FY 2012 - FY 2013
UPWP 3.3

MPO
SAN ANTONIO – BEXAR COUNTY
METROPOLITAN PLANNING ORGANIZATION

Development of the Extended June 2006 Photochemical Modeling Episode

Technical Report

October 2013

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Abstract: The photochemical modeling episode currently being refined and used for the San Antonio, Austin, and Dallas regions is based on a period of high ozone from May 31st to July 2nd, 2006. This episode was chosen for the most recent modeling effort as it represents a variety of meteorological conditions are commonly associated with ozone exceedance days. Once the base case emission inventory was completed, the June 2006 model was projected to 2012 and 2018 using forecasted changes in anthropogenic emissions. The largest source of NO_X emissions in 2006 are on-road vehicles, 134.7 tons per weekday, followed by point, 71.3 tons per weekday, and non-road, 43.6 tons per weekday in the San Antonio New Braunfels MSA. By 2018, the largest sources of NO_X emissions are projected to be point, 50.8 tons per weekday, followed by on-road, 43.0 tons per weekday, and area, 15.9 tons per weekday. Using the June 2006 base case inventory, the CAMx model over predicted ozone concentrations at monitors on the northwest side of San Antonio, C23, C25, and C505, on two of the episode's exceedance days: June 13 and 14th, 2006. On other days of the episode, the model's ozone estimations correlated well with observed peak hourly ozone values. Once the emission inventory in the model was projected to 2018, an attainment test was conducted on the modeling results. These results indicate that all regulatory-sited monitors meet the 75 ppb 8-hour ozone standard for every 2018 projection case. However, the 2018 design value at C58 is very close to the current 75 ppb 8-hour ozone NAAQS. If the EPA lowers the 8-hour ozone standard, it will be difficult for the San Antonio-New Braunfels MSA to meet that lower attainment threshold.

Related Reports:
FY 2008 - FY 2009, UPWP 3.3, June 2006 Ozone Episode Photochemical Modeling Development

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Executive Summary

Ground-level ozone is one of the most common air pollutants in the country as well as one of the six "criteria" pollutants for which the EPA established standards. Ozone concentrations measured in the San Antonio-New Braunfels MSA in 2012 and 2013 were high enough to place the area in violation of the federal standard based on the three-year calculations on which attainment is determined. While the area has not been designated by the EPA as a non-attainment region for ozone, local and state agencies conduct air quality planning, modeling, and analyses that could provide support for attainment demonstrations or control strategy analyses, should the region's attainment status change in the future. These analyses involve development of emissions inventories that identify local sources of the chemicals that form ozone and quantify their emission rates; identification of the meteorological and atmospheric conditions conducive to the accumulation of high ozone concentrations; and development of models that simulate those conditions in order to allow planners to predict future ozone values and evaluate pollution control strategies.

Ozone analysis is conducted using photochemical models that simulate actual high ozone episodes which prevailed in a region over the course of several days. The modeling episode currently used for the San Antonio, Austin, and Dallas regions, and undergoing refinement by the Alamo Area Council of Governments, is based on the period of high ozone that occurred from May 31st to July 2nd, 2006. This episode was chosen for the most recent modeling effort as it represents a variety of meteorological conditions that are commonly associated with ozone exceedance days.

In addition to meteorological conditions, an important input to the model is an emissions inventory that spatially and temporally allocates emissions throughout the photochemical model domain. Detailed emissions inventories were developed by the Texas Commission on Environmental Quality (TCEQ) for Texas. Emission inventories were also developed by the EPA for other states in the modeling domain and Mexico. Local updates to the San Antonio-New Braunfels MSA emission inventory were obtained from AACOG's emission inventory, TCEQ, Eastern Research Group (ERG), and Texas Transportation Institute (TTI).

Once complete, the June 2006 model was projected to 2012 and 2018 using forecasted changes in anthropogenic emissions. As part of these projections, several different emission inventory scenarios were developed for Eagle Ford Shale oil and gas production in 2018. Since photochemical models simulate the atmospheric and meteorological conditions that helped produce high ozone values during a particular episode, an important advantage the models provide is the ability to test various scenarios, such as changes in emission rates, under the same set of meteorological conditions that favor high ozone concentrations. The largest source of nitrogen oxides (NO_X) emissions in 2006 were on-road vehicles, 134.7 tons per weekday, followed by point, 71.3 tons per weekday, and non-road, 43.6 tons per weekday. By 2018, the largest sources of NO_X emissions are projected to be point, 50.8 tons per weekday, followed by on-road, 43.0 tons per weekday, and area, 15.9 tons per weekday. The largest contributors of volatile organic compounds (VOC) emissions are area sources: 147.2 tons per weekday in 2006 and 153.8 tons per weekday in 2018. Other significant sources of VOC emissions in the San Antonio-New Braunfels MSA are on-road, 22.1 tons per weekday in 2018, and non-road, 19.0 tons per weekday in 2018.

Once the emission inventories, chemistry, and meteorological data were input into the CAMx photochemical model, the model was run to produce several 2006 base case and projection case runs. The CAMx model over predicted 8-hour ozone concentrations at monitors on the northwest side of San Antonio, C23, C25, and C505, on two of the episode's exceedance days: June 13 and 14th, 2006. On other days, the model's ozone estimations correlated well with observed peak hourly ozone. When examining the diurnal bias, model results for C58 over predicted diurnal ozone on most exceedance days during the episode. The model also over predicted diurnal hourly ozone in the second part of the episode at monitors located in rural areas of the San Antonio-New Braunfels MSA, C502, C503, C504, and C506.

Although there were several significant differences in the local emission inventory for each run, model results are similar for each run at every monitor. Every modeling run exhibited similar performance for unpaired peak accuracy, paired peak accuracy, peak bias, peak error, normalized bias, and normalized error. Results for paired peak accuracy were very good for C58, C622, C501, C502, C503, and C506 and paired peak accuracy for the remaining monitors also met EPA recommended guidelines. Tile plots indicated that there were no unusual patterns of ozone formation predicted by the model runs. Ozone plumes were produced in the vicinity of San Antonio and Austin. As expected, these urban plumes were predicted for each urban core and areas downwind of the cities.

Once the emission inventory was projected to 2018 and applied to the photochemical model, an attainment test was conducted on the modeling results. The model attainment test requires the calculation of a daily relative response factor (RRF). For the Eagle Ford Shale low production scenario, the 2018 design value was 70.9 ppb at C23, 73.8 ppb at C58, and 65.0 ppb at C59. Under the Eagle Ford high scenario, the design values were 71.4 ppb at C23, 74.3 ppb at C58, and 65.6 ppb at C59. Therefore, the design value increased by 0.5 ppb at C23, 0.6 ppb at C58, and 0.7 ppb at C59 under the Eagle Ford high production scenario, compared to the low production scenario. All regulatory-sited monitors meet the 75 ppb 8-hour ozone standard for every 2018 projection case. However, the 2018 design value at C58 is very close to the current 75 ppb 8-hour ozone NAAQS. If the EPA lowers the 8-hour ozone standard, it will be difficult for the San Antonio-New Braunfels MSA to meet that lower attainment threshold.

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1 Background

The U.S. Environmental Protection Agency (EPA) is charged with the maintenance of regional air quality across the United States through a series of standards, the National Ambient Air Quality Standards (NAAQS). When regions fail to comply with these standards, the Clean Air Act requires that the state, in consultation with local governments, revise the state implementation plan (SIP) to address the violation. The SIP is a blueprint for the methodology that the region and state will follow to attain and maintain the federal air quality standards.[1]

Ground-level ozone is one of the most common air pollutants in the country as well as one of the six "criteria" pollutants for which the EPA established standards. A region is in violation of the Clean Air Act if the annual fourth highest 8-hour average ozone concentration, averaged over three consecutive years, exceeds 75 parts per billion (ppb).[2] This average is referred to as the ***design value***. The fourth highest 8-hour averages and design values for the three most recent complete years of data, 2010-2012, from the regulatory continuous ambient monitoring stations (CAMS) in the San Antonio region are listed in Table 1-1.

Table 1-1: 4th Highest Ozone Values[3] and Design Values at San Antonio Regional Monitors, 2010-2012

CAMS	2010 (ppb)	2011 (ppb)	2012 (ppb)	**2010-2012 Design Value**
C23	**72**	**79**	**81**	**77**
C58	**78**	**75**	**87**	**80**
C678	67	71	70	**69**
C59	69	**79**	74	**74**
C622	64	**75**	70	**69**

Under the 1997 revision to the Clean Air Act, a region was in violation of the NAAQS if the design value for ozone was equal to or greater than 85 ppb. A 2008 revision to the Clean Air Act modified the ozone standard to improve the law's ability to protect human health and the environment. Under the 2008 revision, a region is in violation of the ozone NAAQS when the design value exceeds 75 ppb. As shown in Table 1-1, the 2010 - 2012 design value (truncated average) is 80 ppb at C58 and 77 ppb at C23, indicating that the San Antonio region has two monitors measuring concentrations in violation of the 75 ppb eight hour ozone NAAQS.

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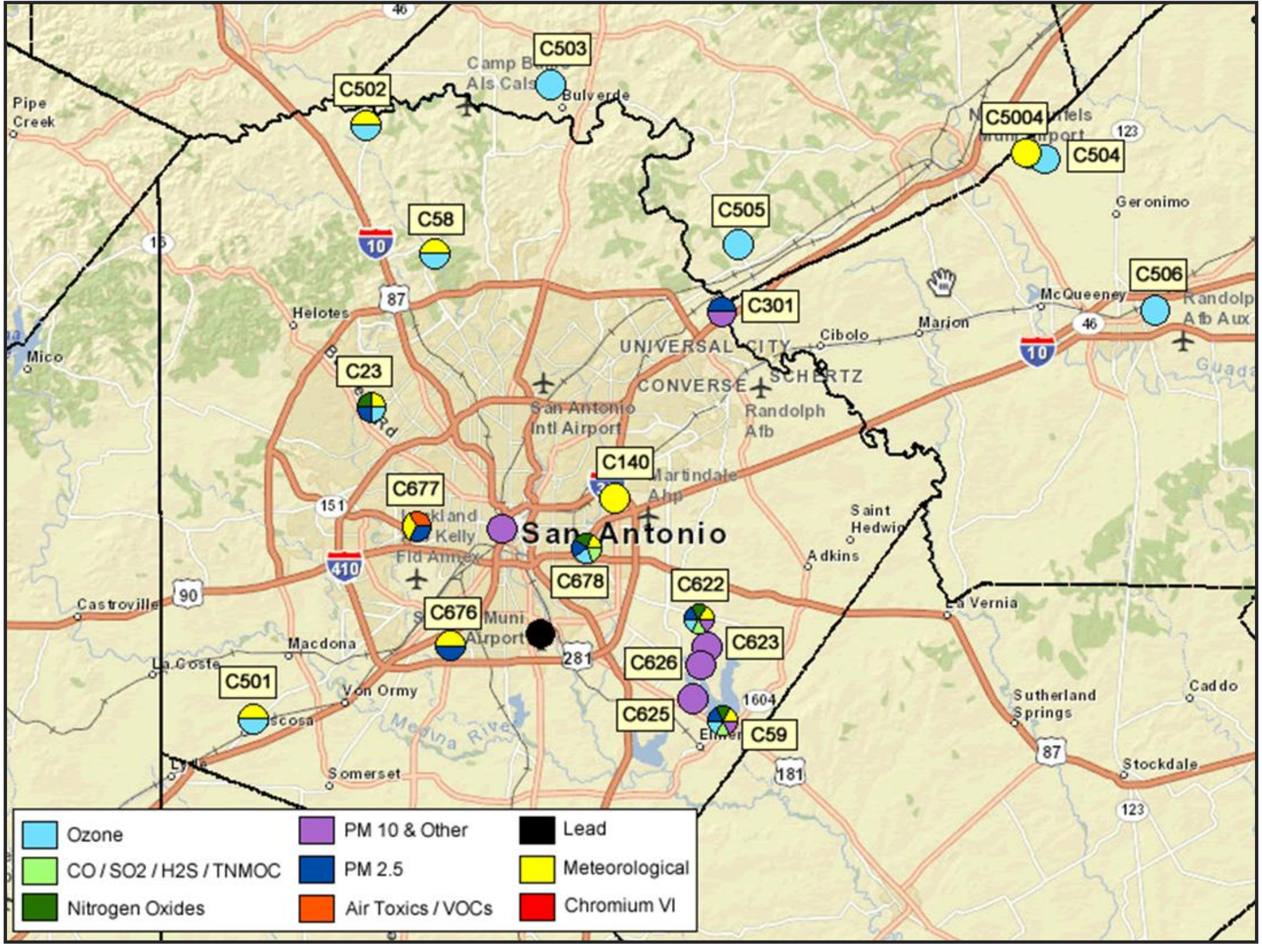
[1] Environmental Protection Agency (EPA), "The Plain English Guide to the Clean Air Act." Available online: http://www.epa.gov/air/caa/peg/. Accessed 06/26/13.

[2] EPA, March 2008. "Fact Sheet: Final Revisions to the National Ambient Air Quality Standards For Ozone". Available online: http://www.epa.gov/groundlevelozone/pdfs/2008_03_factsheet.pdf. Accessed 06/26/13.

[3] Texas Commission on Environmental Quality (TCEQ). "Four Highest Eight-Hour Ozone Concentrations." Austin, Texas. Available online: http://www.tceq.state.tx.us/cgi-bin/compliance/monops/8hr_4highest.pl. Accessed 06/26/13.

There are 17 regulatory and non-regulatory air quality monitors in the San Antonio region that record meteorological data and air pollutant concentrations, including ozone levels. The data collected at these sites is processed for quality assurance by the Texas Commission on Environmental Quality (TCEQ) and is accessible via the Internet.[4] Figure 1-1 displays the location of the CAMS within the San Antonio region. Meteorological data measured at these sites includes temperature, wind speed, wind direction, precipitation, solar radiation, and relative humidity. Most stations measure one or more air pollutants including ozone (O_3), carbon monoxide (CO), nitrogen oxides (NO, NO_2), particulate matter equal to or less than 2.5 micrometers in diameter (PM2.5), particulate matter greater than 2.5 but less than 10 micrometers in diameter (PM10), and volatile organic compounds (VOCs).

Figure 1-1: Monitoring Sites the San Antonio-New Braunfels MSA



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[4] TCEQ, "Air and Water Monitoring". Austin, Texas. Available online: http://www.tceq.state.tx.us/assets/public/compliance/monops/graphics/clickable/region13.gif. Accessed 06/26/13.

Ozone is monitored at C23, C58, C59, C501, C502, C503, C504, C505, C506, C622, and C678. Other ambient air monitors include C27 (CO and NO_X), C140 (meteorological data), C301 (PM 2.5), C676 (meteorological data and PM 2.5), C677 (meteorological data, PM 2.5, and VOC sampling), and C5004 (meteorological data). In addition, there are three water quality monitors displayed on the map: C623, C625, and C626.

The Alamo Area Council of Governments conducts ozone analysis using photochemical models that simulate actual high ozone episodes which prevailed in the region over the course of several days. The modeling episode currently being refined and used for the San Antonio, Austin, and Dallas regions is based on the May 31st to July 3rd, 2006 time period. This episode included several periods of high ozone across Texas.[5]

Once complete, the June 2006 model was projected to 2012 and 2018 using forecasted changes in anthropogenic emissions. The years 2012 and 2018 were selected because of the availability of several forecasted emissions inventories from previous work completed by TCEQ. As part of these projections, several different emission inventory scenarios were developed for Eagle Ford production in 2018. Since photochemical models simulate the atmospheric and meteorological conditions that helped produce high ozone values during a particular episode, an important advantage the models provide is the ability to test various scenarios, such as changes in emission rates, under the same set of meteorological conditions that favor high ozone concentrations.

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[5] TCEQ. “Daily Maximum Eight-Hour Ozone Averages.” Austin, Texas. Available online: http://www.tceq.state.tx.us/cgi-bin/compliance/monops/8hr_monthly.pl. Accessed 06/24/13.

2 Meteorological and Photochemical Modeling Development

2.1 EPA Modeling Guidance

EPA modeling guidance provides a detailed process, from the planning stage through control strategy development and evaluation, for developing and analyzing photochemical modeling episodes. If a region fails to meet the National Ambient Air Quality Standards (NAAQS), EPA can declare the region in non-attainment. The region must submit a State Implementation Plan revision with an attainment demonstration designed to achieve attainment of the ozone NAAQS. The EPA outlines nine recommended steps for applying photochemical models to generate the information used in attainment demonstrations:

1. “Develop a conceptual description of the problem to be addressed.
2. Develop a modeling/analysis protocol.
3. Select an appropriate model to support the demonstration.
4. Select appropriate meteorological time periods to model.
5. Choose an appropriate area to model with appropriate horizontal/vertical resolution and establish the initial and boundary conditions that are suitable for the application.
6. Generate meteorological inputs to the air quality model.
7. Generate emissions inputs to the air quality model.
8. Run the air quality model with base case emissions and evaluate the performance. Perform diagnostic tests to improve the model, as necessary.
9. Perform future year modeling (including additional control strategies, if necessary) and apply the attainment test.”[6]

The following chapters describe this process as followed by AACOG in the development and analysis of the June 2006 AACOG modeling episode.

2.2 Conceptual Description

An initial step in model development for attainment demonstrations requires creating a conceptual description and model of ambient ozone in the San Antonio region. The conceptual model provided a basis for determining subsequent steps in episode selection and model development. One of the intents of the conceptual model is to summarize both the local meteorological conditions and associated synoptic weather patterns typically experienced during periods of elevated ozone concentrations. Assembling and reviewing available ambient air quality data, meteorological data, upper air measurements, and previous photochemical modeling efforts facilitate this process.

Ozone formation in the San Antonio region is influenced by many of the same factors as in other regions of Texas and ozone concentrations peak during the warm weather that predominates in the San Antonio region from May through October. These factors include sunny skies, high-pressure

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[6] EPA, April 2007. “Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze,” EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 2. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13.

systems, low wind speeds, wind directions that facilitate transport from urban areas and industrial sites, and low humidity. Low mixing heights and low nocturnal wind speeds allow local ozone precursor pollutants to concentrate. With a rapid rise in mixing height during the morning, local and transport pollutants can combine to form elevated ozone levels.

The 2008 Conceptual Model defines the factors that influence ozone formation in the San Antonio region as:

- Temperature – Days with ozone exceedances tended to have peak temperatures above 83° F.
- Precipitation – Days with ozone exceedances had little to no precipitation.
- Humidity and Cloud Cover – Days with ozone exceedances had clear skies and relative humidity below 50% at 2 p.m.
- Wind Direction – Morning wind direction on high ozone days tended to be from the northwest in the early mornings at C58 and northwest to northeast at C23. Early afternoon wind direction tended to be from the southeast on ozone exceedance days.
- Wind Speed – Ozone exceedance days had calm winds that were below 7 mph.
- Mixing Heights – Mixing heights were typically lower in the early morning hours, followed by a rapid rise in late morning through early afternoon on days of high ozone concentrations.
- Ozone Seasonal Peaks – San Antonio region was shown to have three ozone peaks (late May – June, early August, and September) during the ozone season of April - October.
- Diurnal Ozone Patterns – There was a strong correlation between one-hour and eight-hour readings, indicating no significant one-hour peaks resulting from large VOC plumes from industrial or other sources. Urban core monitors recorded lower nighttime diurnal ozone measurements on average than monitors outside the urban core.
- Regional Air Masses – Air masses over central Texas were stagnant on days of high ozone with few frontal movements, characteristic of high pressure cells.
- Surface Back Trajectories – Air parcels on ozone exceedance days tended to originate from the northeast, east, and southeast; while, on days with low ozone, air parcels were predominately from the southeast.
- Seasonal Pattern of Surface Back Trajectories – On ozone exceedance days, back trajectories in June tended to originate from the southeast; while back trajectories in September on ozone exceedance days tended to originate from the northeast.
- 24-hour Back Trajectory Origins – On high ozone days, back trajectories originated closer to San Antonio and traveled fewer miles to arrive at local ozone monitoring stations, indicating an association between low wind speeds/stagnated conditions and ozone exceedances.
- Maximum Ozone Readings – The difference between the San Antonio MSA maximum peak ozone readings and the minimal peak ozone readings at monitors on ozone exceedance days was 21.2 ppb or 25.2 percent.
- Aircraft Sampling – Aircraft sampling between Houston and San Antonio indicated large ozone plumes from Houston could impact areas hundreds of miles downwind including San Antonio and Austin. This may affect local ozone levels and increase the difficulty of attaining the 75 ppb 8-hour ozone standard at downwind monitors.

- Local Ozone Contribution – The 2013 ozone design value was reduced 19.1 ppb when all local anthropogenic emissions from the San Antonio MSA were removed from the CAMx photochemical model simulation (25.2% reduction).
- New Point Sources – Power plants being built in Texas between 2007 and 2013 could affect future ozone levels in San Antonio. These power plants may release an additional 76.9 tons of NO_X per year in areas upwind from San Antonio. The impact of these power plants may make it more difficult for the San Antonio region to attain the 75 ppb 8-hour ozone standard[7].

2.3 Modeling/Analysis Protocol

As stated by the EPA, "the most important function of a protocol is to serve as a means for planning and communicating up front how a modeled attainment demonstration will be performed".[8] Many stakeholders were involved in the modeling protocol process that led to the development of the June 2006 ozone episode. Decisions as to which modeling episode, air quality simulation model, and modeling consultant(s) to use were made by TCEQ staff and representatives of two Texas NNAs: Austin (Capital Area Planning Council and Central Texas Clean Air Force), and San Antonio (Alamo Area Council of Governments). The decision to model the June 2006 episode was also approved by the AACOG Board of Directors during their April 2, 2008 meeting. The AACOG board consists of elected officials representing the 12-county AACOG region: Atascosa, Bandera, Bexar, Comal, Frio, Gillespie, Guadalupe, Karnes, Kendall, Kerr, Medina, and Wilson counties.

Modeling decisions were reviewed by AACOG's Air Improvement Resources Technical Committee and the San Antonio-Bexar County Metropolitan Planning Organization (SA-BC MPO) Technical Advisory Committee (TAC), which are composed of technical staff representing local governments and stakeholders. Recommendations from the AIR Technical Committee were forwarded to the Air Improvement Resources (AIR) Executive and Advisory Committee during regularly scheduled public meetings for final approval of modeling decisions at the local level. Executive members (voting members) of the AIR Committee included one representative each from Atascosa County, Bexar County, Comal County, City of Floresville, Guadalupe County, City of New Braunfels, City of San Antonio, City of Seguin, Wilson County, the Alamo Area Council of Governments Board of Directors, Greater Bexar County Council of Cities (GBCCC), and the San Antonio-Bexar County Metropolitan Planning Organization (SA-BC MPO). The Advisory committee, although not consisting of voting members, includes representatives of governmental entities, industries, and private citizens.

2.4 Model Selection

The EPA recommends that regions consider five factors as criteria for choosing qualifying air quality models:

1. "Documentation and Past Track Record of Candidate Models.
2. Advanced Technical Features.

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[7] Alamo Area Council of Governments (AACOG), April 2009. "Conceptual Model - Ozone Analysis of the San Antonio Region: Updates through Year 2008". San Antonio, Texas.

[8] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 133. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13.

3. Experience of Staff and Available Contractors.
4. Required vs. Available Time and Resources.
5. Consistency of a Proposed Model with Models Used in Adjacent Regions."[9]

An important component of selecting peer-reviewed meteorological and photochemical models includes evaluating these five factors and demonstrating that the models perform satisfactorily in similar applications.

According to the EPA, "Ozone chemistry is complex, involving more than 80 chemical reactions and hundreds of chemical compounds. As a result, ozone cannot be evaluated using simple dilution and dispersion algorithms. Due to the chemical complexity and the requirement to evaluate the effectiveness of future controls, the EPA's guidance strongly recommends using photochemical computer models to analyze ozone issues. While photochemical grid modeling has uncertainties, EPA strongly supports the use of photochemical grid modeling as the most sophisticated and scientifically sound tool available to develop attainment demonstrations."[10]

WRF v3.2, released in April 2010,[11] was used to calculate the meteorological inputs for the June 2006 photochemical model. The "WRF Model is a next-generation mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. It features multiple dynamical cores, a 3-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. WRF is suitable for a broad spectrum of applications across scales ranging from meters to thousands of kilometers."[12] The highlights of WRF v3.2 include:

1. "fully compressible nonhydrostatic equations with hydrostatic option
2. complete coriolis and curvature terms
3. two-way nesting with multiple nests and nest levels
4. one-way nesting
5. moving nest
6. mass-based terrain following coordinate (note that the height-based dynamic core is no longer supported)
7. vertical grid-spacing can vary with height

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[9] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 137. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13.

[10] Erik M. Snyder and Biswadev (Dev) Roy, July 2008. "Technical Support Document For Dallas Fort Worth Modeling and Other Analyses Attainment Demonstration (DFW-MOAAD)". EPA-R06-OAR-2007-0524. Air Quality Modeling Group Air Programs Branch-Planning Section Multimedia Planning & Permitting Division, U.S. EPA Region-6. Dallas, Texas. p. 63. Available online: http://www.regulations.gov/search/redirect.jsp?objectId=090000648066d902&disposition=attachment&contentType=pdf. Accessed 03/08/09.

[11] Jimy Dudhia, NCAR/NESL/MMM. "WRF Version 3.2: New Features and Updates". Presented at the 11th Annual WRF Users' Workshop, June 21 - 25, 2010. Available online: http://www.mmm.ucar.edu/wrf/users/workshops/WS2010/presentations/session%201/1-1_wrf10.pdf. Accessed 06/21/13.

[12] National Center for Atmospheric Research. "The Weather Research and Forecasting Model". Available online: http://www.wrf-model.org/index.php. Accessed 06/21/13.

8. map-scale factors for conformal projections:
9. Arakawa C-grid staggering
10. Runge-Kutta 2nd and 3rd order timestep options
11. scalar-conserving flux form for prognostic variables
12. 2nd to 6th order advection options (horizontal and vertical)
13. time-split small step for acoustic and gravity-wave modes:
    a. small step horizontally explicit, vertically implicit
    b. divergence damping option and vertical time off-centering
    c. external-mode filtering option
14. lateral boundary conditions
    a. idealized cases: periodic, symmetric, and open radiative
    b. real cases: specified with relaxation zone
15. upper boundary absorbing layer option
    a. increased diffusion
    b. Rayleigh relaxation
    c. implicit gravity-wave damping
16. rigid upper lid option
17. positive definite and monotonic advection scheme for scalars (microphysics species, scalars and tke)
18. adaptive time stepping (new in V3.0)"[13]

CAMx is a non-proprietary model developed by ENVIRON to be used in analysis of pollutants including ozone, PM2.5, PM10, air toxins, and mercury. The model "is an Eulerian photochemical dispersion model that allows for an integrated 'one-atmosphere' assessment of gaseous and particulate air pollution over many scales ranging from sub-urban to continental. It is designed to unify all of the technical features required of state-of-the-science air quality models into a single system that is computationally efficient, easy to use, and publicly available."[14] To increase the compatibility between WRF and CAMx, there are readily available FORTRAN programs to convert raw output data from WRF into CAMx ready file formats. Wrf2camx with YSU Kv and the 100m kvpatch were used to convert the WRF output into CAMx format for the extended June 2006 episode.

The latest version of CAMx 5.40 was used in all the photochemical model runs performed by AACOG. The updates for the new version of CAMx include:

1. "Version 6 of the Carbon Bond photochemical mechanism (CB6).
2. Improved MPI efficiency by reducing the amount of data passed back to the master node each hour.
3. Two internal and transparent structural modifications:
    a) Dimensions and MPI passing of "height" and "depth" arrays are handled similarly as all other met variables;

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[13] National Center for Atmospheric Research. "WRF Model Version 3.2" http://www.mmm.ucar.edu/wrf/users/wrfv3.2/wrf_model.html. Accessed 06/21/13.

[14] ENVIRON International Corporation, September 2011. "User's Guide: Comprehensive Air Quality Modeling with Extensions, Version 5.40". Novato, CA. p. 1-1.

    b) Radicals and 'state' species concentrations are combined into a single vector.

4. PiG puff growth rates were modified to ignore growth contributions from horizontal and vertical shear during stable/nighttime conditions. Shear effects remain during neutral/unstable/daytime conditions. Reduced minimum limits on vertical diffusivity, turbulent flux moment, and nighttime PBL depth.”[15]

CAMx advanced technical features were used to model the June 2006 episode and are described in the CAMx user guide.[16] The advanced CAMx features include:

1.	Two-Way nested grid structure:	for the 36-, 12-, and 4-km grid system
2.	Plume-in-grid (PiG):	to track chemistry and dispersion of large individual point source NO_X emission plumes
3.	Horizontal advection solver:	Piecewise Parabolic Method (PPM)[17]
4.	Gas Phase Chemistry Mechanism:	Carbon Bond Version 6 (CB6)[18]
5.	Chemical Kinetics Solver:	set to ENVIRON’s CMC solver to increase the speed of the chemistry solution and model performance

All the CAMx advanced settings used to simulate the extended June 2006 episode are the same as settings that are being used to conduct SIP modeling for other areas in Texas. Both the CAMx and WRF models are being used to develop attainment demonstrations for multiple Texas regions including Dallas and Houston. Both WRF and CAMx met all EPA recommendations regarding the selection of a model.

2.5 Meteorological Time Period of Episode Selection

The EPA recommends four criteria for selecting periods of elevated ozone concentrations that are appropriate to model. The recommendations favor ozone episodes that:

1) “Simulate a variety of meteorological conditions: 8-Hour Ozone - choose time periods which reflect a variety of meteorological conditions which frequently correspond with observed 8-hour daily maxima > 84 ppb at multiple monitoring sites.
2) Model time periods in which observed concentrations are close to the appropriate baseline design value or visibility impairment.
3) Model periods for which extensive air quality/meteorological databases exist.
4) Model a sufficient number of days so that the modeled attainment test applied at each monitor violating the NAAQS is based on multiple days.”[19]

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[15] ENVIRON, Oct 10, 2011. “RELEASE NOTES for CAMx v5.40”. Novato, CA. Available online: http://www.camx.com/camx/files/2f/2f85f4aa-dfa9-4492-96a2-0c931b0dba5c.txt. Accessed 06/21/13.

[16] ENVIRON International Corporation, September 2011. “User’s Guide: Comprehensive Air Quality Modeling with Extensions, Version 5.40”. Novato, CA. p. 1-1.

[17] Colella, P. and P.R. Woodward, 1984. “The Piecewise Parabolic Method (PPM) for Gas-Dynamical Simulations.” Journal of Computation Physics. Volume 54, pp. 174-201. Available online: http://seesar.lbl.gov/anag/publications/colella/A_1_4_1984.pdf. Accessed: 06/24/13.

[18] Yarwood. G, Whitten G. Z., Gookyoung, H, Mellberg, J. and Estes, M. 2010. “Updates to the Carbon Bond Mechanism for Version 6 (CB6)”. Presented at the 9th Annual CMAS Conference, Chapel Hill, NC, October 11-13, 2010. Available online: http://www.cmascenter.org/conference/2010/abstracts/emery_updates_carbon_2010.pdf. Accessed 06/10/13.

The San Antonio region typically experiences three seasonal peaks during the ozone season: late May – June, early August, and the month of September. Selecting a modeling episode during one of these peaks is recommended. Work conducted on the 2008 Conceptual Model identified ten potential candidate episodes for modeling purposes, eight of which occurred during these peaks. By applying EPA's guidance for the selection process, the field of potential candidates was narrowed and eventually led to the selection of the June 2006 episode.

The June 2006 high ozone episode was chosen for the most recent modeling effort as it represents a variety of meteorological conditions that occur on typical ozone exceedance days. The June 2006 episode meets all four recommended EPA criteria for modeling time period selection. Detailed episode selection analysis of all candidate episodes is provided in the 2008 Conceptual model.[20] A review of the conceptual model in 2009 confirmed that the June 2006 exceedances were still typical of current ozone exceedance events in San Antonio.[21]

A variety of meteorological conditions on ozone exceedance days are simulated in the extended June 2006 episode. EPA recommends "modeling 'longer' episodes that encompass full synoptic cycles to improve model performance and modeling responses to emission control strategies. Time periods, which include a ramp-up to a high ozone period and a ramp-down to cleaner conditions, allow for a more complete evaluation of model performance under a variety of meteorological conditions."[22] The extended June 2006 model contains several full ozone synoptic cycles.

The June 2006 meteorological episode consists of one ramp-up day, May 31st, thirty primary episode days, June 1st - 30th and two ramp-down days, July 1st and 2nd. As shown in Figure 2-1, there was a period of high ozone from June 3 to June 14 and from June 26 to June 29 in San Antonio. In between periods of high ozone, the area experienced lower ozone from May 29 to June 2, June 15 to June 25, and June 30 to July 2. On two episode days, June 14 and 29, eight-hour average ozone levels exceeded 75 ppb at all area monitors. Since all local monitors – upwind and downwind – exceeded 75 ppb, transported ozone concentrations were high enough to cause exceedances in the San Antonio area without the impact of local emissions. Attaining the NAAQS is extremely difficult under such conditions and demonstrates the region's dependence on local as well as national and state implemented control measures.

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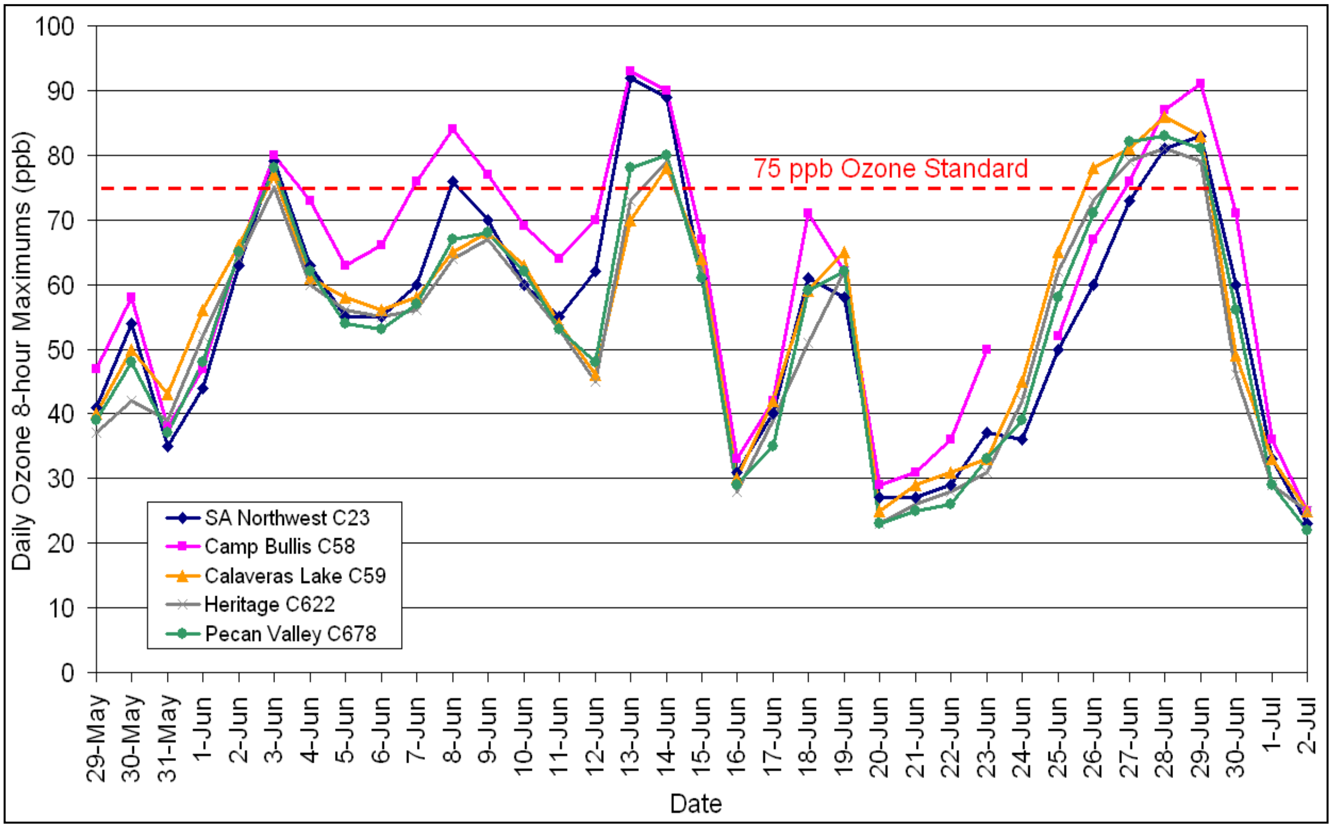
[19] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 140. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13

[20] AACOG, April 2007. "Conceptual Model - Ozone Analysis of the San Antonio Region: Updates through Year 2006". San Antonio, Texas.

[21] AACOG, April 2009. "Conceptual Model - Ozone Analysis of the San Antonio Region: Updates through Year 2008". San Antonio, Texas.

[22] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 140. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13.

Figure 2-1: Daily Ozone 8-hour Maximums for the June 2006 Episode at Regulatory Sited Monitors



2.5.1 June 2006 – Monitors Measuring High Ozone

During the extended June 2006 episode, 8-hour ozone averages exceeded 75 ppb on nine days at C58 and six days at C23. As provided in Table 2-1, every regulatory sited monitor recorded 8-hour averages in excess of 75 ppb on at least five days, and averages above 70 ppb on seven days of the 2006 episode. The highest number of ozone exceedances in the San Antonio region occurred at C58, C23, C501, C502, and C503 on the northwest, north, and southwest side of the city (Table 2-2). These monitors typically record the highest ozone concentrations on exceedance days as transported pollutants arrive from the northeast, east, and southeast. Transported ozone and precursor pollutants combine with local emissions resulting in higher ozone measurements downwind of the city core. The June 26th exceedance occurred at C59 in southeast Bexar County, which is unusual for the San Antonio region. Back trajectory analysis on this day indicated winds and transported pollutants came from the north and passed over San Antonio before arriving at CAMS 59.[23]

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[23] TCEQ. *Daily Maximum Eight-Hour Ozone Averages*. Available online: http://www.tceq.state.tx.us/cgi-bin/compliance/monops/8hr_monthly.pl. Accessed 06/21/13.

Table 2-1: Regulatory Sited Monitor-specific Eight-Hour Ozone Data during the Extended June 2006 Episode

Monitor	Max 8-hour Ozone (ppb)	Days > 80 ppb	Days > 75 ppb	Days > 70 ppb	Site-Specific Baseline Design Value (ppb)
San Antonio Northwest C23	92	4	6	8	77.3
Camp Bullis C58	93	6	9	13	80.0
Calaveras Lake C59	86	3	6	7	69.3
Heritage C622	81	1	5	7	68.0
CPS Pecan Valley C678	83	4	6	7	70.6

2.5.2 June 2006 – Wind Speed and Direction at the Monitors

Periods of high ozone during the 2006 episode were usually dominated by light winds and high-pressure systems over Texas. In contrast, several days of low ozone during the episode were associated with winds greater than 8 mph. On most ozone exceedance days, early morning winds were from the southwest, west, northwest, and north, while morning winds on days of low ozone were from the south, southeast, and east (Table 2-2). During the afternoon, winds tended to be from the south, southeast, and east on both days of high and low ozone. These dominating wind patterns match the results from the conceptual model for typical days of high and low ozone. During several days of the episode, afternoon winds blew from the northeast, which did not match typical patterns but are not considered exceptional. Several fronts passed through the region before exceedances occurred during the episode.

Days in which ozone exceedances occurred during the June 2006 episode were associated with meteorological conditions typical of high-ozone events (Table 2-3).[24] Peak temperatures on exceedance days ranged from 87.9° F degrees on June 26th to 98.0° F on June 13th. Typical of ozone exceedance days, humidity was below 32%, solar radiation was above 1.1 Langleys/min, and there was no precipitation. On the June 26, 2006 exceedance day, there were unusually high wind speeds (up to 9.5 mph) for an ozone exceedance day and the 250-mile back trajectory indicated the winds traveled a significant distance from the north before arriving at C58. Since other monitors, C622, C506, C501, C678, and C504, on the eastern and southern sides of San Antonio recorded higher ozone measurements, this is an indication of significant transport of pollutants into the region on this day.

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[24] AACOG, April 2009. "Conceptual Model - Ozone Analysis of the San Antonio Region: Updates through Year 2008". San Antonio, Texas.

Table 2-2: May 31st-July 2nd, 2006 Daily Maximum Ozone and Number of Monitors with Exceedances

Day of the Week	Date	Max. Ozone	CAMS with Highest Reading	Number of Monitors with Exceedances	Morning Wind Direction at C58 (6-9)	Afternoon Wind Direction at C58 (12-15)	Remarks
Wed	May 31	43	C59	0	NE	E	Ramp - up, low Ozone
Thu	June 1	56	C59	0	NE	NE	
Fri	June 2	66	C59	0	NW	NE	Weak Front
Sat	**June 3**	**80**	**C58**	**5**	**NW**	**SE**	High Pressure System
Sun	June 4	73	C58	0	SW	SE	Light Winds
Mon	June 5	63	C58	0	SW	SE	
Tue	June 6	68	C502	0	S	S	
Wed	**June 7**	**76**	**C58**	**1**	**SW**	**S**	High Pressure System - Light Winds
Thu	**June 8**	**84**	**C58**	**4**	**SW**	**SE**	
Fri	**June 9**	**77**	**C58 & C502**	**1**	**NW**	**SE**	
Sat	June 10	71	C503	0	SW	S	
Sun	June 11	64	C58 & C502	0	S	SE	
Mon	June 12	70	C58	0	S	SE	
Tue	**June 13**	**93**	**C58**	**6**	**NW**	**E**	Weak Front in Morning
Wed	**June 14**	**90**	**C58**	**10**	**NE**	**E**	
Thu	June 15	69	C502	0	SE	SE	Strong Winds
Fri	June 16	35	C502	0	S	S	
Sat	June 17	44	C504	0	N	SE	
Sun	June 18	71	C58	0	E	S	Light Winds
Mon	June 19	65	C59	0	W	N	
Tue	June 20	29	C58 & C502	0	E	SE	
Wed	June 21	32	C502	0	SE	SE	Strong Winds
Thu	June 22	36	C58 & C502	0	SE	SE	
Fri	June 23	50	C58	0	S	S	
Sat	June 24	45	C59	0		N	Front
Sun	June 25	65	C59	0	NW	NE	Strong Winds
Mon	**June 26**	**78**	**C59**	**1**	**N**	**NE**	
Tue	**June 27**	**88**	**C501**	**7**	**N**	**NE**	High Pressure System - Light Winds
Wed	**June 28**	**90**	**C501**	**10**	**NW**	**E**	
Thu	**June 29**	**91**	**C58**	**11**	**W**	**SE**	
Fri	June 30	71	C58	0	SE	SE	Ramp - down, low Ozone, light winds
Sat	July 1	38	C503	0	NW	SE	
Sun	July 2	26	C505	0	E	E	

Table 2-3: Comparison of Episode Exceedance Day Conditions to Typical Meteorological Conditions in the San Antonio Region on Ozone Exceedance Days

Existing Episode	Day	Peak 1-hour ppb Ozone at regulatory monitors	Peak 8-hour ppb Ozone at regulatory monitors	Peak Temperature at C58 > 83°F	Wind Speed 6 am – 2 pm at C58 < 7.0 mph	Precipitation (inches) at C678 - None	Max. Solar Radiation at C58 > 0.9 langleys/min.	Relative Humidity at C5004 2p.m. < 50%	Morning Wind Direction at C58 (6-9)	Afternoon Wind Direction at C58 (12-15)	Back Trajectory Classification
June 2006	3	86	80	89.7	4.9	0	1.148	27.5%	NW	SE	Stagnated
	7	87	76	94.3	5.0	0	1.309	31.8%	SW	S	Weak Transport
	8	96	84	92.6	4.4	0	1.291	29.6%	SW	SE	Weak Transport
	9	86	77	92.5	5.5	0	1.369	29.6%	NW	SE	Weak Transport
	13	106	93	98.0	5.3	0	1.301	20.2%	NW	E	Weak Transport
	14	94	90	93.9	**7.4**	0	1.305	29.4%	NE	E	Stagnated
	26	86	78	89.6	**9.5**	0	1.324	26.1%	N	**NE**	Transport
	27	88	82	87.9	5.8	0	1.238	23.1%	N	**NE**	Weak Transport
	28	97	87	90.0	5.9	0	1.338	22.3%	NW	E	Weak Transport
	29	94	91	89.4	4.9	0	1.174	27.8%	W	SE	Stagnated

Bolded values represent unusual meteorological conditions on ozone exceedance days

2.5.3 Transport Classification Using Back Trajectories

Back trajectories and daily weather maps were reviewed to classify episode winds as "stagnated," "weak transport," or "transport" during the episode. Back trajectories were categorized by the distance air parcels, at heights of 100 meters and 1,000 meters, traveled from origin to C58 monitor in San Antonio: within 250 kilometers, 251 – 500 kilometers, and >500 kilometers. Days when the 48-hour 100-meter height back trajectories stayed within approximately 250 kilometers of San Antonio were considered "stagnated" days. If the 48-hour back trajectory originated farther than 500 kilometers from San Antonio, the back trajectory was labeled as "transport." All other back trajectories were labeled as "weak transport." Of the episode 10 exceedance day back trajectories listed in Table 2-3, three fell within the stagnated category: June 3, 14, and 29. One back trajectory, June 26, was classified as transport and the rest were classified as weak transport.

During the June 2006 episode, 55 percent of the 48-hour back trajectories originated within 150 km of CAMS 58. These back trajectories represent meteorological conditions on ozone exceedance days in San Antonio. By developing an episode with a variety of back trajectories directions and speeds, effectiveness of control strategies can be tested under different meteorological conditions. The 1,000 meter back trajectories indicate transported pollutants arrived in San Antonio primarily from the east and northeast on ozone exceedance days during the episode. However, on three exceedance days during the June 2006 episode, June 7th, 8th, and 9th, elevated winds arrived at C58 from the south.

2.5.4 Peak Ozone and Local Ozone Contribution

On ozone exceedance days during the 2006 episode, the average difference between maximum peak ozone and minimum peak ozone readings at San Antonio monitors was 16.3 ppb. This indicates that local emissions accounted for 19% and transported pollutants contributed 81% to the ambient ozone levels recorded at San Antonio area monitors on exceedance days during the 2006 episode. Consequently, local sources of ozone precursors contributed less to regional ambient ozone levels than the 2008 conceptual model findings based on the older June 2006 modeling episode, which attribute 20% to 25% of average ambient ozone concentrations to local sources on exceedance days in 2013.

2.5.5 Plume Animation and Urban Emissions

TCEQ develops plume animation showing the length of the vectors "corresponds to the distance traveled by the air during the hour of measurement. The vectors are plotted from the station circle toward the direction from which the wind was blowing and show approximately where the air that arrived at the end of the hour was located at the beginning of the hour." In reference to the 2006 episode, TCEQ states "plume animation shows the estimated plume tracks from large industrial sources of oxides of nitrogen (NO_X) and/or volatile organic compounds (VOC), as well as plume tracks for the center of the broad urban plumes coming from downtown Austin, downtown San Antonio, and other major urban centers. The plume animation suggests that urban and industrial emissions from the San Antonio area were in the vicinity of the highest ozone measurements in the San Antonio area and that the highest ozone levels may have been well downwind to the west and southwest of the San Antonio area where there are no monitoring sites."[25]

2.5.6 Wind Speed and Direction

An episode's value as a candidate for modeling increases if the exceedance days of the episode exhibited a variety of wind speeds and directions. Figure 2-2 demonstrates that the June 2006 250-km 100-meter back trajectories are from the east (33.2%), southeast (29.8%), and northeast (17.3%) on ozone exceedance days. Another strong component of the back trajectory analysis is the presence of winds from the south (15.0 percent) during the extended June 2006 episode. Although wind direction on average ozone exceedance days from 2005 to 2010 tend to originate from the north and northeast in a greater percentage when compared to the June 2006 episode, there is still a strong correlation between the 2006 episode 250-mile 100-meter back trajectories and 250-mile back trajectories for average ozone exceedance days.

A similar pattern occurred when comparing the average 250-mile 1,000-meter back trajectories on ozone exceedance days and the ozone exceedances during the June 2006 episode. As shown on Figure 2-3, a higher percentage of 1,000-meter back trajectories originated from the east during the 2006 episode (41%) than for exceedance days on average, but there is a similar pattern between all exceedance days and the episode exceedance days. Individual 250-mile 100-meter back trajectories, displayed in Figure 2-4, during the June 2006 episode provide a variety of directions and speeds on ozone exceedance days.

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[25] TCEQ. "2006 Air Pollution Events." Austin, Texas. Available online: http://www.tceq.state.tx.us/compliance/monitoring/air/monops/sigevents06.html. Accessed 12/10/08.

Figure 2-2: Statistical Analysis of San Antonio's 250-mile 100-meter Back Trajectory Wind Directions: All Exceedance Days 2000-2008 and June 2006 Exceedance Days

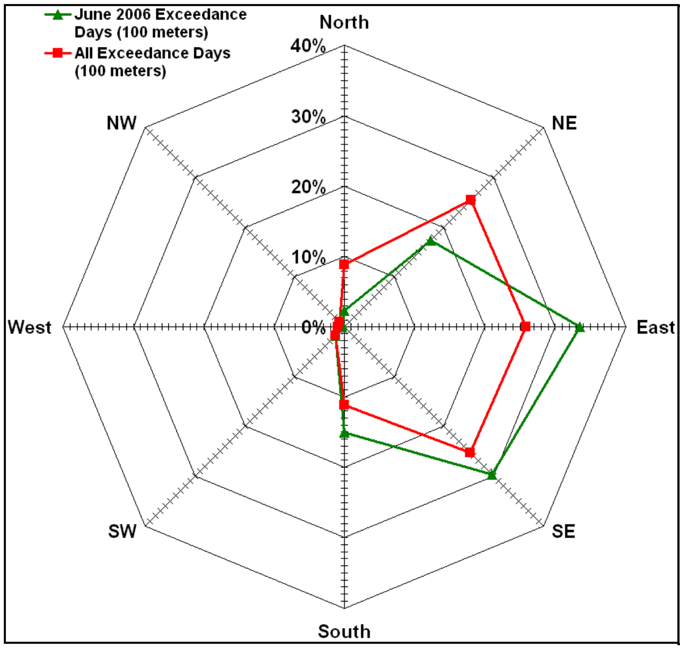
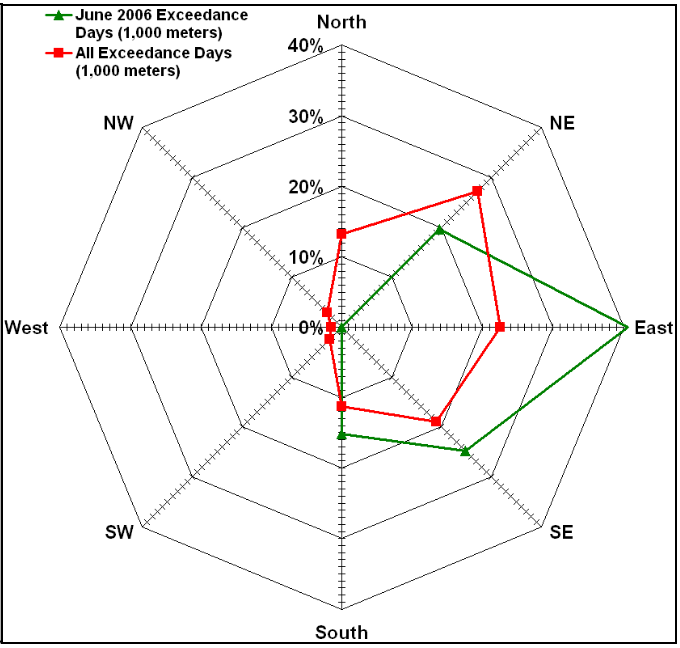


Figure 2-3: Statistical Analysis of San Antonio's 250-mile 1,000-meter Back Trajectory Wind Directions: All Exceedance Days 2005-2008 and June 2006 Exceedance Days

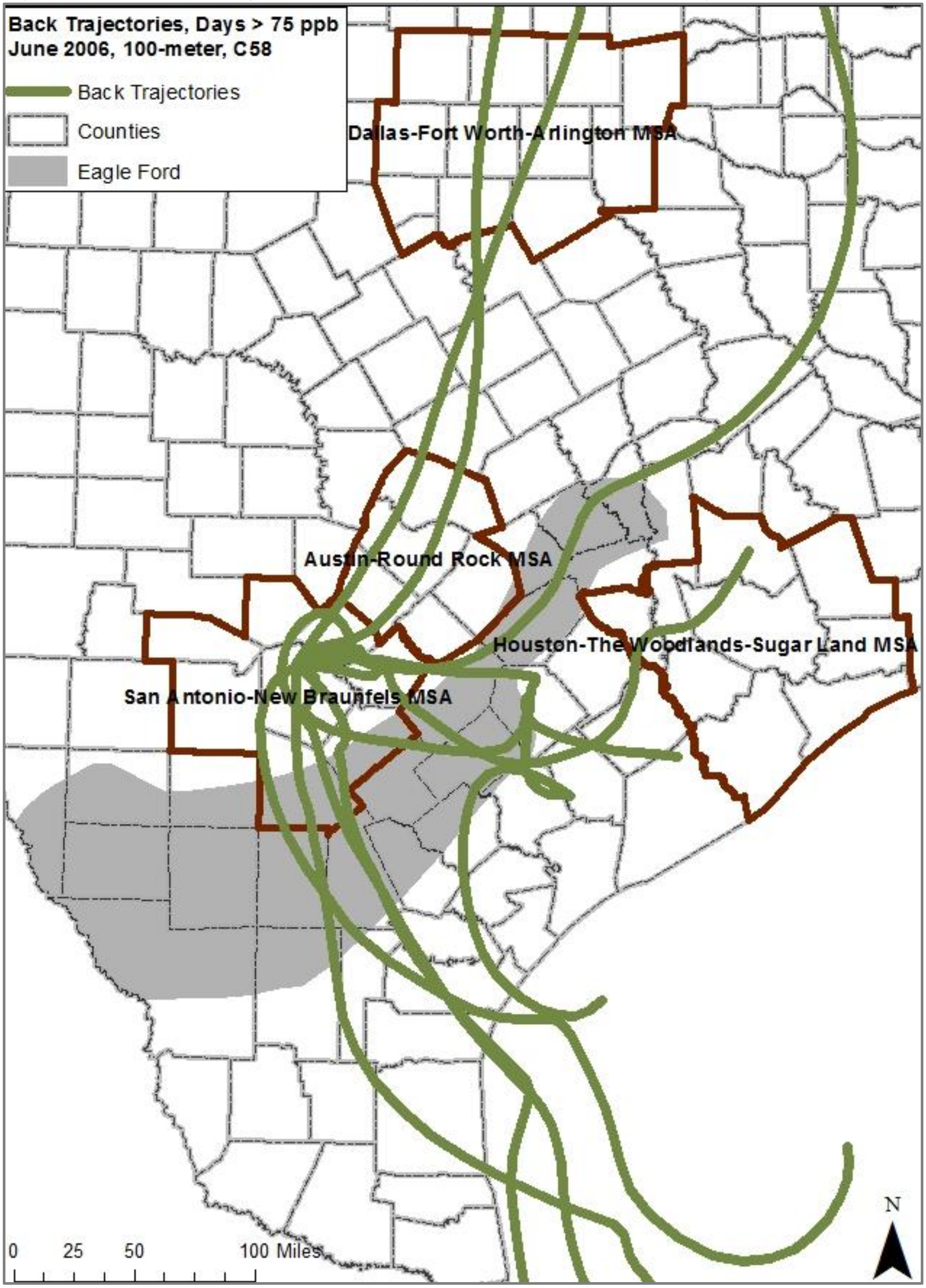


2.5.7 Mixing Height

Mixing heights were also examined to determine if typical meteorological conditions occurred during the June 2006 episode. In 2005, a profiler was installed near New Braunfels, Texas in Guadalupe County for the purpose of recording meteorological data aloft. The profiler operated from June 29 to August 31, 2005 and from May 30 to October 16, 2006. Mixing height at the profiler was available on all 10 exceedance days during the June 2006 episode and 19 exceedance days total between 2005 and 2006. Figure 2-5 compares the hourly mixing height measures for all exceedance days when the profiler was operating, June 2006 exceedance days, and days when peak 8-hour ozone was less than 40 ppb.

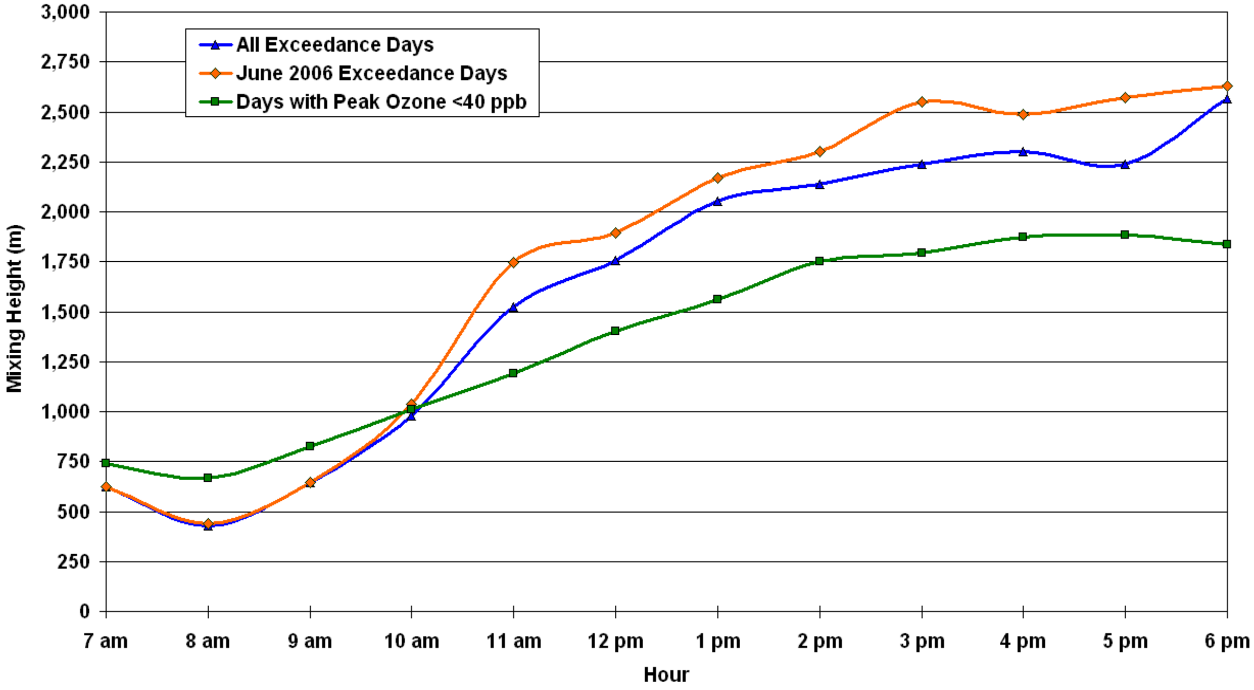
The mixing height pattern during the June 2006 episode corresponded with mixing heights for all exceedance days. In both cases, the mixing height on ozone exceedance days was lower at night than average, which can result in a concentration of pollutants near the surface. As temperatures increased in the morning, there was a rapid rise in mixing height that allowed transported pollutants aloft to mix with local concentrations and form elevated ozone at surface monitors. During days in which peak 8-hour average ozone concentrations were less than 40 ppb between 2005 and 2006, mixing heights before 9 a.m. were higher and the mixing height rose more gently during the morning than on exceedance days.

Figure 2-4: June 2006 Episode Back Trajectories on Exceedance Days



Plot Date: June 21, 2013
Map Compilation: June 21, 2013
Source: Hysplit Model

Figure 2-5: Hourly Mixing Height Measures for all Exceedance days, June 2006 Exceedance days, and Days with Peak Ozone < 40 ppb at New Braunfels Profiler



2.5.8 *High Ozone Values and Design Values*

During the June 2006 episode, observed ozone concentrations were close to the baseline site-specific design value. The June 2006 episode contains ozone exceedances in which observed concentrations are close to the site-specific design values. Of the 31 exceedances recorded at regulatory monitors during the episode, 28 were within 10 ppb of the site-specific modeling design value (Table 1-4). On June 13th, C23 and C58 measured ozone exceedances that were11 ppb and 13 ppb greater than the site-specific design value. Significantly higher temperatures were observed on this day compared to other exceedance days and there were strong indications of a large local contribution to ozone measurements at both monitors.

Table 2-4: June 2006 Site-Specific Weighted Modeling Design Values and Percentage of Daily Ozone Readings within ±10 ppb

Monitoring Site	Weighted 2006 Modeling Design Value	Number of Exceedance Days (>75 ppb)	Number of Exceedance Days within 10 pbb	% of Days within 10 ppb
SA Northwest C23	79	6	5	83%
Camp Bullis C58	82	9	8	89%
Calaveras Lake C59	75	6	5	83%
Heritage C622	74	5	5	100%
Pecan Valley C678	74	6	6	100%
Total		31	28	90%

2.5.9 One-hour and Eight-hour Average Ozone Correlation

There is a strong correlation between peak one-hour and eight-hour average ozone concentrations during the June 2006 modeling episode. The average difference between peak one-hour and eight-hour ozone on all exceedance days between 2000 and 2008 is 10.87 ppb with a standard deviation of 5.25 ppb at regulatory monitors. The correlation between one-hour and eight-hour peak ozone concentrations was within one standard deviation on all but two modeling days, June 14th and June 29th (Table 2-5). On both days, the peak one-hour ozone reading was close to the peak eight-hour average. C23 and C58 recorded high, sustained ozone readings for seven to nine hours on these days.

Table 2-5: Observed and Predicted Correlation with Trend Line, June 2006

Exceedance Day	Peak 1-hr O_3 at Regulatory Monitors (ppb)	Peak 8-hr O_3 at Regulatory Monitors (ppb)	Diff. between 1-hr and 8-hr O_3 (ppb)	Within 1 Standard Deviation	Predicted 1-Hr Daily High O_3 (ppb)	Observed 1-Hr - Predicted 1-Hr O_3 (ppb)
3	86	80	6.0	Yes	90.5	-4.5
7	87	76	11.0	Yes	86.0	1.0
8	96	84	12.0	Yes	94.9	1.1
9	86	77	9.0	Yes	87.1	-1.1
13	106	93	13.0	Yes	105.0	1.0
14	94	90	4.0	**No**	101.7	-7.7
26	86	78	8.0	Yes	88.2	-2.2
27	88	82	6.0	Yes	92.7	-4.7
28	97	87	10.0	Yes	98.3	-1.3
29	94	91	3.0	**No**	102.8	-8.8

2.5.10 TexAQSII Data

Extensive air quality and meteorological databases were available to enhance modeling of the June 2006 episode as a result of the Texas Air Quality Study II (TexAQSII) conducted by TCEQ during the 2005 and 2006 ozone seasons. “TexAQSII is a comprehensive research initiative to better understand the causes of air pollution. The study gathers technical information for policy makers to help them design plans that will clean the air in Texas.” [26] Information collected during TexAQSII provided additional meteorological data, including local wind profiler data, useful for improving meteorological model performance.

2.5.11 Secondary Selection Criteria

The decision to model the June 2006 episode was supported by secondary selection criteria, i.e., the episode coincides with ozone exceedances in other urban areas and the episode includes a weekend exceedance. Multiple regions of Texas experienced elevated ozone levels during the June 2006 episode including Austin, Dallas, Houston, and San Antonio. The benefits of developing a model covering four regions included cost sharing and a consistent base case on which to model clean air strategies. TCEQ conducted the initial work on the June 2006 meteorological modeling, which lowered the cost of model development.

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[26] TCEQ, Nov. 2007. “TexAQS II.” Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/research/texaqs. Accessed 06/24/13.

The June 2006 ozone episode included one weekend exceedance day, June 3rd. Ozone exceedances that occur on weekend days often result from a different mix of emissions and 8-hour ozone spatial patterns compared to weekdays. To properly test control strategy effectiveness, which is the ultimate goal of developing photochemical model simulations, it is advisable to include weekends as well as weekdays in the modeled episode.[27]

2.6 Modeling Domain

The modeling domain identifies the geographic boundaries of the study area including the horizontal grid, vertical layers, and initial and boundary conditions. When selecting the modeling domain, all major upwind continental emission sources should be included in the model. The June 2006 meteorological and photochemical modeling domains include all of the eastern and central U.S. as well as parts of southeastern Canada and northern Mexico. The modeling domains are large enough to capture major sources that would be upwind from San Antonio, as winds tend to arrive from the southeast, east, and northeast on ozone exceedance days.[28]

The CAMx photochemical model utilizes a nested grid system that geographically distributes emissions. The fine grid (or 4 kilometer grid) allows for high spatial resolution at the local level. Data from regions outside the 4-kilometer grid are assigned to coarser grids where geographic accuracy is less important. This allows the majority of the computer resources be used to run the model at the 4-km fine-grid level. The EPA recommends establishing the size of the fine grid based on several factors including:

1) “The size of the non-attainment area.
2) Proximity to other large source areas and/or non-attainment areas.
3) Proximity of topographical features, which appear to affect observed air quality.
4) Whether the model application is intended to cover multiple non-attainment areas.
5) Typical wind speeds and re-circulation patterns.
6) Whether the photochemical model utilizes one-way or two-way nested grids.
7) Computer and time resource issues.”[29]

2.6.1 Meteorological Horizontal Grid

For development of the WRF model, TCEQ used a nested 4-km grid that encompasses eastern Texas and portions of Louisiana, the Gulf of Mexico, Oklahoma, and Arkansas. The coarse grid covers all of the continental US, southern Canada, northern Mexico, and parts of the Caribbean.

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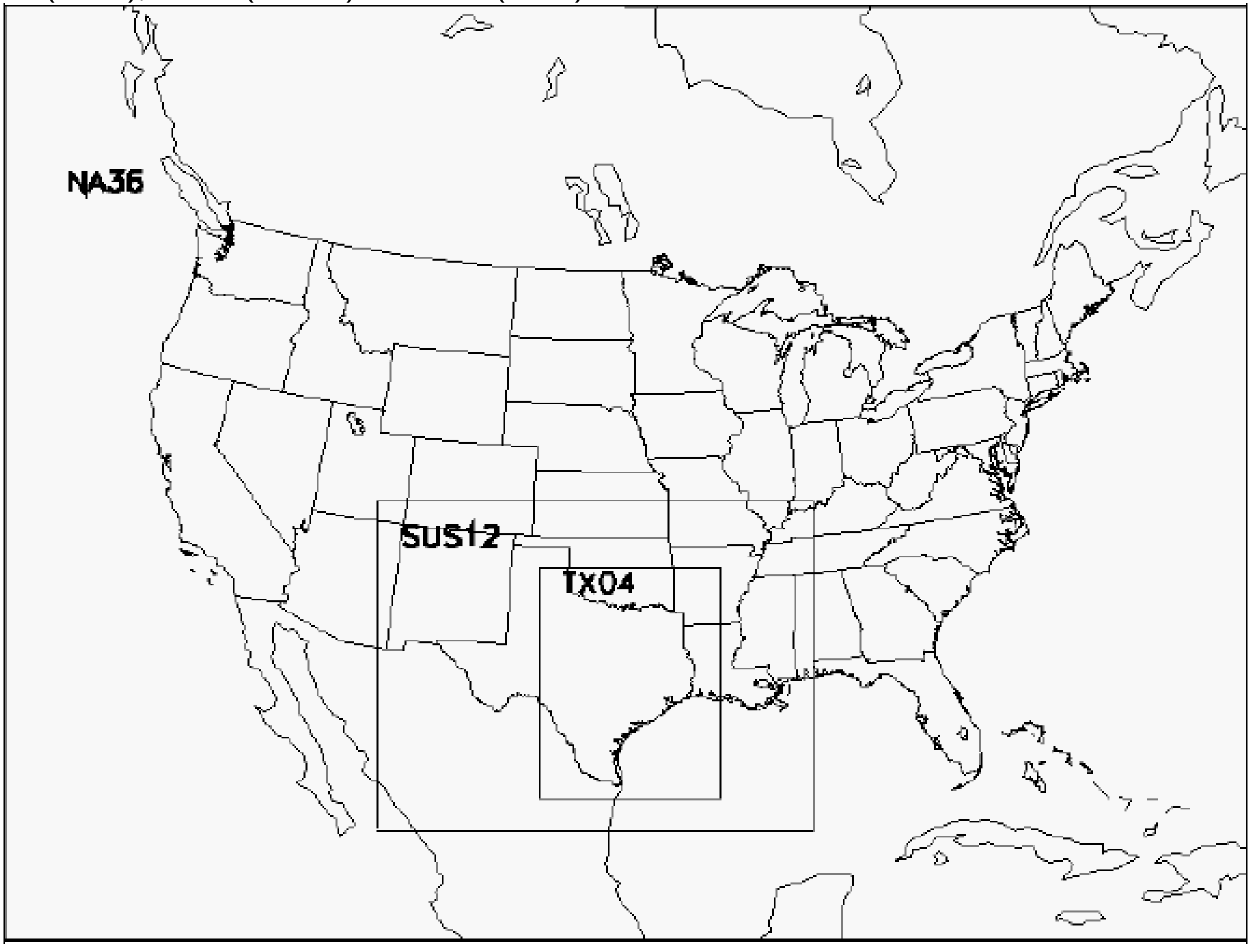
[27] EPA, April 2007. “Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze.” EPA -454/B-07-002. Research Triangle Park, North Carolina. pp. 150 - 151. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13.

[28] AACOG, April 2009. “Conceptual Model - Ozone Analysis of the San Antonio Region: Updates through Year 2008”. San Antonio, Texas.

[29] EPA, April 2007. “Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze.” EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 153. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13.

The grids have resolutions of 36-km, 12-km, and 4-km, and the number of rows and columns for each grid is 162x128, 174x138, and 216x218, respectively (Figure 2-6).[30] The two coarse domains were run with two-way nesting using 1 point feedback with light smoothing, while the 4-km domain was run with one-way nesting. The MM5 model was run with overlaps between the grid domains to avoid adverse boundary effects at the edges of the 4-km, 12-km, and 36-km nested grids. To ensure accurate modeling results, the photochemical modeling domains at each grid level are contained within the meteorological grid domains.

Figure 2-6: WRF domains used for model simulations in three different spatial resolutions: 36-km (NA36), 12-km (SUS12) and 4-km (TX04).



Domain name	**NA36**	**SUS12**	**TX04**
Resolution	36 km	12 km	4 km
Domain coverage	Continental US	Texas & adjoined states	Eastern Texas
Horizontal grid	162 x 128	174 x 138	216 x 288

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[30] Pius Lee, Hyun-Cheol Kim, and Fantine Ngan, Air Resources Laboratory National Oceanic and Atmospheric Administration U.S. Department of Commerce, March 15, 2012. “Investigation of nocturnal surface wind bias by the Weather Research and Forecasting (WRF)/ Advanced Research WRF (ARW) meteorological model for the Second Texas Air Quality Study (TexAQS-II) in 2006”. Silver Spring, Maryland P. 8. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mm/5820886246FY12-20120315-noaa-wrf_wind_bias.pdf. Accessed 06/21/13.

2.6.2 Photochemical Horizontal Grid

The photochemical modeling domain covers a much larger geographical area than southern Texas alone to reduce the influence of boundary conditions (Figure 2-7). The larger domain is necessary to simulate the effects of meteorological and atmospheric processes, including transport of precursors and background concentrations of ozone, on the San Antonio region. The 48-hour back trajectories for the 2006 episode originated as far away as Kansas, Oklahoma, and the Gulf of Mexico. Consequently, the 36-km coarse grid used in the model simulation (US 36km) extends throughout the central and eastern U.S. to reduce the impact from boundary conditions on the 4-km grid. The larger 36 km grid, RPO 36km, will be used in the future to improve modeling performance.

The 4km grid includes ozone pre-cursor emissions from all major cities in Eastern Texas including San Antonio, Austin, Corpus Christi, Dallas, and Houston. The grid system used in the model is consistent with EPA's Regional Planning Organizations (RPO) Lambert Conformal Conic map projection with the following parameters:

First True Latitude (Alpha):	33°N
Second True Latitude (Beta):	45°N
Central Longitude (Gamma):	97°W
Projection Origin:	(97°W, 40°N)
Spheroid: Perfect Sphere, Radius:	6,370 km[31]

2.6.3 Vertical Layers

The vertical structures used in the WRF and CAMx models are listed in Table 2-6. The meteorological model has 38 vertical layers extending from the surface up to approximately 15-km, while the CAMx model uses 28 vertical layers up to approximately 13.6 km. The surface layer is roughly 34-m thick.[32] The meteorological and photochemical layers are finer at the surface to capture vertical gradients as the mixing height changes during the day and to model pollutant concentrations at the surface.

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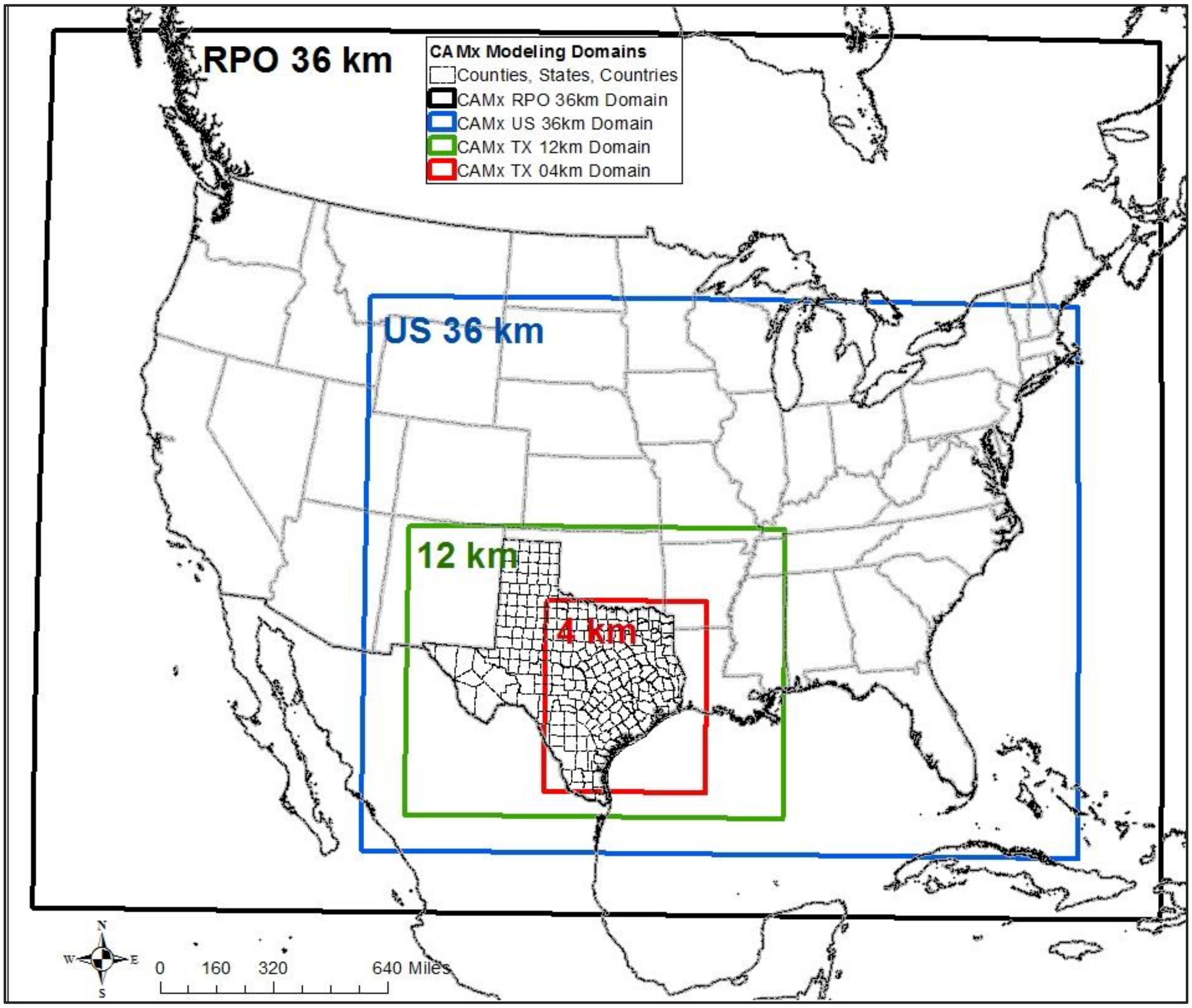
[31] TCEQ. "Rider 8 State and Local Air Quality Planning Program - Modeling Domains". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/rider8/modeling/domain. Accessed 06/10/13.

[32] Susan Kemball-Cook, Yiqin Jia, Ed Tai, and Greg Yarwood August 31, 2007. "Performance Evaluation of an MM5 Simulation of May 29-July 3, 2006." Prepared for Texas Commission on Environmental Quality. ENVIRON International Corporation, Novato, CA. p. 2-1. Available online: http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/mm/2006_MM5_Modeling_Final_Report-20070830.pdf. Accessed 06/24/13.

Figure 2-7: Nested Photochemical Modeling Grids for June 2006 Episode[33]
Coordinates from NW to SE corners:



CAMx RPO 36-km	= 148 x 112	(-2,736, 1,944) to	(2,592, -2,088)
CAMx US 36-km	= 94 x 70	(-1,188, 720) to	(2,196, -1,800)
CAMx TX 12-km	= 149 x 110	(-984, -312) to	(804, -1,632)
CAMx TX 4-km	= 191 x 218	(-328, -644) to	(436, -1,516)

Plot Date: June 10, 2013
Map Compilation: June 10, 2013
Source: TCEQ.

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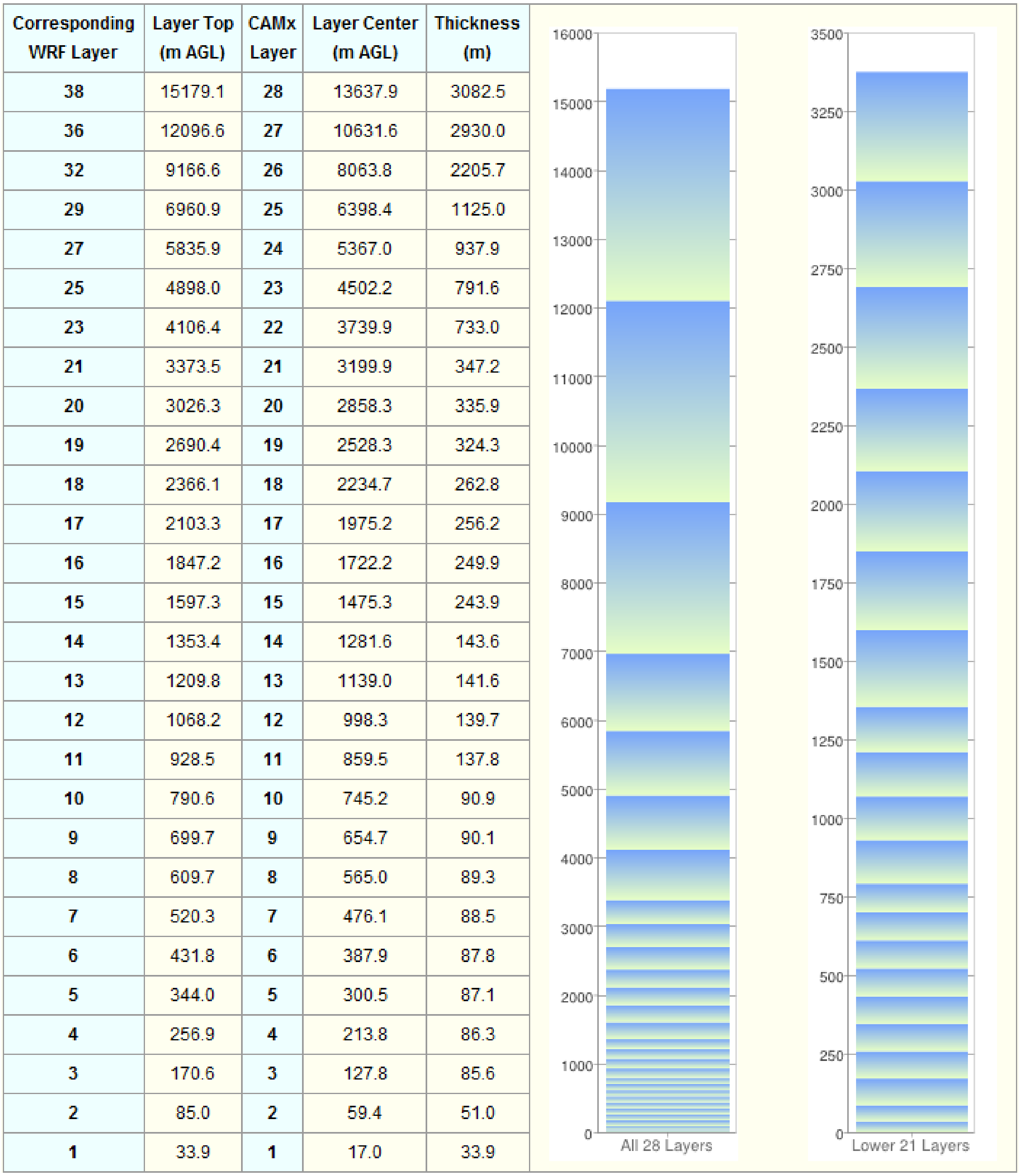
[33] ENVIRON, June 30, 2009. “Application of CAMx for the Austin San Antonio Joint Meteorological Model Refinement Project”. prepared by Chris Emery, Jeremiah Johnson, and Piti Piyachaturawat of ENVIRON International Corporation, Air Sciences Group, Novato, CA, p. 1-2.

Table 2-6: WRF and CAMx Vertical Layer Structure[34]



Corresponding WRF Layer	Layer Top (m AGL)	CAMx Layer	Layer Center (m AGL)	Thickness (m)
38	15179.1	28	13637.9	3082.5
36	12096.6	27	10631.6	2930.0
32	9166.6	26	8063.8	2205.7
29	6960.9	25	6398.4	1125.0
27	5835.9	24	5367.0	937.9
25	4898.0	23	4502.2	791.6
23	4106.4	22	3739.9	733.0
21	3373.5	21	3199.9	347.2
20	3026.3	20	2858.3	335.9
19	2690.4	19	2528.3	324.3
18	2366.1	18	2234.7	262.8
17	2103.3	17	1975.2	256.2
16	1847.2	16	1722.2	249.9
15	1597.3	15	1475.3	243.9
14	1353.4	14	1281.6	143.6
13	1209.8	13	1139.0	141.6
12	1068.2	12	998.3	139.7
11	928.5	11	859.5	137.8
10	790.6	10	745.2	90.9
9	699.7	9	654.7	90.1
8	609.7	8	565.0	89.3
7	520.3	7	476.1	88.5
6	431.8	6	387.9	87.8
5	344.0	5	300.5	87.1
4	256.9	4	213.8	86.3
3	170.6	3	127.8	85.6
2	85.0	2	59.4	51.0
1	33.9	1	17.0	33.9

AGL - Above Ground Level

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[34] TCEQ. "Rider 8 State and Local Air Quality Planning Program - Modeling Domains". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/rider8/modeling/domain. Accessed 06/10/13.

2.7 Meteorological Model Parameters

A meteorological model was developed to simulate the meteorological conditions that occurred during the 2006 high ozone episode. This process involved selecting the meteorological model (WRF), determining the time period, defining the region, and obtaining data inputs. The data output from the meteorological model was used as input for the photochemical model in order to simulate processes that form, transport, and remove ozone and ozone pre-cursor pollutants. Meteorological inputs into the photochemical model include mixing heights, wind speeds, wind direction, vertical mixing, temperature, and other meteorological parameters. .

The WRF model was run using a diffusion package called the Yonsei University planetary boundary layer (YSU PBL) at each grid level. "The YSU PBL increases boundary layer mixing in the thermally induced free convection regime and decreases it in the mechanically induced forced convection regime, which alleviates the well-known problems in the Medium-Range Forecast (MRF) PBL."[35] The Kain-Fritsch cumulus one-dimensional cloud model was used to simulate cloud formation in each grid level.[36] The WRF-Single-Moment 5-clasee Microphysics scheme (WSM5) was used for the 36km and 12km grids, while the WRF-Single-Moment 6-clasee Microphysics scheme (WSM6) was used for the 4km grid. The WSM5 and WSM6 microphysics were used to determine condensation, precipitation, and thermodynamic effects of latent heat release

The WRF model includes a 5 layer thermal diffusion and no land use model. Wind data from the National Oceanic and Atmospheric Administration (NOAA) Profiler Network (NPN) troposphere profilers[37] were used to perform nudging in the updated meteorological runs. The process was performed "to nudge model predictions towards observational analysis and/or discrete measurements to control model 'drift' from conditions that actually occurred."[38]

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[35] Hong, Song-You, Yign Noh, Jimy Dudhia, 2006. "A New Vertical Diffusion Package with an Explicit Treatment of Entrainment Processes ".Mon. Wea. Rev., 134, 2318–2341. Available online: http://journals.ametsoc.org/doi/full/10.1175/MWR3199.1. Accessed 06/21/13.

[36] Kain, John S., J. Michael Fritsch, 1990. "A One-Dimensional Entraining/Detraining Plume Model and Its Application in Convective Parameterization". J. Atmos. Sci., 47, 2784–2802. Available online: http://journals.ametsoc.org/doi/abs/10.1175/1520-0469%281990%29047%3C2784%3AAODEPM%3E2.0.CO%3B2. Accessed 06/21/13.

[37] National Oceanic and Atmospheric Administration. "NOAA Profiler Network." Available online: http://www.profiler.noaa.gov/npn/. Accessed 06/21/13.

[38] Susan Kemball-Cook, Yiqin Jia, Ed Tai, and Greg Yarwood August 31, 2007. "Performance Evaluation of an MM5 Simulation of May 29-July 3, 2006." Prepared for Texas Commission on Environmental Quality. ENVIRON International Corporation, Novato, CA. p. 2-3. Available online: http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/mm/2006_MM5_Modeling_Final_Report-20070830.pdf. Accessed 06/24/13.

3 Base Case Emissions Inventory

Three anthropogenic emission inventories were created for the June 2006 modeling episode: 2006 base line inventory, 2012 projection case, and 2018 projection case. The model was run with each of these emission inventories to predict the impact of emissions changes over time – both quantitative and spatial – on ozone formation and dispersion. Model inputs accounted for the chemical and meteorological characteristics associated with the May 31st to July 2nd, extended 2006 episode. Also, three different projection scenarios for emissions from oil and gas development and production in the Eagle Ford Shale region were developed for the 2018 projection case. The meteorological inputs, chemistry parameters, and biogenic emissions were identical for every model run.

The 2006 base case inventory was used to validate the meteorological and photochemical model. To determine if the meteorological model and emission inventory are representative of the May 31st to July 2nd, 2006 episode, photochemical model performance was reviewed and analyzed. Precursor emissions and ozone concentrations in the photochemical model were evaluated to determine if locations, concentrations, and timing of emissions met performance criteria. The 2006 base case inventory was projected to 2012 and 2018 using EPA approved methodologies, local emissions, point sources added since 2006, and proposed new power plants to calculate future emissions. The 2012 and 2018 future year inventories were developed using the same hourly adjustment and emission calculation methodologies used in the base case inventory.

Before the emission inventories were entered into the photochemical model, the emissions were pre-processed using the Emissions Processor version 3 (EPS3)[39] to allocate the data to the proper spatial and temporal resolutions used by the photochemical model. The Emissions Processor allocates emissions to account for monthly, weekly, and hourly variations in emission rates, assigns emissions to the appropriate grid cells, and disaggregates or speciates chemical compounds for the photochemical model's chemical mechanism. To accurately predict ozone formation, the photochemical model requires a detailed emission inventory for every grid used in the model.

3.1 Emission Inventory Parameters

CO, speciated NO_X, and speciated VOC emissions from all anthropogenic and biogenic sources were included in the model for all grid domains. Emissions data was processed through EPS3 for the following source categories:

1. Biogenic Sources
2. Point Sources
3. Area
4. Non-Road
5. Off-Road

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[39] ENVIRON International Corporation, August 2009. "User's Guide Emissions Processor Version 3". Novato, CA. Available online: ftp://amdaftp.tceq.texas.gov/pub/HGB8H2/ei/EPS3_manual/EPS3UG_UserGuide_200908.pdf. Accessed 06/27/13.

6. Mobile Sources
7. Eagle Ford

The emissions for each of these categories were temporally allocated to the appropriate hours, week days, and seasons based on data obtained from surveys of local sources. In the absence of survey data, EPA defaults or other appropriate surrogates were used.

Monthly Adjustments

Since the National Emissions Inventories (NEI)[40] was estimated based on average ozone season day, emissions sources, including on-road, recreational marine vessels, pesticides, agriculture equipment, fertilizers, and defoliants, were adjusted to account for seasonal differences in usage and temperatures. For example, use of agricultural pesticides increases during the spring and summer growing seasons. Monthly adjustment values were based on survey results from local emissions sources or EPA defaults.[41]

Weekly and Daily Adjustments

The release of pollutants does not occur at a steady rate per unit of time, so allocation of emissions to a desired weekly time-period is recommended. "Under actual conditions, emissions sources may not operate on Sundays, or their activity may peak during certain hours of the day. Temporal allocations allows for emissions variability during the desired modeling periods to be modeled correctly. The desired modeling periods vary depending upon the purpose of the inventory."[42]

Weekly adjustment values were based on survey results from local emissions sources and EPA Defaults.[43] On-road vehicles, extended diesel truck idling, quarry equipment, industrial equipment, construction equipment, and commercial lawn and garden equipment are examples of emissions sources that typically operate more frequently on weekdays as compared to weekend days. Other sources, including recreational marine vessels and recreational equipment, operate more often on weekends.

Hourly Adjustments

Hourly adjustment factors were calculated based on the results of locally conducted surveys or obtained from values published by TTI, ERG, ENVIRON, TCEQ, and EPA. CPS Energy provided hourly emissions data for each power plant. San Antonio International Airport (SAIA) and other regional airport emissions were allocated hourly based on operational data from the Airport IQ Data center.[44]

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[40] EPA. March 15, 2013. "The National Emissions Inventory. Available online: http://www.epa.gov/ttnchie1/eiinformation.html. Accessed 06/27/13.
[41] EPA. May 3, 2007. "Emissions Modeling Clearinghouse Temporal Allocation". Available online: http://www.epa.gov/ttn/chief/emch/temporal/. Accessed 6/27/13.
[42] *Ibid*.
[43] EPA. May 3, 2007. "Emissions Modeling Clearinghouse Temporal Allocation." Available Online: http://www.epa.gov/ttn/chief/emch/temporal/. Accessed 06/27/13.
[44] GCR & Associates, Inc., 2005. "Airport IQ Data Center". Available Online: http://www.airportiq.com/. Accessed 09/17/2009

3.2 Conversion of Inventory Data into the Photochemical Model Ready Files

Spatial Allocation

The coarse 36km grid used in the photochemical model encompasses all anthropogenic and biogenic emissions in the continental United States, southern Canada, and northern Mexico. Emissions data was allocated to each grid cell for the entire domain; elevated point sources emissions and SAIA aircraft operations were allocated both spatially and vertically.

Local emissions were allocated spatially using Google Earth[45] and ArcGIS. These programs were used to calculate the fraction of county total emissions in each grid cell based on surrogate data. Local data included roadway types, truck stops, employment, population, navigable lake acreage, and data collected for industrial sites, landfills, quarries, and highway construction projects. When emission sources were insignificant or local data was not available, EPA default spatial allocation factors were used.

Chemical Speciation

All VOC and NO_X emissions were chemically speciated in EPS3 based on the latest version of the carbon bond mechanism design, Carbon Bond 6 (CB6). This mechanism is critical because it provides the link between ozone precursors and ozone formation in the CAMx model. CB6 was developed in 2010 by ENVIRON and is now being used in SIP applications across the United States. As noted by ENVIRON, the updates to the CB6 mechanism from the previous chemical speciation mechanism, version 5 of the Carbon Bond Mechanism (CB05), are:

1. "Incorporating new scientific information released since the previous mechanism update in 2005 (CB05)
2. Reviewing and updating reactions for alkanes, alkenes and aromatics with the most changes resulting for isoprene and aromatics.
3. Adding explicitly several long-lived VOCs that form ozone at regional scales, specifically propane, benzene, acetone and other ketones.
4. Adding explicitly acetylene and benzene because they are precursors to Secondary organic aerosol (SOA) formation and useful as anthropogenic emission tracers.
5. Adding explicitly VOC degradation products that can produce SOA via aqueous-phase reactions, specific"[46]

By updating to CB6 in the model, "The number of reactions is about 40% greater and the number of species about 50% greater in CB6 than CB05".[47]

3.3 Quality Assurance

"An overall QA program comprises two distinct components. The first component is that of quality control (QC), which is a system of routine technical activities implemented by inventory development

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[45] Google. "Google Earth". Available online: http://www.google.com/earth/index.html. Accessed 06/27/13.

[46] Greg Yarwood, Jaegun Jung, Gary Z. Whitten, Gookyoung Heo, Jocelyn Mellberg, and Mark Estes, Oct. 2010. "Updates to the Carbon Bond Mechanism for Version 6 (CB6)". Presented at the 9th Annual CMAS Conference, Chapel Hill, NC, October 11-13, 2010. p. 2. Available online: http://www.cmascenter.org/conference/2010/abstracts/emery_updates_carbon_2010.pdf. Accessed 06/27/13.

[47] *Ibid*.

personnel to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

1. Provide routine and consistent checks and documentation points in the inventory development process to verify data integrity, correctness, and completeness;
2. Identify and reduce errors and omissions;
3. Maximize consistency within the inventory preparation and documentation process; and
4. Facilitate internal and external inventory review processes.

QC activities include technical reviews, accuracy checks, and the use of approved standardized procedures for emission calculations. These activities should be included in inventory development planning, data collection and analysis, emission calculations, and reporting."[48]

Equations, data sources, and methodologies were checked throughout the processing of each emission source. "Simple QA procedures, such as checking calculations and data input, can and should be implemented early and often in the process. More comprehensive procedures should target:

- Critical points in the process;
- Critical components of the inventory; and
- Areas or activities where problems are anticipated"[49]

Quality assurance (QA) procedures used to check emissions inventory preparation for the photochemical mode included:

- Examination of raw data files for inconsistencies in emissions and/or locations,
- Review of message files from EPS3 scripts for errors and warnings,
- Verification of consistency between input and output data, and
- Creation of output emissions tile plots for visual review.

Special emphasis was placed on critical components, such as on-road vehicles, Eagle Ford emission sources, and point sources, for quality checks.

All raw data files were checked to ensure emissions were consistent by county and source type. Any inconsistencies were noted, checked, and corrected. When running the EPS3 job scripts, several message files are generated from each script that record data inputs, results, and errors. As part of the QA procedure, modeling staff reviewed all error messages and corrected the input data accordingly.

Errors can occur in EPS3 and go unnoticed by the built-in quality assurance mechanisms; therefore further QA methods were applied. Input and output emissions by source category were compared. If there were inconsistencies between values, input data was reviewed and any necessary corrections were made. Emission tile plots by source category were also developed and reviewed for

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[48] Eastern Research Group, Inc, Jan. 1997. "Introduction: The Value of QA/QC'. Quality Assurance Committee Emission Inventory Improvement Program, U.S. Environmental Protection Agency. p. 1.2-1. Available online: http://www.epa.gov/ttn/chief/eiip/techreport/volume06/vi01.pdf. Accessed 06/04/2012.

