Appendix E-5

Model Performance Evaluation for Ozone of the CAMx 6.40 Modeling System and the VISTAS II 2011 Updated Modeling Platform

August 17, 2020

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Model Performance Evaluation for Ozone of the CAMx 6.40 Modeling System and the VISTAS II 2011 Updated Modeling Platform (Task 8.0)

Prepared for:
Southeastern States Air Resource Managers, Inc. (SESARM)
205 Corporate Center Dr., Suite D
Stockbridge, GA 30281-7383

Under Contract No. V-2018-03-01

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

and

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

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Abbreviations/Acronym List

Alpine	Alpine Geophysics, LLC
AQS	Air Quality Subsystem
CAMx	Comprehensive Air quality Model with eXtensions
ERG	Eastern Research Group, Inc.
EGU	Electric Generating Unit
EPA	United States Environmental Protection Agency
FL	Florida
GA	Georgia
km	Kilometer
MAPS	Model Performance Evaluation, Analysis, and Plotting Software
MB	Mean Bias
MDA8	Maximum Daily 8-Hour
ME	Mean Error
MPE	Model Performance Evaluation
MS	Mississippi
n	Number of observations
NC	North Carolina
NMB	Normalized Mean Bias
NME	Normalized Mean Error
OSAT	Ozone Source Apportionment Technology
ppb	parts per billion
PSAT	Particulate Source Apportionment Technology
R^2	Pearson correlation coefficient, squared
RADM-AQ	Regional Acid Deposition Model – aqueous chemistry
SC	South Carolina
SESARM	Southeastern States Air Resource Managers, Inc.
SIPS	State Implementation Plans
SOA	Secondary organic aerosol
SOAP	Secondary organic aerosol partitioning
TN	Tennessee
VA	Virginia
VISTAS	Visibility Improvement – State and Tribal Association of the Southeast
WI	Wisconsin
WV	West Virginia

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1.0 INTRODUCTION

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

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

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

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

requires states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

To demonstrate progress toward the improvement goals, the SESARM partners modeled visibility and air quality conditions for a base year of 2011 and future year of 2028. The SESARM VISTAS II Regional Haze modeling analysis was performed by the contractor team Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine). The preparation and modeling were conducted over several contract tasks, including emission inventory development, ambient data collection, Comprehensive Air quality Model with extensions (CAMx) modeling, and model performance evaluation (MPE) of the base year. The VISTAS II modeling included particulate matter simulations and source apportionment studies using the 12-kilometer (km) grid based on EPA's 2011/2028el modeling platform and preliminary source contribution assessment,[2] updated to include a 12-km subdomain over the VISTAS region and augmented with revisions to electric generating unit (EGU) and non-EGU point source projections. The air quality modeling was conducted using CAMx. A detailed description of the modeling platform can be found in the Task 6 modeling report.

Under Task 8 of the Regional Haze Modeling for Southeastern VISTAS II Regional Haze Analysis Project, a thorough MPE was conducted for Maximum Daily 8-Hour (MDA8) ozone concentrations to examine the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. This report documents the MPE for the base year CAMx modeling.

The VISTAS II modeling for 2011 is based on the EPA modeling conducted for Regional Haze Analysis, sometimes referred to as the "2011el" modeling. Updates to the EPA platform in the VISTAS II modeling include updating the version of CAMx from version 6.32 to 6.40. Many updates to the CAMx model were implemented between the 6.32 and 6.40 release. According to the CAMx 6.40 release notes, the significant changes included:

1. Updates to the chemistry to include a condensed halogen mechanism for ocean-borne inorganic reactive iodine, hydrolysis of isoprene-derived organic nitrate and SO_2

[2] EPA. 2017. Documentation for the EPA's Preliminary 2028 Regional Haze Modeling. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October. Available at: https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

oxidation on primary crustal fine PM. This update includes the changes to the Ozone and Particulate Source Apportionment Technology (OSAT/PSAT) algorithms;
2. Inclusion of in-line inorganic iodine emissions to support halogen chemical mechanisms;
3. A major revision to the Secondary organic aerosol partitioning (SOAP) and secondary organic aerosol (SOA) chemistry algorithm;
4. Updates to the Regional Acid Deposition Model aqueous chemistry (RADM-AQ) algorithm; and
5. A major revision to the wet deposition algorithm to identify assumptions or processes that were unintentionally or otherwise unreasonably limiting gas and PM update into precipitation. The wet deposition algorithm was simplified and improved in several ways, resulting in the increased scavenging of gases and PM.

In addition to the model version, the CAMx 6.32 and 6.40 simulations contained differences in the EPA modeling platform that had been made subsequent to the 2011el/2028el model release. In the most current 2023en simulation, EPA developed new photolysis rates and ozone column data. These updates were included in the updated modeling platform and resulting CAMx 6.40 simulation and were used in the VISTAS II 2011el (hereafter "VISTAS12") simulations.

Figure 1-1 presents the VISTAS12 modeling domain.

Figure 1-1. VISTAS12 Modeling Domain. Areas in green denote Class I Areas.

An operational model evaluation was conducted for the 2011 base year CAMx v6.40 simulation performed for the VISTAS12 modeling domain defined by SESARM and shown in Figure 1-1. The purpose of this evaluation is to examine the ability of this 2011 air quality modeling platform to represent the magnitude and spatial and temporal variability of measured (i.e., observed) ozone concentrations within the modeling domain. The evaluation presented here is based on model simulations using the 2011 emissions platform (i.e., scenario name 2011el.ag.v6_40.vistas12). This model evaluation for ozone focuses on comparisons of model predicted 8-hour daily maximum concentrations to the corresponding observed data at monitoring sites in the EPA Air Quality System (AQS).

Included in the evaluation are statistical measures of model performance based upon model-predicted versus observed concentrations that were paired in space and time. Model performance statistics were calculated for several spatial scales and temporal periods. Statistics were calculated for individual monitoring sites, and in aggregate for monitoring sites within states of the 12-km modeling domain.

For MDA8 ozone, model performance statistics were created for the periods May through September. The aggregated statistics by state and VISTAS region as a whole are presented in this document. Model performance statistics for MDA8 ozone at individual monitoring sites based on days with observed values ≥ 60 ppb can be found as Appendix A to this document.

In addition to the above performance statistics, we prepared several graphical presentations of model performance for MDA8 ozone. These graphical presentations include:

1. spatial maps that show the mean bias and error as well as normalized mean bias and error calculated for MDA8 ≥ 60 ppb for May through September at individual AQS monitoring sites within the VISTAS12 modeling domain;
2. time series plots (May through September) of observed and predicted MDA8 ozone concentrations for select sites from each VISTAS state located within the VISTAS12 modeling domain; and
3. scatter plots (May through September) that show the correlation of the predicted and observed MDA8 ozone concentrations for select sites from each VISTAS state located within the VISTAS12 modeling domain.

The Model Performance Evaluation, Analysis, and Plotting Software (MAPS) tool was used to calculate the model performance statistics used in this document.[3] For this evaluation we have selected the mean bias, mean error, normalized mean bias, and normalized mean error to characterize model performance, statistics which are consistent with the recommendations in

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

Simon et al. (2012),[4] the photochemical modeling guidance (U.S. EPA, 2018),[5] and EPA's recent performance evaluation of the 2011en platform (EPA, 2018).

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

$$MB(ppb) = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)$$

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

$$ME(ppb) = \frac{1}{n}\sum_{i=1}^{n}|P_i - O_i|$$

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

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

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

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

As described in more detail below, the model performance statistics indicate that the 8-hour daily maximum ozone concentrations predicted by the VISTAS12 modeling platform closely reflect the corresponding 8-hour observed ozone concentrations in each region in the modeling domain. The acceptability of model performance was judged by considering the 2011 CAMx performance results in light of the range of performance found in recent regional ozone

4 Simon, H., K. Baker and S. Phillips. 2012. Compilations and Interpretation of Photochemical Model Performance Statistics Published between 2006 and 2012. *Atmos. Env.* 61 (2012) 124-139. December.

5 EPA, 2018. Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. Internet address: https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf

model applications.[5,6,7,8,9,10,11,12] These other modeling studies represent a wide range of modeling analyses that cover various models, model configurations, domains, years and/or episodes, chemical mechanisms, and aerosol modules.

Overall, the ozone model performance results for the VISTAS12 modeling are within the range found in other recent peer-reviewed and regulatory applications. The model performance results, as described in this document, demonstrate that the predictions from the VISTAS12 modeling domain using the EPA's 2011el modeling platform corresponds closely to observed concentrations in terms of the magnitude, temporal fluctuations, and geographic differences for 8-hour daily maximum ozone.

2.0 RESULTS

The 8-hour ozone model performance bias and error statistics for the months of May through September for the region and VISTAS states in the VISTAS12 modeling domain are provided in Tables 2-1 and 2-2, respectively. The statistics shown in Tables 2-1 and 2-2 were calculated using data pairs on days with observed 8-hour ozone of ≥ 60 ppb. Spatial plots of the mean bias and error as well as the normalized mean bias and error for individual monitors are shown in Figures 2-3 through 2-6. Time series plots of observed and predicted MDA 8-hour ozone during the period May through September at select sites listed in Table 5 are provided in Figures 2-1 through 2-16. The correlations of observed and predicted 8-hour ozone by month in the period of May through September for each region are shown in Figures 2-17 through 2-27.

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

7 Phillips et al., 2007. Phillips, S., K. Wang, C. Jang, N. Possiel, M. Strum, T. Fox, 2007. Evaluation of 2002 Multi-pollutant Platform: Air Toxics, Ozone, and Particulate Matter, 7th Annual CMAS Conference, Chapel Hill, NC, October 6-8, 2008.

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

9 EPA. 2009. U.S. Environmental Protection Agency, Proposal to Designate an Emissions Control Area for Nitrogen Oxides, Sulfur Oxides, and Particulate Matter: Technical Support Document. EPA-420-R-007.

10 EPA. 2010. U.S. Environmental Protection Agency, 2010, Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis. EPA-420-R-10-006. February 2010. Sections 3.4.2.1.2 and 3.4.3.3. Docket EPA-HQ-OAR-2009-0472-11332.

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

12 EPA. 2018. Air Quality Modeling Technical Support Document for the Updated 2023 Projected Ozone Design Values. Office of Air Quality Planning and Standards, United States Environmental Protection Agency. June 2018.

Overall, model performance for MDA8 ozone concentrations for the VISTAS12 modeling is similar to what was found in EPA's model performance evaluation conducted for the EPA's 2011en CAMx v6.40 simulation performed in support of the 2008 and 2015 ozone NAAQS reviews.[11]

2.1 Performance Statistics by State and Month

As indicated by the statistics in Table 2-1, bias and error for 8-hour daily maximum ozone are relatively low in the region. Generally, mean bias (MB) for 8-hour ozone ≥ 60 ppb during each month of the May through September period, demonstrating within ±5 ppb at AQS sites in VISTAS states, ranging from -0.13 ppb (September) to 3.79 ppb (July). The mean error (ME) is less than 10 ppb in all months. Normalized mean bias (NMB) is within ±5 percent for AQS sites in all months except July (5.63%). The mean bias and normalized mean bias statistics indicate a tendency for the model to overpredict MDA8 ozone concentrations in month of May through August and slightly underpredict MDA8 ozone concentrations in September for AQS sites. The normalized mean error (NME) is less than 15 percent in the region across all months.

