This Appendix was compiled from information provided by ARB's Planning and Technical Support Division.

For additional information, please refer to the references on pages F-129 thru F-135, which provides additional website links and supporting documentation available from the California Air Resources Board.

Appendix F

Photochemical Modeling Support Documents

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Appendix F: Photochemical Modeling Support Documents

F.1 INTRODUCTION

For District review purposes, this document summarizes modeling-based calculation procedures to estimate future year design value and future year carrying capacity. The first section of this document describes the approach utilized while the second section presents the associated results using the model simulations presented in the Volume 1 document, which describes model performance results for 8-hour ozone model simulations of the July 1999 and July-August, 2000 episodes.

As indicated in the Volume 1 documentation and repeated here, sub-regional model performance was conducted for 5 days per episode (10 days total) for each of the 15 sub-regions (Figure F-1). Table F-1 summarizes the number of modeled days that passed the model performance criteria. With the exception of the North Coast (0 days), 2-9 days of the possible 10 days per sub-region are available for consideration in calculating future year design values.

Table F-1 Combined Number of Available Days* Per Sub-region Under 8-hour Metrics

Region Name	July 1999	July-Aug 2000	Total
North Coast	0	0	**0**
BAAQMD	1	1	**2**
MBAQMD	1	1	**2**
Sacramento Valley North	4	1	**5**
Sacramento Region	5	0	**5**
SJVAPCD Central	4	3	**7**
SJVAPCD Kern	4	5	**9**
SJVAPCD North	3	1	**4**
Sierra Nevada Central	2	4	**6**
SJVAPCD Above 3000 ft	3	0	**3**
South Central Coast	3	4	**7**
Sierra Nevada North	3	4	**7**
Desert	1	2	**3**
Nevada	3	0	**3**
Total	**37**	**26**	**63**

** For days that a region meets the associated performance criteria a value of 1 is assigned. A value of 0 means that region doesn't meet the criteria for the respective day and, if there is no model simulated concentrations above 60 ppb, then -99 is assigned.*

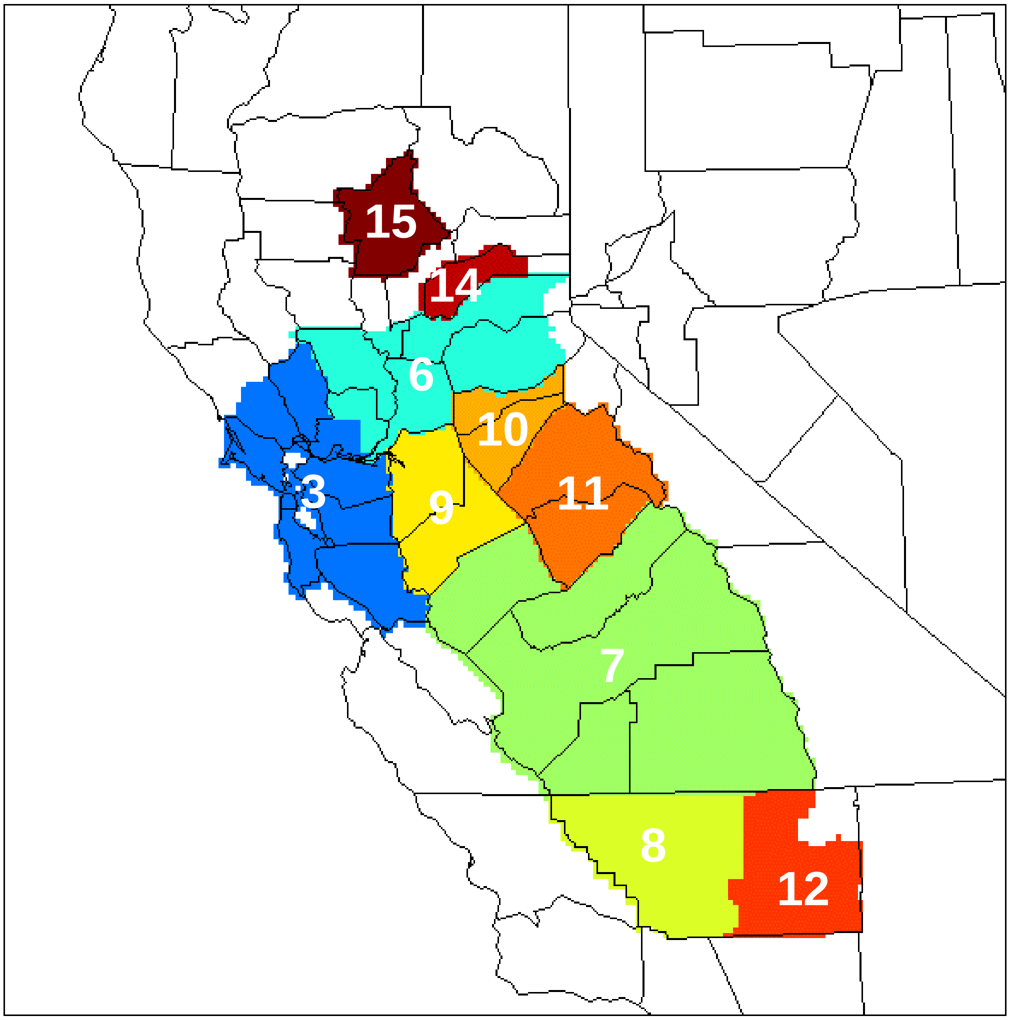


Figure F-1 Sub-regions for air quality model performance evaluation
(3: Bay Area region, 6: Metro Sacramento region, 7: Central San Joaquin Valley region , 8 southern San Joaquin Valley region, 9: Northern San Joaquin Valley region, 10: Central Mountain Counties region, 11: Southern Mountain Counties region, 12; eastern Kern County region, 14: Western Nevada County region, and 15: Butte County region).

F.2. APPROACH

This section describes ARB's proposed procedures, based on USEPA guidance, for calculating and applying RRFs for California's 8-hour ozone State Implementation

Plans. The information in this section was previously provided to the San Joaquin Valley Unified Air Pollution Control District for review and comment (still pending).

F.2.1 Description of Methodology

While the emphasis of this discussion is on site-specific RRFs, it is noted that the USEPA (2005) also requires an analysis to demonstrate that high ozone concentrations occurring away from monitors (e.g., unpaired in space) will also be controlled in future years to meet air quality standards. This issue is addressed as well.

The application of photochemical ozone models has a long history in California, for uses ranging from the preparation of State Implementation Plans to research activities to regulatory development. The modeling community has applied these tools in the State for over 30 years, and much has been learned about their proper uses and limitations.

One of the fundamental understandings that has been learned about photochemical models is that they are best used to estimate the relative difference between scenarios, rather than for absolute concentration estimates. That is, their strength is in estimating the relative change in concentration levels from a baseline condition (e.g., a current year) to an alternative scenario (e.g., a future year), rather than predicting the exact concentration level that will result from the alternative scenario.

EPA’s guidance on the use of models for attainment demonstrations in support of 8-hour ozone planning (USEPA, 2005) is consistent with the fundamental strength of models described above. EPA’s recommended modeled attainment test is to utilize relative model response on a site-by-site basis, in the form of a relative reduction factor (RRF), to predict future-year 8-hour ozone design values. This methodology relies on the base year for the modeling for conducting model performance analyses, a baseline year of 2002 for projecting forward site-specific design values, and a future year for the attainment test.

$$\mathbf{DV_F = (RRF)\,(DV_B)}$$

where DV_B = *a baseline year (2002) concentration (design value) measured at a monitoring site*

DV_F = *the estimated future year design value at the same site*

RRF = *the relative reduction factor at the same site*

The RRF is calculated as the ratio of future year to baseline year modeled ozone concentrations at a site:

$$\mathbf{RRF} = \frac{\mathbf{FY_{8-hr}}}{\mathbf{BY_{8-hr}}}$$

where RRF = *the relative reduction factor for a monitor*
$FY_{8\text{-}hr}$ = *the modeled future year 8-hour daily maximum concentration predicted near the same monitor*
$BY_{8\text{-}hr}$ = *the modeled baseline year 8-hour daily maximum concentration predicted near the same monitor*

In principle, this concept is simple. Unfortunately, it can be confounded by a number of factors, including the limited number of modeled days available, the choice of year(s) to use for specification of the baseline design value, the uncertainties inherent in air quality modeling, and the presence of a non-zero background level of ozone. As a result of this, EPA technical staff have indicated that there is flexibility in the application of RRFs, as long as the methodology is technically sound and is properly documented.

F.2.2 Estimating Base-Year (2002) Design Values

Specification of the baseline design value is a key consideration in the modeled attainment test, since this is the value that is projected forward and used to test for attainment at each site. Since the baseline design value is presumably reflective of conditions in the baseline year, it should be representative of the emissions used for that year. However, many areas experience fluctuations in their year-to-year meteorology, as well as emissions levels. In recognition of this year-to-year variability, the baseline design value should in some fashion also reflect this variability. A standard methodology for minimizing the influence of year-to-year variations is to calculate an average value over multiple years. Therefore, the following methodology is recommended for specification of the baseline design value at each monitoring site:

> **The baseline design value (DV_B) will be calculated as the average of the three design values for the three years commencing with the baseline year of the modeling. The baseline year for modeling in support of the 8-hour ozone SIPs is 2002. Therefore, the baseline design value will be calculated at each monitoring site as the average of the design values for 2002, 2003, and 2004.**

California design values are calculated as the three-year average of the 4th highest 8-hour ozone peak values, and are assigned to the last year. Thus, a design value for 2002 would be based on data for 2000-2002. The recommendation above implies that the baseline design value at each monitoring site will be calculated as the average of nine design values over five years: the three years which make up the 2002 design value (2000-2002), the 2003 design value (2001-2003), and the 2004 design value (2002-2004). This gives the greatest weight to 2002, since that year is included in the calculation of the design value for all three years. Table F-2 summarizes the recommended process for calculating the baseline design value at each monitoring site.

Table F-2 Baseline Design Value Calculation

Year	Years Averaged for Design Value				
2002	2000	2001	2002		
2003		2001	2002	2003	
2004			2002	2003	2004
Yearly Weighting for Average Design Value for Modeled Attainment Test					
2002-2004 Average	$\mathrm{DV_B} = \frac{\mathrm{Year}_{2000} + (2)(\mathrm{Year}_{2001}) + (3)(\mathrm{Year}_{2002}) + (2)(\mathrm{Year}_{2003}) + \mathrm{Year}_{2004}}{9}$				

F.2.3 Relative Reduction Factors

As discussed above, the relative reduction factor (RRF) is a monitor-specific value that is calculated based on daily peak 8-hour ozone concentrations simulated in a future year, divided by daily peak concentrations simulated in the base year. To be consistent with the principle that the modeled attainment test and design values should be robust and stable over a number of different types of meteorology, the RRF should be based on multiple simulated days. The following methodology will be used to calculate site-specific RRFs:

Site-specific RRFs will be calculated as the ratio of the average daily peak 8-hour modeled ozone concentration in the future year, divided by the average daily peak 8-hour modeled ozone concentration in the baseline year. Only those days satisfying the model performance and threshold criteria described below shall be included in the RRF calculation.

$$\mathbf{RRF_{AVG}} = \frac{(\mathbf{FY_{8-hr}})_{\mathbf{AVG}}}{(\mathbf{BY_{8-hr}})_{\mathbf{AVG}}}$$

where RRF_{AVG} = *the average relative reduction factor for a monitor*

$(FY_{8\text{-}hr})_{AVG}$ = *the average future year 8-hour daily maximum concentration predicted near the same monitor, averaged over those days which satisfy model performance and threshold criteria*

$(BY_{8\text{-}hr})_{AVG}$ = *the modeled baseline year 8-hour daily maximum concentration predicted near the same monitor, averaged over those days which satisfy model performance and threshold criteria*

F.2.4 Criteria for Use of Modeled Days in RRF Calculations

Adequate model performance is a requirement for use of modeled results. The lack of acceptable performance greatly increases uncertainty in the use of the modeling results, and casts doubt on conclusions based on the modeling. Although it is desirable to include as many days as possible in the RRF calculations, our experience has demonstrated that not all modeled days meet the minimum performance standards, and are thus not suitable for use. Therefore only those days which satisfy the following model performance criteria will be utilized in subsequent RRF calculations.

The USEPA (1991) and ARB (1990) outline a number of procedures for analysis of base year, air quality model performance. These include spatial and time-series plots, and statistical analyses, comparing simulated and observed pollutant concentrations, as well as sensitivity analysis of selected input fields. The purpose of the performance analysis is to provide some confidence that the air quality simulations – which are the basis of future-year ozone concentration estimates – are performing properly.

The application of air quality modeling results to demonstrate attainment of the federal 1-hour ozone standard emphasized the simulated unpaired peak ozone concentration. Three statistical measures were recommended to evaluate model performance: unpaired peak ratio (UPR), paired mean normalized bias (NB), and paired gross error (GE). These statistical measures were calculated for the modeling domain as a whole, and the NB and GE were calculated from all hourly concentrations in excess of 60 ppb (to avoid biasing the statistical measures with low concentrations). To meet performance guidelines, recommendations were that the UPR should be within ± 20%, NB should be within ± 15%, and the GE less than 35%. However, California's geography is very complex and modeling domains have evolved to cover large geographic areas. Thus it is recommended that the domains be divided into sub-regions, and that the performance measures be calculated independently for each sub-region. The configuration of these sub-regions is somewhat arbitrary; however, they should be configured to isolate "common" regions of higher ozone.
The USEPA (2005) recommends that the emphasis for 8-hour model performance be based on concentrations occurring at, or in the vicinity of, individual monitoring sites. Specifically, modeled concentrations occurring within 15 km of a site are considered to be in the vicinity of the site. The recommended statistical measures to assess simulated versus observed maximum 8-hour ozone concentrations include paired (in space, but not time) peak prediction accuracy (PPPA), paired mean normalized bias (NB), and paired gross error (GE). Although limited performance analysis has been completed for 8-hour ozone modeling in California, it seems prudent at this point to carry forward the 1-hour statistical goals and apply them for the 8-hour standard (UPR within ± 20%, NB within ± 15%, and the GE less than 35%). However, these limits may need to be revised as 8-hour SIP modeling progresses and rigorous model performance evaluations are completed.

While statistical measures for 1-hour model performance were typically calculated independently for each modeled day available, the USEPA also recommends that PPPA, NB, and GE be calculated for each site over all modeled days. However, because the number of episode days available may be very limited, the statistical uncertainties in these latter calculations would be large and they are not recommended herein.

In order to have confidence in future year estimates from air quality models, there must be confidence in the air quality modeling for the base year. That is, days not meeting model acceptance criteria provide high uncertainty, and should not be used for the modeled attainment test.

In addition to the issue of model performance, analyses conducted by the USEPA (2005) suggest that air quality models respond more to emission reductions at higher predicted ozone values. Correspondingly, the model predicts less benefit at lower concentrations. This is consistent with preliminary modeling in support of the 8-hour ozone standard conducted by the ARB and the districts. These results imply that RRF calculations should be restricted to days with predicted high ozone concentrations. It is thus reasonable to establish a minimum threshold for predicted peak 8-hour ozone concentrations in the baseline year. Days for which the predicted daily peak 8-hour ozone concentration at a site is less than the threshold, would not be used for calculating RRFs at that site. Consistent with EPA's recommendation, we propose to use a value of 85 ppb for the baseline year threshold.

Based on the above discussion, we propose the following methodology for determining sites and modeled days to be used in the RRF calculations:

> **Only those modeled days meeting the following criteria will be used to calculate site-specific RRFs:**
>
> 1) **The modeled daily 8-hour peak ozone concentration within 15 km of the site for the base year of the modeling must be within ± 20% of the observed value at the site.**
> 2) **The modeled daily 8-hour peak ozone concentration within 15 km of the site in the baseline year must be 85 ppb or greater.**
> 3) **The sub-regional 1-hour and 8-hour statistical measures of NB and GE must fall within the thresholds of ± 15% and 35%, respectively.**

F.2.5 Estimating Future-Year Design Values

As discussed above, the EPA's 8-hour modeling guidance recommends utilizing relative model response on a site-by-site basis, in the form of an average relative reduction factor (RRF_{AVG}), to predict future-year 8-hour design values for attainment planning.

The average RRF is then multiplied by a site-specific design value to estimate the future-year design value. One of the confounding factors in this approach is consideration of the effects that background levels have on the effectiveness of emission control programs.

There is a large body of information that suggests that ambient concentrations consist of some (perhaps nonlinear) background value and a contribution due to anthropogenic emissions. That is, if all man-made emissions could be zeroed out, ozone concentrations would not go to zero but rather some finite value. The literature suggests that 40 ppb is a reasonable global background ozone value, and it is quite likely that continental background is some other, somewhat higher, value. One possibility for estimating background ozone values in a given modeling domain would be to exercise the model without anthropogenic emissions, and to thus develop a gridded "background" ozone field. One concern with this approach is that at such low levels, the model's boundary conditions exert a large influence, and appropriate temporally- and spatially-resolved data to specify boundary conditions rarely exist. Thus boundary conditions can be subjective and uncertain. Whether the background value is established at some finite value (e.g., 40 ppb) or is model-derived, it represents that portion of a site's ozone problem that cannot be mitigated by anthropogenic emission controls.

According to EPA's 8-hour ozone modeling guidance, the modeled attainment test requires that a future year Design Value (DV_F) be calculated at each site and compared to the standard to determine if the site is predicted to be in attainment. To calculate the future year Design Value, the Design Value for the baseline year (DV_B) is multiplied by RRF_{AVG}. Although EPA's guidance says nothing about background ozone, we propose to calculate the future year Design Value with consideration of background. The Table F-3 illustrates calculation of the DV_F with and without background.

Table F-3 Calculation of the Average Relative Reduction Factor with and without Consideration of Background Ozone

Without consideration of background	With consideration of background
$RRF_{AVG} = \frac{(FY)_{AVG}}{(BY)_{AVG}}$ $DV_F = (RRF_{AVG}) \times (DV_B)$	$RRF_{AVG} = \frac{(FY - BG)_{AVG}}{(BY - BG)_{AVG}}$ $DV_F = [(RRF_{AVG}) \times (DV_B - BG)] + BG$

Definitions
DV_B = Design Value for the baseline year
BY = base year model prediction
FY = future year model prediction
BG = background ozone

Future year design values will be calculated with consideration of background ozone. Because the model's boundary conditions exert a large influence on modeled background ozone levels, 40 ppb will be used to represent background ozone concentrations.

F.2.6 Unpaired Peak Concentrations

This information will be available in future ARB documentation.

F.2.7 Other Potential Technical Issues

The process outlined above for calculating site-specific RRFs seems straightforward. However, in practice, the process may turn out to be tedious and cumbersome; especially if a large number of sites need to be evaluated, and for different years. The greatest difficulty may be that the number of days used for the calculation of the RRF for each site may vary. The days used for each site in the future year must match those used in the base year. Because the selection of these days is based, in part, on model performance statistical measures, it may be necessary to do much of this work by hand.

Another problem that is almost certain to arise is that for some sites either the model performance or the observed and simulated concentrations will fail to meet the recommended guidelines on all of the available episode days. This may result in situations wherein the day of the peak ozone concentration is not used in the calculation of the RRF and days with lesser concentrations are. The risk is that if the episode and simulation results do not adequately represent high ozone concentrations at a site, the simulation results may overstate the emissions reductions necessary to reach attainment for the ozone air quality standards due to the model's relatively limited response to controls at lower concentrations. In addition, the process of estimating a future year design value at an unmonitored peak location will always be subject to great uncertainty.

Some of the above difficulties may be avoided if a more simple and straightforward approach was used. For example, an RRF could be calculated from the base- and future-year sub-regional maximum 8-hour daily maximum ozone concentrations. The RRF could then be multiplied by the maximum design value within the control district or attainment area. This would deviate from the USEPA (2005) guidelines in a number if respects. But, it would greatly simplify the required calculations. A lot more study of this approach would be necessary to understand the implications of such an approximation. This would also have to be vetted with the EPA.

F.3 FUTURE YEAR RESULTS

This chapter presents draft base year design values and describes the future year design values and carrying capacity results contained in the Appendices.

F.3.1 Base-Year Design Values

Section 1 discusses a proposed approach for calculating future year design values. Based on this recommended approach, Table F-4 presents the results of base year design value calculations for the San Joaquin Valley. These values are preliminary and are subject to review and change.

Table F-4 San Joaquin Valley Design Values for 2002-2004 (Preliminary)

Site	8-Hour Ozone Design Values			
	2002	2003	2004	2002-04 Avg.
Fresno County				
Clovis - N Villa Avenue	106	103	95	101
Fresno - 1st Street	105	106	102	104
Fresno - Sierra Skypark #2	115	111	104	110
Parlier	110	111	104	108
Kern County				
Arvin - Bear Mountain Blvd	112	115	116	114
Bakersfield - 5558 California Avenue	100	100	97	99
Bakersfield - Golden State Highway	98	98	94	97
Edison	106	104	101	104
Maricopa - Stanislaus Street	99	99	96	98
Oildale - 3311 Manor Street	100	99	98	99
Shafter - Walker Street	95	96	92	94
Kings County				
Hanford - S Irwin Street	99	95	93	96
Madera County				
Madera - Pump Yard	91	93	89	91
Merced County				
Merced - S Coffee Avenue	101	102	102	102
Stanislaus County				
Turlock - S Minaret Street	95	96	94	95
Tulare County				
Visalia-N Church Street	100	99	95	98

F.3.2 Future Year Design Value and Carrying Capacity Estimates

Data processing programs are used to generate reports from modeling results to illustrate future year design values and carrying capacities. These reports are generated for each 8-hour ozone non-attainment monitoring station following the methodology described in section 1. For illustration purposes, this section discusses the information contained on a sample report page (Figure 2). The Appendices contain future-year-specific results for specific years in the same form as the sample format.

Report Header. At the top of the report, four header lines provide a variety of information, including the subject future year (2020), the station (site) name, the associated sub-region (per Figure 1, Chapter 1), and the 8-hour ozone design value for the USEPA-defined baseline year of 2002 (114 ppb) from Table 2, shown previously in Section 2.1).

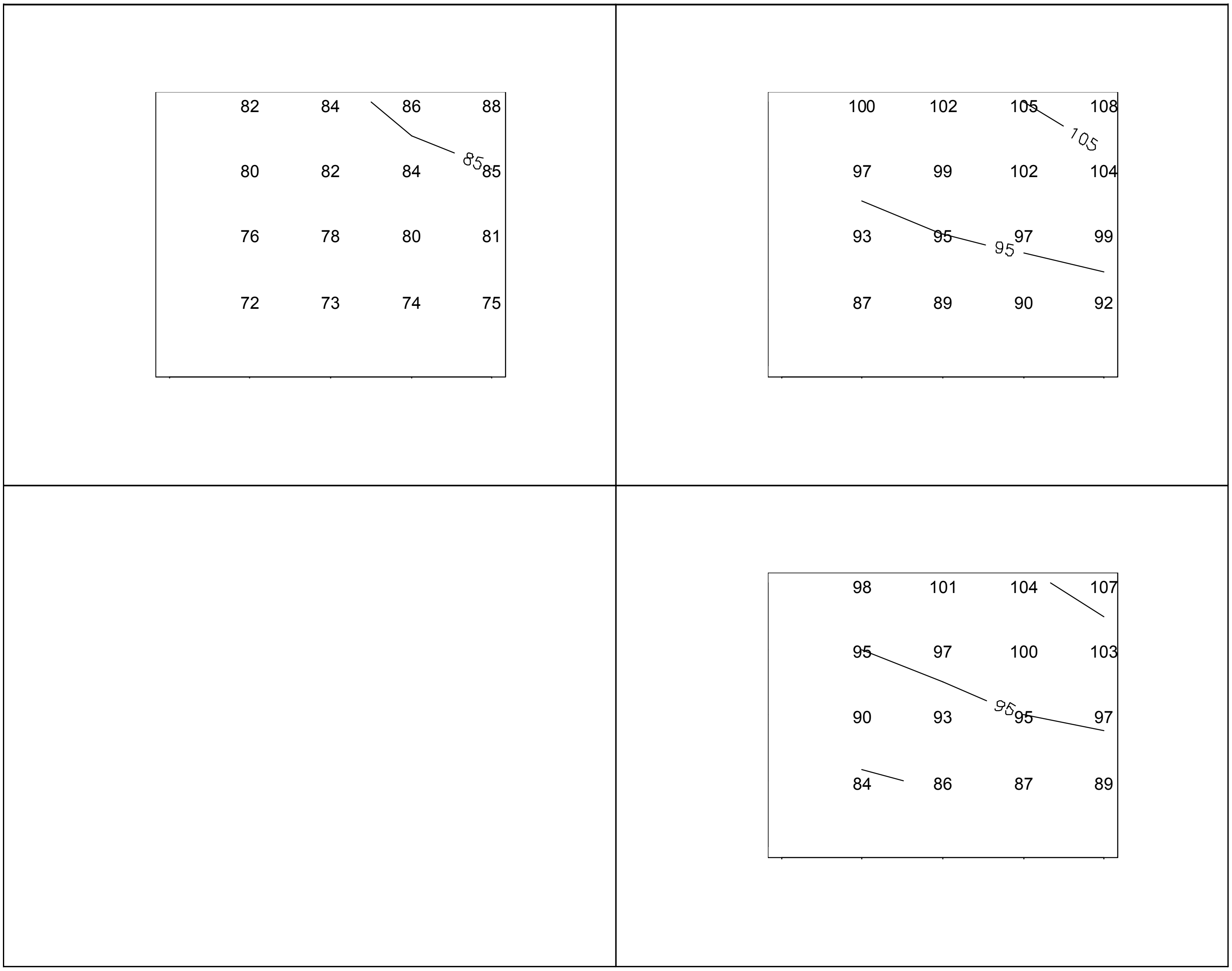
Report Table. The mid-section of the report contains a table with 8 rows: a header row, plus 7 rows of information. For specific episode days (columns), this table contains a pass/fail summary of sub-regional model performance results for the site (row 2), a variety of concentration data (rows 3-7), and a yes/no assessment as to whether the station data are useable in the RRF analysis (row 8). A “-99” value in rows 3-7 indicates that acceptable data are not available. The purpose of each row is described below:

- **Row 1**: *Header*. Columns represent episode days via two digit year followed by three digit day-of-year, or Julian day.
- **Row 2**: *Performance Status*: This line lists the model performance status for each of the episode days. The model performance status is a pass/fail designation as to whether the model performance for the sub-region within which the monitoring station is located meets both the 1-hour and the 8-hour statistical model performance criteria, per Section 1.1.3 and the Volume 1 report. Per the Figure 2 report header, Arvin is located in Region 8, Southern San Joaquin Valley.
- **Row 3**: *Peak Observed 8-hour Ozone*. These data represent the peak, measured 8-hour ozone concentrations at the Arvin station for each specific day. These 8-hour ozone concentrations need to be above 70ppb to be used in the RRF calculation (U.S. EPA guidance recommends excluding days with concentrations less than 70 ppb from RRF calculations to avoid a strong RRF dependence on the predicted baseline maximum concentrations).
- **Row 4**: *Peak Simulated 8-hour Ozone*. These are the model-simulated, peak 8-hour ozone concentrations occurring in the modeling grid cell within which the station (Arvin in this case) is geographically located. Per Section 1, simulated concentrations must be 85ppb or greater to be used in the RRF calculation.
- **Row 5**: *Peak Simulated 8-hour Ozone within 15km*. These values represent the model-simulated, daily 8-hour peak ozone concentration within 15 km of the site for the base year of the modeling. Per Section 1.1.3, these concentrations must be 85 ppb or greater and within ± 20% of the observed value at the site.

Figure F-2 Sample Report Page for the Arvin monitoring site

Year: 2012 **Model:** CAMX/MM5/SAPRC99
Site: ARV - Arvin Stn **Subregion:** 8 **Baseline Year Design Value:** 114 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Fail	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	102	109	92	54	70	-99	-99	93	105	98
Peak Simulated 8-hour Ozone	84	91	89	76	81	88	91	94	88	81
Peak Simulated 8-hour Ozone within 15 km	94	95	91	82	86	92	94	95	91	89
Baseline Year 15-km, 8-hour Average Ozone	93									
Future Year 15-km, 8-hour Average Ozone	87	88	85	80	83	87	88	90	86	86
Use in RRF Analysis?	No	No	No	No	No	No	No	Yes	Yes	No



- **Row 6**: *Baseline Year, 15km, 8-hour Average Ozone*. This represents the average of the Row 4 values for which the data are useable in RRF analyses (per row 8). For Arvin, since row 8 indicates that only days 00213 and 00214 are usable, 93 ppb is calculated from the average of 95 ppb and 91 ppb.
- **Row 7**: *Future Year, 15km, 8-hour Average Ozone*. This represents the average, future-year simulated concentrations within 15 km of the site.
- **Row 8**: Use in RRF Analysis? This YES/NO field represents whether data for the days can be used in calculating the RRF. As indicated in Section 1.1.3 and in the row descriptions above, the criteria for selecting which days will be used in the RRF calculation include an assessment of sub-regional model performance as well as concentration thresholds for observed and simulated 8-hour ozone concentrations. That is, In addition to meeting model performance criteria, the observed base-year ozone concentration must be 70 ppb or greater and the maximum simulated ozone concentration for the year 2002 must be 85 ppb or greater.

RRF Calculation Example. Of the 10 available episode days reported in Figure 2 for Arvin, six of the days fail to meet the 1-hour and/or the 8-hour model performance criteria ('99190', '99191', '99192', '99193', ‘00211’, and '00215'). Of the four remaining days, day '99194' cannot used because the observed and simulated (rows 3-4) 8-hour ozone concentrations were too low and day '00212' cannot be used because observed concentrations are missing (-99 in row 3). Therefore, of the 10 days simulated, the simulation results from 2 days are used in the RRF calculation: days '00213' and '00214' (per row 8). Per Section 1.1.4 the sample RRF for Arvin, without a background offset, is calculated as follows:

$$RRF_{AVG} = \frac{(FY)_{AVG}}{(BY)_{AVG}} = ((90+86)/2) / ((95+91)/2) = (88/93) = 0.95$$

Also per Section 1.1.4, with a 40 ppb background offset, the RRF is calculated as:

$$RRF_{AVG} = \frac{(FY - BG)_{AVG}}{(BY - BG)_{AVG}} = (88-40)/(93-40) = 0.91$$

Reported Design-Value-Based Carrying Capacity Diagrams. The lower half of the page for each report contains four design-value-based carrying capacity diagrams. These diagrams are intended to characterize the effect of domain-wide emission changes on a design value, based upon multiple model simulations. The diagrams are based on model response to 16 future year emission scenarios for which baseline, domain-wide NO_x and ROG emissions for the 2020 future year are scaled by factors ranging from 1 to 0.4 in increments of 0.2 (i.e. 20% NO_x and/or ROG reductions at a time).

The two diagrams on the left side of the report page are the same, and are based on the average of the "Future Year 15-km, 8-hour Average Ozone" values reflected in row 6 of the report table, for those days that meet all the criteria for RRF application. However, no RRF is applied. Thus the future year design value indicated at the top right of each diagram is calculated as follows:

$$DV_F = (90 + 96) / 2 = 88 \text{ ppb}$$

The two diagrams on the right incorporate RRFs, without consideration of background ozone (top diagram) and with consideration of background (bottom diagram). The future year design value indicated at the top right of the top diagram on the right is calculated as follows, using the RRFs discussed above:

$$DV_F = (RRF_{AVG}) \times (DV_B) = 0.95 \times 114 \text{ ppb} = 108 \text{ ppb}$$

Similarly, the future year design value indicated at the top right for the bottom right diagram is calculated as follows, using the background-adjusted RRFs discussed previously and equations in section 1.1.4:

$$DV_F = [(RRF_{AVG}) \times (DV_B - BG)] + BG = [\ 0.91 \times (\ 114 - 40\ )\ ] + 40 = 107 \text{ ppb}$$

Note that this value is 1 ppb lower than the value in the bottom right diagram. This is due to round-off, since the RRF values are calculated using actual model outputs with many significant digits.

F.4 ANALYSIS OF MODEL-SIMULATED, UNMONITORED PEAKS

This information will be available in future ARB documentation.

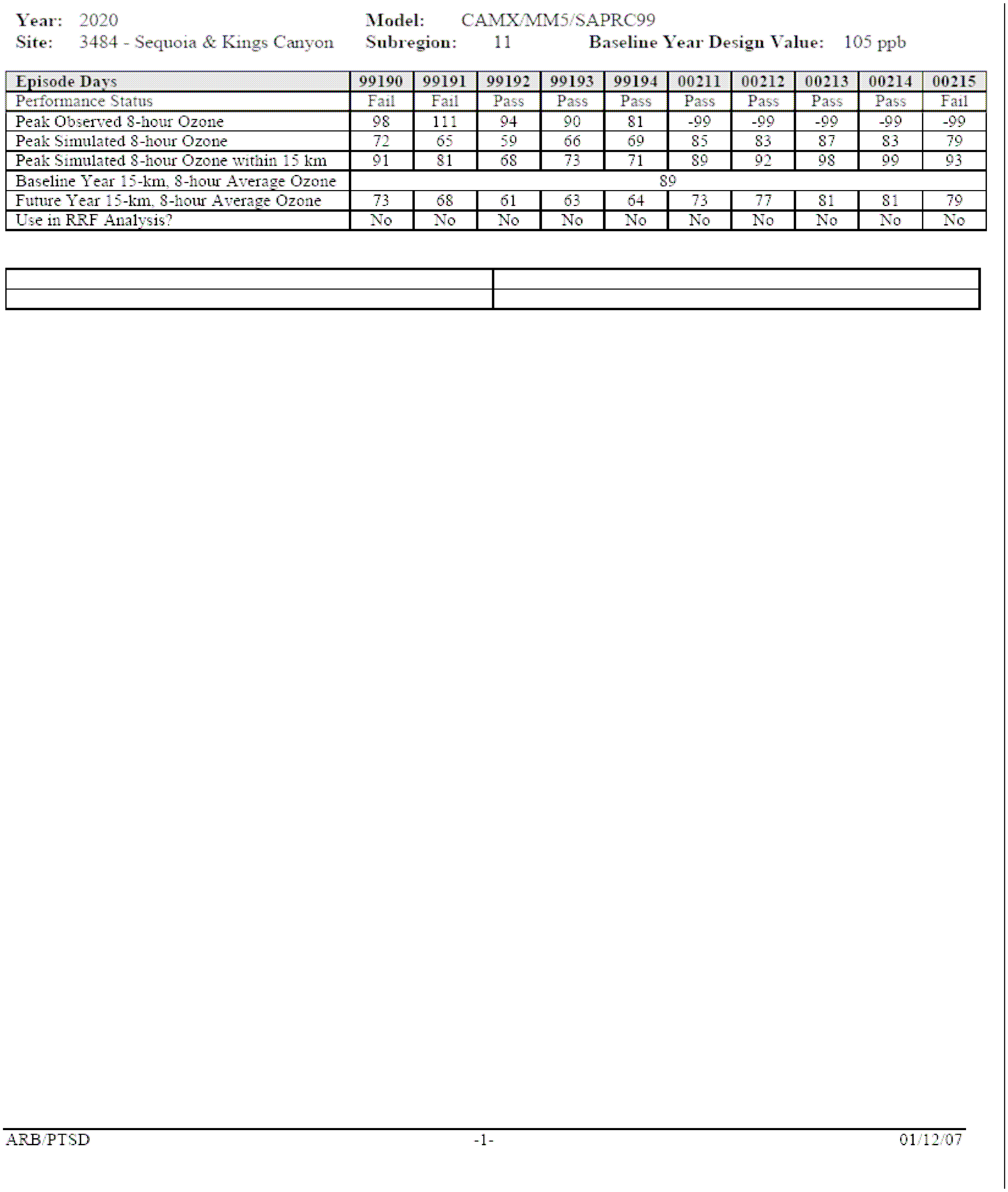
References

Air Resources Board, 1990. "TECHNICAL GUIDANCE DOCUMENT: Photochemical Modeling".

USEPA, 1991. "Guideline for Regulatory Application of the Urban Airshed Model". EPA-450/4-91-013. USEPA, OAQPS. Research Triangle Park, NC 27711. July, 1991.

USEPA, 2005. "Guidance on the Use of Models and Other Analysis in the Attainment Demonstration for the 8-Hour Ozone NAAQS". Final Draft. USEPA, OAR/OAQPS, Research Triangle Park, NC 2771. February, 2005.

F.5 FUTURE YEAR, 2020 CARRYING CAPACITIES



Year: 2020 **Model:** CAMX/MM5/SAPRC99

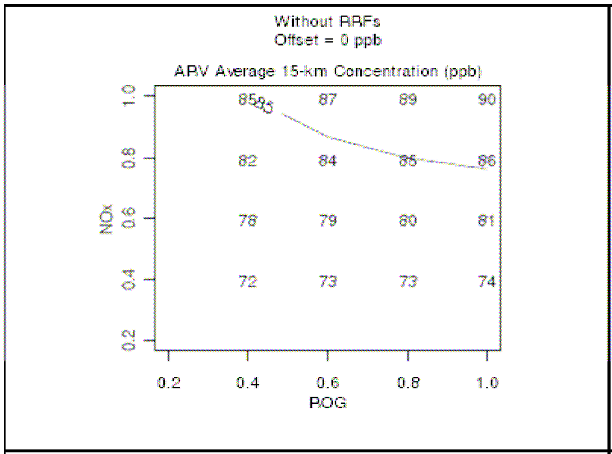
Site: 3484 - Sequoia & Kings Canyon **Subregion:** 11 **Baseline Year Design Value:** 105 ppb

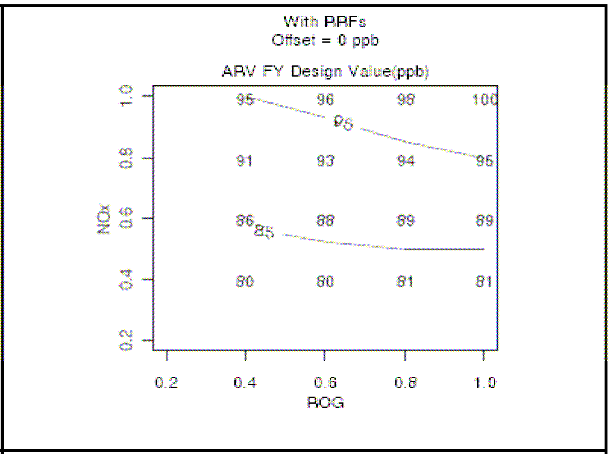
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	98	111	94	90	81	-99	-99	-99	-99	-99
Peak Simulated 8-hour Ozone	72	65	59	66	69	85	83	87	83	79
Peak Simulated 8-hour Ozone within 15 km	91	81	68	73	71	89	92	98	99	93
Baseline Year 15-km, 8-hour Average Ozone	89									
Future Year 15-km, 8-hour Average Ozone	73	68	61	63	64	73	77	81	81	79
Use in RRF Analysis?	No	No	No	No	No	No	No	No	No	No

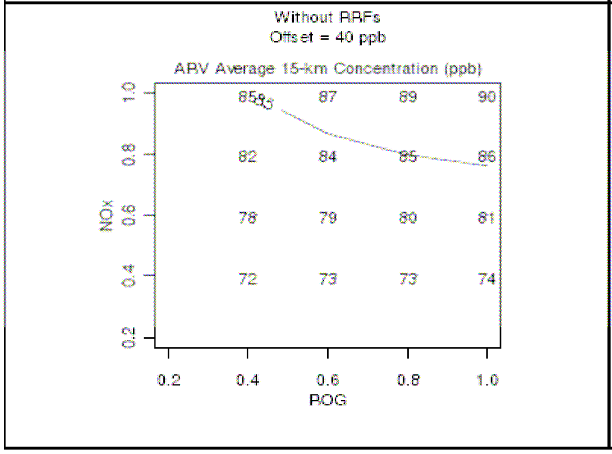
ARB/PTSD -1- 01/12/07

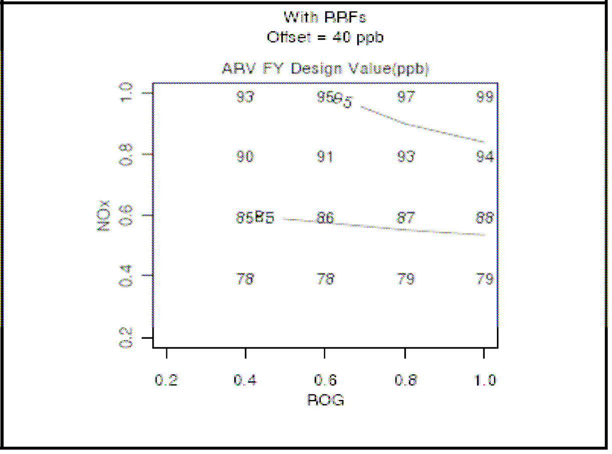
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: ARV - Arvin Stn **Subregion:** 8 **Baseline Year Design Value:** 114 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	102	109	92	54	70	-99	-99	93	105	98
Peak Simulated 8-hour Ozone	84	90	88	76	81	95	98	105	95	88
Peak Simulated 8-hour Ozone within 15 km	94	94	91	81	86	99	103	106	99	98
Baseline Year 15-km, 8-hour Average Ozone	102									
Future Year 15-km, 8-hour Average Ozone	78	79	78	76	78	87	88	93	87	92
Use in RRF Analysis?	No	No	No	No	No	No	No	Yes	Yes	No



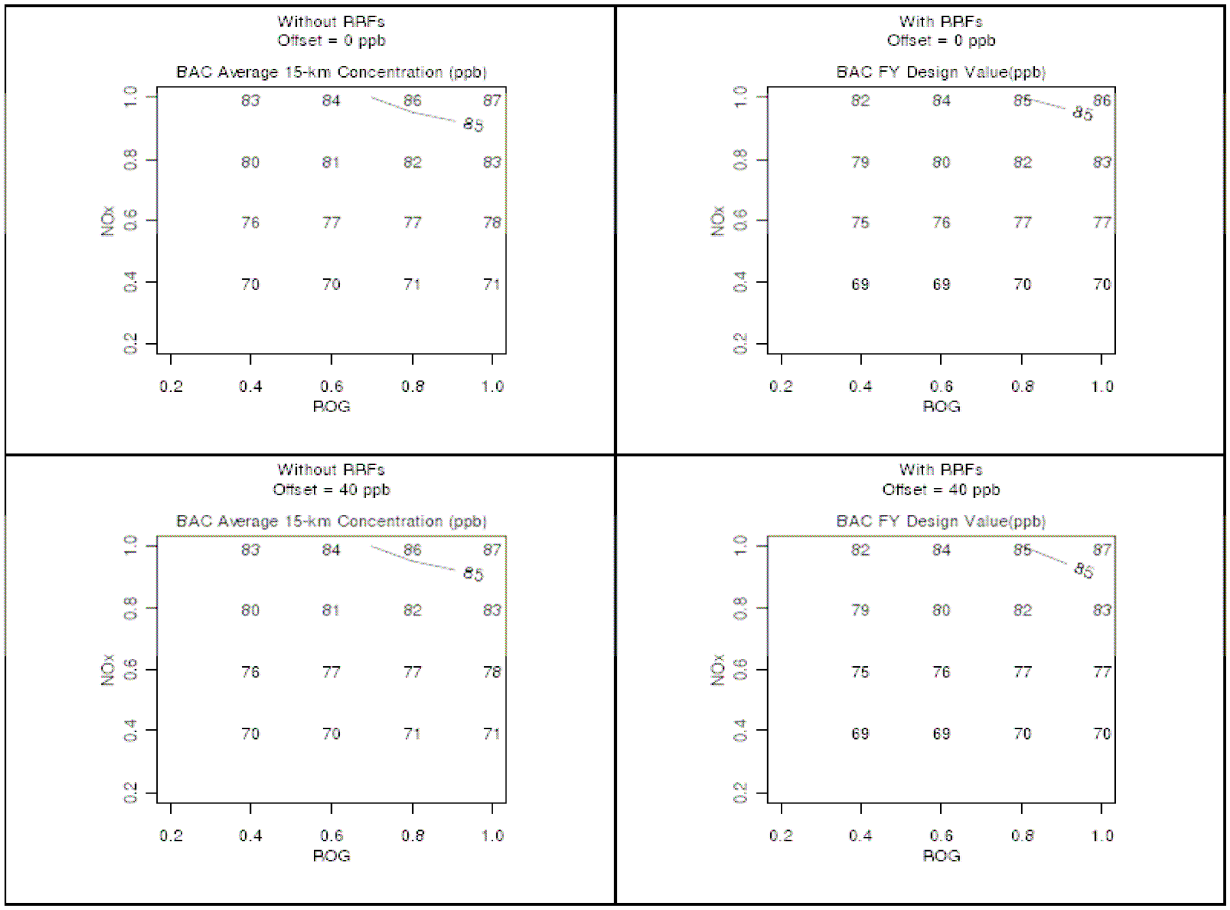






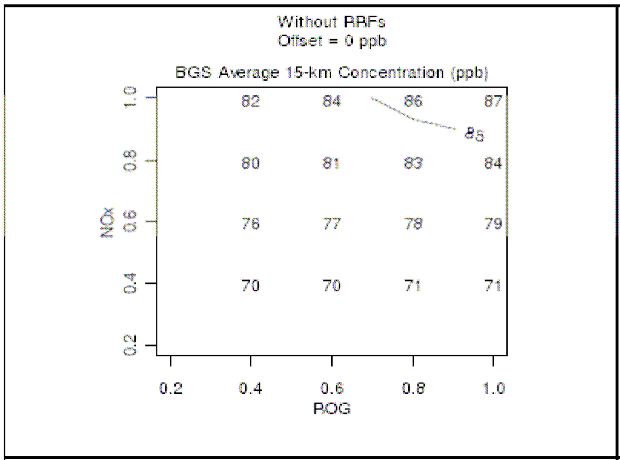
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: BAC - Bakersfield Stn (5558 C **Subregion:** 8 **Baseline Year Design Value:** 99 ppb

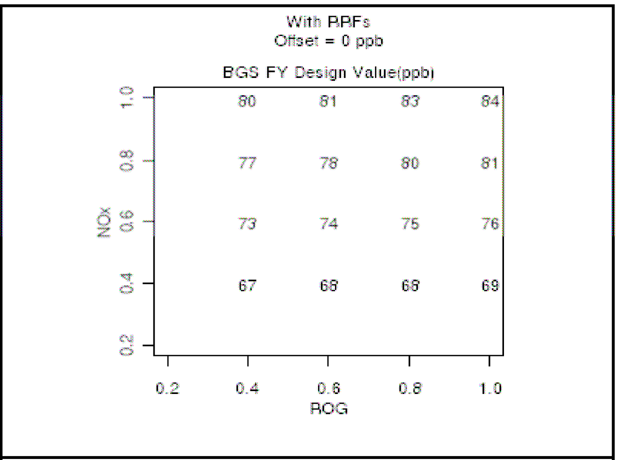
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	94	97	97	51	72	96	87	84	93	107
Peak Simulated 8-hour Ozone	77	76	77	73	76	86	89	87	87	92
Peak Simulated 8-hour Ozone within 15 km	84	85	83	79	82	100	104	100	94	100
Baseline Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	73	74	74	75	78	86	90	90	84	94
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No

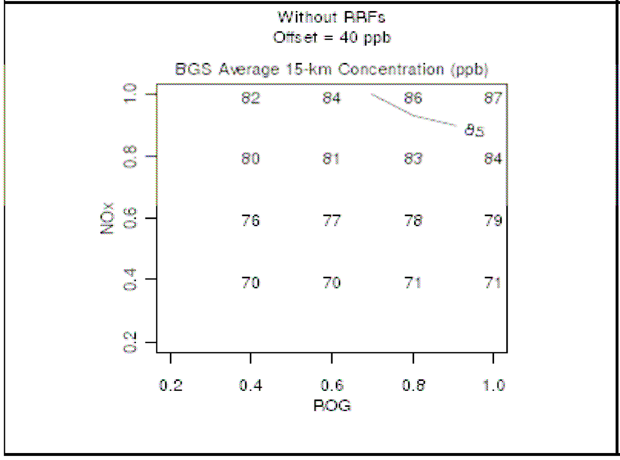


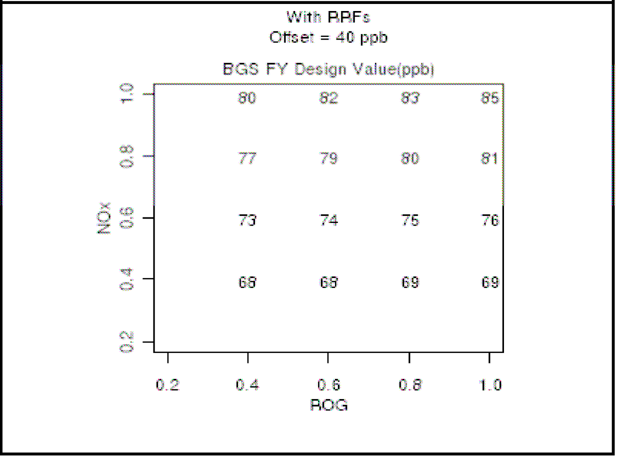
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: BGS - Bakersfield Stn (1128 G **Subregion:** 8 **Baseline Year Design Value:** 96 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	91	95	93	50	68	98	92	78	93	101
Peak Simulated 8-hour Ozone	70	74	72	64	70	78	86	80	81	84
Peak Simulated 8-hour Ozone within 15 km	90	91	87	81	84	99	101	102	93	99
Baseline Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	78	78	76	76	79	87	89	92	82	94
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No



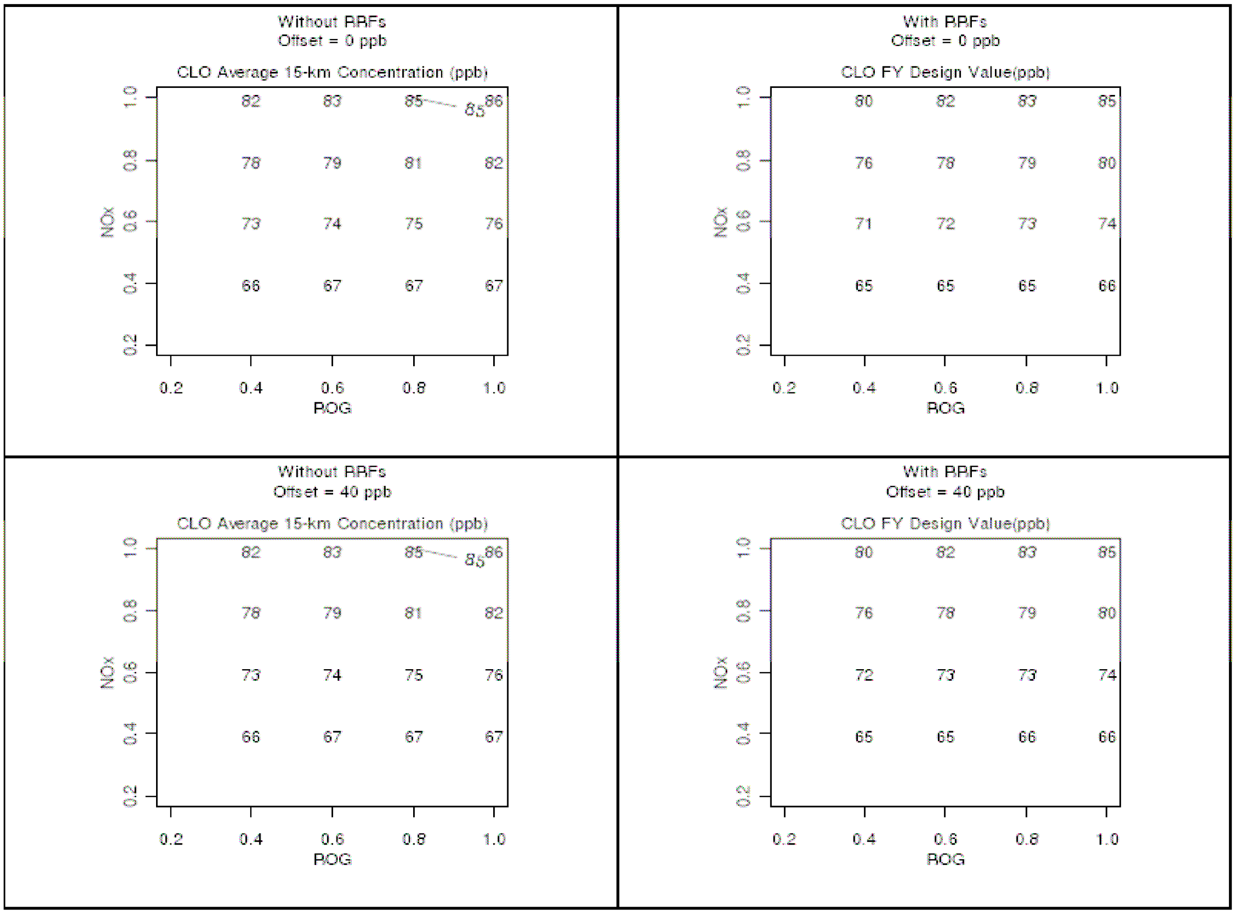






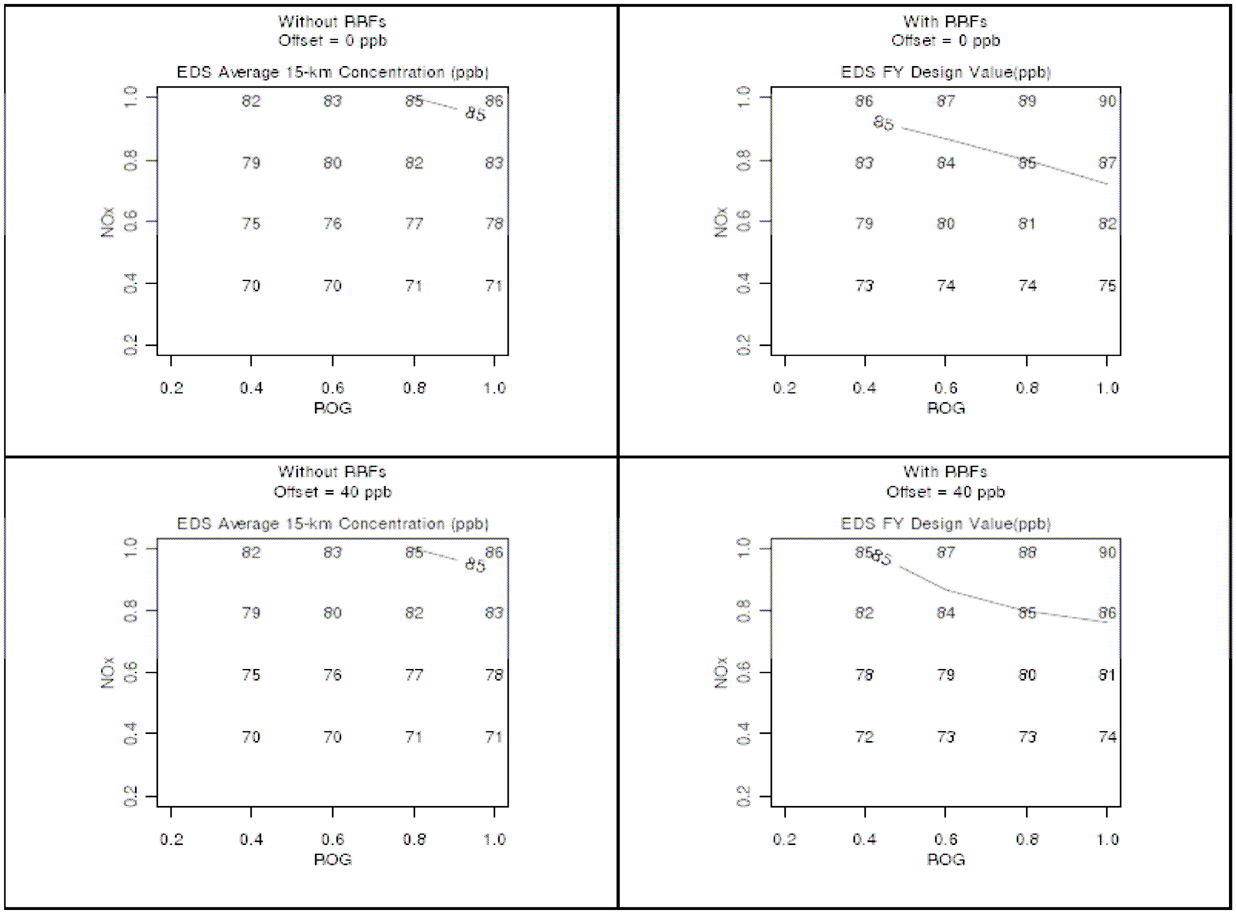
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: CLO - Clovis Stn (908 N Villa **Subregion:** 7 **Baseline Year Design Value:** 101 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	94	99	122	104	98	98	96	102	92	99
Peak Simulated 8-hour Ozone	81	85	93	100	86	95	93	100	99	111
Peak Simulated 8-hour Ozone within 15 km	88	95	101	103	89	102	99	105	112	118
Baseline Year 15-km, 8-hour Average Ozone	103									
Future Year 15-km, 8-hour Average Ozone	79	80	84	85	74	86	84	90	92	97
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes



