MAG 2017 EIGHT-HOUR OZONE MODERATE AREA PLAN FOR THE MARICOPA NONATTAINMENT AREA

APPENDICES

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MARICOPA ASSOCIATION of GOVERNMENTS

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EXHIBIT 1:

Technical Support Document in Support of the MAG 2017 Eight-Hour Ozone Moderate Area Plan for the Maricopa Nonattainment Area. Maricopa Association of Governments.

TECHNICAL SUPPORT DOCUMENT

IN SUPPORT OF

THE MAG 2017 EIGHT-HOUR OZONE MODERATE AREA PLAN FOR

THE MARICOPA NONATTAINMENT AREA

DECEMBER 2016

Maricopa Association of Governments
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MARICOPA ASSOCIATION of GOVERNMENTS

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Acronyms

AC	Air Commercial
ADOT	Arizona Department of Transportation
ADEQ	Arizona Department of Environmental Quality
ADWM	Arizona Department of Weights and Measures
APM	Aviation Performance Metrics
APU	Auxiliary Power Unit
AQMP	Air Quality Modeling Platform
AQS	Air Quality System
ARW	Advanced Research WRF
ASOS	Automated Surface Observing System
AT	Air Taxi
ATADS	Air Traffic Activity Data System
AVFT	Alternative Vehicle and Fuel Technologies
BC	Boundary Condition
CAA	Clean Air Act
CAMx	Comprehensive Air Quality Model with Extensions
CBG	Cleaner Burning Gasoline
CEMS	Continuous Emission Monitoring System
CPA	Chemical Process Analysis
CSAPR	Cross-State Air Pollution Rule
DDM	Decoupled Direct Method
$DEASCO_3$	Deterministic & Empirical Assessment of Smoke's Contribution to Ozone
DV	Design Value
DVB	Base Year Design Value
DVF	Future Year Design Value
EDMS	Emissions and Dispersion Modeling System
EF	Emission Factor
EGU	Electric Generating Units
EKMA	Empirical Kinetic Modeling Approach
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group
ESRL	Earth System Research Laboratory
ETMSC	Enhanced Traffic Management System Counts
FAA	Federal Aviation Administration
FINN	Fire Inventory from NCAR
FMYN	Fort McDowell Yavapai Nation
FR	Federal Register
GA	General Aviation
GCIP	GEWEX Continental-Scale International Project
GEOS	Goddard Earth Observing System Model
GEWEX	Global Energy and Water Cycle Experiment
GIS	Geographic Information Systems

GRIC	Gila River Indian Community of Gila River Indian Reservation
GSE	Ground Support Equipment
HDDM	High-order Decoupled Direct Method
HPA	High Pollution Advisory
I/M	Inspection and Maintenance
ICBC	Initial and Boundary Conditions
ISHD	Integrated Surface Hourly Database
LAI	Leaf Area Index
LCP	Lambert Conformal Projection
LSM	Land Surface Model
LTO	Landing and Takeoff
MAG	Maricopa Association of Governments
MATS	Model Attainment Test Software
MCAQD	Maricopa County Air Quality Department
MCIP	Meteorology-Chemistry Interface Processor
MEGAN	Model of Emissions of Gases and Aerosols from Nature
ML	Military
MOVES	Motor Vehicle Emission Simulator
MOZART	Model for Ozone and Related Chemical Tracers
MPO	Metropolitan Planning Organization
MR	Mixing Ratio
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Information
NEI	National Emissions Inventory
OSAT	Ozone Source Apportionment Technology
PAMS	Photochemical Assessment Monitoring Stations
PCAQCD	Pinal County Air Quality Control District
PEI	Periodic Emissions Inventory
PFC	Portable Fuel Containers
PFT	Plant Function Type
PTE	Potential To Emit
RFP	Reasonable Further Progress
RMSE	Root Mean Square Errors
RRF	Relative Response Factor
RRTM	Rapid Radiative Transfer Model
RVP	Reid Vapor Pressure
SCC	Standard Classification Codes
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SRPMIC	Salt River Pima-Maricopa Indian Community of Salt River Reservation
TAF	Terminal Area Forecast
TDM	Travel Demand Model

TOMS	Total Ozone Mapping Spectrometer
USB	US Background
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled
WOE	Weight Of Evidence
WPS	WRF Preprocessing System
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting

Abbreviations

g	gram
CO	Carbon Monoxide
H_2O_2	Hydrogen Peroxide
HNO_3	Nitric Acid
hPa	hectopascal
m	meter
mph	miles per hour
NOx	Oxides of Nitrogen
O_3	Ozone
P	Production Rate
ppb	parts per billion
ppm	parts per million
T	Temperature
TNMOC	Total Non-Methane Organic Compounds
VOC	Volatile Organic Compounds
WD	Wind Direction
WS	Wind Speed

I. INTRODUCTION

The Maricopa eight-hour ozone nonattainment area has not yet attained the 2008 eight-hour ozone standard of 0.075 parts per million (ppm). The area is currently classified as a Moderate Area under the Clean Air Act. The attainment date for Moderate Areas is July 20, 2018. A Moderate Area Plan is due by January 1, 2017. The MAG 2017 Eight-Hour Ozone Moderate Area Plan has been prepared to meet the requirements in Section 182(b) of the Clean Air Act.

As the designated Regional Air Quality Planning Agency, the Maricopa Association of Governments (MAG) conducted modeling for emissions and air quality, and prepared the air quality plans including attainment demonstrations. This Technical Support Document (TSD) presents the analyses of the ground-level eight-hour ozone concentrations for an area encompassing the Maricopa eight-hour ozone nonattainment area and the modeled attainment demonstration of the 2008 ozone standard.

I-1. Background

On May 21, 2012, the U.S. Environmental Protection Agency (EPA) published a final rule classifying the Maricopa eight-hour ozone nonattainment area as a Marginal Area for the 2008 ozone National Ambient Air Quality Standard (NAAQS) of 0.075 parts per million (ppm). The Maricopa eight-hour ozone nonattainment area includes a 5,017 square mile area located predominantly in Maricopa County and Apache Junction in Pinal County. EPA published a final rule on March 6, 2015, which revised the attainment date for Marginal area from December 31, 2015 to July 20, 2015.

On June 27, 2014, the MAG 2014 Eight-Hour Ozone Plan-Submittal of Marginal Area Requirements for the Maricopa Nonattainment Area was transmitted to EPA. For Marginal Areas, EPA assumed that the areas would be in attainment within three years of designation without any additional control measures. Marginal Areas were not required to submit an attainment demonstration; reasonably available control technologies and measures, reasonable further progress demonstration, and contingency measures. On October 16, 2015, EPA published a final notice to take direct final action to approve the MAG 2014 Eight-Hour Ozone Plan-Submittal of Marginal Area Requirements for the Maricopa eight-hour ozone nonattainment area.

Since the Maricopa eight-hour ozone nonattainment area did not attain the 2008 ozone standard by July 20, 2015, the nonattainment area was subsequently reclassified from a Marginal Area to a Moderate Area by EPA on May 4, 2016. The attainment date for the Moderate Area is July 20, 2018. EPA requires that all control measures necessary to demonstrate attainment be implemented prior to the start of ozone season preceding the attainment year. Thus, the modeled attainment demonstration in this TSD verifies that the existing and implemented federal state and local control measures in the Maricopa eight-hour ozone nonattainment area provide the emission reductions needed to attain the 2008 ozone standard by the end of the ozone season in 2017.

MAG developed the draft ozone modeling protocol, in support of the MAG 2017 Eight-Hour Ozone Moderate Area Plan for the Maricopa Nonattainment Area, and submitted it to EPA and the Air Quality Planning Team for review and comments on November 20, 2015. The draft modeling protocol in Appendix A presented details of the technical approaches and modeling assumptions that would be used in the modeled attainment demonstration for the 2008 ozone standard in the Maricopa eight-hour ozone nonattainment area. No comments were provided on the draft modeling protocol by the deadline of December 17, 2015.

The primary objective of this TSD is to demonstrate that the Maricopa eight-hour ozone nonattainment area will attain the 2008 ozone standard by the end of the 2017 ozone season. The secondary objective is to develop the 2017 conformity budget for onroad mobile source emissions using the most recent version of the EPA Motor Vehicle Emission Simulator (MOVES) model, MOVES2014a.

I-2. Overview of Modeling Analysis

Ozone (O_3) is a pale blue gas with a distinctively pungent smell. It is a secondary air pollutant which is generated by chemical reactions between volatile organic compounds (VOC) and oxides of nitrogen (NOx) in the presence of sunlight. Ozone is harmful to the human respiratory system, especially for children, the elderly, and people of all ages who have lung diseases such as asthma. Elevated local ozone concentrations are typically generated with local and transported ozone and precursor emissions from anthropogenic and biogenic sources under strong sunlight of the summer ozone season.

This modeling analysis evaluated the effects of emission growth and emission control strategies on future eight-hour ozone concentrations in the Maricopa eight-hour ozone nonattainment area. The results of the modeling analysis provide a quantitative assessment of the potential for compliance with the federal ozone standard and also the basis for the development of the attainment plan.

For the eight-hour ozone modeling analysis, the Comprehensive Air Quality Model with Extensions (CAMx) was used to simulate ozone concentrations during the ozone season of May 1 through September 30 for the 2011 base year and the 2017 future year. The meteorological input data for CAMx were generated by the Weather Research and Forecasting (WRF) model. Point and area source emissions inventories were developed based on the data provided by the Maricopa County Air Quality Department (MCAQD) and the Pinal County Air Quality Control District (PCAQCD). Onroad and nonroad mobile source emissions were developed using the Motor Vehicle Emission Simulator (MOVES2014a). The Emissions and Dispersion Modeling System (EDMS) was used to develop emissions from aircraft, Ground Support Equipment (GSE), and Auxiliary Power Units (APU) at airports. The Model of Emissions of Gases and Aerosols from Nature (MEGAN) was used to develop biogenic source emissions. The Sparse Matrix Operator Kernel Emissions (SMOKE) model was used to develop hourly gridded and chemically speciated emissions, and to merge anthropogenic and biogenic source emissions. Figure I-1 illustrates the MAG air quality modeling system that was used in this modeling analysis.

The WRF and CAMx model performances were evaluated with weather and ozone observation data in 2011. Input data and modeling configurations of physical and chemical solvers for the WRF and CAMx were revised or changed until the model performances satisfied the EPA recommended statistical criteria.

The peak design value for the 2017 attainment year based on the CAMx modeling results in this study was predicted at 75.6 parts per billion (ppb) at North Phoenix, which is lower than the cutpoint of 75.9 ppb (or 0.0759 ppm) for the attainment demonstration. The supplemental analyses in support of the attainment demonstration results are provided in Section VI and Appendix II. Based on the results from the attainment demonstration and the weight-of-evidence (WOE) discussed in the supplemental analyses, it is concluded that the Maricopa eight-hour ozone nonattainment area will meet the 2008 ozone standard by the end of ozone season in 2017.

This plan established the 2017 conformity budgets of 45.7 metric tons per day for VOC and 62.7 metric tons per day for NOx for onroad mobile source emissions in the Maricopa eight-hour ozone nonattainment area. The budgets were developed using the average daily onroad motor vehicle emissions for the period of May 1 through September 30, 2017, which were used in the attainment demonstration for the 2008 ozone standard. The new 2017 VOC and NOx emissions budgets will be used in the regional transportation conformity analyses that begin after the budgets have been found to be adequate or are approved by EPA. In subsequent conformity analyses, onroad mobile source emissions for conformity horizon years cannot exceed the 2017 VOC and NOx onroad emissions budgets.

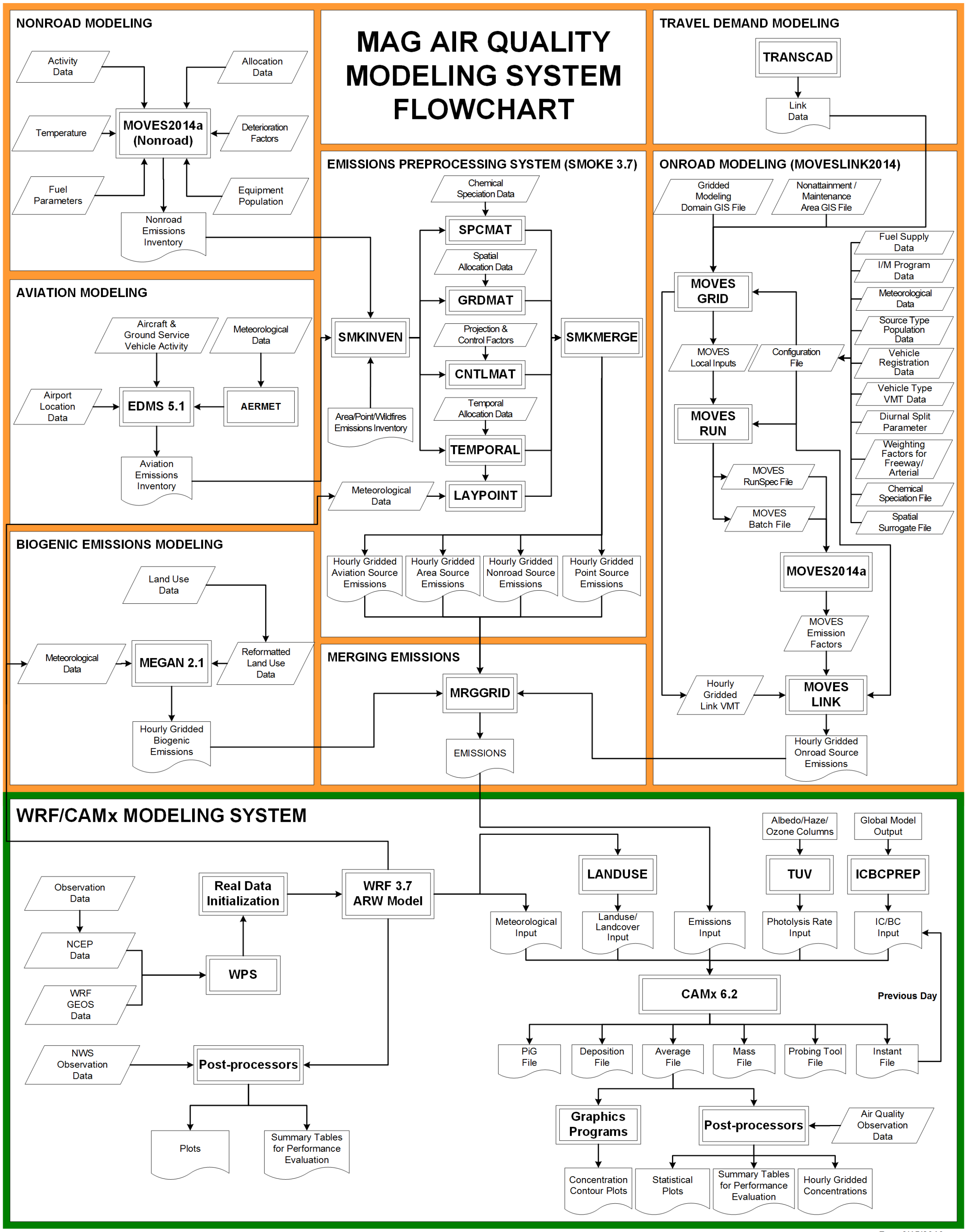


Figure I-1. MAG air quality modeling system flow chart

I-3. Data Access Procedure

All modeling input and output files were saved in a dedicated hard drive, and will be provided on a request basis since the files used in the modeling analysis require an extensive data storage space (e.g., more than 5 terabytes). A summary of the input and output files, and the structures of files used in the air quality modeling are provided in Appendix C. The input and output files are grouped by model, and the file summary provides a sequential outline of the overall air quality modeling chain.

The job file list indicates the names of the job control files which were used to run each model or program. Each job control file is the executable file which was used to run the particular air quality model. Note that since some emission models were not run by job file (i.e., MOVES2014a), no job files are listed. Also, some air quality models have very simple job files (e.g., MOVESLINK2014) whose purpose is calling a large control file. Since these job files are very simple, a sample job file was provided in Appendix G. These sample job files may be changed easily to call a different control file. All input and output files are organized by program or model in separate directories.

I-4. Structure of Document

Section I of this technical support document provides the background, objectives, and access procedure for modeling input and output data of this modeling study. Section II describes horizontal and vertical structures of the modeling domains, and criteria of the ozone episode selection. Section III presents the descriptions of the preparation of emissions and meteorological input data for the attainment demonstration. Section IV describes the WRF and CAMx model performance evaluation methodologies and results. Section V provides the attainment demonstration for the monitors and the unmonitored area in the Maricopa eight-hour ozone nonattainment area, the proposed conformity budgets in 2017, the Reasonable Further Progress (RFP) 15 percent reduction in VOC anthropogenic emissions, and the descriptions of ozone control and contingency measures. Section VI is dedicated to the supplemental and weight of evidence analyses which support the model attainment demonstration in Section V. Section VII provides conclusions that were found from the modeled attainment demonstrations and the supplemental and weight of evidence analyses.

II. MODELING DOMAIN AND OZONE EPISODE SELECTION

II-1. Modeling Domain

Selection of the modeling domains takes into account the Maricopa eight-hour ozone nonattainment area boundaries, the distribution of major emissions sources, the locations of the meteorological and air quality monitoring sites, and the prevailing winds associated with elevated ozone concentrations, as well as regional air pollutant transport. Figure II-1 shows the spatial relationship among the master (36 km grid resolution), first-nested (12 km grid resolution), and second-nested (4 km grid resolution) CAMx and WRF modeling domains. Figure II-2 illustrates the inner modeling domain of 4-by-4 km grid cells that covers the Maricopa eight-hour ozone nonattainment area, Maricopa County, and portions of Pinal, Gila, and Yavapai Counties.

Since ozone concentrations in the Maricopa eight-hour ozone nonattainment area can be substantially influenced by transported ozone and precursor emissions from upwind sources of the Maricopa eight-hour ozone nonattainment area (EPA, 2015a), the master 36 km grid modeling domain (36 km modeling domain) covers the 48 contiguous United States along with the southern portion of Canada and the northern portion of Mexico. The extensive coverage of the master modeling domains of CAMx and WRF was designed to capture the characteristics of long-range transport of ozone and precursor emissions to the Maricopa eight-hour ozone nonattainment area. The 36 km modeling domain was used to generate initial and boundary conditions for the 12 km grid modeling domain (12 km modeling domain). The 12 km modeling domain was used to provide boundary and initial condition data for the core 4 km grid modeling domain (4 km modeling domain). The CAMx modeled attainment demonstration was performed with the 4 km modeling domain.

In accordance with the EPA modeling guidance (EPA, 2014a), the meteorological modeling domains were developed to be larger than the air quality modeling domains to minimize complications associated with air mass recirculation and to minimize boundary influences. The map projection parameters and domain sizes for both WRF and CAMx modeling domains are provided in Tables II-1 and II-2, respectively. The CAMx inner 4 km modeling domain encompasses the entire Maricopa eight-hour ozone nonattainment area, consisting of 56 grid cells in the west-east direction and 44 grid cells in the south-north direction. The domain covers an area of approximate 15,222 square miles.

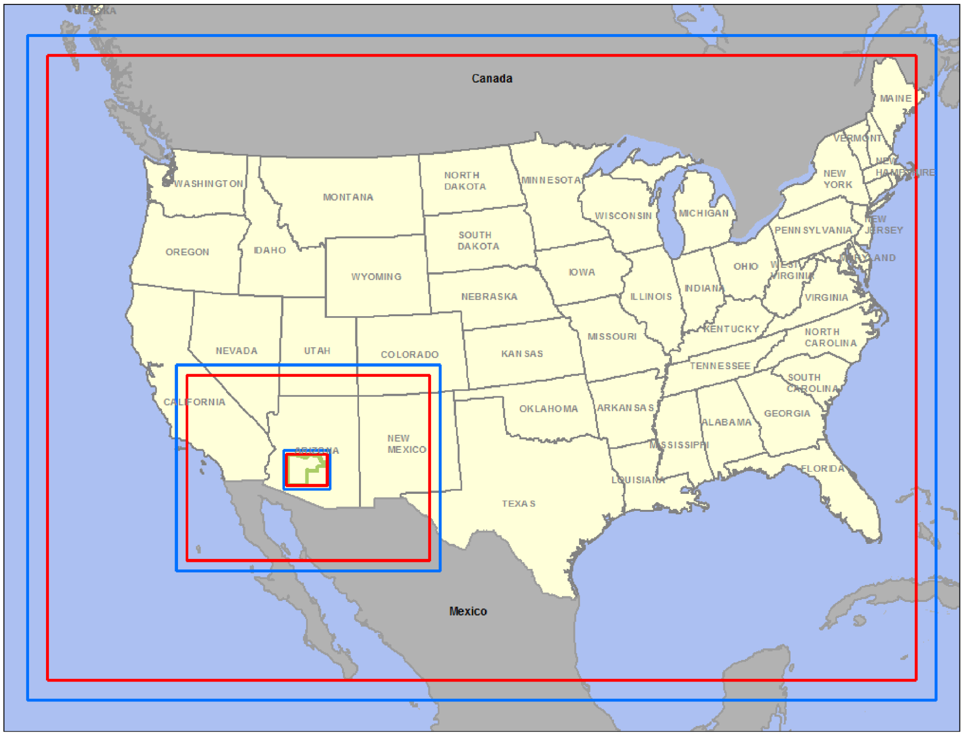


Figure II-1. CAMx air quality modeling domains (red: 36/12/4 km) and WRF meteorological modeling domains (blue: 36/12/4 km)

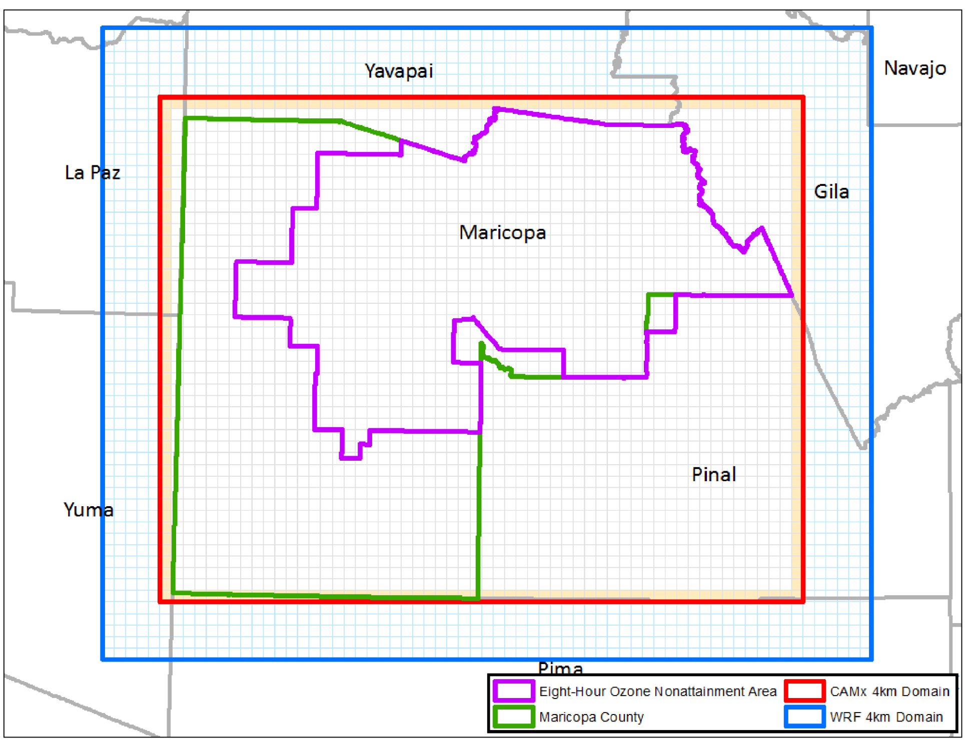


Figure II-2. The inner CAMx modeling domain (red) and WRF modeling domain (blue)

Table II-1. Map projection parameters for the 36/12/4 km modeling domains

Parameter	Value
Projection	Lambert-Conformal Projection (LCP)
1st True Latitude	33 degrees N
2nd True Latitude	45 degrees N
Central Longitude	111 degrees W
Central Latitude	33.355 degrees N

Table II-2. WRF and CAMx modeling domain configurations

WRF Modeling Domains		
Grid Resolution	Grid Size	LCP Range (km)
36 km x 36 km	141 by 103	(-1,674.000, -1,290.252) to (3,402.000, 2,417.748)
12 km x 12 km	123 by 96	(-846.000, -570.252) to (630.000, 581.748)
4 km x 4 km	66 by 54	(-246.000, -114.252) to (18.000, 101.748)
CAMx Modeling Domains		
Grid Resolution	Grid Size	LCP Range (km)
36 km x 36 km	135 by 97	(-1,566.000, -1,182.252) to (3,294.000, 2,309.748)
12 km x 12 km	113 by 86	(-786.000, -510.252) to (570.000, 521.748)
4 km x 4 km	56 by 44	(-226.000, -94.252) to (-2.000, 81.748)

II-2. Vertical Layer Structure

The vertical layer resolution and coordinates for WRF and CAMx modeling are based on the sigma coordinate system. The sigma coordinate system uses the terrain-following hydrostatic pressure vertical coordinate ranging from 1 at the surface to 0 at the upper boundary of the modeling domain. The 23 vertical layer configuration was used for both CAMx and WRF modeling. The upper boundary was based on the reference pressure of 50.0 hectopascal (hPa). The numbers of approximate pressures and heights of vertical layers for the CAMx and WRF modeling are presented in Table II-3. The three modeling domains have the same vertical layer structures.

Table II-3. Approximate pressures and heights of WRF and CAMx vertical layers

Layer No.	Vertical Layer Pressure (hPa)	Vertical Layer Height (m)
1	933	20
2	929	60
3	925	100
4	921	140
5	914	201
6	906	282
7	898	364
8	889	446
9	877	571
10	860	740
11	843	911
12	826	1,085
13	801	1,352
14	764	1,764
15	713	2,341
16	663	2,945
17	622	3,479
18	580	4,042
19	538	4,638
20	496	5,271
21	392	7,192
22	225	11,339
23	121	14,949

II-3. Ozone Episode Selection

The EPA modeling guidance (EPA, 2014a) suggests the consideration of the following criteria in selecting the ozone modeling episode: 1) The most recently compiled and quality-assured national emissions inventory databases should be available for the modeling episode, 2) a sufficient number of days should be available so that the modeled attainment test applied at each monitor is based on the ten highest modeled days, 3) the modeling episode should ensure that the modeling system appropriately characterizes low pollution periods, development of elevated periods, and transition back to low pollution periods through synoptic cycles, and 4) the modeling episode should cover a variety of meteorological conditions conducive to elevated ozone concentrations.

Since the EPA National Emissions Inventory (NEI) for the year 2011 was the most recently compiled and quality-assured national emissions inventory, the year 2011 was selected as the base year for the development of the baseline emissions inventory and baseline design values. The baseline design values of monitors in 2011 were developed using ozone observations at monitors during the five-year period of 2009 - 2013. Since the full ozone season from May 1 through September 30 provided a sufficient amount of days (i.e., 153 days) for the development of the ten highest modeled days for ozone concentrations, covered a variety of meteorological conditions, and characterized high-low and transitional conditions of ozone concentrations in the Maricopa eight-hour ozone nonattainment area, the period of May 1 through September 30 in 2011 was selected as the modeling episode for the attainment demonstration. For the attainment demonstration, the initial three days of the modeling episode were used as the model spin-up period to minimize the impact of fluctuations in the initial condition data. Thus, modeling results from the spin-up period of May 1 - 3 were not used for the modeled attainment demonstration.

III. AIR QUALITY MODEL INPUT PREPARATION

III-1. Base and Future Year Emissions Inventory

The anthropogenic emissions inventory for 2011 and 2017 for the 12 km and 36 km modeling domains were obtained from the EPA 2011 Air Quality Modeling Platform (AQMP) version 6.2 (EPA, 2015b). This inventory includes point, area, nonroad, and onroad sources emissions for individual states and counties within the contiguous U.S.. The anthropogenic emissions inventory from the southern portion of Canada and the northern portion of Mexico in the 12 km and 36 km modeling domains were provided by Eastern Research Group (ERG), Inc. on August 31, 2015. The details of the Mexico and Canada data and ERG's modeling assumptions are available in Appendix A.

Biogenic emissions for the 12 km and 36 km modeling domains were calculated with the same modeling approaches used for the 4 km modeling domain (see Section III-1-5). Wildfires and prescribed burning within the 12 km and 36 km modeling domains that fall within the U.S. territory were provided by AQMP v6.2. The data for the southern portion of Canada and the northern portion of Mexico were obtained from the Western Regional Air Partnership (WRAP) Deterministic & Empirical Assessment of Smoke's Contribution to Ozone ($DEASCO_3$) project. $DEASCO_3$ data were pre-processed for the SMOKE emissions processing. The base year and the attainment year biogenic and wildfire emissions were assumed to be constant between 2011 and 2017.

The following subsections describe the methodologies used in the development of daily emissions inventory for the 4 km modeling domain. The daily emissions inventory for the five-month modeling episode for the years 2011 and 2017 are provided in Appendix E.

III-1-1. Point Source Emissions

Point sources include major stationary sources that emit a significant amount of air pollutants. A point source is required to report emissions if it qualifies as a major source as defined by 40 CFR Part 70. For this emissions inventory, point sources in the modeling domain were divided into Electric Generating Units (EGU) and non-EGU. EGU is referred to as power plant, while non-EGU includes all other major stationary sources, such as landfills, petroleum storage, transfer facilities, and large industrial installations.

The SMOKE model was used to process stack parameters (i.e. height, width, temperature, and exit velocity) of point sources and to separate elevated point source emissions from the ground-level point source emissions based on the plume rise above 20 meters. For Maricopa County, the annual EGU emissions were processed using monthly, weekly, and daily temporal profiles to develop hourly emissions for a specific day of week for a specific month. The temporal profiles were developed using the 2011 Continuous Emission Monitoring System (CEMS) data for EGUs in Maricopa County. Details on temporal allocation processes can be found in Section III-2-3.

For the EGU emissions in 2017 for Maricopa County, the maximum emissions over the 10-year period of 2005 through 2014 was assumed for individual power plants, as provided by MCAQD (MCAQD, 2015). The new Buckeye Generation Center is expected to start operating in 2017. Since prior emissions data for this new power plant were not available, the Potential to Emit (PTE) emissions were assumed for this power plant in 2017. EGU emissions for Maricopa County in 2011 and 2017 are provided in Table III-1.

Table III-1. EGU emissions for Maricopa County in 2011 and 2017 (unit: metric tons/day)

Facility Name	2011			2017*		
	VOC	NOx	CO	VOC	NOx	CO
APS West Phoenix Power Plant	0.07	1.89	0.19	0.09	2.09	0.25
Arlington Valley LLC	0.00	0.27	0.17	0.10	0.54	0.41
Buckeye Generation Center LLC	0.00	0.00	0.00	0.06	0.22	0.28
Gila River Power Station	0.04	0.81	0.23	0.12	2.18	0.36
Mesquite Generating Station	0.06	0.52	0.06	0.08	0.66	0.15
New Harquahala Generating Co	0.08	0.11	0.18	0.12	0.43	0.28
Ocotillo Power Plant	0.02	0.49	0.09	0.03	0.94	0.17
Redhawk Generating Facility	0.01	0.37	0.40	0.02	0.45	0.42
Santan Generating Station	0.04	1.28	0.75	0.21	1.56	0.88
SRP Agua Fria Generating Station	0.01	0.86	0.22	0.05	4.07	0.83
SRP Kyrene Generating Station	0.01	0.11	0.03	0.03	0.26	0.13

* MCAQD provided projected power plant emissions in 2017 (Downing, 2015).

Maricopa County non-EGU point source emissions for the base year were based on ozone season day emissions reported in the Addendum for the 2011 Periodic Emissions Inventory (PEI) for ozone precursors (MCAQD, 2015). Growth factors for non-EGU from 2011 to 2017 were derived from socioeconomic and census data (e.g. population, employment, agricultural area, gasoline consumption, etc.) for Maricopa County, as shown in Table III-2. These growth factors were applied to the base year non-EGU point source emissions to obtain the 2017 future year emissions. Non-EGU emissions for Maricopa County in 2011 and 2017 are provided in Table III-3.

Table III-2. Growth factors for non-EGU point and area sources in Maricopa County

Growth Index	2011	2017	Growth Factor
Agricultural Acres	275,050	268,346	0.98
Airport Operations (operations/year)*	1,718,536	1,805,295	1.05
Gasoline Consumption (gallons/day)	4,308,054	3,901,057	0.91
Industrial Employment	336,654	393,824	1.17
Locomotive Diesel Usage (gallons/year)	8,273,092	6,097,290	0.74
Number of Aircrafts at Luke AFB	136	132	0.97
Population	3,843,373	4,239,606	1.10
Roadway Lane Miles	22,551	23,137	1.03

* Total airport operations from the eight major airports in Maricopa County based on a fiscal year calendar.

Table III-3. Non-EGU emissions for Maricopa County in 2011 and 2017 (unit: metric tons/day)

Facility Name	Growth Index	2011			2017		
		VOC	NOx	CO	VOC	NOx	CO
CMC Steel Fabricators Inc	Industrial Employment	0.10	0.14	1.99	0.12	0.17	2.32
Luke AFB - 56th Fighter Wing	Number of Aircrafts	0.02	0.02	0.01	0.02	0.02	0.01
New WinCup Holdings Inc	Industrial Employment	0.31	0.03	0.01	0.36	0.03	0.01
Northwest Regional Landfill	Total Population	0.01	0.02	0.01	0.01	0.03	0.02
Oak Canyon Manufacturing Inc	Industrial Employment	0.22	0.00	0.00	0.26	0.00	0.00
Rexam Beverage Can Company	Industrial Employment	0.22	0.01	0.01	0.26	0.01	0.01
SFPP LP Phoenix Terminal	Industrial Employment	0.25	0.02	0.02	0.30	0.02	0.03
Trendwood Inc	Industrial Employment	0.45	0.00	0.00	0.52	0.00	0.00
Offset Emission Credit	(no change)	0.53	0.04	0.04	0.53	0.04	0.04

For Pinal County, annual EGU and non-EGU point source emissions for the 2011 base year were provided by PCAQCD. EGU and non-EGU emissions for Pinal County in 2011 and 2017 are provided in Tables III-4 and III-5. The growth factor for non-EGU point sources was derived from the ratio of industrial employment in 2011 and 2017 for Pinal County, as shown in Table III-6. The growth factors for EGU point sources were derived from the 2011 and 2017 EGU point source emissions data in the AQMP v6.2. Those growth factors were applied to the base year point source emissions to project the 2017 future year emissions. The 2017 emissions for the Coolidge Generation Station were not available in the AQMP v6.2. PCAQCD provided a growth factor of 20% for this power plant (DiBiase, 2015).

Table III-4. EGU emissions for Pinal County in 2011 and 2017 (unit: metric tons/day)

Facility Name	2011			2017*		
	VOC	NOx	CO	VOC	NOx	CO
Coolidge Generating Station	0.00	0.02	0.01	0.00	0.02	0.01
Desert Basin Generating Station	0.02	0.08	0.87	0.02	0.09	0.67
Saguaro Power Plant	0.00	0.01	0.00	0.01	0.00	0.00
Sundance Power Plant	0.01	0.06	0.02	0.01	0.06	0.02

* PCAQCD provided projected power plant emissions in 2017 (DiBiase, 2015).

Table III-5. Non-EGU emissions for Pinal County in 2011 and 2017 (unit: metric tons/day)

Facility Name*	Growth Index	2011			2017		
		VOC	NOx	CO	VOC	NOx	CO
Arizona Environmental Container Corporation	Industrial Employment	0.02	0.00	0.00	0.02	0.00	0.00
Casa Grande Compressor Station	Industrial Employment	0.00	0.03	0.01	0.00	0.03	0.01
Casa Grande Plant	Industrial Employment	0.15	0.00	0.00	0.15	0.00	0.00
Frito-Lay Inc	Industrial Employment	0.01	0.07	0.09	0.01	0.07	0.09
Hexcel Corporation	Industrial Employment	0.32	0.03	0.02	0.31	0.03	0.02
Republic Plastics, LP	Industrial Employment	0.32	0.00	0.00	0.30	0.00	0.00

* Non-EGU point sources located outside the 4 km modeling domain were excluded.

Table III-6. Growth factors for non-EGU point and area sources in Pinal County

Growth Index	2011	2017	Growth Factor
Agricultural Acres	449,368	447,425	1.00
Airport Operations (operations/year)	175,528	260,812	1.49
Gasoline Consumption (gallons/day)	417,529	378,125	0.91
Industrial Employment	8,111	7,752	0.96
Population	384,221	444,680	1.16
Roadway Lane Miles	6,368	6,508	1.02

III-1-2. Area Source Emissions

Area sources includes the stationary sources which are too small or too numerous to be treated as point sources. Area source emissions for Maricopa County in 2011 were obtained from ozone season average daily emissions reported in the Addendum for the 2011 PEI for ozone precursors. The ozone season average daily emissions for the period of June through August were assumed constant throughout the five-month period of the modeling episode.

Ozone season day emissions for area sources in 2011 were projected to the 2017 future year emissions using growth factors for Maricopa County shown in Table III-2. The growth factors applied to individual area source categories in Maricopa County are provided in Table D-5, Appendix D.

The Maricopa County 2011 PEI for ozone precursors indicated that most area sources operated seven days per week, while eight area source categories were reported to operate six days per week and five area source categories were reported to operate five days per week. Emissions from the area sources operating seven days per week were equally distributed to seven days regardless of weekdays and weekends. For the eight area source categories reported to operate six days per week, Saturday was treated as a weekday for emissions and zero emissions were assigned to Sunday. For the five area source categories reported to operate five days per week, emissions were distributed to the five weekdays and zero emissions were assigned to Saturday and Sunday.

For Pinal County, area source emissions for the 2011 base year were obtained primarily from the AQMP v6.2 since the Pinal County 2011 PEI for ozone precursors was not available. The AQMP v6.2 emissions inventory, however, overestimated emissions for land clearing debris, architectural coatings, landfills, and crematories in Pinal County. PCAQCD provided correct emissions for these area source categories. The growth factors shown in Table III-6 were applied to project the 2017 future year area source emissions for Pinal

County. The growth factors that were applied to individual area source categories for Pinal County are provided in Table D-6, Appendix D.

The portable fuel container (PFC) rules were applied to ten area source categories for residential and industrial uses. The 2011 controlled emissions for those PFC area sources were obtained from the EPA 2011 NEI v2 for Maricopa and Pinal Counties. EPA provided annual emissions for the ten PFC area sources for the years 2015 and 2020 for Maricopa and Pinal Counties (September 23, 2013, Rich Cook, EPA). The 2017 annual PFC emissions for both counties were obtained by interpolating the EPA 2015 and 2020 emissions data. Table III-7 presents the PFC emissions by Standard Classification Code (SCC) for Maricopa and Pinal Counties in 2011 and 2017. Area source emissions for Maricopa and Pinal Counties in 2011 and 2017 are provided in Table III-8.

Table III-7. Portable fuel container VOC emissions in 2011 and 2017 (unit: metric tons/day)

No.	SCC	Description	Maricopa County		Pinal County	
			2011	2017	2011	2017
1	2501011011	Residential Permeation	2.21	0.14	0.08	0.01
2	2501011012	Residential Evaporation	4.31	0.28	0.16	0.01
3	2501011013	Residential Spill in Transport	0.56	0.55	0.02	0.02
4	2501011014	Residential Vapor Displacement	0.21	0.21	0.01	0.01
5	2501011015	Residential Spill at Pump	0.02	0.02	0.00	0.00
6	2501012011	Commercial Permeation	0.07	0.00	0.00	0.00
7	2501012012	Commercial Evaporation	0.14	0.01	0.00	0.00
8	2501012013	Commercial Spill in Transport	0.77	0.75	0.03	0.03
9	2501012014	Commercial Vapor Displacement	0.40	0.41	0.01	0.01
10	2501012015	Commercial Spill at Pump	0.03	0.04	0.00	0.00
Total			8.72	2.41	0.31	0.09

Table III-8. Ozone season average daily area source emissions for Maricopa and Pinal Counties in 2011 and 2017 (unit: metric tons/day)

County	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Maricopa County	97.79	11.83	10.06	99.46	13.56	10.83
Pinal County	8.32	0.28	1.49	8.67	0.32	1.72

III-1-3. Nonroad Mobile Source Emissions

Nonroad mobile sources include off-highway recreational vehicles and pleasure craft, locomotives, aircraft and airport support vehicles, and equipment from commercial industrial, agricultural, lawn maintenance and construction activities.

The nonroad emissions inventory was developed for the 4 km modeling domain using MOVES2014a. There were no emissions from logging equipment or underground mining/oil field equipment in Maricopa and Pinal Counties. Locomotive emissions were obtained from the AQMP v6.2. Airport ground support equipment, aircraft, and auxiliary power unit emissions were developed with the Federal Aviation Administration (FAA)'s Emission and Dispersion Modeling System (EDMS) model.

<u>MOVES2014a Nonroad Equipment Emissions</u>

Base year meteorology inputs (daily minimum, maximum and average temperature and relative humidity), which were obtained from the National Climate Data Center (NCDC) for the Sky Harbor International Airport station, were used for Maricopa and Pinal Counties. Local fuel properties including oxygen content, sulfur content, Reid Vapor Pressure (RVP), and ethanol blend percentage were provided by the Arizona Department of Weights and Measures. The MOVES2014a fuel wizard was used to pre-process this data to supply monthly county-specific values to the model. For the 2017 future year modeling, the MOVES2014a default fuel parameters for 2017 were used for the EPA Tier 3 Fuel Standards.

For the local commercial lawn and garden industry, ENVIRON performed a survey as a part of the Cap and Trade Oversight Committee work (ENVIRON, 2003). Survey results showed that equipment populations for most categories of this sector in Maricopa County were significantly lower than EPA default values, while the average annual hours of operation for most equipment in this sector were slightly higher than EPA defaults. Thus, equipment population numbers and activity levels for commercial lawn and garden equipment were adjusted based on the ENVIRON's survey results. The information for these updates were reflected in the MOVES2014a input database. Default population and activity data were used in MOVES2014a for all other categories in Maricopa County. MOVES2014a nonroad emissions for Pinal County were developed using the MOVES2014 default data for Pinal County.

MOVES2014a was simulated for each modeling episode day in 2011 using unique day-specific meteorology. Care was taken to properly define each date as weekend or weekday relative to the 2011 calendar. In the case of holidays (Memorial Day, Independence Day, and Labor Day), these holidays were manually set with weekend profiles to best approximate altered activity. The 2017 future year emissions inventory was obtained by running MOVES2014a with the 2017 fuel inputs and the 2011 meteorology based on the 2011 calendar.

Within the 4km modeling domain, some nonroad sources were located outside Maricopa and Pinal Counties, such as pleasure craft emissions on the Roosevelt Lake in Gila County and Lake Pleasant in Yavapai County. These nonroad mobile source emissions were taken from the AQMP v6.2 for 2011 and 2017. MOVES2014a nonroad mobile source emissions for Maricopa and Pinal Counties in 2011 and 2017 are provided in Tables III-9 and III-10.

