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ADDENDUM REPORT – NEW MEXICO OZONE ATTAINMENT INITIATIVE STUDY – REVISED 2014V2 BASE CASE AND MODEL PERFORMANCE EVALUATION

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ACRONYMS AND ABBREVIATIONS

AIRS	Aerometric Information Retrieval System
AMET	Atmospheric Model Evaluation Tool
APCA	Anthropogenic Precursor Culpability Assessment
AQ	Air Quality
AQS	Air Quality System
BC	Boundary Condition
BEIS	Biogenic Emissions Information System
CAMx	Comprehensive Air-quality Model with extensions
CASTNet	Clean Air Status and Trends Network
CB6r2	Carbon Bond mechanism version 6, revision 2
CMAQ	Community Multiscale Air Quality modeling system
CONUS	Continental United States
CSAPR	Cross State Air Pollution Rule
CSN	Chemical Speciation Network
EC	Elemental Carbon Fine Particulate Matter
EGU	Electrical Generating Units
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FB	Fractional Bias
FE	Fractional Error
FRM	Federal Reference Method
GEOS-Chem	Goddard Earth Observing System (GEOS) global chemistry model
GIRAS	Geographic Information Retrieval and Analysis System
IMPROVE	Interagency Monitoring of PROtected Visual Environments
IWDW	Intermountain West Data Warehouse
LCC	Lambert Conformal Conic projection
MEGAN	Model of Emissions of Gases and Aerosols in Nature
MNGE	Mean Normalized Gross Error
MNB	Mean Normalized Bias
MNE	Mean Normalized Error
MOVES	Motor Vehicle Emissions Simulator
MOZART	Model for OZone And Related chemical Tracers
MPE	Model Performance Evaluation
NAAQS	National Ambient Air Quality Standard
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NMED	New Mexico Environmental Division
NO_2	Nitrogen Dioxide
OAI	Ozone Attainment Initiative
OSAT	Ozone Source Apportionment Technology
PAVE	Package for Analysis and Visualization
PGM	Photochemical Grid Model
PPB	Parts Per Billion

PPM	Piecewise Parabolic Method
QA	Quality Assurance
QC	Quality Control
RRF	Relative Response Factor
SCC	Source Classification Code
SIP	State Implementation Plan
SMOKE	Sparse Matrix Kernel Emissions modeling system
SNMOS	Southern New Mexico Ozone Study
TCEQ	Texas Commission on Environmental Quality
VMT	Vehicle Miles Traveled
WAQS	Western Air Quality Study
WESTAR	Western States Air Resources Council
WestJumpAQMS	West-Wide Jump-Start Air Quality Modeling Study
WESTUS	Western United States
WRAP	Western Regional Air Partnership
WRF	Weather Research Forecast model

1. INTRODUCTION

The New Mexico Environmental Division (NMED) is conducting an Ozone Attainment Initiative (OAI) Photochemical Modeling Study ("NM OAI Study") to assess the causes of high ozone concentrations in New Mexico and evaluate the effects that potential control strategies will have on ozone concentrations. The NMED has contracted with a team consisting of Western States Air Resources Council (WESTAR) and Ramboll US Consulting, Inc. to conduct the NM OAI Study. The NM OAI Study leverages the 2014 PGM modeling platform developed by the Western Regional Air Partnership (WRAP) and the Western Air Quality Study (WAQS) and enhances it by adding a 4-km grid resolution modeling domain covering New Mexico and adjacent regions. Future year, source apportionment and control measure evaluation modeling are planned to assist the NMED in ozone air quality planning for the state.

1.1 Purpose of this Addendum Report

In September 2020, the NM OAI Study released a 2014 Modeling Platform Development and Model Evaluation report (Ramboll and WESTAR, 2020c[1]) that evaluated the Comprehensive Air Quality Model with extensions (CAMx[2]) v7.0 2014 36/12/4-km base case simulation focusing on ozone concentrations within the 4-km New Mexico domain and in particular on ozone within New Mexico. Since then, a new versions of CAMx (v7.1) has been released (Ramboll, 2020[3]) and an update made to the 2014 base case emissions that required a revised CAMx v7.1 2014v2 base case simulation. This report is an Addendum to the 2014 Modeling Platform Development and Model Performance Evaluation report (Ramboll and WESTAR, 2020c) that discusses the revised CAMx v7.1 base case simulation and ozone model evaluation and compares it to the original CAMx v7.0 2014 base case ozone model performance.

1.2 Overview of NM OAI Study Modeling Approach

The procedures used for the NM OAI Study photochemical modeling were described in a detailed Modeling Protocol dated May 19, 2020 (Ramboll and WESTAR, 2020a[4]). A description of the original tasks and schedule for completing the NM OAI Study is contained in a Work Plan (Ramboll and WESTAR, 2020b[5]) with presentations, results and reports posted to the NM OAI Study webpage[6] as they are produced.

The NM OAI Study is conducting PGM modeling by enhancing the WRAP-WAQS 2014v2 36/12-km PGM modeling platform[7] with the addition of a new 4-km grid resolution domain covering New Mexico and surrounding areas, especially the oil and gas (O&G) production regions in the Permian and San Juan Basins. The NM OAI Study PGM modeling performed 2014 base year modeling and model performance evaluation (Ramboll and WESTAR, 2020c). The NM OAI Study PGM modeling is being conducted in

[1] https://www.wrapair2.org/pdf/NM_OAI_2014_BaseCase_MPE_v3.pdf
[2] http://www.camx.com/
[3] http://www.camx.com/files/camxusersguide_v7-10.pdf
[4] https://www.wrapair2.org/pdf/NM_OAI_Modeling_Protocol_v5.pdf
[5] https://www.wrapair2.org/pdf/NM_OAI_Work_Plan_v2.pdf
[6] https://www.wrapair2.org/NMOAI.aspx
[7] http://views.cira.colostate.edu/wiki#WAQS-2014-Modeling-Platform

accordance with EPA's guidance for ozone State Implementation Plan (SIP) attainment demonstration modeling (EPA, 2018).

Originally the NM OAI Study was going to conduct 2023 future year modeling using the 2014 36/12/4-km CAMx modeling platform. However, the NMED wanted to evaluate the effects of their proposed Ozone Precursor Rule for the Oil and Natural Gas Sector[8] that would not be fully implemented by 2023. Thus, on December 11, 2020 NMED issued WESTAR/Ramboll a Contract Amendment to:

- Develop 2028 emissions scenario with 2028 New Mexico O&G emissions.
- Conduct CAMx 2028 36/12/4-km base case modeling and 2028 ozone design value projections.
- Process 2028 NM O&G control strategy emissions provided by NMED and conduct CAMx 2028 NM O&G control strategy modeling and 2028 ozone design value projections.
- Document the effects of the 2028 NM O&G control strategy on ozone concentrations and ozone design values in a draft Air Quality Technical Support Document (AQTSD).
- Conduct CAMx 2028 36/12/4-km ozone source apportionment modeling and document in the final AQTSD.

The NM OAI Study modeling is using the same 36-km 36US and 12-km 12WUS2 domains as used in the WRAP-WAQS 2014 modeling platform. A new 4-km New Mexico domain was added to the 36/12-km domain structure. Figure 1-1 displays the 36/12/4-km domain structure with Figure 1-2 showing the 4-km New Mexico domain. New WRF 2014 36/12/4-km meteorological modeling was conducted to generate finer scale 4-km meteorological conditions for the New Mexico domain and consistent meteorology among the 36/12/4-km domains. CAMx is run using the 36/12/4-km domain structure shown in Figure 1-1 using two-way interactive grid nesting.

[8] https://www.env.nm.gov/new-mexico-methane-strategy/wp-content/uploads/sites/15/2020/07/Draft-Ozone-Precursor-Rule-for-Oil-and-Natural-Gas-Sector-Version-Date-7.20.20.pdf

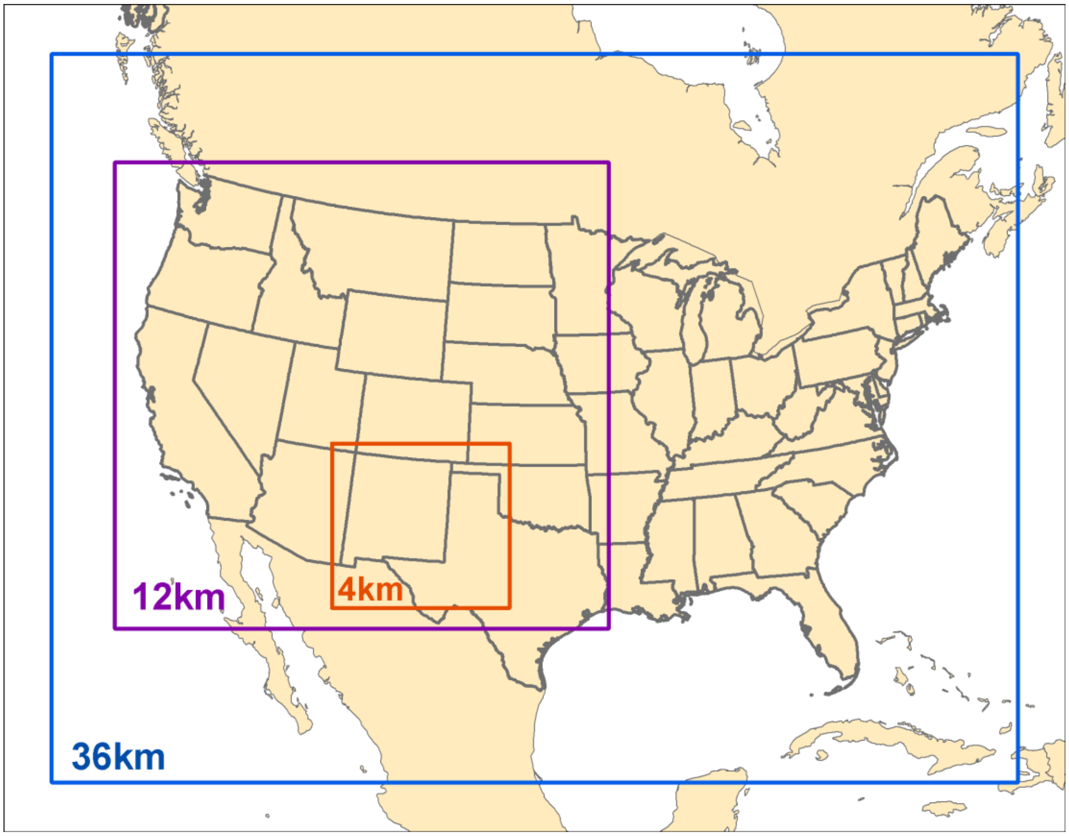

Figure 1-1. NM OAI Study 2014 36/12/4-km PGM and emissions modeling domains.

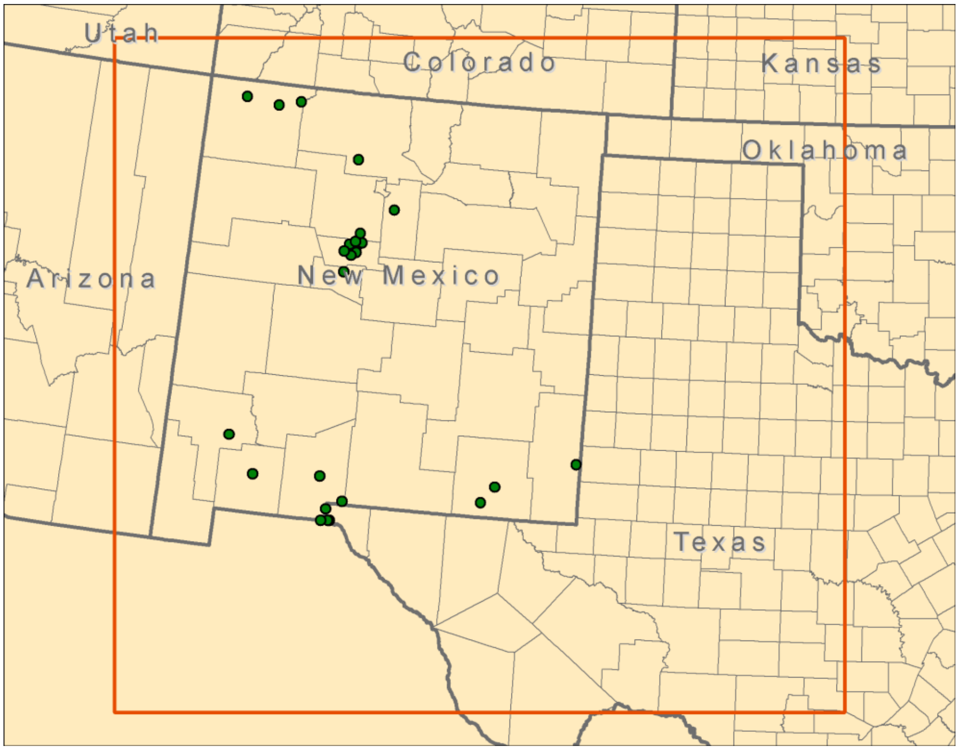

Figure 1-2. 4-km New Mexico modeling domain for PGM and emissions modeling, with locations of New Mexico ozone monitors that were operating during some portion of 2014.

Boundary conditions (BC) for the outer 36-km 36US domain were based on a 2014 simulation of the GEOS-Chem global chemistry model conducted by WRAP processed by the GC2CAMx converter. The result is day-specific diurnally varying BCs for the lateral boundaries around the 36-km 36US modeling domain (Figure 1-1). The top BC (TopCon) was based on a zero-gradient assumption where concentrations above the top of the model (above 50 mb, or ~19-km above sea level) are assumed to be the same as in the top vertical layer of CAMx.

2. REVISED CAMX 2014V2 BASE CASE MODELING

The NM OAI Study original CAMx 2014 36/12/4-km base case modeling and model evaluation used version 7.0 (v7.0) of CAMx and is documented in WESTAR and Ramboll (2020c). A revised CAMx 2014v2 36/12/4-km base case simulation was conducted that had two updates as described below.

2.1 New Version of CAMx v7.1

On January 8, 2021, a new version 7.10 (v7.1) of CAMx was released that contained several updates and bug fixes over CAMx v7.0 used in the original CAMx 2014 base case simulation in the NM OAI Study. Of particular note was an error in the source apportionment tool (SAT) in CAMx v7.0 that injected emissions into the incorrect grid cells when running 3 or more nested grids (as being used in the NMED OAI Study 36/12/4-km domains). A second bug in CAMx v7.0 that was corrected in CAMx v7.1 had incorrect species mappings for point sources when running SAT. As the NMED OAI Study planned to conduct 2028 CAMx ozone source apportionment modeling, this meant we had to switch to v7.1 of CAMx. Ozone design value projection procedures use the relative changes in the base (2014) and future (2028) year ozone modeling results to scale the base year observed ozone design values so the base and future year modeling must be consistent. This meant that a revised 2014v2 simulation was required using CAMx v7.1 to be consistent with the 2028 modeling.

2.2 New Version of Biogenic Emissions in the 4-km NM Domain

The second update to the original CAMx 2014 base case in the 2014v2 revised base case was the source of the biogenic emissions in the 4-km New Mexico domain. The original CAMx 2014 base case (Ramboll and WESTAR, 2020c) used version 3.1 of the Model of Emissions of Gases and Aerosols from Nature (MEGAN[9]). MEGAN v3.1 is very new version that corrected some bugs in MEGAN v3.0. However, the Leaf Area Index (LAI) inputs used in MEGAN v3.1 are missing for urban areas so produced zero biogenic emissions for the urban land cover category. Ideally, plant surveys of urban areas would be conducted to determine the correct LAI values for an urban area for input into MEGAN v3.1, which was beyond the schedule and budget of the NMED OAI Study.

In addition, the MEGAN v3.1 soil NOx emissions were very different and much higher than previous versions of MEGAN and EPA’s Biogenic Emissions Information System (BEIS[10]) biogenic emissions model. The MEGAN v3.1 biogenic emissions in the 4-km New Mexico domain were also inconsistent with the BEIS biogenic emissions used in the 12-km domain from the WRAP-WAQS 2014v2 platform modeling.