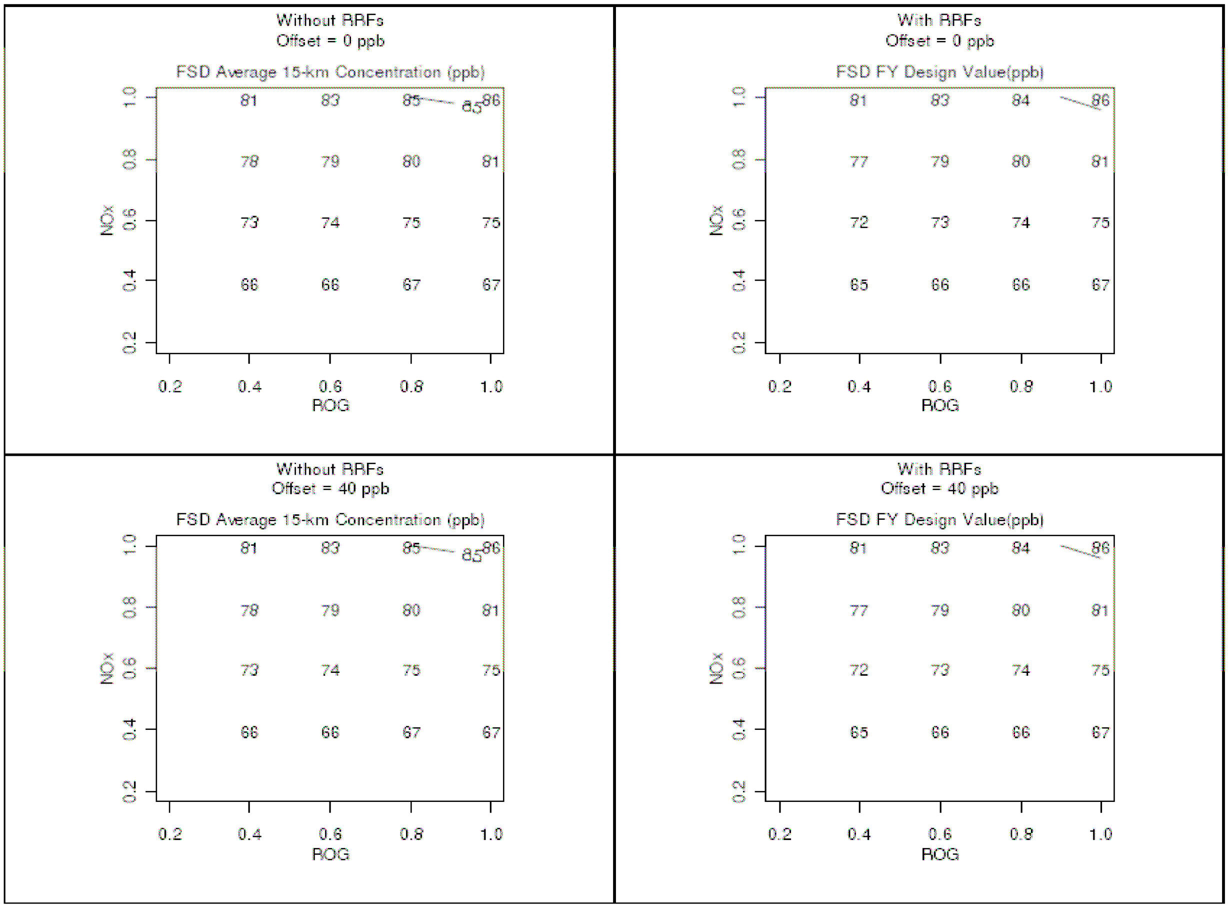
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: EDS - Edison Stn **Subregion:** 8 **Baseline Year Design Value:** 103 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	95	97	96	46	71	105	99	96	103	113
Peak Simulated 8-hour Ozone	88	87	81	79	83	94	92	91	88	96
Peak Simulated 8-hour Ozone within 15 km	94	94	91	81	86	100	104	106	95	100
Baseline Year 15-km, 8-hour Average Ozone	98									
Future Year 15-km, 8-hour Average Ozone	79	79	78	76	79	87	90	93	84	94
Use in RRF Analysis?	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No



Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: FSD - Fresno Stn (Drummond) **Subregion:** 7 **Baseline Year Design Value:** 102 ppb

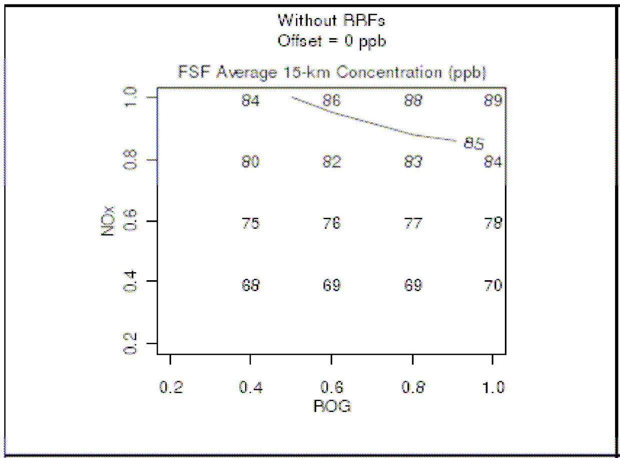
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	84	94	107	93	91	91	93	85	84	91
Peak Simulated 8-hour Ozone	81	84	101	82	76	89	98	97	97	106
Peak Simulated 8-hour Ozone within 15 km	88	94	101	101	87	102	100	105	109	117
Baseline Year 15-km, 8-hour Average Ozone	102									
Future Year 15-km, 8-hour Average Ozone	79	80	84	84	72	86	84	90	90	96
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes



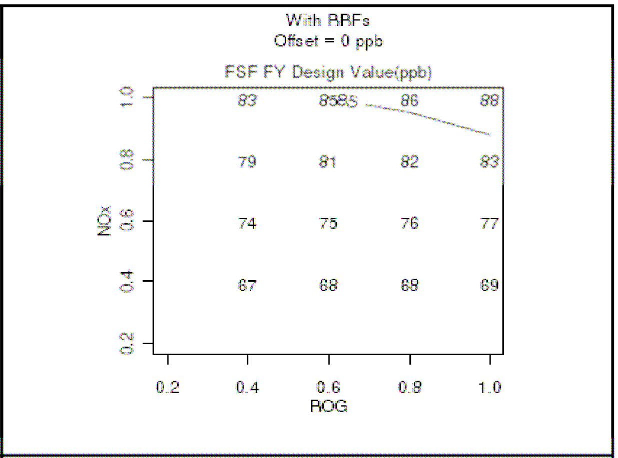
Year: 2020 **Model:** CAMX/MM5/SAPRC99

Site: FSF - Fresno Stn (3425 First **Subregion:** 7 **Baseline Year Design Value:** 104 ppb

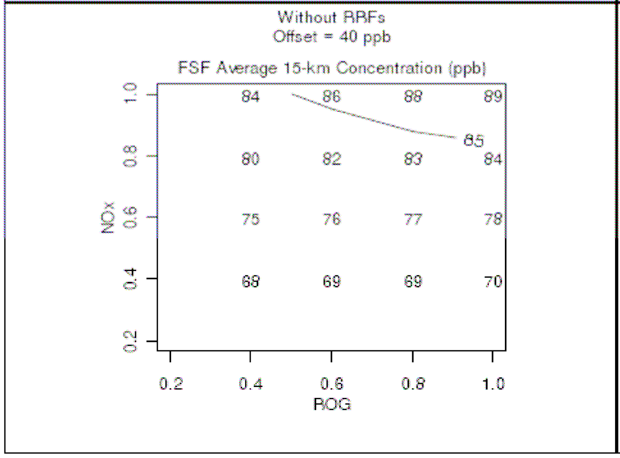
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	-99	-99	-99	-99	-99	98	99	97	95	98
Peak Simulated 8-hour Ozone	78	82	94	88	79	88	95	96	94	104
Peak Simulated 8-hour Ozone within 15 km	85	92	101	103	89	100	99	104	105	116
Baseline Year 15-km, 8-hour Average Ozone	105									
Future Year 15-km, 8-hour Average Ozone	78	79	84	85	73	86	84	90	88	96
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes


Without RRFs
Offset = 0 ppb

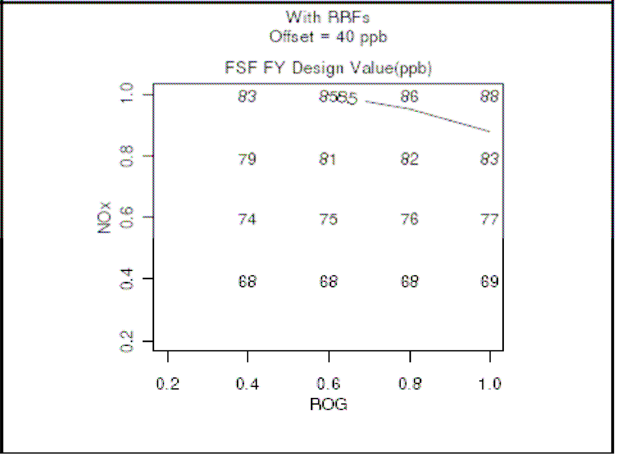
FSF Average 15-km Concentration (ppb)


With RRFs
Offset = 0 ppb

FSF FY Design Value(ppb)


Without RRFs
Offset = 40 ppb

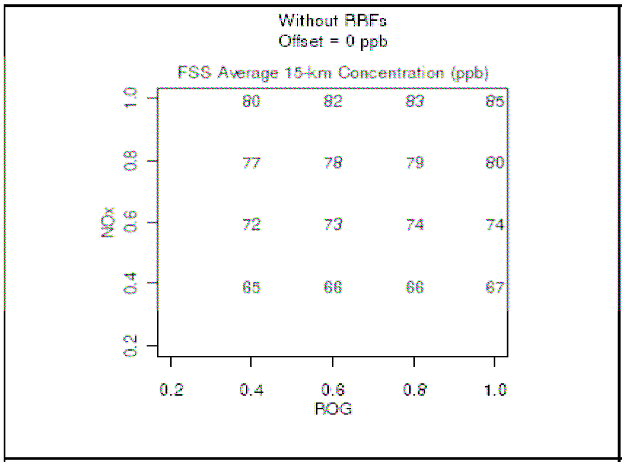
FSF Average 15-km Concentration (ppb)

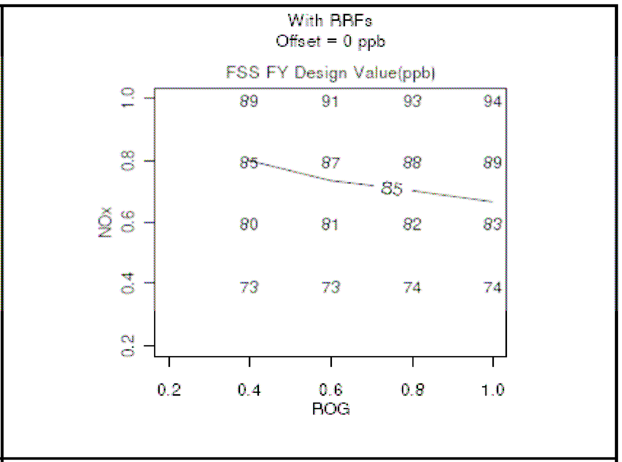

With RRFs
Offset = 40 ppb

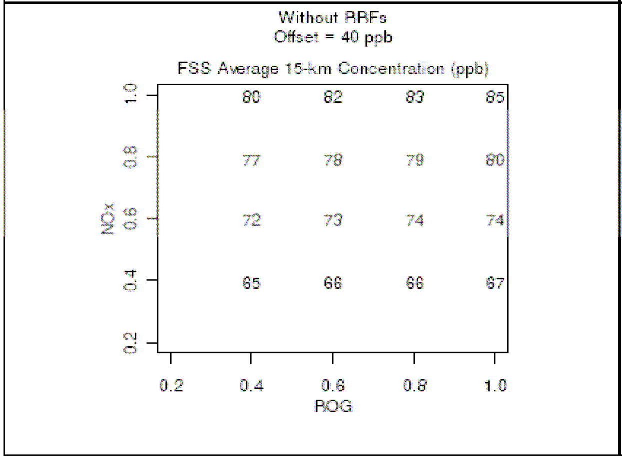
FSF FY Design Value(ppb)

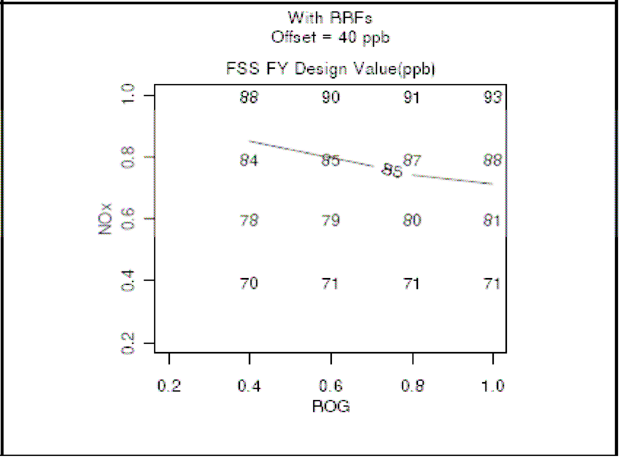
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: FSS - Fresno Stn (Sierra Skyp **Subregion:** 7 **Baseline Year Design Value:** 110 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	76	78	95	60	59	103	100	104	110	106
Peak Simulated 8-hour Ozone	82	84	86	87	80	88	93	98	94	103
Peak Simulated 8-hour Ozone within 15 km	83	86	101	99	89	92	98	103	98	109
Baseline Year 15-km, 8-hour Average Ozone	98									
Future Year 15-km, 8-hour Average Ozone	75	74	84	84	74	83	84	90	83	94
Use in RRF Analysis?	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes



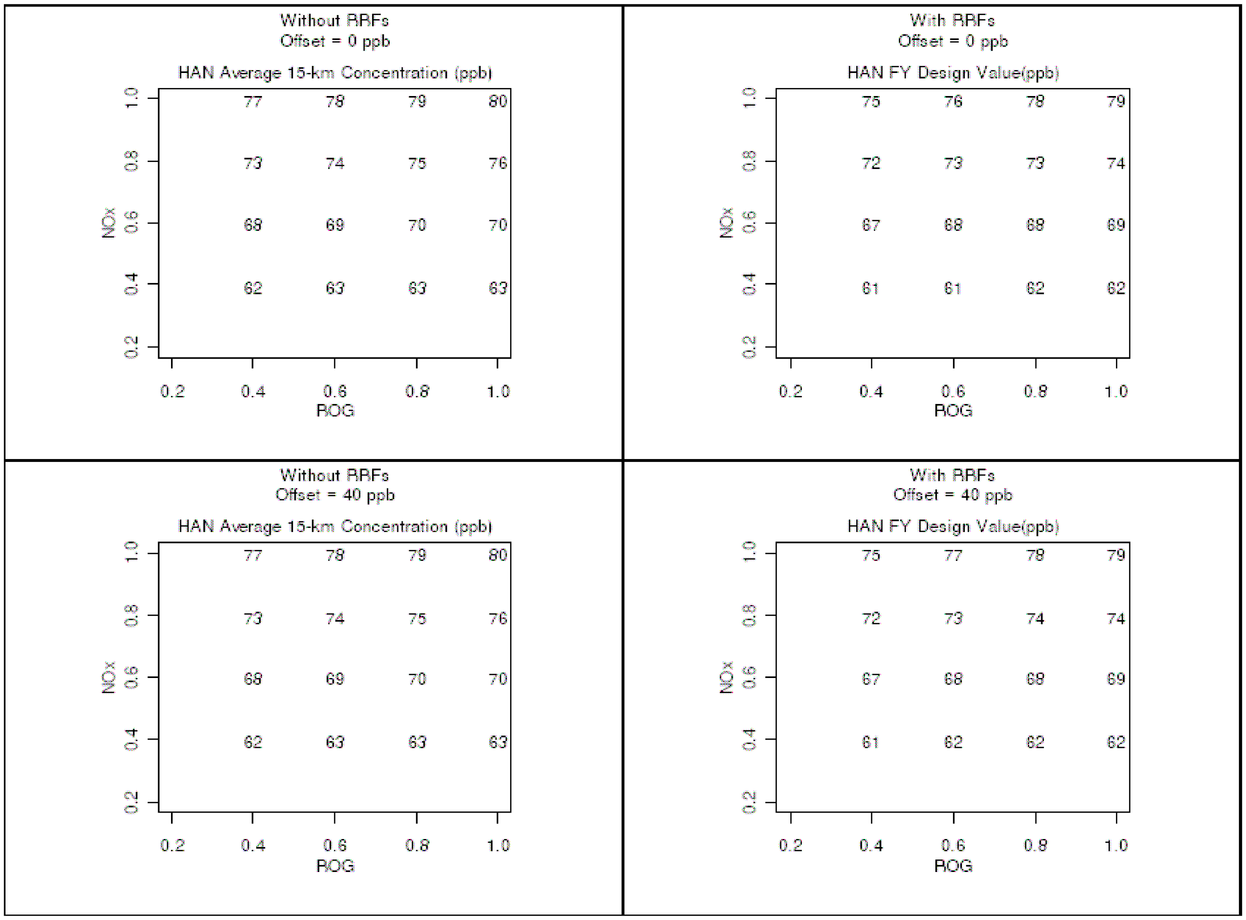






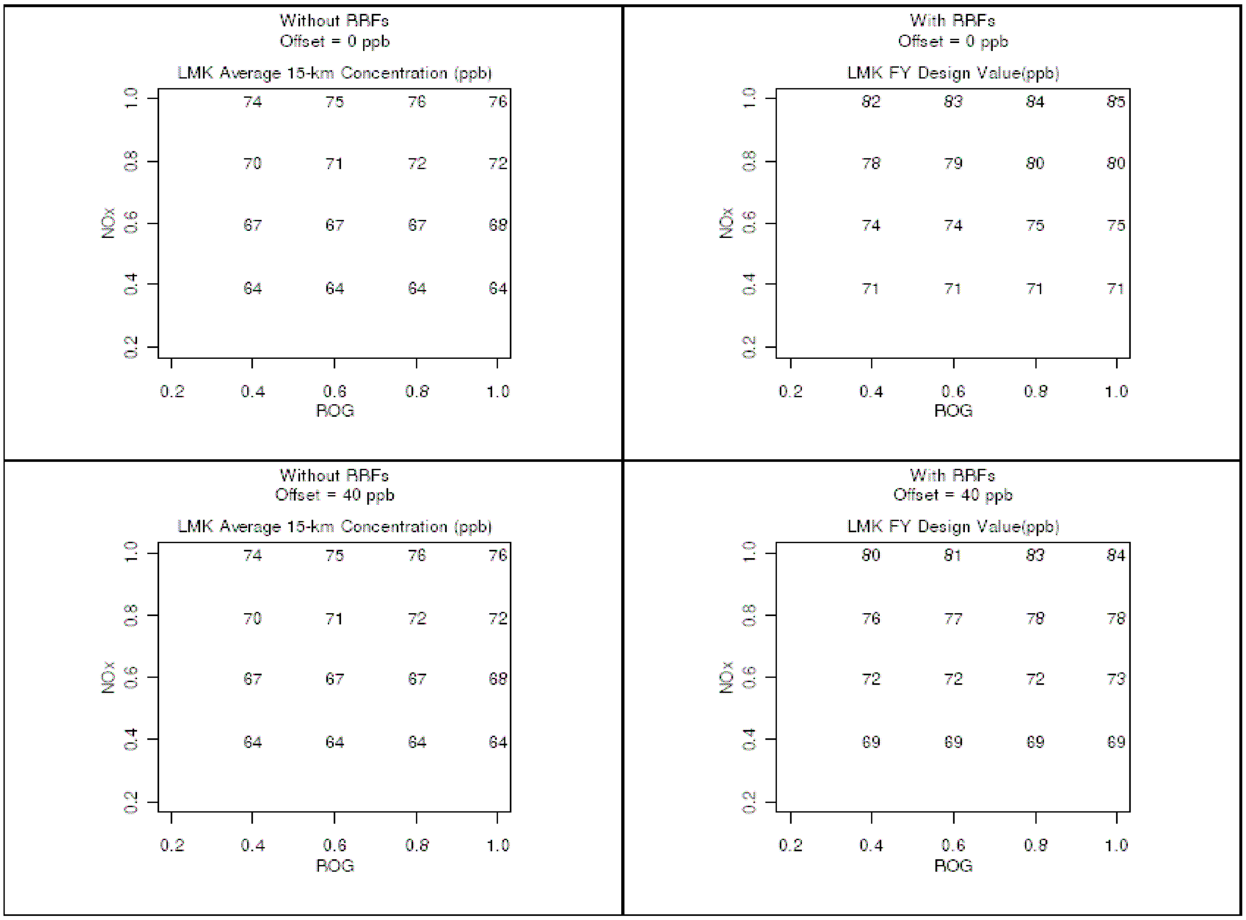
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: HAN - Hanford Stn (Irwin St.) **Subregion:** 7 **Baseline Year Design Value:** 95 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	90	96	105	94	97	92	89	86	102	105
Peak Simulated 8-hour Ozone	79	74	77	82	72	82	84	94	96	98
Peak Simulated 8-hour Ozone within 15 km	82	75	80	83	75	87	93	104	99	99
Baseline Year 15-km, 8-hour Average Ozone	96									
Future Year 15-km, 8-hour Average Ozone	70	64	69	71	65	71	77	86	82	84
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes



Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: LMK - Mineral King Lookout Po **Subregion:** 11 **Baseline Year Design Value:** 103 ppb

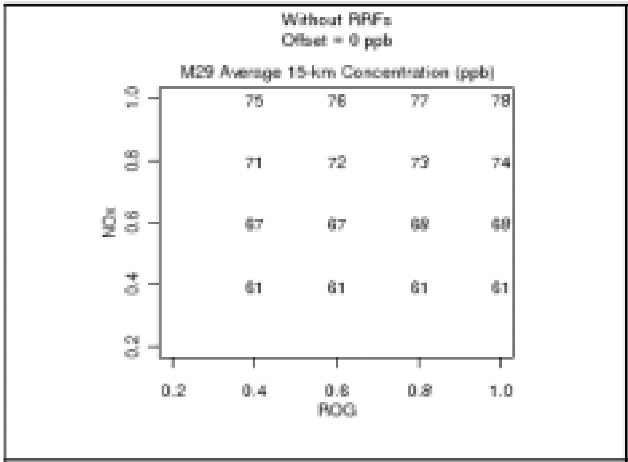
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	102	106	97	68	67	101	96	98	82	-99
Peak Simulated 8-hour Ozone	71	63	59	64	67	80	78	83	79	74
Peak Simulated 8-hour Ozone within 15 km	90	78	67	73	71	88	91	96	93	88
Baseline Year 15-km, 8-hour Average Ozone	92									
Future Year 15-km, 8-hour Average Ozone	72	66	64	63	64	72	76	79	78	76
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No

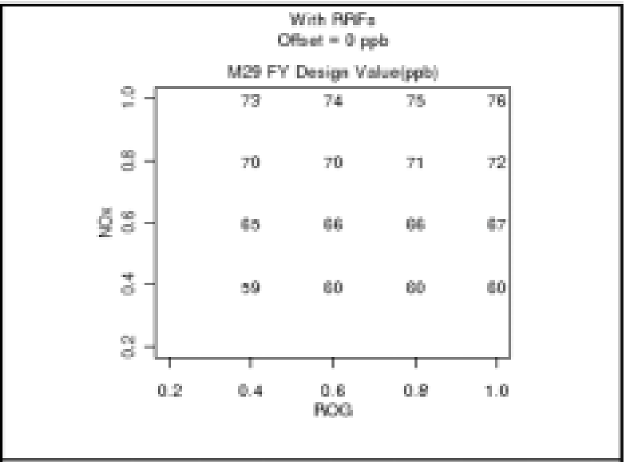


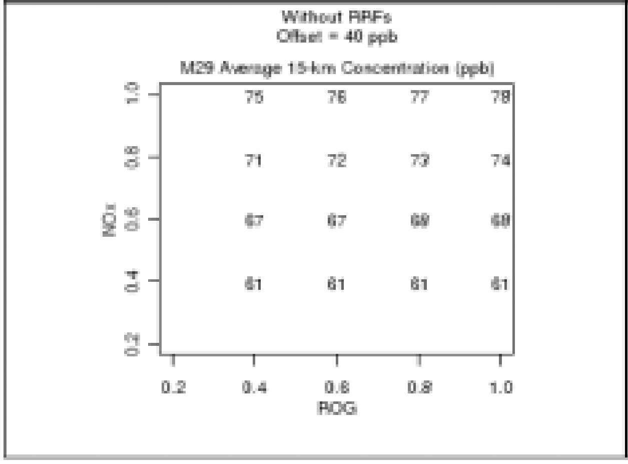
Year: 2020 **Model:** CAMX/MM5/SAPRC99

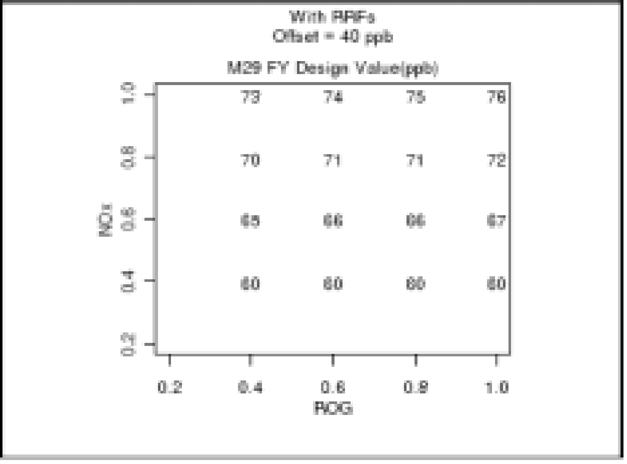
Site: M29 - Madera Stn (29 1/2 No. **Subregion:** 7 **Baseline Year Design Value:** 91 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	74	80	92	89	95	71	66	69	84	80
Peak Simulated 8-hour Ozone	81	82	84	83	78	86	88	98	94	97
Peak Simulated 8-hour Ozone within 15 km	83	87	86	89	89	89	93	102	99	105
Baseline Year 15-km, 8-hour Average Ozone	93									
Future Year 15-km, 8-hour Average Ozone	73	73	74	76	74	74	79	86	81	89
Use in RRF Analysis?	No	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes



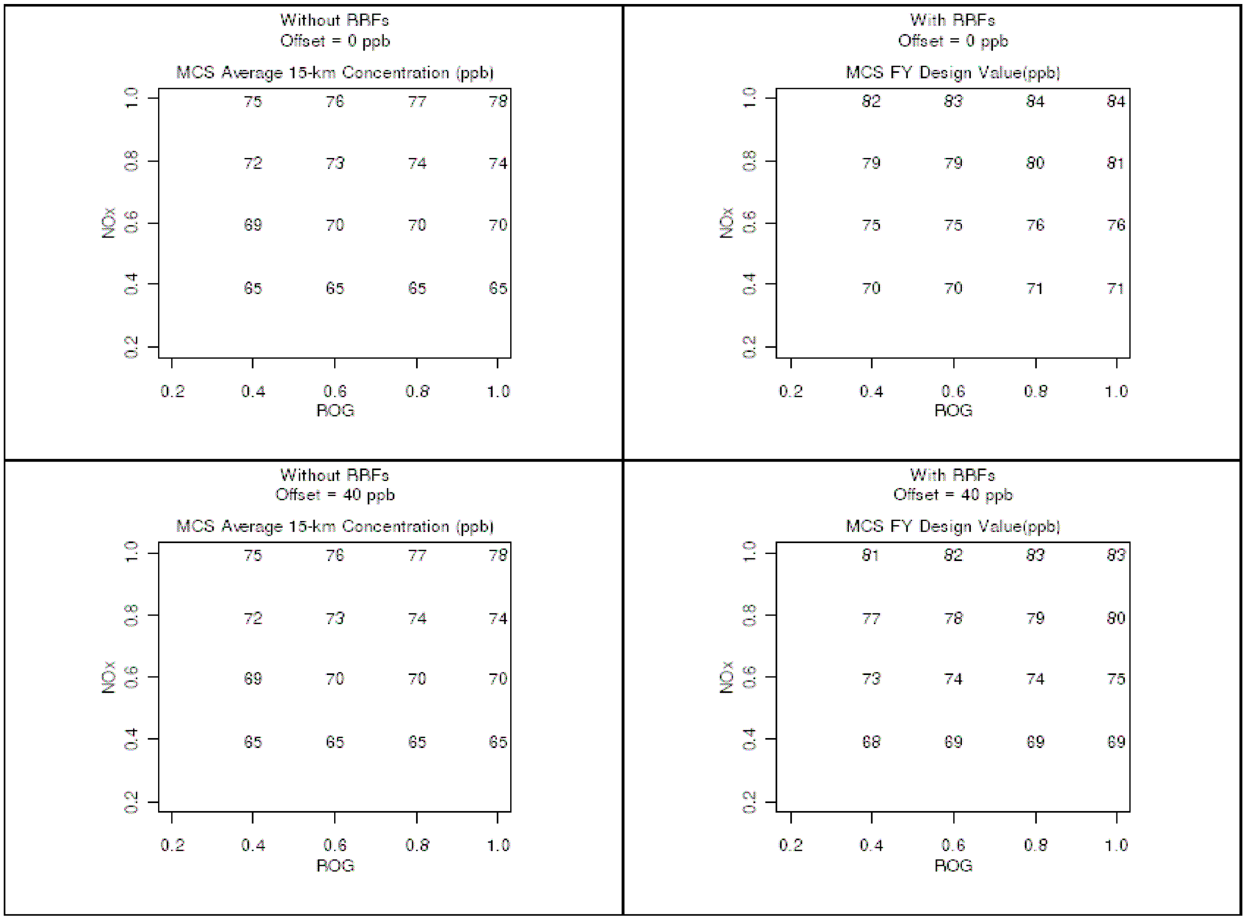






Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: MCS - Maricopa School/Stanisl **Subregion:** 8 **Baseline Year Design Value:** 98 ppb

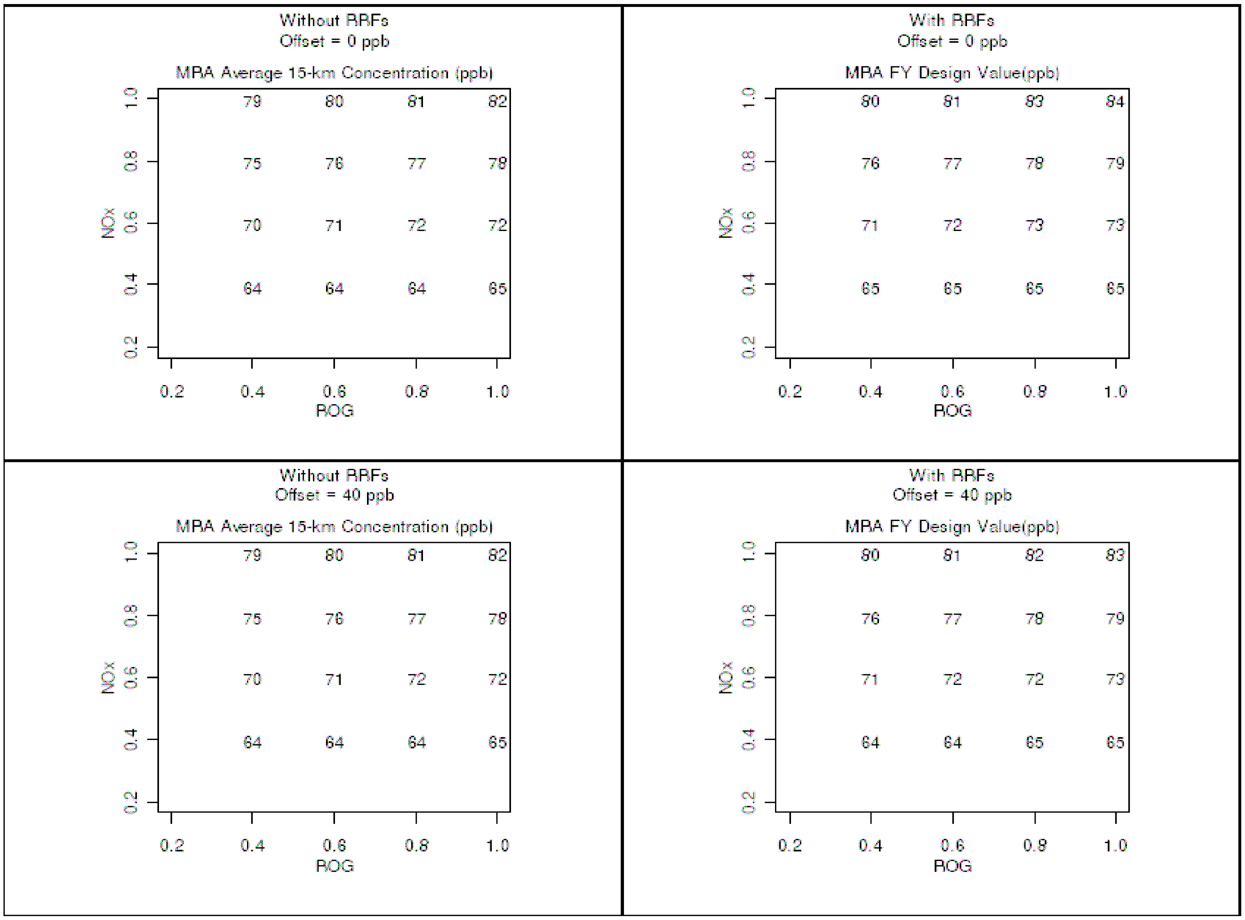
Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	87	81	84	57	61	95	91	86	77	10
Peak Simulated 8-hour Ozone	78	77	74	71	73	85	89	88	89	90
Peak Simulated 8-hour Ozone within 15 km	80	77	76	74	74	87	91	90	91	94
Baseline Year 15-km, 8-hour Average Ozone	90									
Future Year 15-km, 8-hour Average Ozone	66	67	67	67	67	73	79	79	80	81
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No



Year: 2020 **Model:** CAMX/MM5/SAPRC99

Site: MRA - Merced Stn (385 S Coffe **Subregion:** 7 **Baseline Year Design Value:** 101 ppb

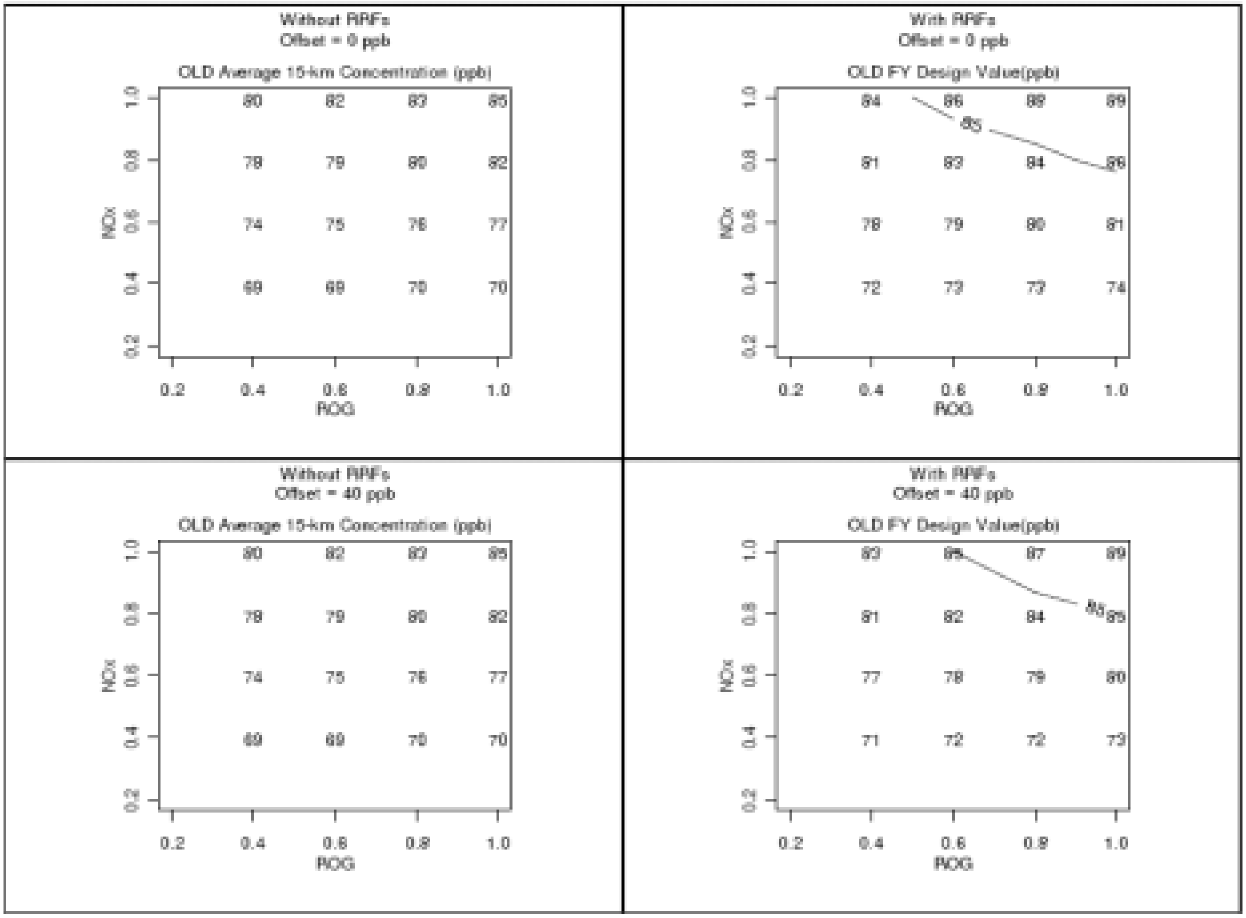
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	97	106	113	116	117	99	88	97	103	112
Peak Simulated 8-hour Ozone	83	91	89	114	80	88	77	97	102	92
Peak Simulated 8-hour Ozone within 15 km	90	98	92	115	84	92	83	103	105	99
Baseline Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	78	84	74	90	72	78	72	85	87	83
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes



Year: 2020 **Model:** CAMX/MM5/SAPRC99

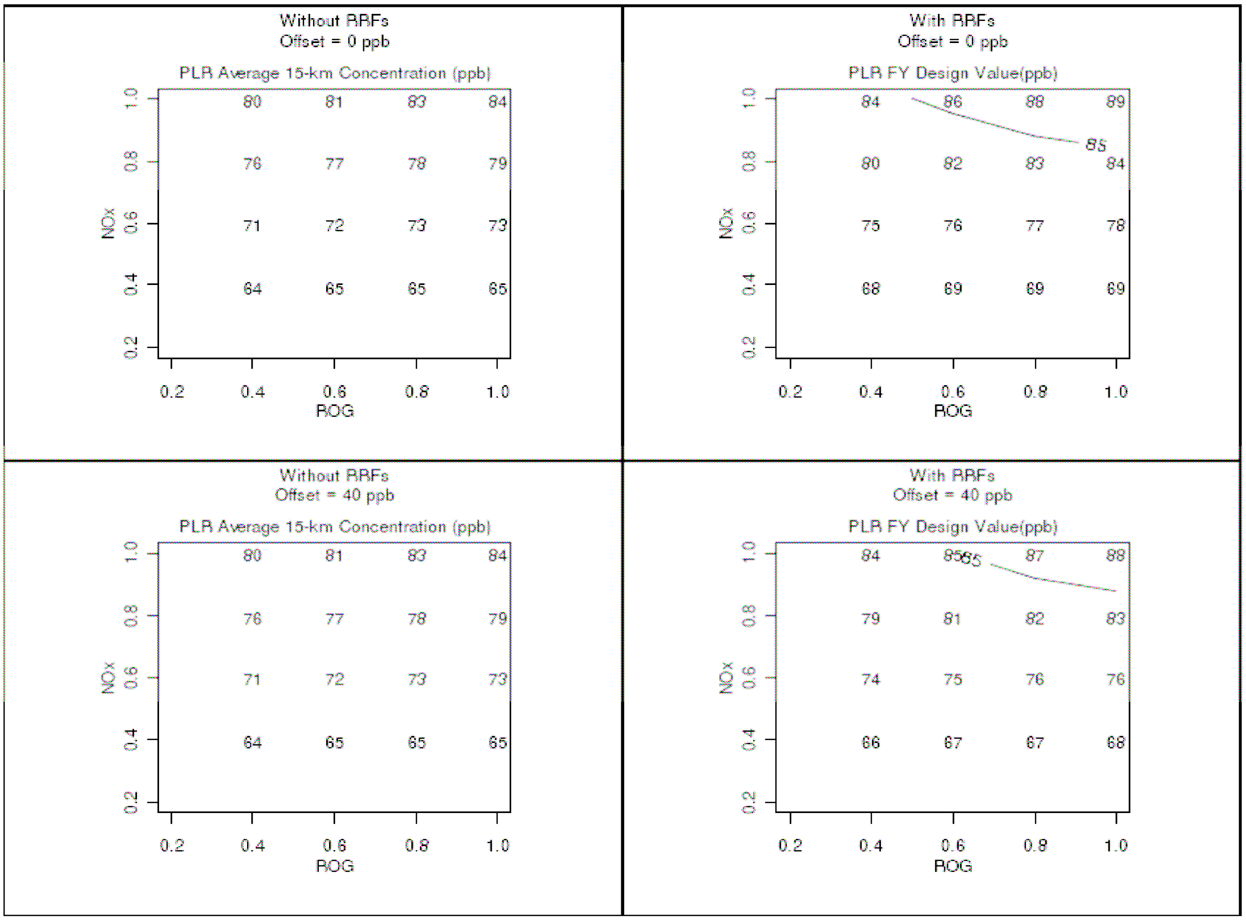
Site: OLD - Oildale Stn (3311 Manor **Subregion:** 8 **Baseline Year Design Value:** 99 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	92	95	88	59	77	92	85	81	98	103
Peak Simulated 8-hour Ozone	77	77	75	72	78	83	87	88	86	91
Peak Simulated 8-hour Ozone within 15 km	87	86	83	78	83	94	97	92	91	98
Baseline Year 15-km, 8-hour Average Ozone						94				
Future Year 15-km, 8-hour Average Ozone	76	76	75	75	79	86	86	87	81	94
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No



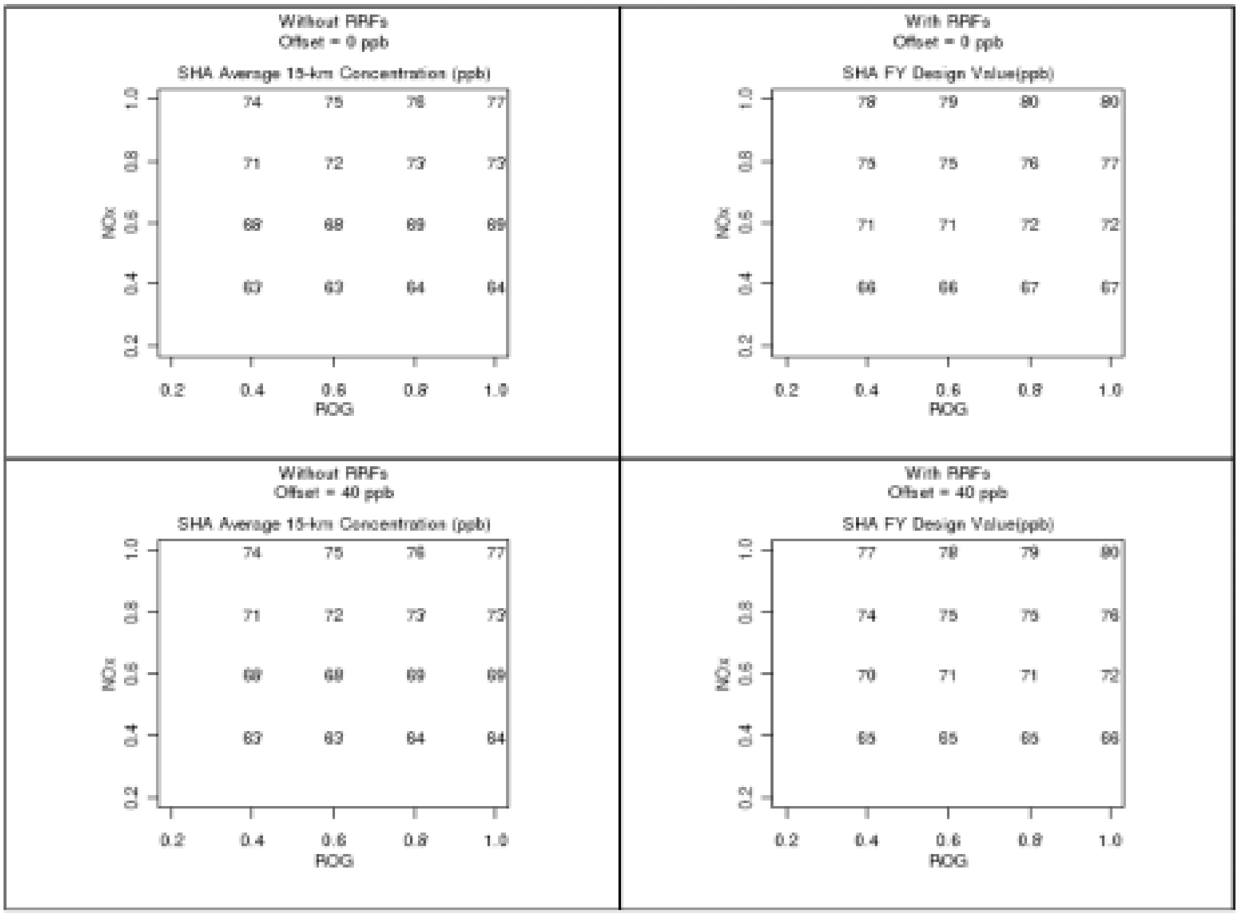
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: PLR - Parlier Stn **Subregion:** 7 **Baseline Year Design Value:** 108 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	102	104	105	82	84	108	106	88	88	88
Peak Simulated 8-hour Ozone	93	89	88	80	77	96	101	107	107	103
Peak Simulated 8-hour Ozone within 15 km	95	95	97	89	80	100	101	108	116	112
Baseline Year 15-km, 8-hour Average Ozone	101									
Future Year 15-km, 8-hour Average Ozone	80	80	79	73	68	84	84	90	94	92
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes



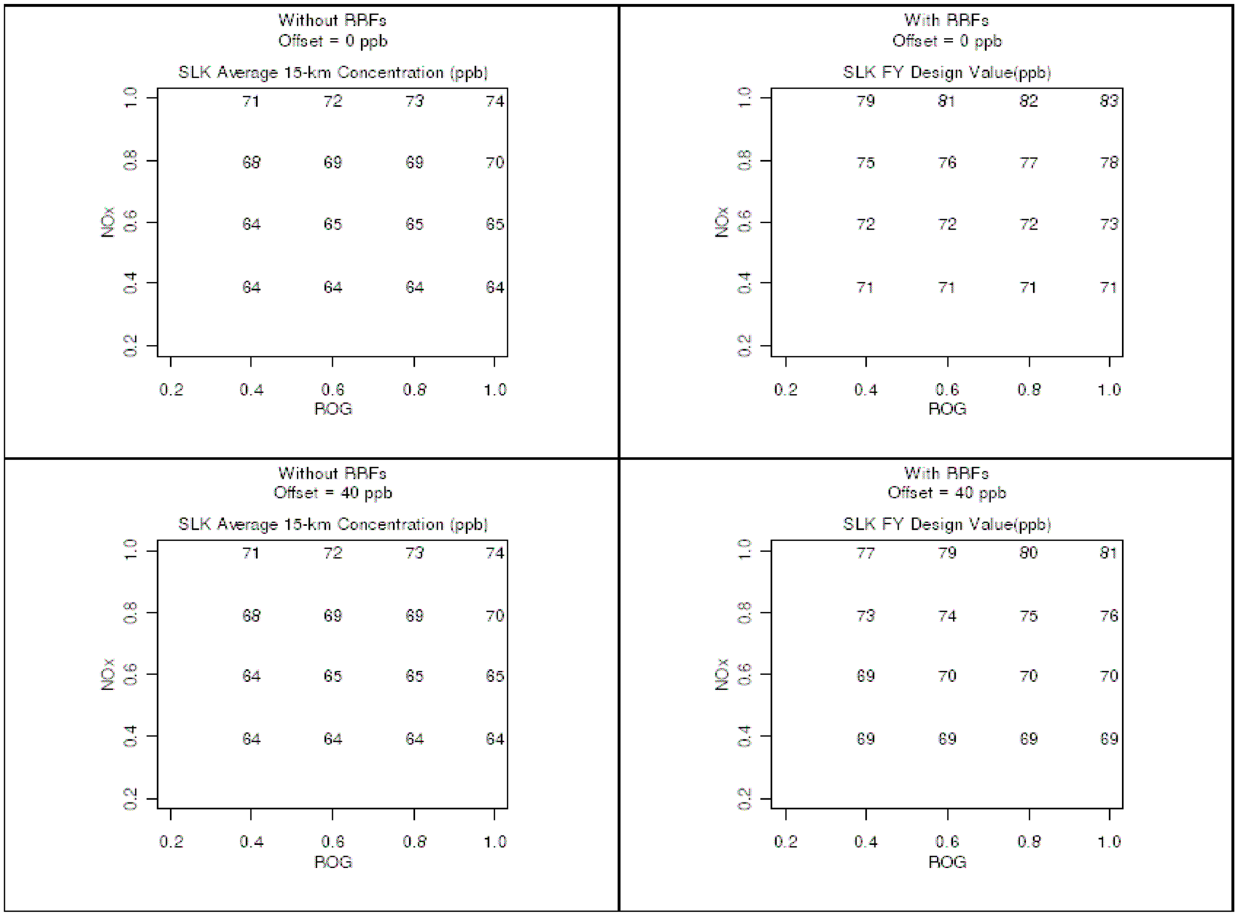
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: SHA - Shafter Stn (Walker St. **Subregion:** 8 **Baseline Year Design Value:** 94 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	94	94	95	62	80	86	78	79	91	77
Peak Simulated 8-hour Ozone	77	73	73	71	74	81	85	88	91	94
Peak Simulated 8-hour Ozone within 15 km	79	77	76	75	82	86	88	91	92	96
Baseline Year 15-km, 8-hour Average Ozone	89									
Future Year 15-km, 8-hour Average Ozone	67	66	65	67	72	72	76	79	80	83
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No



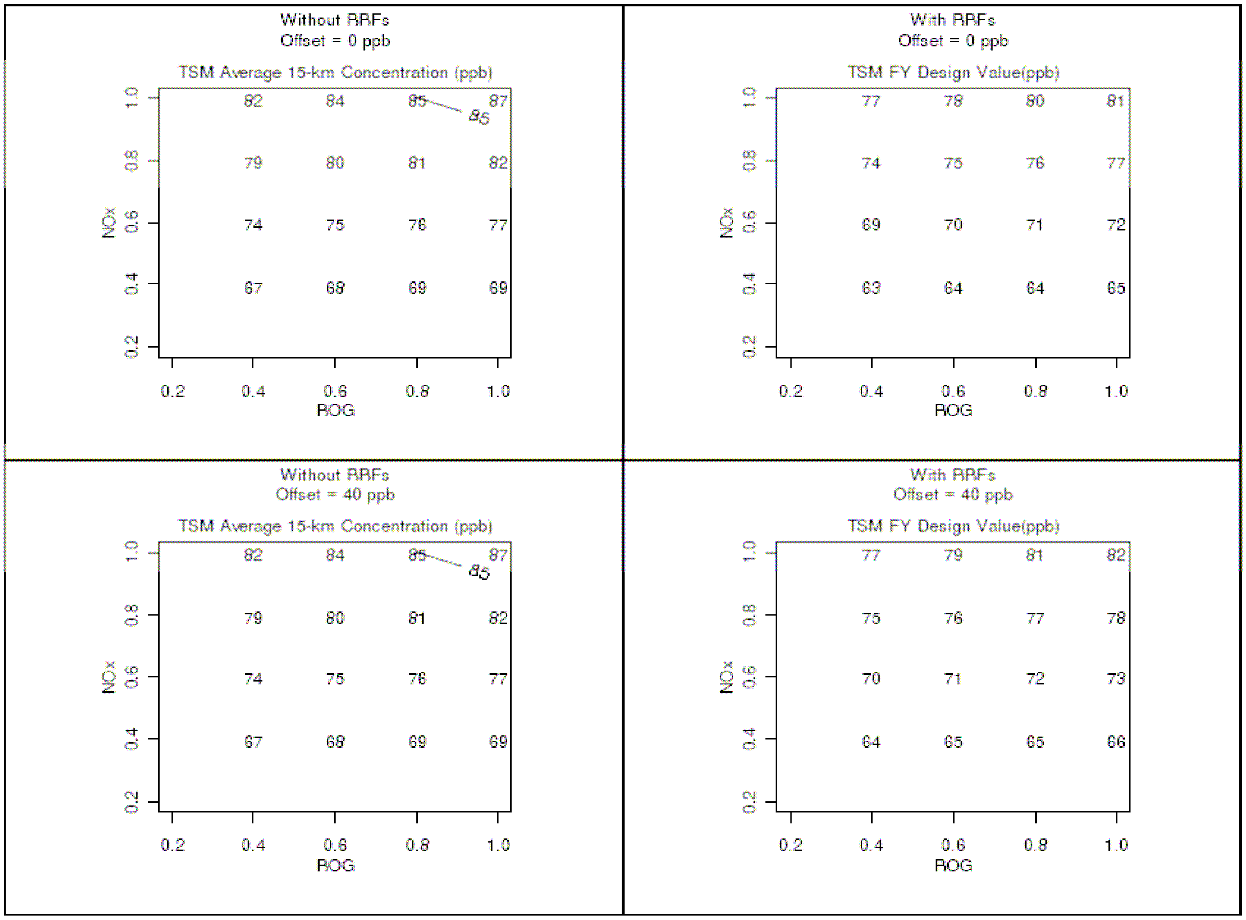
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: SLK - Sequoia Lower Keawah St **Subregion:** 11 **Baseline Year Design Value:** 100 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	93	81	73	60	58	72	70	69	61	54
Peak Simulated 8-hour Ozone	67	60	58	63	67	81	77	80	79	75
Peak Simulated 8-hour Ozone within 15 km	84	74	64	70	71	88	90	94	92	87
Baseline Year 15-km, 8-hour Average Ozone	89									
Future Year 15-km, 8-hour Average Ozone	68	64	62	62	63	72	76	78	77	75
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	No	No	No



