APPENDIX B

COMPARISON OF MODELING USINGMOVES2010A WITH MODELING USING MOBILE6.2 FOR THE HGB ATTIANMENT DEMONSTRATION SIP REVISION FOR THE 1997 EIGHT-HOUR OZONE STANDARD, ADOPTED MARCH 10, 2010

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COMPARISON OF MODELING USING MOVES2010a WITH MODELING USING MOBILE6.2 FOR THE HGB ATTAINMENT DEMONSTRATION SIP REVISION FOR THE 1997 EIGHT-HOUR OZONE STANDARD, ADOPTED MARCH 10, 2010

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1 OVERVIEW

This appendix supplements Appendix C: *Photochemical Modeling of the March 10, 2010 Houston-Galveston-Brazoria (HGB) Ozone Attainment Demonstration (AD) State Implementation Plan (SIP) Revision*. Because the only substantive change between that SIP revision and this proposed *Houston-Galveston-Brazoria 1997 Eight-Hour Ozone Standard Nonattainment Area Motor Vehicle Emissions Budgets Update State Implementation Plan Revision* is the use of the United States Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator, version 2010a (MOVES2010a) instead of the earlier MOBILE6.2, this document will focus on only the most relevant changes to model performance evaluation (MPE) and future-case modeling results in the HGB area. Notably, this appendix does not revisit the very extensive MPE using the TexAQS II data from the 2005 to 2006 field study. Also, since MOVES2010a was only applied to the 2006 base year, this appendix will not discuss modeling of the three 2005 episodes that were part of the 2010 HGB AD SIP.

The Texas Commission on Environmental Quality (TCEQ) believes that a side-by-side comparison of modeling conducted with MOVES2010a and modeling conducted with MOBILE6.2 will be more meaningful than simply revising Appendix C: *Photochemical Modeling for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* of the 2010 HGB AD SIP Revision to show MOVES2010a results in place of those generated using MOBILE6.2.

Finally, note that some of the model performance statistics and graphics for the modeling have changed slightly from the 2010 HGB AD SIP Revision due to the recent release of data from researchers.

2 EPISODIC MODEL PERFORMANCE ASSESSMENT FOR OZONE

The following graphics show episode-wide model performance statistics comparing the final 2006 base cases from the 2010 HGB AD SIP Revision, i.e., Reg10 base case using MOBILE6.2, with the new 2006 base cases, i.e., Reg11_MVS base case using MOVES2010a. Descriptions of the three 2006 episodes can be found in Chapter 3: *Photochemical Modeling* of this SIP revision. Descriptions of the statistics themselves and their formulae can be found in Section 2.1.3: *Episodic Model Performance Assessment for Ozone* of Appendix C to the 2010 HGB AD SIP Revision.

Figure 1: *Episode Mean One-Hour Ozone Relative Bias for the Reg10 and Reg11_MVS Base Cases* compares the mean relative bias of the two sets of three base cases across all monitors and all modeled hours (with observed hourly ozone concentrations of 60 parts per billion (ppb) or higher) in the HGB ozone nonattainment area. It shows that using MOVES2010a, the Reg11_MVS base case, improves the slight under-prediction characteristic of the Reg10 base case (MOBILE6.2) for each episode and for the average. For the June 2006 episode, the bias improved from -4.06% to -2.68%, while for the AQS-1 episode, the bias improved from -1.46% to +0.63%. For the AQS-2 episode, the bias improved from -3.09% to -2.42%. The average across all 2006 episode days improved from -2.87% to -1.34%. While the Reg10 base case (MOBILE6.2) showed a relatively small under-predictive bias, the bias for Reg11_MVS (MOVES2010a) is even less, about half the magnitude of the Reg10 (MOBILE6.2) bias.

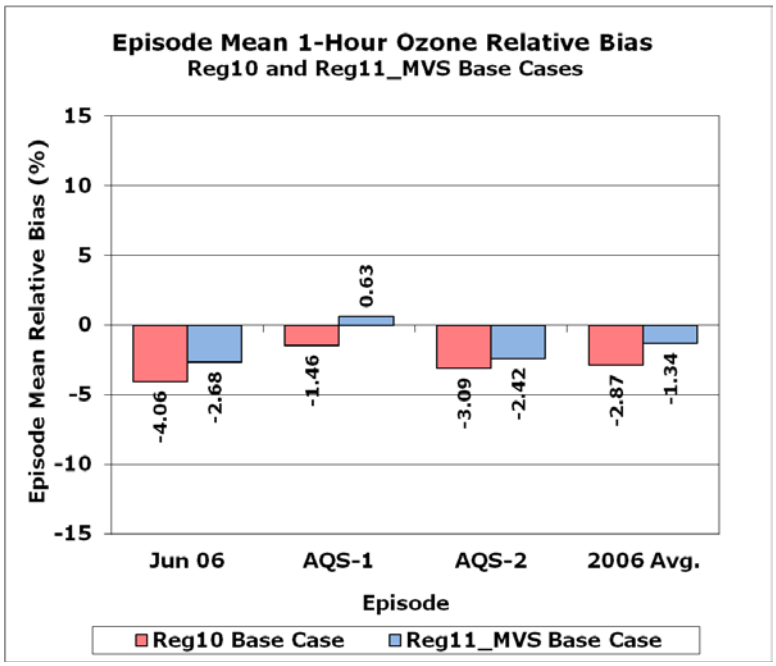

Figure 1: Episode Mean One-Hour Ozone Relative Bias for the Reg10 and Reg11_MVS Base Cases

Figure 2: *Episode Mean One-Hour Relative Error for the Reg10 and Reg11_MVS Base Cases* compares the mean relative error of the two base cases across all monitors and all modeled hours (with observed hourly ozone concentrations of 60 ppb or higher) in the HGB ozone nonattainment area. It shows that using MOVES2010a in the Reg11_MVS base case reduces the error slightly on two of the three episodes and in the average across all 2006 episode days. In the June 2006 episode, the relative error decreased from 12.86 to 12.55%, while in the AQS-1 episode, the error declined from 15.29 to 14.87%. The error increased from 13.89 to 14.06% in the AQS-2 episode. The average error across all modeled days decreased from 14.00 to 13.74%.

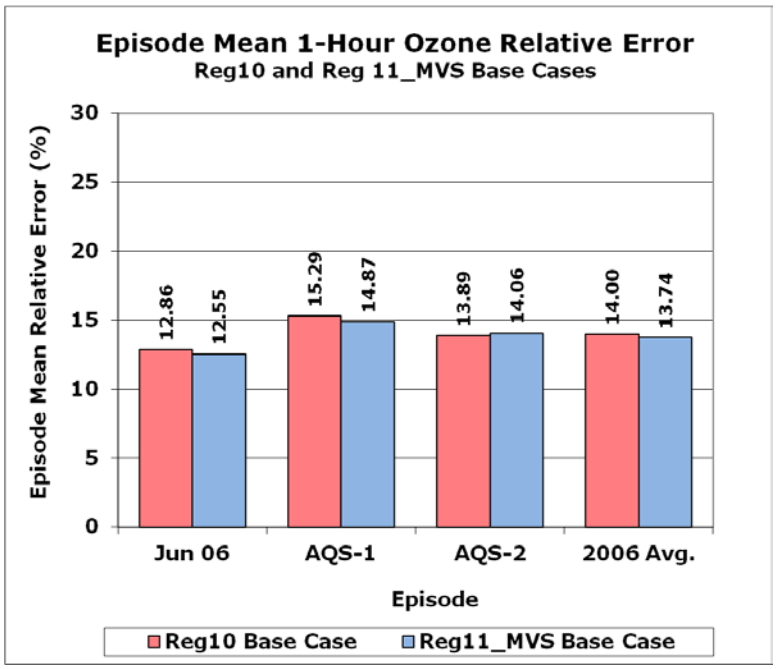

Figure 2: Episode Mean One-Hour Relative Error for the Reg10 and Reg11_MVS Base Cases

Figure 3: *Episode Mean One-Hour Unpaired Peak Modeled and Observed Ozone Concentrations for the Reg10 and Reg11_MVS Base Cases* compares the average area-wide observed peak one-hour ozone concentration (average of the highest single daily monitor reading in the HGB area) with the highest modeled peak one-hour ozone concentration (average of the highest modeled concentration anywhere in the HGB area) for each base case Reg10 and Reg11_MVS. For the June 2006 episode, switching to the Reg11_MVS base case increased the mean peak concentration from 115.3 to 116 ppb, compared with an observed mean peak of 119.1 ppb. For the AQS-1 episode, the Reg11_MVS base case increased the mean peak from 114.1 to 115.7 ppb, compared with an observed mean peak of 112.6 ppb[1]. For the AQS-2 episode, the Reg11_MVS base case increased the mean peak value from 95 to 95.6 ppb and the average across all modeled days from 110.8 to 111.6 ppb, compared with observed mean peak concentrations of 100.4 and 111.7 ppb, respectively. The modeling using MOVES2010a thus represents a small improvement in the model's tendency to under-predict peak concentrations by a modest amount.

[1] Since the observed value is based on only a limited number of discrete monitoring locations, while the modeled value is the highest value across the entire HGB nonattainment area, a perfect model would always produce a peak at least as high as the highest observed concentration. Thus, modeled values of this statistic higher than observed values do not necessarily indicate over-prediction. On the other hand, modeled values lower than observed are an indication of under-prediction.

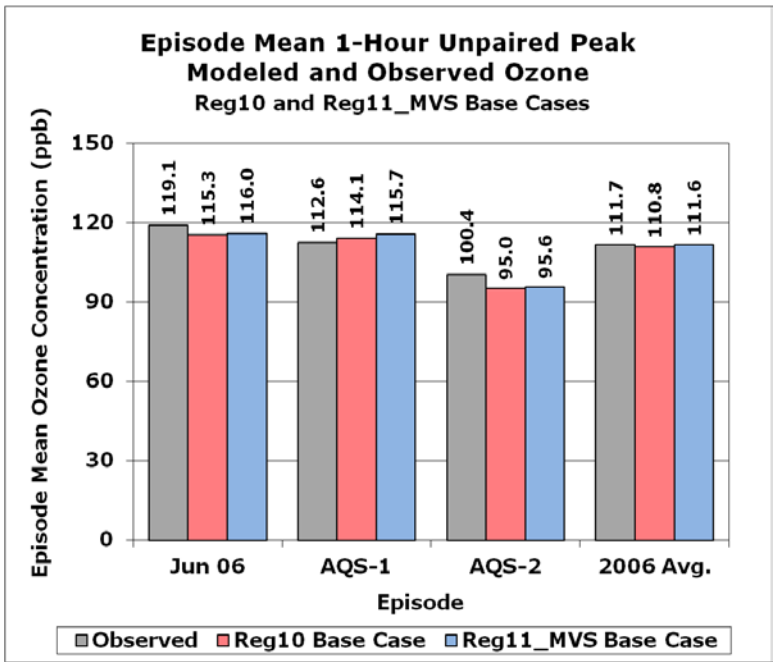

Figure 3: Episode Mean One-Hour Unpaired Peak Modeled and Observed Ozone Concentrations for the Reg10 and Reg11_MVS Base Cases

The next two figures address the model's ability to simulate eight-hour ozone concentrations. For these assessments, only the daily eight-hour average peak concentrations are considered. Figure 4: *Episode Mean Eight-Hour Observed and Modeled Eight-Hour Peak Ozone Concentrations at Monitoring Sites for the Reg10 and Reg11_MVS Base Cases* compares the mean eight-hour peak modeled concentrations at monitoring sites with the mean observed concentrations at those locations (averaged across days and locations). It is seen from the figure that the Reg10 base case already tended to over-predict the eight-hour peaks, and this tendency is slightly exaggerated by the Reg11_MVS base case, contrary to the under-prediction seen for the one-hour peaks. The explanation is that, although the model slightly under-predicts the single highest daily peak one-hour concentration, the model over-predicts the concentrations for other hours in the eight-hour period containing the one-hour peak, which typically constitutes the eight-hour peak. Specifically, the Reg11_MVS base case increases the mean eight-hour peak concentrations from 71.3 to 72.2 ppb for the June, 2006 episode, compared with an observed value of 68.5 ppb. For the AQS-1 episode the Reg11_MVS base case increased the mean eight-hour peak concentration from 68.9 to 70.4 ppb, compared with an observed average of 60.8 ppb, and for AQS-2 the Reg11_MVS base case increased the average peak from 64.2 to 64.7 ppb, compared with an observed value of 57.6 ppb. The average over all days increased from 68.4 to 69.4 ppb, compared with an observed concentration of 62.4 ppb. So it is seen that the switch to MOVES2010a slightly exacerbated the model's tendency to over-predict the observed daily peak eight-hour ozone concentrations.

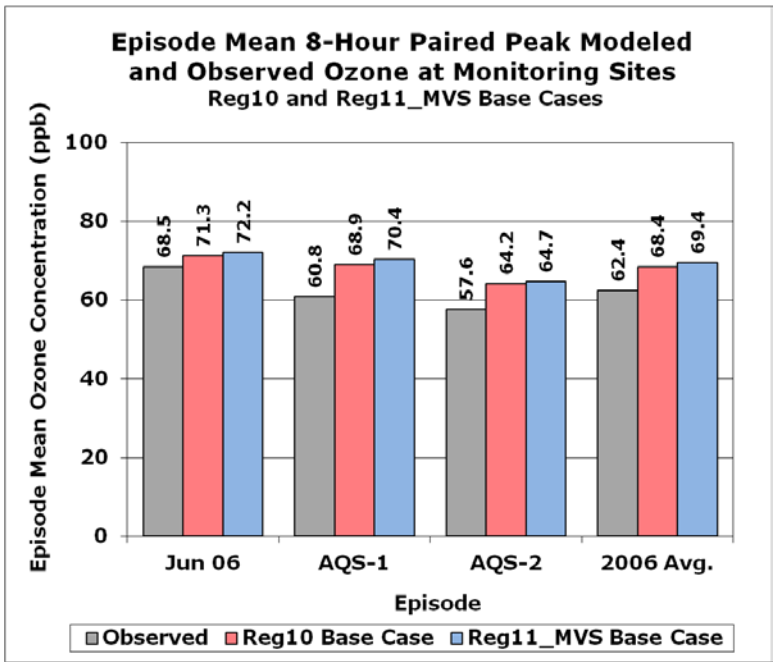

Figure 4: Episode Mean Eight-Hour Observed and Modeled Eight-Hour Peak Ozone Concentrations at Monitoring Sites for the Reg10 and Reg11_MVS Base Cases

Figure 5: *Episode Mean Eight-Hour Unpaired Peak Modeled and Observed Ozone Concentrations for the Reg10 and Reg11_MVS Base Cases* is similar to Figure 3 above, except that it shows domain-wide observed and modeled eight-hour peak concentrations (averaged across days) instead of one-hour peaks. The figure shows that for all three episodes and for the average across all episode days, the model predicts the magnitude of the single highest eight-hour ozone concentration quite well. Unlike the paired results shown in Figure 4, in this case the fact that the modeled peaks are higher than observed values is not an indication of model bias (see footnote 1 above). The switch from MOBILE6.2 to MOVES2010a is seen to increase the mean domain-wide peak eight-hour concentration from 95.7 to 96.6 ppb for the June 2006 episode, compared with an observed value of 94.7 ppb, from 95.1 to 95.3 ppb for the AQS-1 episode, compared with an observed value of 87.9 ppb, and from 82.2 to 82.5 ppb for the AQS-2 episode, compared with an observed 80.1 ppb. The mean peak over all episode days increased from 91.8 to 92.7 ppb, compared with an observed peak of 87.9 ppb. Overall, it is seen that switching from MOBILE6.2 to MOVES2010a increased the modeled area-wide peak eight-hour concentrations by less than one ppb on average.

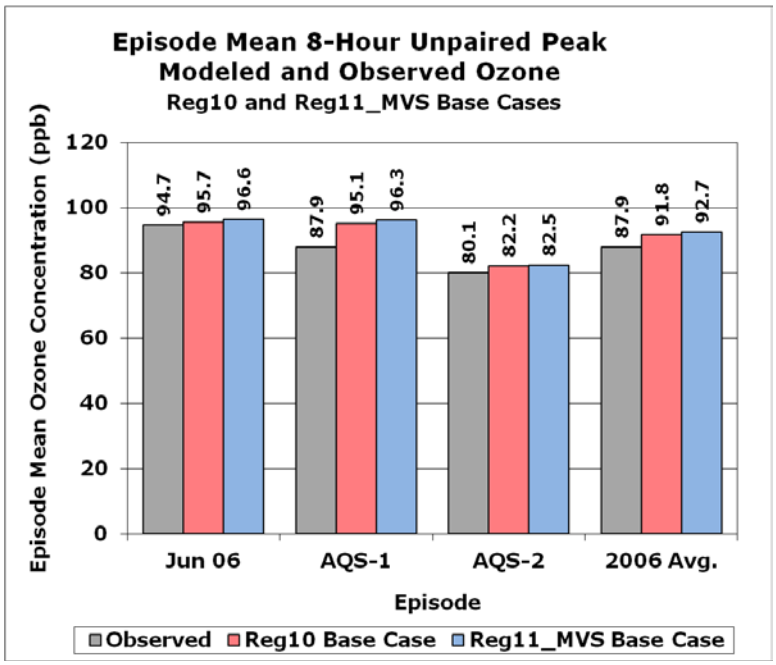

Figure 5: Episode Mean Eight-Hour Unpaired Peak Modeled and Observed Ozone Concentrations for the Reg10 and Reg11_MVS Base Cases

Since there are no established performance standards for episode-wide measures, the overall model performance assessment is, of necessity, somewhat subjective, but placed in the context of previous modeling applications for the HGB region, the model appears to be replicating observed ozone concentrations in all three 2006 episodes quite well. Switching to MOVES2010a from MOBILE6.2 slightly improves one-hour model performance statistics but slightly degrades overall performance for eight-hour peaks. However, performance for the highest eight-hour peaks remains good.

3 EPISODE DAY AND MONITOR SPECIFIC MODEL PERFORMANCE EVALUATION BY EPISODE

The statistical measures presented in this section are similar to those shown in the preceding section, except these are calculated for each monitor or each episode day separately. Examining these statistics allows the reader to see where and when the model performs well and where it does not. In addition to the statistics, time series plots comparing observed and modeled ozone, nitrogen oxides (NO_X), and total volatile organic compounds (VOC) concentrations are presented. These statistics and graphics are selected to provide the most relevant comparisons between the Reg10 (MOBILE6.2) and Reg11_MVS (MOVES2010a) base case episodes. Finally, tile plots (similar to contour plots) showing the spatial distribution of modeled and measured ozone concentrations across the HGB nonattainment and surrounding areas are shown.

Detailed model performance evaluations for the Reg10 base case are available in Appendix C of the 2010 HGB AD SIP Revision. Comparative results between Reg10 and Reg11_MVS base cases are presented separately for each episode in the following sections.

3.1 June, 2006 Episode (bc06ep0) Detailed Model Performance Evaluation

This section presents comparative model performance analysis for the June 2006 episode, also called bc06ep0, for two modeling base cases, Reg10, described in detail in the 2010 HGB AD SIP Revision, and Reg11_MVS, which replaces MOBILE6.2 on-road mobile source emissions with

emissions calculated by MOVES2010a. While the episode ran from May 31 through June 15, 2006, some of the statistics shown in this section omit the May 31 ramp-up day.

3.1.1 Statistical Measures

Statistical measures comprised of the Unpaired Peak Accuracy (UPA), the Mean Normalized Bias (MNB) and the Mean Normalized Gross Error (MNGE) were calculated comparing measured and bi-linearly interpolated modeled ozone concentrations for all episode days and regulatory and non-regulatory monitors. Unlike the statistics computed for one-hour ozone concentrations, which used all hourly observations with monitored values above 60 ppb, these statistics are calculated using only the peak daily eight-hour concentration at each monitor. Site-day combinations with peak eight-hour ozone concentrations below 40 ppb were excluded from the calculations.

