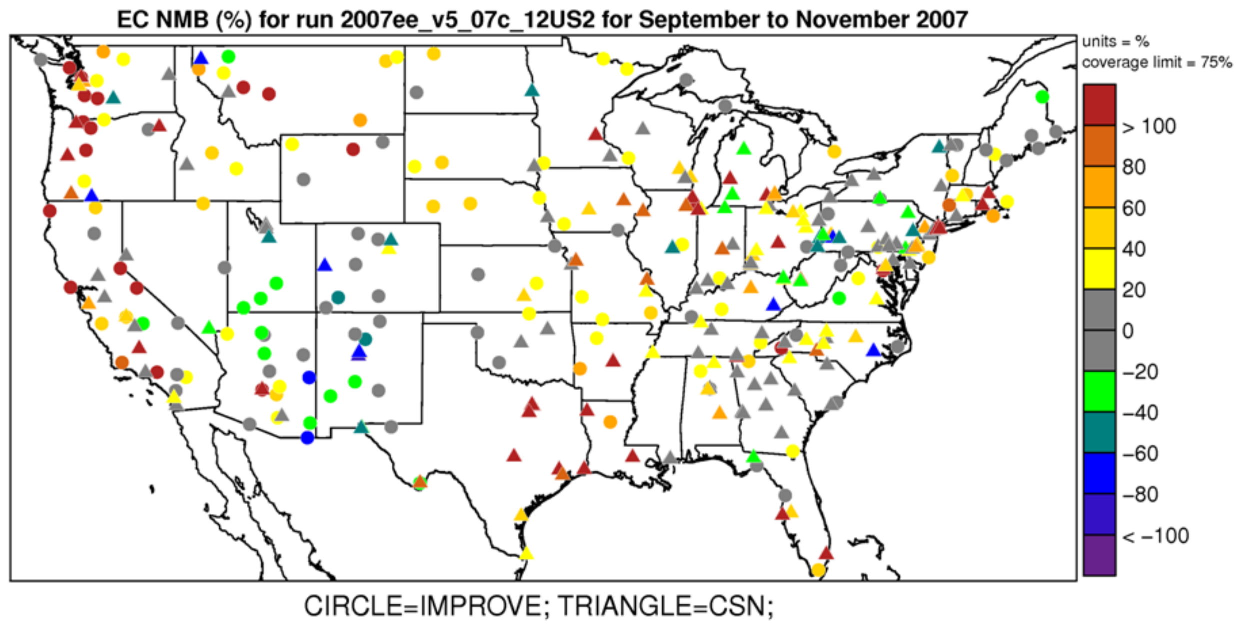

Figure A-31a. Normalized Mean Bias (%) of elemental carbon during fall 2007 at monitoring sites in Continental U.S. modeling domain.

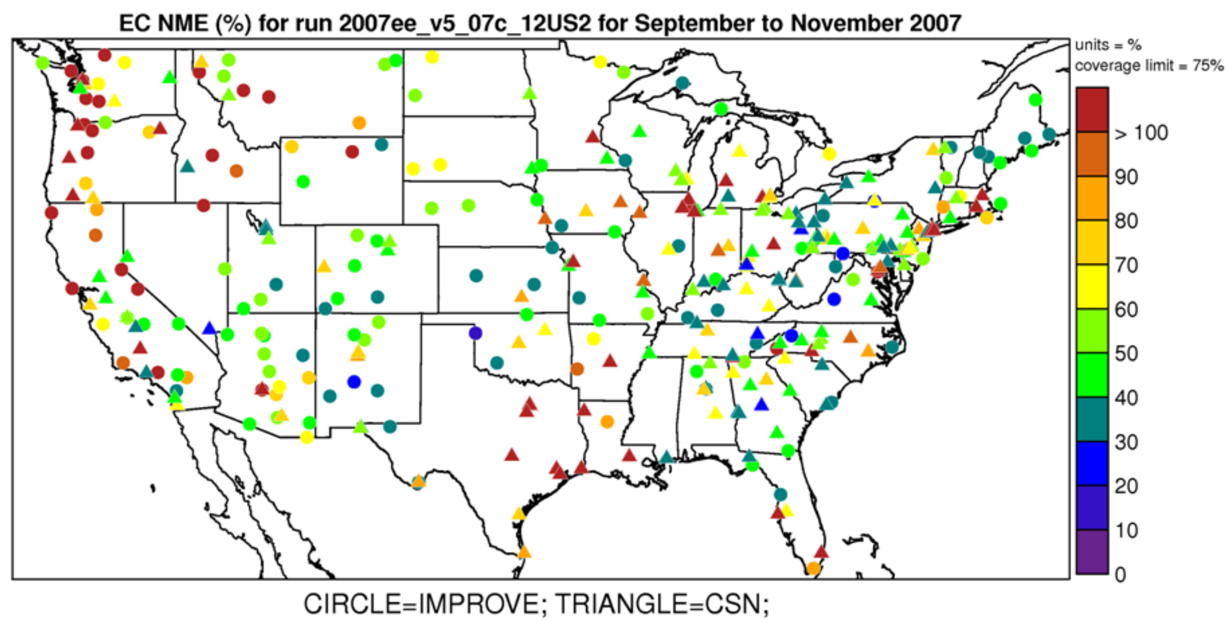

Figure A-31b. Normalized Mean Error (%) of elemental carbon during fall 2007 at monitoring sites in Continental U.S. modeling domain.

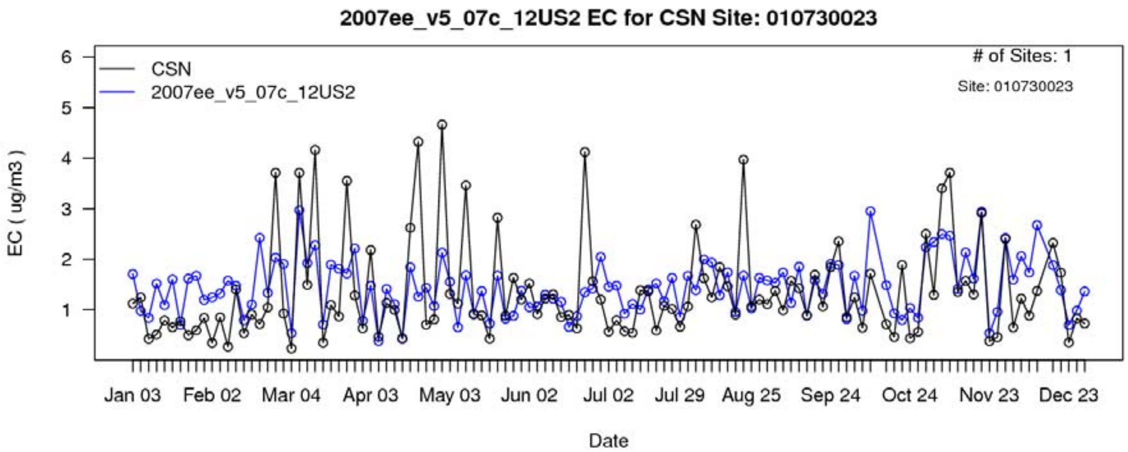

Figure A-32a. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 010730023 in Jefferson County, AL.

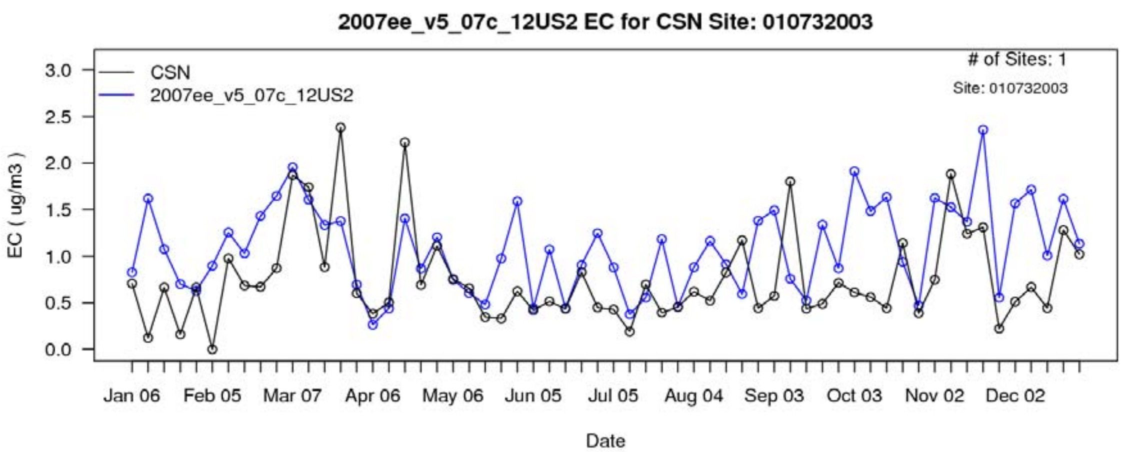

Figure A-32b. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 010732003 in Jefferson County, AL.

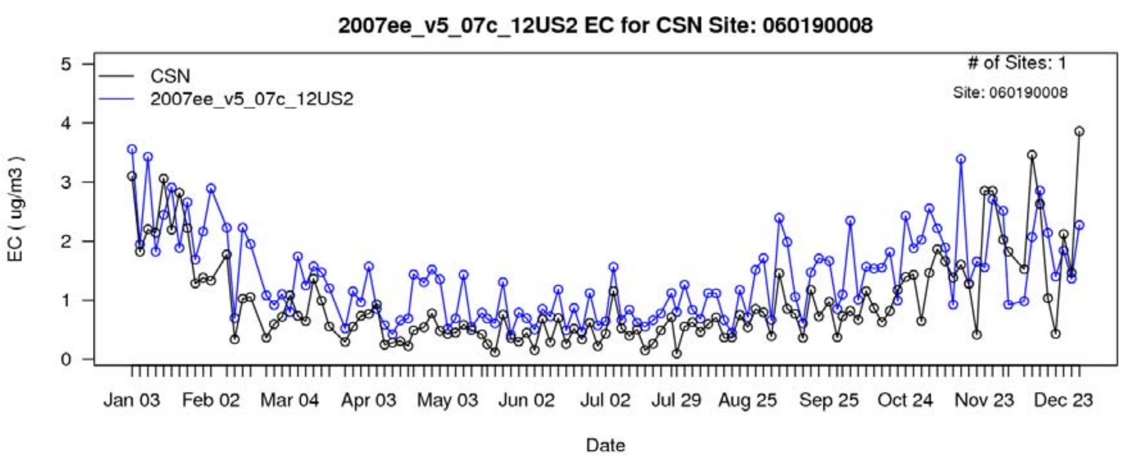

Figure A-32c. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 060190008 in Fresno County, CA.

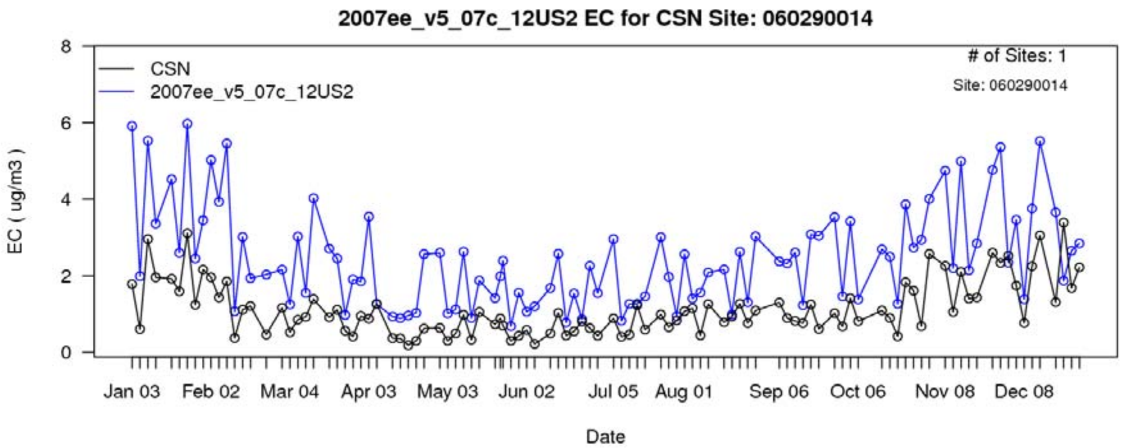

Figure A-32d. Time series of observed (black) and predicted (red) 24-hour average elemental carbon for 2007 at site 060290014 in Kern County, CA.

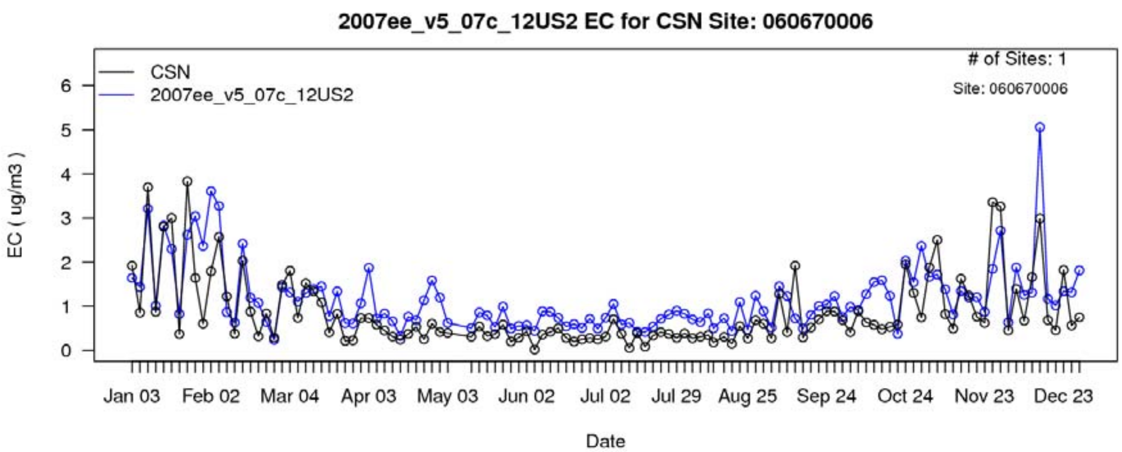

Figure A-32e. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 060990005 in Stanislaus County, CA.

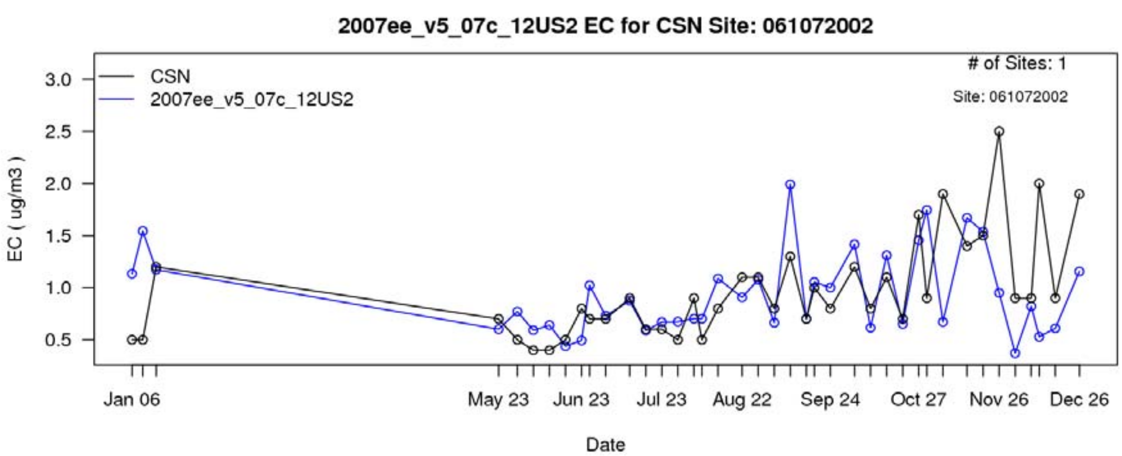

Figure A-32f. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 061072002 in Tulare County, CA.

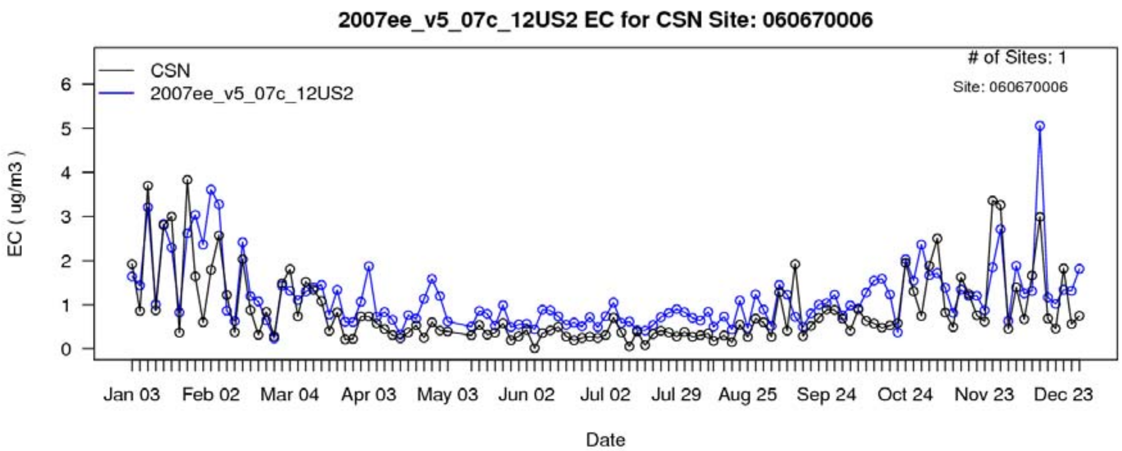

Figure A-32g. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 060670006 in Sacramento County, CA.

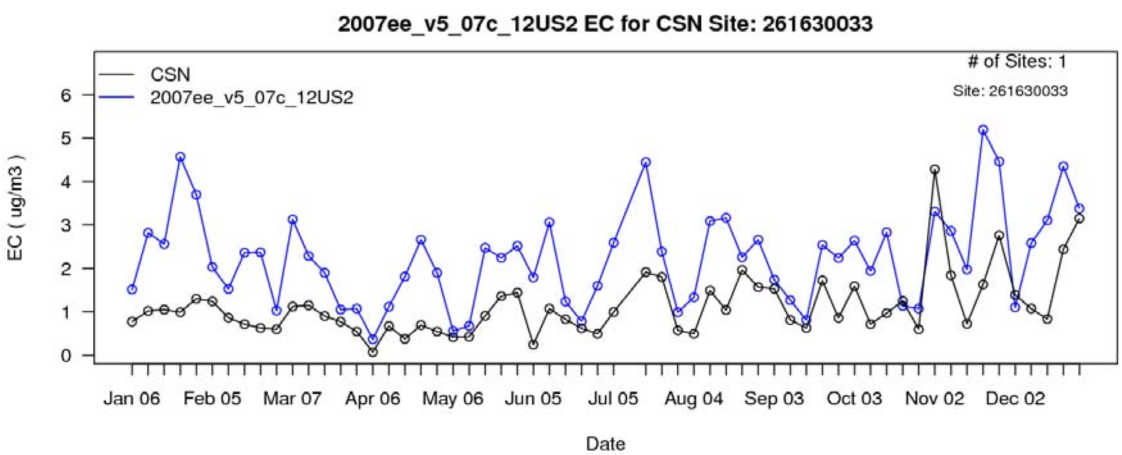

Figure A-32h. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 261630033 in Wayne County, MI.

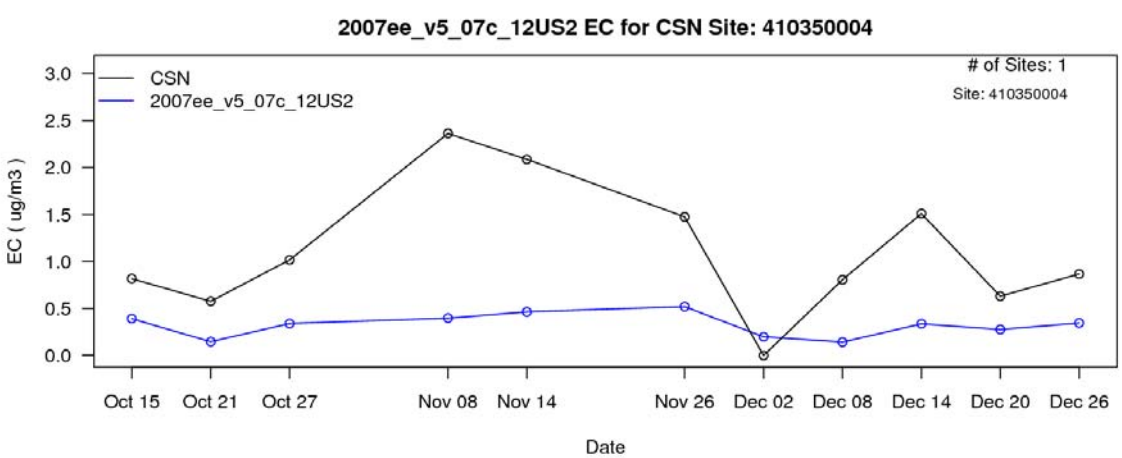

Figure A-32i. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 410350004 in Klamath County, OR.

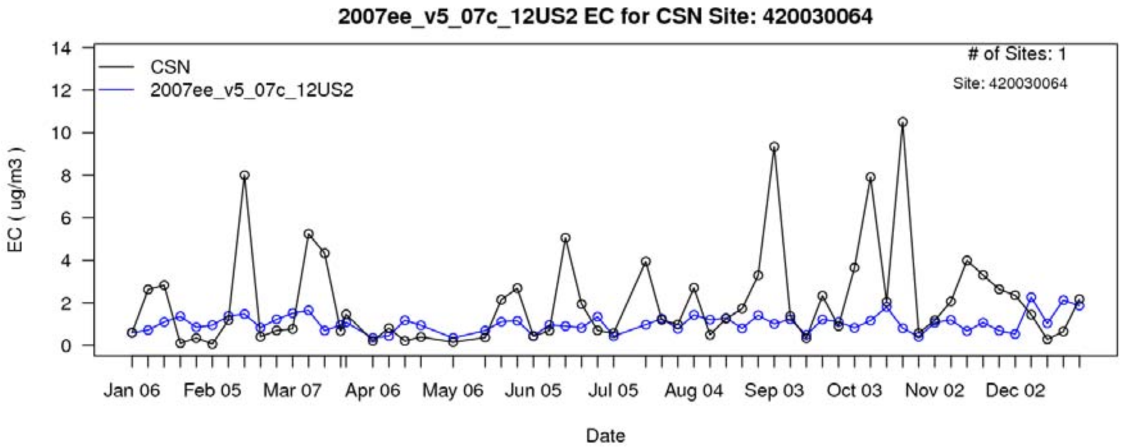

Figure A-32j. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 420030064 in Allegheny County, PA.

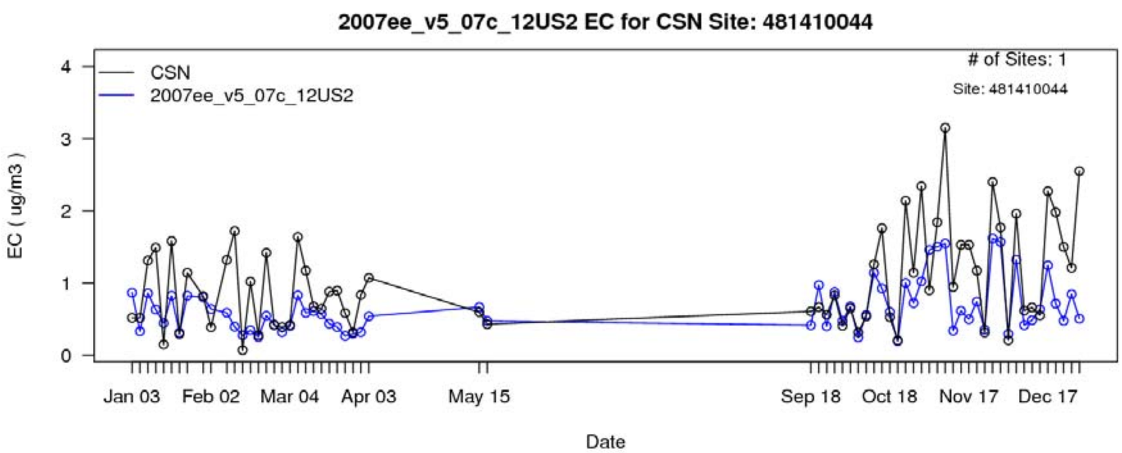

Figure A-32k. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 481410044 in El Paso County, TX.

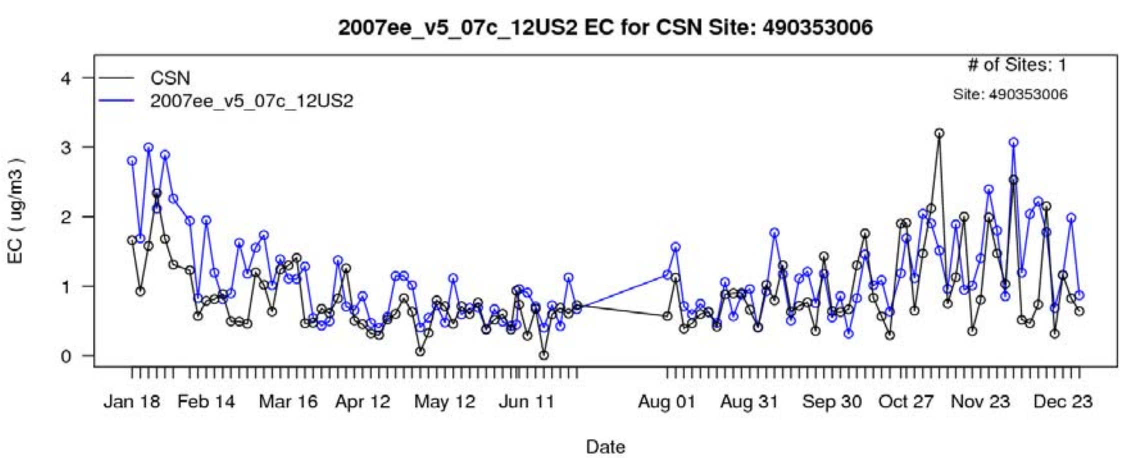

Figure A-32l. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 490353006 in Salt Lake County, UT.

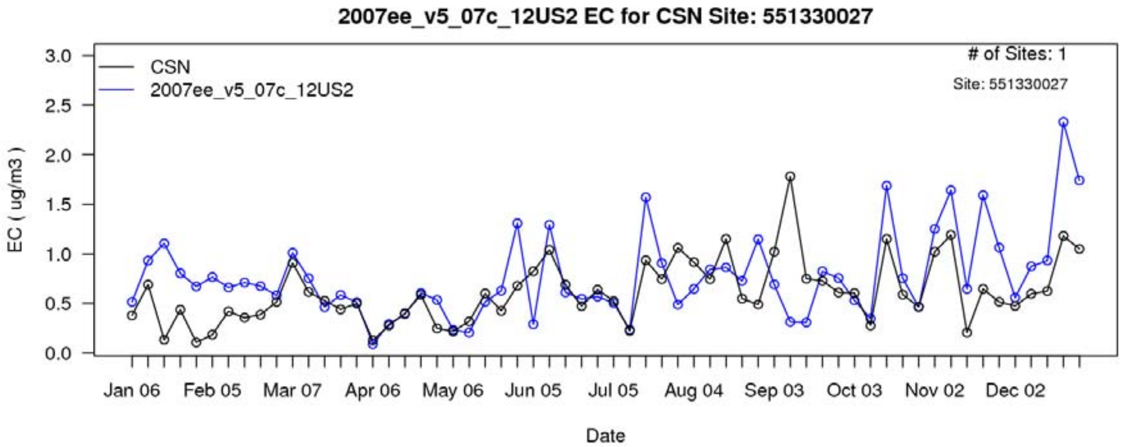

Figure A-32m. Time series of observed (black) and predicted (blue) 24-hour average elemental carbon for 2007 at site 551330027 in Waukesha County, WI.

A.2.5. Model Evaluation for Organic Carbon

The model performance bias and error statistics for organic carbon for each subregion and each season are provided in Table A-8. Spatial plots of the normalized mean bias and error by season for individual monitors are shown in Figures A-33 through A-36. Time series plots of observed and predicted 24-hour average organic carbon concentration at selected CSN monitoring sites are provided in Figure A-37a-o. The statistics in Table A-8 indicate a tendency for the modeling platform to under-predict observed organic carbon concentrations during the spring, summer, and fall at urban and rural locations across the Eastern subregions. There is also a tendency for the modeling platform to under-predict organic carbon at urban and rural locations in the West. The median NMB for the subregions and seasons is -19% with a range of -49.1% to 78.5%. The biases and errors for organic carbon could be due in part to sampling artifacts among each monitoring network. In addition, uncertainties exist for primary organic mass emissions, particularly from residential wood combustion, and secondary organic aerosol formation. The large under-prediction of organic carbon in winter for Klamath County (Figure A-37k) is likely caused by an under-estimation of residential wood combustion emissions and possibly challenges associated with simulating meteorology in complex terrain. Research efforts are ongoing to improve fire and residential wood combustions emission estimates as well as to improve understanding of the formation of semi-volatile organic compounds and their subsequent partitioning between the gas and particulate phases.

Table A-8. Organic Carbon performance statistics by subregion, by season for the 2007 CMAQ model simulation.