For the CAMx revised 2014v2 base case simulation, biogenic emissions in the 4-km NM domain were based on the BEIS v3.7 biogenic emissions model. BEIS v3.7 uses updated biomass and emissions factors, and the Biogenic Emissions Landcover Database version 5 (BELD5) which includes the following land use databases:

[9] https://bai.ess.uci.edu/megan

[10] https://www.epa.gov/air-emissions-modeling/biogenic-emission-inventory-system-beis

- Newer version of the Forest Inventory and Analysis (FIA) version 8.0
- Agricultural land use from the 2017 US Department of Agriculture (USDA) crop data layer
- Global Moderate Resolution Imaging Spectroradiometer (MODIS) 20 category data with enhanced lakes

2.2.1 Comparison of BEIS v3.7 and MEGAN v3.1 Biogenic Emissions

Figures 2-1 and 2-2 compare the spatial distribution of the BEIS and MEGAN monthly average VOC and NOx emissions across the 4-km New Mexico domain with a summary comparison of domain-wide total emissions given in Table 2-1. In May, BEIS has 25% more VOC emissions than MEGAN, about the same VOC emissions in June and 20-40% less VOC emissions in July and August. In July and August 2014, MEGAN has higher VOC emissions over the Permian Basin and south-eastern Arizona and Mexico (Figure 2-1). But MEGAN also has holes in the biogenic VOC emissions, presumably due to missing LAI data.

There are much larger differences in the MEGAN and BEIS biogenic NOx emissions. MEGAN v3.1 has a new soil NOx algorithms that has higher NOx emissions for agricultural areas, produces pulses of NO emissions after rainfall and has a larger temperature dependence. Compared to BEIS v3.7, MEGAN v3.1 produces 3-4 times more soil NOx emissions. MEGAN has several hot spots of higher soil NOx emissions not reflected in BEIS.

With lower biogenic NOx emissions and lower biogenic VOC emissions in July and August, we would expect the revised CAMx 2014v2 base case to produce slightly lower ozone concentrations compared to the original CAMx 2014 base case.

Table 2-1. Comparison of BEIS v3.7 and MEGAN v3.1 monthly average biogenic VOC and NOx emissions within the 4-km New Mexico domain.

Month	MEGAN	BEIS	BEIS-MEGAN
	VOC		
May	128,323	159,809	25%
June	267,055	256,379	-4%
July	317,697	251,562	-21%
August	354,570	216,032	-39%
	NOx		
May	35,050	10,602	-70%
June	42,445	13,134	-69%
July	51,639	12,838	-75%
August	41,002	11,923	-71%

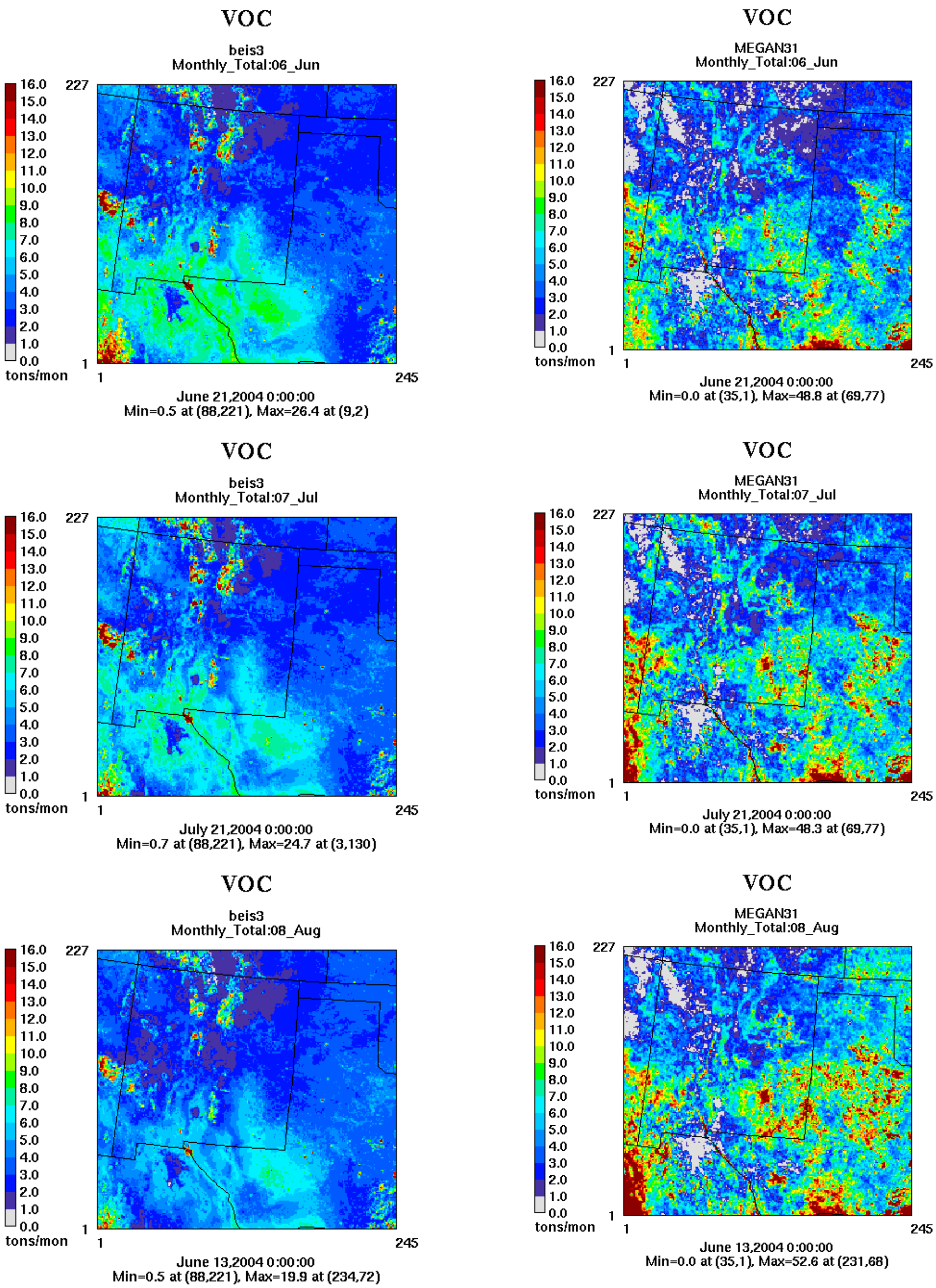

Figure 2-1. Monthly average biogenic VOC emissions within the 4-km New Mexico domain from BEIS v3.7 (left) and MEGAN v3.1 (right) and June (top), July (middle) and August (bottom) 2014.

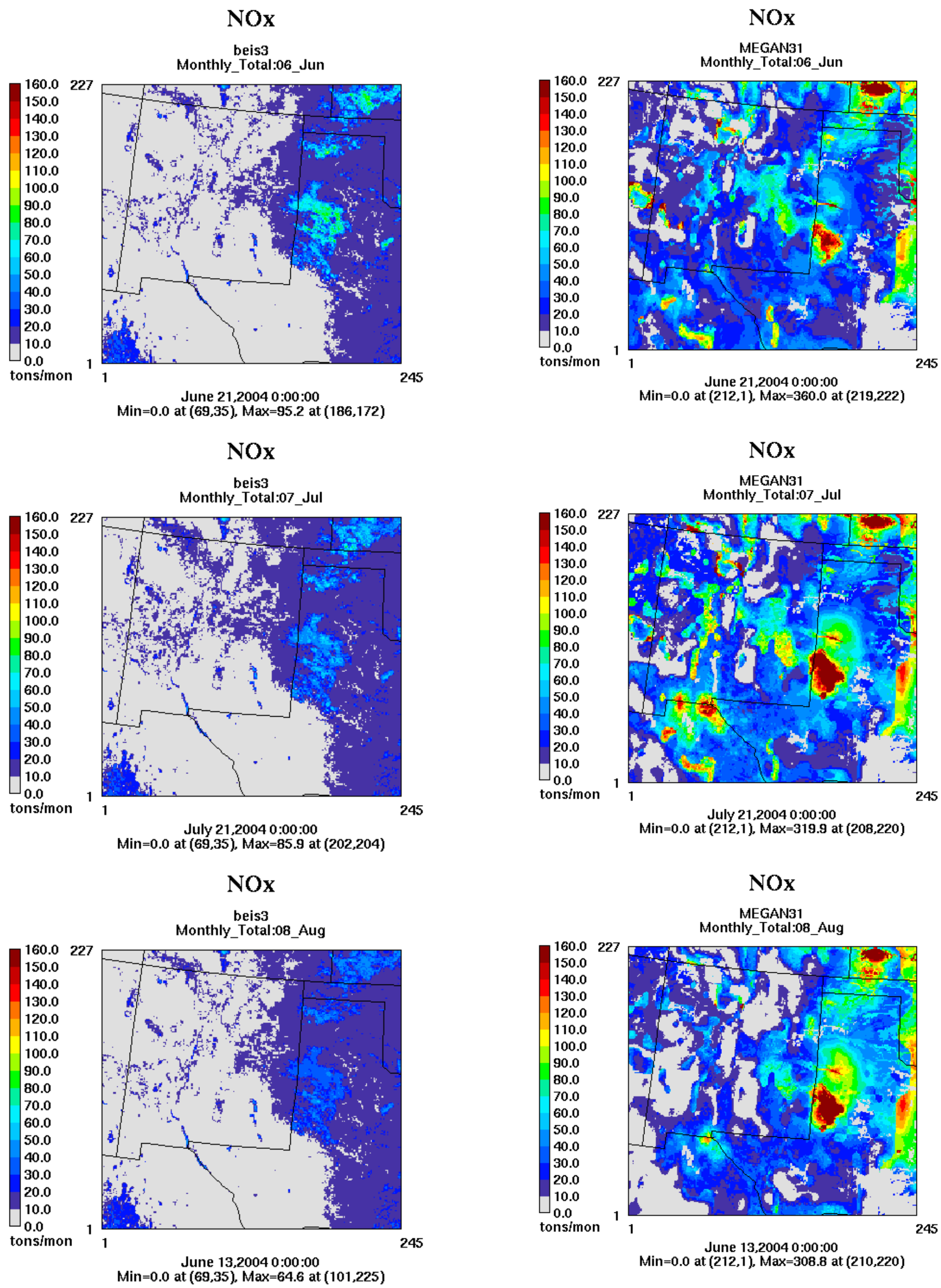

Figure 2-2. Monthly average biogenic NOx emissions within the 4-km New Mexico domain from BEIS v3.7 (left) and MEGAN v3.1 (right) and June (top), July (middle) and August (bottom) 2014.

3. REVISED CAMX 2014V2 MODEL EVALUATION

The CAMx revised 2014v2 base case simulation was identical to the original CAMx 2014 base case, as documented in Ramboll and WESTAR (2020c) except for the two updates described in Chapter 2: (1) use of CAMx v7.1 instead of CAMx v7.0; and (2) use of BEIS v3.7 biogenic emissions in the 4-km NM domain instead of MEGAN v3.1.

Below we compare the ozone model performance of the CAMx revised 2014v2 and original 2014 base case simulations.

3.1 Ozone Model Performance Goals and Criteria

Emery and co-workers (2016) analyzed almost 100 PGM model applications and came up with a set of PGM model performance goals and criteria based on the variability in the past PGM model performance. "Goals" indicate statistical values that about a third of the top performance past PGM applications have met and should be viewed as the best a model can be expected to achieve. "Criteria" indicates statistics values that about two thirds of past PGM applications have met and should be viewed as what a majority of the models have achieved. In this Chapter we compare the CAMx revised 2014v2 and original 2014 base case simulations ozone model performance statistics for normalized mean bias (NMB) and normalized mean error (NME) against the ozone model performance goals and criteria developed by Emery et al., (2016) that are given in Table 3-1.

Table 3-1. Recommended ozone benchmarks for photochemical model statistics (Source: Emery et al., 2016).

Species	NMB		NME		r	
	Goal	Criteria	Goal	Criteria	Goal	Criteria
1-hr & MDA8 Ozone	<±5%	<±15%	<15%	<25%	>0.75	>0.50

3.2 Spatial Ozone Model Performance

Figures 3-1 and 3-2 display the spatial distribution of bias (NMB) performance at monitoring sites in the 4-km NM domain for the revised 2014v2 and original 2014 CAMx base case simulation with and without using a 60 ppb observed ozone cutoff concentrations (i.e., only include predicted and observed MDA8 ozone pairs in the statistics when the observed MDA8 ozone is greater than 60 ppb). When the symbols are grey, they achieve the within ±5% ozone bias Performance Goal and when the symbols are the brightest green or yellow color they are within the ozone bias Performance Criteria (i.e., between ±5% and ±15%).

With the exception of one monitoring site in El Paso, the NMB at all of the ozone sites in the 4-km domain achieve the ozone Performance Criteria using no cutoff in both CAMx base case simulations, although some sites have an overestimation bias greater than 5% Performance Goal (Figure 3-1). The CAMx 2014v2 and 2014 base case ozone bias performance looks nearly identical with the only noticeable differences being two sites (in Dona Ana and Luna Counties) that achieve the ozone bias Performance Goal in the revised 2014v2 CAMx base case (i.e., are colored grey in Figure 3-1, top) but have bias between the 5% and 15% in the original CAMx base case (Figure 3-1, bottom) so fall between the Performance Goal and Criteria (i.e., are colored bright yellow).

Whereas the CAMx base cases tend to have a small ozone overestimation bias when no observed ozone 60 ppb cutoff is used, when using an ozone cutoff both base cases tend to have a small underestimation bias (Figure 3-2). When using the cutoff, with one exception, all sites achieve the ozone Performance Criteria and many sites achieve the ozone bias Performance Goal. The bias performance of the two base case simulation are nearly identical. The one exception is a site in Eddy County that is between the Performance Goal and Criteria (i.e., between -5% and -15%) in the original 2014 base case (Figure 3-2, bottom), but has a NMB between -15% and -20% in the revised 2014v2 base case so fails to achieve the ozone bias Performance Criteria (Figure 3-2, top).

We also compared the spatial model performance of the two base cases for error (NME) and correlation (r), but the spatial maps were identical so did not provide any relevant information on the relative performance of the two base case simulations.

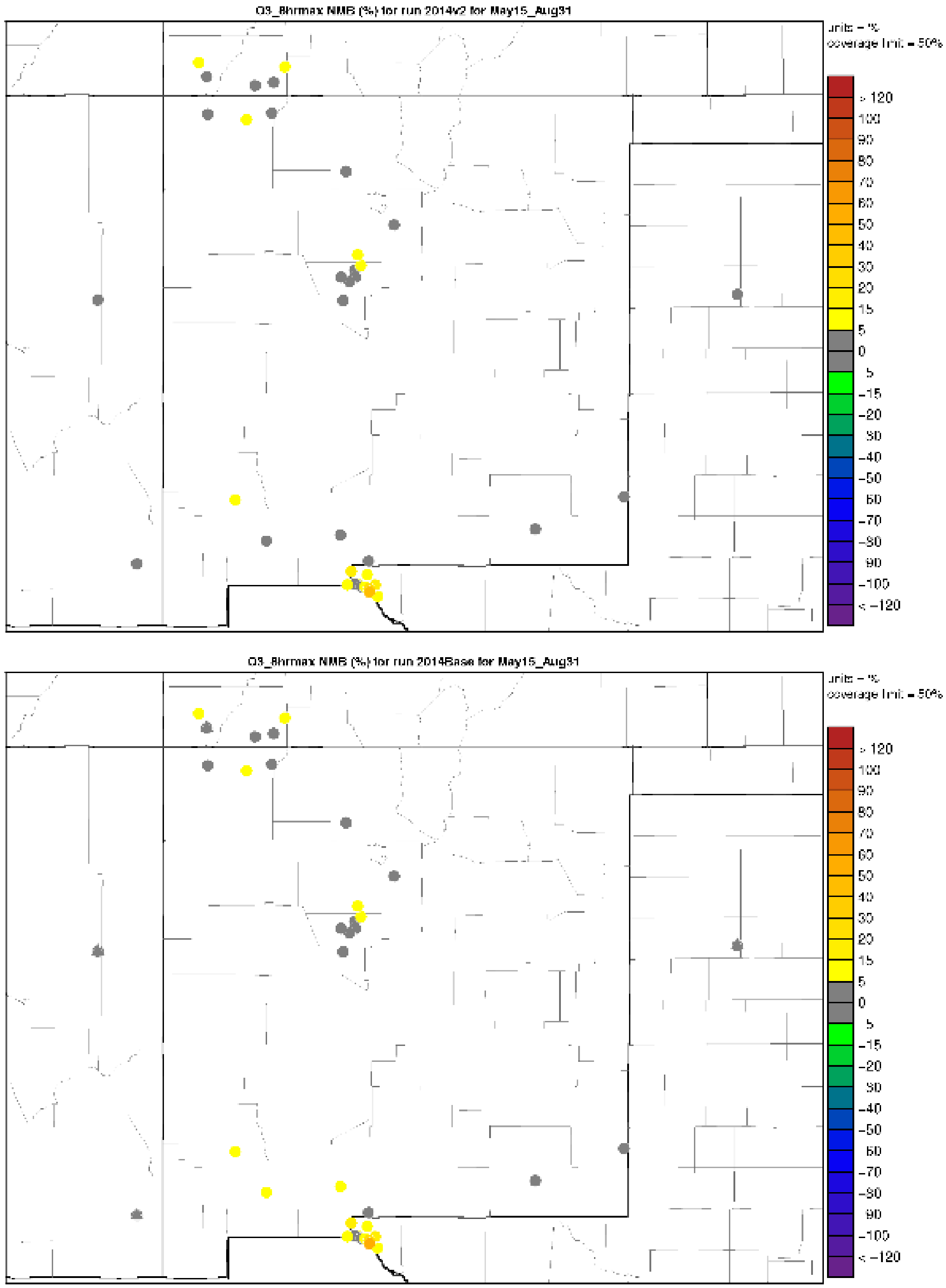

Figure 3-1. Normalized Mean Bias (NMB) for MDA8 ozone concentrations for the revised 2014v2 (top) and original 2014 (bottom) CAMx base case simulations with no ozone cutoff.