Figure 6: *Chart of Measured versus Modeled Peak Eight-Hour Ozone Concentrations for the June 2006 Episode* compares the measured and modeled peak eight-hour ozone concentrations for each episode day for the base case modeling scenarios Reg10 and Reg11_MVS. The error bars (+/-20%) show the UPA for measured peak eight-hour ozone concentrations for the June 2006 episode. For the 13 episode days with measured peak eight-hour ozone concentrations greater than 84 ppb, the modeled peak eight-hour ozone concentrations are within the +/-20% range for ten days for the Reg10 modeling scenario and 11 days for the Reg11_MVS modeling scenario. For June 3rd, with a measured peak eight-hour ozone concentration of 85 ppb, both the Reg10 or Reg11_MVS modeling scenarios yield values of the UPA greater than +20% (over prediction[2]). For June 8th, with the highest measured peak eight-hour ozone concentration (122.9 ppb) of the episode days, both modeling scenarios yield a UPA less than -20% (under prediction).

Figure 7: *Soccer-Style Plot of Daily Maximum Eight-Hour MNGE and MNB for the June 2006 Episode by Day* shows the MNGE and MNB statistics for paired modeled and measured daily maximum eight-hour ozone concentrations for each episode day for base case modeling scenarios Reg10 and Reg11_MVS. Although there are no recommended limits for the eight-hour MNGE and MNB, it is reasonable to expect that the criteria for eight-hour MNGE and MNB should generally not be more than 30% and +/-15%, respectively, used for one-hour model performance evaluation. Excluding the ramp-up days, all but one day (June 4) lies in the green box indicating acceptable statistical performance for both base cases. Generally, the points on the graph shifted slightly to the right, indicating a positive change in the bias, while the gross error remained fairly steady.

Figure 8: *Soccer-Style Plot of Daily Maximum Eight-Hour MNGE and MNB for the June 2006 Episode by Monitor* shows the MNGE and MNB statistics for paired modeled and measured eight-hour ozone concentrations for base case modeling scenarios Reg10 and Reg11_MVS. Three key monitors, Bayland Park (BAYP, CAMS 0053), Deer Park (DRPK, CAMS 0035), and Wallisville (WALV, CAMS 0617) are highlighted with solid symbols while other sites are shown as open circles. All but one site lies in the green box for the Reg10 base case, the exception being Clinton Drive (C35C, CAMS 0403) where ozone was fairly significantly over-predicted. Switching from MOBILE6.2 to MOVES2010a (Reg11_MVS) moved one site (Texas Avenue,

[2] Note that the modeled peak used in calculating the UPA can occur anywhere in the 2 km modeling domain while the observed peak must occur at a monitor. Therefore, a perfect model would always have a peak at least as high as the observed peak. A positive value of the UPA does not in itself signal model over-prediction. However, because the HGB area has a very extensive monitoring network, a large value of the UPA strongly suggests model over-prediction of the peak.

HTCA, CAMS 0411) just outside with a bias of 15.3%; otherwise all sites are within the green box. The three specifically identified sites, BAYP (CAMS 0053), DRPK (CAMS 0035), and WALV (CAMS 0617) are all well within the green box.

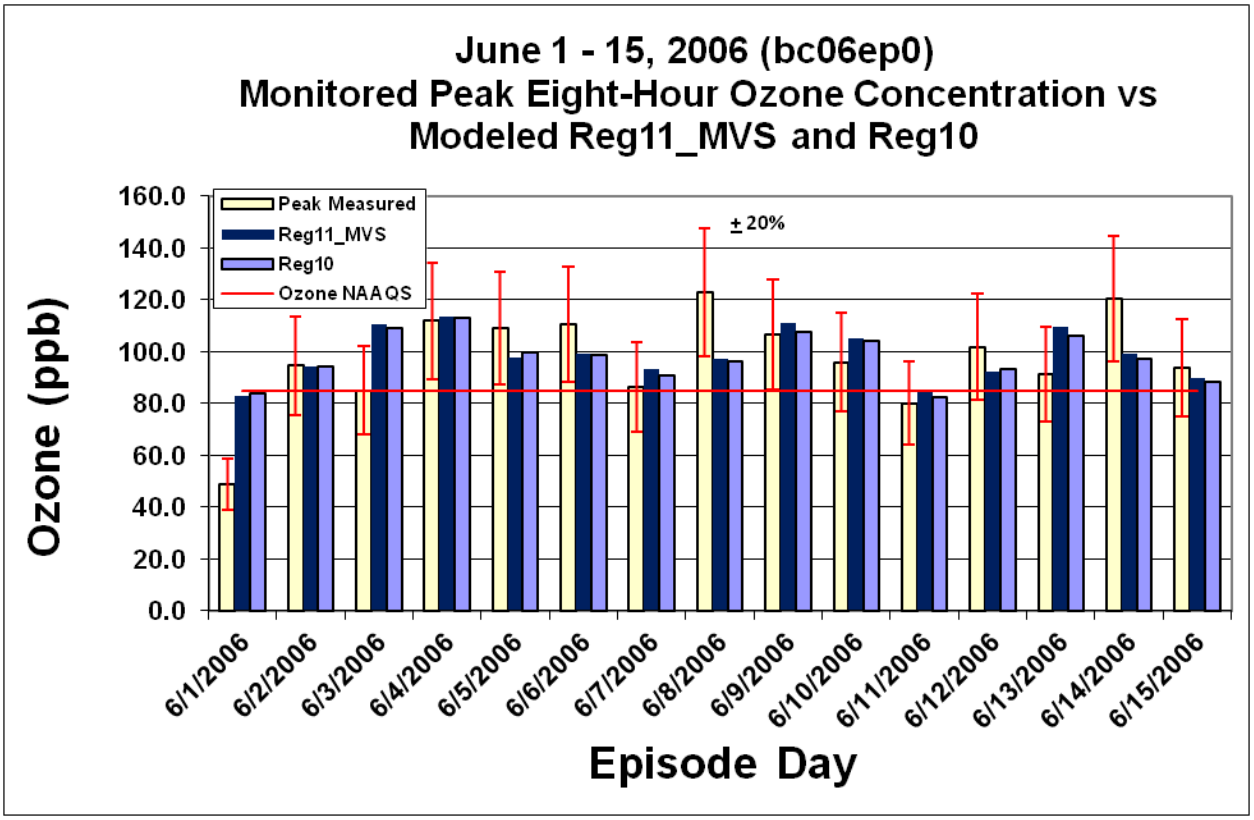

Figure 6: Chart of Measured versus Modeled Peak Eight-Hour Ozone Concentrations for the June 2006 Episode

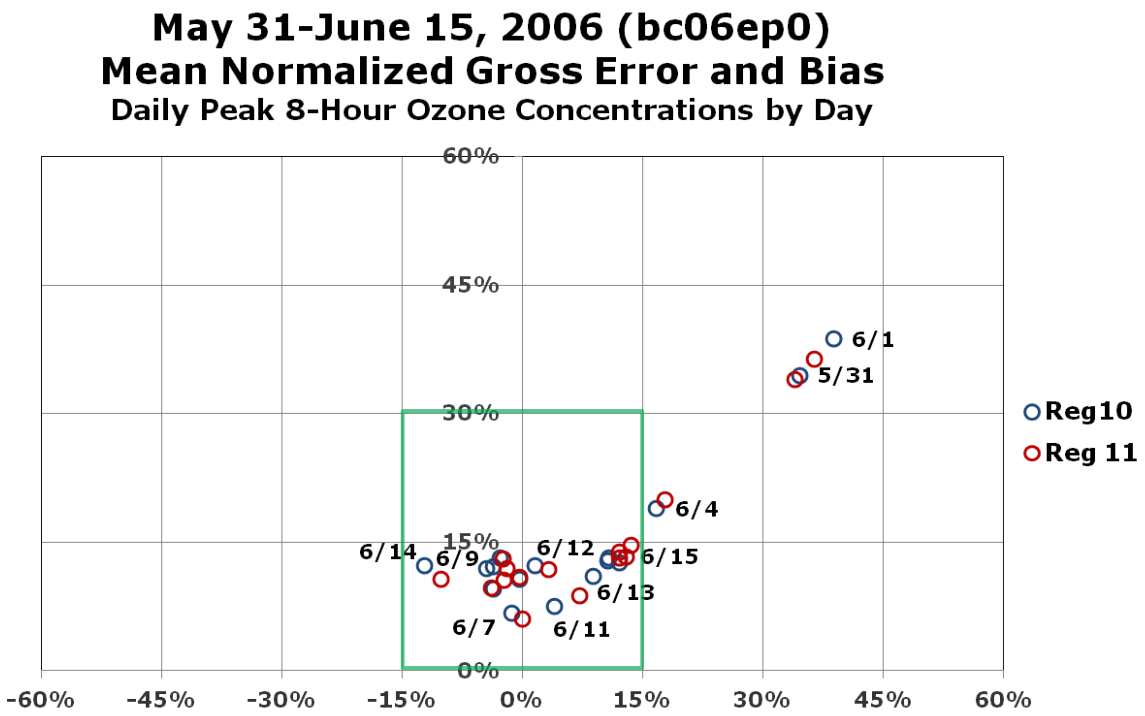

Figure 7: Soccer-Style Plot of Daily Maximum Eight-Hour MNGE and MNB for the June 2006 Episode by Day

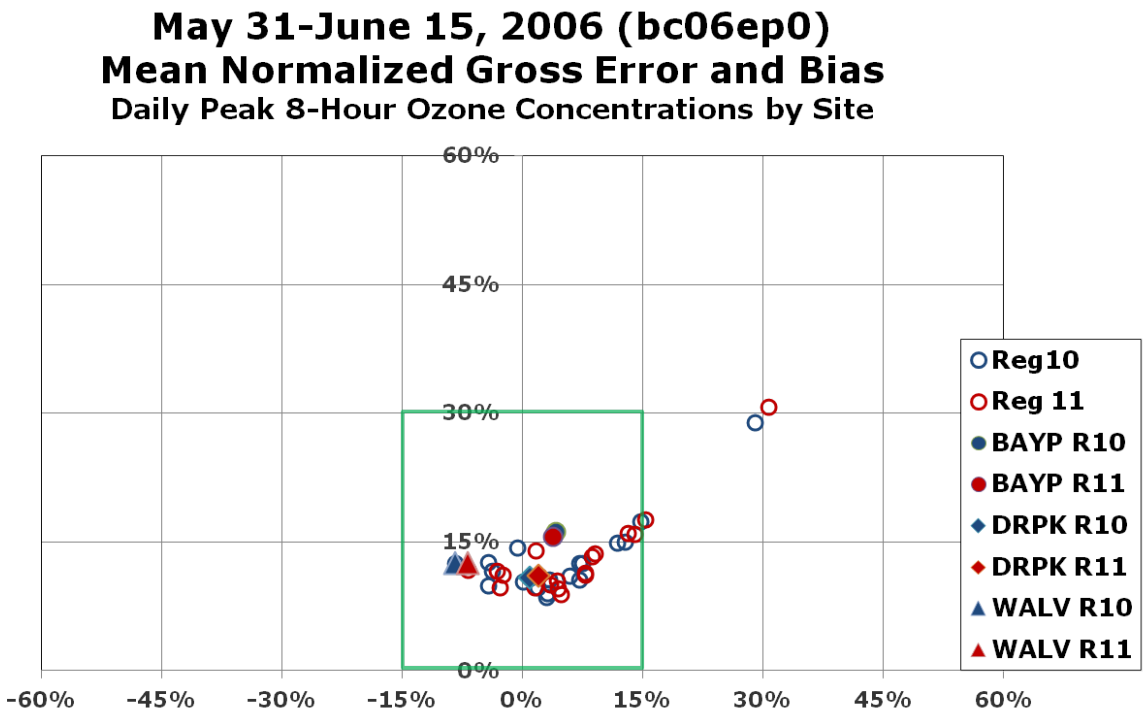

Figure 8: Soccer-Style Plot of Daily Maximum Eight-Hour MNGE and MNB for the June 2006 Episode by Monitor

Table 1: *June 2006 Episode Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10 and Reg11_MVS Modeling Scenarios by Day* summarizes the daily maximum eight-hour ozone concentration statistics (i.e., MNB, MNGE, and UPA) by episode day evaluated for all monitors for the Reg10 and Reg11_MVS modeling scenarios for all data pairs with measured peak eight-hour ozone concentrations greater than 40 ppb. The MNB and MNGE values are those plotted in Figure 7, and the UPA values correspond to the percent difference between the modeled and measured peak daily maximum eight-hour ozone concentrations, which are those plotted in Figure 6.

Table 1: June 2006 Episode Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10 and Reg11_MVS Modeling Scenarios by Day

Episode Day	Reg10 MNB (%)	Reg10 MNGE (%)	Reg10 UPA (%)	Reg11_MVS MNB (%)	Reg11_MVS MNGE (%)	Reg11_MVS UPA (%)
6/1/2006	38.8	38.8	20.4	36.4	36.4	70.1
6/2/2006	-2.9	13.2	71.7	-2.5	13.1	-0.4
6/3/2006	10.8	13.2	-0.4	13.5	14.7	29.9
6/4/2006	16.7	18.9	28.2	17.7	20.0	1.4
6/5/2006	-3.7	9.6	1.3	-3.9	9.7	-10.5
6/6/2006	-0.4	10.8	-8.7	-0.4	10.9	-10.4
6/7/2006	-1.4	6.8	-10.8	0.0	6.1	8.0
6/8/2006	-3.6	12.2	5.2	-2.0	12.0	-21.0
6/9/2006	-4.5	12.0	-21.6	-2.4	10.6	4.0
6/10/2006	12.0	12.7	1.1	12.9	13.4	9.7
6/11/2006	3.9	7.5	8.7	7.1	8.8	5.0
6/12/2006	1.6	12.3	3.0	3.3	11.9	-9.5
6/13/2006	8.8	11.1	-8.3	12.0	13.3	19.8
6/14/2006	-12.2	12.3	16.2	-10.1	10.7	-17.5
6/15/2006	10.7	12.9	-19.1	12.0	13.9	-4.0

Table 2: *June 2006 Episode Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10 and Reg11_MVS Modeling Scenarios by Site* summarizes the eight-hour ozone concentration statistics (i.e., MNB, MNGE, UPA) by monitor. The MNB and MNGE are evaluated using paired measured and modeled eight-hour ozone concentrations for all data pairs with measured peak eight-hour ozone concentrations greater than 40 ppb. The MNB and MNGE values are those plotted in Figure 8. The UPA indicates the percentage by which the modeled peak eight-hour ozone concentrations over- (+) or under- (-) predicted the measured peak eight-hour ozone concentrations at each monitor.

Table 2: June 2006 Episode Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10 and Reg11_MVS Modeling Scenarios by Site

Monitor Code	Reg10 MNB (%)	Reg10 MNGE (%)	Reg10 UPA (%)	Reg11_MVS MNB (%)	Reg11_MVS MNGE (%)	Reg11_MVS UPA (%)
BAYP	4.2	16.1	7.54	3.9	15.5	9.07
C35C	29.0	29.0	43.54	30.7	30.7	44.59
CNR2	0.9	10.9	-12.93	2.1	11.1	-11.93
DRPK	0.9	10.9	-9.18	2.1	11.1	-7.87
GALC	11.8	14.9	0.66	13.1	16.0	4.75
H03H*	-4.3	9.9	11.45	-2.8	9.7	12.62
HALC	3.1	9.0	10.00	4.4	9.7	11.31
HCHV	2.9	8.5	19.21	4.8	9.0	20.56
HCQA	12.8	15.0	1.13	14.0	16.0	2.46
HNWA	-0.7	14.4	-12.49	1.7	14.1	-9.17
HOEA	-3.8	11.7	8.95	-2.5	11.2	10.09
HROC	7.1	10.6	19.09	7.8	11.2	18.00
HSMA	7.1	12.6	-7.76	8.7	13.4	-6.68
HTCA	14.7	17.4	30.03	15.3	17.6	28.70
LYNF	5.9	11.1	7.36	7.8	11.4	8.49
MACP	-4.3	12.7	-19.45	-3.2	11.6	-18.36
MSTG*	7.4	12.6	5.89	9.1	13.7	9.60
SBFP	0.0	10.4	-9.72	1.5	9.8	-8.03
SHWH	2.0	9.7	6.35	3.5	10.1	7.54
TXCT*	3.4	10.6	-6.85	4.4	10.6	-3.86
WALV*	-8.4	12.5	1.52	-6.8	11.8	2.99

*Non regulatory, industry-sponsored monitor

3.1.2 Time Series for Selected Monitors

For the June 2006 (May 31 through June 15, 2006) episode, time series of ozone (O_3) and NO_X observed and modeled (Reg10 and Reg11_MVS base cases) hourly average concentrations are shown for three significant sites: BAYP (CAMS 0053), DRPK (CAMS 0035), and WALV (CAMS 0617). The first, BAYP (CAMS 0053), is selected because it has the highest modeled future design value for the Reg11_MVS base case, while WALV (CAMS 0617) has the highest modeled future design value with the Reg10 base case. The DRPK (CAMS 0035) monitor is near the Houston Ship Channel and has high future design values with both base cases. Both WALV (CAMS 0617) and DRPK (CAMS 0035), along with six additional sites in the area, have continuous monitoring of VOC, but the time series plots of various VOC showed only very minor differences between the two base cases and therefore are not included.

Figure 9: *Time Series Plots of Ozone and NO_X Concentrations at Bayland Park for the June 2006 Episode* shows time series of O_3 and NO_X at BAYP (CAMS 0053), with the Reg10 modeled concentrations shown as a continuous green line and the Reg11_MVS modeled concentrations shown as a continuous blue line. Monitored concentrations are shown as solid red squares. In the top series, it is seen that there are relatively minor differences in modeled ozone concentrations between Reg10 and Reg11_MVS. For most of the graph, the two are

indistinguishable, but where differences are discernible, especially between noon on May 31 and noon on June 2, and during the daytime hours of June 12, the modeled ozone concentrations for the Reg11_MVS base case are lower by a few ppb than those modeled with the Reg10 base case.

The lower plot shows that the modeled NO_X concentrations with Reg11_MVS, however, are nearly universally higher than those modeled with Reg10, suggesting the lower ozone concentrations are the result of the increased NO_X emissions from MOVES2010a.[3] Excluding the two ramp-up days of May 31 and June 1, the Reg11_MVS base case performance for ozone is very similar to that of Reg10 (see Appendix C of the 2010 HGB AD SIP Revision for a thorough discussion of the performance of the Reg10 base case). The NO_X, performance for Reg11_MVS is comparable to that of Reg10, but the Reg11_MVS base case does cause some over-prediction of the morning peaks, particularly on June 5, 6, 8, and 9.