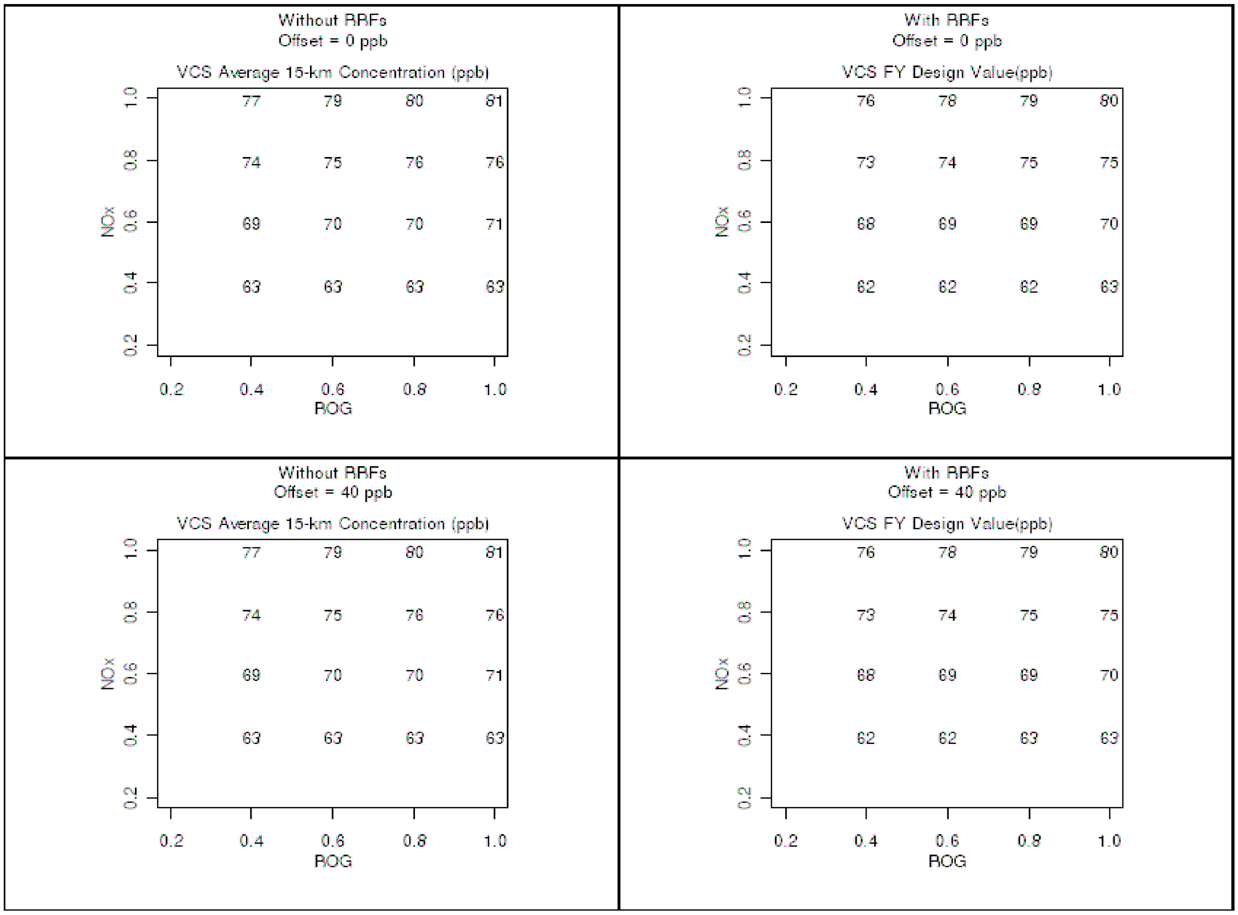
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: TSM - Turlock Stn (900 S Mina **Subregion:** 9 **Baseline Year Design Value:** 95 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Pass	Fail	Pass	Fail	Fail	Pass	Fail	Fail	Fail	Pass
Peak Observed 8-hour Ozone	73	80	91	99	84	91	73	84	91	108
Peak Simulated 8-hour Ozone	87	103	98	109	82	91	80	95	102	98
Peak Simulated 8-hour Ozone within 15 km	91	106	112	114	90	96	88	102	107	103
Baseline Year 15-km, 8-hour Average Ozone	101									
Future Year 15-km, 8-hour Average Ozone	85	91	90	90	79	83	80	87	92	88
Use in RRF Analysis?	Yes	No	Yes	No	No	Yes	No	No	No	Yes



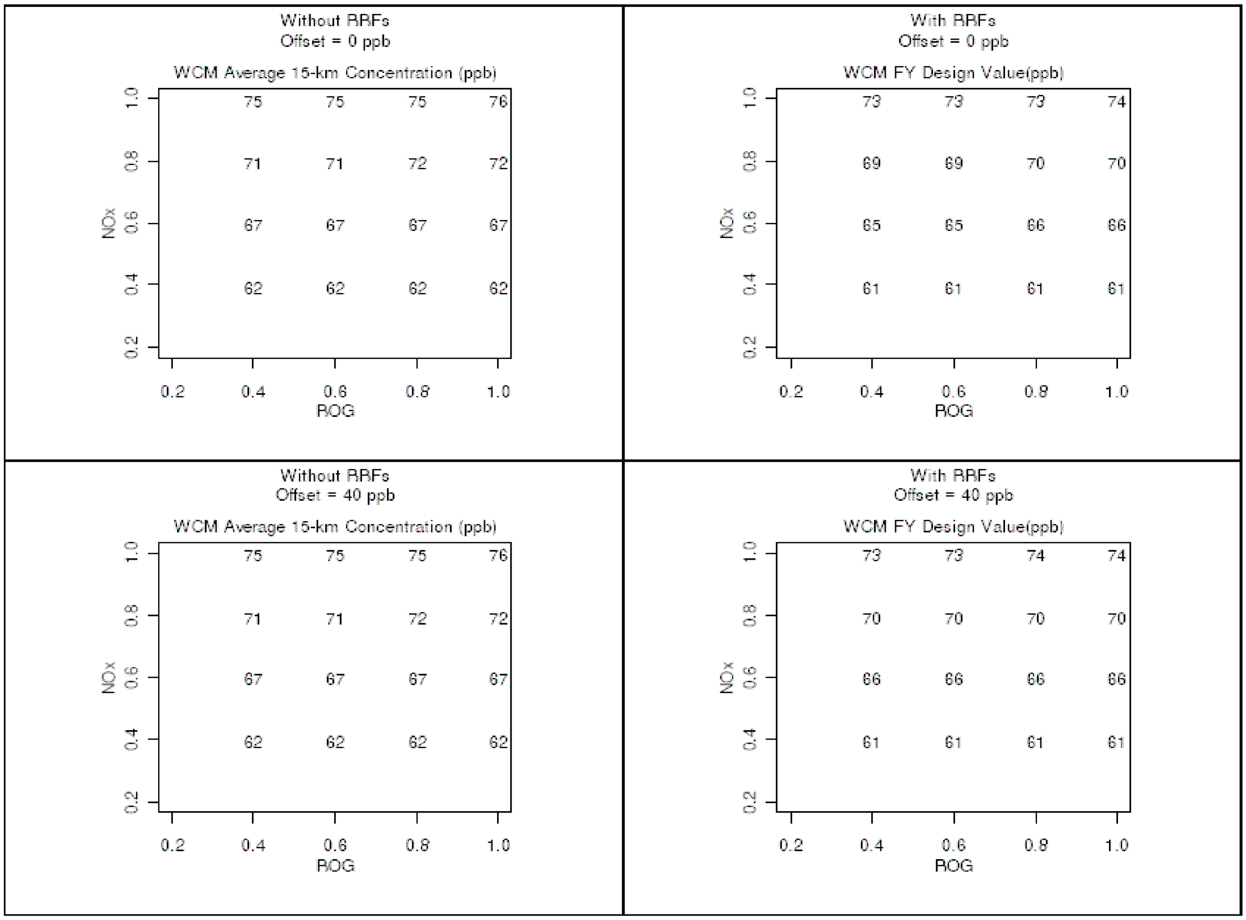
Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: VCS - Visalia Stn (Church St. **Subregion:** 7 **Baseline Year Design Value:** 98 ppb

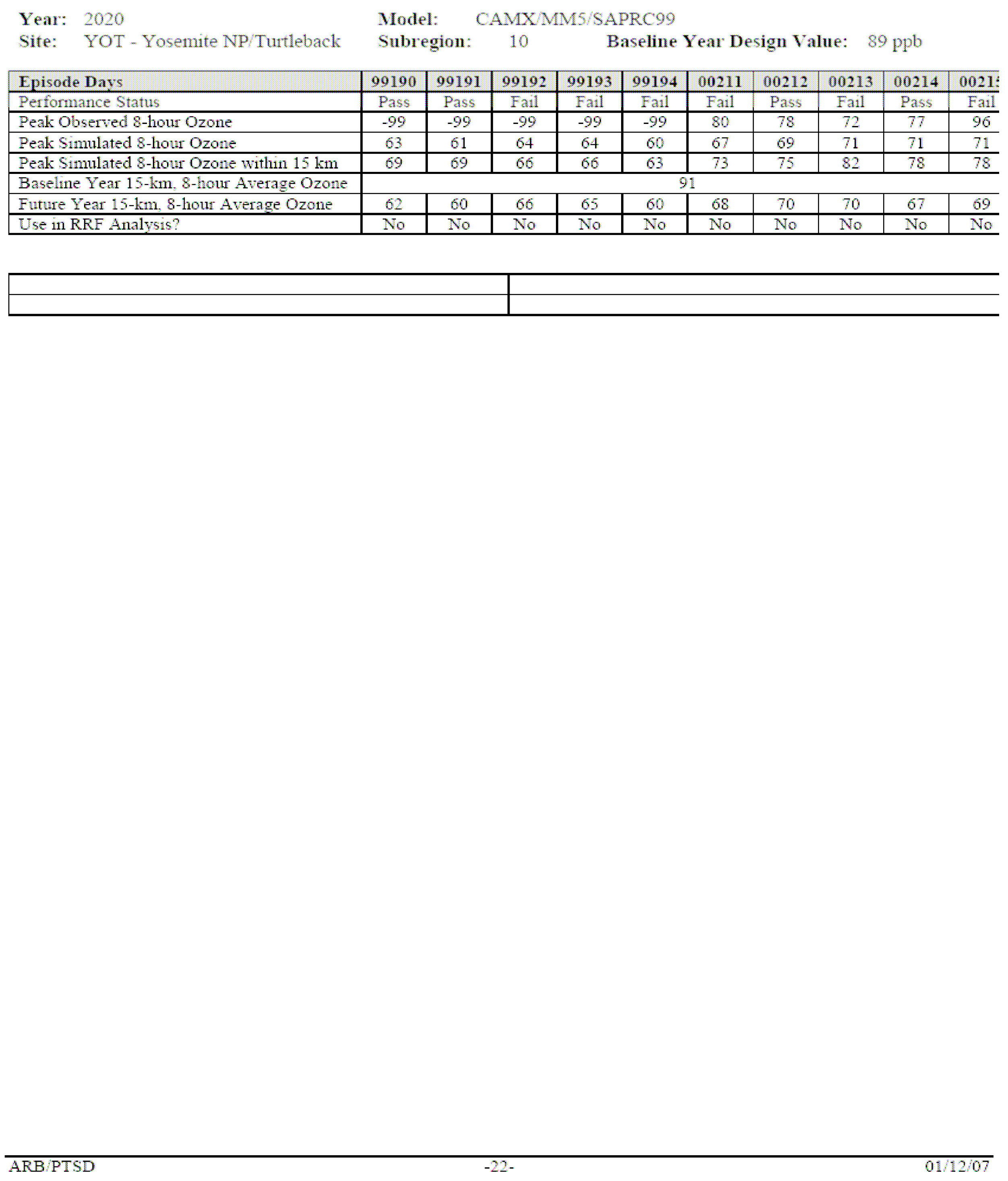
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	94	99	107	87	86	94	95	83	90	94
Peak Simulated 8-hour Ozone	88	80	79	78	73	93	96	104	102	96
Peak Simulated 8-hour Ozone within 15 km	94	90	84	84	76	96	98	106	105	101
Baseline Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	77	73	70	69	67	78	81	87	86	84
Use in RRF Analysis?	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes



Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: WCM - White Cloud Mtn. Stn **Subregion:** 13 **Baseline Year Design Value:** 90 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	102	85	83	85	91	75	79	72	66	108
Peak Simulated 8-hour Ozone	72	64	71	72	66	73	74	68	70	81
Peak Simulated 8-hour Ozone within 15 km	79	71	81	75	70	75	77	72	80	92
Baseline Year 15-km, 8-hour Average Ozone	92									
Future Year 15-km, 8-hour Average Ozone	65	60	65	64	62	68	69	65	66	76
Use in RRF Analysis?	No	No	No	No	No	No	No	No	No	Yes



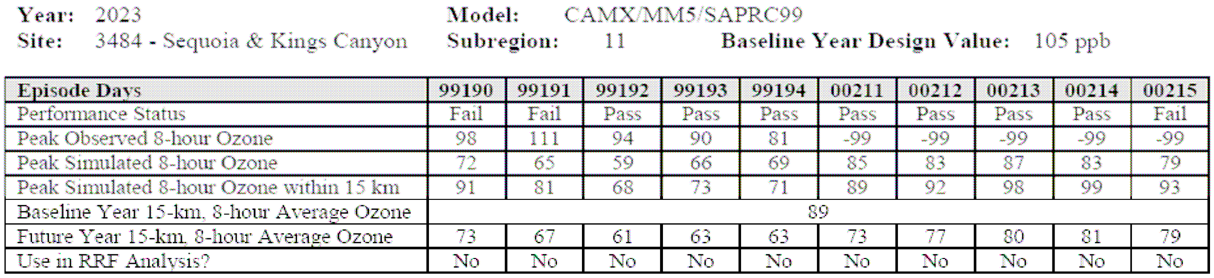


Year: 2020 **Model:** CAMX/MM5/SAPRC99
Site: YOT - Yosemite NP/Turtleback **Subregion:** 10 **Baseline Year Design Value:** 89 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**0021**
Performance Status	Pass	Pass	Fail	Fail	Fail	Fail	Pass	Fail	Pass	Fail
Peak Observed 8-hour Ozone	-99	-99	-99	-99	-99	80	78	72	77	96
Peak Simulated 8-hour Ozone	63	61	64	64	60	67	69	71	71	71
Peak Simulated 8-hour Ozone within 15 km	69	69	66	66	63	73	75	82	78	78
Baseline Year 15-km, 8-hour Average Ozone	91									
Future Year 15-km, 8-hour Average Ozone	62	60	66	65	60	68	70	70	67	69
Use in RRF Analysis?	No	No	No	No	No	No	No	No	No	No

ARB/PTSD -22- 01/12/07

F.6 FUTURE YEAR, 2023 CARRYING CAPACITIES



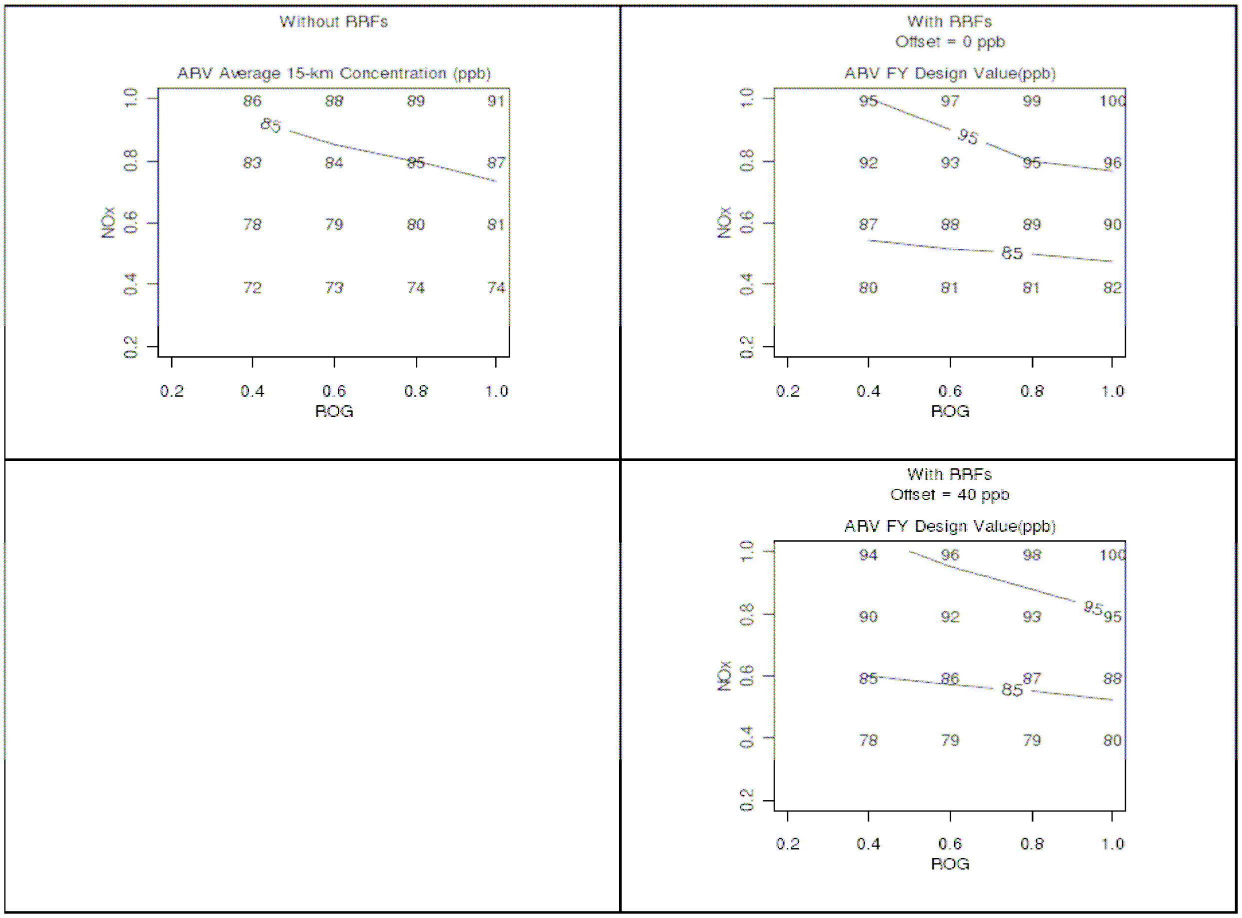
Year: 2023 **Model:** CAMX/MM5/SAPRC99

Site: 3484 - Sequoia & Kings Canyon **Subregion:** 11 **Baseline Year Design Value:** 105 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	98	111	94	90	81	-99	-99	-99	-99	-99
Peak Simulated 8-hour Ozone	72	65	59	66	69	85	83	87	83	79
Peak Simulated 8-hour Ozone within 15 km	91	81	68	73	71	89	92	98	99	93
Baseline Year 15-km, 8-hour Average Ozone	89									
Future Year 15-km, 8-hour Average Ozone	73	67	61	63	63	73	77	80	81	79
Use in RRF Analysis?	No	No	No	No	No	No	No	No	No	No

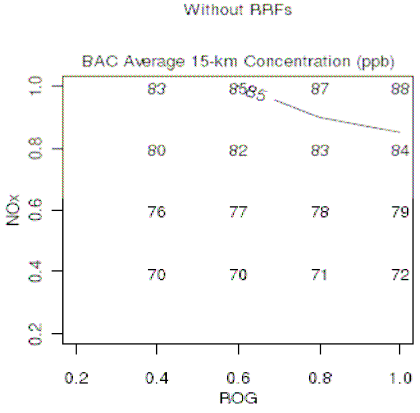
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: ARV - Arvin Stn **Subregion:** 8 **Baseline Year Design Value:** 114 ppb

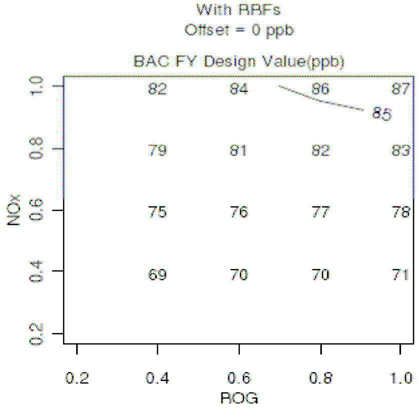
Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	102	109	92	54	70	-99	-99	93	105	98
Peak Simulated 8-hour Ozone	84	90	88	76	81	95	98	105	95	88
Peak Simulated 8-hour Ozone within 15 km	94	94	91	81	86	99	103	106	99	98
Baseline Year 15-km, 8-hour Average Ozone	102									
Future Year 15-km, 8-hour Average Ozone	78	80	78	76	78	88	90	94	88	92
Use in RRF Analysis?	No	No	No	No	No	No	No	Yes	Yes	No

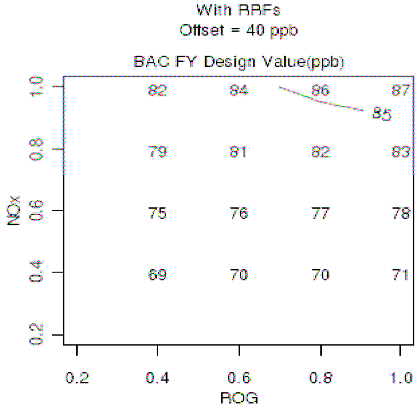


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: BAC - Bakersfield Stn (5558 C **Subregion:** 8 **Baseline Year Design Value:** 99 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	94	97	97	51	72	96	87	84	93	107
Peak Simulated 8-hour Ozone	77	76	77	73	76	86	89	87	87	92
Peak Simulated 8-hour Ozone within 15 km	84	85	83	79	82	100	104	100	94	100
Baseline Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	73	75	74	75	78	86	91	91	84	94
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No

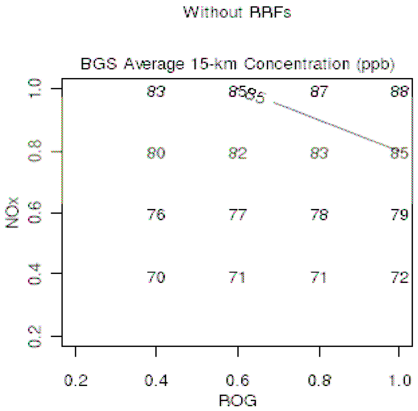


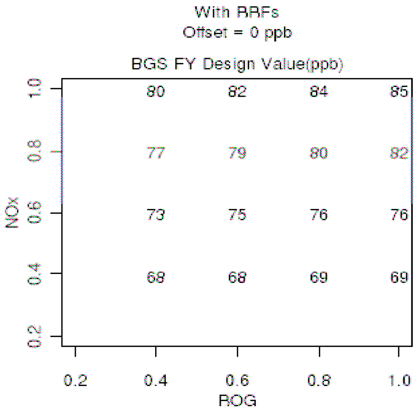


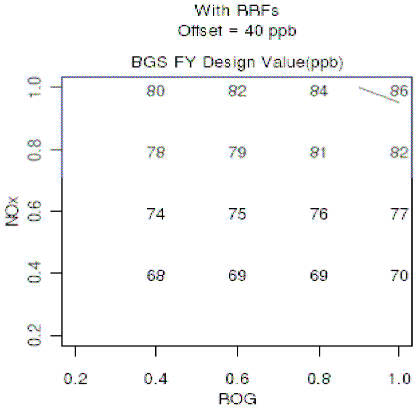


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: BGS - Bakersfield Stn (1128 G **Subregion:** 8 **Baseline Year Design Value:** 96 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	91	95	93	50	68	98	92	78	93	101
Peak Simulated 8-hour Ozone	70	74	72	64	70	78	86	80	81	84
Peak Simulated 8-hour Ozone within 15 km	90	91	87	81	84	99	101	102	93	99
Baseline Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	78	79	76	76	79	88	90	93	83	95
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No

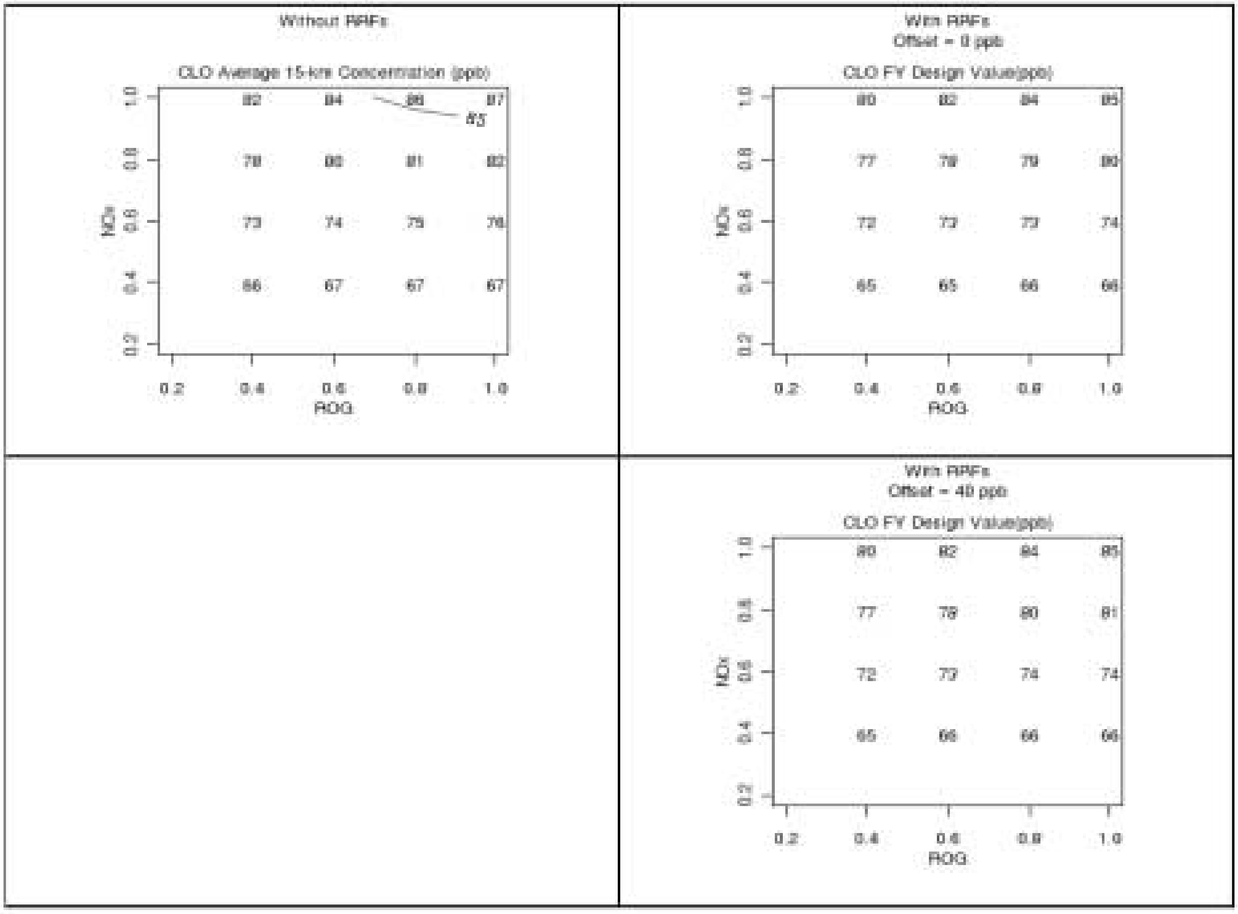






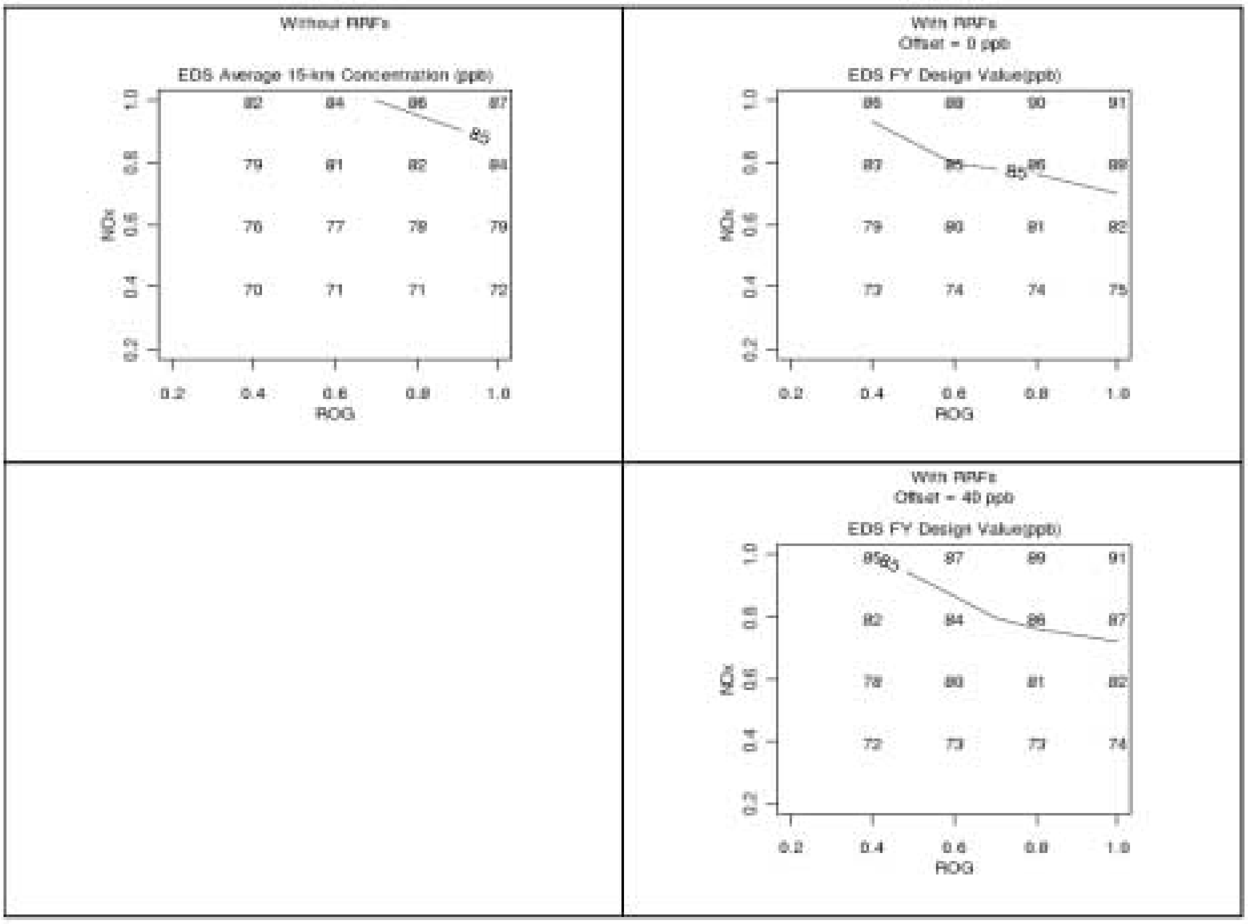
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: CLO - Clovis Stn (908 N Villa **Subregion:** 7 **Baseline Year Design Value:** 101 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	94	99	122	104	98	98	96	102	92	99
Peak Simulated 8-hour Ozone	81	85	93	100	86	95	93	100	99	111
Peak Simulated 8-hour Ozone within 15 km	88	95	101	103	89	102	99	105	112	118
Baseline Year 15-km, 8-hour Average Ozone	103									
Future Year 15-km, 8-hour Average Ozone	80	80	85	85	73	87	85	92	92	97
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes



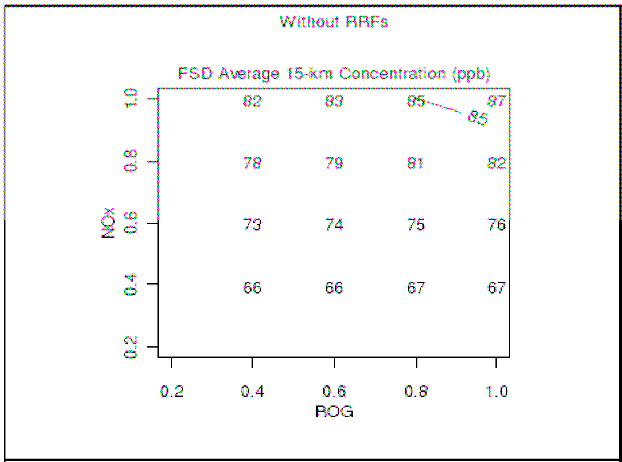
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: EDS - Edison Stn **Subregion:** 8 **Baseline Year Design Value:** 103 ppb

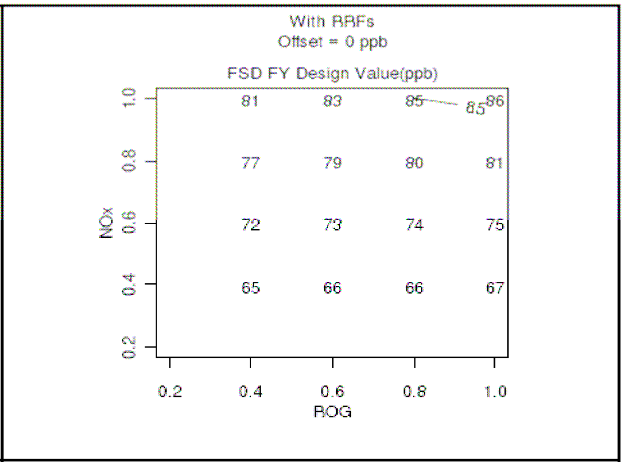
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	95	97	96	46	71	105	99	96	103	113
Peak Simulated 8-hour Ozone	88	87	81	79	83	94	92	91	88	96
Peak Simulated 8-hour Ozone within 15 km	94	94	91	81	86	100	104	106	95	100
Baseline Year 15-km, 8-hour Average Ozone	98									
Future Year 15-km, 8-hour Average Ozone	79	80	78	76	79	88	91	94	84	95
Use in RRF Analysis?	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No

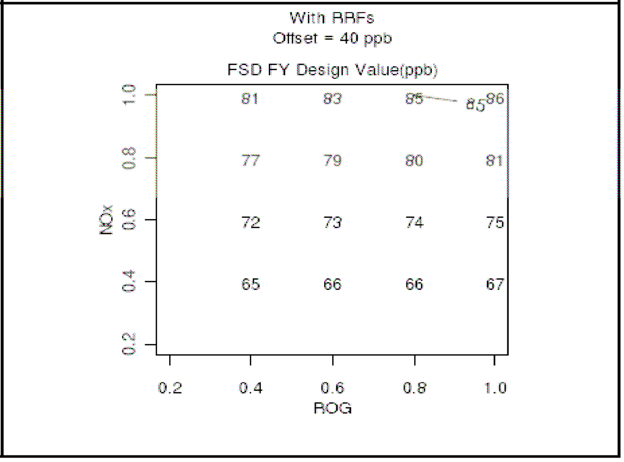


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: FSD - Fresno Stn (Drummond) **Subregion:** 7 **Baseline Year Design Value:** 102 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	84	94	107	93	91	91	93	85	84	91
Peak Simulated 8-hour Ozone	81	84	101	82	76	89	98	97	97	106
Peak Simulated 8-hour Ozone within 15 km	88	94	101	101	87	102	100	105	109	117
Baseline Year 15-km, 8-hour Average Ozone	102									
Future Year 15-km, 8-hour Average Ozone	80	80	85	85	72	87	85	92	91	96
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes

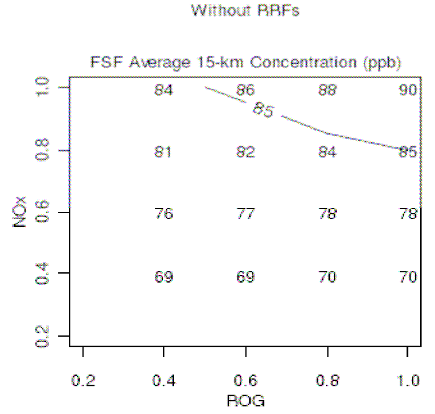


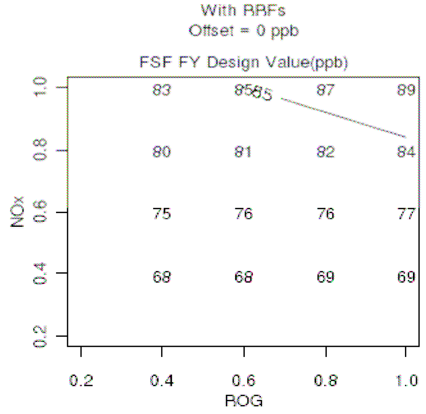


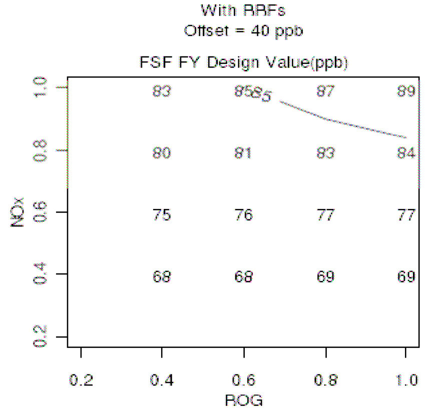


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: FSF - Fresno Stn (3425 First **Subregion:** 7 **Baseline Year Design Value:** 104 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	-99	-99	-99	-99	-99	98	99	97	95	98
Peak Simulated 8-hour Ozone	78	82	94	88	79	88	95	96	94	104
Peak Simulated 8-hour Ozone within 15 km	85	92	101	103	89	100	99	104	105	116
Baseline Year 15-km, 8-hour Average Ozone	105									
Future Year 15-km, 8-hour Average Ozone	79	79	85	85	73	87	85	92	88	97
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

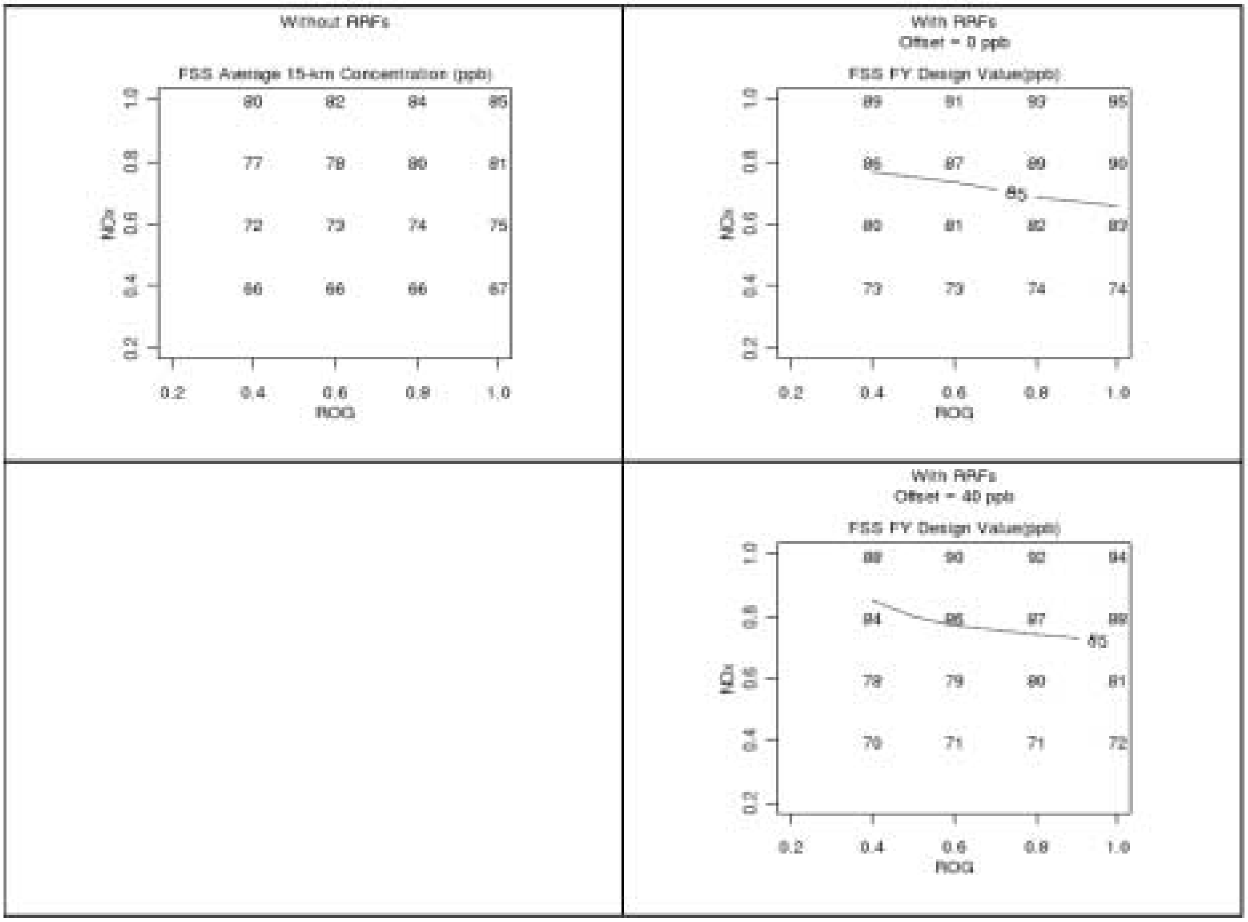

Without RRFs


With RRFs
Offset = 0 ppb


With RRFs
Offset = 40 ppb

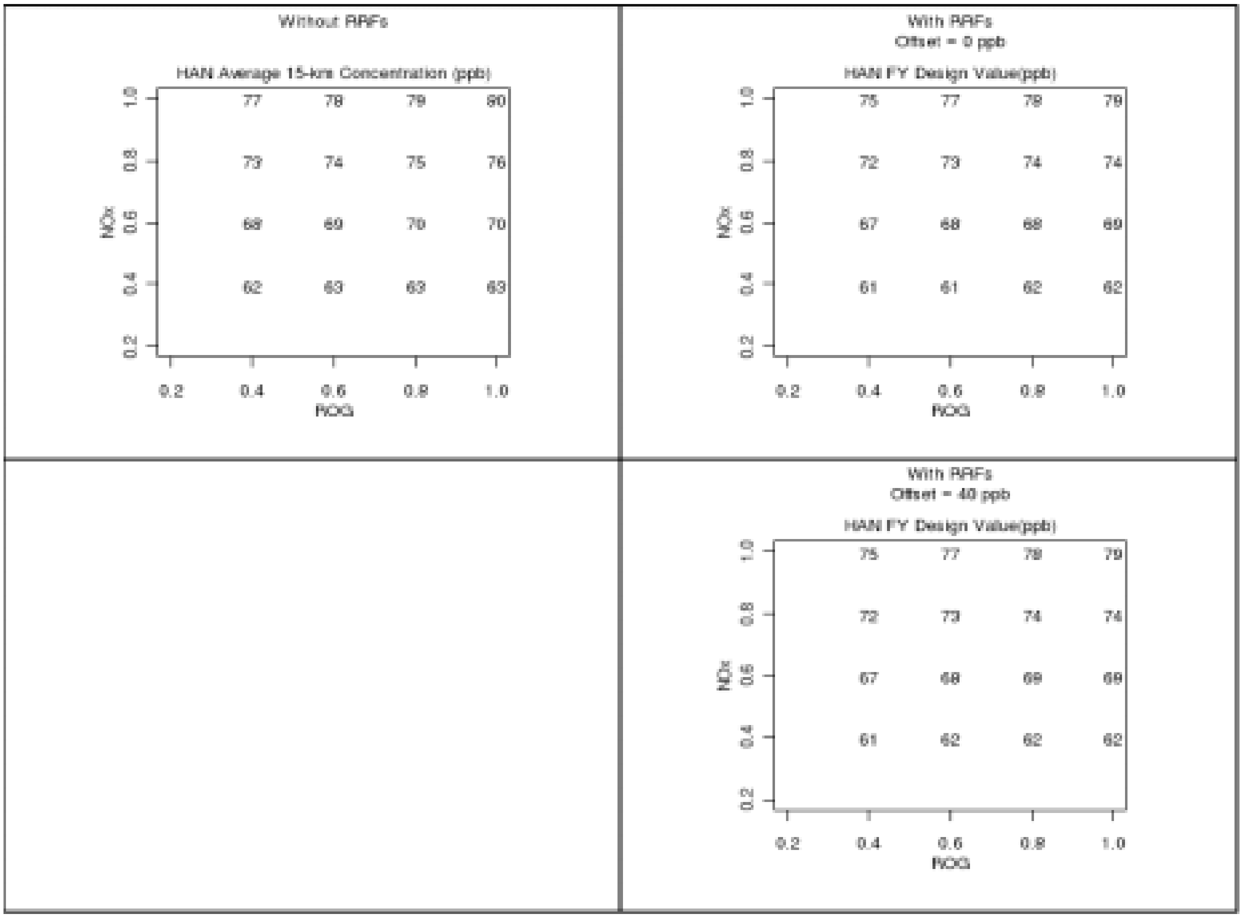
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: FSS - Fresno Sta (Sierra Skyp **Subregion:** 7 **Baseline Year Design Value:** 110 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	76	78	95	60	59	103	100	104	110	106
Peak Simulated 8-hour Ozone	82	84	86	87	80	88	93	98	94	103
Peak Simulated 8-hour Ozone within 15 km	83	86	101	99	89	92	98	103	98	109
Baseline Year 15-km, 8-hour Average Ozone	98									
Future Year 15-km, 8-hour Average Ozone	76	75	85	85	73	83	85	91	83	94
Use in RRF Analysis?	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes



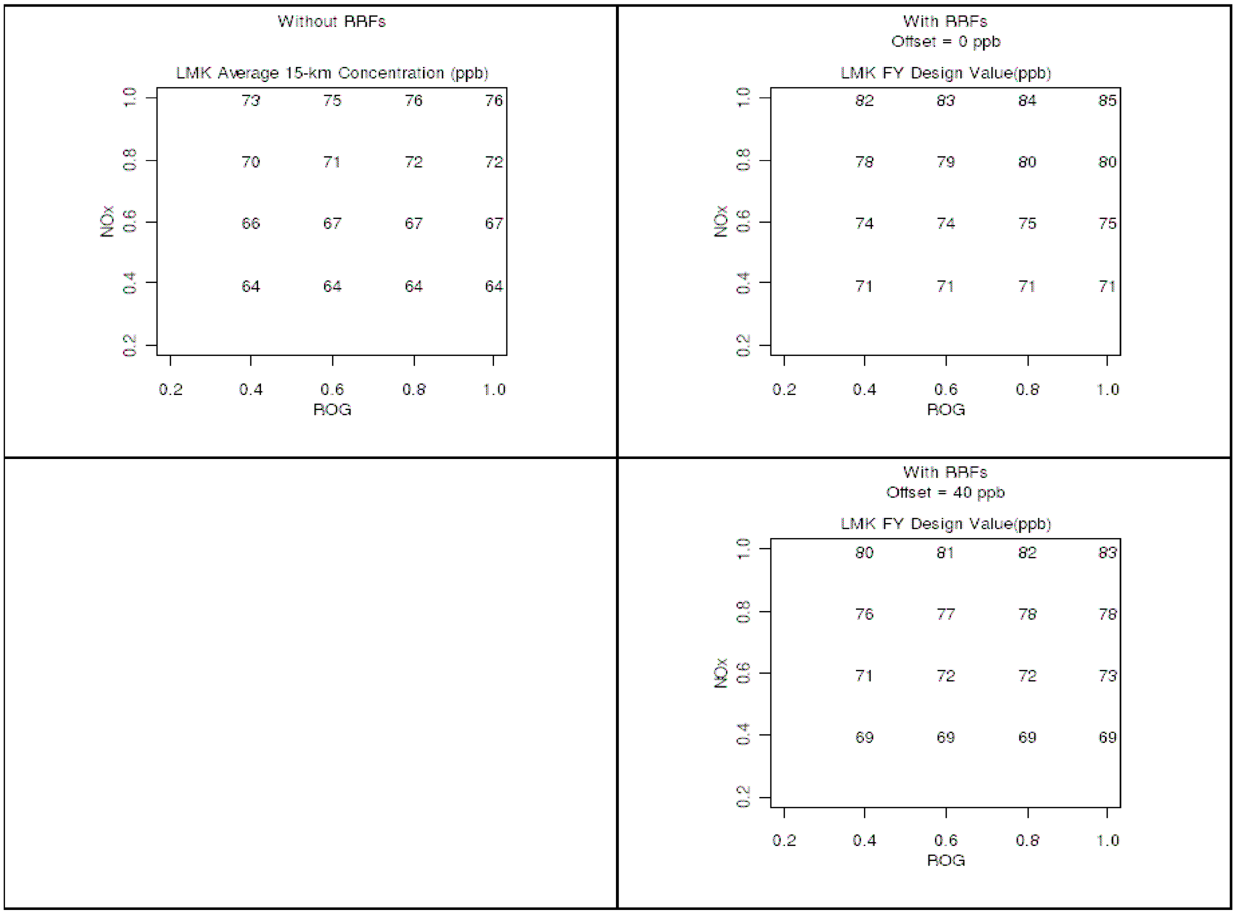
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: HAN - Hanford Stn (Irwin St.) **Subregion:** 7 **Baseline Year Design Value:** 95 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	90	96	105	94	97	92	89	86	102	105
Peak Simulated 8-hour Ozone	79	74	77	82	72	82	84	94	96	98
Peak Simulated 8-hour Ozone within 15 km	82	75	80	83	75	87	93	104	99	99
Baseline Year 15-km, 8-hour Average Ozone	96									
Future Year 15-km, 8-hour Average Ozone	70	64	68	70	65	71	78	87	83	84
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes



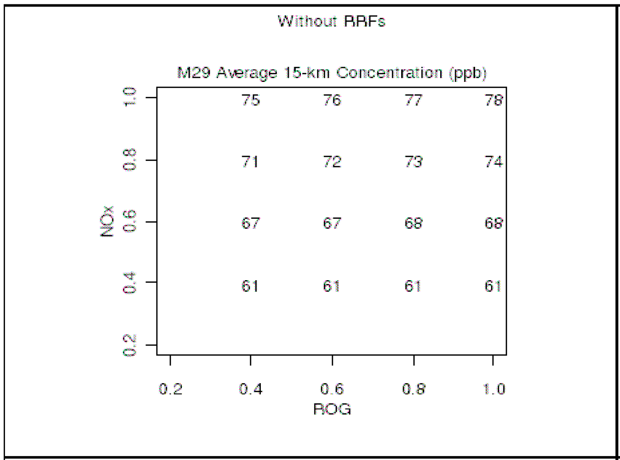
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: LMK - Mineral King Lookout Po **Subregion:** 11 **Baseline Year Design Value:** 103 ppb

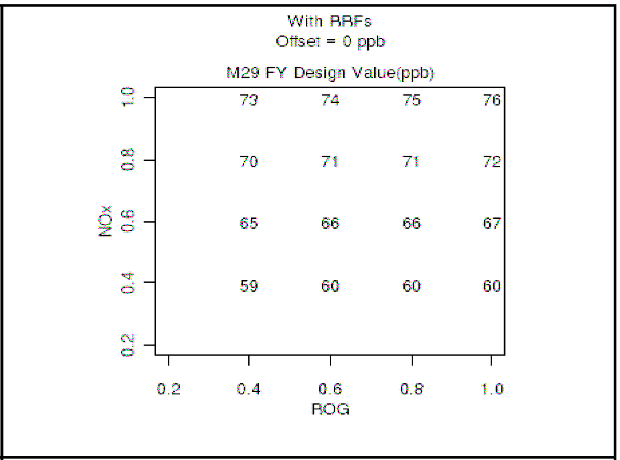
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	102	106	97	68	67	101	96	98	82	-99
Peak Simulated 8-hour Ozone	71	63	59	64	67	80	78	83	79	74
Peak Simulated 8-hour Ozone within 15 km	90	78	67	73	71	88	91	96	93	88
Baseline Year 15-km, 8-hour Average Ozone	92									
Future Year 15-km, 8-hour Average Ozone	72	66	64	63	63	73	76	79	78	76
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No

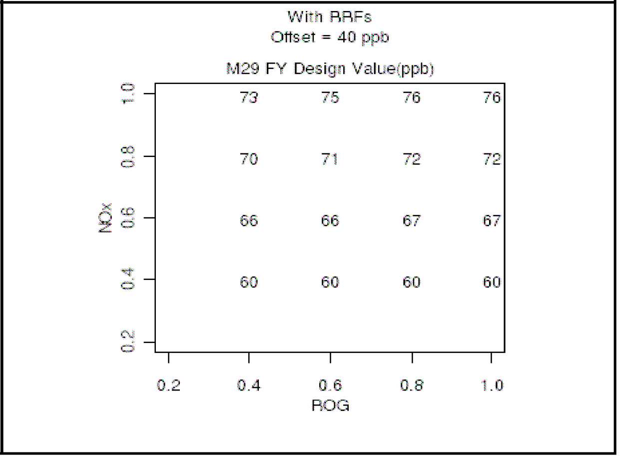


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: M29 - Madera Stn (29 1/2 No. **Subregion:** 7 **Baseline Year Design Value:** 91 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	74	80	92	89	95	71	66	69	84	80
Peak Simulated 8-hour Ozone	81	82	84	83	78	86	88	98	94	97
Peak Simulated 8-hour Ozone within 15 km	83	87	86	89	89	89	93	102	99	105
Baseline Year 15-km, 8-hour Average Ozone	93									
Future Year 15-km, 8-hour Average Ozone	73	73	74	75	73	75	80	87	82	89
Use in RRF Analysis?	No	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes

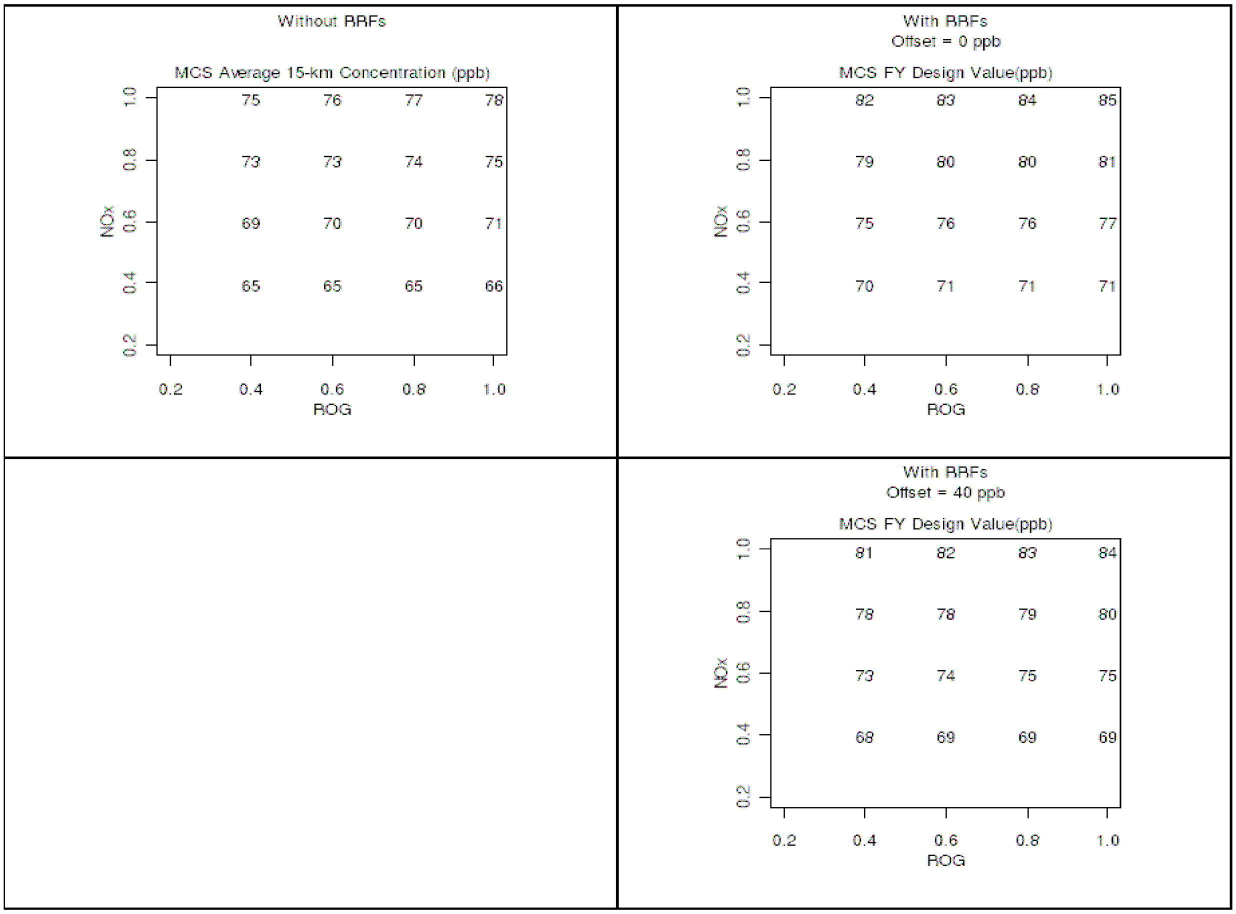






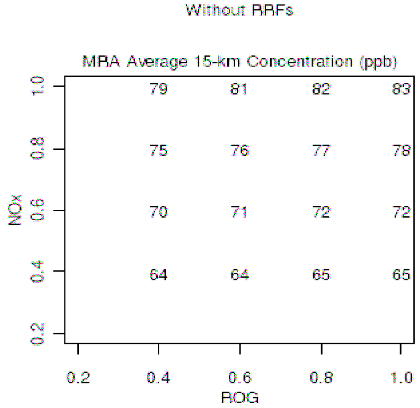
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: MCS - Maricopa School/Stanisl **Subregion:** 8 **Baseline Year Design Value:** 98 ppb