[49] *Ibid*., p. 1.2-2.

inconsistencies in emissions and spatial allocation. When errors and omissions were identified, they were corrected and all documentation was updated with the corrections.

3.4 Base Case Inventory

The modeling grid used in the photochemical model covers the eastern United States, southern Canada, and northeastern Mexico. To accurately predict local ozone concentrations and to determine the impact of transport, emission inventories were calculated for the complete photochemical model domain. Figure 2-7, located in the previous section, displays the photochemical modeling domain used to simulate the May 31st to July 2nd, 2006 high ozone episode. The figure indicates the boundaries of the 36-km, 12 km, and 4-km modeling grids.

Providing accurate emission rates, locations, and timing for all emission inputs in the modeling domain is essential for predicting ozone levels at local monitors. Following EPA guidelines, the most critical emission inventory is the local San Antonio-New Braunfels MSA emissions inventory[50] because these emissions are emitted near San Antonio's regulatory monitors and previous modeling predicted that local emissions account for 25 percent of recorded ozone at C23 and C58 monitors.[51] Local emissions were calculated using the most current, accurate, and practical methods available including the use of local data and surveys.

Adjacent and nearby areas with large emission sources can also have a significant impact on local ozone monitors. Back trajectory analysis indicates Austin, Houston, Dallas, Corpus Christi, and other large, southern United States cities can significantly influence local ozone readings.[52] Determining accurate emissions inventories for these areas are essential for good model performance. Detailed emissions inventories were developed by TCEQ for other counties in Texas. Emission inventories were also developed by the EPA for other states in the modeling domain[53] and Mexico[54]. The detailed emission inventory for Canada was developed by Environment Canada.[55] Since EPA lowered the ozone standard to a 75 ppb threshold, the impact of long-range transport can have a greater impact on local ozone concentrations.

Local emissions in the San Antonio-New Braunfels MSA were obtained from AACOG EI updates, TCEQ, ERG, and Texas Transportation Institute (TTI). All emission inventory inputs in the modeling domain were calculated using EPA approved methodologies and data sources. Data sources for the modeled emissions inventory in the United States are listed in Table 3-1.

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[50] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze," EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 172. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13.

[51] Alamo Area Council of Governments, April 2009. "Conceptual Model –Ozone Analysis of the San Antonio Region: Updates through Year 2008." San Antonio TX.

[52] *Ibid*.

[53] EPA. "National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data". Available online: http://www.epa.gov/ttnchie1/trends/. Accessed 07/01/13.

[54] EPA, Oct. 2006. "North American Emissions Inventories – Mexico". Available online: http://www.epa.gov/ttnchie1/net/mexico.html. Accessed 07/08/13.

[55] Environment Canada. "National Pollutant Release Inventory". Available online: http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1. Accessed 07/08/13.

3.5 Biogenic Emissions

Biogenic emissions originate from natural sources due to chemical processes in vegetation and soil. These include emission of ozone precursor chemicals: NO_X, VOC and CO. Day-specific, gridded, hourly biogenic emissions for the 4 km and 12 km grids were developed by the Department of Ecosystem Science & Management at the Texas A&M University. To create the necessary biogenic emissions inventory, an “expansion of Texas Land Use/Land Cover through Class Crosswalking and light detection and ranging (lidar) Parameterization of Arboreal Vegetation project“ was used.[56]

“This expansion was used to provide a more detailed and accurate map of land cover necessary for air quality modeling for the 12km Comprehensive Air Quality Model with Extensions (CAMx) domain. The project consisted of crosswalking classes from the LANDFIRE and Texas Parks and Wildlife Vegetation classes and classifying LandSat imagery to the Texas Land Classification System, and to derive forest composition characteristics with lidar for more accurate biogenic emission modeling. Lidar was used to estimate tree height, canopy base height, diameter at breast height, individual tree biomass, and canopy bulk density. Individual trees were identified through lidar and the TreeVaw software, which uses a local maxima varying filter”.[57] “LANDFIRE is a program that provides over 20 national geo-spatial layers (e.g. vegetation, fuel, disturbance, etc.), databases, and ecological models that are available to the public for the US and territories.”[58] The temperatures used to calculate biogenic emissions are based on calculated modeling surface temperatures from the WRF meteorological model for the June 2006 modeling episode.

For the 36km grid, biogenic emissions were developed by TCEQ using BEIS. The BEIS model “requires a land use database known as the Biogenic Emissions Landuse Database, version 3 (BELD3). BELD3 data provides distributions of 230 vegetation classes at 1km resolution over most of North America.”[59]

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[56] Sorin C. Popescu “Expansion of Texas Land Use/Land Cover through Class Crosswalking and Lidar Parameterization of Arboreal Vegetation”. Texas A&M University. TCEQ Grant # 582-5-64593-FY09-25. p. 1. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/oth/5820564593FY0925-20110419-tamu-expension_tx_lulc_arboreal_vegetation.pdf. Accessed 06/28/13.

[57] *Ibid*.

[58] “LandFire”. Available online: http://www.landfire.gov/. Accessed 06/28/13.

[59] EPA, Nov. 7, 2007. “Emissions Modeling Clearinghouse
Biogenic Emission Sources”. Available online: http://www.epa.gov/ttnchie1/emch/biogenic/. Accessed 06/28/13.

Table 3-1: Emission Inventory Sources by Type for 2006

Type	Sub Category	Source
Point	Electric Generating Units (EGU)	- Texas and US hourly acid rain database (EGU emissions) - CB6 Chemical Speciation
	Non-Electric Generating Units (NEGU)	- Texas Ozone Season Day (OSD) 2006 based on 01Jun-01Sep2006 STARS - US OSD based on NEI 2008 annual emissions. - HGB 2006 generic day extra alkenes. - HGB 2006 generic day hourly tank landing losses. - Offshore platforms monthly emissions from 2005 GWEI. - Mexico 1999 generic day from NEI phase III. - Canada 2006 annual National Pollutant Release Inventory (NPRI) and Upstream Oil and Gas (UOG) inventories from Environment Canada. - CB6 Chemical Speciation for NEGUs in Texas and the United States - CB05 Chemical Speciation for other sources.
Area	Area Sources	-TexAER v4 area09c for Texas - nei2008v2-based for other sates - CB6 Chemical Speciation
	Oil and Gas	- DFW SIP special oil and gas production emission inventory - New TX 2008 offshore oil and gas production - Other areas in Texas use TexAER v4 area09c - nei2008v2-based for other sates - CB6 Chemical Speciation
Mobile	All Categories	- MOVES2010a model was used to estimate 2006 on-road emissions for all U.S. portions of the modeling domain. - Within Texas, the vehicle miles traveled (VMT) estimates are based on travel demand modeling (TDM) for major metropolitan areas and the Highway Performance Monitoring System (HPMS) for more rural areas. - MOVES2010a was run in default mode for all non-Texas U.S. states. - On-road emission estimates for Canada and Mexico are based on MOBILE6-Canada and MOBILE6-Mexico, respectively. - Profiles from EPA's SPECIATE Version 4.3 Database were used to allocate VOC exhaust and evaporative emission estimates with CB6 mechanism. - Local data for Extended Diesel Truck Idling

Type	Sub Category	Source
Non-Road	All Categories	- TexN model - Drill rigs are based on TexAER data back cast to 2006 - Local data for construction equipment, quarry equipment, mining equipment, landfill equipment, agricultural tractors, and combines - CB6 Chemical Speciation
Off-Road	Locomotives	- ERG contract 2011-based switcher and line-haul locomotives - NEI2008v2 locos (switchers as points) - CB6 Chemical Speciation
	Marine	- NEI2008v2 harbor vessels - limited to 3.0 tpd max per county in port; 6.0 tpd max. underway. - CB6 Chemical Speciation
	Aircraft	- ERG airport specific 2011-based EI with new surrogates for hgb8co and attainment counties - DFW airports based on NCTCOG data for the DFW SIP - new NEI2008v2 airports as points (with ground support equipment - GSE). - local data for San Antonio International Airport (SAIA) - CB6 Chemical Speciation
Eagle Ford	All Categories	- None
Biogenic	All Categories	- 4 km and 12 km grid emissions were developed by Department of Ecosystem Science & Management at the Texas A&M University. - 36km grid were developed by TCEQ using BIES - WRF calculated modeling surface temperature - CB6 Chemical Speciation[60]

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[60] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/13.

3.6 Area Source Emissions

Area sources are small industrial, commercial, and residential sources that are widely distributed and include refueling, painting, asphalt, surface coating, landfills, and wastewater treatment emissions. Area sources outside of Texas are based on EPA's National Emissions Inventory 2008 v2.[61] Emissions for other states were back cast to 2006 based on EPA's Economic Growth and Analysis System (EGAS).[62] EGAS 5.0 "is an economic activity forecast tool designed by EPA that generates credible growth factors used in the development of emissions inventories. This tool is intended for use by States, Regional Planning Organizations, local governments, and the EPA so these entities may project air pollution emissions and design appropriate policies to control them."[63]

Emissions for Texas were based on the 2008 Texas Air Emissions Repository (TexAER) v4 database. "TexAER contains historical, current, and projected future case emissions inventory data, as well as control strategy information. You can customize your report to include specific locations, source classification codes (SCCs), time periods, units of measure, and other parameters."[64] Texas area source emissions were back cast to 2006 based on an ERG study completed for TCEQ.[65]

3.6.1 Oil and Gas Production Emissions

Emissions from oil and gas production were obtained from the ERG 2008 emission inventory. ERG's efforts included work to "identify and characterize area source emissions from upstream onshore oil and gas production sites that operated in Texas in 2008" and develop a 2008 base year air emissions inventory from these sites. "ERG was able to compile the 2008 area source emissions inventory from upstream onshore oil and gas production sites by obtaining both county-level activity data, and specific emissions and emission factor data for each source type. This data was obtained from a variety of sources, including existing databases (such as the Texas Railroad Commission (TRC) oil and gas production data), point source emissions inventory reports submitted to TCEQ (for dehydrators), vendor data (for compression engines and pumpjack engines), and published emission factor and activity data from the Houston

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[61] EPA. "National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data". Available online: http://www.epa.gov/ttnchie1/trends/. Accessed 07/01/13.

[62] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/2013.

[63] Abt Associates Inc. January 2006. "The Economic Growth and Analysis System EGAS 5.0 User Manual and Documentation". Office of Air Quality Planning and Standards U.S. Environmental Protection Agency, Research Triangle Park, NC. Available online: http://www.epa.gov/ttnecas1/egas5.htm. Accessed 02/03/13.

[64] TCEQ. "TexAER (Texas Air Emissions Repository)". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/areasource/TexAER.html. Accessed 07/03/13.

[65] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/2013.

Advanced Research Center (HARC), the Central Regional Air Planning Association (CENRAP), and the U.S. Environmental Protection Agency (EPA)."[66]

Emission files for oil and gas are allocated appropriately to the Barnett Shale, Haynesville Shale, and other regions in Texas. "The spatial distribution within counties for oil and gas production was built from Texas Railroad Commission data for active wellhead density. The number of active wells in a given model grid cell over the total number of active wells in the county assigned the proportionate amount of the county's total emissions to that cell. Active wells for year-end 2006 were used for the base case."[67]

3.7 Non-Road Emissions

Non-road sources are equipment used for off road purposes and include construction equipment, recreational marine vessels, industrial equipment, agricultural equipment, recreational vehicles, lawn and garden equipment, railroad maintenance equipment, and commercial equipment. Non-road sources outside of Texas are based on EPA's National Emissions Inventory 2008 v2.[68] The EPA's National Mobile Inventory Model (NMIM) was used to back cast non-road emissions to 2006. NMIM "is a consolidated emissions modeling system for EPA's MOBILE6 and NONROAD models. It was developed to produce, in a consistent and automated way, national, county-level mobile source emissions inventories for the National Emissions Inventory (NEI) and for EPA rule making."[69]

Non-road emissions for Texas were calculated using the TexN model. The "Texas NONROAD Model (TexN) provides emissions estimates for a large number of non-road equipment categories operating in Texas." "The TexN model calculates emissions estimates for the same equipment categories included in EPA's NONROAD model."[70] "The TexN model incorporates the unmodified NONROAD2005 model to generate its core emission estimates, utilizing region-specific adjustment factors in order to refine the NONROAD outputs for Texas. The model also incorporates geographic and equipment-specific improvements to the NONROAD model,

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[66] ERG, 2010. "Characterization of Oil and Gas Production Equipment and Develop a Methodology to Estimate Statewide Emissions". Final Report to the Texas Commission on Environmental Quality (TCEQ), Contract No. 582-7-84003-FY10-26. p. IV-V. http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784003FY1026-20101124-ergi-oilGasEmissionsInventory.pdf. Accessed 07/03/13.

[67] TCEQ, "TexAER (Texas Air Emissions Repository)". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/areasource/TexAER.html. Accessed 07/16/13

[68] EPA. "National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data". Available online: http://www.epa.gov/ttnchie1/trends/. Accessed 07/01/13.

[69] EPA, April 2009. "National Mobile Inventory Model (NMIM)". Available online: http://www.epa.gov/oms/nmim.htm. Accessed 07/03/13.

[70] Eastern Research Group, Inc. April 26, 2013. "Texas NONROAD (TexN) Model". Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Nonroad_EI/TexN/. Accessed 07/03/13.

reflecting the efforts of numerous TCEQ studies."[71] All Diesel equipment in eastern Texas was adjusted by TCEQ to take into account TXLED.

3.7.1 Drill Rigs

Drill rig emissions were based on ERG's drill rig emission inventory for Texas. The purpose of ERG's "study was to develop a comprehensive emissions inventory for drilling rig engines associated with onshore oil and gas exploration activities occurring in Texas in 2008."[72] "While drilling activities are generally short-term in duration, typically covering a few weeks to a few months, the associated diesel engines are usually very large, from several hundred to over a thousand horsepower. As such, drilling activities can generate a substantial amount of NO_X emissions."[73] "In order to gain a more accurate understanding of emissions from drilling rig engines, data regarding typical rig profiles (number of engines, engine sizes, and engine load factors) were collected through phone and email surveys for drilling operations for the 2008 base year."[74] Drill Rig emissions were back cast to 2006 using BakerHughes.com and RigData.com drill rig counts.[75]

3.7.2 Construction Equipment

The local construction equipment inventory includes emissions from the equipment used to build roads, highways, buildings, houses, and utility lines in the San Antonio-New Braunfels MSA. When calculating local construction equipment populations, surrogate factors were used to adjust TexN equipment populations for each county. To determine surrogate factors for the MSA, each Diesel Construction Equipment (DCE) subsector was calculated separately based on comparisons of industry trends and other data closely related to diesel construction

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[71] Eastern Research Group, Inc. April 26, 2013. "Texas NONROAD (TexN) Model". Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Nonroad_EI/TexN/. Accessed 07/03/13.

[72] Eastern Research Group, Inc. July 15, 2009. "Drilling Rig Emission Inventory for the State of Texas". Austin, Texas. p. 2-1. Available online: http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/ei/5820783985FY0901-20090715-ergi-Drilling_Rig_EI.pdf. Accessed 07/03/13.

[73] Eastern Research Group, Inc. July 15, 2009. "Drilling Rig Emission Inventory for the State of Texas". Austin, Texas. p. 2-1. Available online: http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/ei/5820783985FY0901-20090715-ergi-Drilling_Rig_EI.pdf. Accessed 07/03/13.

[74] Eastern Research Group, Inc. July 15, 2009. "Drilling Rig Emission Inventory for the State of Texas". Austin, Texas. p. 2-1. Available online: http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/ei/5820783985FY0901-20090715-ergi-Drilling_Rig_EI.pdf. Accessed 07/03/13.

[75] Doug Boyer, TCEQ, Nov. 5, 2010. "2006/2012 DFW Modeling Update". Presented to the DFW Photochemical Modeling Technical Committee. p. 6. Available online http://www.tceq.texas.gov/assets/public/implementation/air/am/committees/pmt_dfw/20101105/20101105_PMTC_modeling_update.pdf. Accessed 07/01/13.

equipment populations. Data sources for the surrogate factors included employment[76], population[77], TxDOT[78], and Census Building permits[79].

To allocate construction equipment emissions accurately in the photochemical model, emissions were spatially allocated by subsector based on type and purpose of equipment used. Local departments of transportation, utility companies, government agencies, and private companies were contacted to collect data on size and location of construction projects. Residential building permits, commercial building permits, and demolition permits were also collected to geo-code construction emissions.

3.7.3 *Quarry, Landfill, and Mining Equipment*

Due to the abundance of limestone, aggregate, granite, sand, and gravel deposits, there are numerous quarries in the AACOG region. In addition, there are 6 active landfills in the AACOG region and one lignite mine. Data on quarry, landfill, and mining equipment was collected using a "bottom-up" methodology to refine equipment populations, equipment horsepower, activity profiles, and spatial allocation of emissions. A survey questionnaire was sent to local quarries, landfills, and mines to collect data on:

1. Equipment Populations
2. Activity Rates – total annual hours of use by type of equipment
3. Temporal Profiles – equipment use on weekdays and weekend days
4. Engine Characteristics

Ozone season day emissions from equipment were estimated based on survey responses and existing data from the TexN model. Emissions were geo-coded to the location of quarries, landfills, and mines identified through TCEQ permits[80], Mineral Locations Database[81], Find the Best directory[82], and aerial photographs.

3.7.4 *Agricultural Tractors and Combines*

To calculate tractor and combine emissions, crop acres planted and harvested for every county was collected. Volume I of the 2007 Census of Agriculture, which was made available by the

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[76] U.S. Census Bureau. June 30, 2011. "County Business Patterns (CBP)". Available online: http://www.census.gov/econ/cbp/index.html. Accessed 07/12/11.

[77] U.S. Census Bureau, Population Division. "Population Estimates". Available online: http://www.census.gov/popest/counties/. Accessed 07/13/11.

[78] Texas Department of Transportation. "TxDOT Letting Schedule". Finance Division. Austin, Texas. Available online: http://www.dot.state.tx.us/business/schedule.htm. Accessed 07/11/11.

[79] U.S. Census Bureau. "Building Permits". Available online: http://censtats.census.gov/bldg/bldgprmt.shtml. Accessed 07/13/11.

[80] TCEQ. Permit Database". Austin Texas. Available online: https://webmail.tceq.state.tx.us/gw/webpub. Accessed 07/27/11.

[81] MineralMundi. "Mineral Locations Database". United States Geological Survey Mineral Resources Program. Available online: http://www.mineralmundi.com/texas.htm. Accessed 07/27/11.

[82] Find the Best, 2011. "Texas Active Mines". Available online: http://active-mines.findthebest.com/directory/d/Texas. Accessed 07/27/11.

United States Department of Agriculture (USDA), contained acreage of hay by county.[83] Crop acreages for all other crop types were retrieved from the 2008 Texas Agricultural Statistics report published by the USDA (Table 5-1).[84]

Agricultural tasks that use tractors include soil preparation, plowing, planting, fertilizing, cultivating, and applying pesticides, while combines are used for harvesting. For each crop type, the climate of south-central Texas influences the time of the year for each agricultural activity. Emissions from agricultural tractors and combines for the June modeling period were based on estimates of equipment usage during the activities of plowing, planting, fertilizing, cultivating, and harvesting each crop. Activity data was provided via correspondence from local Texas Agricultural Service County Extension agents who have observed farm activity over the past 20 years in the AACOG region

Local activity data and existing data in the TexN Model were used to calculate tractor and combine emissions. Emissions estimates were based on activity data, horsepower, load factor, emission factors, and fuel ratio. Data from the Natural Agricultural Statistics Service was used to geo-code tractor and combine emissions.[85] Once crop locations were identified, tractor and combine emissions were spatially allocated to the 4-km photochemical grid system. VOC and NO_X average ozone season day emissions from tractors and combines were allocated to the location of each crop type.

3.8 Off-Road

Off-road emission sources consist of marine vessels, locomotives/switchers, and aircraft/GSE. Emissions from these sources are not included in the TexN model, NMIM model, or EPA's NonRoad model.

3.8.1 *Marine Vessels*

Emissions from marine vessels were split into 2 groups: in-port harbor vessels and ocean going marine vessels. "Slow turnover to new vessels/engines combined with regulation under international law means fewer emission reductions for ocean-going vessels."[86] Emissions from

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[83] United States Department of Agriculture, Updated December 2009. "2007 Census of Agriculture". AC-07-A-51. National Agricultural Statistics Service. Available online: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Texas/st48_2_027_027.pdf. Accessed 12/20/10.

[84] United States Department of Agriculture, Updated December 2009. "Texas Agricultural Statistics, 2008". National Agricultural Statistics Service, Texas Field Office". Available online: http://www.nass.usda.gov/Statistics_by_State/Texas/Publications/Annual_Statistical_Bulletin/index.asp. Accessed 12/20/10.

[85] National Agricultural Statistics Service. "CropScape – Cropland Data Layer". United States Department of Agriculture. Available online: http://nassgeodata.gmu.edu/CropScape/. Accessed 06/06/11.

[86] ENVIRON International Corporation, August 18, 2010. "Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling". Novato, CA. Work Order No. 582-7-84006-FY10-5. p. 1. Available online:

marine vessels outside of Texas are based on EPA's National Emissions Inventory 2008 v2.[87] Emissions were projected to 2006 by TCEQ based on EPA's "Proposal to Designate an Emission Control Area for Nitrogen Oxides, Sulfur Oxides and Particulate Matter".[88]

For Texas, "contract work by Environ and data from the Port of Houston were integrated to update the HGB shipping emission inventory to 2007 ship movements. Environ work also allowed improved emissions treatment for the Gulf of Mexico and the Atlantic Ocean in the modeling domains to be based on actual ship location data and ship traffic data rather than simple shipping lanes."[89] ENVIRON created a "marine vessels emission inventory for the most significant commercial marine vessel categories including ocean going vessels, tugs, push boats, and large support vessels. Vessel activity for the Ports of Texas City, Galveston, and Freeport and the Intracoastal Waterway was combined with Port of Houston vessel activity to create a complete Houston-Galveston-Brazoria 8-county area commercial marine emission inventory."[90] Elevated stack emissions from marine vessels were included in the point source processing step.

3.8.2 <u>Locomotives</u>

"Locomotive emissions were separated into line-haul and switchers to allow different spatial allocation. Switcher emissions were allocated to railyards and line-haul emissions were based on a Gross Ton Miles (GTM) distribution."[91] Emission data from EPA's National Emissions Inventory 2008 v2 was used to estimate locomotive emissions outside of Texas.[92] Emissions

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http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784006FY1005-20100818-environ-HGBShipsEI.pdf. Accessed 07/03/13.

[87] EPA. "National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data". Available online: http://www.epa.gov/ttnchie1/trends/. Accessed 07/01/13.

[88] EPA, April 2009. "Proposal to Designate an Emission Control Area for Nitrogen Oxides, Sulfur Oxides and Particulate Matter". EPA-420-R-09-007. Available online: http://www.epa.gov/nonroad/marine/ci/420r09007.pdf. Accessed 07/05/13.

[89] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-110. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[90] ENVIRON International Corporation, August 18, 2010. "Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling". Novato, CA. Work Order No. 582-7-84006-FY10-5. p. 27. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784006FY1005-20100818-environ-HGBShipsEI.pdf. Accessed 07/03/13.

[91] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-93. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[92] EPA. "National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data". Available online: http://www.epa.gov/ttnchie1/trends/. Accessed 07/01/13.

were projected to 2006 by TCEQ using EGAS and adjustments were applied based on EPA's locomotive control regulations.[93]

For Texas, "TCEQ created county-level surrogates of railyards to best allocate switcher locomotives spatially. Diesel categories county-specific NO_X-humidity corrections were applied, as was TxLED."[94] Emissions from line-haul locomotives were allocated on a virtual link base in the 4km modeling grid.

3.8.3 Aircraft Emissions

Aircraft and GSE emission inputs were based on EPA's National Emissions Inventory 2008 v2 for areas outside of Texas.[95] Emissions for other states were projected to 2006 using EGAS.[96] Emissions for airports in the 12-county Dallas-Fort Worth Area were developed by the North Central Texas Council of Governments (NCTCOG). NCTCOG developed the "annual emissions inventory and activity data for airports for 1996, 2000, 2002, 2008, 2011, 2014, 2017, 2020, 2023, 2026, and 2029 analysis years. This inventory was developed for the 12-County Metropolitan Statistical Area (MSA) that covers Collin, Dallas, Denton, Ellis, Henderson, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, and Tarrant Counties."[97]

Emissions for other airports in Texas were based on ERG's annual emission inventory and activity data for airports in Texas. ERG developed "statewide annual emission inventories for Texas airport activities for the calendar years 1996, 2000, 2002, 2011, 2014, 2017, 2020, 2023, 2026, 2029, and the base year 2008." ERG used "publically available 2008 activity data that was compiled and supplemented with 2008 activity data provided by local airports. Two approaches were used to estimate emissions from the compiled activity data. If the activity data had aircraft specific data, the Federal Aviation Administration's (FAA) Emissions Dispersion Modeling System (EDMS) was employed. If such detailed data was not available, then ERG applied a more general approach for different aircraft types (i.e., air taxis, general aviation, and military aircraft) using available generic emission estimating procedures. Once the base year of

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[93] EPA, Sept. 2012. "Locomotives". Available online: http://www.epa.gov/otaq/locomotives.htm. Accessed 07/05/13.

[94] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-93. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[95] EPA. "National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data". Available online: http://www.epa.gov/ttnchie1/trends/. Accessed 07/01/13.

[96] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/13.

[97] North Central Texas Council of Governments, August 2011. "Development of Annual Emissions Inventories and Activity Data for Airports in the 12-County Dallas-Fort Worth Area". Dallas, Texas. p. i.

2008 was established, the inventory was backcasted and forecasted based on FAA's Terminal Area Forecast (TAF) data."[98]

3.8.4 San Antonio International Airport

AACOG updated and expanded the following emission inventory categories for the San Antonio International Airport:

- Aircraft Operations (commercial, military operations, and general aviation)
- Ground Support Equipment (GSE)
- Parking Garages
- Aircraft Evaporative Loss
- Fuel Storage & Transfer
- Stationary Sources
- Auxiliary Power Units (APU)
- Non-road Equipment (Lawn and Garden, Commercial, and Light Industrial)

To calculate emissions based on a "bottom-up" approach, local data from the above sources were collected. Emissions from aircraft landing and take-off (LTO) cycles at SAIA were calculated using the EDMS model, version 5.1.3.[99] The EDMS model uses EPA approved emission factors and methodologies to estimate emissions from aircraft operations. October 2008 flight schedules for commercial airliners, obtained from "FlightStats"[100] and the general avaiation (GA) flight data obtained from GCR Inc, was analyzed to determine the hourly arrival and departure patterns for commercial and GA operations at SAIA. Hourly emissions were allocated in the photochemical model by aircraft category based on the percentage of flights occurring during that hour.

To allocate elevated and ground level emissions spatially, information on runway usage patterns for each aircraft category was obtained from the San Antonio Department of Aviation. The data provides the percentage of landings and take-offs occurring at each runway annually by aircraft category. The aircraft 2006 surface and elevated emissions were spatially and temporally allocated to a 3-dimensional (3-D) photochemical modeling grid cell system using GIS software. Elevated aircraft emissions generated from landing, take-off, and climb-out were allocated to the 3-D grid cells containing multiple nodes, with specific height, latitude, and longitude at incremental ground distances from the end of the runway.

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[98] Eastern Research Group, Inc. July 15, 2011. "Development of Statewide Annual Emissions Inventory and Activity Data for Airports". 582-11-99776. Morrisville, North Carolina. p. ES-1.

[99] FAA, Nov. 2010. "Emissions & Dispersion Modeling System". Available online: http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/. Accessed 09/21/11.

[100] FlightStats, Conducive Technology Corp, 2005. Available online: http://www.flightstats.com/go/FlightStatus/flightStatusByAirport.do . Accessed 12/15/11.

A list of GSE equipment was compiled from a survey that was sent to all tenants at SAIA. Other necessary information such as horsepower output (HP), emission factors, and load factors for the equipment were compiled from equipment user's manuals and existing data in the EDMS model. After the survey forms were completed and returned, tenants at SAIA and the COSA's Department of Aviation were contacted and consulted to determine the accuracy and completeness of the data. To estimate emissions from non-road equipment, a survey was conducted to determine population, equipment type, and activity data for equipment used by tenants and the COSA at SAIA.

Vehicles owned by employees, businesses, vacationers, and business travelers frequently use parking lots at SAIA. Emissions from parking lots at SAIA were calculated using on-road and idling emission factors generated by the MOVES2010a[101] model and the EPA. Data on the number of vehicles using each facility, emission factors, idling time, and average distance traveled in the parking lot were used to calculate CO, NO_X, and VOC emissions.

3.9 On-Road Emissions

On-road emissions are mobile source emissions that are produced during operation of vehicles on urban and rural roadway networks. Due to their significant contribution, on-road emissions are regulated by the EPA and subject to federal standards and control. EPA's MOVES2010a model was used to calculate on-road emissions for every county in the United States. To run the model, "the user specifies vehicle types, time periods, geographical areas, pollutants, vehicle operating characteristics, and road types to be modeled. The model then performs a series of calculations, which have been carefully developed to accurately reflect vehicle operating processes, such as cold start or extended idle, and provide estimates of bulk emissions or emission rates. Specifying the characteristics of the particular scenario to be modeled is done by creating a Run Specification, or RunSpec."[102]

3.9.1 <u>On-Road Vehicle Emissions</u>

"For all non-Texas areas contained within the modeling domain, EPA's MOVES model is run in default mode to develop daily emission estimates by county for an average Summer Weekday. These emissions are processed with EPS3 and adjustments are applied to develop Friday, Saturday, and Sunday day type inventories based on pollutant-specific ratios from the Texas on-road inventories for Friday/Weekday, Saturday/Weekday, and Sunday/Weekday. In

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[101] U.S. Environmental Protection Agency, December 2009. "Motor Vehicle Emission Simulator". Office of Transportation and Air Quality Washington, DC. Available online: http://www.epa.gov/otaq/models/moves/index.htm. Accessed 12/15/11.

[102] EPA, Dec. 2009. "Motor Vehicle Emission Simulator (MOVES) 2010 User Guide". p. 4. Available online: http://www.epa.gov/otaq/models/moves/420b09041.pdf. Accessed 07/09/13.

addition, the hourly distributions of the Texas on-road inventories by both pollutant and day type are applied to the non-Texas portions of the modeling domain."[103]

For the Mexico portions of the modeling domain, the on-road portion of the 1999 Mexican National Emissions Inventory (NEI)[104] "is projected to specific years using a combination of the MOBILE6-Mexico model and an assumed annual VMT growth rate of 2%."[105] In a similar way, the 2006 Canadian National Pollutant Release Inventory (NPRI)[106] "is used and projected with MOBILE6-Canada and a 2% annual VMT growth rate assumption. The end result of this process is a gridded and speciated inventory for photochemical model input with relatively high spatial and temporal resolution of on-road emissions."[107]

The Texas Transportation Institute (TTI) "developed hourly, photochemical model preprocessor ready, on-road mobile summer (June 1 through August 31) Weekday, Friday, Saturday, and Sunday EIs for"[108] 2006, 2012, and 2018 using the MOVES 2010a model. "TTI used an hourly, Highway Performance Monitoring System (HPMS) virtual link, MOVES 'rates-peractivity' emissions inventory method to produce hourly emissions estimates by MOVES source use type (SUT) and fuel type, pollutant, and pollutant process for all 254 Texas counties for each year and day type. The methods TTI used to produce these inventories were consistent with EPA guidance on the production of photochemical modeling emissions inventories."[109]

Hourly VMT estimates by roadway type are multiplied by emissions rates from MOVES that vary as a function of

1. speed,
2. meteorological inputs (temperature, humidity, and barometric pressure), and
3. drive cycle (i.e., high-speed freeway driving versus stop-and-go arterial driving).[110]

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[103] TCEQ, Dec. 2012. "Introduction to Air Quality Modeling: Emissions Modeling". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html. Accessed 07/03/13.

[104] EPA, Oct. 2006. "North American Emissions Inventories – Mexico". Available online: http://www.epa.gov/ttnchie1/net/mexico.html. Accessed 07/08/13.

[105] TCEQ, Dec. 2012. "Introduction to Air Quality Modeling: Emissions Modeling". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html. Accessed 07/03/13.

[106] Environment Canada. "National Pollutant Release Inventory". Available online: http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1. Accessed 07/08/13.

[107] TCEQ, Dec. 2012. "Introduction to Air Quality Modeling: Emissions Modeling". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html. Accessed 07/03/13.

[108] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 1. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[109] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 1. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[110] TCEQ, Dec. 20, 2012. "Introduction to Air Quality Modeling: Emissions Modeling". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html. Accessed 07/09/13.

The emissions were calculated for each on-road segment by fuel type, emission process, and the source use type (SUT) listed in Table 3-2.[111] MOVES 2010a emission estimates were broken into running exhaust, crankcase running exhaust, start exhaust, crankcase start exhaust, extended idle exhaust, crankcase extended idle exhaust, evaporative permeation, evaporative fuel vapor venting, and evaporative fuel leaks.[112]

Table 3-2: MOVES2010a Source Use Type

Source Use Type ID	Source Use Type Description	Source Use Type Abbreviation
11	Motorcycle	MC
21	Passenger Car	PC
31	Passenger Truck	PT
32	Light Commercial Truck	LCT
41	Intercity Bus	IBus
42	Transit Bus	TBus
43	School Bus	SBus
51	Refuse Truck	RT
52	Single Unit Short-Haul Truck	SUShT
53	Single Unit Long-Haul Truck	SULhT
54	Motor Home	MH
61	Combination Short-Haul Truck	CShT
62	Combination Long-Haul Truck	CLhT

Age distribution and VMT mix by MOVES2010a vehicle class was based on data from TxDOT or the Texas Department of Motor Vehicles (TxDMV). The vehicle age distribution for TxDOT's San Antonio district is shown in Figure 3-1.[113]

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[111] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. pp. 7-8. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[112] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 2. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[113] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling: Appendix H: Source Type Age and Fuel Engine Fractions Inputs to MOVES". College Station, Texas. College Station, Texas. p. 63. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

Figure 3-1: TxDOT's San Antonio District 2006 Age Distribution Inputs to MOVES

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.12681	0.06181	0.04266	0.04266	0.08288	0.0684	0.0795	0.04963	0.11057	0.12564	0.07721	0.07202	0.05684
1	0.13462	0.08278	0.06430	0.0643	0.08365	0.06904	0.08024	0.04527	0.15618	0.15905	0.07794	0.06153	0.05897
2	0.09173	0.07452	0.07937	0.07937	0.06755	0.05575	0.06479	0.03679	0.12151	0.1103	0.06293	0.03595	0.04217
3	0.11063	0.07556	0.08391	0.08391	0.05482	0.04524	0.05258	0.02766	0.09215	0.09163	0.05107	0.03957	0.03840
4	0.08696	0.07876	0.08497	0.08497	0.04810	0.03969	0.04613	0.02817	0.08104	0.07282	0.04481	0.03462	0.03826
5	0.06887	0.0754	0.08277	0.08277	0.05545	0.04576	0.05319	0.02979	0.07789	0.07793	0.05166	0.05296	0.05608
6	0.05676	0.07583	0.06701	0.06701	0.06027	0.04974	0.05781	0.04216	0.05882	0.06614	0.05615	0.07842	0.07349
7	0.04446	0.06539	0.06316	0.06316	0.05966	0.04924	0.05723	0.04785	0.05695	0.06101	0.05558	0.06527	0.07225
8	0.03196	0.05600	0.04886	0.04886	0.04616	0.05900	0.04611	0.03703	0.02631	0.03018	0.03337	0.05501	0.06008
9	0.02414	0.05120	0.05334	0.05334	0.03835	0.05505	0.04386	0.03076	0.03391	0.03769	0.05245	0.03716	0.04558
10	0.02262	0.04335	0.03922	0.03922	0.03238	0.05178	0.03863	0.06652	0.01889	0.02076	0.03317	0.04572	0.04637
11	0.01942	0.04642	0.04162	0.04162	0.04298	0.04334	0.05039	0.07789	0.02362	0.02560	0.03997	0.05887	0.05998
12	0.01719	0.03707	0.04000	0.04000	0.03381	0.03861	0.02484	0.04923	0.01889	0.01722	0.03893	0.04464	0.04052
13	0.01379	0.03264	0.02915	0.02915	0.02843	0.03271	0.03030	0.04295	0.01643	0.01313	0.02737	0.04259	0.03922
14	0.01063	0.02558	0.02208	0.02208	0.02162	0.02932	0.02524	0.01880	0.00930	0.00980	0.02479	0.02618	0.02752
15	0.00668	0.02245	0.01934	0.01934	0.02503	0.03031	0.03292	0.05219	0.01023	0.00955	0.01884	0.02618	0.03269
16	0.00781	0.01748	0.01590	0.01590	0.02871	0.04532	0.03799	0.04541	0.01041	0.00951	0.02521	0.02944	0.03062
17	0.00746	0.01447	0.01576	0.01576	0.02910	0.03524	0.02215	0.03622	0.00941	0.00802	0.03329	0.02340	0.02516
18	0.00598	0.01099	0.01329	0.01329	0.02767	0.02835	0.02692	0.04981	0.00824	0.00690	0.03017	0.02075	0.02118
19	0.00629	0.00859	0.00958	0.00958	0.02907	0.02652	0.02757	0.04033	0.00515	0.00485	0.02979	0.02232	0.01848
20	0.01281	0.00727	0.01224	0.01224	0.02493	0.02283	0.0246	0.05090	0.00678	0.00651	0.02246	0.02123	0.01709
21	0.01172	0.00644	0.01094	0.01094	0.02226	0.02003	0.02159	0.02737	0.00696	0.00587	0.02437	0.02292	0.01852
22	0.00844	0.00522	0.0094	0.0094	0.01771	0.01579	0.01686	0.02873	0.00602	0.00422	0.02499	0.01508	0.01421
23	0.00957	0.00309	0.00602	0.00602	0.00715	0.01531	0.00630	0.00842	0.00310	0.00213	0.01656	0.00820	0.00647
24	0.01199	0.00213	0.00618	0.00618	0.00616	0.00844	0.00471	0.00958	0.00456	0.00389	0.00988	0.01315	0.01001
25	0.00938	0.00185	0.00529	0.00529	0.00541	0.00371	0.00560	0.00859	0.00333	0.00290	0.00549	0.00977	0.01009
26	0.00492	0.00173	0.00388	0.00388	0.00712	0.01019	0.00556	0.00218	0.00266	0.00198	0.00073	0.00438	0.00501
27	0.00637	0.00123	0.00397	0.00397	0.00433	0.00305	0.00465	0.00227	0.00278	0.00183	0.00572	0.00503	0.00426
28	0.00482	0.00113	0.00349	0.00349	0.00339	0.00133	0.00397	0.00221	0.00204	0.00150	0.00762	0.00448	0.00472
29	0.00387	0.00092	0.00196	0.00196	0.00364	0.00027	0.00399	0.00000	0.00215	0.00129	0.01044	0.00362	0.00463
30	0.0213	0.01271	0.02034	0.02034	0.00221	0.00067	0.00377	0.00531	0.01369	0.01017	0.00704	0.01954	0.02112

Since the emission factors from MOVES are speed dependent, the congested speed for each link is required. "There are three critical parameters for estimating operation speeds: hourly lane capacity, free-flow speed, and hourly volume by direction. The hourly lane capacity is the maximum flow past a given point on a roadway, which varies by road type (or functional classification). The free-flow speed is the maximum speed that traffic will move along a given roadway if there are no impediments (e.g., congestion, bad weather). The hourly volume by direction is the hourly link VMT by direction divided by the link's centerline miles." [114]

"To estimate a link's directional, time-of-day congested speed, a speed model involving both the estimated free-flow speed and estimated directional delay as a function of volume and capacity for the link and time period (i.e., hour) was applied. The model was applied to each link for each hour and direction."[115] Weekday hourly speed by urban road type for the San Antonio-New Braunfels MSA is provided in Figure 3-2. Average speed is reduced during the morning and afternoon rush periods on every roadway type except local roads. Average hourly weekday speeds for interstate freeways vary between 56 mph and 69 mph, while freeway speeds vary between 51 mph and 59 mph. For other road types, the average weekday speeds varied between 29 mph and 39 mph.

The 2006 temperature distribution for TxDOT's San Antonio district is provided in Figure 3-3 while hourly relative humidity is provided in Figure 3-4. The diurnal temperature profile varies between 74 degrees and 94 degrees Fahrenheit. During the night, average humidity is above 70 percent, but in the afternoon humidity varies between 34 and 44 percent. The temperature distribution and relative humidity are based on June 1st through August 31st, 2006 monitored hourly averages.[116] TCEQ developed the input data based on "June through August hourly temperature and relative humidity, and 24-hour barometric pressure averages by district using hourly data from numerous weather stations within each" TxDOT district.[117]

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[114] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 18. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[115] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 18. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[116] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 161 and 167. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[117] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 39. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

Figure 3-2: Weekday Hourly Speed for the San Antonio-New Braunfels MSA by Urban Road Type, 2006

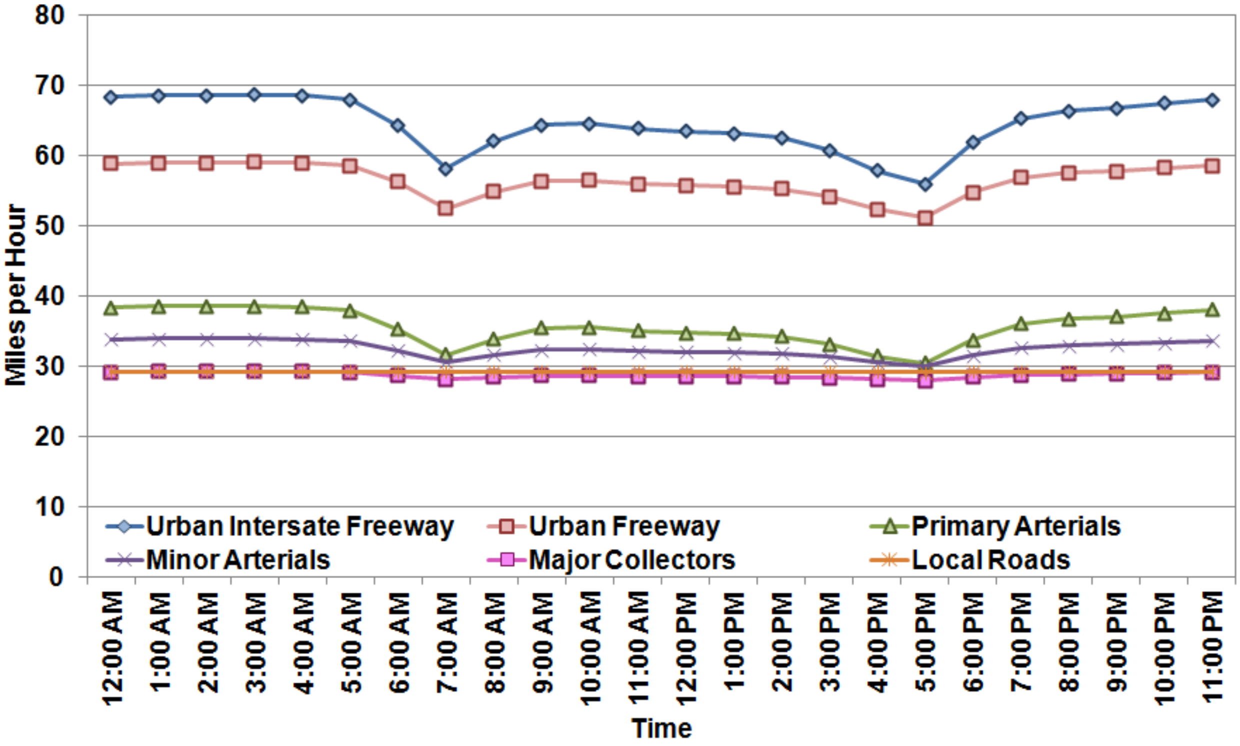


Figure 3-3: Temperature Inputs to MOVES for Summer, San Antonio TxDOT District 2006

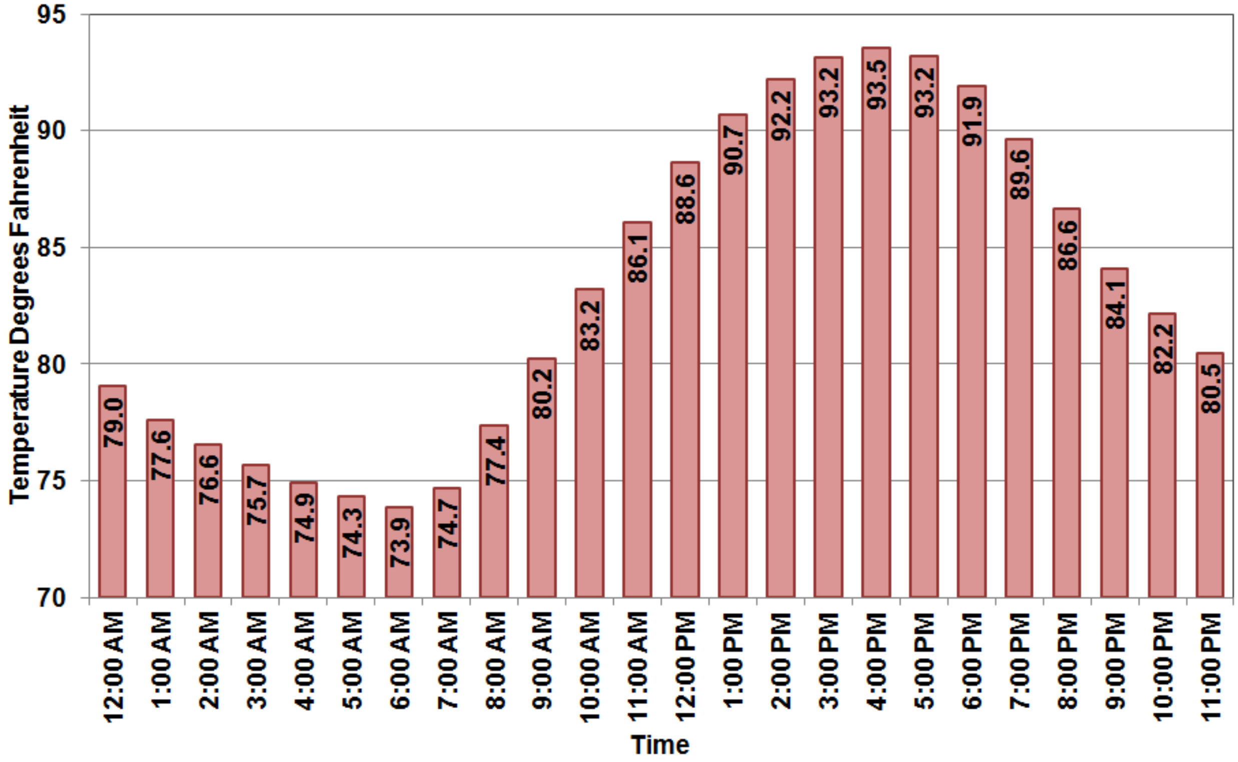
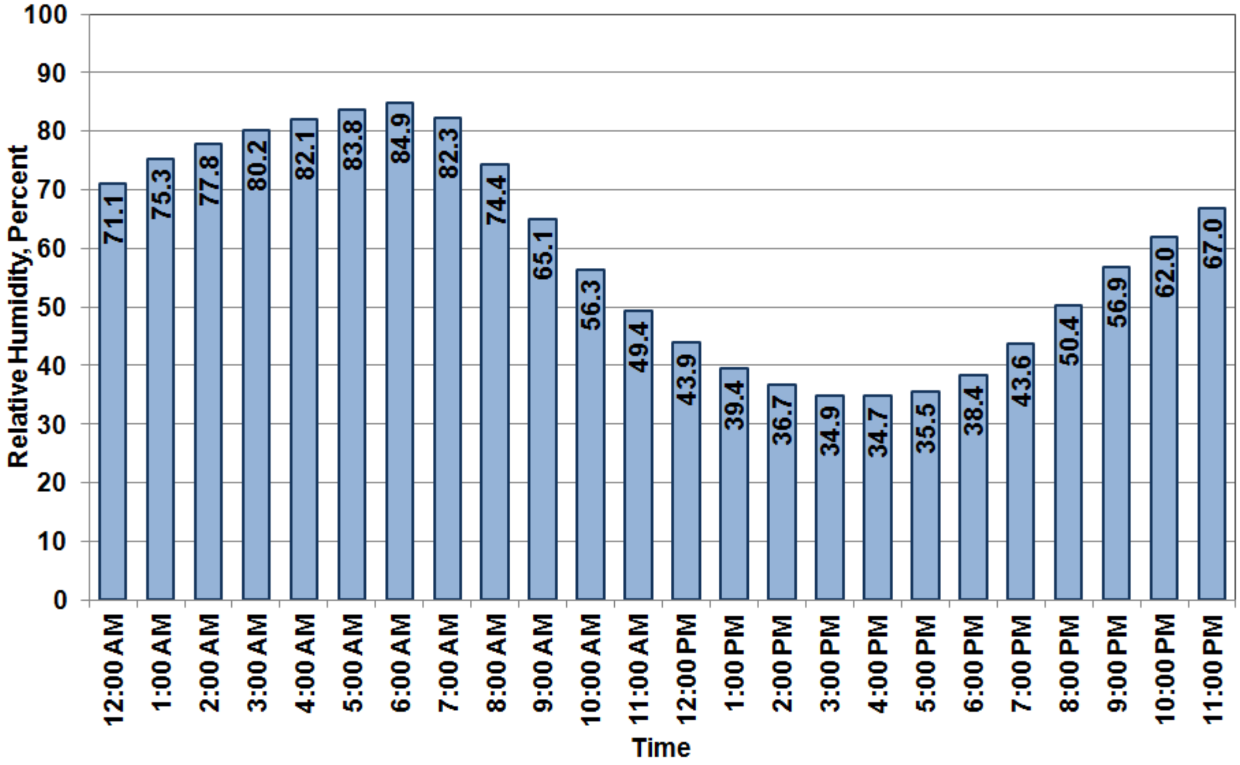
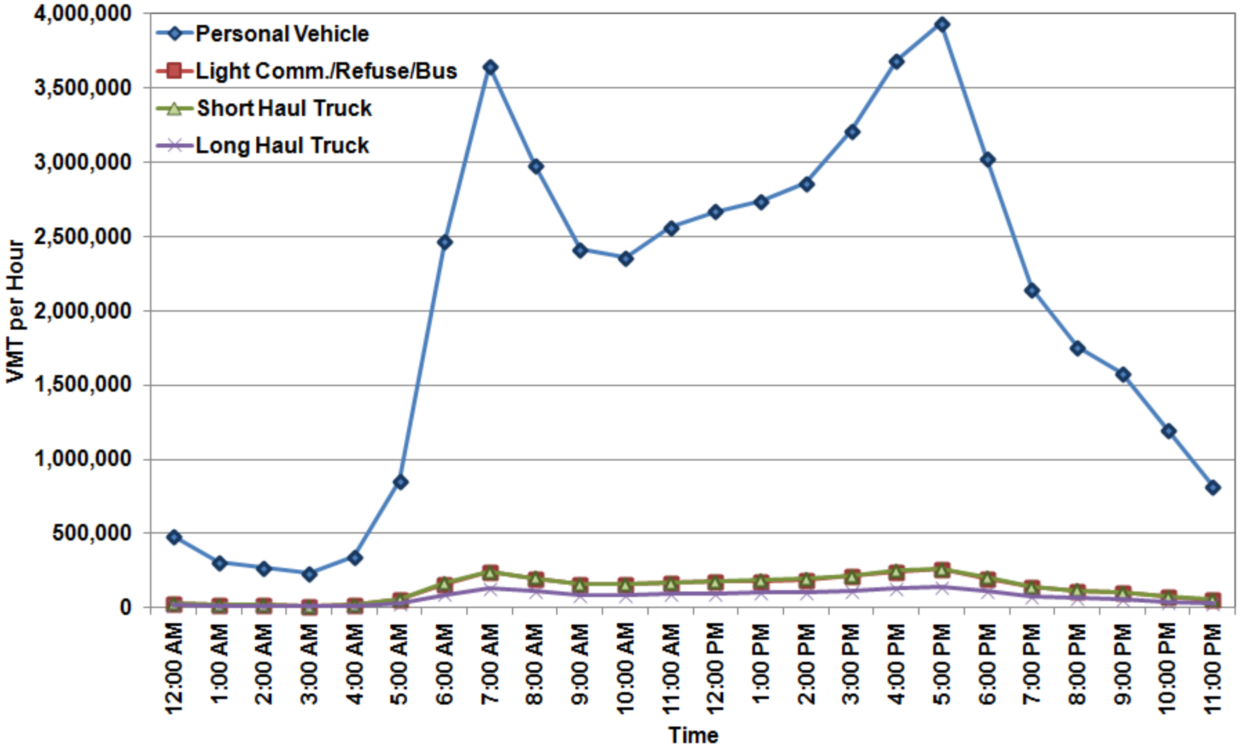


Figure 3-4: Relative Humidity Inputs to MOVES for Summer, San Antonio TxDOT District 2006



As shown in Figure 3-5, VMT varies greatly by hour of the day with a morning rush hour peak and afternoon rush hour peak. Personal vehicles contribute 85% of the 56,869,253 total daily VMT on an average summer weekday in the San Antonio-New Braunfels MSA. Light commercial trucks, refuse trucks, buses, short haul trucks, and long haul trucks have significantly lower VMT.

Figure 3-5: Weekday Hourly VMT by Vehicle Class, San Antonio-New Braunfels MSA, 2006



All federal requirements for vehicles and fuel were accounted for by the MOVES2010a runs. Fuel properties used in the model runs were based on surveys of retail gasoline and diesel fuel sold in Texas. The Low Reid Vapor Pressure (RVP) gasoline control strategy for 95 counties in eastern Texas was included in the modeling.[118] "Low RVP gasoline is fuel that is refined to have a lower evaporation rate and lower volatility than conventional gasoline. It also reduces the evaporative emissions generated during vehicle refueling and therefore decreases the emissions of volatile organic compounds (VOCs) and other ozone-forming emissions."[119] Diesel sulfur content was based on survey data and MOVES default values.[120] To calculate 2006 emissions in TxDOT's San Antonio district, fuel properties of RVP of 7.54 and sulfur content of 39.6 was used.[121]

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[118] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 4. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[119] TCEQ, Jan. 3, 2012. Motor Vehicle Fuel Programs in Texas". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/mobilesource/vetech/fuelprograms.html. Accessed 07/09/13.

[120] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 31. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[121] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station,

Diesel vehicle NO_X emissions factors were post-processed “for the 110 Eastern Texas counties subject to the Texas Low Emission Diesel (TxLED) program”. NO_X adjustment factors used were provided by TCEQ using reductions of 4.8 percent for 2002-and-newer model year vehicles, and 6.2 percent for 2001-and-older model year vehicles.” (Table 3-3)[122] The San Antonio-New Braunfels MSA counties under the low RVP and TxLED rule are Atascosa, Bexar, Comal, Guadalupe, and Wilson.

NO_X emissions display a similar hourly pattern to VMT with morning and afternoon rush hour peaks (Figure 3-6). Although short haul and long haul trucks have low VMT compared to passenger trucks, these trucks contribute 65 tons (49%) of total weekday on-road NO_X emissions. Passenger cars contribute 57 tons or 43% of weekday on-road NO_X emissions (Table 3-4). Hourly NO_X emissions, plotted in Figure 3-7 are similar between a weekday (Monday through Thursday) and a Friday with slightly higher emissions on Friday. Both Saturday and Sunday NO_X emissions have a different temporal profile with peak emissions occurring between noon and 4 pm.

Table 3-3: TxLED Adjustment Factor for Diesel Fuel, 2006

Source Use Type	2006 TxLED Reduction
Passenger Car	5.06%
Passenger Truck	5.68%
Light Commercial Truck	5.56%
Intercity Bus	5.97%
Transit Bus	5.94%
School Bus	5.92%
Refuse Truck	5.85%
Single Unit Short-Haul Truck	5.31%
Single Unit Long-Haul Truck	5.35%
Motor Home	5.77%
Combination Short-Haul Truck	5.82%
Combination Long-Haul Truck	5.83%

Texas. College Station, Texas. p. 41. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[122] TTI, July 2011. “Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling”. College Station, Texas. College Station, Texas. p. 4. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

Figure 3-6: Hourly NO_X Emissions by Vehicle Class, San Antonio-New Braunfels MSA, 2006

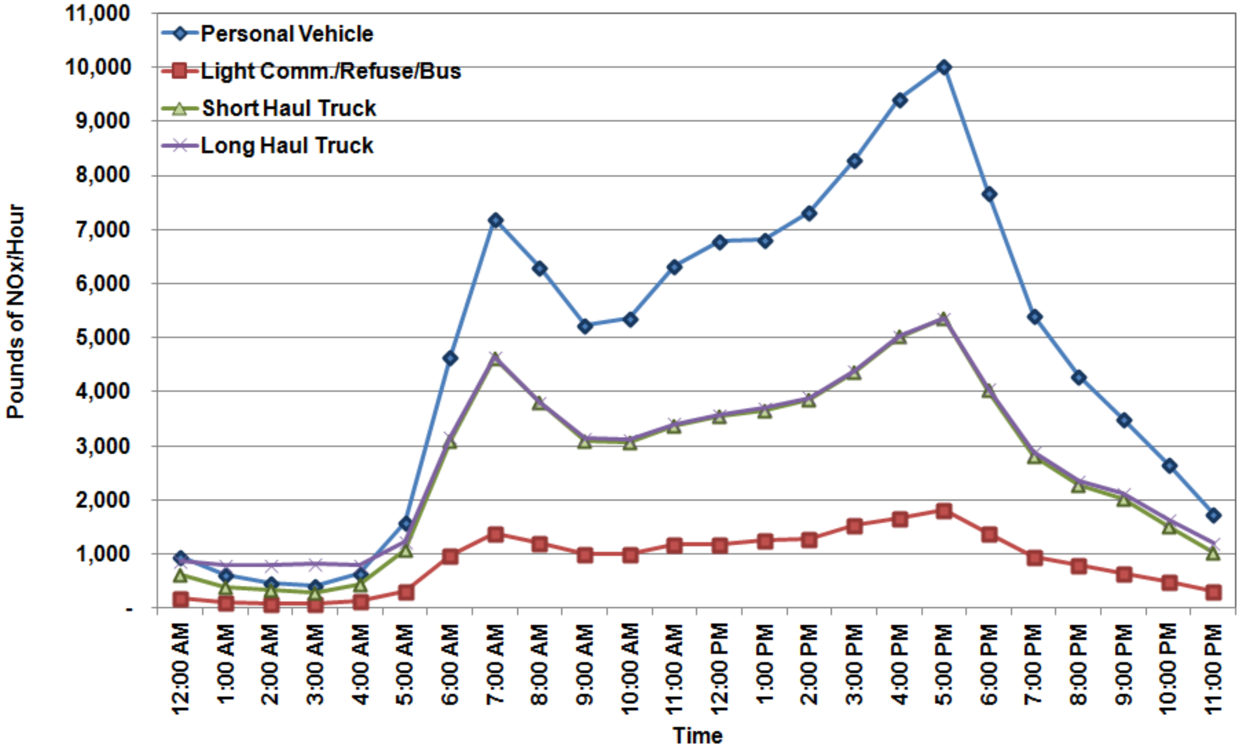

Figure 3-7: Hourly NO_X Emissions by Day of the Week, San Antonio-New Braunfels MSA, 2006

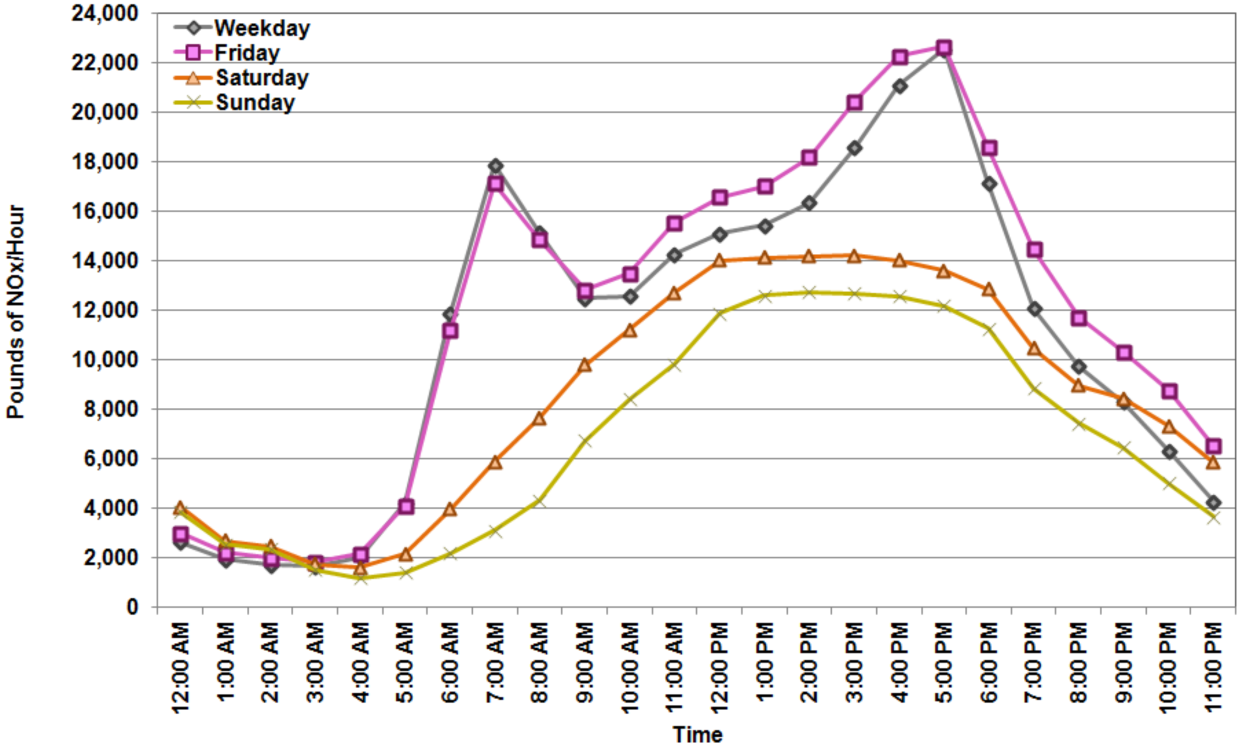

Table 3-4: VMT, NO_X and VOC emissions by Time of The Day, San Antonio-New Braunfels MSA, 2006

Time	Personal Vehicle			Light Comm./Refuse/Bus			Short Haul Truck			Long Haul Truck		
	VMT	Tons of NO_X	Tons of VOC	VMT	Tons of NO_X	Tons of VOC	VMT	Tons of NO_X	Tons of VOC	VMT	Tons of NO_X	Tons of VOC
12:00 AM	488,937	0.48	0.36	32,557	0.09	0.04	33,200	0.31	0.02	18,093	0.44	0.06
1:00 AM	309,566	0.31	0.31	20,613	0.05	0.03	21,020	0.19	0.02	11,456	0.40	0.08
2:00 AM	270,779	0.23	0.23	18,031	0.05	0.02	18,386	0.17	0.01	10,020	0.40	0.09
3:00 AM	233,449	0.21	0.23	15,545	0.04	0.02	15,852	0.15	0.01	8,639	0.41	0.10
4:00 AM	347,188	0.32	0.30	23,118	0.06	0.04	23,575	0.22	0.02	12,848	0.40	0.07
5:00 AM	854,620	0.79	0.58	56,907	0.15	0.06	58,030	0.54	0.05	31,626	0.62	0.05
6:00 AM	2,464,928	2.32	1.62	164,134	0.48	0.26	167,373	1.55	0.13	91,215	1.58	0.08
7:00 AM	3,646,687	3.60	2.65	242,824	0.70	0.33	247,617	2.32	0.20	134,947	2.32	0.11
8:00 AM	2,983,185	3.15	2.43	198,643	0.60	0.31	202,564	1.90	0.19	110,394	1.91	0.09
9:00 AM	2,411,335	2.62	1.82	160,565	0.51	0.23	163,734	1.55	0.13	89,232	1.57	0.08
10:00 AM	2,359,975	2.69	1.94	157,145	0.50	0.22	160,247	1.54	0.13	87,332	1.56	0.07
11:00 AM	2,558,084	3.16	2.32	170,337	0.59	0.28	173,699	1.68	0.15	94,663	1.71	0.08
12:00 PM	2,668,716	3.40	2.47	177,704	0.60	0.27	181,211	1.77	0.15	98,757	1.79	0.08
1:00 PM	2,737,163	3.40	2.35	182,261	0.63	0.29	185,859	1.83	0.15	101,290	1.86	0.08
2:00 PM	2,861,339	3.66	2.46	190,530	0.64	0.26	194,290	1.93	0.16	105,885	1.95	0.09
3:00 PM	3,214,110	4.15	2.69	214,020	0.77	0.35	218,244	2.18	0.18	118,939	2.19	0.10
4:00 PM	3,685,571	4.70	2.84	245,413	0.84	0.33	250,257	2.51	0.20	136,386	2.51	0.11
5:00 PM	3,936,399	5.02	2.98	262,116	0.90	0.36	267,289	2.68	0.21	145,668	2.68	0.12
6:00 PM	3,022,409	3.84	2.49	201,255	0.69	0.30	205,227	2.01	0.16	111,845	2.04	0.09
7:00 PM	2,147,157	2.71	1.86	142,974	0.48	0.21	145,796	1.41	0.11	79,456	1.45	0.07
8:00 PM	1,753,124	2.15	1.49	116,736	0.40	0.19	119,040	1.14	0.09	64,875	1.18	0.06
9:00 PM	1,575,356	1.76	1.13	104,899	0.32	0.12	106,970	1.01	0.08	58,297	1.06	0.06
10:00 PM	1,197,585	1.33	0.92	79,744	0.25	0.11	81,318	0.76	0.06	44,317	0.82	0.05
11:00 PM	816,513	0.87	0.65	54,370	0.15	0.06	55,443	0.52	0.04	30,215	0.60	0.05
Total	48,544,177	56.87	39.11	3,232,442	10.49	4.70	3,296,241	31.86	2.64	1,796,393	33.46	1.92

*Note: totals do not include long term idling emissions from long haul diesel combination trucks or traffic from the Eagle Ford

As shown in Table 3-5, Bexar County has the highest NO_X emissions in the San Antonio-New Braunfels MSA: 93 tons per weekday in 2006. Guadalupe County's, 11 tons per weekday, and Comal County's, 10 tons per weekday, are also significant sources of on-road NO_X emissions. Summer weekday on-road emissions accounted for 133 tons of NO_X and 48 tons of VOC in the San Antonio-New Braunfels MSA.

Table 3-5: Weekday VMT, NO_X Emissions, and VOC Emissions by County, San Antonio New Braunfels MSA, 2006

County	VMT	Tons of NO_X	Tons of VOC
Atascosa	1,645,740	5.44	1.24
Bandera	493,632	1.41	0.53
Bexar	43,339,519	93.28	37.17
Comal	4,062,411	10.40	3.13
Guadalupe	3,661,652	10.67	3.04
Kendall	1,108,735	4.09	1.03
Medina	1,526,961	4.66	1.20
Wilson	1,030,604	2.73	1.02
Total	56,869,254	132.68	48.36

The Emissions Preprocessor System (EPS3) was used "to convert the on-road inventory data into a gridded format appropriate for photochemical model input. Grid cell allocation is based on the X-Y locations of the link endpoints."[123] "Grid cell allocation is based on spatial surrogates specific to each county and roadway type. For example, if a single grid cell contains 15% of the interstate highway miles in a specific county, then 15% of the interstate highway emissions are assigned to that grid cell. In addition to gridding the hourly emissions, EPS3 assigns speciation profiles to appropriately group the exhaust and evaporative hydrocarbon emissions estimates based on reactivity for ozone formation."[124] "Profiles from EPA's SPECIATE Version 4.3 Database were used to allocate VOC exhaust and evaporative emission estimates with the Carbon Bond 6 (CB6) mechanism."[125]

3.9.2 Heavy Duty Diesel Vehicles Idling Emissions

The trucking industry is a major contributor to North America's economy, transporting over 80% of the nation's goods, and truck traffic is growing rapidly. The population of large trucks is estimated at 4.2 million, 1.3 million of which are "long haul" trucks equipped with sleeper cabs and powered by diesel engines. The Department of Transportation requires rest of 10 hours after every 11 hours driving for property-carrying commercial motor vehicle (CMV) drivers.

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[123] TCEQ, Dec. 2012. "Introduction to Air Quality Modeling: Emissions Modeling". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html. Accessed 07/03/13.

[124] TCEQ, Dec. 2012. "Introduction to Air Quality Modeling: Emissions Modeling". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html. Accessed 07/03/13.

[125] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/13.

Since IH-35, IH-10, and other major highways converge in San Antonio, truck drivers frequently use truck stops, rest areas, picnic areas, and other facilities in the San Antonio area to comply with the mandatory rest breaks. Truck drivers sometimes idle their engines throughout their rest periods to provide electricity for cooling and heating their cabins, or to keep their engine fluids warm. This extended idling consumes fuel, creates air and noise pollution, and is an inefficient use of the nation's energy supply. According to an estimate by the US Department of Energy, each year in the U.S., trucks consume over 25 million barrels of fuel a year for overnight truck idling.

A survey was conducted between October 2010 and June 2011 that involved observing and documenting the incidence of extended (30 minutes or more) engine idling at truck stops and rest areas in the San Antonio-New Braunfels MSA. Survey results provided inputs that were used to estimate extended idling emissions for the combination (tractor/trailer) long-haul trucks, the only source use type within the current version of the EPA’s Motor Vehicle Emission Simulator model (MOVES) for which extended idling emissions can be estimated. This vehicle category is more commonly referred to as diesel-powered five-axle “eighteen-wheelers”, but other four-axle and six-axle configurations are also included in this category. Combination long-haul trucks are classified in MOVES as trucks with a majority of their operation outside a 200-mile radius of home base. The primary inputs needed by MOVES to estimate idling emissions from long-haul trucks are the number of source hours operating (SHO) in extended idling mode by source type.

Drivers idle their trucks’ engines at the following locations:

- Truck Stops
- Rest Stops
- Picnic Areas
- Other Idling Locations

Extensive research was conducted to identify and locate all such facilities in the San Antonio-New Braunfels MSA. All identified truck stops, rest stops, and picnic areas were included in this survey. Additional truck stops that were not listed on maps or other information sources were identified during the survey and were added to the inventory of facilities surveyed.

Table 3-6: Truck Stops in the San Antonio-New Braunfels MSA

Truck Stop	Address	Exit Number	County	Parking Spaces*
Kuntry Korner Steak & Eggs	IH 37 / Jim Brite Rd, Pleasanton	104	Atascosa	45
ZS Super Stop	IH 37 / FM 97, Pleasanton	109	Atascosa	24
EZ Mart	15537 IH 37, Elmendorf	125	Bexar	25
Tex Best Travel Center	20290 IH 37, Elmendorf	125	Bexar	30
Valero Ram Travel Center	IH 37, Elmendorf	130	Bexar	12
Texas Best Fuel Stop (Exxon)	14650 IH 35, Von Ormy	140	Bexar	15
Valero AAA Travel Center	14555 IH 35, Von Ormy	140	Bexar	70
Shell Time Wise Landmark	13437 IH 35, Von Ormy	141	Bexar	24
Love's Country Store	11361 IH 35, S Von Ormy	145	Bexar	108
Valero	IH 35, S Von Ormy	145	Bexar	50
Shell Truck Stop	11607 N IH 35, San Antonio	169	Bexar	45
PICO	25284 IH 10, San Antonio	550	Bexar	15
Petro Travel Plaza	1112 Ackerman Rd, San Antonio	582	Bexar	320
Pilot Travel Center	5619 IH 10 E, San Antonio	582	Bexar	50
Flying J Travel Plaza	1815 Foster Rd., San Antonio	583	Bexar	283
TA Travel Center	6170 IH 10 E, San Antonio	583	Bexar	258
Shell Truck Stop	8755 IH 10 E, Converse	585	Bexar	60
Alamo Travel Center	13183 IH 10, Converse	591	Bexar	40
Texaco	IH 10, Converse	593	Bexar	30
Trainer Hale Truck Stop	14462 IH 10, Converse	593	Bexar	25
Pilot Travel Center	4142 Loop 337, New Braunfels	184	Comal	80
Tex Best Travel Center	2735 N IH 35, New Braunfels	191	Comal	28
TA Truck Stop	4817 IH 35, New Braunfels	193	Comal	250
Sunmart No 167	6150 W IH 10, Seguin	601	Guadalupe	40
Jud’s Food and Fuel - Shell	IH10/Hwy 123, Seguin	610	Guadalupe	40
Chevron	IH 10, Comfort	523	Kendall	20
Exxon Valley Mart	US 90, Hondo	533	Medina	10
Total				1,997

*****Data on number of parking spaces are from truck stop surveys

TxDOT’s new generation of Safety Rest Areas feature regional designs, modern restrooms, interpretive displays, exhibits of local features, separate parking for cars and trucks, and wireless Internet access.”[126] Construction of new rest stops with designated truck parking spaces and better amenities, such as air conditioned rooms and wireless Internet access, have made rest stops suitable resting places for long-haul truckers. All the rest stops and picnic areas that were surveyed, with the number of estimated parking spaces, are provided in Table 3-7.

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[126] TxDOT, Sept. 2009. “Texas Safety Rest Area Program”. Available online: ftp://ftp.dot.state.tx.us/pub/txdot-info/library/pubs/travel/sra_brochure.pdf. Accessed 07/11/11.

Table 3-7: Rest Areas and Picnic Areas in the San Antonio Region

Type	Location	Mile Marker	County	Parking Spaces*
Rest Areas	Northbound - IH 35	180	Comal	18
	Southbound - IH 35	180	Comal	18
	Eastbound - IH 10	619	Guadalupe	26
	Westbound - IH 10	619	Guadalupe	32
	Northbound - IH 35	130	Medina	17
	Southbound - IH 35	130	Medina	20
	Eastbound - US 90	518	Medina	15
	Westbound - US 90	518	Medina	13
Picnic Areas	Northbound - IH 37	112	Atascosa	28
	Southbound - IH 37	111	Atascosa	28
	Eastbound - IH 10	529	Kendall	17
	Westbound - IH 10	531	Kendall	25
	US 90	548	Medina	6

*****Data on number of parking spaces are from surveys

Each truck stop, rest area, and picnic area in the San Antonio-New Braunfels MSA was surveyed at least 6 times: 3 times on weekdays and 3 times on weekends and for each of three time periods. Since every site was surveyed multiple times, the results are statistically significant.

Observations of truck engine idling were collected during the following three time periods:

- Morning (5 am – 10 am)
- Daytime (10 am – 10 pm)
- Evening/Night (10 pm – 5 am)

For data collected on weekdays, the morning and daytime periods included observations during local “rush hours” for consistency with how travel demand modeling is conducted. The largest number of surveys occurred between 5 am to 9 am and from 10 pm to midnight, but at least 4 surveys were collected for each hour of the day. Overall, 184 truck stop, 57 rest area, and 31 picnic area surveys were collected. Each facility was surveyed for time periods of weekday, weekend, morning, daytime, and nighttime. The number of sites and parking spaces surveyed by time period are provided in Table 3-8.

Table 3-8: Data Collection Summary by Facility Type

Type	Time Period	Number of Surveys Conducted			Truck Parking Spaces Surveyed		
		Weekday	Weekend	Total	Weekday	Weekend	Total
Truck Stops	Morning	34	30	64	2,543	2,063	4,606
	Day	32	30	62	2,940	2,390	5,330
	Night	27	31	58	2,017	2,234	4,251
Rest Areas	Morning	10	8	18	195	159	354
	Day	10	11	21	196	201	397
	Night	8	10	18	180	196	376
Picnic Areas	Morning	5	7	12	104	160	264
	Day	5	4	9	104	90	194
	Night	4	6	10	76	132	208
Total		135	137	272	8,355	7,625	15,980

The primary inputs needed by MOVES to estimate long-haul truck idling emissions were the number of source hours operating (SHO) in extended idling mode, which were obtained from the survey's results. Other local input data came from Texas Transportation Institute's (TTI) 2008 report entitled "On-Road Mobile Source Emissions Trends for all 254 Texas Counties: 1990 through 2040".[127] Idling emission factors for heavy duty long-haul trucks are provided in Table 3-9.

Table 3-9: Heavy Duty Truck Idling Emission Factors from the MOVES Model

Year	NO_X	VOC
2006	226.01 grams/hour	57.90 grams/hour

Truck parking spaces in the San Antonio-New Braunfels MSA included 1,997 parking spaces at truck stops, 159 parking spaces at rest areas, and 104 parking spaces at picnic areas. Idling rates used to calculate emissions per parking space by facility type and time of the day are provided in Table 3-10. Data for picnic areas are limited because there are only five picnic areas on major highways in the San Antonio-New Braunfels MSA.

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[127] TCEQ, August 2008. "On-Road Mobile Source Emissions Trends for all 254 Texas Counties: 1990 Through 2040". TTI. College Station, Texas.

Table 3-10: Percentage of Time each Parking Space is Occupied by an idling vehicle by Day Type, Facility Type, and Time Period

Day Type	Statistical Test	Weekday			Weekend		
		Truck Stops	Rest Areas	Picnic Areas	Truck Stops	Rest Areas	Picnic Areas
Total Morning	Low	17%	15%	1%	11%	11%	11%
	Mean	22%	24%	11%	15%	19%	25%
	High	27%	33%	20%	19%	27%	39%
	Standard Dev.	14%	14%	11%	11%	12%	19%
	N	34	10	5	30	8	7
	Confidence Level	5%	9%	10%	4%	8%	14%
Total Day	Low	9%	6%	2%	10%	3%	0%
	Mean	13%	17%	6%	14%	8%	2%
	High	17%	28%	10%	18%	13%	5%
	Standard Dev.	10%	18%	5%	11%	9%	3%
	N	32	10	5	30	11	4
	Confidence Level	4%	11%	4%	4%	5%	3%
Total Night	Low	19%	17%	9%	18%	7%	8%
	Mean	25%	32%	24%	26%	16%	14%
	High	32%	46%	38%	35%	26%	19%
	Standard Dev.	17%	21%	15%	25%	15%	7%
	N	27	8	4	31	10	6
	Confidence Level	7%	14%	15%	9%	9%	6%

Based on 95 % confidence level

The following equation was used to calculate county level total daily emissions for extended truck idling at each facility type for the photochemical model.

Equation 3-1, Daily emissions for each facility type and time period per county

DE_{ABC} = $RATE_{BC}$ x SP_{AC} x HRS x EF_{MOVES} / 907,184.74 grams/ton

Where,

DE_{ABC} = Daily Emissions from County A for Time Period B and Facility Type C (tons)
$RATE_{BC}$ = Idling Rates per Parking Space for Time Period B and Facility Type C (from survey data located in Table 3-10)
SP_{AC} = Number of Truck Parking Spaces in County A for Facility Type C (from survey data located in Table 3-6 and Table 3-7)
HRS = Number of Hours per Time Period B (Morning – 5 hrs, Daytime – 12 hrs, and Nighttime – 12 hrs)
EF_{MOVES} = Idling Emissions factor for Combination Long-Haul Trucks in 2006, 226.01 grams of NO_X-hr and 57.90 grams of VOC-hr (from the MOVES model)

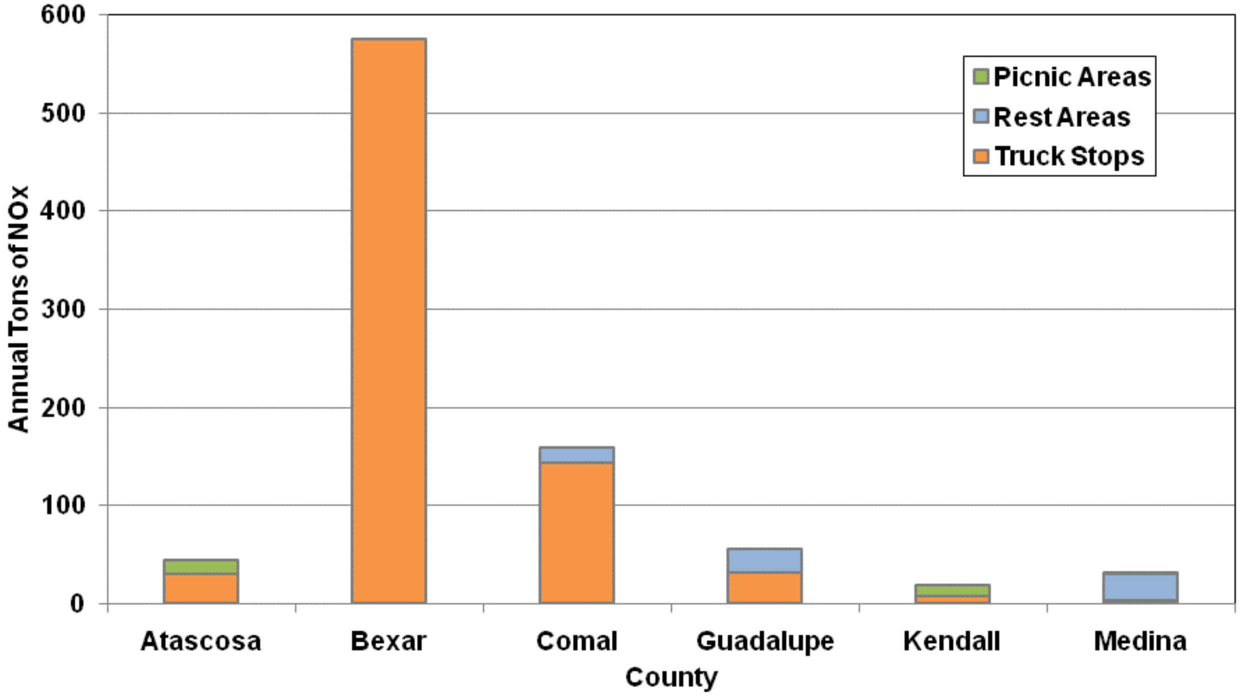
Sample calculation for morning NO_X emissions from truck stops in Bexar County

DE_{ABC} = 22.02% Idling Rate per Parking Space During Weekday Mornings x 1,434 Truck Stop Parking Spaces x 5 hours x 226.01 grams of NO_X-hr / 907,184.74 grams/ton
= 0.39 tons of NO_X/weekday morning emissions from truck stops in Bexar County

Extended truck idling emission totals for each facility type and county is provided in Figure 3-8. Total annual NO_X emissions from extended truck idling in the San Antonio-New Braunfels MSA were estimated to be 883 tons per year while total VOC emissions were estimated to be 226 tons per year. Bexar County dominates total idling emissions, because there is a concentration of large truck stops on the east side of the city near the IH-410 and IH-10 interchange. In addition, there are concentrations of truck stops on IH-35 in the southwest part of the county and on IH-37 in south Bexar County.

Comal County also has several large truck stops where significant amounts of NO_X emissions, 144 tons of NO_X a year, are generated from idling truck engines. These truck stops are concentrated along IH-35 between San Antonio and Austin. Rest areas are located in Comal, Guadalupe, and Medina counties. Truck idling also occurs at picnic areas, which are located in Atascosa and Kendall counties.

Figure 3-8: Extended Truck Idling NO_X Emissions by Facility Type and County, 2006*



*Bandera and Wilson County are not included because they do not have any significant truck parking facilities

3.10 Point Source Emissions

According to the Texas Administrative Code, “the owner or operator of an account or source in the State of Texas or on waters that extend 25 miles from the shoreline meeting one or more of the following conditions shall submit emissions inventories and/or related data as required in subsection (b) of this section to the commission on forms or other media approved by the commission:

(1) an account which meets the definition of a major facility/stationary source, as defined in §116.12 of this title (relating to Nonattainment Review Definitions), or any account in an ozone nonattainment area emitting a minimum of ten tons per year (tpy) volatile organic compounds (VOC), 25 tpy nitrogen oxides (NO_X), or 100 tpy or more of any other contaminant subject to national ambient air quality standards (NAAQS);
(2) any account that emits or has the potential to emit 100 tpy or more of any contaminant;
(3) any account which emits or has the potential to emit 10 tons of any single or 25 tons of aggregate hazardous air pollutants (HAPS); and
(4) any minor industrial source, area source, non-road mobile source, or mobile source of emissions subject to special inventories under subsection (b)(3) of this section. For purposes of this section, the term "area source" means a group of similar activities that, taken collectively, produce a significant amount of air pollution."[128]

Any sources that meet the Texas Administrative Code definition were processed in the photochemical model as point sources.

To collect data on point sources, "TCEQ mails annual emissions inventory questionnaires (EIQs) to all sources identified as meeting the reporting requirements. Subject entities are required to report levels of emissions subject to regulation from all emissions-generating units and emissions points, and also must provide representative samples of calculations used to estimate the emissions. Descriptive information is also required on process equipment, including operating schedules, emission control devices, abatement device control efficiencies, and emission point discharge parameters such as location, height, diameter, temperature, and exhaust gas flow rate. All data submitted in the EIQ are subjected to quality assurance (QA) procedures."[129]

In the photochemical modeling files, point sources are categorized according to electric generating units (EGU) and non-electric generating units (NEGU). Hourly EGU point source emissions were obtained by EPA's acid rain database for every modeling day130, while NEGUs were based on the State of Texas Air Reporting System (STARS). "The TCEQ processes industrial point source emissions for use in photochemical modeling in several steps. The first

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[128] "Texas Administrative Code: Title 30, Part 1, Chapter 101, Subchapter A, Rule §101.10". Available online: http://info.sos.state.tx.us/pls/pub/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=101&rl=10. Accessed 07/11/13.

[129] TCEQ. "Appendix B: Emissions Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-12. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[130] EPA. "Acid Rain". Available online: http://www.epa.gov/acidrain/related.html. Accessed 07/11/13.

step is to acquire a point source emissions inventory for the year being modeled. Point source emissions are retrieved from the agency's database, the State of Texas Air Reporting System (STARS). STARS data extracted include reported daily average emission rates, location coordinates, stack parameters, chemical species, standard industrial classification (SIC), source classification code (SCC), and other data needed to model each source. Location coordinates (for example, longitude and latitude) allow the emissions to be placed at the appropriate location in the modeling grid. Depending on stack parameters (stack height, discharge velocity, temperature, etc.), the emissions may also be placed directly into elevated layers of the three-dimensional grid."[131]

NEGU point source emissions outside of Texas are based on EPA's NEI 2008 annual emissions.132 For point sources located in Mexico, the 1999 Mexican National Emissions Inventory (NEI)133 phase III was used. The 2006 Canadian National Pollutant Release Inventory (NPRI) and the upstream oil and gas inventories from Environmental Canada[134] were used for Canadian point sources. The 2005 offshore emissions[135] were "developed by Eastern Research Group (ERG) under contract to the Minerals Management Service (MMS). The report and data are divided into two parts, oil and gas exploration and production platform (point) sources and non-platform (area) sources."[136]

"Additionally, a supplemental 'extra olefins' file was developed to account for reconciled HRVOC emissions in the HGB area. HRVOC include ethylene, propylene, 1,3-butadiene, and all isomers of butene "[137] "The reconciled extra emissions were placed at a single pseudo point in each affected modeling cell, in modeling cells that contain point sources, and assigned an emission rate for each HRVOC to best offset the difference between modeled and calculated concentrations. A new VOC AFS record was created for each pseudo point source. The pseudo

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[131] TCEQ, Dec. 2012. "Introduction to Air Quality Modeling: Emissions Modeling". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html. Accessed 07/03/2013.

[132] EPA. "National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data". Available online: http://www.epa.gov/ttnchie1/trends/. Accessed 07/01/13.

[133] EPA, Oct. 2006. "North American Emissions Inventories – Mexico". Available online: http://www.epa.gov/ttnchie1/net/mexico.html. Accessed 07/08/13.

[134] Environment Canada. "National Pollutant Release Inventory". Available online: http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1. Accessed 07/08/13.

[135] Darcy Wilson, Eastern Research Group, Inc. Dec. 2007. "Year 2005 Gulfwide Emission Inventory Study". Morrisville, NC. Available online: http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/Air-Quality/2005-Gulfwide-Emission-Inventory.aspx. Accessed 07/11/13.

[136] TCEQ. "Appendix B: Emissions Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-22. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[137] TCEQ. "Appendix B: Emissions Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-11. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

point source was placed in the middle of each affected cell and assigned default stack parameters (e.g., 5.0 meter stack height). Since these reconciled points do not exist in the STARS database, unique plant, stack and point identifiers were assigned to new speciation cross reference and profile files." [138]

"Episode-specific survey results of HGB floating roof tank landing losses (TLL) were averaged and used to develop files of hourly Texas Point Sources emissions for the 2006 episode."[139] "Land Loss emissions come from most tanks storing moderate or high vapor pressure liquids and are controlled with the use of floating roofs equipped with seals to prevent the direct contact of the stored liquid with the ambient air. Air emissions from tanks are greater while the tank roof is landed and remain so until the tank is either completely emptied and/or purged of organics or the tank is refilled and the roof is again floating. Air emissions that occur during this period are referred to as landing loss emissions."[140]

CB6 chemical speciation was used for Texas and other states while CB05 chemical speciation was used for other point sources.[141] "Because the composition of VOC emissions is critically important to accurately simulating ozone formation, the TCEQ asks industries to provide detailed breakdowns of the hydrocarbon species emitted at each reported emission point. In cases where this information is unavailable or incomplete, default speciation profiles are used to complete the speciation of each point based on its reported SCC. TCEQ occasionally conducts special inventory surveys to obtain hourly speciated emissions from specific sources. The TCEQ conducted such a survey during the Second Texas Air Quality Study (TexAQS II) intensive period, collecting hourly emissions from major point sources in East Texas from August 15 through September 15, 2006. A 2011 survey of certain flare operations in the Houston-Galveston-Brazoria area was recently conducted as well."[142]

3.11 2006 Base Case Emission Inventory Development

Development of the 2006 emissions database for the extended May 31st to July 2nd, 2006 photochemical modeling episode required the review and adoption of data from a variety of

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[138] TCEQ. "Appendix B: Emissions Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-17. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[139] TCEQ. "Appendix B: Emissions Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-11. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[140] Eden, Dan. "Letter on Air Emissions During Tank Floating Roof Landings." December 5, 2006. Available online: http://www.tceq.state.tx.us/assets/public/permitting/air/memos/tank_landing_final.pdf. Accessed 07/11/13

[141] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/13.

[142] TCEQ, Dec. 2012. "Introduction to Air Quality Modeling: Emissions Modeling". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html. Accessed 07/03/2013.

sources. A major step in the development and refinement process entailed developing/obtaining improved emission inventories and adjusting emissions to the correct time periods, speciating the emissions, and converting the results to model-ready format. Emissions data was obtained from a variety of sources including AACOG data, TCEQ, EPA, TxDOT, TTI, FAA, North Central Texas Council of Governments, United States Department of Agriculture, Environment Canada, and other entities.

Daily 2006 NO_X and VOC emissions for the San Antonio MSA, used in the photochemical model, are summarized in Table 3-11, Figure 3-9, and Figure 3-10. The source category with the largest amount of VOC emitted per day was area, followed by on-road and non-road. Emissions on the weekends are lower for every source except point source emissions. Point sources usually operate 7 days a week and the emissions vary greatly from day to day. Eagle Ford emissions are zero during the 2006 episode because most production in the Eagle Ford did not start until 2008.

The largest source of NO_X emissions in 2006 were on-road vehicles: 135 tons of NO_X per weekday in the San Antonio-New Braunfels MSA. Point sources are the second largest emitter of NO_X at 80 tons per day. Non-road, area, and off-road NO_X emissions are lower than the other two categories.