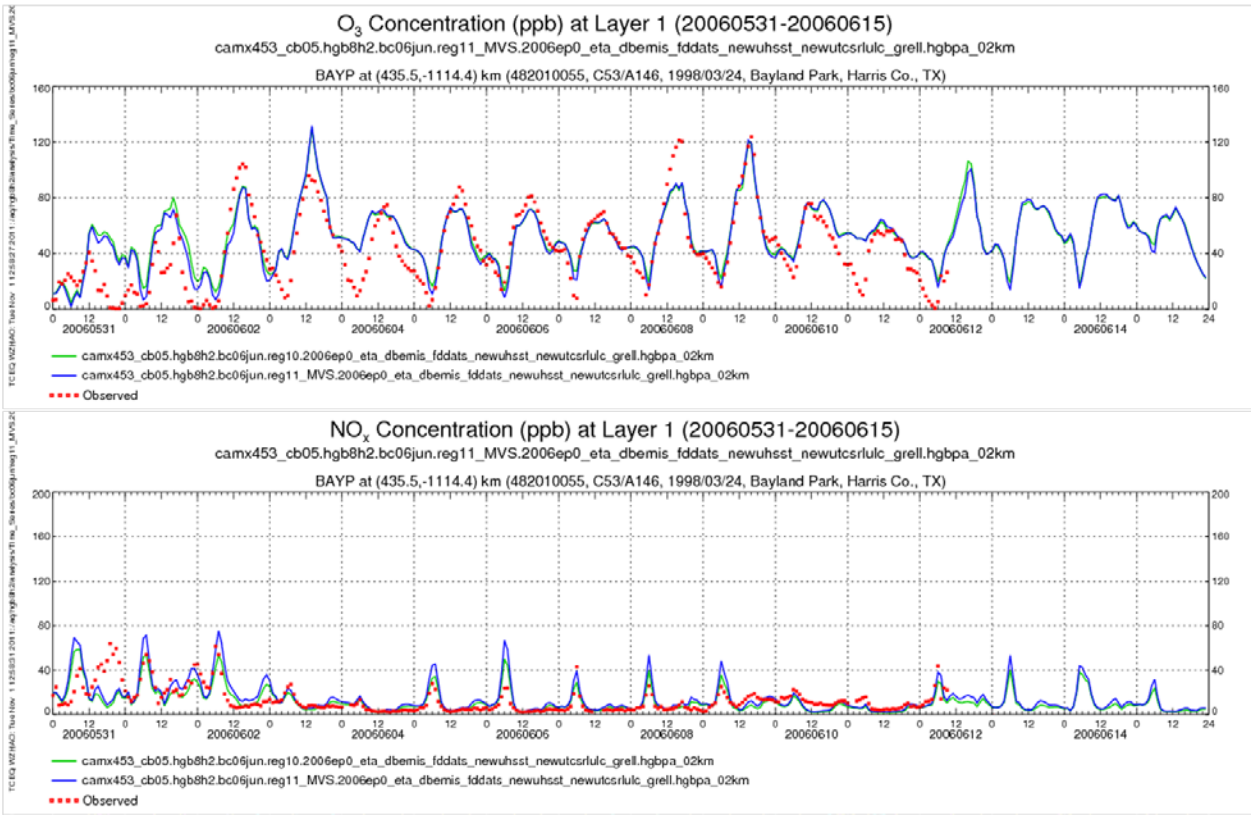

Figure 9: Time Series Plots of Ozone and NO_X Concentrations at Bayland Park for the June 2006 Episode

Figure 10: *Time Series Plots of Ozone and NO_X Concentrations at Deer Park for the June 2006 Episode* is similar to Figure 9, with the Reg10 modeled concentrations shown as a continuous green line and the Reg11_MVS modeled concentrations shown as a continuous blue line. At this site, which is close to several large industrial complexes, the differences between the two base cases are relatively smaller than at BAYP (CAMS 0053). Close examination of the top graph in the figure shows slightly higher ozone concentrations from Reg11_MVS, particularly late in the

[3] Interestingly, BAYP's (CAMS 0053) future ozone design value is higher with MOVES than with MOBILE6.2. The difference is that the relative response factor (RRF) is higher with MOVES than with MOBILE6.2, leading to a higher 2018 future design value.

episode, but overall ozone performance is very similar to that of Reg10. The lower graph shows a slightly larger difference for NO_X, especially during the morning peaks, but the differences in model performance between the base cases is minor.

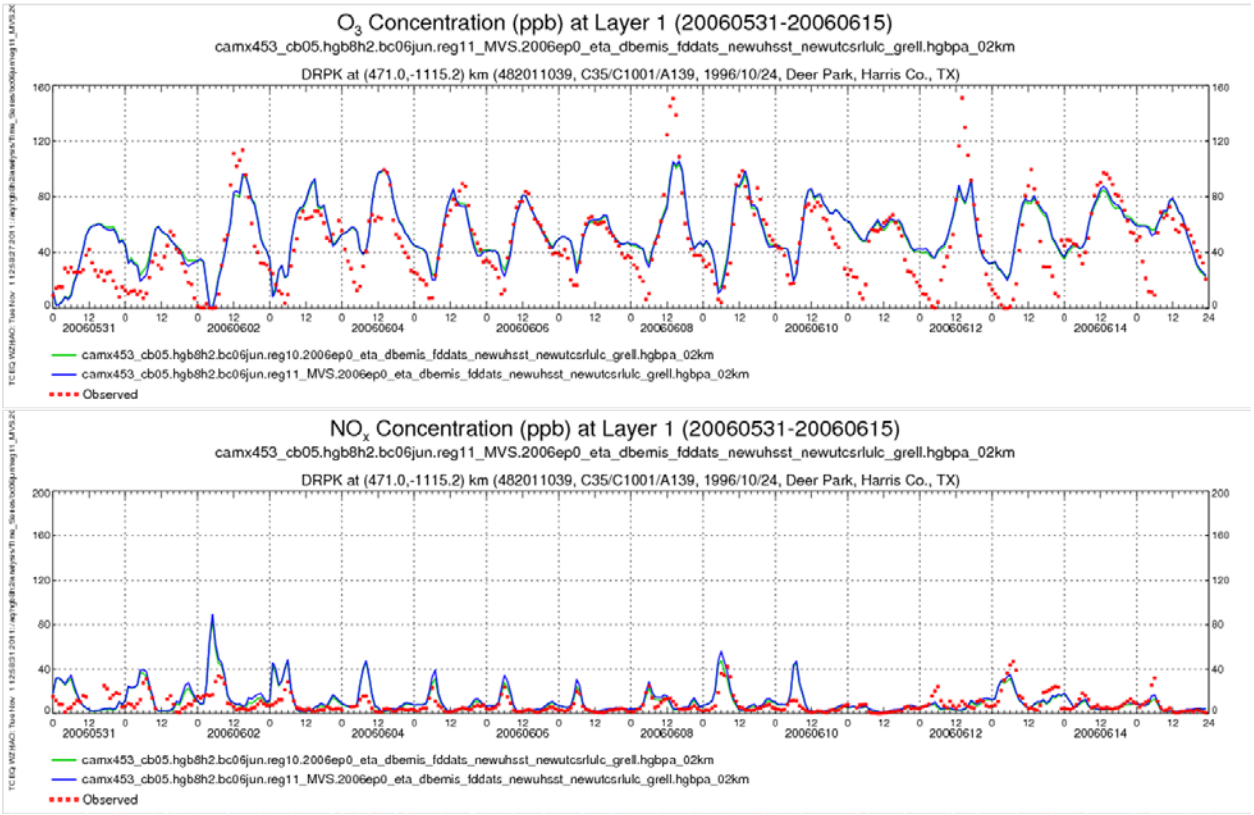

Figure 10: Time Series Plots of Ozone and NO_X Concentrations at Deer Park for the June 2006 Episode

Figure 11: *Time Series Plots of Ozone and NO_X Concentrations at Wallisville for the June 2006 Episode* shows model performance at WALV (CAMS 0617), a relatively rural site that is impacted frequently by industrial emissions from Mont Belvieu and also by those from the Houston Ship Channel and Texas City industrial complexes. The lower plot shows only very minor changes in modeled NO_X concentrations due to a relatively small contribution from vehicular emissions. Ozone concentrations are increased by Reg11_MVS over Reg10 by a few ppb on several occasions, generally improving performance for ozone slightly.

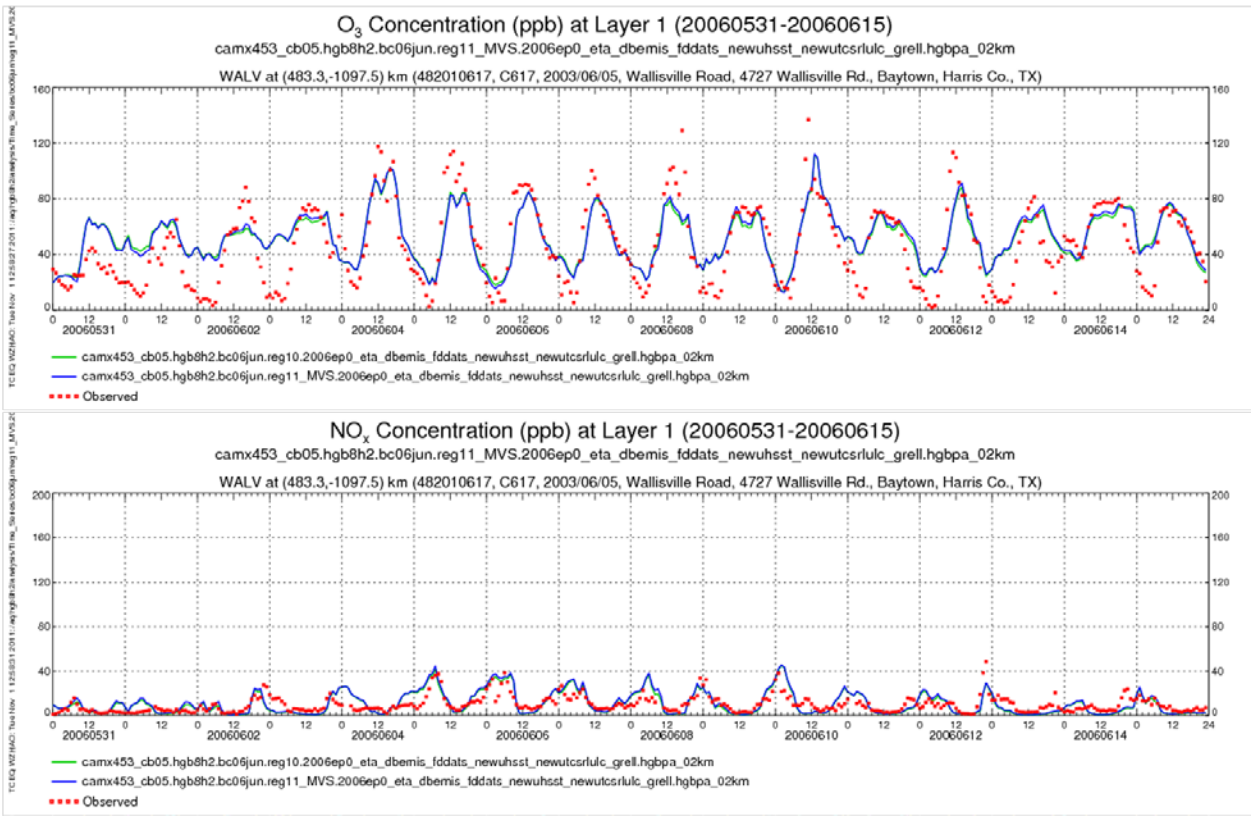

Figure 11: Time Series Plots of Ozone and NO_X Concentrations at Wallisville for the June 2006 Episode

3.1.3 Peak Daily Maximum Eight-Hour Ozone Tile Plots for Selected Days

Ozone concentration tile plots are created by color-coding each modeling grid cell to represent the modeled ozone concentration in that cell (the effect is similar to contour plots of ozone concentration). For the plots in this section, we plot the daily maximum eight-hour ozone concentration modeled in each grid cell. It is important to note that the maximum ozone concentrations in one geographic area may occur at different times from those in another geographic area. For example, the maximum ozone concentrations in areas downwind of the city typically occur later in the day than in areas closer to the urban core. Peak daily tile plots do not represent any specific eight-hour period.

Figure 12: *Maximum Modeled Daily Eight-Hour Ozone Concentrations on June 5 and 8, 2006* and Figure 13: *Maximum Modeled Daily Eight-Hour Ozone Concentrations on June 9 and 14, 2006* show the peak daily eight-hour ozone concentrations from the Reg10 and Reg11_MVS base cases for the four episode days (June 5, 8, 9, and 14) with the highest and most pervasive daily maximum eight-hour ozone concentrations during the episode. Modeled eight-hour peak daily ozone concentrations are shown for each grid cell in the 2 km domain as well as the measured daily maximum ozone concentrations for each monitor (including non-regulatory monitors). Also shown for each day is a plot of the difference of the daily peak eight-hour ozone from each run.

On June 5, 2006, the highest observed daily maximum eight-hour ozone concentration of 109.1 ppb occurred at HRM-4 (CAMS 0604), located in east-central Harris County about 4 km east of the Sam Houston Tollway a little south of U.S. 90. The left column of Figure 12 (June 5, 2006)

shows that the two modeling scenarios distributed the simulated high ozone concentrations very well, but both significantly under-predicted the highest observed concentrations, with only Reg10 coming within 10 ppb of the observed peak. Using MOVES2010a in the Reg11_MVS run resulted in lower ozone by about 2 ppb over central Houston and increased ozone up to 2 ppb north of the city.

On June 8, 2006, the highest observed daily maximum eight-hour ozone concentration of 122.9 ppb occurred at the Baytown Wetlands Center (BYWC, CAMS 0552)), located in Baytown in eastern Harris County, about 1 km east of the Exxon petrochemical complex. The right column of Figure 12 (June 8, 2006) shows that high ozone concentrations were seen across all of Harris County and into western Chambers County. Both model runs placed the highest simulated ozone concentrations in the general area of the observed highest concentrations, but neither simulated the very high concentrations observed across southeastern Harris County on this day. The Reg11_MVS base case generated more ozone but still underestimated by 15 ppb the recorded peak. Comparing the two runs with the difference plot, Reg11_MVS generated a 1 ppb or more increase in peak eight-hour ozone throughout the domain, except for central Houston where the added NO_X emissions with MOVES2010a titrated ozone on the order of 1 ppb.

On June 9, 2006, the highest observed daily maximum eight-hour ozone concentration of 106.5 ppb occurred at Bunker Hill Village (BUHV, CAMS 0562), located about 20 km west of downtown Houston near the junction of IH-10 and the Sam Houston Tollway. The left-hand column of Figure 13 shows the two modeling scenarios for this day. Monitored high concentrations of eight-hour ozone were widespread across most of the entire eight-county nonattainment area, except northeastern Harris County. Both model runs simulated the peak near BUHV (CAMS 0562) and within 5 ppb of the observed maximum. While neither of the scenarios matched the magnitude of concentrations recorded in northern Brazoria County, both runs simulated high ozone concentrations in most of the areas where they were observed. Reg11_MVS estimated the elevated ozone concentrations in southeastern Harris County, northern Brazoria County, and around Galveston Bay better than the Reg10 run. The difference plot shows that MOVES2010a added up to 4 ppb in Harris and the surrounding counties. A small area of ozone decreases up to near 4 ppb was observed in central Houston.

On June 14, 2006, the highest observed daily maximum eight-hour ozone concentration of 120.4 ppb occurred at Tom Bass (TOMB, CAMS 0558), which is located in southern Harris County almost on the Brazoria County line. The right-hand column of Figure 13 shows that, once again, the model located the highest ozone concentrations in approximately the correct area but failed to match the intensity of the observations. The highest concentration of 99.3 ppb was simulated by Reg11_MVS, but it still fell short of the observed maximum by 21 ppb. Reg11_MVS generated higher peak eight-hour ozone by up to 3 ppb across the western two-thirds of the 2 km grid, with some modest decreases seen in Chambers County.

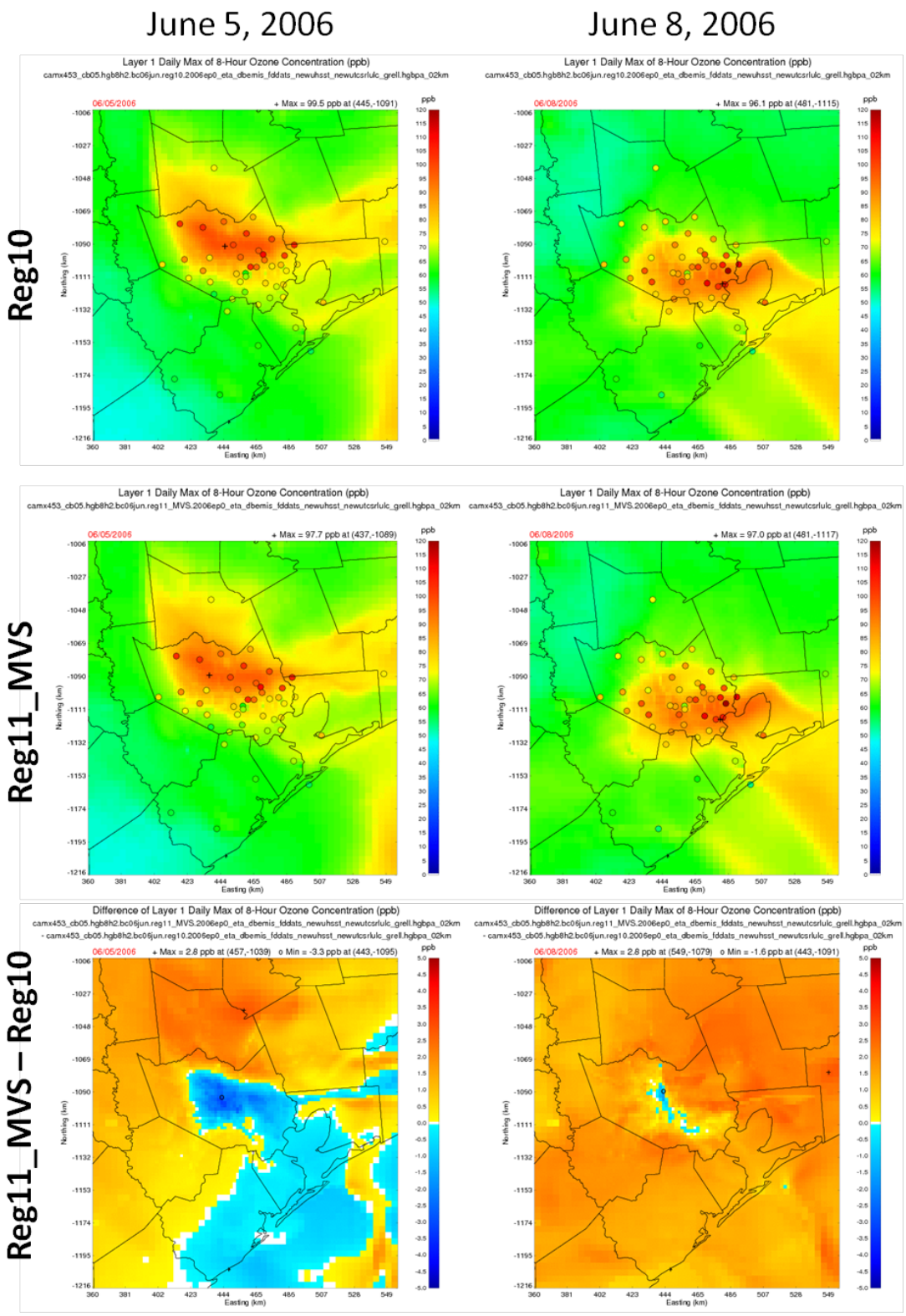

Figure 12: Maximum Modeled Daily Eight-Hour Ozone Concentrations on June 5 and 8, 2006

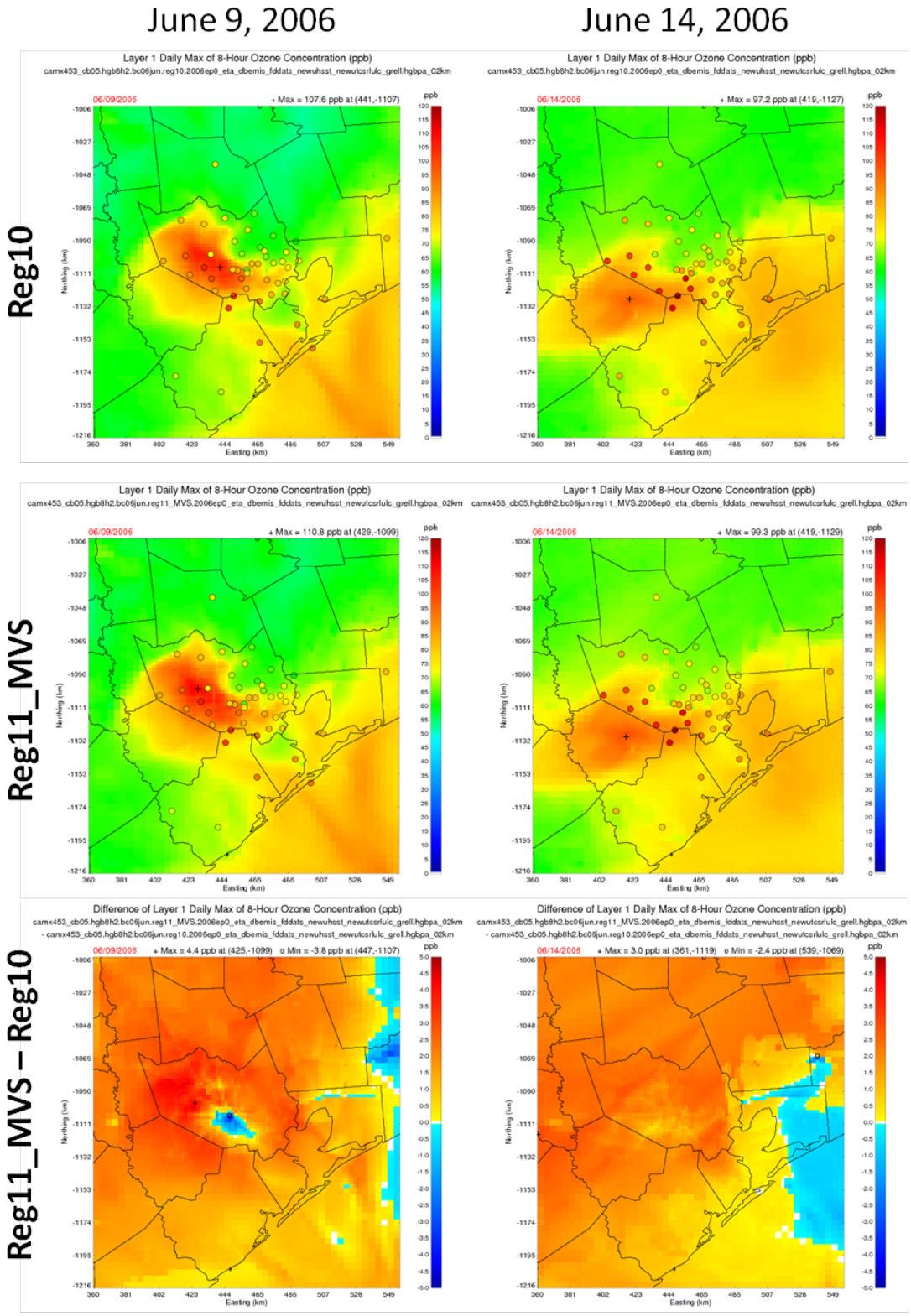

Figure 13: Maximum Modeled Daily Eight-Hour Ozone Concentrations on June 9 and 14, 2006

3.2 AQS-1 Episode (bc06aqs1) Detailed Model Performance Evaluation

This section provides an in-depth analysis of model performance for the August 14 to September 14, 2006 (bc06aqs1), episode. The episode is composed of three sequential periods: August 15th to August 22nd; August 29th to September 8th; and September 12th to September 14th, 2006. Note that the AQS-1 episode used the TexAQS II special hourly point source emissions inventory, which is indicated by the "si" addition to the base case names (e.g., Reg10si).