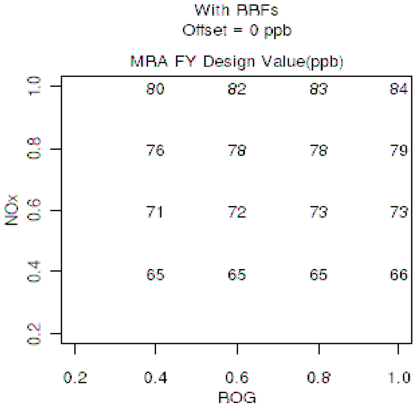
Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	87	81	84	57	61	95	91	86	77	10
Peak Simulated 8-hour Ozone	78	77	74	71	73	85	89	88	89	90
Peak Simulated 8-hour Ozone within 15 km	80	77	76	74	74	87	91	90	91	94
Baseline Year 15-km, 8-hour Average Ozone	90									
Future Year 15-km, 8-hour Average Ozone	66	68	67	67	67	74	79	80	80	81
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No

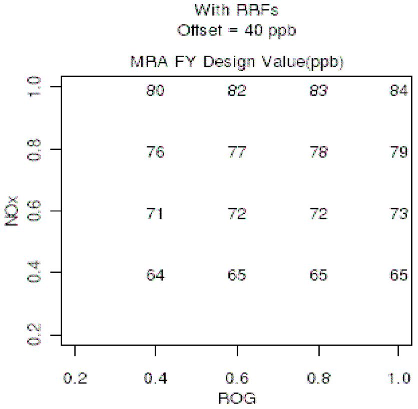


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: MRA - Merced Stn (385 S Coffe **Subregion:** 7 **Baseline Year Design Value:** 101 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	97	106	113	116	117	99	88	97	103	112
Peak Simulated 8-hour Ozone	83	91	89	114	80	88	77	97	102	92
Peak Simulated 8-hour Ozone within 15 km	90	98	92	115	84	92	83	103	105	99
Baseline Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	79	84	74	90	72	79	73	86	88	83
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes

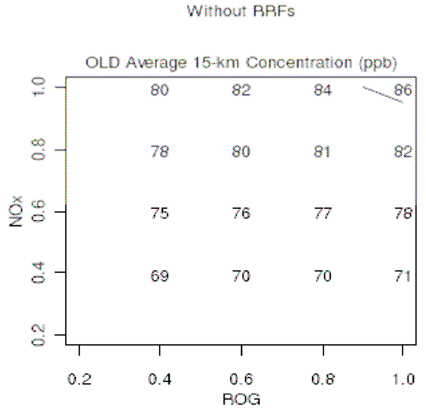




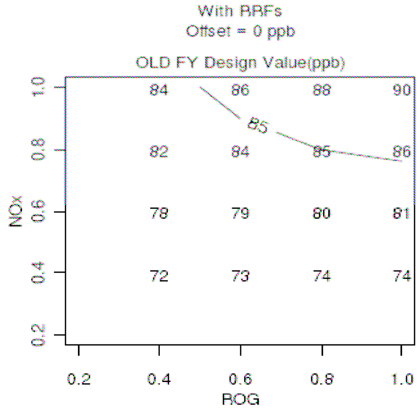


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: OLD - Oildale Stn (3311 Manor **Subregion:** 8 **Baseline Year Design Value:** 99 ppb

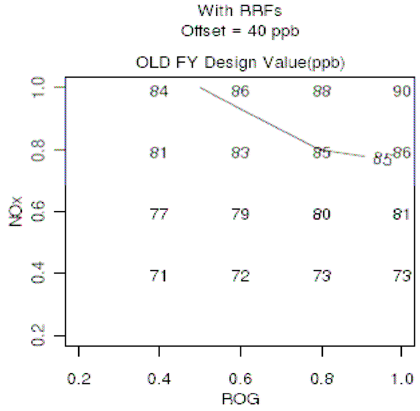
Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	92	95	88	59	77	92	85	81	98	103
Peak Simulated 8-hour Ozone	77	77	75	72	78	83	87	88	86	91
Peak Simulated 8-hour Ozone within 15 km	87	86	83	78	83	94	97	92	91	98
Baseline Year 15-km, 8-hour Average Ozone	94									
Future Year 15-km, 8-hour Average Ozone	76	77	75	76	79	87	87	88	81	95
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No


Without RRFs

OLD Average 15-km Concentration (ppb)


With RRFs
Offset = 0 ppb

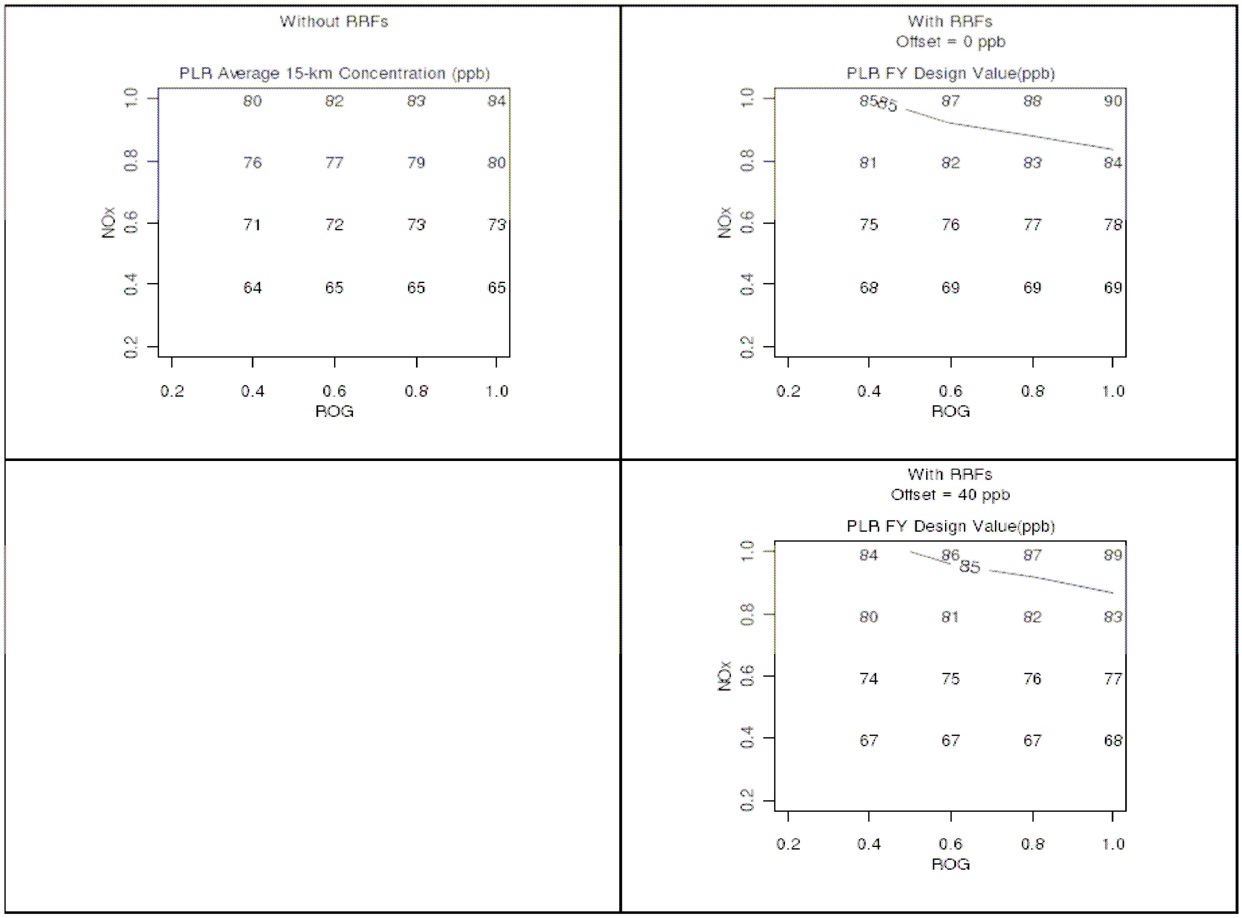
OLD FY Design Value(ppb)


With RRFs
Offset = 40 ppb

OLD FY Design Value(ppb)

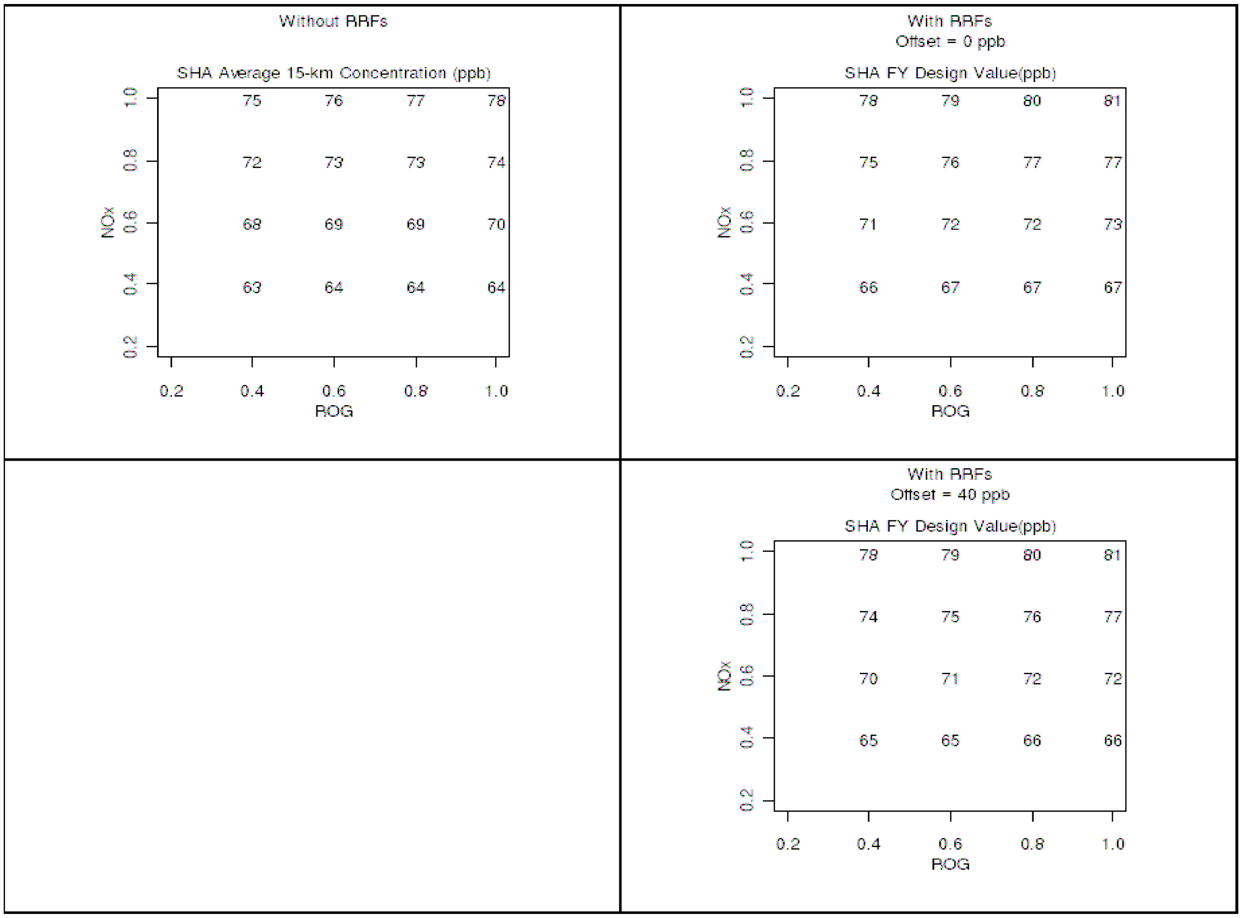
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: PLR - Parlier Stn **Subregion:** 7 **Baseline Year Design Value:** 108 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	102	104	105	82	84	108	106	88	88	88
Peak Simulated 8-hour Ozone	93	89	88	80	77	96	101	107	107	103
Peak Simulated 8-hour Ozone within 15 km	95	95	97	89	80	100	101	108	116	112
Baseline Year 15-km, 8-hour Average Ozone	101									
Future Year 15-km, 8-hour Average Ozone	81	80	80	73	67	85	84	91	94	92
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes



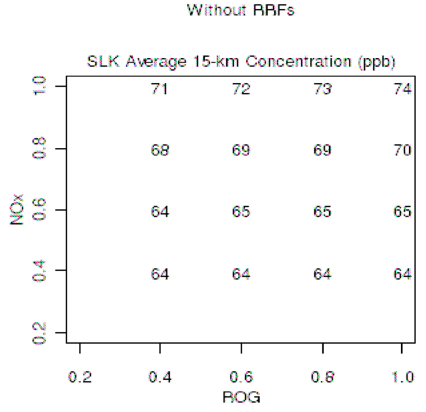
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: SHA - Shafter Stn (Walker St. **Subregion:** 8 **Baseline Year Design Value:** 94 ppb

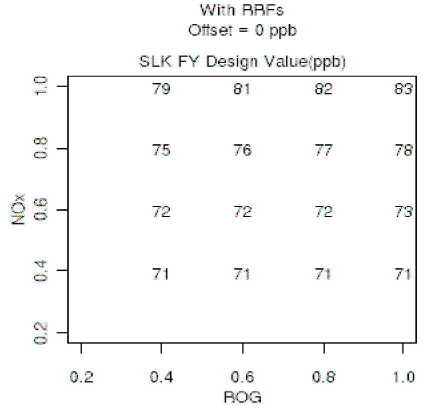
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	94	94	95	62	80	86	78	79	91	77
Peak Simulated 8-hour Ozone	77	73	73	71	74	81	85	88	91	94
Peak Simulated 8-hour Ozone within 15 km	79	77	76	75	82	86	88	91	92	96
Baseline Year 15-km, 8-hour Average Ozone	89									
Future Year 15-km, 8-hour Average Ozone	67	66	65	67	72	73	77	80	80	84
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	Yes	Yes	No

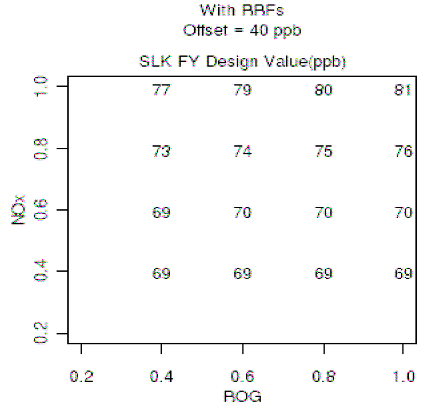


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: SLK - Sequoia Lower Keawah St **Subregion:** 11 **Baseline Year Design Value:** 100 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail
Peak Observed 8-hour Ozone	93	81	73	60	58	72	70	69	61	54
Peak Simulated 8-hour Ozone	67	60	58	63	67	81	77	80	79	75
Peak Simulated 8-hour Ozone within 15 km	84	74	64	70	71	88	90	94	92	87
Baseline Year 15-km, 8-hour Average Ozone	89									
Future Year 15-km, 8-hour Average Ozone	68	64	62	62	63	72	76	78	77	75
Use in RRF Analysis?	No	No	No	No	No	Yes	Yes	No	No	No

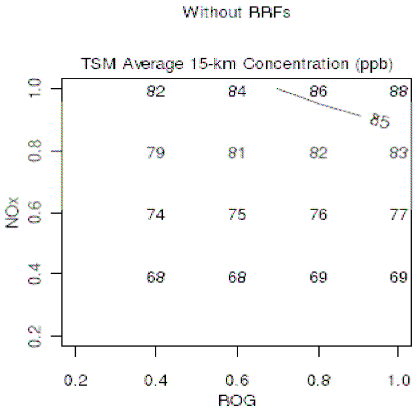




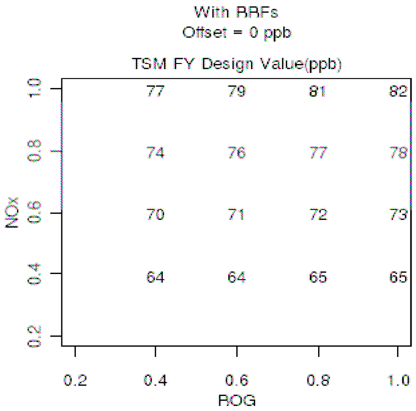


Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: TSM - Turlock Stn (900 S Mina **Subregion:** 9 **Baseline Year Design Value:** 95 ppb

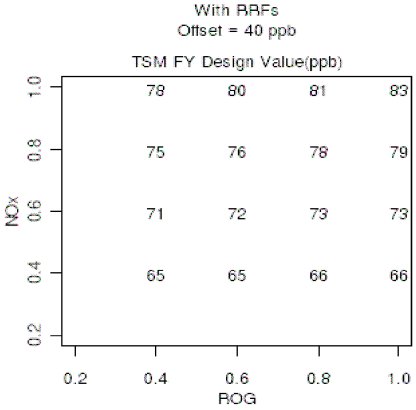
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Fail	Pass	Fail	Fail	Pass	Fail	Fail	Fail	Pass
Peak Observed 8-hour Ozone	73	80	91	99	84	91	73	84	91	108
Peak Simulated 8-hour Ozone	87	103	98	109	82	91	80	95	102	98
Peak Simulated 8-hour Ozone within 15 km	91	106	112	114	90	96	88	102	107	103
Baseline Year 15-km, 8-hour Average Ozone	101									
Future Year 15-km, 8-hour Average Ozone	86	92	91	90	79	85	82	88	93	89
Use in RRF Analysis?	Yes	No	Yes	No	No	Yes	No	No	No	Yes


Without RRFs

TSM Average 15-km Concentration (ppb)


With RRFs
Offset = 0 ppb

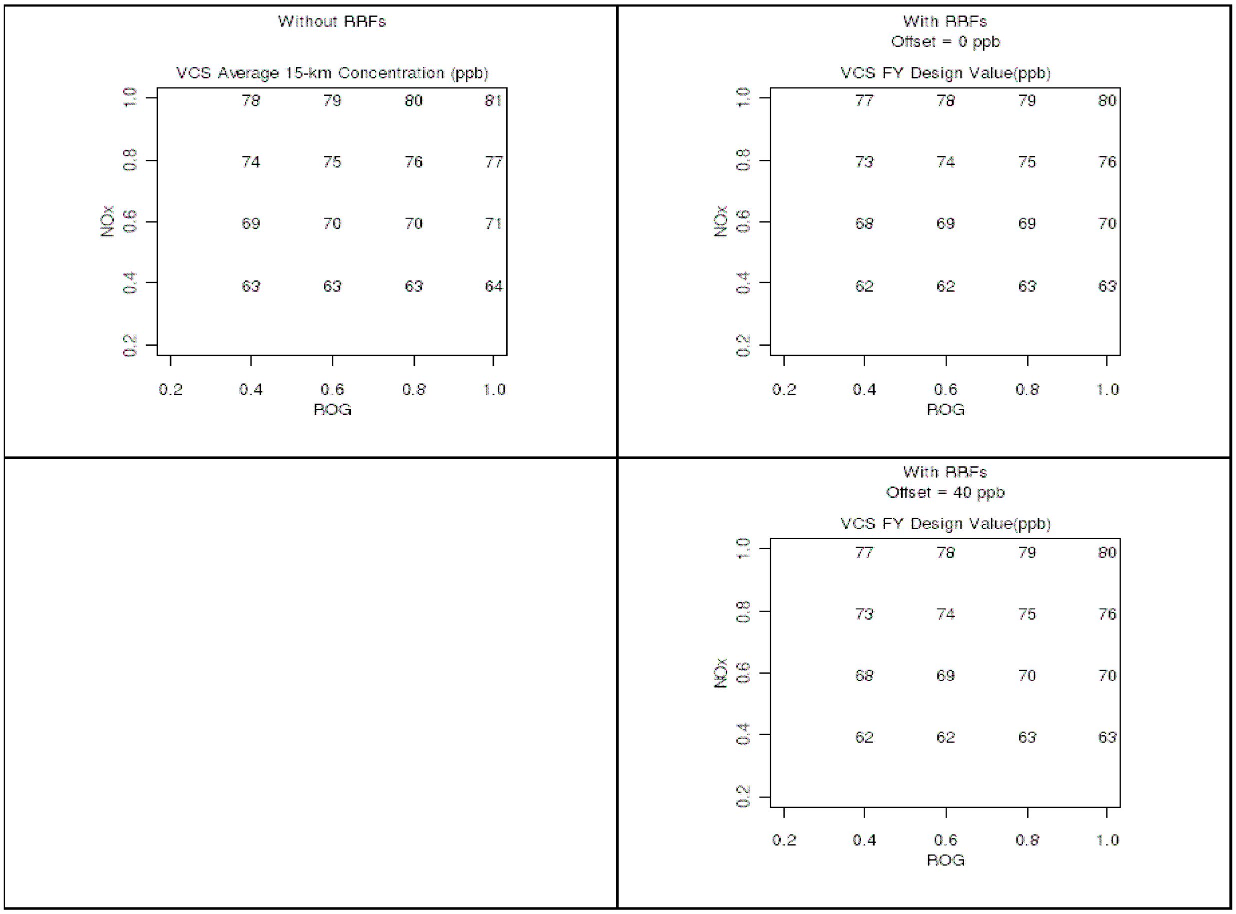
TSM FY Design Value(ppb)


With RRFs
Offset = 40 ppb

TSM FY Design Value(ppb)

Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: VCS - Visalia Stn (Church St. **Subregion:** 7 **Baseline Year Design Value:** 98 ppb

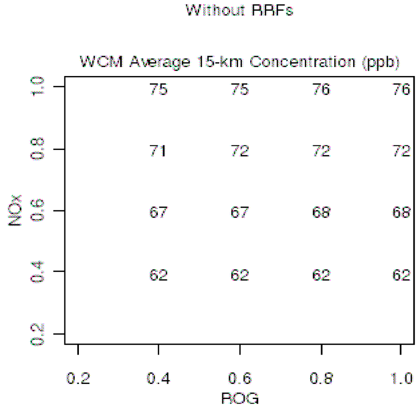
Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	94	99	107	87	86	94	95	83	90	94
Peak Simulated 8-hour Ozone	88	80	79	78	73	93	96	104	102	96
Peak Simulated 8-hour Ozone within 15 km	94	90	84	84	76	96	98	106	105	101
Baseline Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	77	73	70	69	66	78	82	88	86	84
Use in RRF Analysis?	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes

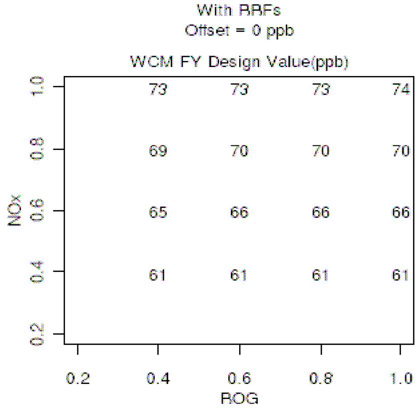


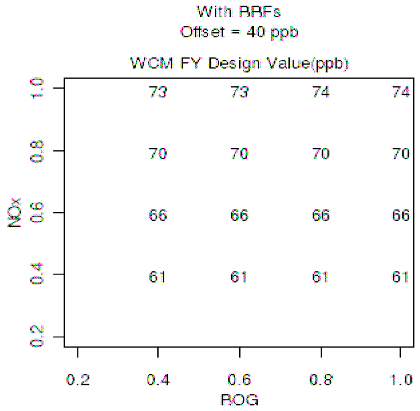
ARB/PTSD -20- 02/22/07

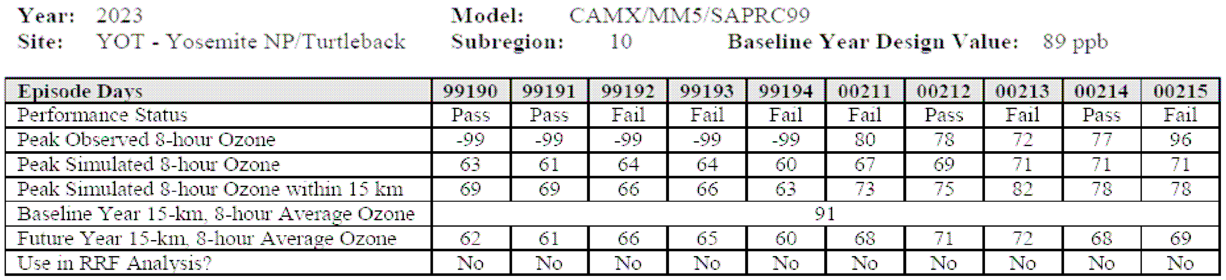
Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: WCM - White Cloud Mtn. Stn **Subregion:** 13 **Baseline Year Design Value:** 90 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Peak Observed 8-hour Ozone	102	85	83	85	91	75	79	72	66	108
Peak Simulated 8-hour Ozone	72	64	71	72	66	73	74	68	70	81
Peak Simulated 8-hour Ozone within 15 km	79	71	81	75	70	75	77	72	80	92
Baseline Year 15-km, 8-hour Average Ozone	92									
Future Year 15-km, 8-hour Average Ozone	65	60	65	64	62	68	69	65	67	76
Use in RRF Analysis?	No	No	No	No	No	No	No	No	No	Yes









Year: 2023 **Model:** CAMX/MM5/SAPRC99
Site: YOT - Yosemite NP/Turtleback **Subregion:** 10 **Baseline Year Design Value:** 89 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Fail	Fail	Fail	Fail	Pass	Fail	Pass	Fail
Peak Observed 8-hour Ozone	-99	-99	-99	-99	-99	80	78	72	77	96
Peak Simulated 8-hour Ozone	63	61	64	64	60	67	69	71	71	71
Peak Simulated 8-hour Ozone within 15 km	69	69	66	66	63	73	75	82	78	78
Baseline Year 15-km, 8-hour Average Ozone	91									
Future Year 15-km, 8-hour Average Ozone	62	61	66	65	60	68	71	72	68	69
Use in RRF Analysis?	No	No	No	No	No	No	No	No	No	No

PHOTOCHEMICAL MODELING IN SUPPORT OF ATTAINING THE FEDERAL 8-HOUR OZONE AIR QUALITY STANDARD IN CENTRAL CALIFORNIA

Volume 1:
Model Performance Evaluation

California Air Resources Board
Planning and Technical Support Division
Sacramento, California 95814

Date 2/28/07

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For District review purposes, this document summarizes model performance procedures and results for meteorological modeling (Section 1) as well as air quality modeling (Section 2) for the July 1999 and July-August, 2000, episodes. The model performance evaluations are based on USEPA guidance (1991 and 2005) as well as recommendations from Emery (2001), Tesche (1994) and Tesche et al. (2001). The third section (Section 3) provides a summary of the performance analysis and Section 4 provides a tabular listing of complete graphical and statistical results that can downloaded via ftp from eos.arb.ca.gov.

Of note is that the two episodes have both been extended by two days at the beginning of the original episode periods in an effort to increase the number of useable days for future year design value calculations.

Meteorological Model Performance

METEOROLOGICAL MODEL PERFORMANCE METRICS

Meteorological model performance is assessed both quantitatively using statistical metrics as well as qualitatively against known conceptual meteorological flows and observed episodic meteorological features.

Quantitative Performance Evaluation

There are a number of statistical and graphical approaches for evaluating meteorological model outputs. However, none of them are independently conclusive. Most of these approaches involve comparisons between observed and simulated meteorological parameter values. These analyses pose a difficult challenge, since most of the available meteorological monitoring stations are located in urbanized areas. Thus, the majority of observations tend to represent those areas versus the full complexity of meteorology throughout the CCOS domain. Furthermore, since the use of objective analysis and observational nudging forces the meteorological modeling results towards the observations, model performance problems can increase in areas away from observation locations.

It also needs to be recognized that output from the various meteorological models must be preprocessed for input into the air quality model. This preprocessing may inadvertently perturb the meteorological fields. Therefore, meteorological model performance should be based on the air quality model input files, rather than the meteorological model outputs.

The SIP modeling domain is geographically very complex and the observational data on which meteorological model outputs were evaluated are not distributed uniformly. Therefore, it is unreasonable to evaluate model performance for the domain as a whole. For purposes of meteorological model performance analysis, the CCOS domain is divided into sub-regions, representing areas of similar meteorological features. The graphical and statistical model evaluations will be done for each of these sub-regions.

A number of standard statistical and graphical techniques are used for meteorological model performance analysis. The most widely used application is the METSTAT program (Tesche, 1994, Tesche et al, 2001). Two graphical representations of the METSTAT statistics were used in meteorological model performance analysis conducted here: a) “Root Mean Square Error (RMSE) of Wind Speed” vs. “Gross Error (E) of Wind Direction”, and b) “Bias Error (B)” vs. “Gross Error (E)” for temperature. Equations used for these comparisons were taken from the user documentation of the METSTAT program and are given below:

Bias Error (B): calculated as the mean difference in prediction-observation pairings with valid data within a given analysis region and for a given time period (hourly or daily):

$$B = \frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left(P_j^i - O_j^i\right)$$

Here, *P* and *O* indicate model predictions and observations, respectively. Similarly, I and J are the indices of grid points in x and y directions, respectively.

Gross Error (E): calculated as the mean *absolute* difference in prediction-observation pairings with valid data within a given analysis region and for a given time period (hourly or daily):

$$E = \frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left|P_j^i - O_j^i\right|$$

Note that the bias and gross error for winds are calculated from the predicted-observed residuals in speed and direction (not from vector components *u* and *v*). The direction error for a given prediction-observation pairing is limited to range from 0 to ±180°.

Root Mean Square Error (RMSE): calculated as the square root of the mean squared difference in prediction-observation pairings with valid data within a given analysis region and for a given time period (hourly or daily):

$$RMSE = \left[\frac{1}{IJ}\sum_{j=1}^{J}\sum_{i=1}^{I}\left(P_j^i - O_j^i\right)^2\right]^{1/2}$$

The RMSE, as is the gross error, is a good overall measure of model performance. However, since large errors are weighted heavily (due to squaring), large errors in small subregions may produce a large RMSE even though the errors may be small and quite acceptable elsewhere.

Table 1-1 shows the criteria used to decide if the results of a given model fall within acceptable performance limits.

Table 1-1 Statistical comparisons between observed and simulated meteorological parameter values. Statistical comparisons are made by model performance sub-regions.

Parameter	Abbreviation	Benchmark
Wind Speed	RMSE:	≤ 2 m/s
	Bias:	≤ ±0.5 m/s
	IOA:	≥ 0.6
Wind Direction	Gross Error:	≤ 30 deg
	Bias:	≤ ±10 deg
Temperature	Gross Error:	≤ 2 ºK
	Bias:	≤ ±0.5 ºK
	IOA	≥ 0.8

In an ideal situation, meteorological field evaluation would be done independent of the air quality model results. However, in practice, meteorological field evaluation is limited by the relative paucity of observational data, especially aloft. Therefore, base year air quality model performance was also considered in the selection of meteorological fields used for air quality simulations.

Table 1-2 Graphical analysis of meteorological model fields. Time series plots are made for each station and spatial plots are made over the whole modeling domain.

Time-series plots of hourly mean air temperature

Time-series plots of hourly mean wind speeds.

Spatial plots of hourly wind vectors

Spatial plots of hourly air temperatures

Qualitative Performance Analyses

Given episode-specific information on the meteorological features that were observed with field measurements, additional subjective analyses of observed versus predicted mesoscale features can be conducted. Examples of such qualitative analyses that will be considered are described below.

1. Determine and compare modeled and observed horizontal flow patterns over the modeling domain. Features to consider include flow splitting, the structure of the sea breeze, urban circulations, local flows such as Fresno and Schultz eddy circulations, slope and drainage flows, up/down valley flows, and the existence of cloud formations.

2. Study the 3-D spatial characteristics of the flow field by using time-height cross sections of wind profiler observations and the simulated wind field at the wind profiler location.

3. Determine the spatial and temporal characteristics of the mixing layer height using available upper air observations, and compare it with the simulated behavior of mixing layer height.

4. Perform some sensitivity tests to see the effects of certain model parameters on the model results, such as observational nudging vs. analysis nudging, the choice of soil physics, and boundary layer parameterizations.

METEOROLOGICAL MODEL PERFORMANCE RESULTS

The following two sections present the results of meteorological model performance for the two modeling episodes, based on the criteria discussed above. For illustration purposes, a small number of the graphics that were produced are used in the subsequent discussions. However, all of the graphics that have been generated are available via ftp per the table in the Appendix.

July 1999 Episode (Routine Episode)

The July 1999 simulation covers the period from July 5th 12Z, 1999 to July 14th 12Z, 1999. Meteorological model performance is assessed for the 7-day period spanning July 7th through July 13th.

The July 1999 episode model performance is assessed for three MM5 runs as follows:

Table 1-3. July-1999 Episode. Three ARB simulations are considered.

Simulation Number	Abbreviation	Description
1	C108	7 day simulation; without FDDA
2	C109	7 day simulation; with FDDA; includes all the available observational data.
3	C110	7 day simulation; with FDDA; but excludes from the FDDA file all known 2-meter station height data (i.e. CIMIS and NWS stations).

The FDDA file for run C109 includes all of the available observational data that are available for this routine field measurement episode. The Bay Area Air Quality Management District and their contractors, AtMet and ENVIRON, produced FDDA data for the original 'core' episode days, July 9th through July 12th. For the extended episode days that fall outside of the original core days, ARB FDDA data are used. The third run (c110) has the same model setup as "c109", except that data from sources utilizing 2-meter station heights are excluded from the C109 FDDA file. Simulation C110 is a sensitivity run to evaluate the effect of 2-meter observational station heights on MM5 performance for this episode.

To calculate model performance statistics, the results from all three MM5 simulations are processed through the METSTAT program. Performance statistics and site-averaged time series are calculated for 5 regions: Bay Area region, Sacramento region, Central San Joaquin Valley, Southern San Joaquin Valley and Northern San Joaquin Valley. The resulting statistics are presented in soccer plots, where, ideally, model performance statistics fall within the central box of the goal.

Figure 1-1 shows sites-averaged time series for winds and temperatures in the Bay Area region. There is little difference between the three simulations. Wind speeds were generally under-predicted over the entire simulation period. On the other hand, temperature performance is good, as noted by the simulated diurnal pattern. The exception to this is that temperatures were over-predicted on July 13th. In terms of model performance statistics for the Bay Area region, Figure 1-2 shows the soccer goal plots of daily performance for winds and temperature. There was little difference between c109 and c110.

Figure 1-3 shows sites-averaged time series for winds and temperatures in the Sacramento region. In general, there is little difference between the three simulations. Wind speeds are over-predicted on July 7th and July 12th. Otherwise, the wind speed performance is good over the simulation period. On the other hand, temperatures were under-predicted during the day and over-predicted in the morning. Figure 1-4 shows the soccer goal plots of daily performance for winds and temperature.

Figure 1-5 shows sites-averaged time series for winds and temperatures in the Central San Joaquin Valley. Wind speeds were generally over-predicted. Temperatures were under-predicted during the day and over-predicted in the morning. There was little difference between the three simulations. Figure 1-6 shows the soccer goal plots of daily performance for winds and temperature.

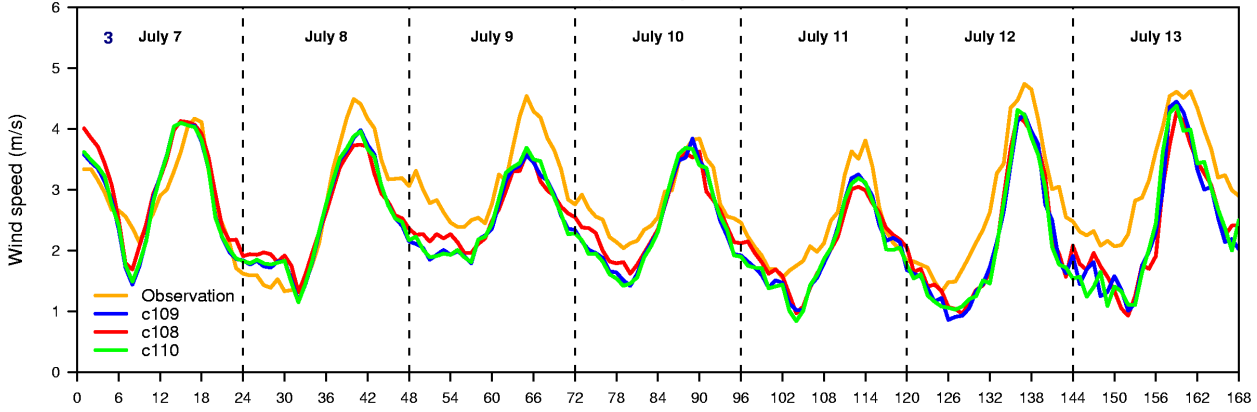
Figure 1-7 shows sites-averaged time series for winds and temperatures in the Southern San Joaquin Valley. Wind speeds were generally over-predicted. Temperatures were under-predicted during the day and over-predicted in the morning. There was little difference between the three simulations. Figure 1-8 shows the soccer goal plots of daily performance for winds and temperature.

Figure 1-9 shows sites-averaged time series for winds and temperatures in the Northern San Joaquin Valley. Wind speeds were generally over-predicted. Temperatures were under-predicted during the day and over-predicted in the morning. There was little difference between the three simulations. Figure 1-10 shows the soccer goal plots of daily performance for winds and temperature.

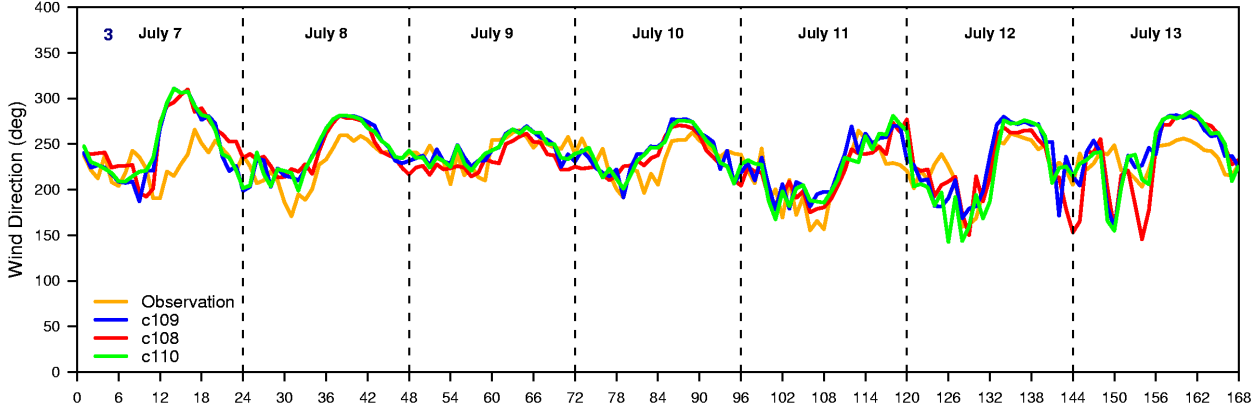
It should be noted that both the ARB and the Bay Area Air Quality Management District have done much work to improve meteorological model performance for this episode. However, little additional progress has been made over the past two years and performance statistics still remain outside of the 'ideal' range. Alone, however, this is not grounds to dismiss the met simulations as poor. We are hopeful that statistical performance can be improved and will continue to work closely with the districts and other stakeholders, including CCOS contractors, with this goal in mind.

Among the three July 1999 simulations, MM5 with observation nudging (c109 and c110) improves the wind speed and wind direction a little over c108, which has no observation nudging. Since there were no significant differences between c109 and c110, it is assumed that the 2-meter station data included in the FDDA file play no significant role in degrading model performance. As a result, c109 is used as input for the air quality model.

(a) Wind Speed



(b) Wind Direction



(c) Temperature

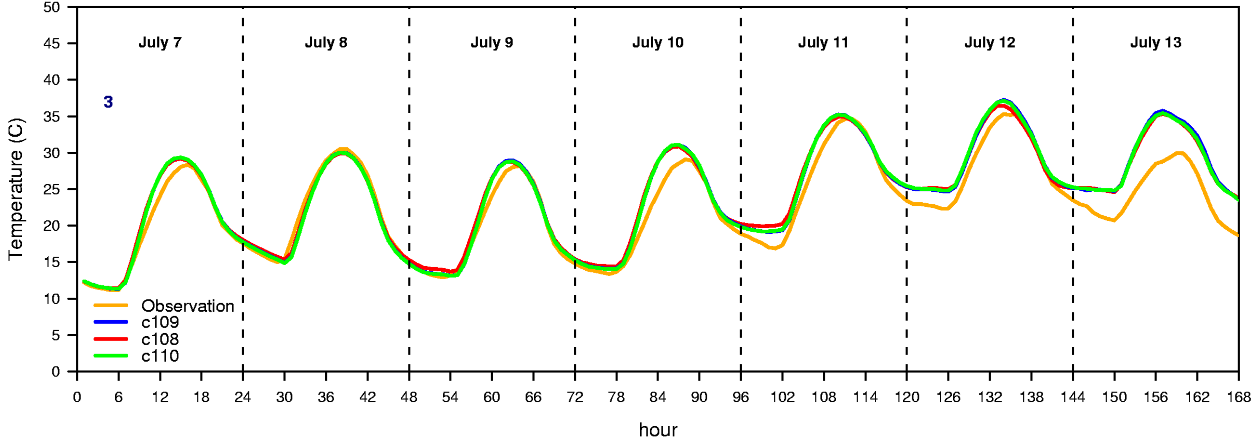
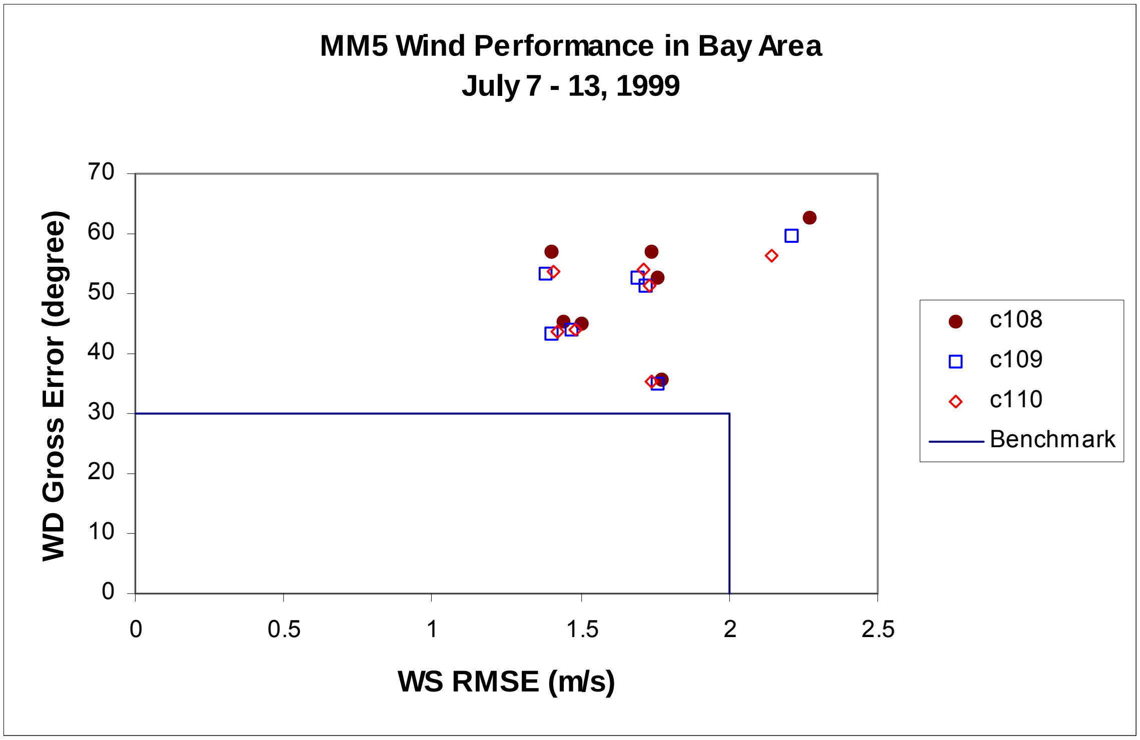


Figure 1-1. Time series of wind speed, direction, and temperature for the Bay Area region over the July 7-13, 1999 modeling period.



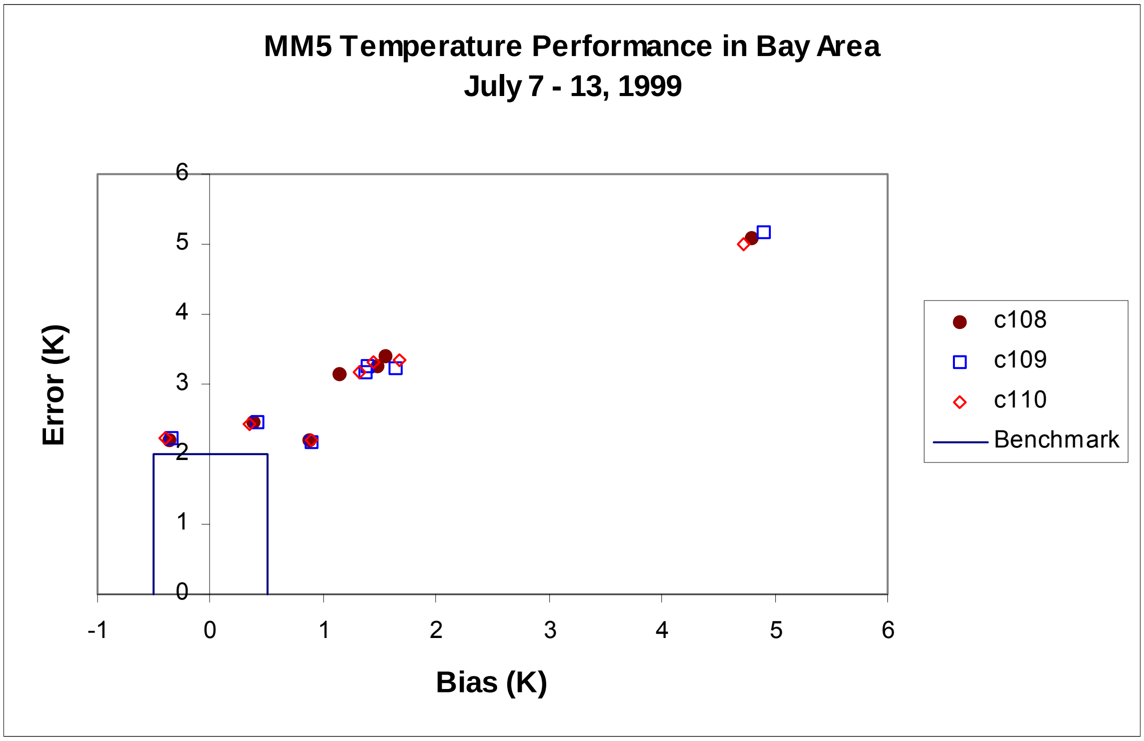


Figure 1-2. MM5 performance for winds and temperature in the Bay Area region.

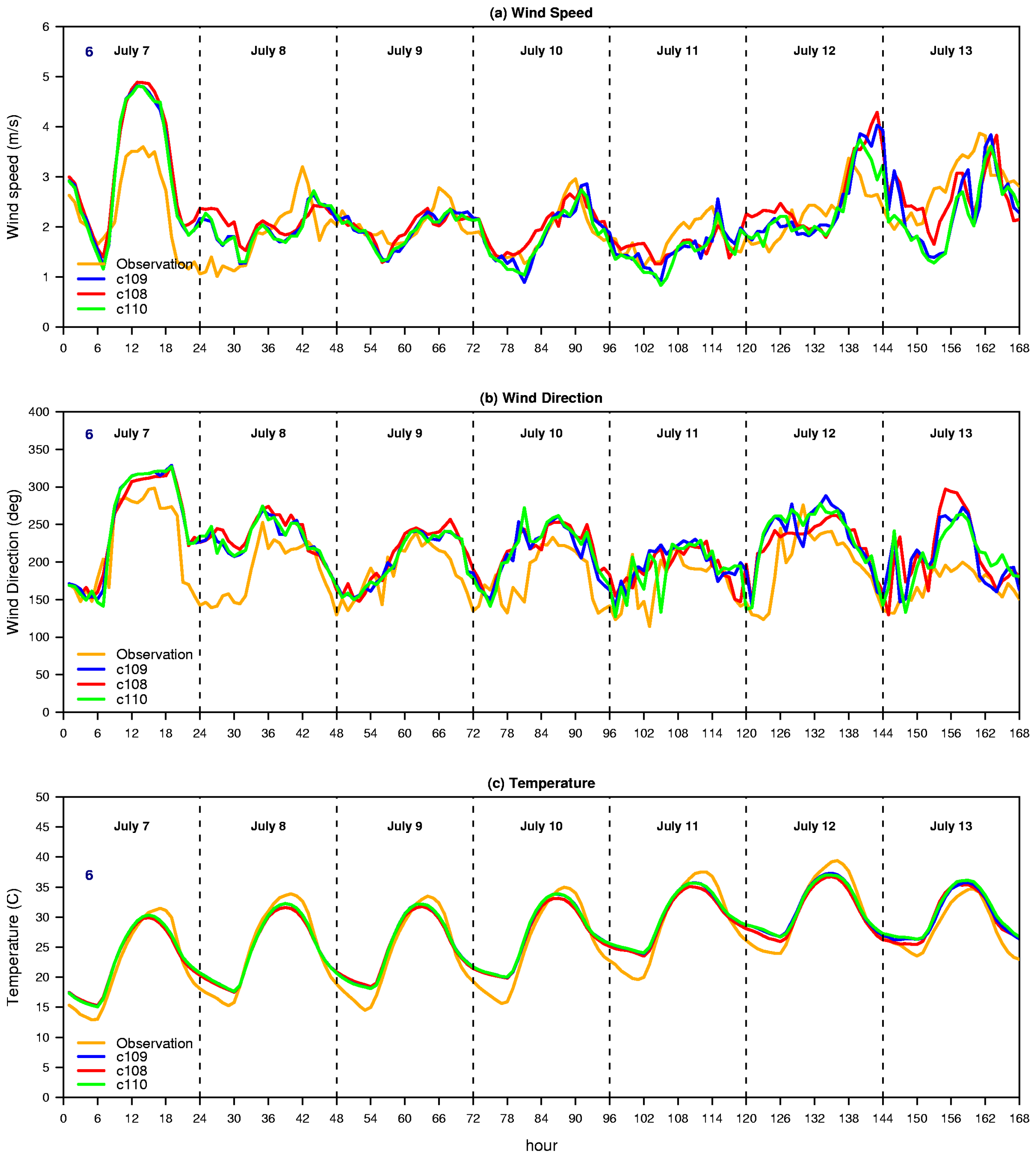
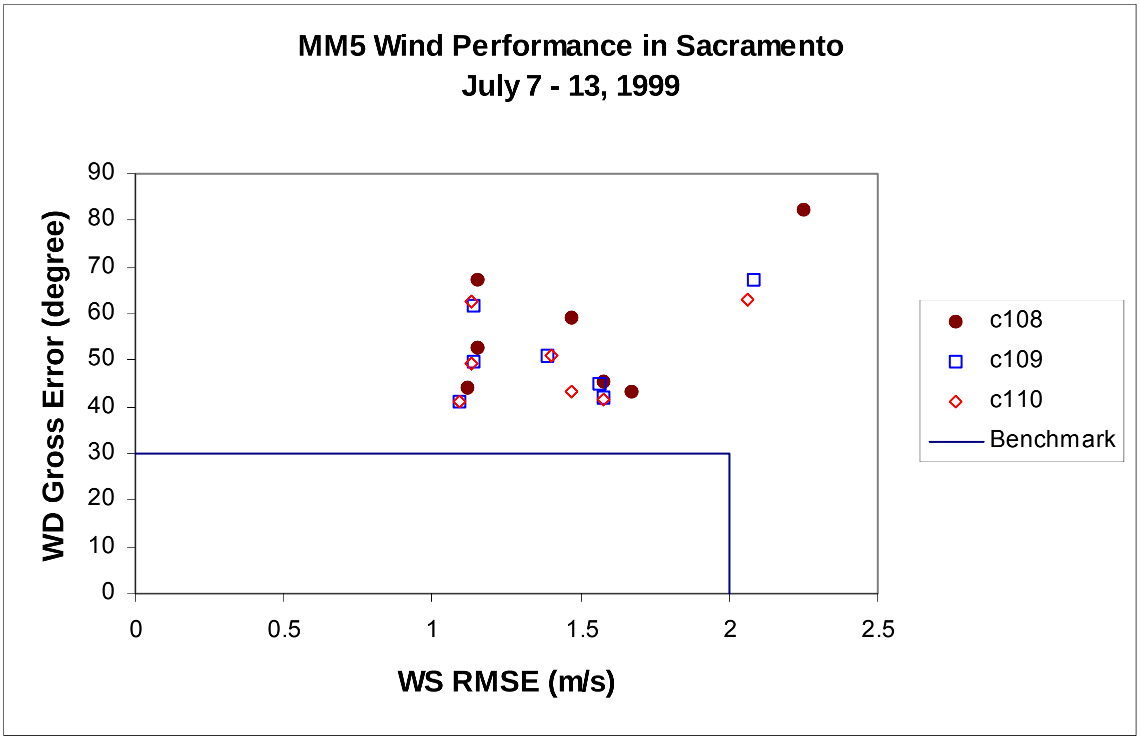


Figure 1-3. Time series of wind speed, direction, and temperature for the Sacramento region over the July 7-13, 1999 modeling period.