Table 2-1. Performance Statistics for MDA8 Ozone ≥ 60 ppb by Month for VISTAS States Based on Data at AQS Network Sites.

Region	Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
VISTAS	May	838	2.48	6.11	3.79	9.34
VISTAS	Jun	2028	1.73	7.11	2.57	10.55
VISTAS	Jul	1233	3.79	8.88	5.63	13.21
VISTAS	Aug	1531	2.38	6.94	3.59	10.48
VISTAS	Sep	681	-0.13	6.09	-0.19	9.08

Looking at 12-km model performance for individual states located within the VISTAS12 domain (Table 2-2) indicates that mean bias is within ± 5 ppb for the majority of the months and states for all but July in Alabama (6.18ppb), July in Florida (-5.32 ppb), August in Georgia (5.67 ppb), July in Kentucky (5.04 ppb), May in Virginia (5.57 ppb), and July in West Virginia (5.27 ppb). The mean error is less than 10 ppb for nearly all months and states, with exceptions occurring in July (Alabama, Florida, and Georgia) and August (Florida). The normalized mean bias is within ±10 percent in all months and states. The normalized mean error is within 15 percent for all months and states with again exceptions occurring in July (Alabama, Florida, and Georgia) and August (Florida).

Table 2-2. Performance Statistics for MDA8 Ozone ≥ 60 ppb by Month and VISTAS State Within VISTAS12 Domain Based on Data at AQS Network Sites.

Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
Alabama					
May	75	2.55	4.89	3.89	7.47
June	235	3.30	7.53	4.95	11.29
July	83	6.18	10.64	9.12	15.71
August	241	3.56	6.77	5.30	10.09
September	80	1.67	5.83	2.61	9.11
Florida					
May	241	2.47	6.44	3.72	9.72
June	137	1.23	7.59	1.83	11.30
July	20	-5.32	14.73	-8.21	22.74
August	62	3.17	10.49	4.74	15.67
September	78	0.98	7.52	1.48	11.40
Georgia					
May	130	3.91	5.87	5.85	8.78
June	251	2.07	8.43	3.05	12.41
July	111	2.89	11.09	4.19	16.06
August	218	5.67	7.95	8.44	11.84
September	97	1.22	5.03	1.81	7.48
Kentucky					
May	25	3.93	6.03	6.30	9.66
June	227	0.68	6.86	1.03	10.37
July	170	5.04	9.83	7.57	14.76
August	167	-0.32	7.30	-0.49	11.03
September	78	-0.82	6.60	-1.20	9.62
Mississippi					
May	33	-2.97	5.50	-4.49	8.30
June	64	1.38	8.80	2.07	13.23
July	24	2.42	8.18	3.74	12.64
August	74	2.25	9.02	3.39	13.60
September	37	2.19	8.12	3.35	12.39
North Carolina					
May	117	4.44	6.52	6.99	10.27
June	473	2.36	6.22	3.46	9.12
July	299	4.29	7.41	6.39	11.03
August	257	2.68	5.65	4.10	8.66

Table 2-2. Performance Statistics for MDA8 Ozone ≥ 60 ppb by Month and VISTAS State Within VISTAS12 Domain Based on Data at AQS Network Sites.

Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
September	129	-1.35	5.36	-2.00	7.96
South Carolina					
May	46	3.34	4.56	5.30	7.23
June	148	0.34	5.25	0.50	7.82
July	74	0.94	7.52	1.42	11.38
August	86	2.15	6.81	3.32	10.53
September	49	-0.44	4.34	-0.66	6.56
Tennessee					
May	108	-1.18	5.38	-1.82	8.32
June	237	1.98	7.96	2.93	11.77
July	158	4.28	9.39	6.41	14.08
August	295	-0.03	6.04	-0.04	9.09
September	99	-2.67	6.83	-3.87	9.91
Virginia					
May	41	5.57	9.47	8.01	13.62
June	200	0.55	7.40	0.82	10.99
July	225	2.82	8.63	4.12	12.59
August	90	2.93	7.27	4.50	11.18
September	17	1.32	6.53	2.07	10.25
West Virginia					
May	22	0.40	7.54	0.63	11.90
June	56	0.95	5.00	1.44	7.56
July	69	5.27	6.96	8.03	10.60
August	41	2.61	5.91	4.01	9.08
September	17	0.21	5.78	0.28	7.82

Monitor specific performance metrics for monitors in the VISTAS12 modeling domain are provided as Appendix A to this document.

2.2 Spatial Performance Evaluation

Figures 2-1 through 2-4 show the spatial variability in bias and error at monitor locations. Mean bias, as seen from Figure 2-1, is within ±5 ppb at most sites across the VISTAS12 domain with a maximum under-prediction of 23.44 ppb at one site (AQS monitor 550030010) in Ashland County, WI and a maximum over-prediction of 17.95 ppb in York County, SC (AQS monitor 450910006); both with small sample sizes (n=1 and n=7, respectively). A positive mean bias is generally seen in the range of 5 to 10 ppb with regions of 10 to 15 ppb over-prediction seen scattered throughout the domain. The model has a tendency to underestimate in the western portion of the domain and overestimate in the eastern portion of the domain.

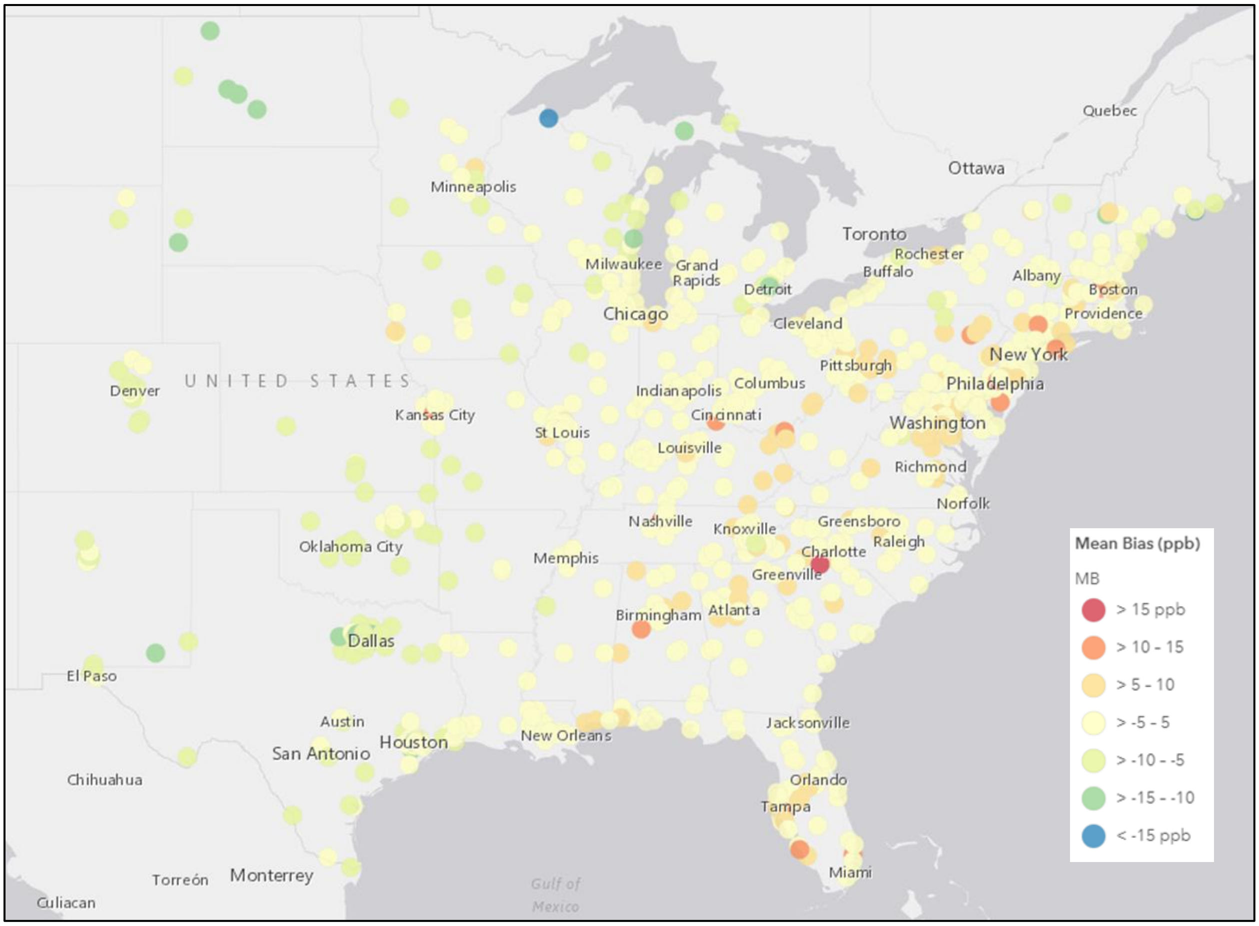

Figure 2-1. Mean Bias (ppb) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.[13]

Figure 2-2 indicates that the normalized mean bias for days with observed 8-hour daily maximum ozone ≥ 60 ppb is within ± 10 percent at the vast majority of monitoring sites across the VISTAS12 modeling domain. Monitors in Ashland County, WI and York County, SC again bookend the NMB range with 38.03% and 27.44%, respectively. There are regional differences in model performance, as the model tends to overpredict at most sites in eastern region of the

13 Appendix A-2 presents the Mean Bias data in a Google Earth .kmz file to allow the user to zoom to specific geographic regions.

VISTAS12 domain and generally underpredict at sites in and around the western and north western borders of the domain.