3.2.1 *Statistical Measures*

Figure 14: *Chart of Monitored versus Modeled Peak Eight-Hour Ozone Concentrations for the August/September 2006 Episode* compares the measured and modeled peak eight-hour ozone concentrations for each episode day for the base case modeling scenarios: Reg10si, which used MOBILE6.2, and Reg11si_MVS, which used MOVES2010a. The error bars (+/-20%) show the UPA for measured peak eight-hour ozone concentrations for the August/September 2006 episode. The peak modeled eight-hour ozone concentrations for the Reg11si_MVS scenario are consistently somewhat larger than for the Reg10si modeling scenario throughout the episode. Both the Reg10si and Reg11si_MVS modeling scenarios over-predicted the peak measured eight-hour ozone concentrations for the three days during the first period of the episode, for which the peak measured eight-hour ozone concentrations were greater than 84 ppb. During the second period of the episode, there were five days with peak measured eight-hour ozone concentrations greater than 84 ppb, and the peak modeled eight-hour ozone concentrations, for both the Reg10si and Reg11si_MVS modeling scenarios, were within +/-20% for four of the days. Both the Reg10si and Reg11si_MVS modeling scenarios under-predicted the notably high peak measured eight-hour ozone concentration on August 31, 2006 (127.1 ppb), by less than -20%. For the three days of the third period, both the Reg10si and Reg11si_MVS modeling scenarios predicted peak modeled eight-hour ozone concentrations within +/-20% for the two days with peak measured eight-hour ozone concentrations greater than 84 ppb. However, for the first day of this period with peak measured eight-hour ozone concentrations less than 84 ppb, both the Reg10si and Reg11si_MVS modeling scenarios predicted peak modeled eight-hour ozone concentrations in excess of +20% and well above 84 ppb.

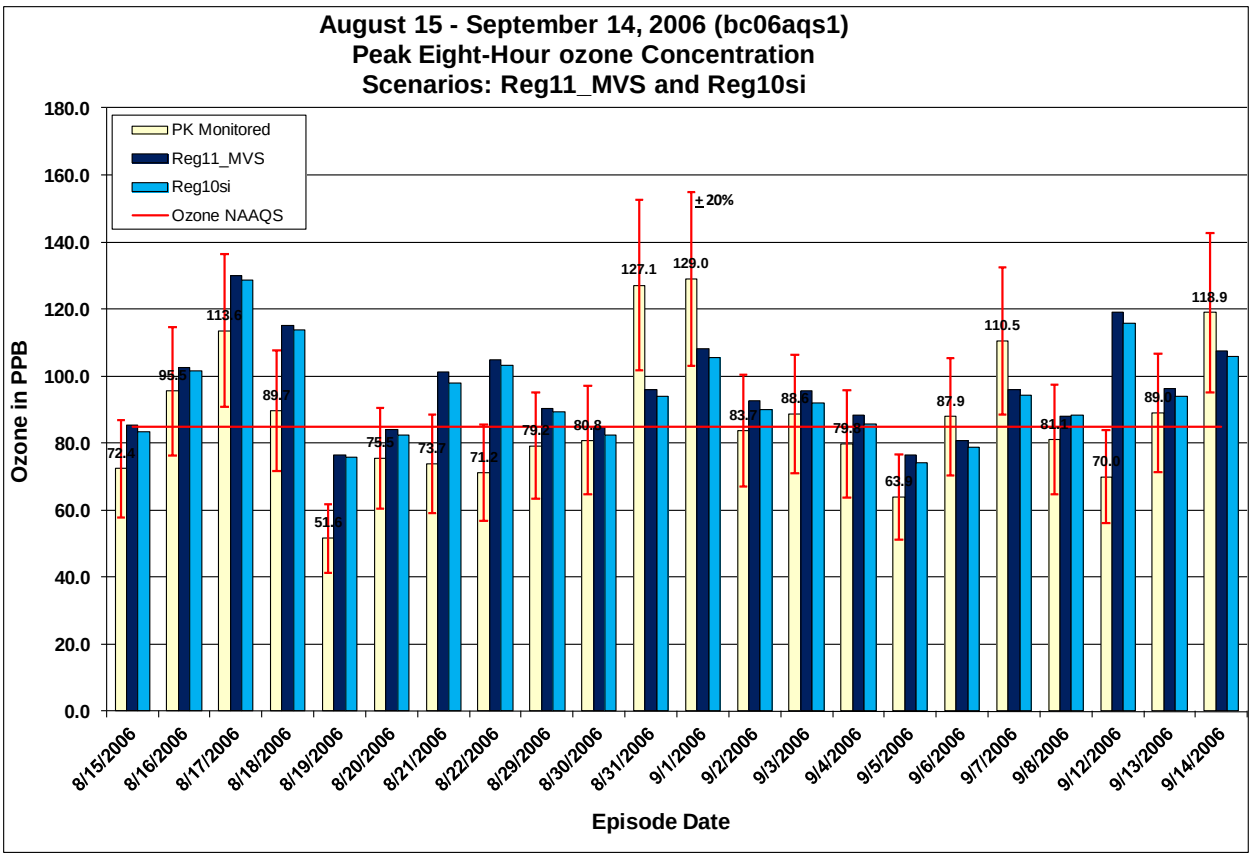

Figure 14: Chart of Monitored versus Modeled Peak Eight-Hour Ozone Concentrations for the August/September 2006 Episode

Figure 15: *Soccer-style Plot of Eight-Hour MNGE and MNB for the August/September 2006 Episode by Day* shows the MNGE and MNB statistics for paired modeled and measured daily maximum eight-hour ozone concentrations for both the Reg10si and Reg11si_MVS modeling scenarios for each episode day. Points from the Reg10si base case are labeled with dates except for areas where the density of data makes labeling impractical.

In this episode, nine out of the 22 episode days have bias greater than 15%, and one day (August 31) has bias less than -15%. This over-prediction occurs primarily on days with relatively low domain-wide ozone concentrations and results from the model's tendency to over-predict low ozone concentrations. Model performance is much better on days (e.g., August 17, September 1, and September 7) during which widespread high ozone was seen across the area, except for August 31 when the model under-predicted ozone concentrations across much of the domain. Overall, using MOVES2010a instead of MOBILE6.2 made a slight difference in model performance, shifting the bias on most days a little to the right (positive).

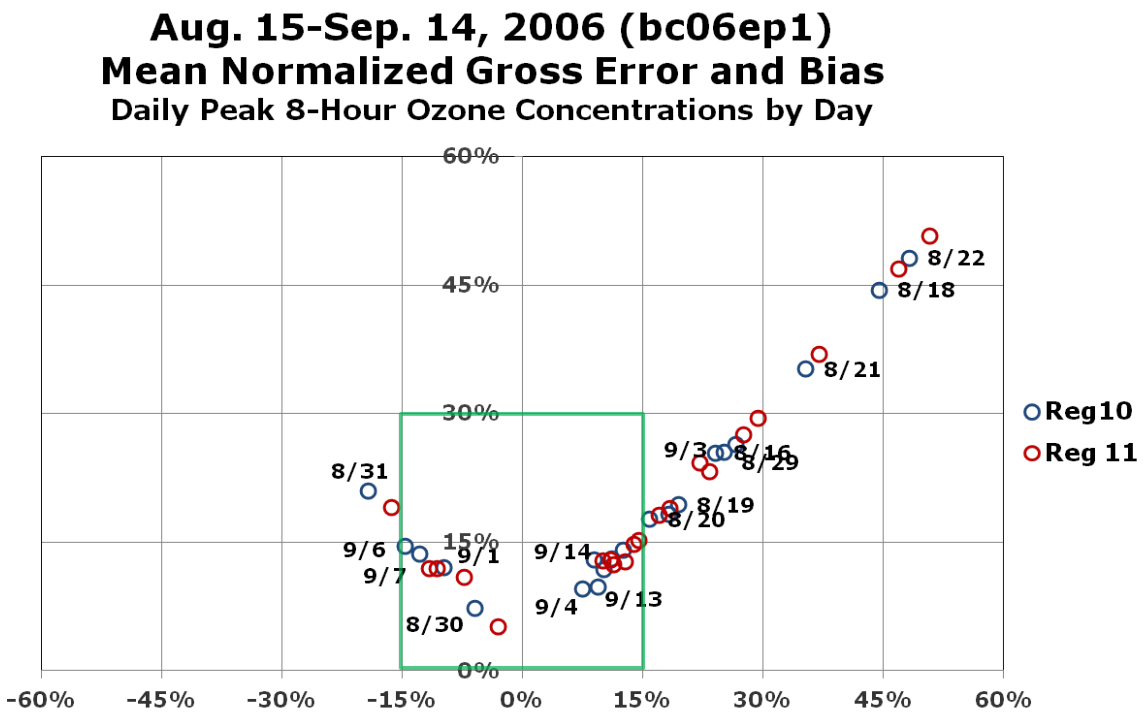

Figure 15: Soccer-style Plot of Eight-Hour MNGE and MNB for the August/September 2006 Episode by Day

Figure 16: *Soccer-style Plot of Eight-Hour MNGE and MNB for the August/September 2006 Episode by Site* shows the MNGE and MNB statistics for paired modeled and measured peak eight-hour ozone concentrations for both Reg10si and Reg11si_MVS modeling scenarios for all data pairs with measured peak eight-hour ozone concentrations greater than 40 ppb. The average site bias and error statistics are somewhat better for sites than for days, with only seven of 22 sites outside the green box for the Reg10si base case. Two sites, Clinton Drive (C35C, CAMS 0403) and Croquet (HCQA, CAMS 0409), showed bias over 25%, but the remainder of the modeled Reg10si biases were below 20%. Shifting to MOVES2010a (Reg11si_MVS) caused an additional site, Galveston (GALC, CAMS 1034) to exceed 20% bias, and also caused the Deer Park (DRPK, CAMS 0035) monitor to exit the box with a bias of 16.8%.

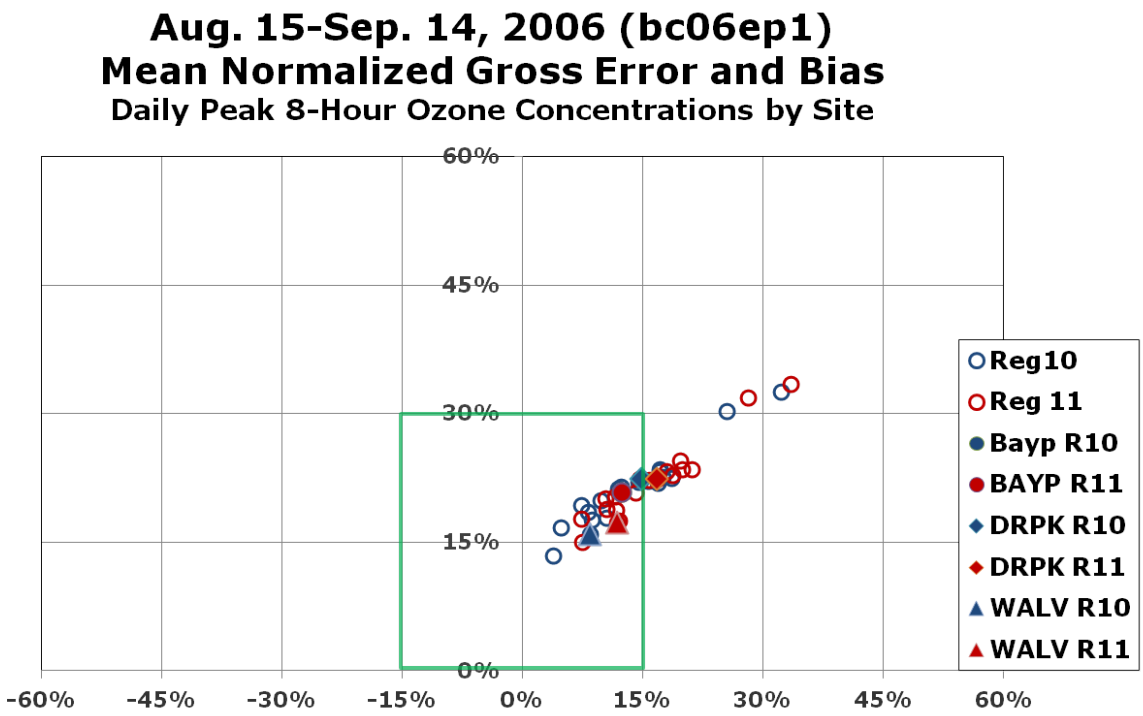

Figure 16: Soccer-style Plot of Eight-Hour MNGE and MNB for the August/September 2006 Episode by Site

Table 3: *August/September 2006 Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10si and Reg11si_MVS Modeling Scenarios by Day* summarizes the daily maximum eight-hour ozone concentration statistics (i.e., MNB, MNGE, UPA) by episode day evaluated for all monitors for the Reg10si and Reg11si_MVS modeling scenarios for all data pairs with measured peak eight-hour ozone concentrations greater than 40 ppb. The MNB and MNGE values are those plotted in Figure 15, and the UPA values correspond to the percent difference between the modeled and measured peak daily maximum eight-hour ozone concentrations, which are those plotted in Figure 14.

Table 3: August/September 2006 Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10si and Reg11si_MVS Modeling Scenarios by Day

Episode Day	Reg10 MNB (%)	Reg10 MNGE (%)	Reg10 UPA (%)	Reg11_MVS MNB (%)	Reg11_MVS MNGE (%)	Reg11_MVS UPA (%)
8/15/2006	24.4	24.4	15.3	23.0	23.0	17.8
8/16/2006	24.0	25.4	6.3	22.1	24.3	7.3
8/17/2006	12.6	14.2	13.4	13.9	14.8	14.3
8/18/2006	44.4	44.4	26.8	46.9	46.9	28.4
8/19/2006	19.4	19.4	46.5	18.3	19.0	48.3
8/20/2006	15.8	17.7	9.0	17.0	18.2	11.5
8/21/2006	35.2	35.2	33.0	37.0	37.0	37.2
8/22/2006	48.2	48.2	45.0	50.7	50.7	47.1
8/29/2006	26.5	26.5	12.6	27.6	27.6	14.1
8/30/2006	-5.9	7.4	2.1	-3.1	5.2	4.7
8/31/2006	-19.3	21.0	-26.2	-16.4	19.2	-24.5
9/1/2006	-9.8	12.1	-18.1	-7.3	11.0	-16.1
9/2/2006	10.1	11.9	7.5	14.5	15.3	10.7
9/3/2006	25.1	25.6	3.9	29.4	29.5	7.8
9/4/2006	7.5	9.6	7.4	11.3	12.4	10.8
9/5/2006	18.3	18.3	15.7	23.3	23.3	19.7
9/6/2006	-14.6	14.6	-10.5	-11.6	12.0	-8.1
9/7/2006	-12.8	13.6	-14.7	-10.7	12.0	-13.0
9/8/2006	11.1	13.2	8.9	11.0	12.9	8.5
9/12/2006	65.1	65.1	65.2	68.5	68.5	70.4
9/13/2006	9.4	9.8	5.5	12.7	12.7	8.2
9/14/2006	8.9	13.0	-11.0	10.0	12.9	-10.7

Table 4: *August/September 2006 Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10si and Reg11si_MVS Modeling Scenarios by Site* summarizes the eight-hour ozone concentration statistics (i.e., MNB, MNGE, UPA) by monitor. The MNB and MNGE are evaluated using paired- measured and modeled peak eight-hour ozone concentrations. The MNB and MNGE values are those plotted in Figure 16 for the Reg10si and Reg11si_MVS modeling scenarios. The UPA indicates the percentage by which the modeled peak eight-hour ozone concentrations over- (+) or under- (-) predicted the measured peak eight-hour ozone concentrations at each monitor.

Table 4: August/September 2006 Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10si and Reg11si_MVS Modeling Scenarios by Site

Monitor Code	Reg10 MNB (%)	Reg10 MNGE (%)	Reg10 UPA (%)	Reg11_MVS MNB (%)	Reg11_MVS MNGE (%)	Reg11_MVS UPA (%)
BAYP	12.5	20.8	1.07	12.4	20.8	3.02
C35C	25.5	30.3	33.75	28.2	31.9	34.77
CNR2	3.8	13.4	5.75	7.5	15.1	7.89
DRPK	14.8	22.4	-8.31	16.8	22.4	-7.50
GALC	18.5	22.5	40.18	21.1	23.6	43.16
H03H*	8.2	18.5	-15.04	10.5	18.9	-12.92
HALC	12.2	21.5	-5.50	14.6	22.4	-5.25
HCHV	8.7	17.6	-4.01	11.6	18.8	-1.06
HCQA	32.3	32.5	35.49	33.5	33.5	37.71
HNWA	7.3	19.3	-0.90	10.3	20.1	1.29
HOEA	9.8	19.9	-11.65	11.5	20.3	-10.55
HROC	17.2	23.3	20.88	18.0	23.3	21.48
HSMA	16.9	21.9	12.28	18.7	22.8	12.65
HTCA	15.7	22.1	28.25	16.9	22.6	28.88
LYNF	4.8	16.7	-5.38	7.3	17.8	-3.51
MACP	10.5	17.9	26.69	12.1	17.5	29.68
MSTG*	17.1	23.5	26.72	19.6	24.6	28.66
SBFP	17.5	22.6	-4.60	20.0	23.5	-3.43
SHWH	14.5	22.1	0.47	15.8	22.3	2.02
TXCT*	12.0	21.2	18.62	14.1	20.8	20.09
WALV*	8.5	15.9	5.98	11.8	17.3	10.01

*Non regulatory, industry-sponsored monitor

3.2.2 Time Series for Selected Monitors

For the AQS-1 (August 15 to September 14, 2006) episode time series of ozone and NO_X observed and modeled (Reg10si and Reg11si_MVS base cases) hourly average concentrations are shown for three significant sites: BAYP (CAMS 0053), DRPK (CAMS 0035), and WALV (CAMS 0617).