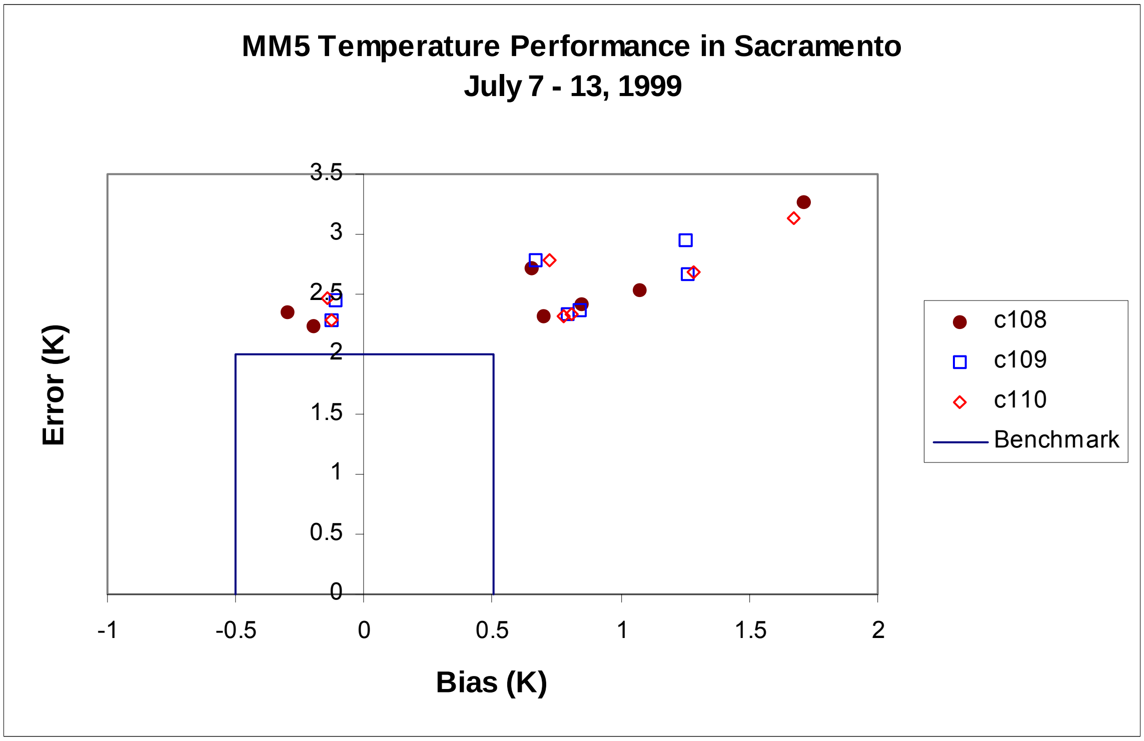
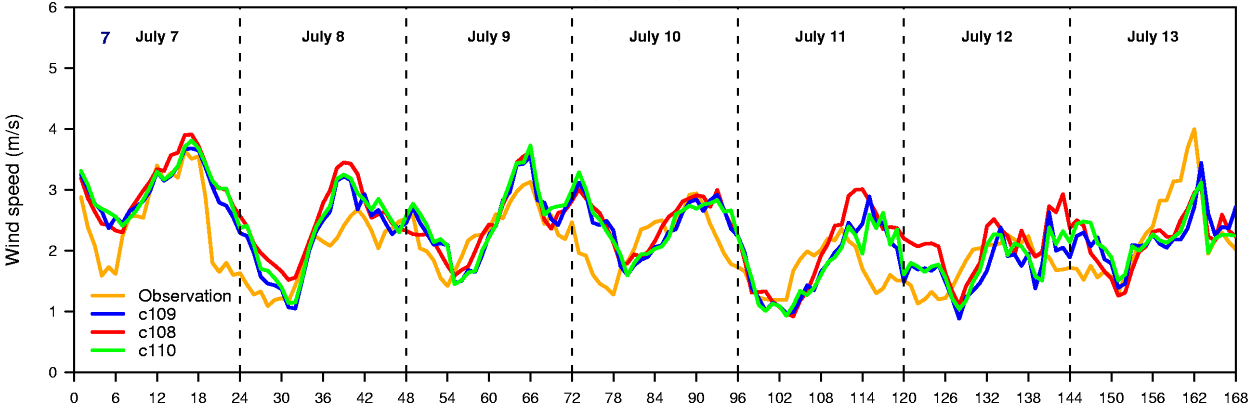
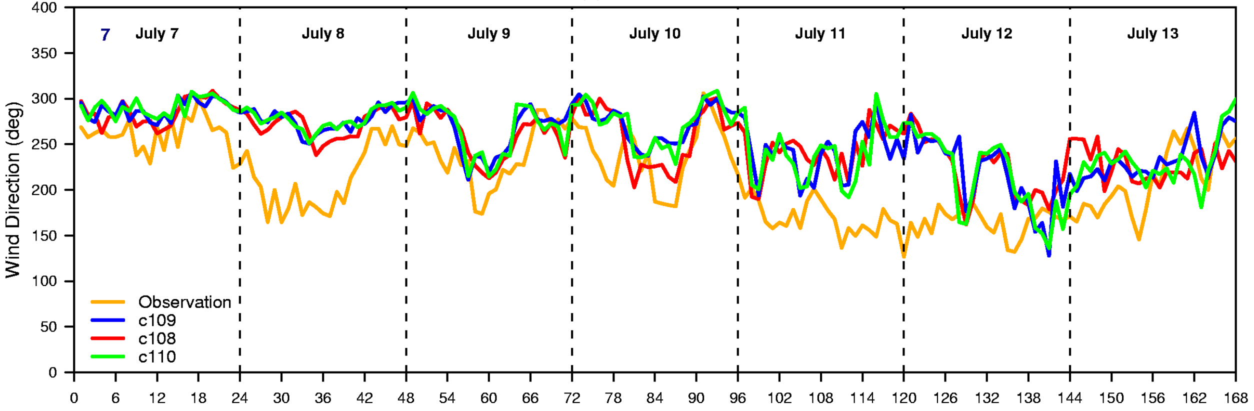


Figure 1-4. MM5 performance for winds and temperature in the Sacramento region.

(a) Wind Speed



(b) Wind Direction



(c) Temperature

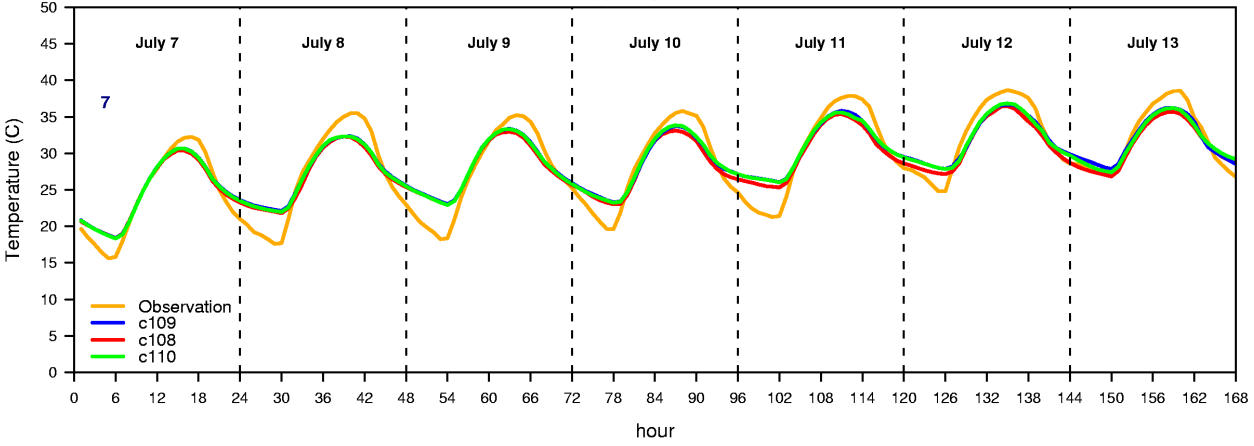
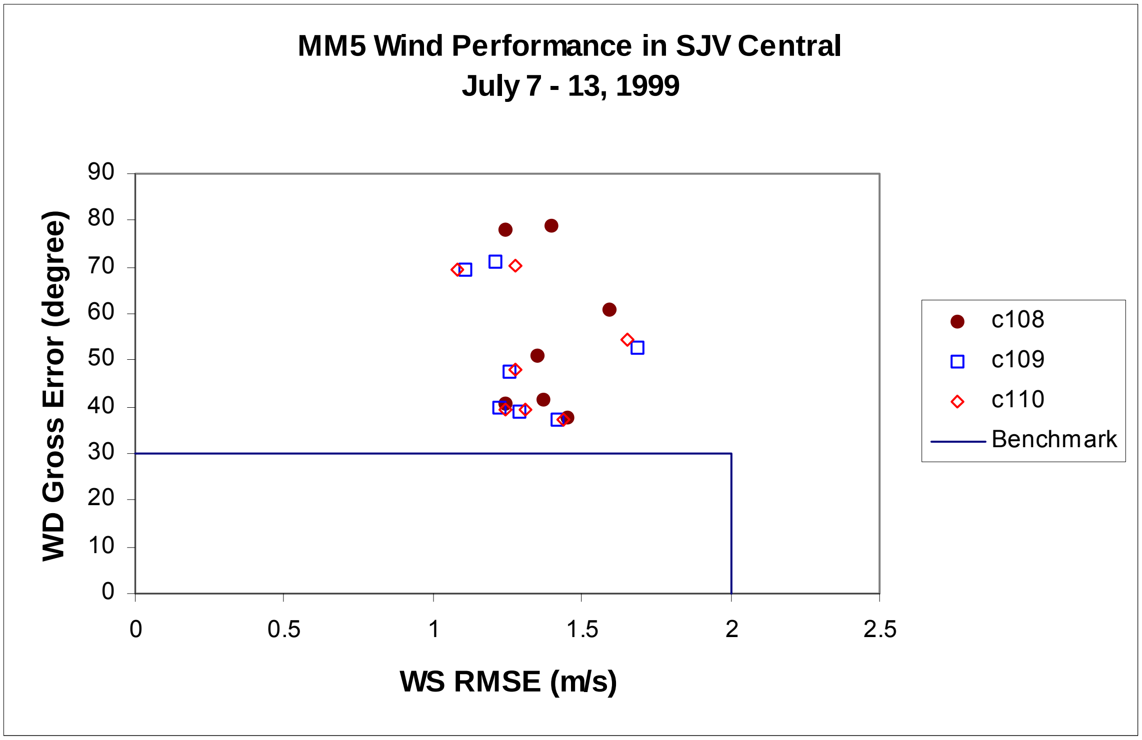


Figure 1-5. Time series of wind speed, wind direction, and temperature for the Central San Joaquin Valley over the July 7-13, 1999 modeling period.



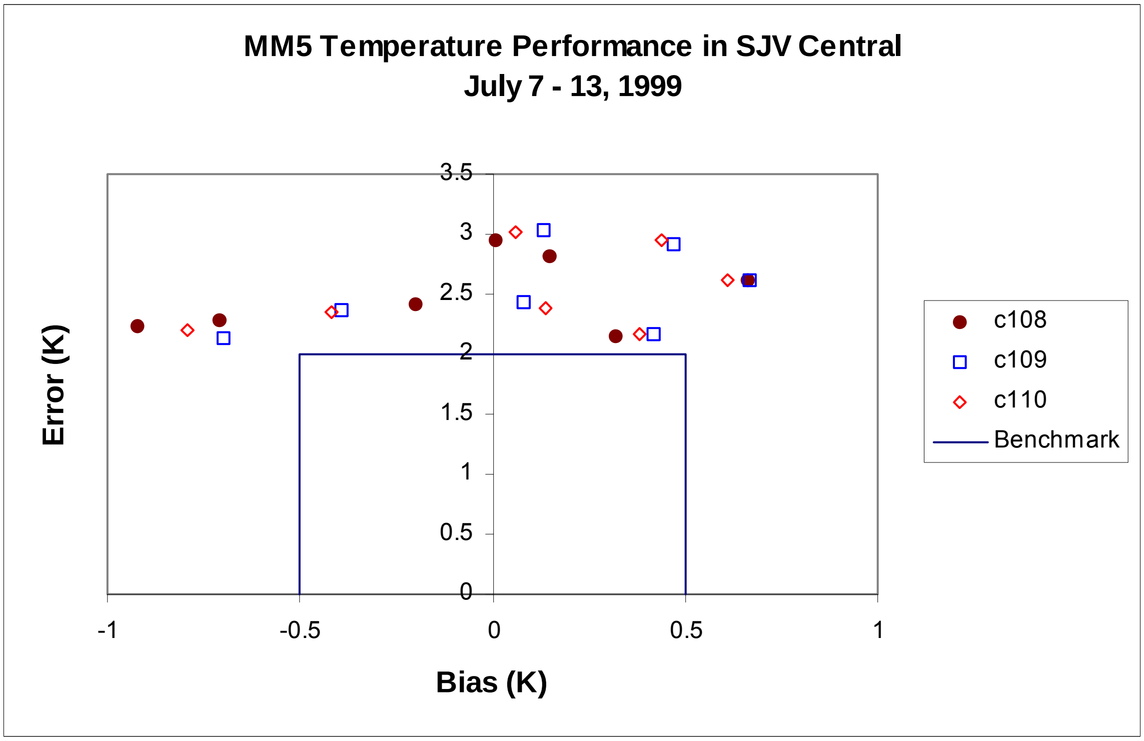
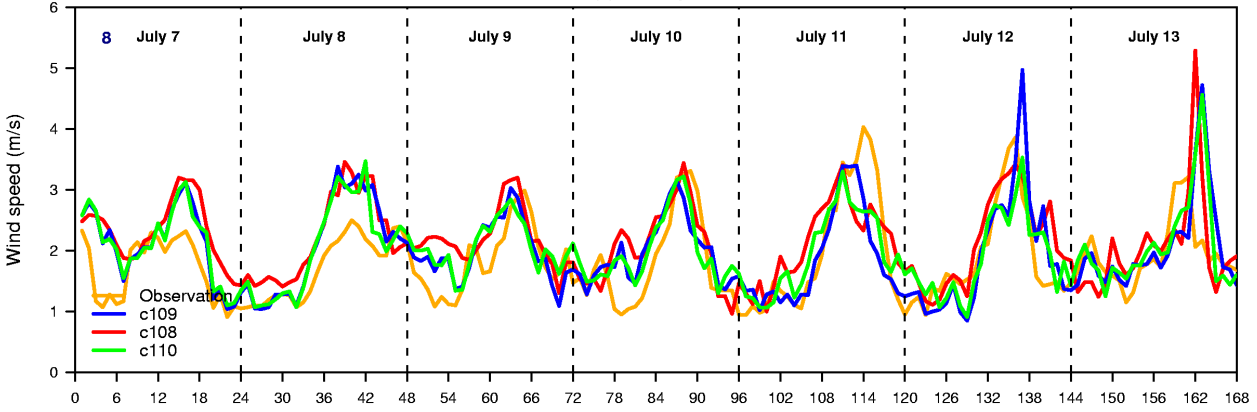
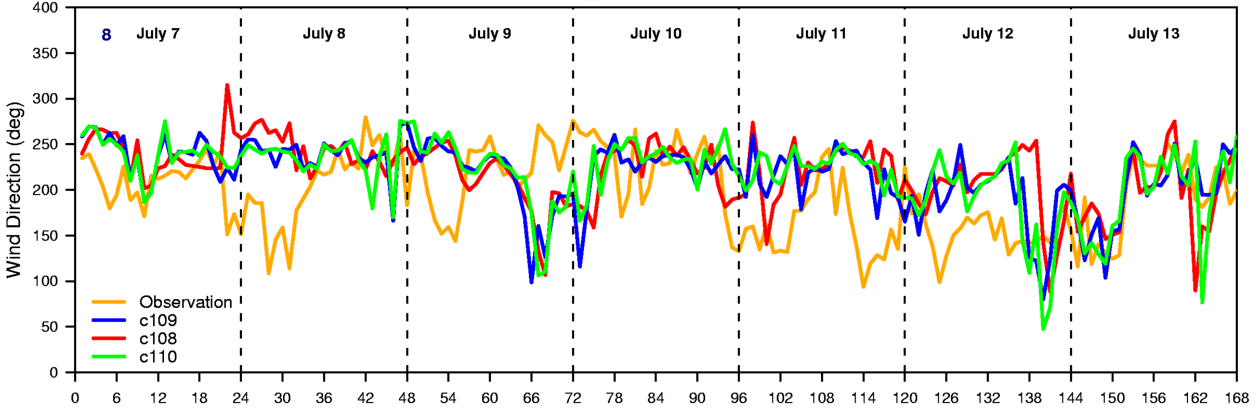


Figure 1-6. MM5 performance for winds and temperature in the Central San Joaquin Valley.

(a) Wind Speed



(b) Wind Direction



(c) Temperature

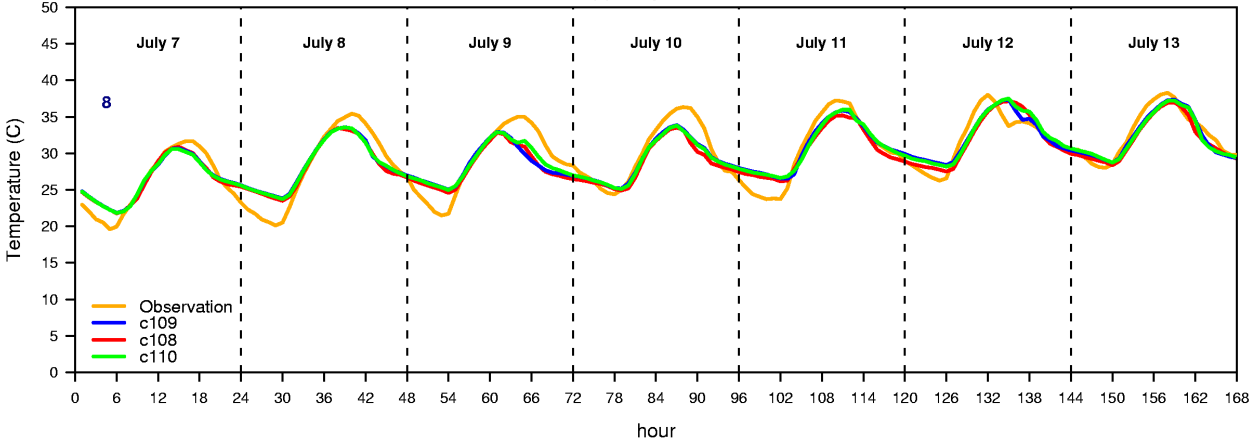
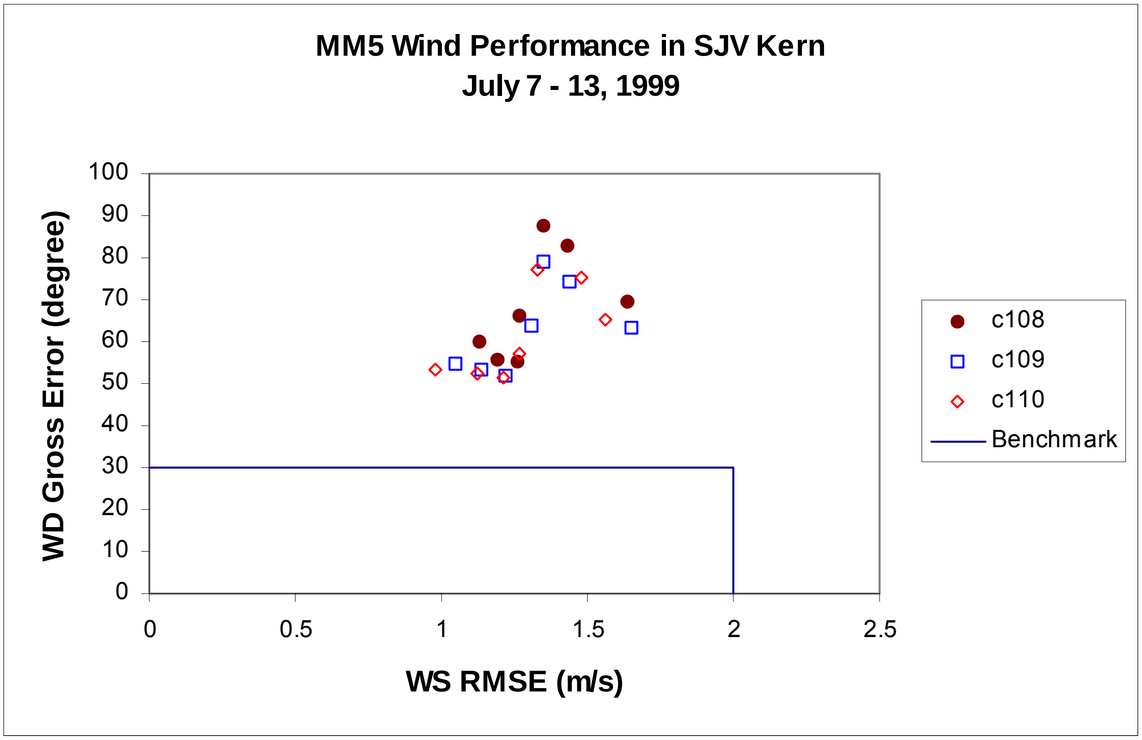


Figure 1-7. Time series of wind speed, wind direction, and temperature for the Southern San Joaquin Valley over the July 7-13, 1999 modeling period.



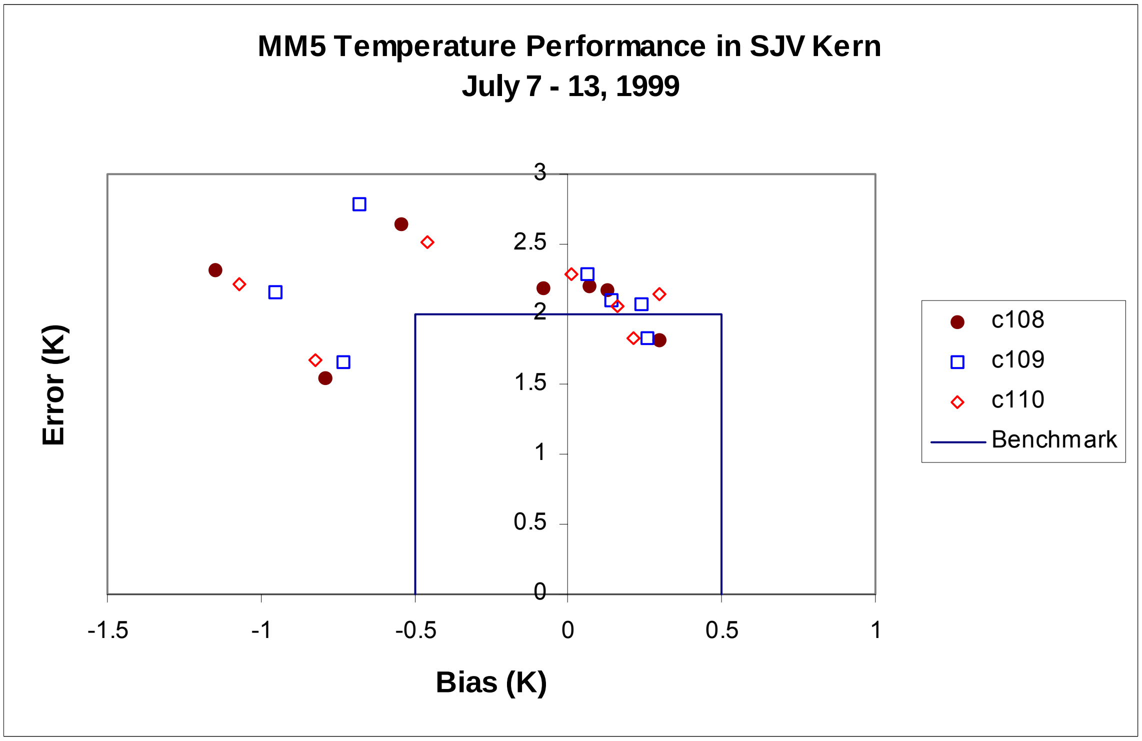


Figure 1-8. MM5 performance for winds and temperature in the Southern San Joaquin Valley.

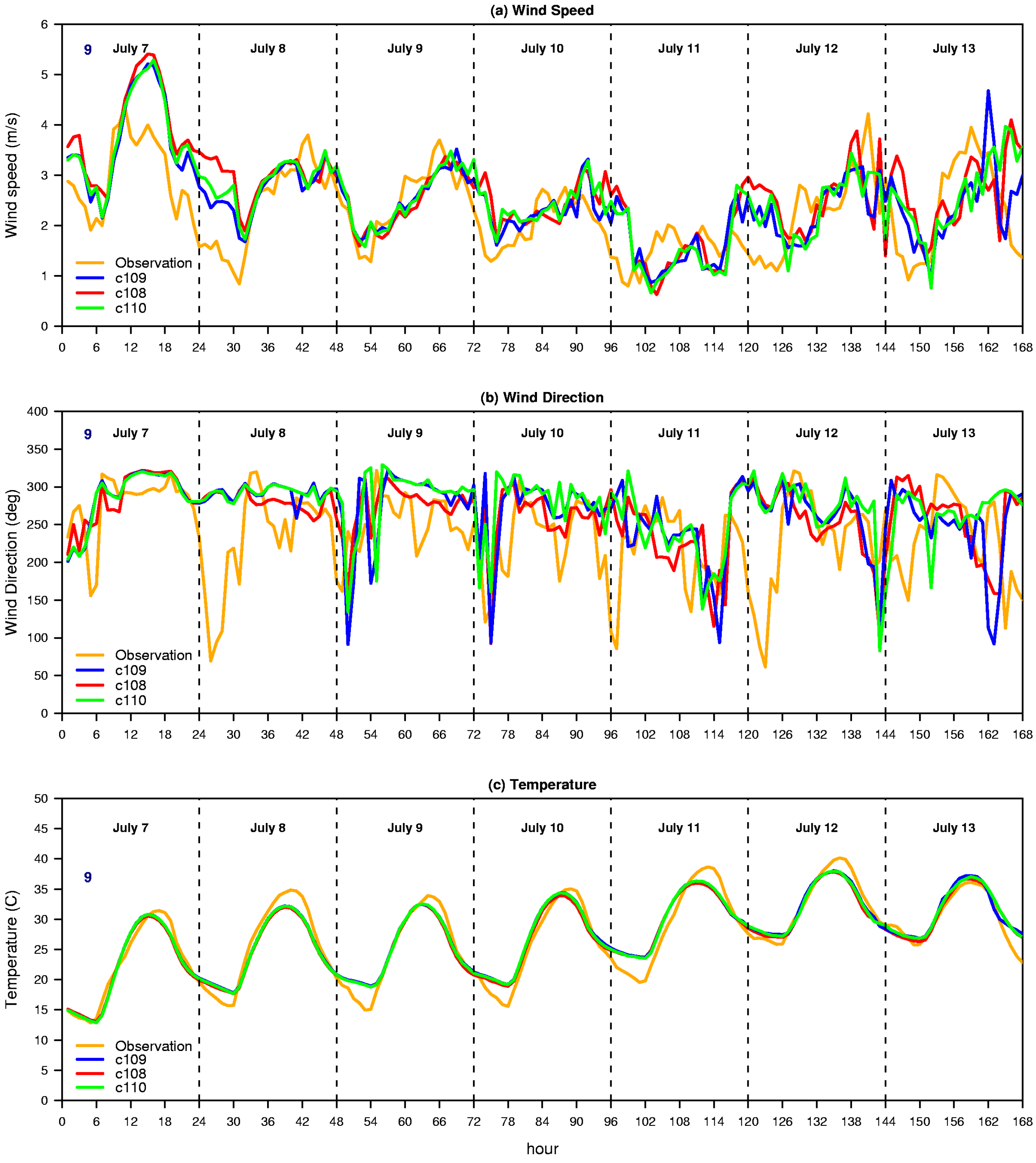
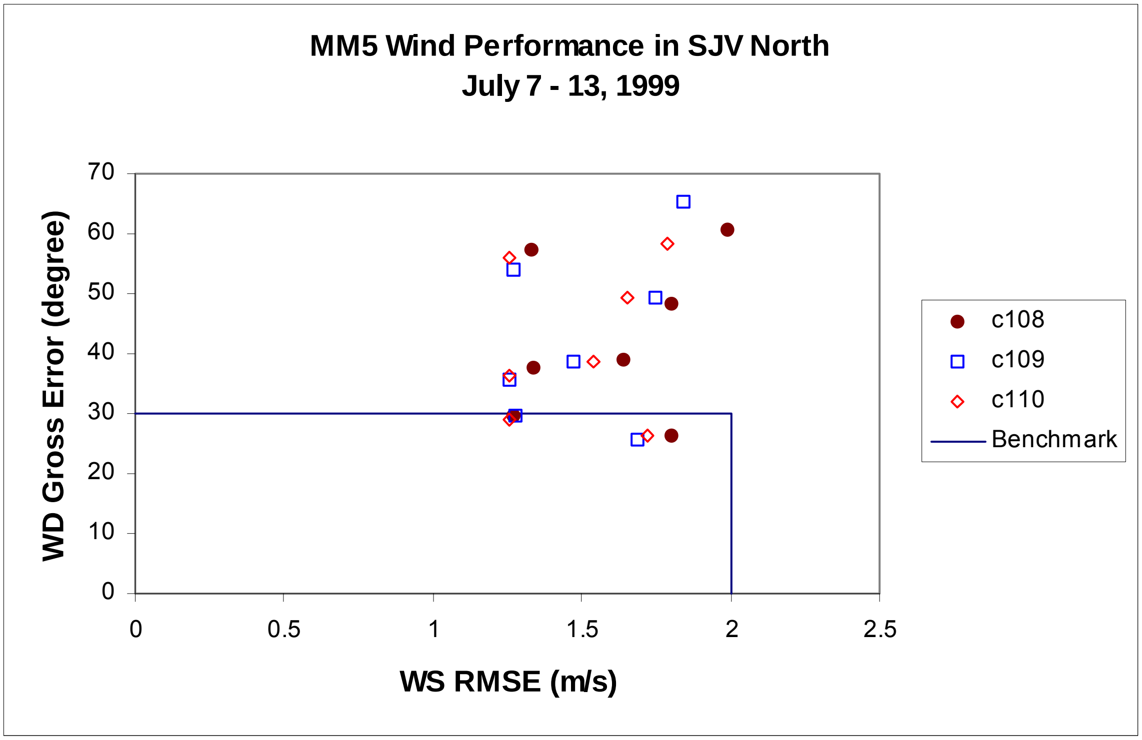


Figure 1-9. Time series of wind speed, direction, and temperature for the Northern San Joaquin Valley over the July 7-13, 1999 modeling period.



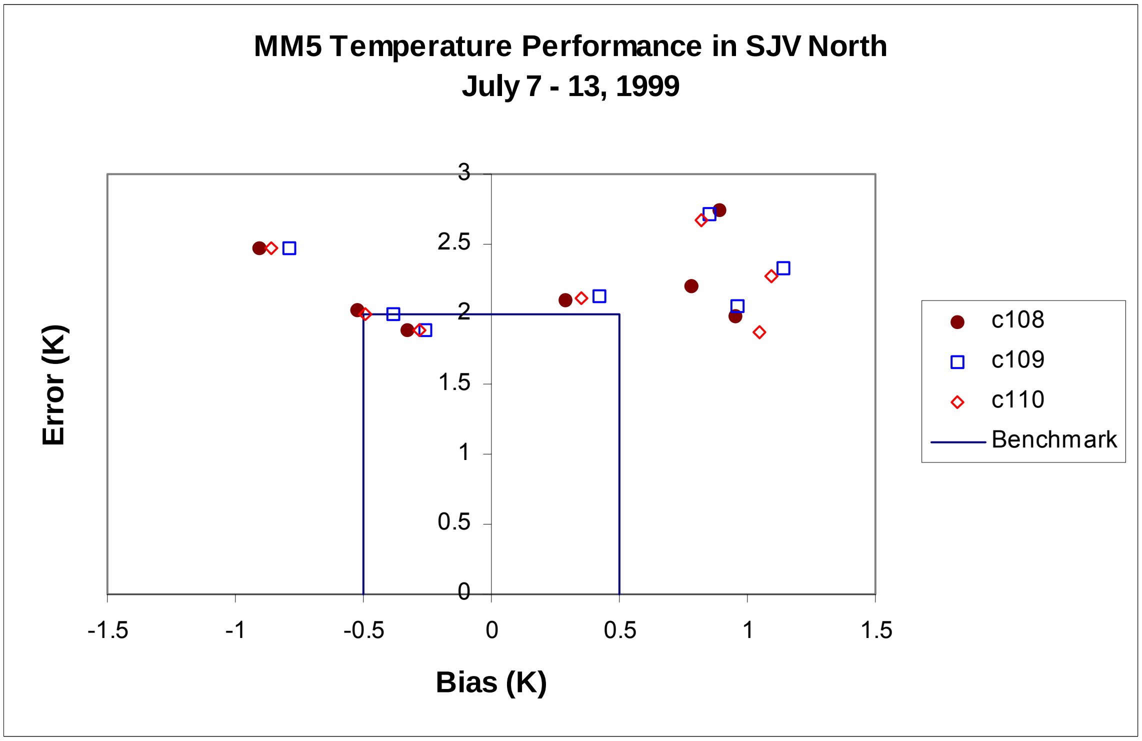


Figure 1-10. MM5 performance for winds and temperature in the Northern San Joaquin Valley.

July-August 2000 Episode (CCOS Episode)

Under the CCOS program, the meteorological modeling group at the National Oceanic and Atmospheric Administration (NOAA) was selected as a contractor to study the July 29, 2000 12Z – Aug 3, 2000 12Z ozone episode that occurred during CCOS. Under this CCOS contract, NOAA studied the meteorology of this episode using the MM5 numerical model with various model options and initial and boundary conditions.

After extensive internal simulations, NOAA produced and distributed an MM5 model output in 2003 that is referred to as the “NOAA placeholder” simulation. Subsequently, NOAA produced several additional MM5 outputs. Three of these other simulations as well as the placeholder simulation were selected by ARB as candidates for SIP modeling purposes. The last two of these simulations are considered by NOAA to be their ‘best available’ runs. The model setups in all of these simulations are identical except as noted in the first four rows of the table below (Table 1-3).

Table 1-3 July-Aug 2000 CCOS Episode. Four 5-day NOAA simulations and two 7-day ARB simulations are considered.

Simulation Number	Abbreviation	Description
1	NOAA placeholder	5 day simulation using 5 layer soil model and observational FDDA file prepared by the Bay Area AQMD
2	NOAA FDDA1	5 day simulation; Same as NOAA placeholder (#1), except using NOAH land-surface model
3	NOAA FDDA2	5 day simulation; Same as NOAA FDDA1 (#2), above, except using observational FDDA file prepared by NOAA and with roughness length doubled.
4	NOAA FDDA3	5 day simulation; Same as NOAA FDDA1 (#2), above, except using observational FDDA file prepared by NOAA and with 5 times the roughness length.
5	ARB NO FDDA	7 day simulation
6	ARB FDDA	7 day simulation

As indicated in the last two rows of the table above, model simulations were also conducted at ARB. In these two ARB simulations, different model options were used: the Gayno Seaman boundary layer scheme was used; a larger radius of influence was selected; and the model was started approximately two days earlier, on July 27, 00Z, in order to provide additional days for Relative Reduction Factor calculations performed for air quality analyses. Thus, both ARB runs are for 7 days.

The four five-day NOAA outputs along with two seven-day ARB outputs, called ARB NO FDDA and ARB FDDA, were analyzed and compared against observational data using the comparison methods discussed previously.

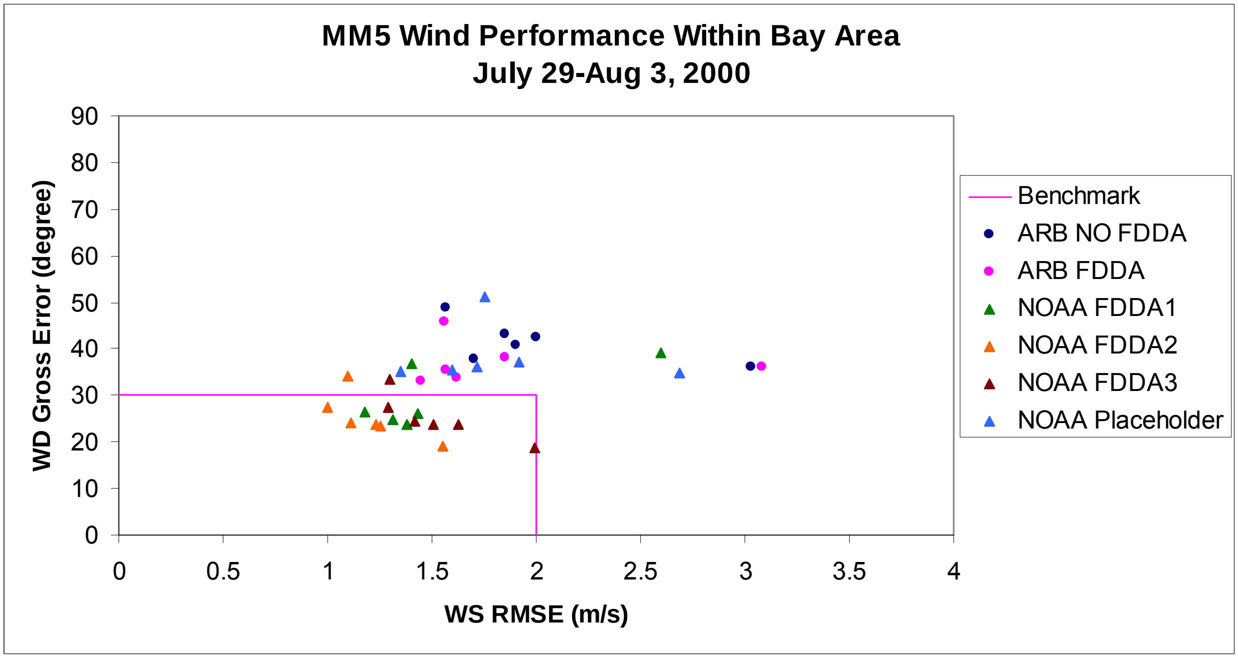
Model performance statistics provided in Figures 1-10 (a-g) and 1-11(a-g) point out that the statistical error of simulation NOAA FDDA3 are within the acceptable limits of EPA standards for wind speed and direction while temperature predictions are not very good.

The temporal comparison of model variables at the Angiola site is illustrated in Figures 1-12 (a and b). Comparisons at other stations are available by ftp through the ARB modeling section. While previous figures show the station averaged model performance statistics within each subregion, these give a detailed perspective of model performance at an individual observation station. Examination of these temporal comparisons show that model performance can vary dramatically from one station to the next. While all NOAA and ARB FDDA simulations appear to adequately produce the observed wind field, the NOAA Placeholder model appears to produce observed temperatures better than the other model runs do.

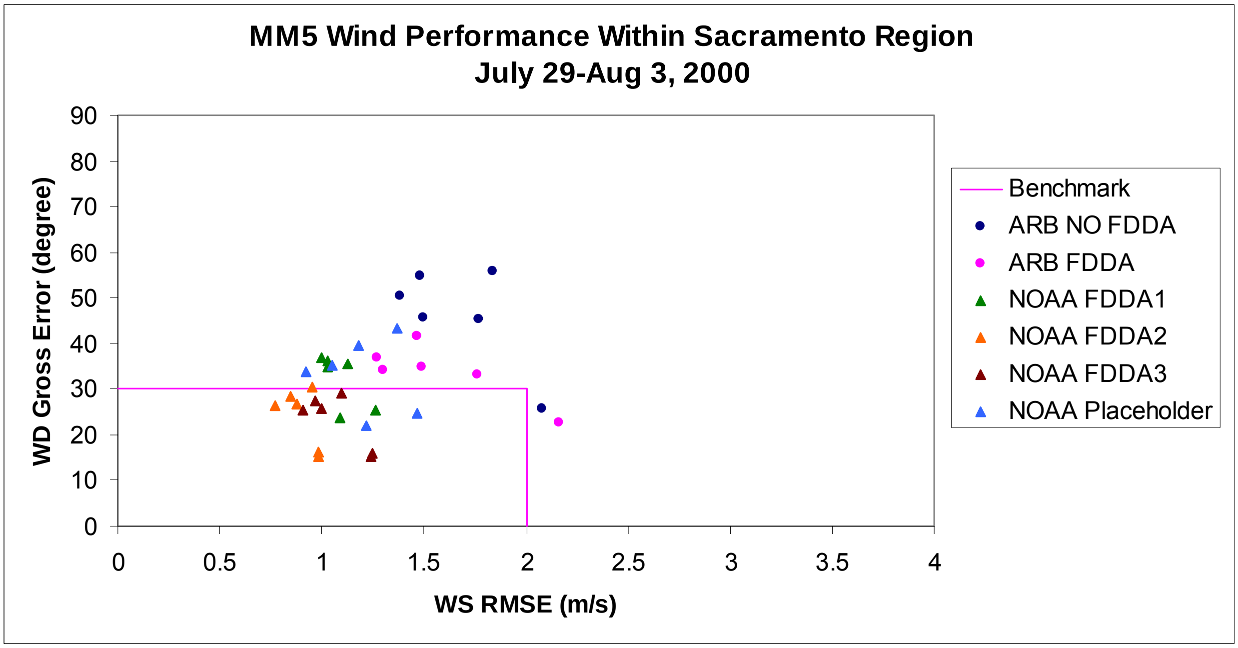
Figures 1-13(a-f) compare horizontal wind vectors against observations at 21Z on July 29, 2000 (2 PM local time) when the flow field is expected to play an important role in maximum ozone concentrations. Each model has slightly different wind flows, however the flows in the NOAA FDDA2, FDDA3 and Placeholder simulations seem to be more organized than in the other models.

Since NOAA FDDA2 and NOAA FDDA3 are sensitivity tests generated by varying roughness length, these results will not be considered in air quality simulations until the effects of these tests are further understood and accepted. Presently, it appears that this has an adverse impact on temperature performance. ARB is currently working with NOAA to better understand these runs. The figures indicate that the overall performance of NOAA's placeholder model for all variables is generally as acceptable as all other MM5 results that were considered. Therefore, the NOAA placeholder model output is used in air quality simulations.

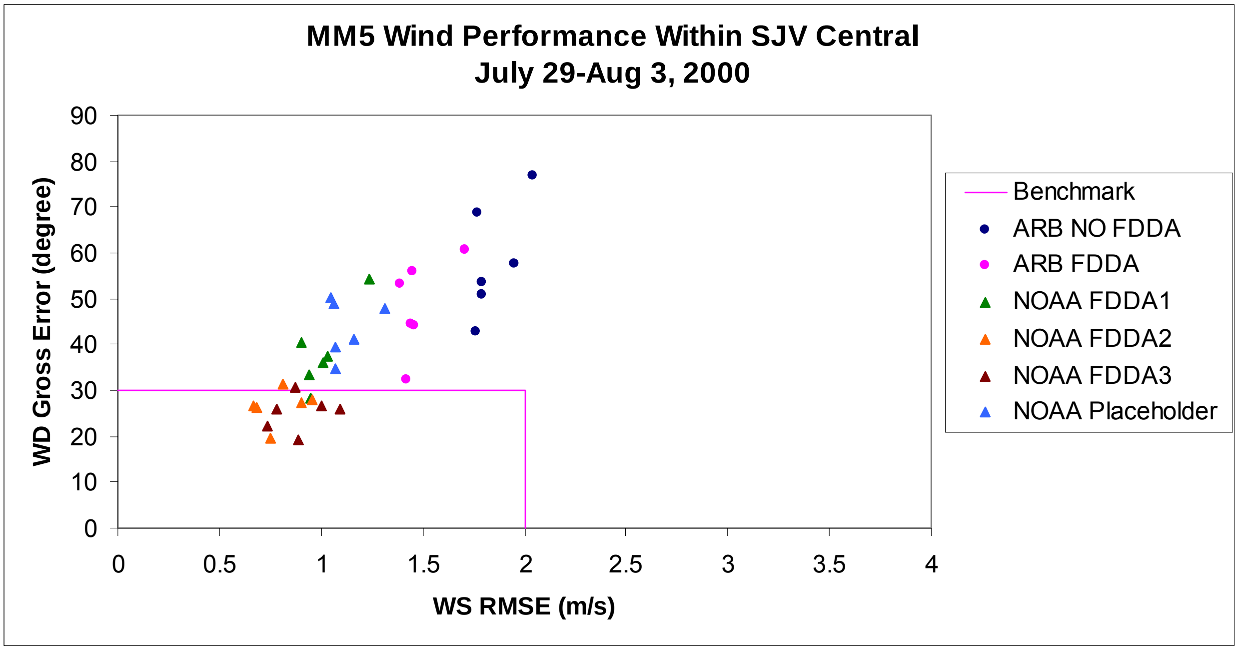
Figures 1-11 (a-g): Model performance statistics of wind speed and direction created for subregions 3, 6, 7, 8, 9, 10 and 11, respectively.



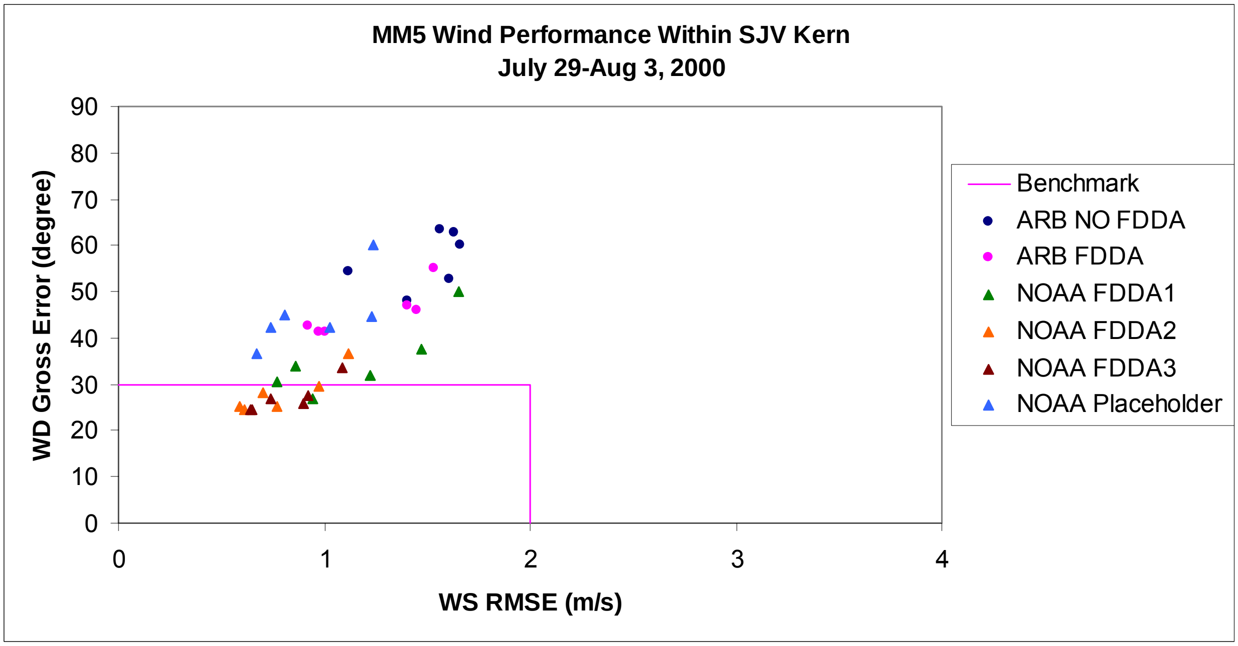
(a)



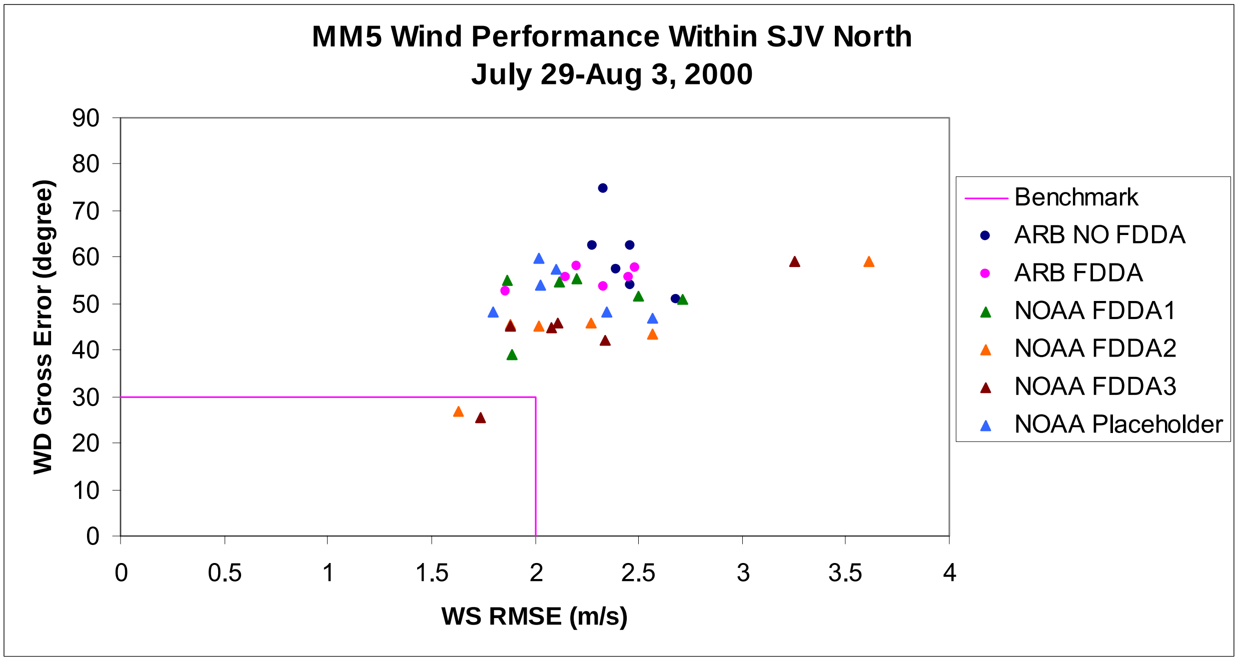
(b)


MM5 Wind Performance Within SJV Central
July 29-Aug 3, 2000
WD Gross Error (degree)
0
10
20
30
40
50
60
70
80
90
WS RMSE (m/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

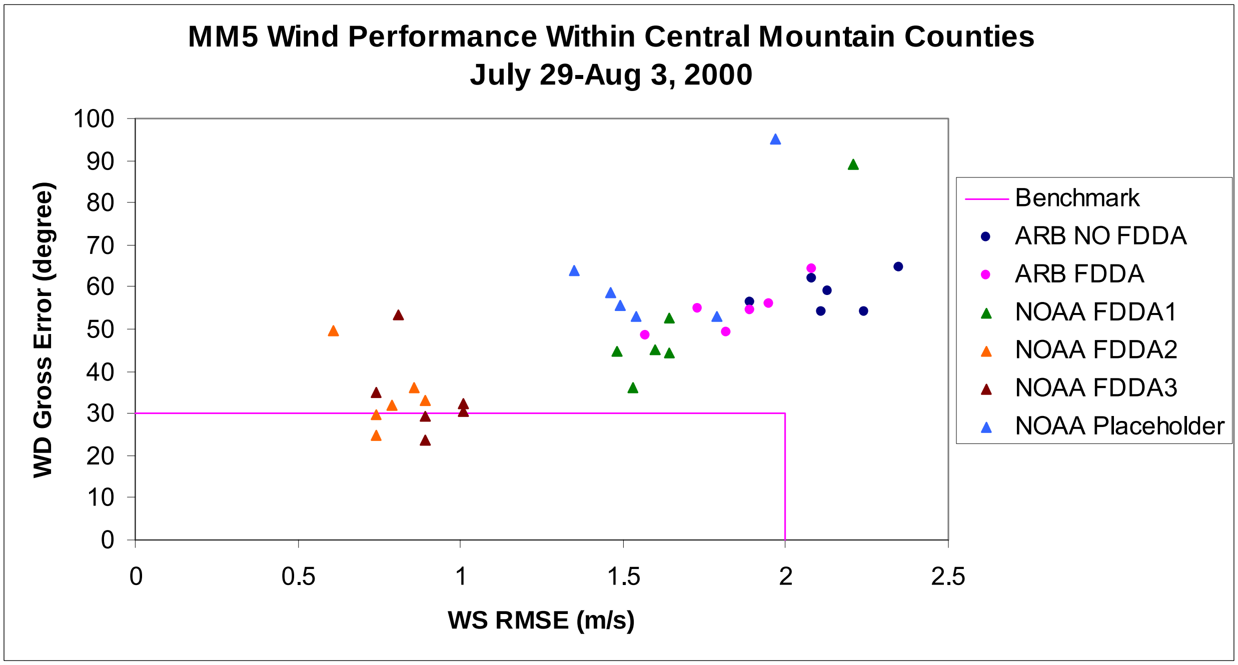
(c)


MM5 Wind Performance Within SJV Kern
July 29-Aug 3, 2000
WD Gross Error (degree)
0
10
20
30
40
50
60
70
80
90
WS RMSE (m/s)
0
1
2
3
4
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

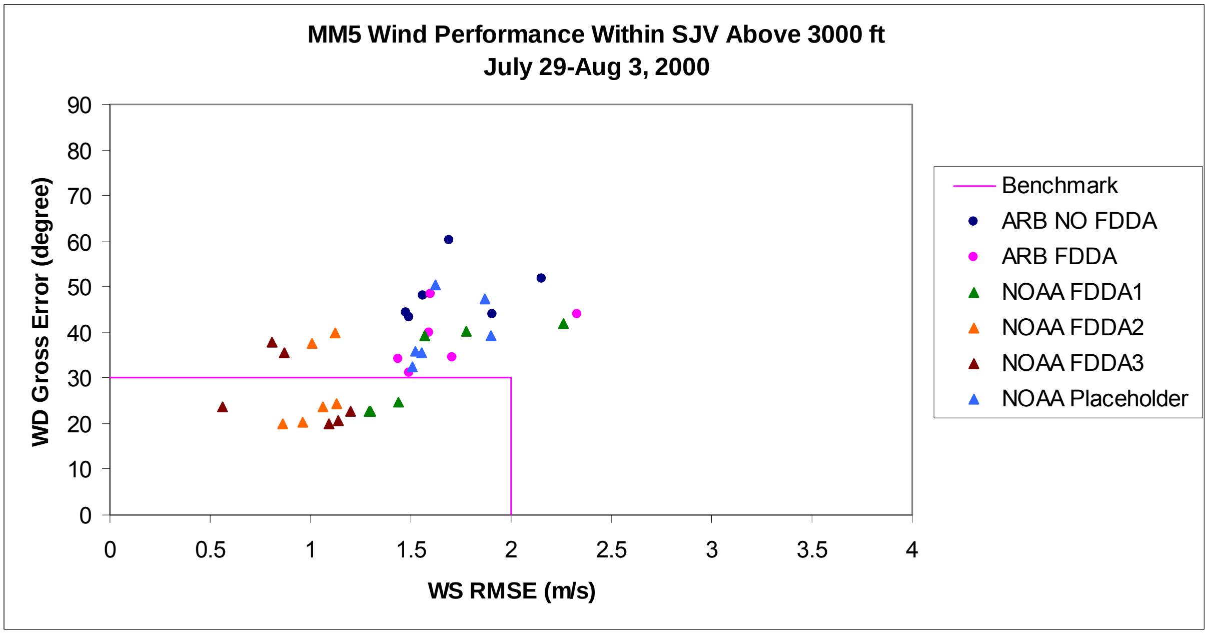
(d)


MM5 Wind Performance Within SJV North
July 29-Aug 3, 2000
WD Gross Error (degree)
0
10
20
30
40
50
60
70
80
90
WS RMSE (m/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

(e)

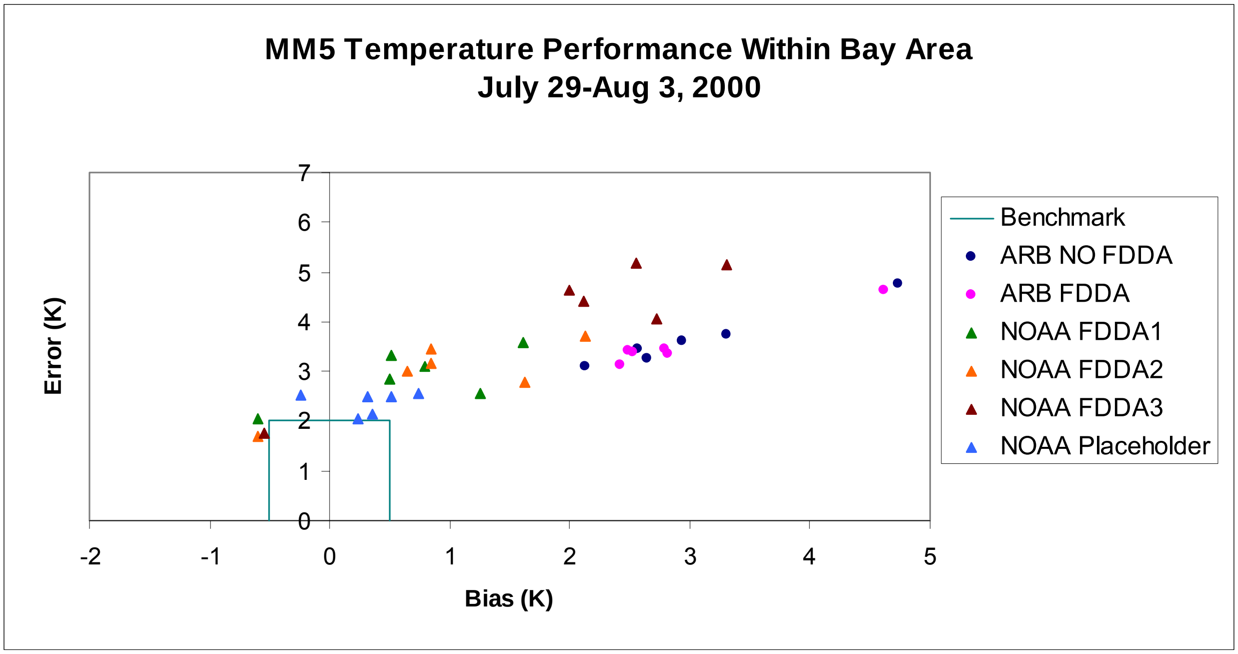

MM5 Wind Performance Within Central Mountain Counties
July 29-Aug 3, 2000
WD Gross Error (degree)
0
10
20
30
40
50
60
70
80
90
100
WS RMSE (m/s)
0
0.5
1
1.5
2
2.5
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

(f)

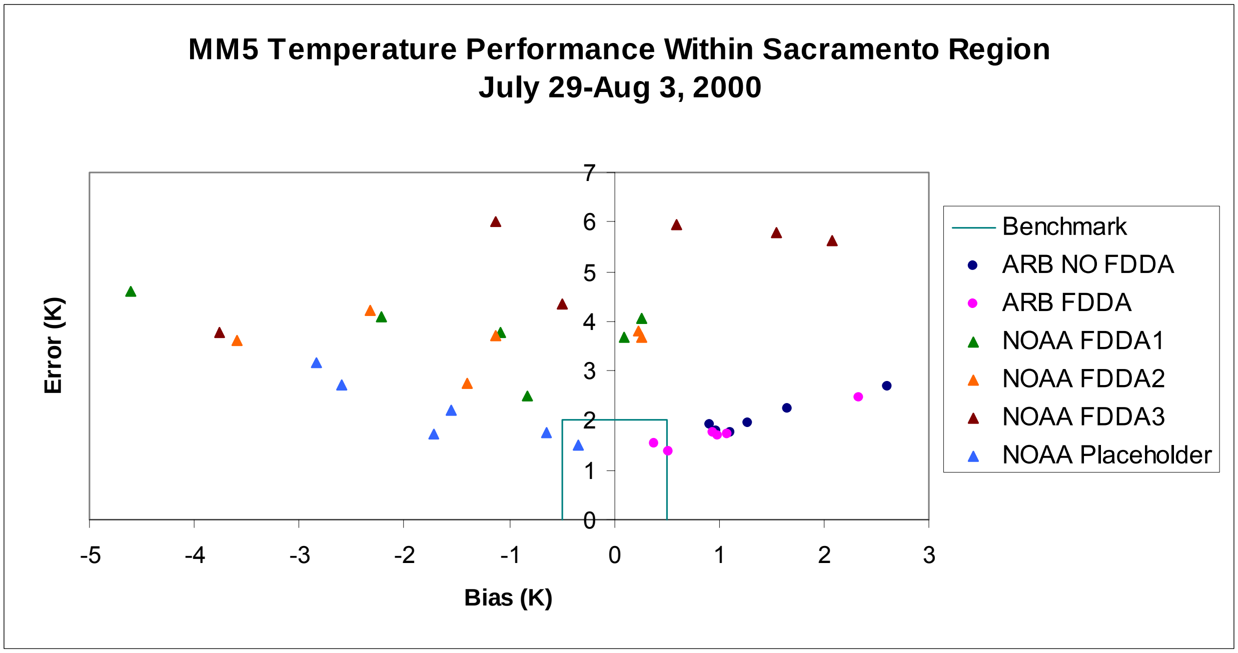

MM5 Wind Performance Within SJV Above 3000 ft
July 29-Aug 3, 2000
WD Gross Error (degree)
0
10
20
30
40
50
60
70
80
90
WS RMSE (m/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

(g)

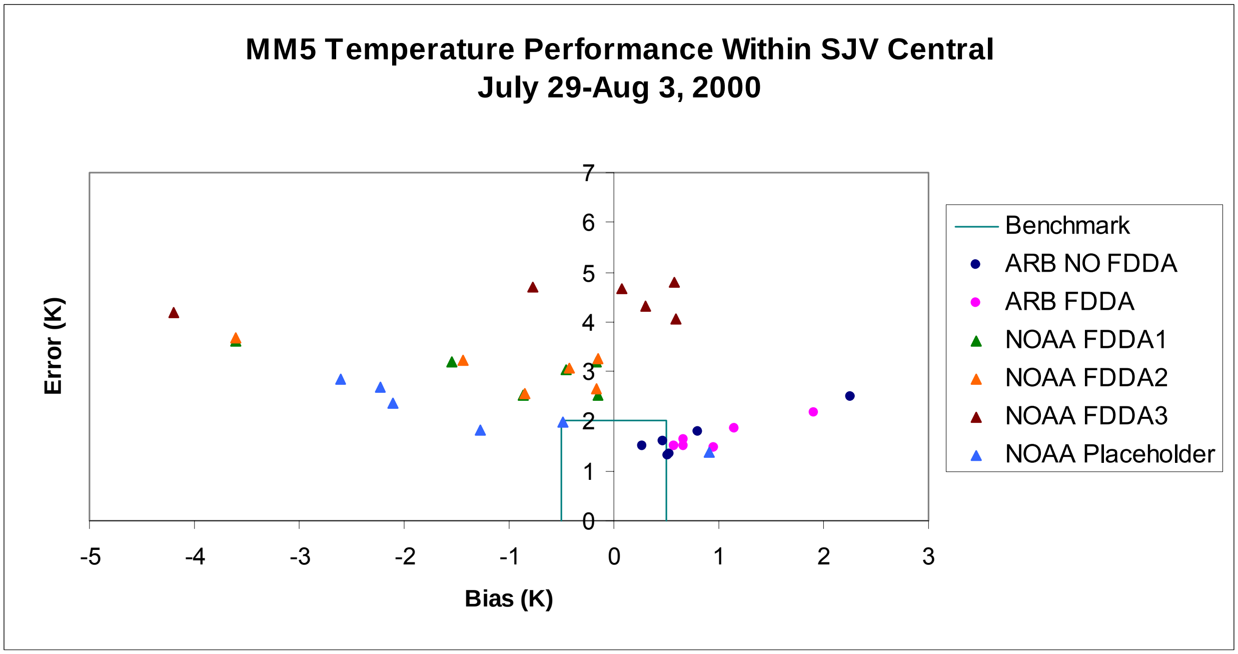
Figures 1-12 (a-g): Same as Figures 1-11, except for temperature.



