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December 12, 2018

Alec Messina, Director
Illinois Environmental Protection Agency
1021 North Grand Ave. East
Springfield IL 62794-9276

Re: Proposed Infrastructure State Implementation Plan for the 2015 Ozone NAAQS.

Dear Director Messina:

The Midwest Ozone Group (MOG) is pleased to have the opportunity to comment in support of the Good Neighbor SIP portion of Illinois EPA's proposed Infrastructure State Implementation Plan related to the 2015 ozone NAAQS.

MOG is an affiliation of companies, trade organizations, and associations that draws upon its collective resources to seek solutions to the development of legally and technically sound air quality programs.[1] MOG's primary efforts are to work with policy makers in evaluating air quality policies by encouraging the use of sound science. MOG has been actively engaged in a variety of issues and initiatives related to the development and implementation of air quality policy, including the development of transport rules, NAAQS standards, nonattainment designations, petitions under Sections 176A and 126 of the Clean Air Act, NAAQS implementation guidance, the development of Good Neighbor state implementation plans (SIPs) and related regional haze and climate change issues. MOG members and participants operate a variety of emission sources including more than 75,000 MW of coal-fired and coal-refuse fired electric power generation in more than ten states. MOG Members and Participants also own and operate several fossil-fired generating units in the State of Illinois. They are concerned about the development of technically or legally unsubstantiated interstate air pollution actions and the impacts of those actions on their facilities, their employees, their contractors, and the consumers of their products.

[1] The members of and participants in the Midwest Ozone Group include: American Coalition for Clean Coal Electricity, American Electric Power, American Forest & Paper Association, American Wood Council, Ameren, Alcoa, Appalachian Region Independent Power Producers Association (ARIPPA), ArcelorMittal, Associated Electric Cooperative, Citizens Energy Group, Council of Industrial Boiler Owners, Duke Energy, East Kentucky Power Cooperative, FirstEnergy, Indiana Energy Association, Indiana Utility Group, LGE / KU, National Lime Association, Ohio Utility Group, Olympus Power, and City Water, Light and Power (Springfield IL).

While the attached comments will identify several factors that support Illinois EPA's proposal, we will highlight only a few in this letter.

1. **MOG supports the conclusion that no additional emissions reductions beyond existing and planned controls are necessary to comply with CAA Section 110(a)(2)(D)(i)(I).**

Relying principally on modeling work performed by LADCO, Illinois EPA has analyzed nonattainment and maintenance monitors in the region and the contribution that Illinois makes to each of those monitors as part of its assessment of the requirements of CAA section 110(a)(2)(D)(i)(I). Illinois EPA's analysis is indeed conservative. Beyond the analysis performed by Illinois EPA's, MOG offers in these comments additional data and comments that we believe compel the conclusion that no further emission requirements are necessary to satisfy the requirements of CAA section 110(a)(2)(D)(i)(I).

2. **New updated state-of-the-science 4km modeling performed by Alpine Geophysics on behalf of MOG confirms the elimination of certain of the nonattainment and maintenance monitors analyzed by Illinois EPA.**

To address concerns about whether LADCO modeling with a 12 km grid is sufficiently refined to address the land/water interface issues, MOG undertook to run EPA's modeling platform at a finer 4km grid. When this state-of-the-science modeling is used to assess air quality downwind of Illinois at the appropriate attainment date, all monitors are in attainment, except for a single monitor at Sheboygan WI which has a predicted concentration of 71.5 ppb. This prediction includes a significant component related to international emissions (where recognition of even a small portion of those emissions would be more than adequate to reduce the predicted concentration at the Sheboygan monitor to attainment).

We also recognize that even with the inclusion of international emissions, the LADCO modeling relied upon by Illinois EPA predicts this monitor to be in attainment with the 2015 ozone NAAQS by 2023 and treats this monitor as a maintenance monitor.

Accordingly, the combination of the various modeling platforms available to Illinois EPA provides an adequate basis for concluding that Sheboygan should not be treated as a nonattainment monitor.

3. **An alternative methodology should be used to determine whether the Allegan MI and Sheboygan WI monitors should be considered maintenance monitors.**

Illinois EPA has determined that it is linked only to two maintenance monitors – Allegan MI and Sheboygan WI – a determination that is based upon the technique used by EPA in the CSAPR rule to identify maintenance monitors. On October 19, 2018, EPA issued new guidance which offers states the option of using an alternative method of identifying maintenance monitors to be addressed in their Good Neighbor SIPs related to the 2015 ozone NAAQS. As pointed out in these comments, when current data are applied to the various criteria identified by EPA, it is clear that neither Allegan MI nor Sheboygan WI monitors should be considered maintenance monitors for purposes related to the 2015 ozone NAAQS. Accordingly, there is no basis for imposing additional controls on sources in Illinois to address downwind maintenance monitors.

Conclusion

As is stated in detail in the attached comments, the Midwest Ozone Group supports Illinois EPA's draft Good Neighbor SIP as a conservative justification for the conclusion that no additional emissions reductions beyond existing and planned controls are necessary to mitigate any contribution Illinois may have to any downwind monitors to comply with CAA section 110(a)(2)(D)(i)(I).

Very truly yours,

David M. Flannery

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cc:

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COMMENTS OF THE MIDWEST OZONE GROUP REGARDING THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED INFRASTRUCTURE STATE IMPLEMENTATION PLAN

DECEMBER 12, 2018

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COMMENTS OF THE MIDWEST OZONE GROUP REGARDING THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED INFRASTRUCTURE STATE IMPLEMENTATION PLAN

The Midwest Ozone Group (MOG) is pleased to have the opportunity to comment[1] on the proposed "Illinois Infrastructure State Implementation Plan for the 2015 Ozone National Ambient Air Quality Standard (with Emission Statement and Interstate Transport)" by the Illinois Environmental Protection Agency (Illinois EPA). While the full proposal relates to the requirements of Section 110(a)(1) and (2) of the federal Clean Air Act (CAA), these comments will be limited to the interstate transport provisions. MOG strongly supports Illinois EPA's proposed plan as fully satisfying the requirements CAA section 110(a)(2)(D)(i)(I) regarding the interstate transport for the 2015 ozone NAAQS.

MOG is an affiliation of companies, trade organizations, and associations that draws upon its collective resources to seek solutions to the development of legally and technically sound air quality programs.[2] MOG's primary efforts are to work with policy makers in evaluating air quality policies by encouraging the use of sound science. MOG has been actively engaged in a variety of issues and initiatives related to the development and implementation of air quality policy, including the development of transport rules, NAAQS standards, nonattainment designations, petitions under Sections 176A and 126 of the Clean Air Act, NAAQS implementation guidance, the development of Good Neighbor state implementation plans (SIPs) and related regional haze and climate change issues. MOG members and participants operate a variety of emission sources including more than 75,000 MW of coal-fired and coal-refuse fired electric power generation in more than ten states. MOG Members and Participants also own and operate several fossil-fired generating units in the State of Illinois. They are concerned about the development of technically or legally unsubstantiated interstate air pollution actions and the impacts of those actions on their facilities, their employees, their contractors, and the consumers of their products.

[1] Comments or questions about this document should be directed to David M. Flannery, Kathy G. Beckett, or Edward L. Kropp, Legal Counsel, Midwest Ozone Group, Steptoe & Johnson PLLC, 707 Virginia Street East, Charleston West Virginia 25301; 304-353-8000; dave.flannery@steptoe-johnson.com and kathy.beckett@steptoe-johnson.com and skipp.kropp@steptoe-johnson.com respectively. These comments were prepared with the technical assistance of Alpine Geophysics, LLC

[2] The members of and participants in the Midwest Ozone Group include: American Coalition for Clean Coal Electricity, American Electric Power, American Forest & Paper Association, American Wood Council, Ameren, Alcoa, Appalachian Region Independent Power Producers Association (ARIPPA), ArcelorMittal, Associated Electric Cooperative, Citizens Energy Group, Council of Industrial Boiler Owners, Duke Energy, East Kentucky Power Cooperative, FirstEnergy, Indiana Energy Association, Indiana Utility Group, LGE / KU, National Lime Association, Ohio Utility Group, Olympus

1. MOG supports the conclusion that no additional emissions reductions beyond existing and planned controls are necessary to comply with CAA Section 110(a)(2)(D)(i)(I).

The issue being addressed in the proposed Good Neighbor SIP, is whether these existing measures also satisfy the Good Neighbor requirements of Section 110(a)(2)(D)(i)(I) which prohibits a state from significantly contributing to nonattainment or interfering with maintenance of any primary or secondary NAAQS in another state.

As was identified in the March 27, 2018, memorandum of EPA's Peter Tsirigotis[3], a four step process is to be used by EPA to address Good Neighbor requirements. These four steps are:

Step 1: identify downwind air quality problems;

Step 2: identify upwind states that contribute enough to those downwind air quality problems to warrant further review and analysis;

Step 3: identify the emissions reductions necessary to prevent an identified upwind state from contributing significantly to those downwind air quality problems; and

Step 4: adopt permanent and enforceable measure needed to achieve those emission reductions.

Relying principally on modeling work performed by LADCO to address Step 1 and Step 2 in this analysis and its own data to assess Step 3, Illinois EPA has analyzed nonattainment and maintenance monitors in the region and the contribution that Illinois makes to each of those monitors.

Throughout its analysis, Illinois EPA offers several reasons why even its analysis is conservative. Among the conservative factors cited by Illinois EPA are:

- Use of a 1 ppb (versus 2 ppb) significant contribution test;
- Use of EPA's original methodology for identifying maintenance monitors; and
- Reliance on modeling that may over-estimate EGU NOx emissions beyond those estimated by EPA.

Power, and City Water, Light and Power (Springfield IL).

[3] *Information on the Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards under Clean Air Act Section 110(a)(2)(D)(i)(I)*, prepared by Peter Tsirigotis, March 27, 2018. https://www.epa.gov/airmarkets/march-2018-memo-and-supplemental-information-regarding-interstate-transport-sips-2015.

In addition, Illinois EPA makes it clear that it is continuing to work with USEPA to identify additional flexibilities for defining maintenance, quantifying interstate transport, excluding international transport, and demonstrating attainment.

Illinois EPA's analysis is indeed a conservative one. MOG not only supports this analysis, MOG will offer in these comments additional data and comments that we believe support the conclusion that no further emission requirements in Illinois are necessary to satisfy the requirements of CAA section 110(a)(2)(D)(i)(I).

2. New updated state-of-the-science 4km modeling performed by Alpine Geophysics on behalf of MOG confirms the elimination of certain of the nonattainment and maintenance monitors analyzed by Illinois EPA.

At MOG's request, Alpine Geophysics has performed state-of-the-science modeling to address the concerns about whether modeling with a 12 km grid is sufficiently refined to address the land/water interface issues. To address this concern, Alpine Geophysics undertook to rerun EPA's 2011/2023en modeling platform using 4km-processed emissions. This was done in an effort to refine modeled ozone concentrations at and near land-water interface receptors. Alpine Geophysics has completed the model performance evaluation on these domains and at key receptors. These results provide confidence in the ability of the modeling platform to provide a reasonable projection of expected future year ozone concentrations and contributions.

This model performance evaluation and the results of the refined 4km modeling have been incorporated into a Technical Support Document (TSD)[4] that is attached to these comments and identified as Exhibit A.

Set out in the table below is a summary of these refined 4km results taken from the TSD for those monitors that the agency has identified as being either nonattainment or maintenance monitors.

[4] "Air Quality Modeling Technical Support Document for Midwest Ozone Group's Updated 4km Modeling," prepared by Alpine Geophysics, LLC, Burnsville, NC. December 2018. http://www.midwestozonegroup.com/files/Final_TSD_-_Updated_4km_Ozone_Modeling_Dec_2018_.pdf.

			Ozone Design Value (ppb)	
Monitor	State	County	DVf (2023) Ave	DVf (2023) Max
90010017	Connecticut	Fairfield	66.8	69.0
90013007	Connecticut	Fairfield	69.2	73.1
90019003	Connecticut	Fairfield	68.3	71.0
90099002	Connecticut	New Haven	68.9	71.5
90110124	Connecticut	New London	66.0	69.1
240251001	Maryland	Harford	70.9	73.3
260050003	Michigan	Allegan	70.0	72.8
340150002	New Jersey	Gloucester	68.8	71.0
360810124	New York	Queens	68.5	70.2
360850067	New York	Richmond	69.6	71.0
361030002	New York	Suffolk	70.6	72.0
421010024	Pennsylvania	Philadelphia	67.5	70.5
551170006	Wisconsin	Sheboygan	71.5	73.8

From these results there are several conclusions that offer additional support for the agency's proposal, including:

-Using MOG's updated 4km modeling, the Harford MD, Suffolk NY, and Fairfield CT monitors (that had been modeled by LADCO as nonattainment) now have predicted average design values of 70.9 ppb, 70.6 ppb and 68.3 ppb which means they should no longer be considered to be in nonattainment with the 2015 ozone NAAQS in 2023.

-The new MOG modeling predicts an average design value for the Sheboygan WI monitor of 71.5 ppb. This prediction includes a significant component related to international emissions (where recognition of even a small portion of those emissions would be more than adequate to reduce the predicted concentration at the Sheboygan monitor to attainment). We also recognize that even with the inclusion of international emissions, the LADCO modeling relied upon by Illinois EPA predicts this monitor to be in attainment with the 2015 ozone NAAQS by 2023 and treats this monitor as a maintenance monitor.

-There are no other monitors in the eastern U.S. that are predicted to be in nonattainment with the 2015 ozone NAAQS.

-The monitors located at Queens NY and Fairfield CT are no longer maintenance monitors and need not be addressed in the state's Good Neighbor SIP.

-Without consideration of any maintenance monitor flexibility guidance (to be discussed later), the only maintenance monitors linked to Illinois are the monitors at Sheboygan WI and Allegan MI.

MOG's modeling data alone offers additional support for the conclusion that the agency's proposal is very conservative and that no additional emission reductions beyond existing and planned controls are necessary to comply with the requirements of Section 110(a)(2)(D)(i)(I) of the federal Clean Air Act. This conclusion is further strengthened with the consideration of the maintenance monitor flexibility guidance to be discussed later in these comments.

3. An alternative methodology should be used to determine whether the Allegan MI and Sheboygan WI monitors are maintenance monitors.

As stated above, Illinois EPA has determined that it is linked to only two maintenance monitors – Allegan MI and Sheboygan WI – based upon the technique used by EPA to identify maintenance monitors in the CSAPR rule.

On October 19, 2018, EPA issued new guidance[5] in the form of a memorandum entitled "Considerations or Identifying Maintenance Receptors for Use in Clean Air Act Section 110(a)(2)(D)(i)(I) Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards" ("EPA's Memo"). That guidance recognizes an alternative methodology for making the determination of the monitor's status as a maintenance monitor. A copy of that guidance is attached to these comments and identified as Exhibit B.

Alpine Geophysics was tasked by MOG to review EPA's Memo and to apply MOG's refined 4km modeling results presented in this letter as well as observed ozone concentrations[6] to relevant monitors to determine whether those monitors would qualify as maintenance monitors under EPA's alternative methodology.

Under EPA's Memo, a modeled demonstration would first need to show that using an alternative base year period would lead to a projected future year design value at or below a concentration of 70.9 ppb which demonstrates modeled attainment of the 2015 ozone NAAQS of 70 ppb. If that demonstration is successful, EPA's Memo states that EPA would expect states to include with their SIP demonstration submission technical analyses showing that:

1. meteorological conditions in the area of the monitoring site were conducive to ozone formation during the period of clean data or during the alternative base period design value used for projections;

[5] https://www.epa.gov/airmarkets/considerations-identifying-maintenance-receptors-memo
[6] Appendix, "Addressing Maintenance Monitor Flexibilities Using the 2023 Cross-State Air Pollution Rule Closeout Modeling Platform - Revised December 2018," prepared by Alpine Geophysics, LLC, Burnsville, NC. December 2018. http://www.midwestozonegroup.com/files/Maintenance_Monitor_Flexibility_Dec_2018_.pdf.

2. ozone concentrations have been trending downward at the site since 2011 (and ozone precursor emissions of nitrogen oxide (NOx) and volatile organic compounds (VOC) have also decreased); and
3. emissions are expected to continue to decline in the upwind states out to the attainment date of the receptor.

EPA's Memo provided the meteorological data to support #1 above. EPA also provided historical emission trends[7] and emission projections[8] that demonstrate continued decline of ozone precursors through 2023 to support #3. Alpine Geophysics then used modeled ozone concentration data from EPA's 12km and MOG's refined 4km modeling, as well as historical observed concentrations, to demonstrate #2.

a. **Utilization of alternative base period design values results in a projection of clean data for the monitors in question.**

The Allegan MI and Sheboygan WI monitors have been identified by Illinois EPA as the only monitors linked to Illinois that can be characterized as maintenance monitors under the CSAPR test. A first step in applying the flexibility guidance set forth in EPA's Memo is to determine whether these monitors can be shown to attain the 2015 ozone NAAQS under the alternative methodology, Alpine Geophysics reviewed 2023 ozone design values using alternate base year concentrations (from the three, three-year time periods between 2009 – 2013) for each of these two monitors. These data, presented in the following table, demonstrate that each of the monitors has at least one alternate base year period design value that results in a 2023 projection equal to or lower than the 70.9 ppb. This data satisfies this condition of EPA's alternative methodology.

Alternate Base Year Projections of 2023 ozone Design Values (ppb) from Alpine 4km Modeling for Key Monitors in the 4km Domains.

				2023 Ozone Design Value (ppb)		
Monitor	**State**	**County**	**DVb (2011)**	**DVf (Ave)**	**DVf (Max)**	**DVf (Max 2009/11)**
260050003	Michigan	Allegan	82.7	70.0	72.8	66.1
551170006	Wisconsin	Sheboygan	84.3	71.5	73.8	68.7

b. **Meteorological conditions of the monitors were conducive to ozone formation.**

[7] https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data
[8] https://www.epa.gov/air-emissions-modeling/additional-updates-2011-and-2023-emissions-version-63-platform-technical

One of the criteria established in EPA's Memo for approving an alternative demonstration of a monitor's maintenance status is that the "meteorological conditions in the area of the monitoring site were conducive to ozone formation during the period of clean data or during the alternative base period design value used for projections."

EPA's Memo at page A-3 goes on to offer the following general comment on meteorological conditions:

> In general, below average temperatures are on indication that meteorological conditions are unconducive for ozone formation, whereas above average temperatures are an indication that meteorology is conducive to ozone formation. Within a particular summer season, the degree that meteorology is conducive for ozone formation can vary from region to region and fluctuate with time within a particular region. For example, the temperature-related information presented below suggests that summer meteorology was generally conducive for ozone formation in 2010, 2011, 2012 and 2016 in most regions. In contrast, the summer of 2009 was generally unconducive for ozone formation, overall, in most regions. In addition, the summers of 2013 and 2014 were not particularly conducive for ozone formation in the Upper Midwest, Ohio Valley, South, Southeast.

With respect to Allegan MI and Sheboygan WI, the alternative demonstration is based upon alternative base year periods involving the years 2009 through 2011.While EPA offers the caution that the summer of 2009 was generally not conducive for ozone formation, we have been careful to develop an alternative demonstration for this monitor that does not rely on 2009 exclusively. Rather, the alternative base case period selected for the following monitors also includes the average of the years 2010 and 2011 which clearly are ozone conducive years:

By basing model projections for the attainment year of 2023 on alternative base period design values for ozone conducive years, the Allegan MI and Sheboygan WI monitors meet the meteorological threshold of EPA's Memo.

c. **Ozone concentrations are trending downward.**

As an additional supporting case to the flexibility in identifying maintenance monitors, EPA guidance provides that a state would need to show that "ozone concentrations have been trending downward at the site since 2011". The first table below presents 4th high ozone concentration data[9] measured at each noted receptor and a calculated slope between 2011 and the most recently EPA-approved 4th high concentrations from 2017. The second table below presents a count of the number of ozone exceedance days per monitor per year relative to the 2015 70 ppb ozone NAAQS.

[9] Appendix, "Addressing Maintenance Monitor Flexibilities Using the 2023 Cross-State Air Pollution Rule Closeout Modeling Platform - Revised December 2018," prepared by Alpine Geophysics, LLC, Burnsville, NC. December 2018. http://www.midwestozonegroup.com/files/Maintenance_Monitor_Flexibility_Dec_2018_.pdf.

4th High Ozone Concentrations (ppb) and Slope Calculation for Key Monitors in the 4km Domains.

			4th High Ozone Concentration (ppb)							
Monitor	**State**	**County**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Slope (2011-2017) (ppb/yr)**
260050003	Michigan	Allegan	85	95	78	77	72	76	71	-3.07
551170006	Wisconsin	Sheboygan	84	93	78	72	81	85	75	-1.43

Daily Ozone Exceedance Counts and Slope Calculation for Key Monitors in the 4km Domains.

			Daily Ozone Exceedance Counts							
Monitor	**State**	**County**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Slope (2011-2017**
260050003	Michigan	Allegan	9	36	8	7	4	9	4	-2.61
551170006	Wisconsin	Sheboygan	13	35	10	4	11	11	13	-1.68

In the case of each of the Allegan MI and Sheboygan WI monitors, negative slopes for both 4th high ozone concentrations and daily ozone exceedance counts demonstrates the necessary downward trends in ozone concentrations necessary to satisfy this requirement of EPA's Memo.

d. **Emissions of ozone precursors have been trending downwards since 2011 and are expected to continue to decline.**

NOx and VOC emissions across the CSAPR region have been dramaticaly reduced in recent years. These emission reductions will continue as the result of "on-the-books" regulatory programs already required by states on their own sources, "on-the-way" regulatory programs that have already been identified by state regulatory agencies as efforts that they must undertake as well as from the effectiveness of a variety of EPA programs including the CSAPR Update Rule.

Presented below are tables developed from EPA modeling platform summaries10 illustrating the estimated total anthropogenic emission reduction emission reduction in the CSAPR states.

As can be seen in the first table, total annual anthropogenic NOx emissions are predicted to decline by 29% between 2011 and 2017 over the CSAPR domain and by 43% (an additional 1.24 million tons) between 2011 and 2023.

[10] 83 Fed. Reg. 7716 (February 22, 2018).

Final CSAPR Update Modeling Platform Anthropogenic NOx Emissions (Annual Tons).

	Annual Anthropogenic NOx Emissions (Tons)			Emissions Delta (2017-2011)		Emissions Delta (2023-2011)	
State	**2011**	**2017**	**2023**	**Tons**	**%**	**Tons**	**%**
Alabama	359,797	220,260	184,429	139,537	-39%	175,368	-49%
Arkansas	232,185	168,909	132,148	63,276	-27%	100,037	-43%
Illinois	506,607	354,086	293,450	152,521	-30%	213,156	-42%
Indiana	444,421	317,558	243,954	126,863	-29%	200,467	-45%
Iowa	240,028	163,126	124,650	76,901	-32%	115,377	-48%
Kansas	341,575	270,171	172,954	71,404	-21%	168,621	-49%
Kentucky	327,403	224,098	171,194	103,305	-32%	156,209	-48%
Louisiana	535,339	410,036	373,849	125,303	-23%	161,490	-30%
Maryland	165,550	108,186	88,383	57,364	-35%	77,167	-47%
Michigan	443,936	296,009	228,242	147,927	-33%	215,694	-49%
Mississippi	205,800	128,510	105,941	77,290	-38%	99,859	-49%
Missouri	376,256	237,246	192,990	139,010	-37%	183,266	-49%
New Jersey	191,035	127,246	101,659	63,789	-33%	89,376	-47%
New York	388,350	264,653	230,001	123,696	-32%	158,349	-41%
Ohio	546,547	358,107	252,828	188,439	-34%	293,719	-54%
Oklahoma	427,278	308,622	255,341	118,656	-28%	171,937	-40%
Pennsylvania	562,366	405,312	293,048	157,054	-28%	269,318	-48%
Tennessee	322,578	209,873	160,166	112,705	-35%	162,411	-50%
Texas	1,277,432	1,042,256	869,949	235,176	-18%	407,482	-32%
Virginia	313,848	199,696	161,677	114,152	-36%	152,171	-48%
West Virginia	174,219	160,102	136,333	14,117	-8%	37,886	-22%
Wisconsin	268,715	178,927	140,827	89,788	-33%	127,888	-48%
CSAPR States	**8,651,264**	**6,152,990**	**4,914,012**	**2,498,274**	**-29%**	**3,737,252**	**-43%**

It is significant that the estimated 2017 emissions used in the EPA modeling are inflated as compared to the actual 2017 CEM-reported EGU emissions. As can be seen in the following table, when the CSAPR-modeled 2017 annual EGU emissions are compared to the actual CEM-reported 2017 annual EGU emissions, it becomes apparent that there is a significant domain-wide overestimation (129,000 annual tons NOx) of the predicted emissions for this category. The modeled values from state-to-state vary between over- and under-estimated, domain-wide, CEM-reported annual NOx ranging from 158% overestimation (2017 actual emissions are 61% of modeled emissions) for Pennsylvania to 54% underestimation (2017 actual emissions are 118% of modeled emissions) for Virginia with a domain-wide overestimation of 18% (129,553 tons) of annual NOx emissions from EGUs.

Final CSAPR Update Modeling Platform EGU NOx Emissions Compared to CEM-Reported EGU NOx Emissions (Annual Tons).

	Annual EGU NOx Emissions (Tons)			Emissions Delta 2017 CEM-2017 EPA	
State	**2011 EPA**	**2017 EPA**	**2017 CEM**	**Tons**	**%**
Alabama	64,008	23,207	24,085	878	4%
Arkansas	38,878	24,103	27,500	3,397	14%
Illinois	73,689	31,132	33,066	1,934	6%
Indiana	119,388	89,739	63,421	(26,318)	-29%
Iowa	39,712	26,041	22,564	(3,477)	-13%
Kansas	43,405	25,104	13,032	(12,072)	-48%
Kentucky	92,279	57,520	46,053	(11,467)	-20%
Louisiana	52,010	19,271	29,249	9,978	52%
Maryland	19,774	6,001	6,112	111	2%
Michigan	77,893	52,829	37,739	(15,090)	-29%
Mississippi	28,039	14,759	12,162	(2,597)	-18%
Missouri	66,170	38,064	49,692	11,628	31%
New Jersey	7,241	2,918	3,443	524	18%
New York	27,379	10,191	11,253	1,062	10%
Ohio	104,203	68,477	57,039	(11,438)	-17%
Oklahoma	80,936	32,366	21,761	(10,606)	-33%
Pennsylvania	153,563	95,828	37,148	(58,680)	-61%
Tennessee	27,000	14,798	18,201	3,402	23%
Texas	148,473	112,670	109,914	(2,756)	-2%
Virginia	40,141	7,589	16,545	8,957	118%
West Virginia	56,620	63,485	44,079	(19,406)	-31%
Wisconsin	31,881	15,374	17,856	2,482	16%
CSAPR States	**1,392,682**	**831,466**	**701,913**	**(129,553)**	**-16%**

As can be seen in the second table, total annual anthropogenic VOC emissions are predicted to decline by 9% between 2011 and 2017 over the CSAPR domain and by 15% (an additional 1.43 million tons) between 2011 and 2023.

Final CSAPR Update Modeling Platform Anthropogenic VOC Emissions (Annual Tons).

	Annual Anthropogenic VOC Emissions (Tons)			Emissions Delta (2017-2011)		Emissions Delta (2023-2011)	
State	**2011**	**2017**	**2023**	**Tons**	**%**	**Tons**	**%**
Alabama	393,465	328,996	306,583	64,468	-16%	86,882	-22%
Arkansas	342,779	312,750	295,210	30,029	-9%	47,569	-14%
Illinois	372,137	320,543	294,087	51,594	-14%	78,049	-21%
Indiana	284,378	226,734	200,827	57,644	-20%	83,551	-29%
Iowa	191,201	158,520	144,326	32,681	-17%	46,875	-25%
Kansas	461,871	457,042	388,734	4,828	-1%	73,137	-16%
Kentucky	273,603	236,383	214,051	37,220	-14%	59,551	-22%
Louisiana	692,238	647,568	586,378	44,670	-6%	105,860	-15%
Maryland	125,468	105,316	95,511	20,152	-16%	29,957	-24%
Michigan	450,276	350,937	301,599	99,339	-22%	148,677	-33%
Mississippi	274,537	236,316	213,200	38,221	-14%	61,338	-22%
Missouri	377,268	331,054	307,386	46,214	-12%	69,882	-19%
New Jersey	183,091	152,805	141,113	30,286	-17%	41,978	-23%
New York	417,438	337,078	301,794	80,361	-19%	115,645	-28%
Ohio	391,315	306,215	303,144	85,101	-22%	88,172	-23%
Oklahoma	607,943	561,947	538,770	45,996	-8%	69,172	-11%
Pennsylvania	376,322	317,876	293,703	58,446	-16%	82,618	-22%
Tennessee	290,998	231,537	207,178	59,461	-20%	83,820	-29%
Texas	2,194,868	2,324,259	2,244,343	(129,391)	6%	(49,475)	2%
Virginia	295,360	254,049	235,605	41,311	-14%	59,755	-20%
West Virginia	139,516	173,841	172,511	(34,324)	25%	(32,995)	24%
Wisconsin	288,296	231,988	204,074	56,308	-20%	84,222	-29%
CSAPR States	**9,424,368**	**8,603,753**	**7,990,125**	**820,614**	**-9%**	**1,434,242**	**-15%**

EPA's October 19, 2018, guidance memo offers states the option of using an alternative method of identifying maintenance monitors to be addressed in their Good Neighbor SIPs related to the 2015 ozone NAAQS. When current data is applied to the various criteria identified by EPA, it is clear that neither Allegan MI nor Sheboygan WI monitors should be considered maintenance monitors for purposes related to the 2015 ozone NAAQS.

4. In the development of its Good Neighbor SIP, maintenance areas should not be treated the same as nonattainment areas.

Illinois EPA is correct in addressing on page 9 of the proposed GNS that maintenance monitors should not be treated the same as nonattainment monitors. Maintenance areas should not be subject to the same "significance" test as is applied to nonattainment areas. Maintenance areas do not require the same emission reduction requirements as nonattainment areas, and therefore, require different management.

The U.S. Supreme Court opinion in *EPA v. EME Homer City* offered the following on "interference with maintenance,"

> *The statutory gap identified also exists in the Good Neighbor Provision's second instruction. That instruction requires EPA to eliminate amounts of upwind pollution that "interfere with maintenance" of a NAAQS by a downwind State. §7410(a)(2)(D)(i). This mandate contains no qualifier analogous to "significantly," and yet it entails a delegation of administrative authority of the same character as the one discussed above. Just as EPA is constrained, under the first part of the Good Neighbor Provision, to eliminate only those amounts that "contribute . . . to nonattainment," EPA is limited, by the second part of the provision, to reduce only by "amounts" that "interfere with maintenance," i.e., by just enough to permit an already-attaining State to maintain satisfactory air quality. (Emphasis added). With multiple upwind States contributing to the maintenance problem, however, EPA confronts the same challenge that the "contribute significantly" mandate creates: How should EPA allocate reductions among multiple upwind States, many of which contribute in amounts sufficient to impede downwind maintenance" Nothing in either clause of the Good Neighbor Provision provides the criteria by which EPA is meant to apportion responsibility.*[11]

The D.C. Circuit opinion in *EME Homer City v. EPA*, also informs the maintenance area issue:

> *The statute also requires upwind States to prohibit emissions that will "interfere with maintenance" of the NAAQS in a downwind State. "Amounts" of air pollution cannot be said to "interfere with maintenance" unless they leave the upwind State and reach a downwind State's maintenance area. To require a State to reduce "amounts" of emission pursuant to the "interfere with maintenance" prong, EPA must show some basis in evidence for believing that those "amounts" from an upwind State, together with amounts from other upwind contributors, will reach a specific maintenance area in a downwind State and push that maintenance area back over the NAAQS in the near future. Put simply, the "interfere with maintenance" prong of the statute is not an open-ended invitation for EPA to impose*

[11] 134 S. Ct. at 1064, Ftn 18.

reductions on upwind States. Rather, it is a carefully calibrated and commonsense supplement to the "contribute significantly" requirement.[12]

EPA's January 17, 2018, brief in the CSAPR Update litigation (*Wisconsin et al. v EPA*, Case No. 16-1406) documents with the following statement on pages 77 and 78 that EPA is ready to concede that a lesser level of control is appropriate in situations not constrained by the time limits of the CSAPR Update:

Ultimately, Petitioners' complaint that maintenance-linked states are unreasonably subject to the "same degree of emission reductions" as nonattainment linked states must fail. Indus. Br. 25. There is no legal or practical prohibition on the Rule's use of a single level of control stringency for both kinds of receptors, provided that the level of control is demonstrated to result in meaningful air quality improvements without triggering either facet of the Supreme Court's test for over-control. So while concerns at maintenance receptors can potentially be eliminated at a lesser level of control in some cases given the smaller problem being addressed, this is a practical possibility, not a legal requirement. See 81 Fed. Reg. at 74,520. Here, EPA's use of the same level of control for both maintenance-linked states and nonattainment-linked states is attributable to the fact that the Rule considered only emission reduction measures available in time for the 2017 ozone season. Id. at 74,520. Under this constraint, both sets of states reduced significant emissions, without over-control, at the same level of control. Id. at 74,551-52. Accordingly, EPA's selection of a uniform level of control for both types of receptors was reasonable. Emphasis added.

As an alternative to maintenance monitors being treated the same as nonattainment monitors, we urge that Illinois EPA take the position that no additional control would be needed to address a maintenance monitor if it is apparent that emissions and air quality trends make it likely that the maintenance monitor will remain in attainment. Such an approach is consistent with Section 175A(a) of the Clean Air Act which provides:

Each State which submits a request under section 7407 (d) of this title for redesignation of a nonattainment area for any air pollutant as an area which has attained the national primary ambient air quality standard for that air pollutant shall also submit a revision of the applicable State implementation plan to provide for the maintenance of the national primary ambient air quality standard for such air pollutant in the area concerned for at least ten years after the redesignation. The plan shall contain such additional measures, if any, as may be necessary to ensure such maintenance.

It is also consistent with the John Calcagni memorandum of September 4, 1992, entitled "Procedures for Processing Requests to Redesignate Areas to Attainment", which contains the following statement on page 9:

[12] EME Homer City v. EPA, 96 F.3d 7, 27 Ftn. 25 (D.C. Cir 2012).

> *A State may generally demonstrate maintenance of the NAAQS by either showing that future emissions of a pollutant or its precursors will not exceed the level of the attainment inventory, or by modeling to show that the future mix of source and emission rates will not cause a violation of the NAAQS. Under the Clean Air Act, many areas are required to submit modeled attainment demonstrations to show that proposed reductions in emissions will be sufficient to attain the applicable NAAQS. For these areas, the maintenance demonstration should be based upon the same level of modeling. In areas where no such modeling was required, the State should be able to rely on the attainment inventory approach. In both instances, the demonstration should be for a period of 10 years following the redesignation.*

Accordingly, MOG urges that Illinois EPA apply an alternate methodology to address maintenance monitors than it does to address nonattainment monitors. Any impacts which Illinois has on maintenance areas will certainly be addressed by consideration of controls that are already on the books and by emissions reductions that have been and will continue to apply to Illinois sources as is well-demonstrated by these comments and the proposed GNS.

5. MOG agrees with Illinois's conclusion that ERTAC overestimates EGU emissions that can be expected in 2023.

In the modeling platform Illinois EPA uses to support their proposal, LADCO replaced the EGU emissions in the U.S. EPA platform with 2023 EGU forecasts estimated with the ERTAC EGU Tool version 2.7. ERTAC EGU 2.7 integrates state-reported information on EGU operations and forecasts as of May 2017. In their modeling TSD, LADCO states that the ERTAC EGU Tool provided more accurate estimates of the growth and control forecasts for EGUs in the Midwest and Northeast states than the U.S. EPA approach used for the "EN" platform. It is significant, however, that the annual NOx emissions for EGUs assumed in the modeling work relied upon by Illinois (see page 11 of the agency's proposal) are more than 3,300 tons greater than EPA has estimated for purposes of its modeling.

It is apparent, therefore, that the modeling results being relied upon by Illinois EPA are likely to overstate Illinois's EGU impact on downwind areas adding to the conservative nature of the conclusion that nothing more needs to be done by Illinois to comply with the requirements of CAA section 110(a)(2)(D)(i)(I).

6. Emission trends in the CSAPR Update region have been decreasing for many years and will continue to do so in the immediate future adding assurance that there will be no interference with any downwind maintenance areas.

NOx emissions have been dramaticaly reduced in recent years. These NOx emission reductions will continue as the result of "on-the-books" regulatory programs already required by states on their own sources, "on-the-way" regulatory programs that have already been identified by state regulatory agencies as efforts that they must undertake as well as from the effectiveness of a variety of EPA programs including the CSAPR Update Rule.

Set forth below are tables developed from EPA modeling platform summaries[13] illustrating the estimated total anthropogenic emission reduction and EGU-only emission reduction in the several eastern states. As can be seen in the first table, total annual anthropogenic NOx emissions are predicted to decline by 29% between 2011 and 2017 over the CSAPR domain and by 43% (an additional 1.24 million tons) between 2011 and 2023.

Final CSAPR Update Modeling Platform Anthropogenic NOx Emissions (Annual Tons).

	Annual Anthropogenic NOx Emissions (Tons)			Emissions Delta (2017-2011)		Emissions Delta (2023-2011)	
State	**2011**	**2017**	**2023**	**Tons**	**%**	**Tons**	**%**
Alabama	359,797	220,260	184,429	139,537	-39%	175,368	-49%
Arkansas	232,185	168,909	132,148	63,276	-27%	100,037	-43%
Illinois	506,607	354,086	293,450	152,521	-30%	213,156	-42%
Indiana	444,421	317,558	243,954	126,863	-29%	200,467	-45%
Iowa	240,028	163,126	124,650	76,901	-32%	115,377	-48%
Kansas	341,575	270,171	172,954	71,404	-21%	168,621	-49%
Kentucky	327,403	224,098	171,194	103,305	-32%	156,209	-48%
Louisiana	535,339	410,036	373,849	125,303	-23%	161,490	-30%
Maryland	165,550	108,186	88,383	57,364	-35%	77,167	-47%
Michigan	443,936	296,009	228,242	147,927	-33%	215,694	-49%
Mississippi	205,800	128,510	105,941	77,290	-38%	99,859	-49%
Missouri	376,256	237,246	192,990	139,010	-37%	183,266	-49%
New Jersey	191,035	127,246	101,659	63,789	-33%	89,376	-47%
New York	388,350	264,653	230,001	123,696	-32%	158,349	-41%
Ohio	546,547	358,107	252,828	188,439	-34%	293,719	-54%
Oklahoma	427,278	308,622	255,341	118,656	-28%	171,937	-40%
Pennsylvania	562,366	405,312	293,048	157,054	-28%	269,318	-48%
Tennessee	322,578	209,873	160,166	112,705	-35%	162,411	-50%
Texas	1,277,432	1,042,256	869,949	235,176	-18%	407,482	-32%
Virginia	313,848	199,696	161,677	114,152	-36%	152,171	-48%
West Virginia	174,219	160,102	136,333	14,117	-8%	37,886	-22%
Wisconsin	268,715	178,927	140,827	89,788	-33%	127,888	-48%
CSAPR States	**8,651,264**	**6,152,990**	**4,914,012**	**2,498,274**	**-29%**	**3,737,252**	**-43%**

[13] 83 Fed. Reg. 7716 (February 22, 2018).

When looking exclusively at the estimated EGU emissions used in these modeling platforms, even greater percent decrease is noted between 2011 and 2017 (40% reduction CSAPR-domain wide) and between 2011 and 2023 (51% reduction). These reductions are particularly significant since the CSAPR Update Rule focus exclusively on EGU sources.

Final CSAPR Update Modeling Platform EGU NOx Emissions (Annual Tons).

	Annual EGU NOx Emissions (Tons)			Emissions Delta (2017-2011)		Emissions Delta (2023-2011)	
State	**2011**	**2017**	**2023**	**Tons**	**%**	**Tons**	**%**
Alabama	64,008	23,207	24,619	40,800	-64%	39,388	-62%
Arkansas	38,878	24,103	17,185	14,775	-38%	21,693	-56%
Illinois	73,689	31,132	30,764	42,557	-58%	42,926	-58%
Indiana	119,388	89,739	63,397	29,649	-25%	55,991	-47%
Iowa	39,712	26,041	20,122	13,671	-34%	19,590	-49%
Kansas	43,405	25,104	14,623	18,301	-42%	28,781	-66%
Kentucky	92,279	57,520	42,236	34,759	-38%	50,043	-54%
Louisiana	52,010	19,271	46,309	32,740	-63%	5,701	-11%
Maryland	19,774	6,001	9,720	13,773	-70%	10,054	-51%
Michigan	77,893	52,829	33,708	25,064	-32%	44,186	-57%
Mississippi	28,039	14,759	13,944	13,280	-47%	14,095	-50%
Missouri	66,170	38,064	44,905	28,106	-42%	21,265	-32%
New Jersey	7,241	2,918	5,222	4,323	-60%	2,019	-28%
New York	27,379	10,191	16,256	17,188	-63%	11,123	-41%
Ohio	104,203	68,477	37,573	35,727	-34%	66,630	-64%
Oklahoma	80,936	32,366	21,337	48,570	-60%	59,599	-74%
Pennsylvania	153,563	95,828	49,131	57,735	-38%	104,432	-68%
Tennessee	27,000	14,798	11,557	12,201	-45%	15,442	-57%
Texas	148,473	112,670	103,675	35,804	-24%	44,799	-30%
Virginia	40,141	7,589	20,150	32,553	-81%	19,992	-50%
West Virginia	56,620	63,485	46,324	(6,865)	12%	10,296	-18%
Wisconsin	31,881	15,374	15,419	16,507	-52%	16,462	-52%
CSAPR States	**1,392,682**	**831,466**	**688,175**	**561,216**	**-40%**	**704,508**	**-51%**

Importantly, these estimated 2017 emissions used in the EPA modeling are inflated as compared to the actual 2017 CEM-reported EGU emissions. As can be seen in the following table, when the CSAPR-modeled 2017 annual EGU emissions are compared to the actual CEM-reported 2017 annual EGU emissions, it becomes apparent that there is a significant domain-wide overestimation (129,000 annual tons NOx) of the predicted emissions for this category. The modeled values from state-to-state vary between over- and under-estimated, domain-wide, CEM-reported annual NOx ranging from 158% overestimation (2017 actual emissions are 61% of modeled emissions) for Pennsylvania to 54% underestimation (2017 actual emissions are 118% of modeled emissions) for Virginia with a domain-wide overestimation of 18% (129,553 tons) of annual NOx emissions from EGUs.

Final CSAPR Update Modeling Platform EGU NOx Emissions Compared to CEM-Reported EGU NOx Emissions (Annual Tons).

	Annual EGU NOx Emissions (Tons)			**Emissions Delta 2017 CEM-2017 EPA**	
State	**2011 EPA**	**2017 EPA**	**2017 CEM**	**Tons**	**%**
Alabama	64,008	23,207	24,085	878	4%
Arkansas	38,878	24,103	27,500	3,397	14%
Illinois	73,689	31,132	33,066	1,934	6%
Indiana	119,388	89,739	63,421	(26,318)	-29%
Iowa	39,712	26,041	22,564	(3,477)	-13%
Kansas	43,405	25,104	13,032	(12,072)	-48%
Kentucky	92,279	57,520	46,053	(11,467)	-20%
Louisiana	52,010	19,271	29,249	9,978	52%
Maryland	19,774	6,001	6,112	111	2%
Michigan	77,893	52,829	37,739	(15,090)	-29%
Mississippi	28,039	14,759	12,162	(2,597)	-18%
Missouri	66,170	38,064	49,692	11,628	31%
New Jersey	7,241	2,918	3,443	524	18%
New York	27,379	10,191	11,253	1,062	10%
Ohio	104,203	68,477	57,039	(11,438)	-17%
Oklahoma	80,936	32,366	21,761	(10,606)	-33%
Pennsylvania	153,563	95,828	37,148	(58,680)	-61%
Tennessee	27,000	14,798	18,201	3,402	23%
Texas	148,473	112,670	109,914	(2,756)	-2%
Virginia	40,141	7,589	16,545	8,957	118%
West Virginia	56,620	63,485	44,079	(19,406)	-31%
Wisconsin	31,881	15,374	17,856	2,482	16%
CSAPR States	**1,392,682**	**831,466**	**701,913**	**(129,553)**	**-16%**

These data conclusively demonstrate that annual anthopogenic NOx emissions in the CSAPR Update region are projected to be significantly reduced through 2017, with overall actual EGU 2017 emissions being even lower than these estimates. Emission trends for these states have been deceasing for many years and will continue to decrease through at least 2023 as the result of nothing more than on-the-books controls.

7. Had current air modeling projections taken into account the significant emission reduction programs that are legally mandated to occur prior to 2023, even better air quality would have been predicted.

There are several on-the-books NOx emission reductions programs that have not yet been included in the current modeling efforts related to 2023 ozone predictions. These programs, both individually and collectively, will have a material effect on predicted air quality, particularly in the East. As part of its review of the adequacy of this proposed rule, we urge EPA to take note of these additional control programs and to adjust the emissions inventories used to perform any modeling to include these on-the books NOx reductions as part of the assessment of the adequacy of this proposed rule.

These programs as well other local control programs will almost certainly improve ozone predictions in 2023. Accounting for the programs and the related emission reductions at this time offers additional support for EPA's conclusion that on-the-books control programs are all that is needed to address the 2015 ozone NAAQS.

8. Consideration of international emissions also adds support to the conclusion that there is no further obligation to reduce emissions.

As an integral part of the consideration of this proposal, MOG supports an assessment of the impact of natural and manmade international emissions not only on the red lines calculation of proportional responsibility (see page 45 of the proposal) but also on the ultimate question of whether the downwind monitors can be properly considered either nonattainment or maintenance monitors.

The CAA addresses international emissions directly. Section 179(B)(a) states that -

(a) Implementation plans and revisions

> *Notwithstanding any other provision of law, an implementation plan or plan revision required under this chapter shall be approved by the Administrator if—*
> *(1) such plan or revision meets all the requirements applicable to it under the* [14] *chapter other than a requirement that such plan or revision demonstrate attainment and maintenance of the relevant national ambient air quality standards by the attainment date specified under the applicable provision of this chapter, or in a regulation promulgated under such provision, and*
> *(2) the submitting State establishes to the satisfaction of the Administrator that the implementation plan of such State would be adequate to attain and maintain the relevant national ambient air quality standards by the attainment date specified under the applicable provision of this chapter, or in a regulation promulgated under such provision, but for emissions emanating from outside of the United States.*

In addition, addressing international emissions is particularly important to upwind states as they implement the requirements of CAA section 110(a)(2)(D)(i)(I).