Figure 17: *Time Series Plots of Ozone and NO_X Concentrations at Bayland Park for the AQS-1 Episode* shows time series of ozone and NO_X at BAYP (CAMS 0053), with the Reg10si modeled concentrations shown as a continuous green line and the Reg11si_MVS modeled concentrations shown as a continuous blue line. Monitored concentrations are shown as solid red squares. In the top series, it is seen that there are relatively minor differences in modeled ozone concentrations between Reg10si and Reg11si_MVS. As with the June 2006 episode, the two are indistinguishable for much of the graph. The Reg11si_MVS episode produces moderately lower peaks on August 29 and 31 and somewhat increases the modeled peak ozone concentration on September 3. In the lower series, it is seen that NO_X concentrations for the Reg11si_MVS are higher than those for the Reg10si base, especially for the morning peak hours. This leads to better agreement with monitored NO_X concentrations on days with high observed peaks, notably

August 21 and 31, September 7 to 9, and September 14, but the Reg11si_MVS base exacerbates the over-prediction of many smaller peaks such as August 15 to 18 and on September 1, 5, and 6.

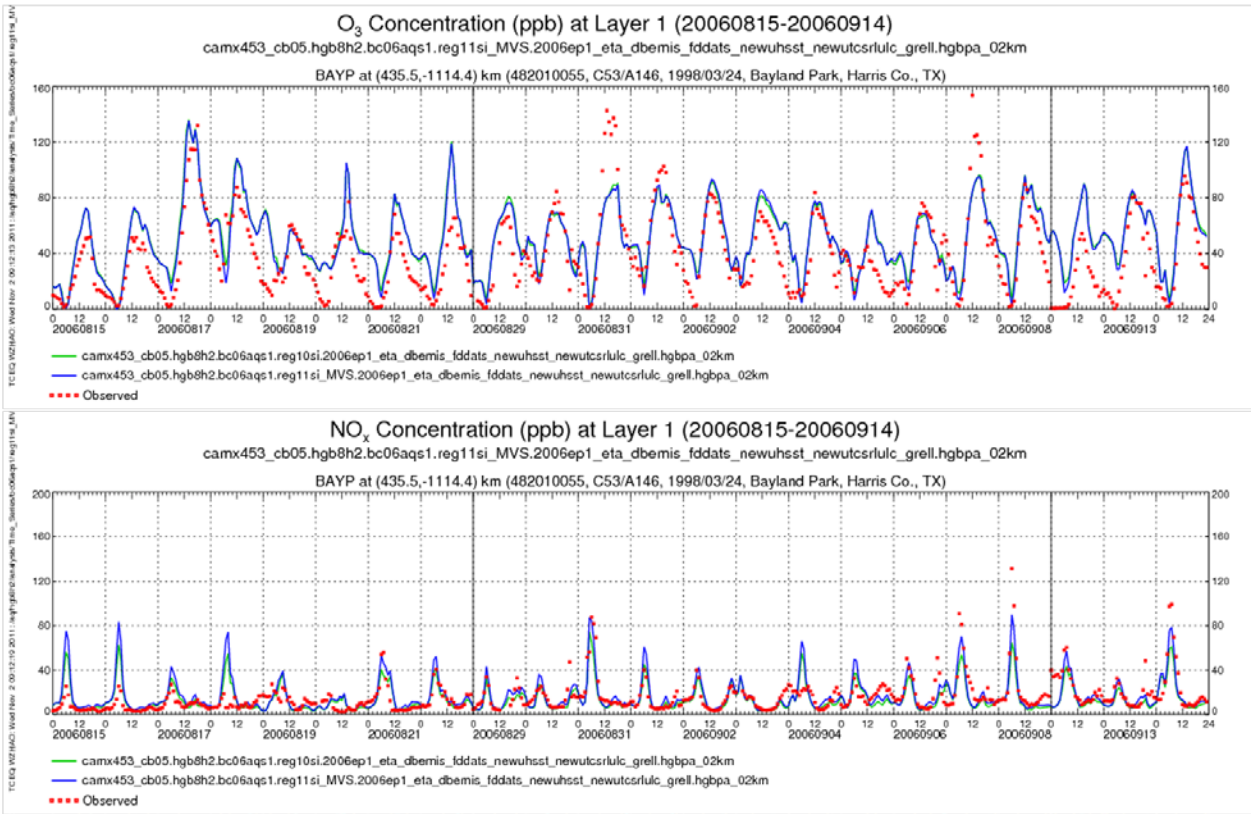

Figure 17: Time Series Plots of Ozone and NO_X Concentrations at Bayland Park for the AQS-1 Episode

Figure 18: *Time Series Plots of Ozone and NO_X Concentrations at Deer Park for the AQS-1 Episode* is similar to Figure 17 but is for DRPK (CAMS 0035). For this episode, DRPK (CAMS 0035) saw a modest increase in modeled ozone concentrations with Reg11si_MVS that lasted for multiple hours, especially from August 31 through the end of the episode. Because these multi-hour increases occurred near the peak, the effect on modeled eight-hour concentrations is significant. The lower graph shows only minimal differences in modeled NO_X concentrations since most of the local NO_X emissions near DRPK (CAMS 0035) are from industrial, not mobile, sources.

At first glance, it seems anomalous that ozone concentrations at DRPK (CAMS 0035) change noticeably in this episode while NO_X concentrations barely changed at all from one base case to the next. The explanation lies in the basic nature of NO_X, which is directly emitted, and ozone, which is formed in the atmosphere. The ozone measured at DRPK (CAMS 0035) was created from emissions from sources at some distance from the site, not from the more local NO_X emissions. But while local NO_X emissions do not create ozone locally (except under very calm conditions), fresh NO_X emissions can rapidly titrate (react with) ozone to reduce ozone in the immediate vicinity of the NO_X sources. This effect is seen at BAYP (CAMS 0053), where NO_X concentrations increased significantly from Reg10si to Reg11si_MVS yet peak ozone concentrations decreased for some days.

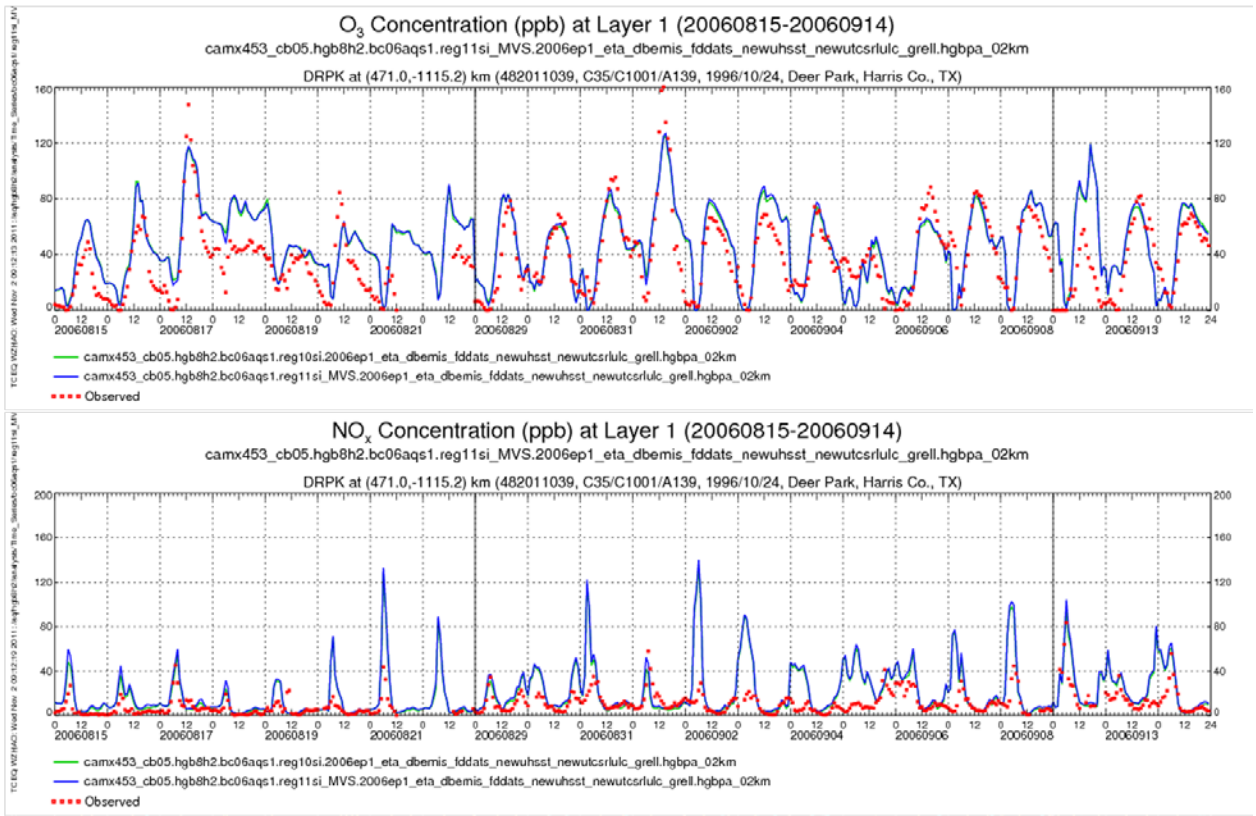

Figure 18: Time Series Plots of Ozone and NO_X Concentrations at Deer Park for the AQS-1 Episode

Figure 19: *Time Series Plots of Ozone and NO_X Concentrations at Wallisville for the AQS-1 Episode* shows that Reg11si_MVS moderately increased ozone concentrations for several hours on most modeled days, leading to increased eight-hour daily peak concentrations. Because roughly half the days in this episode were under-predicted with the Reg10si base case, the overall increase in daytime ozone concentrations improved performance in about half the cases, while increasing over-prediction in the remainder. Only small differences in NO_X concentrations were seen except for a few hours, but generally both modeled and measured NO_X concentrations at WALV (CAMS 0617) were fairly small.

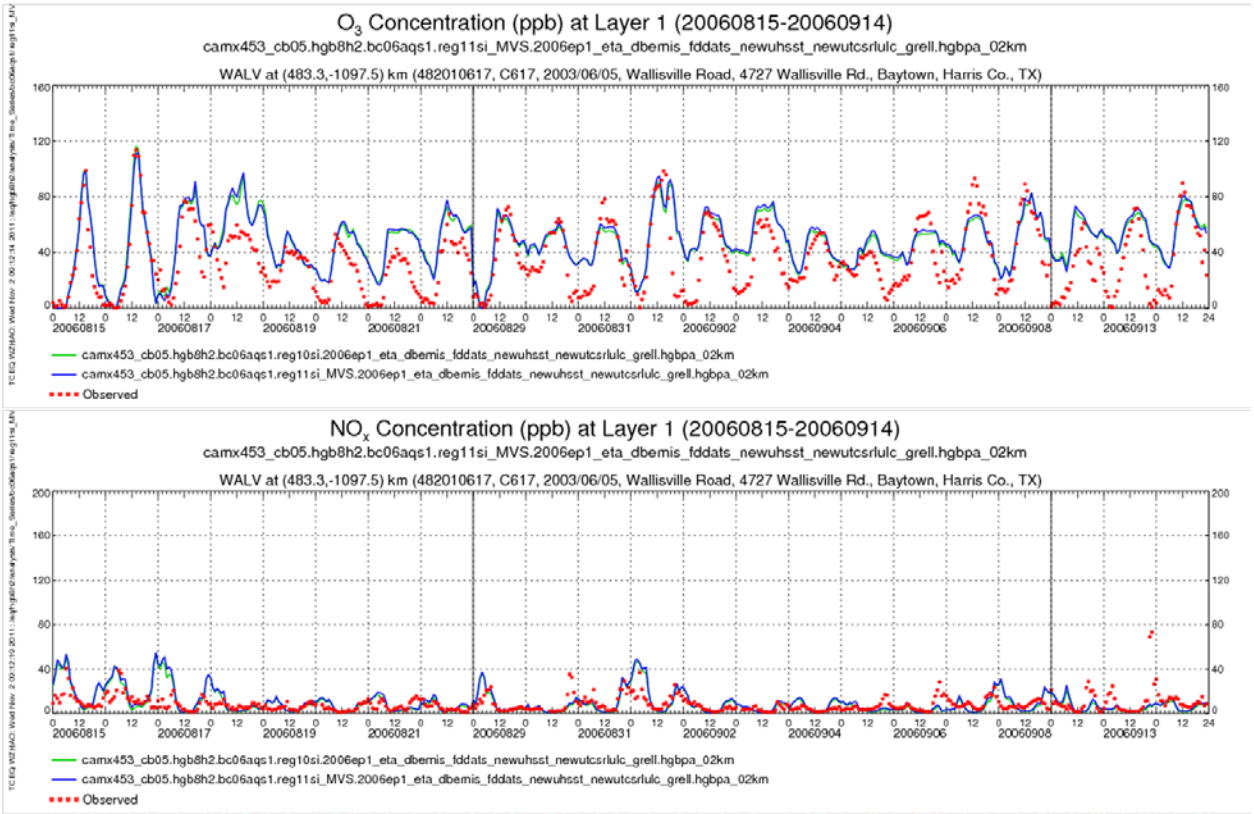

Figure 19: Time Series Plots of Ozone and NO_X Concentrations at Wallisville for the AQS-1 Episode

3.2.3 Peak Daily Maximum Eight-Hour Ozone Tile Plots For Selected Days

Figure 20: *Maximum Modeled Daily Eight-Hour Ozone Concentrations on August 17 and 31, 2006* and Figure 21: *Maximum Modeled Daily Eight-Hour Ozone Concentrations on September 1 and 7, 2006* show the four episode days with the highest and most pervasive daily maximum eight-hour ozone concentrations. Modeled eight-hour ozone concentrations are shown for each grid cell in the 2 km domain as well as the measured daily maximum ozone concentrations for each monitor for the Reg10si and Reg11si_MVS modeling scenarios. Also shown for each day is a plot of the difference of the daily maximum eight-hour ozone from each run.

On August 17, 2006, both model runs replicate the areas of high ozone located along the borders of Harris County with Fort Bend and Brazoria Counties very well, but they overestimated the daily maximum eight-hour ozone concentrations there and throughout most of the 2km domain. In Montgomery and northern Harris Counties, where both modeling scenarios under-predict the peak eight-hour ozone concentrations, the Reg11si_MVS scenario did better than Reg10si. The difference plot shows an area of peak ozone decreases in southeastern Harris County due to the increased NO_X emissions from MOVES2010a. Much of the rest of the domain shows increases of 0 to 4 ppb.

On August 31, 2006, the highest eight-hour concentration of 127.1 ppb for all episode days was observed. Both modeling scenarios underestimated the daily maximum eight-hour ozone concentrations and displaced the highest concentrations southwest of Harris County in Fort Bend County. The Reg11si_MVS scenario's peak of 96.0 ppb was higher than Reg10si, though still 30 ppb less than the observed. Peak concentrations at monitors away from western Harris

County were slightly better with Reg11si_MVS than Reg10si. Similar to other days, the difference plot shows regional increases in ozone and a small area of peak ozone decreases near the center of Houston, both due to increased NO_X emissions with MOVES2010a.

On September 1, 2006, both modeling scenarios show the highest modeled daily maximum eight-hour ozone concentrations to be located in the southeastern portion of Harris County, coincident with the highest measured daily maximum eight-hour ozone concentrations. The model underestimated the peak concentrations and the aerial extent of the higher observed concentrations. The Reg11si_MVS scenario predicted a peak of 108.3 ppb compared to the Reg10si scenario of 106.8 ppb, both of which were significantly less than the 121.8 ppb observed at DRPK (CAMS 0035). The Reg11si_MVS scenario predicted slightly higher regional ozone concentrations, which matched the limited observations better than the Reg10si scenario. The only areas where Reg11si_MVS concentrations were lower than those of Reg10si aligned with short segments of major freeways. This was due to increased NO_X emissions with MOVES2010a.

On September 7, 2006, the modeling scenarios show the modeled daily maximum eight-hour ozone concentrations to be located southwest of Harris County in Fort Bend County, with somewhat lower than measured daily maximum eight-hour ozone concentrations within Harris County. The peak measured daily maximum eight-hour ozone concentration was 110.5 ppb at BAYP (CAMS 0053), and the modeled daily maximum eight-hour ozone concentrations for both scenarios were less than 100 ppb, with Reg10si (94.8 ppb) being slightly less than Reg11si_MVS (96.1 ppb). Again, the Reg11si_MVS scenario predicts slightly higher ozone concentrations on the perimeter of the urban area (also shown in the difference plot), which matches the observations better than the Reg10si scenario. A small area to the southwest of the urban core and a fairly large swath of the Gulf east of Point Bolivar showed a slight reduction using Reg11si_MVS.