Table 3-11: NO$_X$ and VOC Emissions (ton/day) for the San Antonio-New Braunfels MSA, 2006

Date	Date	NO$_X$						VOC					
		On-Road	Point	Area	Non-Road	Off-Road	Eagle Ford	On-Road	Point	Area	Non-Road	Off-Road	Eagle Ford
31-May	Wednesday	134.7	77.6	16.5	43.6	7.9	0.0	49.2	8.4	147.2	26.4	1.6	0.0
1-Jun	Thursday	134.7	71.3	16.5	43.6	7.9	0.0	49.2	8.3	147.2	26.4	1.6	0.0
2-Jun	Friday	144.4	74.9	16.5	43.6	7.9	0.0	51.1	8.4	147.2	26.4	1.6	0.0
3-Jun	Saturday	101.2	76.5	13.9	29.7	3.4	0.0	39.8	8.5	94.6	45.0	0.5	0.0
4-Jun	Sunday	81.8	76.0	12.3	13.7	3.4	0.0	37.6	8.5	73.4	40.3	0.5	0.0
5-Jun	Monday	134.7	80.9	16.5	43.6	7.9	0.0	49.2	8.8	147.2	26.4	1.6	0.0
6-Jun	Tuesday	134.7	81.1	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
7-Jun	Wednesday	134.7	80.9	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
8-Jun	Thursday	134.7	84.1	16.5	43.6	7.9	0.0	49.2	8.8	147.2	26.4	1.6	0.0
9-Jun	Friday	144.4	81.5	16.5	43.6	7.9	0.0	51.1	8.7	147.2	26.4	1.6	0.0
10-Jun	Saturday	101.2	80.4	13.9	29.7	3.4	0.0	39.8	8.6	94.6	45.0	0.5	0.0
11-Jun	Sunday	81.8	79.6	12.3	13.7	3.4	0.0	37.6	8.6	73.4	40.3	0.5	0.0
12-Jun	Monday	134.7	81.6	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
13-Jun	Tuesday	134.7	83.2	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
14-Jun	Wednesday	134.7	82.3	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
15-Jun	Thursday	134.7	83.2	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
16-Jun	Friday	144.4	80.4	16.5	43.6	7.9	0.0	51.1	8.7	147.2	26.4	1.6	0.0
17-Jun	Saturday	101.2	79.4	13.9	29.7	3.4	0.0	39.8	8.6	94.6	45.0	0.5	0.0
18-Jun	Sunday	81.8	78.7	12.3	13.7	3.4	0.0	37.6	8.5	73.4	40.3	0.5	0.0
19-Jun	Monday	134.7	83.9	16.5	43.6	7.9	0.0	49.2	8.8	147.2	26.4	1.6	0.0
20-Jun	Tuesday	134.7	78.1	16.5	43.6	7.9	0.0	49.2	8.5	147.2	26.4	1.6	0.0
21-Jun	Wednesday	134.7	81.6	16.5	43.6	7.9	0.0	49.2	8.6	147.2	26.4	1.6	0.0
22-Jun	Thursday	134.7	83.6	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
23-Jun	Friday	144.4	85.3	16.5	43.6	7.9	0.0	51.1	8.8	147.2	26.4	1.6	0.0
24-Jun	Saturday	101.2	87.1	13.9	29.7	3.4	0.0	39.8	8.7	94.6	45.0	0.5	0.0
25-Jun	Sunday	81.8	87.0	12.3	13.7	3.4	0.0	37.6	8.8	73.4	40.3	0.5	0.0
26-Jun	Monday	134.7	83.7	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
27-Jun	Tuesday	134.7	78.9	16.5	43.6	7.9	0.0	49.2	8.6	147.2	26.4	1.6	0.0
28-Jun	Wednesday	134.7	83.1	16.5	43.6	7.9	0.0	49.2	8.7	147.2	26.4	1.6	0.0
29-Jun	Thursday	134.7	80.8	16.5	43.6	7.9	0.0	49.2	8.6	147.2	26.4	1.6	0.0
30-Jun	Friday	144.4	80.5	16.5	43.6	7.9	0.0	51.1	8.6	147.2	26.4	1.6	0.0
1-Jul	Saturday	101.2	72.1	13.9	29.7	3.4	0.0	39.8	8.3	94.6	45.0	0.5	0.0
2-Jul	Sunday	81.8	71.5	12.3	13.7	3.4	0.0	37.6	8.3	73.4	40.3	0.5	0.0

Figure 3-9: Daily Graph of 2006 VOC Emissions (ton/day) for the San Antonio-New Braunfels MSA

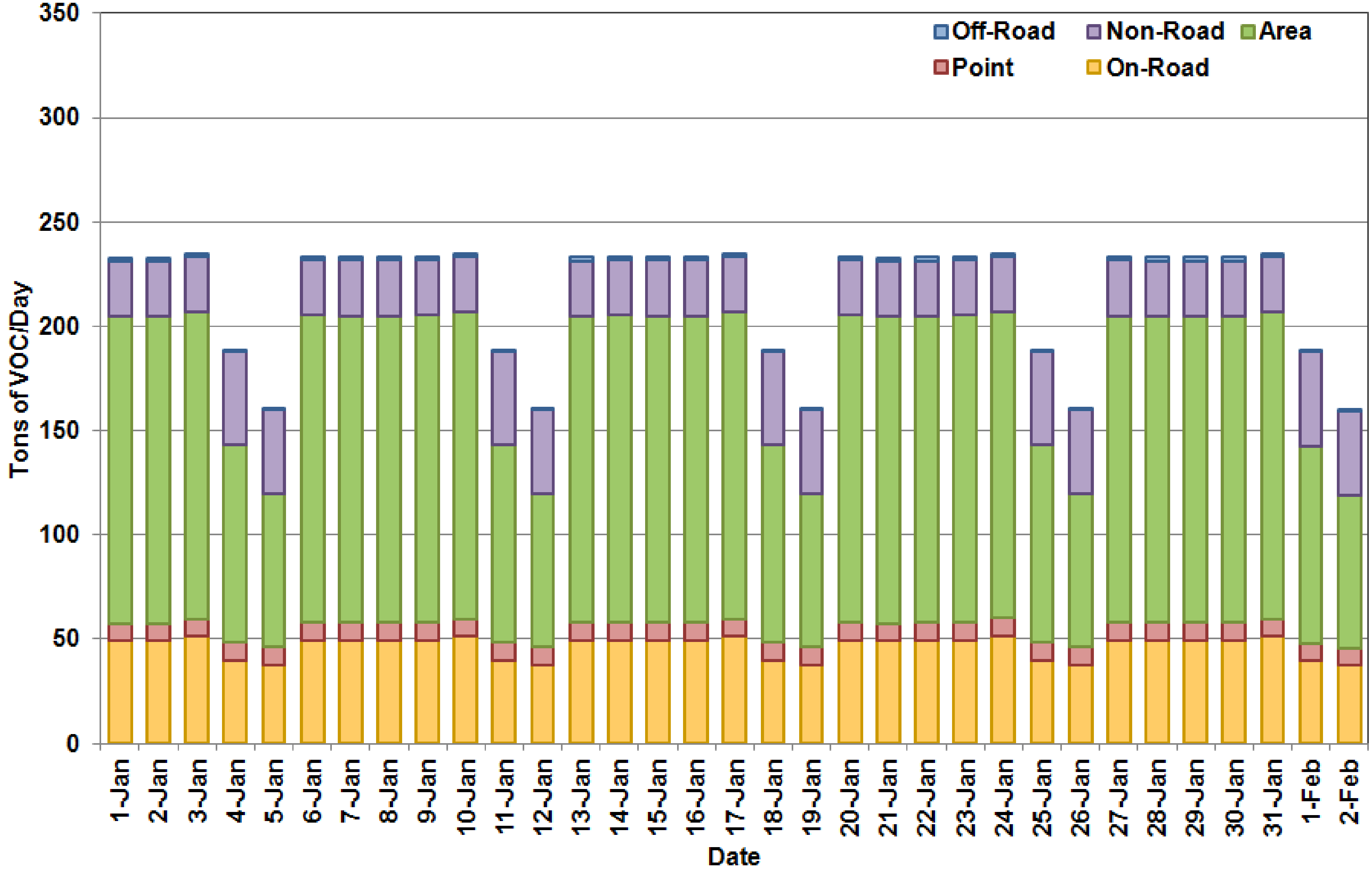
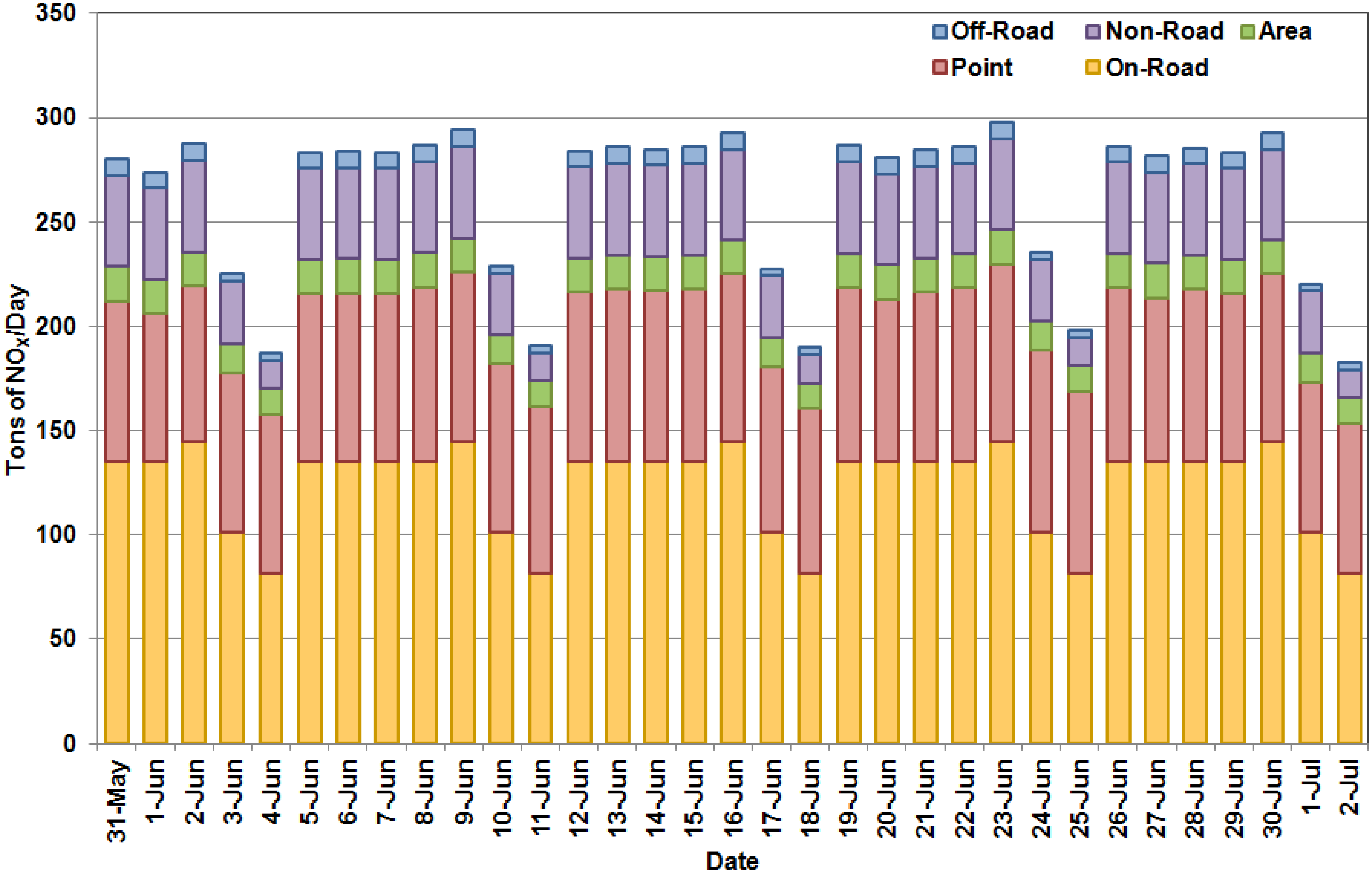


Figure 3-10: Daily Graph of 2006 NO_X Emissions (ton/day) for the San Antonio-New Braunfels MSA



4 Future-Year Inventory, 2012 and 2018

4.1 Development of the Future Year Inventory

To predict future impacts on air quality in the San Antonio-New Braunfels MSA, emission inventories for 2012 and 2018 were developed for the extended June 2006 modeling episode. The 2012 and 2018 projection inventories were used as inputs in the photochemical model to calculate future ozone concentrations. Future Year Inventories were developed using the same temporal, chemical speciation, and methodologies used to develop the Base Case Inventory, as described in Chapter 3. To predict future air quality, it is important to maintain consistency in developing all photochemical modeling emission inventories.

EPA's emission inventory guidance for ozone advises modelers to follow a four-step process when developing a Future Year Inventory.

- "Identify sectors of the inventory that require projections and sectors for which projections are not advisable, and prioritize these sectors based on their expected impact on the modeling region. (Section 17.6.1 of Guidance Document (U.S. EPA, 2005/2007)).
- Collect the available data and models that can be used to project emissions for each of the sectors (Section 17.6.2 of Guidance Document (U.S. EPA, 2005/2007)).
- For key sectors, determine what information will impact the projection results the most, and ensure that the data values reflect conditions or expectations of the modeling region (Section 17.6.3 of Guidance Document (U.S. EPA, 2005/2007)).
- Create inputs needed for emissions models, create future year inventories, quality assure them, and create air quality model inputs from them (Section 17.6.4 of Guidance document (U.S. EPA, 2005/2007))."[143]

These four steps were used to develop the 2012 and 2018 Future Year Inventories and used as input to project the June 2006 photochemical modeling episode to 2012 and 2018. CO, NO_X, and VOC emissions from all anthropogenic sources were projected from 2006 to 2012 and 2018. Biogenic emissions, meteorology inputs, and chemical speciation remained the same for every base case and projection year. All new emissions sources including new point sources and the Eagle Ford shale emissions were included in the future year emission inventory projections. Table 4-1 shows the data sources for the 2012 Emissions Inventory, while Table 4-2 provides the data sources for 2018.

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[143] EPA. November 2005. "The Emission Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards (NAAQS)." Available online http://www.epa.gov/ttn/chief/eidocs/eiguid/index.html. Accessed 07/15/13.

Table 4-1: Emission Inventory Sources by Type for 2012

Type	Sub Category	Source
Point	Electric Generating Units (EGU)	- Generic OSD emissions from TCEQ - each modeling day has the same emissions - Local data for EGUs in the San Antonio-New Braunfels MSA (CPS Energy and San Miguel) - EGUs for other Texas counties and other states based on data from county totals from the Dallas SIP - Canadian and Mexico EGU emissions are the same as the 2006 Base Line - CB6 Chemical Speciation
	Non-Electric Generating Units (NEGU)	- Local data for Cement Kilns in the San Antonio-New Braunfels MSA and Austin–Round Rock–San Marcos MSA (Alamo Cement, Chemical Lime, Capitol Cement, TXI, CEMEX, and Texas Lehigh) - NEGUs for other Texas counties and other states based on data from county totals from the Dallas SIP - HGB 2006 generic day extra alkenes. - HGB 2006 generic day hourly tank landing losses. - Offshore platforms monthly emissions from 2005 GWEI. - Mexico 1999 generic day from NEI phase III. - Canada 2006 annual National Pollutant Release Inventory (NPRI) and Upstream Oil and Gas (UOG) inventories from Environment Canada. - CB6 Chemical Speciation for NEGUs in Texas and the United States - CB05 Chemical Speciation for other sources.
Area	Area Sources	- TexAER v4 area09c for Texas projected to 2012 using EGAS - nei2008v2-based for other states projected to 2012 using EGAS - Canadian and Mexico area sources remain the same as the 2006 base line - CB6 Chemical Speciation
	Oil and Gas	- DFW SIP special oil and gas production emission inventory - New TX 2008 offshore oil and gas production projected to 2012 by TCEQ - 2012 Louisiana Haynesville Shale Emissions - nei2008v2-based for other states projected to 2012 using EGAS - CB6 Chemical Speciation

Type	Sub Category	Source
Mobile	All Categories	- MOVES2010a model was used to estimate 2012 on-road emissions for all U.S. portions of the modeling domain. - Within Texas, the vehicle miles traveled (VMT) estimates are based on the Highway Performance Monitoring System (HPMS) for more rural areas. - MOVES2010a was run in default mode for all non-Texas U.S. states. - On-road emission estimates for Canada and Mexico are based on 2006 MOBILE6-Canada and MOBILE6-Mexico, respectively. - Profiles from EPA's SPECIATE Version 4.3 Database were used to allocate VOC exhaust and evaporative emission estimates with CB6 mechanism. - Local data for Extended Diesel Truck Idling
Non-Road	All Categories	- Emissions in Texas projected to 2012 using the TexN model - Drill rigs projected to 2012 based on ERG drill rig emission inventory - Local data for construction equipment, quarry equipment, mining equipment, landfill equipment, agricultural tractors, and combines projected to 2012 using TexN model - Emissions for other states projected to 2012 using NMIM Model - Canadian and Mexico non-road emissions are the same as the 2006 Base Line - CB6 Chemical Speciation
Off-Road	Locomotives	- ERG contract 2011-based switcher and line-haul locomotives - Texas locomotives projected to 2012 using Pechan & Associates, Inc Locomotive emission inventory - NEI2008v2 locos (switchers as points) for other states projected to 2012 using EPA's Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder - CB6 Chemical Speciation
	Marine	- NEI2008v2 marine vessels projected to 2012 using EPA's Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder - CB6 Chemical Speciation
	Aircraft	- hgb8co and attainment counties aircraft projected to 2012 using ERG's Development of Statewide Annual Emissions Inventory and Activity Data for Airports - DFW airports based on NCTCOG data for the DFW SIP projected to 2012 using ERG's Development of Statewide Annual Emissions Inventory and Activity Data for Airports - new NEI2008v2 airports (with ground support equipment - GSE) for other states projected to 2012 using projected operations by aircraft type from Terminal Area Forecast (TAF) - local data for San Antonio International Airport (SAIA) - CB6 Chemical Speciation

Type	Sub Category	Source
Eagle Ford	All Categories	- Draft Eagle Ford Emission Inventory for 2012 - Exploration, Pad Constriction, Drilling, Hydraulic Fracturing, Completion, Production, Mid-Stream, and On-Road emissions
Biogenic	All Categories	- Same emissions as 2006 - 4 km and 12 km grid emissions were developed by Department of Ecosystem Science & Management at the Texas A&M University. - 36km grid were developed by TCEQ using BIES - WRF calculated modeling surface temperature - CB6 Chemical Speciation[144]

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[144] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/13.

Table 4-2: Emission Inventory Sources by Type for 2018

Type	Sub Category	Source
Point	Electric Generating Units (EGU)	- Generic OSD emissions from TCEQ - Each modeling day has the same emissions - Local data for EGUs in the San Antonio-New Braunfels MSA (CPS Energy and San Miguel) - EGUs for other Texas counties and other states based on data from county totals from the Dallas SIP for 2012 (there was no projection of existing EGU units) - Canadian and Mexico EGU emissions are the same as the 2006 Base Line - CB6 Chemical Speciation
	Non-Electric Generating Units (NEGU)	- Local data for Cement Kilns in the San Antonio-New Braunfels MSA and Austin–Round Rock–San Marcos MSA (Alamo Cement, Chemical Lime, Capitol Cement, TXI, CEMEX, and Texas Lehigh) - NEGUs for other Texas counties and other states based on data from county totals from the Dallas SIP for 2012 (there was no projection of existing NEGUs) - HGB 2006 generic day extra alkenes. - HGB 2006 generic day hourly tank landing losses. - Offshore platforms monthly emissions from 2005 GWEI. - Mexico 1999 generic day from NEI phase III. - Canada 2006 annual National Pollutant Release Inventory (NPRI) and Upstream Oil and Gas (UOG) inventories from Environment Canada. - CB6 Chemical Speciation for NEGUs in Texas and the United States - CB05 Chemical Speciation for other sources.
Area	Area Sources	- TexAER v4 area09c for Texas projected to 2018 using EGAS - nei2008v2-based for other states projected to 2018 using EGAS - Canadian and Mexico area sources remain the same as the 2006 base line - CB6 Chemical Speciation
	Oil and Gas	- DFW SIP special oil and gas production emission inventory - New TX 2008 offshore oil and gas production projected to 2012 by TCEQ - 2012 Louisiana Haynesville Shale Emissions - Texas data projected from 2012 to 2018 using EGAS - nei2008v2-based for other states projected to 2018 using EGAS - CB6 Chemical Speciation

Type	Sub Category	Source
Mobile	All Categories	- MOVES2010a model was used to estimate 2018 on-road emissions for all U.S. portions of the modeling domain. - Within Texas, the vehicle miles traveled (VMT) estimates are based on the Highway Performance Monitoring System (HPMS) for more rural areas. - MOVES2010a was run in default mode for all non-Texas U.S. states. - On-road emission estimates for Canada and Mexico are based on 2006 MOBILE6-Canada and MOBILE6-Mexico, respectively. - Profiles from EPA's SPECIATE Version 4.3 Database were used to allocate VOC exhaust and evaporative emission estimates with CB6 mechanism. - Local data for Extended Diesel Truck Idling
Non-Road	All Categories	- Emissions in Texas projected to 2018 using the TexN model - Drill rigs projected to 2018 based on ERG drill rig emission inventory - Local data for construction equipment, quarry equipment, mining equipment, landfill equipment, agricultural tractors, and combines projected to 2018 using TexN model - Emissions for other states projected to 2018 using NMIM Model - Canadian and Mexico non-road emissions are the same as the 2006 Base Line - CB6 Chemical Speciation
Off-Road	Locomotives	- ERG contract 2011-based switcher and line-haul locomotives - Texas locomotives projected to 2018 using Pechan & Associates, Inc Locomotive emission inventory - NEI2008v2 locos (switchers as points) for other states projected to 2018 using EPA’s Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder - CB6 Chemical Speciation
	Marine	- 2018 Texas marine emissions inventory from the Houston SIP - NEI2008v2 harbor vessels projected to 2018 using EPA’s Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder - CB6 Chemical Speciation
	Aircraft	- 2018 Texas airport emissions inventory from the Houston SIP - new NEI2008v2 airports (with ground support equipment - GSE) for other states projected to 2018 using projected operations by aircraft type from Terminal Area Forecast (TAF) - local data for San Antonio International Airport (SAIA) - CB6 Chemical Speciation

Type	Sub Category	Source
Eagle Ford	All Categories	- Draft 2018 Eagle Ford Emission Inventories - Exploration, Pad Constriction, Drilling, Hydraulic Fracturing, Completion, Production, Mid-Stream, and On-Road emissions - Emission projection based on projected number of drill rigs, well decline curves, estimate ultimate recover (EUR), MOVES2010b, TexN model, Tier4 standards, and other sources - Three scenarios: Low, Moderate, High
Biogenic	All Categories	- Same emissions as 2006 - 4 km and 12 km grid emissions were developed by Department of Ecosystem Science & Management at the Texas A&M University. - 36km grid were developed by TCEQ using BIES - WRF calculated modeling surface temperature - CB6 Chemical Speciation[145]

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[145] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/13.

The modeling projection years of 2012 and 2018 were selected because of the availability of emission inventory data from the latest Dallas and Houston SIP submittals. If San Antonio goes into non-attainment, 2012 could be one of the modeling design value years and 2018 could be the attainment year. Data for the 2012 future year emission inventory is based on the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard[146], while the 2018 emission inventory is based on the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard[147]. The 2012 and 2018 modeling emission inventories include the benefits of the Federal Motor Vehicle Control Program (FMVCP), TexLED, Tier 4 emission standards, Mass Emissions Cap and Trade (MECT) Program, the Highly Reactive VOC Emission Cap and Trade (HECT) Program in the Houston-Galveston-Brazoria (HGB) area, and Phase One of the Clean Air Interstate Rule (CAIR).[148]

The 2012 and 2018 projection year emission inventories were based on generic ozone season days instead of day-specific emissions. The projection year emission inventory is based on weekday (Monday-Thursday), Friday, Saturday, and Sunday emission estimates. The main difference between the 2006 base line emission inventory and the future projections are emissions from electric generating units (EUG). In the base case, EGU emissions are day specific, while the future emission inventories used average OSD emissions for every day of the modeling episode. All emissions from Mexico, Canada, and off-shore sources in the projection cases were the same as those used in the 2006 base line emission inventory.

4.2 Biogenic Emissions

Biogenic emissions are the same in the 2012 and 2018 projection as in the 2006 Base Case Inventory, following EPA guidance. Biogenic emissions remain consistent across modeled years so the photochemical model's response to changes in anthropogenic emissions can be measured.

4.3 Area Source Emissions

All area source emissions were projected to 2012 and 2018 from the 2006 Base Case using EGAS 5.0. Equation 4-1 was used to project area source emissions for Texas and other states.

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[146] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-10. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[147] TCEQ. "Emissions Modeling for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/sip/HGB_eight_hour.html#AD. Accessed 07/23/13.

[148] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-10. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

Equation 4-1, Ozone season day area source emissions, 2012 or 2018

$E_{Local.FY.A.B} = E_{Local.06.A.B} \times (E_{EGAS.FY.A.B} / E_{EGAS.06.A.B})$

Where,

$E_{Local.FY.A.B}$ = Ozone season day 2012 or 2018 emissions in county A for SCC code B (NO_X, VOC, or CO)

$E_{Local.06.A.B}$ = Ozone season day 2006 emissions in county A for SCC code B (NO_X, VOC, or CO)

$E_{EGAS.FY.A.B}$ = EGAS 5.0 ozone season day 2012 or 2018 emissions in county A for SCC code B (NO_X, VOC, or CO)

$E_{EGAS.06.A.B}$ = EGAS 5.0 ozone season day 2006 emissions in county A for SCC code B (NO_X, VOC, or CO)

Sample Equation: 2012 NO_X emissions from Distillate Oil fuel combustion in Bexar County, SCC code 2102004000

$E_{Local.FY.A.B}$ = 0.0088 tons of NO_X in 2006 x (0.0200 tons of NO_X in 2012 / 0.0100 tons of NO_X in 2006)

= 0.0176 tons of NO_X per day from Distillate Oil fuel combustion in Bexar County, 2012

4.3.1 *Oil and Gas Production Emissions*

Calculated 2012 oil and gas production emissions were based on an Eastern Research Group report using 2006 and June 2010 natural gas production.[149] TCEQ projected oil and gas production emissions from 2010 to 2012 "using the simple assumption of 10% growth for the 23 Barnett shale counties, 10% growth for the 10 Haynesville shale counties. 10% growth was also assigned to the remainder of the Texas counties in the domain. No additional controls were assumed between 2010 and 2012."[150]

"The spatial distribution within counties for oil and gas production was built from Texas Railroad Commission data for active wellhead density. The number of active wells in a given model grid cell over the total number of active wells in the county assigned the proportionate amount of the county's total emissions to that cell. Year-end 2010 wellhead densities were used to distribute the 2012 future case emissions"[151] Texas oil and gas production emissions for 2018 were

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[149] Eastern Research Group, Inc., November 24, 2010. "Characterization of Oil and Gas Production Equipment and Develop a Methodology to Estimate Statewide Emissions". Morrisville, NC. TCEQ Contract No. 582-7-84003. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784003FY1026-20101124-ergi-oilGasEmissionsInventory.pdf. Accessed 07/25/13.

[150] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-76. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[151] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-76. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

projected from 2012 using EGAS. Likewise, oil and gas production emissions in other states were projected to 2012 and 2018 using EGAS.

4.4 Non-Road

Non-road NO_X, VOC, and CO emissions in Texas were projected using the TexN model[152] using Equation 4-2. The TexN Model run specifications were:

- Analysis Year = 2006, 2012, and 2018
- Max Tech. Year = 2018
- Met Year = Typical Year
- Period = Ozone season day
- Summation Type = Typical weekday
- Post Processing Adjustments = All
- Rules Enabled = All
- Regions = All Texas Counties
- Sources = All Equipment

All control strategies were selected in the model including the Texas Low Emission Diesel (TxLED) program, Tier 1 to Tier 4 diesel rules, small spark ignition rule, large spark ignition rule, diesel recreation marine rule, small spark ignited (SI)/ SI Marine rule, and reformulated gasoline.

Equation 4-2, Ozone season day non-road emissions in Texas, 2012 or 2018

$$E_{Local.FY.A.B} = E_{Local.06.A.B} \text{ x } (E_{TexN.FY.A.B} / E_{TexN.06.A.B})$$

Where,

$E_{Local.FY.A.B}$ = Ozone season day 2012 or 2018 emissions in county A for non-road equipment type B (NO_X, VOC, or CO)

$E_{Local.06.A.B}$ = Ozone season day 2006 emissions in county A for non-road equipment type B (NO_X, VOC, or CO)

$E_{TexN.FY.A.B}$ = TexN model ozone season day 2012 or 2018 emissions in county A for non-road equipment type B (NO_X, VOC, or CO)

$E_{TexN.06.A.B}$ = TexN model ozone season day 2006 emissions in county A for non-road equipment type B (NO_X, VOC, or CO)

Sample Equation: 2012 NO_X emissions from diesel construction pavers, SCC code 2270002003, in Bexar County

$E_{Local.FY.A.B}$ = 0.100 tons of NO_X per day x (0.080 tons of NO_X per day in 2012 from TexN Model / 0.110 tons of NO_X per day in 2006 from TexN Model)
= 0.073 tons of NO_X per day from diesel construction pavers in Bexar County in 2012

For areas outside of Texas, the NMIM 2008 model[153] was used to project non-road emissions following the same formula listed above.

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[152] Eastern Research Group, Inc. April 26, 2013. "Texas NONROAD (TexN) Model". Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Nonroad_EI/TexN/. Accessed 07/03/13.

4.4.1 Drill Rigs

Drill rig emissions were projected to 2012 and 2018 based on ERG's drill rig emission inventory for Texas. "Based on the projected oil and gas production levels in Texas from the EIA, drilling activity is estimated to remain relatively constant across the state from 2011 through 2035. However, the continued phase-in of more stringent Non-Road diesel engine emission standards should cause a steady decrease in drilling-related emissions over time."[154]

4.4.2 AACOG local data

San Antonio-New Braunfels MSA emissions for construction equipment, quarry equipment, landfill equipment, mining equipment, agricultural tractors, and agricultural combines were projected to 2012 and 2018 using the TexN model.

4.5 Off-Road

4.5.1 Commercial Marine Vessels

The Environmental Protection Agency (EPA) proposed "a comprehensive three-part program to reduce emissions of particulate matter (PM) and oxides of nitrogen (NO_X) from locomotives and marine diesel engines below 30 liters per cylinder displacement. This proposal is part of EPA's ongoing National Clean Diesel Campaign (NCDC) to reduce harmful emissions from diesel engines of all types."[155] Emissions and adjustment factors for commercial[156] and recreational[157] marine vessels are provided in Table 4-3. To project marine vessels in other states to 2012 and 2018, Equation 4-3 was used.

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[153] EPA "National Mobile Inventory Model (NMIM) 2008". Available online: http://www.epa.gov/oms/nmim.htm. Accessed 08/02/13.

[154] Eastern Research Group, Inc. August 15, 2011. "Development of Texas Statewide Drilling Rigs Emission Inventories for the Years 1990, 1993, 1996, and 1999 through 2040". Austin, Texas. Work Order No. 582-11-99776-FY11-05. p. 1-5. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5821199776FY1105-20110815-ergi-drilling_rig_ei.pdf. Accessed 07/01/13.

[155] U.S. Environmental Protection Agency, U.S. Environmental Protection Agency, March 2007. "Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder". p. ES-1. Available online: http://www.epa.gov/nonroad/420d07001.pdf. Accessed 08/02/13.

[156] U.S. Environmental Protection Agency, U.S. Environmental Protection Agency, March 2007. "Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder". p. 26-28. Available online: http://www.epa.gov/nonroad/420d07001chp3.pdf. Accessed 07/29/13.

[157] U.S. Environmental Protection Agency, U.S. Environmental Protection Agency, March 2007. "Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder". p. 61. Available online: http://www.epa.gov/nonroad/420d07001chp3.pdf. Accessed 07/29/13.

Table 4-3: U.S. Commercial and Recreational Marine Emissions and Adjustment Factors, 2006, 2012, and 2018

Type	Year	NO_X		VOC		CO	
		tons/year	factor	tons/year	factor	tons/year	factor
Commercial Marine Vessels	2006	820,269	1.0000	17,278	1.0000	153,928	1.0000
	2012	742,453	0.9051	16,344	0.9459	146,227	0.9500
	2018	591,991	0.7217	12,851	0.7438	140,443	0.9124
Recreational Marine Vessels	2006	44,089	1.0000	1,720	1.0000	7,161	1.0000
	2012	44,931	1.0191	2,104	1.2233	8,150	1.1381
	2018	43,742	0.9921	2,379	1.3831	9,073	1.2670

Equation 4-3, Ozone season day marine vessel emissions, 2012 or 2018

$E_{Local.FY.A.B}$ = $E_{Local.06.A.B}$ x ($E_{EPA.FY.B}$ / $E_{EPA.06.B}$)

Where,

$E_{Local.FY.A.B}$ = Ozone season day 2012 or 2018 emissions in county A for marine vessel type B (NO_X, VOC, or CO)

$E_{Local.06.A.B}$ = Ozone season day 2006 emissions in county A for marine vessel type B (NO_X, VOC, or CO)

$E_{EPA.FY.B}$ = EPA Annual 2012 or 2018 emissions for marine vessel type B (NO_X, VOC, or CO from Table 4-3)

$E_{EPA.06.B}$ = EPA Annual 2006 emissions for marine vessel type B (NO_X, VOC, or CO from Table 4-3)

Sample Equation: 2012 NO_X emissions from commercial marine vessels in St. John the Baptist Parish in Louisiana

$E_{Local.FY.A.B}$ = 10.0 tons of NO_X per day in 2006 x (742,453 tons of NO_X per year in 2012 from EPA / 820,269 tons of NO_X per year in 2006 from EPA)
= 9.1 tons of NO_X per day from commercial marine vessels in St. John the Baptist Parish in Louisiana, 2012

The above formula was also used to project Texas marine vessel emissions to 2012. Commercial and recreational marine vessel emissions for all regions in Texas for 2018 were obtained from the Houston SIP.[158] According to the TCEQ, "starting in 2000, NO_X emissions from large Category 3 engines have been regulated under international rules, so baseline emissions reductions are used to estimate the historic year NO_X emissions. Interpolation of the baseline NO_X estimates were used to estimate emission control factors through 2014. In 2015, under the ECA regulations, more stringent NO_X controls and significant particulate matter (PM)

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[158] TCEQ. March 10, 2010. "Emissions Modeling for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard". Available online: http://www.tceq.texas.gov/airquality/sip/HGB_eight_hour.html. Accessed 08/02/13.

controls begin, so more significant emission reduction should begin in 2015."[159] "Smaller craft are found in a number of occupations including assist tugs, tow boats (tug and barge), and push boats. EPA provides forecasted emissions that include a growth rate of 0.9% per year. By accounting for the growth rate and comparing the emission estimates to those for year 2007, a relative emission control factor was calculated."[160]

4.5.2 Locomotive

Emissions from locomotives in Texas were projected to 2012 and 2018 using Pechan & Associates locomotive emission inventory. "Pechan developed statewide annual and ozone season daily emissions inventories for Class I line haul and switchyard locomotives. Annual and daily inventories were developed for every year between 1990 and 2040." "For this effort, Pechan compiled existing data on Class I line haul and switchyard operations in the state of Texas. Special emphasis was placed on the Houston-Galveston-Brazoria (HGB) and Dallas-Fort Worth (DFW) nonattainment areas. These areas had also been the focus of previous projects to obtain detailed fuel consumption data from Class I companies operating in these areas, namely Burlington Northern Santa Fe (BNSF) and Union Pacific (UP). Data for these companies had been obtained and compiled for the TCEQ's Texas Railroad Emission Inventory Model (TREIM)."[161]

"The activity data used as the base year activity for this project were derived in part from available estimates, and also from newly acquired data (e.g., for BNSF). Growth factors were then applied to base year activity to estimate annual activity for all 51 years of interest. Annual emission rates applied to activity estimates based on updated Environmental Protection Agency (EPA) guidance (2009) reflect revised Federal Tier 0, Tier 1, and Tier 2, as well as new Tier 3 and 4 federal emission standards."[162] Emissions were projected to 2012 and 2018 using the following equation:

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[159] ENVIRON International Corporation, August 18, 2010. "Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling". Novato, CA. Work Order No. 582-7-84006-FY10-5. p. 12. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784006FY1005-20100818-environ-HGBShipsEI.pdf. Accessed 07/03/13.

[160] ENVIRON International Corporation, August 18, 2010. "Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling". Novato, CA. Work Order No. 582-7-84006-FY10-5. p. 13. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784006FY1005-20100818-environ-HGBShipsEI.pdf. Accessed 07/03/13.

[161] Ms. Kirstin B. Thesing. E.H. Pechan & Associates, Inc., July 2010. "Development of Locomotive and Commercial Marine Emissions Inventory - 1990 TO 2040". Durham, NC. TCEQ Grant Agreement No. 582-07-84008. p. 1. Available online: ftp://amdaftp.tceq.texas.gov/pub/Offroad_EI/Locomotives/. Accessed 08/04/13.

[162] Ms. Kirstin B. Thesing. E.H. Pechan & Associates, Inc., July 2010. "Development of Locomotive and Commercial Marine Emissions Inventory - 1990 TO 2040". Durham, NC. TCEQ Grant Agreement No. 582-07-84008. p. 1. Available online: ftp://amdaftp.tceq.texas.gov/pub/Offroad_EI/Locomotives/. Accessed 08/04/13.

Equation 4-4, Ozone season day railway emissions for Texas, 2012 or 2018

$E_{Local.FY.A.B} = E_{Local.06.A.B} \times (E_{Pechan.FY.A.B} / E_{Pechan.06.A.B})$

Where,

$E_{Local.FY.A.B}$ = Ozone season day 2012 or 2018 emissions in county A for railway type B (NO_X, VOC, or CO)

$E_{Local.06.A.B}$ = Ozone season day 2006 emissions in county A for railway type B (NO_X, VOC, or CO)

$E_{Pechan.FY.A.B}$ = Annual 2012 or 2018 emissions in county A for railway type B from Pechan & Associates (NO_X, VOC, or CO)

$E_{Pechan.06.A.B}$ = Annual 2006 emissions in county A for railway type B from Pechan & Associates (NO_X, VOC, or CO)

Sample Equation: 2018 NO_X emissions from large line-haul locomotives in Bexar County

$E_{Local.FY.A.B}$ = 1.00 tons of NO_X per day in 2006 x (215.46 tons of NO_X per year in 2018 from Pechan & Associates / 328.20 tons of NO_X per year in 2006 from Pechan & Associates)

= 0.66 tons of NO_X per day from large line-haul locomotives in Bexar County, 2018

For areas outside of Texas, EPA's "Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder" was used. EPA calculated locomotive emissions "based on estimated current and projected fuel consumption rates. Emissions were calculated separately for the following locomotive categories:

- Large Railroad Line-Haul Locomotives
- Other Line-Haul Locomotives (i.e., local and regional railroads)
- Other Switch/Terminal Locomotives
- Passenger/Commuter Locomotives
- Large Railroad Switching (including Class II/III Switch railroads owned by Class I railroads)"[163]

Table 4-4 lists the annual NO_X and VOC emissions from each locomotive type and the adjustment factored used to project emissions. CO emissions stayed the same for each projection year. These adjustment factors were used in Equation 4-5, to project emissions to 2012 and 2018.

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[163] U.S. Environmental Protection Agency, U.S. Environmental Protection Agency, March 2007. "Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder". p. 77-79. Available online: http://www.epa.gov/nonroad/420d07001chp3.pdf. Accessed 07/29/13.

Table 4-4: U.S. Railroad and Adjustment Factors, 2006, 2012, and 2018

Type	SCC	Year	NO_X		VOC	
			tons/year	factor	tons/year	factor
Large Line-haul	2285002006	2006	779,842	1.0000	43,874	1.0000
		2012	692,606	0.8881	35,890	0.8180
		2018	608,010	0.7797	23,607	0.5381
Small Railroads	2285002007	2006	37,690	1.0000	2,891	1.0000
		2012	41,456	1.0999	3,179	1.0996
		2018	44,299	1.1754	3,497	1.2096
Passenger/ Commuter	2285002008 2285002009	2006	38,466	1.0000	1,609	1.0000
		2012	25,933	0.6742	1,301	0.8086
		2018	19,496	0.5068	771	0.4792
Large Switch	2285002010	2006	86,861	1.0000	5,501	1.0000
		2012	86,614	0.9972	5,364	0.9751
		2018	84,612	0.9741	5,066	0.9209

Equation 4-5, Ozone season day railway for other states, 2012 or 2018

$$E_{Local.FY.A.B} = E_{Local.06.A.B} \times (E_{EPA.FY.B} / E_{EPA.06.B})$$

Where,

$E_{Local.FY.A.B}$ = Ozone season day 2012 or 2018 emissions in county A for railway type B (NO_X or VOC)

$E_{Local.06.A.B}$ = Ozone season day 2006 emissions in county A for railway type B (NO_X or VOC)

$E_{EPA.FY.B}$ = EPA Annual 2012 or 2018 emissions for railway type B (NO_X or VOC from Table 4-4)

$E_{EPA.06.B}$ = EPA Annual 2006 emissions for railway type B (NO_X or VOC from Table 4-4)

Sample Equation: 2012 NO_X emissions from large line-haul locomotives in Clayton County, Alabama

$E_{Local.FY.A.B}$ = 2.00 tons of NO_X per day in 2006 x (692,606 tons of NO_X per year in 2012 from EPA / 779,842 tons of NO_X per year in 2006 from EPA)

= 1.78 tons of NO_X per day from large line-haul locomotives in Clayton County, 2012

4.5.3 Aircraft Emissions

Texas aircraft emissions in 2012 were based on ERG's annual emission inventory and activity data for airports in Texas. ERG developed "statewide annual emission inventories for Texas airport activities for the calendar years 1996, 2000, 2002, 2011, 2014, 2017, 2020, 2023, 2026, 2029, and the base year 2008." ERG's report indicated that "publically available 2008 activity data was compiled and supplemented with 2008 activity data provided by local airports. Two approaches were used to estimate emissions from the compiled activity data. If the activity data had aircraft specific data, the Federal Aviation Administration's (FAA) Emissions Dispersion

Modeling System (EDMS) was employed. If such detailed data were not available, then ERG applied a more general approach for different aircraft types (i.e., air taxis, general aviation, and military aircraft) using available generic emission estimating procedures. Once the base year of 2008 was established, the inventory was backcasted and forecasted based on FAA's Terminal Area Forecast (TAF) data."[164] Texas aircraft emissions in 2012 were projected using the following equation:

Equation 4-6, Ozone season day aircraft emissions in Texas for 2012

$$E_{Local.FY.A.B} = E_{Local.06.A.B} \times (E_{ERG.FY.A.B} / E_{ERG.06.A.B})$$

Where,

$E_{Local.FY.A.B}$ = Ozone season day 2012 emissions in county A for SCC code B (NO_X, VOC, or CO)
$E_{Local.06.A.B}$ = Ozone season day 2006 emissions in county A for SCC code B (NO_X, VOC, or CO)
$E_{ERG.FY.A.B}$ = ERG annual 2012 emissions in county A for SCC code B (NO_X, VOC, or CO)
$E_{ERG.06.A.B}$ = ERG annual 2006 emissions in county A for SCC code B (NO_X, VOC, or CO)

Sample Equation: 2012 NO_X emissions from general aviation aircraft in Bexar County

$E_{Local.FY.A.B}$ = 0.200 tons of NO_X in 2006 x (31.48 tons of NO_X in 2012 from ERG / 86.15 tons of NO_X in 2006 from ERG)
= 0.073 tons of NO_X per day from general aviation aircraft in Bexar County, 2012

With the exception of emission estimates for the San Antonio International Airport (SAIA), 2018 airport emissions for all regions in Texas were obtained from the Houston SIP[165]. Aircraft emissions for other states were projected based on total number of aircraft operations per state, as listed in the TAF, using Equation 4-7.[166]

Equation 4-7, Ozone season day aircraft emissions for other states, 2012 or 2018

$$E_{Local.FY.A.B} = E_{Local.06.A.B} \times (OPS_{TAF.FY.B} / OPS_{TAF.06.B})$$

Where,

$E_{Local.FY.A.B}$ = Ozone season day 2012 or 2018 emissions in county A for aircraft type B (NO_X, VOC, or CO)
$E_{Local.06.A.B}$ = Ozone season day 2006 emissions in county A for aircraft type B (NO_X, VOC, or CO)
$OPS_{TAF.FY.B}$ = Number of aircraft operation from TAF for the state in 2012 or 2018 for aircraft type B
$OPS_{TAF.06.B}$ = Number of aircraft operation from TAF for the state in 2006 for aircraft type B

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[164] Eastern Research Group, Inc. July 15, 2011. "Development of Statewide Annual Emissions Inventory and Activity Data for Airports". 582-11-99776. Morrisville, North Carolina. p. ES-1.

[165] TCEQ. March 10, 2010. "Emissions Modeling for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard". Available online: http://www.tceq.texas.gov/airquality/sip/HGB_eight_hour.html. Accessed 08/02/13.

[166] Federal Aviation Administration. "Terminal Area Forecast". Washington, DC. Available online: https://aspm.faa.gov/main/taf.asp. Accessed 07/29/13.

Sample Equation: 2012 NO_X emissions from General Aviation aircraft in Clayton County in Alabama

$E_{Local.FY.A.B}$ = 0.50 tons of NO_X from general aviation emissions from Clayton County in 2006 x (1,851,463 general aviation operation in Alabama for 2012 from TAF / 1,713,651 general aviation operation in Alabama for 2006 from TAF)
= 0.54 tons of NO_X per day in 2012 from general aviation emissions in Clayton County

4.6 On-Road Emissions

4.6.1 On-Road Vehicle Emissions

The Texas Transportation Institute (TTI) "developed hourly, photochemical model preprocessor ready, on-road mobile summer (June 1 through August 31) Weekday, Friday, Saturday, and Sunday EIs for"[167] 2006, 2012, and 2018 using the MOVES 2010a model. "TTI used an hourly, Highway Performance Monitoring System (HPMS) virtual link, MOVES 'rates-peractivity' emissions inventory method to produce hourly emissions estimates by MOVES source use type (SUT) and fuel type, pollutant, and pollutant process for all 254 Texas counties for each year and day type. The methods TTI used to produce these inventories were consistent with EPA guidance on the production of photochemical modeling emissions inventories."[168] The 30-year age distribution estimates used in MOVES for 2012 and 2018 are provided in Figure 3-1 for TxDOT's San Antonio district.[169]

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[167] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 1. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[168] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 1. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[169] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling: Appendix H: Source Type Age and Fuel Engine Fractions Inputs to MOVES". College Station, Texas. College Station, Texas. p. 65. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

Figure 4-1: San Antonio TxDOT District 2012 and 2018 Age Distributions Inputs to MOVES

Age	MC	PC	PT	LCT	IBus	TBus	SBus	RT	SUShT	SULhT	MH	CShT	CLhT
0	0.04927	0.07586	0.02421	0.02421	0.07151	0.06398	0.06992	0.03103	0.08842	0.09911	0.06948	0.03549	0.03826
1	0.05263	0.06567	0.0418	0.04180	0.06680	0.05977	0.06532	0.02966	0.11468	0.13601	0.06490	0.02619	0.03098
2	0.03916	0.06136	0.03923	0.03923	0.06148	0.05501	0.06012	0.02844	0.04274	0.04725	0.05973	0.01456	0.01922
3	0.09724	0.05031	0.02965	0.02965	0.05906	0.05284	0.05775	0.0285	0.03882	0.04461	0.05738	0.03206	0.03344
4	0.09169	0.07449	0.05699	0.05699	0.06438	0.05761	0.06296	0.03168	0.11490	0.12800	0.06256	0.04394	0.04608
5	0.11319	0.07440	0.06287	0.06287	0.06522	0.05836	0.06377	0.03316	0.07490	0.07834	0.06337	0.11051	0.09874
6	0.09823	0.06846	0.05884	0.05884	0.06452	0.05773	0.06309	0.05515	0.08961	0.08649	0.06269	0.08910	0.07450
7	0.07328	0.06697	0.05815	0.05815	0.06317	0.05653	0.06177	0.04879	0.08688	0.07753	0.06138	0.06291	0.06429
8	0.05303	0.06008	0.06978	0.06978	0.04948	0.04427	0.04838	0.03847	0.06817	0.05467	0.04807	0.04271	0.04397
9	0.06387	0.05715	0.07235	0.07235	0.03895	0.03485	0.03809	0.02805	0.04759	0.04426	0.03784	0.03708	0.03689
10	0.04784	0.05551	0.07162	0.07162	0.03314	0.02965	0.03240	0.02770	0.04213	0.03482	0.03202	0.03304	0.03588
11	0.03744	0.04988	0.06802	0.06802	0.03743	0.03349	0.03660	0.02870	0.03882	0.03637	0.03636	0.04773	0.04942
12	0.02943	0.04686	0.05335	0.05335	0.03943	0.03529	0.03856	0.03937	0.03227	0.02938	0.03832	0.07086	0.06045
13	0.02417	0.03773	0.04750	0.04750	0.03823	0.03421	0.03738	0.04376	0.02709	0.02641	0.03715	0.05422	0.05301
14	0.01747	0.02905	0.03433	0.03433	0.02897	0.04015	0.02950	0.03316	0.01306	0.01239	0.02184	0.04381	0.04290
15	0.01353	0.02432	0.03515	0.03515	0.02332	0.03630	0.02719	0.02670	0.01554	0.01387	0.03327	0.02643	0.03308
16	0.01118	0.01813	0.02484	0.02484	0.01928	0.03343	0.02345	0.05654	0.00932	0.00800	0.02060	0.02717	0.03003
17	0.00996	0.01729	0.02517	0.02517	0.02480	0.02711	0.02964	0.06413	0.00910	0.00869	0.02405	0.03757	0.03814
18	0.00738	0.01277	0.02358	0.02358	0.01909	0.02364	0.01430	0.03968	0.00701	0.00570	0.02293	0.02289	0.02485
19	0.00649	0.01001	0.01642	0.01642	0.01555	0.01940	0.01690	0.03353	0.00594	0.00398	0.01561	0.02252	0.02235
20	0.00498	0.00761	0.01215	0.01215	0.01145	0.01684	0.01363	0.01421	0.00349	0.00281	0.01369	0.01346	0.01610
21	0.00289	0.0062	0.01016	0.01016	0.01298	0.01703	0.01740	0.03861	0.00385	0.00303	0.01019	0.01407	0.01775
22	0.00344	0.00466	0.00809	0.00809	0.01441	0.02466	0.01944	0.03252	0.00392	0.00293	0.01320	0.01444	0.01531
23	0.00334	0.00370	0.00797	0.00797	0.01429	0.01876	0.01109	0.02538	0.00302	0.00236	0.01705	0.01089	0.01189
24	0.00263	0.00274	0.00598	0.00598	0.01329	0.01477	0.01319	0.03416	0.00234	0.00194	0.01512	0.00955	0.00984
25	0.00297	0.00226	0.00425	0.00425	0.01367	0.01351	0.01321	0.02705	0.00183	0.00121	0.01461	0.00930	0.00808
26	0.00459	0.00195	0.00523	0.00523	0.01146	0.01138	0.01153	0.03340	0.00158	0.00146	0.01077	0.00930	0.00780
27	0.00415	0.00174	0.00456	0.00456	0.01001	0.00977	0.00990	0.01757	0.00205	0.00117	0.01143	0.00832	0.00711
28	0.00334	0.00149	0.00395	0.00395	0.00779	0.00753	0.00756	0.01804	0.00158	0.00097	0.01147	0.00551	0.00544
29	0.00360	0.00092	0.00260	0.00260	0.00307	0.00714	0.00276	0.00517	0.00104	0.00059	0.00743	0.00294	0.00248
30	0.02761	0.01041	0.02122	0.02122	0.00378	0.00499	0.00319	0.00769	0.00831	0.00565	0.00533	0.02142	0.02101

Diesel vehicle NO_X emissions factors were post-processed "for the 110 Eastern Texas counties subject to the Texas Low Emission Diesel (TxLED) program".[170] "NO_X adjustment factors used were provided by TCEQ for 2012 and 2018 using reductions of 4.8 percent for 2002-and-newer model year vehicles, and 6.2 percent for 2001-and-older model year vehicles." (Table 4-5)[171] The San Antonio-New Braunfels MSA counties under the low RVP and TxLED rule are Atascosa, Bexar, Comal, Guadalupe, and Wilson. To calculate 2012 and 2018 emissions in the TxDOT's San Antonio district, fuel properties with a RVP of 7.80 and sulfur content of 22.91 were used.[172]

Table 4-5: TxLED Adjustment Factor for Diesel Fuel, 2012 and 2018

Source Use Type	2012 TxLED Reduction	2018 TxLED Reduction
Passenger Car	5.02%	4.84%
Passenger Truck	5.32%	5.02%
Light Commercial Truck	5.29%	5.07%
Intercity Bus	5.80%	5.64%
Transit Bus	5.77%	5.52%
School Bus	5.76%	5.59%
Refuse Truck	5.69%	5.38%
Single Unit Short-Haul Truck	5.04%	4.90%
Single Unit Long-Haul Truck	5.08%	4.93%
Motor Home	5.53%	5.35%
Combination Short-Haul Truck	5.47%	5.17%
Combination Long-Haul Truck	5.45%	5.11%

As shown on Table 4-6, on-road emissions are projected to decrease rapidly from 2006 to 2018. NO_X emissions in the San Antonio-New Braunfels MSA are projected to decrease from 133 tons/weekday in 2006 to 43 tons/weekday in 2018 (Figure 4-2). Similarly, weekday VOC emissions are projected to decrease from 48 tons to 24 tons. These reductions are occurring even though weekday VMT increases from 57 million in 2006 to 63 million in 2018. Emission reductions are occurring because of engine controls being placed on new cars that have significantly reduced emissions.

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[170] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 4. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

[171] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 4. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

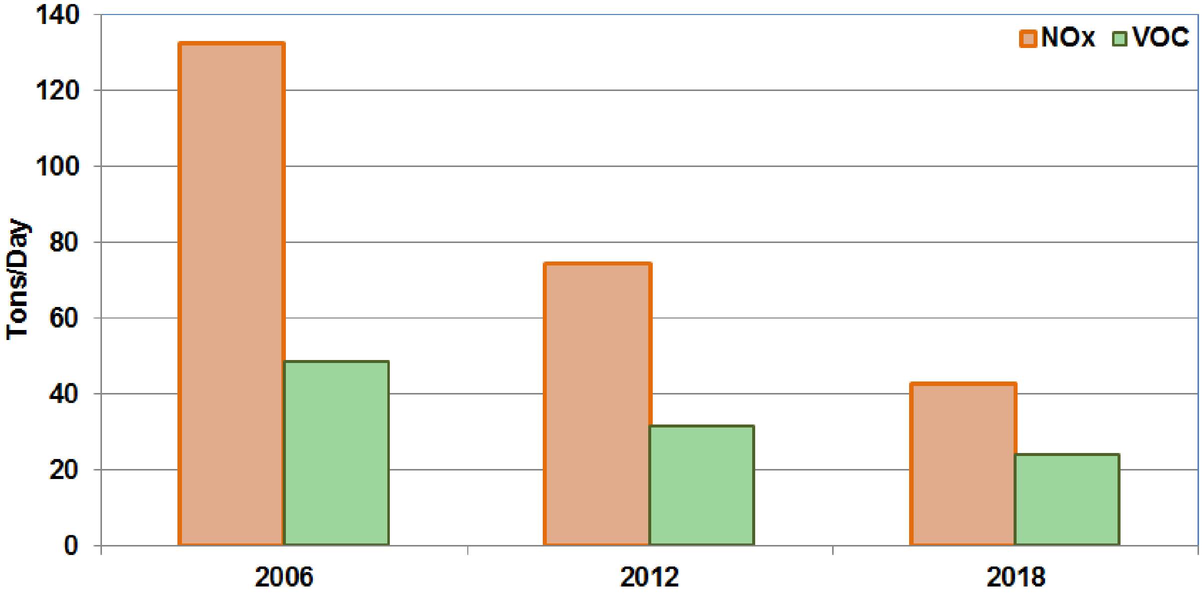
[172] TTI, July 2011. "Production of Statewide Non-Link-Based, On-Road Emissions Inventories with the Moves Model for the Eight-Hour Ozone Standard Attainment Demonstration Modeling". College Station, Texas. College Station, Texas. p. 36. Available online: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/. Accessed 07/05/13.

Table 4-6: Weekday VMT, NO_X Emissions, and VOC Emissions by County, San Antonio New Braunfels MSA, 2006, 2012, and 2018

County	VMT			Tons of NO_X			Tons of VOC		
	2006	2012	2018	2006	2012	2018	2006	2012	2018
Atascosa	1,645,740	1,713,192	1,956,427	5.44	3.10	1.81	1.24	0.77	0.59
Bandera	493,632	531,410	511,131	1.41	0.88	0.45	0.53	0.40	0.30
Bexar	43,339,519	43,171,178	46,619,601	93.28	52.74	29.94	37.17	23.80	18.05
Comal	4,062,411	4,268,618	5,277,660	10.40	5.67	3.58	3.13	2.10	1.69
Guadalupe	3,661,652	3,605,424	4,120,938	10.67	5.34	3.15	3.04	1.99	1.60
Kendall	1,108,735	1,292,394	1,329,894	4.09	2.34	1.23	1.03	0.80	0.60
Medina	1,526,961	1,580,167	1,639,215	4.66	2.73	1.50	1.20	0.86	0.62
Wilson	1,030,604	1,095,406	1,316,568	2.73	1.66	1.02	1.02	0.70	0.56
Total	56,869,254	57,257,789	62,771,434	132.68	74.45	42.68	48.36	31.43	24.00

*Note: totals do not include long term idling emissions from long haul diesel combination trucks or traffic from the Eagle Ford

Figure 4-2: On-Road NO_X and VOC Emissions, San Antonio New Braunfels MSA, 2006, 2012, and 2018



“Profiles from EPA's SPECIATE Version 4.3 Database were used to allocate VOC exhaust and evaporative emission estimates with the Carbon Bond 6 (CB6) mechanism.”[173] On-road emissions from Mexico and Canada were kept the same as the 2006 base line emission inventory.

4.6.2 *Heavy Duty Diesel Vehicles Idling Emissions*

The same EPA-recommended 2006 NO_X and VOC emission factors for Class 8 truck idling were used for the 2012 and 2018 Forecast Year Inventories. The 2012 and 2018 projections also used the same activity data as the 2006 base line emission inventory.

4.7 Point Source Emissions

EGU and NEGU point source emissions outside of the San Antonio-New Braunfels MSA are based on the TCEQ’s Dallas and Houston attainment demonstration SIP revision for the 1997 eight-hour ozone standard. To develop the 2012 EGU emission projection, TCEQ based the projections on the 2008 Acid Rain database. “To develop the Acid Rain EGU 2008 baseline, the TCEQ averaged the Acid Rain NO_X for each hour of the day for each unit for the third quarter of 2008 (3Q2008). The TCEQ chose this dataset from which to project because it is newer and contains more of the actual emissions growth from newer units. Not all EGUs are Acid Rain sources and not all NO_X point sources at EGU facilities are Acid Rain sources. The non-Acid Rain EGUs were modeled at their 2008 emissions along with the NEGU point sources. The complete set of 2012 EGUs consists of the 3Q2008 ARD EGUs, the 2008 non-Acid Rain EGUs, and post-2008 EGUs that have approved TCEQ

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[173] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/. Accessed 07/02/13.

permits. As with previous SIP revisions, the TCEQ assumes that the EGU growth in the state comes from the TCEQ newly-permitted EGUs."[174]

"Emissions from NEGUs in the attainment areas of the state were projected to 2012 using a combination of projection factors. Projection factors derived from the Dallas Federal Reserve Bank's Texas Industrial Production Index (TIPI) exist for growth from 2006 to 2018 and are based on an industry's Standard Industrial Classification (SIC). For SICs not covered by TIPI, projection factors from EPA's Economic Growth Analysis System version 5.0 (EGAS5) with a Texas-specific version of the Regional Economic Models, Inc (REMI) update were used. This version of EGAS with Texas-specific REMI is hereafter referred to as REMI-EGAS which, like the TIPI growth factors exists for growth from 2006 to 2018. No individual new permits were modeled as growth for NEGUs. The TCEQ modeled 2008 to 2012 by interpolating the 2006-2018 data, using one third of the growth for the shorter time span."[175]

"The 2012 NEGU emissions for states beyond Texas were interpolated from the 2018 CenRAP/RPO file after the EGUs were removed. Growing 2006 emissions to 2012 would not have captured the controls that were built into the regional modeling files." [176] Equation 4-8 was used to project the 2006 point source emissions to 2012 and 2018.

Equation 4-8, Ozone season day point source emissions for other states, 2012 or 2018

$$E_{Local.FY.A.C} = E_{Local.06.A.C} \text{ x } (E_{TCEQ.FY.B} / E_{TCEQ.06.B})$$

Where,

$E_{Local.FY.A.C}$ = Ozone season daily 2012 or 2018 emissions in county A for point source C (NO_X, VOC, or CO)

$E_{TCEQ.06.A.C}$ = Ozone season daily 2006 emissions in county A for point source C (NO_X, VOC, or CO from the Dallas or Houston SIP)

$E_{TCEQ.FY.A.B}$ = Ozone season daily 2012 or 2018 emissions in county A for point source type B (NO_X, VOC, or CO from the Dallas or Houston SIP)

$E_{TCEQ.06.A.B}$ = Ozone season daily 2006 emissions in county A for point source type B (NO_X, VOC, or CO from the Dallas or Houston SIP)

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[174] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-10. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[175] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-43. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[176] TCEQ. "Appendix B: Emissions Modeling for the Dfw Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-56. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

Sample Equation: Ozone season daily 2012 NO_X emissions from a NEGU point source in Floyd County, GA (FIPS Code 13115)

$E_{Local.FY.A.C}$ = 2.00 tons of NO_X per day in 2006 from NEGU C x (11.969 tons of NO_X per day in 2012 from TCEQ / 8.0925 tons of NO_X per day in 2006 from TCEQ)
= 2.96 tons of NO_X per day from NEGU C in Floyd County, 2012

Flares, "extra olefins" emissions in the HGB area, elevated ships, SAIA, HGB floating roof tank landing losses, offshore, Mexican, and Canadian point source emissions remained the same for each projection year. CB6 chemical speciation was used for Texas and other states while CB05 chemical speciation was used for point sources outside the USA.

4.7.1 CPS Energy

"CPS Energy is the nation's largest municipally owned energy utility providing both natural gas and electric service. Acquired by the City of San Antonio in 1942, today CPS Energy serve more than 728,000 electric customers and 328,000 natural gas customers in and around the seventh-largest city in the nation. CPS Energy serves customers in Bexar County and portions of Atascosa, Bandera, Comal, Guadalupe, Kendall, Medina, and Wilson Counties."[177]

In 2012, CPS Energy signed a contract with Tenaska Capital Management LLC "to purchase Rio Nogales, an 800-megawatt combined-cycle gas plant" in Guadalupe County.[178] With this addition to the organization's facilities, ozone season average daily emissions from CPS Energy in 2012 and 2018 were determined to be 26.46 tons of NO_X, 0.41 tons of VOC, and 17.62 tons of CO (Table 4-7). The average hourly emissions profile for CPS Energy is provided in Figure 4-3.[179] Emission projections for 2018 may vary from 2012 levels because of market demand. Since the 2012 emission rates for CPS Energy are the most recent data available, however, they are considered the best estimates of future generation. It is not reasonable to base emissions estimates on an equal distribution of CPS Energy's annual permitted emissions because actual daily emissions fluctuate with some days that have higher generation and some days that have lower generation. CPS Energy complies with short-term and long-term emissions limitations; however multiplying daily figures by 365 does not compare well with annual emissions rates.

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[177] CPS Energy, 2013. "Who We Are: CPS Energy Works for You". San Antonio, Texas. Available online: http://cpsenergy.com/About_CPS_Energy/Who_We_Are/. Accessed: 08/07/13.

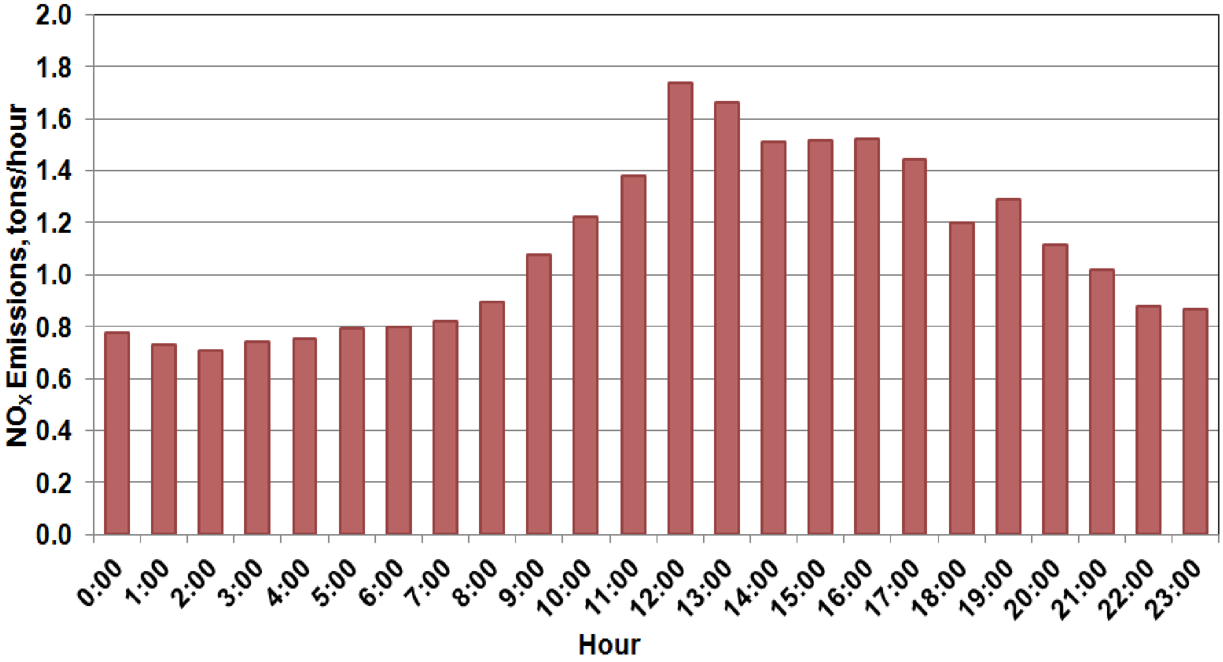
[178] Bob Thaxton, Seguin Gazette, April 11, 2012 "CPS finishes Rio Nogales acquisition". Seguin, TX. Available online: http://seguingazette.com/news/article_2edfc6fc-836d-11e1-9470-001a4bcf887a.html. Accessed 08/07/13.

[179] CPS Energy, San Antonio, Texas. "For AACOG NOx CO VOC Dec 2012.xls". Email to Steven Smeltzer. 11/29/12

Table 4-7: Emissions (ton/day) from CPS Energy Power Plant Units. 2012 and 2018

CPS Energy Plant	NO_X	VOC	CO
Leon Creek CGT #2	0.01	0.00	0.01
Leon Creek CGT #3	0.01	0.00	0.00
V. H. Braunig #1	0.43	0.03	0.01
V. H. Braunig #2	0.49	0.02	0.03
V. H. Braunig #3	1.99	0.08	0.35
A V Rosenberg CT#1	0.14	0.00	0.01
A V Rosenberg CT#2	0.14	0.00	0.01
V. H. Braunig CGT #5	0.01	0.00	0.01
V. H. Braunig CGT #6	0.01	0.00	0.01
V. H. Braunig CGT #7	0.02	0.00	0.01
V. H. Braunig CGT #8	0.02	0.00	0.01
O. W. Sommers #1	2.52	0.08	1.84
O. W. Sommers #2	1.42	0.07	0.02
J. T. Deely #1 & #2	6.84	0.00	7.67
J. K. Spruce #1	7.86	0.06	6.96
J. K. Spruce #2	3.50	0.03	0.12
Rio CT#1	0.29	0.01	0.23
Rio CT#2	0.46	0.02	0.03
Rio CT#3	0.29	0.01	0.29
Total	26.46	0.41	17.62

Figure 4-3: CPS Energy Hourly NO_X Emissions for the June 2006 Modeling Episode, 2012 and 2018



4.7.2 San Miguel Electric Cooperative

"San Miguel Electric Cooperative, Inc. (San Miguel) was created on February 17, 1977, under the Rural Electric Cooperative Act of the State of Texas, for the purpose of owning and operating a 400-MW mine-mouth, lignite-fired generating plant and associated mining facilities that furnish power and energy to Brazos Electric Power Cooperative, Inc. (BEPC) and South Texas Electric Cooperative, Inc. (STEC)."[180] Projected 2012 emissions for San Miguel Electric Cooperative are 10.18 tons/day of NO_X, 0.22 tons/day of VOC, and 8.50 tons/day of CO. For 2018, the projected emissions are 7.98 tons/day of NO_X, 0.22 tons/day of VOC, and 8.50 tons/day of CO.[181]

4.7.3 Cement Kilns

There are 9 cement kilns operating in the San Antonio-New Braunfels MSA and Hays County. "Cement kilns are used for the pyroprocessing stage of manufacture of Portland and other types of hydraulic cement, in which calcium carbonate reacts with silica-bearing minerals to form a mixture of calcium silicates."[182] The main fuel for the cement kilns in the region is coal, but other sources of fuel are used including natural gas, wood, and used tires. In 2006, these kilns emitted 29.15 tons of NO_X per day, while in 2012 and 2018 the NO_X emissions are 30.34 tons per day

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[180] San Miguel Electric Cooperative, Inc. Available online: http://www.smeci.net/index2.htm. Accessed 08/05/13.

[181] Eutizi, Joe. San Miguel Electric Cooperative. Atascosa County, Texas. "Projected San Miguel Power Plant Emissions". Email to Steven Smeltzer. 11/29/12.

[182] Wikipedia, Sept. 9, 2013. "Cement kiln". Available online: http://en.wikipedia.org/wiki/Cement_kiln. Accessed 09/17/13.

Table 4-8: Local Cement Kilns Emissions, 2006, 2012, and 2018 (ton/day)

Plant	County	Kiln	2006			2012			2018		
			VOC	NO_X	CO	VOC	NO_X	CO	VOC	NO_X	CO
APG Lime Corp	Comal	Kiln 1	0.00	1.07	0.64	0.00	1.07	0.64	0.00	1.07	0.64
		Kiln 2	0.00	0.74	0.46	0.00	0.74	0.46	0.00	0.74	0.46
Alamo Cement	Bexar		0.11	6.57	2.00	0.11	6.57	2.00	0.11	6.57	2.00
Capital Cement	Bexar	Kiln 1	0.31	2.48	1.44	0.28	2.48	1.44	0.28	2.48	1.44
		Kiln 2	0.12	2.33	0.49	-	-	-	-	-	-
CEMEX	Comal	Kiln 1	0.01	5.99	2.73	0.01	5.99	2.73	0.01	5.99	2.73
TXI	Comal	Kiln 1	0.16	3.72	1.95	0.24	2.78	7.92	0.24	2.78	7.92
		Kiln 2	-	-	-	0.18	3.51	2.84	0.18	3.51	2.84
Texas Lehigh	Hays		0.55	6.25	9.32	0.56	7.20	10.89	0.56	7.20	10.89

4.7.4 New Point Sources

Growth in EGU and NEGU point sources are based on new permitted point sources or major proposed power plants from 2007 to 2012 and from 2013 to 2018. The databases used to collect data on the new point sources were obtained from:

- TCEQ Point Source database (for new EGUs from 2007 to 2011)[183]
- Public Utility Commission of Texas[184]
- Electric Reliability Council of Texas (ERCOT)[185]
- TCEQ air permitting projects with combustion turbines[186], and
- TCEQ document server for newly-permitted point sources[187]

For all the newly-permitted EGUs, emissions are based on the Maximum Allowable Emission Rates Table (MAERT) from the permit. When available, the 30-day emissions limitation was used. As stated by TCEQ, "these were most often available for solid fuel-fired units. This time frame represents a good compromise between the standard short-term allowable, which sometimes includes MSS, and the standard long-term permit allowable. The short term allowable in pph, when converted to tpd, is often substantially more than a unit would realistically emit in any day; the long-term allowable in tpy, when converted to tpd, may under-represent what a unit could emit during any one day, especially during a summer day during the ozone season."[188]

Maintenance, startup and shutdown (MSS) "activities help provide a more realistic operating scenario than the maximum of the short-term or long-term emission rates. This is especially important for those units that have many MSS events during a typical summer, such as the peaking units, which operate only during the peak demand times. MSS limits vary between permits on how they are represented."[189] "The emission rates calculated represent worst

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[183] TCEQ, Jan. 2013. "Detailed Data from the Point Source Emissions Inventory". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/point-source-ei/psei.html. Accessed 08/08/13.

[184] Public Utility Commission of Texas, January 23, 2013. "New Electric Generating Plants in Texas Since 1995 (excluding renewable)". Austin, Texas. Available online: http://www.puc.texas.gov/industry/maps/elecmaps/gentable.pdf. Accessed 02/25/13.

[185] Electric Reliability Council of Texas. Available online: http://www.ercot.com/. Accessed 08/04/13.

[186] TCEQ, March 15, 2012. "Turbines Rated 20 MW and Greater Electric Output". Available online: http://m.tceq.texas.gov/assets/public/permitting/air/memos/turbine_lst.pdf. Accessed 02/25/13.

[187] TCEQ. "Document Server". Available online: https://webmail.tceq.state.tx.us/gw/webpub. Accessed 08/04/13.

[188] TCEQ. "Appendix B: Emissions Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-40. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

[189] TCEQ. "Appendix B: Emissions Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-40. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

case for some units, but for most units they represent a typical summer day during the ozone season."[190]

New EGUs from 2007 to 2012 are presented in Figure 4-4, while new proposed EGUs between 2013 and 2018 are provided on the map in Figure 4-5. The three large coal power plants that went into operation between 2007 and 2012 are V.H. Braunig in Bexar County, Sand Hill Energy northeast of Austin, and Oak Grove in east central Texas. As indicated, several new natural gas plants and one new pet coke plant also began operations during this time period. Total daily emissions from these new EGUs are 34.82 tons of NO_X, 6.94 tons of VOC, and 81.88 tons of CO (Table 4-9).

From 2013 to 2018, most new power plants will be natural gas or biomass. Of the two new coal plants indicated in Figure 4-5, Trailblazer Energy and Sandy Creek, the Sandy Creek power plant is already in operation. On June 21st, 2013, Tenaska announced plans that it will be abandoning plans to build Trailblazer Energy plant.[191] However, the modeling runs were started before the announcement was made and the plant is included in the 2018 projection year emission inventory. As listed on Table 4-10, daily emissions from new proposed EGUs between 2013 and 2018 are only 16.43 tons of NO_X, 16.73 tons of VOC, and 163.85 tons of CO.

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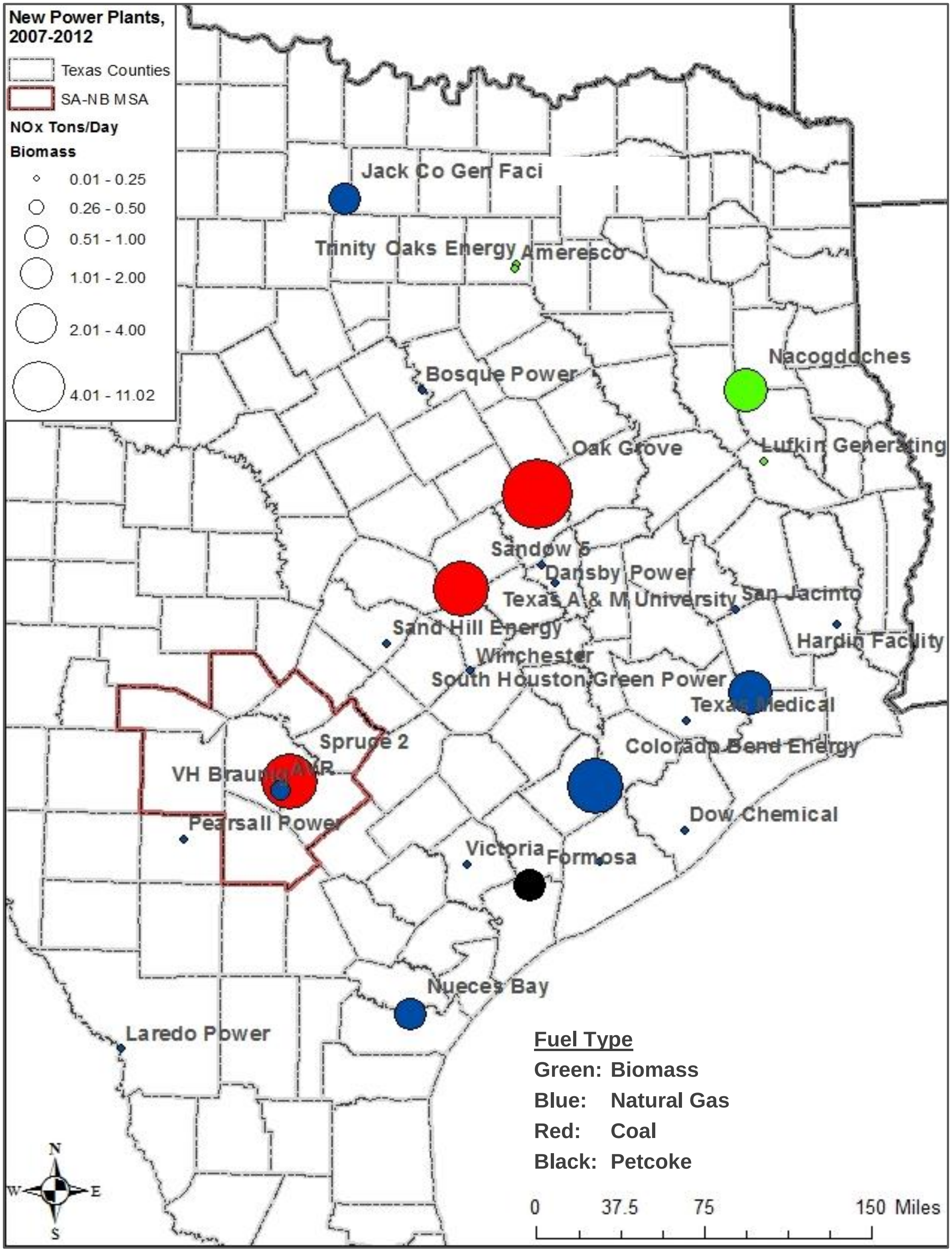
[190] TCEQ. "Appendix B: Emissions Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. B-41. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppB_EI_ado.pdf. Accessed 07/03/13.

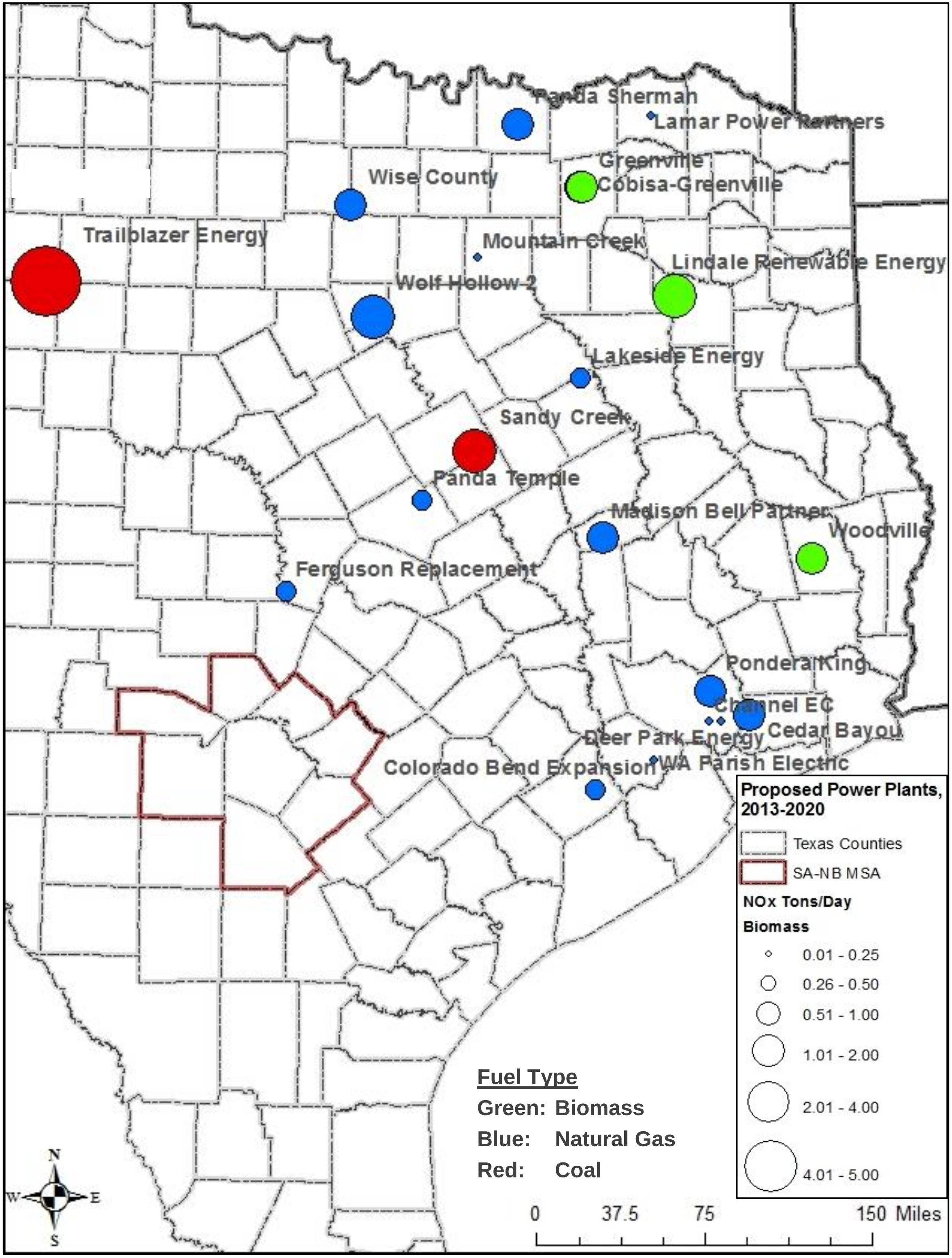
[191] John Mangalonzo, June 21, 2013. "Tenaska abandons coal plant project near Sweetwater". Abilene Reporter-News. Available online: http://www.reporternews.com/news/2013/jun/21/tenaska-abandons-coal-plant-project-near/. Accessed 08/08/13.

Figure 4-4: New Power Plants in Texas, 2007-2012



Plot Date: May 29, 2013
Map Compilation: May 5, 2013
Source: Public Utility Commission of Texas, ERCOT, TCEQ air permitting projects with combustion turbines, and TCEQ document server

Figure 4-5: Proposed Power Plants in Texas, 2013-2018



Plot Date: June 3, 2013
Map Compilation: May 5, 2013
Source: Public Utility Commission of Texas, ERCOT, TCEQ air permitting projects with combustion turbines, and TCEQ document server

Table 4-9: Newly Permitted EGUs in Texas and OSD Emissions, 2007-2012

Plant	County	In Operation	Capacity (MW)	Energy	NO_X	VOC	CO
Dow Chemical Cogen	Brazoria	2007	236	Natural Gas	0.16	0.66	4.32
Colorado Bend Energy	Wharton	2007	138	Natural Gas	0.66	0.04	0.11
Colorado Bend Energy	Wharton	2007	138	Natural Gas	0.66	0.04	0.11
Laredo Power Station	Webb	2008	97	Natural Gas	0.06	0.05	0.34
Laredo Power Station	Webb	2008	97	Natural Gas	0.06	0.05	0.34
Colorado Bend Energy	Wharton	2008	138	Natural Gas	0.66	0.04	0.11
Colorado Bend Energy	Wharton	2008	138	Natural Gas	0.66	0.04	0.11
Texas A & M University	Brazos	2008	33	Natural Gas	0.15	0.01	0.07
Oak Grove 1	Robertson	2009	855	Coal	5.51	0.02	13.51
J K Spruce Unit 2	Bexar	2009	750	Coal	3.50	0.03	0.12
Sandow 5	Milam	2009	291	Coal	1.76	0.00	0.55
Sandow 5	Milam	2009	291	Coal	1.76	0.00	0.55
Barney M Davis	Nueces	2009	180	Natural Gas	0.14	0.02	0.02
Barney M Davis	Nueces	2009	180	Natural Gas	0.14	0.02	0.02
Nueces Bay WLE	Nueces	2009	351	Natural Gas	0.28	0.47	6.09
Nueces Bay WLE	Nueces	2009	351	Natural Gas	0.28	0.47	6.09
East TX Elec Coop Ha	Hardin	2009	84	Natural Gas	0.03	0.00	0.03
Hardin Facility	Hardin	2009	84	Natural Gas	0.03	0.00	0.03
San Jacinto Facility	San Jacinto	2009	84	Natural Gas	0.04	0.00	0.05
San Jacinto Facility	San Jacinto	2009	84	Natural Gas	0.04	0.00	0.05
Dansby Power Plant	Brazos	2009	48	Natural Gas	0.07	0.03	1.03
Winchester PowerPark	Fayette	2009	45	Natural Gas	0.01	0.01	0.00
Winchester PowerPark	Fayette	2009	45	Natural Gas	0.01	0.01	0.00
Winchester PowerPark	Fayette	2009	45	Natural Gas	0.01	0.01	0.00
Winchester PowerPark	Fayette	2009	45	Natural Gas	0.01	0.01	0.00
Trinity Oaks Energy	Dallas	2009	3	Biomass	0.04	0.00	0.29
South Houston Green Power	Chambers	2009	244	Natural Gas	1.06	0.41	3.94
Bosque Power Company, LLC	Bosque	2009	255	Natural Gas	0.23	0.03	0.34
Oak Grove 2	Robertson	2010	855	Coal	5.51	0.02	13.51

Plant	County	In Operation	Capacity (MW)	Energy	NO_X	VOC	CO
Lufkin Generating Pl	Angelina	2010	50	Biomass	0.14	0.08	0.62
TECO Central Plant	Harris	2010	25	Natural Gas	0.08	0.10	1.63
TECO Central Plant	Harris	2010	25	Natural Gas	0.08	0.10	1.63
Sand Hill Energy Ctr	Travis	2010	47	Natural Gas	0.07	0.06	1.41
Sand Hill Energy Ctr	Travis	2010	47	Natural Gas	0.07	0.06	1.41
Ameresco Dallas	Dallas	2010	4	Biomass	0.03	0.04	0.14
Jack Co Gen Facility	Jack	2011	310	Natural Gas	0.40	0.53	7.67
Jack Co Gen Facility	Jack	2011	310	Natural Gas	0.40	0.53	7.67
Formosa Pt. Comfort	Calhoun	2011	150	Petcoke	4.29	0.77	1.16
Formosa Pt. Comfort	Calhoun	2011	150	Petcoke	4.29	0.77	1.16
Victoria Power Plant	Victoria	2011	332	Natural Gas	0.14	0.71	0.09
South Texas Project	Matagorda	2011	20	Natural Gas	0.14	0.01	0.04
Pearsall Power Plant	Frio	2011	200	Natural Gas	0.17	0.14	0.17
Nacogdoches Power	Nacogdoches	2012	50	Biomass	0.68	0.34	2.72
Nacogdoches Power	Nacogdoches	2012	50	Biomass	0.37	0.24	2.63
Total					34.82	6.94	81.88

Table 4-10: Proposed EGUs in Texas and OSD Emissions, 2013-2018

Plant	County	In Operation	Capacity (MW)	Energy	NO_X	VOC	CO
Sandy Creek	Mclennan	2013	925	Coal	0.18	0.02	0.06
WA Parish	Fort Bend	2013	89	Natural Gas	0.05	0.01	0.15
Wolf Hollow	Hood	2013	508	Natural Gas	1.57	0.98	15.96
Greenville Generating Plant	Hunt	2013	63	Biomass	0.65	0.07	0.65
Deer Park Energy Cen	Harris	2014	130	Natural Gas	0.10	0.87	6.68
Deer Park Energy Cen	Harris	2014	130	Natural Gas	0.10	0.87	6.68
Lakeside Energy Center	Freestone	2014	640	Natural Gas	0.46	0.23	1.72
Ferguson Replacement Project	Llano	2014	590	Natural Gas	0.41	0.19	0.83
Panda Sherman Power LLC	Grayson	2014	809	Natural Gas	0.63	0.69	10.28
Woodville	Tyler	2014	50	Biomass	0.58	0.17	1.32
Channel EC expansion	Harris	2014	180	Natural Gas	0.17	0.07	0.64
Tenaska Trailblazer	Nolan	2014	600	Coal	4.98	0.36	9.97
Cobisa-Greenville	Hunt	2016	299	Natural Gas	0.15	1.24	5.90
Cobisa-Greenville	Hunt	2016	299	Natural Gas	0.15	1.24	5.90
Cobisa-Greenville	Hunt	2016	299	Natural Gas	0.15	1.24	5.90
Cobisa-Greenville	Hunt	2016	299	Natural Gas	0.15	1.11	4.43
Cobisa-Greenville	Hunt	2016	299	Natural Gas	0.15	1.11	4.43
Cobisa-Greenville	Hunt	2016	299	Natural Gas	0.15	1.11	4.43
Panda Temple Power	Bell	2016	405	Natural Gas	0.10	0.60	5.78
Panda Temple Power	Bell	2016	405	Natural Gas	0.10	0.60	5.78
Panda Temple Power	Bell	2016	390	Natural Gas	0.10	0.60	5.78
Panda Temple Power	Bell	2016	390	Natural Gas	0.10	0.60	5.78
Pondera King Power Project	Harris	2016	1380	Natural Gas	0.98	0.72	2.08
Madison Bell Partner	Madison	2018	138	Natural Gas	0.22	0.13	2.10
Madison Bell Partner	Madison	2018	138	Natural Gas	0.22	0.13	2.10
Madison Bell Partner	Madison	2018	138	Natural Gas	0.22	0.13	2.10
Madison Bell Partner	Madison	2018	138	Natural Gas	0.22	0.13	2.10
Wise County Power Pl	Wise	2018	175	Natural Gas	0.19	0.07	3.62
Wise County Power Pl	Wise	2018	175	Natural Gas	0.19	0.07	3.62

Plant	County	In Operation	Capacity (MW)	Energy	NOX	VOC	CO
Wise County Power Pl	Wise	2018	175	Natural Gas	0.19	0.07	3.62
Wise County Power Pl	Wise	2018	175	Natural Gas	0.19	0.07	3.62
Cedar Bayou	Chambers	2018	270	Natural Gas	0.18	0.15	6.50
Cedar Bayou	Chambers	2018	270	Natural Gas	0.16	0.15	6.50
NRG Cedar Bayou	Chambers	2018	300	Natural Gas	0.14	0.20	6.22
NRG Cedar Bayou	Chambers	2018	300	Natural Gas	0.14	0.20	6.22
Lamar Power Partners	Lamar	2018	310	Natural Gas	0.12	0.10	0.89
Lamar Power Partners	Lamar	2018	310	Natural Gas	0.12	0.10	0.89
Colorado Bend expansion	Wharton	2018	275	Natural Gas	0.29	0.06	1.46
Lindale Renewable Energy	Smith	2018	50	Biomass	1.23	0.14	0.09
Mountain Creek	Dallas	2018	400	Natural Gas	0.23	0.13	1.08
Total					16.43	16.73	163.85

Sometimes stack parameters were not available from TCEQ's permit database for the smaller EGUs built after 2006. If the parameters were not available, the height, stack diameter, temperature, and velocity were based on the averages of existing EGUs by fuel type and size (Table 4-11).

Table 4-11: Stack parameters for small EGUs if permit data is not available, 2012 and 2018.

Energy	Size (MW)	Height (m)	Diameter (m)	Temp (K)	Velocity (m/s)
Natural Gas	Less Than 100	33	4	616	28
	100 - 200	38	5	475	25
	200 +	45	6	361	20
Biomass		58	4	415	25
Coal		128	9	361	16

Several new NEGU point sources were added to the 2018 modeling scenario. For the San Antonio-New Braunfels MSA, daily emissions from these NEGUs were estimated to be 0.056 tons of NO_X, 0.216 tons of VOC, and 0.084 tons of CO (Table 4-12). Similar to EGUs, if stack parameters where not available from the permits, they were based on the averages of existing NEGUs by SCC code for each process.

Table 4-12: New NEGUs in the San Antonio-New Braunfels MSA, tons per day.

Company	County	SCC Code	Stack height (m)	Stack diameter (m)	Temperature (K)	Velocity (m/s)	NO_X	VOC	CO
Travis Industry's	Bexar	40202501	12	0.6	487	8	-	0.014	-
Texas Scenic Company, Inc.	Bexar	40202501	12	0.6	487	8	-	0.020	-
Monterrey Iron & Metal, LTD	Bexar	20100102	8	0.3	679	21	0.056	0.000	0.084
Avanzar Interior Technologies	Bexar	40202501	12	0.6	487	8	-	0.068	-
M7 Aerospace LLC	Bexar	40202501	12	0.6	487	8	-	0.034	-
Salof Refrigeration Co., Inc.	Guadalupe	40202501	12	0.6	487	8	-	0.066	-
Fox Tank Company	Kendall	40202501	12	0.6	487	8	-	0.013	-

4.8 Eagle Ford Emissions

"The Eagle Ford Shale is a hydrocarbon producing formation of significant importance due to its capability of producing both gas and more oil than other traditional shale plays. It contains a much higher carbonate shale percentage, upwards to 70% in south Texas, and becomes shallower and the shale content increases as it moves to the northwest. The high percentage of carbonate makes it more brittle and 'fracable'."[192] Hydraulic fracturing is a technological advancement which allows producers to recover natural gas and oil resources from these shale formations. "Experts have known for years that natural gas and oil deposits existed in deep shale formations, but until recently the vast quantities of natural gas and oil in these formations were not able to be technically or economically recoverable."[193] Today, significant amounts of natural gas and oil from deep shale formations across the United States are being produced through the use of horizontal drilling and hydraulic fracturing.[194]

Hydraulic fracturing is the process of creating fissures, or fractures, in underground formations to allow natural gas and oil to flow up the wellbore to a pipeline or tank battery. In the Eagle Ford Shale, a company engaged in extraction "pumps water, sand and other additives under high pressure into the formation to create fractures. The fluid is approximately 98% water and sand, along with a small amount of special-purpose additives. The newly created fractures are "propped" open by the sand, which allows the natural gas and oil to flow into the wellbore and be collected at the surface. Variables such as surrounding rock formations and thickness of the targeted shale formation are studied by scientists before fracking is conducted."[195]

Locations of the Eagle Ford and other Shale Plays in the lower 48 states are provided in Figure 4-6.[196] Unlike the Haynesville and Barnett Shale formations in northern Texas that primarily produce gas, the Eagle Ford Shale features high oil yields and wet gas/condensate across much of the play. Consequently, equipment types, processes, and activities in the Eagle Ford may differ from those employed in more traditional shale formations. Emission processes addressed in the inventory include exploration and pad construction, drilling,

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[192] Railroad Commission of Texas, May 22, 2012. "Eagle Ford Information". Austin, Texas. Available online: http://www.rrc.state.tx.us/eagleford/index.php. Accessed 05/30/12.

[193] Chesapeake Energy, Sept. 2011. "Eagle Ford Shale Hydraulic Fracturing". Available online: http://www.chk.com/Media/Educational-Library/Fact-Sheets/EagleFord/EagleFord_Hydraulic_Fracturing_Fact_Sheet.pdf. Accessed: 04/12/12.

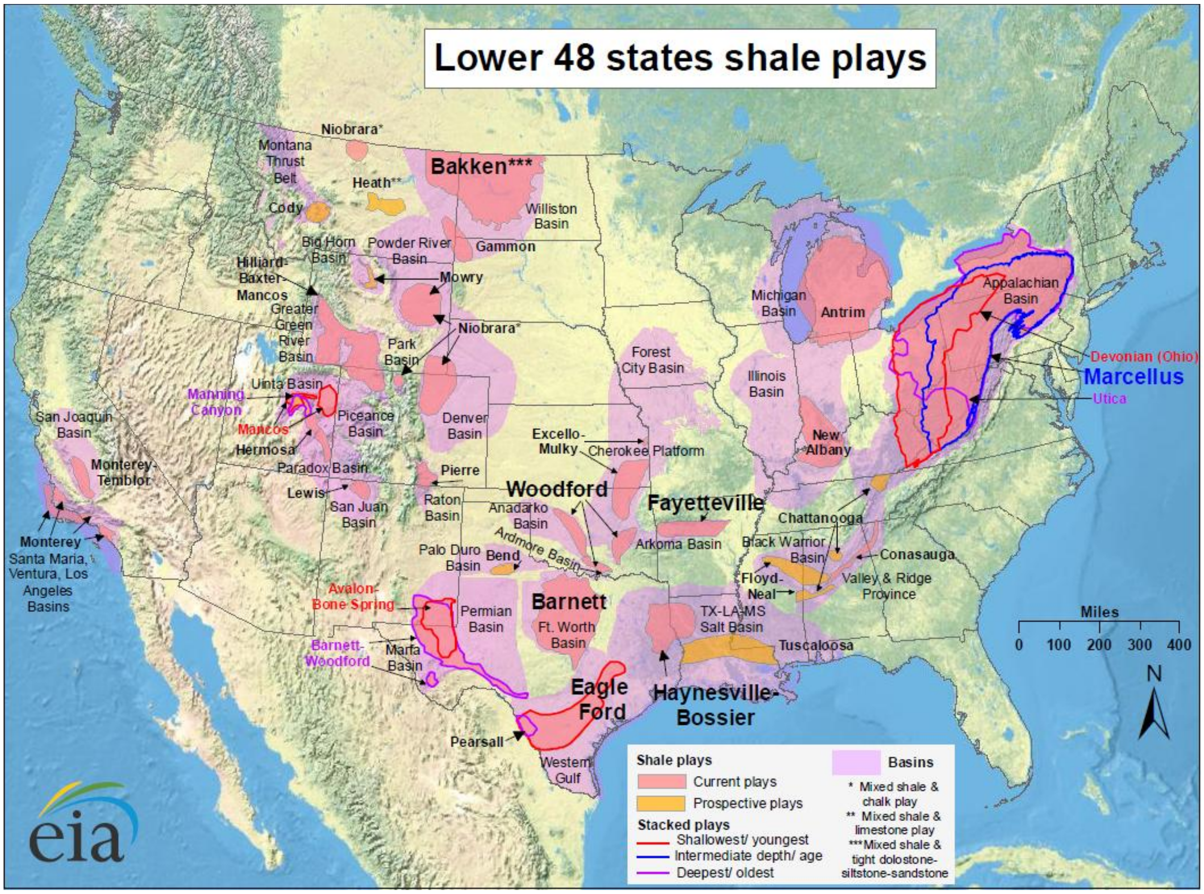
[194] Chesapeake Energy, Sept. 2011. "Eagle Ford Shale Hydraulic Fracturing". Available online: http://www.chk.com/Media/Educational-Library/Fact-Sheets/EagleFord/EagleFord_Hydraulic_Fracturing_Fact_Sheet.pdf. Accessed: 04/12/12.

[195] *Ibid*.

