Technical Support Document for the 2011 Ozone Transport Commission/Mid-Atlantic Northeastern Visibility Union Modeling Platform

Ozone Transport Commission

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Section 1. Introduction

Purpose

The purpose of this document is to technically support the SIP quality modeling efforts undertaken by OTC and MANE-VU for use in regional ozone and haze planning and for inclusion in any member's SIP submittal for either demonstrating ozone attainment or for showing reasonable further progress for haze.

EPA's guidance on modeling for ozone, $PM_{2.5}$, and regional haze includes recommendations for documentation of the modeling platform that should be included in SIP submissions. EPA recommends that the following be included in the technical documentation:

- *Overview of the air quality issue being considered including historical background*
- *List of the planned participants in the analysis and their expected roles*
- *Schedule for completion of key steps in the analysis and final documentation*
- *Description of the conceptual model for the area*
- *Description of periods to be modeled, how they comport with the conceptual model, and why they are sufficient*
- *Models to be used in the demonstration and why they are appropriate*
- *Description of model inputs and their expected sources (e.g., emissions, met, etc.)*
- *Description of the domain to be modeled (expanse and resolution)*
- *Process for evaluating base year model performance (meteorology, emissions, and air quality) and demonstrating that the model is an appropriate tool for the intended use*
- *Description of the future years to be modeled and how projection inputs will be prepared*
- *Description of the attainment test procedures and (if known) planned weight of evidence*
- *Expected diagnostic or supplemental analyses needed to develop weight of evidence analyses*
- *Commitment to specific deliverables fully documenting the completed analysis* (US EPA 2014a).

Document Outline

The remainder of this section will review the items listed above that are not addressed in other sections of the document. Section 2 is an assessment of the meteorological model used in the platform in order to determine if many of the mechanisms that lead to ozone formation are fundamentally sound. Section 3 assesses whether an upgrade to a more recent biogenic emissions model is warranted. Section 4 describes the methods used in processing emissions for use in the SIP quality modeling platform for the base year. Section 5 describes the setup of the photochemical model. Section 6 assesses the model performance for ozone, $PM_{2.5}$, and regional haze in the base year. Section 7 describes a methodology for improving performance using nested gridding and analyzed the results from implementing the methodology. Section 8 describes the methods used in processing emissions for use in the SIP quality modeling platform for the future years. Section 9 describes the method for calculating future projected ozone design values and instances where the default method may not be warranted. Section 10 describes the results from future year modeling projections. Section 11 describes the methodology for conducting screening analysis using only ozone episodes, and evidence for its reasonability.

History

Clean Air Act

The Clean Air Act was designed to control air pollution in the United States, is administered by the EPA, and its implementing regulations are codified at 40 C.F.R. Subchapter C, Parts 50-97.

The history of national air pollution legislation began with the 1955 Air Pollution Control Act, but the first piece of legislation to control air pollution was the Clean Air Act of 1963. The Air Quality Act of 1967 continued the processes of developing legislation to reduce air pollution, but it was in 1970 that the Clean Air Act in its modern form was adopted. Amendments were added in 1977 and 1990, which further expanded the control of emissions.

One of the programs to come out of the 1970 Clean Air Act Amendments was the creation of NAAQS , thresholds of air pollution considered to be the upper limit of healthy air that are based on the best scientific evidence available that must be met nationally (*Clean Air Act Amendments of 1970* 1970). NAAQS were developed for several pollutants, including ground-level ozone.

The 1970 Clean Air Act also introduced the SIP, which is intended to demonstrate how an area that is not complying with the NAAQS will meet that standard through state programs that become federally enforceable following approval of the SIP. The 1990 amendments expanded the requirements for SIPs, in particular in regards to ground-level ozone (*Clean Air Act Amendments of 1990* 1990).

The 1977 amendments saw the introduction of provisions to reduce visibility impairment at areas termed “Class I” areas, which are significant national parks and other natural areas (*Clean Air Act Amendments of 1977* 1977). This program was further strengthened in 1990 setting requirements for regional haze SIPs, including the setting of RPGs.

The following is an overview of some of the more recent NAAQS that are applicable to this document, as well as an overview of the regional haze program.

1997 8-hour Ozone NAAQS

In 1997 the primary and secondary NAAQS were set to 0.08 ppm for the three year average of the 4th highest 8-hour average ozone concentration, which due to rounding conventions is equivalent to 84 ppb (US EPA 1997). This standard was revoked as of April 6, 2015 and will no longer be considered in this document (US EPA 2015a).

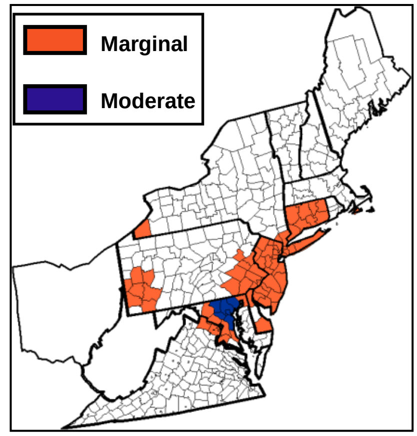
2008 8-hour Ozone NAAQS

In 2008 the primary and secondary NAAQS were set to 0.075 ppb for the three year average of the 4th highest 8-hour average ozone concentration, which is equivalent to 75 ppb (US EPA 2008). After some delays in timeframes outlined in the Clean Air Act, areas were designated for the 2008 NAAQS as seen in Figure 1-1 and Table 1-1 (US EPA 2012).

Table 1-1: Nonattainment areas in the OTR for 2008 Ozone NAAQS

Area Name	State	Classification as of 8/4/16	No. Counties	2012 DVs (ppm)
Baltimore, MD	MD	Moderate	6	0.089
Greater Connecticut, CT	CT	Moderate	5	0.079
NYC-N. NJ-Long Island, NY-NJ-CT	CT	Moderate	3	0.084
NYC -N. NJ-Long Island, NY-NJ-CT	NJ	Moderate	12	0.084
NYC -N. NJ-Long Island, NY-NJ-CT	NY	Moderate	9	0.084
Allentown-Bethlehem-Easton, PA	PA	Marginal	3	0.076
Dukes County, MA	MA	Marginal	1	0.076
Jamestown, NY	NY	Marginal	1	0.077
Lancaster, PA	PA	Marginal	1	0.077
Phila.-Wilm.-Atl. City, PA-NJ-MD-DE	NJ	Marginal	9	0.083
Phila.-Wilm.-Atl. City, PA-NJ-MD-DE	DE	Marginal	1	0.083
Phila.-Wilm.-Atl. City, PA-NJ-MD-DE	MD	Marginal	1	0.083
Phila.-Wilm.-Atl. City, PA-NJ-MD-DE	PA	Marginal	5	0.083
Pittsburgh-Beaver Valley, PA	PA	Marginal	7	0.080
Reading, PA	PA	Marginal	1	0.077
Seaford, DE	DE	Marginal	1	0.077
Washington, DC-MD-VA	DC	Marginal	1	0.081
Washington, DC-MD-VA	MD	Marginal	5	0.081
Washington, DC-MD-VA	VA	Marginal	9	0.081

Figure 1-1: 2008 Ozone NAAQS Designations in the OTR as originally designated in 2012



Following the designation of an area as nonattainment for the criteria pollutant Ozone, the Clean Air Act requires submission of a SIP to demonstrate how that area will be meeting the pollutant standard (NAAQS) in the time period established by the Act. Areas designated as marginal require no air quality modeling (US EPA 2015a). One nonattainment area, Baltimore, MD, was designated moderate, and was expected to require the submission of an attainment demonstration using photochemical modeling, with the attainment demonstration being based on 2018 design values (US EPA 2012). However, following the DC Circuit decision in NRDC vs. EPA on December 23, 2014, the attainment deadline was advanced from December 31, 2018 to July 20, 2018, so that the states now needed to demonstrate attainment using 2017 design values (DC Circuit 2014).

The New York City, NY-NJ-CT nonattainment area, which was originally designated marginal in 2012 was reclassified to moderate effective June 3, 2016 given its continued monitoring of nonattainment (US EPA 2016a).

2015 8-hour Ozone NAAQS

In 2015 the primary and secondary NAAQS were set to 0.070 ppm for the three year average of the 4^{th} highest 8-hour average ozone concentration, which is equivalent to 70 ppb (US EPA 2015b). The Clean Air Act does not require EPA to issue designations for the 2015 Ozone NAAQS until October 1, 2016. Given the planning horizon it is not expected that this platform will be used in demonstrating attainment of the 2015 Ozone NAAQS.

Regional Haze

EPA's regional haze regulations require regional haze SIPs to be updated for the second planning period by July 31, 2018. This SIP requires modeling to demonstrate reasonable further progress towards background visibility conditions at Class I areas and to set 2028 RPGs using estimates of visibility following controls anticipated as the result of the consultation process between the states and FLMs. The controls will be included in each state's long-term strategy and deemed to be reasonable following a four-factor analysis. The deadline for SIP submittals may be extended to December 31, 2021 if a rule that is currently proposed is finalized (US EPA 2016b). A list of the Class I areas in MANE-VU is in Table 1-2.

Table 1-2: List of Class I Areas in MANE-VU (40 CFR 81)

STATE	AREA NAME	ACREAGE	FLM	MONITORED
ME	Acadia National Park	37,503	NPS	Yes
	Moosehorn Wilderness Area	7,501	FWS	Yes
NH	Great Gulf Wilderness Area	5,552	FS	Yes
	Presidential Range-Dry River Wilderness Area	20,000	FS	No
NJ	Brigantine Wilderness Area	6,603	FWS	Yes
VT	Lye Brook Wilderness	12,430	FS	Yes
ME & NB, CA	Roosevelt Campobello International Park	2,721	Chairman, RCIP Commission	No

Geographic Definitions

Throughout the document several geographic definitions will be used that are based on the boundaries of RPOs. To allow for clarity as to which states are included Table 1-3 has been provided, though in some cases figures are limited to what is within the OTC modeling domain.

Table 1-3: List of states in geographic areas based on RPOs

OTC	MANE-VU	SESARM	LADCO	CenSARA
Connecticut	Connecticut	Alabama	Illinois	Arkansas
District of Columbia	District of Columbia	Florida	Indiana	Iowa
Delaware	Delaware	Georgia	Michigan	Kansas
Massachusetts	Massachusetts	Kentucky	Minnesota	Louisiana
Maryland	Maryland	Mississippi	Ohio	Missouri
Maine	Maine	North Carolina	Wisconsin	Nebraska
New Hampshire	New Hampshire	South Carolina		Oklahoma
New Jersey	New Jersey	Tennessee		Texas
New York	New York	Virginia		
Pennsylvania	Pennsylvania	West Virginia		
Rhode Island	Rhode Island			
Virginia	Vermont			
Vermont				

Participants

OTC Air Directors

OTC Air Directors will serve as overseers of the work products developed by the OTC Modeling Committee. The OTC Air Directors will oversee the design of ozone control strategies for the OTR and make decisions surrounding modeling of the air quality impacts of policies. The Air Directors will review all OTC SIP quality modeling platform documentation before it is finalized. The state members of the OTC Modeling Committee will keep Air Directors informed of the development of the OTC SIP quality modeling platform.

OTC Modeling Committee

The OTC Modeling Committee will serve as first tier reviewers of the work products developed for the SIP quality modeling platform. The OTC Modeling Committee will approve technical approaches used in the modeling platform, review results, and approve products for review by the Air Directors. Since members of the three EPA regions are members of the OTC Modeling Committee, they will provide insights into any issues that may occur involving the acceptability of the OTC SIP quality modeling platform in a SIP so that problems can be corrected at the regional level.

OTC Modeling Planning Group

The OTC Modeling Planning Group will be made up of members of the modeling centers and the OTC Modeling Committee leadership. The workgroup will review technical decisions to bring recommendations on approaches to the OTC Modeling Committee.

OTC Technical Support Document Workgroup

The OTC TSD Workgroup is responsible for compiling drafts of the technical documentation for review by the OTC Modeling Planning Group.

OTC Modeling Centers

The OTC Modeling Centers are the state staff and academics that perform modeling and conduct analyses of modeling results. They include NYSDEC, NJDEP, VADEQ, UMD via MDE, and ORC at Rutgers via NJDEP.

MANE-VU Technical Support Committee

The MANE-VU Technical Support Committee will serve as first tier reviewers of the work products developed for the SIP quality modeling platform with a focus on regional haze issues. Since members of the three EPA regions and the FLMs are members of the TSC, they will provide insights into any issues that may occur involving the acceptability of the OTC SIP quality modeling platform in a SIP so that problems can be corrected at the regional level.

MARAMA Emission Inventory Leads Committee

The MARAMA Emission Inventory Leads Committee is made up of state staff that make technical recommendations involving the multi-pollutant emissions inventory, as well as quality assure the inventories.

Schedule

Table 1-4 provides an overview schedule intended as a guideline for finalization of the modeling in the document, though given that the SIP quality modeling platform is being used for planning that runs on different timelines some revisions may occur.

Table 1-4: Multi-pollutant modeling schedule using 2011 platform

PROCESS POINT	TIMEFRAME
2011 Alpha 2 Inventory for Regional Haze	June 2015
2011 Base Case Modeling for Regional Haze	August 2015

2018/2028 Alpha 2 Inventory for Regional Haze	December 2015
2011 Base Case Modeling for Ozone	June 2016
Draft TSD (excepting Future results)	August 2016
2017 Beta Inventory for Ozone	August 2016
OTC Stakeholder Meeting	September 2016
2028 Future Case Modeling for Regional Haze	October 2016
2017 Future Case Modeling for Ozone	October 2016
Final TSD	November 2016
NYC and Greater CT Attainment SIP Due (US EPA 2016a)	January 1, 2017
Regional Haze SIPs Due	July 31, 2018

Conceptual Model

Ozone

The interaction of meteorology, chemistry, and topography lead to a complex process of ozone formation and transport. Ozone episodes in the eastern United States often begin with an eastern moving large high pressure area from the Midwest to the OTR, which collects pollution from stationary and mobile sources as it moves. When the air mass settles in the OTR, sometimes even for days, local pollution is added. The air mass, which is stagnant and cloudless exacerbates ozone levels, since it allows sunlight more time to promote ozone formation and increase reactions of VOCs and NO_X, the precursors to ozone. Additional pollution can be introduced to the systems from the Southeast through the nocturnal low level jet, a fast moving air mass that resides below the nocturnal boundary layer. This highly polluted air can also be kept from dissipating along the coast due to bay and sea breezes push pollution back to shore.

Some ozone is also natural, or transported internationally leading to ozone that is not considered relatable. This US Background ozone in the Eastern United States is in the range of 30 to 35 ppb though it can be as high as 50 ppb in the Intermountain West (US EPA 2014b).

Another complexity involves the nonlinear relationship between NO_X and VOC levels and ozone formation. Areas such as the majority of the landscape in the OTR that have extensive forests that produce high levels of isoprene and other VOCs during the summer month achieve the best ozone reduction through reductions in regional NO_X, but dense urban areas such as New York City that lack natural VOC production can be VOC limited, and in some cases NO_X reductions increase ozone levels due to less NO_X being available to destroy already formed ozone through titration.

To address this great level of complexity that occurs when evaluating the conceptual model of ozone we will be basing the modeling exercise on the conceptual model as described in "The Nature of the Ozone Air Quality Problem in the Ozone Transport Region: A Conceptual Description (Hudson et al. October 2006)."

Visibility

Under natural atmospheric conditions, the view in the eastern United States would extend about 60 to 80 miles, whereas in the western United States this can extend from 110 to 115 miles (Malm May 1999). Current visibility conditions result in less distance that can be viewed due to impacts of anthropogenic pollution. However, the current conditions in the Eastern US are remarkably improved from the early 2000's when the regional haze program began.

Anthropogenic visibility impairment in the eastern United States is largely due to the presence of light-absorbing and light-scattering PM of which the impact can be estimated through the IMPROVE algorithm. This impact is sensitive to the chemical composition of the particles involved, and also depend strongly on ambient relative humidity. Secondary particles (e.g., ammonium sulfate, ammonium nitrate), which form in the atmosphere through chemical reactions, tend to fall within a size range that is most effective at scattering visible light (NARSTO February 2003) A great level of complexity occurs when evaluating the conceptual model of fine $PM_{2.5}$. We will be basing the modeling exercise on the conceptual model found in "The Nature of the Fine Particle and Regional Haze Air Quality Problems in the MANE-VU Region: A Conceptual Description (Downs et al. 10 August 2010)."

Base Year Selection

Analyses of monitored data and meteorological data concluded that for the OTR, 2010, 2011 and 2012 are the candidate base years to model for future ozone NAAQS planning and 2011 is the best base year for future Regional Haze and annual $PM_{2.5}$ NAAQS planning. Transport patterns of 2011 ozone events in the OTR confirm that using 2011 would be appropriate. When other factors were considered including availability of a national emission inventory, research data availability, and decisions on base years by nearby RPOs and EPA more weight was given to using 2011 as a base year. As a result, 2011 was determined to be the best candidate base year for this multi-pollutant platform (Ozone, Regional Haze and $PM_{2.5}$). More details can be found in the document "Future Modeling Platform Base Year Determination" produced by the MANE-VU Technical Support Committee (MANE-VU Technical Support Committee 9 October 2013, p.).

Future Year Selection

Since a 2018 inventory was needed for Baltimore to demonstrate attainment, OTC developed inventories for that year. However, following the DC Circuit decision discussed earlier, developing a 2017 inventory became necessary. As such the 2018 inventory was no longer needed as an ozone modeling inventory.

To conserve resources through multi-pollutant planning, the region also developed a 2028 inventory required for the submission of regional haze SIPs.

As a result we began our modeling platform using 2018 and 2028 future years, and later migrated 2018 to 2017.

References

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Determinations of Attainment by the Attainment Date, Extensions of the Attainment Date, and Reclassification of Several Areas for the 2008 Ozone National Ambient Air Quality Standards, Vol. 81, No. 86 (United States|US 2016a).

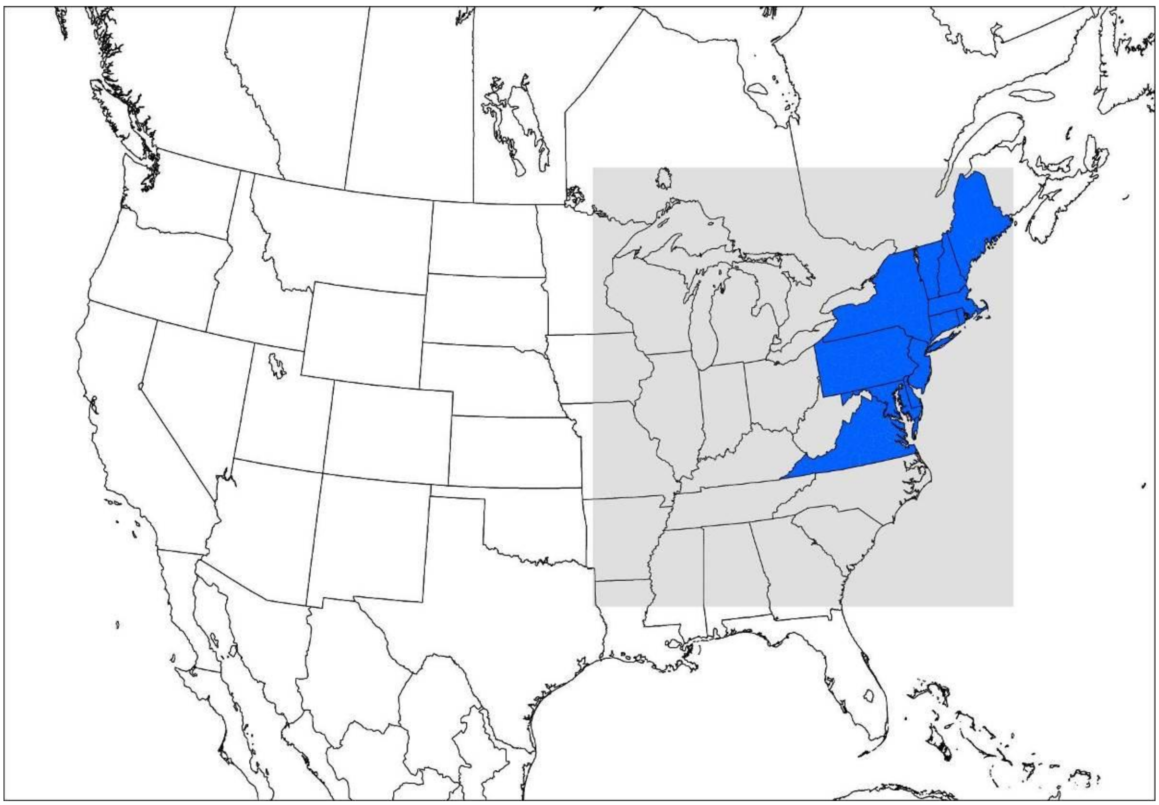
Proposed Rule: Protection of Visibility: Amendments to Requirements for State Plans, Vol. 81, No. 86 (United States|US 2016b).

Section 2. Evaluation of Meteorological Modeling using WRF

Overview

The OTC Modeling Committee extracted the meteorological data from EPA's 2011 photochemical modeling of the CONUS. That modeling used WRF v.3.4 to develop meteorological data. The OTC modeling used only a subset of the EPA modeling domain as illustrated in Figure 2-1 (US EPA 2014). The meteorological data for the OTC domain was extracted from the EPA CONUS domain modeling using MCIP (Otte and Pleim 2010). The OTC retained the same 12 km square grid size and 35 layer column depth as was used by EPA.

Figure 2-1: Extent of EPA CONUS domain with the and OTR Modeling Domain in grey and the OTR states in blue



Assessment

Certain critical parameters of the model were assessed for their ability to characterize actual conditions occurring over the base year. EPA provides the following guidance concerning evaluation of meteorological models in section 2.6.3.

> *While the air quality models used in attainment demonstrations have consistently been subjected to a rigorous performance assessment, in many cases the meteorological inputs to these models have received less rigorous evaluation, even though this component of the modeling is quite complex and has the potential to substantially affect air quality predictions (Tesche, 2002). EPA recommends that air agencies devote appropriate effort to the process of evaluating the meteorological inputs to the air quality model as we believe good meteorological model performance will yield more confidence in predictions from the air quality model. One of*

the objectives of this evaluation should be to determine if the meteorological model output fields represent a reasonable approximation of the actual meteorology that occurred during the modeling period. Further, because it will never be possible to exactly simulate the actual meteorological fields at all points in space/time, a second objective of the evaluation should be to identify and quantify the existing biases and errors in the meteorological predictions in order to allow for an downstream assessment of how the air quality modeling results are affected by issues associated with the meteorological data. To address both objectives, it will be necessary to complete both an operational evaluation (i.e., quantitative, statistical, and graphical comparisons) as well as a more phenomenological assessment (i.e., generally qualitative comparisons of observed features vs. their depiction in the model data).

For our assessment 2011 WRF modeled data were compared to data for the year. For several factors we relied on EPA's own assessments, while looking more specifically at data in the OTR. We also expanded on EPA's work by looking at the ways WRF modeled temperature, mixing ratio, and the PBL height. Details of the assessment follow.

Model Performance Analyzed by EPA

Winds Speed

EPA found that WRF v. 3.4 slightly over-predicts wind speed in the Eastern United States with the bias being highest during the midday hours. EPA also found that the error in wind displacement tends to be about 5 km, which, being less than the size of a grid cell, should be negligible in affecting position of air masses temporally and spatially (Eyth and Vukovich 2015).

Precipitation comparison

EPA found that WRF v. 3.4 performs adequately in terms of spatial pattern recognition and predicting the amount of precipitation throughout the year when compared to the PRISM climate data. The results compared well in the OTR, including the forecast of a high band of coastal precipitation that occurred during the month of August, although the precipitation in March and September appears to be respectively overestimated and underestimated throughout the OTR (US EPA 2014).

Solar Radiation

Photosynthetically-activated radiation is important in estimating isoprene, which plays an important role in the formation of ozone and secondary organic aerosols in the heavily forested OTR (Carlton and Baker 2011). EPA evaluated the performance of solar radiation using SURFRAD and ISIS network monitors and found little bias during the fall and winter months, but growing bias during the spring with a peak in the summer, "though the spread in over-predictions tends to be less than 100 W/m^2 on average, with a median bias close to zero (US EPA 2014)." WRF also tends to over-predict from about 7 AM to Noon, while under-predicting from 1 PM to 5 PM. Additionally, EPA stated that "radiation performance evaluation also gives an indirect assessment of how well the model captures cloud formation during daylight hours" so cloud cover would be expected to be under-predicted in the morning and over-predicted in the late afternoon.

Model Performance Analyzed by OTC

Temperature and Mixing Ratio

NYSDEC conducted the review of temperature and mixing ratios for the OTC Modeling Committee. NYSDEC relied on RTMA, a component of the NWS Analysis of Record project and produced by NOAA/NCEP.

RTMA provides a high-spatial and temporal resolution analysis/assimilation system for near-surface weather conditions RTMA produces hourly analyses at 5 km and 2.5 km grid resolution for the CONUS NDFD grid. The parameters in RTMA include pressure height and air pressure at the surface, air temperature, dew point temperature, and specific humidity at 2m, U- and V-components of wind momentum at 10m, along with cloud cover and precipitation. Observational data from the RTMA 2.5 (http://www.nco.ncep.noaa.gov/pmb/products/rtma/#RTMA2p5) is used in this evaluation and interpolated to the 12km WRF grid.

NYSDEC compared the modeled WRF temperature and mixing ratio values with the real world data from RTMA. NYSDEC found that WRF temperature had a low bias in winter months and a high bias in summer months (Figure 2-2) and the WRF mixing ratio had a high bias in winter months and a low bias in summer months (Figure 2-3). When NYSDEC examined the absolute error, they found that WRF had a low absolute error for temperature and a large absolute error for mixing ratios in the summer (Figure 2-4 and Figure 2-5). Additionally, several low correlation coefficients were observed in July and August on grid cells along the coastline (Figure 2-6 and Figure 2-7).

NYSDEC next compared the diurnal modeled WRF temperature and mixing ratio values during the months of February (winter) and August (summer). In February WRF temperature bias was minimal at all times of day (Figure 2-8) and the mixing ratio was biased high throughout the 24 hours (Figure 2-9). In August WRF temperature bias was bias high in the morning hours and bias low in the afternoon (Figure 2-10). Mixing ratio for August was biased low in the evening (Figure 2-11). In February the temperature mean absolute error varied between and 1 and 1.5 ^{o}F (Figure 2-12). The mean absolute error for the mixing ratio in February was worst in the evenings with means around 5 g/kg (Figure 2-13). In August the temperature mean absolute error was typically around 1 ^{o}F at all times of the day (Figure 2-14) and was worst in the evening, but had a mean absolute error for the mixing rations that was closer to 1.5 g/kg (Figure 2-15). Correlation coefficients were much closer to 1 in February for both temperature and mixing ratio than in August, when in some cases during the early evening hours zero correlation was found (Figure 2-16-Figure 2-19).

Figure 2-2: Monthly average Bias (RMTA – WRF) for Temperature[1]

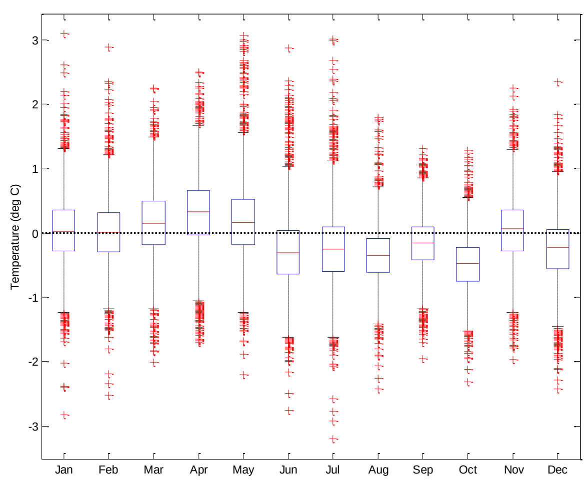


Figure 2-3: Monthly average Bias (RMTA – WRF) for Mixing Ratio[1]

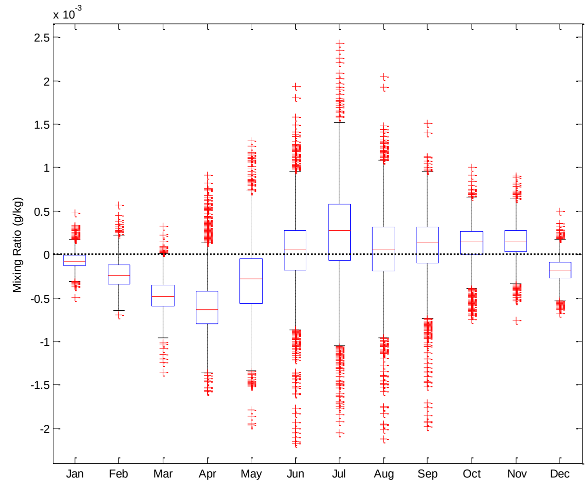


Figure 2-4: Monthly average absolute error for temperature[1]

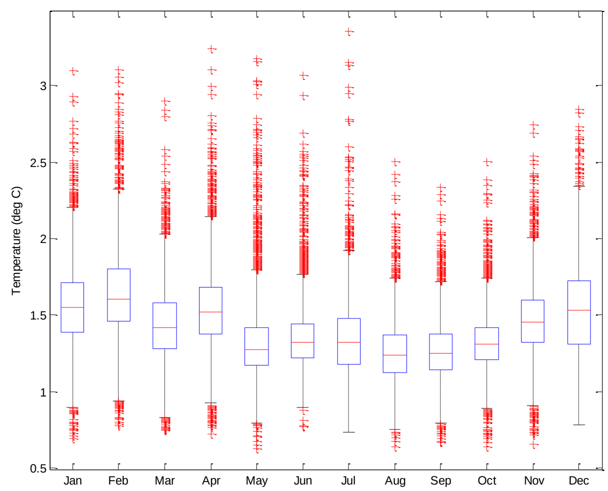


Figure 2-5: Monthly average absolute error for mixing ratio[1]

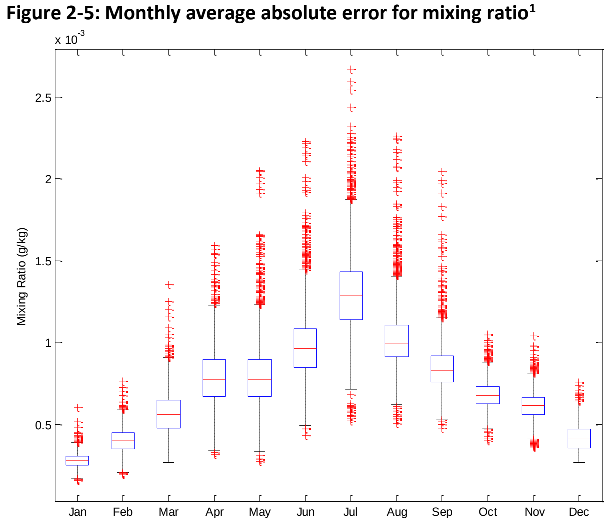


Figure 2-6: Correlation coefficients for temperature[1]

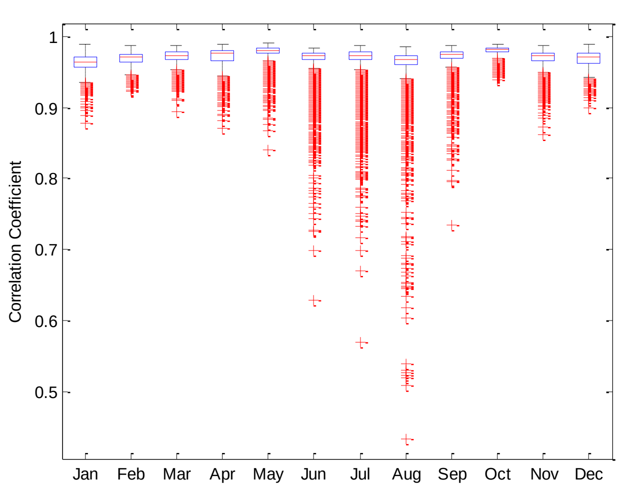
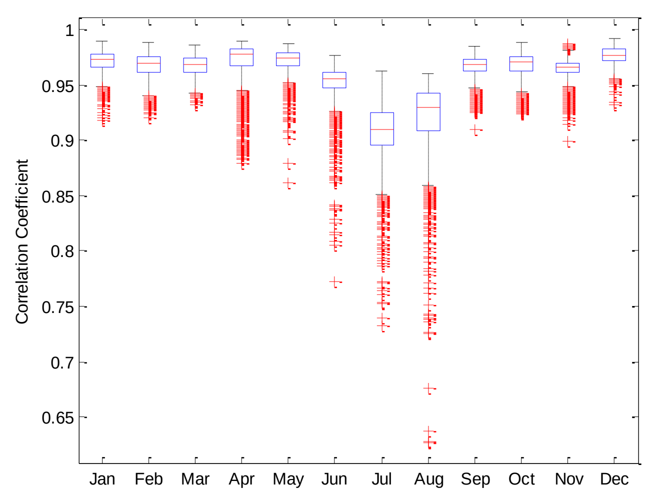


Figure 2-7: Correlation coefficients for mixing ratio[1]



[1] Box plots demarcations are for the 25th, 50th and 75th percentiles, and red crosses are values greater than 2 standard deviations.

Figure 2-8: Diurnal BIAS (RMTA – WRF) for temperature in Feb.[1]

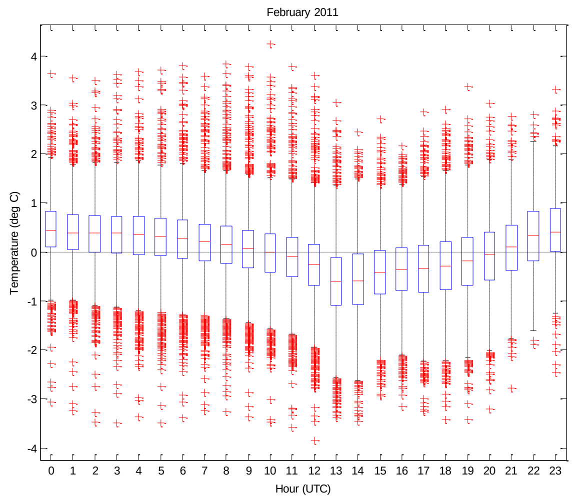


Figure 2-9: Diurnal BIAS (RMTA – WRF) for mixing ratio in Feb.[1]

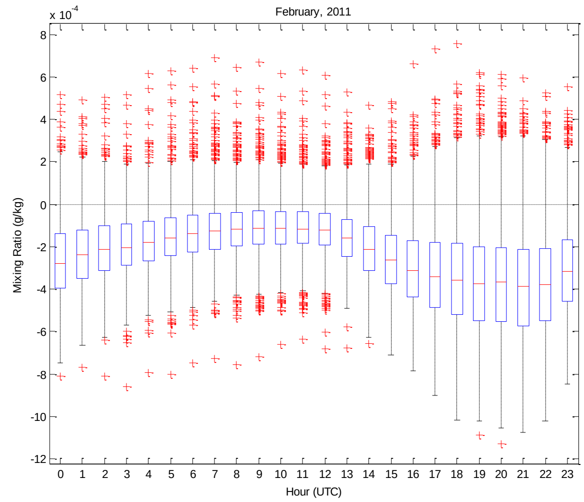


Figure 2-10: Diurnal BIAS (RMTA – WRF) for temperature in Aug.[1]

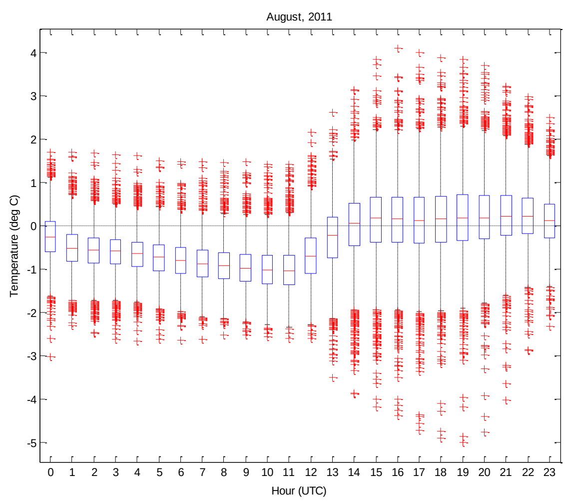


Figure 2-11: Diurnal BIAS (RMTA – WRF) mixing ratio in Aug.[1]

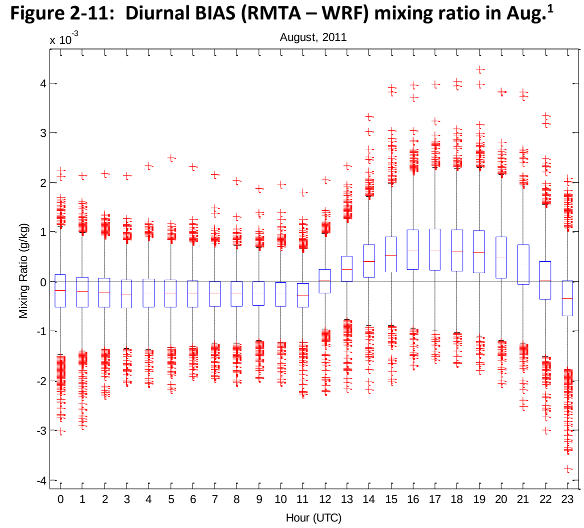


Figure 2-12: Diurnal absolute error for temperature in Feb.[1]

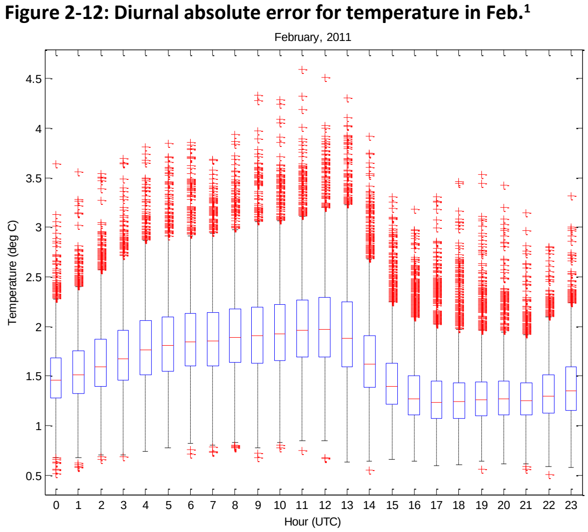


Figure 2-13: Diurnal absolute error for mixing ratio in Feb.[1]

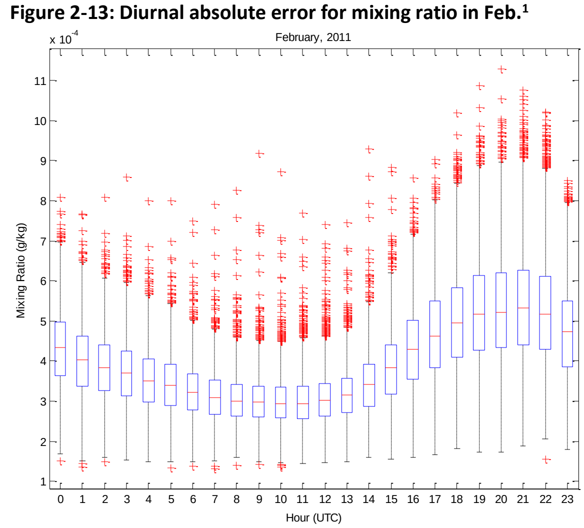


Figure 2-14: Diurnal absolute error for temperature in Aug.[1]

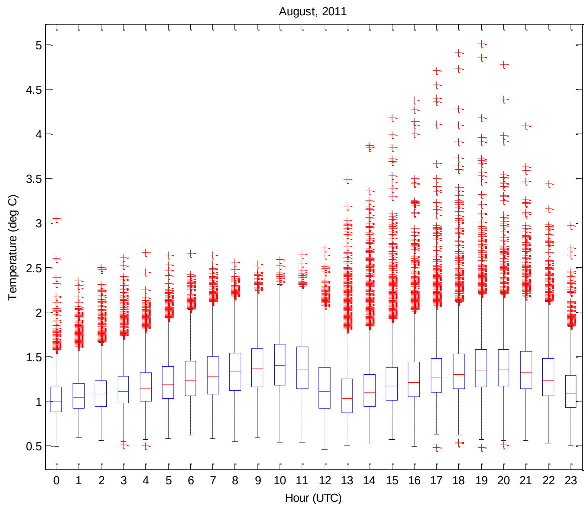


Figure 2-15: Diurnal absolute error for mixing ratio in Aug.[1]

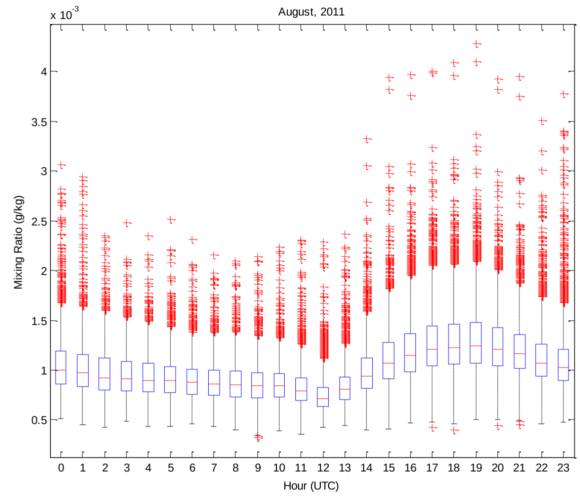


Figure 2-16: Diurnal correlation coefficient for temperature in Feb.[1]

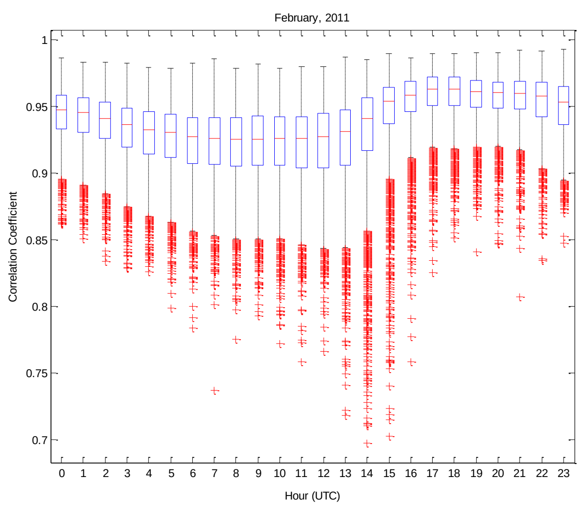


Figure 2-17: Diurnal correlation coefficient for mixing ratio in Feb.[1]

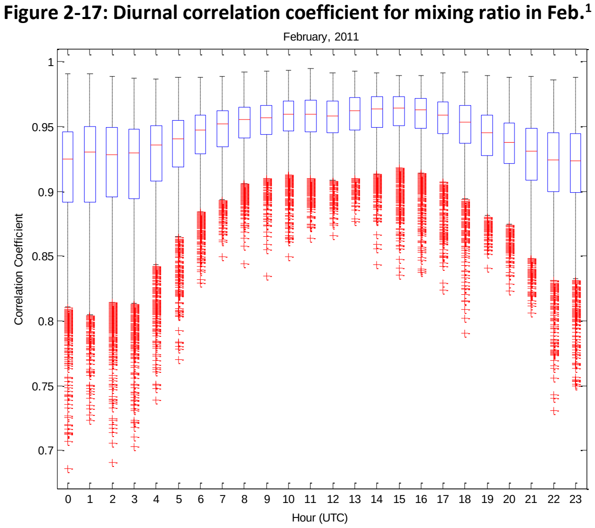


Figure 2-18: Diurnal correlation coefficient for temperature in Aug.[1]

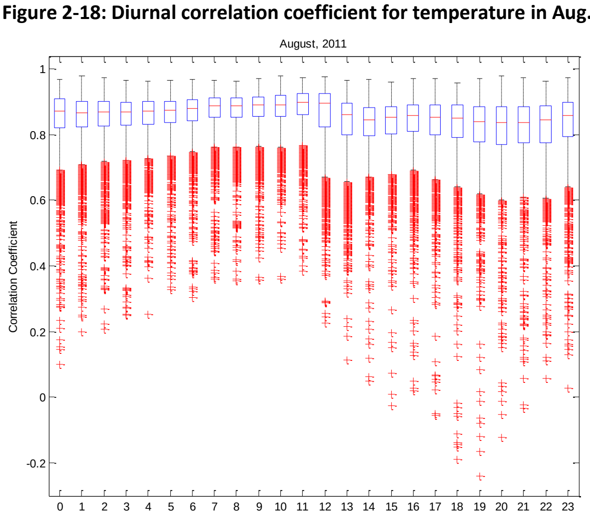
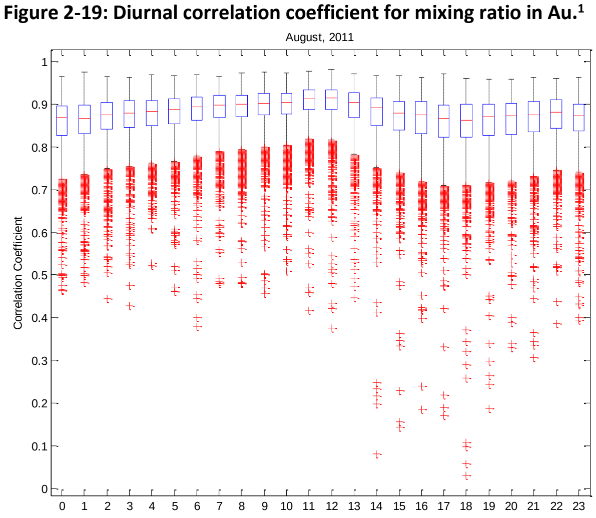


Figure 2-19: Diurnal correlation coefficient for mixing ratio in Au.[1]



Planetary Boundary Layer

The CALIPSO satellite began operation in 2006 with three instruments, the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), the Imaging Infrared Radiometer (IIR), and the Wide Field Camera (WFC). Its repetition cycle is 16 days. CALIOP is a two-wavelength polarization sensitive Lidar (532 nm and 1064 nm). At 532 nm, it has horizontal and vertical resolutions of 333 m and 30 m (up to 8 km), respectively. The CALIPSO aerosol layer product provides data for PBL height covering vast areas on a regular basis.

The NYSDEC derived PBL-height from the CALIPSO Level-1B-attenuated aerosol backscatter profile using the wavelet transform technique, which assumes a structure from the backscatter profile at the height of the air column where the scattering has a strong increase just under the PBL and a strong negative gradient of the backscatter. They averaged the raw signal over 40km to improve signal-to-noise-ratio, and discarded low-cloud data. Then they extracted and refined the CALIPSO Level-2 aerosol layer-top in the lower atmosphere for PBL-height by choosing:

1. single aerosol-layer top, while rejecting multiple layers data;
2. the layer with the base ≤0.3 km above sea level and the top ≤6.0 km above sea level, while rejecting aloft aerosol layers;
3. the layer with the depth > 0.10 km, while rejecting the potentially noisy outlier layers;
4. the layer with cloud-aerosol-discrimination score: -100 ≤ CAD ≤ -20, while rejecting clouds and low-confidence feature layers; and
5. only daytime data to avoid detection of nighttime residual layers.

Figure 2-20: Seasonal Frequency of CALIPSO PBL height

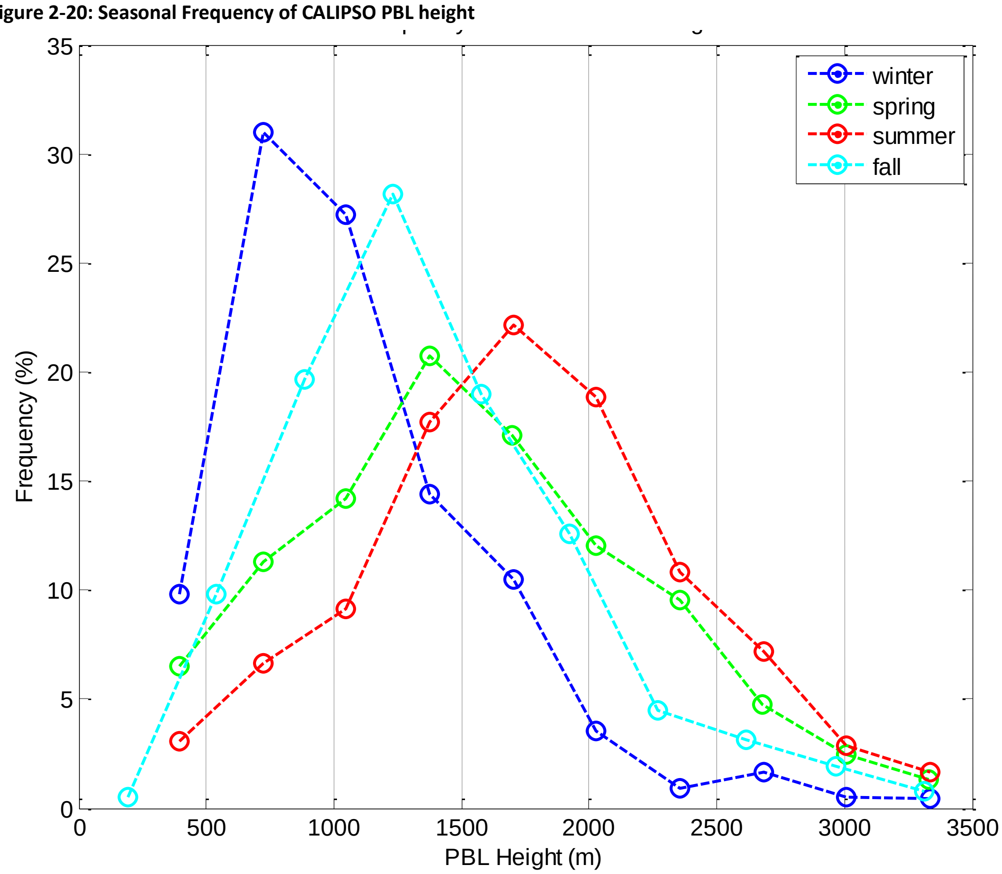


Figure 1-22 showed the frequency distribution of CALIPSO PBL height. The PBL is, on average, lower during the winter at 500 – 1000 meter range, and highest during the summer at 1500 – 2000 meter range. WRF underestimated daytime PBL height compared to CALIPSO particularly over water and more so during the summer (Figure 2-21 and Figure 2-22). WRF PBL height showed significantly larger land-water contrast than the CALIPSO data, with the underestimation being larger in summer than in winter (Figure 2-23 - Figure 2-26).

Figure 2-21: CALIPSO to WRF (PBL height ratio) Winter (D/J/F) 2011 (blue and red dots over land and water respectively)

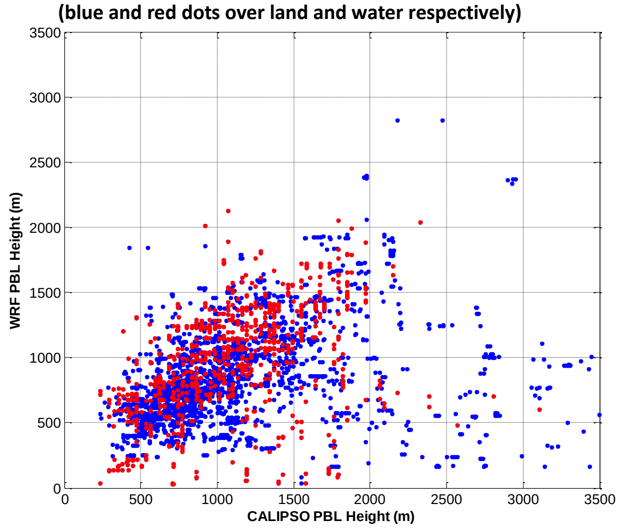


Figure 2-22 CALIPSO to WRF (PBL height ratio) Summer (J/J/A) 2011 (blue and red dots over land and water respectively)

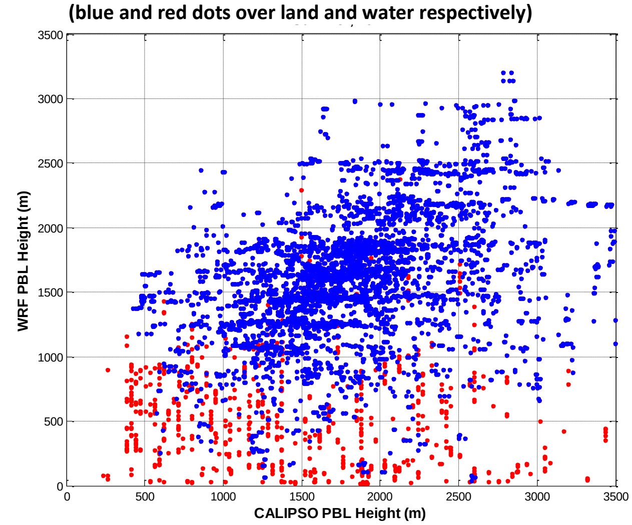


Figure 2-23: CALIPSO to WRF (PBL height ratio) Winter (D/J/F) 2011

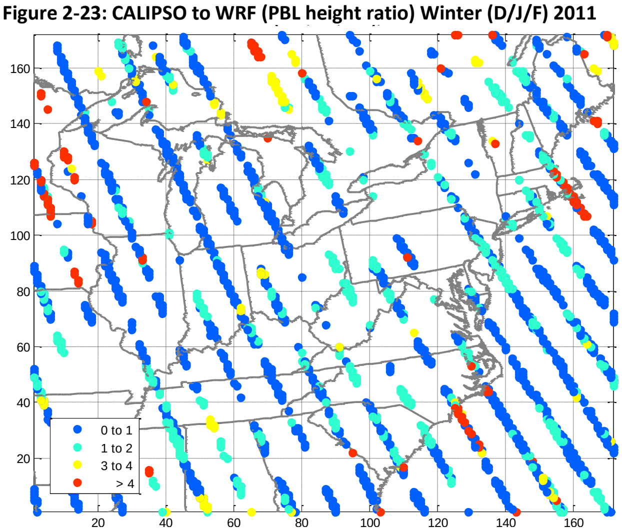


Figure 2-24: CALIPSO to WRF (PBL height ratio) Summer (J/J/A) 2011

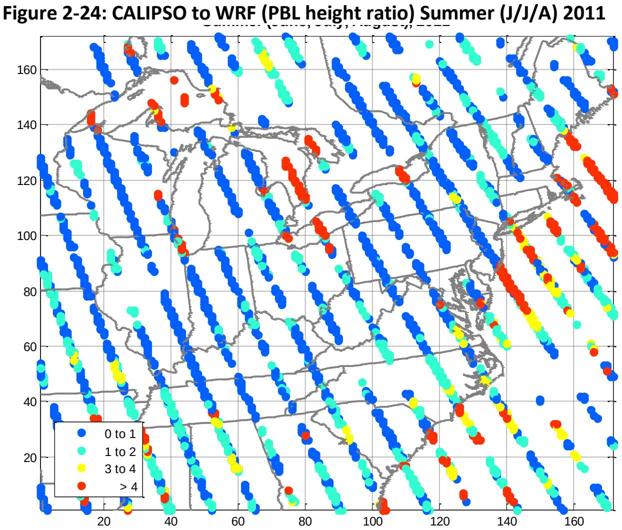


Figure 2-25: CALIPSO to WRF (PBL height ratio) Spring (M/A/M) 2011

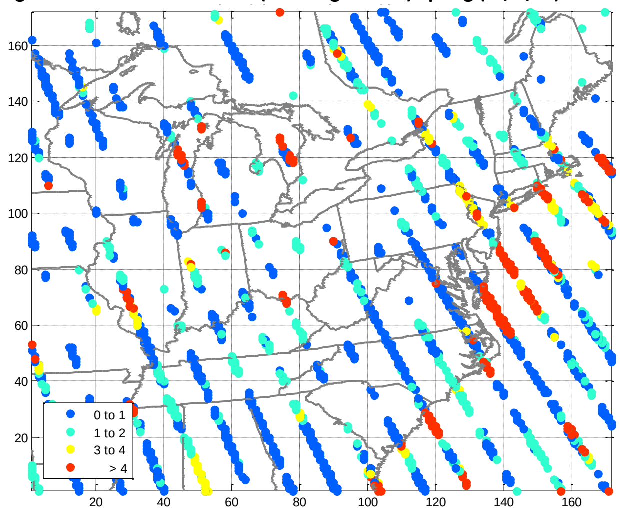
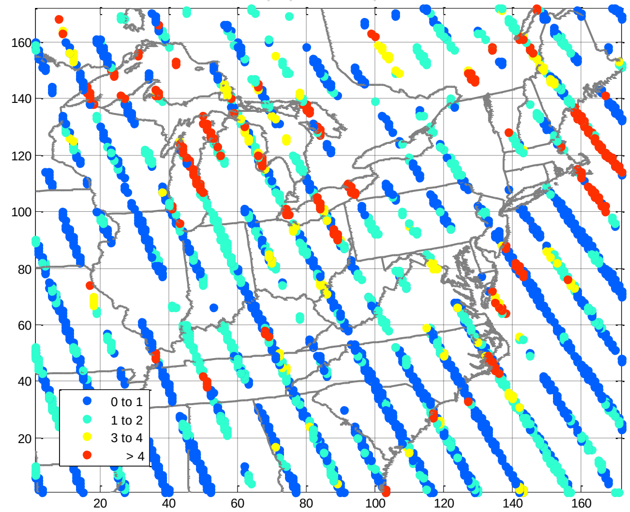


Figure 2-26: CALIPSO to WRF (PBL height ratio) Fall (S/O/N) 2011



One area of uncertainty involves PBL height estimates over bodies of water. CALIPSO data lacks the information necessary to properly evaluate PBL over water.

Summary

EPA has developed a significant look at the WRF v.3.4 model runs that OTC/MANE-VU is employing in its modeling platform and they have found the model to be quite acceptable for use in their national regulatory processes. OTC reviewed EPA's assessment and found that WRF v.3.4 modeled the Eastern US appropriately with regards to the factors EPA analyzed. NYSDEC went further to examine how WRF v.3.4 modeled temperature, mixing ratios, and PBL compared to monitored data and also found the results to be reasonable approximations. The data presented in EPA's documentation as well as OTC's analysis also provide evidence of areas needing further scrutiny (e.g., PBL height over bodies of water). OTC Modeling Committee expects that the 12 km WRF v.3.4 model results will lead to scientifically sound air quality modeling.

References

Carlton, AG and Baker, KR 2011, 'Photochemical Modeling of the Ozark Isoprene Volcano: MEGAN, BEIS, and Their Impacts on Air Quality Predictions', *Environmental Science & Technology*, vol. 45, no. 10, pp. 4438–4445.