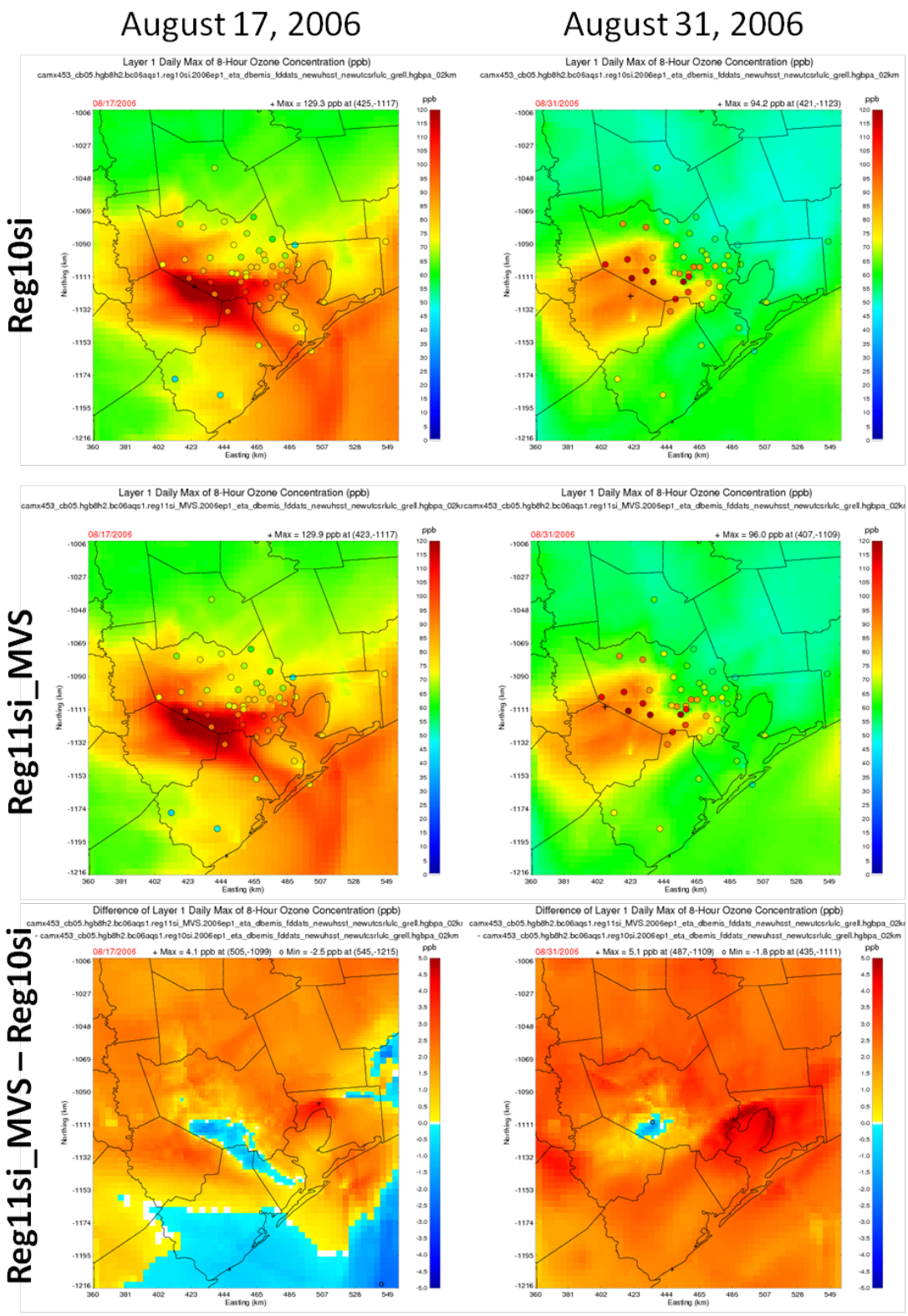

Figure 20: Maximum Modeled Daily Eight-Hour Ozone Concentrations on August 17 and 31, 2006

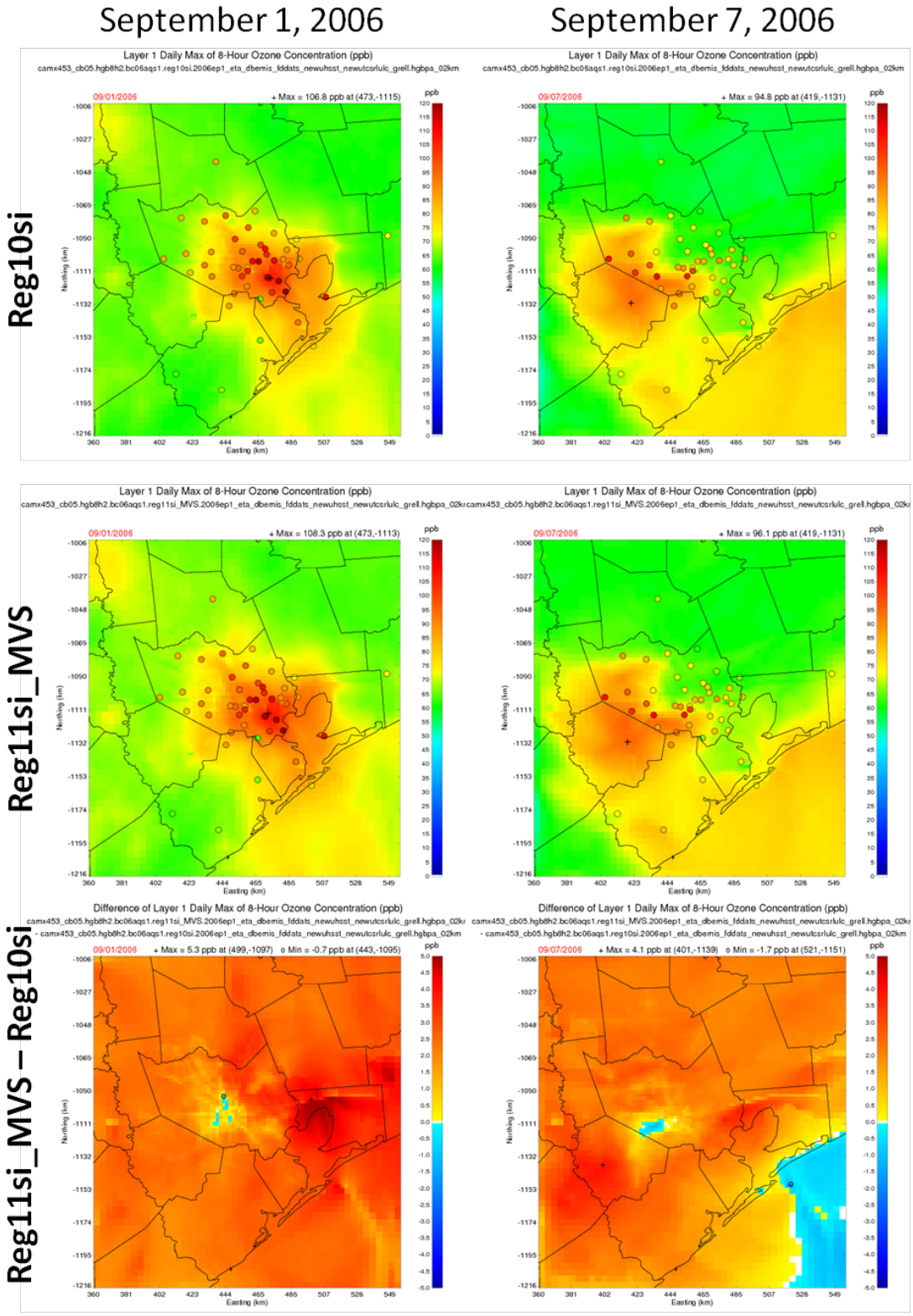

Figure 21: Maximum Modeled Daily Eight-Hour Ozone Concentrations on September 1 and 7, 2006

3.3 AQS-2 Episode (bc06aqs2) Detailed Model Performance Evaluation

This section provides an in-depth analysis of model performance for the September 19 to October 11, 2006 (bc06aqs2) episode. This episode occurred during the second part of the TexAQS II intensive period and is treated separately from the first part (episode bc06aqs1) because it occurs after the end of the special hourly emissions inventory. The episode is composed of three distinct consecutive day periods: September 19 to 20; September 25 to 27; and October 3 to 11, 2006.

3.3.1 Statistical Measures

Figure 22: *Chart of Measured versus Modeled Peak Eight-Hour Ozone Concentrations for the September/October 2006 Episode* compares the measured and modeled peak eight-hour ozone concentrations for each episode day for the base case modeling scenarios: Reg10, which used MOBILE6.2, and Reg11_MVS, which used MOVES2010a. The error bars (+/-20%) show the UPA for measured peak eight-hour ozone concentrations for the September/October 2006 episode (bc06aqs2). The peak modeled eight-hour ozone concentrations for the Reg10 and Reg11_MVS scenarios are nearly equal for all days of the episode. In the first period of the episode, there is only one day (September 20, 2006) with a peak measured eight-hour ozone concentration greater than 84 ppb, and although both Reg10 and Reg11_MVS under-predict, the modeled eight-hour ozone concentration for both scenarios is within +/-20% of the measured peak. For the two days of the second period, for which the peak measured eight-hour ozone concentration is greater than 84 ppb, again both Reg10 and Reg11_MVS under-predicted the measured peak ozone concentration, but the modeled eight-hour ozone concentration for both scenarios is within +/-20%. During the nine days of the third period, only three days had peak measured eight-hour ozone concentrations greater than 84 ppb. For each of these three days, both the Reg10 and Reg11_MVS modeling scenarios predicted peak modeled eight-hour ozone concentrations comparable to the measured peaks.

Figure 23: *Soccer-style Plot of Daily Maximum Eight-Hour MNGE and MNB for the September/October 2006 Episode by Day* shows the MNGE and MNB statistics for paired-modeled and measured daily maximum eight-hour ozone concentrations for the Reg10 and Reg11_MVS modeling scenarios. The date labels are for the Reg10 scenario, and for this episode the data points were dispersed enough that all days could be labeled. For this episode, half (seven) of the days had bias greater than 15% while the other half remained in the green box for both modeling scenarios.

Figure 24: *Soccer-style Plot of Eight-Hour MNGE and MNB for the September/October 2006 Episode by Site* shows the MNGE and MNB statistics for paired modeled and measured eight-hour peak ozone concentrations for the Reg10 and Reg11_MVS modeling scenarios. For this episode, six sites had large enough bias' to be outside the right side of the green box (bias > 15%) for both Reg10 and Reg11_MVS, with only one site (HCQA (CAMS 0409)) exceeding 20% bias.

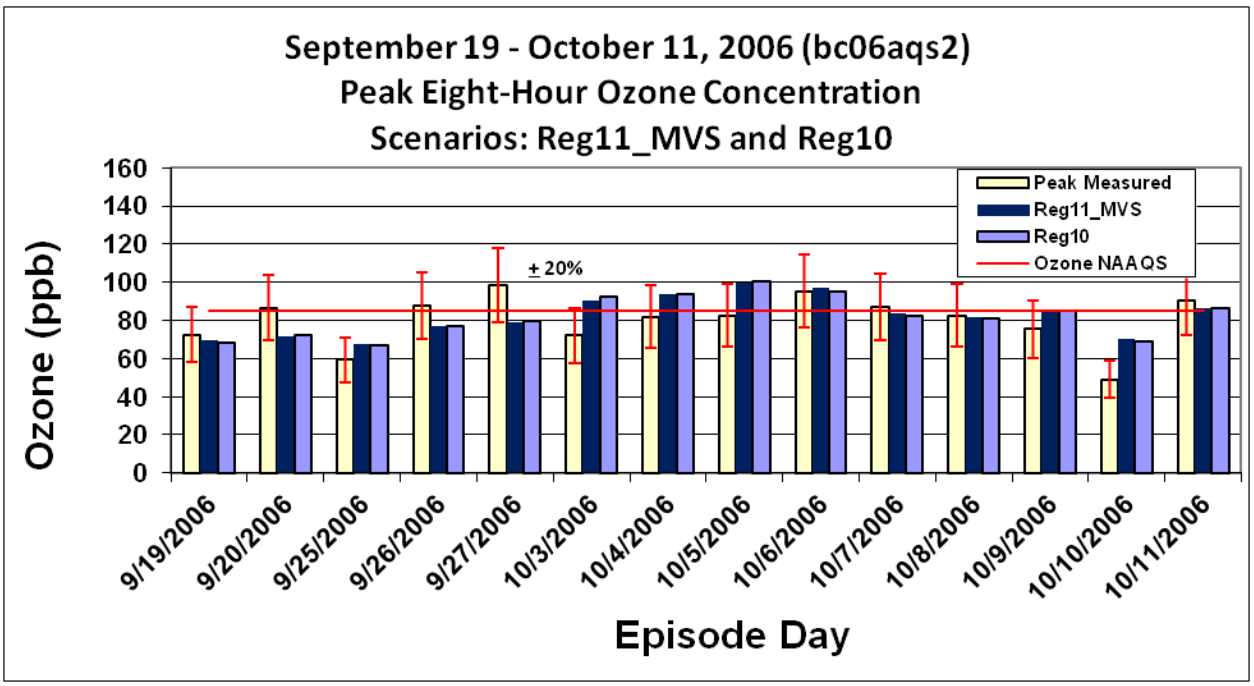

Figure 22: Chart of Measured versus Modeled Peak Eight-Hour Ozone Concentrations for the September/October 2006 Episode

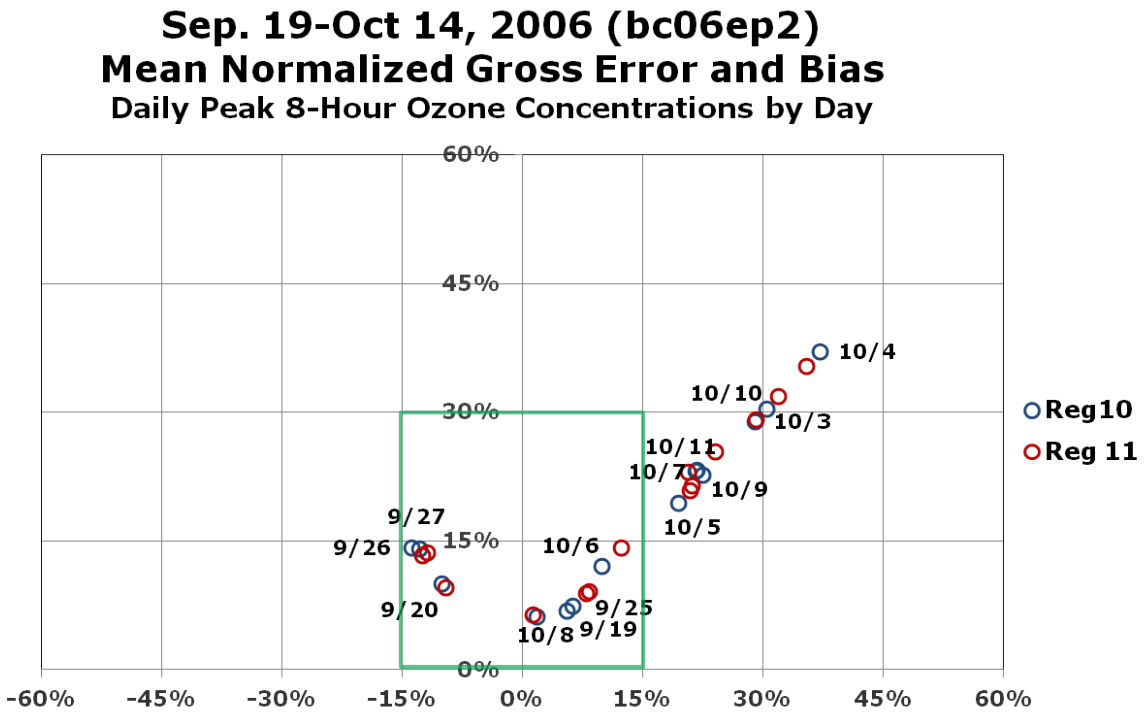

Figure 23: Soccer-style Plot of Daily Maximum Eight-Hour MNGE and MNB for the September/October 2006 Episode by Day

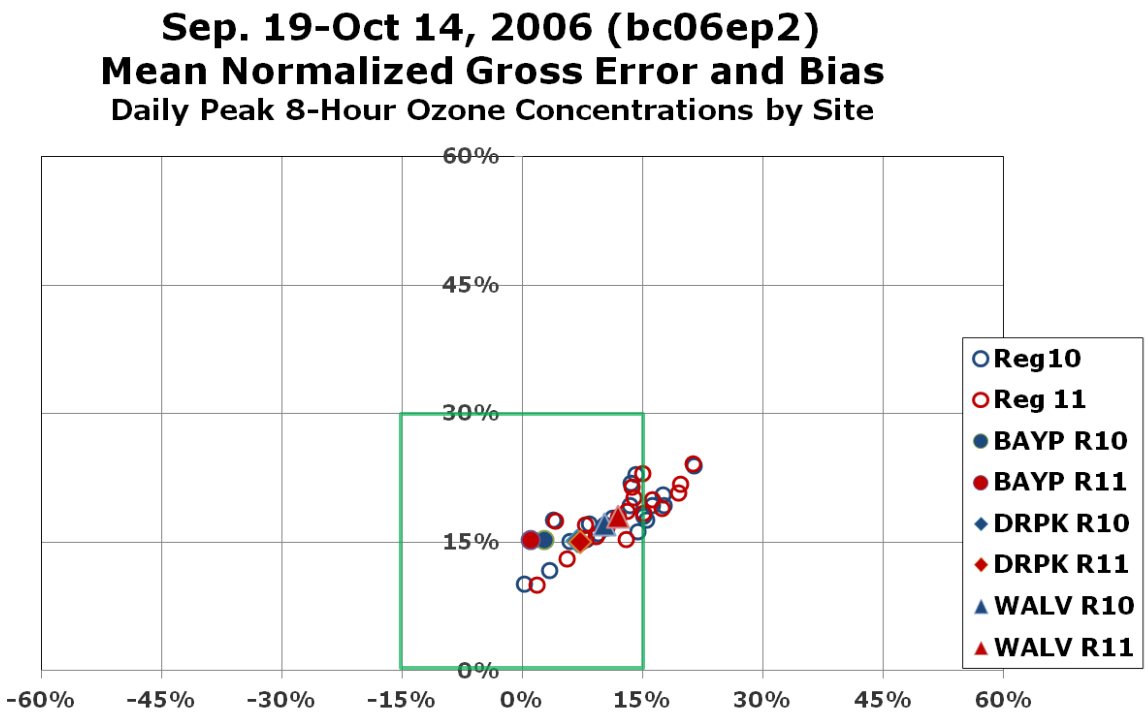

Figure 24: Soccer-style Plot of Eight-Hour MNGE and MNB for the September/October 2006 Episode by Site

Table 5: *September/October 2006 Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10 and Reg11_MVS Modeling Scenarios by Day* summarizes the daily maximum eight-hour ozone concentration statistics (i.e., MNB, MNGE, UPA) by episode day for all monitors for the Reg10 and Reg11_MVS modeling scenarios. The MNB and MNGE values are those plotted in Figure 23, and the UPA values correspond to the percent difference between the modeled and measured peak daily maximum eight-hour ozone concentrations, which are those plotted in Figure 22.

Table 6: *September/October 2006 Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10 and Reg11_MVS Modeling Scenarios by Site* summarizes the daily maximum eight-hour ozone concentration statistics (i.e., MNB, MNGE, UPA) by monitor for all episode days for the Reg10 and Reg11_MVS modeling scenarios for all data pairs with measured peak eight-hour ozone concentrations greater than 40 ppb. The MNB and MNGE values are those plotted in Figure 24 for the Reg10 and Reg11_MVS modeling scenarios. The UPA indicates the percentage by which the modeled peak eight-hour ozone concentrations over- (+) or under- (-) predicted the measured peak eight-hour ozone concentrations at each monitor.

Table 5: September/October 2006 Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10 and Reg11_MVS Modeling Scenarios by Day

Episode Day	Reg10 MNB (%)	Reg10 MNGE (%)	Reg10 UPA (%)	Reg11_MVS MNB (%)	Reg11_MVS MNGE (%)	Reg11_MVS UPA (%)
9/19/2006	5.5	6.9	-6.1	8.3	9.2	-3.8
9/20/2006	-10.1	10.1	-16.6	-9.6	9.6	-17.0
9/25/2006	6.2	7.5	12.9	7.9	9.0	14.4
9/26/2006	-13.8	14.2	-12.4	-12.4	13.3	-12.0
9/27/2006	-12.8	14.1	-18.7	-11.9	13.6	-19.7
10/3/2006	29.0	29.0	28.1	29.2	29.2	25.4
10/4/2006	37.1	37.1	14.4	35.4	35.4	14.1
10/5/2006	19.5	19.5	21.9	20.9	20.9	21.2
10/6/2006	9.9	12.1	0.0	12.3	14.2	1.7
10/7/2006	21.7	23.3	-5.1	24.0	25.5	-3.8
10/8/2006	1.8	6.3	-2.0	1.3	6.4	-0.8
10/9/2006	22.4	22.7	12.9	21.2	21.5	13.3
10/10/2006	30.4	30.4	40.4	31.9	31.9	44.2
10/11/2006	21.6	23.2	-4.7	20.7	23.1	-4.6

Table 6: September/October 2006 Daily Maximum Eight-Hour Ozone Statistical Measures for the Reg10 and Reg11_MVS Modeling Scenarios by Site

Monitor Code	Reg10 MNB (%)	Reg10 MNGE (%)	Reg10 UPA (%)	Reg11_MVS MNB (%)	Reg11_MVS MNGE (%)	Reg11_MVS UPA (%)
BAYP	2.7	15.3	13.58	1.0	15.3	15.30
C35C	17.5	20.6	34.85	19.7	21.9	36.65
CNR2	3.4	11.8	-19.47	5.5	13.1	-20.03
DRPK	6.9	15.1	11.19	7.2	15.1	15.15
GALC	13.4	19.3	12.09	13.9	20.2	14.68
H03H*	7.9	15.4	11.09	9.2	15.7	13.19
HALC	9.4	16.0	8.43	10.5	16.8	9.82
HCHV	11.2	17.9	12.37	13.1	18.7	15.64
HCQA	21.4	23.9	24.60	21.2	24.1	26.87
HNWA	0.2	10.1	3.26	1.8	10.0	2.34
HOEA	14.2	22.9	7.43	14.9	23.1	9.46
HROC	16.1	19.4	14.63	15.1	18.5	15.56
HSMA	13.5	22.0	7.61	13.7	21.5	10.12
HTCA	14.4	16.3	19.74	12.9	15.4	22.25
LYNF	5.9	15.2	1.14	7.9	15.5	4.16
MACP	3.8	17.6	-7.75	4.1	17.5	-6.68
MSTG*	17.6	19.4	24.13	19.4	20.8	26.54
SBFP	15.5	17.6	28.66	17.3	19.0	33.63

Monitor Code	Reg10 MNB (%)	Reg10 MNGE (%)	Reg10 UPA (%)	Reg11_MVS MNB (%)	Reg11_MVS MNGE (%)	Reg11_MVS UPA (%)
SHWH	8.3	17.2	3.45	7.8	17.0	5.42
TXCT*	15.0	18.1	20.95	16.1	20.0	24.88
WALV*	10.2	17.1	14.60	12.0	17.9	19.42

*Non regulatory, industry-sponsored monitor

3.3.2 Time Series for Selected Monitors

For the AQS-2 (September 19 - October 11, 2006) episode time series of ozone and NO_X, observed and modeled (Reg10 and Reg11_MVS base cases) hourly average concentrations are shown for three significant sites: BAYP (CAMS 0053), DRPK (CAMS 0035), and WALV (CAMS 0617).

