Air Quality Modeling Technical Support Document for the 2008 Ozone NAAQS Cross-State Air Pollution Rule Proposal

Office of Air Quality Planning and Standards
United States Environmental Protection Agency
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1. Introduction

In this technical support document (TSD) we describe the air quality modeling performed to support the proposed Cross-State Air Pollution Rule for the 2008 ozone National Ambient Air Quality Standards (NAAQS)[1]. In this document, air quality modeling is used to project ozone concentrations at individual monitoring sites to 2017[2] and to estimate state-by-state contributions to those 2017 concentrations. The projected 2017 ozone concentrations are used to identify ozone monitoring sites that are projected to be nonattainment or have maintenance problems for the 2008 ozone NAAQS in 2017. Ozone contribution information is then used to quantify projected interstate contributions from emissions in each upwind state to ozone concentrations at projected 2017 nonattainment and maintenance sites in other states (i.e., in downwind states).

The remaining sections of this TSD are as follows. Section 2 describes the air quality modeling platform and the evaluation of model predictions using measured concentrations. Section 3 defines the procedures for projecting ozone design value concentrations to 2017 and the approach for identifying monitoring sites with projected nonattainment and/or maintenance problems. Section 4 describes (1) the source contribution (i.e., apportionment) modeling and (2) the procedures for quantifying contributions to individual monitoring sites including nonattainment and/or maintenance sites. For questions about the information in this TSD please contact Norm Possiel at possiel.norm@epa.gov or (919) 541-5692. An electronic copy of the 2009 – 2013 base period and projected 2017 ozone design values and 2017 ozone contributions based on the proposal modeling can be obtained from docket EPA-HQ-OAR-2015-0500. The ozone design values for individual monitoring sites are in docket item EPA-HQ-OAR-2015-0500-0006 and the ozone contributions are in docket item EPA-HQ-OAR-2015-0500-0007. Electronic copies of the ozone design values and contributions can also be obtained at www.epa.gov/airtransport.[3]

[1] The EPA revised the levels of the primary and secondary 8-hour ozone standards to 0.075 parts per million (ppm). 40 CFR 50.15. 73 FR 16436 (March 27, 2008).

[2] 2017 was selected as the future year analytic base case because 2017 corresponds to the attainment date for ozone nonattainment areas classified as Moderate.

[3] Note that the air quality modeling used for the proposed rule was made available for public review as part of the August 4, 2015 Notice of Data Availability (80 FR 46271).

2. Air Quality Modeling Platform

EPA has developed a 2011-based air quality modeling platform which includes emissions, meteorology and other inputs for 2011. The 2011 base year emissions were projected to a future year base case scenario, 2017. The 2011 modeling platform and projected 2017 emissions were used to drive the 2011 base year and 2017 base case air quality model simulations.[4] The base year 2011 platform was chosen in part because it represents the most recent, complete set of base year emissions information currently available for national-scale air quality modeling. In addition, the meteorological conditions during the summer of 2011 were generally conducive for ozone formation across much of the U.S., particularly the eastern U.S.

2.1 Air Quality Model Configuration

The photochemical model simulations performed for this ozone transport assessment used the Comprehensive Air Quality Model with Extensions (CAMx version 6.11) (Environ, 2014). CAMx is a three-dimensional grid-based Eulerian air quality model designed to simulate the formation and fate of oxidant precursors, primary and secondary particulate matter concentrations, and deposition over regional and urban spatial scales (e.g., the contiguous U.S.). Consideration of the different processes (e.g., transport and deposition) that affect primary (directly emitted) and secondary (formed by atmospheric processes) pollutants at the regional scale in different locations is fundamental to understanding and assessing the effects of emissions on air quality concentrations. CAMx was applied with the carbon-bond 6 revision 2 (CB6r2) gas-phase chemistry mechanism[5] (Ruiz and Yarwood, 2013) and the Zhang dry deposition scheme (Zhang, et al., 2003).

Figure 2-1 shows the geographic extent of the modeling domain that was used for air quality modeling in this analysis. The domain covers the 48 contiguous states along with the southern portions of Canada and the northern portions of Mexico. This modeling domain contains 25 vertical layers with a top at about 17,550 meters, or 50 millibars (mb), and horizontal

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[4] EPA also used the 2011-based air quality modeling platform to perform a 2017 "illustrative" control case air quality model simulation to inform (1) the analysis to quantify upwind state emissions that significantly contribute to nonattainment or interfere with maintenance of the NAAQS in downwind states and (2) the analysis of the costs and benefits of this proposed rule. The 2017 illustrative control case emissions and air quality modeling results are described in the Ozone Transport Policy Analysis Proposed Rule TSD and in the Regulatory Impact Assessment for the proposed rule.

[5] The "chemparam.2_CF" chemical parameter file was used in the CAMx model simulations.

grid resolution of 12 km x 12 km. The model simulations produce hourly air quality concentrations for each 12 km grid cell across the modeling domain.

CAMx requires a variety of input files that contain information pertaining to the modeling domain and simulation period. These include gridded, hourly emissions estimates and meteorological data, and initial and boundary concentrations. Separate emissions inventories were prepared for the 2011 base year and the 2017 base case. All other inputs (i.e. meteorological fields, initial concentrations, and boundary concentrations) were specified for the 2011 base year model application and remained unchanged for the future-year model simulations[6].

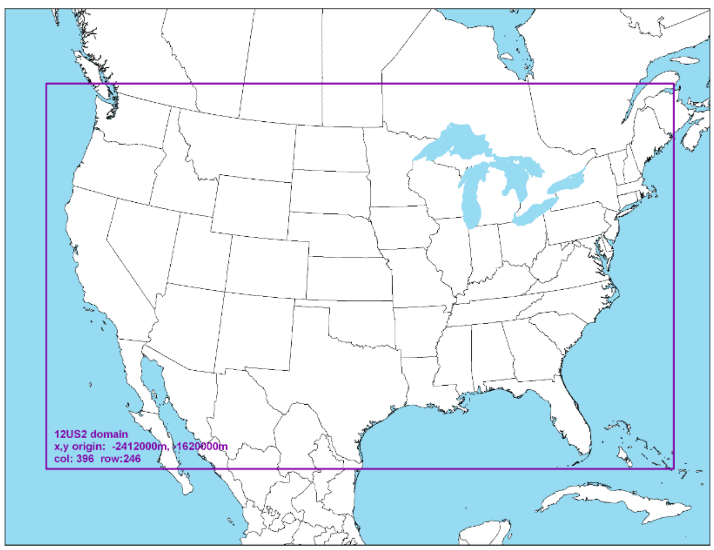

Figure 2-1. Map of the CAMx modeling domain used for transport modeling.

2.2 Characterization of 2011 Summer Meteorology

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. Conversely, ozone production is more limited on days that are cloudy, cool, rainy, and windy

[6] The CAMx annual simulations for 2011 and 2017 were each performed using two time segments (January 1 through April 30, 2011 with a 10-day ramp-up period at the end of December 2010 and May 1 through December 31, 2011 with a 10-day ramp-up period at the end of April 2011). The CAMx 2017 contribution modeling was performed for the period May 1 through September 30, 2011 with a 10-day ramp-up period at the end of April 2011.

(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).

In selecting a year for air quality modeling it is important to simulate a variety of meteorological conditions that are generally associated with elevated air quality (US EPA, 2014a). Specifically for ozone, modeled time periods should reflect meteorological conditions that frequently correspond with observed 8-hour daily maximum concentrations greater than the NAAQS at monitoring sites in nonattainment areas (US EPA, 2014a). However, because of inter-annual variability in weather patterns it is not possible to identify a single year that will be representative of "typical" meteorological conditions within each region of the U.S.

As part of the development of the 2011 modeling platform we have examined the temperature and precipitation regimes across the U.S. in 2011 compared to long-term, climatological normal (i.e., average) conditions. Table 2-1 describes the observed 2011 surface temperature anomalies (i.e., departure from normal) for individual months from May through September relative to the period 1895-2011 for each of the nine National Oceanic and Atmospheric Administration (NOAA) climate regions shown in Figure 2-2. The aggregate temperature and precipitation anomalies by state for the core summer months, June through August, are shown in Figures 2-3 and 2-4, respectively. Overall, temperatures were warmer than normal during the summer of 2011 in nearly all regions, except for the West and Northwest. Record warmth occurred in portions of the South and Southwest regions. The summer months experienced below average precipitation for much of the southern and southeastern US, whereas wetter conditions than average were experienced in California and in several northern tier states. Extensive drought conditions occurred in portions of the southern Great Plains states. The warmer and dryer conditions were associated with a strong upper air ridge over the central U.S during the summer of 2011. While warmer than the long-term normal, 2011 summer temperatures in the U.S. were comparable to those in several other recent years. For example, 2006, 2007, 2010, 2012 were also all among the ten warmest on record. Analysis of meteorological-adjusted trends in seasonal mean ozone for the period 2000 through 2012 indicates that, on a regional basis, the summer of 2011 was typical of high ozone years in the Eastern U.S. in terms of being conducive to the formation of ozone. In Figure 2-5, those years with downward adjustments (compared to the "unadjusted for weather" line) were generally more conducive to ozone formation than years that were adjusted upward. For example, in the Northeast region, the years 2002, 2005, 2007, 2010, 2011, and 2012 were more conducive to ozone formation than 2000, 2003, 2004, 2006, and 2009. In 2011, the South and Southeast regions had the largest adjustment (most ozone conducive), whereas the Northeast and Central regions were slightly above normal. The Western regions experienced generally near normal ozone, with the Northwest somewhat below normal.

Table 2-1. Surface temperature anomalies in 2011 by month and geographic region.*

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

*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.

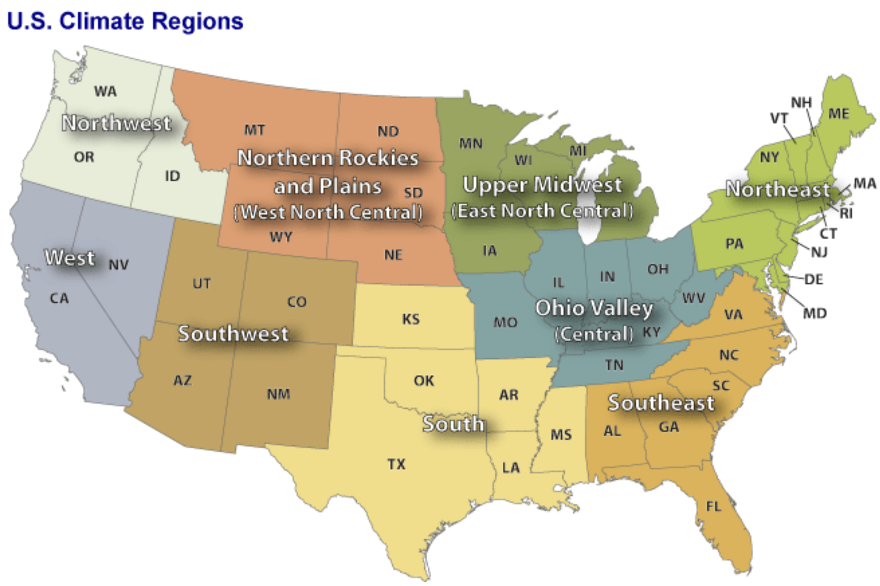

Figure 2-2. U.S. climate regions.
(http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-regions.php)

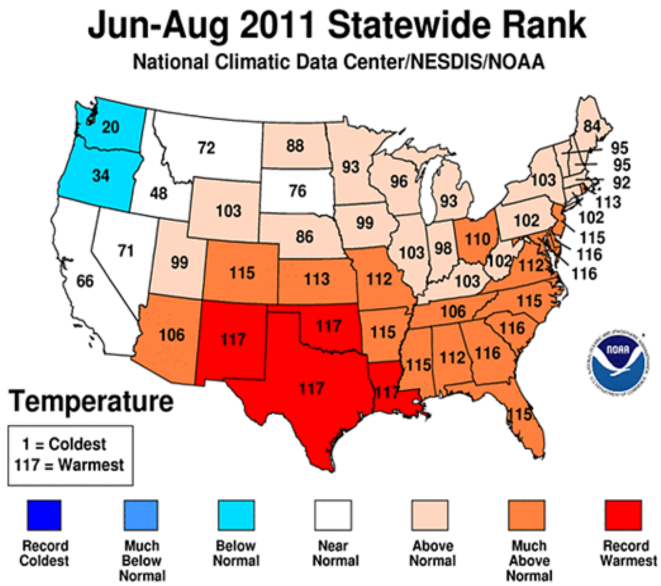

Figure 2-3. Statewide rank of temperatures in 2011 relative to 1895-2011 period. (http://www.ncdc.noaa.gov/temp-and-precip/maps.php)

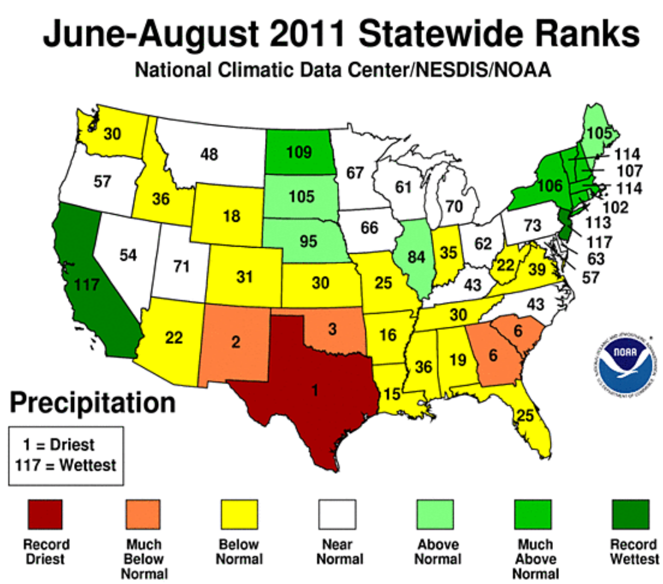

Figure 2-4. Statewide rank of precipitation in 2011 relative to 1895-2011 period. (http://www.ncdc.noaa.gov/temp-and-precip/maps.php)

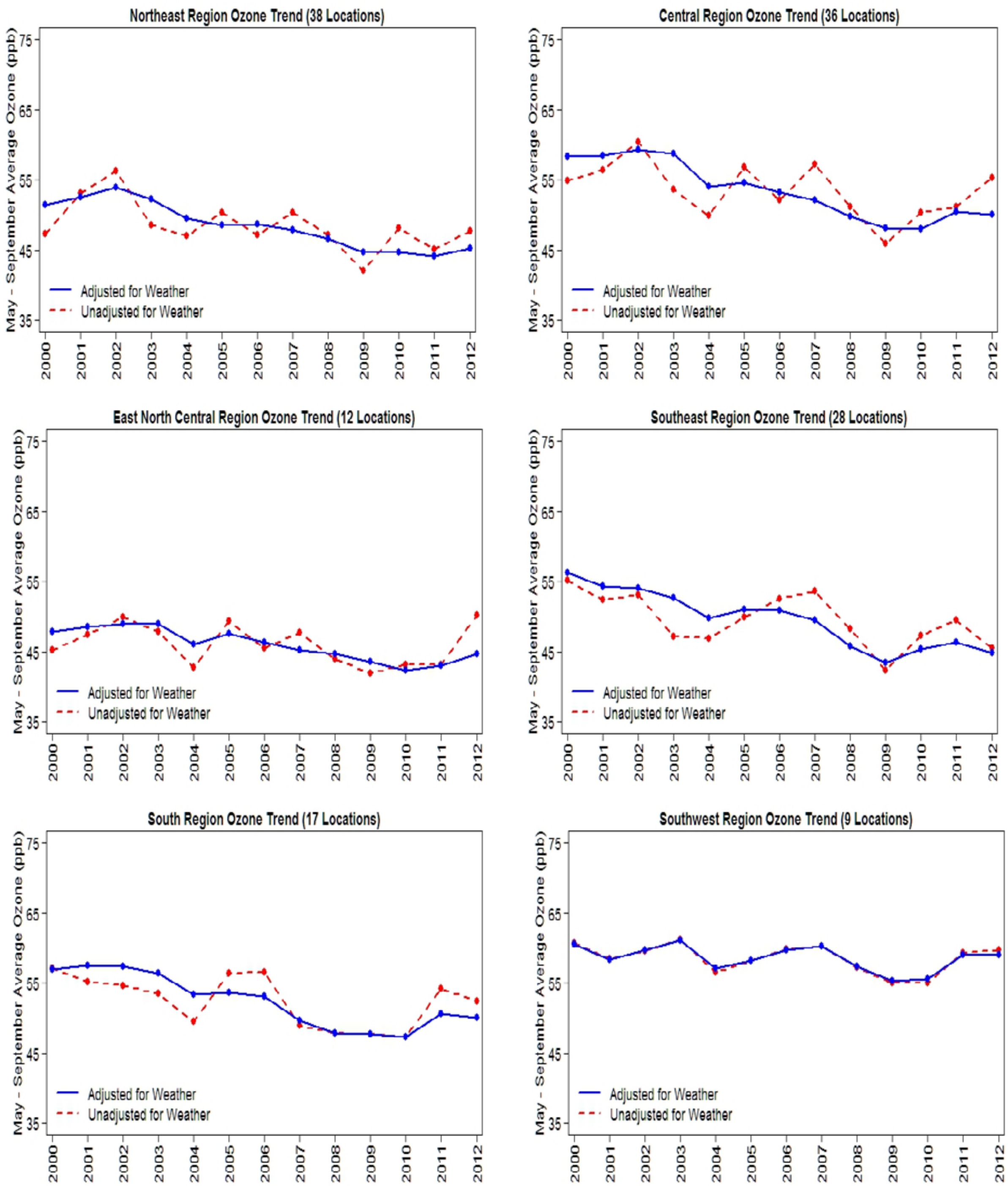

Figure 2-5a. Meteorological-adjusted ozone trends by climate region:
Northeast, Central (Ohio Valley), East North Central (Upper Midwest), Southeast, South, and Southwest. (http://www.epa.gov/airtrends/weather.html)

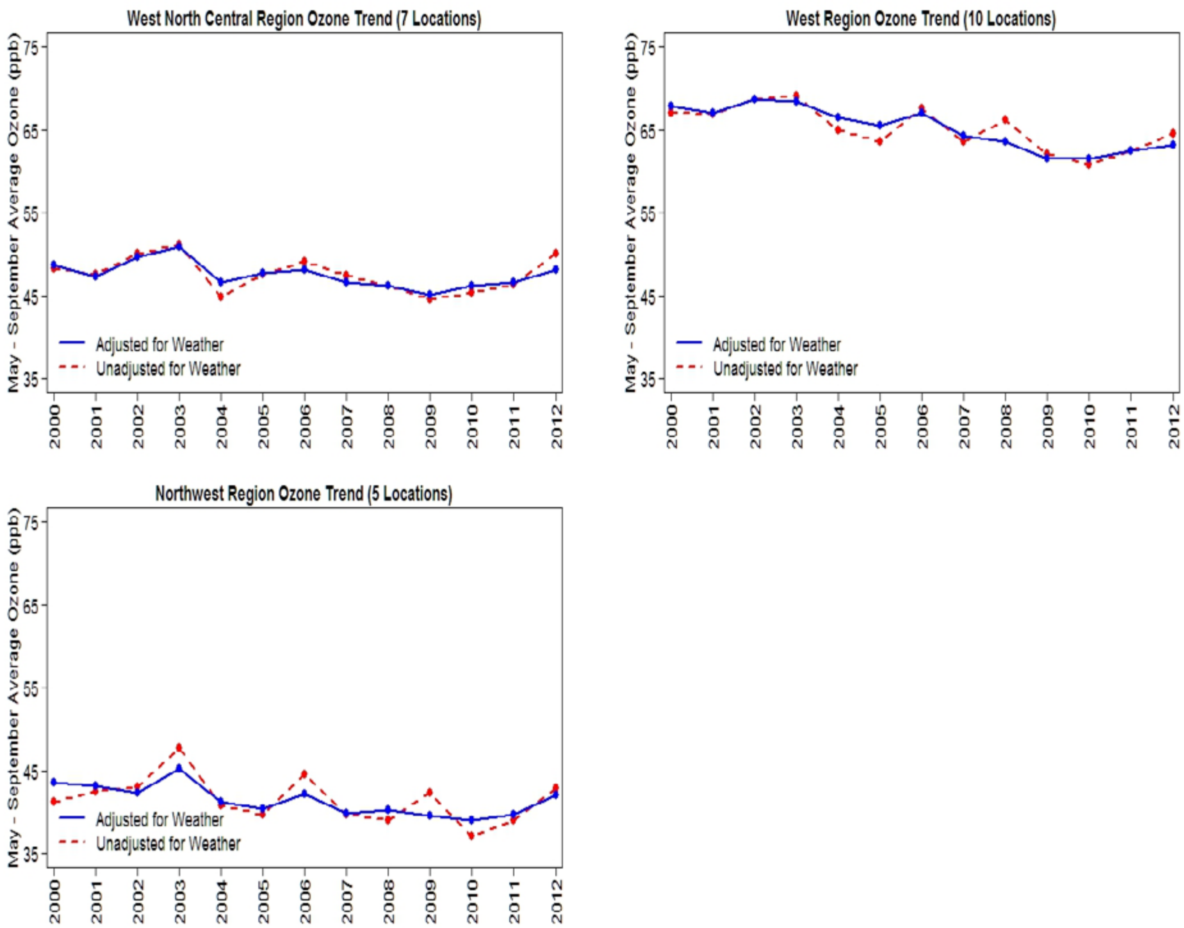

Figure 2-5b. Meteorological-adjusted ozone trends by climate region:
West North Central (Northern Rockies and Plains), West, and Northwest.
(http://www.epa.gov/airtrends/weather.html)

2.3 Meteorological Data for 2011

The meteorological data for air quality modeling of 2011 were derived from running Version 3.4 of the Weather Research Forecasting Model (WRF) (Skamarock, et al., 2008). The meteorological outputs from WRF include hourly-varying horizontal wind components (i.e., speed and direction), temperature, moisture, vertical diffusion rates, and rainfall rates for each grid cell in each vertical layer. Selected physics options used in the WRF simulation include Pleim-Xiu land surface model (Xiu and Pleim, 2001; Pleim and Xiu, 2003), Asymmetric Convective Model version 2 planetary boundary layer scheme (Pleim 2007a,b), Kain-Fritsch cumulus parameterization (Kain, 2004) utilizing the moisture-advection trigger (Ma and Tan, 2009), Morrison double moment microphysics (Morrison, et al., 2005; Morrison and Gettelman, 2008), and RRTMG longwave and shortwave radiation schemes (Iacono, et.al., 2008).