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
Central U.S.	CSN	Winter	515	37.1	85.9	23.6	65.5
		Spring	604	-32.4	59.3	-38.6	66.8
		Summer	552	-39.4	49.3	-46.5	63.9
		Fall	588	-7.2	53.8	-19.0	54.9
	IMPROVE	Winter	556	-1.2	50.2	-17.2	44.6
		Spring	661	-48.4	66.0	-74.6	84.0
		Summer	659	-47.7	57.8	-85.6	90.8
		Fall	644	-19.2	49.9	-52.1	64.6
Midwest	CSN	Winter	539	56.6	86.4	57.4	74.1
		Spring	578	-28.0	56.0	-5.6	62.3
		Summer	596	-47.2	52.5	-61.7	69.2
		Fall	591	-19.8	41.1	-17.8	45.2
	IMPROVE	Winter	161	34.5	55.7	25.1	46.1
		Spring	182	-38.6	51.9	-41.2	61.7
		Summer	174	-44.6	56.1	-76.0	80.9
		Fall	145	-30.4	42.4	-47.3	57.5

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
Southeast	CSN	Winter	654	-15.7	43.9	-10.3	49.8
		Spring	728	-45.4	54.6	-45.4	68.0
		Summer	485	-43.9	53.8	-72.2	79.9
		Fall	690	-23.9	42.0	-23.4	49.7
	IMPROVE	Winter	479	0.7	53.8	-23.7	53.6
		Spring	512	-48.6	59.5	-60.0	69.4
		Summer	485	-49.1	54.6	-65.4	76.7
		Fall	492	-20.7	40.2	-39.7	54.2
Northeast	CSN	Winter	698	78.5	94.8	59.1	71.4
		Spring	735	7.3	61.8	18.8	66.1
		Summer	752	-46.7	54.5	-59.9	74.5
		Fall	761	-2.7	53.1	-0.9	52.5
	IMPROVE	Winter	565	73.9	92.1	34.1	52.4
		Spring	621	1.6	60.5	-4.2	54.1
		Summer	615	-42.2	55.0	-67.7	76.7
		Fall	569	9.7	56.4	-14.9	51.8
West without California	CSN	Winter	431	-14.3	66.2	5.0	71.1
		Spring	470	-0.5	70.2	-3.1	70.2
		Summer	471	-18.3	63.0	-39.2	73.2
		Fall	472	-10.7	63.3	-12.8	61.3
	IMPROVE	Winter	1,747	4.3	76.3	-23.2	67.0
		Spring	1,978	-41.5	76.6	-75.5	92.6
		Summer	1,976	-6.4	74.2	-66.4	86.8
		Fall	1,898	2.2	81.4	-40.9	73.5
California	CSN	Winter	190	-27.0	48.7	-11.2	58.9
		Spring	183	6.9	45.1	19.6	50.4
		Summer	215	-22.3	39.5	-18.6	43.5
		Fall	214	-8.2	37.5	-1.1	36.9
	IMPROVE	Winter	460	15.2	71.7	-2.1	62.0
		Spring	516	-26.0	55.0	-33.4	65.3
		Summer	523	-20.3	62.6	-27.9	66.1
		Fall	495	11.8	74.3	-8.5	62.4

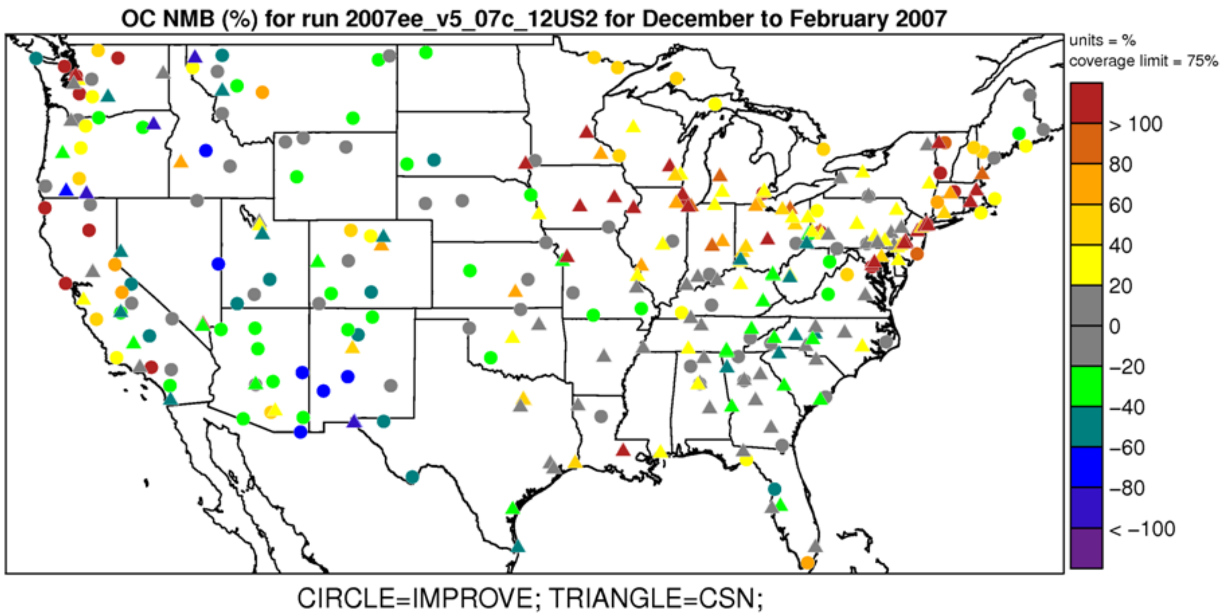

Figure A-33a. Normalized Mean Bias (%) of organic carbon during winter 2007 at monitoring sites in Continental U.S. modeling domain.

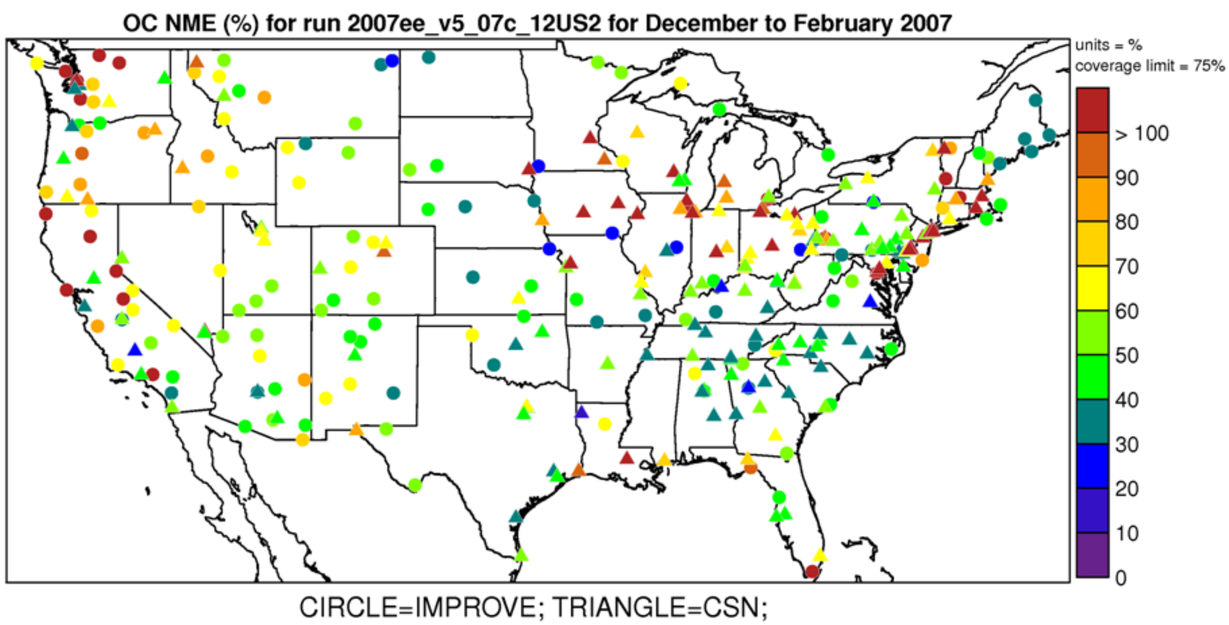

Figure A-33b. Normalized Mean Error (%) of organic carbon during winter 2007 at monitoring sites in Continental U.S. modeling domain.

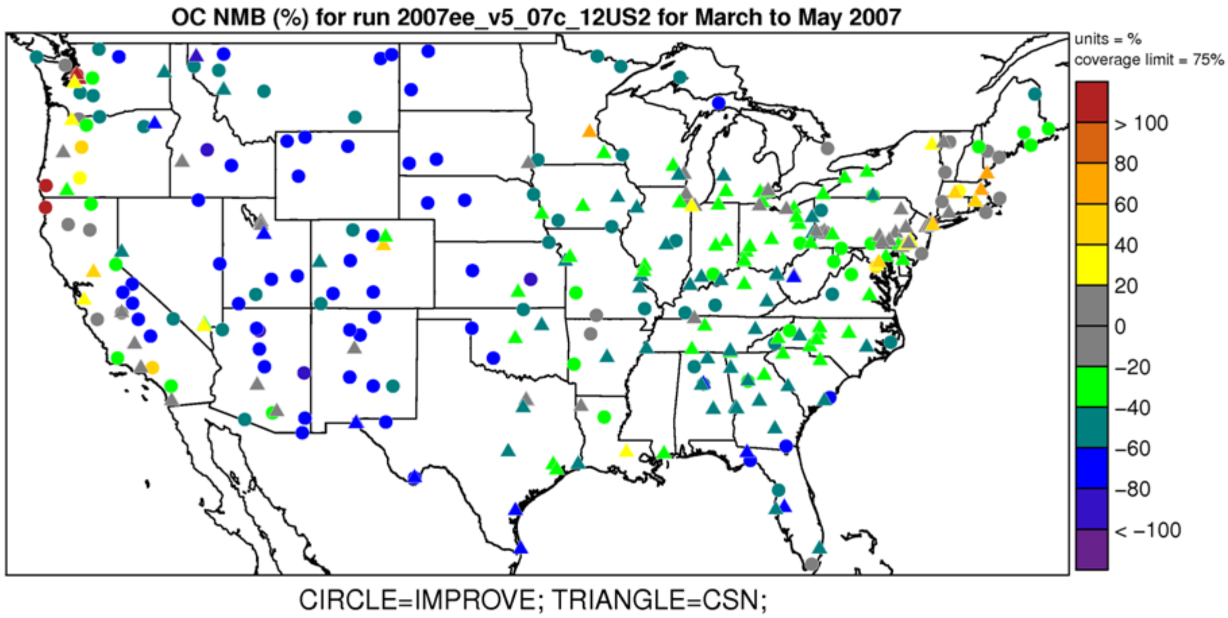

Figure A-34a. Normalized Mean Bias (%) of organic carbon during spring 2007 at monitoring sites in Continental U.S. modeling domain.

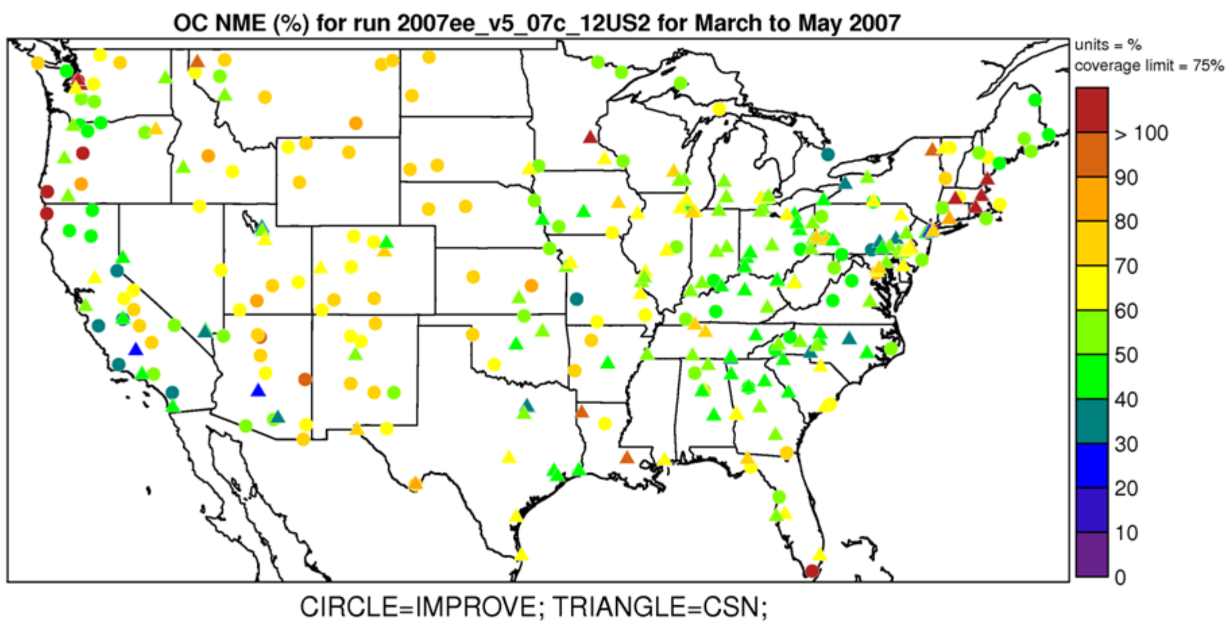

Figure A-34b. Normalized Mean Error (%) of organic carbon during spring 2007 at monitoring sites in Continental U.S. modeling domain.

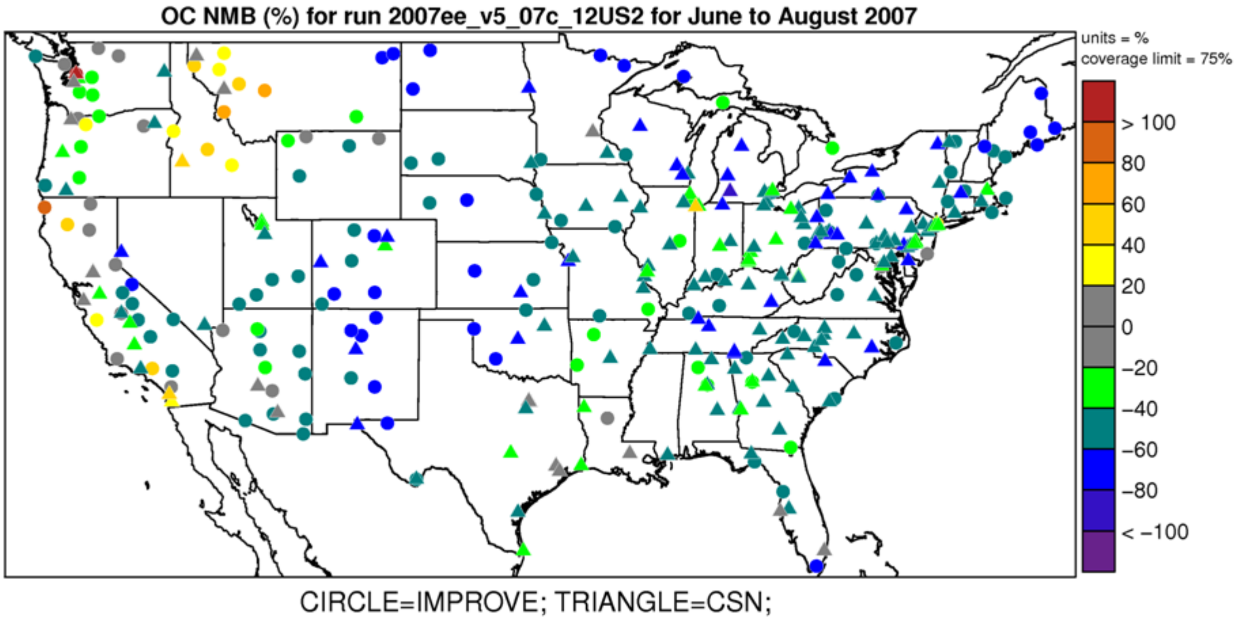

Figure A-35a. Normalized Mean Bias (%) of organic carbon during summer 2007 at monitoring sites in Continental U.S. modeling domain.

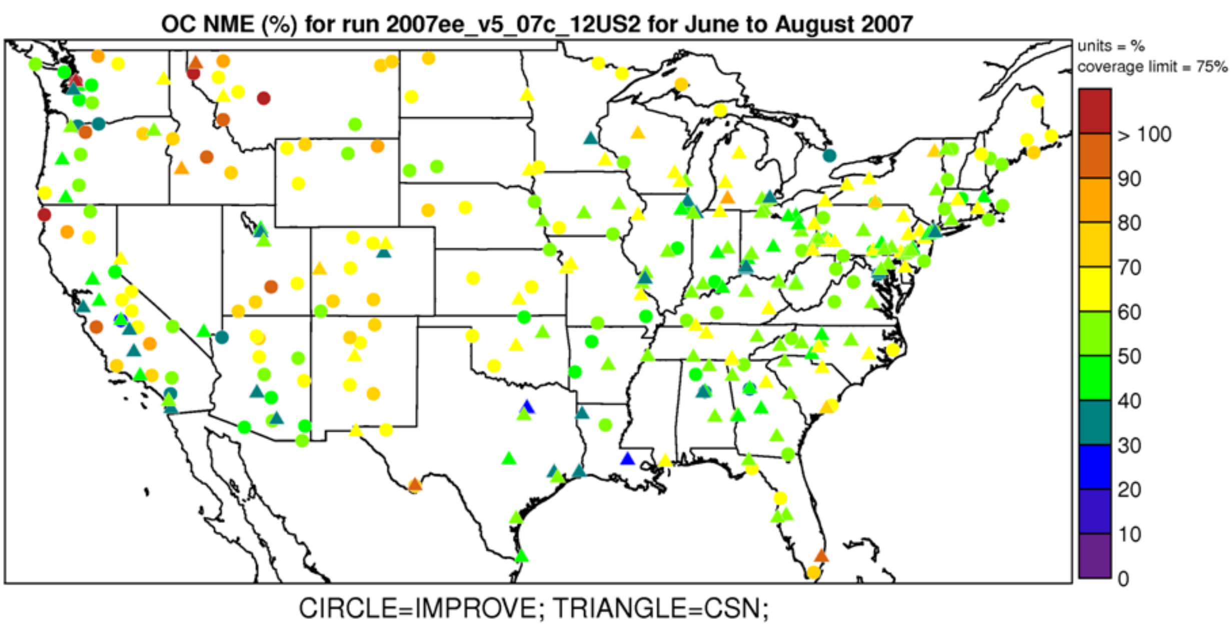

Figure A-35b. Normalized Mean Error (%) of organic carbon during summer 2007 at monitoring sites in Continental U.S. modeling domain.

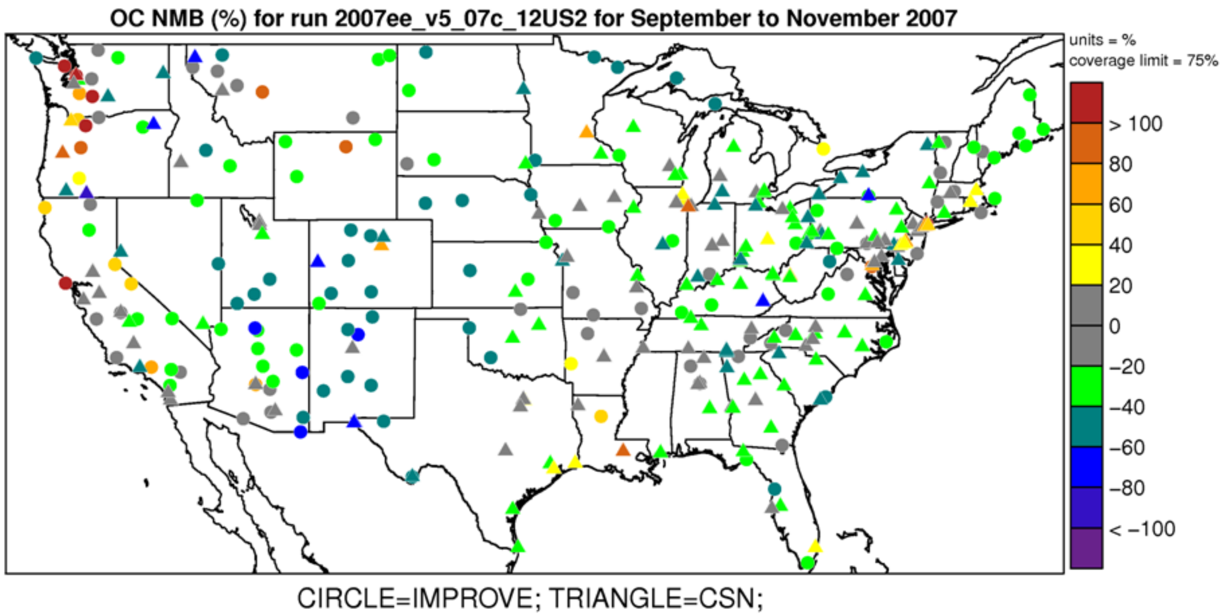

Figure A-36a. Normalized Mean Bias (%) of organic carbon during fall 2007 at monitoring sites in Continental U.S. modeling domain.

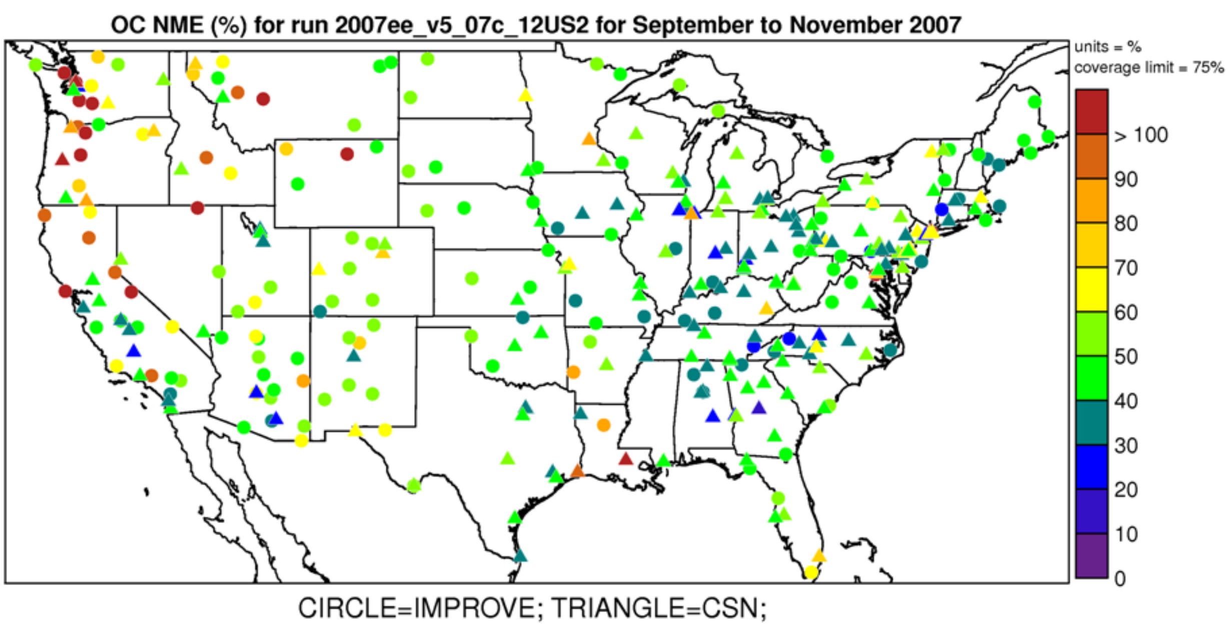

Figure A-36b. Normalized Mean Error (%) of organic carbon during fall 2007 at monitoring sites in Continental U.S. modeling domain.

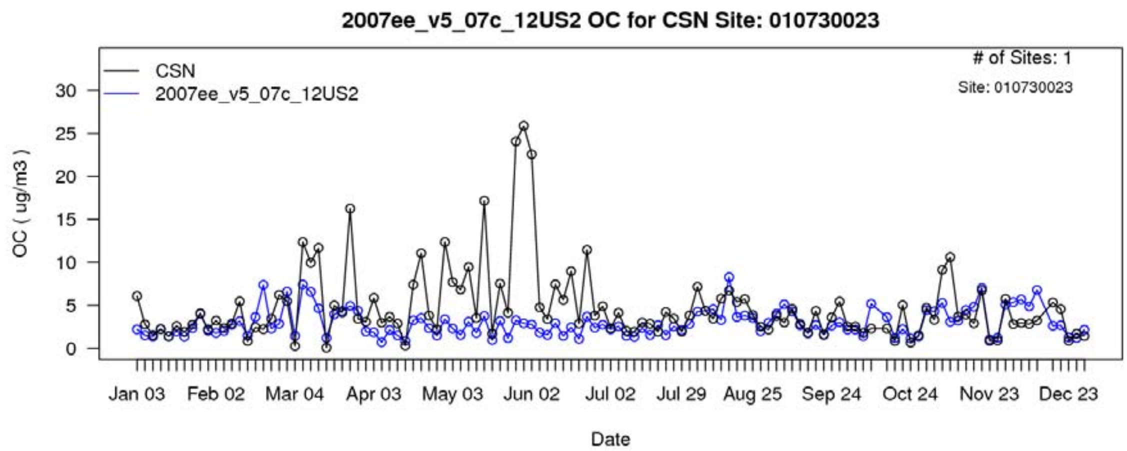

Figure A-37a. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 010730023 in Jefferson County, AL.

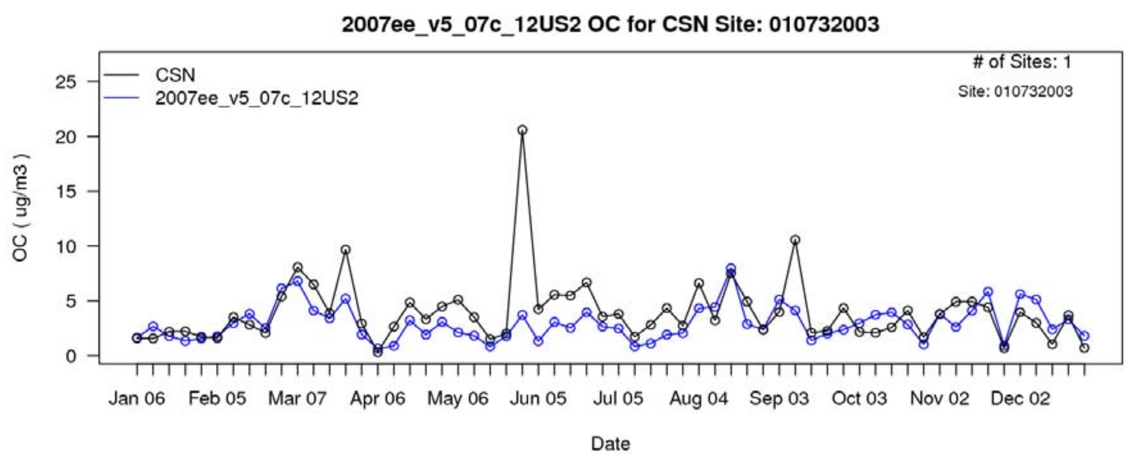

Figure A-37b. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 010732003 in Jefferson County, AL.

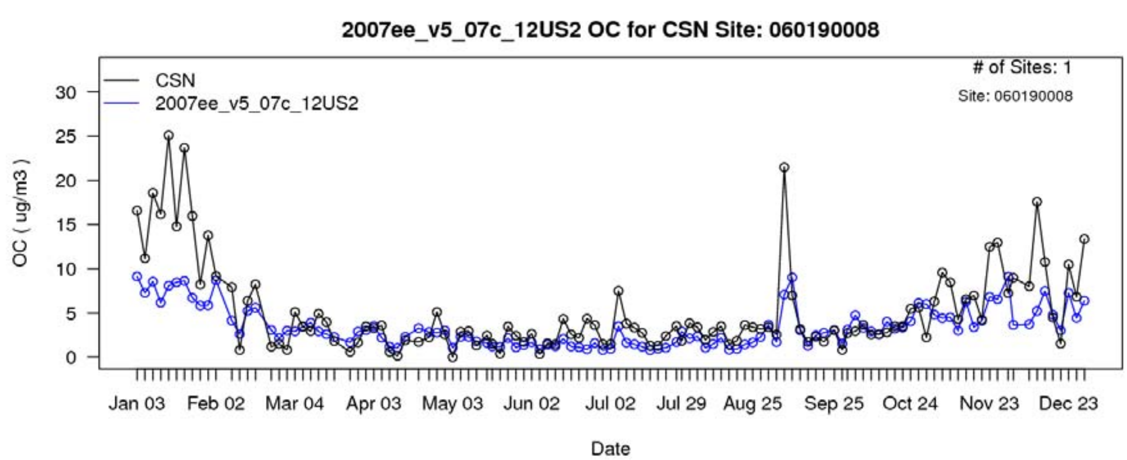

Figure A-37c. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 060190008 in Fresno County, CA.

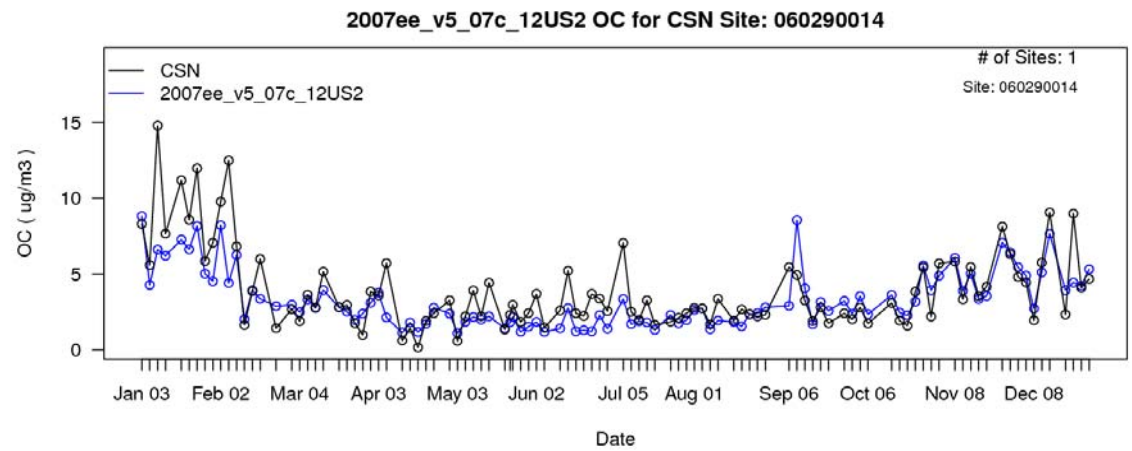

Figure A-37d. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 060290014 in Kern County, CA.