Figure 25: *Time Series Plots of Ozone and NO_X Concentrations at Bayland Park for the AQS-2 Episode* shows time series of ozone and NO_X at BAYP (CAMS 0053) with the Reg10 modeled concentrations shown as a continuous green line and the Reg11_MVS modeled concentrations shown as a continuous blue line. Monitored concentrations are shown as solid red squares. As for the two preceding episodes, modeled concentrations for Reg11_MVS are mostly the same or lower than those seen for Reg10, although on October 7 the Reg11_MVS concentrations noticeably exceeded those of Reg10 for a few peak hours. In the bottom series, the increase in NO_X concentrations with Reg11_MVS is very evident, exacerbating over-prediction in some cases, but improving NO_X performance in others, most notably on October 3 and 4 and in the twin evening and morning peaks seen on the night of October 5 to 6.

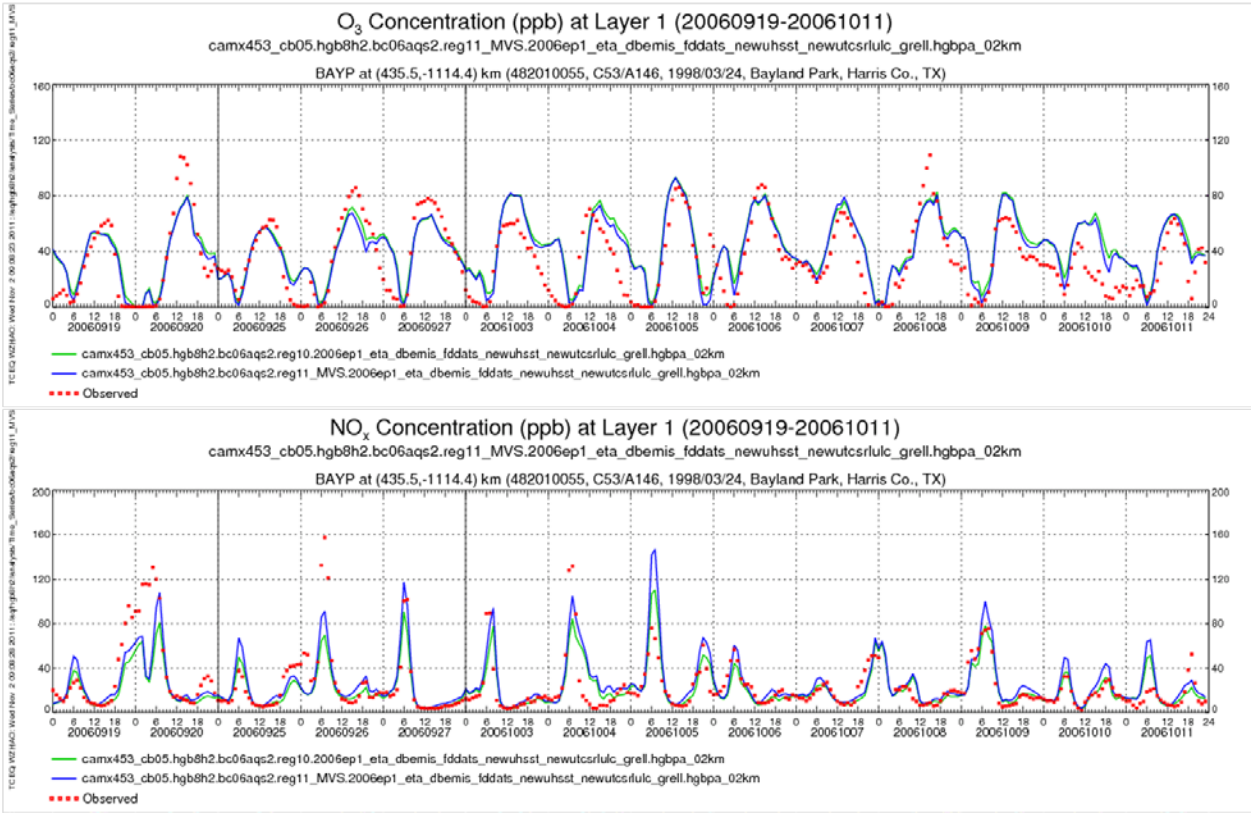

Figure 25: Time Series Plots of Ozone and NO_X Concentrations at Bayland Park for the AQS-2 Episode

Figure 26: *Time Series Plots of Ozone and NO_X Concentrations at Deer Park for the AQS-2 Episode* shows small differences in modeled ozone concentrations between the two base cases, with slight increases in the ozone peak concentrations on September 27 and October 7 and a slightly lower peak on October 11. On several days in the episode, the Reg11_MVS concentrations in the evening hours were below those seen with Reg10. As with the other episodes, the difference in NO_X concentrations between the two base cases was much smaller than that seen at BAYP (CAMS 0053), but perceptible increases were seen on several occasions, especially on October 3 to 5 and October 11.

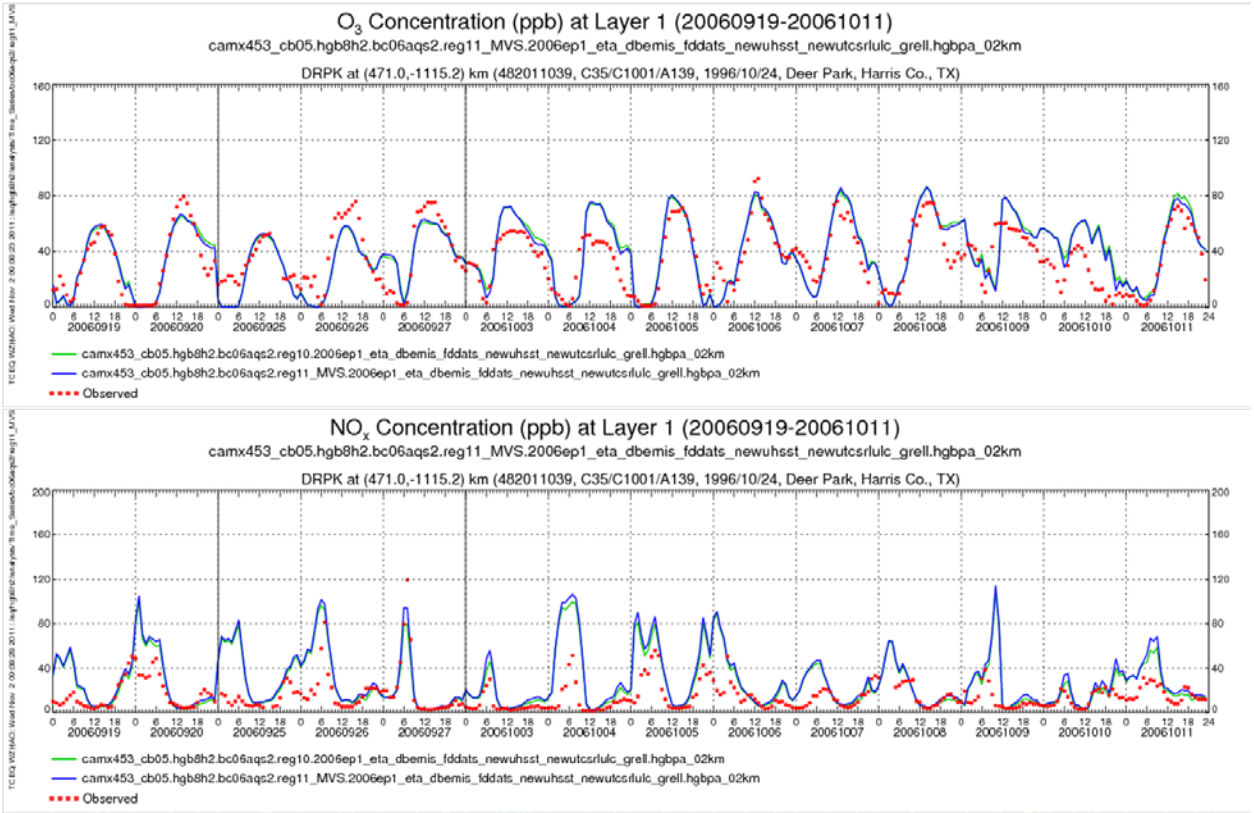

Figure 26: Time Series Plots of Ozone and NO_X Concentrations at Deer Park for the AQS-2 Episode

Figure 27: *Time Series Plots of Ozone and NO_X Concentrations at Wallisville for the AQS-2 Episode* shows modestly increased peak ozone concentrations on September 26 and on October 5 to 7, but performance was improved by these increases on only the first of these days. Some small decreases in ozone concentrations were seen during off-peak hours on several days, owing to additional ozone removal via NO_X titration. NO_X concentrations increased overall, but both modeled and measured concentrations were fairly low to begin with.

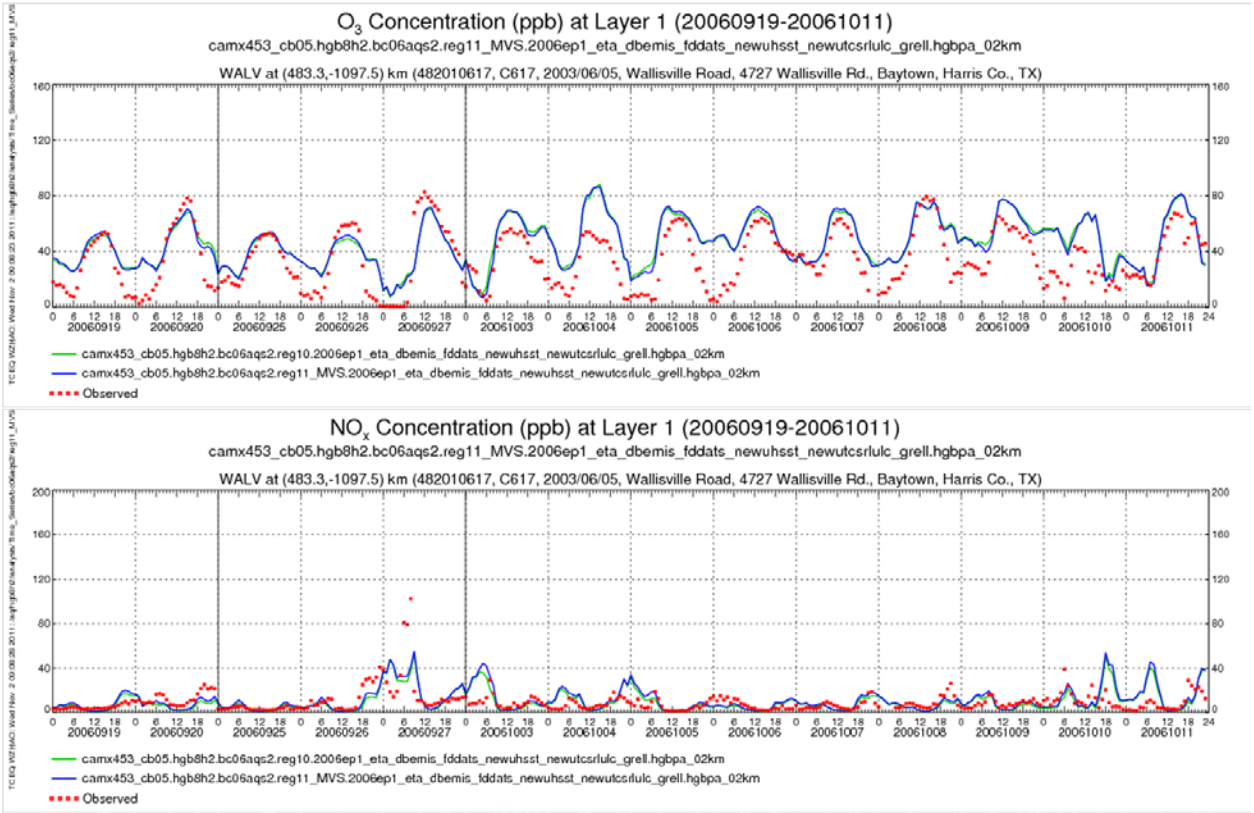

Figure 27: Time Series Plots of Ozone and NO_X Concentrations at Wallisville for the AQS-2 Episode

3.3.3 Peak Daily Maximum Eight-Hour Ozone Tile Plots for Selected Days

Figure 28: *Maximum Modeled Daily Eight-Hour Ozone Concentrations on September 20 and 27, 2006* and Figure 29: *Maximum Modeled Daily Eight-Hour Ozone Concentrations on October 6 and 11, 2006* show daily maximum eight-hour ozone concentrations for the four episode days with the highest and most pervasive daily maximum eight-hour ozone concentrations. Modeled eight-hour ozone concentrations are shown for each grid cell in the 2 km domain as well as the measured daily maximum ozone concentrations for each monitor (including non-regulatory monitors) for the Reg10 and Reg11_MVS model scenarios. Also shown for each day is a plot of the difference of the daily peak eight-hour ozone from each scenario.

On September 20, 2006, the highest observed daily maximum eight-hour ozone concentration of 87.7 ppb occurred at BAYP (CAMS 0053), west of downtown Houston. Figure 28 shows that monitors along a relatively narrow band stretching from the Houston Ship Channel area across southern Harris County measured moderately high daily maximum eight-hour ozone concentrations (above 70 ppb). A few monitors in other areas also measured ozone concentrations above 70 ppb, including monitors in northern and western Brazoria County, eastern Jefferson County, and near the Harris/Chambers county line. Both modeling scenarios produced moderately high ozone concentrations in western Harris County and westward into Liberty and Waller Counties, as well as in western Jefferson County. However, neither of the modeling scenarios matched either the magnitude or spatial extent of the observed ozone concentrations. The Reg10 scenario predicted a peak of 72.3 ppb while the Reg11_MVS scenario predicted 71.9 ppb just west of the Waller County line. Some subtle differences between the

modeling scenarios can be noted, but both were unable to reproduce the highest ozone concentrations seen on this day. The difference plot shows that Reg11_MVS decreased peak ozone over southwestern Harris and northern Fort Bend Counties where the highest ozone was observed, as well as across Galveston Bay and the part of the Gulf of Mexico in the 2 km domain.

Both modeling scenarios performed slightly better on September 27, 2006, than on September 20, but they still under-predicted the widespread high ozone concentrations (greater than 80 ppb) measured across most of Harris and Montgomery counties. Both modeling scenarios produced the highest daily maximum eight-hour ozone concentrations at the northern boundary of the 2 km grid, each simulating the daily maximum eight-hour ozone concentration measured at Conroe (CNR2, CAMS 0078) reasonably well. However, both model scenarios notably under-predicted peak daily maximum ozone concentrations everywhere south of the Montgomery-Harris County line. Again, the Reg11_MVS scenario reduced peak ozone at the highest observations while increasing regional ozone.

On October 6, 2006, performance was good for both the Reg10 and Reg11_MVS modeling scenarios, with ozone produced in the correct locations at about the correct levels. However, both scenarios under-predicted the highest observed daily maximum eight-hour ozone concentrations measured near the Harris/Brazoria county line (95.3 ppb at TOMB (CAMS 0558), a non-regulatory monitor), but produced comparable ozone concentrations (over 90 ppb) somewhat farther to the southwest in Brazoria County. The Reg11_MVS scenario did a better job predicting the observed peaks, both in magnitude and location, than the Reg10 scenario because of the regional increase in ozone concentrations (also shown in the difference plot).

On October 11, 2006, both modeling scenarios performed fairly well for the monitors near Galveston Bay, with the highest observed daily maximum eight-hour ozone concentrations (90.4 ppb at Anahuac (ANAH, CAMS 0096), a non-regulatory monitor). In addition, both model scenarios simulated the plume of high ozone that developed over Galveston Bay very well and only slightly under-predicted the magnitude of the highest daily maximum eight-hour ozone concentrations measured at the ANAH (CAMS 0096) and Texas City (TXCT, CAMS 0620) monitors near the Bay. However, the modeling scenarios over-predicted daily maximum eight-hour ozone concentrations in eastern Harris County. The difference plot shows that the Reg11_MVS scenario reduced peak ozone in southeastern Harris County where the over-prediction was greatest, but also reduced concentrations in Texas City and Galveston where the Reg10 scenario was already under-predicting the peaks. Both the Reg10 and Reg11_MVS scenarios simulated peak daily maximum eight-hour ozone concentrations (86.2 ppb and 86.3 ppb, respectively) close to the observed peak daily maximum eight-hour ozone concentration of 90.4 ppb at ANAH (CAMS 0096).