The WRF model simulation was initialized using the 12km North American Model (12NAM) analysis product provided by the National Climatic Data Center (NCDC). Where 12NAM data were unavailable, the 40km Eta Data Assimilation System (EDAS) analysis (ds609.2) from the National Center for Atmospheric Research (NCAR) was used. Analysis nudging for temperature, wind, and moisture was applied above the boundary layer only. The model simulations were conducted in 5.5 day blocks with soil moisture and temperature carried from one block to the next via the "ipxwrf" program (Gilliam and Pleim, 2010). Landuse and land cover data were based on the 2006 National Land Cover Database (NLCD2006) data.[7] Sea surface temperatures at 1 km resolution were obtained from the Group for High Resolution Sea Surface Temperatures (GHRSST) (Stammer, et al., 2003). As shown in Table 2-2, the WRF simulations were performed with 35 vertical layers up to 50 mb, with the thinnest layers being nearest the surface to better resolve the planetary boundary layer (PBL). The WRF 35-layer structure was collapsed to 25 layers for the CAMx air quality model simulations, as shown in Table 2-2.

Table 2-2. WRF and CAMx layers and their approximate height above ground level.

CAMx Layers	WRF Layers	Sigma P	Pressure (mb)	Approximate 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

[7] The 2006 NLCD data are available at http://www.mrlc.gov/nlcd06_data.php

CAMx Layers	WRF Layers	Sigma P	Pressure (mb)	Approximate Height (m AGL)
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

Details of the annual 2011 meteorological model simulation and evaluation are provided in a separate technical support document (US EPA, 2014b) which can be obtained at http://www.epa.gov/ttn/scram/reports/MET_TSD_2011_final_11-26-14.pdf

The meteorological data generated by the WRF simulations were processed using a modified version of the wrfcamx v4.0 (Environ, 2013) meteorological data processing program to create model-ready meteorological inputs to CAMx. The modification to wrfcamx included reactivating the wrfcamx option to analyze sub-grid stratiform clouds from the WRF output in order to more fully account for the effects of clouds on photolysis rates. In running wrfcamx, vertical eddy diffusivities (Kv) were calculated using the Yonsei University (YSU) (Hong and Dudhia, 2006) mixing scheme. We used 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 nighttime “urban heat island” effect.

2.4 Initial and Boundary Concentrations

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 were used for the 2011 and 2017 model simulations. The procedures for translating GEOS-Chem predictions to initial and boundary concentrations are described elsewhere (Henderson, 2014). More information about the GEOS-Chem model and other applications using this tool is available at: http://www-as.harvard.edu/chemistry/trop/geos.

2.5 Emissions Inventories

CAMx requires detailed emissions inventories containing temporally allocated (i.e., hourly) emissions for each grid-cell in the modeling domain for a large number of chemical species that act as primary pollutants and precursors to secondary pollutants. Annual emission inventories for 2011 and 2017 were preprocessed into CAMx-ready inputs using the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system (Houyoux et al., 2000).[8] Information on the emissions inventories used as input to the CAMx model simulations can be found in the following emissions inventory technical support documents: Preparation of Emissions Inventories for the Version 6.2, 2011 Emissions Modeling Platform (US EPA, 2015a) and 2011 National Emissions Inventory, version 2 (US EPA, 2015b).

[8] The SMOKE output emissions case name for the 2011 base year is “2011eh_cb6v2_v6_11g” and the emissions case name for the 2017 base case is “2017eh_cb6v2_v6_11g”.

2.6 Air Quality Model Evaluation

An operational model performance evaluation for ozone was conducted to examine the ability of the CAMx v6.11 modeling system to replicate 2011 measured concentrations. This evaluation focused on statistical assessments of model predictions versus observations paired in time and space depending on the sampling period of measured data. Details on the evaluation methodology and the calculation of performance statistics are provided in Appendix A. Overall, the ozone model performance statistics for the CAMx 2011 simulation are within or close to the ranges found in other recent peer-reviewed applications (Simon et al, 2012). The model performance results, as described in Appendix A, demonstrate that the predictions from the 2011 modeling platform closely replicate the corresponding observed concentrations in terms of the magnitude, temporal fluctuations, and geographic differences for 8-hour daily maximum ozone. These results provide confidence that our application of CAMx using this 2011 modeling platform provides a scientifically credible approach for assessing ozone concentrations relevant for the transport assessment described in this TSD.

3. Identification of Future Nonattainment and Maintenance Receptors

3.1 Definition of Nonattainment and Maintenance Receptors

The approach in the propose rule for identifying the 2017 nonattainment and maintenance receptors is described in Section V.C of the preamble. In brief, we are proposing to identify nonattainment receptors in this rulemaking as those sites that are violating the NAAQS based on current measured air quality (i.e., 2012-2014 design values) and that also have projected 2017 average design values that exceed the NAAQS (i.e., 2017 average design values of 76 ppb or greater).[9] We followed the approach in the CSAPR to identify sites that would have difficulty maintaining the 2008 ozone NAAQS in a scenario that takes into account historic variability in air quality at the monitoring site. In the CSAPR approach, monitoring sites with a 2017 maximum design value that exceeds the NAAQS, even if the 2017 average design value is below the NAAQS, are projected to have a maintenance problem in 2017. Monitoring sites with a 2017 average design value below the NAAQS, but with a maximum design value that exceeds the

[9] In determining compliance with the NAAQS, ozone design values are truncated to integer values. For example, a design value of 75.9 ppb is truncated to 75 ppb which is attainment. In this manner, design values at or above 76.0 ppb are considered to be violations of the NAAQS.

NAAQS, are considered maintenance-only sites. In addition, those sites that have projected 2017 average design values that exceed the NAAQS, but are currently measuring clean data based on 2012-2014 design values are also defined as maintenance-only receptors. Maintenance-only receptors therefore include both (1) those sites with projected average 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 76 ppb or greater. In addition to the maintenance-only receptors, the 2017 ozone nonattainment receptors are also maintenance receptors because the maximum design values for each of these sites is always greater than or equal to the average design value. The procedures for calculating projected 2017 average and maximum design values are described below. The monitoring sites that we project to be nonattainment and maintenance receptors for the ozone NAAQS in the 2017 base case are used for assessing the contribution of emissions in upwind states to downwind nonattainment and maintenance of ozone NAAQS as part of this proposal.

3.2 Approach for Projecting 2017 Ozone Design Values

The ozone predictions from the 2011 and 2017 CAMx model simulations were used to project ambient (i.e., measured) ozone design values to 2017 following the approach described in EPA's current guidance for attainment demonstration modeling (US EPA, 2014a),[10] as summarized here. The modeling guidance recommends using 5-year weighted average ambient design values[11] centered on the base modeling year as the starting point for projecting average design values to the future. Because 2011 is the base emissions year, we used the average ambient 8-hour ozone design values for the period 2009 through 2013 (i.e., the average of design values for 2009-2011, 2010-2012 and 2011-2013) to calculate the 5-year weighted average design values. The 5-year weighted average ambient design value at each site was projected to 2017 using the Model Attainment Test Software program (Abt Associates, 2014**)**. This program calculates the 5-year weighted average DV based on observed data and projects future year

[10] EPA's ozone attainment demonstration modeling guidance is referred to as "the modeling guidance" in the remainder of this document.

[11] The air quality design value for a site is the 3-year average of the annual fourth-highest daily maximum 8-hour average ozone concentration.

values using the relative response predicted by the model. Equation (3-1) describes the recommended model attainment test in its simplest form, as applied for monitoring site *i*:

$$(\mathrm{DVF})_\mathrm{i} = (RRF)_i * (DVB)_i \qquad \text{Equation 3-1}$$

$\mathrm{DVF_i}$ is the estimated design value for the future year at monitoring site i; $\mathrm{RRF_i}$ is the relative response factor for monitoring site *i*; and $\mathrm{DVB_i}$ is the base period design value monitored at site i. The relative response factor for each monitoring site $(RRF)_i$ is the fractional change in 8-hour daily maximum ozone between the base and future year. The RRF is based on the average ozone on model-predicted "high" ozone days in grid cells in the vicinity of the monitoring site. The modeling guidance recommends calculating RRFs based on the highest 10 modeled ozone days in the base year simulation at each monitoring site. Specifically, the RRF was calculated based on the 10 highest days in the 2011 base year modeling in the vicinity of each monitor location.

As recommended by the modeling guidance, we considered model response in grid cells immediately surrounding the monitoring site along with the grid cell in which the monitor is located. The RRF was based on a 3 x 3 array of 12 km grid cells centered on the location of the grid cell containing the monitor. On each high ozone day, the grid cell with the highest base year ozone value in the 3 x 3 array surrounding the location of the monitoring site was used for both the base and future components of the RRF calculation (paired in space). In cases for which the base year model simulation did not have 10 days with ozone values greater than or equal to 60 ppb at a site, we used all days with ozone >= 60 ppb, as long as there were at least 5 days that meet that criteria. At monitor locations with less than 5 days with modeled 2011 base year ozone >= 60 ppb, no RRF or DVF was calculated for the site and the monitor in question was not included in this analysis.

The approach for calculating 2017 maximum design values is similar to the approach for calculating 2017 average design values. To calculate the 2017 maximum design value we start with the highest (i.e., maximum) ambient design value from the 2011-centered 5-year period (i.e., the maximum of design values from 2009-2011, 2010-2012, and 2011-2013). The base period maximum design value at each site was projected to 2017 using the site-specific RRFs, as determined using the procedures for calculating RRFs described above.

Table 3-1 contains the 2009-2013 base period average and maximum 8-hour ozone design values, the 2017 base case average and maximum design values, and the 2012-2014 design values for the 8 sites in the eastern U.S. projected to be 2017 nonattainment receptors.

Table 3-2 contains this same information for the 6 maintenance-only sites in the eastern U.S. that are projected nonattainment but currently measuring clean data. Table 3-3 contains this same information for the 23 maintenance-only sites in the eastern U.S. that are projected to have average design values below the NAAQS, but maximum design values above the NAAQS. The design values for all monitoring sites in the U.S. are provided in docket item EPA-HQ-OAR-2015-0500-0006.[12]

Table 3-1. Average and maximum 2009-2013 and 2017 base case 8-hour ozone design values and 2012-2014 design values (ppb) at projected nonattainment sites in the eastern U.S. (nonattainment receptors).

Monitor ID	State	County	Average Design Value 2009-2013	Maximum Design Value 2009-2013	Average Design Value 2017	Maximum Design Value 2017	2012-2014 Design Value
90013007	Connecticut	Fairfield	84.3	89.0	77.1	81.4	84.0
90019003	Connecticut	Fairfield	83.7	87.0	78.0	81.1	85.0
90099002	Connecticut	New Haven	85.7	89.0	77.2	80.2	81.0
480391004	Texas	Brazoria	88.0	89.0	81.4	82.3	80.0
481210034	Texas	Denton	84.3	87.0	76.9	79.4	81.0
484392003	Texas	Tarrant	87.3	90.0	79.6	82.1	77.0
484393009	Texas	Tarrant	86.0	86.0	78.6	78.6	80.0
551170006	Wisconsin	Sheboygan	84.3	87.0	77.0	79.4	81.0

[12] There are 7 sites in 3 counties in the West that were excluded from this listing because the ambient design values at these sites were dominated by wintertime ozone episodes and not summer season conditions that are the focus of this transport assessment. High winter ozone concentrations that have been observed in certain parts of the Western U.S. are believed to result from the combination of strong wintertime inversions, large NOx and VOC emissions from nearby oil and gas operations, increased UV intensity due to reflection off of snow surfaces and potentially still uncharacterized sources of free radicals. The 7 sites excluded from this analysis are in Rio Blanco County, CO (site ID 081030006), Fremont County, WY (site ID 560130099), and Sublette County, WY (site IDs 560350097, 560350099, 560350100, 560350101, and 560351002). Information on the analysis to identify these sites as influenced by wintertime ozone episodes can be found in Appendix 3A of the Regulatory Impact Analysis of the Proposed Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone (EPA, 2014d) (http://www.epa.gov/ttn/ecas/ria.html)

Table 3-2. Average and maximum 2009-2013 and 2017 base case 8-hour ozone design values and 2012-2014 design values (ppb) at sites in the eastern U.S. that are projected nonattainment but currently measuring clean data (maintenance-only receptors).

Monitor ID	State	County	Average Design Value 2009-2013	Maximum Design Value 2009-2013	Average Design Value 2017	Maximum Design Value 2017	2012-2014 Design Value
240251001	Maryland	Harford	90.0	93.0	81.3	84.0	75.0
360850067	New York	Richmond	81.3	83.0	76.3	77.8	73.0
361030002	New York	Suffolk	83.3	85.0	79.2	80.8	73.0
390610006	Ohio	Hamilton	82.0	85.0	76.3	79.1	75.0
482011034	Texas	Harris	81.0	82.0	76.8	77.8	72.0
482011039	Texas	Harris	82.0	84.0	78.2	80.2	72.0

Table 3-3. Average and maximum 2009-2013 and 2017 base case 8-hour ozone design values and 2012-2014 design values (ppb) at projected maintenance sites in the eastern U.S. Based on the CSAPR methodology (maintenance-only receptors).

Monitor ID	State	County	Average Design Value 2009-2013	Maximum Design Value 2009-2013	Average Design Value 2017	Maximum Design Value 2017	2012-2014 Design Value
90010017	Connecticut	Fairfield	80.3	83.0	75.8	78.4	82.0
211110067	Kentucky	Jefferson	82.0	85.0	75.8	78.6	Incomplete Data
211850004	Kentucky	Oldham	82.0	86.0	73.7	77.3	74.0
240053001	Maryland	Baltimore	80.7	84.0	73.2	76.2	72.0
260050003	Michigan	Allegan	82.7	86.0	75.5	78.5	83.0
261630019	Michigan	Wayne	78.7	81.0	74.0	76.2	74.0
340071001	New Jersey	Camden	82.7	87.0	74.2	78.1	76.0
340150002	New Jersey	Gloucester	84.3	87.0	75.1	77.5	76.0
340230011	New Jersey	Middlesex	81.3	85.0	73.0	76.3	74.0
340290006	New Jersey	Ocean	82.0	85.0	73.9	76.6	75.0
360810124	New York	Queens	78.0	80.0	75.7	77.6	72.0
420031005	Pennsylvania	Allegheny	80.7	82.0	75.3	76.5	77.0
421010024	Pennsylvania	Philadelphia	83.3	87.0	75.1	78.4	75.0
480850005	Texas	Collin	82.7	84.0	74.9	76.0	78.0
481130069	Texas	Dallas	79.7	84.0	74.0	78.0	78.0
481130075	Texas	Dallas	82.0	83.0	75.8	76.7	77.0
481211032	Texas	Denton	82.7	84.0	75.1	76.3	79.0
482010024	Texas	Harris	80.3	83.0	75.9	78.5	72.0
482010026	Texas	Harris	77.3	80.0	73.5	76.1	67.0
482010055	Texas	Harris	81.3	83.0	75.4	77.0	75.0
482011050	Texas	Harris	78.3	80.0	74.6	76.2	72.0
484390075	Texas	Tarrant	82.0	83.0	75.5	76.4	79.0
484393011	Texas	Tarrant	80.7	83.0	74.5	76.6	75.0

4. Ozone Contribution Modeling

4.1 Methodology

The EPA performed nationwide,[13] state-level ozone source apportionment modeling using the CAMx OSAT/APCA technique[14] (ENVIRON, 2014) to quantify the contribution of 2017 base case NO_X and VOC emissions from all sources in each state to projected 2017 ozone concentrations at ozone monitoring sites. In the source apportionment model run, we tracked the ozone formed from each of the following contribution categories (i.e., "tags"):

- States – anthropogenic NO_X and VOC emissions from each state tracked individually (emissions from all anthropogenic sectors in a given state were combined);
- Biogenics – biogenic NO_X and VOC emissions domain-wide (i.e., not by state)[15];
- Boundary Concentrations – concentrations transported into the modeling domain;
- Tribes – the emissions from those tribal lands for which we have point source inventory data in the 2011 NEI (we did not model the contributions from individual tribes);
- Canada and Mexico – anthropogenic emissions from sources in the portions of Canada and Mexico included in the modeling domain (we did not model the contributions from Canada and Mexico separately);
- Fires – combined emissions from wild and prescribed fires domain-wide (i.e., not by state); and
- Offshore – combined emissions from offshore marine vessels and offshore drilling platforms.

The contribution modeling provided contributions to ozone from anthropogenic NO_X and VOC emissions in each state, individually. The contributions to ozone from chemical reactions between biogenic NO_X and VOC emissions were modeled and assigned to the "biogenic" category. The contributions from wild fire and prescribed fire NO_X and VOC emissions were modeled and assigned to the "fires" category. That is, the contributions from the "biogenic" and

[13] As shown in Figure 2-1, the EPA's nationwide modeling includes the 48 contiguous states.

[14] As part of this technique, ozone formed from reactions between biogenic VOC and NOx with anthropogenic NOx and VOC are assigned to the anthropogenic emissions.

[15] Biogenic emissions and emissions from wild fires and prescribed fires were held constant between 2011 and 2017 since (1) these emissions are tied to the 2011 meteorological conditions and (2) the focus of this rule is on the contribution from anthropogenic emissions to projected ozone nonattainment and maintenance.

“fires” categories are not assigned to individual states nor are they included in the state contributions.

CAMx OSAT/APCA model run was performed for the period May 1 through September 30 using the projected 2017 base case emissions and 2011 meteorology for this time period. The hourly contributions[16] from each tag were processed to calculate an 8-hour average contribution metric. The process for calculating the contribution metric uses the contribution modeling outputs in a “relative sense” to apportion the projected 2017 average design value at each monitoring location into contributions from each individual tag. This process is similar in concept to the approach described above for using model predictions to calculate 2017 ozone design values. The approach used to calculate the contribution metric is described by the following steps:

Step 1. Modeled hourly ozone concentrations are used to calculate the 8-hour daily maximum ozone (MDA8) concentration in each grid cell on each day.

Step 2. The gridded hourly ozone contributions from each tag are subtracted from the corresponding gridded hourly total ozone concentrations to create a “pseudo” hourly ozone value for each tag for each hour in each grid cell.

Step 3. The hourly “pseudo” concentrations from Step 2 are used to calculate 8-hour average “pseudo” concentrations for each tag for the time period that corresponds to the MDA8 concentration from Step 1. Step 2 results in spatial fields of 8-hour average “pseudo” concentrations for each grid cell for each tag on each day.