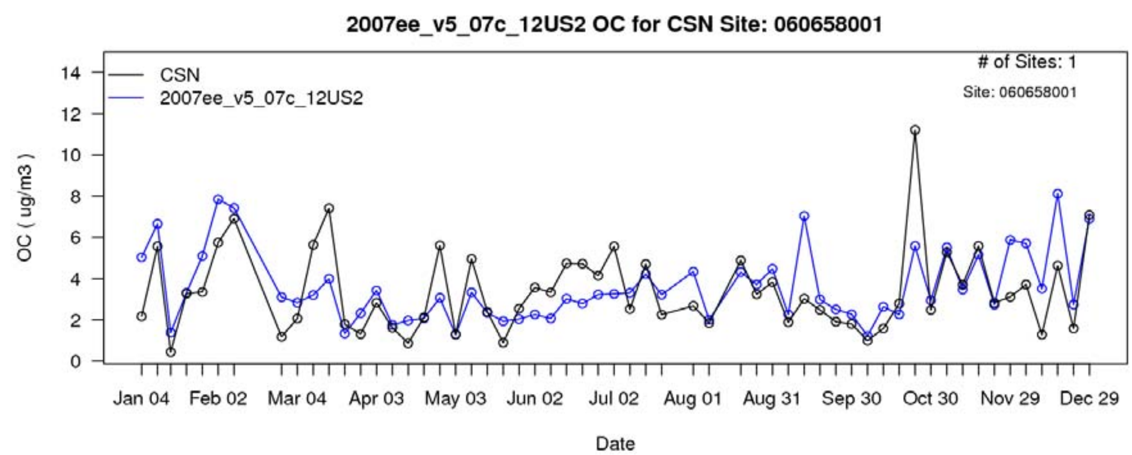

Figure A-37e. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 060658001 in Riverside County, CA.

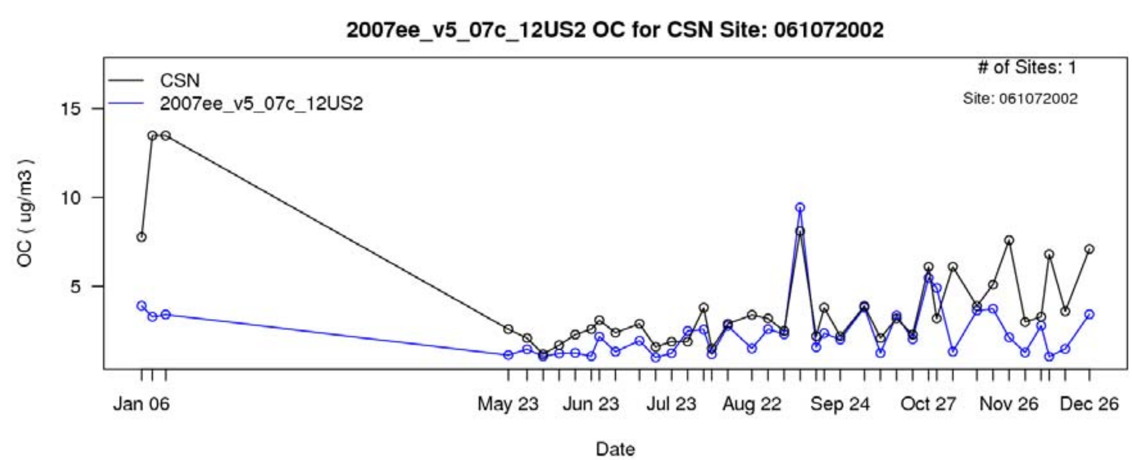

Figure A-37f. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 060712002 in San Bernardino County, CA.

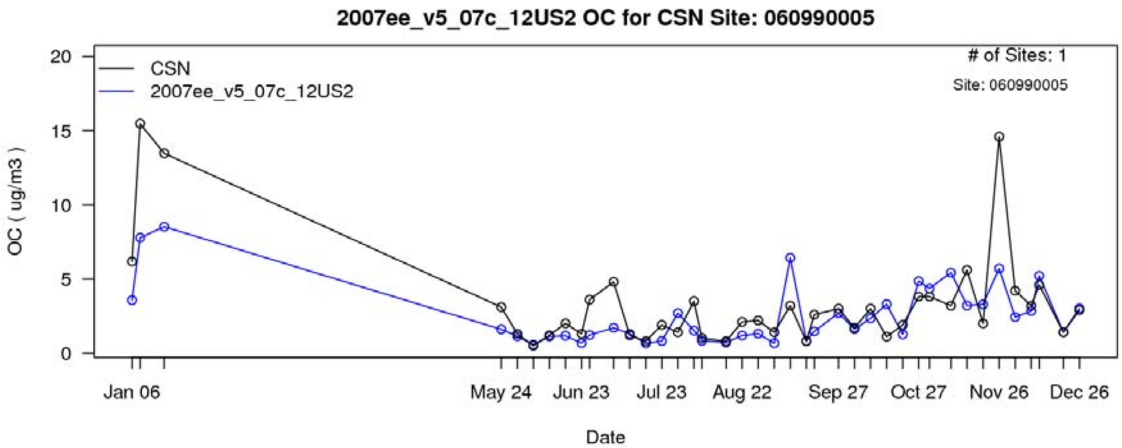

Figure A-37g. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 060990005 in Stanislaus County, CA.

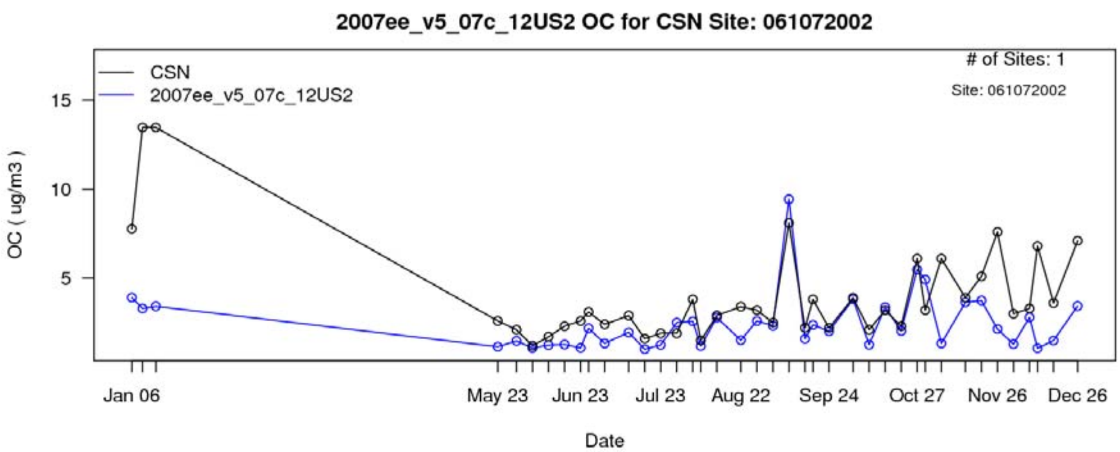

Figure A-37h. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 061072002 in Tulare County, CA.

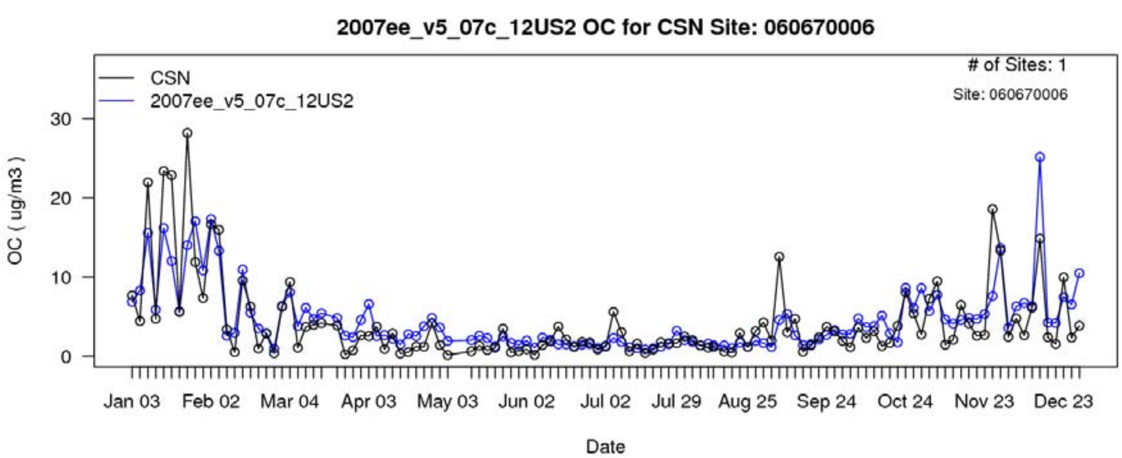

Figure A-37i. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 060670006 in Sacramento County, CA.

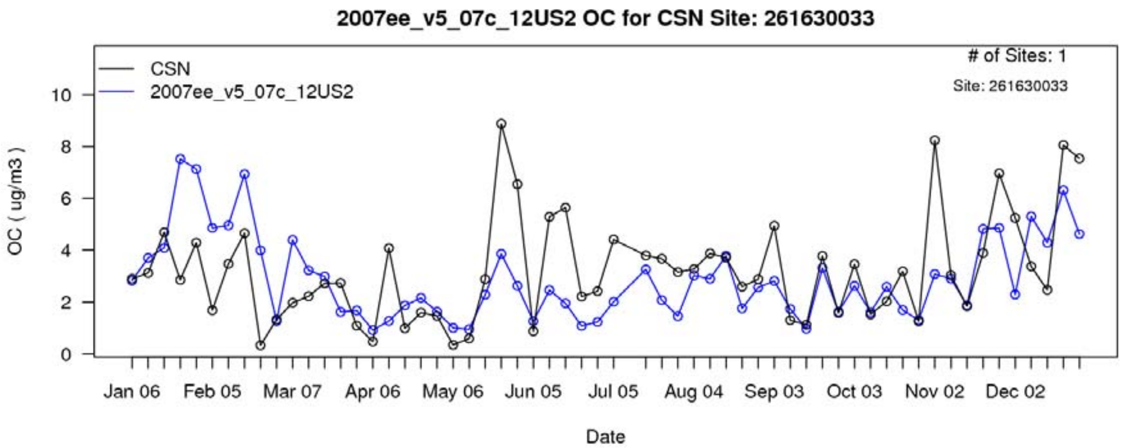

Figure A-37j. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 261630033 in Wayne County, MI.

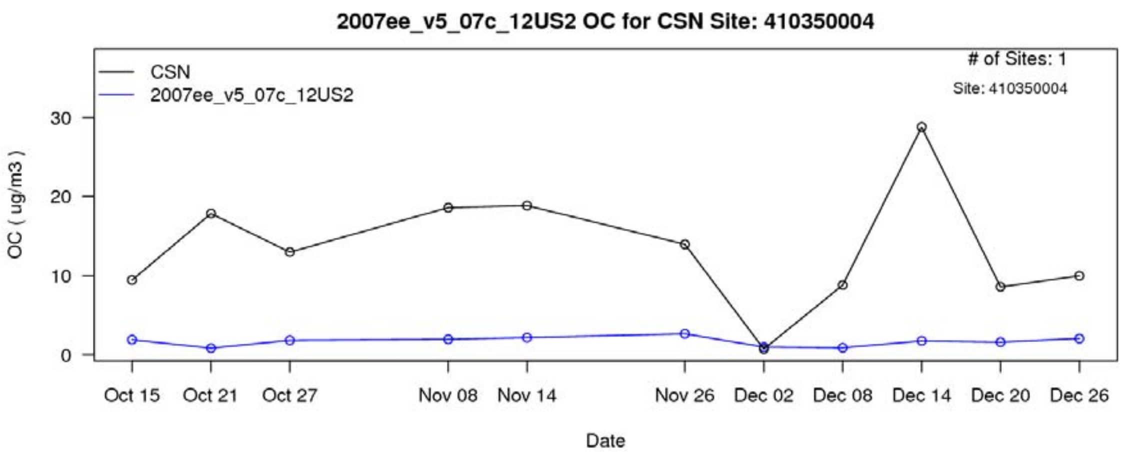

Figure A-37k. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 410350004 in Klamath County, OR.

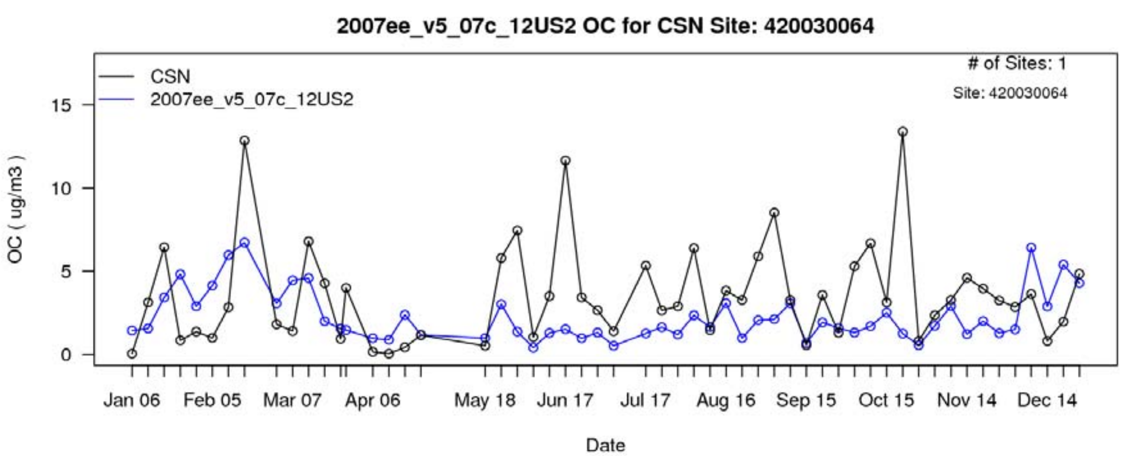

Figure A-37l. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 420030064 in Allegheny County, PA.

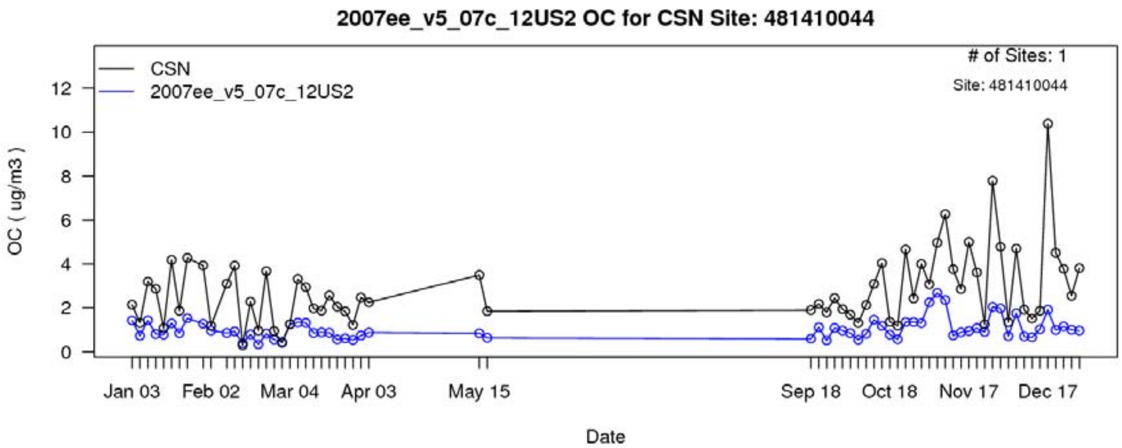

Figure A-37m. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 481410044 in El Paso County, TX.

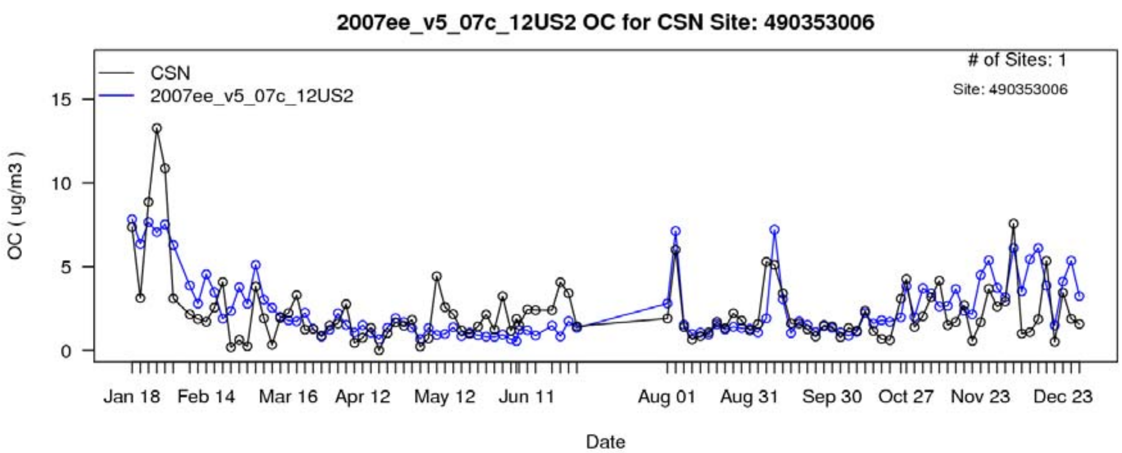

Figure A-37n. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 490353006 in Salt Lake County, UT.

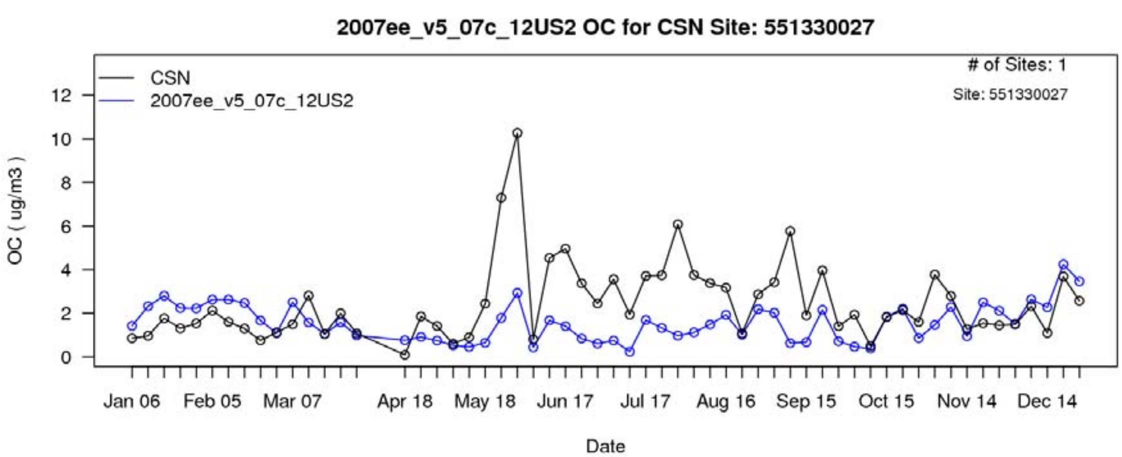

Figure A-37o. Time series of observed (black) and predicted (blue) 24-hour average organic carbon for 2007 at site 551330027 in Waukesha County, WI.

A.2.6. Model Evaluation for Crustal Material

The model performance bias and error statistics for crustal material for each subregion and each season are provided in Table A-9. As indicated by the performance statistics in this table, the modeling platform over-predicts observed concentrations at urban and rural sites in each season for all four subregions. The magnitude of the over-prediction is quite large with NMBs that exceed 100 percent. Research is ongoing to improve understanding of the chemical speciation of crustal $PM_{2.5}$ in order to develop better estimates of emissions of this material.

Table A-9. Crustal Material performance statistics by subregion, by season for the 2007 CMAQ model simulation

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
Central U.S.	CSN	Winter	579	484.0	522.0	141.0	146.0
		Spring	665	183.0	236.0	91.2	111.0
		Summer	621	25.7	119.0	47.7	101.0
		Fall	658	335.0	364.0	121.0	128.0
	IMPROVE	Winter	587	220.0	250.0	93.1	105.0
		Spring	673	57.0	108.0	25.7	72.0
		Summer	673	-26.5	72.9	-17.8	71.5
		Fall	639	111.0	125.0	59.4	76.4
Midwest	CSN	Winter	571	732.0	734.0	157.0	157.0
		Spring	640	239.0	251.0	109.0	113.0
		Summer	600	328.0	333.0	116.0	118.0
		Fall	612	462.0	463.0	135.0	135.0
	IMPROVE	Winter	143	343.0	346.0	112.0	115.0
		Spring	142	143.0	153.0	61.3	80.5
		Summer	152	116.0	150.0	47.6	75.5
		Fall	145	196.0	201.0	84.3	92.9
Southeast	CSN	Winter	741	626.0	629.0	145.0	146.0
		Spring	805	179.0	198.0	88.4	95.3
		Summer	757	58.2	110.0	50.8	82.1
		Fall	758	374.0	381.0	127.0	130.0
	IMPROVE	Winter	462	344.0	379.0	117.0	124.0
		Spring	490	131.0	150.0	61.9	78.5
		Summer	483	-4.2	86.7	-3.8	76.8
		Fall	489	183.0	196.0	86.3	97.3
Northeast	CSN	Winter	853	1000.0	1000.0	162.0	162.0
		Spring	923	308.0	314.0	117.0	119.0
		Summer	890	282.0	286.0	109.0	111.0

Region	Network	Season	No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
		Fall	905	452.0	456.0	137.0	138.0
	IMPROVE	Winter	562	606.0	607.0	140.0	141.0
		Spring	594	208.0	224.0	91.7	101.0
		Summer	595	120.0	134.0	63.2	74.3
		Fall	573	289.0	290.0	111.0	112.0
West without California	CSN	Winter	519	488.0	501.0	125.0	131.0
		Spring	593	117.0	161.0	55.8	89.9
		Summer	561	135.0	180.0	49.1	89.4
		Fall	562	298.0	319.0	96.4	110.0
	IMPROVE	Winter	1,907	152.0	205.0	53.0	88.3
		Spring	2,087	-51.4	86.4	-55.8	95.7
		Summer	2,044	10.9	123.0	-34.6	88.0
		Fall	2,033	45.8	129.0	18.2	82.6
California	CSN	Winter	257	643.0	652.0	143.0	146.0
		Spring	292	196.0	228.0	98.0	112.0
		Summer	279	166.0	199.0	89.6	106.0
		Fall	257	643.0	652.0	143.0	146.0
	IMPROVE	Winter	495	283.0	336.0	59.3	99.9
		Spring	565	-14.4	82.5	-22.0	83.1
		Summer	552	16.3	83.6	2.9	73.5
		Fall	495	283.0	336.0	59.3	99.9

Appendix B

$PM_{2.5}$ Design Values for Ambient 2005-2009 Data and the Adjusted 2020 Base Case

Annual and 24-hr $PM_{2.5}$ Design Values for 2005-2009 Ambient Data and for the Adjusted 2020 Base Case are provided in Table B-1 of this appendix. See Section 3.2 for additional details.

Table B-1. Annual and 24-hr $PM_{2.5}$ Design Values for 2005-2009 Ambient Data and for the Adjusted 2020 Base Case

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
10030010	1003	Alabama	Baldwin	10.80	23.7	7.38	15.4
10270001	1027	Alabama	Clay	12.04	27.2	8.06	15.7
10331002	1033	Alabama	Colbert	12.05	28.1	8.27	15.7
10491003	1049	Alabama	DeKalb	12.79	28.4	7.91	15.8
10530002	1053	Alabama	Escambia	13.18	28.2	9.72	20.0
10550010	1055	Alabama	Etowah	13.87	NA	8.89	NA
10690003	1069	Alabama	Houston	11.89	25.5	8.59	18.0
10730023	1073	Alabama	Jefferson	17.01	38.8	11.56	25.9
10731005	1073	Alabama	Jefferson	14.11	29.8	9.77	20.0
10731009	1073	Alabama	Jefferson	12.49	30.6	8.67	18.6
10731010	1073	Alabama	Jefferson	14.58	29.9	9.67	18.6
10732003	1073	Alabama	Jefferson	15.92	36.7	11.39	27.0
10732006	1073	Alabama	Jefferson	13.75	28.8	9.36	17.2
10735002	1073	Alabama	Jefferson	13.37	31.1	8.54	17.6
10735003	1073	Alabama	Jefferson	13.18	31.9	8.49	17.8
10890014	1089	Alabama	Madison	12.80	29.5	8.06	16.5
10970003	1097	Alabama	Mobile	11.39	24.1	8.01	15.8
10972005	1097	Alabama	Mobile	11.09	NA	7.58	NA
11010007	1101	Alabama	Montgomery	13.70	29.1	9.85	21.0
11030011	1103	Alabama	Morgan	12.59	28.9	8.17	15.7
11130001	1113	Alabama	Russell	14.29	30.3	10.28	22.5
11170006	1117	Alabama	Shelby	13.11	28.4	8.83	19.4
11250004	1125	Alabama	Tuscaloosa	12.59	26.9	8.77	16.8
11270002	1127	Alabama	Walker	13.06	29.6	8.71	17.7
40031005	4003	Arizona	Cochise	6.83	12.9	7.05	13.4
40051008	4005	Arizona	Coconino	6.93	18.7	6.63	18.1
40070008	4007	Arizona	Gila	8.93	22.7	8.54	21.3
40130019	4013	Arizona	Maricopa	11.50	28.6	9.71	22.8
40131003	4013	Arizona	Maricopa	8.88	17.1	7.95	15.4
40134003	4013	Arizona	Maricopa	11.98	29.0	10.46	24.7
40137020	4013	Arizona	Maricopa	7.24	13.7	6.51	12.2
40139997	4013	Arizona	Maricopa	9.44	23.0	8.04	19.3
40190011	4019	Arizona	Pima	5.79	12.1	5.36	11.5

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
40191028	4019	Arizona	Pima	5.64	11.8	5.21	10.8
40210001	4021	Arizona	Pinal	9.33	19.5	8.65	17.8
40213002	4021	Arizona	Pinal	6.49	12.8	5.97	11.8
50010011	5001	Arkansas	Arkansas	11.82	27.3	8.82	17.4
50030005	5003	Arkansas	Ashley	12.03	25.9	9.26	18.3
50350005	5035	Arkansas	Crittenden	12.53	31.0	8.50	17.0
50450002	5045	Arkansas	Faulkner	11.82	26.0	8.99	18.8
50510003	5051	Arkansas	Garland	11.79	26.1	9.10	17.7
50670001	5067	Arkansas	Jackson	11.19	26.1	8.24	17.4
51070001	5107	Arkansas	Phillips	11.68	26.9	8.12	16.4
51130002	5113	Arkansas	Polk	11.38	25.5	8.89	18.0
51150003	5115	Arkansas	Pope	12.30	26.6	9.73	19.8
51190007	5119	Arkansas	Pulaski	12.37	28.0	9.34	19.6
51191004	5119	Arkansas	Pulaski	12.85	30.3	9.79	21.3
51191008	5119	Arkansas	Pulaski	12.01	26.7	9.18	19.6
51310008	5131	Arkansas	Sebastian	11.42	24.5	8.96	17.8
51390006	5139	Arkansas	Union	12.02	25.7	9.32	18.8
51450001	5145	Arkansas	White	11.54	27.9	8.64	19.3
60010007	6001	California	Alameda	9.43	42.0	8.18	33.0
60011001	6001	California	Alameda	9.35	35.5	8.06	27.6
60070002	6007	California	Butte	12.62	60.9	10.65	33.9
60090001	6009	California	Calaveras	7.90	27.0	7.02	23.6
60130002	6013	California	Contra Costa	8.87	36.1	7.78	32.5
60190008	6019	California	Fresno	17.40	60.5	13.44	39.6
60195001	6019	California	Fresno	16.57	57.7	12.78	39.9
60195025	6019	California	Fresno	16.70	58.1	13.14	39.7
60231002	6023	California	Humboldt	7.38	24.3	6.91	23.0
60231004	6023	California	Humboldt	7.30	24.7	6.84	23.4
60250005	6025	California	Imperial	12.90	39.0	13.20	37.7
60250007	6025	California	Imperial	8.03	20.1	7.55	19.2
60251003	6025	California	Imperial	8.48	20.3	8.17	19.3
60271003	6027	California	Inyo	6.14	30.8	5.85	29.2
60290010	6029	California	Kern	19.10	69.6	14.26	44.5
60290014	6029	California	Kern	20.47	66.5	15.41	42.3
60290016	6029	California	Kern	21.47	69.1	16.29	43.4
60310004	6031	California	Kings	17.28	59.2	13.57	41.0
60333001	6033	California	Lake	4.84	22.9	4.58	22.3
60370002	6037	California	Los Angeles	15.54	43.3	12.37	32.1

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
60371002	6037	California	Los Angeles	16.06	43.8	12.61	32.9
60371103	6037	California	Los Angeles	16.18	44.3	12.62	33.8
60371201	6037	California	Los Angeles	12.14	NA	9.53	NA
60371301	6037	California	Los Angeles	16.23	43.6	12.48	34.8
60371602	6037	California	Los Angeles	16.07	44.4	12.37	33.9
60372005	6037	California	Los Angeles	13.64	38.1	10.63	28.7
60374002	6037	California	Los Angeles	14.07	38.3	10.50	29.4
60374004	6037	California	Los Angeles	13.26	35.5	9.86	26.9
60379033	6037	California	Los Angeles	7.77	18.5	6.37	14.5
60450006	6045	California	Mendocino	6.81	19.0	6.38	17.9
60472510	6047	California	Merced	14.70	52.1	12.63	36.3
60531003	6053	California	Monterey	6.90	14.2	5.96	11.5
60570005	6057	California	Nevada	6.14	27.1	5.79	25.9
60571001	6057	California	Nevada	6.91	22.4	6.61	21.4
60590007	6059	California	Orange	13.18	38.8	10.15	31.4
60592022	6059	California	Orange	10.66	28.8	7.92	21.7
60610006	6061	California	Placer	9.43	28.3	8.47	26.3
60631006	6063	California	Plumas	10.32	31.9	9.98	30.6
60631009	6063	California	Plumas	11.48	32.5	11.16	31.3
60651003	6065	California	Riverside	16.29	46.9	12.55	34.5
60652002	6065	California	Riverside	9.24	21.8	8.09	17.7
60655001	6065	California	Riverside	7.63	17.6	6.80	14.4
60658001	6065	California	Riverside	18.24	50.0	14.39	36.1
60658005	6065	California	Riverside	19.41	51.2	15.55	38.3
60670006	6067	California	Sacramento	12.39	56.8	10.71	38.2
60670010	6067	California	Sacramento	11.43	41.5	9.77	30.7
60674001	6067	California	Sacramento	10.96	44.1	9.34	34.0
60690002	6069	California	San Benito	6.24	17.0	5.25	13.5
60710025	6071	California	San Bernardino	17.41	45.0	13.96	34.5
60710306	6071	California	San Bernardino	9.52	18.2	8.00	14.2
60712002	6071	California	San Bernardino	17.25	50.7	13.72	36.6
60718001	6071	California	San Bernardino	9.77	35.1	9.15	29.3
60719004	6071	California	San Bernardino	16.21	51.7	13.10	39.7
60730001	6073	California	San Diego	11.99	29.5	9.55	24.0
60730003	6073	California	San Diego	12.44	NA	9.92	NA
60730006	6073	California	San Diego	10.76	24.7	8.19	19.1
60731002	6073	California	San Diego	12.34	32.7	9.90	28.4
60731010	6073	California	San Diego	12.97	31.4	10.54	25.9