[14] So in original. Probably should be "this".

The U.S. Supreme Court has ruled that it is essential that Good Neighbor states be required to eliminate only those amounts of pollutants that contribute to the nonattainment of NAAQS in downwind States. Specifically, the Supreme Court stated: "EPA cannot require a State to reduce its output of pollution by more than is necessary to achieve attainment in every downwind State. . ." EPA v. EME Homer City Generation, 134 S. Ct. 1584, 1608 (2014).

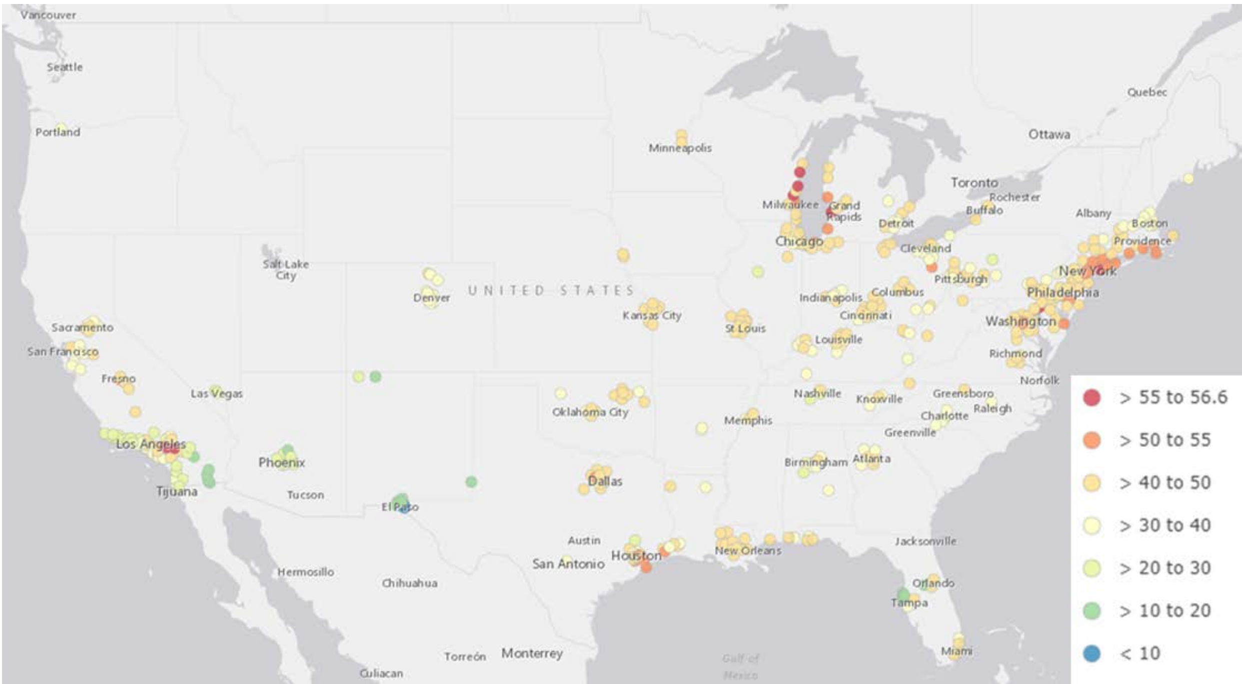
In addition, the D.C. Circuit has commented that ". . . the good neighbor provision requires upwind States to bear responsibility for their fair share of the mess in downwind States."[15] However, this "mess" seems to be related to international emissions for which upwind states and sources have no responsibility.

The D.C. Circuit has also stated "section 110(a)(2)(D)(i)(I) gives EPA no authority to force an upwind state to share the burden of reducing other upwind states' emissions," *North Carolina*, 531 F.3d at 921. Given this ruling by the Court it seems logical that the CAA would not require upwind states to offset downwind air-quality impacts attributable to other *countries*' emissions. Simply put, EPA over-controls a state if the state must continue reducing emissions *after* its linked receptors would attain in the absent of international emissions.

Projected 2023 ozone design values (ppb) excluding the contribution from boundary condition, initial condition, Canadian and Mexican emission sources shown below was prepared by Alpine Geophysics for MOG and depicts the projected 2023 8-hour ozone design values across the U.S. excluding the contribution from boundary and initial condition, Canadian, and Mexican emission sources. The exclusion of boundary condition and international emissions was executed for all such emissions whether from international border areas or beyond. Note that this projection shows all monitors in the continental U.S. with a design value equal to or less than 56.6 ppb when these categories are excluded. Modeling the U.S. emissions inventory projected to 2023 but without the impact of uncontrollable emission sources demonstrates that the CAA programs in the U.S. are performing as intended.

[15] *EME Homer City Generation, L.P. v EPA*, 696 F3.3d 7, 13 (D.C. Cir. 2012).

Projected 2023 ozone design values (ppb) excluding the contribution from boundary condition, initial condition, Canadian and Mexican emission sources



In addition to changing emissions resulting from growth and control in the continental U.S., EPA has identified updated projected emissions in both Canada and Mexico that have been integrated into the modeling platform used in this modeling.[16] EPA's modeling boundary conditions, however, have been held constant at 2011 levels. This is inconsistent with recent publications that indicate emissions from outside of the U.S., specifically contributing to international transport, are on the rise.[17]

In support of conclusion that boundary conditions are significantly impacted by international emissions, the following chart illustrates that 89% of the emissions being modeled to establish boundary conditions are related to international sources.[18]

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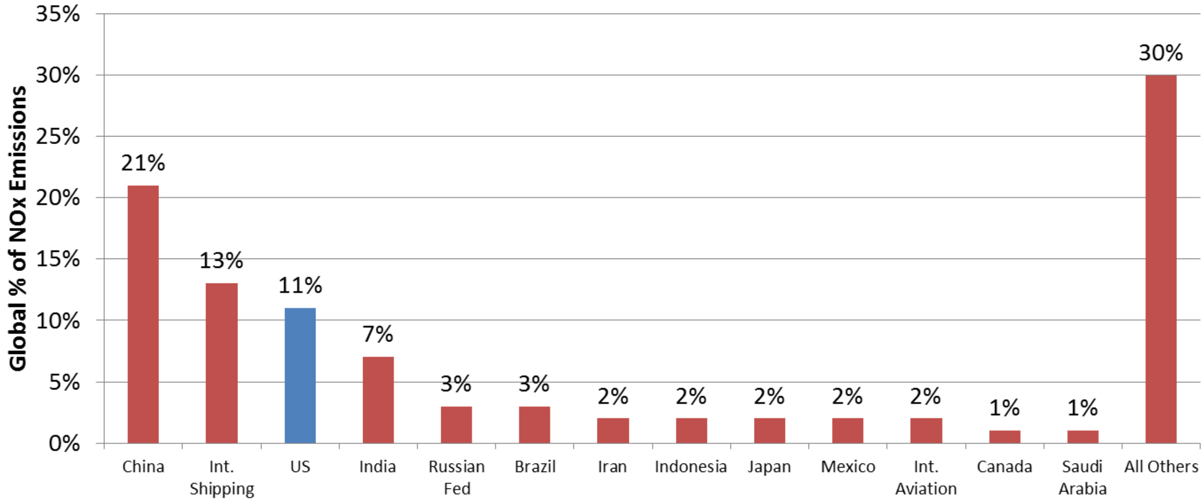
[16] EPA-HQ-OAR-2016-0751-0009.

[17] Atmos. Chem. Phys., 17, 2943–2970(2017).

[18] European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency. Emission Database for Global Atmospheric Research (EDGAR), https://protect-us.mimecast.com/s/N-G6CERPwVI3vMWjhNVQlp?domain=edgar.jrc.ec.europa.eu

Relative International NOx Emissions (% of Total) Used to Inform Global Model Boundary Concentrations of Ozone



There can be no doubt that international emissions have a significant impact on ozone measurements at all monitors related to this proposal. MOG urges that the agency recognize the significance of this impact and to determine that but for international emissions there would be no downwind problems areas and therefore no need to for additional action to be undertaken to satisfy the requirements of CAA section 110(a)(2)(D)(i)(I).

9. Mobile sources have the most significant impact on ozone concentrations at the problem monitors identified in the Illinois EPA proposal.

While the CSAPR Update Rule addressed only emissions from EGU sources, it must be recognized that it is emissions from mobile, including both on-road and non-road, and local area sources have the most significant impact on ozone concentrations and the problem monitors identified in this proposal and that these sources must be addressed by EPA before requiring additional emission reductions from upwind states.

EPA recently recognized the significance of mobile source emissions in preamble to its full remedy proposal. There EPA stated:

> *Mobile sources also account for a large share of the NOx emissions inventory (i.e., about 7.3 million tons per year in the 2011 base year, which represented more than 50% of continental U.S. NOx emissions), and the EPA recognizes that emissions reductions achieved from this sector as well can reduce transported ozone pollution. The EPA has national programs that serve to reduce emissions from all contributors to the mobile source inventory (i.e., projected NOx emissions reductions of about 4.7 million tons per year between the*

2011 base year and the 2023 future analytical year). A detailed discussion of the EPA's mobile source emissions reduction programs can be found at www.epa.gov/otaq.

In light of the regional nature of ozone transport discussed herein, and given that NOx emissions from mobile sources are being addressed in separate national rules, in the CSAPR Update (as in previous regional ozone transport actions) the EPA relied on regional analysis and required regional ozone season NOx emissions reductions from EGUs to address interstate transport of ozone.

83 Federal Register 31918.

We strongly agree that mobile source emissions are the dominant contributor to predicted ozone concentrations across the nation. At the request of MOG, Alpine Geophysics has examined not only the relative contribution of mobile and local area sources to problem monitors but also how a small reduction in these emissions could bring about significant additional reductions in ozone concentrations.

The following table presents the annual mobile source NOx emission totals (onroad plus nonroad) for eastern states as presented in the final CSAPR update emission summary files[19]. As can been seen in this table, consistent with EPA's national assessment of mobile source emissions, annual mobile source NOx emissions in this region comprise 51%, 41%, and 33% of the annual anthropogenic emission totals for 2011, 2017, and 2023, respectively.

[19] ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/reports/

Eastern State Mobile Source NOx Emissions (Annual Tons).

	Annual Anthropogenic NOx Emissions (Tons)			Annual Mobile Source NOx Emissions (Tons)			Mobile Sources as % of All Annual Emissions (%)		
State	**2011**	**2017**	**2023**	**2011**	**2017**	**2023**	**2011**	**2017**	**2023**
Alabama	359,797	220,260	184,429	175,473	88,094	54,104	49%	40%	29%
Arkansas	232,185	168,909	132,148	113,228	68,949	44,583	49%	41%	34%
Connecticut	72,906	46,787	37,758	49,662	26,954	18,718	68%	58%	50%
Delaware	29,513	18,301	14,511	17,788	10,387	6,819	60%	57%	47%
District of Columbia	9,404	6,052	4,569	7,073	3,947	2,500	75%	65%	55%
Florida	609,609	410,536	323,476	406,681	232,319	153,275	67%	57%	47%
Georgia	451,949	295,397	236,574	267,231	147,690	90,541	59%	50%	38%
Illinois	506,607	354,086	293,450	261,727	166,393	114,243	52%	47%	39%
Indiana	444,421	317,558	243,954	218,629	122,633	76,866	49%	39%	32%
Iowa	240,028	163,126	124,650	132,630	82,212	53,712	55%	50%	43%
Kansas	341,575	270,171	172,954	115,302	68,491	43,169	34%	25%	25%
Kentucky	327,403	224,098	171,194	139,866	80,244	50,633	43%	36%	30%
Louisiana	535,339	410,036	373,849	117,529	67,331	43,962	22%	16%	12%
Maine	59,838	42,918	32,186	34,933	18,380	12,240	58%	43%	38%
Maryland	165,550	108,186	88,383	103,227	60,164	38,922	62%	56%	44%
Massachusetts	136,998	90,998	73,082	83,398	45,031	30,508	61%	49%	42%
Michigan	443,936	296,009	228,242	250,483	135,434	88,828	56%	46%	39%
Minnesota	316,337	216,925	174,797	176,424	102,728	65,868	56%	47%	38%
Mississippi	205,800	128,510	105,941	108,198	57,751	34,561	53%	45%	33%
Missouri	376,256	237,246	192,990	219,505	122,137	75,380	58%	51%	39%
Nebraska	217,427	159,062	119,527	88,985	55,067	35,556	41%	35%	30%
New Hampshire	36,526	22,413	18,794	24,919	14,780	10,322	68%	66%	55%
New Jersey	191,035	127,246	101,659	133,073	75,538	51,231	70%	59%	50%
New York	388,350	264,653	230,001	224,454	130,023	92,171	58%	49%	40%
North Carolina	369,307	231,783	167,770	250,549	114,952	70,812	68%	50%	42%
North Dakota	163,867	135,009	128,864	57,289	37,071	23,956	35%	27%	19%
Ohio	546,547	358,107	252,828	311,896	168,799	100,058	57%	47%	40%
Oklahoma	427,278	308,622	255,341	139,550	79,830	50,525	33%	26%	20%
Pennsylvania	562,366	405,312	293,048	249,792	135,765	81,645	44%	33%	28%
Rhode Island	22,429	15,868	12,024	13,689	7,705	5,209	61%	49%	43%
South Carolina	210,489	134,436	104,777	132,361	73,359	44,886	63%	55%	43%
South Dakota	77,757	49,014	37,874	48,499	30,473	19,685	62%	62%	52%
Tennessee	322,578	209,873	160,166	213,748	122,738	77,135	66%	58%	48%
Texas	1,277,432	1,042,256	869,949	554,463	292,609	189,601	43%	28%	22%
Vermont	19,623	14,063	10,792	14,031	8,569	5,958	72%	61%	55%
Virginia	313,848	199,696	161,677	179,996	108,175	67,678	57%	54%	42%
West Virginia	174,219	160,102	136,333	48,294	27,487	17,494	28%	17%	13%
Wisconsin	268,715	178,927	140,827	167,753	100,814	67,201	62%	56%	48%
Eastern US Total	**11,455,243**	**8,042,552**	**6,411,386**	**5,852,332**	**3,291,024**	**2,110,555**	**51%**	**41%**	**33%**

The regulation of mobile sources is specifically addressed in the CAA section 209, which provides guidance on the management roles of mobile sources for the federal government, California and other states. Section 209(a) opens with the statement concerning on-road engines and vehicles, "No State or any political subdivision thereof shall adopt or attempt to enforce any standard relating to the control of emissions from new motor vehicles or new motor vehicle engines subject to this part." Relative to non-road engines or vehicles, CAA 209(e) provides similar language.

The exception to these prohibitions is set forth in CAA §177 for California and any other state that chooses to adopt an "EPA-approved California control on emissions of new motor vehicles or engines." Regulation of new mobile-source emissions has been principally federally- driven, but states continue to have a role. *Engine Mfrs. Ass'n v. EPA*, 88 F.3d 1075, 1079 (D.C. Cir. 1996). The CAA §209(d) preserves the authority of the states to control, regulate, or restrict the use, operations, or movement of registered or licensed motor vehicles. The D.C. Circuit has interpreted this as maintaining state power to regulate pollution from motor vehicles once they are no longer new; for instance, through in-use regulations such as car pools and other incentive programs. *Id.* In response to the D.C. Circuit opinion, EPA clarified its position relative to state non-road regulatory authority in 40 CFR 89, Subpart A, Appendix A - State Regulation of Nonroad Internal Combustion Engines as follows:

EPA believes that states are not precluded under section 209 from regulating the use and operation of nonroad engines, such as regulations on hours of usage, daily mass emission limits, or sulfur limits on fuel; nor are permits regulating such operations precluded, once the engine is no longer new. EPA believes that states are precluded from requiring retrofitting of used nonroad engines except that states are permitted to adopt and enforce any such retrofitting requirements identical to California requirements which have been authorized by EPA under section 209 of the Clean Air Act. [62 FR 67736, Dec. 30, 1997]

Given the dominant role of mobile sources in impacting on ozone air quality, MOG believes that additional local mobile source controls in downwind states are necessary before requiring additional emission reductions from upwind states. We urge that downwind states take full advantage of all of the authority provided to each of them under the CAA and to reduce mobile source emissions appropriately to assure continued attainment of the 2015 ozone NAAQS.

10. 2023 is the appropriate year for assessing Good Neighbor SIP requirements related to the 2015 ozone NAAQS.

It is appropriate for the modeling results relied upon by the DEP to have been based on 2023 as the future analytic year. That year was selected by EPA as the basis for its modeling "because it aligns with the anticipated attainment year for the Moderate ozone nonattainment areas".[20] Indeed, 2023 aligns with the last full ozone season before the attainment year for Moderate ozone nonattainment areas.

[20] *Information on the Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards under Clean Air Act Section 110(a)(2)(D)(i)(I)*, prepared by Peter Tsirigotis, March 27, 2018, p. 3. https://www.epa.gov/airmarkets/march-2018-memo-and-supplemental-information-regarding-

We note with interest the affidavit submitted by Assistant Administrator McCabe in the litigation involving the challenge to the Kentucky Good Neighbor SIP in which Assistant Administrator McCabe stated:

> In order to establish the appropriate future analytic year for purposes of the EPA's analysis, including the air quality modeling, the EPA considers several factors related to anticipated compliance timing of the rulemaking. It is essential to consider how best to align the future analytic year with compliance timing in order for the assessment of significant contribution to nonattainment and interference with maintenance to align with the identified air quality challenge. Compliance timing is informed by the D.C. Circuit's decision in *North Carolina,* where the court held that the EPA should align implementation of its interstate transport rules with a date by which states are required to demonstrate attainment with the applicable NAAQS. 531 F.3d at 911-12. However, the determination as to how to align implementation with the attainment is not ready-made. Rather, the EPA considers several factors including the relevant attainment dates for the NAAQS, timelines necessary for installing appropriate control technologies, whether or not emission reductions preceding the relevant attainment dates (if possible) would further assist downwind areas in demonstrating attainment and maintenance of the NAAQS, or in the event that emission reductions are not feasible by the relevant attainment deadline, what date is as soon as practicable for EPA to require reductions following the relevant attainment deadline.[21]

Equally significant is the following statement appearing in EPA's brief in the same litigation:

> Nonetheless, EPA is mindful of the need to align implementation of emission reductions in upwind states with the applicable attainment dates in downwind areas, as instructed by the court in *North Carolina v. EPA*, 531 F.3d 896, 911-12 (D.C. Cir. 2008).[22]

MOG strongly urges continued efforts to follow the court holding *North Carolina v. EPA*, 531 F.3d 896, 911-12 (D.C. Cir. 2008), and to assure alignment of the implementation of Good Neighbor SIPs with the date by which states are required to demonstrate attainment with the applicable NAAQS. There must be continued recognition that air quality will improve between the 2018 due date for Good Neighbor SIPs and the 2023 attainment deadline as a result of additional local controls in nonattainment areas as well as CAA programs including Federal Measures, federally mandated state RACT rules, nonattainment infrastructure SIPs, and Good Neighbor SIPs. While the Federal measures, state RACT rules, nonattainment infrastructure SIPs, and other control

interstate-transport-sips-2015.

[21] Declaration of Janet D. McCabe, at ¶81.

[27] Defendant EPA's Reply to Plaintiff's Opposition to EPA's Cross-Motion for Summary Judgment, Sierra Club v. EPA, Case No. 3:15-cv-JD, Sept. 22, 2015) ED No. 68, p. 7.

programs will all significantly improve air quality in many nonattainment areas, those programs will all be implemented after the Good Neighbor SIPs are due, which means that states will need to carefully consider how best to address those air quality improvements as part of their Good Neighbor SIP submittals.

The failure to include the benefits of these programs in Good Neighbor SIPs will result in over-control of upwind states, which is, of course, illegal given the Supreme Court decision in *EPA v. EME Homer City Generation* in which stands for the proposition that EPA cannot require an upwind state to reduce its output of pollution by more than necessary to achieve attainment in every downwind state. The Good Neighbor SIP is a "down payment" on attainment and not a stand-alone attainment program. Numerous control programs will take effect now and between the 2018 Good Neighbor SIP due date and the 2023 attainment deadline. The Good Neighbor SIPs that are due in 2018 must take into account the impact of legally mandated controls on air quality by the attainment date to avoid violating the CAA prohibition against over-control.

11. The 1% significant contribution test is inappropriate and should not be applied.

For many months, EPA has had under consideration the appropriateness of the use of its 1% significance test to determine whether an upwind state significantly contributes to downwind non-attainment or interference with downwind maintenance areas. While EPA's March 27, 2018 memo related to interstate transport state implementation plan submission involving the 2015 ozone NAAQS provides a set of contributions by upwind states to downwind states, that data is not based on a particular significance threshold.[23] Indeed, that memo identifies the significance threshold as one of the flexibilities that a state may wish to consider in the development of its Good Neighbor SIP. Specifically, EPA offers the following description of this flexibility:

> "Consideration of different contribution thresholds for different regions based on regional differences in the nature and extent of the transport problem."

In commenting on this flexibility, states have made the point that the significant contribution threshold of 1% of the NAAQS (0.70 ppb for the 2015 ozone NAAQS) value is arbitrary and is not supported by scientific argument.[24]

On August 31, 2018, EPA issued significant new guidance in which it analyzed 1 ppb and 2 ppb alternatives to the 1% significance level that it has historically used.[25] In that memo, EPA offers the following statement:

[23] *Id* at p. A-2.
[24] Georgia EPD Comments on EPA's March 27, 2018 Interstate Transport Memo, J.W. Boylan, Air Protection Branch, George EPD, May 4, 2018. https://www.epa.gov/sites/production/files/2018-08/documents/ga_epd_comments_on_epa_march_27_2018_ozone_transport_memo.pdf.
[25] *Analysis of Contribution Thresholds for Use in Clean Air Act Section 110(a)(2)(D)(i)(I) Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards*, Peter Tsirigotis,

Based on the data and analysis summarized here, the EPA believes that a threshold of 1 ppb may be appropriate for states to use to develop SIP revisions addressing the good neighbor provisions for the 2015 ozone NAAQS.

In reaching its conclusion that a 2 ppb threshold was not recommended, EPA compared the 2 ppb alternative to the 1 ppb alternative using data which averaged all receptors outside California. In that circumstance, EPA determined that using a 1 ppb threshold captures 86 percent of the net contribution captured using a 1% threshold whereas a 2 ppb threshold captures only half of the net contribution using 1%. A different picture is presented, however, when the receptors east of the Mississippi River (involving the states of Connecticut, Maryland, Michigan, New York and Wisconsin) are considered separately from the states of Arizona, Colorado and Texas. In that case, use a 1 ppb threshold captures 92% of the net contribution captured using a 1% threshold compared with 78% for the 2 ppb threshold.

In the case of either a 1 ppb threshold or a 2 ppb threshold, a significant reduction in downwind linkages occurs.

The following chart compares all three alternatives when applied to EPA's modeling result:

			Ozone Concentration (ppb)						
EPA Identified Nonattainment Site ID	State	County	2009-2013 Avg DV	2023 Avg DV	Contrib from Upwind 1%	Contrib from Upwind 1ppb	Contrib from Upwind 2ppb	% of 1ppb from 1%	% of 2ppb from 1%
90013007	Connecticut	Fairfield	84.3	71.0	36.91	33.63	27.38	91%	74%
90019003	Connecticut	Fairfield	83.7	73.0	38.55	36.93	32.28	96%	84%
361030002	New York	Suffolk	83.3	74.0	22.31	18.74	15.74	84%	71%
480391004	Texas	Brazoria	88.0	74.0	7.48	4.80	3.80	64%	51%
484392003	Texas	Tarrant	87.3	72.5	4.20	3.42	0.00	81%	0%
550790085	Wisconsin	Milwaukee	80.0	71.2	28.45	23.61	22.39	83%	79%
551170006	Wisconsin	Sheboygan	84.3	72.8	31.62	29.02	24.90	92%	79%

The results of the same comparison when applied to the LADCO modeling results are set forth in the following chart:

			Ozone Concentration (ppb)					
LADCO Identified Nonattainment Monitor	State	County	2023 Avg DV	Contrib from Upwind 1%	Contrib from Upwind 1ppb	Contrib from Upwind 2ppb	% of 1ppb from 1%	% of 2ppb from 1%
90019003	Connecticut	Fairfield	71.4	36.15	34.51	28.21	95%	78%
240251001	Maryland	Harford	71.0	19.9	17.51	14.56	88%	73%
361030002	New York	Suffolk	71.6	20.85	17.42	14.6	84%	70%
480391004	Texas	Brazoria	74.1	7.45	4.65	3.62	62%	49%
484392003	Texas	Tarrant	72.6	4.99	3.4	0	68%	0%
482011039	Texas	Harris	71.7	8.14	5.64	4.5	69%	55%

August 31, 2018. https://www.epa.gov/sites/production/files/2018-09/documents/contrib_thresholds_transport_sip_subm_2015_ozone_memo_08_31_18.pdf.

The results of the same comparison for the MOG modeling results are set forth in the following chart:

			Ozone Concentration (ppb)						
MOG Identified Nonattainment Site ID	State	County	2009-2013 Avg DV	2023 Avg DV	Contrib from Upwind 1%	Contrib from Upwind 1ppb	Contrib from Upwind 2ppb	% of 1ppb from 1%	% of 2ppb from 1%
90010017	Connecticut	Fairfield	80.3	69.2	26.85	25.98	21.68	97%	81%
90013007	Connecticut	Fairfield	84.3	69.7	23.91	23.04	18.57	96%	78%
90019003	Connecticut	Fairfield	83.6	69.9	27.78	26.12	21.49	94%	77%
90110124	Connecticut	New London	80.3	68.2	19.60	17.86	12.98	91%	66%
90099002	Connecticut	New Haven	85.7	70.3	21.08	17.92	15.04	85%	71%
240251001	Maryland	Harford	90.0	71.1	17.99	17.09	14.23	95%	79%
340150002	New Jersey	Gloucester	84.3	68.8	30.27	30.27	20.92	100%	69%
360850067	New York	Richmond	81.3	69.6	29.17	26.64	20.29	91%	70%
361030002	New York	Suffolk	83.3	70.7	22.52	19.85	14.50	88%	64%
421010024	Pennsylvania	Philadelphia	83.3	68.0	18.65	15.91	8.54	85%	46%

In the case of Illinois, EPA's modeling data below show that at the 1% threshold, Illinois would be linked to four non-attainment areas and five maintenance areas. Applying the 1 ppb threshold to this data would reduce the linkage to non-attainment areas to three while keeping the linkage to maintenance areas to two.

			Ozone (ppb)		Significant Contribution (ppb)																	
EPA Identified Nonattainment Site ID	State	County	2009-2013 Avg DV (ppb)	2023 Avg DV (ppb)	AR	IL	IN	IA	KY	LA	MD	MI	MO	NJ	NY	OH	OK	PA	TX	VA	WV	WI
90013007	Connecticut	Fairfield	84.3	71.0	0.13	0.72	0.97	0.16	0.89	0.11	1.8	0.7	0.38	6.94	14.12	1.84	0.21	6.32	0.44	1.51	1.1	0.24
90019003	Connecticut	Fairfield	83.7	73.0	0.13	0.67	0.83	0.17	0.79	0.11	2.17	0.63	0.37	7.75	15.8	1.6	0.21	6.56	0.45	1.91	1.14	0.2
361030002	New York	Suffolk	83.3	74.0	0.12	0.64	0.69	0.2	0.49	0.13	1.24	0.94	0.39	8.88	18.11	1.76	0.34	6.86	0.6	0.99	0.81	0.25
480391004	Texas	Brazoria	88.0	74.0	0.9	1	0.32	0.4	0.14	3.8	0	0.22	0.88	0	0	0.06	0.9	0.01	26	0.02	0.02	0.4
484392003	Texas	Tarrant	87.3	72.5	0.78	0.29	0.18	0.19	0.13	1.71	0.01	0.13	0.38	0	0.01	0.1	1.71	0.05	27.64	0.05	0.05	0.13
550790085	Wisconsin	Milwaukee	80.0	71.2	0.4	15.1	5.28	0.79	0.77	0.72	0.03	2.01	0.93	0	0.02	0.87	0.76	0.33	1.22	0.12	0.59	13.39
551170006	Wisconsin	Sheboygan	84.3	72.8	0.51	15.73	7.11	0.45	0.81	0.84	0.03	2.06	1.37	0	0.02	1.1	0.95	0.41	1.65	0.1	0.64	9.09

					Significant Contribution (ppb)																				
EPA Identified Maintenance Site ID	State	County	2009-2013 Max DV (ppb)	2023 Max DV (ppb)	AR	CT	IL	IN	IA	KS	KY	LA	MD	MI	MS	MO	NJ	NY	OH	OK	PA	TX	VA	WV	WI
90010017	Connecticut	Fairfield	83.0	71.2	0.07	8.7	0.39	0.44	0.11	0.09	0.34	0.05	1.18	0.5	0.03	0.21	6.24	17.31	1.04	0.15	5.11	0.3	1.27	0.68	0.26
90099002	Connecticut	New Haven	89.0	72.6	0.08	9.1	0.46	0.5	0.16	0.14	0.32	0.08	1.37	0.73	0.04	0.29	5.06	15.03	1.17	0.24	4.87	0.41	1.26	0.61	0.25
240251001	Maryland	Harford	93.0	73.3	0.17	0	0.84	1.35	0.23	0.23	1.52	0.19	22.6	0.79	0.08	0.59	0.07	0.16	2.77	0.35	4.32	0.74	5.05	2.78	0.24
260050003	Michigan	Allegan	86.0	71.7	1.64	0	19.62	7.11	0.77	0.77	0.58	0.7	0.01	3.32	0.4	2.61	0	0	0.19	1.31	0.05	2.39	0.04	0.11	1.95
261630019	Michigan	Wayne	81.0	71.0	0.27	0	2.37	2.51	0.44	0.44	0.65	0.22	0.02	20.39	0.09	0.92	0.01	0.06	3.81	0.62	0.18	1.12	0.16	0.23	1.08
360810124	New York	Queens	80.0	72.0	0.09	0.57	0.73	0.69	0.26	0.19	0.42	0.13	1.56	1.26	0.04	0.38	8.57	13.55	1.88	0.32	7.16	0.58	1.56	1.01	0.38
481210034	Texas	Denton	87.0	72.0	0.58	0	0.23	0.16	0.1	0.4	0.11	1.92	0.01	0.08	0.33	0.24	0	0.01	0.08	1.23	0.04	26.69	0.05	0.04	0.08
482010024	Texas	Harris	83.0	72.8	0.29	0	0.34	0.13	0.17	0.17	0.1	3.06	0	0.06	0.5	0.38	0	0	0.05	0.2	0.02	25.62	0.06	0.05	0.07
482011034	Texas	Harris	82.0	71.6	0.54	0	0.51	0.12	0.27	0.32	0.05	3.38	0	0.17	0.39	0.63	0	0	0.05	0.68	0.01	25.66	0.03	0.03	0.22
482011039	Texas	Harris	84.0	73.5	0.99	0	0.88	0.24	0.33	0.33	0.11	4.72	0	0.27	0.79	0.88	0	0	0.05	0.58	0.01	22.82	0.02	0.01	0.28

We urge Illinois EPA to carefully evaluate these additional flexibilities as further support for the conclusion that Illinois has already satisfied the requirements of CAA section 110(a)(2)(D)(i)(I).

12. Conclusion.

Accordingly, the Midwest Ozone Group supports Illinois EPA's proposed Good Neighbor SIP as a conservative justification for the conclusion that no additional emissions reductions beyond existing and planned controls are necessary to mitigate any contribution Illinois may have to any downwind monitors to comply with CAA section 110(a)(2)(D)(i)(I).

Air Quality Modeling Technical Support Document for Midwest Ozone Group's Updated 4km Modeling

Final Technical Support Document

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Contents

TABLES

FIGURES

1.0 INTRODUCTION

1.1 OVERVIEW

Sections 110(a)(1) and (2) of the Clean Air Act (CAA) require all states to adopt and submit to the U. S. Environmental Protection Agency (EPA) any revisions to their infrastructure State Implementation Plans (SIP) which provide for the implementation, maintenance and enforcement of a new or revised national ambient air quality standard (NAAQS). CAA section 110(a)(2)(D)(i)(I) requires each state to prohibit emissions that will significantly contribute to nonattainment of a NAAQS, or interfere with maintenance of a NAAQS, in a downwind state. The EPA revised the ozone NAAQS in March 2008 and completed the designation process to identify nonattainment areas in July 2012. Under this revision, the 8-hour ozone NAAQS form is the three year average of the fourth highest daily maximum 8-hour ozone concentrations with a threshold not to be exceeded of 0.075 ppm (75 ppb).

On October 1, 2015, EPA promulgated a revision to the ozone NAAQS, lowering the level of both the primary and secondary standards to 70 parts per billion (ppb) (80 FR 65292). Pursuant to CAA section 110(a), good neighbor SIPs are, therefore, due by October 1, 2018. This promulgated revision changed the threshold as to not exceed a value of 0.070 ppm (70 ppb). This document serves to provide a technical support document for recently updated 4km air quality modeling and results recently conducted by Alpine Geophysics, LLC (Alpine) under contract to the Midwest Ozone Group (MOG) for purposes of individual state review and preparation of 8-hour ozone modeling analysis in support of revisions of the 2008 and 2015 8-hour ozone Good Neighbor State Implementation Plans (GNS).

This document describes our initial modeling effort was developed using EPA's national 12km modeling domain (12US2) and further refined with two 4km modeling domains over a Mid-Atlantic region and Lake Michigan. It uses the 2011/2023en modeling platform which represents EPA's estimation of a projected "base case" that demonstrates compliance with final CSAPR update seasonal EGU NOx budgets.

Our 4km modeling exercise largely utilized the same platform configuration with new meteorological and emissions data prepared for the 4km domains to support both attainment demonstration and source apportionment simulations.

1.2 STUDY BACKGROUND

Section 110(a)(2)(D)(i)(I) of the CAA requires that states address the interstate transport of pollutants and ensure that emissions within the state do not contribute significantly to nonattainment in, or interfere with maintenance by, any other state.

On October 26, 2016, EPA published in the Federal Register (81 FR 74504) a final update to the Cross-State Air Pollution Rule (CSAPR) for the 2008 ozone NAAQS. In this final update, EPA outlines its four-tiered approach to addressing the interstate transport of pollution related to the ozone NAAQS, or states' Good Neighbor responsibilities. EPA's approach determines which states contribute significantly to nonattainment areas or significantly interfere with air quality in maintenance areas in downwind states. EPA has determined that if a state's contribution to downwind air quality problems is below one percent of the applicable NAAQS, then it does not consider that state to be significantly contributing to the downwind area's nonattainment or maintenance concerns. EPA's approach to addressing interstate transport has been shaped by public notice and comment and refined in response to court decisions.

As part of the final CSAPR update, EPA released regional air quality modeling to support the 2008 ozone NAAQS attainment date of 2017, indicating which states significantly contribute to nonattainment or maintenance area air quality problems in other states. To make these determinations, the EPA projected future ozone nonattainment and maintenance receptors, then conducted state-level ozone source apportionment modeling to determine which states contributed pollution over a pre-identified "contribution threshold."

A follow-up technical memorandum was issued by EPA on October 27, 2017 (Page, 2017) that provided supplemental information on interstate SIP submissions for the 2008 ozone NAAQS. In this memorandum, EPA provided future year 2023 design value calculations and source contribution results with updated modeling and included background on the four-step process interstate transport framework that the EPA uses to address the good neighbor provision for regional pollutants. This document also explains EPA's choice of 2023 as the new analytic year for the 2008 ozone NAAQS, introduced the "no water" approach to calculating relative response factors (RRFs) at coastal sites, and confirmed that there are no monitoring sites, outside of California, that were projected to have nonattainment or maintenance problems with respect to the 2008 ozone NAAQS of 75 ppb in 2023.

Concurrent with EPA's modeling documented in the October 2017 memo, Alpine was conducting good neighbor SIP modeling for the Commonwealth of Kentucky (Alpine, 2017) using EPA's 2023en modeling platform. This analysis confirmed EPA's "3x3 grid cell" findings and specifically noted that none of the problem monitors identified in EPA's final rule were predicted to be in nonattainment or have issues with maintenance in 2023 and therefore Kentucky (and by extension, any other upwind state) was not required to estimate its contribution to these monitors.

On March 27, 2018, EPA released a technical memorandum (Tsirigotis, 2018) providing additional information on interstate SIP submissions for the 2015 ozone NAAQS. In this memo, EPA provided incremental results of their 12km modeling using a projection year of 2023, including updated source apportionment results, a "no water" grid cell RRF methodology, and a discussion of potential flexibilities in analytical approaches that an upwind state may consider in developing GNS. As discussed in greater detail in Section 1.3.3, the year of 2023 was selected as the analytic year in EPA's modeling primarily because it aligned with the anticipated attainment year for Moderate ozone nonattainment areas and because it reflected the timeframe for implementing further emission reductions.

EPA's goal in providing these new ozone air quality projections for 2023 was to assist states' efforts to develop GNS for the 2015 ozone NAAQS.

A number of monitors in the eastern U.S. were found to be in nonattainment of the 2015 ozone NAAQS with multiple states demonstrating contribution to projected downwind nonattainment area air quality over the one-percent threshold at EPA-identified nonattainment or maintenance monitors. These EPA-identified monitors are provided in Table 1-1 along with their 3-yr design value for the period 2014-2016.

As EPA found that multiple state contributions to projected downwind maintenance problems at these monitors is above the one percent threshold and thus significant, additional analyses are required to identify these upwind state responsibilities under the Good Neighbor Provisions for the various ozone NAAQS.

Table 1-1. EPA-identified eastern U.S. nonattainment and maintenance monitors.

Monitor	State	County	2009-2013 Avg	2009-2013 Max	2023en "3x3" Avg	2023en "3x3" Max	2023en "No Water" Avg	2023en "No Water" Max	2014-2016
90010017	CT	Fairfield	80.3	83	69.8	72.1	68.9	71.2	80
90013007	CT	Fairfield	84.3	89	71.2	75.2	71.0	75.0	81
90019003	CT	Fairfield	83.7	87	72.7	75.6	73.0	75.9	85
90099002	CT	New Haven	85.7	89	71.2	73.9	69.9	72.6	76
240251001	MD	Harford	90.0	93	71.4	73.8	70.9	73.3	73
260050003	MI	Allegan	82.7	86	69.0	71.8	69.0	71.7	75
261630019	MI	Wayne	78.7	81	69.0	71.0	69.0	71.0	72
360810124	NY	Queens	78.0	80	70.1	71.9	70.2	72.0	69
360850067	NY	Richmond	81.3	83	71.9	73.4	67.1	68.5	76
361030002	NY	Suffolk	83.3	85	72.5	74.0	74.0	75.5	72
480391004	TX	Brazoria	88.0	89	74.0	74.9	74.0	74.9	75
481210034	TX	Denton	84.3	87	69.7	72.0	69.7	72.0	80
482011024	TX	Harris	80.3	83	70.4	72.8	70.4	72.8	79
482011034	TX	Harris	81.0	82	70.8	71.6	70.8	71.6	73
482011039	TX	Harris	82.0	84	71.8	73.6	71.8	73.5	67
484392003	TX	Tarrant	87.3	90	72.5	74.8	72.5	74.8	73
550790085	WI	Milwaukee	80.0	82	65.4	67.0	71.2	73.0	71
551170006	WI	Sheboygan	84.3	87	70.8	73.1	72.8	75.1	79

1.2.2 Purpose

This document primarily serves to provide the air quality modeling approach and results for two 4km grid domains in support of revisions that states may make to their 2008 or 2015 8-hour ozone Good Neighbor State Implementation Plan (GNS). This document demonstrates that many of the eastern state receptors demonstrate modeled attainment using a finer grid 4km modeling domain (compared to 12km results).

1.3 OVERVIEW OF MODELING APPROACH

The GNS 8-Hour ozone SIP modeling documented here includes an ozone simulation study using the 12 km grid based on EPA's 2011/2023en modeling platform supplemented with two additional 4km modeling domains over the Mid-Atlantic region and Lake Michigan.

1.3.1 Episode Selection

Episode selection is an important component of an 8-hour ozone attainment demonstration. EPA guidance recommends that 10 days be used to project 8-hour ozone Design Values at each critical monitor. The May 1 through August 31 2011 ozone season period was selected for the ozone SIP modeling primarily due to the following reasons:

- It is aligned with the 2011 NEI year, which is the latest NEI modeled in a regulatory platform.
- It is not an unusually low ozone year.
- Ambient meteorological and air quality data are available.
- A 2011 12 km CAMx modeling platform was available from the EPA that was leveraged for the GNS ozone SIP modeling.

More details of the summer 2011 episode selection and justification using criteria in EPA's modeling guidance are contained in Section 3.

1.3.2 Model Selection

Details on the rationale for model selection are provided in Section 2. The Weather Research Forecast (WRF) prognostic meteorological model was selected for the GNS ozone modeling using both the EPA 12US2 grid and two additional 4km modeling grids. Additional emission modeling was not required for the 12km simulation as the 2023en platform was provided to Alpine in pre-merged CAMx ready format. For both the base and future years, 4km subgrids were created using the EPA-provided SMOKE emissions input files and the CONUS 4km spatial surrogates developed by EPA for the 2014 platform modelling

Emissions processing was completed by EPA for the 12km domain and Alpine for the two 4km domains using the SMOKE emissions model for most source categories. The exceptions are that BEIS model was used for biogenic emissions and there are special processors for fires, windblown dust, lightning and sea salt emissions. The MOVES2014 on-road mobile source emissions model was used with SMOKE-MOVES to generate on-road mobile source emissions with EPA generated vehicle activity data provided in the NAAQS NODA. The same version of the CAMx photochemical grid model was also used. The setup is based on the same WRF/SMOKE/BEIS/CAMx modeling system used in the EPA 2023en platform modeling.

1.3.3 Base and Future Year Emissions Data

The 2023 future year was selected for the attainment demonstration modeling based on OAQPS Director Steven Page's October 27, 2017 memo (Page, 2017, page 4) to Regional Air Directors. In this memo, Director Page identified the two primary reasons the EPA selected 2023 for their 2008 NAAQS modeling; (1) the D.C. Circuit Court's response to *North Carolina v. EPA* in considering downwind attainment dates for the 2008 NAAQS, and (2) EPA's consideration of the timeframes that may be required for implementing further emission reductions as expeditiously as possible. The 2011 base case and 2023 future year emissions were based on EPA's "en" inventories with no adjustment. This platform has been identified by EPA as the base case for compliance with the final CSAPR update seasonal EGU NOx emission budgets.

1.3.4 Input Preparation and QA/QC

Quality assurance (QA) and quality control (QC) of the emissions datasets are some of the most critical steps in performing air quality modeling studies. Because emissions processing is tedious, time consuming and involves complex manipulation of many different types of large databases, rigorous QA measures are a necessity to prevent errors in emissions processing from occurring. The GNS 8-Hour ozone modeling study utilized EPA's pre-QA/QC'd emissions platform that followed a multistep emissions QA/QC approach for the 12km domain. Additional tabular and graphical review of the 4km emissions was conducted to ensure consistency with the 12km modeling results on spatial, temporal, and speciated levels.

1.3.5 Meteorology Input Preparation and QA/QC

The CAMx 2011 12 km meteorological inputs are based on WRF meteorological modeling conducted by EPA. Details on the EPA 2011 WRF application and evaluation are provided by EPA (EPA 2014d). Additional WRF simulations were conducted to generate meteorological data fields to support the 4km modeling domains. A performance evaluation of this incremental modeling was prepared (Alpine, 2018a) and confirmed adequacy of the files for SIP attainment and contribution analyses.

1.3.6 Initial and Boundary Conditions Development

Initial concentrations (IC) and Boundary Conditions (BC) are important inputs to the CAMx model. We ran 15 days of model spin-up before the first of each month so the ICs are washed out of the modeling domain. The lateral boundary and initial species concentrations are provided by a three dimensional global atmospheric chemistry model, GEOS-Chem (Yantosca, 2004) standard version 8-03-02 with 8-02-01 chemistry and were unchanged from the files EPA used in the "en" modeling platform.

The 4km domains were run as two-way interactive nests within the 12km simulation and therefore were provided with updated boundary conditions at each integration time step and provided up-scale feedback from the 4km domains to the 12km domain.

1.3.7 Air Quality Modeling Input Preparation and QA/QC

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

1.3.8 Model Performance Evaluation

The Model Performance Evaluation (MPE) relied on the 12km CAMx MPE from EPA's associated modeling platforms. EPA's MPE recommendations in their ozone modeling guidance (EPA, 2007; 2014e) were followed in this evaluation. Many of EPA's MPE procedures have already been performed by EPA in their CAMx 2011 modeling database being used in the GNS ozone SIP modeling. An additional MPE was prepared by Alpine (Alpine, 2018b) to support the 4km domains and confirmed the adequacy of the analysis for SIP and contribution analyses.

1.3.9 Diagnostic Sensitivity Analyses

Since no issues were identified in confirming Alpine's 12km CAMx runs compared to EPA's using the same modeling platform and configuration, additional diagnostic sensitivity analyses were not required.

2.0 MODEL SELECTION

This section documents the models used in this 8-hour ozone GNS SIP modeling study. The selection methodology presented in this chapter mirrors EPA's and other's regulatory modeling in support of the 2008 Ozone NAAQS Preliminary Interstate Transport Assessment (Page, 2017; Alpine, 2017; EPA, 2016b) and technical memorandum providing additional information on the Interstate SIP submissions for the 2015 Ozone NAAQS (Tsirigotis, 2018).

Unlike previous ozone modeling guidance that specified a particular ozone model (e.g., EPA, 1991 that specified the Urban Airshed Model; Morris and Myers, 1990), the EPA now recommends that models be selected for ozone SIP studies on a "case-by-case" basis. The latest EPA ozone guidance (EPA, 2014) explicitly mentions the CMAQ and CAMx PGMs as the most commonly used PGMs that would satisfy EPA's selection criteria but notes that this is not an exhaustive list and does not imply that they are "preferred" over other PGMs that could also be considered and used with appropriate justification. EPA's current modeling guidelines lists the following criteria for model selection (EPA, 2014e):

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

For the GNS 8-hour ozone modeling, we used the WRF/SMOKE/MOVES2014/BEIS/CAMx modeling system as the primary tool for demonstrating attainment of the ozone NAAQS at downwind monitors at downwind problem monitors. The utilized modeling system satisfies all of EPA's selection criteria. A description of the key models to be used in the GNS ozone SIP modeling follows.