Table III-9. Ozone season average daily nonroad mobile source emissions for Maricopa County in 2011 and 2017 from MOVES2014a (unit: metric tons/day)

	2011			2017		
Sector	VOC	NOx	CO	VOC	NOx	CO
Recreational Equipment	4.72	0.19	21.43	3.44	0.18	21.82
Construction Equipment	1.42	33.44	38.14	1.16	20.73	29.11
Industrial Equipment	0.61	4.46	17.26	0.15	2.35	5.87
Lawn and Garden Equipment	12.67	2.13	156.41	8.64	1.60	148.23
Agriculture Equipment	0.02	1.04	0.98	0.01	0.76	0.74
Commercial Equipment	4.28	3.18	78.20	2.85	2.48	78.49
Pleasure Craft	1.89	0.35	4.86	1.12	0.36	4.15
Railroad Equipment	0.00	0.02	0.04	0.00	0.01	0.03
Total	25.61	44.81	317.32	17.37	28.47	288.44

Table III-10. Ozone season average daily nonroad mobile source emissions for Pinal County in 2011 and 2017 from MOVES2014a (unit: metric tons/day)

	2011			2017		
Sector	VOC	NOx	CO	VOC	NOx	CO
Recreational Equipment	2.39	0.06	8.04	1.73	0.07	7.33
Construction Equipment	0.12	2.82	3.42	0.10	1.75	2.45
Industrial Equipment	0.01	0.13	0.42	0.00	0.08	0.14
Lawn and Garden Equipment	1.08	0.17	15.06	0.75	0.13	12.60
Agriculture Equipment	0.02	0.93	0.92	0.01	0.68	0.66
Commercial Equipment	0.08	0.05	1.64	0.05	0.04	1.47
Pleasure Craft	0.41	0.07	1.21	0.25	0.08	0.91
Railroad Equipment	0.00	0.01	0.03	0.00	0.01	0.02
Total	4.11	4.24	30.74	2.89	2.90	25.58

Airport Emissions

Airport emissions include emissions from aircraft, auxiliary power units (APU), and ground support equipment (GSE). A total of 21 airports are located within the 4 km modeling domain, as shown in Figure III-1. Airport emissions in Maricopa and Pinal Counties were developed using the EDMS v5.1.4, with the exception of Luke Air Force Base (AFB). Luke AFB emissions were scaled using the F-16 and F-35 aircraft data provided by the facility.

The names, locations, and annual operations for the 21 airports within the 4 km modeling domain are provided in Table III-11. Operational landing and takeoff (LTO) cycles, aircraft fleet mix, and operational temporal profiles by aircraft for each airport were developed for the EDMS model runs for four aircraft categories: Air Commercial (AC), Air Taxi (AT), General Aviation (GA), and Military (ML).

Day-specific LTO for the first eight major airports in Table III-11 were retrieved from the Airport Operations database in the FAA Air Traffic Activity Data System (ATADS). The other six airports except Luke AFB were based upon the monthly LTO data from the MAG 2009 and 2014 survey data.

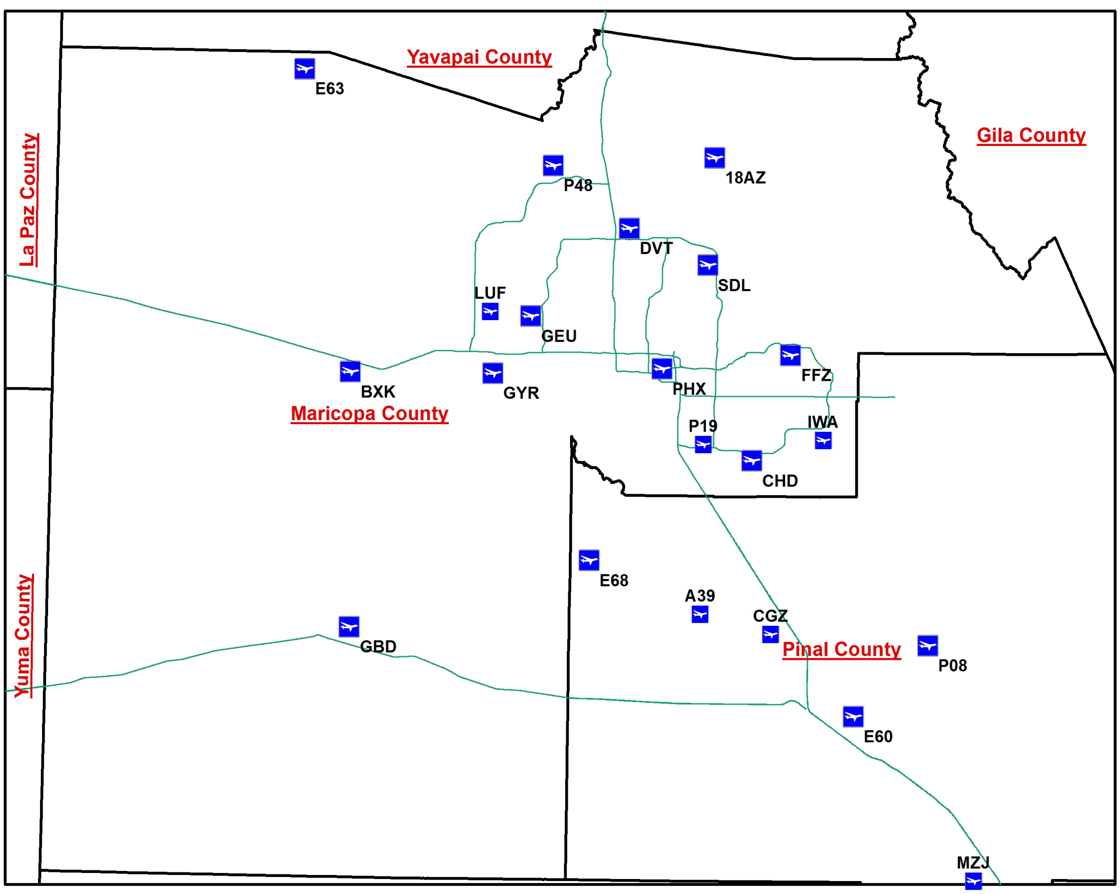


Figure III-1. Map of 21 airports located within the 4 km modeling domain

Aircraft fleet mix accounting for the operation distribution of aircraft types was developed using data from the FAA Enhanced Traffic Management Counts (ETMSC). Monthly and weekly temporal profiles for each airport were developed from day-specific LTO for each aircraft category. Hourly temporal profiles were created using the operation data from the FAA Aviation Performance Metrics (APM).

To develop hourly mixing heights, surface meteorological data for Phoenix Sky Harbor International Airport and upper air data for the Tucson monitor were obtained from the NCDC Integrated Surface Hourly Database (ISHD), 1-minute Automated Surface Observing System (ASOS), and the Earth System Research Laboratory (ESLR) radiosonde database. The surface and upper air meteorological data were combined using the EPA AERMET v15181 and AERSURFACE v13016 models for the EDMS modeling for airports.

The 2017 airport emissions inventory for Maricopa County was developed using the 2017 LTO projections from the FAA Terminal Area Forecast (TAF) (FAA, 2015) for the first eight major airports in Table III-11. LTO cycles for the other airports in Maricopa County were assumed to be unchanged from 2011 since they were small or had no operation projections in 2017.

The Luke AFB emissions for the 2011 base year were developed by scaling the 2008 emissions (Weston, 2010) with the numbers of F-16 aircraft in 2008 and 2011, which were provided by Luke AFB. Luke AFB also provided the number of F-16 and F-35 aircrafts for the 2017 future year. The ratio of F-16 aircrafts between the 2011 base year and the 2017 future year was applied to project the Luke AFB F-16 aircraft emissions for the 2017 future year. The emissions from a single F-35 aircraft at the Luke AFB were derived from L6 scenario in the 2012 environmental impact statement (USAF, 2012). The Luke AFB F-35 aircraft emissions for the 2017 future year were calculated by multiplying the emissions per F-35 aircraft and numbers of F-35 in 2017. The Luke AFB emissions for the 2017 future year were developed by adding the F-16 aircraft emissions in 2017 to the F-35 aircraft emissions in 2017.

Aircraft operation data for six airports in Pinal County within the 4 km modeling domain were obtained from the MAG airport survey, the FAA TAF database, and the AirNav.com website. Fleet mix data for airports in Pinal County were based on averages of fleet mix data for general aviation and military categories of municipal airports in Maricopa County. Mixing height data for Pinal County were extracted from the National Weather Service (NWS) for the Casa Grande Airport. Average daily emissions by airport in 2011 and 2017 are provided in Table III-12.

Table III-11. Annual operations for airports in the 4 km modeling domain in 2011 and 2017

No.	Airport Name	Code	County	Latitude	Longitude	Operations	
						2011	2017
1	Chandler Municipal Airport	CHD	Maricopa	33.269	-111.811	161,589	233,855
2	Deer Valley Airport	DVT	Maricopa	33.688	-112.083	317,443	317,247
3	Falcon Field Airport	FFZ	Maricopa	33.461	-111.728	220,080	275,171
4	Glendale Municipal Airport	GEU	Maricopa	33.527	-112.295	87,124	59,130
5	Phoenix Goodyear Airport	GYR	Maricopa	33.423	-112.376	138,606	76,282
6	Phoenix-Mesa Gateway Airport	IWA	Maricopa	33.308	-111.655	171,200	221,259
7	Phoenix Sky Harbor Airport	PHX	Maricopa	33.434	-112.008	461,989	458,242
8	Scottsdale Airport	SDL	Maricopa	33.623	-111.911	141,640	148,813
9	Buckeye Municipal Airport	BXK	Maricopa	33.420	-112.686	53,070	53,070
10	Gila Bend Municipal Airport	GBD	Maricopa	32.958	-112.678	3,536	3,536
11	Pleasant Valley Airport	P48	Maricopa	33.801	-112.251	6,010	6,010
12	Sky Ranch at Carefree Airport	18AZ	Maricopa	33.818	-111.898	3,030	3,030
13	Stellar Airpark	P19	Maricopa	33.299	-111.916	39,056	39,056
14	Luke Air Force Base*	LUF	Maricopa	33.535	-112.383	n/a	n/a
15	Wickenburg Municipal Airport	E63	Maricopa	33.969	-112.799	12,000	12,000
16	Ak-Chin Regional Airport**	A39	Pinal	32.991	-111.919	1,095	36,500
17	Arizona Soaring	E68	Pinal	33.084	-112.161	20,075	20,075
18	Casa Grande Municipal Airport	CGZ	Pinal	32.955	-111.767	119,680	119,680
19	Coolidge Municipal Airport	P08	Pinal	32.936	-111.427	4,250	4,250
20	Eloy Municipal Airport	E60	Pinal	32.807	-111.587	19,800	23,450
21	Pinal Airpark	MZJ	Pinal	32.510	-111.325	10,628	56,857

* Emissions were scaled by numbers of aircrafts in 2011 and 2017.

** Operational data at the Ak-Chin Regional Airport were collected through a phone conversation with airport manager Tim Costello on 10/27/2015.

Table III-12. Summary of average daily airport emissions for the 4 km modeling domain (unit: metric tons/day)

No.	Airport	VOC		NOx		CO	
		2011	2017	2011	2017	2011	2017
1	Chandler Municipal Airport	0.220	0.301	0.057	0.054	2.652	3.582
2	Deer Valley Airport	0.227	0.236	0.093	0.085	3.511	3.421
3	Falcon Field Airport	0.251	0.411	0.099	0.133	3.860	4.436
4	Glendale Municipal Airport	0.222	0.147	0.064	0.032	1.527	0.921
5	Phoenix Goodyear Airport	0.191	0.110	0.119	0.079	2.492	1.303
6	Phoenix-Mesa Gateway Airport	0.670	0.924	0.264	0.301	2.883	3.279
7	Phoenix Sky Harbor Airport	1.180	1.073	4.674	4.467	9.981	7.013
8	Scottsdale Airport	0.594	0.618	0.212	0.188	1.926	1.706
9	Buckeye Municipal Airport	0.016	0.014	0.015	0.009	0.701	0.646
10	Gila Bend Municipal Airport	0.001	0.001	0.001	0.001	0.047	0.043
11	Pleasant Valley Airport	0.000	0.000	0.002	0.001	0.003	0.003
12	Sky Ranch at Carefree Airport	0.003	0.003	0.001	0.001	0.033	0.030
13	Stellar Airpark	0.021	0.019	0.012	0.007	0.607	0.566
14	Luke Air Force Base	0.365	0.229	0.792	0.698	1.449	1.382
15	Wickenburg Municipal Airport	0.034	0.033	0.009	0.007	0.201	0.180
16	Ak-Chin Regional Airport	0.004	0.126	0.001	0.024	0.014	0.415
17	Arizona Soaring	0.070	0.069	0.017	0.013	0.263	0.228
18	Casa Grande Municipal Airport	0.420	0.413	0.104	0.083	1.582	1.368
19	Coolidge Municipal Airport	0.015	0.015	0.004	0.003	0.057	0.049
20	Eloy Municipal Airport	0.070	0.081	0.017	0.016	0.261	0.267
21	Pinal Airpark	0.042	0.268	0.044	0.527	0.202	1.491
Total		4.616	5.091	6.601	6.729	34.252	32.329

Locomotive Emissions

Locomotive and rail yard emissions for the 2011 base year in Maricopa and Pinal Counties were obtained from the Maricopa County 2011 PEI and the AQMP v6.2, respectively. The growth factor of 0.74 for the locomotive emissions between 2011 and 2017 was derived from locomotive diesel usages in Maricopa County. The locomotive diesel usage of 6,097,290 gallons/year in 2017 was extrapolated using the locomotive diesel usages of 9,360,993 gallons/year in 2008 and 8,273,092 gallons/year in 2011. The same growth factor applied for locomotive emissions for Maricopa County was assumed for Pinal County. Locomotive emissions for Maricopa and Pinal Counties in 2011 and 2017 are provided in Table III-13. Nonroad mobile source emissions for the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain in 2011 and 2017 are provided in Table III-14.

Table III-13. Ozone season average daily locomotive emissions for Maricopa and Pinal Counties in 2011 and 2017 (unit: metric tons/day)

County	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Maricopa County	0.19	3.49	0.61	0.14	2.58	0.45
Pinal County	0.17	3.42	0.49	0.13	2.52	0.36

Table III-14. Ozone season average daily nonroad mobile source emissions for the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain in 2011 and 2017 (unit: metric tons/day)

Area	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Eight-hour ozone NA	27.89	53.58	343.58	20.26	36.26	310.41
4 km modeling domain	36.60	62.78	387.21	26.89	43.49	350.04

III-1-4. Onroad Mobile Source Emissions

MOVES2014a is the latest onroad and off-network emissions model developed by EPA. The MOVES2014a and MAG MOVESLINK2014 were used to develop onroad emissions inventory for the 4 km modeling domain. The MAG MOVESLINK2014 tool prepares MOVES2014a input, executes MOVES2014a, and processes onroad network and off-network emission factors extracted from MOVES2014a and link-level traffic data from the TransCAD Travel Demand Model (TDM). This tool was developed using the Python programming language and Geographic Information Systems (GIS) technology.

To calculate onroad exhaust, evaporative, refueling, and extended idling emissions for the selected years, MOVES2014a is executed using local input data for each day of the modeling episode. MOVES modeling scenarios were created using the county scale setting with the inventory and emissions rate options for all road types including off-network.

MOVES2014a requires local input data such as Inspection and Maintenance (I/M) programs, meteorological data, vehicle population, source type age distribution, annual vehicle miles traveled (VMT), monthly/daily/hourly fractions, road type distribution, average speed distribution, ramp fraction, fuel parameter data, and Alternative Vehicle and Fuel Technologies (AVFT). These MOVES2014a local inputs were developed using local data from multiple sources such as the Arizona Department of Transportation (ADOT), the Arizona Department of Weights and Measures (ADWM), the MAG Transportation Division, and the National Climatic Data Center (NCDC). The specific MOVES2014a model RunSpec and input data are provided in Appendix G.

Since the modeling area contains a subarea (i.e., Area A) where control measures such as I/M programs and fuel programs were enforced, MOVES2014a were run separately for the subarea and outside the subarea. The Area A boundary was defined in Arizona Senate Bill 1427 (SB 1427), and expanded in Arizona House Bill 2538 (HB 2538). The air quality measures described in HB 2538 were implemented in the Area A. The Area A boundary (HB 2538) covers portions of Maricopa, Pinal, and Yavapai Counties. Onroad vehicles registered and operating in the Area A are subject to the vehicle emissions inspection programs and the Cleaner Burning Gasoline (CBG) fuel requirements. The 4 km modeling domain covers the Area A. Input data for Area A and outside Area A were separately prepared.

I/M Programs

MOVES2014a has an [IMCoverage] table for I/M programs, which reflects the actual proportions of vehicles subject to the specified levels of inspection. The term "I/M vehicles" denotes vehicles which are required to undergo an emission test and/or inspection under the Vehicle Inspection/Maintenance Programs. The participation in the I/M programs is required for all vehicles registered in the Area A, with the exception of certain model years and vehicle classes. However, it is assumed that 91.6 percent of the vehicles operating within the Area A participate in the I/M programs and the remaining 8.4 percent do not participate in the program. These percentages reflect the control measures "Tougher Enforcement of Vehicle Registration and Emissions Test Compliance" and "Expansion of Area A Boundaries," described in the MAG Eight-Hour Ozone Redesignation Request and Maintenance Plan for the Maricopa Nonattainment Area (MAG, 2009). This percentage is directly applied to the Compliance Factor in the [IMCoverage] table. The same I/M programs were applied for the Maricopa eight-hour ozone nonattainment area.

Meteorological Data

MOVES2014a requires hourly temperature and relative humidity data by a specific month of the year. Meteorological data for the Phoenix Sky Harbor International Airport in 2011 were obtained from NCDC for the selected episode days in 2011. The same hourly average temperature and relative humidity data were used in the base and future year modeling.

Vehicle Population

In MOVES2014a, off-network emissions including start, evaporative, and extended idle emissions were determined by the population of vehicles in an area. The vehicle population in Maricopa and Pinal Counties was obtained from the July 2011 vehicle registration data provided by ADOT. The vehicle population data were allocated to the 13 MOVES source types based upon MOVES default vehicle population fractions for Maricopa and Pinal

Counties in 2011. The vehicle population in a subarea was estimated by multiplying the ratio of the population of a specific geographical subarea to the population of Maricopa County or Pinal County by the vehicle population in Maricopa County or Pinal County. The population ratio for 2011 was derived from the MAG socioeconomic data. For the 2017 future year modeling, the vehicle registration data for the year 2015 were adjusted by applying the ratio of the future year source type population to the 2015 source type population.

Source Type Age Distribution

MOVES2014a categorizes vehicles by vehicle class and model year. The source type age distribution input table was prepared using the EPA MOVES data converter and the vehicle registration data from ADOT. For the 2017 future year modeling, the source type age distribution was projected by using the EPA Age Distribution Projection Tool.

Annual Vehicle Miles Traveled (VMT)

The annual average daily VMT data were derived from the TDM provided by the MAG Transportation Division in April 2015. The outputs from the TDM were clipped using GIS to calculate VMT in the 4 km modeling domain. The 2011 and 2017 VMT for the 4 km modeling domain are provided in Table III-15. The annual average daily VMT were multiplied by 365 days to obtain the annual VMT.

Table III-15. 2011 and 2017 average daily VMT for subareas (unit: miles/day)

Area	2011	2017
Area A	85,936,496	95,576,055
Outside Area A	8,159,403	9,392,622
4 km modeling domain	94,095,899	104,968,677

Road Type Distribution

MOVES2014a requires the distribution of VMT by road type as a local input. For each modeling year, the VMT distribution of road types was derived using the 2011 and 2017 traffic assignment data provided by the MAG Transportation Division.

VMT Fraction

Since the TDM network assignments provide average weekday VMT, the average weekday VMT were adjusted using month, day, and hour VMT fractions in order to derive hourly VMT for each weekday/weekend and month from the annual VMT. The month/day/hour VMT fractions were developed from data recorded by continuous traffic counters on freeways (ADOT Freeway Management System) and arterials (Phoenix Automatic Traffic Recorders) in 2007. The same month, day, and hour VMT fractions were applied to the 2011 and 2017 average weekday VMTs from the 2011 and 2017 network assignments.

Average Speed Distribution

For the inventory option, MOVES2014a estimated emission effects from vehicle power, speed, and acceleration on arterials and freeways by assigning activity to operating mode distributions, which were determined by the distribution of vehicle hours traveled (VHT) in sixteen speed bins. In this study, link-specific emissions were calculated for arterials and freeways using link-specific VMT and the MOVES emission rates for link-specific speed. As a MOVES2014a input requirement, the average speed distributions of arterials and freeways for each modeling year were developed by post-processing the outputs from the TDM network assignment data provided by the MAG Transportation Division. To develop the average speed distribution, VHT in sixteen speed bins were separately accumulated for each hour of the day, source type, and road type. The average speed distribution was calculated by normalizing VHT in sixteen speed bins for each hour of the day, source type, and road type.

Ramp Fraction

MOVES2014a requires the ramp fraction which represents the percent of VHT on ramps on both rural and urban freeways. The fraction of VHT on ramps was derived by dividing the total VHT on ramps by the total VHT for each restricted road type. Those VHT for each modeling year were obtained from the traffic assignment data provided by the MAG Transportation Division.

Fuel Data

Regarding the fuel input data, MOVES2014a provides three MOVES tables, which are [fuelsupply], [fuelformulation], and [fuelusagefraction]. Using the MOVES Fuel Wizard, the fuel parameters extracted from the ADWM 2011 fuel inspection data in Maricopa and Pinal Counties were used in the 2011 base year modeling. For the 2017 future year modeling, the MOVES2014a default fuel parameters for 2017 were used for the EPA Tier 3 Fuel Standards.

AVFT strategy

MOVES2014a allows users to modify the default fuel engine fractions for local vehicles using different fuels and technologies by vehicle model year. The fleet data for diesel and natural gas transit buses were provided by Valley Metro. The data were used to update the AVFT input for diesel and natural gas transit buses. Since the local fleet data for transit buses using alternative fuels were available only for some model years, MOVES2014a default values extracted from the MOVES [fuelEngFraction] table were used for the rest of the vehicle model years.

Onroad mobile source emissions for the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain in 2011 and 2017 are provided in Tables III-16 and III-17.

Table III-16. Ozone season average daily onroad mobile source emissions for the Maricopa eight-hour ozone nonattainment area in 2011 and 2017 (unit: metric tons/day)

Road Type	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Off-Network	48.01	24.31	187.98	33.81	18.13	133.85
Rural Restricted Access	1.25	15.68	28.54	0.53	7.55	16.33
Rural Unrestricted Access	2.41	9.81	51.04	0.99	4.35	29.86
Urban Restricted Access	6.01	33.9	188.95	3.01	17.13	150.7
Urban Unrestricted Access	13.28	33.45	219.46	7.31	15.53	162.24
Total	70.96	117.15	675.97	45.65	62.69	492.98

Table III-17. Ozone season average daily onroad mobile source emissions for the 4 km modeling domain in 2011 and 2017 (unit: metric tons/day)

RoadType	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Off-Network	53.25	30.01	208.10	38.00	23.38	147.44
Rural Restricted Access	1.39	19.36	31.60	0.60	9.74	17.99
Rural Unrestricted Access	2.67	12.11	56.50	1.11	5.61	32.89
Urban Restricted Access	6.67	41.85	209.18	3.38	22.09	166.00
Urban Unrestricted Access	14.73	41.30	242.95	8.22	20.03	178.72
Total	78.71	144.63	748.33	51.31	80.85	543.04

III-1-5. Biogenic Source Emissions

Biogenic emissions inventory for the three modeling domains was prepared using the latest Model of Emissions of Gases and Aerosols from Nature (MEGAN) version 2.10, which incorporates the extensive biogenic chemical species of ozone precursors (Guenther et al., 2012). The MEGAN v2.10 is the state-of-the-art biogenic emissions model developed by the National Center for Atmospheric Research (NCAR). MEGAN was used to generate gridded hourly emissions of VOC, NOx, and CO for the modeling domains for the period of May 1 through September 30, 2011. Chemical species of the Carbon Bond Model version 6 (CB6) chemical mechanism were used for the MEGAN biogenic emissions modeling. The hourly gridded emissions from the model were post-processed and merged with anthropogenic emissions by SMOKE for the CAMx air quality modeling.

MEGAN used the 2011 gridded meteorological data generated by WRF and pre-processed by the Meteorology-Chemistry Interface Processor (MCIP). The MCIP is an interface tool between WRF and MEGAN that converts WRF meteorology to MEGAN. The WRF gridded meteorological data include solar radiation, surface temperature, wind speed, humidity, soil moisture, and accumulated rainfall. MEGAN requires gridded 8-day average leaf area index (LAI), plant function type (PFT) for 16 plant categories, and emission factors (EF) for 20 MEGAN plant species. These gridded inputs were derived from the North America Leaf

Index version 2011, the North America Plant Functional Type version 2011, and the MEGAN global emission factor in 30 arc-second (approximately 1 km) spatial resolution.

The MEGAN default land cover data for North America were used in the 36 km, 12 km, and 4 km modeling domains. The MEGAN default land use data for the 4 km modeling domain were compared with the MAG study results, which were based on satellite and ground observations for local land use and biogenic emissions (MAG, 2006). For broadleaf deciduous temperate tree and needle leaf evergreen temperate tree, which had discrepancy on the vegetation distribution, the MEGAN default vegetation data were updated with the local data for the 4 km modeling domain. Figure III-2 illustrates the MEGAN biogenic daily emissions of VOC, NOx, and CO in the 4 km modeling domain during ozone season from May 1 through September 30, 2011. The base year and the attainment year biogenic emissions were assumed to be constant between 2011 and 2017. Biogenic source emissions for the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain in 2011 and 2017 are provided in Table III-18.

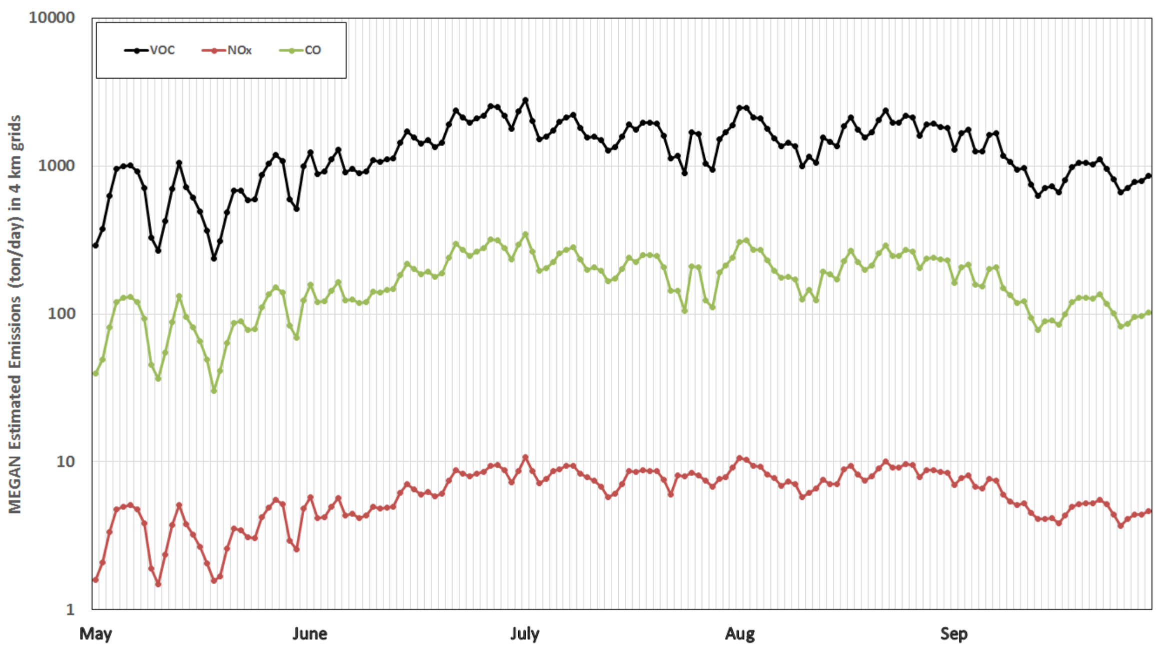


Figure III-2. Total daily biogenic emissions of VOC , NOx, and CO for the 4 km modeling domain from May 1 through September 30, 2011

Table III-18. Ozone season average daily biogenic source emissions for the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain (unit: metric tons/day)

Area	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Maricopa eight-hour ozone NA	487.52	2.37	63.46	487.52	2.37	63.46
4 km modeling domain	1,336.57	6.32	169.62	1,336.57	6.32	169.62

III-1-6. Wildfires and Prescribed Burning

Emissions from wildfires and prescribed burning extracted from AQMP v6.2 were located by geographic coordinates (point locations) and had daily ozone precursor emissions and such parameters as burned acres and fuel load. Agricultural burning and other open burning emissions were processed as area sources. EPA used the SmartFire 2/Blue system to develop wildfire and prescribed burning emissions. SMOKE was used to process the wildfire and prescribed burning emissions as point sources for the CAMx air quality modeling. The base year and the attainment year wildfire emissions were assumed to be constant between 2011 and 2017. Wildfire emissions for the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain in 2011 are provided in Table III-19. The day-specific wildfire emissions are provided in Table D-7, Appendix D.

Table III-19. Ozone season average daily wildfire emissions for the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain (unit: metric tons/day)

Area	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Maricopa eight-hour ozone NA	70.36	7.57	294.03	70.36	7.57	294.03
4 km modeling domain	499.00	57.18	2,080.97	499.00	57.18	2,080.97

III-2. Emissions Preprocessing

Emissions inventory data described in Section III-1 should be pre-processed for use in air quality model. The SMOKE modeling system transforms the emissions inventories from their original spatial and temporal resolutions into the hourly gridded and chemically speciated emissions required by the CAMx air quality model. The spatial resolution for the emissions inventory varies by emission source and area. Temporal resolutions of emissions vary depending upon emissions source categories. Hourly, daily, monthly, or annual total emissions were typically provided.

The SMOKE modeling system read emission inventories and applied spatial and temporal allocations, and chemical speciation for emissions. The MOVES2014a/ MOVESLINK2014 was used to develop chemically speciated and hourly gridded onroad emissions. MEGAN also calculated speciated and hourly gridded biogenic emissions without using SMOKE.

Anthropogenic and biogenic emissions including wildfires were merged using SMOKE to provide a combined emissions input file for CAMx model runs. The ground-level point source emissions were separated from the elevated point source emissions using the SMOKE model.

III-2-1. Spatial Allocation

Anthropogenic emissions except point, onroad mobile, and airport emission sources were reported as county-level emissions. These emissions were spatially allocated to grid cells for photochemical air quality modeling. For instance, gridded agricultural are were used as the spatial surrogate to assign county-level agricultural pesticide emissions to grid cells with the SMOKE modeling system.

The EPA Spatial Allocator v4.2 was used to develop spatial surrogates that were inputs to the SMOKE modeling system. Three components were used for developing spatial surrogates. The first component was a weighted shapefile, such as shapefiles for roadways, population density, or golf courses for each county. The second component was a county/province/municipal boundary shapefile. The last component was the grid or polygon configuration for the modeling domains.

A total of 21 spatial surrogates were developed for Maricopa and Pinal Counties by using MAG GIS shapefiles. For Maricopa County, the MAG GIS shapefiles include 2010 census data, 2011 MAG regional traffic data, 2012 MAG land use and land cover, and 2011 Maricopa County employment data. The recent local landuse and employment data for Pinal County were used in developing spatial surrogates for gridded emissions in Pinal County. Table III-20 presents 21 spatial surrogates and surrogate codes for Maricopa and Pinal Counties in the 4 km modeling domain. Spatial surrogates for SCCs are given in Table D-10, Appendix D. Development of spatial surrogates for both the 12 km and 36 km modeling domains covering the southern portion of Canada, the northern portion of Mexico, and the U.S. were based on the shapefiles and technical support document provided in the AQMP v6.2.

Emission density plots in Figures III-3 through III-8 were developed using gridded emissions from the SMOKE model runs. Since emissions density plots provide the spatial distribution of emissions for the emission source sectors, they were used to review the accuracy or appropriateness of spatial distributions of the gridded emissions for quality assurance and quality checking purposes. Point source emissions were spatially distributed to grid cells according to source specific geographic latitude and longitude data. Area and nonroad sources were gridded using the aforementioned spatial surrogates. Onroad and biogenic source emissions were provided as the grid-level emissions that were developed by the MAG MOVESLINK2014 and MEGAN models. Wildfire emissions were spatially distributed based on the emission levels of grid cells.

Table III-20. Spatial surrogates and codes used in gridding emissions in Maricopa and Pinal Counties

No.	Surrogate	Surrogate Code
1	Population	100
2	Construction	141
3	Total Road Miles	240
4	Total Railroad Density	261
5	Agriculture	309
6	Water	350
7	Open Land	401
8	Commercial Land	500
9	Aircraft Engine Manufacturers	504
10	Industrial Land	505
11	Commercial plus Industrial	510
12	Commercial plus Institutional Land	515
13	Residential	531
14	Residential + Commercial + Industrial + Institutional + Government	535
15	Auto refinish	544
16	Hospital	560
17	Fuel Dispensing Facility	601
18	Golf Courses	850
19	Wastewater Treatment Facilities	870
20	Landfills	871
21	Crematories	872