[196] Energy Information Administration (EIA), May 9, 2011. "Maps: Exploration, Resources, Reserves, and Production". Available online: ftp://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm. Accessed 06/04/12.

hydraulic fracturing and completion operations, production, and midstream facilities. Emissions sources can include heavy duty trucks, light duty trucks, drill rigs, compressors, pumps, heaters, other non-road equipment, process emissions, flares, storage tanks, and fugitive emissions.

Figure 4-6: Lower 48 States Shale Plays



Existing oil and gas drilling inventories in Texas and data from the Railroad Commission of Texas was used to develop an emissions inventory of the Eagle Ford. These studies include: Eastern Research Group's (ERG) "Characterization of Oil and Gas Production Equipment and Develop a Methodology to Estimate Statewide Emissions", ERG's Drilling Rig Emission Inventory for the State of Texas, and ENVIRON's "An Emission Inventory for Natural Gas Development in the Haynesville Shale and Evaluation of Ozone Impacts". TCEQ also conducted a mail survey through the Barnett Shale area for the special inventory phase two study on natural gas fracturing operations west of Dallas.

Eagle Ford activities produce oil, natural gas, and condensate during five main phases.

- Exploration and Pad Construction: Exploration uses vibrator trucks to produce sound waves beneath the surface that are useful in the exploration for oil and natural gas. Construction of the drill pad requires clearing, grubbing, and grading, followed by placement of a base material by construction equipment and trucks. Reserve pits are also usually required at each well pad because the drilling and hydraulic fracturing process uses a large volume of fluid that is circulated through the well and back to the surface.

- Drilling Operation: "Drilling of a new well is typically a two to three week process from start to finish and involves several large diesel-fueled generators."[197] Other emission sources related to drilling operations include construction equipment and trucks to haul supplies, equipment, fluids, and employees.
- Hydraulic Fracturing and Completion Operation: Hydraulic fracturing "is the high pressure injection of water mixed with sand and a variety of chemical additives into the well to fracture the shale and stimulate natural gas production from the well. Fracking operations can last for several weeks and involve many large diesel-fueled generators"[198] "Once drilling and other well construction activities are finished, a well must be completed in order to begin producing. The completion process requires venting of the well for a sustained period of time to remove mud and other solid debris in the well, to remove any inert gas used to stimulate the well (such as CO_2 and/or N_2) and to bring the gas composition to pipeline grade". [199] In the Eagle Ford, vented gas from the completion process is usually flared.
- Production: Once the product is collected from the well, emissions can occur at well sites from compressors, flares, heaters, and pneumatic devices. There can also be significant emissions from equipment leaks, storage tanks, and loading operation fugitives. Trucks are often used to transport product to processing facilities and refineries; consequently, emissions generated during production may also originate from on-road sources.
- Midstream Sources: Midstream sources in the Eagle Ford consist mostly of compressor stations and processing facilities, but may also include cryogenic plants, saltwater disposal facilities, tank batteries, and other facilities. "The most significant emissions from compressor stations are usually from combustion at the compressor engines or turbines. Other emissions sources may include equipment leaks, storage tanks, glycol dehydrators, flares, and condensate and/or wastewater loading. Processing facilities generally remove impurities from the natural gas, such as carbon dioxide, water, and hydrogen sulfide. These facilities may also be designed to remove ethane, propane, and butane fractions from the natural gas for downstream marketing. Processing facilities are usually the largest emitting natural gas-related point sources including multiple emission sources such as, but

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[197] University of Arkansas and Argonne National Laboratory. "Fayetteville Shale Natural Gas: Reducing Environmental Impacts: Site Preparation". Available online: http://lingo.cast.uark.edu/LINGOPUBLIC/natgas/siteprep/index.htm. Accessed: 04/20/12.

[198] *Ibid*.

[199] Amnon Bar-Ilan, Rajashi Parikh, John Grant, Tejas Shah, Alison K. Pollack, ENVIRON International Corporation. Nov. 13, 2008. "Recommendations for Improvements to the CENRAP States' Oil and Gas Emissions Inventories". Novato, CA. p. 48. Available online: http://www.wrapair.org/forums/ogwg/documents/2008-11_CENRAP_O&G_Report_11-13.pdf. Accessed: 04/30/12.

> not limited to equipment leaks, storage tanks, separator vents, glycol dehydrators, flares, condensate and wastewater loading, compressors, amine treatment and sulfur recovery units."[200]

4.9 On-Road Emissions in the Eagle Ford

4.9.1 Well Pad Construction On-Road Emissions

On-road emissions associated with gas and oil production in the Eagle Ford Shale originate from heavy duty diesel trucks that carry equipment and light duty trucks that transport employees and supplies to the well pads. Surveys from other regions found between 20 and 75 heavy duty truck trips are required for pad construction, while there was a wide variation in the number of trips by light duty trucks needed during the construction process. ENVIRON provided detailed information on activity rates, speeds, and idling hours need for each trip for well pad construction in the Piceance Basin of Northwestern Colorado. There were 22.86 trips by heavy duty vehicles and 82.46 trips by light duty trucks to construct each well pad. The study found that idling times by heavy duty trucks was 0.40 hours for each trip and light duty trucks varied between 2.00 and 2.15 idling hours per trip.[201] TxDOT reported an average of 70 heavy duty truck loads were needed for pad construction in the Barnett shale development.[202]

A study by New York City's Department of Environmental Protection on the Marcellus Shale Gas Development found 20 to 40 heavy duty diesel truck trips were needed for pad construction, which was similar to ENVIRON's survey.[203] Other studies by Cornell University[204], the National Park Service[205], and All Consulting[206], regarding development of

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[200] Eastern Research Group Inc. July 13, 2011. "Fort Worth Natural Gas Air Quality Study Final Report". Prepared for: City of Fort Worth, Fort Worth, Texas. p. 3-2. Available online: http://fortworthtexas.gov/gaswells/?id=87074. Accessed: 04/09/12.

[201] Amnon Bar-Ilan, John Grant, Rajashi Parikh, Ralph Morris, ENVIRON International Corporation, July 2011. "Oil and Gas Mobile Sources Pilot Study". Novato, California. pp. 11-12. Available online: http://www.wrapair2.org/pdf/2011-07_P3%20Study%20Report%20(Final%20July-2011).pdf. Accessed: 04/12/12.

[202] Richard Schiller, P.E. Fort, Worth District. Aug. 5, 2010. "Barnett Shale Gas Exploration Impact on TxDOT Roadways". TxDOT, Forth Worth. Slide 15.

[203] Haxen and Sawyer, Environmental Engineers & Scientists, Sept. 2009. "Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed Rapid Impact Assessment Report". New York City Department of Environmental Protection. p. 47. Available online: http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/rapid_impact_assessment_091609.pdf. Accessed: 04/20/12.

[204] Santoro, R.L.; R.W. Howarth; A.R. Ingraffea. 2011. Indirect Emissions of Carbon Dioxide from Marcellus Shale Gas Development. A Technical Report from the Agriculture, Energy, & Environment Program at Cornell University. June 30, 2011. p. 8. Available online: http://www.eeb.cornell.edu/howarth/IndirectEmissionsofCarbonDioxidefromMarcellusShaleGasDevelopment_June302011%20.pdf. Accessed: 04/02/12.

[205] National Park Service U.S. Department of the Interior, Dec. 2008. "Potential Development of the Natural Gas Resources in the Marcellus Shale: New York, Pennsylvania, West Virginia, and Ohio". p. 9. Available online: http://www.nps.gov/frhi/parkmgmt/upload/GRD-M-Shale_12-11-2008_high_res.pdf. Accessed: 04/22/12.

the Marcellus Shale had similar results for the number of trips by heavy duty trucks. ENVIRON's study of the Southern Ute Indian Reservation reported slightly more heavy duty truck trips: 56 heavy duty truck loads.[207]

With regard to light duty vehicle use, the Pinedale Anticline Project in Wyoming[208] reported significantly more trips[209] during the pad construction phase than ENVIRON's survey, while studies about the San Juan Public Lands Center in Colorado[210], Tumbleweed II in Utah[211], Jonah Infill in Wyoming [212]. and West Tavaputs Plateau in Utah[213] found less light duty truck trips compared to ENVIRON's report in tin the Piceance Basin of Northwestern Colorado. Since data for development in the Eagle Ford Shale area is not available, the number of trips by vehicle type and the idling time per vehicle trip was based on TxDOT findings in the Barnett shale and ENVIRON's report's in Colorado. These reports were selected because

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[206] All Consulting, Sept. 16, 2010. "NY DEC SGEIS Information Requests". Prepared for Independent Oil & Gas Association, Project no.: 1284. Available online: http://catskillcitizens.org/learnmore/20100916IOGAResponsetoDECChesapeake_IOGAResponsetoDEC.pdf. Accessed: 04/16/12.

[207] ENVIRON, August 2009. "Programmatic Environmental Assessment for 80 Acre Infill Oil and Gas Development on the Southern Ute Indian Reservation". Novato, California. Appendix A, p. 62. Available online: http://www.suitdoe.com/Documents/Appendix_G_AirQualityTSD.pdf. Accessed: 04/25/12.

[208] U.S. Department of the Interior, Bureau of Land Management, Sept. 2008. "Final Supplemental Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project: Pinedale Anticline Project Area Supplemental Environmental Impact Statement". Sheyenne, Wyoming. p. F42. Available online: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/pfodocs/anticline/rd-seis/tsd.Par.13395.File.dat/07appF.pdf. Accessed: 04/12/12.

[209] U.S. Department of the Interior, Bureau of Land Management, Sept. 2008. "Final Supplemental Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project: Pinedale Anticline Project Area Supplemental Environmental Impact Statement". Sheyenne, Wyoming. pp. F39-F40. Available online: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/pfodocs/anticline/rd-seis/tsd.Par.13395.File.dat/07appF.pdf. Accessed: 04/12/12.

[210] BLM National Operations Center, Division of Resource Services, December, 2007. "San Juan Public Lands Center Draft Land Management Plan & Draft Environmental Impact Statement: Air Quality Impact Assessment Technical Support Document". Bureau of Land Management, San Juan Public Lands Center, Durango, Colorado. p. A-4. Available online: http://ocs.fortlewis.edu/forestplan/DEIS/pdf/120507_TSD&App%20A.pdf. Accessed: 04/03/2012.

[211] U.S. Department of the Interior, Bureau of Land Management. June 2010. "Tumbleweed II Exploratory Natural Gas Drilling Project". East City, Utah. DOI-BLM-UTG010-2009-0090-EA. p. 12 of 29. Available online: http://www.blm.gov/pgdata/etc/medialib/blm/ut/lands_and_minerals/oil_and_gas/november_2011.Par.24530.File.dat/. Accessed: 04/12/12.

[212] Amnon Bar-Ilan, ENVIRON Corporation, June 2010. "Oil and Gas Mobile Source Emissions Pilot Study: Background Research Report". UNC-EMAQ (3-12)-006.v1. Novato, CA. p. 17. Available online: http://www.wrapair2.org/documents/2010-06y_WRAP%20P3%20Background%20Literature%20Review%20(06-06%20REV).pdf. Accessed: 04/03/12.

[213] Buys & Associates, Inc., Sept. 2008. "APPENDIX J: Near-Field Air Quality Technical Support Document for the West Tavaputs Plateau Oil and Gas Producing Region Environmental Impact Statement". Prepared for: Bureau of Land Management Price Field Office Littleton, Colorado. Available online: http://www.blm.gov/ut/st/en/fo/price/energy/Oil_Gas/wtp_final_eis.html. Accessed: 04/20/12.

the TxDOT report provided data from well pad construction in a similar area in Texas and the ENVIRON's report is the only report with specific data on idling rates.

4.9.2 Drilling On-Road Emissions

Energy in Depth, a research, education, and outreach program created by the Independent Petroleum Association of America, states that it takes approximately 35-45 semi trucks (10,000 foot well) trips to move and assemble a rig.[214] This result is very similar to TxDOT's findings that 44 heavy duty trucks are needed to move a rig in the Barnett Shale.[215] TxDOT also states that an additional 73 heavy duty truck trips are needed to move drilling rig equipment and deliver supplies. The results are similar to most other studies that predicted between 80 and 235 truck trips are needed including Cornell University's report about the Marcellus[216], Buys & Associates' research in Utah[217], and Jonah Infill's field study in Wyoming.[218] Data from NCTCOG on the number of heavy duty truck trips, 187, in the Barnett was used to estimate emissions generated by on-road sources during the process of moving and assembling rigs in the Eagle Ford.[219] The TxDOT report was used because it contains data in Texas from a comparable area.

4.9.3 Hydraulic Fracturing On-Road Emissions

Heavy duty trucks are needed to provide equipment, water, sand/ proppant, chemicals, and supplies, while trucks are sometimes also needed to remove flowback from the well site. Previous studies found between 15 and 2,100 truck trips are needed during hydraulic fracturing and completion of the well site. Jonah Infill in Wyoming[220] and NCTCOG[221] found

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[214] Energy in Depth: A coalition led by Independent Petroleum Association of America. Available online: http://www.energyindepth.org/rig/index.html. Accessed: 04/18/12.

[215] Richard Schiller, P.E. Fort, Worth District. Aug. 5, 2010. "Barnett Shale Gas Exploration Impact on TxDOT Roadways". TxDOT, Forth Worth. Slide 15.

[216] Santoro, R.L.; R.W. Howarth; A.R. Ingraffea. 2011. Indirect Emissions of Carbon Dioxide from Marcellus Shale Gas Development. A Technical Report from the Agriculture, Energy, & Environment Program at Cornell University. June 30, 2011. p. 8. Available online: http://www.eeb.cornell.edu/howarth/IndirectEmissionsofCarbonDioxidefromMarcellusShaleGasDevelopment_June302011%20.pdf. Accessed: 04/02/12.

[217] Buys & Associates, Inc., Sept. 2008. "APPENDIX J: Near-Field Air Quality Technical Support Document for the West Tavaputs Plateau Oil and Gas Producing Region Environmental Impact Statement". Prepared for: Bureau of Land Management Price Field Office Littleton, Colorado. Available online: http://www.blm.gov/ut/st/en/fo/price/energy/Oil_Gas/wtp_final_eis.html. Accessed: 04/20/12.

[218] Amnon Bar-Ilan, ENVIRON Corporation, June 2010. "Oil and Gas Mobile Source Emissions Pilot Study: Background Research Report". UNC-EMAQ (3-12)-006.v1. Novato, CA. pp. 17-18. Available online: http://www.wrapair2.org/documents/2010-06y_WRAP%20P3%20Background%20Literature%20Review%20(06-06%20REV).pdf. Accessed: 04/03/12.

[219] Lori Clark, Shannon Stevenson, and Chris Klaus North Central Texas Council of Governments, August 2012. "Development of Oil and Gas Mobile Source Inventory in the Barnett Shale in the 12-County Dallas-Fort Worth Area". Arlington, Texas. Texas Commission on Environmental Quality Grant Number: 582-11-13174. p. 11. Available online: http://www.nctcog.org/trans/air/barnettshale.asp. Accessed 01/23/13.

[220] Amnon Bar-Ilan, ENVIRON Corporation, June 2010. "Oil and Gas Mobile Source Emissions Pilot Study: Background Research Report". UNC-EMAQ (3-12)-006.v1. Novato, CA. p. 17. Available

between 400 and 440 heavy duty truck trips are needed during hydraulic fracturing. A Cornell University report determined that 790 heavy duty truck trips are used in the Marcellus during the fracturing process.[222] These results are similar to All Consulting's vehicle count of 868 heavy duty trucks[223] and the National Park Service's average of 695 heavy duty truck trips in the Marcellus.[224]

Data from TxDOT's study of the Barnett Shale indicating use of 807 heavy duty truck trips during hydraulic fracking was used for calculating fracturing-related on-road emissions in the Eagle Ford. When calculating truck trips, TxDOT assumed that 50% of the freshwater used during the fracturing process was provided by pipeline. This is similar to operations conducted by some companies in the Eagle Ford. For example, Rosetta Resources, one of the companies operating in the Eagle Ford, "has built water gathering pipelines to eliminate the need to truck water to the fracturing crew". [225]

The number of trips made with light duty vehicles during the fracturing process ranged from 30 found in the San Juan Public Lands Center study in Colorado[226] to All Consulting's estimation of 461 in the Marcellus. Most of the studies found approximately 140 light duty vehicle trips were needed including ENVIRON's Southern Ute[227] and Buys & Associates'

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online: http://www.wrapair2.org/documents/2010-06y_WRAP%20P3%20Background%20Literature%20Review%20(06-06%20REV).pdf. Accessed: 04/03/12.

[221] North Central Texas Council of Governments. "Barnett Shale Truck Traffic Survey". Dallas, Texas. Slide 9. Available online: http://www.nctcog.org/trans/air/barnettshale.asp. Accessed 05/04/12.

[222] Santoro, R.L.; R.W. Howarth; A.R. Ingraffea. 2011. Indirect Emissions of Carbon Dioxide from Marcellus Shale Gas Development. A Technical Report from the Agriculture, Energy, & Environment Program at Cornell University. June 30, 2011. p. 8. Available online: http://www.eeb.cornell.edu/howarth/IndirectEmissionsofCarbonDioxidefromMarcellusShaleGasDevelopment_June302011%20.pdf. Accessed: 04/02/12.

[223] All Consulting, Sept. 16, 2010. "NY DEC SGEIS Information Requests". Prepared for Independent Oil & Gas Association, Project no.: 1284. Available online: http://catskillcitizens.org/learnmore/20100916IOGAResponsetoDECChesapeake_IOGAResponsetoDEC.pdf. Accessed: 04/16/12.

[224] National Park Service U.S. Department of the Interior, Dec. 2008. "Potential Development of the Natural Gas Resources in the Marcellus Shale: New York, Pennsylvania, West Virginia, and Ohio". p. 9. Available online: http://www.nps.gov/frhi/parkmgmt/upload/GRD-M-Shale_12-11-2008_high_res.pdf. Accessed: 04/22/12.

[225] Colter Cookson. June, 2011. "Operators Converge On Eagle Ford's Oil and Liquids-Rich Gas". The American Oil and Gas Reporter. p. 3. Available online: http://www.laredoenergy.com/sites/default/files/0611LaredoEnergyEprint.pdf. Accessed: 04/12/12.

[226] BLM National Operations Center, Division of Resource Services, December, 2007. "San Juan Public Lands Center Draft Land Management Plan & Draft Environmental Impact Statement: Air Quality Impact Assessment Technical Support Document". Bureau of Land Management, San Juan Public Lands Center, Durango, Colorado. p. A-9. Available online: http://ocs.fortlewis.edu/forestplan/DEIS/pdf/120507_TSD&App%20A.pdf. Accessed: 04/03/12.

[227] ENVIRON, August 2009. "Programmatic Environmental Assessment for 80 Acre Infill Oil and Gas Development on the Southern Ute Indian Reservation". Novato, California. Appendix A, p. 68. Available online: http://www.suitdoe.com/Documents/Appendix_G_AirQualityTSD.pdf. Accessed: 04/25/12.

research in Utah[228]. To calculate on-road vehicle emissions associated with fracturing activities in the Eagle Ford, the number of light duty vehicles and idling rates per trip were based on ENVIRON's survey in the Piceance Basin of Northwestern Colorado.[229] This report contains the most comprehensive data on vehicles used for hydraulic fracturing and there was very little data available in Texas.

4.9.4 Production On-Road Emissions

Documentation on annual truck traffic per well pad during the production phase varies widely: from 2 - 3 trucks per year according to New York City's study of the Marcellus[230] to 365 trucks per year as reported by the BLM for the Pinedale Anticline Project in Wyoming.[231] Cornell University estimated only 15 truck trips per well pad in the Marcellus,[232] while San Juan Public Lands Center estimated the use of 158 truck trips in Colorado.[233]

For light duty vehicle use during production, the Tumble-weed II study in Utah reported 365 vehicles annually[234], while Jonah Infill in Wyoming stated that there were 122 light duty

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[228] Buys & Associates, Inc., Sept. 2008. "APPENDIX J: Near-Field Air Quality Technical Support Document for the West Tavaputs Plateau Oil and Gas Producing Region Environmental Impact Statement". Prepared for: Bureau of Land Management Price Field Office Littleton, Colorado. Available online: http://www.blm.gov/ut/st/en/fo/price/energy/Oil_Gas/wtp_final_eis.html. Accessed: 04/20/12.

[229] Amnon Bar-Ilan, John Grant, Rajashi Parikh, Ralph Morris, ENVIRON International Corporation, July 2011. "Oil and Gas Mobile Sources Pilot Study". Novato, California. p. 11. Available online: http://www.wrapair2.org/documents/2011-07_P3%20Study%20Report%20(Final%20July-2011).pdf. Accessed: 04/12/12.

[230] Haxen and Sawyer, Environmental Engineers & Scientists, Sept. 2009. "Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed Rapid Impact Assessment Report" New York City Department of Environmental Protection. p. 47. Available online: http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/rapid_impact_assessment_091609.pdf. Accessed: 04/20/12.

[231] U.S. Department of the Interior, Bureau of Land Management, Sept. 2008. "Final Supplemental Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project: Pinedale Anticline Project Area Supplemental Environmental Impact Statement". Sheyenne, Wyoming. pp. F51-52. Available online: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/pfodocs/anticline/rd-seis/tsd.Par.13395.File.dat/07appF.pdf. Accessed: 04/12/12.

[232] Santoro, R.L.; R.W. Howarth; A.R. Ingraffea. 2011. Indirect Emissions of Carbon Dioxide from Marcellus Shale Gas Development. A Technical Report from the Agriculture, Energy, & Environment Program at Cornell University. June 30, 2011. Available online: http://www.eeb.cornell.edu/howarth/IndirectEmissionsofCarbonDioxidefromMarcellusShaleGasDevelopment_June302011%20.pdf Accessed: 04/02/12.

[233] BLM National Operations Center, Division of Resource Services, December, 2007. "San Juan Public Lands Center Draft Land Management Plan & Draft Environmental Impact Statement: Air Quality Impact Assessment Technical Support Document". Bureau of Land Management, San Juan Public Lands Center, Durango, Colorado. p. A-16. Available online: http://ocs.fortlewis.edu/forestplan/DEIS/pdf/120507_TSD&App%20A.pdf. Accessed: 04/03/2012.

[234] U.S. Department of the Interior, Bureau of Land Management. June 2010. "Tumbleweed II Exploratory Natural Gas Drilling Project". East City, Utah. DOI-BLM-UTG010-2009-0090-EA. p. 24 of 29. Available online: http://www.blm.gov/pgdata/etc/medialib/blm/ut/lands_and_minerals/oil_and_gas/november_2011.Par.24530.File.dat/. Accessed: 04/12/12.

vehicles used during production.[235] Data from ENVIRON's report in the Piceance Basin of Northwestern Colorado, 73.2 light duty vehicles trips annually per pad site, was used to estimate emissions from light duty vehicles during well production in the Eagle Ford. ENVIRON's report was the only study that had detailed light duty vehicle counts and idling hours.

TxDOT's estimation of 353 heavy duty truck trips per year for each well in the Barnett Shale was used to calculate heavy duty truck emissions from production in the Eagle Ford.[236] The TxDOT report was used because it contains data in Texas from a comparable area. The number of trucks provided by TxDOT match very closely to Chesapeake Energy's statement that there is one truck per well pad per day during production.[237] Data on idling rates from the ENVIRON report was used to estimate idling emissions. In the report, ENVIRON estimated that heavy duty trucks idle between 0.9 hours to 3 hours, while light duty vehicles idle approximately 2.5 hours per trip.[238]

An analysis of 66 wells in the Eagle Ford found that almost all oil and condensate was transported by truck. Only three wells transported condensate by pipeline and no oil was transported by pipeline.[239] Over time, the number of trips by trucks will decrease during production as the number of pipelines to haul product increases in the Eagle Ford. However, many of the wells will not be directly connected to the pipelines. Also, the number of truck trips will decrease over time due to steep liquid decline curves at wells in the Eagle Ford. As the well ages, production will significantly decline and fewer truck visits will be needed for each well. The parameters used to calculate emissions for each stage of the Eagle Ford are provided in Table 4-13.

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[235] Amnon Bar-Ilan, ENVIRON Corporation, June 2010. "Oil and Gas Mobile Source Emissions Pilot Study: Background Research Report". UNC-EMAQ (3-12)-006.v1. Novato, CA. p. 18. Available online: http://www.wrapair2.org/documents/2010-06y_WRAP%20P3%20Background%20Literature%20Review%20(06-06%20REV).pdf. Accessed: 04/03/12.

[236] Richard Schiller, P.E. Fort, Worth District. Aug. 5, 2010. "Barnett Shale Gas Exploration Impact on TxDOT Roadways". TxDOT, Forth Worth. Slide 18.

[237] Chesapeake Energy Corporation, 2012. "Part 1 – Drilling". Available online: http://www.askchesapeake.com/Barnett-Shale/Multimedia/Educational-Videos/Pages/Information.aspx. Accessed: 04/22/12.

[238] Amnon Bar-Ilan, John Grant, Rajashi Parikh, Ralph Morris, ENVIRON International Corporation, July 2011. "Oil and Gas Mobile Sources Pilot Study". Novato, California. pp. 11-12. Available online: http://www.wrapair2.org/documents/2011-07_P3%20Study%20Report%20(Final%20July-2011).pdf. Accessed: 04/12/2012.

[239] Railroad Commission of Texas. "Specific Lease Query". Austin, Texas. Available online: http://webapps.rrc.state.tx.us/PDQ/quickLeaseReportBuilderAction.do. Accessed 06/01/2012.

Table 4-13: On-Road Vehicle Parameters used in the Eagle Ford

Vehicle Type	Parameter	Pad Construction	Drilling	Hydraulic Fracturing and Completion	Production
Heavy Duty Diesel Trucks (HDDV)	Number/pad	70	187	807	353/year
	Distance (miles)	50	50	50	22
	Speed (mph)	35	35	35	35
	Idling Hours/Trip	0.4	0.7	1.1	0.9
Light Duty Trucks (LDT)	Number/pad	12.86 (Construction) 69.60 (Employees)	68.1 (Rig and Eq.), 66 (Employees)	41 (Eq. and Supplies), 86.7 (Employees)	68.5 (Production), 4.7 (Maintenance)
	Distance (miles)	To the nearest Town	To the nearest Town	To the nearest Town	To the nearest Town
	Speed (mph)	35	35	35	35
	Idling Hours/Trip	2.00 (Eq. and supplies), 2.15 (Employees)	1.55 (Rig and Eq.), 2.1 (Employees)	2.0 (Eq. and Supplies), 2.1 (Employees)	2.5 (Production), 2.55 (Maintenance)

4.9.5 On-Road Emission Factors

Light duty truck emission factors were based on MOVES2010b categories of gasoline and diesel passenger trucks and light commercial trucks (Table 4-14).[240] For heavy duty trucks, emissions were calculated using local data and emissions factors from MOVES for diesel short haul combination trucks. Combination short-haul trucks are classified in MOVES as trucks that conduct the majority of their operations within 200 miles of home base.[241] Idling emissions factors for heavy duty trucks and light duty trucks were provided by EPA.[242]

On-road VOC, NO_X, and CO emission factors for vehicles were calculated using the formula provided below (Equation 4-9), while idling emissions were calculated using formula in Equation 4-10. The inputs into the formula were obtained from local data, MOVES output emission factors, TxDOT, and data from ENVIRON's survey in Colorado. Data from the Railroad Commission of Texas on average distance from the well site to the nearest town was used as an approximation of the traveling distance for light duty vehicles trips by county because resources and housing are usually centrally located in towns.

NO_X emission reductions from the use of TxLED were included in the calculations of on-road emissions. According to TCEQ, "TxLED requirements are intended to result in reductions in NO_X emissions from diesel engines. Currently, reduction factors of 5.7% (0.057) for on-road use and 7.0% (0.07) for non-road use have been accepted as a NO_X reduction estimate resulting from use of TxLED fuel. However, this reduction estimate is subject to change, based on the standards accepted by the EPA for use in the Texas State Implementation Plan (SIP)."[243]

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[240] Office of Transportation and Air Quality, August 2010. "MOVES". U.S. Environmental Protection Agency, Washington, DC. Available online: http://www.epa.gov/otaq/models/moves/index.htm. Accessed: 04/02/12.

[241] John Koupal, Mitch Cumberworth, and Megan Beardsley, June 9, 2004. "Introducing MOVES2004, the initial release of EPA's new generation mobile source emission model". U.S. EPA Office of Transportation and Air Quality, Assessment and Standards Division. Ann Arbor, MI. Available online: http://www.epa.gov/ttn/chief/conference/ei13/ghg/koupal.pdf. Accessed: 07/11/11.

[242] Brzezinski, Office of Transportation and Air Quality, U.S. Environmental Protection Agency, Washington, DC, e-mail dated 05/19/12.

[243] TCEQ, July 24, 2012. "Texas Emissions Reduction Plan (TERP) Emissions Reduction Incentive Grants Program". Austin, Texas. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/terp/techsup/2012onvehicle_ts.pdf. Accessed 8/27/13.

Table 4-14 MOVES2011b 2011 Ozone Season Day Emission Factors for On-Road Vehicles in Eagle Ford Counties, 2012 and 2018

Vehicle Type	Fuel Type	Location	Speed	2012			2018		
				VOC EF	NO_X EF	CO EF	VOC EF	NO_X EF	CO EF
Light Duty Trucks	Diesel and Gasoline	On-Road	35 mph	1.00 g/mile	1.55 g/mile	12.85 g/mile	0.62 g/mile	0.97 g/mile	9.29 g/mile
		Idling	-	4.09 g/hr	11.11 g/hr	N/A	4.09 g/hr	11.11 g/hr	N/A
Heavy Duty Trucks	Diesel	On-Road	35 mph	0.45 g/mile	8.43 g/mile	2.64 g/mile	0.37 g/mile	3.73 g/mile	1.26 g/mile
		Idling	-	40.09 g/hr	177.11 g/hr	88.67 g/hr	29.88 g/hr	170.98 g/hr	88.75 g/hr

N/A – not available from MOVES2010b and not provided by EPA

Equation 4-9, Ozone season day on-road emissions during pad construction

$E_{pad.road.ABC}$ = NUM_{BC} x $TRIPS_{A.TXDOT}$ x ($DIST_{B.RCC}$ x 2) x (1 - $TxLED_{TCEQ}$) x $OEF_{A.MOVES}$ / $WPAD_{B.RCC}$ / 907,184.74 grams per ton / 365 days/year

Where,

$E_{pad.road.ABC}$ = Ozone season day NO_X, VOC, or CO emissions from type A on-road vehicles in county B for Eagle Ford development type C wells (Gas or Oil)

NUM_{BC} = Annual number of wells drilled in county B for Eagle Ford development type C wells (from Schlumberger Limited)

$TRIPS_{A.TXDOT}$= Annual number of trips for vehicle type A, 70 for heavy duty trucks (from TxDOT 's Barnett report) and 82.46 for light duty trucks in Table 4-13 (from ENVIRON's Colorado report)

$DIST_{B.RCC}$ = Distance, 25 miles (25 miles one way, 50 miles per round trip) for heavy duty trucks and to the nearest town for light duty vehicles in county B (from Railroad Commission of Texas)

$TxLED_{TCEQ}$ = On-road emission reductions from TxLED, 0.057 for NO_X from Heavy Duty Diesel Trucks, 0.0 for VOC, 0.0 for CO, and 0.0 for Gasoline Light Duty Vehicles (from TCEQ)

$OEF_{A.MOVES}$ = NO_X, VOC, or CO on-road emission factor for vehicle type A in Table 4-14 (from MOVES2010b Model)

$WPAD_{B.RCC}$ = Number of wells per pad for county B (calculated from data provided by the Railroad Commission of Texas)

Sample Equation: 2012 Wilson County NO_X emissions for Heavy Duty Truck Exhaust during the construction of oil well pads

$E_{pad.road.ABC}$ = 62 oil wells x 70 trips x (25 miles x 2) x (1 - 0.057) x 8.43 g/mile / 1.1 wells per well pad / 907,184.74 grams per ton / 365 days/year

= 0.005 tons of NO_X per day from heavy duty truck exhaust in Wilson County during the construction of oil well pads

Equation 4-10, Ozone season day idling emissions during pad construction

$E_{pad.idling.ABC}$ = NUM_{BC} x $TRIPS_{A.TXDOT}$ x $IDLE_A$ x (1 - $TxLED_{TCEQ}$) x $IEF_{A.EPA}$ / $WPAD_{BC.RCC}$ / 907,184.74 grams per ton / 365 days/year

Where,

$E_{pad.idling.ABC}$ = Ozone season day NO_X, VOC, or CO emissions from idling vehicles in county B for Eagle Ford development type C wells (Gas or Oil)

NUM_{BC} = Annual number of wells drilled in county B for Eagle Ford development type C wells (from Schlumberger Limited)

$TRIPS_{A.TXDOT}$= Annual number of trips for vehicle type A, 70 for heavy duty trucks (from TxDOT 's Barnett report), 12.86 for light duty trucks for equipment, and 69.6 light duty trucks for employees in Table 4-13 (from ENVIRON's Colorado report)

$IDLE_A$ = Number of idling hours/trip for vehicle type A, 0.4 hours for heavy duty trucks, 2.0 for light duty trucks for equipment, and 2.15 light duty trucks for employees (from ENVIRON's Colorado report)

$TxLED_{TCEQ}$ = On-road emission reductions from TxLED, 0.057 for NO_X from Heavy Duty Diesel Trucks, 0.0 for VOC, 0.0 for CO, and 0.0 for Gasoline Light Duty Vehicles (from TCEQ)

$IEF_{A.EPA}$ = NO_X, VOC, or CO idling emission factor for vehicle type A in Table 4-14 (from EPA based on the MOVES model)

$WPAD_{B.RCC}$ = Number of wells per pad for county B (calculated from data provided by the Railroad Commission of Texas)

Sample Equation: 2012 NO_X emissions from Heavy Duty Truck Idling in Wilson County during the construction of oil well pads

$E_{pad.road.ABC}$ = 62 oil wells x 70 trips x 0.4 hours idling x (1 - 0.057) x 177.11 g/hour / 1.1 wells per well pad / 907,184.74 grams per ton / 365 days/year

= 0.001 tons of NO_X per day from heavy duty truck idling in Wilson County during the construction of oil well pads

4.9.6 Temporal Adjustment of On-Road Emissions

Temporal distribution for on-road vehicles in the Eagle Ford are based on North Central Texas Council of Governments work on a heavy duty truck mobile source inventory in the Barnett Shale. "To develop a diurnal distribution of emissions, NCTCOG staff utilized automatic traffic recorder (ATR) data which distributes volume of trips across 24 hours in a day. Use of this data is standard NCTCOG process for travel demand modeling. NCTCOG staff did not expect industry operating patterns to vary depending on school or summer seasons. Indeed, survey results did not indicate any seasonal variation in operation. Therefore, Annual Average Daily adjustment factors were applied with no seasonal adjustment. The diurnal distribution is derived from vehicle classification counts of multi-unit trucks from year 2004."[244] Figure 4-7 shows the diurnal distribution for multi-unit trucks from the Barnett Shale used to temporally allocate on-road emissions in the Eagle Ford.

4.10 Non-Road and Area Source Emissions in the Eagle Ford

A variety of data sources were used to estimate emissions from Eagle Ford oil and gas production. Whenever possible, local data was used to calculate emissions and project future production. Counts of drill rigs operating in the Eagle Ford and number of wells drilled are provided by Schlumberger.[245] Similarly, well characteristics and production data were collected from Schlumberger and the Railroad Commission of Texas[246]. Non-road equipment was calculated using local industry data, emission factors from the TexN model, manufacturers' information, TCEQ, and the results of surveys conducted by the Texas Center for Applied Technology (TCAT).

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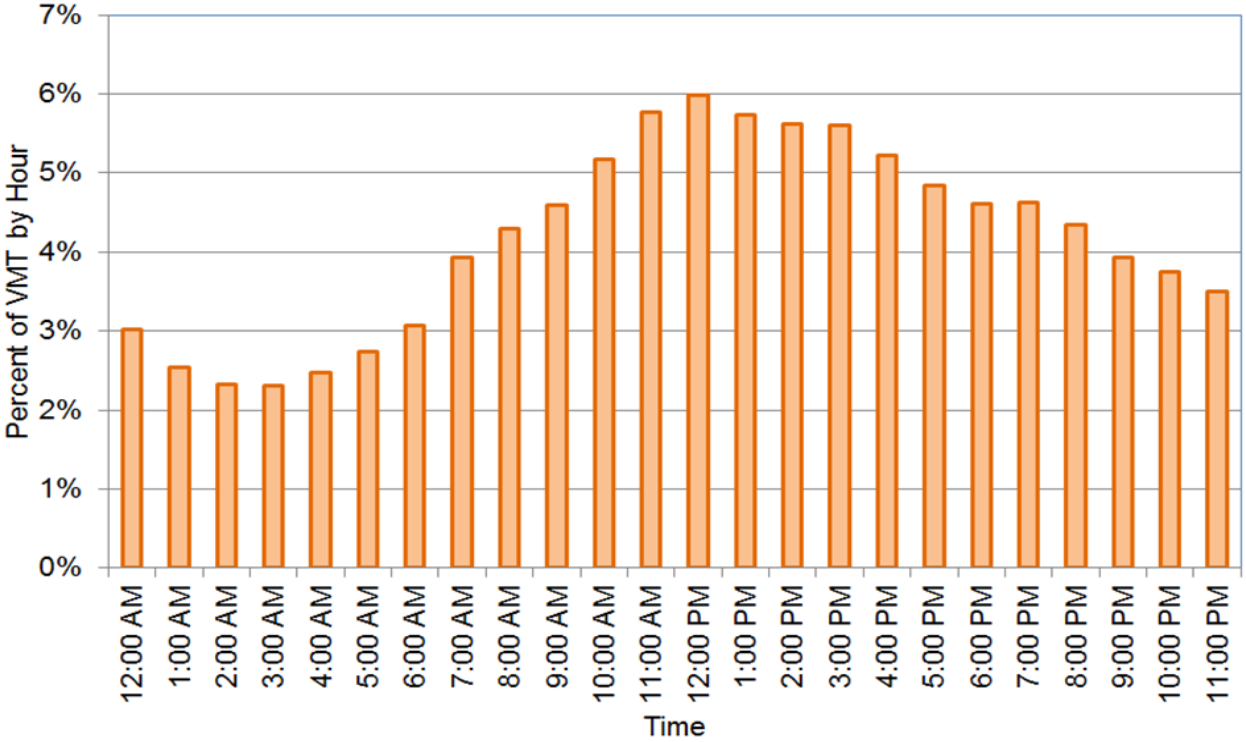
[244] Lori Clark, Shannon Stevenson, and Chris Klaus North Central Texas Council of Governments, August 2012. "Development of Oil and Gas Mobile Source Inventory in the Barnett Shale in the 12-County Dallas-Fort Worth Area". Arlington, Texas. Texas Commission on Environmental Quality Grant Number: 582-11-13174. pp. 34-35. Available online: http://www.nctcog.org/trans/air/barnettshale.asp. Accessed 01/23/13.

[245] Schlumberger Limited. "STATS Rig Count History". Available online: http://stats.smith.com/new/history/statshistory.htm. Accessed: 04/21/12.

[246] Railroad Commission of Texas, April 3, 2012. "Eagle Ford Information". Austin, Texas. Available online http://www.rrc.state.tx.us/eagleford/index.php. Accessed: 05/01/12.

Figure 4-7: Distribution of Multi-Unit Trucks by Time of Day in the Barnett Shale



Production emissions calculations were based on data produced by TCEQ's Barnett Shale special inventory. Other sources for production emissions included local industry data, ERG's Texas emission inventory[247], ENVIRONS CENRAP emission inventory[248], and AP42 emission factors for flares[249].

4.11 Eagle Ford Projection Scenarios

Emissions from Eagle Ford production are projected to continue growing as oil and gas development increases over the next few years. Projections of activity in the Eagle Ford were developed using a methodology similar to ENVIRON's Haynesville Shale emission inventory which was based on three scenarios: low development, moderate development, and high

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[247] Mike Pring, Daryl Hudson, Jason Renzaglia, Brandon Smith, and Stephen Treimel, Eastern Research Group, Inc. Nov. 24, 2010. "Characterization of Oil and Gas Production Equipment and Develop a Methodology to Estimate Statewide Emissions". Prepared for: Texas Commission on Environmental Quality Air Quality Division. Austin, Texas. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784003FY1026-20101124-ergi-oilGasEmissionsInventory.pdf. Accessed: 04/10/12.

[248] Amnon Bar-Ilan, Rajashi Parikh, John Grant, Tejas Shah, Alison K. Pollack, ENVIRON International Corporation. Nov. 13, 2008. "Recommendations for Improvements to the CENRAP States' Oil and Gas Emissions Inventories". Novato, CA. Available online: http://www.wrapair.org/forums/ogwg/documents/2008-11_CENRAP_O&G_Report_11-13.pdf. Accessed: 04/30/12.

[249] EPA, Sept. 1991. "AP42: 13.5 Industrial Flares". Available online: http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s05.pdf. Accessed 05/16/2012.

development.[250] The scenarios cover a range of potential growth in the Eagle Ford based on best available information including local data, industrial projections, and projected price of petroleum products. Projected VOC, NO_X, and CO emissions are derived by drilling activity in the region and production estimations for each well. Since hydraulic fracturing of oil reserves on a wide scale is a relatively new occurrence, activity and emission projections will have a high uncertainty factor.

Daily on-road emissions from the Eagle Ford are estimated to be 6.935 tons of NO_X and 0.908 tons of VOC in 2012 (Table 4-15). NO_X emissions from these vehicles are expected to be from 6.519 to 10.449 tons in 2018 while VOC emissions are expected to be from 0.961 to 1.523 tons. Heavy duty trucks are the main source of NO_X emissions from on-road vehicles operating in the Eagle Ford.

Figure 4-8 provides estimated 2018 NO_X emissions by source type under the three Eagle Ford projection scenarios, while Figure 4-9 shows estimated 2018 VOC emissions for the three scenarios. Mid-steam sources, wellhead compressors, flares, drill rigs, and on-road vehicles are the major sources of NO_X emissions. Total NO_X emissions are 87.5 tons per day for the low scenario and 152.6 tons per day under the high scenario. VOC emissions are primarily from storage tanks, mid-stream sources, flares, and fugitive sources. Under the development scenarios, VOC emissions vary from 144.2 tons per day to 276.9 tons per day.

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[250] John Grant, Lynsey Parker, Amnon Bar-Ilan, Sue Kemball-Cook, and Greg Yarwood, ENVIRON International Corporation. August 31, 2009. “Development of an Emission Inventory for Natural Gas Exploration and Production in the Haynesville Shale and Evaluation of Ozone Impacts”. Novato, CA. p. 13. Available online: http://www.netac.org/UserFiles/File/NETAC/9_29_09/Enclosure_2b.pdf. Accessed: 04/19/12.

Table 4-15: Daily On-Road Vehicles Emissions in the Eagle Ford

Phase	Scenario	Heavy Duty Trucks On-Road		Heavy Duty Trucks Idling		Light Duty Trucks On-Road		Light Duty Trucks Idling	
		VOC	NO_X	VOC	NO_X	VOC	NO_X	VOC	NO_X
Pad Construction	2012	0.015	0.241	0.009	0.041	0.016	0.025	0.006	0.016
	2018 Low	0.004	0.065	0.004	0.024	0.006	0.009	0.004	0.010
	2018 Moderate	0.007	0.103	0.007	0.038	0.010	0.015	0.006	0.015
	2018 High	0.010	0.140	0.009	0.051	0.013	0.021	0.008	0.021
Drilling	2012	0.040	0.644	0.043	0.189	0.026	0.040	0.008	0.022
	2018 Low	0.012	0.174	0.020	0.112	0.010	0.015	0.005	0.014
	2018 Moderate	0.019	0.275	0.031	0.177	0.016	0.024	0.008	0.021
	2018 High	0.026	0.375	0.042	0.241	0.022	0.034	0.011	0.029
Hydraulic Fracturing and Completion	2012	0.171	2.779	0.295	1.284	0.025	0.039	0.009	0.024
	2018 Low	0.052	0.752	0.132	0.758	0.009	0.014	0.005	0.015
	2018 Moderate	0.082	1.189	0.209	1.197	0.015	0.023	0.009	0.023
	2018 High	0.111	1.620	0.285	1.631	0.021	0.033	0.012	0.032
Production	2012	0.051	0.822	0.162	0.706	0.024	0.037	0.010	0.026
	2018 Low	0.104	1.517	0.497	2.842	0.057	0.090	0.040	0.108
	2018 Moderate	0.120	1.741	0.570	3.261	0.066	0.103	0.046	0.124
	2018 High	0.142	2.071	0.678	3.879	0.079	0.123	0.054	0.148
Total	2012	0.276	4.485	0.509	2.220	0.090	0.141	0.032	0.088
	2018 Low	0.172	2.509	0.653	3.735	0.082	0.129	0.054	0.146
	2018 Moderate	0.227	3.308	0.817	4.673	0.106	0.166	0.068	0.184
	2018 High	0.289	4.206	1.014	5.802	0.135	0.211	0.085	0.229

Figure 4-8: Daily NO_X Emissions in the Eagle Ford for the Three Scenarios, 2018

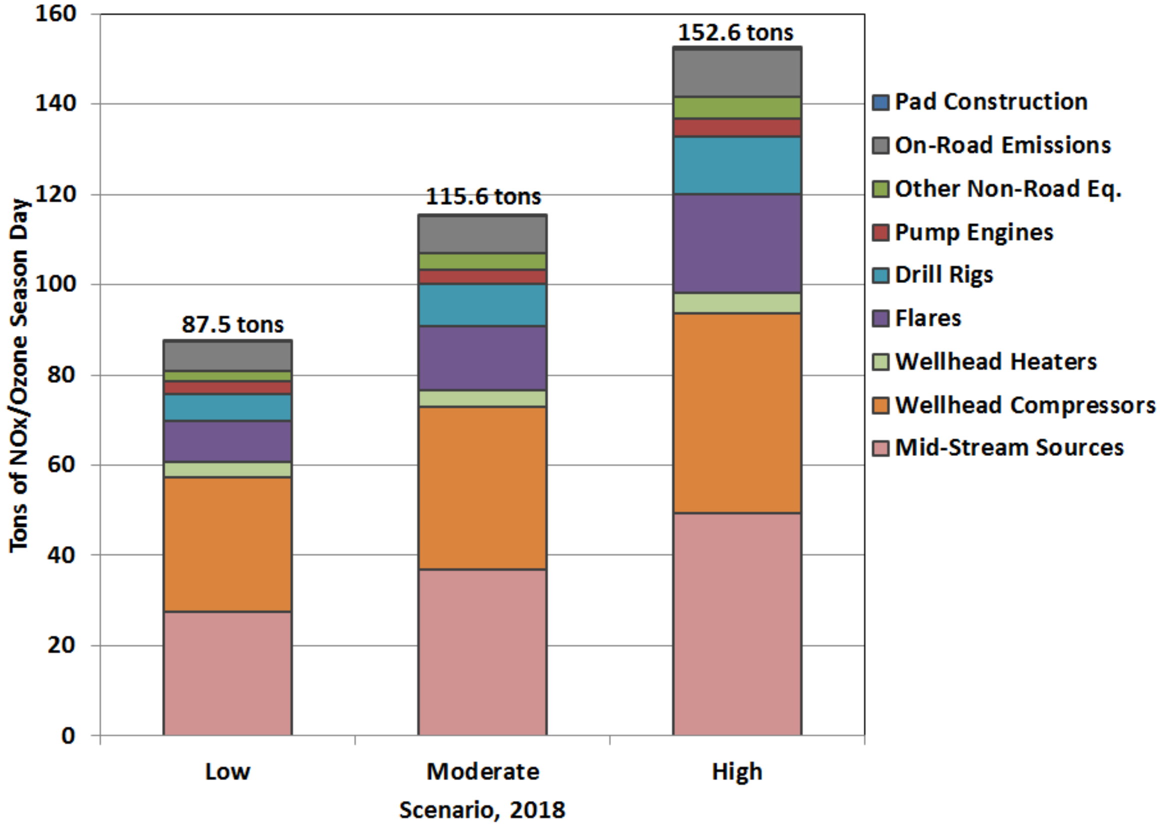
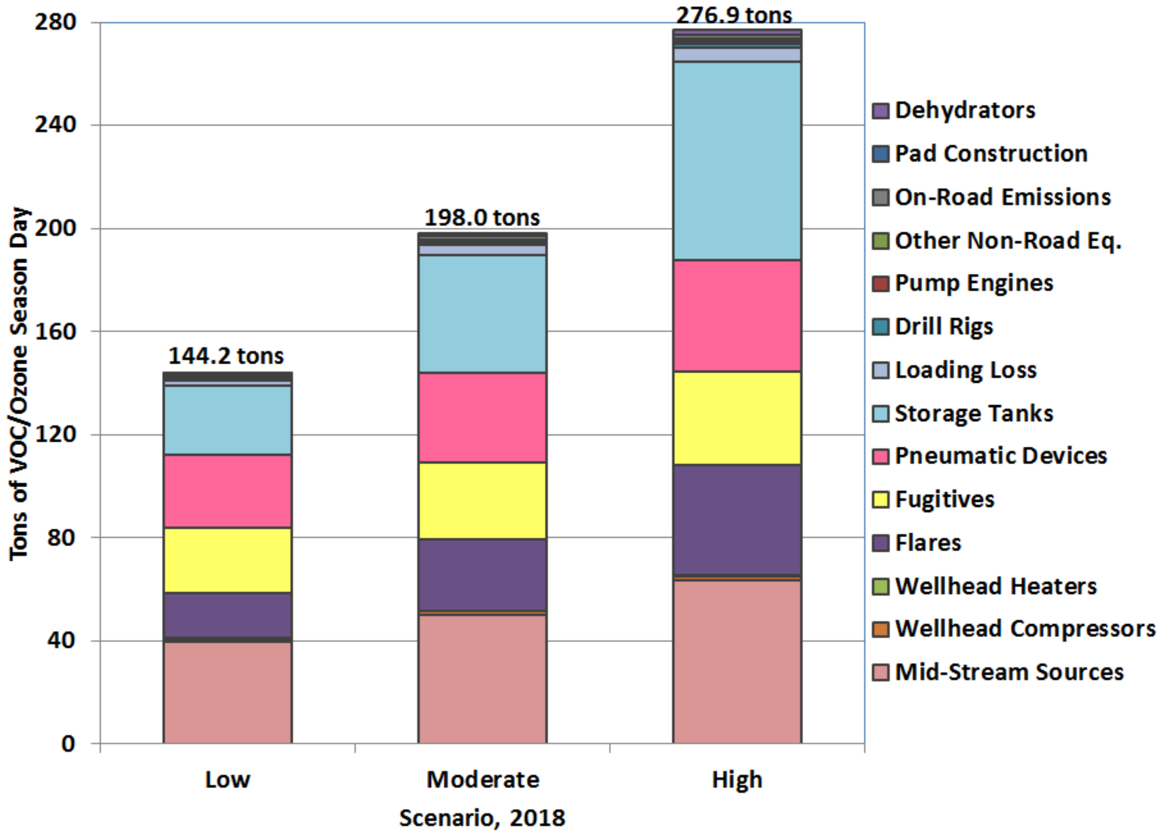


Figure 4-9: Daily VOC Emissions in the Eagle Ford for the Three Scenarios, 2018



4.12 Summary of the 2012 and 2018 Projection Year Emission Inventory Development

Projected NO_X and VOC emissions (tons/day) for the San Antonio-New Braunfels MSA region are provided in Figure 4-10 and Figure 4-11. Emissions are lower on Saturday and Sunday compared to weekdays. Estimated NO_X emissions are significantly lower in 2018: emissions decreased from 273.9 tons per weekday in 2006 to 134.0 tons per weekday in 2018. VOC emissions are reduced from 232.7 tons per weekday in 2006 to 208.4 tons per weekday in 2018.

The largest source of NO_X emissions in 2006 are on-road vehicles, 134.7 tons per weekday, followed by point, 71.3 tons per weekday, and non-road, 43.6 tons per weekday (Table 4-16). By 2018, the largest sources of NO_X emissions are point, 50.8 tons per weekday, followed by on-road, 43.0 tons per weekday, and area, 15.9 tons per weekday. As expected, the largest contributors of VOC emissions are area sources: 147.2 tons per weekday in 2006 and 153.8 tons per weekday in 2018 (Table 4-17). Other significant sources of VOC emissions in the San Antonio-New Braunfels MSA are on-road, 22.1 tons per weekday in 2018, and non-road, 19.0 tons per weekday in 2018. Eagle Ford emissions are not a large contributor to emissions, 4.0 tons of NO_X and 7.4 tons of VOC per day under the moderate scenario in 2018, in the San Antonio-New Braunfels MSA because most of the production is occurring outside of the MSA.

Figure 4-10: NO_X Emissions (tons/day) for the San Antonio-New Braunfels MSA, 2006, 2012, and 2018 Eagle Ford Moderate Scenario

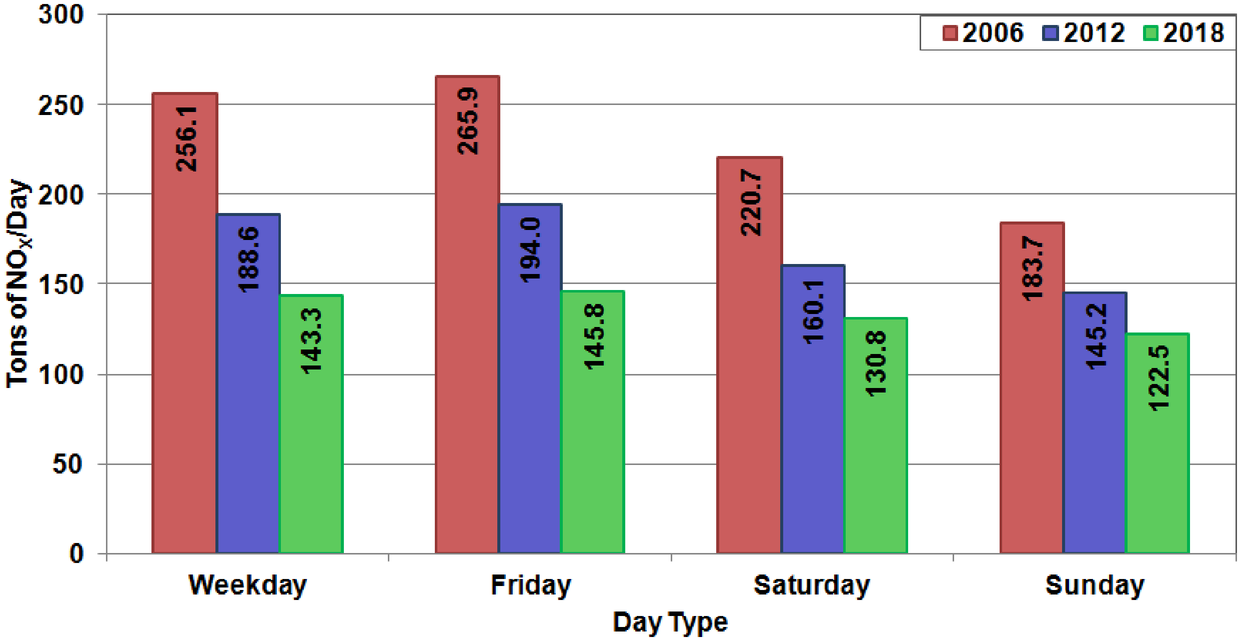


Figure 4-11: VOC Emissions (tons/day) for the San Antonio-New Braunfels MSA, 2006, 2012, and 2018 Eagle Ford Moderate Scenario

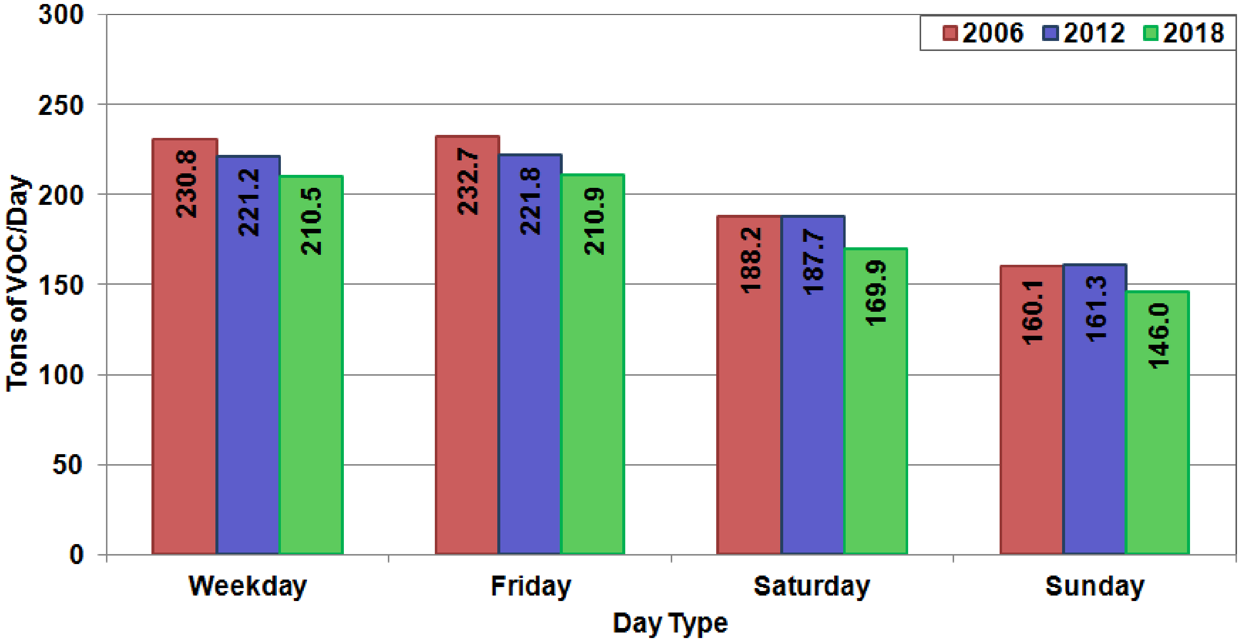


Table 4-16: NO_X Emissions (tons/day) for the San Antonio-New Braunfels MSA, 2012 and 2018 Eagle Ford Moderate Scenario

Year	Day of Week	On-Road	Point	Area	Non-Road	Off-Road	Eagle Ford	Total NO_X
2006	Weekday	134.7	71.3	16.5	25.7	7.9	0.0	256.1
	Friday	144.4	71.3	16.5	25.7	7.9	0.0	265.9
	Saturday	101.2	71.3	15.0	29.7	3.4	0.0	220.7
	Sunday	81.8	71.3	13.4	13.7	3.4	0.0	183.7
2012	Weekday	75.4	68.1	15.6	19.6	6.0	3.9	188.6
	Friday	80.8	68.1	15.6	19.6	6.0	3.9	194.0
	Saturday	57.8	68.1	13.9	13.5	2.9	3.9	160.1
	Sunday	47.2	68.1	12.3	11.0	2.9	3.9	145.2
2018	Weekday	41.4	65.3	15.9	11.3	5.2	4.1	143.3
	Friday	44.0	65.3	15.9	11.3	5.2	4.1	145.8
	Saturday	31.7	65.3	14.2	8.5	7.1	4.1	130.8
	Sunday	26.1	65.3	12.4	7.5	7.1	4.1	122.5

Table 4-17: VOC Emissions (tons/day) for the San Antonio-New Braunfels MSA, 2012 and 2018 Eagle Ford Moderate Scenario

Year	Day of Week	On-Road	Point	Area	Non-Road	Off-Road	Eagle Ford	Total VOC
2006	Weekday	49.2	8.3	147.2	24.5	1.6	0.0	230.8
	Friday	51.1	8.3	147.2	24.5	1.6	0.0	232.7
	Saturday	39.8	8.3	94.6	45.0	0.5	0.0	188.2
	Sunday	37.6	8.3	73.4	40.3	0.5	0.0	160.1
2012	Weekday	32.1	6.6	151.2	27.1	1.1	3.1	221.2
	Friday	32.7	6.6	151.2	27.1	1.1	3.1	221.8
	Saturday	27.2	6.6	95.7	54.2	0.9	3.1	187.7
	Sunday	25.5	6.6	73.7	51.5	0.9	3.1	161.3
2018	Weekday	21.8	7.5	153.8	19.0	0.9	7.4	210.5
	Friday	22.2	7.5	153.8	19.0	0.9	7.4	210.9
	Saturday	18.6	7.5	97.4	38.0	1.0	7.4	169.9
	Sunday	17.6	7.5	74.6	37.9	1.0	7.4	146.0

4.13 Emission Inventory Tile Plots

The graphic software, Package for Analysis and Visualization of Environmental data (PAVE),[251] was used to display EPS3 formatted 4-km fine grid emissions by source type. Tile plots are used to visually verify the distribution of emissions in the photochemical model compared to actual locations. Also, hourly tile plots were checked to make sure there were no unusual patterns of emissions. Through the use of emission tile plots, the photochemical modeling emission inputs were evaluated spatially for accuracy using EPA modeling guidance.[252]

Non-road/off-road NO_X emissions tile plots are provided in Figure 4-12 for 2006, 2012, and 2018, while VOC plots are provided in Figure 4-13. These plots show concentrations of high NO_X and VOC emissions in the population centers of Eastern Texas. The highest emissions are in Houston, Dallas, San Antonio, and Austin, while the less populated counties in west and south Texas tend to have the lowest emissions. In the 2018 projected emission inventory, non-road/off road emissions decreased in the urban areas and across the 4km modeling domain. Area source NO_X and VOC emissions are concentrated in the urban areas and oil producing regions of Texas. When comparing projection years, area source emissions are similar for 2006, 2012, and 2018 (Figure 4-14 and Figure 4-15).

On-road NO_X emissions for 2006, 2012, and 2018 are presented in Figure 4-16 and on-road VOC emissions are provided in Figure 4-17. The largest concentrations of on-road emissions are in Dallas, Houston, Austin, and San Antonio. On-road emissions are also concentrated in other urban areas and along major highways including I-10, I-35, and I-37. There is a significant decrease in NO_X and VOC emissions from on-road sources in the 2018 projection emission inventory. The main reason for these decreases are emissions standards for both gasoline and diesel engines that are significantly stricter for cars built after 2006.

Figure 4-18 and Figure 4-19 shows NO_X and VOC low elevation point source emissions tile plots for each modeling year. As shown on the three plots, point source emissions are highest in Houston, Beaumont, Dallas, and Corpus Christi. These urban areas have the highest concentrations of large industrial point sources. There are also numerous low level off-shore point sources in the 4km grid. Eagle Ford emission inventory plots (Figure 4-20 and Figure 4-21) show no emissions in 2006 and NO_X and VOC emissions across the 25 county Eagle Ford development in 2012 and 2018. Emissions from Eagle Ford are concentrated southeast, south and southwest of the San Antonio-New Braunfels MSA.

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[251] The University of North Carolina at Chapel Hill, UNC Institute for the Environment. "PAVE User's Guide - Version 2.3". Available online http://www.ie.unc.edu/cempd/EDSS/pave_doc/index.shtml#TOC. Accessed 08/07/13.

[252] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." Research Triangle Park, NC: Office of Air Quality Planning and Standards." Available online. http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 08/07/13.

Emissions for offshore sources, Figure 4-22, shows NO_X emissions concentrated along main shipping channels to Corpus Christi, Galveston, Houston, Beaumont, and Lake Charles. These cities have major port facilities for transporting raw materials and finished products. Emissions from Mexico, shown in Figure 4-23, are concentrated in Nuevo Laredo and along Mexico's Highway 85. Emissions for off-shore and Mexican sources remain the same for each projection year.

Figure 4-12: Non-Road/Off-Road NO_X Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

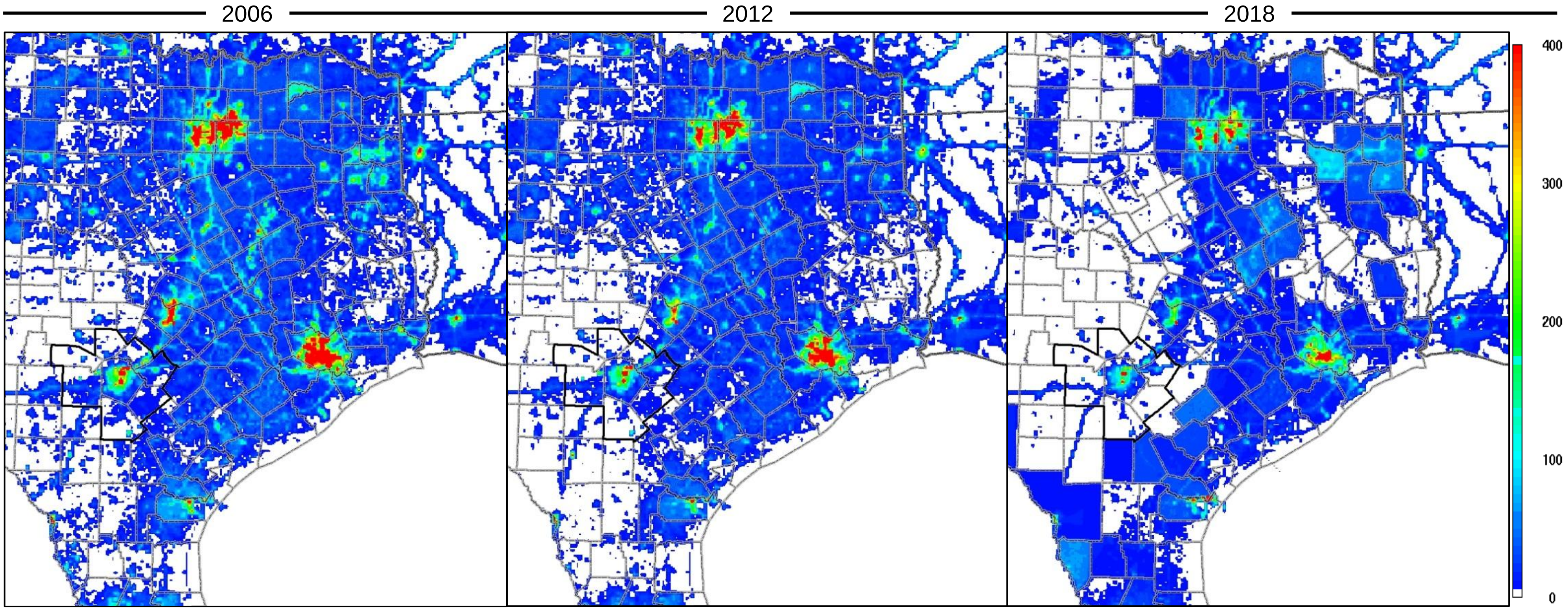


Figure 4-13: Non-Road/Off Road VOC Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

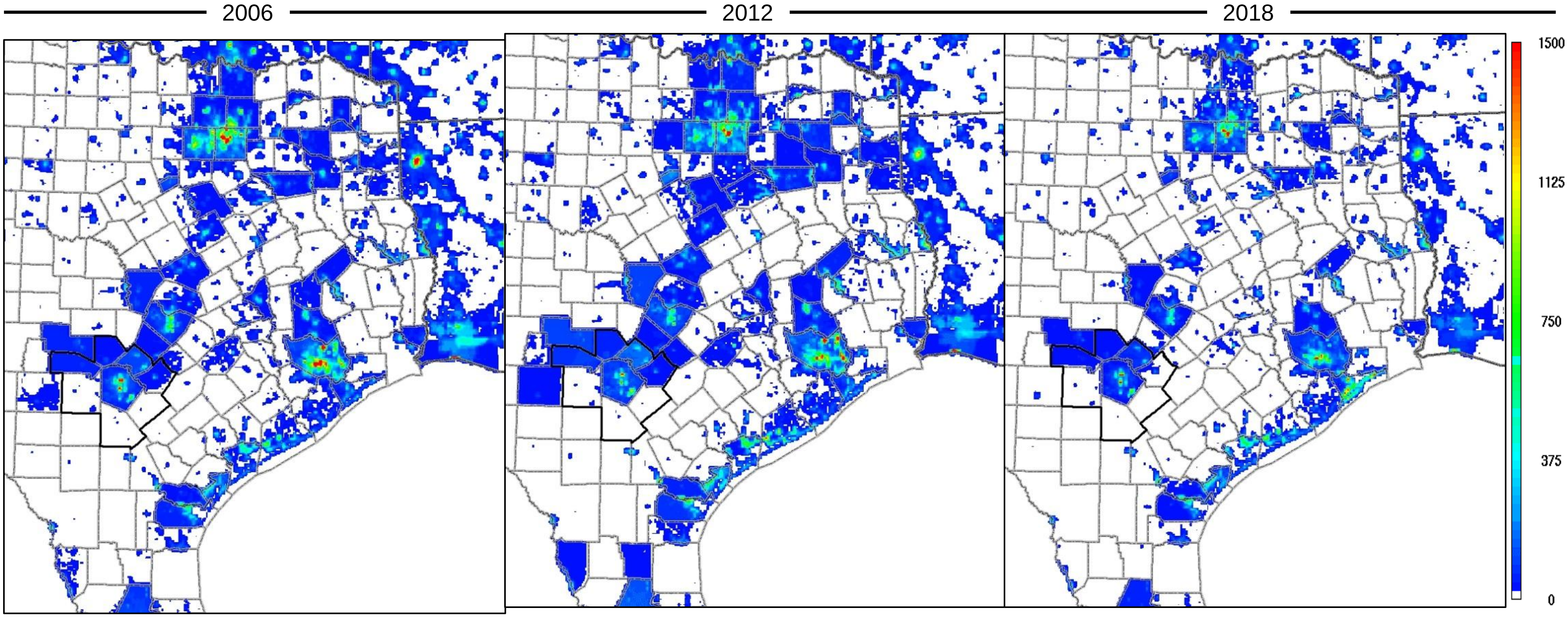


Figure 4-14: Area NO_X Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

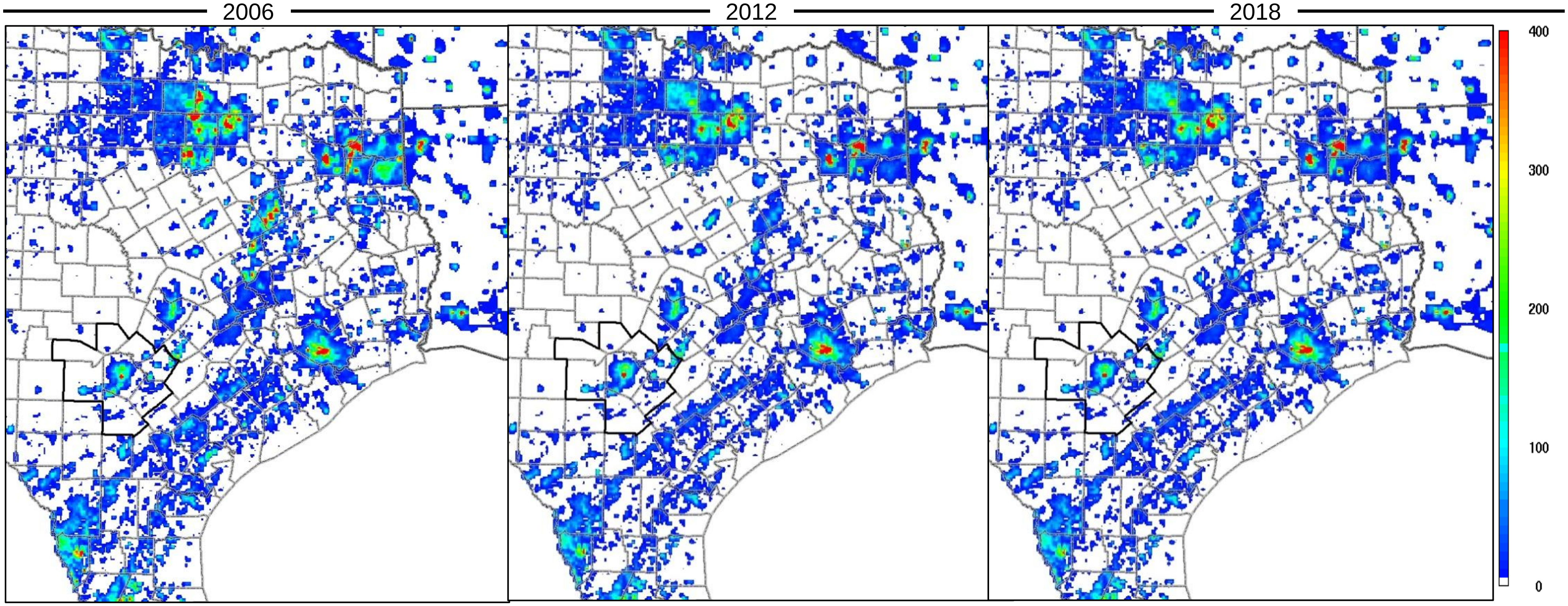


Figure 4-15: Area VOC Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

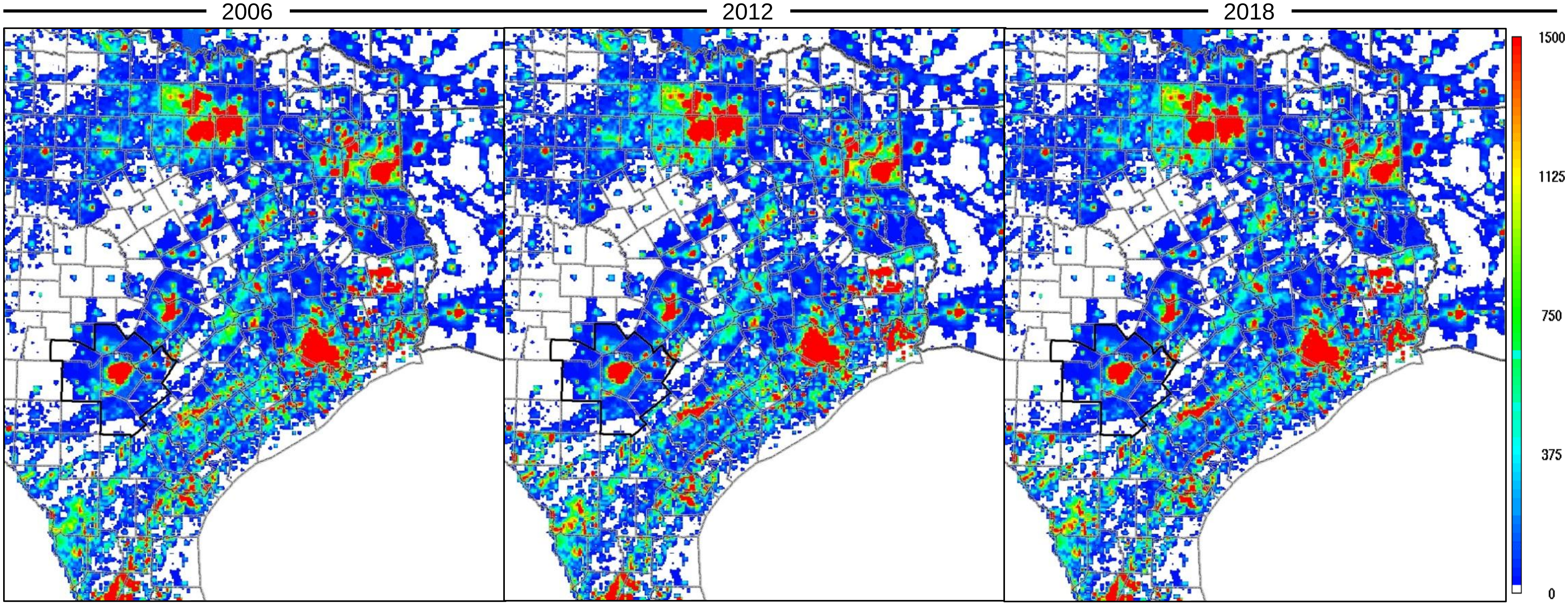


Figure 4-16: On-Road NO_X Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

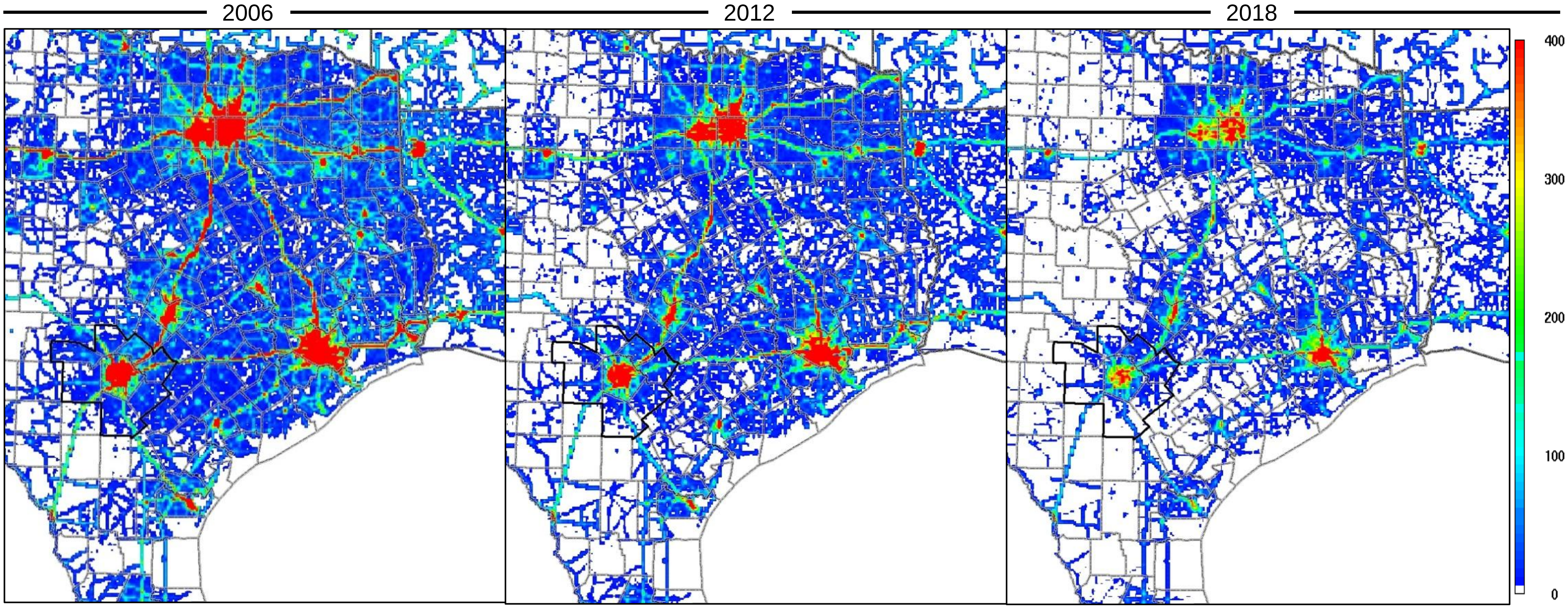


Figure 4-17: On-Road VOC Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

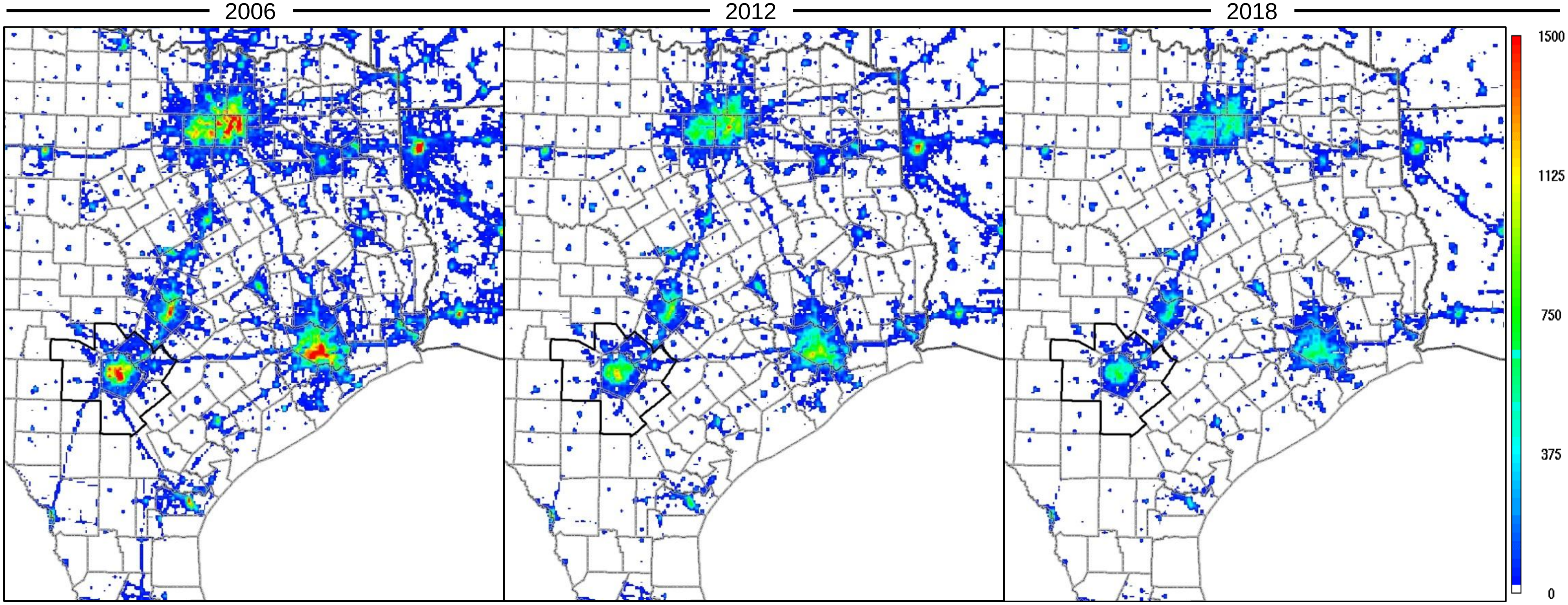


Figure 4-18: Low Point NO_X Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

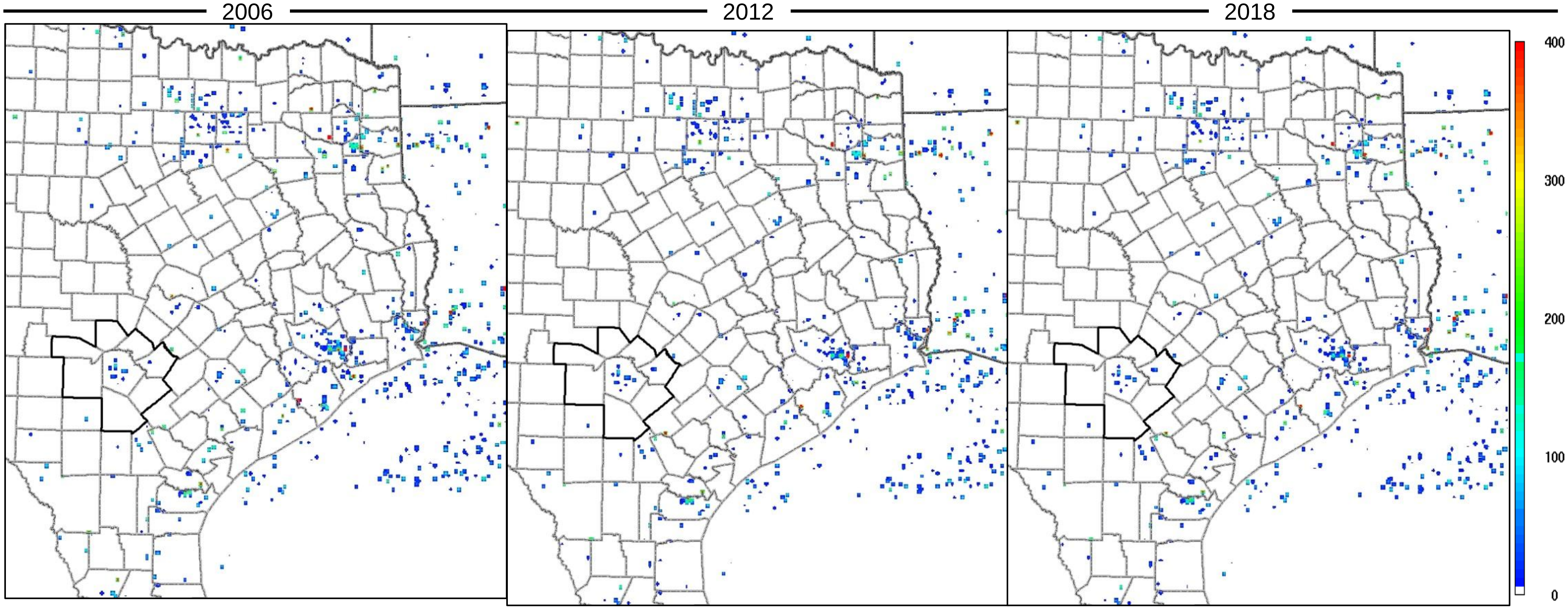


Figure 4-19: Low Point VOC Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

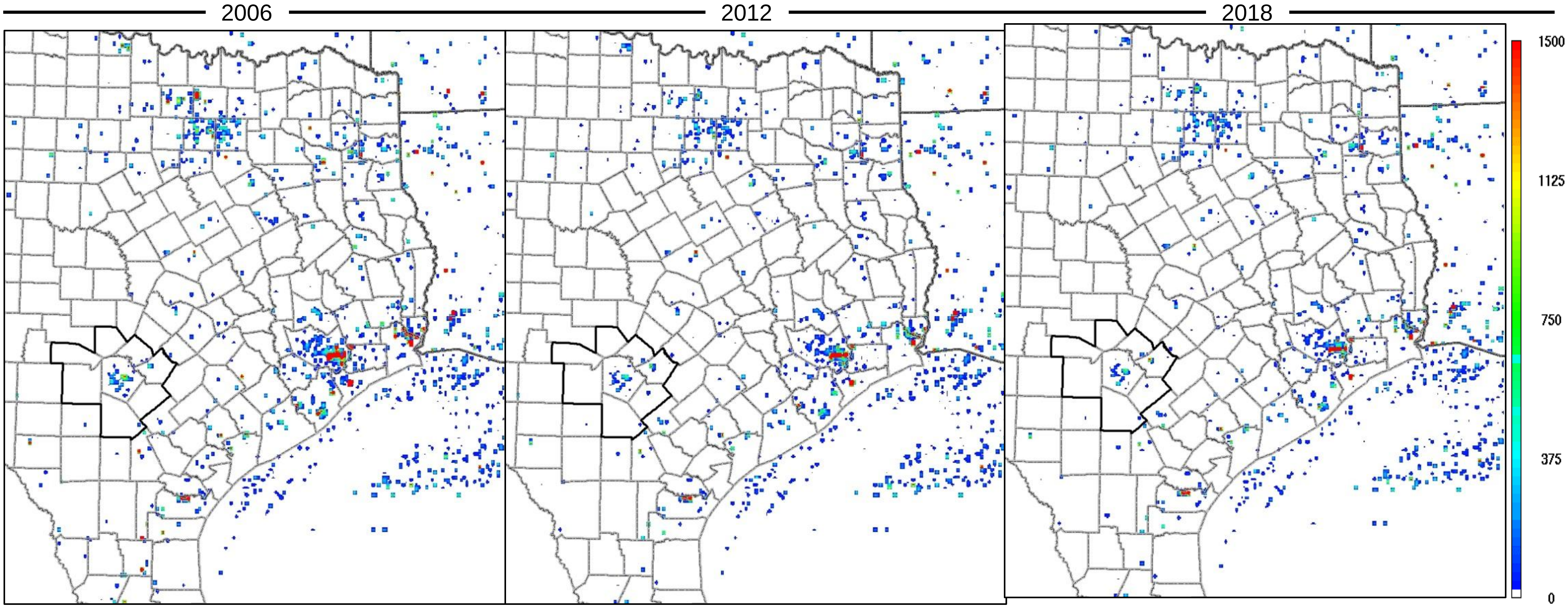


Figure 4-20: Eagle Ford NO$_X$ Emissions 4-km grid Tile Plots, Moderate Scenario, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

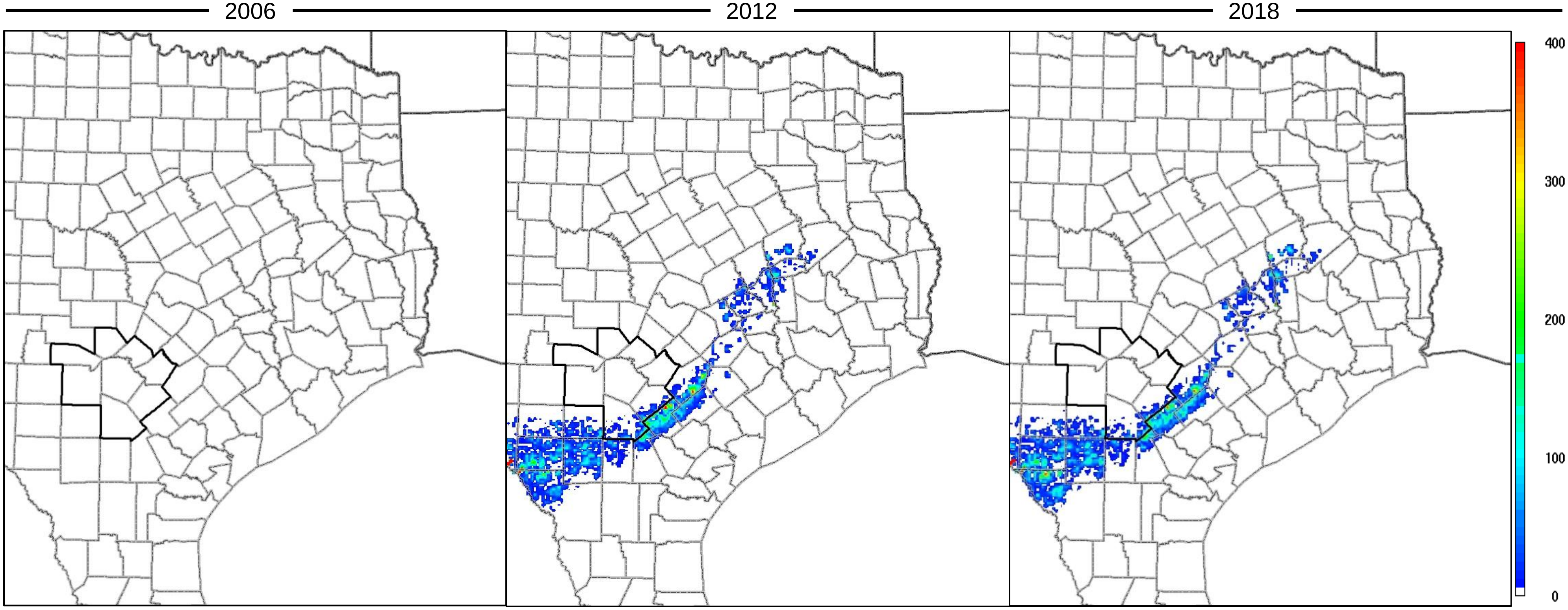


Figure 4-21: Eagle Ford VOC Emissions 4-km grid Tile Plots, Moderate Scenario, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

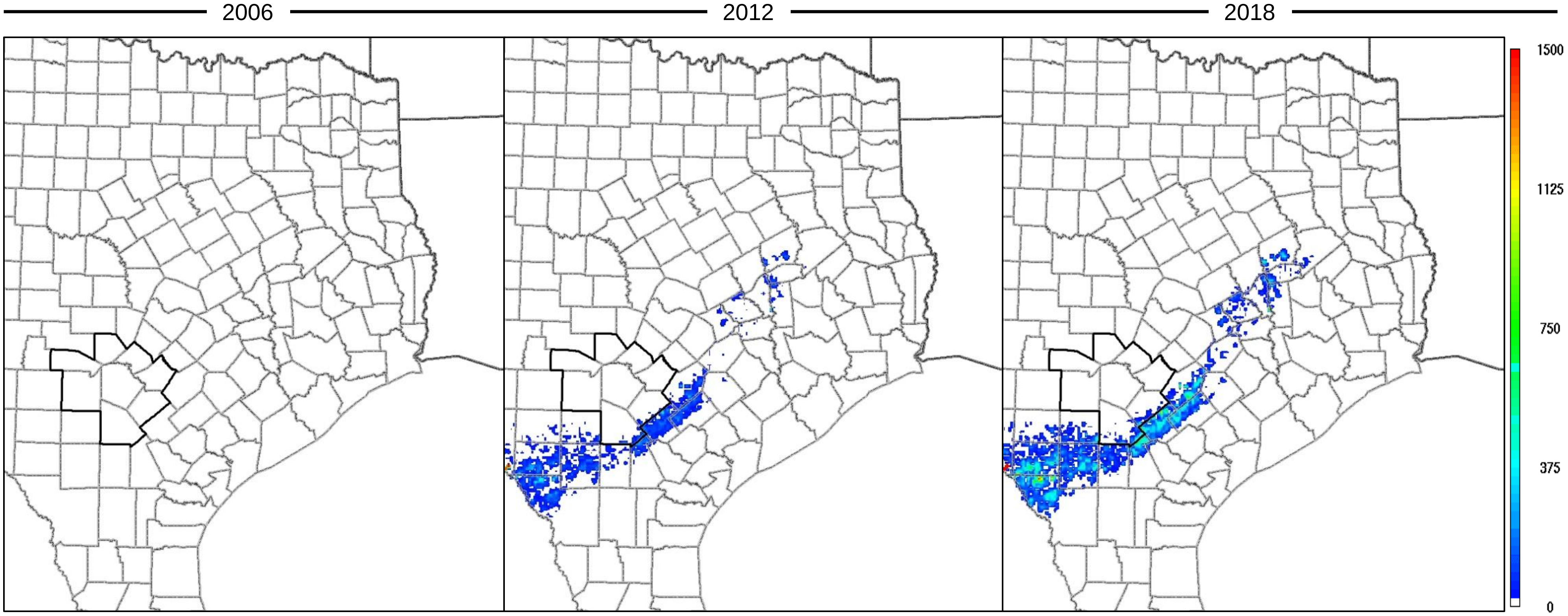
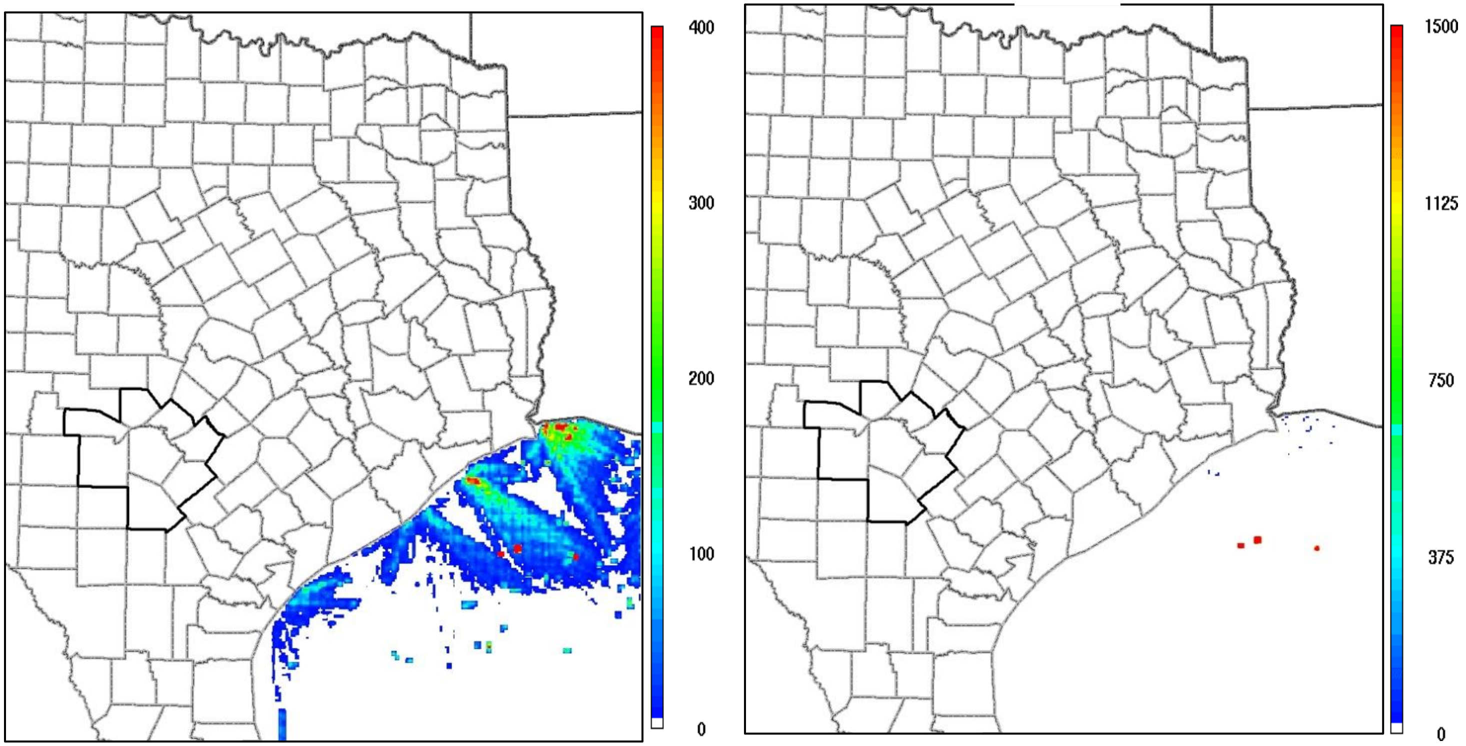

2006 — 2012 — 2018

Figure 4-22: Offshore Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

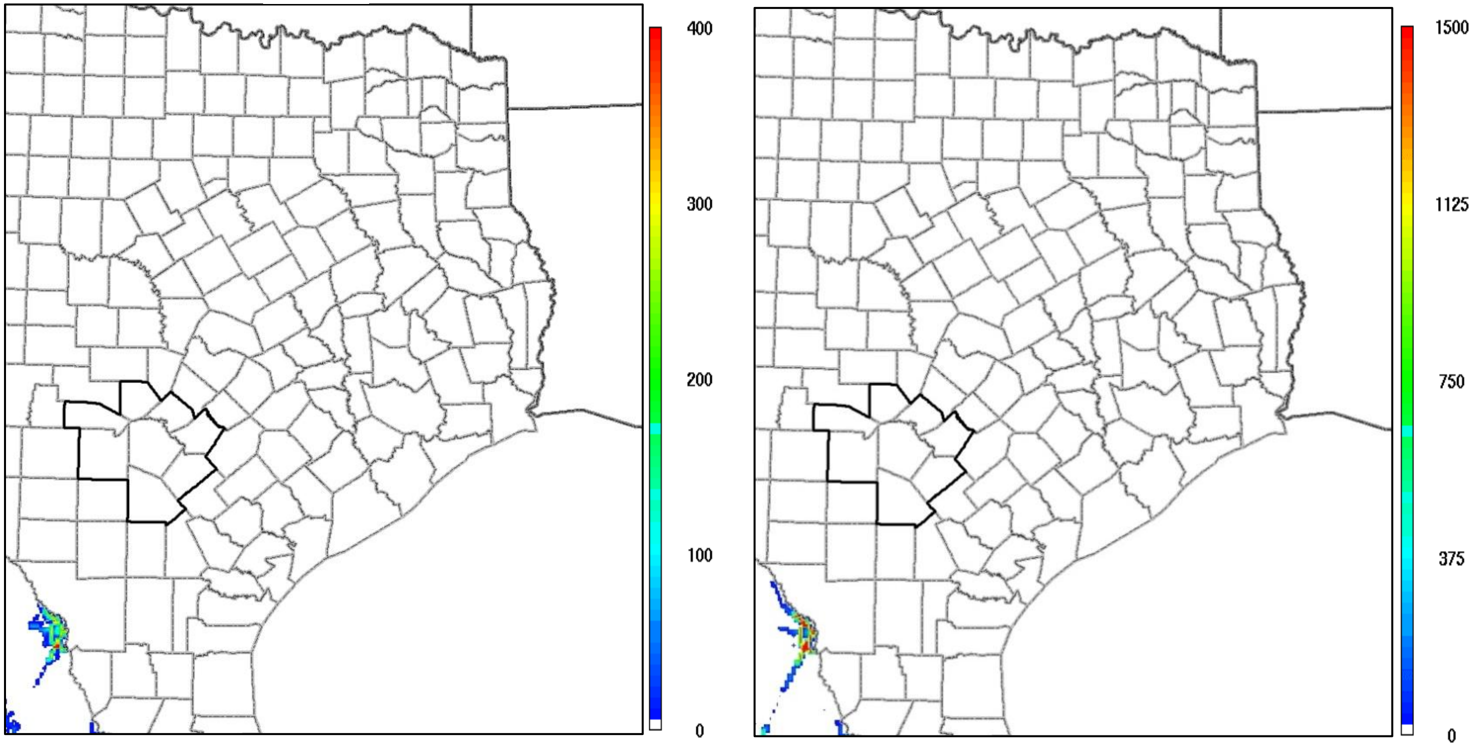

NO$_x$

VOC

Note: Offshore emissions are the same for each projection year.