WRF/ARW: The Weather Research and Forecasting (WRF)[1] Model is a mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs (Skamarock, 2004; 2006; Skamarock et al., 2005). The Advanced Research WRF (ARW) version of WRF was used in this ozone modeling study. It features multiple dynamical cores, a 3-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. WRF is suitable

[1] http://www.wrf-model.org/index.php

for a broad spectrum of applications across scales ranging from meters to thousands of kilometers. The effort to develop WRF has been a collaborative partnership, principally among the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (NOAA), the National Centers for Environmental Prediction (NCEP) and the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, the University of Oklahoma, and the Federal Aviation Administration (FAA). WRF allows researchers the ability to conduct simulations reflecting either real data or idealized configurations. WRF provides operational forecasting a model that is flexible and efficient computationally, while offering the advances in physics, numerics, and data assimilation contributed by the research community.

SMOKE: The Sparse Matrix Operator Kernel Emissions (SMOKE)[2] modeling system is an emissions modeling system that generates hourly gridded speciated emission inputs of mobile, non-road, area, point, fire and biogenic emission sources for photochemical grid models (Coats, 1995; Houyoux and Vukovich, 1999). As with most 'emissions models', SMOKE is principally an emission processing system and not a true emissions modeling system in which emissions estimates are simulated from 'first principles'. This means that, with the exception of mobile and biogenic sources, its purpose is to provide an efficient, modern tool for converting an existing base emissions inventory data into the hourly gridded speciated formatted emission files required by a photochemical grid model. SMOKE was used by EPA to prepare 2023en emission inputs for non-road mobile, area and point sources. These files were adopted and used as-is for this analysis.

SMOKE-MOVES: SMOKE-MOVES uses an Emissions Factor (EF) Look-Up Table from MOVES, gridded vehicle miles travelled (VMT) and other activity data and hourly gridded meteorological data (typically from WRF) and generates hourly gridded speciated on-road mobile source emissions inputs.

MOVES2014: MOVES2014[3] is EPA's latest on-road mobile source emissions model that was first released in July 2014 (EPA, 2014a,b,c). MOVES2014 includes the latest on-road mobile source emissions factor information. Emission factors developed by EPA were used in this analysis.

BEIS: Biogenic emissions were modeled by EPA using version 3.61 of the Biogenic Emission Inventory System (BEIS). First developed in 1988, BEIS estimates volatile organic compound (VOC) emissions from vegetation and nitric oxide (NO) emissions from soils. Because of resource limitations, recent BEIS development has been restricted to versions that are built within the Sparse Matrix Operational Kernel Emissions (SMOKE) system.

CAMx: The Comprehensive Air quality Model with Extensions (CAMx[4]) is a state-of-science "One-Atmosphere" photochemical grid model capable of addressing ozone, particulate matter (PM), visibility and acid deposition at regional scale for periods up to one year (ENVIRON,

2 http://www.smoke-model.org/index.cfm
3 http://www.epa.gov/otaq/models/moves/
4 http://www.camx.com

2015[5]). CAMx is a publicly available open-source computer modeling system for the integrated assessment of gaseous and particulate air pollution. Built on today's understanding that air quality issues are complex, interrelated, and reach beyond the urban scale, CAMx is designed to (a) simulate air quality over many geographic scales, (b) treat a wide variety of inert and chemically active pollutants including ozone, inorganic and organic $PM_{2.5}$ and PM_{10} and mercury and toxics, (c) provide source-receptor, sensitivity, and process analyses and (d) be computationally efficient and easy to use. The U.S. EPA has approved the use of CAMx for numerous ozone and PM State Implementation Plans throughout the U.S., and has used this model to evaluate regional mitigation strategies including those for most recent regional rules (e.g., Transport Rule, CAIR, NO_X SIP Call, etc.). CAMx Version 6.40 was used in this study.

<u>SMAT-CE:</u> The Software for the Modeled Attainment Test - Community Edition (SMAT-CE)[6] is a PC-based software tool that can perform the modeled attainment tests for particulate matter and ozone, and calculate changes in visibility at Class I areas as part of the reasonable progress analysis for regional haze. Version 1.2 (Beta) was used in this analysis.

5 http://www.camx.com/files/camxusersguide_v6-20.pdf
6 https://www.epa.gov/scram/photochemical-modeling-tools

3.0 EPISODE SELECTION

EPA's most recent 8-hour ozone modeling guidance (EPA, 2014e) contains recommended procedures for selecting modeling episodes The GNS ozone SIP revision modeling used the May through end of August 2011 modeling period because it satisfies the most criteria in EPA's modeling guidance episode selection discussion.

EPA guidance recommends that 10 days be used to project 8-hour ozone Design Values at each critical monitor. The May through August 2011 period has been selected for the ozone SIP modeling primarily due to being aligned with the 2011 NEI year, not being an unusually low ozone year and availability of a 2011 12 km CAMx modeling platform from the EPA NAAQS NODA.

4.0 MODELING DOMAIN SELECTION

This section summarizes the modeling domain definitions for the GNS 8-hour ozone modeling, including the domain coverage, resolution, and map projection. It also discusses emissions, aerometric, and other data available for use in model input preparation and performance testing.

4.1 HORIZONTAL DOMAINS

The GNS ozone SIP modeling used a 12 km continental U.S. (12US2) domain and two 4 km subnested domains; one over the Mid-Atlantic region and another over Lake Michigan and surrounding states.

The 12 km nested grid modeling domain configuration is shown in Figure 4-1 with the two 4km domains represented in Figure 4-2. The 12km domain shown in Figure 4-1 represents the CAMx 12km air quality and SMOKE/BEIS emissions modeling domain. The WRF meteorological modeling was run on larger 12 km modeling domains than used for CAMx as demonstrated in EPA's meteorological model performance evaluation document (EPA, 2014d). The WRF meteorological modeling domains are defined larger than the air quality modeling domains because meteorological models can sometimes produce artifacts in the meteorological variables near the boundaries as the prescribed boundary conditions come into dynamic balance with the coupled equations and numerical methods in the meteorological model.

Figure 4-1. Map of 12km CAMx modeling domains. Source: EPA NAAQS NODA.

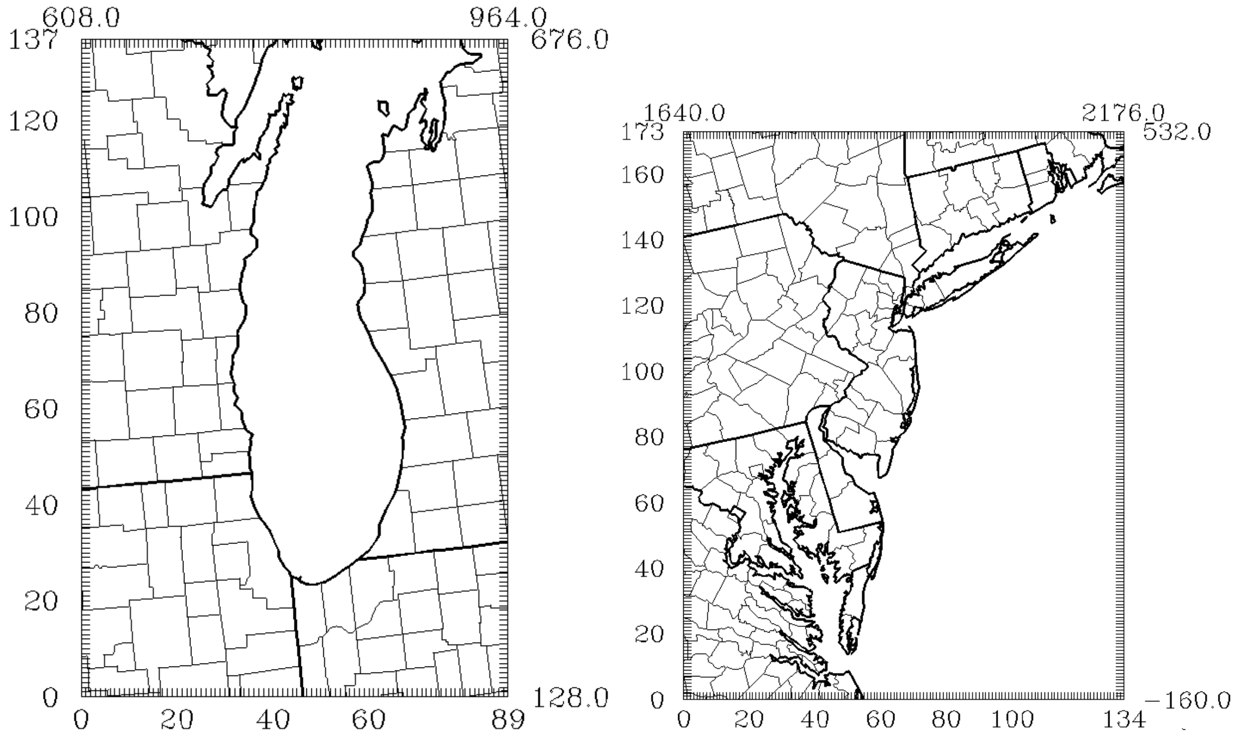

Figure 4-2. Maps of 4km CAMx modeling domains. Lake Michigan (left) and Mid-Atlantic (right).

4.2 VERTICAL MODELING DOMAIN

The CAMx vertical structure is primarily defined by the vertical layers used in the WRF meteorological modeling. The WRF model employs a terrain following coordinate system defined by pressure, using multiple layer interfaces that extend from the surface to 50 mb (approximately 19 km above sea level). EPA ran WRF using 35 vertical layers. A layer averaging scheme is adopted for CAMx simulations whereby multiple WRF layers are combined into one CAMx layer to reduce the air quality model computational time. Table 4-1 displays the approach for collapsing the WRF 35 vertical layers to 25 vertical layers in CAMx for the 12km and 4km grid domains.

Table 4-1. WRF and CAMx layers and their approximate height above ground level.

CAMx Layer	WRF Layers	Sigma P	Pressure (mb)	Approx. Height (m AGL)
25	35	0.00	50.00	17,556
	34	0.05	97.50	14,780
24	33	0.10	145.00	12,822
	32	0.15	192.50	11,282
23	31	0.20	240.00	10,002
	30	0.25	287.50	8,901
22	29	0.30	335.00	7,932
	28	0.35	382.50	7,064
21	27	0.40	430.00	6,275
	26	0.45	477.50	5,553
20	25	0.50	525.00	4,885
	24	0.55	572.50	4,264
19	23	0.60	620.00	3,683
18	22	0.65	667.50	3,136
17	21	0.70	715.00	2,619
16	20	0.74	753.00	2,226
15	19	0.77	781.50	1,941
14	18	0.80	810.00	1,665
13	17	0.82	829.00	1,485
12	16	0.84	848.00	1,308
11	15	0.86	867.00	1,134
10	14	0.88	886.00	964
9	13	0.90	905.00	797
	12	0.91	914.50	714
8	11	0.92	924.00	632
	10	0.93	933.50	551
7	9	0.94	943.00	470
	8	0.95	952.50	390
6	7	0.96	962.00	311
5	6	0.97	971.50	232
4	5	0.98	981.00	154
	4	0.99	985.75	115
3	3	0.99	990.50	77
2	2	1.00	995.25	38
1	1	1.00	997.63	19

4.3 DATA AVAILABILITY

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

4.3.1 Emissions Data

Without exception, the 2011 base year and 2023 base case emissions inventories for ozone modeling for this analysis were based on emissions obtained from the EPA's "en" modeling platform. This platform was obtained from EPA, via LADCO, in late September of 2017 and represents EPA's best estimate of all promulgated national, regional, and local control strategies, including final implementation of the seasonal EGU NOx emission budgets outlined in CSAPR.

4.3.2 Air Quality

Data from ambient monitoring networks for gas species are used in the model performance evaluation. Table 4-2 summarizes routine ambient gaseous and PM monitoring networks available in the U.S.

4.3.4 Meteorological Data

The 12km meteorological data were generated by EPA using the WRF prognostic meteorological model (EPA, 2014d). Alpine ran WRF with identical physics options (with the exception that no cumulus-parameterization was used on the 4km grid) and configuration for the 4km domains as was run by EPA for the 12km domain. WRF was run on a continental U.S. 12 km grid for the NAAQS NODA platform and for two subnested 4km domains as described in earlier sections.

4.3.5 Initial and Boundary Conditions Data

The lateral boundary and initial species concentrations are provided by a three dimensional global atmospheric chemistry model, GEOS-Chem (Yantosca, 2004) standard version 8-03-02 with 8-02-01 chemistry. The global GEOS-Chem model simulates atmospheric chemical and physical processes driven by assimilated meteorological observations from the NASA's Goddard Earth Observing System (GEOS-5; additional information available at: http://gmao.gsfc.nasa.gov/GEOS/ and http://wiki.seas.harvard.edu/geos-chem/index.php/GEOS-5). This model was run for 2011 with a grid resolution of 2.0 degrees x 2.5 degrees (latitude-longitude). The predictions were used to provide one-way dynamic boundary concentrations at one-hour intervals and an initial concentration field for the CAMx simulations. The 2011 boundary concentrations from GEOS-Chem will be used for the 2011 and 2023 model simulations.

The 4km domains were run as two-way interactive nests within the 12km simulation and therefore provided with updated boundary conditions at each integration time step and provided up-scale feedback from the 4km domains to the 12km domain.

Table 4-2. Overview of routine ambient data monitoring networks.

Monitoring Network	Chemical Species Measured	Sampling Period	Data Availability/Source
The Interagency Monitoring of Protected Visual Environments (IMPROVE)	Speciated PM25 and PM10 (see species mappings)	1 in 3 days; 24 hr average	
Clean Air Status and Trends Network (CASTNET)	Speciated PM25, Ozone (see species mappings)	Approximately 1-week average	http://www.epa.gov/castnet/data.html
National Atmospheric Deposition Program (NADP)	Wet deposition (hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium)), Mercury	1-week average	http://nadp.sws.uiuc.edu/
Air Quality System (AQS) or Aerometric Information Retrieval System (AIRS)	CO, NO2, O3, SO2, PM25, PM10, Pb	Typically hourly average	http://www.epa.gov/air/data/
Chemical Speciation Network (CSN)	Speciated PM	24-hour average	http://www.epa.gov/ttn/amtic/amticpm.html
Photochemical Assessment Monitoring Stations (PAMS)	Varies for each of 4 station types.		http://www.epa.gov/ttn/amtic/pamsmain.html
National Park Service Gaseous Pollutant Monitoring Network	Acid deposition (Dry; SO4, NO3, HNO3, NH4, SO2), O3, meteorological data	Hourly	http://www2.nature.nps.gov/ard/gas/netdata1.htm

5.0 MODEL INPUT PREPARATION PROCEDURES

This section summarizes the procedures used in developing the meteorological, emissions, and air quality inputs to the CAMx model for the GNS 8-hour ozone modeling on the 12km and 4km grids for the May through August 2011 period. Both the 12km and 4km CAMx modeling databases are based on the EPA "en" platform (EPA, 2017a; Page, 2017) databases. While some of the data prepared by EPA for this platform are new, many of the files are largely based on the NAAQS NODA platform. More details on the NAAQS NODA 2011 CAMx database development are provided in EPA documentation as follows:

- Technical Support Document (TSD) Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform (EPA, 2016a).
- Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation (EPA, 2014d).
- Air Quality Modeling Technical Support Document for the 2015 Ozone NAAQS Preliminary Interstate Transport Assessment (EPA, 2016b).

The modeling procedures used in the modeling are consistent with over 20 years of EPA ozone modeling guidance documents (e.g., EPA, 1991; 1999; 2005a; 2007; 2014), other recent 8-hour ozone modeling studies conducted for various State and local agencies using these or other state-of-science modeling tools (see, for example, Morris et al., 2004a,b, 2005a,b; 2007; 2008a,b,c; Tesche et al., 2005a,b; Stoeckenius et al., 2009; ENVIRON, Alpine and UNC, 2013; Adelman, Shanker, Yang and Morris, 2014; 2015), as well as the methods used by EPA in support of the recent Transport analysis (EPA, 2010; 2015b, 2016b, 2018).

5.1 METEOROLOGICAL INPUTS

5.1.1 WRF Model Science Configuration

For the 12km domain, Version 3.4 of the WRF model, Advanced Research WRF (ARW) core (Skamarock, 2008) was used for generating the 2011 simulations. Selected physics options include Pleim-Xiu land surface model, Asymmetric Convective Model version 2 planetary boundary layer scheme, Kain Fritsch cumulus parameterization utilizing the moisture-advection trigger (Ma and Tan, 2009), Morrison double moment microphysics, and RRTMG longwave and shortwave radiation schemes (Gilliam and Pleim, 2010). The WRF model configuration was prepared by EPA (EPA, 2014d).

The 4km domains were prepared using a nested WRF 3.9 simulation with domains shown in Figure 5-1. This domain, a 36km continental domain and a 12km domain that extends from the western border of the Dakotas off the eastern seaboard has two focused 4km domains over Lake Michigan and the Mid-Atlantic states. The WRF configuration options used in the 4km simulation were the same as those used by EPA, with the exception that no cumulus parameterization was used on the 4km domains. A summary of the 4km WRF application and evaluation are presented elsewhere (Alpine, 2018a).

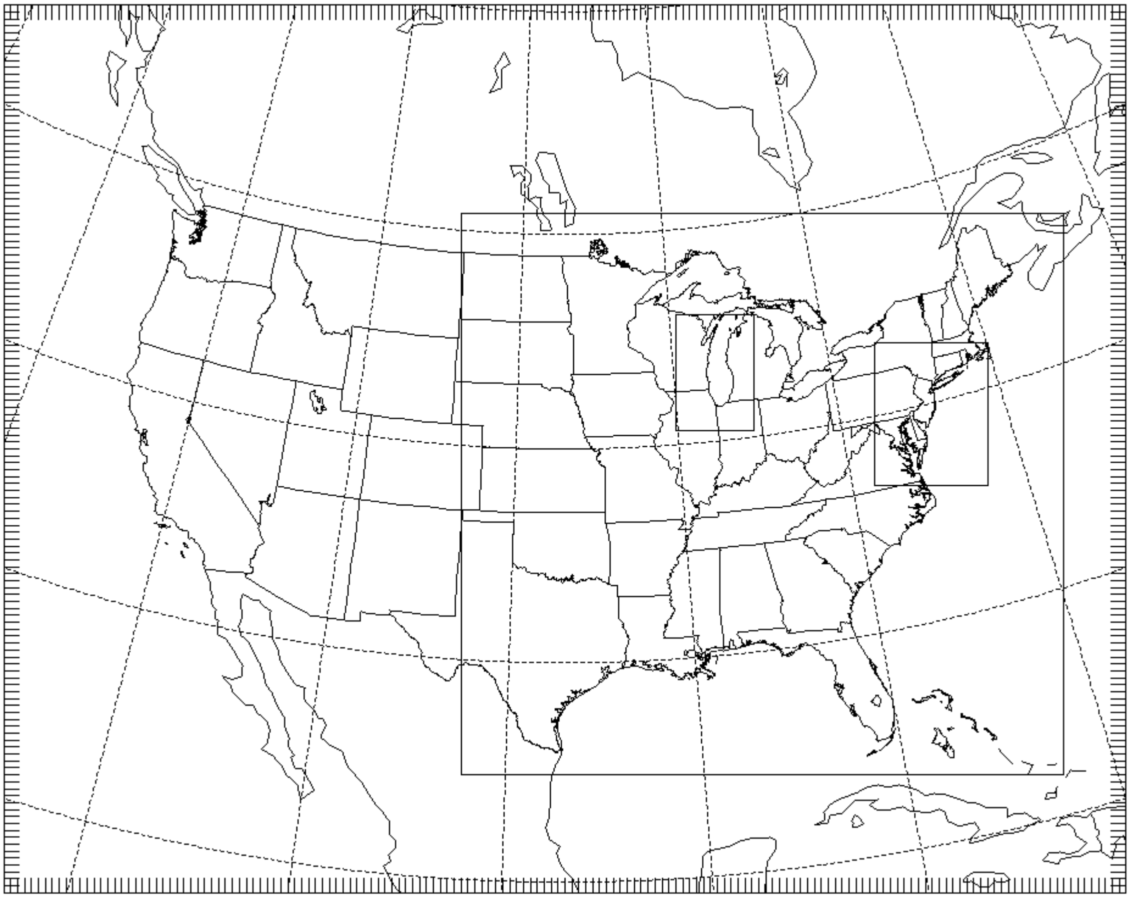

Figure 5-1. Map of WRF domains. The outer domain is the 36km CONUS domain, the large domain is the 12km domain and the inner are the Lake Michigan (left) and Mid-Atlantic (right) 4km domains.

5.1.2 WRF Input Data Preparation Procedures

For the 4km domain a summary of the WRF input data preparation procedures that were used are listed in EPA's documentation (EPA, 2014d). A summary of the 4km WRF application and evaluation are presented elsewhere (Alpine, 2018a).

5.1.3 WRF Model Performance Evaluation

The WRF model evaluation approach was based on a combination of qualitative and quantitative analyses. The quantitative analysis was divided into monthly summaries of 2-m temperature, 2-m mixing ratio, and 10-m wind speed using the boreal seasons to help generalize the model bias and error relative to a set of standard model performance benchmarks. The qualitative approach was to compare spatial plots of model estimated monthly total precipitation with the monthly PRISM precipitation. The WRF model performance evaluation for the 12km domain is provided in EPA's documentation (EPA, 2014d). A separate MPE for the 4km WRF simulations was prepared by Alpine (Alpine, 2018a). This evaluation is comprised of a quantitative and qualitative evaluation of WRF generated fields. The quantitative model performance evaluation of WRF using surface meteorological measurements was performed using the publicly available METSTAT[7] evaluation tool. METSTAT calculates statistical performance metrics for bias, error and correlation for surface winds, temperature and mixing ratio and can produce time series of predicted and observed meteorological variables and performance statistics. Alpine also conducted a qualitative comparison of WRF estimated precipitation with the Climate Prediction Center (CPC) retrospective analysis data.

5.1.4 WRFCAMx/MCIP Reformatting Methodology

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

The meteorological data generated by the WRF simulations were processed by EPA using WRFCAMx v4.3 (Ramboll Environ, 2014) meteorological data processing program to create model-ready meteorological inputs to CAMx. The 4km domains were processed using WRFCAMx v4.6[8]. In running WRFCAMx, vertical eddy diffusivities (Kv) were calculated using the Yonsei University (YSU) (Hong and Dudhia, 2006) mixing scheme with a minimum Kv of 0.1 m^2/sec except for urban grid cells where the minimum Kv was reset to 1.0 m^2/sec within the lowest 200 m of the surface in order to enhance mixing associated with the night time "urban heat island" effect. In addition, all domains used the subgrid convection and subgrid stratoform stratiform cloud options in our wrfcamx.

5.2 EMISSION INPUTS

5.2.1 Available Emissions Inventory Datasets

EPA's 2011 base year and 2023 future year emission inventories from the "en" modeling platform (EPA, 2017a) were used for all categories without exception.

5.2.2 Development of CAMx-Ready Emission Inventories

CAMx-ready emission inputs were generated by EPA mainly by the SMOKE and BEIS emissions models. CAMx requires two emission input files for each day: (1) low level gridded emissions that are emitted directly into the first layer of the model from sources at the surface with little or no plume rise; and (2) elevated point sources (stacks) with plume rise calculated from stack parameters and meteorological conditions. For this analysis, CAMx was operated using version 6 revision 4 of the Carbon Bond chemical mechanism (CB6r4).

Additional emission modeling was not required for the 12km simulation as the 2023en platform was provided to Alpine in pre-merged near CAMx ready format. For the base and future years, 4km subgrids were created using the EPA-provided SMOKE emissions input files and the CONUS 4km spatial surrogates developed by EPA for the 2014 platform modeling.

7 http://www.camx.com/download/support-software.aspx
8 http://www.camx.com/getmedia/7f3ee9dc-d430-42d6-90d5-dedb3481313f/wrfcamx-11jul17.tgz

5.2.2.1 Episodic Biogenic Source Emissions

Biogenic emissions were generated by EPA using the BEIS biogenic emissions model within SMOKE. BEIS uses high resolution GIS data on plant types and biomass loadings and the WRF surface temperature fields, and solar radiation (modeled or satellite-derived) to develop hourly emissions for biogenic species on the 12 km grids. Alpine ran BEIS using the same underlying data sets as EPA to generate emissions for the 4km domains. BEIS generates gridded, speciated, temporally allocated emission files.

5.2.2.2 Point Source Emissions

2011 point source emissions were from the 2011 “en” modeling platform. Point sources were developed in two categories: (1) major point sources with Continuous Emissions Monitoring (CEM) devices; and (2) point sources without CEMs. For point sources with continuous emissions monitoring (CEM) data, day-specific hourly NO_x and SO_2 emissions were used for the 2011 base case emissions scenario. The VOC, CO and PM emissions for point sources with CEM data were based on the annual emissions temporally allocated to each hour of the year using the CEM hourly heat input. The locations of the point sources were converted to the LCP coordinate system used in the modeling. They were processed by EPA using SMOKE to generate the temporally varying (i.e., day-of-week and hour-of-day) speciated emissions needed by CAMx, using profiles by source category from the EPA “en” modeling platform. Since the elevated point source locations are allocated directly to the grid, rather than by spatial surrogate, rerunning the elevated emissions for the 4km grids was not required.

5.2.2.3 Area and Non-Road Source Emissions

2011 area and non-road emissions were from the 2011 “en” modeling platform. The area and non-road sources were spatially allocated to the grid using an appropriate surrogate distribution (e.g., population for home heating, etc.). The area sources were temporally allocated by month and by hour of day using the EPA source-specific temporal allocation factors. The SMOKE source-specific CB6 speciation allocation profiles were also used.

5.2.2.4 Wildfires, Prescribed Burns, Agricultural Burns

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

5.2.2.5 On-Road Motor Vehicle Emissions

On-road motor vehicle emissions were processed using the SMOKE-MOVES module. The MOVES emissions factors table for the 2011 on-road segments were combined with the 2011 4km meteorology and 4km spatial surrogates to create actual 4km resolution for the on-road emissions.

5.2.2.6 QA/QC and Emissions Merging

EPA processed the emissions by major source category in several different "streams", including area sources, on-road mobile sources, non-road mobile sources, biogenic sources, non-CEM point sources, CEM point sources using day-specific hourly emissions, and emissions from fires. Separate Quality Assurance (QA) and Quality Control (QC) were performed for each stream of emissions processing and in each step following the procedures utilized by EPA. SMOKE includes advanced quality assurance features that include error logs when emissions are dropped or added. In addition, we generated visual displays that included spatial plots of the hourly emissions for each major species (e.g., NOX, VOC, some speciated VOC, SO2, NH3, PM and CO). Emissions for the 4km subgrids were reprocessed using the same emissions streams, lookup and cross reference tables, and adjustment factors as used by the EPA.

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

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

In addition, the 4km subgrid nest results were compared with the results from original EPA files that had been windowed from the 12km to the 4km domains. This provided assurance that all of the segments were being represented properly in the new subgrids.

5.2.3 Use of the Plume-in-Grid (PiG) Subgrid-Scale Plume Treatment

Consistent with the EPA 2011 modeling platform, no PiG subgrid-scale plume treatment will be used.

5.2.4 Future-Year Emissions Modeling

Future-year emission inputs were generated by processing the 2023 emissions data provided with EPA's "en" modeling platform without exception.

5.3 PHOTOCHEMICAL MODELING INPUTS

5.3.1 CAMx Science Configuration and Input Configuration

Version of CAMx (Version 6.40) was used in the GNS ozone modeling. The CAMx model setup used is defined by EPA in its air quality modeling technical support documents (EPA, 2016b, 2017, 2018).

6.0 MODEL PERFORMANCE EVALUATION

The CAMx 2011 base case model estimates are compared against the observed ambient ozone and other concentrations to establish that the model is capable of reproducing the current year observed concentrations so it is likely a reliable tool for estimating future year ozone levels.

6.1 MODEL PERFORMACE EVALUATION

6.1.1 Overview of EPA Model Performance Evaluation Recommendations

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

- Operation evaluation that includes statistical and graphical analysis aimed at determining how well the model simulates observed concentrations (i.e., does the model get the right answer).
- Diagnostic evaluation that focuses on process-oriented evaluation and whether the model simulates the important processes for the air quality problem being studied (i.e., does the model get the right answer for the right reason).
- Dynamic evaluation that assess the ability of the model air quality predictions to correctly respond to changes in emissions and meteorology.
- Probabilistic evaluation that assess the level of confidence in the model predictions through techniques such as ensemble model simulations.

EPA's guidance recommends that "At a minimum, a model used in an attainment demonstration should include a complete operational MPE using all available ambient monitoring data for the base case model simulations period" (EPA, 2014, pg. 63). And goes on to say "*Where practical, the MPE should also include some level of diagnostic evaluation*." EPA notes that there is no single definite test for evaluation model performance, but instead there are a series of statistical and graphical MPE elements to examine model performance in as many ways as possible while building a "weight of evidence" (WOE) that the model is performing sufficiently well for the air quality problem being studied.

6.1.2 MPE Results

Because this 2011 ozone modeling is using a CAMx 2011 modeling database developed by EPA, we include by reference the air quality modeling performance evaluation as conducted by EPA (EPA, 2016b) on the national 12km domain. Alpine additionally conducted an MPE (Appendix B) on the 4km domains (Alpine, 2018b) that generated results consistent with the 12km simulation and configuration.

In summary, EPA conducted an operational model performance evaluation for ozone to examine the ability of the CAMx v6.32 and v.6.40 modeling systems to simulate 2011 measured concentrations. This evaluation focused on graphical analyses and statistical metrics of model predictions versus observations. Details on the evaluation methodology, the calculation of performance statistics, and results are provided in Appendix A of that report.

Overall, the ozone model performance statistics for the CAMx v6.32 2011 simulation are similar to those from the CAMx v6.20 2011 simulation performed by EPA for the final CSAPR Update. The 2011 CAMx model performance statistics are within or close to the ranges found in other recent peer-reviewed applications (Simon et al, 2012). As described in Appendix A of the EPA AQ TSD, the predictions from the 2011 modeling platform correspond closely to observed concentrations in terms of the magnitude, temporal fluctuations, and geographic differences for 8-hour daily maximum ozone.

Alpine conducted a separate operational model performance evaluation for the two 4km modeling domains (Alpine, 2018b) and found that 4km domains for the 2011en platform performed similarly to EPA's 12km MPE that fell within or close to the ranges found in other recent peer-reviewed applications (Simon et al, 2012). Thus, the model performance results demonstrate the scientific credibility of the two 4km domains using the 2011 modeling platform chosen and used for this analysis. These results provide confidence in the ability of the modeling platform to provide a reasonable projection of expected future year ozone concentrations and contributions over the two 4km grids.

7.0 FUTURE YEAR MODELING

This chapter discusses the future year modeling used in the GNS 8-hour ozone modeling effort.

7.1 FUTURE YEAR TO BE SIMULATED

As discussed in Section 1, to support the 2008 and 2015 ozone NAAQS preliminary interstate transport assessment, EPA conducted air quality modeling to project ozone concentrations at individual monitoring sites to 2023 and to estimate state-by-state contributions to those 2023 concentrations. The projected 2023 ozone concentrations were used to identify ozone monitoring sites that are projected to be nonattainment or have maintenance problems for the two ozone NAAQS in 2023 and for which upwind states have been identified as significant contributors.

7.2 FUTURE YEAR GROWTH AND CONTROLS

In September 2017, EPA released the revised “en” modeling platform that was the source for the 2023 future year emissions in this analysis. This platform has been identified by EPA as the base case for compliance with the final CSAPR update seasonal EGU NOx emission budgets. Additionally, there were several emission categories and model inputs/options that were held constant at 2011 levels as follows:

- Biogenic emissions.
- Wildfires, Prescribed Burns and Agricultural Burning (open land fires).
- Windblown dust emissions.
- Sea Salt.
- 36 km CONUS domain Boundary Conditions (BCs).
- 2011 12 km meteorological conditions.
- All model options and inputs other than emissions.

The effects of climate change on the future year meteorological conditions were not accounted. It has been argued that global warming could increase ozone due to higher temperatures producing more biogenic VOC and faster photochemical reactions (the so called climate penalty). However, the effects of inter-annual variability in meteorological conditions will be more important than climate change given the 12 year difference between the base (2011) and future (2023) years. It has also been noted that the level of ozone being transported into the U.S. from Asia has also increased.

7.3 FUTURE YEAR BASELINE AIR QUALITY SIMULATIONS

A 2023 future year base case CAMx simulation was conducted and 2023 ozone design value projection calculations were made based on EPA’s latest ozone modeling guidance (EPA, 2014e) for the 12US2 and two 4km modeling domains in this analysis.

7.3.1 Identification of Future Nonattainment and Maintenance Receptors

The ozone predictions from the 2011 and 2023 CAMx model simulations were used to project 2009-2013 average and maximum ozone design values to 2023 following the approach described in the EPA's draft guidance for attainment demonstration modeling (US EPA, 2014b). Using the approach in the final CSAPR Update, we evaluated the 2023 projected average and maximum design values in conjunction with the most recent measured ozone design values (i.e., 2014-2016) to identify sites that may warrant further consideration as potential nonattainment or maintenance sites in 2023.

If the approach in the CSAPR Update is applied to evaluate the projected design values, those sites with 2023 average design values that exceed the NAAQS (i.e., 2023 average design values of 71 ppb or greater) and that are currently measuring nonattainment would be considered to be nonattainment receptors in 2023. Similarly, with the CSAPR Update approach, monitoring sites with a projected 2023 maximum design value that exceeds the NAAQS would be projected to be maintenance receptors in 2023. In the CSAPR Update approach, maintenance-only receptors include both those monitoring sites where the projected 2023 average design value is below the NAAQS, but the maximum design value is above the NAAQS, and monitoring sites with projected 2023 average design values that exceed the NAAQS, but for which current design values based on measured data do not exceed the NAAQS.

As documented in EPA's March 2018 technical memorandum (Tsirigotis, 2018), EPA used results of CAMx v6.40 to model emissions in 2011 and 2023 to project base period 2009-2013 average and maximum ozone design values to 2023 at monitoring sites nationwide. In projecting these future year design values, EPA applied its own modeling guidance, which recommends using model predictions from the "3x3" array of grid cells surrounding the location of the monitoring site. In response to comments submitted on the January 2017 NODA and other analyses, EPA also projected 2023 design values based on a modified version of the "3x3" approach for those monitoring sites located in coastal areas (Tsirigotis, 2018). This modeling was intended as an alternate approach to addressing complex meteorological monitor locations without having to rerun the simulations on finer grid scales.

Alpine's applied approach in developing and using 4km grid domains further followed EPA's guidance recommendation that "grid resolution finer than 12 km would generally be more appropriate for areas with a combination of complex meteorology, strong gradients in emissions sources, and/or land-water interfaces in or near the nonattainment area(s)." (EPA, 2014e)

We used the finer grid resolution and the Software for the Modeled Attainment Test - Community Edition[9] (SMAT-CE) tool consistent with EPA's 12km attainment demonstration modeling methods calculating relative response factors and "3x3" neighborhoods (EPA, 2014e). Alpine also prepared 2023 projected average and maximum design values in conjunction with the most recent measured ozone design values (2015-2017) to identify sites in these 4km

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

domains that may warrant further consideration as potential nonattainment or maintenance sites in 2023.

After applying the approach outlined in the final CSAPR update (and described above) to evaluate the projected design values from the 4km analysis, we developed a list of nonattainment and maintenance monitors located within these two eastern 4km domains resulting from the approach. Modeled nonattainment monitors defined using Alpine's 4km simulation are provided in Table 7-1 along with their calculated 2023 average and maximum design values from both EPA's "no water" calculation approach and Alpine's 4km simulation and most current 2015-2017 design values. Similarly, Table 7-2 presents the modeled maintenance monitors with their calculated average and maximum design values from both simulations and the most current 2015-2017 design value data. Monitors originally designated as nonattainment or maintenance by EPA using their "no water" calculation and found to be neither nonattainment or maintenance using Alpine's 4km modeling are presented in Table 7-3. A full list of monitor locations and modeled average and maximum ozone design values for the 4km domain modeling is provided in Appendix A of this report.

Table 7-1. Alpine 4km Modeling-identified nonattainment monitors in the 4km domains.

			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Alpine Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
551170006	WI	Sheboygan	84.3	72.8	75.1	71.5	73.8	80

Table 7-2. Alpine 4km Modeling-identified maintenance monitors in the 4km domains.

			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Alpine Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
90013007	CT	Fairfield	84.3	71.0	75.0	69.2	73.1	83
90019003	CT	Fairfield	83.7	73.0	75.9	68.3	71.0	83
90099002	CT	New Haven	85.7	69.9	72.6	68.9	71.5	82
240251001	MD	Harford	90.0	70.9	73.3	70.9	73.3	75
260050003	MI	Allegan	82.7	69.0	71.7	70.0	72.8	73
340150002	NJ	Gloucester	84.3	68.2	70.4	68.8	71.0	74
360850067	NY	Richmond	81.3	67.1	68.5	69.6	71.0	76
361030002	NY	Suffolk	83.3	74.0	75.5	70.6	72.0	76

Table 7-3. Alpine 4km modeling-identified attainment monitors in the 4km domains previously identified by EPA as nonattainment or maintenance.

			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Alpine Updated 4km Modeling		2015-2017 DV
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	
90010017	CT	Fairfield	80.3	68.9	71.2	66.8	69.0	79
90110124	CT	New London	80.3	67.3	70.4	66.0	69.1	76
360810124	NY	Queens	78.0	70.2	72.0	68.5	70.2	74
421010024	PA	Philadelphia	83.3	67.3	70.3	67.5	70.5	78
550790085	WI	Milwaukee	80.0	71.2	73.0	67.1	68.8	71

The procedures for calculating projected 2023 average and maximum design values are described in Section 3.2 of EPA's air quality technical support document (EPA, 2016b). The only noted differences are that Alpine used 4km modeling results, compared to EPA's 12km, compared modeled design values with 3yr design values from 2015-2017, and did not remove "no water" cells from the calculation as further described in the March 2018 memorandum.

8.0 REFERENCES

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

Alpine. 2017a. "Good Neighbor" Modeling for the Kentucky 2008 8-Hour Ozone State Implementation Plan - Final Modeling Protocol. Alpine Geophysics, LLC. October.

Alpine. 2017b. "Good Neighbor" Modeling for the Kentucky 2008 8-Hour Ozone State Implementation Plan - Final Modeling Report. Alpine Geophysics, LLC. November.

Alpine. 2018a. Midwest Ozone Group 2011 WRF Model Application and Performance Evaluation Report. Alpine Geophysics, LLC. February.

Alpine. 2018b. Ozone Model Performance Evaluation Of Midwest Ozone Group Updated 4km Modeling Domains. Alpine Geophysics, LLC. December.

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

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

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

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

Boylan, J. W. (May 4, 2018). *Georgia EPD Comments on EPA's March 27, 2018 Interstate Transport Memo* [Memorandum]. Air Protection Branch, Georgia EPD.

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

Calcagni. J. (September 4, 1992). *Procedures for Processing Requests to Redesignate Areas to Attainment* [Memorandum]. Research Triangle Park, NC: U.S. EPA, Office of Air Quality Planning and Standards. Retrieved from https://www.epa.gov/sites/production/files/2016-03/documents/calcagni_memo_-_procedures_for_processing_requests_to_redesignate_areas_to_attainment_090492.pdf

Carter, W.P.L. 1999. Documentation of the SAPRC-99 Chemical Mechanism for VOC Reactivity Assessment, Draft report to the California Air Resources Board, Contracts 92-329 and 95-308, 9/13/99.

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

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

Emery, C., E. Tai, and G. Yarwood. 2001. "Enhanced Meteorological Modeling and Performance Evaluation for Two Texas Episodes", report to the Texas Natural Resources Conservation Commission, prepared by ENVIRON, International Corp, Novato, CA.

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

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

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

ENVIRON and UCR. 2004. "Modeling Protocol for the CENRAP 2002 Annual Emissions and Air Quality Modeling." ENVIRON International Corporation and University of California at Riverside. November.

ENVIRON and Alpine. 2005. CONCEPT Emissions Modeling User's Guide. ENVIRON International Corporation, Novato, CA. Alpine Geophysics, LLC, Arvada, CO. May 27 (http://www.ladco.org/reports/rpo/emissions/new_emissions_model_concept_introduction_alpine_environ.pdf)

ENVIRON. 2015. User's Guide Comprehensive Air-quality Model with extensions Version 6.3. ENVIRON International Corporation, Novato, CA. March. (http://www.camx.com/files/camxusersguide_v6-3.pdf).

EPA. 1991. "Guidance for Regulatory Application of the Urban Airshed Model (UAM), "Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, N.C.

EPA. 1999. "Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hr Ozone NAAQS". Draft (May 1999), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C

EPA. 2001. "Guidance Demonstrating Attainment Air Quality Goals for PM2.5 and Regional Haze". Draft Final (17 February 2005), U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C.

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

EPA. 2003b. National Emission Inventory QA and Augmentation Memo, prepared by Anne Pope, U.S. EPA, June. http://www.epa.gov/ttn/chief/emch/invent/qaaugmementationmemo_99nei_60603.pdf

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

EPA. 2005b. Technical Support Document for the Final Clean Air Interstate Rule – Air Quality Modeling. U.S. Environmental Protection Agency, Office of Air Quality and Planning Standards, Research Triangle Park, North Carolina, 27711. March.

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

EPA. 2007. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-454/B-07-002. April. (http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf).

EPA. 2010. Technical Support Document for the Transport Rule. Docket ID No. EPA-HQ-OAR-2009-0491. Air Quality Modeling. U.S. Environmental Protection Agency, Office of Pair Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, NC. June.

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

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

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

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

EPA. 2014e. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, U.S. Environmental Protection Agency. December 2014.

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

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

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

EPA. 2017a. Technical Support Document (TSD) Additional Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2023. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October

2017. https://www.epa.gov/sites/production/files/2017-11/documents/2011v6.3_2023en_update_emismod_tsd_oct2017.pdf

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

EPA. 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

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

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

Kemball-Cook, S., Y. Jia, C. Emery, R. Morris, Z. Wang and G. Tonnesen. 2004. Comparison of CENRAP, VISTAS and WRAP 36 km MM5 Model Runs for 2002, Task 3: Meteorological Gatekeeper Report. http://pah.cert.ucr.edu/aqm/cenrap/ppt_files/CENRAP_VISTAS_WRAP_2002_36km_MM5_eval.ppt. December.

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

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

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

Moore, C.T. et al. 2011. "Deterministic and Empirical Assessment of Smoke's Contribution to Ozone – Final Report. Western Governors' Association, Denver, CO. (https://wraptools.org/pdf/11-1-6-6_final_report_DEASCO3_project.pdf)

Morris, R. E. and T. C. Myers. 1990. "User's Guide for the Urban Airshed Model. Volume I: User's Manual for UAM (CB-IV)" prepared for the U.S. Environmental Protection Agency (EPA-450/4-90-007a), Systems Applications International, San Rafael, CA.

Page. S. (October 27, 2017). *Supplemental Information on the Interstate Transport State Implementation Plan Submissions for the 2008 Ozone national Ambient Air Quality*

Standards under Clean Air Act Section 110(a)(2)(D)(i)(I) [Memorandum]. Research Triangle Park, NC: U.S. EPA, Office of Air Quality Planning and Standards. Retrieved from https://www.epa.gov/sites/production/files/2017-10/documents/final_2008_o3_naaqs_transport_memo_10-27-17b.pdf

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

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

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

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

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

Tsirigotis, P. (March 27, 2018). *Information on the Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards under Clean Air Act Section 110(a)(2)(D)(i)(I)* [Memorandum]. Research Triangle Park, NC: U.S. EPA, Office of Air Quality Planning and Standards. Retrieved from https://www.epa.gov/sites/production/files/2018-03/documents/transport_memo_03_27_18_1.pdf

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

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

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

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

(http://vibe.cira.colostate.edu/wiki/Attachments/Modeling/3SAQS_2011_WRF_MPE_v05Mar2015.pdf).