Step 4. The 8-hour average “pseudo” concentrations for each tag and the MDA8 concentrations are extracted for those grid cells containing ozone monitoring sites. We used the data for all days with 2017 MDA8 concentrations >=76 ppb (i.e., projected 2017 exceedance days) in the downstream calculations. If there were fewer than five 2017 exceedance days at a particular monitoring site then the data from the top five 2017 MDA8 concentration days are extracted and used in the calculations.[17]

[16] Contributions from anthropogenic emissions under “NO_X-limited” and “VOC-limited” chemical regimes were combined to obtain the net contribution from NO_X and VOC anthropogenic emissions in each state.

[17] If there were fewer than 5 days with a modeled 2017 MDA8 concentration $\geq$ 60 ppb for the location of a particular monitoring site, then contributions were not calculated at that monitor.

Step 5. For each monitoring site and each tag, the 8-hour "pseudo" concentrations are then averaged across the days selected in Step 4 to create a multi-day average "pseudo" concentration for tag at each site. Similarly, the MDA8 concentrations were average across the days selected in Step 4.

Step 6. The multi-day average "pseudo" concentration and the corresponding multi-day average MDA8 concentration are used to create a Relative Contribution Factor (RCF) for each tag at each monitoring site. The RCF is the difference between the MDA8 concentration and the corresponding "pseudo" concentration, normalized by the MDA8 concentration.

Step 7. The RCF for each tag is multiplied by the 2017 average ozone design value to create the ozone contribution metrics for each tag at each site. Note that the sum of the contributions from each tag equals the 2017 average design value for that site.

Step 8. The contributions calculated from Step 7 are truncated to two digits to the right of the decimal (e.g., a calculated contribution of 0.78963… is truncated to 0.78 ppb).

Table 4-1 provides an example of the calculation of contributions from two states (state A and state B) to a particular nonattainment site starting with Step 4, above. The table includes the daily "pseudo" concentrations for state A and state B and corresponding MDA8 ozone concentrations on those days with 2017 model-predicted exceedances at this site. The MDA8 ozone concentrations on these days are ranked-ordered in the table. The 2017 average design value for this example is 77.5 ppb. Using the data in Table 4-1, the RCF for state A and state B are calculated as:

(90.372 – 81.857) / 90.372 = 0.09422 for state A, and

(90.372 – 90.163) / 90.372 = 0.00231 for state B

The contributions from state A and state B to the 2017 average design value at this site are calculated as:

77.5 x 0.09422 = 7.3020 which is truncated to 7.30 ppb for state A, and

77.5 x 0.00231 = 0.1790 which is truncated to 0.17 ppb for state B

Table 4-1. Example calculation of ozone contributions (units are ppb).

Month	Day	Predicted MDA8 O3 on 2017 Modeled Exceedance Days	"Pseudo" 8-Hr O3 for State A	"Pseudo" 8-Hr O3 for State B
7	11	110.832	98.741	110.817
7	6	102.098	89.017	102.081
7	21	100.739	87.983	100.560
6	9	94.793	87.976	93.179
6	8	92.255	84.707	92.207
7	18	84.768	72.196	84.635
8	1	81.719	81.065	81.718
7	17	81.453	73.034	81.443
7	22	78.377	74.500	78.303
6	16	76.695	69.357	76.695
Multi-Day Average =>		90.372	81.857	90.163
2017 Average Design Value is 77.5 ppb		Relative Contribution Factors =>	0.09422	0.00231
		Contributions =>	7.3020	0.1790
		Truncated Contributions =>	7.30	0.17

The average contribution metric calculated in this manner is intended to provide a reasonable representation of the contribution from individual states to the projected 2017 design value, based on modeled transport patterns and other meteorological conditions generally associated with modeled high ozone concentrations in the vicinity of the monitoring site. This average contribution metric is beneficial since the magnitude of the contributions is directly related to the magnitude of the design value at each site.

4.2 Contribution Modeling Results

The contributions from each tag to individual nonattainment and maintenance-only sites are provided in Appendix B. The largest contributions from each state to 2017 downwind nonattainment sites and to downwind maintenance-only sites are provided in Table 4-2. The 2017 contributions from each tag to each monitoring site are provided in docket item EPA-HQ-OAR-2015-0500-0007.

Table 4-2. Largest ozone contributions from each state to downwind 2017 projected nonattainment and 2017 projected maintenance-only sites in the eastern U.S. (units are ppb).

Upwind State	Largest Downwind Contribution to Nonattainment Receptors for Ozone (ppb)	Largest Downwind Contribution to Maintenance Receptors for Ozone (ppb
AL	0.79	1.28
AR	0.98	2.15
CT	0.00	0.46
DE	0.37	2.23
DC	0.06	0.73
FL	0.54	0.72
GA	0.47	0.58
IL	17.48	23.17
IN	6.24	14.95
IA	0.61	0.85
KS	0.80	1.03
KY	0.75	11.17
LA	3.09	4.23
ME	0.00	0.08
MD	2.07	7.11
MA	0.10	0.37
MI	2.69	1.79
MN	0.40	0.47
MS	0.78	1.48
MO	1.63	3.69
NE	0.24	0.36
NH	0.02	0.07
NJ	8.84	12.38
NY	16.96	17.21
NC	0.55	0.93
ND	0.11	0.28
OH	2.18	7.92
OK	1.70	2.46
PA	9.39	15.93
RI	0.02	0.08
SC	0.16	0.21
SD	0.08	0.12
TN	0.51	1.67

Upwind State	Largest Downwind Contribution to Nonattainment Receptors for Ozone (ppb)	Largest Downwind Contribution to Maintenance Receptors for Ozone (ppb
TX	2.44	2.95
VT	0.01	0.05
VA	1.87	5.29
WV	0.95	3.11
WI	0.34	2.59

As discussed in the preamble, the EPA is proposing to establish an air quality screening threshold calculated as one percent of the NAAQS. For this rule, we propose an 8-hour ozone threshold of 0.75 ppb as the quantification of one percent of the 2008 ozone NAAQS. This threshold is used to identify upwind states that contribute to downwind ozone concentrations in amounts sufficient to “link” them to these to downwind nonattainment and maintenance receptors.

States in the East whose contributions to a specific receptor meet or exceed the screening threshold are considered linked to that receptor; those states’ ozone contributions and emissions (and available emission reductions) are analyzed further, as described in the premable, to determine whether and what emissions reductions might be required from each state.

Based on the maximum downwind contributions in Table 4-2, the following states contribute at or above the 0.75 ppb threshold to downwind nonattainment receptors: Alabama, Arkansas, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Missouri, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Texas, Virginia, and West Virginia. Based on the maximum downwind contributions in Table 4-2, the following states contribute at or above the 0.75 ppb threshold to downwind maintenance-only receptors: Alabama, Arkansas, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, Virginia, West Virginia, and Wisconsin. The linkages between each upwind state and downwind nonattainment receptors and maintenance-only receptors in the eastern U.S. are provided in Table 4-3 and Table 4-4, respectively.

Table 4-3. Linkages between each upwind state and downwind nonattainment receptors in the eastern U.S.

Upwind State	Downwind Nonattainment Receptors		
AL	Tarrant Co, TX (484392003)		
AR	Brazoria Co, TX (480391004)	Tarrant Co, TX (484392003)	Tarrant Co, TX (484393009)
IL	Brazoria Co, TX (480391004)	Sheboygan Co, WI (551170006)	
IN	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	Sheboygan Co, WI (551170006)
KS	Sheboygan Co, WI (551170006)		
KY	Sheboygan Co, WI (551170006)		
LA	Brazoria Co, TX (480391004)	Denton Co, TX (481210034)	Tarrant Co, TX (484392003)
	Tarrant Co, TX (484393009)	Sheboygan Co, WI (551170006)	
MD	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	New Haven Co, CT (90099002)
MI	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	New Haven Co, CT (90099002)
	Sheboygan Co, WI (551170006)		
MS	Brazoria Co, TX (480391004)		
MO	Brazoria Co, TX (480391004)	Sheboygan Co, WI (551170006)	
NJ	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	New Haven Co, CT (90099002)
NY	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	New Haven Co, CT (90099002)
OH	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	New Haven Co, CT (90099002)
	Sheboygan Co, WI (551170006)		
OK	Denton Co, TX (481210034)	Tarrant Co, TX (484392003)	Tarrant Co, TX (484393009)

Upwind State	Downwind Nonattainment Receptors		
	Sheboygan Co, WI (551170006)		
PA	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	New Haven Co, CT (90099002)
TX	Sheboygan Co, WI (551170006)		
VA	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	New Haven Co, CT (90099002)
WV	Fairfield Co, CT (90013007)	Fairfield Co, CT (90019003)	

Table 4-4. Linkages between each upwind states and downwind maintenance-only receptors in the eastern U.S.

Upwind State	Downwind Nonattainment Receptors		
AL	Hamilton Co, OH (390610006)	Harris Co, TX (482010055)	
AR	Oldham Co, KY (211850004)	Allegan Co, MI (260050003)	Dallas Co, TX (481130069)
	Dallas Co, TX (481130075)	Harris Co, TX (482010026)	Harris Co, TX (482010055)
	Harris Co, TX (482011039)	Harris Co, TX (482011050)	Tarrant Co, TX (484390075)
	Tarrant Co, TX (484393011)		
DE	Camden Co, NJ (340071001)	Gloucester Co, NJ (340150002)	Ocean Co, NJ (340290006)
	Philadelphia Co, PA (421010024)		
IL	Jefferson Co, KY (211110067)	Oldham Co, KY (211850004)	Allegan Co, MI (260050003)
	Wayne Co, MI (261630019)	Camden Co, NJ (340071001)	Gloucester Co, NJ (340150002)
	Ocean Co, NJ (340290006)	Queens Co, NY (360810124)	Suffolk Co, NY (361030002)
	Hamilton Co, OH (390610006)	Allegheny Co, PA (420031005)	Harris Co, TX (482010026)

Upwind State	Downwind Nonattainment Receptors		
	Harris Co, TX (482011039)		
IN	Jefferson Co, KY (211110067)	Oldham Co, KY (211850004)	Baltimore Co, MD (240053001)
	Harford Co, MD (240251001)	Allegan Co, MI (260050003)	Wayne Co, MI (261630019)
	Camden Co, NJ (340071001)	Gloucester Co, NJ (340150002)	Middlesex Co, NJ (340230011)
	Ocean Co, NJ (340290006)	Queens Co, NY (360810124)	Richmond Co, NY (360850067)
	Suffolk Co, NY (361030002)	Hamilton Co, OH (390610006)	Allegheny Co, PA (420031005)
	Philadelphia Co, PA (421010024)		
IA	Allegan Co, MI (260050003)		
KS	Allegan Co, MI (260050003)	Tarrant Co, TX (484390075)	Tarrant Co, TX (484393011)
KY	Baltimore Co, MD (240053001)	Harford Co, MD (240251001)	Camden Co, NJ (340071001)
	Gloucester Co, NJ (340150002)	Middlesex Co, NJ (340230011)	Ocean Co, NJ (340290006)
	Richmond Co, NY (360850067)	Hamilton Co, OH (390610006)	Allegheny Co, PA (420031005)
	Philadelphia Co, PA (421010024)		
LA	Collin Co, TX (480850005)	Dallas Co, TX (481130069)	Dallas Co, TX (481130075)
	Denton Co, TX (481211032)	Harris Co, TX (482010024)	Harris Co, TX (482010026)
	Harris Co, TX (482010055)	Harris Co, TX (482011034)	Harris Co, TX (482011039)
	Harris Co, TX (482011050)	Tarrant Co, TX (484390075)	Tarrant Co, TX (484393011)
MD	Fairfield Co, CT (90010017)	Gloucester Co, NJ (340150002)	Middlesex Co, NJ (340230011)
	Ocean Co, NJ (340290006)	Queens Co, NY (360810124)	Richmond Co, NY (360850067)
	Suffolk Co, NY (361030002)	Philadelphia Co, PA (421010024)	

Upwind State	Downwind Nonattainment Receptors		
MI	Fairfield Co, CT (90010017)	Jefferson Co, KY (211110067)	Oldham Co, KY (211850004)
	Harford Co, MD (240251001)	Camden Co, NJ (340071001)	Gloucester Co, NJ (340150002)
	Ocean Co, NJ (340290006)	Queens Co, NY (360810124)	Richmond Co, NY (360850067)
	Suffolk Co, NY (361030002)	Hamilton Co, OH (390610006)	Allegheny Co, PA (420031005)
MS	Harris Co, TX (482010055)	Harris Co, TX (482011039)	
MO	Oldham Co, KY (211850004)	Allegan Co, MI (260050003)	Camden Co, NJ (340071001)
	Hamilton Co, OH (390610006)	Harris Co, TX (482010026)	Harris Co, TX (482010055)
	Harris Co, TX (482011039)	Harris Co, TX (482011050)	
NJ	Fairfield Co, CT (90010017)	Queens Co, NY (360810124)	Richmond Co, NY (360850067)
	Suffolk Co, NY (361030002)	Philadelphia Co, PA (421010024)	
NY	Fairfield Co, CT (90010017)	Camden Co, NJ (340071001)	Gloucester Co, NJ (340150002)
	Middlesex Co, NJ (340230011)	Ocean Co, NJ (340290006)	
NC	Baltimore Co, MD (240053001)		
OH	Fairfield Co, CT (90010017)	Jefferson Co, KY (211110067)	Oldham Co, KY (211850004)
	Baltimore Co, MD (240053001)	Harford Co, MD (240251001)	Wayne Co, MI (261630019)
	Camden Co, NJ (340071001)	Gloucester Co, NJ (340150002)	Middlesex Co, NJ (340230011)
	Ocean Co, NJ (340290006)	Queens Co, NY (360810124)	Richmond Co, NY (360850067)
	Suffolk Co, NY (361030002)	Allegheny Co, PA (420031005)	Philadelphia Co, PA (421010024)
OK	Allegan Co, MI (260050003)	Hamilton Co, OH (390610006)	Dallas Co, TX (481130069)
	Dallas Co, TX (481130075)	Denton Co, TX (481211032)	Harris Co, TX (482010026)

Upwind State	Downwind Nonattainment Receptors		
	Harris Co, TX (482011034)	Harris Co, TX (482011039)	Tarrant Co, TX (484390075)
	Tarrant Co, TX (484393011)		
PA	Fairfield Co, CT (90010017)	Baltimore Co, MD (240053001)	Harford Co, MD (240251001)
	Camden Co, NJ (340071001)	Gloucester Co, NJ (340150002)	Middlesex Co, NJ (340230011)
	Ocean Co, NJ (340290006)	Queens Co, NY (360810124)	Richmond Co, NY (360850067)
	Suffolk Co, NY (361030002)		
TN	Hamilton Co, OH (390610006)	Philadelphia Co, PA (421010024)	
TX	Baltimore Co, MD (240053001)	Harford Co, MD (240251001)	Allegan Co, MI (260050003)
	Camden Co, NJ (340071001)	Gloucester Co, NJ (340150002)	Ocean Co, NJ (340290006)
	Queens Co, NY (360810124)	Richmond Co, NY (360850067)	Suffolk Co, NY (361030002)
	Hamilton Co, OH (390610006)	Allegheny Co, PA (420031005)	Philadelphia Co, PA (421010024)
VA	Fairfield Co, CT (90010017)	Baltimore Co, MD (240053001)	Harford Co, MD (240251001)
	Gloucester Co, NJ (340150002)	Middlesex Co, NJ (340230011)	Ocean Co, NJ (340290006)
	Queens Co, NY (360810124)	Richmond Co, NY (360850067)	Suffolk Co, NY (361030002)
	Philadelphia Co, PA (421010024)		
WV	Baltimore Co, MD (240053001)	Harford Co, MD (240251001)	Camden Co, NJ (340071001)
	Gloucester Co, NJ (340150002)	Middlesex Co, NJ (340230011)	Ocean Co, NJ (340290006)
	Queens Co, NY (360810124)	Richmond Co, NY (360850067)	Suffolk Co, NY (361030002)
	Hamilton Co, OH (390610006)	Allegheny Co, PA (420031005)	Philadelphia Co, PA (421010024)
WI	Allegan Co, MI (260050003)	Wayne Co, MI (261630019)	

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Appendix A

2011 Model Performance Evaluation

An operational model evaluation was conducted for the 2011 base year CAMx annual model simulation performed for the 12-km U.S. modeling domain. The purpose of this evaluation is to examine the ability of the 2011 air quality modeling platform to represent the magnitude and spatial and temporal variability of measured (i.e., observed) ozone concentrations within the modeling domain. The evaluation presented here is based on model simulations using the v2 version of the 2011 emissions platform (i.e., case name 2011eh_cb6v2_v6_11g). The 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) and the Clean Air Status and Trends Network (CASTNet) (Figures A-1a and A-1b).

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 for each of nine climate regions of the 12-km U.S. modeling domain. The regions include the Northeast, Ohio Valley, Upper Midwest, Southeast, South, Southwest, Northern Rockies, Northwest and West[1,2], which are defined based upon the states contained within the National Oceanic and Atmospheric Administration (NOAA) climate regions (Figure A-2)[3] as defined in Karl and Koss (1984).

For maximum daily average 8-hour (MDA8) ozone, model performance statistics were created for each climate region for the period May through September.[4] In addition to the performance statistics, we prepared several graphical presentations of model performance for MDA8 ozone. These graphical presentations include:

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[1] The nine climate regions are defined by States where: Northeast includes CT, DE, ME, MA, MD, NH, NJ, NY, PA, RI, and VT; Ohio Valley includes IL, IN, KY, MO, OH, TN, and WV; Upper Midwest includes IA, MI, MN, and WI; Southeast includes AL, FL, GA, NC, SC, and VA; South includes AR, KS, LA, MS, OK, and TX; Southwest includes AZ, CO, NM, and UT; Northern Rockies includes MT, NE, ND, SD, WY; Northwest includes ID, OR, and WA; and West includes CA and NV.
[2] Note most monitoring sites in the West region are located in California (see Figures 2A-2a and 2A-2b), therefore statistics for the West will be mostly representative of California ozone air quality.
[3] NOAA, National Centers for Environmental Information scientists have identified nine climatically consistent regions within the contiguous U.S., http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-regions.php.
[4] In calculating the ozone season statistics we limited the data to those observed and predicted pairs with observations that are greater than or equal 60 ppb in order to focus on concentrations at the upper portion of the distribution of values.

(1) density scatter plots of observed AQS data and predicted MDA8 ozone concentrations for May through September;

(2) regional 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 and CASTNet monitoring sites;

(3) bar and whisker plots that show the distribution of the predicted and observed MDA8 ozone concentrations by month (May through September) and by region and by network; and

(4) time series plots (May through September) of observed and predicted MDA8 ozone concentrations for 13 of the projected 2017 nonattainment and maintenance-only sites as identified below.

The Atmospheric Model Evaluation Tool (AMET) was used to calculate the model performance statistics used in this document (Gilliam et al., 2005). For this evaluation of the ozone predictions in the 2011 CAMx modeling platform, 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) and the draft photochemical modeling guidance (US EPA, 2014c). As noted above, we calculated the performance statistics by climate region for the period May through September.

Mean bias (MB) is the average of the difference (predicted – observed) divided by the total number of replicates (*n*). Mean bias is given in units of ppb and is defined as:

MB = $\frac{1}{n}\sum_{1}^{n}(P - O)$, where P = predicted and O = observed concentrations.

Mean error (ME) calculates the absolute value of the difference (predicted - observed) divided by the total number of replicates (*n*). Mean error is given in units of ppb and is defined as:

ME = $\frac{1}{n}\sum_{1}^{n}|P - O|$

Normalized mean bias (NMB) is the average the difference (predicted - observed) over the sum of observed values. NMB is a useful model performance indicator because it avoids over inflating the observed range of values, especially at low concentrations. Normalized mean bias is given in percentage units and is defined as:

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

Normalized mean error (NME) is the absolute value of the difference (predicted - observed) over the sum of observed values. Normalized mean error is given in percentage units and is defined as:

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

As described in more detail below, the model performance statistics indicate that the 8-hour daily maximum ozone concentrations predicted by the 2011 CAMx modeling platform closely reflect the corresponding 8-hour observed ozone concentrations in space and time 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; US EPA, 2005; US EPA, 2009; US EPA, 2011). 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 2011 modeling platform closely replicate the corresponding observed concentrations in terms of the magnitude, temporal fluctuations, and spatial differences for 8-hour daily maximum ozone.