Figure 4-23: Mexico Emissions 4-km grid Tile Plots, Weekday, 12:00PM – 1:00PM (Grams Mole/Hr)

NO$_x$ VOC



Note: Mexico emissions are the same for each projection year.

5 Base Case Modeling

5.1 CAMx Model Development

The base case CAMx simulation was developed for an elevated ozone episode in the San Antonio region that extended from May 31st to July 2nd 2006. To simulate ozone formation, transport, and dispersion for the June 2006 episode, CAMx required several inputs including:

- Three-dimensional hourly meteorological fields generated by WRF via the WRF2CAMx interface tool;
- Land use distribution fields;
- Three-dimensional hourly emissions generated by EPS3 by pollutant (latitude, longitude, and height);
- Initial conditions and boundary conditions (IC/BC);
- Photolysis rate inputs, including ultraviolet (UV) albedo, haze opacity, and total atmospheric ozone column fields.

5.1.1 CAMx Configurations

CAMx version 5.40 was used to model the 2006 episode to match the current TCEQ platform being developed for Texas. The configurations used for the extended June 2006 CAMx episode were:

- Duration: May 31st – July 2nd, 2006
- Time zone: CST (central standard time)
- I/O frequency: 1 hour
- Map projection: Lambert Conformal Conic
- Nesting: 2-way fully interactive 36/12/4-km computational grids
- Chemistry mechanism: CB6
- Chemistry solver: EBI (Euler-Backward Iterative)
- Advection solver: PPM (Piecewise Parabolic Method)
- Dry deposition model: ZHANG03[253]
- Plume-in-Grid model: On for large NO_X sources, parameters set by TCEQ
- Probing Tools: None
- Dry deposition: On
- Wet deposition: On
- 3-D output: Off (2-D surface output only)
- PiG sampling grids: Off
- Asymmetric Convective Model 2 (ACM2) Diffusion[254]
- TUV Cloud Adjustment

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[253] L. Zhang, J. R. Brook, and R. Vet, 2003. “A revised parameterization for Gaseous Dry Deposition in Air-Quality Models”. Atmos. Chem. Phys., 3, 2067–2082. Available online: http://www.atmos-chem-phys.net/3/2067/2003/acp-3-2067-2003.pdf. Accessed 06/24/13.

[254] Jonathan Pleim. “A New Combined Local and Non-Local Pbl Model for Meteorology and Air Quality Modeling”. U.S. Environmental Protection Agency, Research Triangle Park, NC. Available online: http://www.cmascenter.org/conference/2006/abstracts/pleim_session1.pdf. Accessed 06/24/13

- Photolysis rate adjusted by cloud cover
- BC/IC from GEOS-CHEM model

The sampling grid was turned off during the model run because it's used solely to produce a graphical display of plume animation at the fine grid level and does not impact CAMx ozone predictions. These fine grid levels are typically less than 1 km and are smaller than the finest grid resolution, 4 km, used in this modeling application.

5.1.2 Plume-in-Grid Sub-model

The photochemical model runs developed for the June 2006 episode utilize the Plume-in-Grid sub-model (PiGs) to track individual plume sources and help reduce the artificial diffusion of point source emissions in the modeling grid. The PiGs accounts "for plume-scale dispersion and chemical evolution, until such time as puff mass can be adequately represented within the larger grid model framework."[255] All CAMx runs employed the PiGs option for large NO_X point sources using TCEQ PiGs threshold values. These PiGs threshold values are:

Texas	5 tons/day NO_X
Mexico, Oklahoma, Louisiana, Arkansas	7.5 tons/day NO_X
Mississippi	10 tons/day NO_X
Alabama, Tennessee, Ohio	15 tons/day NO_X
Other states	25 tons/day NO_X

5.1.3 Boundary Conditions, Initial Conditions, and Land Use File

Boundary and initial conditions used for the 36 km domain were provided by the GEOS–Chem Model. "GEOS–Chem is a global 3-D chemical transport model (CTM) for atmospheric composition driven by meteorological input from the Goddard Earth Observing System (GEOS) of the NASA Global Modeling and Assimilation Office. It is applied by research groups around the world to a wide range of atmospheric composition problems."[256] Boundary conditions were developed for each grid cell at the edge of the 36km grid for every layer and hour of the modeling episode.

The land use distribution file is used to determine the dry deposition rates of all gases and surface albedo. The fraction of land use in each grid for the 4 km, 12 km, and 36 km grids was based on the Leaf Area Index (LAI) database. The GLASS Leaf Area Index (LAI) product is described as a "global LAI product with long time series, generated and released by the Center for Global Change Data Processing and Analysis of Beijing Normal University." [257]

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[255] ENVIRON International Corporation, May 2008. "User's Guide: Comprehensive Air Quality Modeling with Extensions, Version 5.40". Novato, CA. p. 4-1.

[256] Harvard University and Dalhousie University, April 12, 2013. "GEOS–Chem Model". Available online: http://geos-chem.org/. Accessed 06/24/13.

[257] Shunlin Liang, Zhiqiang Xiao, 2012. "Global Land Surface Products: Leaf Area Index Product Data Collection (1985-2010)". Beijing Normal University. Available online: http://glcf.umd.edu/data/lai/index.shtml. Accessed 06/24/13.

5.2 CAMx Base Case Runs

Once all the data was input into CAMx, the model was run to produce several 2006 base case and projection case runs. Four base case runs were tested with different emission inventories to determine modeling performance before the photochemical model was projected to 2012 and 2018. A fifth base case run with MM5 was also included in the analysis to provide a comparison to previous modeling results. All CAMx base case runs utilized WRF data with 4-km grid 1-way nesting with 3D upper-air and surface nudging using NWS data with time shift.[258]

MM5 Base Case Run 7

- Met run 11 with MM5 and MRF
- CAMx 4.53
- 5-layer soil model
- 1-hour surface wind analysis nudging using a 1-hour ADP observation dataset in conjunction with 3-hour EDAS analyses
- MM5CAMx “OB70” diffusivity option

WRF TCEQ Base Case Run 1

- WRF v3.2
- CAMx 5.40
- 5 layer thermal diffusion and no LSM
- YSU PBL scheme
- Kain-Fritsch cumulus
- WSM5 microphysics for us_36km and tx_12km domains
- WSM6 microphysics for tx_4km domain
- 3D upper-air and surface nudging using NWS data with time shift (ts) for tx_4km domain
- WRF to CAMx conversion: wrf2camx v3.2 with YSU Kv, and 100m kvpatch (kv100)
- Existing merged TCEQ emission files
- US 36km grid system

WRF TCEQ Base Case Run 2

- WRF v3.2
- CAMx 5.40
- 5 layer thermal diffusion and no LSM
- YSU PBL scheme
- Kain-Fritsch cumulus
- WSM5 microphysics for us_36km and tx_12km domains
- WSM6 microphysics for tx_4km domain
- 3D upper-air and surface nudging using NWS data with time shift (ts) for tx_4km domain
- WRF to CAMx conversion: wrf2camx v3.2 with YSU Kv, and 100m kvpatch (kv100)

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[258] TCEQ. Austin, Texas. Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/camx/basecase/bc06_06jun.reg2a.2006ep0ext_5layer_YSU_WSM6_3dsfc_fddats/. Accessed 06/12/13.

- AACOG EPS3 processed and merged TCEQ Emission Files
- US 36km grid system

<u>WRF AACOG Base Case Run 3</u>

- WRF v3.2
- CAMx 5.40
- 5 layer thermal diffusion and no LSM
- YSU PBL scheme
- Kain-Fritsch cumulus
- WSM5 microphysics for us_36km and tx_12km domains
- WSM6 microphysics for tx_4km domain
- 3D upper-air and surface nudging using NWS data with time shift (ts) for tx_4km domain
- WRF to CAMx conversion: wrf2camx v3.2 with YSU Kv, and 100m kvpatch (kv100)
- Local San Antonio-New Braunfels MSA emission data including construction equipment, landfill equipment, quarry equipment, agricultural tractors, combines, commercial airports, point sources, and heavy duty truck idling
- US 36km grid system

<u>WRF AACOG RPO Base Case Run 4</u>

- WRF v3.2
- CAMx 5.40
- 5 layer thermal diffusion and no LSM
- YSU PBL scheme
- Kain-Fritsch cumulus
- WSM5 microphysics for us_36km and tx_12km domains
- WSM6 microphysics for tx_4km domain
- 3D upper-air and surface nudging using NWS data with time shift (ts) for tx_4km domain
- WRF to CAMx conversion: wrf2camx v3.2 with YSU Kv, and 100m kvpatch (kv100)
- Local San Antonio-New Braunfels MSA emission data including construction equipment, landfill equipment, quarry equipment, agricultural tractors, combines, commercial airports, point sources, and heavy duty truck idling
- RPO 36km grid system

5.3 Diagnostic and Statistical Analysis of CAMx Runs

Each CAMx run was compared to observed data from eleven monitors in the San Antonio - New Braunfels MSA, C23, C58, C59, C501, C502, C503, C504, C505, C506, C622, and C678, to evaluate the model's performance in predicting ozone concentrations. The performance of the June 2006 modeling episode was evaluated in two ways: (1) how well was the model able to replicate observed concentrations of ozone and (2) how accurate was the model in characterizing the sensitivity of ozone to changes in emissions?[259]

The first question was answered by a series of operational evaluations including time series comparisons, daily ozone plots, statistical analyses, scatter plots, and plots of daily maximum 8-hour ozone fields. These operation tests specifically address the accuracy of the model's predictions as compared to actual ozone concentrations observed at AACOG monitors. [260]

5.3.1 Hourly Ozone Time Series

Time series plots of observed and predicted hourly ozone were constructed for each potential non-attainment regulatory monitor located in the San Antonio New Braunfels MSA. EPA recommends creating these plots because they "can indicate if there are particular times of the day or days of the week when the model performs especially poorly".[261] Figure 5-1 through Figure 5-11 provide a comparison of the hourly observed and predicted data for every ozone monitor in the San Antonio-New Braunfels MSA. The data for these time series plots was derived solely from AACOG base case run 3, as all four WRF runs had similar results.

Using the inputs described earlier, the CAMx model over predicted ozone concentrations at the monitors on the northwest side of San Antonio, C23, C25, and C505 on two of the episode's exceedance days: June 13 and 14th. On other days of the episode, the model's ozone estimations correlated well with observed peak hourly ozone values and predicted peak hourly ozone values. For most monitors, there was an excellent correlation between observed peak hourly ozone and predicted hourly ozone in the second half of the episode, with some under prediction at C503.

When examining the diurnal bias, model results for C58 over predicted diurnal ozone on most exceedance days during the episode. The model also over predicted diurnal hourly ozone in the second part of the episode at monitors located in rural areas of the San Antonio-New Braunfels MSA, C502, C503, C504, and C506, .

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[259] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." U.S. EPA Office of Air Quality Planning and Standards, Air Quality Analysis Division, Air Quality Modeling Group, Research Triangle Park, NC. Section 18.0, p. 190.

[260] *Ibid*.

[261] *Ibid*., p. 200.

Figure 5-1: 1-Hour Ozone Time Series Observed (C23) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

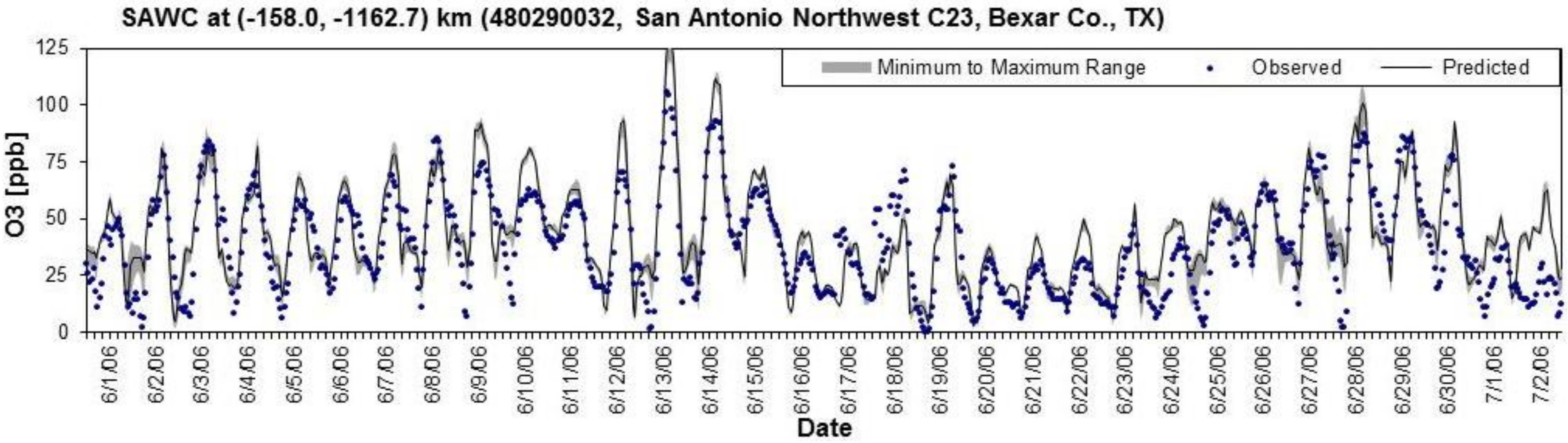


Figure 5-2: 1-Hour Ozone Time Series Observed (C58) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

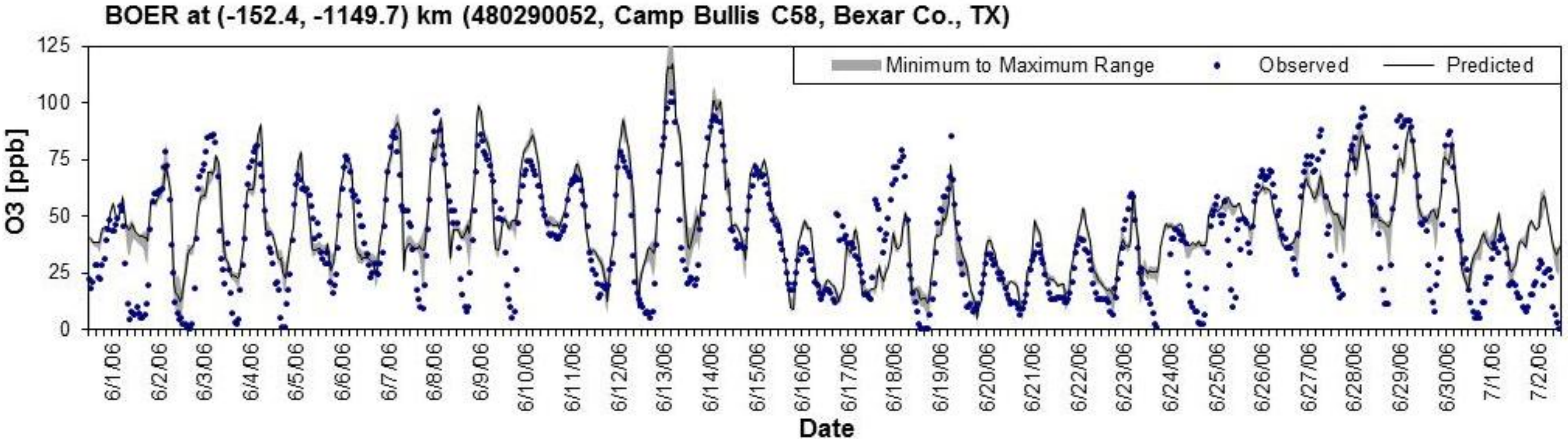


Figure 5-3: 1-Hour Ozone Time Series Observed (C59) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

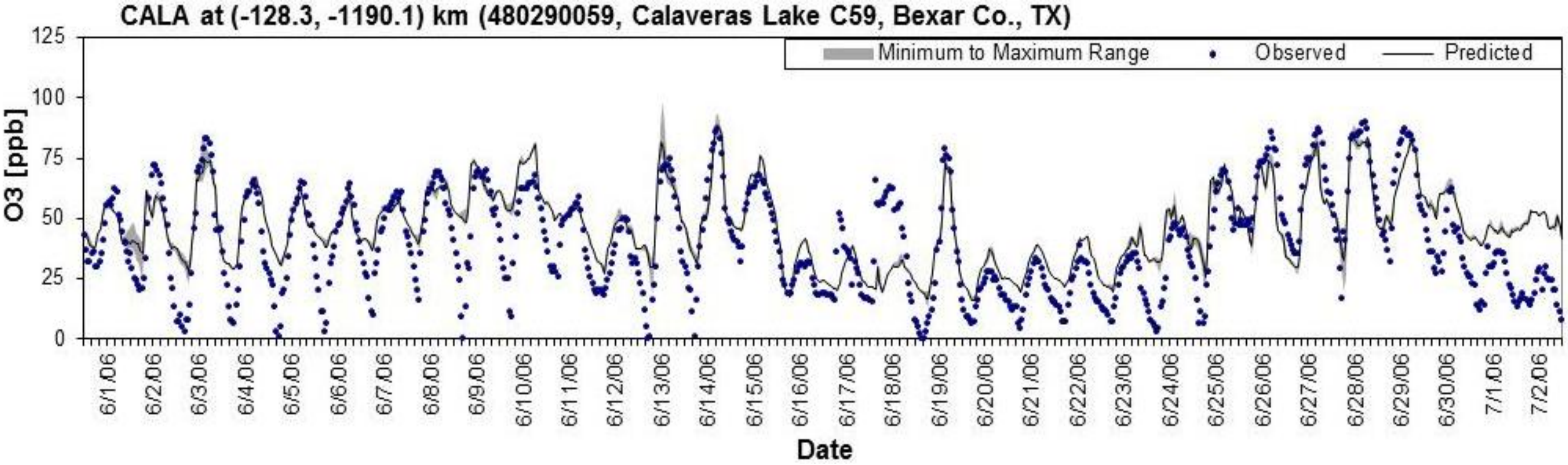


Figure 5-4: 1-Hour Ozone Time Series Observed (C622) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

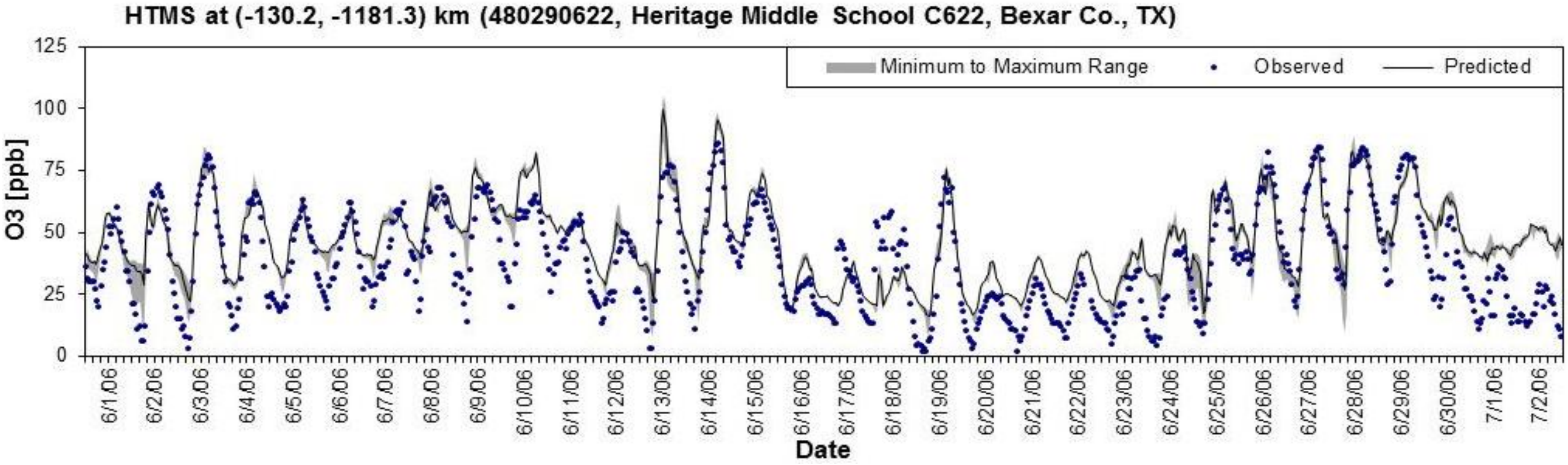


Figure 5-5: 1-Hour Ozone Time Series Observed (C678) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

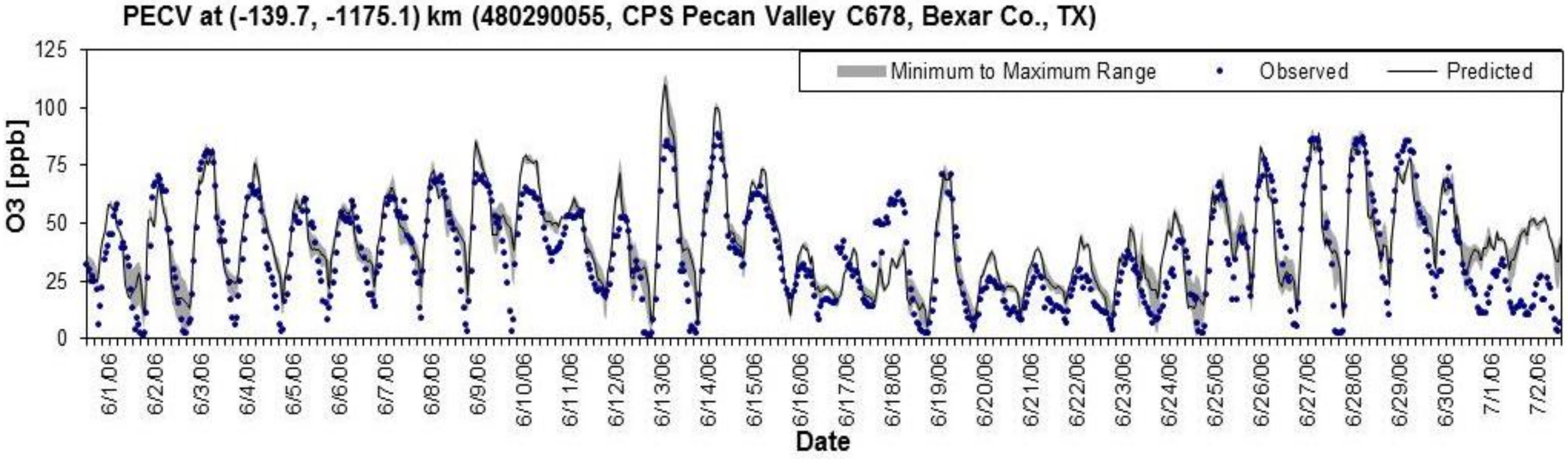


Figure 5-6: 1-Hour Ozone Time Series Observed (C501) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

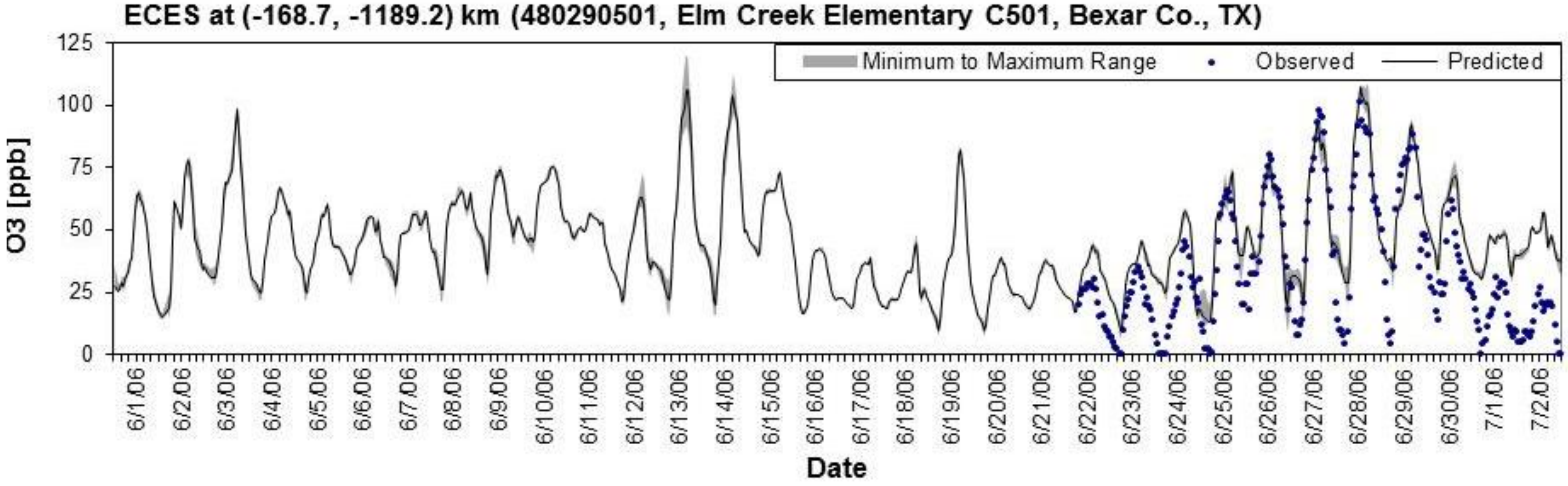


Figure 5-7: 1-Hour Ozone Time Series Observed (C502) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

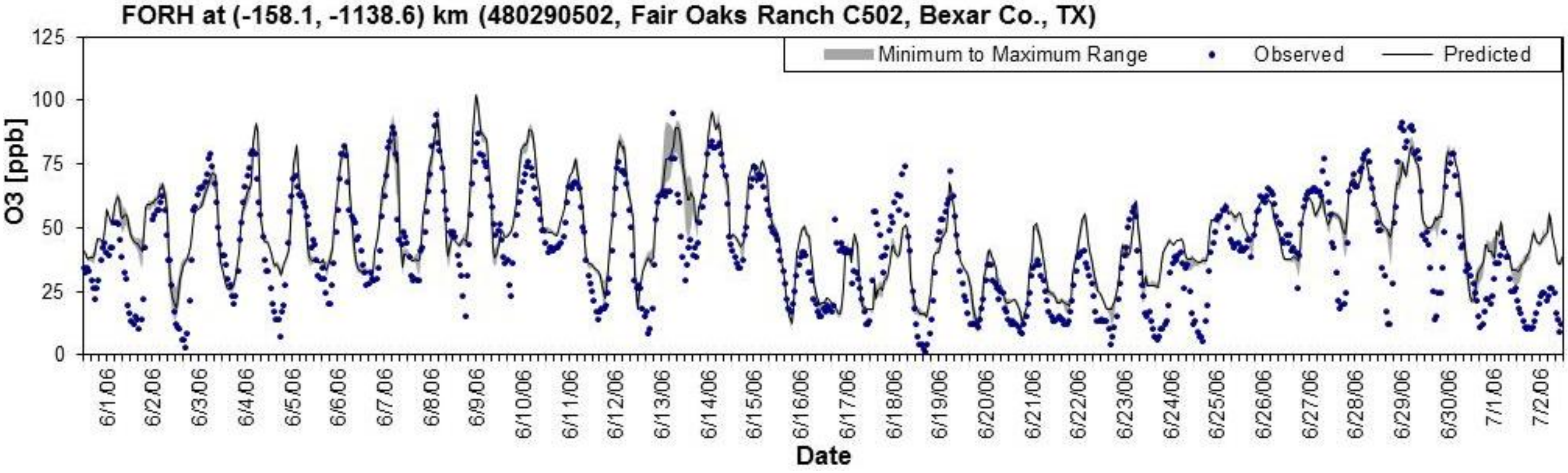


Figure 5-8: 1-Hour Ozone Time Series Observed (C503) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

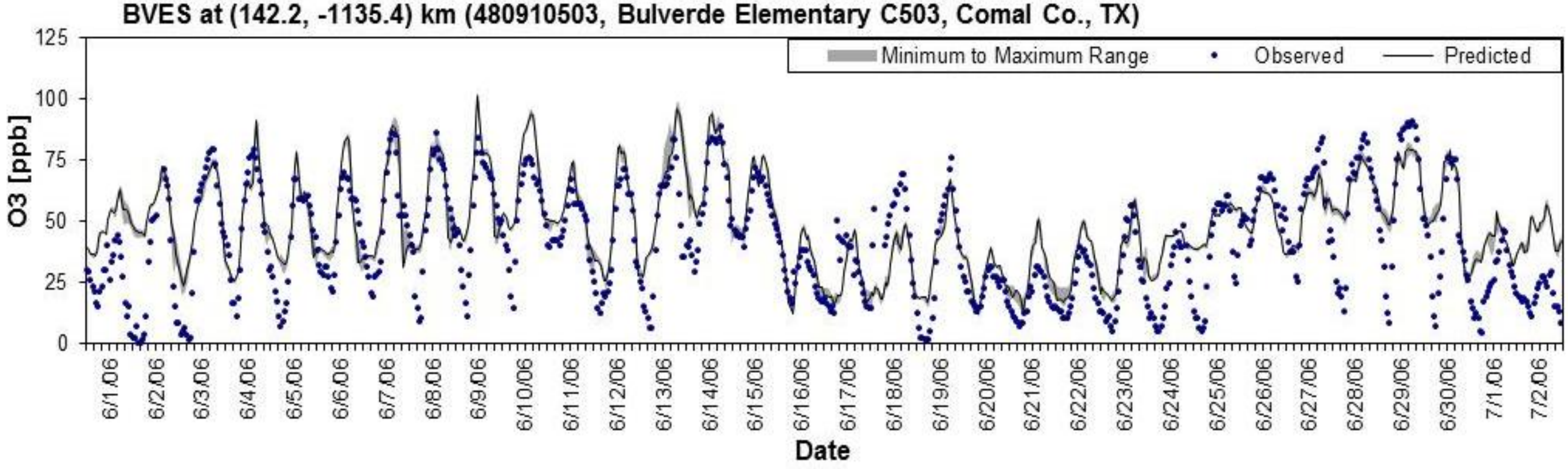


Figure 5-9: 1-Hour Ozone Time Series Observed (C504) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

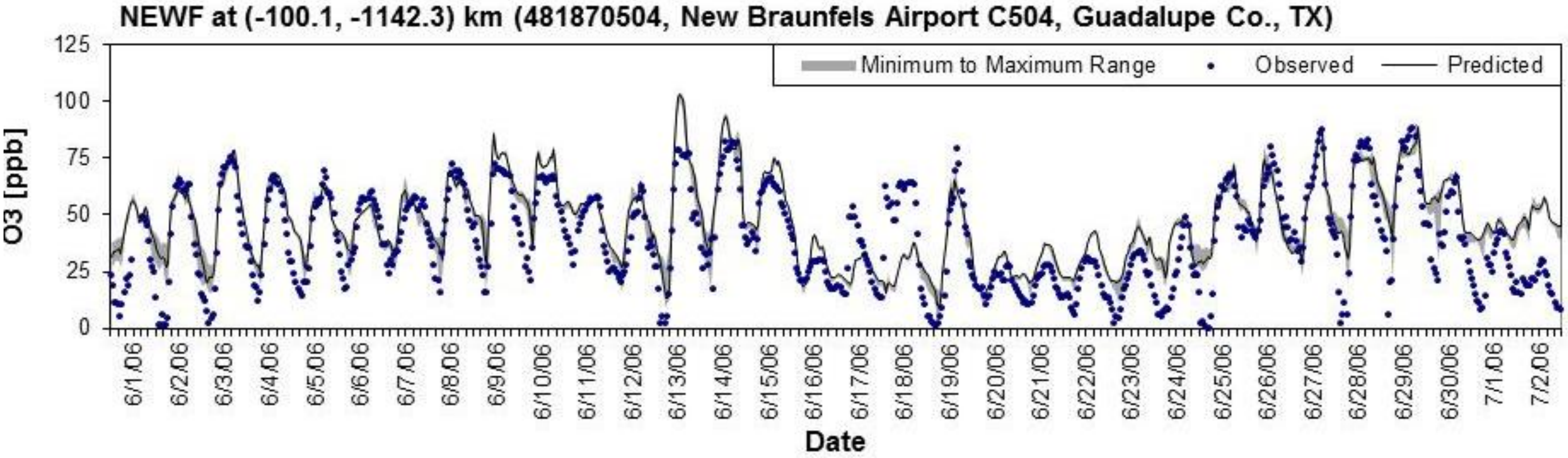


Figure 5-10: 1-Hour Ozone Time Series Observed (C505) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

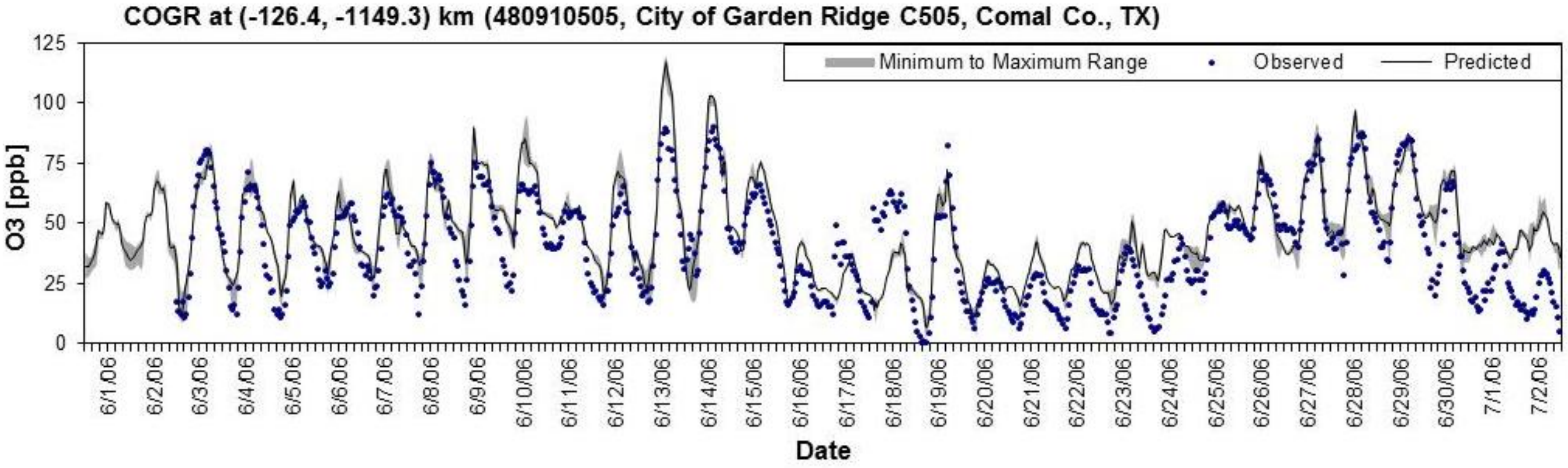
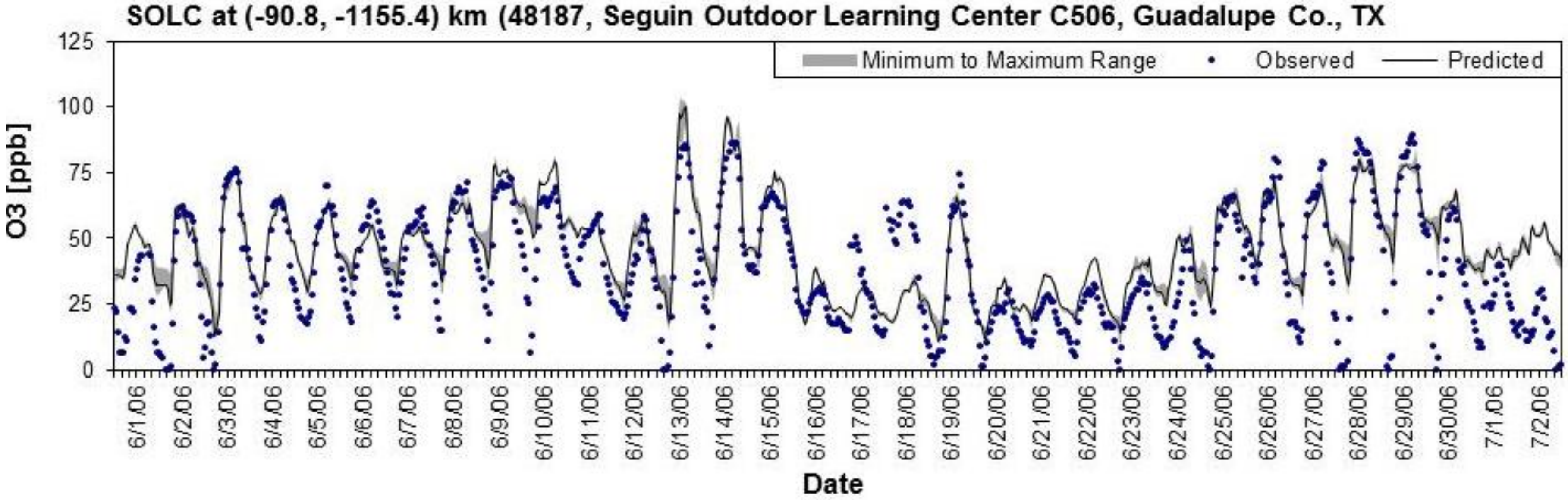


Figure 5-11: 1-Hour Ozone Time Series Observed (C506) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

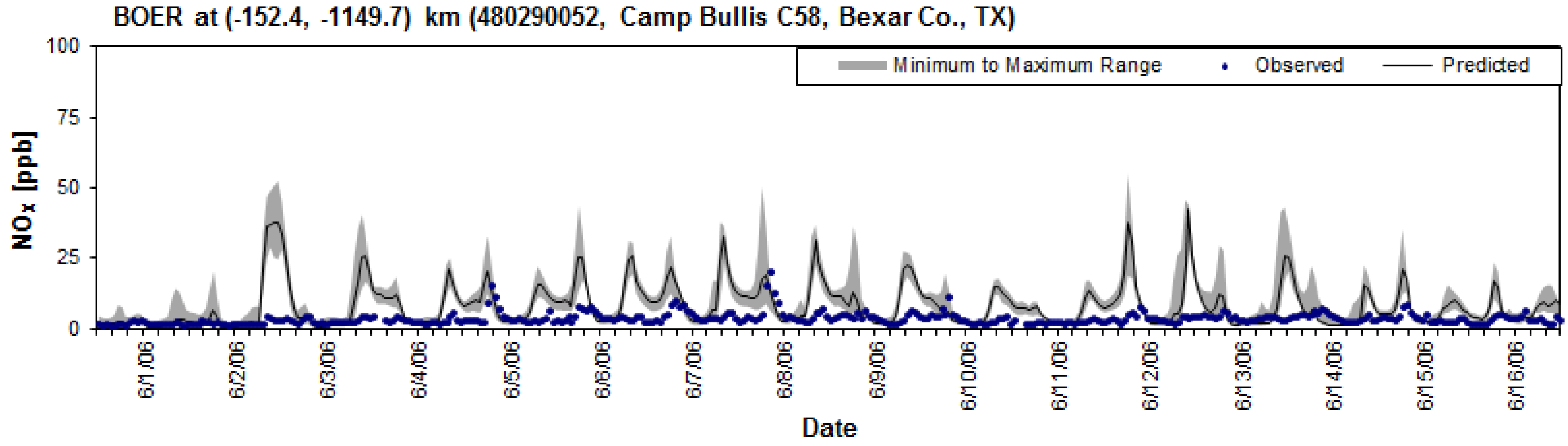


5.3.2 Hourly NO_X Time Series

Time series plots of modeled and predicted hourly NO_X for each monitor located in the San Antonio MSA were constructed. The model over predicted NO_X emissions at the C58 monitor on almost every day during the June 2006 episode. The average predicted hourly NO_X was 7.3 ppb, while the average observed hourly NO_X was only 3.9 ppb. Likewise, the average predicted maximum NO_X was 20.1 ppb, whereas the average observed maximum NO_X was 8.5 ppb. This over prediction of NO_X at C58 probably caused the poor model performance of predicted diurnal ozone at the monitor.

In contrast, C59 under predicted NO_X on several days including the ozone exceedance days of June 7th, 8th, 9th, 13th, and 14th. Model performance was good for most days at the C622 and C678 NO_X monitors in southeast Bexar County. However, the model over predicted ozone at the C678 monitor on several days, although most of these days were not associated with elevated ozone levels. The average predicted NO_X was higher at C678, and lower at both the C59 and C622 monitors on the southeast side of San Antonio.

Figure 5-12: 1-Hour NO_X Time Series Observed (C58) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006



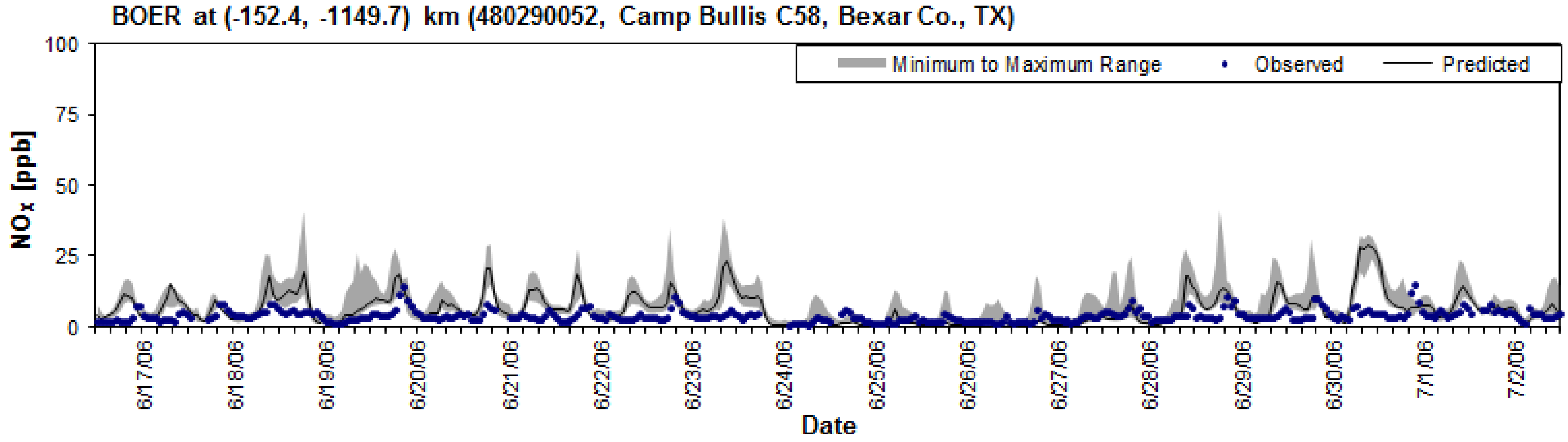


Figure 5-13: 1-Hour NO_X Time Series Observed (C59) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006

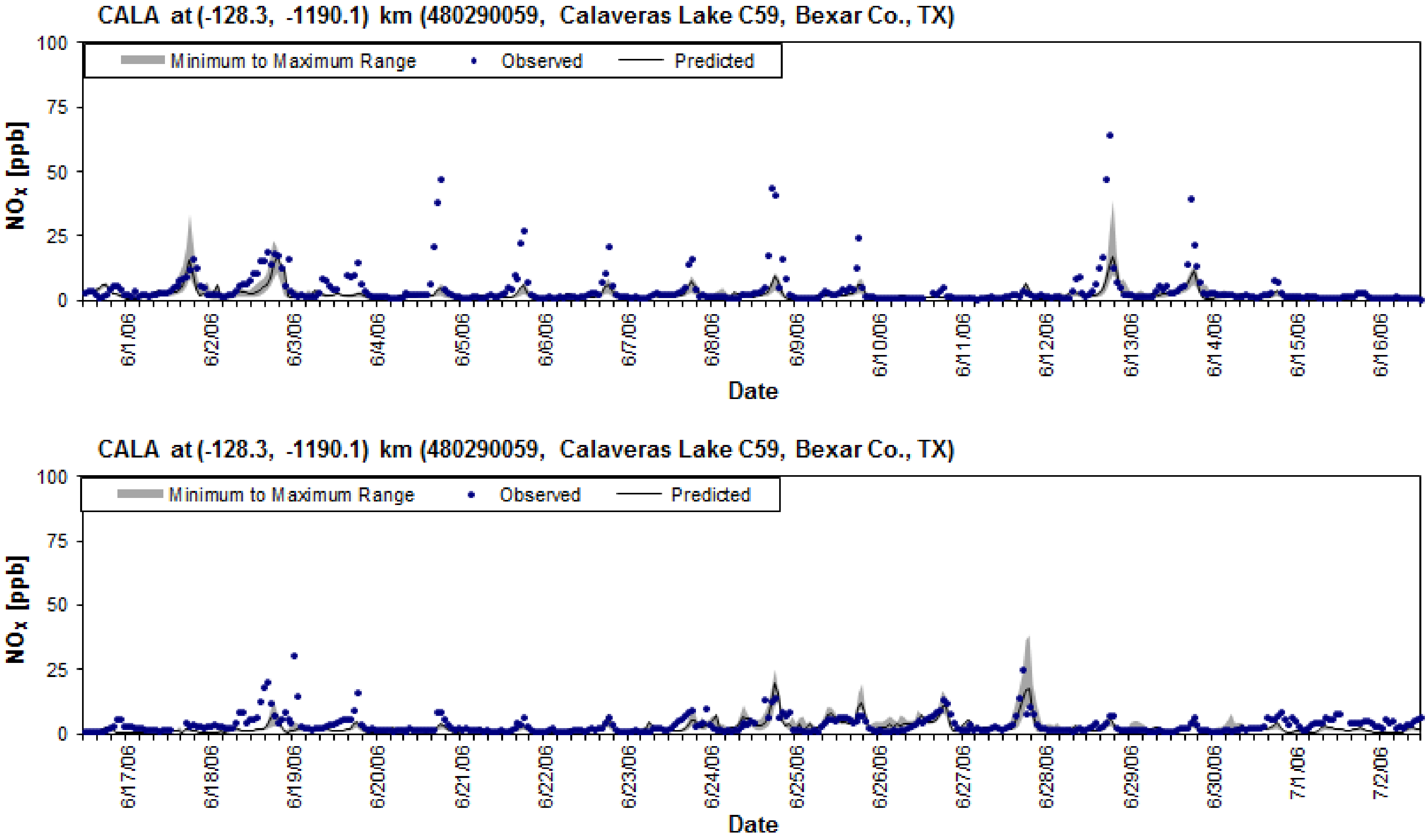
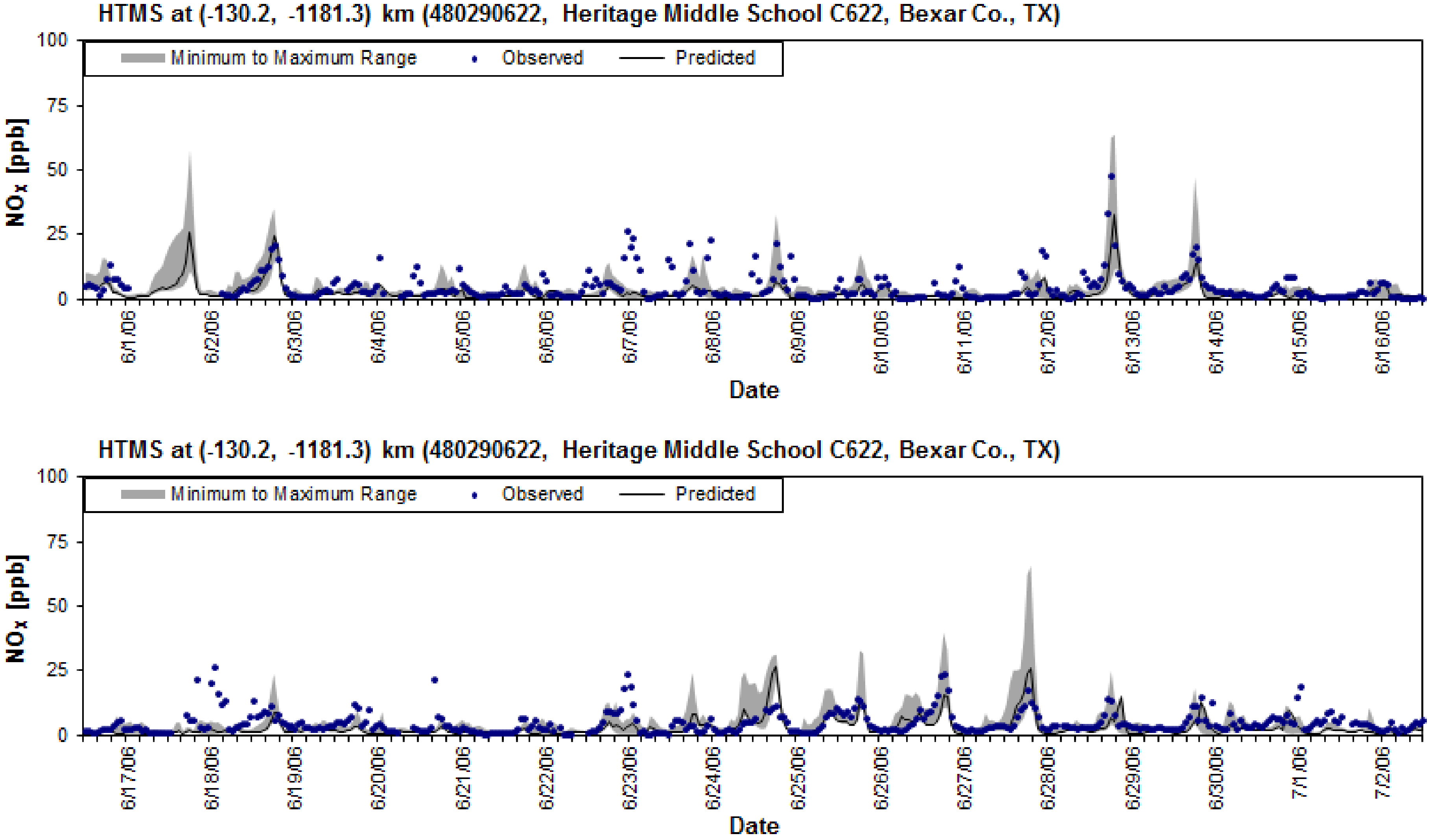


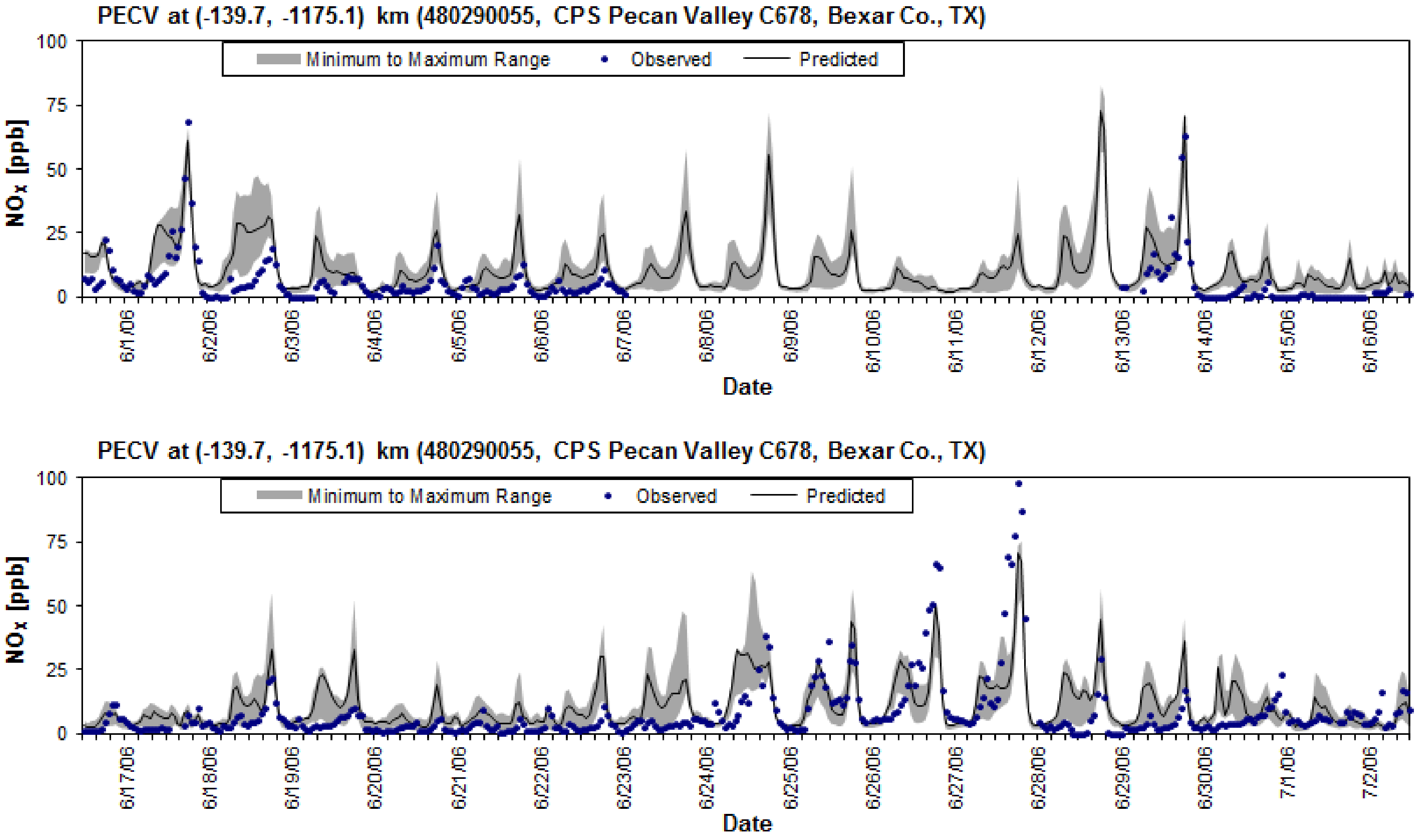
Figure 5-14: 1-Hour NO_X Time Series Observed (C622) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006



HTMS at (-130.2, -1181.3) km (480290622, Heritage Middle School C622, Bexar Co., TX)

HTMS at (-130.2, -1181.3) km (480290622, Heritage Middle School C622, Bexar Co., TX)

Figure 5-15: 1-Hour NO_X Time Series Observed (C678) v. Predicted (CAMx) for WRF AACOG Base Case Run 3, 2006



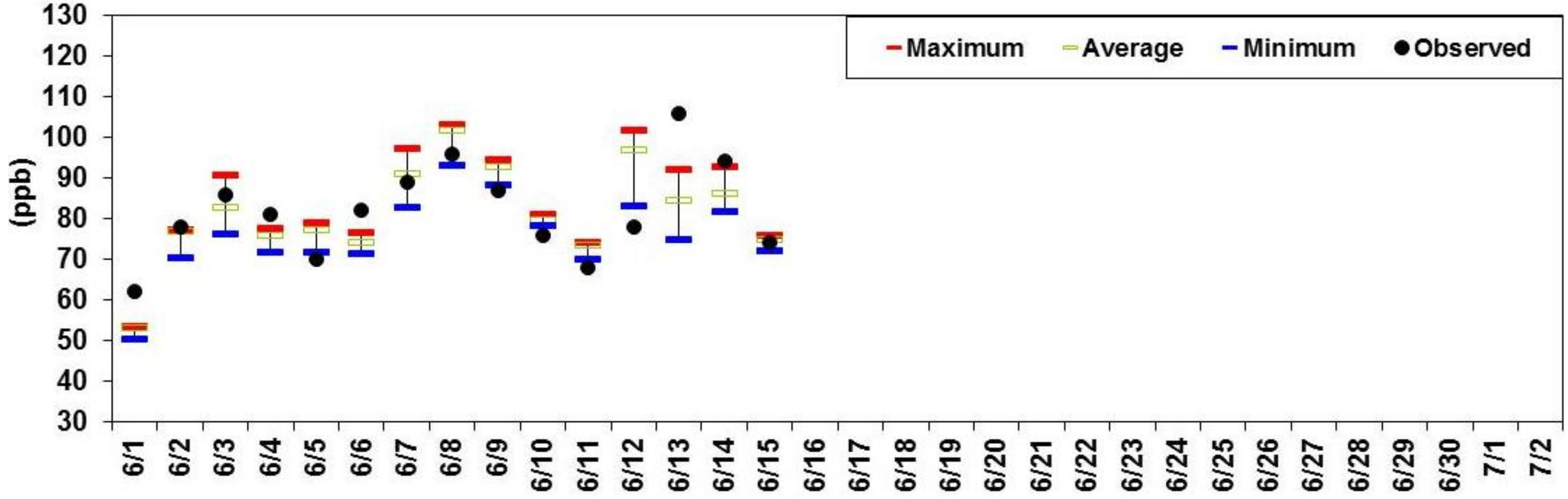
5.3.3 *Daily Ozone Plots*

Daily peak predicted maximum, peak average, and peak minimum ozone in a 7 x 7 4-km grid around all monitors, C23 monitor, and C58 monitor are plotted in Figure 5-16, Figure 5-17, and Figure 5-18. MM5 base case run 7 exhibited poor modeling performance when predicting ozone formation on the June 13 exceedance day. Data is not available for the second half of the episode because MM5 was only run during the May 29th to June 15th, 2006 time period.

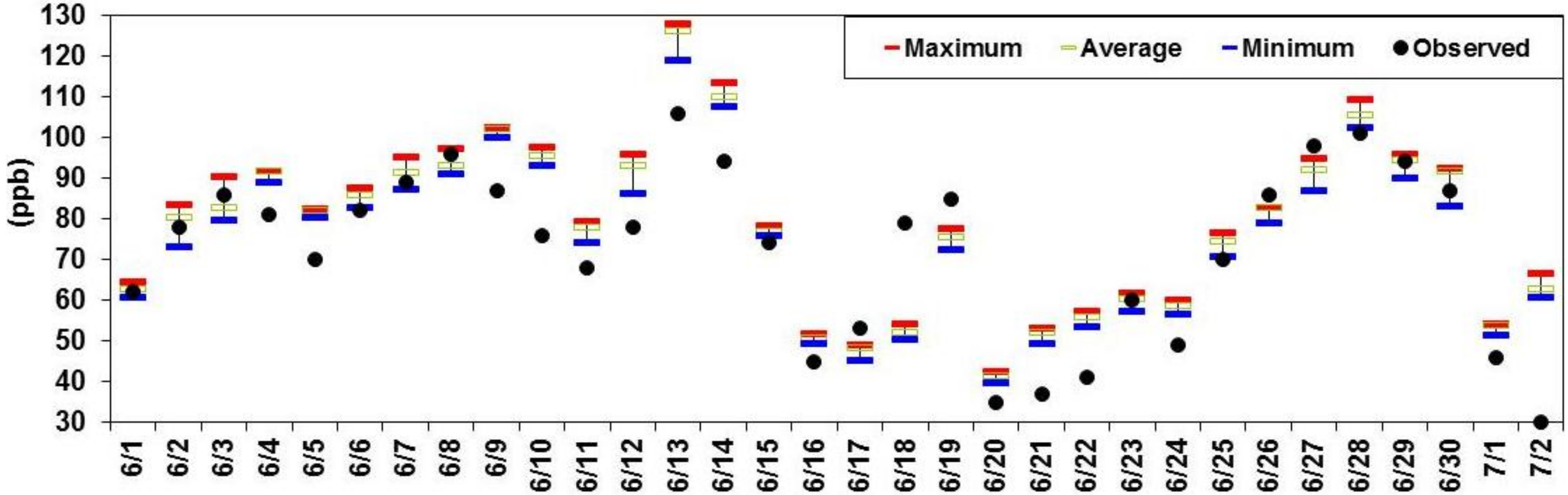
Runs using WRF over predicted hourly ozone on June 13th and June 14th. There was also a slight over prediction on the June 9th exceedance day. The WRF runs slightly under predicted ozone at C58 on June 3rd, but model performance was good overall. Modeling performance for the exceedance days in the second half of the episode, June 26th, 27th, 28th, and 29th, was good. Overall, modeling performance was improved when using WRF instead of MM5.

Although there were several significant differences in the local emission inventory, model results are similar for TCEQ run 1, TCEQ run 2, and AACOG run 3 for every monitor. Changes in meterological conditions had a greater impact on the model's predicted ozone formation than changes to the emission inventories. For AACOG run 4 using the RPO grid, predicted ozone on some exceedance days was higher than the other 3 runs. Notably, AACOG run 4 predicted higher ozone on both the June 13th and 14th exceedance days.

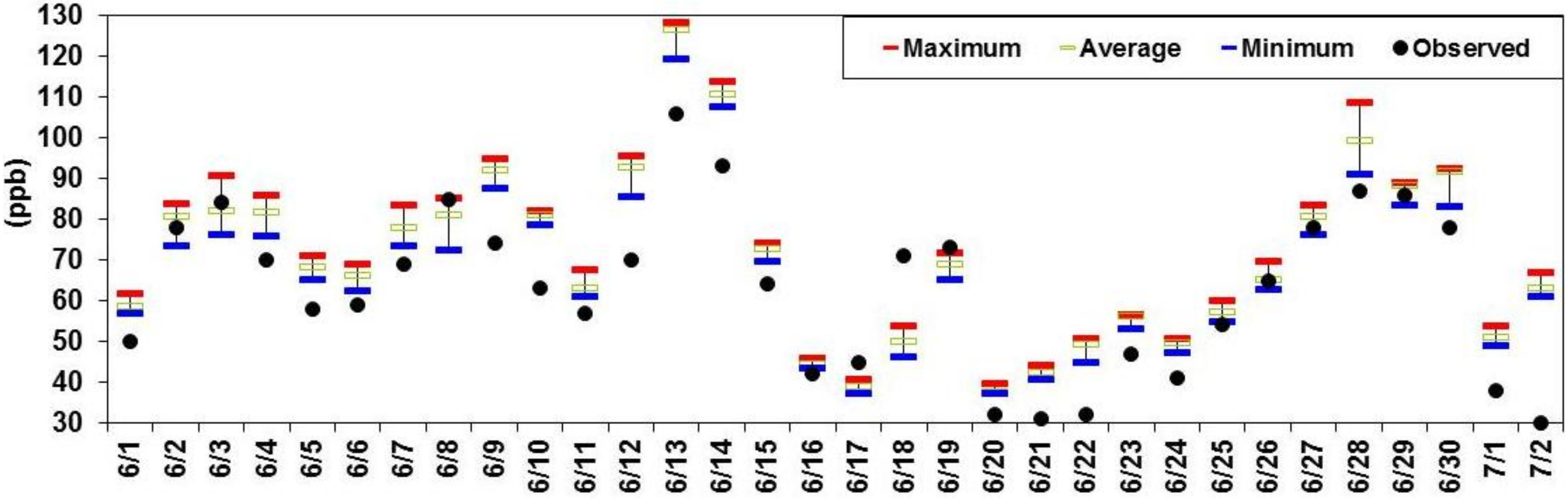
Figure 5-16: San Antonio Observed Ozone for All CAMS Daily Maximum 1-hr Average

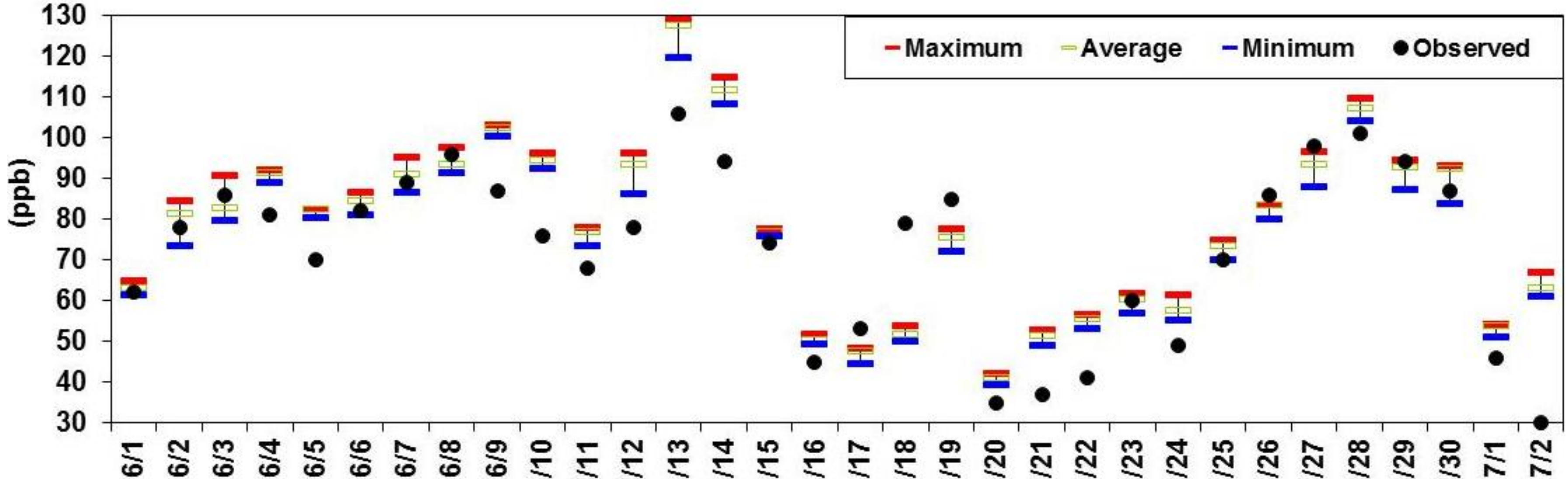


MM5 Base Case Run 7



WRF TCEQ Base Case Run 1


WRF TCEQ Base Case Run 2


WRF AACOG Base Case Run 3

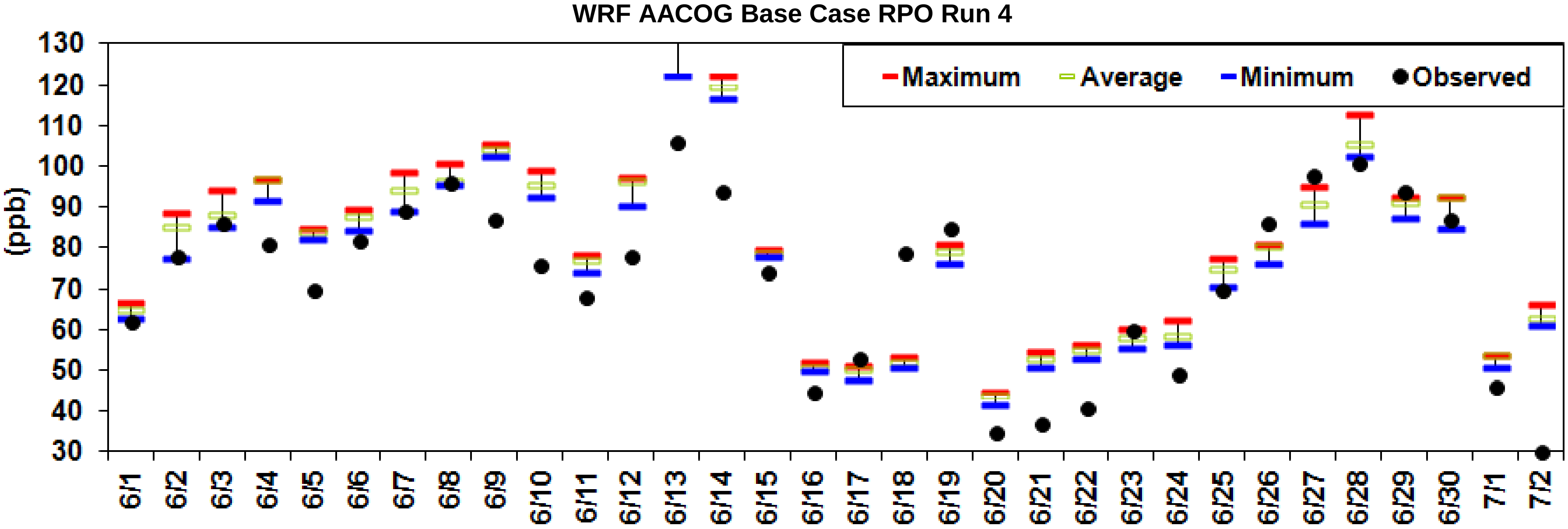
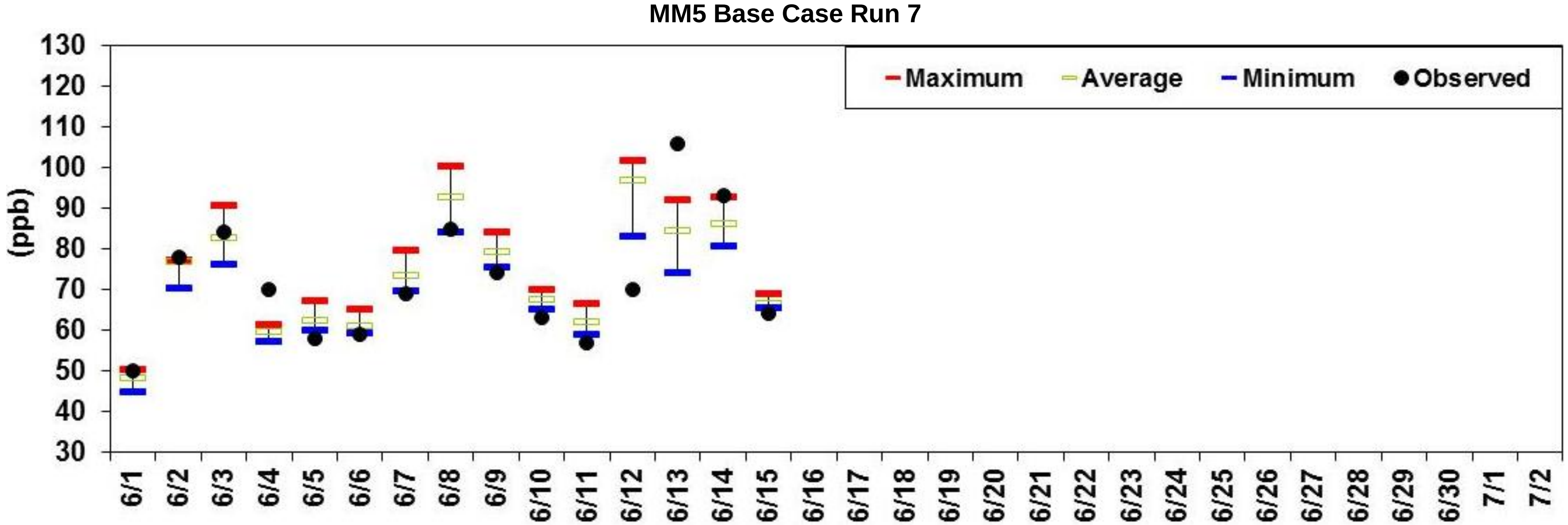
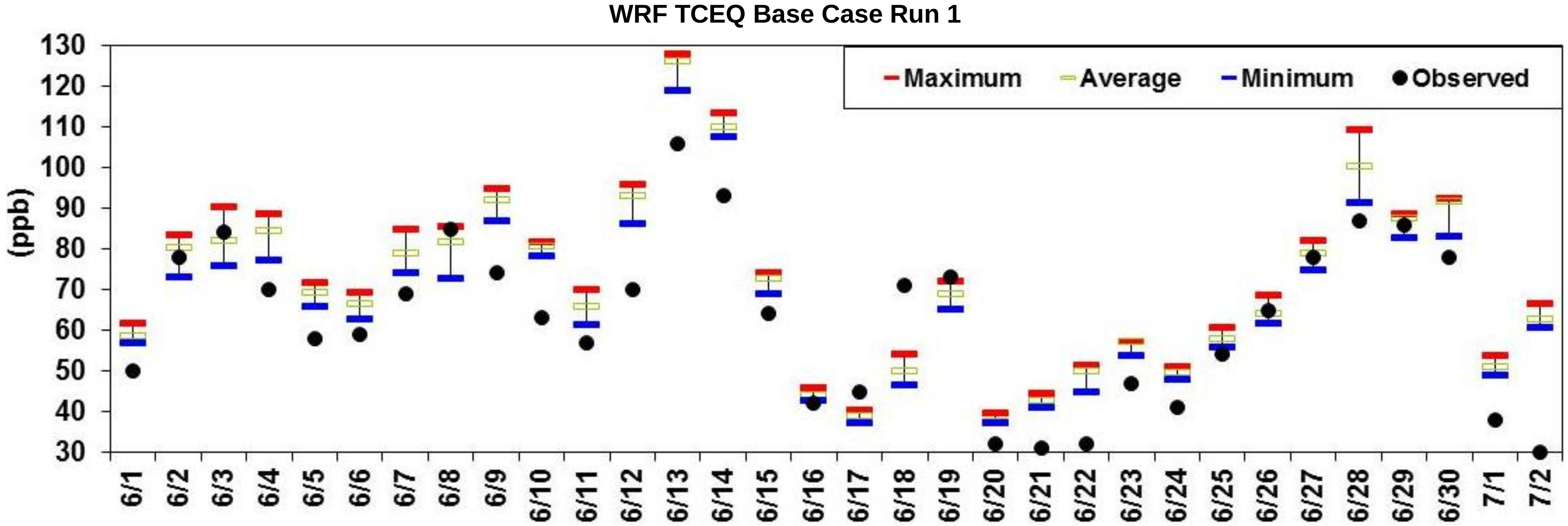
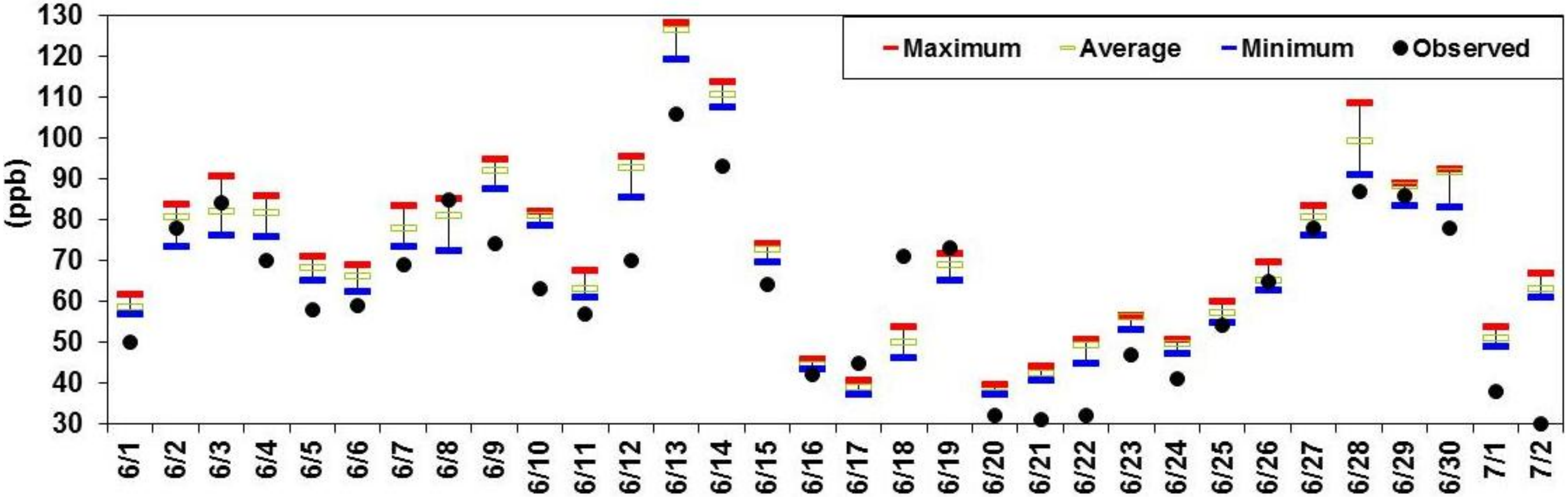

WRF AACOG Base Case RPO Run 4
Maximum
Average
Minimum
Observed
(ppb)
130
120
110
100
90
80
70
60
50
40
30
6/1
6/2
6/3
6/4
6/5
6/6
6/7
6/8
6/9
6/10
6/11
6/12
6/13
6/14
6/15
6/16
6/17
6/18
6/19
6/20
6/21
6/22
6/23
6/24
6/25
6/26
6/27
6/28
6/29
6/30
7/1
7/2

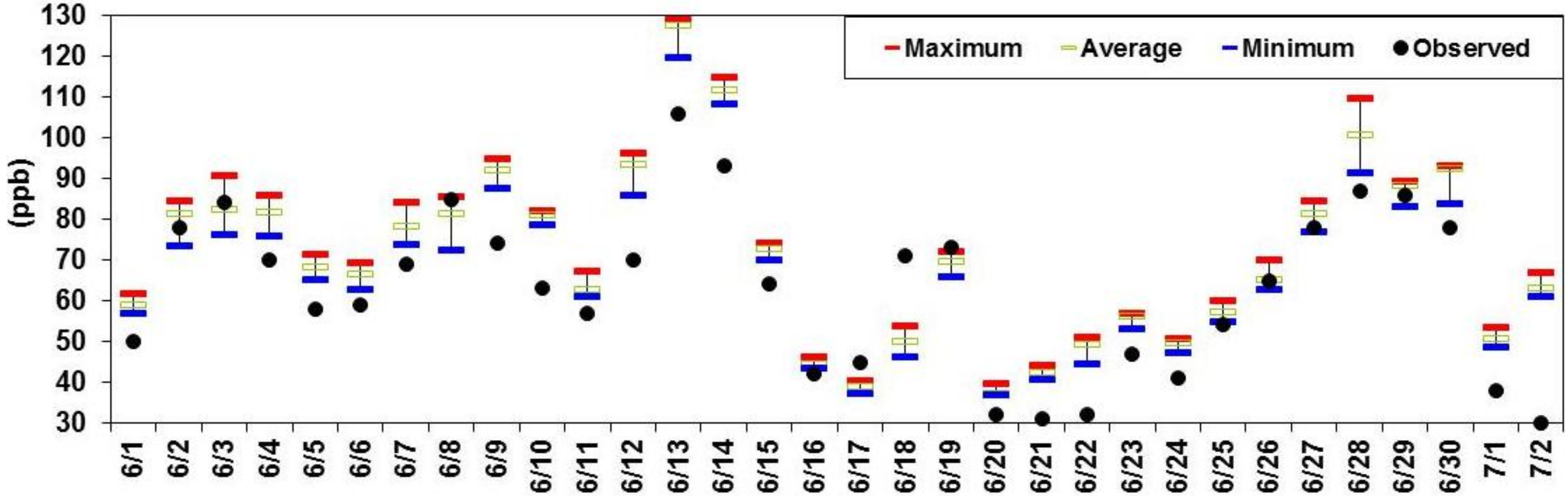
Figure 5-17: San Antonio Observed Ozone for CAMS 23 Daily Maximum 1-hr Average







WRF TCEQ Base Case Run 2



WRF AACOG Base Case Run 3

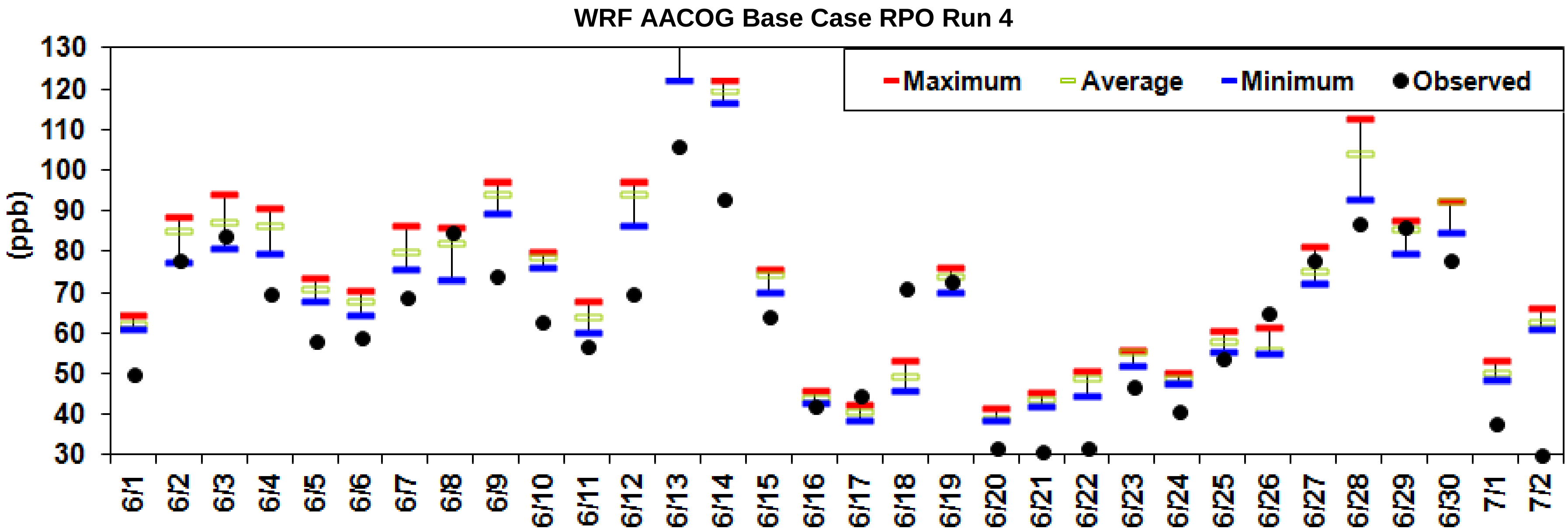
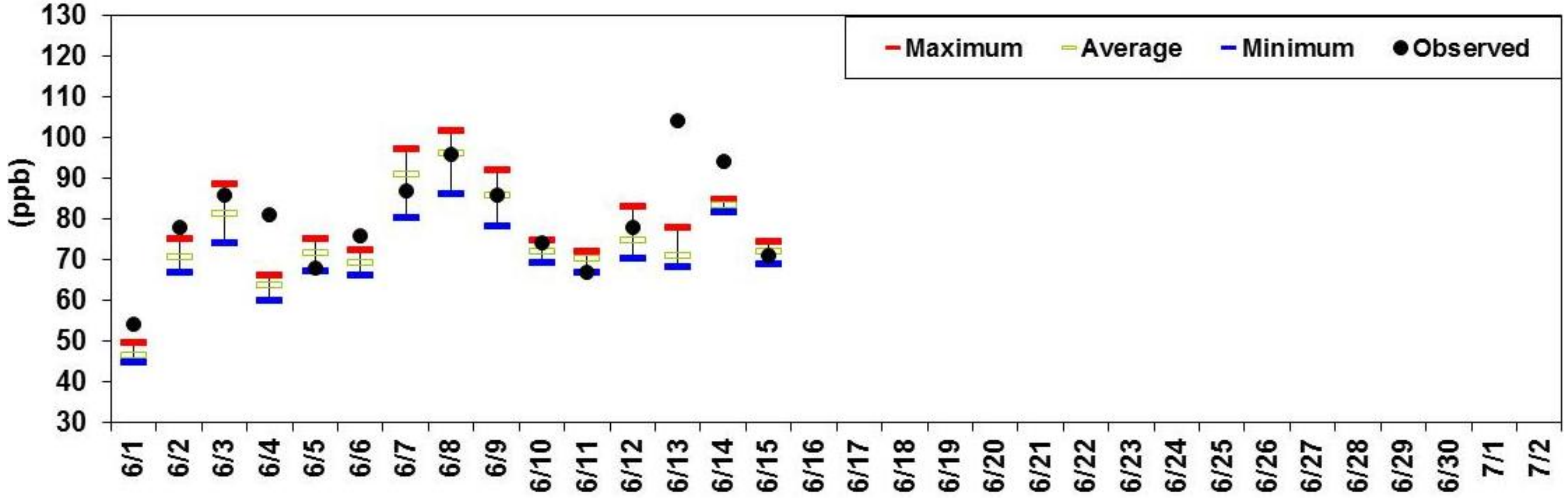
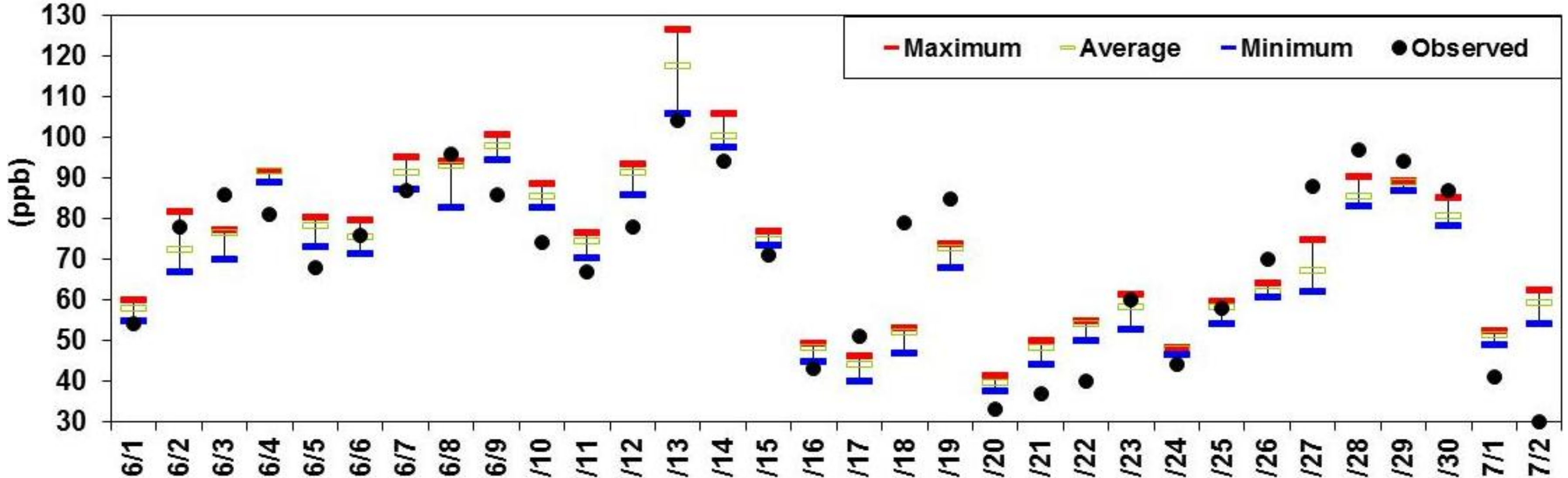

WRF AACOG Base Case RPO Run 4
(ppb)
130
120
110
100
90
80
70
60
50
40
30
Maximum
Average
Minimum
Observed
6/1
6/2
6/3
6/4
6/5
6/6
6/7
6/8
6/9
6/10
6/11
6/12
6/13
6/14
6/15
6/16
6/17
6/18
6/19
6/20
6/21
6/22
6/23
6/24
6/25
6/26
6/27
6/28
6/29
6/30
7/1
7/2

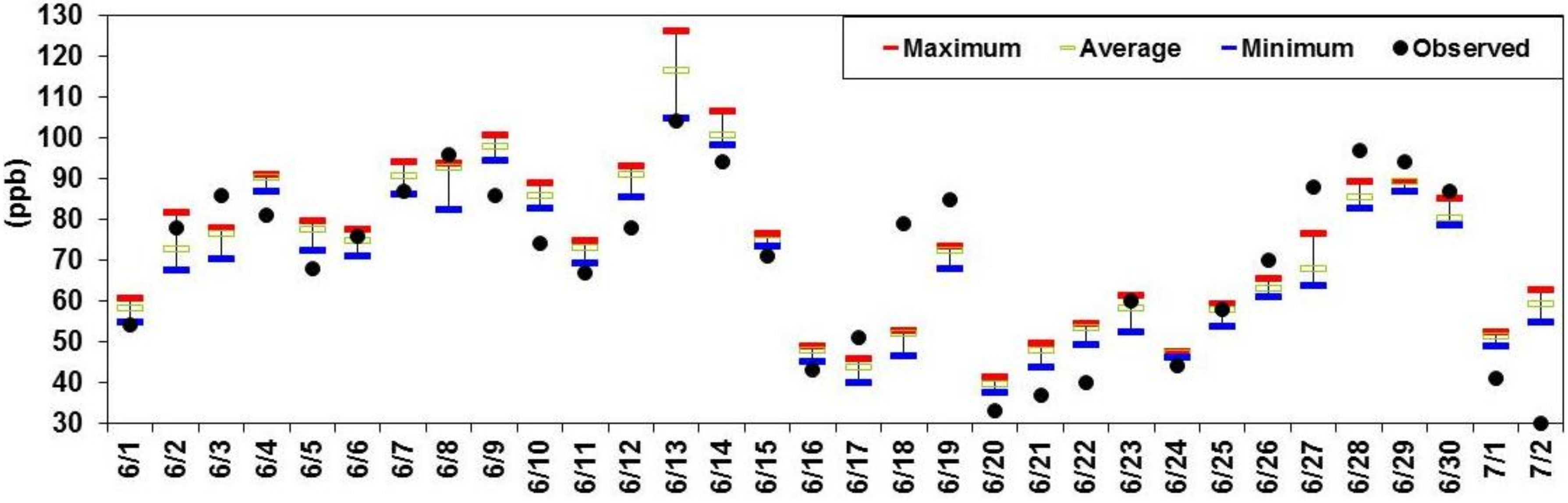
Figure 5-18: San Antonio Observed Ozone for CAMS 58 Daily Maximum 1-hr Average

MM5 Base Case Run 7

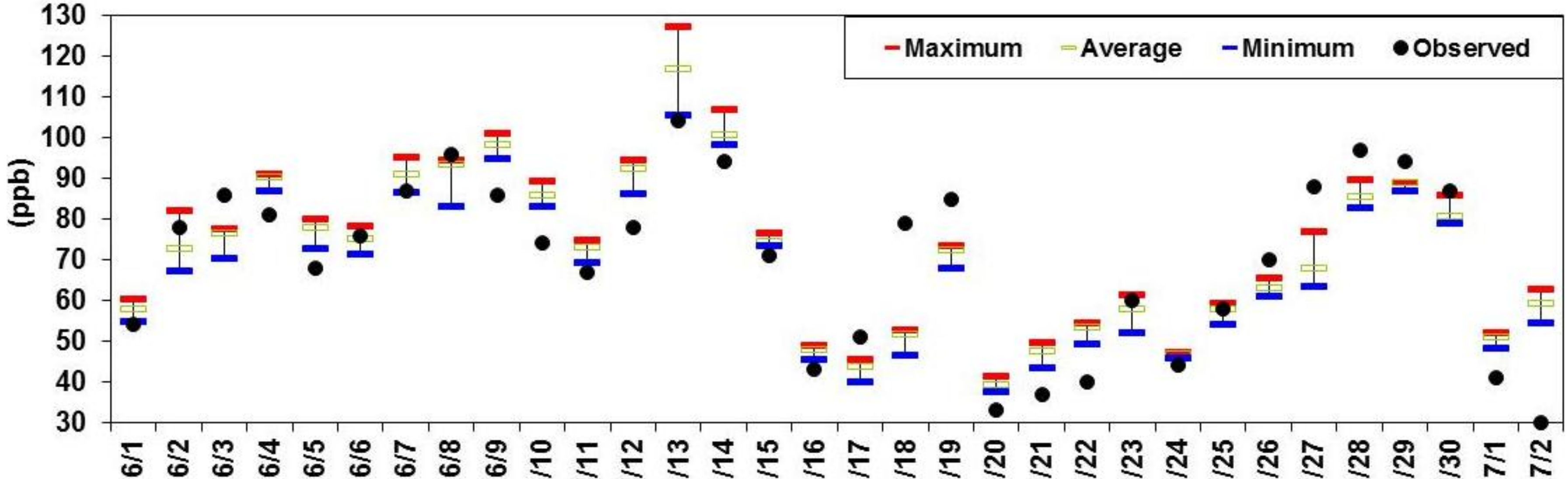


WRF TCEQ Base Case Run 1

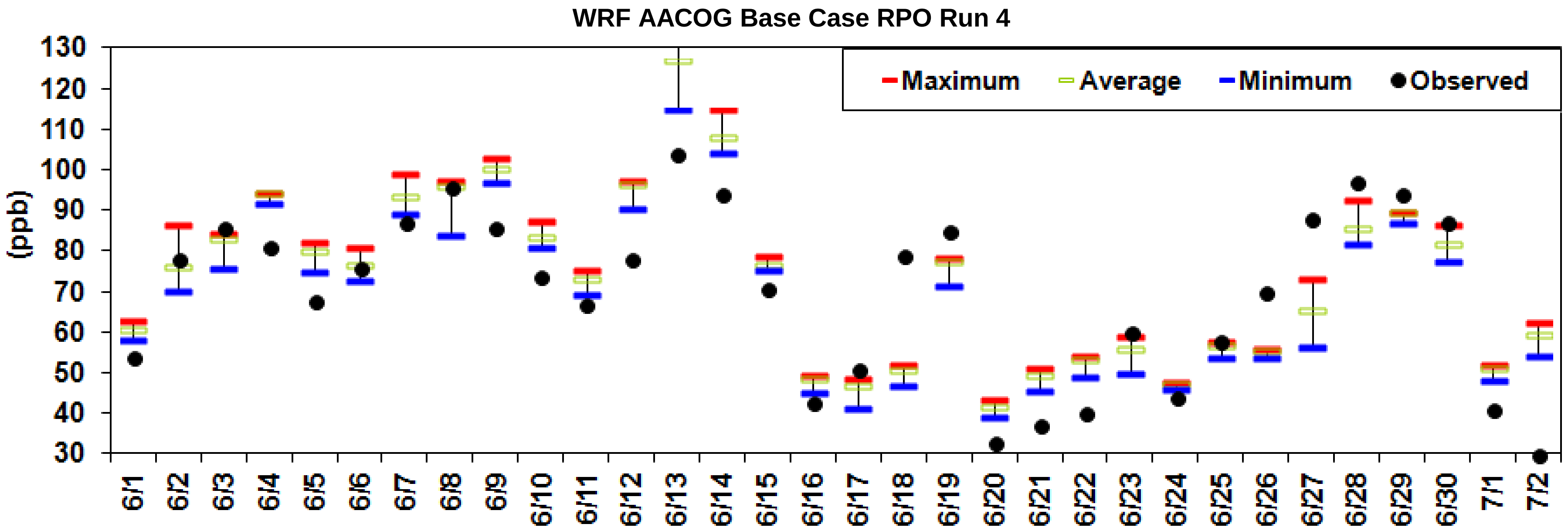




WRF TCEQ Base Case Run 2



WRF AACOG Base Case Run 3


WRF AACOG Base Case RPO Run 4
Maximum
Average
Minimum
Observed
(ppb)
130
120
110
100
90
80
70
60
50
40
30
6/1
6/2
6/3
6/4
6/5
6/6
6/7
6/8
6/9
6/10
6/11
6/12
6/13
6/14
6/15
6/16
6/17
6/18
6/19
6/20
6/21
6/22
6/23
6/24
6/25
6/26
6/27
6/28
6/29
6/30
7/1
7/2

5.4 Statistical Analysis

There are several statistical measures recommended by the EPA for the purpose of evaluating performance of each base case run. This section will describe each statistical measurement, the statistical results for the modeled runs, and what the statistics indicate about overall model performance. The following six statistical measures were calculated to analyze the model's ability to predict ozone concentrations for the June 2006 episode: unpaired peak prediction accuracy, paired peak predicted accuracy, mean normalized bias, mean normalized gross error, average peak predicted bias, and average peak predicted error. All results are based on predicted hourly ozone values above 60 ppb at each monitor.