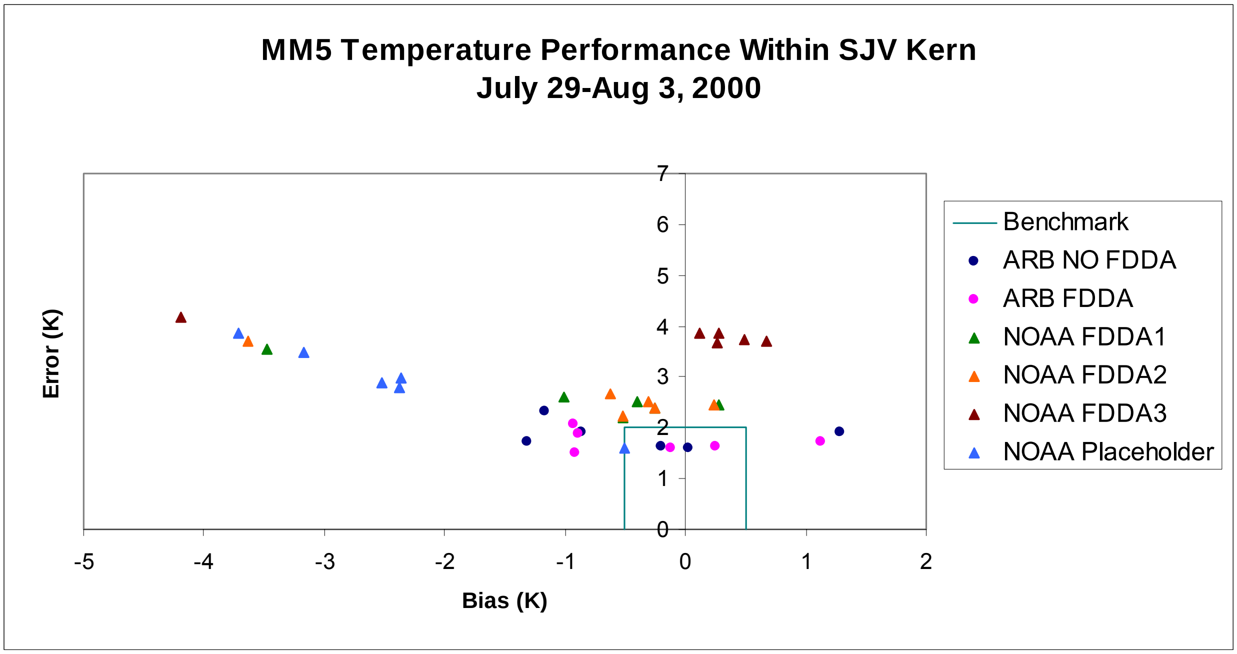
(a)



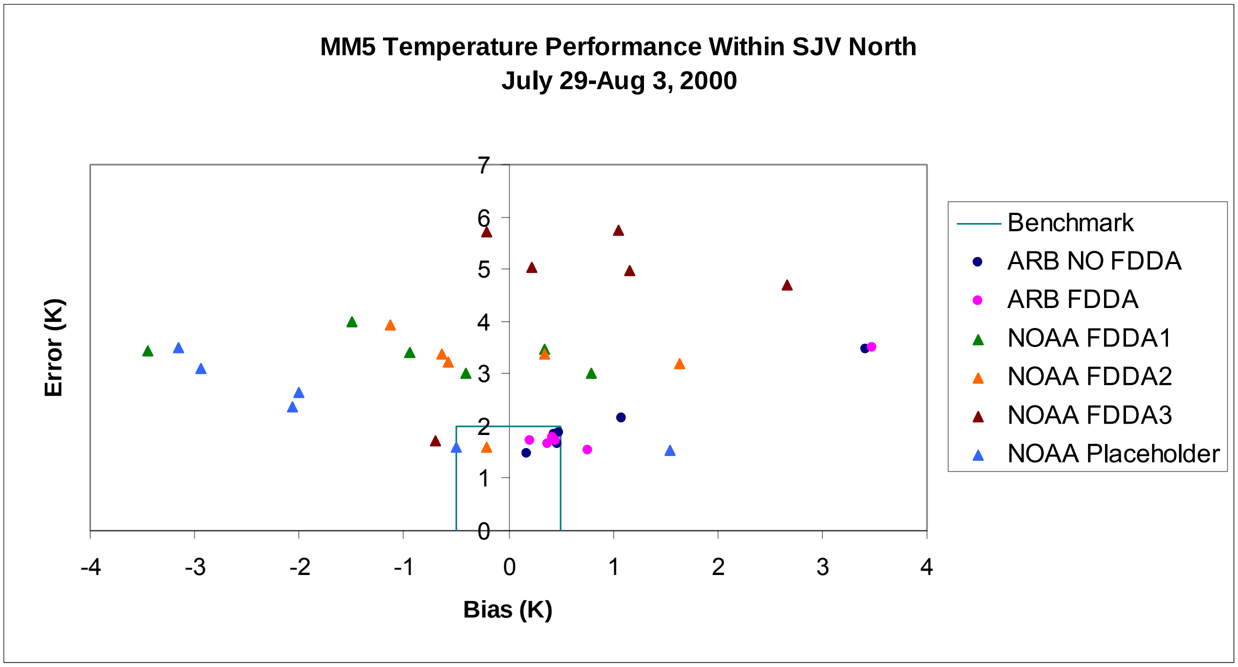
(b)


MM5 Temperature Performance Within SJV Central
July 29-Aug 3, 2000
Error (K)
Bias (K)
7
6
5
4
3
2
1
0
-5
-4
-3
-2
-1
0
1
2
3
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

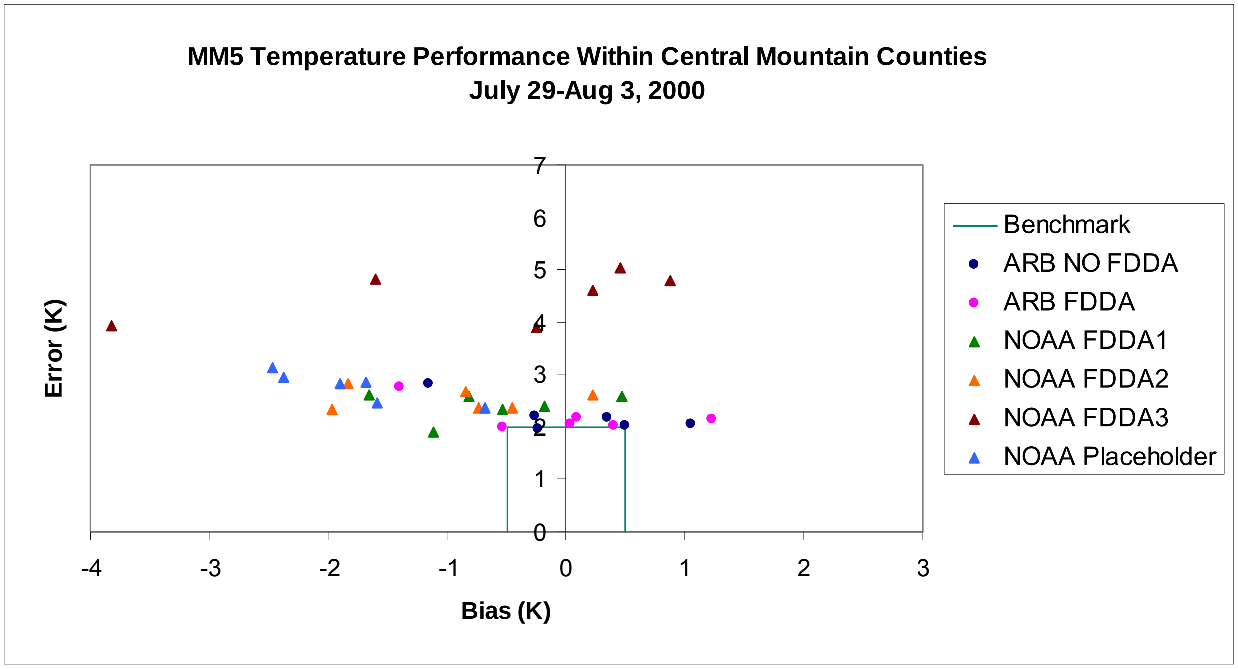
(c)


MM5 Temperature Performance Within SJV Kern
July 29-Aug 3, 2000
Error (K)
Bias (K)
7
6
5
4
3
2
1
0
-5
-4
-3
-2
-1
0
1
2
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

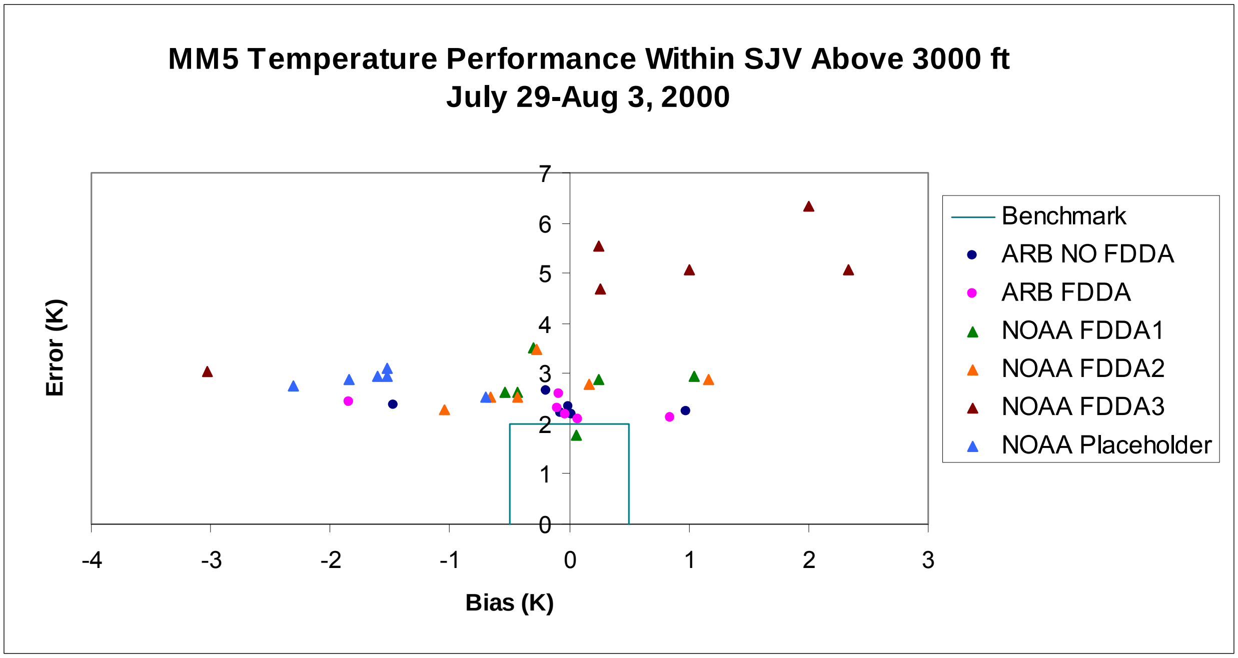
(d)


MM5 Temperature Performance Within SJV North
July 29-Aug 3, 2000
Error (K)
Bias (K)
7
6
5
4
3
2
1
0
-4
-3
-2
-1
0
1
2
3
4
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

(e)

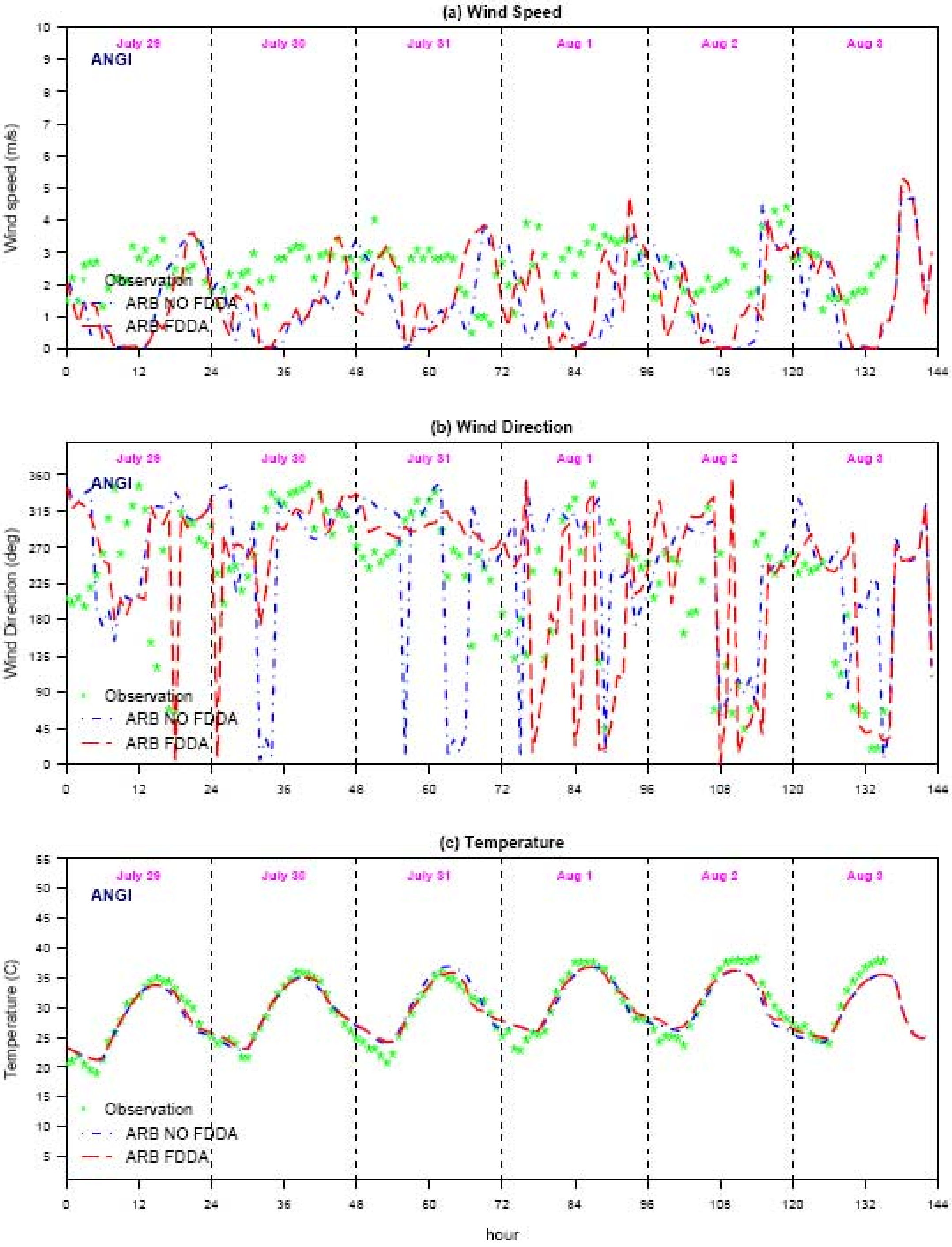

MM5 Temperature Performance Within Central Mountain Counties
July 29-Aug 3, 2000
Error (K)
Bias (K)
7
6
5
4
3
2
1
0
-4
-3
-2
-1
0
1
2
3
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

(f)

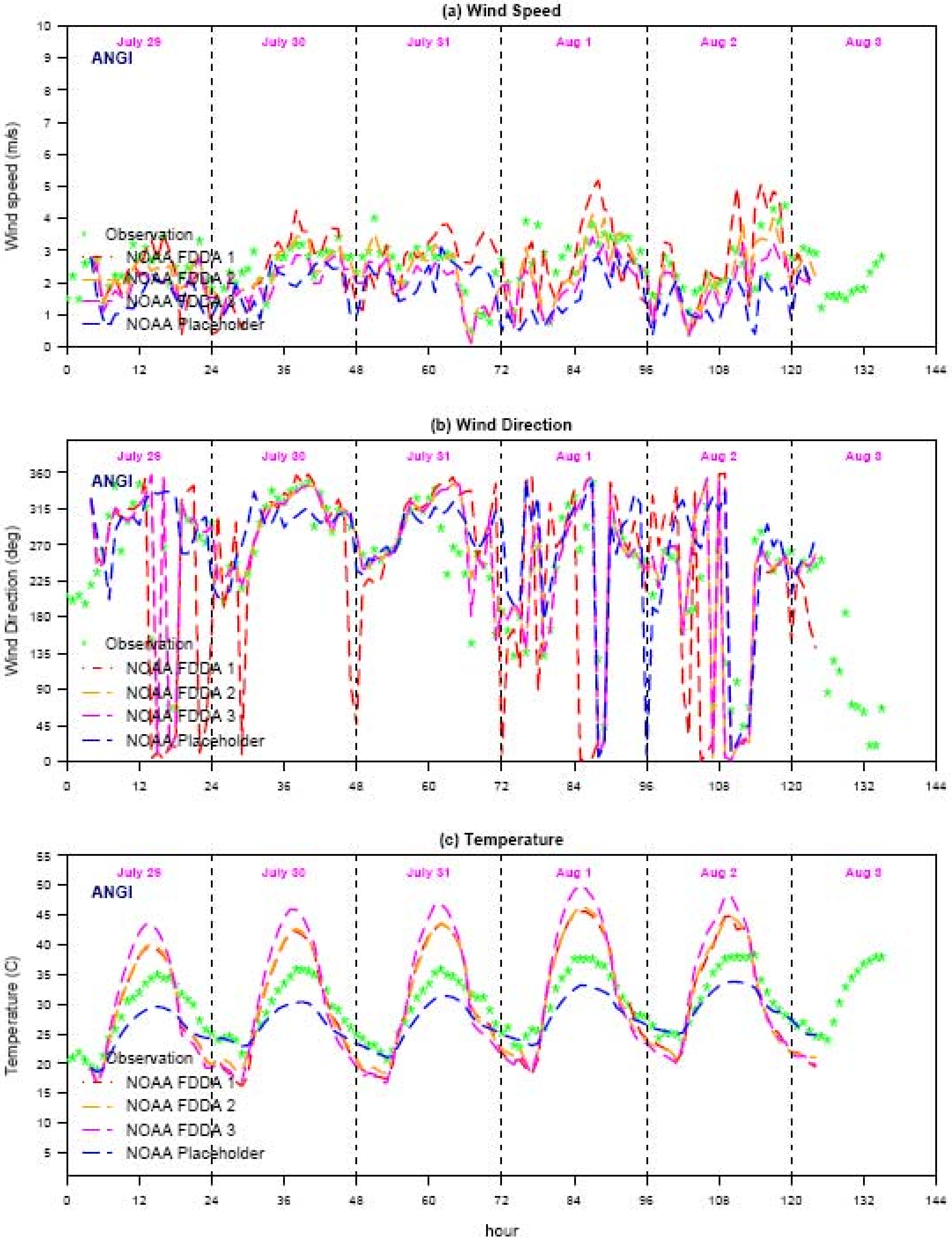

MM5 Temperature Performance Within SJV Above 3000 ft
July 29-Aug 3, 2000
Error (K)
Bias (K)
0
1
2
3
4
5
6
7
-4
-3
-2
-1
0
1
2
3
Benchmark
ARB NO FDDA
ARB FDDA
NOAA FDDA1
NOAA FDDA2
NOAA FDDA3
NOAA Placeholder

(g)

Figures 1-12 (a and b): Temporal comparisons of wind speed, direction and temperature at Angiola station for ARB (a) and NOAA (b) model results

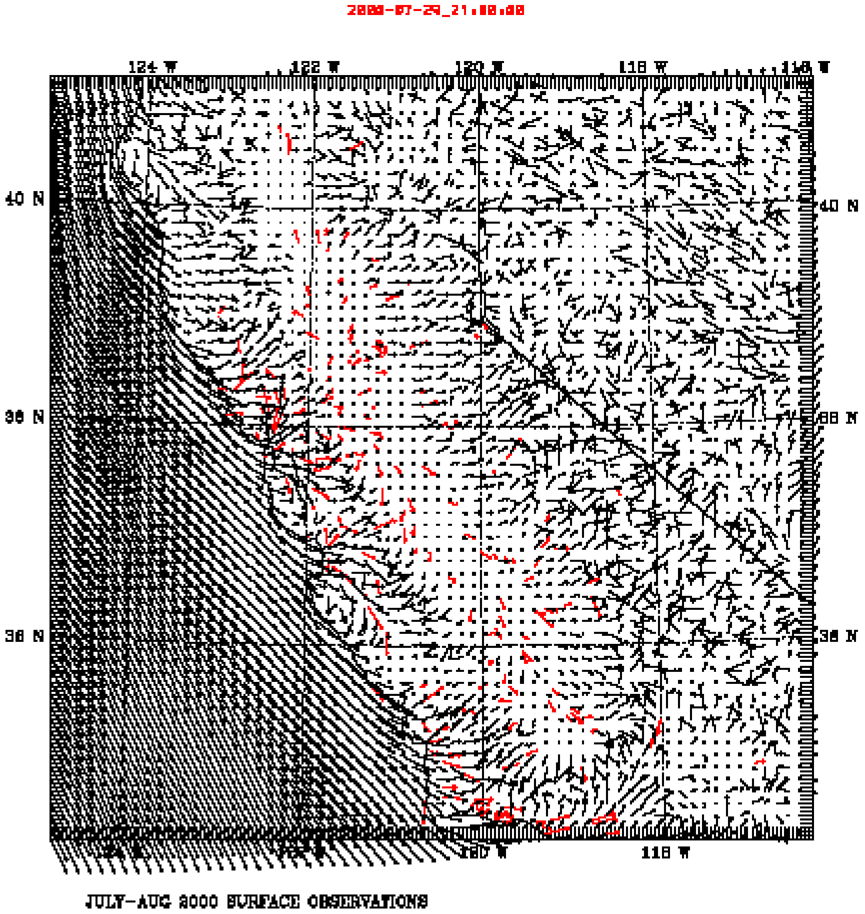


(a)

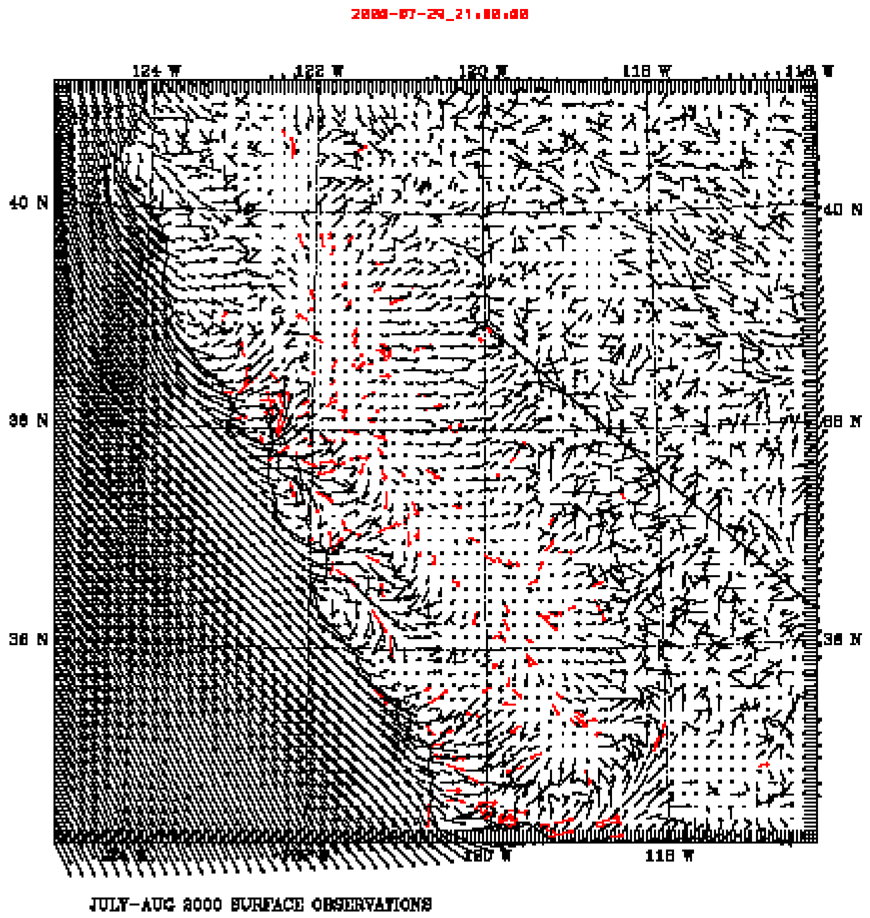

(a) Wind Speed
Wind speed (m/s)
(b) Wind Direction
Wind Direction (deg)
(c) Temperature
Temperature (C)
ANGI
July 29
July 30
July 31
Aug 1
Aug 2
Aug 3
Observation
NOAA FDDA 1
NOAA FDDA 2
NOAA FDDA 3
NOAA Placeholder
0
12
24
36
48
60
72
84
96
108
120
132
144
hour

(b)

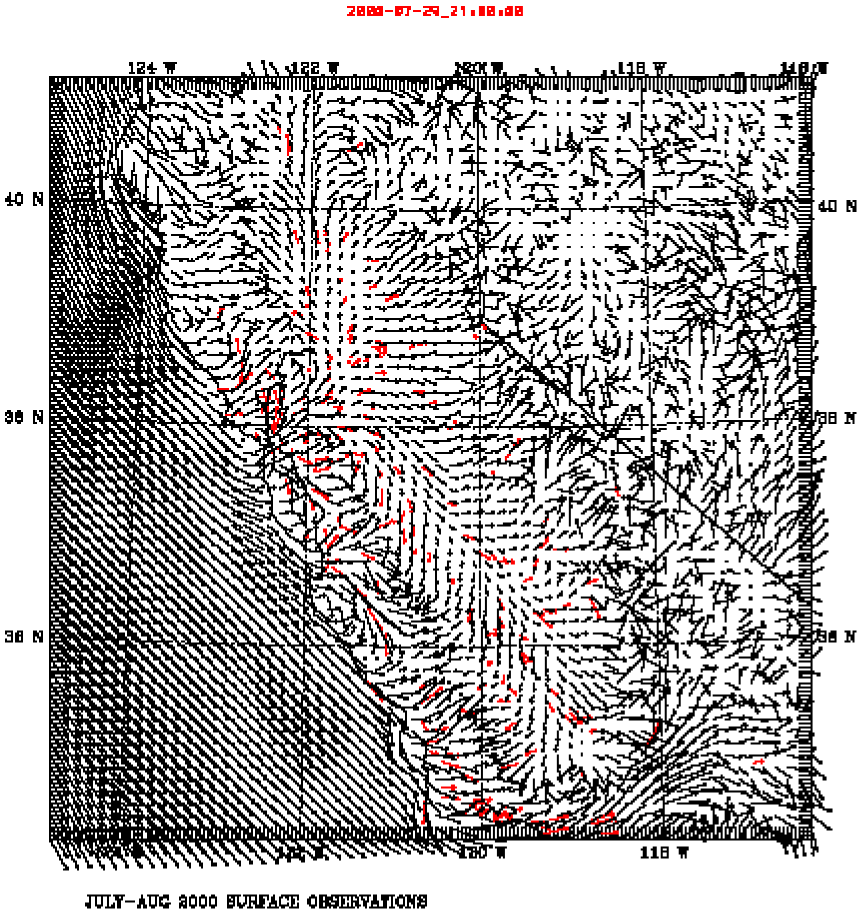
Figures 1-13(a-f): Horizontal variation of wind vectors on July 29, 2000 21Z (2 PM local time) compared to the observations for ARB NO FDDA (a), ARB FDDA (b), NOAA FDDA1 (c), NOAA FDDA2 (d), NOAA FDDA3 (e) and NOAA Placeholder models (f).



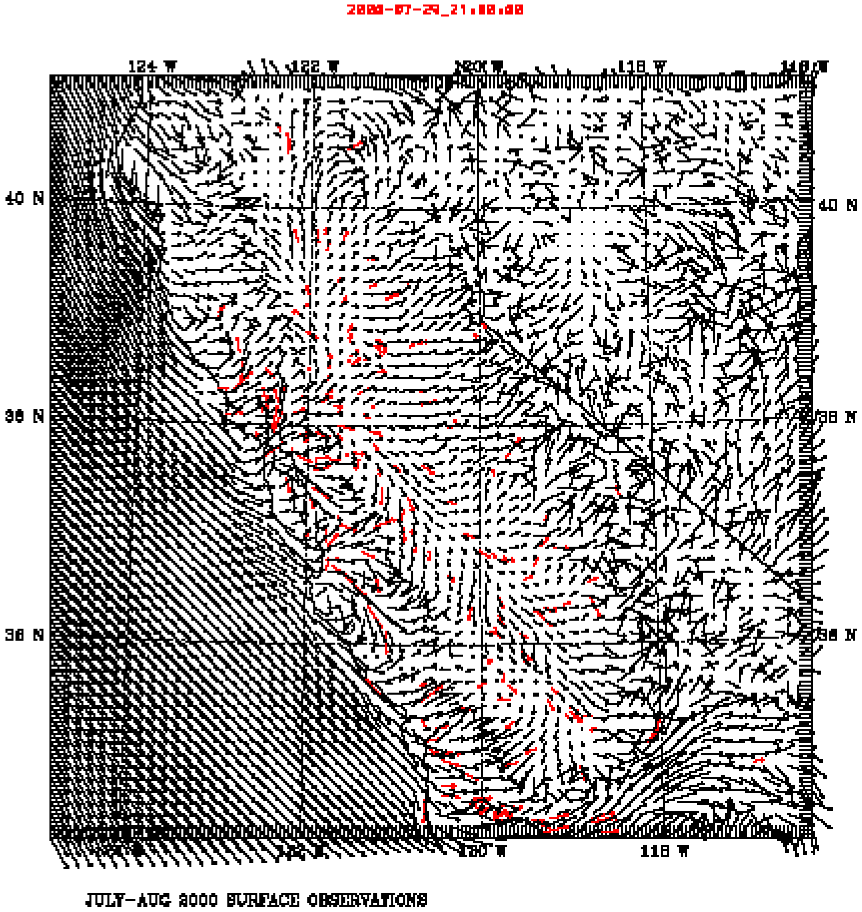
(a)


2000-07-29_21:00:00
124 W
122 W
120 W
118 W
116 W
40 N
38 N
36 N
JULY-AUG 2000 SURFACE OBSERVATIONS

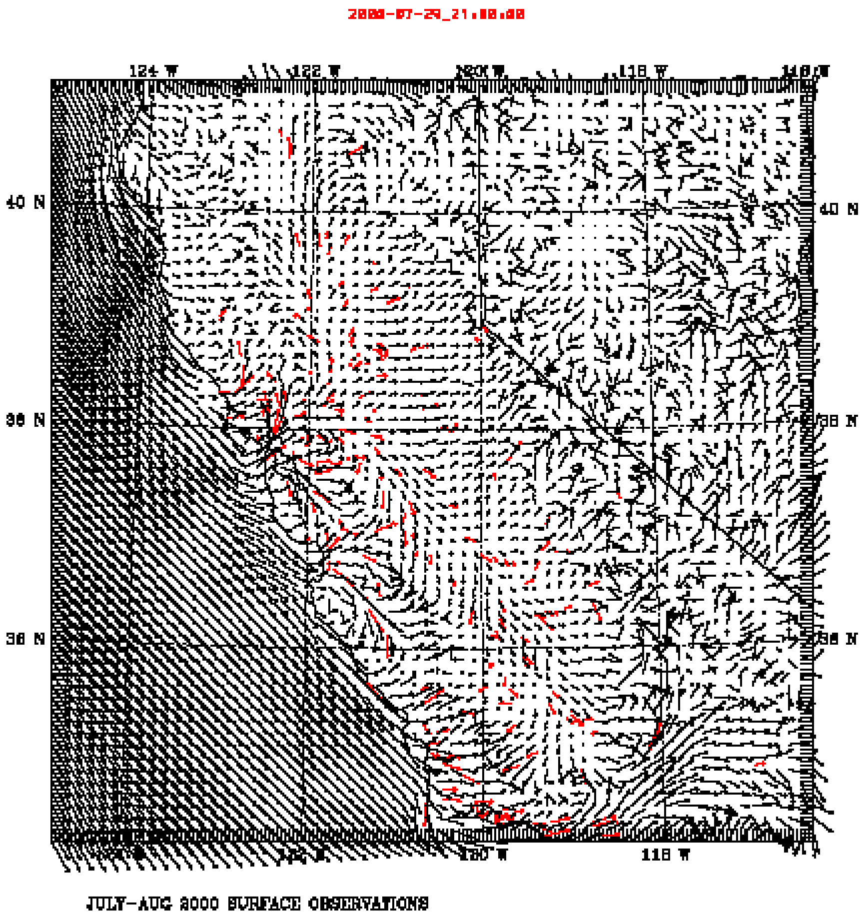
(b)


2000-07-29_21:00:00
124 W
122 W
120 W
118 W
116 W
40 N
38 N
36 N
JULY-AUG 2000 SURFACE OBSERVATIONS

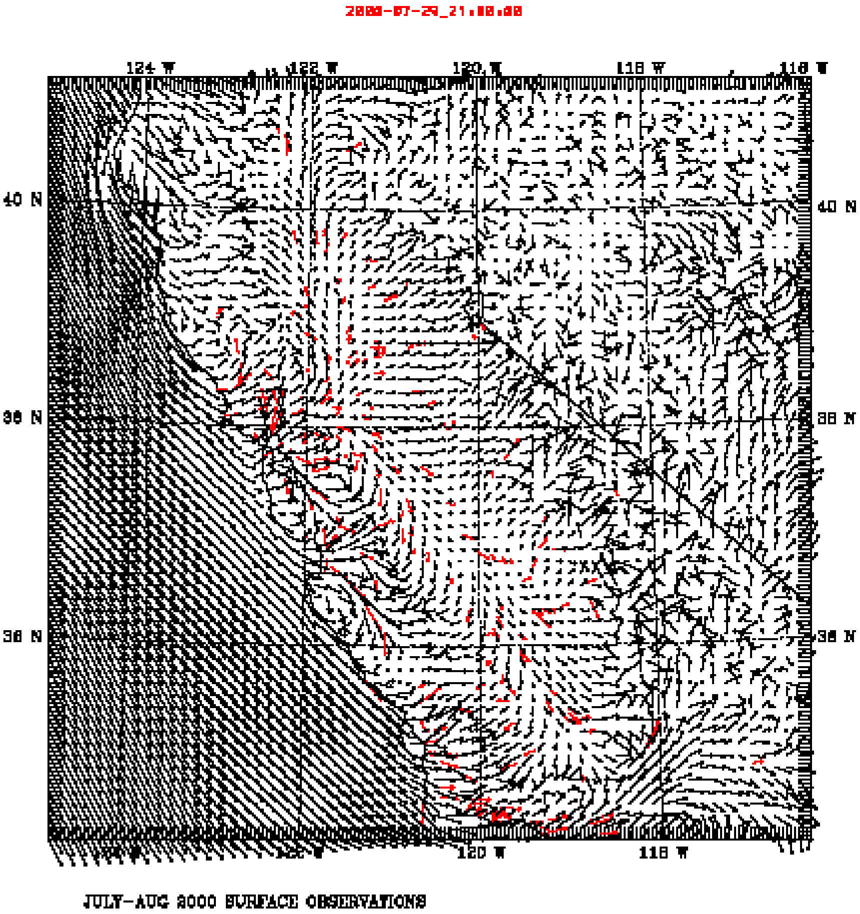
(c)


2000-07-29_21:00:00
124 W
122 W
120 W
118 W
116 W
40 N
38 N
36 N
120 W
118 W
JULY-AUG 2000 SURFACE OBSERVATIONS

(d)


2000-07-29_21:00:00
124 W
122 W
120 W
118 W
116 W
40 N
38 N
36 N
JULY-AUG 2000 SURFACE OBSERVATIONS

(e)


2000-07-29_21:00:00
124 W
122 W
120 W
118 W
116 W
40 N
38 N
36 N
40 N
38 N
36 N
122 W
120 W
118 W
JULY-AUG 2000 SURFACE OBSERVATIONS

(f)

Air Quality Model Performance

AIR QUALITY MODEL PERFORMANCE METRICS

Air quality model results are used to develop strategies for attaining the federal 8-hour ozone standard. The development of these strategies relies on the use of relative reduction factors (RRFs). More detailed discussion of RRFs is provided in other documents. However, the use of RRFs requires an evaluation of relative air quality model response at specific monitoring sites in the base year(s), a baseline year, and a future year.

Adequate model performance is a requirement for use of modeled results. The lack of acceptable performance greatly increases uncertainty in the use of the modeling results, and casts doubt on conclusions based on the modeling. Although it is desirable to include as many days as possible in the RRF calculations, our experience has demonstrated that not all modeled days meet the minimum performance standards, and are thus not suitable for use. Therefore only those days that satisfy the following model performance criteria will be utilized in subsequent RRF calculations.

The USEPA (1991) and ARB (1990) outline a number of procedures for analysis of base year, air quality model performance. These include spatial and time-series plots, and statistical analyses, comparing simulated and observed pollutant concentrations, as well as sensitivity analysis of selected input fields. The purpose of the performance analysis is to provide some confidence that the air quality simulations – which are the basis of future-year ozone concentration estimates – are performing properly.

The application of air quality modeling results to demonstrate attainment of the federal 1-hour ozone standard emphasized the simulated unpaired peak ozone concentration. Three statistical measures were recommended to evaluate model performance: unpaired peak ratio (UPR), paired mean normalized bias (NB), and paired gross error (GE). These statistical measures were calculated for the modeling domain as a whole, and the NB and GE were calculated from all hourly concentrations in excess of 60 ppb (to avoid biasing the statistical measures with low concentrations). To meet performance guidelines, recommendations were that the UPR should be within ± 20%, NB should be within ± 15%, and the GE less than 35%. However, California's geography is very complex and modeling domains have evolved to cover large geographic areas. Thus it is recommended that the domains be divided into subregions, and that the performance measures be calculated independently for each subregion. The configuration of these subregions is somewhat arbitrary; however, they should be configured to isolate "common" regions of higher ozone. Figure 2-1 illustrates the proposed subregions for the CCOS domain.

The USEPA (2005) recommends that model performance be evaluated for 8-hour concentrations as well . The recommended statistical measures to assess simulated versus observed maximum 8-hour ozone concentrations include paired (in space, but not time) peak prediction accuracy (PPPA), paired mean normalized bias (NB), and paired gross error (GE). Although limited performance analysis has been completed for 8-hour ozone modeling in California, it seems prudent at this point to carry forward the 1-hour statistical goals and apply them for the 8-hour standard (UPR within ± 20%, NB within ± 15%, and the GE less than 35%). However, these limits may need to be revised as 8-hour SIP modeling progresses and rigorous model performance evaluations are completed.

While statistical measures for 1-hour model performance were typically calculated independently for each modeled day available, the USEPA also suggests that PPPA, NB, and GE be calculated for each site over all modeled days. However, because the number of episode days available may be very limited, the statistical uncertainties in these latter calculations would be large and they are not recommended or used herein.

In order to have confidence in future year estimates from air quality models, there must be confidence in the air quality modeling for the base year. That is, days not meeting model acceptance criteria provide high uncertainty, and should not be used for the modeled attainment test.

In addition to the issue of model performance, analyses conducted by the USEPA (2005) suggest that air quality models respond more to emission reductions at higher predicted ozone values. Correspondingly, the model predicts less benefit at lower concentrations. This is consistent with preliminary modeling in support of the 8-hour ozone standard conducted by the ARB and the districts. These results imply that RRF calculations should be restricted to days with predicted high ozone concentrations. It is thus reasonable to establish a minimum threshold for predicted peak 8-hour ozone concentrations in the baseline year. Days for which the predicted daily peak 8-hour ozone concentrations at a site are less than the threshold, would not be used for calculating RRFs at that site. Consistent with USEPA's recommendation, we propose to use a value of 85 ppb for the baseline year threshold. However, USEPA guidelines allow the use of the maximum 8-hour concentrations within 15km of a site for this purpose.

Based on the above discussion, we propose the following model performance based methodology for determining sites and modeled days to be used in the RRF calculations:

Only those modeled days meeting the following criteria will be used to calculate site-specific RRFs:

1) **The modeled daily 8-hour peak ozone concentration within 15 km of the site for the base year of the modeling must be within ±20% of the observed value at the site.**
2) **The modeled daily 8-hour peak ozone concentration within 15 km of the site in the baseline year must be 85 ppb or greater.**
3) **The subregional 1-hour and 8-hour statistical measures of NB and GE must fall within the thresholds of ± 15% and 35%, respectively.**

Of these three criteria, only the third is considered in this document.

Along with the statistical measures discussed above, the graphical and statistical tests recommended by the USEPA (1991 and 2005) and shown in Tables 2-1 and 2-2 will be used to assess overall model performance. Several sensitivity tests recommended by the USEPA (1991) will also be used (Table 2-3) for qualitative evaluation. While the results of these sensitivity analyses are inherently subjective, they are designed to provide confidence that the air quality model is not only performing well, but is also properly responding to changes in inputs.

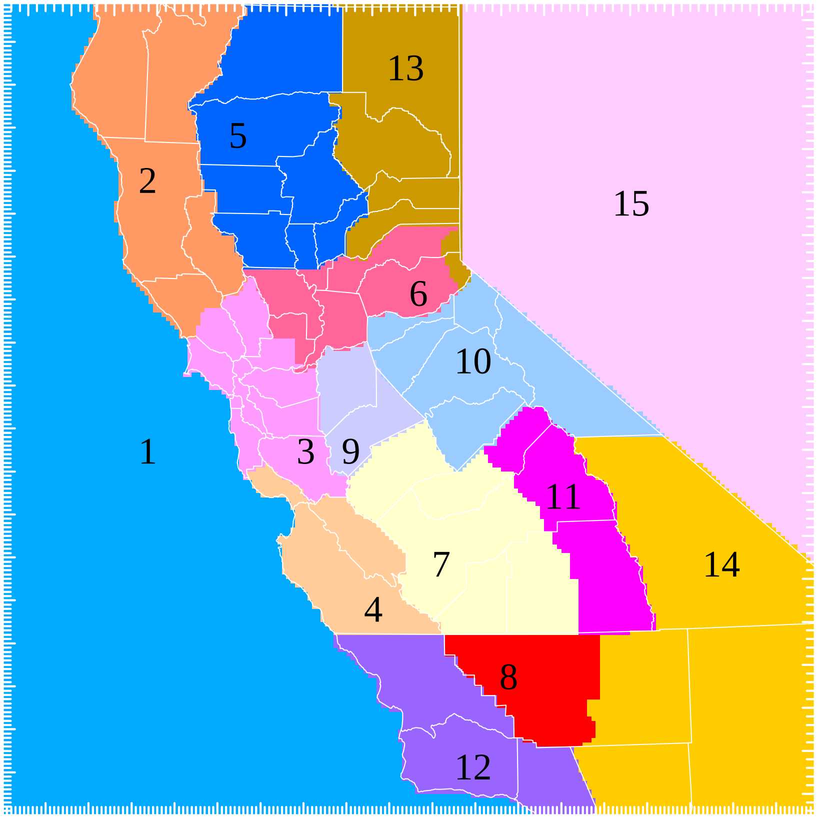


Figure 2-1 Sub-regions of air quality model performance evaluation (3: Bay area region, 6: metro Sacramento region, 7: central San Joaquin valley region , 8 southern San Joaquin valley region, 9: northern San Joaquin valley region).

Table 2-1. Statistics for evaluating base year air quality model performance for all sub-regions.

- mean normalized bias for all 1-hour ozone concentrations (60 ppb), unpaired in time and space for all sites
- mean normalized gross error for all 1-hour ozone concentrations (≥60 ppb), unpaired in time and space for all sites
- peak 1-hour ozone concentration ratio, unpaired in time and space
- mean normalized bias for all 8-hour ozone concentrations (≥60 ppb), unpaired in time for all sites
- mean normalized gross error for all 8-hour ozone concentrations (≥60 ppb), unpaired in time for all sites
- peak 8-hour ozone concentration ratio, unpaired in time and space

Table 2-2. Graphical tools for evaluating base year air quality model performance.

- time-series plots comparing 1-hour measured and simulated concentrations of ozone, NO, NO2, and CO for each site.
- hourly spatial plots of 1-hour measured and simulated concentrations of ozone, NO, NO2, and CO for the CCOS modeling domain.
- scatter plot of 1-hour ozone concentrations for each day, and for each subregion of the modeling domain.

Table 2-3. Sensitivity tests for evaluation of Base Year air quality simulations. The results of these analyses will be tabulated by subregion.

1 Minimize vertical diffusivity based on land cover

2 Zero anthropogenic emissions

3 Zero biogenic emissions

4 Set lateral ozone boundary conditions to 50 ppb

5 Set lateral ozone boundary conditions to 90 ppb

6 Set initial ozone conditions to 40 ppb everywhere

7 Set initial conditions to 0.1 ppb NO2 and 0.0 NO (run with all emissions)

8 Set initial conditions to 0.1 ppb NO2 and 0.0 NO (run with biogenic emissions only)

9 Double biogenic emissions

10 Remove wildfires

11 Zero mobile emissions

12 Set top ozone boundary conditions to 135ppb at 15km

AIR QUALITY MODEL PERFORMANCE RESULTS

The following two sections present the results of air quality model performance for the two modeling episodes, based on the criteria discussed in the previous section. For illustration purposes, only a portion of the graphics that were actually produced are presented. All of the graphics that have been generated are available via ftp per the table in the Appendix.

July 1999 Episode (Routine Episode)

The July 1999 air quality model simulation covers the 7-day period from July 7, 1999, through July 13, 1999. However, the model performance assessment only covers the 5-day, non-spin-up period from July 9 to July 13, 1999. As discussed previously in Section 1.2.1, the ARB c109 MM5 meteorological simulation is used for these air quality simulations.

Tables 2-4 and 2-5 summarize the 1-hour and 8-hour statistical model performance assessment in terms of identifying the days for which simulated results fall within acceptable statistical performance thresholds in each model performance region (performance regions were shown in Figure 2-1). Each cell in the tables represents whether model-simulated results, on a region-wide basis, are statistically acceptable. The cell is assigned a value of 1 if the model-simulated results pass the statistical model performance criteria; while a value of 0 means that the model-simulated results for the region do not meet the criteria. If all simulated ozone concentrations in the region are below 60 ppb, then the region-day cell is assigned -99 and the modeling results cannot be used for that region. Total days for each episode day and region are provided at the bottom row and far right column of the table, respectively.

For the Bay Area region, 4 days meet the 1-hour criteria and only 1 day meets the 8-hour criteria. For the Sacramento region, all 5 days meet both the 1-hour and 8-hour criteria. For the Central San Joaquin Valley region, 5 days meet the 1-hour criteria and 3 days meet the 8-hour criteria. For the Southern San Joaquin Valley region, only 1 day meets the 1-hour criteria and 4 days meet the 8-hour criteria. For the Northern San Joaquin Valley region, 2 days meet the 1-hour criteria and 3 days meet the 8-hour criteria.

Figures 2-2 through 2-6 show the site-averaged time series of modeled versus predicted CO, ozone, NO and NO_2 for the Bay Area, Sacramento, Central San Joaquin Valley, Southern San Joaquin Valley, and Northern San Joaquin Valley regions, respectively. The orange and blue lines represent observations and model predictions, respectively. The time series for individual stations for these five regions have also been plotted and are available via the ftp site and filename indicated in the Appendix.

Figure 2-2 shows the hourly averaged CO, ozone, NO and NO_2 for the Bay Area region. Predicted CO concentrations are slightly under-predicted for most of the simulation period. However, the simulated ozone is generally over-predicted for the entire simulation period. The model captures the magnitude and diurnal variation of the NO and NO_2 reasonably well.

Figure 2-3 shows the hourly averaged CO, ozone, NO and NO_2 for the Sacramento region. Predicted CO concentrations are over-predicted for most of the simulation period. Ozone concentrations perform well for the first three days and the last day of the simulation period, but are under-predicted from July 10 to July 12. Predicted NO and NO_2 concentrations generally agree with the observations.

Figure 2-4 shows the hourly averaged CO, ozone, NO and NO_2 for the Central San Joaquin Valley region. Predicted CO concentrations are under-predicted for the entire simulation period. The simulated ozone is generally under-predicted during the day, but over-predicted in the morning. Both predicted NO and NO_2 concentrations are under-predicted for the entire simulation period.

Figure 2-5 shows the hourly averaged CO, ozone, NO and NO_2 for the Southern San Joaquin Valley region. Predicted CO concentrations are generally under-predicted in the morning, but over-predicted in the afternoon. The simulated ozone is generally under-predicted during the day, but over-predicted in the morning. NO concentrations are under-predicted for the entire simulation period. In general, NO_2 concentrations are also under-predicted. However, the NO_2 concentrations are over-predicted at night on July 9 and July 11.

Figure 2-6 shows the hourly averaged CO, ozone, NO and NO_2 for the Northern San Joaquin Valley region. Predicted CO concentrations are under-predicted for the entire simulation period. The simulated ozone is generally predicted well for all days. The model captures the diurnal variation of the NO, but predicted concentrations are generally less than the observed values. NO_2 concentrations also generally agree with the observations.

Plots of model performance statistics for each region are provided in Figures 2-7 and 2-8, which show the predicted 1-hour and 8-hour unpaired peak ratio and normalized bias in graphical format for each station in each of the five regions.

Table 2-4. 1-hour ozone performance by each region over the July 9-13, 1999 modeling period.