Eyth, A and Vukovich, J 2015, 'Technical Support Document (TSD) Preparation of Emissions Inventories for the Version 6.2, 2011 Emissions Modeling Platform', accessed March 18, 2016, from <http://www3.epa.gov/ttn/chief/emch/2011v6/2011v6_2_2017_2025_EmisMod_TSD_aug2015.pdf>.

Otte, TL and Pleim, JE 2010, 'The Meteorology-Chemistry Interface Processor (MCIP) for the CMAQ modeling system: updates through MCIPv3.4.1', accessed March 16, 2016, from <http://www.geosci-model-dev.net/3/243/2010/gmd-3-243-2010.pdf>.

US EPA 2014, 'Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation', accessed March 4, 2016, from <https://www3.epa.gov/ttn/scram/reports/MET_TSD_2011_final_11-26-14.pdf>.

Section 3. Evaluation of Biogenic Model Versions

Overview

The modeling platform made available by EPA, v. 6.2, relied on BEIS v. 3.6 for biogenic emissions (Eyth and Vukovich 2015, p.2). More recently BEIS v. 3.6.1 was produced which came with more recent land use data which was expected to lead to more accurate results. OTC expects that EPA in future modeling will upgrade to the more recent version of BEIS, but since that has not yet to occur OTC determined that a brief evaluation of BEIS v. 3.6.1 was warranted.

Assessment

NYSDEC conducted an evaluation of two versions (3.6 and 3.6.1) of the biogenic model BEIS in order to determine which version produced more accurate base year modeling results. The major difference between the two versions of BEIS is the land use data employed by the model: v. 3.6 uses NCLD 2006 and v.3.6.1 uses NCLD 2011 (http://www.mrlc.gov/). The land use data in v. 3.6.1 shows much higher levels of isoprene than v. 3.6 (Bash, Baker and Beaver 2015). It was expected that v. 3.6.1 would produce the more accurate results given that it more accurately reflects the state of land use in the base year and also due to the improvements in isoprene production in the newer version.

In order to test the accuracy of the two biogenic model versions, two base year photochemical modeling runs were completed using CMAQ. The details on how CMAQ was configured for these model runs are in a later section (see Section 5). The model runs were completed using the 2011 Alpha 2 inventory (see Section 4).

Overall the difference between using v. 3.6.1 and v. 3.6 did not change the overall bias and error in the modeled results in the OTR as seen in Figure 3-1 (MFB), Figure 3-2 (MFE), and Figure 3-3 (MAGE), but the improvements in the response at the high ozone monitors warrant upgrading to BEIS v. 3.6.1.

Figure 3-1: MFE % for OTR monitors for CMAQ model runs conducted using BEIS 3.61 (left axis) and BEIS 3.6 (bottom axis)

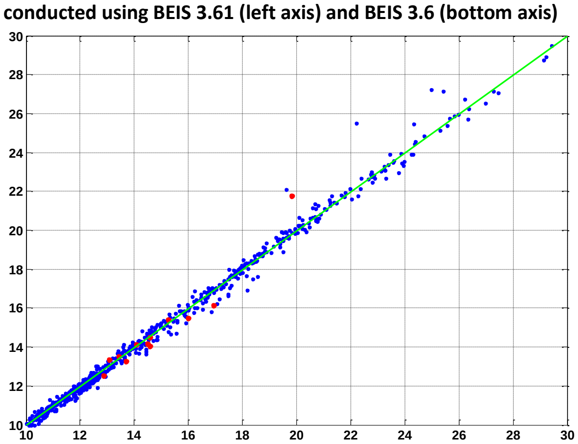


Figure 3-2: MFB % for OTR monitors for CMAQ model runs conducted using BEIS 3.61 (left axis) and BEIS 3.6 (bottom axis)

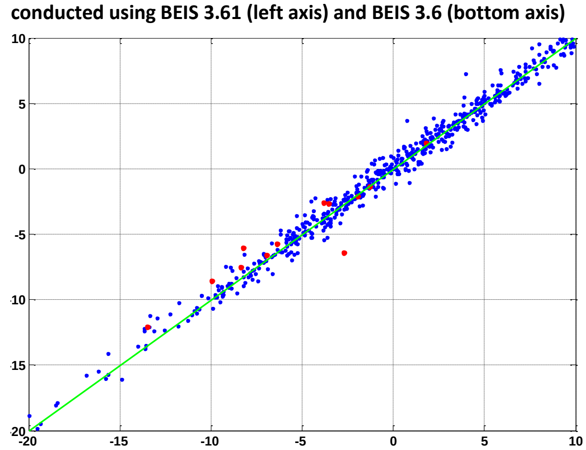
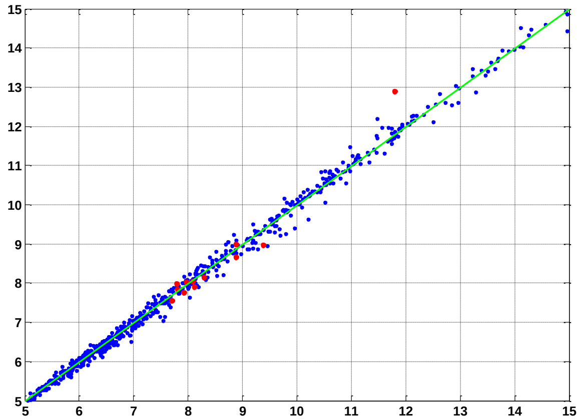


Figure 3-3: MAGE (ppb) for OTR monitors for CMAQ model runs conducted using BEIS 3.61 (left axis) and BEIS 3.6 (bottom axis)



In order to test the impact of design value projections between the two biogenic model versions, two future year photochemical modeling runs were completed using CMAQ. The details on how CMAQ was configured for these model runs are in a later section (see Section 5). The model runs were completed using the 2018 Alpha 2 inventory (see Section 8).

NYSDEC found that using BEIS v. 3.6.1 resulted a greater response to reductions in NO_X at many higher valued monitors as seen in Table 3-1. One exception to this rule was Sherwood Island, CT (Monitor ID #090019003), which saw increases in ozone in both photochemical model runs.

Deleted:

Four monitors, including Sherwood Island, saw no change in projected ozone when v. 3.6.1 was used, and this is likely due to their proximity to the land-water interface. The highest value in the 9x9 grid surrounding the monitor is used in calculating the projected ozone at a monitor. The highest values at the nearby grid cells to these monitors that are likely over water, which means those grid cells are not impacted by changes in biogenic emissions. As a result we would expect to see little to no change in projected ozone at monitors near to the land-water interface. More details on the issues surround projected ozone calculations for monitors near the land-water interface is in Section 9.

Table 3-1: Modeled 2018 DVFs for 12 high ozone monitors in the OTR comparing BEIS v. 3.6 and BEIS v. 3.6.1

AQS Code	Site	DVC2011	DVF BEIS v. 3.6	DVF BEIS v. 3.6.1
090019003	Sherwood Island	83.7	84	84
240251001	Edgewood	90	82	81
361030002	BABYLON	83.3	82	77
090010017	Greenwich Point Park	80.3	80	77
090013007	Fairfield	84.3	78	78
360810124	QUEENS COLLEGE	78	78	74
361192004	WHITE PLAINS	75.3	78	74
090099002	Hammonasset State Park	85.7	77	77
360850067	SUSAN WAGNER HS	81.3	77	77
340150002	Clarksboro	84.3	75	75
360050133	PFIZER LAB SITE	74	75	72
421010024	North East Airport (NEA)	83.3	75	74

References

Bash, JO, Baker, KR and Beaver, MR 2015, 'Evaluation of improved land use and canopy representation in BEIS v3.61 with biogenic VOC measurements in California', *Geoscientific Model Development Discussions*, vol. 8, no. 9, pp. 8117–8154.

Eyth, A and Vukovich, J 2015, 'Technical Support Document (TSD) Preparation of Emissions Inventories for the Version 6.2, 2011 Emissions Modeling Platform', accessed March 18, 2016, from <http://www3.epa.gov/ttn/chief/emch/2011v6/2011v6_2_2017_2025_EmisMod_TSD_aug2015.pdf>.

Section 4. Emissions Inventories and Processing for 2011 12km Base Year Simulation

Overviews

ERTAC EGU

The majority of the tools that OTC/MANE-VU are currently using to develop emissions inventory have already become standards in the field including MOVES for onroad emissions, NONROAD for nonroad emissions, EPA's RWC tool for residential wood combustion, BEIS for biogenic emissions, and EMF for growing inventories for other sectors. However, the ERTAC EGU projection tool is not as well known.

The ERTAC EGU tool has been developed through the ERTAC collaborative process to be used for use in projecting future year EGU emissions. However, some units are partial year reporters or do not have to report SO_2 emissions to CAMD due to only being in the NO_X Budget Trading Program. To resolve these issues the ERTAC EGU group ran ERTAC EGU projecting the CAMD data to the base year with no growth. This run, called Base Equals Future Year or "BY=FY", allowed missing emissions to be included, as well as smoothing out erratic data that is often created when missing data are replaced with maximum possible values (McDill, McCusker and Sabo 2015).

Alpha

The Alpha version of the inventory was used to generate CMAQ-ready emissions for initial modeling. EPA's 2011 emissions data from nearly every sector were included directly into CMAQ without SMOKE processing since these data were not altered in any way. The inventories were based on v. 6.2 of the EPA modeling inventory (also called v. "eh", which is in turn was based on NEI v. 2) and were processed through SMOKE v. 3.5.1 (Eyth and Vukovich 2015). Although OTC/MANE-VU did not process most of the emissions using SMOKE, the SMOKE input files are available on the MARAMA EMF system.

The exceptions that NYSDEC did process using SMOKE are the ERTAC EGU, Small EGU, and Non-EGU Point sectors. ERTAC v. 2.3 was used in the Alpha inventory. These were all processed using SMOKE v. 3.6.

Alpha 2

The Alpha 2 version of the inventory was primarily done to correct the C3 Marine sector to rectify double counting that occurred in the inventories used in the Alpha inventory (McDill, McCusker and Sabo 2015). In addition, a few other minor corrections were made. This is the version that is intended to be used in 2018 Regional Haze SIPs. EPA's 2011 emissions data from nearly every sector were included directly into CMAQ without SMOKE processing since these data were not altered in any way. EPA had processed their inventories using SMOKE v. 3.5.1 (Eyth and Vukovich 2015).

Beta/Beta 2

The Beta 2 version of the inventory is intended to be used in 2008 Ozone SIPs. For the base year there are no differences between Beta and Beta 2, they exist only in the future year work. The Beta 2 inventory uses some of the same files used in Alpha and Alpha 2 inventories that were provided by EPA, but it also relies on files that were updated in EPA's "eh" inventory and new inputs compiled by MARAMA, which includes states' feedback. The sectors that were updated from EPA's "eh" inventory required SMOKE processing using v. 3.7, and in the case of onroad mobile running SMOKE-MOVES v. 3.7. ERTAC v. 2.3 was upgraded to v. 2.5 for the Beta/Beta 2 inventory, which includes updated stacked parameters and the addition of SO_2 emissions for NO_X only reporters. The following sectors were reprocessed through SMOKE for the Beta/Beta 2 inventory:

1. Agriculture
2. Area Source
3. ERTAC EGU
4. Ethanol
5. Non-EGU Point
6. Non-ERTAC IPM EGUs
7. Nonroad
8. Point Oil & Gas
9. Refueling
10. Residential Wood Combustion
11. Wild Fires

Emission Inventory Sectors

This section lists the emission inventory sectors with a brief description of the sector. A full list of all of the files used are in Appendix A.

Agricultural

NH_3 emissions, at the county and annual resolution, from nonpoint livestock and from fertilizer application.

Agricultural Fugitive Dust

PM_{10} and $PM_{2.5}$ at the county and annual resolution from nonpoint fugitive dust sources including building construction, road construction, agricultural dust, and road dust.

Area Source

All nonpoint emissions, at the county and annual resolution, not included in other files. Also include agricultural burning, portable fuel container emissions merged into the sector.

Biogenic Emissions

Non-anthropogenic emissions at the grid cell and hourly resolution, including emissions from Canada, generated with the BEIS v. 3.61.

C1/C2 Marine and Rail

Locomotives and category 1 (C1) and category 2 (C2) commercial marine vessel emissions at the county and annual resolution. This category also includes some Category 3 emissions that were estimated by state agencies. Where these overlapped with the International Marine Organization (IMO) Category 3 sector described in the following section, the IMO Category 3 emissions were deleted to avoid double counting.

IMO C3 Marine

IMO Category 3 (C3) commercial marine vessel emissions at annual resolution - in the Alpha inventory distributed throughout the Atlantic Ocean, and in the Alpha 2 and Beta inventories distributed to shipping lanes.

Ethanol

Point sources that produce ethanol fuel.

ERTAC EGUs

All EGUs that are projected through the ERTAC projection tool, at the point and hourly resolution. These EGUs are from the universe of units with CEMS that are tracked by CAMD (though several units that meet that description are removed at state request) and were almost entirely found in EPA's sector files projected by IPM.

Non-EGU Point

All point emissions at the point and annual resolution, not included in other files. Some units were removed from EPA's prepared file since they were included in an ERTAC file. In the Beta inventory some sources were determined to be peaking EGUs and temporalized using an hourly emission file.

Non-ERTAC IPM EGUs

All units, at the point and annual resolution projected by EPA using IPM that were not projected using ERTAC and were also not included in the Non-EGU point sector, In the Beta inventory some sources were confirmed to be peaking EGUs and temporalized using an hourly emission file.

NonPoint Oil &Gas

Nonpoint emissions from the oil and gas sector at the county and annual resolution.

Nonroad

Mobile emissions, at the county and monthly resolution, processed using NONROAD 2008 from vehicles and equipment that are not included in other files.

Onroad

Mobile emissions, at the grid cell and hourly resolution, from onroad vehicles processed using MOVES and SMOKE-MOVES. The MOVES emission factors used for the Alpha and Alpha 2 inventories were produced using MOVES2014 and the emissions factors used for Beta were produced using MOVES2014a.

Point Oil & Gas

Point emissions from the oil and gas sector at the point and annual resolution.

Prescribed Burn

Point source daily prescribed fires computed using SMARTFIRE2.

Refueling

Area source emissions from gas station refueling.

Residential Wood Combustion

Nonpoint emissions from residential wood combustion at the county and annual resolution.

Wild Fires

Point source daily wildfires computed using SMARTFIRE2.

Speciation

The speciation and cross-reference files were taken from EPA's 2011 v6.2 modeling platform and are based on the SPECIATE 4.4 database (Abt Associates 19 February 2014; Eyth and Vukovich 2015, p.2)

Spatial Allocation

The spatial surrogates for the 12 km domain for both the United States and Canada were extracted from the national grid 12 km U.S. gridding surrogates provided with EPA's 2011 v6.2 modeling platform (Adelman 1 July 2015; Eyth and Vukovich 2015, p.2).

Temporal Allocation

In most cases emissions for the sectors were allocated temporally in the same fashion as done in EPA's 2011 v6.2 modeling platform which is described in section 3.3 (Eyth and Vukovich 2015, p.2). Exceptions to this are sectors called ERTAC EGU, Non-ERTAC IPM EGUs, and Non-EGU point.

In the case of ERTAC EGU, the ERTAC code produces hourly EGU emissions that are ground in the base year CEMS data. As mentioned earlier, the hourly results were developed using ERTAC EGU to create the BY=FY run. V. 1.01 of the ERTAC EGU code was used in all inventories. The inputs files used for the Alpha and Alpha 2 inventories were from ERTAC EGU v. 2.3, and for the Beta inventory from ERTAC EGU v. 2.5. In all cases they were post-processed using v. 1.02 of the ERTAC to SMOKE conversion tool. Given the fine level of detail that ERTAC EGU produces, the hourly ERTAC EGU results are used to temporalize EGUs in the modeling platform. In order to include the temporalization during SMOKE process, hourly ff10 files were produced by the ERTAC to SMOKE post processor in additional to the annual ff10 files.

In the case of Non-ERTAC IPM EGUs and Non-EGU point, some of the units were confirmed to be EGUs that are <25 MW (Small EGUs), through an MDE research project as outlined in Appendix A of the temporalization documentation (Ozone Transport Commission n.d.). The units were expected to be EGUs based on their SCC and NAICS, and further refinement to the list of EGUs occurred through a state comment period. These units still function as EGUs, but produce too small an amount of power and emissions to be required to report hourly emissions to CAMD and thus are not temporalized through the ERTAC EGU process. MDE has developed a temporalization profile using hourly data from units that burn the same primary fuel and do report to CAMD. The EMF tool was used to create hourly profiles for these units so that they operate during times when electricity demand is highest rather than at a steady rate throughout the year. An example of a gas fired Small EGU in MD is shown in Figure 4-1 and details on the profiles employed are in Appendix C of the documentation developed by MDE (Ozone Transport Commission n.d.). An example of the change in daily emissions that result from the application of the temporal profiles on three HEDDs in 2011 are in Table 4-1.

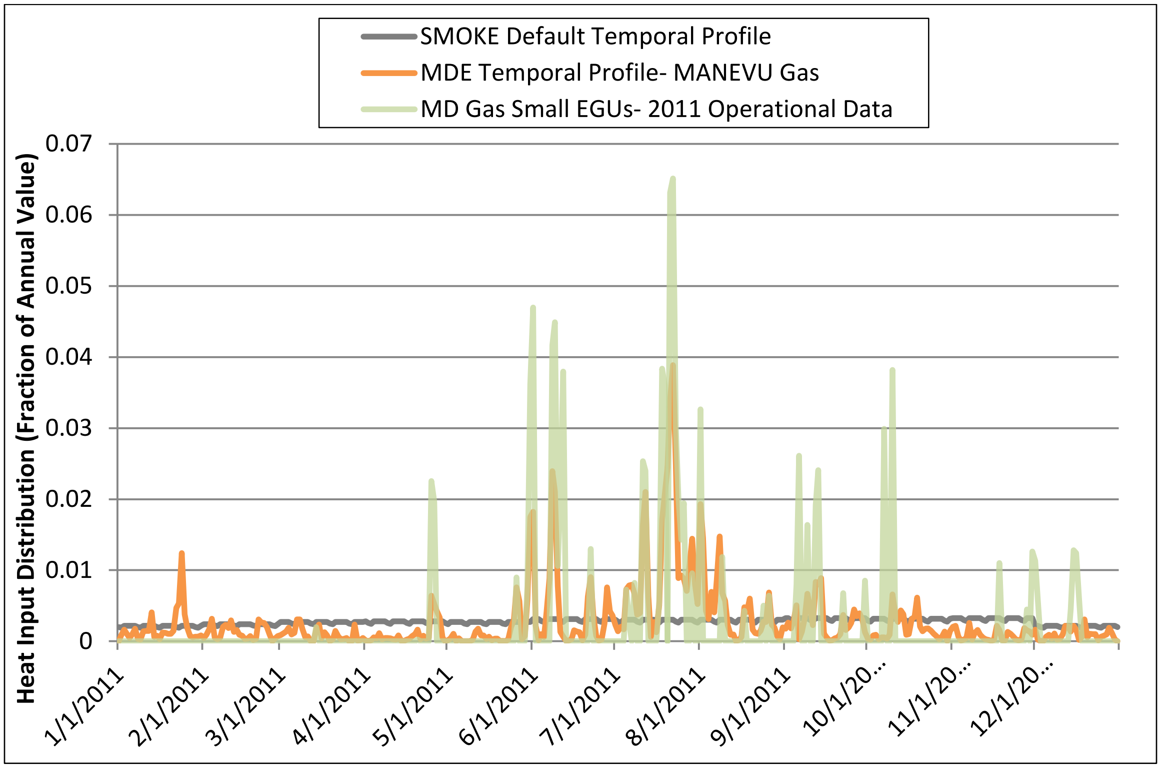
In order to develop the hourly ff10 files for the Small EGU's to process in SMOKE a multistep process was implemented. First, default temporal profiles were developed using SMOKE (TREF and TPRO) and they were then imported into EMF. Next hourly ff10 files were produced in EMF using the imported profiles. MDE in conjunction with UMD completed this work.

It should be noted that EPA did undertake an approach to temporalizing some non-CAMD EGUs as well in the 2011 v. 6.2 platform using an average fuel-specific season-to-month factors for each of the 64 IPM regions ((Eyth and Vukovich 2015)). OTC decided our approach was an improvement because it contained a more expansive list of sources that should be temporalized that was confirmed by individual states.

Table 4-1: Change in NO_X emissions (tons) on selected episode days in July 2011 as the result of Small EGU temporalization

	July 20	July 21	July 22
MANE-VU	25	41	48
LADCO	211	230	186
SESARM	20	23	19
CENSARA	83	42	38

Figure 4-1: Comparison of temporalization of SMOKE defaults, MANE-VU gas temporal profile, and operational data from a typical gas fired Small EGU in MD



SMOKE Processed Emission Results

In order to quality assure the outputs from SMOKE were properly distributed geographically and develop a better understanding of the geographical and temporalization of emissions we looked at daily emissions on a typical summer day (June 24, 2011) and during an ozone event (July 22, 2011). We looked at NO_X, VOC (with and without biogenic emissions) and SO_2 gridded emissions. Urban areas, interstates in rural areas, and shipping lanes are clearly distinguishable in the maps of NO_X emissions (Figure 4-2). There are minor differences at this scale on a peak day where one can notice increases in some grid cells during the ozone event (Figure 4-3). On a typical summer day, VOC emissions are higher as one looks further south which is expected given the greater biogenic emissions found in the south (Figure 4-4). It is quite noticeable how much VOC emissions increase on an ozone conducive day throughout the modeling domain (Figure 4-5). When biogenic emissions are removed from the mapping there is little difference between a typical summer day and an ozone event, but one can clearly distinguish urban cores where the majority of anthropogenic VOCs are produced (Figure 4-6 and Figure 4-7). One can see the importance of point sources in terms of SO_2 emissions and very minor increases throughout the modeling domain during an ozone event (Figure 4-8 and Figure 4-9).

Additionally, summary tables of emissions by state, sector, and pollutant were outputted from SMOKE processing. These results are aggregated for the 2011 Alpha 2 inventory in Table 4-2 and the 2011 Beta inventory in

Table 4-3.

Figure 4-2: MARAMA Alpha 2 NO_X SMOKE Gridded Emissions (June 24, 2011)

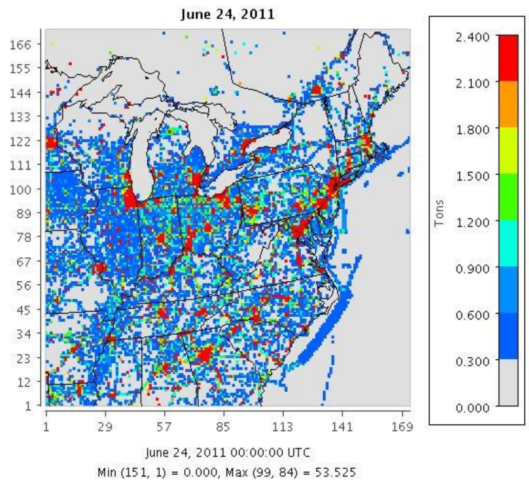


Figure 4-3: MARAMA Alpha 2 NO_X SMOKE Gridded Emissions (July 22, 2011)

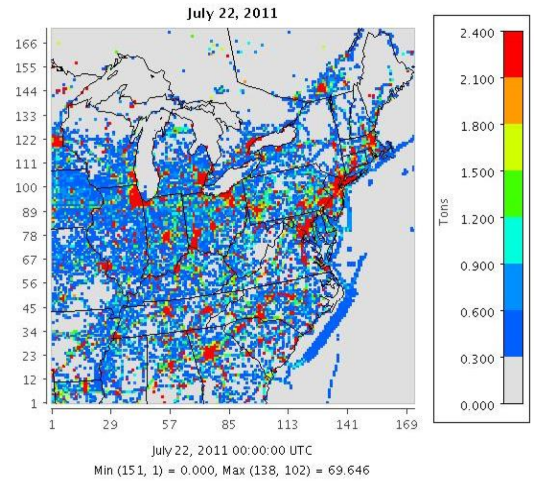


Figure 4-4: MARAMA Alpha 2 VOC All SMOKE Gridded Emissions (June 24, 2011)

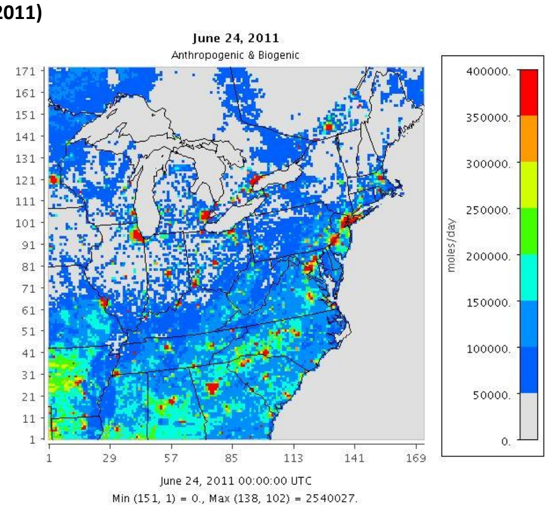


Figure 4-5: MARAMA Alpha 2 VOC All SMOKE Gridded Emissions (July 22, 2011)

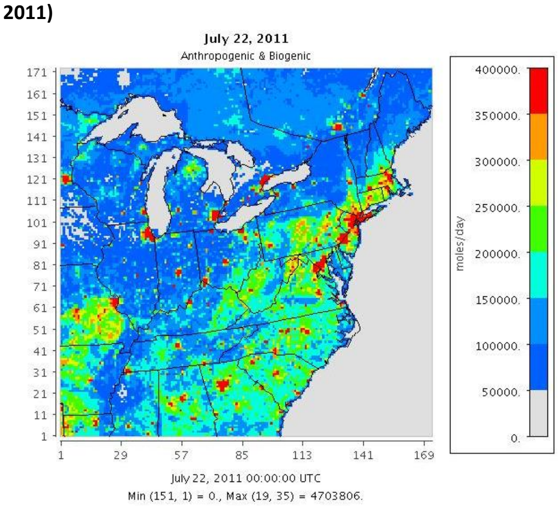


Figure 4-6: MARAMA Alpha 2 VOC Anthropogenic SMOKE Gridded Emissions (June 24, 2011)

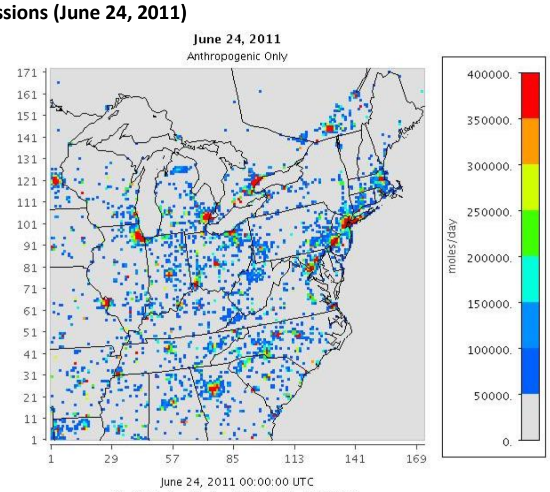


Figure 4-7: MARAMA Alpha 2 VOC Anthropogenic SMOKE Gridded Emissions (July 22, 2011)

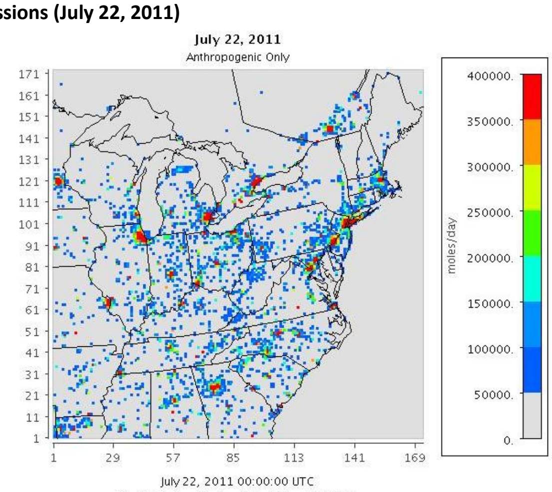


Figure 4-8: MARAMA Alpha 2 SO_2 SMOKE Gridded Emissions (June 24, 2011)

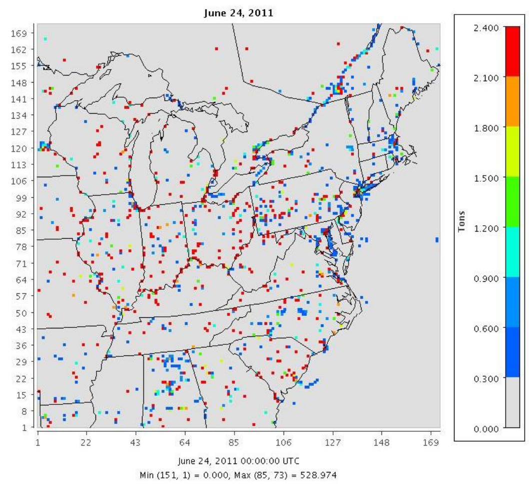


Figure 4-9: MARAMA Alpha 2 SO_2 SMOKE Gridded Emissions (July 22, 2011)

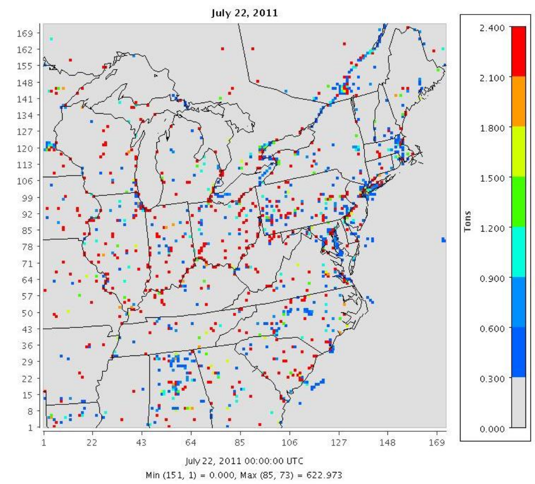


Table 4-2: 2011 base case Alpha 2 emissions (tons) by pollutant and RPO for aggregated sectors from SMOKE processed emission reports

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
				NO_X				
MANE-VU	206,647	158,385	346,366	699,944	195,502	53,407	1,018	**1,661,269**
LADCO	425,419	303,668	492,498	1,064,832	181,370	85,986	12,458	**2,566,230**
SESARM	415,026	283,147	435,277	1,245,114	109,193	151,801	77,295	**2,716,854**
CENSARA	476,036	325,158	711,395	1,150,395	143,345	626,084	116,659	**3,549,072**
CANADA		159,482	218,823	249,114	59,134			**686,553**
US EEZ			517,740					**517,740**
INTERNATIONAL			9,170					**9,170**
NO_X TOTAL	1,523,128	1,229,840	2,731,268	4,409,399	688,544	917,278	207,430	**11,706,887**
				VOC				
MANE-VU	2,482	53,690	366,461	356,969	678,462	29,028	21,238	**1,508,331**
LADCO	7,663	169,572	469,687	538,026	786,881	85,188	227,782	**2,284,799**
SESARM	9,218	234,252	367,733	586,331	790,334	144,742	496,938	**2,629,547**
CENSARA	11,975	209,440	269,531	497,121	875,210	1,520,510	1,635,856	**5,019,642**
CANADA		1,457	157,565	117,735	532,666			**809,423**
US EEZ			14,792					**14,792**
INTERNATIONAL			330					**330**
VOC TOTAL	31,339	668,411	1,646,099	2,096,182	3,663,553	1,779,468	2,381,813	**12,266,865**
				SO_2				
MANE-VU	462,603	108,742	25,481	5,069	135,409	2,103	612	**740,020**
LADCO	1,502,618	357,280	6,439	5,475	25,550	1,444	7,039	**1,905,845**
SESARM	1,079,218	260,522	11,832	6,040	62,121	22,615	28,139	**1,470,487**
CENSARA	1,087,853	324,686	23,579	5,594	44,155	21,060	58,760	**1,565,688**
CANADA		436,584	36,343	1,380	36,964			**511,271**
US EEZ			50,654					**50,654**
INTERNATIONAL			5,775					**5,775**
SO_2 TOTAL	4,132,292	1,487,814	160,102	23,559	304,198	47,222	94,551	**6,249,738**
				$PM_{2.5}$				
MANE-VU	17,952	28,839	27,585	26,839	161,721	1,676	27,277	**291,889**
LADCO	67,914	69,045	37,267	38,503	199,911	1,547	221,987	**636,174**
SESARM	67,176	79,204	31,430	38,457	183,154	3,442	384,047	**786,909**

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
CENSARA	77,558	84,589	40,187	38,085	123,174	15,966	1,026,201	**1,405,760**
CANADA		25,777	16,908	8,934	105,607		323,474	**480,700**
US			15,722					**15,722**
INTERNATIONAL			716					**716**
$PM_{2.5}$ TOTAL	230,599	287,454	169,815	150,818	773,568	22,631	1,982,986	**3,617,870**
				NH_3				
MANE-VU	2,925	4,974	380	18,106	14,580	14	165,666	**206,644**
LADCO	-	8,923	523	20,419	22,967	58	680,237	**733,127**
SESARM	444	16,497	429	24,401	8,356	6	579,545	**629,678**
CENSARA	-	22,208	1,121	19,701	17,123	52	1,366,962	**1,427,166**
CANADA		4,983	250	15,303	3,091		183,853	**207,480**
US EEZ			-					**-**
INTERNATIONAL			-					**-**
NH_3 TOTAL	3,369	57,585	2,702	97,929	66,117	129	2,976,263	**3,204,094**
				CO				
MANE-VU	41,340	235,436	2,769,526	3,498,866	892,083	40,947	90,739	**7,568,938**
LADCO	153,424	770,725	2,885,340	5,234,025	1,198,037	53,623	966,320	**11,261,494**
SESARM	166,730	489,203	2,503,935	5,616,897	1,018,104	110,496	2,814,505	**12,719,870**
CENSARA	201,076	412,960	1,820,066	4,791,071	783,366	474,018	6,907,096	**15,389,654**
CANADA		585,732	1,889,841	2,204,940	648,333			**5,328,846**
US EEZ			83,618					**83,618**
INTERNATIONAL			778					**778**
CO TOTAL	562,570	2,494,057	11,953,104	21,345,799	4,539,922	679,085	10,778,661	**52,353,197**

Table 4-3: 2011 base case Beta emissions (tons) by pollutant and RPO for aggregated sectors from SMOKE processed emission reports

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
				NO_X				
MANE-VU	206,457	155,892	346,258	717,012	195,137	53,407	1,018	**1,675,179**
LADCO	408,335	302,954	492,498	981,420	180,284	85,986	12,458	**2,463,934**
SESARM	415,015	280,126	435,277	1,168,980	102,231	152,364	77,295	**2,631,289**
CENSARA	491,941	323,997	805,686	284,258	127,522	626,557	116,659	**2,776,620**
CANADA		159,482	218,823	249,114	59,134			**686,553**
US EEZ			517,740					**517,740**
INTERNATIONAL			9,170					**9,170**
NO_X TOTAL	1,521,748	1,222,451	2,825,450	3,400,784	664,307	918,314	207,430	**10,760,484**
				VOC				
MANE-VU	2,477	53,046	366,247	362,357	701,998	29,028	21,238	**1,536,392**
LADCO	7,075	168,380	469,687	480,674	822,762	85,188	227,782	**2,261,546**
SESARM	8,008	233,565	367,733	554,022	825,772	144,792	496,938	**2,630,829**
CENSARA	10,069	208,963	327,909	109,269	879,881	1,520,538	1,635,856	**4,692,484**
CANADA		1,457	157,565	117,735	532,666			**809,423**
US EEZ			14,792					**14,792**
INTERNATIONAL			1					**1**
VOC TOTAL	27,628	665,412	1,703,934	1,624,056	3,763,079	1,779,546	2,381,813	**11,945,467**
				SO_2				
MANE-VU	462,551	108,301	25,481	4,793	135,936	2,102	612	**739,777**

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
LADCO	1,500,310	357,264	6,439	4,785	25,051	1,444	7,039	**1,902,332**
SESARM	1,079,181	255,343	11,832	5,443	54,572	27,673	28,139	**1,462,182**
CENSARA	1,088,313	324,666	23,801	1,071	38,551	21,060	58,760	**1,556,222**
CANADA		436,584	36,343	1,380	36,964			**511,271**
US EEZ			50,654					**50,654**
INTERNATIONAL			5,775					**5,775**
SO_2 TOTAL	4,130,355	1,482,158	160,324	17,473	291,074	52,279	94,551	**6,228,214**
				$PM_{2.5}$				
MANE-VU	17,987	28,669	27,582	27,133	159,622	1,676	27,277	**289,946**
LADCO	51,636	68,899	37,267	33,650	197,691	1,547	221,987	**612,677**
SESARM	49,543	78,805	31,430	35,586	168,966	3,452	382,291	**750,073**
CENSARA	45,622	84,418	48,640	10,236	88,011	15,977	1,026,201	**1,319,104**
CANADA		25,777	16,908	8,934	105,607		323,474	**480,700**
US			15,722					**15,722**
INTERNATIONAL			716					**716**
$PM_{2.5}$ TOTAL	164,788	286,568	178,265	115,539	719,897	22,653	1,981,229	**3,468,939**
				NH_3				
MANE-VU	2,923	4,950	380	18,094	14,555	14	165,666	**206,582**
LADCO	998	8,922	523	19,137	22,967	58	680,237	**732,842**
SESARM	3,363	16,357	429	23,066	8,345	6	579,545	**631,110**
CENSARA	6,488	22,207	1,223	4,131	14,549	52	1,389,837	**1,438,486**
CANADA		4,983	250	15,303	3,091		183,853	**207,480**
US EEZ			216					**216**
INTERNATIONAL								
NH_3 TOTAL	13,772	57,419	3,020	79,732	63,507	129	2,999,138	**3,216,716**
				CO				
MANE-VU	41,310	234,702	2,768,157	3,495,020	881,048	40,947	90,739	**7,551,923**
LADCO	88,937	769,979	2,885,340	4,684,400	1,174,185	53,623	966,320	**10,622,785**
SESARM	104,722	487,080	2,503,935	5,271,800	876,198	110,674	2,814,505	**12,168,913**
CENSARA	199,495	412,002	2,279,704	985,507	434,457	474,162	6,907,096	**11,692,424**
CANADA		585,732	1,889,841	2,204,940	648,333			**5,328,846**
US EEZ			83,618					**83,618**
INTERNATIONAL			778					**778**
CO TOTAL	434,464	2,489,495	12,411,373	16,641,667	4,014,221	679,407	10,778,661	**47,449,287**

References

Abt Associates 2014, *SPECIATE Version 4.4 Database Development Documentation*, accessed from <https://www3.epa.gov/ttn/chief/software/speciate/speciate_version4_4_finalreport.pdf>.

Adelman, Z 2015, *Emissions Modeling Platform Spatial Surrogate Documentation*, accessed from <ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/spatial_surrogates/US_SpatialSurrogate_Documentation_v070115.pdf>.

Eyth, A and Vukovich, J 2015, 'Technical Support Document (TSD) Preparation of Emissions Inventories for the Version 6.2, 2011 Emissions Modeling Platform', accessed March 18, 2016, from

<http://www3.epa.gov/ttn/chief/emch/2011v6/2011v6_2_2017_2025_EmisMod_TSD_aug2015.pdf>.

McDill, J, McCusker, S and Sabo, E 2015, 'Technical Support Document: Emission Inventory Development for 2011, 2018, and 2028 for the Northeastern U.S. Alpha 2 Version', accessed March 7, 2016, from <http://marama.org/images/stories/documents/2011-2018-2028_Technical_Support_Docs/TSD%20ALPHA2%20Northeast%20Emission%20Inventory%20for%202011%202018%202028%20DraftFinal%2020151123.pdf>.

Ozone Transport Commission Draft *White Paper: Examining the Air Quality Effects of Small EGUs, Behind the Meter Generators, and Peaking Units during High Electric Demand Days*.

Section 5. 8-hour Ozone/Regional Haze Modeling Using the CMAQ system

Air Quality Modeling Domain

The modeling domain used in this application represented a subset of the EPA continental-modeling domain that covered the entire 48-state region with emphasis on the OTR. The OTC/MANE-VU modeling domain at 12 km horizontal mesh is displayed in Figure 2-1. The 12 km domain used in this analysis includes the eastern US with a 172X172 mesh in the horizontal and 35 vertical layers, the same as WRF setup from surface up to 50 mb.

Photochemical Modeling -- CMAQ

The CMAQ (version 5.0.2) was used in this study. Photochemical modeling was performed with the CCTM software that is part of the CMAQ modeling package. Version 5.0.2 of this modeling software was obtained from the CMAS modeling center (http://www.cmascenter.org). Module options are listed in Table 2. It should be noted that the newer version of the gas phase chemical mechanism termed CB06 was not yet available in the CMAQ model at the time of this project.

Table 2: Module options used in compiling the CCTM executable

Horizontal advection: yamo	Vertical advection: wrf	Horizontal diffusion: multiscale
Vertical diffusion: ACM2	Gas phase chemical mechanism: CB05	Biogenic Emission: BEIS
Chemical solver: EBI	Aerosol module: aero6	

The following files are saved as running CMAQ:

- Layer 1 hourly-average concentration file (ACONC) which contains whole 154 species
- Dry deposition file (DRYDEP)
- Wet deposition file (WETDEP1)
- Aerosol/visibility file

Initial/Boundary Conditions/Initial Conditions

The boundary conditions for the 12 km grid were developed from a 2.5 x 2.5 degree GEOS-Chem (version 8) global simulation produced by EPA for use in the 2011 modeling platform (Eyth and Vukovich 2015, p.2). To address the transport of the pollutants through the boundaries, the GEOS-Chem data were used to develop the initial and boundary condition for the 2011 OTC modeling platform. The CMAQ simulations used a 15-day ramp-up period to wash out the effect of the initial fields.

References

Eyth, A and Vukovich, J 2015, 'Technical Support Document (TSD) Preparation of Emissions Inventories for the Version 6.2, 2011 Emissions Modeling Platform', accessed March 18, 2016, from <http://www3.epa.gov/ttn/chief/emch/2011v6/2011v6_2_2017_2025_EmisMod_TSD_aug2015.pdf>.

Section 6. CMAQ Model Performance and Assessment of 8-hour Ozone/Regional Haze Modeling

Air Quality Model Evaluation and Assessment

One of the tasks required as part of demonstrating attainment for the 8-hr ozone NAAQS is the evaluation and assessment of the air quality modeling system used to predict future air quality over the region of interest. As part of the attainment demonstration, the SMOKE/CMAQ modeling system was applied to simulate the pollutant concentration fields for the base year 2011 emissions with the corresponding meteorological information. The modeling databases for meteorology using WRF, the emissions using SMOKE, and application of CMAQ provide simulated pollutant fields that are compared to measurements to establish credibility of the modeling system. In the following section a comparison between the measured and predicted concentrations is performed and the results presented, demonstrating the overall utility of the modeling system in this application.

The results presented here should serve as an illustration of the evaluation and assessment performed on the base 2011 CMAQ simulation. Additional information can be made available by request from the New York State Department of Environmental Conservation.

Simulations

Base case simulations were run using each of the 2011 base case inventories (Alpha, Alpha 2, and Beta). Meteorology, chemistry, boundary conditions, etc. were all held consistent in the base case simulations.

Summary of Measured Data

The ambient air quality data for both gaseous and aerosol species for the simulation period were obtained from EPA AQS for ozone, AQS for $PM_{2.5}$ mass, CSN and IMPROVE for $PM_{2.5}$ speciation, and DISCOVER-AQ. Measured data from all sites within the modeling domain are included here. The model-based data were obtained at the grid-cell corresponding to the monitor location and no interpolation was performed.

Ozone

Hourly ozone is measured at a large number of State, Local, and National Air Monitoring Stations (SLAMS/NAMS) across the US on a routine basis, and the data from 226 OTR and 427 non-OTR sites were extracted from the AQS database (https://aqs.epa.gov/api).

Fine Particulate Matter ($PM_{2.5}$)

Federal Reference Method (FRM) $PM_{2.5}$ mass data collected routinely at SLAMS/NAMS sites across the US and the data from 745 sites across the modeling domain were extracted from AQS.

Fine Particulate Speciation

The 24-hour average $PM_{2.5}$ and fine particulate speciation (sulfate (SO_4), nitrate (NO_3), elemental carbon (EC), organic carbon/organic mass (OC/OM), and soil/crustal matter) from Class I areas across the US collected every 3rd day were obtained from the IMPROVE web site (http://vista.cira.colostate.edu/IMPROVE). Additionally, CSN speciated data was downloaded from the AQS system (https://www3.epa.gov/ttnamti1/speciepg.html). Data from 58 IMPROVE sites and 127 CSN sites in the modeling domain were used in this analysis.

DISCOVER-AQ

Two research airplanes (a NASA P-3B and a UC-12) flew 14 days, sampling in coordination with ground sites, monitoring air quality in the Baltimore-Washington corridor in 2011. The NASA P-3B, spiraled over six ground stations in Maryland and the UC-12 used a LiDAR to observe "profiles" of particulate pollution in the atmosphere. This data resource was predominantly used to inform a qualitative assessment of vertical ozone profiles.

Evaluation of CMAQ predictions

The following sections provide model evaluation information for the above referenced pollutants over the 12-km modeling domain. Details on the formulas used in this section can be seen in

Daily Maximum 8-hour Ozone Concentration

Model evaluation statistics, based on daily maximum 8-hour average ozone levels on days having: (1) at least 10 valid observations, and (2) an observed daily maximum ozone concentration of at least 60 ppb, are presented here for all sites across the modeling domain. The data covered the period from April 15 through October 30. Modeling results were computed using the Alpha2 platform. There are 226 OTR and 427 non-OTR SLAMS/NAMS sites. The use of the 60 ppb threshold focuses on model performance evaluation on the highest ozone days.

Figure 6-1 and Figure 6-2 display daily averages of observed and predicted daily maximum 8-hour ozone concentrations averaged across all SLAMS/NAMS sites in the OTR and outside of the OTR, respectively. These averages were computed for each day and considered all sites, not just ones that met the threshold. The dashed black line denotes 1:1, colored lines denote linear regression lines, and the green line denotes observed daily maximum ozone ≥60 ppb.

The overall tendency of CMAQ is to over-predict daily maximum ozone – 63% of CMAQ values at OTR sites are higher than observed (Figure 6-1); 60% of CMAQ values at non-OTR sites are higher than observed (Figure 6-1). However, at observed daily maximum ozone concentrations >60 ppb, CMAQ tends to under-predict ozone – on such days 68% of CMAQ values at OTR sites are lower than observed, and 77% of CMAQ values at non-OTR sites are lower than observed. The under-prediction in the OTR is less when solely looking at the 1st high maximum and the 4th high maximum (Figure 6-3). It is also less in the region outside of OTR for the 1st high maximum and the 4th high maximum (Figure 6-3).

Figure 6-1: Comparison of daily maximum 8-hour ozone concentrations at OTR sites

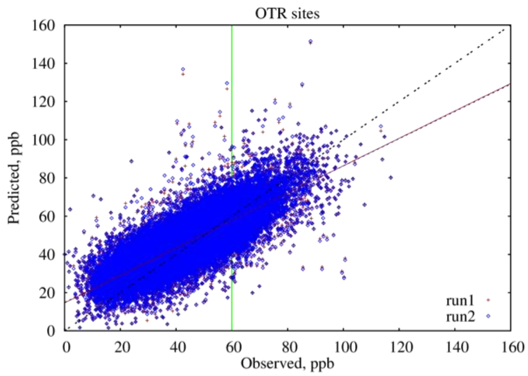


Figure 6-2: Comparison of daily maximum 8-hour ozone concentrations at non-OTR sites

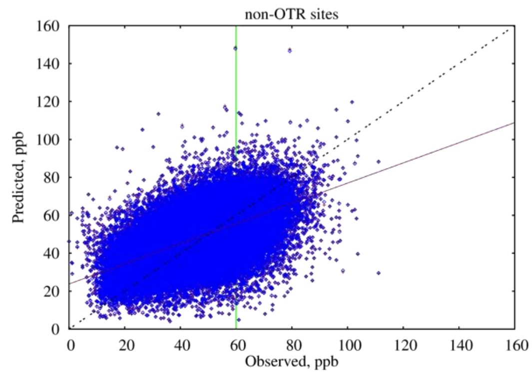
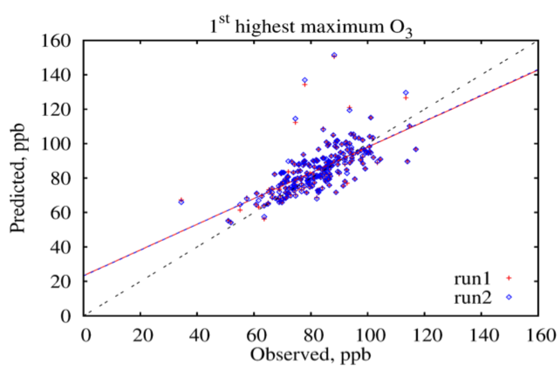


Table 6-1: Correlation coefficients for 1st and 4th highest maximum 8-hour ozone concentrations in 2011 base case modeling

	1st highest maximum	4th highest maximum
OTR	0.68	0.78
Outside-OTR	0.31	0.38

Figure 6-3: Comparison of 1st highest maximum (left) and 4th highest maximum (right) 8-hour ozone concentrations at OTR sites



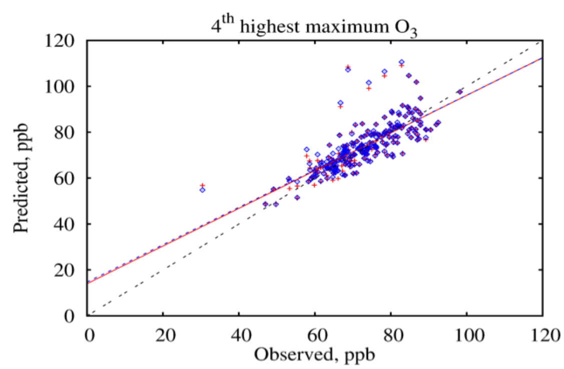
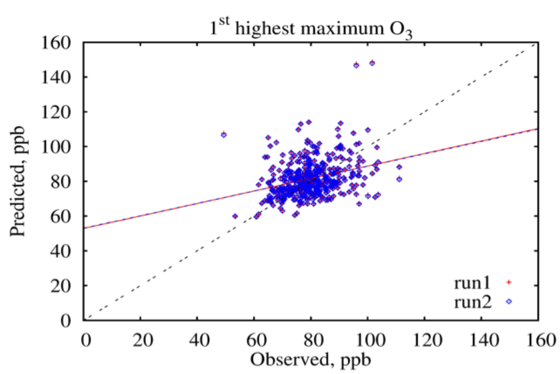
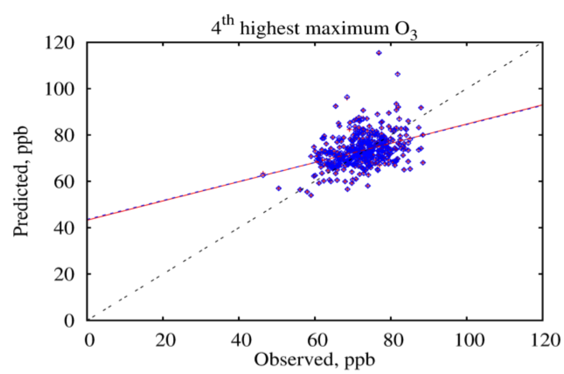


Figure 6-4: Comparison of 1st highest maximum (left) and 4th highest maximum (right) 8-hour ozone concentrations at non-OTR sites





CMAQ captured the observed temporal variation well, and CMAQ showed under-prediction early in the ozone season matched observed results well after July. CMAQ captured the observed temporal variation well with both Alpha 2 and Beta emissions with the Beta emissions yielding comparable 8-hour ozone results to Alpha2 emissions though in a few cases Beta results were slightly higher (Figure 6-5 and Figure 6-6).

Figure 6-5: Observed versus predicted 2011 ozone concentration (ppb; mean ± 1 standard deviation) using Alpha 2 Inventory in the OTR where daily max was greater than 40 ppb

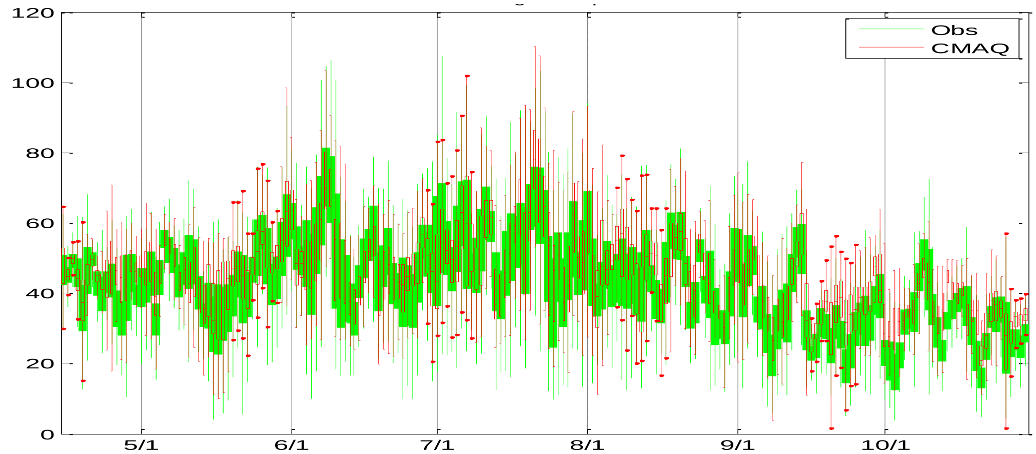
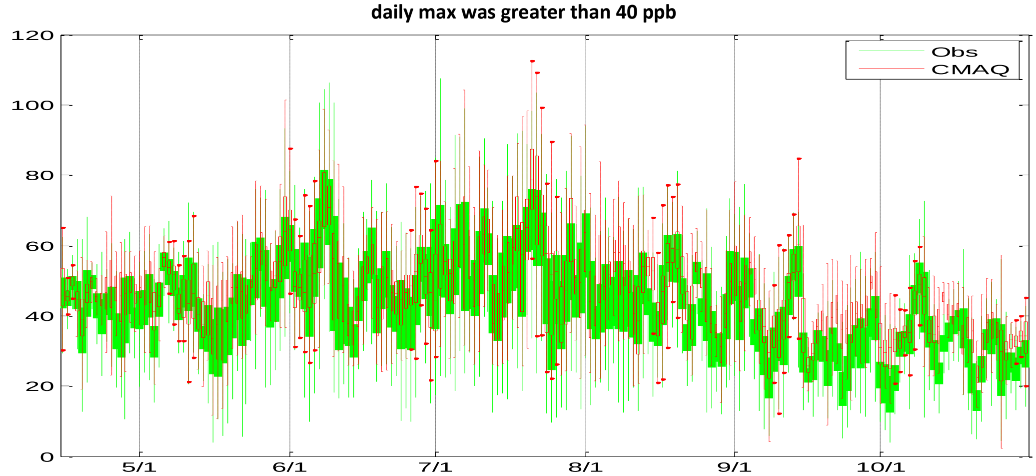


Figure 6-6: Observed versus predicted 2011 ozone concentration (ppb; mean ± 1 standard deviation) using Beta Inventory in the OTR where daily max was greater than 40 ppb



Geographically, the MFE is higher in New England than in the Mid-Atlantic OTR and much higher outside of the region, in particular in LADCO (Figure 6-7). The Beta emission showed a reducing MFE in comparing to Alpha2 emissions, especially within the inner-OTR region (Figure 6-8). MFB are small and close to zero bias in the northeast region while in the LADCO region MFB is more negative indicating the CMAQ's underprediction which may be caused by the boundary conditions (Figure 6-9). The Beta emissions also showed improvement in correcting the bias prediction, especially in the inner-OTR region (Figure 6-10). There are several monitors on the Atlantic coast, in particular along the Long Island Sound, that have a positive MFB, and the general under-prediction in the OTR is more prominent in southern

New England. Outside of the region MFB shows the most under-prediction in LADCO and CENSARA states. MAGE is most prominent along the I-95 corridor and along Lake Erie, though the highest MAGE is seen at Mt Washington in New Hampshire (Figure 6-11). Similar to MFE, the Beta emissions also indicated the improvement in reducing error by CMAQ predictions (Figure 6-12). MAGE is also higher outside of the OTR, in particular in the LADCO and CENSARA states. One potential reason for higher MFE and MAGE in the LADCO and CENSARA regions may be boundary conditions.