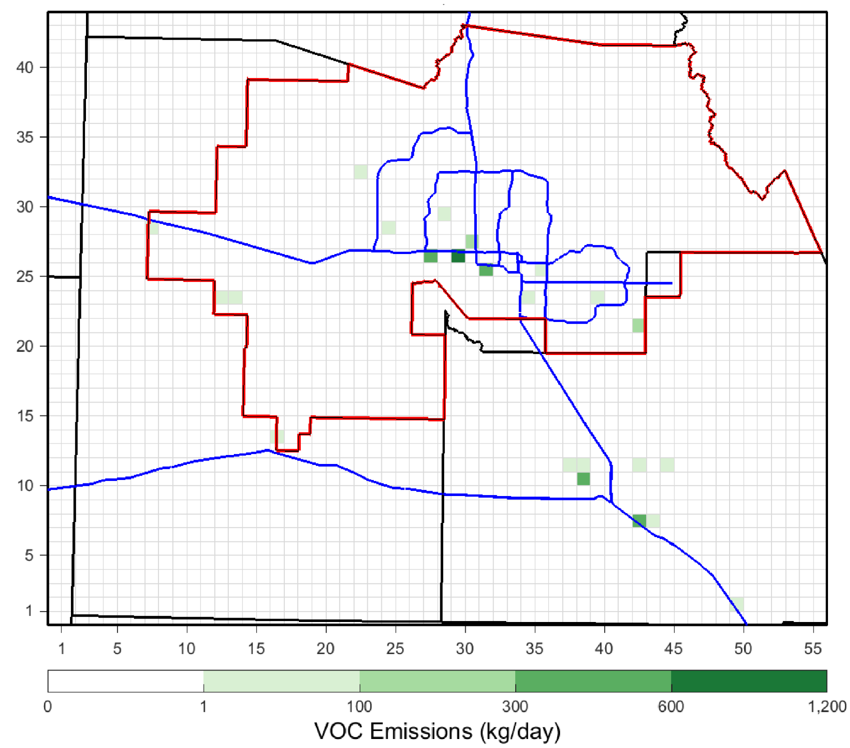


Figure III-3 (a). Point source daily VOC emissions for a typical weekday in 2011

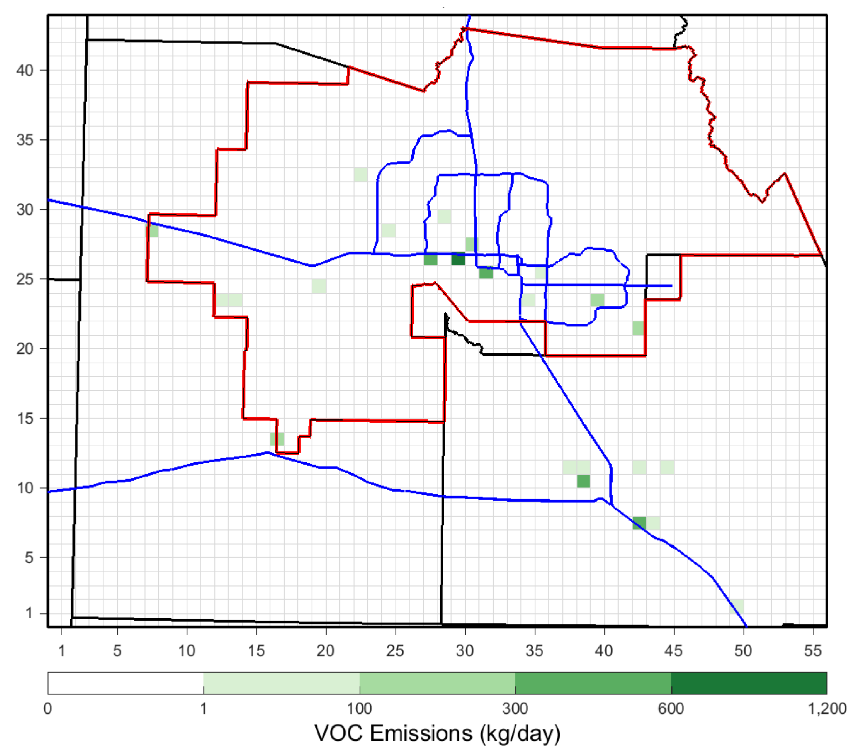


Figure III-3 (b). Point source daily VOC emissions for a typical weekday in 2017

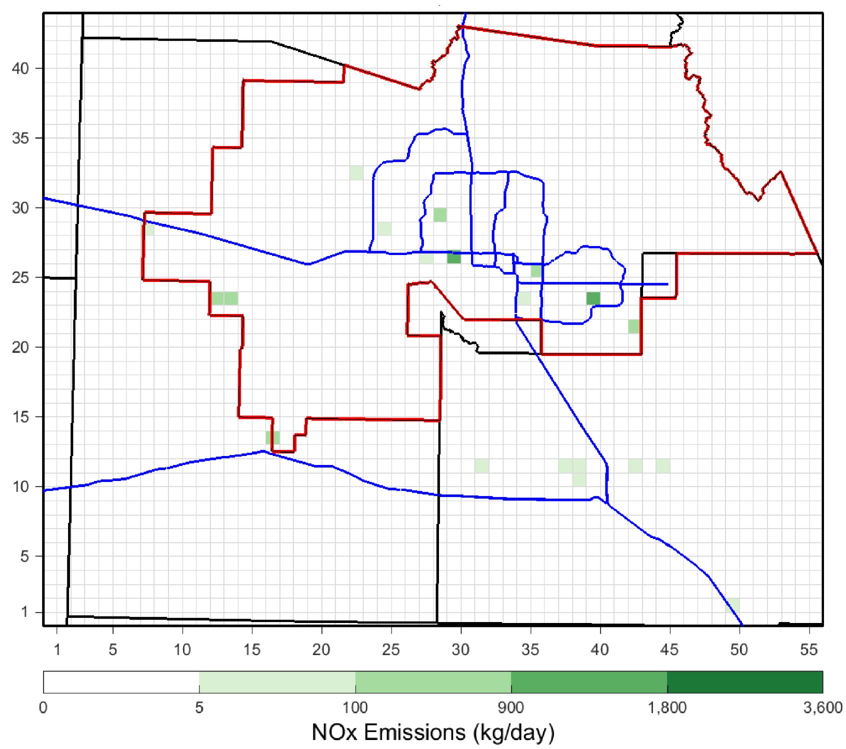


Figure III-3 (c). Point source daily NOx emissions for a typical weekday in 2011

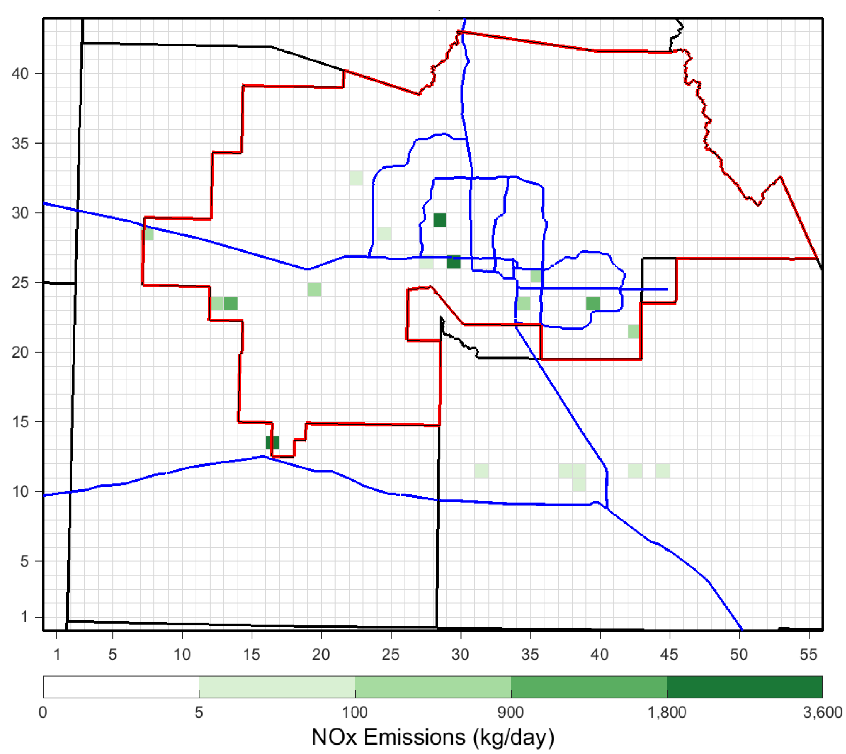


Figure III-3 (d). Point source daily NOx emissions for a typical weekday in 2017

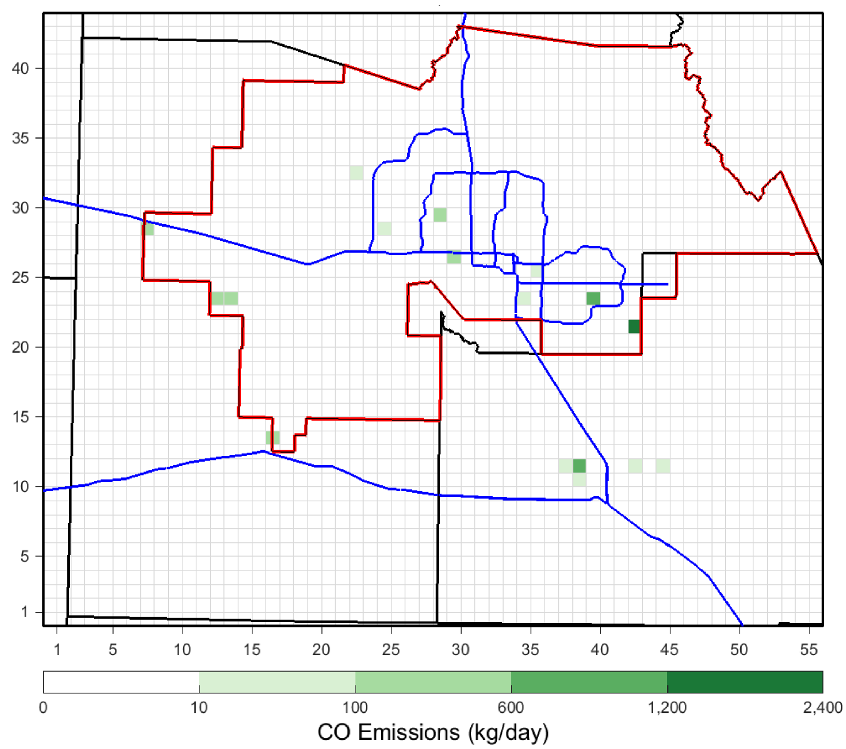


Figure III-3 (e). Point source daily CO emissions for a typical weekday in 2011

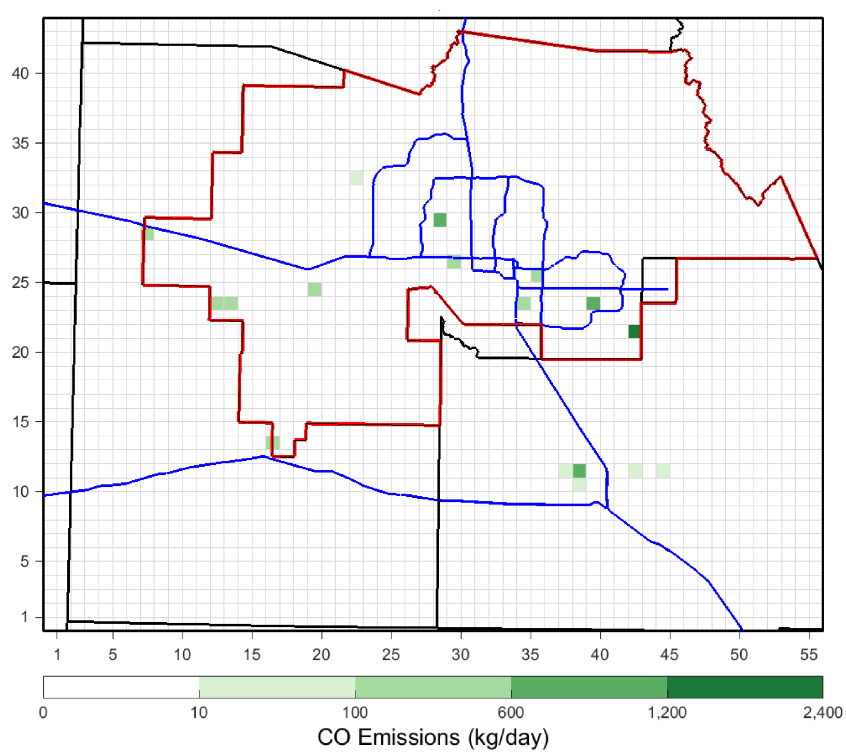


Figure III-3 (f). Point source daily CO emissions for a typical weekday in 2017

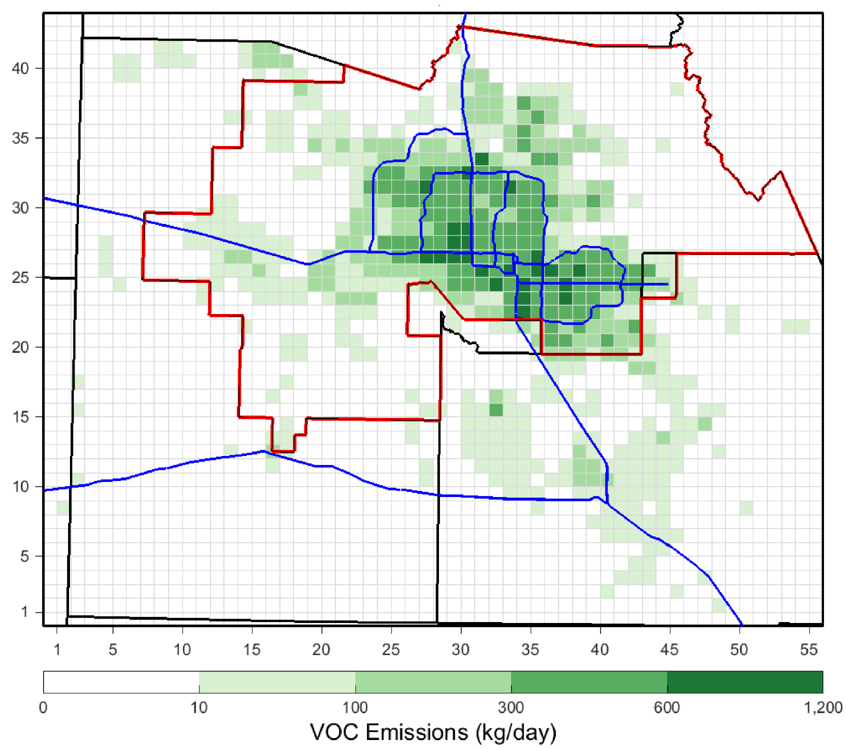


Figure III-4 (a). Area source daily VOC emissions for a typical weekday in 2011

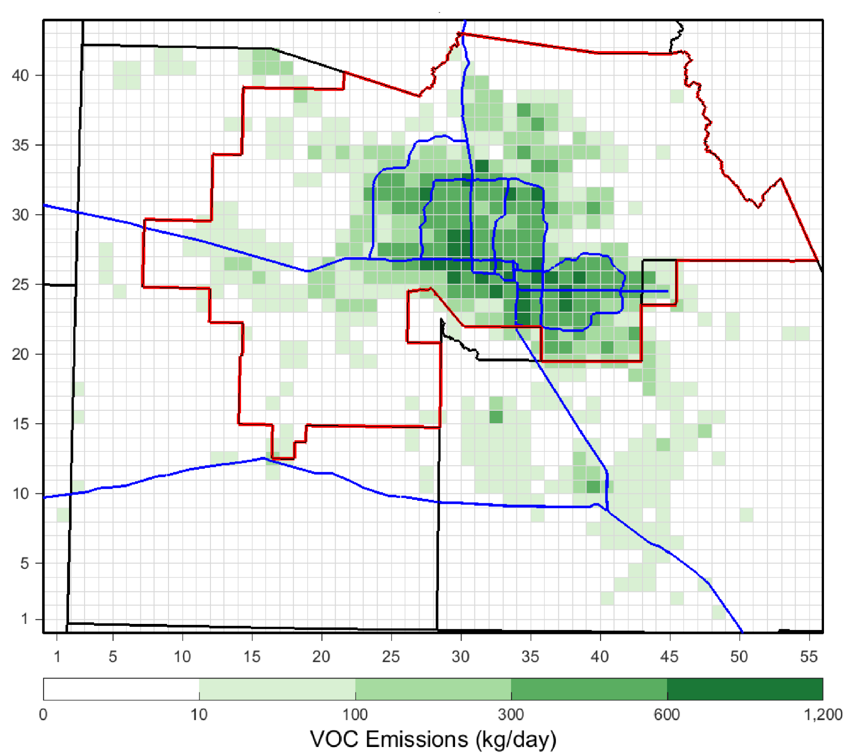


Figure III-4 (b). Area source daily VOC emissions for a typical weekday in 2017

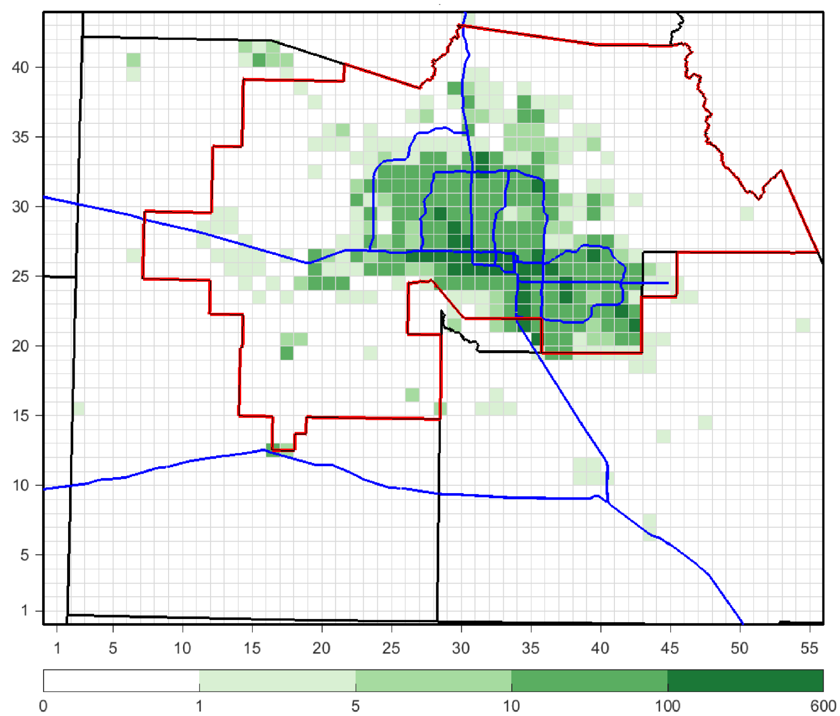


Figure III-4 (c). Area source daily NOx emissions for a typical weekday in 2011

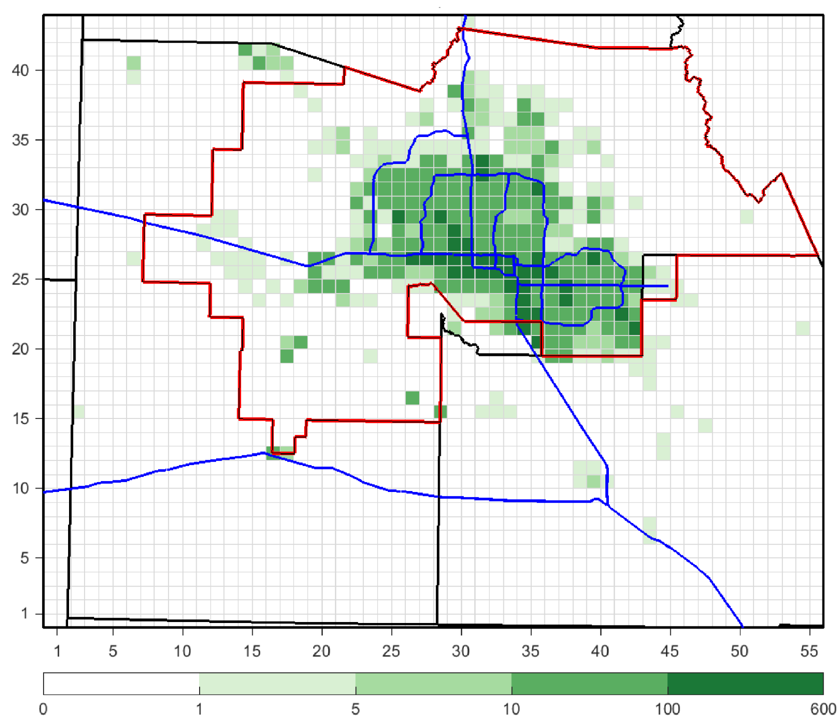


Figure III-4 (d). Area source daily NOx emissions for a typical weekday in 2017

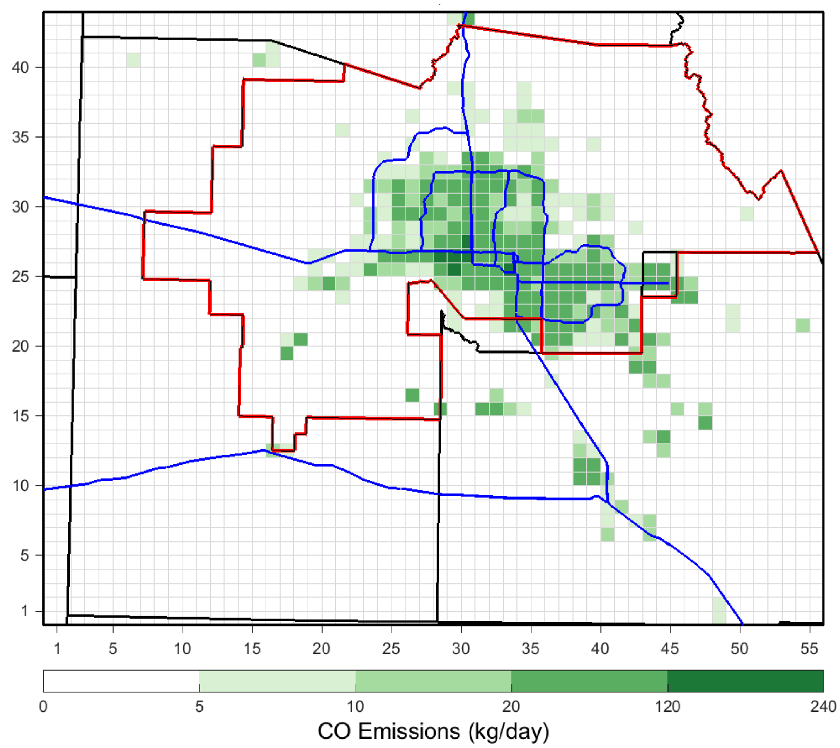


Figure III-4 (e). Area source daily CO emissions for a typical weekday in 2011

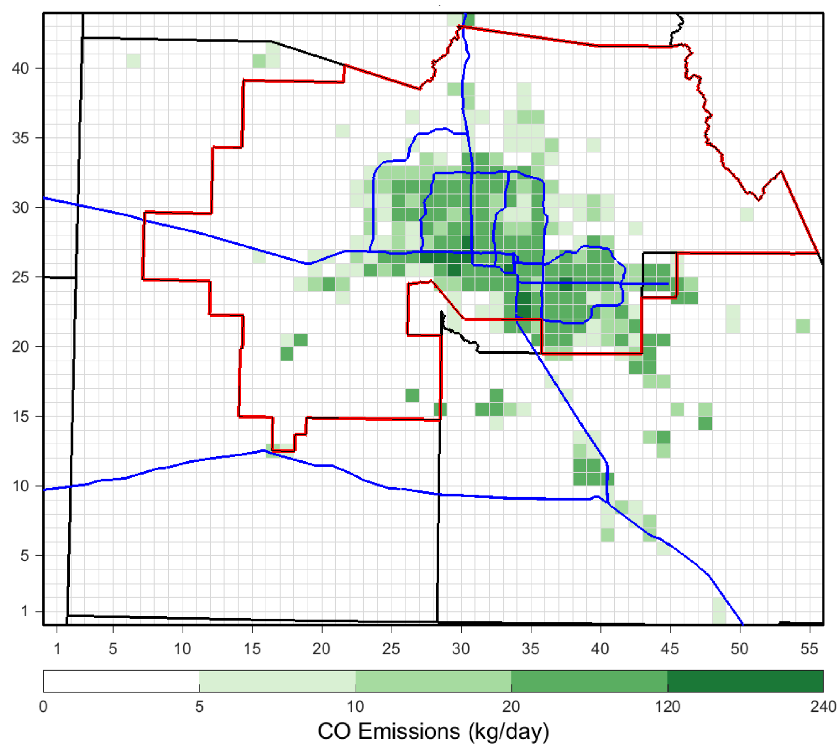


Figure III-4 (f). Area source daily CO emissions for a typical weekday in 2017

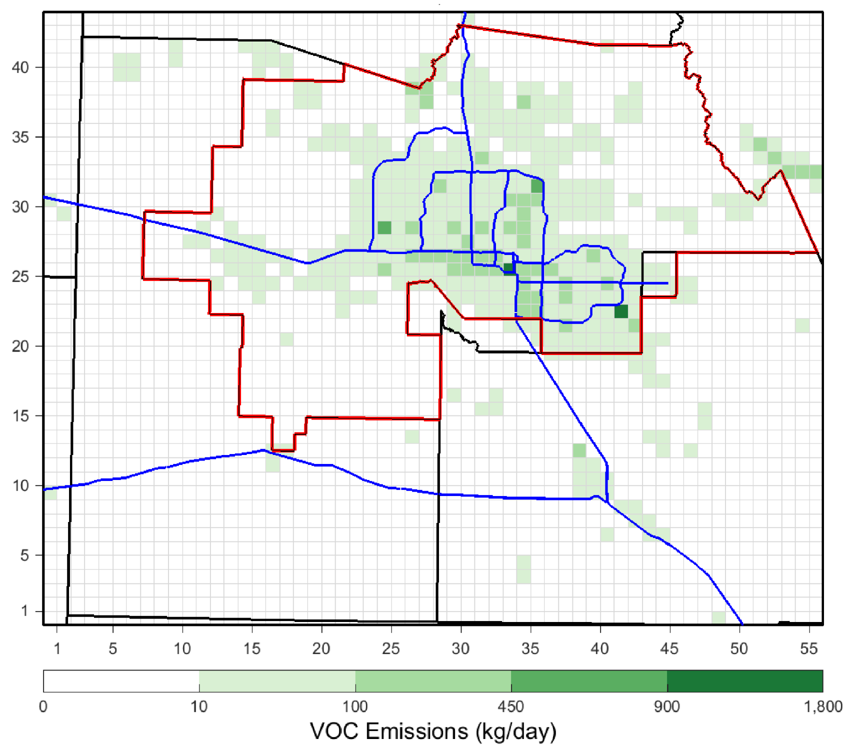


Figure III-5 (a). Nonroad source daily VOC emissions for a typical weekday in 2011

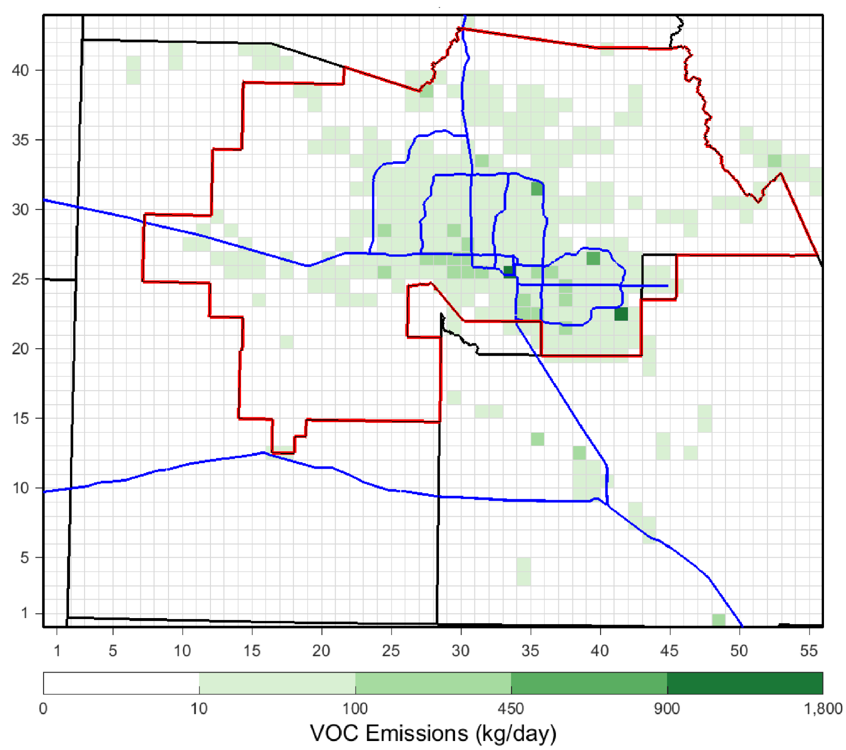


Figure III-5 (b). Nonroad source daily VOC emissions for a typical weekday in 2017

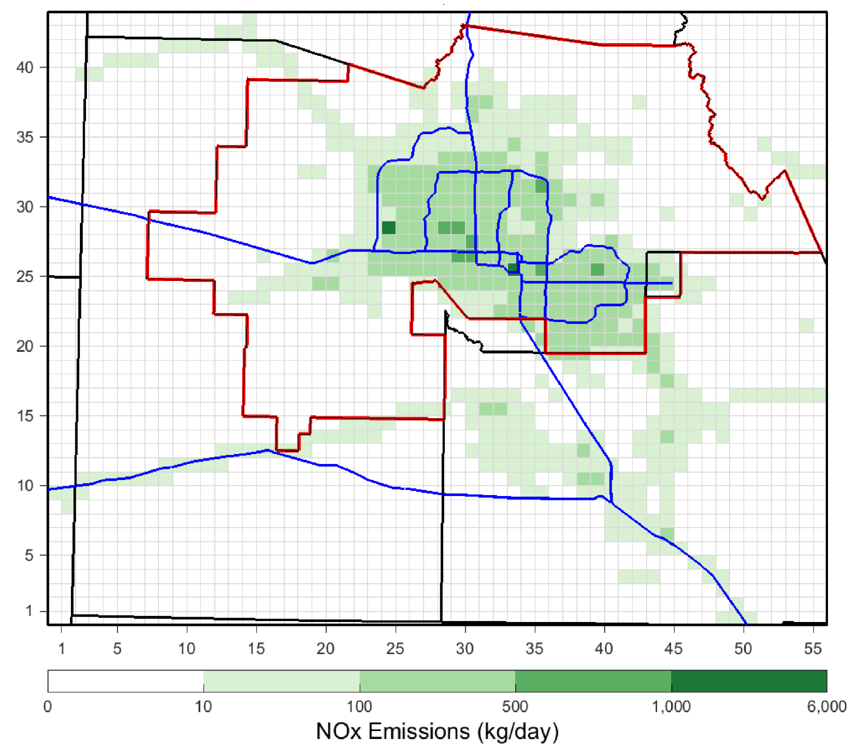


Figure III-5 (c). Nonroad source daily NOx emissions for a typical weekday in 2011

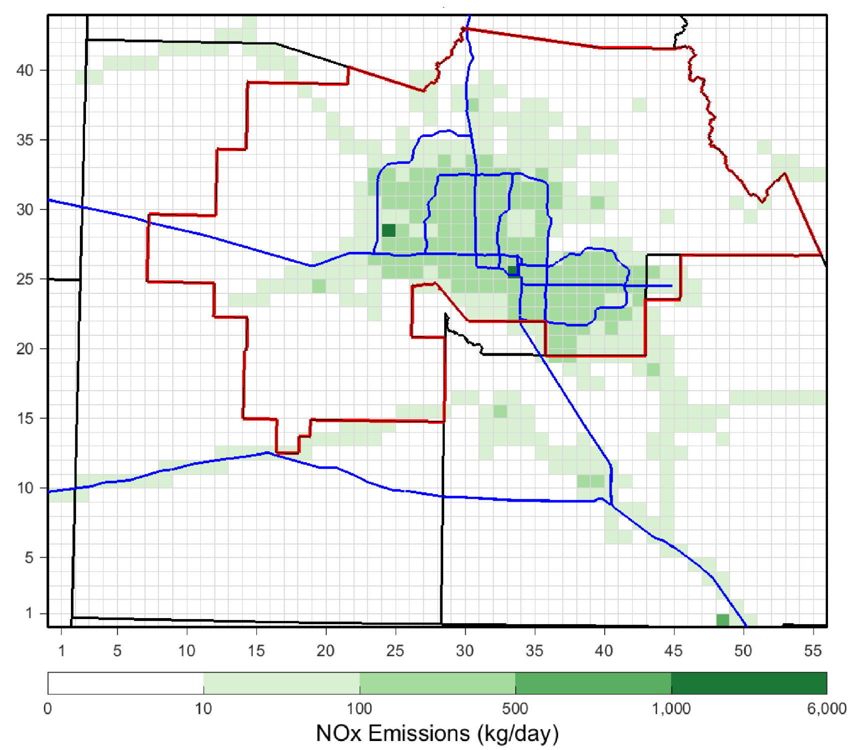


Figure III-5 (d). Nonroad source daily NOx emissions for a typical weekday in 2017

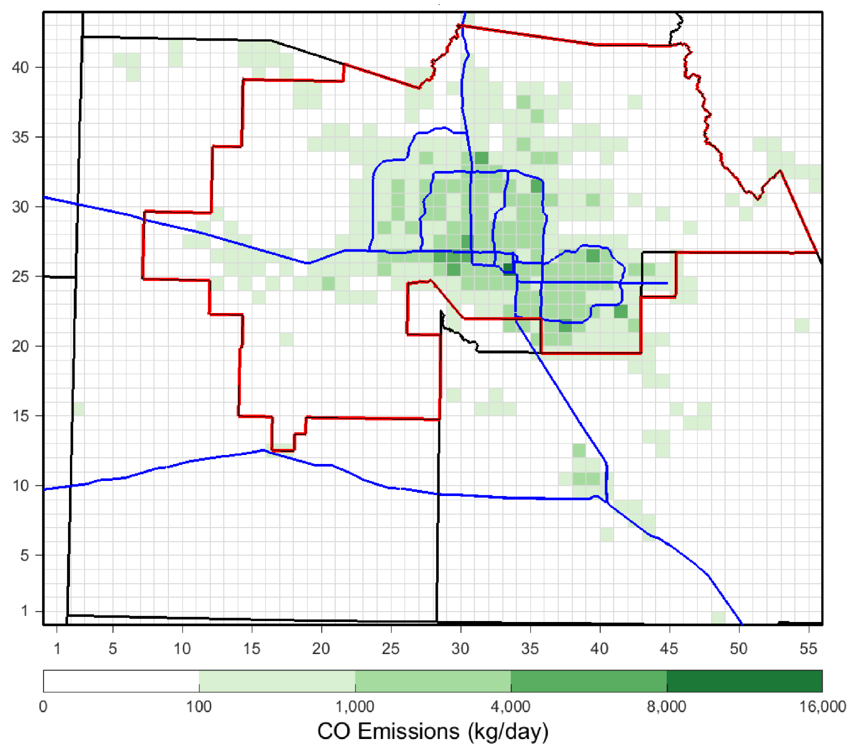


Figure III-5 (e). Nonroad source daily CO emissions for a typical weekday in 2011

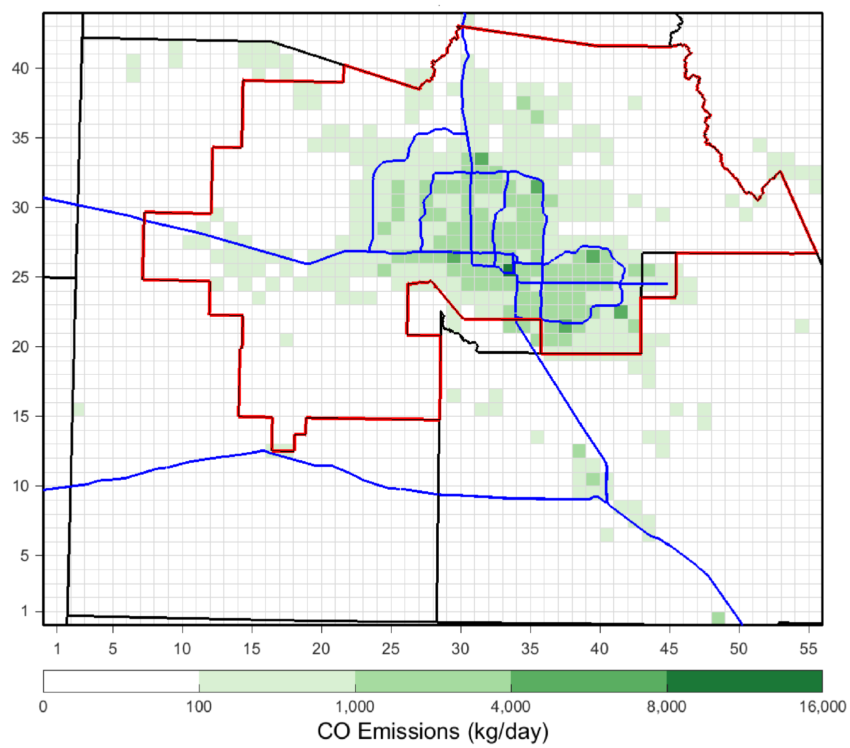


Figure III-5 (f). Nonroad source daily CO emissions for a typical weekday in 2017

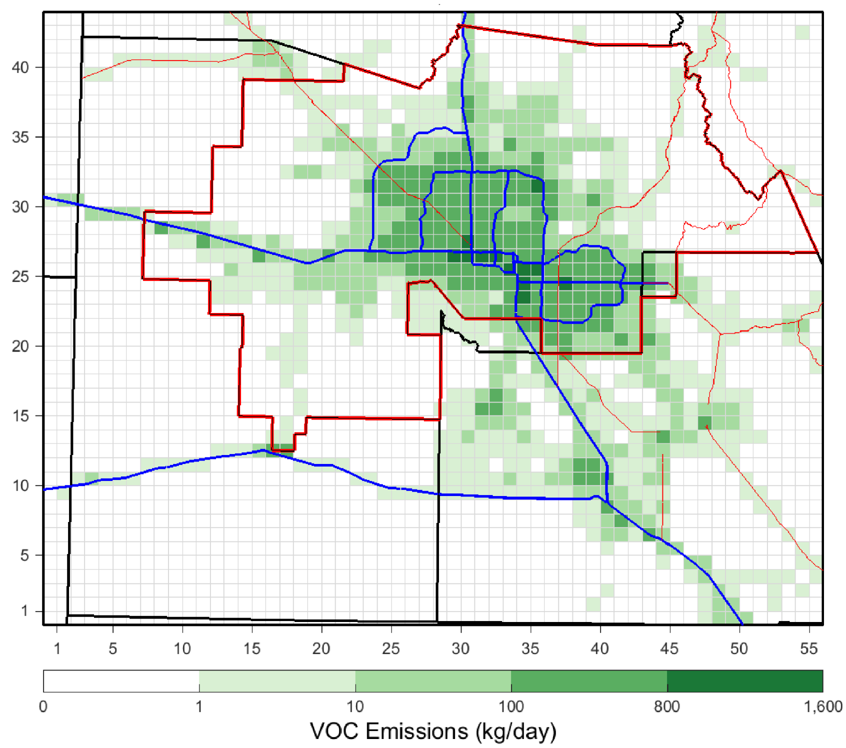


Figure III-6 (a). Onroad source daily VOC emissions for a typical weekday in 2011

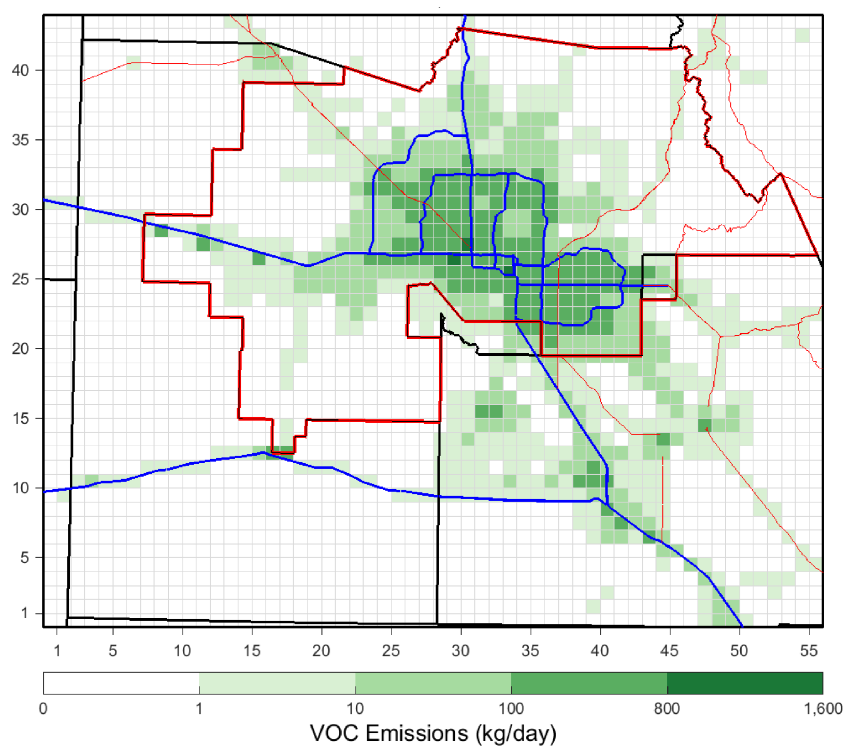


Figure III-6 (b). Onroad source daily VOC emissions for a typical weekday in 2017

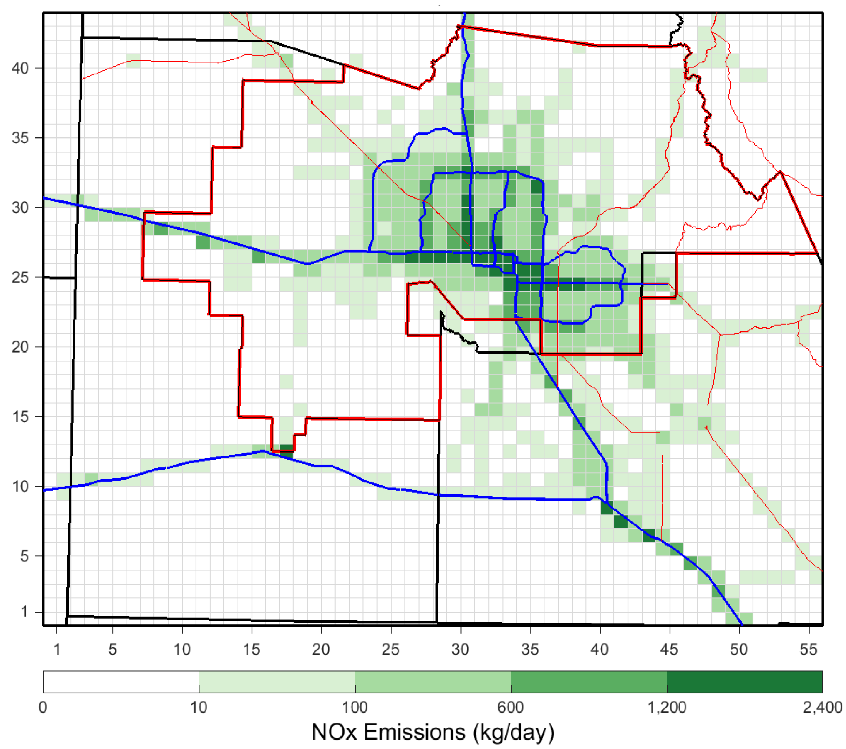


Figure III-6 (c). Onroad source daily NOx emissions for a typical weekday in 2011

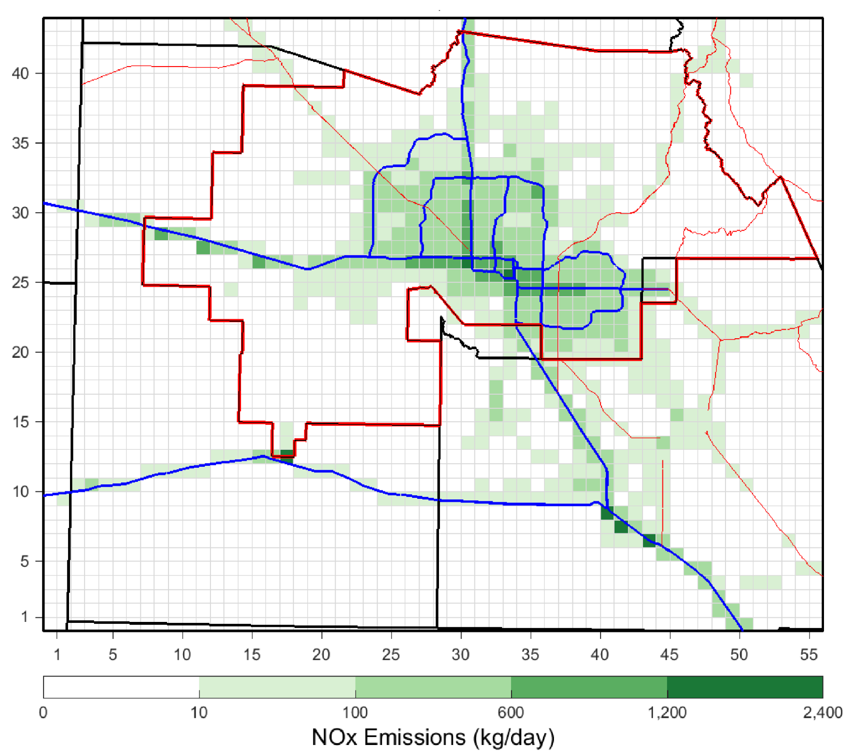


Figure III-6 (d). Onroad source daily NOx emissions for a typical weekday in 2017

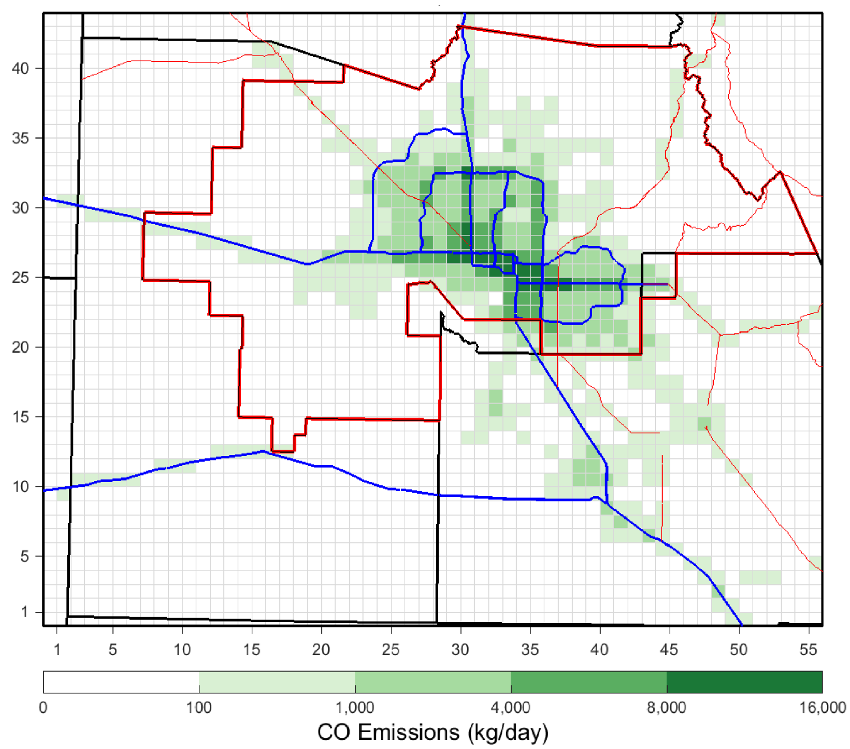


Figure III-6 (e). Onroad source daily CO emissions for a typical weekday in 2011

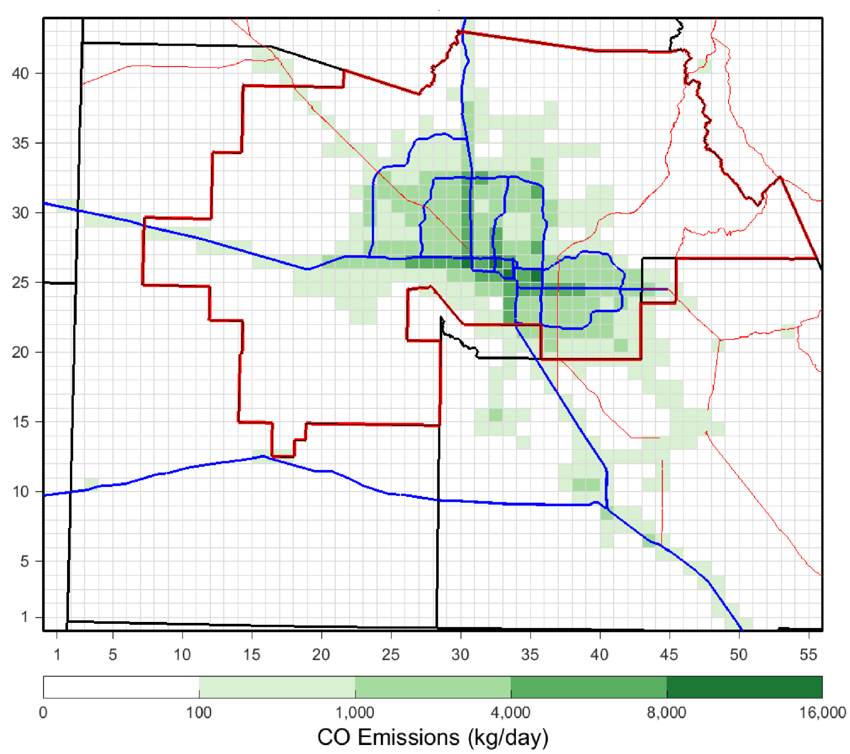


Figure III-6 (f). Onroad source daily CO emissions for a typical weekday in 2017

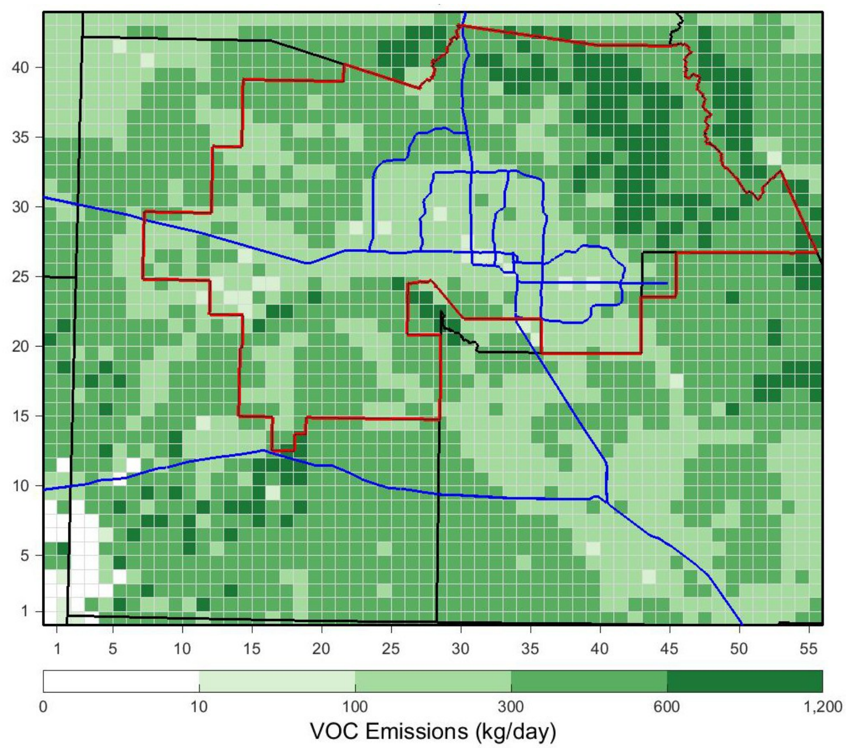


Figure III-7 (a). Biogenic source daily VOC emissions for a typical weekday in 2011

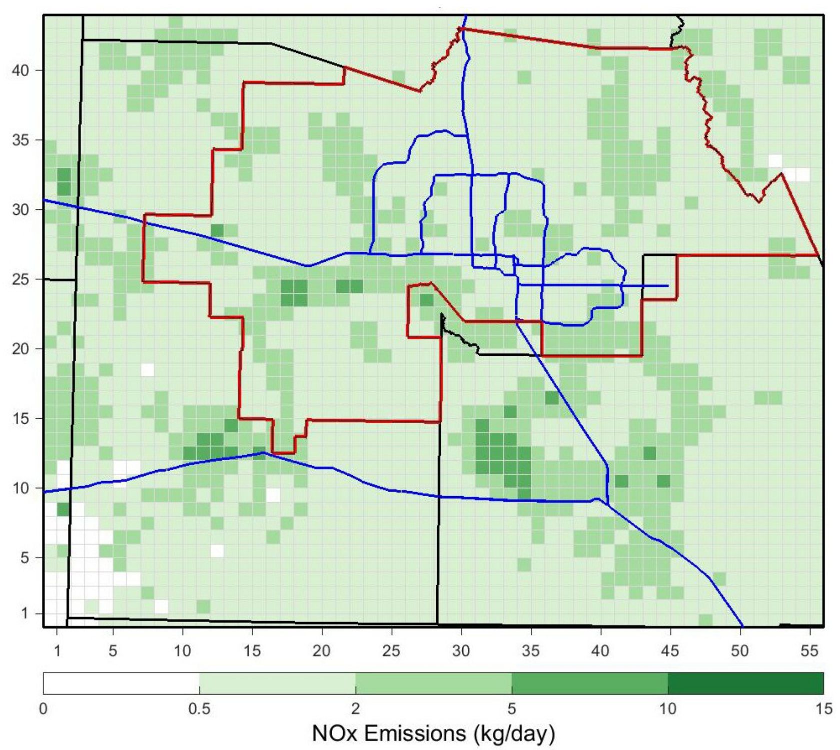


Figure III-7 (b). Biogenic source daily NOx emissions for a typical weekday in 2011