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

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

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

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

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

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

Appendix A

Updated 4km Modeling Results for Mid-Atlantic and Lake Michigan Domains Compared To EPA 12km "No Water" Design Value Calculations from March 2018 Memorandum

Table A-1. 4km and EPA "No Water" 12km Design Value Results for Monitors Located in 4km Mid-Atlantic Modeling Domain.								
			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
90010017	Connecticut	Fairfield	80.3	68.9	71.2	66.8	69.0	79
90011123	Connecticut	Fairfield	81.3	66.4	67.8	65.2	66.6	77
90013007	Connecticut	Fairfield	84.3	71.0	75.0	69.2	73.1	83
90019003	Connecticut	Fairfield	83.7	73.0	75.9	68.3	71.0	83
90031003	Connecticut	Hartford	73.7	60.7	61.7	60.3	61.3	72
90050005	Connecticut	Litchfield	70.3	57.2	57.8	56.8	57.3	72
90070007	Connecticut	Middlesex	79.3	64.7	66.1	63.8	65.2	79
90090027	Connecticut	New Haven	74.3	61.9	65.0	61.8	64.9	77
90099002	Connecticut	New Haven	85.7	69.9	72.6	68.9	71.5	82
90110124	Connecticut	New London	80.3	67.3	70.4	66.0	69.1	76
90131001	Connecticut	Tolland	75.3	61.4	62.8	61.3	62.7	71
100010002	Delaware	Kent	74.3	57.6	60.5	58.4	61.4	66
100031007	Delaware	New Castle	76.3	59.2	62.0	59.8	62.7	67
100031010	Delaware	New Castle	78.0	61.2	61.2	61.7	61.7	74
100031013	Delaware	New Castle	77.7	60.8	62.6	61.6	63.5	71
100032004	Delaware	New Castle	75.0			59.0	59.0	72
100051002	Delaware	Sussex	77.3	59.7	62.6	60.5	63.4	65
100051003	Delaware	Sussex	77.7	61.1	63.7	61.7	64.3	67
110010041	District Of Columbia	District of Columbia	76.0	58.7	61.7	60.5	63.6	
110010043	District Of Columbia	District of Columbia	80.7	62.3	64.8	65.2	67.9	71
240030014	Maryland	Anne Arundel	83.0	63.4	66.4	64.9	68.0	
240051007	Maryland	Baltimore	79.0	63.9	66.3	61.6	64.0	
240053001	Maryland	Baltimore	80.7	65.3	67.9	63.9	66.5	73

Table A-1. 4km and EPA "No Water" 12km Design Value Results for Monitors Located in 4km Mid-Atlantic Modeling Domain.								
			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
240090011	Maryland	Calvert	79.7	63.2	65.9	64.0	66.7	67
240130001	Maryland	Carroll	76.3	58.8	60.9	59.4	61.5	69
240150003	Maryland	Cecil	83.0	64.5	66.8	65.2	67.5	74
240170010	Maryland	Charles	79.0	61.6	64.7	63.2	66.4	69
240199991	Maryland	Dorchester	75.0	59.4	59.4	59.7	59.7	65
240210037	Maryland	Frederick	76.3	59.6	61.8	60.4	62.5	69
240251001	Maryland	Harford	90.0	70.9	73.3	70.9	73.3	75
240259001	Maryland	Harford	79.3	62.2	64.3	62.4	64.5	73
240290002	Maryland	Kent	78.7	61.2	63.7	61.2	63.8	70
240313001	Maryland	Montgomery	75.7	60.0	61.0	60.0	61.1	68
240330030	Maryland	Prince George's	79.0	60.5	62.8	61.0	63.3	70
240338003	Maryland	Prince George's	82.3	63.2	66.8	64.0	67.7	71
240339991	Maryland	Prince George's	80.0	61.0	61.0	61.9	61.9	69
240430009	Maryland	Washington	72.7			56.6	58.4	67
245100054	Maryland	Baltimore (City)	73.7	59.4	60.4	59.2	60.2	69
250034002	Massachusetts	Berkshire	69.0			56.2	57.9	
250051002	Massachusetts	Bristol	74.0	61.2	61.2	60.8	60.8	
250070001	Massachusetts	Dukes	77.0	64.1	66.6	64.8	67.4	
250130008	Massachusetts	Hampden	73.7	59.3	59.5	60.4	60.7	71
250150103	Massachusetts	Hampshire	64.7			52.4	53.5	
250154002	Massachusetts	Hampshire	71.3			57.3	57.9	70
250213003	Massachusetts	Norfolk	72.3			57.6	58.1	70
250270015	Massachusetts	Worcester	68.3			55.4	56.8	65
250270024	Massachusetts	Worcester	69.0			55.3	56.1	66
340010006	New Jersey	Atlantic	74.3	58.6	60.0	60.2	61.5	64

Table A-1. 4km and EPA "No Water" 12km Design Value Results for Monitors Located in 4km Mid-Atlantic Modeling Domain.								
			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
340030006	New Jersey	Bergen	77.0	64.1	65.0	65.5	66.4	74
340071001	New Jersey	Camden	82.7	66.3	69.8	65.9	69.3	68
340110007	New Jersey	Cumberland	72.0	57.0	59.4	57.1	59.5	66
340130003	New Jersey	Essex	78.0	64.3	67.6	63.4	66.7	68
340150002	New Jersey	Gloucester	84.3	68.2	70.4	68.8	71.0	74
340170006	New Jersey	Hudson	77.0	64.6	65.4	65.3	66.2	70
340190001	New Jersey	Hunterdon	78.0	62.0	63.6	60.8	62.4	72
340210005	New Jersey	Mercer	78.3	63.2	65.4	62.7	64.9	71
340219991	New Jersey	Mercer	76.0	60.4	60.4	58.5	58.5	73
340230011	New Jersey	Middlesex	81.3	65.0	68.0	64.5	67.4	75
340250005	New Jersey	Monmouth	80.0	64.1	66.5	65.4	67.9	68
340273001	New Jersey	Morris	76.3	62.4	63.8	62.6	64.0	69
340290006	New Jersey	Ocean	82.0	65.8	68.2	64.8	67.2	73
340315001	New Jersey	Passaic	73.3	61.3	62.7	59.9	61.3	68
340410007	New Jersey	Warren	66.0	54.0	54.0	50.9	50.9	65
360010012	New York	Albany	68.0			56.8	58.4	64
360050133	New York	Bronx	74.0	63.3	65.0	63.8	65.6	70
360150003	New York	Chemung	66.5			55.3	55.7	
360270007	New York	Dutchess	72.0	58.6	60.2	57.0	58.6	67
360530006	New York	Madison	67.0			54.4	54.4	
360610135	New York	New York	73.3	64.2	66.5	62.9	65.2	70
360671015	New York	Onondaga	69.3			57.7	59.9	64
360715001	New York	Orange	67.0	55.3	56.9	54.2	55.8	65
360750003	New York	Oswego	68.0			55.9	57.6	61
360790005	New York	Putnam	70.0	58.4	59.2	56.7	57.5	70

Table A-1. 4km and EPA “No Water” 12km Design Value Results for Monitors Located in 4km Mid-Atlantic Modeling Domain.								
			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
360810124	New York	Queens	78.0	70.2	72.0	68.5	70.2	74
360850067	New York	Richmond	81.3	67.1	68.5	69.6	71.0	76
360870005	New York	Rockland	75.0	62.0	62.8	63.7	64.5	72
361030002	New York	Suffolk	83.3	74.0	75.5	70.6	72.0	76
361030004	New York	Suffolk	78.0	65.2	66.9	63.8	65.4	76
361030009	New York	Suffolk	78.7	67.6	68.7	66.5	67.5	69
361111005	New York	Ulster	69.0			56.3	56.3	
361192004	New York	Westchester	75.3	63.8	64.4	64.6	65.2	73
420110006	Pennsylvania	Berks	71.7	56.2	58.8	55.8	58.4	66
420110011	Pennsylvania	Berks	76.3	58.9	61.0	59.9	62.1	70
420170012	Pennsylvania	Bucks	80.3	64.6	66.8	64.4	66.6	80
420290100	Pennsylvania	Chester	76.3	58.7	60.8	59.9	62.0	73
420430401	Pennsylvania	Dauphin	69.0	54.7	54.7	54.9	54.9	65
420431100	Pennsylvania	Dauphin	74.7	58.3	60.1	59.1	61.0	66
420450002	Pennsylvania	Delaware	75.7	60.3	62.1	60.7	62.6	71
420550001	Pennsylvania	Franklin	67.0			52.6	53.4	59
420690101	Pennsylvania	Lackawanna	71.0			55.7	56.4	67
420692006	Pennsylvania	Lackawanna	68.7			53.5	55.3	64
420710007	Pennsylvania	Lancaster	77.0	60.1	62.4	60.6	63.0	70
420710012	Pennsylvania	Lancaster	78.0	60.2	63.3	60.6	63.7	66
420750100	Pennsylvania	Lebanon	76.0	58.6	58.6	59.0	59.0	69
420770004	Pennsylvania	Lehigh	76.0	59.5	61.1	59.4	61.0	70
420791100	Pennsylvania	Luzerne	65.0			49.5	50.3	
420791101	Pennsylvania	Luzerne	64.3			49.7	51.0	64
420810100	Pennsylvania	Lycoming	67.0			52.6	54.2	64

Table A-1. 4km and EPA "No Water" 12km Design Value Results for Monitors Located in 4km Mid-Atlantic Modeling Domain.								
			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
420890002	Pennsylvania	Monroe	66.7	52.9	55.6	52.6	55.2	67
420910013	Pennsylvania	Montgomery	76.3	61.0	62.4	62.0	63.4	72
420950025	Pennsylvania	Northampton	76.0	58.5	60.6	58.8	59.6	70
420958000	Pennsylvania	Northampton	69.7	54.8	55.9	54.7	55.7	69
420990301	Pennsylvania	Perry	68.3			54.7	56.1	
421010004	Pennsylvania	Philadelphia	66.0	53.9	57.1	54.2	57.5	
421010024	Pennsylvania	Philadelphia	83.3	67.3	70.3	67.5	70.5	78
421011002	Pennsylvania	Philadelphia	80.0	64.7	64.7	65.3	65.3	
421174000	Pennsylvania	Tioga	69.7			57.4	58.5	64
421330008	Pennsylvania	York	72.3	56.9	58.3	58.3	59.7	66
421330011	Pennsylvania	York	74.3	58.0	60.1	58.8	61.0	70
440030002	Rhode Island	Kent	73.7	60.4	60.7	59.5	59.7	72
440071010	Rhode Island	Providence	74.0	59.5	61.1	59.9	61.6	70
440090007	Rhode Island	Washington	76.3	62.6	64.0	62.3	63.7	71
510130020	Virginia	Arlington	81.7	64.9	68.3	66.1	69.6	71
510330001	Virginia	Caroline	71.7	56.0	57.6	55.2	57.0	61
510360002	Virginia	Charles	75.7	59.4	62.0	61.1	63.7	61
510410004	Virginia	Chesterfield	72.0	56.8	59.2	55.6	58.0	62
510590030	Virginia	Fairfax	82.3	65.1	68.1	66.2	69.1	71
510610002	Virginia	Fauquier	62.7			49.8	50.9	58
510850003	Virginia	Hanover	73.7	56.9	58.6	55.3	57.1	63
510870014	Virginia	Henrico	75.0	58.8	61.2	57.7	60.0	65
511071005	Virginia	Loudoun	73.0	57.8	59.4	58.7	60.3	68
511479991	Virginia	Prince Edward	62.0			50.2	50.2	58
511530009	Virginia	Prince William	70.0	56.2	57.8	54.8	56.3	66

Table A-1. 4km and EPA “No Water” 12km Design Value Results for Monitors Located in 4km Mid-Atlantic Modeling Domain.								
			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
511790001	Virginia	Stafford	73.0	57.1	59.4	57.0	59.4	62
515100009	Virginia	Alexandria City	80.0	63.4	65.8	64.7	67.1	
516500008	Virginia	Hampton City	74.0	56.9	58.4	54.8	56.3	65
518000004	Virginia	Suffolk City	71.3	56.2	57.5	56.5	57.9	61
518000005	Virginia	Suffolk City	69.7			54.9	56.0	59

Table A-2. 4km and EPA "No Water" 12km Design Value Results for Monitors Located in 4km Lake Michigan Modeling Domain.								
			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
170310001	Illinois	Cook	72.0	63.2	64.9	60.3	62.0	73
170310032	Illinois	Cook	77.7	66.6	69.5	57.7	60.1	72
170310064	Illinois	Cook	71.3	61.1	64.3	55.1	58.0	
170310076	Illinois	Cook	71.7	62.7	64.7	61.1	63.0	72
170311003	Illinois	Cook	69.7	62.4	64.4	59.7	61.7	67
170311601	Illinois	Cook	71.3	61.5	63.9	62.2	64.5	69
170314002	Illinois	Cook	71.7	62.3	64.3	62.3	64.3	68
170314007	Illinois	Cook	65.7	58.0	60.0	55.7	57.6	71
170314201	Illinois	Cook	75.7	66.8	68.8	62.6	64.5	72
170317002	Illinois	Cook	76.0	66.8	70.3	59.7	62.8	73
170436001	Illinois	DuPage	66.3	57.9	59.4	58.6	60.1	70
170890005	Illinois	Kane	69.7	62.8	63.9	60.5	61.6	69
170971007	Illinois	Lake	79.3	63.4	65.6	60.2	62.2	73
171110001	Illinois	McHenry	69.7	61.8	62.9	59.8	60.9	69
171971011	Illinois	Will	64.0	55.6	56.5	54.7	55.5	65
172012001	Illinois	Winnebago	67.3	57.5	58.0	57.5	58.1	66
180150002	Indiana	Carroll	69.0			56.5	58.2	63
180390007	Indiana	Elkhart	67.7	54.6	56.5	55.0	56.9	64
180690002	Indiana	Huntington	65.0			53.5	54.4	60
180890022	Indiana	Lake	66.7	58.3	60.3	55.2	57.1	68
180890030	Indiana	Lake	69.7	61.9	64.8	55.6	58.2	
180892008	Indiana	Lake	68.0	60.4	60.4	56.8	56.8	
180910005	Indiana	LaPorte	79.3	67.2	70.4	65.4	68.4	
180910010	Indiana	LaPorte	69.7	58.9	60.9	57.7	59.6	67
181270024	Indiana	Porter	70.3	61.8	63.3	59.3	60.8	69

Table A-2. 4km and EPA "No Water" 12km Design Value Results for Monitors Located in 4km Lake Michigan Modeling Domain.								
			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
181270026	Indiana	Porter	63.0	54.4	55.3	53.2	54.0	69
181410010	Indiana	St. Joseph	62.7			51.4	52.5	65
181410015	Indiana	St. Joseph	69.3	56.9	59.9	57.6	60.7	70
181411007	Indiana	St. Joseph	64.0	52.5	52.5	52.5	52.5	
260050003	Michigan	Allegan	82.7	69.0	71.7	70.0	72.8	73
260190003	Michigan	Benzie	73.0	60.6	62.3	60.3	61.9	68
260210014	Michigan	Berrien	79.7	66.9	68.8	66.3	68.2	73
260270003	Michigan	Cass	76.7	62.0	63.1	61.5	62.6	72
260770008	Michigan	Kalamazoo	73.7			60.7	61.8	69
260810020	Michigan	Kent	73.0	59.8	61.4	60.0	61.7	68
260810022	Michigan	Kent	72.7			57.5	58.5	67
261010922	Michigan	Manistee	72.3	60.5	61.9	59.6	61.0	67
261050007	Michigan	Mason	73.3	60.7	62.1	60.6	62.0	68
261130001	Michigan	Missaukee	68.3			56.3	57.7	66
261210039	Michigan	Muskegon	79.7	65.8	67.7	66.7	68.6	74
261390005	Michigan	Ottawa	76.0	62.3	64.0	63.0	64.7	68
550090026	Wisconsin	Brown	68.3			57.8	59.3	65
550210015	Wisconsin	Columbia	67.0			55.6	57.2	65
550250041	Wisconsin	Dane	66.3			56.0	58.2	65
550270001	Wisconsin	Dodge	71.5			60.2	60.7	65
550290004	Wisconsin	Door	75.7	63.3	65.2	63.8	65.7	73
550390006	Wisconsin	Fond du Lac	70.0			58.9	60.6	64
550410007	Wisconsin	Forest	64.7			53.0	54.9	62
550550002	Wisconsin	Jefferson	68.5			57.0	58.2	
550590019	Wisconsin	Kenosha	81.0	64.8	67.2	59.6	61.8	78

Table A-2. 4km and EPA "No Water" 12km Design Value Results for Monitors Located in 4km Lake Michigan Modeling Domain.

			Ozone Design Value (ppb)					
				EPA "No Water" 12km Modeling		Updated 4km Modeling		
Monitor	State	County	DVb (2011)	DVf (2023) Ave	DVf (2023) Max	DVf (2023) Ave	DVf (2023) Max	2015-2017 DV
550610002	Wisconsin	Kewaunee	75.0	64.5	67.1	64.6	67.2	69
550710007	Wisconsin	Manitowoc	78.7	67.6	68.7	66.6	67.7	74
550790010	Wisconsin	Milwaukee	69.7	60.6	62.6	60.2	62.2	65
550790026	Wisconsin	Milwaukee	74.7	66.5	69.4	65.2	68.1	67
550790085	Wisconsin	Milwaukee	80.0	71.2	73.0	67.1	68.8	71
550870009	Wisconsin	Outagamie	69.3			58.6	60.8	65
550890008	Wisconsin	Ozaukee	76.3	67.2	70.5	65.0	68.2	71
550890009	Wisconsin	Ozaukee	74.7	63.6	65.5	63.3	65.2	73
551010017	Wisconsin	Racine	77.7	62.2	64.8	58.2	60.7	
551050024	Wisconsin	Rock	69.5			59.4	61.5	
551170006	Wisconsin	Sheboygan	84.3	72.8	75.1	71.5	73.8	80
551270005	Wisconsin	Walworth	69.3			58.4	59.8	68
551330027	Wisconsin	Waukesha	66.7	58.1	60.1	57.8	59.8	65

Appendix B

Ozone Model Performance Evaluation Of Midwest Ozone Group Updated 4km Modeling Domains

Ozone Model Performance Evaluation
Of Midwest Ozone Group
Updated 4km Modeling Domains

Final Report

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Project Number: TS-533

Contents

TABLES

FIGURES

1.0 INTRODUCTION

An operational model evaluation was conducted for the 2011 base year CAMx v6.40 simulation performed for the EPA continental 12km and two 4km modeling domains defined by the Midwest Ozone Group (MOG) and shown in Figure 1-2. 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 two modeling domains. The evaluation presented here is based on model simulations using the 2011 emissions platform (i.e., scenario name 2011en_cb6r4_v6_11g). 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).

The model simulations are identical to the EPA CSAPR Closeout modeling simulation (EPA, 2018) with the exception that meteorology was developed at 4km resolution using the Weather, Research and Forecasting (WRF) model and spatially resolved emissions source coverage files were applied to the CAMx simulation for the Lake Michigan and Mid-Atlantic regions (Alpine, 2018a, 2018b). All other CAMx model inputs were taken from the EPA simulation.

Figure 1. Maps of 12km CAMx modeling domain.

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 and regions of the 12km and 4 km modeling domains.

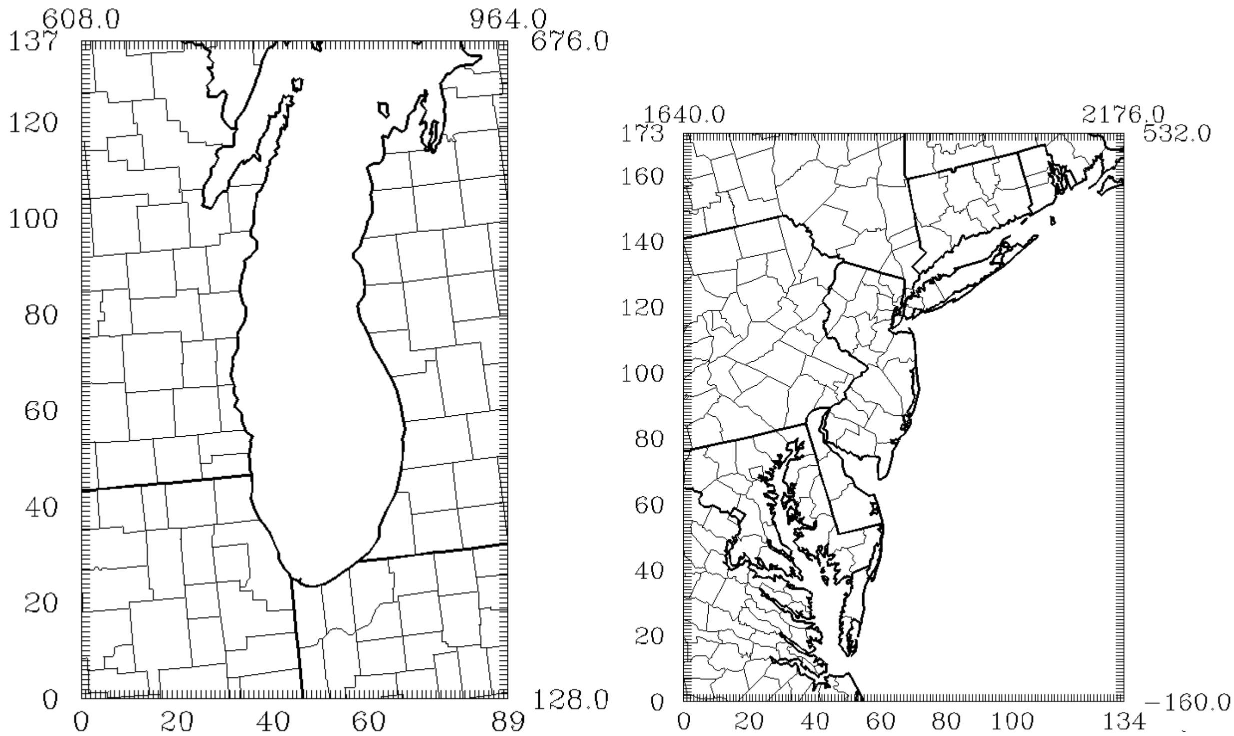

Figure 2. Maps of 4km CAMx modeling domains. Lake Michigan (left) and Mid-Atlantic (right).

For maximum daily average 8-hour (MDA8) ozone, model performance statistics were created for the periods May through September. The aggregate statistics by state and by climate region 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;
2. time series plots (May through September) of observed and predicted MDA8 ozone concentrations for the 2023 nonattainment and maintenance-only sites for which EPA's 12km modeling indicates that upwind states contribute at or above the 1 percent of the NAAQS screening threshold and are located within one of the two 4km modeling domains; and
3. scatter plots that show the correlation of the predicted and observed MDA8 ozone concentrations by monitor for May through September.

The Model Performance Evaluation, Analysis, and Plotting Software (MAPS) tool was used to calculate the model performance statistics used in this document (McNally and Tesche, 1993). 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 Simon et al. (2012), the draft photochemical modeling guidance (U.S. EPA, 2014a), 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 4km 8-hour daily maximum ozone concentrations predicted by the 2011en CAMx modeling platform closely reflect the corresponding 8-hour observed ozone concentrations in each region of the 12 km U.S. modeling domain. The acceptability of model performance was judged by considering the 2011 CAMx performance results in light of the range of performance found in recent regional ozone model applications (NRC, 2002; Phillips et al., 2007; Simon et al., 2012; EPA, 2005; EPA, 2009; EPA, 2010, EPA, 2016, EPA, 2018). 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 2011 CAMx simulations 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 4km domains using the 2011en modeling platform correspond 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 May through September for each region and select states in the 12km modeling domain are provided in Tables 1 through 3, respectively. The 8-hour ozone model performance bias and error statistics by the months May through September across all monitors in each 4km modeling domain are provided in Table 4. The statistics shown 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 3 through 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 Figure7 through 17. The correlations of observed and predicted 8-hour ozone by month in the period May through September for each region are shown in Figures 18 through 28.

Overall, model performance for MDA8 ozone concentrations for this 2011 CAMx v6.40 simulation is similar to what was found in EPA's model performance evaluation conducted for the 2011en CAMx v6.40 simulation performed in support of the 2008 and 2015 ozone NAAQS reviews (EPA, 2018). In general, the 4km simulations tend to under predict MDA8 ozone in the Lake Michigan domain and over predict MDA8 concentrations in the Mid-Atlantic domain.

2.1 PERFORMANCE STATISTICS BY REGION AND MONTH

As indicated by the statistics in Table 1, bias and error for 8-hour daily maximum ozone are relatively low in each region. Generally, mean bias for 8-hour ozone ≥ 60 ppb during each month of the May through September period, demonstrating within ± 5 ppb at AQS sites in the two eastern RPO regions (MANE-VU and LADCO) with the exception of September in the LADCO domain (-6.99 ppb). The mean error is 10 ppb or less in all regions. Normalized mean bias is within ± 5 percent for AQS sites in May, June, and July in the MANE-VU region, with somewhat larger values in MANE-VU in August (6.30%) and September (6.24%) and in the LADCO domain during September (-9.63%) of the ozone season. The mean bias and normalized mean bias statistics indicate a tendency for the model to over predict MDA8 ozone concentrations in the Mid-Atlantic domain and under predict MDA8 ozone concentrations in the Lake Michigan regions for AQS sites. The normalized mean error is less than 15 percent for both regions across all months.

We note that for regions outside those covered by the 4km domains, this simulation differs from the EPA simulation only in the feedback from the 4km domains on the 12km domains. Additionally, for the 12km metrics presented in this report and for portions of states that are included in the 4km domain, results from the 4km simulation are aggregated in CAMx to 12km grid resolution.

Table 1. Performance statistics for MDA8 ozone ≥60 ppb by month and region for MANE-VU and LADCO states in 12km domain based on data at AQS network sites.

Region	Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
MANE-VU	05	332	2.72	7.65	4.15	11.67
MANE-VU	06	982	1.72	8.73	2.46	12.50
MANE-VU	07	1606	2.74	9.32	3.94	13.40
MANE-VU	08	420	4.12	7.03	6.30	10.73
MANE-VU	09	164	4.08	7.88	6.24	12.05
MANE-VU	All		2.68	8.65	3.94	12.60
LADCO	05	245	-3.02	7.68	-4.78	12.13
LADCO	06	1232	-1.30	6.91	-1.90	10.12
LADCO	07	1493	0.79	8.69	1.16	12.84
LADCO	08	576	-1.61	7.53	-2.43	11.38
LADCO	09	415	-6.99	9.54	-9.63	13.15
LADCO	All		-1.26	7.99	-1.81	11.77

Looking at 12km model performance for individual states located within the Lake Michigan 4km domain (Table 2) indicates that mean bias is within ± 5 ppb for a majority of the months and states and within ± 10 ppb for all but September in Wisconsin. The mean error is less than 10 ppb for nearly all months and states, again with the exceptions occurring in May (Wisconsin), July (Illinois, Wisconsin) and September (Michigan, Wisconsin). The normalized mean bias is within ± 10 percent except May in Illinois (-11.92 %) and September in Wisconsin (-26.05 %). The normalized mean error is within 15 percent for all but May and September in Wisconsin.

Table 2. Performance statistics for MDA8 ozone ≥60 ppb by month and state within Lake Michigan 4km domain based on data at AQS network sites.

State	Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
IL	05	27	-7.52	8.39	-11.92	13.30
IL	06	197	1.58	6.32	2.38	9.53
IL	07	257	-1.59	10.09	-2.35	14.92
IL	08	100	-2.56	7.15	-3.83	10.68
IL	09	81	-5.34	7.17	-7.52	10.10
MI	05	53	-4.82	8.93	-7.63	14.14
MI	06	199	-6.29	8.55	-9.02	12.26
MI	07	263	-1.52	8.29	-2.20	11.99
MI	08	52	-4.49	6.24	-6.97	9.69
MI	09	56	-6.45	10.44	-9.01	14.60
OH	05	103	0.14	6.35	0.23	10.04
OH	06	355	-1.18	6.98	-1.70	10.08
OH	07	501	4.01	8.05	5.92	11.89
OH	08	231	-1.10	8.81	-1.65	13.23

State	Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
OH	09	119	-4.37	8.16	-5.97	11.15
WI	05	22	-4.26	12.02	-6.69	18.90
WI	06	158	-3.61	6.82	-5.31	10.03
WI	07	143	-3.50	10.72	-5.11	15.68
WI	08	24	-4.34	7.21	-6.52	10.82
WI	09	35	-21.49	22.59	-26.05	27.39

Even better model performance for individual states is seen in the 12km modeling for states in the Mid-Atlantic 4km domain (Table 3). Mean bias is within ± 5 ppb for most months and states with the exception of July, August, and September in Connecticut (6.73 ppb, 6.19 ppb, and 6.98 ppb, respectively), August and September in Maryland (6.18 ppb and 6.17 ppb, respectively), July and September in New Jersey (6.00 ppb and 5.70 ppb, respectively), July in Rhode Island and Virginia (5.02 ppb and 5.06, respectively). The mean error is less than 10 ppb for nearly all months and states, with the exceptions occurring in June and July in Connecticut. The normalized mean bias is within ± 10 percent in all months and states except September in Connecticut. The normalized mean error is within 15 percent in most months and states with the exceptions of June and July in Connecticut (15.02 and 15.95 percent, respectively) and September in Maryland (15.01 percent).

Table 3. Performance statistics for MDA8 ozone ≥60 ppb by month and select states within Mid-Atlantic 4km domain based on data at AQS network sites.

State	Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
CT	05	8	1.62	4.81	2.57	7.63
CT	06	69	4.60	11.12	6.21	15.02
CT	07	98	6.73	11.67	9.20	15.95
CT	08	28	6.19	7.93	9.55	12.24
CT	09	19	6.98	7.90	10.88	12.30
MD	05	70	6.24	8.01	9.17	11.77
MD	06	196	2.47	7.72	3.47	10.86
MD	07	286	4.53	9.89	6.36	13.89
MD	08	88	6.18	7.31	9.19	10.88
MD	09	22	6.17	9.58	9.68	15.01
NJ	05	33	2.59	7.71	3.86	11.51
NJ	06	101	1.53	8.67	2.10	11.91
NJ	07	149	6.00	9.02	8.49	12.76
NJ	08	41	4.22	6.61	6.42	10.07
NJ	09	6	5.70	5.86	8.86	9.12
NY	05	34	0.45	8.33	0.70	12.97
NY	06	129	1.10	8.67	1.59	12.59

State	Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
NY	07	220	0.35	8.02	0.51	11.54
NY	08	52	0.86	6.34	1.32	9.76
NY	09	25	2.10	7.83	3.29	12.25
RI	05	5	-4.70	4.70	-7.47	7.47
RI	06	21	-1.76	7.43	-2.57	10.87
RI	07	38	5.02	9.72	7.25	14.04
RI	08	11	-3.24	6.75	-5.02	10.46
RI	09	4	3.85	3.91	5.98	6.07
VA	05	41	1.96	8.56	2.81	12.32
VA	06	199	2.49	6.86	3.71	10.19
VA	07	224	5.06	9.05	7.38	13.20
VA	08	87	3.83	8.59	5.88	13.17
VA	09	16	1.10	7.52	1.72	11.77

While we make general comparisons below in both the Lake Michigan and Mid-Atlantic 4km results to the 12km results from Table 1, we note that there is a spatial mismatch preventing direct comparison as the 4km results only includes the portions of states that are included in the 4km domain while the 12km results capture each state in its entirety and contain averaged 4km results for regions covered by the 4km domains.

Table 4 presents model performance statistics for all monitors across the two 4km modeling domains.

Table 4. Performance statistics for MDA8 ozone ≥60 ppb by month and region for 4km domains based on data at AQS network sites.

Region	Month	# of Obs	MB (ppb)	ME (ppb)	NMB (%)	NME (%)
Mid-Atlantic	05	239	4.46	7.65	6.65	11.41
Mid-Atlantic	06	820	3.39	8.75	4.78	12.34
Mid-Atlantic	07	1247	5.09	9.84	7.24	13.99
Mid-Atlantic	08	339	5.41	8.04	8.19	12.18
Mid-Atlantic	09	93	5.99	8.03	9.40	12.61
Mid-Atlantic	All		4.60	9.04	6.64	13.00
Lake Michigan	05	50	-2.79	9.35	-4.43	14.88
Lake Michigan	06	381	-2.29	6.92	-3.38	10.21
Lake Michigan	07	487	-3.72	10.75	-5.46	15.75
Lake Michigan	08	101	-3.18	7.13	-4.86	10.90
Lake Michigan	09	112	-12.28	13.89	-16.04	18.14
Lake Michigan	All		-4.00	9.39	-5.71	13.65

Compared to the 12km results (Table 1), bias and error for 8-hour daily maximum ozone are slightly higher in each 4km region. Generally, mean bias for 8-hour ozone ≥ 60 ppb during each month of the May through September period is demonstrated to be within ± 5 ppb at AQS sites for all months in the Lake Michigan domain, with the exception of September. June, July, and August in the Mid-Atlantic domain demonstrate mean bias just outside of ± 5 ppb (5.09 ppb, 5.41 ppb, and 5.99 ppb, respectively). September in the Lake Michigan is the only month within the two 4km domains that exceeds ± 10 ppb (-12.28 ppb). The mean error is 10 ppb or less for most months, except July and September in the Lake Michigan domain. Normalized mean bias is within ± 10 percent for AQS sites in all months except September in the Lake Michigan domain, with somewhat larger values in the Mid-Atlantic domain (ranging from 4.78 percent in June to 9.40 percent in September).

Consistent with the 12km results, the mean bias and normalized mean bias statistics again indicate a tendency for the model to over predict MDA8 ozone concentrations in the Mid-Atlantic domain and under predict MDA8 ozone concentrations in the Lake Michigan regions for AQS sites. The normalized mean error is less than 15 percent for months other than July and September in the Lake Michigan 4km domain.

When performing higher grid resolution (e.g., 4km) simulations, we often see poorer performance than in using coarser grid resolution (e.g., 12km). This is likely a result of the 12km results smoothing the results and not capturing the steep concentration gradients that are often present in higher resolution simulations. In this analysis and averaged over the modeling period, the model statistically performs better at 12km for the Mid-Atlantic domain and better at 4km for the Lake Michigan domain.

Monitor specific performance metrics for the two 4km modeling domains are provided as Appendix A to this document.

2.2 GRAPHICAL DISTRIBUTION OF STATISTICS

Figures 3 through 6 show the spatial variability in bias and error at monitor locations. Mean bias, as seen from Figure 3, is within ± 5 ppb at most sites across the Lake Michigan domain with a maximum under-prediction of 9.16 ppb at one site (171971011) southwest of Joliet, IL. In the Mid-Atlantic, a positive mean bias is generally seen in the range of 5 to 10 ppb with spots of 10 to 15 ppb over-prediction seen scattered throughout the domain. The maximum mean bias in the Mid-Atlantic domain (340110007 at 13.78 ppb) is located near Atlantic City, NJ.

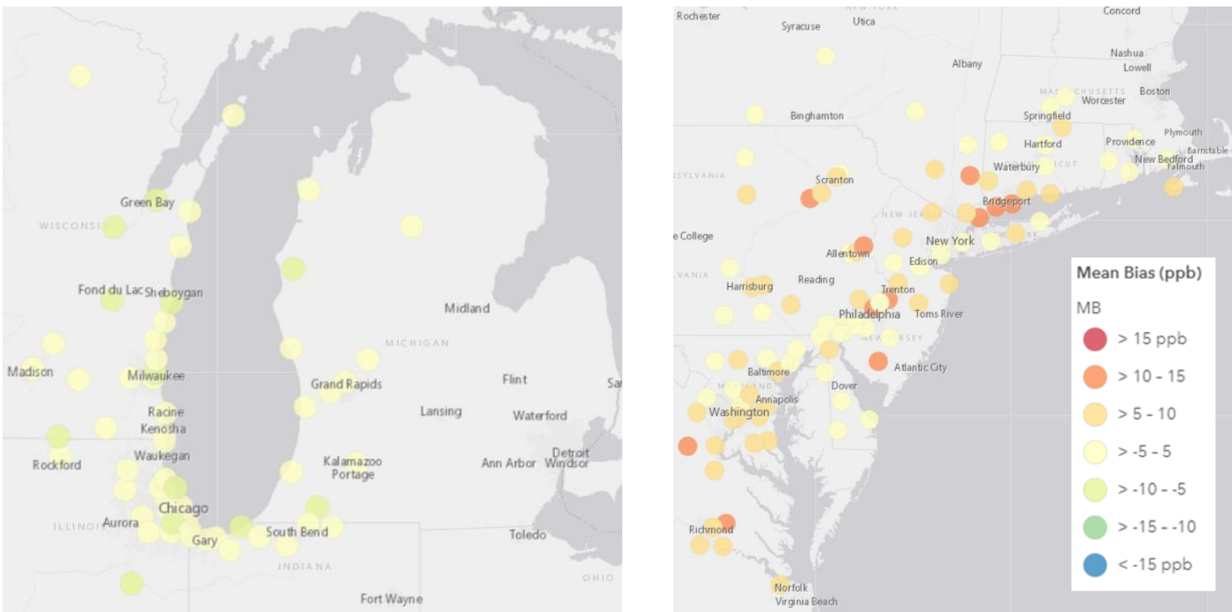

Figure 3. Mean Bias (ppb) of MDA8 ozone > 60 ppb over the period May-September 2011 at AQS monitoring sites in Lake Michigan (left) and Mid-Atlantic (right) 4km domains.

Figure 4 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 Lake Michigan 4km modeling domain. Monitor (171971011) exceeds -10 percent with a NMB of -13.5 percent. There are clear regional differences in model performance, as the model tends to over predict at most sites in the 4km Mid-Atlantic domain and generally under predict at sites in and around the 4km Lake Michigan domain. Model performance in the Mid-Atlantic domain shows that about two thirds of sites are within + 10 percent normalized mean bias.

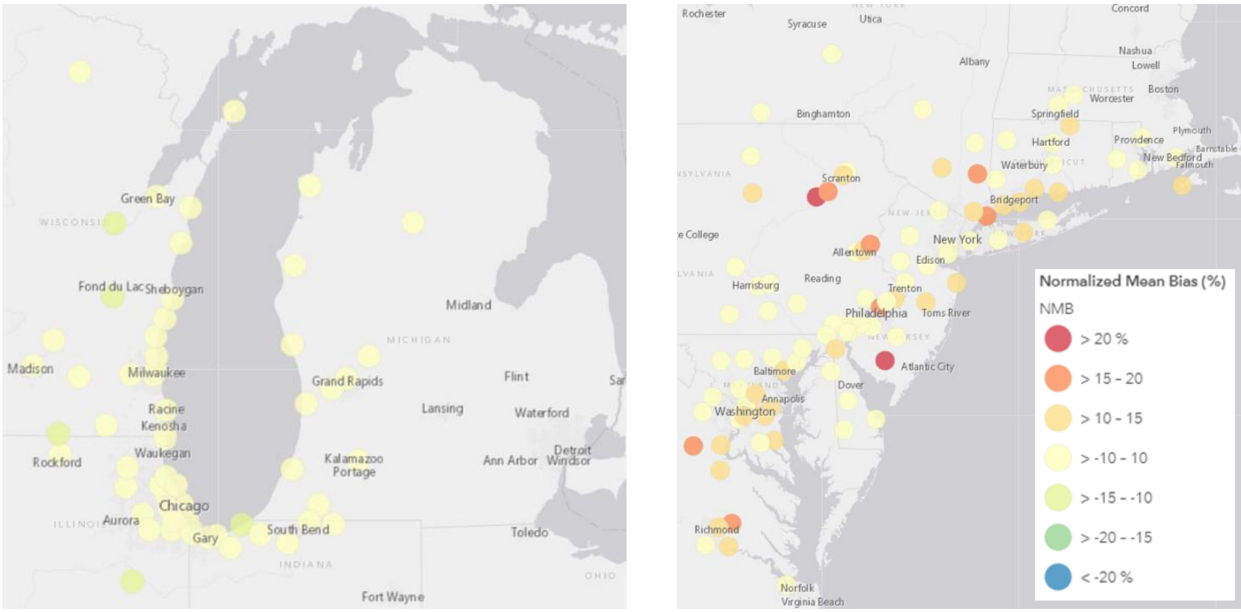

Figure 4. Normalized Mean Bias (%) of MDA8 ozone > 60 ppb over the period May-September 2011 at AQS monitoring sites in Lake Michigan (left) and Mid-Atlantic (right) 4km domains.

Mean error (ME), as seen from Figure 5, is generally 10 ppb or less at most of the sites across the Lake Michigan 4km modeling domain although monitor (170317002) outside of Evanston, IL shows a much higher ME of 16.13 ppb. The Mid-Atlantic 4km domain shows approximately one third of its monitors above 10 ppb model error, with the majority of those exceeding this value being located along the I-95 interstate corridor or along coastal waterways. Figure 6 indicates that the normalized mean error (NME) for days with observed 8-hour daily maximum ozone > 60 ppb is less than 15 percent at the vast majority of monitoring sites across the Lake Michigan 4km modeling domain. The noted exception seen is monitor (170317002) outside of Evanston, IL with a NME of 23.1%. Somewhat greater error (i.e., 15 to 20 percent) is again seen at several sites in the 4km Mid-Atlantic domain, most notably along the I-95 interstate corridor.

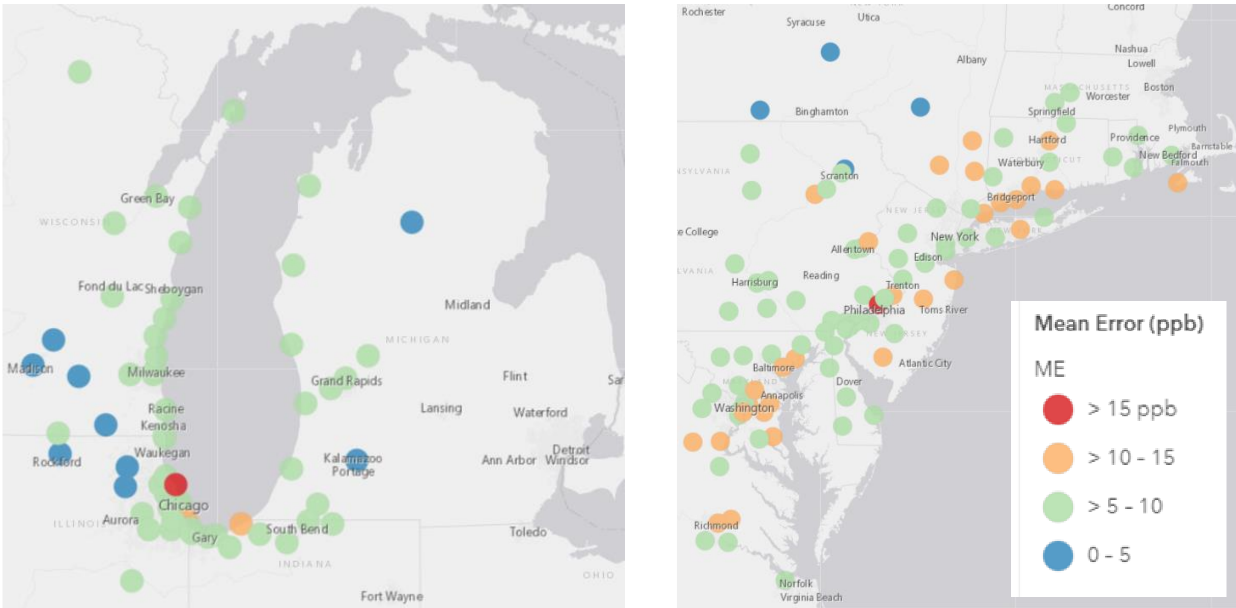

Figure 5. Mean Error (ppb) of MDA8 ozone > 60 ppb over the period May-September 2011 at AQS monitoring sites in Lake Michigan (left) and Mid-Atlantic (right) 4km domains.

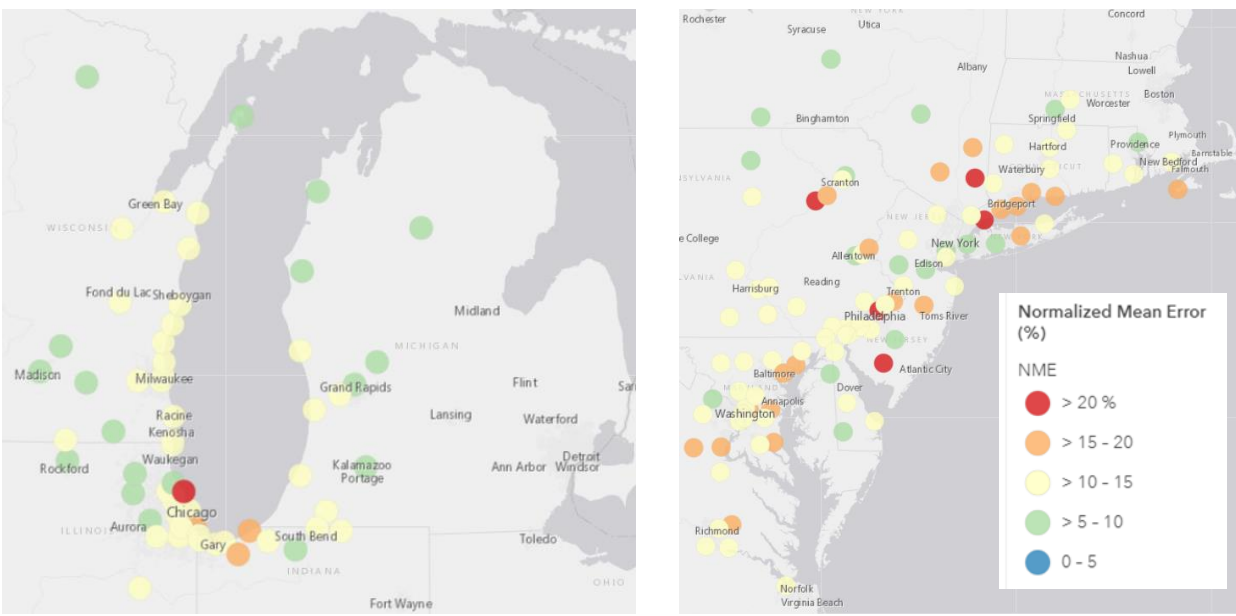

Figure 6. Normalized Mean Error (%) of MDA8 ozone > 60 ppb over the period May-September 2011 at AQS monitoring sites in Lake Michigan (left) and Mid-Atlantic (right) 4km domains.

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 using data for select nonattainment and maintenance sites identified in the 4km modeling or via EPA's March 2018 technical memorandum (Tsirigotis, 2018) as presented in Table 5.

Table 5. Monitoring sites included in the ozone time series analysis.

AIRS Monitor ID	State	County
90013007	Connecticut	Fairfield
90019003	Connecticut	Fairfield
90099002	Connecticut	New Haven
240251001	Maryland	Harford
260050003	Michigan	Allegan
340150002	New Jersey	Gloucester
360810124	New York	Queens
360850067	New York	Richmond
361030002	New York	Suffolk
421010024	Pennsylvania	Philadelphia
551170006	Wisconsin	Sheboygan

For this site-specific analysis we present the time series of observed and predicted 8-hour daily maximum concentrations by site in the 4km simulation over the period May through September. The results, as shown in Figures 7 through 17, 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: Harford Co., MD; Allegan Co., MI; Gloucester Co., NJ; Queens, Richmond, and Suffolk Co., NY; Philadelphia Co., PA; and Sheboygan Co., WI each track closely with the observations, but there is a tendency to over predict on several of the observed high ozone days at locations in the Mid-Atlantic 4km domain and under predict on several of the observed high ozone days at locations in the Lake Michigan 4km domain. Of particular note are the over predictions at Connecticut monitors during a mid-July episode and the under prediction of MDA8 at the Sheboygan, WI receptor during an early September episode.