Figure 6-7: MFE in daily max 8-hr ozone Alpha 2, 60 ppb threshold, Apr 15-Oct 30; only monitors with 10 days greater than 60 ppb threshold (183 of 226 OTR sites; 372 of 427 non-OTR-sites)

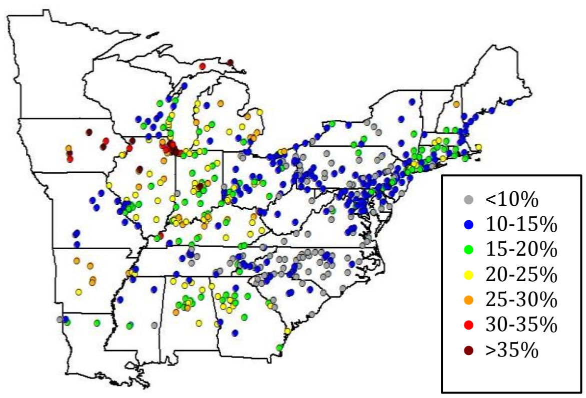


Figure 6-8: MFE in daily max 8-hr ozone Beta, 60 ppb threshold, Apr 15-Oct 30; only monitors with 10 days greater than 60 ppb threshold (183 of 226 OTR sites; 372 of 427 non-OTR-sites)

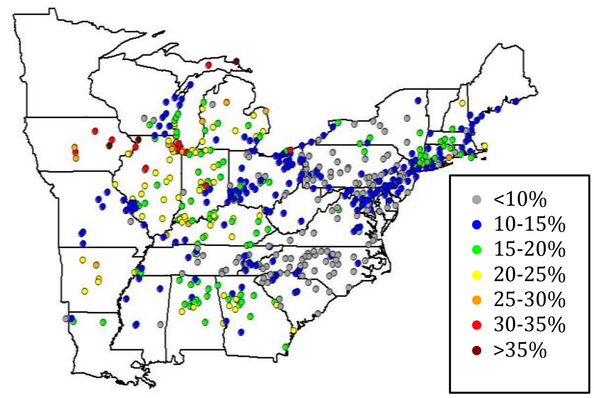


Figure 6-9: MFB in daily max 8-hr ozone Alpha 2, 60 ppb threshold, Apr 15-Oct 30; only monitors with 10 days greater than 60 ppb threshold (183 of 226 OTR sites; 372 of 427 non-OTR-sites)

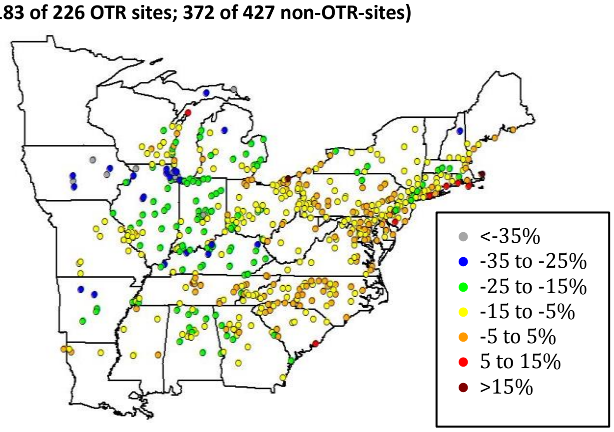


Figure 6-10: MFB in daily max 8-hr ozone Beta, 60 ppb threshold, Apr 15-Oct 30; only monitors with 10 days greater than 60 ppb threshold (183 of 226 OTR sites; 372 of 427 non-OTR-sites)

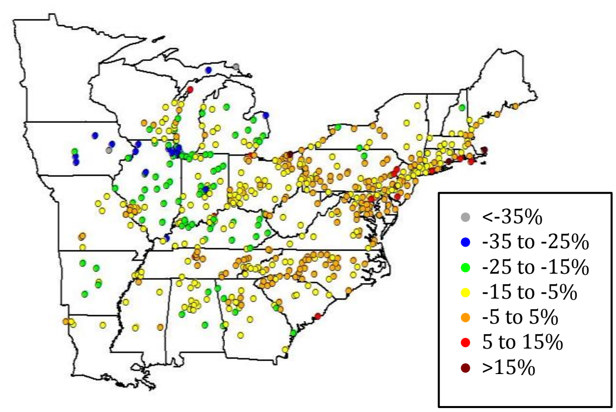


Figure 6-11: MAGE in daily max 8-hr ozone Alpha 2, 60 ppb threshold, Apr 15-Oct 30; only monitors with 10 days greater than 60 ppb threshold (183 of 226 OTR sites; 372 of 427 non-OTR-sites)

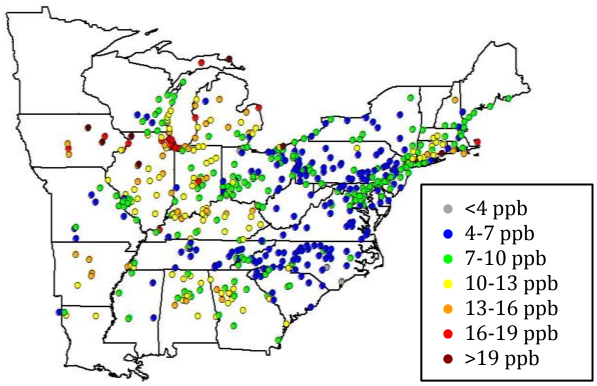
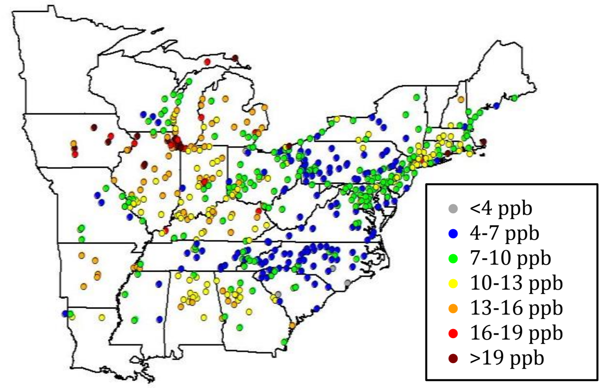


Figure 6-12: MAGE in daily max 8-hr ozone Beta, 60 ppb threshold, Apr 15-Oct 30; only monitors with 10 days greater than 60 ppb threshold (183 of 226 OTR sites; 372 of 427 non-OTR-sites)



Evaluation of Ozone Aloft

On June 8-9 and July 21-23, 2011 ozone sondes were launched at Edgewood, MD (Penn State University), Beltsville, MD (Howard University), and Egbert, ON. UMD flew aircraft spirals over Churchville, MD (0W3), Cumberland, MD (CBE), Easton, MD (ESN), Frederick, MD (FDK), Massey, MD (MD1), Luray, VA (W45), and Winchester, VA (OKV). The NASA P3 from the DISCOVER-AQ program flew spirals over Beltsville, MD, Padonia, MD, Fairhill, MD, Aldino, MD, Edgewood, MD, and Essex, MD.

Averages and standard deviations for the measurements were calculated for each elevation that corresponded to the height of a layer used in CMAQ modeled runs. Grid cells that corresponded temporally and geographically to the measurements from the location of the ozone measurement (e.g., sonde launch site) from DISCOVER-AQ that occurred at the same time as the measurement were used as the prediction with which the observed data would be compared.

Predictions above 3 km were generally accurate when compared to the morning profile, but under-predicted, especially above 8 km (Figure 6-13). Between 0.5 km and 3 km CMAQ under-predicted observed concentrations by around 5 ppb during both the morning and evening hours. We found that CMAQ predictions were fairly accurate below approximately 0.5 km. The results are similar with CMAQ run with both inline point sources (Run 1) and SMOKE processed point sources (Run 2).

Figure 6-13: Observed ozone concentration (ppb) layer average and standard deviation compared to CMAQ layers up to 10 km

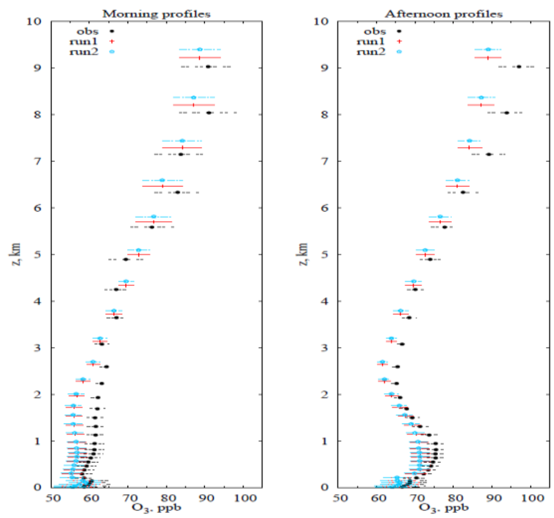
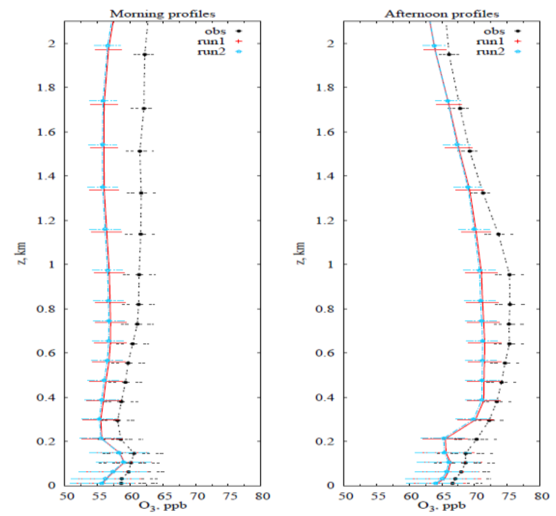


Figure 6-14: Observed ozone concentration (ppb) layer average and standard deviation compared to CMAQ layers up to 2 km



Evaluation of Fine Particulate Matter

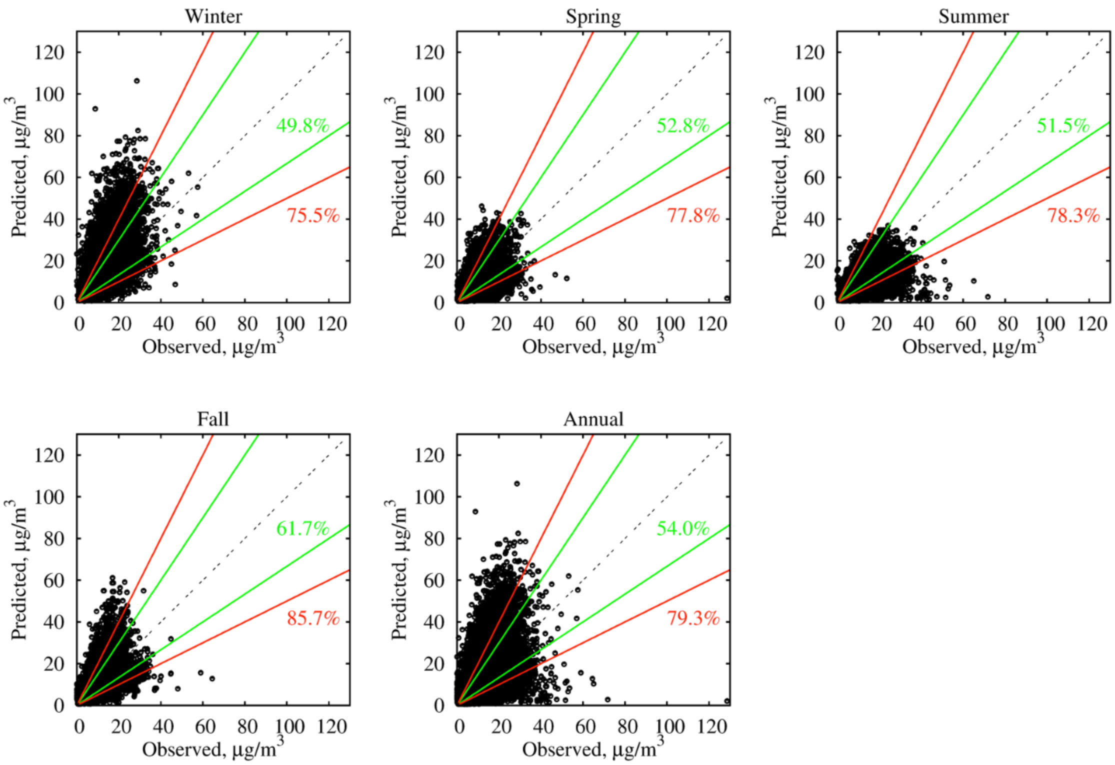
Composite daily average predicted and observed concentrations of $PM_{2.5}$ FRM mass were compared to determine the validity of the modeling results prior to evaluating individual species needed for haze model validation. Our model performance goals of MFB ≤ ±30% and MFE ≤50% as well as model performance criteria of MFB ≤±60% and MFE ≤75% were set by the OTC modeling committee. These performance goals and criteria were also used by other RPOs when evaluating $PM_{2.5}$ model performance (Brewer et al. 2007). CMAQ met the MFB ±30% goal on 63% of days, MFB ±60%performance criteria nearly every day. CMAQ met the MFE 50% goal on 82% of days, MFE 75%performance criteria every day as seen in Table 6-2. MAGE was also found to be acceptably low on 64% of days.

Table 6-2: Summary statistics for predicted $PM_{2.5}$ FRM mass

	ALL DAYS (N=365)	**1-IN-3-DAY (N=121)**
MFB ≤ ±30%	230 (63.0%)	79 (65.3%)
MFB ≤ ±60%	360 (98.6%)	121 (100%)
MFE ≤ 50%	300 (82.2%)	98 (81.1%)
MFE ≤ 75%	365 (100%)	121 (100%)
MAGE ≤ 5 mg/m^3	235 (64.4%)	80 (66.1%)

Annually, $PM_{2.5}$ is over predicted, with the great over-prediction occurring during the winter months, with the summer months leaning towards a slight under-prediction (Figure 6-15).

Figure 6-15: Comparison of daily observed and predicted $PM_{2.5}$ FRM mass, annual and by season with 1:1 (dashed), 1:1.5 (green) and 1:2 (red) lines for Winter (D/J/F), Spring (M/A/M), Summer (J/J/A), Fall (S/O/N), and Annually.



When looking temporally, one finds the greatest over-prediction during the winter months and slight under-prediction during the summer (Figure 6-16, Figure 6-17) and the result holds for those monitors on the 1 in 3 day schedule. MFE is high throughout the year with the greatest peaks in the summer time (Figure 6-18, Figure 6-19). MFB is positive in the winter time which is indicative of the under-prediction and negative during the summer time which is indicative of over-prediction (Figure 6-20, Figure 6-21). MAGE is greatest during the winter and summer (Figure 6-22, Figure 6-23).

Figure 6-16: Observed and predicted $PM_{2.5}$ FRM mass, all days

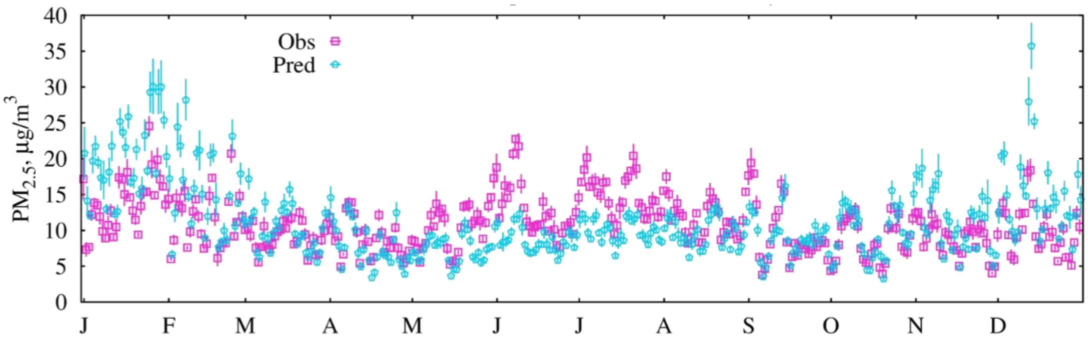


Figure 6-17: Observed and predicted $PM_{2.5}$ FRM mass, 1-in-3 day schedule

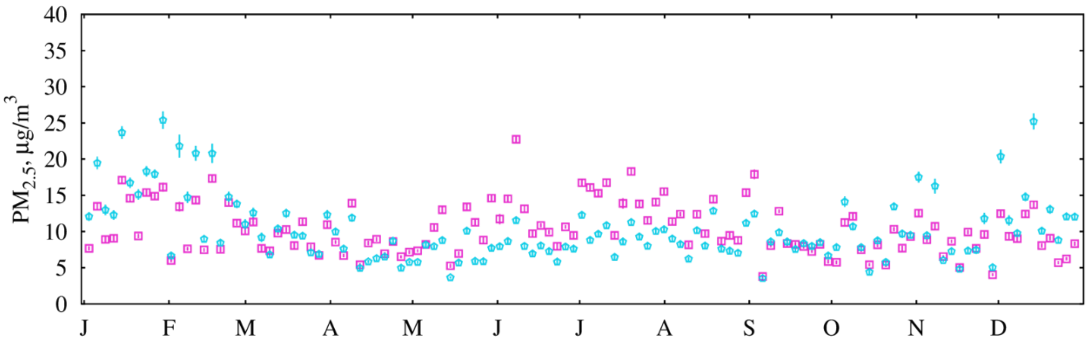


Figure 6-18: MFE $PM_{2.5}$ FRM mass, all days

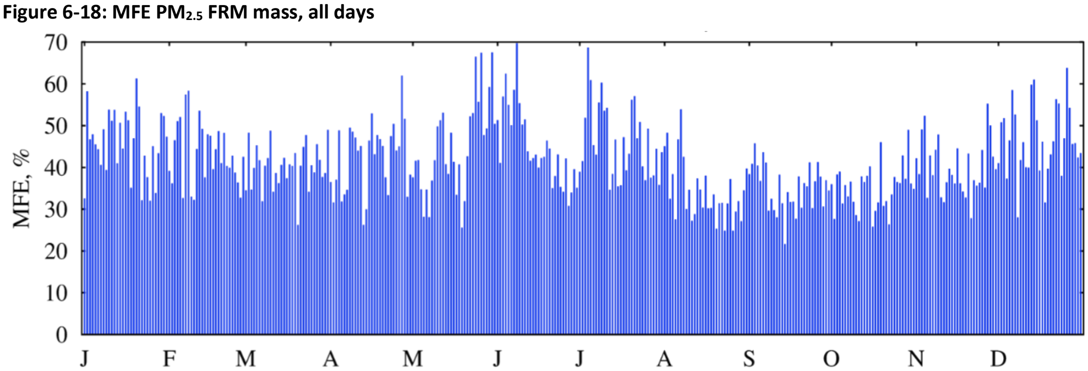


Figure 6-19: MFE $PM_{2.5}$ FRM mass, 1-in-3 day schedule

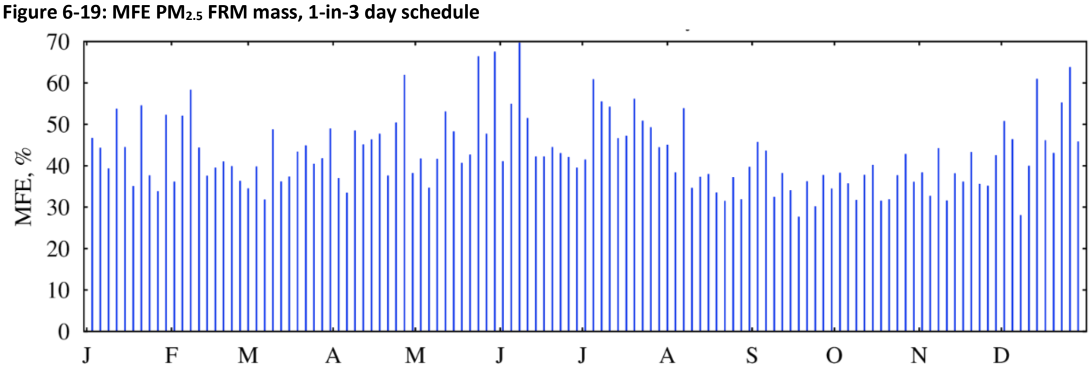


Figure 6-20: MFB $PM_{2.5}$ FRM mass, all days

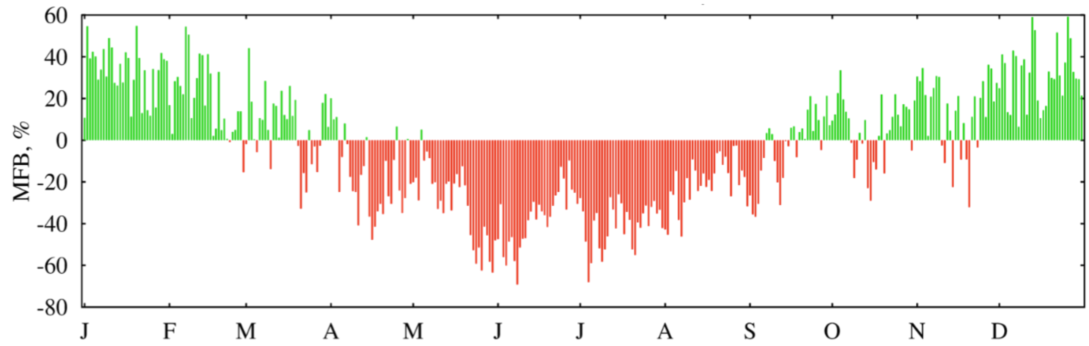


Figure 6-21: MFB $PM_{2.5}$ FRM mass, 1-in-3 day schedule

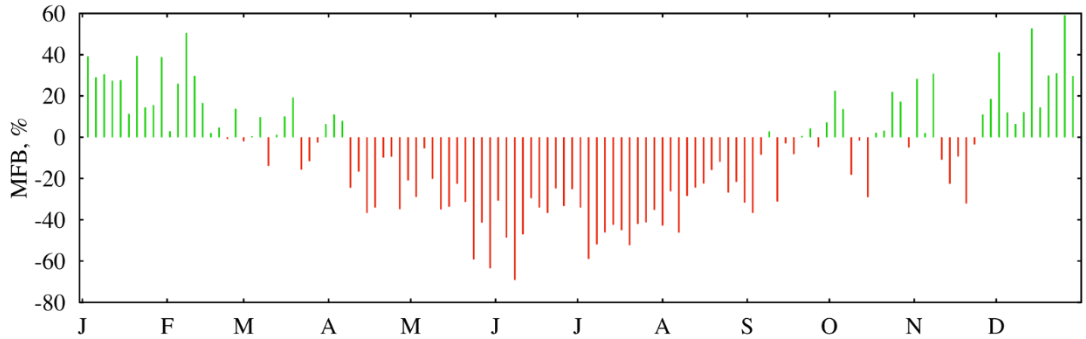


Figure 6-22: MAGE $PM_{2.5}$ FRM mass, all days

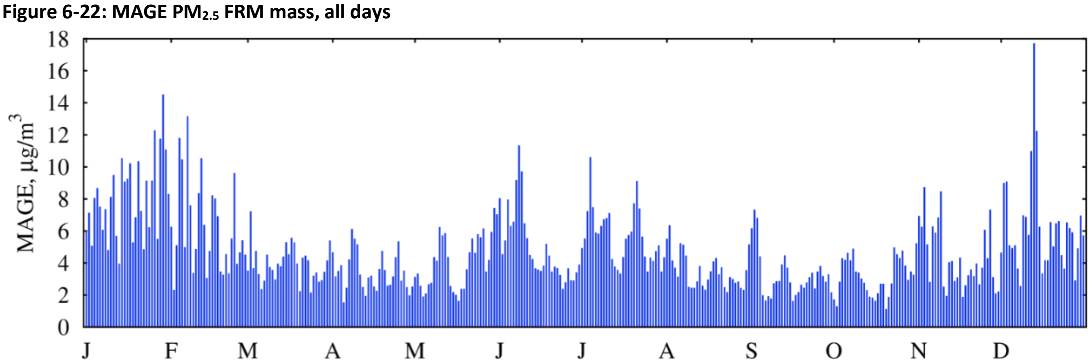
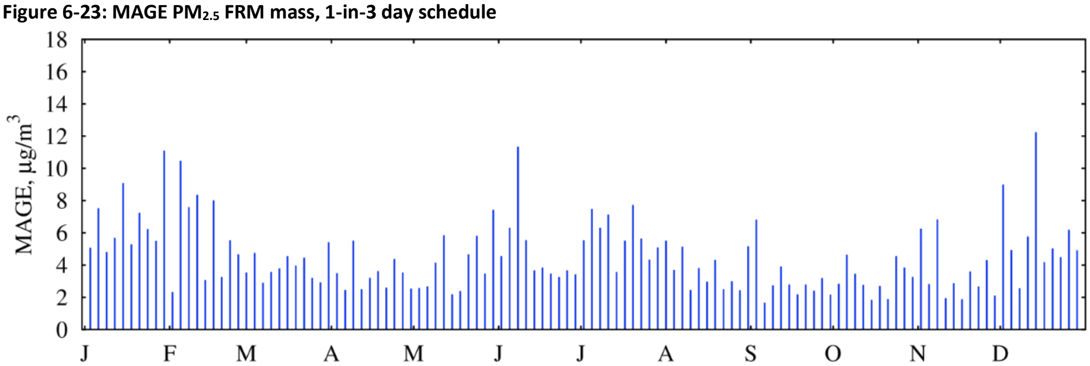


Figure 6-23: MAGE $PM_{2.5}$ FRM mass, 1-in-3 day schedule



As a first step in geographic evaluation we looked at the differences between observed (Figure 6-24) and predicted values (Figure 6-25) and one can see that some areas of MANE-VU are achieving different results annually. The greatest MFE for $PM_{2.5}$ in MANE-VU occurs in northern New England and decreases towards the southern portion of MANE-VU, though there are also some higher MFE values along the coast (Figure 6-26). The same areas in New England are biased towards over-prediction as well, with under-prediction occurring in more populated portions of MANE-VU (Figure 6-27). MAGE remains fairly consistent geographically (Figure 6-28).

Figure 6-24: Observed annual average $PM_{2.5}$ FRM mass, 2011 (only monitors with ≥10 days of data are shown)

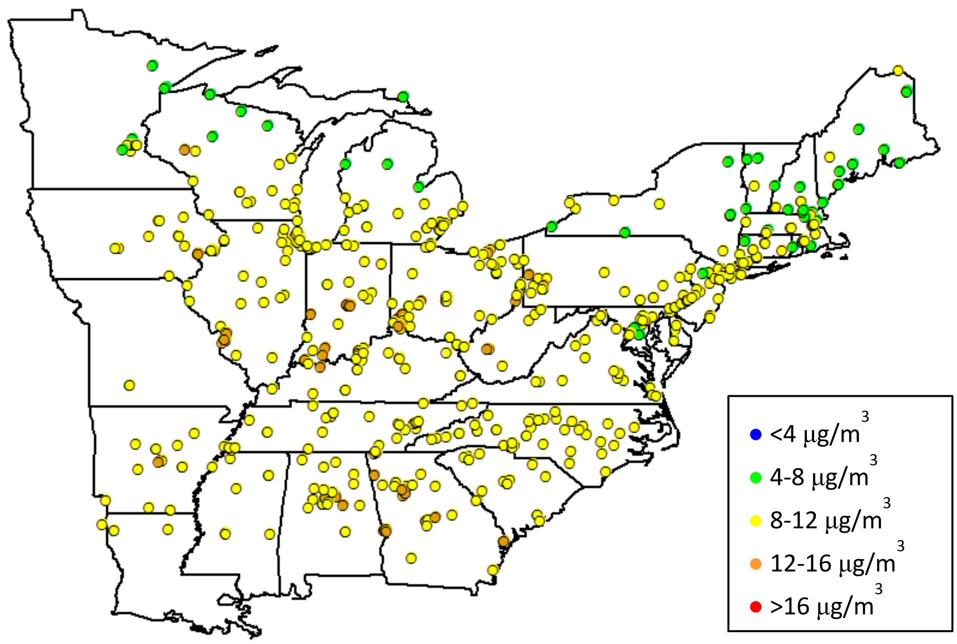


Figure 6-25: Predicted annual average $PM_{2.5}$ FRM mass, 2011 (only monitors with ≥10 days of data are shown)

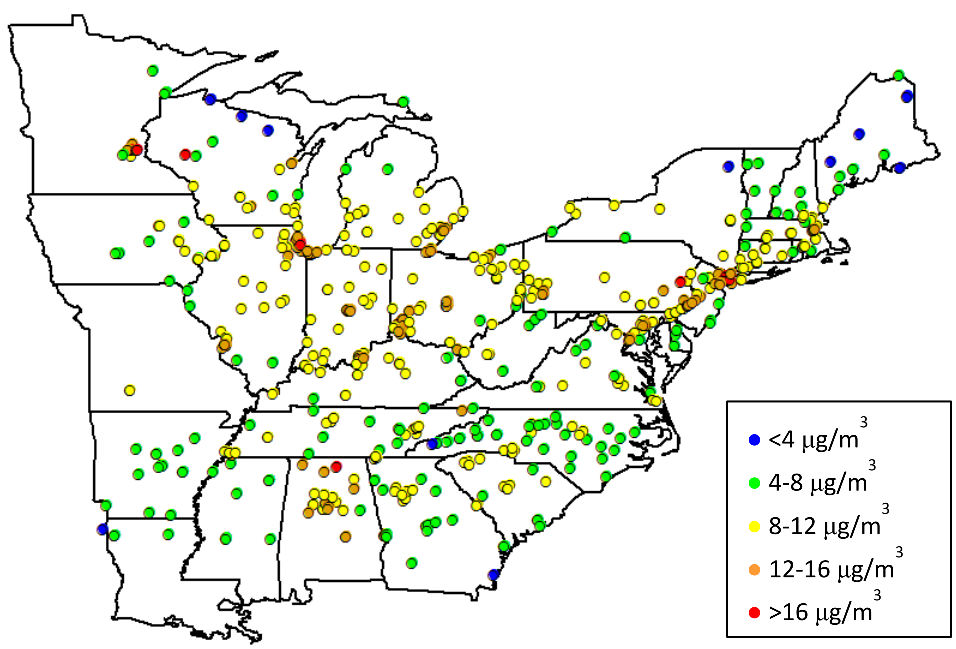


Figure 6-26: MFE in $PM_{2.5}$ FRM mass, 2011 (only monitors with ≥10 days of data are shown)

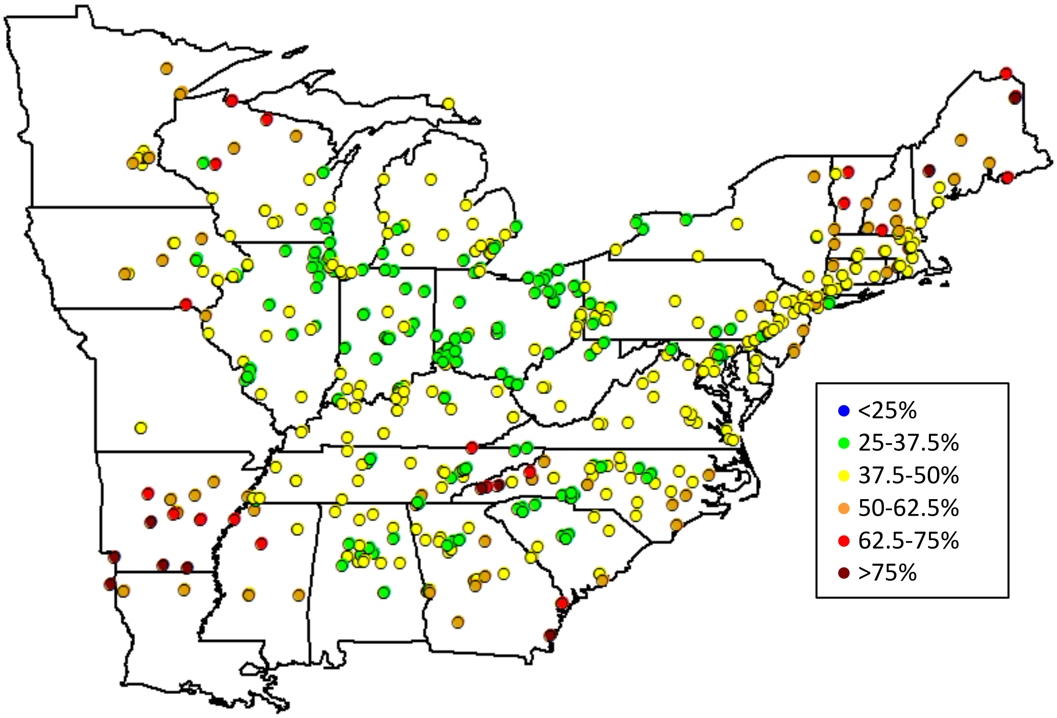


Figure 6-27: MFB in $PM_{2.5}$ FRM mass, 2011 (only monitors with ≥10 days of data are shown)

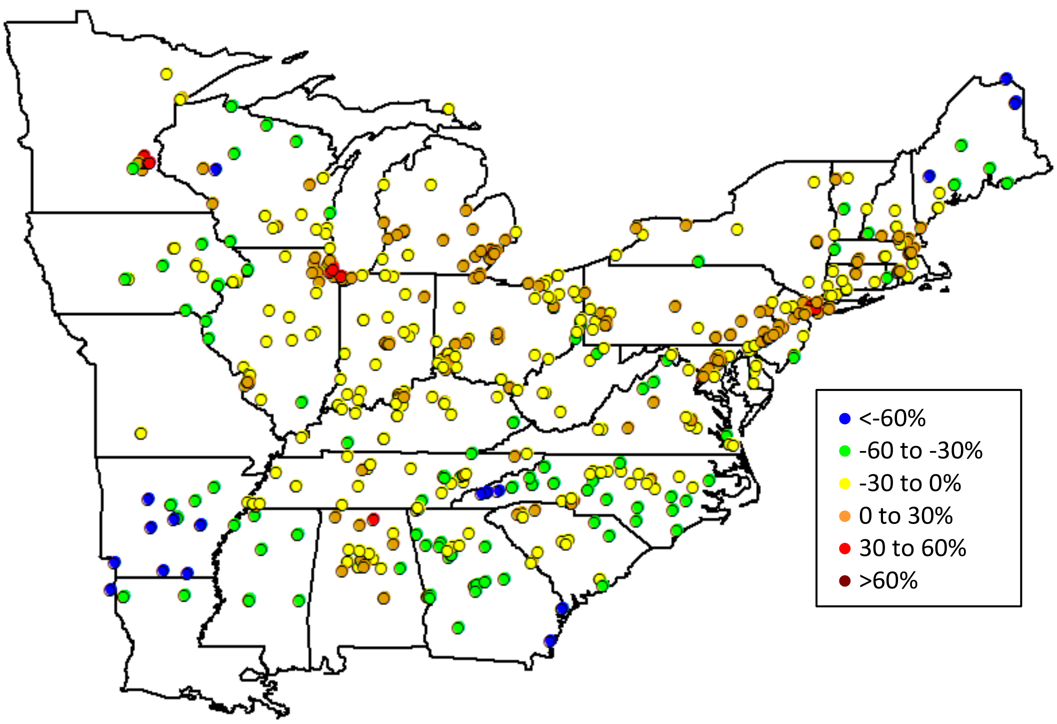
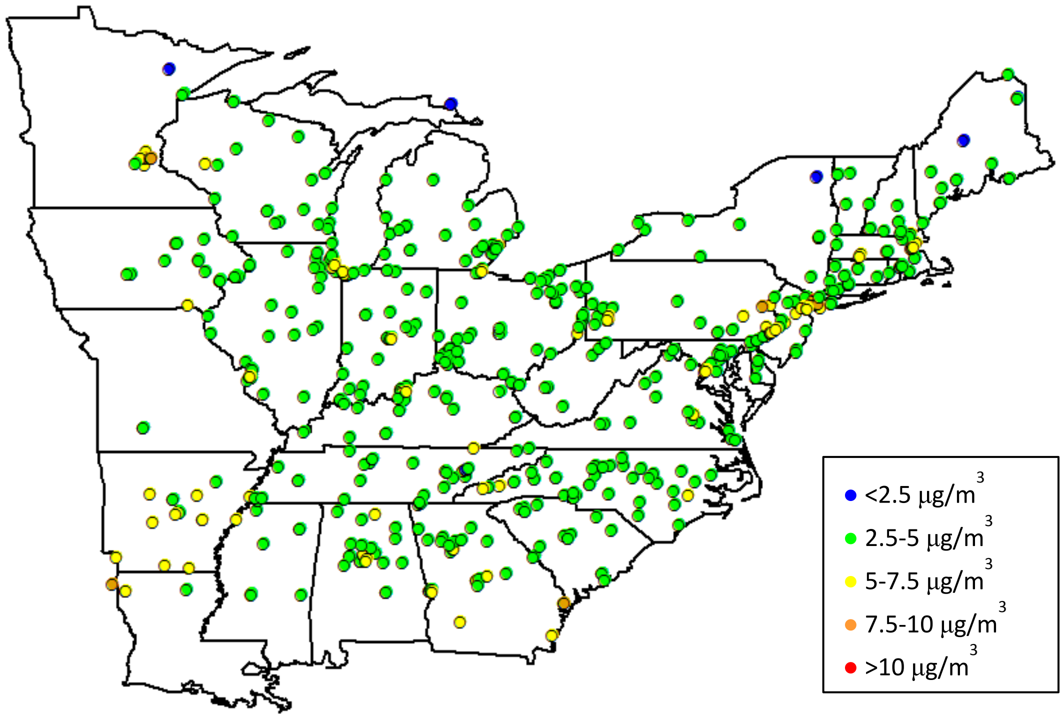


Figure 6-28: MAGE in $PM_{2.5}$ FRM mass, 2011 (only monitors with ≥10 days of data are shown)



Evaluation of Visibility

In this section we evaluate the model performance with respect to visibility, in particular of the $PM_{2.5}$ species used in the IMPROVE algorithm to estimate visibility impairment. Data from 58 IMPROVE sites and 127 CSN sites in the modeling domain were used in this analysis and the data cover the entire 2011 year.

Soil/crustal matter is assumed to consist of oxides of Aluminum (Al), Calcium (CA), Iron (Fe), Silicon (Si), and Titanium (Ti). The IMPROVE OC blanks are assumed to equal zero. Since CMAQ was employed, we used 2.5 m "sharp cutoff" variables as opposed to the sum of I+J modes.

CSN reports EC & OC by TOT and TOR, IMPROVE only by TOR; for this analysis, TOR data from CSN and IMPROVE were combined and CSN TOT data were considered separately. IMPROVE reports blank-corrected OC and CSN does not, so for this analysis, annual average site-specific blank values (generally about 0.2-0.3 $\mu g/m^3$) were subtracted from the CSN data.

The equations used to calculate RCFM and light extinction are as follows:

Equation 6-1: Calculation of RCFM

$$RCFM = 1.37Mass_{SO4} + 1.29Mass_{NO3} + Mass_{EC} + 1.8Mass_{OC} + Mass_{Soil} + 1.8Mass_{Cl}$$

Equation 6-2: Calculation of extinction from Ammonium Sulfate

$$Ext_{NH4SO4} = 3f(RH) * 1.37Mass_{SO4}\ (assume\ SO4\ fully\ neutralized\ by\ NH4)$$

Equation 6-3: Calculation of extinction from Ammonium Nitrate

$$Ext_{NH4NO3} = 3f(RH) * 1.2Mass_{NO3}\ (assume\ NO3\ fully\ neutralized\ by\ NH4)$$

Equation 6-4: Calculation of extinction from Elemental Carbon

$$Ext_{LAC} = 10Mass_{EC}$$

Equation 6-5: Calculation of extinction from POM

$$Ext_{POM} = 4 * 1.8 Mass_{OC} \; (assume \; Mass_{POM} = 1.8 \; Mass_{OC})$$

Equation 6-6: Calculation of extinction from Soil

$$Ext_{SOIL} = Mass_{SOIL}$$

Equation 6-7: Calculation of extinction from Sea Salt

$$Ext_{Salt} = 1.7 f(RH) * 1.8 Mass_{Cl}$$

Equation 6-8: Calculation of extinction from Coarse PM

$$Ext_{PM10} = 0.6 Mass_{PM10}$$

We found that sulfate was underpredicted consistently throughout the year by 1 μg/m^3 with slightly higher over-prediction during summer (Figure 6-29). Nitrate was over-predicted by small margins during the winter months and very slightly under-predicted during summer (Figure 6-30). Ammonium was under-predicted throughout most of the year, although there was over-prediction during fall (Figure 6-31). Elemental carbon was over-predicted at all times of the year compared to TOR observations, though the over-prediction was less during the summer than other times of year (Figure 6-32). Organic carbon was over-predicted in the winter and under predicted in the summer and neither during the shoulder months compared to TOR observations (Figure 6-33). Soil was over-predicted throughout the year with the least amount of over-prediction during the spring (Figure 6-34). Elemental carbon was over-predicted even more when compared to TOT observations than TOR (Figure 6-35). Organic carbon was over-predicted less in the winter and under-predicted more in the summer compared to TOT observations than TOR (Figure 6-36). The pattern of over and under-prediction more closely resembles that of organic carbon since the magnitude of organic carbon is much higher than that of elemental carbon (Figure 6-37).

Figure 6-29: SO_4 concentration (observed, CSN and IMPROVE, vs. predicted)

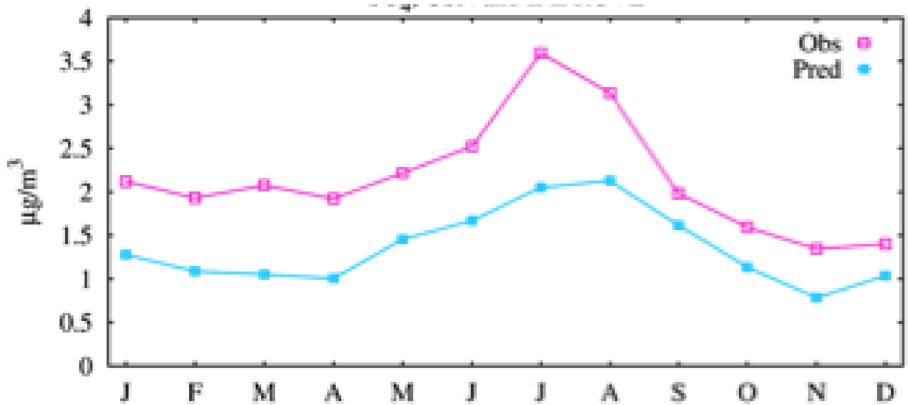


Figure 6-30: NO_3 concentration (observed, CSN and IMPROVE, vs. predicted)

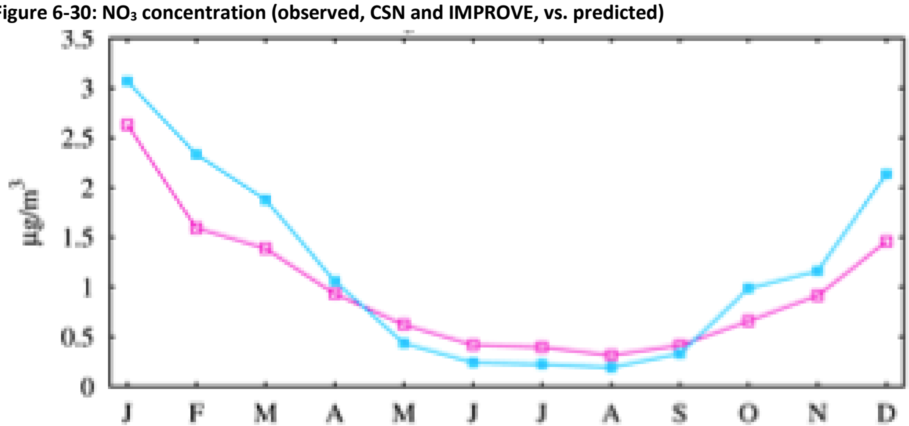


Figure 6-31: NH_4 concentration (observed, CSN only, vs. predicted)

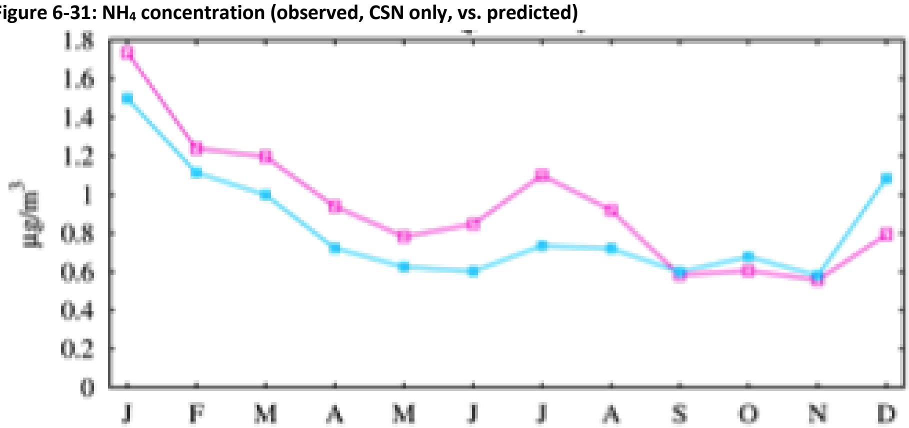


Figure 6-32: EC (TOR) concentration (observed, CSN and IMPROVE, vs. predicted)

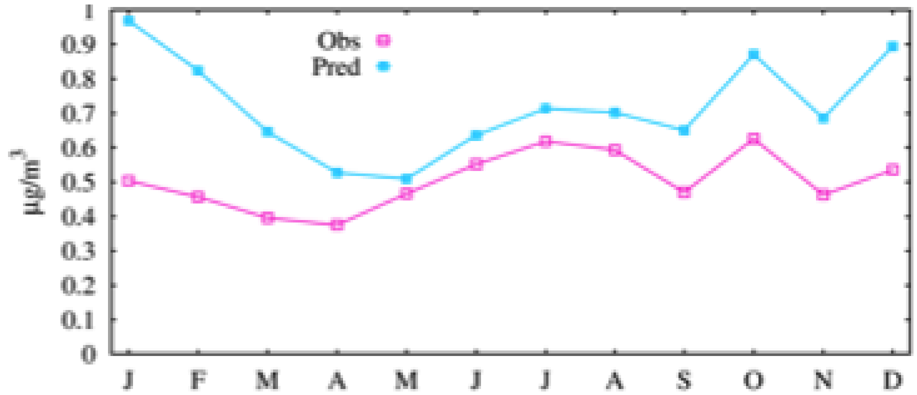


Figure 6-33: OC (TOR) concentration (observed, CSN and IMPROVE, vs. predicted)

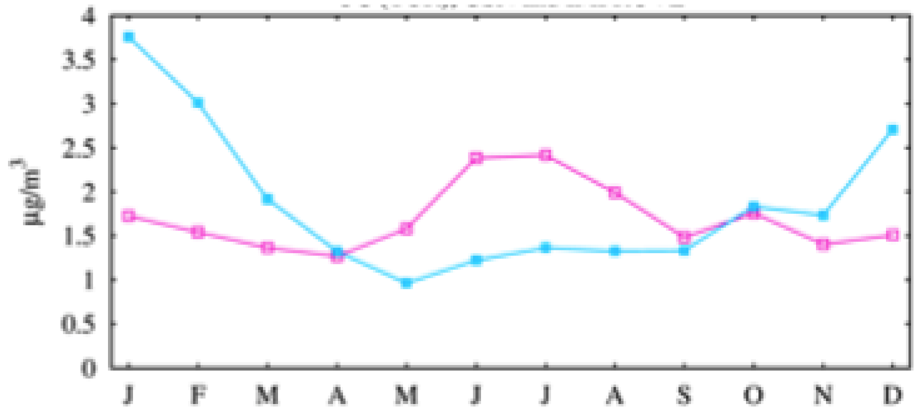


Figure 6-34: Soil concentration (observed, CSN and IMPROVE, vs. predicted)

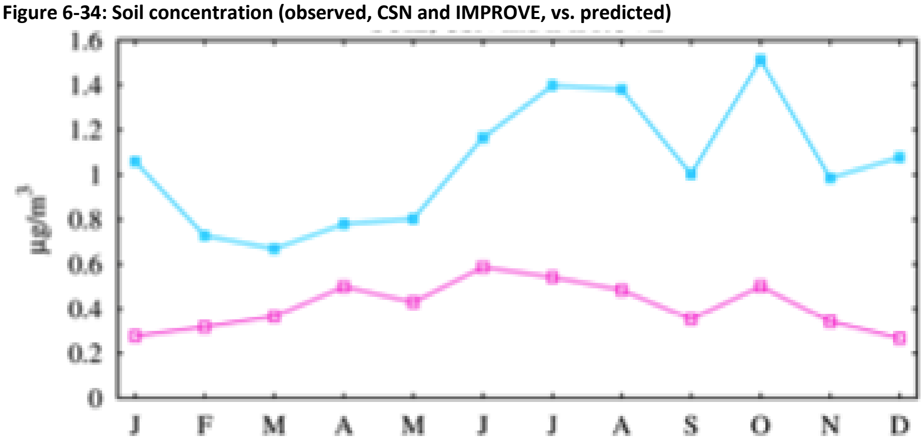


Figure 6-35: EC (TOR & TOT) concentration (observed, CSN only, vs. predicted)

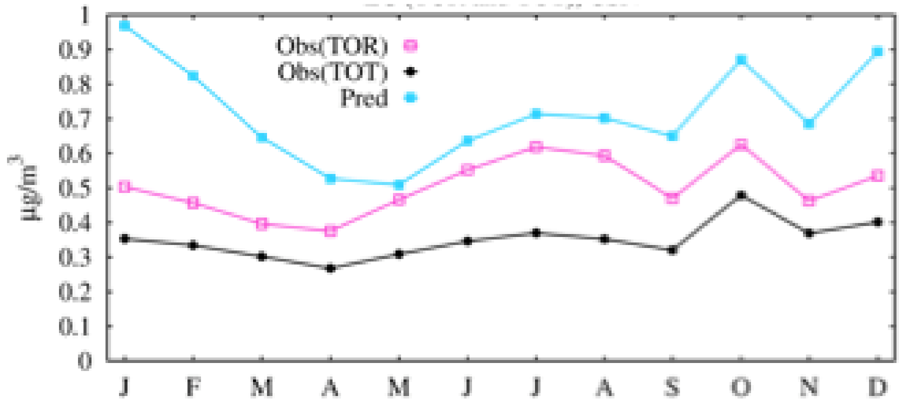


Figure 6-36: OC (TOR & TOT) concentration (observed, CSN only, vs. predicted)

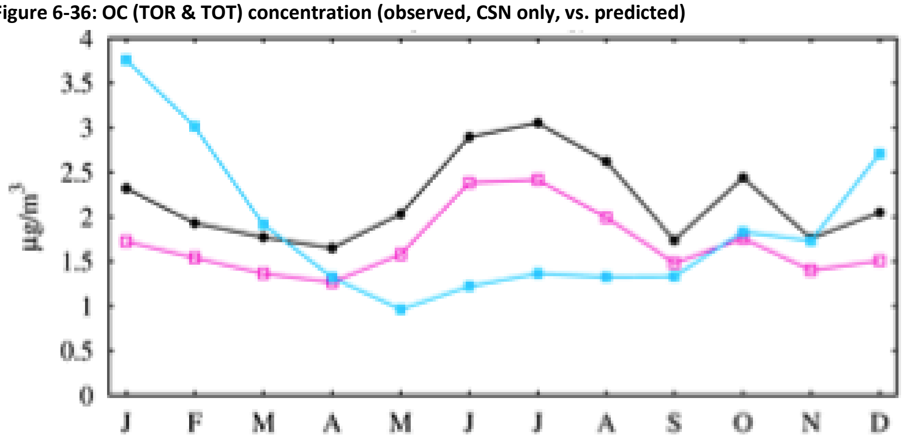
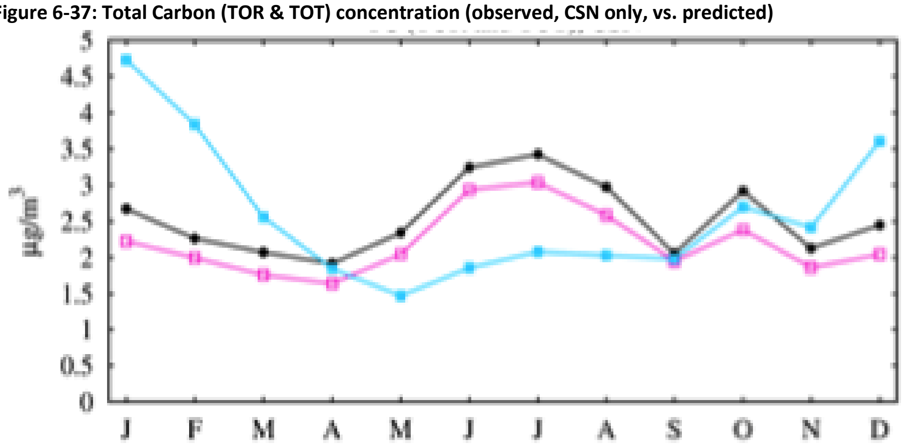


Figure 6-37: Total Carbon (TOR & TOT) concentration (observed, CSN only, vs. predicted)



Geographically MFB and MFE for SO_4 had the highest magnitude in northern New England (Figure 6-38 and Figure 6-39, respectively). MFB for NO_3 was lowest in magnitude in northern New England and biased quite low along the I-95 corridor, whereas MFE for NO_3 was quite high throughout the region (Figure 6-40 and Figure 6-41, respectively). MFB for NH_4 often tended to not be too high or low throughout the region and MFE was higher in New England than in the Mid-Atlantic (Figure 6-42 and Figure 6-43, respectively). MFB was high throughout the region, with the highest levels along the inner corridor and MFE was higher in New England than in the Mid-Atlantic (Figure 6-44 and Figure 6-45, respectively). MFB was high in along the inner corridor and sometimes quite low at more rural sites, and MFE was high throughout the MANE-VU region (Figure 6-46 and Figure 6-47, respectively). MFB and MFE were quite high for soil throughout MANE-VU (Figure 6-48 and Figure 6-49, respectively).

Figure 6-38: MFB SO_4, 2011 (only monitors with ≥10 days of data are shown)

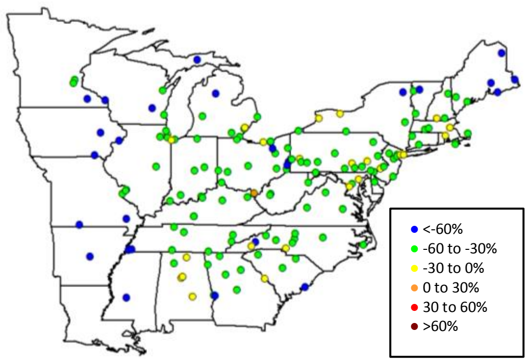


Figure 6-39: MFE SO_4, 2011 (only monitors with ≥10 days of data are shown)

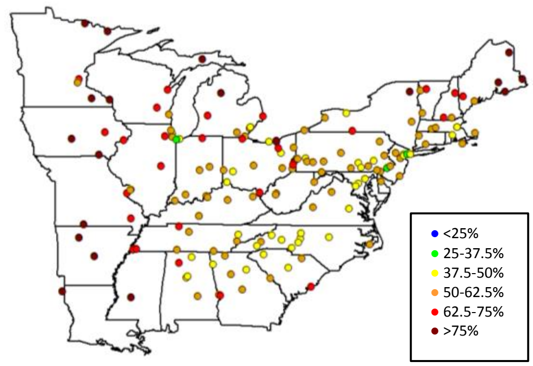


Figure 6-40: MFB NO_3, 2011 (only monitors with ≥10 days of data are shown)

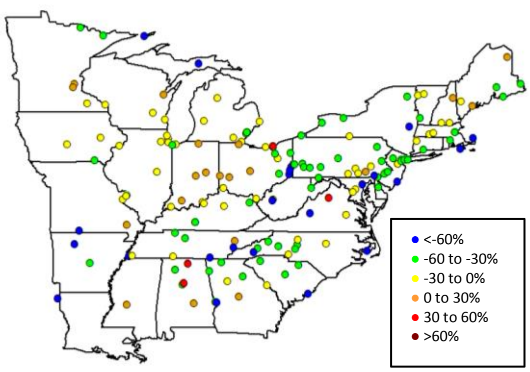


Figure 6-41: MFE NO_3, 2011 (only monitors with ≥10 days of data are shown)

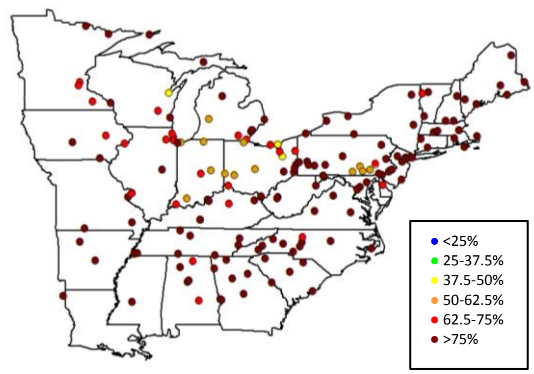


Figure 6-42: MFB NH_4, 2011 (only monitors with ≥10 days of data are shown)

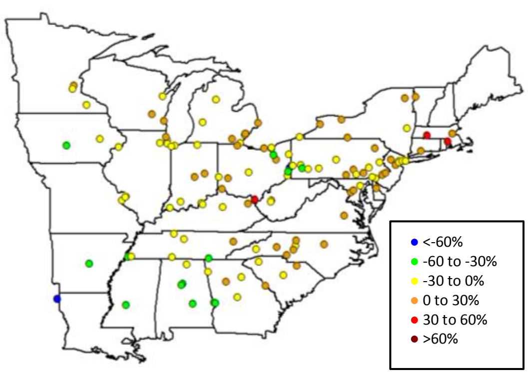


Figure 6-43: MFE NH_4, 2011 (only monitors with ≥10 days of data are shown)

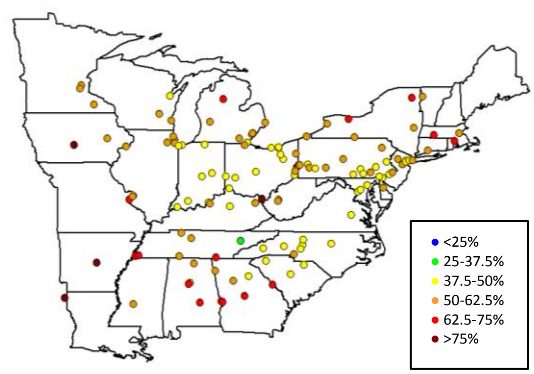


Figure 6-44: MFB EC, 2011 (only monitors with ≥10 days of data are shown)

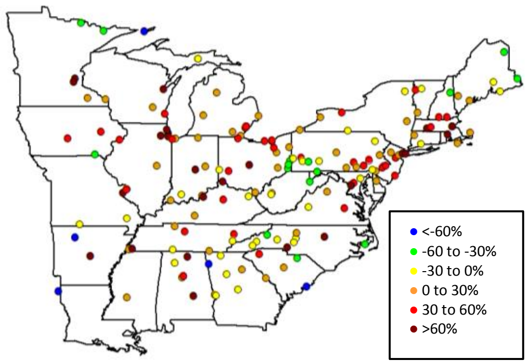


Figure 6-45: MFE EC, 2011 (only monitors with ≥10 days of data are shown)

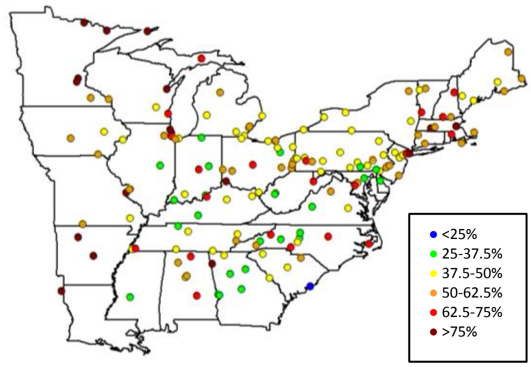


Figure 6-46: MFB OC, 2011 (only monitors with ≥10 days of data are shown)

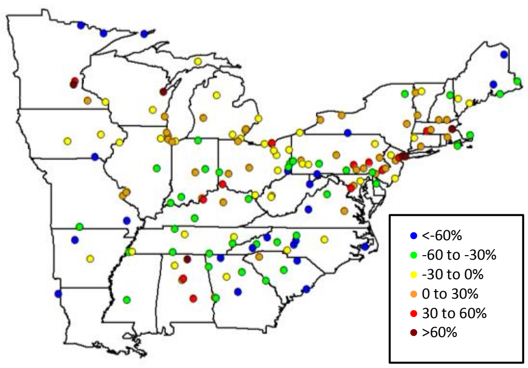


Figure 6-47: MFE OC, 2011 (only monitors with ≥10 days of data are shown)

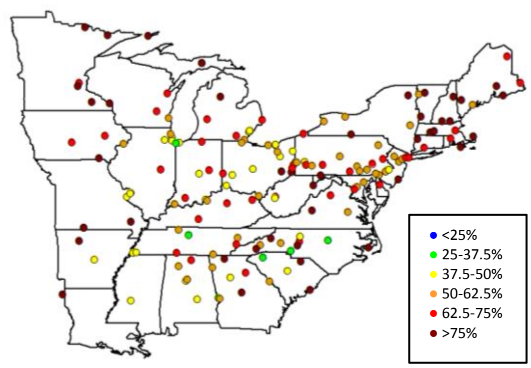


Figure 6-48: MFB Soil, 2011 (only monitors with ≥10 days of data are shown)

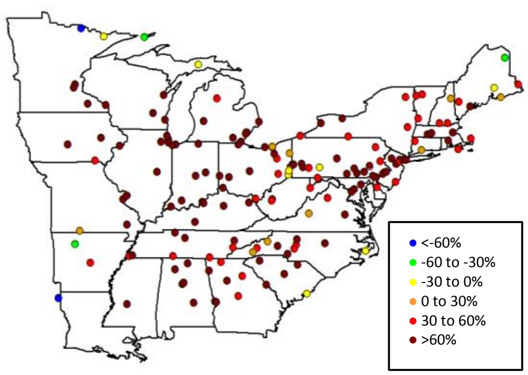
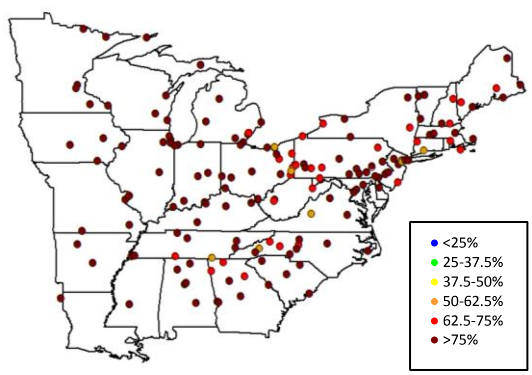
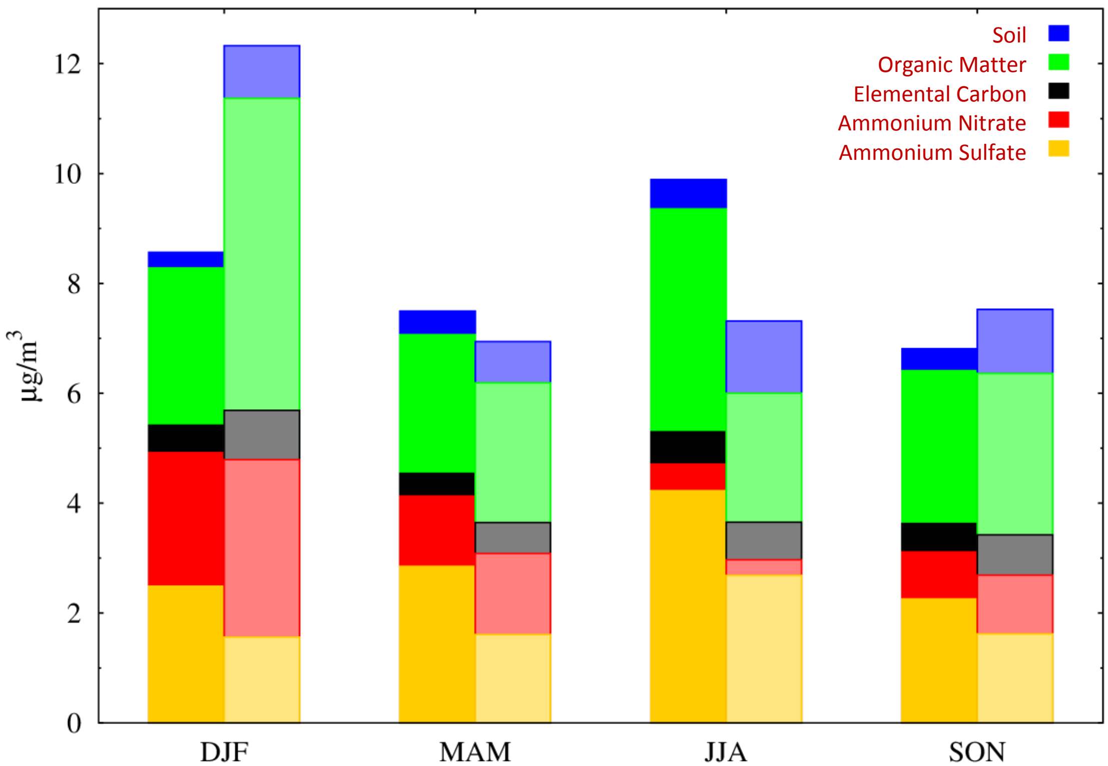


Figure 6-49: MFE Soil, 2011 (only monitors with ≥10 days of data are shown)



When the various species are reconstituted as shown in Equation 6-1 over-prediction by about 3 $\mu g/m^3$ in the winter months, under-prediction by about 2 $\mu g/m^3$ in the summer months, and fairly close results during the shoulder seasons (Figure 6-50) are seen.