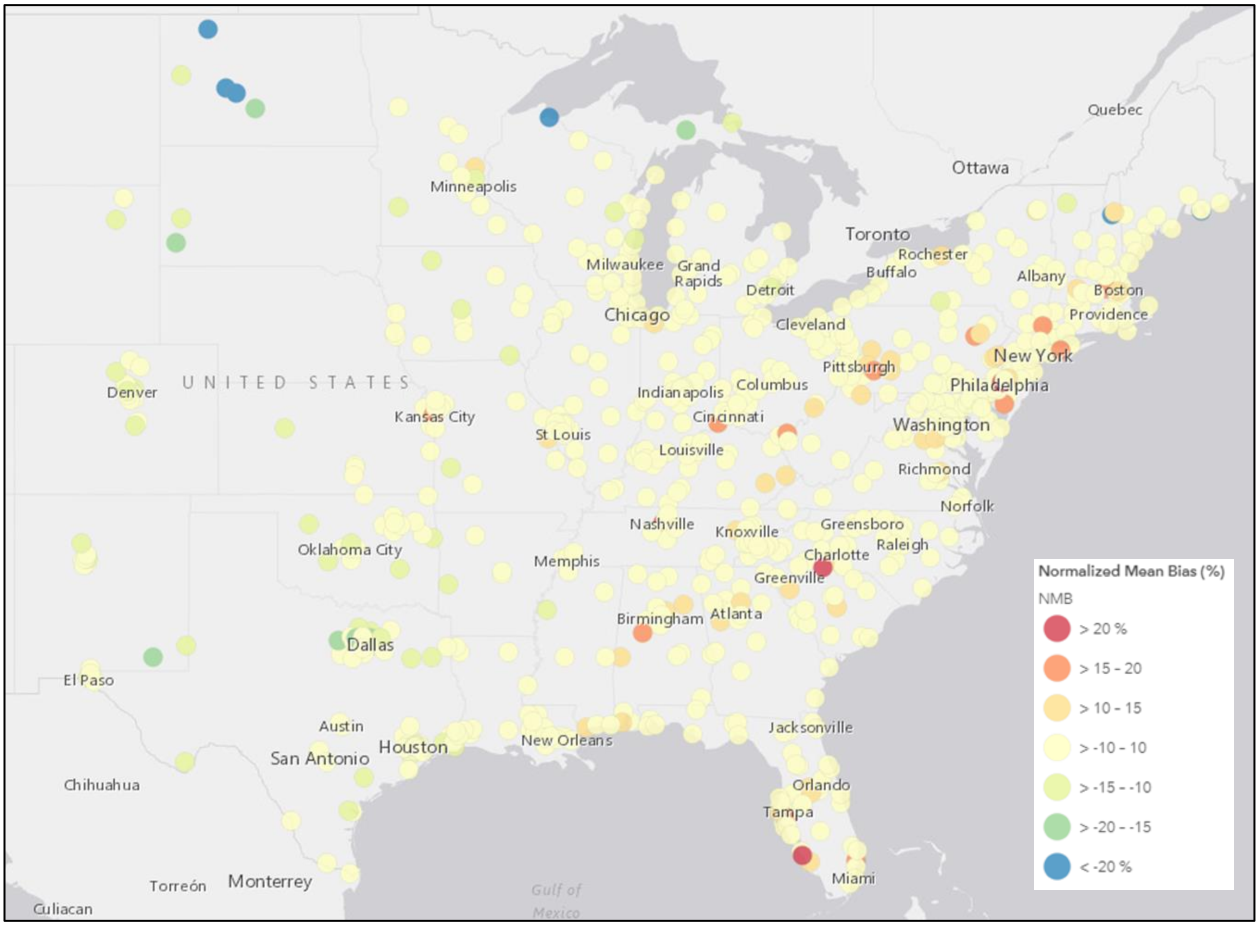

Figure 2-2. Normalized Mean Bias (%) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.[14]

Mean error (ME), as seen from Figure 2-3, is generally 10 ppb or less at most of the sites across the VISTAS12 modeling domain although the Ashland, WI and York, SC monitors show much higher ME of 23.44 and 17.95 ppb, respectively. VISTAS states show less than ten percent of their monitors above 10 ppb model error, with the majority of those within this value. Figure 2-4 indicates that the normalized mean error (NME) for days with observed 8-hour daily

14 Appendix A-3 presents the Normalized Mean Bias data in a Google Earth .kmz file to allow the user to zoom to specific geographic regions.

maximum ozone ≥ 60 ppb is less than 15 percent at the vast majority of monitoring sites across the VISTAS12 modeling domain. Noted exceptions seen are monitors 450910006 (York County, SC), 470370011 (Davidson County, TN), and 120713002 (Lee County, FL) with NMEs of 27.44%, 25.4%, and 23.07%, respectively. Somewhat elevated NMEs (> 15%) are seen in and around many of the VISTAS state metro areas.

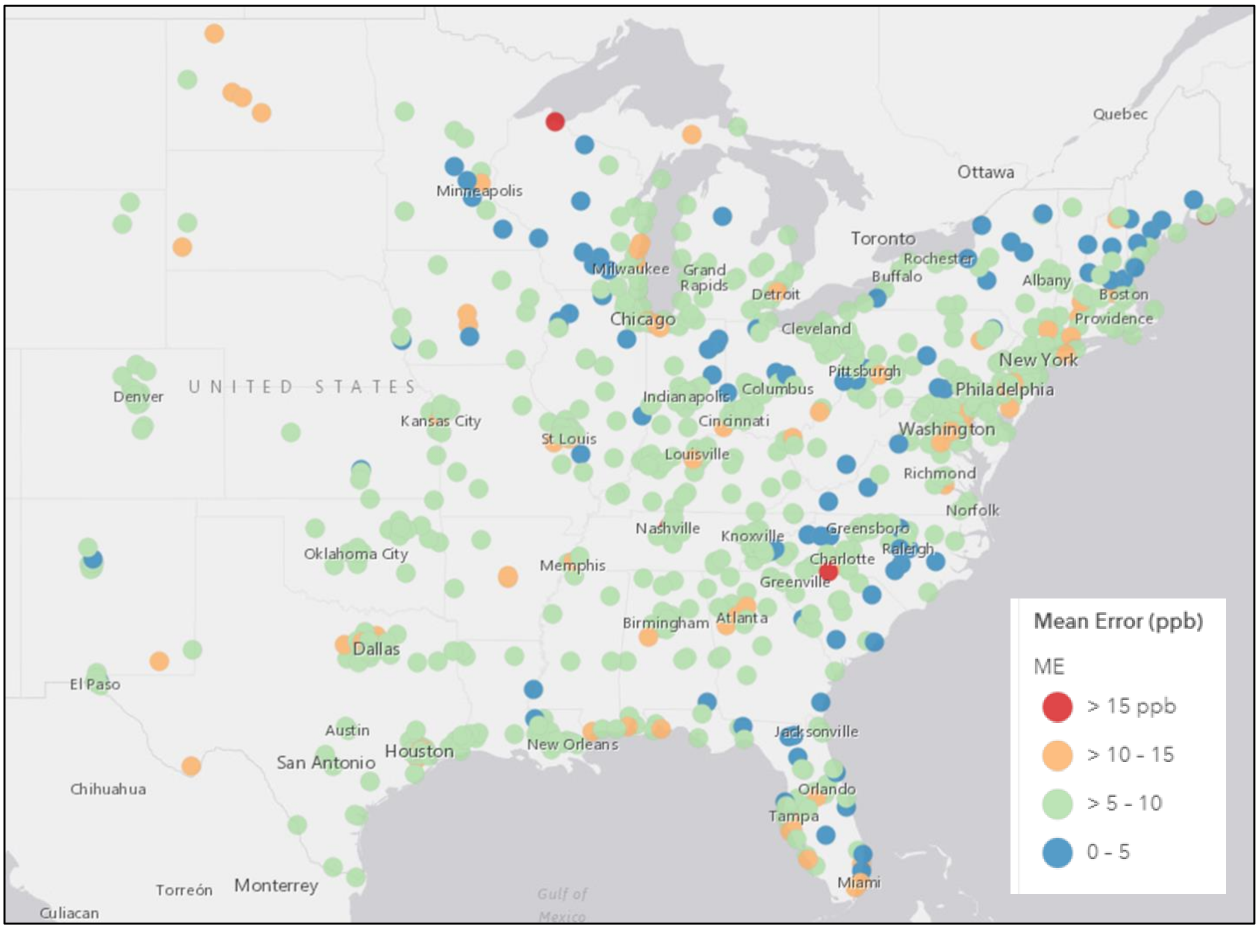

Figure 2-3. Mean Error (ppb) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain. [15]

[15] Appendix A-4 presents the Mean Error data in a Google Earth .kmz file to allow the user to zoom to specific geographic regions.

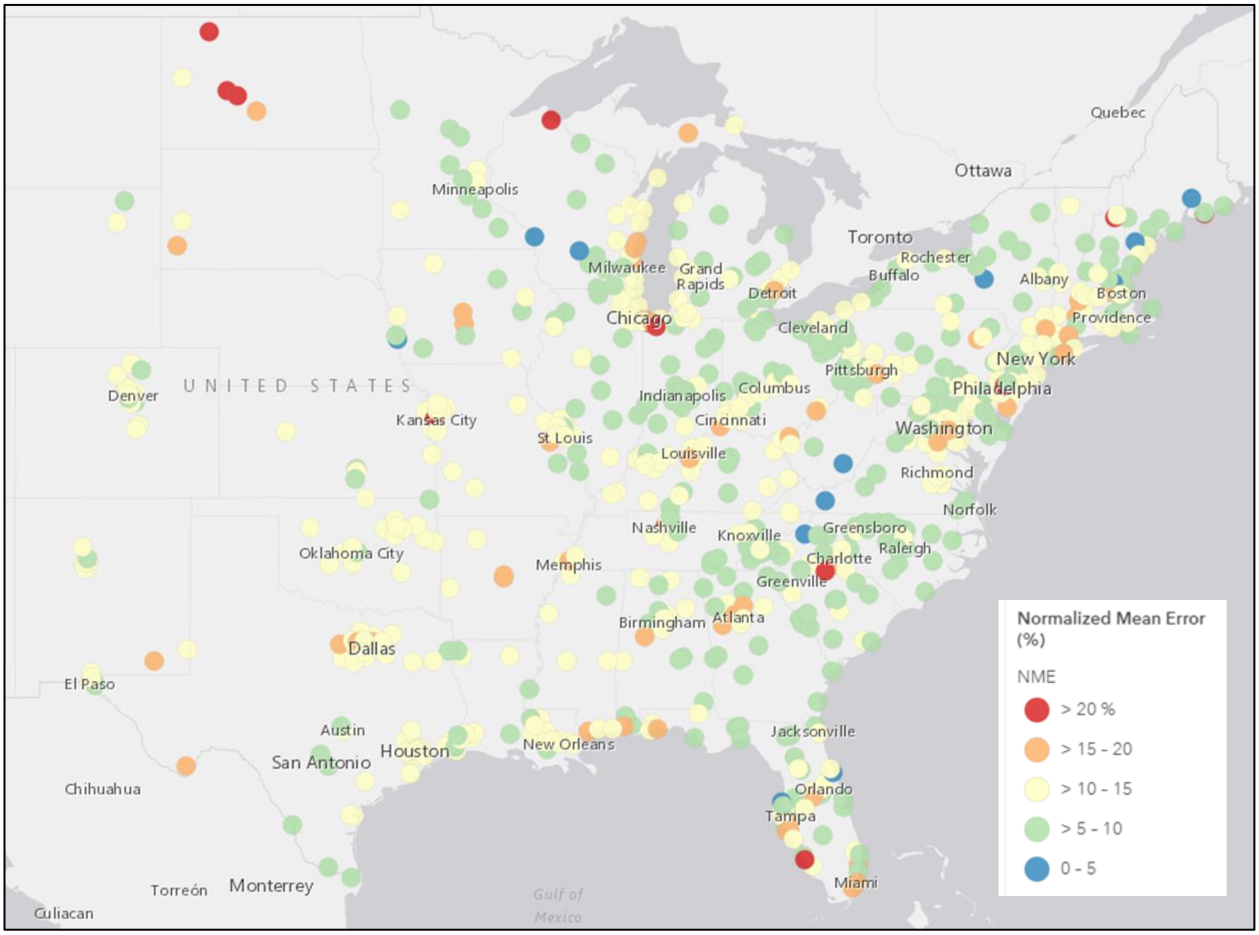

Figure 2-4. Normalized Mean Error (%) of MDA8 Ozone ≥ 60 ppb Over the Period May-September 2011 at AQS Monitoring Sites in VISTAS12 Domain.[16]

2.3 Time Series Plots by Monitor

In addition to the above analysis of overall model performance, we also examined how well the modeling platform replicates day to day fluctuations in observed 8-hour daily maximum concentrations. Table 2-3 presents data for the highest 2011 3-year design value site in each VISTAS state.