Unpaired Peak Prediction Accuracy (***PPAu***)

This statistical evaluation "compares the peak concentration modeled anywhere in the selected area against the peak ambient concentration anywhere in the same area. The difference of the peaks (model - observed) is then normalized by the peak observed concentration."[262] EPA recommends that the unpaired peak prediction accuracy be within 20 percent of the observed hourly ozone. The main purpose of this statistical analysis is to determine if the model is under predicting ozone formation at each monitor.

Equation 5-1, Unpaired Peak Prediction Accuracy

$$\text{PPAu} = 100 \times [(\text{peak}_{\text{pred}} \div \text{peak}_{\text{obs}})] - 1)$$

Mean Normalized Bias (**MB**)

"This performance statistic averages the model/observation residual, paired in time, normalized by observation, over all monitor times/locations. A value of zero would indicate that the model over-predictions and model under-predictions exactly cancel each other out."[263] The calculation of this measure is shown in Equation 5-2. According to the EPA, mean normalized bias should be within 15 percent.

Equation 5-2, Mean Normalized Bias

$$\text{MNB} = 1/n \sum_{1}^{n} \left[\frac{(\text{Model} - \text{Obs.})}{\text{Obs.}} \right] \bullet 100\%$$

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[263] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." EPA Office of Air Quality Planning and Standards, Air Quality Analysis Division Air Quality Modeling Group Research Triangle Park, NC. EPA - 454/B-07-002. p. 198. Accessed online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Last accessed 06/24/13.

Mean Normalized Gross Error (ME)

"Mean Normalized Gross Error (MNGE): This performance statistic averages the absolute value of the model/observation residual, paired in time, normalized by observation, over all monitor times/locations. A value of zero would indicate that the model exactly matches the observed values at all points in space/time."[264] The calculation of this measure is shown in Equation 5-3. The recommended maximum value for mean normalized gross error should be 35 percent.

Equation 5-3, Mean Normalized Gross Error

$$\text{ME} = 1/n \sum_{1}^{n} \left(\frac{|\text{Model} - \text{Obs.}|}{\text{Obs.}} \right) \bullet 100\%$$

Average Peak Predicted Bias and Error (*APPB* and *APPE*)

"Average Peak Prediction Bias and Error: These are measures of model performance that assesses only the ability of the model to predict daily peak 1-hour and 8-hour ozone. They are calculated essentially the same as the mean normalized bias and error …, except that they only consider daily maxima data (predicted versus observed) at each monitoring location."[265] These statistical measurements use Equation 5-2 for APPB and Equation 5-3 for APPE.

Following EPA guidance, these statistical measures were calculated for all hourly ozone pairs, ozone pairs on days that the 8-hour peak observed concentrations are greater than 60 ppb, and ozone exceedance days.[266] The statistical measures were also calculated for individual monitors averaged over all days in the June 2006 modeling episode. Days without complete observed datasets were removed from the statistics.

The results of these statistical analyses indicate the model over predicted peak ozone on most exceedance days except the June 26th exceedance day. Statistical results for the June 13th and 14th exceedance days were above the level recommended by EPA. Although, the statistics indicated significant over prediction on June, 20th, 21st, and 22nd, none of these days had peak ozone levels observed or predicted above 60 ppb. For model performance, over prediction of peak accuracy is considered better than under prediction because the calculations are based on the highest value in the grids cells surrounding the monitors. Figure 1-19 compares unpaired peak accuracy, mean normalized bias, and mean normalized error for each base case run.

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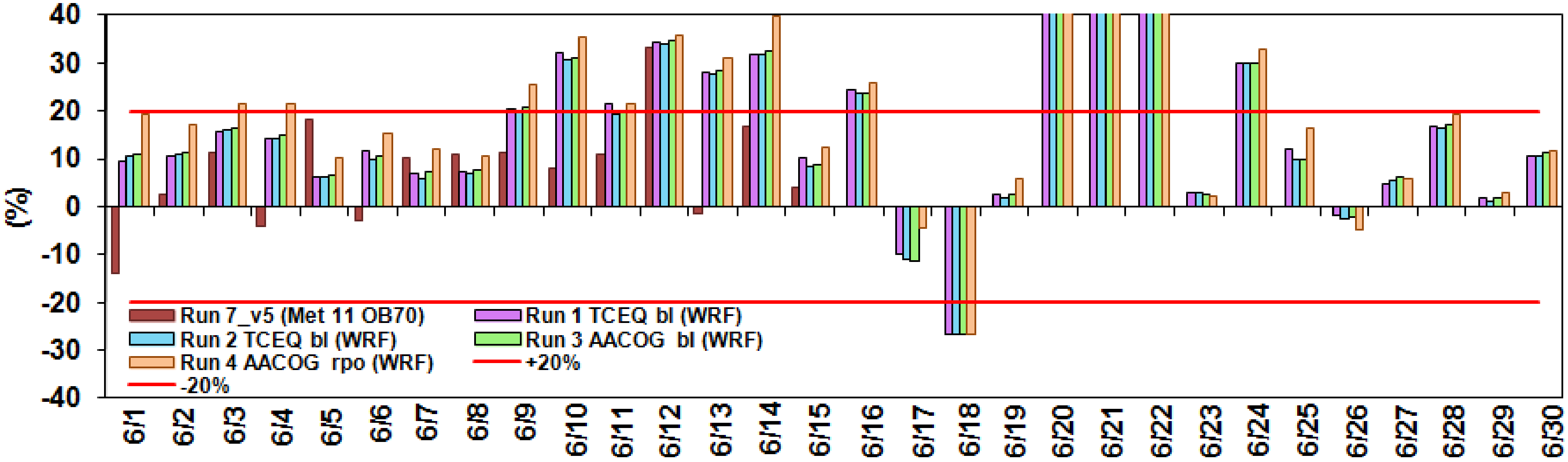
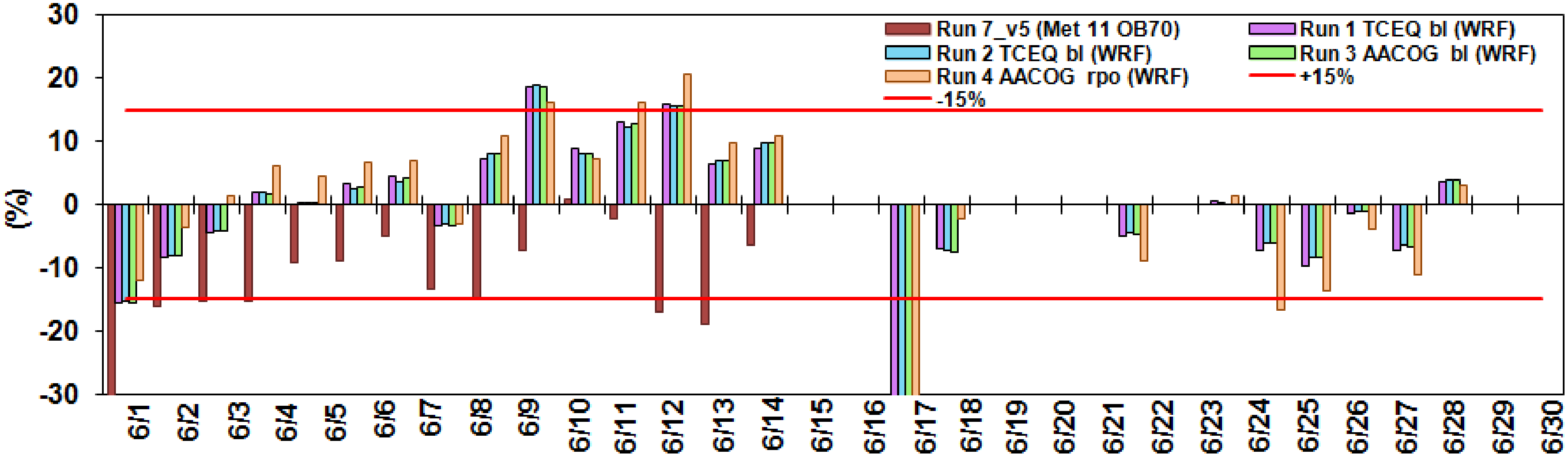
[264] *Ibid*., p. 198.
[265] *Ibid*., pp. 198 – 199.
[266] *Ibid*., p. 199.

Figure 5-19: Daily performance for 1-hour Ozone in San Antonio on all Days for MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4



Unpaired Peak Accuracy



Mean Normalized Bias

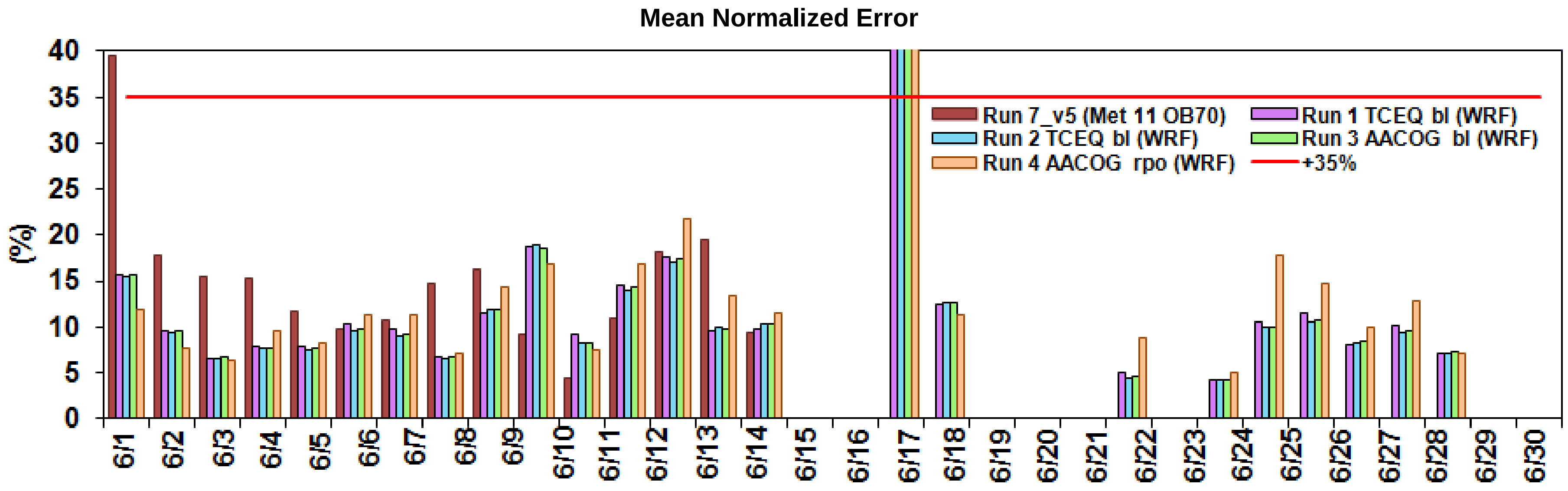

Mean Normalized Error
40
35
30
25
20
15
10
5
0
(%)
Run 7_v5 (Met 11 OB70)
Run 1 TCEQ bl (WRF)
Run 2 TCEQ bl (WRF)
Run 3 AACOG bl (WRF)
Run 4 AACOG rpo (WRF)
+35%
6/1
6/2
6/3
6/4
6/5
6/6
6/7
6/8
6/9
6/10
6/11
6/12
6/13
6/14
6/15
6/16
6/17
6/18
6/19
6/20
6/21
6/22
6/23
6/24
6/25
6/26
6/27
6/28
6/29
6/30

Table 5-1: Daily performance for 1-hour Ozone in San Antonio on all Days for WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4

Statistical Analysis	**Average All Days**				**Days > 60 ppb observed**				**Average On Exceedance Days**			
	WRF TCEQ Run 1	WRF TCEQ Run 2	WRF AACOG Run 3	WRF AACOG Run 4	WRF TCEQ Run 1	WRF TCEQ Run 2	WRF AACOG Run 3	WRF AACOG Run 4	WRF TCEQ Run 1	WRF TCEQ Run 2	WRF AACOG Run 3	WRF AACOG Run 4
Unpaired Peak Prediction Accuracy	16.1	15.5	16.0	19.6	13.1	11.7	12.3	15.5	12.4	12.7	13.7	16.4
Peak Bias (unpaired time)	*-0.4*	-0.3	-0.4	**0.2**	**0.1**	0.2	0.1	*0.8*	*0.5*	0.4	0.3	**0.2**
Peak Error (unpaired time)	7.9	**7.7**	7.8	*8.7*	8.0	**7.9**	7.9	*8.9*	7.5	**7.3**	7.4	*9.5*
Bias (normalized)	*-0.7*	-0.6	-0.7	**0.2**	**0.2**	0.3	0.2	*1.2*	*0.8*	0.6	0.5	**0.2**
Error (normalized)	11.5	**11.3**	11.4	*12.7*	11.7	**11.4**	11.5	*12.9*	10.3	**9.9**	10.0	*12.9*

The performance of MM5 run 7 version 5 was degraded as indicated by mean normalized bias and mean normalized error on most modeling days. However, model performance was good on most exceedance days for every WRF run. The only exceedance day on which every run failed to meet the EPA recommended value for mean normalized bias was on June 13th . Every exceedance day exhibited normalized error within EPA recommended levels. As shown in Table 5-1, every WRF modeling runs exhibited similar performance for unpaired peak accuracy, paired peak accuracy, peak bias, peak error, normalized bias, and normalized error. Model performance on all days was improved with TCEQ run 2 and exceedance day performance was best for AACOG run 1. Performance for AACOG run 4 using the RPO grid was degraded for peak error and normalized error. This run predicted higher peak 1-hour ozone concentrations compared to the other 3 WRF runs.

The soccer-style plot in Figure 5-20 show most days are within EPA's recommendation for statistical analysis for values greater than 60 ppb for the first three WRF runs. To meet EPA's guidance for error and bias, values should be within the plots' blue squares. The one day for which measures of error and bias were near to the blue box in the graphs was June 18th (upper left hand corner of the plot). The model significantly under-predicted ozone on this day, however June 18th is not an exceedance day in the San Antonio New Braunfels MSA. June 13th was the only exceedance day for which the normalized gross error-normalized bias was just outside of the box because the model over-predicted ozone on this day. For AACOG run 4 using the RPO grid, model performance was slightly degraded and two exceedance days - June 13th and June 26th - did not fall within the blue box.

When statistical analysis was performed on data for individual monitors (Figure 5-22), model performance was significantly improved for the WRF runs compared to MM5. Results for paired peak accuracy were very good for C58, C622, C501, C502, C503, and C506 and paired peak accuracy for the remaining monitors also met EPA recommended guidelines. Normalized error on exceedance days was between 8.64% and 17.37% for every monitor in the AACOG region: these values are well below EPA's recommendation of 35%. TCEQ run 2 with WRF demonstrated the best modeling performance overall, with the best performance for normalized error at every monitor except C505 on exceedance days (Table 5-3). WRF run 4 with the RPO grid had degraded performance for normalized error. Additionally, peak prediction accuracy was higher for most monitors.

Figure 5-20: Soccer-style Plot of Normalized Gross Error and Normalized Bias by Day, WRF AACOG Base Case Run 3

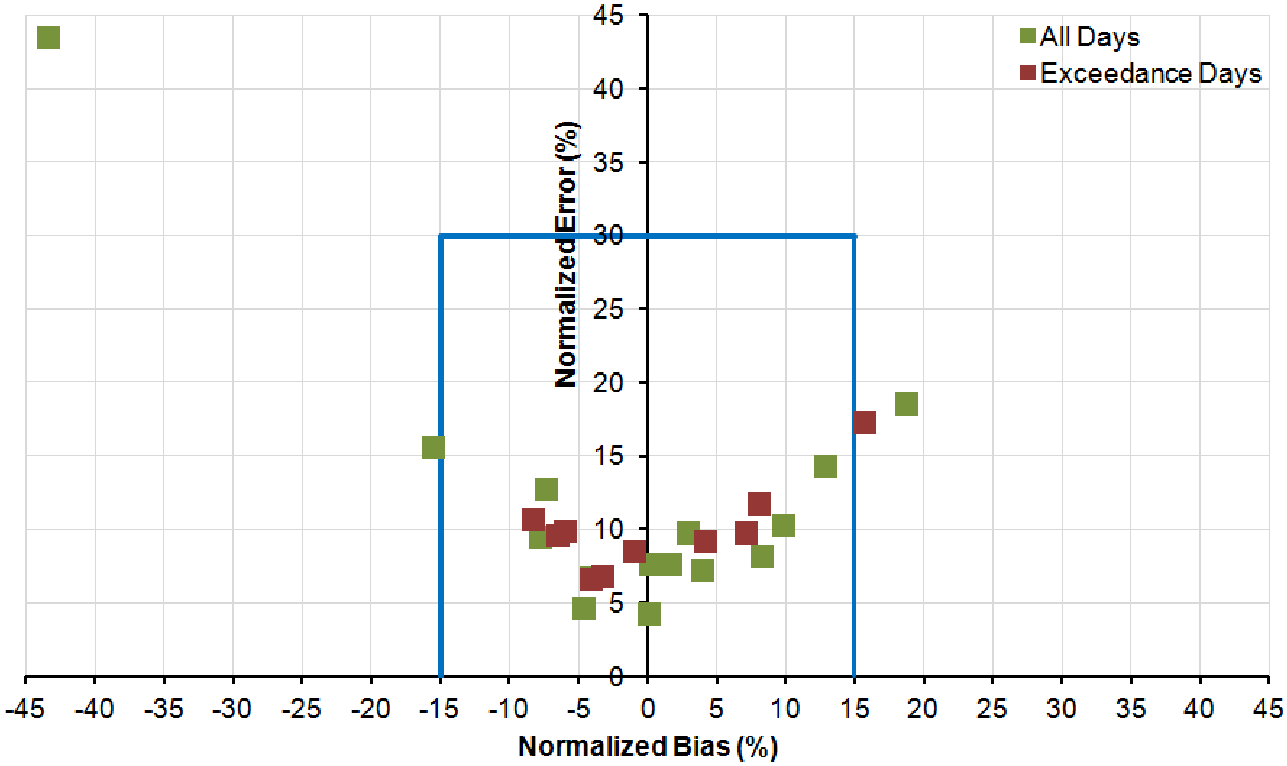


Figure 5-21: Soccer-style Plot of Normalized Gross Error and Normalized Bias by Exceedance Days, WRF AACOG RPO Base Case Run 4

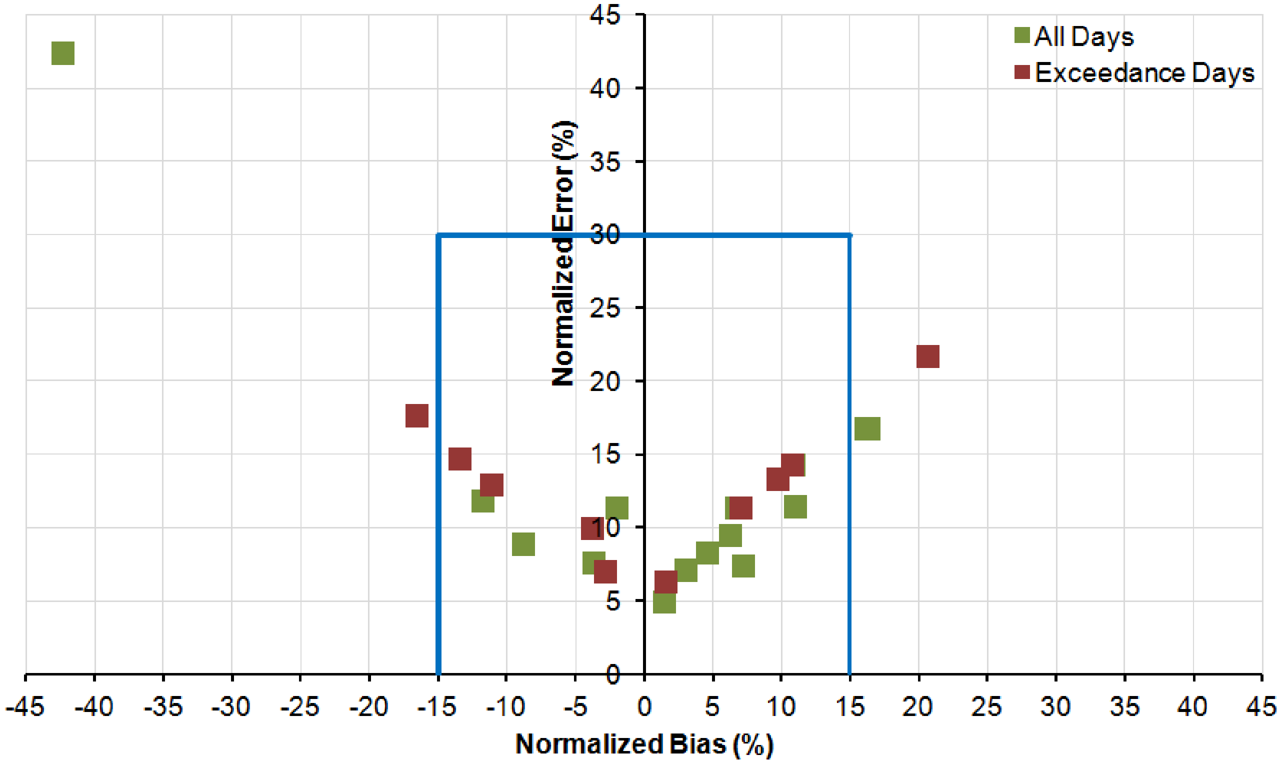
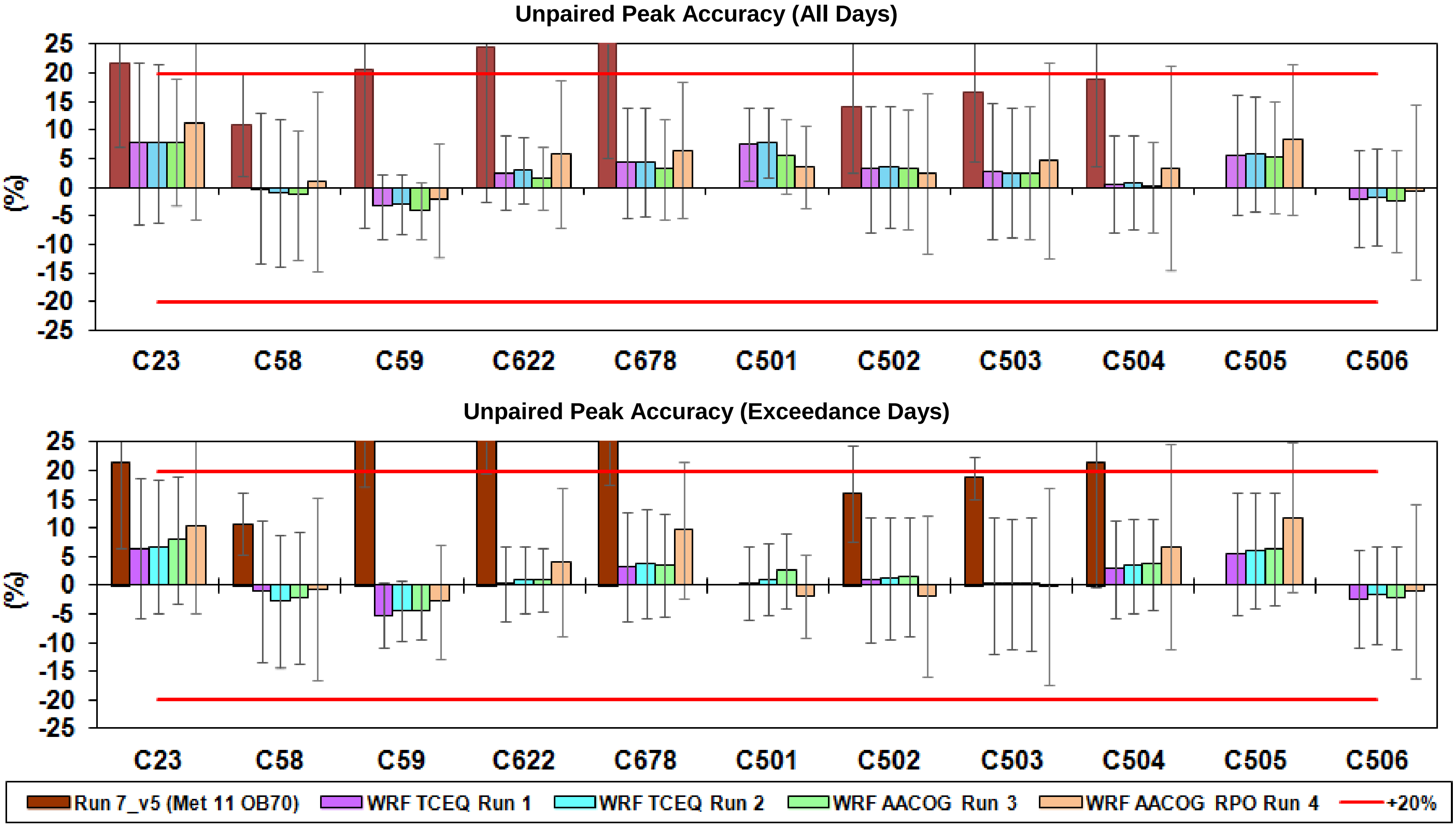
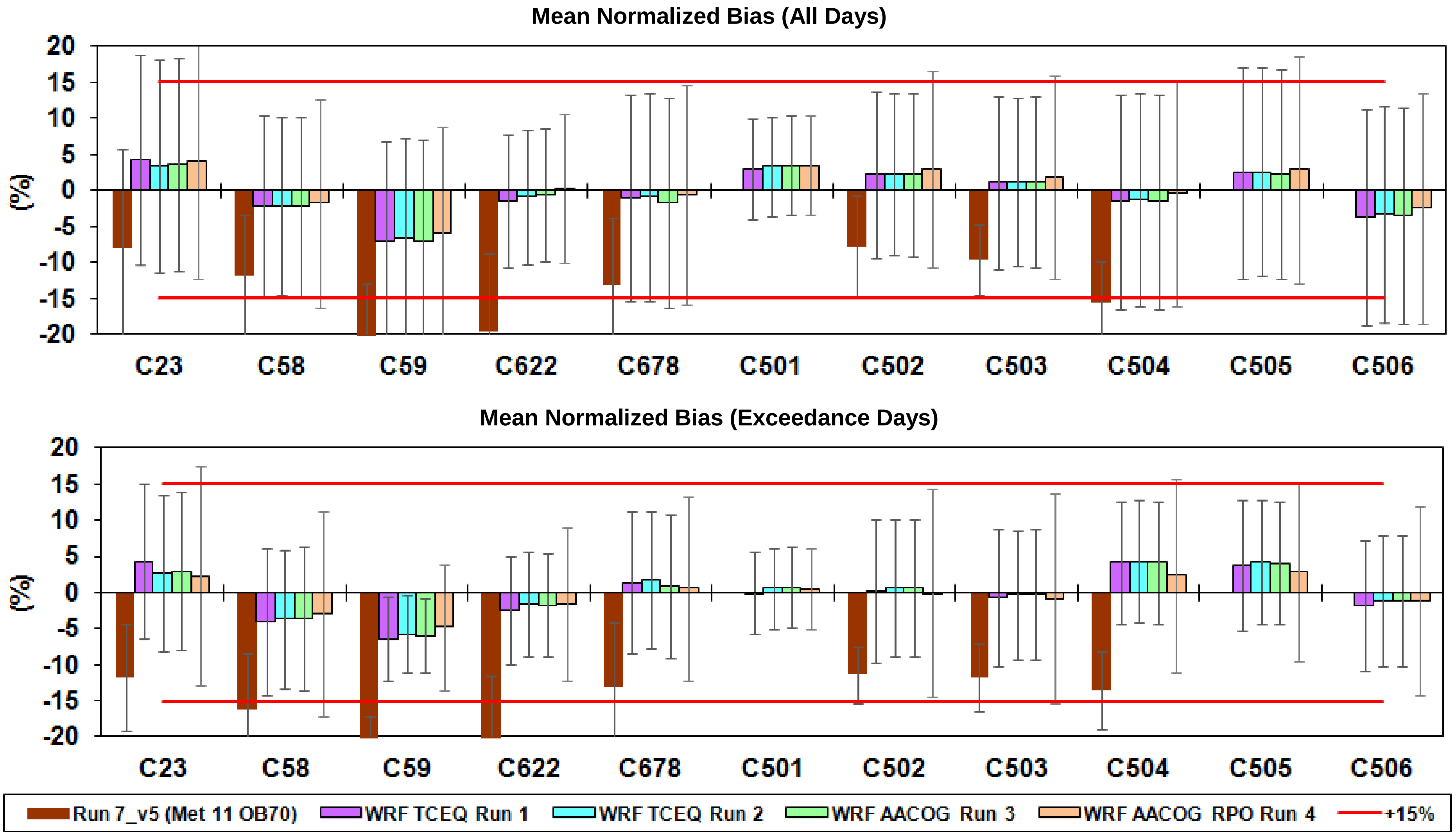


Figure 5-22: San Antonio CAMs performance for MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4

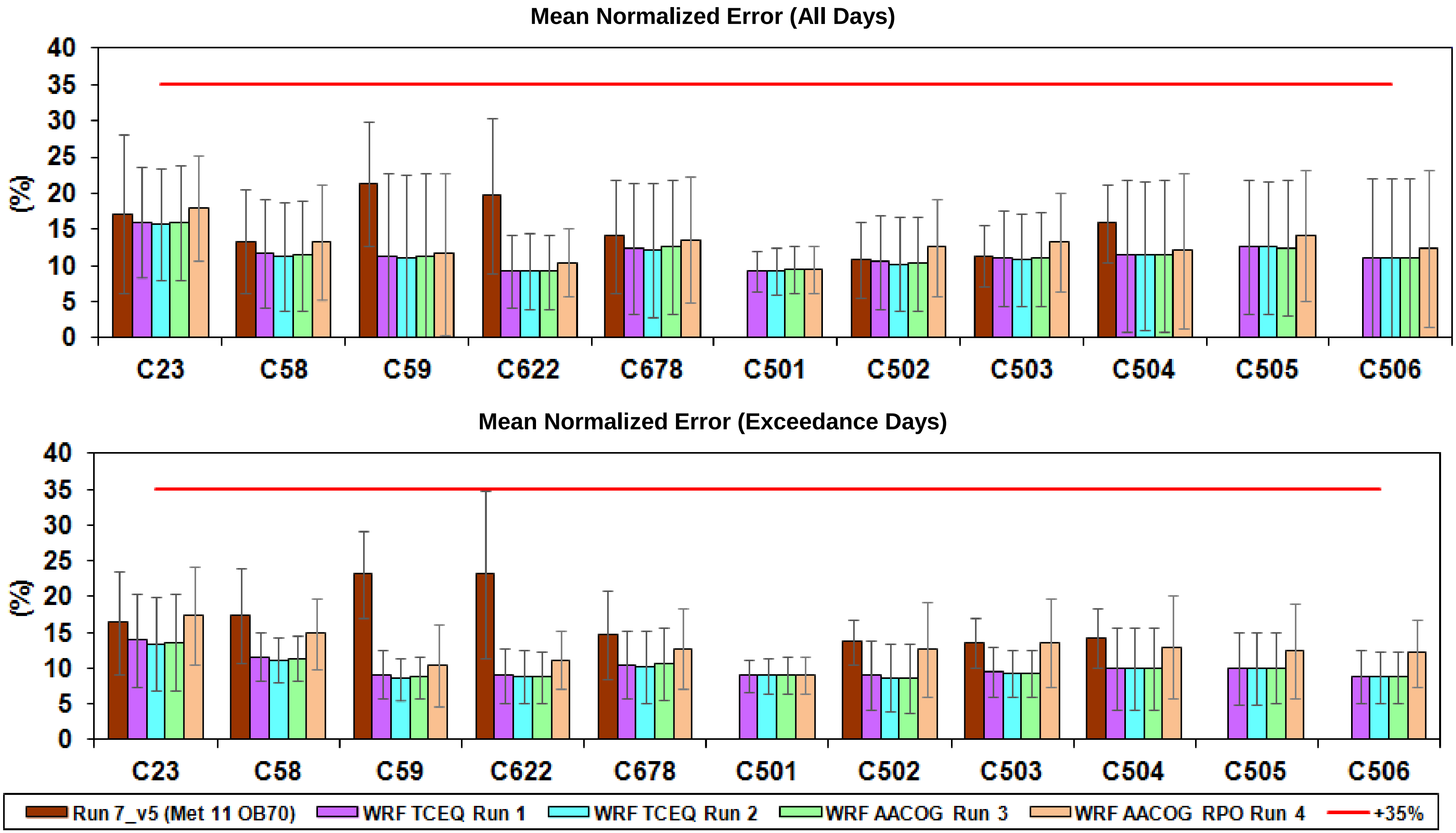

Unpaired Peak Accuracy (All Days)

Unpaired Peak Accuracy (Exceedance Days)

Note: Data for C501, C505, and C506 is not available for run MM5 Base Case Run 7



Note: Data for C501, C505, and C506 is not available for run MM5 Base Case Run 7



Note: Data for C501, C505, and C506 is not available for run MM5 Base Case Run 7

Figure 5-23: Soccer-style Plot of Normalized Gross Error and Normalized Bias by Monitor for Every Day, WRF AACOG Base Case Run 3

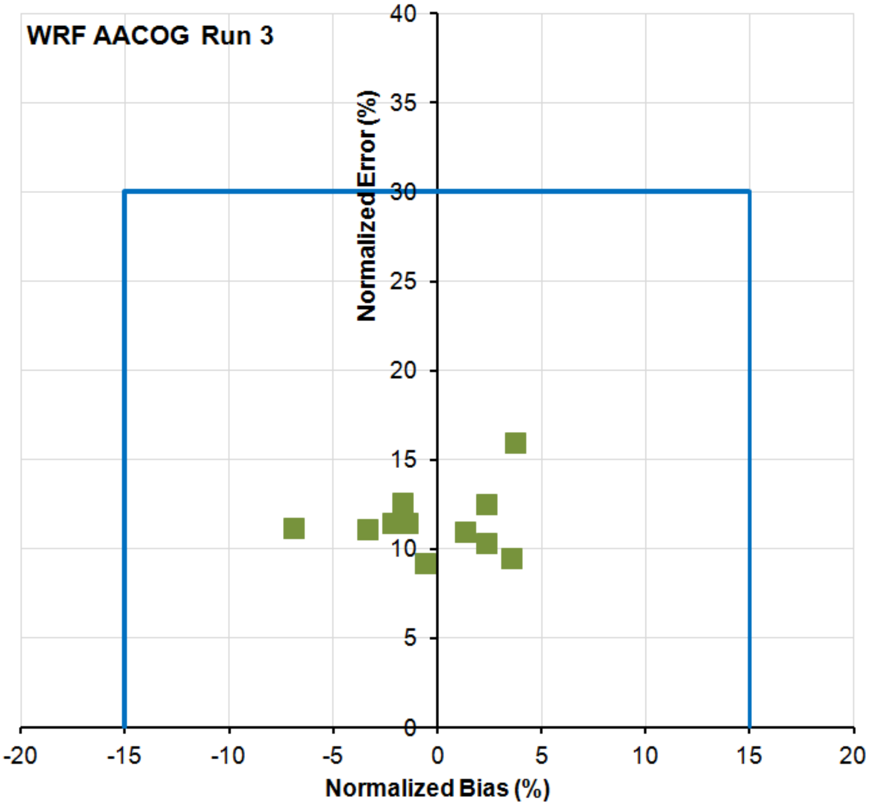


Figure 5-24: Soccer-style Plot of Normalized Gross Error and Normalized Bias by Monitor for Every Day, WRF AACOG RPO Base Case Run 4

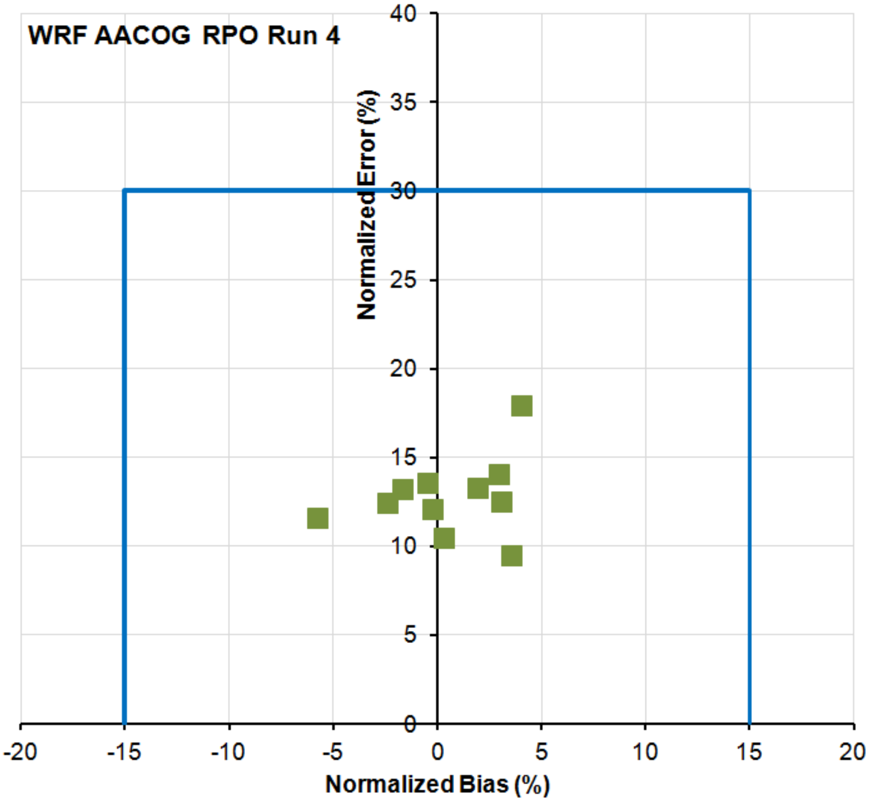


Figure 5-25: Soccer-style Plot of Normalized Gross Error and Normalized Bias by Monitor for Exceedance Days, WRF AACOG Base Case Run 3

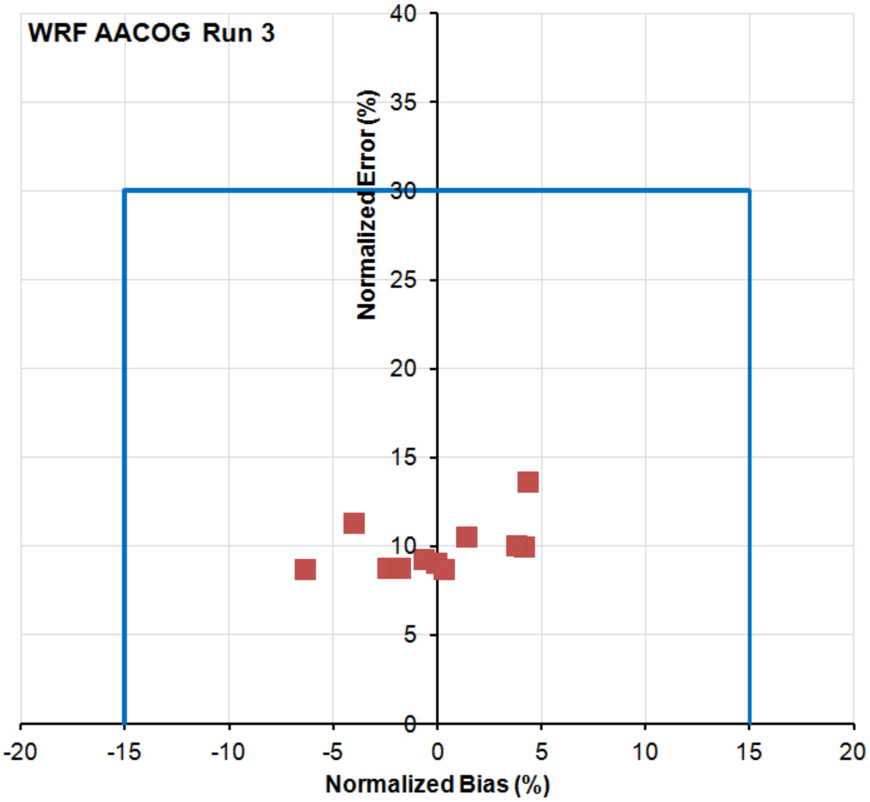


Figure 5-26: Soccer-style Plot of Normalized Gross Error and Normalized Bias by Monitor for Exceedance Days, WRF AACOG RPO Base Case Run 4

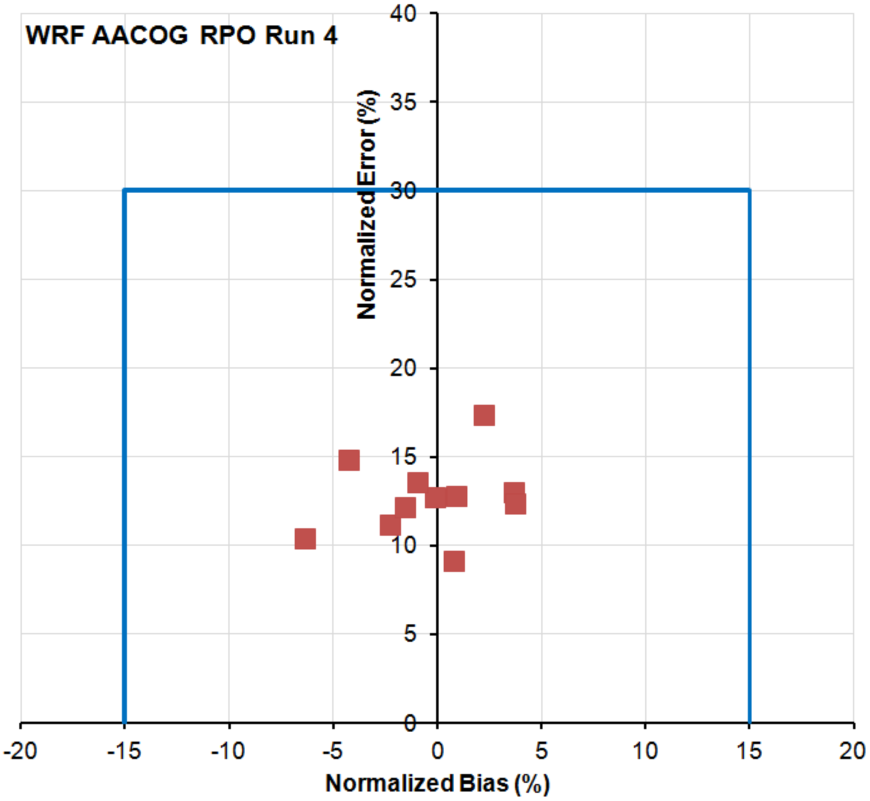


Table 5-2: San Antonio 8-hour Ozone CAMs performance in San Antonio, All Days average for MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4

Statistical	CAMS Station	Average All Days				
		Run 7_v5 (Met 11 OB70)	WRF TCEQ Run 1	WRF TCEQ Run 2	WRF AACOG Run 3	WRF AACOG RPO Run 4
Unpaired Peak Prediction Accuracy	C23	21.87	7.73	7.77	7.93	11.33
	C58	11.04	-0.10	-0.94	-1.33	1.04
	C59	20.55	-3.29	-2.86	-4.02	-2.17
	C622	24.63	2.57	3.03	1.53	5.81
	C678	28.56	4.36	4.48	3.17	6.51
	C501		7.57	7.85	5.48	3.52
	C502	14.14	3.22	3.47	3.23	2.49
	C503	16.76	2.85	2.57	2.48	4.64
	C504	18.83	0.50	0.81	0.10	3.45
	C505		5.67	5.86	5.32	8.35
	C506		-2.04	-1.68	-2.35	-0.73
Peak Bias (unpaired time)	C23	**2.45**	*3.22*	2.52	2.71	3.06
	C58	*-5.56*	-1.70	-1.69	-1.68	**-1.22**
	C59	*-15.27*	-4.90	-4.59	-4.80	**-4.06**
	C622	*-11.83*	-0.97	-0.54	-0.43	**0.24**
	C678	*-6.31*	-0.66	-0.47	-1.04	**-0.31**
	C501		1.82	2.07	*2.23*	**0.32**
	C502	*-3.68*	**1.44**	**1.44**	1.49	2.07
	C503	*-3.24*	**0.69**	0.75	0.81	1.27
	C504	*-7.99*	-0.91	-0.77	-0.91	**-0.14**
	C505		1.76	1.92	**1.72**	*2.11*
	C506		*-2.43*	-2.14	-2.21	**-1.60**
Peak Error (unpaired time)	C23	**10.74**	11.24	11.04	11.19	*12.67*
	C58	**7.92**	8.67	8.37	8.47	*9.84*
	C59	*15.27*	7.61	**7.48**	7.56	7.90
	C622	*11.83*	6.18	6.15	**6.11**	7.16
	C678	**7.67**	8.38	8.24	8.49	*9.26*
	C501		6.70	**6.67**	6.80	*7.18*
	C502	*10.09*	7.28	**7.09**	7.15	8.66
	C503	**5.63**	7.65	7.46	7.56	*9.22*
	C504	*9.46*	7.67	**7.66**	7.67	8.21
	C505		8.70	8.64	**8.63**	*9.76*
	C506		7.47	**7.43**	**7.43**	*8.44*

Statistical	CAMS Station	Average All Days				
		Run 7_v5 (Met 11 OB70)	WRF TCEQ Run 1	WRF TCEQ Run 2	WRF AACOG Run 3	WRF AACOG RPO Run 4
Bias (normalized)	C23	*-8.08*	4.34	**3.47**	3.71	4.01
	C58	*-11.71*	-2.15	-2.15	-2.16	**-1.70**
	C59	*-21.32*	-7.10	-6.65	-6.93	**-5.80**
	C622	*-19.59*	-1.45	-0.82	-0.62	**0.25**
	C678	*-13.03*	-1.04	-0.86	-1.68	**-0.52**
	C501		3.02	3.37	*3.55*	**0.97**
	C502	*-7.79*	**2.25**	2.26	2.30	3.04
	C503	*-9.55*	**1.15**	1.24	1.30	1.92
	C504	*-15.60*	-1.47	-1.25	-1.47	**-0.26**
	C505		2.45	2.64	**2.34**	2.89
	C506		-3.69	-3.29	-3.39	**-2.43**
Error (normalized)	C23	*17.20*	16.06	**15.77**	15.97	17.96
	C58	*13.38*	11.73	**11.30**	11.44	13.28
	C59	*21.32*	11.27	**11.07**	11.19	11.63
	C622	*19.72*	9.27	9.26	**9.18**	10.49
	C678	*14.15*	12.46	**12.26**	12.62	13.61
	C501		9.33	**9.32**	9.50	*10.00*
	C502	*10.79*	10.52	**10.24**	10.31	12.57
	C503	*11.33*	11.06	**10.80**	10.95	13.28
	C504	*15.88*	**11.46**	**11.46**	**11.46**	12.10
	C505		12.62	12.54	**12.51**	*14.11*
	C506		11.16	11.16	**11.15**	*12.45*

Although the results of the paired prediction accuracy analyses were similar for each of the 4 WRF runs, there were some differences for individual monitors. The first run, TCEQ run 1, exhibited the lowest paired prediction accuracy at most monitors besides C58. Peak prediction accuracy was between 6.48% and 10.23% at C23 and between -0.57% and -2.81% at C58 on exceedance days. As shown in Figure 5-23 to Figure 5-26, these analyses were well within the criteria area ("goal box") on the soccer plots for all monitors and on all days.

Table 5-3: San Antonio 8-hour Ozone CAMs performance in San Antonio, Exceedance Days average for MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4

Statistical	CAMS Station	Average All Days				
		Run 7_v5 (Met 11 OB70)	WRF TCEQ Run 1	WRF TCEQ Run 2	WRF AACOG Run 3	WRF AACOG RPO Run 4
Unpaired Peak Prediction Accuracy	C23	21.43	6.48	6.79	8.06	10.23
	C58	10.77	-1.09	-2.81	-2.10	-0.57
	C59	34.42	-5.16	-4.45	-4.54	-2.72
	C622	36.65	0.36	1.02	1.08	4.21
	C678	35.13	3.27	3.78	3.66	9.70
	C501		0.55	1.13	2.63	-1.93
	C502	16.05	0.98	1.30	1.54	-1.84
	C503	18.77	0.01	0.37	0.29	-0.21
	C504	21.44	2.87	3.46	3.73	6.77
	C505		5.57	6.06	6.45	11.93
	C506		-2.35	-1.64	-2.19	-0.99
Peak Bias (unpaired time)	C23	**-1.13**	3.64	2.34	2.56	2.33
	C58	-7.25	-2.97	-2.71	**-2.64**	-2.88
	C59	-17.68	-4.73	**-4.24**	-4.44	-4.77
	C622	-14.30	-1.63	**-1.06**	-1.19	-1.53
	C678	-6.98	0.94	1.32	0.63	**0.62**
	C501		**-0.10**	0.35	0.50	*-2.43*
	C502	-6.17	0.07	0.29	0.30	**-0.04**
	C503	-6.83	-0.70	-0.42	**-0.39**	-0.80
	C504	-6.38	**2.77**	2.86	2.77	**2.41**
	C505		**2.87**	*3.24*	3.12	2.88
	C506		*-1.29*	**-0.76**	-0.79	-1.12
Peak Error (unpaired time)	C23	**8.57**	10.49	10.17	10.35	*13.05*
	C58	**8.82**	9.13	8.83	8.98	*11.62*
	C59	*17.68*	6.64	**6.27**	6.37	7.59
	C622	*14.30*	6.32	**6.17**	**6.17**	7.90
	C678	*9.48*	7.64	**7.43**	7.71	9.35
	C501		6.93	**6.90**	7.03	*7.65*
	C502	*11.10*	6.57	**6.32**	6.35	9.05
	C503	*9.60*	6.99	**6.71**	6.79	9.81
	C504	*9.90*	7.17	**7.13**	7.17	9.38
	C505		**7.37**	7.38	7.43	*9.13*
	C506		6.47	**6.32**	6.33	*8.85*

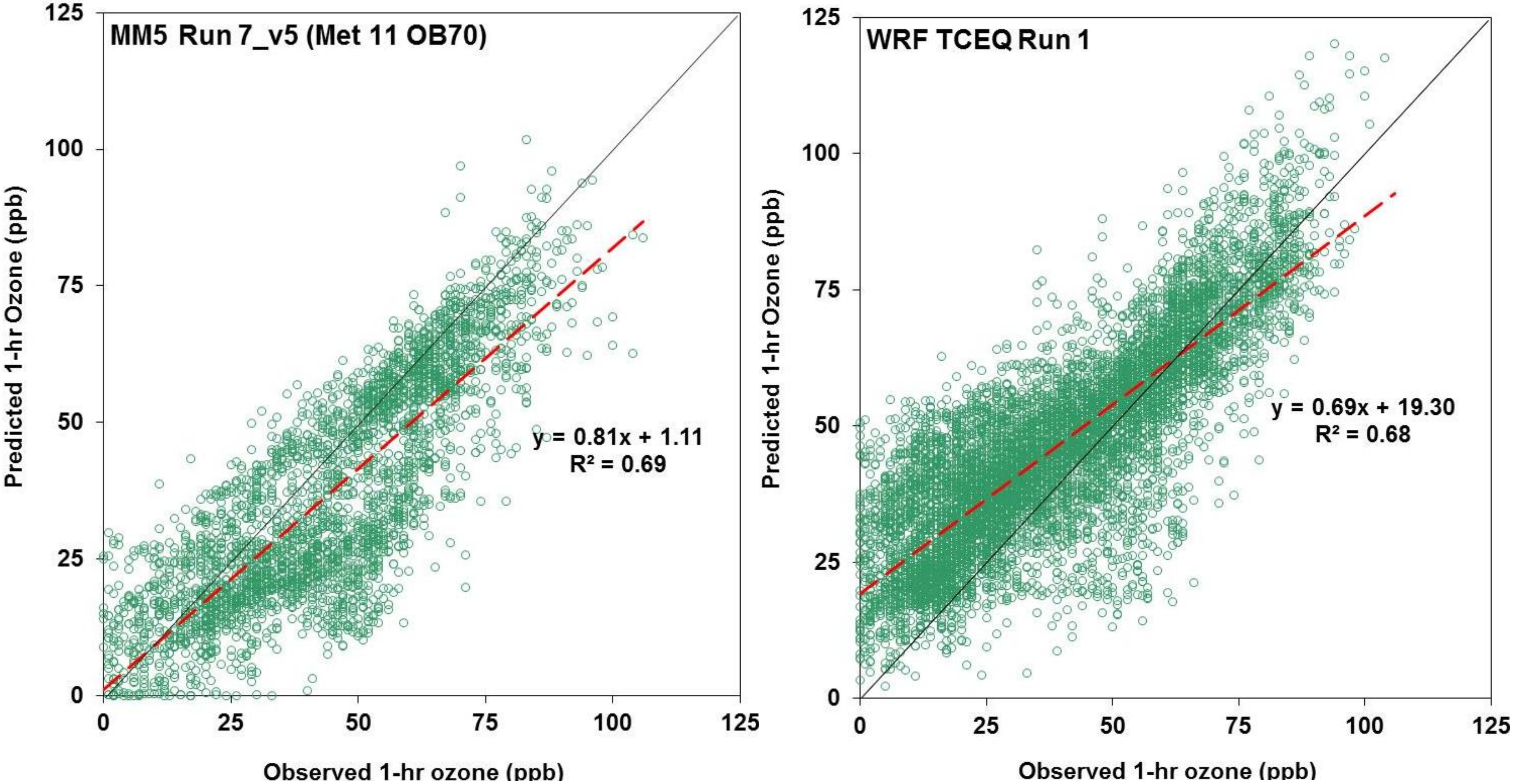
Statistical	CAMS Station	Average All Days				
		Run 7_v5 (Met 11 OB70)	WRF TCEQ Run 1	WRF TCEQ Run 2	WRF AACOG Run 3	WRF AACOG RPO Run 4
Bias (normalized)	C23	*-11.68*	4.33	2.69	2.96	**2.18**
	C58	*-16.25*	-4.01	-3.62	**-3.58**	-4.30
	C59	*-23.15*	-6.37	**-5.70**	-5.97	-6.40
	C622	*-23.15*	-2.38	**-1.59**	-1.75	-2.32
	C678	*-13.00*	1.41	1.81	**0.86**	0.88
	C501		**-0.05**	0.60	0.75	*-3.25*
	C502	*-11.37*	0.29	0.64	0.65	**-0.13**
	C503	*-11.78*	-0.67	-0.28	**-0.25**	-0.98
	C504	*-13.58*	4.16	4.28	4.16	**3.63**
	C505		**3.80**	*4.29*	4.16	3.63
	C506		*-1.82*	**-1.10**	-1.16	-1.59
Error (normalized)	C23	16.48	13.96	**13.48**	13.69	*17.37*
	C58	*17.35*	11.60	**11.19**	11.40	14.84
	C59	*23.15*	9.17	**8.64**	8.77	10.39
	C622	*23.18*	9.02	**8.81**	8.83	11.19
	C678	*14.72*	10.53	**10.18**	10.62	12.78
	C501		**9.00**	**9.00**	9.15	*9.95*
	C502	*13.73*	9.09	**8.71**	8.73	12.73
	C503	*13.55*	9.61	**9.23**	9.32	*13.55*
	C504	*14.24*	10.03	**10.02**	10.03	13.01
	C505		**10.00**	10.03	10.11	*12.37*
	C506		*8.96*	**8.77**	8.80	12.15

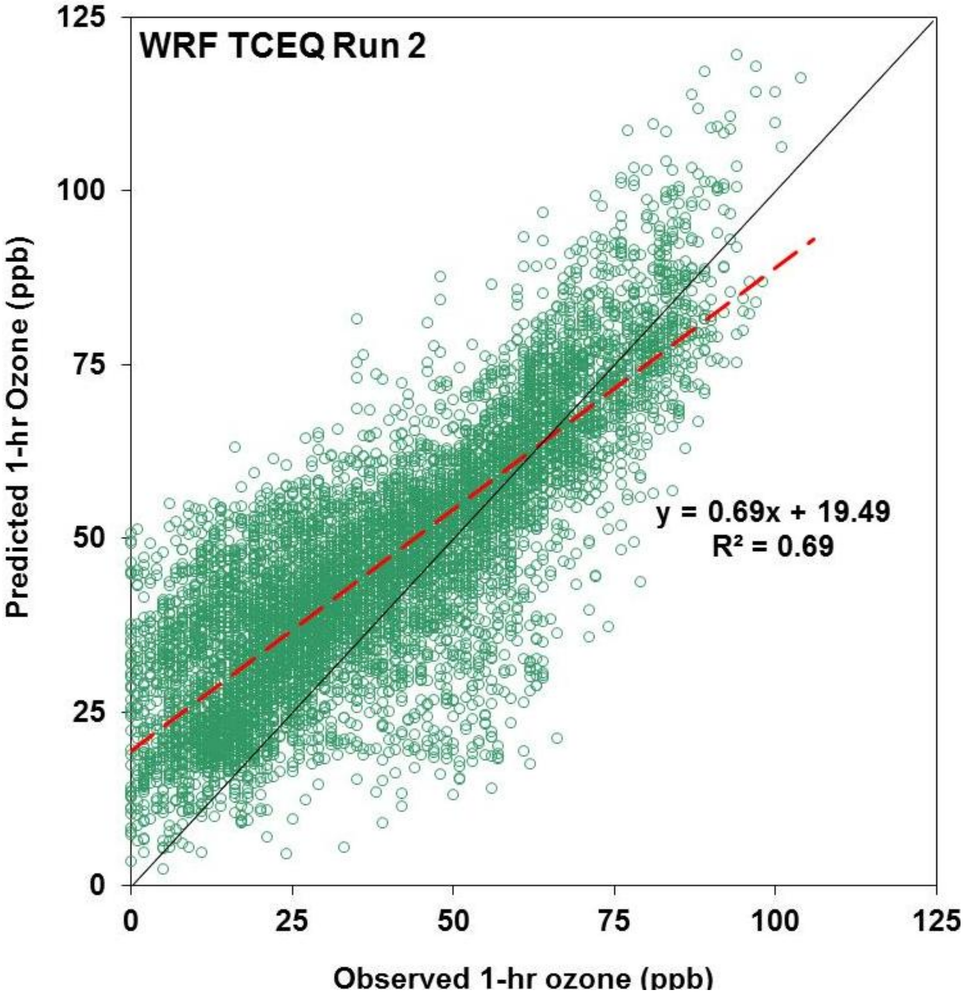
5.5 Ozone Scatter Plots

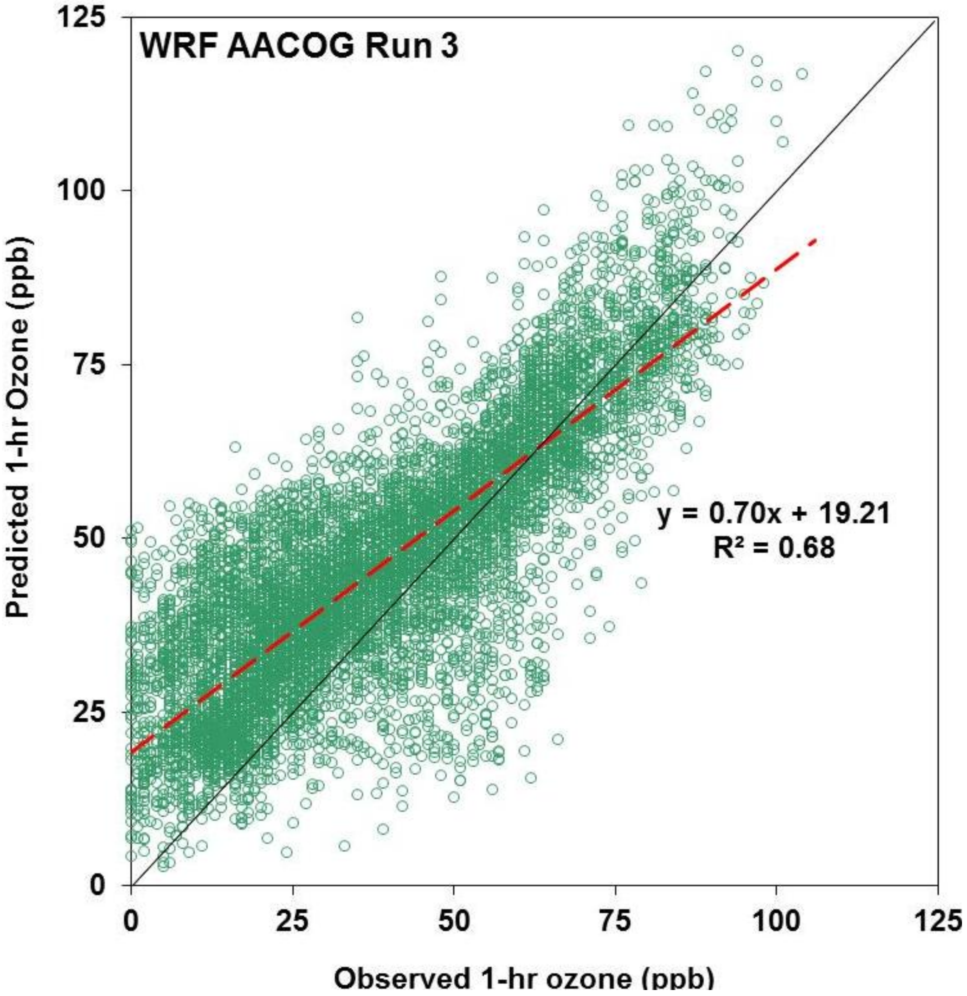
Scatter plots of hourly predicted and observed ozone readings at CAMS stations were plotted to determine how well the base case runs represented observed ozone (Figure 5-27). The scatter plots are based on hourly observed and predicted data from all the ozone monitors in the San Antonio-New Braunfels MSA. Each run tended to over predict ozone below 60 ppb, but correlated well for higher ozone values. Figure 5-28 provides the scatter plots for 8-hour daily maximum ozone for each run. Eight-hour observed and predicted ozone correlated well, although values below 60 ppb tended to be slightly over predicted.

The R^2 values for predicted 8-hour ozone ranged from 0.74 to 0.75. Correlation between predicted and observed hourly ozone was good for both C23 and C58: R^2 values ranged from 0.67 to 0.70. Overall TCEQ run 2 demonstrated the best correlation for both 1 hour and 8 hour ozone (Table 5-4). Surprisingly, performance was slighted degraded when local emission inventory inputs were included in AACOG run 3. AACOG run 4 with the RPO grid, had degraded performance for hourly ozone values for all monitors, C23 and C58. Although performance was degraded for 1 hour values and on days > 60 ppb, ACCOG run 4 had the best performance for 8 hour values at C23 and C58 (R^2 was 0.75 and 0.73).

Figure 5-27: San Antonio Hourly Ozone Scatter Plots in San Antonio for MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4




WRF TCEQ Run 2
y = 0.69x + 19.49
R² = 0.69
Predicted 1-hr Ozone (ppb)
Observed 1-hr ozone (ppb)
0
25
50
75
100
125


WRF AACOG Run 3
y = 0.70x + 19.21
R² = 0.68
Predicted 1-hr Ozone (ppb)
Observed 1-hr ozone (ppb)
0
25
50
75
100
125

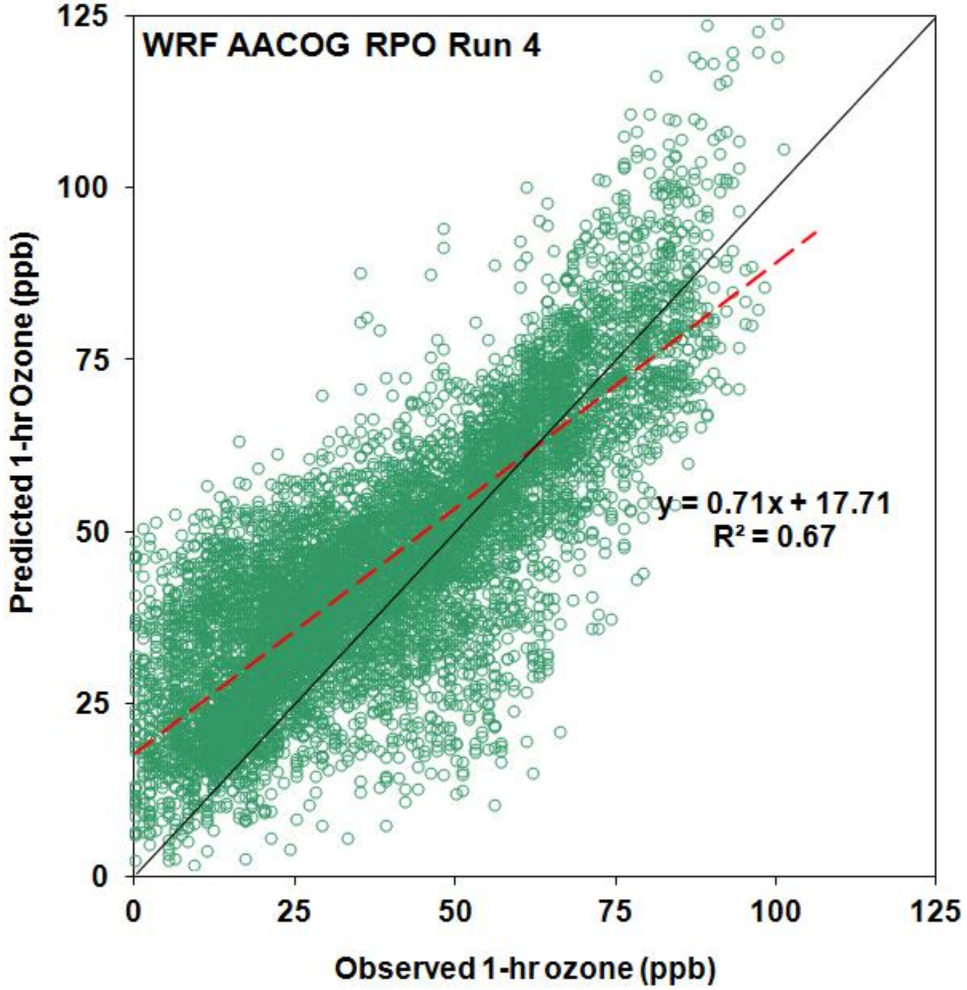
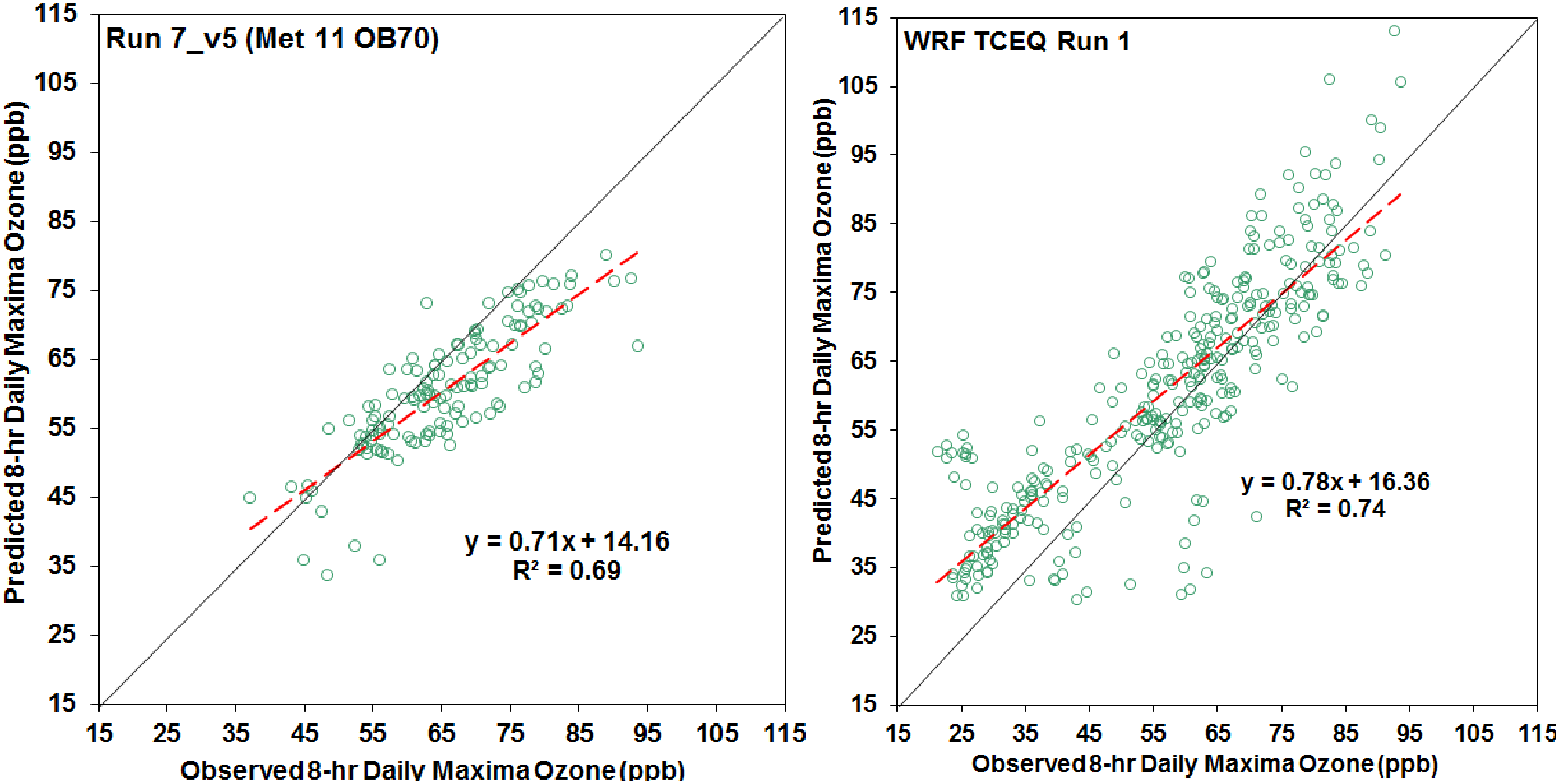
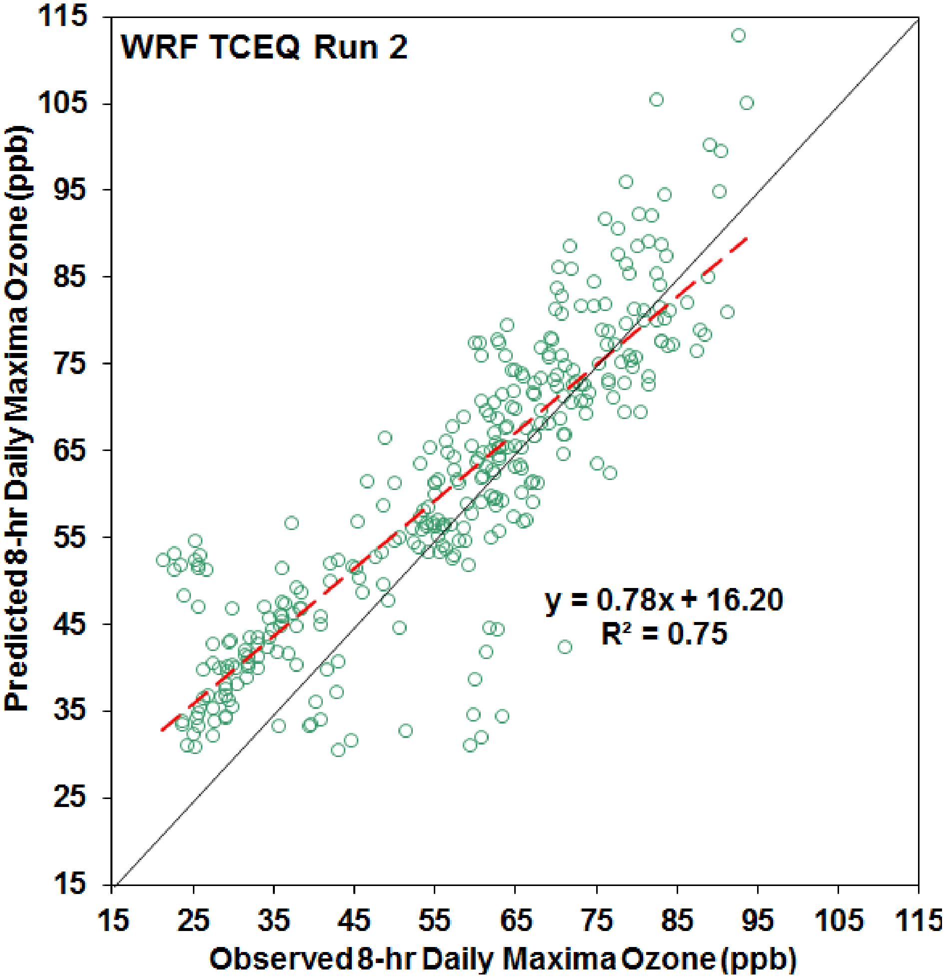
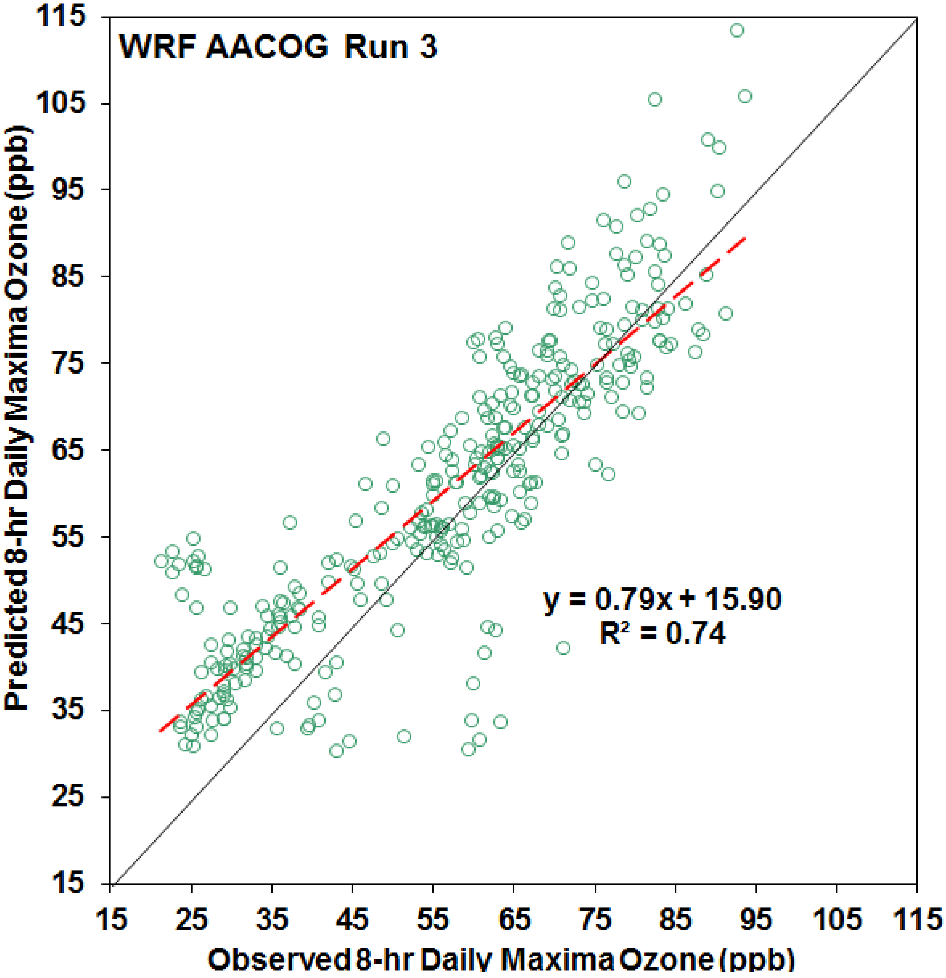

WRF AACOG RPO Run 4
y = 0.71x + 17.71
R² = 0.67
Predicted 1-hr Ozone (ppb)
Observed 1-hr ozone (ppb)
0
25
50
75
100
125
0
25
50
75
100
125

Figure 5-28: San Antonio 8-Hour Daily Maximum Ozone Scatter Plots in San Antonio for MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4




WRF TCEQ Run 2
y = 0.78x + 16.20
R² = 0.75
Predicted 8-hr Daily Maxima Ozone (ppb)
Observed 8-hr Daily Maxima Ozone (ppb)
115
105
95
85
75
65
55
45
35
25
15
15
25
35
45
55
65
75
85
95
105
115


WRF AACOG Run 3
y = 0.79x + 15.90
R² = 0.74
Predicted 8-hr Daily Maxima Ozone (ppb)
Observed 8-hr Daily Maxima Ozone (ppb)
115
105
95
85
75
65
55
45
35
25
15
15
25
35
45
55
65
75
85
95
105
115

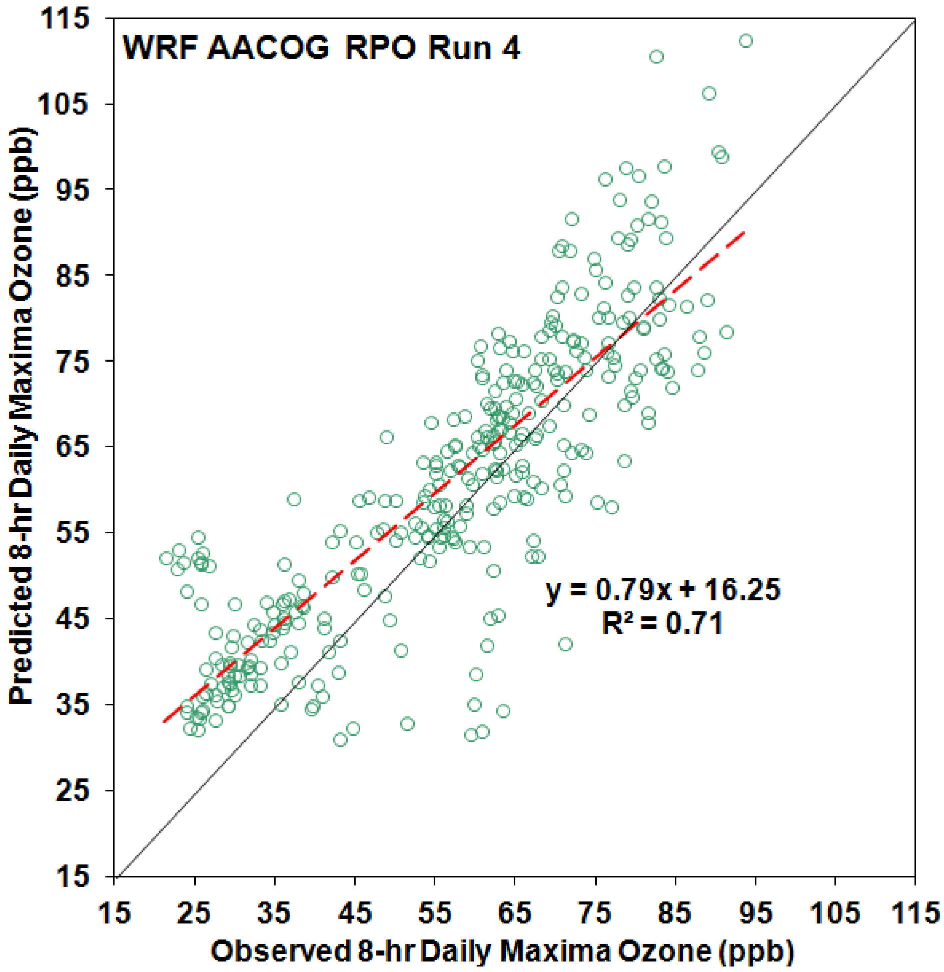

WRF AACOG RPO Run 4
y = 0.79x + 16.25
R² = 0.71
Predicted 8-hr Daily Maxima Ozone (ppb)
Observed 8-hr Daily Maxima Ozone (ppb)
115
105
95
85
75
65
55
45
35
25
15
15
25
35
45
55
65
75
85
95
105
115

Table 5-4: R^2 values for San Antonio Ozone Scatter Plots: MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4

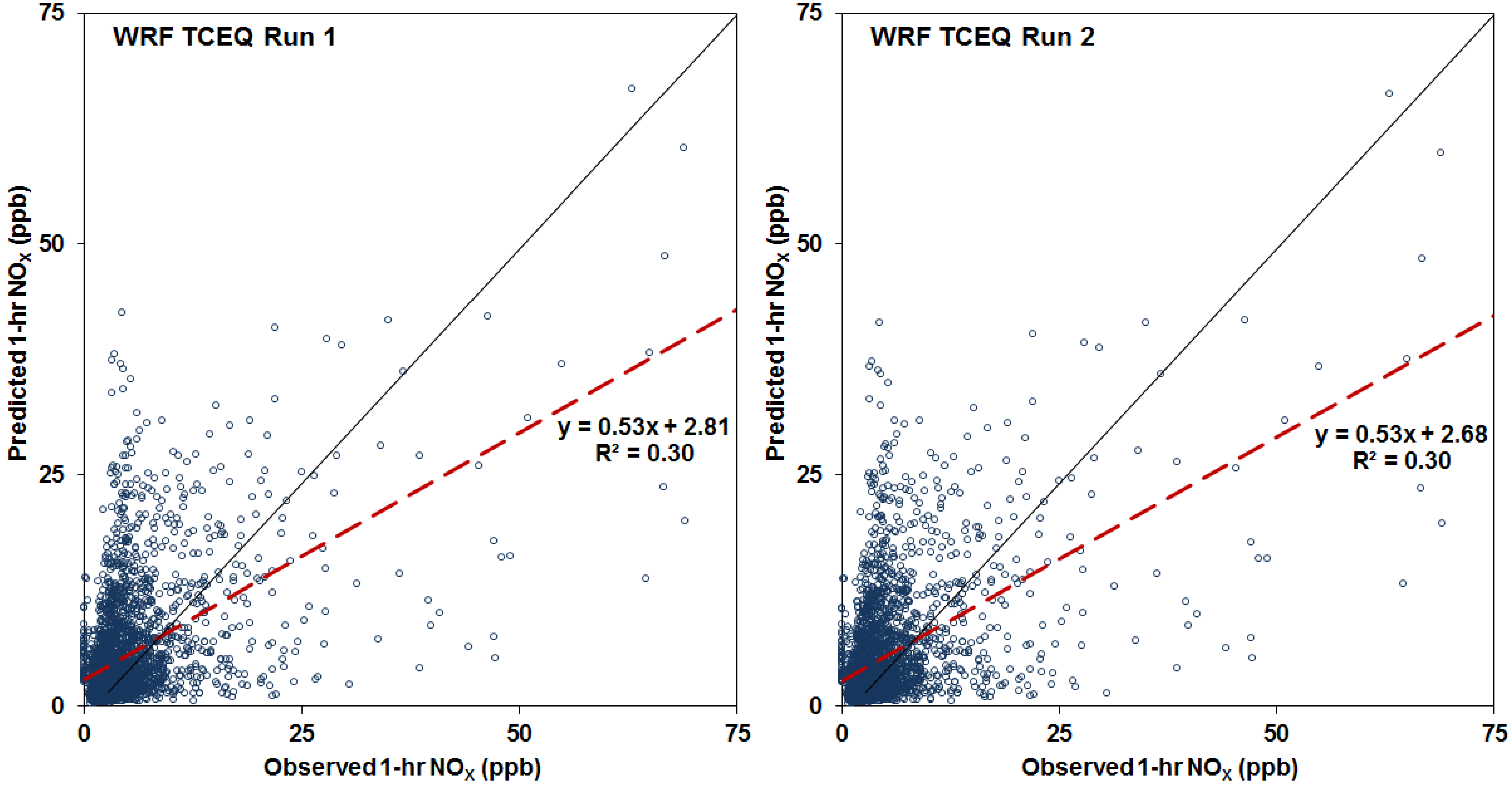
Date	Run	Hourly Ozone R^2						8-hour Daily Maxima Ozone R^2					
		All Hours			>60 ppb			All Hours			>60 ppb		
		All CAMS	C23	C58	All CAMS	C23	C58	All CAMS	C23	C58	All CAMS	C23	C58
June 1-15, 2006	MM5 Run 7_v5	*0.688*	*0.629*	*0.719*	*0.274*	*0.145*	*0.299*	*0.690*					
	WRF TCEQ Run 1	**0.737**	0.742	0.738	0.436	0.643	0.498	**0.775**	0.777	0.784	0.469	0.574	*0.540*
	WRF TCEQ Run 2	0.737	**0.744**	**0.741**	0.441	0.648	0.508	0.774	**0.778**	**0.785**	0.470	0.574	0.544
	AACOG Run 3	0.733	0.738	0.737	0.439	0.649	0.502	0.771	*0.773*	0.781	*0.463*	*0.569*	0.541
	AACOG RPO Run 4	0.734	0.741	0.738	**0.469**	**0.672**	**0.522**	0.772	**0.778**	*0.778*	**0.516**	**0.633**	**0.563**
June 1-July 2, 2006	WRF TCEQ Run 1	0.685	0.693	0.680	0.290	0.392	0.318	0.719	0.730	0.725	0.342	0.411	0.351
	WRF TCEQ Run 2	**0.686**	**0.697**	**0.681**	**0.298**	0.401	**0.328**	**0.720**	0.733	0.726	**0.355**	**0.416**	**0.360**
	AACOG Run 3	0.684	0.693	0.679	0.295	**0.403**	0.325	0.718	*0.730*	*0.724*	0.347	0.412	0.358
	AACOG RPO Run 4	*0.672*	*0.681*	*0.668*	*0.252*	*0.371*	*0.300*	*0.702*	**0.753**	**0.727**	*0.269*	*0.395*	*0.311*

5.6 NO_X Scatter Plots

Scatter plots of hourly predicted and observed NO_X concentrations at CAMS stations were plotted to determine how well the base case runs represented observed ozone (Figure 5-29). The scatter plots are based on observed and predicted data from C58, C59, C622, and C678 NO_X monitors for June 1st – July 2nd. The model over predicted NO_X when the observed value was below 10 ppb and under predicted when higher NO_X readings were recorded. The model performance for NO_X was poorer compared to the performance for ozone.

Model performance was poor for the C58 NO_X monitor in northwest San Antonio with an R^2 value between 0.12 and 0.13 (Table 5-5). The model significantly over predicted NO_X at C58 during most days of the modeling episode. Model performance was slightly improved at C59 and C622 with good performance at C678. AACOG run 4 with the RPO grid had improved performance at C58 and C622, but degraded performance at C59.

Figure 5-29: San Antonio Hourly NO_X Scatter Plots in San Antonio for WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4



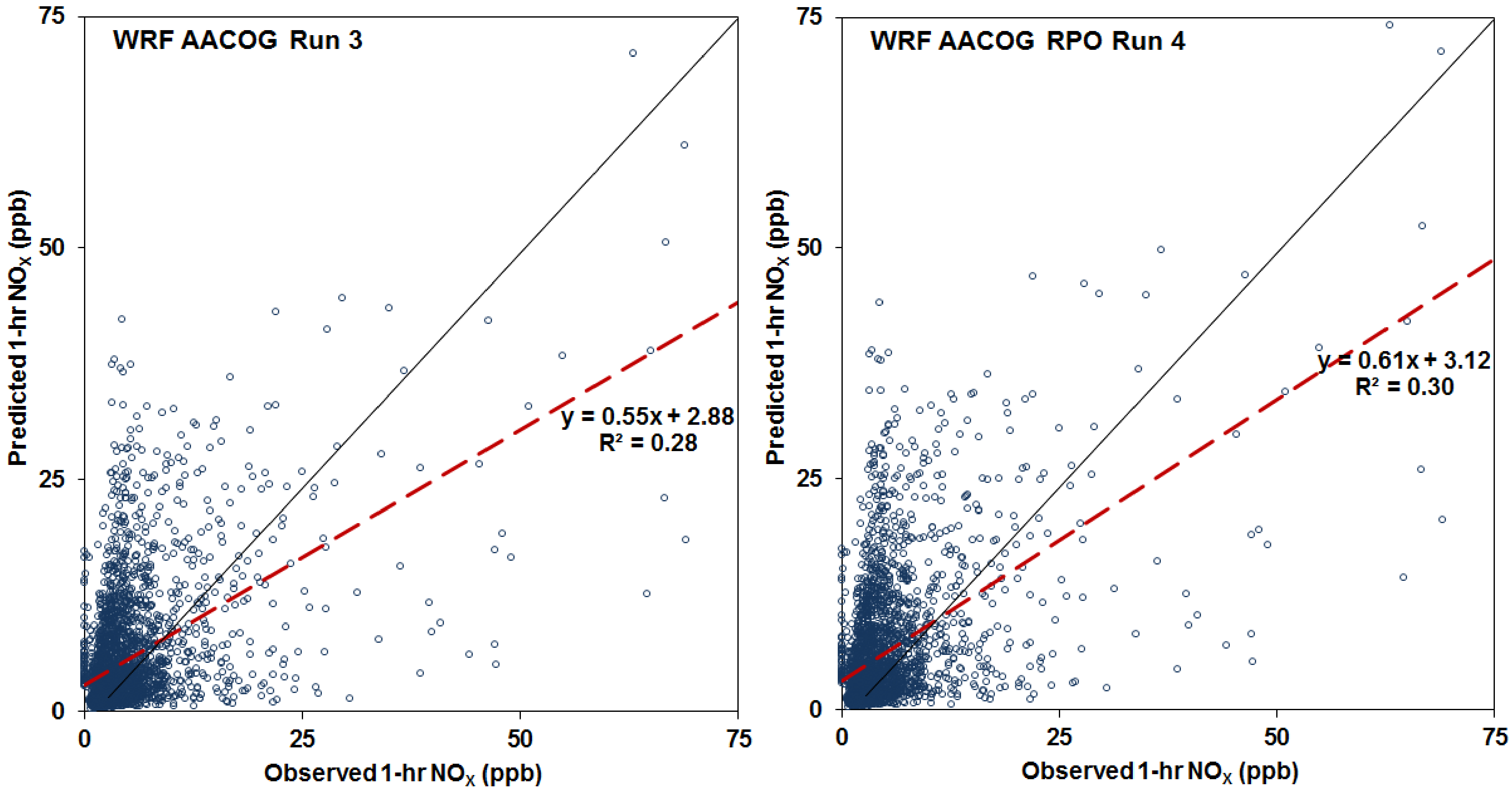

WRF AACOG Run 3
y = 0.55x + 2.88
R² = 0.28
Predicted 1-hr NOx (ppb)
Observed 1-hr NOx (ppb)
0
25
50
75
WRF AACOG RPO Run 4
y = 0.61x + 3.12
R² = 0.30

Table 5-5: R^2 values for San Antonio NO_X Scatter Plots, June 1-July 2, 2006: WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4

Run	All	C58	C59	C622	C678
TCEQ Run 1 (WRF)	0.298	*0.121*	0.270	*0.254*	0.573
TCEQ Run 2 (WRF)	**0.301**	0.123	**0.286**	0.265	**0.573**
AACOG Run 3 (WRF)	*0.281*	0.128	0.281	0.264	*0.500*
AACOG RPO Run 4 (WRF)	0.296	**0.131**	*0.261*	**0.266**	0.534

5.7 EPA Quantile-Quantile Plots

"The quantile-quantile (q-q) plot is a graphical technique for determining if two data sets come from populations with a common distribution. A q-q plot is a plot of the quantiles of the first data set against the quantiles of the second data set. By a quantile, we mean the point below which a given fraction (or percent) of points lies. That is, the 0.3 (or 30%) quantile is the point at which 30% percent of the data fall below and 70% fall above that value. A 45-degree reference line is also plotted. If the two sets come from a population with the same distribution, the points should fall approximately along this reference line. The greater the departure from this reference line, the greater the evidence for the conclusion that the two data sets have come from populations with different distributions."[267]

EPA quantile-quantile plots are provided in Figure 5-30 for daily maximum 8-hour ozone at each monitor, nearest daily maximum 8-hour ozone, and daily maximum 8-hour ozone near monitor. If the Q-Q plot results are close to the 1-1 line on each plot, the same number of low, medium, and high ozone values are predicted by the model as was measured at the monitor. For both 8-hour and 1-hour ozone plots, TCEQ run 2 had the best results. The R^2 value was similar for all 4 WRF runs and improved compared to the MM5 run 7. The R^2 value varied from 0.72 to 0.92 for the WRF runs which indicates good model performance with some degradation of performance for AACOG run 4 with the RPO grid.