The density scatter plots of MDA8 ozone are provided Figure A-3. The 8-hour ozone model performance bias and error statistics by network for the ozone season (May-September average) for each region are provided in Table A-1. The statistics shown were calculated using data pairs on days with observed 8-hour ozone of $\geq$ 60 ppb. The distributions of observed and predicted 8-hour ozone by month in the period May through September for each region are shown in Figures A-4 through A-12. Spatial plots of the mean bias and error as well as the normalized mean bias and error for individual monitors are shown in Figures A-13 through A-16. Time series plots of observed and predicted MDA 8-hour ozone during the period May through September at 13 sites are provided in Figure A-17, (a) through (m). These sites are listed in Table A-2.

The density scatter plots in Figure A-3 provide a qualitative comparison of model-predicted and observed MDA8 ozone concentrations. In these plots the intensity of the colors indicates the density of individual observed/predicted paired values. The greatest number of individual paired values is denoted by the core area in white. The plots indicate that the predictions correspond closely to the observations in that a large number of observed/predicted paired values lie along or close to the 1:1 line shown on each plot. Overall, performance is best for observed values ≥ 60. The model tends to over-predict the observed values to some extent particularly at low and mid-range concentrations generally < 60 ppb in each of the regions. This feature is most evident in the South and Southeast regions. In the West, high concentrations are under-predicted and low and mid-range concentrations are over-predicted. Observed and predicted values are in close agreement in the Southwest and Northwest regions.

As indicated by the statistics in Table A-1, bias and error for 8-hour daily maximum ozone are relatively low in each region. Generally, MB for 8-hour ozone ≥ 60 ppb during the ozone season is less than 5 ppb except at AQS sites in the West region and at rural CASTNet sites in the South, Southwest, and West for which ozone is somewhat under-predicted. The monthly distribution of 8-hour daily maximum ozone during the ozone season generally corresponds well with that of the observed concentrations, as indicated by the graphics in Figures A-4 through A-12. The distribution of predicted concentrations tends to be close to that of the observed data at the 25th percentile, median and 75th percentile values for each region, although there is a small persistent overestimation bias for these metrics in the Northeast, Southeast, and Ohio Valley regions, and under-prediction at CASTNet sites in the West and Southwest[5]. The CAMx model, as applied here, also has a tendency to under-predict the highest observational concentrations at both the AQS and CASTNet network sites.

[5] The over-prediction at CASTNet sites in the Northwest may not be representative of performance in rural areas of this region because there are so few observed and predicted data pairs in this region.

Figures A-13 through A-16 show the spatial variability in bias and error at monitor locations. Mean bias, as seen from Figure A-13, is less than 5 ppb at many sites across the East with over-prediction of 5 to 10 ppb at some sites from the Southeast into the Northeast. Elsewhere, mean bias is generally in the range of -5 to -10 ppb. Figure A-14 indicates that the normalized mean bias for days with observed 8-hour daily maximum ozone greater than or equal to 60 ppb is within ± 10 percent at the vast majority of monitoring sites across the modeling domain. There are regional differences in model performance, where the model tends to over-predict from the Southeast into the Northeast and generally under predict in the Southwest, Northern Rockies, Northwest and West. Model performance in the Ohio Valley and Upper Midwest states shows both under and over predictions.

Model error, as seen from Figure A-15, is 10 ppb or less at most of the sites across the modeling domain. Figure A-16 indicates that the normalized mean error for days with observed 8-hour daily maximum ozone greater than or equal to 60 ppb is within 10 percent at the vast majority of monitoring sites across the modeling domain. Somewhat greater error (i.e., greater than 15 percent) is evident at sites in several areas most notably along portions of the Northeast and in portions of Florida, North Dakota, Illinois, Ohio, North Carolina, and the western most part of the modeling domain.

In addition to the above analysis of overall model performance, we also examine how well the modeling platform replicates day to day fluctuations in observed 8-hour daily maximum concentrations using data for 13 of the projected 2017 nonattainment and maintenance-only sites. For this site-specific analysis we present the time series of observed and predicted 8-hour daily maximum concentrations by site over the period May through September. The results, as shown in Figures A-17 (a) through (m), indicate that the modeling platform generally replicates the day-to-day variability in ozone during this time period. For example, several of the sites not only have minimal bias but also accurately capture the day-to-day variability in the observations: Jefferson County, KY; Alleghany County, PA; and Philadelphia, PA. Other sites generally track well and capture day-to-day variability but underestimate some of the peak ozone days: Imperial County, CA; Suffolk, NY; Tarrant County, TX; Brazoria County, TX; and Sheboygan County, WI. Note that at the site in Brazoria County, TX there is an extended period from mid-July to mid-August with very low observed ozone concentrations, mostly in the range of 30 to 40 ppb.

The model predicted values during this period in the range of 40 to 60 ppb which is not quite as low as the observed values. The sites in Douglas County, CO, Harford County, MD, Allegan, MI, and Hamilton County, OH closely track the day-to-day variability in the observed MDA8 values, but some days are over predicted while other days are under predicted to some extent. Finally, the site in Fairfield County, CT tracks closely with the observations, but there is a tendency to over predict on several of the observed high ozone days. Looking across all 13 sites indicates that the modeling platform is able to capture the site to site differences in the short-term variability of the observed ozone concentrations.

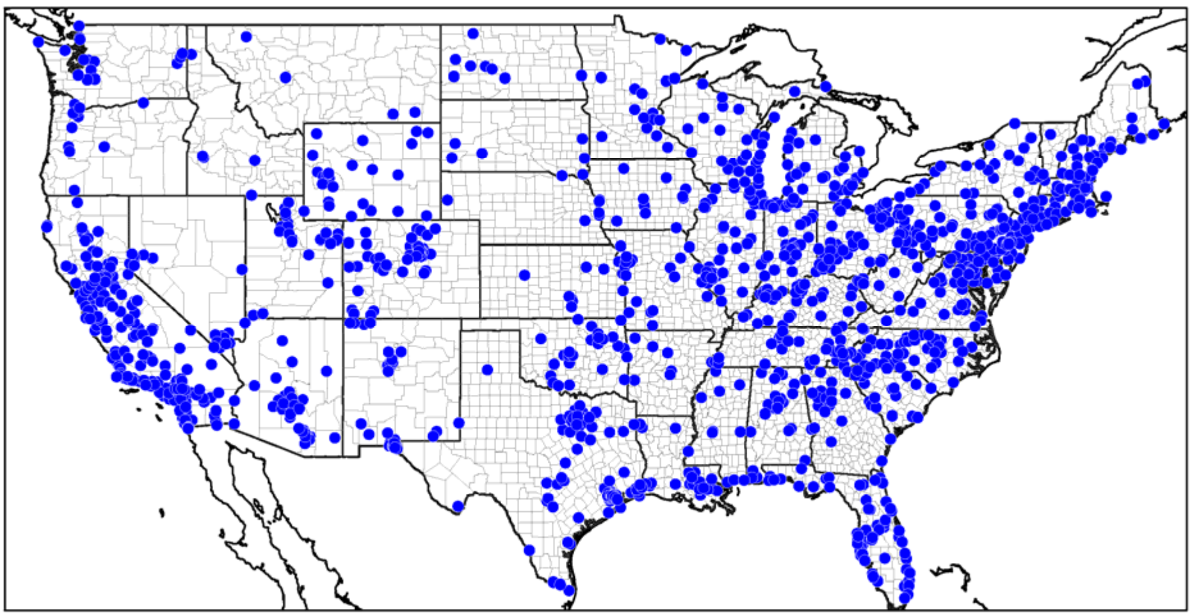
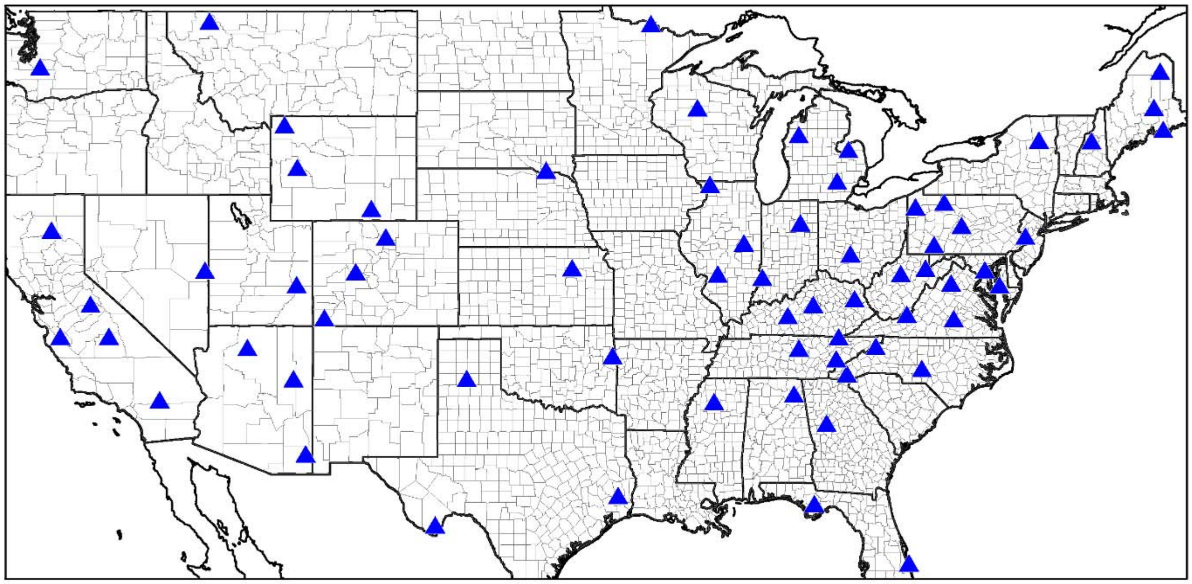


Figure A-1a. AQS ozone monitoring sites.



TRIANGLE=CASTNET;

Figure A-1b. CASTNet ozone monitoring sites.

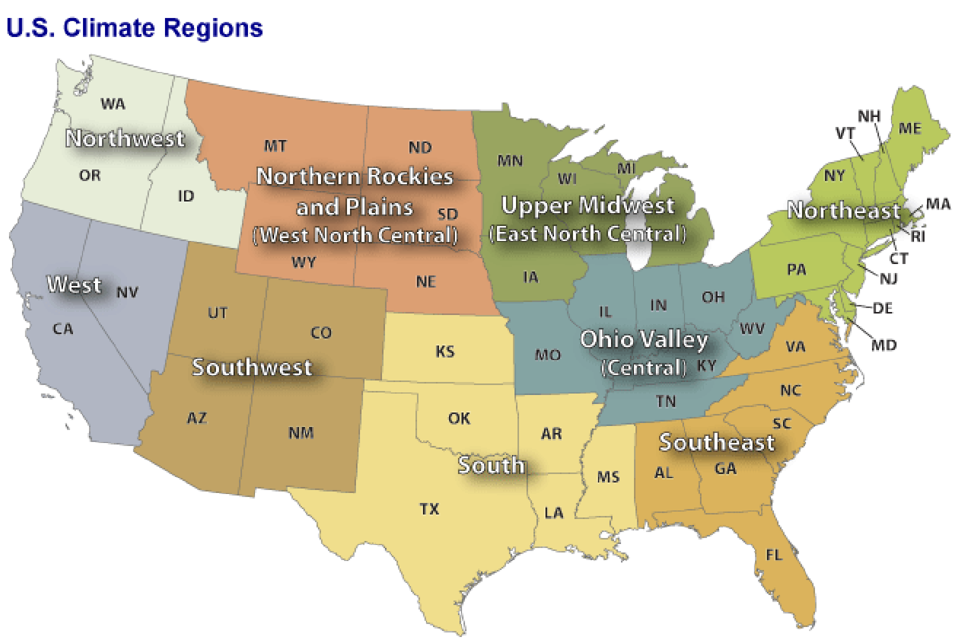


Figure A-2. NOAA climate regions (source: http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-regions.php#references)

Table A-1. Performance statistics for MDA8 ozone ≥ 60 ppb for May through September by climate region, by network.

Network	Climate region	No. of Obs	MB	ME	NMB (%)	NME (%)
AQS	Northeast	3,998	2.2	7.4	3.2	10.8
	Ohio Valley	6,325	0.3	7.6	0.4	11.3
	Upper Midwest	1,162	-3.0	7.5	-4.4	11.0
	Southeast	37,280	-2.5	8.1	-3.6	11.9
	South	5,694	-3.7	8.1	-5.4	11.7
	Southwest	6,033	-5.2	7.9	-7.8	12.0
	Northern Rockies	380	-5.9	7.4	-9.4	11.7
	Northwest	79	-5.4	8.1	-8.5	12.6
	West	8,665	-7.3	9.5	-10.3	13.5
CASTNet	Northeast	264	2.3	6.1	3.4	9.1
	Ohio Valley	107	-2.3	6.2	-3.4	9.4
	Upper Midwest	38	-3.9	5.9	-5.8	8.8
	Southeast	2,068	-5.0	8.2	-7.5	12.1
	South	215	-7.1	8.0	-10.7	12.0
	Southwest	382	-7.7	8.6	-11.7	13.1
	Northern Rockies	110	-7.8	8.1	-12.2	12.8
	Northwest	-	-	-	-	-
	West	425	-12.1	12.5	-16.6	17.1

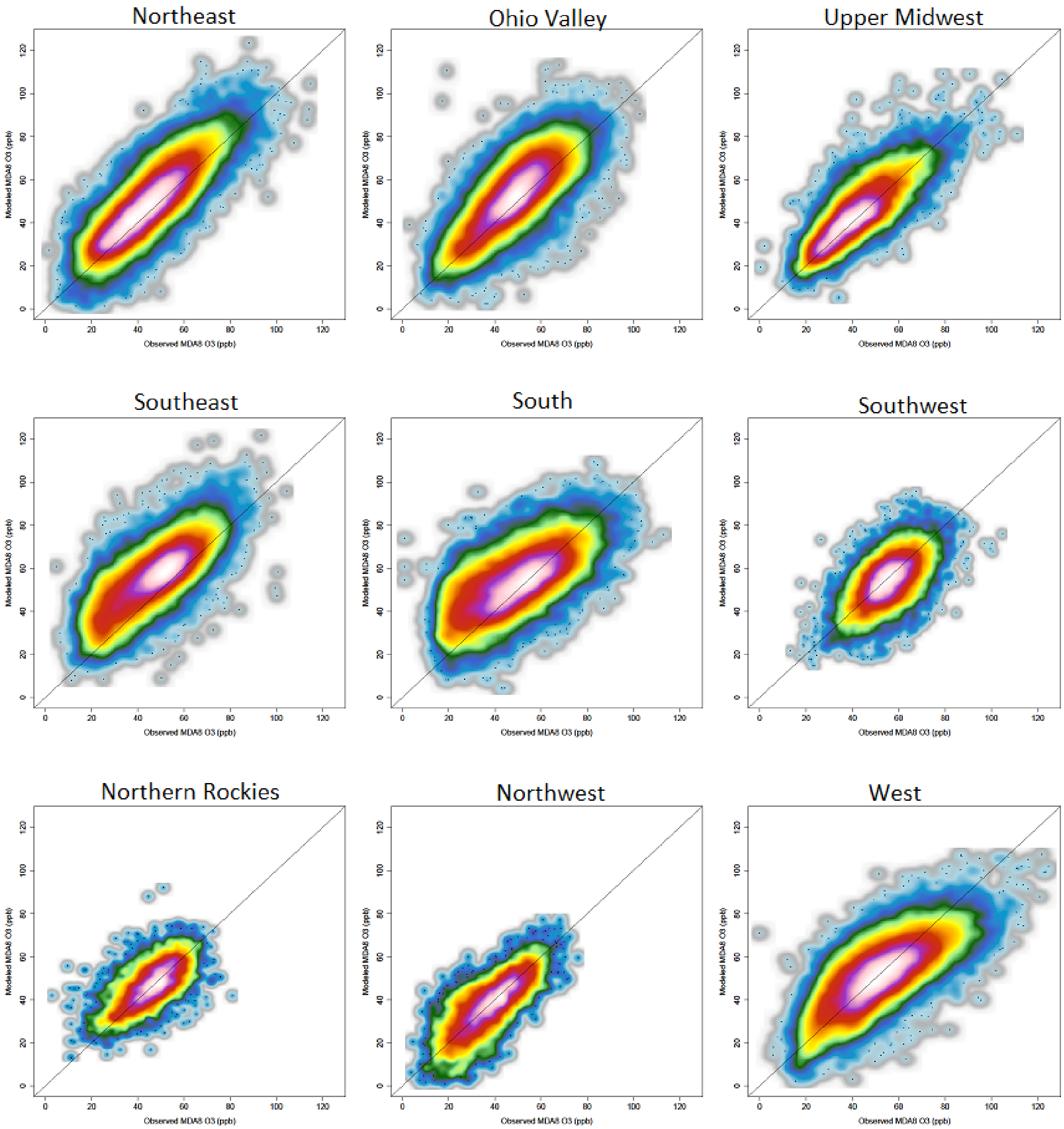


Figure A-3. Density scatter plots of observed vs predicted MDA8 ozone for the Northeast, Ohio River Valley, Upper Midwest, Southeast, South, Southwest, Northern Rockies, Northwest, and West Regions.

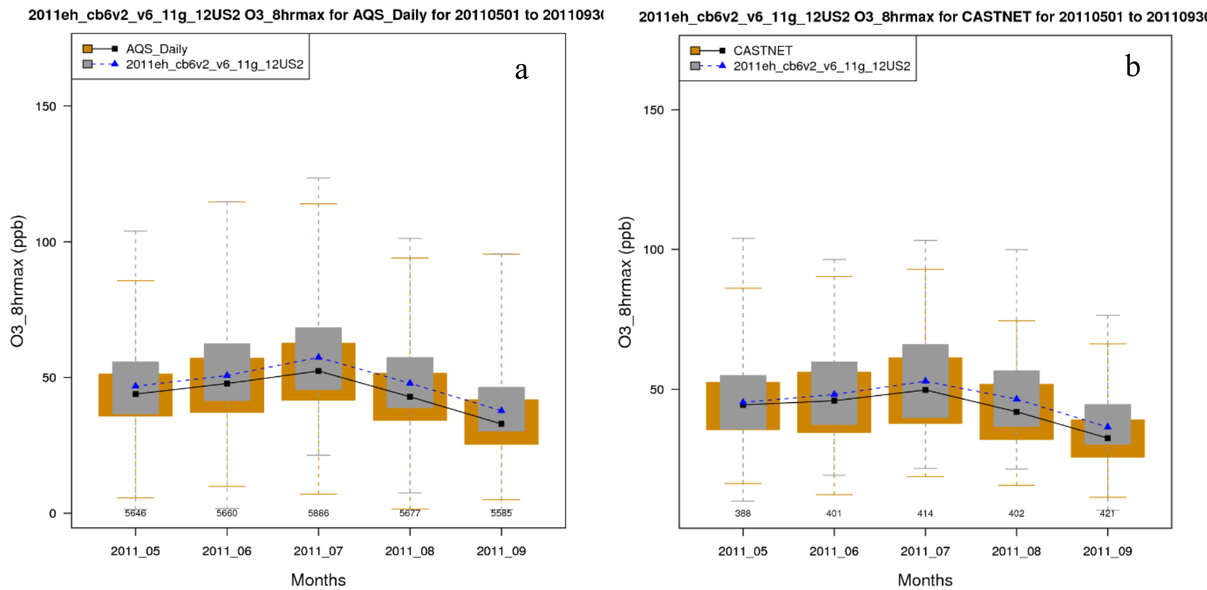


Figure A-4. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the Northeast region, (a) AQS Network and (b) CASTNet Network. [symbol = median; top/bottom of box = 75th/25th percentiles; top/bottom line = max/min values]

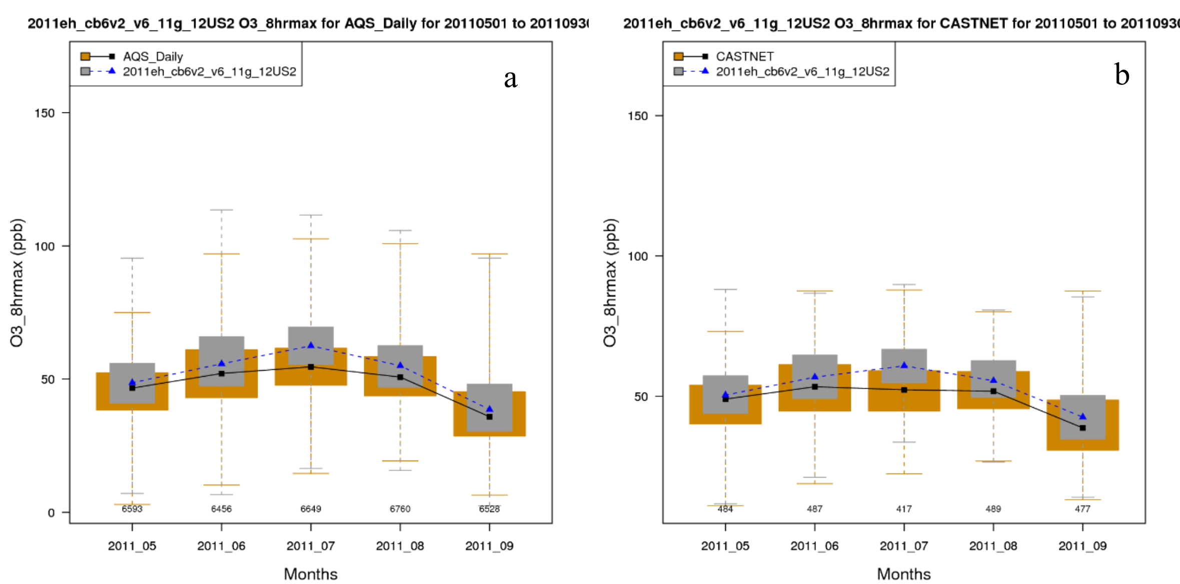


Figure A-5. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the Ohio Valley region, (a) AQS Network and (b) CASTNet Network.