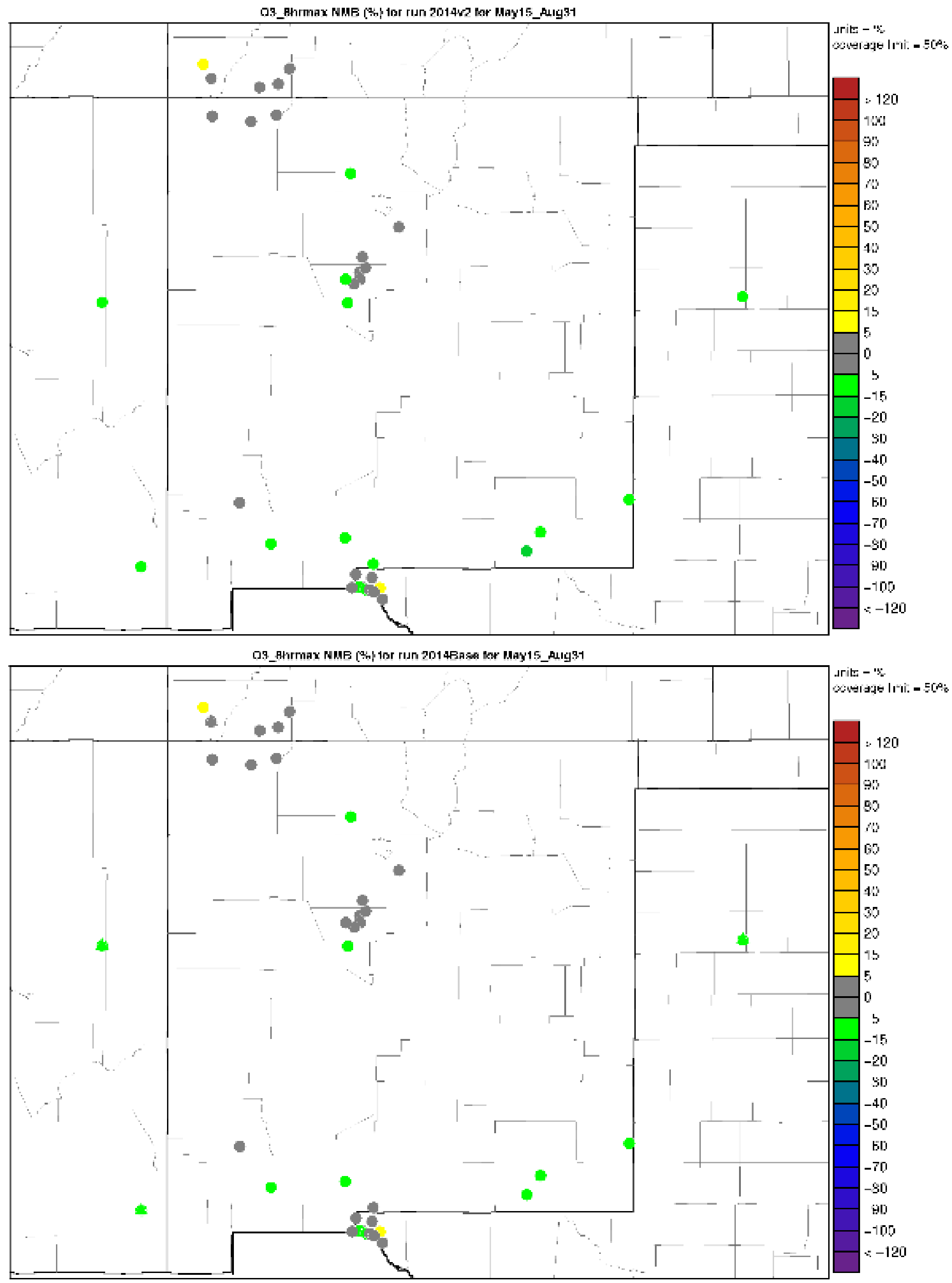

Figure 3-2. Normalized Mean Bias (NMB) for MDA8 ozone concentrations for the revised 2014v2 (top) and original 2014 (bottom) CAMx base case simulations with an observed 60 ppb ozone cutoff.

3.3 Scatter Plots of MDA8 Ozone

Figure 3-3 display scatter plots and summary statistics of MDA8 ozone across AQS or CASTNet sites in the 4-km domain for the revised 2014v2 and original 2014 CAMx base case simulations. The 2014v2 and 2014 MDA8 scatter plots look identical with the MDA8 performance at the AQS sites exhibiting a slight MDA8 ozone overestimation bias as indicated by the center density of the scatterplot being slightly above the 1:1 line of perfect agreement. This is in contrast to the CASTNet MDA8 scatterplots that are centered on the 1:1 line of perfect agreement so the two base case simulations are less biased.

The AQS performance statistics across the 4-km domain for the May-August 2014 modeling period show that the 2014v2 and 2014 MDA8 ozone performance is not exactly identical with the revised 2014v2 base case having a NMB of 4.4% that achieves the ozone bias Performance Goal, whereas the original 2014 base case has a NMB of 6.2% that falls between the ozone bias Performance Goal and Criteria. The 2014v2 NME (10.6%) is also slightly better than the original 2014 base case (10.9%).

Both CAMx base case simulations exhibit extremely good MDA8 ozone model performance across the CASTNet sites in the 4-km domain with near zero bias (-1.4% and +0.1%) and errors (8.1% and 7.9%) that are almost half the ozone error Performance Goal (<15%).

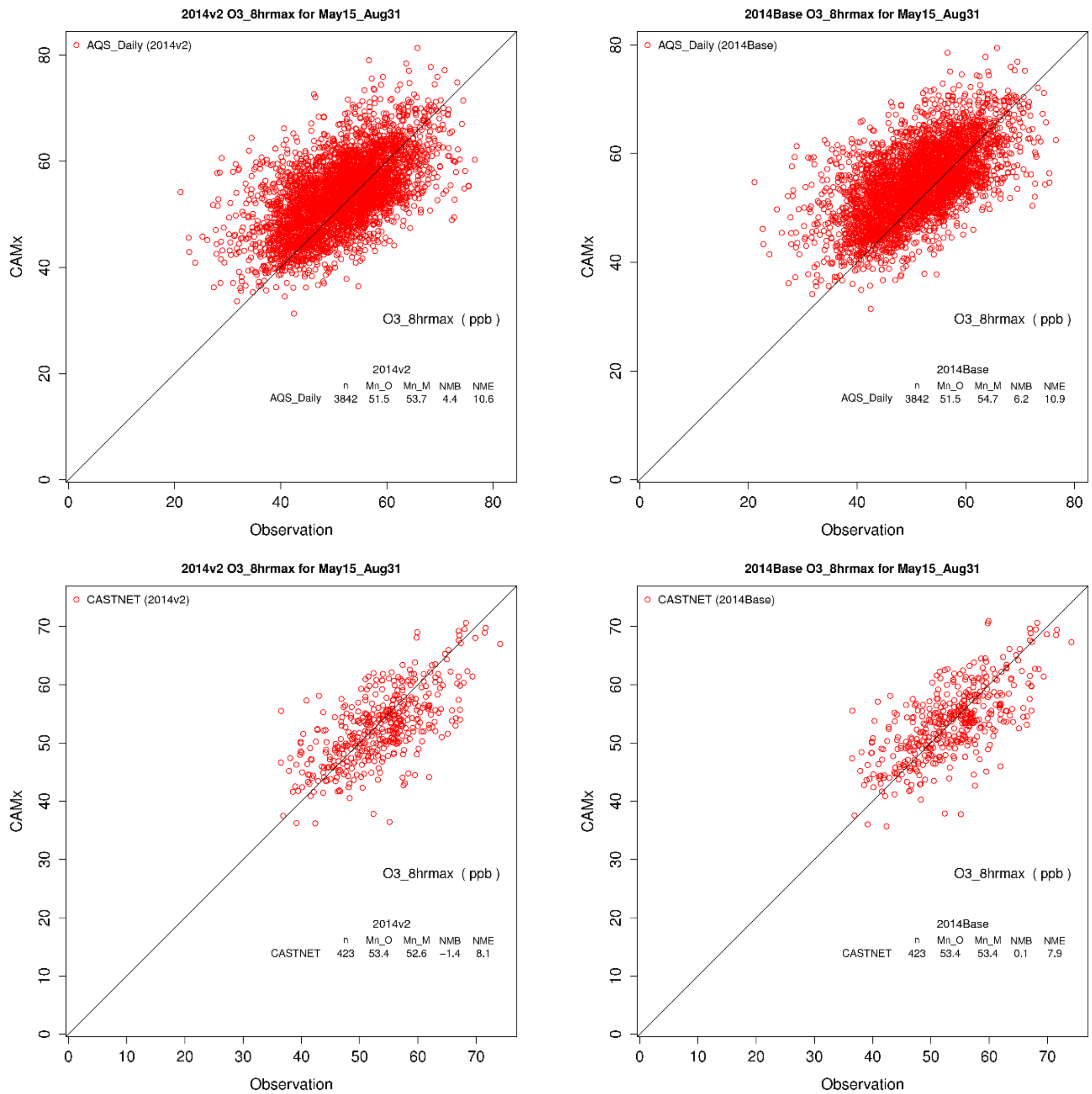

Figure 3-3. Scatter plots of predicted and observed MDA8 ozone concentrations for AQS (top) and CASTNet (bottom) monitoring sites within the 4-km New Mexico domain and the revised 2014v2 (left) and original 2014 (right) CAMx base case simulations.

3.4 MDA8 Ozone Time Series

Appendix A contains time series of predicted and observed ozone concentrations for the two CAMx base case simulations at all monitoring sites in New Mexico, with three illustrative examples reproduced below.

Figure 3-4 displays MDA8 ozone time series at the Desert View monitoring site in Dona Ana County in southern New Mexico that is one of the two sites in New Mexico with an 2012-2016 ozone design value (72.0 ppb) above the 70 ppb 2015 ozone NAAQS. The CAMx MDA8 ozone predictions for the revised 2014v2 (blue) and original 2014 (green) base case simulations are almost on top of each other. In general, when they are a little different the revised 2014v2 MDA8 ozone is slightly lower, although that is not always the case as seen in the MDA8 ozone peaks in early June, mid-July and end of August.

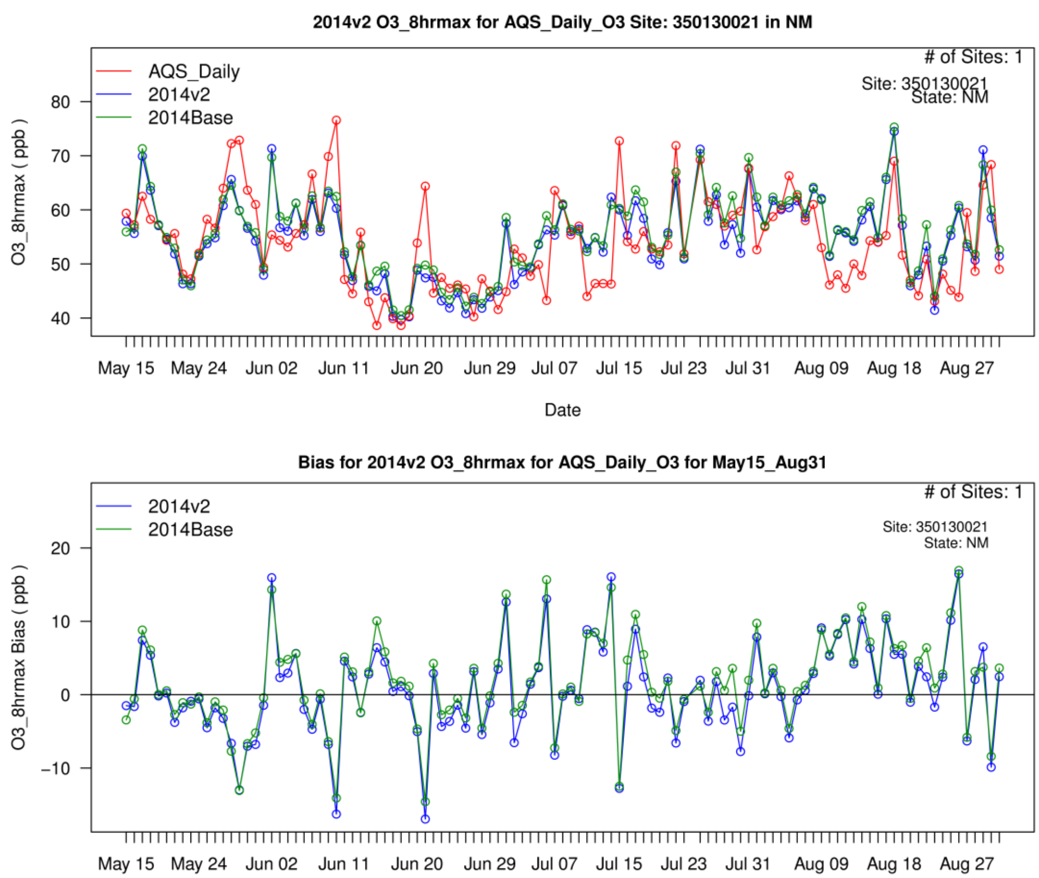

Figure 3-4. Time series of predicted and observed (red) MDA8 ozone at Desert View in Dona Ana County for the CAMx revised 2014v2 (blue) and original 2014 (green) CAMx base case simulations.

The MDA8 ozone time series comparison for the South East Heights monitoring site in Bernalillo County is shown in Figure 3-5. South East Heights is the site with the highest 2012-2016 ozone design value (68.0 ppb) in Bernalillo County. With the exception of a period in early July where the revised 2014v2 base case has a larger underestimation bias compared to the original 2014 base case, the two CAMx base case simulations are predicting nearly identical MDA8 ozone concentrations at this site.

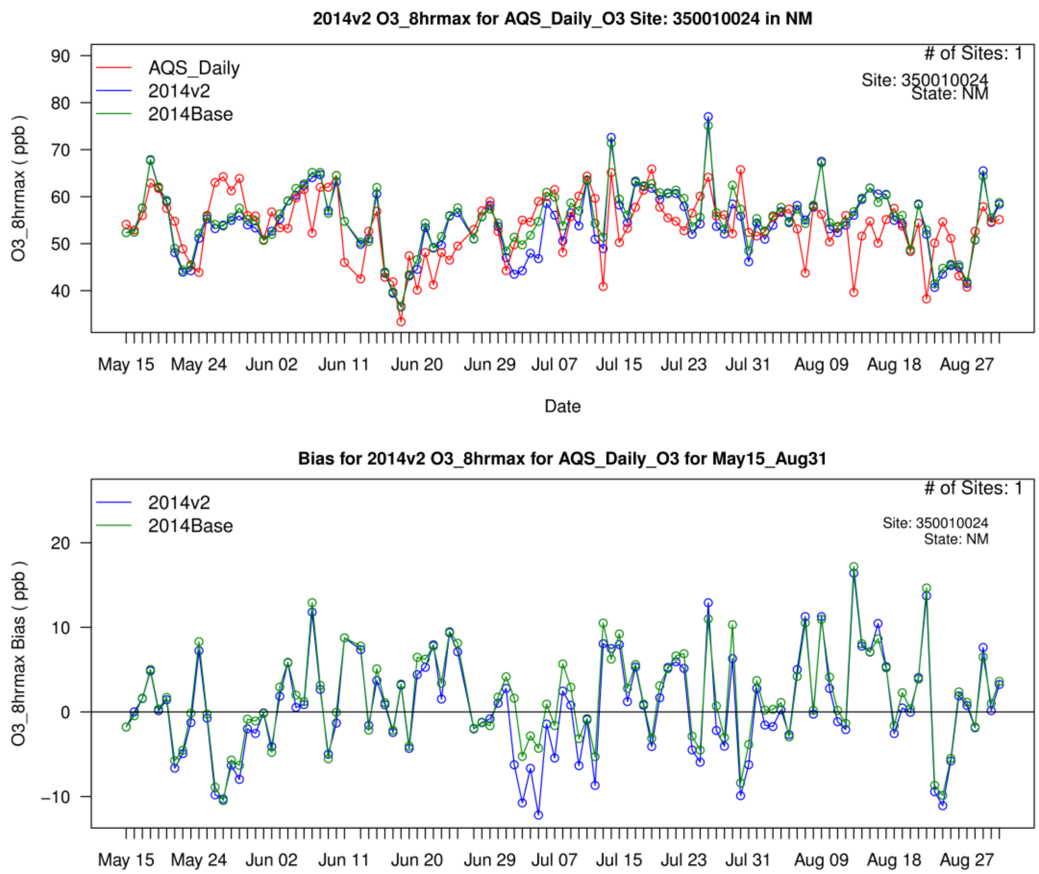

Figure 3-5. Time series of predicted and observed (red) MDA8 ozone at South East Heights in Bernalillo County for the CAMx revised 2014v2 (blue) and original 2014 (green) CAMx base case simulations.