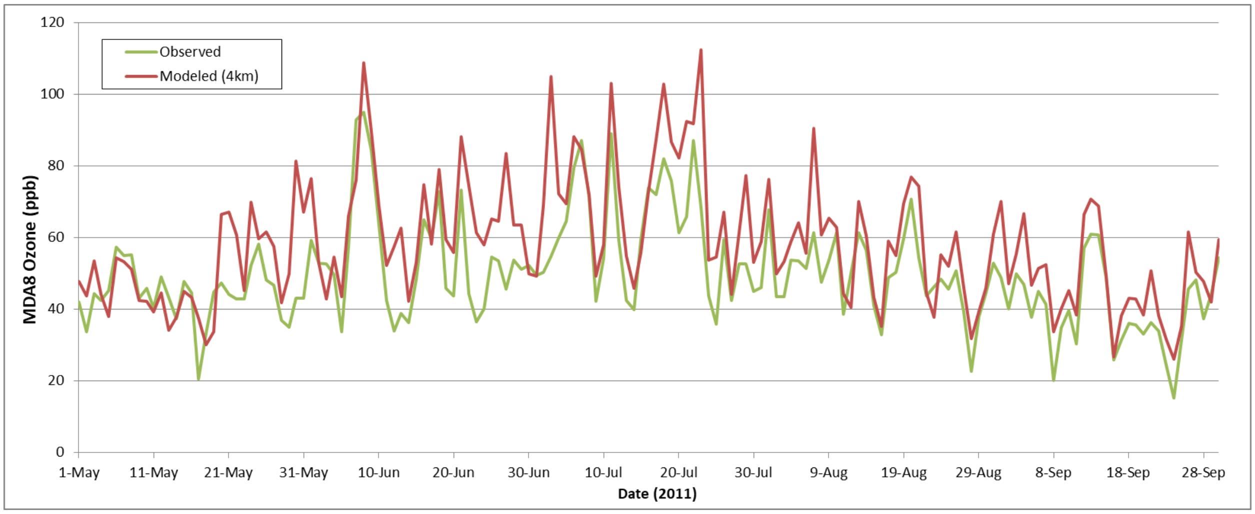

Figure 7. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 90013007 in Fairfield Co., Connecticut.

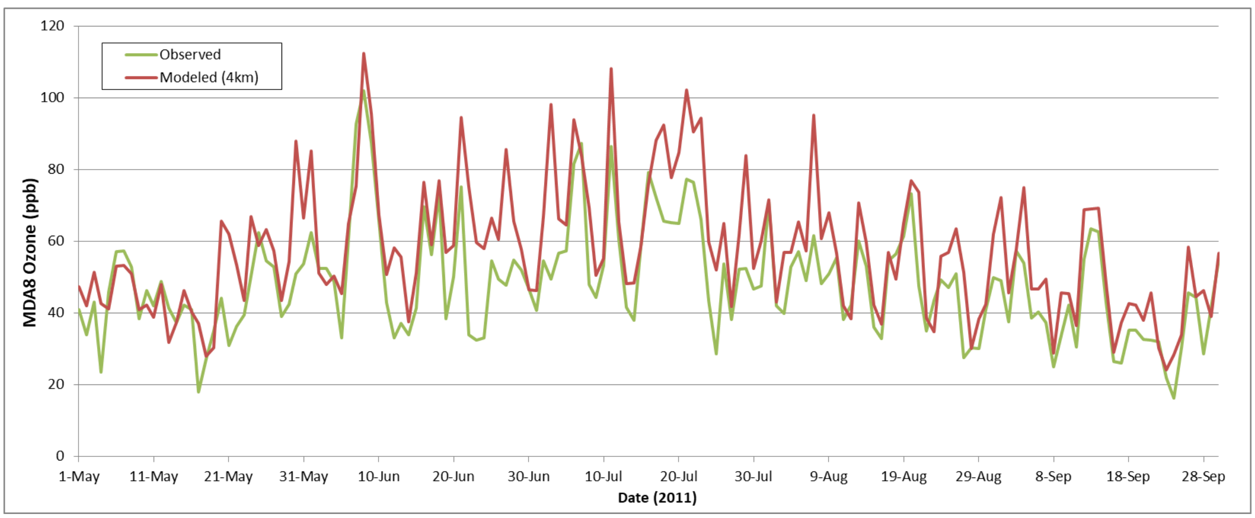

Figure 8. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 90019003 in Fairfield Co., Connecticut.

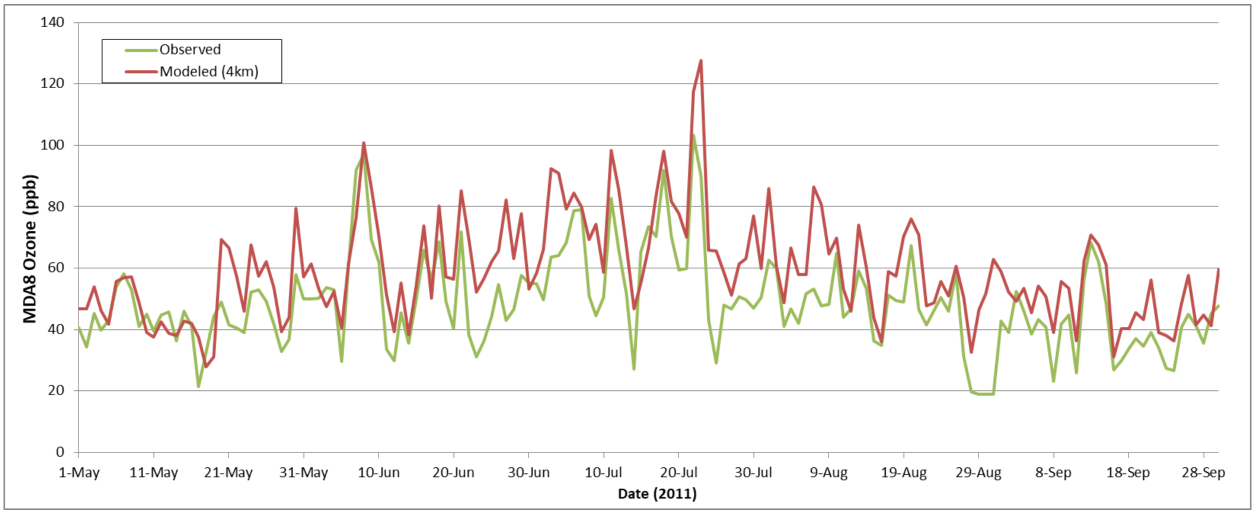

Figure 9. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 90099002 in New Haven Co., Connecticut.

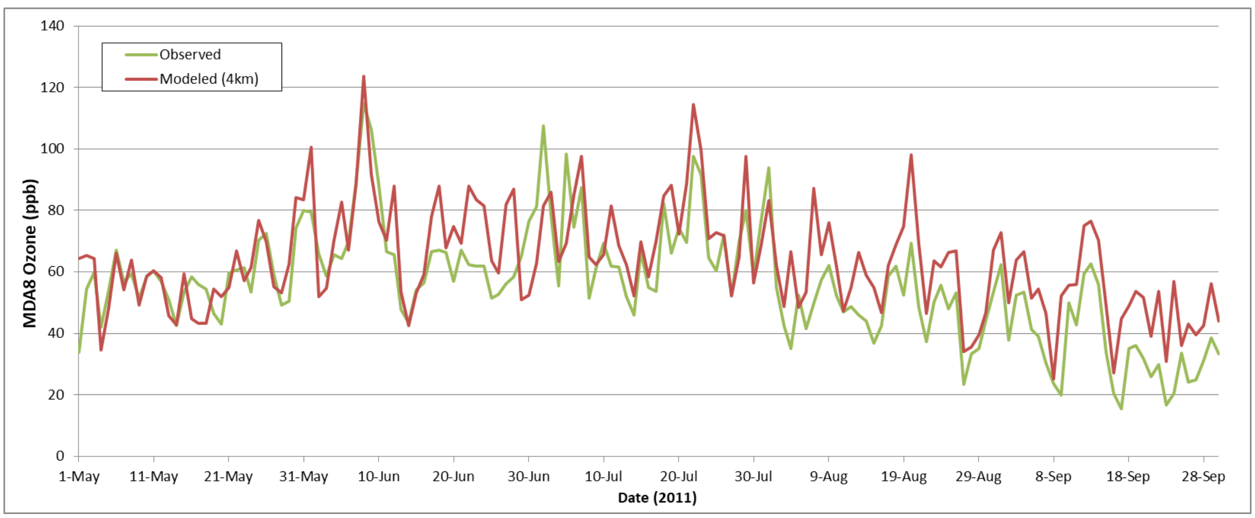

Figure 10. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 240251001 in Harford Co., Maryland.

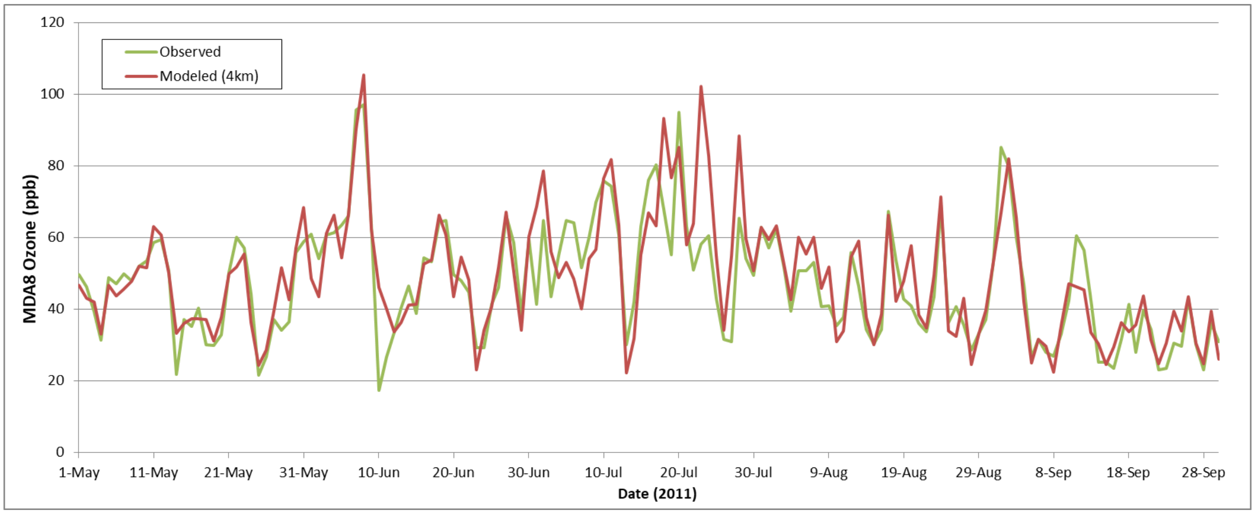

Figure 11. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 260050003 in Allegan Co., Michigan.

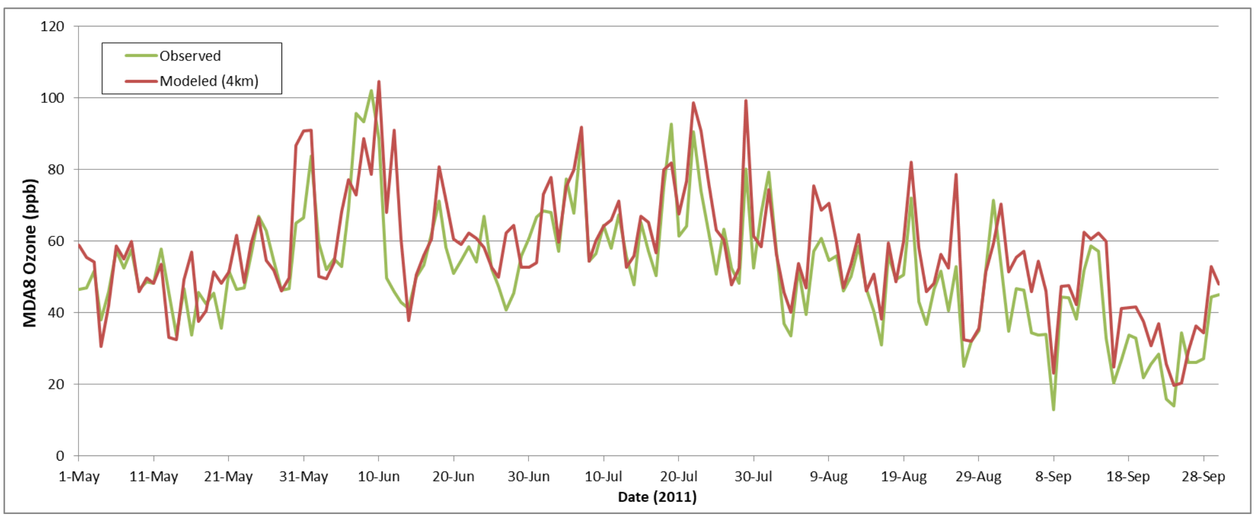

Figure 12. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 340150002 in Gloucester Co., New Jersey.

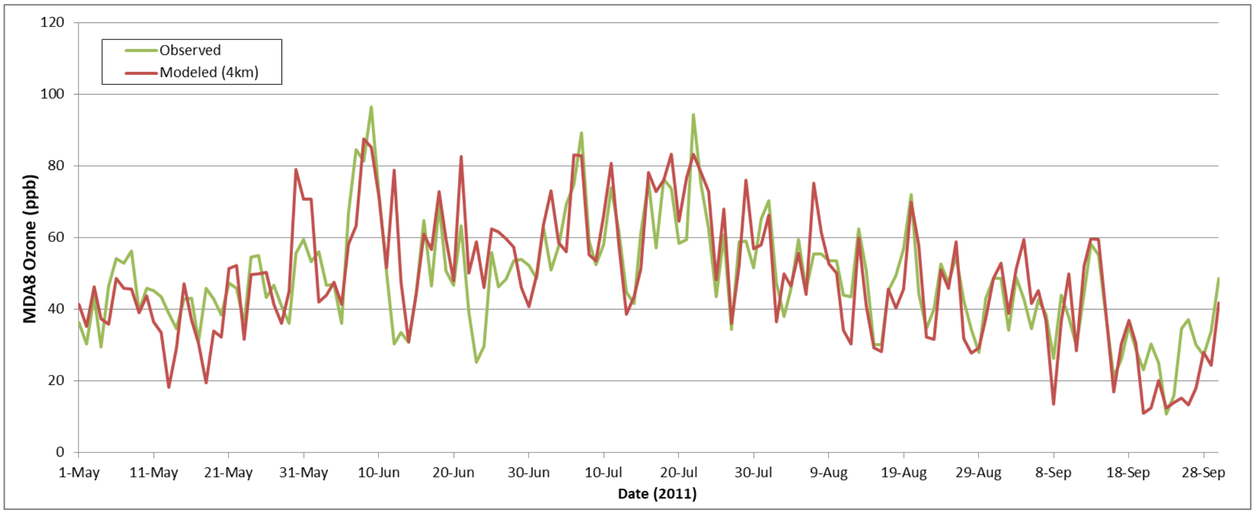

Figure 13. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 360810124 in Queens Co., New York.

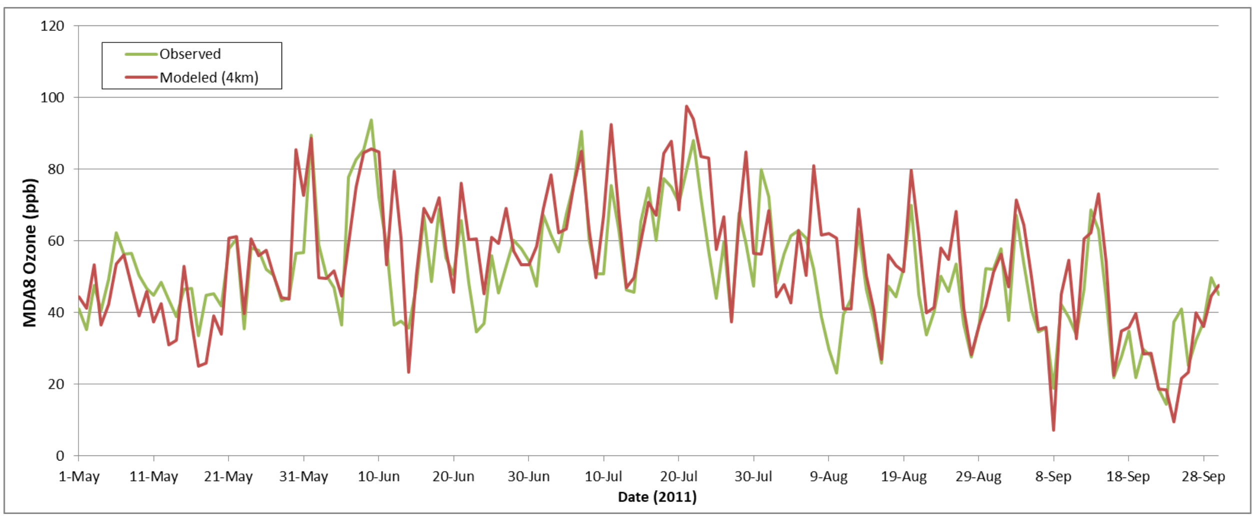

Figure 14. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 360850067 in Richmond Co., New York.

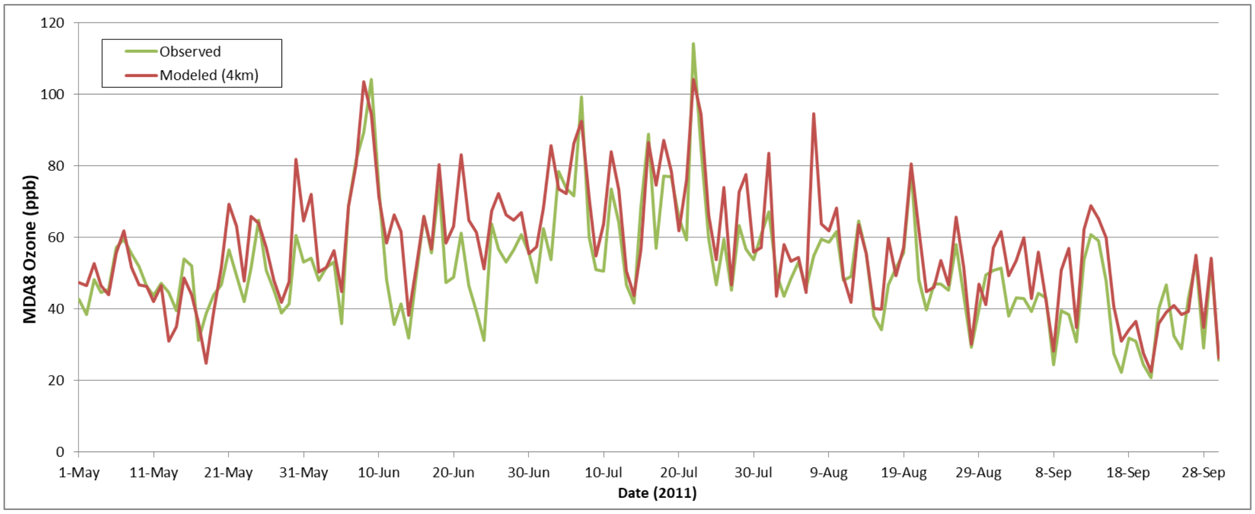

Figure 15. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 361030002 in Suffolk Co., New York.

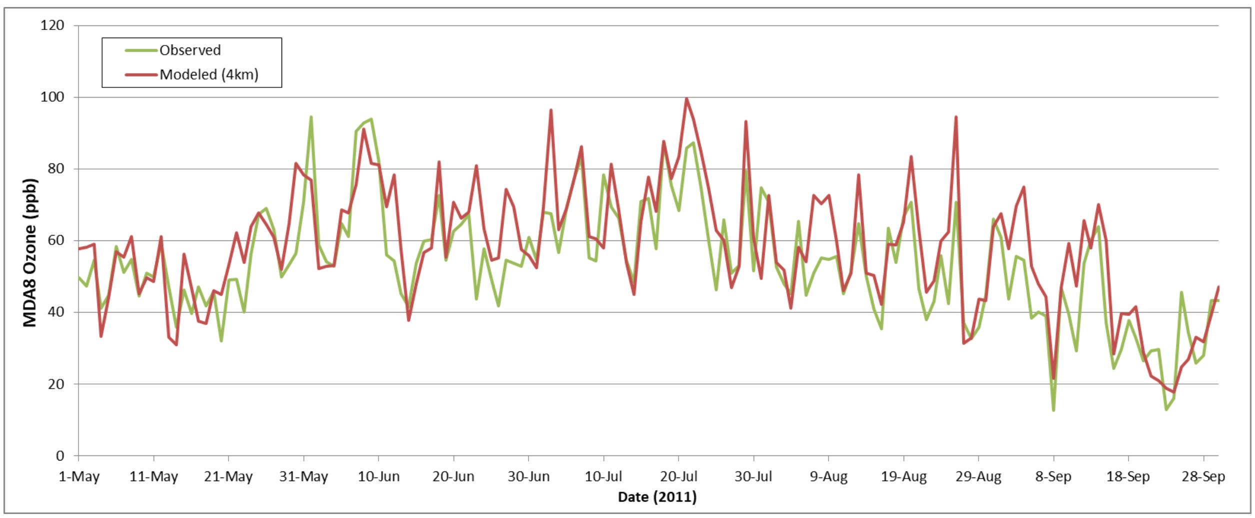

Figure16. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 421010024 in Philadelphia Co., Pennsylvania.

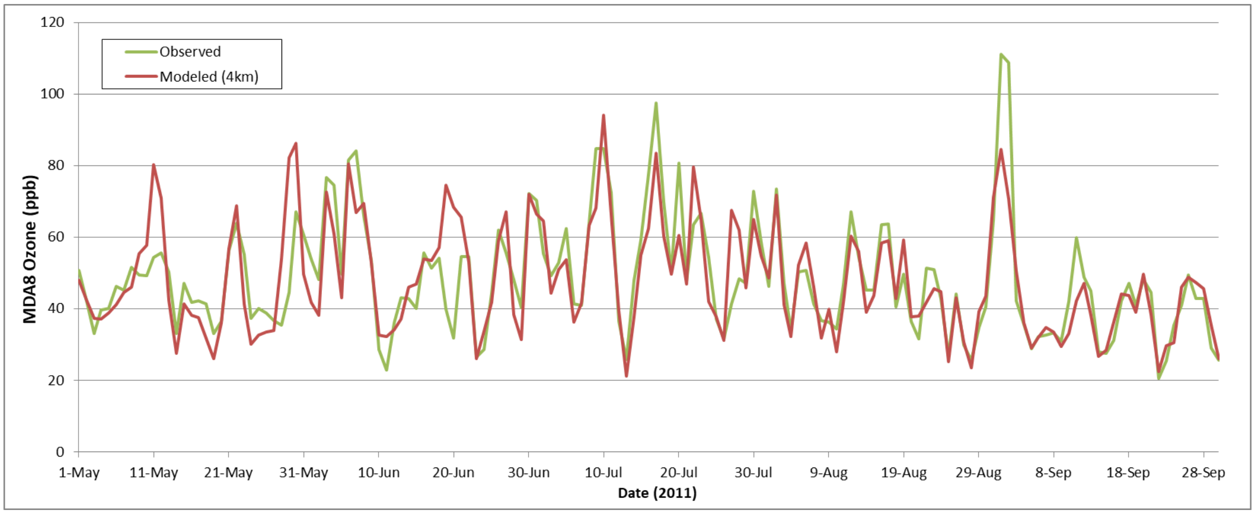

Figure 17. Time series of observed (green) and predicted 4km (red) MDA8 ozone for May through September 2011 at site 551170006 in Sheboygan Co., Wisconsin.

2.4 CONCENTRATION CORRELATION PLOTS

Under and over predictions can also be reviewed through examination of correlation plots of observed vs. modeled MDA8 concentrations by location during the May through September episode (Figures 18 through 28). On these graphics each daily MDA8 concentration at a monitor is plotted as a single ordered pair with the observed ozone on and 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. In the figures the fourth highest observation is plotted with a red square and the fourth highest model estimate has a yellow square.

While many of the sites generally track well and capture day-to-day variability, the following sites do demonstrate the underestimation of ozone on some of the days with measured high ozone concentrations, specifically at locations in Connecticut in the Mid-Atlantic 4km domain. At the monitors in Richmond Co., NY; Suffolk Co., NY; and Sheboygan Co., WI, the model has over predicted the 4th high observed values where at all other represented monitors, the model has under predicted this value.

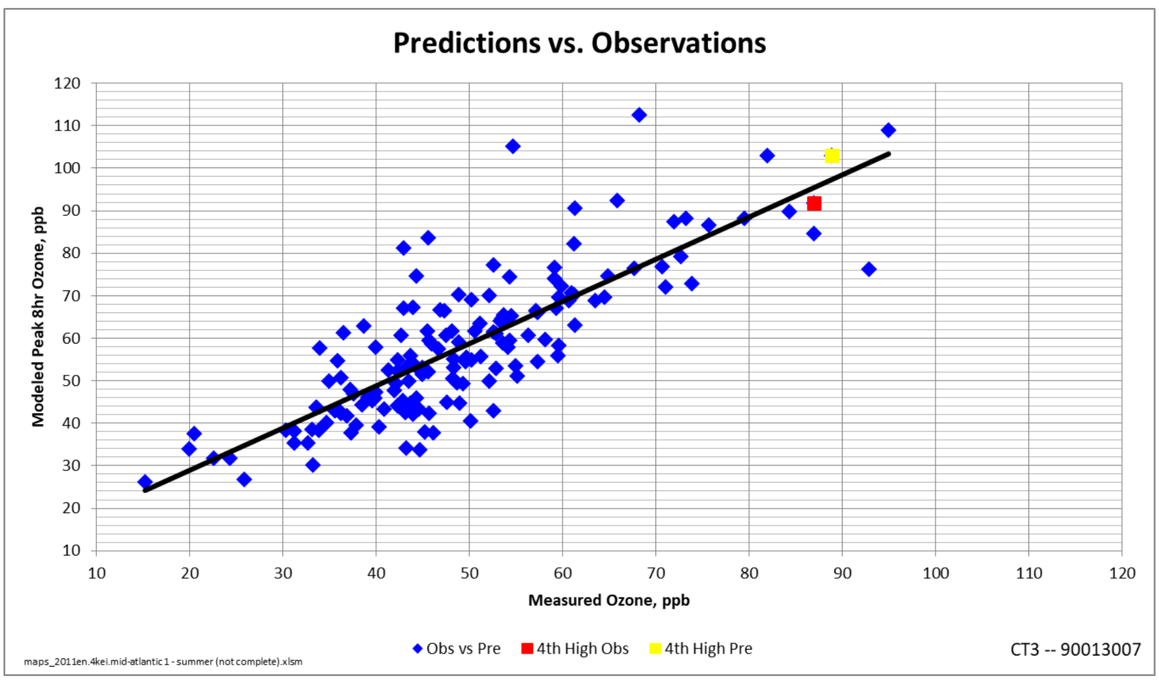

Figure 18. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 90013007 in Fairfield Co., Connecticut. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

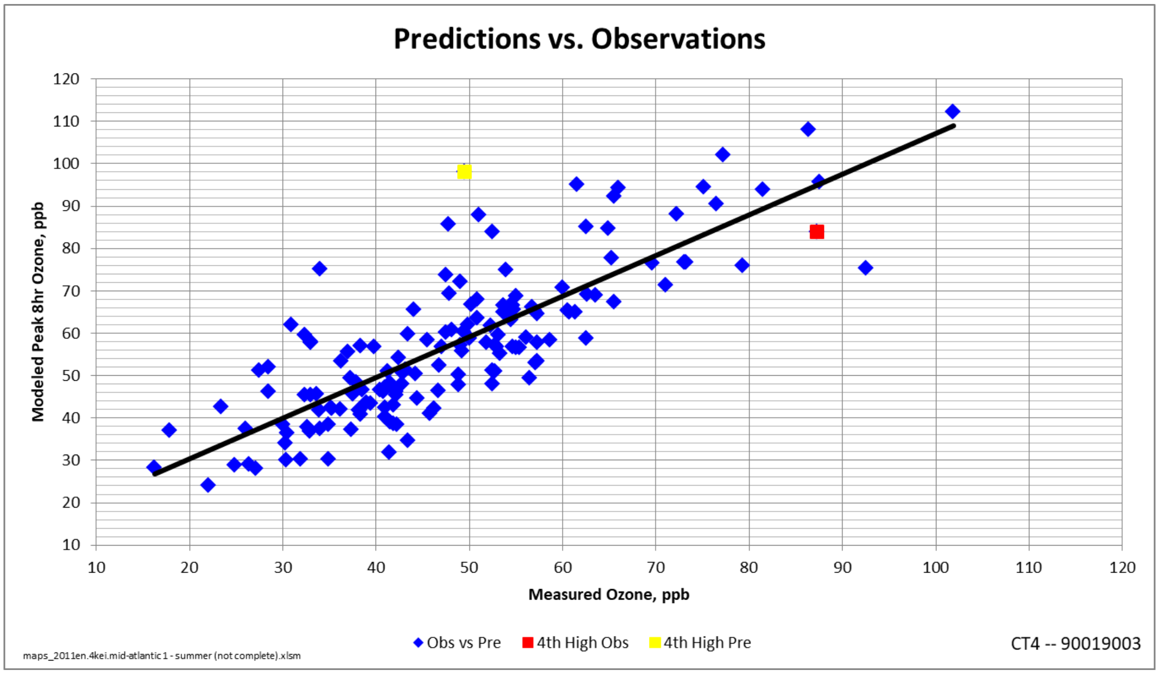

Figure 19. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 90019003 in Fairfield Co., Connecticut. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

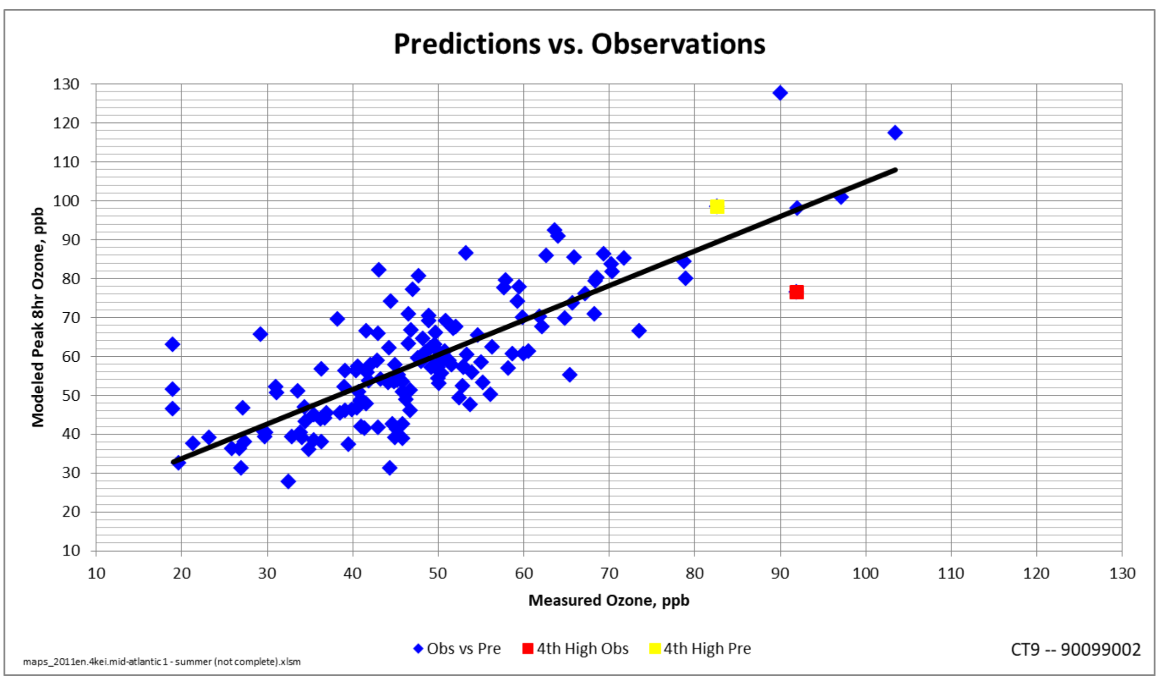

Figure 20. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 90099002 in New Haven Co., Connecticut. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

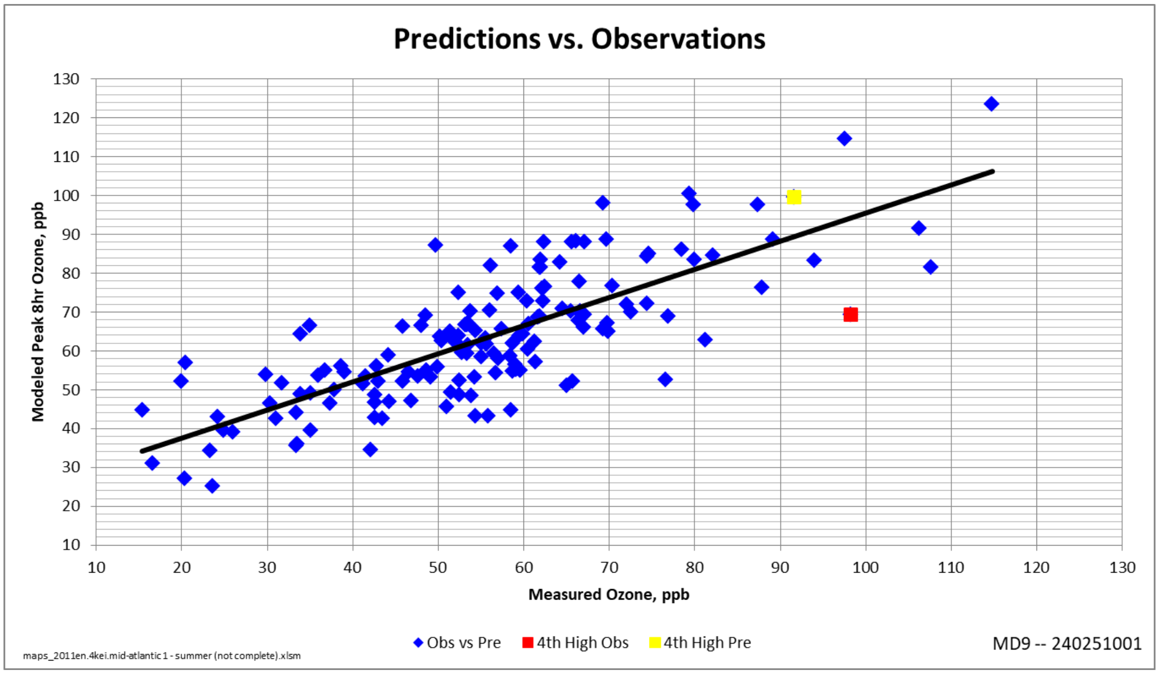

Figure 21. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 240251001 in Harford Co., Maryland. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

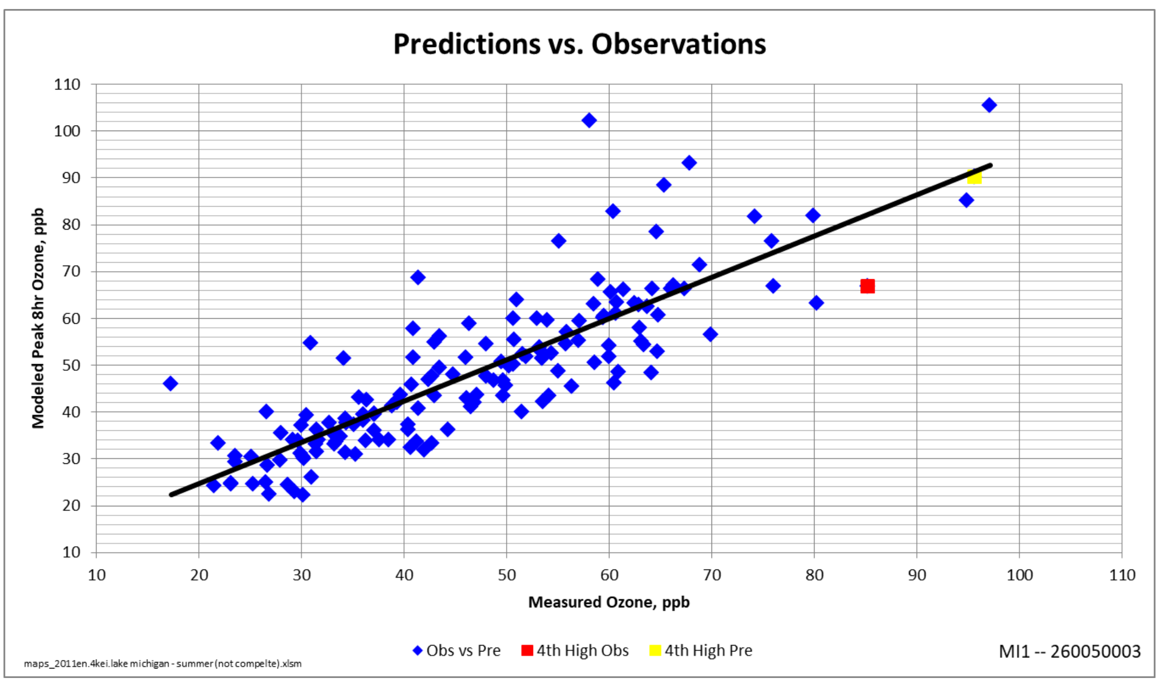

Figure 22. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 260050003 in Allegan Co., Michigan. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

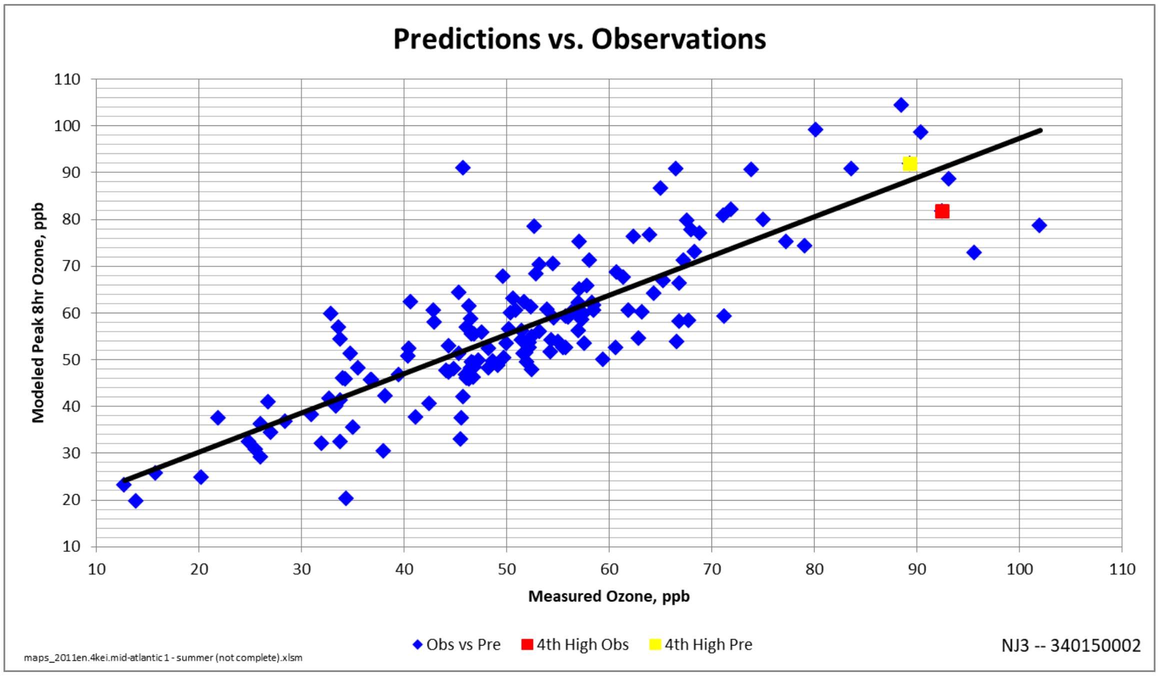

Figure 23. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 340150002 in Gloucester Co., New Jersey. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

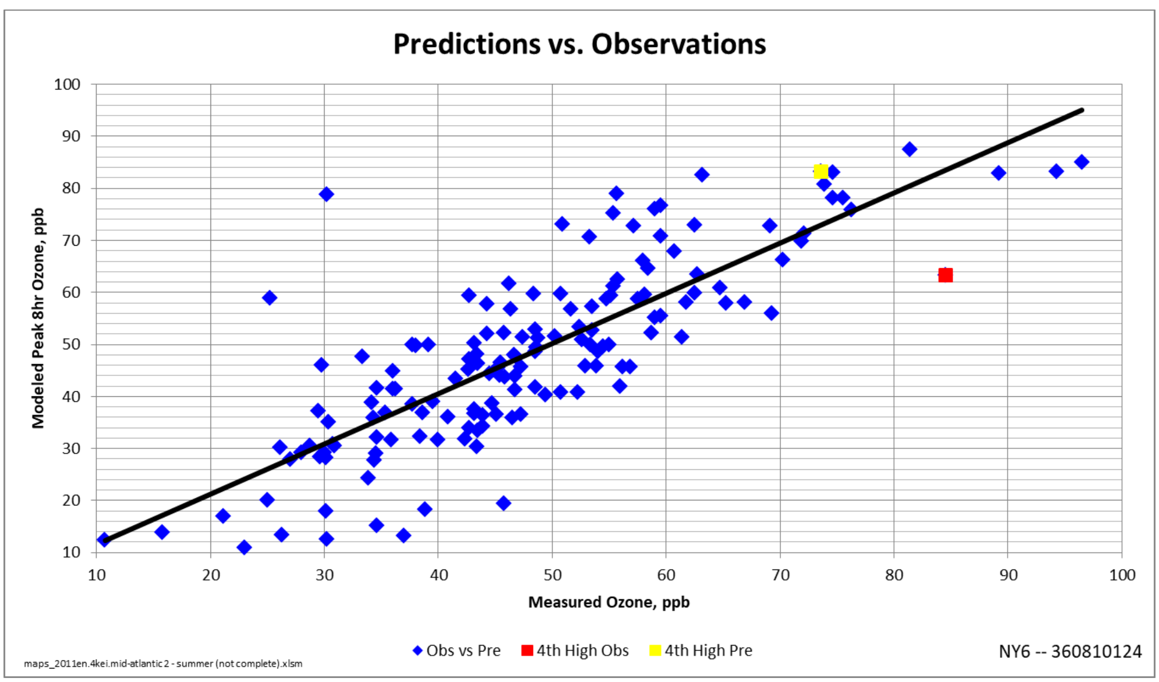

Figure 24. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 360810124 in Queens Co., New York. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

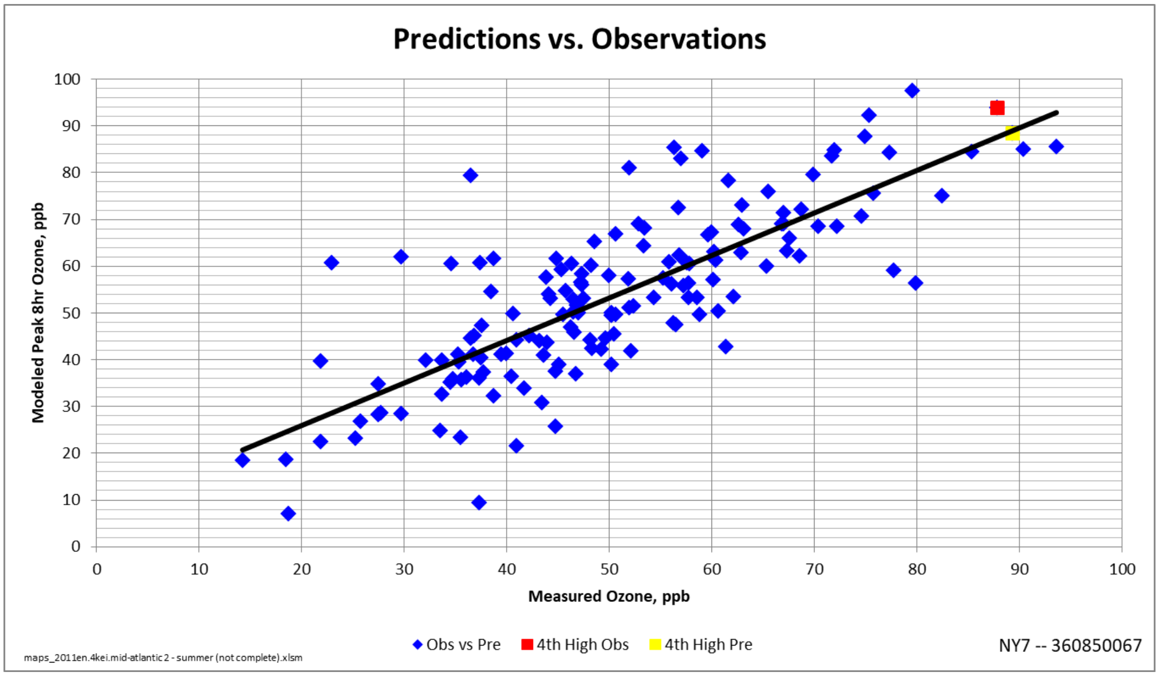

Figure 25. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 360850067 in Richmond Co., New York. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

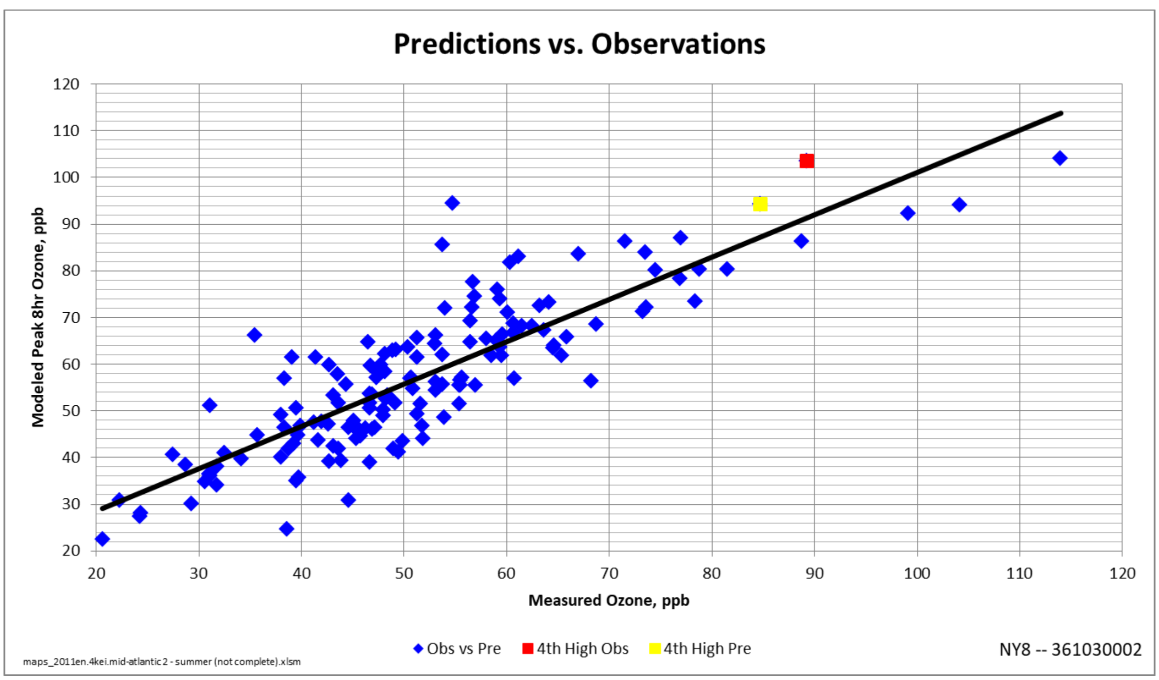

Figure 26. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 361030002 in Suffolk Co., New York. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

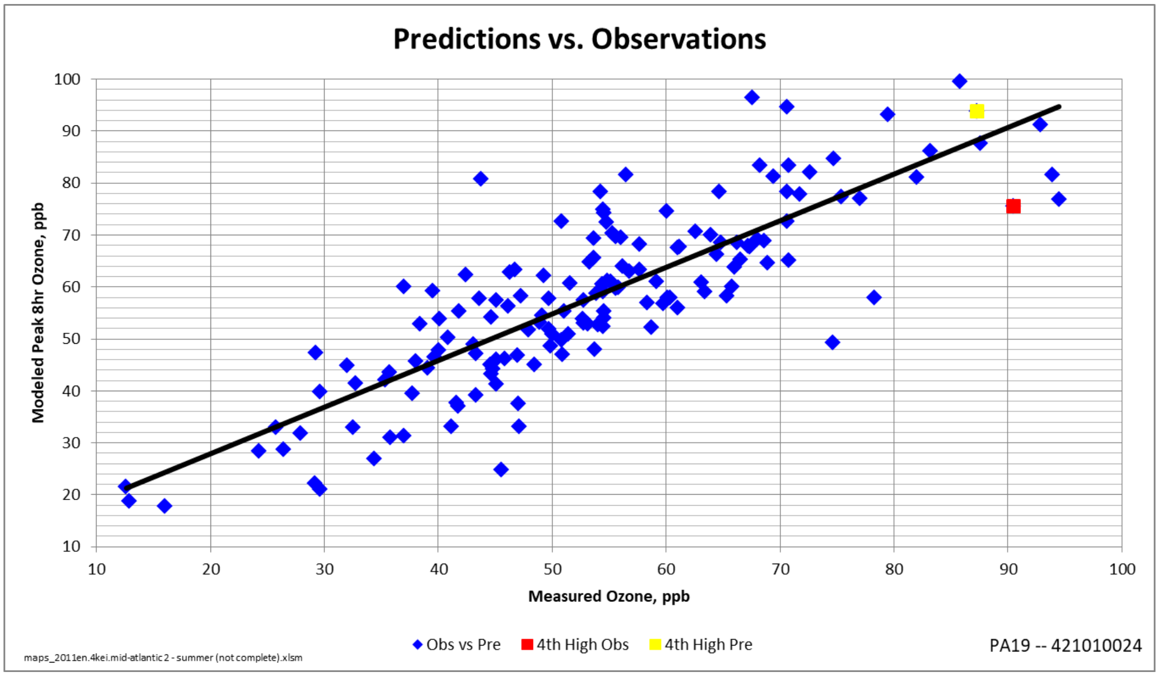

Figure 27. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 421010024 in Philadelphia Co., Pennsylvania. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

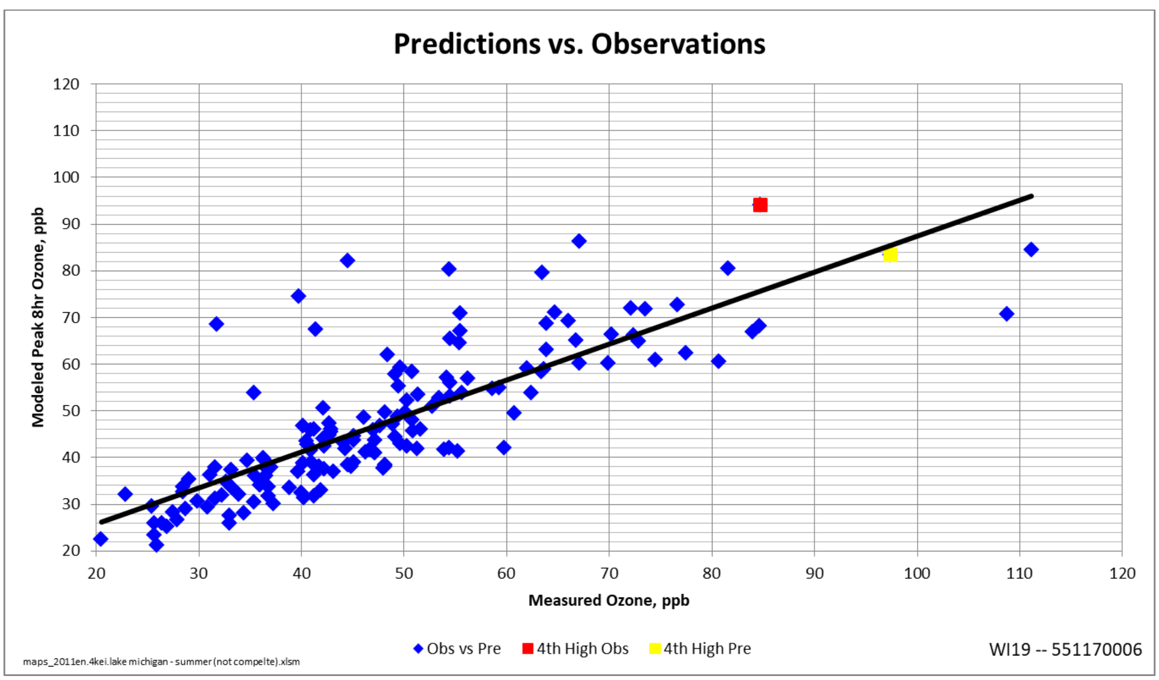

Figure 28. Correlation of observed and predicted MDA8 ozone for May through September 2011 at site 551170006 in Sheboygan Co., Wisconsin. Red square indicates 4th high observed value and yellow diamond indicates 4th high modeled value.