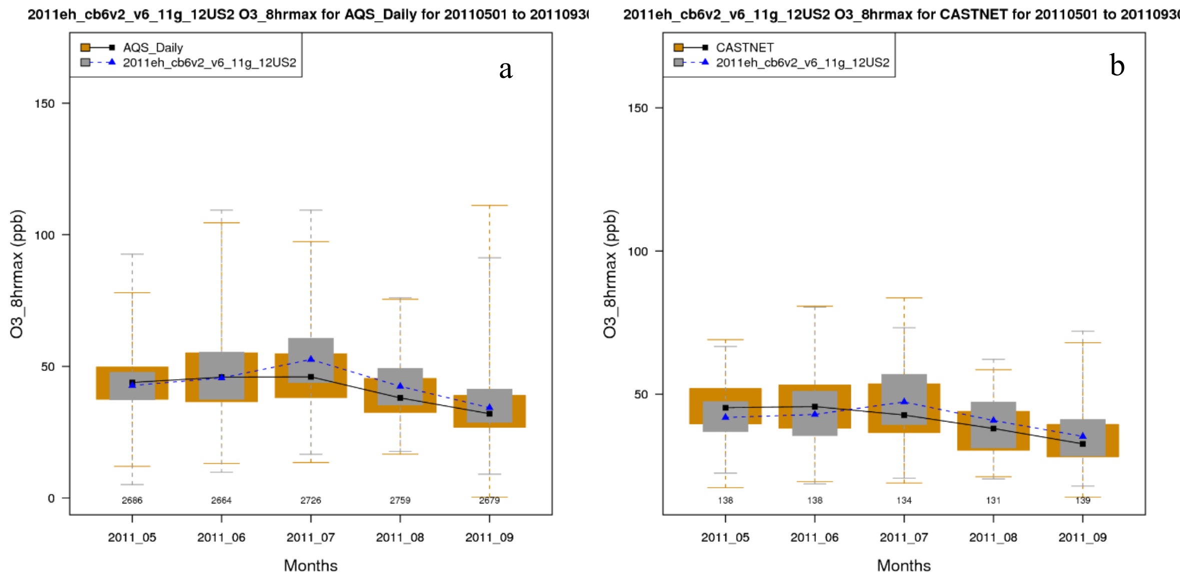


Figure A-6. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the Upper Midwest region, (a) AQS Network and (b) CASTNet Network.

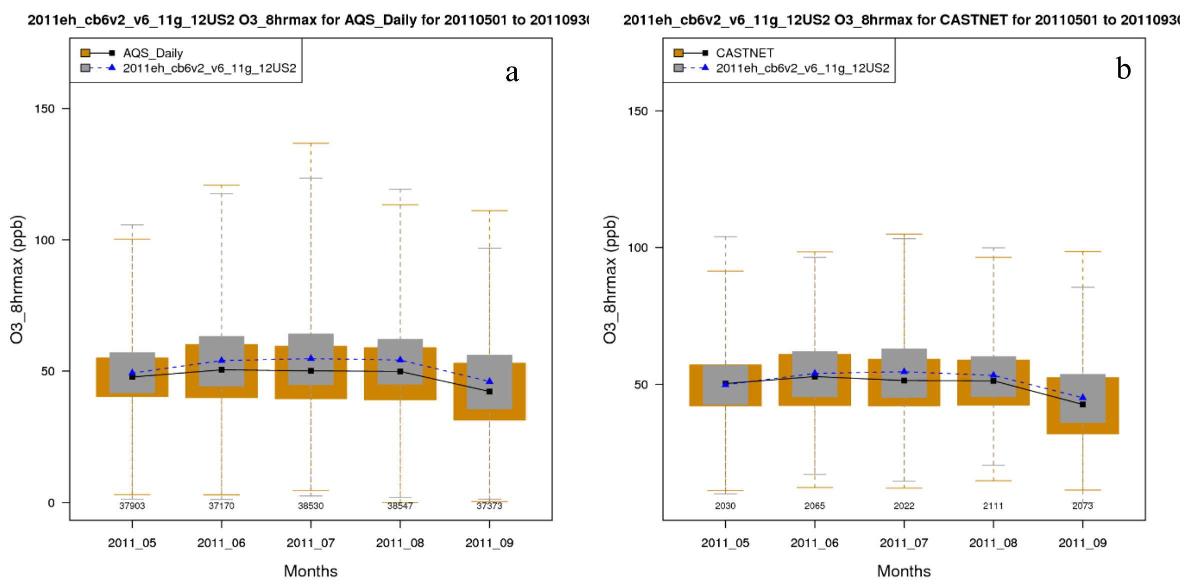


Figure A-7. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the Southeast region, (a) AQS Network and (b) CASTNet Network.

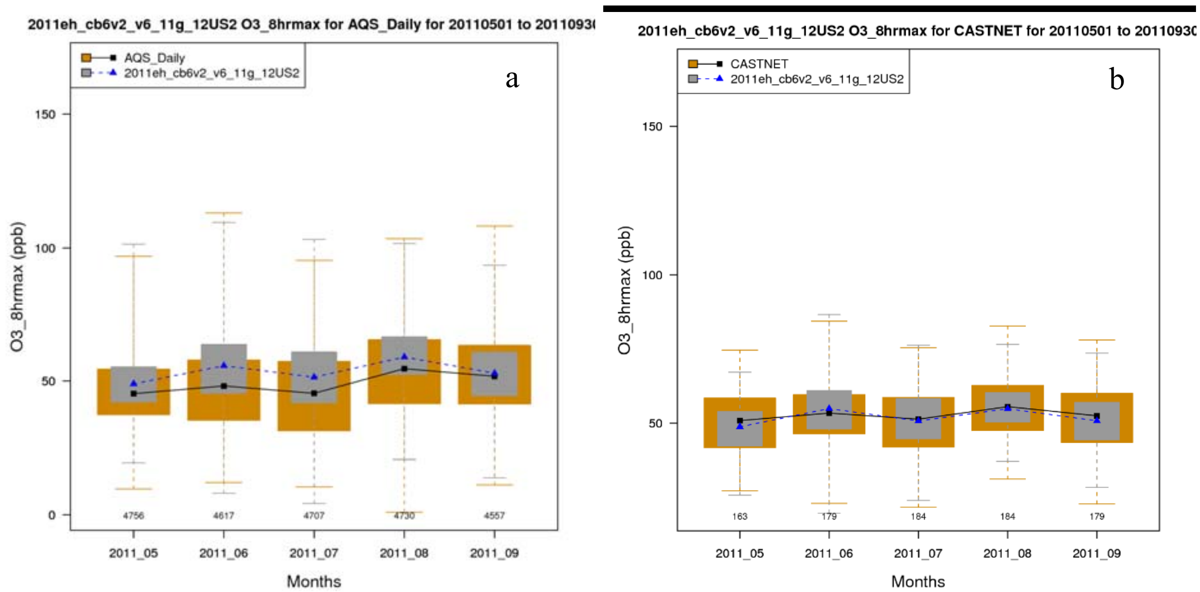


Figure A-8. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the South region, (a) AQS Network and (b) CASTNet Network.

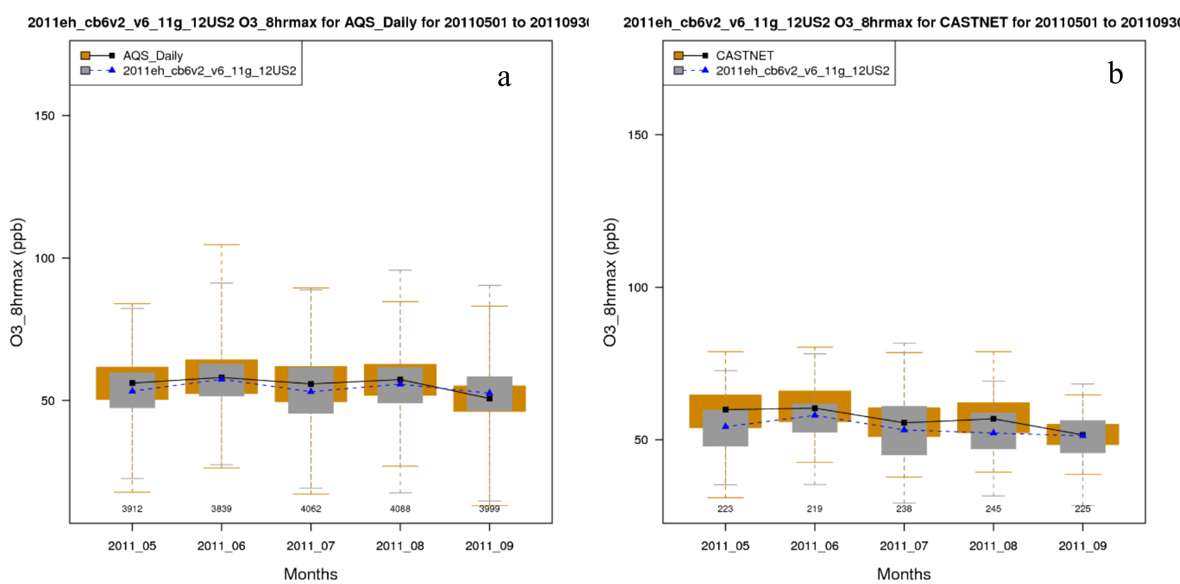


Figure A-9. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the Southwest region, (a) AQS Network and (b) CASTNet Network.

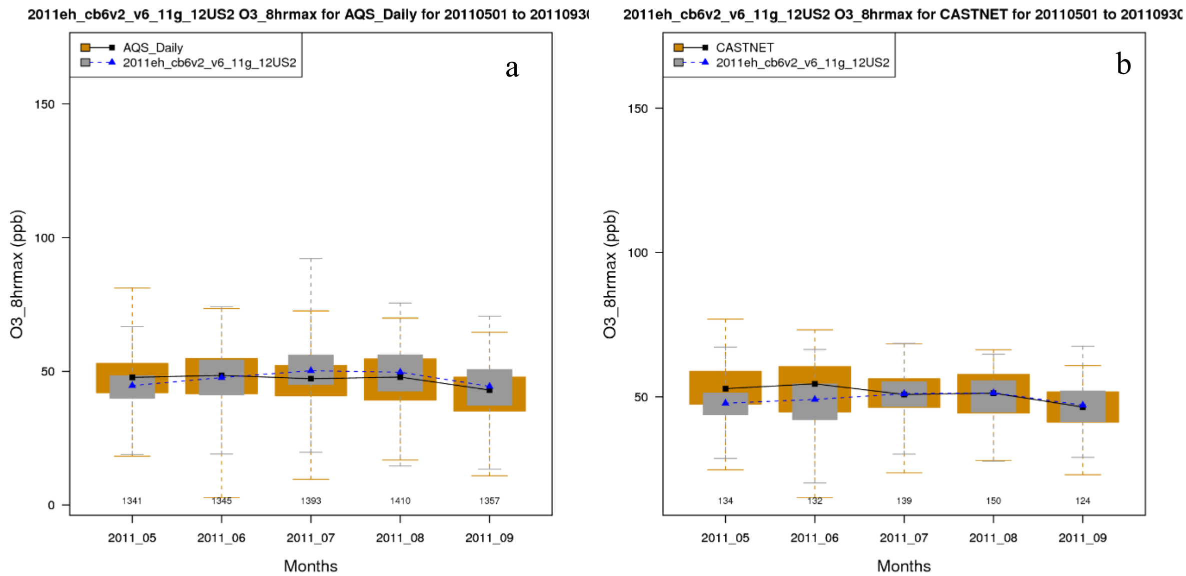


Figure A-10. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the Northern Rockies region, (a) AQS Network and (b) CASTNet Network.

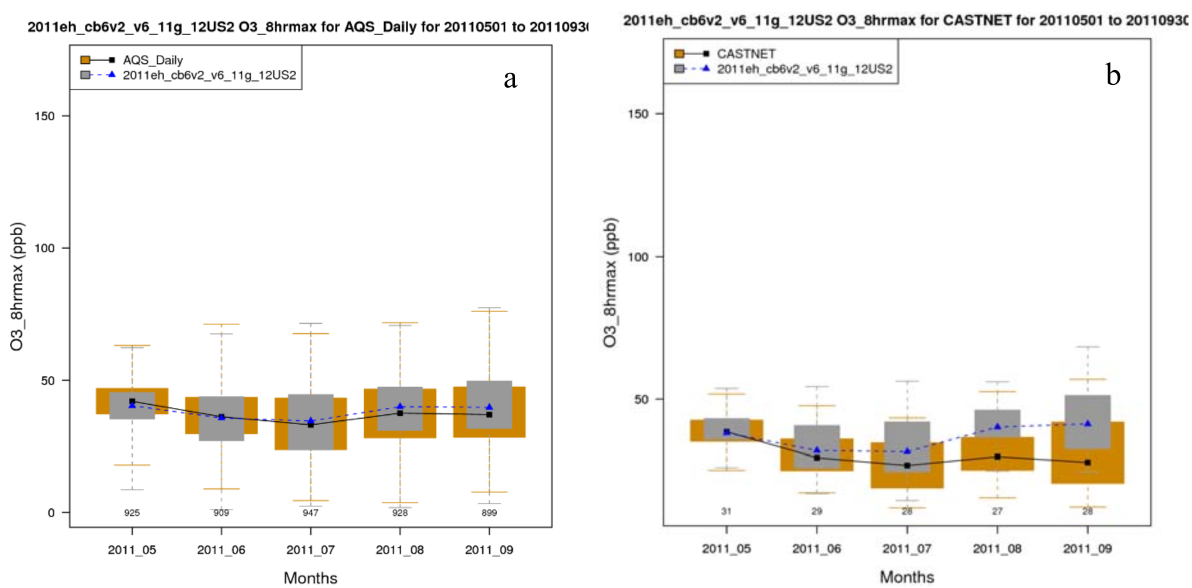


Figure A-11. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the Northwest region, (a) AQS Network and (b) CASTNet Network.

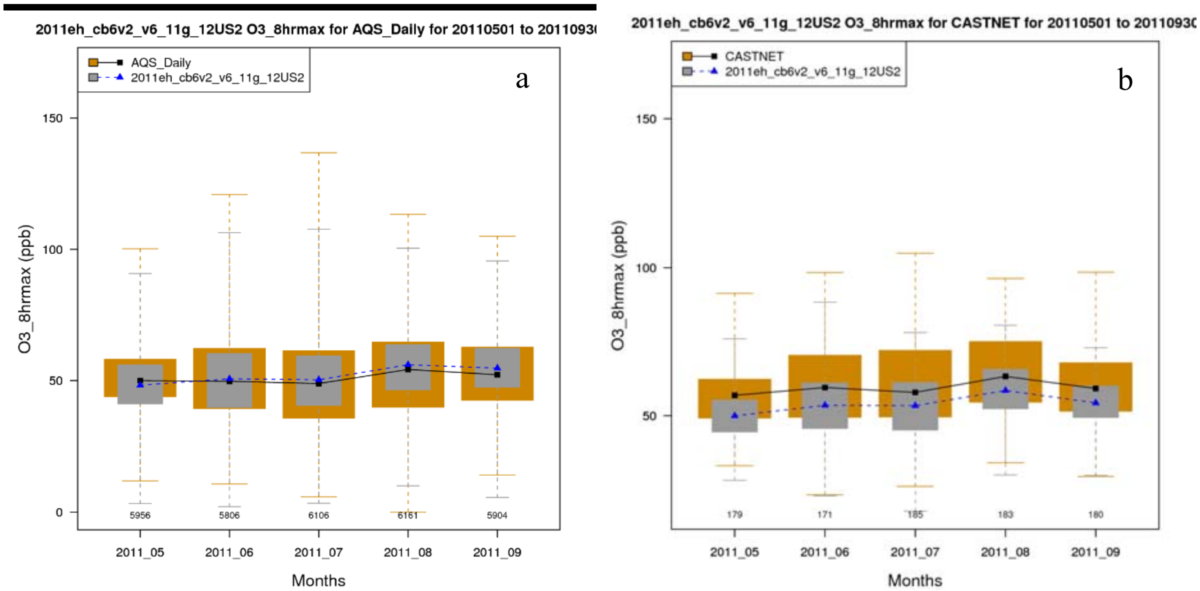


Figure A-12. Distribution of observed and predicted MDA8 ozone by month for the period May through September for the West region, (a) AQS Network and (b) CASTNet Network.

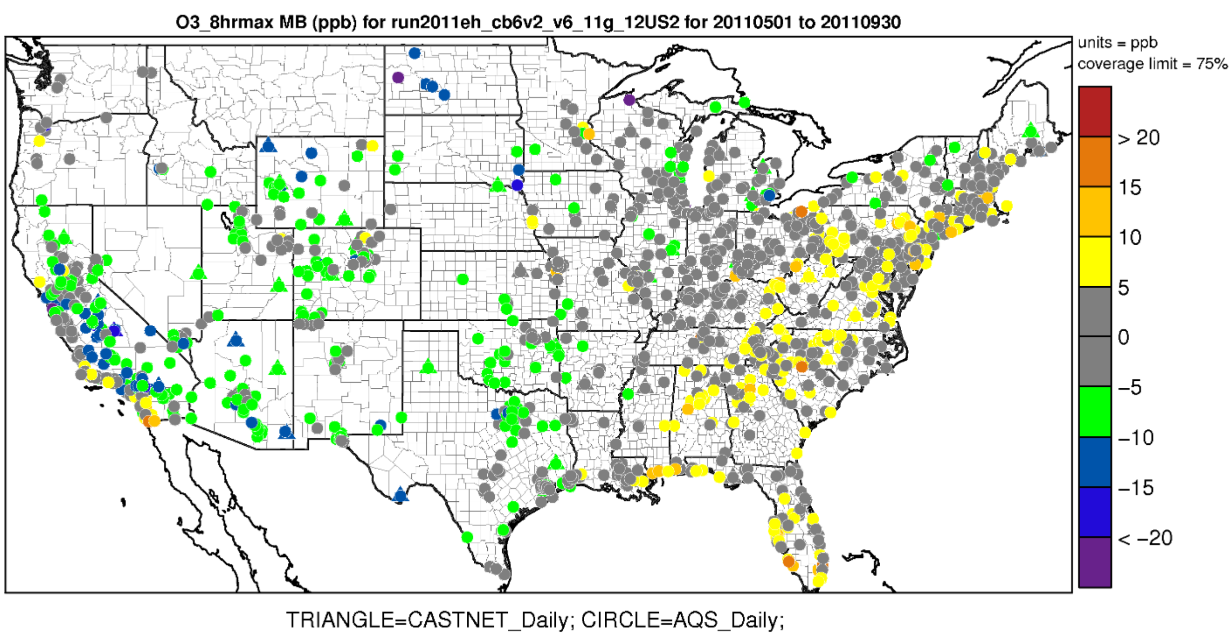


Figure A-13. Mean Bias (ppb) of MDA8 ozone ≥ 60 ppb over the period May-September 2011 at AQS and CASTNet monitoring sites.