Figure 6-50: 2011 RCFM by season (observed values darker shading, predicted values lighter shading)



Summary

Various model evaluation statistics are presented here for a variety of gaseous and aerosol species in addition to O_3. In general, the CMAQ results were best for daily maximum O_3 and daily average $PM_{2.5}$ and SO_4 mass. Other species vary tremendously over the course of a day, or from day to day, and small model over- or under-prediction at low concentrations can lead to large biases on a composite basis. We demonstrate that the model performs reasonably well over the diurnal cycle and not just in terms of daily maximum or average values. Also, we demonstrate that the model can reliably reproduce concentrations above the ground level. The analyses shown in this section demonstrates that OTC's 2011 based modeling platform can adequately reproduce air pollution produced through photochemical processes to a degree that will allow states to demonstrate future air pollution levels for ozone, $PM_{2.5}$ and regional haze SIPs.

References

Brewer, P, Tanner, J, Engelbrecht, J, Morris, R and Reynolds, S 2007, 'Carbon Analyses in the VISTAS Region for $PM_{2.5}$ and Haze', accessed August 16, 2006, from <http://www.marama.org/calendar/events/presentations/2007_07Science/BrewerMVScience07.pdf>.

Section 7. Evaluation of 4km Nested Gridding

Overview

Figure 7-1: OTC 12km modeling domain and 4km nested grid

In previous SIP modeling using the 2007 OTC modeling platform we found that error increased towards coastal errors. In Section 6 ozone predictions were less accurate, particularly in terms of MFB, but also MFE and MAGE, at many of the coastal monitors (see Figure 6-7 through Figure 6-12). In particular, very high ozone in Long Island sound showed little response to emission reductions. It was expected that due to the intricate meteorology, often due to land-water interface issues, many of the problematic monitors in the OTR that could be improved through better representation of the conditions at those monitors.

One technique to improve model performance in areas with complex meteorology is to conduct photochemical modeling with a finer resolution nested grid in the areas needing improvement. A finer grid allows emissions, particularly from point sources, to be located more precisely. It also allows the greater complexities of meteorology to play a role in modeling. The downside of using a finer grid is the increase in model run time, necessary computing power, and staff resources. Previous research has shown that as the resolution improves from 12 km marginal improvements in results decrease (Thompson and Selin 2012). OTC examined the impact of using a finer, 4km grid in the core of the OTR, as shown in Figure 6-7 through Figure 6-12 in order to examine the potential benefits of refined grid modeling.

Meteorology Processing

NYSDEC ran WRF v. 3.6.1 using the same process and parameters as EPA used in developing the 12km meteorological data.

We relied on NAM from NCEP in 12km grid spacing to drive the WRF model. The NAM archive was missing during early March of 2011 so only the months of January, February, and April until December were processed. This was not expected to introduce major errors given that March is not typically associated with ozone production in the OTR, nor is it during the required ozone monitoring season. NLCD 2006 land use data was employed in this exercise, as was GHRSST for sea surface temperature. GHRSST has a daily resolution of 0.01 x 0.01 degree (about 1km).

Emission Inventory

We relied on EPA's modeling inventory "eh" that was based on NEI v. 2 for emissions. At the time that SMOKE processing occurred the Alpha 2 inventory was not available, but since the Alpha 2 inventory is largely uses "eh" directly in the base year this was not seen as introducing any major inaccuracies. The differences of note between the Alpha 2 inventory and the inventory used in this exercise is that CEMS data would have been directly used rather than the ERTAC smoothed EGU data. MOVES and biogenic were not processed using SMOKE at the 4km resolution. If MOVES emission factors were used in 4km SMOKE processing the results would resolve better in particular for mobile emissions along the I-95 corridor. Biogenic emissions were re-gridded from 12km to 4km instead of being processed at 4km resolution.

Results

NMB results from the 12km in smaller domain are biased negatively and the 4km gridded results are a marked improvement throughout the entirety of the smaller domain (Figure 7-2 and Figure 7-3). NME on the other hand does not improve throughout the entirety of the smaller domain. NME results do improve along the I-95 corridor but there are increases in NME in the western part of the smaller domain, in particular in the Pittsburgh areas (Figure 7-4 and Figure 7-5).

Figure 7-2: Ozone NMB, July 2011 4 km grid

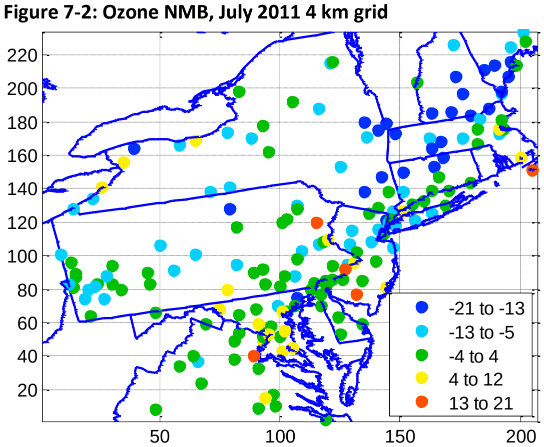


Figure 7-3: Ozone NMB, July 2011 12 km grid

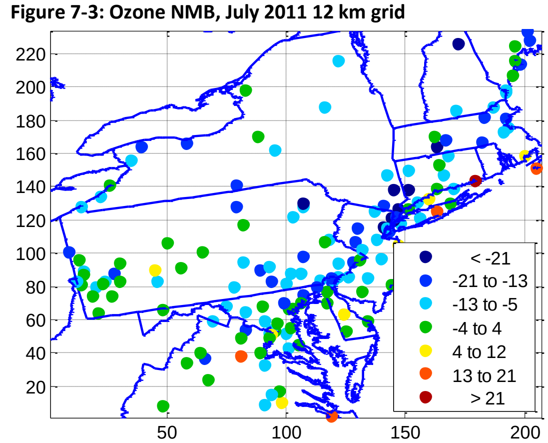


Figure 7-4: Ozone NME, July 2011 4 km grid

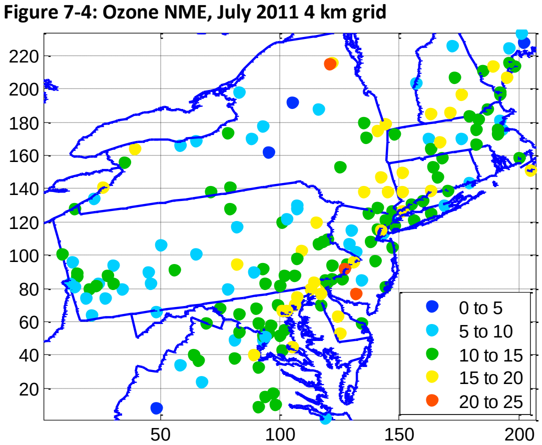
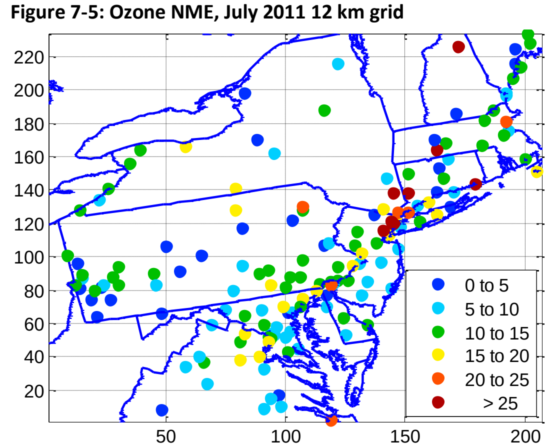


Figure 7-5: Ozone NME, July 2011 12 km grid



We then took a look diurnally for 10 key monitors in the inner corridor (3 in Connecticut, 5 in New York, and 1 each in Maryland and New Jersey). There are clear improvements with predicting average monthly and peak ozone at all ten monitors in the month of June though there are instances such as with monitor 361030002 where the peak is pushed back in the day from where it is observed (Figure 7-6 through Figure 7-15).

Figure 7-6: Observed and modeled (4km/12km grids) ozone (ppb) for June 2011 at monitor #090010017 (thick line: monthly avg., thin line: max day)

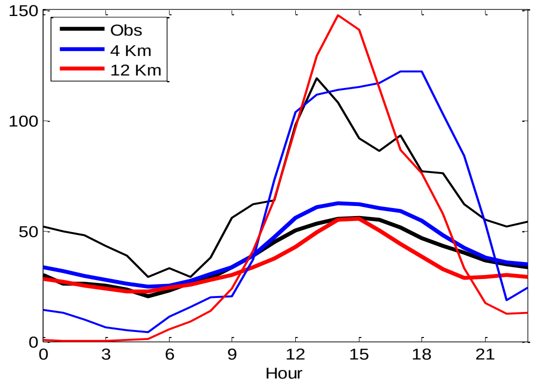


Figure 7-7: Observed and modeled (4km/12km grids) ozone (ppb) for June 2011 at monitor #090013007 (thick line: monthly avg., thin line: max day)

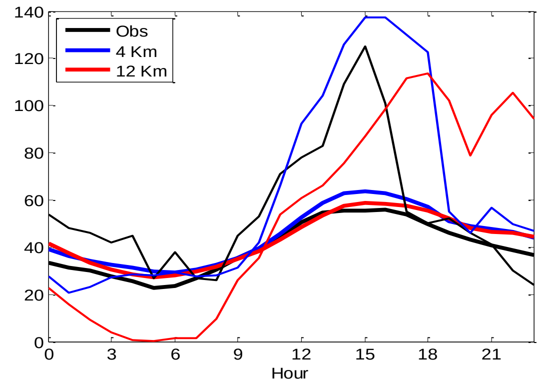


Figure 7-8: Observed and modeled (4km/12km grids) ozone (ppb) for June 2011 at monitor #090019003 (thick line: monthly avg., thin line: max day)

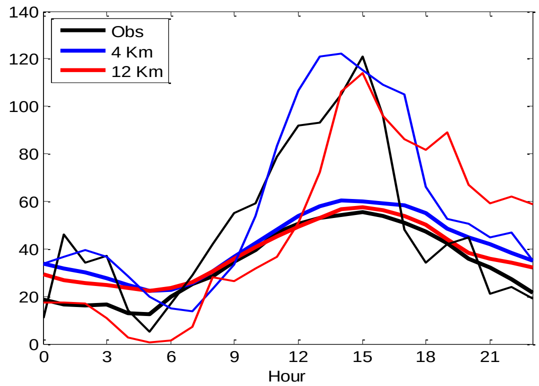


Figure 7-9: Observed and modeled (4km/12km grids) ozone (ppb for June 2011 at monitor #240251001 (thick line: monthly avg., thin line: max day)

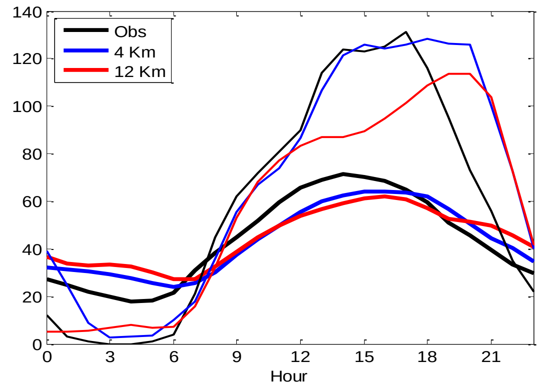


Figure 7-10: Observed and modeled (4km/12km grids) ozone (ppb for June 2011 at monitor #34015002 (thick line: monthly avg., thin line: max day)

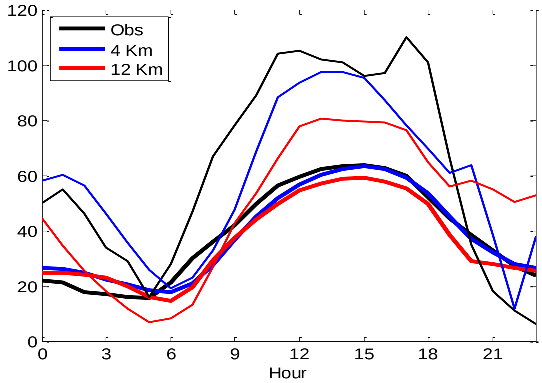


Figure 7-11: Observed and modeled (4km/12km grids) ozone (ppb) for June 2011 at monitor #360050133 (thick line: monthly avg., thin line: max day)

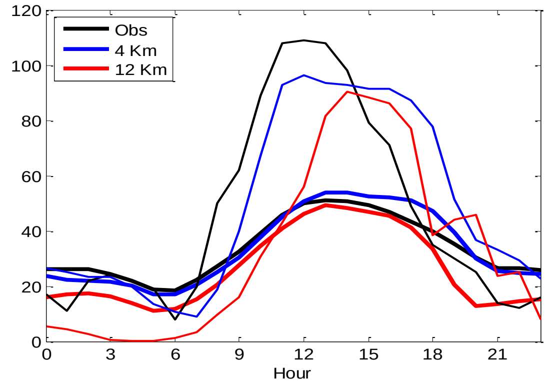


Figure 7-12: Observed and modeled (4km/12km grids) ozone (ppb) for June 2011 at monitor #360810124 (thick line: monthly avg., thin line: max day)

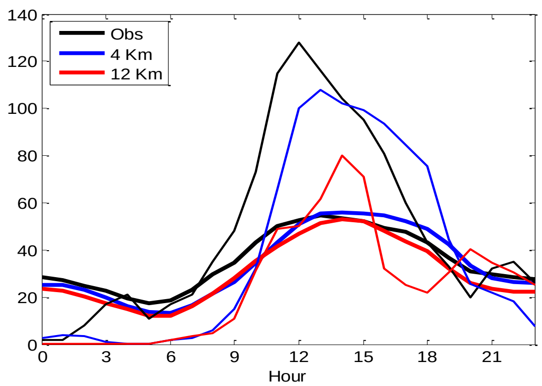


Figure 7-13: Observed and modeled (4km/12km grids) ozone (ppb) for June 2011 at monitor #360850067 (thick line: monthly avg., thin line: max day)

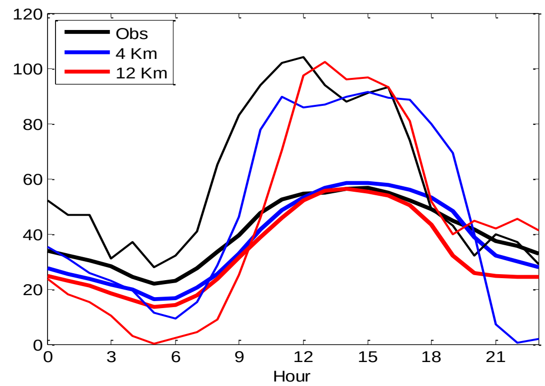


Figure 7-14: Observed and modeled (4km/12km grids) ozone (ppb) for June 2011 at monitor #361030002 (thick line: monthly avg., thin line: max day)

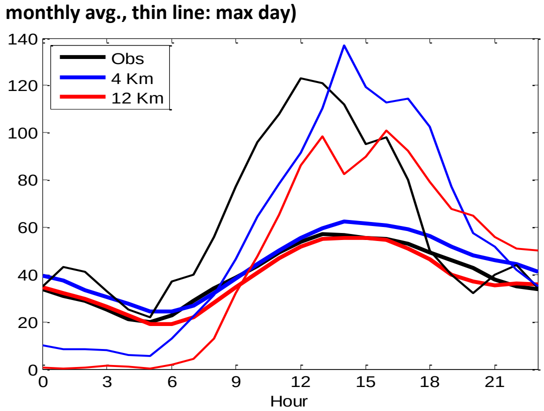
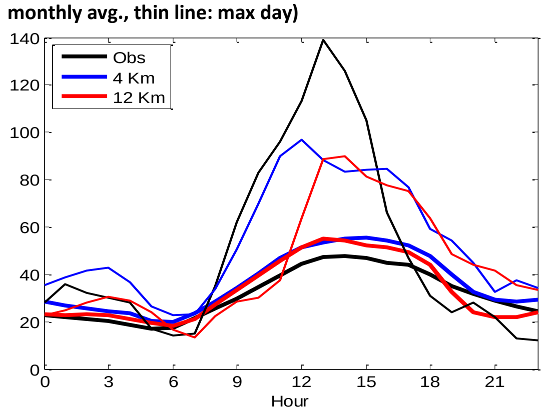


Figure 7-15: Observed and modeled (4km/12km grids) ozone (ppb) for June 2011 at monitor #361192004 (thick line: monthly avg., thin line: max day)



The same pattern holds for July, excepting monitor 240251001, which is underpredicted slightly more on the peak day (Figure 7-16 through Figure 7-25).

Figure 7-16: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #090010017 (thick line: monthly avg., thin line: max day)

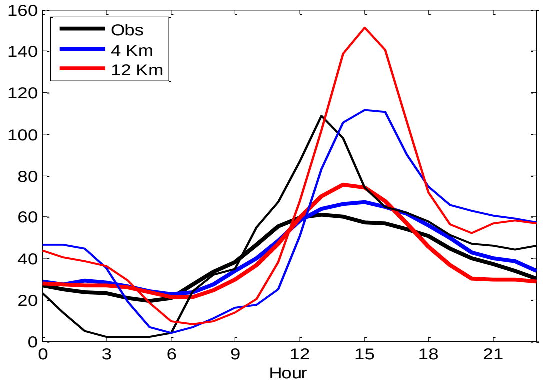


Figure 7-17: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #090013007 (thick line: monthly avg., thin line: max day)

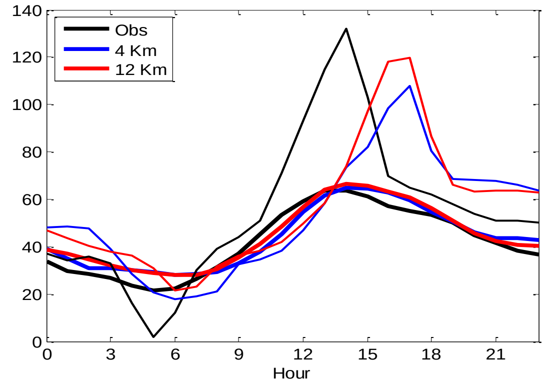


Figure 7-18: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #090019003 (thick line: monthly avg., thin line: max day)

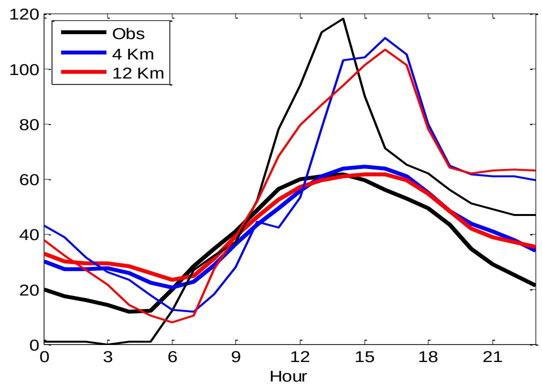


Figure 7-19: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #240251001 (thick line: monthly avg., thin line: max day)

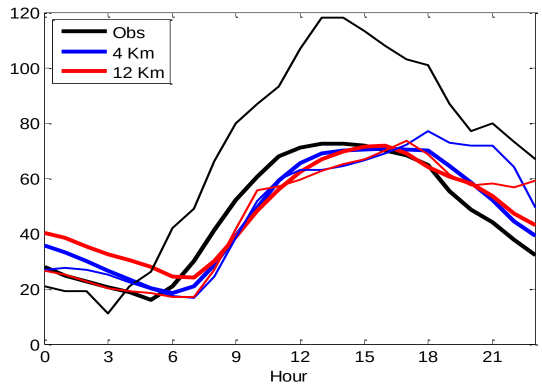


Figure 7-20: Observed and modeled (4km/12km grids) ozone (ppb for July 2011 at monitor #34015002 (thick line: monthly avg., thin line: max day)

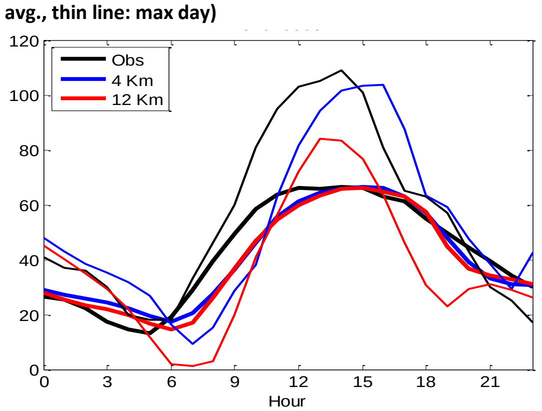


Figure 7-21: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #360050133 (thick line: monthly avg., thin line: max day)

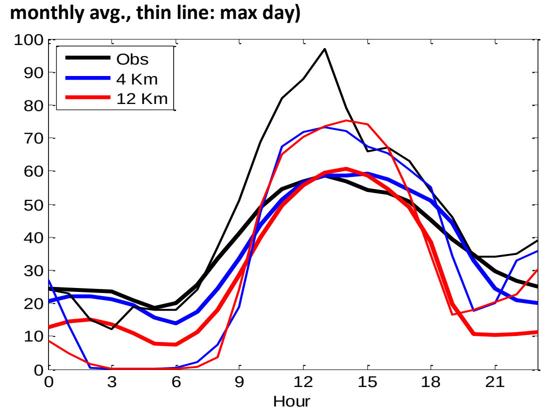


Figure 7-22: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #360810124 (thick line: monthly avg., thin line: max day)

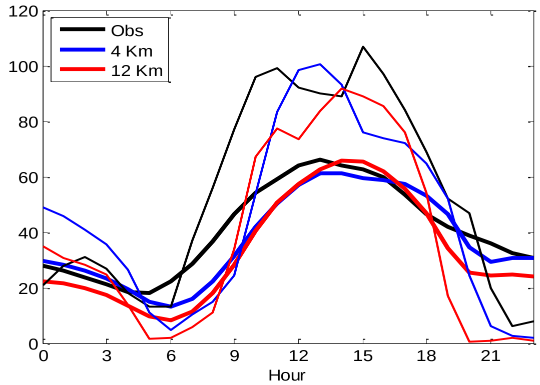


Figure 7-23: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #360850067 (thick line: monthly avg., thin line: max day)

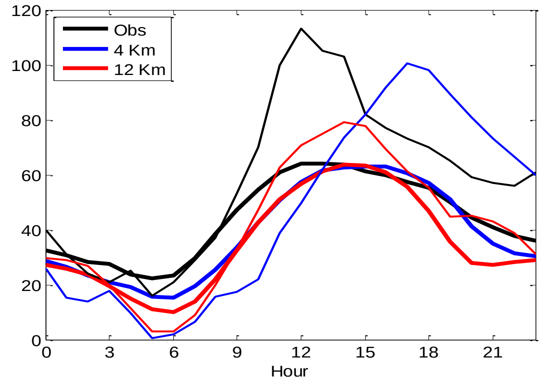


Figure 7-24: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #361030002 (thick line: monthly avg., thin line: max day)

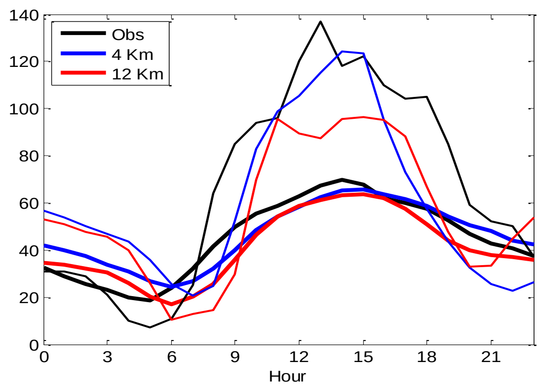
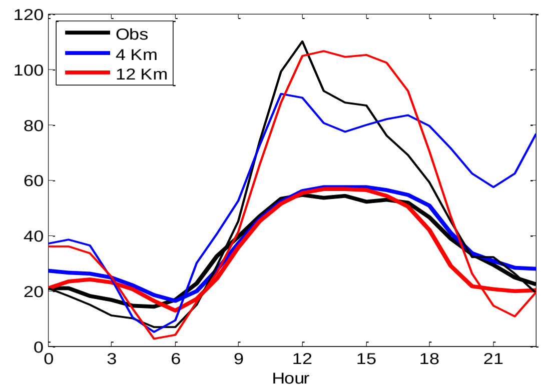


Figure 7-25: Observed and modeled (4km/12km grids) ozone (ppb) for July 2011 at monitor #361192004 (thick line: monthly avg., thin line: max day)



The same pattern also holds for August, with monitors 090019003 and 240251001 having peak concentrations predicted later in the day than observations on the peak day (Figure 7-26 through Figure 7-35).

Figure 7-26: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #090010017 (thick line: monthly avg., thin line: max day)

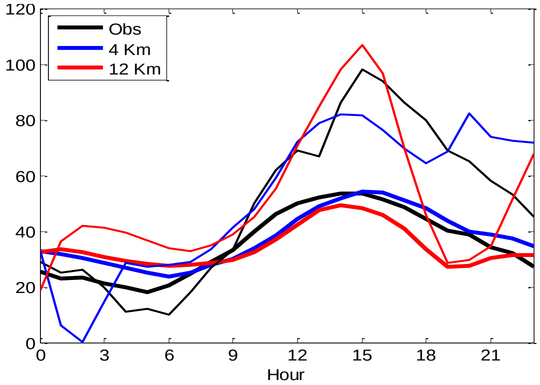


Figure 7-27: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #090013007 (thick line: monthly avg., thin line: max day)

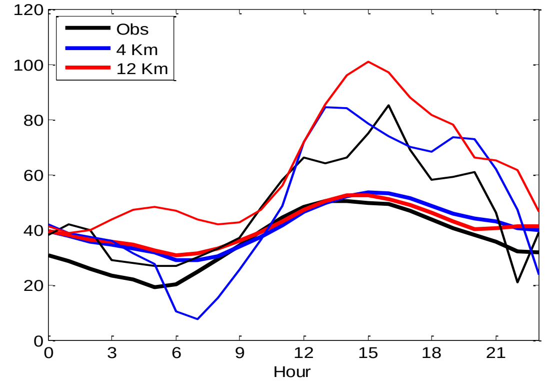


Figure 7-28: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #090019003 (thick line: monthly avg., thin line: max day)

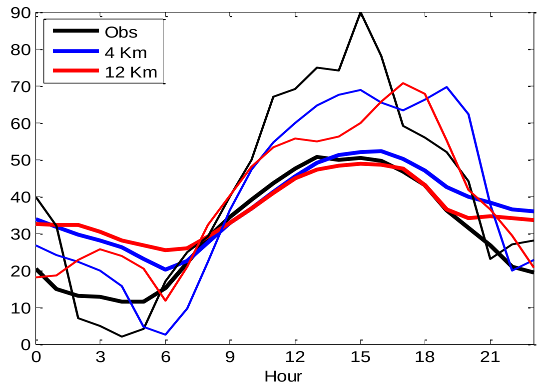


Figure 7-29: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #240251001 (thick line: monthly avg., thin line: max day)

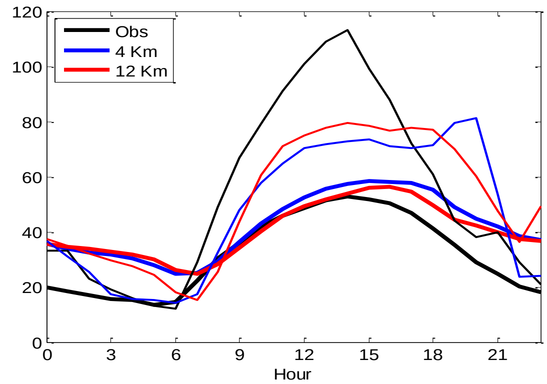


Figure 7-30: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #34015002 (thick line: monthly avg., thin line: max day)

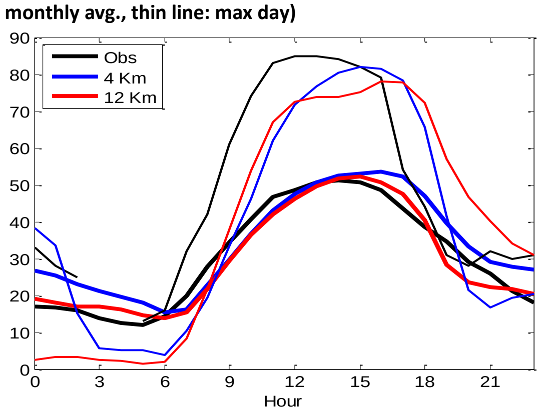


Figure 7-31: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #360050133 (thick line: monthly avg., thin line: max day)

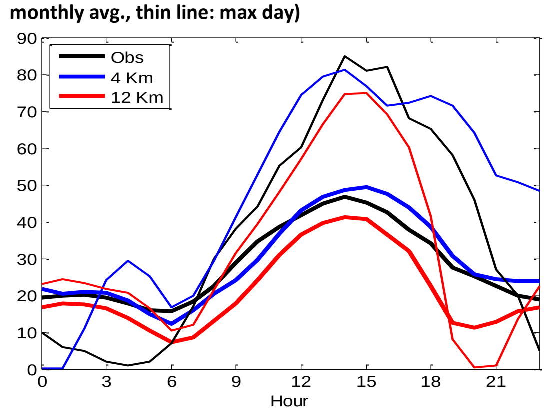


Figure 7-32: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #360810124 (thick line: monthly avg., thin line: max day)

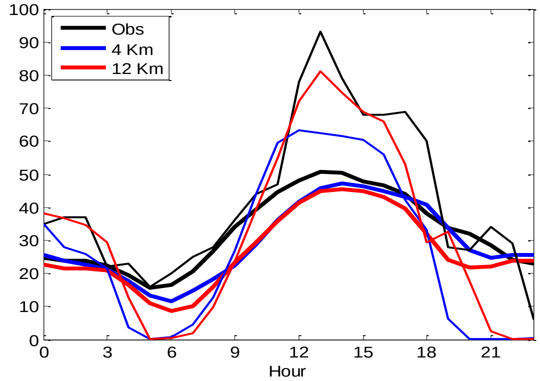


Figure 7-33: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #360850067 (thick line: monthly avg., thin line: max day)

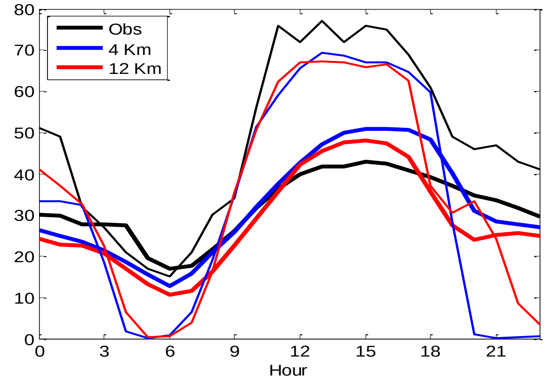


Figure 7-34: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #361030002 (thick line: monthly avg., thin line: max day)

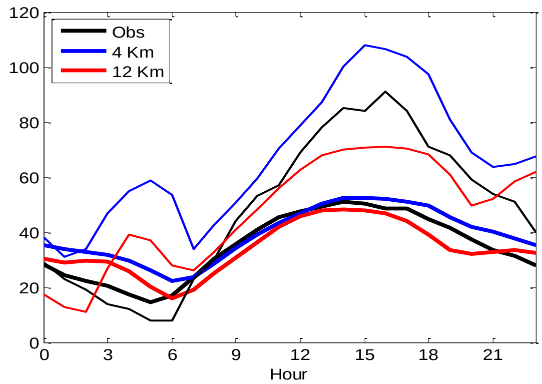
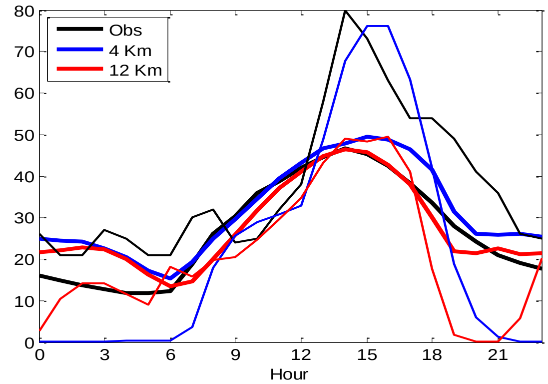


Figure 7-35: Observed and modeled (4km/12km grids) ozone (ppb) for August 2011 at monitor #361192004 (thick line: monthly avg., thin line: max day)



Conclusion

Use of a 4km nested grid in the OTR does lead to improvements in modeled performance, in particular when looking at predictions during peak days at coastal monitors. When looking at the entirety of the smaller domain there are even disbenefits in terms of model performance in the western portion of the domain. Processing time using the 4km domain described in this section is increased six fold which results in a 7-month CMAQ run that takes over a month to complete. If further work is conducted using 4km modeling that relies on use of OTC inventory, to both conserve computing resources and improve model performance, it is recommended that only the inner corridor be modeled with the finer grid.

References

Thompson, TM and Selin, NE 2012, 'Influence of air quality model resolution on uncertainty associated with health impacts', *Atmospheric Chemistry and Physics*, vol. 12, no. 20, pp. 9753–9762.

Section 8. Emissions Inventories and Processing for 2017/2018/2028 12 km Future Year Simulation

Emission Inventory Sectors

All the inventory sectors are the same as in the base year and their brief descriptions can be found in Section 4.

US Future Year Emissions Inventories

The OTR states, through MANE-VU and MARAMA, developed the majority of the 2017 Beta/Beta 2, 2018 Alpha/Alpha 2, and 2028 Alpha/Alpha 2 inventories based on 2011 inventories as discussed earlier. MARAMA, through a contractor SRA, in consultation with the states, developed the necessary growth and control factors to project the 2011 inventory to a future year and applied them to develop both 2018 and 2028 inventories. These growth factors were used for all the jurisdictions in the OTC, in addition to West Virginia, North Carolina, and the rest of Virginia (McDill, McCusker and Sabo 2015). Growth rates for the states in LADCO were obtained from LADCO and we relied on default assumptions from EPA for all other states (McDill, McCusker and Sabo 2015). The same process was undertaken for the Beta/Beta 2 inventory projections to 2017 (McDill, McCusker and Sabo 2016). It should be noted that emissions for mobile sources and the electric energy generating units (EGUs) were not part of this effort.

EGU emissions were processed using the ERTAC EGU tool v. 1.01 and were post-processed using ERTAC to SMOKE version 1.02. The projections for the Alpha and Alpha 2 inventories were based on growth assumptions from the 2014 AEO and the collection of inputs were termed ERTAC EGU v. 2.3 (MARAMA n.d.; US Energy Information Administration April 2014). The projections for the Beta inventory were upgraded to ERTAC v. 2.5 and to ERTAC v. 2.5L2 for the Beta 2 inventory , which both were processed using the same versions of the code and were based on growth assumptions from the 2015 AEO (‘Documentation of ERTAC EGU CONUS 2.5’ n.d.; US Energy Information Administration April 2015).

EPA provided emission factors developed using MOVES2014a for both 2017 and 2025, as well as other input files needed to run SMOKE-MOVES such as vehicle activity and vehicle population. NYSDEC and NJDEP processed the emission factors for 2017 and 2025, respectively, using SMOKE-MOVES. The MANE-VU Technical Support Committee had determined that using 2025 as a surrogate for 2028 mobile emissions would be a conservative estimate and thus appropriate.

Canadian Emissions

Canadian emissions were estimated in the future years by taking the ratio of US domain 2011 emissions to 2017, 2018, and 2028 emissions and applying that ratio to the 2010 Canadian emissions used in the base year (McDill, McCusker and Sabo 2015, 2016).

Application of SMOKE

The 2017 and 2028 inventories were processed by NYSDEC using a template similar to that used for processing 2011 base year emissions for the 12 km domain. In particular, all gridding and speciation profiles, cross-reference files, and temporal allocation profiles used in the 2011 processing were also used for future year processing, excepting the hourly temporal files for ERTAC EGUs for 2017 and 2028 and small EGUs for 2017. A full list of files are in Appendix A.

Emissions for all source categories were processed by SMOKE version 3.7 for 2017 Beta and Beta 2 and SMOKE version 3.6 for Alpha and Alpha 2. The SMOKE programs downloaded from CMAS website have been compiled for LINUX system and ready for use.

SMOKE Processed Emission Results

In order to quality assure the outputs from SMOKE were properly distributed geographically and develop a better understanding of the geographical and temporalization of emissions maps of emissions in each grid cell were produced. These maps were produced from the Alpha 2 inventory. We looked at projected daily emissions on a typical summer day during 2011 (June 24) and projected daily emissions during a 2011 ozone event (July 22). We looked at NO_X and SO_2 gridded emissions. We chose not to include VOCs since biogenic emissions are held constant and overwhelm regional anthropogenic VOC emissions. Urban areas, interstate highways in rural areas, and shipping lanes are clearly distinguishable in the maps of NO_X emissions (Figure 8-1). There are minor differences at this scale on a peak day where one can notice increases in some grid cells during the ozone event (Figure 8-2). One can see the importance of point sources in terms of SO_2 emissions and there were increases at some grid cells, particularly in the Long Island Sound, on the New England coast and some Pennsylvanian EGUs, during the projected ozone event (Figure 8-3 and Figure 8-4).

When one compares the projections to the baseline found in Section 4 one notices that on both the typical summer day and the ozone conducive day that emissions of NO_X decrease regionally and that a fair number of SO_2 point sources disappear in the projection.

Additionally, summary tables of emissions by state, sector, and pollutant were outputted from SMOKE processing. These results are aggregated for the 2018 Alpha 2 inventory in Table 8-1, the 2028 Alpha 2 inventory in Table 8-2, and the 2017 Beta 2 inventory in Table 8-3.

Figure 8-1: MARAMA 2018 Projected Alpha 2 NO_X SMOKE Gridded Emissions (June 24)

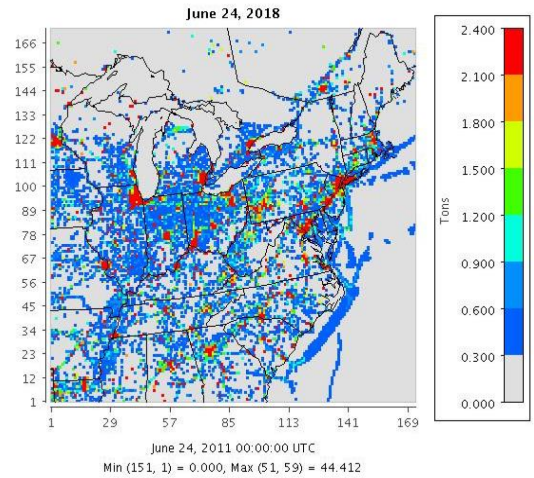


Figure 8-2: MARAMA 2018 Projected Alpha 2 NO_X SMOKE Gridded Emissions (July 22)

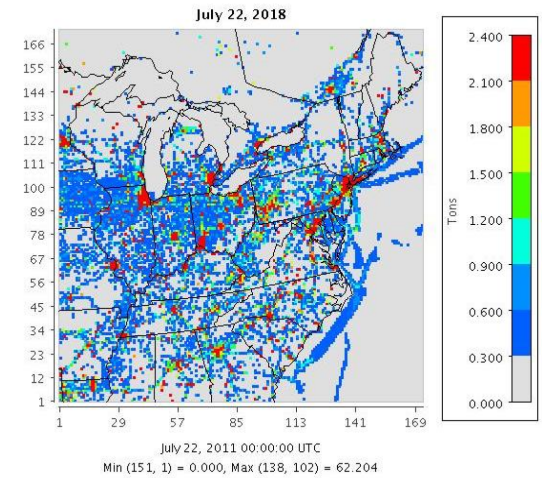


Figure 8-3: MARAMA 2018 Projected Alpha 2 SO_2 SMOKE Gridded Emissions (June 24)

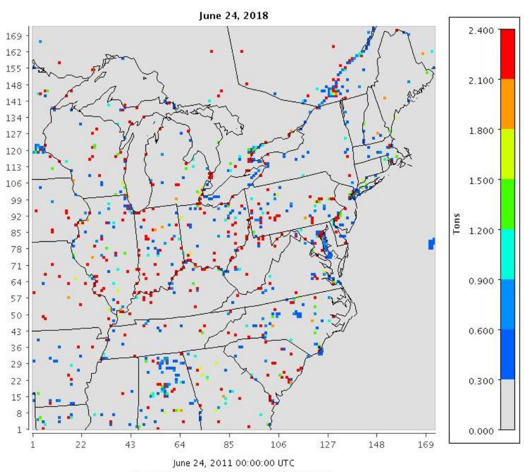


Figure 8-4: MARAMA 2018 Projected Alpha 2 SO_2 SMOKE Gridded Emissions (July 22)

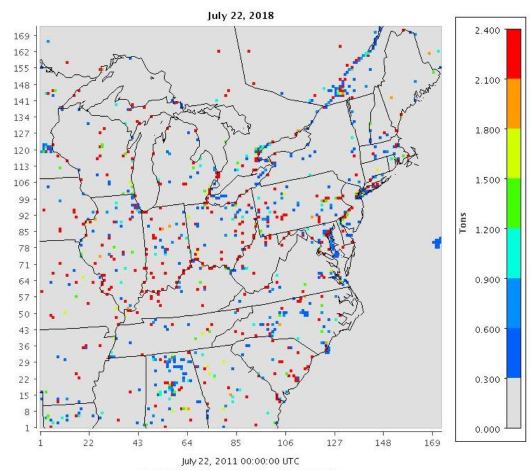


Table 8-1: 2018 base case Alpha 2 emissions (tons) by pollutant and RPO for aggregated sectors from SMOKE processed emission reports

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
				NO_X				
MANE-VU	141,249	161,900	272,855	345,812	195,191	89,499	1,018	**1,207,525**
LADCO	294,427	280,880	342,483	527,635	181,632	82,212	12,458	**1,721,726**
SESARM	322,839	286,058	520,988	577,071	109,198	194,360	77,295	**2,087,808**
CENSARA	403,929	336,448	397,841	574,792	143,136	663,430	116,659	**2,636,234**
CANADA		143,534	189,400	124,557	59,134			**516,625**
US EEZ			1,016,290					**1,016,290**
INTERNATIONAL			2,380,100					**2,380,100**
NO_X TOTAL	1,162,444	1,208,820	5,119,956	2,149,867	688,291	1,029,500	207,430	**11,566,309**
				VOC				

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
MANE-VU	2,266	55,126	250,649	192,119	657,271	47,889	21,238	**1,226,558**
LADCO	8,389	167,311	316,188	273,485	756,592	55,434	227,782	**1,805,180**
SESARM	9,336	233,768	251,523	272,305	743,965	211,691	496,938	**2,219,525**
CENSARA	12,551	222,180	207,909	254,668	835,803	1,728,134	1,635,856	**4,897,101**
CANADA		193,891	123,156	60,045	532,666			**909,758**
US EEZ			41,341					**41,341**
INTERNATIONAL			95,716					**95,716**
VOC TOTAL	32,541	872,277	1,286,483	1,052,622	3,526,297	2,043,148	2,381,813	**11,195,180**
				SO_2				
MANE-VU	239,683	77,689	4,897	1,948	56,235	4,434	612	**385,498**
LADCO	555,498	251,320	945	2,272	25,869	1,605	7,039	**844,549**
SESARM	430,479	171,733	2,122	2,547	60,675	29,525	28,139	**725,219**
CENSARA	882,412	233,504	3,016	2,451	43,881	25,286	58,760	**1,249,310**
CANADA		362,365	32,651	607	36,964			**432,586**
US EEZ			113,282					**113,282**
INTERNATIONAL			1,672,100					**1,672,100**
SO_2 TOTAL	2,108,072	1,096,611	1,829,013	9,825	223,623	60,849	94,551	**5,422,544**
				$PM_{2.5}$				
MANE-VU	13,776	28,341	19,768	16,436	170,115	2,560	25,958	**276,954**
LADCO	63,283	64,553	23,575	22,557	212,405	1,417	217,292	**605,082**
SESARM	66,461	72,813	26,301	21,653	184,630	4,432	384,209	**760,499**
CENSARA	73,452	84,040	25,312	21,852	123,688	17,071	1,033,122	**1,378,538**
CANADA		25,261	13,805	5,093	105,607		323,474	**473,240**
US			27,544					**27,544**
INTERNATIONAL			207,330					**207,330**
$PM_{2.5}$ TOTAL	216,972	275,009	343,634	87,590	796,445	25,479	1,984,056	**3,729,185**
				NH_3				
MANE-VU	2,381	5,220	419	13,243	14,920	17	169,173	**205,372**
LADCO	-	8,923	571	14,136	23,519	59	692,892	**740,099**
SESARM	275	16,606	606	16,682	8,431	6	605,596	**648,202**
CENSARA	-	23,279	1,194	14,475	17,190	48	1,394,423	**1,450,609**
CANADA		5,232	203	9,641	3,091		183,853	**202,020**
US EEZ			216					**216**
INTERNATIONAL								
NH_3 TOTAL	2,656	59,260	3,208	68,176	67,152	130	3,045,936	**3,246,518**
				CO				
MANE-VU	68,463	237,066	2,550,632	2,145,813	884,490	80,265	90,739	**6,057,469**
LADCO	152,964	729,588	2,496,295	2,915,260	1,276,180	49,068	966,320	**8,585,675**
SESARM	169,605	455,526	2,310,513	3,002,247	1,023,682	164,784	2,814,505	**9,940,862**
CENSARA	200,347	398,047	1,947,730	2,853,610	787,726	502,020	6,907,096	**13,596,576**
CANADA		568,160	2,003,059	1,300,915	648,333			**4,520,467**
US EEZ			63,245					**63,245**
INTERNATIONAL			34,933					**34,933**
CO TOTAL	591,379	2,388,387	11,406,408	12,217,845	4,620,411	796,137	10,778,661	**42,799,227**

Table 8-2: 2028 base case Alpha 2 emissions (tons)) by pollutant and RPO for aggregated sectors from SMOKE processed emission reports

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
NO_X								
MANE-VU	157,287	156,319	205,249	213,308	192,539	109,952	1,018	**1,035,672**
LADCO	317,206	257,652	250,173	315,186	181,393	79,429	12,458	**1,413,496**
SESARM	326,962	271,453	233,634	335,672	103,453	216,288	77,295	**1,564,758**
CENSARA	448,052	342,985	444,053	351,529	127,495	680,492	116,659	**2,511,264**
CANADA		143,534	189,400	124,557	59,134			**516,625**
US EEZ			557,770					**557,770**
INTERNATIONAL			1,859,000					**1,859,000**
NO_X TOTAL	1,249,507	1,171,943	3,739,279	1,340,251	664,015	1,086,161	207,430	**9,458,586**
VOC								
MANE-VU	3,184	55,840	219,555	132,470	699,334	39,140	21,238	**1,170,762**
LADCO	8,751	167,753	263,821	178,055	811,119	43,931	227,782	**1,701,212**
SESARM	10,330	235,514	208,253	167,262	780,868	177,362	496,938	**2,076,526**
CENSARA	15,686	237,064	196,286	163,445	825,579	1,694,250	1,635,856	**4,768,166**
CANADA		193,891	123,156	60,045	532,666			**909,758**
US EEZ			33,413					**33,413**
INTERNATIONAL			84,972					**84,972**
VOC TOTAL	37,951	890,062	1,129,457	701,277	3,649,567	1,954,683	2,381,813	**10,744,810**
SO_2								
MANE-VU	271,979	65,242	3,598	1,881	39,869	5,837	612	**389,018**
LADCO	565,721	205,422	3,806	2,203	26,041	1,631	7,039	**811,862**
SESARM	377,251	144,700	6,121	2,493	57,660	35,235	28,139	**651,599**
CENSARA	953,655	209,473	19,337	2,439	38,639	24,168	58,760	**1,306,472**
CANADA		362,365	32,651	607	36,964			**432,586**
US EEZ			9,977					**9,977**
INTERNATIONAL			44,104					**44,104**
SO_2 TOTAL	2,168,606	987,201	119,594	9,624	199,173	66,870	94,551	**3,645,620**
$PM_{2.5}$								
MANE-VU	15,259	28,108	14,941	11,779	170,107	2,986	29,594	**272,774**
LADCO	70,561	61,398	16,524	14,874	225,060	1,336	227,925	**617,676**
SESARM	67,797	71,052	15,519	14,548	171,406	4,921	391,321	**736,565**
CENSARA	79,005	85,109	22,377	14,569	89,090	17,241	1,070,790	**1,378,181**
CANADA		25,261	13,805	5,093	105,607		323,474	**473,240**
US			5,987					**5,987**
INTERNATIONAL			3,906					**3,906**
$PM_{2.5}$ TOTAL	232,621	270,928	93,058	60,861	761,271	26,485	2,043,104	**3,488,330**
NH_3								
MANE-VU	2,229	4,983	459	13,087	15,049	17	169,292	**205,115**
LADCO	505	8,570	636	13,803	24,203	59	709,084	**756,859**
SESARM	828	16,435	506	16,129	8,506	7	614,094	**656,505**
CENSARA	1,616	23,423	1,782	14,361	14,673	45	1,420,557	**1,476,457**
CANADA		5,232	203	9,641	3,091		183,853	**202,020**
US EEZ			21,202					**21,202**
INTERNATIONAL			270,060					**270,060**
NH_3 TOTAL	5,179	58,643	294,848	67,021	65,522	127	3,096,879	**3,588,218**

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
CO								
MANE-VU	51,587	239,457	2,712,333	1,561,530	976,393	103,418	90,739	**5,735,457**
LADCO	167,143	734,519	2,555,291	2,013,892	1,355,846	45,583	966,320	**7,838,594**
SESARM	175,042	460,756	2,379,436	2,063,691	891,427	192,493	2,814,505	**8,977,351**
CENSARA	230,509	417,035	2,413,115	2,002,015	446,099	513,122	6,907,096	**12,928,991**
CANADA		568,160	2,003,059	1,300,915	648,333			**4,520,467**
US EEZ			132,827					**132,827**
INTERNATIONAL			200,230					**200,230**
CO TOTAL	624,281	2,419,927	12,396,291	8,942,042	4,318,099	854,616	10,778,661	**40,333,916**

Table 8-3: 2017 base case Beta 2 emissions (tons) by pollutant and RPO for aggregated sectors from SMOKE processed emission reports

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
				NO_X				
MANE-VU		151,352	264,570	381,046	180,425	75,550	1,018	**1,153,083**
LADCO		281,914	357,117	544,560	181,056	66,389	12,458	**1,715,219**
SESARM		263,717	325,234	614,570	102,354	134,760	77,295	**1,794,242**
CENSARA		329,949	622,921	154,499	131,281	588,721	116,659	**2,345,959**
CANADA		143,534	189,400	124,557	59,134			**516,625**
US EEZ			460,270					**460,270**
INTERNATIONAL			24,340					**24,340**
NO_X TOTAL		1,170,466	2,243,853	1,819,232	654,251	865,421	207,430	**8,009,739**
				VOC				
MANE-VU		54,220	260,225	214,498	655,025	50,611	21,238	**1,258,392**
LADCO		164,384	331,982	276,250	755,188	84,179	227,782	**1,846,588**
SESARM		228,666	256,485	295,349	746,708	225,660	496,938	**2,257,666**
CENSARA		225,001	226,113	63,870	834,819	1,969,444	1,635,856	**4,965,238**
CANADA		193,891	123,156	60,045	532,666			**909,758**
US EEZ			15,611					**15,611**
INTERNATIONAL			962					**962**
VOC TOTAL		866,162	1,214,536	910,012	3,524,407	2,329,894	2,381,813	**11,254,216**
				SO_2				
MANE-VU		83,208	1,523	1,922	32,936	6,357	612	**317,198**
LADCO		268,588	722	2,103	18,374	1,347	7,039	**866,986**
SESARM		206,455	905	2,379	29,509	30,346	28,139	**619,116**
CENSARA		265,990	1,467	518	6,437	31,987	58,760	**1,195,950**
CANADA		362,365	32,651	607	36,964			**432,586**
US EEZ			2,803					**2,803**
INTERNATIONAL			16,830					**16,830**
SO_2 TOTAL		1,186,606	56,901	7,530	124,219	70,037	94,551	**3,451,470**
				$PM_{2.5}$				
MANE-VU		28,387	18,956	17,186	157,362	3,200	28,216	**267,540**
LADCO		66,045	25,024	21,862	202,736	1,376	223,842	**582,008**
SESARM		77,374	21,657	22,102	171,034	4,088	385,852	**719,581**
CENSARA		91,684	31,650	5,742	91,570	17,208	1,043,767	**1,322,563**

	ERTAC EGU	Non-EGU Point & Small EGU	Nonroad (including M/A/R)	Onroad	Area (including Refueling & RWC)	Oil/Gas	Other (including biogenic)	Total
CANADA		25,261	13,805	5,093	105,607		323,474	**473,240**
US			8,379					**8,379**
INTERNATIONAL			2,087					**2,087**
$PM_{2.5}$ TOTAL	133,773	288,752	121,557	71,984	728,310	25,871	2,005,152	**3,375,398**
				NH_3				
MANE-VU		5,151	413	13,738	14,395	17	167,741	**204,063**
LADCO		9,009	563	14,082	23,034	12	689,515	**737,163**
SESARM		16,132	462	16,753	8,432	6	605,925	**650,859**
CENSARA		22,805	1,315	3,117	14,702	51	1,412,037	**1,459,655**
CANADA		5,232	203	9,641	3,091		183,853	**202,020**
US EEZ			216					**216**
INTERNATIONAL								
NH_3 TOTAL		58,329	3,172	57,331	63,654	85	3,059,070	**3,253,975**
				CO				
MANE-VU		238,478	2,541,821	2,279,190	864,069	73,624	90,739	**6,126,487**
LADCO		762,627	2,504,016	2,903,900	1,177,242	48,763	966,320	**8,448,474**
SESARM		481,736	2,259,626	3,062,300	876,020	121,867	2,814,505	**9,716,532**
CENSARA		436,622	1,997,595	640,342	448,849	472,366	6,907,096	**11,087,685**
CANADA		568,160	2,003,059	1,300,915	648,333			**4,520,467**
US EEZ			85,941					**85,941**
INTERNATIONAL			2,267					**2,267**
CO TOTAL		2,487,623	11,394,325	10,186,647	4,014,513	716,619	10,778,661	**39,987,853**

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Section 9. Relative Response Factor (RRF) and "Modeled Attainment Test"

Overview

EPA guidance requires the use of a modeled attainment test, which is described as a procedure in which an air quality model is used to simulate current and future air quality (US EPA 2014). If future estimates, after rounding, of ozone concentrations are less than or equal to 75 ppb, then this element of the attainment test is satisfied. A modeled attainment demonstration that consists of analyses which estimate whether selected emissions reductions will result in ambient concentrations that meet the NAAQS or progress goals.