3.0 SUMMARY

As was seen with the 12km evaluation conducted by EPA on the 2011en platform (EPA, 2018), this 4km CAMx modeling configuration 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, both low-end observed concentrations (less than 40 ppb) and high-end (greater than 60 ppb) concentrations tend to be under predicted by this platform configuration on both 4km domains.

Over the entire concentration range, the model tends to under predict MDA8 ozone in the Lake Michigan 4km domain and over predict MDA8 ozone concentrations in the 4km Mid-Atlantic domain. However, looking across all represented monitors in the two 4km domains, 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 4km domains using this configuration of the 2011en 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 2011 modeling platform for these two 4km domains. These results provide confidence in the ability of the modeling platform to be used for future year ozone concentration projections and contribution analyses.

4.0 REFERENCES

Alpine. 2017a. “Good Neighbor” Modeling for the Kentucky 2008 8-Hour Ozone State Implementation Plan - Final Modeling Protocol. Alpine Geophysics, LLC. October.

Alpine. 2017b. “Good Neighbor” Modeling for the Kentucky 2008 8-Hour Ozone State Implementation Plan - Final Modeling Report. Alpine Geophysics, LLC. November.

Alpine. 2018a. Air Quality Modeling Technical Support Document for Midwest Ozone Group’s Updated 4km Modeling. Alpine Geophysics, LLC. December.

Alpine. 2018b. Midwest Ozone Group 2011 WRF Model Application and Performance Evaluation Report. Alpine Geophysics, LLC. February.

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

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

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

ENVIRON. 2015. User’s Guide Comprehensive Air-quality Model with extensions Version 6.3. ENVIRON International Corporation, Novato, CA. March. (http://www.camx.com/files/camxusersguide_v6-3.pdf).

EPA. 1991. "Guidance for Regulatory Application of the Urban Airshed Model (UAM), "Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, N.C.

EPA. 1999. “Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hr Ozone NAAQS”. Draft (May 1999), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C

EPA. 2001. “Guidance Demonstrating Attainment Air Quality Goals for PM2.5 and Regional Haze”. Draft Final (17 February 2005), U.S. Environmental Protection Agency, Atmospheric Sciences Modeling Division, Research Triangle Park, N.C.

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.

EPA. 2007. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-454/B-07-002. April. (http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf).

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

EPA. 2014b. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, U.S. Environmental Protection Agency. December 2014.

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

EPA. 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.

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

EPA. 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

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

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

Morris, R. E. and T. C. Myers. 1990. "User's Guide for the Urban Airshed Model. Volume I: User's Manual for UAM (CB-IV)" prepared for the U.S. Environmental Protection Agency (EPA-450/4-90-007a), Systems Applications International, San Rafael, CA.

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

Tsirigotis, P. (March 27, 2018). *Information on the Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards under Clean Air Act Section 110(a)(2)(D)(i)(I)* [Memorandum]. Research Triangle Park, NC: U.S. EPA, Office of Air Quality Planning and Standards. Retrieved from https://www.epa.gov/sites/production/files/2018-03/documents/transport_memo_03_27_18_1.pdf

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

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

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

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

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

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

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

Appendix A

Model performance statistics for MDA8 ozone at individual monitoring sites based on days with observed values > 60 ppb.

MOG 4km Monitor-Level Model Performance Statistics
Mid-Atlantic Domain

AIRS Station Id	Thresh (ppb)	N	Avg Obs (ppb)	Peak Obs (ppb)	Peak Obs Day	Avg Pre (ppb)	Peak Pre (ppb)	Peak Pre Day	AU (%)	Variance (ppb^2)	MB (ppb)	MNB (%)	NMB (%)	MFB (%)	NMBF	MEr (ppb)	NME (%)	MNGE (%)	MFE (%)	NMEF	RMSE (ppb)	RSQR
90010017	60	31	69.76	93.63	2011060824	82.89	111.49	2011060824	19.08	144.65	13.13	19.38	18.82	16.46	0.19	14.13	20.26	20.66	17.80	0.20	17.81	0.25
90011123	60	26	70.00	89.38	2011072124	75.48	94.88	2011060924	6.15	68.76	5.48	7.97	7.83	6.99	0.08	8.26	11.79	12.05	11.31	0.12	9.94	0.48
90013007	60	27	72.89	95.00	2011060824	83.20	112.46	2011072324	18.38	126.27	10.31	15.05	14.15	13.00	0.14	11.82	16.22	16.71	14.80	0.16	15.25	0.30
90019003	60	29	71.95	101.88	2011060824	82.12	112.27	2011060824	10.20	124.29	10.17	14.87	14.13	12.82	0.14	12.06	16.76	17.10	15.20	0.17	15.09	0.37
90031003	60	15	72.08	95.00	2011060924	73.12	96.06	2011072124	1.12	234.23	1.04	3.90	1.45	1.89	0.01	10.45	14.50	14.24	14.25	0.14	15.34	0.03
90050005	60	19	67.53	85.50	2011072124	70.90	89.40	2011072124	4.56	53.79	3.37	5.22	5.00	4.48	0.05	7.04	10.43	10.62	10.34	0.10	8.07	0.32
90070007	60	22	71.42	92.00	2011060924	73.84	103.37	2011072124	12.36	82.14	2.42	3.86	3.39	3.05	0.03	7.27	10.18	10.29	9.98	0.10	9.38	0.44
90090027	60	17	72.80	98.25	2011071124	80.66	101.76	2011060824	3.57	137.88	7.86	11.88	10.79	10.01	0.11	11.95	16.42	17.06	15.55	0.16	14.13	0.19
90099002	60	28	72.84	103.43	2011072224	82.37	127.57	2011072324	23.34	127.37	9.53	13.50	13.09	11.66	0.13	11.85	16.27	16.48	14.87	0.16	14.77	0.50
90131001	60	14	66.34	87.88	2011071124	73.17	96.32	2011072124	9.60	114.52	6.83	11.10	10.29	9.36	0.10	7.60	11.46	12.11	10.38	0.11	12.69	0.08
100010002	60	32	67.86	94.25	2011060824	71.63	102.66	2011060824	8.92	89.03	3.77	5.55	5.56	4.51	0.06	7.97	11.75	11.78	11.17	0.12	10.16	0.40
100031007	60	26	69.42	82.75	2011061024	78.36	98.03	2011060124	18.47	66.02	8.94	12.89	12.88	11.53	0.13	9.89	14.25	14.39	13.10	0.14	12.08	0.44
100031010	60	27	69.31	86.00	2011072224	72.70	94.57	2011072224	9.97	103.44	3.39	5.12	4.89	3.89	0.05	8.63	12.45	12.69	12.30	0.12	10.72	0.28
100031013	60	34	70.66	100.75	2011060724	73.91	91.02	2011072224	-9.66	139.48	3.25	5.62	4.60	4.20	0.05	9.84	13.92	14.04	13.47	0.14	12.25	0.20
100032004	60	31	68.23	82.38	2011072224	69.49	87.81	2011072224	6.59	89.05	1.26	1.89	1.84	0.90	0.02	8.07	11.82	11.88	11.77	0.12	9.52	0.29
100051002	60	42	68.63	94.50	2011060824	68.17	96.66	2011072924	2.29	58.09	-0.47	-0.51	-0.68	-1.11	-0.01	6.27	9.14	9.11	9.08	0.09	7.64	0.35
100051003	60	42	68.03	85.00	2011060824	70.85	89.60	2011072924	5.41	64.92	2.82	4.44	4.14	3.67	0.04	7.04	10.35	10.51	10.12	0.10	8.54	0.23
110010041	60	37	69.10	85.50	2011061024	78.91	105.69	2011061024	23.61	106.33	9.81	14.58	14.20	12.59	0.14	11.57	16.75	17.21	15.37	0.17	14.23	0.24
110010043	60	51	69.71	92.38	2011061024	72.67	104.94	2011061024	13.60	70.56	2.96	4.45	4.25	3.65	0.04	7.33	10.51	10.66	10.29	0.11	8.91	0.43
240030014	60	42	71.02	94.13	2011061024	80.91	119.50	2011060824	26.95	108.05	9.89	14.30	13.93	12.48	0.14	11.65	16.40	16.52	14.85	0.16	14.35	0.36
240051007	60	50	69.84	92.63	2011070224	72.64	93.84	2011072124	1.31	100.26	2.80	4.73	4.00	3.62	0.04	8.86	12.69	12.88	12.61	0.13	10.40	0.17
240053001	60	46	70.88	101.13	2011060824	78.00	124.57	2011060824	23.18	168.25	7.11	10.48	10.03	8.53	0.10	11.59	16.35	16.55	15.07	0.16	14.79	0.30
240090011	60	37	69.46	93.75	2011060924	79.31	104.23	2011072924	11.18	112.21	9.85	14.88	14.19	12.87	0.14	11.08	15.96	16.37	14.42	0.16	14.47	0.19
240130001	60	45	66.70	85.13	2011070224	72.66	94.79	2011060824	11.35	80.86	5.96	9.32	8.94	8.09	0.09	8.52	12.78	12.93	12.02	0.13	10.79	0.14
240150003	60	38	71.16	94.63	2011060824	74.33	95.15	2011060824	0.55	93.40	3.18	5.08	4.47	4.06	0.04	8.05	11.31	11.64	11.19	0.11	10.17	0.30
240170010	60	41	69.25	98.38	2011061024	75.42	110.42	2011053124	12.24	93.19	6.16	9.47	8.90	8.20	0.09	8.14	11.76	12.21	11.01	0.12	11.45	0.25
240210037	60	47	66.73	85.50	2011070224	71.39	88.30	2011053124	3.27	56.46	4.65	7.23	6.97	6.39	0.07	7.10	10.64	10.80	10.15	0.11	8.84	0.26
240251001	60	57	73.37	114.75	2011060824	77.83	123.54	2011060824	7.66	171.52	4.46	7.36	6.08	5.64	0.06	11.20	15.27	15.46	14.66	0.15	13.84	0.30
240259001	60	46	72.01	98.25	2011070224	72.15	96.25	2011072124	-2.04	102.71	0.14	0.88	0.20	-0.10	0.00	7.79	10.81	10.77	10.84	0.11	10.14	0.21
240290002	60	42	70.89	100.75	2011060924	73.25	106.16	2011072224	5.37	57.31	2.36	3.24	3.33	2.62	0.03	6.88	9.70	9.76	9.53	0.10	7.93	0.63
240313001	60	42	68.72	88.63	2011070224	73.11	98.75	2011072024	11.42	84.75	4.39	6.76	6.39	5.71	0.06	8.26	12.02	12.18	11.58	0.12	10.20	0.22
240330030	60	37	70.25	94.00	2011070724	77.53	101.27	2011072524	7.73	118.82	7.28	11.11	10.36	9.41	0.10	10.34	14.72	15.27	13.93	0.15	13.11	0.20
240338003	60	38	73.68	95.63	2011060824	82.74	120.97	2011060824	26.50	91.82	9.06	12.47	12.30	11.06	0.12	10.25	13.92	14.02	12.70	0.14	13.19	0.47
250051002	60	20	67.92	85.50	2011060724	72.50	94.18	2011072324	10.15	140.15	4.58	7.45	6.74	5.73	0.07	9.87	14.53	14.96	13.99	0.15	12.69	0.08
250070001	60	20	73.28	113.43	2011072224	82.11	118.06	2011072324	4.08	184.14	8.83	12.96	12.05	10.93	0.12	13.01	17.76	17.80	16.14	0.18	16.19	0.25
250130008	60	15	69.09	81.00	2011072124	71.58	94.58	2011060124	16.77	71.65	2.49	3.85	3.61	3.13	0.04	6.31	9.13	9.00	8.66	0.09	8.82	0.19
250154002	60	12	66.50	84.00	2011072124	71.25	89.95	2011060124	7.08	125.06	4.75	8.12	7.14	6.50	0.07	8.47	12.74	13.26	11.96	0.13	12.15	0.02
340071001	60	40	69.81	97.75	2011060824	72.60	99.28	2011060824	1.57	64.50	2.79	3.96	4.00	3.28	0.04	6.94	9.94	9.86	9.56	0.10	8.50	0.57
340110007	60	20	64.57	77.88	2011060924	78.34	94.45	2011072224	21.28	83.32	13.78	21.55	21.34	18.68	0.21	14.13	21.89	22.11	19.25	0.22	16.53	0.14
340150002	60	37	73.01	102.00	2011060924	75.41	104.41	2011061024	2.36	128.14	2.40	3.90	3.28	2.73	0.03	9.56	13.10	13.05	12.68	0.13	11.57	0.34
340170006	60	25	69.90	88.75	2011072124	72.86	99.35	2011072124	11.94	58.11	2.96	4.20	4.24	3.54	0.04	6.60	9.44	9.46	9.13	0.09	8.18	0.54
340190001	60	35	70.12	88.25	2011072224	73.12	96.89	2011072224	9.79	47.12	3.00	4.51	4.28	3.93	0.04	5.69	8.11	8.31	7.91	0.08	7.49	0.49
340210005	60	29	69.85	89.75	2011060924	74.99	97.37	2011072124	8.49	43.52	5.14	7.53	7.36	6.85	0.07	7.12	10.19	10.28	9.69	0.10	8.36	0.58
340230011	60	42	70.18	92.88	2011072124	72.66	98.19	2011072124	5.72	66.99	2.47	3.74	3.52	2.93	0.04	6.90	9.83	10.17	9.96	0.10	8.55	0.49
340250005	60	29	70.51	97.50	2011060924	77.77	103.25	2011072224	5.90	91.12	7.26	10.98	10.29	9.68	0.10	10.11	14.35	14.24	13.26	0.14	11.99	0.33
340273001	60	29	68.92	84.63	2011060724	75.07	97.33	2011072224	15.01	51.85	6.15	9.09	8.92	8.21	0.09	7.55	10.95	11.03	10.25	0.11	9.47	0.50
340290006	60	27	73.22	101.13	2011060924	81.84	113.04	2011072224	11.78	111.92	8.62	12.53	11.77	10.94	0.12	11.23	15.34	15.60	14.18	0.15	13.65	0.34
340315001	60	19	69.09	81.88	2011072024	75.36	90.27	2011070824	10.25	70.45	6.27	9.69	9.07	8.55	0.09	8.48	12.28	12.75	11.73	0.12	10.47	0.10
360150003	60	18	64.00	72.13	2011060824	62.05	71.07	2011060724	-1.47	21.04	-1.95	-2.94	-3.05	-3.25	-0.03	4.21	6.58	6.60	6.71	0.07	4.98	0.07
360270007	60	16	69.79	96.38	2011072024	74.02	91.34	2011072124	-5.23	125.13	4.23	6.70	6.06	5.29	0.06	10.53	15.08	15.12	14.50	0.15	11.96	0.16
360530006	60	12	63.45	70.25	2011060824	66.46	72.73	2011060924	3.53	8.48	3.01	4.76	4.75	4.55	0.05	3.33	5.24	5.26	5.06	0.05	4.19	0.46
360715001	60	11	68.43	92.00	2011072024	76.88	89.14	2011062824	-3.11	151.55	8.44	13.85	12.34	11.64	0.12	12.59	18.40	18.65	16.93	0.18	14.93	0.01
360790005	60	10	66.53	75.00	2011072024	78.62	94.88	2011072024	26.51	74.91	12.09	18.10	18.18	15.93	0.18	13.64	20.50	20.40	18.38	0.21	14.87	0.32
360810124	60	26	72.26	96.50	2011060924	71.16	87.45	2011060824	-9.38	76.51	-1.10	-1.05	-1.52	-1.80	-0.02	7.13	9.87	9.88	9.98	0.10	8.82	0.40
360850067	60	40	71.08	93.63	2011060924	71.87	97.41	2011072124	4.04	89.73	0.79	1.29	1.12	0.37	0.01	7.47	10.51	10.58	10.62	0.11	9.51	0.43
361030002	60	34	73.00	114.00	2011072224	76.74	104.00	2011072224	-8.77	71.43	3.74	6.07	5.13	5.23	0.05	7.27	9.97	10.34	9.70	0.10	9.24	0.61
361030004	60	25	70.32	89.00	2011072224	75.27	107.72	2011072324	21.03	123.46	4.95	7.02	7.03	5.68	0.07	9.62	13.67	13.68	12.87	0.14	12.16	0.41
361030009	60	20	69.84	94.25	2011072224	79.43	102.45	2011072224	8.70	78.58	9.59	14.65	13.73	12.94	0.14	10.50	15.03	15.74	14.06	0.15	13.06	0.42
361111005	60	16	67.04	77.63	2011052624	65.20	75.20	2011072124	-3.13	25.05	-1.84	-2.63	-2.74	-2.97	-0.03	4.37	6.52	6.60	6.76	0.07	5.33	0.35
361192004	60	21	69.37	98.75	2011060924	78.25	101.52	2011062124	2.81	89.94	8.88	13.70	12.79	12.00	0.13	9.96	14.36	14.96	13.29	0.14	12.99	0.25
420010002	60	17	65.97	82.75	2011070224	65.52	81.81	2011060824	-1.14	85.68	-0.45	-0.34	-0.68	-1.29	-0.01	7.48	11.33	11.21	11.50	0.11	9.27	0.02
420170012	60	27	69.91	85.50	2011060124	79.92	97.50	2011072224	14.04	140.96	10.01	14.99	14.32	12.66	0.14	12.96	18.54	19.02	17.08	0.19	15.53	0.09
420290100	60	32	69.64	90.88	2011060824	72.82	92.50	2011072224	1.78	121.39	3.18	5.03	4.57	3.65	0.05	8.96	12.87	13.32	12.67	0.13	11.47	0.16
420430401	60	26	65.49	82.13	2011070224	71.88	89.60	2011060824	9.10	65.59	6.40	10.24	9.77	9.09	0.10	8.10	12.37	12.50	11.55	0.12	10.32	0.07
420431100	60	30	68.18	85.50	2011070224	73.63	99.90	2011060824	16.84	68.32	5.45	8.40	8.00	7.41	0.08	7.89	11.57	11.75	11.02	0.12	9.90	0.21
420450002	60	29	69.69	84.75	2011060724	72.70	89.99	2011072924	6.18	120.81	3.02	4.75	4.33	3.44	0.04	9.73	13.97	14.09	13.65	0.14	11.40	0.14

MOG 4km Monitor-Level Model Performance Statistics
Mid-Atlantic Domain

AIRS Station Id	Thresh (ppb)	N	Avg Obs (ppb)	Peak Obs (ppb)	Peak Obs Day	Avg Pre (ppb)	Peak Pre (ppb)	Peak Pre Day	AU (%)	Variance (ppb^2)	MB (ppb)	MNB (%)	NMB (%)	MFB (%)	NMBF	MEr (ppb)	NME (%)	MNGE (%)	MFE (%)	NMEF	RMSE (ppb)	RSQR
420690101	60	16	67.03	73.88	2011060924	71.00	82.91	2011072124	12.22	11.94	3.98	5.90	5.93	5.61	0.06	4.04	6.03	6.01	5.72	0.06	5.27	0.69
420692006	60	14	64.67	70.50	2011071724	71.89	82.28	2011072124	16.71	17.08	7.21	11.07	11.15	10.33	0.11	7.21	11.15	11.07	10.33	0.11	8.31	0.59
420710007	60	36	68.41	87.50	2011070224	74.20	100.51	2011060824	14.87	97.67	5.79	8.79	8.46	7.48	0.08	9.25	13.52	13.58	12.73	0.14	11.45	0.26
420770004	60	34	68.04	84.75	2011072024	69.97	90.22	2011072024	6.45	64.74	1.93	3.02	2.84	2.25	0.03	6.57	9.65	9.83	9.73	0.10	8.27	0.32
420791100	60	5	64.25	70.13	2011071724	77.48	83.02	2011060724	18.38	20.36	13.23	20.61	20.59	18.49	0.21	13.23	20.59	20.61	18.49	0.21	13.98	0.39
420791101	60	10	64.12	69.50	2011071724	73.88	80.64	2011060724	16.03	17.97	9.76	15.18	15.22	13.93	0.15	9.76	15.22	15.18	13.93	0.15	10.64	0.48
420810100	60	10	63.13	71.88	2011072124	71.66	79.71	2011090124	10.89	25.53	8.53	13.73	13.51	12.56	0.14	8.53	13.51	13.73	12.56	0.14	9.91	0.08
420910013	60	34	69.38	86.63	2011060824	74.45	96.32	2011082624	11.19	97.89	5.07	7.65	7.31	6.35	0.07	8.61	12.41	12.90	12.10	0.12	11.12	0.23
420950025	60	26	66.09	79.25	2011060924	73.56	90.09	2011072024	13.68	35.36	7.48	11.51	11.31	10.52	0.11	8.45	12.79	12.98	12.04	0.13	9.55	0.43
420958000	60	17	65.72	74.25	2011060724	77.46	90.48	2011072024	21.86	39.99	11.73	18.28	17.85	16.33	0.18	11.75	17.87	18.31	16.36	0.18	13.33	0.15
420990301	60	21	63.53	74.00	2011070224	67.46	81.77	2011060824	10.50	57.37	3.94	6.47	6.20	5.61	0.06	7.07	11.13	11.16	10.68	0.11	8.54	0.01
421010004	60	13	66.04	73.26	2011060724	77.78	90.14	2011072124	23.04	137.55	11.74	17.94	17.78	15.08	0.18	15.00	22.72	23.02	20.47	0.23	16.60	0.07
421010024	60	48	71.68	94.50	2011060124	73.67	99.51	2011072124	5.30	104.81	1.99	3.25	2.78	2.25	0.03	7.67	10.70	10.64	10.38	0.11	10.43	0.32
421174000	60	25	65.65	74.13	2011060824	61.36	72.88	2011090124	-1.69	27.37	-4.30	-6.45	-6.54	-7.03	-0.07	5.85	8.91	8.92	9.39	0.10	6.77	0.19
421330008	60	31	67.52	84.25	2011070224	71.76	89.29	2011060824	5.98	73.18	4.23	6.60	6.27	5.68	0.06	7.43	11.00	10.98	10.39	0.11	9.55	0.06
440030002	60	26	67.51	84.88	2011070624	70.63	89.68	2011072324	5.66	60.17	3.13	4.62	4.63	3.90	0.05	6.82	10.10	10.12	9.75	0.10	8.36	0.44
440071010	60	23	67.01	78.50	2011070624	66.87	79.74	2011072124	1.58	51.52	-0.15	-0.24	-0.22	-0.92	0.00	5.19	7.74	7.91	8.20	0.08	7.18	0.36
440090007	60	31	68.18	84.38	2011071624	70.73	102.97	2011072324	22.03	112.25	2.55	3.71	3.73	2.54	0.04	8.65	12.69	12.63	12.23	0.13	10.90	0.28
510130020	60	54	70.35	100.25	2011061024	74.41	101.82	2011060524	1.57	70.80	4.06	5.97	5.77	5.13	0.06	7.31	10.39	10.48	9.94	0.10	9.34	0.45
510330001	60	18	67.30	82.63	2011053124	74.42	93.45	2011053124	13.09	31.40	7.12	10.58	10.58	9.75	0.11	7.82	11.62	11.59	10.78	0.12	9.06	0.59
510360002	60	26	70.41	104.50	2011060824	77.83	113.54	2011060824	8.65	51.52	7.42	11.34	10.54	10.22	0.11	8.25	11.72	12.36	11.27	0.12	10.33	0.57
510410004	60	15	67.71	78.63	2011070124	74.01	98.46	2011053124	25.22	92.65	6.30	9.59	9.30	8.33	0.09	9.02	13.32	13.13	12.10	0.13	11.50	0.08
510590030	60	48	70.03	99.50	2011061024	76.74	102.51	2011060524	3.03	71.66	6.71	9.99	9.59	8.84	0.10	8.09	11.55	11.98	10.91	0.12	10.80	0.48
510610002	60	8	62.83	67.25	2011070224	73.34	84.86	2011080424	26.19	45.18	10.51	16.72	16.72	14.98	0.17	10.59	16.85	16.85	15.10	0.17	12.47	0.11
510850003	60	28	68.51	80.75	2011060824	81.13	107.01	2011060924	32.52	92.41	12.63	18.52	18.43	16.22	0.18	12.95	18.91	18.97	16.68	0.19	15.87	0.26
510870014	60	37	69.19	86.63	2011060824	76.69	102.65	2011072524	18.49	104.41	7.50	11.09	10.84	9.54	0.11	10.28	14.86	14.99	13.76	0.15	12.68	0.21
511071005	60	37	66.85	86.63	2011072024	68.31	94.08	2011072024	8.60	52.48	1.46	2.11	2.18	1.50	0.02	5.94	8.88	8.93	8.79	0.09	7.39	0.47
511530009	60	28	65.40	79.13	2011070224	71.12	85.81	2011070724	8.44	73.60	5.72	8.80	8.75	7.64	0.09	9.05	13.84	13.87	13.11	0.14	10.31	0.19
511790001	60	21	68.19	86.38	2011053124	77.24	109.53	2011080424	26.80	155.48	9.05	14.20	13.27	11.79	0.13	10.97	16.08	16.99	14.72	0.16	15.41	0.01
515100009	60	42	69.85	100.63	2011061024	78.62	105.66	2011061024	5.00	88.01	8.76	13.12	12.55	11.49	0.13	10.40	14.88	15.41	13.90	0.15	12.84	0.38
518000004	60	22	67.61	79.88	2011072924	73.40	90.60	2011053124	13.42	68.73	5.78	9.21	8.55	8.12	0.09	7.86	11.62	11.92	11.02	0.12	10.11	0.03

MOG 4km Monitor-Level Model Performance Statistics
Lake Michigan Domain

AIRS Station Id	Thresh (ppb)	N	Avg Obs (ppb)	Peak Obs (ppb)	Peak Obs Day	Avg Pre (ppb)	Peak Pre (ppb)	Peak Pre Day	AU (%)	Variance (ppb^2)	MB (ppb)	MNB (%)	NMB (%)	MFB (%)	NMBF	MEr (ppb)	NME (%)	MNGE (%)	MFE (%)	NMEF	RMSE (ppb)	RSQR
170310001	60	18	65.93	80.00	2011090224	68.50	77.82	2011060424	-2.73	63.27	2.57	4.46	3.89	3.67	0.04	7.31	11.09	11.17	10.71	0.11	8.36	0.02
170310032	60	33	67.47	89.63	2011090224	63.97	89.25	2011070224	-0.42	227.29	-3.50	-4.20	-5.19	-7.13	-0.05	11.74	17.40	17.36	18.69	0.18	15.48	0.01
170310064	60	23	67.46	89.00	2011072124	64.80	84.31	2011072124	-5.27	167.64	-2.66	-2.95	-3.95	-4.97	-0.04	9.31	13.80	13.64	14.84	0.14	13.22	0.00
170310072	60	29	66.56	85.50	2011080124	61.64	85.78	2011072124	0.33	82.17	-4.92	-7.24	-7.39	-8.58	-0.08	8.47	12.72	12.69	13.67	0.14	10.31	0.22
170310076	60	29	67.11	82.13	2011090124	61.90	81.14	2011072124	-1.21	99.86	-5.21	-7.69	-7.76	-9.32	-0.08	9.39	14.00	14.08	15.26	0.15	11.27	0.17
170311003	60	13	64.71	76.13	2011090124	65.94	81.15	2011072124	6.59	166.78	1.22	2.50	1.89	0.32	0.02	9.19	14.20	14.07	14.96	0.14	12.97	0.02
170311601	60	25	66.06	82.00	2011090124	67.24	99.68	2011071924	21.56	87.27	1.18	1.97	1.79	1.09	0.02	6.72	10.17	10.00	9.63	0.10	9.42	0.08
170314002	60	19	67.16	89.25	2011090124	63.79	78.57	2011072124	-11.97	125.92	-3.37	-4.05	-5.02	-5.59	-0.05	8.55	12.73	12.21	13.28	0.13	11.72	0.00
170314007	60	10	65.37	76.00	2011090124	66.41	79.23	2011090124	4.25	135.84	1.04	2.10	1.60	0.41	0.02	9.14	13.99	14.09	14.61	0.14	11.70	0.01
170314201	60	23	68.43	86.50	2011090124	70.16	81.46	2011090124	-5.83	78.71	1.73	2.90	2.53	1.93	0.03	6.00	8.76	8.87	9.12	0.09	9.04	0.19
170317002	60	20	69.82	88.38	2011073124	63.25	132.10	2011072324	49.47	453.09	-6.57	-8.12	-9.41	-13.10	-0.10	16.13	23.10	23.35	23.96	0.25	22.28	0.01
170436001	60	16	65.50	76.63	2011073024	68.31	92.08	2011071924	20.16	56.77	2.81	4.44	4.28	3.79	0.04	6.54	9.99	9.77	9.39	0.10	8.04	0.19
170890005	60	21	66.27	78.88	2011073024	66.55	80.86	2011061824	2.51	41.72	0.28	0.66	0.43	0.20	0.00	5.00	7.54	7.51	7.37	0.08	6.47	0.19
170971007	60	25	69.19	95.63	2011090124	73.00	102.04	2011071024	6.70	135.62	3.81	5.76	5.51	4.33	0.06	8.69	12.56	12.63	11.70	0.13	12.25	0.30
171110001	60	21	66.09	79.75	2011073024	63.51	72.13	2011071924	-9.55	34.21	-2.57	-3.62	-3.89	-4.06	-0.04	4.82	7.30	7.08	7.42	0.08	6.39	0.16
171971011	60	7	67.77	91.75	2011071924	58.61	71.21	2011071924	-22.39	39.71	-9.16	-12.71	-13.52	-13.89	-0.16	9.16	13.52	12.71	13.89	0.16	11.12	0.75
172012001	60	15	64.79	75.25	2011061724	64.62	74.93	2011061824	-0.43	30.93	-0.17	0.04	-0.26	-0.32	0.00	4.51	6.96	6.82	6.90	0.07	5.56	0.03
180390007	60	22	67.43	85.16	2011090224	62.63	83.68	2011072124	-1.74	49.86	-4.80	-6.71	-7.12	-7.46	-0.08	6.80	10.08	9.75	10.35	0.11	8.54	0.19
180890022	60	13	66.00	84.22	2011090224	66.68	90.22	2011072124	7.12	156.92	0.68	1.67	1.03	-0.04	0.01	8.88	13.46	13.24	13.20	0.13	12.55	0.00
180890030	60	17	65.98	75.76	2011090224	62.71	83.19	2011060424	9.81	155.78	-3.26	-4.83	-4.94	-7.19	-0.05	8.91	13.50	13.75	15.14	0.14	12.90	0.05
180892008	60	27	67.67	77.53	2011090124	64.69	81.42	2011070224	5.02	99.45	-2.98	-4.10	-4.40	-5.40	-0.05	7.44	10.99	10.87	11.67	0.11	10.41	0.04
180910005	60	38	71.09	96.43	2011090224	63.94	102.71	2011071124	6.51	192.55	-7.15	-9.49	-10.06	-12.08	-0.11	12.43	17.48	17.18	18.90	0.19	15.61	0.10
180910010	60	18	67.10	82.56	2011090224	64.41	82.09	2011060424	-0.57	110.47	-2.69	-3.42	-4.01	-4.62	-0.04	8.71	12.98	12.48	13.02	0.14	10.85	0.00
181270024	60	11	67.32	82.55	2011090224	69.06	91.94	2011072124	11.37	144.95	1.74	3.13	2.59	1.56	0.03	9.82	14.58	14.35	14.37	0.15	12.16	0.07
181270026	60	11	63.91	77.70	2011090224	66.12	84.37	2011080124	8.58	145.89	2.21	4.11	3.45	2.38	0.03	9.63	15.07	15.08	14.46	0.15	12.28	0.03
181410010	60	13	65.40	83.57	2011090224	63.60	76.93	2011060424	-7.95	52.62	-1.81	-2.24	-2.77	-2.81	-0.03	5.85	8.95	8.64	8.75	0.09	7.48	0.03
181411007	60	17	68.58	85.70	2011090224	65.76	86.90	2011072124	1.40	79.22	-2.83	-3.66	-4.12	-4.61	-0.04	7.81	11.38	11.45	11.69	0.12	9.34	0.12
260050003	60	36	68.79	97.13	2011060824	67.50	105.44	2011060824	8.56	112.62	-1.29	-1.65	-1.88	-2.87	-0.02	8.13	11.82	11.94	12.01	0.12	10.69	0.41
260190003	60	18	68.44	84.00	2011060724	64.07	85.63	2011060724	1.94	23.98	-4.37	-6.29	-6.38	-6.78	-0.07	5.40	7.90	7.91	8.37	0.08	6.56	0.58
260210014	60	38	69.69	96.50	2011090124	70.21	101.51	2011072324	5.19	136.05	0.52	1.48	0.75	0.20	0.01	9.34	13.40	13.26	12.94	0.13	11.68	0.17
260270003	60	32	70.02	87.13	2011090224	64.84	81.93	2011070224	-5.97	63.08	-5.18	-6.97	-7.40	-7.88	-0.08	8.10	11.57	11.36	11.95	0.12	9.48	0.25
260770008	60	26	68.05	77.00	2011071724	65.83	79.50	2011070224	3.25	33.63	-2.22	-3.26	-3.26	-3.70	-0.03	4.77	7.01	7.06	7.31	0.07	6.21	0.37
260810020	60	16	68.05	82.00	2011060824	68.78	86.85	2011060824	5.91	58.62	0.73	1.35	1.07	0.67	0.01	6.04	8.88	9.13	8.95	0.09	7.69	0.34
260810022	60	18	67.50	81.38	2011060824	64.71	88.10	2011060724	8.26	41.67	-2.79	-4.33	-4.13	-4.95	-0.04	5.85	8.67	8.88	9.21	0.09	7.03	0.64
261050007	60	14	70.73	94.25	2011060724	65.50	89.07	2011060724	-5.50	23.13	-5.22	-7.24	-7.38	-7.77	-0.08	5.68	8.03	7.97	8.49	0.09	7.10	0.76
261130001	60	12	66.12	77.63	2011060724	62.16	80.22	2011060724	3.34	30.70	-3.95	-6.16	-5.98	-6.78	-0.06	4.81	7.28	7.36	7.97	0.08	6.81	0.58
261210039	60	28	69.14	104.50	2011060724	73.51	100.92	2011060724	-3.43	90.22	4.36	7.04	6.31	5.86	0.06	7.64	11.05	11.64	10.77	0.11	10.45	0.43
261390005	60	26	68.95	88.38	2011060824	66.96	95.26	2011060824	7.78	91.19	-1.99	-2.37	-2.88	-3.40	-0.03	7.62	11.05	11.04	11.26	0.11	9.75	0.28
550090026	60	13	68.61	84.00	2011090124	63.35	72.23	2011060724	-14.01	58.12	-5.25	-6.97	-7.66	-7.83	-0.08	7.44	10.85	10.48	11.17	0.12	9.26	0.05
550210015	60	12	65.42	69.50	2011060624	62.09	69.17	2011060624	-0.47	3.55	-3.33	-5.11	-5.09	-5.29	-0.05	3.36	5.14	5.16	5.35	0.05	3.83	0.75
550250041	60	15	64.61	70.63	2011060624	61.20	67.51	2011061824	-4.42	17.65	-3.41	-5.21	-5.28	-5.58	-0.06	4.12	6.38	6.33	6.67	0.07	5.41	0.09
550290004	60	17	71.59	90.50	2011060724	73.68	88.94	2011060724	-1.72	73.88	2.09	3.14	2.92	2.38	0.03	6.55	9.15	9.36	9.08	0.09	8.85	0.33
550390006	60	14	68.65	82.25	2011063024	61.45	72.91	2011090124	-11.36	26.68	-7.19	-10.19	-10.48	-11.01	-0.12	7.41	10.79	10.55	11.36	0.12	8.85	0.47
550410007	60	6	65.86	75.13	2011060324	63.34	69.71	2011060724	-7.21	35.04	-2.52	-3.41	-3.82	-3.89	-0.04	5.17	7.85	7.77	8.05	0.08	6.43	0.12
550550002	60	15	65.19	71.75	2011090124	61.07	68.30	2011061824	-4.81	16.06	-4.12	-6.41	-6.32	-6.86	-0.07	4.32	6.63	6.73	7.17	0.07	5.75	0.55
550590019	60	31	71.00	96.00	2011090124	74.40	105.94	2011071024	10.35	131.10	3.39	4.86	4.78	3.58	0.05	8.96	12.62	12.71	11.97	0.13	11.94	0.36
550610002	60	15	71.32	103.71	2011090224	69.84	81.17	2011053024	-21.73	139.80	-1.48	-0.23	-2.07	-1.31	-0.02	8.91	12.50	11.76	11.86	0.13	11.92	0.15
550710007	60	19	73.22	100.13	2011090224	71.40	87.66	2011071024	-12.45	107.61	-1.82	-1.41	-2.48	-2.28	-0.03	8.35	11.40	10.93	10.98	0.12	10.53	0.26
550790010	60	13	68.36	89.13	2011090124	65.06	79.80	2011071024	-10.47	100.10	-3.30	-4.61	-4.83	-5.96	-0.05	8.04	11.77	11.86	12.73	0.12	10.54	0.18
550790026	60	15	69.37	96.50	2011090124	62.64	80.75	2011071024	-16.32	101.58	-6.73	-9.23	-9.71	-10.85	-0.11	9.20	13.26	12.92	14.32	0.15	12.12	0.16
550790085	60	15	70.81	103.25	2011090124	69.49	89.72	2011072324	-13.10	138.26	-1.32	-0.61	-1.87	-1.96	-0.02	9.06	12.80	12.58	12.65	0.13	11.83	0.11
550870009	60	11	70.16	76.88	2011063024	61.34	73.11	2011060324	-4.90	21.95	-8.82	-12.83	-12.57	-14.04	-0.14	8.82	12.57	12.83	14.04	0.14	9.99	0.73
550890008	60	23	69.58	98.38	2011090124	64.95	93.62	2011071024	-4.84	100.46	-4.63	-6.01	-6.65	-7.23	-0.07	8.54	12.27	11.89	12.59	0.13	11.04	0.15
550890009	60	15	71.45	96.00	2011090124	72.60	96.17	2011071024	0.18	127.77	1.15	2.58	1.60	1.35	0.02	8.60	12.03	12.23	11.71	0.12	11.36	0.10
551010017	60	21	70.37	101.63	2011090124	71.09	100.32	2011071024	-1.29	113.77	0.72	1.49	1.03	0.35	0.01	8.46	12.03	12.05	11.91	0.12	10.69	0.32
551050024	60	20	66.50	73.75	2011071524	58.54	66.36	2011060624	-10.02	23.14	-7.96	-11.94	-11.98	-13.00	-0.14	7.96	11.98	11.94	13.00	0.14	9.30	0.30
551170006	60	30	74.26	111.13	2011090124	68.32	94.06	2011071024	-15.36	133.13	-5.94	-6.75	-8.00	-8.01	-0.09	9.88	13.30	12.56	13.31	0.14	12.98	0.26
551270005	60	18	65.67	72.38	2011060324	63.07	74.46	2011071524	2.87	27.52	-2.60	-3.93	-3.95	-4.35	-0.04	4.93	7.51	7.50	7.81	0.08	5.85	0.17
551330027	60	13	67.01	75.88	2011070924	63.06	75.41	2011090124	-0.62	78.50	-3.95	-5.33	-5.90	-6.45	-0.06	7.04	10.50	10.27	11.16	0.11	9.70	0.03

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

OCT 19 2018

MEMORANDUM

SUBJECT: Considerations for Identifying Maintenance Receptors for Use in Clean Air Act Section 110(a)(2)(D)(i)(I) Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards

FROM: Peter Tsirigotis
Director

TO: Regional Air Division Directors, Regions 1–10

The purpose of this memorandum is to present information that states may consider as they evaluate the status of monitoring sites that the Environmental Protection Agency (EPA) identified as potential maintenance receptors with respect to the 2015 ozone National Ambient Air Quality Standards (NAAQS) based on EPA's 2023 modeling.[1] States may use this information when developing state implementation plans (SIPs) for the 2015 ozone NAAQS addressing the good neighbor provision in Clean Air Act (CAA) section 110(a)(2)(D)(i)(I). In brief, this document discusses (1) using alternative technical methods for projecting whether future air quality warrants identifying monitors as maintenance receptors and (2) considering current monitoring data when identifying monitoring sites that, although projected to be in attainment, as described below, should be identified as maintenance receptors because of the risk that they could exceed the NAAQS due to year-to-year (*i.e.*, inter-annual) variability in meteorological conditions.