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60750005	6075	California	San Francisco	9.35	32.7	8.08	28.9
60771002	6077	California	San Joaquin	13.04	48.4	11.08	34.5
60792006	6079	California	San Luis Obispo	6.91	17.0	5.50	13.4
60798001	6079	California	San Luis Obispo	8.12	22.7	6.58	16.7
60811001	6081	California	San Mateo	8.87	31.0	7.64	28.3
60830011	6083	California	Santa Barbara	9.98	22.4	8.92	20.6
60831008	6083	California	Santa Barbara	7.64	14.8	6.44	12.0
60850005	6085	California	Santa Clara	10.95	40.3	9.71	29.8
60870007	6087	California	Santa Cruz	6.47	13.4	5.72	12.2
60890004	6089	California	Shasta	6.88	22.1	6.64	21.3
60950004	6095	California	Solano	9.81	40.0	8.75	31.2
60970003	6097	California	Sonoma	8.24	30.4	7.60	28.3
60990005	6099	California	Stanislaus	14.83	54.8	12.29	39.6
61010003	6101	California	Sutter	9.55	42.5	8.29	30.5
61072002	6107	California	Tulare	19.25	58.0	15.46	38.5
61110007	6111	California	Ventura	10.32	22.9	7.95	18.4
61110009	6111	California	Ventura	9.71	20.3	7.76	15.7
61112002	6111	California	Ventura	10.94	27.6	8.53	20.9
61113001	6111	California	Ventura	10.26	23.5	8.12	17.6
61131003	6113	California	Yolo	8.66	33.1	7.92	31.9
80010006	8001	Colorado	Adams	9.86	29.4	8.43	25.5
80050005	8005	Colorado	Arapahoe	7.61	19.4	6.40	16.8
80130003	8013	Colorado	Boulder	8.13	22.8	7.23	20.0
80130012	8013	Colorado	Boulder	6.88	19.3	6.06	17.0
80310002	8031	Colorado	Denver	8.85	24.9	7.45	21.2
80310023	8031	Colorado	Denver	9.19	25.1	7.76	21.6
80350004	8035	Colorado	Douglas	6.17	16.6	5.27	14.4
80390001	8039	Colorado	Elbert	4.44	13.5	4.02	12.5
80410011	8041	Colorado	El Paso	7.70	15.8	7.03	15.6
80690009	8069	Colorado	Larimer	7.28	18.8	6.63	17.2
80770017	8077	Colorado	Mesa	9.34	26.1	8.79	25.2
81010012	8101	Colorado	Pueblo	7.69	15.6	7.15	15.7
81230006	8123	Colorado	Weld	8.32	24.1	7.42	21.8
81230008	8123	Colorado	Weld	9.08	NA	8.13	NA
90010010	9001	Connecticut	Fairfield	12.28	32.9	8.49	22.1
90011123	9001	Connecticut	Fairfield	11.83	30.5	8.46	21.9
90013005	9001	Connecticut	Fairfield	11.71	31.5	7.84	18.8
90019003	9001	Connecticut	Fairfield	10.64	30.2	6.89	18.3

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90031003	9003	Connecticut	Hartford	10.00	28.6	7.36	20.7
90050004	9005	Connecticut	Litchfield	8.83	24.0	6.28	14.3
90050005	9005	Connecticut	Litchfield	7.35	25.4	4.98	12.4
90090026	9009	Connecticut	New Haven	11.50	32.1	7.80	19.8
90090027	9009	Connecticut	New Haven	11.60	32.9	7.91	21.1
90091123	9009	Connecticut	New Haven	12.15	33.7	8.55	22.8
90092008	9009	Connecticut	New Haven	10.60	29.3	7.12	19.0
90092123	9009	Connecticut	New Haven	11.84	32.2	8.72	22.4
90113002	9011	Connecticut	New London	10.12	27.9	7.29	18.8
100010002	10001	Delaware	Kent	11.71	29.4	6.99	16.4
100010003	10001	Delaware	Kent	11.65	28.9	7.03	15.6
100031003	10003	Delaware	New Castle	12.83	NA	8.20	NA
100031007	10003	Delaware	New Castle	11.88	28.8	7.36	17.1
100031012	10003	Delaware	New Castle	12.85	28.8	7.99	18.8
100032004	10003	Delaware	New Castle	13.95	34.8	9.06	22.4
100051002	10005	Delaware	Sussex	12.59	30.3	7.79	17.1
110010041	11001	District of Columbia	District of Columbia	13.00	31.9	7.80	19.2
110010042	11001	District of Columbia	District of Columbia	13.12	30.4	7.84	17.3
110010043	11001	District of Columbia	District of Columbia	12.56	31.2	7.45	19.7
120010023	12001	Florida	Alachua	8.35	18.9	5.87	13.4
120010024	12001	Florida	Alachua	8.66	20.8	6.12	15.0
120051004	12005	Florida	Bay	10.55	24.2	7.61	16.8
120090007	12009	Florida	Brevard	7.72	20.5	5.36	15.5
120111002	12011	Florida	Broward	7.71	18.7	5.12	12.1
120112004	12011	Florida	Broward	7.84	19.0	5.22	13.2
120113002	12011	Florida	Broward	7.83	16.8	5.23	11.3
120170005	12017	Florida	Citrus	8.18	18.6	5.40	11.6
120310098	12031	Florida	Duval	9.05	20.9	6.27	14.5
120310099	12031	Florida	Duval	9.60	22.1	6.87	15.7
120330004	12033	Florida	Escambia	10.45	24.0	7.24	15.8
120570030	12057	Florida	Hillsborough	9.56	20.0	6.30	13.6
120573002	12057	Florida	Hillsborough	9.24	19.7	6.16	12.8
120710005	12071	Florida	Lee	7.67	16.4	5.44	11.9
120730012	12073	Florida	Leon	11.11	23.5	8.31	17.9
120814012	12081	Florida	Manatee	8.68	19.2	5.77	12.6
120830003	12083	Florida	Marion	9.59	22.5	6.74	15.7
120860033	12086	Florida	Miami-Dade	7.31	19.2	5.06	11.3

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120861016	12086	Florida	Miami-Dade	8.64	18.5	5.99	10.7
120866001	12086	Florida	Miami-Dade	7.37	17.3	5.54	12.3
120951004	12095	Florida	Orange	8.47	19.0	5.71	12.8
120952002	12095	Florida	Orange	8.41	19.6	5.63	12.9
120990008	12099	Florida	Palm Beach	6.34	15.3	3.98	10.4
120990009	12099	Florida	Palm Beach	7.00	16.3	4.92	11.5
120992005	12099	Florida	Palm Beach	7.03	17.8	4.87	11.7
121030018	12103	Florida	Pinellas	8.90	20.0	5.71	13.6
121031009	12103	Florida	Pinellas	8.63	19.6	5.48	11.6
121056006	12105	Florida	Polk	8.63	17.0	5.89	11.5
121111002	12111	Florida	St. Lucie	7.90	17.7	5.50	13.2
121150013	12115	Florida	Sarasota	7.79	17.4	5.23	12.4
121171002	12117	Florida	Seminole	8.50	19.0	5.74	13.6
121275002	12127	Florida	Volusia	9.25	23.9	6.44	16.4
130210007	13021	Georgia	Bibb	15.06	33.6	10.95	25.3
130210012	13021	Georgia	Bibb	12.73	29.0	8.96	20.5
130510017	13051	Georgia	Chatham	12.54	26.0	8.86	18.7
130510091	13051	Georgia	Chatham	13.68	26.7	9.68	20.5
130590002	13059	Georgia	Clarke	14.90	NA	9.90	NA
130630091	13063	Georgia	Clayton	14.98	30.3	9.39	18.6
130670003	13067	Georgia	Cobb	14.83	32.2	9.27	18.8
130670004	13067	Georgia	Cobb	14.14	30.2	8.63	17.4
130890002	13089	Georgia	DeKalb	14.16	30.8	8.56	17.6
130892001	13089	Georgia	DeKalb	14.25	30.9	8.58	17.5
130950007	13095	Georgia	Dougherty	13.72	33.6	10.47	28.3
131150003	13115	Georgia	Floyd	14.71	34.9	9.51	21.8
131210032	13121	Georgia	Fulton	15.64	33.6	9.44	18.4
131270006	13127	Georgia	Glynn	11.13	25.0	8.21	18.7
131350002	13135	Georgia	Gwinnett	14.30	28.4	8.84	17.2
131390003	13139	Georgia	Hall	12.92	28.4	8.26	16.4
131530001	13153	Georgia	Houston	12.31	30.1	8.80	23.5
131850003	13185	Georgia	Lowndes	11.44	25.9	8.76	19.9
132150001	13215	Georgia	Muscogee	14.07	29.5	10.09	20.6
132150008	13215	Georgia	Muscogee	14.15	29.8	10.13	22.3
132150011	13215	Georgia	Muscogee	13.63	29.5	9.78	24.2
132230003	13223	Georgia	Paulding	13.23	32.3	8.05	17.9
132450005	13245	Georgia	Richmond	14.48	30.8	10.09	22.4
132450091	13245	Georgia	Richmond	14.67	29.6	10.25	20.3

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133030001	13303	Georgia	Washington	13.94	29.4	9.87	19.2
133190001	13319	Georgia	Wilkinson	15.20	32.3	10.87	24.4
160010010	16001	Idaho	Ada	6.88	22.3	6.32	19.8
160090010	16009	Idaho	Benewah	9.63	28.6	9.28	27.6
160270004	16027	Idaho	Canyon	8.15	28.2	7.52	24.4
160410001	16041	Idaho	Franklin	7.70	36.7	6.83	31.5
160490003	16049	Idaho	Idaho	9.58	28.4	9.33	27.9
160790017	16079	Idaho	Shoshone	11.85	35.0	11.52	34.1
170190004	17019	Illinois	Champaign	11.94	29.2	8.95	21.2
170191001	17019	Illinois	Champaign	12.06	28.2	8.88	21.3
170310022	17031	Illinois	Cook	14.14	32.8	11.22	27.1
170310050	17031	Illinois	Cook	13.35	30.9	10.36	23.9
170310052	17031	Illinois	Cook	14.38	35.3	11.01	28.3
170310057	17031	Illinois	Cook	13.84	34.0	10.52	27.4
170310076	17031	Illinois	Cook	13.47	33.3	10.17	24.7
170311016	17031	Illinois	Cook	NA	36.2	NA	26.4
170312001	17031	Illinois	Cook	13.59	32.3	10.30	24.6
170313103	17031	Illinois	Cook	NA	38.9	NA	30.1
170313301	17031	Illinois	Cook	13.83	33.7	10.53	25.4
170314007	17031	Illinois	Cook	12.05	30.5	9.07	23.2
170314201	17031	Illinois	Cook	11.92	30.6	9.01	24.1
170316005	17031	Illinois	Cook	15.12	36.9	11.52	29.7
170434002	17043	Illinois	DuPage	12.74	32.8	9.66	25.6
170650002	17065	Illinois	Hamilton	12.15	28.6	8.44	20.1
170831001	17083	Illinois	Jersey	11.97	28.0	8.74	19.5
170890003	17089	Illinois	Kane	12.22	33.0	9.27	24.3
170890007	17089	Illinois	Kane	12.82	31.1	9.79	25.3
170971007	17097	Illinois	Lake	10.91	29.3	8.19	22.1
170990007	17099	Illinois	LaSalle	NA	27.5	NA	21.3
171110001	17111	Illinois	McHenry	11.33	28.7	8.58	21.6
171132003	17113	Illinois	McLean	11.65	29.0	8.70	22.2
171150013	17115	Illinois	Macon	12.87	30.6	9.58	22.4
171191007	17119	Illinois	Madison	15.43	34.8	11.70	25.6
171192009	17119	Illinois	Madison	13.54	31.5	10.23	22.8
171193007	17119	Illinois	Madison	13.36	30.4	10.01	22.0
171430037	17143	Illinois	Peoria	12.31	30.2	9.45	23.1
171570001	17157	Illinois	Randolph	12.36	26.8	8.96	21.5
171613002	17161	Illinois	Rock Island	11.31	26.7	9.03	20.6

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171630010	17163	Illinois	St. Clair	14.41	30.0	10.65	22.4
171634001	17163	Illinois	St. Clair	13.27	30.0	9.76	21.7
171670012	17167	Illinois	Sangamon	12.21	29.7	9.22	21.2
171971002	17197	Illinois	Will	13.03	33.5	9.91	25.2
171971011	17197	Illinois	Will	10.93	25.2	8.15	18.5
172010013	17201	Illinois	Winnebago	12.10	30.6	9.55	25.1
180030004	18003	Indiana	Allen	12.62	32.7	9.30	24.7
180030014	18003	Indiana	Allen	13.46	31.1	9.84	22.1
180190006	18019	Indiana	Clark	15.55	35.6	9.87	21.4
180350006	18035	Indiana	Delaware	12.73	28.6	8.91	19.1
180370005	18037	Indiana	Dubois	13.71	31.1	9.09	18.5
180372001	18037	Indiana	Dubois	14.94	34.9	9.83	20.3
180431004	18043	Indiana	Floyd	13.87	31.1	8.59	17.4
180650003	18065	Indiana	Henry	11.74	26.0	8.18	17.2
180670003	18067	Indiana	Howard	12.79	32.9	9.17	20.9
180830004	18083	Indiana	Knox	13.10	30.7	8.73	19.9
180890006	18089	Indiana	Lake	13.40	32.1	10.55	26.8
180890022	18089	Indiana	Lake	NA	32.3	NA	26.6
180890026	18089	Indiana	Lake	NA	34.2	NA	26.2
180890027	18089	Indiana	Lake	12.16	NA	9.47	NA
180890031	18089	Indiana	Lake	13.14	32.2	10.36	24.2
180891003	18089	Indiana	Lake	14.09	32.8	11.17	27.1
180892004	18089	Indiana	Lake	13.40	31.7	10.52	27.0
180892010	18089	Indiana	Lake	13.07	31.6	10.26	25.4
180910011	18091	Indiana	LaPorte	11.71	29.7	8.82	21.3
180910012	18091	Indiana	LaPorte	12.52	30.7	9.33	23.0
180950009	18095	Indiana	Madison	12.97	30.0	9.03	19.2
180970042	18097	Indiana	Marion	14.38	35.3	9.71	21.7
180970043	18097	Indiana	Marion	NA	35.8	NA	23.9
180970066	18097	Indiana	Marion	NA	37.0	NA	24.6
180970078	18097	Indiana	Marion	14.46	33.6	9.96	21.8
180970079	18097	Indiana	Marion	14.79	35.8	10.13	23.7
180970081	18097	Indiana	Marion	15.00	34.9	10.42	23.6
180970083	18097	Indiana	Marion	14.70	33.4	10.18	23.2
181270020	18127	Indiana	Porter	12.68	NA	9.61	NA
181270024	18127	Indiana	Porter	12.51	30.3	9.61	23.9
181410014	18141	Indiana	St. Joseph	12.31	30.0	9.31	23.9
181410015	18141	Indiana	St. Joseph	11.80	29.2	8.94	22.9

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181412004	18141	Indiana	St. Joseph	12.74	30.4	9.61	23.4
181470009	18147	Indiana	Spencer	13.39	28.8	8.69	17.4
181570008	18157	Indiana	Tippecanoe	12.61	30.5	8.96	20.2
181630006	18163	Indiana	Vanderburgh	14.05	32.9	9.47	20.0
181630012	18163	Indiana	Vanderburgh	14.25	30.3	9.66	20.5
181630016	18163	Indiana	Vanderburgh	13.90	29.8	9.45	19.6
181670018	18167	Indiana	Vigo	13.36	30.6	9.41	20.9
181670023	18167	Indiana	Vigo	12.89	34.5	8.91	22.6
190130008	19013	Iowa	Black Hawk	11.18	29.1	9.06	24.4
190450019	19045	Iowa	Clinton	12.73	33.0	10.67	28.5
190450021	19045	Iowa	Clinton	11.89	29.6	9.68	24.4
191032001	19103	Iowa	Johnson	11.56	30.6	9.27	23.9
191110008	19111	Iowa	Lee	11.41	26.0	9.23	21.3
191130037	19113	Iowa	Linn	10.53	27.2	8.25	21.9
191370002	19137	Iowa	Montgomery	9.72	23.7	7.65	17.6
191390015	19139	Iowa	Muscatine	13.08	36.2	10.81	32.3
191471002	19147	Iowa	Palo Alto	9.19	24.3	7.32	18.1
191530030	19153	Iowa	Polk	10.18	26.2	7.87	20.5
191532510	19153	Iowa	Polk	9.84	24.5	7.58	17.4
191550009	19155	Iowa	Pottawattamie	10.95	26.3	8.59	21.7
191630015	19163	Iowa	Scott	11.82	29.2	9.51	23.5
191630018	19163	Iowa	Scott	11.59	29.9	9.27	24.5
191630019	19163	Iowa	Scott	13.97	34.6	11.51	27.9
191770006	19177	Iowa	Van Buren	10.17	26.2	8.06	20.2
191930017	19193	Iowa	Woodbury	10.40	28.3	8.58	21.8
191970004	19197	Iowa	Wright	10.06	NA	7.88	NA
200910007	20091	Kansas	Johnson	9.92	22.5	7.47	16.3
200910010	20091	Kansas	Johnson	9.16	20.8	6.90	14.5
201070002	20107	Kansas	Linn	10.14	22.5	7.87	15.9
201730008	20173	Kansas	Sedgwick	9.61	22.0	7.80	16.7
201730009	20173	Kansas	Sedgwick	9.60	23.1	7.76	17.0
201730010	20173	Kansas	Sedgwick	9.66	22.7	7.84	16.7
201770013	20177	Kansas	Shawnee	9.96	22.8	8.00	16.9
201910002	20191	Kansas	Sumner	9.29	21.6	7.53	16.3
202090021	20209	Kansas	Wyandotte	11.41	24.2	8.64	18.1
202090022	20209	Kansas	Wyandotte	10.38	23.4	7.78	17.5
210130002	21013	Kentucky	Bell	13.73	26.9	8.90	20.1
210190017	21019	Kentucky	Boyd	13.51	31.2	8.49	15.5

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
210290006	21029	Kentucky	Bullitt	14.17	31.6	8.89	17.4
210430500	21043	Kentucky	Carter	11.58	27.0	7.51	14.5
210470006	21047	Kentucky	Christian	13.19	32.3	8.62	17.6
210590005	21059	Kentucky	Daviess	13.28	30.6	8.67	17.4
210670012	21067	Kentucky	Fayette	13.49	29.5	8.00	18.5
210670014	21067	Kentucky	Fayette	13.48	29.0	8.05	18.3
210730006	21073	Kentucky	Franklin	12.60	29.5	7.49	16.6
210930006	21093	Kentucky	Hardin	13.27	31.8	8.24	17.9
211010014	21101	Kentucky	Henderson	13.36	29.2	8.89	18.4
211110043	21111	Kentucky	Jefferson	14.47	32.1	9.04	17.8
211110044	21111	Kentucky	Jefferson	14.51	33.1	9.02	18.9
211110048	21111	Kentucky	Jefferson	14.68	35.1	9.02	19.1
211110051	21111	Kentucky	Jefferson	14.11	31.2	8.84	16.7
211170007	21117	Kentucky	Kenton	13.27	30.6	8.20	17.0
211451004	21145	Kentucky	McCracken	13.11	31.9	8.93	18.2
211510003	21151	Kentucky	Madison	12.26	27.8	7.06	16.2
211830032	21183	Kentucky	Ohio	12.78	29.6	8.37	15.8
211930003	21193	Kentucky	Perry	13.42	29.8	8.48	16.0
211950002	21195	Kentucky	Pike	12.61	28.4	7.90	16.5
212270007	21227	Kentucky	Warren	NA	NA	NA	NA
212270008	21227	Kentucky	Warren	NA	29.0	NA	15.5
220170008	22017	Louisiana	Caddo Parish	11.89	24.7	9.37	19.3
220190009	22019	Louisiana	Calcasieu Parish	9.84	22.9	7.43	17.4
220190010	22019	Louisiana	Calcasieu Parish	9.99	23.3	7.56	16.9
220330009	22033	Louisiana	East Baton Rouge Parish	12.27	26.1	9.26	19.2
220331001	22033	Louisiana	East Baton Rouge Parish	10.96	20.9	8.20	15.5
220470005	22047	Louisiana	Iberville Parish	12.07	25.8	8.81	18.9
220470009	22047	Louisiana	Iberville Parish	10.37	22.9	7.55	16.7
220511001	22051	Louisiana	Jefferson Parish	10.45	23.2	7.29	16.6
220512001	22051	Louisiana	Jefferson Parish	10.42	21.1	7.44	15.4
220550006	22055	Louisiana	Lafayette Parish	10.17	22.3	7.51	15.7
220550007	22055	Louisiana	Lafayette Parish	9.76	21.9	7.22	15.2
220730004	22073	Louisiana	Ouachita Parish	10.95	25.8	8.20	17.8
220790002	22079	Louisiana	Rapides Parish	10.08	22.5	7.48	15.8
220870007	22087	Louisiana	St. Bernard Parish	10.90	22.0	7.91	15.9
221050001	22105	Louisiana	Tangipahoa Parish	11.18	25.7	7.98	17.9
221090001	22109	Louisiana	Terrebonne Parish	9.87	22.8	7.15	16.4

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221210001	22121	Louisiana	West Baton Rouge Parish	12.71	26.0	9.69	19.3
230010011	23001	Maine	Androscoggin	8.79	23.8	7.62	20.3
230030013	23003	Maine	Aroostook	9.22	22.3	8.74	20.9
230031011	23003	Maine	Aroostook	7.49	19.7	6.98	18.0
230050015	23005	Maine	Cumberland	9.82	21.7	8.37	17.8
230090103	23009	Maine	Hancock	5.11	20.5	4.12	11.9
230110016	23011	Maine	Kennebec	8.79	21.4	7.66	18.6
230172011	23017	Maine	Oxford	9.24	22.5	8.26	20.3
230190002	23019	Maine	Penobscot	8.36	21.4	7.17	16.4
230210004	23021	Maine	Piscataquis	5.55	17.2	4.68	13.0
240031003	24003	Maryland	Anne Arundel	13.30	33.1	8.28	19.9
240051007	24005	Maryland	Baltimore	12.66	30.7	7.60	17.6
240053001	24005	Maryland	Baltimore	13.54	33.0	8.47	22.8
240150003	24015	Maryland	Cecil	11.79	27.8	7.24	17.9
240251001	24025	Maryland	Harford	11.69	28.6	7.05	17.2
240313001	24031	Maryland	Montgomery	11.45	28.0	6.72	15.9
240330025	24033	Maryland	Prince George's	12.40	27.5	7.63	16.8
240330030	24033	Maryland	Prince George's	11.37	28.9	6.77	14.9
240338003	24033	Maryland	Prince George's	11.83	29.6	7.04	15.7
240430009	24043	Maryland	Washington	12.28	29.1	7.48	16.8
245100006	24510	Maryland	Baltimore city	12.78	31.8	7.78	21.0
245100007	24510	Maryland	Baltimore city	12.92	32.1	7.90	20.4
245100008	24510	Maryland	Baltimore city	14.16	34.7	8.90	21.5
245100035	24510	Maryland	Baltimore city	NA	36.2	NA	24.1
245100040	24510	Maryland	Baltimore city	NA	34.0	NA	24.2
250035001	25003	Massachusetts	Berkshire	9.87	27.9	7.34	20.5
250051004	25005	Massachusetts	Bristol	8.87	24.1	6.31	16.1
250092006	25009	Massachusetts	Essex	8.81	25.7	6.20	16.7
250095005	25009	Massachusetts	Essex	8.67	25.0	6.60	16.9
250096001	25009	Massachusetts	Essex	9.18	26.2	6.90	18.3
250130008	25013	Massachusetts	Hampden	9.34	27.5	6.74	18.7
250130016	25013	Massachusetts	Hampden	11.42	30.1	8.84	22.8
250132009	25013	Massachusetts	Hampden	11.18	30.8	8.58	23.0
250170009	25017	Massachusetts	Middlesex	8.64	21.7	6.38	13.3
250230004	25023	Massachusetts	Plymouth	9.39	27.0	6.67	17.5
250250002	25025	Massachusetts	Suffolk	11.41	29.2	8.31	20.7
250250027	25025	Massachusetts	Suffolk	11.11	27.5	8.15	18.9
250250042	25025	Massachusetts	Suffolk	10.05	27.8	7.12	17.1

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250250043	25025	Massachusetts	Suffolk	11.59	28.7	8.52	20.1
250270016	25027	Massachusetts	Worcester	10.24	28.8	7.73	18.3
250270023	25027	Massachusetts	Worcester	10.77	28.2	8.25	19.5
260050003	26005	Michigan	Allegan	10.93	30.4	8.36	22.7
260170014	26017	Michigan	Bay	9.90	26.9	7.90	22.7
260210014	26021	Michigan	Berrien	10.90	28.8	8.22	21.1
260490021	26049	Michigan	Genesee	10.68	26.9	8.08	21.2
260650012	26065	Michigan	Ingham	11.07	28.5	8.26	21.9
260770008	26077	Michigan	Kalamazoo	12.05	28.9	9.21	23.8
260810007	26081	Michigan	Kent	11.29	28.4	8.69	23.1
260810020	26081	Michigan	Kent	11.78	31.1	9.03	24.3
260990009	26099	Michigan	Macomb	11.50	31.2	8.64	23.6
261010922	26101	Michigan	Manistee	7.41	22.5	6.03	17.0
261130001	26113	Michigan	Missaukee	7.50	22.5	6.17	16.3
261150005	26115	Michigan	Monroe	12.60	32.4	9.31	23.1
261210040	26121	Michigan	Muskegon	10.57	29.4	8.17	21.9
261250001	26125	Michigan	Oakland	12.38	35.0	9.04	24.1
261390005	26139	Michigan	Ottawa	11.54	29.7	8.77	23.4
261470005	26147	Michigan	St. Clair	11.08	35.5	8.77	25.5
261610008	26161	Michigan	Washtenaw	12.40	33.6	9.38	25.5
261630001	26163	Michigan	Wayne	12.83	32.4	9.47	24.8
261630015	26163	Michigan	Wayne	14.10	35.9	10.53	27.2
261630016	26163	Michigan	Wayne	13.10	35.5	9.69	26.1
261630019	26163	Michigan	Wayne	12.67	34.8	9.35	26.0
261630025	26163	Michigan	Wayne	12.08	31.7	8.81	23.9
261630033	26163	Michigan	Wayne	15.57	38.3	11.58	29.7
261630036	26163	Michigan	Wayne	12.75	30.9	9.41	24.4
261630038	26163	Michigan	Wayne	11.99	30.2	8.88	23.4
261630039	26163	Michigan	Wayne	12.65	34.2	9.35	25.5
270210001	27021	Minnesota	Cass	5.74	17.9	5.04	14.7
270370470	27037	Minnesota	Dakota	9.47	25.7	7.75	22.0
270530961	27053	Minnesota	Hennepin	9.26	25.1	7.50	21.2
270530963	27053	Minnesota	Hennepin	9.74	25.6	7.93	21.3
270531007	27053	Minnesota	Hennepin	9.99	27.2	8.16	22.9
270953051	27095	Minnesota	Mille Lacs	6.67	22.2	5.58	16.1
271095008	27109	Minnesota	Olmsted	10.01	29.7	8.03	24.2
271230866	27123	Minnesota	Ramsey	11.06	28.1	9.25	24.6
271230868	27123	Minnesota	Ramsey	10.82	28.4	8.95	24.9

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271230871	27123	Minnesota	Ramsey	9.80	29.8	7.96	25.8
271377001	27137	Minnesota	St. Louis	5.96	17.7	5.48	15.5
271377550	27137	Minnesota	St. Louis	6.29	20.8	5.45	16.8
271377551	27137	Minnesota	St. Louis	7.57	23.6	6.70	19.7
271390505	27139	Minnesota	Scott	9.25	24.5	7.59	20.0
271453052	27145	Minnesota	Stearns	8.50	22.1	7.15	18.9
271630446	27163	Minnesota	Washington	NA	30.2	NA	27.5
280010004	28001	Mississippi	Adams	10.79	24.0	7.85	16.9
280110001	28011	Mississippi	Bolivar	11.80	26.4	8.52	18.1
280330002	28033	Mississippi	DeSoto	11.92	26.9	8.05	15.0
280350004	28035	Mississippi	Forrest	13.49	28.4	10.23	21.6
280430001	28043	Mississippi	Grenada	10.46	22.8	7.24	14.0
280470008	28047	Mississippi	Harrison	10.93	24.5	7.72	16.5
280490010	28049	Mississippi	Hinds	12.27	26.2	8.89	17.9
280590006	28059	Mississippi	Jackson	10.95	24.7	7.70	16.0
280670002	28067	Mississippi	Jones	13.89	28.5	10.53	21.7
280750003	28075	Mississippi	Lauderdale	12.51	26.4	9.12	18.5
280810005	28081	Mississippi	Lee	12.31	29.8	8.59	16.7
280870001	28087	Mississippi	Lowndes	12.38	28.1	8.73	19.0
290210005	29021	Missouri	Buchanan	12.08	27.0	9.72	21.6
290370003	29037	Missouri	Cass	10.38	24.6	7.88	17.5
290470005	29047	Missouri	Clay	10.63	24.7	8.05	17.6
290770032	29077	Missouri	Greene	11.19	25.7	8.76	19.1
290950034	29095	Missouri	Jackson	12.00	26.6	9.18	21.4
290990012	29099	Missouri	Jefferson	13.89	34.2	10.22	22.6
291831002	29183	Missouri	St. Charles	13.30	32.8	9.80	22.8
291860006	29186	Missouri	Ste. Genevieve	12.75	29.8	9.54	20.1
291892003	29189	Missouri	St. Louis	12.85	30.9	9.24	22.7
295100007	29510	Missouri	St. Louis city	13.46	30.5	9.93	22.1
295100085	29510	Missouri	St. Louis city	13.50	31.2	9.84	23.0
295100087	29510	Missouri	St. Louis city	14.08	32.4	10.27	23.6
300131026	30013	Montana	Cascade	6.02	17.3	5.89	17.0
300290009	30029	Montana	Flathead	9.71	22.7	9.28	21.9
300290047	30029	Montana	Flathead	8.56	19.9	8.22	19.5
300310008	30031	Montana	Gallatin	8.63	27.0	8.37	26.1
300310016	30031	Montana	Gallatin	7.39	23.5	7.18	22.7
300490018	30049	Montana	Lewis and Clark	8.42	29.5	8.26	29.2
300630031	30063	Montana	Missoula	9.82	29.8	9.37	28.6