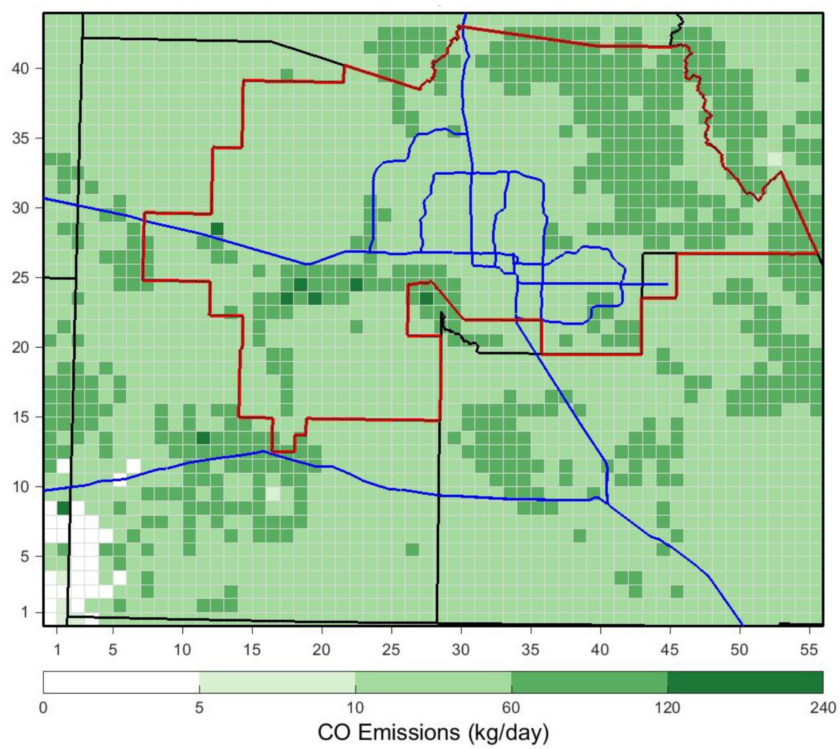


Figure III-7 (c). Biogenic source daily CO emissions for a typical weekday in 2011

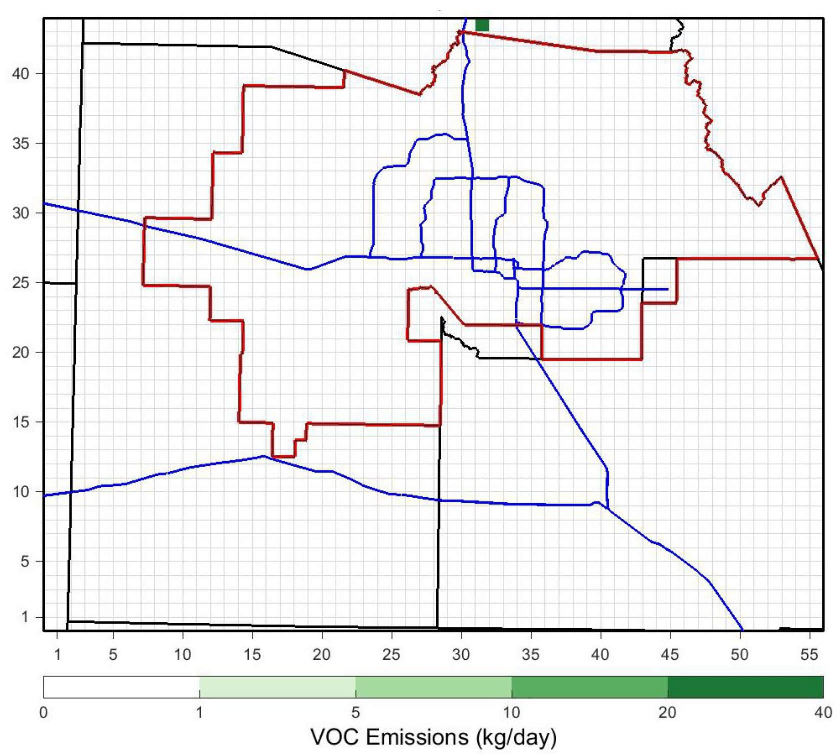


Figure III-8 (a). Wildfire source daily VOC emissions for a typical weekday in 2011

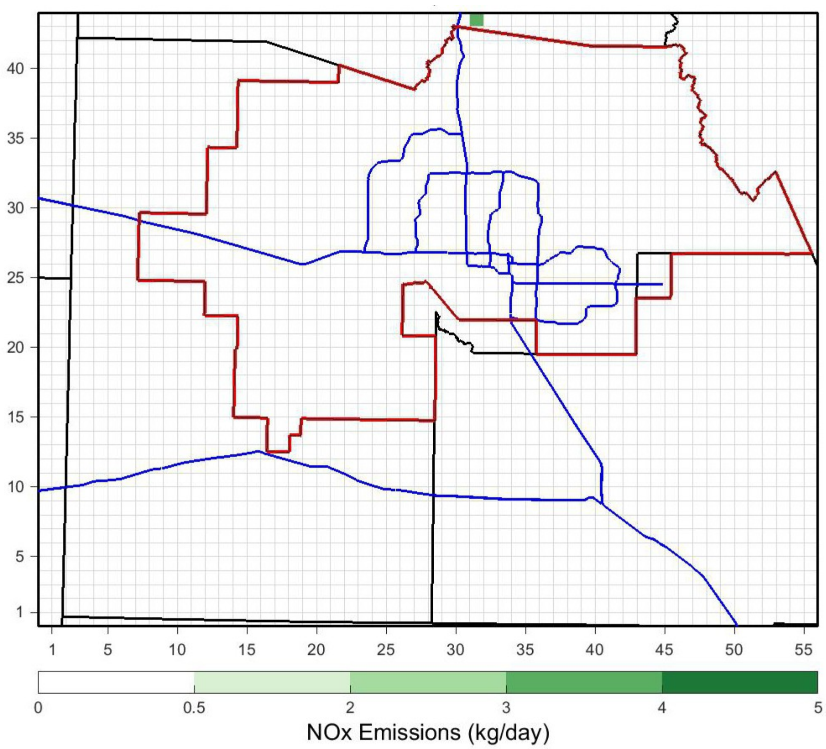


Figure III-8 (b). Wildfire source daily NOx emissions for a typical weekday in 2011

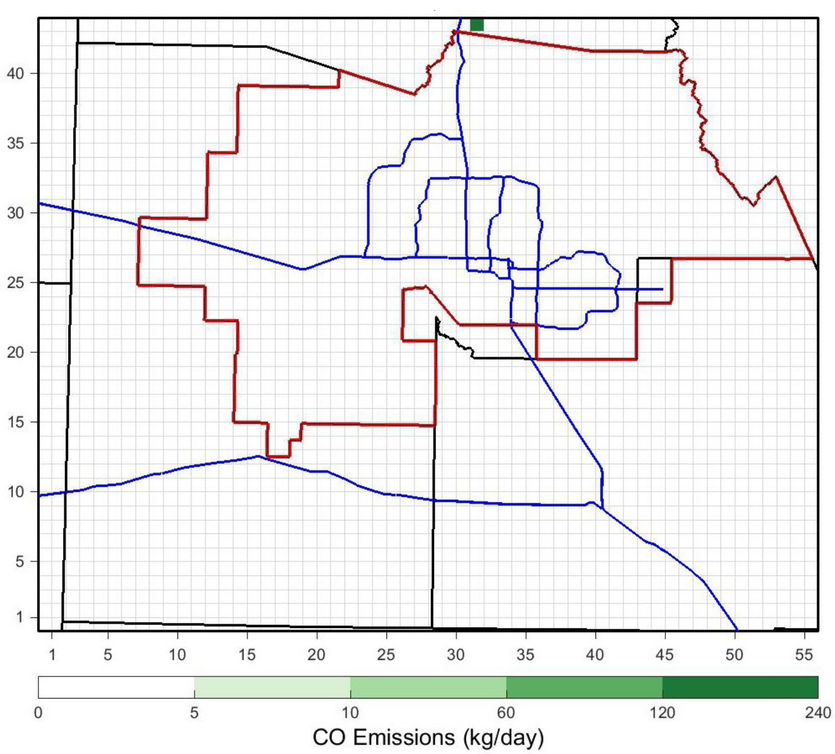


Figure III-8 (c). Wildfire source daily CO emissions for a typical weekday in 2011

III-2-2. Chemical Speciation

The CAMx modeling analysis was based upon the most up-to-date chemical mechanism, CB6 version 2 (CB6r2), to characterize photochemical reactions of ozone precursor emissions. This version of chemical mechanism had updated chemistry of isoprene and aromatic hydrocarbons and NOx recycling from the degradation of organic nitrates. The chemical mechanism contained 137 model species and 216 chemical reactions to simulate atmospheric photochemical reactions (ENVIRON, 2014). The SMOKE modeling system was used to convert ozone precursor emissions (i.e., VOC and NOx) into the model species emissions for ozone chemistry according to chemical speciation profiles for emission source categories. The latest SMOKE CB6 speciation profiles were used to perform the chemical speciation process for the CAMx modeling.

III-2-3. Temporal Allocation

Emissions inventories were provided at various temporal levels. (i.e., hourly, daily, monthly, and annual). Table III-21 shows time resolutions of all emission inventory data for the CAMx 4 km modeling domain. Temporal allocation distributed aggregated annual emissions to monthly, daily, and hourly emissions. This process was typically done by applying temporal profiles to the inventories in this order: monthly, day of the week, and hourly. These temporal profiles might differ by county, sector, or season.

Table III-21. Raw emission inventories for the 4 km modeling domain at different temporal levels

Category	Maricopa County	Pinal County	Other Counties
Point (EGU)	Annual	Annual	N/A
Point (Non-EGU)	Daily	Annual	Annual
Area	Daily	Annual	Annual
Nonroad (Airport)	Hourly	Hourly	N/A
Nonroad (Other)	Daily	Daily	Monthly
Onroad	Hourly	Hourly	Hourly
Biogenic	Hourly	Hourly	Hourly
Wildfires	Daily	Daily	Daily

Since the default temporal profiles for EGU point sources from AQMP v6.2 did not appropriately represent the temporal changes of emissions in the 4 km modeling domain, the EGU temporal profiles were developed using the EPA hourly CEMS data from the AQMP v6.2 for both Maricopa and Pinal Counties.

The 2011 hourly CEMS data for EGU sources in Maricopa and Pinal Counties were used to develop monthly profiles for Maricopa and Pinal Counties. The weekday/weekend and daily temporal profiles for the counties were developed based on hourly CEMS data for the summer ozone season from May 1 to September 30, 2011. The temporal profiles were normalized to keep the mass balance of input and output emissions. Figure III-9 shows the normalized monthly, weekly, and daily temporal profiles for the EGU point source emissions for both counties.

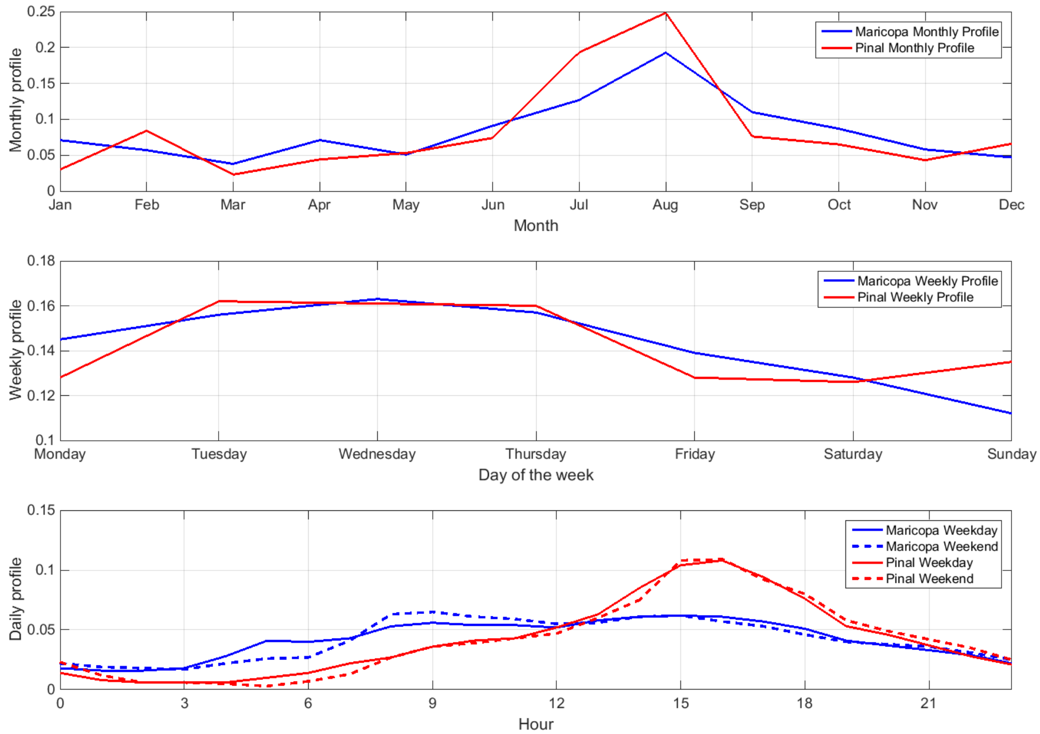
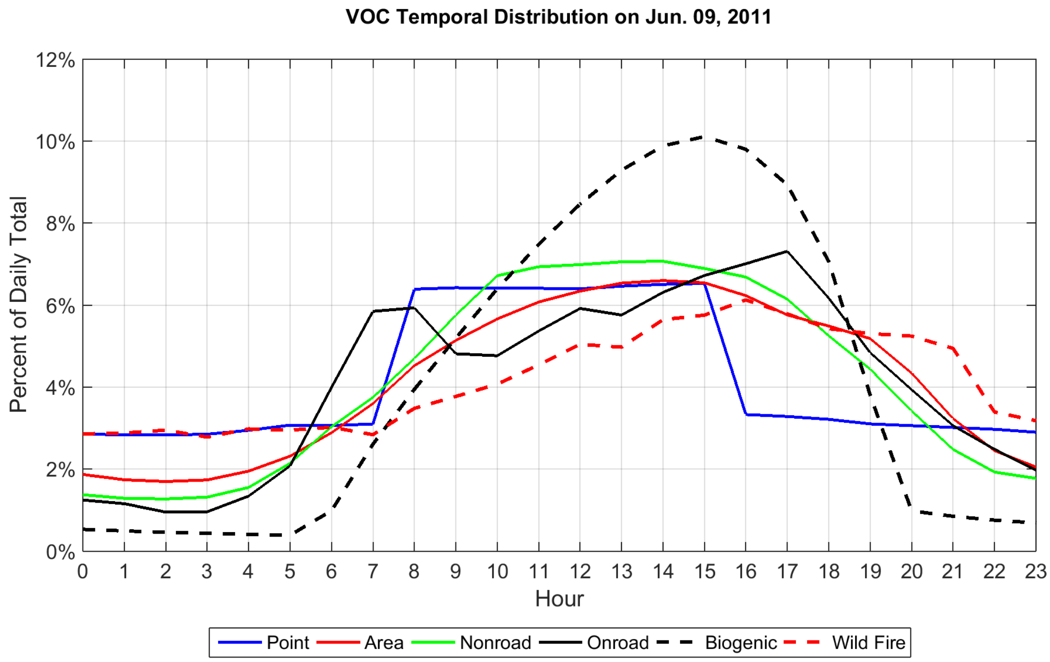


Figure III-9. Normalized monthly, weekly, and daily temporal profiles for EGU point source emissions in Maricopa and Pinal Counties

For non-EGU point sources in Maricopa County, summer ozone season average daily emissions were temporally distributed using the EPA hourly profiles from the AQMP v6.2. Pinal County non-EGU annual emissions were processed to develop hourly emissions using the EPA monthly, weekly, and diurnal temporal profiles. For the temporal allocation of area source in Maricopa County and nonroad sources (except airports) in Maricopa and Pinal Counties, the EPA temporal profiles were used to develop day-specific hourly emissions by the SCC. Figure III-10 shows the diurnal distributions of point, area, nonroad, onroad, biogenic, and wildfire emissions for a typical weekday in 2011 and 2017.



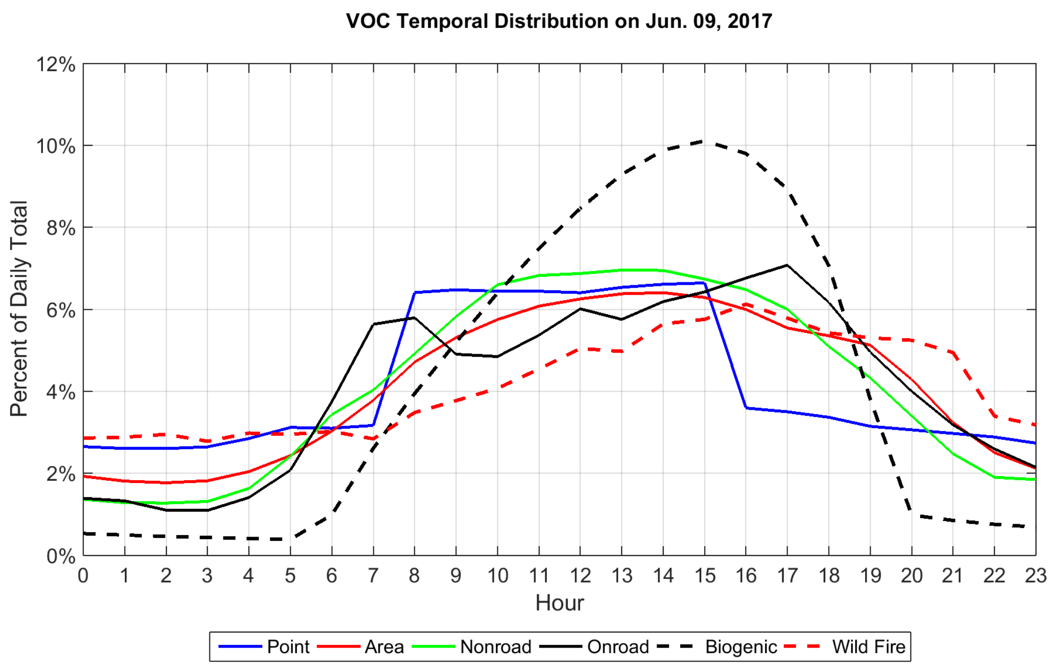
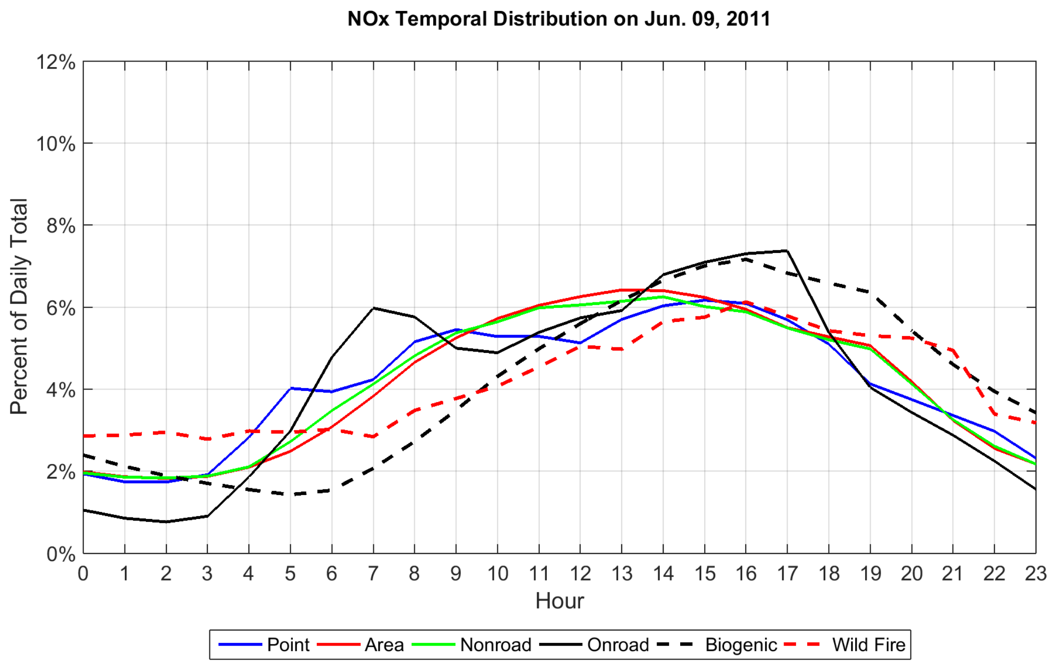


Figure III-10 (a). Temporal profiles for VOC on a typical weekday in 2011 and 2017



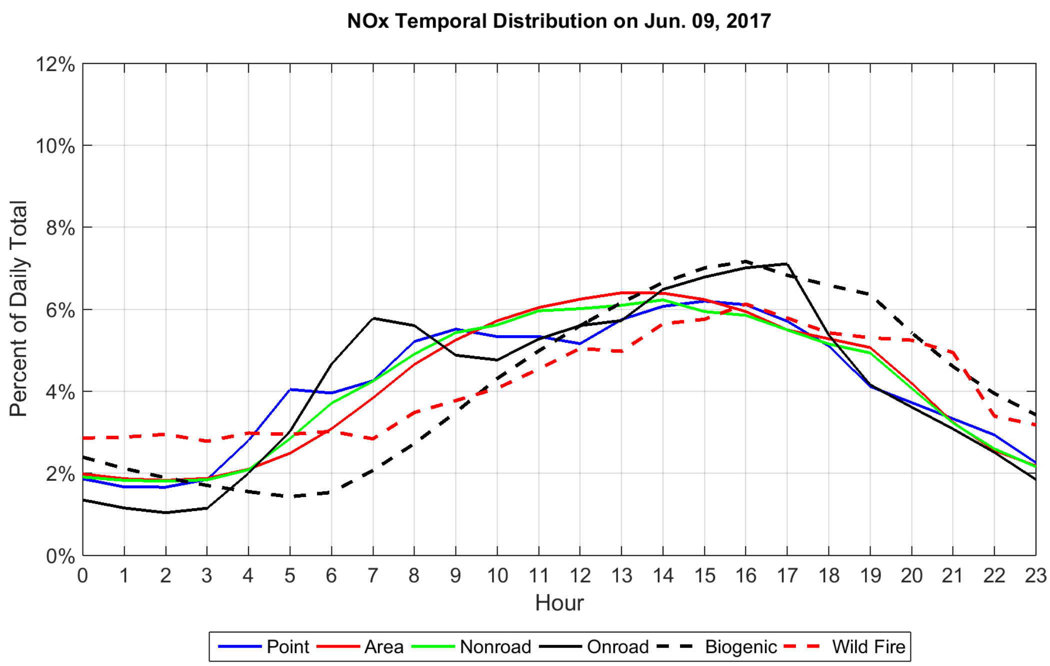


Figure III-10 (b). Temporal profiles for NOx on a typical weekday in 2011 and 2017

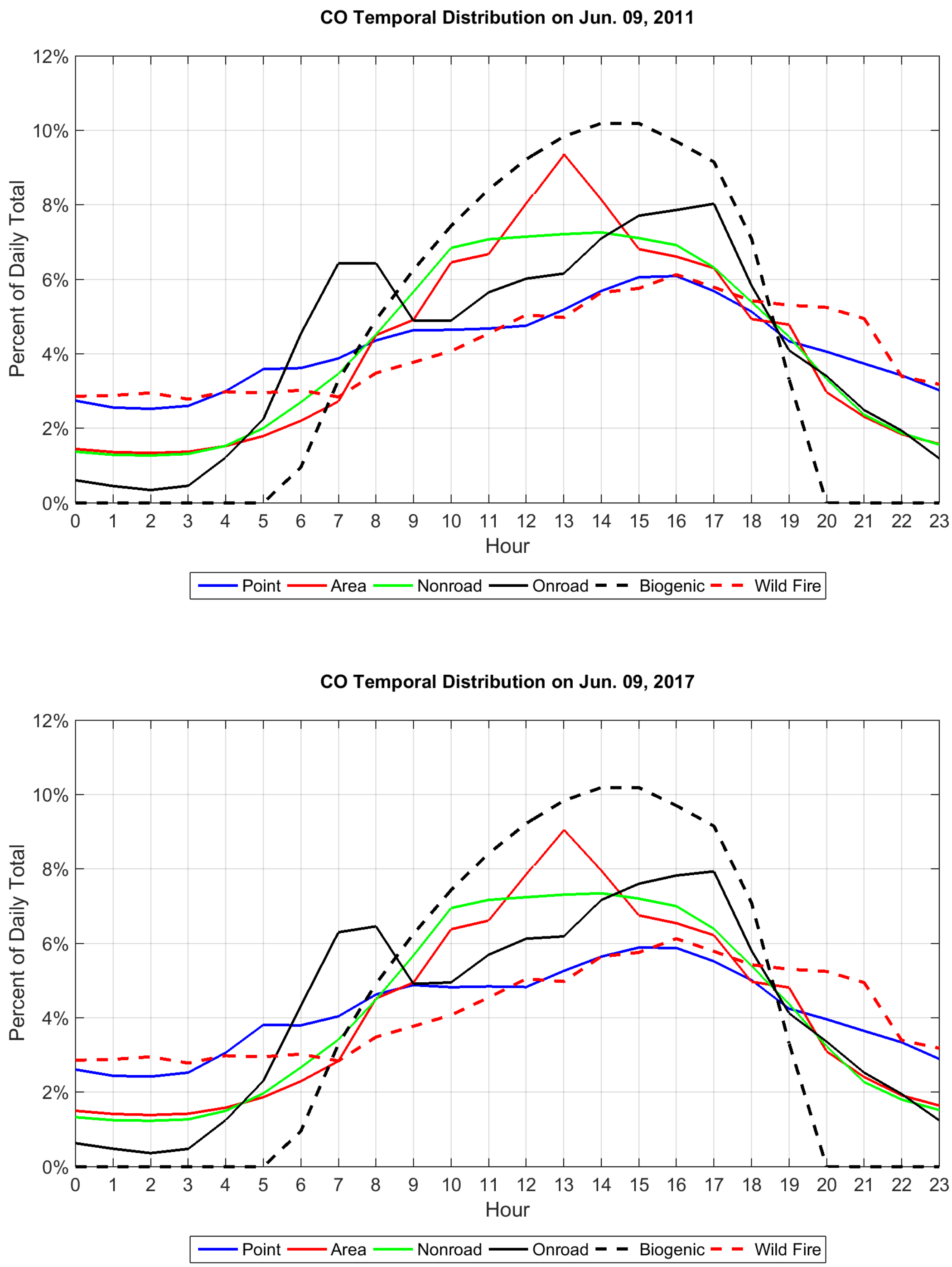


Figure III-10 (c). Temporal profiles for CO on a typical weekday in 2011 and 2017

III-3. Emissions Summaries

The ozone season daily average emissions in the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain are provided for the years 2011 and 2017 in Tables III-22 and III-23. Wildfire emissions are excluded from the ozone season average daily emissions for the five month period because wildfires occurred on specific days in 2011 and assumed to be constant between 2011 and 2017. Pie charts showing the 2011 and 2017 VOC, NOx, and CO by source are presented for the Maricopa eight-hour ozone nonattainment area in Figure III-11 and the 4 km modeling domain in Figure III-12. The daily emissions of anthropogenic and biogenic sources during May - September in 2011 and 2017 are presented in Appendix E.

Table III-22. Ozone season average daily emissions during May - September in 2011 and 2017 in the Maricopa eight-hour ozone nonattainment area (unit: metric tons/day)

Category	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Point	2.47	7.02	4.41	3.32	13.75	6.75
Area	94.46	10.96	7.71	96.05	12.59	8.50
Nonroad Mobile	27.89	53.58	343.58	20.26	36.26	310.41
Onroad Mobile	70.96	117.15	675.97	45.65	62.69	492.98
Biogenic	487.52	2.37	63.46	487.52	2.37	63.46
Total	683.30	191.08	1,095.13	652.80	127.66	882.10

Table III-23. Ozone season average daily emissions during May - September in 2011 and 2017 in the 4 km modeling domain (unit: metric tons/day)

Category	2011			2017		
	VOC	NOx	CO	VOC	NOx	CO
Point	3.33	7.40	5.95	4.16	14.16	7.98
Area	103.79	11.16	10.09	105.54	12.81	11.02
Nonroad Mobile	36.60	62.78	387.21	26.89	43.49	350.04
Onroad Mobile	78.71	144.63	748.33	51.31	80.85	543.04
Biogenic	1,336.57	6.32	169.62	1,336.57	6.32	169.62
Total	1,559.00	232.29	1,321.20	1,524.47	157.63	1,081.70

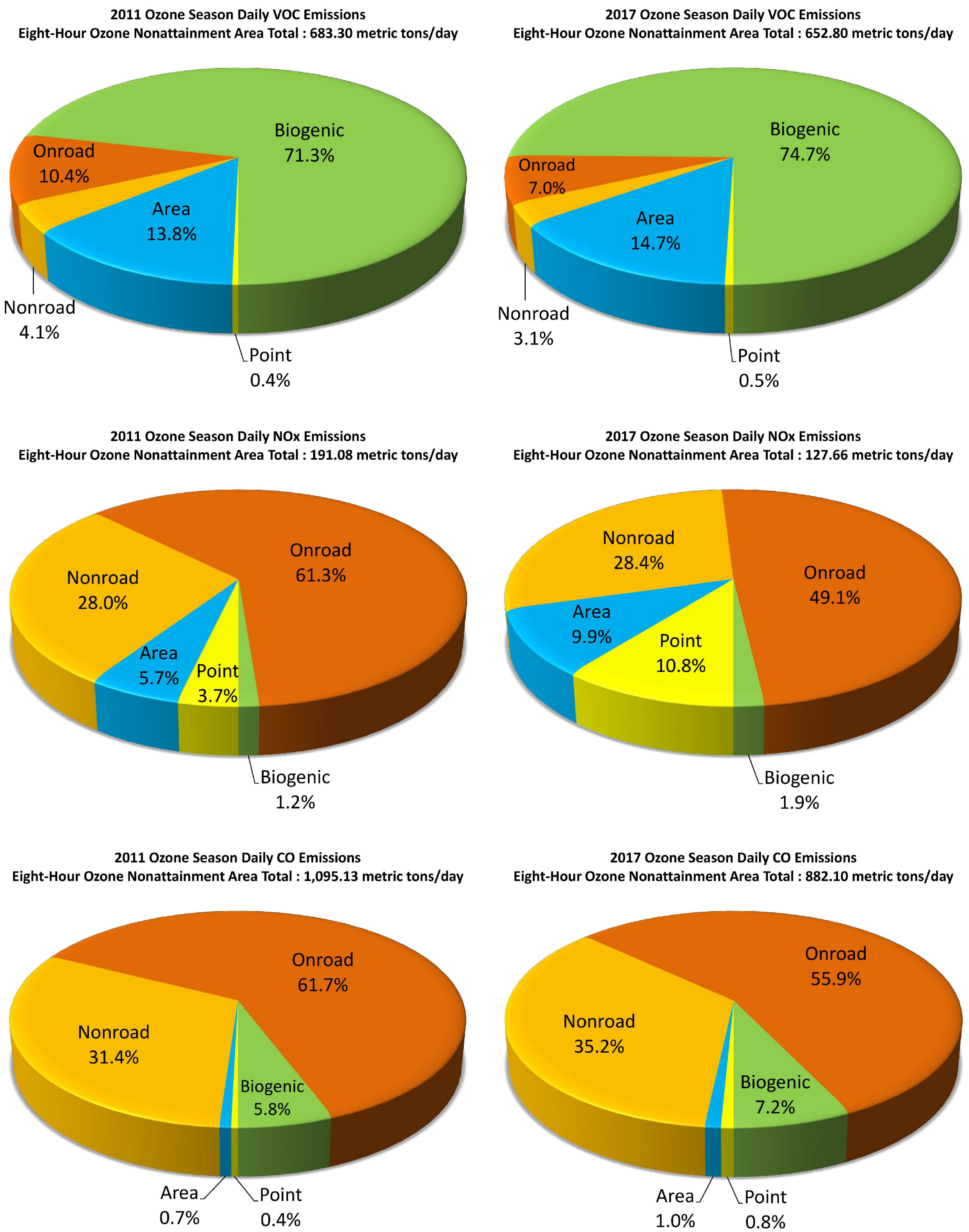


Figure III-11. Pie charts for ozone season average daily VOC, NOx, and CO emissions in 2011 and 2017 in the Maricopa eight-hour ozone nonattainment area

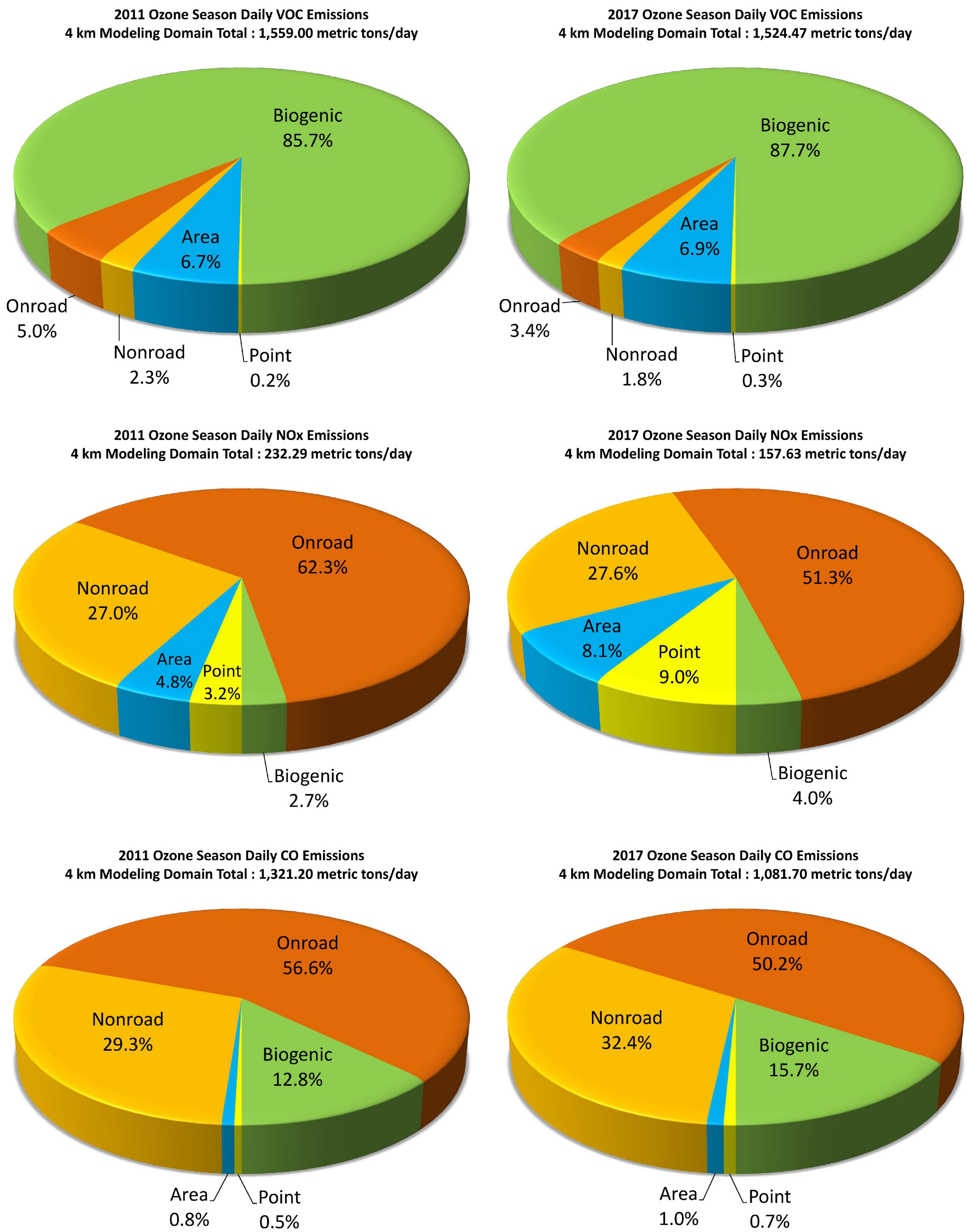


Figure III-12. Pie charts for ozone season average daily VOC, NOx, and CO emissions in 2011 and 2017 in the 4 km modeling domain

III-4. WRF Meteorology

III-4-1. Model Configuration

Version 3.7 of the Weather Research and Forecasting (WRF) model with the Advanced Research WRF (ARW) dynamic solver was used to generate the meteorology simulations for the 2011 ozone season. The model was configured with three two-way nested domains of 36/12/4 km horizontal resolution (Figure II-1). The innermost domain contains Maricopa County and the Maricopa eight-hour ozone nonattainment area. A total number of 23 vertical sigma layers were used (see Section II-2), with the first 11 layers below 1 km to better resolve the boundary layer in which most of the influences on surface ozone are confined. Selected physics options included the new YSU scheme for planetary boundary layer physics; the Noah Land Surface Model (LSM) for surface physics; Single-Moment 5-class (WSM5) microphysics scheme for cloud processes over 36 km grids, and the Thompson Microphysics scheme for cloud in 12 km and 4 km modeling domains; new Multi-scale Kain-Fritsch cumulus parameterization utilizing the moisture-advection trigger for both 36 km and 12 km modeling domains; the Rapid Radiative Transfer Model (RRTM) for long wave radiation transfer, and the Goddard scheme for short wave radiation.

The simulation was initialized using the National Centers for Environmental Information (NCEP) GEWEX Continental-Scale International Project (GCIP) 40 km Eta Data (ds609.2) obtained from the Computational & Information Systems Laboratory (CISL) at the National Center for Atmospheric Research (NCAR). Analysis nudging for temperature, wind, and moisture was applied above the boundary layer only for coarse domains. Land use and land cover data were based on National Land Cover Database 2011 data.

The entire simulation was stitched from many shorter runs to enhance accuracy and form a continuous data set. Each individual simulation started at 12:00 UTC and lasted for a segment of 1.5 days (36 hours). The first 12-hour period for each simulation was considered as the model spin-up. A one hour interval was set for the time stamps in the output files.

III-4-2. Post Processing

The Meteorology-Chemistry Interface Processor (MCIP v4.2) was used to process WRF output files into MEGAN and SMOKE-ready file formats. The WRFCAMx (v4.3) was used to directly convert WRF output files into UAM-format. MCIP and WRFCAMx are designed to maintain dynamic consistency between the meteorological model and the chemical transport model as much as possible. The CAMx uses a smaller modeling domain than WRF because WRF simulations in the cells near the boundary may not be adequate for use in air quality simulation by CAMx. The MCIP and WRFCAMx accommodated the WRF domains into the smaller domains needed for SMOKE and CAMx runs.

III-5. Initial and Boundary Conditions

Meteorological Initial and Boundary Conditions

The initial and boundary conditions (ICBC) for the 36 km meteorological modeling domain were prepared by the WRF Preprocessing System (WPS) using the ds609.2 data downloaded from NCAR's Research Data Archive. WPS output provides ICBC data at a standard 3-hour interval for WRF simulation. The ICBC for nested domains are dynamically provided every hour by the parent domain during the model simulation. That is, the 36 km parent modeling domain serves as the ICBC for the 12 km modeling domain, and the 12 km modeling domain serves as the ICBC for the 4 km modeling domain.

Photochemical Initial and Boundary Conditions

ICBC based on global chemical transport model simulations are required to provide information about background concentrations, long-range transport, and stratospheric ozone influences for nested photochemical model simulations. The Model for Ozone and Related Chemical Tracers, version 4 (MOZART-4) outputs were used to define ICBCs for the MAG photochemical modeling. MOZART-4 is driven by meteorological fields from the National Aeronautics and Space Administration (NASA) Goddard Earth Observing System Model, version 5 (GEOS-5) (Emmons et al., 2010). It uses global anthropogenic emissions based on an international inventory and fire emissions from the Fire Inventory from NCAR (FINN) version 1.0 (Wiedinmyer et al., 2011). The MOZART-4 model has a global coverage with a resolution of 1.9 x 2.5 degree and 56 vertical levels.

The CAMx pre-processor was used to interpolate the MOZART-4 output from its native resolution and coordinate system to a Lambert Conformal Projection coordinate system in the CAMx vertical layer structure. Additionally, the MOZART chemical species were mapped to the CB6 chemical species used in CAMx as shown in Table III-24. For one-way offline air quality modeling with nested domains, ICBC for the 36 km modeling domain were provided by MOZART, and the inner nest domains received their ICBC from the CAMx simulations.

III-6. Ozone Column Data

The CAMx photochemical mechanism requires ozone column and clear-sky photolysis rate data. Day-specific ozone column data for ozone episode days in 2011 were obtained from the Total Ozone Mapping Spectrometer (TOMS) data measured by the satellite-based Ozone Monitoring Instrument. The o3map preprocessor was used to process ozone column data for CAMx. The CAMx Tropospheric Ultraviolet Visible radiative transfer model uses TOMS ozone column data to calculate clear-sky photolysis rates and to adjust the clear-sky photolysis rates in presence of cloud and aerosols. The photolysis rates for CAMx were prepared using tuv4.8.camx6.00 preprocessor.

Table III-24. Mapping of the MOZART chemical species to the CB6 chemical mechanism

CMAQ Species	Equivalent MOZART Species
NO	NO
NO2	NO2
O3	O3
H2O2	H2O2
NO3	NO3
N2O5	N2O5
HNO3	HNO3
PNA	HO2NO2
PAN	PAN
PANX	MPAN
NTR	ONIT
INTR	ONITR + ISOPNO3
CO	CO
PAR	C3H6 + BIGENE + 5 BIGALK + 2 HYAC + HYDRALD + 3 MEK + 0.333 TOLUENE + 2 ONIT
OLE	C3H6 + 0.5 BIGENE + HYDRALD
IOLE	0.5 BIGENE
FORM	CH2O
ALD2	CH3CHO
ALDX	HYDRALD
GLYD	GLYALD
MGLY	CH3COCHO
ETHA	C2H6
ETH	C2H4
ETHY	C2H2
PRPA	C3H8
ACET	CH3COCH3
ETOH	C2H5OH
MEOH	CH3OH
MEPX	CH3OOH
FACD	HCOOH
AACD	CH3COOH
PACD	CH3COOOH
KET	HYAC + MEK + ONIT
ISOP	ISOP
ISPD	MACR + MVK
TERP	C10H16
TOL	0.333 TOLUENE
XYL	0.333 TOLUENE
CRES	CRESOL
OPEN	BIGALD
SO2	SO2 + DMS
NH3	NH3
MECN	CH3CN
HCN	HCN
TOLA	0.333 TOLUENE
XYLA	0.333 TOLUENE
ISP	ISOP
TRP	C10H16
PSO4	SO4
PNO3	NH4NO3
PNH4	NH4
SOA5	0.4 SOA
SOA6	0.4 SOA
POA	0.0655 OC1 + 0.0655 OC2
PEC	0.12 CB1 + 0.12 CB2
FCRS	1.35 DUST1 + 1.35 DUST2
CCRS	1.35 DUST3 + 1.35 DUST4
NA	SA1 + 0.834 SA2
PCL	SA1 + 0.834 SA2

IV. MODEL PERFORMANCE EVALUATION

Model performance evaluations for the WRF meteorological and CAMx air quality models were conducted according to the EPA guidance (EPA, 2014a). The purpose of the model performance evaluation is to assess if the model accurately replicates meteorological observations and ambient ozone concentrations for the 2011 base year. The uses of the models for the future air quality modeling analysis may be justified through the model performance evaluation. The twelve statistical metrics provided in Table IV-1 were used for the model performance evaluation, as was recommended by EPA. The statistical metrics were typically assessed by comparing modeled values with observed values for the ozone season in 2011.