[16] Appendix A-5 presents the Normalized Mean Error data in a Google Earth .kmz file to allow the user to zoom to specific geographic regions.

Table 2-3. Monitoring Sites Included in the Ozone Time Series Analysis.

AQS Monitor ID	State	County	2009-2011 Ozone Design Value (ppb)
010731005	Alabama	Jefferson	75
121130015	Florida	Santa Rosa	74
131210055	Georgia	Fulton	80
211110051	Kentucky	Jefferson	78
280470008	Mississippi	Harrison	75
371190041	North Carolina	Mecklenburg	79
450830009	South Carolina	Spartanburg	74
470090101	Tennessee	Blount	76
510590030	Virginia	Fairfax	82
540690010	West Virginia	Ohio	73

For this site-specific analysis we present the time series of observed and predicted 8-hour daily maximum concentrations by site in the 12-km simulation over the period of May through September. The results, as shown in Figures 2-5 through 2-14, indicate that the modeling platform generally replicates the day-to-day variability in ozone during this time period at these sites. That is, days with high modeled concentrations are generally also days with high measured concentrations and, conversely, days with low modeled concentrations are also days with low measured concentrations in most cases.

For example, model predictions at several sites not only accurately capture the day-to-day variability in the observations, but also appear to have relatively low bias on individual days. Santa Rosa County, FL and Harrison County, MS each track closely with the observations, but there is a tendency to overpredict on several of the observed high ozone days at these coastal state locations. Of particular note are the overpredictions at the Mecklenburg County, NC monitor early in the ozone season, at the Fairfax County, VA monitor during a late season episode, and at the Ohio County, WV monitor mid-season and the underprediction of MDA8 at the Fulton County, GA monitor during an early ozone season episode and multiple days at the coastal monitors in Florida and Mississippi.

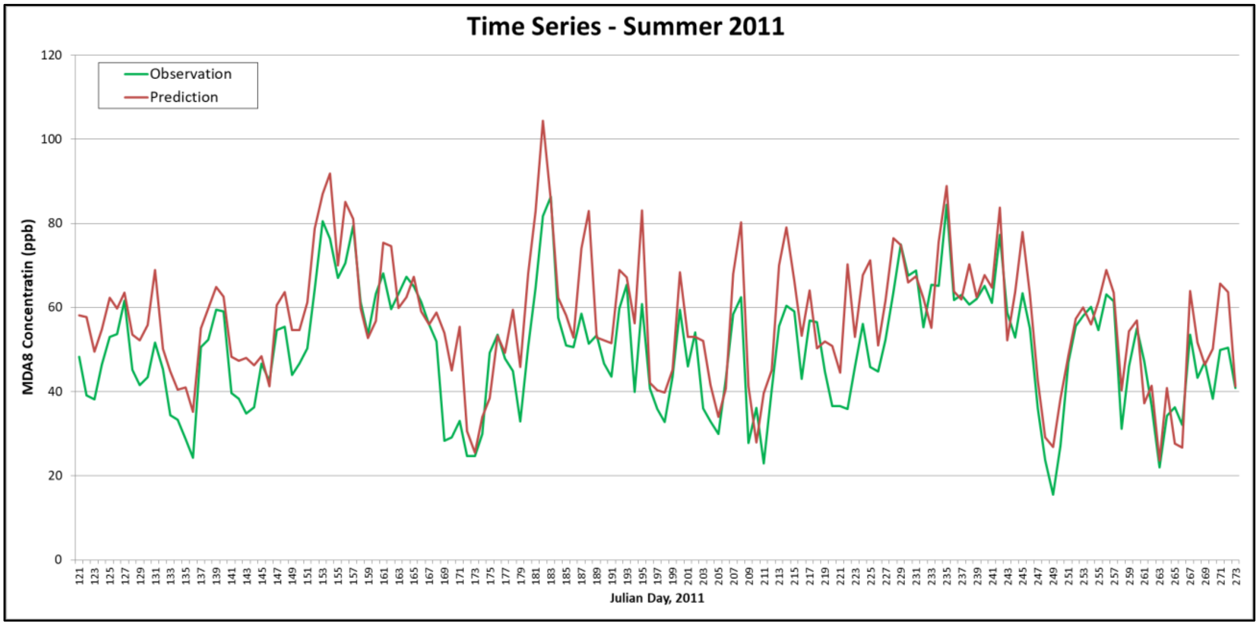

Figure 2-5. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 010731005 in Alabama.

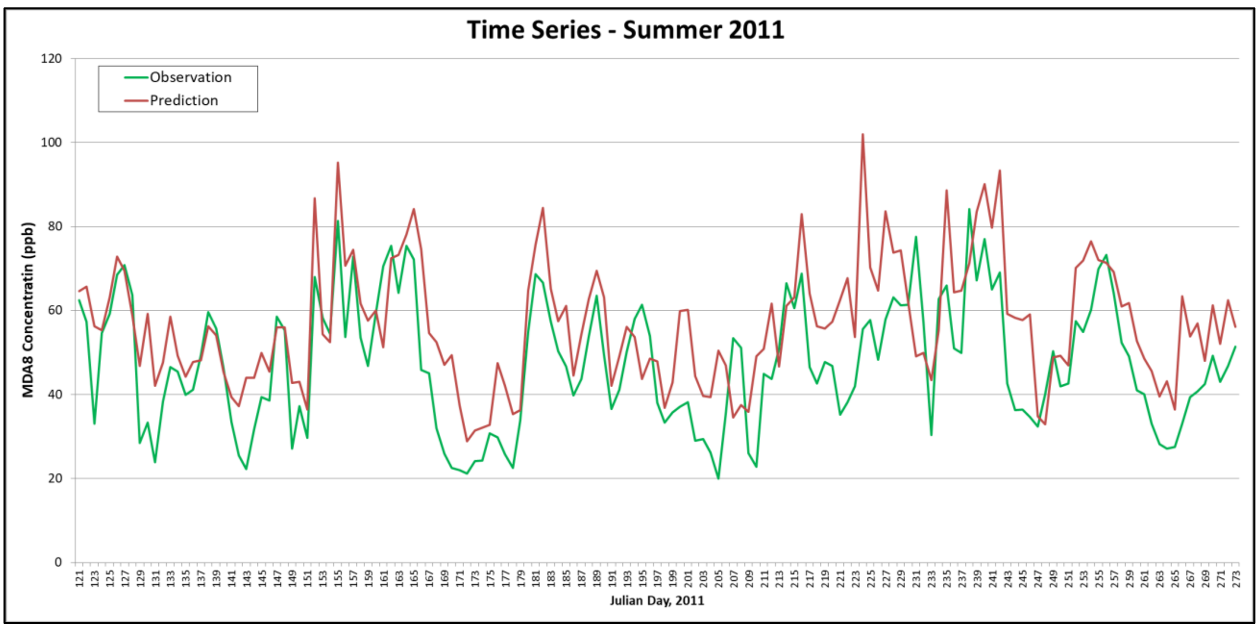

Figure 2-6. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 121130015 in Florida.

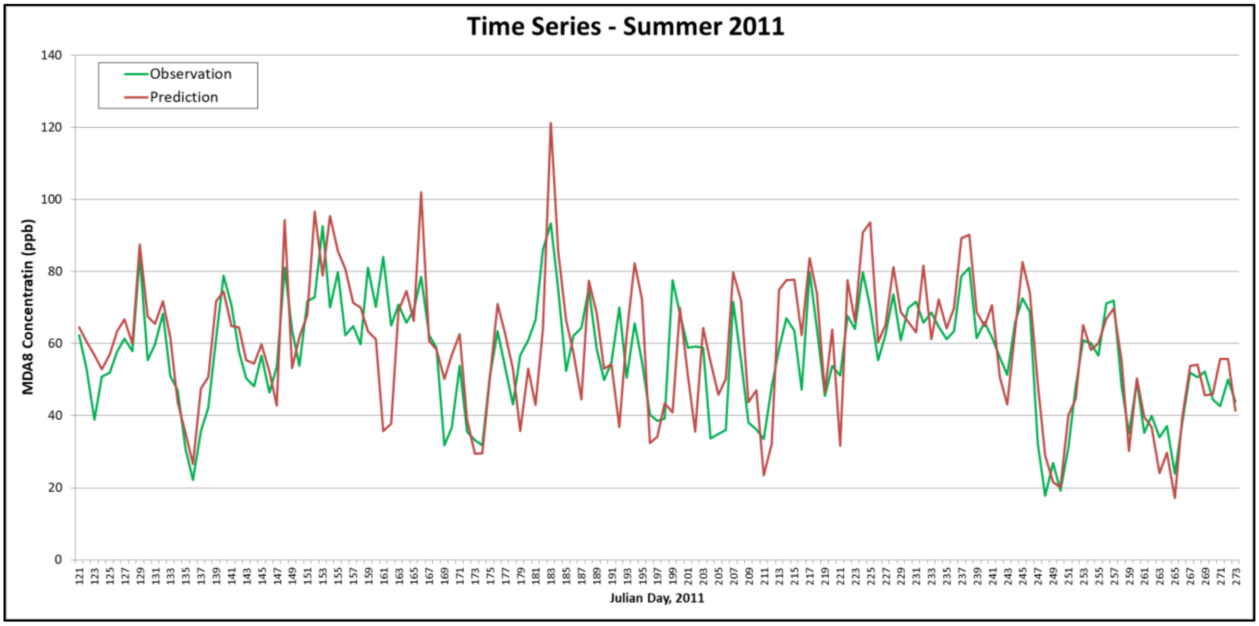

Figure 2-7. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 131210055 in Georgia.

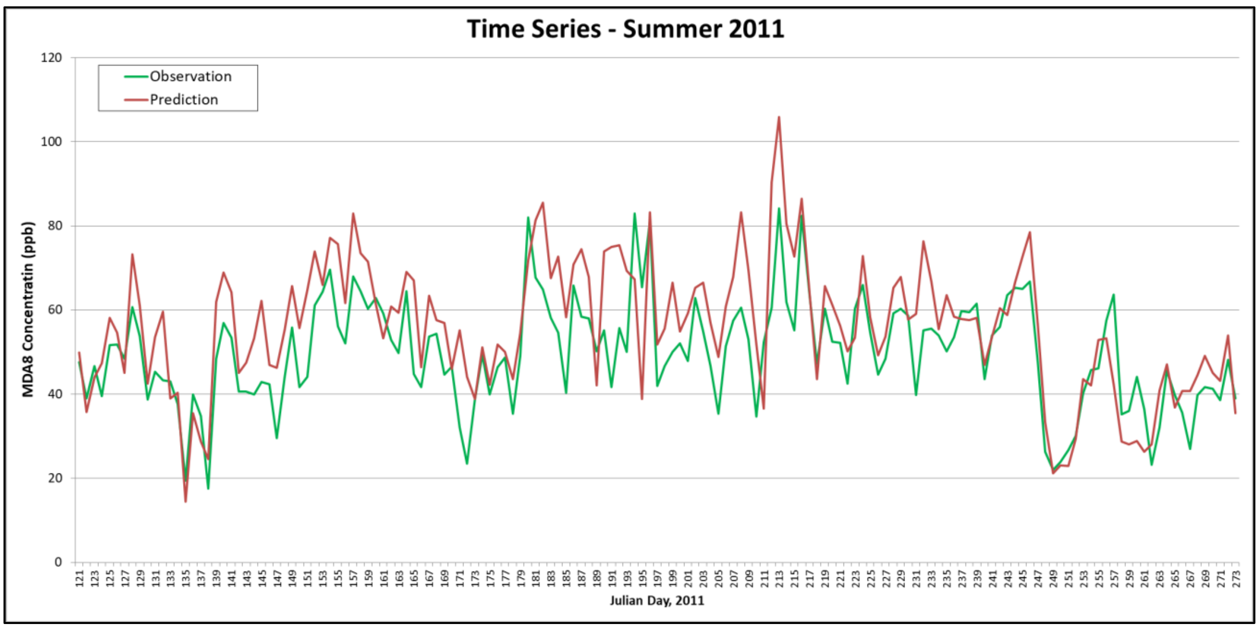

Figure 2-8. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 211110051 in Kentucky.