Caution should be used when elevating the results from quantile-quantile plots. According to the EPA, quantile-quantile "plots may also provide additional information with regards to the distribution of the observations vs. predictions. But due to the fact that Q-Q plots are not paired in time, they may not always provide useful information. Care should be taken in interpreting the results."[268]

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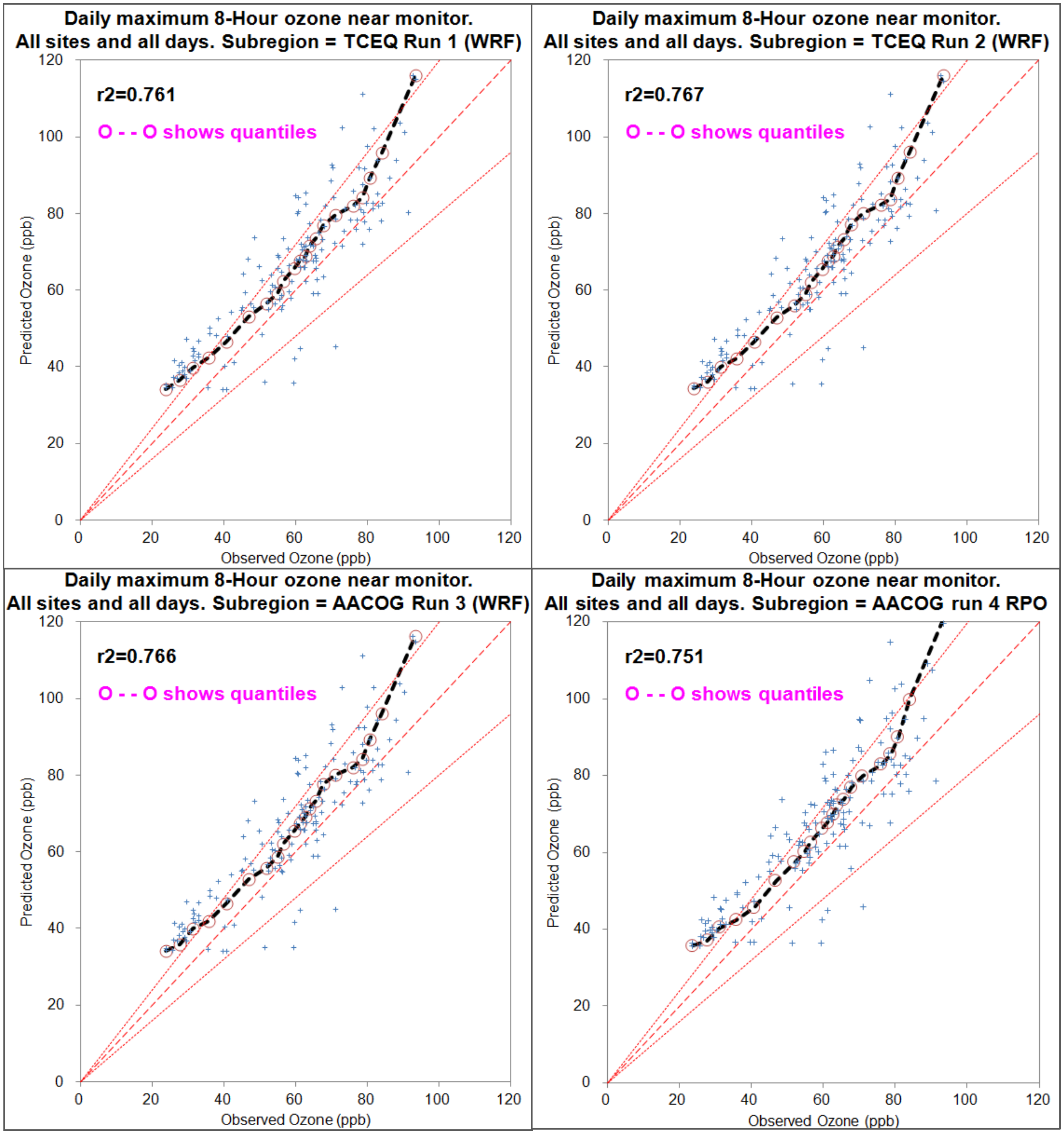
[267] NIST/SEMATECH, April, 2012. "e-Handbook of Statistical Methods". Available online: http://www.itl.nist.gov/div898/handbook/eda/section3/qqplot.htm. Accessed 06/12/13.

[268] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 201. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/24/13.

Figure 5-30: Quantile-Quantile Plots of daily peak 8-hour ozone for San Antonio: WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4.

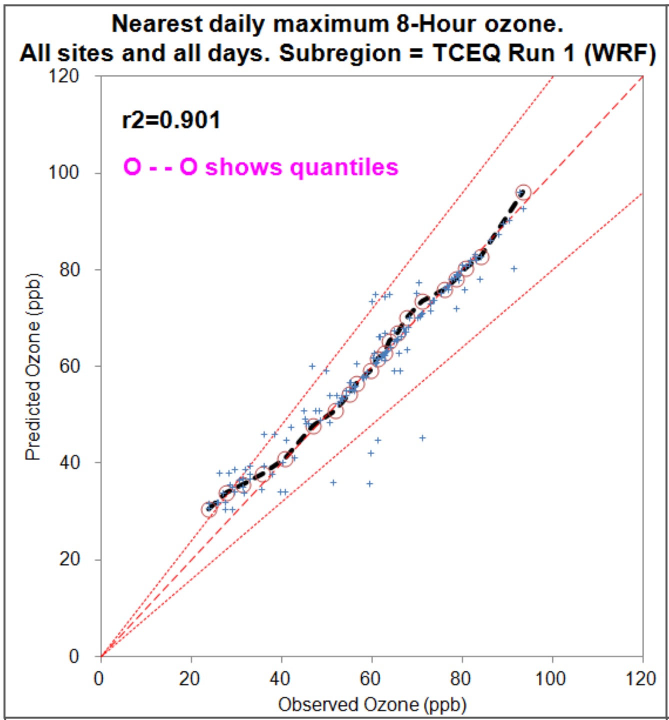


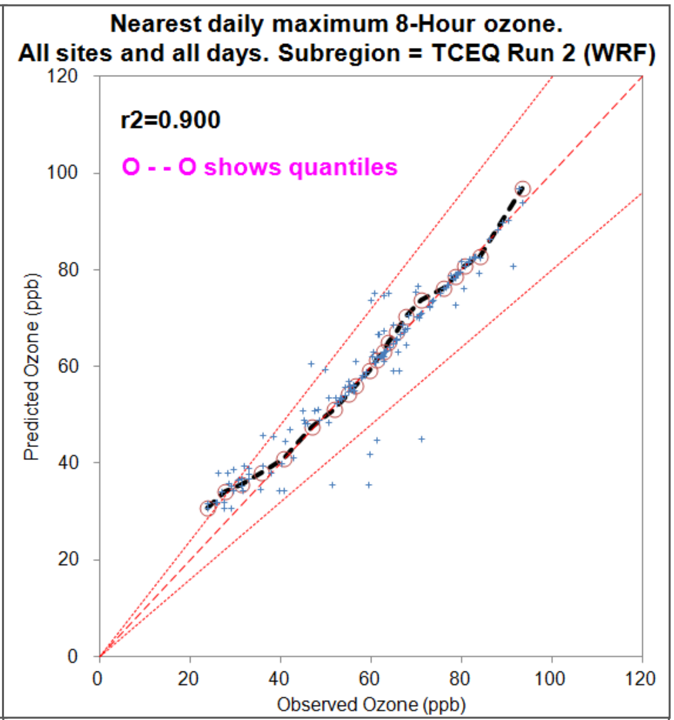
Daily maximum 8-Hour ozone near monitor. All sites and all days. Subregion = TCEQ Run 1 (WRF)

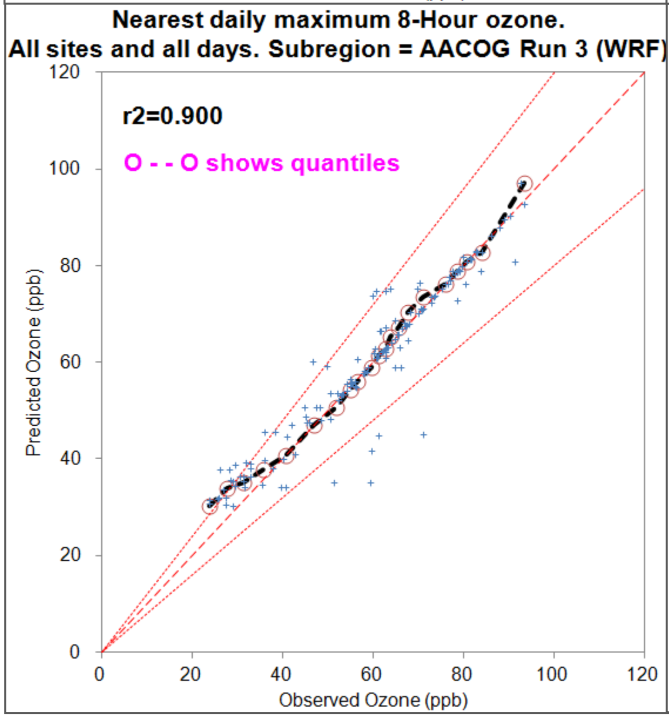
Daily maximum 8-Hour ozone near monitor. All sites and all days. Subregion = TCEQ Run 2 (WRF)

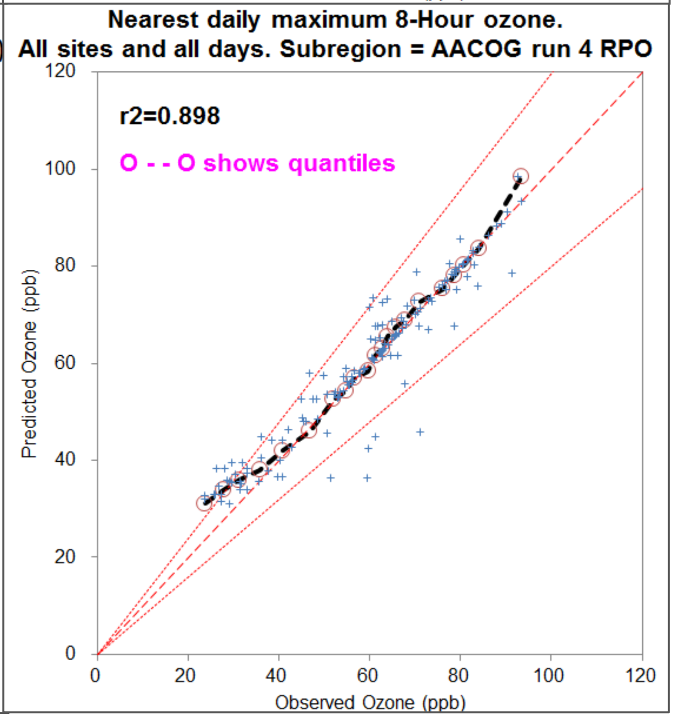
Daily maximum 8-Hour ozone near monitor. All sites and all days. Subregion = AACOG Run 3 (WRF)

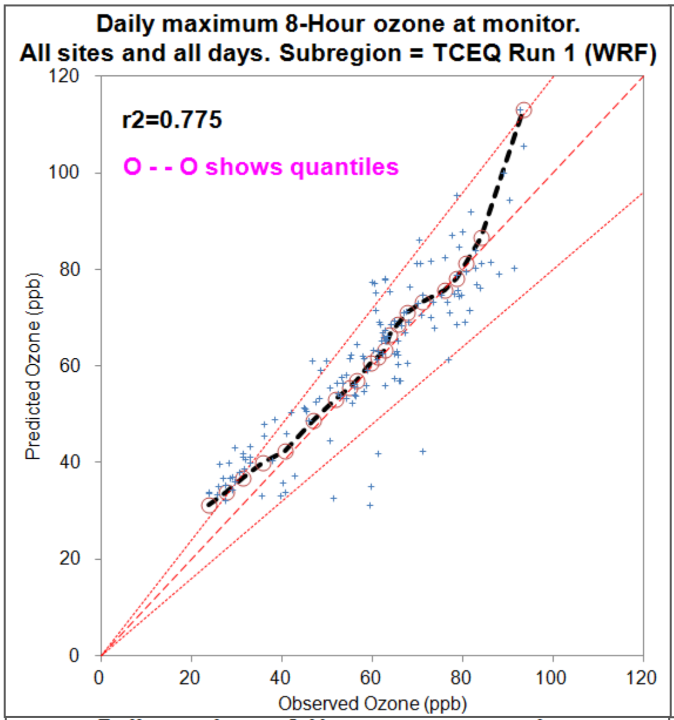
Daily maximum 8-Hour ozone near monitor. All sites and all days. Subregion = AACOG run 4 RPO

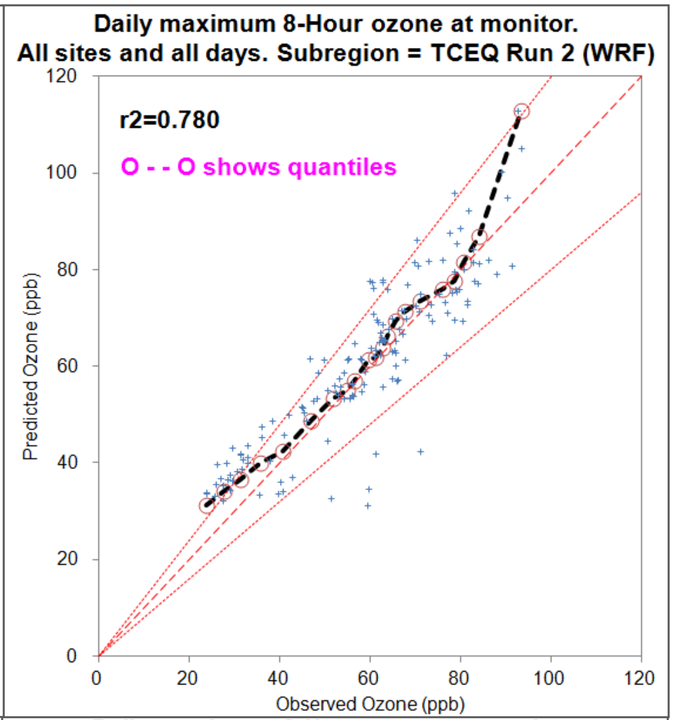

Nearest daily maximum 8-Hour ozone.
All sites and all days. Subregion = TCEQ Run 1 (WRF)
r2=0.901
O - - O shows quantiles
Predicted Ozone (ppb)
Observed Ozone (ppb)
0
20
40
60
80
100
120

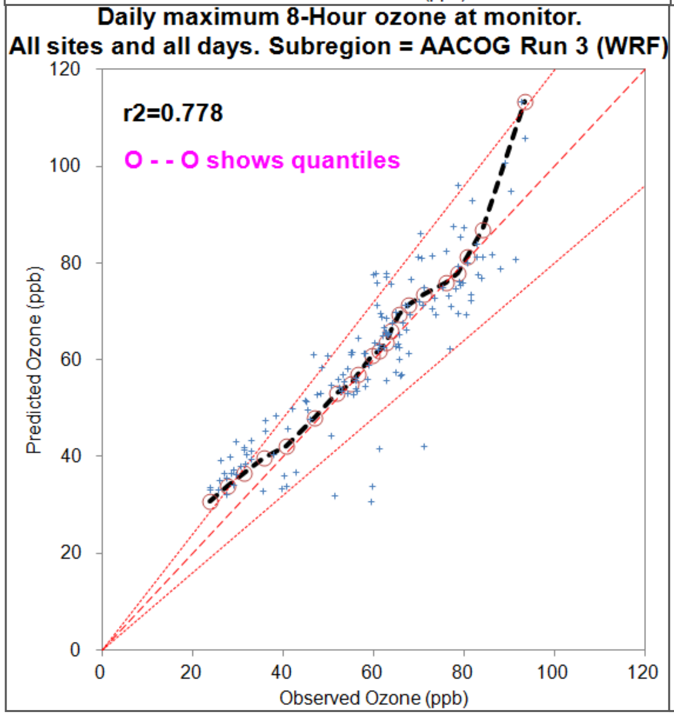

Nearest daily maximum 8-Hour ozone.
All sites and all days. Subregion = TCEQ Run 2 (WRF)
r2=0.900
O - - O shows quantiles
Predicted Ozone (ppb)
Observed Ozone (ppb)
0
20
40
60
80
100
120


Nearest daily maximum 8-Hour ozone.
All sites and all days. Subregion = AACOG Run 3 (WRF)
r2=0.900
O - - O shows quantiles
Predicted Ozone (ppb)
Observed Ozone (ppb)
0
20
40
60
80
100
120


Nearest daily maximum 8-Hour ozone.
All sites and all days. Subregion = AACOG run 4 RPO
r2=0.898
O - - O shows quantiles
Predicted Ozone (ppb)
Observed Ozone (ppb)
0
20
40
60
80
100
120


Daily maximum 8-Hour ozone at monitor.
All sites and all days. Subregion = TCEQ Run 1 (WRF)


Daily maximum 8-Hour ozone at monitor.
All sites and all days. Subregion = TCEQ Run 2 (WRF)


Daily maximum 8-Hour ozone at monitor.
All sites and all days. Subregion = AACOG Run 3 (WRF)

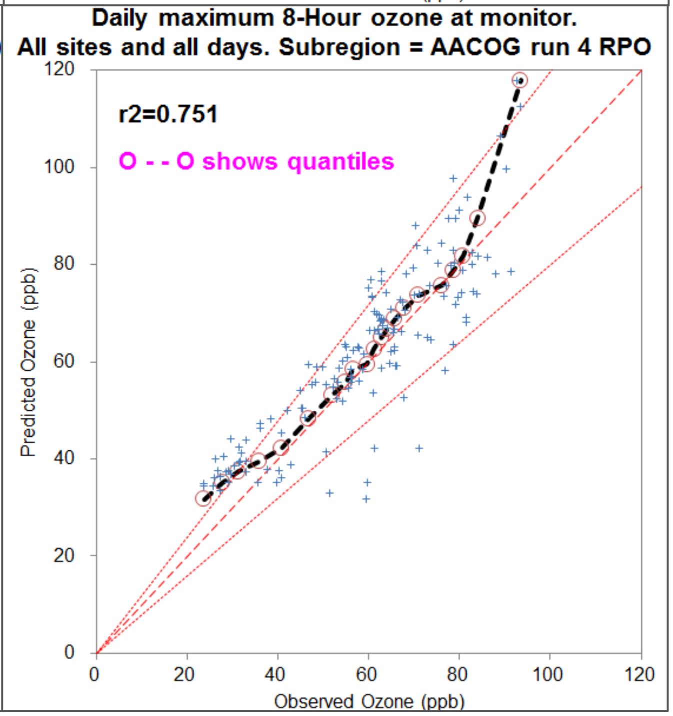

Daily maximum 8-Hour ozone at monitor.
All sites and all days. Subregion = AACOG run 4 RPO

Table 5-6: R^2 values for San Antonio Quantile-Quantile Plots: MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, and WRF AACOG Base Case Run 3

Run	Daily Maximum 1-Hour Ozone at Monitor R^2	Nearest Daily Maximum 1-Hour Ozone R^2	Daily Maximum 1-Hour Ozone Near Monitor R^2	Daily Maximum 8-Hour Ozone at Monitor R^2	Nearest Daily Maximum 8-Hour Ozone R^2	Daily Maximum 8-Hour Ozone Near Monitor R^2
Run 7_v5 (Met 11 OB70)	*0.582*	*0.908*	*0.585*	*0.689*	*0.881*	*0.658*
TCEQ Run 1 (WRF)	0.745	**0.922**	0.737	0.779	**0.901**	0.761
TCEQ Run 2 (WRF)	**0.751**	0.919	**0.742**	**0.780**	0.900	**0.767**
AACOG Run 3 (WRF)	0.748	0.920	0.742	0.778	0.900	0.766
AACOG RPO Run 4 (WRF)	0.724	0.919	0.736	0.751	0.898	0.751

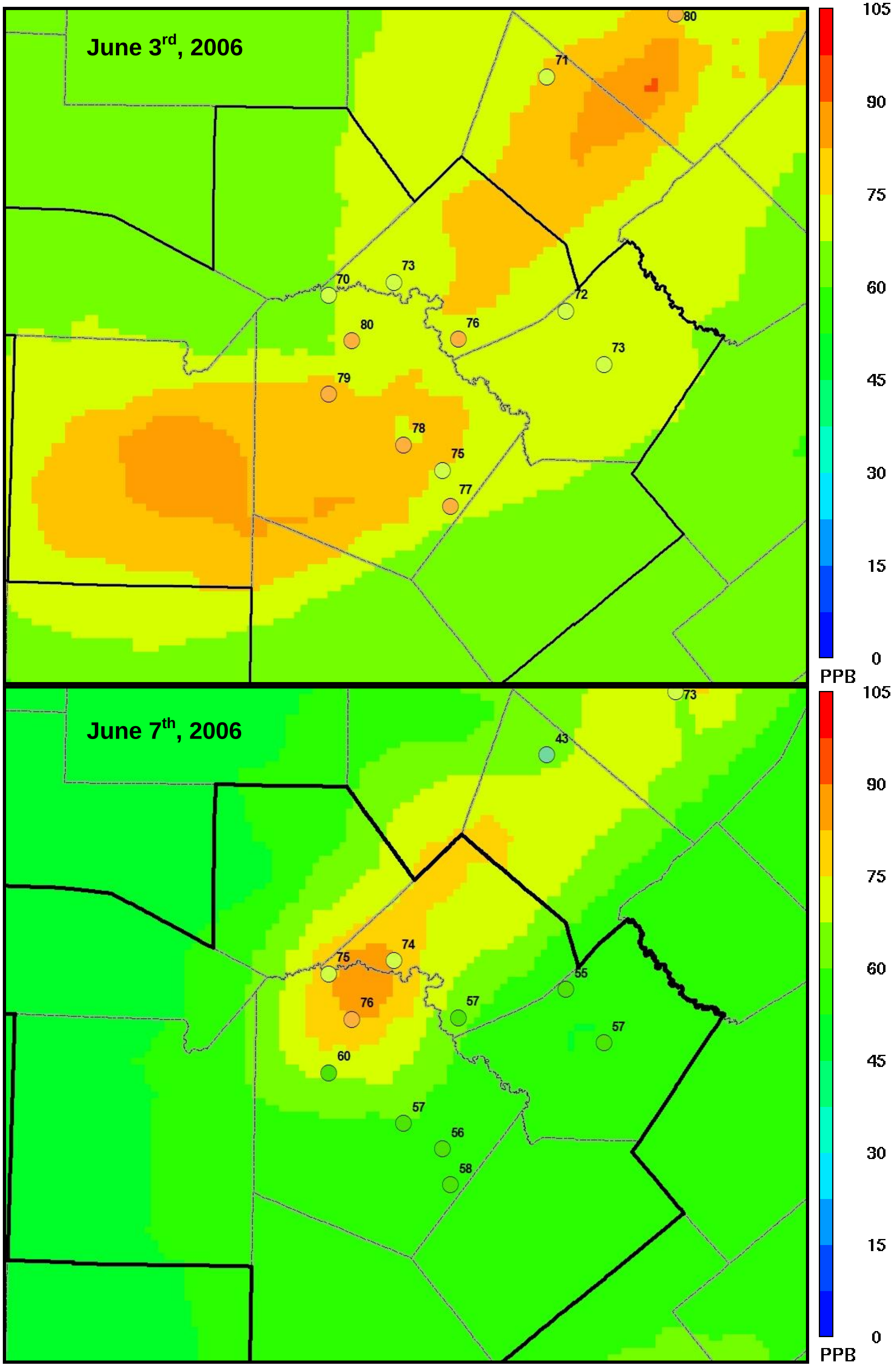
5.8 Daily Maximum 8-Hour Ozone Fields

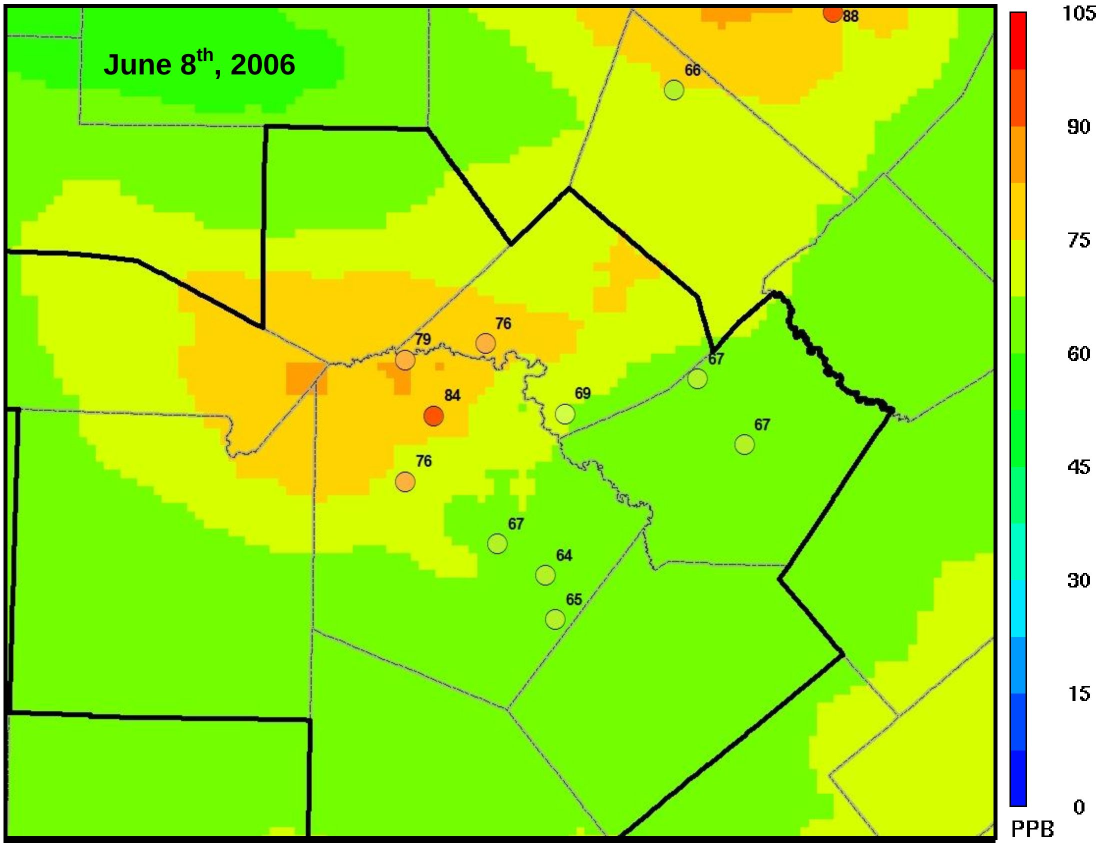
Another means of analyzing model performance recommended by the EPA is use of tile plot graphics. Figure 5-31 shows tile plots of predicted maximum ozone across the modeling domain for AACOG run 3 for each exceedance day. The plots for AACOG run 3 are similar to TCEQ run 1 and TCEQ run 2. These plots display the geographic distribution of the model's ozone predictions. Observed ozone at each monitor is plotted, color coded, and overlaid above the map of predicted ozone. The tile plots indicated that there were no unusual patterns of ozone formation. As seen on the plots for ozone exceedance days, ozone plumes were produced in the vicinity of San Antonio and Austin. These urban plumes were predicted for each urban core and downwind areas of the cities. The plots were also animated to examine the timing and location of ozone formation. The animation of the tile plots indicated that there was adequate model performance on all days.

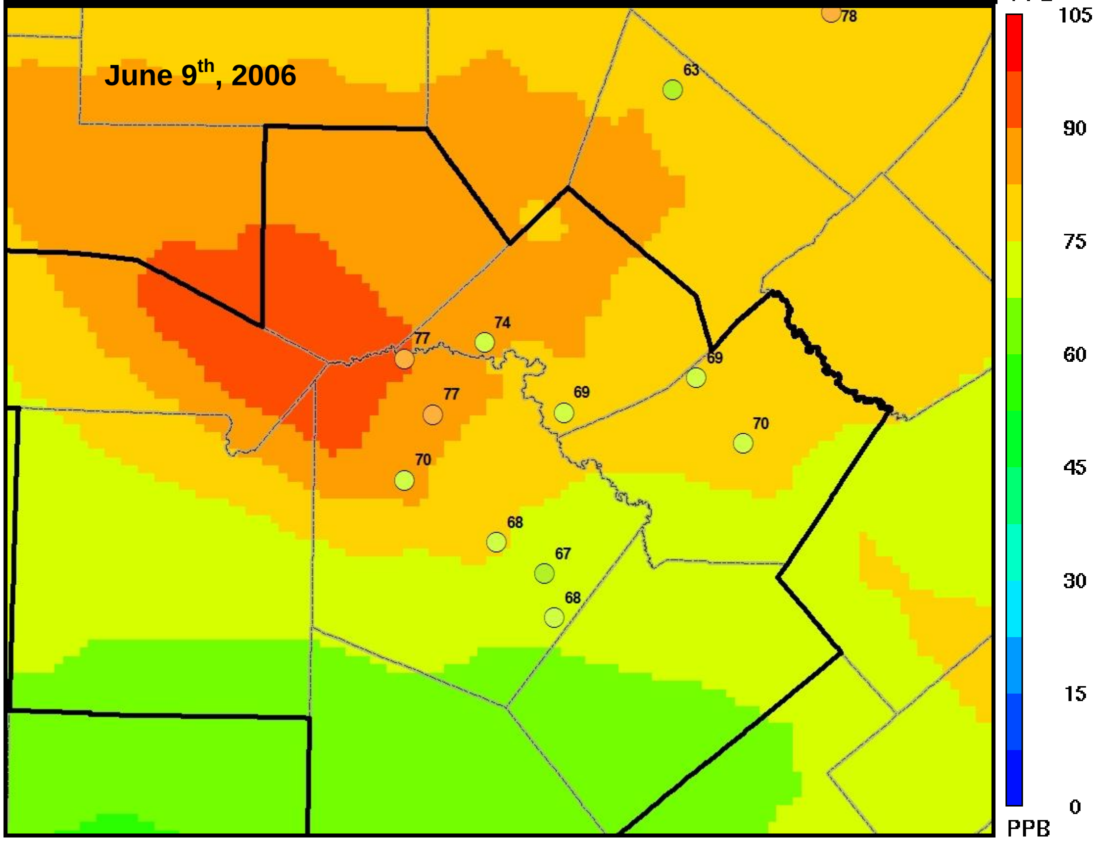
The daily tile plots for June 3rd, June 27th, and June 28th indicate good correlation between predicted and observed peak ozone. The model accurately predicted the locations of high ozone located at C58 and low ozone at C23 and the monitors southeast of San Antonio on June 7th. There was a slight over prediction of ozone in the San Antonio region on June 9th and on June 13th at C502. Ozone was over predicted at the monitors in northwest San Antonio, C23, C58, C502, and C504, on June 29th.

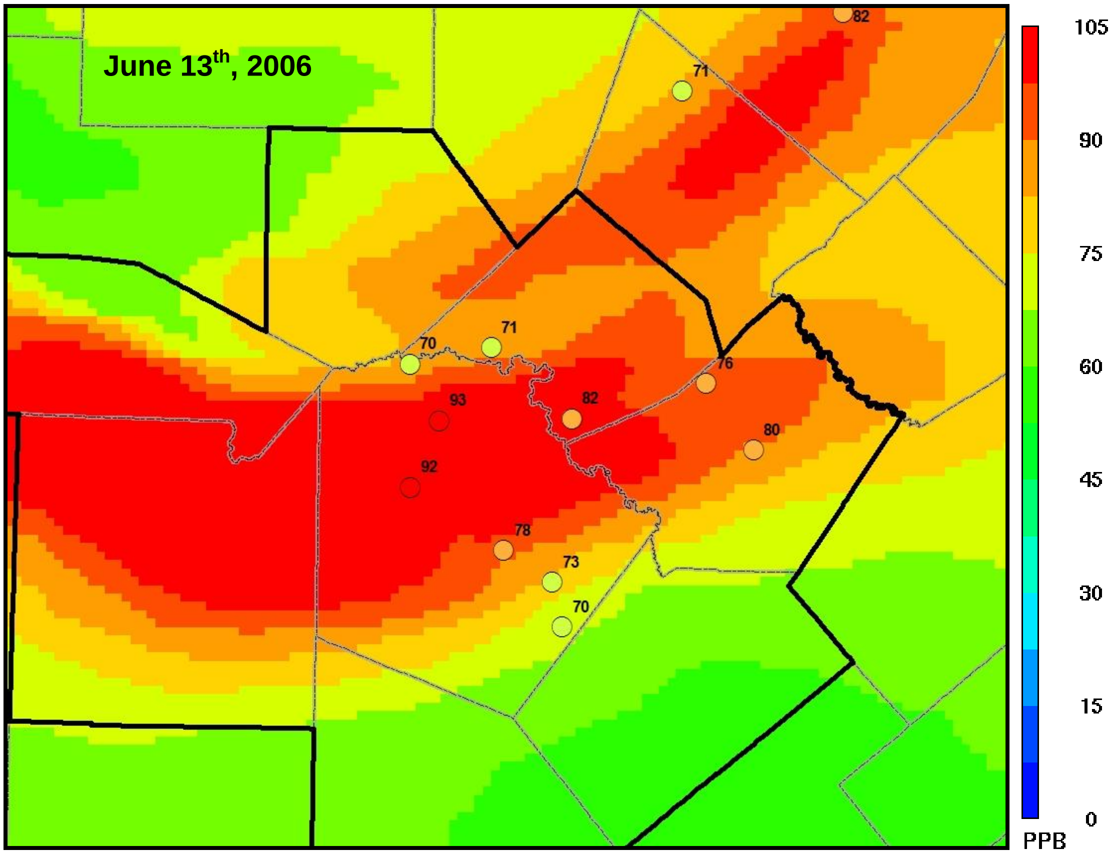
On Table 5-7, the predicted daily maximum 1-hour ozone concentrations within the San Antonio MSA are listed for each run. There was good correlation between observed and predicted ozone on the June 3rd, June 7th, June 8th, June 26th, June 27th, and June 29th exceedance days. On these days, there was only a -3.2 ppb to 6.3 ppb difference between predicted and observed hourly ozone. Every WRF run over-predicted ozone formation on the June 9th, 13th, and 14th exceedance days. Over prediction on these days ranged from 15.4 ppb to 23.0 ppb. Model performance was improved using WRF compared to MM5, especially on the exceedance days of June 7th and 8th. When comparing the WRF runs, TCEQ run 2 exhibited the best performance for all days and days greater than 74 ppb, while AACOG run 3 exhibited the best performance on days when the maximum hourly ozone was greater than 84 ppb.

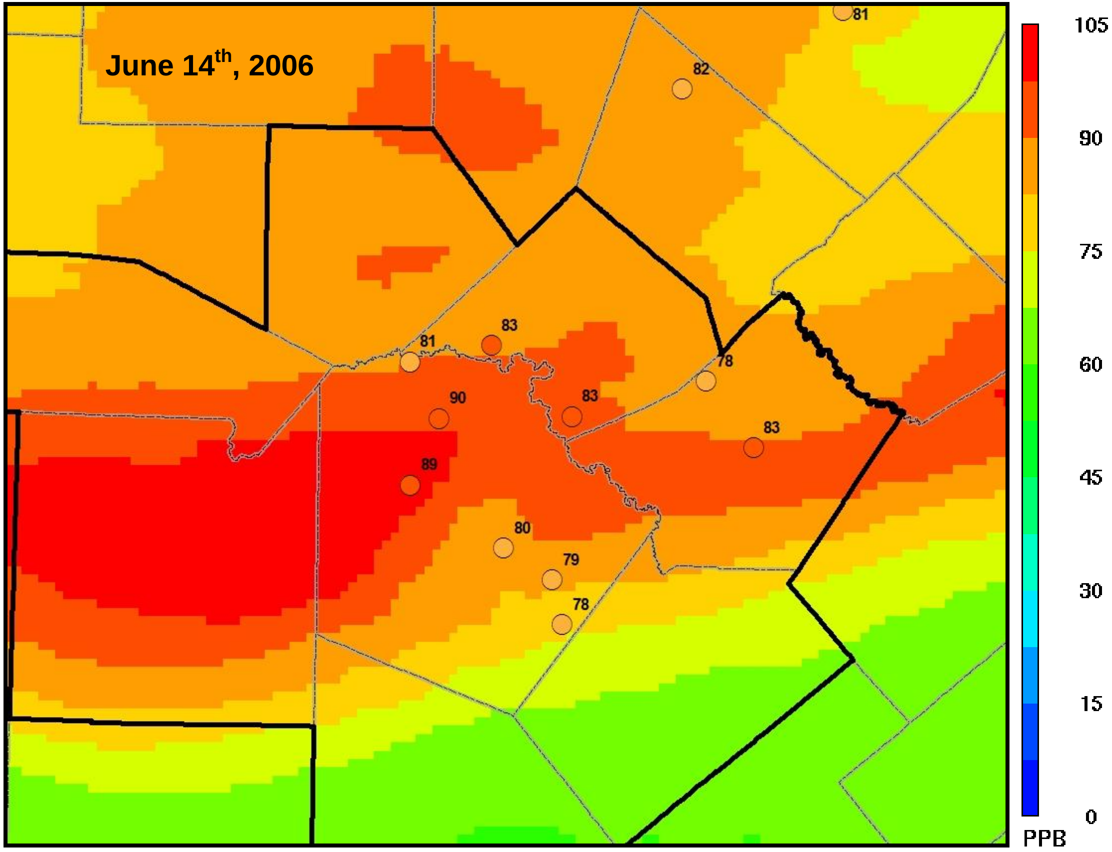
Figure 5-31: Predicted Daily Maximum 8-hour Ozone Concentrations for WRF AACOG Base Case Run 3: June 3, 7, 8, 9, 13, 14, 27, 28, and 29, 2006

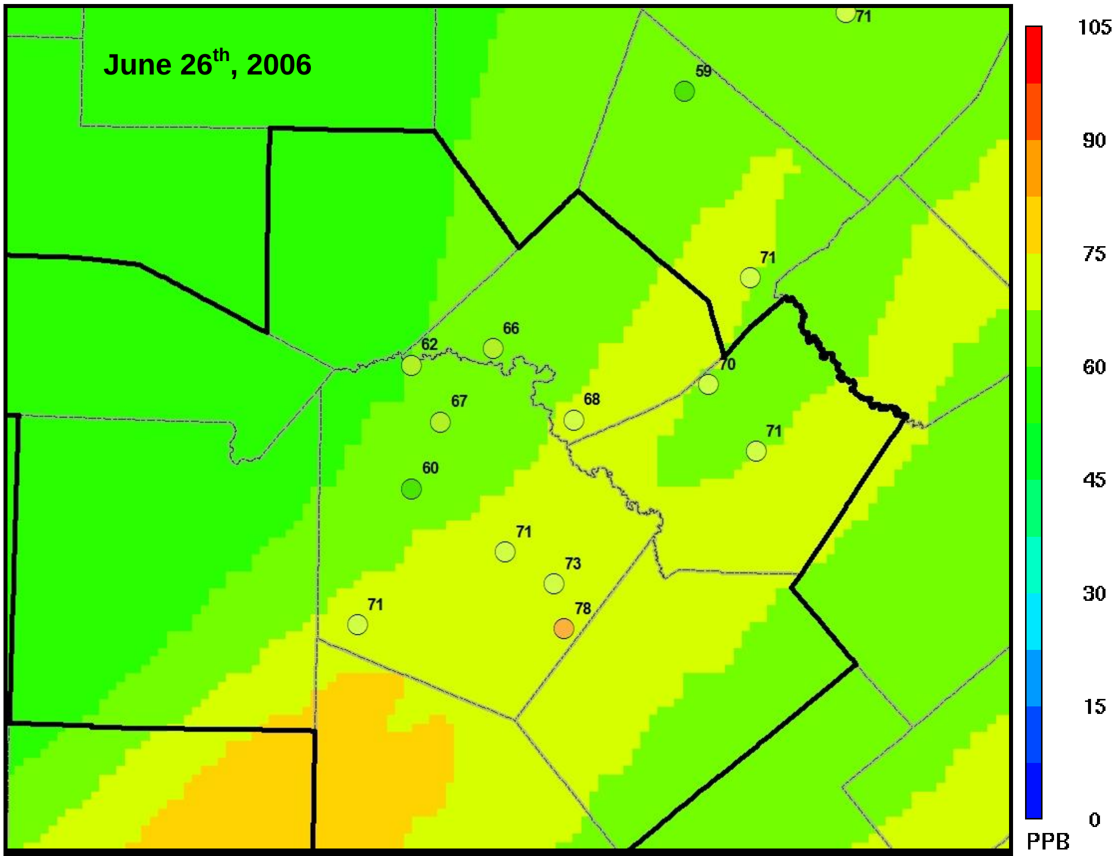


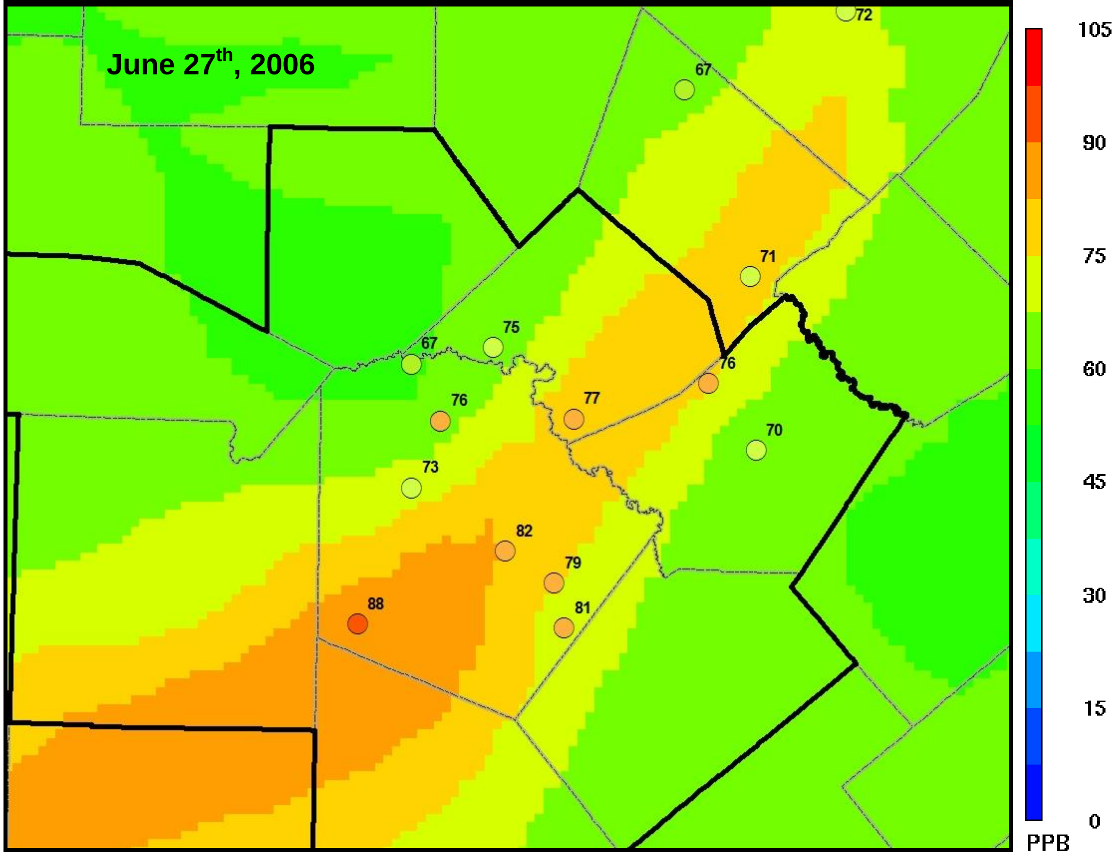

June 8th, 2006
88
66
76
79
84
69
67
67
76
67
64
65
105
90
75
60
45
30
15
0
PPB

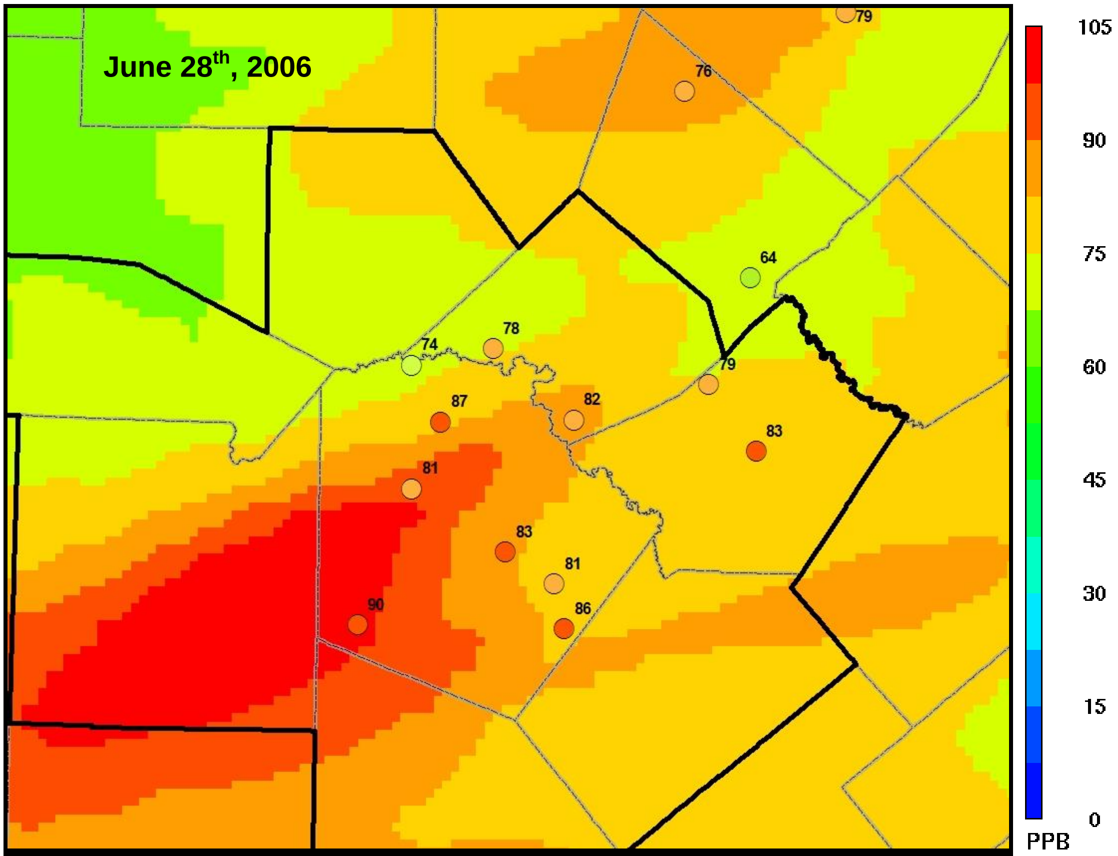

June 9th, 2006
78
63
74
77
69
77
69
70
70
68
67
68
105
90
75
60
45
30
15
0
PPB


June 13th, 2006
82
71
71
70
76
93
82
80
92
78
73
70
105
90
75
60
45
30
15
0
PPB

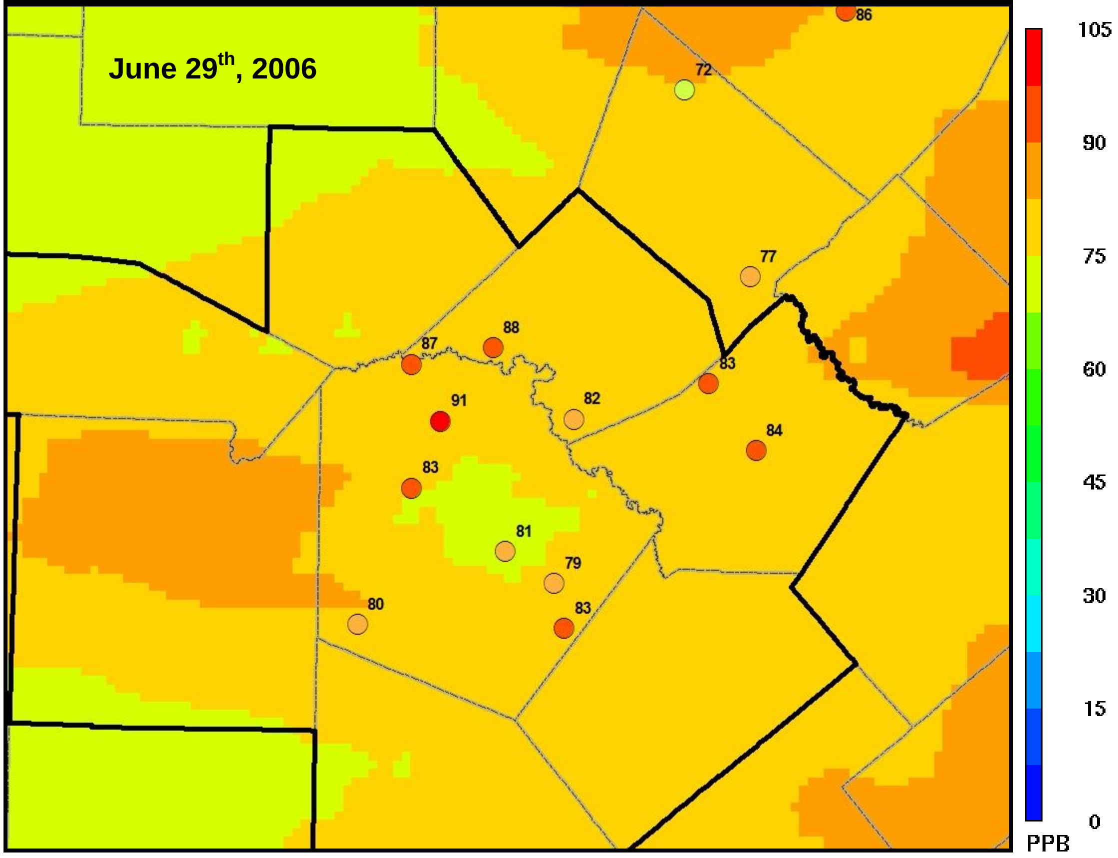

June 14th, 2006
81
82
83
81
78
90
83
83
89
80
79
78
105
90
75
60
45
30
15
0
PPB


June 26th, 2006
71
59
71
66
62
70
67
68
71
60
71
73
71
78
105
90
75
60
45
30
15
0
PPB


June 27th, 2006
72
67
71
75
67
76
76
77
70
73
82
79
88
81
105
90
75
60
45
30
15
0
PPB



June 28th, 2006



June 29th, 2006

Table 5-7: Predicted Daily Maximum 1-hour Ozone Concentrations within the San Antonio MSA for MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4

Modeling Day	Peak 1-hr Monitored ozone in SA	Run 7_v5 (Met 11 OB70)		Run 1 TCEQ bl (WRF)		Run 2 TCEQ bl (WRF)		Run 3 AACOG bl (WRF)		Run 4 AACOG RPO (WRF)	
		ppb	Diff.	ppb	Diff.	ppb	Diff.	ppb	Diff.	ppb	Diff.
1-Jun-06	62	53	*-8.6*	**64**	**2.4**	65	2.9	65	2.9	67	4.9
2-Jun-06	78	**77**	**-0.7**	84	5.6	84	5.9	85	6.5	*89*	*11.2*
3-Jun-06	**86**	91	4.5	**90**	**4.4**	91	4.7	91	4.7	*95*	*8.5*
4-Jun-06	81	**78**	**-3.4**	92	10.8	92	10.7	*92*	*11.1*	*97*	*16.1*
5-Jun-06	70	**79**	**9.0**	82	12.3	82	12.0	*83*	*12.5*	*85*	*15.3*
6-Jun-06	82	76	-5.6	88	5.7	**86**	**3.9**	86	4.5	*90*	*7.9*
7-Jun-06	**89**	97	8.2	95	6.3	**94**	**5.1**	95	6.3	*99*	*9.9*
8-Jun-06	**96**	103	*7.0*	97	1.1	**97**	**0.6**	98	1.5	101	5.3
9-Jun-06	**87**	**94**	**7.4**	102	15.4	103	15.5	103	16.2	*106*	*18.9*
10-Jun-06	76	**81**	**5.2**	98	21.7	96	20.0	96	20.2	*99*	*23.1*
11-Jun-06	68	**74**	**6.0**	*79*	*11.2*	78	9.8	78	10.0	79	10.5
12-Jun-06	78	102	*23.7*	96	17.7	95	17.4	96	18.2	97	19.4
13-Jun-06	**106**	**92**	**-14.0**	128	22.1	128	22.3	129	23.0	*135*	*28.7*
14-Jun-06	**94**	**93**	**-1.3**	113	19.4	114	19.7	115	20.7	*122*	*28.4*
15-Jun-06	74	**76**	**1.8**	78	4.2	77	3.4	77	3.4	*80*	*5.9*
16-Jun-06	45			52	6.8	**52**	**6.5**	52	6.6	*52*	*7.3*
17-Jun-06	53			49	-4.1	48	-4.8	*48*	*-4.9*	**51**	**-1.6**
18-Jun-06	79			**54**	**-24.9**	54	-25.1	54	-25.1	*54*	*-25.3*
19-Jun-06	85			77	-7.5	*77*	*-7.8*	78	-7.4	**81**	**-3.7**
20-Jun-06	35			42	7.3	42	7.2	**42**	**7.1**	*45*	*10.1*
21-Jun-06	37			53	16.0	**53**	**15.5**	53	15.7	*55*	*18.0*
22-Jun-06	41			*57*	*16.2*	**56**	**15.3**	56	15.5	56	15.5
23-Jun-06	60			62	1.6	*62*	*1.7*	62	1.6	**61**	**0.5**
24-Jun-06	49			**60**	**11.2**	61	12.2	62	12.5	*63*	*13.6*
25-Jun-06	70			76	6.4	**75**	**4.6**	75	4.8	*78*	*7.7*
26-Jun-06	**86**			83	-3.2	83	-2.7	**83**	**-2.6**	*81*	*-4.9*

Modeling Day	Peak 1-hr Monitored ozone in SA	Run 7_v5 (Met 11 OB70)		Run 1 TCEQ bl (WRF)		Run 2 TCEQ bl (WRF)		Run 3 AACOG bl (WRF)		Run 4 AACOG RPO (WRF)	
		ppb	Diff.	ppb	Diff.	ppb	Diff.	ppb	Diff.	ppb	Diff.
27-Jun-06	**98**			*95*	*-3.1*	96	-2.1	**96**	**-1.6**	95	-2.5
28-Jun-06	**101**			109	8.2	**109**	**7.7**	110	8.7	*113*	*12.2*
29-Jun-06	**94**			*96*	*1.7*	**94**	**0.3**	94	0.3	93	-1.2
30-Jun-06	87			**92**	**5.3**	92	5.5	*93*	*6.0*	93	5.8
1-Jul-06	46			*54*	*8.3*	*54*	*8.3*	**54**	**8.1**	**54**	**8.1**
2-Jul-06	30			*66*	*36.4*	*67*	*36.9*	**67**	**36.8**	**67**	**36.8**
Avg. All Days			2.6		7.6		7.3		7.6		9.7
Avg. on Days > 74 ppb			3.4		6.4		6.0		6.2		8.8
Avg. on Days > 84 ppb			2.0		7.2		7.1		6.3		8.8

Table 5-8: Predicted Daily Maximum 8-hour Ozone Concentrations within the San Antonio MSA for MM5 Base Case Run 7, WRF TCEQ Base Case Run 1, WRF TCEQ Base Case Run 2, WRF AACOG Base Case Run 3, and WRF AACOG RPO Base Case Run 4

Modeling Day	Peak 8-hr Monitored ozone in SA	Run 7_v5 (Met 11 OB70)		*Run 1 TCEQ bl (WRF)*		Run 2 TCEQ bl (WRF)		Run 3 AACOG bl (WRF)		Run 4 AACOG RPO (WRF)	
		ppb	Diff.	*ppb*	*Diff.*	ppb	Diff.	ppb	Diff.	ppb	Diff.
1-Jun-06	56	**55.8**	**-0.2**	59.1	3.1	59.6	3.6	59.6	3.6	*61.8*	*5.8*
2-Jun-06	66	**65.0**	**-1.0**	68.3	2.3	68.5	2.5	68.8	2.8	*72.1*	*6.1*
3-Jun-06	**80**	78.9	-1.1	79.3	-0.7	**79.5**	**-0.5**	79.4	-0.6	*83.5*	*3.5*
4-Jun-06	73	68.5	-4.5	75.5	2.5	**75.3**	**2.3**	75.4	2.4	*78.7*	*5.7*
5-Jun-06	63	**63.1**	**0.1**	68.2	5.2	68.1	5.1	68.0	5.0	*70.4*	*7.4*
6-Jun-06	68	**66.6**	**-1.4**	77.5	9.5	76.5	8.5	76.9	8.9	*78.9*	*10.9*
7-Jun-06	**76**	**79.2**	**3.2**	85.3	9.3	84.6	8.6	85.4	9.4	*88.6*	*12.6*
8-Jun-06	**84**	*79.1*	*-4.9*	82.8	-1.2	82.6	-1.4	82.8	-1.2	**84.5**	**0.5**
9-Jun-06	**77**	**76.9**	**-0.1**	91.2	14.2	91.5	14.5	91.8	14.8	*95.0*	*18.0*
10-Jun-06	71	**73.8**	**2.8**	*89.6*	*18.6*	89.1	18.1	89.3	18.3	89.2	18.2
11-Jun-06	64	**65.8**	**1.8**	*71.8*	*7.8*	71.2	7.2	71.3	7.3	70.8	6.8
12-Jun-06	70	**77.2**	**7.2**	81.5	11.5	81.0	11.0	81.5	11.5	*83.8*	*13.8*
13-Jun-06	**93**	**83.3**	**-9.7**	114.0	21.0	113.8	20.8	114.3	21.3	*118.9*	*25.9*
14-Jun-06	**90**	**94.9**	**4.9**	101.0	11.0	101.0	11.0	101.5	11.5	*106.9*	*16.9*
15-Jun-06	69	**70.5**	**1.5**	73.7	4.7	73.7	4.7	73.8	4.8	*74.7*	*5.7*
16-Jun-06	35			47.4	12.4	47.3	12.3	**47.3**	**12.3**	*48.0*	*13.0*
17-Jun-06	44			41.7	-2.3	41.6	-2.4	*41.4*	*-2.6*	**43.2**	**-0.8**
18-Jun-06	71			45.8	-25.2	45.7	-25.3	*45.6*	*-25.4*	**46.8**	**-24.2**
19-Jun-06	65			66.0	1.0	65.9	0.9	**65.7**	**0.7**	*68.7*	*3.7*
20-Jun-06	29			36.2	7.2	36.2	7.2	**36.1**	**7.1**	*37.6*	*8.6*
21-Jun-06	32			45.2	13.2	45.1	13.1	**45.0**	**13.0**	*46.1*	*14.1*
22-Jun-06	36			48.6	12.6	**48.3**	**12.3**	48.3	12.3	*48.3*	*12.3*
23-Jun-06	50			**49.8**	**-0.2**	49.6	-0.4	49.6	-0.4	*48.0*	*-2.1*
24-Jun-06	45			*53.1*	*8.1*	52.9	7.9	53.0	8.0	**52.6**	**7.6**
25-Jun-06	65			**67.0**	**2.0**	67.6	2.6	67.6	2.6	*67.9*	*2.9*
26-Jun-06	**78**			72.6	-5.4	73.3	-4.8	**73.4**	**-4.6**	*68.1*	*-9.9*
27-Jun-06	**88**			86.5	-1.5	87.5	-0.5	**88.0**	**0.0**	*85.5*	*-2.5*

Modeling Day	Peak 8-hr Monitored ozone in SA	Run 7_v5 (Met 11 OB70)		*Run 1 TCEQ bl (WRF)*		Run 2 TCEQ bl (WRF)		Run 3 AACOG bl (WRF)		Run 4 AACOG RPO (WRF)	
		ppb	Diff.	*ppb*	*Diff.*	ppb	Diff.	ppb	Diff.	ppb	Diff.
28-Jun-06	**90**			**102.5**	**12.5**	103.0	13.0	*103.3*	*13.3*	102.9	12.9
29-Jun-06	**91**			83.1	-8.0	**83.2**	**-7.8**	83.1	-7.9	*80.5*	*-10.5*
30-Jun-06	71			77.8	6.8	78.1	7.1	*78.5*	*7.5*	**77.4**	**6.4**
1-Jul-06	38			**48.1**	**10.1**	*48.5*	*10.5*	*48.5*	*10.5*	*48.5*	*10.5*
2-Jul-06	26			**56.2**	**30.2**	*56.7*	*30.7*	*56.7*	*30.7*	*56.7*	*30.7*
Avg. All Days			-0.1		6.0		6.0		6.2		7.2
Avg. on Days > 60 ppb			-0.1		4.4		4.4		4.7		6.0
Avg. on Ozone Exceedance days			-1.3		5.1		5.3		5.6		6.5

When looking at the results for maximum 8-hour ozone, there was a slight under-prediction of ozone on June 3rd, June 8th, June 26th, and June 29th. As expected, 8 hour ozone maximums were over predicted on June 9th, June 13th, June 14th, and June 28th. In the San Antonio-New Braunfels MSA, prediction of 8-hour maximums ranged from -10.5 ppb to 25.9 ppb of monitored values on exceedance days. TCEQ run 1 demonstrated the best average prediction for maximum 8-hour ozone on all days (6.0 ppb) and exceedance days (5.1 ppb). AACOG run 4 with the RPO grid had the highest average over predictions for 8-hour maximum values for all days and for exceedance days. "Since the modeled peak is taken across every grid cell in the domain and the observed peak is from only a limited number of monitoring sites, it is expected that the domain-wide peak simulated by a good-performing model will exceed the monitored peak."[269]

5.9 Summary of CAMx Base Case Runs

The CAMx model over predicted ozone concentrations at monitors on the northwest side of San Antonio, C23, C25, and C505, on two of the episode's exceedance days: June 13 and 14th. On other days of the episode, the model's ozone estimations correlated well with observed peak hourly ozone values and predicted peak hourly ozone values. For most monitors, there was an excellent correlation between observed peak hourly ozone and predicted hourly ozone in the second half of the episode, with some under prediction at C503. When examining the diurnal bias, model results for C58 over predicted diurnal ozone on most exceedance days during the episode. The model also over predicted diurnal hourly ozone in the second part of the episode at monitors located in rural areas of the San Antonio-New Braunfels MSA, C502, C503, C504, and C506. The model over predicted NO_X emissions at C58 on almost every day of the June 2006 episode. This over prediction of NO_X at C58 provides a plausible explanation for the model's poor performance regarding diurnal ozone forecasts for the monitor.

Although there were several significant differences in the local emission inventory, model results are similar for TCEQ run 1, TCEQ run 2, and AACOG run 3 for every monitor. Changes in meteorological conditions had a greater impact on the model's ozone predictions than changes to the emission inventories. For AACOG run 4 using the RPO grid, predicted ozone on some exceedance days was higher than the other 3 WRF runs.

Every WRF modeling run exhibited similar performance for unpaired peak accuracy, paired peak accuracy, peak bias, peak error, normalized bias, and normalized error. Model performance on all days was improved with TCEQ run 2 and exceedance day performance was best for AACOG run 1. Performance for AACOG run 4 using the RPO grid was degraded for

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[269] TCEQ, Dec. 7, 2011. "Appendix C: Photochemical Modeling for the DFW Attainment Demonstration Sip Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. P. C-45. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppC_CAMx_ado.pdf. Accessed 06/26/13.

peak error and normalized error. This run provided higher peak 1-hour ozone predictions compared to the other 3 WRF runs. Results for paired peak accuracy were very good for C58, C622, C501, C502, C503, and C506 and paired peak accuracy for the remaining monitors also met EPA recommended guidelines.

Tile plots indicated that there were no unusual patterns of ozone formation predicted by the model runs. Ozone plumes were produced in the vicinity of San Antonio and Austin. As expected, these urban plumes were predicted for each urban core and areas downwind of the cities. AACOG run 3 was used as the 2006 base case because it has the latest and most accurate emission inventory. When the base case was completed, the emission inventory in the model was projected to 2012 and 2018. There were three different emission inventory scenarios in 2018, low, moderate, and high, based on projected activity in the Eagle Ford. Future work will include continued evaluation of using the RPO grid for the emission inventory and evaluating the newly released CAMx6.0 model performance with the extended June 2006 modeling episode.

6 Future Year Modeling

The photochemical model developed to simulate the extended June 2006 high-ozone episode was updated with 2012 and 2018 projected anthropogenic emission inventories to estimate future ozone concentrations under the same meteorological conditions as the 2006 base case. The projected emission inventories account for existing local, state, and federal air quality control strategies to determine whether such measures are sufficient to help the region meet the 2008 NAAQS 8-hour ozone standard. The 2018 projection case was compared to the 2012 projection to determine future ozone design values.

6.1 Projections Cases

A total of 6 future year scenarios were developed from the June 2006 modeling episode.

2012 Without Eagle Ford

- WRF v3.2
- CAMx 5.40
- Local 2012 San Antonio-New Braunfels MSA emission data including construction equipment, landfill equipment, quarry equipment, agricultural tractors, combines, commercial airports, point sources, and heavy duty truck idling

2012 With Eagle Ford Emission Inventory

- WRF v3.2
- CAMx 5.40
- Local 2012 San Antonio-New Braunfels MSA emission data including construction equipment, landfill equipment, quarry equipment, agricultural tractors, combines, commercial airports, point sources, and heavy duty truck idling
- Eagle Ford 2012 Emission Inventory

2018 Without Eagle Ford Emission Inventory

- WRF v3.2
- CAMx 5.40
- Local 2018 San Antonio-New Braunfels MSA emission data including construction equipment, landfill equipment, quarry equipment, agricultural tractors, combines, commercial airports, point sources, and heavy duty truck idling

2018 Low Scenario Eagle Ford Emission Inventory

- WRF v3.2
- CAMx 5.40
- Local 2018 San Antonio-New Braunfels MSA emission data including construction equipment, landfill equipment, quarry equipment, agricultural tractors, combines, commercial airports, point sources, and heavy duty truck idling
- Eagle Ford 2018 Emission Inventory Low Scenario

2018 Moderate Eagle Ford Emission Inventory

- WRF v3.2
- CAMx 5.40
- Local San Antonio-New Braunfels MSA emission data including construction equipment, landfill equipment, quarry equipment, agricultural tractors, combines, commercial airports, point sources, and heavy duty truck idling
- Eagle Ford 2018 Emission Inventory Moderate Scenario

2018 High Eagle Ford Emission Inventory

- WRF v3.2
- CAMx 5.40
- Local 2018 San Antonio-New Braunfels MSA emission data including construction equipment, landfill equipment, quarry equipment, agricultural tractors, combines, commercial airports, point sources, and heavy duty truck idling
- Eagle Ford 2018 Emission Inventory High Scenario

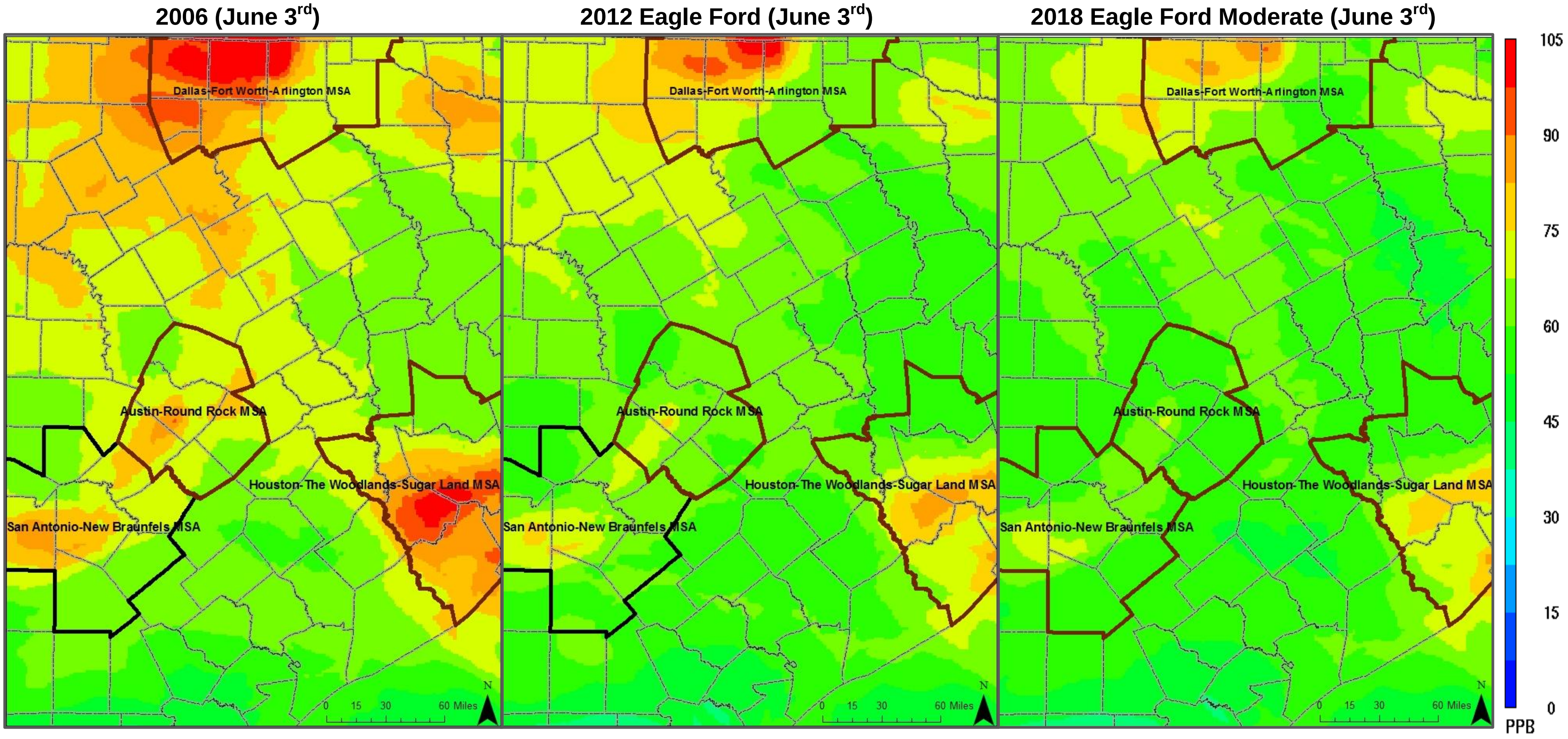
6.2 Tile Plots – Ozone Concentration: 2006, 2012, and 2018

Tile plots can be used as a means of determining if there is an error in the input data or model performance. The plots are visual representations of the model output, displaying ozone concentrations by hour for the episode day or the maximum ozone by day. The following tile plots (Figure 6-1) represent comparisons between the model results for 2006, 2012 Eagle Ford, and 2018 Moderate Eagle Ford 8-hour daily maximum ozone concentrations in the 4km grid for each day.

Peak ozone concentrations are predicted downwind of city centers and major point sources in these tile plots. In addition, the overall reduction in total NO_X, VOC, and CO emissions (local and regional) between 2006 and 2018 diminishes the magnitude of the urban plumes each day of the 2018 projection compared to its 2006 counterpart. Likewise, the spatial extent of 8-hour ozone plumes greater than 75 ppb are significantly reduced for every exceedance day in the San Antonio region in 2018.

Although there is an overall reduction of ozone on every exceedance day in the San Antonio-New Braunfels MSA when comparing the 2018 simulation with the 2006 model results, significant transport still occurs. On the June 14th plots, Houston's elevated ozone plume can be observed reaching the San Antonio-New Braunfels MSA. Although the concentration of the Houston plume diminishes between the 2006 and 2018 model runs, the tile plots indicate the 8-hour ozone levels in the 2018 scenario remain above 65 ppb. A similar pattern occurs on June 27th where the Austin plume has a significant impact on ozone levels in the San Antonio-New Braunfels MSA.

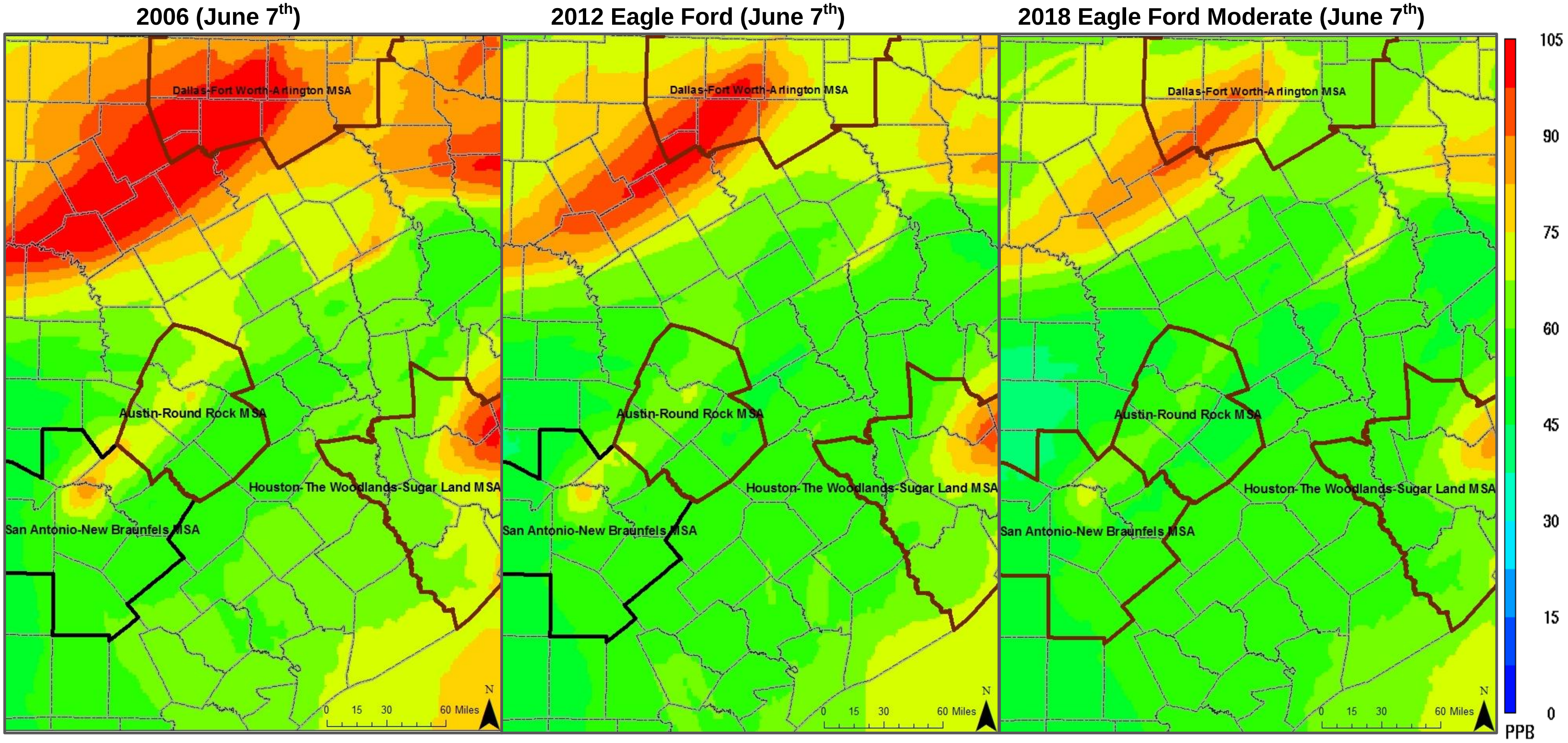
Figure 6-1: Predicted Daily Maximum 8-hour Ozone Concentrations in the 4-km Subdomain, 2006, 2012 Eagle Ford, and 2018 Eagle Ford Moderate Scenario

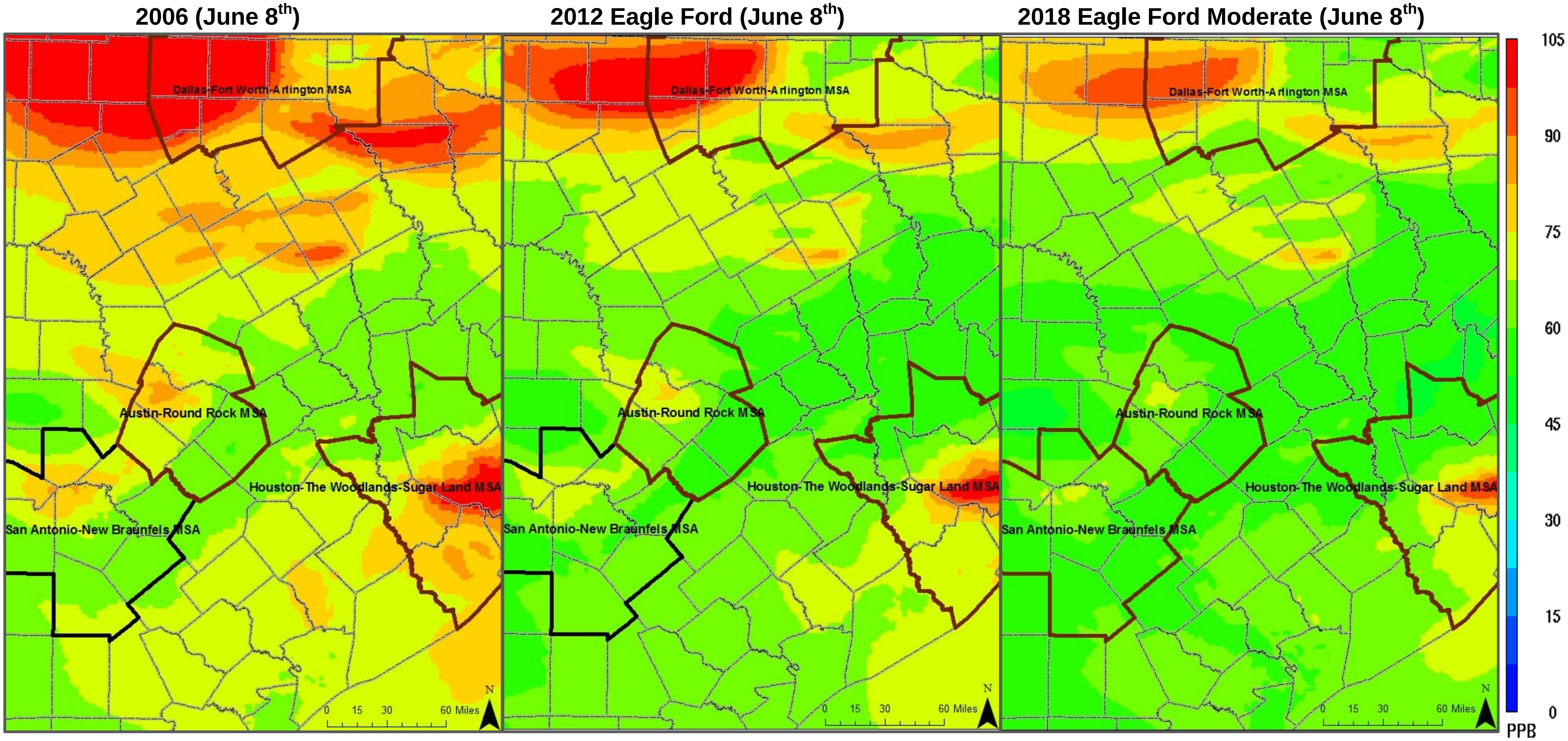


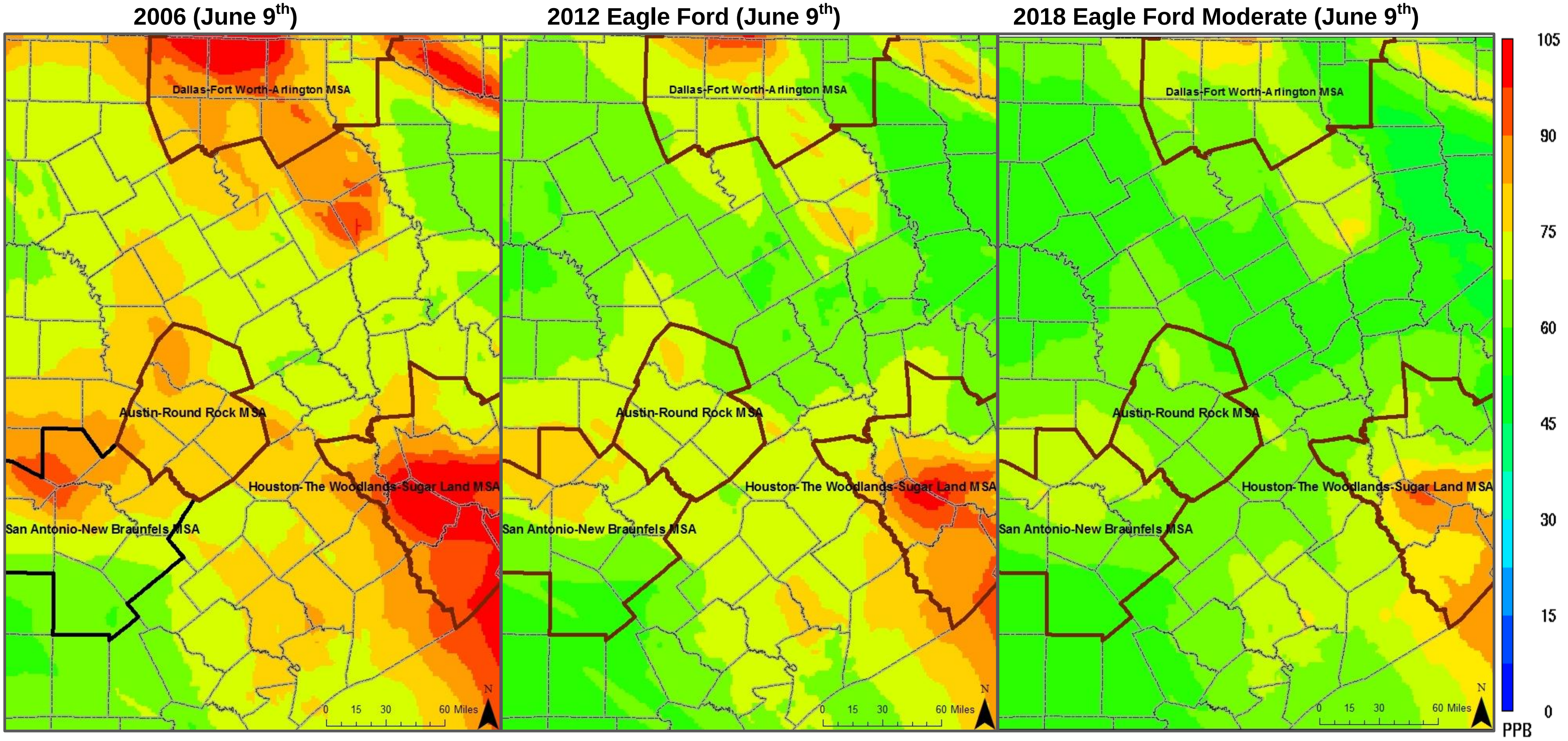
2006 (June 3rd)

2012 Eagle Ford (June 3rd)

2018 Eagle Ford Moderate (June 3rd)

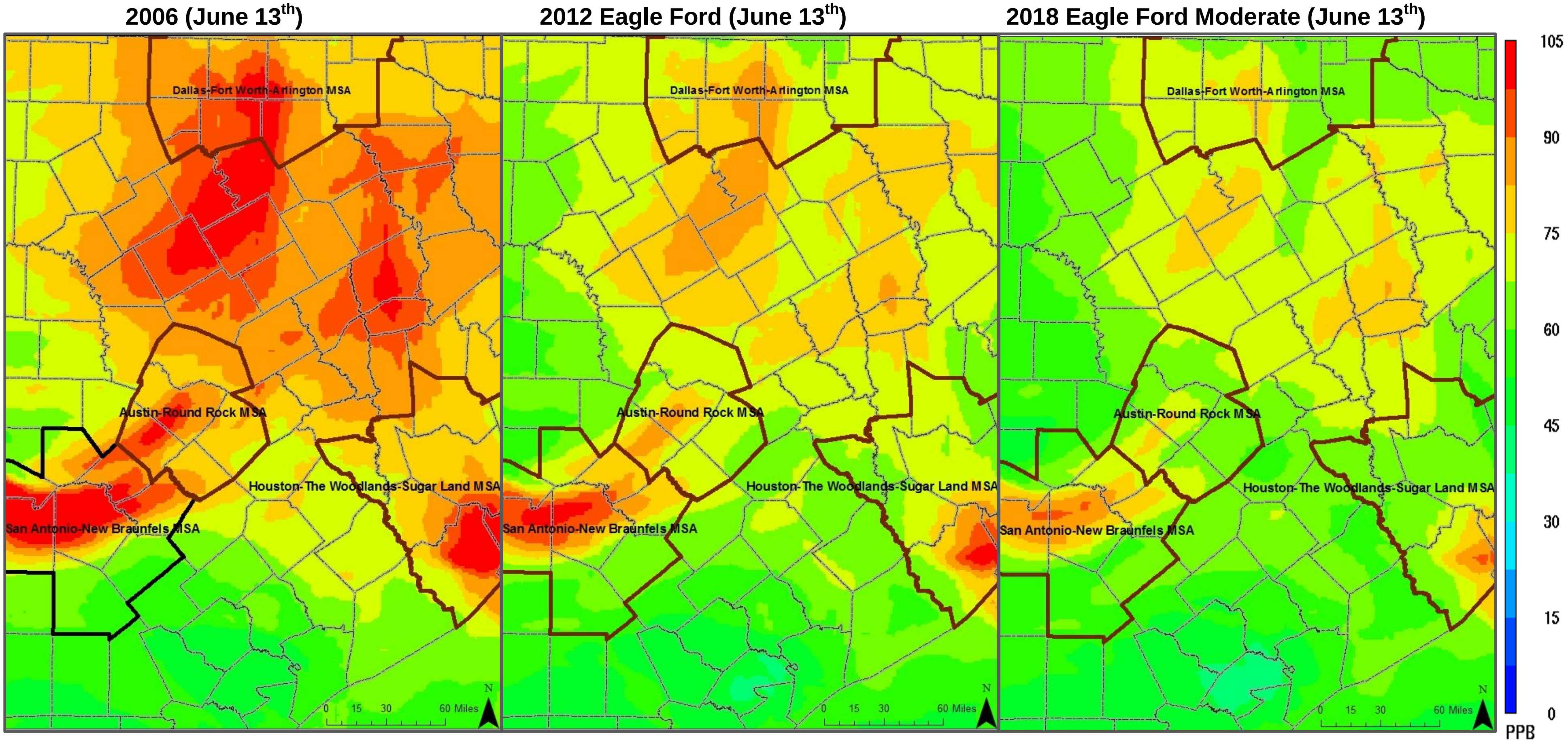

2006 (June 7th)
2012 Eagle Ford (June 7th)
2018 Eagle Ford Moderate (June 7th)
Dallas-Fort Worth-Arlington MSA
Austin-Round Rock MSA
Houston-The Woodlands-Sugar Land MSA
San Antonio-New Braunfels MSA
N
0
15
30
60 Miles
105
90
75
60
45
30
15
0
PPB


2006 (June 8th)
2012 Eagle Ford (June 8th)
2018 Eagle Ford Moderate (June 8th)
Dallas-Fort Worth-Arlington MSA
Austin-Round Rock MSA
Houston-The Woodlands-Sugar Land MSA
San Antonio-New Braunfels MSA
N
0 15 30 60 Miles
105
90
75
60
45
30
15
0
PPB


2006 (June 9th)

2012 Eagle Ford (June 9th)

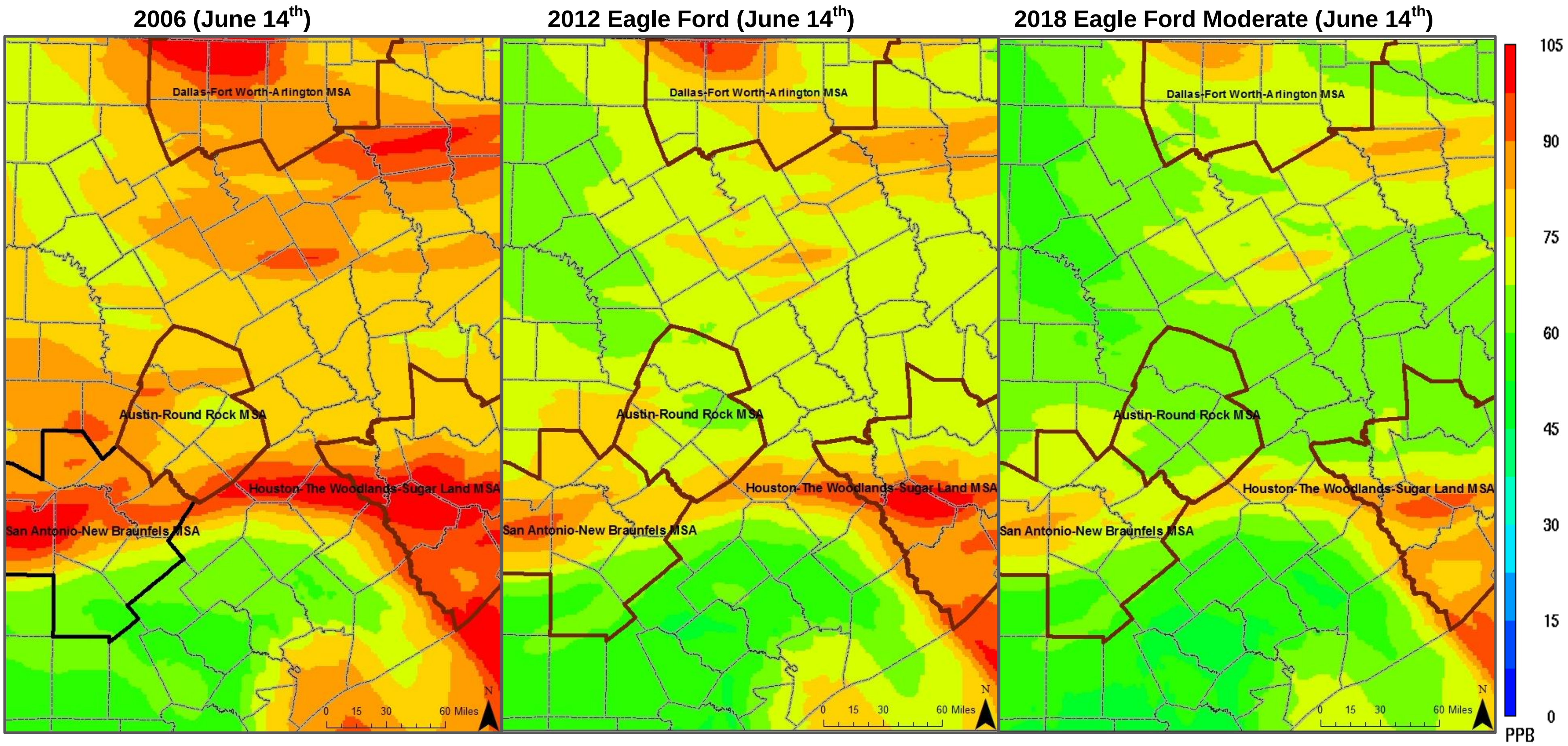
2018 Eagle Ford Moderate (June 9th)

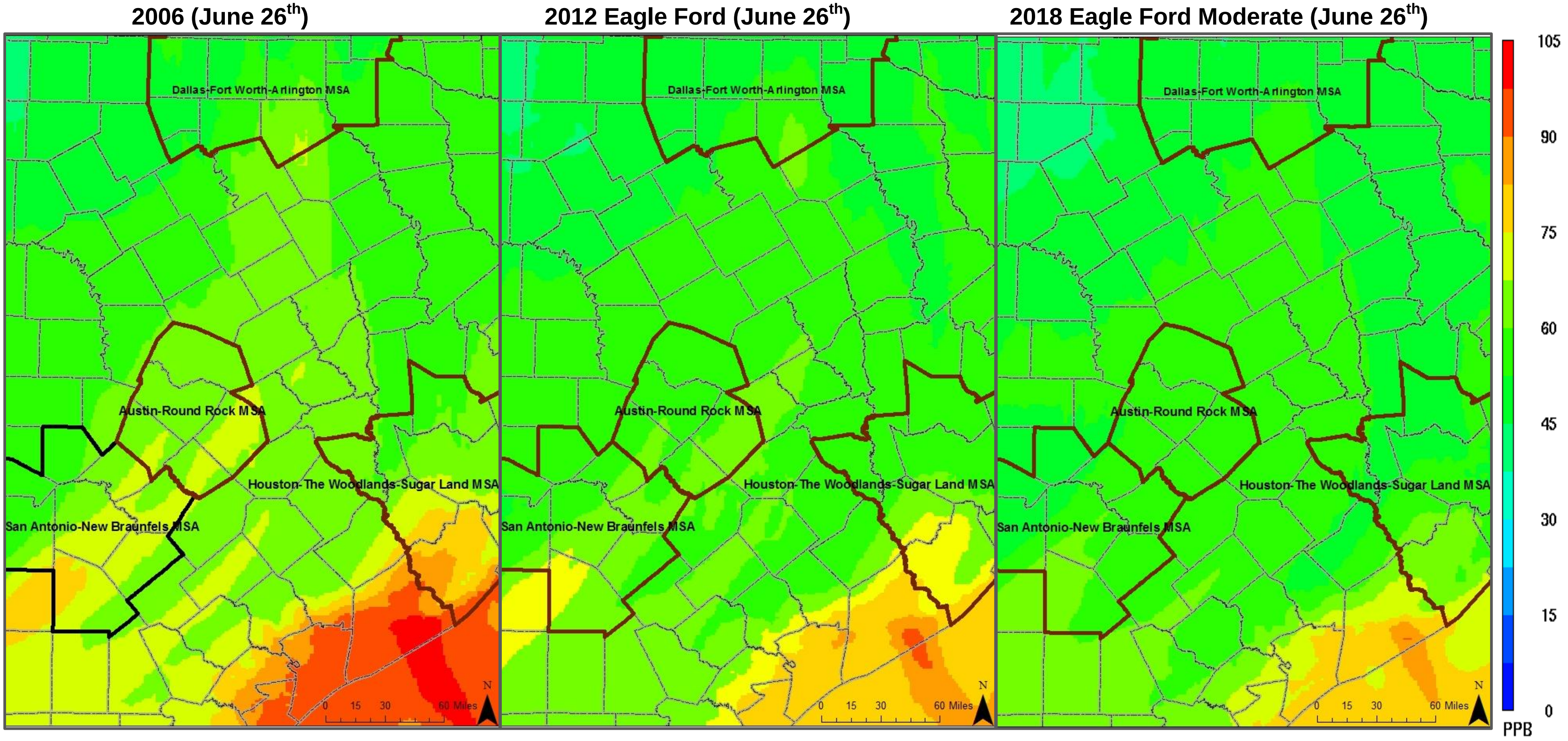


2006 (June 13th)