Table IV-1. Quantitative statistical performance measures for evaluating models

Metric Name	Definition
Number of Pairs	N
Average Observed Value	$\overline{O} = \frac{1}{N}\sum O_i$
Average Modeled Value	$\overline{M} = \frac{1}{N}\sum M_i$
Mean Bias (MB)	$MB = \frac{1}{N}\sum (M_i - O_i)$
Mean Error (ME)	$ME = \frac{1}{N}\sum \lvert M_i - O_i\rvert$
Root Mean Square Error (RMSE)	$RMSE = \sqrt{\frac{\sum (M_i - O_i)^2}{N}}$
Fractional Bias (FB)	$FB = 100\% \times \frac{2}{N}\sum \frac{(M_i - O_i)}{(M_i + O_i)}$
Fractional Error (FE)	$FE = 100\% \times \frac{2}{N}\sum \frac{\lvert M_i - O_i\rvert}{(M_i + O_i)}$
Normalized Mean Bias (NMB)	$NMB = 100\% \times \frac{\sum (M_i - O_i)}{\sum O_i}$
Normalized Mean Error (NME)	$NME = 100\% \times \frac{\sum \lvert M_i - O_i\rvert}{\sum O_i}$
Coefficient of Determination (R^2)	$R^2 = \left(\frac{\sum((M_i - \overline{M})\times(O_i - \overline{O}))}{\sqrt{(\sum (M_i - \overline{M})^2 \times \sum (O_i - \overline{O})^2)}}\right)^2$
Index of Agreement (IOA)	$IA = 1 - \frac{\sum (O_i - M_i)^2}{\sum (\lvert M_i - \overline{O}\rvert + \lvert O_i - \overline{O}\rvert)^2}$

IV-1. WRF Model Performance Evaluation

Temperatures, water vapor mixing ratios, and wind speeds and directions modeled by the WRF were assessed using the observed meteorological data for the modeling episode in 2011. Use of such meteorological modeling data with the good model performance assures more confidence and robustness of the CAMx air quality modeling results. The WRF meteorological model performance evaluation was conducted for the 4 km modeling domain. For the performance evaluation, temperature and water mixing ratio measured at 2 meters above ground, and wind speed and direction measured at 10 meters above ground were extracted from the U.S. and Canada Surface Hourly Observation data set in the National Center for Atmospheric Research (NCAR) Data Archive ds472.0 (NCAR, 1987). The data set provided meteorological observations at 13 weather stations in the 4 km modeling domain. Locations of the weather stations are provided in Figure IV-1.

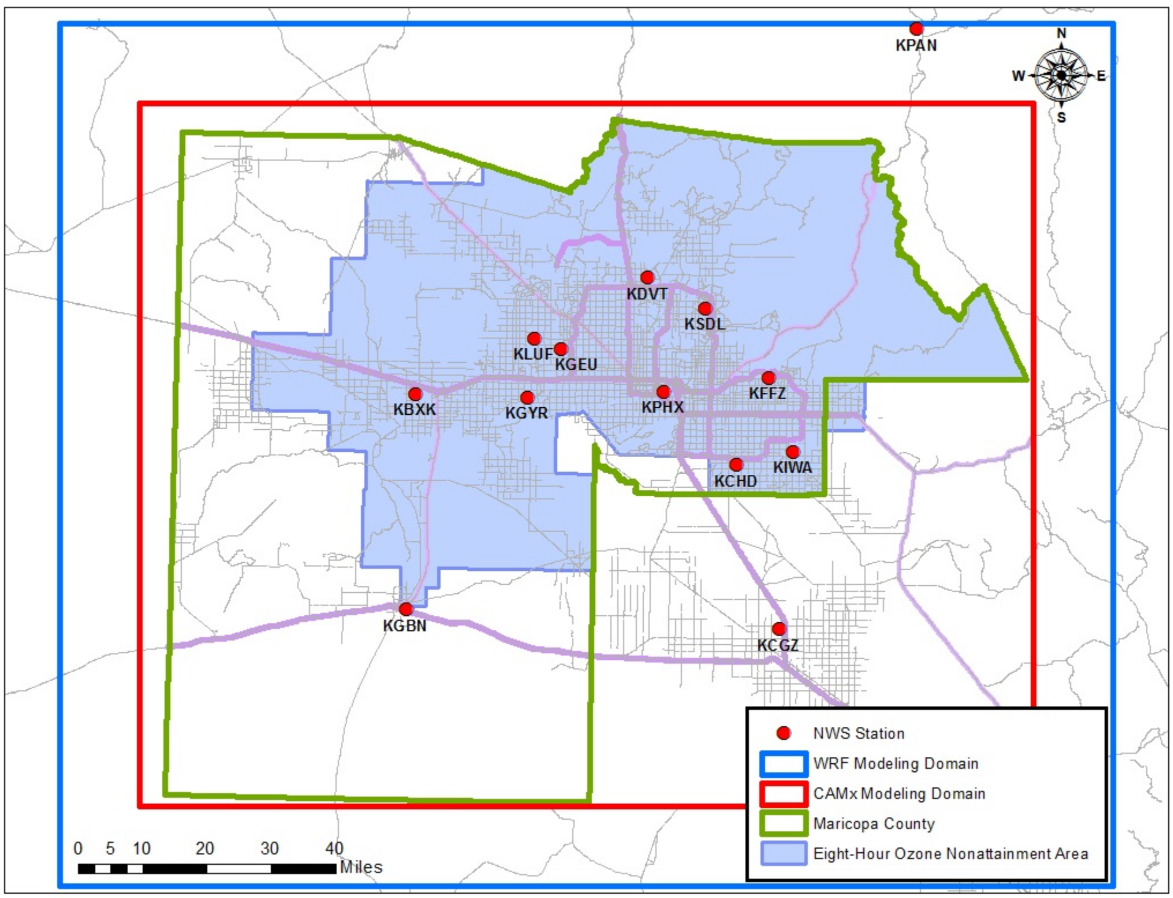


Figure IV-1. The locations of 13 weather stations within the 4 km modeling domain used for the WRF meteorological performance evaluation

Modeled and observed temperature, water vapor mixing ratio, and wind fields (wind speeds and directions) were paired and compared in time and space. The statistical metrics for the WRF meteorology are provided in Table IV-2. The WRF modeled values for diurnal surface temperatures and day-time peak temperatures were generally accurate. The modeled water vapor mixing ratio provided a small bias for the entire modeling period. The good WRF model performance was provided in modeling the monsoon season. The modeled wind speeds had a small bias over the typical diurnal cycle. Since accurate modeling for wind directions is challenging, the statistical metrics for wind directions indicated a poor model performance, as shown in Table IV-2.

Table IV-2. Model performance statistics for meteorological parameters during ozone season in 2011

Metric Name	Temperature (°F)	Mixing Ratio (g/kg)	Wind Speed (mph)	Wind Direction (°)
Number of Pairs	3,649	3,646	3,649	3,649
Average Modeled Value	88.1	6.6	6.2	208
Average Observed Value	87.3	6.7	6.6	158
Mean Bias	0.8	-0.1	-0.3	49.4
Mean Error	2.2	0.9	1.9	57.2
Normalized Mean Bias (%)	0.9	-1.8	-5.0	31.2
Normalized Mean Error (%)	2.5	12.8	29.1	36.1
Root Mean Square Error	3.0	1.1	2.5	74.2
Coefficient of Determination	0.94	0.90	0.48	0.31
Index of Agreement	0.98	0.97	0.78	0.66

The coefficient of determination (R^2) provides the measure of accuracy for the modeled values, and ranges from zero to one. Zero indicates the poorest accuracy and one is the best accuracy. The coefficients of determination for temperature and water vapor mixing ratio were 0.94 and 0.90, respectively. The modeled temperatures and water vapor mixing ratios are in good agreement with measurements. Biases for the two meteorological parameters were very small. The coefficients of determination for wind speed and direction are low because resolving wind speeds and directions with WRF is difficult due to the complex terrains of the Phoenix Valley because the wind fields are very sensitive to terrain features. The Root Mean Square Errors (RMSE) for wind directions could vary in the range of 60-80 degrees for the various topographies (Jimenez, et al., 2013). The results are consistent with the findings of the MAG WRF model performance.

A scatter plot provides information that the observed and modeled values are in good agreement if the data are clustered around the line of best fit, the modeled values are overestimated if above the best-fit-line or underestimated if under the best-fit-line. The scatter plots in Figure IV-2 presented the good agreement between observed and modeled values for temperature and water vapor mixing ratio, the overestimation for lower wind speeds and the underestimation for higher wind speeds, and the significant overestimation for wind directions of south-east sectors.

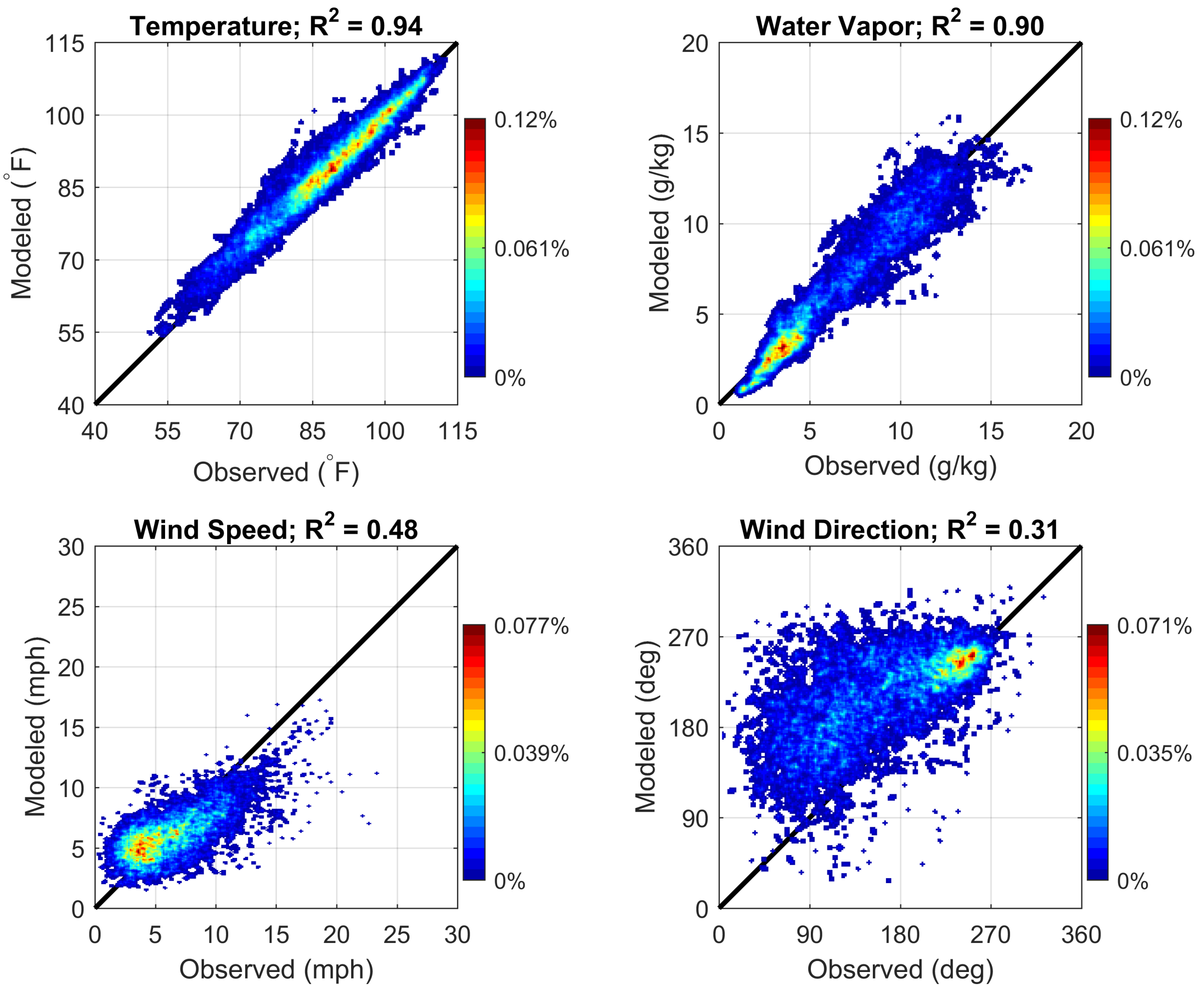


Figure IV-2. Scatter plots between modeled and observed temperature, water vapor mixing ratio, wind speed and wind direction during 2011 ozone season from May 1 through September 30

A Taylor diagram (Taylor, 2001) is also used to provide a statistical summary of how well modeled and observed values match each other in terms of their correlation and the ratio of their variances. In the Taylor diagram, the distance between modeled and observed values reflects the model simulation skills (Taylor, 2001). Figure IV-3 shows that WRF has the best skill in simulating the water vapor mixing ratio among all four variables because the point of standard deviation of water vapor mixing ratio lies closest to the reference arc line representing observations or zero mean error. The second best is temperature and then followed by wind speed and wind direction. The temporal and spatial patterns of modeled temperature are regarded as the best agreement with observations because its correlation coefficient is the highest among four variables. Model performance for wind direction is poor because of the larger errors and biases with the lower correlation coefficient.

A soccer plot in Figure IV-4 provides normalized mean error and bias. Biases for temperature, mixing ratio, and wind speed are close to zero and are within the inner goal or first target box. Wind direction approaches to the second target box for bias and error. The literature review for the WRF model performance indicated that the MAG WRF model performance was comparable to the benchmark proposed by ENVIRON (Emery et al., 2001). The MAG WRF model performance for water vapor mixing ratio was improved by using the new cumulus physics and fractional cloud cover in the latest version of the WRF model. The MAG WRF model performance was also comparable to or even better than the EPA 2011 WRF simulations over North America (EPA, 2014b). The index of agreement for temperature and vapor mixing ratio provided better model performance in the MAG WRF simulations than the recent WRF sensitivity study results (Xie et al., 2012).

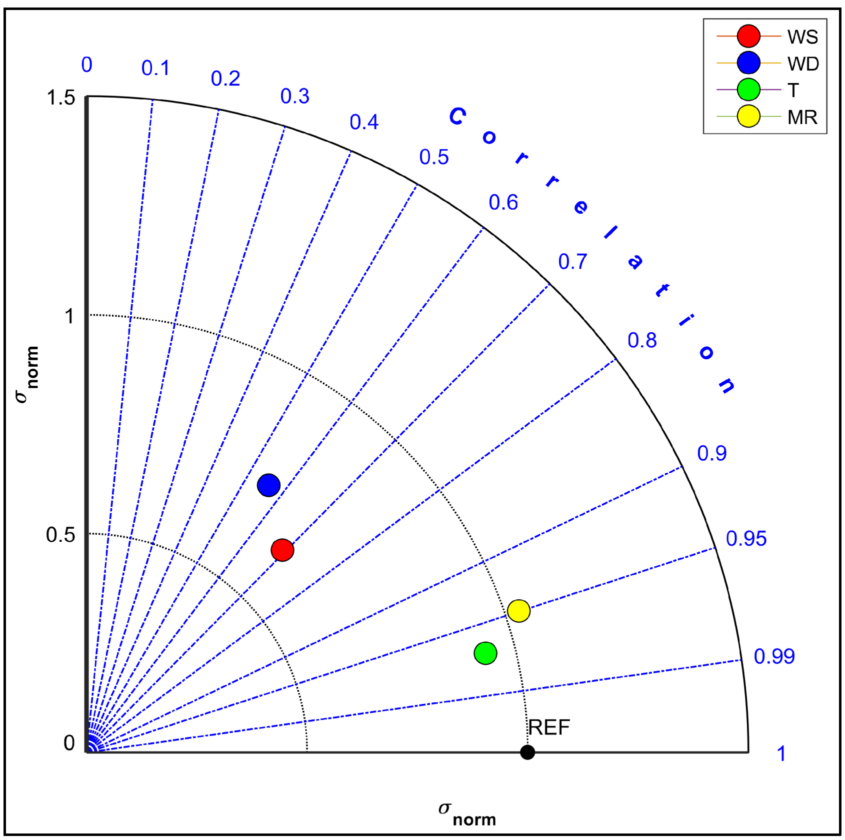


Figure IV-3. Taylor diagram showing the performance of WRF to simulate temperature (T), water vapor mixing ratio (MR), wind speed (WS), and wind direction (WD) over the 4 km modeling domain (REF denotes reference based on observations.)

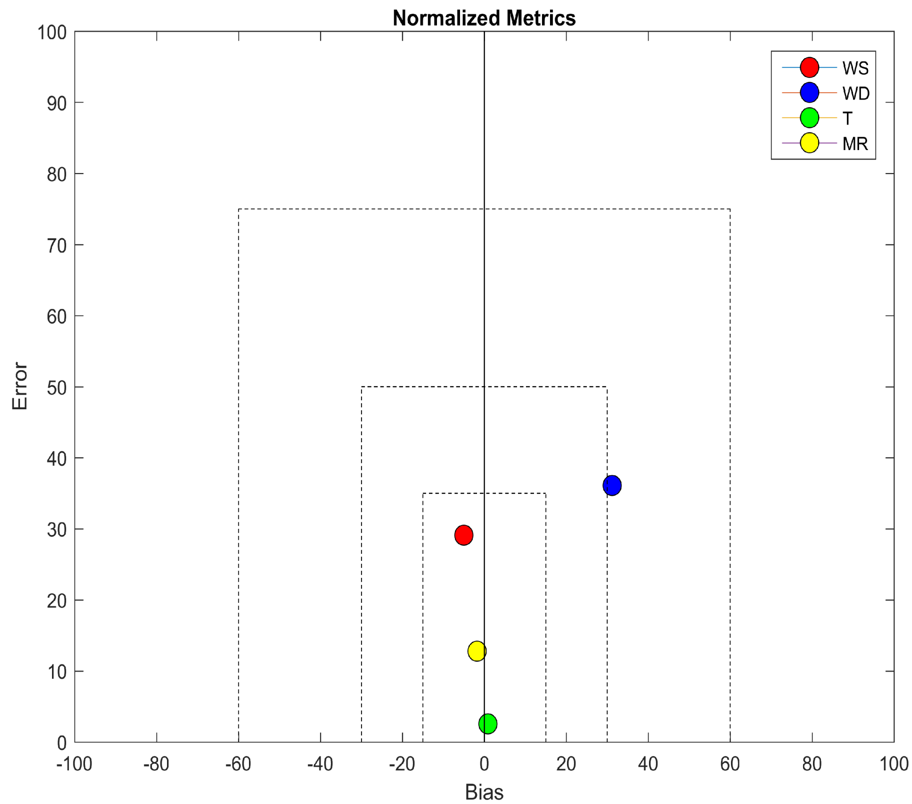


Figure IV-4. Soccer plot showing the performance of WRF to simulate surface temperature (T), water vapor mixing ratio (MR), wind speed (WS), and wind direction (WD) over the 4 km modeling domain

IV-2. CAMx Model Performance Evaluation

For the CAMx model performance evaluation, operational evaluation was conducted to assess how accurately the CAMx model replicates observed ozone concentrations for the 2011 base year. Statistical metrics, time series plots, scatter plots, maps of mean error and bias for monitors, and box plots were provided for the operational evaluation. The operational evaluation for the CAMx model may identify limitations and uncertainties in the model and model inputs that may require further improvements.

For the statistical performance evaluation, the observed and modeled ozone values in 2011 were evaluated for the statistical metrics provided in Table IV-1. Two numeric goals were used to determine if the CAMx model performed within the desirable statistical goals. The goal for normalized mean bias (NMB) is within ±15%, and the goal for the normalized mean error (NME) is less than 35%. The Index of Agreement is the standardized measure of the degree of model prediction error, and varies between zero and one. A value of zero indicates the poorest agreement between modeled and observed values, and one is the perfect match.

Normalized mean biases and errors for one-hour and peak eight-hour ozone modeled values, and eight-hour ozone modeled values paired with eight-hour observed ozone values greater than 60 ppb for the five-month modeling period of May-September, 2011 were well within the goals, as shown in Tables IV-3, IV-4, and IV-5. All normalized mean biases for one-hour and peak eight-hour modeled ozone values, eight-hour modeled ozone values paired with eight-hour observed ozone values greater than 60 ppb in July, however, were over ±15% goal, which indicates that the CAMx model systematically underestimated ozone values in July. The Index of Agreement showed that one-hour and peak eight-hour modeled ozone values are overall in good agreement between modeled and observed values, but eight-hour ozone modeled values paired with eight-hour observed ozone values greater than 60 ppb did not match as well with observed values.

The percent of modeled days that meet the statistical goals for NME and NMB for all modeled ozone values and modeled values paired with observed ozone values greater than 60 ppb are provided in Table IV-6. Table IV-6 presented that more than 80% of the modeled days satisfied the goal for NME while roughly 60% of the modeled days met the goal for NMB.

Table IV-3. Statistical metrics by month for one-hour ozone modeled values for monitors

Metric	May	Jun	Jul	Aug	Sep	May-Sep
Number of Pairs (#)	20,435	19,810	20,137	20,098	19,686	100,166
Average Observed Value (ppb)	45.5	43.8	41.0	41.2	37.2	41.8
Average Modeled Value (ppb)	48.4	42.4	32.4	37.7	40.5	40.3
Mean Bias (ppb)	3.2	-1.1	-8.2	-3.0	3.7	-1.5
Mean Error (ppb)	12.3	10.3	12.0	11.1	12.0	11.5
Root Mean Square Error (ppb)	15.8	13.6	15.6	14.4	15.1	14.9
Fractional Bias (%)	1.6	-10.7	-28.8	-16.6	-5.1	-11.9
Fractional Error (%)	33.7	36.8	41.8	38.1	46.9	39.4
Normalized Mean Bias (%)	6.4	-3.3	-20.9	-8.4	8.7	-3.5
Normalized Mean Error (%)	26.8	23.4	29.5	26.9	31.7	27.5
Coefficient of Determination (R^2)	0.40	0.58	0.46	0.52	0.55	0.49
Index of Agreement	0.77	0.87	0.77	0.83	0.83	0.82

Table IV-4. Statistical metrics by month for eight-hour ozone modeled values for monitors

Metric	May	Jun	Jul	Aug	Sep	May-Sep
Number of Pairs (#)	851	829	839	840	808	4,167
Average Observed Value (ppb)	58.8	61.7	55.6	56.3	53.2	57.1
Average Modeled Value (ppb)	63.4	60.4	46.2	56.3	69.6	57.2
Mean Bias (ppb)	4.7	-1.1	-9.0	0.4	6.7	0.0
Mean Error (ppb)	9.3	6.4	10.9	9.2	10.2	9.2
Root Mean Square Error (ppb)	11.2	8.0	14.3	11.2	11.9	11.5
Fractional Bias (%)	6.6	-2.0	-19.0	-1.6	10.2	-1.2
Fractional Error (%)	15.0	10.5	22.1	16.2	17.9	16.3
Normalized Mean Bias (%)	7.8	-2.1	-16.9	-0.1	12.0	0.0
Normalized Mean Error (%)	15.7	10.4	19.9	16.1	18.9	16.0
Coefficient of Determination (R^2)	0.34	0.38	0.26	0.40	0.29	0.29
Index of Agreement	0.69	0.78	0.64	0.75	0.62	0.71

Table IV-5. Statistical metrics by month for eight-hour ozone modeled values paired with eight-hour observed ozone values greater than 60 ppb for monitors

Metric	May	Jun	Jul	Aug	Sep	May-Sep
Number of Pairs (#)	348	452	345	337	145	1,627
Average Observed Value (ppb)	66.2	68.6	65.6	66.2	64.7	66.7
Average Modeled Value (ppb)	70.9	64.5	51.5	66.1	68.9	63.8
Mean Bias (ppb)	4.8	-3.9	-13.8	0.0	4.2	-2.9
Mean Error (ppb)	10.4	6.9	15.7	11.0	9.0	10.5
Root Mean Square Error (ppb)	11.8	8.6	18.7	13.4	10.6	13.1
Fractional Bias (%)	5.9	-6.4	-26.1	-1.9	5.7	-6.2
Fractional Error (%)	15.0	10.4	28.6	16.8	13.2	16.7
Normalized Mean Bias (%)	7.0	-6.0	-21.5	-0.2	6.4	-4.5
Normalized Mean Error (%)	15.7	10.0	24.1	16.6	13.8	13.8
Coefficient of Determination (R^2)	0.02	0.14	0.00	0.01	0.01	0.03
Index of Agreement	0.38	0.57	0.22	0.33	0.28	0.37

Table IV-6. Percent of modeled days that meet the statistical goals for all modeled ozone values and ozone modeled values paired with observed ozone values above 60 ppb

Subset	Percent of Days with Normalized Mean Error less than 35%		Percent of Days with Normalized Mean Bias between +/- 15%	
	All Values	> 60 ppb	All Values	> 60 ppb
Eight-hour O_3	95%	97%	58%	68%
One-hour O_3	84%	93%	58%	64%

Time series plots of daily peak eight-hour ozone modeled values plotted over observations for each monitoring site are given in Figure IV-5. A time series plot of the network average daily peak eight-hour ozone values over the observed values is provided in Figure IV-6. Time series plots indicated that the CAMx model tended to underestimate the observed values in July and overestimate in August.

A scatter plot of daily peak eight-hour ozone modeled and observed values for all monitors are provided in Figure IV-7. The plot indicates that the CAMx modeled ozone values generally clustered around the best-fit-line, and have a slightly larger bias at higher ozone values above 60 ppb than at lower ozone values.

Figures IV-8 and 9 illustrated the spatial distributions of mean errors and mean biases of monitors for the daily peak eight-hour ozone modeled values. The mean errors for the West Phoenix and West Chandler monitors were the highest, those for all other monitors are relatively uniform in the range of 8-10 ppb. The mean biases of monitors in Figure IV-9 are relatively lower in the Phoenix urban core area and higher outside the urban core area.

The MAG CAMx model performance was compared against other modeling studies in Figure IV-10. Figure IV-10 presents the statistical metrics for the MAG CAMx modeled ozone values (with a red ‘x' within a box) overlaid over the documented results of numerous other modeling studies (Simon et al., 2012 and Appel et al., 2011). The box-and whisker plots in Figure IV-10 indicate that the bold center line in the box shows the median value from the survey of other modeling studies, the box outlines the 25th and 75th percentile values, and the whiskers extend to 1.5 times the interquartile range. The amount of studies used in each distribution is shown as "n" above the box-and-whisker. This comparison demonstrates that the metrics derived from the MAG CAMx modeled values are within or close to the distribution of the range of other published modeling studies. The MAG CAMx results were better than the median of the study sample sets for one-hour and eight-hour daily peak values for multiple metrics such as MB, NMB, RMSE, and ME.

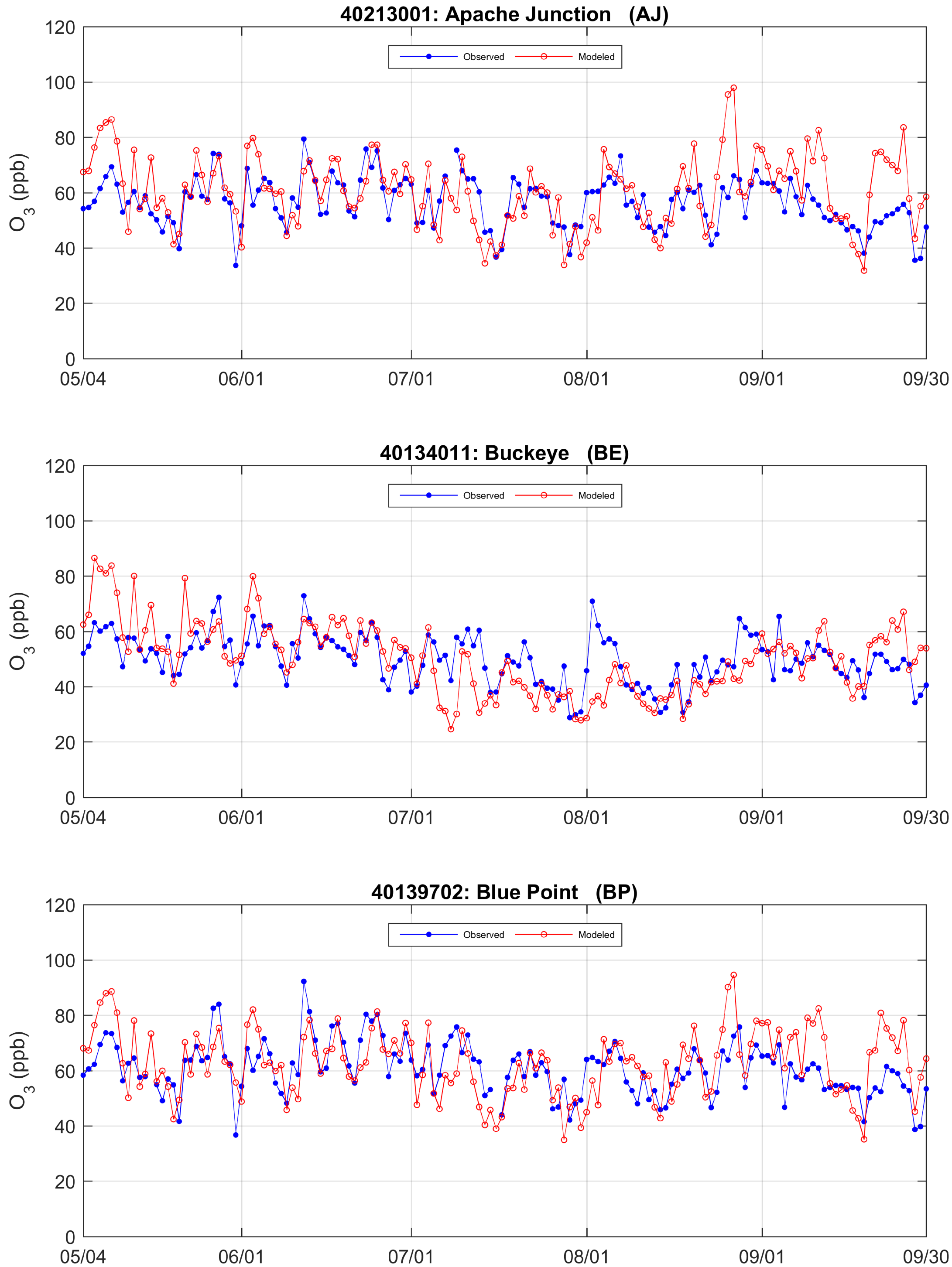


Figure IV-5. Time series plots of daily peak eight-hour ozone modeled values over observed ozone values for monitors

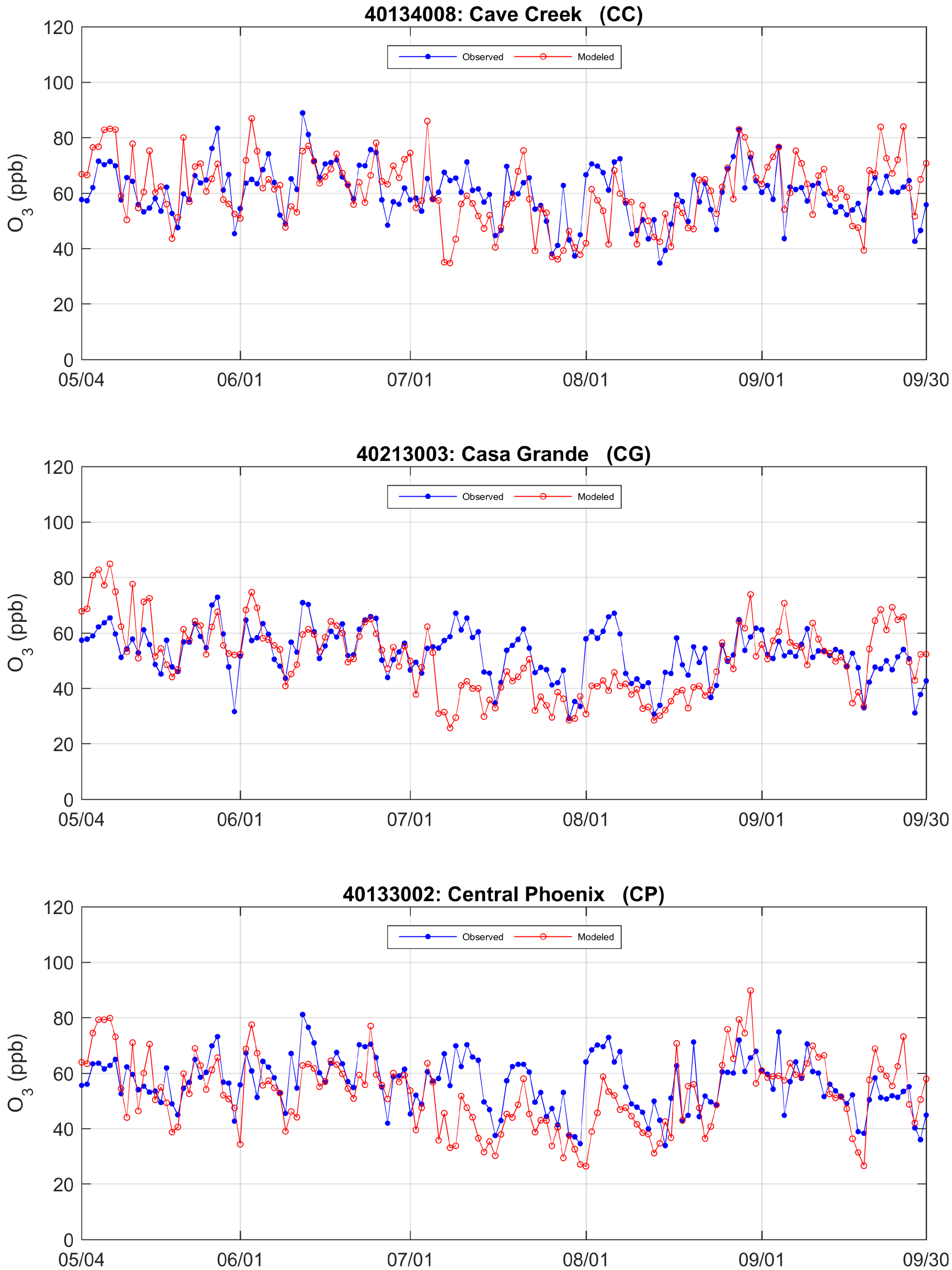


Figure IV-5. (Continued.)

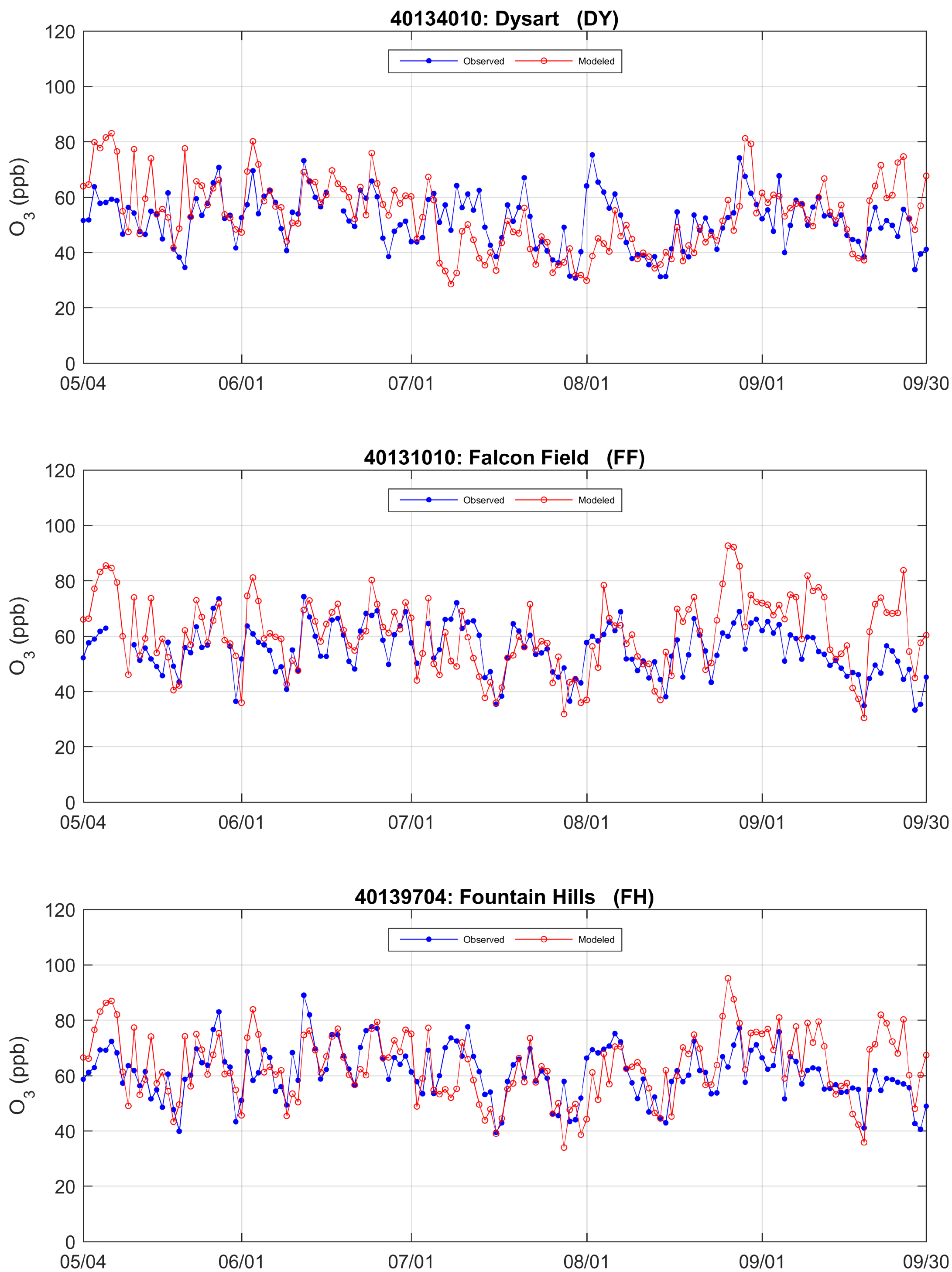


Figure IV-5. (Continued.)

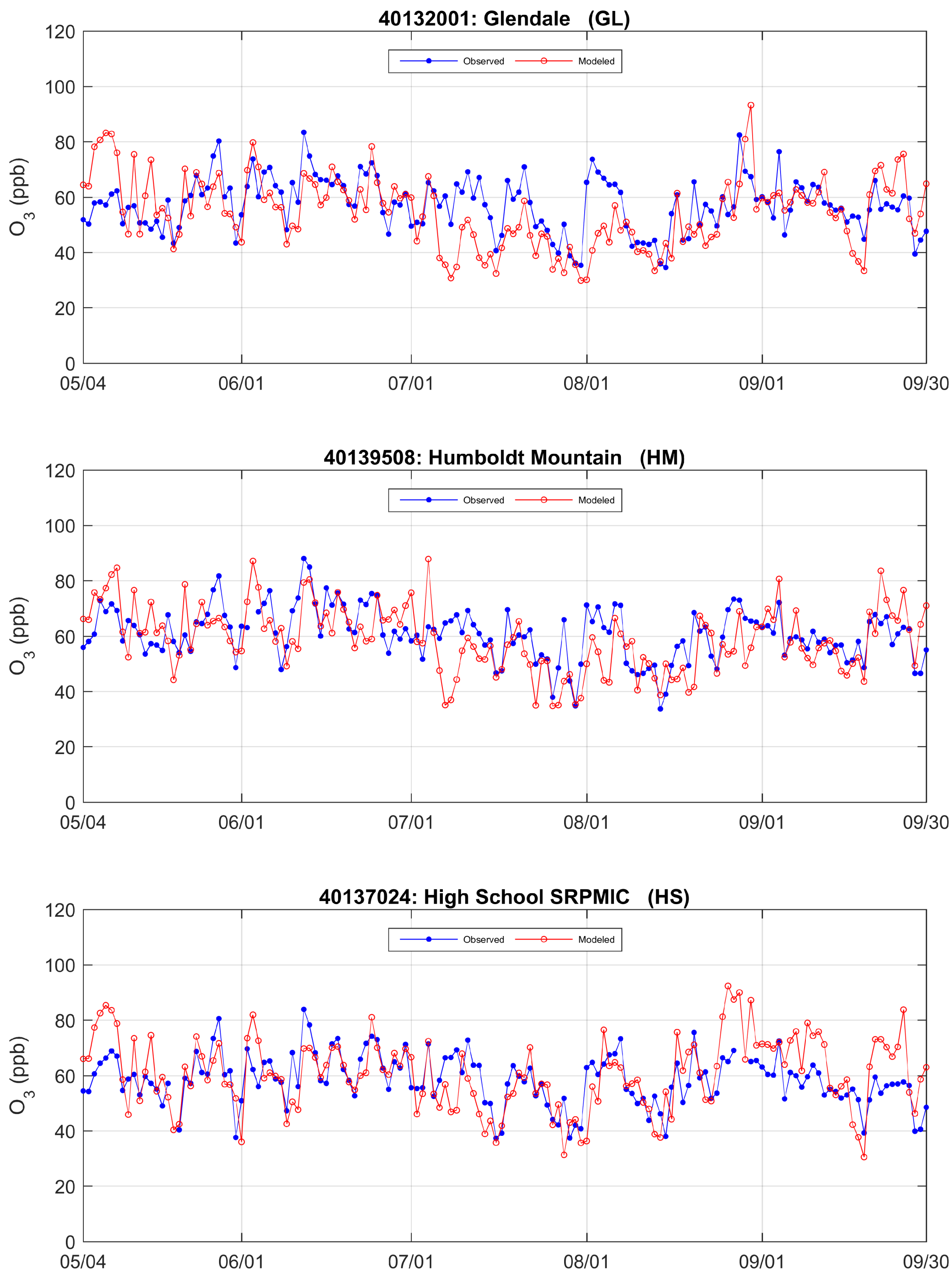
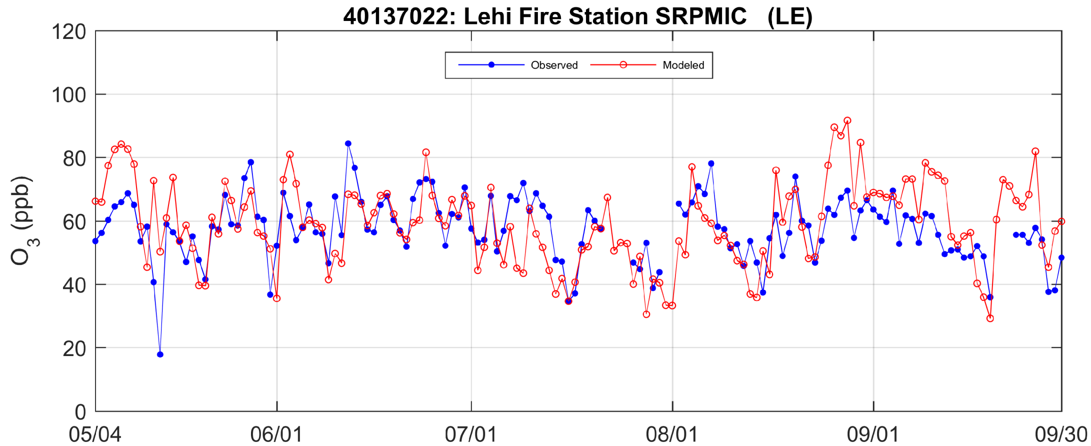
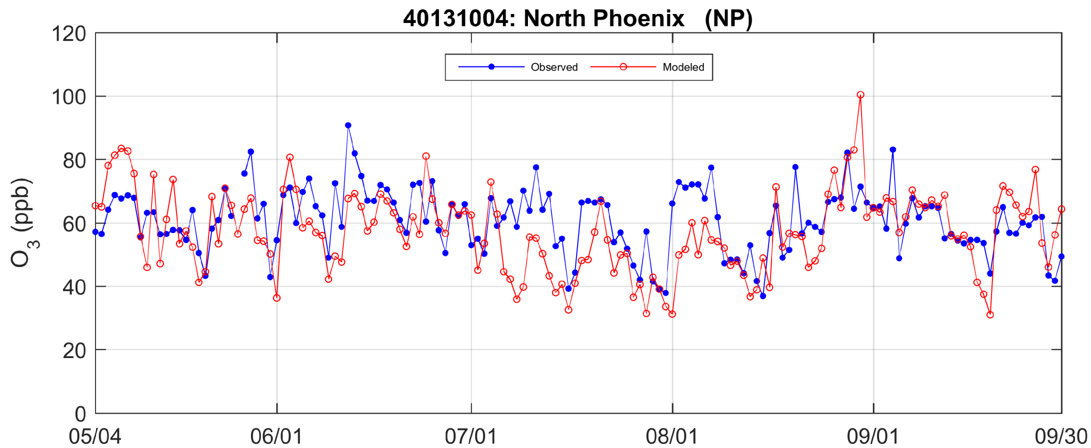
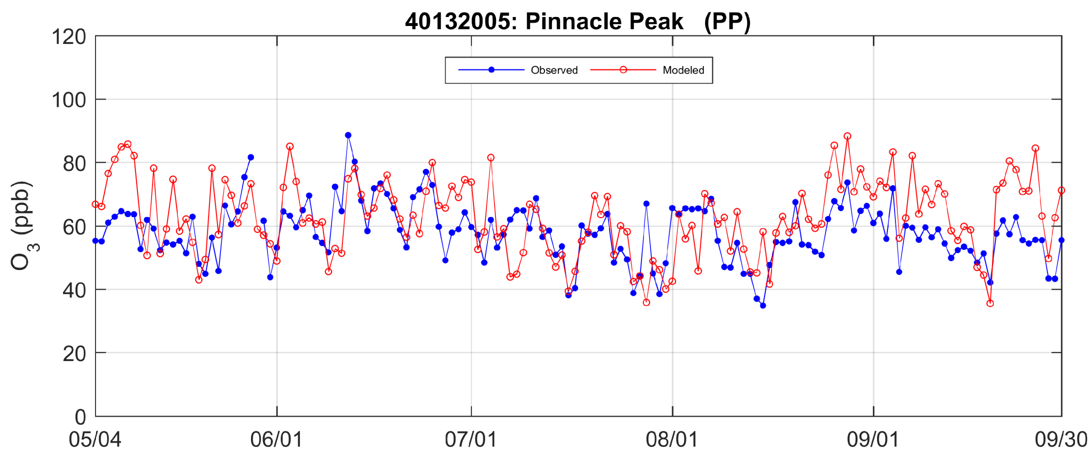


Figure IV-5. (Continued.)