For this modeled attainment test, model estimates are used in a "relative" rather than "absolute" sense. That is, one calculates the ratio of the model's future to current (baseline) predictions at ozone monitors. These ratios are called RRF. Future ozone concentrations are estimated at existing monitoring sites by multiplying modeled RRF at locations "near" each monitor by the observation-based monitor-specific "baseline" ozone design value. The following equation describes the approach as applied to a monitoring site i:

$$DVF_i = RRF_i * DVC_i$$

where DVC_i is the baseline concentration monitored at site i, RRF_i is the relative response factor calculated for site i, and DVF_i is the estimated future design value for site i. The RRF is the ratio of the future 8-hour daily maximum concentration predicted at a monitor to the baseline 8-hour daily maximum concentration predicted at the monitor location averaged over multiple days determined from the base case.

General Design Value Calculation

The following sections describe the calculation of each of the elements in Equation 1 as implemented by NYSDEC through an in-house computer program written in FORTRAN (n.b. the subscript "i" from equation is dropped in the following description). However, all calculations are still performed on a monitor-by-monitor basis.

It should be noted that while this algorithm describes the techniques OTC uses to calculate RRFs for a typical monitor it in no way precludes states from doing so differently in order to evaluate a particular monitor either in their attainment demonstration or for weight-of-evidence. Further information later in this section describes one particular scenario that might lead states to want to adopt a different method for particular monitors.

Step 1 - Calculation of DVC

Design values are calculated in accordance with 40 CFR Part 50.10, Appendix I, as 3-year averages of the fourth highest monitored daily 8-hour maximum value at each monitoring site. For example, the design value for 2009-2011 is the average of the fourth highest monitored daily 8-hour maximum values in 2009, 2010 and 2011. Design values are labeled with the *last* year of the design value period, i.e. the design value for the 2009 – 2011 is labeled as "2011 design value".

For MAT, the guidance defines DVC in Equation 1 as the average of the design values which straddle the baseline inventory year. Here the baseline inventory year is 2011, therefore DVC is the average of the "2010 design value" (determined from 2010-2012 observations), the "2011 design value" (determined from 2010-2012 observations), and the "2012 design value" (determined from 2011-2013 observations). Consequently, DVC is derived from observations covering a five-year period and is a weighted average with 2011 observations "weighted" three times, 2010 and 2012 observations weighted twice, and 2009 and 2013 observations weighted once.

The following criteria concerning missing design values were implemented in the FORTRAN code calculating DVC:

a) For monitors with only four years of consecutive data, the guidance allows DVC to be computed as the average of two design values within that period.
b) For monitors with only three years of consecutive data, the DVC is equal to the design value calculated for that three year period
c) For monitors with less than three years of consecutive data, no DVC can be estimated

Step 2 - Calculation of RRF

The guidance requires the calculation of RRF with CMAQ output from grids that are "near" a monitor. Because of the 12 km grid spacing used in the CMAQ simulations, model predictions in a 3X3 grid array centered on the monitoring location are considered "near" that monitor. For each day, the maximum base case and control case concentration within that array is selected for RRF calculation as set forth in the guidance document.

Because photochemical models were found to be less responsive to emission reductions on days of lower simulated ozone concentrations, the guidance recommends applying screening criteria to the daily model predictions at individual monitors to determine whether that day's predictions are to be used to calculate the RRF or not. Only "high ozone days" are to be selected, i.e. days with ozone values that are greater than 60ppb.

RRF = (average control case over high ozone days selected based on base case concentrations) / (average base case over selected high ozone days)

In addition, the guidance recommends that preferably ten "high ozone days", as identified below, be selected for RRF calculation. In no case can the RRF be calculated with fewer than five "high ozone days".

The following describes the logic with which NYSDEC implemented these screening criteria into its FORTRAN code for RRF calculation:

a) Selecting concentrations from grid cells surrounding the monitor
    i. Determine the grid cell in which the monitor is located and include the surrounding 8 grid cells to form a 3X3 grid cell array.
    ii. Determine daily maximum 8-hr ozone concentrations for each day for each of the 9 grid cells for both base case and control case.
    iii. For each day, pick the highest daily maximum 8-hr ozone value out of all 9 grid cells. This is the daily maximum 8-hr ozone concentration for that monitor for that day to be used in RRF calculations (following the screening criteria listed below).
    iv. This is done for the base case only. For the future case the same grid cell is used regardless of whether it is the highest or not.
b) Selecting modeling days to be used in the RRF computation (again done on a monitor-by-monitor basis)
    i. Starting with an ozone threshold (TO_3) of 75 ppb and a minimum required number of days (Dmin) of 10, determine all days for which the simulated base case concentration (as determined in step (a) is at or above the threshold TO_3.
    ii. If the number of such days is greater to or equal Dmin, identify these days and proceed to step (c). Otherwise, continue to b(iii), below.
    iii. Lower the threshold (TO_3) by 1 ppb interval and go back to b(i) to identify the days. If the minimum number of days is not reached, then reduce that requirement by 1 (but no lower than 5 days) and $TO_3 \geq 60$ ppb, and go back to b(i). Otherwise proceed to b(iv) below.
    iv. Stop. No RRF can be calculated for this monitor because there were less than 5 days with base case daily maximum concentration ≥60 ppb.

c) RRF computation: Compute the RRF by averaging the daily maximum 8-hr ozone concentrations for base case and control case determined in step (a) over all of the days determined in step (b). The RRF is the ratio of average control case concentrations over average base case concentrations.

Step 3 - Computation of DVF

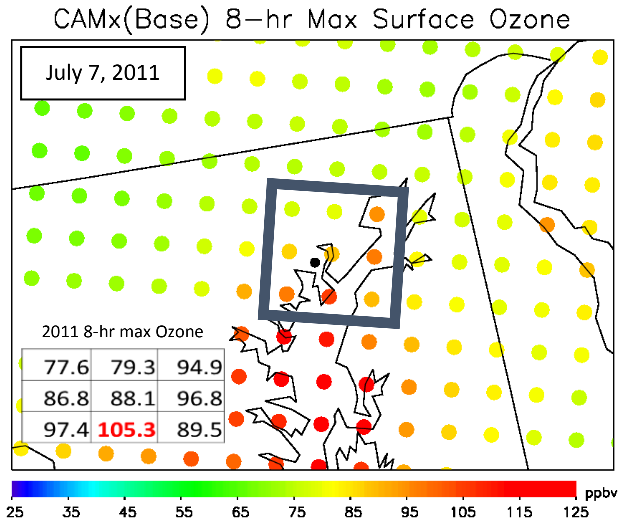
Compute DVF as the product of DVC from step (1) and RRF from step (2). Note, the following conventions on numerical precision (truncation, rounding) were applied:

a) DV are truncated in accordance with 40 CFR Part 50.10, Appendix I. This applies to the 2009, 2010, and 2011 design values.
b) DVC (averages of design values over multiple years) are calculated in ppb and carried to 1 significant digit
c) RRF are calculated and carried to three significant digits
d) DVF is calculated by multiplying DVC with RRF, followed by truncation.

Land-Water Interface Issues

When monitors are located so as to result in one or more of the 8 additional grid cells falling over a body of water OTC has found that those monitors are often not responsive to changes in emissions. Research conducted by the University of Maryland on the calculation of future design values has demonstrated some potential flaws with EPA modeling guidance in regards to calculating RRFs for these particular monitors.

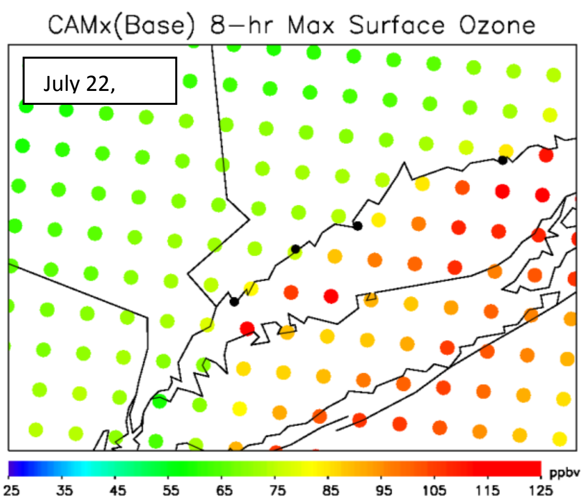
Figure 9-1: Modeled Ozone on July 7, 2011 near Edgewood, MD (Monitor #240251001)



It is often the case that due to slower dry deposition of ozone, fewer clouds being over bodies of water, PBL venting, PBL height, and high emissions from marine vessels, ozone measurements are much higher over bodies of water than nearby land masses (Goldberg et al. 2014; Loughner et al. 2011, 2014). As a result the maximum values in the 3x3 grid occur in a grid cell over water where ozone pollution is higher and less responsive to changes in emissions.

Since people are not generally exposed to the high levels of ozone that occurs over bodies of water for eight hours, there is less of a need to evaluate these values in regards to the health based ozone standard, yet they are included in modeled design value calculations due to way the 3x3 grid is employed in the default method for calculated projected ozone values.

Figure 9-2: Modeled Ozone on July 2, 2011 near monitors in Southern Connecticut



An example of the misalignment created by the default modeled attainment test can be seen in Figure 9-1. In this case, the grid cell geographically nearest to the monitor models an 8 hour maximum of 88.1ppb, but the maximum grid cell is largely over water and reads 17.2 ppb higher. This results in modeled ozone calculations on high ozone days that don't correlate well with monitored data. Similar issues are illustrated in the Long Island Sound in Figure 9-2.

This problem can be seen to a greater extent when comparing Figure 9-3 and Figure 9-4. The former figure relies on the nearest grid cell for calculations and the latter figure relies on the technique recommended in EPA guidance. The former technique results in calculations that are much less biased, have a lower RMSE, and correspond well to the 1:1 line.

Figure 9-3: Modeled vs Observed 8-hour maximum Ozone at Edgewood, MD calculated using nearest grid cell (Monitor #240251001)

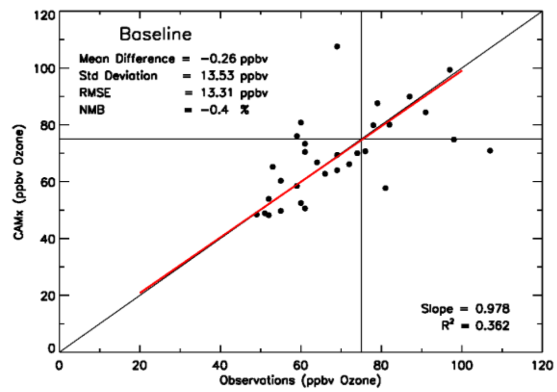
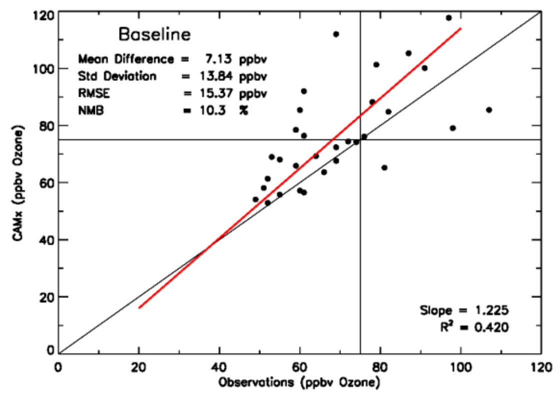


Figure 9-4: Modeled vs Observed 8-hour maximum Ozone at Edgewood, MD calculated using nearest maximum from 3x3 grid (Monitor #240251001)



Another technique that could be used to correct potential inaccuracies in calculation of design values at monitors at the land-water interface involves removing grid cells that are of a certain percentage of water. This can be done prior to running the algorithm discussed earlier in the document by applying a mask that contains cells considered to be water cells to the grid and zeroing them out so that they cannot be considered the maximum. Determination of what percentage of the grid cell must be water to be removed should be left to the state submitting the demonstration.

To analyze this technique NYSDEC removed any grid cell that was considered water in the mask provided with the WRF 3.4 package and recalculated the design values. This technique was tested using the Alpha 2 inventory. The results are shown for 10 monitors (3 in Connecticut, 5 in New York, and 1 each in Maryland and New Jersey) in Figure 9-5 though Figure 9-24, with the odd numbered figures being those corresponding to values calculated using all of the grid cells and the even numbered figures having the cells containing water removed. The one monitor in New Jersey acts as a control in this case since it is inland and will not be impacted by water grid cells.

At every monitor, except #340150002, removing the water cells resulted in a reduction in the maximum 8-hr ozone on the days examined. #340150002 also happens to be the only one of the 10 monitors examined that had 2011 8-hr maximums that were not grossly overpredicted from the 2011 observed monitors. The other nine monitors saw dramatic improvements in performance on the 10 days examined. When including the water cells the 2011 8-hr modeled values over-predicted observed by as much as 80ppb, often in the 40ppb range, with under-prediction only occurring a few times. However, the over-prediction once the water cells were removed in the worst case was brought down to 40 ppb and some monitors had as many days under-predicted as over-predicted.

Figure 9-5: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #090010017 using all grid cells for 10 selected days ordered by 2011 8-hr max

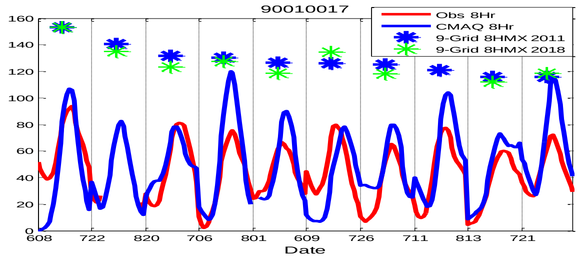


Figure 9-6: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #090010017 using less water grid cells for 10 selected days ordered by 2011 8-hr max

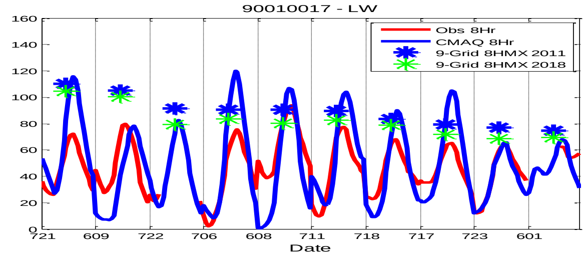


Figure 9-7: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #090013007 using all grid cells for 10 selected days ordered by 2011 8-hr max

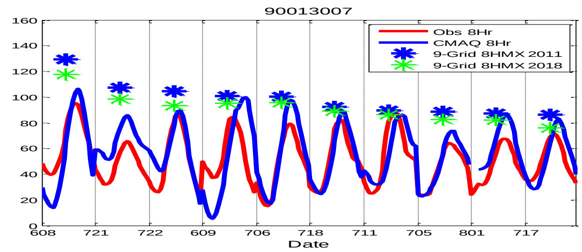


Figure 9-8: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #090013007 using less water grid cells for 10 selected days ordered by 2011 8-hr max

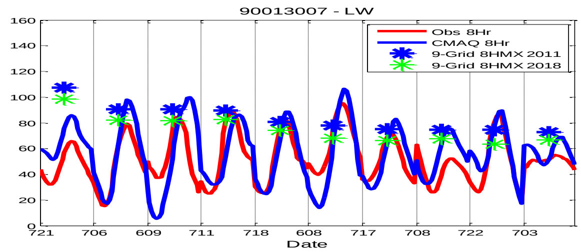


Figure 9-9: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #090019003 using all grid cells for 10 selected days ordered by 2011 8-hr max

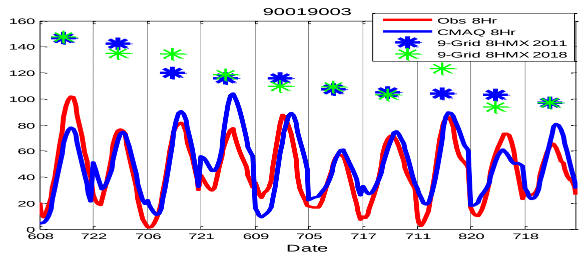


Figure 9-10: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #090019003 using less water grid cells for 10 selected days ordered by 2011 8-hr max

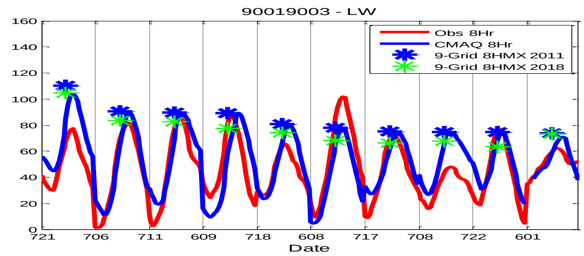


Figure 9-11: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #240251001 using all grid cells for 10 selected days ordered by 2011 8-hr max

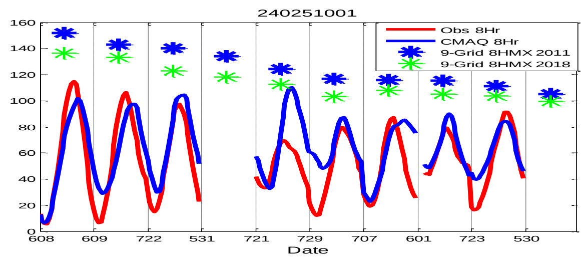


Figure 9-12: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #240251001 using less water grid cells for 10 selected days ordered by 2011 8-hr max

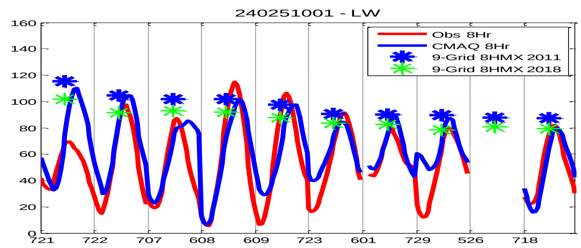


Figure 9-13: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #340150002 using all grid cells for 10 selected days ordered by 2011 8-hr max

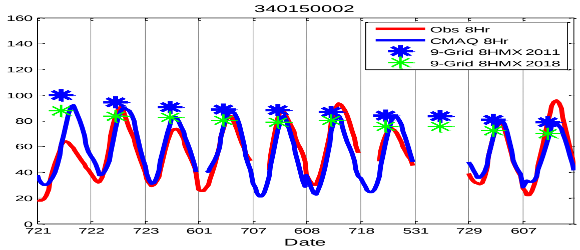


Figure 9-14: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #340150002 using less water grid cells for 10 selected days ordered by 2011 8-hr max

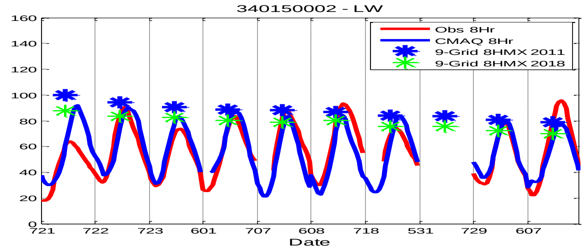


Figure 9-15: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #360050133 using all grid cells for 10 selected days ordered by 2011 8-hr max

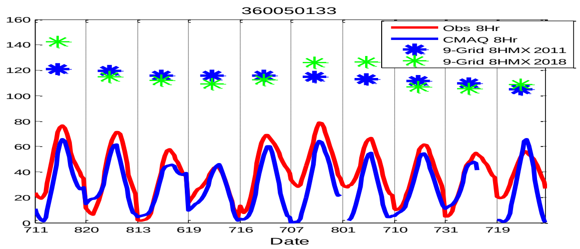


Figure 9-16: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #360050133 using less water grid cells for 10 selected days ordered by 2011 8-hr max

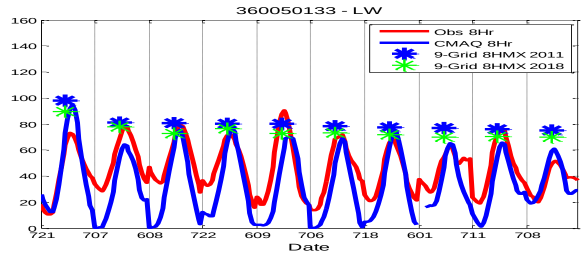


Figure 9-17: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #360810124 using all grid cells for 10 selected days ordered by 2011 8-hr max

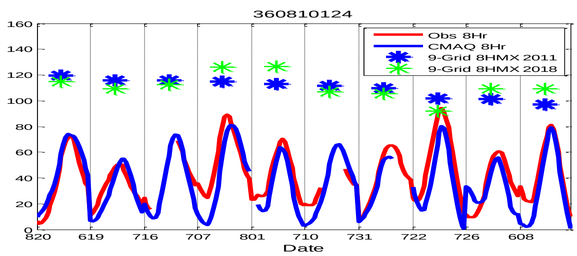


Figure 9-18: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #360810124 using less water grid cells for 10 selected days ordered by 2011 8-hr max

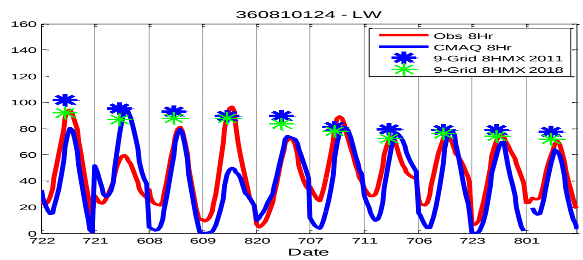


Figure 9-19: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #360850067 using all grid cells for 10 selected days ordered by 2011 8-hr max

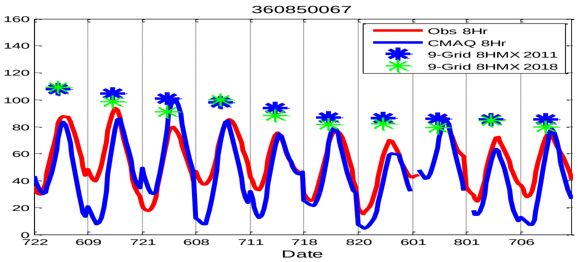


Figure 9-20: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #360850067 using less water grid cells for 10 selected days ordered by 2011 8-hr max

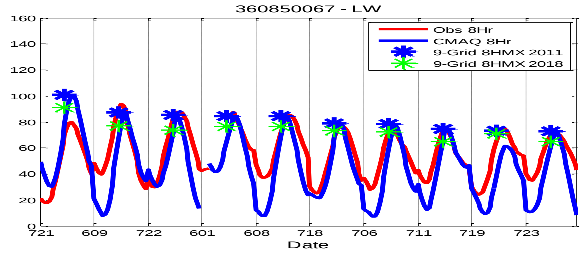


Figure 9-21: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #361030002 using all grid cells for 10 selected days ordered by 2011 8-hr max

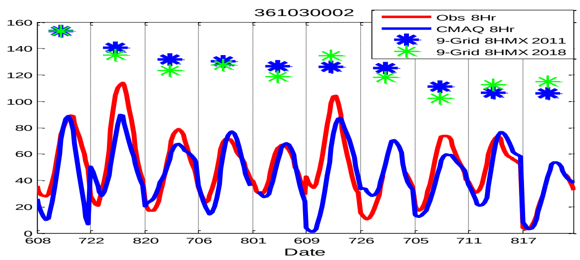


Figure 9-22: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #361030002 using less water grid cells for 10 selected days ordered by 2011 8-hr max

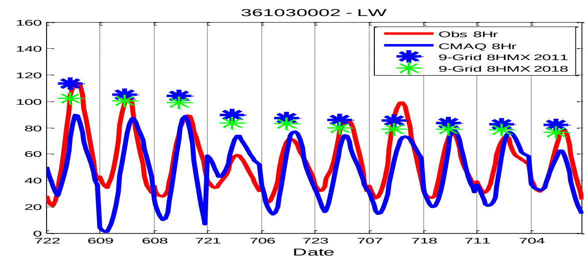


Figure 9-23: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #361192004 using all grid cells for 10 selected days ordered by 2011 8-hr max

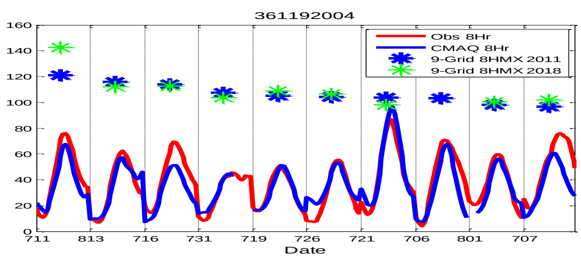
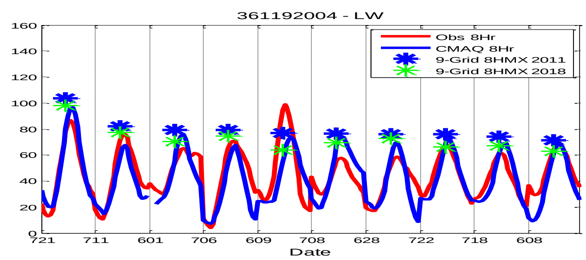


Figure 9-24: Observed and modeled 8-hr ozone (ppb) for 2011/2018 at monitor #361192004 using less water grid cells for 10 selected days ordered by 2011 8-hr max



We also looked at the results at all monitors, comparing modeling statistics for land-water monitors and monitors unaffected by the masking technique. In particular we looked at the deviation between the ten values uses in design value calculations for each monitor (Table 9-1). We began by using the same formula as for MAGE presented in Appendix A, but took a slightly different approach. Rather than comparing the values on the same day as is typically done with MAGE and other modeling statistics, we compared the highest, 2nd highest, etc. values onto the tenth highest between observations and modeled values. When those numbers are compared for the monitors impacted by the land-water technique in the OTR+VA the deviation becomes of similar magnitude to those that were not impacted by the land-water technique, whereas using EPA's methods those monitors deviated over three times higher. A similar story occurs for monitors outside of the OTR. A full set of results for every monitor in the modeling domain is available upon request from OTC.

Table 9-1: MAGE for monitors impacted and not impacted by use of the land-water masking technique

REGION	Monitor Status	EPA Method	Less Water
OTR+VA	Impacted	30.7144	9.2985
	Not Impacted	9.3182	9.3182
Non-OTR	Impacted	25.0910	11.8325
	Not Impacted	7.8990	7.8990

When 2018 projections were examined there was a reduction in future projected ozone at all of the monitors, anywhere from 1 to 12 ppb, except the New Jersey monitor, which was not expected to change given its inland location (Table 9-2).

Table 9-2: 2018 ozone projections for 10 key monitors with and without water grids cells

Monitor ID	DVC	DVF 2018	DVF 2018 (less water)
#090010017	80.3	80	73
#090013007	84.3	78	75
#090019003	83.7	84	76
#240251001	90	81	80
#340150002	84.3	75	75
#360050133	74	75	68
#360810124	78	78	73
#360850067	81.3	77	73
#361030002	83.3	82	78
#361192004	75.3	78	68

While the OTC Modeling Committee does not believe that the technique described in EPA's guidance for calculating RRFs is problematic in most instances, monitors such as Edgewood, MD or those along the Long Island Sound should be analyzed in several ways in order to determine a method that produces the least biased results with the lowest error. Examples of some of the methods that could be used to reevaluate monitors at the land-water interface are:

1. Choosing the nearest grid cell to the monitor rather than use the 9 cell grid.
2. Averaging the 9 cell grid rather than using the maximum.
3. Using the maximum value from the 9 cell grid, but exclude grid cells over water though a mask or another technique.

References

Goldberg, DL, Loughner, CP, Tzortziou, M, Stehr, JW, Pickering, KE, Marufu, LT and Dickerson, RR 2014, 'Higher surface ozone concentrations over the Chesapeake Bay than over the adjacent land: Observations and models from the DISCOVER-AQ and CBODAQ campaigns', *Atmospheric Environment*, vol. 84, pp. 9–19.

Loughner, CP, Allen, DJ, Pickering, KE, Zhang, D-L, Shou, Y-X and Dickerson, RR 2011, 'Impact of fair-weather cumulus clouds and the Chesapeake Bay breeze on pollutant transport and transformation', *Atmospheric Environment*, vol. 45, no. 24, pp. 4060–4072.

Loughner, CP, Tzortziou, M, Follette-Cook, M, Pickering, KE, Goldberg, D, Satam, C, Weinheimer, A, Crawford, JH, Knapp, DJ, Montzka, DD, Diskin, GS and Dickerson, RR 2014, 'Impact of Bay-Breeze Circulations on Surface Air Quality and Boundary Layer Export', *Journal of Applied Meteorology and Climatology*, vol. 53, no. 7, pp. 1697–1713.

US EPA 2014, 'Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze', accessed from <https://www3.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf>.

Section 10. Projected 8-hour Ozone Air Quality Over the Ozone Transport Region

Overview

The US EPA guidance recommends the use of relative reduction factor (RRF) approach to demonstrate the attainment of the 8-hr ozone NAAQS (US EPA 2014). The OTC Modeling Committee implemented this approach in performing attainment assessment of the OTC areas.

Ozone Results

As described in Section 9, the RRFs were determined for all monitors for future year simulations with emissions data from the Alpha and Alpha 2 inventories for 2018 and Beta 2 for 2017 inventory (Beta inventories were not included given the lack of difference between Beta and Beta 2). The base DVC for 2011 representing the number of DVs estimated on the basis of 3-year averages available from 2009 to 2013 are listed in Table 10-1 along with the RRF and future year projected ozone concentrations for each monitor identified by its AIRS ID. More information concerning the air quality monitors is in Appendix C. Projected results are provided for Alpha, Alpha 2, and Beta 2 inventories. The values in red represent DVC or DVF that exceed the 75 ppb 8-hr ozone NAAQS. The Beta 2 results are also presented using the technique of removing water grid cells from consideration discussed in Section 9.

When looking at differences in the modeled design values between the Alpha 2 inventory (Figure 10-1) and the Beta 2 inventory (Figure 10-2) in the OTR one can observe some minor differences. There do appear to be decreases in ozone values throughout the OTR, in particular in the Mid-Atlantic. This would be expected that the use of an updated version of MOVES in Beta 2 decreased NO_X emissions throughout the region and upwind. There do appear

Figure 10-1: 2018 Projected Alpha 2 Base Case Design Values

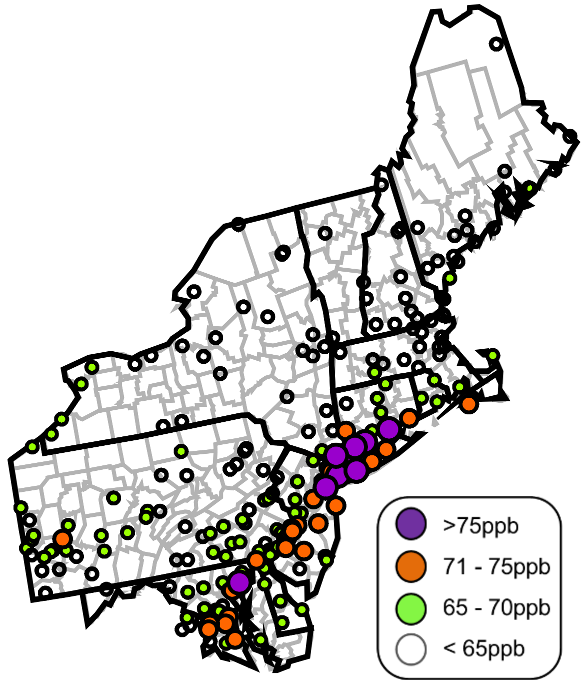
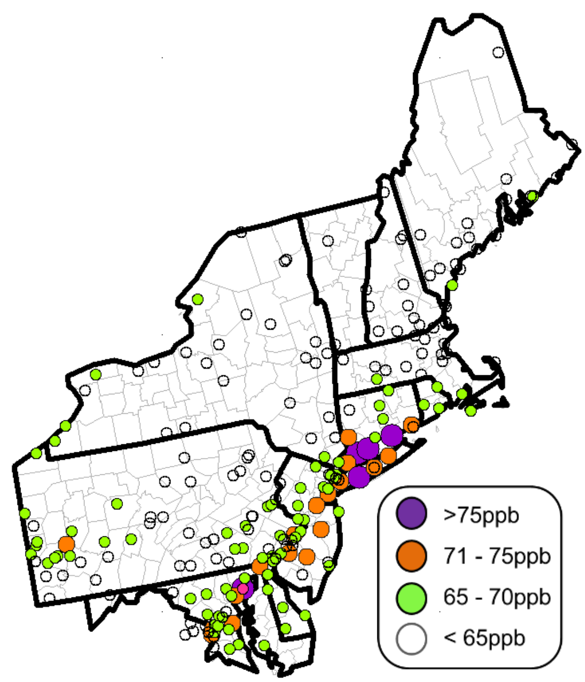


Figure 10-2: 2017 Projected Beta 2 Base Case Design Values



to be several monitors in Massachusetts and upstate New York that do increase between Alpha 2 and Beta 2 (see Section 8).

We also examined the impact of using the water masking technique. The results are presented in Figure 10-3. One can see some decreases in ozone levels throughout the region when examining the Beta results when water grid cells are remvoed from calculations.

Figure 10-3: 2017 Projected Beta 2 Base Case Design Values (Less Water)

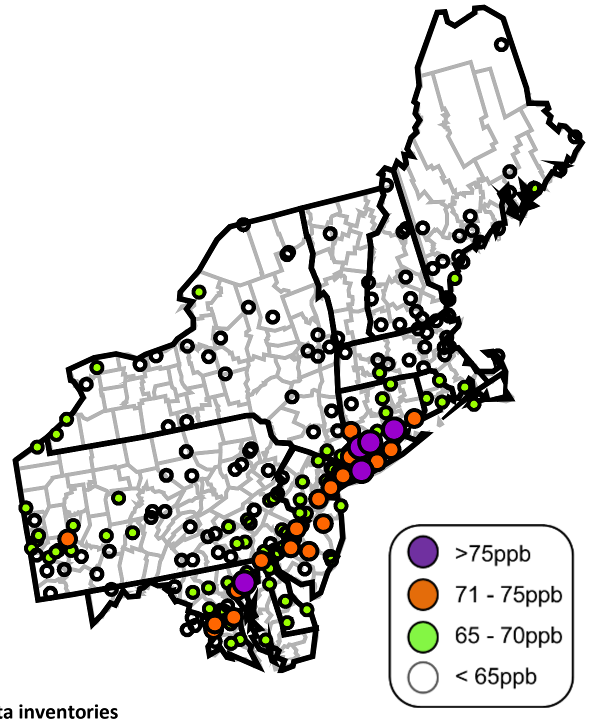


Table 10-1: Base case modeling for 2018 Alpha, 2018 Alpha 2, and 2017 Beta inventories

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
OTR	CT	90010017	80.3	80.003	0.996	80.000	0.997	77.000	0.967	73.000	0.911
		90011123	81.3	73.007	0.898	72.000	0.889	74.000	0.912	74.000	0.912
		90013007	84.3	77.564	0.920	78.000	0.928	77.000	0.921	76.000	0.908
		90019003	83.7	84.487	1.009	84.000	1.013	83.000	1.000	76.000	0.912
		90031003	73.7	65.998	0.896	65.000	0.890	66.000	0.897	66.000	0.897
		90050005	70.3	63.235	0.900	62.000	0.895	62.000	0.895	62.000	0.895
		90070007	79.3	70.894	0.894	70.000	0.889	70.000	0.887	70.000	0.887
		90090027	74.3	68.378	0.920	69.000	0.938	67.000	0.915	67.000	0.911
		90099002	85.7	76.324	0.891	77.000	0.899	77.000	0.907	76.000	0.895
		90110124	80.3	70.134	0.873	71.000	0.887	73.000	0.912	72.000	0.902
		90131001	75.3	67.371	0.895	66.000	0.888	67.000	0.892	67.000	0.892
	CT Max			**84.487**	**1.009**	**84.000**	**1.013**	**83.000**	**1.000**	**76.000**	**0.912**
	DC	110010041	76	67.002	0.882	66.000	0.879	65.000	0.861	65.000	0.861
		110010043	80.7	71.145	0.882	70.000	0.879	69.000	0.861	69.000	0.861
	DC Max			**71.145**	**0.882**	**70.000**	**0.879**	**69.000**	**0.861**	**69.000**	**0.861**
	DE	100010002	74.3	67.160	0.904	67.000	0.906	66.000	0.895	65.000	0.883
		100031007	76.3	68.311	0.895	68.000	0.894	67.000	0.880	67.000	0.880
		100031010	78	69.966	0.897	69.000	0.896	67.000	0.867	67.000	0.867
		100031013	77.7	69.378	0.893	69.000	0.891	67.000	0.868	67.000	0.868
		100032004	75			66.000	0.891	65.000	0.868	65.000	0.868
		100051002	77.3	68.596	0.887	68.000	0.886	67.000	0.873	67.000	0.873
		100051003	77.7	69.596	0.896	69.000	0.900	69.000	0.895	68.000	0.883
	DE Max			**69.966**	**0.904**	**69.000**	**0.906**	**69.000**	**0.895**	**68.000**	**0.883**
	MA	250010002	73	65.999	0.904	66.000	0.911	66.000	0.906	-8.000	-9.000
		250034002	69	62.769	0.910	62.000	0.906	62.000	0.904	62.000	0.904
		250051002	74	66.741	0.902	67.000	0.918	66.000	0.905	67.000	0.911
		250070001	77	70.794	0.919	72.000	0.938	71.000	0.926	70.000	0.913
		250092006	71	61.820	0.871	62.000	0.874	65.000	0.925	63.000	0.900
		250094005	70			63.000	0.910	63.000	0.902	62.000	0.895

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		250095005	69.3	62.467	0.901	62.000	0.908	61.000	0.892	61.000	0.892
		250130008	73.7	65.423	0.888	65.000	0.886	65.000	0.885	65.000	0.885
		250150103	64.7	57.816	0.894	57.000	0.888	57.000	0.886	57.000	0.886
		250154002	71.3	62.808	0.881	62.000	0.879	62.000	0.883	62.000	0.883
		250170009	67.3	60.146	0.894	60.000	0.895	59.000	0.887	59.000	0.887
		250171102	67	59.436	0.887	59.000	0.887	59.000	0.881	59.000	0.881
		250213003	72.3	60.696	0.840	61.000	0.856	63.000	0.881	64.000	0.886
		250250041	68.3	57.317	0.839	58.000	0.851	59.000	0.876	60.000	0.888
		250250042	60.7	50.946	0.839	51.000	0.855	53.000	0.880	53.000	0.887
		250270015	68.3	60.896	0.892	60.000	0.890	60.000	0.885	60.000	0.885
		250270024	69	60.955	0.883	60.000	0.882	60.000	0.883	60.000	0.883
	MA Max			**70.794**	**0.919**	**72.000**	**0.938**	**71.000**	**0.926**	**70.000**	**0.913**
	MD	240030014	83	72.393	0.872	72.000	0.870	71.000	0.861	71.000	0.861
		240051007	79	70.768	0.896	70.000	0.894	69.000	0.879	69.000	0.879
		240053001	80.7	74.744	0.926	74.000	0.924	74.000	0.924	71.000	0.892
		240090011	79.7	73.770	0.926	73.000	0.922	73.000	0.925	70.000	0.879
		240130001	76.3	67.587	0.886	67.000	0.884	67.000	0.879	67.000	0.879
		240150003	83	74.559	0.898	74.000	0.897	73.000	0.886	73.000	0.886
		240170010	79	70.887	0.897	70.000	0.895	69.000	0.877	69.000	0.877
		240199991	75			68.000	0.907	67.000	0.907	65.000	0.878
		240210037	76.3	67.899	0.890	67.000	0.888	67.000	0.878	67.000	0.878
		240230002	72	61.301	0.851	61.000	0.850	60.000	0.837	60.000	0.837
		240251001	90	82.053	0.912	81.000	0.909	81.000	0.908	80.000	0.894
		240259001	79.3	71.243	0.898	70.000	0.894	70.000	0.888	70.000	0.891
		240290002	78.7	69.854	0.888	69.000	0.886	68.000	0.876	68.000	0.876
		240313001	75.7	66.866	0.883	66.000	0.881	65.000	0.869	65.000	0.869
		240330030	79	68.801	0.871	68.000	0.868	68.000	0.862	68.000	0.862
		240338003	82.3	72.037	0.875	71.000	0.873	70.000	0.859	70.000	0.859
		240339991	80			69.000	0.871	69.000	0.865	69.000	0.865
		240430009	72.7	63.838	0.878	63.000	0.874	63.000	0.877	63.000	0.877
		245100054	73.7	68.401	0.928	68.000	0.926	68.000	0.924	65.000	0.893
	MD Max			**82.053**	**0.928**	**81.000**	**0.926**	**81.000**	**0.925**	**80.000**	**0.894**
	ME	230010014	61	56.041	0.919	56.000	0.928	54.000	0.899	55.000	0.911
		230031100	51.3			-8.000	-9.000	-8.000	-9.000	-8.000	-9.000
		230052003	69.3	63.202	0.912	63.000	0.913	62.000	0.898	62.000	0.909
		230090102	71.7	66.394	0.926	68.000	0.953	65.000	0.907	65.000	0.908
		230090103	66.3	61.321	0.925	63.000	0.952	60.000	0.910	60.000	0.906
		230112005	62.7	56.342	0.899	55.000	0.891	55.000	0.892	55.000	0.892
		230130004	67.7	62.325	0.921	63.000	0.941	60.000	0.899	60.000	0.897
		230173001	54.3	49.956	0.920	-8.000	-9.000	49.000	0.919	49.000	0.919
		230194008	57.7			-8.000	-9.000	-8.000	-9.000	-8.000	-9.000
		230230006	61	56.077	0.919	56.000	0.927	54.000	0.895	54.000	0.890
		230290019	58.3	54.015	0.927	55.000	0.957	53.000	0.917	53.000	0.918
		230290032	53	49.592	0.936	50.000	0.962	49.000	0.929	49.000	0.929
		230310038	60.3	54.312	0.901	-8.000	-9.000	54.000	0.898	54.000	0.898
		230310040	64.3	58.050	0.903	58.000	0.904	57.000	0.900	57.000	0.900
		230312002	73.7	66.654	0.904	65.000	0.892	65.000	0.890	66.000	0.898
	ME Max			**66.654**	**0.936**	**68.000**	**0.962**	**65.000**	**0.929**	**66.000**	**0.929**
	NH	330012004	62.3	55.771	0.895	55.000	0.892	55.000	0.895	55.000	0.895
		330050007	62.3	55.341	0.888	55.000	0.884	55.000	0.887	55.000	0.887
		330074001	69.3	64.303	0.928	63.000	0.916	64.000	0.927	64.000	0.927
		330074002	59.7	55.396	0.928	54.000	0.916	55.000	0.927	55.000	0.927
		330090010	59.7	53.891	0.903	53.000	0.900	53.000	0.902	53.000	0.902
		330111011	66.3	59.319	0.895	59.000	0.895	58.000	0.889	58.000	0.889
		330115001	69	61.686	0.894	61.000	0.890	61.000	0.891	61.000	0.891
		330131007	64.7	58.515	0.904	58.000	0.901	57.000	0.896	57.000	0.896
		330150014	66	60.456	0.916	60.000	0.924	59.000	0.902	59.000	0.897
		330150016	66.3	60.731	0.916	61.000	0.924	59.000	0.902	59.000	0.897

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		330150018	68			61.000	0.899	60.000	0.889	60.000	0.889
	NH Max			**64.303**	**0.928**	**63.000**	**0.924**	**64.000**	**0.927**	**64.000**	**0.927**
	NJ	340010006	74.3	66.350	0.893	67.000	0.905	66.000	0.890	65.000	0.882
		340030006	77	69.377	0.901	69.000	0.900	68.000	0.891	68.000	0.891
		340071001	82.7	74.058	0.896	73.000	0.894	72.000	0.880	72.000	0.880
		340110007	72	64.994	0.903	64.000	0.902	64.000	0.889	64.000	0.889
		340130003	78	70.418	0.903	70.000	0.905	69.000	0.890	69.000	0.890
		340150002	84.3	75.828	0.900	75.000	0.898	74.000	0.884	74.000	0.884
		340170006	77	70.209	0.912	70.000	0.919	69.000	0.902	69.000	0.898
		340190001	78	69.061	0.885	68.000	0.883	68.000	0.873	68.000	0.873
		340210005	78.3	70.016	0.894	69.000	0.892	68.000	0.878	68.000	0.878
		340219991	76			67.000	0.893	66.000	0.875	66.000	0.875
		340230011	81.3	72.430	0.891	72.000	0.888	71.000	0.884	71.000	0.884
		340250005	80	72.104	0.901	72.000	0.902	71.000	0.891	69.000	0.868
		340273001	76.3	67.808	0.889	67.000	0.887	67.000	0.880	67.000	0.880
		340290006	82	72.455	0.884	72.000	0.882	72.000	0.879	72.000	0.879
		340315001	73.3	67.062	0.915	67.000	0.917	65.000	0.899	65.000	0.899
		340410007	66			57.000	0.878	57.000	0.874	57.000	0.874
	NJ Max			**75.828**	**0.915**	**75.000**	**0.919**	**74.000**	**0.902**	**74.000**	**0.899**
	NY	360010012	68	61.955	0.911	61.000	0.907	61.000	0.903	61.000	0.903
		360050133	74	75.051	1.014	75.000	1.020	71.000	0.972	68.000	0.920
		360130006	73.3	66.578	0.908	66.000	0.904	66.000	0.913	65.000	0.899
		360130011	74	66.445	0.898	66.000	0.896	66.000	0.901	66.000	0.905
		360150003	66.5	61.566	0.926	61.000	0.923	61.000	0.919	61.000	0.919
		360270007	72	63.821	0.886	63.000	0.887	64.000	0.899	64.000	0.899
		360290002	71.3	65.532	0.919	65.000	0.915	65.000	0.922	64.000	0.907
		360310002	70.3	64.662	0.920	54.000	1.807	55.000	1.835	55.000	1.835
		360310003	67.3	61.903	0.920	60.000	0.904	61.000	0.917	61.000	0.917
		360337003	45			-8.000	-9.000	-8.000	-9.000	-8.000	-9.000
		360410005	66	59.690	0.904	59.000	0.898	59.000	0.903	59.000	0.903
		360430005	62			-8.000	-9.000	-8.000	-9.000	-8.000	-9.000
		360450002	71.7	63.791	0.890	62.000	0.875	65.000	0.907	65.000	0.911
		360530006	67	61.801	0.922	61.000	0.919	61.000	0.917	61.000	0.917
		360610135	73.3	73.513	1.003	74.000	1.010	70.000	0.959	67.000	0.919
		360631006	72.3	67.651	0.936	65.000	0.912	67.000	0.934	65.000	0.900
		360650004	61.5	56.254	0.915	55.000	0.906	56.000	0.913	56.000	0.913
		360671015	69.3	63.555	0.917	63.000	0.913	63.000	0.916	63.000	0.916
		360715001	67	60.468	0.903	60.000	0.902	60.000	0.903	60.000	0.903
		360750003	68	60.513	0.890	59.000	0.880	61.000	0.902	61.000	0.909
		360790005	70	62.272	0.890	61.000	0.884	63.000	0.908	63.000	0.908
		360810124	78	78.187	1.002	78.000	1.010	74.000	0.959	72.000	0.926
		360830004	67	60.809	0.908	60.000	0.903	60.000	0.901	60.000	0.901
		360850067	81.3	77.194	0.950	77.000	0.957	78.000	0.965	72.000	0.896
		360870005	75	68.048	0.907	68.000	0.907	67.000	0.903	67.000	0.903
		360910004	67	60.481	0.903	60.000	0.900	59.000	0.894	59.000	0.894
		361010003	65.3	61.167	0.937	60.000	0.932	60.000	0.934	60.000	0.934
		361030002	83.3	82.217	0.987	82.000	0.986	77.000	0.932	77.000	0.925
		361030004	78	71.058	0.911	71.000	0.917	71.000	0.920	71.000	0.912
		361030009	78.7	73.356	0.932	65.000	1.906	64.000	1.871	63.000	1.844
		361111005	69	64.011	0.928	63.000	0.920	63.000	0.921	63.000	0.921
		361173001	65	59.157	0.910	57.000	0.891	59.000	0.911	58.000	0.906
		361192004	75.3	78.448	1.042	78.000	1.041	73.000	0.976	68.000	0.911
	NY Max			**82.217**	**1.042**	**82.000**	**1.041**	**78.000**	**0.976**	**77.000**	**0.934**
	PA	420030008	76.3	71.402	0.936	70.000	0.926	70.000	0.930	70.000	0.930
		420030010	73.7	68.968	0.936	68.000	0.926	68.000	0.930	68.000	0.930
		420030067	75.7	69.629	0.920	69.000	0.913	69.000	0.912	69.000	0.912
		420031005	80.7	74.260	0.920	73.000	0.913	73.000	0.908	73.000	0.908
		420050001	74.3	68.668	0.924	67.000	0.915	67.000	0.908	67.000	0.908

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		420070002	70.7	65.595	0.928	65.000	0.927	65.000	0.922	65.000	0.922
		420070005	74.7	69.859	0.935	69.000	0.930	69.000	0.935	69.000	0.935
		420070014	72.3	67.275	0.931	66.000	0.923	66.000	0.925	66.000	0.925
		420110006	71.7	63.627	0.887	63.000	0.885	62.000	0.870	62.000	0.870
		420110011	76.3	67.167	0.880	66.000	0.878	65.000	0.861	65.000	0.861
		420130801	72.7	67.982	0.935	67.000	0.933	65.000	0.898	65.000	0.898
		420170012	80.3	71.579	0.891	71.000	0.890	70.000	0.877	70.000	0.877
		420210011	70.3	66.033	0.939	65.000	0.931	63.000	0.899	63.000	0.899
		420270100	71	66.193	0.932	66.000	0.931	64.000	0.907	64.000	0.907
		420279991	72			66.000	0.929	64.000	0.902	64.000	0.902
		420290100	76.3	69.074	0.905	68.000	0.904	66.000	0.867	66.000	0.867
		420334000	72.3	68.107	0.942	67.000	0.940	65.000	0.908	65.000	0.908
		420430401	69	62.707	0.909	62.000	0.907	60.000	0.875	60.000	0.875
		420431100	74.7	67.223	0.900	67.000	0.897	64.000	0.866	64.000	0.866
		420450002	75.7	68.054	0.899	67.000	0.898	66.000	0.880	66.000	0.880
		420490003	74	65.904	0.891	66.000	0.894	66.000	0.904	67.000	0.906
		420550001	67	60.662	0.905	60.000	0.903	59.000	0.883	59.000	0.883
		420590002	69	62.528	0.906	62.000	0.902	61.000	0.890	61.000	0.890
		420630004	75.7	70.378	0.930	70.000	0.926	67.000	0.898	67.000	0.898
		420690101	71	63.502	0.894	63.000	0.893	62.000	0.884	62.000	0.884
		420692006	68.7	61.445	0.894	61.000	0.893	60.000	0.884	60.000	0.884
		420710007	77	70.563	0.916	70.000	0.915	65.000	0.854	65.000	0.854
		420710012	78	71.050	0.911	70.000	0.909	66.000	0.858	66.000	0.858
		420730015	71	65.206	0.918	64.000	0.912	64.000	0.910	64.000	0.910
		420750100	76			67.000	0.891	65.000	0.865	65.000	0.865
		420770004	76	67.321	0.886	67.000	0.884	66.000	0.875	66.000	0.875
		420791100	65	57.740	0.888	57.000	0.887	56.000	0.867	56.000	0.867
		420791101	64.3	56.944	0.886	56.000	0.884	56.000	0.872	56.000	0.872
		420810100	67	60.849	0.908	60.000	0.907	60.000	0.898	60.000	0.898
		420850100	76.3	68.334	0.896	68.000	0.893	68.000	0.900	68.000	0.900
		420890002	66.7	59.143	0.887	59.000	0.885	58.000	0.871	58.000	0.871
		420910013	76.3	68.678	0.900	68.000	0.899	66.000	0.870	66.000	0.870
		420950025	76	67.290	0.885	67.000	0.884	66.000	0.873	66.000	0.873
		420958000	69.7	62.054	0.890	61.000	0.889	61.000	0.877	61.000	0.877
		420990301	68.3	63.020	0.923	62.000	0.920	60.000	0.890	60.000	0.890
		421010004	66	59.756	0.905	59.000	0.904	58.000	0.886	58.000	0.886
		421010024	83.3	75.137	0.902	75.000	0.901	73.000	0.880	73.000	0.880
		421011002	80			72.000	0.901	70.000	0.880	70.000	0.880
		421119991	65			56.000	0.865	55.000	0.850	55.000	0.850
		421174000	69.7	65.176	0.935	65.000	0.933	64.000	0.920	64.000	0.920
		421250005	70	63.959	0.914	63.000	0.908	63.000	0.902	63.000	0.902
		421250200	70.7	64.132	0.907	63.000	0.900	63.000	0.901	63.000	0.901
		421255001	70.3	64.838	0.922	64.000	0.915	64.000	0.919	64.000	0.919
		421290006	71.7	66.007	0.921	65.000	0.913	65.000	0.910	65.000	0.910
		421290008	71	64.688	0.911	64.000	0.905	63.000	0.898	63.000	0.898
		421330008	72.3	66.516	0.920	66.000	0.919	62.000	0.858	62.000	0.858
		421330011	74.3	67.955	0.915	67.000	0.913	63.000	0.859	63.000	0.859
	PA Max			**75.137**	**0.942**	**75.000**	**0.940**	**73.000**	**0.935**	**73.000**	**0.935**
	RI	440030002	73.7	67.067	0.910	67.000	0.913	66.000	0.902	66.000	0.902
		440071010	74	67.407	0.911	67.000	0.911	66.000	0.899	66.000	0.896
		440090007	76.3	68.525	0.898	69.000	0.914	69.000	0.906	69.000	0.911
	RI Max			**68.525**	**0.911**	**69.000**	**0.914**	**69.000**	**0.906**	**69.000**	**0.911**
	VA	510130020	81.7	72.541	0.888	72.000	0.886	71.000	0.876	71.000	0.876
		510590030	82.3	72.737	0.884	72.000	0.882	72.000	0.879	72.000	0.879
		511071005	73	65.620	0.899	65.000	0.896	64.000	0.889	64.000	0.889
		511530009	70	63.336	0.905	63.000	0.903	62.000	0.897	62.000	0.897
		515100009	80	70.664	0.883	70.000	0.881	69.000	0.866	69.000	0.866
	VA Max			**72.737**	**0.905**	**72.000**	**0.903**	**72.000**	**0.897**	**72.000**	**0.897**

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
	VT	500030004	63.7	57.973	0.910	57.000	0.905	57.000	0.904	57.000	0.904
	VT Max			**57.973**	**0.910**	**57.000**	**0.905**	**57.000**	**0.904**	**57.000**	**0.904**
Outside-OTR	**AL**	10331002	65	49.017	0.754	48.000	0.751	47.000	0.737	47.000	0.737
		10499991	66			58.000	0.888	58.000	0.884	58.000	0.884
		10510001	66.3	57.529	0.868	57.000	0.861	56.000	0.854	56.000	0.854
		10550011	61.7	52.649	0.853	52.000	0.853	52.000	0.848	52.000	0.848
		10730023	72.3	62.503	0.865	62.000	0.864	61.000	0.854	61.000	0.854
		10731003	72	63.187	0.878	63.000	0.877	61.000	0.860	61.000	0.860
		10731005	75.3	65.488	0.870	65.000	0.870	64.000	0.859	64.000	0.859
		10731009	72	65.390	0.908	65.000	0.912	63.000	0.879	63.000	0.879
		10731010	73.7	62.910	0.854	62.000	0.854	62.000	0.849	62.000	0.849
		10732006	75	63.743	0.850	63.000	0.850	63.000	0.848	63.000	0.848
		10735002	72	62.402	0.867	62.000	0.867	61.000	0.851	61.000	0.851
		10735003	71	62.700	0.883	62.000	0.887	62.000	0.874	62.000	0.874
		10736002	76.7	66.790	0.871	66.000	0.871	65.000	0.852	65.000	0.852
		10890014	70.7	60.632	0.858	60.000	0.857	60.000	0.854	60.000	0.854
		11011002	67.3	57.656	0.857	57.000	0.857	57.000	0.862	57.000	0.862
		11030011	68.7	60.655	0.883	60.000	0.883	60.000	0.875	60.000	0.875
		11130002	66	57.341	0.869	57.000	0.869	57.000	0.868	57.000	0.868
		11170004	73.3	61.733	0.842	61.000	0.842	61.000	0.834	61.000	0.834
		11190002	61	55.583	0.911	55.000	0.911	52.000	0.866	52.000	0.866
		11250010	58.7	51.908	0.884	51.000	0.884	50.000	0.862	50.000	0.862
	AL Max			**66.790**	**0.911**	**66.000**	**0.912**	**65.000**	**0.884**	**65.000**	**0.884**
	AR	50350005	77.3	68.488	0.886	68.000	0.886	67.000	0.867	67.000	0.867
		51010002	68	64.410	0.947	64.000	0.942	66.000	0.976	66.000	0.976
		51130003	72.3	72.069	0.997	72.000	0.996	72.000	0.997	72.000	0.997
		51190007	72.3	64.007	0.885	64.000	0.885	64.000	0.886	64.000	0.886
		51191002	75.7	67.396	0.890	67.000	0.890	67.000	0.889	67.000	0.889
		51191008	73	65.795	0.901	65.000	0.901	65.000	0.898	65.000	0.898
		51430005	71	70.794	0.997	70.000	0.997	70.000	1.000	70.000	1.000
	AR Max			**72.069**	**0.997**	**72.000**	**0.997**	**72.000**	**1.000**	**72.000**	**1.000**
	GA	130210012	72.3	60.609	0.838	60.000	0.839	60.000	0.837	60.000	0.837
		130510021	63.3	57.084	0.902	57.000	0.912	57.000	0.905	57.000	0.905
		130550001	66.3	57.442	0.866	57.000	0.870	57.000	0.868	57.000	0.868
		130590002	70.7	59.756	0.845	59.000	0.845	59.000	0.843	59.000	0.843
		130670003	76	63.475	0.835	64.000	0.844	63.000	0.842	63.000	0.842
		130730001	68.7	59.522	0.866	59.000	0.867	59.000	0.869	59.000	0.869
		130770002	65	52.501	0.808	52.000	0.808	52.000	0.802	52.000	0.802
		130850001	66.3	56.547	0.853	56.000	0.851	56.000	0.855	56.000	0.855
		130890002	77.3	65.620	0.849	65.000	0.849	64.000	0.829	64.000	0.829
		130970004	73.3	61.257	0.836	61.000	0.840	61.000	0.834	61.000	0.834
		131210055	81	68.275	0.843	68.000	0.844	68.000	0.842	68.000	0.842
		131270006	60	56.856	0.948	57.000	0.963	57.000	0.956	57.000	0.954
		131350002	76.7	64.328	0.839	64.000	0.838	64.000	0.838	64.000	0.838
		131510002	80	67.928	0.849	67.000	0.849	67.000	0.843	67.000	0.843
		132130003	70.3	60.381	0.859	60.000	0.857	59.000	0.852	59.000	0.852
		132150008	66	57.341	0.869	57.000	0.869	57.000	0.869	57.000	0.869
		132230003	70.7	62.159	0.879	62.000	0.885	61.000	0.873	61.000	0.873
		132319991	72			60.000	0.844	60.000	0.840	60.000	0.840
		132450091	70	60.018	0.857	60.000	0.868	60.000	0.860	60.000	0.860
		132470001	77	64.457	0.837	64.000	0.837	64.000	0.834	64.000	0.834
		132611001	64.7	57.285	0.885	57.000	0.887	57.000	0.884	57.000	0.884
	GA Max			**68.275**	**0.948**	**68.000**	**0.963**	**68.000**	**0.956**	**68.000**	**0.954**
	IA	190170011	64	62.349	0.974	62.000	0.981	62.000	0.976	62.000	0.976
		190450021	66.7	63.258	0.948	63.000	0.948	62.000	0.941	62.000	0.941
		191130028	64.3	61.876	0.962	61.000	0.962	61.000	0.962	61.000	0.962
		191130033	64	61.427	0.960	61.000	0.958	61.000	0.959	61.000	0.959
		191130040	62.7	60.487	0.965	60.000	0.965	60.000	0.966	60.000	0.966