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300810007	30081	Montana	Ravalli	9.10	NA	8.94	NA
300890007	30089	Montana	Sanders	7.07	20.1	6.93	19.8
300930005	30093	Montana	Silver Bow	11.14	32.8	10.87	32.1
301111065	30111	Montana	Yellowstone	7.68	18.3	7.50	18.3
310550019	31055	Nebraska	Douglas	9.59	24.3	7.31	19.4
310550052	31055	Nebraska	Douglas	9.12	23.0	6.94	18.0
310790004	31079	Nebraska	Hall	7.81	18.3	6.38	14.9
311090022	31109	Nebraska	Lancaster	8.26	18.9	6.33	13.9
311530007	31153	Nebraska	Sarpy	9.46	22.9	7.23	17.1
311570003	31157	Nebraska	Scotts Bluff	6.29	17.6	5.66	16.0
311770002	31177	Nebraska	Washington	8.77	20.8	6.75	15.4
320030561	32003	Nevada	Clark	9.43	23.0	8.75	22.0
320031019	32003	Nevada	Clark	3.96	10.2	3.76	9.1
320032002	32003	Nevada	Clark	8.49	19.8	7.90	18.7
320310016	32031	Nevada	Washoe	8.49	34.9	7.80	31.5
330012004	33001	New Hampshire	Belknap	6.77	17.9	5.36	11.3
330050007	33005	New Hampshire	Cheshire	11.02	28.9	9.35	25.3
330090010	33009	New Hampshire	Grafton	7.80	20.5	6.63	14.1
330111015	33011	New Hampshire	Hillsborough	9.57	26.5	7.59	21.6
330131006	33013	New Hampshire	Merrimack	9.28	24.6	7.60	19.6
330150014	33015	New Hampshire	Rockingham	8.45	23.7	7.05	18.6
330190003	33019	New Hampshire	Sullivan	9.31	23.3	8.03	17.9
340010006	34001	New Jersey	Atlantic	9.62	27.4	6.24	14.8
340011006	34001	New Jersey	Atlantic	10.82	24.4	7.17	14.6
340030003	34003	New Jersey	Bergen	12.24	34.6	7.79	19.3
340070003	34007	New Jersey	Camden	13.40	35.2	8.90	20.7
340071007	34007	New Jersey	Camden	12.63	33.2	8.26	21.8
340130015	34013	New Jersey	Essex	13.29	38.4	8.36	24.4
340150004	34015	New Jersey	Gloucester	11.38	25.7	7.23	16.1
340171003	34017	New Jersey	Hudson	12.93	35.3	8.28	23.6
340172002	34017	New Jersey	Hudson	13.57	39.6	9.03	28.3
340210008	34021	New Jersey	Mercer	11.74	32.0	7.73	21.6
340218001	34021	New Jersey	Mercer	10.06	NA	6.29	NA
340230006	34023	New Jersey	Middlesex	11.27	29.9	7.30	17.7
340270004	34027	New Jersey	Morris	10.43	28.9	6.58	17.0
340273001	34027	New Jersey	Morris	9.40	28.1	5.99	15.6
340292002	34029	New Jersey	Ocean	10.14	28.0	6.36	15.9
340310005	34031	New Jersey	Passaic	12.17	33.3	7.78	20.7

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340390004	34039	New Jersey	Union	13.56	37.6	8.53	23.0
340390006	34039	New Jersey	Union	12.49	34.6	7.97	21.1
340392003	34039	New Jersey	Union	12.28	36.3	7.76	21.7
340410006	34041	New Jersey	Warren	11.81	33.6	7.84	22.9
350010023	35001	New Mexico	Bernalillo	6.61	16.9	5.88	14.9
350010024	35001	New Mexico	Bernalillo	6.17	15.8	5.47	14.2
350050005	35005	New Mexico	Chaves	6.47	16.2	6.12	12.9
350130017	35013	New Mexico	Doña Ana	10.36	29.4	10.23	27.3
350130025	35013	New Mexico	Doña Ana	6.16	13.6	5.83	12.8
350171002	35017	New Mexico	Grant	5.01	10.1	4.89	9.9
350431003	35043	New Mexico	Sandoval	4.93	9.8	4.39	8.8
350439011	35043	New Mexico	Sandoval	7.81	15.4	7.31	14.5
350450006	35045	New Mexico	San Juan	5.82	12.5	5.55	12.2
350490020	35049	New Mexico	Santa Fe	4.62	9.1	4.24	8.2
360010005	36001	New York	Albany	9.26	26.5	6.86	19.8
360050080	36005	New York	Bronx	14.58	35.3	9.66	24.3
360050083	36005	New York	Bronx	13.03	34.6	8.34	20.8
360050110	36005	New York	Bronx	12.38	33.7	7.87	21.6
360130011	36013	New York	Chautauqua	8.88	26.5	5.99	13.9
360290005	36029	New York	Erie	11.43	29.5	8.16	19.9
360291007	36029	New York	Erie	11.15	30.4	7.90	20.6
360310003	36031	New York	Essex	5.27	17.5	4.01	9.7
360470122	36047	New York	Kings	13.01	33.1	8.45	20.1
360551007	36055	New York	Monroe	9.64	27.9	6.58	18.2
360590008	36059	New York	Nassau	10.86	NA	6.95	NA
360610056	36061	New York	New York	15.86	39.2	10.77	26.0
360610062	36061	New York	New York	NA	NA	NA	NA
360610079	36061	New York	New York	12.77	34.2	8.11	21.5
360610128	36061	New York	New York	15.30	38.0	10.23	26.4
360632008	36063	New York	Niagara	10.62	28.7	7.82	19.1
360671015	36067	New York	Onondaga	9.03	25.8	6.47	15.2
360710002	36071	New York	Orange	10.03	27.6	6.56	17.1
360810124	36081	New York	Queens	11.25	30.7	7.26	20.5
360850055	36085	New York	Richmond	12.43	31.4	7.87	19.0
360850067	36085	New York	Richmond	10.85	29.1	6.87	15.9
360893001	36089	New York	St. Lawrence	6.22	20.3	4.81	12.5
361010003	36101	New York	Steuben	8.15	24.6	5.35	13.2
361030002	36103	New York	Suffolk	10.06	27.4	6.35	15.0

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
361191002	36119	New York	Westchester	11.16	31.2	7.01	17.9
370010002	37001	North Carolina	Alamance	12.73	28.5	7.48	18.4
370210034	37021	North Carolina	Buncombe	11.22	26.7	7.06	14.9
370330001	37033	North Carolina	Caswell	12.01	26.6	6.90	16.1
370350004	37035	North Carolina	Catawba	13.98	29.5	8.74	17.1
370370004	37037	North Carolina	Chatham	11.24	25.0	6.72	15.6
370510009	37051	North Carolina	Cumberland	12.74	27.5	8.13	17.3
370570002	37057	North Carolina	Davidson	14.15	28.5	8.70	16.5
370610002	37061	North Carolina	Duplin	10.31	24.1	6.30	13.4
370630001	37063	North Carolina	Durham	13.39	30.0	8.37	17.3
370650004	37065	North Carolina	Edgecombe	11.55	24.6	7.23	15.4
370670022	37067	North Carolina	Forsyth	13.02	28.4	7.68	17.2
370670030	37067	North Carolina	Forsyth	12.41	27.2	7.34	15.5
370710016	37071	North Carolina	Gaston	13.14	27.5	8.06	15.3
370810013	37081	North Carolina	Guilford	11.28	24.1	6.40	16.1
370870010	37087	North Carolina	Haywood	13.00	28.5	9.13	19.3
370990006	37099	North Carolina	Jackson	11.47	NA	7.58	NA
371070004	37107	North Carolina	Lenoir	10.33	23.0	6.30	13.1
371110004	37111	North Carolina	McDowell	12.92	28.0	8.47	16.4
371170001	37117	North Carolina	Martin	10.14	22.1	6.42	14.1
371190041	37119	North Carolina	Mecklenburg	13.49	28.9	8.24	16.3
371190042	37119	North Carolina	Mecklenburg	13.73	27.1	8.45	16.4
371190043	37119	North Carolina	Mecklenburg	12.62	26.9	7.61	15.3
371210001	37121	North Carolina	Mitchell	11.90	27.3	7.72	17.4
371230001	37123	North Carolina	Montgomery	11.59	25.4	7.09	14.3
371290002	37129	North Carolina	New Hanover	9.68	25.4	5.92	15.4
371330005	37133	North Carolina	Onslow	10.48	24.7	6.35	14.5
371350007	37135	North Carolina	Orange	12.90	29.0	7.68	16.7
371470005	37147	North Carolina	Pitt	11.18	24.7	7.05	15.6
371550005	37155	North Carolina	Robeson	12.09	26.8	7.80	18.1
371590021	37159	North Carolina	Rowan	13.28	27.5	8.27	17.1
371730002	37173	North Carolina	Swain	11.98	26.0	7.93	16.5
371830014	37183	North Carolina	Wake	12.46	29.1	7.84	17.2
371890003	37189	North Carolina	Watauga	10.75	25.2	6.33	13.4
371910005	37191	North Carolina	Wayne	11.97	27.2	7.69	15.6
380070002	38007	North Dakota	Billings	4.66	12.8	4.34	12.1
380150003	38015	North Dakota	Burleigh	6.77	16.1	6.10	14.7
380171004	38017	North Dakota	Cass	7.85	19.1	6.79	15.9

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
380570004	38057	North Dakota	Mercer	6.28	15.1	5.85	13.7
390090003	39009	Ohio	Athens	11.78	30.8	6.96	14.8
390170003	39017	Ohio	Butler	14.20	33.3	9.59	21.6
390170016	39017	Ohio	Butler	14.58	34.1	9.41	21.4
390171004	39017	Ohio	Butler	14.96	38.1	9.92	21.5
390230005	39023	Ohio	Clark	13.83	33.1	9.50	22.2
390250022	39025	Ohio	Clermont	13.07	30.1	8.22	16.5
390350027	39035	Ohio	Cuyahoga	14.24	35.7	9.59	23.3
390350034	39035	Ohio	Cuyahoga	12.44	33.3	8.23	19.7
390350038	39035	Ohio	Cuyahoga	15.41	39.0	10.64	27.0
390350045	39035	Ohio	Cuyahoga	14.71	33.8	9.94	22.5
390350060	39035	Ohio	Cuyahoga	15.86	37.6	10.75	23.9
390350065	39035	Ohio	Cuyahoga	14.87	34.7	10.11	22.1
390351002	39035	Ohio	Cuyahoga	12.79	31.4	8.42	18.3
390490024	39049	Ohio	Franklin	13.84	32.7	9.16	21.6
390490025	39049	Ohio	Franklin	13.77	33.3	9.13	21.3
390490081	39049	Ohio	Franklin	11.66	28.1	7.44	19.3
390570005	39057	Ohio	Greene	12.65	29.9	8.27	18.8
390610006	39061	Ohio	Hamilton	13.79	32.6	8.78	19.5
390610014	39061	Ohio	Hamilton	16.00	34.6	10.55	24.0
390610040	39061	Ohio	Hamilton	14.21	32.3	8.91	18.8
390610042	39061	Ohio	Hamilton	15.46	33.6	10.07	20.3
390610043	39061	Ohio	Hamilton	14.80	34.3	9.53	20.3
390617001	39061	Ohio	Hamilton	14.75	33.6	9.45	21.8
390618001	39061	Ohio	Hamilton	15.80	35.6	10.36	23.3
390810017	39081	Ohio	Jefferson	14.80	37.0	9.05	22.1
390811001	39081	Ohio	Jefferson	14.83	34.3	8.85	20.7
390853002	39085	Ohio	Lake	12.28	31.7	8.15	16.9
390870010	39087	Ohio	Lawrence	15.44	34.8	9.69	21.0
390933002	39093	Ohio	Lorain	12.10	30.7	8.44	20.5
390950024	39095	Ohio	Lucas	13.40	31.9	9.88	23.7
390950025	39095	Ohio	Lucas	13.88	34.7	10.18	24.2
390950026	39095	Ohio	Lucas	13.25	31.5	9.72	22.3
390990005	39099	Ohio	Mahoning	13.62	32.3	9.16	19.1
390990014	39099	Ohio	Mahoning	13.79	32.8	9.28	21.7
391030003	39103	Ohio	Medina	11.94	28.7	8.02	19.5
391130032	39113	Ohio	Montgomery	14.48	33.7	9.54	20.7
391330002	39133	Ohio	Portage	12.82	30.9	8.42	19.5

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
391351001	39135	Ohio	Preble	12.92	29.8	8.61	20.3
391450013	39145	Ohio	Scioto	13.55	31.6	8.48	19.9
391510017	39151	Ohio	Stark	16.11	36.0	10.86	22.5
391530017	39153	Ohio	Summit	14.22	34.7	9.71	22.9
391530023	39153	Ohio	Summit	13.29	30.7	8.90	21.3
391550007	39155	Ohio	Trumbull	13.90	33.2	9.37	20.9
391650007	39165	Ohio	Warren	12.53	27.1	8.12	18.1
400159008	40015	Oklahoma	Caddo	8.60	NA	6.95	NA
400219002	40021	Oklahoma	Cherokee	12.28	27.4	9.79	20.2
400719010	40071	Oklahoma	Kay	10.29	26.8	8.68	21.9
400970186	40097	Oklahoma	Mayes	11.55	25.4	9.20	18.3
400979014	40097	Oklahoma	Mayes	11.62	26.3	9.14	18.3
401010169	40101	Oklahoma	Muskogee	11.68	27.5	9.26	20.6
401090035	40109	Oklahoma	Oklahoma	10.12	22.5	7.81	16.8
401091037	40109	Oklahoma	Oklahoma	10.21	24.2	7.91	18.4
401159004	40115	Oklahoma	Ottawa	11.26	24.9	8.92	18.1
401210415	40121	Oklahoma	Pittsburg	11.16	24.8	8.85	18.3
401359015	40135	Oklahoma	Sequoyah	12.07	27.3	9.56	21.6
401430110	40143	Oklahoma	Tulsa	11.47	24.8	8.89	18.7
401431127	40143	Oklahoma	Tulsa	11.43	27.4	8.86	20.4
410250002	41025	Oregon	Harney	9.68	33.0	9.76	34.4
410290133	41029	Oregon	Jackson	9.96	33.2	9.74	32.6
410291001	41029	Oregon	Jackson	5.32	16.1	5.21	15.7
410330114	41033	Oregon	Josephine	8.69	30.6	8.60	31.1
410350004	41035	Oregon	Klamath	11.55	46.1	11.30	34.2
410370001	41037	Oregon	Lake	9.99	41.4	9.93	42.4
410390060	41039	Oregon	Lane	8.00	33.4	7.50	23.6
410391009	41039	Oregon	Lane	7.08	22.2	6.62	16.3
410392013	41039	Oregon	Lane	11.15	42.4	10.71	34.7
410510080	41051	Oregon	Multnomah	8.60	29.1	7.79	27.2
410510246	41051	Oregon	Multnomah	7.66	21.6	6.90	20.1
410590121	41059	Oregon	Umatilla	7.97	24.7	7.68	23.9
410610119	41061	Oregon	Union	7.54	21.7	7.33	21.0
410670004	41067	Oregon	Washington	8.59	31.6	8.12	31.8
420010001	42001	Pennsylvania	Adams	12.00	31.4	7.36	19.2
420030008	42003	Pennsylvania	Allegheny	14.06	35.8	8.70	20.3
420030064	42003	Pennsylvania	Allegheny	18.36	54.4	11.62	39.0
420030067	42003	Pennsylvania	Allegheny	12.13	32.4	7.27	15.8

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
420030093	42003	Pennsylvania	Allegheny	NA	40.2	NA	19.0
420030095	42003	Pennsylvania	Allegheny	13.55	35.5	8.19	18.7
420031008	42003	Pennsylvania	Allegheny	14.29	38.1	8.82	21.4
420031301	42003	Pennsylvania	Allegheny	15.24	38.8	9.42	21.3
420033007	42003	Pennsylvania	Allegheny	14.28	33.6	9.04	20.2
420070014	42007	Pennsylvania	Beaver	15.19	37.0	10.15	24.2
420110011	42011	Pennsylvania	Berks	13.06	34.1	8.65	25.3
420170012	42017	Pennsylvania	Bucks	12.65	32.9	8.39	23.1
420210011	42021	Pennsylvania	Cambria	14.35	35.3	9.19	19.0
420270100	42027	Pennsylvania	Centre	11.42	31.6	7.04	18.3
420290100	42029	Pennsylvania	Chester	NA	36.4	NA	22.9
420410101	42041	Pennsylvania	Cumberland	13.24	34.4	8.52	24.4
420430401	42043	Pennsylvania	Dauphin	13.86	35.8	8.80	25.6
420450002	42045	Pennsylvania	Delaware	14.24	33.0	9.41	21.5
420490003	42049	Pennsylvania	Erie	11.57	30.9	8.11	18.7
420692006	42069	Pennsylvania	Lackawanna	10.77	29.4	7.20	19.6
420710007	42071	Pennsylvania	Lancaster	14.73	37.0	9.36	28.4
420850100	42085	Pennsylvania	Mercer	12.31	29.8	8.08	19.2
420910013	42091	Pennsylvania	Montgomery	11.99	28.5	7.66	19.1
420950025	42095	Pennsylvania	Northampton	12.89	35.8	8.75	24.6
421010004	42101	Pennsylvania	Philadelphia	12.97	34.9	8.62	23.6
421010024	42101	Pennsylvania	Philadelphia	11.58	NA	7.64	NA
421010047	42101	Pennsylvania	Philadelphia	12.97	36.6	8.62	24.3
421250005	42125	Pennsylvania	Washington	14.52	33.9	8.58	18.5
421250200	42125	Pennsylvania	Washington	13.06	29.6	7.60	16.7
421255001	42125	Pennsylvania	Washington	12.41	37.7	7.55	18.1
421290008	42129	Pennsylvania	Westmoreland	14.45	35.2	8.52	19.5
421330008	42133	Pennsylvania	York	14.77	34.6	9.49	26.4
440030002	44003	Rhode Island	Kent	7.54	23.1	5.18	13.5
440070022	44007	Rhode Island	Providence	9.50	27.1	6.90	19.1
440070026	44007	Rhode Island	Providence	11.27	28.2	8.64	21.0
440070028	44007	Rhode Island	Providence	9.96	25.0	7.32	16.6
440071010	44007	Rhode Island	Providence	9.21	26.6	6.63	17.9
450130007	45013	South Carolina	Beaufort	11.39	NA	7.51	NA
450190048	45019	South Carolina	Charleston	10.99	23.1	7.25	15.4
450190049	45019	South Carolina	Charleston	10.37	21.6	6.68	13.6
450250001	45025	South Carolina	Chesterfield	11.75	24.9	7.59	15.8
450370001	45037	South Carolina	Edgefield	12.30	26.8	8.20	16.8

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450410002	45041	South Carolina	Florence	12.32	26.7	7.89	16.3
450450008	45045	South Carolina	Greenville	14.74	30.4	9.86	21.7
450450009	45045	South Carolina	Greenville	13.54	28.0	8.59	18.3
450470003	45047	South Carolina	Greenwood	13.52	29.3	8.88	18.4
450510002	45051	South Carolina	Horry	11.92	29.2	7.76	20.8
450630008	45063	South Carolina	Lexington	13.46	28.4	8.63	18.1
450730001	45073	South Carolina	Oconee	10.32	23.3	6.40	13.4
450790007	45079	South Carolina	Richland	13.38	28.3	8.44	17.1
450790019	45079	South Carolina	Richland	13.15	28.5	8.39	17.9
450830010	45083	South Carolina	Spartanburg	13.08	28.5	8.36	17.5
460110002	46011	South Dakota	Brookings	8.66	21.6	7.20	16.3
460130003	46013	South Dakota	Brown	8.07	17.5	7.07	14.5
460290002	46029	South Dakota	Codington	9.45	23.9	8.13	18.6
460330132	46033	South Dakota	Custer	5.55	14.1	5.24	13.3
460710001	46071	South Dakota	Jackson	5.22	12.4	4.83	11.8
460990006	46099	South Dakota	Minnehaha	9.64	25.5	7.88	18.8
460990007	46099	South Dakota	Minnehaha	9.32	23.0	7.50	16.2
461030020	46103	South Dakota	Pennington	8.19	17.4	7.85	16.5
461031001	46103	South Dakota	Pennington	7.05	15.5	6.73	14.7
470090011	47009	Tennessee	Blount	13.89	31.0	9.42	19.7
470370023	47037	Tennessee	Davidson	13.09	29.9	8.30	18.4
470370025	47037	Tennessee	Davidson	14.04	31.5	9.12	20.4
470370036	47037	Tennessee	Davidson	12.00	29.3	7.45	17.2
470450004	47045	Tennessee	Dyer	11.57	28.9	7.77	16.6
470650031	47065	Tennessee	Hamilton	13.95	29.2	8.93	19.0
470651011	47065	Tennessee	Hamilton	12.85	27.4	7.80	16.3
470654002	47065	Tennessee	Hamilton	14.10	31.3	8.79	19.8
470930028	47093	Tennessee	Knox	14.35	32.6	9.37	19.9
470931017	47093	Tennessee	Knox	15.71	NA	10.19	NA
470931020	47093	Tennessee	Knox	14.04	28.1	8.84	17.5
470990002	47099	Tennessee	Lawrence	11.18	29.6	7.46	17.8
471050108	47105	Tennessee	Loudon	14.76	31.0	10.02	19.9
471071002	47107	Tennessee	McMinn	13.89	32.8	9.07	19.5
471130006	47113	Tennessee	Madison	11.17	28.1	7.40	15.4
471192007	47119	Tennessee	Maury	12.22	28.1	7.88	16.3
471251009	47125	Tennessee	Montgomery	12.67	32.6	8.20	17.8
471410005	47141	Tennessee	Putnam	11.26	25.5	6.97	14.8
471450004	47145	Tennessee	Roane	13.86	29.0	8.95	17.3

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471570014	47157	Tennessee	Shelby	12.56	29.6	8.42	16.5
471570038	47157	Tennessee	Shelby	13.57	33.5	9.11	18.9
471570047	47157	Tennessee	Shelby	12.44	30.0	8.39	17.0
471571004	47157	Tennessee	Shelby	12.08	30.4	8.08	16.2
471631007	47163	Tennessee	Sullivan	13.24	29.4	8.09	17.4
471650007	47165	Tennessee	Sumner	12.65	29.6	7.93	18.9
480370004	48037	Texas	Bowie	12.19	27.2	9.45	18.9
481130069	48113	Texas	Dallas	10.99	23.6	8.16	16.0
481130087	48113	Texas	Dallas	10.24	23.9	7.47	15.3
481350003	48135	Texas	Ector	8.13	17.4	7.64	15.2
481410037	48141	Texas	El Paso	8.90	20.9	8.97	22.3
481410044	48141	Texas	El Paso	11.21	27.1	11.39	27.3
482010058	48201	Texas	Harris	10.99	22.5	8.00	15.5
482011035	48201	Texas	Harris	15.04	29.8	11.43	21.2
482030002	48203	Texas	Harrison	11.01	23.4	8.32	17.7
482150043	48215	Texas	Hidalgo	10.94	24.3	9.84	21.0
483550032	48355	Texas	Nueces	10.71	27.8	8.60	20.6
483611001	48361	Texas	Orange	11.29	28.7	8.50	20.6
483750320	48375	Texas	Potter	6.17	14.8	5.32	12.9
484391002	48439	Texas	Tarrant	10.75	24.1	8.11	16.4
484391006	48439	Texas	Tarrant	11.32	24.5	8.63	17.2
484530020	48453	Texas	Travis	9.06	20.9	7.05	15.0
490030003	49003	Utah	Box Elder	8.28	33.8	7.32	30.4
490050004	49005	Utah	Cache	9.79	39.3	8.74	34.0
490110004	49011	Utah	Davis	10.25	37.1	9.18	33.0
490350003	49035	Utah	Salt Lake	11.22	46.4	9.69	33.6
490350012	49035	Utah	Salt Lake	NA	NA	NA	NA
490351001	49035	Utah	Salt Lake	8.68	30.5	7.59	23.5
490353006	49035	Utah	Salt Lake	10.68	47.5	9.23	36.8
490353007	49035	Utah	Salt Lake	11.69	42.4	10.27	32.5
490353008	49035	Utah	Salt Lake	7.77	24.1	6.81	21.1
490353010	49035	Utah	Salt Lake	NA	37.4	NA	29.8
490450003	49045	Utah	Tooele	6.84	25.1	6.29	22.5
490490002	49049	Utah	Utah	10.04	38.6	8.74	29.2
490494001	49049	Utah	Utah	10.50	46.1	9.06	33.9
490495008	49049	Utah	Utah	8.79	35.5	7.60	27.2
490495010	49049	Utah	Utah	9.17	38.9	8.00	29.9
490570002	49057	Utah	Weber	10.58	37.5	9.37	32.7

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490570007	49057	Utah	Weber	8.94	31.4	7.85	27.2
490571003	49057	Utah	Weber	9.08	35.5	8.06	30.8
500030004	50003	Vermont	Bennington	7.67	23.2	5.74	14.1
500070007	50007	Vermont	Chittenden	5.71	17.7	4.68	12.9
500070012	50007	Vermont	Chittenden	8.39	25.9	7.08	18.9
500210002	50021	Vermont	Rutland	10.67	28.9	9.50	28.4
510130020	51013	Virginia	Arlington	12.93	29.6	7.70	16.7
510360002	51036	Virginia	Charles City	11.35	28.1	6.93	14.7
510410003	51041	Virginia	Chesterfield	12.30	27.7	7.45	14.8
510590030	51059	Virginia	Fairfax	12.07	31.1	7.08	16.5
510591005	51059	Virginia	Fairfax	13.47	32.2	7.89	16.1
510595001	51059	Virginia	Fairfax	12.67	29.3	7.59	16.1
510870014	51087	Virginia	Henrico	12.03	29.0	7.22	14.9
510870015	51087	Virginia	Henrico	11.75	26.8	6.99	13.3
511071005	51107	Virginia	Loudoun	12.17	29.0	7.31	15.3
511390004	51139	Virginia	Page	11.71	27.7	6.85	14.5
511650003	51165	Virginia	Rockingham	11.66	26.1	7.49	15.6
515200006	51520	Virginia	Bristol city	12.60	27.5	7.61	16.7
516500004	51650	Virginia	Hampton city	11.64	29.0	7.10	15.9
516800015	51680	Virginia	Lynchburg city	11.78	27.9	7.35	15.3
517100024	51710	Virginia	Norfolk city	12.13	28.0	7.73	17.6
517700014	51770	Virginia	Roanoke city	13.96	31.0	8.94	17.6
517700015	51770	Virginia	Roanoke city	11.52	26.8	7.32	16.1
518100008	51810	Virginia	Virginia Beach city	11.56	31.1	7.27	18.7
530330024	53033	Washington	King	8.95	31.0	7.64	29.1
530330057	53033	Washington	King	9.27	25.8	7.74	21.7
530330080	53033	Washington	King	7.10	18.5	5.98	16.8
530530029	53053	Washington	Pierce	9.89	44.2	8.55	30.4
530610020	53061	Washington	Snohomish	7.42	34.2	7.02	33.5
530611007	53061	Washington	Snohomish	9.06	33.8	8.13	31.8
530630016	53063	Washington	Spokane	9.56	30.1	8.95	28.8
530770009	53077	Washington	Yakima	9.70	37.2	8.75	34.1
540030003	54003	West Virginia	Berkeley	14.90	31.2	10.03	21.1
540090005	54009	West Virginia	Brooke	15.40	36.0	9.27	20.4
540090011	54009	West Virginia	Brooke	15.00	40.4	9.09	23.4
540110006	54011	West Virginia	Cabell	15.35	32.9	10.04	18.1
540291004	54029	West Virginia	Hancock	14.31	38.0	8.59	19.6
540330003	54033	West Virginia	Harrison	13.37	30.2	8.20	14.0

Site ID	FIPS	State	County	Ambient Data (2005-2009) Annual DV	Ambient Data (2005-2009) 24-hr DV	Adjusted 2020 Base Case Annual DV	Adjusted 2020 Base Case 24-hr DV
540390010	54039	West Virginia	Kanawha	14.21	32.8	8.51	16.3
540391005	54039	West Virginia	Kanawha	15.46	35.2	9.45	17.2
540490006	54049	West Virginia	Marion	14.44	31.1	9.07	15.8
540511002	54051	West Virginia	Marshall	14.27	33.2	8.39	18.1
540610003	54061	West Virginia	Monongalia	13.58	33.3	7.71	13.0
540690010	54069	West Virginia	Ohio	13.81	30.6	7.87	16.6
540810002	54081	West Virginia	Raleigh	12.00	27.0	7.13	12.9
541071002	54107	West Virginia	Wood	14.58	33.9	9.25	18.6
550030010	55003	Wisconsin	Ashland	6.16	19.0	5.35	14.2
550090005	55009	Wisconsin	Brown	11.73	35.4	9.84	31.0
550250047	55025	Wisconsin	Dane	12.57	34.7	10.41	29.7
550270007	55027	Wisconsin	Dodge	11.00	28.7	9.03	24.5
550410007	55041	Wisconsin	Forest	7.09	20.9	5.94	16.5
550430009	55043	Wisconsin	Grant	12.27	34.5	10.18	30.5
550590019	55059	Wisconsin	Kenosha	12.62	32.1	9.93	26.1
550630012	55063	Wisconsin	La Crosse	11.76	32.1	10.11	29.3
550710007	55071	Wisconsin	Manitowoc	10.67	29.6	8.89	25.0
550790010	55079	Wisconsin	Milwaukee	13.45	37.2	10.87	30.1
550790026	55079	Wisconsin	Milwaukee	13.39	37.7	10.84	31.6
550790043	55079	Wisconsin	Milwaukee	13.85	37.2	11.25	30.9
550790059	55079	Wisconsin	Milwaukee	14.69	34.6	12.02	28.5
550790099	55079	Wisconsin	Milwaukee	13.83	37.1	11.22	29.5
550870009	55087	Wisconsin	Outagamie	11.25	32.8	9.31	28.3
550890009	55089	Wisconsin	Ozaukee	11.84	31.7	9.57	27.2
551091002	55109	Wisconsin	St. Croix	10.28	26.7	8.71	22.8
551110007	55111	Wisconsin	Sauk	10.50	28.1	8.46	24.3
551198001	55119	Wisconsin	Taylor	8.73	27.7	7.54	23.0
551250001	55125	Wisconsin	Vilas	6.78	26.5	5.80	22.2
551330027	55133	Wisconsin	Waukesha	13.82	32.3	11.30	27.9
560050892	56005	Wyoming	Campbell	5.52	14.0	5.26	13.6
560050899	56005	Wyoming	Campbell	5.05	12.5	4.78	12.3
560090819	56009	Wyoming	Converse	3.73	9.8	3.46	9.4
560131003	56013	Wyoming	Fremont	7.72	26.2	7.44	25.7
560210001	56021	Wyoming	Laramie	4.28	10.2	3.78	9.1
560330002	56033	Wyoming	Sheridan	9.07	25.7	8.73	25.0
560330003	56033	Wyoming	Sheridan	5.62	16.4	5.41	16.0

Appendix C

Impact of Burn Ban Adjustments on 2020 Base Case Design Values

The impacts of burn ban adjustments on design values for the 2020 base case are provided in Table C-1 of this appendix. See Section 3.2.1 for details on the methodology used in making the adjustments.