The ozone time series at the Sub Station monitoring site in San Juan County is shown in Figure 3-6. Both CAMx base cases track the observed MDA8 ozone concentrations very well at the Sub Station monitoring site. Most of the time, the predicted MDA8 ozone are on top or nearly on top of each other and when different the revised 2014v2 MDA8 ozone is a little lower than the original CAMx 2014 base case.

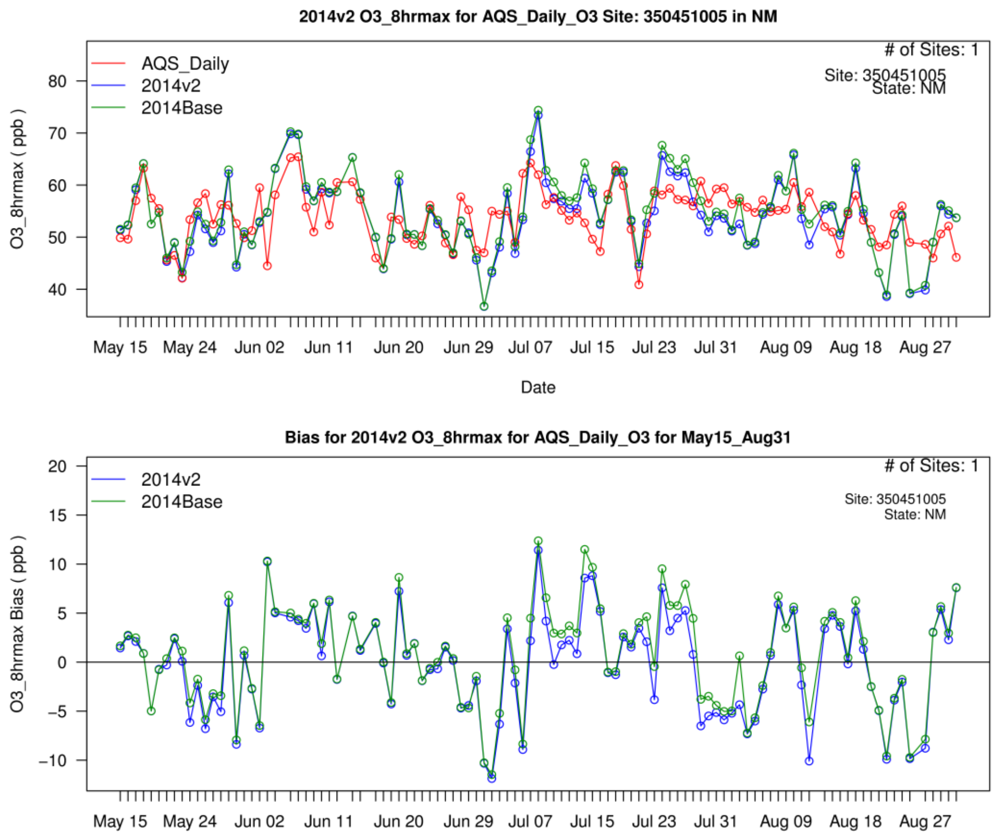

Figure 3-6. Time series of predicted and observed (red) MDA8 ozone at Sub Station in San Juan County for the CAMx revised 2014v2 (blue) and original 2014 (green) CAMx base case simulations.

3.5 Summary Ozone Model Performance Statistics in New Mexico

Ozone model performance statistics were calculated for the northern, central (i.e., Bernalillo County) and southern regions of New Mexico as defined by the site mappings in Table 3-2.

Table 3-2. AQS monitoring sites categorized into subregions of southern New Mexico (orange), Bernalillo County (yellow) and northern New Mexico (blue).

Site ID	Site Name	County	Latitude	Longitude
350130022	Santa Teresa	Dona Ana	31.79	-106.68
350130017	Sunland Park Yard	Dona Ana	31.80	-106.56
350130021	Desert View	Dona Ana	31.80	-106.58
350130008	La Union	Dona Ana	31.93	-106.63
350130020	Chaparral	Dona Ana	32.04	-106.41
350290003	Deming Airport	Luna	32.26	-107.72
350130023	Solano	Dona Ana	32.32	-106.77
350151005	Carlsbad	Eddy	32.38	-104.26
350171003	Chino Copper Smelter	Grant	32.69	-108.13
350250008	Hobbs Jefferson	Lea	32.73	-103.12
350610008	Los Lunas	Valencia	34.81	-106.74
350010029	South Valley	Bernalillo	35.02	-106.66
350010024	South East Heights	Bernalillo	35.06	-106.58
350010032	Westside	Bernalillo	35.06	-106.76
350010023	Del Norte	Bernalillo	35.13	-106.59
350011012	Foot Hills	Bernalillo	35.19	-106.51
350431001	Bernalillo	Sandoval	35.30	-106.55
350490021	Santa Fe Airport	Santa Fe	35.62	-106.08
350390026	Coyote Ranger District	Rio Arriba	36.19	-106.70
350450009	Bloomfield	San Juan	36.74	-107.98
350451005	Sub Station	San Juan	36.80	-108.47
350450018	Navajo Lake	San Juan	36.81	-107.65

Tables 3-3 and 3-4 display the bias and error MDA8 ozone performance statistics with and without the observed MDA8 ozone 60 ppb cutoff for the three New Mexico subregions and the, respectively, original 2014 and revised 2014v2 CAMx base case simulations. The bias and error MDA8 ozone performance statistics are colored green when they achieve the Performance Goal, yellow when they lie between the Performance Goal and Criteria and red when they fail to achieve the Performance Criteria. The CAMx 2014 and 2014v2 base case performance statistics are very good and very similar with the bias for the revised 2014v2 base case being 1-2 percentage points lower than the original 2014 CAMx base case simulation. Using no cutoff, when CAMx has a slight ozone overestimation tendency, the revised 2014v2 exhibits better performance statistics than the original 2014 base case. For example, the bias in the southern New Mexico region in original 2014 base case (5.8%) that fails to achieve the ozone bias Performance Goal due to too high ozone overestimation, achieves the ozone bias Performance Goal in the revised 2014v2 base case (3.5%). On the other hand, when an observed ozone cutoff is used the model tends to underestimate ozone a little so the revised 2014v2 base case ozone model performance degrades a little compared to the original 2014 base case. For example, for the southern New Mexico subregion the original CAMx 2014 base case has a -6.1% NMB that is -7.8% for the revised CAMx 2014v2 base case, both of which fall between the ozone bias Performance Goal and Criteria.

Table 3-3. Bias and error MDA8 ozone performance statistics for the original CAMx 2014 base case and the three subregions of New Mexico calculated with and without using an observed MDA8 ozone 60 ppb cutoff.

	Nocutoff		Withcutoff	
Region	NMB(%)	NME(%)	NMB(%)	NME(%)
North NM	4.3	9.1	0	6.4
Bernalillo	4.3	9.4	-2.8	7.1
South NM	5.8	10.5	-6.1	8.5

Table 3-4. Bias and error MDA8 ozone performance statistics for the revised CAMx 2014v2 base case and the three subregions of New Mexico calculated with and without using an observed MDA8 ozone 60 ppb cutoff.

	Nocutoff		Withcutoff	
Region	NMB(%)	NME(%)	NMB(%)	NME(%)
North NM	2.6	8.6	-1.0	6.6
Bernalillo	2.6	9.6	-4.3	8.5
South NM	3.5	10.2	-7.8	9.9

Tables 3-5 and 3-6 contain the bias performance statistics with and without a cutoff for each monitoring site in New Mexico and the, respectively, original CAMx 2014 and revised CAMx 2014v2 base case simulations. When not using the observed ozone cutoff, the original 2014 base case has 59% of the sites achieving the ozone bias Performance Goal with 36% of the sites falling between the Performance Goal and Criteria and one site failing to achieve the ozone bias Performance Criteria due to a 17.4% overestimation bias. The revised 2014v2 base case bias with no cutoff has 68% of the sites achieving the Performance Goal, 27% falling between the Performance Goal and Criteria and one site right at (15.0%) the Performance Criteria.

When an observed ozone cutoff is used, the number of sites achieving the ozone bias Performance Goal is flipped between the two base cases with 68% of the sites achieving the Performance Goal for the original 2014 base case and 59% of the sites achieving the Performance Goal for the revised 2014v2 base case with the remainder of the sites falling between the ozone bias Performance Goal and Criteria.

Table 3-5. Bias MDA8 ozone performance statistics with and without an observed ozone cutoff for each site in New Mexico and the original CAMx 2014 base case simulation.

2014Base (with MEGAN)			
SiteID	**SiteNames**	**NMB No Cutoff**	**NMB 60 ppb Cutoff**
350010023	Del Norte	1.7	-3.9
350010024	South East Heights	3.1	-2.4
350010029	South Valley	3.1	-2.8
350010032	Westside	1.1	-3.4
350011012	Foot Hills	13.6	2.0
350130008	La Union	17.4	-1.6
350130017	Sunland Park Yard	9.0	-3.6
350130020	Chaparral	4.8	-4.7
350130021	Desert View	3.2	-5.1
350130022	Santa Teresa	8.2	0.1
350130023	Solano	6.1	-6.5
350151005	Carlsbad	-1.1	-12.3
350171003	Chino Copper	9.1	-1.0
350250008	Hobbs Jefferson	2.1	-9.9
350290003	Deming Airport	6.2	-5.0
350390026	Coyote Ranger	3.3	-5.4
350431001	Bernalillo	8.1	3.8
350450009	Bloomfield	7.2	2.5
350450018	Navajo Lake	2.2	-0.6
350451005	Sub Station	1.4	3.3
350490021	Santa Fe Airport	3.8	-1.7
350610008	Los Lunas	0.8	-6.5

Table 3-6. Bias MDA8 ozone performance statistics with and without an observed ozone cutoff for each site in New Mexico and the revised CAMx 2014v2 base case simulation.

2014v2 (with BEIS)			
SiteID	**SiteNames**	**NMB No Cutoff**	**NMB 60 ppb Cutoff**
350010023	Del Norte	0.5	-4.9
350010024	South East Heights	1.3	-3.6
350010029	South Valley	0.9	-4.4
350010032	Westside	-1.0	-5.4
350011012	Foot Hills	11.9	0.8
350130008	La Union	15.0	-3.0
350130017	Sunland Park Yard	7.4	-4.1
350130020	Chaparral	2.8	-5.8
350130021	Desert View	1.4	-6.3
350130022	Santa Teresa	5.8	-1.8
350130023	Solano	3.9	-8.2
350151005	Carlsbad	-4.3	-14.5
350171003	Chino Copper	7.0	-1.8
350250008	Hobbs Jefferson	-1.2	-12.6
350290003	Deming Airport	3.8	-8.6
350390026	Coyote Ranger	1.2	-5.6
350431001	Bernalillo	6.4	3.3
350450009	Bloomfield	6.0	1.7
350450018	Navajo Lake	0.5	-3.6
350451005	Sub Station	-0.1	2.2
350490021	Santa Fe Airport	1.5	-2.5
350610008	Los Lunas	-1.7	-9.0

4. CONCLUSIONS

The CAMx revised 2014v2 base case produced nearly identical ozone model performance as the CAMx original base case so the two base cases share the same salient features. Thus, the discussion of model performance and summary of the CAMx model performance from the original 2014 base case report (Ramboll and WESTAR, 2020c) also applies to the revised 2014v2 base case with the final conclusion reproduced below.

In conclusion, the NM OAI Study CAMx revised 2014v2 and original 2014 base case ozone model performance within New Mexico is as good or better than most recent PGM applications (e.g., WRAP-WAQS, EPA 2016v1 and Denver ozone SIP) and appears to be a reliable PGM modeling platform for evaluating emission reduction strategies for reducing ozone concentrations in New Mexico.

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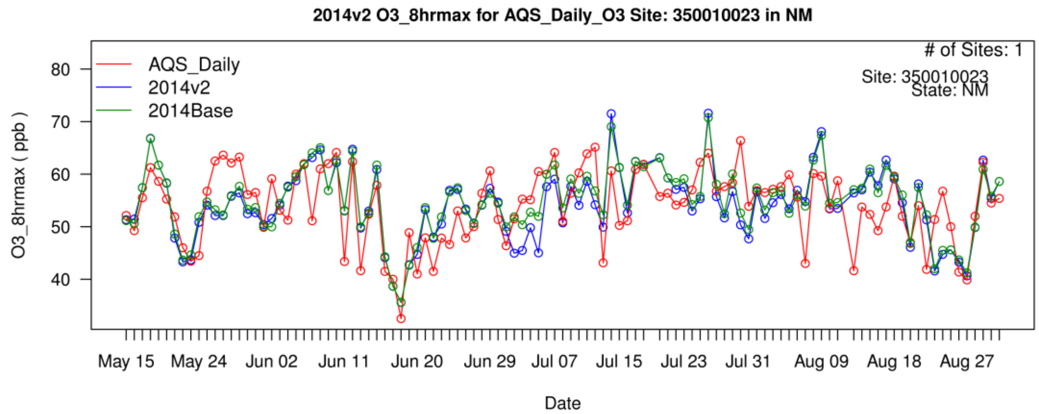
Appendix A