Region ID	Region Name	7/9/1999	7/10/1999	7/11/1999	7/12/1999	7/13/1999	Total
2	North Coast	1	0	0	1	-99	2
3	BAAQMD	1	1	1	1	0	4
4	MBAQMD	1	0	0	1	0	2
5	Sacramento Valley North	1	0	1	1	0	3
6	Sacramento Region	1	1	1	1	1	5
7	SJVAPCD Central	1	1	1	1	1	5
8	SJVAPCD Kern	0	0	0	0	1	1
9	SJVAPCD North	1	0	1	0	0	2
10	Sierra Nevada Central	0	1	0	0	0	1
11	SJVAPCD Above 3000 ft	0	0	1	1	1	3
12	South Central Coast	1	1	0	1	0	3
13	Sierra Nevada North	1	0	0	1	1	3
14	Desert	0	0	0	0	0	0
15	Nevada	1	0	-99	1	0	2
Total:		10	5	6	10	5	36

Table 2-5. 8-hour ozone performance by each region over the July 9-13, 1999 modeling period.

Region ID	Region Name	7/9/1999	7/10/1999	7/11/1999	7/12/1999	7/13/1999	Total
2	North Coast	-99	-99	0	1	-99	1
3	BAAQMD	0	0	1	0	0	1
4	MBAQMD	1	-99	0	0	-99	1
5	Sacramento Valley North	1	1	1	1	0	4
6	Sacramento Region	1	1	1	1	1	5
7	SJVAPCD Central	1	1	0	1	0	3
8	SJVAPCD Kern	1	1	1	0	1	4
9	SJVAPCD North	1	0	1	0	1	3
10	Sierra Nevada Central	1	1	0	0	0	2
11	SJVAPCD Above 3000 ft	0	0	1	1	1	3
12	South Central Coast	0	1	0	1	1	3
13	Sierra Nevada North	1	0	0	1	1	3
14	Desert	0	0	0	1	0	1
15	Nevada	1	-99	-99	1	1	3
Total:		9	6	6	9	7	37

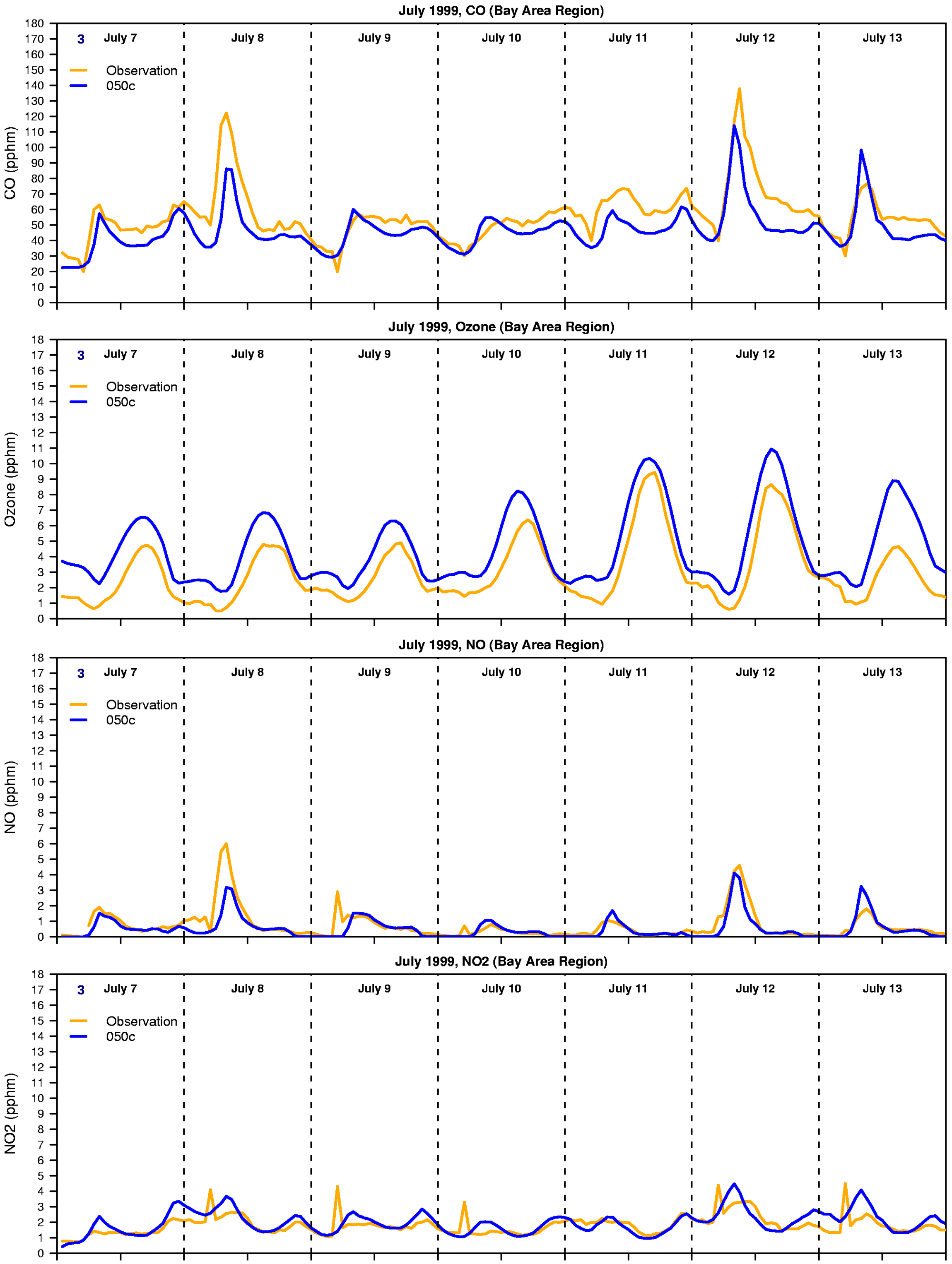


Figure 2-2. Hourly averaged of CO, ozone, NO and NO_2 for the Bay Area region over the July 7-13, 1999 modeling period.

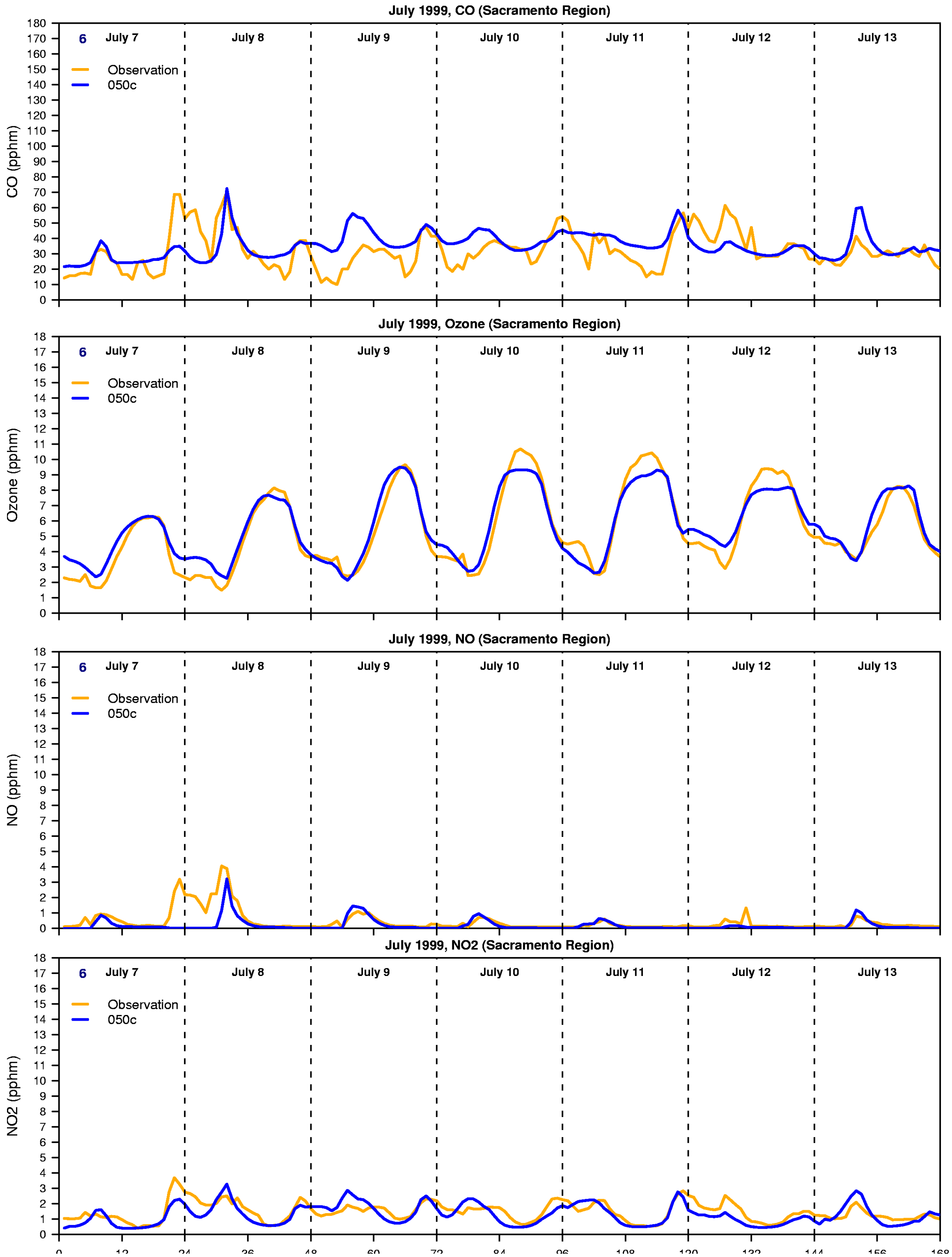


Figure 2-3. Hourly averaged CO, ozone, NO and NO_2 for the Sacramento region over the July 7-13, 1999 modeling period.

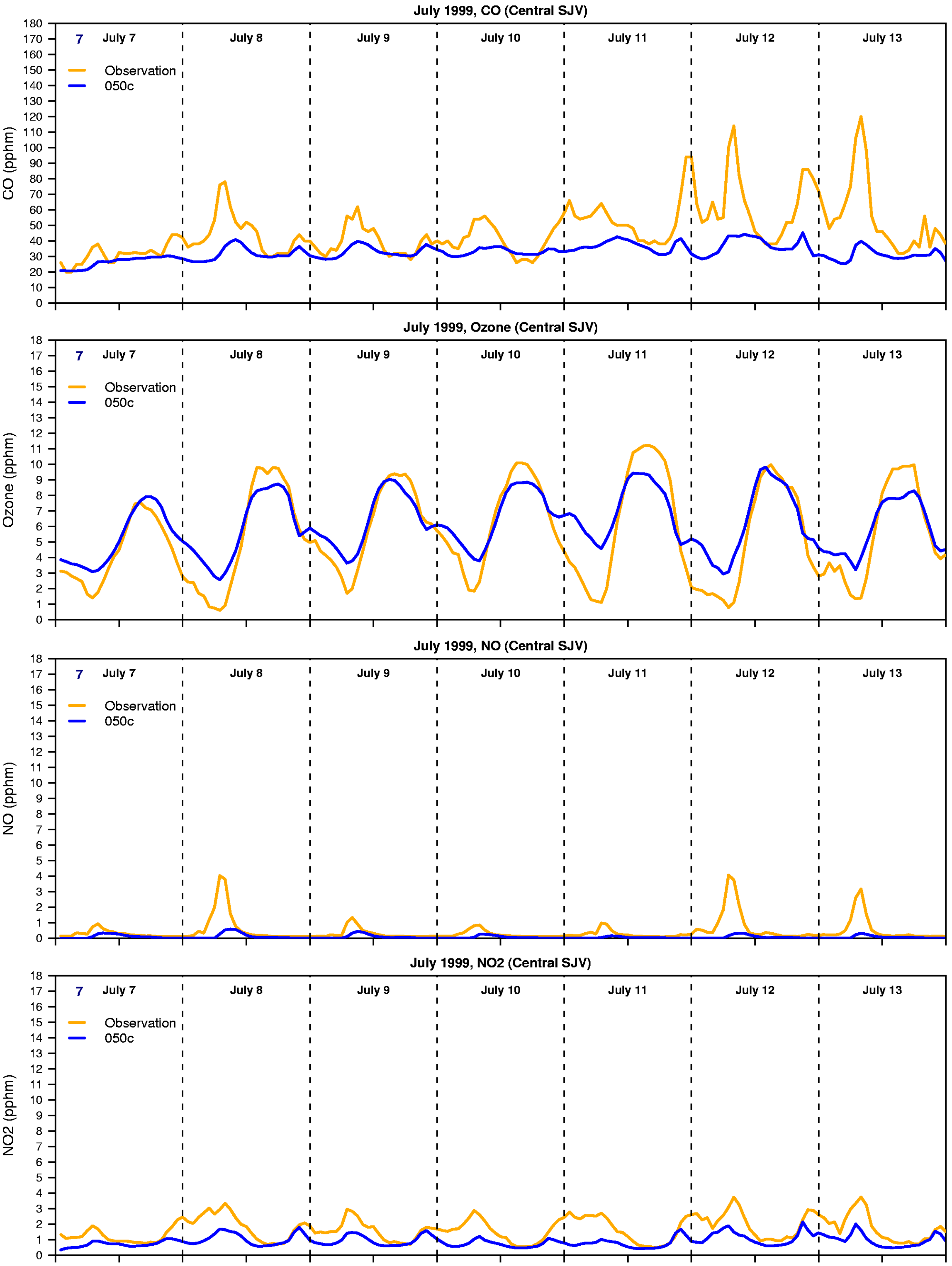


Figure 2-4. Hourly averaged CO, ozone, NO and NO_2 for the Central San Joaquin Valley over the July 7-13, 1999 modeling period.

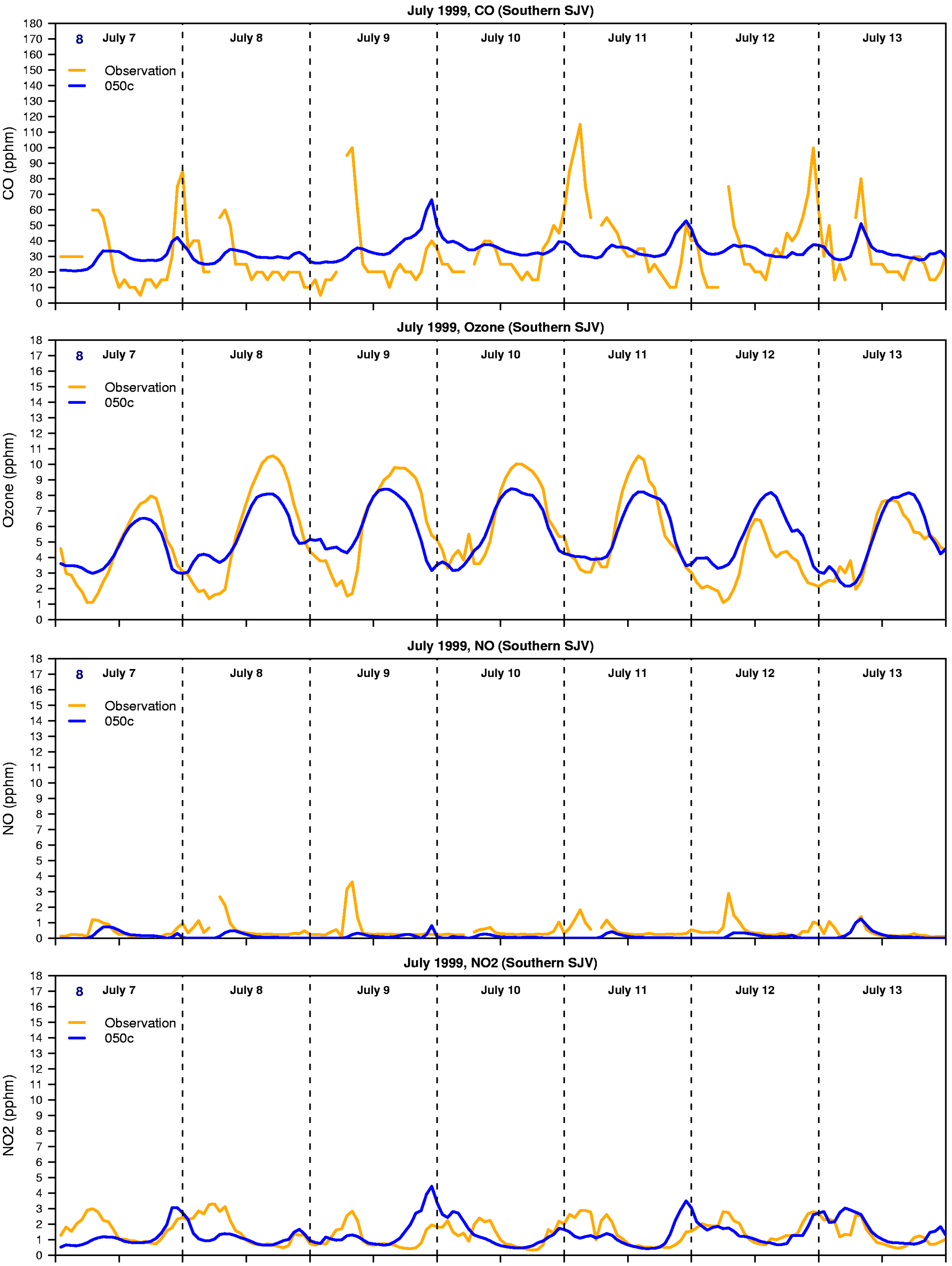


Figure 2-5. Hourly averaged CO, ozone, NO and NO_2 for the Southern San Joaquin Valley over the July 7-13, 1999 modeling period.

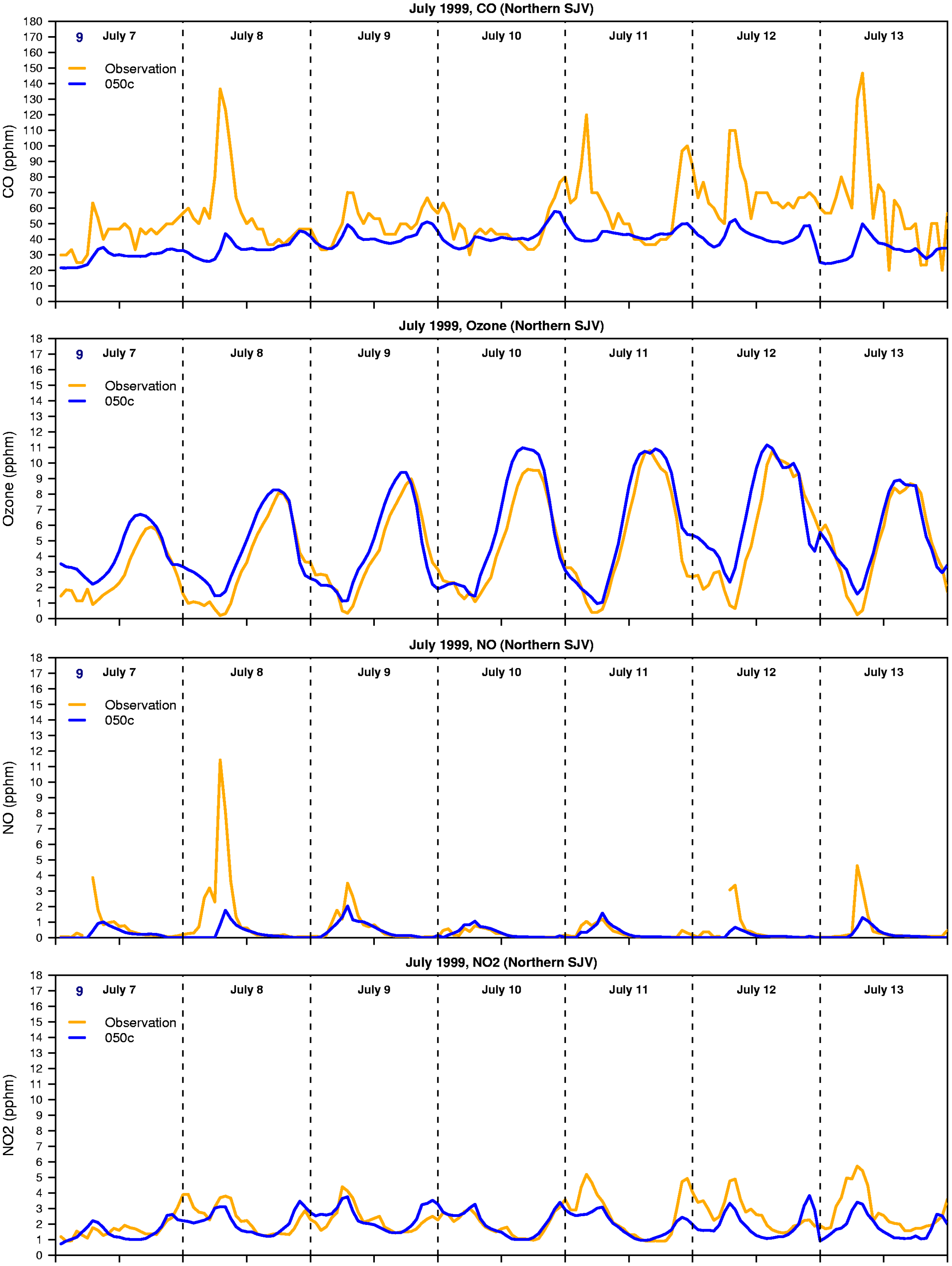
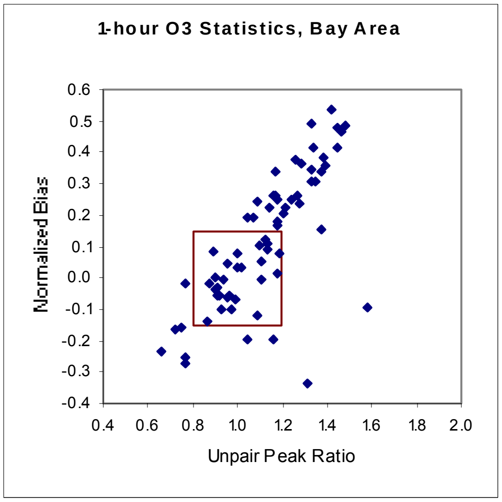
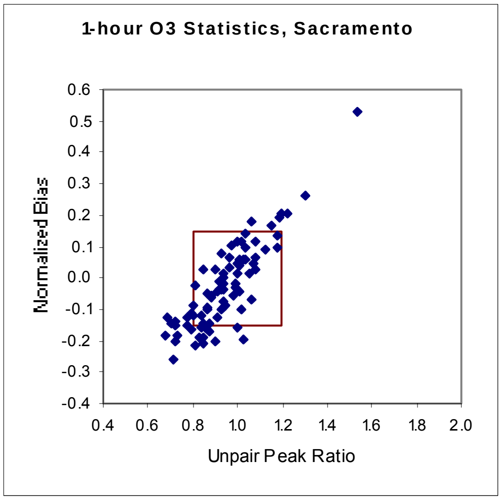
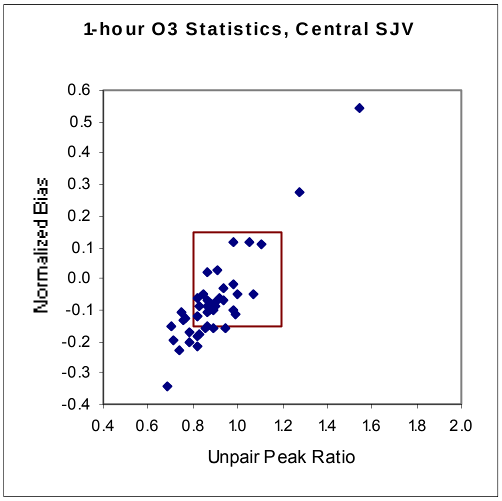
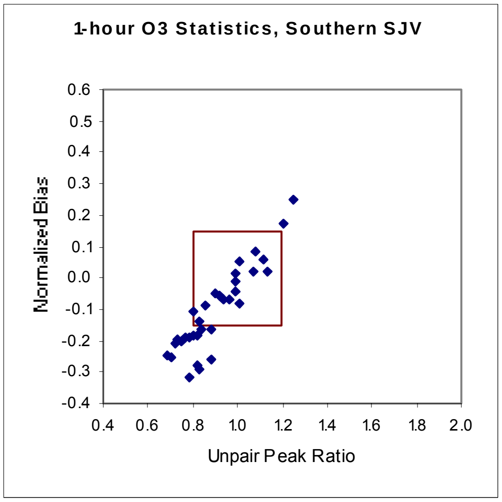


Figure 2-6. Hourly averaged CO, ozone, NO and NO_2 for the Northern San Joaquin Valley over the July 7-13, 1999 modeling period.


1-hour O3 Statistics, Bay Area
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio


1-hour O3 Statistics, Sacramento
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio


1-hour O3 Statistics, Central SJV
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio



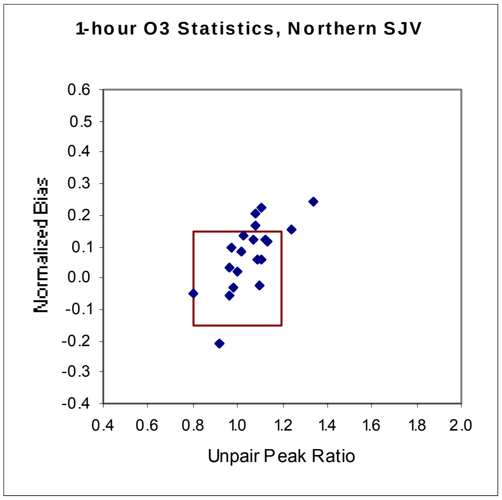
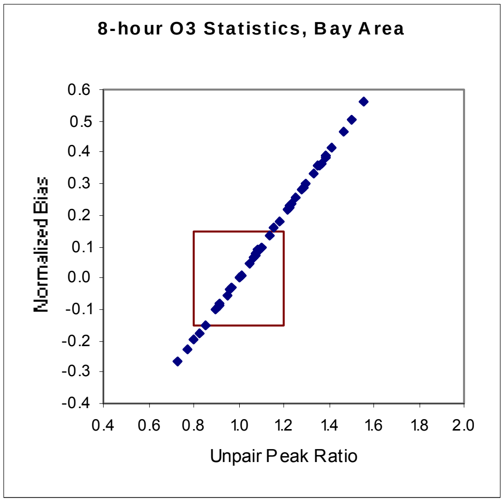
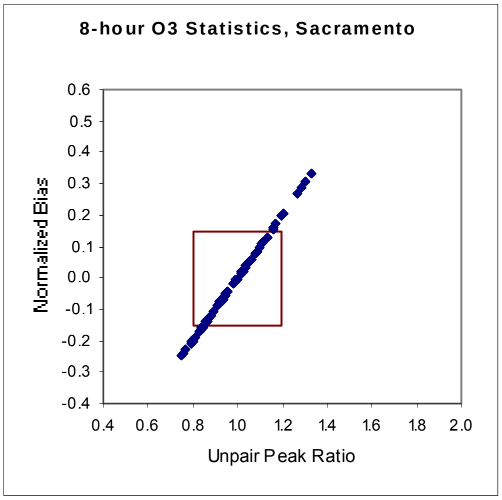
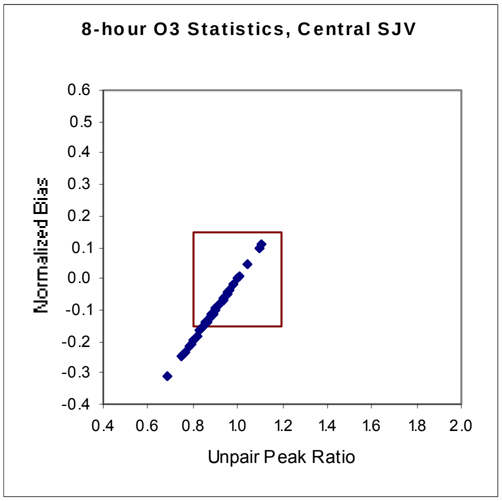


Figure 2-7. Unpaired peak ratio vs. normalized bias for 1-hour ozone for the July 9-13, 1999 modeling period. Each dot represents one-day results for an individual site.


8-hour O3 Statistics, Bay Area
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio


8-hour O3 Statistics, Sacramento
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio


8-hour O3 Statistics, Central SJV
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio

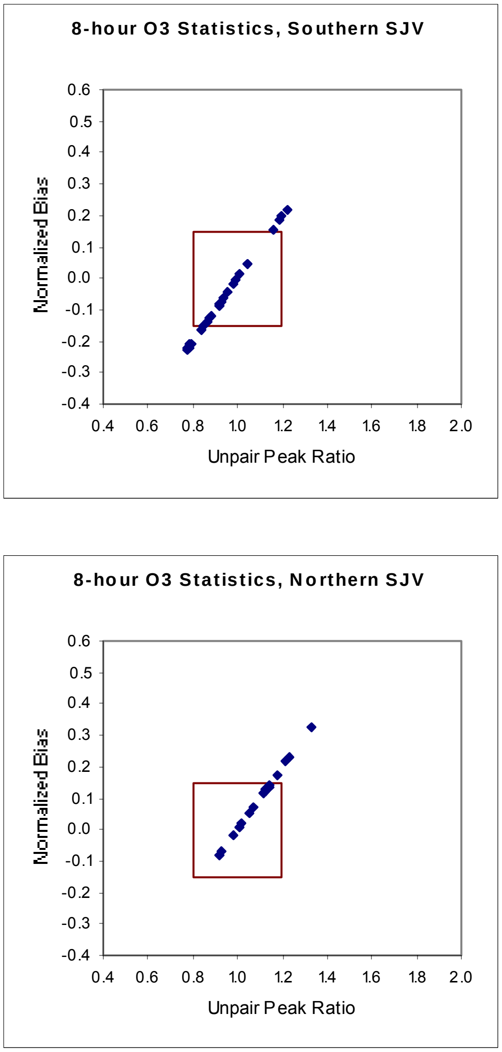


Figure 2-8. Unpaired peak ratio vs. normalized bias for 8-hour ozone for the July 9-13, 1999 modeling period. Each dot represents one-day results for an individual site.

July-August 2000 Episode (CCOS Episode)

The air quality model simulation covers the period from July 27, 2000, to August 2, 2000. The first two days of the simulation are treated as a model spin-up period for which model performance is not considered. As a result, the statistical model performance assessment only covers the non-spin-up period, from July 29th through August 2nd. As described previously in Section 1.2.2, the NOAA placeholder MM5 meteorological simulation is used for these air quality simulations.

Performance statistics for 1-hour and 8-hour model performance were calculated for each region and are listed in Table 2-6 and 2-7, respectively. For days that a region meets the criteria a value of 1 is assigned. A value of 0 means that region doesn't meet the criteria for the respective day and, if there is no model simulated concentrations above 60ppb, then -99 is assigned. The following paragraph summarizes the subregional statistical results.

For the Bay Area region, the model performance meets both the 1-hour and 8-hour criteria on July 29, 2000 and August 2, 2000, but fails on all the other days. For the Sacramento region, 4 days meet the 1-hour criteria and 3 days meet the 8-hour criteria. For the Central San Joaquin Valley region, all 5 days meet both the 1-hour and 8-hour criteria. For the Southern San Joaquin Valley region, 4 days meet the 1-hour criteria and all 5 days meet the 8-hour criteria. For the Northern San Joaquin Valley region, only 2 days meet both the 1-hour and 8-hour criteria.

Figures 2-9 through 2-13 show the site-averaged time series of observed versus predicted CO, ozone, NO and NO_2 for the Bay Area, Sacramento, Central San Joaquin Valley, Southern San Joaquin Valley and Northern San Joaquin Valley regions, respectively. The orange and blue lines represent observations and model predictions, respectively. Take note that the start hour of the simulation is 0600 PDT, so the first day has only 18 data points. Also, note that the 1-hour and 8-hour region-wide statistics are not directly calculated from site-averaged time series, but from the statistics of each station and then arithmetically averaged. The time series for individual stations for these five regions have also been plotted and are available via the ftp site and filename indicated in the Appendix.

Figure 2-9 shows the hourly averaged CO, ozone, NO and NO_2 for the Bay Area region. Predicted CO concentrations are over-predicted for the entire simulation period. Ozone concentrations are significantly over-predicted for the entire simulation period although predictions gradually begin to match observations by the last day. Predicted NO concentrations generally match the observed concentrations but are under-predicted for the last two days of the simulation period. The model predicts NO_2 concentrations that have a significant diurnal variation, where the NO_2 increases in the morning traffic hours and in the evening hours when the atmospheric boundary layer becomes less turbulent. However, the regional averaged observation does not exhibit this NO_2 variation.

Figure 2-10 shows the hourly averaged CO, ozone, NO and NO_2 for the Sacramento region. Predicted CO concentrations generally agree with the observations. Ozone concentrations show excellent agreement with observations for all days. The NO concentrations generally agree with the observations and clearly reproduce the early morning traffic peak. The model captures the magnitude as well as the diurnal variation of the NO_2.

Figure 2-11 shows the hourly averaged CO, ozone, NO and NO_2 for the Central San Joaquin Valley region. Predicted CO concentrations are under-predicted for the entire simulation period. Ozone concentrations show excellent agreement with observations for all the days. The NO concentrations also generally agree with the observations and clearly reproduced the early morning traffic peak. The model captures the diurnal variation of the NO_2, but predicted concentrations are generally less than the observed values.

Figure 2-12 shows the hourly averaged CO, ozone, NO and NO_2 for the Southern San Joaquin Valley region. Predicted CO concentrations are under-predicted for the entire simulation period. Ozone concentrations show excellent agreement with observations for all the days. The NO concentrations also generally agree with the observations and clearly reproduced the early morning traffic peak. The model captures the magnitude as well as the diurnal variation of the NO_2.

Figure 2-13 shows the hourly averaged CO, ozone, NO and NO_2 for the San Joaquin Valley North region. Predicted CO concentrations generally match the observed concentrations through July 29th, but, the sharp peaks in the observations later in the episode are not captured in the simulated concentrations. These sharp peaks, however, are likely from some high-emitters near the observation site and cannot be captured by a regional scale model. Ozone concentrations generally agree with the observations, but some days are over-predicted. The NO concentrations also generally agree with the observations and clearly reproduced the early morning traffic peak. The predicted NO_2 concentrations are generally higher than the observations.

Figures 2-14 and 2-15 show the correlation between the unpaired peak and the mean normalized bias for each individual site in a region. Through experience it has been observed that, if the NB statistical metric is satisfied, then the GE statistic is also satisfied. Hence, GE statistical results are not presented.

The results shown above were generated using NOAA's 'placeholder' MM5 meteorology. Since the first 'placeholder' version of the NOAA meteorology, CARB and NOAA have been working together to improve the meteorological model performance. A more recent NOAA meteorology, as described in the previous meteorology section, was developed and used as an alternative input to air quality modeling simulations. The model performance results using this alternative meteorological field are provided in Tables 2-8 and 2-9 for 1-hour and 8-hour averaging periods, respectively. Using the updated meteorology inputs slightly degrades the 1-hour model performance, but improves the 8-hour model performance. However, as mentioned in section 1.2.2, this alternative wind field as well as the associated meteorological model options and inputs are still in draft form and continue to be investigated.

Table 2-6. 1-hour ozone performance by each region over the July 29-August 2, 2000 modeling period.

Region ID	Region Name	7/29/2000	7/30/2000	7/31/2000	8/1/2000	8/2/2000	Total
2	North Coast	-99	0	-99	-99	-99	0
3	BAAQMD	1	0	0	0	1	2
4	MBAQMD	0	0	0	1	1	2
5	Sacramento Valley North	1	1	1	1	1	5
6	Sacramento Region	1	1	0	1	1	4
7	SJVAPCD Central	1	1	1	1	1	5
8	SJVAPCD Kern	1	1	1	1	0	4
9	SJVAPCD North	1	0	0	0	1	2
10	Sierra Nevada Central	0	1	0	1	1	3
11	SJVAPCD Above 3000 ft	1	1	1	1	1	5
12	South Central Coast	1	1	0	0	0	2
13	Sierra Nevada North	1	1	1	1	1	5
14	Desert	1	1	0	0	0	2
15	Nevada	-99	-99	-99	-99	-99	0
Total:		10	9	5	8	9	41

Table 2-7. 8-hour ozone performance by each region over the July 29-August 2, 2000 modeling period.

Region ID	Region Name	7/29/2000	7/30/2000	7/31/2000	8/1/2000	8/2/2000	Total
2	North Coast	-99	-99	-99	-99	-99	0
3	BAAQMD	1	0	0	0	1	2
4	MBAQMD	-99	0	0	1	1	2
5	Sacramento Valley North	1	1	1	1	0	4
6	Sacramento Region	1	0	0	1	1	3
7	SJVAPCD Central	1	1	1	1	1	5
8	SJVAPCD Kern	1	1	1	1	1	5
9	SJVAPCD North	1	0	0	0	1	2
10	Sierra Nevada Central	1	1	0	1	0	3
11	SJVAPCD Above 3000 ft	1	1	1	1	0	4
12	South Central Coast	0	0	0	0	1	1
13	Sierra Nevada North	1	1	1	1	1	5
14	Desert	1	1	1	1	1	5
15	Nevada	-99	-99	-99	-99	-99	0
Total:		10	7	6	9	9	41

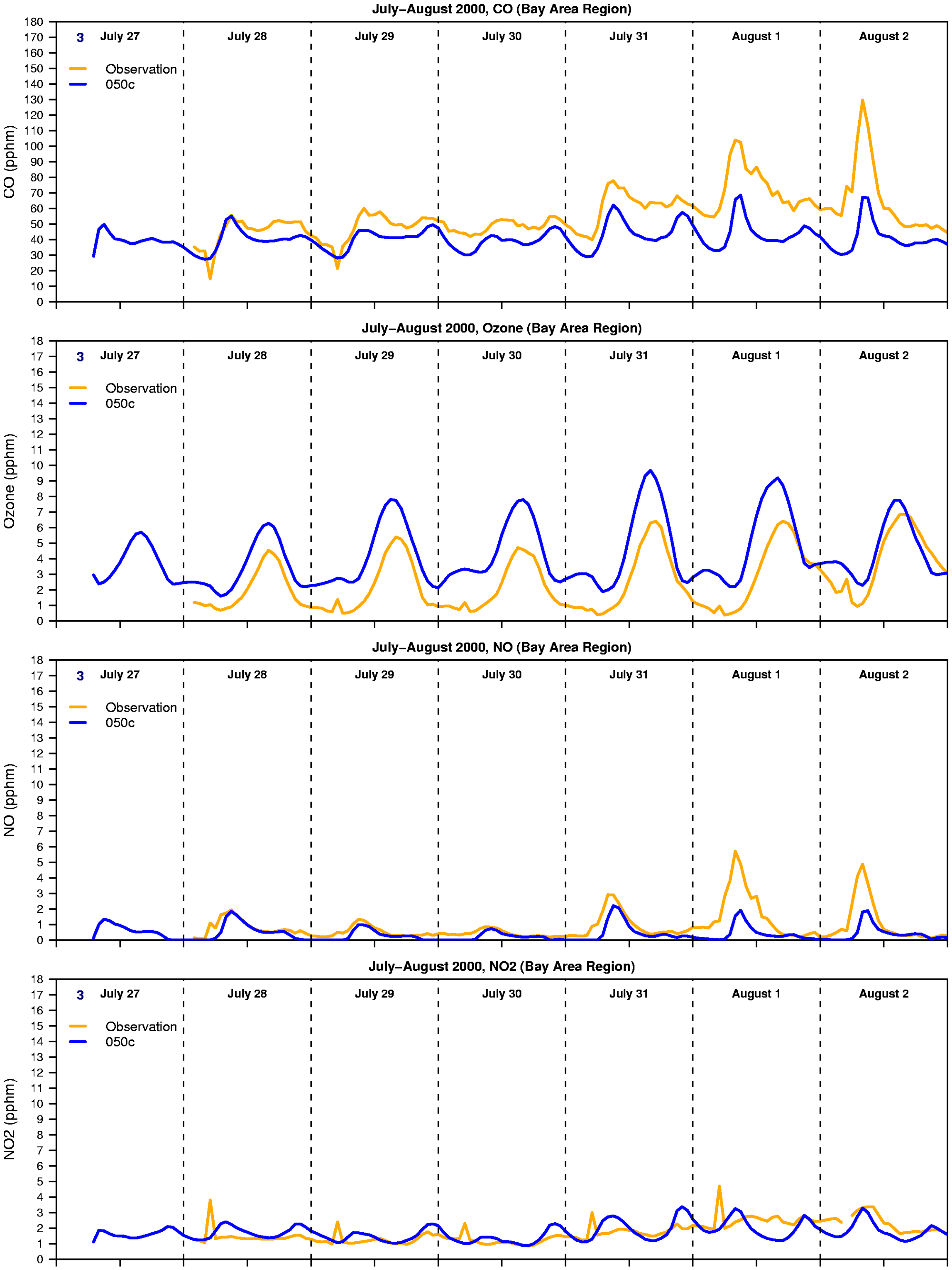


Figure 2-9. Hourly averaged CO, ozone, NO and NO_2 for the Bay Area region over the July 27 – August 2, 2000 modeling period.

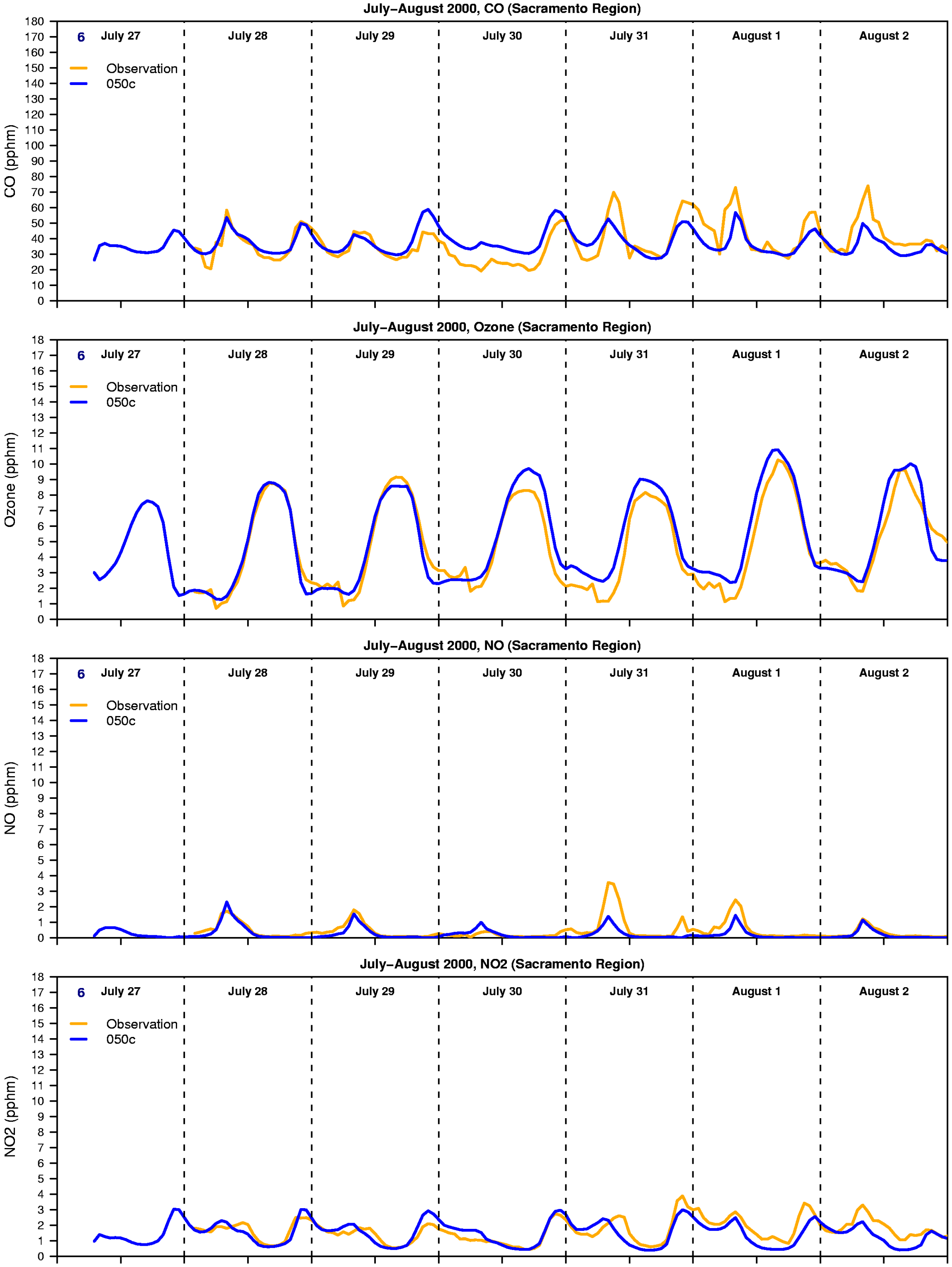


Figure 2-10. Hourly averaged CO, ozone, NO and NO_2 for the Sacramento region over the July 27 – August 2, 2000 modeling period.

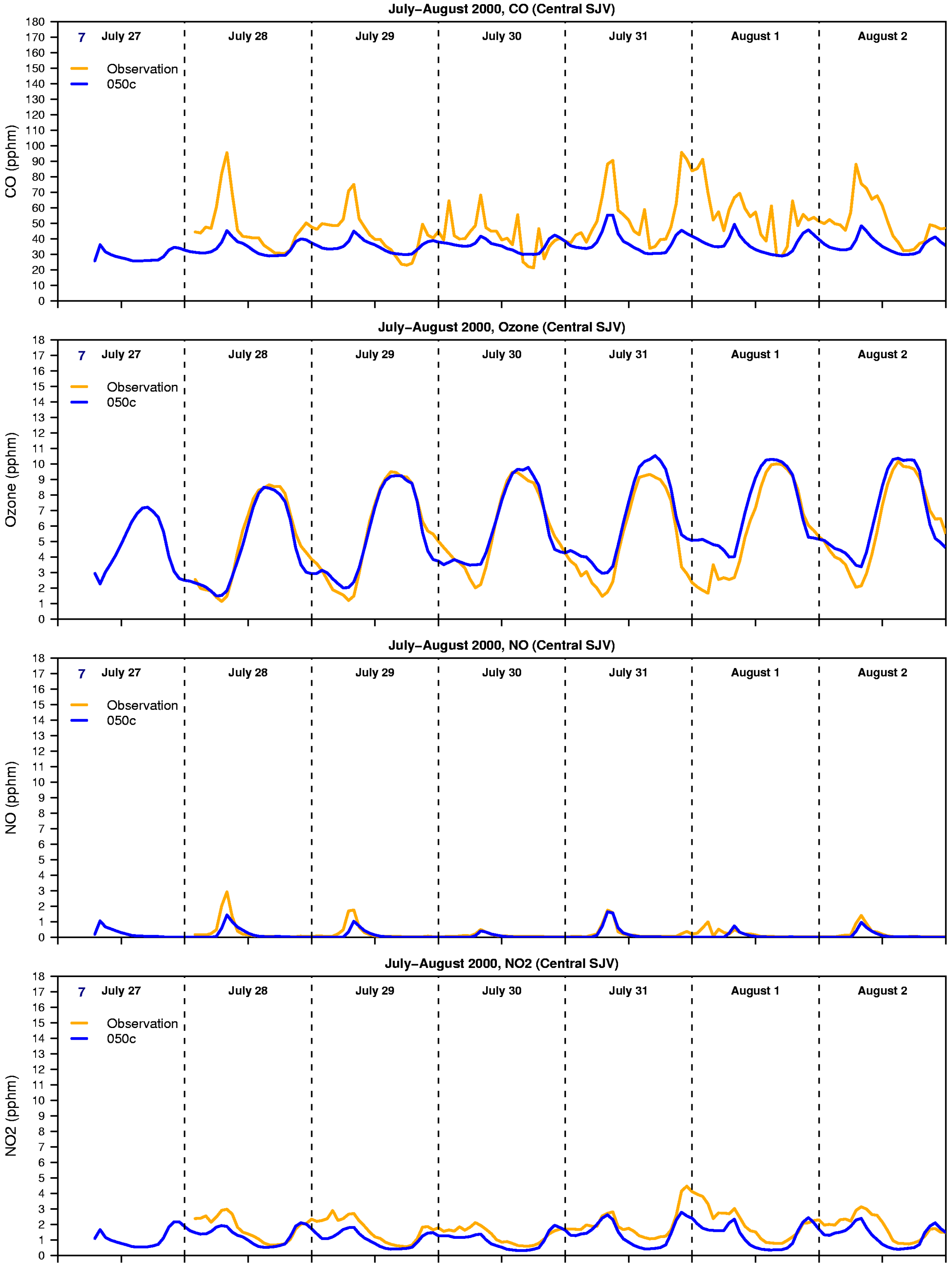


Figure 2-11. Hourly averaged CO, ozone, NO and NO_2 for the Central San Joaquin Valley region over the July 27 – August 2, 2000 modeling period.

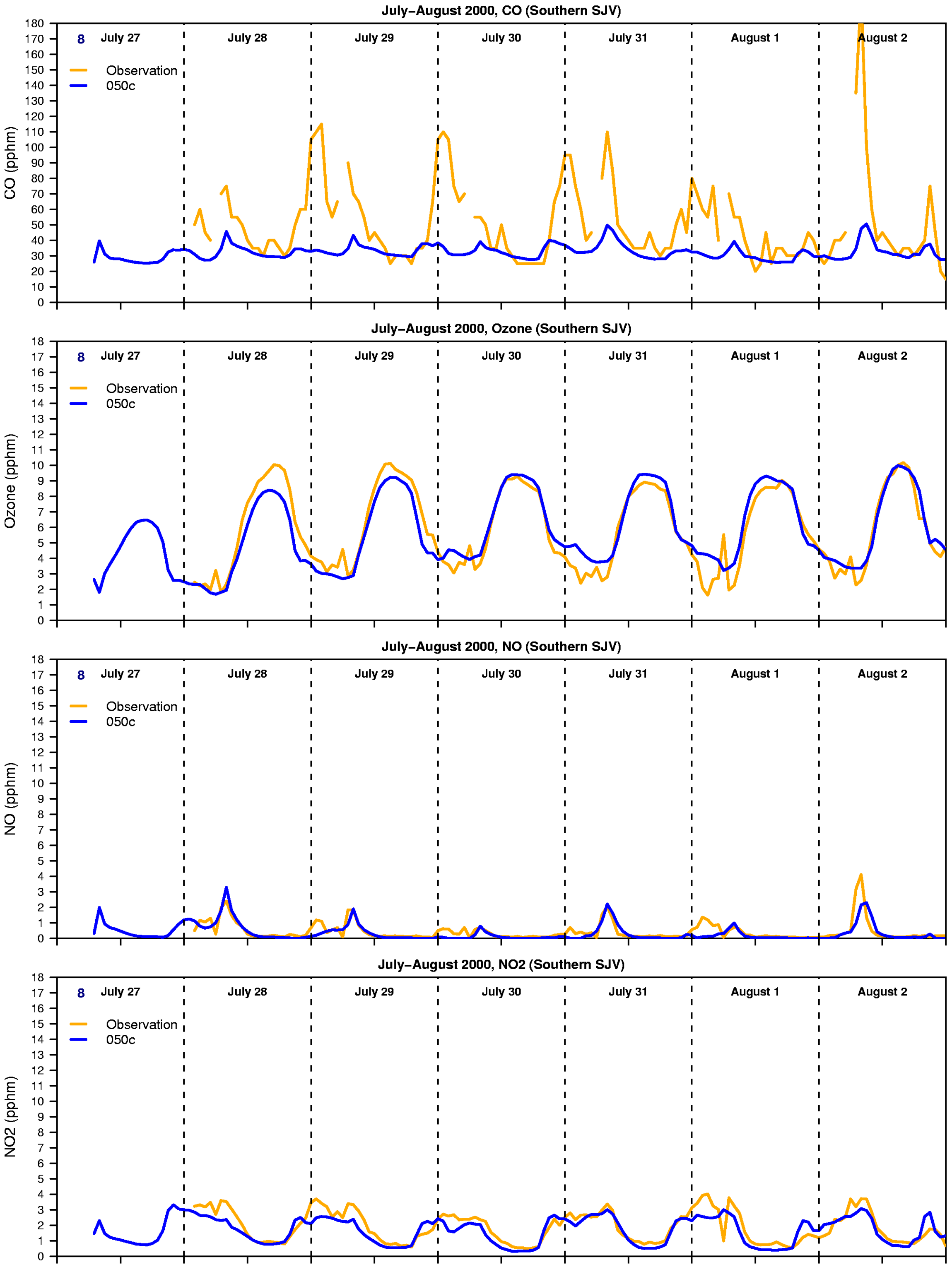


Figure 2-12. Hourly averaged CO, ozone, NO and NO_2 for the Southern San Joaquin Valley region over the July 27 – August 2, 2000 modeling period.

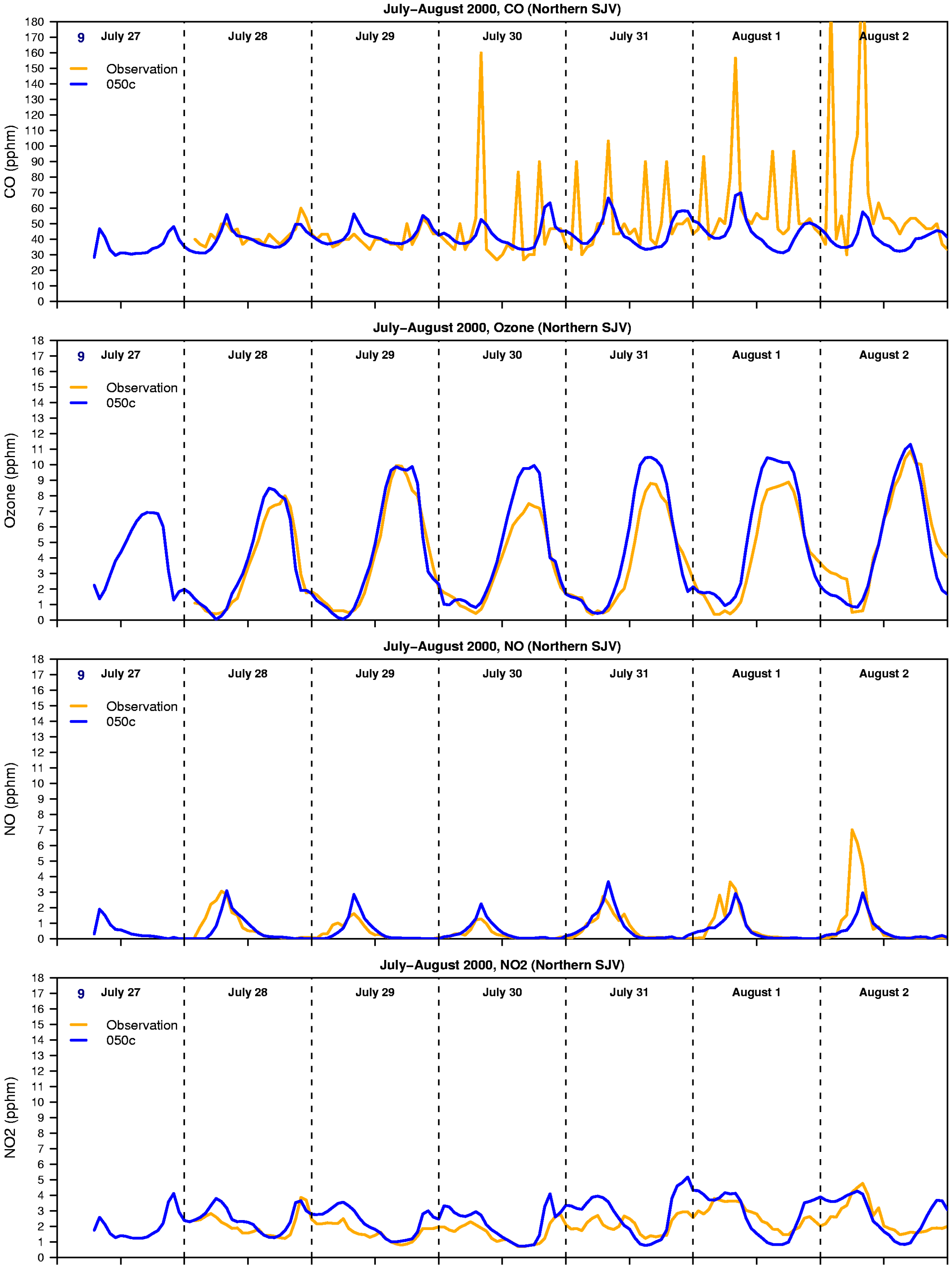
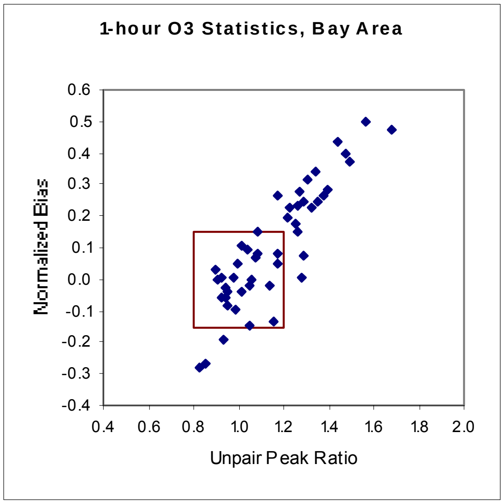
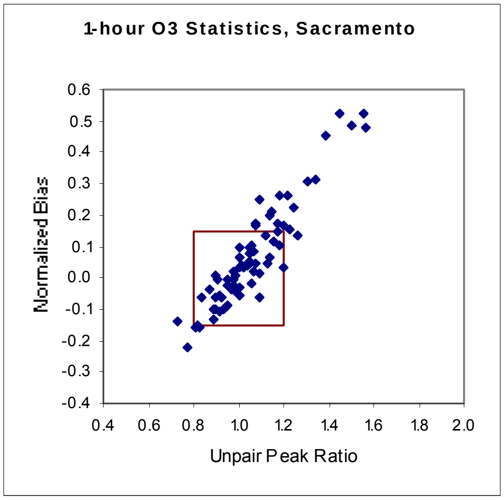
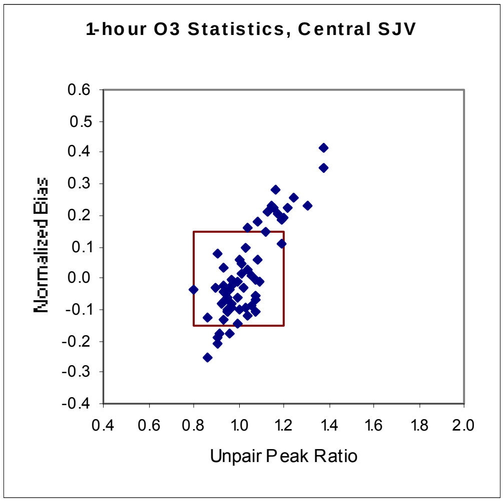
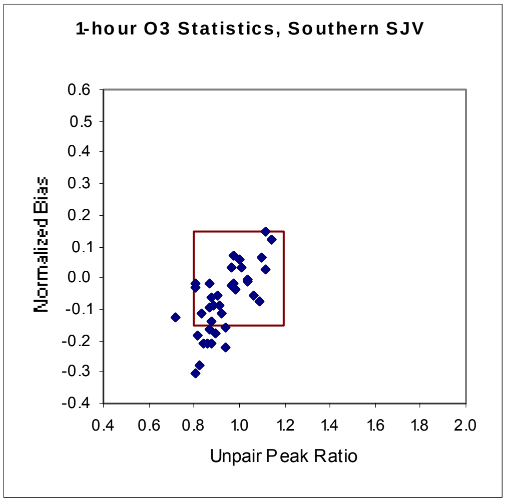


Figure 2-13. Hourly averaged CO, ozone, NO and NO_2 for the Northern San Joaquin Valley region over the July 27 – August 2, 2000 modeling period.