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		191530030	59.7	58.518	0.980	58.000	0.980	58.000	0.983	58.000	0.983
		191630014	63	59.321	0.942	59.000	0.941	58.000	0.931	58.000	0.931
		191630015	66			61.000	0.938	61.000	0.938	61.000	0.938
		191690011	61.3	60.362	0.985	60.000	0.985	60.000	0.981	60.000	0.981
		191770006	65.7	64.189	0.977	64.000	0.979	63.000	0.972	63.000	0.972
		191810022	63.7	63.413	0.996	63.000	0.996	63.000	0.995	63.000	0.995
	IA Max			**64.189**	**0.996**	**64.000**	**0.996**	**63.000**	**0.995**	**63.000**	**0.995**
	IL	170010007	67	63.040	0.941	64.000	0.961	63.000	0.950	63.000	0.950
		170190007	71			65.000	0.921	64.000	0.915	64.000	0.915
		170230001	66	60.093	0.911	59.000	0.907	60.000	0.914	60.000	0.914
		170310001	72	67.111	0.932	67.000	0.932	67.000	0.933	67.000	0.933
		170310032	77.7	67.413	0.868	65.000	0.846	68.000	0.883	72.000	0.931
		170310064	71.3	61.860	0.868	60.000	0.846	62.000	0.883	66.000	0.931
		170310076	71.7	66.444	0.927	66.000	0.927	67.000	0.937	67.000	0.937
		170311003	69.7	55.328	0.794	53.000	0.774	59.000	0.853	65.000	0.943
		170311601	71.3	66.815	0.937	66.000	0.934	66.000	0.930	66.000	0.930
		170314002	71.7	57.805	0.806	58.000	0.813	60.000	0.848	67.000	0.944
		170314007	65.7	53.585	0.816	52.000	0.799	55.000	0.844	61.000	0.942
		170314201	75.7	61.741	0.816	51.000	1.599	54.000	1.687	62.000	1.884
		170317002	76	60.792	0.800	58.000	0.776	64.000	0.846	71.000	0.941
		170436001	66.3	62.441	0.942	62.000	0.938	62.000	0.942	62.000	0.942
		170491001	68.3	62.187	0.911	61.000	0.907	61.000	0.901	61.000	0.901
		170650002	74.3	69.582	0.937	69.000	0.941	68.000	0.927	68.000	0.927
		170831001	76	67.336	0.886	67.000	0.887	67.000	0.886	67.000	0.886
		170859991	68			64.000	0.946	63.000	0.940	63.000	0.940
		170890005	69.7	66.870	0.959	66.000	0.956	66.000	0.953	66.000	0.953
		170971007	79.3	61.196	0.772	61.000	0.774	64.000	0.813	73.000	0.923
		171110001	69.7	65.539	0.940	65.000	0.946	66.000	0.951	66.000	0.951
		171132003	70.3	64.753	0.921	65.000	0.925	64.000	0.920	64.000	0.920
		171150013	71.3	65.026	0.912	65.000	0.917	64.000	0.906	64.000	0.906
		171170002	71.3	62.887	0.882	63.000	0.886	62.000	0.871	62.000	0.871
		171190008	77	69.046	0.897	68.000	0.894	68.000	0.888	68.000	0.888
		171191009	78.3	68.278	0.872	68.000	0.873	68.000	0.876	68.000	0.876
		171193007	76.7	68.777	0.897	68.000	0.894	68.000	0.888	68.000	0.888
		171199991	76			67.000	0.892	67.000	0.882	67.000	0.882
		171430024	61.7	57.042	0.925	57.000	0.925	57.000	0.924	57.000	0.924
		171431001	70.7	65.362	0.925	65.000	0.925	65.000	0.924	65.000	0.924
		171570001	67.7	63.110	0.932	63.000	0.932	60.000	0.887	60.000	0.887
		171613002	58.3	54.884	0.941	54.000	0.938	54.000	0.938	54.000	0.938
		171630010	74.7	66.304	0.888	66.000	0.888	65.000	0.880	65.000	0.880
		171670014	72			64.000	0.897	64.000	0.890	64.000	0.890
		171971011	64	60.326	0.943	60.000	0.943	60.000	0.943	60.000	0.943
		172012001	67.3	63.141	0.938	62.000	0.934	62.000	0.933	62.000	0.933
	IL Max			**69.582**	**0.959**	**69.000**	**0.961**	**68.000**	**0.953**	**73.000**	**0.953**
	IN	180030002	68.3	61.470	0.900	61.000	0.898	61.000	0.906	61.000	0.906
		180030004	69.3	62.633	0.904	62.000	0.898	62.000	0.908	62.000	0.908
		180110001	72.3	65.178	0.902	65.000	0.903	65.000	0.905	65.000	0.905
		180150002	69	63.314	0.918	62.000	0.906	63.000	0.918	63.000	0.918
		180190008	78	70.021	0.898	69.000	0.890	69.000	0.887	69.000	0.887
		180350010	68.7	60.614	0.882	60.000	0.879	61.000	0.890	61.000	0.890
		180390007	67.7	62.230	0.919	61.000	0.915	61.000	0.912	61.000	0.912
		180431004	76	67.169	0.884	67.000	0.886	66.000	0.872	66.000	0.872
		180550001	77	70.925	0.921	70.000	0.920	71.000	0.925	71.000	0.925
		180570006	71	63.488	0.894	63.000	0.890	63.000	0.890	63.000	0.890
		180590003	66.7	59.356	0.890	58.000	0.883	60.000	0.901	60.000	0.901
		180630004	67	59.503	0.888	59.000	0.891	60.000	0.899	60.000	0.899
		180690002	65	59.079	0.909	58.000	0.907	59.000	0.919	59.000	0.919
		180710001	66	59.935	0.908	59.000	0.903	60.000	0.913	60.000	0.913

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		180810002	69	61.686	0.894	61.000	0.896	62.000	0.901	62.000	0.901
		180839991	73			66.000	0.916	66.000	0.917	66.000	0.917
		180890022	66.7	58.916	0.883	57.000	0.862	58.000	0.884	61.000	0.924
		180890030	69.7	61.197	0.878	60.000	0.873	62.000	0.890	65.000	0.934
		180892008	68	59.704	0.878	59.000	0.873	60.000	0.890	63.000	0.934
		180910005	79.3	69.911	0.882	69.000	0.882	72.000	0.909	73.000	0.924
		180910010	69.7	62.876	0.902	62.000	0.902	64.000	0.919	64.000	0.925
		180950010	68.3	60.131	0.880	60.000	0.879	60.000	0.889	60.000	0.889
		180970050	72.7	65.008	0.894	64.000	0.893	66.000	0.909	66.000	0.909
		180970057	69	61.997	0.899	61.000	0.897	62.000	0.911	62.000	0.911
		180970073	72	64.577	0.897	64.000	0.894	65.000	0.914	65.000	0.914
		180970078	69.7	62.625	0.899	62.000	0.897	63.000	0.911	63.000	0.911
		181090005	69	61.210	0.887	60.000	0.880	61.000	0.897	61.000	0.897
		181230009	72.7	67.938	0.935	67.000	0.925	67.000	0.927	67.000	0.927
		181270024	70.3	61.934	0.881	61.000	0.873	63.000	0.896	64.000	0.917
		181270026	63	57.248	0.909	57.000	0.908	58.000	0.921	58.000	0.921
		181290003	70.3	64.641	0.920	64.000	0.917	64.000	0.923	64.000	0.923
		181410010	62.7	58.374	0.931	58.000	0.926	58.000	0.931	58.000	0.931
		181410015	69.3	63.500	0.916	63.000	0.919	63.000	0.923	63.000	0.923
		181411007	64	58.643	0.916	58.000	0.919	59.000	0.923	59.000	0.923
		181450001	74	65.453	0.885	65.000	0.889	67.000	0.908	67.000	0.908
		181630013	71.7	65.663	0.916	65.000	0.915	65.000	0.920	65.000	0.920
		181630021	74	67.947	0.918	67.000	0.914	68.000	0.928	68.000	0.928
		181670018	65.7	58.434	0.889	58.000	0.885	59.000	0.905	59.000	0.905
		181670024	64	56.307	0.880	56.000	0.878	57.000	0.905	57.000	0.905
		181730008	71	66.563	0.938	66.000	0.935	66.000	0.938	66.000	0.938
		181730009	69.7	64.912	0.931	64.000	0.927	64.000	0.923	64.000	0.923
		181730011	71	66.626	0.938	66.000	0.937	66.000	0.940	66.000	0.940
	IN Max			**70.925**	**0.938**	**70.000**	**0.937**	**72.000**	**0.940**	**73.000**	**0.940**
	KY	210130002	63.3	56.831	0.898	57.000	0.901	56.000	0.889	56.000	0.889
		210150003	68	61.547	0.905	61.000	0.902	61.000	0.905	61.000	0.905
		210190017	70	63.105	0.902	62.000	0.897	61.000	0.878	61.000	0.878
		210290006	72.3	66.039	0.913	65.000	0.909	64.000	0.897	64.000	0.897
		210373002	76.7	68.278	0.890	68.000	0.894	66.000	0.868	66.000	0.868
		210430500	67	60.059	0.896	59.000	0.894	58.000	0.873	58.000	0.873
		210470006	70.7	62.683	0.887	62.000	0.887	62.000	0.883	62.000	0.883
		210590005	76.3	71.653	0.939	71.000	0.935	71.000	0.936	71.000	0.936
		210610501	72	63.842	0.887	64.000	0.897	63.000	0.887	63.000	0.887
		210670012	71.3	63.478	0.890	63.000	0.885	63.000	0.888	63.000	0.888
		210890007	69.7	63.016	0.904	62.000	0.901	62.000	0.899	62.000	0.899
		210910012	73.7	69.691	0.946	69.000	0.940	69.000	0.940	69.000	0.940
		210930006	70.3	63.249	0.900	62.000	0.893	62.000	0.889	62.000	0.889
		211010014	76.3	71.089	0.932	70.000	0.930	71.000	0.932	71.000	0.932
		211110027	77	69.339	0.901	68.000	0.896	68.000	0.894	68.000	0.894
		211110051	77.3	70.737	0.915	70.000	0.909	69.000	0.898	69.000	0.898
		211110067	82	74.530	0.909	74.000	0.904	73.000	0.899	73.000	0.899
		211130001	70	63.084	0.901	62.000	0.896	61.000	0.882	61.000	0.882
		211390003	72.3	67.579	0.935	67.000	0.938	66.000	0.924	66.000	0.924
		211451024	73.7	69.418	0.942	70.000	0.953	69.000	0.949	69.000	0.949
		211850004	82	71.725	0.875	71.000	0.872	71.000	0.876	71.000	0.876
		211930003	65.3	62.309	0.954	62.000	0.952	58.000	0.901	58.000	0.901
		211950002	65.7	64.169	0.977	64.000	0.981	58.000	0.897	58.000	0.897
		211990003	66.7	58.823	0.882	59.000	0.886	57.000	0.859	57.000	0.859
		212130004	69.3	60.804	0.877	61.000	0.883	61.000	0.881	61.000	0.881
		212218001	69	61.734	0.895	62.000	0.902	61.000	0.889	61.000	0.889
		212270008	64	56.698	0.886	57.000	0.892	56.000	0.887	56.000	0.887
		212299991	69			61.000	0.890	61.000	0.889	61.000	0.889
	KY Max			**74.530**	**0.977**	**74.000**	**0.981**	**73.000**	**0.949**	**73.000**	**0.949**

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
	LA	220150008	77.3	73.937	0.957	73.000	0.957	72.000	0.941	72.000	0.941
		220170001	74.7	72.272	0.968	72.000	0.968	70.000	0.938	70.000	0.938
		220730004	63.3	60.844	0.961	60.000	0.955	58.000	0.925	58.000	0.925
	LA Max			**73.937**	**0.968**	**73.000**	**0.968**	**72.000**	**0.941**	**72.000**	**0.941**
	MI	260050003	82.7	74.256	0.898	75.000	0.910	75.000	0.907	75.000	0.908
		260190003	73	66.160	0.906	66.000	0.906	66.000	0.915	67.000	0.918
		260210014	79.7	72.073	0.904	72.000	0.912	72.000	0.908	73.000	0.918
		260270003	76.7	70.273	0.916	70.000	0.924	70.000	0.917	70.000	0.917
		260330901	63.5	59.969	0.944	59.000	0.945	61.000	0.962	58.000	0.923
		260370001	69.3	63.396	0.915	63.000	0.912	64.000	0.924	64.000	0.924
		260490021	73	66.291	0.908	66.000	0.908	66.000	0.917	66.000	0.917
		260492001	72.3	65.338	0.904	65.000	0.905	65.000	0.907	65.000	0.907
		260630007	71.3	64.241	0.901	64.000	0.909	64.000	0.911	64.000	0.907
		260650012	70.3	64.275	0.914	63.000	0.909	64.000	0.921	64.000	0.921
		260770008	73.7	67.178	0.912	67.000	0.916	67.000	0.918	67.000	0.918
		260810020	73	66.233	0.907	66.000	0.906	66.000	0.915	66.000	0.915
		260810022	72.7	65.052	0.895	65.000	0.900	66.000	0.910	66.000	0.910
		260910007	75.5	67.633	0.896	67.000	0.896	67.000	0.896	67.000	0.896
		260990009	76.7	70.717	0.922	70.000	0.921	70.000	0.925	70.000	0.917
		260991003	77.3	71.920	0.930	71.000	0.925	70.000	0.918	70.000	0.918
		261010922	72.3	66.321	0.917	66.000	0.917	66.000	0.924	66.000	0.922
		261050007	73.3	66.644	0.909	66.000	0.909	67.000	0.921	67.000	0.921
		261130001	68.3	63.068	0.923	62.000	0.915	63.000	0.931	63.000	0.931
		261210039	79.7	73.069	0.917	73.000	0.918	73.000	0.917	72.000	0.914
		261250001	76.3	70.463	0.924	70.000	0.924	70.000	0.918	70.000	0.918
		261390005	76	68.955	0.907	68.000	0.907	69.000	0.917	69.000	0.917
		261470005	75.3	69.073	0.917	69.000	0.920	69.000	0.918	68.000	0.908
		261530001	71.7	67.061	0.935	66.000	0.926	67.000	0.938	67.000	0.938
		261610008	73.3	66.454	0.907	66.000	0.903	66.000	0.904	66.000	0.904
		261630001	71.7	64.480	0.899	65.000	0.907	64.000	0.899	64.000	0.899
		261630019	78.7	72.451	0.921	72.000	0.925	73.000	0.935	73.000	0.935
	MI Max			**74.256**	**0.944**	**75.000**	**0.945**	**75.000**	**0.962**	**75.000**	**0.938**
	MN	270031001	67	62.960	0.940	62.000	0.940	63.000	0.952	63.000	0.952
		270031002	66.3	64.543	0.974	64.000	0.974	64.000	0.966	64.000	0.966
		270177416	55.5			-8.000	-9.000	-8.000	-9.000	-8.000	-9.000
		270495302	62.5	60.431	0.967	60.000	0.974	60.000	0.970	60.000	0.970
		270750005	58	57.896	0.998	-8.000	-9.000	57.000	0.999	57.000	0.999
		271095008	63.5	61.309	0.966	61.000	0.969	61.000	0.973	61.000	0.973
		271370034	61.3			-8.000	-9.000	-8.000	-9.000	-8.000	-9.000
		271377550	49.7	46.882	0.943	46.000	0.944	47.000	0.947	47.000	0.956
		271390505	63.5	61.671	0.971	61.000	0.973	61.000	0.973	61.000	0.973
		271713201	63.5	61.290	0.965	61.000	0.965	61.000	0.965	61.000	0.965
	MN Max			**64.543**	**0.998**	**64.000**	**0.974**	**64.000**	**0.999**	**64.000**	**0.999**
	MO	290190011	69	66.081	0.958	66.000	0.958	66.000	0.967	66.000	0.967
		290270002	67.7	64.782	0.957	64.000	0.957	64.000	0.958	64.000	0.958
		290390001	71.7	71.499	0.997	71.000	0.998	71.000	0.999	71.000	0.999
		290770036	69.3	65.454	0.945	65.000	0.945	65.000	0.952	65.000	0.952
		290770042	71.7	67.721	0.945	67.000	0.945	68.000	0.952	68.000	0.952
		290990019	76.3	67.060	0.879	67.000	0.879	66.000	0.874	66.000	0.874
		291130003	77	67.552	0.877	67.000	0.877	67.000	0.872	67.000	0.872
		291370001	68.7	66.247	0.964	66.000	0.964	65.000	0.949	65.000	0.949
		291570001	74.3	68.096	0.917	68.000	0.917	67.000	0.909	67.000	0.909
		291831002	82.3	72.490	0.881	72.000	0.881	72.000	0.881	72.000	0.881
		291831004	77.7	66.892	0.861	66.000	0.861	67.000	0.874	67.000	0.874
		291860005	72.3	64.831	0.897	64.000	0.897	64.000	0.893	64.000	0.893
		291890005	71.7	121.427	1.738	121.000	1.738	121.000	1.751	121.000	1.751
		291890014	79	131.855	1.712	131.000	1.712	130.000	1.706	130.000	1.706
		292130004	69	67.006	0.971	67.000	0.971	67.000	0.981	67.000	0.981

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		295100085	75.7	65.314	0.863	65.000	0.863	65.000	0.861	65.000	0.861
	MO Max			**72.490**	**0.997**	**72.000**	**0.998**	**72.000**	**0.999**	**72.000**	**0.999**
	MS	280110001	71.7	69.183	0.965	69.000	0.969	69.000	0.962	69.000	0.962
		280330002	72.3	64.860	0.897	64.000	0.897	63.000	0.874	63.000	0.874
		280490010	67	58.089	0.867	58.000	0.871	58.000	0.867	58.000	0.867
		280750003	62.7	57.552	0.918	57.000	0.909	56.000	0.905	56.000	0.905
		280810005	65	56.784	0.874	57.000	0.885	56.000	0.869	56.000	0.869
		281619991	63			58.000	0.925	57.000	0.917	57.000	0.917
	MS Max			**69.183**	**0.965**	**69.000**	**0.969**	**69.000**	**0.962**	**69.000**	**0.962**
	NC	370030004	66.7	59.370	0.890	59.000	0.895	58.000	0.877	58.000	0.877
		370110002	63.3	56.337	0.890	56.000	0.898	56.000	0.890	56.000	0.890
		370119991	63			55.000	0.879	54.000	0.864	54.000	0.864
		370210030	66.7	57.435	0.861	57.000	0.860	56.000	0.844	56.000	0.844
		370270003	66	57.684	0.874	57.000	0.878	57.000	0.870	57.000	0.870
		370330001	70.7	61.000	0.863	61.000	0.866	60.000	0.858	60.000	0.858
		370370004	64	55.981	0.875	55.000	0.874	54.000	0.854	54.000	0.854
		370510008	68.7	59.219	0.862	59.000	0.866	58.000	0.846	58.000	0.846
		370511003	70.7	60.569	0.857	60.000	0.855	59.000	0.843	59.000	0.843
		370590003	71	62.587	0.882	62.000	0.880	62.000	0.874	62.000	0.874
		370630015	70	58.765	0.840	58.000	0.838	58.000	0.836	58.000	0.836
		370650099	70	61.530	0.879	61.000	0.878	60.000	0.868	60.000	0.868
		370670022	75.3	65.910	0.875	65.000	0.875	65.000	0.871	65.000	0.871
		370670028	69.7	61.782	0.886	62.000	0.891	61.000	0.878	61.000	0.878
		370670030	72.7	63.176	0.869	63.000	0.872	62.000	0.864	62.000	0.864
		370671008	72.3	63.147	0.873	63.000	0.874	62.000	0.863	62.000	0.863
		370690001	69.3	59.917	0.865	59.000	0.864	58.000	0.848	58.000	0.848
		370750001	70.3	64.261	0.914	64.000	0.918	63.000	0.900	63.000	0.900
		370770001	70.7	65.150	0.922	65.000	0.921	62.000	0.891	62.000	0.891
		370810013	74	63.492	0.858	63.000	0.857	62.000	0.850	62.000	0.850
		370870008	61			56.000	0.920	54.000	0.894	54.000	0.894
		370870036	67.7	61.269	0.905	61.000	0.904	60.000	0.898	60.000	0.898
		370990005	67			59.000	0.894	60.000	0.898	60.000	0.898
		371010002	71.7	61.232	0.854	61.000	0.853	59.000	0.836	59.000	0.836
		371070004	67.7	60.023	0.887	59.000	0.885	59.000	0.880	59.000	0.880
		371090004	72.7	64.194	0.883	64.000	0.888	63.000	0.867	63.000	0.867
		371170001	66.3	58.835	0.887	58.000	0.886	58.000	0.887	58.000	0.887
		371190041	80	68.008	0.850	67.000	0.849	68.000	0.850	68.000	0.850
		371191005	75	64.478	0.860	64.000	0.859	64.000	0.856	64.000	0.856
		371191009	79.7	65.800	0.826	65.000	0.824	64.000	0.813	64.000	0.813
		371239991	66			56.000	0.856	55.000	0.843	55.000	0.843
		371290002	63	54.117	0.859	55.000	0.875	52.000	0.840	52.000	0.831
		371450003	71	70.020	0.986	69.000	0.983	66.000	0.940	66.000	0.940
		371470006	69.7	62.493	0.897	62.000	0.895	61.000	0.884	61.000	0.884
		371570099	71	63.169	0.890	62.000	0.886	61.000	0.870	61.000	0.870
		371590021	75.3	65.413	0.869	65.000	0.868	64.000	0.857	64.000	0.857
		371590022	75	64.680	0.862	64.000	0.855	63.000	0.851	63.000	0.851
		371730002	60.7	55.006	0.906	54.000	0.906	54.000	0.898	54.000	0.898
		371790003	71	59.789	0.842	59.000	0.841	59.000	0.845	59.000	0.845
		371830014	70.3	60.282	0.858	60.000	0.857	58.000	0.833	58.000	0.833
		371830016	73	62.948	0.862	63.000	0.870	61.000	0.837	61.000	0.837
		371990004	69.7	61.566	0.883	61.000	0.880	60.000	0.871	60.000	0.871
	NC Max			**70.020**	**0.986**	**69.000**	**0.983**	**68.000**	**0.940**	**68.000**	**0.940**
	OH	390030009	73	65.430	0.896	65.000	0.895	65.000	0.901	65.000	0.901
		390071001	77.3	68.009	0.880	67.000	0.869	68.000	0.892	68.000	0.892
		390090004	69	61.997	0.899	62.000	0.902	61.000	0.895	61.000	0.895
		390170004	77	68.592	0.891	68.000	0.890	68.000	0.885	68.000	0.885
		390170018	79.7	71.013	0.891	71.000	0.896	69.000	0.877	69.000	0.877
		390179991	77			67.000	0.880	68.000	0.886	68.000	0.886

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		390230001	75	66.165	0.882	65.000	0.880	66.000	0.881	66.000	0.881
		390230003	74	65.031	0.879	64.000	0.870	64.000	0.876	64.000	0.876
		390250022	78.7	67.548	0.858	67.000	0.857	66.000	0.851	66.000	0.851
		390271002	78.7	67.572	0.859	67.000	0.859	67.000	0.859	67.000	0.859
		390350034	77.7	67.265	0.866	67.000	0.865	68.000	0.885	70.000	0.907
		390350060	68.5	60.465	0.883	60.000	0.882	62.000	0.916	62.000	0.916
		390350064	70	63.161	0.902	63.000	0.900	64.000	0.920	65.000	0.934
		390355002	76.7	66.238	0.864	66.000	0.863	67.000	0.884	69.000	0.912
		390410002	73	64.218	0.880	64.000	0.877	64.000	0.883	64.000	0.883
		390479991	72			61.000	0.859	62.000	0.865	62.000	0.865
		390490029	80.3	72.166	0.899	71.000	0.895	71.000	0.888	71.000	0.888
		390490037	75	66.420	0.886	66.000	0.883	65.000	0.877	65.000	0.877
		390490081	71	63.368	0.893	63.000	0.890	62.000	0.885	62.000	0.885
		390550004	74.7	66.565	0.891	66.000	0.893	67.000	0.899	67.000	0.899
		390570006	73	63.320	0.867	63.000	0.864	63.000	0.870	63.000	0.870
		390610006	82	73.669	0.898	74.000	0.904	72.000	0.884	72.000	0.884
		390610010	76.3	68.144	0.893	68.000	0.893	67.000	0.881	67.000	0.881
		390610040	78.7	70.854	0.900	71.000	0.903	69.000	0.878	69.000	0.878
		390810017	70.3	64.078	0.912	63.000	0.904	64.000	0.911	64.000	0.911
		390830002	73.7	65.136	0.884	64.000	0.880	64.000	0.881	64.000	0.881
		390850003	80	67.352	0.842	67.000	0.843	69.000	0.872	72.000	0.903
		390850007	71.7	61.425	0.857	60.000	0.850	63.000	0.891	64.000	0.901
		390870011	65	58.637	0.902	58.000	0.898	58.000	0.895	58.000	0.895
		390870012	70	63.287	0.904	63.000	0.901	62.000	0.899	62.000	0.899
		390890005	74.3	65.228	0.878	64.000	0.874	65.000	0.879	65.000	0.879
		390930018	71.7	60.601	0.845	60.000	0.843	61.000	0.860	65.000	0.920
		390950024	68	59.806	0.880	59.000	0.875	59.000	0.882	60.000	0.892
		390950027	66.7	60.097	0.901	59.000	0.899	60.000	0.906	60.000	0.906
		390950034	73.7	63.014	0.855	62.000	0.854	64.000	0.869	65.000	0.888
		390970007	74.3	64.752	0.872	64.000	0.873	65.000	0.883	65.000	0.883
		390990013	70.7	63.609	0.900	63.000	0.896	63.000	0.903	63.000	0.903
		391030004	69			61.000	0.898	62.000	0.908	62.000	0.908
		391090005	73.3	64.951	0.886	64.000	0.882	65.000	0.888	65.000	0.888
		391130037	76.7	66.944	0.873	66.000	0.868	66.000	0.871	66.000	0.871
		391331001	68.3	61.108	0.895	61.000	0.895	61.000	0.903	61.000	0.903
		391351001	72.3	64.296	0.889	64.000	0.895	65.000	0.899	65.000	0.899
		391510016	76.7	68.217	0.889	67.000	0.884	68.000	0.899	68.000	0.899
		391510022	72	64.541	0.896	64.000	0.894	65.000	0.903	65.000	0.903
		391514005	72.3	64.311	0.890	64.000	0.890	65.000	0.899	65.000	0.899
		391530020	72	65.174	0.905	64.000	0.901	65.000	0.910	65.000	0.910
		391550009	71	63.311	0.892	63.000	0.892	63.000	0.899	63.000	0.899
		391550011	76.3	68.250	0.895	68.000	0.894	68.000	0.901	68.000	0.901
		391650007	77.7	67.591	0.870	67.000	0.866	67.000	0.865	67.000	0.865
		391670004	71.3	60.619	0.850	60.000	0.843	61.000	0.868	61.000	0.868
		391730003	71.3	64.113	0.899	63.000	0.897	64.000	0.902	64.000	0.902
	OH Max			**73.669**	**0.912**	**74.000**	**0.904**	**72.000**	**0.920**	**72.000**	**0.934**
	SC	450010001	62	53.686	0.866	53.000	0.865	53.000	0.868	53.000	0.868
		450030003	64.3	55.433	0.862	55.000	0.865	55.000	0.867	55.000	0.867
		450070005	70	59.381	0.848	59.000	0.847	60.000	0.863	60.000	0.863
		450150002	62.3	55.977	0.899	55.000	0.898	56.000	0.901	56.000	0.901
		450190046	64.7	58.133	0.899	60.000	0.939	59.000	0.913	57.000	0.885
		450250001	64.3	56.108	0.873	56.000	0.871	56.000	0.878	56.000	0.878
		450290002	61	54.144	0.888	53.000	0.885	53.000	0.880	53.000	0.880
		450310003	68	59.548	0.876	59.000	0.873	59.000	0.872	59.000	0.872
		450370001	61.3	52.926	0.863	52.000	0.863	53.000	0.868	53.000	0.868
		450450016	68	57.106	0.840	57.000	0.839	58.000	0.853	58.000	0.853
		450451003	65.3	55.812	0.855	55.000	0.857	55.000	0.857	55.000	0.857
		450770002	69.7	59.740	0.857	60.000	0.869	60.000	0.870	60.000	0.870

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		450790007	67.5	57.645	0.854	58.000	0.862	57.000	0.855	57.000	0.855
		450790021	60	51.486	0.858	51.000	0.863	51.000	0.863	51.000	0.863
		450791001	71.7	61.232	0.854	61.000	0.862	61.000	0.855	61.000	0.855
		450830009	73.7	63.249	0.858	63.000	0.855	62.000	0.853	62.000	0.853
		450910006	64	54.867	0.857	55.000	0.864	54.000	0.856	54.000	0.856
	SC Max			**63.249**	**0.899**	**63.000**	**0.939**	**62.000**	**0.913**	**62.000**	**0.901**
	TN	470010101	70.7	61.396	0.868	61.000	0.872	60.000	0.861	60.000	0.861
		470090101	76.7	66.913	0.872	66.000	0.869	66.000	0.865	66.000	0.865
		470090102	66.3	57.708	0.870	57.000	0.873	56.000	0.860	56.000	0.860
		470259991	62			55.000	0.892	54.000	0.878	54.000	0.878
		470370011	65.7	57.494	0.875	57.000	0.874	57.000	0.882	57.000	0.882
		470370026	70.3	61.744	0.878	61.000	0.874	62.000	0.882	62.000	0.882
		470651011	72.3	63.284	0.875	63.000	0.876	62.000	0.870	62.000	0.870
		470654003	73.3	63.698	0.869	63.000	0.865	62.000	0.859	62.000	0.859
		470890002	74.7	64.347	0.861	64.000	0.861	64.000	0.862	64.000	0.862
		470930021	69	60.002	0.870	59.000	0.869	59.000	0.864	59.000	0.864
		470931020	71.7	61.569	0.859	61.000	0.857	61.000	0.854	61.000	0.854
		471050109	72.3	63.834	0.883	63.000	0.885	62.000	0.871	62.000	0.871
		471210104	71.3	62.459	0.876	62.000	0.876	61.000	0.869	61.000	0.869
		471490101	68.5	59.650	0.871	59.000	0.871	60.000	0.880	60.000	0.880
		471550101	74.3	65.198	0.878	65.000	0.881	65.000	0.885	65.000	0.885
		471570021	76.7	68.056	0.887	68.000	0.887	66.000	0.869	66.000	0.869
		471570075	78			68.000	0.880	67.000	0.862	67.000	0.862
		471571004	75	65.903	0.879	66.000	0.885	64.000	0.864	64.000	0.864
		471632002	71.7	64.896	0.905	64.000	0.904	62.000	0.866	62.000	0.866
		471632003	70.3	63.882	0.909	63.000	0.908	60.000	0.865	60.000	0.865
		471650007	76.7	66.921	0.873	66.000	0.870	67.000	0.876	67.000	0.876
		471650101	73	63.320	0.867	63.000	0.865	64.000	0.885	64.000	0.885
		471870106	70.3	60.901	0.866	60.000	0.866	61.000	0.872	61.000	0.872
		471890103	71.7	62.924	0.878	62.000	0.878	63.000	0.893	63.000	0.893
		500070007	61			-8.000	-9.000	55.000	0.907	55.000	0.907
	TN Max			**68.056**	**0.909**	**68.000**	**0.908**	**67.000**	**0.907**	**67.000**	**0.907**
	TX	482030002	72.7	71.864	0.989	71.000	0.989	68.000	0.939	68.000	0.939
	TX Max			**71.864**	**0.989**	**71.000**	**0.989**	**68.000**	**0.939**	**68.000**	**0.939**
	VA	510030001	66.7	59.543	0.893	59.000	0.891	59.000	0.890	59.000	0.890
		510330001	71.7	63.684	0.888	63.000	0.885	62.000	0.878	62.000	0.878
		510360002	75.7	67.146	0.887	66.000	0.884	66.000	0.876	66.000	0.876
		510410004	72	64.498	0.896	64.000	0.894	64.000	0.890	64.000	0.890
		510610002	62.7	56.173	0.896	56.000	0.894	55.000	0.885	55.000	0.885
		510690010	66.7	59.003	0.885	58.000	0.882	58.000	0.870	58.000	0.870
		510719991	63			57.000	0.909	56.000	0.897	56.000	0.897
		510850003	73.7	64.716	0.878	64.000	0.875	65.000	0.884	65.000	0.884
		510870014	75	66.795	0.891	66.000	0.888	67.000	0.894	67.000	0.894
		511130003	70.7	64.775	0.916	64.000	0.915	64.000	0.907	64.000	0.907
		511390004	66.3	60.466	0.912	60.000	0.911	60.000	0.906	60.000	0.906
		511479991	62			56.000	0.919	56.000	0.906	56.000	0.906
		511611004	67.3	61.209	0.910	61.000	0.912	60.000	0.901	60.000	0.901
		511630003	62.3	58.400	0.937	58.000	0.935	56.000	0.915	56.000	0.915
		511650003	66	60.317	0.914	60.000	0.913	60.000	0.909	60.000	0.909
		511790001	73	63.583	0.871	63.000	0.864	62.000	0.861	64.000	0.878
		511970002	64.3	59.490	0.925	59.000	0.920	58.000	0.917	58.000	0.917
		516500008	74	67.510	0.912	67.000	0.907	66.000	0.903	64.000	0.870
		518000004	71.3	66.965	0.939	67.000	0.944	66.000	0.929	62.000	0.882
		518000005	69.7	62.361	0.895	62.000	0.893	61.000	0.881	61.000	0.881
	VA Max			**67.510**	**0.939**	**67.000**	**0.944**	**67.000**	**0.929**	**67.000**	**0.917**
	WI	550030010	58.3			55.000	0.950	56.000	0.969	-8.000	-9.000
		550090026	68.3	61.613	0.902	62.000	0.912	62.000	0.911	63.000	0.935
		550210015	67	63.456	0.947	63.000	0.950	63.000	0.950	63.000	0.950

OTC	State	AQS Code	DVC	2018 Alpha		2018 Alpha 2		2017 Beta 2		2017 Beta 2 (less water)	
				DVF	RRF	DVF	DVF	DVF	RRF	DVF	RRF
		550250041	66.3	61.937	0.934	62.000	0.943	61.000	0.934	61.000	0.934
		550270001	71.5	66.252	0.927	67.000	0.938	66.000	0.935	66.000	0.935
		550290004	75.7	67.691	0.894	67.000	0.892	68.000	0.907	69.000	0.923
		550350014	62			58.000	0.949	58.000	0.947	58.000	0.947
		550390006	70	65.100	0.930	65.000	0.941	65.000	0.934	65.000	0.934
		550410007	64.7			-8.000	-9.000	60.000	0.940	60.000	0.940
		550550002	68.5	64.102	0.936	64.000	0.948	64.000	0.942	64.000	0.942
		550590019	81	63.941	0.789	62.000	0.767	68.000	0.843	73.000	0.913
		550610002	75	67.470	0.900	67.000	0.901	68.000	0.910	69.000	0.922
		550630012	63.3	60.015	0.948	60.000	0.958	60.000	0.948	60.000	0.948
		550710007	78.7	71.704	0.911	71.000	0.913	72.000	0.918	72.000	0.922
		550730012	63.3	59.116	0.934	59.000	0.939	59.000	0.937	59.000	0.937
		550790010	69.7	59.419	0.853	58.000	0.846	60.000	0.871	65.000	0.936
		550790026	74.7	65.071	0.871	64.000	0.870	66.000	0.884	70.000	0.947
		550790085	80	70.448	0.881	70.000	0.881	71.000	0.892	75.000	0.942
		550870009	69.3	64.567	0.932	64.000	0.934	64.000	0.934	64.000	0.934
		550890008	76.3	71.089	0.932	71.000	0.940	71.000	0.936	71.000	0.936
		550890009	74.7	68.754	0.920	68.000	0.915	69.000	0.930	69.000	0.932
		551010017	77.7	64.273	0.827	63.000	0.820	66.000	0.851	71.000	0.916
		551050024	69.5	64.927	0.934	64.000	0.933	64.000	0.935	64.000	0.935
		551110007	65	62.023	0.954	62.000	0.959	61.000	0.946	61.000	0.946
		551170006	84.3	77.194	0.916	77.000	0.920	77.000	0.921	77.000	0.921
		551199991	63			-8.000	-9.000	59.000	0.942	59.000	0.942
		551250001	62			-8.000	-9.000	58.000	0.951	58.000	0.951
		551270005	69.3	65.031	0.938	65.000	0.946	65.000	0.949	65.000	0.949
		551330027	66.7	62.218	0.933	62.000	0.934	62.000	0.940	62.000	0.940
	WI Max			**77.194**	**0.954**	**77.000**	**0.959**	**77.000**	**0.969**	**77.000**	**0.951**
	WV	540030003	68	60.221	0.886	59.000	0.882	59.000	0.872	59.000	0.872
		540110006	69.3	62.169	0.897	61.000	0.894	60.000	0.879	60.000	0.879
		540219991	60			56.000	0.944	54.000	0.903	54.000	0.903
		540250003	64.7	59.957	0.927	59.000	0.924	59.000	0.919	59.000	0.919
		540291004	73	67.248	0.921	66.000	0.917	67.000	0.920	67.000	0.920
		540390010	72.3	68.078	0.942	67.000	0.935	66.000	0.920	66.000	0.920
		540610003	69.7	64.277	0.922	64.000	0.918	63.000	0.904	63.000	0.904
		540690010	72.3	64.636	0.894	64.000	0.890	65.000	0.901	65.000	0.901
		541071002	68.3	58.902	0.862	59.000	0.876	58.000	0.863	58.000	0.863
	WV Max			**68.078**	**0.942**	**67.000**	**0.944**	**67.000**	**0.920**	**67.000**	**0.920**

Regional Haze Results

This section is pending and will be issued as an addendum at a later point.

Section 11. Episodic Modeling using the 2011 Ozone Transport Commission Modeling Platform

Overview

This section presents procedures the OTC is using or plans to use to for episodic model runs using the CMAQ modeling system, an acceptable photochemical model (US EPA 2014). The focus of this modeling is to provide analyses to guide SIP development for the eight-hour ozone standard using a future year of 2018 and potentially be used in the WOE analyses in the aforementioned SIPs. The OTC Commissioners and Air Directors requested that the OTC Modeling Committee develop this tool to allow sensitivity and screening modeling to occur with greater ease and speed than occurred with full year photochemical runs.

The modeling will use a base case episode from June 30 to August 4 2011. This period includes time periods focused on during the DISCOVER-AQ program. Modeling a period of time closer in length to a month will reduce the time and computing resources necessary to model the extensive number of scenarios needed to properly plan for control programs to include in Ozone SIPs.

The objective of this modeling protocol is to maintain and enhance the technical credibility of the study by describing the procedures for conducting a successful modeling project. By including information as to why episodes were selected, concerning the model platform the work was based on, on the model based evaluation of the selected episode, and on how runs should be conducted we are ensuring a replicable exercise that should stand up to scrutiny.

Selection of Episodes

In recent years the OTC has relied on two modeling platforms for planning work. Both modeling platforms use CMAQ for photochemical modeling. The first of these platforms uses 2007 as a base year for meteorology and emissions inventories, and the second uses 2011. The committee determined that no new modeling platform would be developed as a result of this work thus limiting the choice of episodes of ozone pollution during only those two years. In 2007 and 2011 the committee found four episodes, two per year, that were considered to be valuable for further scrutiny. These were time periods with high ozone values and a relatively large number of exceedances of the 2008 75 ppb NAAQS, which suggested a sustained bought of ozone pollution throughout the region.

Given the level of resources available and because of the purposes of this work for screening purposes OTC determined that only one of four episodes be used. The time periods of the four episodes are in Table 11-1 and general informative maps of the four episodes in question can be seen in Figure 11-1 to Figure 11-8.

Table 11-1: Descriptions of episodes

	TIME SPAN	NUMBER OF DAYS
Episode A	May 25-June 12, 2011	19
Episode B	June 27-August 2, 2011	37
Episode C	June 15-June 28, 2007	19
Episode D	July 30-August 4, 2007	5

We wanted to choose an episode(s) that complies with the primary criteria set forth in EPA's eight-hour ozone modeling guidance for selecting ozone episodes for eight-hour ozone attainment demonstration modeling:

1. Select periods, preferably during NEI years, for which extensive air quality/meteorological databases exist;
2. Model a sufficient number of days so that the modeled attainment can be applied at all of the ozone monitoring sites that are in violation of the NAAQS;

3. Model time periods that include pollution concentration episodes to ensure the modeling system appropriately include a mix of high and low periods; and
4. Select a mix of episodes reflecting a variety of meteorological conditions that frequently correspond with observed eight-hour daily maximum ozone concentrations greater than the level of the NAAQS at different monitoring sites (US EPA 2014).

Figure 11-1: Monitored Ozone Data for Episode A (May 25-June 12, 2011)

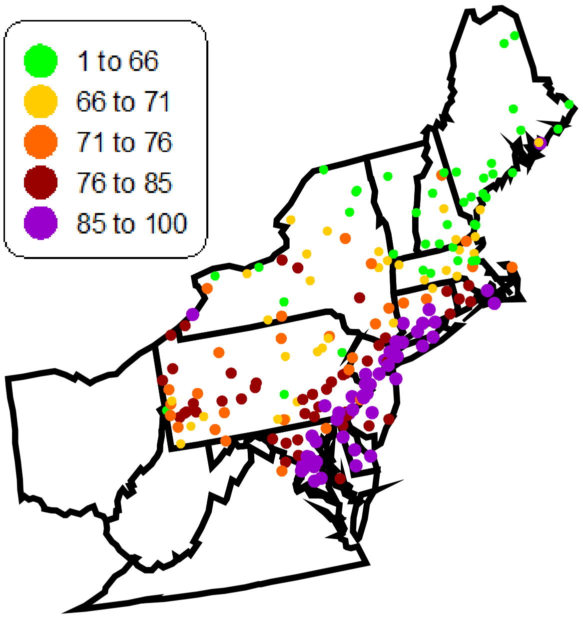


Figure 11-2: Number of Days with Ozone > 75ppb for Episode A (May 25-June 12, 2011)

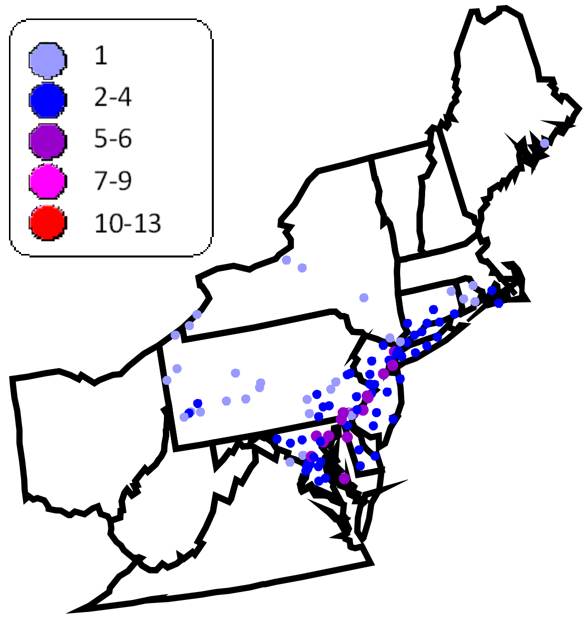


Figure 11-3: Monitored Ozone Data for Episode B (June 27-August 2, 2011)

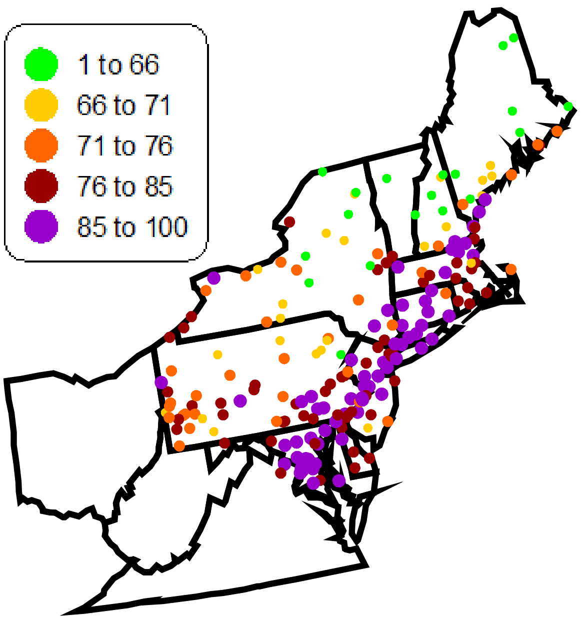


Figure 11-4: Number of Days with Ozone > 75ppb for Episode B (June 27-August 2, 2011)

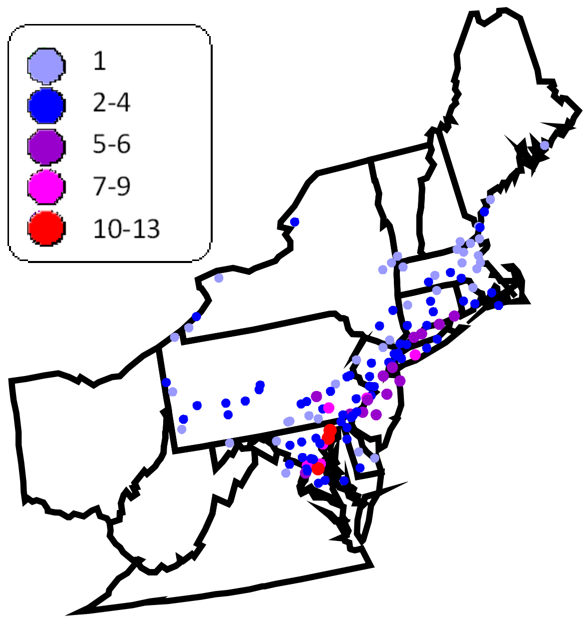


Figure 11-5: Monitored Ozone Data for Episode C (June 15-June 28, 2007)

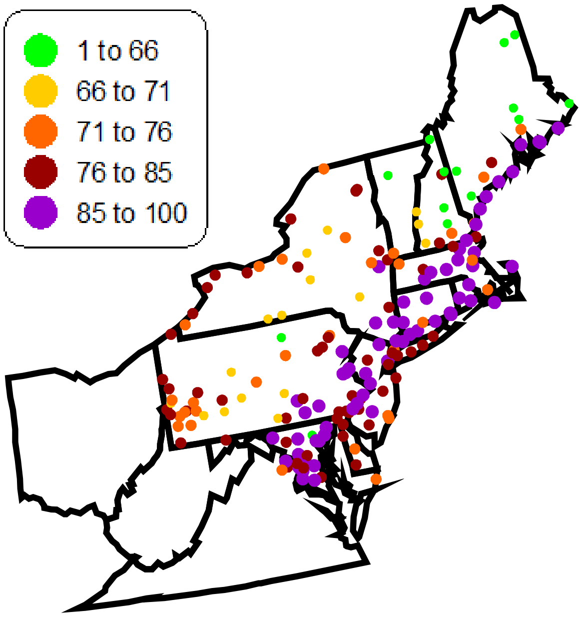


Figure 11-6: Number of Days with Ozone > 75ppb for Episode C (June 15-June 28, 2007)

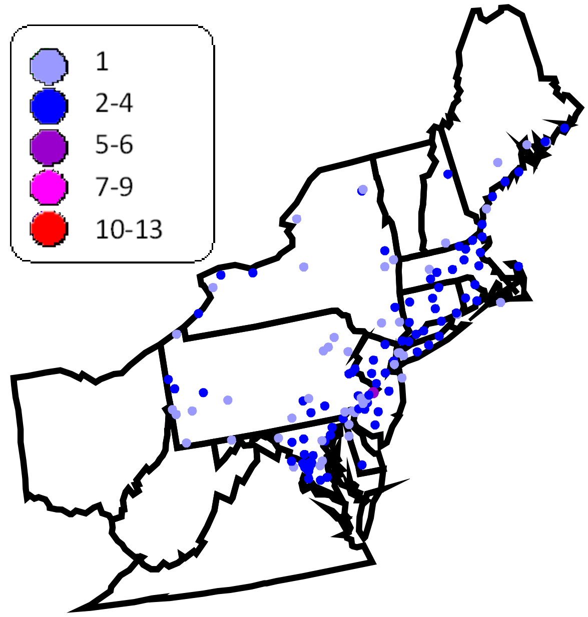


Figure 11-7: Monitored Ozone Data for Episode D (July 30-August 4, 2007)

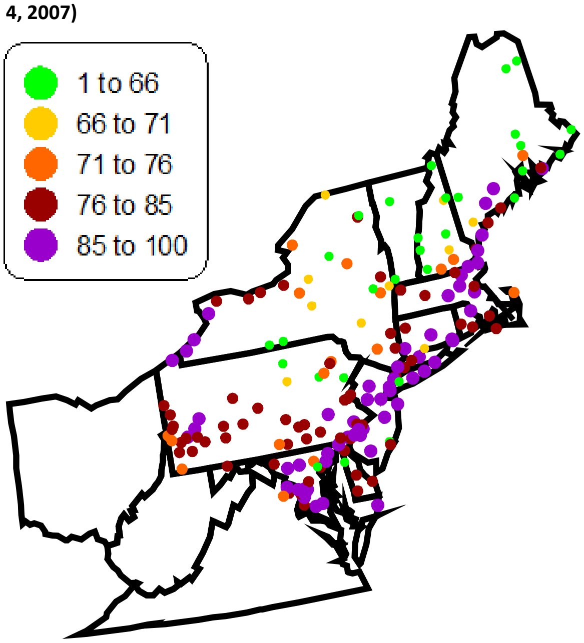
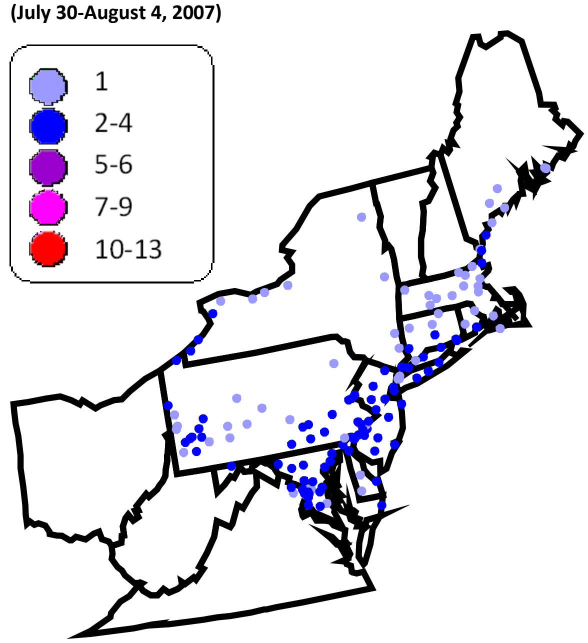


Figure 11-8: Number of Days with Ozone > 75ppb for Episode D (July 30-August 4, 2007)



Available Data Sets

The summer of 2011 has the benefit of being the best selection in regards to the third criteria since it corresponds with the time period studied by the DISCOVER-AQ project, which provides an additional wealth of data in regards to air quality than is otherwise available. Given the 2007 episodes do not have the corresponding data sets use of 2011 is preferable.

Additionally, the inventories available for use in 2011 are more recent, built upon the NEI, developed with more modern tools (e.g. MOVES 2014 rather than MOVES 2010), and are in formats that the states are now more accustomed to work with (e.g. ff10). These factors would benefit choosing Episode A or B.

Sufficient Time Span

It is important that there are enough days with high ozone that can be used when calculating relative reduction factors. When comparing the four episodes Episode B has a greater magnitude of exceedances in terms of both the number of monitor-days and the maximum number of violations at a given monitor. When looking at individual states there are a greater number of exceedances in New England save Connecticut in Episode C, but only one monitor is violating in those states so focusing on the states from Connecticut south is of greater importance in choosing episodes. Though as a whole Episode B is the most sufficient in terms of exceedances, none of the episodes seem to capture the meteorological conditions found during the 2013, 2014, and 2015 ozone season where exceedances were centered on the New York City nonattainment area rather than the Baltimore nonattainment area. Also Episode D is so short, only 5 days long, the additional trait of having days that lack exceedances are not met as well.

Table 11-2: Exceedances of 75ppb by state during episodes in the OTR

	CT	*DC*	*DE*	*MA*	*MD*	*ME*	*NH*	*NJ*	*NY*	*PA*	*RI*	*VT*	*VA*	*Total*
Monitor-Days Ep. A	20	7	17	4	66	1	0	50	30	63	3	0	12	***273***
Max Days/Monitor Ep. A	3	4	5	2	6	1	0	5	5	5	1	0	4	***6***
Monitor-Days Ep. B	41	10	22	19	90	4	5	54	43	79	5	1	17	***390***
Max Days/Monitor Ep. B	6	7	5	2	13	2	2	6	7	7	2	1	6	***13***
Monitor-Days Ep. C	29	6	5	28	38	14	7	25	34	51	8	0	20	***265***
Max Days/Monitor Ep. C	4	2	2	4	4	2	2	3	3	5	3	0	3	***5***
Monitor-Days Ep. D	21	5	11	15	40	9	4	33	36	68	4	0	19	***265***
Max Days/Monitor Ep. D	4	3	3	2	4	2	2	4	4	4	2	0	3	***4***

Meteorological Conditions

Several major airflows can play important role in creating the conditions for ozone exceedances to occur in the OTR; 1) over mountain interregional transport from sources in the Midwest, 2) multi-state transport from the nocturnal low level jet, and 3) local stagnation (Hudson et al. October 2006). Following the determination of which time periods were appropriate for analysis it was necessary to determine whether these time periods had an appropriate distribution of the different ozone conducive air flows. Selection of an episode that was not representative could have the effect of causing strategies needed to reduce ozone originating form a particular region going unrealized or strategies not being sufficient to overcome situations where all three transport regimes are acting in tandem.

To determine the appropriateness of the episodes in regards to air flows HySplit was employed to conduct back trajectory analyses for two monitors, Westport CT and Edgewood, MD, which have particularly persistent ozone problems. The trajectory analyses were conducted at X height level. Figure 11-9 to Figure 11-16 show the trajectory analyses for the four episodes for the two monitors, odd and even figures respectively. Three of the episodes were found to have the necessary airflows to result in sufficient analyses, whereas Episode D lacked a southerly air flow.