This document does not substitute for provisions or regulations of the CAA, nor is it a regulation itself. Rather, it provides recommendations for states using the included analytical information in developing SIP submissions, and for EPA Regional offices in acting on them. Thus, it does not impose binding, enforceable requirements on any party. State air agencies retain the discretion to develop good neighbor SIP revisions that differ from this guidance.

Following the recommendations in this guidance does not ensure that EPA will approve a SIP revision in all instances where the recommendations are followed, as the guidance may not apply to the facts and circumstances underlying a particular SIP. Final decisions by EPA to approve

[1] Information on the Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards under Clean Air Act Section 110(a)(2)(D)(i)(I) (March 2018). *https://www.epa.gov/airmarkets/2015-ozone-naaqs-mem.*

a particular SIP revision will only be made based on the requirements of the statute following an air agency's final submission of the SIP revision to EPA and after appropriate notice and opportunity for public review and comment. Interested parties may raise comments about the appropriateness of the application of this guidance to a particular SIP revision. EPA and air agencies should consider whether the recommendations in this guidance are appropriate for each situation.

Introduction

CAA section 110(a)(2)(D)(i)(I), otherwise known as the good neighbor provision, requires states to prohibit emissions "which will contribute significantly to nonattainment in, or interfere with maintenance by, any other state with respect to any" NAAQS. EPA has historically used a 4-step framework to determine upwind state obligations (if any) under the good neighbor provision for regional pollutants like ozone: (1) identify downwind areas, referred to as "receptors," expected to have problems attaining or maintaining the NAAQS; (2) identify upwind states that contribute to those downwind air quality problems and warrant further review and analysis; (3) identify the emissions reductions (if any) necessary to eliminate an upwind state's significant contribution to nonattainment and/or interference with maintenance of the NAAQS in the downwind areas, considering cost and air quality factors; and (4) adopt permanent and enforceable measures needed to achieve those emissions reductions. EPA notes that, in developing their SIP revisions for the 2015 ozone NAAQS, states have flexibility to follow this framework or develop alternative frameworks to evaluate interstate transport obligations, so long as a state's chosen approach has adequate technical justification and is consistent with the requirements of the CAA.

At Step 1, EPA has historically used base year and future year air quality modeling coupled with base period measured ozone design values to project design values to a future analytic year.[2] In a memo issued in March 2018, EPA released updated modeling, which uses 2011 as the base year and 2023 as the future analytic year, to evaluate interstate transport for the 2015 ozone NAAQS.[3] As part of EPA's 2023 modeling analysis, EPA projected the average and maximum base period 2009 – 2013 design values to 2023.[4,5] EPA evaluated the projected 2023 design values in combination with measured 2016 design values using the same methodology used in the Cross-State Air Pollution Rule Update (CSAPR Update)[6] to identify receptors with anticipated potential nonattainment and maintenance issues with respect to the 2015 ozone NAAQS in 2023. Under the CSAPR Update methodology, those sites that are violating the NAAQS based on 2016 design values (*i.e.*, currently not attaining) and that also have projected 2023 *average* design values that exceed the NAAQS (*i.e.*, 2023 average design values of 71 parts per billion (ppb) or greater) are

[2] Air Quality Modeling Technical Support Document for the Final Cross State Air Pollution Rule Update (August 2016). *https://www.epa.gov/airmarkets/air-quality-modeling-technical-support-document-final-cross-state-air-pollution-rule*.

[3] Information on the Interstate Transport State Implementation Plan Submissions for the 2015 Ozone National Ambient Air Quality Standards under Clean Air Act Section 110(a)(2)(D)(i)(I) (March 2018). *https://www.epa.gov/airmarkets/march-2018-memo-and-supplemental-information-regarding-interstate-transport-sips-2015*.

[4] The base period includes the three design values that contain 2011 monitoring data (*i.e.*, 2009-2011, 2010-2012, and 2011-2013).

[5] The base period maximum design value is the highest of the three design values in the period 2009-2013.

[6] *See* 81 FR 74504 (October 26, 2016).

identified as potential nonattainment receptors in 2023.[7] Under the CSAPR Update methodology, those sites with a 2023 *maximum* 3-year design value that exceeds the NAAQS are identified as potential maintenance receptors. This methodology considers the effects of inter-annual variability in ozone-conducive meteorology to identify sites that may have difficulty maintaining the ozone NAAQS. A projected maximum design value that exceeds the NAAQS indicates that when meteorology is conducive to ozone formation, the receptor struggles with maintenance of the standard. Under the CSAPR Update methodology, maintenance-only receptors therefore include both (1) those sites with projected average and maximum design values above the NAAQS that are currently measuring clean data and (2) those sites with projected average design values below the level of the NAAQS but with projected maximum design values of 71 ppb or greater.[8]

Considerations for Identifying Maintenance Receptors

The D.C. Circuit's decision in *North Carolina v. EPA* requires that EPA and the states identify separate nonattainment and maintenance receptors to give independent significance to the "contribute significantly" and "interfere with maintenance" clauses of the good neighbor provision when identifying downwind air quality problems that must be addressed.[9] In particular, the court held that the good neighbor provision requires states to address emissions that interfere with maintenance in downwind areas struggling to meet the NAAQS despite air quality modeling projecting attainment.[10] While the court did not specify a particular methodology for identifying downwind areas that would struggle to maintain the NAAQS, the court cited the state petitioner's demonstration regarding historic variability in ozone concentrations in areas otherwise projected to attain the NAAQS in support of its holding.[11]

In rules promulgated after *North Carolina*, EPA has relied on projections of base period maximum design values to identify those sites that are at risk of being nonattainment in the future due to inter-annual variability in ozone-conducive meteorology, as indicated above. EPA acknowledges that there may be other valid methodologies for identifying such areas. However, consistent with the holding in *North Carolina*, EPA believes that any alternative methods used to identify maintenance receptors must be different than those used to identify nonattainment receptors and should demonstrate that the alternative method considers variability in meteorological conditions that are conducive for ozone formation in the area containing the monitoring site.

[7] In determining compliance with the NAAQS, EPA truncates ozone design values to integer values. For example, EPA truncates a design value of 70.9 ppb to 70 ppb, which is attainment. Similarly, EPA considers design values at or above 71.0 ppb to be violations of the 2015 ozone NAAQS.
[8] The nonattainment receptors are also identified as maintenance receptors because the maximum design values for each of these sites is always greater than or equal to the average design value.
[9] 531 F.3d 896, 909-911 (2008).
[10] *Id.*
[11] *Id.* at 909.

Flexibilities Related to Identifying Maintenance Receptors

In response to comments received through stakeholder outreach, EPA has identified two potential flexibilities that states may use to identify maintenance receptors with an appropriate technical demonstration. First, EPA believes that states may, in some cases, eliminate a site as a maintenance receptor if the site is currently measuring clean data. Second, EPA believes that a state may, in some cases, use a design value from the base period that is not the maximum design value.[12] For either of these alternative methods to satisfy the D.C. Circuit's instruction to consider areas struggling to meet the NAAQS, EPA would expect states to include with their SIP demonstration technical analyses showing that:

(1) meteorological conditions in the area of the monitoring site were conducive to ozone formation during the period of clean data or during the alternative base period design value used for projections;
(2) ozone concentrations have been trending downward at the site since 2011 (and ozone precursor emissions of nitrogen oxide (NOx) and volatile organic compounds (VOC) have also decreased); and
(3) emissions are expected to continue to decline in the upwind and downwind states out to the attainment date of the receptor.

The intent of these analyses is to demonstrate that monitoring sites that would otherwise be identified as maintenance receptors under the CSAPR Update approach, as previously described, are not likely to violate the NAAQS in the future analytic year. EPA expects that, with such analyses, the state could justify exclusion of a monitoring site as a maintenance receptor, notwithstanding modeling projections showing a maximum design value exceeding the 2015 ozone NAAQS.

To assist states with the recommended analyses, EPA is providing the following information related to analyzing meteorological conduciveness and ozone and emissions trends:

(1) information on meteorological conduciveness for ozone formation based on regional and state-level historical and current climatological data for summertime monthly and seasonal temperature (*see* Attachment A);
(2) a data file containing ozone design values for individual monitoring sites nationwide for the years 2008 through 2017 and for 2023, based on EPA's modeling. This information is available on EPA's website at: *https://www.epa.gov/airmarkets/march-2018-memo-and-supplemental-information-regarding-interstate-transport-sips-2015-0*; and
(3) a data file containing state-level annual NOx and VOC emissions from anthropogenic sources with a breakout by major source category, for individual years from 2011 through 2017 and for 2023, based on EPA's projections. This information is available on EPA's website at:

[12] Stakeholder comments on potential 2015 NAAQS transport flexibilities can be found at *https://www.epa.gov/airmarkets/march-2018-memo-and-supplemental-information-regarding-interstate-transport-sips-2015*.

https://www.epa.gov/airmarkets/march-2018-memo-and-supplemental-information-regarding-interstate-transport-sips-2015-0.

States developing the technical analyses necessary to support use of the flexibilities described in this memo are encouraged to supplement EPA-provided information with additional data (as appropriate) to support a showing that a specific monitoring site is not at risk of exceeding the NAAQS in the future. For example, states may show that such a site should not be identified as a maintenance receptor by providing (1) a more refined analysis of meteorological conduciveness that considers additional relevant or more locally tailored meteorological parameters, (2) a more temporally or spatially refined emissions trends analysis, and/or (3) an analysis of historical ozone trends that considers, in addition to the design value, trends in other ozone metrics such as annual 4^{th} high 8-hour daily maximum ozone concentrations and the number of days with measured exceedances of the 2015 NAAQS.

Please share this information with the air agencies in your Region.

For Further Information

If you have any questions concerning this memorandum, please contact Norm Possiel at (919) 541-5692, *possiel.norm@epa.gov* for modeling information or Chris Werner at (919) 541-5133, *werner.christopher@epa.gov* for any other information.

Attachment

Attachment A

Information on Meteorological Conduciveness for Ozone Formation

Meteorological conditions including temperature, humidity, winds, solar radiation, and vertical mixing affect the formation and transport of ambient ozone concentrations. Ozone is more readily formed on warm, sunny days when the air is stagnant and/or when the winds are favorable for transport from upwind source areas. Conversely, ozone production is more limited on days that are cloudy, cool, rainy, and windy (*http://www.epa.gov/airtrends/weather.html*). Statistical modeling analyses have shown that temperature and certain other meteorological variables are highly correlated with the magnitude of ozone concentrations (Camalier, et al., 2007).[1] The overall extent to which meteorological conditions vary from year-to-year (*i.e.*, inter-annual variability) depends on the nature of large scale meteorological drivers such as the strength and position of the jet stream. Inter-annual cycles in the jet stream contribute to inter-annual variability in the degree to which summertime meteorological conditions are favorable for ozone formation within a particular region. Meteorological conditions that frequently correspond with observed 8-hour daily maximum concentrations greater than the National Ambient Air Quality Standards (NAAQS) are referred to as being conducive to ozone formation.

This attachment contains information to help evaluate whether particular summers had ozone-conducive or unconducive meteorology within the 10-year period 2008 through 2017. Information is provided on a state-by-state basis and for individual regions (*see* Figure 1).

- Table A-1 contains tabular summaries of the difference (*i.e.*, anomaly[2]) of monthly average temperature compared to the long-term average.[3]
- Figure A-2 contains maps of the 3-month (June, July, August) statewide anomalies and rank[4] for average temperature compared to the long-term average.
- Figure A-3 contains maps showing spatial fields of daily maximum temperature anomalies (percentiles) for the period June through August for the years 2011 through 2017 (maps are unavailable for years prior to 2011).
- Figure A-4 contains graphical summaries of the total number of cooling degree days for the 3-month period June through August in each region.

The above tabular and graphic information was obtained from the NOAA National Centers for Environmental Information (NCEI) at *https://www.ncdc.noaa.gov/temp-and-precip/us-maps/* and *https://www.ncdc.noaa.gov/cag/.*

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[1] Additional references related to ozone formation and meteorology are provided on page A-3.

[2] "The term temperature anomaly means a departure from a reference value or long-term average. A positive anomaly indicates that the observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value." *https://www.ncdc.noaa.gov/monitoring-references/faq/anomalies.php*.

[3] Note that because of the relatively large inter-annual variability in certain meteorological conditions such as temperature and precipitation, long-term "average" conditions, usually referred to as "normal," are often the mathematical mean of extremes and thus, "average" or "normal" values of temperature or precipitation should not necessarily be considered as representing "typical" conditions.

[4] "In order to place each month and season into historical context, the National Centers for Environmental Information assigns ranks for each geographic area (division, state, region, etc.) based on how the temperature or precipitation value compares with other values throughout the entire record when sorted from lowest to highest value. In other words, the numeric rank value within the area represents the position or location of the sorted value throughout the historical record (1895-present)." *https://www.ncdc.noaa.gov/monitoring-references/dyk/ranking-definition*.

In general, below average temperatures are an indication that meteorological conditions are unconducive for ozone formation, whereas above average temperatures are an indication that meteorology is conducive to ozone formation. Within a particular summer season, the degree that meteorology is conducive for ozone formation can vary from region to region and fluctuate with time within a particular region. For example, the temperature-related information presented below suggests that summer meteorology was generally conducive for ozone formation in 2010, 2011, 2012, and 2016 in most regions. In contrast, the summer of 2009 was generally unconducive for ozone formation, overall, in most regions. In addition, the summers of 2013 and 2014 were not particularly conducive for ozone formation in the Upper Midwest, Ohio Valley, South, Southeast.

Additional information on the relationships between ozone and meteorological conditions can be found in the following publications:

Blanchard et al., 2010 - *NMOC, ozone, and organic aerosol in the southeastern United States, 1999-2007: 2. Ozone trends and sensitivity to NMOC emissions in Atlanta, GA.*
Reinforces the relationship between temperature, relative humidity and winds to ozone formation.
https://www.sciencedirect.com/science/article/pii/S1352231010005996?via%3Dihub

Blanchard et al., 2014 - *Ozone in the southeastern United States: An observation-based model using measurements from the SEARCH network.*
Update to the 2007 paper by Camalier with data from the SEARCH network from 2002-2011.
https://www.sciencedirect.com/science/article/pii/S1352231014001022?via%3Dihub

Bloomer et al., 2009 – *Observed relationships of ozone air pollution with temperature and emissions.*
Statistical analysis of 21 years of ozone and temperature data (1987-2008). From a climate scenario perspective, authors examine the climate penalty or how ozone levels change as temperature changes. Reinforces the standing that as temperature increases, ozone concentrations increase, but indicates that due to decreasing emissions, the rate is slower in future scenarios.
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2009GL037308

Kavassalis & Murphy, 2017 - *Understanding ozone-meteorology correlations: A role for dry deposition.*
Authors observe the strong correlation between temperature and relative humidity, but work to understand other reasoning why models under predict the strength of the correlation between relative humidity and ozone. Includes a statistical analysis of 28 years of data and examines vapor pressure deficit and dry deposition as factors. Reinforces meteorological conditions that lead to high ozone days.
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016GL071791

Reddy & Pfister, 2016 - *Meteorological Factors contributing to the interannaul variability of midsummer surface ozone in Colorado, Utah, and other western US States.*

Authors found strong correlation between 500-mb and 7008-mb patterns, surface temperature, and zonal winds with the resulting high 8-hour daily maximum ozone values.
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015JD023840

Tawfik and Steiner, 2013 - *A proposed physical mechanism for ozone-meteorology correlations using land-atmosphere coupling regimes.*
Discusses the north-south gradient of temperature and relative humidity correlations with ozone formation. Examines 17 years of ozone, NOx, and isoprene measurements.
https://linkinghub.elsevier.com/retrieve/pii/S1352231013001672

White et al., 2007 - *Comparing the impact of meteorological variability on surface ozone during the NEAQS (2002) and ICARTT (2004) field campaigns.*
Authors found that while deep boundary layers are noted during periods of elevated ozone, this is likely due to being coincident with other meteorological factors (high temperatures, high pressure systems, low winds).
https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2006JD007590

Zhang et al., 2017 – *Quantifying the relationship between air pollution events and extreme weather events.*
Authors examined ozone from 1980-2009 and built a statistical model to examine the impacts of extreme meteorological events on extreme air quality conditions. Found ozone extremes have decreased over the last 30 years, more rapidly recently, but remain highly correlated to extreme temperature events. Highest correlation was found in the eastern United States (U.S.).
https://www.sciencedirect.com/science/article/pii/S0169809516306093?via%3Dihub

Figure 1. U.S. climate regions.
http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-regions.php

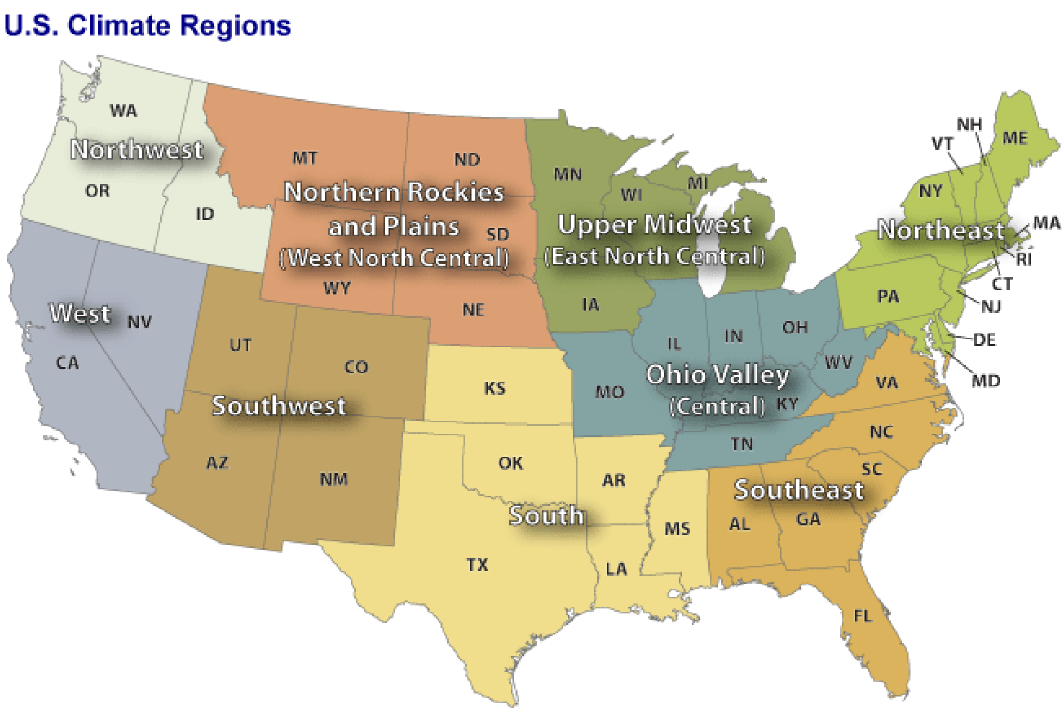


Table A-1. Temperature anomalies by month for May through September for each climate region for the years 2008 through 2017.[1]

2008	May	Jun	Jul	Aug	Sep
Northeast	C	W	W	C	N
Southeast	C	WW	N	C	N
Ohio Valley	C	W	C	C	N
Upper Midwest	C	N	N	N	W
South	N	W	N	C	CC
Northern Rockies	C	C	N	N	N
Southwest	N	W	W	W	N
Northwest	N	N	W	W	N
West	N	W	W	WW	W

[1]Unshaded boxes with the "N" marker represent near-normal temperatures that fall within the interquartile range. Blue colors indicate cooler than normal conditions, with the number of "C"s indicating the degree of the anomaly. CCC = coolest on record, CC = coolest 10th percentile, C = coolest 25th percentile. Red colors indicate warmer than normal conditions, with the number of "W"s indicating the degree of the anomaly. WWW = warmest on record, WW = warmest 10th percentile, W = warmest 25th percentile. N/A = data not available. More on the definition of temperature ranks can be found at: *https://www.ncdc.noaa.gov/monitoring-content/monitoring-references/dyk/images/ranking-definition-legend.png.*

2009	May	Jun	Jul	Aug	Sep
Northeast	N	C	CC	W	C
Southeast	N	W	CC	N	N
Ohio Valley	N	W	CC	C	N
Upper Midwest	N	C	CC	C	W
South	N	W	N	N	C
Northern Rockies	N	C	C	C	WW
Southwest	WW	C	W	W	W
Northwest	W	C	WW	W	WW
West	WW	C	W	N	WWW

2010	May	Jun	Jul	Aug	Sep
Northeast	WW	W	WW	W	W
Southeast	WW	WW	WW	WW	W
Ohio Valley	W	WW	W	WW	N
Upper Midwest	W	N	W	WW	C
South	W	WW	N	WW	W
Northern Rockies	C	N	N	W	N
Southwest	C	W	W	W	WWW
Northwest	CC	C	N	N	W
West	CC	W	W	N	W

2011	May	Jun	Jul	Aug	Sep
Northeast	W	W	WW	N	WW
Southeast	N	WW	WW	WW	N
Ohio Valley	N	W	WW	W	C
Upper Midwest	N	N	WW	W	N
South	N	WW	WWW	WWW	N
Northern Rockies	C	N	W	W	W
Southwest	C	W	WW	WWW	W
Northwest	CC	C	C	W	WW
West	C	C	N	W	WW

2012	May	Jun	Jul	Aug	Sep
Northeast	WW	N	WW	W	N
Southeast	WW	C	WW	N	N
Ohio Valley	WW	N	WW	N	C
Upper Midwest	W	W	WW	N	N
South	WW	W	WW	N	N
Northern Rockies	W	W	WW	W	W
Southwest	WW	WW	W	WW	W
Northwest	N	C	W	WW	W
West	W	W	N	WWW	WW

2013	May	Jun	Jul	Aug	Sep
Northeast	W	W	WW	N	N
Southeast	C	W	C	C	N
Ohio Valley	N	N	C	C	N
Upper Midwest	N	N	N	N	W
South	C	W	C	N	W
Northern Rockies	N	N	N	W	WW
Southwest	W	WW	W	W	W
Northwest	W	W	WW	WW	WW
West	W	WW	WW	N	W

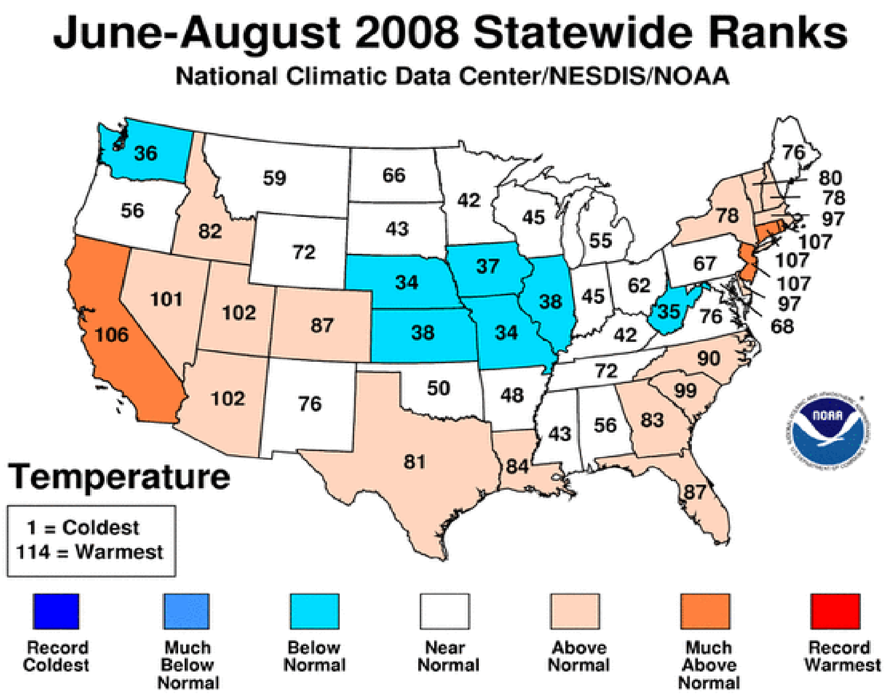
2014	May	Jun	Jul	Aug	Sep
Northeast	W	W	N	N	W
Southeast	W	W	C	N	W
Ohio Valley	N	W	CC	N	N
Upper Midwest	N	W	CC	N	N
South	N	N	C	N	N
Northern Rockies	N	C	N	N	N
Southwest	N	W	W	C	WW
Northwest	W	N	WW	W	W
West	W	W	WW	N	WW

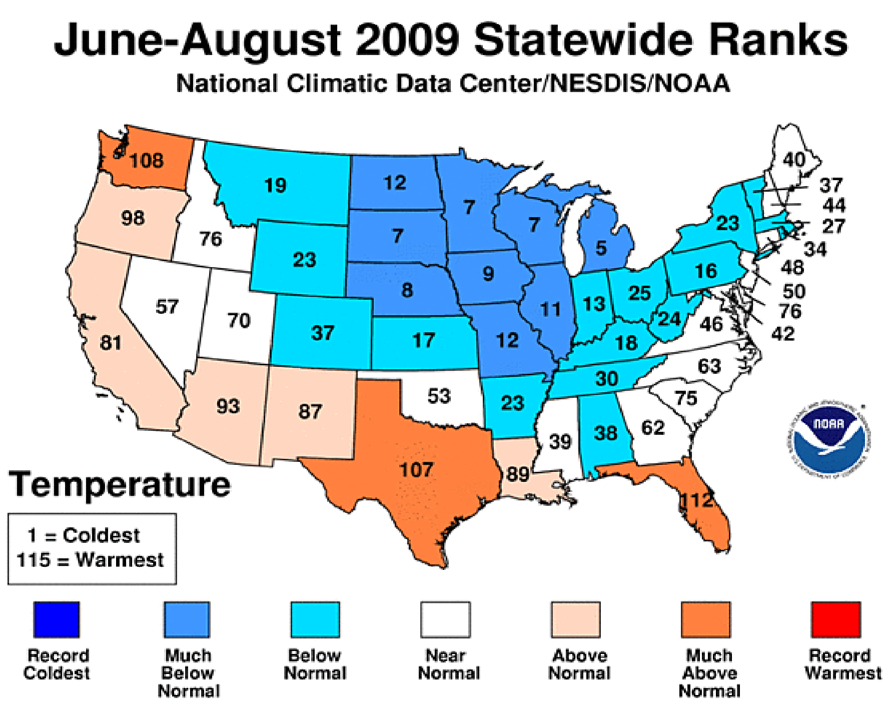
2015	May	Jun	Jul	Aug	Sep
Northeast	WWW	N	N	W	WW
Southeast	W	WW	W	N	N
Ohio Valley	W	W	N	C	W
Upper Midwest	N	N	N	N	WWW
South	C	N	W	N	WW
Northern Rockies	C	WW	N	N	WW
Southwest	C	WW	C	WW	WWW
Northwest	W	WWW	W	W	N
West	N	WWW	C	WW	WW

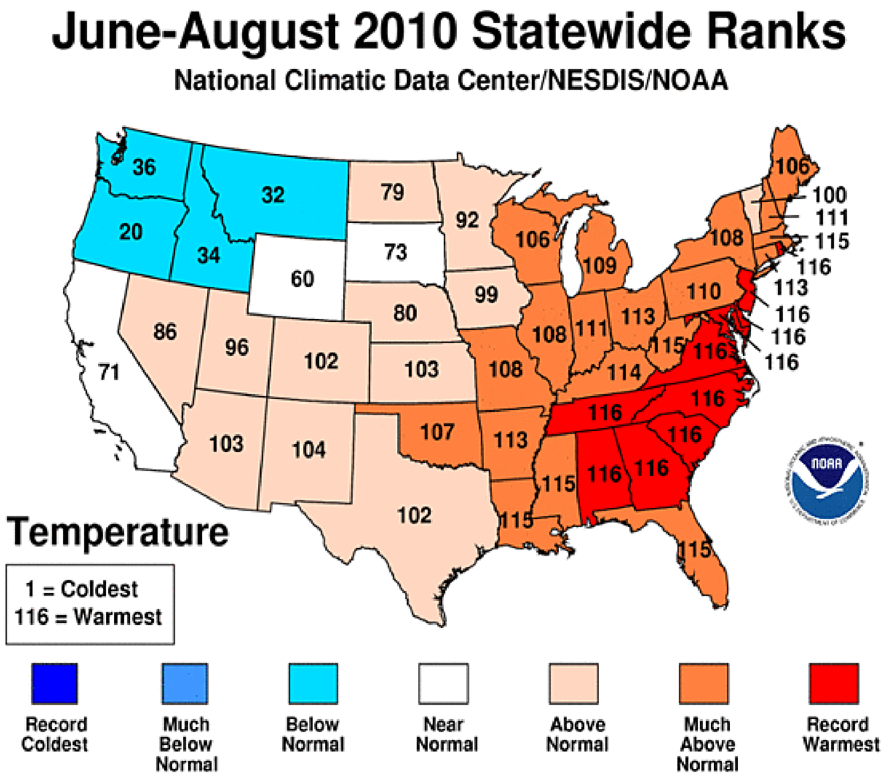
2016	May	Jun	Jul	Aug	Sep
Northeast	N	W	W	WWW	WW
Southeast	N	W	WW	WW	WW
Ohio Valley	N	W	W	W	WW
Upper Midwest	N	W	N	W	WW
South	C	W	WW	N	W
Northern Rockies	N	WW	N	N	W
Southwest	C	WWW	WW	N	N
Northwest	W	WW	C	W	N
West	N	WW	W	W	N

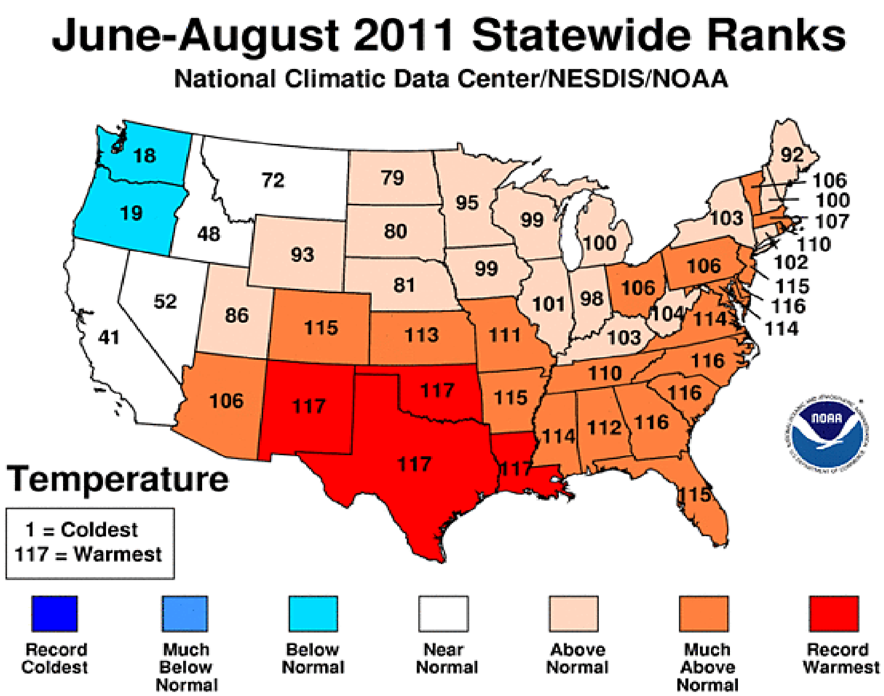
2017	May	Jun	Jul	Aug	Sep
Northeast	N	W	N	N	WW
Southeast	N	N	W	N	N
Ohio Valley	N	N	W	CC	N
Upper Midwest	N	W	N	C	WW
South	C	N	W	C	N
Northern Rockies	N	W	WW	N	W
Southwest	N	WW	WW	W	W
Northwest	W	W	WW	WWW	W
West	W	WW	WW	WW	N

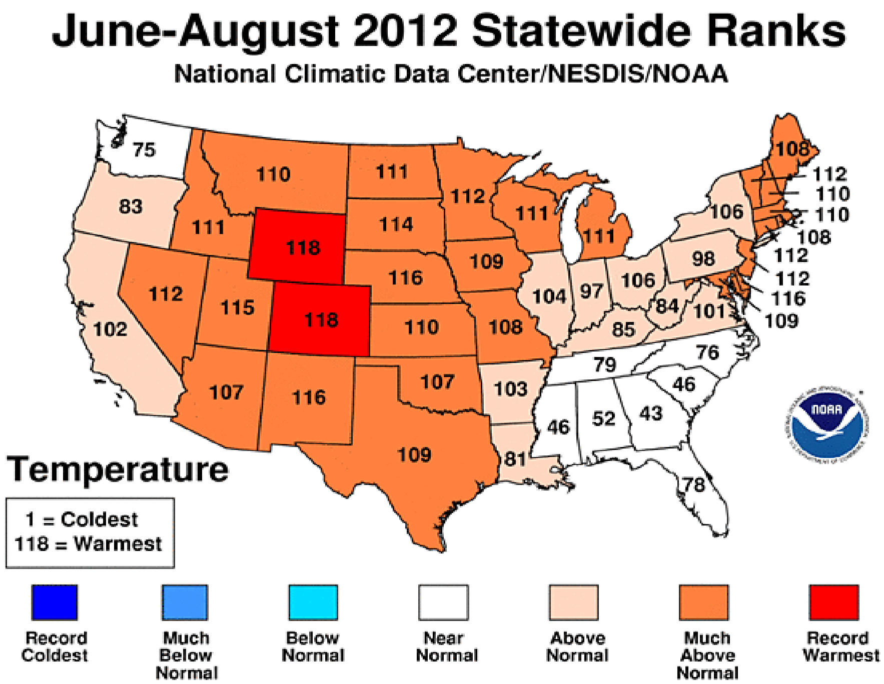
Figure A-2. Statewide average temperature ranks for the period June through August for the years 2008 through 2017. Note that the NCEI changed the display format of temperature rank maps beginning in 2014.

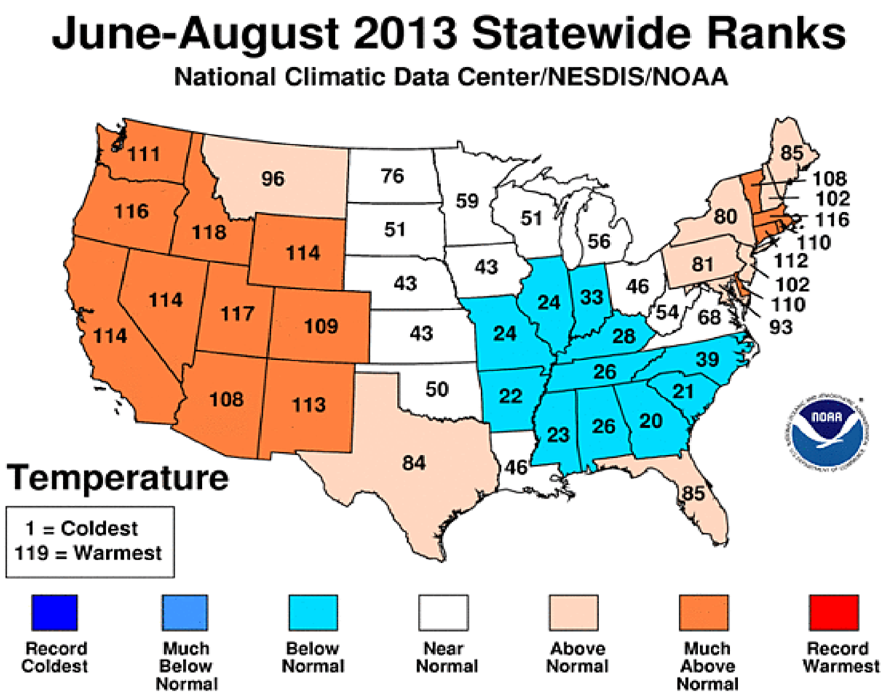


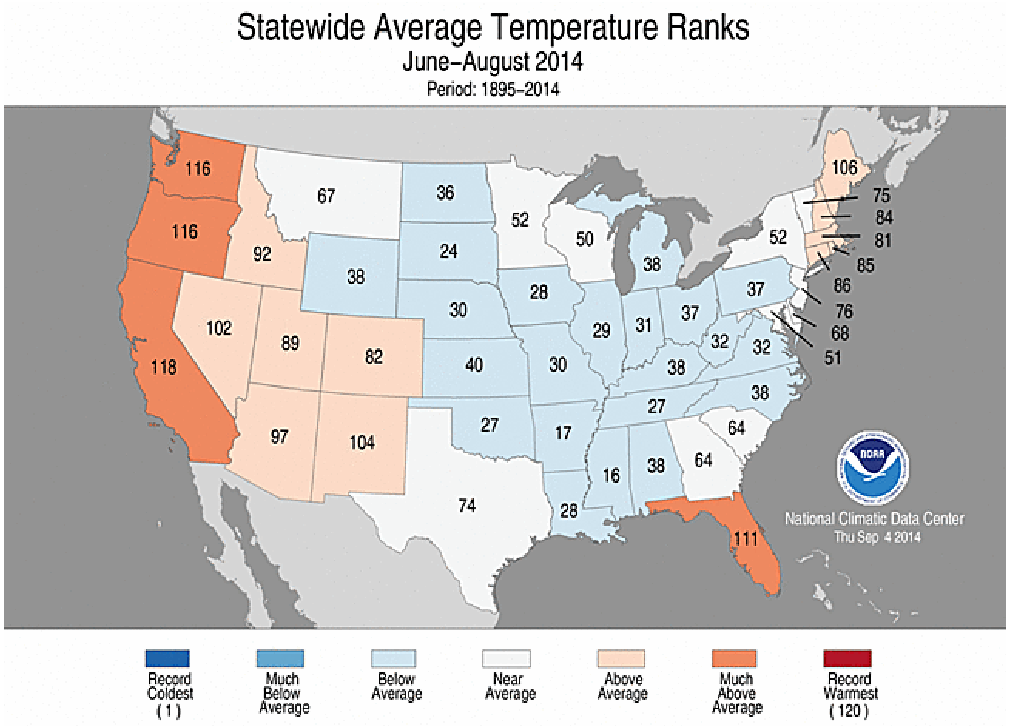


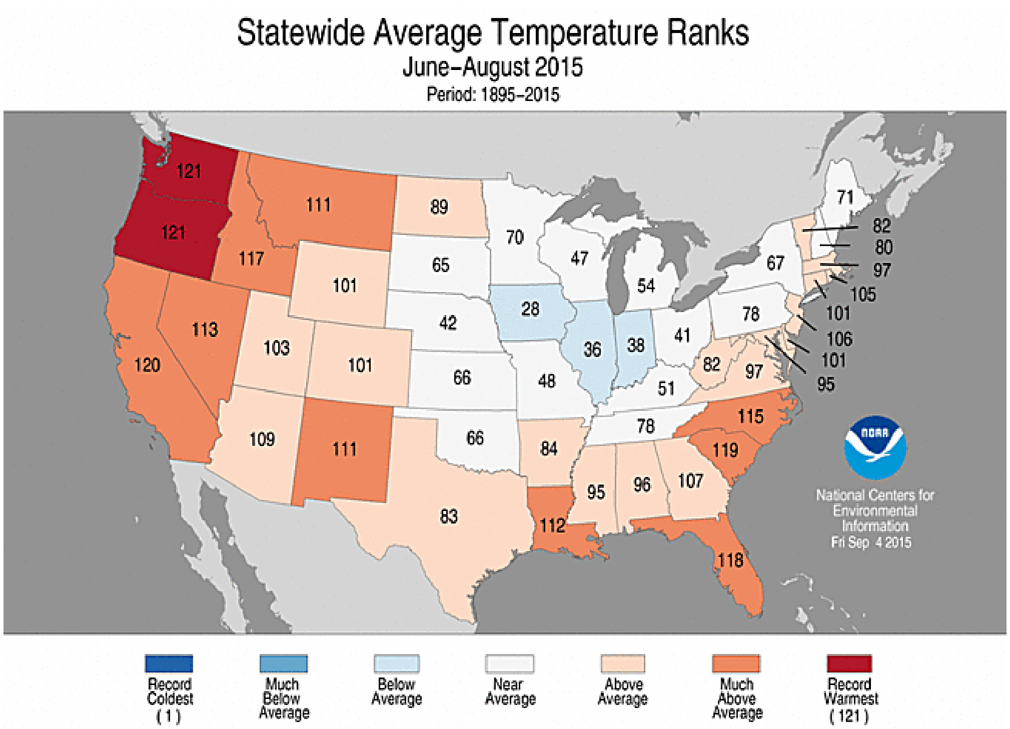

June-August 2010 Statewide Ranks
National Climatic Data Center/NESDIS/NOAA
Temperature
1 = Coldest
116 = Warmest
Record Coldest
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Warmest

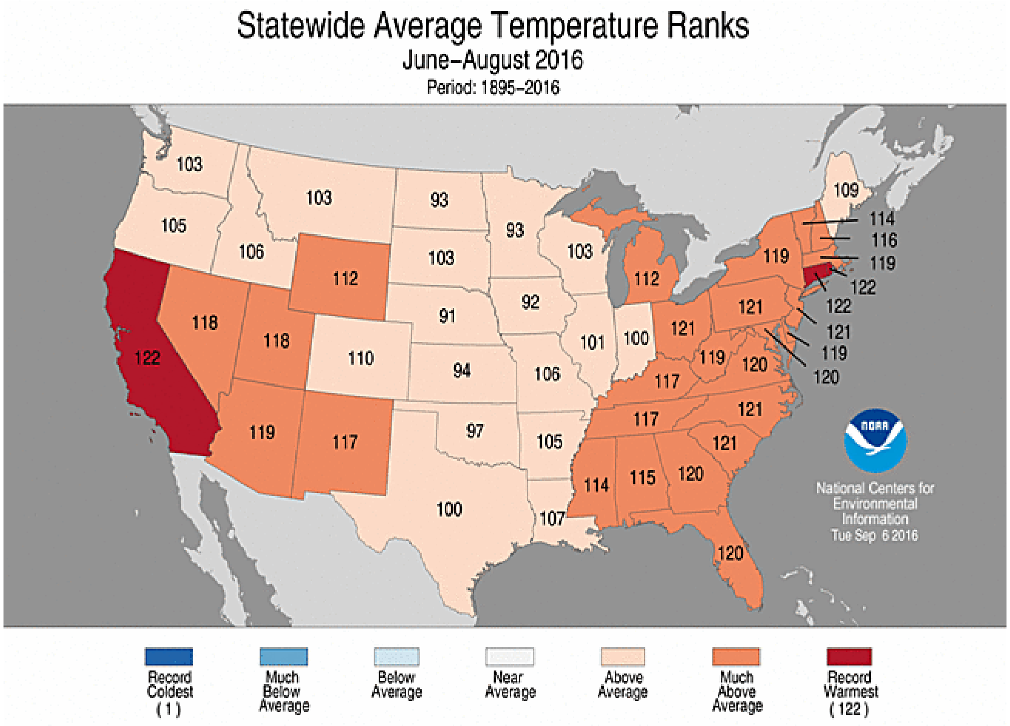

June-August 2011 Statewide Ranks
National Climatic Data Center/NESDIS/NOAA
Temperature
1 = Coldest
117 = Warmest
Record Coldest
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Warmest


June-August 2012 Statewide Ranks
National Climatic Data Center/NESDIS/NOAA
Temperature
1 = Coldest
118 = Warmest
Record Coldest
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Warmest


June-August 2013 Statewide Ranks
National Climatic Data Center/NESDIS/NOAA
Temperature
1 = Coldest
119 = Warmest
Record Coldest
Much Below Normal
Below Normal
Near Normal
Above Normal
Much Above Normal
Record Warmest


Statewide Average Temperature Ranks
June–August 2014
Period: 1895–2014
116
67
36
52
50
106
75
84
81
116
92
24
38
52
85
38
28
37
86
30
31
37
76
102
89
29
32
32
68
118
82
40
30
38
51
38
27
27
17
64
97
104
16
38
64
74
28
111
National Climatic Data Center
Thu Sep 4 2014
Record Coldest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest (120)


Statewide Average Temperature Ranks
June–August 2015
Period: 1895–2015
121
111
89
71
121
70
82
117
65
47
67
80
101
54
97
28
105
42
78
101
113
36
38
41
106
103
120
101
66
48
82
97
101
51
95
78
115
109
111
66
84
119
95
96
107
83
112
118
National Centers for Environmental Information
Fri Sep 4 2015
Record Coldest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest (121)


Statewide Average Temperature Ranks
June–August 2016
Period: 1895–2016
103
103
93
105
106
112
103
93
103
112
109
114
116
119
122
122
121
119
120
119
121
121
119
120
117
117
121
121
118
118
122
110
91
92
94
106
101
100
119
117
97
105
114
115
120
100
107
120
National Centers for Environmental Information
Tue Sep 6 2016
Record Coldest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest (122)