1-hour O3 Statistics, Bay Area
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio


1-hour O3 Statistics, Sacramento
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio


1-hour O3 Statistics, Central SJV
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio



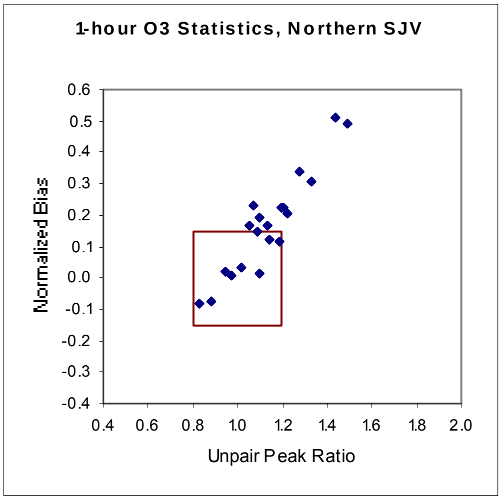
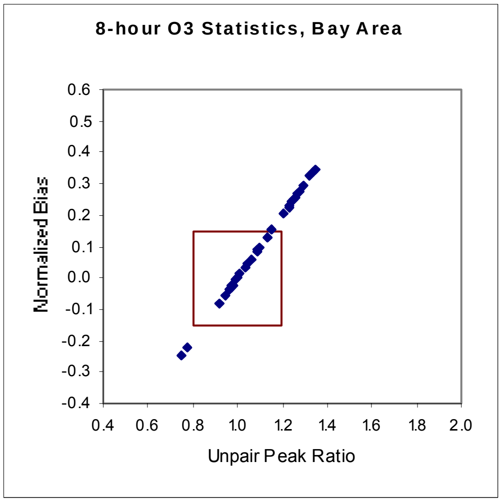
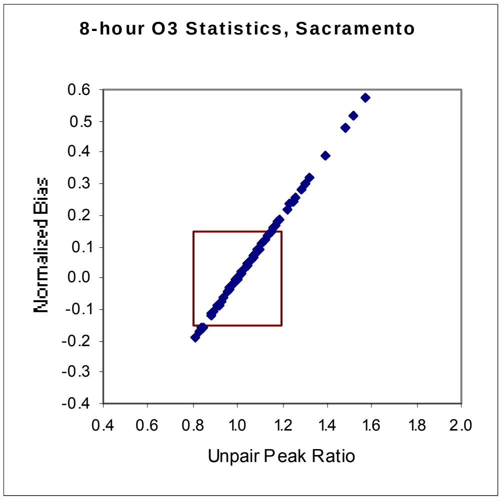
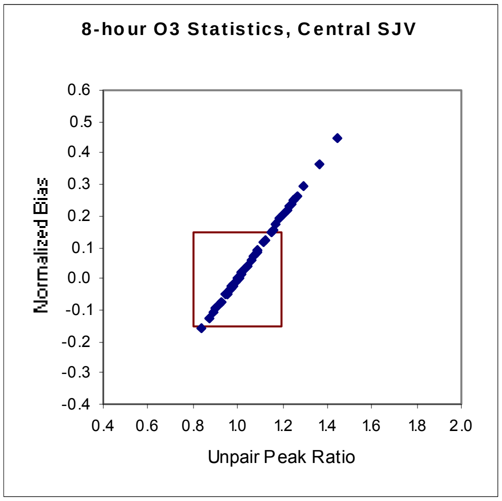


Figure 2-14. Unpaired peak ratio vs. normalized bias for 1-hour ozone for the July 29 – August 2, 2000 modeling period. Each dot represents one-day results for an individual site.


8-hour O3 Statistics, Bay Area
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio


8-hour O3 Statistics, Sacramento
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio


8-hour O3 Statistics, Central SJV
Normalized Bias
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Unpair Peak Ratio

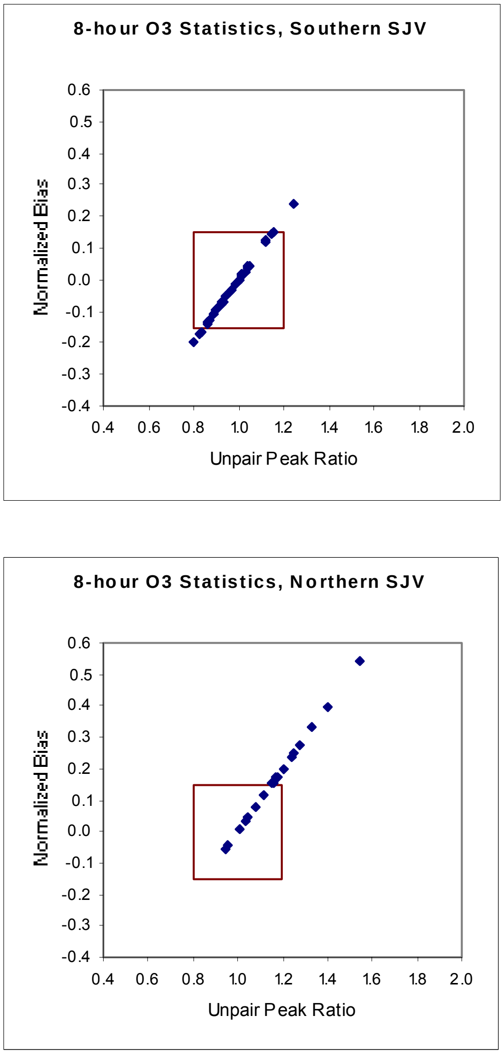


Figure 2-15. Unpaired peak ratio vs. normalized bias for 8-hour ozone for the July 29 – August 2, 2000 modeling period. Each dot represents one-day results for an individual site.

Table 2-8. 1-hour ozone performance by each region over the July 27-August 2, 2000 modeling period using the most recent NOAA meteorology (under ARB investigation)

Region ID	Region Name	7/29/2000	7/30/2000	7/31/2000	8/1/2000	8/2/2000	Total
2	North Coast	-99	0	-99	-99	-99	0
3	BAAQMD	1	1	1	1	1	5
4	MBAQMD	1	1	1	1	1	5
5	Sacramento Valley North	1	1	1	1	1	5
6	Sacramento Region	0	1	1	0	1	3
7	SJVAPCD Central	0	1	1	1	1	4
8	SJVAPCD Kern	0	0	1	0	0	1
9	SJVAPCD North	1	1	1	1	1	5
10	Sierra Nevada Central	0	1	1	0	0	2
11	SJVAPCD Above 3000 ft	0	0	0	1	1	2
12	South Central Coast	1	1	0	0	0	2
13	Sierra Nevada North	1	1	1	0	0	3
14	Desert	0	0	0	0	0	0
15	Nevada	-99	-99	-99	-99	-99	0
Total:		6	9	9	6	7	37

Table 2-9. 1-hour ozone performance by each region over the July 27-August 2, 2000 modeling period using the most recent NOAA meteorology (under ARB investigation)

Region ID	Region Name	7/29/2000	7/30/2000	7/31/2000	8/1/2000	8/2/2000	Total
2	North Coast	-99	-99	-99	-99	-99	0
3	BAAQMD	1	0	1	1	1	4
4	MBAQMD	-99	1	1	1	1	4
5	Sacramento Valley North	1	1	1	1	1	5
6	Sacramento Region	1	1	1	1	1	5
7	SJVAPCD Central	1	1	1	1	1	5
8	SJVAPCD Kern	1	1	1	1	1	5
9	SJVAPCD North	1	0	0	1	1	3
10	Sierra Nevada Central	1	1	1	0	0	3
11	SJVAPCD Above 3000 ft	0	1	1	1	1	4
12	South Central Coast	1	1	1	1	1	5
13	Sierra Nevada North	1	1	1	1	0	4
14	Desert	1	0	1	1	1	4
15	Nevada	-99	-99	-99	-99	-99	0
Total:		10	9	11	11	10	51

1 Conclusion – Cumulative 1-hour and 8-hour Days

Per the prior discussion of performance statistics and analyses of model performance, Tables 3-1 and 3-2 provide a summary of 1-hour and 8-hour episode days that meet model performance criteria for both episodes. As noted previously with regard to these types of tables, for days that a region meets the associated performance criteria a value of 1 is assigned. A value of 0 means that region doesn't meet the criteria for the respective day and, if there is no model simulated concentrations above 60ppb, then -99 is assigned.

As is illustrated in the tables, of 10 possible days per region (5 per episode), 2-10 days are available for each region based on 1-hour metrics and, with the exception of the North Coast (1 day), 1-9 days are available based on 8-hour metrics.

Table 3-1. Combined Number of Available Days Per Subregion Under 1-hour Metrics

Region Name	July 1999	July-Aug 2000	Total
North Coast	2	0	**2**
BAAQMD	4	2	**6**
MBAQMD	2	2	**4**
Sacramento Valley North	3	5	**8**
Sacramento Region	5	4	**9**
SJVAPCD Central	5	5	**10**
SJVAPCD Kern	1	4	**5**
SJVAPCD North	2	2	**4**
Sierra Nevada Central	1	3	**4**
SJVAPCD Above 3000 ft	3	5	**8**
South Central Coast	3	2	**5**
Sierra Nevada North	3	5	**8**
Desert	0	2	**2**
Nevada	2	0	**2**
Total	**36**	**41**	**77**

Table 3-2. Combined Number of Available Days Per Subregion Under 8-hour Metrics

Region Name	July 1999	July-Aug 2000	Total
North Coast	1	0	**1**
BAAQMD	1	2	**3**
MBAQMD	1	2	**3**
Sacramento Valley North	4	4	**8**
Sacramento Region	5	3	**8**
SJVAPCD Central	3	5	**8**
SJVAPCD Kern	4	5	**9**
SJVAPCD North	3	2	**5**
Sierra Nevada Central	2	3	**5**
SJVAPCD Above 3000 ft	3	4	**7**
South Central Coast	3	1	**4**
Sierra Nevada North	3	5	**8**
Desert	1	5	**6**
Nevada	3	0	**3**
Total	**37**	**41**	**78**

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Appendix – Information Available for Downloading

Anonymous ftp to eos.arb.ca.gov, then change directories to /pub/outgoing/model_protocol2

Model	**Episode**	**Task/Item**	**Complete?**	**File Name on eos.arb.ca.gov**
AQ	1999	Regional daily tabulation of 1-hour performance results (1,0,-99)	Y	Included in document
AQ	1999	Station-specific tabulation of 1-hour performance results (1,0,-99)	Y	1999 ozone performance by each station.doc
AQ	1999	Station-specific tabulation of 1-hour performance STATISTICS	Y	1999.050c.1hO3.doc
AQ	1999	Station-specific time-series plots of 1-hour ozone	Y	1999.pdf.zip
AQ	1999	Station-specific time-series plots of 1-hour precursors (CO, NO, NO2); ok to combine w/ ozone	Y	1999.pdf.zip
AQ	1999	Regional daily tabulation of 8-hour performance results (1,0,-99)	Y	Included in document
AQ	1999	Station-specific tabulation of 8-hour performance results (1,0,-99)	Y	1999 ozone performance by each station.doc
AQ	1999	Station-specific tabulation of 8-hour performance STATISTICS	Y	1999.050c.8hO3.doc
AQ	2000	Regional daily tabulation of 1-hour performance results (1,0,-99)	Y	Included in document
AQ	2000	Station-specific tabulation of 1-hour performance results (1,0,-99)	Y	2000 ozone performance by each station.doc
AQ	2000	Station-specific tabulation of 1-hour performance STATISTICS	Y	2000.050c.1hO3.doc
AQ	2000	Station-specific time-series plots of 1-hour ozone	Y	2000.pdf.zip
AQ	2000	Station-specific time-series plots of 1-hour precursors (CO, NO, NO2); ok to combine w/ ozone	Y	2000.pdf.zip
AQ	2000	Regional daily tabulation of 8-hour performance results (1,0,-99)	Y	Included in document
AQ	2000	Station-specific tabulation of 8-hour performance results (1,0,-99)	Y	2000 ozone performance by each station.doc
AQ	2000	Station-specific tabulation of 8-hour performance STATISTICS	Y	2000.050c.8hO3.doc

Anonymous ftp to eos.arb.ca.gov, then change directories to /pub/outgoing/model_protocol2

Model	**Episode**	**Task/Item**	**Complete?**	**File Name on eos.arb.ca.gov**
Met	1999	Wind Speed Statistics per Performance Region (RMSE < 2 m/s; Bias::< ±0.5 m/s; IOA:^{3} 0.6)	Y	Included in document
Met	1999	Wind Direction Statistics per Performance Region(Gross Error:< 30 deg; Bias:< ±10 deg)	Y	Included in document
Met	1999	Temperature Statistics per Performance Region(Gross Error:< 2 K; Bias:< ±0.5 K; IOA^{3} 0.8)	Y	Included in document
Met	1999	Station-specific, time-series plots of hourly mean air temperature	Y	July1999.met.regionN.pdf, where N is region number
Met	1999	Station-specific, time-series plots of hourly mean wind speeds.	Y	same as above
Met	1999	Domain-wide spatial plots of hourly wind vectors	Y	July1999_surface_hourly_wind.EEEE.pdf, where EEEE is simulation ID
Met	1999	Domain-wide, spatial plots of hourly air temperatures	N	
Met	2000	Wind Speed Statistics per Performance Region (RMSE < 2 m/s; Bias::< ±0.5 m/s; IOA:^{3} 0.6)	Y	Included in document
Met	2000	Wind Direction Statistics per Performance Region(Gross Error:< 30 deg; Bias:< ±10 deg)	Y	Included in document
Met	2000	Temperature Statistics per Performance Region(Gross Error:< 2 K; Bias:< ±0.5 K; IOA^{3} 0.8)	Y	Included in document
Met	2000	Station-specific, time-series plots of hourly mean air temperature	Y	<<to be posted>>
Met	2000	Station-specific, time-series plots of hourly mean wind speeds.	Y	<<to be posted>>
Met	2000	Domain-wide spatial plots of hourly wind vectors	Y	Included in document
Met	2000	Domain-wide, spatial plots of hourly air temperatures	N	

CORROBORATIVE ANALYSES/WEIGHT OF EVIDENCE ELEMENTS

Prepared by Air Resources Board
Date: March 1, 2007

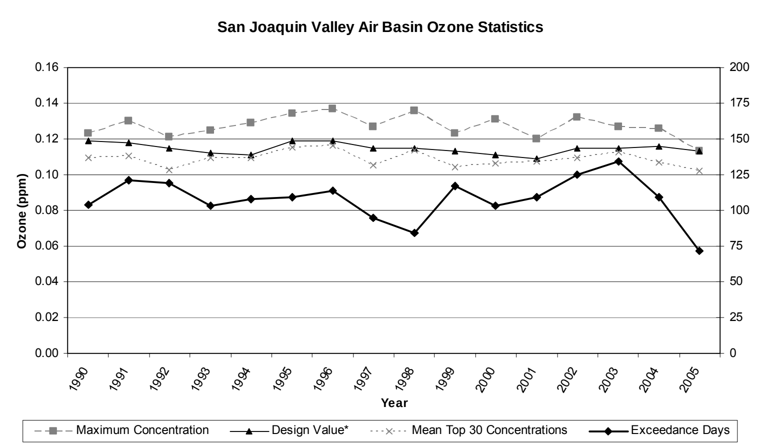
SAN JOAQUIN VALLEY AIR BASIN: OZONE

Historical Context

Over the years, ozone has posed a persistent problem in the San Joaquin Valley Air Basin (SJV or Valley). Looking at ozone air quality from an historical perspective is challenging because of the lack of long-term sites in this area. Between 1975 and 1990, monitoring began at a number of sites, but was discontinued after several years. Furthermore, these transient monitors did not include sites in the worst areas of the central and southern portions of the Basin. For these reasons, 1990 was chosen as the start year for long-term trends in the SJV. 1990 is the first year for which Arvin, consistently one of the highest sites in the Valley, has complete data during the May through October ozone season. In addition, data are available for a number of other typically high concentration sites, including Clovis, Edison, Parlier, and several Fresno area sites.

Over the long-term, emissions control programs have improved ozone air quality in the SJV, but not to the same degree as seen in other areas of California, including the South Coast Air Basin. Both the climate and geography of the Valley present significant challenges to progress in the SJV. Figure 5-1 shows the 1990 to 2005 basinwide trends for several air quality indicators. Because the trend lines for both federal 8-hour exceedance days and maximum concentrations reflect values for individual years, they show a fair amount of variability, with only a small amount of progress over the 15-year period. The decrease in the number of exceedance days in the SJV over the last ten years was more substantial than the decrease in maximum concentrations. In contrast to these two indicators, the other two indicators

Figure 5-1: San Joaquin Valley Air Basin Ozone Statistics 1990 to 2005



* The design value for 1990 is based on 2 years of data, while the design values for all other years are based on 3 years of data.

shown on the graph, the design value and the mean of the maximum concentrations on the Top 30 days, are less variable because these indicators are more robust. While these two indicators show less change over the 15-year period, the 2005 values are lower than the 1990 values.

Although not shown in Figure 5-1, perhaps the greatest indicator of ozone air quality improvement in the SJV is the reduction in population-weighted exposure. This indicator shows a 50 percent reduction in exposure to concentrations above the level of the federal 8-hour standard between 1990 and 2005. Despite the gains in improving population-weighted exposure, the magnitude of the problem in the SJV is severe, and this area will face tremendous challenges in reaching attainment.

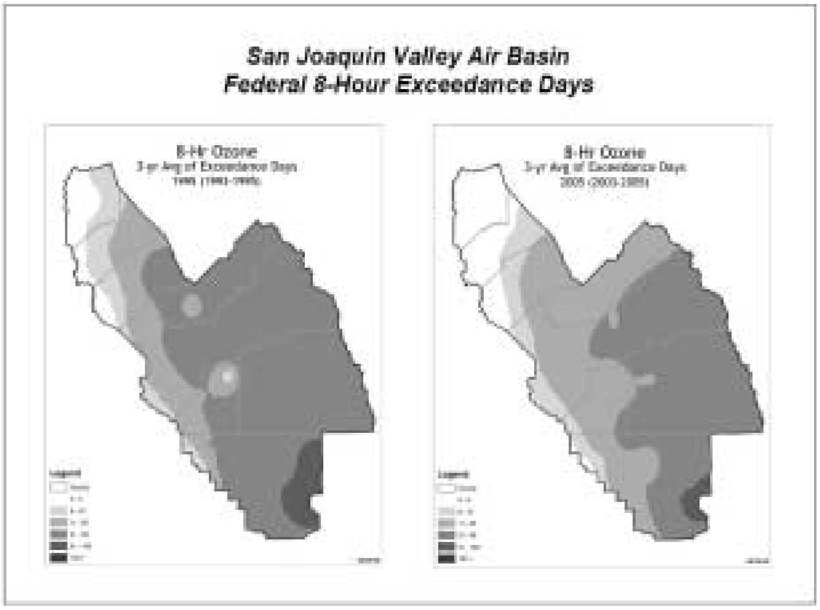
Assessment of Recent Air Quality Trends

General Basinwide Perspective

Over the years, ozone improvement in the SJV has lagged behind other areas of California, and the Valley ranks second only to the South Coast Air Basin with respect to the nation’s worst ozone air quality. Modest levels of progress have occurred in the SJV over the last ten years, with a 15 percent drop in maximum concentration, a 5 percent drop in design value, and a 35 percent drop in exceedance days between 1995 and 2005 (refer to Figure 5-1). However, most of this improvement has occurred since 2003. While values for 2006 were up slightly from 2005 (maximum concentration of 0.121 ppm and 86 exceedance days), they were still among the lowest values over the last 15 years. Although ozone levels in the SJV are not as high as in the South Coast, maximum concentrations during 2006 were still more than 40 percent higher than the federal standard, with nearly three months of exceedance days each year.

While ozone levels are still unhealthy, modest improvements over the years have resulted in a reduction of the extent of the problem, especially in the northern portion of the Valley. The maps in Figure 5-2 are based on monitoring data and show the reduction in days exceeding the national 8-hour standard over the last decade (1995 to 2005), throughout the San Joaquin Valley Air Basin, thereby providing an estimate of the spatial extent of the ozone problem. Ten years ago (1993 to 1995 average map), more than half of the SJV experienced between 21 and 50 federal 8-hour exceedance days, with the worst site experiencing about 90 days. Areas in the northern SJV were cleaner than areas in the central and southern Valley. However, only a relatively small portion of the Basin averaged 10 or fewer exceedance days.

Figure 5-2: San Joaquin Valley Air Basin Change in Federal 8-Hour Exceedance Days 1995 to 2005



Today (2003 to 2005 average map), we see a substantial expansion of areas with 10 or fewer exceedance days. Ambient concentrations in most of San Joaquin and Stanislaus counties are now below the level of the federal 8-hour ozone standard. Much of the rest of the Valley experiences an average of only 6 to 20 exceedance days per year. Areas with more than 20 exceedance days are now generally limited to the eastern portion of the central and southern SJV. While the extent of these areas is much smaller than during 1995, the areas of poor ozone air quality are also some of the most heavily populated (Fresno and Kern counties). Even though these areas still pose a substantial challenge, the worst sites show an average reduction in exceedance days of approximately 35 percent over the last ten years.

In summary, although there has been some progress in the SJV over the last ten years, the rate of progress has been slow in comparison to other areas of the State. Overall, the trend lines for various air quality indicators, including maximum concentration, exceedance days, design value, and mean of the Top 30 concentrations, are relatively flat, with some year-to-year variability caused by meteorology (refer to Figure 5-1). Most of the progress seen over the last 15 years has occurred since 2003. While there has been only a 15 percent decrease in maximum concentration since 1995, the decrease in the number of exceedance days has been more substantial, at close to 35 percent. In spite of the slow rate of progress, the ozone problem is now confined mostly to the central and southern portions of the Valley, as continued emissions reductions have been successful in shrinking the spatial extent of the problem areas. At the same time, the “clean” areas have expanded substantially, and nearly all of San Joaquin and Stanislaus counties now have air quality that meets the federal 8-hour standard. However, although these counties are generally clean with respect to ozone, emissions from the northern SJV area can impact ozone air quality in other portions of the Valley.

Regional Analyses

The basinwide air quality indicators for the SJV show limited progress because they are dominated by the high sites, which pose the most severe problems. However, when the Basin is subdivided into different regions, different patterns of progress emerge. For the following discussion, the Valley is divided into three general areas, as shown in Figure 5-3: the northern SJV, the central SJV, and the southern SJV. For convenience, these regions are divided along county boundaries. However, they generally represent three distinct areas with respect to geography, meteorology, and air quality. While ozone air quality within each of the three subregions tends to be similar, the level of air quality and rates of progress from one area to another can vary substantially.

Figure 5-3: San Joaquin Valley Air Basin Subregions

A third of the Basin population lives in the northern SJV. This lowland area is bordered by the Sacramento Valley and Delta lowland to the north, the central portion of the SJV to the south, and on the other two sides by mountains. Because of the marine influence, which extends into this area through gaps in the coastal mountains to the west, the northern SJV experiences a more temperate climate than the rest of the Basin. These cooler temperatures and the predominant air flow patterns generally favor better air quality.

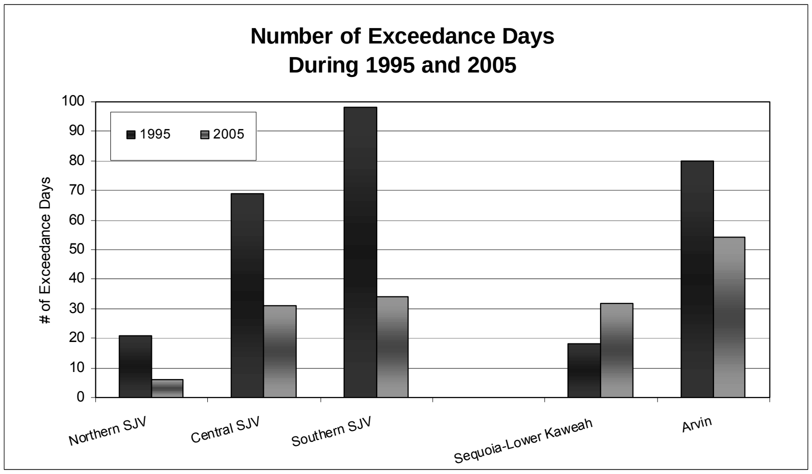
In contrast to the northern SJV, most of the Valley population lives in the central and southern portions of the Basin, in and around the Fresno and Bakersfield urban areas. Sites in the central and southern areas exceed the federal standard by the greatest margin, and geography, emissions, and climate pose significant challenges to air quality progress. Similar to the northern SJV, the central and southern SJV are also low lying areas, flanked by mountains on their west and east sides. The southern SJV represents the terminus of the Valley and is flanked by mountains on the south, as well. The surrounding mountains in both areas act as barriers to air flow, and combined with recirculation patterns and stable air, trap emissions and pollutants. The higher temperatures and more stagnant conditions in these two regions lead to a build-up of ozone and overall poorer air quality. In addition to the urban air quality problems, emissions and pollutants from these areas are transported downwind, making for even poorer air quality in downwind areas such as Arvin and the Sequoia National Park.

ARB staff completed an analysis of ozone episodes that occurred in both the central and southern SJV during 2004 and 2005. Based on these data, high ozone concentrations occurred as multi-day episodes more than 65 percent of the time, in both regions. Furthermore, episodes with higher federal 8-hour concentrations typically spanned a greater number of days, with the highest concentrations occurring in the middle of the episode period. During 2004 and 2005, more than 75 percent of the central SJV ozone episodes showed their highest 8-hour concentration at sites located within the Sequoia National Park. During more than 40 percent of the episodes, exceedances were limited only to sites located within the Sequoia National Park. While the downwind Sequoia sites tend to be the most problematic in the central SJV, is it interesting to note that very few central SJV episodes began prior to the start of an episode in the southern SJV. In fact, nearly 90 percent of the central SJV episodes started on the same day or during an ozone episode in the southern SJV. The most problematic site in the southern SJV is Arvin, and during 2004 and 2005, about 95 percent of the southern SJV ozone episodes showed their highest 8-hour concentration at Arvin.

Figure 5-4 shows the average number of exceedance days during 1995 and 2005 for each of the subregions mapped in Figure 5-3. Two sites, Sequoia National Park-Lower Kaweah and Arvin are plotted separately, and therefore, data for these two sites are not included in the totals for the central and southern SJV areas. The Sequoia National Park-Lower Kaweah and Arvin sites are located downwind of the Fresno and Bakersfield urban areas, respectively, and tend to have poorer air quality.

The northern SJVAB continues to be far cleaner than the other areas of the SJV. Over the last decade, the number of exceedance days in this area has decreased about 70 percent. During 2005, about 80 percent of the days during the May through October ozone season were below the more stringent State 8-hour standard. However, while the number of days in this region has shown improvement, Modesto stands out as the high site in the northern SJV.

Figure 5-4: San Joaquin Valley Air Basin Change in Number of Federal 8-Hour Exceedance Days by Subregion 1995 and 2005



From north to south, the severity of the ozone problem in the SJV generally increases. Between 1995 and 2005, the number of exceedance days at sites in the central SJV (excluding the Sequoia area) decreased 55 percent. Although the decrease is still relatively high, the number of days in the central SJV during 2005 was five times higher than in the northern SJV. The number of exceedance days in the southern SJV (excluding Arvin) decreased about 65 percent during the last decade, and the number of exceedance days during 2005 was just slightly higher than the number of days in the central SJV. With respect to days below the State 8-hour standard, about 40 percent of the days during the ozone season were below this level in both the central SJV and the southern SJV areas during 2005. Similar to the basinwide trends, most of the progress in the central and southern SJV subregions has occurred since 2003.

The sites downwind of the Fresno and Bakersfield urban areas continue to pose the most severe problems in the SJV, and improvements in these areas have been much slower than in other areas. Arvin has always been one of the high sites in the Basin. Between 1995 and 2005, federal exceedance days declined about 30 percent, which is lower than the rate seen at other sites in the southern

SJV region. In contrast, sites located at higher elevations in the Sequoia National Park have shown worsening ozone air quality over the last several years. Between 1995 and 2005, the number of federal exceedance days actually increased more than 75 percent at the Sequoia-Lower Kaweah site. This increase highlights the problem of transported emissions and pollutants from the upwind urban area. The Sequoia-Lower Kaweah site was used in this comparison because it is a long-term site with data for both 1995 and 2005. However, it should be noted that during 2005, the Sequoia-Kings Canyon site had even poorer air quality. In fact, during 2005, the Kings Canyon site had the same number of exceedance days as Arvin, as well as a similar maximum concentration.

Similar to exceedance days, concentrations have also been decreasing at a faster rate in the urban areas than at Arvin or Sequoia. Peak concentrations, as measured by the mean of the Top 4 daily concentrations, decreased only 3 percent over the last five years at Arvin and increased in the Sequoia area. However, the same indicator decreased at twice that rate in the Bakersfield and Fresno urban areas. Today, the 4th highest 8-hour ozone concentration averages 0.095 ppm for sites in both urban areas, compared with 0.105 ppm five years ago. Similarly, the mean of the Top 30 concentrations for both urban areas is declining and is now close to the level of the federal standard. The mean of the Top 30 concentrations is 0.084 ppm for the Fresno/Merced area and 0.089 ppm for the Bakersfield region. Five years ago, both of these urban areas had mean Top 30 concentrations greater than 0.100 ppm. Although the mean of the Top 30 concentrations is not directly comparable to the federal standard, it is a fairly stable statistic that is less influenced by year-to-year changes in meteorology. Therefore, it provides an indication of how concentrations on the worst days of the year are changing over time.

In summary, there have been changes in the patterns of exceedances on a subregional basis in the SJV over the last ten years. Today, the numbers of exceedance days in all areas except the Sequoia region are smaller than they were ten years ago. The most progress occurred in the northern SJV, and ozone concentrations in this area are now below the level of the more stringent State 8-hour standard 80 percent of the time during the ozone season. Trends in peak ozone concentrations reflect similar subregional differences. Based on current air quality and past trends, the areas downwind of Bakersfield and Fresno pose the most difficulty for attainment.

Meteorology and Air Quality Trends

Ozone in the ambient air is the result of several factors, two of the most important being pollutant emissions and meteorology. The meteorological and photochemical processes leading to ozone formation are somewhat complex, involving interactions both at the surface and in the upper air. However, they can be characterized in very general terms: strong sunlight and weak dispersion generate relatively high ozone levels, while weak sunlight and strong dispersion generate relatively low ozone levels. Meteorology, or weather conditions, can vary widely, and these day-to-day conditions strongly influence ambient ozone concentrations.

The previous trends discussion looked at air quality as measured at ambient monitoring sites, without any consideration of or adjustment for meteorological variability. The following discussions characterize the effects of meteorological conditions on ozone concentrations and use different methods of accounting for meteorological variability. These analyses are an effort to better understand the impact of meteorology on air quality and thereby track improvements attributable to emissions reductions. One of the goals of these analyses is to determine the role meteorology has played in the SJVAB, where ozone improvement has lagged behind other areas of the State. Although ozone improvements have been slower to occur in the SJV, the following analyses show that modest progress has occurred.

High Ozone Forming Potential

As one approach to help understand the types of meteorological conditions leading to high ozone concentrations, ARB staff completed an analysis of ozone and meteorology using Classification and Regression Tree (CART) techniques. The CART analysis determined rules that separated days into 15 groups, based on the degree to which weather conditions favor ozone formation. The CART rules used daily data for surface air temperature, air temperature at 1500 meters[1], wind speed/direction, atmospheric stability, and other factors in relation to daily maximum 8-hour ozone concentrations. From the 15 groups, a subset with high average ozone levels and containing on average about one-third of the ozone season were considered to represent high ozone forming potential (OFP).

The analysis, presented in Figure 5-5, shows the number of days with high OFP along with the number of days exceeding the federal 8-hour ozone standard each year (three-year moving means). The changes in exceedance days relative to the changes in high OFP days helps distinguish changes due to meteorology from changes due to emissions reductions. Progress is shown when the number of exceedance days decreases in relation to the number of high OFP days.

The two lines generally track together, indicating that year-to-year changes in exceedance days have been largely attributable to year-to-year changes in weather, rather than changes in emissions. Relative to the high OFP line, however, the number of exceedance days has decreased. During the 1990’s, the trend for exceedance days averaged 14 days above the trend for high OFP days. Since 1999, however, the trend for exceedance days averaged 4 days below the trend for high OFP days, indicating a “real” decrease of about 18 days.

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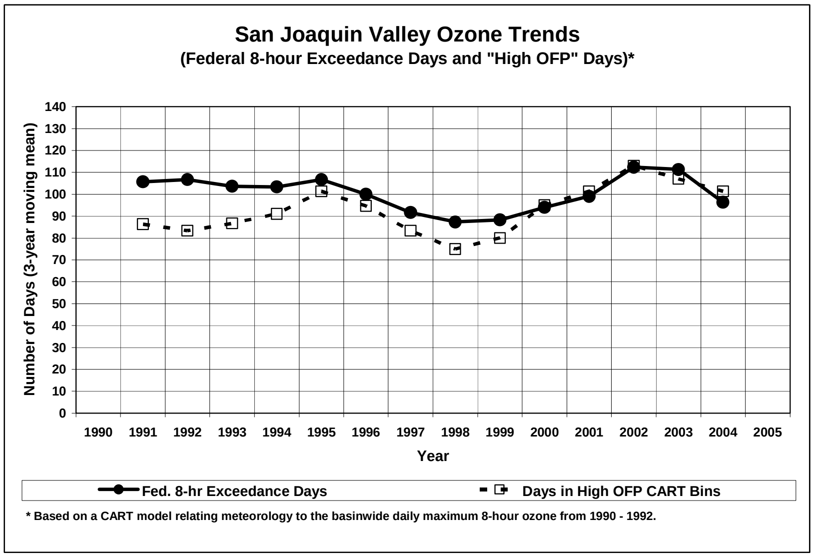
[1] Above sea level

Figure 5-5: San Joaquin Valley Air Basin Three-Year Means of Federal 8-Hour Exceedance Days and High OFP Days 1990 to 2005

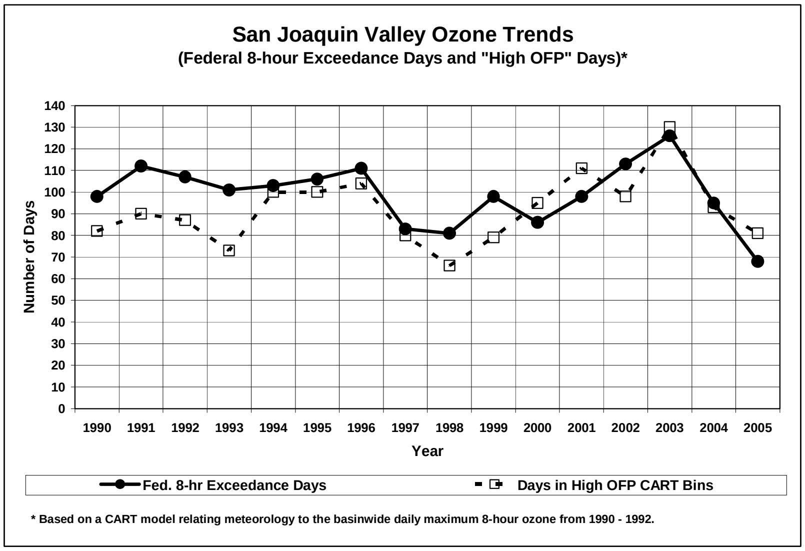


Furthermore, the unsmoothed trends in Figure 5-6 show the 68 exceedance days measured in 2005 was a new low for the Basin (note that the 68 exceedance days reflects only those occurring during the May through October ozone season). Three years, 1990, 1997, and 1999, had OFP values similar to 2005, but exceedance days during these years averaged 13 days above the OFP trend. In contrast, the 68 exceedance days measured during 2005 were 13 fewer than the number of high OFP days. These results indicate that some real progress in reducing ozone is now taking place in the SJV, as increasingly adverse meteorological conditions are needed to create ozone levels exceeding the federal 8-hour standard.

Meteorologically Adjusted Trends

As discussed above, meteorological parameters such as temperature, pressure, and wind speed are systematically correlated with sunlight and dispersion, and they can be used in formulas that predict daily ozone levels. As a second method to address the role of meteorology, a statistical model that predicts daily maximum ozone on the basis of daily meteorological data was used to adjust daily ozone observations.

Figure 5-6: San Joaquin Valley Air Basin Federal 8-Hour Exceedance Days and High OFP Days 1990 to 2005

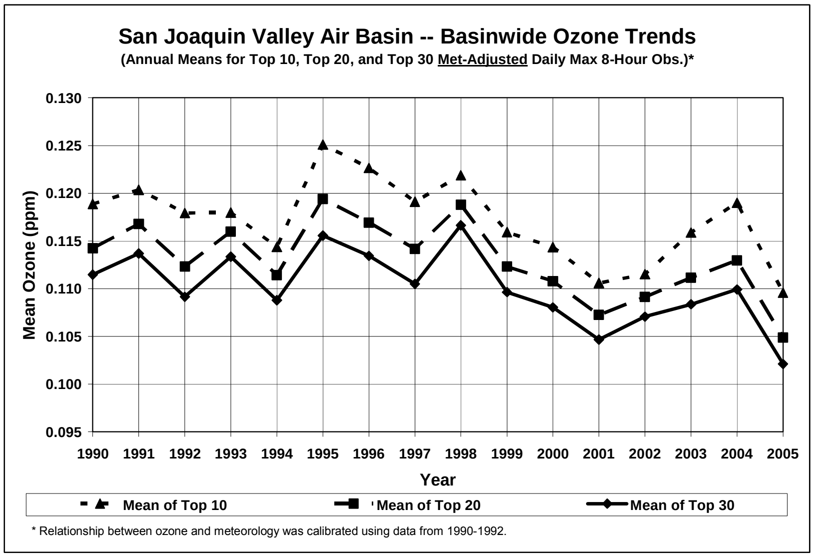


First, days from the May through October ozone season for the years 1990 to 2005 were assigned to separate groups based on pressure and temperature gradients, along with selected wind speeds and directions. Together, three of the groups accounted for the vast majority of exceedance days during the ozone season in the San Joaquin Valley. For each of these groups, data from 1990 through 1993 were used to calibrate a within-group model to predict daily maximum 8-hour ozone from daily weather data. The limited span of years was used for calibration so that when it was applied for all the years (1990 through 2005), it would provide a level playing field for meteorological effects, apart from the influence of changes in emissions.

Met-adjusted trends are presented in the following three figures. The figures are based on data for basinwide daily maximum ozone concentrations after these have been reconciled to long-term meteorological norms regarding group frequencies and concentrations within each group. The three lines on each graph represent the mean of the Top 10, Top 20, and Top 30 met-adjusted concentrations. The trends in Figures 5-8 and 5-9 were smoothed using a three-year moving mean, because the process of met-adjustment does not remove all meteorological effects perfectly, and other factors also affect the year-to-year changes.

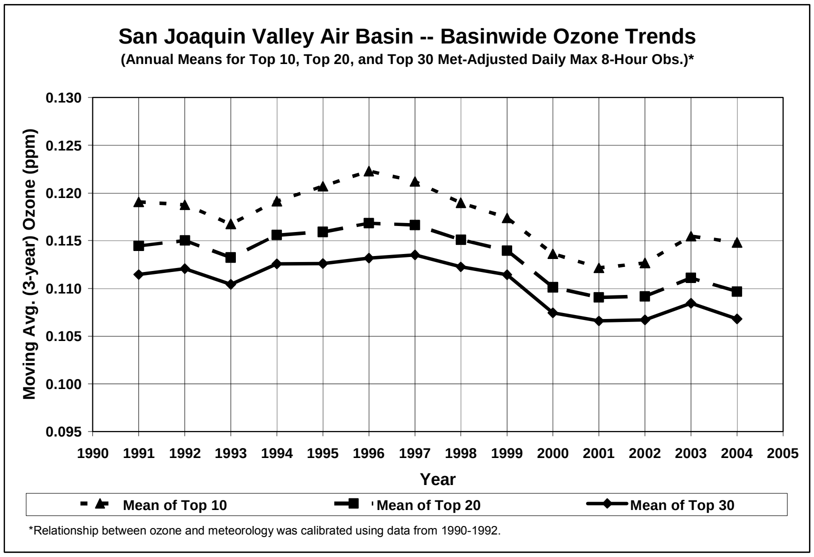
Figures 5-7 and 5-9 show that ozone declined approximately five percent from 1990 to 2005. An upswing in the trend from 2001 to 2004 may be attributable to meteorological effects for which the process of met-adjustment is incomplete.

Figure 5-7: San Joaquin Valley Air Basin Ozone Trends 1990 to 2005 Adjusted for Meteorology



* Relationship between ozone and meteorology was calibrated using data from 1990-1992.

Figure 5-8: San Joaquin Valley Air Basin Three-Year Mean Ozone Trends 1990 to 2005 Adjusted for Meteorology

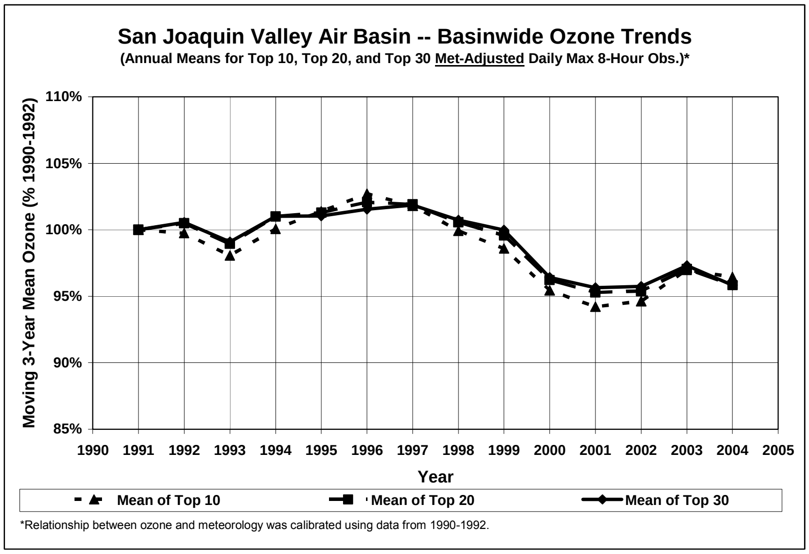


*Relationship between ozone and meteorology was calibrated using data from 1990-1992.

Following the upswing, the met-adjusted values for 2005 reached a new low for all three indicators, indicating that modest improvement (5 percent) in ozone occurred in the San Joaquin Valley in the 2000s, compared to the 1990s. It is also noteworthy that this progress has been similar for all three indicators: mean of the Top10, Top20, and

Top30 ozone concentrations. This shows that the Top 30 (top 16 percent[2]) summer ozone concentrations have responded very similarly to emissions reductions in the SJV since 1990.

Figure 5-9: San Joaquin Valley Air Basin Ozone Trends 1990 to 2005 Adjusted for Meteorology and Expressed as a Percentage of the Base Year



The above analyses use different methods to account for the variable impacts of meteorology on ozone air quality. Results of these analyses confirm that progress has occurred in the San Joaquin Valley Air Basin, especially during the last several years. Although adjusting ozone air quality for meteorology does not change the overall flatness of the trend in the SJV throughout most of the analysis period, it does show some measure of real progress during the most recent years.

Emissions and Precursor Trends

Oxides of nitrogen (NOx) and reactive organic gases (ROG) are precursors to ozone. Emissions controls have reduced the amounts of these precursors throughout the Basin, resulting in the modest improvement in ozone air quality observed in the SJV. The following sections describe the NOx and ROG emissions trends in the SJV since 1990, as well as the amounts of these precursors measured in the ambient air.

Emissions Trends

Emissions controls have substantially reduced the amounts of both ROG and NOx emitted by various sources throughout the San Joaquin Valley. Figure 5-10 shows the estimated basinwide trend in these precursor emissions from 1990 to 2005. The totals

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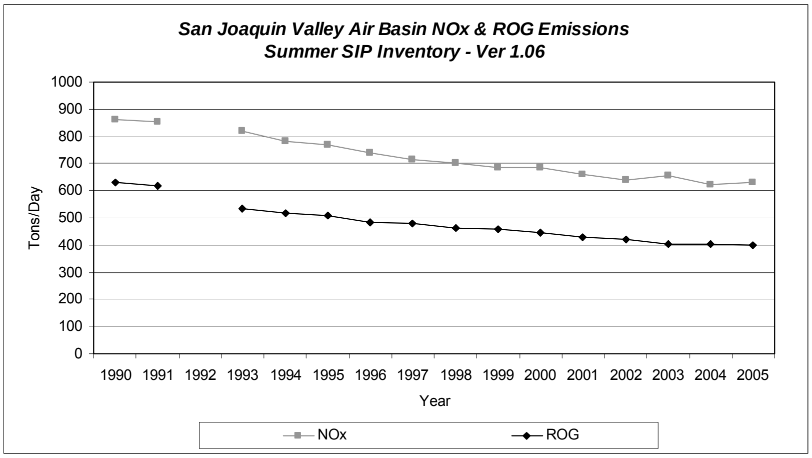
[2] The May – October ozone season has 184 days, of which 30 is 16%.

reflect estimates for the summer season in tons per day and do not include emissions from natural sources.[3]

Figure 5-10: San Joaquin Valley Air Basin NOx and ROG Emissions 1990 to 2005



Since 1990, there has been a steady decrease, basinwide, in both ROG and NOx emissions, at an average rate of about 2 percent per year for both precursors. However, the overall reduction in ROG emissions (35 percent) has been greater than the overall reduction in NOx emissions (25 percent). Furthermore, the level of NOx emissions (in tons per day) is greater than the level of ROG emissions throughout the time period. The relative amounts of the two precursors have been fairly constant over the sixteen years, and the ratio of ROG to NOx emissions has remained relatively stable, with annual ratios ranging from 0.73 to 0.62, and averaging 0.66 for all years.

Figures 5-11 and 5-12 show the emissions trends for the three SJV subregions, which look very similar to the basinwide trends. In all three areas, NOx emissions are at a higher level than ROG emissions over the entire time period. The overall average ROG to NOx emissions ratios are 0.67 for the northern SJV, 0.74 for the central SJV, and 0.56 for the southern SJV. The percentage reductions of ROG and NOx vary by subregion, with all three areas showing a greater percentage of ROG reduction. Overall, the greatest reductions (with respect to both percentages and tons per day) occurred in the southern SJV.

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[3] ARB did not publish an emissions inventory for the 1992 calendar year. Historical point source emissions data are utilized in the construction of emission trends. Therefore, to avoid any misrepresentation of the trend data, 1992 is left out rather than being mathematically estimated with either interpolation or backcasted information.

Figure 5-11: Northern and Central SJV ROG and NOx Emissions 1990 to 2005

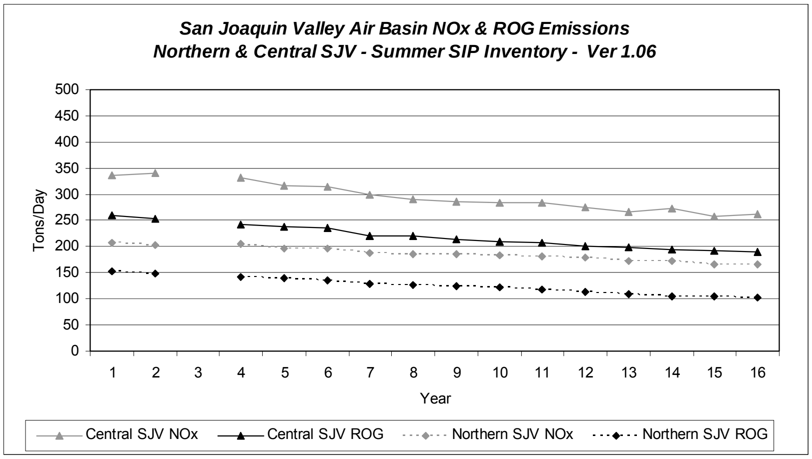
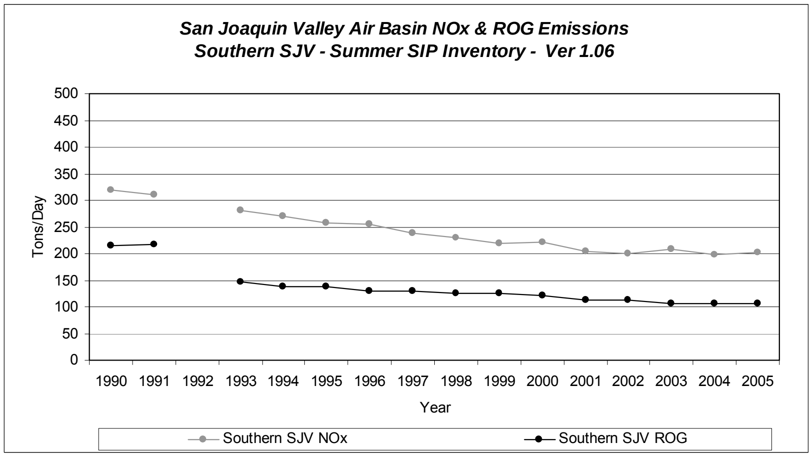


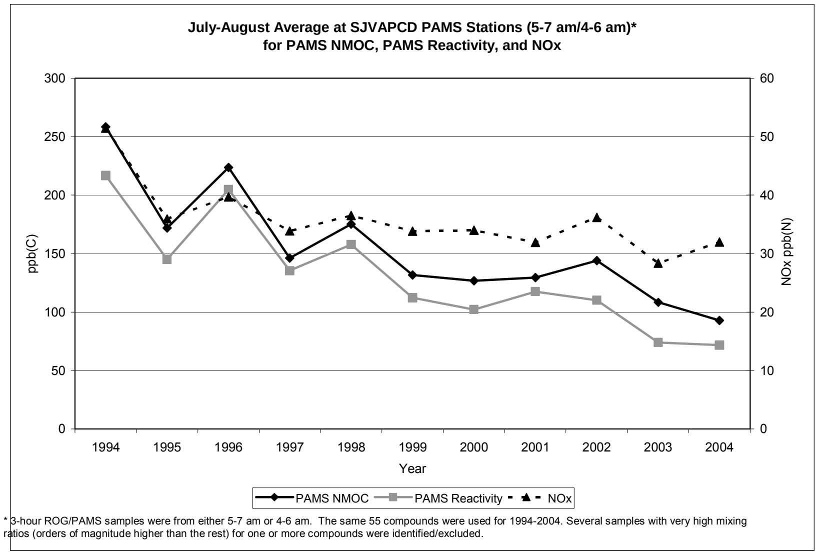
Figure 5-12: Southern SJV ROG and NOx Emissions 1990 to 2005



Precursor Trends

As a result of the reduction in overall emissions as estimated by the emissions inventory, amounts of ROG and NOx in the ambient air have also been reduced. Ambient monitoring data from the Photochemical Assessment Monitoring Stations (PAMS) network plotted in Figure 5-13 show reductions in both precursors. Since 1994, ROG, as measured by the PAMS network in the SJV, shows an overall reduction of approximately 50 percent. Coupled with the reduction in ROG is a reduction in the reactivity of the hydrocarbon mix (also approximately 50 percent from 1994 to 2004). During this same timeframe, ambient NOx concentrations decreased approximately 60 percent, with most of the decrease occurring between 1994 and 1995. Between 1995 and 2004, ambient NOx concentrations were flatter, with only a modest reduction of about 5 percent. Because ambient ROG levels have changed faster than NOx levels, the ratio of ROG to NOx has decreased from 5.0 in 1994 to 2.9 in 2004. The overall trends from the ambient monitoring network are generally consistent with the trends in estimated emissions in that they both show ROG decreasing at a faster rate than NOx, especially during the last decade.

Figure 5-13: San Joaquin Valley Air Basin Summer Morning Average ROG, Reactivity, and NOx at PAMS Stations



July-August Average at SJVAPCD PAMS Stations (5-7 am/4-6 am)*
for PAMS NMOC, PAMS Reactivity, and NOx

* 3-hour ROG/PAMS samples were from either 5-7 am or 4-6 am. The same 55 compounds were used for 1994-2004. Several samples with very high mixing ratios (orders of magnitude higher than the rest) for one or more compounds were identified/excluded.

While both the emissions inventory derived ROG to NOx ratios and the ambient ROG to NOx ratios have been declining, it is interesting to note that the ratio of ROG to NOx is less than 1.0 based on the emissions estimates, while the ratio is greater than 1.0 based on the ambient data. Some of this difference may be due to the fact that the ambient PAMS data are collected from 5:00 to 7:00 a.m., during which time ambient NOx typically peaks from morning commute traffic. In contrast, the emissions estimates reflect typical summer day averages. Further work is ongoing to understand these differences.