Figure 11-9: Wind trajectories of ozone (ppb) for Westport, CT monitor during Episode A (May 25-June 12, 2011)

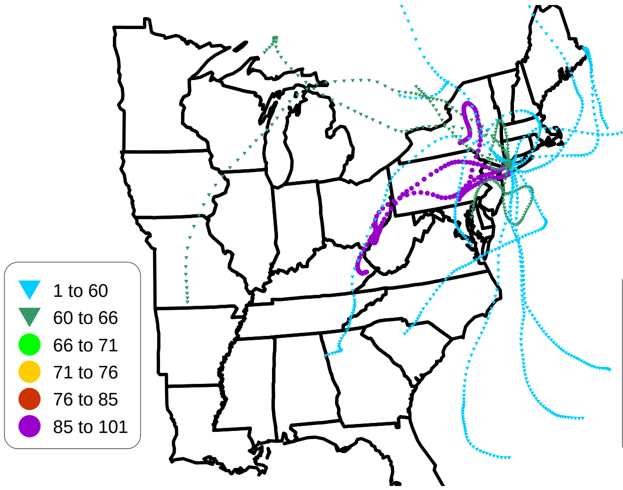


Figure 11-10: Wind trajectories of ozone (ppb) for Edgewood, MD monitor during Episode A (May 25-June 12, 2011)

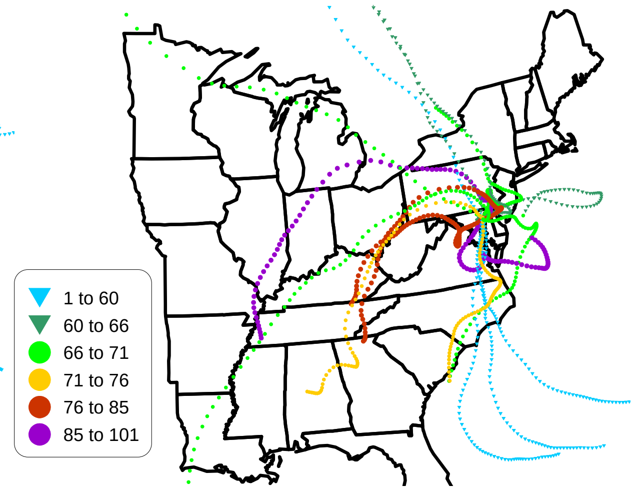


Figure 11-11: Wind trajectories of ozone (ppb) for Westport, CT monitor during Episode B (June 27-August 2, 2011)

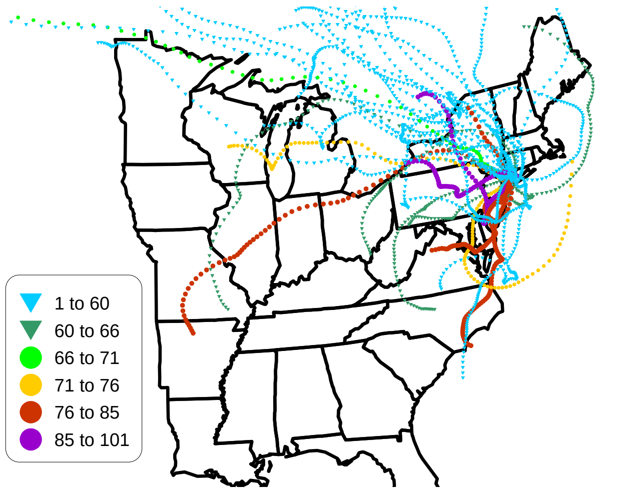


Figure 11-12: Wind trajectories of ozone (ppb) for Edgewood monitor during Episode B (June 27-August 2, 2011)

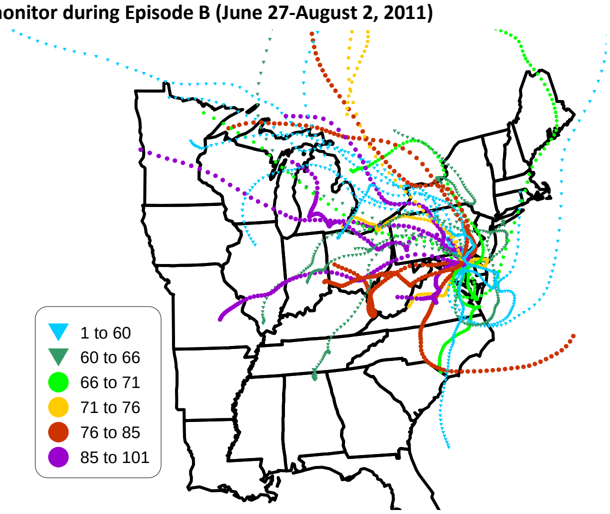


Figure 11-13: Wind trajectories of ozone (ppb) for Westport, CT monitor during Episode C (June 15-June 28, 2007)

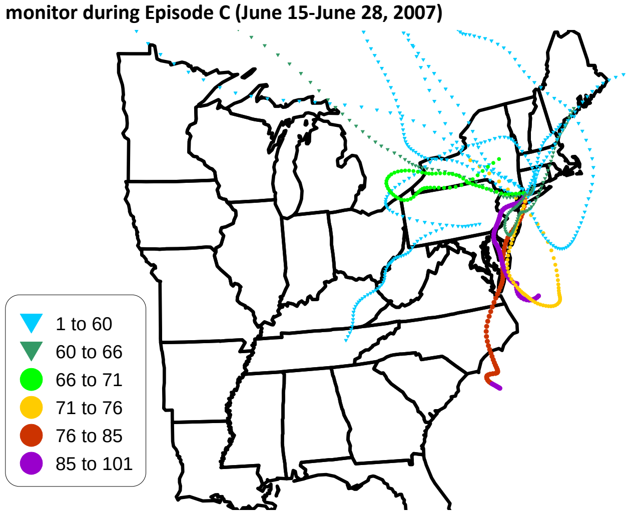


Figure 11-14: Wind trajectories of ozone (ppb) for Edgewood, MD monitor during Episode C (June 15-June 28, 2007)

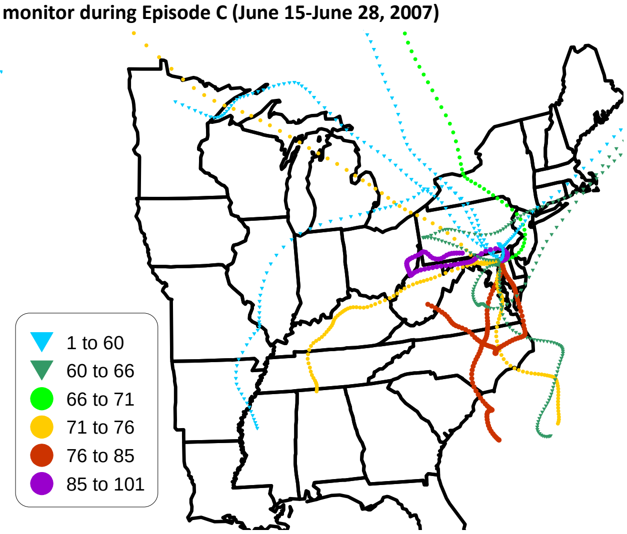


Figure 11-15: Wind trajectories of ozone (ppb) for Westport, CT monitor during Episode D (July 30-August 4, 2007)

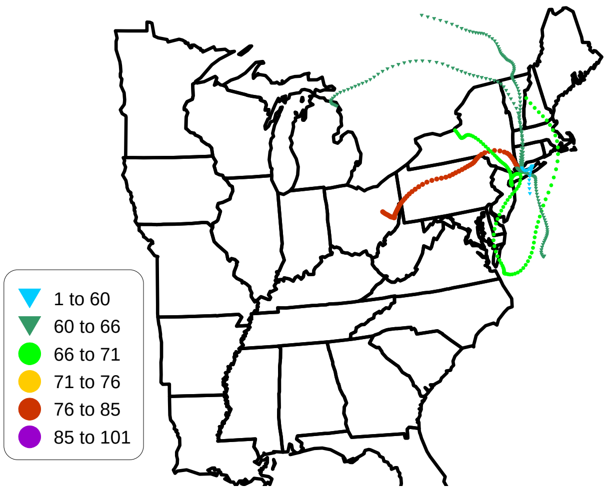
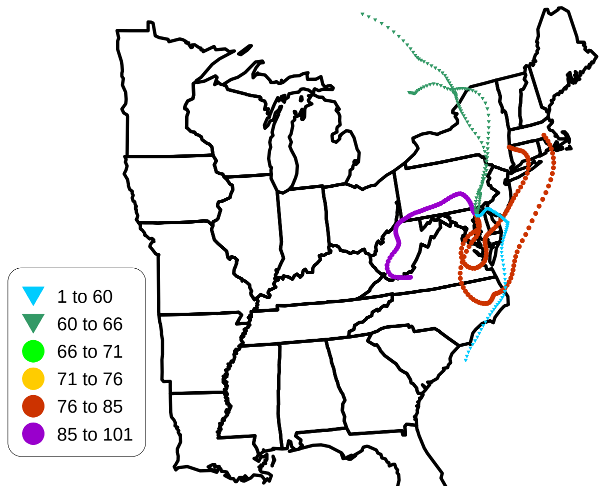


Figure 11-16: Wind trajectories of ozone (ppb) for Edgewood monitor during Episode D (July 30-August 4, 2007)



Summary

After examining each episode according to EPA's four criteria Episode B was selected. It occurred during the year for which better inventory data is available, contained a high number of exceedances as well as enough days without ozone exceedances, and a fair mix of meteorological conditions.

Modeling Platform

Model Selection

To ensure that a modeling study can be successfully used as technical support for an attainment demonstration SIP, the air quality model must be scientifically sound and appropriate for the intended application, and be freely accessible to all stakeholders. In a regulatory environment, it is crucial that oversight groups (e.g., EPA), the regulated community, and the interested public have access to and also be convinced of the suitability of the model. EPA in guidance cites the Community Multiscale Air Quality Model (CMAQ) and the CAMx as two appropriate photochemical models to use (US EPA 2014). OTC staff has prior experience using CMAQ, CMAQ is open source allowing for greater scrutiny, and comparisons during prior analyses have shown CMAQ to be superior when analyzing Ozone in the OTR. For these reasons we have chosen CMAQ to conduct our episodic analyses. Several other models are needed to provide inputs to the photochemical model including a meteorological model and an emission processing model. The full list of the models used in the analyses are in Table 11-3.

Table 11-3: Model versions used in OTC episodic modeling analyses

	Model and Version
Photochemical Model	CMAQ v. 5.0.2
Meteorological Model	WRF v. 3.4
Emissions Processing:	
Emissions Modeling System	SMOKE v. 3.5.1 (C3 Marine Emissions Processed with SMOKE v. 3.6)

Biogenic Emissions Model	BEIS v. 3.6
Mobile on-road Emissions	MOVES 2014
EGU Emission	ERTAC EGU v. 2.3

More details on the selection of the photochemical modeling platform for the OTC modeling platform can found in the OTC modeling protocol.

Emissions Inventory

When work began on episodic modeling the Alpha 2 inventory was used to supply emissions estimates. There were no changes made beyond the Alpha 2 for the episodic modeling runs. Details on the Alpha inventory are located in "Technical Support Document Emission Inventory Development for 2011, 2018, and 2028 for the Northeastern US Alpha 2 Version (McDill, McCusker and Sabo 2015)."

Monitor to Model Comparison

When comparing the modeled ozone values obtained from run that only contains the days in July (a slightly shorter period than the episode to be modeled) and the full ozone season there is good agreement between the results. Table 11-4, Figure 11-17, July only, compared to Figure 11-18, full ozone season, and Figure 11-19, July only, compared to Figure 11-20, full ozone season, show consistent results for both the 2011 and 2018 modeled results in design value calculations, though in both cases values are higher in the full ozone season, which would be expected since they are based on extreme (4^{th} high) rather than average values.

Table 11-4: Evaluation of Monitors in the OTR

	Count	***% Compared to Monitors with Base***
Monitors with Base Values	193	
Monitors with Future Values	159	83%
Monitors with > 5% differential	12	6%
Monitors with > 1% differential	58	30%

Figure 11-17: Comparison of 4th high 8-hour ozone from July only 2011 runs

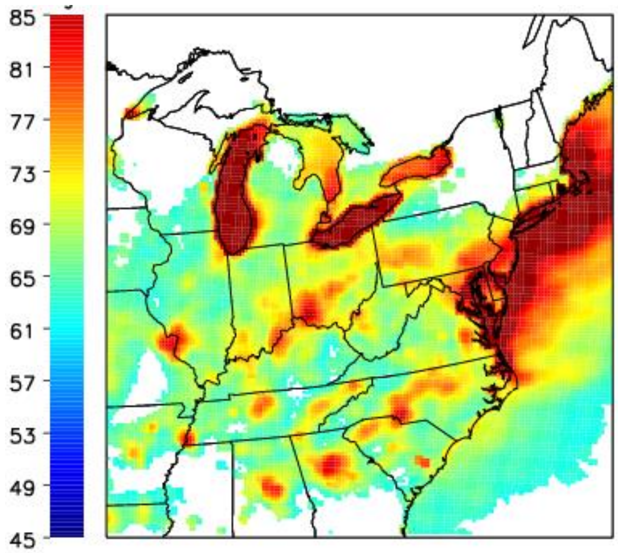


Figure 11-18: Comparison of 4th high 8-hour ozone from full ozone season 2011 runs

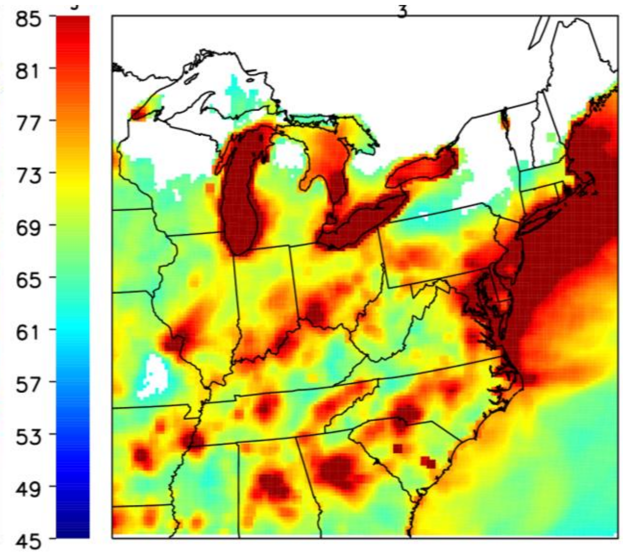


Figure 11-19: Comparison of 4th high 8-hour ozone from July only 2018 runs

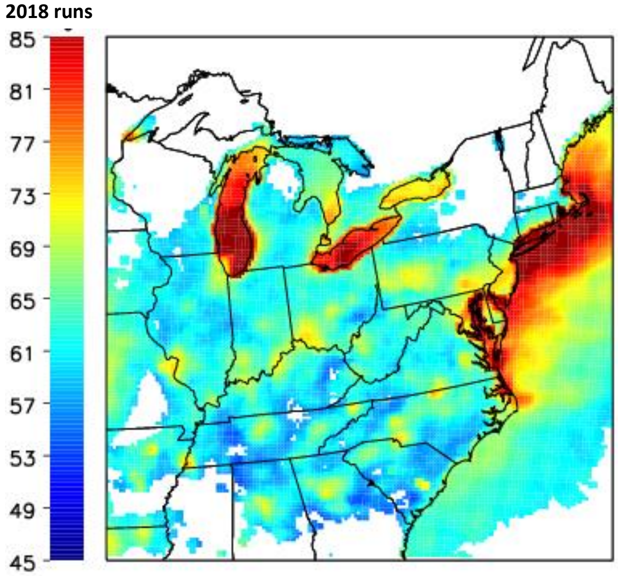
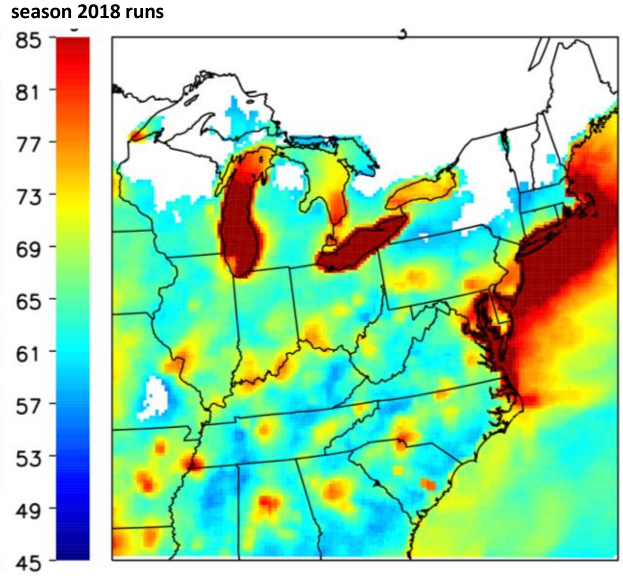


Figure 11-20: Comparison of 4th high 8-hour ozone from full ozone season 2018 runs



When you begin to examine the geographic span of monitors that have greater differential between the full ozone season and July run they are largely found along the Southern and coastal OTR, with the highest differentials along the coast as can be seen in Figure 11-21 and more clearly in Figure 11-22. Again this would be expected since these are the areas that are most likely to have higher ozone values in other months during the ozone season and that are no longer being considered in calculating RRFs.

Figure 11-21: Comparison of differences (2018 minus 2011) of 4th high 8-hour ozone from July only and full ozone season

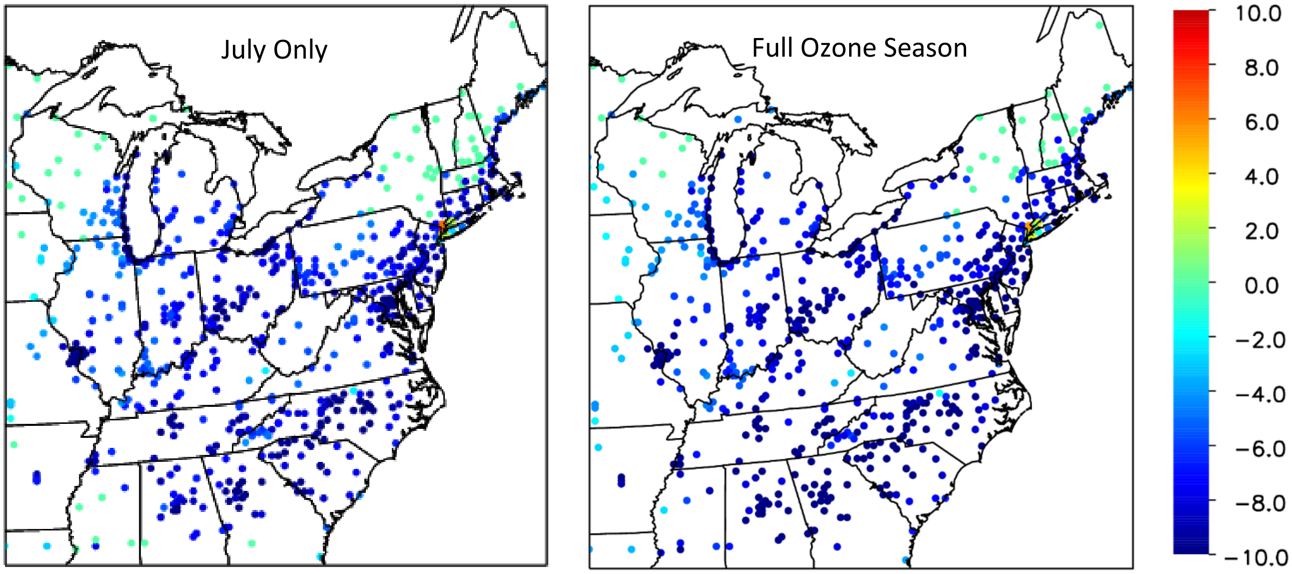
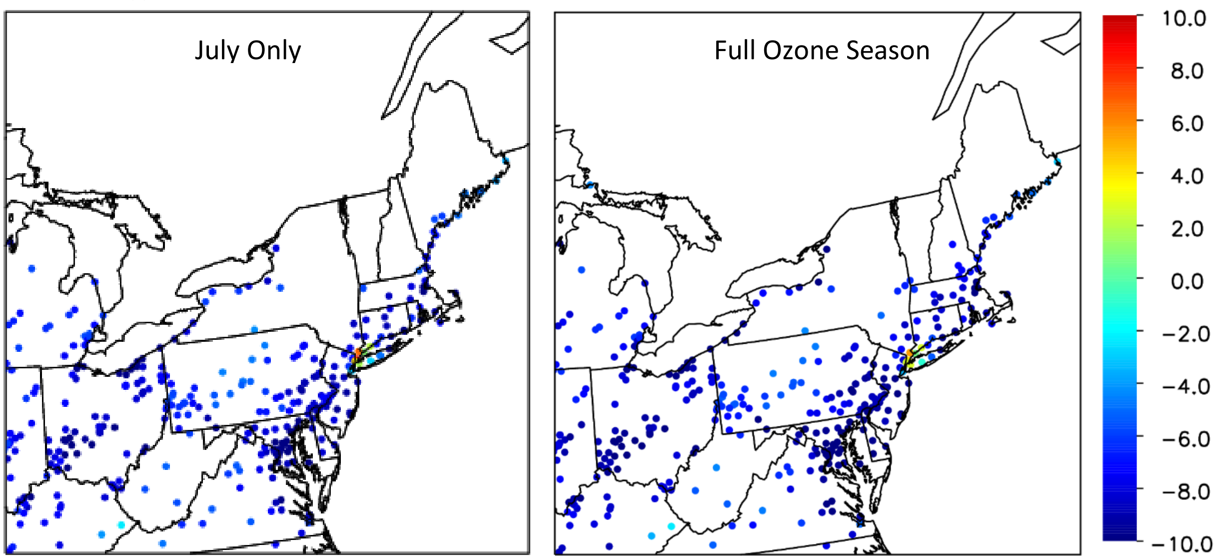


Figure 11-22: Comparison of differences (2018 minus 2011) of 4th high 8-hour ozone from July only and full ozone season (only differences greater than 0.5 ppb)



Protocol

When conducting episodic modeling runs nearly all of the procedures laid out in the OTC modeling protocol should be followed with some exceptions.

Given the shorter time period in question the recommended using the "ten highest modeled 8-hour average daily maximum ozone days" to calculate the RRF (US EPA 2014). However, this would result in nearly one third of all days being included in the calculation and would also likely include days that would not be included in a full ozone season analysis. Thus at least six maximum modeled 8-hour average daily maximum ozone days should be used when calculating RRF.

The modeling runs consisted of a two week spin up period prior to the actual July 1 – 31 episodic modeling run. More information concerning the air quality monitors is in Appendix C.

Table 11-5: Monitor comparison of 4th high 8-hour ozone from July only and full ozone season 2018 runs

State	AQS Code	DVC 2011	DV 2018 July Only	DV 2018 Ozone Season	Diff
CT	**90010017**	80.3	81.034	80.685	-0.349
	90011123	81.3	72.71	72.691	-0.019
	90013007	84.3	77.907	78.452	0.545
	90019003	83.7	85.379	85.602	0.223
	90031003	73.7	64.68	65.415	0.735
	90050005	70.3	61.648	62.902	1.254
	90070007	79.3	69.913	70.257	0.344
	90090027	74.3	68.771	69.849	1.078
	90099002	85.7	77.643	77.319	-0.324
	90110124	80.3	68.68	71.804	3.124
	90131001	75.3	66.485	66.797	0.312
DE	**100010002**	74.3	67.243	66.842	-0.401
	100031007	76.3	68.343	67.815	-0.528
	100031010	78	69.803	69.463	-0.34
	100031013	77.7	69.349	68.837	-0.512
	100032004	75	66.939	66.445	-0.494
	100051002	77.3	68.855	67.969	-0.886
	100051003	77.7	69.721	69.584	-0.137
DC	**110010041**	76	66.838	66.439	-0.399
	110010043	80.7	70.971	70.548	-0.423
ME	**230010014**	61	56.392	56.189	-0.203
	230031100	51.3	-999	-999	NA
	230052003	69.3	63.456	62.939	-0.517
	230090102	71.7	67.621	67.443	-0.178
	230090103	66.3	61.674	61.976	0.302
	230112005	62.7	-999	-999	NA
	230130004	67.7	63.319	62.902	-0.417
	230173001	54.3	-999	-999	NA
	230194008	57.7	-999	-999	NA
	230230006	61	56.283	56.124	-0.159
	230290019	58.3	55.227	54.849	-0.378
	230290032	53	49.992	50.516	0.524
	230310038	60.3	-999	-999	NA
	230310040	64.3	-999	-999	NA
	230312002	73.7	65.971	65.435	-0.536
MD	**240030014**	83	72.282	71.801	-0.481
	240051007	79	70.839	70.195	-0.644
	240053001	80.7	74.298	74.253	-0.045
	240090011	79.7	72.25	73.125	0.875
	240130001	76.3	68.337	66.945	-1.392
	240150003	83	74.618	73.984	-0.634
	240170010	79	70.401	70.232	-0.169
	240199991	75	67.297	67.238	-0.059
	240210037	76.3	68.071	67.169	-0.902
	240230002	72	61.729	60.884	-0.845
	240251001	90	82.131	81.223	-0.908
	240259001	79.3	70.702	70.266	-0.436
	240290002	78.7	70.546	69.287	-1.259

State	AQS Code	DVC 2011	DV 2018 July Only	DV 2018 Ozone Season	Diff
	240313001	75.7	66.522	66.226	-0.296
	240330030	79	68.366	68.156	-0.21
	240338003	82.3	71.777	71.463	-0.314
	240339991	80	69.564	69.317	-0.247
	240430009	72.7	64.268	63.015	-1.253
	245100054	73.7	67.471	67.953	0.482
MA	**250010002**	73	65.947	66.399	0.452
	250034002	69	62.671	62.134	-0.537
	250051002	74	66.958	67.307	0.349
	250070001	77	71.503	71.495	-0.008
	250092006	71	63.903	61.92	-1.983
	250094005	70	62.736	63.56	0.824
	250095005	69.3	63.658	62.581	-1.077
	250130008	73.7	-999	64.893	NA
	250150103	64.7	-999	57.466	NA
	250154002	71.3	62.625	62.259	-0.366
	250170009	67.3	-999	59.921	NA
	250171102	67	59.281	59.053	-0.228
	250213003	72.3	63.731	63.421	-0.31
	250250041	68.3	60.061	59.053	-1.008
	250250042	60.7	53.484	53.21	-0.274
	250270015	68.3	-999	60.426	NA
	250270024	69	60.612	60.41	-0.202
NH	**330012004**	62.3	-999	55.588	NA
	330050007	62.3	-999	-999	NA
	330074001	69.3	-999	-999	NA
	330074002	59.7	-999	-999	NA
	330090010	59.7	-999	-999	NA
	330111011	66.3	-999	58.849	NA
	330115001	69	-999	-999	NA
	330131007	64.7	-999	-999	NA
	330150014	66	59.415	60.786	1.371
	330150016	66.3	59.685	61.063	1.378
	330150018	68	-999	60.802	NA
NJ	**340010006**	74.3	66.127	67.387	1.26
	340030006	77	69.733	68.889	-0.844
	340071001	82.7	73.005	73.557	0.552
	340110007	72	64.716	64.543	-0.173
	340130003	78	71.508	70.249	-1.259
	340150002	84.3	75.284	75.27	-0.014
	340170006	77	71.082	70.64	-0.442
	340190001	78	69.105	68.442	-0.663
	340210005	78.3	69.778	69.481	-0.297
	340219991	76	67.41	67.432	0.022
	340230011	81.3	72.332	71.845	-0.487
	340250005	80	71.841	71.981	0.14
	340273001	76.3	67.585	67.386	-0.199
	340290006	82	72.874	71.9	-0.974
	340315001	73.3	65.293	66.913	1.62
	340410007	66	58.049	57.581	-0.468
NY	**360010012**	68	-999	61.286	NA
	360050133	74	79.849	76.649	-3.2
	360130006	73.3	66.032	65.967	-0.065
	360130011	74	66.808	66.161	-0.647
	360150003	66.5	-999	-999	NA
	360270007	72	62.813	63.434	0.621

State	AQS Code	DVC 2011	DV 2018 July Only	DV 2018 Ozone Season	Diff
	360290002	71.3	65.728	64.988	-0.74
	360310002	70.3	-999	-999	NA
	360310003	67.3	-999	-999	NA
	360337003	45	-999	-999	NA
	360410005	66	-999	-999	NA
	360430005	62	-999	-999	NA
	360450002	71.7	64.116	62.405	-1.711
	360530006	67	-999	-999	NA
	360610135	73.3	76.408	75.048	-1.36
	360631006	72.3	66.165	65.816	-0.349
	360650004	61.5	-999	-999	NA
	360671015	69.3	63.307	62.962	-0.345
	360715001	67	-999	59.979	NA
	360750003	68	60.928	59.592	-1.336
	360790005	70	61.868	61.867	-0.001
	360810124	78	79.322	79.877	0.555
	360830004	67	-999	60.12	NA
	360850067	81.3	78.321	78.317	-0.004
	360870005	75	66.758	67.648	0.89
	360910004	67	-999	-999	NA
	361010003	65.3	60.963	60.723	-0.24
	361030002	83.3	81.147	82.656	1.509
	361030004	78	71.541	71.143	-0.398
	361030009	78.7	74.622	74.572	-0.05
	361111005	69	-999	63.663	NA
	361173001	65	58.222	57.513	-0.709
	361192004	75.3	80.265	79.146	-1.119
PA	**420030008**	76.3	70.151	70.966	0.815
	420030010	73.7	67.761	68.548	0.787
	420030067	75.7	69.17	69.108	-0.062
	420031005	80.7	73.668	73.61	-0.058
	420050001	74.3	67.523	68.137	0.614
	420070002	70.7	64.915	65.082	0.167
	420070005	74.7	69.157	69.437	0.28
	420070014	72.3	66.566	66.864	0.298
	420110006	71.7	63.259	62.976	-0.283
	420110011	76.3	67.191	66.521	-0.67
	420130801	72.7	67.622	67.5	-0.122
	420170012	80.3	71.503	71.116	-0.387
	420210011	70.3	65.447	65.594	0.147
	420270100	71	66.19	65.723	-0.467
	420279991	72	66.653	66.527	-0.126
	420290100	76.3	68.279	68.571	0.292
	420334000	72.3	67.66	67.58	-0.08
	420430401	69	62.368	62.243	-0.125
	420431100	74.7	67.377	66.67	-0.707
	420450002	75.7	67.978	67.573	-0.405
	420490003	74	65.697	65.875	0.178
	420550001	67	60.534	60.071	-0.463
	420590002	69	60.955	61.877	0.922
	420630004	75.7	70.174	69.836	-0.338
	420690101	71	63.517	62.911	-0.606
	420692006	68.7	61.459	60.873	-0.586
	420710007	77	70.214	70.077	-0.137
	420710012	78	70.247	70.555	0.308
	420730015	71	64.039	64.709	0.67

State	AQS Code	DVC 2011	DV 2018 July Only	DV 2018 Ozone Season	Diff
	420750100	76	67.564	67.277	-0.287
	420770004	76	66.909	66.727	-0.182
	420791100	65	58.146	57.156	-0.99
	420791101	64.3	57.46	56.35	-1.11
	420810100	67	60.441	60.133	-0.308
	420850100	76.3	68.463	67.847	-0.616
	420890002	66.7	59.088	58.593	-0.495
	420910013	76.3	68.378	68.141	-0.237
	420950025	76	66.935	66.778	-0.157
	420958000	69.7	61.621	61.599	-0.022
	420990301	68.3	62.277	62.469	0.192
	421010004	66	59.739	59.358	-0.381
	421010024	83.3	75.076	74.66	-0.416
	421011002	80	72.102	71.702	-0.4
	421119991	65	56.723	55.845	-0.878
	421174000	69.7	64.731	64.668	-0.063
	421250005	70	63.416	63.296	-0.12
	421250200	70.7	63.744	63.539	-0.205
	421255001	70.3	63.883	64.289	0.406
	421290006	71.7	64.732	65.446	0.714
	421290008	71	63.148	64.008	0.86
	421330008	72.3	66.991	66.132	-0.859
	421330011	74.3	67.582	67.503	-0.079
RI	**440030002**	73.7	67.261	66.734	-0.527
	440071010	74	67.994	67.339	-0.655
	440090007	76.3	69.022	69.001	-0.021
VT	**500030004**	63.7	-999	57.308	NA
	500070007	61	-999	-999	NA
VA-OTR	**510130020**	81.7	72.35	71.886	-0.464
	510590030	82.3	72.82	72.065	-0.755
	511071005	73	65.663	64.914	-0.749
	511530009	70	62.617	62.726	0.109
	515100009	80	70.794	70.092	-0.702

References

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US EPA 2014, 'Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze', accessed from <https://www3.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf>.

Appendix A. Model Evaluation Statistic Formulae

The statistical formulations that have been computed for each species are as follows:

P_i and O_i are the individual (daily maximum 8-hour ozone or daily average for the other species) predicted and observed concentrations respectively, $\overline{P}$ and $\overline{O}$ are the average concentrations, respectively, and N is the sample size.

Observed average, in ppb:

$$\overline{O} = \frac{1}{N}\sum O_i$$

Predicted average, in ppb (only use P_i when O_i is valid):

$$\overline{P} = \frac{1}{N}\sum P_i$$

Correlation coefficient, R^2:

$$R^2 = \frac{\left[\sum (P_i - \overline{P})(O_i - \overline{O})\right]^2}{\sum (P_i - \overline{P})^2 \sum (O_i - \overline{O})^2}$$

Normalized mean error (NME), in %:

$$NME = \frac{\sum |P_i - O_i|}{\sum O_i} \times 100\%$$

Root mean square error (RMSE), in ppb:

$$RMSE = \left[\frac{1}{N}\sum (P_i - O_i)^2\right]^{1/2}$$

Fractional error (FE), in %:

$$FE = \frac{2}{N}\sum \left|\frac{P_i - O_i}{P_i + O_i}\right| \times 100\%$$

Mean absolute gross error (MAGE), in ppb:

$$MAGE = \frac{1}{N}\sum \left|P_i - O_i\right|$$

Mean normalized gross error (MNGE), in %:

$$MNGE = \frac{1}{N}\sum \frac{\left|P_i - O_i\right|}{O_i} \times 100\%$$

Mean bias (MB), in ppb:

$$MB = \frac{1}{N}\sum (P_i - O_i)$$

Mean normalized bias (MNB), in %:

$$MNB = \frac{1}{N}\sum \frac{(P_i - O_i)}{O_i} \times 100\%$$

Mean fractionalized bias (MFB), in %:

$$MFB = \frac{2}{N}\sum \left[\frac{P_i - O_i}{P_i + O_i}\right] \times 100\%$$

Normalized mean bias (NMB), in %:

$$NMB = \frac{\sum (P_i - O_i)}{\sum O_i} \times 100\%$$

Appendix B. Emissions Inventory Files

Emission Inventories

This section lists the emission inventory sectors with a compilation of all of the SMOKE input files in the EMF system, in FF10 or ORL format, that were used for developing model ready emission files, for the Alpha, Alpha 2, and Beta, Beta 2 inventories for the base year of 2011 and the projected years of 2018, 2028, and 2017.

Agricultural

- 2011
    - Alpha, Alpha 2:
      ag_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
      Prepared by EPA, uploaded to MARAMA EMF on November 13, 2014.
    - Beta, Beta 2:
      ag_2011NEIv2_NONPOINT_20141108_04feb2015_v3
      Prepared by EPA, uploaded to MARAMA EMF on February 4, 2015.
- 2017
    - Beta, Beta 2:
      2017_NONPOINT_ag_28jun2016
      Prepared by MARAMA, uploaded to MARAMA EMF on June 28, 2016.
- 2018
    - Alpha, Alpha 2:
      MARAMA_Alpha_2018_ag_2011NEIv2_NONPOINT_20141108_11nov2014_v0_csv_v0_14jan2015_nf_v1
      Prepared by MARAMA, uploaded to MARAMA EMF on January 14, 2015.
- 2028
    - Alpha 2:
      MARAMA_Alpha_2028_ag_2011NEIv2_NONPOINT_20141108_11nov2014_v0
      Prepared by MARAMA, uploaded to MARAMA EMF on August 20, 2015.

Agricultural Fugitive Dust

- 2011
    - Alpha, Alpha 2, Beta, Beta 2:
      afdust_2011NEIv2_NONPOINT_20141108_11nov2014_v1.csv
      EPA_2011_afdust_no_precipadj_paved_unpaved_noNEIv2RPOstates_23sep2014_v0.csv
      Prepared by EPA, uploaded to MARAMA EMF on November 13, 2014 and September 28, 2014, respectively.
- 2017
    - Beta, Beta 2:
      2017_NONPOINT_afdust_unadj_RPOstates_paved_unpaved_28jun2016
      2017_NONPOINT_afdust_unadj_NEI_28jun2016
      Prepared by MARAMA, uploaded to MARAMA EMF on June 28, 2016.
- 2018
    - Alpha, Alpha 2:
      MARAMA_Alpha_2018_afdust_2011NEIv2_NONPOINT_20141108_11nov2014_v1
      MARAMA_Alpha_2018_EPA_2011_afdust_no_precipadj_paved_unpaved_noNEIv2RPOstates_23sep2014_v0_csv_v0_20jan2015_nf_v1
      Prepared by MARAMA, uploaded to MARAMA EMF on August 25, 2015 and January 20, 2015, respectively.
- 2028
    - Alpha 2:
      MARAMA_Alpha_2028_afdust_2011NEIv2_NONPOINT_20141108_11nov2014_v1
      MARAMA_Alpha_2028_EPA_2011_afdust_no_precipadj_paved_unpaved_noNEIv2RPOstates_23sep2014_v0
      Prepared by MARAMA, uploaded to MARAMA EMF on August 20, 2015.

Area Source

- 2011
  - Alpha, Alpha 2:
    nonpt_2011NEIv2_NONPOINT_20141108_11nov2014_v1.csv
    pfc_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    agburn_monthly_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    Prepared by EPA, uploaded to MARAMA EMF on November 13, 2014.
  - Beta, Beta 2:
    nonpt_2011NEIv2_NONPOINT_20141108_21jan2015_v5_MARAMA
    pfc_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    agburn_monthly_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    Prepared by EPA and MARAMA, uploaded to MARAMA EMF on September 9, 2015, November 13, 2014 and November 13, 2014, respectively.
- 2017
  - Beta, Beta 2:
    2017_NONPOINT_nonpt_29jun2016
    2017_NONPOINT_pfc_29jun2016
    agburn_monthly_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    cement_newkilns_year_2018_from_ISIS2013_NEI2011v1_NONPOINT_12feb2015_v1_MARAMA
    2017_cellulosic_inventory_06jan2014_v1_MARAMA
    2017_cellulosic_new_Iowa_plants_from2018docket_2011v6_2_ff10_28jan2015_v0
    Prepared by MARAMA, uploaded to MARAMA EMF on June 29, 2016, June, 29, 2016, November 13, 2014, February 25, 2016, and February 25, 2016, respectively.
- 2018
  - Alpha, Alpha 2:
    MARAMA_Alpha_2018_nonpt_2011NEIv2_NONPOINT_20141108_11nov2014_v1_csv_v0_21jan2015_nf_v1
    MARAMA_Alpha_2018_pfc_2011NEIv2_NONPOINT_20141108_11nov2014_v0_csv_21jan2015_nf_v1
    MARAMA_Alpha_2018_agburn_monthly_2011NEIv2_NONPOINT_20141108_11nov2014_v0_csv_v0_20jan2015_nf_v1
    Prepared by MARAMA, uploaded to MARAMA EMF on January 20, 2015.
- 2028
  - Alpha 2:
    MARAMA_Alpha_2028_nonpt_2011NEIv2_NONPOINT_20141108_11nov2014_v1
    MARAMA_Alpha_2028_pfc_2011NEIv2_NONPOINT_20141108_11nov2014_v0
    MARAMA_Alpha_2028_agburn_monthly_2011NEIv2_NONPOINT_20141108_11nov2014_v0
    cement_newkilns_year_2025_from_ISIS2013_NEI2011v1_NONPOINT_12feb2015_v1_MARAMA
    2018_cellulosic_inventory_06jan2014_v1_19nov2015_nf_v1_MARAMA
    Cellulosic_new_Iowa_plants_from2018docket_2011v6_2_ff10_28jan2015_v0
    Prepared by MARAMA, uploaded to MARAMA EMF on August 20, 2015, August 20, 2015, August 20, 2015, November 19, 2015, November 19, 2015, and March 17, 2015 respectively.

Biogenics

- 2011, 2018, 2028, 2017
  - Alpha, Alpha 2:
    biogenic_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    Prepared by EPA, uploaded to MARAMA EMF on November 13, 2014.
  - Beta, Beta 2:
    biogenic_2011ek_BEIS3_61_BELD4_1_08sep2016.csv
    Prepared by EPA, uploaded to MARAMA EMF on September 6, 2016.

C1/C2 Marine and Rail

- 2011
  - Alpha, Alpha 2, Beta, Beta 2:
    c1c2_offshore_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    c1c2rail_2011NEIv2_NONPOINT_20141108_11nov2014_v1.csv
    Prepared by EPA, uploaded to MARAMA EMF on November 13, 2014.

- 2017
    - Beta, Beta 2:
      2017_NONPOINT_c1c2rail_27jun2016
      2017_NONPOINT_c1c2offshore_06may2016.csv
      Prepared by MARAMA, uploaded to MARAMA EMF on June 27, 2016 and May 6, 2016, respectively.
- 2018
    - Alpha, Alpha 2:
      MARAMA_Alpha_2018_c1c2_offshore_2011NEIv2_NONPOINT_20141108_11nov2014_v0_csv_v0_20jan2015_v0
      MARAMA_Alpha_2018_c1c2rail_2011NEIv2_NONPOINT_20141108_11nov2014_v1_csv_v0_20jan2015_nf_v1
      Prepared by MARAMA, uploaded to MARAMA EMF on January 20, 2015 and June 9, 2015, respectively.
- 2028
    - Alpha 2:
      MARAMA_Alpha_2028_c1c2_offshore_2011NEIv2_NONPOINT_20141108_11nov2014_v0
      MARAMA_Alpha_2028_c1c2rail_2011NEIv2_NONPOINT_20141108_11nov2014_v1
      Prepared by MARAMA, uploaded to MARAMA EMF on August 19, 2015 and August 20, 2015, respectively.

C3 Marine

- 2011
    - Alpha:
      c3marine_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
      c3_offshore_2011NEIv2_NONPOINT_20141108_11no v2014_v0.csv
      Prepared by EPA, uploaded to MARAMA EMF on November 13, 2014.
    - Alpha 2, Beta, Beta 2:
      c3marine_2011NEIv2_NONPOINT_20141108_14nov2014_v1.csv
      eca_imo_nonUS_nonCANADA_caps_vochaps_2011_16jun2015_v1_orl_MARAMA.txt
      Prepared by EPA, uploaded to MARAMA EMF on January 2, 2015 and June 30, 2015 respectively.
- 2017
    - Beta, Beta 2:
      2017_NONPOINT_c3marine_28jun2016
      2017eh_from_eca_imo_nonUS_nonCANADA_caps_vochaps_2011_25feb2015_v0_orl_MARAMA.txt
      Prepared by MARAMA and EPA, respectively, uploaded to MARAMA EMF on June 28, 2016 and August 9, 2016, respectively.
- 2018
    - Alpha, Alpha 2:
      MARAMA_Alpha_2018_c3marine_2011NEIv2_NONPOINT_20141108_14nov2014_v1_csv
      eca_imo_nonUS_nonCANADA_caps_vochaps_2018_04dec2013_v0
      Prepared by MARAMA and EPA, respectively, uploaded to MARAMA EMF on June 24, 2015 and December 18, 2013, respectively.
- 2028
    - Alpha 2:
      MARAMA_Alpha_2028_c3marine_2011NEIv2_NONPOINT_20141108_14nov2014_v1
      eca_imo_nonUS_nonCANADA_caps_haps_2025_07mar2014_v0
      Prepared by MARAMA and EPA, respectively, uploaded to MARAMA EMF on August 20, 2015 and November 20, 2014, respectively.

ERTAC EGUs

- 2011
    - Alpha, Alpha 2:
        - Annual Files: *OTC_2011_ERTACEGUv23_150227_MENHVTMARICTNYNJDEPAMDDCVA.csv*
          SESARM_2011_ERTACEGUv23_150227_WVNCSCGAKYTNALMS.csv
          LADCO_2011_ERTACEGUv23_150227_MIOHINILWIMN.csv
          CenSARA_2011_ERTACEGUv23_150227_TXOKNEKSIAARLAMO.csv
          Prepared by ERTAC and OTC, uploaded to MARAMA EMF on February 27, 2015.
        - Hourly Files:
          Prepared by ERTAC and OTC, not uploaded to the MARAMA EMF system due to size
    - Beta, Beta 2:

        - Annual Files: *OTC_2011_ERTACEGUv25_20160607_MENHVTMARICTNYNJDEPAMDDCVA.csv*
          SESARM_2011_ERTACEGUv25_20160607_WVNCSCGAKYTNALMS.csv
          LADCO_2011_ERTACEGUv25_20160607_MIOHINILWIMN.csv
          CenSARA_2011_ERTACEGUv25_20160607_TXOKNEKSIAARLAMO.csv
          Prepared by ERTAC and OTC, uploaded to MARAMA EMF on June 7, 2016.
        - Hourly Files:
          Prepared by ERTAC and OTC, not uploaded to the MARAMA EMF system due to size.

- 2017
    - Beta:
        - Annual Files: *OTC_2017_ERTACEGUv25_20160707_MENHVTMARICTNYNJDEPAMDDCVA.csv*
          SESARM_2017_ERTACEGUv25_20160707_WVNCSCGAFLKYTNALMS_2018.csv
          LADCO_2017_ERTACEGUv25_20160707_MIOHINILWIMN.csv
          CenSARA_2017_ERTACEGUv25_20160707_TXOKNEKSIAARLAMO.csv
          Prepared by ERTAC and OTC, uploaded to MARAMA EMF on July 13, 2016.
        - Hourly Files:
          Prepared by ERTAC and OTC, not uploaded to the MARAMA EMF system due to size.
    - Beta 2:
        - Annual Files:
          OTC_2017_ERTACEGUv25L2_20160919_MENHVTMARICTNYNJDEPAMDDCVA
          SESARM_2017_ERTACEGUv25L2_20160919_WVNCSCGAKYTNALMS
          LADCO_2017_ERTACEGUv25L2_20160919_MIOHINILWIMN
          CENSARA_2017_ERTACEGUv25L2_20160919_TXOKNEKSIAARLAMO
          Prepared by ERTAC and OTC, uploaded to MARAMA EMF on September 22, 2016.
        - Hourly Files:
          Prepared by ERTAC and OTC, not uploaded to the MARAMA EMF system due to size.
- 2018
    - Alpha, Alpha 2:
        - Annual Files: *OTC_2018_ERTACEGUv23_150227_MENHVTMARICTNYNJDEPAMDDCVA.csv*
          SESARM_2018_ERTACEGUv23_150227_WVNCSCGAFLKYTNALMS_2018.csv
          LADCO_2018_ERTACEGUv23_150227_MIOHINILWIMN.csv
          CenSARA_2018_ERTACEGUv23_150227_TXOKNEKSIAARLAMO.csv
          Prepared by ERTAC and OTC, uploaded to MARAMA EMF on April 2, 2015.
        - Hourly Files:
          Prepared by ERTAC and OTC, not uploaded to the MARAMA EMF system due to size.
- 2028
    - Alpha 2:
        - Annual Files: *OTC_2028_ERTACEGUv23_150611_MENHVTMARICTNYNJDEPAMDDCVA.csv*
          SESARM_2028_ERTACEGUv23_150611_WVNCSCGAFLKYTNALMS.csv
          LADCO_2028_ERTACEGUv23_150611_MIOHINILWIMN.csv
          CenSARA_2028_ERTACEGUv23_150611_TXOKNEKSIAARLAMO.csv
          Prepared by ERTAC and OTC, uploaded to MARAMA EMF on July 8, 2015.
        - Hourly Files:
          Prepared by ERTAC and OTC, not uploaded to the MARAMA EMF system due to size.

Non-EGU Point

- 2011
    - Alpha, Alpha 2:
      MARAMA_Alpha_ptnonipm_2011NEIv2_POINT_20140913_revised_20141007_08oct2014_nf_v1_csv_23oct2014_v0
      Ethanol_plants_2011_OTAQ_17oct2014_v6.csv
      Prepared by EPA and OTC, uploaded to MARAMA EMF on December 11, 2014 and November 13, 2014, respectively.
    - Beta, Beta 2:
        - Annual Files:
          ptnonipm_2011NEIv2_POINT_20140913_revised_20150115_09feb2015_v2_MARAMA.csv
          ethanol_plants_2011NEIv2_POINT_20141123_03feb2015_v1
          Prepared by EPA and MARAMA, uploaded to MARAMA EMF on December 23, 2015 and February 3, 2015, respectively.

        - Hourly Files:
          Prepared by MDE, not uploaded to the MARAMA EMF system due to size.
- 2017
    - Beta, Beta 2:
        - Annual Files:
          2017_POINT_ptnonipm_25jul2016
          Biodiesel_Plants_2018_ff10_11apr2013_v0.csv
          MARAMA_Beta_2017_cement_newkilns_year_2018_from_ISIS2013_NEI2011v1_17mar2015_v2
          2017eh_from_ethanol_plants_2011NEIv2_POINT_20141123_10mar2015_v0_MARAMA
          Prepared by MARAMA, uploaded to MARAMA EMF on July 25, 2016, February 20, 2016, September 14, 2015 and April 23, 2016 respectively.
        - Hourly Files:
          Prepared by MDE, not uploaded to the MARAMA EMF system due to size.
- 2018
    - Alpha, Alpha 2:
      MARAMA_Alpha_2018_MARAMA_Alpha_ptnonipm_2011NEIv2_POINT_20140913_revised_20141007_08oct2014_nf_v1_csv_23oct2014_v0_mar_v0_01feb2015_nf_v1
      MARAMA_Alpha_2018_Ethanol_plants_2011_OTAQ_17oct2014_v6_csv_06nov2014_v0_v0_01feb2015_nf_v1
      Prepared by MARAMA, uploaded to MARAMA EMF on February 1, 2015.
- 2028
    - Alpha 2:
      MARAMA_Alpha_2028_ptnonipm_2011NEIv2_POINT_20140913_revised_20141007_08oct2014_nf_v1
      Biodiesel_Plants_2018_ff10_11apr2013_v0

      cement_newkilns_year_2025_from_ISIS2013_NEI2011v1_30jan2015_v1
      MARAMA_Alpha_2028_Ethanol_plants_2011_OTAQ_17oct2014_v6
      The first file was prepared by MARAMA and the remainder by EPA, uploaded to MARAMA EMF on October 23, 2015, March 17, 2015, November 19, 2015, and August 21, 2015, respectively.

Non-ERTAC IPM EGUs

- 2011
    - Alpha, Alpha 2:
      MARAMA_Alpha_output_for_NEI_smallEGUpt_from_NEI_EGU_.csv
      Prepared by EPA and OTC, uploaded to MARAMA EMF on December 11, 2014.
    - Beta, Beta 2:
        - Annual Files:
          ptnonERTAC_ipm_2011NEIv2_20160512.csv
          Prepared by EPA and OTC, uploaded to MARAMA EMF onMay 12, 2016.
        - Hourly Files:
          Prepared by MDE, not uploaded to the MARAMA EMF system due to size.
- 2017
    - Beta, Beta 2:
        - Annual Files:
        2017_POINT_PTNONERTAC_IPM_20jun2016
        Prepared by MARAMA, uploaded to MARAMA EMF on June 20, 2016.
        - Hourly Files:
          Prepared by MDE, not uploaded to the MARAMA EMF system due to size.

- 2018
    - Alpha, Alpha 2:
      MARAMA_Alpha_2018_MARAMA_Alpha_output_for_NEI_smallEGUpt_from_NEI_EGU__csv_v0_01feb2015_nf_v1
      Prepared by MARAMA, uploaded to MARAMA EMF on February 1, 2015.
- 2028
    - Alpha 2:
      MARAMA_Alpha_2028_output_for_NEI_smallEGUpt_from_NEI_EGU_v0
      Prepared by MARAMA, uploaded to MARAMA EMF on October 23, 2015.

NonPoint Oil &Gas

- 2011
  - Alpha, Alpha 2, Beta, Beta 2:
    np_oilgas_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    Prepared by EPA, uploaded to MARAMA EMF on November 13, 2014.
- 2017
  - Beta, Beta 2:
    2017_NONPOINT_oilgas_15jul2016
    Prepared by MARAMA, uploaded to MARAMA EMF on July 15, 2015.
- 2018
  - Alpha, Alpha 2:
    MARAMA_Alpha_2018_np_oilgas_2011NEIv2_NONPOINT_20141108_11nov2014_v0_csv_v0_21jan2015_nf_v1
    Prepared by MARAMA, uploaded to MARAMA EMF on January 21, 2015.
- 2028
  - Alpha 2:
    MARAMA_Alpha_2028_np_oilgas_2011NEIv2_NONPOINT_20141108_11nov2014_v0
    Prepared by MARAMA, uploaded to MARAMA EMF on August 20, 2015.

Nonroad

- 2011
  - Alpha, Alpha 2:
    2011NEIv1_nonroad_20130621_04sep2013_v4.csv
    Prepared by EPA, uploaded to MARAMA EMF on March 2, 2014.
  - Beta, Beta 2:
    2011NEIv1_nonroad_20130621_17oct2014_v6_MARAMA
    Prepared by EPA, uploaded to MARAMA EMF on January 8, 2016.
- 2017
  - Beta, Beta 2:
    2017_nonroad_ff10_adjusted_from_2018_noCalif_23mar2015_v0_MARAMA
    Prepared by EPA, uploaded to MARAMA EMF on June 9, 2016.
- 2018
  - Alpha, Alpha 2:
    2018_nonroad_20130829_30oct2013_v2.csv
    Prepared by EPA, uploaded to MARAMA EMF on March 5, 2014.
- 2028
  - Alpha 2:
    2028_from_NEI2025_nonroad_ff10_NCD20130831_23feb2015_v3_MARAMA
    Prepared by EPA, uploaded to MARAMA EMF on October 19, 2015.

Onroad

- 2011
  - Alpha, Alpha 2:
    2011eh_onroad_SMOKE_MOVES_MOVES2014_no_speciated_pm_MARAMA
    Prepared by EPA, uploaded to MARAMA EMF on October 6, 2015.
- 2017
  - Beta, Beta 2:
    MOVES2014a_ONROAD_EPA2017ek_FF10
    Prepared by EPA, uploaded to MARAMA EMF on July 5, 2016.
- 2018
  - Alpha, Alpha 2:
    2018eh_onroad_SMOKE_MOVES_MOVES2014_no_speciated_pm_MARAMA
    Prepared by EPA, uploaded to MARAMA EMF on October 6, 2015.
- 2028
  - Alpha 2:
    2028_from_2025eh_onroad_SMOKE_MOVES_MOVES2014_no_speciated_pm_v0_MARAMA
    Prepared by EPA, uploaded to MARAMA EMF on October 22, 2015.

Point Oil & Gas

- 2011
  - Alpha, Alpha 2:
    othpt_offshore_oil_2011NEIv2_POINT_20140913_16sep2014_v0.csv
    pt_oilgas_2011NEIv2_POINT_20140913_17oct2014_v2.csv
    Prepared by EPA, uploaded to MARAMA EMF on November 5, 2014.
  - Beta, Beta 2:
    othpt_offshore_oil_2011NEIv2_POINT_20140913_16sep2014_v0.csv
    pt_oilgas_2011NEIv2_POINT_20140913_03feb2015_v4
    Prepared by EPA, uploaded to MARAMA EMF on November 5, 2014 and February 3, 2015, respectively.
- 2017
  - Beta, Beta 2:
    Othpt_offshore_oil_2011NEIv2_POINT_20140913_16sep2014_v0.csv
    2017_POINT_oilgas_23jul2016
    Prepared by MARAMA, uploaded to MARAMA EMF on July 23, 2016, July 23, 2016, and November 5, 2014, respectively.
- 2018
  - Alpha, Alpha 2:
    MARAMA_Alpha_2018_othpt_offshore_oil_2011NEIv2_POINT_20140913_16sep2014_v0_csv_v0_01feb2015_v0
    MARAMA_Alpha_2018_pt_oilgas_2011NEIv2_POINT_20140913_17oct2014_v2_csv_v0_01feb2015_nf_v1
    Prepared by MARAMA, uploaded to MARAMA EMF on February 1, 2015.
- 2028
  - Alpha 2:
    MARAMA_Alpha_2028_othpt_offshore_oil_2011NEIv2_POINT_20140913_16sep2014_v0.csv
    MARAMA_Alpha_2028_pt_oilgas_2011NEIv2_POINT_20140913_17oct2014_v2
    Prepared by MARAMA, uploaded to MARAMA EMF on August 18, 2015 and October 23, 2015, respectively.

Prescribed Burn

- 2011, 2018, 2028, 2017
  - Alpha, Alpha 2, Beta, Beta 2:
    ptfire_jan_2011v2_prescribed_16jan2015_v0
    ptfire_feb_2011v2_prescribed_16jan2015_v0
    ptfire_mar_2011v2_prescribed_16jan2015_v0
    ptfire_apr_2011v2_prescribed_16jan2015_v0
    ptfire_may_2011v2_prescribed_16jan2015_v0
    ptfire_jun_2011v2_prescribed_16jan2015_v0
    ptfire_jul_2011v2_prescribed_16jan2015_v0
    ptfire_aug_2011v2_prescribed_16jan2015_v0
    ptfire_sep_2011v2_prescribed_16jan2015_v0
    ptfire_oct_2011v2_prescribed_16jan2015_v0
    ptfire_nov_2011v2_prescribed_16jan2015_v0
    ptfire_dec_2011v2_prescribed_16jan2015_v0
    Prepared by EPA, uploaded to MARAMA EMF on January 15, 2015.

Refueling

- 2011
  - Alpha, Alpha 2:
    refueling_refueling_2011NEIv2_POINT_20140913_23sep2014_v0.csv
    refueling_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    Prepared by EPA, uploaded to MARAMA EMF on November 6, 2014 and November 13, 2014, respectively.
  - Beta, Beta 2:
    refueling_2011NEIv2_POINT_20140913_04dec2014_v2
    refueling_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    Prepared by EPA, uploaded to MARAMA EMF on February 3, 2015 and November 13, 2014, respectively.
- 2017

- Beta, Beta 2:
  2017_POINT_refueling_15jul2016
  2017_NONPOINT_refueling_20jun2016
  Prepared by MARAMA, uploaded to MARAMA EMF on July 15, 2016 and June 20, 2016, respectively.

- 2018
  - Alpha, Alpha 2:
    MARAMA_Alpha_2018_refueling_refueling_2011NEIv2_POINT_20140913_23sep2014_v0_csv_v0_02feb2015_nf_v1
    MARAMA_Alpha_2018_refueling_2011NEIv2_NONPOINT_20141108_11nov2014_v0_csv_v0_21jan2015_nf_v1
    Prepared by MARAMA, uploaded to MARAMA EMF on February 1, 2015 and January 5, 2015, respectively.
- 2028
  - Alpha 2:
    MARAMA_Alpha_2028_refueling_refueling_2011NEIv2_POINT_20140913_23sep2014_v0
    MARAMA_Alpha_2028_refueling_2011NEIv2_NONPOINT_20141108_11nov2014_v0
    Prepared by MARAMA, uploaded to MARAMA EMF on October 23, 2015 and August 20, 2015, respectively.

Residential Wood Combustion

- 2011
  - Alpha, Alpha 2:
    rwc_2011NEIv2_NONPOINT_20141108_11nov2014_v0.csv
    Prepared by EPA, uploaded to MARAMA EMF on November 13, 2014.
  - Beta, Beta 2:
    rwc_2011NEIv2_NONPOINT_20141108_24nov2014_v3
    Prepared by EPA, uploaded to MARAMA EMF on January 5, 2015.
- 2017
  - Beta, Beta 2:
    2017_NONPOINT_RWC_20jun2016
    Prepared by MARAMA, uploaded to MARAMA EMF on June 20, 2016.
- 2018
  - Alpha, Alpha 2:
    MARAMA_Alpha_2018_rwc_2011NEIv2_NONPOINT_20141108_11nov2014_v0_csv_v0_21jan2015_nf_v1
    Prepared by MARAMA, uploaded to MARAMA EMF on January 21, 2015.
- 2028
  - Alpha 2:
    MARAMA_Alpha_2028_rwc_2011NEIv2_NONPOINT_20141108_11nov2014_v0
    Prepared by MARAMA, uploaded to MARAMA EMF on August 20, 2015.