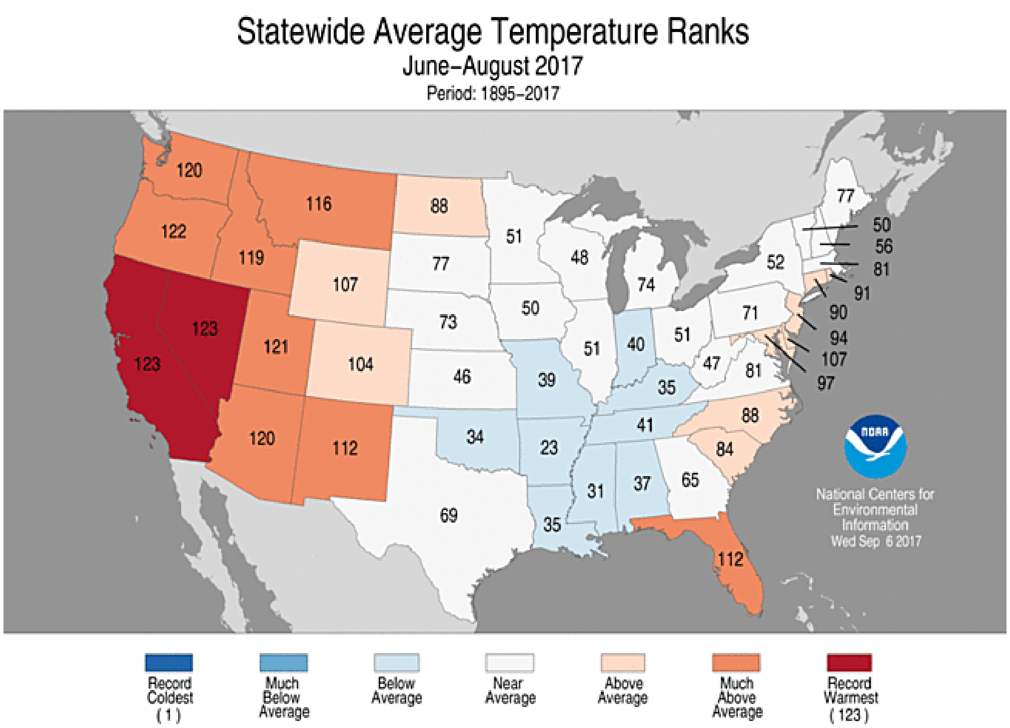
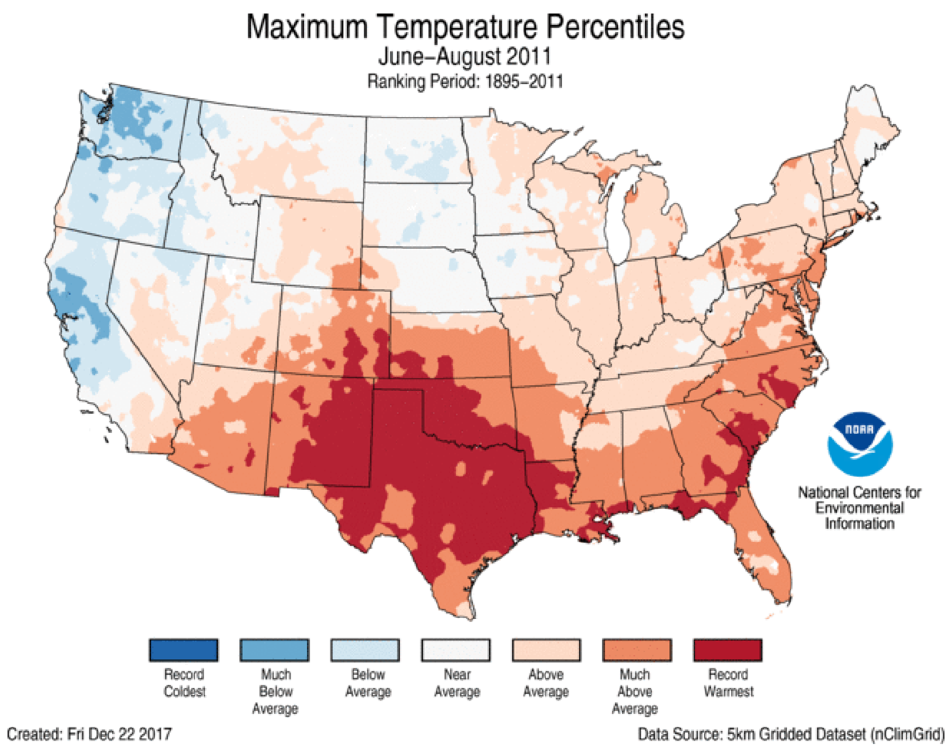
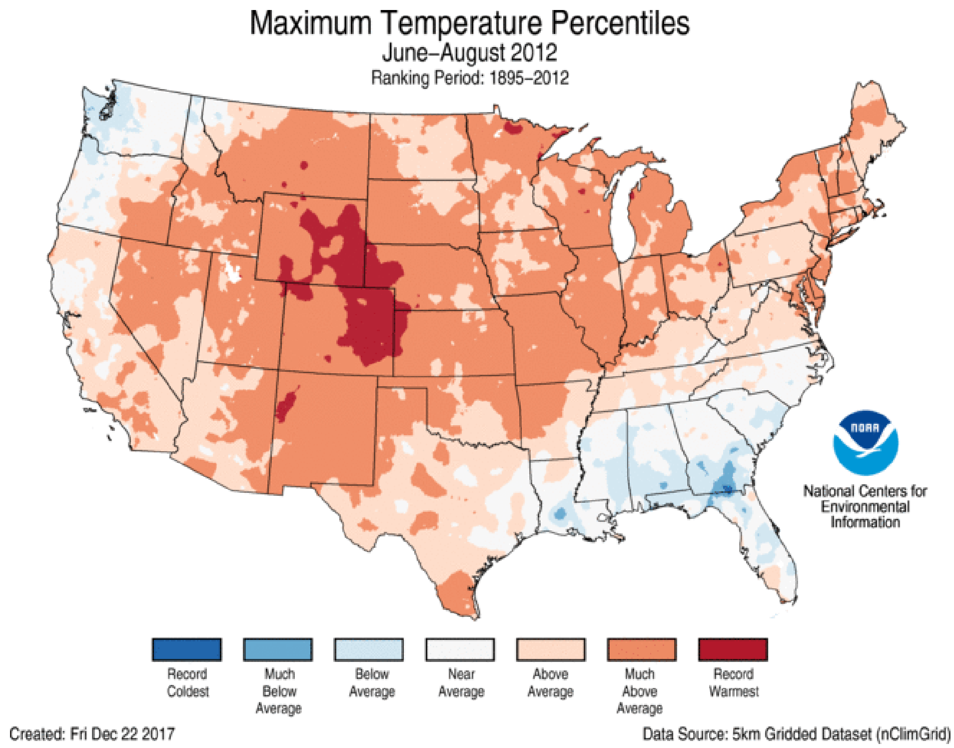
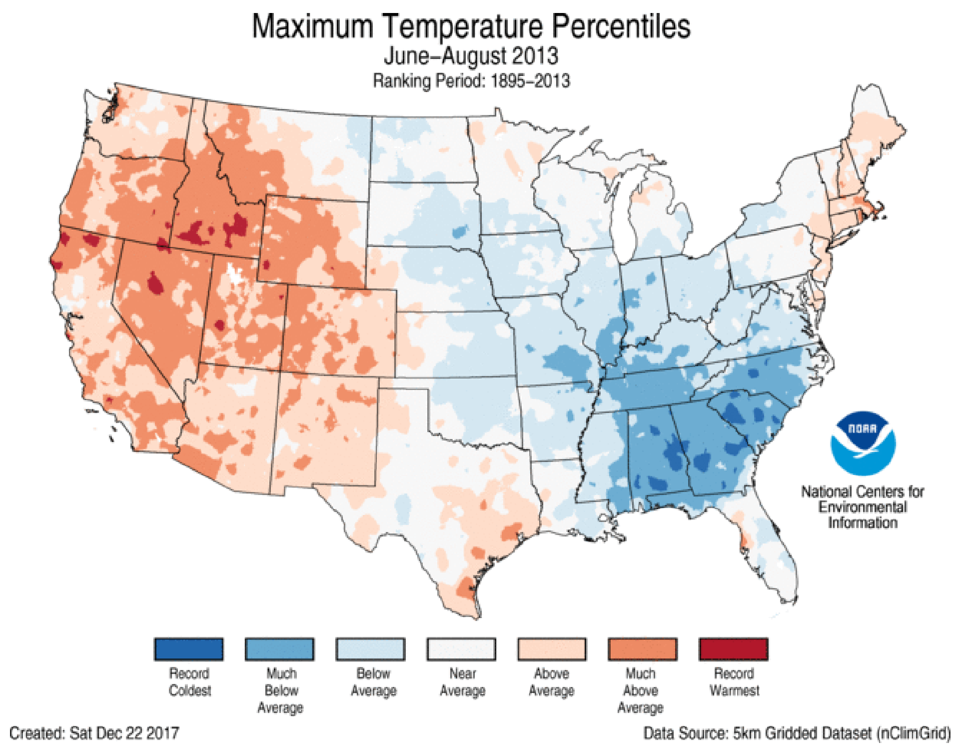
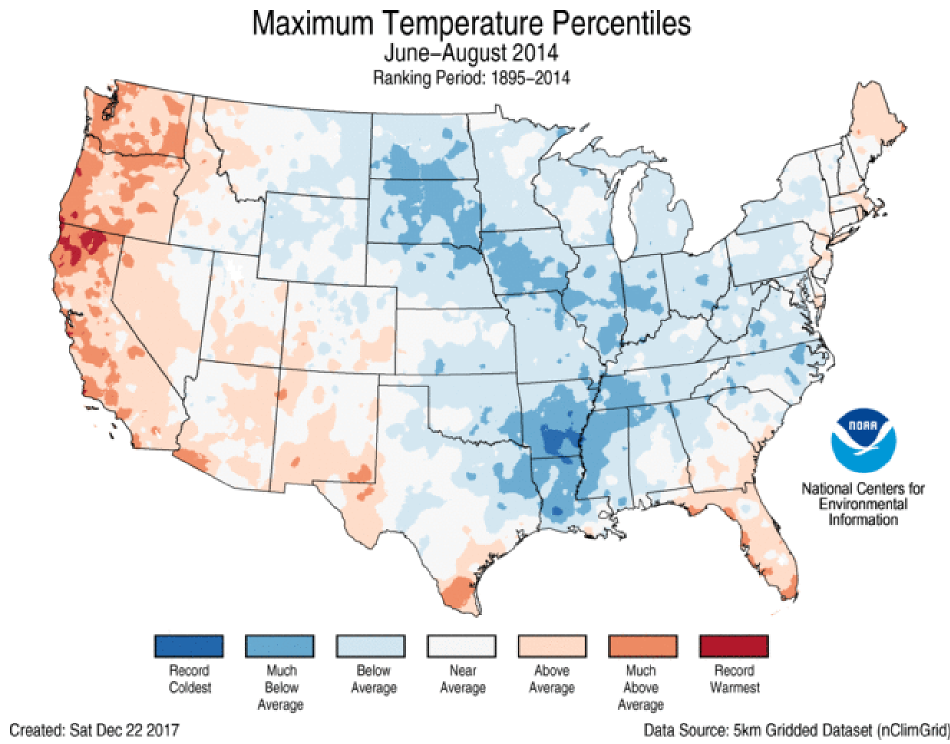

Statewide Average Temperature Ranks
June–August 2017
Period: 1895–2017
120
116
88
122
119
51
48
77
107
74
52
77
50
56
81
91
90
94
107
97
123
123
121
104
73
50
51
40
51
71
46
39
47
81
35
34
23
41
88
84
120
112
31
37
65
69
35
112
National Centers for Environmental Information
Wed Sep 6 2017
Record Coldest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest (123)

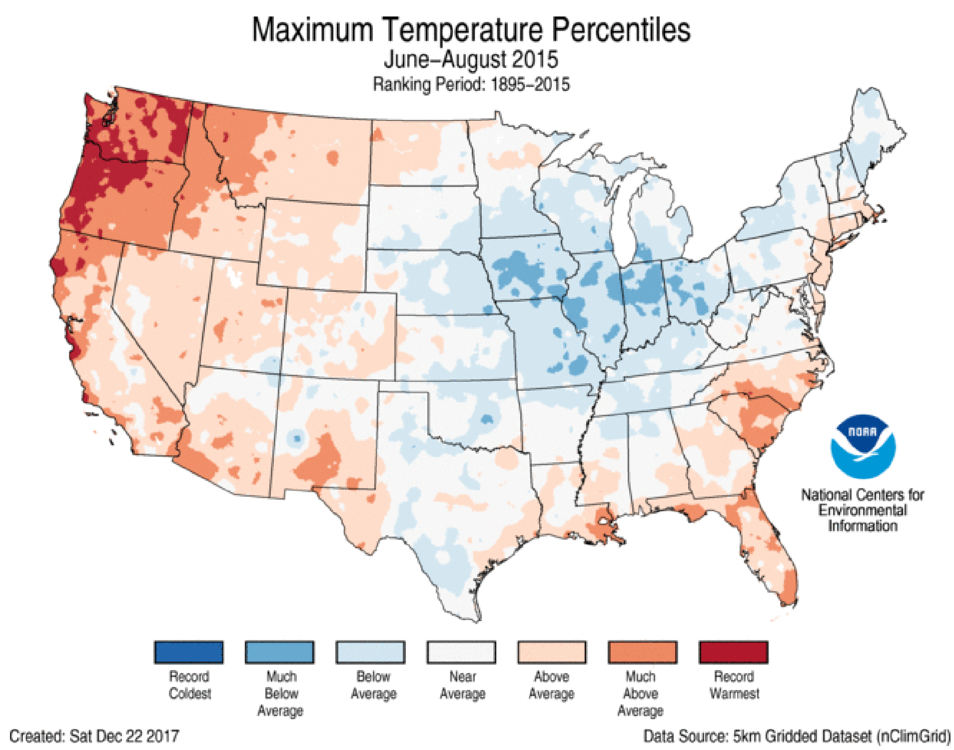
Figure A-3. Spatial fields of daily maximum temperature anomalies (percentiles) for the period June through August for the years 2011 through 2017. Note that the NCDC began creating these maps in 2011.

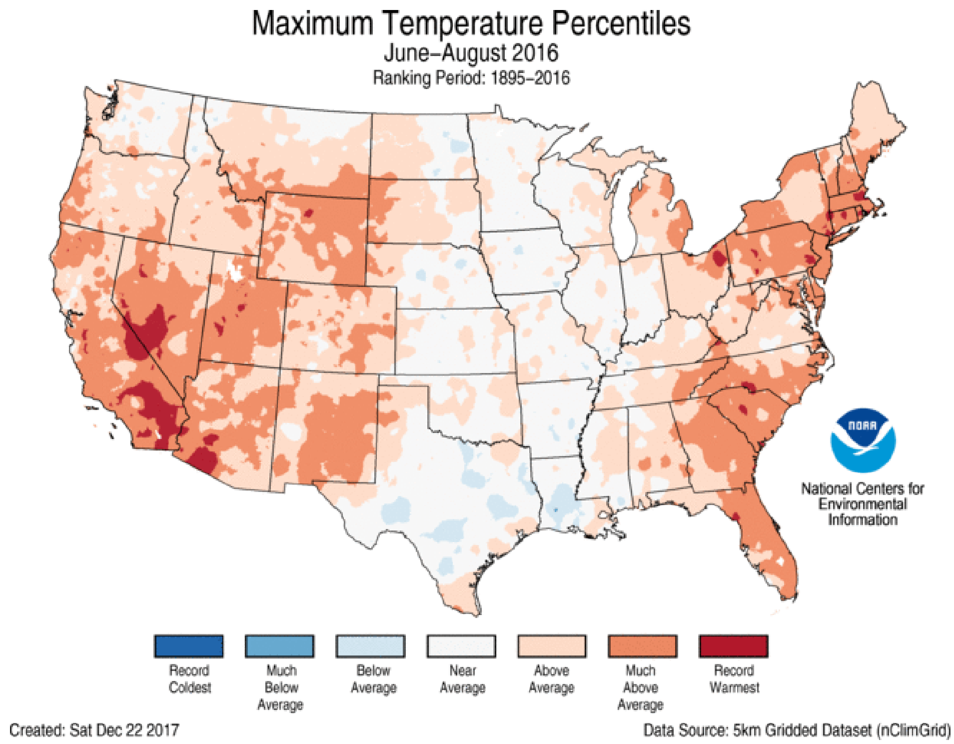



Maximum Temperature Percentiles
June–August 2012
Ranking Period: 1895–2012
National Centers for Environmental Information
Record Coldest
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest
Created: Fri Dec 22 2017
Data Source: 5km Gridded Dataset (nClimGrid)


Maximum Temperature Percentiles
June–August 2013
Ranking Period: 1895–2013
National Centers for Environmental Information
Record Coldest
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest
Created: Sat Dec 22 2017
Data Source: 5km Gridded Dataset (nClimGrid)


Maximum Temperature Percentiles
June–August 2014
Ranking Period: 1895–2014
National Centers for Environmental Information
Record Coldest
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest
Created: Sat Dec 22 2017
Data Source: 5km Gridded Dataset (nClimGrid)


Maximum Temperature Percentiles
June–August 2015
Ranking Period: 1895–2015
National Centers for Environmental Information
Record Coldest
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest
Created: Sat Dec 22 2017
Data Source: 5km Gridded Dataset (nClimGrid)


Maximum Temperature Percentiles
June–August 2016
Ranking Period: 1895–2016
National Centers for Environmental Information
Record Coldest
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest
Created: Sat Dec 22 2017
Data Source: 5km Gridded Dataset (nClimGrid)

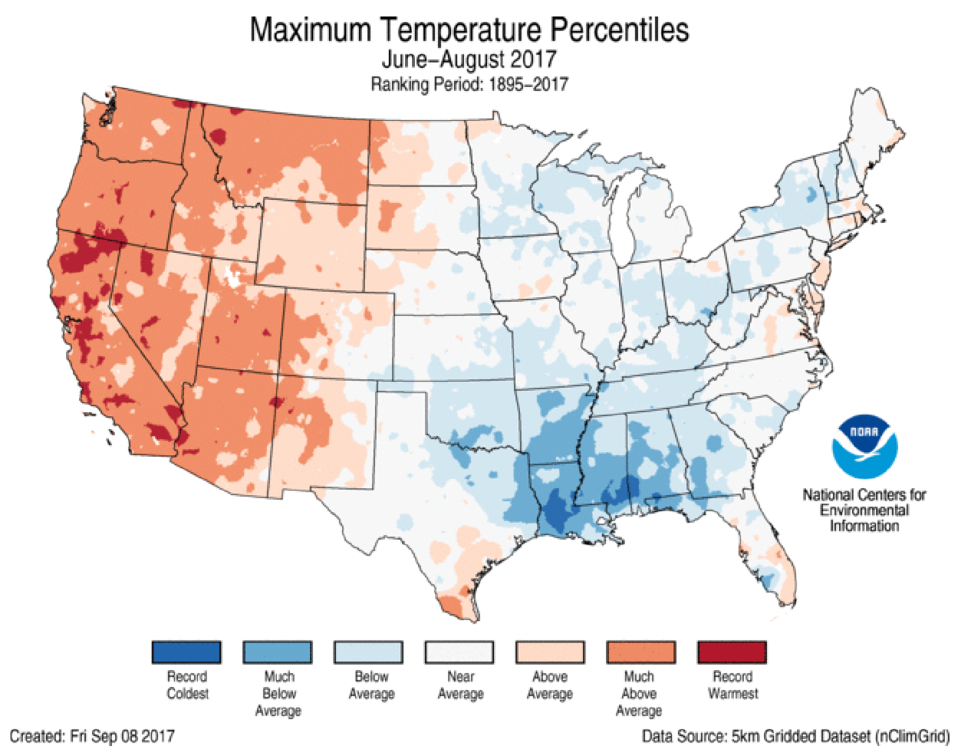
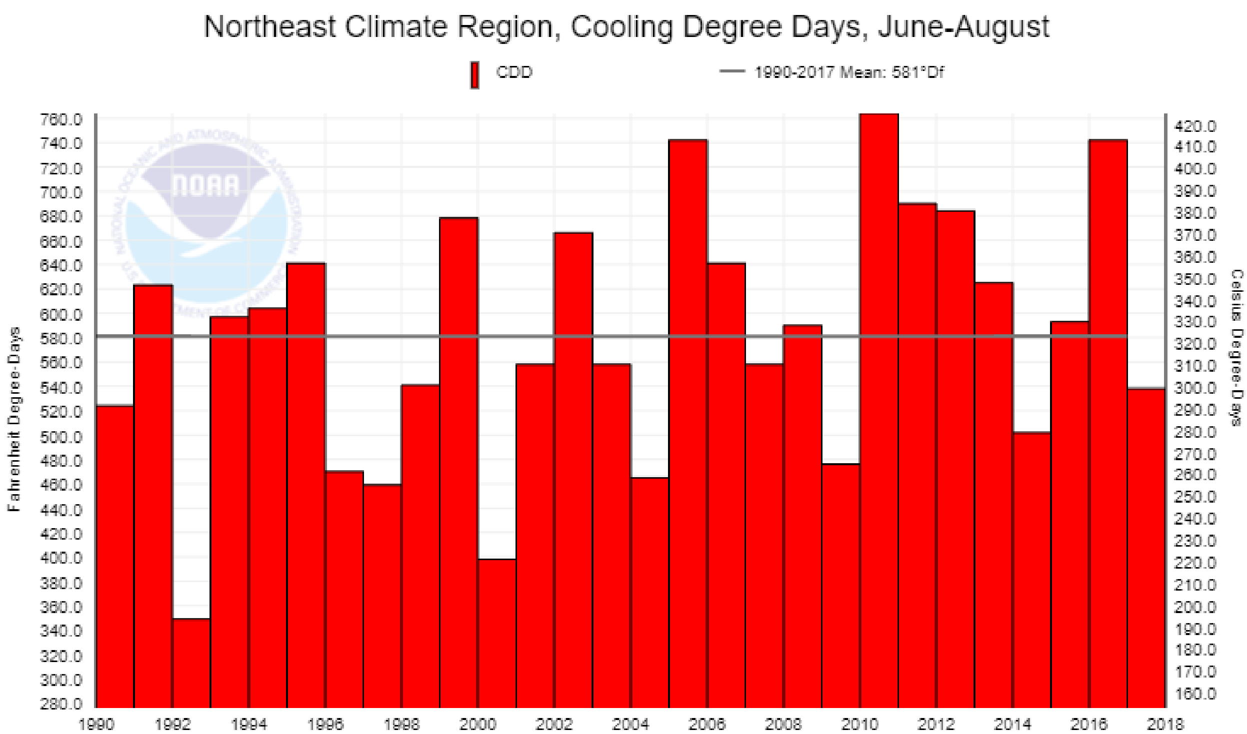
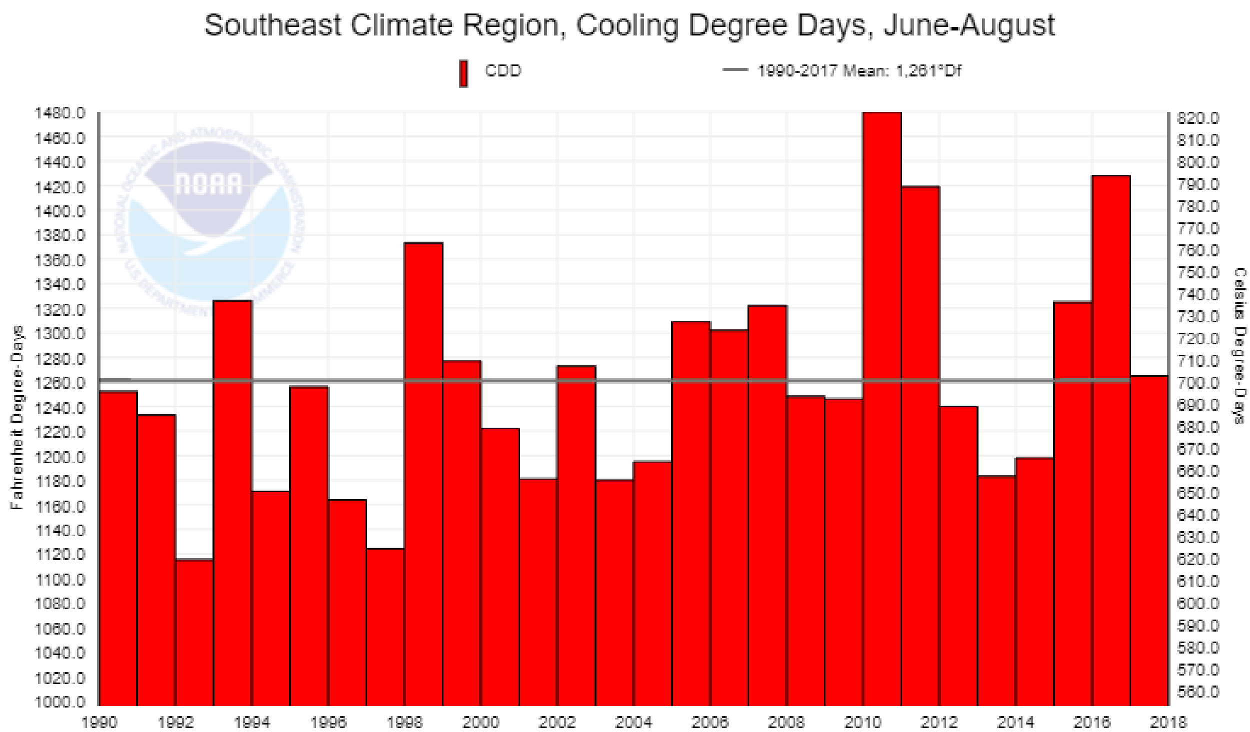
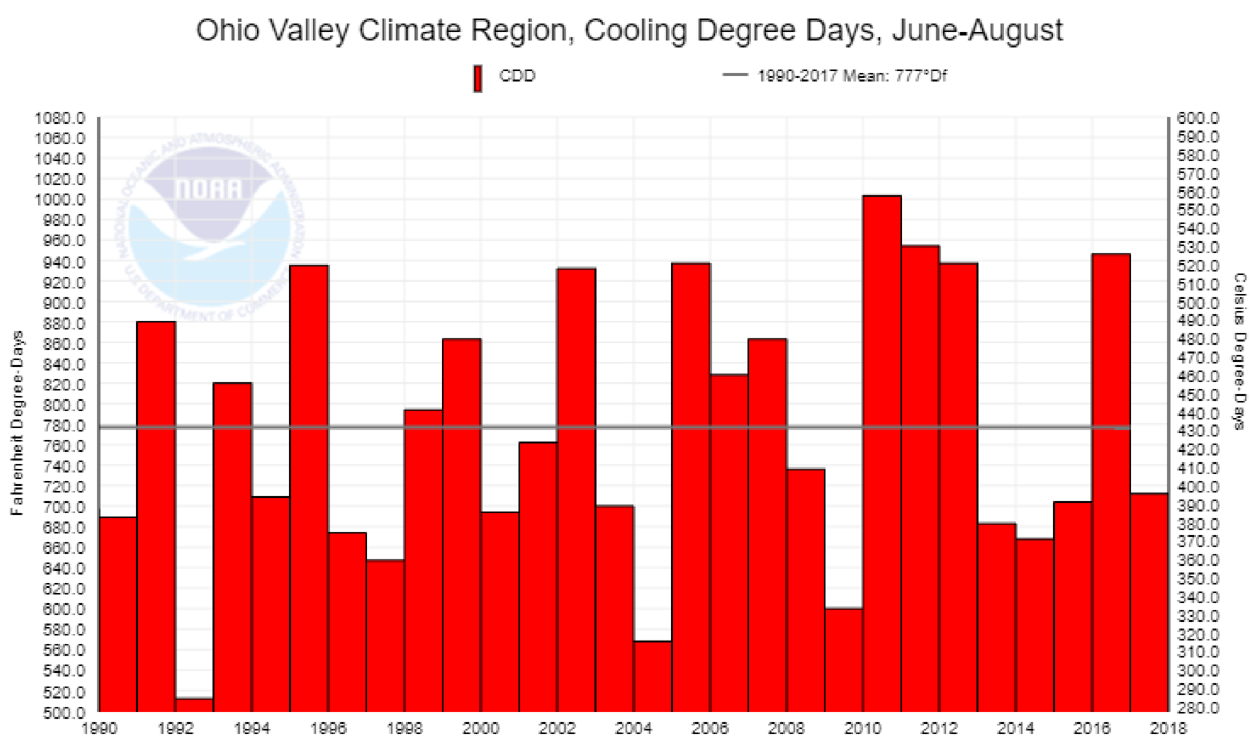

Maximum Temperature Percentiles
June–August 2017
Ranking Period: 1895–2017
National Centers for Environmental Information
Record Coldest
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Warmest
Created: Fri Sep 08 2017
Data Source: 5km Gridded Dataset (nClimGrid)

Figure A-4. Cooling degree days for June through August for each climate region. Note that (1) data are provided back to 1990 and (2) the range of the y-axis differs in some cases by climate region.

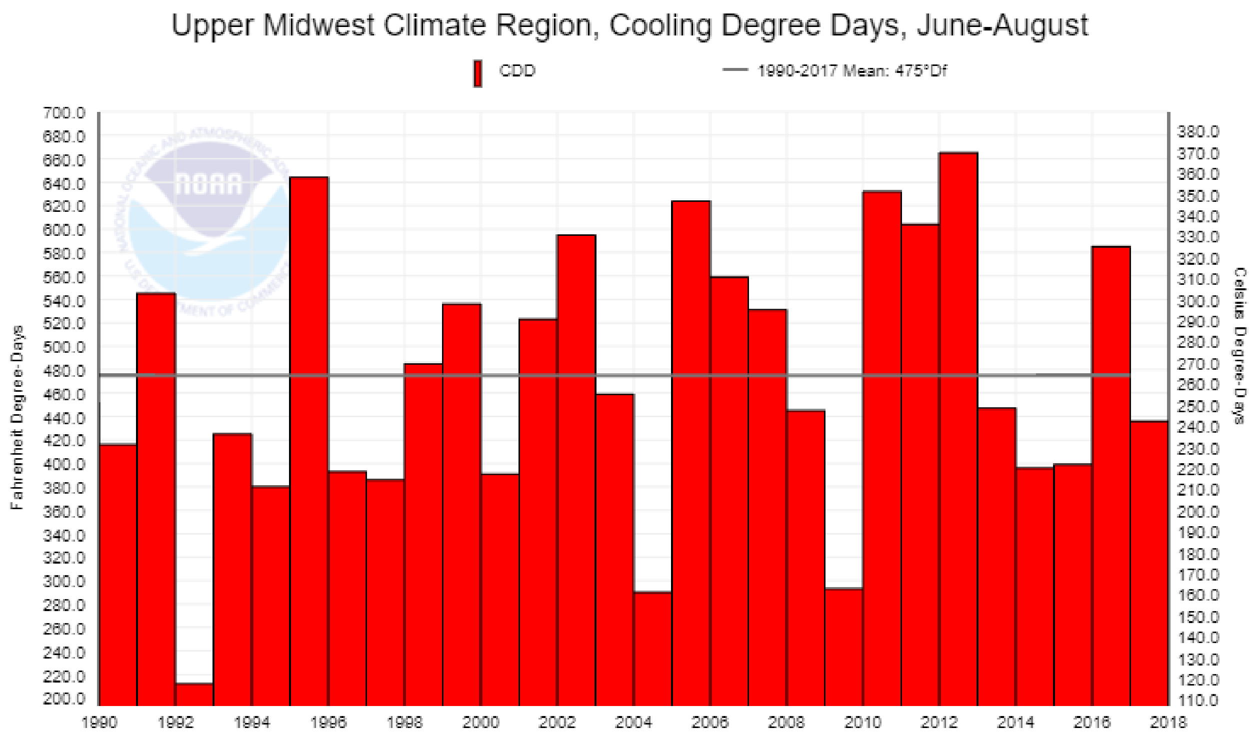


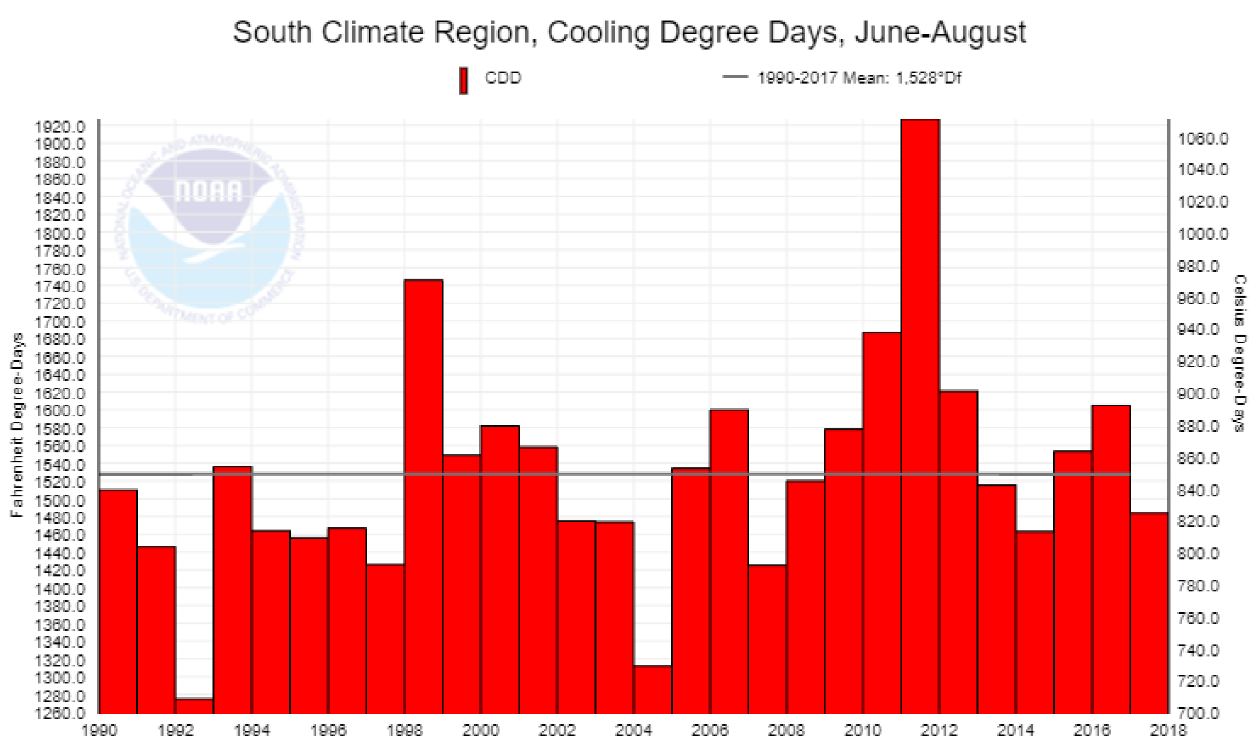


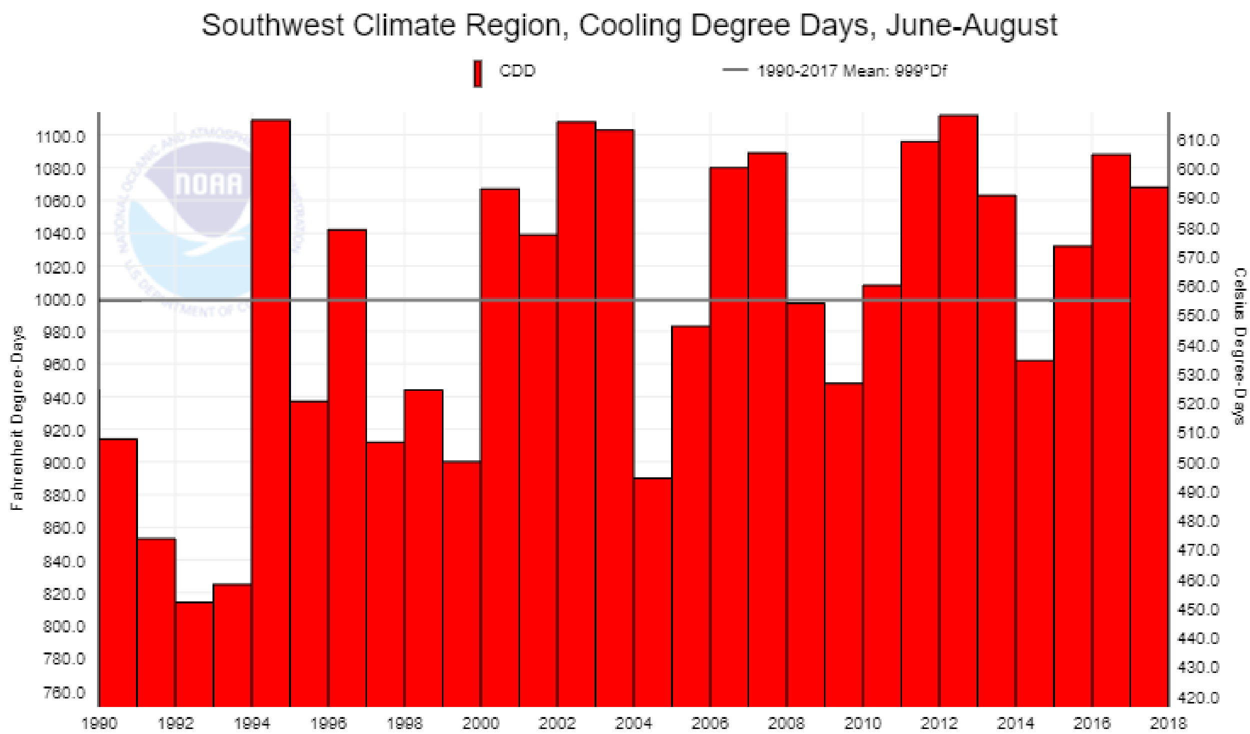
Southeast Climate Region, Cooling Degree Days, June-August
CDD
1990-2017 Mean: 1,261°Df
Fahrenheit Degree-Days
Celsius Degree-Days



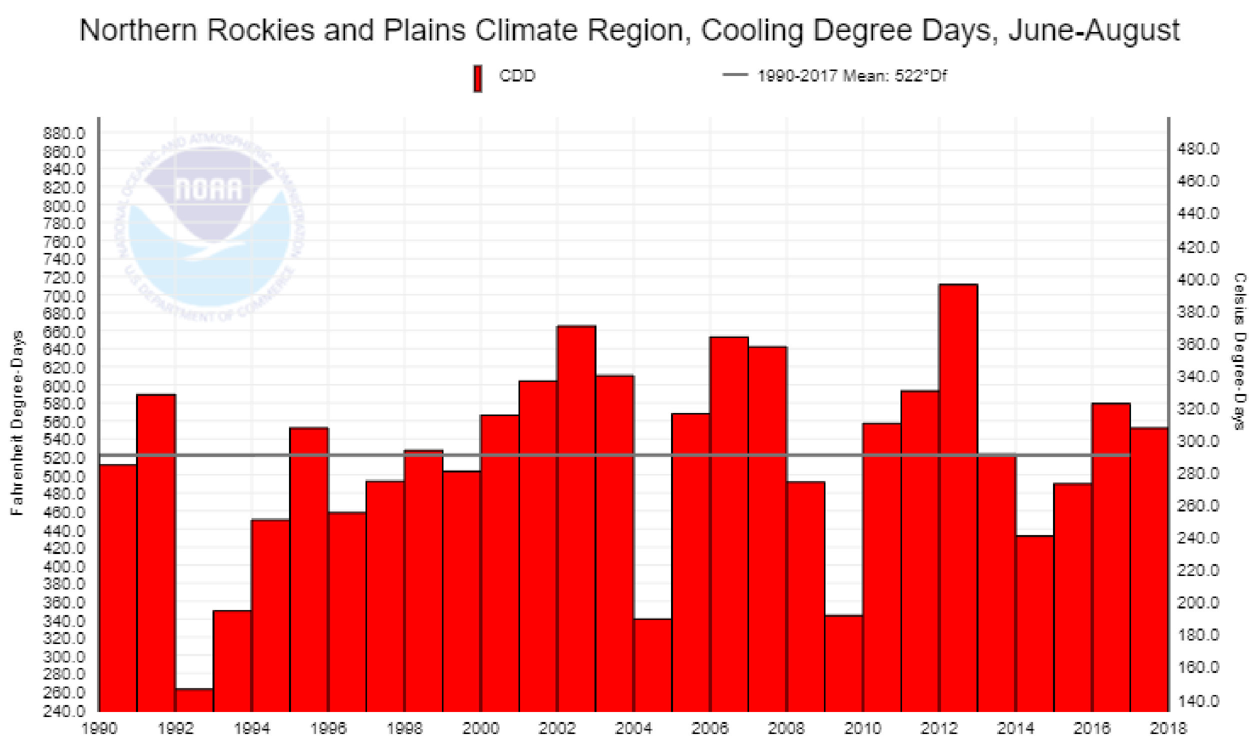
Ohio Valley Climate Region, Cooling Degree Days, June-August
CDD
1990-2017 Mean: 777°Df
Fahrenheit Degree-Days
Celsius Degree-Days


Upper Midwest Climate Region, Cooling Degree Days, June-August
CDD
1990-2017 Mean: 475°Df
Fahrenheit Degree-Days
Celsius Degree-Days
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018

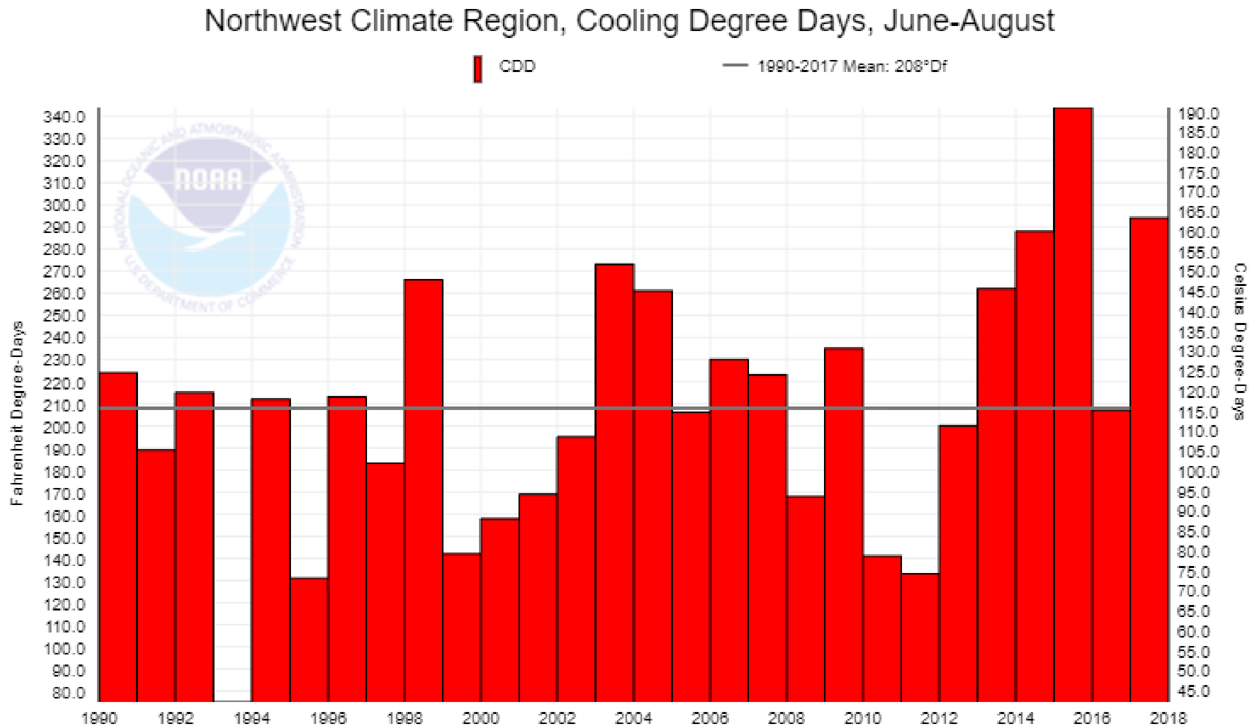

South Climate Region, Cooling Degree Days, June-August
CDD
1990-2017 Mean: 1,528°Df
Fahrenheit Degree-Days
Celsius Degree-Days
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018

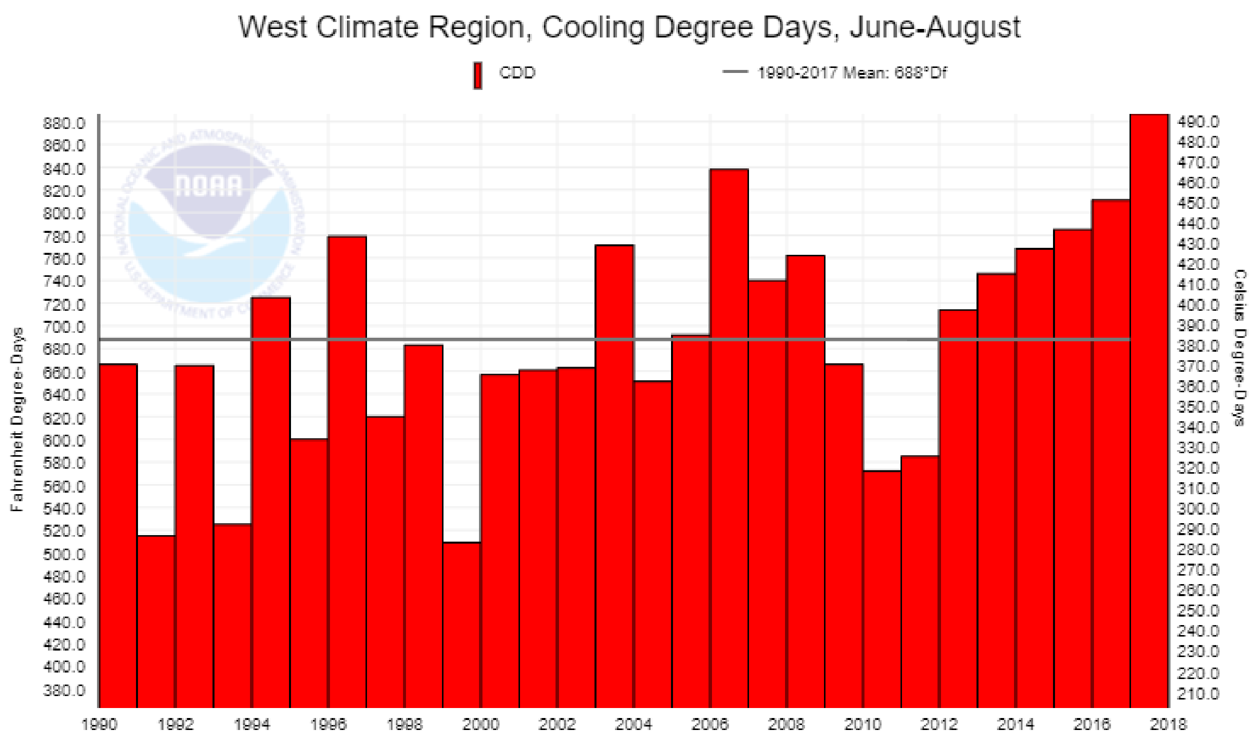


Southwest Climate Region, Cooling Degree Days, June-August
CDD
1990-2017 Mean: 999°Df
Fahrenheit Degree-Days
Celsius Degree-Days



Northern Rockies and Plains Climate Region, Cooling Degree Days, June-August
CDD
1990-2017 Mean: 522°Df
Fahrenheit Degree-Days
Celsius Degree-Days


Northwest Climate Region, Cooling Degree Days, June-August
CDD
1990-2017 Mean: 208°Df
Fahrenheit Degree-Days
Celsius Degree-Days


West Climate Region, Cooling Degree Days, June-August
CDD
1990-2017 Mean: 688°Df
Fahrenheit Degree-Days
Celsius Degree-Days