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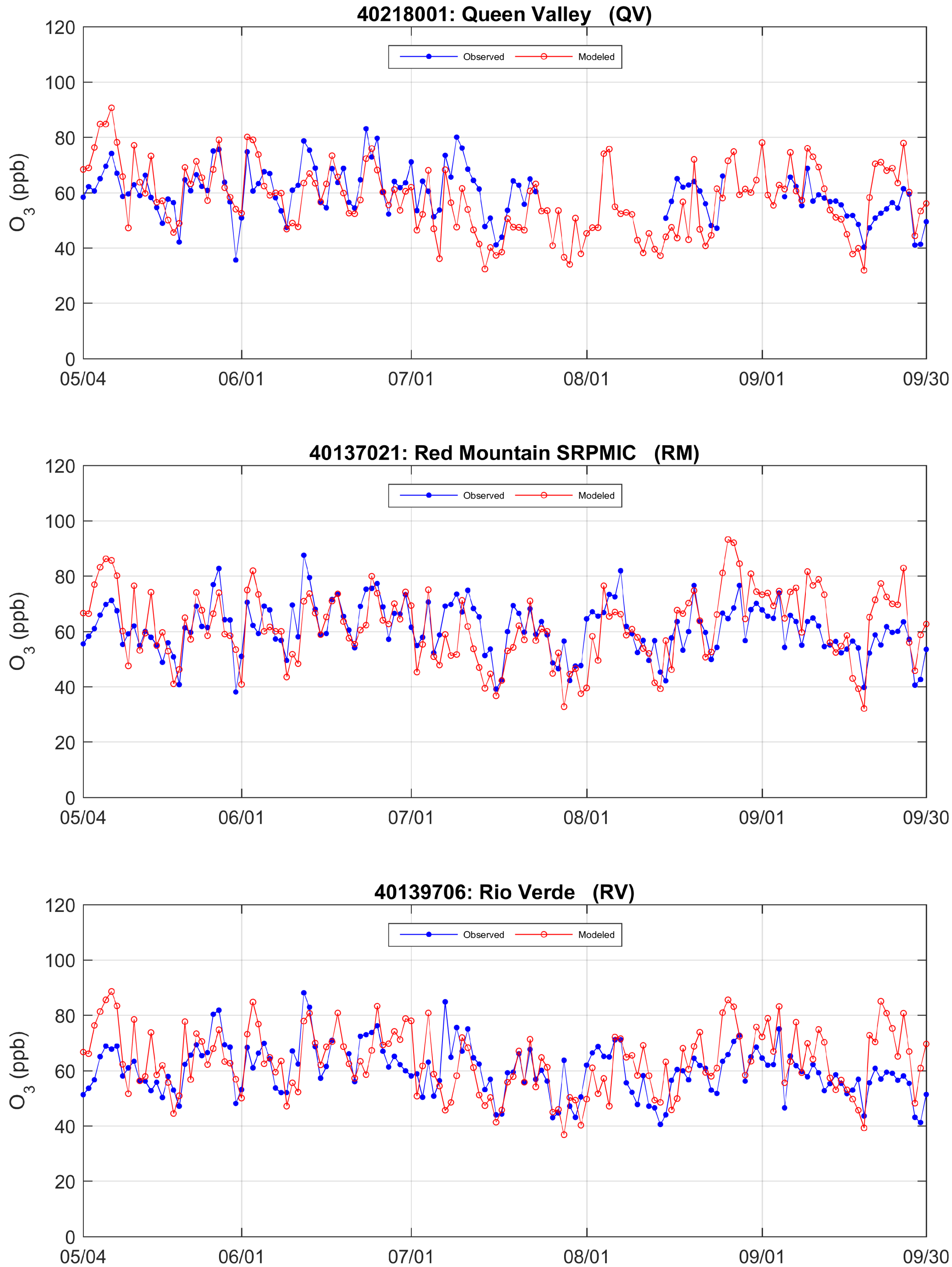

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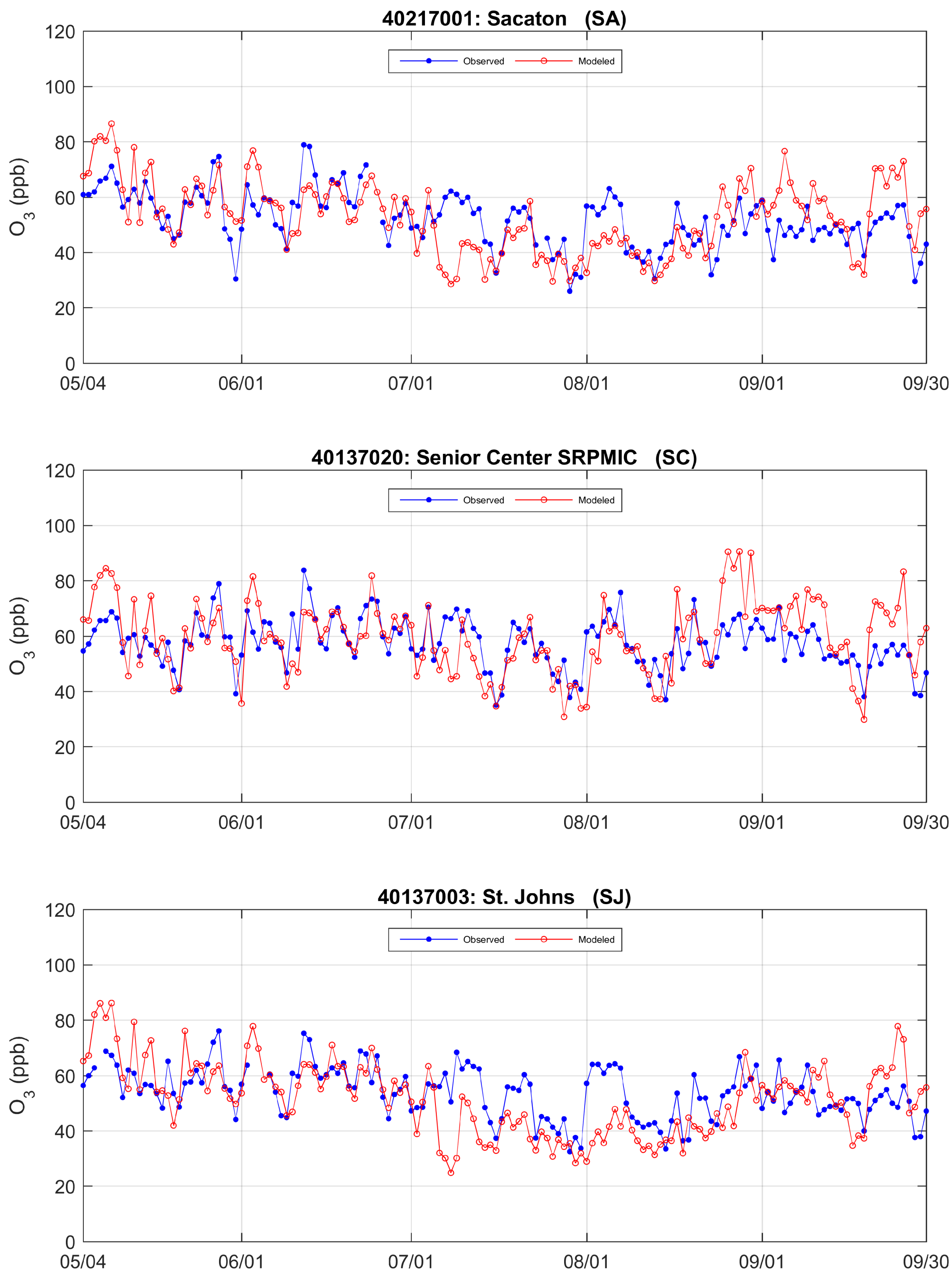

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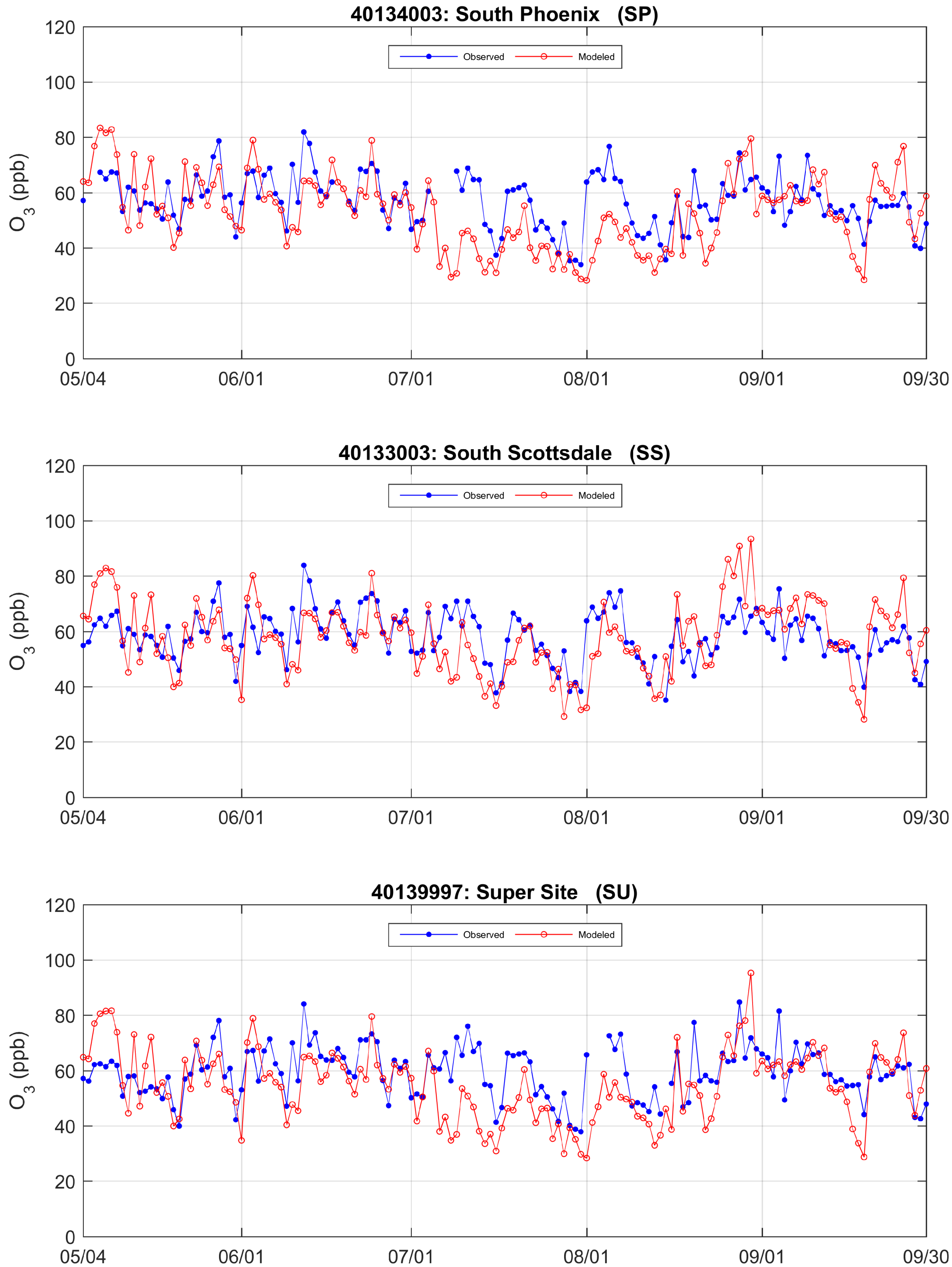

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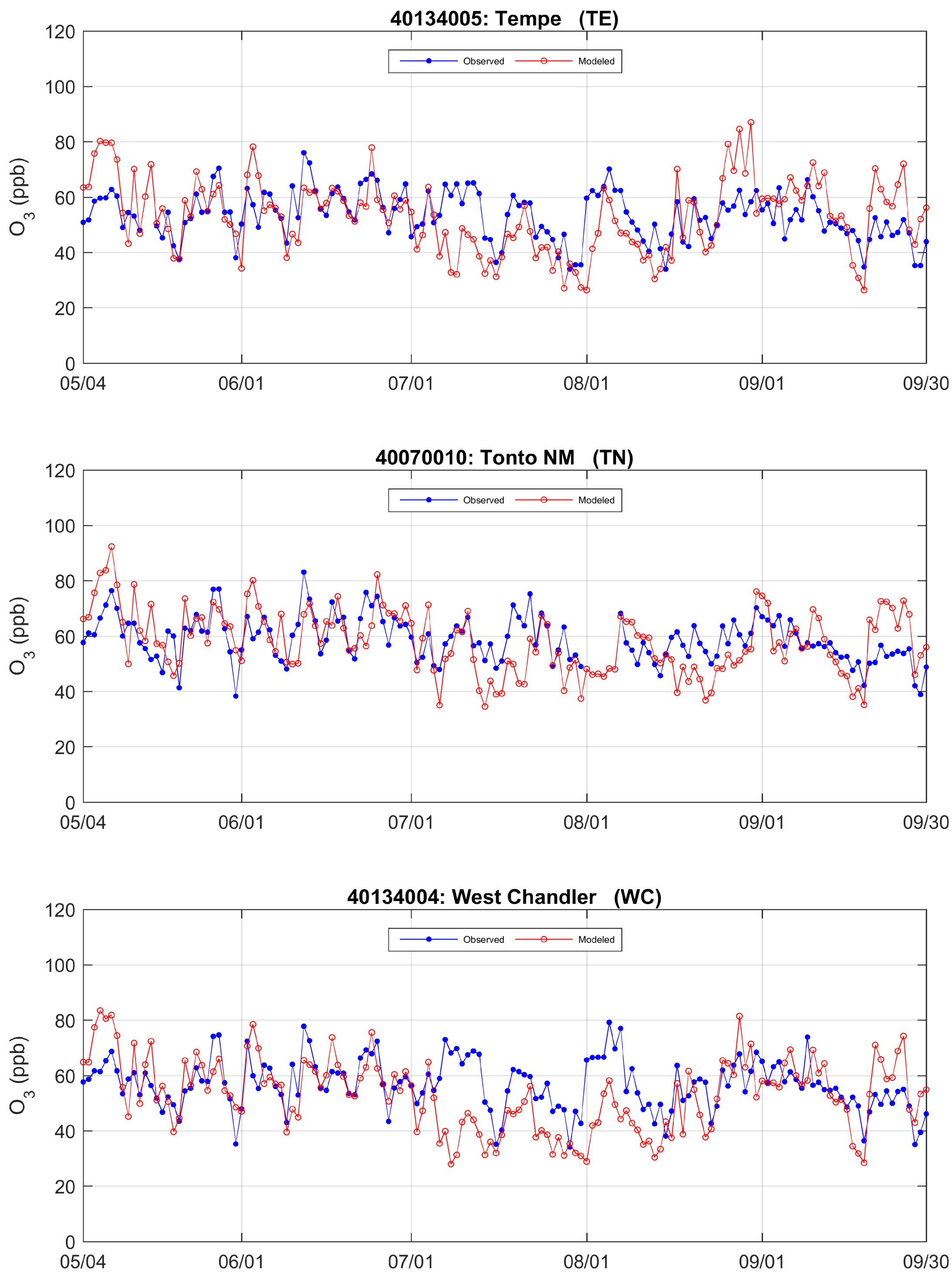

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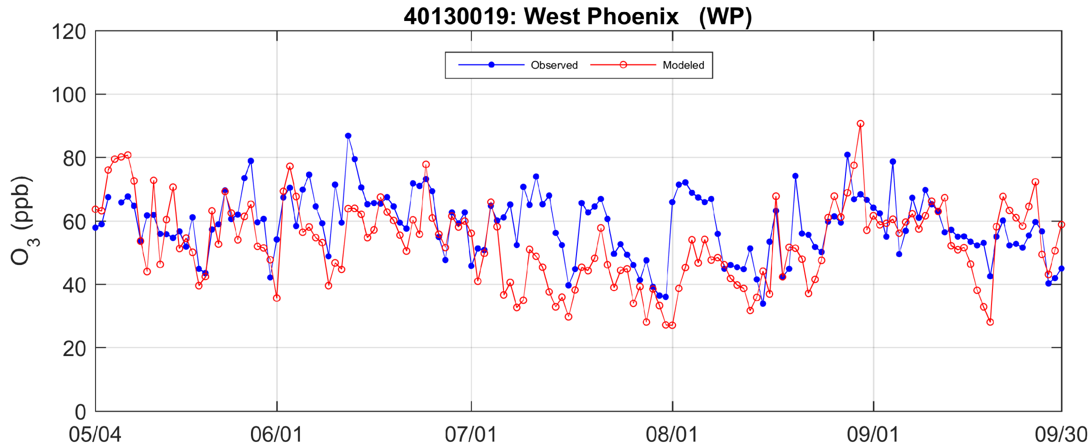

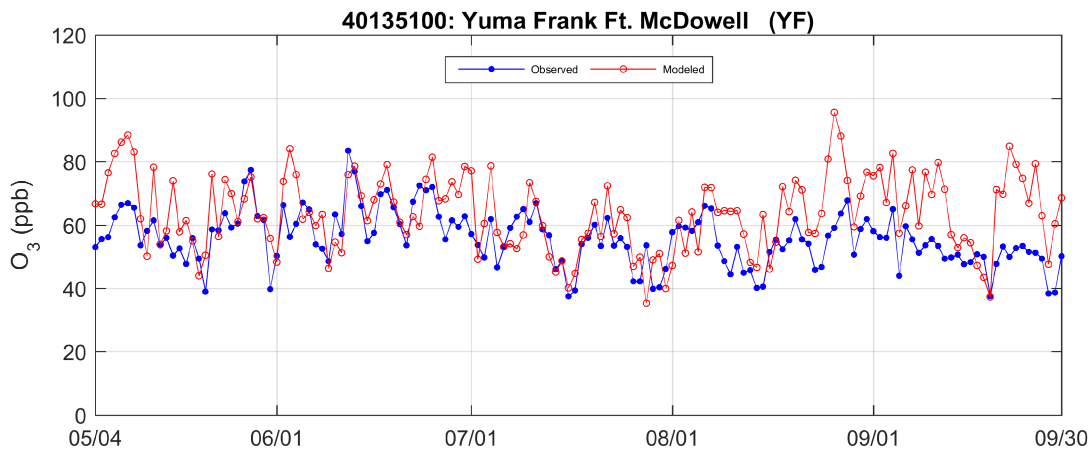

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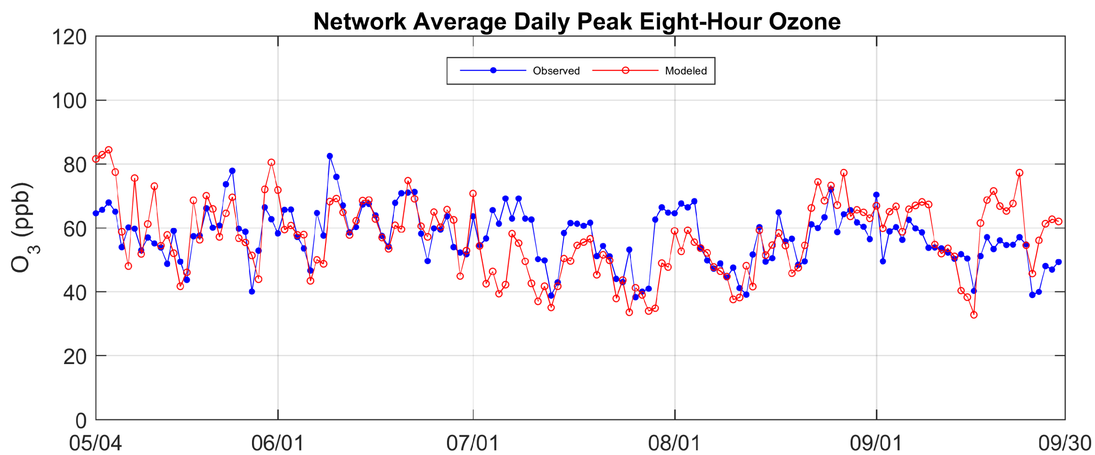


Figure IV-6. Time series of eight-hour daily peak ozone averaged over the network for observed and modeled concentrations for the base year simulation period

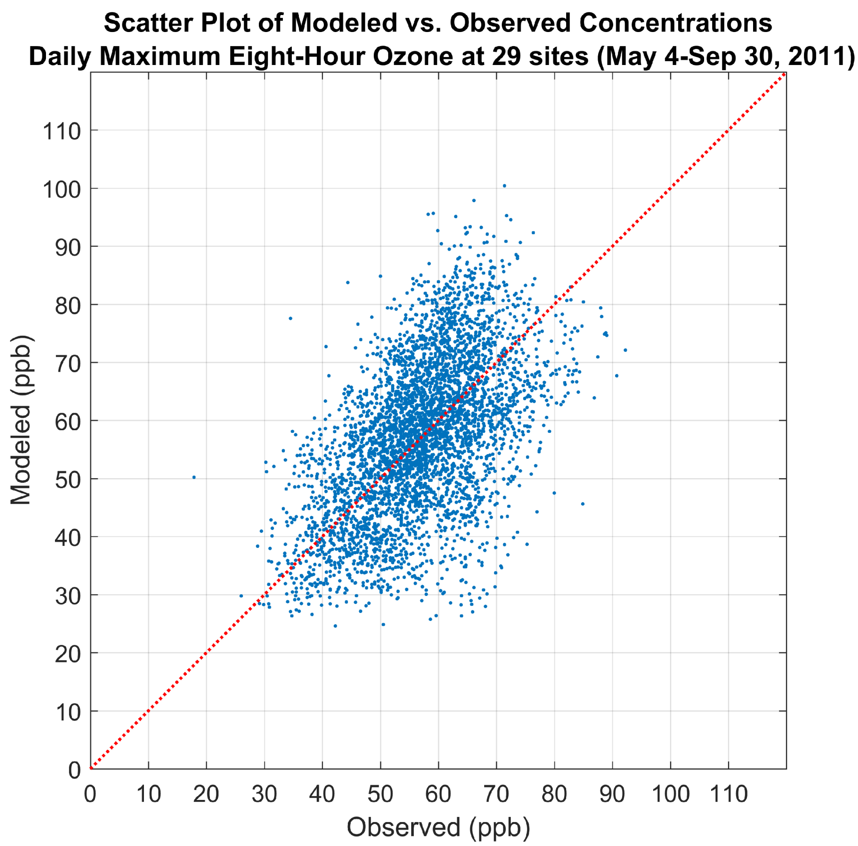


Figure IV-7. Scatter plot of daily peak eight-hour ozone observed and modeled concentrations for monitors

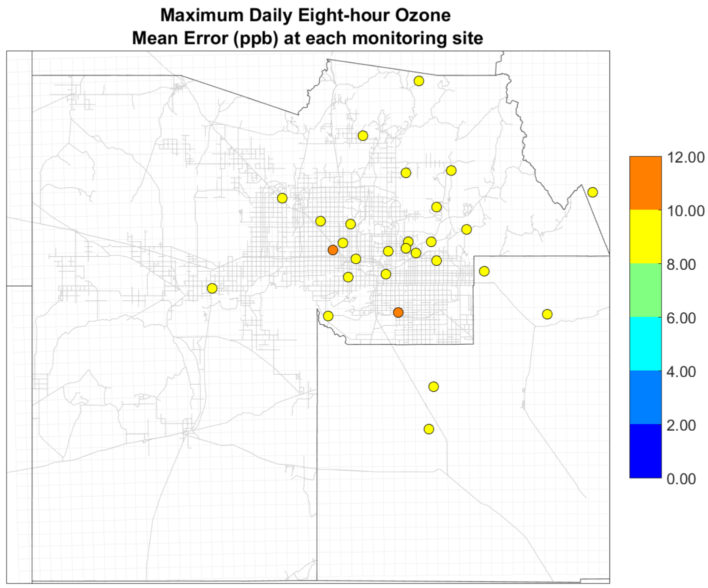


Figure IV-8. Spatial distribution of mean errors of monitors for daily peak eight-hour ozone values

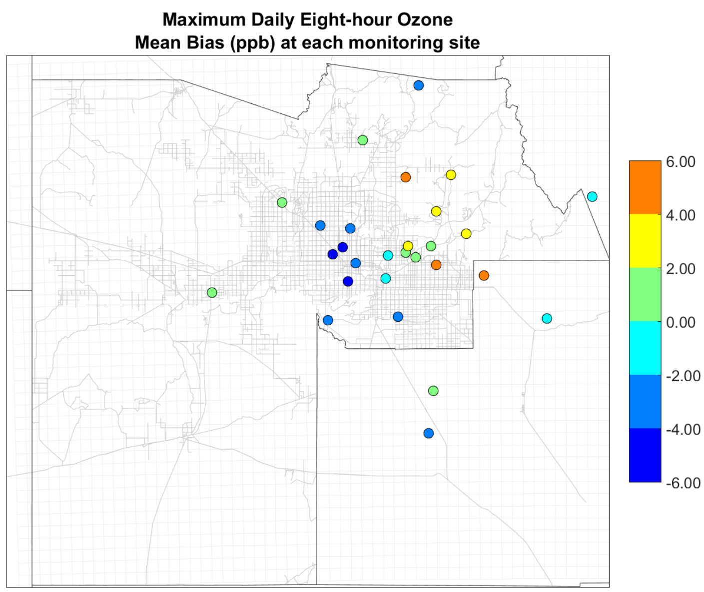


Figure IV-9. Spatial distribution of mean biases of monitors for daily peak eight-hour ozone values

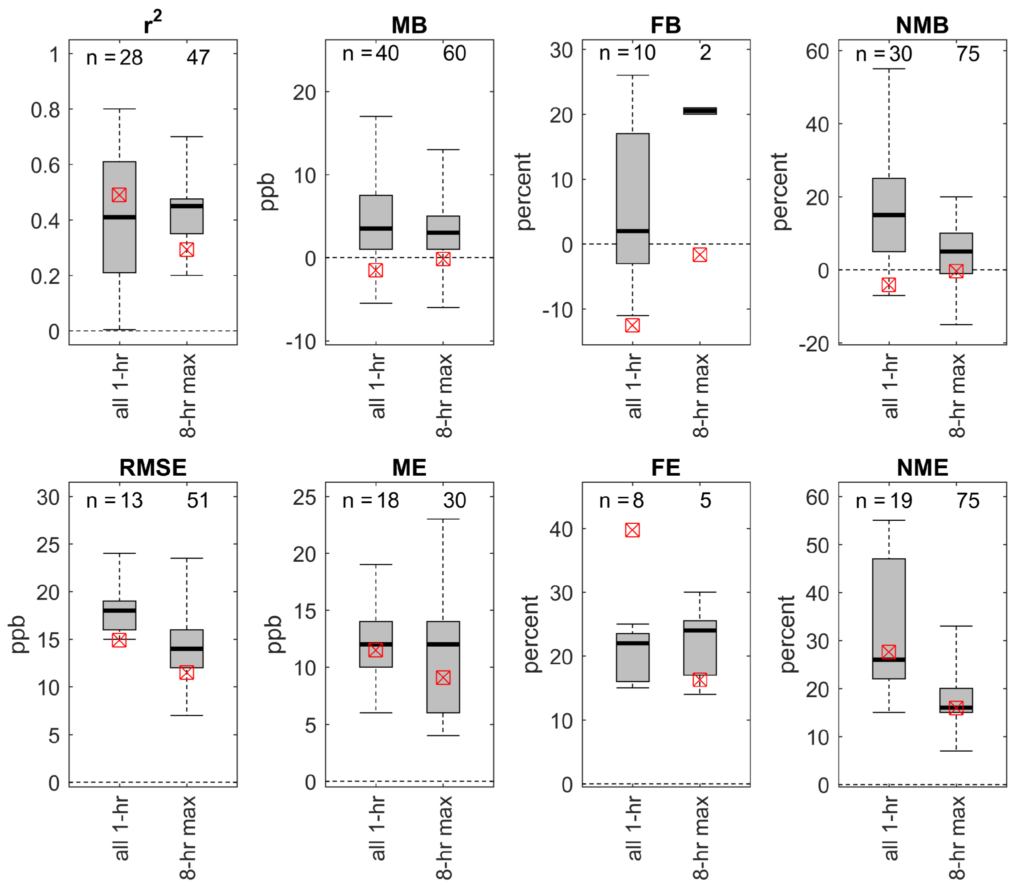


Figure IV-10. Comparison of the MAG CAMx model performance (the red box with a check mark) with other air quality model performance studies (Simon et al., 2012)

The operational model performance evaluation for the model episode days indicates that the CAMx model replicated ozone concentrations well, except for a few periods of under-predictions in July and over-prediction in August. However, these do not significantly affect the results of the attainment test presented in Section V of this document because the attainment test depends upon the base year design values for monitors and Relative Response Factors.

V. ATTAINMENT DEMONSTRATION

V-1. Monitoring Site Attainment Tests

Following the procedures described in the EPA guidance for the attainment demonstration (EPA, 2014a), the modeled ozone values from the CAMx 2011 and 2017 simulations were used to project the 2011 base year design values (DVB) to the 2017 future design values (DVF) for monitors. The 2011 base year design values for individual monitors were based on ozone observations for the five-year period of 2009 through 2013: the five-year weighted average of three design values for 2009-2011, 2010-2012, and 2011-2013. The DVB at each monitoring site was projected to the 2017 future design value with Relative Response Factor (RRF), which was facilitated by the EPA Model Attainment Test Software (MATS) v2.6.1 program. Equation 1 below describes the process in the simplified form.

$$(DVF)_i = (RRF)_i (DVB)_i \tag{1}$$

where:

$(DVB)_i$ = Baseline design value monitored at monitoring site i (unit: ppb)
$(RRF)_i$ = Relative response factor for monitoring site i (unitless)
$(DVF)_i$ = Estimated design value for the future year at monitoring site i (unit: ppb)

The RRF for each monitoring site is the ratio of the CAMx 2017 future year ozone prediction to the CAMx 2011 base year ozone prediction. The RRF for a monitor is based on the average of the maximum ozone predictions in the 3x3 grid cells surrounding the monitor for the highest 10 modeled days in the CAMx 2011 base year simulation and the average of the CAMx 2017 ozone predictions on the same grid cells of the maximum ozone predictions for the highest ten modeled days in the CAMx 2011 base year simulation.

The 2017 design values for monitors were compared to the 2008 ozone NAAQS for the attainment test. The sites with 2017 design values that do not exceed the NAAQS are projected to be attainment in 2017. Since ozone design values are truncated to integer values in determining compliance with the NAAQS, a design value of 75.9 ppb is truncated to 75 ppb which is considered attainment, whereas design values at or above 76.0 ppb are considered nonattainment.

Table V-1 presented the three-year average design values of monitors, which are the three-year average of the annual fourth-highest daily maximum eight-hour average ozone concentrations, and the five-year weighted baseline design values (DVB) of monitors for the 2011 base year. The maximum DVB for the 2011 base year was estimated at 79.7 ppb at the North Phoenix monitoring site.

Table V-1. Three-year average design values and five-year weighted baseline design values (DVB) for monitors for the 2011 base year (unit: ppb)

Site Name	Site Abbr.	AIRS	2009-2011	2010-2012	2011-2013	DVB*
West Phoenix	WP	040130019	73	78	79	76.7
North Phoenix	NP	040131004	77	81	81	79.7
Falcon Field	FF	040131010	68	69	72	69.7
Glendale	GL	040132001	72	76	76	74.7
Pinnacle Peak	PP	040132005	74	77	77	76.0
Central Phoenix	CP	040133002	71	74	75	73.3
South Scottsdale	SS	040133003	74	77	76	75.7
South Phoenix	SP	040134003	72	76	76	74.7
West Chandler	WC	040134004	72	74	72	72.7
Tempe	TE	040134005	68	70	71	69.7
Cave Creek	CC	040134008	75	77	77	76.3
Dysart	DY	040134010	70	71	72	71.0
Buckeye	BE	040134011	64	66	65	65.0
Fort McDowell/Yuma Frank	YF	040135100	69	70	72	70.3
Senior Center	SC	040137020	72	74	75	73.7
Red Mountain	RM	040137021	76	77	77	76.7
Lehi	LE	040137022	72	73	75	73.3
High School	HS	040137024	72	74	74	73.3
Humboldt Mountain	HM	040139508	71	75	76	74.0
Blue Point	BP	040139702	72	75	77	74.7
Fountain Hills	FH	040139704	73	76	74	74.3
Rio Verde	RV	040139706	73	74	75	74.0
Super Site	SU	040139997	75	76	77	76.0
Apache Junction	AJ	040213001	72	74	73	73.0

* The EPA Guidance (EPA, 2014a) recommended that the tenths of design value in ppb be used in all documentation and be truncated to integer value for the future design value in ppb to compare to the NAAQS.

Ozone design values for the 2011 base year and the 2017 future year and RRF for each monitoring site in the Maricopa eight-hour ozone nonattainment area are provided in Table V-2. All monitoring sites have RRFs less than one, which indicates that the CAMx ozone predictions in the future year are lower than those for the base year. The maximum 2017 future design value of 75.6 ppb at the North Phoenix site was calculated as follows:

$$\underset{(DVB_{2011})}{79.7\ \text{ppb}} \quad \times \quad \underset{(RRF_{NP})}{0.9487} \quad = \quad \underset{(DVB_{2017})}{75.6\ \text{ppb}}$$

Significant figures to the right of the decimal point in the future design values were truncated as the final future design value for the attainment test. The peak predicted future design value for monitors is 75 ppb, as shown in Table V-2. The range of the 2017 future design values for monitors in the Maricopa eight-hour ozone nonattainment area are 63 - 75 ppb. Eight monitors in the Maricopa eight-hour ozone nonattainment area were predicted above 70 ppb and below 75 ppb, which are mostly located in the Phoenix urban core area. Since all these future design values are less than or equal to 75 ppb, the Maricopa eight-hour ozone nonattainment area has successfully passed the model attainment test for the 2008 ozone standard for the 2017 attainment year.

Table V-2. 2011 and 2017 design values for monitors in the Maricopa eight-hour ozone nonattainment area

Site Name	Site Abbr.	AIRS	2011 Base Year Design Value (ppb)	RRF	2017 Future Year Design Value (ppb)
West Phoenix	WP	040130019	76.7	0.9561	73.3
North Phoenix	NP	040131004	79.7	0.9487	**75.6**
Falcon Field	FF	040131010	69.7	0.9318	64.9
Glendale	GL	040132001	74.7	0.9633	71.9
Pinnacle Peak	PP	040132005	76.0	0.9232	70.1
Central Phoenix	CP	040133002	73.3	0.9518	69.7
South Scottsdale	SS	040133003	75.7	0.9463	71.6
South Phoenix	SP	040134003	74.7	0.9580	71.5
West Chandler	WC	040134004	72.7	0.9602	69.8
Tempe	TE	040134005	69.7	0.9721	67.7
Cave Creek	CC	040134008	76.3	0.9391	71.6
Dysart	DY	040134010	71.0	0.9597	68.1
Buckeye	BE	040134011	65.0	0.9754	63.4
Fort McDowell/Yuma Frank	YF	040135100	70.3	0.9309	65.4
Senior Center	SC	040137020	73.7	0.9454	69.6
Red Mountain	RM	040137021	76.7	0.9343	71.6
Lehi	LE	040137022	73.3	0.9470	69.4
High School	HS	040137024	73.3	0.9403	68.9
Humboldt Mountain	HM	040139508	74.0	0.9438	69.8
Blue Point	BP	040139702	74.7	0.9383	70.0
Fountain Hills	FH	040139704	74.3	0.9351	69.4
Rio Verde	RV	040139706	74.0	0.9243	68.3
Super Site	SU	040139997	76.0	0.9590	72.8
Apache Junction	AJ	040213001	73.0	0.9314	67.9

V-2. Unmonitored Area Analysis

Since high ozone concentrations can occur in unmonitored areas, the unmonitored area analysis was conducted to investigate ozone concentrations in unmonitored areas in the 4 km modeling domain. This analysis may identify the areas where future year design values are greater than the 2008 ozone standard. The EPA guidance (EPA, 2014a) recommends the following procedures:

- Interpolates base year design values, which are also used in the attainment test, to develop spatial fields using the inverse distance weights.
- Adjusts the spatial fields using gridded model output.
- Calculates gridded RRF, which are derived by gridded modeled outputs for base and future years.
- Creates future year spatial fields by applying the gridded RRF to the base year gradient adjusted spatial fields.

The EPA MATS v2.6.1 was coded by following the above procedures, and used to conduct the unmonitored analysis. The EPA MATS model predicted all values in the grid cells of the Maricopa eight-hour ozone nonattainment area below the 2008 ozone standard. The maximum design value of 75.5 ppb was predicted in a grid cell in unmonitored area located northwest of the Supersite. The contour plot of the unmonitored area analysis results is illustrated in Figure V-1.

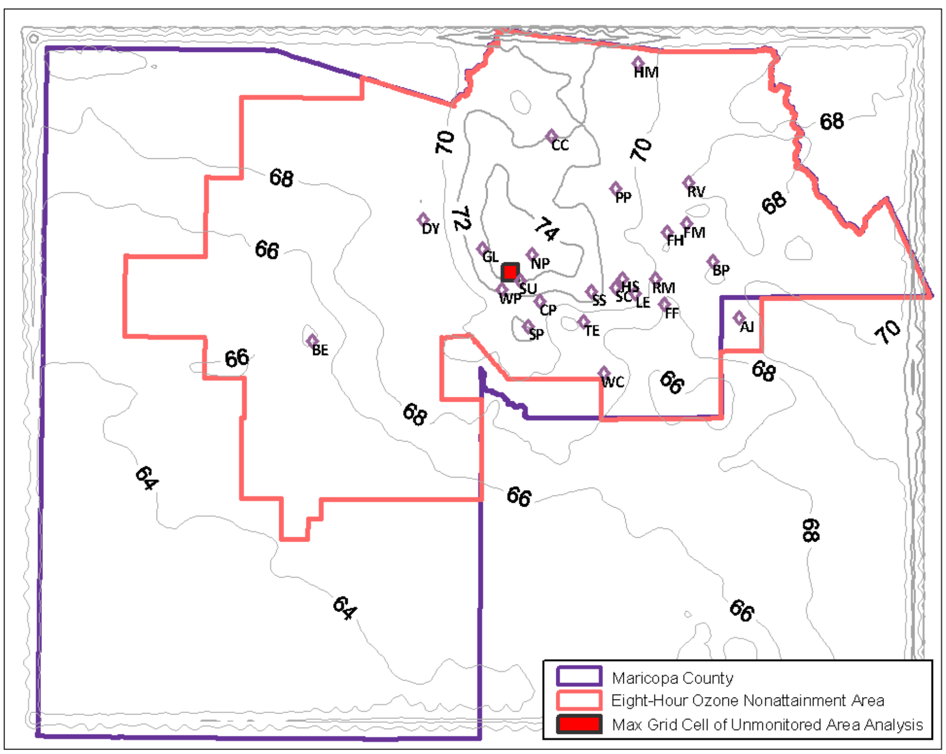


Figure V-1. Contour plot of the future design values for unmonitored area

V-3. Onroad Emissions Budget for Conformity

In accordance with the 1990 Clean Air Act (CAA) Amendments, transportation conformity requirements are intended to ensure that transportation activities do not result in air quality degradation. Section 176 of the CAA requires that transportation plans, programs, and projects conform to applicable air quality plans before the transportation action is approved by a Metropolitan Planning Organization (MPO). The designated MPO for Maricopa County is the Maricopa Association of Governments.

Section 176(c) of the CAA provides the framework for ensuring that Federal actions conform to air quality plans under section 110. Conformity to an implementation plan means that proposed activities should not: (1) cause or contribute to any new violation of any standard in any area, (2) increase the frequency or severity of any existing violation of any standard in any area, or (3) delay timely attainment of any standard or any required interim emission reductions or other milestones in any area.

EPA transportation conformity regulations establish criteria involving comparison of projected transportation plan emissions with the motor vehicle emissions assumed in applicable air quality plans. These regulations define the term “motor vehicle emissions budget” as meaning “the portion of the total allowable emissions defined in a revision of the applicable implementation plan (or in an implementation plan revision which was endorsed by the Governor or his or her designee) for a certain date for the purpose of meeting reasonable further progress milestones or attainment demonstrations, for any criteria pollutants or its precursors, allocated by the applicable implementation plan to highway and transit vehicles.”

On June 13, 2012, EPA published the final rule approving the MAG 2007 Eight-Hour Ozone Plan, including the 2008 emissions budgets for VOC of 67.9 metric tons per day and NOx of 138.2 metric tons per day, effective July 13, 2012. On September 17, 2014, EPA published a final rule approving the MAG 2009 Eight-Hour Ozone Maintenance Plan, including the 2025 emissions budget for VOC of 43.8 metric tons per day and NOx of 101.8 metric tons per day, effective October 17, 2014.

The MAG 2017 Moderate Area Ozone Plan establishes 2017 conformity budgets based on 2017 onroad mobile source VOC and NOx emissions in the Maricopa eight-hour ozone nonattainment area that were used to model attainment of the 2008 ozone standard of 0.075 ppm. The 2017 conformity budgets are represented by the onroad VOC and NOx emissions on average daily emissions of May 1 through September 30. The methodology used in estimating onroad mobile source emissions in 2017 is discussed in Section III-1-4. As shown in Table V-3, the average daily onroad motor vehicle emissions in the Maricopa eight-hour ozone nonattainment area for the period of May through September are 45.7 metric tons per day for VOC and 62.7 metric tons per day for NOx. These represent the 2017 emissions budgets that will be used in future transportation conformity analyses that begin after these emissions budgets have been found to be adequate or are approved by EPA as part of this plan. In subsequent conformity analyses, onroad mobile source emissions for conformity horizon years of 2017 and beyond should not exceed the 2017 VOC and NOx emissions budgets.