Wild Fires

- 2011, 2018, 2028, 2017
  - Alpha, Alpha 2:
    ptfire_jan_2011v2_wild_16jan2015_v0
    ptfire_feb_2011v2_wild_16jan2015_v0
    ptfire_mar_2011v2_wild_16jan2015_v0
    ptfire_apr_2011v2_wild_16jan2015_v0
    ptfire_may_2011v2_wild_16jan2015_v0
    ptfire_jun_2011v2_wild_16jan2015_v0
    ptfire_jul_2011v2_wild_16jan2015_v0
    ptfire_aug_2011v2_wild_16jan2015_v0
    ptfire_sep_2011v2_wild_16jan2015_v0
    ptfire_oct_2011v2_wild_16jan2015_v0
    ptfire_nov_2011v2_wild_16jan2015_v0
    ptfire_dec_2011v2_wild_16jan2015_v0
    Prepared by EPA, uploaded to MARAMA EMF on January 15, 2015.
  - Beta, Beta 2:
    ptfire_jan_2011v2_wild_16jan2015_v0

ptfire_feb_2011v2_wild_16jan2015_v0
ptfire_mar_2011v2_wild_16jan2015_v0
ptfire_apr_2011v2_wild_16jan2015_v0
ptfire_may_2011v2_wild_16jan2015_v0_MARAMA
ptfire_jun_2011v2_wild_16jan2015_v0_MARAMA
ptfire_jul_2011v2_wild_16jan2015_v0
ptfire_aug_2011v2_wild_16jan2015_v0
ptfire_sep_2011v2_wild_16jan2015_v0
ptfire_oct_2011v2_wild_16jan2015_v0
ptfire_nov_2011v2_wild_16jan2015_v0
ptfire_dec_2011v2_wild_16jan2015_v0
Prepared by EPA and MARAMA, uploaded to MARAMA EMF on January 15, 2015, except the May and June files uploaded March 8, 2016.

Appendix C. List of Air Quality Monitors in OTC Modeling Domain

	STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
OTR	**CT**	Fairfield	**90010017**	Greenwich Point Park	41.003613	-73.584999
			90011123	Western Conn State Univ	41.399166	-73.4431
			90013007	(blank)	41.1525	-73.103104
			90019003	Sherwood Island Connector	41.118332	-73.3367
		Hartford	**90031003**	McAuliffe Park	41.784721	-72.631699
		Litchfield	**90050005**	Mohawk Mt-Cornwall	41.821342	-73.297302
		Middlesex	**90070007**	(blank)	41.552223	-72.629997
		New Haven	**90090027**	Criscuolo Park-New Haven	41.301399	-72.902901
			90099002	Hammonasset State Park	41.260834	-72.550003
		New London	**90110124**	Fort Griswold Park	41.353619	-72.078796
		Tolland	**90131001**	(blank)	41.976391	-72.3881
		(blank)	**90110008**		41.317223	-72.065002
	DC	District of Columbia	**110010025**	TAKOMA SCHOOL	38.583225	-77.121902
			110010041	RIVER TERRACE	38.897221	-76.952797
			110010043	MCMILLAN PAMS	38.921848	-77.013199
	DE	Kent	**100010002**	PROPERTY OF KILLENS POND STATE PARK; BEH	38.984749	-75.555199
		New Castle	**100031007**	(blank)	39.551109	-75.730797
			100031010	OPEN FIELD	39.817223	-75.563904
			100031013	BELLEVUE STATE PARK, FIELD IN SE PORTION	39.773888	-75.496399
		Sussex	**100051002**	Seaford Shipley State Service Center	38.644478	-75.612701
			100051003	SPM SITE, NEAR UD ACID RAIN/MERCURY COLL	38.779198	-75.162697
		(blank)	**100031003**	Bellefonte River Road Park	39.761112	-75.491898
			100032004	CORNER OF MLK BLVD AND JUSTISON ST, NO T	39.739445	-75.558098
	MA	Barnstable	**250010002**	TRURO NATIONAL SEASHORE	41.975803	-70.023598
		Berkshire	**250034002**	MT GREYLOCK SUMMIT	42.636681	-73.167397
		Bristol	**250051002**	LEROY WOOD SCHOOL	41.633278	-70.879204
		Dukes	**250070001**	1 HERRING CREEK RD, AQUINNAH (WAMPANOAG	41.330467	-70.785202
		Essex	**250092006**	LYNN WATER TREATMENT PLANT	42.474644	-70.970802
			250094005	Newbury-B	42.814474	-70.817936
			250095005	CONSENTINO SCHOOL.	42.770836	-71.102303
		Hampden	**250130008**	WESTOVER AFB	42.194382	-72.555099
		Hampshire	**250150103**	AMHERST	42.400578	-72.523102
			250154002	QUABBIN RES	42.298492	-72.334099
		Middlesex	**250170009**	USEPA REGION 1 LAB	42.626678	-71.362099
			250171102	inactive military resv 680 hudson rd sud	42.413574	-71.482803
		Norfolk	**250213003**	BLUE HILL OBSERVATORY	42.211773	-71.113998
		Suffolk	**250250041**	BOSTON LONG ISLAND	42.317371	-70.968399
			250250042	DUDLEY SQUARE ROXBURY	42.329498	-71.082603
		Worcester	**250270015**	WORCESTER AIRPORT	42.274319	-71.875504
			250270024	UXBRIDGE	42.099697	-71.6194
		(blank)	**250094004**	SITE LOCATED OFF PARKING LOT 2.	42.790268	-70.808296
	MD	Anne Arundel	**240030014**	Davidsonville	38.9025	-76.653099
		Baltimore	**240051007**	Padonia	39.462025	-76.631302
			240053001	Essex	39.310833	-76.474403
		Baltimore (City)	**245100054**	Furley	39.328892	-76.552498
		Calvert	**240090011**	Calvert	38.53672	-76.617203
		Carroll	**240130001**	South Carroll	39.444168	-77.041702
		Cecil	**240150003**	Fair Hill Natural Resource Management Ar	39.701111	-75.860001
		Charles	**240170010**	Southern Maryland	38.504166	-76.811897
		Dorchester	**240199991**	Blackwater NWR	38.445	-76.1114
		Frederick	**240210037**	Frederick Airport	39.42276	-77.375198
		Garrett	**240230002**	Piney Run	39.705952	-79.012001
		Harford	**240251001**	Edgewood	39.41	-76.2967
			240259001	Aldino	39.563332	-76.203903
		Kent	**240290002**	Millington	39.305199	-75.797203
		Montgomery	**240313001**	Rockville	39.114445	-77.106903
		Prince George's	**240330030**	HU-Beltsville	39.055279	-76.878304
			240338003	PG Equestrian Center	38.811939	-76.744202
			240339991	Beltsville	39.0284	-76.8171
		Washington	**240430009**	Hagerstown	39.565582	-77.721603
		(blank)	**240030019**	FT MEADE LAT/LONG POINT IS OF THE SAMPLI	39.101112	-76.729401
			240330002	LAT/LONG POINT IS OF SAMPLING INLET.....	39.02	-76.827797
	ME	Androscoggin	**230010014**	DURHAM FIRE STATION	43.974621	-70.124603
		Cumberland	**230052003**	CETL - Cape Elizabeth Two Lights (State	43.561043	-70.207298
		Hancock	**230090102**	TOP OF CADILLAC MTN (FENCED ENCLOSURE)	44.351696	-68.226997
			230090103	MCFARLAND HILL Air Pollutant Research Si	44.377048	-68.260902
		Kennebec	**230112005**	Gardiner, Pray Street School (GPSS)	44.230621	-69.785004
		Knox	**230130004**	Marshall Point Lighthouse	43.917953	-69.260597
		Oxford	**230173001**	(blank)	44.250923	-70.860603
		Sagadahoc	**230230006**	BOWDOINHAM, MERRYMEETING BAY, BROWN'S PT	44.005001	-69.827797
		Washington	**230290019**	Harbor Masters Office; Jonesport Public	44.531906	-67.595901

STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
		230290032	(blank)	44.963634	-67.060699
	York	**230310038**	WBFD - West Buxton (Hollis) Fire Departm	43.656765	-70.629097
		230310040	SBP - Shapleigh Ball Park	43.58889	-70.877296
		230312002	KPW - Kennebunkport Parson'd Way	43.343166	-70.471001
	(blank)	**230031100**	MICMAC HEALTH DEPARTMENT	46.69643	-68.032997
		230050027	SHELTER IN PARKING LOT OF INTERSECTION O	43.662373	-70.2649
		230090301	OZONE AND METEOROLOGY MONITORING STARTED	44.423073	-68.805702
		230194008	WLBZ TV Transmitter Building - Summit of	44.735977	-68.670799
		230230004		43.793568	-69.731796
		230313002	___________NO INFORMATION AT THIS TIME	43.083332	-70.75
NH	Belknap	**330012004**	FIELD OFFICE ON THE GROUNDS OF THE FORME	43.566113	-71.496399
	Cheshire	**330050007**	WATER STREET	42.930473	-72.2724
	Coos	**330074001**	(blank)	44.270168	-71.303802
		330074002	CAMP DODGE, GREENS GRANT	44.308167	-71.217697
	Grafton	**330090010**	LEBANON AIRPORT ROAD	43.629612	-72.309601
	Hillsborough	**330111011**	GILSON ROAD	42.718662	-71.5224
		330115001	MILLER STATE PARK	42.861752	-71.878403
	Merrimack	**330131007**	HAZEN DRIVE	43.218498	-71.514503
	Rockingham	**330150014**	PORTSMOUTH - PEIRCE ISLAND	43.075333	-70.748001
		330150016	SEACOAST SCIENCE CENTER	43.045277	-70.713799
		330150018	Londonderry-Moose Hill	42.862536	-71.380172
	(blank)	**330074003**	MONITOR LOCATED IN THE GATEHOUSE FOR THE	45.051109	-71.391899
		330110020	PEARL ST MUNICIPAL PARKING LOT	42.995777	-71.462502
		330190003		43.364445	-72.338303
NJ	Atlantic	**340010006**	Brigantine	39.46487	-74.4487
	Bergen	**340030006**	Leonia	40.870438	-73.991997
	Camden	**340071001**	Ancora State Hospital	39.68425	-74.861504
	Cumberland	**340110007**	Millville	39.422272	-75.0252
	Essex	**340130003**	Newark - Firehouse	40.720989	-74.192902
	Gloucester	**340150002**	Clarksboro	39.800339	-75.212097
	Hudson	**340170006**	Bayonne	40.67025	-74.126099
	Hunterdon	**340190001**	Flemington	40.515263	-74.806702
	Mercer	**340210005**	Rider University	40.283092	-74.742599
		340219991	Wash Crossing	40.3125	-74.8729
	Middlesex	**340230011**	Rutgers University	40.462181	-74.429398
	Monmouth	**340250005**	Monmouth University	40.277645	-74.005096
	Morris	**340273001**	Chester	40.787628	-74.6763
	Ocean	**340290006**	Colliers Mills	40.064831	-74.444099
	Passaic	**340315001**	Ramapo	41.058617	-74.255501
	Warren	**340410007**	Columbia Site	40.924606	-75.067825
	(blank)	**340010005**	NACOTE CREEK RESEARCH STATION	39.530254	-74.460297
		340030005	TEANECK	40.898579	-74.0299
		340070003	CAMDEN LAB	39.923042	-75.097603
NY	Albany	**360010012**	LOUDONVILLE	42.680752	-73.757301
	Bronx	**360050133**	PFIZER LAB SITE	40.867901	-73.878098
	Chautauqua	**360130006**	DUNKIRK	42.49963	-79.318802
		360130011	WESTFIELD	42.29071	-79.5896
	Chemung	**360150003**	ELMIRA	42.110958	-76.8022
	Dutchess	**360270007**	MILLBROOK	41.785549	-73.741402
	Erie	**360290002**	AMHERST	42.993279	-78.7715
	Essex	**360310002**	WHITEFACE SUMMIT	88.732162	-147.806198
		360310003	WHITEFACE BASE	44.393082	-73.858902
	Hamilton	**360410005**	PISECO LAKE	43.44957	-74.516296
	Jefferson	**360450002**	PERCH RIVER	44.087471	-75.973198
	Madison	**360530006**	CAMP GEORGETOWN	42.730461	-75.784401
	New York	**360610135**	CCNY	40.819759	-73.948303
	Niagara	**360631006**	MIDDLEPORT	43.223862	-78.478897
	Oneida	**360650004**	CAMDEN	43.302681	-75.719803
	Onondaga	**360671015**	EAST SYRACUSE	43.052349	-76.059196
	Orange	**360715001**	VALLEY CENTRAL HIGH SCHOOL	41.52375	-74.215302
	Oswego	**360750003**	FULTON	43.284279	-76.463203
	Putnam	**360790005**	MT NINHAM	41.455891	-73.709801
	Queens	**360810124**	Queens College 2	40.736141	-73.821503
	Rensselaer	**360830004**	GRAFTON STATE PARK	42.781891	-73.4636
	Richmond	**360850067**	SUSAN WAGNER HS	40.596642	-74.125298
	Rockland	**360870005**	Rockland County	41.182079	-74.028198
	Saratoga	**360910004**	STILLWATER	43.012089	-73.648903
	Steuben	**361010003**	PINNACLE STATE PARK	42.091419	-77.209801
	Suffolk	**361030002**	BABYLON	40.745289	-73.419197
		361030004	RIVERHEAD	40.960781	-72.712402
		361030009	HOLTSVILLE	81.655982	-146.115006
	Ulster	**361111005**	BELLEAYRE MOUNTAIN	42.144032	-74.494301
	Wayne	**361173001**	WILLIAMSON	43.230862	-77.171402
	Westchester	**361192004**	WHITE PLAINS	41.051922	-73.763702

STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
	(blank)	**360050110**	IS 52	40.816181	-73.902
		360337003	Y001	44.980576	-74.695
		360430005	NICKS LAKE	43.68578	-74.985397
		360551007	ROCHESTER 2	43.146179	-77.548203
		360810098	COLLEGE POINT POST OFFICE	40.784199	-73.847603
		360930003	SCHENECTADY	42.799011	-73.938904
PA	Allegheny	**420030008**	Lawrenceville	40.46542	-79.9608
		420030010	LAT/LON IS APPROXIMATE LOCATION OF SCIEN	40.445576	-80.016197
		420030067	South Fayette	40.375645	-80.169899
		420031005	Harrison	40.613949	-79.729401
	Armstrong	**420050001**	LAT/LON IS CENTER OF TRAILER	40.814182	-79.564697
	Beaver	**420070002**	(blank)	40.562519	-80.503899
		420070005	DRIVEWAY TO BAKEY RESIDENCE	40.684723	-80.359703
		420070014	(blank)	40.747795	-80.316399
	Berks	**420110006**	Kutztown	40.51408	-75.789703
		420110011	Reading Airport	40.38335	-75.968597
	Blair	**420130801**	(blank)	40.535278	-78.370796
	Bucks	**420170012**	A420170012LAT/LONG POINT IS OF SAMPLING	40.107224	-74.882202
	Cambria	**420210011**	(blank)	40.309723	-78.915001
	Centre	**420270100**	LAT/LON=POINT SW CORNER OF TRAILER	40.81139	-77.876999
		420279991	Penn State	40.7208	-77.9319
	Chester	**420290100**	CHESTER COUNTY TRANSPORT SITE INTO PHILA	39.834461	-75.768204
	Clearfield	**420334000**	MOSHANNON STATE FOREST	41.1175	-78.526199
	Dauphin	**420430401**	A420430401LAT/LON POINT IS AT CORNER OF	40.24699	-76.847
		420431100	A420431100LAT/LON POINT IS AT CORNER OF	40.272221	-76.681396
	Delaware	**420450002**	A420450002LAT/LON POINT IS OF CORNER OF	39.835556	-75.372498
	Erie	**420490003**	(blank)	42.14175	-80.038597
	Franklin	**420550001**	HIGH ELEVATION OZONE SITE	39.961109	-77.475601
	Greene	**420590002**	75 KM SSW OF PITTSBURGH RURAL SITE ON A	39.80933	-80.265701
	Indiana	**420630004**	(blank)	40.563332	-78.919998
	Lackawanna	**420690101**	A420690101LAT/LON POINT IS AT CORNER OF	41.479115	-75.578201
		420692006	A420692006LAT/LON POINT IS AT CORNER OF	41.44278	-75.6231
	Lancaster	**420710007**	A420710007LAT/LON POINT AT CORNER OF TRA	40.046665	-76.283302
		420710012	Lancaster DW	40.043835	-76.112396
	Lawrence	**420730015**	(blank)	40.99585	-80.346397
	Lebanon	**420750100**	LEBANON	40.337328	-76.383447
	Lehigh	**420770004**	A420770004LAT/LONG POINT IS OF SAMPLING	40.611942	-75.432503
	Luzerne	**420791100**	A420791100LAT/LON POINT IS AT CORNER OF	41.209167	-76.003304
		420791101	A420791101LAT/LON POINT IS AT CORNER OF	41.265556	-75.846397
	Lycoming	**420810100**	MONTOURSVILLE	41.250801	-76.923798
	Mercer	**420850100**	(blank)	41.215015	-80.484802
	Monroe	**420890002**	SWIFTWATER	41.083061	-75.323303
	Montgomery	**420910013**	A420910013LAT/LON POINT IS OF CORNER OF	40.112221	-75.309196
	Northampton	**420950025**	LAT/LON POINT IS CENTER OF TRAILER	40.628056	-75.341103
		420958000	COMBINED EASTON SITE (420950100) AND EAS	40.692223	-75.237198
	Perry	**420990301**	A420990301LAT/LON POINT IS AT CORNER OF	40.456944	-77.165604
	Philadelphia	**421010004**	Air Management Services Laboratory (AMS	40.008888	-75.097801
		421010024	North East Airport (NEA)	40.076401	-75.011497
		421011002	Pennypack Park-Phil	40.035985	-75.002405
	Somerset	**421119991**	Laurel Hill	39.9878	-79.2515
	Tioga	**421174000**	PENN STATE OZONE MONITORING SITE	41.644722	-76.939201
	Washington	**421250005**	(blank)	40.146667	-79.902199
		421250200	(blank)	40.170555	-80.261398
		421255001	(blank)	40.445278	-80.420799
	Westmoreland	**421290006**	(blank)	40.428078	-79.692802
		421290008	LAT/LON POINT IS TRAILER	40.304695	-79.505699
	York	**421330008**	A421330008LAT/LON POINT AT CORNER OF TRA	39.965279	-76.699402
		421330011	York DW	39.86097	-76.462097
	(blank)	**420010002**		39.93	-77.25
		420110001	A420110001LAT/LONG POINT IS OF SAMPLING	40.511112	-75.786102
		420110009	A420110009LAT/LONG POINT IS OF SAMPLING	40.320278	-75.926697
		420274000	PA DEPT CONSERVATION & NATURAL RESOURCES	40.774555	-77.622101
		420290050	LAT/LON POINT IS OF CORNER OF TRAILER	39.935665	-75.604301
		420814000	NEXT TO TIADAGHTON SPORTMANS CLUB - NORT	41.334057	-77.449097
		421010014	Roxborough (ROX)	40.049618	-75.240799
		421010136	ON AMTRAK RIGHT OF WAY - NEAR AIRPORT HI	39.927502	-75.222801
RI	Kent	**440030002**	AJ	41.615238	-71.720001
	Providence	**440071010**	FRANCIS SCHOOL East Providence	41.841572	-71.360802
	Washington	**440090007**	US-EPA Laboratory	41.49511	-71.423698
VA	Alexandria City	**515100009**	Alexandria Health Dept.	38.810402	-77.044403
	Arlington	**510130020**	Aurora Hills Visitors Center	38.8577	-77.059196
	Fairfax	**510590005**	CUB RUN	38.8941	-77.4652
		510590018	MT VERNON	38.74232	-77.07743
		510590030	Lee District Park	38.77335	-77.104698

	STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
			510591005	Annandale	38.83738	-77.16338
		Loudoun	**511071005**	Broad Run High School, Ashburn	39.024731	-77.489304
		Prince William	**511530009**	James S. Long Park	38.852871	-77.634598
	VT	Bennington	**500030004**	Morse Airport - State of Vermont Propert	42.887589	-73.249802
OUTSIDE-OTR	**AL**	Colbert	**10331002**	MUSCLE SHOALS	34.758781	-87.650597
		DeKalb	**10499991**	Sand Mountain	34.2888	-85.9698
		Elmore	**10510001**	DBT, WETUMPKA	32.498566	-86.136597
		Etowah	**10550011**	SOUTHSIDE	33.904037	-86.053902
		Jefferson	**10730023**	North Birmingham	33.553055	-86.815002
			10731003	(blank)	33.485558	-86.915001
			10731005	McAdory	33.331112	-87.003601
			10731009	(blank)	33.459721	-87.305603
			10731010	Leeds	33.545277	-86.549202
			10732006	(blank)	33.386391	-86.816704
			10735002	(blank)	33.704723	-86.669197
			10735003	(blank)	33.801666	-86.942497
			10736002	(blank)	33.578335	-86.773903
		Madison	**10890014**	HUNTSVILLE OLD AIRPORT	34.687672	-86.586403
		Montgomery	**11011002**	MOMS, ADEM	32.40712	-86.256401
		Morgan	**11030011**	DECATUR, Alabama	34.518734	-86.976898
		Russell	**11130002**	LADONIA, PHENIX CITY	32.467972	-85.083801
		Shelby	**11170004**	HELENA	33.317314	-86.825104
		Sumter	**11190002**	GASTON (SUMTER)	32.36401	-88.201897
		Tuscaloosa	**11250010**	DUNCANVILLE, TUSCALOOSA	33.0896	-87.459702
		(blank)	**10270001**	ASHLAND	33.281261	-85.8022
			10790002	SIPSEY (closed 11-01-2007)	34.342903	-87.339699
			11210003	TALLADEGA, (HONDA) Closed 11/01/06	33.498329	-86.122704
	AR	Crittenden	**50350005**	MARION	35.197289	-90.1931
		Newton	**51010002**	DEER	35.832726	-93.208298
		Polk	**51130003**	EAGLE MOUNTAIN	34.454407	-94.143303
		Pulaski	**51190007**	PARR	34.756187	-92.281303
			51191002	NLR AIRPORT	34.83572	-92.260597
			51191008	DOYLE SPRINGS ROAD	34.681343	-92.328697
		Washington	**51430005**	SPRINGDALE	36.179699	-94.116798
		(blank)	**50970001**		34.649723	-93.816704
			51191005	ADEQ	34.67627	-92.337196
			516500004		37.000984	-76.398598
	GA	Bibb	**130210012**	Macon SE	32.805408	-83.543503
		Chatham	**130510021**	Savannah-E. President Street	32.069229	-81.048798
		Chattooga	**130550001**	Summerville-DNR Fish Hatchery	34.474293	-85.407997
		Clarke	**130590002**	FIRE STATION # 7	33.918068	-83.344498
		Cobb	**130670003**	Kennesaw-National Guard	34.015484	-84.607399
		Columbia	**130730001**	Evans-Riverside Park	33.582146	-82.131203
		Coweta	**130770002**	Newnan	33.404041	-84.746002
		Dawson	**130850001**	Dawsonville, Georgia Forestry Commission	34.376316	-84.059799
		DeKalb	**130890002**	South DeKalb	33.687969	-84.290497
		Douglas	**130970004**	W. Strickland Street	33.743656	-84.779198
		Fulton	**131210055**	Confederate Avenue	33.720192	-84.357101
		Glynn	**131270006**	Risley Middle School	31.169735	-81.495903
		Gwinnett	**131350002**	GWINNETT TECH	33.961269	-84.069
		Henry	**131510002**	McDonough-County Extension Office	33.433575	-84.161697
		Murray	**132130003**	Fort Mountain	34.785198	-84.626404
		Muscogee	**132150008**	Columbus-Airport	32.521301	-84.944801
		Paulding	**132230003**	Yorkville, King Farm	33.928501	-85.045303
		Pike	**132319991**	Georgia Station	33.1787	-84.4052
		Richmond	**132450091**	Bungalow Road	33.43335	-82.022202
		Rockdale	**132470001**	Monastery	33.591076	-84.0653
		Sumter	**132611001**	Leslie-Union High School	31.954298	-84.0811
		(blank)	**130210013**		32.827969	-83.788696
			130893001	Tucker-Idlewood Road	33.845741	-84.213402
			131130001	DOT STORAGE FACILITY	33.455738	-84.418999
			132151003	Columbus-Crime Lab	32.508713	-84.880302
	IA	Bremer	**190170011**	WAVERLY AIRPORT SITE	42.743057	-92.5131
		Clinton	**190450021**	CLINTON, RAINBOW PARK	41.875	-90.177597
		Linn	**191130028**	KIRKWOOD	41.910557	-91.651901
			191130033	COGGON ELEMENTARY SCHOOL BLDG. NORTHERN	42.281013	-91.526901
			191130040	Public Health	41.976768	-91.687698
		Polk	**191530030**	CARPENTER	41.603161	-93.643097
		Scott	**191630014**	SCOTT COUNTY PARK	41.699173	-90.521896
		Story	**191690011**	SLATER CITY HALL	41.882866	-93.687798
		Van Buren	**191770006**	LAKE SUGEMA STATE PARK II	40.69508	-92.006302
		Warren	**191810022**	GRAVEL ROAD IN LAKE AQUABI STATE PARK	41.285534	-93.584
		(blank)	**191530058**		41.607777	-93.571899
			191630015	DAVENPORT, JEFFERSON SCH.	41.53001	-90.587601

STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
		191632011	ARGO, HIGHWAY MAINTENANCE	41.647499	-90.430801
		191770005	LAKE SUGEMA STATE PARK I	40.689167	-91.9944
IL	Adams	**170010007**	JOHN WOOD COMMUNITY COLLEGE	39.915409	-91.335899
	Champaign	**170190007**	THOMAS	40.244913	-88.188519
	Clark	**170230001**	416 S. State St. Hwy 1- West Union	39.210857	-87.668297
	Cook	**170310001**	VILLAGE GARAGE	41.670994	-87.732498
		170310032	SOUTH WATER FILTRATION PLANT	41.755833	-87.545303
		170310064	UNIVERSITY OF CHICAGO	41.790787	-87.601601
		170310076	COM ED MAINTENANCE BLDG	41.7514	-87.713501
		170311003	TAFT HS	41.984333	-87.792
		170311601	COOK COUNTY TRAILER	41.668121	-87.990601
		170314002	COOK COUNTY TRAILER	41.855244	-87.752502
		170314007	REGIONAL OFFICE BUILDING	42.060284	-87.863197
		170314201	NORTHBROOK WATER PLANT	42.139996	-87.799202
		170317002	WATER PLANT	42.061855	-87.674202
	DuPage	**170436001**	MORTON ARBORETUM	41.813049	-88.0728
	Effingham	**170491001**	CENTRAL JR HIGH	39.067158	-88.548897
	Hamilton	**170650002**	TEN MILE CREEK DNR OFFICE	38.082153	-88.624901
	Jersey	**170831001**	ILLINI JR HIGH	39.110538	-90.324097
	Jo Daviess	**170859991**	Stockton	42.2869	-89.9997
	Kane	**170890005**	LARSEN JUNIOR HIGH	42.049149	-88.273003
	Lake	**170971007**	CAMP LOGAN TRAILER	42.467571	-87.809998
	Macon	**171150013**	IEPA TRAILER	39.866833	-88.925598
	Macoupin	**171170002**	IEPA TRAILER	39.396076	-89.8097
	Madison	**171190008**	CLARA BARTON SCHOOL	38.890186	-90.148003
		171191009	SOUTHWEST CABLE TV	38.726574	-89.959999
		171193007	WATER PLANT	38.860668	-90.105904
		171199991	Alhambra	38.869	-89.6228
	McHenry	**171110001**	CARY GROVE HS	42.221443	-88.242203
	McLean	**171132003**	ISU HARRIS PHYSICAL PLANT	40.518734	-88.996902
	Peoria	**171430024**	FIRESTATION	40.68742	-89.606903
		171431001	PEORIA HEIGHTS HS	40.745502	-89.585899
	Randolph	**171570001**	IEPA TRAILER	38.176277	-89.788498
	Rock Island	**171613002**	ROCK ISLAND ARSENAL	41.514729	-90.517403
	Saint Clair	**171630010**	IEPA-RAPS TRAILER	38.612034	-90.1605
	Sangamon	**171670014**	SPFD_IB	39.831522	-89.640926
	Will	**171971011**	COM ED TRAINING CENTER	41.221539	-88.191002
	Winnebago	**172012001**	MAPLE ELEMENTARY SCHOOL	42.334984	-89.037804
	(blank)	**170010006**	ST BONIFACE SCHOOL	39.93301	-91.404198
		170190004	BOOKER T. WASHINGTON ES	40.123795	-88.2295
		170310050	SE POLICE STATION	41.707569	-87.568604
		170650001	DALE ELEMENTARY SCHOOL	37.998222	-88.493103
		170971002	NORTH FIRESTATION	42.386707	-87.8414
		171192007	IEPA-RAPS TRAILER	38.793343	-90.039803
		171670010	IDPH WAREHOUSE	39.844124	-89.604797
		171971008	FITNESS FORUM	41.57571	-88.055099
		172010009	WALKER SCHOOL	42.287189	-89.077003
IN	Allen	**180030002**	(blank)	41.221416	-85.0168
		180030004	Ft. Wayne- Beacon St.	41.094967	-85.101799
	Boone	**180110001**	Perry Worth ELEMENTRY SCHOOL, WEST OF WH	39.997482	-86.395203
	Carroll	**180150002**	Flora-Flora Airport	40.540455	-86.553001
	Clark	**180190008**	Charlestown State Park- 1051.8 meters Ea	38.393833	-85.6642
	Delaware	**180350010**	Albany- Albany Elem. Sch.	40.300014	-85.245399
	Elkhart	**180390007**	Bristol- Bristol Elem. Sch.	41.718048	-85.830597
	Floyd	**180431004**	New Albany- Green Valley Elem. Sch.	38.308056	-85.834198
	Greene	**180550001**	Plummer, 2500 S. W- Citizens gas Plummer	38.985577	-86.990097
	Hamilton	**180570006**	Our Lady of Grace- Noblesville	40.068298	-85.9925
	Hancock	**180590003**	Fortville- Fortville Municipal Building	39.93504	-85.8405
	Hendricks	**180630004**	AVON SCHOOL'S BUS BARN	39.759003	-86.397102
	Huntington	**180690002**	Roanoke- Roanoke Elem. School	40.960709	-85.379799
	Jackson	**180710001**	Brownstown- 225 W & 200 N. Water facilit	38.920845	-86.080498
	Johnson	**180810002**	Indian Creek Elementary School in Trafal	39.417244	-86.152397
	Knox	**180839991**	Vincennes	38.7408	-87.4853
	Lake	**180890022**	Gary-IITRI/ 1219.5 meters east of Tennes	41.606682	-87.304703
		180890030	Whiting- Whiting HS	41.6814	-87.494698
		180892008	HAMMOND CAAP- Hammond- 141st St.	41.639462	-87.493599
	LaPorte	**180910005**	Michigan City- 4th Street NIPSCO Gas St	41.717022	-86.9077
		180910010	LAPORTE OZONE SITE AT WATER TREATMENT PL	41.629097	-86.684601
	Madison	**180950010**	SCHOOL LOCATED ON THE SW CORNER OF US 36	40.002548	-85.656898
	Marion	**180970050**	Indpls.- Ft. Harrison	39.858921	-86.021301
		180970057	Indpls- Harding St.	39.74902	-86.186302
		180970073	Indpls.- E. 16th St.	39.789486	-86.060799
		180970078	Indpls- Washington Park/ in parking lot	39.811096	-86.114502
	Morgan	**181090005**	Monrovia- Monrovia HS.	39.575634	-86.477898

STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
	Perry	**181230009**	Leopold- Perry Central HS	38.113159	-86.6036
	Porter	**181270024**	Ogden Dunes- Water Treatment Plant	41.617558	-87.199203
		181270026	VALPARAISO	41.510292	-87.038498
	Posey	**181290003**	ST. PHILLIPS- St. Phillips road CAAP tra	38.005287	-87.718399
	Shelby	**181450001**	TRITON Middle SCHOOL, NORTH OF FAIRLAND	39.613422	-85.870598
	St. Joseph	**181410010**	Potato Creek State Park	41.551697	-86.370598
		181410015	SOUTH BEND-Shields Dr.	41.696693	-86.214699
		181411007	(blank)	41.742599	-86.110497
	Vanderburgh	**181630013**	Inglefield/ Scott School	38.113949	-87.537003
		181630021	Evansville- Buena Vista	38.013248	-87.577904
	Vigo	**181670018**	TERRE HAUTE CAAP/ McLean High School	39.486149	-87.401398
		181670024	Sandcut/ SITE LOCATED BY HOME BEHIND SH	39.560555	-87.313103
	Warrick	**181730008**	Boonville- Boonville HS	38.052002	-87.278297
		181730009	Lynnville- Tecumseh HS	38.1945	-87.3414
		181730011	Dayville	37.95451	-87.321899
	(blank)	**180510011**	TOYOTA SITE	38.425251	-87.465897
		180570005		40.065193	-86.008102
		180890024	LOWELL CITY WASTEWATER TREATMENT PLANT	41.263889	-87.417503
		180970042		39.646255	-86.248802
		181270020		41.63139	-87.086899
KY	Bell	**210130002**	MIDDLESBORO	36.608429	-83.7369
	Boone	**210150003**	EAST BEND	38.918331	-84.8526
	Boyd	**210190017**	ASHLAND PRIMARY (FIVCO)	38.459339	-82.640404
	Bullitt	**210290006**	SHEPHERDSVILLE	37.98629	-85.711899
	Campbell	**210373002**	NORTHERN KENTUCKY UNIVERSITY (NKU)	39.021881	-84.474503
	Carter	**210430500**	GRAYSON LAKE	38.238869	-82.988098
	Christian	**210470006**	HOPKINSVILLE	36.911709	-87.323303
	Daviess	**210590005**	OWENSBORO PRIMARY	37.780777	-87.075302
	Edmonson	**210610501**	Mammoth Cave National Park, Houchin Mead	37.131943	-86.147797
	Fayette	**210670012**	LEXINGTON PRIMARY	38.065029	-84.497597
	Greenup	**210890007**	WORTHINGTON	38.548138	-82.731201
	Hancock	**210910012**	LEWISPORT	37.93829	-86.897202
	Hardin	**210930006**	ELIZABETHTOWN	37.705612	-85.8526
	Henderson	**211010014**	BASKETT	37.871201	-87.463799
	Jefferson	**211110027**	Bates	38.13784	-85.5765
		211110051	Watson Lane	38.060909	-85.898003
		211110067	CANNONS LANE	38.22876	-85.654503
	Jessamine	**211130001**	NICHOLASVILLE	37.891472	-84.588303
	Livingston	**211390003**	SMITHLAND	37.155392	-88.393997
	McCracken	**211451024**	JACKSON PURCHASE (PADUCAH PRIMARY)	37.05822	-88.572502
	Oldham	**211850004**	BUCKNER	38.4002	-85.444298
	Perry	**211930003**	HAZARD	37.283291	-83.209297
	Pike	**211950002**	PIKEVILLE PRIMARY	37.482601	-82.535301
	Pulaski	**211990003**	SOMERSET	37.09798	-84.611504
	Simpson	**212130004**	FRANKLIN	36.708607	-86.566299
	Trigg	**212218001**	OLD DOVER HIGHWAY CADIZ,KY	36.78389	-87.851898
	Warren	**212270008**	OAKLAND	37.035439	-86.250603
	(blank)	**210370003**	SITE LOCATED AT NORTHERN KY WATER SERVIC	39.065556	-84.451897
		210670001		38.125832	-84.4683
		210830003		36.899166	-88.493599
		211111021		38.26355	-85.710297
		211490001		37.606388	-87.253899
		212090001		38.385834	-84.559998
		212210013		36.90139	-88.013603
		212299991	Mackville	37.704601	-85.0485
LA	Bossier	**220150008**	Shreveport / Airport	32.536259	-93.748901
	Caddo	**220170001**	Dixie	32.676388	-93.859703
	Ouachita	**220730004**	Monroe / Airport	32.509712	-92.046097
MI	Allegan	**260050003**	Holland	42.767784	-86.148598
	Benzie	**260190003**	(blank)	44.616943	-86.109398
	Berrien	**260210014**	Coloma	42.197788	-86.3097
	Cass	**260270003**	Cassopolis	41.895569	-86.001602
	Chippewa	**260330901**	NORTH OF EASTERDAY AVENUE	46.49361	-84.364197
	Clinton	**260370001**	ROSE LAKE, STOLL RD.(8562 E.)	42.79834	-84.393799
	Genesee	**260490021**	(blank)	43.047222	-83.670197
		260492001	Otisville	43.168335	-83.461502
	Huron	**260630007**	RURAL THUMB AREA OZONE SITE	43.836388	-82.642899
	Ingham	**260650012**	(blank)	42.738617	-84.534599
	Kalamazoo	**260770008**	KALAMAZOO FAIRGROUNDS	42.278069	-85.541901
	Kent	**260810020**	GR-Monroe	42.984173	-85.671303
		260810022	APPROXIMATELY 1/4 MILE SOUTH OF 14 MILE	43.176674	-85.416603
	Lenawee	**260910007**	6792 RAISIN CENTER HWY, LENAWEE CO.RD.CO	41.995567	-83.946602
	Macomb	**260990009**	New Haven	42.731396	-82.793503
		260991003	(blank)	42.51334	-83.005997

STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
	Manistee	**261010922**	(blank)	44.306999	-86.242599
	Mason	**261050007**	LOCATED 550 FT NORTH OF US10	43.953335	-86.294403
	Missaukee	**261130001**	LOCATED ABOUT 1/4 MILE WEST OF SITE	44.310555	-84.891899
	Muskegon	**261210039**	(blank)	43.278061	-86.311096
	Oakland	**261250001**	Oak Park	42.463062	-83.183197
	Ottawa	**261390005**	Jenison	42.894451	-85.852699
	Schoolcraft	**261530001**	Seney	46.288876	-85.950203
	St. Clair	**261470005**	Port Huron	42.953335	-82.4562
	Washtenaw	**261610008**	TOWNER ST, SOUTH; 2 LANE RESIDENIAL - HO	42.240566	-83.599602
	Wayne	**261630001**	Allen Park	42.228619	-83.208199
		261630019	East 7 Mile	42.43084	-83.000099
	(blank)	**260890001**		45.028896	-85.629097
		261630016		42.357807	-83.096001
MN	Anoka	**270031001**	Cedar Creek	45.40184	-93.203102
		270031002	Anoka Airport	45.13768	-93.207603
	Goodhue	**270495302**	Stanton Air Field	44.473755	-93.012604
	Lake	**270750005**	Fernberg Road	47.948624	-91.495598
	Olmsted	**271095008**	Ben Franklin School	43.996906	-92.450401
	Saint Louis	**271377550**	WDSE	46.81826	-92.089401
	Scott	**271390505**	Shakopee	44.791435	-93.512497
	Wright	**271713201**	St. Michael	45.20916	-93.669197
	(blank)	**270177416**	Cloquet	46.705269	-92.523804
		271370034	VOYAGEURS NATIONAL PARK, NEAR SULLIVAN B	48.413334	-92.830597
MO	Boone	**290190011**	Finger Lakes	39.078602	-92.315201
	Callaway	**290270002**	New Bloomfield	38.706081	-92.093102
	Cedar	**290390001**	El Dorado Springs	37.689999	-94.035004
	Greene	**290770036**	Hillcrest High School	37.256138	-93.299896
		290770042	Fellows Lake	37.319511	-93.204597
	Jefferson	**290990019**	Arnold West	38.448631	-90.398499
	Lincoln	**291130003**	Foley	39.044701	-90.8647
	Monroe	**291370001**	MTSP	39.475136	-91.789101
	Perry	**291570001**	(blank)	37.702641	-89.698601
	Saint Charles	**291831002**	West Alton	38.872547	-90.226501
		291831004	Orchard Farm	38.899399	-90.449203
	Saint Louis	**291890005**	Pacific	76.9804	-181.4104
		291890014	Maryland Heights	77.421798	-180.951798
		291893001	Ladue	38.650259	-90.350463
	Sainte Genevieve	**291860005**	Bonne Terre	37.900841	-90.423897
	St. Louis City	**295100085**	Blair Street	38.656498	-90.198601
	Taney	**292130004**	Branson	36.707726	-93.222
	(blank)	**290770026**		37.122631	-93.263397
		291890004	FORMERLY 5962 SOUTH LINDBERGH.	38.53278	-90.382401
		291890006		38.613659	-90.495903
		291895001		38.766159	-90.285896
		291897003	.7 MILES E FROM OLD SITE ON S SIDE OF ST	38.720966	-90.367104
		295100086	MARGARETTA CATEGORY B CORE SLAM PM2.5.	38.673222	-90.239197
MS	Bolivar	**280110001**	Cleveland	33.746056	-90.723
	DeSoto	**280330002**	Hernando	34.821659	-89.987801
	Hinds	**280490010**	Jackson FS19	32.385731	-90.141197
	Lauderdale	**280750003**	Meridian	32.364567	-88.731499
	Lee	**280810005**	TUPELO AIRPORT NEAR OLD NWS OFFICE	34.264915	-88.766197
	Yalobusha	**281619991**	COFFEEVILLE	34.0026	-89.799
	(blank)	**280890002**		32.564835	-90.178596
		281490004		32.322834	-90.8871
NC	Alexander	**370030004**	Waggin` Trail	35.929001	-81.189796
	Avery	**370110002**	Linville Falls	35.972221	-81.933098
		370119991	CRANBERRY	36.1058	-82.0454
	Buncombe	**370210030**	Bent Creek	35.500103	-82.599899
	Caldwell	**370270003**	Lenoir (city)	35.935833	-81.530296
	Caswell	**370330001**	Cherry Grove	36.307034	-79.4674
	Chatham	**370370004**	Pittsboro	35.757221	-79.159698
	Cumberland	**370510008**	(blank)	35.158688	-78.727997
		370511003	Golfview	34.968887	-78.962502
	Davie	**370590003**	Mocksville	35.897068	-80.557297
	Durham	**370630015**	Durham Armory	36.032944	-78.905403
	Edgecombe	**370650099**	Leggett	35.988335	-77.582802
	Forsyth	**370670022**	(blank)	36.110558	-80.2267
		370670028	NEW O3 SLAMS SITE 4/1/96; REPLACES FERGU	36.203056	-80.215797
		370670030	(blank)	36.026001	-80.342003
		370671008	(blank)	36.050835	-80.143898
	Franklin	**370690001**	Franklinton	36.096188	-78.463699
	Graham	**370750001**	Joanna Bald	35.257931	-83.795601
	Granville	**370770001**	Butner	36.141109	-78.768097
	Guilford	**370810013**	Mendenhall School	36.100712	-79.810501

STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
	Haywood	**370870008**	WAYNSVL ELEM SCH	35.50716	-82.96337
		370870036	Purchase Knob	35.59	-83.077499
	Johnston	**371010002**	West Johnston Co.	35.590832	-78.461899
	Lenoir	**371070004**	Lenoir Co. Comm. Coll.	35.231461	-77.568802
	Lincoln	**371090004**	Crouse	35.438557	-81.276802
	Martin	**371170001**	Jamesville School	35.810692	-76.897797
	Mecklenburg	**371190041**	Garinger High School	35.240101	-80.785698
		371191005	Arrowood	35.113163	-80.919502
		371191009	County Line	35.347221	-80.695
	Montgomery	**371239991**	CANDOR	35.2632	-79.8365
	New Hanover	**371290002**	Castle Hayne	34.364166	-77.8386
	Person	**371450003**	Bushy Fork	36.306965	-79.092003
	Pitt	**371470006**	Pitt Agri. Center	35.638611	-77.358101
	Rockingham	**371570099**	Bethany sch.	36.308887	-79.8592
	Rowan	**371590021**	Rockwell	35.551868	-80.394997
		371590022	Enochville School	35.534481	-80.667603
	Swain	**371730002**	Bryson City	35.435509	-83.443703
	Union	**371790003**	Monroe School	34.973888	-80.540802
	Wake	**371830014**	Millbrook School	35.85611	-78.574203
		371830016	Fuquay-Varina	35.596943	-78.792503
	Yancey	**371990004**	Mt. Mitchell	35.765411	-82.2649
	(blank)	**370590002**	Cooleemee WATER TREATMENT PLANT	35.809288	-80.559097
		370610002	Kenansville	34.954823	-77.9608
		370630013		36.035557	-78.904198
		370670027	NEAR TOWN OF TOBACCOVILLE, BY POLLIROSA	36.236389	-80.410599
		370810011		36.113335	-79.703903
		370870004	SW CORNER OF ROOF HAYWOOD CO HEALTH DEPA	35.50528	-82.964699
		370870035	Frying Pan Mountain	35.379166	-82.792503
		370990005	OZONE MONITOR ON SW SIDE OF TOWER/MET EQ	35.524445	-83.236099
		371310002	SITE IS APPROX1/2DISTANCE BETWEEN GASTON	36.484379	-77.620003
		371470099		35.583332	-77.5989
		371510004	SITE AT NEW MARKET ELEMENTARY SCHOOL	35.830555	-79.865303
		371830015		35.790024	-78.619698
		371830017	TV TOWER LOCATED AT AUBURN NC	35.676388	-78.535301
		371990003		35.737736	-82.285202
OH	Allen	**390030009**	LIMA BATH	40.770943	-84.053902
	Ashtabula	**390071001**	CONNEAUT	41.959694	-80.5728
	Athens	**390090004**	ATHENS OU	39.30798	-82.118202
	Butler	**390170004**	HAMILTON	39.383381	-84.544403
		390170018	MIDDLETOWN	39.52948	-84.393402
		390179991	Oxford	39.5327	-84.7286
	Clark	**390230001**	SPRINGFIELD WELL FIELD	40.00103	-83.804604
		390230003	MUD RUN	39.855671	-83.997704
	Clermont	**390250022**	BATAVIA	39.082802	-84.144096
	Clinton	**390271002**	LAUREL OAKS_JVS	39.430038	-83.788498
	Cuyahoga	**390350034**	5TH DISTRICT	41.555229	-81.575302
		390350060	GT CRAIG	41.492119	-81.678398
		390350064	BEREA	41.361889	-81.864601
		390355002	MAYFIELD	41.537346	-81.458801
	Delaware	**390410002**	DELAWARE	40.356693	-83.064003
	Fayette	**390479991**	Deer Creek	39.6359	-83.2605
	Franklin	**390490029**	NEW_ALBNY	40.084499	-82.815498
		390490037	FRANKLIN_PK	39.965229	-82.955498
		390490081	MAPLE_C	40.0877	-82.959801
	Geauga	**390550004**	GEAUGA	41.515053	-81.249901
	Greene	**390570006**	XENIA	39.665749	-83.942902
	Hamilton	**390610006**	SYCAMORE	39.278702	-84.366096
		390610010	COLERAIN	39.214939	-84.690903
		390610040	TAFT	39.12886	-84.503998
	Jefferson	**390810017**	STEUBEN	40.36644	-80.615601
	Knox	**390830002**	CENTERBURG	40.310024	-82.691704
	Lake	**390850003**	EASTLAKE	41.673004	-81.422501
		390850007	JFS (PAINSVILLE)	41.72681	-81.242203
	Lawrence	**390870011**	WILGUS	38.629009	-82.4589
		390870012	ODOT (IRONTON)	38.508114	-82.659302
	Licking	**390890005**	HEATH	40.026035	-82.432999
	Lorain	**390930018**	SHEFFIELD	41.420883	-82.095703
	Lucas	**390950024**	ERIE	41.644066	-83.546303
		390950027	WATERVILLE	41.494175	-83.718903
		390950034	LOW_SER	41.675213	-83.3069
	Madison	**390970007**	LONDON	39.788189	-83.476097
	Mahoning	**390990013**	(blank)	41.096142	-80.658897
	Miami	**391090005**	MIAMI EAST	40.084549	-84.114098
	Montgomery	**391130037**	EASTWOOD	39.785629	-84.134399

STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
	Portage	**391331001**	Rockwell	41.182465	-81.330498
	Preble	**391351001**	NATIONAL TRAIL SCHOOL	39.835621	-84.720497
	Stark	**391510016**	MALONE_COL	40.828053	-81.378304
		391510022	BREWSTER (WANDLE)	40.712776	-81.598297
		391514005	ALLIANCE	40.931396	-81.123497
	Summit	**391530020**	PATTERSON PARK (PATT_PARK)	41.106487	-81.503502
	Trumbull	**391550009**	KINSMAN	41.454235	-80.591003
		391550011	TCSEG	41.240456	-80.662598
	Warren	**391650007**	LEBANON	39.426891	-84.200798
	Washington	**391670004**	MARIETTA_TWP.	39.432117	-81.460403
	Wood	**391730003**	BOWLING GREEN	41.377686	-83.611099
	(blank)	**390490028**	KOEBEL SCHOOL IN SOUTH COLUMBUS	39.913761	-82.957497
		390870006		38.52079	-82.666397
		390950081	FRIENDSHIP PARK	41.719482	-83.475197
		391030003	MEDINA	41.100868	-81.911598
		391030004	CHIPPEWA	41.060398	-81.923897
		391130019		39.813889	-84.195
		391511009		40.870277	-81.331703
SC	Abbeville	**450010001**	DUE WEST	34.325317	-82.386398
	Aiken	**450030003**	JACKSON MIDDLE SCHOOL	33.342224	-81.788696
	Anderson	**450070005**	Big Creek	34.623238	-82.532097
	Berkeley	**450150002**	BUSHY PARK PUMP STATION	32.987251	-79.936699
	Charleston	**450190046**	CAPE ROMAIN (VISTAS)	32.941025	-79.657204
	Chesterfield	**450250001**	CHESTERFIELD	34.615368	-80.198799
	Colleton	**450290002**	ASHTON	33.007866	-80.964996
	Darlington	**450310003**	Pee Dee Experimental Station	34.285694	-79.744904
	Edgefield	**450370001**	TRENTON	33.739964	-81.8536
	Greenville	**450450016**	Hillcrest Middle School	34.751846	-82.256699
		450451003	FAMODA FARM	35.057396	-82.372902
	Pickens	**450770002**	CLEMSON CMS	34.653606	-82.838699
	Richland	**450790007**	PARKLANE	34.09396	-80.962303
		450790021	CONGAREE BLUFF	33.814678	-80.781097
		450791001	SANDHILL EXPERIMENTAL STATION	34.131264	-80.868301
	Spartanburg	**450830009**	NORTH SPARTANBURG FIRE STATION #2 (Shady	34.988705	-82.075798
	York	**450910006**	YORK CMS	34.935818	-81.228401
	(blank)	**450110001**	BARNWELL CMS	33.320343	-81.4655
		450210002	Cowpens	35.130398	-81.816597
		450230002	Chester	34.792969	-81.203697
		450730001	LONG CREEK	34.80526	-83.237701
		450870001	DELTA	34.539379	-81.560402
		450890001	INDIANTOWN	33.723808	-79.565102
TN	Anderson	**470010101**	Freel's Bend ozone and SO2 monitoring	35.965221	-84.223198
	Blount	**470090101**	Great Smoky Mountains National Park, Loo	35.631489	-83.943497
		470090102	Great Smoky Mountains National Park, Cad	35.603058	-83.7836
	Claiborne	**470259991**	SPEEDWELL	36.47	-83.8268
	Davidson	**470370011**	(blank)	36.205002	-86.744698
		470370026	(blank)	36.150742	-86.623299
	Hamilton	**470651011**	Soddy-Daisy High School	35.233475	-85.181602
		470654003	(blank)	35.102638	-85.162201
	Jefferson	**470890002**	New Market ozone monitor	36.105629	-83.602097
	Knox	**470930021**	East Knox Elementary School	36.085506	-83.764801
		470931020	Spring Hill Elementary School	36.019184	-83.873802
	Loudon	**471050109**	Loudon Middle School ozone monitor	35.720894	-84.342201
	Meigs	**471210104**	Meigs County Ozone monitor	35.289379	-84.946098
	Rutherford	**471490101**	Eagleville Ozone Monitor	35.73288	-86.5989
	Sevier	**471550101**	(blank)	35.696667	-83.609703
	Shelby	**471570021**	Frayser Ozone Monitor	35.217503	-90.019699
		471570075	Memphis-NCORE	35.151699	-89.850249
		471571004	Edmund Orgill Park Ozone	35.378155	-89.834503
	Sullivan	**471632002**	Blountville Ozone Monitor	36.541439	-82.424797
		471632003	Kingsport ozone monitor	36.582111	-82.485703
	Sumner	**471650007**	Hendersonville Ozone Site at Old Hickory	36.297562	-86.653099
		471650101	Cottontown Ozone Monitor	36.453976	-86.564102
	Williamson	**471870106**	FAIRVIEW MIDDLE SCHOOL ozone monitor	35.951534	-87.137001
	Wilson	**471890103**	Cedars of Lebanon Ozone Monitor	36.060833	-86.286301
	(blank)	**470750003**	SHELTER IS IN A FLAT GRASSY AREA NEAR US	35.468719	-89.171097
		470990002	Lawrence Co ozone monitor	35.115967	-87.470001
		471410004	TVA PSD SITE IN PUTNAM COUNTY, TN	36.205151	-85.399803
		471550102	Great Smoky Mountains National Park, Cli	35.562778	-83.4981
		500070007	PROCTOR MAPLE RESEARCH CTR	44.528389	-72.868797
TX	Harrison	**482030002**	Karnack	32.668987	-94.167503
VA	Albemarle	**510030001**	Albemarle High School	38.076569	-78.503998
	Caroline	**510330001**	USGS Geomagnetic Center, Corbin	38.200871	-77.377403
	Charles	**510360002**	Shirley Plantation	37.344379	-77.2593

STATE	COUNTY	AQS CODE	SITE	LATITUDE	LONGITUDE
	Chesterfield	**510410004**	VDOT Chesterfield Residency Shop	37.357479	-77.593597
	Fairfax	**510595001**	LEWINSVILLE	38.9326	-77.19822
	Fauquier	**510610002**	Chester Phelps Wildlife Management Area,	38.473671	-77.7677
	Frederick	**510690010**	Rest	39.281021	-78.081596
	Giles	**510719991**	Horton Station	37.3297	-80.5578
	Hampton City	**516500008**	NASA Langley Research Center	37.103733	-76.387001
	Hanover	**510850003**	Turner Property, Old Church	37.606129	-77.218803
	Henrico	**510870014**	MathScience Innovation Center	37.556519	-77.400299
	Madison	**511130003**	Shenandoah National Park, Big Meadows	38.521984	-78.435799
	Page	**511390004**	Luray Caverns Airport	38.663731	-78.504402
	Prince Edward	**511479991**	Prince Edward	37.1655	-78.3069
	Roanoke	**511611004**	East Vinton Elementary School	37.283421	-79.884499
	Rockbridge	**511630003**	Natural Bridge Ranger Station	37.626678	-79.512604
	Rockingham	**511650003**	ROCKINGHAM CO. VDOT	38.477531	-78.819504
	Stafford	**511790001**	Widewater Elementary School	38.481232	-77.370399
	Suffolk City	**518000004**	Tidewater Community College	36.90118	-76.438103
		518000005	VA Tech Agricultural Research Station, H	36.665249	-76.730797
	Wythe	**511970002**	Rural Retreat Sewage Treatment Plant	36.891171	-81.254204
WI	Brown	**550090026**	UW GREEN BAY	44.530979	-87.907997
	Columbia	**550210015**	COLUMBUS	43.315601	-89.108902
	Dane	**550250041**	MADISON EAST	43.100838	-89.3573
	Dodge	**550270001**	Horicon Wildlife Area	43.46611	-88.621101
	Door	**550290004**	NEWPORT PARK	45.237	-86.992996
	Eau Claire	**550350014**	Eau Claire DOT	44.7614	-91.413
	Fond du Lac	**550390006**	FOND DU LAC	43.687401	-88.421997
	Jefferson	**550550002**	JEFFERSON	43.001999	-88.818604
	Kenosha	**550590019**	CHIWAUKEE PRAIRIE-STATELINE	42.504723	-87.809303
	Kewaunee	**550610002**	JUMBOS DRIVE-IN PROPERTY, SOUTH END OF K	44.443119	-87.505203
	La Crosse	**550630012**	LACROSSE - DOT BUILDING	43.7775	-91.226898
	Manitowoc	**550710007**	MANITOWOC/WOODLAND DUNES	44.138618	-87.616096
	Marathon	**550730012**	LAKE DUBAY	44.707352	-89.771797
	Milwaukee	**550790010**	HEALTH CENTER	43.016666	-87.933296
		550790026	DNR SER HQRS SITE	43.060974	-87.913498
		550790085	BAYSIDE	43.181	-87.900002
	Outagamie	**550870009**	APPLETON AAL	44.307381	-88.395103
	Ozaukee	**550890008**	(blank)	43.342999	-87.919998
		550890009	HARRINGTON BEACH PARK	43.498058	-87.809998
	Racine	**551010017**	RACINE	42.713898	-87.798599
	Rock	**551050024**	BELOIT-CUNNINGHAM	42.509079	-89.062798
	Sauk	**551110007**	DEVILS LAKE PARK	43.435101	-89.679703
	Sheboygan	**551170006**	SHEBOYGAN KOHLER ANDRE	43.679001	-87.716003
	Taylor	**551199991**	Perkinstown	45.2066	-90.5969
	Walworth	**551270005**	LAKE GENEVA	42.580009	-88.499001
	Waukesha	**551330027**	CLEVELAND SITE	43.020077	-88.215103
	(blank)	**550030010**	BAD RIVER	46.602001	-90.655998
		550270007	MAYVILLE	43.435001	-88.527802
		550370001		45.794998	-88.400002
		550410007		45.563	-88.8088
		550450001	NW CORNER OF TRAILER	42.53389	-89.659401
		550590002	KENOSHA - BARBERSHOP QUARTET SOCIETY	42.559166	-87.826103
		550710004	MOBILE SHELTER, APPROX 3/4 MI E OF COLLI	44.0825	-87.968597
		550790041	MILWAUKEE UWM-NORTH	43.075001	-87.884003
		550790044	APPLETON AVE	43.092777	-88.0056
		550791025		42.896389	-87.878098
		551091002	SOMERSET	45.124435	-92.662697
		551170007	ON ROOF	43.718334	-87.813103
		551230008	ON HILL NEAR PARK OFFICE AND MAINTENANCE	43.702221	-90.568298
		551250001	TROUT LAKE	46.051998	-89.653
		551310009	REPLACED SITE 55-131-0007	43.327221	-88.220299
		551330017	WAUKESHA, CARROLL COLLEGE	43.003887	-88.231903
		551390011	ON SOUTHERN PROPERTY LINE OF PVHC PROPER	44.075279	-88.529701
WV	Berkeley	**540030003**	MARTINSBURG BALL FIELD	39.448006	-77.964104
	Cabell	**540110006**	HENDERSON CENTER/MARSHALL UNIVERSITY - M	38.424133	-82.425903
	Gilmer	**540219991**	Cedar Creek	38.8795	-80.8477
	Greenbrier	**540250003**	SAM BLACK CHURCH - DOH GARAGE - GREENBRI	37.908531	-80.632599
	Hancock	**540291004**	(blank)	40.421539	-80.580704
	Kanawha	**540390010**	CHARLESTON BAPTIST TEMPLE/SITE MOVED FRO	38.3456	-81.628304
	Monongalia	**540610003**	(blank)	39.649368	-79.920898
	Ohio	**540690010**	(blank)	40.114876	-80.700996
	Wood	**541071002**	Neale Elementary School	39.323532	-81.552399