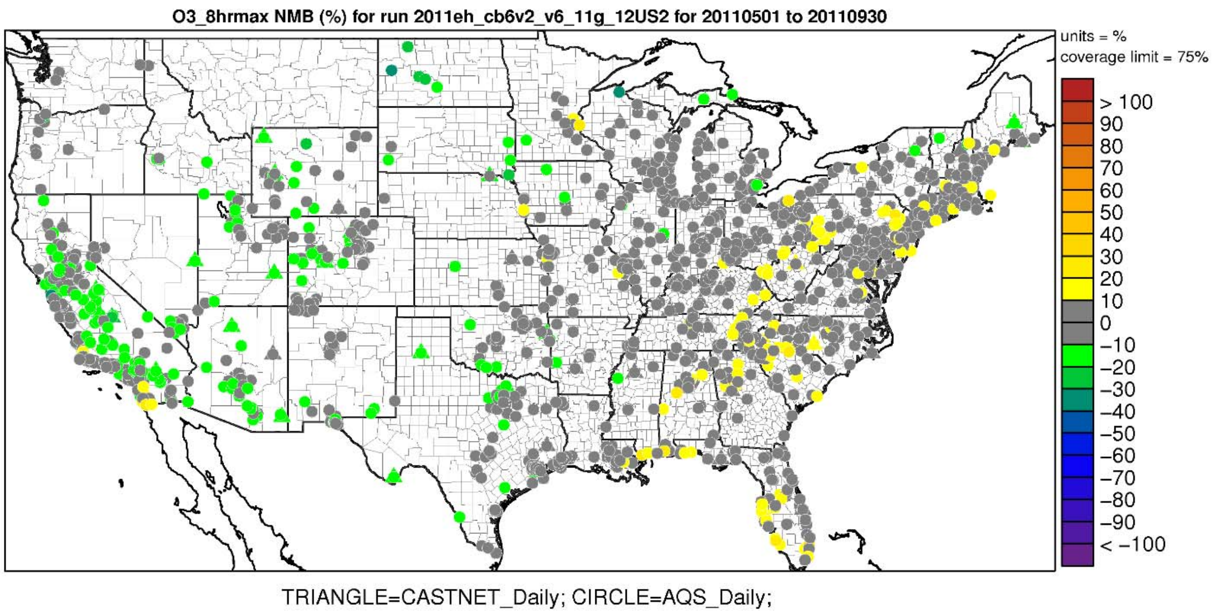


Figure A-14. Normalized Mean Bias (%) of MDA8 ozone ≥ 60 ppb over the period May-September 2011 at AQS and CASTNet monitoring sites.

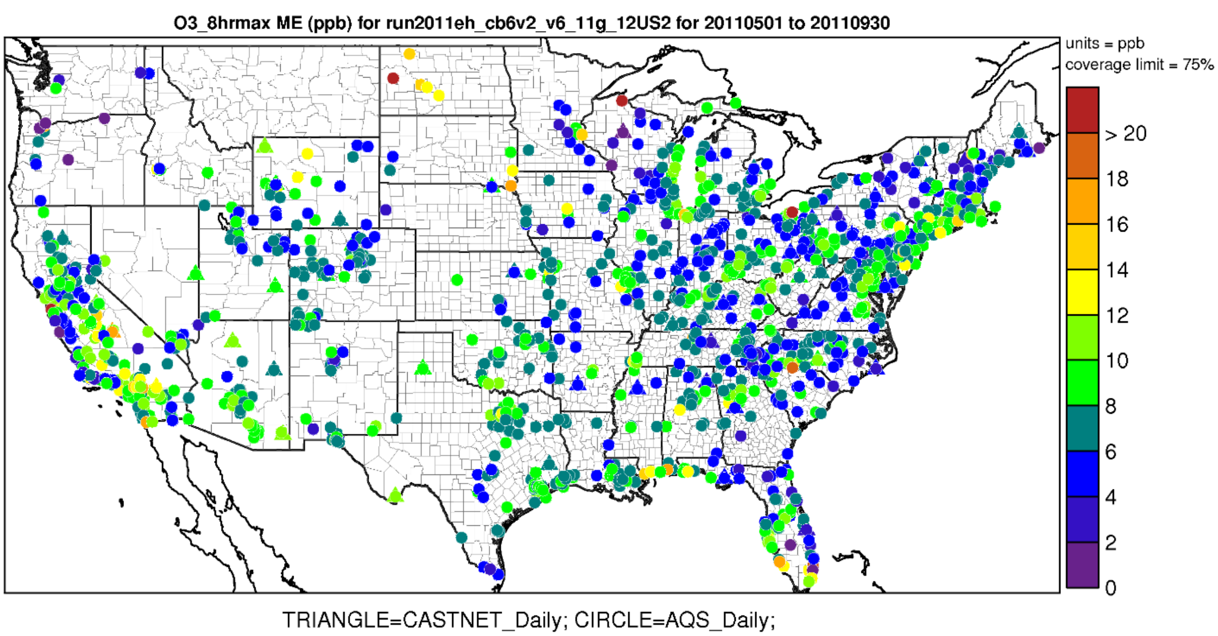


Figure A-15. Mean Error (ppb) of MDA8 ozone ≥ 60 ppb over the period May-September 2011 at AQS and CASTNet monitoring sites.

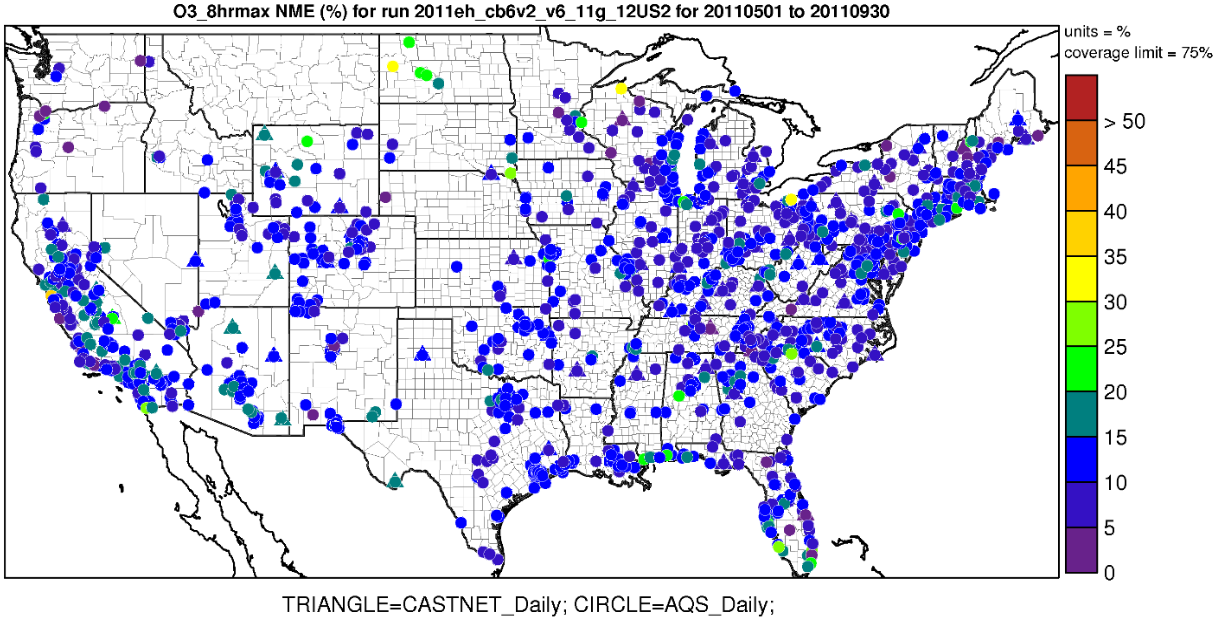


Figure A-16. Normalized Mean Error (%) of MDA8 ozone ≥ 60 ppb over the period May-September 2011 at AQS and CASTNet monitoring sites.

Table A-2. Monitoring sites used for the ozone time series analysis.

County	State	Monitoring Site ID
Fairfield	Connecticut	090013007
Suffolk	New York	361030002
Philadelphia	Pennsylvania	421010024
Harford	Maryland	240251001
Allegheny	Pennsylvania	420031005
Hamilton	Ohio	390610006
Jefferson	Kentucky	211110067
Allegan	Michigan	261630019
Sheboygan	Wisconsin	551170006
Tarrant	Texas	484392003
Brazoria	Texas	480391004
Douglas	Colorado	080350004
Imperial	California	060251003

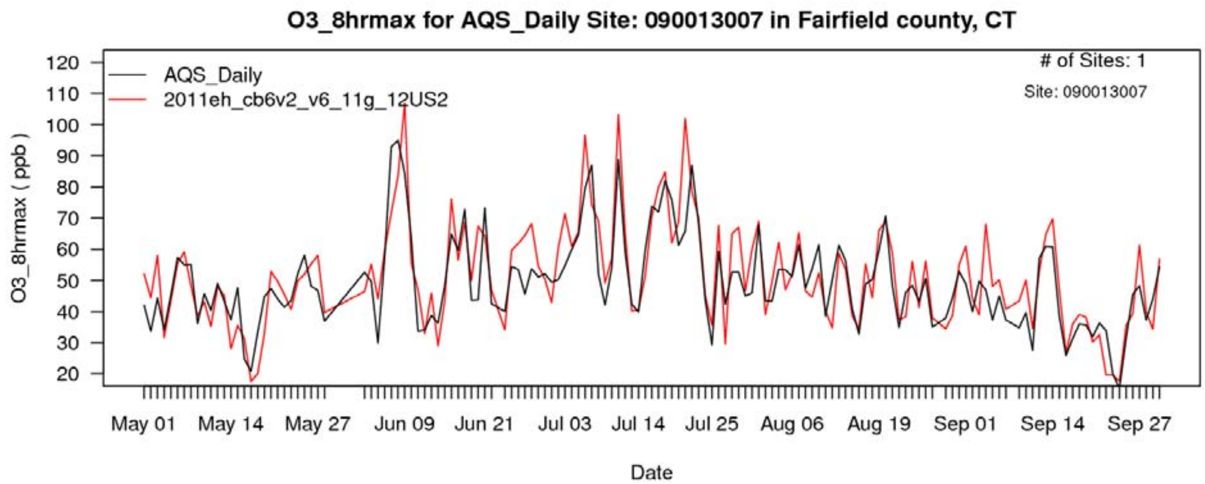


Figure A-17a. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 090013007 in Fairfield Co., Connecticut.

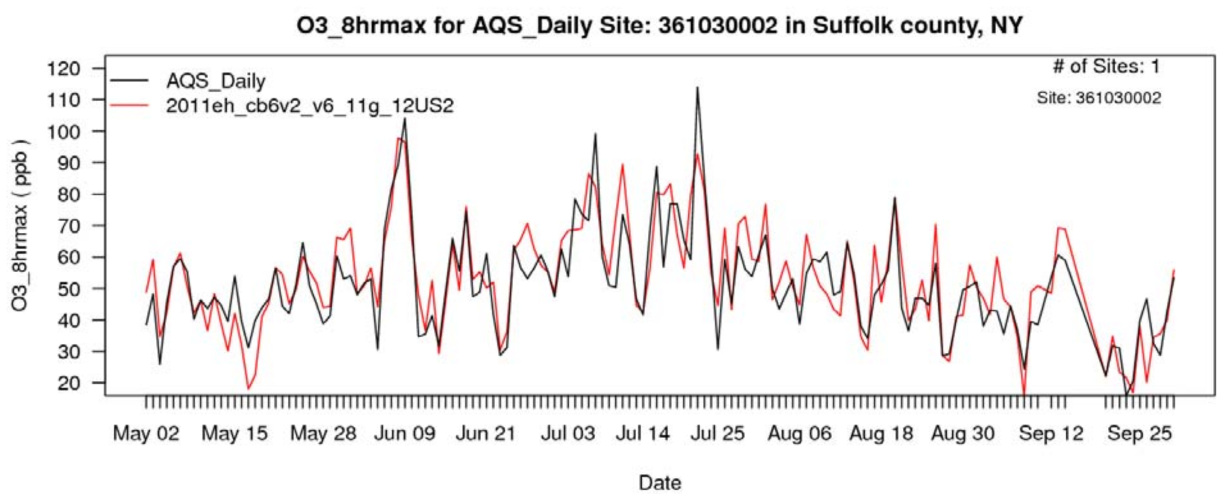


Figure A-17b. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 361030002 in Suffolk Co., New York.

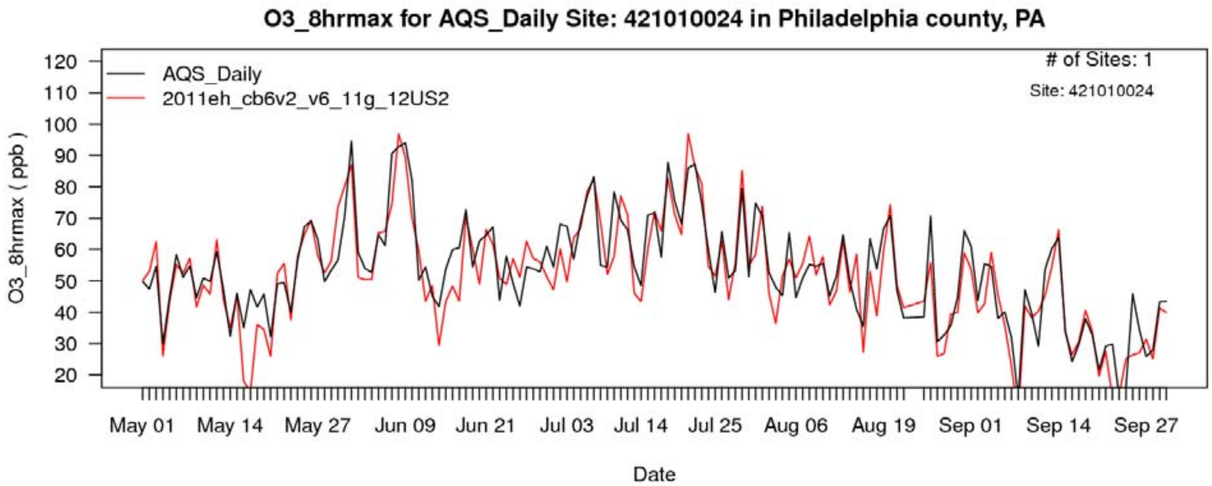


Figure A-17c. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 421010024 in Philadelphia Co., Pennsylvania.

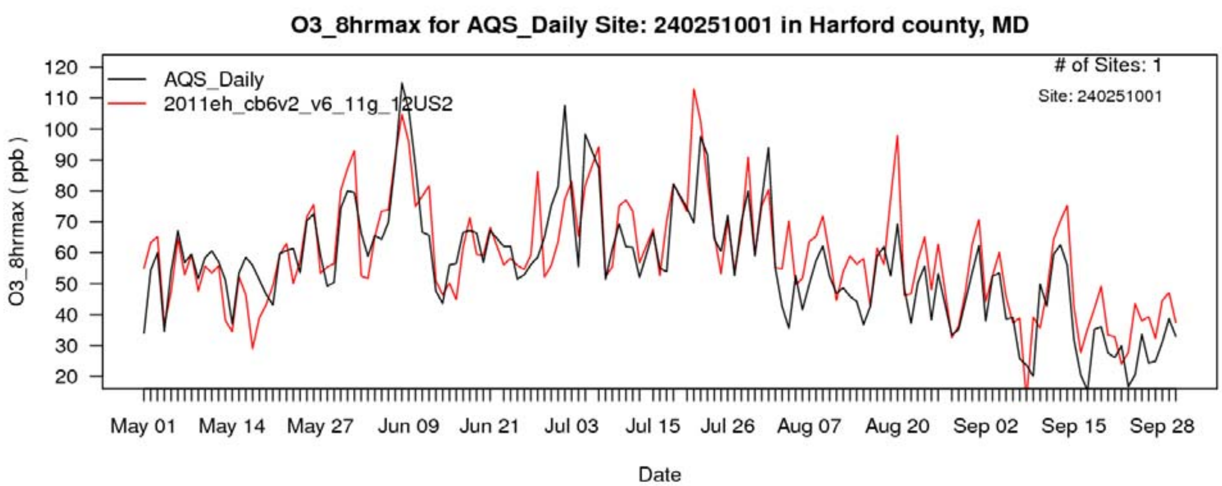


Figure A-17d. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 240251001 in Harford Co., Maryland.

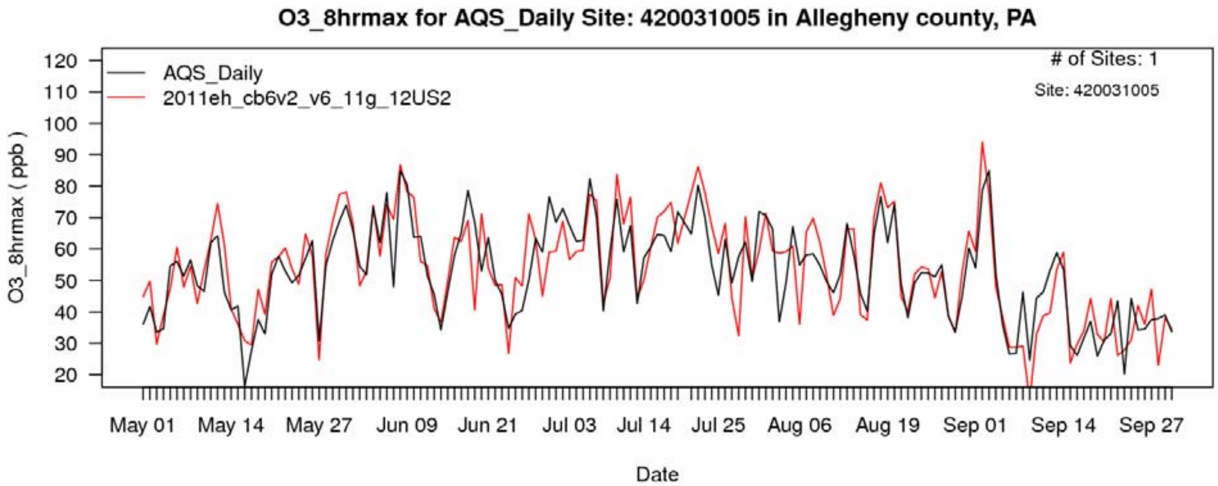


Figure A-17e. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 420031005 in Allegheny Co., Pennsylvania.

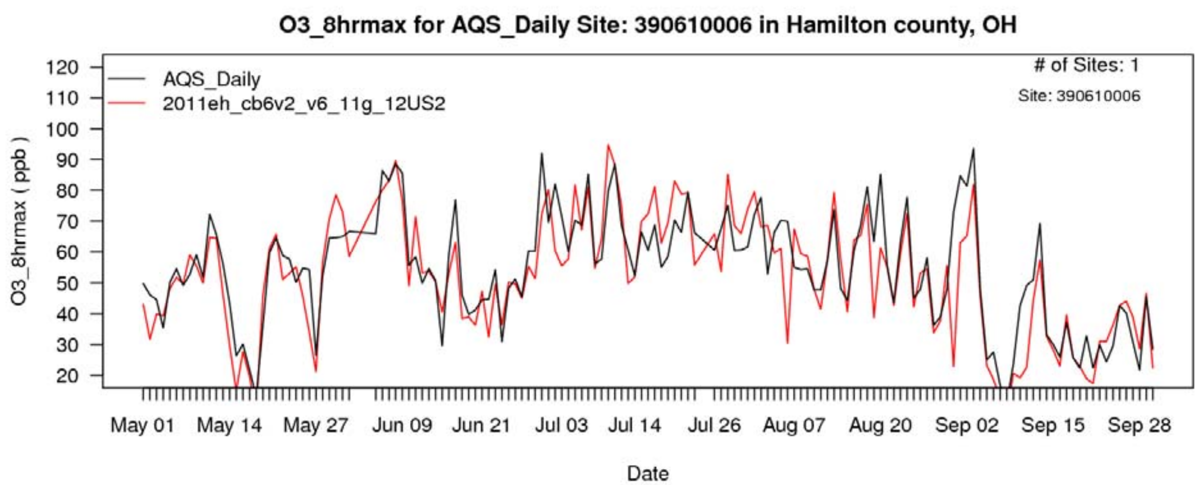


Figure A-17f. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 390610006 in Hamilton Co., Ohio.