Table V-3. Average daily anthropogenic emissions of May 1 through September 30 in the Maricopa eight-hour ozone nonattainment area (unit: metric tons/day)

Emission Source	VOC			NOx			CO		
	2011	2017	Emission Reduction (2017-2011)	2011	2017	Emission Reduction (2017-2011)	2011	2017	Emission Reduction (2017-2011)
Point	2.47	3.32	+0.85	7.02	13.75	+6.73	4.41	6.75	+2.34
Area	94.46	96.05	+1.59	10.96	12.59	+1.63	7.71	8.50	+0.79
Nonroad	27.89	20.26	-7.63	53.58	36.26	-17.32	343.58	310.41	-33.17
Onroad	70.96	45.65	-25.31	117.15	62.69	-54.46	675.97	492.98	-182.99
Total	195.78	165.28	-30.50	188.71	125.29	-63.42	1,031.67	818.64	-213.03

V-4. Reasonable Further Progress - 15 Percent Rate of Progress Demonstration

In accordance with Clean Air Act Section 182(b)(1), the nonattainment area that is classified as Moderate for the 2008 ozone standard must submit a Rate of Progress (ROP) plan to provide for a 15 percent reduction in VOC emissions across the nonattainment area over a six-year period from the base year anthropogenic emissions, the years 2012 through 2017. For the purpose of meeting the 15 percent ROP requirements in the Maricopa eight-hour ozone nonattainment area, the base year 2011 average daily anthropogenic VOC emissions for the period of May 1 through September 30 in the nonattainment area were reduced by at least 15 percent by 2017. The 2017 ROP 15 percent reduction target of 166.41 metric tons per day is calculated by multiplying the 2011 average daily anthropogenic VOC emissions of 195.78 metric tons per day (Table V-3) by 85% (100% - 15%) as follows:

195.78 metric tons per day x (100% - 15%) = 166.41 metric tons per day

The 2017 average daily anthropogenic VOC emissions of 165.28 metric tons per day is less than the 2017 ROP 15 percent reduction target of 166.41 metric tons per day. Therefore, the 2017 average daily anthropogenic VOC emissions in the Maricopa eight-hour ozone nonattainment area satisfy the CAA Section 182(b)(1) reasonable further progress and 15 percent ROP plan requirements.

V-5. Ozone Control Measures Used for Numeric Credit

Chapter Five of the MAG 2017 Eight-Hour Ozone Moderate Area Plan includes a table of the 93 existing federal, state and local ozone control measures. The 93 existing ozone control measures have been approved by EPA in prior regional air quality plans or in separate EPA actions. The continuous implementation of these existing control measures in the nonattainment area assists in the attainment of the 2008 ozone standard in 2017. Only a subset of these control measures has quantifiable emission reduction benefits that were used to demonstrate attainment and meet contingency measure requirements. The federal, state, and local control measures used in demonstrating attainment of the 2008 ozone standard are as follows:

1. Summer Fuel Reformulation: California Phase 2 and Federal Phase II Reformulated Gasoline with 7 psi from May 1 through September 30
2. Phased-In Emission Test Cutpoints
3. One-time Waiver from Vehicle Emissions Test
4. Tougher Enforcement of Vehicle Registration and Emissions Test Compliance
5. Expansion of Area A Boundaries
6. Gross Polluter Option for I/M Program Waivers
7. Coordinated Traffic Signal Systems
8. Develop Intelligent Transportation Systems
9. Federal Tier 2 and Tier 3 Motor Vehicle Emissions and Fuel Standards
10. Federal Phase 1 and 2 Light-Duty and Heavy-Duty Phase 1 Greenhouse Gas Rules
11. Federal Nonroad Equipment Standards
12. Federal Heavy Duty Diesel Vehicle Emissions Standards
13. Federal Portable Fuel Container Rules

The emissions reduction benefits of ozone control measures 1 through 12 are included in the onroad and nonroad emissions inventories that were developed by MOVES2014a. The aggregated emission reductions from these measures are used in modeling attainment in this plan. Measures 1 through 6, 9, 11, and 12 are reflected in the fuel parameters (e.g., RVP, gasoline and diesel sulfur contents, oxygen contents, etc.), vehicle registration data, and I/M programs for the MOVES2014a onroad and nonroad modeling. Measures 7 and 8 are incorporated into transportation network assignments of the Travel Demand Model (TDM), which were developed by the MAG Transportation Division. Onroad and nonroad mobile source emissions factors in MOVES2014a reflect the benefits of measures 9, 11, and 12 through the onroad and nonroad engine and fuel standards. Measure 10 contributes ozone precursor emissions reductions by way of improved fuel efficiency.

The MOVES2014a and SMOKE models estimated aggregated emissions reductions of 25.3 metric tons per day of VOC and 54.5 metric tons per day of NOx for onroad mobile sources in the Maricopa eight-hour ozone nonattainment area. Aggregated nonroad mobile source emissions reductions of 7.6 metric tons per day of VOC and 17.3 metric tons per day of NOx were estimated in the Maricopa eight-hour ozone nonattainment area. The benefits of measure 13, the federal portable fuel container rules, were provided by EPA for

Maricopa and Pinal Counties. The 2011 controlled emissions for the portable fuel containers were obtained from the EPA 2011 National Emissions Inventory (NEI). The 2017 emission reduction benefits were interpolated using the EPA 2015 and 2020 emissions benefits for the portable fuel container rules. Measure 13 provided 6.2 metric tons per day of VOC emission reduction benefit in the Maricopa eight-hour ozone nonattainment area in 2017. The attainment demonstration in this plan was primarily dependent upon the emissions benefits of the tighter federal standards for new onroad and nonroad engines and fuel requirements, and the continuing fleet turnover in the nonattainment area.

In addition to the ozone control measures used for numeric credit in the attainment demonstration, numerous other control measures, as shown in the Chapter Five of this plan, have been implemented in the Maricopa eight-hour ozone nonattainment area. These measures have been approved by EPA in prior regional air quality plans or separate EPA action and contribute to improve air quality, but cannot be quantified. As a result, the measures were not used as numeric credit for the attainment demonstration. As an example, the Arizona Department of Environmental Quality (ADEQ) issues an ozone High Pollution Advisory (HPA) when ozone is likely to exceed the NAAQS and pose health risks. When the HPA is issued, notices are sent to employers participating in trip reduction programs. At that time, employers activate HPA plans to help reduce air pollutants. The HPA plans may include commuting on public transportation, carpooling, vanpooling, and teleworking. The general public is also encouraged to take actions during an HPA such as limiting engine idling, refueling after dark, and limiting uses of gas-powered garden equipment and charcoal BBQs. The emissions reductions attributable to an HPA are not easily quantified, and thus are not used in the attainment demonstration. Many of the 93 existing control measures, such as the HPA program, were not used as numeric credit in the CAMx model attainment demonstration. These measures, while not quantified, improve air quality and contribute to the attainment of the 2008 ozone standard in 2017.

V-6. Contingency Provisions

Section 172(c)(9) of the Clean Air Act requires that the State Implementation Plans provide for the implementation of contingency measures without any further rulemaking action if the Moderate area fails to attain or to meet the standard by the attainment date. Since EPA allows early implementation of contingency measures (EPA, 1993), existing measures that have already been implemented may be contingency measures if they are not needed to show attainment and do not hasten attainment. EPA also allows federal measures to be contingency measures if they are not needed for attainment (EPA, 2005).

EPA requires that contingency measures represent one-year’s worth of progress, amounting to reductions of 3 percent of the 2011 base year VOC and/or NOx emissions for the Maricopa eight-hour ozone nonattainment area. These reductions would be achieved in 2018 in the Maricopa eight-hour ozone nonattainment area while the state is revising its plans for the area if the area failed to meet the ozone standard by the required attainment date, July 20, 2018.

For the MAG 2017 Eight-Hour Ozone Moderate Area Plan, the existing control measures provide enough continuing emission reduction benefits in 2018 to meet the contingency measure requirements. The VOC and NOx emissions reductions of the contingency measures in 2018 for the Maricopa eight-hour ozone nonattainment area are provided in Table V-4. Details on the development of the 2018 emissions inventory for the Maricopa eight-hour ozone nonattainment area are included in Appendix F. Average daily anthropogenic VOC emissions of the modeling episode from May 1 through September 30 in the Maricopa eight-hour ozone nonattainment area are 165.28 metric tons per day in 2017 and 164.08 metric tons per day in 2018. The difference of total anthropogenic VOC emissions between 2017 and 2018 is 1.20 metric tons per day. The one year VOC emissions reduction between 2017 and 2018 amounts to a 0.61 percent reduction from the 2011 base year emissions. In the same way, the NOx emissions reduction between 2017 and 2018 is estimated to be a 3.25 percent reduction from the 2011 base year emissions. The combined VOC and NOx emissions reduction of 3.86 percent in the Maricopa eight-hour ozone nonattainment area meets the 3 percent emission reduction requirements of contingency measures.

Table V-4. Average daily anthropogenic VOC and NOx emissions reductions in 2018 for contingency measure requirements (unit: metric tons/day)

Emission Source	VOC					NOx				
	2011	2017	2018	Emission Reduction (2018-2017)	2018 Reduction from 2011	2011	2017	2018	Emission Reduction (2018-2017)	2018 Reduction from 2011
Point	2.47	3.32	3.39	+0.07	2.83%	7.02	13.75	13.76	+0.01	0.14%
Area	94.46	96.05	97.88	+1.83	1.94%	10.96	12.59	12.98	+0.39	3.56%
Nonroad	27.89	20.26	20.07	-0.19	-0.68%	53.58	36.26	34.36	-1.90	-3.55%
Onroad	70.96	45.65	42.74	-2.91	-4.10%	117.15	62.69	58.05	-4.64	-3.96%
Total	195.78	165.28	164.08	-1.20	-0.61%	188.71	125.29	119.15	-6.14	-3.25%
Combined VOC and NOx Emissions Reduction Percent in 2018: 3.86%										

VI. SUPPLEMENTAL ANALYSES

The EPA modeling guidance (EPA, 2014a) requires the supplemental analysis or the Weight-of-Evidence (WOE) analysis to show that the attainment can be reached in the future with some margin of safety, especially when projected future design values are close to the 2008 ozone standard. The purpose of this section is to provide the supplemental analyses to support the results from the CAMx model attainment demonstration in Section V. MAG had contracted with RAMBOLL ENVIRON for technical assistance on the WOE analyses. The WOE analysis report provided by RAMBOLL ENVIRON is included in Appendix B.

VI-1. Ambient Air Quality Trends

Trend analyses for the ambient ozone concentrations are useful to evaluate progress towards attainment of the 2008 ozone standard based on the historical air quality measurements.

The one-hour ozone monitoring data for the Maricopa eight-hour ozone nonattainment area were obtained from the EPA Air Quality System (AQS), which contains air pollution data collected by federal, state, local, and tribal agencies. Figure VI-1 and Table VI-1 illustrate the locations of the ozone monitoring sites used for the ambient ozone trend analysis.

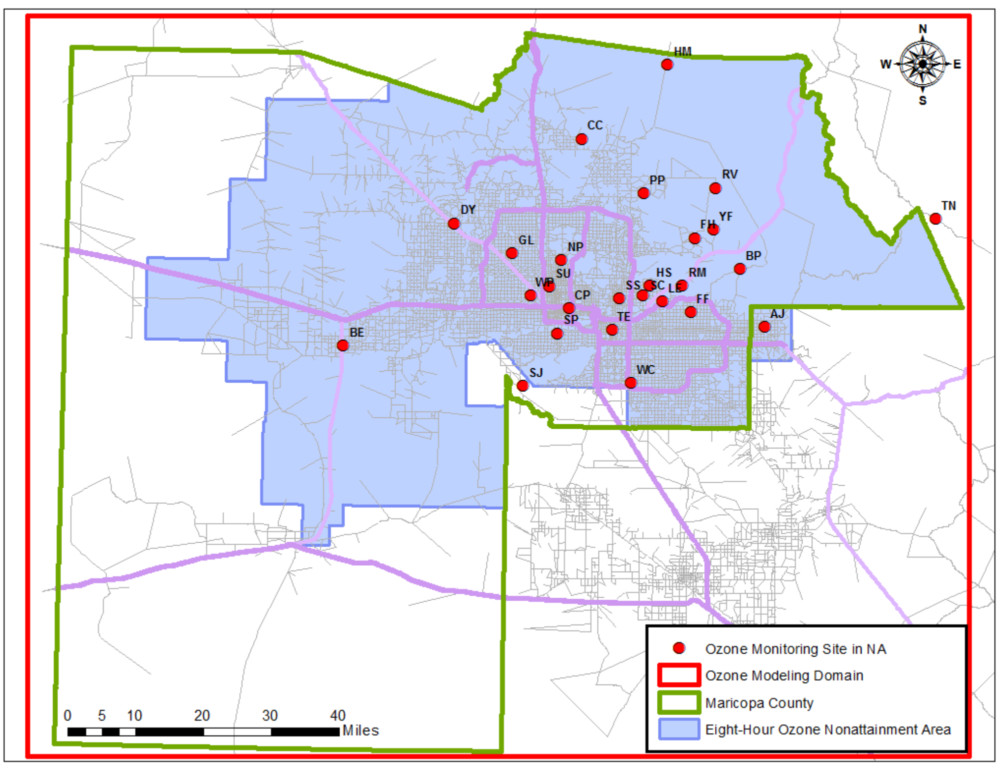


Figure VI-1. Locations of ozone monitoring sites for the ambient ozone trend analysis

Table VI-1. Ozone monitoring sites used for the ambient ozone trend analysis

AIRSID	Site Name	Site Abbr	Agency	Street Address	Latitude	Longitude
40070010	Tonto NM	TN	ADEQ	South of SR88	33.6547	-111.1074
40130019	West Phoenix	WP	MCAQD	3847 W Earll Dr, Phoenix	33.4839	-112.1426
40131004	North Phoenix	NP	MCAQD	601 E Butler Dr & 6th St, Phoenix	33.5603	-112.0663
40131010	Falcon Field	FF	MCAQD	4530 E McKellips Rd, Mesa	33.4522	-111.7333
40132001	Glendale	GL	MCAQD	6000 W Olive Ave, Glendale	33.5745	-112.1920
40132005	Pinnacle Peak	PP	MCAQD	25000 N Windy Walk, Scottsdale	33.7063	-111.8556
40133002	Central Phoenix	CP	MCAQD	1645 E Roosevelt St, Phoenix	33.4579	-112.0460
40133003	South Scottsdale	SS	MCAQD	2857 N Miller Rd, Scottsdale	33.4797	-111.9172
40134003	South Phoenix	SP	MCAQD	33 W Tamarisk Ave, Phoenix	33.4032	-112.0753
40134004	West Chandler	WC	MCAQD	275 S Ellis, Chandler	33.2990	-111.8843
40134005	Tempe	TE	MCAQD	1525 S College Ave, Tempe	33.4124	-111.9347
40134008	Cave Creek	CC	MCAQD	37019 N Lava Ln, Cave Creek	33.8217	-112.0174
40134010	Dysart	DY	MCAQD	16825 N Dysart, Surprise	33.6371	-112.3418
40134011	Buckeye	BE	MCAQD	26453 W MC85, Buckeye	33.3701	-112.6207
40135100	Fort McDowell/ Yuma Frank	YF	FMYN	18791 Yuma Frank Rd, Fort McDowell	33.6292	-111.6769
40137003	St Johns	SJ	GRIC	4208 W Pecos, Laveen	33.2902	-112.1606
40137020	Senior Center	SC	SRPMIC	10844 E Osborn Rd, Scottsdale	33.4882	-111.8557
40137021	Red Mountain	RM	SRPMIC	15115 Beeline Highway, Scottsdale	33.5080	-111.7553
40137022	Lehi	LE	SRPMIC	3250 N Stapley Dr, Mesa	33.4746	-111.8058
40137024	High School	HS	SRPMIC	4827 N Country Club Dr, Scottsdale	33.5081	-111.8385
40139508	Humboldt Mountain	HM	MCAQD	7 Springs Rd, Tonto National Forest	33.9828	-111.7987
40139702	Blue Point	BP	MCAQD	Usery Pass Rd, Blue Point	33.5455	-111.6093
40139704	Fountain Hills	FH	MCAQD	16426 E Palisades Blvd, Fountain Hills	33.6110	-111.7253
40139706	Rio Verde	RV	MCAQD	25608 N Forest Rd, Rio Verde	33.7188	-111.6718
40139997	Super Site	SU	ADEQ	4530 N 17th Ave, Phoenix	33.5038	-112.0958
40213001	Apache Junction	AJ	PCAQCD	305 E Superstition Blvd, Apache Junction	33.4214	-111.5436

Note: The air pollution control agencies maintaining the ozone monitoring sites in this table include Arizona Department of Environmental Quality (ADEQ), MCAQD, PCAQCD, the Salt River Pima-Maricopa Indian Community of Salt River Reservation (SRPMIC), the Gila River Indian Community Gila River Indian Reservation (GRIC), and Fort McDowell Yavapai Nation (FMYN).

The numbers of annual exceeding days for the 2008 eight-hour ozone standard in the Maricopa eight-hour ozone nonattainment area from 2000 to 2015 are given in Figure VI-2. The numbers of the annual exceeding days have steadily decreased from seventy-two in 2000 to nineteen in 2011 and seven in 2015. Exceedances of the 2008 eight-hour ozone standard in the Maricopa eight-hour ozone nonattainment area over this period occurred mostly in May (24%) and June (23%) followed by August (22%) and July (20%). In 2015, the numbers of days exceeding the 2008 ozone standard were five days in June and two days in August.

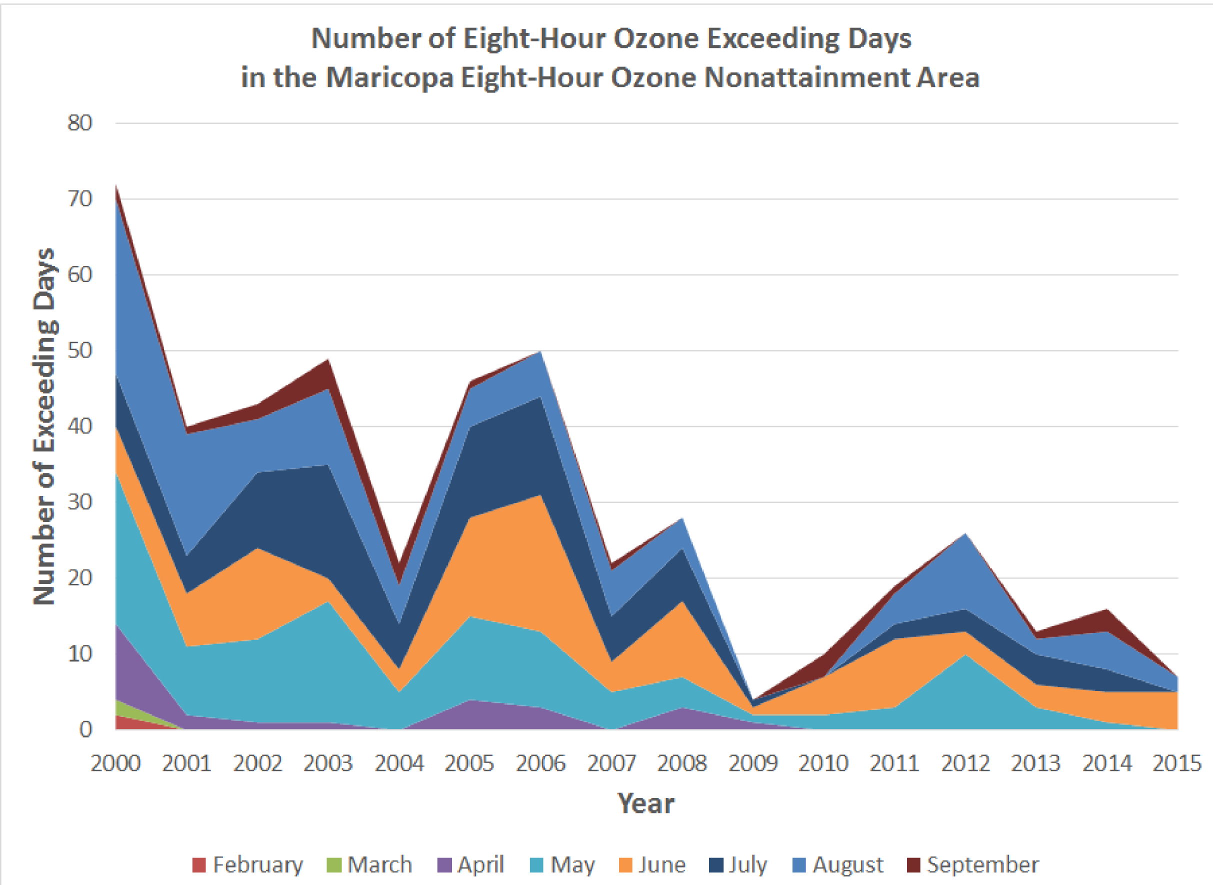


Figure VI-2. Trends in the numbers of eight-hour ozone exceeding days over 2000 - 2015 in the Maricopa eight-hour ozone nonattainment area

The ozone design value (DV) is defined as the three-year average of the annual fourth highest daily maximum eight-hour ozone concentration. Monitoring sites for the historical peak eight-hour ozone DVs in the Maricopa eight-hour ozone nonattainment area from 2002 to 2015 are presented in Table VI-2. The peak eight-hour ozone DVs decreased from 85 ppb to 77 ppb, and the monitoring site for the peak eight-hour ozone DV was shifted from Humboldt Mountain to North Phoenix.

Table VI-2. Monitoring sites with the historical peak eight-hour ozone DVs in the Maricopa eight-hour ozone nonattainment area

Average Period	Peak Eight-Hour Ozone DV	Peak DV Sites
2000 - 2002	85 ppb	North Phoenix (04-013-1004) Pinnacle Peak (04-013-2005) Humboldt Mountain (04-013-9508)
2001 - 2003	87 ppb	Humboldt Mountain (04-013-9508)
2002 - 2004	85 ppb	Humboldt Mountain (04-013-9508)
2003 - 2005	84 ppb	Humboldt Mountain (04-013-9508)
2004 - 2006	86 ppb	Red Mountain (04-013-7021)
2005 - 2007	83 ppb	Red Mountain (04-013-7021) Rio Verde (04-013-9706)
2006 - 2008	81 ppb	North Phoenix (04-013-1004)
2007 - 2009	76 ppb	North Phoenix (04-013-1004) Red Mountain (04-013-7021)
2008 - 2010	77 ppb	North Phoenix (04-013-1004)
2009 - 2011	77 ppb	North Phoenix (04-013-1004)
2010 - 2012	81 ppb	North Phoenix (04-013-1004)
2011 - 2013	81 ppb	North Phoenix (04-013-1004)
2012 - 2014	80 ppb	North Phoenix (04-013-1004)
2013 - 2015	77 ppb	North Phoenix (04-013-1004) Pinnacle Peak (04-013-2005) Supersite (04-013-9997)

*Design Value for this period excludes the June 20, 2015 ozone wildfire exceptional event.

Figure VI-3 presents the eight-hour ozone DV at the five sites that contributed to the peak eight-hour ozone DV for the time period of 2000 - 2015. The monitoring sites were grouped in the following three groups: (1) Central urban sites (blue line), (2) rural urban fringe sites (green lines), and (3) rural sites (orange lines). The downward trend in the eight-hour ozone DVs for the rural sites (Humboldt Mountain and Rio Verde) are apparently more prominent than the other two groups.

The mean, minimum, and maximum values of the annual fourth highest eight-hour ozone concentration for monitoring sites over 2000-2015 are provided in Figure VI-4. The maximum, minimum, and mean annual fourth highest eight-hour ozone concentrations in the Maricopa eight-hour ozone nonattainment area had decreasing trends during 2000-2009, but started increasing after reaching at the lowest level in 2009, and returned to the decreasing trends from 2012.

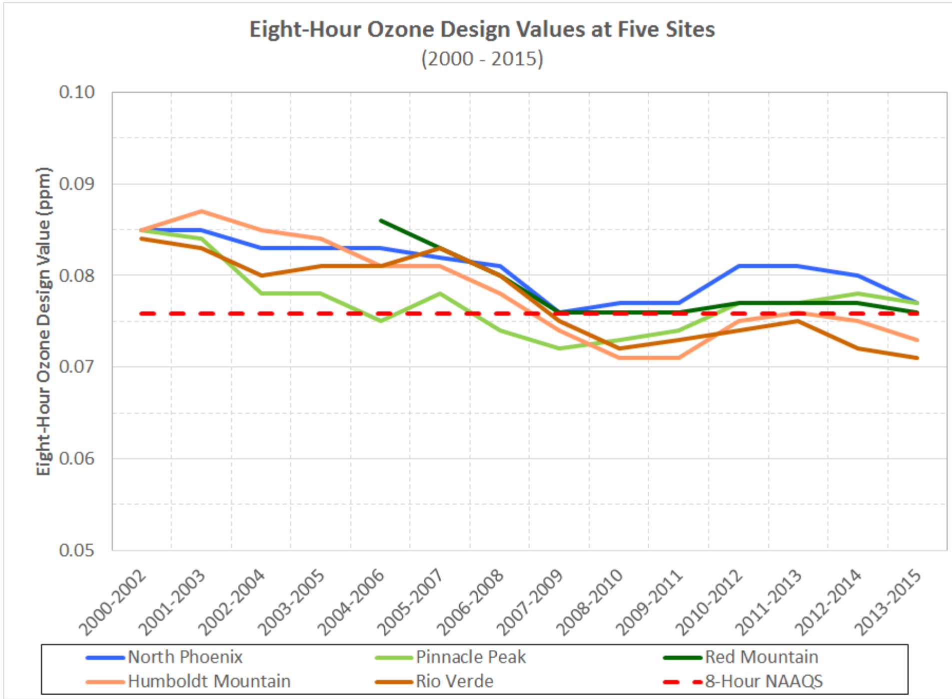


Figure VI-3. Annual eight-hour ozone DVs at the five monitoring sites contributing to the peak eight-hour ozone DV in Table VI-2 (Urban site: blue, rural urban fringe sites: green, and rural sites: orange)

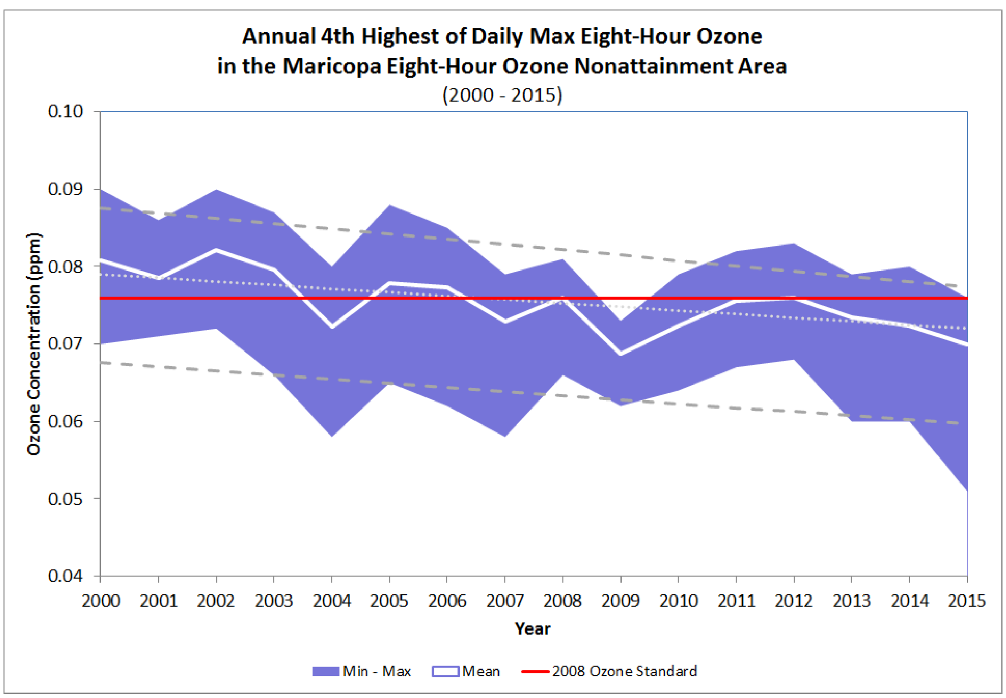


Figure VI-4. Trends in the annual peak fourth highest eight-hour ozone concentrations during 2000-2015 in the Maricopa eight-hour ozone nonattainment area

VI-2. Trends in Ambient Ozone Precursors

This section provides trends in the ambient ozone precursors to support the ambient ozone trends in Section VI-1. As a station of the EPA Photochemical Assessment Monitoring Stations (PAMS) network, the Supersite monitor in Phoenix has collected the ambient concentrations of ozone precursors (NOx, CO, and hydrocarbons) dating back to at least 1999 and current through 2015. The monitoring data at Supersite were downloaded from the EPA AQS system and averaged into annual values from all available observations in the summer ozone season (May 1 to September 30) of each year.

Figure VI-5 shows the NOx trend during the ozone season from 1999 to 2015 at the Supersite monitor. A regression line is shown for the trend, and indicates a general reduction in ambient NOx concentrations on the order of 1.6 ppb/year. This is consistent with the analysis performed in the MAG Eight-Hour Ozone Maintenance Plan (MAG, 2009), which reported on the observations between 1999 - 2007. The updated data indicates the trend has persisted downward in the years that followed. This translates to a 30-40% reduction over the period of 1999-2015.

The trend in ambient CO concentrations at the Supersite is given in Figure VI-6. The regression line indicates a general reduction in ambient CO concentrations on the order of 40.9 ppb per year. This translates in a reduction of 55-65% over 1999 - 2015.

PAMS monitors collect Total Non-Methane Organic Compounds (TNMOC), which will be used herein interchangeably with Volatile Organic Compounds (VOC) for trend analyses purposes. The trend in TNMOC at the Phoenix Supersite is given in Figure VI-7. Despite a lack of summer sampling in years 2000, 2003 and 2007, the regression line indicates a general reduction in ambient concentrations on the order of 11.6 ppbC/year (measured on the basis of number of carbon atoms). This translates to a reduction of 55-65% from 1999 to 2015. Figures VI-8 and VI-9 show the individually measured VOC species of acetaldehyde and formaldehyde, respectively. Both are considered as important anthropogenic tracer species, and the regression line of each trends in similar general direction as the other precursors. Acetaldehyde concentrations had a reduction of approximate 0.05 ppb/year, translating to a 20-30% decrease since 1999. Formaldehyde concentrations had a reduction of approximate 0.4 ppb/year, translating to a 70-80% decrease since 1999.

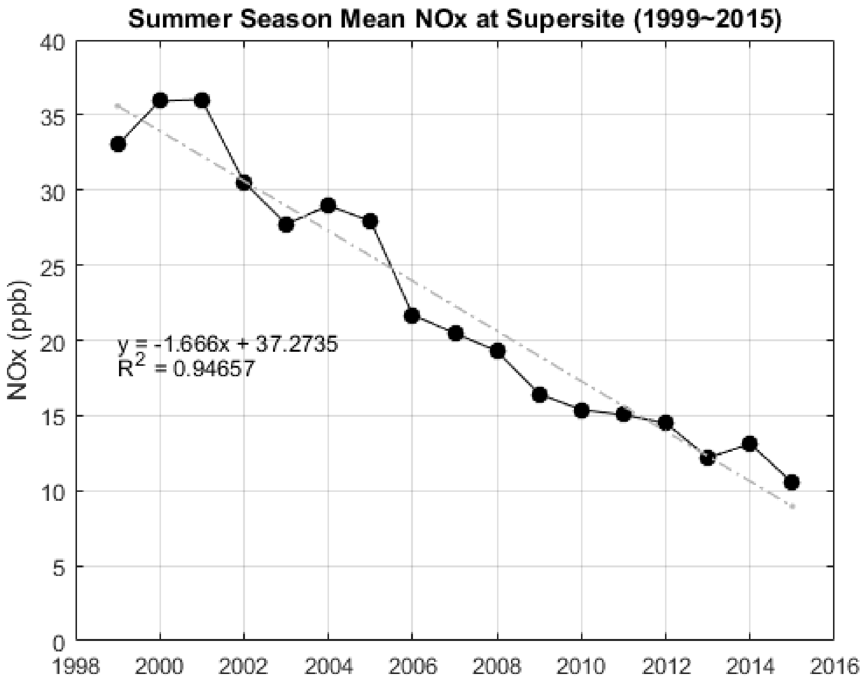


Figure VI-5. Trend with the fitted regression line in NOx concentrations averaged over each ozone season at Supersite from 1999 to 2015

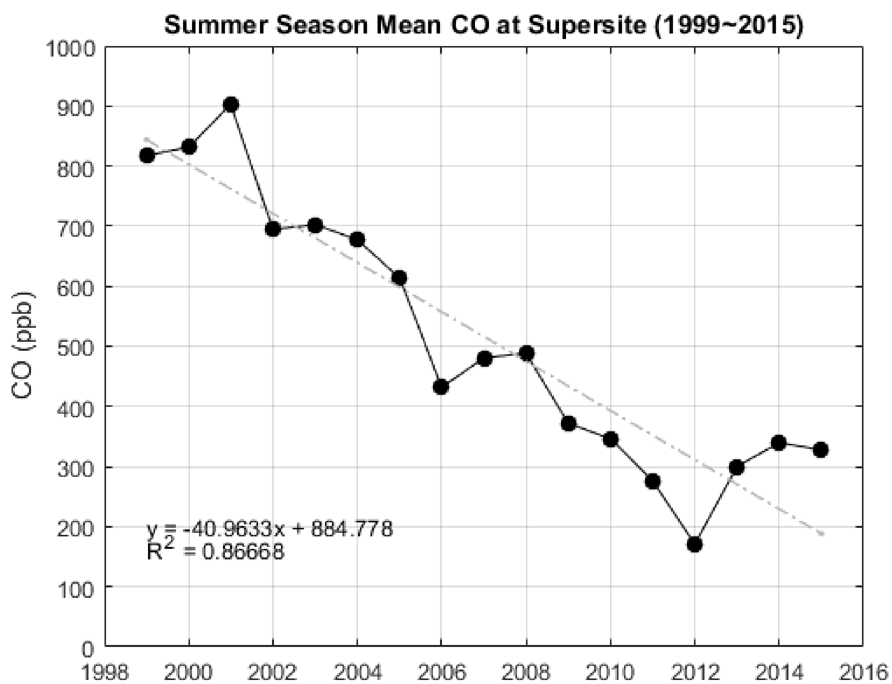


Figure VI-6. Trend with the fitted regression line in CO concentrations averaged over each ozone season at Supersite from 1999 to 2015

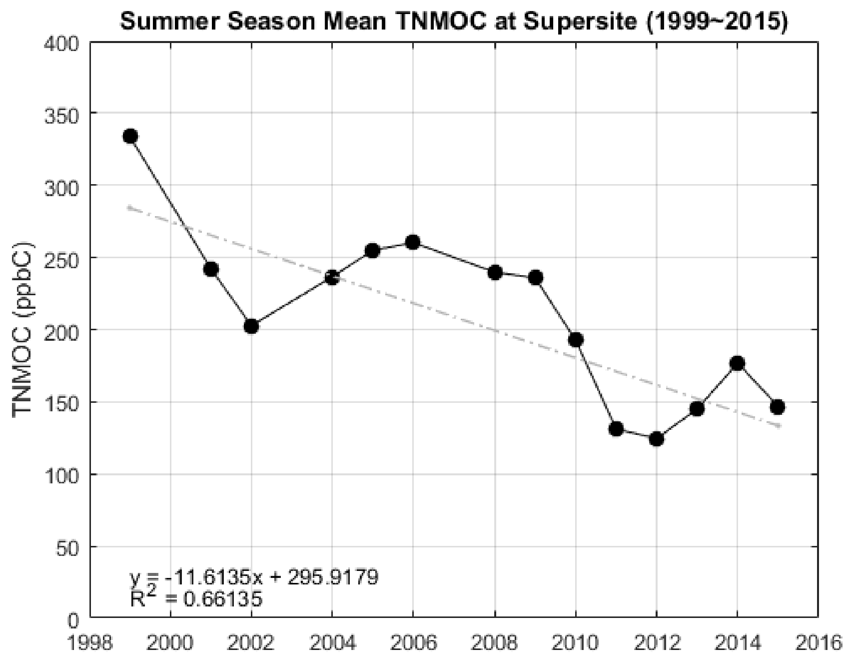


Figure VI-7. Trend with the fitted regression line in TNMOC concentrations averaged over each ozone season at Supersite from 1999 to 2015

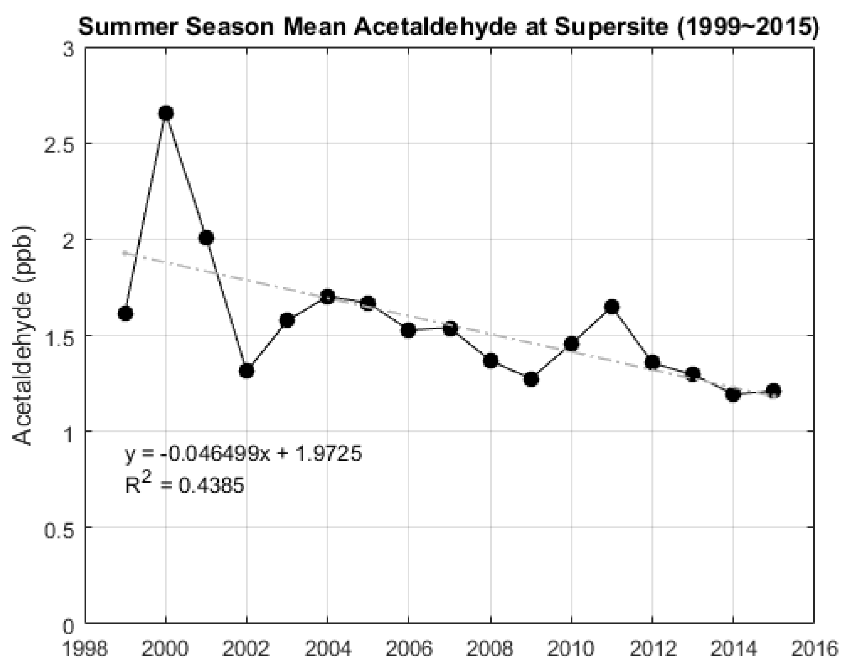


Figure VI-8. Trend with the fitted regression line in acetaldehyde concentrations averaged over each ozone season at Supersite from 1999 to 2015

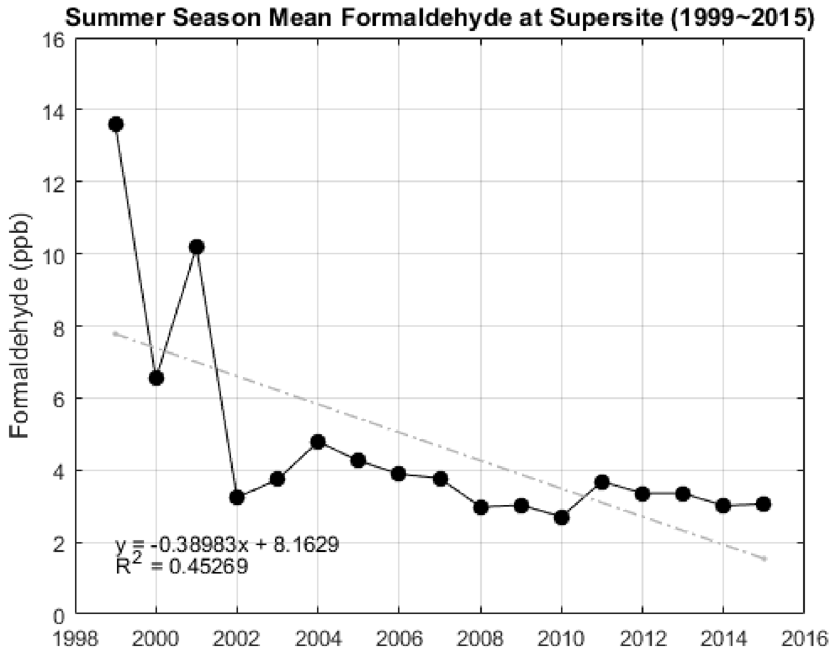


Figure VI-9. Trend with the fitted regression line in formaldehyde concentrations averaged over each ozone season at Supersite from 1999 to 2015

VI-3. Absolute Model Forecasts

To supplement the attainment test results, absolute model forecasts are used to demonstrate substantial reductions in absolute model concentrations from the base year to the future year. The following metrics were used in estimating the magnitude, frequency, and relative amount of nonattainment:

- Percent change in the total amount of ozone greater than 75 ppb
- Percent change in the number of grid cells greater than 75 ppb
- Percent change in the grid cell hours (days) greater than 75 ppb
- Percent change in the maximum modeled eight-hour ozone concentration

Table VI-3 presents the above metrics for the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain for the May - September episode. It is shown that the predicted eight-hour ozone concentration change between the base and future years is substantial in terms of the magnitude, frequency, and relative amount of nonattainment. This is valid for both the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain.

Table VI-3. Absolute modeling metrics for entire episode

Metrics	Eight-Hour Ozone Nonattainment Area			Modeling Domain (4 km)		
	Base Year (2011)	Future Year (2017)	Percent Change	Base Year (2011)	Future Year (2017)	Percent Change
Total Concentration	4,008.46 ppm	2,354.92 ppm	-41.3%	7,801.45 ppm	4,771.22 ppm	-38.8%
Number of Grid	49,941 cells	29,654 cells	-40.6%	97,208 cells	59,969 cells	-38.3%
Grid Cell Hours	346 hours	191 hours	-44.8%	397 hours	213 hours	-46.3%
Maximum Ozone Modeled	100.23 ppb	89.24 ppb	-11.0%	100.23 ppb	90.06 ppb	-10.1%

VI-4. Process Analysis

To assess which ozone precursor (e.g., VOC or NOx) limits ozone production in the Maricopa eight-hour ozone nonattainment area, the CAMx Chemical Process Analysis (CPA) was demonstrated for the base and future years. This analysis provides detailed chemically meaningful attributes over groups of reactions in the chemical mechanism for a selected area. One result of CPA is the classification of NOx-limited and VOC-limited areas. An understanding of such areas is key to assessing the impact of control measures to the complex, nonlinear response of ozone concentrations. If the responses are quantified correctly, the attainment test may have more physical justification.

To classify the NOx-limited and VOC-limited areas, the production rates (P) of hydrogen peroxide (H_2O_2) and nitric acid (HNO_3) are derived using CAMx. The ratio of this two is the indicator which can be used to classify ozone formation as being NOx-limited when $P(H_2O_2)/P(HNO_3)$ is greater than 0.35 and VOC-limited when the ratio is below 0.35 (Sillman, 1995).

Figure VI-10 illustrates the CPA results for four time periods, which were averaged over the entire episode days in 2011 and 2017. Warm (red) and cool (blue) colors in Figure VI-10 denote VOC-limited and NOx-limited conditions, respectively. The 4 km modeling domain is in a VOC-limited condition at night time because of no biogenic emissions from the photosynthesis of plants. It gradually turns to a NOx-limited as sunlight induces biogenic VOC emissions. Finally, it becomes NOx-limited at the PM peak with the exception of the urban core, which has abundant anthropogenic NOx emissions. Figure VI-10 also visualizes a distinct transition of the Phoenix urban core from VOC-limited conditions in 2011 to NOx-limited conditions in 2017. This transition usually occurs when NOx emissions decrease or VOC emissions increase in a given area. According to the emissions inventory in Section III, both NOx and VOC emissions in the Maricopa eight-hour ozone nonattainment area decrease between 2011 and 2017. This result indicates substantial

NOx reduction, primarily contributed by onroad mobile source, which caused the Phoenix urban core area to shift from being VOC-limited towards NOx-limited. According to the Empirical Kinetic Modeling Approach (EKMA) diagrams (EPA, 1981), NOx reductions are generally less effective at bringing ozone levels down under the VOC-limited condition, and can even increase ozone levels. NOx reductions, however, are effective in an area within NOx-limited condition or even in an area in a transitional regime between VOC-limited and NOx-limited conditions. While the Phoenix urban core area is in the transitional regime, outside of the Phoenix urban core area is consistently NOx-limited. This indicates that NOx emission controls may be more effective strategy to reduce ozone levels in the Maricopa eight-hour ozone nonattainment area.