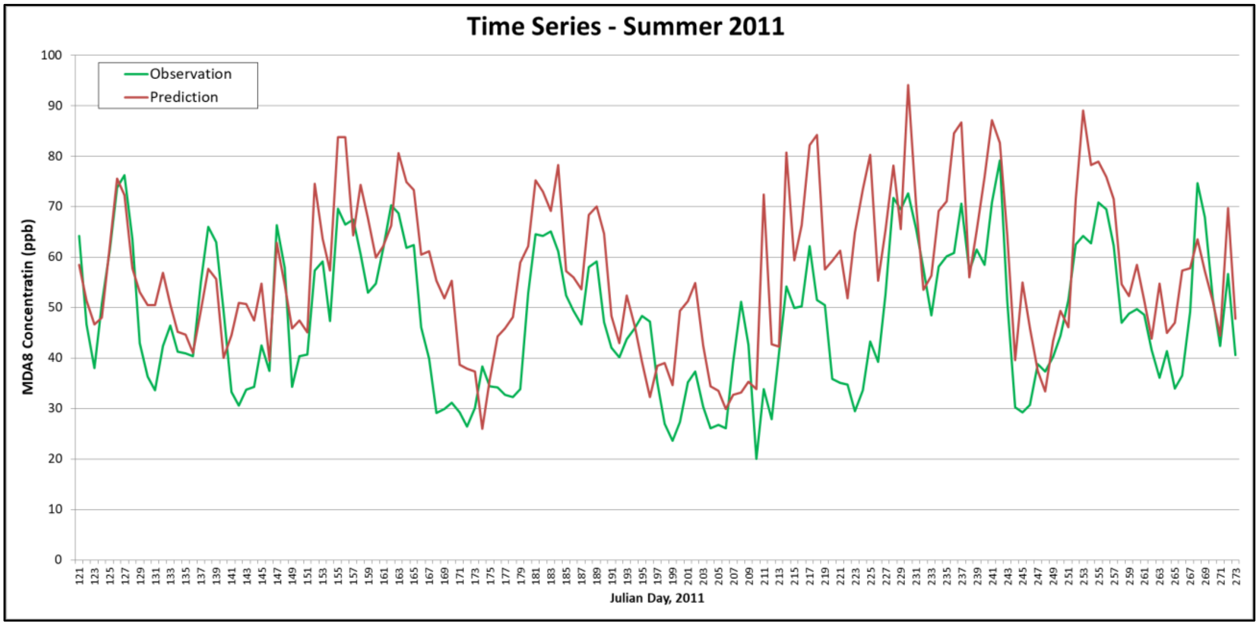

Figure 2-9. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 280470008 in Mississippi.

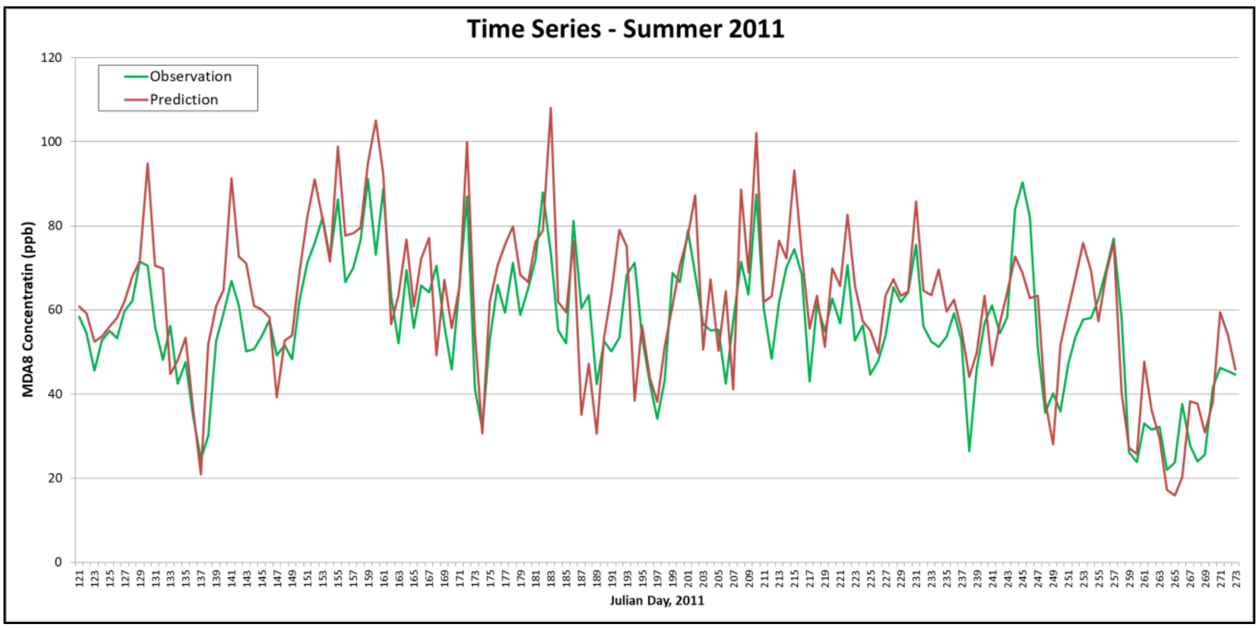

Figure 2-10. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 371190041 in North Carolina.

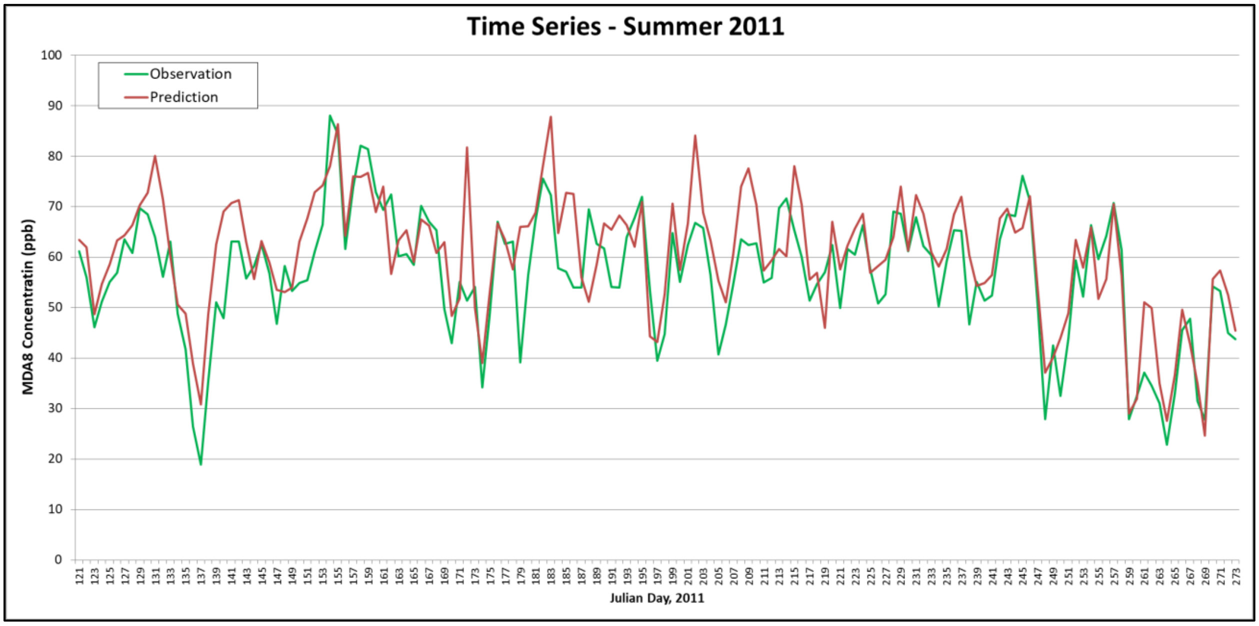

Figure 2-11. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 450830009 in South Carolina.

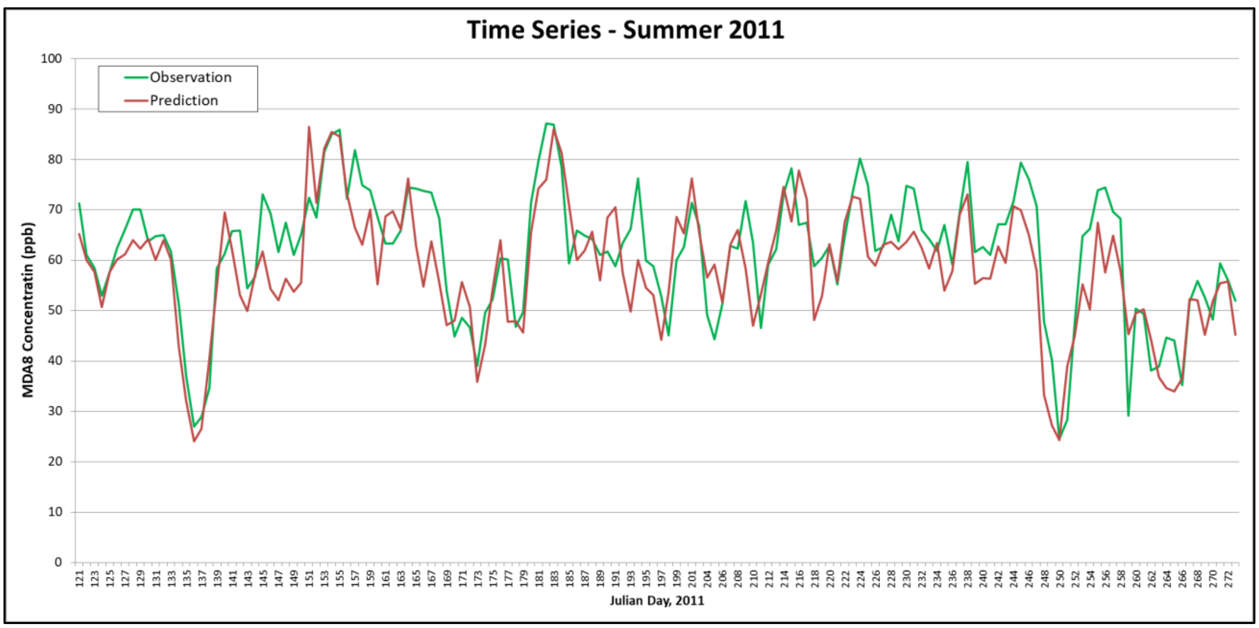

Figure 2-12. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 470090101 in Tennessee.