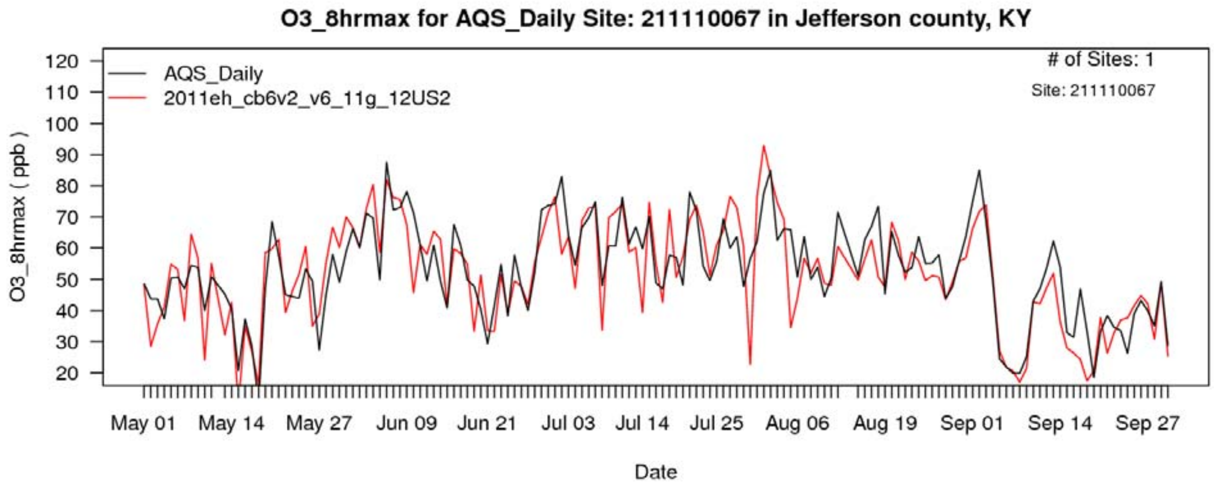


Figure A-17g. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 211110067 in Jefferson Co., Kentucky.

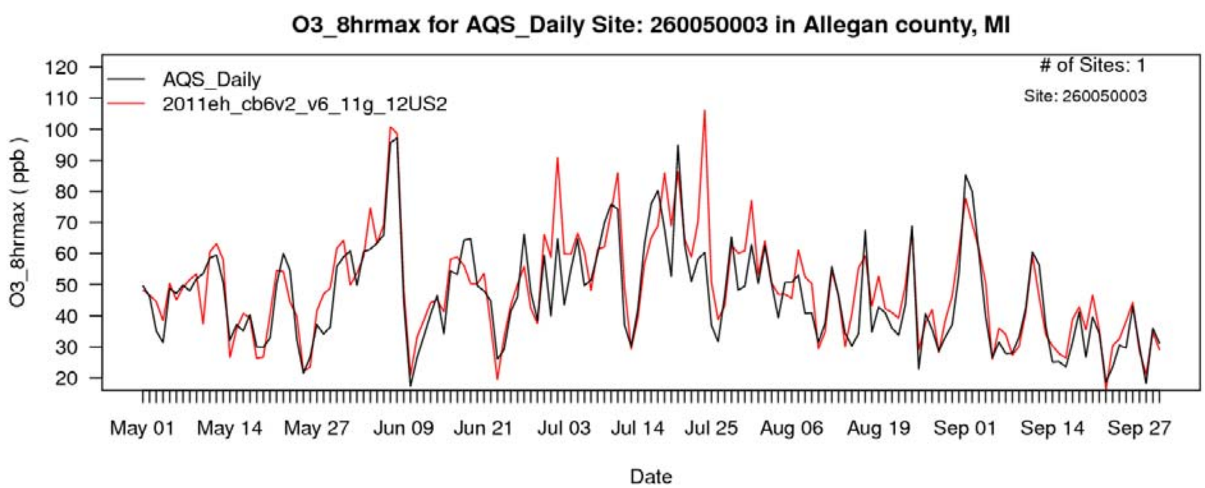


Figure A-17h. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 26005003 in Allegan Co., Michigan.

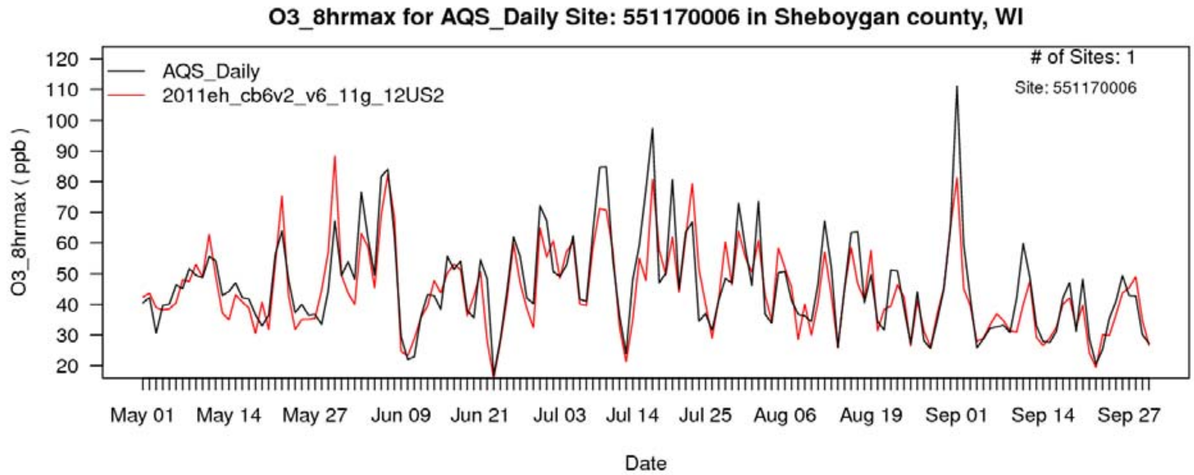


Figure A-17i. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 551170006 in Sheboygan Co., Wisconsin.

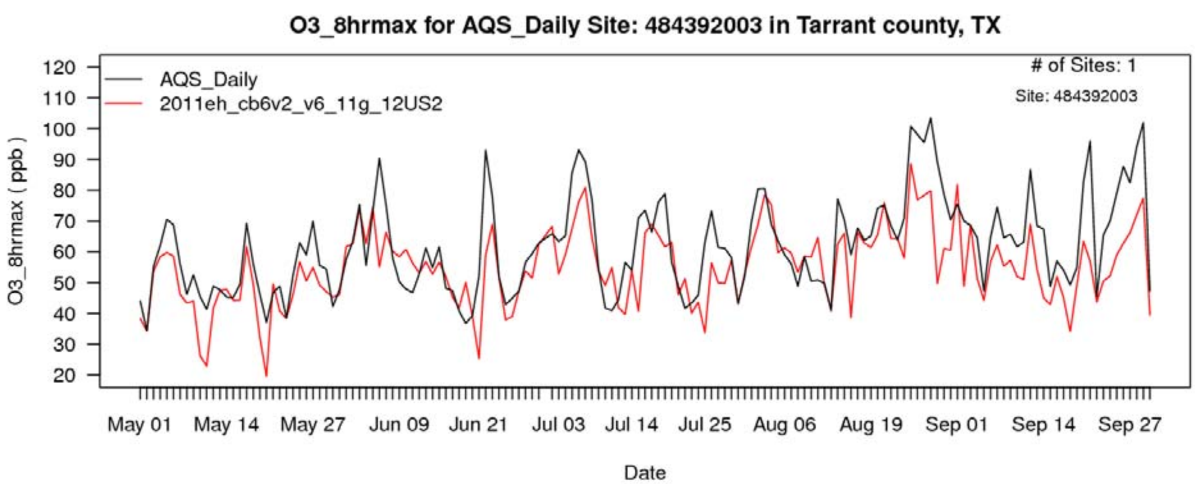


Figure A-17j. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 484392003 in Tarrant Co., Texas.

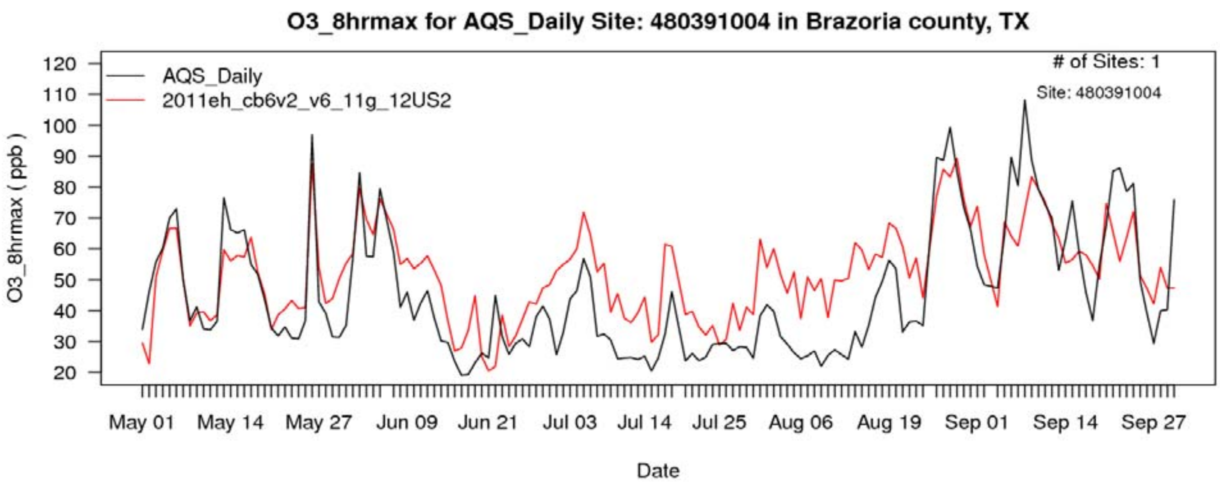


Figure A-17k. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 480391004 in Brazoria Co., Texas.

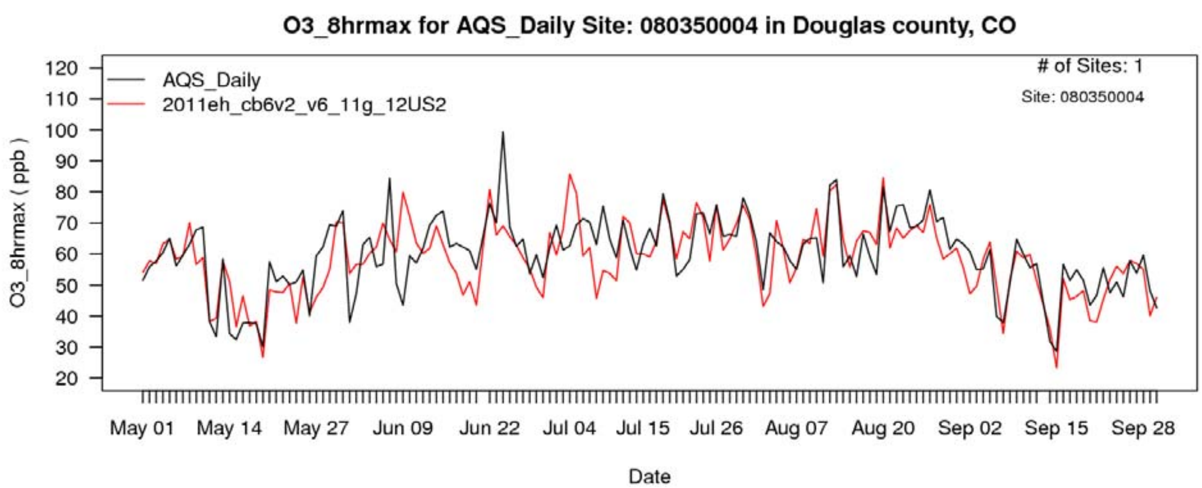


Figure A-17l. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 080350004 in Douglas Co., Colorado.

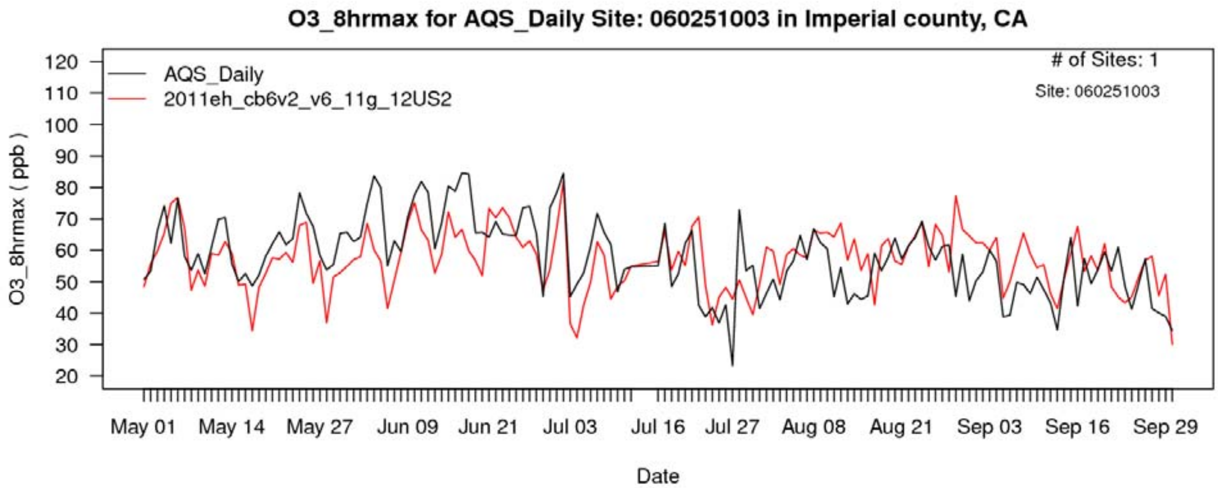


Figure A-17m. Time series of observed (black) and predicted (red) MDA8 ozone for May through September 2011 at site 060251003 in Imperial Co., California.

Appendix B

Contributions to 2017 8-Hour Ozone Design Values

at Projected 2017 Nonattainment and Maintenance-Only Sites

This appendix contains tables with the projected ozone contributions from 2017 anthropogenic NOx and VOC emissions in each state to each projected 2017 nonattainment receptor and each maintenance-only receptor in the eastern U.S. Nonattainment and maintenance-only receptors are defined in section 3 of this TSD. In addition to the state contributions, we have included the contributions from each of the other categories tracked in the contribution modeling including point source emissions on Tribal lands, anthropogenic emissions in Canada and Mexico, emissions from Offshore sources, Fires, Initial and Boundary concentrations, and Biogenics.

For each monitoring site we provide the site ID, state name, and county name in the first three columns of the table. This information is followed by columns containing the projected 2017 average and maximum design values. Next we provide the contributions from each state and the District of Columbia, individually. Lastly, we provide the contributions from the Tribal, Canada and Mexico, Offshore, Fires, Initial and Boundary concentrations, and Biogenics categories. The units of the 2017 design values and contributions are “ppb”. Note that the contributions presented in these tables may not sum exactly to the 2017 average design value due to truncation of the contributions to two places to the right of the decimal.

Contributions to 2017 Nonattainment and Maintenance-Only Sites in the East (Part 1)

Monitor ID	State	County	2017 Average DV	2017 Maximum DV	AL	AZ	AR	CA	CO	CT	DE	DC	FL	GA	ID	IL	IN	IA	KS	KY	LA	ME	MD	MA	MI	MN	MS	MO	MT
90010017	Connecticut	Fairfield	75.8	78.4	0.10	0.04	0.11	0.05	0.10	9.04	0.22	0.04	0.03	0.11	0.03	0.50	0.62	0.21	0.18	0.35	0.07	0.01	1.34	0.06	0.98	0.25	0.07	0.34	0.06
90013007	Connecticut	Fairfield	77.1	81.4	0.15	0.04	0.16	0.04	0.11	5.22	0.34	0.06	0.02	0.20	0.01	0.49	0.76	0.10	0.16	0.48	0.06	0.00	2.07	0.05	0.89	0.11	0.09	0.27	0.03
90019003	Connecticut	Fairfield	78.0	81.1	0.14	0.06	0.15	0.06	0.14	4.75	0.30	0.06	0.04	0.19	0.02	0.70	0.89	0.17	0.20	0.57	0.08	0.00	1.83	0.03	0.89	0.13	0.09	0.38	0.04
90099002	Connecticut	New Haven	77.2	80.2	0.09	0.05	0.12	0.06	0.11	8.29	0.37	0.04	0.04	0.10	0.04	0.57	0.68	0.21	0.20	0.43	0.09	0.00	1.55	0.10	0.91	0.15	0.06	0.39	0.05
211110067	Kentucky	Jefferson	75.8	78.6	0.04	0.03	0.06	0.07	0.13	0.00	0.00	0.00	0.03	0.04	0.05	1.15	11.33	0.23	0.21	22.87	0.10	0.00	0.00	0.00	1.20	0.35	0.04	0.27	0.17
211850004	Kentucky	Oldham	73.7	77.3	0.06	0.03	0.85	0.05	0.14	0.00	0.00	0.00	0.03	0.04	0.04	0.89	14.95	0.14	0.17	20.93	0.33	0.00	0.00	0.00	0.91	0.25	0.10	0.82	0.15
240053001	Maryland	Baltimore	73.2	76.2	0.34	0.07	0.20	0.08	0.14	0.01	0.12	0.64	0.10	0.27	0.02	0.64	1.53	0.19	0.22	1.77	0.20	0.00	23.15	0.01	0.69	0.11	0.13	0.47	0.05
240251001	Maryland	Harford	81.3	84.0	0.40	0.09	0.22	0.11	0.19	0.01	0.15	0.73	0.11	0.30	0.03	0.67	1.88	0.19	0.28	1.97	0.25	0.00	24.59	0.00	0.83	0.11	0.15	0.52	0.06
260050003	Michigan	Allegan	75.5	78.5	0.33	0.08	2.15	0.06	0.23	0.00	0.00	0.00	0.13	0.20	0.01	23.17	8.02	0.85	1.03	0.53	0.57	0.00	0.01	0.00	2.74	0.06	0.42	3.69	0.01
261630019	Michigan	Wayne	74.0	76.2	0.02	0.03	0.09	0.10	0.10	0.00	0.00	0.00	0.03	0.03	0.05	0.90	2.64	0.30	0.23	0.67	0.11	0.00	0.03	0.00	20.77	0.47	0.04	0.28	0.13
340071001	New Jersey	Camden	74.2	78.1	0.32	0.11	0.37	0.11	0.20	0.17	1.36	0.00	0.07	0.15	0.04	1.33	1.71	0.37	0.42	0.93	0.58	0.02	0.57	0.17	1.43	0.15	0.26	0.76	0.07
340150002	New Jersey	Gloucester	75.1	77.5	0.34	0.10	0.15	0.11	0.16	0.10	2.23	0.30	0.14	0.33	0.03	0.87	1.02	0.27	0.17	1.23	0.26	0.00	7.11	0.09	1.01	0.15	0.13	0.48	0.06
340230011	New Jersey	Middlesex	73.0	76.3	0.28	0.08	0.12	0.08	0.14	0.33	0.73	0.07	0.09	0.31	0.03	0.58	0.85	0.18	0.17	1.08	0.14	0.08	2.35	0.33	0.62	0.12	0.10	0.38	0.04
340290006	New Jersey	Ocean	73.9	76.6	0.21	0.06	0.23	0.08	0.15	0.36	0.76	0.06	0.05	0.17	0.04	0.80	1.06	0.34	0.26	0.88	0.19	0.07	2.01	0.37	1.31	0.17	0.12	0.52	0.07
360810124	New York	Queens	75.7	77.6	0.13	0.07	0.12	0.09	0.13	0.41	0.60	0.07	0.08	0.20	0.05	0.84	0.80	0.34	0.24	0.49	0.14	0.00	2.15	0.06	1.79	0.21	0.06	0.49	0.09
360850067	New York	Richmond	76.3	77.8	0.25	0.08	0.16	0.09	0.15	0.30	0.68	0.08	0.09	0.30	0.04	0.74	1.02	0.27	0.27	0.96	0.15	0.00	2.39	0.04	1.20	0.16	0.11	0.54	0.06
361030002	New York	Suffolk	79.2	80.8	0.19	0.07	0.17	0.08	0.16	0.46	0.32	0.04	0.06	0.19	0.05	0.79	1.03	0.30	0.30	0.71	0.13	0.00	1.47	0.01	1.34	0.18	0.11	0.58	0.07
390610006	Ohio	Hamilton	76.3	79.1	0.79	0.06	0.62	0.09	0.18	0.00	0.00	0.00	0.11	0.58	0.04	1.28	7.15	0.29	0.34	11.17	0.26	0.00	0.01	0.00	0.99	0.23	0.30	0.77	0.10
420031005	Pennsylvania	Allegheny	75.3	76.5	0.16	0.05	0.22	0.11	0.13	0.00	0.00	0.00	0.06	0.17	0.07	1.35	1.86	0.17	0.32	1.64	0.17	0.00	0.05	0.00	1.51	0.15	0.13	0.55	0.13
421010024	Pennsylvania	Philadelphia	75.1	78.4	0.51	0.09	0.23	0.09	0.16	0.03	1.33	0.16	0.14	0.54	0.02	0.65	1.71	0.17	0.21	2.14	0.18	0.00	5.10	0.03	0.33	0.07	0.17	0.52	0.04
480391004	Texas	Brazoria	81.4	82.3	0.56	0.08	0.98	0.23	0.25	0.00	0.00	0.00	0.19	0.30	0.09	0.86	0.24	0.42	0.46	0.18	3.09	0.00	0.01	0.00	0.05	0.40	0.78	1.00	0.15
480850005	Texas	Collin	74.9	76.0	0.41	0.07	0.35	0.10	0.19	0.00	0.00	0.00	0.61	0.24	0.02	0.03	0.03	0.02	0.20	0.05	1.40	0.00	0.02	0.00	0.01	0.00	0.24	0.12	0.03
481130069	Texas	Dallas	74.0	78.0	0.41	0.05	0.83	0.09	0.15	0.00	0.00	0.00	0.72	0.33	0.02	0.13	0.06	0.04	0.19	0.10	1.44	0.00	0.02	0.00	0.01	0.04	0.23	0.19	0.03
481130075	Texas	Dallas	75.8	76.7	0.34	0.05	0.92	0.08	0.18	0.00	0.00	0.00	0.65	0.24	0.02	0.14	0.06	0.04	0.23	0.09	1.22	0.00	0.02	0.00	0.01	0.04	0.18	0.21	0.03
481210034	Texas	Denton	76.9	79.4	0.67	0.10	0.51	0.14	0.25	0.00	0.00	0.00	0.30	0.39	0.06	0.11	0.12	0.08	0.43	0.14	1.99	0.00	0.00	0.00	0.11	0.04	0.51	0.23	0.09
481211032	Texas	Denton	75.1	76.3	0.29	0.07	0.68	0.11	0.29	0.00	0.00	0.00	0.27	0.21	0.07	0.05	0.04	0.05	0.39	0.05	1.77	0.00	0.02	0.00	0.06	0.03	0.47	0.15	0.12
482010024	Texas	Harris	75.9	78.5	0.54	0.04	0.28	0.09	0.16	0.00	0.00	0.00	0.62	0.36	0.03	0.16	0.06	0.09	0.13	0.09	2.82	0.00	0.00	0.00	0.02	0.03	0.56	0.31	0.05
482010026	Texas	Harris	73.5	76.1	0.09	0.02	1.21	0.08	0.23	0.00	0.00	0.00	0.07	0.05	0.05	0.76	0.11	0.35	0.42	0.05	3.66	0.00	0.00	0.00	0.24	0.26	0.49	1.13	0.11
482010055	Texas	Harris	75.4	77.0	1.28	0.07	0.79	0.22	0.20	0.00	0.00	0.00	0.64	0.56	0.08	0.60	0.21	0.18	0.33	0.19	4.23	0.00	0.02	0.00	0.02	0.07	1.48	0.78	0.14
482011034	Texas	Harris	76.8	77.8	0.46	0.04	0.52	0.12	0.18	0.00	0.00	0.00	0.57	0.27	0.05	0.40	0.07	0.30	0.39	0.06	3.81	0.00	0.00	0.00	0.10	0.27	0.65	0.69	0.10
482011039	Texas	Harris	78.2	80.2	0.41	0.03	1.24	0.11	0.16	0.00	0.00	0.00	0.15	0.21	0.05	0.87	0.15	0.33	0.38	0.09	3.33	0.00	0.01	0.00	0.28	0.23	0.77	1.15	0.11
482011050	Texas	Harris	74.6	76.2	0.32	0.03	0.92	0.06	0.11	0.00	0.00	0.00	0.18	0.17	0.01	0.74	0.14	0.24	0.21	0.06	2.76	0.00	0.00	0.00	0.34	0.26	0.61	0.75	0.03
484390075	Texas	Tarrant	75.5	76.4	0.66	0.09	0.88	0.13	0.34	0.00	0.00	0.00	0.17	0.35	0.07	0.36	0.26	0.21	0.81	0.21	2.20	0.00	0.00	0.00	0.21	0.13	0.46	0.42	0.12
484392003	Texas	Tarrant	79.6	82.1	0.79	0.10	0.87	0.14	0.36	0.00	0.00	0.00	0.34	0.47	0.07	0.35	0.27	0.09	0.37	0.22	2.64	0.00	0.00	0.00	0.12	0.07	0.54	0.34	0.10
484393009	Texas	Tarrant	78.6	78.6	0.73	0.08	0.80	0.14	0.24	0.00	0.00	0.00	0.54	0.43	0.06	0.29	0.22	0.07	0.33	0.18	2.21	0.00	0.01	0.00	0.09	0.05	0.47	0.30	0.08
484393011	Texas	Tarrant	74.5	76.6	0.15	0.08	1.19	0.11	0.26	0.00	0.00	0.00	0.13	0.16	0.07	0.32	0.10	0.21	0.77	0.09	1.47	0.00	0.01	0.00	0.18	0.13	0.17	0.44	0.13
551170006	Wisconsin	Sheboygan	77.0	79.4	0.25	0.08	0.57	0.09	0.18	0.00	0.00	0.00	0.11	0.12	0.02	17.48	6.24	0.61	0.80	0.75	1.11	0.00	0.02	0.00	2.69	0.07	0.56	1.63	0.03