Time Series of Predicted and Observed (red) MDA8 Ozone Concentrations at Sites in New Mexico for the Original 2014 (green) and Revised 2014v2 (blue) CAMx Base Case Simulations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2014v2
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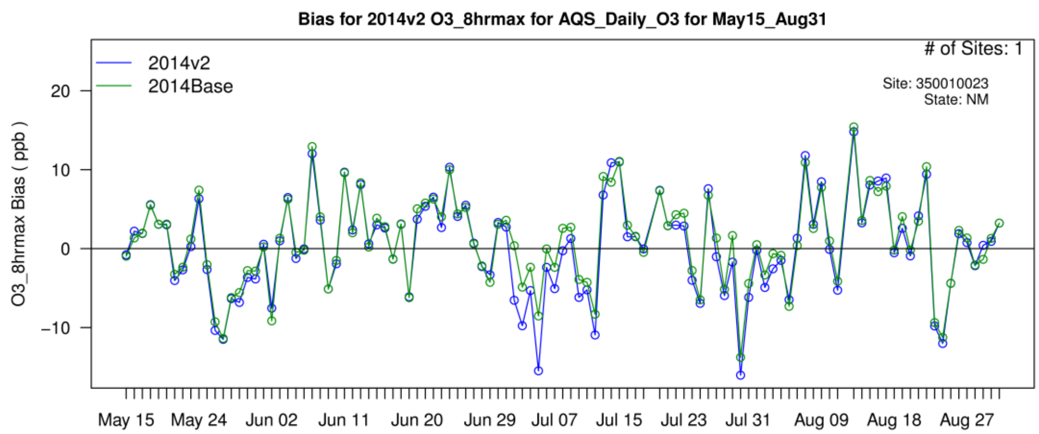
O3_8hrmax (ppb)
80
70
60
50
40
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27
Date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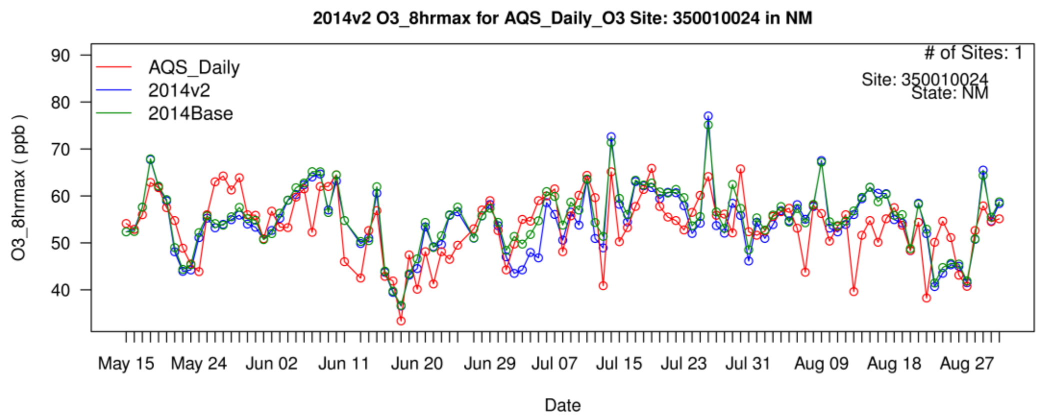
20
10
0
−10
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27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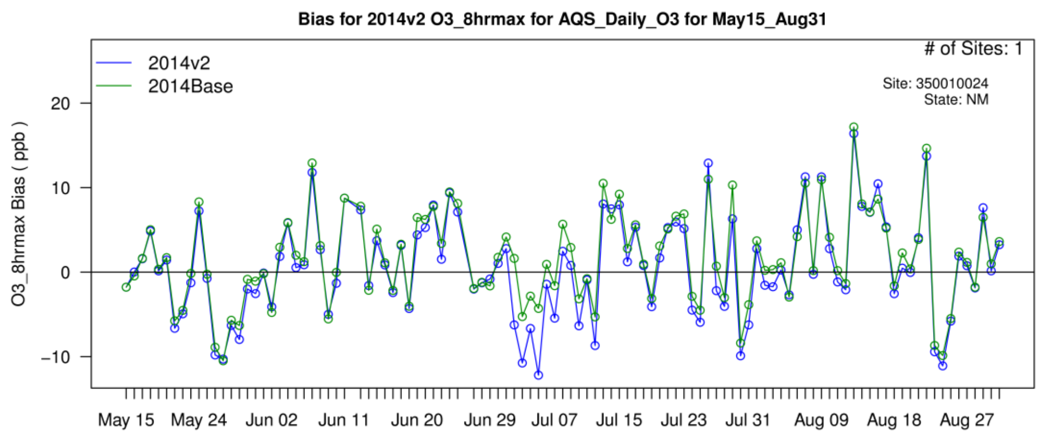
O3_8hrmax (ppb)
Date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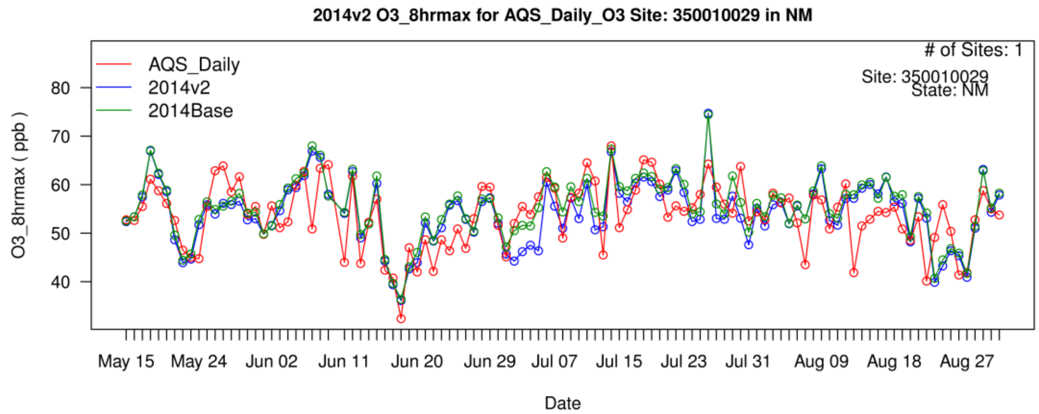
O3_8hrmax Bias (ppb)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2014v2
2014Base
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O3_8hrmax (ppb)
80
70
60
50
40
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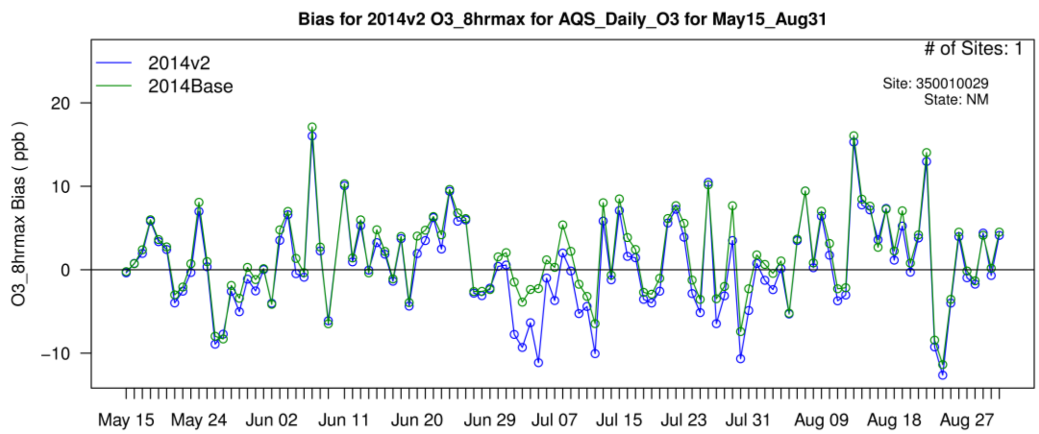
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27
Date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10
0
−10
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
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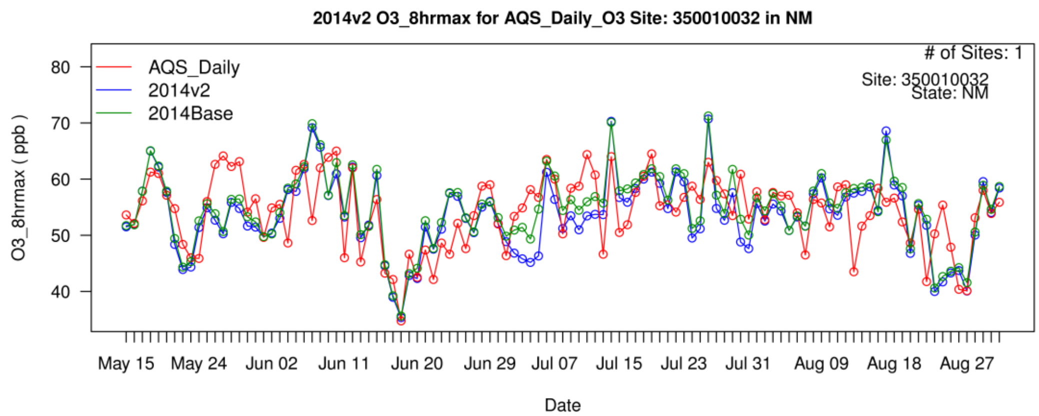
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27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O3_8hrmax (ppb)
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May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
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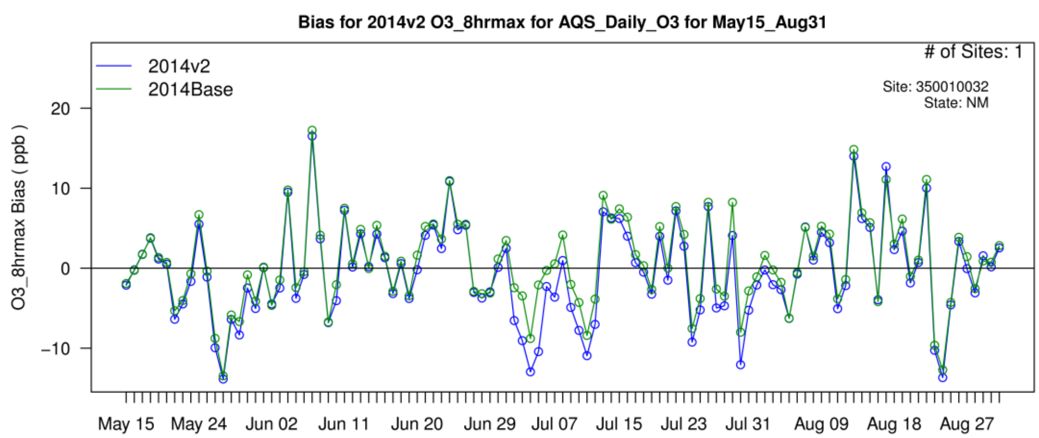
Aug 09
Aug 18
Aug 27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Jun 11
Jun 20
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Jul 15
Jul 23
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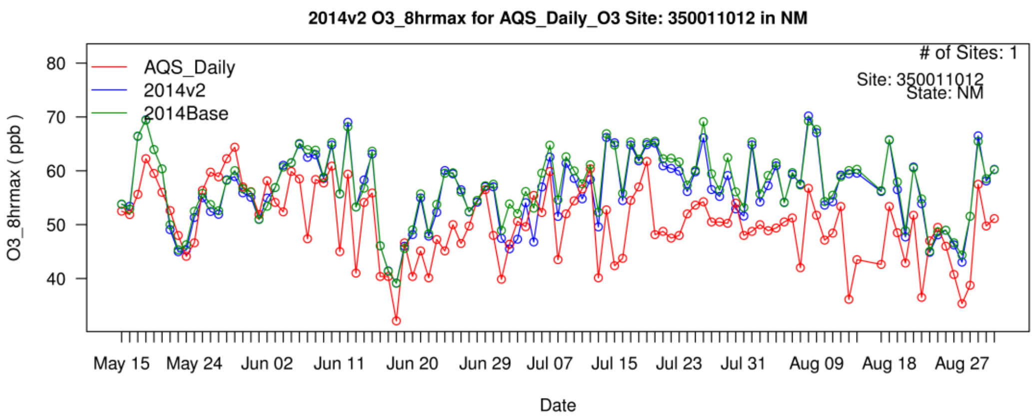
Aug 18
Aug 27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70
60
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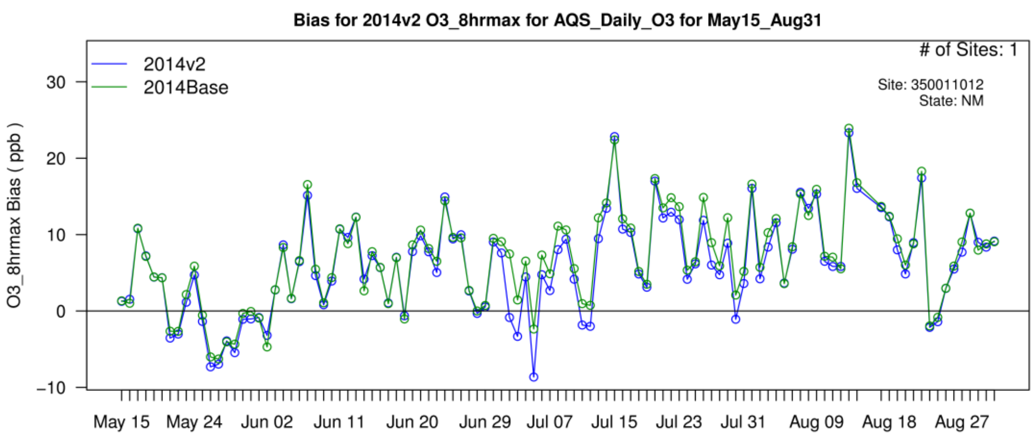
Date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20
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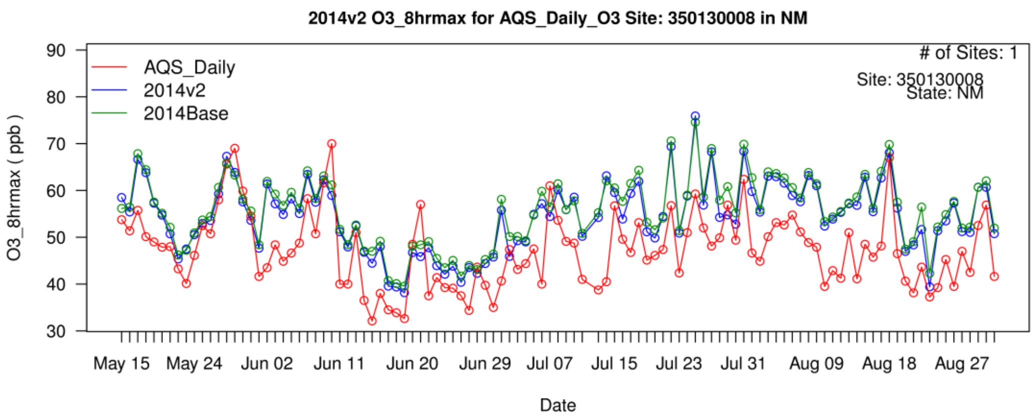
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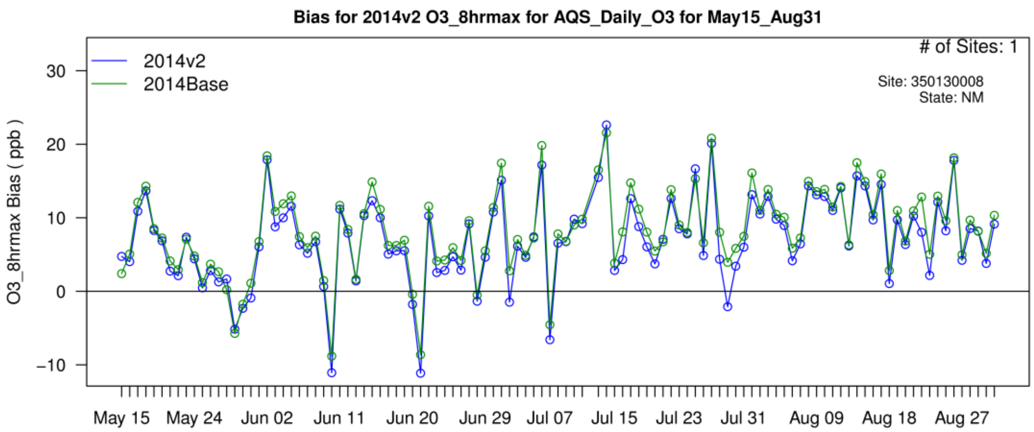
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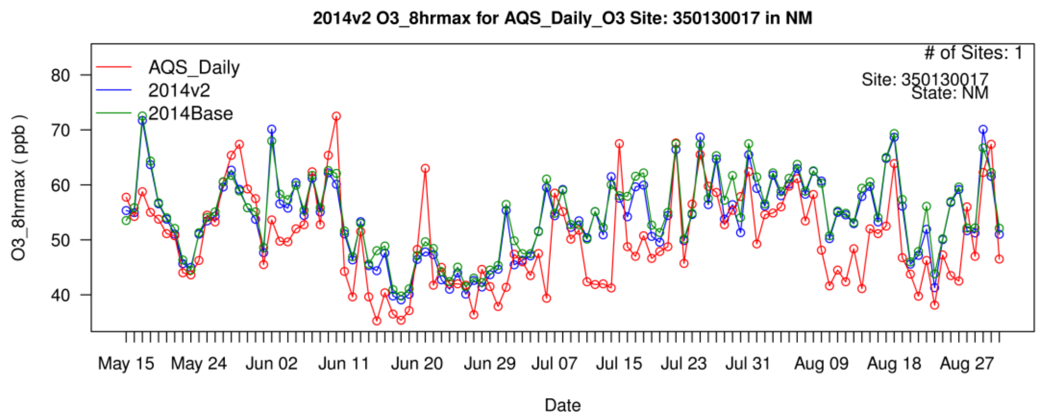
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O3_8hrmax (ppb)
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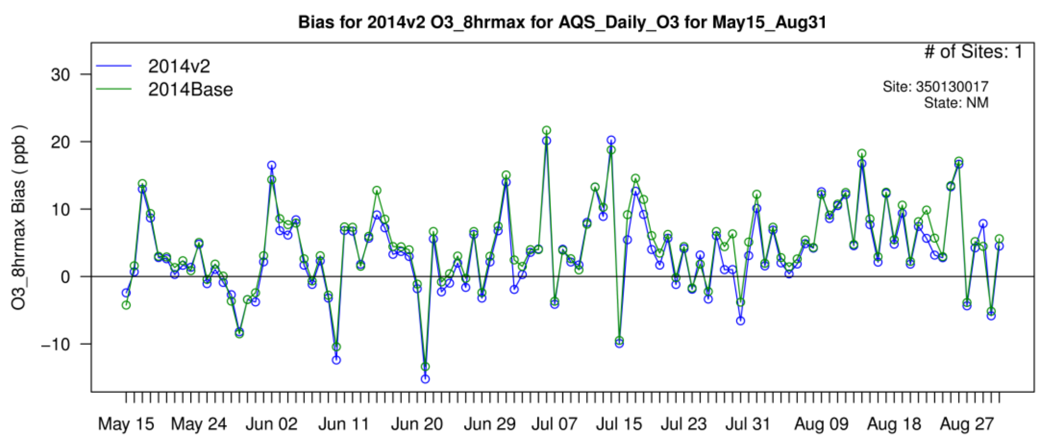
Aug 27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Jun 02
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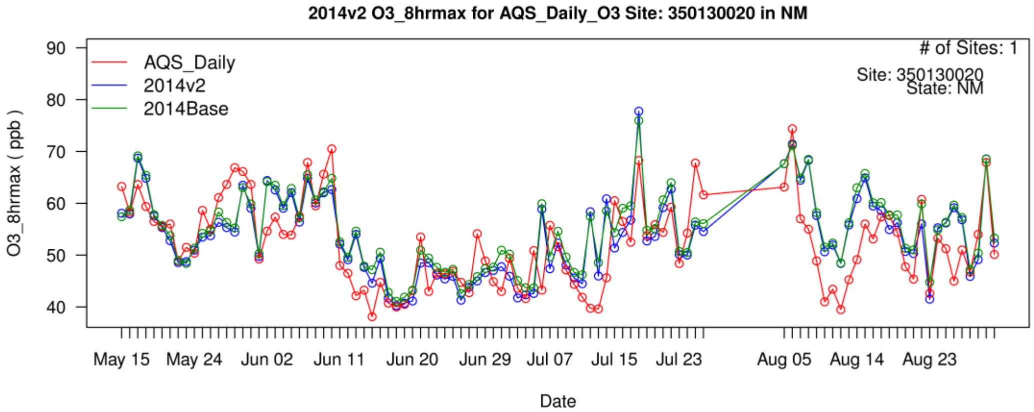
Aug 27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80
70
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Jul 15
Jul 23
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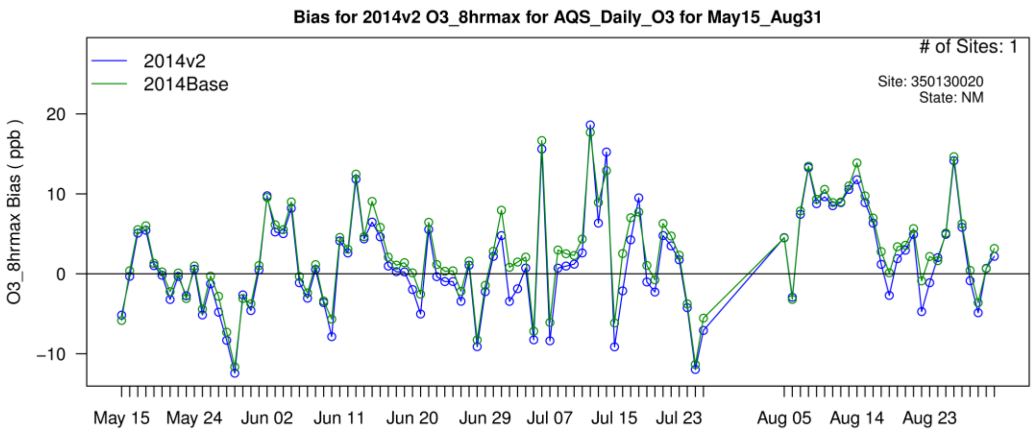