Table C-1. Impact of Burn Ban Adjustments on 2020 Base Case (i.e., 2020re) Annual and 24-hr $PM_{2.5}$ Design Values

Site ID	State	County	2020re Annual DV (ug/m3)	2020re Annual DV Burn Ban (ug/m3)	Impact of Burn Ban on 2020 Annual DV (ug/m3)	2020re Daily DV (ug/m3)	2020re Daily DV Burn Ban (ug/m3)	Impact of Burn Ban on 2020 Daily DV (ug/m3)
60010007	California	Alameda	8.21	8.18	**-0.03**	37.5	33	**-4.5**
60011001	California	Alameda	8.1	8.06	**-0.04**	31.9	27.6	**-4.3**
60070002	California	Butte	11.86	11.54	**-0.32**	58.2	46.4	**-11.8**
60190008	California	Fresno	14.58	13.9	**-0.68**	48.7	42.3	**-6.4**
60195001	California	Fresno	13.78	13.18	**-0.6**	46.3	40.1	**-6.2**
60195025	California	Fresno	13.98	13.38	**-0.6**	46.2	40.1	**-6.1**
60290010	California	Kern	14.92	14.45	**-0.47**	49.2	44.5	**-4.7**
60290014	California	Kern	16.22	15.68	**-0.54**	47.7	43	**-4.7**
60290016	California	Kern	17.02	16.5	**-0.52**	48.2	44.7	**-3.5**
60310004	California	Kings	14.01	13.57	**-0.44**	45.6	41	**-4.6**
60370002	California	Los Angeles	12.52	12.45	**-0.07**	33.5	32.3	**-1.2**
60371002	California	Los Angeles	12.83	12.77	**-0.06**	35.5	34.6	**-0.9**
60371103	California	Los Angeles	12.77	12.72	**-0.05**	35.1	34.5	**-0.6**
60371201	California	Los Angeles	9.59	9.53	**-0.06**	N/A	N/A	**N/A**
60371301	California	Los Angeles	12.55	12.48	**-0.07**	36.1	34.8	**-1.3**
60371602	California	Los Angeles	12.65	12.59	**-0.06**	35.4	34.4	**-1**
60372005	California	Los Angeles	10.68	10.63	**-0.05**	29.3	28.7	**-0.6**
60374002	California	Los Angeles	10.56	10.5	**-0.06**	30.5	29.4	**-1.1**
60374004	California	Los Angeles	9.92	9.86	**-0.06**	27.7	26.9	**-0.8**
60379033	California	Los Angeles	6.4	6.37	**-0.03**	14.6	14.5	**-0.1**
60472510	California	Merced	13.02	12.63	**-0.39**	44.4	36.9	**-7.5**
60651003	California	Riverside	12.62	12.55	**-0.07**	35.3	34.5	**-0.8**
60652002	California	Riverside	8.14	8.09	**-0.05**	18.8	17.7	**-1.1**
60655001	California	Riverside	6.85	6.8	**-0.05**	15.5	14.4	**-1.1**
60658001	California	Riverside	14.6	14.47	**-0.13**	37.4	36.6	**-0.8**
60658005	California	Riverside	15.86	15.7	**-0.16**	39.6	38.3	**-1.3**
60670006	California	Sacramento	11.36	10.96	**-0.4**	53.7	40.6	**-13.1**
60670010	California	Sacramento	10.37	10.01	**-0.36**	38.8	34.6	**-4.2**
60674001	California	Sacramento	9.93	9.56	**-0.37**	40.9	36.5	**-4.4**
60710025	California	San Bernardino	14.25	14.14	**-0.11**	36.5	35.1	**-1.4**

Site ID	State	County	2020re Annual DV (ug/m3)	2020re Annual DV Burn Ban (ug/m3)	Impact of Burn Ban on 2020 Annual DV (ug/m3)	2020re Daily DV (ug/m3)	2020re Daily DV Burn Ban (ug/m3)	Impact of Burn Ban on 2020 Daily DV (ug/m3)
60710306	California	San Bernardino	8.08	8	**-0.08**	14.6	14.2	**-0.4**
60712002	California	San Bernardino	14.06	13.94	**-0.12**	39.1	38	**-1.1**
60718001	California	San Bernardino	9.31	9.15	**-0.16**	34.3	29.3	**-5**
60719004	California	San Bernardino	13.29	13.17	**-0.12**	41.8	39.7	**-2.1**
60771002	California	San Joaquin	11.6	11.36	**-0.24**	44.2	36.7	**-7.5**
60850005	California	Santa Clara	9.82	9.71	**-0.11**	36.8	29.8	**-7**
60950004	California	Solano	8.8	8.75	**-0.05**	36.3	31.2	**-5.1**
60990005	California	Stanislaus	13.06	12.62	**-0.44**	47.8	42.7	**-5.1**
61010003	California	Sutter	8.64	8.61	**-0.03**	37.9	35.5	**-2.4**
61072002	California	Tulare	16.04	15.62	**-0.42**	43.1	39.4	**-3.7**
410350004	Oregon	Klamath	11.6	11.36	**-0.24**	46	34.2	**-11.8**
410390060	Oregon	Lane	7.89	7.5	**-0.39**	34.4	23.6	**-10.8**
410391009	Oregon	Lane	6.88	6.62	**-0.26**	21.7	16.3	**-5.4**
410392013	Oregon	Lane	10.93	10.71	**-0.22**	41.3	34.7	**-6.6**
490350003	Utah	Salt Lake	10.04	9.69	**-0.35**	41.3	33.6	**-7.7**
490351001	Utah	Salt Lake	7.73	7.59	**-0.14**	27.1	23.5	**-3.6**
490353006	Utah	Salt Lake	9.5	9.23	**-0.27**	42.8	36.8	**-6**
490353007	Utah	Salt Lake	10.55	10.27	**-0.28**	38.8	32.5	**-6.3**
490353008	Utah	Salt Lake	6.96	6.81	**-0.15**	22	21.1	**-0.9**
490353010	Utah	Salt Lake	N/A	N/A	**N/A**	33.6	29.8	**-3.8**
490490002	Utah	Utah	8.87	8.74	**-0.13**	33.3	29.2	**-4.1**
490494001	Utah	Utah	9.29	9.13	**-0.16**	40.6	34.1	**-6.5**
490495008	Utah	Utah	7.74	7.6	**-0.14**	30.3	27.2	**-3.1**
490495010	Utah	Utah	8.09	8	**-0.09**	32.6	29.9	**-2.7**
530530029	Washington	Pierce	8.84	8.55	**-0.29**	42.6	30.4	**-12.2**

Appendix D

Impacts of Atypical Event Days on 2020 Base Case Design Values

The list of monitor site-days removed from the RIA analysis due to atypical or unpredictable events is provided in Table D-1 of this appendix. The impacts of removing these site-days on design values for the 2020 base case are provided in Table D-2. See Section 3.2.2 for additional details.

Table D-1. Monitor site-days removed from the RIA analysis due to atypical or unpredictable events.

Site ID	State	County	Day	Year	Quarter	Measured PM2.5 (ug/m3)	Comments
40230004	Arizona	Santa Cruz	20051224	2005	4	49.7	Christmas eve fireworks
40230004	Arizona	Santa Cruz	20061225	2006	4	56.2	Christmas day fireworks
40230004	Arizona	Santa Cruz	20061231	2006	4	79.8	New years eve fireworks
40230004	Arizona	Santa Cruz	20080101	2008	1	46.7	New years day fireworks
40230004	Arizona	Santa Cruz	20090101	2009	1	117.6	New years day fireworks
60070002	California	Butte	20080623	2008	2	93.8	Probable fire
60070002	California	Butte	20080629	2008	2	49.5	Probable fire
60070002	California	Butte	20080711	2008	3	107.6	Probable fire
60070002	California	Butte	20080723	2008	3	47	Probable fire
60190008	California	Fresno	20070704	2007	3	103.8	July 4th or 5th fireworks
60190008	California	Fresno	20070705	2007	3	71	July 4th or 5th fireworks
60190008	California	Fresno	20070906	2007	3	43	Probable fire
60190008	California	Fresno	20070907	2007	3	52	Probable fire
60190008	California	Fresno	20080623	2008	2	35.8	Probable fire
60190008	California	Fresno	20080624	2008	2	63.9	Probable fire
60190008	California	Fresno	20080625	2008	2	50.2	Probable fire
60190008	California	Fresno	20080626	2008	2	62.5	Probable fire
60190008	California	Fresno	20080627	2008	2	79.5	Probable fire
60190008	California	Fresno	20080628	2008	2	49.4	Probable fire
60190008	California	Fresno	20080707	2008	3	42.2	Probable fire
60190008	California	Fresno	20080708	2008	3	47.4	Probable fire
60190008	California	Fresno	20080709	2008	3	48.8	Probable fire
60190008	California	Fresno	20080710	2008	3	60.8	Probable fire
60190008	California	Fresno	20080711	2008	3	36.5	Probable fire
60195001	California	Fresno	20070705	2007	3	40.6	July 4th or 5th fireworks
60195001	California	Fresno	20080623	2008	2	35.6	Probable fire
60195001	California	Fresno	20080711	2008	3	47.5	Probable fire
60195025	California	Fresno	20070705	2007	3	36.9	July 4th or 5th fireworks
60195025	California	Fresno	20080711	2008	3	41.5	Probable fire
60290010	California	Kern	20070705	2007	3	40.3	July 4th or 5th fireworks
60290014	California	Kern	20070704	2007	3	72.3	July 4th or 5th fireworks
60290014	California	Kern	20080624	2008	2	40.4	Probable fire
60290014	California	Kern	20080625	2008	2	52	Probable fire

Site ID	State	County	Day	Year	Quarter	Measured PM2.5 (ug/m3)	Comments
60290014	California	Kern	20080626	2008	2	54.8	Probable fire
60290014	California	Kern	20080627	2008	2	99.3	Probable fire
60290014	California	Kern	20080628	2008	2	36	Probable fire
60290014	California	Kern	20080708	2008	3	39.2	Probable fire
60290014	California	Kern	20080709	2008	3	47	Probable fire
60290014	California	Kern	20080710	2008	3	48.4	Probable fire
60290014	California	Kern	20080922	2008	3	36.5	Probable fire
60290014	California	Kern	20091230	2009	4	195.5	Very high FRM, but low co-located STN data and nearby FRM data (appears to be something wrong with the FRM data on this day)
60290016	California	Kern	20080626	2008	2	61	Probable fire
60290016	California	Kern	20080708	2008	3	41.9	Probable fire
60290016	California	Kern	20091013	2009	4	167.7	Very high crustal and PM10-localized dust event
60370002	California	Los Angeles	20050704	2005	3	59.2	July 4th or 5th fireworks
60370002	California	Los Angeles	20050705	2005	3	132.6	July 4th or 5th fireworks
60370002	California	Los Angeles	20070704	2007	3	43.5	July 4th or 5th fireworks
60371002	California	Los Angeles	20070705	2007	3	56.5	July 4th or 5th fireworks
60371002	California	Los Angeles	20080705	2008	3	57.4	July 4th or 5th fireworks
60371103	California	Los Angeles	20050704	2005	3	45.3	July 4th or 5th fireworks
60371103	California	Los Angeles	20050705	2005	3	50.4	July 4th or 5th fireworks
60371103	California	Los Angeles	20060704	2006	3	40.6	July 4th or 5th fireworks
60371103	California	Los Angeles	20060705	2006	3	39.3	July 4th or 5th fireworks
60371103	California	Los Angeles	20070704	2007	3	39	July 4th or 5th fireworks
60371103	California	Los Angeles	20070705	2007	3	44.8	July 4th or 5th fireworks
60371103	California	Los Angeles	20080704	2008	3	43.7	July 4th or 5th fireworks
60371103	California	Los Angeles	20080705	2008	3	40.3	July 4th or 5th fireworks
60371602	California	Los Angeles	20060704	2006	3	72.2	July 4th or 5th fireworks
60371602	California	Los Angeles	20070705	2007	3	63.6	July 4th or 5th fireworks
60472510	California	Merced	20080623	2008	2	54	Probable fire
60658001	California	Riverside	20050705	2005	3	79.8	July 4th or 5th fireworks
60658001	California	Riverside	20060705	2006	3	39.3	July 4th or 5th fireworks
60658001	California	Riverside	20070705	2007	3	48.9	July 4th or 5th fireworks
60658001	California	Riverside	20080913	2008	3	53.3	Probable fire

Site ID	State	County	Day	Year	Quarter	Measured PM2.5 (ug/m3)	Comments
60658001	California	Riverside	20080914	2008	3	41	Probable fire
60658005	California	Riverside	20070705	2007	3	60	July 4th or 5th fireworks
60658005	California	Riverside	20080705	2008	3	42.1	July 4th or 5th fireworks
60670006	California	Sacramento	20080623	2008	2	54.9	Probable fire
60670006	California	Sacramento	20080626	2008	2	74.4	Probable fire
60670006	California	Sacramento	20080708	2008	3	47.6	Probable fire
60670010	California	Sacramento	20080623	2008	2	51.8	Probable fire
60670010	California	Sacramento	20080626	2008	2	66.1	Probable fire
60670010	California	Sacramento	20080708	2008	3	46.4	Probable fire
60674001	California	Sacramento	20080623	2008	2	50	Probable fire
60674001	California	Sacramento	20080626	2008	2	64.8	Probable fire
60674001	California	Sacramento	20080708	2008	3	46.6	Probable fire
60710025	California	San Bernardino	20070705	2007	3	72.8	July 4th or 5th fireworks
60710025	California	San Bernardino	20080705	2008	3	54.2	July 4th or 5th fireworks
60712002	California	San Bernardino	20070705	2007	3	77.5	July 4th or 5th fireworks
60712002	California	San Bernardino	20080705	2008	3	43.9	July 4th or 5th fireworks
60719004	California	San Bernardino	20070705	2007	3	48.1	July 4th or 5th fireworks
60771002	California	San Joaquin	20080623	2008	2	61.7	Probable fire
60771002	California	San Joaquin	20080626	2008	2	81.2	Probable fire
60771002	California	San Joaquin	20080708	2008	3	49.4	Probable fire
60990005	California	Stanislaus	20070906	2007	3	37	Probable fire
60990005	California	Stanislaus	20080623	2008	2	53.9	Probable fire
60990005	California	Stanislaus	20080626	2008	2	88.3	Probable fire
60990005	California	Stanislaus	20080708	2008	3	44.8	Probable fire
61010003	California	Sutter	20080623	2008	2	45.4	Probable fire
61010003	California	Sutter	20080624	2008	2	68.8	Probable fire
61010003	California	Sutter	20080625	2008	2	94	Probable fire
61010003	California	Sutter	20080626	2008	2	68.5	Probable fire
61010003	California	Sutter	20080627	2008	2	105.5	Probable fire
61010003	California	Sutter	20080707	2008	3	54.2	Probable fire
61010003	California	Sutter	20080709	2008	3	99	Probable fire
61010003	California	Sutter	20080710	2008	3	127.3	Probable fire
61072002	California	Tulare	20080626	2008	2	63.3	Probable fire
61072002	California	Tulare	20080708	2008	3	43.1	Probable fire
61072002	California	Tulare	20080726	2008	3	35.5	Probable fire

Site ID	State	County	Day	Year	Quarter	Measured PM2.5 (ug/m3)	Comments
490494001	Utah	Utah	20050704	2005	3	59.8	July 4th or 5th fireworks
490494001	Utah	Utah	20070711	2007	3	42.1	Probable fire

Table D-2. **Impact of Atypical Event Adjustment on 2020 Base Case (i.e., 2020re) Annual and 24-hr $PM_{2.5}$ Design Values.**

Site ID	State	County	2020re Annual DV (ug/m3)	2020re Atypical Events Removed Annual DV (ug/m3)	Impact of Removal of Atypical Events on 2020 Annual DV (ug/m3)	2020re Daily DV (ug/m3)	2020re Atypical Events Removed Daily DV (ug/m3)	Impact of Removal of Atypical Events on 2020 Daily DV (ug/m3)
40230004	Arizona	Santa Cruz	13.37	12.65	-0.72	37.5	29.7	-7.8
60070002	California	Butte	11.86	10.96	-0.90	58.2	46.3	-11.9
60190008	California	Fresno	14.58	14.12	-0.46	48.7	46.2	-2.5
60195001	California	Fresno	13.78	13.38	-0.40	46.3	46.2	-0.1
60195025	California	Fresno	13.98	13.74	-0.24	46.2	45.9	-0.3
60290010	California	Kern	14.92	14.73	-0.19	49.2	49.2	0.0
60290014	California	Kern	16.22	15.94	-0.28	47.7	47.4	-0.3
60290016	California	Kern	17.02	16.80	-0.22	48.2	48.0	-0.2
60370002	California	Los Angeles	12.52	12.43	-0.09	33.5	33.4	-0.1
60371002	California	Los Angeles	12.83	12.67	-0.16	35.5	33.6	-1.9
60371103	California	Los Angeles	12.77	12.67	-0.10	35.1	34.4	-0.7
60371602	California	Los Angeles	12.65	12.43	-0.22	35.4	34.8	-0.6
60472510	California	Merced	13.02	13.02	0.00	44.4	44.2	-0.2
60658001	California	Riverside	14.60	14.52	-0.08	37.4	37.0	-0.4
60658005	California	Riverside	15.86	15.71	-0.15	39.6	39.6	0.0
60670006	California	Sacramento	11.36	11.11	-0.25	53.7	52.4	-1.3
60670010	California	Sacramento	10.37	10.13	-0.24	38.8	35.7	-3.1
60674001	California	Sacramento	9.93	9.71	-0.22	40.9	39.4	-1.5
60710025	California	San Bernardino	14.25	14.07	-0.18	36.5	36.2	-0.3
60712002	California	San Bernardino	14.06	13.84	-0.22	39.1	37.6	-1.5
60719004	California	San Bernardino	13.29	13.22	-0.07	41.8	41.8	0.0
60771002	California	San Joaquin	11.60	11.33	-0.27	44.2	41.1	-3.1
60990005	California	Stanislaus	13.06	12.74	-0.32	47.8	46.1	-1.7
61010003	California	Sutter	8.64	8.29	-0.35	37.9	30.5	-7.4
61072002	California	Tulare	16.04	15.88	-0.16	43.1	43.0	-0.1
490494001	Utah	Utah	9.29	9.22	-0.07	40.6	40.5	-0.1

Appendix E

Air Quality Ratios for NOx, SO_2, and Direct $PM_{2.5}$ Emissions

Air quality ratios give an estimate of how $PM_{2.5}$ design value components (μg/m^3) would change if 1000 tons of direct $PM_{2.5}$, SO_2 and/or NO_x emissions were reduced in the county group in which the monitor is located. Annual air quality ratios that relate changes in the NH_4NO_3 component of the design value to changes in NO_x emissions are listed in Table E-1 for counties in the South Coast Air Basin and San Joaquin Valley of California that received a mobile NO_x emission adjustment equal to the change in mobile NO_x emissions from the year 2020 to 2025. Annual and daily air quality ratios that relate changes in the $(NH_4)_2SO_4$ component of the design value to changes in SO_2 emissions are listed in Table E-2 for monitors in counties where air quality ratios were used in adjusting daily design values to remove the impact of inappropriate SO_2 controls. Annual and daily air quality ratios that relate changes in the direct $PM_{2.5}$ component of the design value to changes in direct $PM_{2.5}$ emissions are listed in Table E-3 for monitors where the ratios were used to estimate emissions reductions needed to attain NAAQS levels or to remove the impact of certain direct $PM_{2.5}$ controls included in the control run. See Section 3.3 for additional details.

Table E-1. Annual NO_x Air Quality Ratios for Monitors in California Counties that Received a 2025 Mobile NO_x Emission Adjustment

Monitor ID	FIPS Code	State Name	County Name	Annual NO_x Air Quality Ratio (μg/m^3 Change in NO_3 per 1000 tons NO_x)	County Emission Group
60190008	6019	California	Fresno	0.047	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and Sacramento
60195001	6019	California	Fresno	0.046	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and Sacramento
60195025	6019	California	Fresno	0.046	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and Sacramento
60290010	6029	California	Kern	0.043	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and

Monitor ID	FIPS Code	State Name	County Name	Annual NO_x Air Quality Ratio (μg/m^3 Change in NO_3 per 1000 tons NO_x)	County Emission Group
					Sacramento
60290014	6029	California	Kern	0.042	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and Sacramento
60290016	6029	California	Kern	0.042	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and Sacramento
60310004	6031	California	Kings	0.049	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and Sacramento
60370002	6037	California	Los Angeles	0.007	Los Angeles, Orange, Riverside, San Bernardino
60371002	6037	California	Los Angeles	0.006	Los Angeles, Orange, Riverside, San Bernardino
60371103	6037	California	Los Angeles	0.006	Los Angeles, Orange, Riverside, San Bernardino
60371201	6037	California	Los Angeles	0.003	Los Angeles, Orange, Riverside, San Bernardino
60371301	6037	California	Los Angeles	0.005	Los Angeles, Orange, Riverside, San Bernardino
60371602	6037	California	Los Angeles	0.007	Los Angeles, Orange, Riverside, San Bernardino
60372005	6037	California	Los Angeles	0.005	Los Angeles, Orange, Riverside, San Bernardino
60374002	6037	California	Los Angeles	0.004	Los Angeles, Orange, Riverside, San Bernardino
60374004	6037	California	Los Angeles	0.004	Los Angeles, Orange, Riverside, San Bernardino
60379033	6037	California	Los Angeles	0.003	Los Angeles, Orange, Riverside, San

Monitor ID	FIPS Code	State Name	County Name	Annual NO_x Air Quality Ratio ($\mu g/m^3$ Change in NO_3 per 1000 tons NO_x)	County Emission Group
					Bernardino
60472510	6047	California	Merced	0.029	Los Angeles, Orange, Riverside, San Bernardino
60590007	6059	California	Orange	0.006	Los Angeles, Orange, Riverside, San Bernardino
60592022	6059	California	Orange	0.005	Los Angeles, Orange, Riverside, San Bernardino
60651003	6065	California	Riverside	0.012	Los Angeles, Orange, Riverside, San Bernardino
60652002	6065	California	Riverside	0.000	Los Angeles, Orange, Riverside, San Bernardino
60655001	6065	California	Riverside	0.000	Los Angeles, Orange, Riverside, San Bernardino
60658001	6065	California	Riverside	0.012	Los Angeles, Orange, Riverside, San Bernardino
60658005	6065	California	Riverside	0.011	Los Angeles, Orange, Riverside, San Bernardino
60710025	6071	California	San Bernardino	0.009	Los Angeles, Orange, Riverside, San Bernardino
60710306	6071	California	San Bernardino	0.004	Los Angeles, Orange, Riverside, San Bernardino
60712002	6071	California	San Bernardino	0.011	Los Angeles, Orange, Riverside, San Bernardino
60718001	6071	California	San Bernardino	0.000	Los Angeles, Orange, Riverside, San Bernardino
60719004	6071	California	San Bernardino	0.009	Los Angeles, Orange, Riverside, San Bernardino
60771002	6077	California	San Joaquin	0.018	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and Sacramento
60990005	6099	California	Stanislaus	0.041	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and

Monitor ID	FIPS Code	State Name	County Name	Annual NO_x Air Quality Ratio ($\mu g/m^3$ Change in NO_3 per 1000 tons NO_x)	County Emission Group
					Sacramento
61072002	6107	California	Tulare	0.055	Weighted contributions from Kern, Kings/Tulare, Fresno/Madera, Merced, Stanislaus, San Joaquin, Alameda, and Sacramento

Table E-2. Annual and Daily SO_2 Air Quality Ratios for Monitors in Counties where Ratios were Used in Adjusting Daily Design Values to Remove the Impact of SO_2 Controls

Monitor ID	FIPS Code	State Name	County Name	Annual SO_2 Air Quality Ratio ($\mu g/m^3$ Change in SO_4 per 1000 tons SO_2)	Daily SO_2 Air Quality Ratio ($\mu g/m^3$ Change in SO_4 per 1000 tons SO_2)	County Emission Group
60990005	6099	California	Stanislaus	0.123	0.468	Stanislaus, San Joaquin, Merced
420030008	42003	Pennsylvania	Allegheny	0.026	0.084	Allegheny, Armstrong, Beaver, Butler, Washington, Westmoreland
420030064	42003	Pennsylvania	Allegheny	0.028	0.151	Allegheny, Armstrong, Beaver, Butler, Washington, Westmoreland
420030067	42003	Pennsylvania	Allegheny	0.017	0.050	Allegheny, Armstrong, Beaver, Butler, Washington, Westmoreland
420030095	42003	Pennsylvania	Allegheny	0.021	0.066	Allegheny, Armstrong, Beaver, Butler, Washington, Westmoreland
420031008	42003	Pennsylvania	Allegheny	0.019	0.033	Allegheny, Armstrong, Beaver, Butler, Washington, Westmoreland
420031301	42003	Pennsylvania	Allegheny	0.027	0.062	Allegheny, Armstrong, Beaver, Butler, Washington, Westmoreland
420033007	42003	Pennsylvania	Allegheny	0.021	0.068	Allegheny, Armstrong, Beaver, Butler, Washington, Westmoreland

Table E-3. Annual and Daily Direct $PM_{2.5}$ Air Quality Ratios Used in Adjusting Design Values to Meet Annual NAAQS Standard Levels, the 24-hr NAAQS Standard Level, and/or to Remove the Impact of Direct $PM_{2.5}$ Emissions Controls[1]

Monitor ID	FIPS Code	State Name	County Name	Annual $PM_{2.5}$ Air Quality Ratio (μg/m³ Direct $PM_{2.5}$ per 1000 tons $PM_{2.5}$)	Daily $PM_{2.5}$ Air Quality Ratio (μg/m³ Direct $PM_{2.5}$ per 1000 tons $PM_{2.5}$)	Used to Meet Annual Level	Used to Meet 24-hr Level	Used to Adjust Direct $PM_{2.5}$ Control
10730023	1073	Alabama	Jefferson	0.561	N/A	x		
10731005	1073	Alabama	Jefferson	0.257	N/A	x		
10731009	1073	Alabama	Jefferson	0.107	N/A	x		
10731010	1073	Alabama	Jefferson	0.221	N/A	x		
10732003	1073	Alabama	Jefferson	0.602	N/A	x		
10732006	1073	Alabama	Jefferson	0.383	N/A	x		
10735002	1073	Alabama	Jefferson	0.257	N/A	x		
10735003	1073	Alabama	Jefferson	0.195	N/A	x		
60010007	6001	California	Alameda	0.528	N/A	x		x
60011001	6001	California	Alameda	0.693	N/A	x		x
60190008	6019	California	Fresno	1.751	5.714	x	x	
60195001	6019	California	Fresno	1.534	4.825	x	x	
60195025	6019	California	Fresno	1.717	4.921	x	x	
60250005	6025	California	Imperial	1.801	6.594	x	x	
60250007	6025	California	Imperial	1.523	5.309	x	x	
60251003	6025	California	Imperial	1.612	5.270	x	x	
60290010	6029	California	Kern	1.341	4.344	x	x	
60290014	6029	California	Kern	1.531	4.475	x	x	
60290016	6029	California	Kern	1.579	4.892	x	x	
60310004	6031	California	Kings	1.277	4.919	x	x	
60370002	6037	California	Los Angeles	0.367	N/A	x		x
60371002	6037	California	Los Angeles	0.404	N/A	x		x
60371103	6037	California	Los Angeles	0.404	N/A	x		x
60371201	6037	California	Los Angeles	0.279	N/A	x		x
60371301	6037	California	Los Angeles	0.419	N/A	x		x

[1] For Sacramento, CA, Salt Lake City, UT, and Lake, OR, the adjustments made to meet the 24-hr standard level did not impact incremental costs and benefits because the annual design values for monitors in these counties were below the lowest alternative annual standard level in the adjusted 2020 base case.