Contributions to 2017 Nonattainment and Maintenance-Only Sites in the East (Part 2)

Monitor ID	State	County	2017 Average DV	2017 Maximum DV	NE	NV	NH	NJ	NM	NY	NC	ND	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
90010017	Connecticut	Fairfield	75.8	78.4	0.13	0.01	0.01	7.98	0.05	17.21	0.33	0.13	1.57	0.30	0.01	7.14	0.01	0.07	0.06	0.17	0.47	0.06	0.01	1.51	0.02	0.67	0.35	0.16
90013007	Connecticut	Fairfield	77.1	81.4	0.08	0.01	0.01	8.45	0.08	15.98	0.55	0.04	1.89	0.24	0.00	9.29	0.01	0.16	0.02	0.31	0.46	0.05	0.00	1.87	0.01	0.92	0.17	0.12
90019003	Connecticut	Fairfield	78.0	81.1	0.12	0.02	0.00	8.84	0.08	16.16	0.47	0.06	2.18	0.34	0.01	9.39	0.00	0.14	0.03	0.28	0.59	0.07	0.00	1.75	0.01	0.95	0.22	0.20
90099002	Connecticut	New Haven	77.2	80.2	0.13	0.02	0.02	7.04	0.06	16.96	0.38	0.11	1.68	0.36	0.01	7.16	0.02	0.07	0.05	0.18	0.56	0.07	0.01	1.22	0.02	0.66	0.21	0.19
211110067	Kentucky	Jefferson	75.8	78.6	0.16	0.02	0.00	0.00	0.08	0.00	0.01	0.24	4.05	0.35	0.02	0.46	0.00	0.01	0.12	0.11	0.66	0.05	0.00	0.01	0.07	0.61	0.55	0.27
211850004	Kentucky	Oldham	73.7	77.3	0.13	0.01	0.00	0.00	0.06	0.00	0.02	0.20	3.13	0.22	0.02	0.35	0.00	0.02	0.09	0.11	0.39	0.05	0.00	0.00	0.06	0.40	0.41	0.24
240053001	Maryland	Baltimore	73.2	76.2	0.13	0.02	0.00	0.37	0.12	0.35	0.93	0.07	2.98	0.35	0.01	4.80	0.00	0.14	0.05	0.67	0.77	0.07	0.00	4.70	0.02	2.65	0.19	0.17
240251001	Maryland	Harford	81.3	84.0	0.15	0.02	0.00	0.43	0.16	0.40	0.46	0.08	3.99	0.46	0.02	6.07	0.00	0.10	0.05	0.70	1.05	0.09	0.00	5.29	0.03	2.99	0.21	0.20
260050003	Michigan	Allegan	75.5	78.5	0.17	0.01	0.00	0.00	0.21	0.00	0.05	0.01	0.10	1.78	0.00	0.02	0.00	0.05	0.02	0.68	2.95	0.06	0.00	0.03	0.00	0.03	2.59	0.12
261630019	Michigan	Wayne	74.0	76.2	0.09	0.03	0.00	0.01	0.04	0.10	0.32	0.28	7.92	0.22	0.06	0.27	0.00	0.04	0.04	0.12	0.52	0.07	0.00	0.24	0.09	0.27	1.00	0.20
340071001	New Jersey	Camden	74.2	78.1	0.23	0.02	0.04	10.93	0.22	2.70	0.07	0.10	4.16	0.69	0.02	15.93	0.03	0.04	0.09	0.25	1.52	0.10	0.04	0.32	0.03	1.07	0.44	0.24
340150002	New Jersey	Gloucester	75.1	77.5	0.11	0.02	0.01	4.41	0.19	1.22	0.33	0.07	3.85	0.35	0.01	15.73	0.02	0.07	0.04	0.38	1.07	0.08	0.02	3.33	0.02	2.35	0.44	0.19
340230011	New Jersey	Middlesex	73.0	76.3	0.10	0.02	0.07	10.78	0.12	3.71	0.50	0.05	2.42	0.32	0.01	15.16	0.07	0.12	0.03	0.48	0.73	0.08	0.05	2.10	0.01	1.91	0.30	0.17
340290006	New Jersey	Ocean	73.9	76.6	0.17	0.02	0.07	11.44	0.10	5.10	0.33	0.11	2.54	0.44	0.02	13.30	0.08	0.09	0.07	0.40	0.95	0.08	0.05	1.07	0.03	1.08	0.47	0.22
360810124	New York	Queens	75.7	77.6	0.18	0.02	0.01	11.48	0.09	10.61	0.39	0.17	2.36	0.43	0.02	8.83	0.01	0.11	0.08	0.16	0.76	0.09	0.00	2.10	0.03	0.92	0.49	0.24
360850067	New York	Richmond	76.3	77.8	0.18	0.02	0.00	12.38	0.12	4.57	0.55	0.11	2.70	0.44	0.01	13.51	0.00	0.14	0.07	0.42	0.83	0.10	0.00	2.27	0.02	1.64	0.33	0.22
361030002	New York	Suffolk	79.2	80.8	0.21	0.02	0.00	11.37	0.09	15.95	0.38	0.14	2.49	0.52	0.01	9.39	0.00	0.08	0.08	0.35	0.82	0.10	0.00	1.62	0.02	0.98	0.27	0.26
390610006	Ohio	Hamilton	76.3	79.1	0.19	0.03	0.00	0.00	0.14	0.11	0.13	0.12	16.72	0.76	0.03	0.37	0.00	0.14	0.06	1.67	1.74	0.08	0.00	0.11	0.04	0.97	0.56	0.22
420031005	Pennsylvania	Allegheny	75.3	76.5	0.21	0.03	0.00	0.00	0.09	0.24	0.07	0.11	7.89	0.48	0.04	23.66	0.00	0.05	0.10	0.62	0.84	0.07	0.00	0.16	0.05	2.47	0.33	0.21
421010024	Pennsylvania	Philadelphia	75.1	78.4	0.11	0.02	0.00	1.66	0.16	0.20	0.72	0.04	3.55	0.38	0.01	21.46	0.00	0.20	0.03	0.90	0.94	0.07	0.00	2.63	0.00	3.11	0.14	0.16
480391004	Texas	Brazoria	81.4	82.3	0.24	0.07	0.00	0.00	0.11	0.00	0.08	0.06	0.04	0.72	0.05	0.03	0.00	0.08	0.08	0.37	38.93	0.14	0.00	0.04	0.05	0.03	0.34	0.30
480850005	Texas	Collin	74.9	76.0	0.05	0.03	0.00	0.00	0.13	0.01	0.14	0.00	0.04	0.73	0.01	0.04	0.00	0.11	0.01	0.10	40.58	0.08	0.00	0.07	0.01	0.04	0.00	0.16
481130069	Texas	Dallas	74.0	78.0	0.05	0.03	0.00	0.00	0.08	0.01	0.22	0.01	0.05	0.77	0.01	0.05	0.00	0.21	0.01	0.12	35.26	0.07	0.00	0.09	0.01	0.06	0.01	0.14
481130075	Texas	Dallas	75.8	76.7	0.06	0.03	0.00	0.00	0.09	0.01	0.16	0.01	0.04	0.86	0.01	0.04	0.00	0.12	0.01	0.10	37.23	0.08	0.00	0.07	0.01	0.05	0.01	0.16
481210034	Texas	Denton	76.9	79.4	0.17	0.06	0.00	0.00	0.13	0.01	0.08	0.02	0.10	1.33	0.02	0.03	0.00	0.09	0.03	0.19	33.85	0.15	0.00	0.03	0.02	0.04	0.06	0.28
481211032	Texas	Denton	75.1	76.3	0.16	0.04	0.00	0.00	0.11	0.01	0.11	0.02	0.06	1.61	0.02	0.06	0.00	0.11	0.03	0.15	34.09	0.11	0.00	0.07	0.04	0.05	0.03	0.33
482010024	Texas	Harris	75.9	78.5	0.07	0.03	0.00	0.00	0.08	0.00	0.14	0.02	0.03	0.24	0.01	0.02	0.00	0.17	0.02	0.19	32.55	0.07	0.00	0.05	0.01	0.04	0.02	0.14
482010026	Texas	Harris	73.5	76.1	0.26	0.03	0.00	0.00	0.06	0.00	0.00	0.06	0.02	1.05	0.02	0.00	0.00	0.01	0.06	0.12	30.45	0.07	0.00	0.00	0.03	0.00	0.28	0.23
482010055	Texas	Harris	75.4	77.0	0.13	0.07	0.00	0.00	0.11	0.00	0.16	0.04	0.06	0.20	0.04	0.03	0.00	0.15	0.04	0.41	34.58	0.12	0.00	0.06	0.04	0.05	0.08	0.28
482011034	Texas	Harris	76.8	77.8	0.21	0.04	0.00	0.00	0.07	0.00	0.16	0.05	0.04	0.94	0.02	0.02	0.00	0.19	0.05	0.10	32.18	0.09	0.00	0.05	0.02	0.04	0.18	0.21
482011039	Texas	Harris	78.2	80.2	0.21	0.04	0.00	0.00	0.05	0.01	0.06	0.05	0.03	0.83	0.02	0.02	0.00	0.05	0.05	0.31	33.69	0.07	0.00	0.03	0.03	0.02	0.28	0.21
482011050	Texas	Harris	74.6	76.2	0.15	0.01	0.00	0.00	0.05	0.01	0.05	0.03	0.03	0.67	0.00	0.02	0.00	0.05	0.04	0.21	36.47	0.03	0.00	0.02	0.01	0.01	0.35	0.09
484390075	Texas	Tarrant	75.5	76.4	0.36	0.05	0.00	0.00	0.15	0.02	0.05	0.05	0.15	2.46	0.04	0.07	0.00	0.04	0.07	0.20	29.82	0.16	0.00	0.03	0.04	0.05	0.15	0.36
484392003	Texas	Tarrant	79.6	82.1	0.18	0.06	0.00	0.00	0.14	0.01	0.09	0.03	0.12	1.23	0.03	0.03	0.00	0.10	0.03	0.21	34.52	0.18	0.00	0.03	0.03	0.04	0.09	0.36
484393009	Texas	Tarrant	78.6	78.6	0.14	0.05	0.00	0.00	0.11	0.01	0.13	0.02	0.11	1.03	0.02	0.05	0.00	0.11	0.03	0.20	35.64	0.13	0.00	0.06	0.02	0.05	0.07	0.26
484393011	Texas	Tarrant	74.5	76.6	0.34	0.04	0.00	0.00	0.15	0.02	0.10	0.04	0.10	2.41	0.03	0.09	0.00	0.12	0.08	0.10	32.06	0.14	0.00	0.05	0.04	0.07	0.17	0.30
551170006	Wisconsin	Sheboygan	77.0	79.4	0.09	0.02	0.00	0.00	0.21	0.02	0.06	0.04	0.78	1.70	0.01	0.20	0.00	0.04	0.02	0.51	2.44	0.07	0.00	0.08	0.01	0.29	12.22	0.11

Contributions to 2017 Nonattainment and Maintenance-Only Sites in the East (Part 3)

Monitor ID	State	County	2017 Average DV	2017 Maximum DV	Tribal	Canada & Mexico	Offshore	Fires	Initial & Boundary	Biogenics
90010017	Connecticut	Fairfield	75.8	78.4	0.02	1.66	0.61	0.18	15.66	4.08
90013007	Connecticut	Fairfield	77.1	81.4	0.02	1.61	1.30	0.20	16.90	4.17
90019003	Connecticut	Fairfield	78.0	81.1	0.03	1.48	1.00	0.22	16.73	4.49
90099002	Connecticut	New Haven	77.2	80.2	0.02	1.67	2.33	0.21	16.52	4.33
211110067	Kentucky	Jefferson	75.8	78.6	0.01	0.52	0.05	0.20	21.86	6.71
211850004	Kentucky	Oldham	73.7	77.3	0.02	0.41	0.14	0.22	18.81	7.04
240053001	Maryland	Baltimore	73.2	76.2	0.03	0.68	0.51	0.29	15.67	5.04
240251001	Maryland	Harford	81.3	84.0	0.04	0.73	0.44	0.30	16.63	6.08
260050003	Michigan	Allegan	75.5	78.5	0.04	0.28	0.34	0.73	11.71	9.01
261630019	Michigan	Wayne	74.0	76.2	0.01	4.89	0.08	0.17	24.10	5.57
340071001	New Jersey	Camden	74.2	78.1	0.04	1.73	0.55	0.46	14.07	6.14
340150002	New Jersey	Gloucester	75.1	77.5	0.03	1.05	0.62	0.30	15.90	5.75
340230011	New Jersey	Middlesex	73.0	76.3	0.03	1.95	0.64	0.25	16.30	5.01
340290006	New Jersey	Ocean	73.9	76.6	0.03	2.28	0.75	0.31	16.60	5.04
360810124	New York	Queens	75.7	77.6	0.02	2.00	1.54	0.21	17.29	5.14
360850067	New York	Richmond	76.3	77.8	0.03	1.74	1.21	0.29	16.47	5.51
361030002	New York	Suffolk	79.2	80.8	0.03	1.67	1.31	0.31	16.51	5.12
390610006	Ohio	Hamilton	76.3	79.1	0.03	0.76	0.21	0.58	17.48	7.45
420031005	Pennsylvania	Allegheny	75.3	76.5	0.02	1.38	0.11	0.38	21.40	5.03
421010024	Pennsylvania	Philadelphia	75.1	78.4	0.03	0.48	0.71	0.37	16.52	5.62
480391004	Texas	Brazoria	81.4	82.3	0.03	0.35	0.99	1.62	19.53	6.57
480850005	Texas	Collin	74.9	76.0	0.02	0.25	2.23	0.90	19.19	5.62
481130069	Texas	Dallas	74.0	78.0	0.02	0.20	1.93	1.20	22.27	5.78
481130075	Texas	Dallas	75.8	76.7	0.02	0.30	1.76	1.14	22.41	6.02
481210034	Texas	Denton	76.9	79.4	0.03	0.40	1.57	0.95	24.23	6.50
481211032	Texas	Denton	75.1	76.3	0.02	0.35	0.87	0.93	23.75	6.52
482010024	Texas	Harris	75.9	78.5	0.02	0.18	4.14	0.73	27.62	2.68
482010026	Texas	Harris	73.5	76.1	0.01	0.24	2.95	2.36	21.17	4.44
482010055	Texas	Harris	75.4	77.0	0.02	0.31	1.46	1.55	18.26	4.81
482011034	Texas	Harris	76.8	77.8	0.01	0.22	4.08	1.58	22.78	4.22
482011039	Texas	Harris	78.2	80.2	0.01	0.29	2.50	2.70	21.03	5.31
482011050	Texas	Harris	74.6	76.2	0.01	0.31	3.95	1.84	17.62	4.39
484390075	Texas	Tarrant	75.5	76.4	0.03	0.58	0.99	2.06	22.71	6.49
484392003	Texas	Tarrant	79.6	82.1	0.03	0.44	1.62	1.33	23.94	6.28
484393009	Texas	Tarrant	78.6	78.6	0.02	0.34	1.62	1.40	23.61	5.78
484393011	Texas	Tarrant	74.5	76.6	0.03	0.69	0.65	1.54	22.51	6.25
551170006	Wisconsin	Sheboygan	77.0	79.4	0.03	0.47	0.67	0.56	14.91	7.79