Aug 14
Aug 23
Date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May 24
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Jul 07
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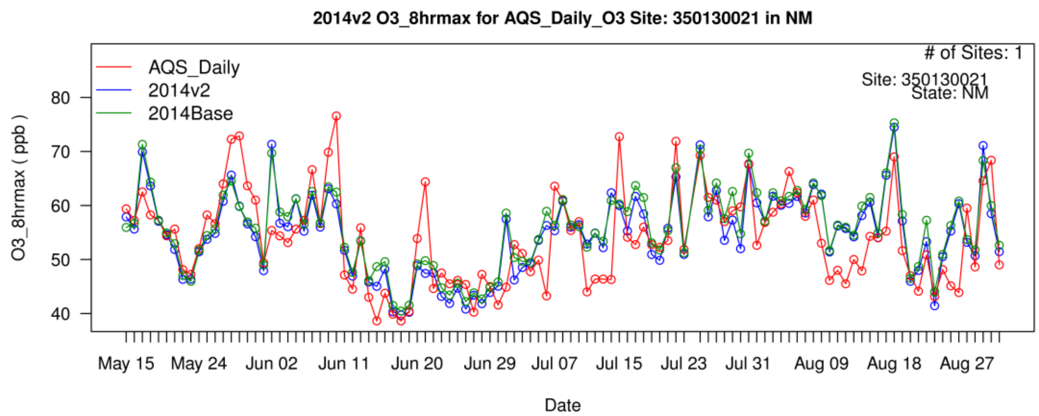
Jul 23
Aug 05
Aug 14
Aug 23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AQS_Daily
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2014Base
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O3_8hrmax (ppb)
80
70
60
50
40
May 15
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Jul 23
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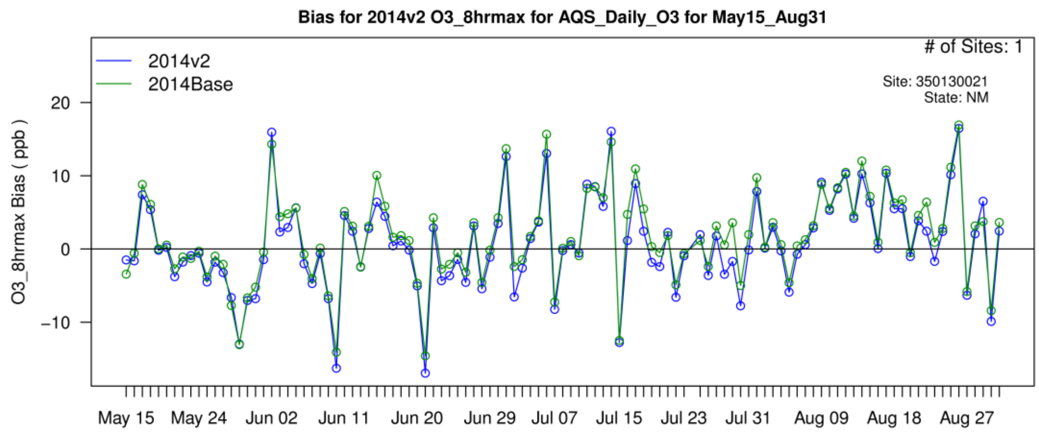
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20
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−10
May 15
May 24
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Jul 15
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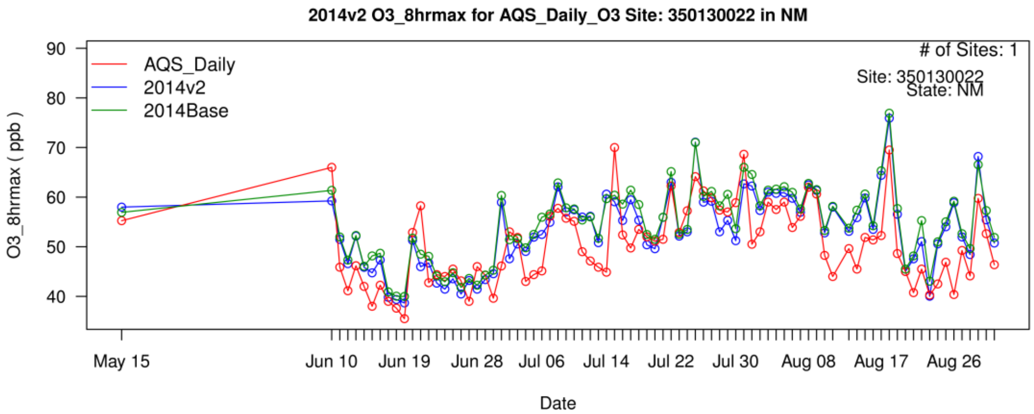
Aug 27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2014v2
2014Base
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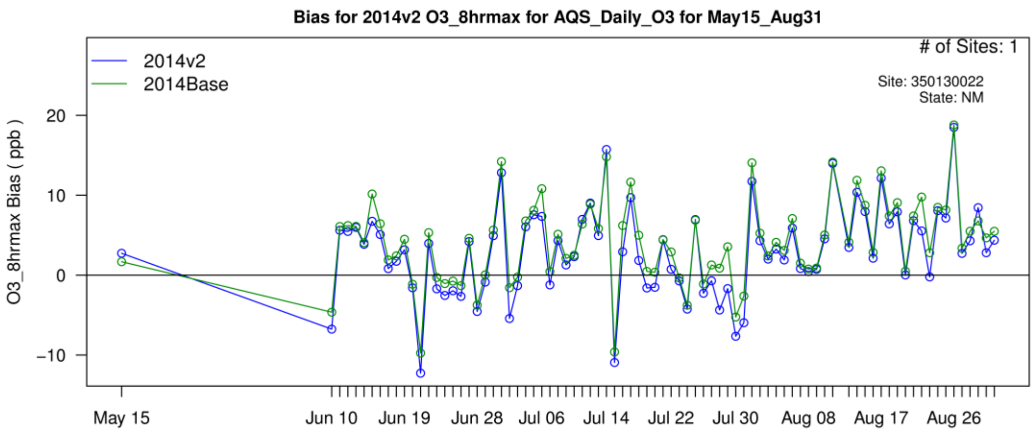
Jun 10
Jun 19
Jun 28
Jul 06
Jul 14
Jul 22
Jul 30
Aug 08
Aug 17
Aug 26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2014v2
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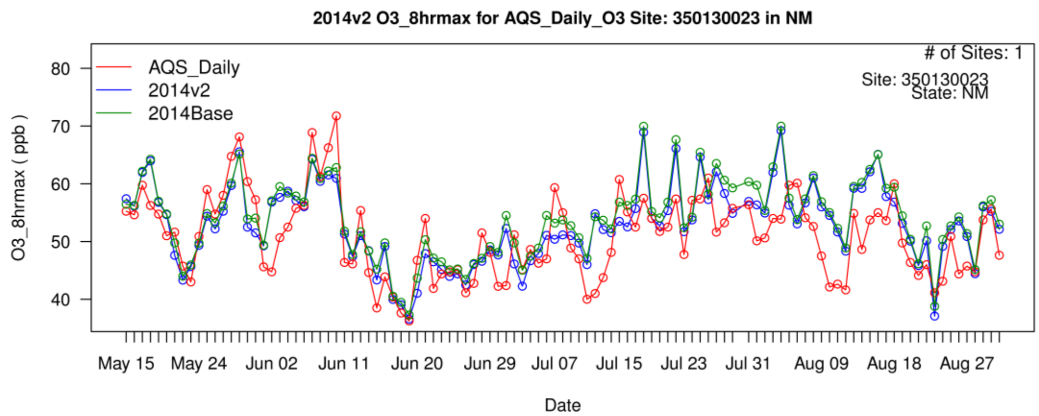
Aug 17
Aug 26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AQS_Daily
2014v2
2014Base
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O3_8hrmax (ppb)
80
70
60
50
40
May 15
May 24
Jun 02
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Jul 23
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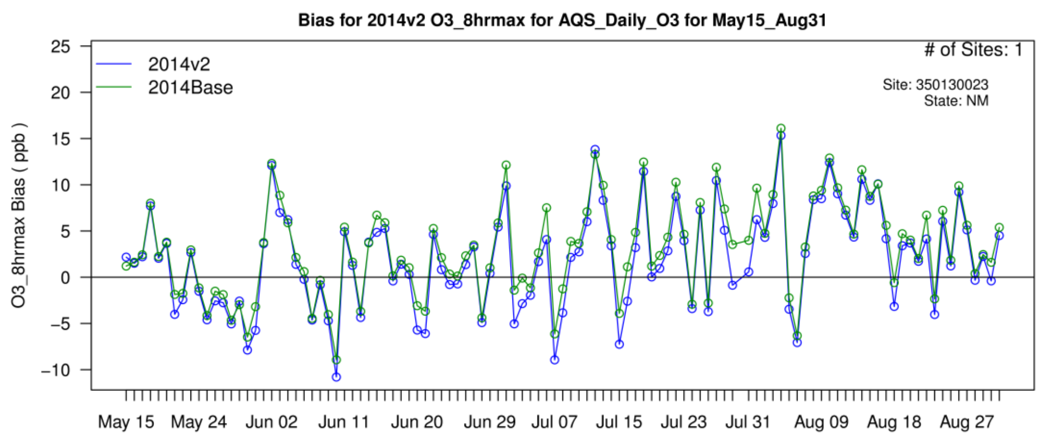
Aug 27
Date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2014Base
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20
15
10
5
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May 24
Jun 02
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Jul 15
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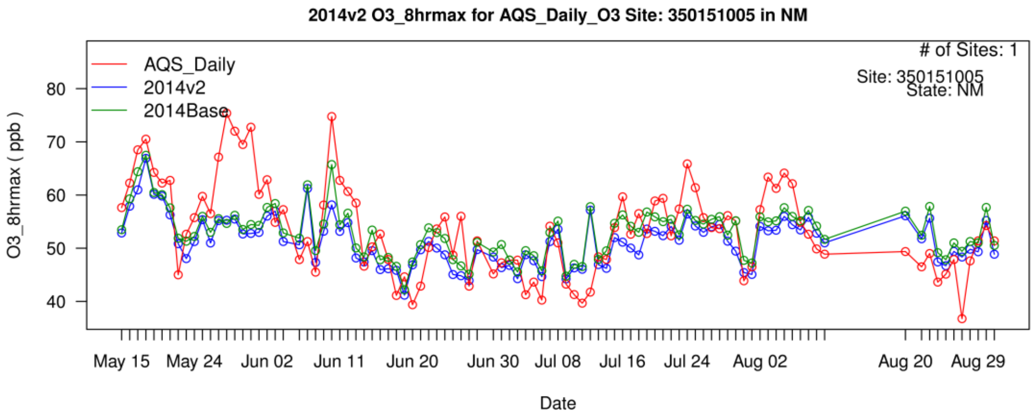
Aug 18
Aug 27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# of Sites: 1
Site: 350151005
State: NM
AQS_Daily
2014v2
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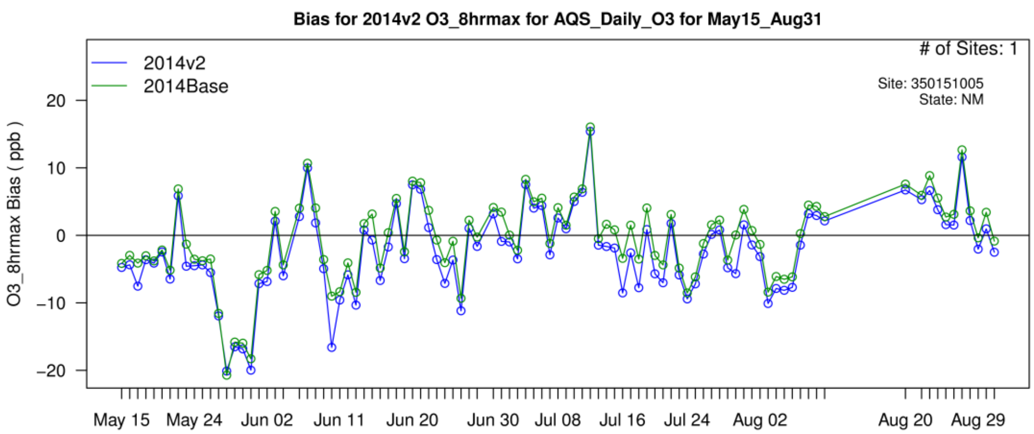
Aug 02
Aug 20
Aug 29
Date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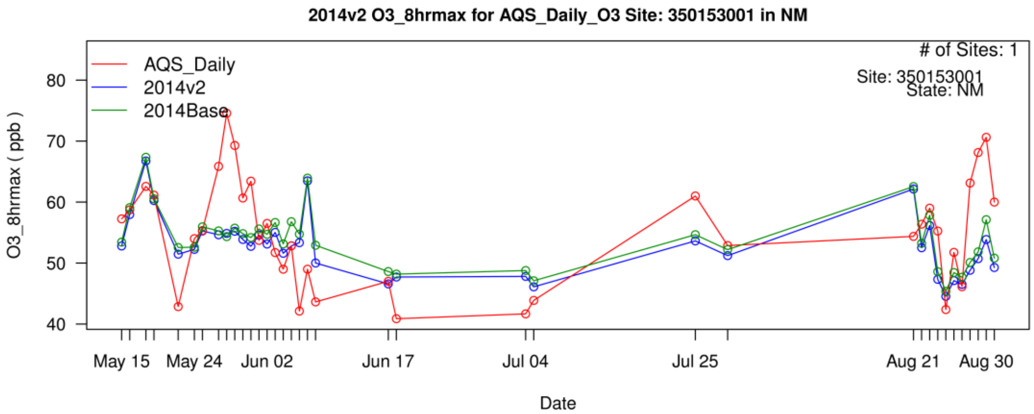
State: NM
2014v2
2014Base
O3_8hrmax Bias (ppb)
−20
−10
0
10
20
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 30
Jul 08
Jul 16
Jul 24
Aug 02
Aug 20
Aug 29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2014v2
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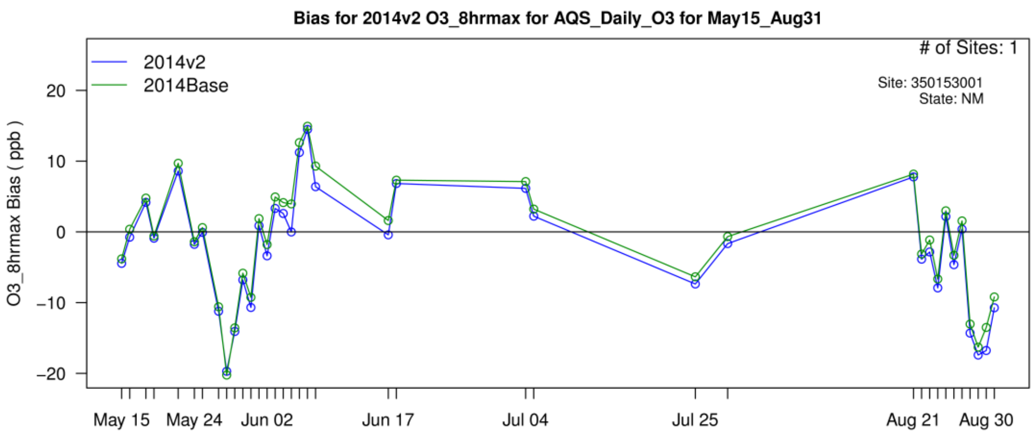
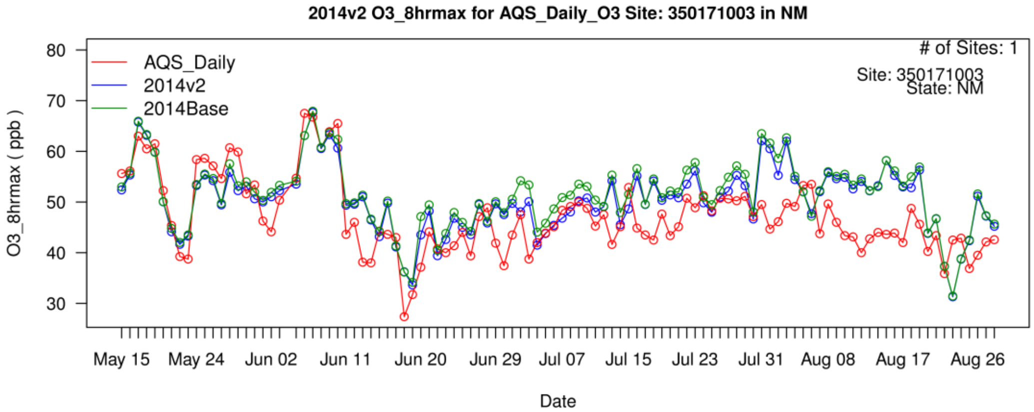
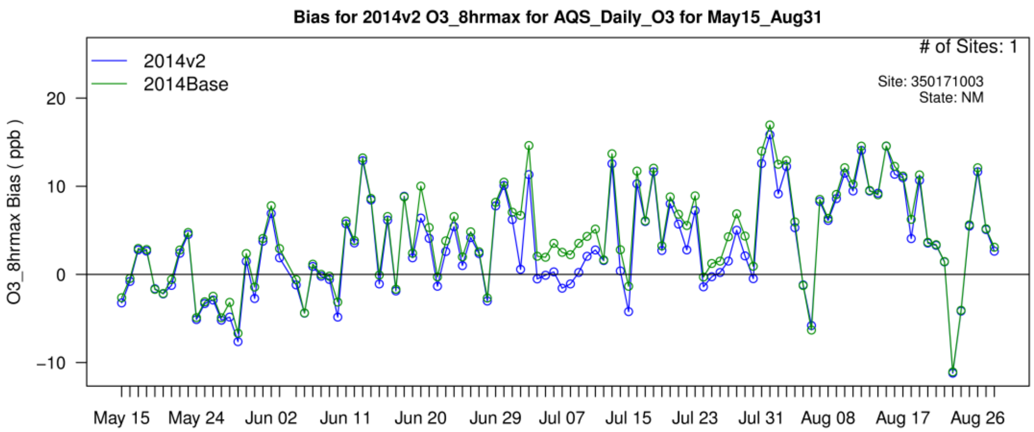
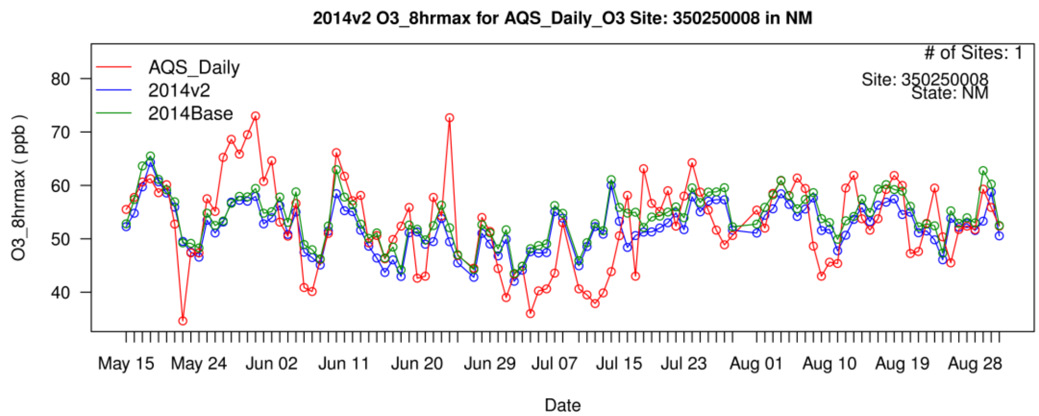
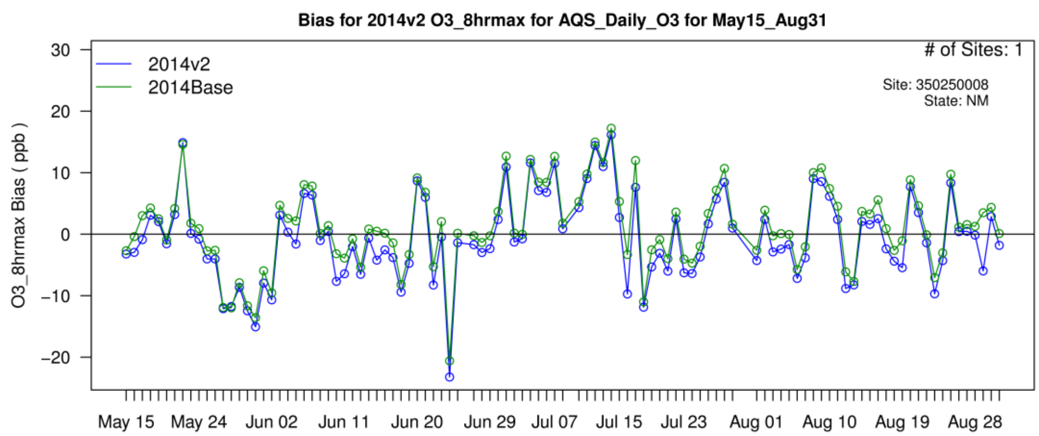
State: NM
O3_8hrmax (ppb)
80
70
60
50
40
May 15
May 24
Jun 02
Jun 17
Jul 04
Jul 25
Aug 21
Aug 30
Date