2012 Eagle Ford (June 13th)

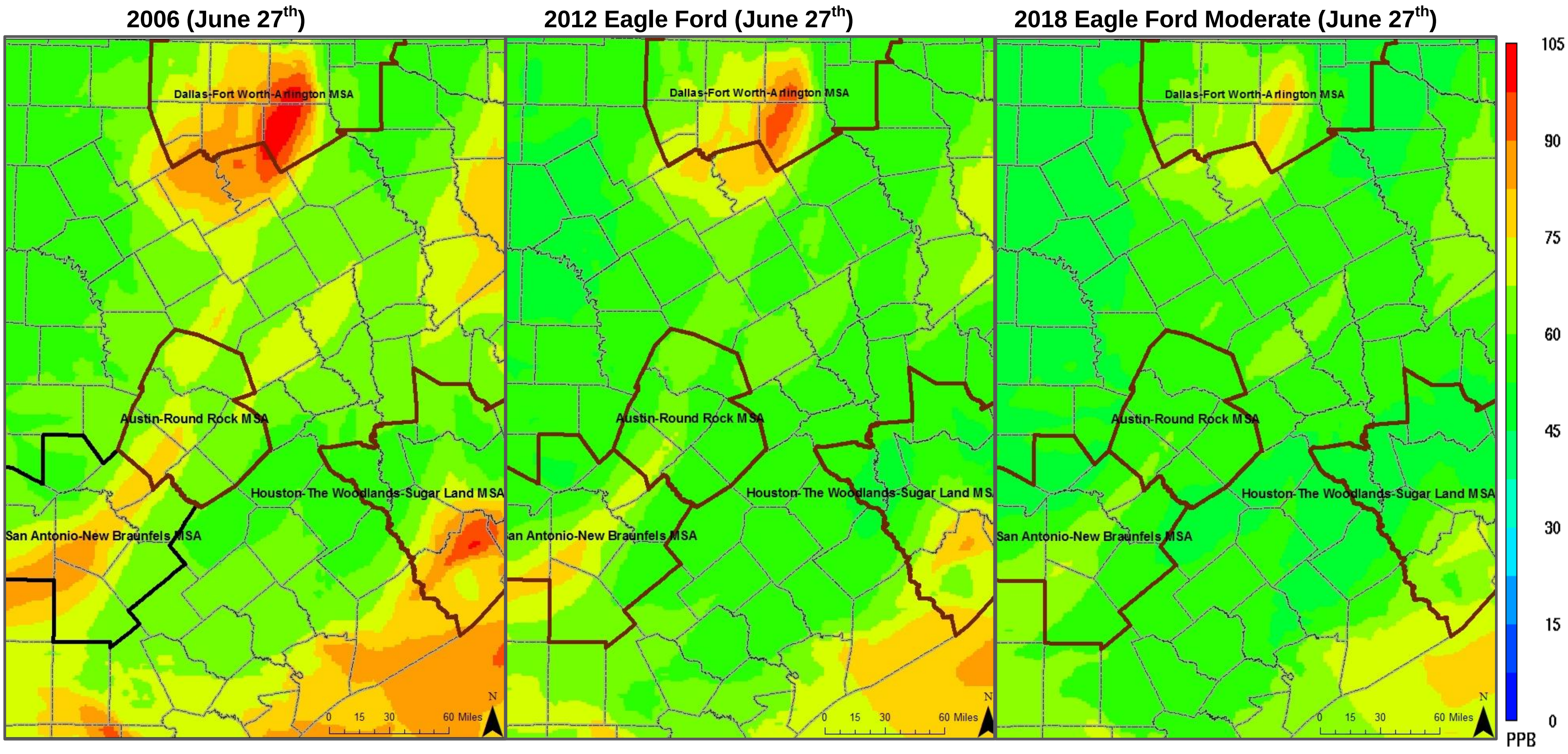
2018 Eagle Ford Moderate (June 13th)


2006 (June 14th)
2012 Eagle Ford (June 14th)
2018 Eagle Ford Moderate (June 14th)
Dallas-Fort Worth-Arlington MSA
Austin-Round Rock MSA
Houston-The Woodlands-Sugar Land MSA
San Antonio-New Braunfels MSA
0 15 30 60 Miles
N
105
90
75
60
45
30
15
0
PPB


2006 (June 26th)

2012 Eagle Ford (June 26th)

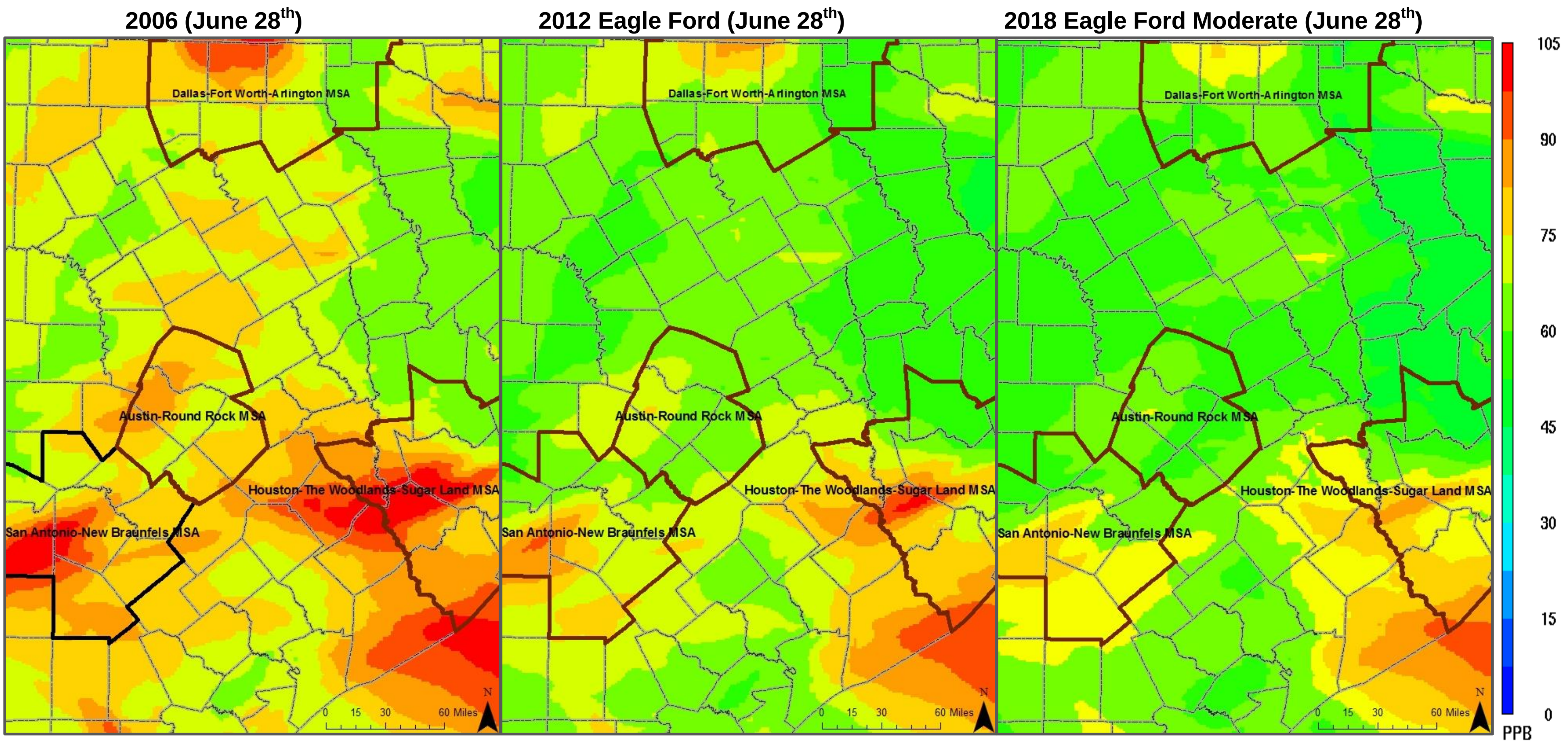
2018 Eagle Ford Moderate (June 26th)



2006 (June 27th)

2012 Eagle Ford (June 27th)

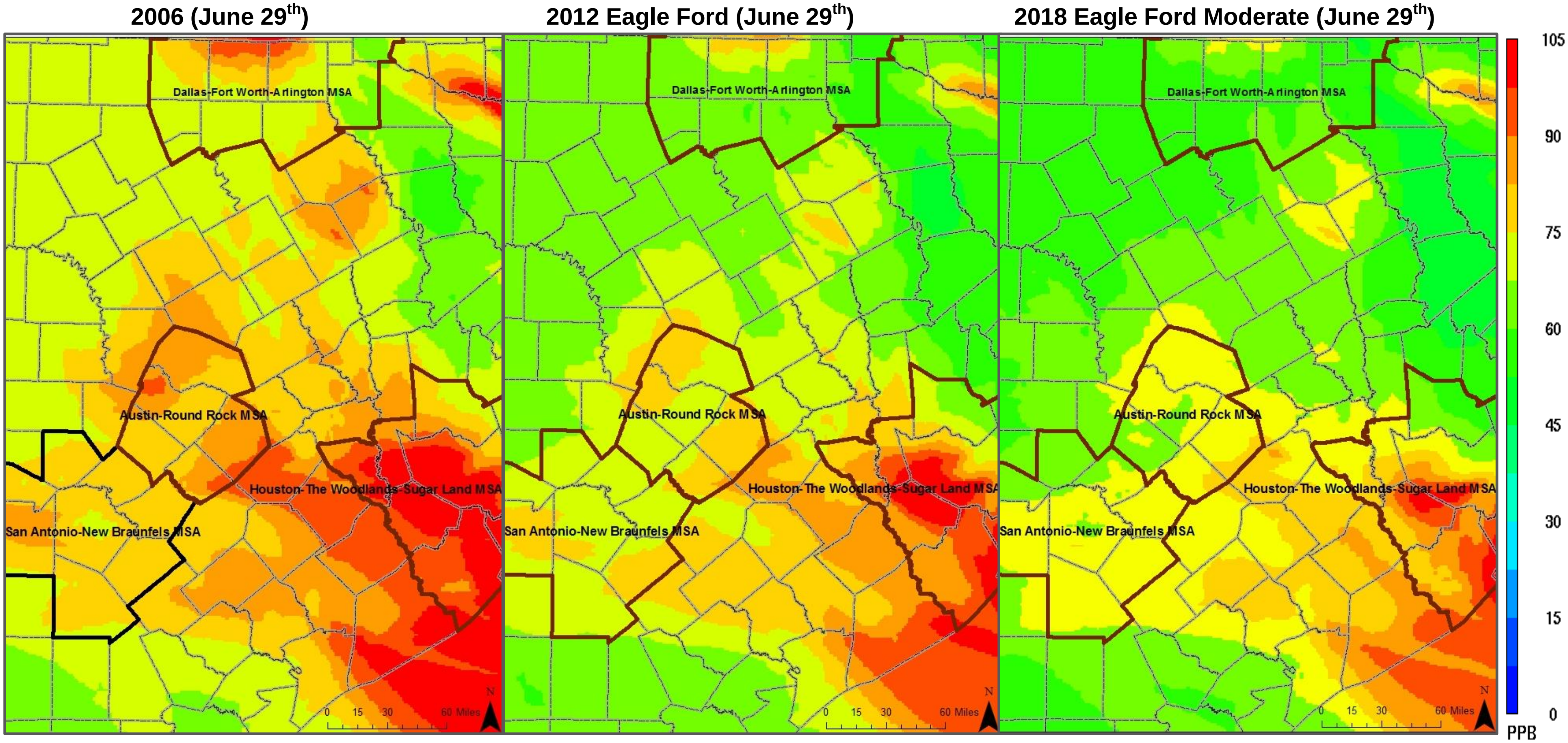
2018 Eagle Ford Moderate (June 27th)



2006 (June 28th)

2012 Eagle Ford (June 28th)

2018 Eagle Ford Moderate (June 28th)



2006 (June 29th)

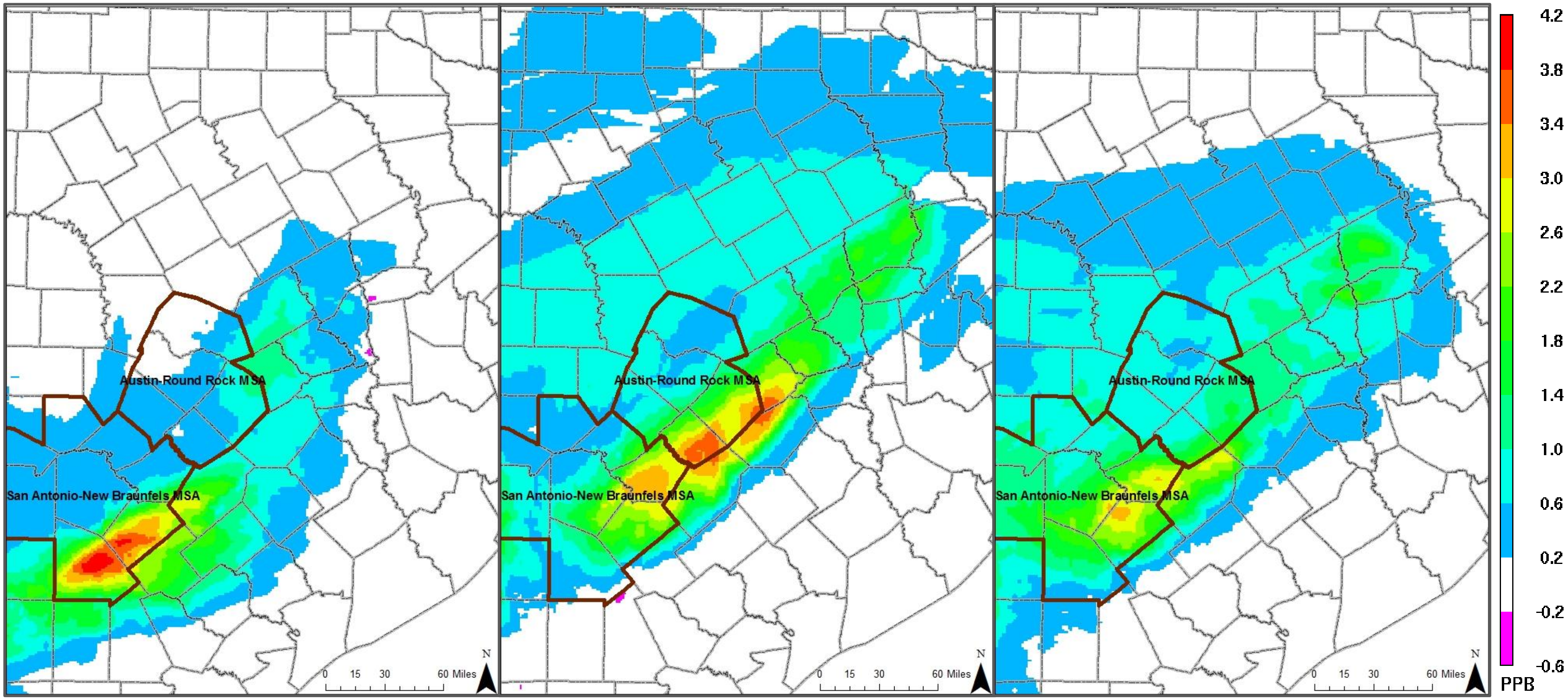
2012 Eagle Ford (June 29th)

2018 Eagle Ford Moderate (June 29th)

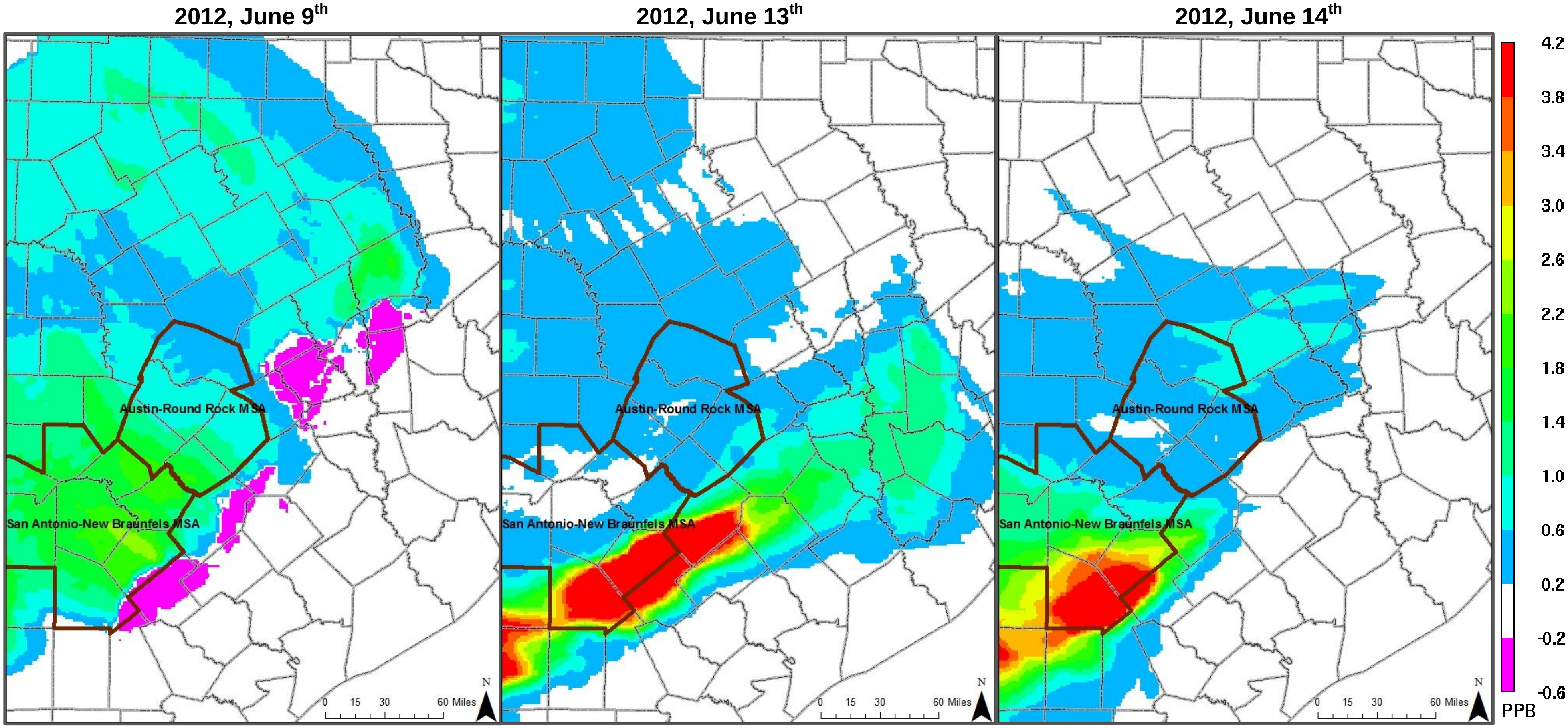
A 2012 base case run was performed with and without the 2012 Eagle Ford emission inventory. Tile plots of the difference in predicted maximum ozone levels for these runs are provided in Figure 6-2. On most days, the model predicts that the maximum impact of the Eagle Ford is southeast of Bexar County, with ozone levels increasing from 3.1 ppb to 9.3 ppb depending on the modeling day. The greatest maximum impact occurred on June 13th (9.3 ppb) and the June 14th (8.4 ppb) exceedance days.

Although the maximum predicted impact is southeast of Bexar County, emissions from the Eagle Ford increase ozone levels in Bexar County and at the regulatory monitors in the region. Significant impacts on Bexar County ozone concentrations occurred on June 7th, 8th, 9th, 14th and June 29th of the modeled episode. The impact from the Eagle Ford development was insignificant on June 26th and 27th exceedance days because the prevailing winds were from the northeast which pushed the ozone impact of the Eagle Ford south of Bexar County. Figure 6-3 shows the difference in 2018 8-hour ozone from Eagle Ford emissions for each modeling day

Figure 6-2: Predicted Daily Maximum Difference in 8-hour Ozone Concentrations in the 4-km Subdomain, 2012 Eagle Ford - Base Case



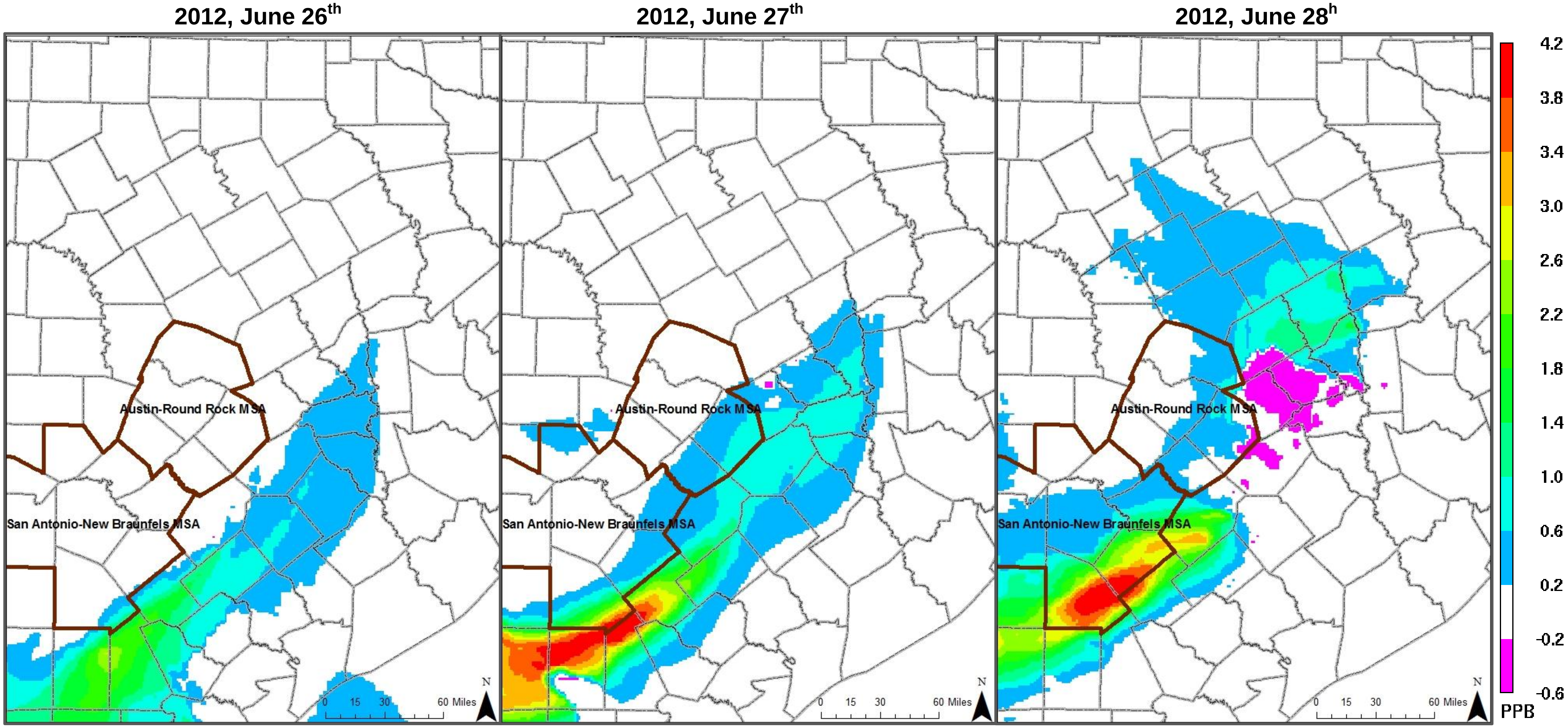
2012, June 3rd **2012, June 7th** **2012, June 8th**



2012, June 9th

2012, June 13th

2012, June 14th


2012, June 26th
2012, June 27th
2012, June 28h
Austin-Round Rock MSA
San Antonio-New Braunfels MSA
0 15 30 60 Miles
N
4.2
3.8
3.4
3.0
2.6
2.2
1.8
1.4
1.0
0.6
0.2
-0.2
-0.6
PPB

2012, June 29th

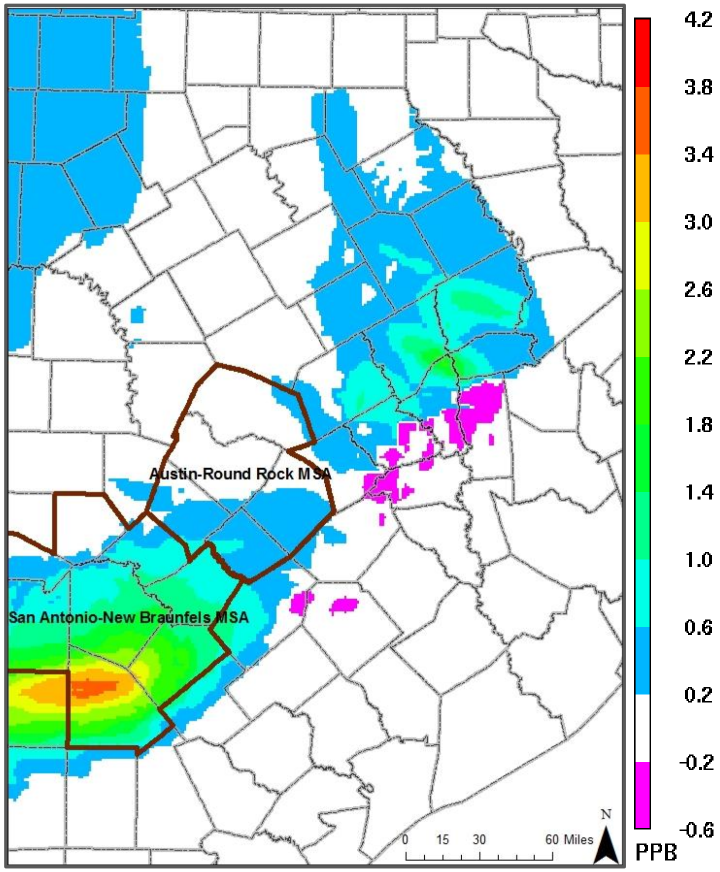
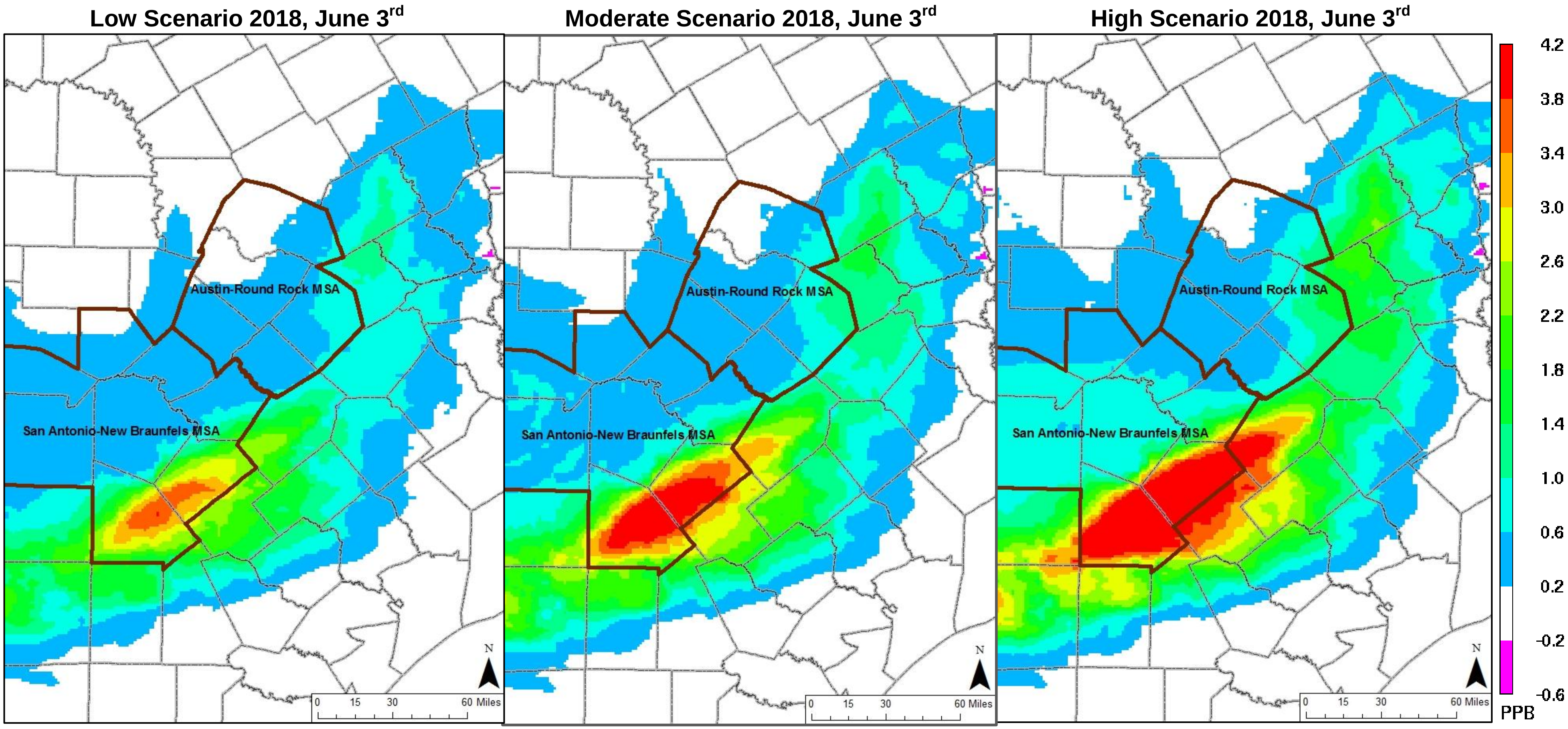


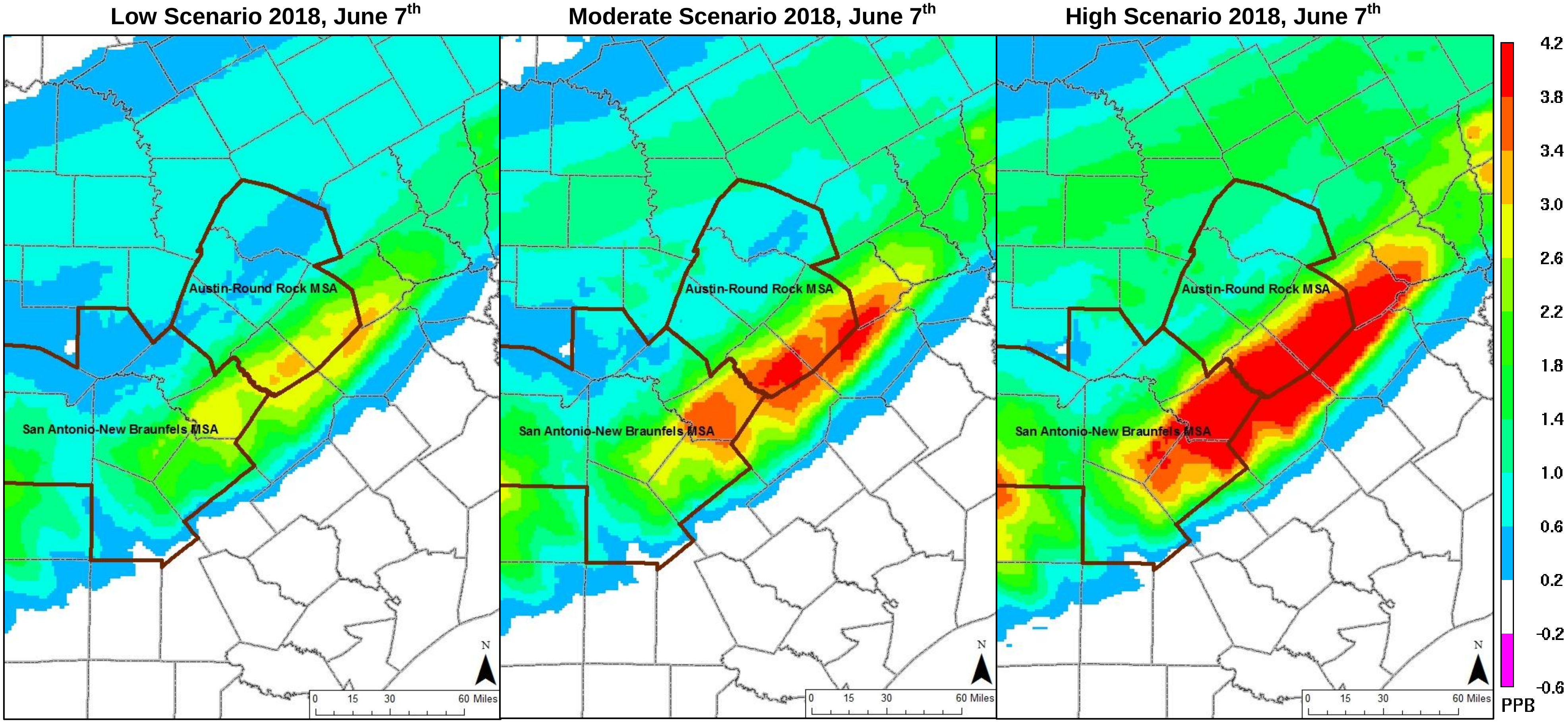
Figure 6-3: Predicted Daily Maximum Difference in 8-hour Ozone Concentrations in the 4-km Subdomain, 2018 Eagle Ford - Base Case



Low Scenario 2018, June 3rd

Moderate Scenario 2018, June 3rd

High Scenario 2018, June 3rd

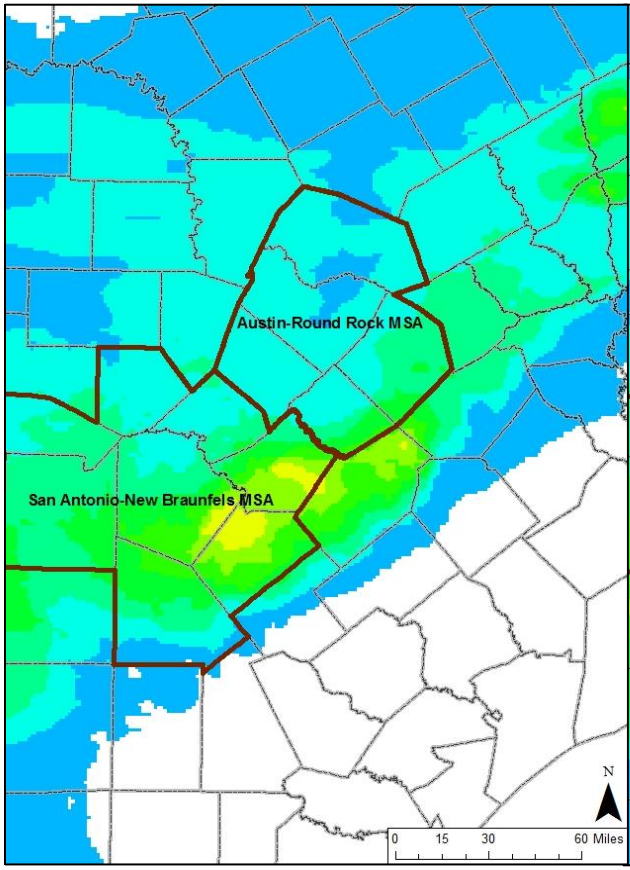


Low Scenario 2018, June 7th

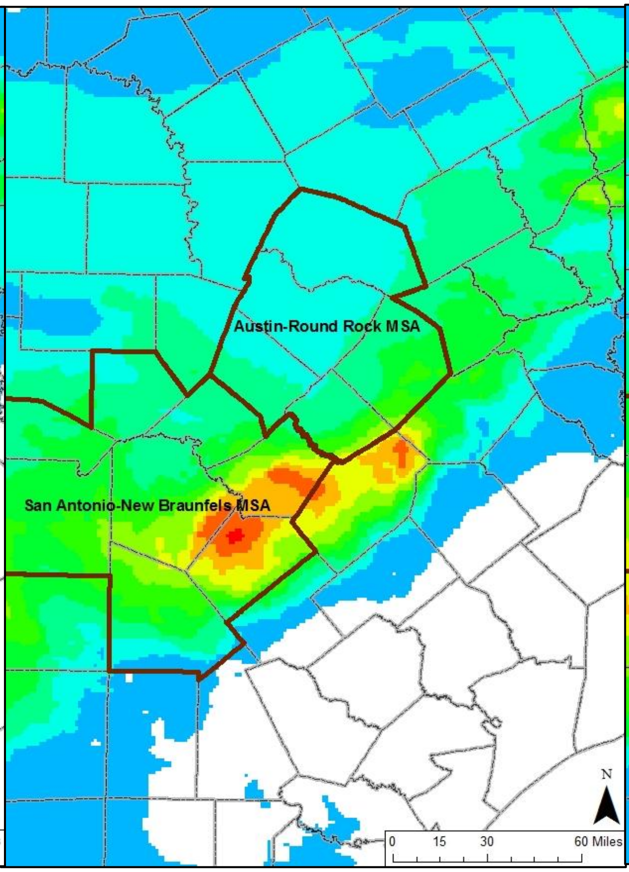
Moderate Scenario 2018, June 7th

High Scenario 2018, June 7th

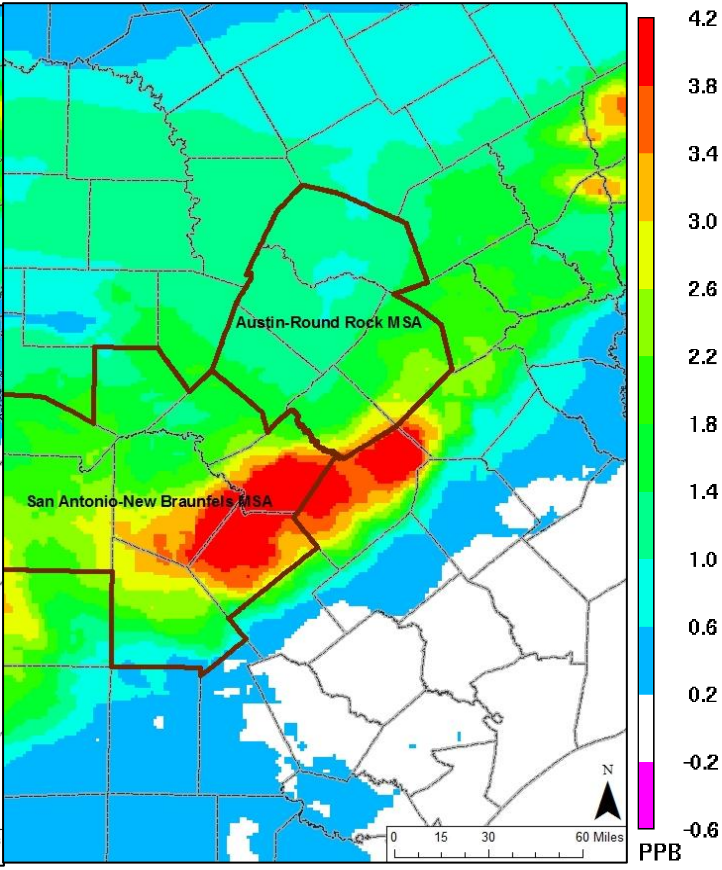
Low Scenario 2018, June 8th

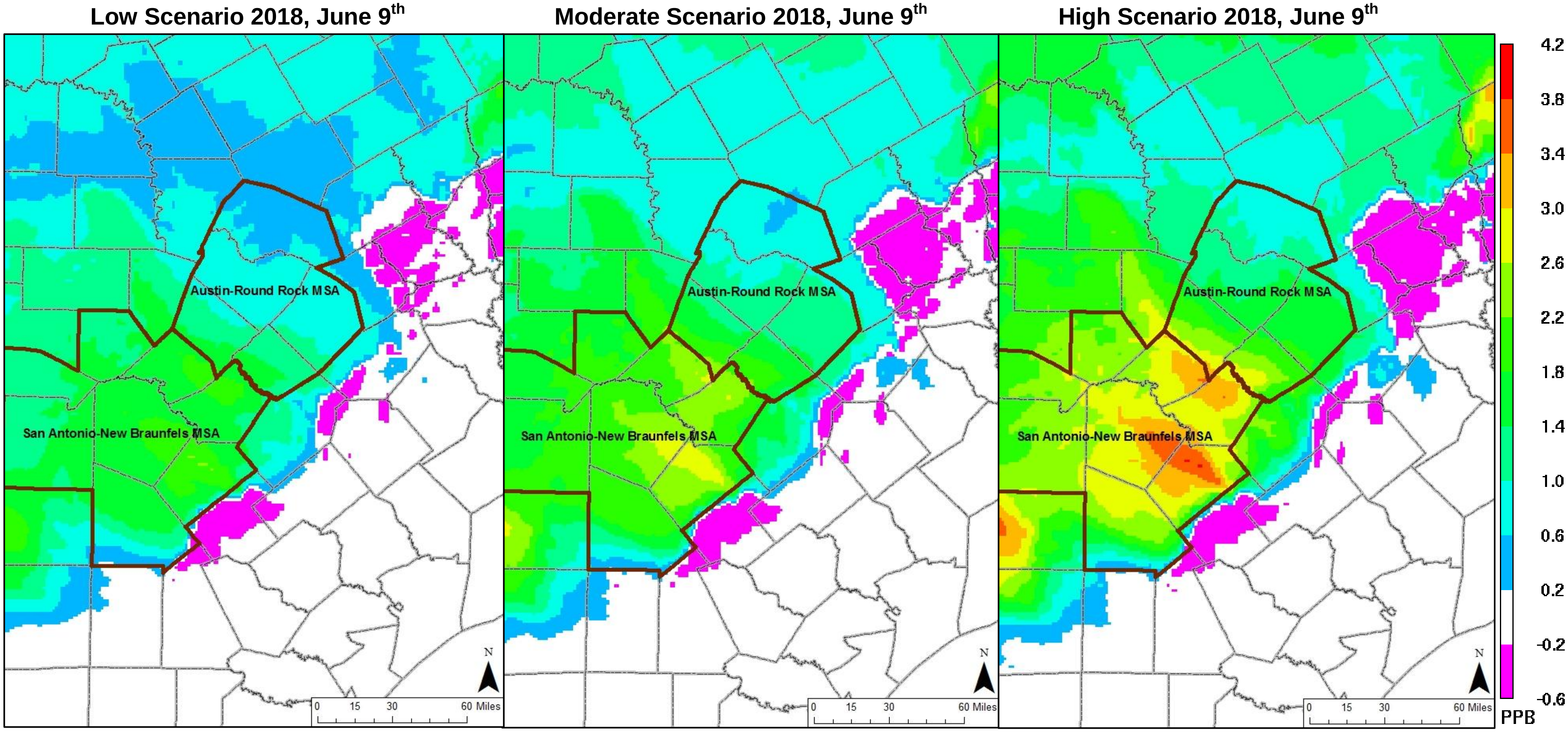


Moderate Scenario 2018, June 8th



High Scenario 2018, June 8th

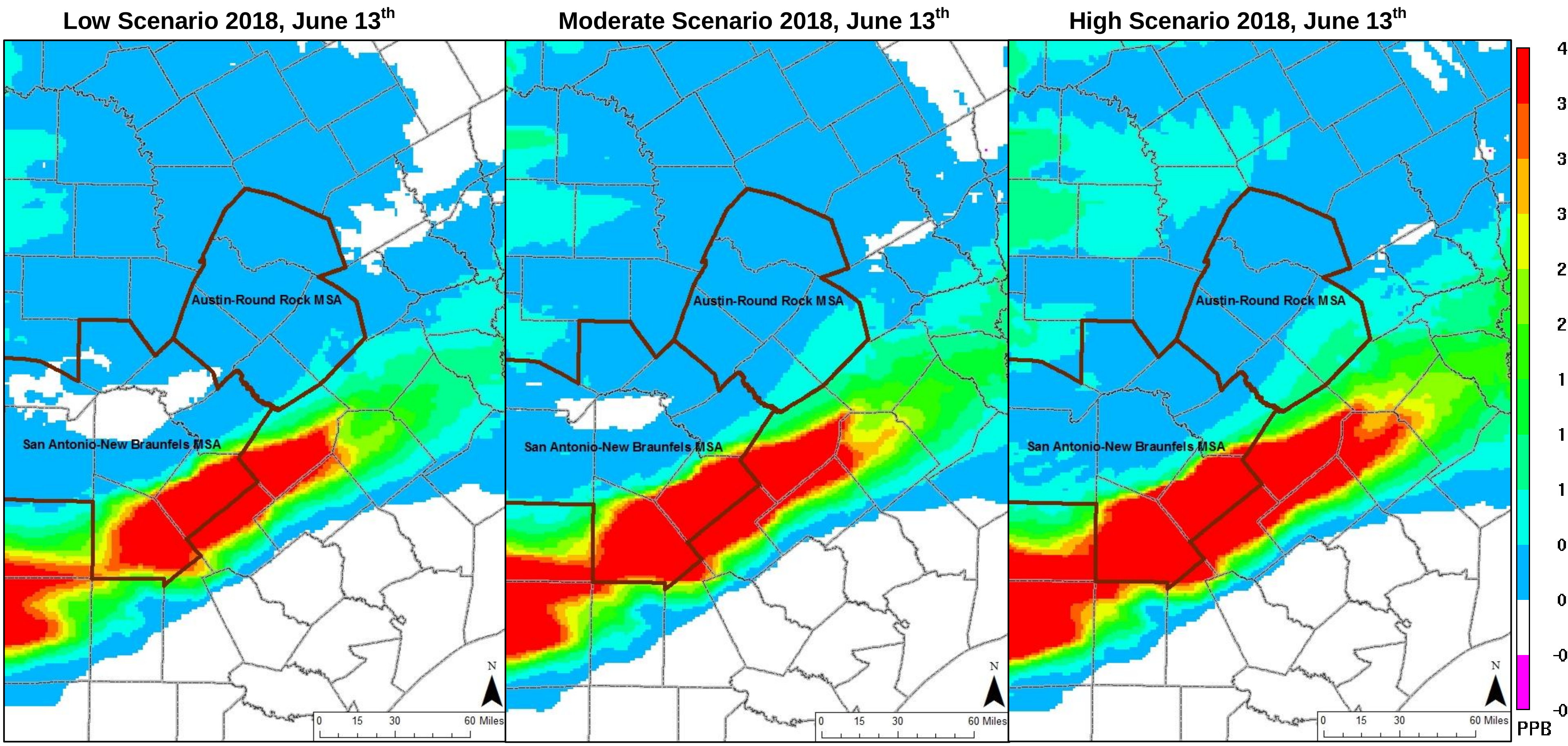




Low Scenario 2018, June 9th

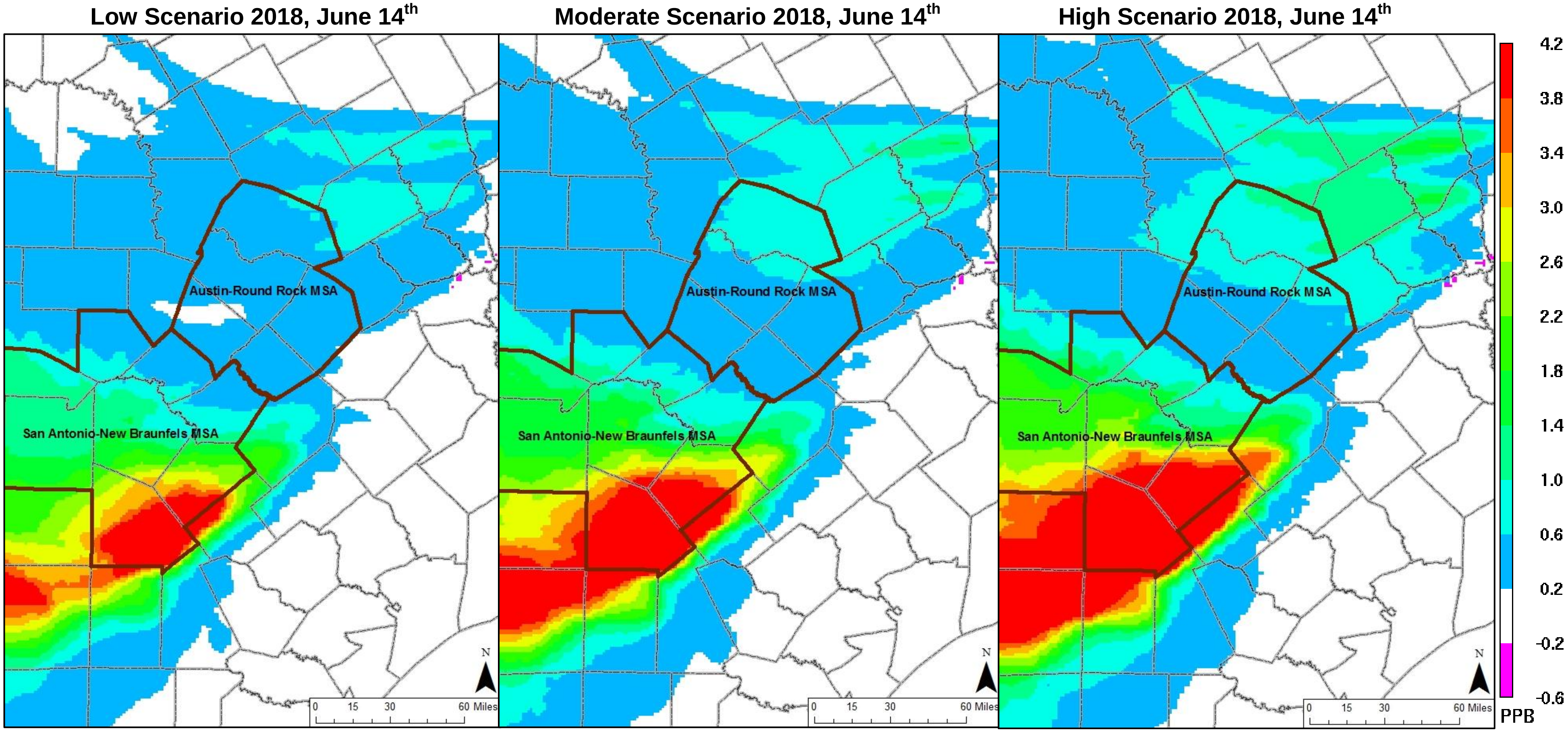
Moderate Scenario 2018, June 9th

High Scenario 2018, June 9th


Low Scenario 2018, June 13th

Moderate Scenario 2018, June 13th

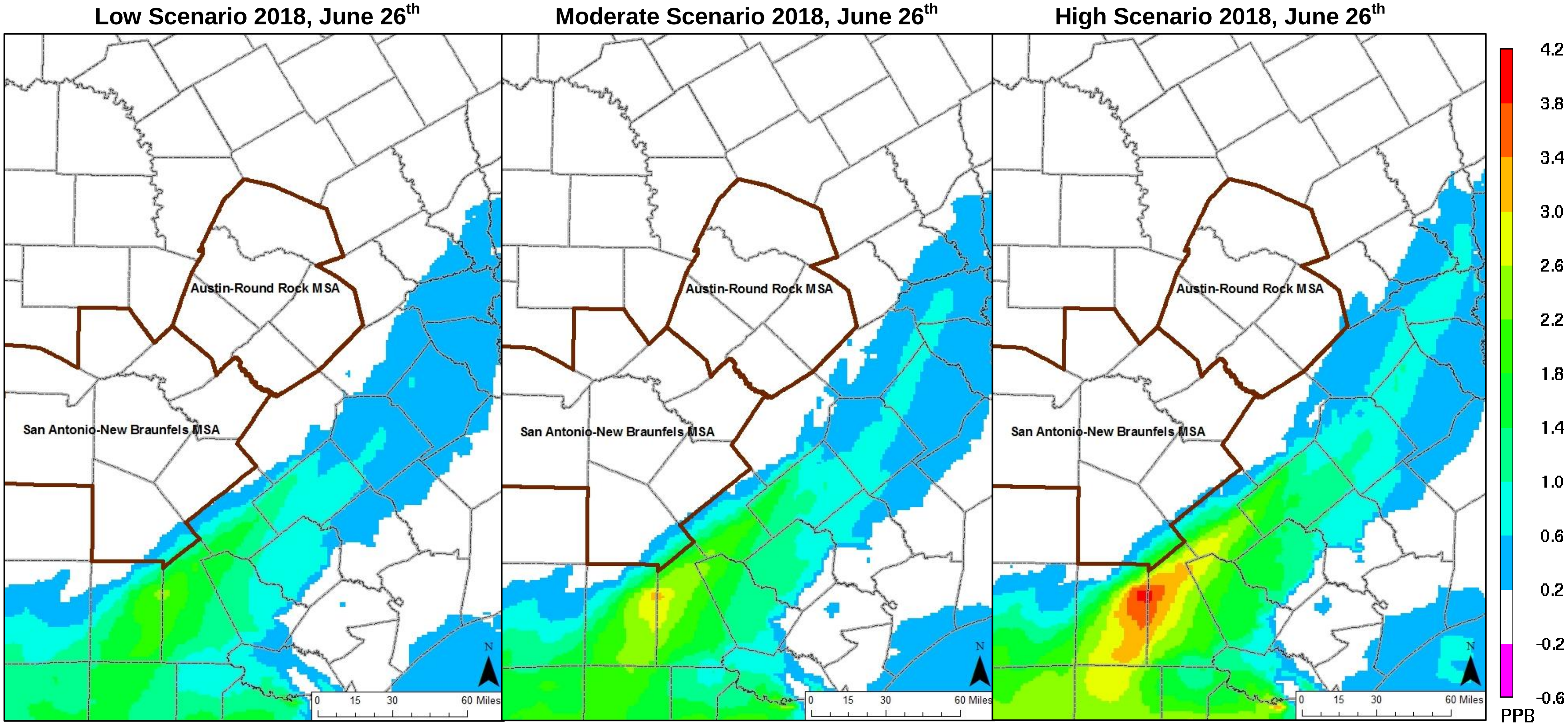
High Scenario 2018, June 13th



Low Scenario 2018, June 14th

Moderate Scenario 2018, June 14th

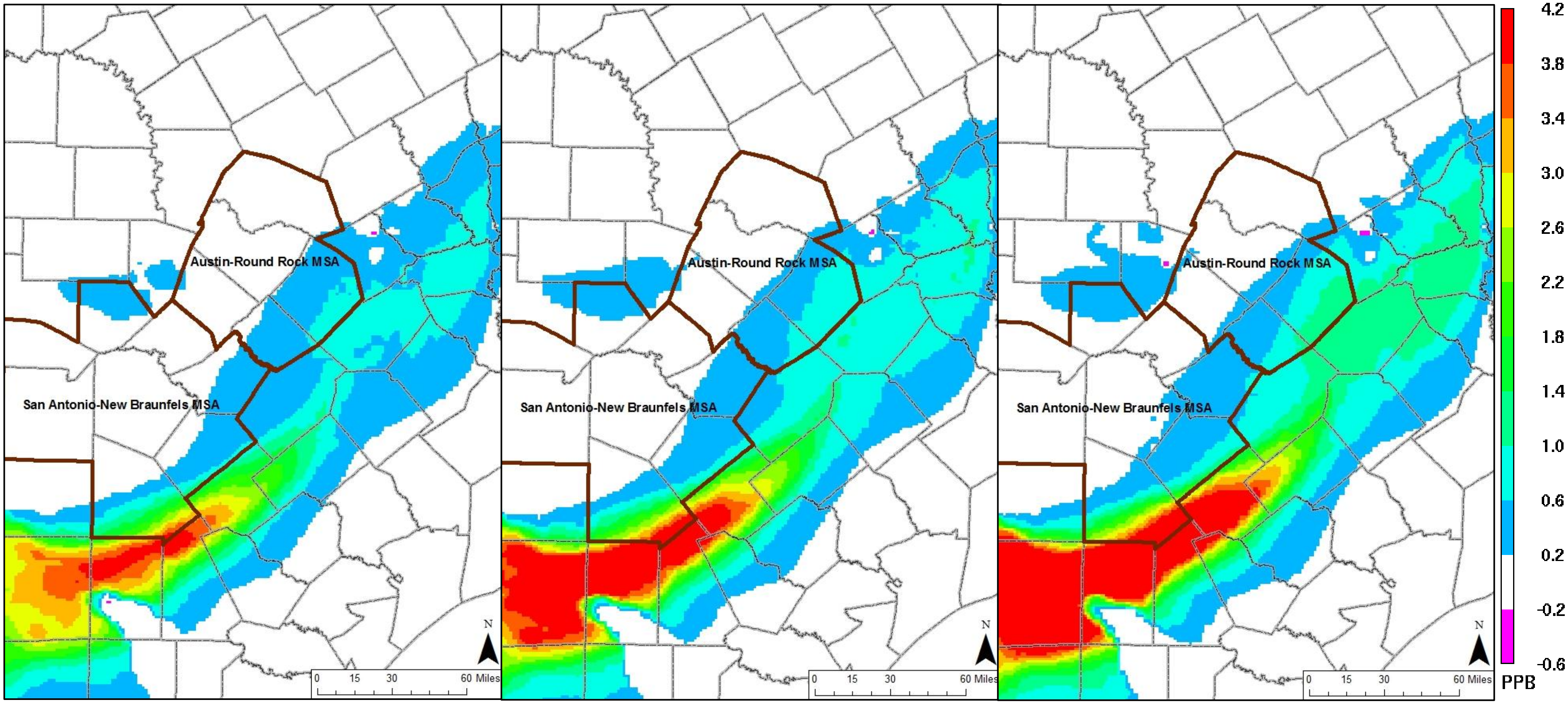
High Scenario 2018, June 14th



Low Scenario 2018, June 26th

Moderate Scenario 2018, June 26th

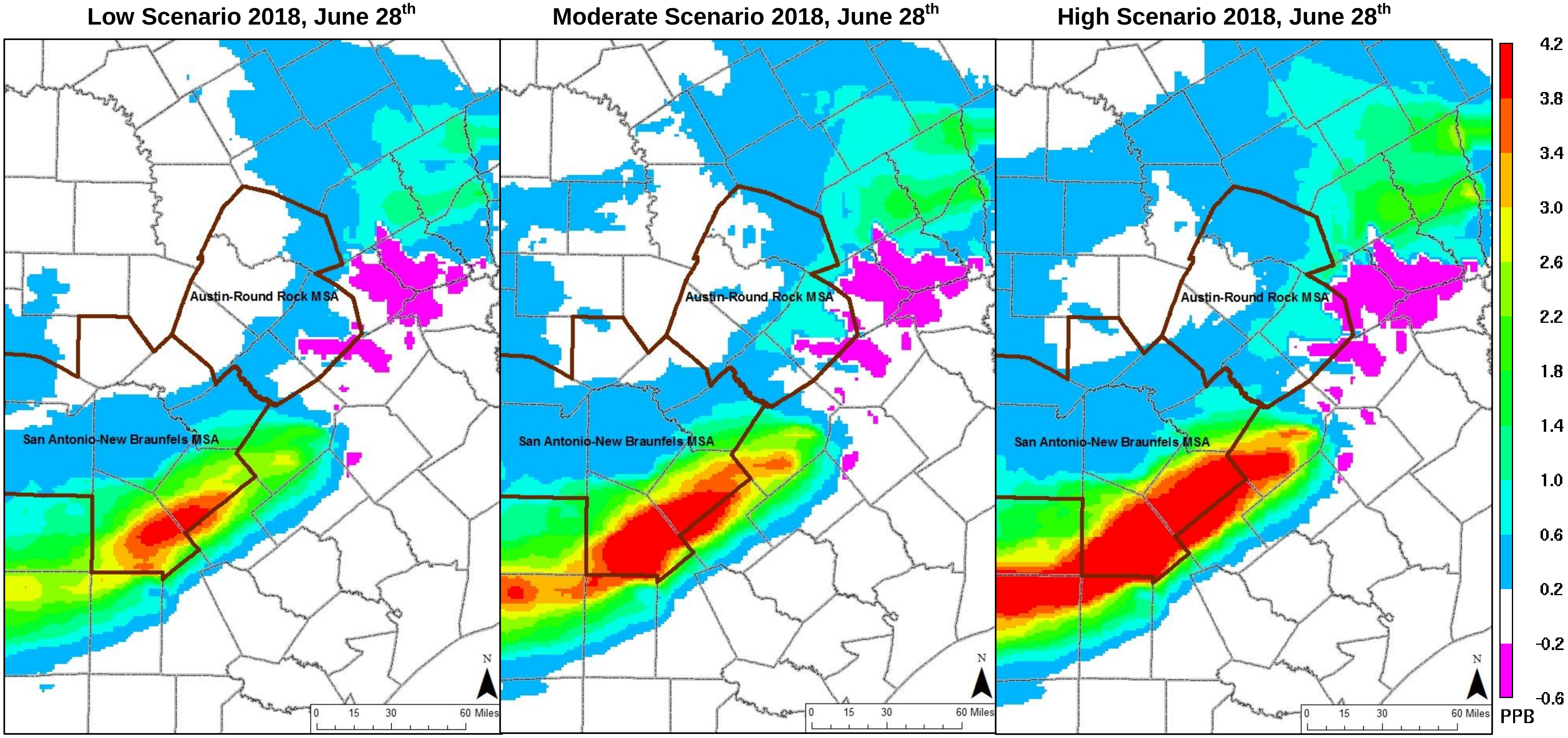
High Scenario 2018, June 26th



Low Scenario 2018, June 27th

Moderate Scenario 2018, June 27th

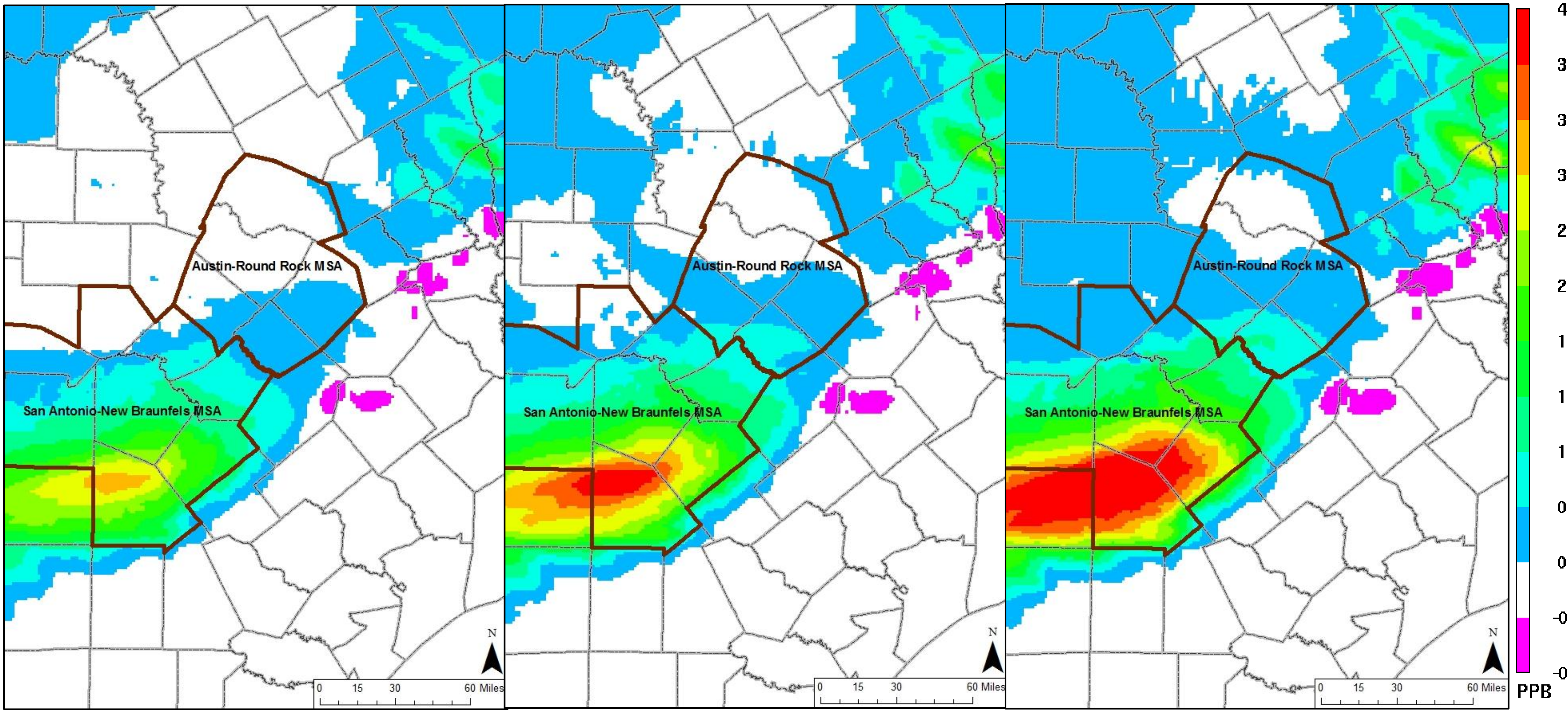
High Scenario 2018, June 27th



Low Scenario 2018, June 28th

Moderate Scenario 2018, June 28th

High Scenario 2018, June 28th



Low Scenario 2018, June 29th

Moderate Scenario 2018, June 29th

High Scenario 2018, June 29th

For the 2012 modeling projection, the greatest impact anywhere in the modeling domain from Eagle Ford Emissions was 9.3 ppb on June 13th (Table 6-1). In 2018, the greatest impact was 8.7 ppb for the Eagle Ford low scenario and 14.2 ppb for the Eagle Ford high scenario. The maximum impact ranged from 3.0 ppb on June 9th to 14.2 ppb on June 13th in 2018.

Table 6-1: Maximum Predicted Change in 8-Hour Ozone in the Modeling Domain, Eagle Ford 2012 and 2018, ppb.

Year	Scenario	6/3	6/7	6/8	6/9	6/13	6/14	6/26	6/27	6/28	6/29
2012	Eagle Ford	4.2	3.7	3.1	2.8	9.3	8.4	3.2	4.9	4.5	3.6
2018	Eagle Ford Low	3.8	3.5	3.2	3.0	8.7	7.3	3.3	4.6	4.3	3.2
	Eagle Ford Moderate	5.0	4.4	4.1	3.8	11.3	9.4	4.3	6.1	5.7	4.2
	Eagle Ford High	6.4	5.6	5.3	4.9	14.2	11.9	5.6	7.8	7.4	5.4

The maximum predicted impacts of the Eagle Ford at monitors in the AACOG region are listed in Table 6-2. Predicted ozone at C23, which is one of two monitors in Bexar County that typically measures the highest ozone concentrations in the region, increased by as much as 1.89 ppb in 2012 and between 1.81 to 3.09 ppb in 2018. The 2018 results at C58 were the same as C23 with the Eagle Ford contribution being between 1.81 to 3.09 ppb at the monitor. Since the C59 monitor is in southeast Bexar County and closer to the Eagle Ford, the impact was greater in 2018: 4.45 ppb to 7.82 ppb.

Table 6-2: Maximum Change in 8-Hour Ozone at each Monitor, Eagle Ford Emission Inventories 2012 and 2018, ppb.

Monitor	Year	Scenario	6/3	6/7	6/8	6/9	6/13	6/14	6/26	6/27	6/28	6/29	Maximum Change	Percentage of Total Ozone
C23	2012	Eagle Ford	0.44	1.20	1.52	1.89	0.18	1.90	0.00	0.06	0.30	1.18	1.89	1.9%
	2018	Eagle Ford Low	0.44	1.30	1.46	1.81	0.24	1.70	0.00	0.06	0.30	1.16	1.81	1.8%
		Eagle Ford Moderate	0.58	1.69	1.96	2.38	0.31	2.24	0.00	0.08	0.40	1.53	2.38	2.6%
		Eagle Ford High	0.76	2.19	2.59	3.09	0.41	2.92	0.00	0.11	0.53	2.00	3.09	3.4%
C58	2012	Eagle Ford	0.47	0.91	1.35	1.82	0.17	1.37	0.00	0.06	0.26	1.08	1.82	1.8%
	2018	Eagle Ford Low	0.46	1.02	1.19	1.81	0.20	1.35	0.00	0.06	0.27	0.90	1.81	2.0%
		Eagle Ford Moderate	0.61	1.32	1.55	2.38	0.24	1.77	0.00	0.08	0.36	1.18	2.38	2.6%
		Eagle Ford High	0.76	2.19	2.59	3.09	0.41	2.92	0.00	0.11	0.53	2.00	3.09	3.4%
C59	2012	Eagle Ford	2.81	2.66	3.06	2.37	3.95	3.55	0.00	0.18	2.44	2.50	3.95	4.7%
	2018	Eagle Ford Low	2.53	2.31	2.83	2.20	4.45	2.99	0.00	0.17	2.13	2.45	4.45	4.9%
		Eagle Ford Moderate	3.34	3.02	3.77	2.90	5.99	3.90	0.00	0.22	2.84	3.23	5.99	7.7%
		Eagle Ford High	4.35	3.93	4.92	3.77	7.82	5.06	0.00	0.30	3.72	4.19	7.82	10.1%
C622	2012	Eagle Ford	1.87	2.73	3.06	2.37	1.24	2.73	0.00	0.15	2.16	2.19	3.06	3.4%
	2018	Eagle Ford Low	1.81	2.32	2.83	2.20	1.18	2.31	0.00	0.15	1.78	2.15	2.83	2.9%
		Eagle Ford Moderate	2.46	3.06	3.77	2.90	2.20	3.08	0.00	0.20	2.42	2.83	3.77	4.5%
		Eagle Ford High	3.26	3.98	4.92	3.77	3.44	4.05	0.00	0.26	3.22	3.67	4.92	5.9%
C678	2012	Eagle Ford	0.79	2.66	2.99	2.36	0.45	2.31	0.00	0.12	1.16	1.87	2.99	3.0%
	2018	Eagle Ford Low	0.72	2.31	2.80	2.18	0.47	2.07	0.00	0.12	0.51	1.82	2.80	3.4%
		Eagle Ford Moderate	0.99	3.02	3.66	2.87	0.62	2.72	0.00	0.16	0.90	2.39	3.66	4.1%
		Eagle Ford High	1.38	3.93	4.72	3.73	0.82	3.54	0.00	0.21	1.44	3.09	4.72	5.3%

Based on the maximum difference in the 7x7 4km grids around each monitor

6.3 Modeled Attainment Demonstration

The modeled attainment demonstration at San Antonio-New Braunfels MSA's regulatory sited monitors was conducted by completing a series of steps that are described in the EPA Guidance on the Use of Models.[270] Two procedures were used to perform the model attainment demonstration: "…analyses which estimate whether selected emissions reductions will result in ambient concentrations that meet the NAAQS and identified set of control measures which will result in the required emissions reductions".[271]

To determine if a regulatory monitor meets the NAAQS, three calculations were performed:

1. determine the baseline five year weighted modeling site-specific design value (DV),
2. calculate the daily relative response factor, and
3. calculate of the future site-specific design values.

These calculations were performed for all monitors that meet EPA regulatory sitting requirements for days when the 8-hour predicted DV is equal or greater than 70 ppb: C23, C58, C59, C622, and C678.[272] Non-regulatory monitors operated by AACOG were not included in the calculations.

The period that was used to determine the baseline DV is the five years that straddle the 2012 baseline inventory year. The design value for 2010-2012 was used to determine the baseline modeling DV. The 2011-2013 and 2012-2014 design values were not included because the 2013 and 2014 ozone seasons are not completed. As determined by the EPA, "the average DV methodology is weighted towards the inventory year (which is the middle year) and also takes into account the emissions and meteorological variability that occurs over the full five year period".[273] The baseline modeling DV was calculated for each regulatory monitor that meets EPA's modeling guideline recommendations (Table 6-3). As shown, C58 has the highest baseline modeling DV at 80 ppb. The baseline modeling DVs at the other regulatory monitors are 77 ppb at C23, 74 ppb at CAMS 622, 69 ppb at C59, and 69 ppb at C678.

Table 6-3: Calculated Baseline Modeling Site-Specific Design Value, 2012

Monitoring Site	2010-2012 DV, ppb	Baseline DV Used in the Modeling Attainment Test, ppb
CAMS 23	77.3	77.3
CAMS 58	80.0	80.0
CAMS 59	69.3	69.3
CAMS 622	74.0	74.0
CAMS 678	69.6	69.6

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[270] EPA, April 2007. "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 39. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/04/13.

[271] *Ibid*., p. 15.

[272] *Ibid*., p. 146.

[273] *Ibid*., p. 22.

The model attainment test requires the calculation of a daily relative response factor (RRF). Instead of using the absolute photochemical model output, a RRF is calculated using the baseline and future case modeling. The ratio between future and baseline modeling 8-hour ozone predictions near each monitor was multiplied by the monitor-specific modeling DV. The formula used to calculate the RRF is:

Equation 6-1, Design Value Calculation

$$(DVF)_I = (RRF)_I\,(DVB)_I$$

Where,

$(DVF)_I$ = the baseline ozone modeling DV at site I (ppb)
$(RRF)_I$ = the relative response factor, calculated near site I
$(DVB)_I$ = the estimated future ozone DV for the time attainment is required (ppb) [274]

Since the June 2006 photochemical modeling episode uses a 4-km fine grid system, the area near a monitor was defined as the 7x7 array of grid cells surrounding the monitor.[275] The highest predicted 8-hour daily ozone was selected in the 7x7 array for each monitor for both the 2012 projection year and the 2018 projection year. The grid cell selected in the baseline year and the future year was not always the same cell. Once the monitor-specific RRF was calculated for each day, the RRF was averaged for days with a peak monitor value greater than 70 ppb in the 2012 base case. The future site-specific DV for each monitor is provided in Table 6-4. The gray strike-through numbers are values that fall below the EPA requirement of 70 ppb.

For the Eagle Ford low scenario, the 2018 design value was 70.9 ppb at C23, 73.8 ppb at C58, and 65.0 ppb at C59. Under the Eagle Ford high scenario, the design values increase to 71.4 ppb at C23, 74.3 ppb at C58, and 65.6 ppb at C59 (Figure 6-4). The design value increased 0.5 ppb at C23, 0.6 ppb at C58, and 0.7 ppb at C59 under the Eagle Ford high scenario. All regulatory-sited monitors meet the 75 ppb 8-hour ozone standard for every 2018 projection case. However, the 2018 design value at C58 is very close the current 75 ppb 8-hour ozone NAAQS. If the EPA lowers the 8-hour ozone standard, it would be difficult for the San Antonio-New Braunfels MSA to attain the new standard.

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[274] EPA, April 2007. “Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze.” EPA -454/B-07-002. Research Triangle Park, North Carolina. p. 20. Available online: http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf. Accessed 06/04/13.

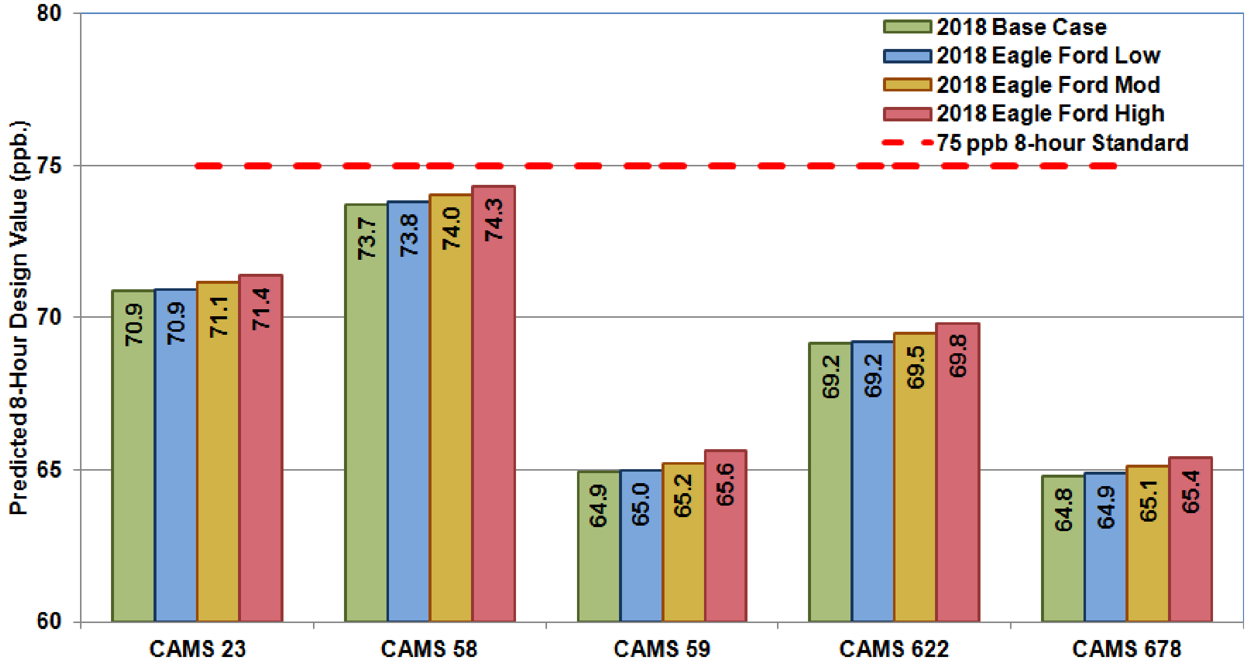
[275] *Ibid*., p. 26.

Table 6-4: Peak 8-hour Ozone (ppb) Predictions at C23, C58, C59, C622, and C678: 2012 and 2018 Modeled Cases

CAMS	Year	Run Label	Episode days														
			1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
C23	2012	Base Case	~~51.9~~	~~61.4~~	72.5	~~66.4~~	~~60.0~~	~~64.3~~	76.1	73.5	79.8	76.2	~~63.6~~	76.0	101.6	89.9	~~64.1~~
	2012	Eagle Ford	~~52.0~~	~~61.5~~	72.9	~~67.4~~	~~61.3~~	~~65.3~~	76.6	74.4	81.4	77.0	~~64.7~~	76.9	101.7	91.1	~~64.8~~
	2018	Base Case	-	-	67.2	-	-	-	69.9	67.5	72.9	70.0	-	69.5	91.1	82.0	-
	2018	Eagle Ford Low	-	-	67.6				70.5	68.4	74.5	70.9		70.4	91.3	83.3	
	2018	Eagle Ford Mod	-	-	67.7	-	-	-	70.7	68.7	75.1	71.2	-	70.7	91.3	83.7	-
	2018	Eagle Ford High	-	-	67.8	-	-	-	70.9	69.0	75.7	71.6	-	71.1	91.4	84.2	-
C58	2012	Base Case	~~51.3~~	~~61.4~~	~~69.1~~	~~67.2~~	~~60.5~~	69.0	77.1	74.1	79.7	79.7	~~65.5~~	75.6	100.6	88.8	~~64.9~~
	2012	Eagle Ford	~~51.4~~	~~61.5~~	~~69.5~~	~~68.2~~	~~61.9~~	70.2	77.6	74.9	81.2	80.4	~~66.6~~	76.4	100.7	90.1	~~65.7~~
	2018	Base Case	-	-	-	-	-	64.5	70.3	68.0	72.7	73.1	-	69.3	90.6	81.8	-
	2018	Eagle Ford Low	-	-	-	-	-	65.7	70.9	68.8	74.2	73.9		70.3	90.8	83.1	-
	2018	Eagle Ford Mod	-	-	-	-	-	66.0	71.0	69.1	74.7	74.1	-	70.6	90.8	83.5	-
	2018	Eagle Ford High	-	-	-	-	-	66.5	71.3	69.4	75.3	74.5	-	71.0	90.9	84.0	-
C59	2012	Base Case	~~51.6~~	~~54.5~~	71.2	~~60.7~~	~~54.0~~	~~52.5~~	~~57.3~~	~~62.8~~	69.8	70.9	~~54.1~~	~~55.1~~	83.7	76.3	~~63.7~~
	2012	Eagle Ford	~~51.8~~	~~54.7~~	71.7	~~62.3~~	~~55.4~~	~~54.5~~	~~59.0~~	~~64.5~~	71.8	72.4	~~55.9~~	~~57.0~~	83.9	77.7	~~64.5~~
	2018	Base Case	-	-	67.0	-	-	-	-	-	66.5	66.7	-	-	77.1	71.6	-
	2018	Eagle Ford Low	-	-	67.5	-	-	-	-	-	68.3	68.3	-	-	77.3	72.9	-
	2018	Eagle Ford Mod	-	-	67.7	-	-	-	-	-	68.8	68.8	-	-	77.4	73.3	-
	2018	Eagle Ford High	-	-	67.9	-	-	-	-	-	69.6	69.4	-	-	77.5	74.2	-
C622	2012	Base Case	~~51.6~~	~~54.5~~	71.2	~~62.3~~	~~54.5~~	~~53.8~~	~~61.6~~	~~62.8~~	71.1	73.7	~~56.8~~	~~59.5~~	90.8	79.6	~~63.7~~
	2012	Eagle Ford	~~51.8~~	~~54.7~~	71.7	~~63.8~~	~~55.9~~	~~55.7~~	~~63.0~~	~~64.5~~	73.1	75.4	~~58.5~~	~~60.8~~	91.0	80.4	~~64.5~~
	2018	Base Case	-	-	67.0	-	-	-	-	-	67.5	69.6	-	-	82.6	74.1	-
	2018	Eagle Ford Low	-	-	67.5	-	-	-	-	-	69.4	71.3	-	-	82.8	75.0	-
	2018	Eagle Ford Mod	-	-	67.7	-	-	-	-	-	69.9	71.8	-	-	82.9	75.3	-
	2018	Eagle Ford High	-	-	67.9	-	-	-	-	-	70.7	72.5	-	-	83.0	75.7	-
C678	2012	Base Case	~~51.8~~	~~57.6~~	71.8	~~64.6~~	~~56.0~~	~~57.5~~	~~66.0~~	~~64.8~~	74.1	75.2	~~60.3~~	~~67.8~~	98.6	85.4	~~63.4~~
	2012	Eagle Ford	~~52.0~~	~~57.8~~	72.2	~~65.9~~	~~57.4~~	~~59.5~~	~~66.8~~	~~66.0~~	75.9	76.6	~~61.6~~	~~68.7~~	98.7	86.7	~~64.4~~
	2018	Base Case	-	-	67.3	-	-	-	-	-	69.8	71.0	-	-	89.5	79.5	-
	2018	Eagle Ford Low	-	-	67.7	-	-	-	-	-	71.5	72.6	-	-	89.6	80.8	-
	2018	Eagle Ford Mod	-	-	67.8	-	-	-	-	-	72.0	73.0	-	-	89.7	81.2	-
	2018	Eagle Ford High	-	-	67.8			66.0	71.0	69.1	75.1	74.1		70.7	91.3	83.7	-

CAMS	Year	Run Label	Episode days															Design Value
			16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	
C23	2012	Base Case	~~43.6~~	~~37.2~~	~~42.0~~	~~55.2~~	~~36.4~~	~~38.2~~	~~44.6~~	~~46.9~~	~~45.2~~	~~54.9~~	~~63.3~~	73.8	90.1	75.8	73.0	77.3
	2012	Eagle Ford	~~44.0~~	~~38.2~~	~~43.1~~	~~55.6~~	~~37.6~~	~~38.9~~	~~45.4~~	~~47.5~~	~~45.5~~	~~55.3~~	~~63.3~~	73.9	90.3	76.6	73.3	77.3
	2018	Base Case	-	-	-	-	-	-	-	-	-	-	-	67.3	82.2	71.0	67.8	70.9
	2018	Eagle Ford Low	-	-	-	-	-	-	-	-	-	-	-	67.4	82.4	71.7	68.1	70.9
	2018	Eagle Ford Mod	-	-	-	-	-	-	-	-	-	-	-	67.4	82.5	72.0	68.2	71.1
	2018	Eagle Ford High	-	-	-	-	-	-	-	-	-	-	-	67.4	82.6	72.3	68.3	71.4
C58	2012	Base Case	~~44.8~~	~~39.0~~	~~42.0~~	~~54.4~~	~~36.3~~	~~41.7~~	~~45.2~~	~~46.9~~	~~42.7~~	~~51.8~~	~~59.1~~	70.2	83.9	74.4	71.7	80.0
	2012	Eagle Ford	~~45.3~~	~~40.3~~	~~43.1~~	~~54.8~~	~~37.5~~	~~42.5~~	~~46.0~~	~~47.4~~	~~43.1~~	~~51.9~~	~~59.1~~	70.2	84.1	75.3	72.0	80.0
	2018	Base Case	-	-	-	-	-	-	-	-	-	-	-	64.7	78.3	70.3	67.1	73.7
	2018	Eagle Ford Low	-	-	-	-	-	-	-	-	-	-	-	64.7	78.5	71.1	67.4	73.8
	2018	Eagle Ford Mod	-	-	-	-	-	-	-	-	-	-	-	64.7	78.6	71.3	67.5	74.0
	2018	Eagle Ford High	-	-	-	-	-	-	-	-	-	-	-	64.8	78.7	71.7	67.6	74.3
C59	2012	Base Case	~~38.1~~	~~32.8~~	~~34.4~~	~~56.6~~	~~33.2~~	~~35.0~~	~~40.1~~	~~40.6~~	~~51.1~~	~~61.6~~	~~66.2~~	74.2	80.4	74.1	~~62.1~~	69.3
	2012	Eagle Ford	~~38.7~~	~~34.1~~	~~36.5~~	~~57.0~~	~~34.4~~	~~36.1~~	~~40.8~~	~~42.3~~	~~51.2~~	~~61.9~~	~~66.2~~	74.3	80.8	75.9	~~63.5~~	69.3
	2018	Base Case	-	-	-	-	-	-	-	-	-	-	-	67.1	75.6	71.1		64.9
	2018	Eagle Ford Low	-	-	-	-	-	-	-	-	-	-	-	67.2	76.0	72.9		65.0
	2018	Eagle Ford Mod	-	-	-	-	-	-	-	-	-	-	-	67.2	76.1	73.4		65.2
	2018	Eagle Ford High	-	-	-	-	-	-	-	-	-	-	-	67.2	76.3	74.1		65.6
C622	2012	Base Case	~~38.1~~	~~32.8~~	~~35.4~~	~~56.9~~	~~33.2~~	~~35.1~~	~~39.8~~	~~40.6~~	~~50.1~~	~~61.1~~	~~65.8~~	74.2	80.4	74.1	~~64.3~~	74.0
	2012	Eagle Ford	~~38.7~~	~~34.1~~	~~37.4~~	~~57.3~~	~~34.4~~	~~36.1~~	~~40.8~~	~~42.3~~	~~50.2~~	~~61.4~~	~~65.8~~	74.3	80.8	75.9	~~64.7~~	74.0
	2018	Base Case	-	-	-	-	-	-	-	-	-	-	-	67.2	75.6	71.1		69.2
	2018	Eagle Ford Low	-	-	-	-	-	-	-	-	-	-	-	67.3	76.0	72.9		69.2
	2018	Eagle Ford Mod	-	-	-	-	-	-	-	-	-	-	-	67.3	76.1	73.4		69.5
	2018	Eagle Ford High	-	-	-	-	-	-	-	-	-	-	-	67.4	76.3	74.1		69.8
C678	2012	Base Case	~~39.9~~	~~33.3~~	~~40.2~~	~~56.9~~	~~33.8~~	~~35.7~~	~~40.5~~	~~41.3~~	~~48.4~~	~~58.9~~	~~66.5~~	77.0	83.9	76.7	~~69.6~~	69.6
	2012	Eagle Ford	~~40.5~~	~~34.6~~	~~41.7~~	~~57.3~~	~~35.0~~	~~36.8~~	~~41.5~~	~~42.3~~	~~48.6~~	~~59.2~~	~~66.5~~	77.0	84.1	78.3	~~69.8~~	69.6
	2018	Base Case	-	-	-	-	-	-	-	-	-	-	-	69.5	78.3	73.6		64.8
	2018	Eagle Ford Low	-	-	-	-	-	-	-	-	-	-	-	69.5	78.5	75.2		64.9
	2018	Eagle Ford Mod	-	-	-	-	-	-	-	-	-	-	-	69.6	78.6	75.7		65.1
	2018	Eagle Ford High	-	-	-	-	-	-	-	-	-	-	-	69.6	78.7	76.3		65.4

Figure 6-4: Change in San Antonio-New Braunfels MSA Eight-Hour Design Values, 2018



6.4 Minimum Threshold Analysis:

The methodology used above follows the EPA's guidance on calculating future design values. However, other methodologies may be used to calculate future design values, so that model sensitivity can be tested.[276] The minimum threshold used in the design value calculation was based on EPA's recommended lowest threshold of 70 ppb. The change in 2018 RRFs, the future design values, and the number of days that meet each criterion are provided in Table 6-5.

By raising the minimum threshold from 70 ppb, used in the above attainment demonstration, to 75 ppb and 80 ppb, the applicable days drop below EPA's guidance that suggests at least 10 days be included in the analysis. While the calculation then uses days that modeled higher baseline ozone concentrations, the calculation becomes less statistically robust. When the minimum threshold was raised to 75 ppb, the maximum design value at C58 was lowered 0.1 ppb. Under the minimum threshold of 80 ppb, the maximum design value was lowered 0.4 ppb to 73.6 ppb, though there are only five days included in the calculation. A similar reduction in the future design value occurred for the other monitors when the minimum threshold was increased to 80 ppb.

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[276] TCEQ. "Appendix C: Photochemical Modeling for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. c-127. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppC_CAMx_ado.pdf. Accessed 06/20/13.

Table 6-5: Minimum Threshold Analysis, 2012-2018.

Site	2012 DV	70 ppb			75 ppb			80 ppb		
		RRF	DVF	# Days	RRF	DVF	# Days	RRF	DVF	# Days
C23	77.3	0.920	71.1	12	0.932	72.0	8	0.912	70.5	4
C58	80.0	0.925	74.0	12	0.923	73.9	8	0.920	73.6	5
C59	69.3	0.941	65.2	8	0.943	65.4	4	0.932	64.6	2
C622	74.0	0.939	69.5	8	0.941	69.6	5	0.929	68.7	3
C678	69.6	0.935	65.1	8	0.935	65.1	7	0.926	64.4	3

6.5 Grid Cell Array Size Analysis

"The grid cell array size is chosen as an area around a monitor to be spatially representative of that site. For the RRF calculation the maximum concentration in the grid cell array around a monitor from the baseline and future case modeling is used, which may not be at the cell where the monitor is located. The EPA guidance states that this method is beneficial for many reasons, including that the model may displace the peak around a monitor."[277]

The 3X3, 5X5, and 7X7 grid cell arrays used in the alternative DV calculations for the regulatory sited monitors in the San Antonio-New Braunfels MSA are shown in Figure 6-5. A 5x5 or 7x7 grid cell array shows overlap among several of San Antonio monitors. The maximum DV at C58 increases from 74.0 ppb to 75.0 ppb when a 3X3 grid cell array is used (Table 6-6). For the other four monitors, the design value decreases from 0.8 ppb to 6.2 ppb when using the 3X3 grid cell array. The model is more sensitive to changes in predicted ozone nearer to the monitoring sites.

Table 6-6: RRFs and DVFs using 3X3, 5X5, and 7X7 Grid Cell Arrays, 2012-2018

Site	2012 DV	3X3 Grid Cell Array		5X5 Grid Cell Array		7X7 Grid Cell Array	
		RRF	DV	RRF	DV	RRF	DV
Area Max	80.0	0.938	75.0	0.923	73.8	0.941	74.0
C23	77.3	0.908	70.2	0.901	69.7	0.920	71.1
C58	80.0	0.938	75.0	0.923	73.8	0.925	74.0
C59	69.3	0.891	61.7	0.877	60.8	0.941	65.2
C622	74.0	0.928	68.7	0.910	67.4	0.939	69.5
C678	69.6	0.847	58.9	0.826	57.5	0.935	65.1

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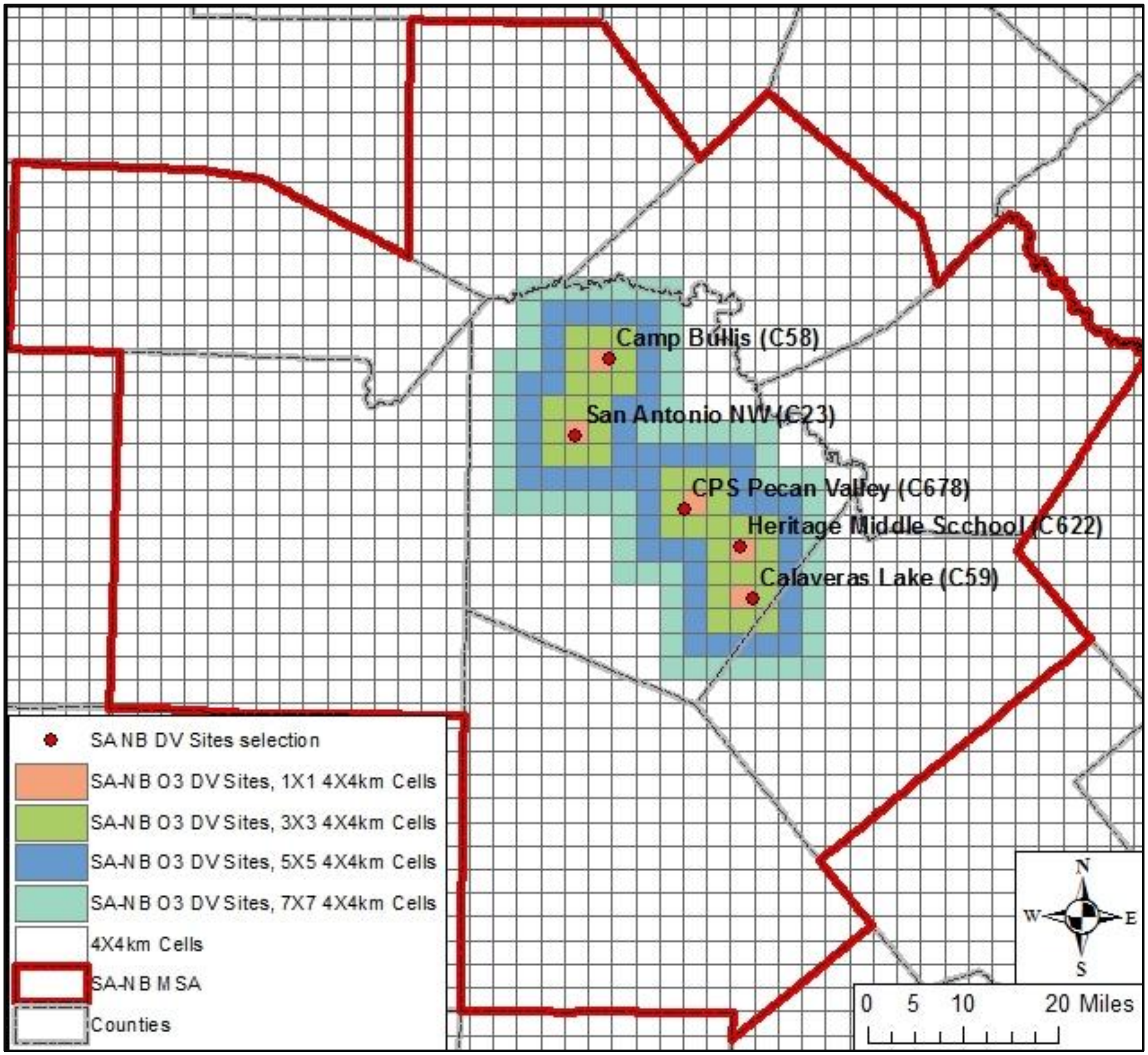
[277] TCEQ. "Appendix C: Photochemical Modeling for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard". Austin, Texas. p. c-127. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/ad_2011/AppC_CAMx_ado.pdf. Accessed 06/20/2013.

Figure 6-5: Grid Cell Array Size around Regulatory Sited San Antonio-New Braunfels Ozone Monitors



Plot Date: June 14, 2013
Map Compilation: June 14, 2013
Source: Monitor Locations based on TCEQ data.