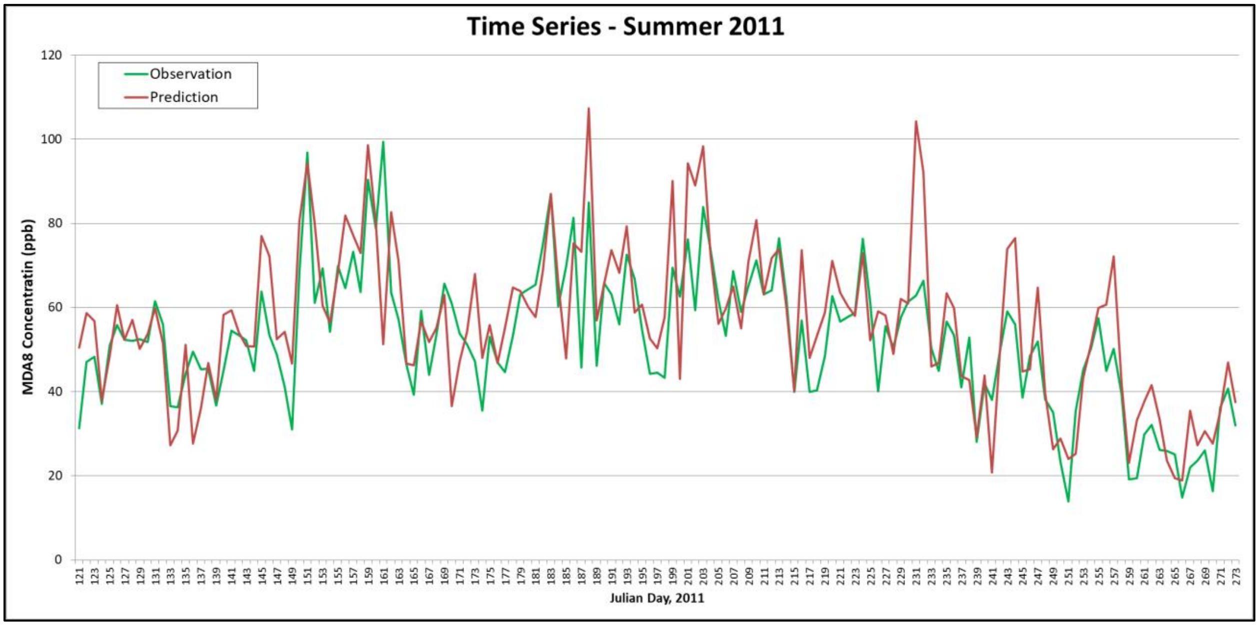

Figure 2-13. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 510590030 in Virginia.

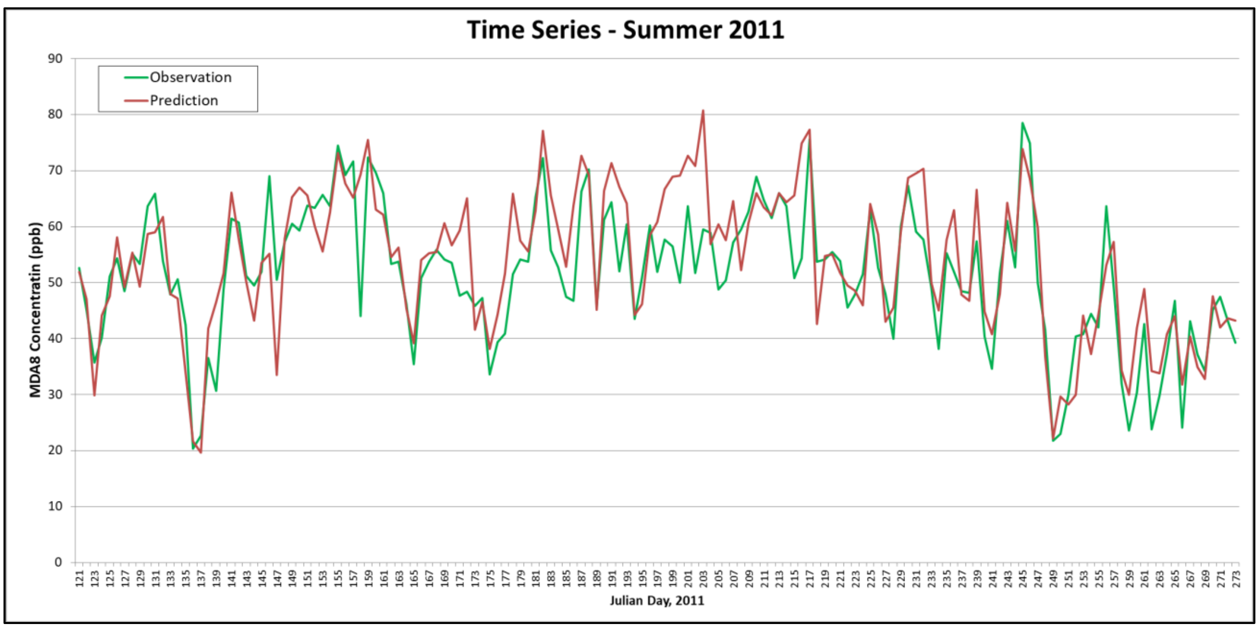

Figure 2-14. Time Series of Observed (Green) and Predicted (Red) MDA8 Ozone for May through September 2011 at Site 540690010 in West Virginia.

2.4 Concentration Correlation Plots

Under and overpredictions can also be reviewed through examination of correlation plots of observed vs. modeled MDA8 concentrations by location during the May through September episode (Figures 2-15 through 2-24). On these graphics each daily MDA8 concentration at a monitor is plotted as a single ordered pair with the observed ozone on the horizontal axis and the corresponding model estimate on the vertical axis. A perfect model would show all points in a single line with a unit slope and a y-axis intercept of zero. In the figures the fourth highest observation is plotted with a red square and the fourth highest model estimate has a yellow diamond.

While many of the sites generally track well and capture day-to-day variability, the presented sites demonstrate a modeled over estimation of ozone on most days with medium range ozone concentrations (40-60 ppb). At all monitors presented here, except in Blount County, TN, the model has overpredicted the 4th high observed values (yellow diamond).

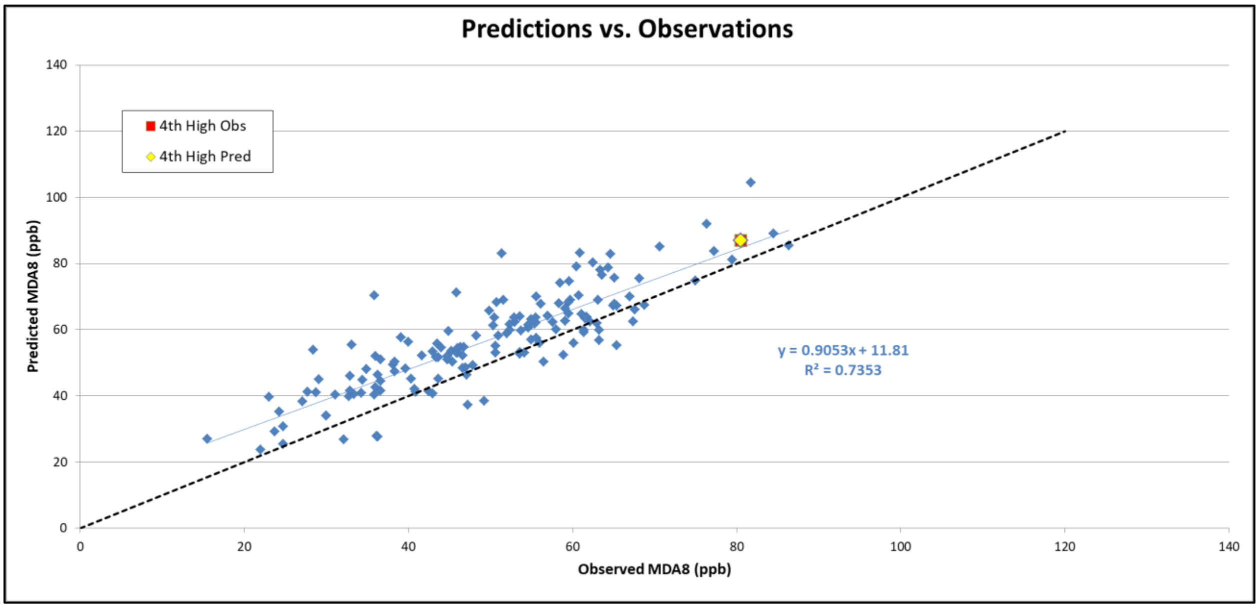

Figure 2-15. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 010731005 in Alabama. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

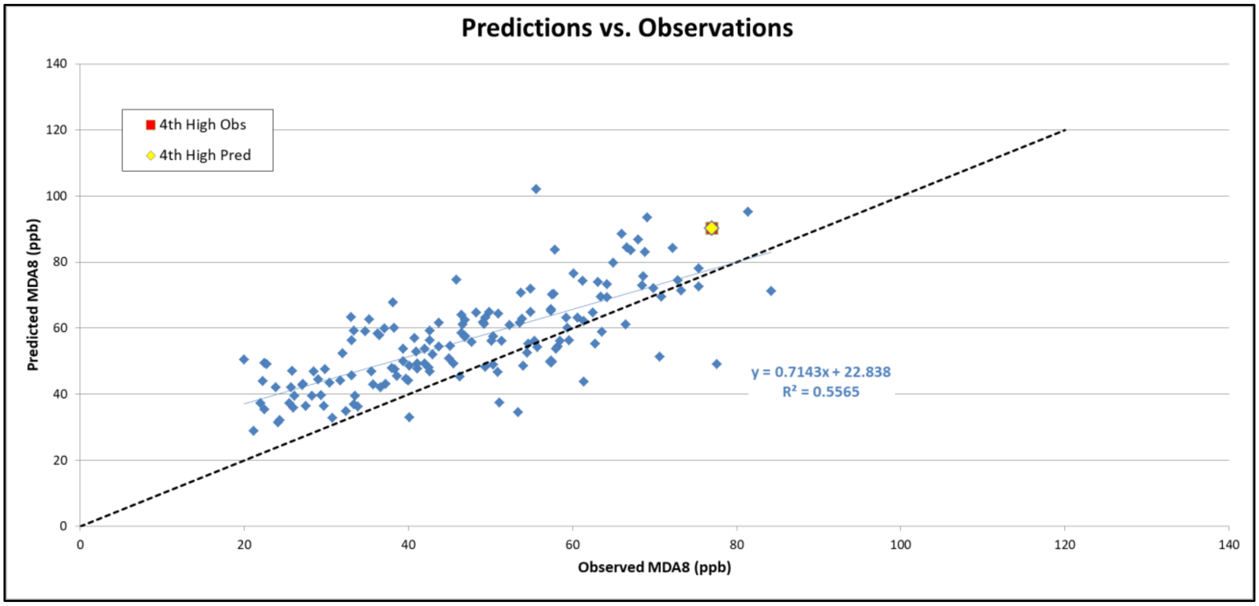

Figure 2-16. Correlation of Observed and Predicted MDA8 Ozone for May Through September 2011 at Site 121130015 in Florida. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