Monitor ID	FIPS Code	State Name	County Name	Annual $PM_{2.5}$ Air Quality Ratio ($\mu g/m^3$ Direct $PM_{2.5}$ per 1000 tons $PM_{2.5}$)	Daily $PM_{2.5}$ Air Quality Ratio ($\mu g/m^3$ Direct $PM_{2.5}$ per 1000 tons $PM_{2.5}$)	Used to Meet Annual Level	Used to Meet 24-hr Level	Used to Adjust Direct $PM_{2.5}$ Control
60371602	6037	California	Los Angeles	0.401	N/A	x		x
60372005	6037	California	Los Angeles	0.322	N/A	x		x
60374002	6037	California	Los Angeles	0.325	N/A	x		x
60374004	6037	California	Los Angeles	0.299	N/A	x		x
60379033	6037	California	Los Angeles	0.119	N/A	x		x
60472510	6047	California	Merced	4.233	17.925	x	x	
60631006	6063	California	Plumas	2.428	N/A	x		
60631009	6063	California	Plumas	2.518	N/A	x		
60651003	6065	California	Riverside	1.620	3.223	x	x	x
60652002	6065	California	Riverside	0.930	2.463	x	x	x
60655001	6065	California	Riverside	0.797	1.885	x	x	x
60658001	6065	California	Riverside	2.089	3.627	x	x	x
60658005	6065	California	Riverside	2.459	5.039	x	x	x
60670006	6067	California	Sacramento	1.099	7.576		x	
60670010	6067	California	Sacramento	0.884	3.189		x	
60674001	6067	California	Sacramento	0.859	3.461		x	
60710025	6071	California	San Bernardino	0.710	1.423	x	x	
60710306	6071	California	San Bernardino	0.305	0.439	x	x	
60712002	6071	California	San Bernardino	0.619	1.180	x	x	
60718001	6071	California	San Bernardino	0.353	1.674	x	x	
60719004	6071	California	San Bernardino	0.606	1.710	x	x	
60771002	6077	California	San Joaquin	1.789	8.486	x		x
60990005	6099	California	Stanislaus	2.449	8.955	x	x	
61072002	6107	California	Tulare	1.875	4.222	x	x	
160790017	16079	Idaho	Shoshone	7.675	N/A	x		
170310022	17031	Illinois	Cook	0.330	N/A	x		
170310050	17031	Illinois	Cook	0.298	N/A	x		
170310052	17031	Illinois	Cook	0.356	N/A	x		
170310057	17031	Illinois	Cook	0.324	N/A	x		
170310076	17031	Illinois	Cook	0.281	N/A	x		
170312001	17031	Illinois	Cook	0.256	N/A	x		
170313301	17031	Illinois	Cook	0.307	N/A	x		

Monitor ID	FIPS Code	State Name	County Name	Annual $PM_{2.5}$ Air Quality Ratio ($\mu g/m^3$ Direct $PM_{2.5}$ per 1000 tons $PM_{2.5}$)	Daily $PM_{2.5}$ Air Quality Ratio ($\mu g/m^3$ Direct $PM_{2.5}$ per 1000 tons $PM_{2.5}$)	Used to Meet Annual Level	Used to Meet 24-hr Level	Used to Adjust Direct $PM_{2.5}$ Control
170314007	17031	Illinois	Cook	0.200	N/A	x		
170314201	17031	Illinois	Cook	0.205	N/A	x		
170316005	17031	Illinois	Cook	0.374	N/A	x		
171191007	17119	Illinois	Madison	0.332	N/A	x		
171192009	17119	Illinois	Madison	0.443	N/A	x		
171193007	17119	Illinois	Madison	0.417	N/A	x		
180890006	18089	Indiana	Lake	0.419	N/A			
180890027	18089	Indiana	Lake	0.320	N/A			
180890031	18089	Indiana	Lake	0.367	N/A			
180891003	18089	Indiana	Lake	0.401	N/A			
180892004	18089	Indiana	Lake	0.404	N/A			
180892010	18089	Indiana	Lake	0.397	N/A			
191630015	19163	Iowa	Scott	1.106	N/A	x		
191630018	19163	Iowa	Scott	1.051	N/A	x		
191630019	19163	Iowa	Scott	1.492	N/A	x		
261630001	26163	Michigan	Wayne	0.404	N/A	x		
261630015	26163	Michigan	Wayne	0.502	N/A	x		
261630016	26163	Michigan	Wayne	0.423	N/A	x		
261630019	26163	Michigan	Wayne	0.335	N/A	x		
261630025	26163	Michigan	Wayne	0.241	N/A	x		
261630033	26163	Michigan	Wayne	0.483	N/A	x		
261630036	26163	Michigan	Wayne	0.336	N/A	x		
261630038	26163	Michigan	Wayne	0.381	N/A	x		
261630039	26163	Michigan	Wayne	0.406	N/A	x		
410350004	41035	Oregon	Klamath	3.994	N/A	x		
410370001	41037	Oregon	Lake	10.977	132.456		x	
420030008	42003	Pennsylvania	Allegheny	0.358	1.463	x	x	
420030064	42003	Pennsylvania	Allegheny	0.519	4.060	x	x	
420030067	42003	Pennsylvania	Allegheny	0.222	0.657	x	x	
420030095	42003	Pennsylvania	Allegheny	0.263	0.931	x	x	
420031008	42003	Pennsylvania	Allegheny	0.172	0.645	x	x	
420031301	42003	Pennsylvania	Allegheny	0.405	1.409	x	x	

Monitor ID	FIPS Code	State Name	County Name	Annual $PM_{2.5}$ Air Quality Ratio ($\mu g/m^3$ Direct $PM_{2.5}$ per 1000 tons $PM_{2.5}$)	Daily $PM_{2.5}$ Air Quality Ratio ($\mu g/m^3$ Direct $PM_{2.5}$ per 1000 tons $PM_{2.5}$)	Used to Meet Annual Level	Used to Meet 24-hr Level	Used to Adjust Direct $PM_{2.5}$ Control
420033007	42003	Pennsylvania	Allegheny	0.397	1.752	x	x	
481410037	48141	Texas	El Paso	1.608	N/A	x		
481410044	48141	Texas	El Paso	2.209	N/A	x		
482010058	48201	Texas	Harris	0.188	N/A	x		
482011035	48201	Texas	Harris	0.408	N/A	x		
490350003	49035	Utah	Salt Lake	1.283	5.128		x	
490351001	49035	Utah	Salt Lake	0.710	2.734		x	
490353006	49035	Utah	Salt Lake	1.096	5.082		x	
490353007	49035	Utah	Salt Lake	1.211	4.392		x	
490353008	49035	Utah	Salt Lake	0.658	2.452		x	
550790010	55079	Wisconsin	Milwaukee	1.566	N/A	x		
550790026	55079	Wisconsin	Milwaukee	1.602	N/A	x		
550790043	55079	Wisconsin	Milwaukee	1.674	N/A	x		
550790059	55079	Wisconsin	Milwaukee	1.869	N/A	x		
550790099	55079	Wisconsin	Milwaukee	1.689	N/A	x		
551330027	55133	Wisconsin	Waukesha	3.297	N/A	x		

Appendix F

Annual $PM_{2.5}$ Design Values for the Analytical Baseline and for Attainment of the 12 $\mu g/m^3$ Level

Annual $PM_{2.5}$ design values for the analytical baseline and the case where the revised annual standard of 12 μg/m^3 is attained (Box 8, Figure 3-1) are provided in Table F-1 of this appendix. See Section 3.3 for additional details.

Table F-1. Annual $PM_{2.5}$ Design Values for the Analytical Baseline and the Case where the Revised Annual Standard Level of 12 μg/m^3 is Attained

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 μg/m^3 Level
10030010	1003	Alabama	Baldwin	7.37	7.37
10270001	1027	Alabama	Clay	8.04	8.04
10331002	1033	Alabama	Colbert	8.24	8.24
10491003	1049	Alabama	DeKalb	7.89	7.89
10530002	1053	Alabama	Escambia	9.71	9.71
10550010	1055	Alabama	Etowah	8.86	8.86
10690003	1069	Alabama	Houston	8.58	8.58
10730023	1073	Alabama	Jefferson	11.56	11.56
10731005	1073	Alabama	Jefferson	9.77	9.77
10731009	1073	Alabama	Jefferson	8.67	8.67
10731010	1073	Alabama	Jefferson	9.67	9.67
10732003	1073	Alabama	Jefferson	11.39	11.39
10732006	1073	Alabama	Jefferson	9.36	9.36
10735002	1073	Alabama	Jefferson	8.54	8.54
10735003	1073	Alabama	Jefferson	8.49	8.49
10890014	1089	Alabama	Madison	8.03	8.03
10970003	1097	Alabama	Mobile	8.00	8.00
10972005	1097	Alabama	Mobile	7.57	7.57
11010007	1101	Alabama	Montgomery	9.83	9.83
11030011	1103	Alabama	Morgan	8.13	8.13
11130001	1113	Alabama	Russell	10.27	10.27
11170006	1117	Alabama	Shelby	8.64	8.64
11250004	1125	Alabama	Tuscaloosa	8.71	8.71
11270002	1127	Alabama	Walker	8.58	8.58
40031005	4003	Arizona	Cochise	7.04	7.04
40051008	4005	Arizona	Coconino	6.63	6.63
40070008	4007	Arizona	Gila	8.54	8.54
40130019	4013	Arizona	Maricopa	9.71	9.71
40131003	4013	Arizona	Maricopa	7.95	7.95
40134003	4013	Arizona	Maricopa	10.46	10.46
40137020	4013	Arizona	Maricopa	6.51	6.51
40139997	4013	Arizona	Maricopa	8.03	8.03
40190011	4019	Arizona	Pima	5.36	5.36
40191028	4019	Arizona	Pima	5.21	5.21

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
40210001	4021	Arizona	Pinal	8.65	8.65
40213002	4021	Arizona	Pinal	5.97	5.97
50010011	5001	Arkansas	Arkansas	8.81	8.81
50030005	5003	Arkansas	Ashley	9.25	9.25
50350005	5035	Arkansas	Crittenden	8.49	8.49
50450002	5045	Arkansas	Faulkner	8.98	8.98
50510003	5051	Arkansas	Garland	9.09	9.09
50670001	5067	Arkansas	Jackson	8.22	8.22
51070001	5107	Arkansas	Phillips	8.11	8.11
51130002	5113	Arkansas	Polk	8.88	8.88
51150003	5115	Arkansas	Pope	9.72	9.72
51190007	5119	Arkansas	Pulaski	9.33	9.33
51191004	5119	Arkansas	Pulaski	9.78	9.78
51191008	5119	Arkansas	Pulaski	9.17	9.17
51310008	5131	Arkansas	Sebastian	8.95	8.95
51390006	5139	Arkansas	Union	9.31	9.31
51450001	5145	Arkansas	White	8.62	8.62
60010007	6001	California	Alameda	8.16	8.16
60011001	6001	California	Alameda	8.06	8.06
60070002	6007	California	Butte	10.65	10.65
60090001	6009	California	Calaveras	6.97	6.97
60130002	6013	California	Contra Costa	7.74	7.74
60190008	6019	California	Fresno	11.61	11.61
60195001	6019	California	Fresno	11.10	11.10
60195025	6019	California	Fresno	11.37	11.37
60231002	6023	California	Humboldt	6.91	6.91
60231004	6023	California	Humboldt	6.83	6.83
60250005	6025	California	Imperial	12.57	12.04
60250007	6025	California	Imperial	7.02	6.49
60251003	6025	California	Imperial	7.62	7.09
60271003	6027	California	Inyo	5.81	5.81
60290010	6029	California	Kern	11.08	10.42
60290014	6029	California	Kern	11.93	11.27
60290016	6029	California	Kern	12.70	12.04
60310004	6031	California	Kings	11.79	10.98
60333001	6033	California	Lake	4.58	4.58
60370002	6037	California	Los Angeles	12.01	11.71
60371002	6037	California	Los Angeles	12.34	12.04
60371103	6037	California	Los Angeles	12.34	12.04
60371201	6037	California	Los Angeles	9.42	9.12

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
60371301	6037	California	Los Angeles	12.24	11.94
60371602	6037	California	Los Angeles	12.06	11.76
60372005	6037	California	Los Angeles	10.38	10.08
60374002	6037	California	Los Angeles	10.29	9.99
60374004	6037	California	Los Angeles	9.67	9.37
60379033	6037	California	Los Angeles	6.02	5.72
60450006	6045	California	Mendocino	6.37	6.37
60472510	6047	California	Merced	12.12	12.04
60531003	6053	California	Monterey	5.94	5.94
60570005	6057	California	Nevada	5.78	5.78
60571001	6057	California	Nevada	6.59	6.59
60590007	6059	California	Orange	9.56	9.56
60592022	6059	California	Orange	7.44	7.44
60610006	6061	California	Placer	8.42	8.42
60631006	6063	California	Plumas	9.96	9.96
60631009	6063	California	Plumas	11.15	11.15
60651003	6065	California	Riverside	11.58	9.04
60652002	6065	California	Riverside	8.04	5.50
60655001	6065	California	Riverside	6.75	4.21
60658001	6065	California	Riverside	13.38	10.84
60658005	6065	California	Riverside	14.58	12.04
60670006	6067	California	Sacramento	10.31	10.31
60670010	6067	California	Sacramento	9.44	9.44
60674001	6067	California	Sacramento	9.02	9.02
60690002	6069	California	San Benito	5.22	5.22
60710025	6071	California	San Bernardino	12.64	12.04
60710306	6071	California	San Bernardino	7.39	6.79
60712002	6071	California	San Bernardino	12.33	11.73
60718001	6071	California	San Bernardino	8.81	8.21
60719004	6071	California	San Bernardino	11.82	11.22
60730001	6073	California	San Diego	9.50	9.50
60730003	6073	California	San Diego	9.87	9.87
60730006	6073	California	San Diego	8.14	8.14
60731002	6073	California	San Diego	9.84	9.84
60731010	6073	California	San Diego	10.49	10.49
60750005	6075	California	San Francisco	8.05	8.05
60771002	6077	California	San Joaquin	10.99	10.99
60792006	6079	California	San Luis Obispo	5.42	5.42
60798001	6079	California	San Luis Obispo	6.46	6.46

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 μg/m^3 Level
60811001	6081	California	San Mateo	7.61	7.61
60830011	6083	California	Santa Barbara	8.87	8.87
60831008	6083	California	Santa Barbara	6.38	6.38
60850005	6085	California	Santa Clara	9.68	9.68
60870007	6087	California	Santa Cruz	5.71	5.71
60890004	6089	California	Shasta	6.63	6.63
60950004	6095	California	Solano	8.72	8.72
60970003	6097	California	Sonoma	7.59	7.59
60990005	6099	California	Stanislaus	11.03	11.03
61010003	6101	California	Sutter	8.24	8.24
61072002	6107	California	Tulare	13.23	12.04
61110007	6111	California	Ventura	7.81	7.81
61110009	6111	California	Ventura	7.65	7.65
61112002	6111	California	Ventura	8.36	8.36
61113001	6111	California	Ventura	8.03	8.03
61131003	6113	California	Yolo	7.89	7.89
80010006	8001	Colorado	Adams	8.42	8.42
80050005	8005	Colorado	Arapahoe	6.39	6.39
80130003	8013	Colorado	Boulder	7.22	7.22
80130012	8013	Colorado	Boulder	6.05	6.05
80310002	8031	Colorado	Denver	7.45	7.45
80310023	8031	Colorado	Denver	7.76	7.76
80350004	8035	Colorado	Douglas	5.27	5.27
80390001	8039	Colorado	Elbert	4.02	4.02
80410011	8041	Colorado	El Paso	7.02	7.02
80690009	8069	Colorado	Larimer	6.63	6.63
80770017	8077	Colorado	Mesa	8.78	8.78
81010012	8101	Colorado	Pueblo	7.15	7.15
81230006	8123	Colorado	Weld	7.42	7.42
81230008	8123	Colorado	Weld	8.13	8.13
90010010	9001	Connecticut	Fairfield	8.48	8.48
90011123	9001	Connecticut	Fairfield	8.46	8.46
90013005	9001	Connecticut	Fairfield	7.84	7.84
90019003	9001	Connecticut	Fairfield	6.88	6.88
90031003	9003	Connecticut	Hartford	7.36	7.36
90050004	9005	Connecticut	Litchfield	6.28	6.28
90050005	9005	Connecticut	Litchfield	4.97	4.97
90090026	9009	Connecticut	New Haven	7.80	7.80
90090027	9009	Connecticut	New Haven	7.90	7.90
90091123	9009	Connecticut	New Haven	8.55	8.55

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
90092008	9009	Connecticut	New Haven	7.12	7.12
90092123	9009	Connecticut	New Haven	8.72	8.72
90113002	9011	Connecticut	New London	7.29	7.29
100010002	10001	Delaware	Kent	6.99	6.99
100010003	10001	Delaware	Kent	7.02	7.02
100031003	10003	Delaware	New Castle	8.19	8.19
100031007	10003	Delaware	New Castle	7.35	7.35
100031012	10003	Delaware	New Castle	7.98	7.98
100032004	10003	Delaware	New Castle	9.05	9.05
100051002	10005	Delaware	Sussex	7.78	7.78
110010041	11001	District of Columbia	District of Columbia	7.79	7.79
110010042	11001	District of Columbia	District of Columbia	7.83	7.83
110010043	11001	District of Columbia	District of Columbia	7.44	7.44
120010023	12001	Florida	Alachua	5.87	5.87
120010024	12001	Florida	Alachua	6.12	6.12
120051004	12005	Florida	Bay	7.60	7.60
120090007	12009	Florida	Brevard	5.35	5.35
120111002	12011	Florida	Broward	5.12	5.12
120112004	12011	Florida	Broward	5.22	5.22
120113002	12011	Florida	Broward	5.22	5.22
120170005	12017	Florida	Citrus	5.40	5.40
120310098	12031	Florida	Duval	6.26	6.26
120310099	12031	Florida	Duval	6.86	6.86
120330004	12033	Florida	Escambia	7.23	7.23
120570030	12057	Florida	Hillsborough	6.30	6.30
120573002	12057	Florida	Hillsborough	6.16	6.16
120710005	12071	Florida	Lee	5.43	5.43
120730012	12073	Florida	Leon	8.31	8.31
120814012	12081	Florida	Manatee	5.76	5.76
120830003	12083	Florida	Marion	6.74	6.74
120860033	12086	Florida	Miami-Dade	5.06	5.06
120861016	12086	Florida	Miami-Dade	5.99	5.99
120866001	12086	Florida	Miami-Dade	5.54	5.54
120951004	12095	Florida	Orange	5.71	5.71
120952002	12095	Florida	Orange	5.63	5.63
120990008	12099	Florida	Palm Beach	3.98	3.98
120990009	12099	Florida	Palm Beach	4.92	4.92
120992005	12099	Florida	Palm Beach	4.87	4.87
121030018	12103	Florida	Pinellas	5.71	5.71

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
121031009	12103	Florida	Pinellas	5.48	5.48
121056006	12105	Florida	Polk	5.89	5.89
121111002	12111	Florida	St. Lucie	5.49	5.49
121150013	12115	Florida	Sarasota	5.23	5.23
121171002	12117	Florida	Seminole	5.73	5.73
121275002	12127	Florida	Volusia	6.44	6.44
130210007	13021	Georgia	Bibb	10.94	10.94
130210012	13021	Georgia	Bibb	8.96	8.96
130510017	13051	Georgia	Chatham	8.86	8.86
130510091	13051	Georgia	Chatham	9.67	9.67
130590002	13059	Georgia	Clarke	9.90	9.90
130630091	13063	Georgia	Clayton	9.38	9.38
130670003	13067	Georgia	Cobb	9.26	9.26
130670004	13067	Georgia	Cobb	8.62	8.62
130890002	13089	Georgia	DeKalb	8.55	8.55
130892001	13089	Georgia	DeKalb	8.57	8.57
130950007	13095	Georgia	Dougherty	10.46	10.46
131150003	13115	Georgia	Floyd	9.49	9.49
131210032	13121	Georgia	Fulton	9.43	9.43
131270006	13127	Georgia	Glynn	8.21	8.21
131350002	13135	Georgia	Gwinnett	8.83	8.83
131390003	13139	Georgia	Hall	8.25	8.25
131530001	13153	Georgia	Houston	8.79	8.79
131850003	13185	Georgia	Lowndes	8.75	8.75
132150001	13215	Georgia	Muscogee	10.08	10.08
132150008	13215	Georgia	Muscogee	10.12	10.12
132150011	13215	Georgia	Muscogee	9.77	9.77
132230003	13223	Georgia	Paulding	8.03	8.03
132450005	13245	Georgia	Richmond	10.08	10.08
132450091	13245	Georgia	Richmond	10.24	10.24
133030001	13303	Georgia	Washington	9.86	9.86
133190001	13319	Georgia	Wilkinson	10.86	10.86
160010010	16001	Idaho	Ada	6.31	6.31
160090010	16009	Idaho	Benewah	9.28	9.28
160270004	16027	Idaho	Canyon	7.52	7.52
160410001	16041	Idaho	Franklin	6.78	6.78
160490003	16049	Idaho	Idaho	9.33	9.33
160790017	16079	Idaho	Shoshone	11.52	11.52
170190004	17019	Illinois	Champaign	8.90	8.90
170191001	17019	Illinois	Champaign	8.83	8.83

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
170310022	17031	Illinois	Cook	11.22	11.22
170310050	17031	Illinois	Cook	10.36	10.36
170310052	17031	Illinois	Cook	11.01	11.01
170310057	17031	Illinois	Cook	10.52	10.52
170310076	17031	Illinois	Cook	10.17	10.17
170311016	17031	Illinois	Cook	NA	NA
170312001	17031	Illinois	Cook	10.30	10.30
170313103	17031	Illinois	Cook	NA	NA
170313301	17031	Illinois	Cook	10.53	10.53
170314007	17031	Illinois	Cook	9.07	9.07
170314201	17031	Illinois	Cook	9.01	9.01
170316005	17031	Illinois	Cook	11.52	11.52
170434002	17043	Illinois	DuPage	9.53	9.53
170650002	17065	Illinois	Hamilton	8.41	8.41
170831001	17083	Illinois	Jersey	8.65	8.65
170890003	17089	Illinois	Kane	9.18	9.18
170890007	17089	Illinois	Kane	9.67	9.67
170971007	17097	Illinois	Lake	8.09	8.09
170990007	17099	Illinois	LaSalle	NA	NA
171110001	17111	Illinois	McHenry	8.51	8.51
171132003	17113	Illinois	McLean	8.64	8.64
171150013	17115	Illinois	Macon	9.53	9.53
171191007	17119	Illinois	Madison	11.70	11.70
171192009	17119	Illinois	Madison	10.23	10.23
171193007	17119	Illinois	Madison	10.01	10.01
171430037	17143	Illinois	Peoria	9.39	9.39
171570001	17157	Illinois	Randolph	8.92	8.92
171613002	17161	Illinois	Rock Island	9.03	9.03
171630010	17163	Illinois	St. Clair	10.56	10.56
171634001	17163	Illinois	St. Clair	9.69	9.69
171670012	17167	Illinois	Sangamon	9.17	9.17
171971002	17197	Illinois	Will	9.76	9.76
171971011	17197	Illinois	Will	8.06	8.06
172010013	17201	Illinois	Winnebago	9.49	9.49
180030004	18003	Indiana	Allen	9.26	9.26
180030014	18003	Indiana	Allen	9.80	9.80
180190006	18019	Indiana	Clark	9.85	9.85
180350006	18035	Indiana	Delaware	8.88	8.88
180370005	18037	Indiana	Dubois	9.06	9.06
180372001	18037	Indiana	Dubois	9.80	9.80

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
180431004	18043	Indiana	Floyd	8.57	8.57
180650003	18065	Indiana	Henry	8.16	8.16
180670003	18067	Indiana	Howard	9.13	9.13
180830004	18083	Indiana	Knox	8.71	8.71
180890006	18089	Indiana	Lake	10.55	10.55
180890022	18089	Indiana	Lake	NA	NA
180890026	18089	Indiana	Lake	NA	NA
180890027	18089	Indiana	Lake	9.47	9.47
180890031	18089	Indiana	Lake	10.36	10.36
180891003	18089	Indiana	Lake	11.17	11.17
180892004	18089	Indiana	Lake	10.52	10.52
180892010	18089	Indiana	Lake	10.26	10.26
180910011	18091	Indiana	LaPorte	8.62	8.62
180910012	18091	Indiana	LaPorte	9.16	9.16
180950009	18095	Indiana	Madison	9.01	9.01
180970042	18097	Indiana	Marion	9.69	9.69
180970043	18097	Indiana	Marion	NA	NA
180970066	18097	Indiana	Marion	NA	NA
180970078	18097	Indiana	Marion	9.94	9.94
180970079	18097	Indiana	Marion	10.11	10.11
180970081	18097	Indiana	Marion	10.40	10.40
180970083	18097	Indiana	Marion	10.15	10.15
181270020	18127	Indiana	Porter	9.36	9.36
181270024	18127	Indiana	Porter	9.13	9.13
181410014	18141	Indiana	St. Joseph	9.23	9.23
181410015	18141	Indiana	St. Joseph	8.88	8.88
181412004	18141	Indiana	St. Joseph	9.52	9.52
181470009	18147	Indiana	Spencer	8.67	8.67
181570008	18157	Indiana	Tippecanoe	8.93	8.93
181630006	18163	Indiana	Vanderburgh	9.45	9.45
181630012	18163	Indiana	Vanderburgh	9.64	9.64
181630016	18163	Indiana	Vanderburgh	9.43	9.43
181670018	18167	Indiana	Vigo	9.38	9.38
181670023	18167	Indiana	Vigo	8.88	8.88
190130008	19013	Iowa	Black Hawk	9.03	9.03
190450019	19045	Iowa	Clinton	10.67	10.67
190450021	19045	Iowa	Clinton	9.68	9.68
191032001	19103	Iowa	Johnson	9.22	9.22
191110008	19111	Iowa	Lee	9.20	9.20
191130037	19113	Iowa	Linn	8.21	8.21

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 μg/m^3 Level
191370002	19137	Iowa	Montgomery	7.64	7.64
191390015	19139	Iowa	Muscatine	10.81	10.81
191471002	19147	Iowa	Palo Alto	7.30	7.30
191530030	19153	Iowa	Polk	7.85	7.85
191532510	19153	Iowa	Polk	7.56	7.56
191550009	19155	Iowa	Pottawattamie	8.58	8.58
191630015	19163	Iowa	Scott	9.51	9.51
191630018	19163	Iowa	Scott	9.27	9.27
191630019	19163	Iowa	Scott	11.51	11.51
191770006	19177	Iowa	Van Buren	8.03	8.03
191930017	19193	Iowa	Woodbury	8.57	8.57
191970004	19197	Iowa	Wright	7.86	7.86
200910007	20091	Kansas	Johnson	7.46	7.46
200910010	20091	Kansas	Johnson	6.89	6.89
201070002	20107	Kansas	Linn	7.86	7.86
201730008	20173	Kansas	Sedgwick	7.79	7.79
201730009	20173	Kansas	Sedgwick	7.76	7.76
201730010	20173	Kansas	Sedgwick	7.83	7.83
201770013	20177	Kansas	Shawnee	7.99	7.99
201910002	20191	Kansas	Sumner	7.53	7.53
202090021	20209	Kansas	Wyandotte	8.63	8.63
202090022	20209	Kansas	Wyandotte	7.77	7.77
210130002	21013	Kentucky	Bell	8.89	8.89
210190017	21019	Kentucky	Boyd	8.48	8.48
210290006	21029	Kentucky	Bullitt	8.88	8.88
210430500	21043	Kentucky	Carter	7.49	7.49
210470006	21047	Kentucky	Christian	8.60	8.60
210590005	21059	Kentucky	Daviess	8.65	8.65
210670012	21067	Kentucky	Fayette	7.99	7.99
210670014	21067	Kentucky	Fayette	8.03	8.03
210730006	21073	Kentucky	Franklin	7.47	7.47
210930006	21093	Kentucky	Hardin	8.22	8.22
211010014	21101	Kentucky	Henderson	8.87	8.87
211110043	21111	Kentucky	Jefferson	9.03	9.03
211110044	21111	Kentucky	Jefferson	9.00	9.00
211110048	21111	Kentucky	Jefferson	9.00	9.00
211110051	21111	Kentucky	Jefferson	8.82	8.82
211170007	21117	Kentucky	Kenton	8.18	8.18
211451004	21145	Kentucky	McCracken	8.91	8.91
211510003	21151	Kentucky	Madison	7.04	7.04

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 μg/m^3 Level
211830032	21183	Kentucky	Ohio	8.36	8.36
211930003	21193	Kentucky	Perry	8.46	8.46
211950002	21195	Kentucky	Pike	7.88	7.88
212270007	21227	Kentucky	Warren	NA	NA
212270008	21227	Kentucky	Warren	NA	NA
220170008	22017	Louisiana	Caddo Parish	9.36	9.36
220190009	22019	Louisiana	Calcasieu Parish	7.42	7.42
220190010	22019	Louisiana	Calcasieu Parish	7.55	7.55
220330009	22033	Louisiana	East Baton Rouge Parish	9.25	9.25
220331001	22033	Louisiana	East Baton Rouge Parish	8.19	8.19
220470005	22047	Louisiana	Iberville Parish	8.80	8.80
220470009	22047	Louisiana	Iberville Parish	7.54	7.54
220511001	22051	Louisiana	Jefferson Parish	7.28	7.28
220512001	22051	Louisiana	Jefferson Parish	7.43	7.43
220550006	22055	Louisiana	Lafayette Parish	7.50	7.50
220550007	22055	Louisiana	Lafayette Parish	7.21	7.21
220730004	22073	Louisiana	Ouachita Parish	8.19	8.19
220790002	22079	Louisiana	Rapides Parish	7.47	7.47
220870007	22087	Louisiana	St. Bernard Parish	7.90	7.90
221050001	22105	Louisiana	Tangipahoa Parish	7.97	7.97
221090001	22109	Louisiana	Terrebonne Parish	7.15	7.15
221210001	22121	Louisiana	West Baton Rouge Parish	9.69	9.69
230010011	23001	Maine	Androscoggin	7.62	7.62
230030013	23003	Maine	Aroostook	8.74	8.74
230031011	23003	Maine	Aroostook	6.98	6.98
230050015	23005	Maine	Cumberland	8.37	8.37
230090103	23009	Maine	Hancock	4.12	4.12
230110016	23011	Maine	Kennebec	7.66	7.66
230172011	23017	Maine	Oxford	8.25	8.25
230190002	23019	Maine	Penobscot	7.17	7.17
230210004	23021	Maine	Piscataquis	4.68	4.68
240031003	24003	Maryland	Anne Arundel	8.27	8.27
240051007	24005	Maryland	Baltimore	7.59	7.59
240053001	24005	Maryland	Baltimore	8.46	8.46