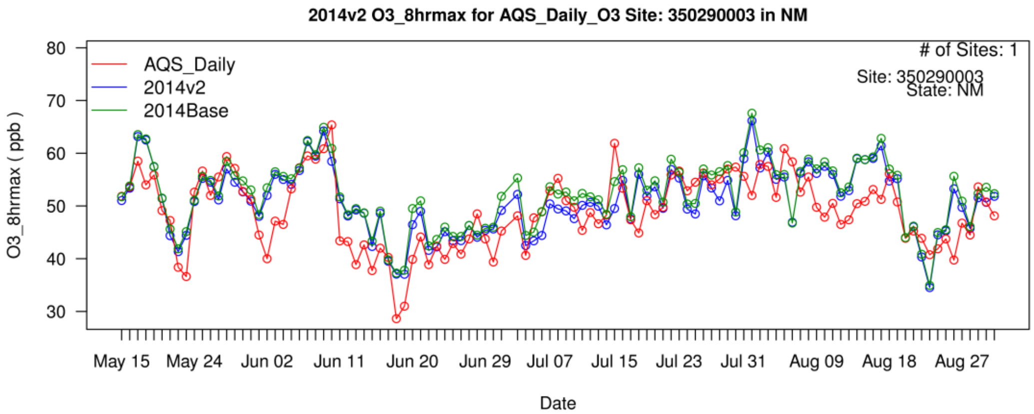

Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350153001
State: NM
O3_8hrmax Bias (ppb)
20
10
0
−10
−20
May 15
May 24
Jun 02
Jun 17
Jul 04
Jul 25
Aug 21
Aug 30

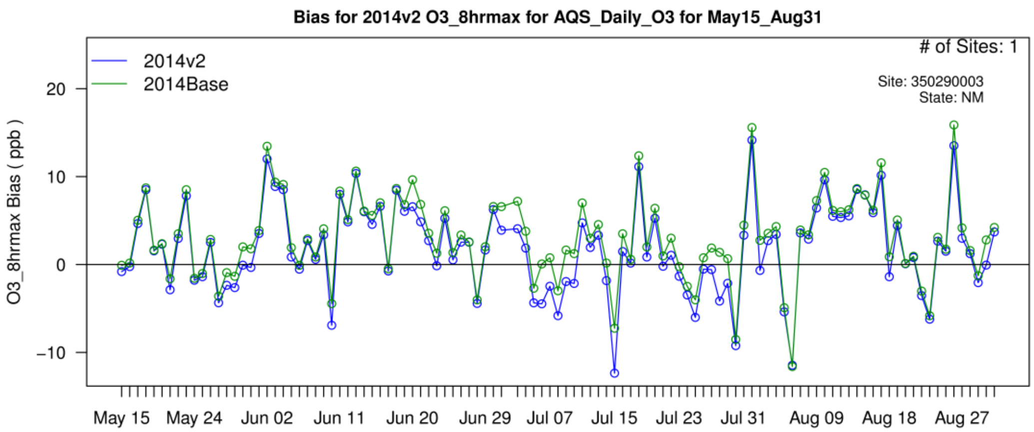

2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350171003 in NM
AQS_Daily
2014v2
2014Base
# of Sites: 1
Site: 350171003
State: NM
O3_8hrmax (ppb)
Date
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 08
Aug 17
Aug 26

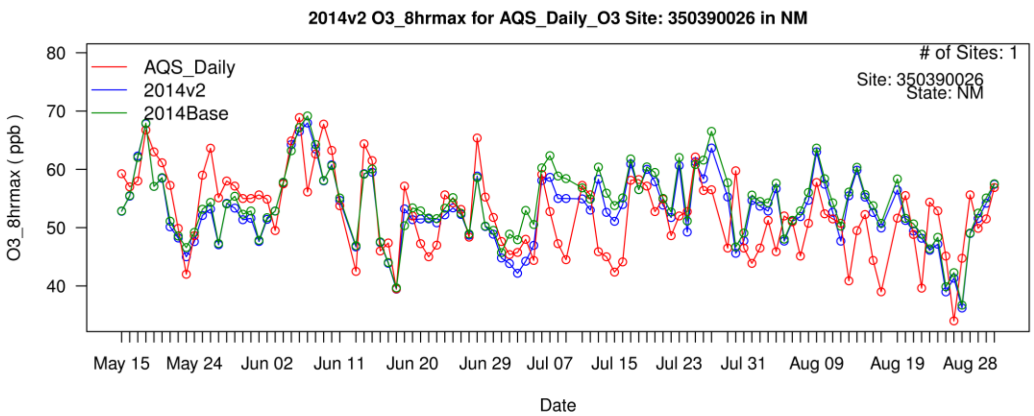

Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350171003
State: NM
O3_8hrmax Bias (ppb)
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 08
Aug 17
Aug 26

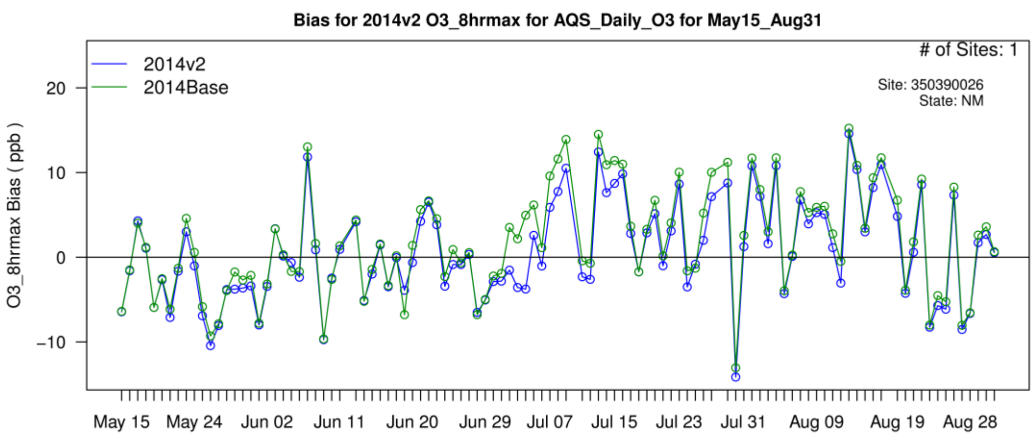

2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350250008 in NM
AQS_Daily
2014v2
2014Base
# of Sites: 1
Site: 350250008
State: NM
O3_8hrmax (ppb)
80
70
60
50
40
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Aug 01
Aug 10
Aug 19
Aug 28
Date


Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350250008
State: NM
O3_8hrmax Bias (ppb)
30
20
10
0
−10
−20
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Aug 01
Aug 10
Aug 19
Aug 28


2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350290003 in NM
# of Sites: 1
Site: 350290003
State: NM
AQS_Daily
2014v2
2014Base
O3_8hrmax (ppb)
80
70
60
50
40
30
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27
Date


Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
# of Sites: 1
Site: 350290003
State: NM
2014v2
2014Base
O3_8hrmax Bias (ppb)
20
10
0
−10
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27


2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350390026 in NM
AQS_Daily
2014v2
2014Base
# of Sites: 1
Site: 350390026
State: NM
O3_8hrmax (ppb)
80
70
60
50
40
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 19
Aug 28
Date


Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350390026
State: NM
O3_8hrmax Bias (ppb)
20
10
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−10
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
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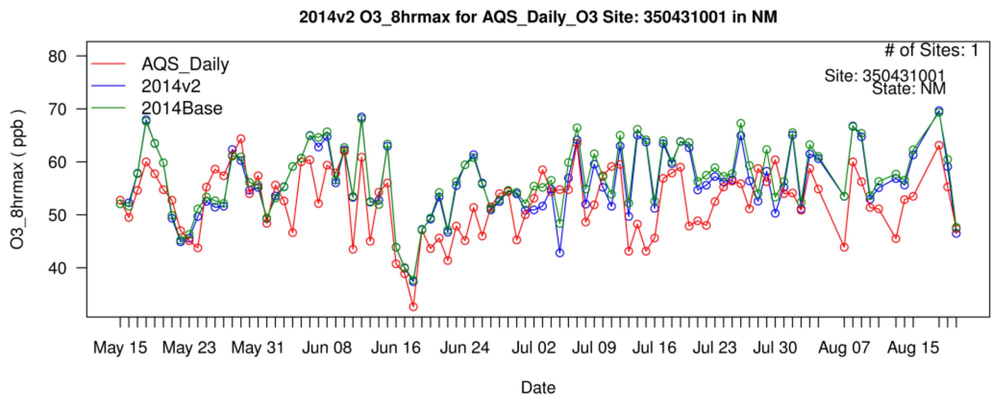
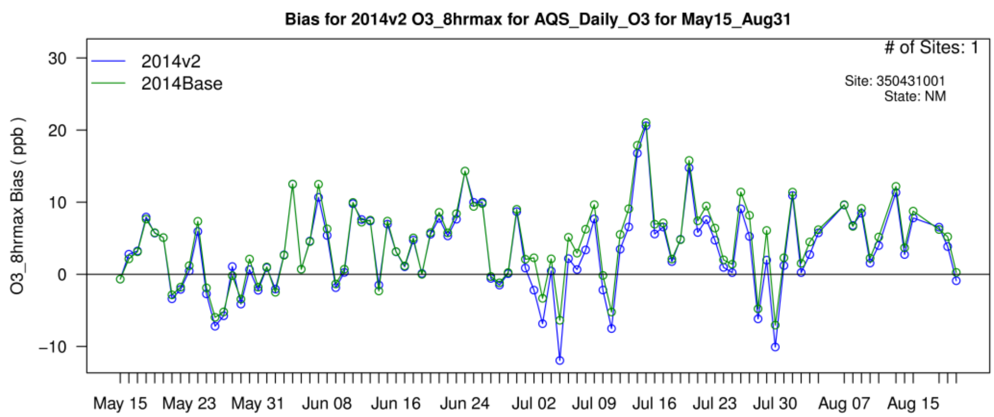
Jul 15
Jul 23
Jul 31
Aug 09
Aug 19
Aug 28


2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350431001 in NM
AQS_Daily
2014v2
2014Base
# of Sites: 1
Site: 350431001
State: NM
O3_8hrmax (ppb)
Date
May 15
May 23
May 31
Jun 08
Jun 16
Jun 24
Jul 02
Jul 09
Jul 16
Jul 23
Jul 30
Aug 07
Aug 15


Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350431001
State: NM
O3_8hrmax Bias (ppb)
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May 23
May 31
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Jun 24
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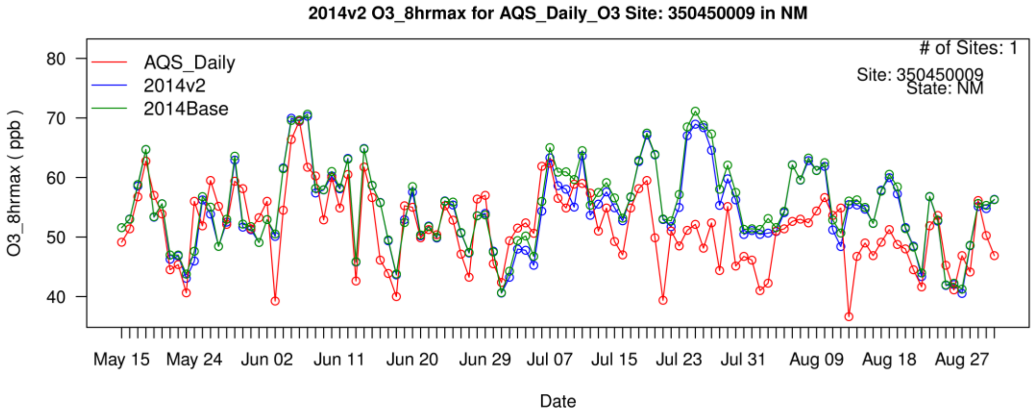
Jul 09
Jul 16
Jul 23
Jul 30
Aug 07
Aug 15


2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350450009 in NM
AQS_Daily
2014v2
2014Base
# of Sites: 1
Site: 350450009
State: NM
O3_8hrmax (ppb)
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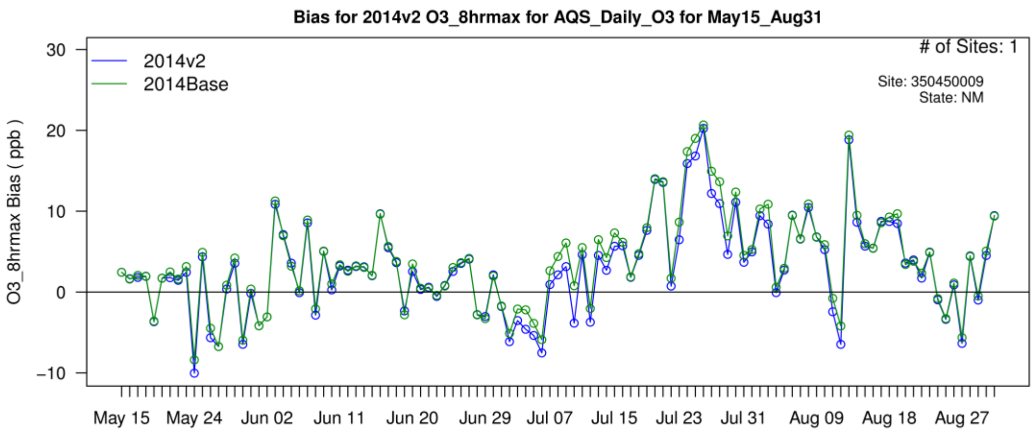
Jul 31
Aug 09
Aug 18
Aug 27


Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350450009
State: NM
O3_8hrmax Bias (ppb)
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May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
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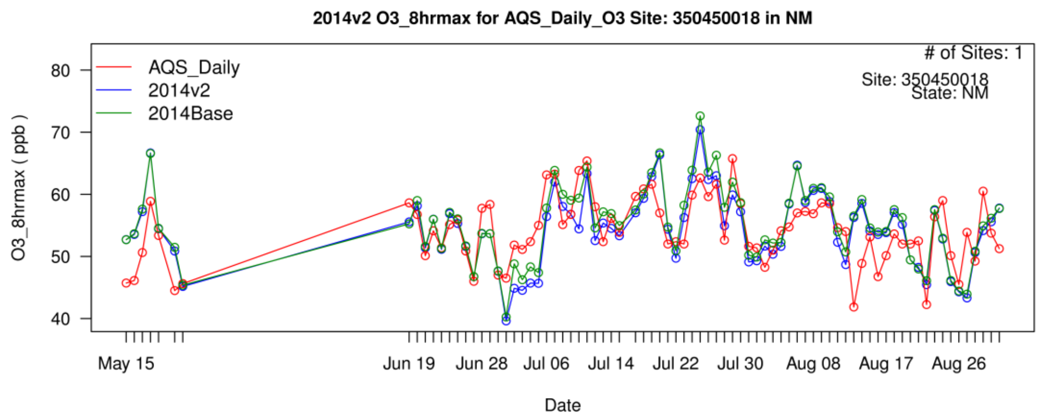
Aug 18
Aug 27


2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350450018 in NM
AQS_Daily
2014v2
2014Base
# of Sites: 1
Site: 350450018
State: NM
O3_8hrmax (ppb)
80
70
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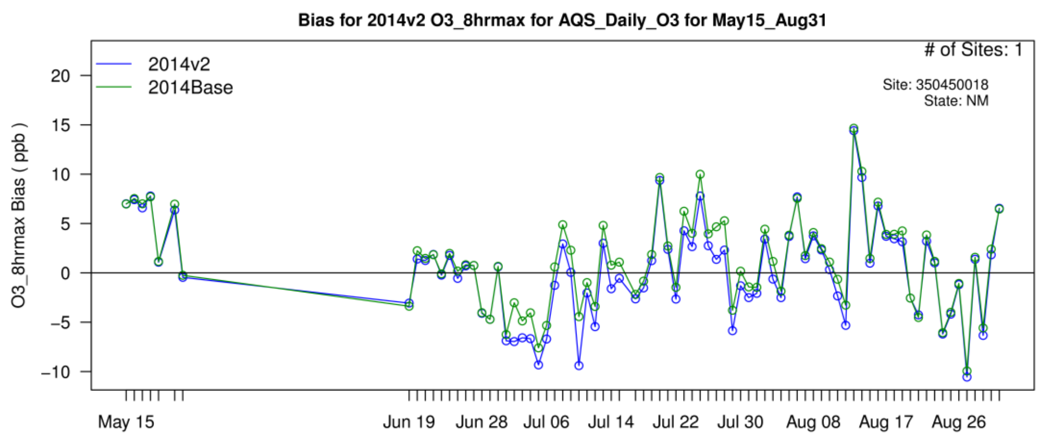
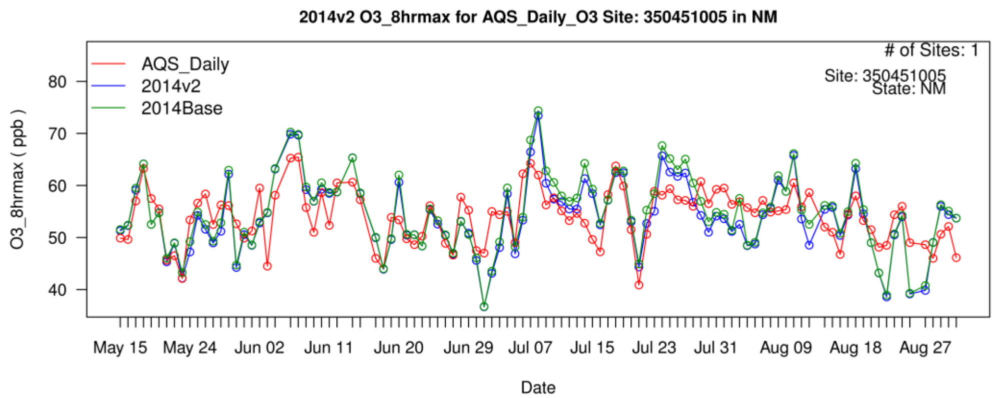
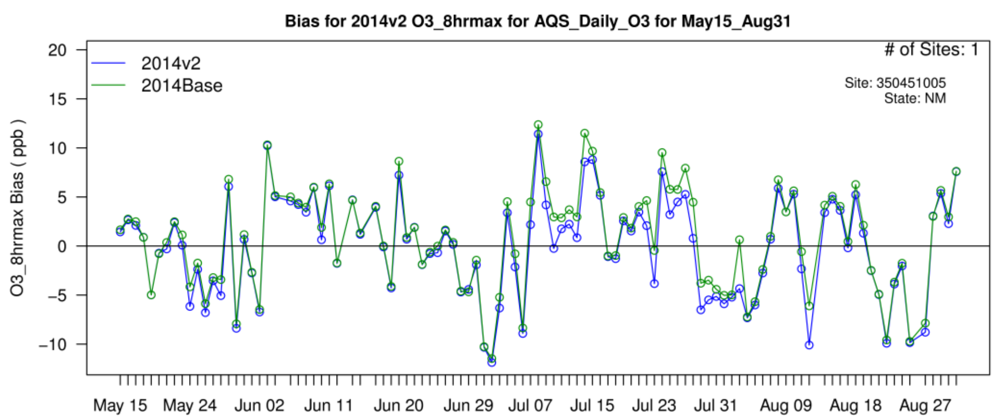
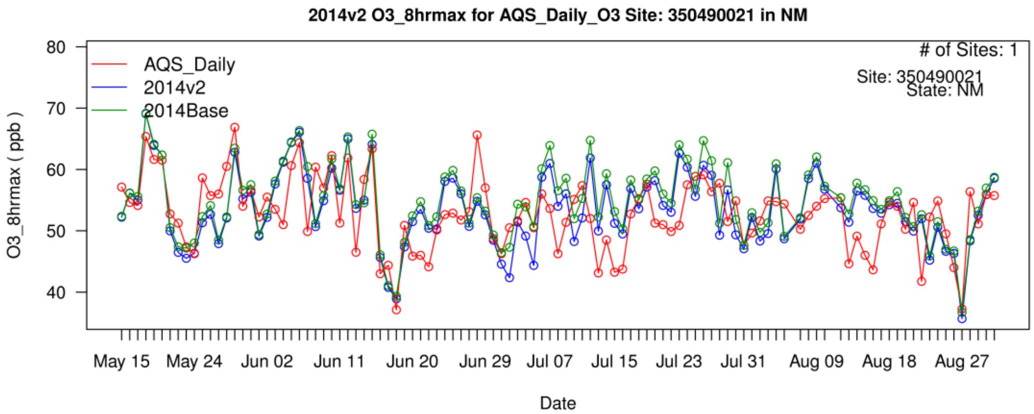
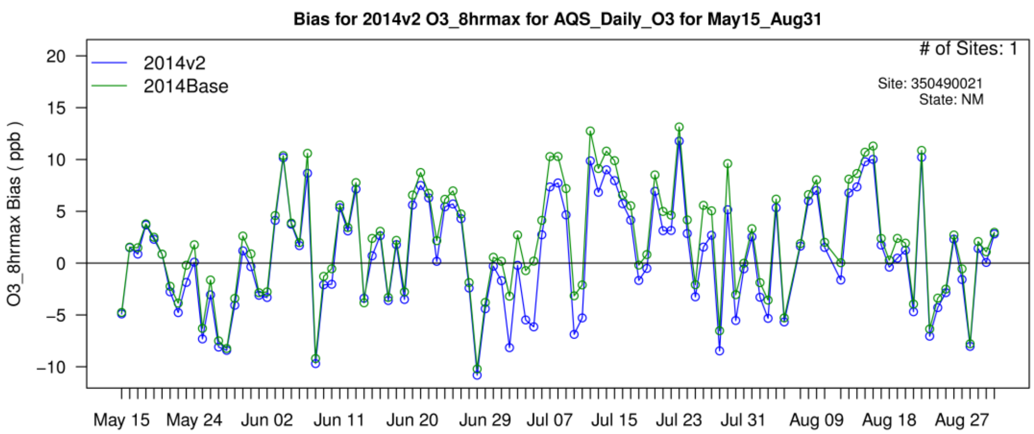
50
40
May 15
Jun 19
Jun 28
Jul 06
Jul 14
Jul 22
Jul 30
Aug 08
Aug 17
Aug 26
Date


Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350450018
State: NM
O3_8hrmax Bias (ppb)
20
15
10
5
0
−5
−10
May 15
Jun 19
Jun 28
Jul 06
Jul 14
Jul 22
Jul 30
Aug 08
Aug 17
Aug 26

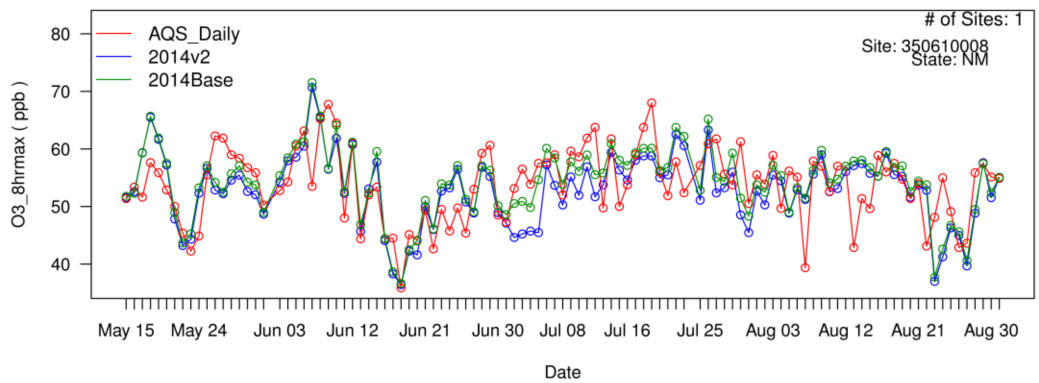

2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350451005 in NM
AQS_Daily
2014v2
2014Base
# of Sites: 1
Site: 350451005
State: NM
O3_8hrmax (ppb)
80
70
60
50
40
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27
Date


Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350451005
State: NM
O3_8hrmax Bias (ppb)
20
15
10
5
0
−5
−10
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27


2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350490021 in NM
AQS_Daily
2014v2
2014Base
# of Sites: 1
Site: 350490021
State: NM
O3_8hrmax (ppb)
80
70
60
50
40
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27
Date


Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31
2014v2
2014Base
# of Sites: 1
Site: 350490021
State: NM
O3_8hrmax Bias (ppb)
20
15
10
5
0
−5
−10
May 15
May 24
Jun 02
Jun 11
Jun 20
Jun 29
Jul 07
Jul 15
Jul 23
Jul 31
Aug 09
Aug 18
Aug 27

2014v2 O3_8hrmax for AQS_Daily_O3 Site: 350610008 in NM



Bias for 2014v2 O3_8hrmax for AQS_Daily_O3 for May15_Aug31