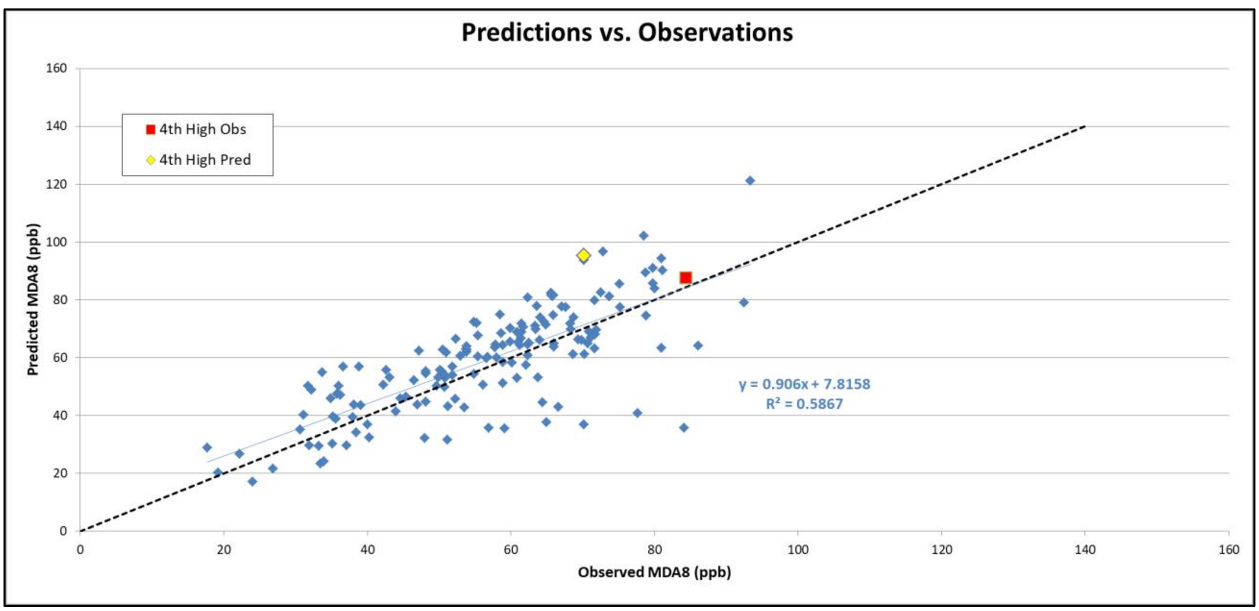

Figure 2-17. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 131210055 in Georgia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

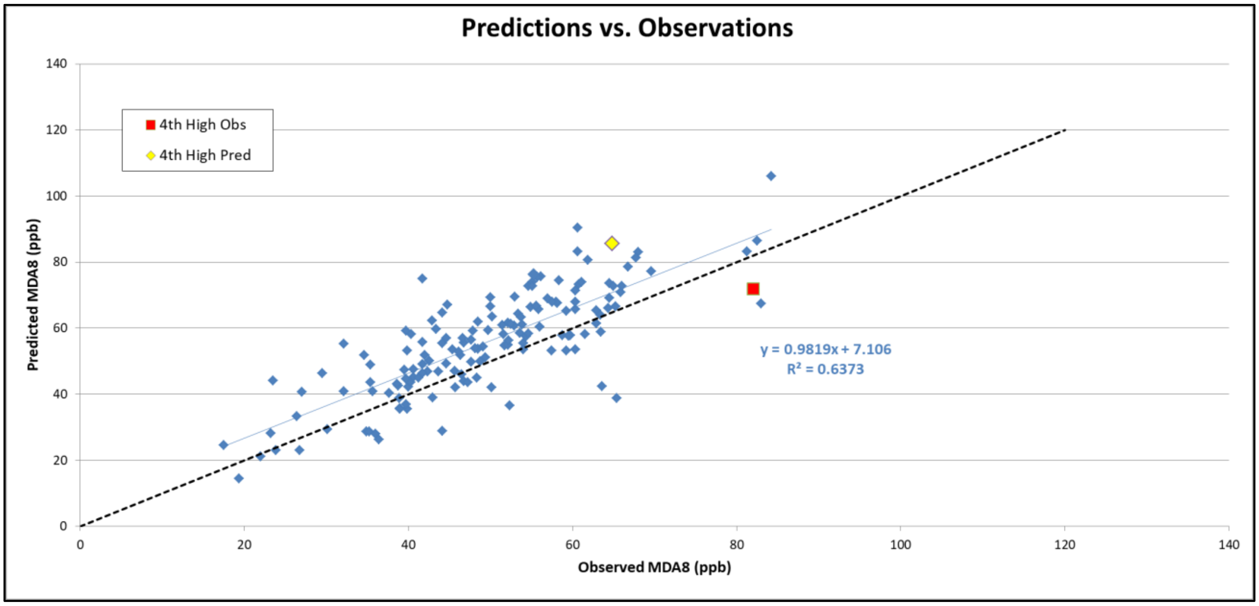

Figure 2-18. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 211110051 in Kentucky. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

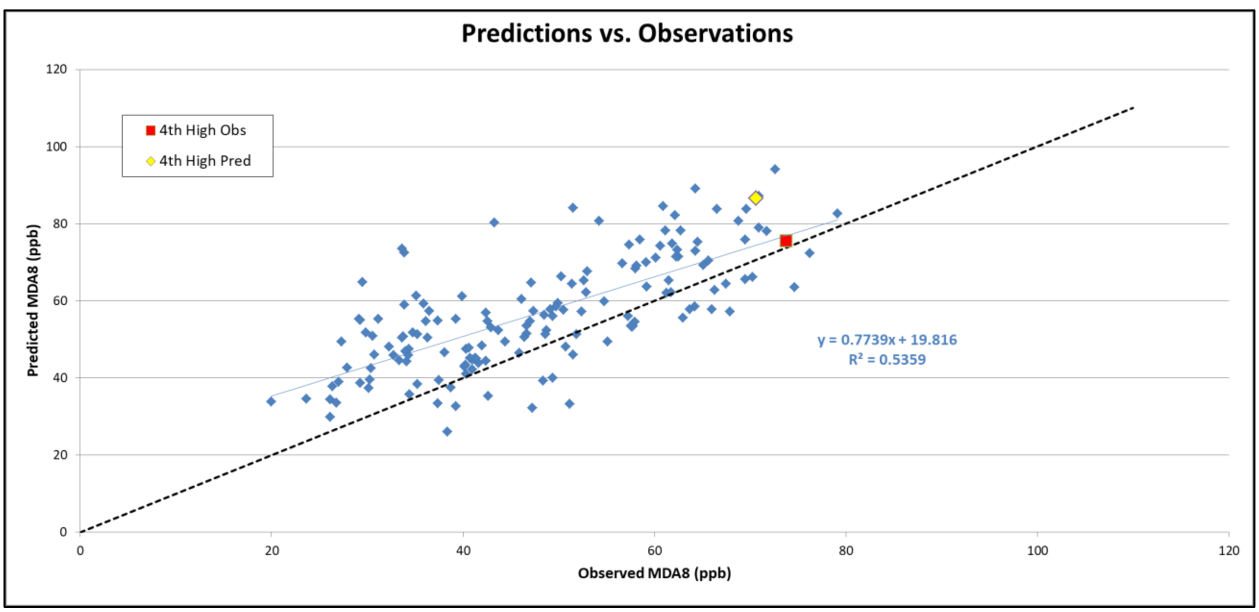

Figure 2-19. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 280470008 in Mississippi. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

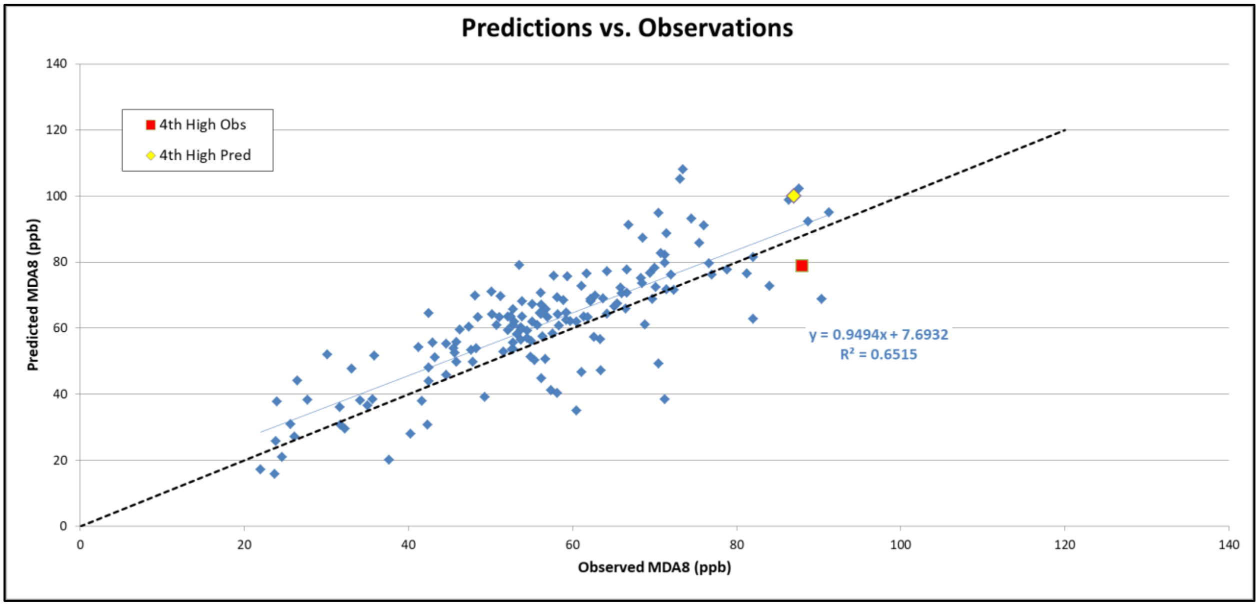

Figure 2-20. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 371190041 in North Carolina. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