The CPA results for 2011 and 2017 were also compared month by month. Figure VI-11 shows a seasonal variation of the VOC-limited area, which is largest in June and smallest in July. The transition from VOC-limited to NOx-limited in the Phoenix urban core area consistently appears for all months. This results indicate that NOx emission controls would be more efficient in reducing ozone than VOC emission controls in 2017.

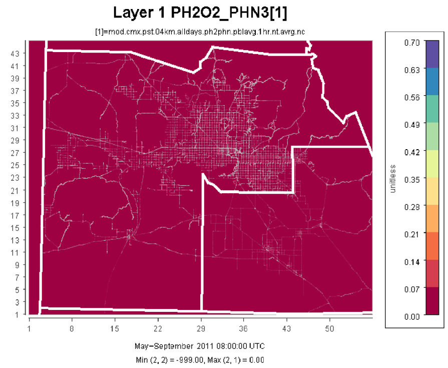
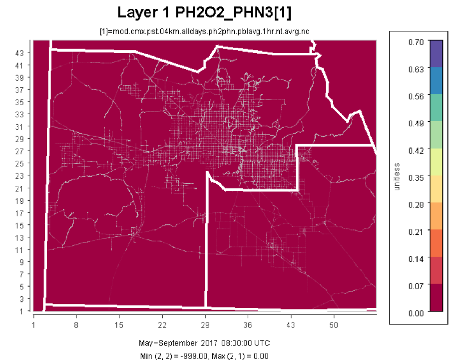
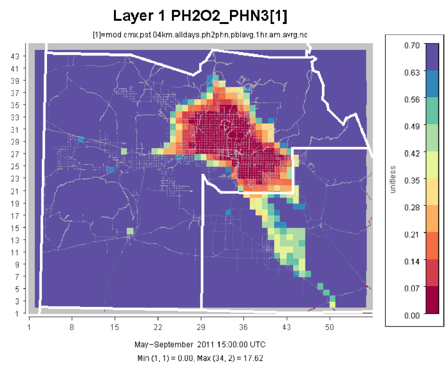
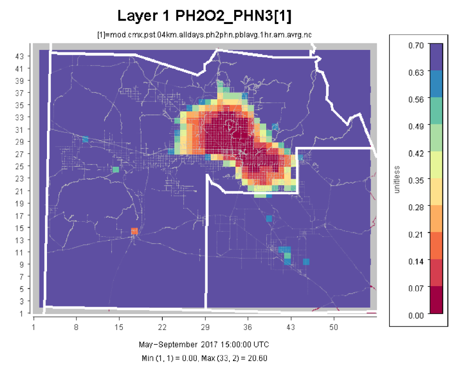
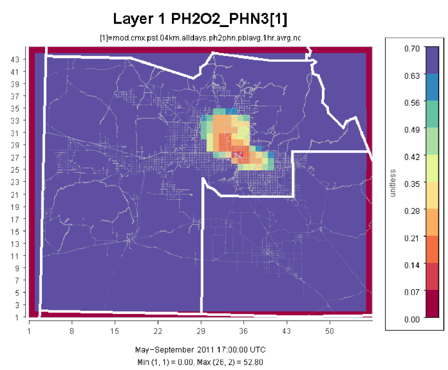
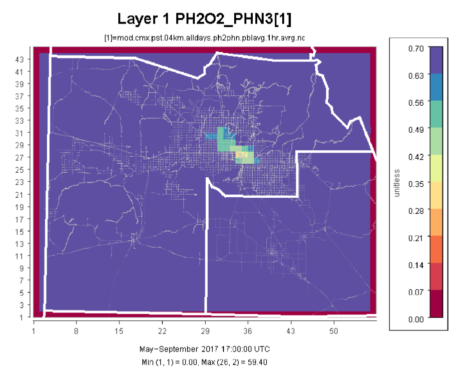
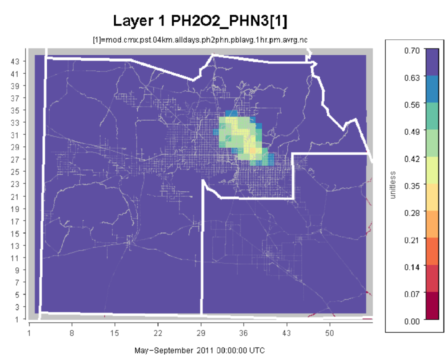
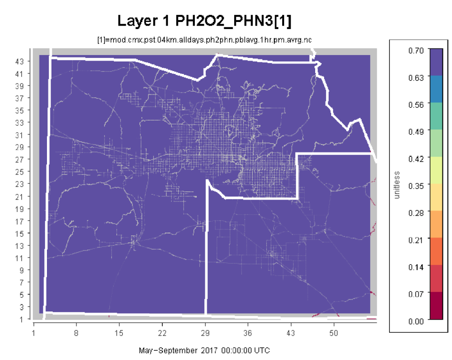
Time	2011	2017
Night Time (1:00 am)		
AM Peak (8:00 am)		
Mid-Day (12:00 pm)		
PM Peak (5:00 pm)		

Figure VI-10. Process analysis results by time of day (episode average)

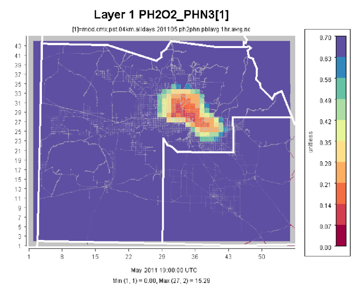
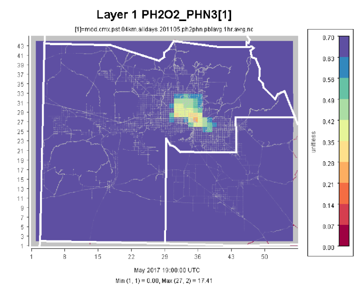
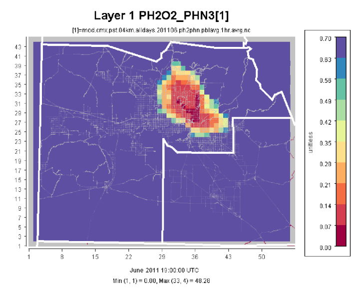
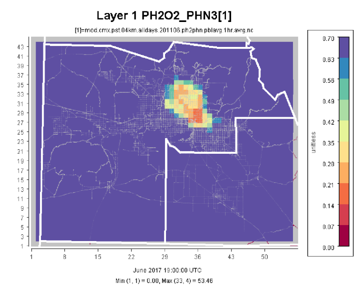
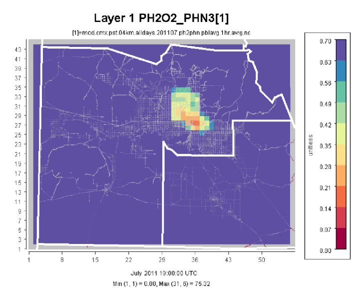
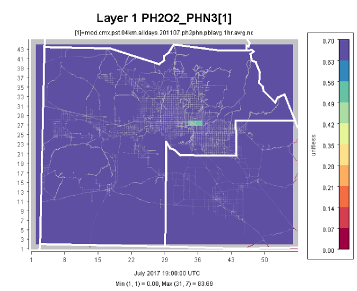
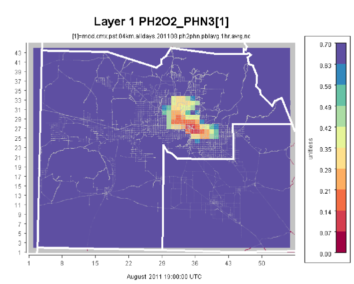
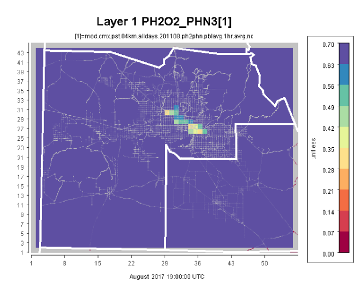
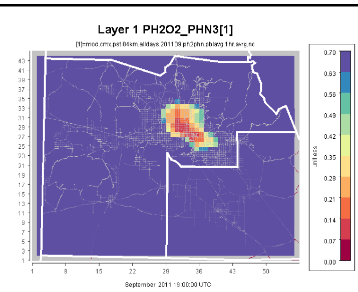
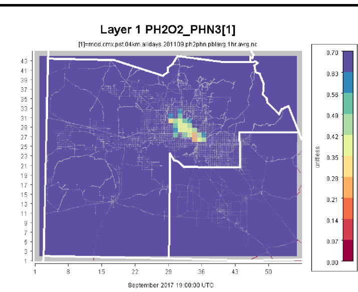
Month	2011	2017
May		
June		
July		
August		
September		

Figure VI-11. Process analysis results (monthly average at noon)

VI-5. Zero-Out Emissions Analysis

Transported ozone from upwind areas may significantly affect local ozone concentration. Zero-out anthropogenic emissions analysis was conducted to evaluate the impact of transported anthropogenic emissions on ozone concentrations in the Maricopa eight-hour ozone nonattainment area. The analysis is based on the underlying assumption that upwind anthropogenic emissions were perfectly controlled. To quantify the contribution of 2017 anthropogenic emissions from all upwind source regions to ozone concentrations in the Maricopa eight-hour ozone nonattainment area, the CAMx runs were implemented with regionally zeroed-out anthropogenic emissions. The zero-out regions include Arizona and the neighboring states of Arizona (California, Nevada, Utah, Colorado, New Mexico, and Texas), groups of states (East, Midwest, and Northwest states groups), U.S., and Mexico as shown in Figure VI-12.

The US background (USB) contribution to the Maricopa eight-hour ozone nonattainment area was quantified in this analysis. The USB is defined by EPA as all global natural sources of ozone and all anthropogenic sources from outside the U.S.

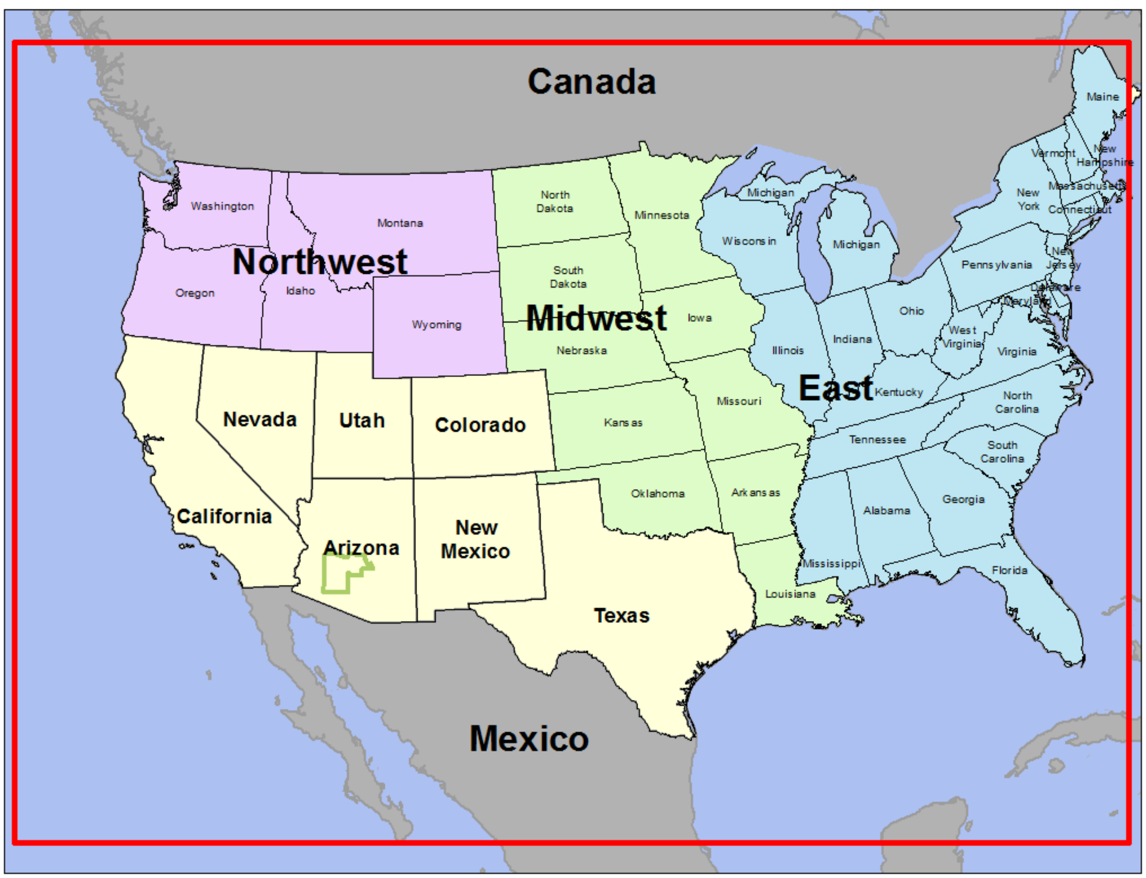


Figure VI-12. Regions for the CAMx zero-out analysis

The CAMx runs were performed using zero-out anthropogenic emissions for the regions for the 2017 attainment year. For the zero-out analysis, future design values (DVF) for monitoring sites in the Maricopa eight-hour ozone nonattainment area were calculated based on the ten highest ozone prediction days for the five-month modeling period and each month of the modeling period. To evaluate the contributions of the zero-out anthropogenic emissions of the regions to the North Phoenix site, on which the peak ozone design value was predicted in 2017, the DVF derived from the zero-out anthropogenic emissions for each region was subtracted from the 2017 DVF developed for the attainment demonstration by using the 2017 emissions inventory. Table VI-4 provides the ozone contributions of each region to the DVF at the North Phoenix site.

For the five-month modeling episode, he USB contributed up to 47.3 ppb (63%) and in-state Arizona sources up to 24.4 ppb (32%) to the DVF at the North Phoenix site, as shown in Table VI-4. The contributions of anthropogenic emissions from California, Mexico, and Texas are also provided in Table VI-4. Mexico contributed 1.9 ppb (3%) to ozone concentrations at North Phoenix, California contributed 1.3 ppb (2%), and Texas contributed 0.9 ppb (1%). Table VI-4 revealed that the transported anthropogenic emissions contribution to ozone concentrations at the North Phoenix site remarkably varied from month-to-month due to different meteorological conditions. The contribution of USB was the highest in May (87% or 68.1 ppb) and the lowest in August (51% or 36.9 ppb). California contributed to the peak 2017 DVF with the highest impact up to 4.5 ppb in June, Mexico contributed with the highest impact up to 7.1 ppb in July, and Texas contributed by greater than 1 ppb in August and September.

Table VI-4. Contributions of regional anthropogenic emissions and USB to DVF at the North Phoenix site (unit: ppb)

Region	May	Jun	Jul	Aug	Sep	May-Sep
Arizona	5.9	15.4	20.8	30.7	22.4	24.4
California	2.4	4.5	1.8	1.1	3.1	1.3
Colorado	0.0	0.2	0.3	0.4	0.3	0.3
New Mexico	0.1	0.3	0.5	0.6	0.5	0.5
Nevada	0.5	0.3	0.3	0.3	0.4	0.4
Texas	0.1	0.2	0.9	1.6	1.1	0.9
Utah	0.2	0.3	0.3	0.3	0.5	0.4
East	0.0	0.0	0.2	0.2	0.2	0.1
Midwest	0.0	0.0	0.2	0.4	0.3	0.2
Northwest	0.6	0.4	0.0	0.1	0.3	0.2
Mexico	0.6	3.2	7.1	4.5	3.5	1.9
USB	68.1	56.8	48.4	36.9	46.4	47.3

VI-6. Decoupled Direct Method

The decoupled direct method (DDM) is an alternative and improved methodology for evaluating model sensitivity, which can be used as further evidence that the attainment demonstration yields reasonable results. The method can be used to characterize the potential uncertainties in the predicted future year emissions and ozone concentrations. The CAMx model provides an option for the high-order DDM (HDDM) to calculate second-order sensitivity coefficients along with first-order sensitivity coefficients with respect to predicted ozone concentrations to pollutant sources such as boundary conditions and anthropogenic emissions. The CAMx HDDM includes options for varying emission inputs to the CAMx model; scaling emissions by a factor; additively increasing emissions by a constant amount everywhere; or zeroing-out emissions by source category and geographic region. The CAMx HDDM was used to evaluate the sensitivity of the CAMx ozone predictions to emission changes in 2017.

The maximum eight-hour ozone DVFs in 2017 for 0%, 5%, 10%, 15%, and 20% reductions of anthropogenic VOC and NOx emissions in the 4 km modeling domain are given in Table VI-5. It reveals that the reduction of NOx is more effective in ozone reduction than the VOC reduction, and an ozone reduction of 1 ppb requires more than a 10% reduction in the 2017 anthropogenic VOC and NOx emissions in the 4 km modeling domain.

Table VI-5. Sensitivity of maximum eight-hour ozone DVF in 2017 to reductions of anthropogenic VOC and/or NOx emissions in the 4 km modeling domain (unit: ppb)

Pollutant	% Reduction				
	0%	5%	10%	15%	20%
VOC	75.6	75.4	75.3	75.2	75.1
NOx	75.6	75.2	74.8	74.3	73.9
VOC & NOx	75.6	75.1	74.6	74.2	73.8

Table VI-6 presents the sensitivity of the maximum eight-hour ozone DVF in 2017 to increases of anthropogenic VOC and/or NOx emissions in the 4 km modeling domain. Increases of anthropogenic VOC emissions up to 15%, NOx emissions up to 5%, and VOC and NOx emissions less than 5% from the 2017 emissions inventory still resulted in the attainment of the 2008 ozone standard. The results indicate that the 2017 anthropogenic emissions used in the attainment demonstration provides an approximate 5% of the safety margin for anthropogenic VOC and NOx emissions for the attainment of the 2008 ozone standard.

Table VI-6. Sensitivity of maximum eight-hour ozone DVF in 2017 to increase of anthropogenic VOC and/or NOx emissions in the 4 km modeling domain (unit: ppb)

Pollutant	% Increase				
	0%	5%	10%	15%	20%
VOC	75.6	75.7	75.8	75.9	76.0
NOx	75.6	75.9	76.2	76.4	76.7
VOC & NOx	75.6	76.0	76.5	77.0	77.5

VI-7. Source Apportionment Technology

Photochemical model source apportionment is a probing tool to estimate the contribution of multiple source areas, categories, and pollutant types to ozone formation. In this analysis, the contribution to future design values from emission sources in the 4 km modeling domain was evaluated using the CAMx Ozone Source Apportionment Technology (OSAT) tool. Emissions in the 2017 future year were used in applying the OSAT tool to evaluate the contribution of emission sources to ozone.

The impacts of point, area, onroad, and nonroad emission sources in the 4 km modeling domain on the North Phoenix site were evaluated by the OSAT analysis since the highest future design value was predicted at the North Phoenix site in Section V-1. The contribution of point, area, onroad, and nonroad emission sources in the 4 km modeling domain to ozone at North Phoenix are provided in Table VI-7. Onroad mobile source contribution was the highest, and then followed by area source, nonroad mobile source, and point source contribution. Since onroad mobile sources are the major contributor to NOx emissions in the Maricopa eight-hour ozone nonattainment area and the 4 km modeling domain, as shown in Tables III-8 and 9, onroad mobile source emission controls are the most efficient in further reducing ozone concentrations in the Maricopa eight-hour ozone nonattainment area.

Table VI-7. Percent contributions of anthropogenic emission source sector in the 4 km modeling domain to high ozone at the North Phoenix site

Emissions Source	May	June	July	August	September
Onroad	45.9%	52.8%	51.2%	58.3%	45.2%
Area	32.1%	20.0%	22.4%	11.6%	32.5%
Nonroad	16.8%	22.4%	20.2%	17.1%	16.1%
Point	5.2%	4.8%	6.2%	13.0%	6.2%

VI-8. Uncertainty of the Projected 2017 Emissions for Electric Generating Units

The projected 2017 emissions for Electric Generating Units (EGU) that were used in the CAMx model attainment demonstration for the Maricopa eight-hour ozone nonattainment area were developed based on the maximum EGU emissions over 2005-2014. The assumption of the ten-year maximum emissions for EGU, however, may be over-estimated for the 2017 EGU emissions. EGU emissions may not grow so rapidly during such a short period of 2011-2017 due to EGU NOx controls and fuel conversions from coal to natural gas. EPA's national power plant emission trends affirm that the nationwide NOx emissions of power plants substantially decreased over 1990 - 2015 even though the capacity of electricity increased over 1990 - 2005 and slightly decreased during the recent five years, as shown in Figure VI-13 (EPA, 2016). As shown in Figures VI-14 and VI-15, the ten-year maximum emissions of most power plants for 2017 are generally higher than the annual VOC and NOx emissions for the period of 2011-2014. Consequently, the maximum 2017 future design value of 75.6 ppb based on the ten-year maximum EGU emissions were likely to be overestimated.

Thus, an alternative no-growth assumption for the EGU emissions was tested for the attainment of the 2008 ozone standard. The same 2011 EGU emissions are assumed for the 2017 EGU emissions for the attainment test. The alternative approach has lowered the future design values up to 0.6 ppb. The maximum 2017 design value was predicted at 75.0 ppb, as shown in Table VI-8. The no-growth assumption for the 2017 EGU emissions provides a significant safety margin for the modeled attainment of the 2008 ozone standard.

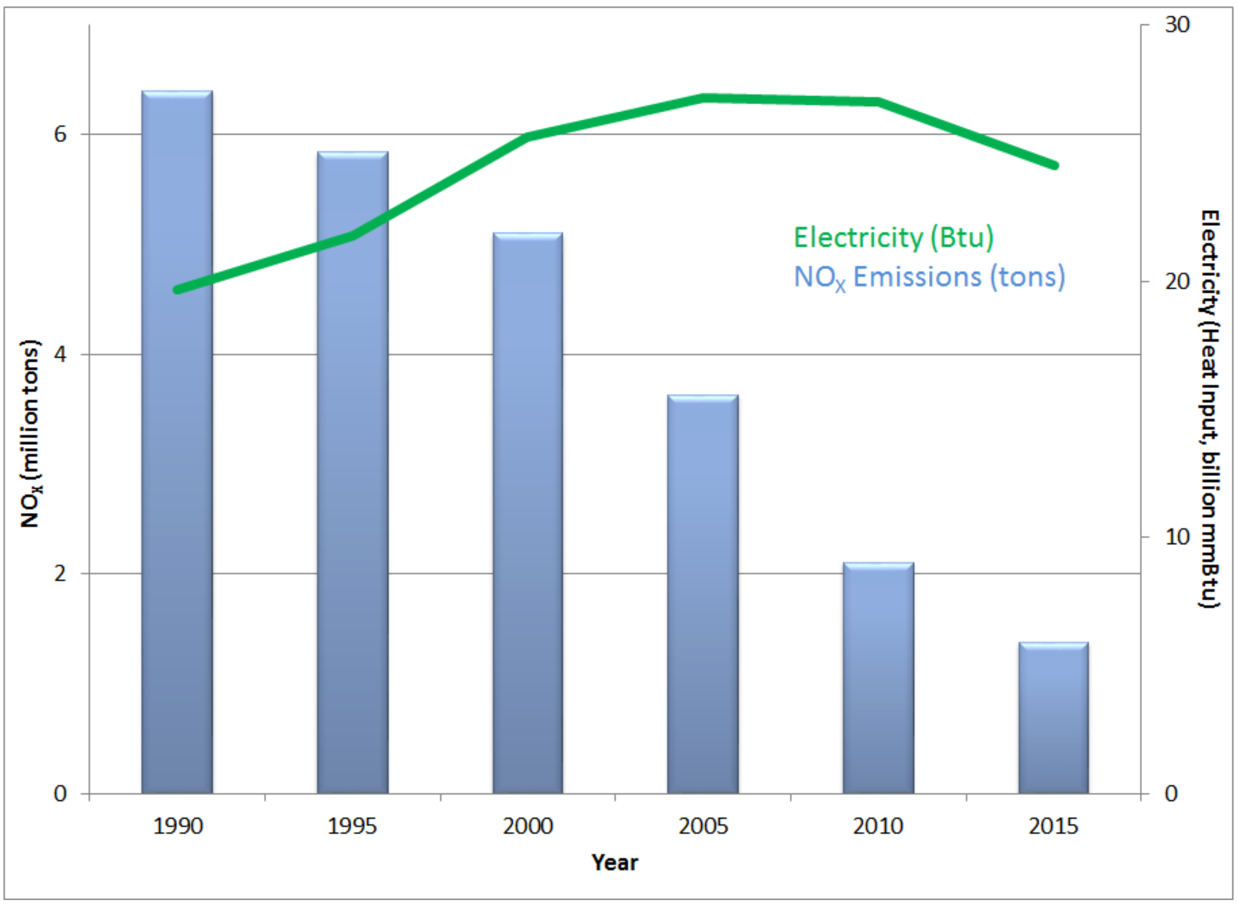


Figure VI-13. EPA national trends of NOx emissions and electricity generation capacity of power plants since 1990

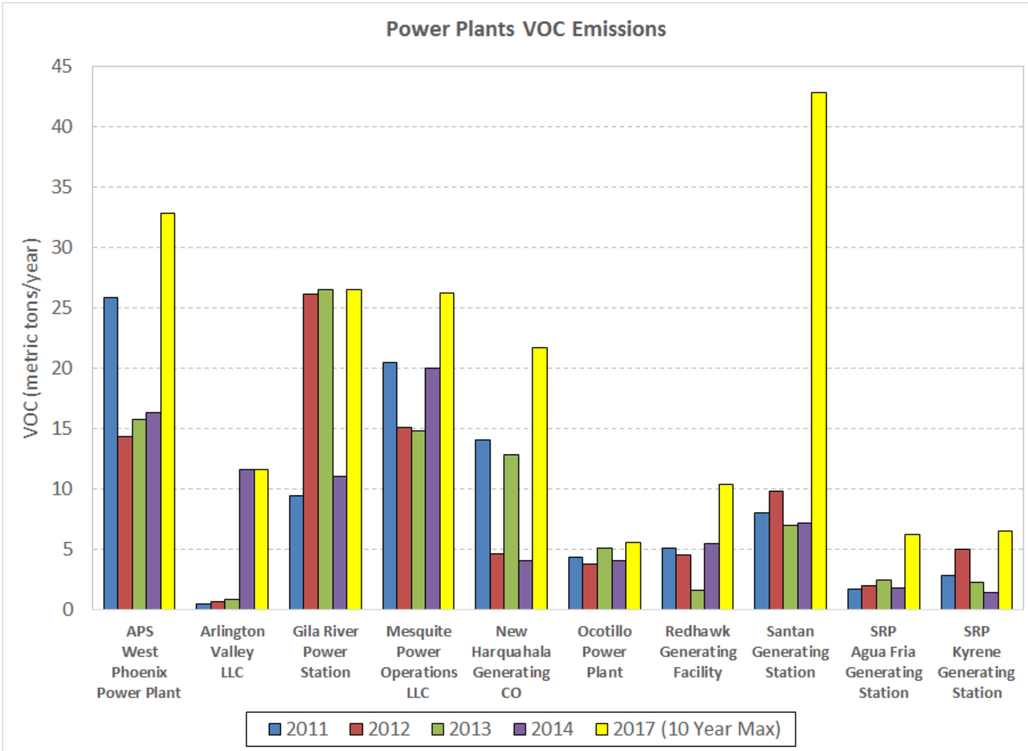


Figure VI-14. VOC emissions of power plants in Maricopa County

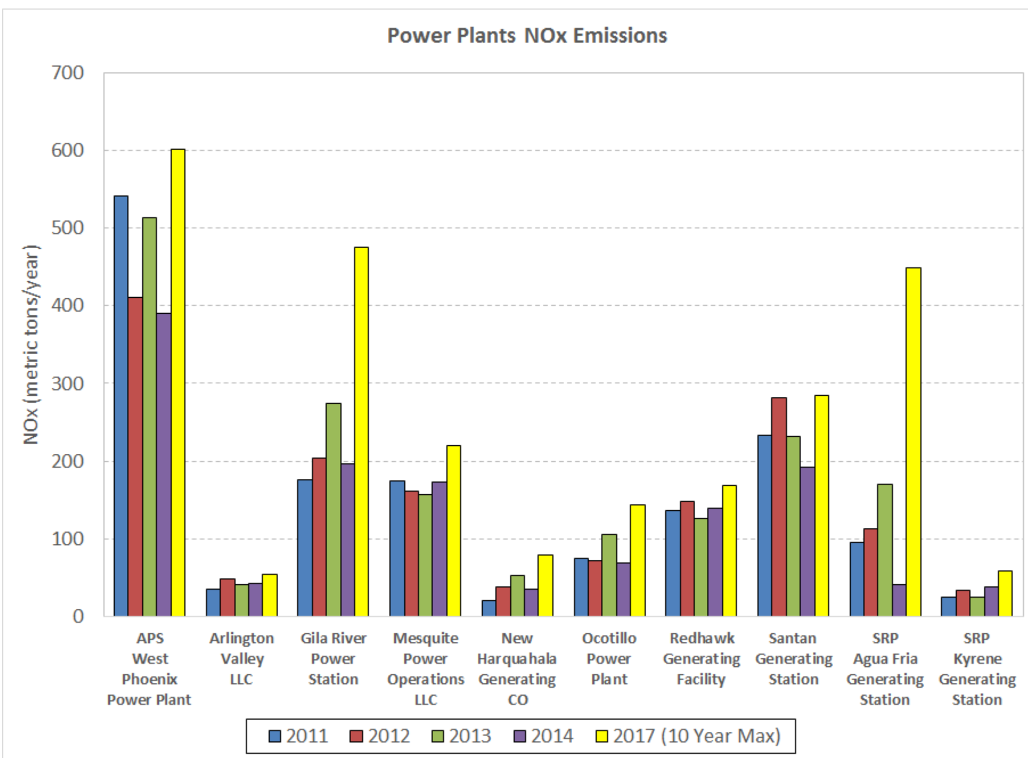


Figure VI-15. NOx emissions of power plants in Maricopa County

Table VI-8. 2017 future design values (DVF) based on the 10-year maximum EGU emissions and the 2011 EGU emissions for 2017 (unit: ppb)

Site Name	AIRS	DVF Based on the 10-Year Max EGU Emissions	DVF Based on the 2011 EGU Emissions	DVF Difference
West Phoenix	040130019	73.3	73.0	0.3
North Phoenix	040131004	**75.6**	**75.0**	**0.6**
Falcon Field	040131010	64.9	64.4	0.5
Glendale	040132001	71.9	71.6	0.3
Pinnacle Peak	040132005	70.1	69.7	0.4
Central Phoenix	040133002	69.7	69.4	0.3
South Scottsdale	040133003	71.6	71.1	0.5
South Phoenix	040134003	71.5	71.3	0.2
West Chandler	040134004	69.8	69.7	0.1
Tempe	040134005	67.7	67.5	0.2
Cave Creek	040134008	71.6	71.3	0.3
Dysart	040134010	68.1	67.8	0.3
Buckeye	040134011	63.4	63.3	0.1
Fort McDowell/Yuma Frank	040135100	65.4	65.1	0.3
Senior Center	040137020	69.6	69.2	0.4
Red Mountain	040137021	71.6	71.1	0.5
Lehi	040137022	69.4	69.0	0.4
High School	040137024	68.9	68.5	0.4
Humboldt Mountain	040139508	69.8	69.6	0.2
Blue Point	040139702	70.0	69.7	0.3
Fountain Hills	040139704	69.4	69.0	0.4
Rio Verde	040139706	68.3	67.9	0.4
Super Site	040139997	72.8	72.4	0.4
Apache Junction	040213001	67.9	67.7	0.2

VII. CONCLUSIONS

The CAMx modeling, as discussed in the previous sections, demonstrated that the Maricopa eight-hour ozone nonattainment area would attain the 2008 ozone standard by the end of ozone season in 2017. The CAMx model attainment demonstration was performed based on the five-year weighted 2011 base year design values for monitors which included the worst ozone episodes induced by the unfavorable meteorology in 2011 and 2012 during the span of 2002-2015. The CAMx modeling predicted the 2017 maximum design value of 0.0756 ppm (or 75.6 ppb) at the North Phoenix monitor. The unmonitored area analysis with CAMx and MATS predicted the 2017 maximum design value of 0.0755 ppm (75.5 ppb) in the unmonitored area of the 4 km modeling domain. The 2017 maximum design value in the unmonitored area was located northwest of the Supersite monitor. The future design values in ppm were truncated to three significant digits for comparison with the 2008 ozone standard of 0.075 ppm (or 75 ppb) for the model attainment demonstration. Since both the truncated 2017 maximum design values for the monitors and the unmonitored area in the 4 km modeling domain are 0.075 ppm and equal to the 2008 ozone standard, the Maricopa eight-hour ozone nonattainment area satisfies the EPA attainment test requirements for the 2008 ozone standard.

To support the CAMx model attainment demonstration for the monitors and the unmonitored area in the Maricopa eight-hour ozone nonattainment area, the supplemental analyses were provided in Section VI and Appendix B. The purpose of the supplemental analyses or Weight-of-Evidence (WOE) analyses is to provide additional evidence that attainment will be reached in the future with some margin of safety, especially when the projected future design value is close to the 2008 ozone standard.

In one of the WOE analyses for the MAG CAMx attainment demonstration, which was discussed in Appendix B, the EPA modeling analysis performed for the proposed Cross-State Air Pollution Rule (CSAPR) for the 2008 ozone standard showed that the peak 2017 five-year weighted design value in Maricopa county is 75.0 ppb at the North Phoenix site and the design values for all other sites are below 73.0 ppb. The EPA modeling analysis affirmed that the Maricopa eight-hour ozone nonattainment area would be in attainment of the 2008 ozone standard in 2017.

The analyses for ambient ozone trends over 2010-2015 pointed out that the annual 4^{th} highest daily maximum eight-hour ozone concentrations in the Maricopa eight-hour ozone nonattainment area have been generally decreasing except for the bump-ups in 2011 and 2012 because of abnormally less cloud coverage in 2011-2012, an unusually large number of high-temperature days in 2012, and more potential impacts from wildfire emissions in 2012 than in 2008-2011. The ambient ozone precursor trends at Supersite demonstrated consistency with the decreasing ozone trends in the area. Ambient NOx concentrations at Supersite show a strong downward trend since 1999. Summer season mean NOx in 2015 has been reduced to one third of the 1999 level. Concentrations of VOC have declined at Supersite during 1999-2010, slightly increased in 2011, and then re-established the decreasing trend in 2012. VOC concentrations have declined by more than half during the

1999-2015 period.

The projected 2017 emissions may contain potential uncertainties due to the incomplete data and assumptions used in the anthropogenic emissions projections. The CAMx decoupled direct method (DDM) was used to evaluate the impact of the uncertainties in the projected 2017 anthropogenic emissions on the model attainment demonstration in Section VI-6. Increases of anthropogenic VOC emissions up to 15%, NOx emissions up to 5%, and both VOC and NOx emissions less than 5% in the Maricopa eight-hour ozone nonattainment area from the 2017 emissions inventory provided a margin of safety for the attainment of the 2008 ozone standard. The CAMx DDM results also indicated less sensitivity of ozone concentrations to changes in VOC emissions than changes in NOx emissions.

The projected 2017 emissions for Electric Generating Units (EGU) that were used in the CAMx model attainment demonstration for the Maricopa eight-hour ozone nonattainment area were based on the maximum EGU emissions over 2005-2014. The assumption of the ten-year maximum emissions for EGU might be too conservative for the 2017 EGU emissions since the EPA power plant emission trends show that the nationwide NOx, SO_2, and CO_2 emissions have substantially decreased over 1990-2015 (EPA, 2016). For this reason, an alternative assumption of the no-growth EGU emissions between 2011 and 2017 was tested for the attainment of the 2008 ozone standard. The maximum 2017 design value was predicted at 75.0 ppb and lowered by as much as 0.6 ppb with constant EGU emissions between 2011 and 2017. The alternative approach provided a higher margin of safety for the attainment of the 2008 ozone standard.

The background ozone analyses verified the extensive background contributions of transported international ozone and precursor emissions from anthropogenic and biogenic sources to local ozone, and indicated that background ozone in the Maricopa eight-hour ozone nonattainment area is rising in response to increasing non-US emissions. It was also found that non-US ozone and precursor emissions (i.e., MOZART boundary data for the 36 km modeling domain) contributed to the 2017 future design values for the monitors up to 47.3 ppb based on the top ten high ozone prediction days for the May-September period. Anthropogenic emissions from Mexico contributed up to 7.1 ppb in July, and anthropogenic emissions from California contributed up to 7.3 ppb in June for the 2017 future design values for the monitors in the Maricopa eight-hour ozone nonattainment area. The background ozone analyses confirmed that the uncontrollable background ozone and precursor emissions significantly influenced ozone concentrations in the Maricopa eight-hour ozone nonattainment area. Ambient ozone controls in the western region may have become less effective and more difficult and burdensome due to the continual rise of transported non-US ozone and precursor emissions.

The model attainment demonstration for the monitors and the unmonitored area, affirmed by the supplemental and weight of evidence analyses, supports the conclusion that the Maricopa eight-hour ozone nonattainment area will attain the 2008 ozone standard by the attainment date of July 20, 2018.

REFERENCES

1. Appel, K. W., Foley, K. M., Bash, J. O., Pinder, R. W., Dennis, R. L., Allen, D. J., and Pickering, K. (2011), A Multi-Resolution Assessment of the Community Multiscale Air Quality (CMAQ) Model v4.7 Wet Deposition Estimates for 2002-2006, Geoscientific Model Development, 4, 357-371.

2. DiBiase, S. (2015), E-mail correspondence with Mr. Scott DiBiase at the Pinal County Air Quality Control District, May 29, 2015.

3. Downing, B. (2015), E-mail correspondence with Mr. Bob Downing at the Maricopa County Air Quality Department, July 10, 2015.

4. Emery, C., Tai, E., and Yarwood, G. (2001), Enhanced Meteorological Modeling and Performance Evaluation for Two Texas Ozone Episodes, ENVIRON International Corporation, August 31, 2001.

5. Emmons, L. K., Walters, S., Hess, P. G., Lamarque, J. F., Pfister, G. G., Fillmore, D., Granier, C., Guenther, A., Kinnison, D., Laepple, T., Orlando, J., Tie, X., Tyndall, G., Wiedinmyer, C., Baughcum, S. L., and Kloster, S. (2010), Description and Evaluation of the Model for Ozone and Related Chemical Tracers, version 4 (MOZART-4), Geoscientific Model Development, 3, 43-67.

6. ENVIRON (2003), Maricopa County 2002 Comprehensive Emission Inventory for the Cap and Trade Oversight Committee, Final Report, Prepared for Arizona Department of Environmental Quality, Oct. 9, 2003.

7. FAA (2015), Aviation Forecasts - Terminal Area Forecast (TAF), Federal Aviation Administration, http://www.faa.gov/data_research/aviation/.

8. FR (2016), Determinations of Attainment by the Attainment Date, Extensions of the Attainment Data, and Reclassification of Several Areas for the 2008 Ozone National Ambient Air Quality Standards, Federal Register Vol. 81, No. 86, May 4, 2016.

9. Guenther, A. B., Jiang, X., Heald, C. L., Sakulyanontvittaya, T., Duhl, T., Emmons, L. K., and Wang, X. (2012), The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1): an Extended and Updated Framework for Modeling Biogenic Emissions, Geoscientific Model Development, 5, 1471-1492.

10. Jimenez, J. A. and Dudhia, J. (2013), On the Ability of the WRF Model to Reproduce the Surface Wind Direction over Complex Terrain, Journal of Applied Meteorology and Climatology, 52, pp. 1610-1617.

11. MAG (2006), MAG 2006 Biogenics Study, Maricopa Association of Governments, September 2006.

12. MAG (2009), MAG Eight-Hour Ozone Redesignation Request and Maintenance Plan for the Maricopa Nonattainment Area, Maricopa Association of Governments, February 2009.

13. MAG (2014), MAG 2014 State Implementation Plan Revision for the Removal of Stage II Vapor Recovery Controls in the Maricopa Eight-hour Ozone Nonattainment Area, Maricopa Association of Governments, August 2014.

14. MCAQD (2014), 2011 Periodic Emission Inventory Reports for Ozone Precursors for the Maricopa County, Arizona, Eight-Hour Ozone Nonattainment Area, Maricopa County Air Quality Department, February 2014.

15. MCAQD (2015), 2011 Periodic Emission Inventory for Ozone Precursors for the Maricopa County, Arizona, Eight-Hour Ozone Nonattainment Area ADDENDUM, Maricopa County Air Quality Department, August 2015.

16. NCAR (1987), Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory (CISL) Research Data Archive, National Weather Service meteorological data, http://rda.ucar.edu /datasets/ds472.0/.

17. Sillman, S. (1995), The Use of NOy, H_2O_2, and HNO_3 as Indicators for Ozone - Nox-Hydrocarbon Sensitivity in Urban Locations, Journal of Geophysical Research, 100, 14,175-14,188.

18. Simon, H., Baker, K.R., and Phillip, S.B. (2012), Compilation and Interpretation of Photochemical Model Performance Statistics Published between 2006 and 2012, Atmospheric Environment, 61, 124-139.

19. Taylor, K.E. (2001), Summarizing Multiple Aspects of Model Performance in a Single Diagram, Journal of Geophysical Research: Atmospheres, 106, D7: 7183-7192.

20. USAF (2012), F-35A Training Basing Environmental Impact Statement, U.S. Air Force, June 2012.

21. U.S. EPA (1981), Guideline for Use of City-Specific EKMA in Preparing Ozone SIPs, EPA-450/4-80-027, March 1981.

22. U.S. EPA (1993), Early Implementation of Contingency Measures for Ozone and Carbon Monoxide (CO) Nonattainment Areas, Prepared by G. T. Helms, August 13, 1993.

23. U.S. EPA (2005), Final Rule to Implement the 8-Hour Ozone National Ambient Air

Quality Standard, November 29, 2005.

24. U.S. EPA (2014a), Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, December 3, 2014.

25. U.S. EPA (2014b), Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation, November 26, 2014.

26. U.S. EPA (2015a), Notice of Availability of the Environmental Protection Agency's Updated Ozone Transport Modeling Data for the 2008 Ozone National Ambient Air Quality Standard (NAAQS), U.S. Environmental Protection Agency, EPA-HQ-OAR-2015-0500, August 4, 2015.

27. U.S. EPA (2015b), 2011 National Emissions Inventory v2-Based Modeling Platform (2011v6.2), ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform.

28. U.S. EPA (2016), Power Plant Emission Trends, EPA Clean Air Markets, https://www3.epa.gov/airmarkets/progress/datatrends/index.html

29. Wiedinmyer, C., Akagi, S. K., Yokelson, R. J., Emmons, L. K., Al-Saadi, J. A., Orlando, J. J., and Soja, A. J. (2011), The Fire INventory from NCAR (FINN): a High Resolution Global Model to Estimate the Emissions from Open Burning, Geoscientific Model Development, 4, 625-641.

30. Xie, B., Fung, J. C. H., Chan, A., and Lau, A. (2012), Evaluation of Nonlocal and Local Planetary Boundary Layer Schemes in the WRF Model, Journal of Geophysical Research, 117, D12103.