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
240150003	24015	Maryland	Cecil	7.23	7.23
240251001	24025	Maryland	Harford	7.04	7.04
240313001	24031	Maryland	Montgomery	6.71	6.71
240330025	24033	Maryland	Prince George's	7.62	7.62
240330030	24033	Maryland	Prince George's	6.76	6.76
240338003	24033	Maryland	Prince George's	7.03	7.03
240430009	24043	Maryland	Washington	7.47	7.47
245100006	24510	Maryland	Baltimore city	7.78	7.78
245100007	24510	Maryland	Baltimore city	7.89	7.89
245100008	24510	Maryland	Baltimore city	8.89	8.89
245100035	24510	Maryland	Baltimore city	NA	NA
245100040	24510	Maryland	Baltimore city	NA	NA
250035001	25003	Massachusetts	Berkshire	7.34	7.34
250051004	25005	Massachusetts	Bristol	6.31	6.31
250092006	25009	Massachusetts	Essex	6.19	6.19
250095005	25009	Massachusetts	Essex	6.60	6.60
250096001	25009	Massachusetts	Essex	6.90	6.90
250130008	25013	Massachusetts	Hampden	6.73	6.73
250130016	25013	Massachusetts	Hampden	8.84	8.84
250132009	25013	Massachusetts	Hampden	8.58	8.58
250170009	25017	Massachusetts	Middlesex	6.38	6.38
250230004	25023	Massachusetts	Plymouth	6.67	6.67
250250002	25025	Massachusetts	Suffolk	8.30	8.30
250250027	25025	Massachusetts	Suffolk	8.15	8.15
250250042	25025	Massachusetts	Suffolk	7.12	7.12
250250043	25025	Massachusetts	Suffolk	8.51	8.51
250270016	25027	Massachusetts	Worcester	7.72	7.72
250270023	25027	Massachusetts	Worcester	8.25	8.25
260050003	26005	Michigan	Allegan	8.30	8.30
260170014	26017	Michigan	Bay	7.89	7.89
260210014	26021	Michigan	Berrien	8.15	8.15
260490021	26049	Michigan	Genesee	8.05	8.05
260650012	26065	Michigan	Ingham	8.23	8.23
260770008	26077	Michigan	Kalamazoo	9.16	9.16
260810007	26081	Michigan	Kent	8.65	8.65
260810020	26081	Michigan	Kent	8.99	8.99
260990009	26099	Michigan	Macomb	8.61	8.61
261010922	26101	Michigan	Manistee	6.00	6.00
261130001	26113	Michigan	Missaukee	6.15	6.15

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 μg/m^3 Level
261150005	26115	Michigan	Monroe	9.28	9.28
261210040	26121	Michigan	Muskegon	8.13	8.13
261250001	26125	Michigan	Oakland	8.97	8.97
261390005	26139	Michigan	Ottawa	8.73	8.73
261470005	26147	Michigan	St. Clair	8.75	8.75
261610008	26161	Michigan	Washtenaw	9.34	9.34
261630001	26163	Michigan	Wayne	9.47	9.47
261630015	26163	Michigan	Wayne	10.53	10.53
261630016	26163	Michigan	Wayne	9.69	9.69
261630019	26163	Michigan	Wayne	9.35	9.35
261630025	26163	Michigan	Wayne	8.81	8.81
261630033	26163	Michigan	Wayne	11.58	11.58
261630036	26163	Michigan	Wayne	9.41	9.41
261630038	26163	Michigan	Wayne	8.88	8.88
261630039	26163	Michigan	Wayne	9.35	9.35
270210001	27021	Minnesota	Cass	5.03	5.03
270370470	27037	Minnesota	Dakota	7.74	7.74
270530961	27053	Minnesota	Hennepin	7.49	7.49
270530963	27053	Minnesota	Hennepin	7.92	7.92
270531007	27053	Minnesota	Hennepin	8.16	8.16
270953051	27095	Minnesota	Mille Lacs	5.58	5.58
271095008	27109	Minnesota	Olmsted	8.02	8.02
271230866	27123	Minnesota	Ramsey	9.24	9.24
271230868	27123	Minnesota	Ramsey	8.95	8.95
271230871	27123	Minnesota	Ramsey	7.95	7.95
271377001	27137	Minnesota	St. Louis	5.48	5.48
271377550	27137	Minnesota	St. Louis	5.45	5.45
271377551	27137	Minnesota	St. Louis	6.69	6.69
271390505	27139	Minnesota	Scott	7.58	7.58
271453052	27145	Minnesota	Stearns	7.14	7.14
271630446	27163	Minnesota	Washington	NA	NA
280010004	28001	Mississippi	Adams	7.84	7.84
280110001	28011	Mississippi	Bolivar	8.51	8.51
280330002	28033	Mississippi	DeSoto	8.03	8.03
280350004	28035	Mississippi	Forrest	10.22	10.22
280430001	28043	Mississippi	Grenada	7.22	7.22
280470008	28047	Mississippi	Harrison	7.71	7.71
280490010	28049	Mississippi	Hinds	8.88	8.88
280590006	28059	Mississippi	Jackson	7.70	7.70
280670002	28067	Mississippi	Jones	10.52	10.52

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
280750003	28075	Mississippi	Lauderdale	9.11	9.11
280810005	28081	Mississippi	Lee	8.57	8.57
280870001	28087	Mississippi	Lowndes	8.70	8.70
290210005	29021	Missouri	Buchanan	9.71	9.71
290370003	29037	Missouri	Cass	7.87	7.87
290470005	29047	Missouri	Clay	8.03	8.03
290770032	29077	Missouri	Greene	8.75	8.75
290950034	29095	Missouri	Jackson	9.17	9.17
290990012	29099	Missouri	Jefferson	10.18	10.18
291831002	29183	Missouri	St. Charles	9.64	9.64
291860006	29186	Missouri	Ste. Genevieve	9.51	9.51
291892003	29189	Missouri	St. Louis	9.19	9.19
295100007	29510	Missouri	St. Louis city	9.88	9.88
295100085	29510	Missouri	St. Louis city	9.77	9.77
295100087	29510	Missouri	St. Louis city	10.18	10.18
300131026	30013	Montana	Cascade	5.89	5.89
300290009	30029	Montana	Flathead	9.28	9.28
300290047	30029	Montana	Flathead	8.22	8.22
300310008	30031	Montana	Gallatin	8.36	8.36
300310016	30031	Montana	Gallatin	7.17	7.17
300490018	30049	Montana	Lewis and Clark	8.26	8.26
300630031	30063	Montana	Missoula	9.37	9.37
300810007	30081	Montana	Ravalli	8.94	8.94
300890007	30089	Montana	Sanders	6.93	6.93
300930005	30093	Montana	Silver Bow	10.86	10.86
301111065	30111	Montana	Yellowstone	7.49	7.49
310550019	31055	Nebraska	Douglas	7.30	7.30
310550052	31055	Nebraska	Douglas	6.93	6.93
310790004	31079	Nebraska	Hall	6.38	6.38
311090022	31109	Nebraska	Lancaster	6.32	6.32
311530007	31153	Nebraska	Sarpy	7.22	7.22
311570003	31157	Nebraska	Scotts Bluff	5.66	5.66
311770002	31177	Nebraska	Washington	6.74	6.74
320030561	32003	Nevada	Clark	8.74	8.74
320031019	32003	Nevada	Clark	3.74	3.74
320032002	32003	Nevada	Clark	7.89	7.89
320310016	32031	Nevada	Washoe	7.79	7.79
330012004	33001	New Hampshire	Belknap	5.36	5.36
330050007	33005	New Hampshire	Cheshire	9.35	9.35
330090010	33009	New Hampshire	Grafton	6.63	6.63

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
330111015	33011	New Hampshire	Hillsborough	7.59	7.59
330131006	33013	New Hampshire	Merrimack	7.59	7.59
330150014	33015	New Hampshire	Rockingham	7.05	7.05
330190003	33019	New Hampshire	Sullivan	8.03	8.03
340010006	34001	New Jersey	Atlantic	6.23	6.23
340011006	34001	New Jersey	Atlantic	7.16	7.16
340030003	34003	New Jersey	Bergen	7.79	7.79
340070003	34007	New Jersey	Camden	8.90	8.90
340071007	34007	New Jersey	Camden	8.26	8.26
340130015	34013	New Jersey	Essex	8.36	8.36
340150004	34015	New Jersey	Gloucester	7.23	7.23
340171003	34017	New Jersey	Hudson	8.28	8.28
340172002	34017	New Jersey	Hudson	9.03	9.03
340210008	34021	New Jersey	Mercer	7.72	7.72
340218001	34021	New Jersey	Mercer	6.29	6.29
340230006	34023	New Jersey	Middlesex	7.30	7.30
340270004	34027	New Jersey	Morris	6.57	6.57
340273001	34027	New Jersey	Morris	5.99	5.99
340292002	34029	New Jersey	Ocean	6.36	6.36
340310005	34031	New Jersey	Passaic	7.78	7.78
340390004	34039	New Jersey	Union	8.53	8.53
340390006	34039	New Jersey	Union	7.96	7.96
340392003	34039	New Jersey	Union	7.76	7.76
340410006	34041	New Jersey	Warren	7.83	7.83
350010023	35001	New Mexico	Bernalillo	5.88	5.88
350010024	35001	New Mexico	Bernalillo	5.47	5.47
350050005	35005	New Mexico	Chaves	6.12	6.12
350130017	35013	New Mexico	Doña Ana	10.23	10.23
350130025	35013	New Mexico	Doña Ana	5.83	5.83
350171002	35017	New Mexico	Grant	4.89	4.89
350431003	35043	New Mexico	Sandoval	4.38	4.38
350439011	35043	New Mexico	Sandoval	7.31	7.31
350450006	35045	New Mexico	San Juan	5.55	5.55
350490020	35049	New Mexico	Santa Fe	4.24	4.24
360010005	36001	New York	Albany	6.86	6.86
360050080	36005	New York	Bronx	9.66	9.66
360050083	36005	New York	Bronx	8.34	8.34
360050110	36005	New York	Bronx	7.86	7.86
360130011	36013	New York	Chautauqua	5.98	5.98
360290005	36029	New York	Erie	8.15	8.15

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 μg/m^3 Level
360291007	36029	New York	Erie	7.89	7.89
360310003	36031	New York	Essex	4.00	4.00
360470122	36047	New York	Kings	8.45	8.45
360551007	36055	New York	Monroe	6.58	6.58
360590008	36059	New York	Nassau	6.94	6.94
360610056	36061	New York	New York	10.77	10.77
360610062	36061	New York	New York	NA	NA
360610079	36061	New York	New York	8.11	8.11
360610128	36061	New York	New York	10.22	10.22
360632008	36063	New York	Niagara	7.81	7.81
360671015	36067	New York	Onondaga	6.46	6.46
360710002	36071	New York	Orange	6.55	6.55
360810124	36081	New York	Queens	7.25	7.25
360850055	36085	New York	Richmond	7.86	7.86
360850067	36085	New York	Richmond	6.87	6.87
360893001	36089	New York	St. Lawrence	4.80	4.80
361010003	36101	New York	Steuben	5.35	5.35
361030002	36103	New York	Suffolk	6.35	6.35
361191002	36119	New York	Westchester	7.01	7.01
370010002	37001	North Carolina	Alamance	7.48	7.48
370210034	37021	North Carolina	Buncombe	7.05	7.05
370330001	37033	North Carolina	Caswell	6.90	6.90
370350004	37035	North Carolina	Catawba	8.73	8.73
370370004	37037	North Carolina	Chatham	6.71	6.71
370510009	37051	North Carolina	Cumberland	8.12	8.12
370570002	37057	North Carolina	Davidson	8.69	8.69
370610002	37061	North Carolina	Duplin	6.30	6.30
370630001	37063	North Carolina	Durham	8.36	8.36
370650004	37065	North Carolina	Edgecombe	7.22	7.22
370670022	37067	North Carolina	Forsyth	7.68	7.68
370670030	37067	North Carolina	Forsyth	7.33	7.33
370710016	37071	North Carolina	Gaston	8.05	8.05
370810013	37081	North Carolina	Guilford	6.39	6.39
370870010	37087	North Carolina	Haywood	9.12	9.12
370990006	37099	North Carolina	Jackson	7.57	7.57
371070004	37107	North Carolina	Lenoir	6.30	6.30
371110004	37111	North Carolina	McDowell	8.46	8.46
371170001	37117	North Carolina	Martin	6.41	6.41
371190041	37119	North Carolina	Mecklenburg	8.23	8.23
371190042	37119	North Carolina	Mecklenburg	8.44	8.44

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 μg/m³ Level
371190043	37119	North Carolina	Mecklenburg	7.60	7.60
371210001	37121	North Carolina	Mitchell	7.71	7.71
371230001	37123	North Carolina	Montgomery	7.08	7.08
371290002	37129	North Carolina	New Hanover	5.92	5.92
371330005	37133	North Carolina	Onslow	6.35	6.35
371350007	37135	North Carolina	Orange	7.67	7.67
371470005	37147	North Carolina	Pitt	7.05	7.05
371550005	37155	North Carolina	Robeson	7.79	7.79
371590021	37159	North Carolina	Rowan	8.26	8.26
371730002	37173	North Carolina	Swain	7.92	7.92
371830014	37183	North Carolina	Wake	7.84	7.84
371890003	37189	North Carolina	Watauga	6.32	6.32
371910005	37191	North Carolina	Wayne	7.68	7.68
380070002	38007	North Dakota	Billings	4.34	4.34
380150003	38015	North Dakota	Burleigh	6.10	6.10
380171004	38017	North Dakota	Cass	6.78	6.78
380570004	38057	North Dakota	Mercer	5.85	5.85
390090003	39009	Ohio	Athens	6.95	6.95
390170003	39017	Ohio	Butler	9.57	9.57
390170016	39017	Ohio	Butler	9.39	9.39
390171004	39017	Ohio	Butler	9.90	9.90
390230005	39023	Ohio	Clark	9.48	9.48
390250022	39025	Ohio	Clermont	8.21	8.21
390350027	39035	Ohio	Cuyahoga	9.57	9.57
390350034	39035	Ohio	Cuyahoga	8.22	8.22
390350038	39035	Ohio	Cuyahoga	10.62	10.62
390350045	39035	Ohio	Cuyahoga	9.92	9.92
390350060	39035	Ohio	Cuyahoga	10.73	10.73
390350065	39035	Ohio	Cuyahoga	10.08	10.08
390351002	39035	Ohio	Cuyahoga	8.40	8.40
390490024	39049	Ohio	Franklin	9.14	9.14
390490025	39049	Ohio	Franklin	9.11	9.11
390490081	39049	Ohio	Franklin	7.43	7.43
390570005	39057	Ohio	Greene	8.25	8.25
390610006	39061	Ohio	Hamilton	8.76	8.76
390610014	39061	Ohio	Hamilton	10.53	10.53
390610040	39061	Ohio	Hamilton	8.90	8.90
390610042	39061	Ohio	Hamilton	10.06	10.06
390610043	39061	Ohio	Hamilton	9.51	9.51
390617001	39061	Ohio	Hamilton	9.43	9.43

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 μg/m³ Level
390618001	39061	Ohio	Hamilton	10.34	10.34
390810017	39081	Ohio	Jefferson	9.02	9.02
390811001	39081	Ohio	Jefferson	8.82	8.82
390853002	39085	Ohio	Lake	8.13	8.13
390870010	39087	Ohio	Lawrence	9.67	9.67
390933002	39093	Ohio	Lorain	8.42	8.42
390950024	39095	Ohio	Lucas	9.85	9.85
390950025	39095	Ohio	Lucas	10.15	10.15
390950026	39095	Ohio	Lucas	9.69	9.69
390990005	39099	Ohio	Mahoning	9.14	9.14
390990014	39099	Ohio	Mahoning	9.26	9.26
391030003	39103	Ohio	Medina	8.00	8.00
391130032	39113	Ohio	Montgomery	9.52	9.52
391330002	39133	Ohio	Portage	8.40	8.40
391351001	39135	Ohio	Preble	8.59	8.59
391450013	39145	Ohio	Scioto	8.47	8.47
391510017	39151	Ohio	Stark	10.83	10.83
391530017	39153	Ohio	Summit	9.69	9.69
391530023	39153	Ohio	Summit	8.89	8.89
391550007	39155	Ohio	Trumbull	9.35	9.35
391650007	39165	Ohio	Warren	8.10	8.10
400159008	40015	Oklahoma	Caddo	6.94	6.94
400219002	40021	Oklahoma	Cherokee	9.78	9.78
400719010	40071	Oklahoma	Kay	8.67	8.67
400970186	40097	Oklahoma	Mayes	9.19	9.19
400979014	40097	Oklahoma	Mayes	9.13	9.13
401010169	40101	Oklahoma	Muskogee	9.24	9.24
401090035	40109	Oklahoma	Oklahoma	7.80	7.80
401091037	40109	Oklahoma	Oklahoma	7.90	7.90
401159004	40115	Oklahoma	Ottawa	8.91	8.91
401210415	40121	Oklahoma	Pittsburg	8.83	8.83
401359015	40135	Oklahoma	Sequoyah	9.55	9.55
401430110	40143	Oklahoma	Tulsa	8.88	8.88
401431127	40143	Oklahoma	Tulsa	8.85	8.85
410250002	41025	Oregon	Harney	9.75	9.75
410290133	41029	Oregon	Jackson	9.73	9.73
410291001	41029	Oregon	Jackson	5.20	5.20
410330114	41033	Oregon	Josephine	8.60	8.60
410350004	41035	Oregon	Klamath	11.30	11.30
410370001	41037	Oregon	Lake	9.35	9.35

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
410390060	41039	Oregon	Lane	7.50	7.50
410391009	41039	Oregon	Lane	6.62	6.62
410392013	41039	Oregon	Lane	10.70	10.70
410510080	41051	Oregon	Multnomah	7.79	7.79
410510246	41051	Oregon	Multnomah	6.89	6.89
410590121	41059	Oregon	Umatilla	7.68	7.68
410610119	41061	Oregon	Union	7.33	7.33
410670004	41067	Oregon	Washington	8.12	8.12
420010001	42001	Pennsylvania	Adams	7.35	7.35
420030008	42003	Pennsylvania	Allegheny	8.34	8.34
420030064	42003	Pennsylvania	Allegheny	11.12	11.12
420030067	42003	Pennsylvania	Allegheny	7.06	7.06
420030093	42003	Pennsylvania	Allegheny	NA	NA
420030095	42003	Pennsylvania	Allegheny	7.93	7.93
420031008	42003	Pennsylvania	Allegheny	8.58	8.58
420031301	42003	Pennsylvania	Allegheny	9.02	9.02
420033007	42003	Pennsylvania	Allegheny	8.65	8.65
420070014	42007	Pennsylvania	Beaver	10.12	10.12
420110011	42011	Pennsylvania	Berks	8.64	8.64
420170012	42017	Pennsylvania	Bucks	8.39	8.39
420210011	42021	Pennsylvania	Cambria	9.17	9.17
420270100	42027	Pennsylvania	Centre	7.02	7.02
420290100	42029	Pennsylvania	Chester	NA	NA
420410101	42041	Pennsylvania	Cumberland	8.51	8.51
420430401	42043	Pennsylvania	Dauphin	8.79	8.79
420450002	42045	Pennsylvania	Delaware	9.40	9.40
420490003	42049	Pennsylvania	Erie	8.09	8.09
420692006	42069	Pennsylvania	Lackawanna	7.20	7.20
420710007	42071	Pennsylvania	Lancaster	9.36	9.36
420850100	42085	Pennsylvania	Mercer	8.06	8.06
420910013	42091	Pennsylvania	Montgomery	7.66	7.66
420950025	42095	Pennsylvania	Northampton	8.74	8.74
421010004	42101	Pennsylvania	Philadelphia	8.61	8.61
421010024	42101	Pennsylvania	Philadelphia	7.63	7.63
421010047	42101	Pennsylvania	Philadelphia	8.61	8.61
421250005	42125	Pennsylvania	Washington	8.56	8.56
421250200	42125	Pennsylvania	Washington	7.58	7.58
421255001	42125	Pennsylvania	Washington	7.52	7.52
421290008	42129	Pennsylvania	Westmoreland	8.50	8.50
421330008	42133	Pennsylvania	York	9.48	9.48

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
440030002	44003	Rhode Island	Kent	5.18	5.18
440070022	44007	Rhode Island	Providence	6.90	6.90
440070026	44007	Rhode Island	Providence	8.63	8.63
440070028	44007	Rhode Island	Providence	7.32	7.32
440071010	44007	Rhode Island	Providence	6.62	6.62
450130007	45013	South Carolina	Beaufort	7.50	7.50
450190048	45019	South Carolina	Charleston	7.25	7.25
450190049	45019	South Carolina	Charleston	6.67	6.67
450250001	45025	South Carolina	Chesterfield	7.58	7.58
450370001	45037	South Carolina	Edgefield	8.20	8.20
450410002	45041	South Carolina	Florence	7.88	7.88
450450008	45045	South Carolina	Greenville	9.85	9.85
450450009	45045	South Carolina	Greenville	8.58	8.58
450470003	45047	South Carolina	Greenwood	8.87	8.87
450510002	45051	South Carolina	Horry	7.75	7.75
450630008	45063	South Carolina	Lexington	8.62	8.62
450730001	45073	South Carolina	Oconee	6.39	6.39
450790007	45079	South Carolina	Richland	8.44	8.44
450790019	45079	South Carolina	Richland	8.38	8.38
450830010	45083	South Carolina	Spartanburg	8.35	8.35
460110002	46011	South Dakota	Brookings	7.19	7.19
460130003	46013	South Dakota	Brown	7.07	7.07
460290002	46029	South Dakota	Codington	8.13	8.13
460330132	46033	South Dakota	Custer	5.24	5.24
460710001	46071	South Dakota	Jackson	4.83	4.83
460990006	46099	South Dakota	Minnehaha	7.87	7.87
460990007	46099	South Dakota	Minnehaha	7.49	7.49
461030020	46103	South Dakota	Pennington	7.85	7.85
461031001	46103	South Dakota	Pennington	6.73	6.73
470090011	47009	Tennessee	Blount	9.41	9.41
470370023	47037	Tennessee	Davidson	8.28	8.28
470370025	47037	Tennessee	Davidson	9.10	9.10
470370036	47037	Tennessee	Davidson	7.43	7.43
470450004	47045	Tennessee	Dyer	7.75	7.75
470650031	47065	Tennessee	Hamilton	8.92	8.92
470651011	47065	Tennessee	Hamilton	7.79	7.79
470654002	47065	Tennessee	Hamilton	8.78	8.78
470930028	47093	Tennessee	Knox	9.36	9.36
470931017	47093	Tennessee	Knox	10.18	10.18
470931020	47093	Tennessee	Knox	8.82	8.82

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
470990002	47099	Tennessee	Lawrence	7.44	7.44
471050108	47105	Tennessee	Loudon	10.01	10.01
471071002	47107	Tennessee	McMinn	9.06	9.06
471130006	47113	Tennessee	Madison	7.39	7.39
471192007	47119	Tennessee	Maury	7.86	7.86
471251009	47125	Tennessee	Montgomery	8.18	8.18
471410005	47141	Tennessee	Putnam	6.96	6.96
471450004	47145	Tennessee	Roane	8.94	8.94
471570014	47157	Tennessee	Shelby	8.40	8.40
471570038	47157	Tennessee	Shelby	9.09	9.09
471570047	47157	Tennessee	Shelby	8.38	8.38
471571004	47157	Tennessee	Shelby	8.06	8.06
471631007	47163	Tennessee	Sullivan	8.08	8.08
471650007	47165	Tennessee	Sumner	7.91	7.91
480370004	48037	Texas	Bowie	9.43	9.43
481130069	48113	Texas	Dallas	8.14	8.14
481130087	48113	Texas	Dallas	7.45	7.45
481350003	48135	Texas	Ector	7.63	7.63
481410037	48141	Texas	El Paso	8.97	8.97
481410044	48141	Texas	El Paso	11.39	11.39
482010058	48201	Texas	Harris	8.00	8.00
482011035	48201	Texas	Harris	11.43	11.43
482030002	48203	Texas	Harrison	8.30	8.30
482150043	48215	Texas	Hidalgo	9.83	9.83
483550032	48355	Texas	Nueces	8.58	8.58
483611001	48361	Texas	Orange	8.49	8.49
483750320	48375	Texas	Potter	5.32	5.32
484391002	48439	Texas	Tarrant	8.10	8.10
484391006	48439	Texas	Tarrant	8.61	8.61
484530020	48453	Texas	Travis	7.03	7.03
490030003	49003	Utah	Box Elder	7.27	7.27
490050004	49005	Utah	Cache	8.69	8.69
490110004	49011	Utah	Davis	9.01	9.01
490350003	49035	Utah	Salt Lake	9.18	9.18
490350012	49035	Utah	Salt Lake	NA	NA
490351001	49035	Utah	Salt Lake	6.96	6.96
490353006	49035	Utah	Salt Lake	8.78	8.78
490353007	49035	Utah	Salt Lake	9.38	9.38
490353008	49035	Utah	Salt Lake	6.29	6.29
490353010	49035	Utah	Salt Lake	NA	NA

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
490450003	49045	Utah	Tooele	5.70	5.70
490490002	49049	Utah	Utah	8.74	8.74
490494001	49049	Utah	Utah	9.06	9.06
490495008	49049	Utah	Utah	7.60	7.60
490495010	49049	Utah	Utah	8.00	8.00
490570002	49057	Utah	Weber	9.31	9.31
490570007	49057	Utah	Weber	7.80	7.80
490571003	49057	Utah	Weber	8.01	8.01
500030004	50003	Vermont	Bennington	5.74	5.74
500070007	50007	Vermont	Chittenden	4.68	4.68
500070012	50007	Vermont	Chittenden	7.07	7.07
500210002	50021	Vermont	Rutland	9.50	9.50
510130020	51013	Virginia	Arlington	7.69	7.69
510360002	51036	Virginia	Charles City	6.92	6.92
510410003	51041	Virginia	Chesterfield	7.44	7.44
510590030	51059	Virginia	Fairfax	7.08	7.08
510591005	51059	Virginia	Fairfax	7.88	7.88
510595001	51059	Virginia	Fairfax	7.58	7.58
510870014	51087	Virginia	Henrico	7.21	7.21
510870015	51087	Virginia	Henrico	6.98	6.98
511071005	51107	Virginia	Loudoun	7.30	7.30
511390004	51139	Virginia	Page	6.83	6.83
511650003	51165	Virginia	Rockingham	7.48	7.48
515200006	51520	Virginia	Bristol city	7.60	7.60
516500004	51650	Virginia	Hampton city	7.10	7.10
516800015	51680	Virginia	Lynchburg city	7.35	7.35
517100024	51710	Virginia	Norfolk city	7.72	7.72
517700014	51770	Virginia	Roanoke city	8.93	8.93
517700015	51770	Virginia	Roanoke city	7.31	7.31
518100008	51810	Virginia	Virginia Beach city	7.26	7.26
530330024	53033	Washington	King	7.64	7.64
530330057	53033	Washington	King	7.74	7.74
530330080	53033	Washington	King	5.97	5.97
530530029	53053	Washington	Pierce	8.55	8.55
530610020	53061	Washington	Snohomish	7.02	7.02
530611007	53061	Washington	Snohomish	8.13	8.13
530630016	53063	Washington	Spokane	8.95	8.95
530770009	53077	Washington	Yakima	8.75	8.75
540030003	54003	West Virginia	Berkeley	10.02	10.02
540090005	54009	West Virginia	Brooke	9.24	9.24

Site ID	FIPS	State	County	Annual DV Analytical Baseline	Annual DV 12 $\mu g/m^3$ Level
540090011	54009	West Virginia	Brooke	9.07	9.07
540110006	54011	West Virginia	Cabell	10.03	10.03
540291004	54029	West Virginia	Hancock	8.56	8.56
540330003	54033	West Virginia	Harrison	8.18	8.18
540390010	54039	West Virginia	Kanawha	8.50	8.50
540391005	54039	West Virginia	Kanawha	9.43	9.43
540490006	54049	West Virginia	Marion	9.05	9.05
540511002	54051	West Virginia	Marshall	8.37	8.37
540610003	54061	West Virginia	Monongalia	7.69	7.69
540690010	54069	West Virginia	Ohio	7.85	7.85
540810002	54081	West Virginia	Raleigh	7.12	7.12
541071002	54107	West Virginia	Wood	9.24	9.24
550030010	55003	Wisconsin	Ashland	5.34	5.34
550090005	55009	Wisconsin	Brown	9.81	9.81
550250047	55025	Wisconsin	Dane	10.37	10.37
550270007	55027	Wisconsin	Dodge	8.99	8.99
550410007	55041	Wisconsin	Forest	5.92	5.92
550430009	55043	Wisconsin	Grant	10.13	10.13
550590019	55059	Wisconsin	Kenosha	9.81	9.81
550630012	55063	Wisconsin	La Crosse	10.08	10.08
550710007	55071	Wisconsin	Manitowoc	8.84	8.84
550790010	55079	Wisconsin	Milwaukee	10.87	10.87
550790026	55079	Wisconsin	Milwaukee	10.84	10.84
550790043	55079	Wisconsin	Milwaukee	11.25	11.25
550790059	55079	Wisconsin	Milwaukee	12.02	12.02
550790099	55079	Wisconsin	Milwaukee	11.22	11.22
550870009	55087	Wisconsin	Outagamie	9.29	9.29
550890009	55089	Wisconsin	Ozaukee	9.50	9.50
551091002	55109	Wisconsin	St. Croix	8.70	8.70
551110007	55111	Wisconsin	Sauk	8.43	8.43
551198001	55119	Wisconsin	Taylor	7.53	7.53
551250001	55125	Wisconsin	Vilas	5.79	5.79
551330027	55133	Wisconsin	Waukesha	11.22	11.22
560050892	56005	Wyoming	Campbell	5.26	5.26
560050899	56005	Wyoming	Campbell	4.77	4.77
560090819	56009	Wyoming	Converse	3.45	3.45
560131003	56013	Wyoming	Fremont	7.43	7.43
560210001	56021	Wyoming	Laramie	3.78	3.78
560330002	56033	Wyoming	Sheridan	8.72	8.72
560330003	56033	Wyoming	Sheridan	5.40	5.40