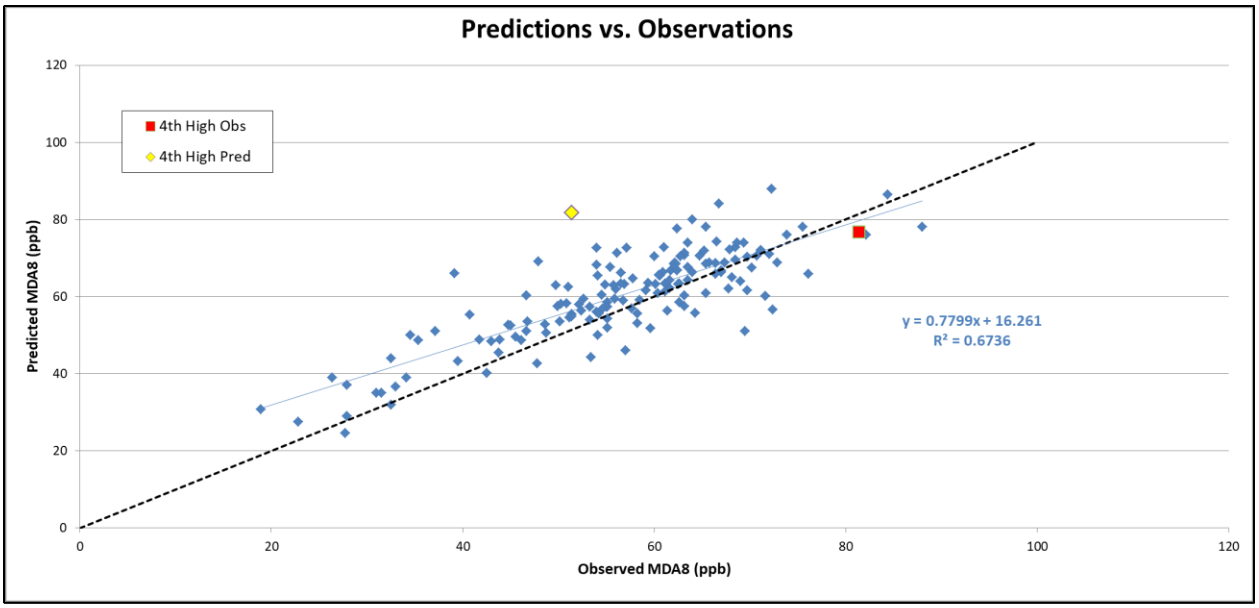

Figure 2-21. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 450830009 in South Carolina. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

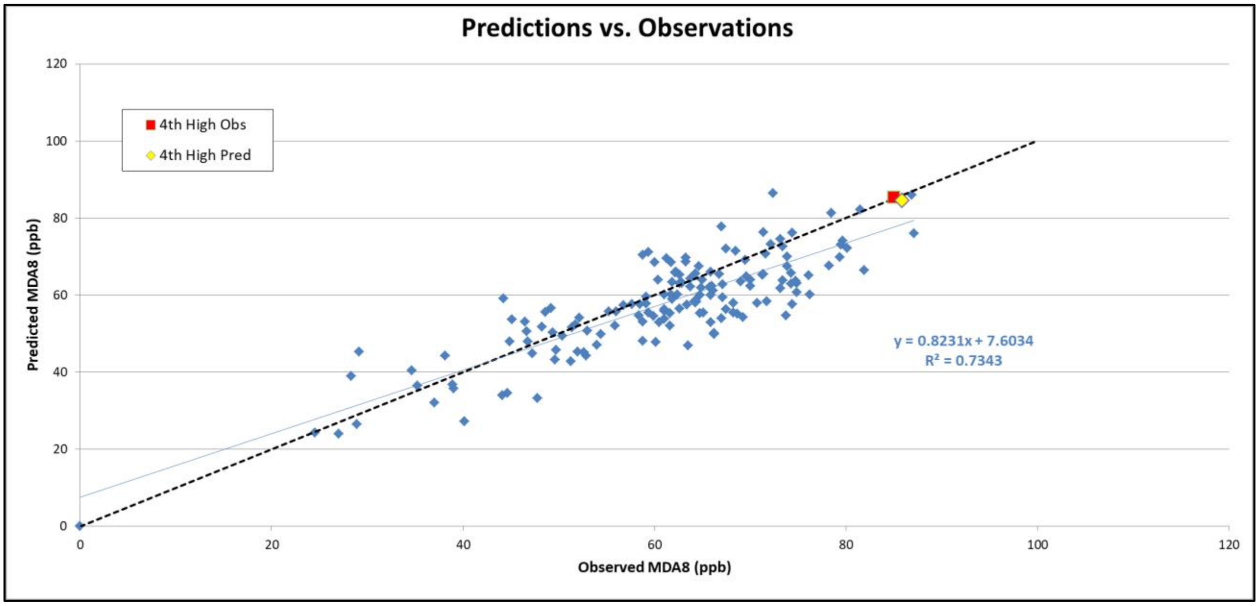

Figure 2-22. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 470090101 in Tennessee. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

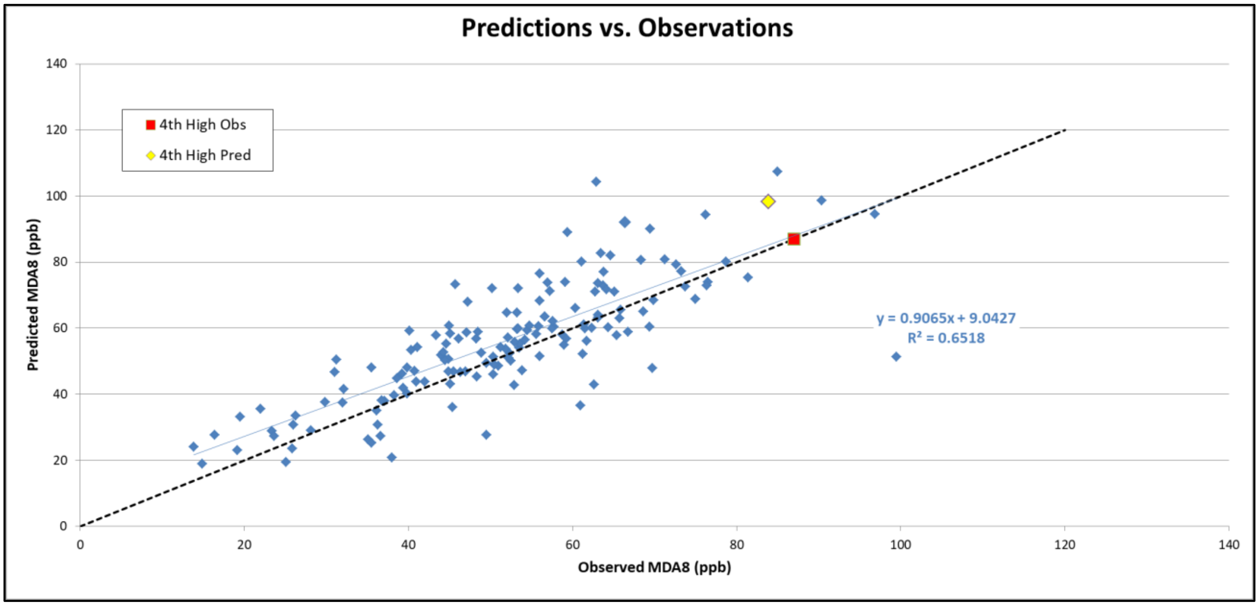

Figure 2-23. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 510590030 in Virginia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

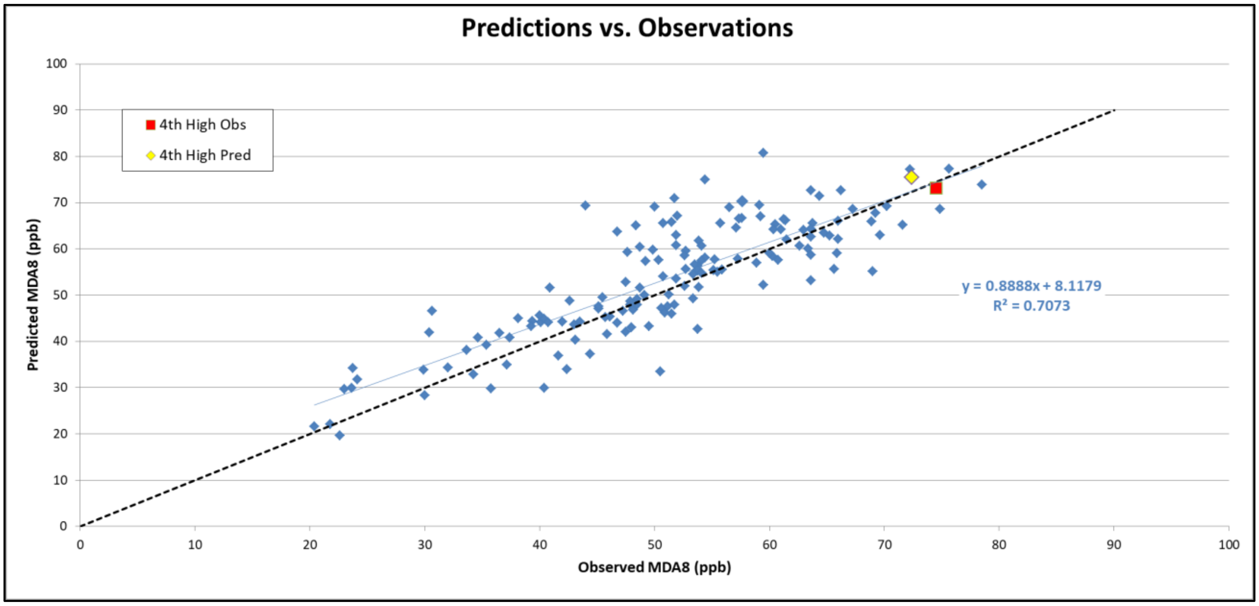

Figure 2-24. Correlation of Observed and Predicted MDA8 Ozone for May through September 2011 at Site 540690010 in West Virginia. The Red Square Indicates 4th High Observed Value and the Yellow Diamond Indicates 4th High Modeled Value.

3.0 SUMMARY

As was seen with the 12-km evaluation conducted by EPA on the 2011en platform,[11] the VISTAS12 modeling has better skill at predicting ozone concentrations in the mid-range of 40 to 60 ppb than it does at the tail ends of the concentration curves. Additionally, as noted above and demonstrated with the statistics and figures of this analysis, the model tends to overestimate ozone concentrations across all ranges and at all presented monitors. It is also noted that compared to observed concentrations, the model overestimates less at high-end concentrations (greater than 60 ppb) than at low-end observed concentrations (less than 40 ppb).

Over the entire concentration range, the model tends to overpredict MDA8 ozone in the VISTAS12 domain. However, looking across all represented monitors in the domain, we note that the model is able to capture site-to-site differences in the short-term (i.e., day-to-day) variability and the general magnitude of the observed ozone concentrations for the May through September 2011 episode.

As a result, and compared to similar results from comparable studies, we find that the predictions from the 12-km domain using this configuration of the 2011el modeling platform correspond closely to observed concentrations in terms of the magnitude, temporal fluctuations, and geographic differences for 8-hour daily maximum ozone.

Thus, the model performance results demonstrate the scientific credibility of the VISTAS12 modeling. These results provide confidence in the ability of the modeling platform to be used for future year ozone concentration projections and contribution analyses.

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Appendix A

Model Performance Statistics for MDA8 Ozone at Individual Monitoring Sites Based on Days with Observed Values ≥ 60 ppb

(see: AppendixA1-OzoneMPEbyStation.xlsx
AppendixA2-MeanBias.kmz
AppendixA3-NormalizedMeanBias.kmz
AppendixA4-MeanError.kmz
AppendixA5-NormalizedMeanError.kmz)

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