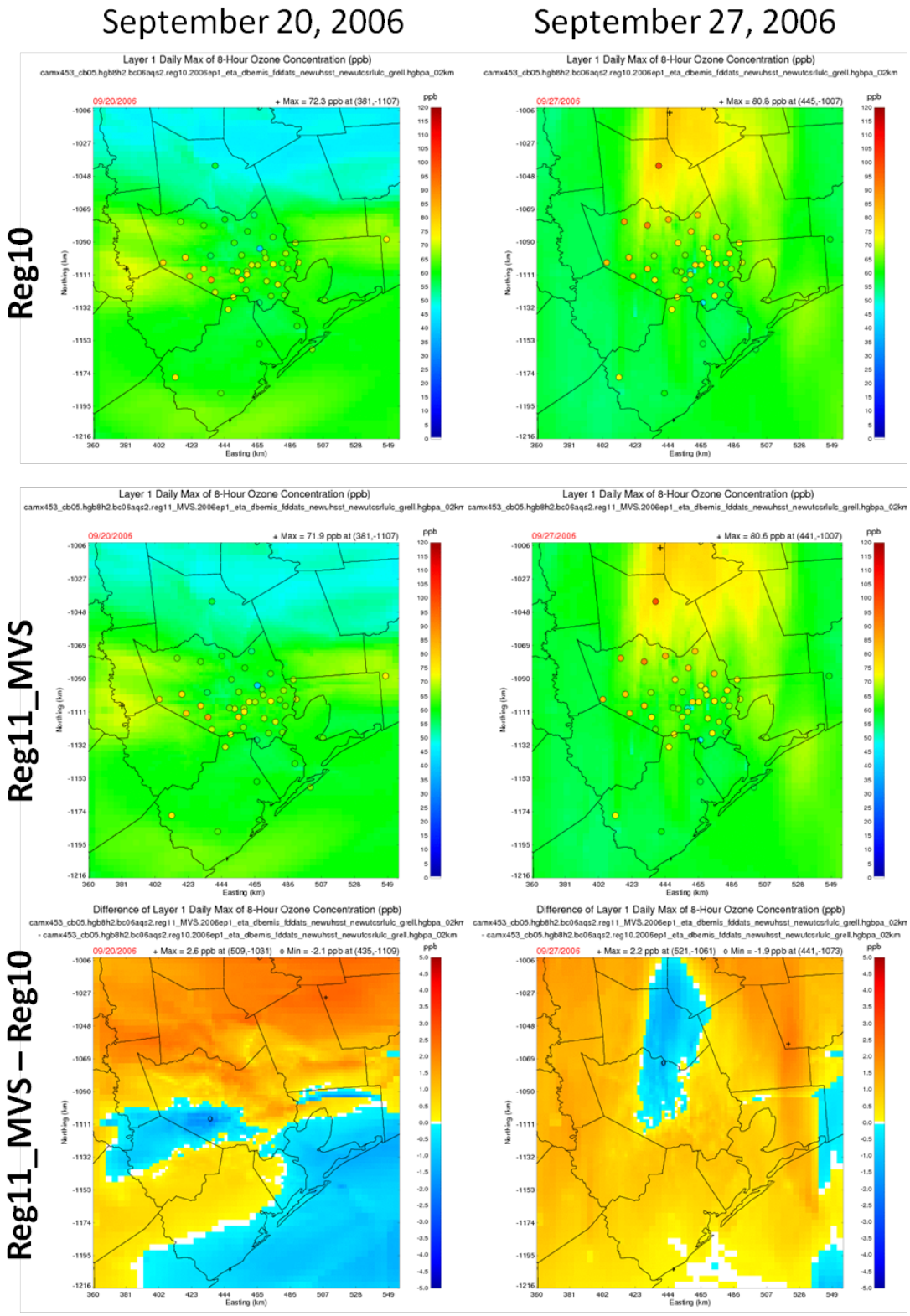

Figure 28: Maximum Modeled Daily Eight-Hour Ozone Concentrations on September 20 and 27, 2006

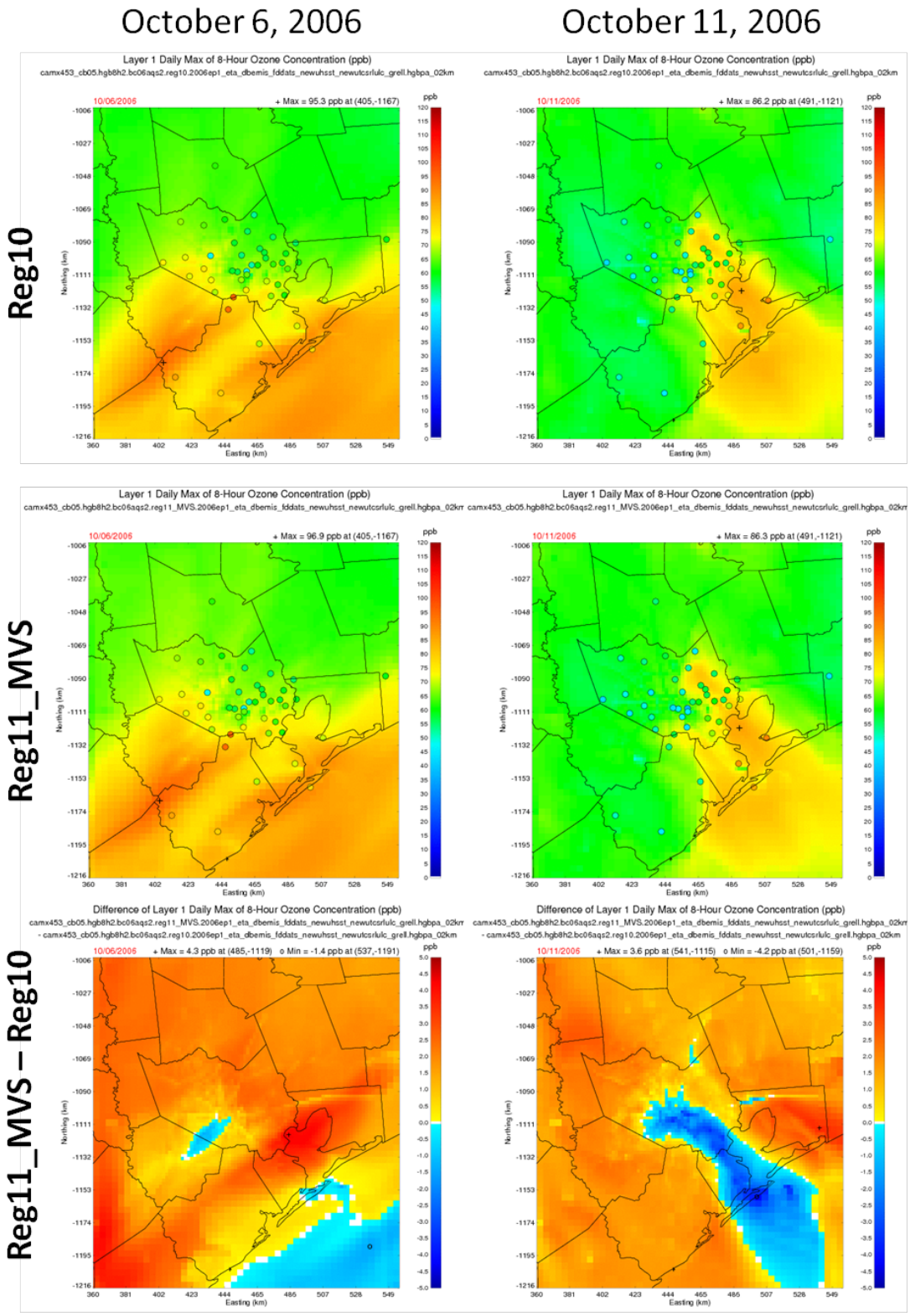

Figure 29: Maximum Modeled Daily Eight-Hour Ozone Concentrations on October 6 and 11, 2006

4 DYNAMIC MODEL PERFORMANCE EVALUATION

4.1 Weekday-Weekend Analysis

One of the ways to evaluate the model's responsiveness to emissions changes is to compare the relationship between weekday and weekend ozone concentrations as modeled with those measured. Chapter 3 of the 2010 HGB Ozone AD SIP Revision discusses the weekday-weekend analysis and shows that it indicates that the model is not as responsive to emission changes as the real atmosphere. In this section, we compare the model's responsiveness using the Reg11_MVS with that calculated using the Reg10 base case. While the analysis discussed here is conceptually similar to that reported in Chapter 3 of the 2010 HGB Ozone AD SIP Revision, there are some important differences that are the result of using improved methodologies.

First, weekday-weekend analysis modeling was conducted for the 2010 HGB AD SIP Revision using a series of runs wherein each episode day was modeled as a Wednesday, then as a Saturday, then as a Sunday (Wednesday is used to represent a typical weekday). This was done to increase the sample size of each day type by matching Wednesday emissions against the meteorology simulated for every episode day, and similarly for each Saturday and Sunday. But traffic patterns differ in magnitude and temporal patterns among the days of the week, so it is somewhat unrealistic to model a Saturday following another Saturday, or a Sunday following another Sunday since the carryover of pollutants from the previous day would be incorrect. So for the analysis described here, each sequence of three episode days was run as Friday to Saturday to Sunday, then as Saturday to Sunday to Friday, then as Sunday to Friday to Saturday. These patterns were repeated for all episode days so that each day was modeled as a Saturday or Sunday with the correct predecessor emissions, requiring a total of three runs for each episode. On the other hand, typical Wednesday emissions are almost identical to Tuesdays, so a single run of all Wednesdays was sufficient.

The second major difference from the analysis reported in the 2010 HGB AD SIP Revision (and mimicked in Chapter 3 of the current revision) is that quartiles were used to characterize the days instead of mean values. This was done for two reasons: first, the distributions of observed concentrations are non-normal, so mean values are not necessarily the best representations of central tendency; secondly, and more importantly, it allows us to characterize high ozone days without setting an arbitrary threshold as was done previously, thus avoiding the "rebound" effect discussed in Chapter 3 of both SIP revisions. For NO_X, 6 a.m. CST median concentrations simulated in the base case scenarios were compared with median observed NO_X concentrations from five ozone seasons (May 15 to October 15, 2005 through 2009). For ozone, however, the 98th percentile of the observed concentrations was used since that value is close to the fourth-highest annual value used to calculate a monitor's design value. The ozone episodes were selected since they represent periods of particularly high ozone, therefore the 98th percentile of the modeled values would not be comparable to that of the observed data, which contains many days which are not conducive for forming high ozone concentrations. Instead, the 90th percentile of the modeled concentrations was selected because the average across monitors of the 90th percentile is 82.0 ppb, near the average across the same monitors of the 98th percentile observed concentrations of 84.4 ppb.

Figure 30: *Median Observed and Modeled 6 a.m. NO_X Concentrations* shows median observed NO_X concentrations by day of week, along with modeled medians for the Reg10 and Reg11_MVS base cases, for fifteen monitoring locations in the HGB area. The figure shows that weekday values for Reg10 are roughly comparable to the observed values, with Reg11_MVS somewhat higher overall. Neither base case, however, reflects the sharp drop-off in median concentrations seen in the observations progressing from weekday (Wkd) to Saturday (Sat) to Sunday (Sun). The pattern is even clearer in Figure 31: *Median Observed and Modeled 6 a.m. NO_X*

Concentrations as a Percentage of Weekday Values in which each day's concentrations are shown as a percentage of weekday. In this figure, the observed Saturday and Sunday are seen to mostly cluster around 60% and 40%, respectively, of weekday values, while the Reg10 modeled values are spread fairly evenly between about 40% and 90% of weekday values on Saturday, and between 30% and 80% on Sunday, with the corresponding Reg11_MVS medians a few percent higher. While these patterns do not hold for every monitor, they do show a general tendency for the modeled NO_X concentrations to not decrease as sharply as the observations on weekend mornings.

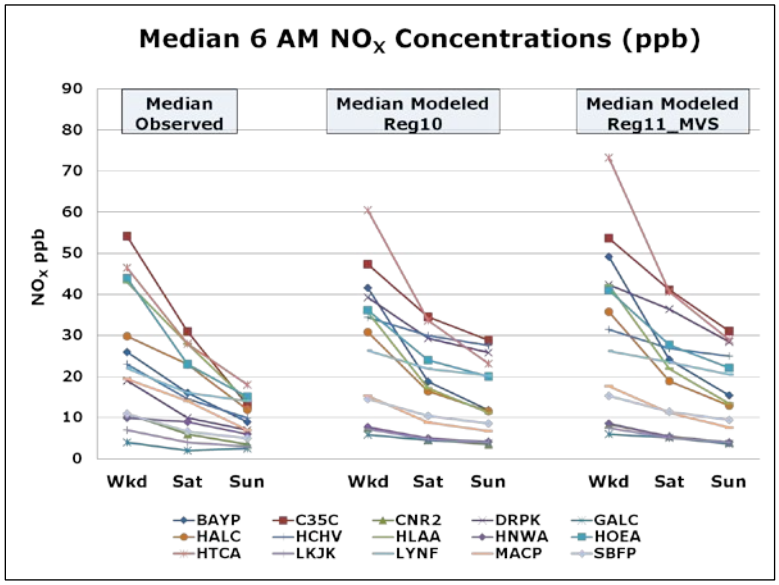

Figure 30: Median Observed and Modeled 6 a.m. NO_X Concentrations

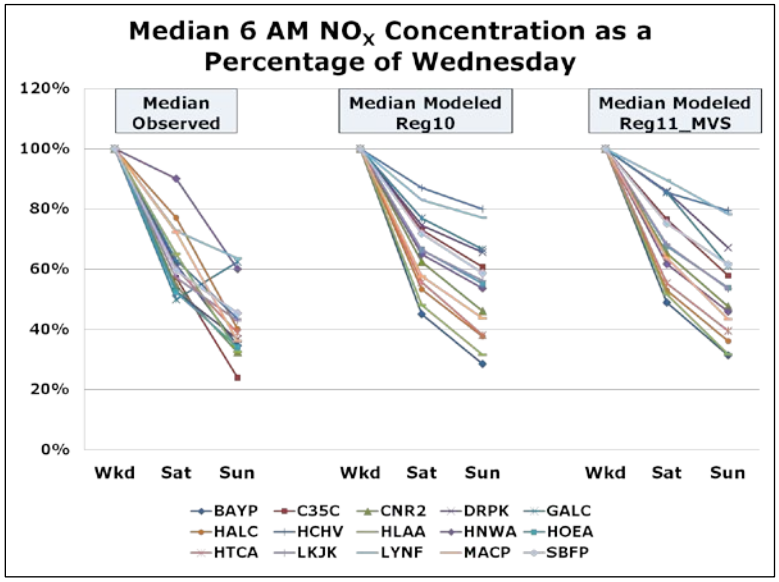

Figure 31: Median Observed and Modeled 6 a.m. NO_X Concentrations as a Percentage of Weekday Values

Figure 32: *98th Percentile Observed and 90th Percentile Modeled Peak Daily 8-Hour Average Ozone Concentrations* shows 98th percentile, observed ozone concentrations alongside 90th percentile, modeled ozone concentrations for weekday, Saturday, and Sunday. From the figure, it is immediately obvious that the observed 98th percentiles show a significant decline from weekday to Saturday, and many but not all decline further to Sunday. The most striking feature, however, is the large amount of variability seen in the observations. On the other hand, both modeling scenarios appear to be very well-behaved. This disparity in behavior is largely due to the fact that in the modeled cases, all day types were matched against the same set of meteorological days, while each observed day had its own unique meteorology.

Again, the picture becomes somewhat clearer when all the concentration values are scaled to weekday, as shown in Figure 33: *98th Percentile Observed and 90th Percentile Modeled Peak Daily 8-Hour Average Ozone Concentrations as a Percent of Weekday*. The observed 98th percentile concentrations drop between 88% and 98% of weekday values on Saturday but do not show a discernible change from Saturday to Sunday. The modeled concentrations, meanwhile, show a modest decrease from weekday to Saturday and show some additional decline to Sunday, but of a smaller magnitude than seen in the observations. Furthermore, the Reg11_MVS scenarios show the smallest declines, which indicates that the Reg11_MVS modeling is less responsive to emission changes than either Reg10 or the real atmosphere.

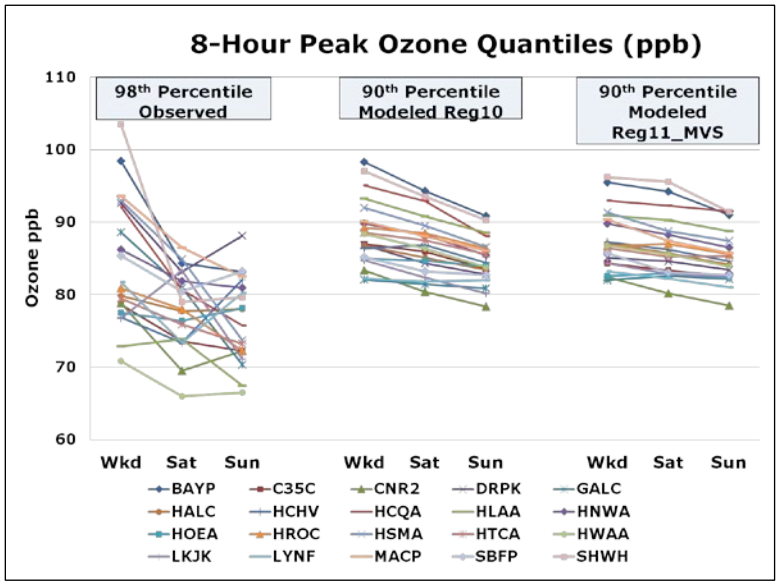

Figure 32: 98th Percentile Observed and 90th Percentile Modeled Peak Daily 8-Hour Average Ozone Concentrations

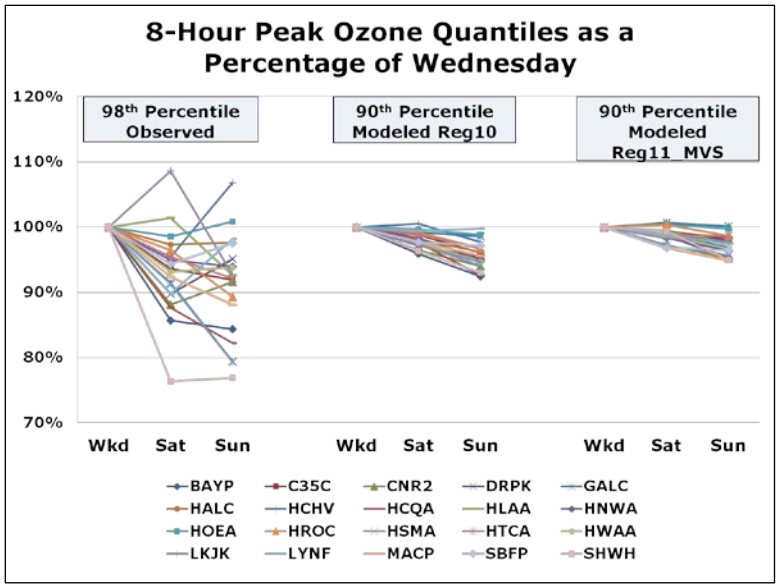

Figure 33: 98th Percentile Observed and 90th Percentile Modeled Peak Daily 8-Hour Average Ozone Concentrations as a Percent of Weekday

Of particular note is the behavior of BAYP (CAMS 0053), the site with the highest modeled 2018 future design value. The observed 98th percentile concentrations for this site are about 85% as high on weekends as on weekdays, but the 90th percentiles are about 96% and 92% (Sat and Sun, respectively) as high as weekday for Reg10 and about 98% and 95% (Sat and Sun, respectively) as high for Reg11_MVS (difficult to see on the graph). The fact that these values remain closer to unity than do the observed values indicates that for this important site the model is not responding to changes in NO_X emissions as well as the atmosphere, and using MOVES2010a (Reg11_MVS) makes the model even less responsive than did MOBILE6.2 (Reg10).

4.2 Retrospective Analysis

The second type of dynamic performance evaluation performed in the 2010 HGB AD SIP Revision was a retrospective analysis where the model was used to "forecast" the observed 2000 eight-hour ozone design values. The analysis itself is described in Chapter 3 of both the 2010 HGB AD SIP Revision (using the Reg10 base case) as well as this revision (using the Reg11_MVS base case). Table 7: *Modeled and Observed Relative Response Factors, 2006 to 2000* compares the relative response factors (RRFs) calculated using the EPA methodology but going backwards in time so the RRFs themselves are all greater than one, reflecting the fact that air quality improved substantially in the HGB area between 2000 and 2006. The observed RRF column in Table 7 is the ratio of the 2000 observed design value at a monitor divided by its 2006 observed design value and represents the observed change in air quality from 2006 to 2000.

The average observed RRF across all sites is 1.186, indicating that on average the 2000 ozone design values were nearly 19% larger than those in 2006. For both the Reg10 and Reg11_MVS, the RRF was near 1.14, indicating the model simulated a smaller change in air quality than did the monitors. The conclusion is that the model did not respond as well as the actual atmosphere to emission changes between 2000 and 2006, and that on average the response of the two modeling scenarios are nearly identical. Interestingly, the response at BAYP (CAMS 0053) is actually stronger with Reg11_MVS than with Reg10, contrary to what was seen in the weekday/weekend analysis. The difference may lie in the fact that the 2000 through 2006

emission changes included a broad set of sources, whereas the weekday to weekend changes are primarily mobile source-driven.

Table 7: Modeled and Observed Relative Response Factors, 2006 to 2000

Modeling Site Code	CAMS Number	2006 Baseline Design Value (ppb)	2000/2006 Relative Response Factor: Reg10	2000/2006 Relative Response Factor: Reg11_MVS	2000/2006 Relative Response Factor: Observed
BAYP	53	96.7	1.11	1.13	1.10
C35C	403	79.0	1.18	1.15	1.23
DRPK	35	92.0	1.18	1.16	1.17
GALC	34	81.7	1.11	1.13	1.20
HALC	8	85.0	1.15	1.14	1.28
HCQA	409	87.0	1.13	1.14	1.21
HLAA	408	77.7	1.11	1.11	1.16
HNWA	26	89.0	1.13	1.12	1.18
HOEA	1	80.3	1.17	1.15	1.27
HROC	95	79.7	1.15	1.15	1.19
HSMA	406	90.3	1.16	1.16	1.07
HWAA	405	76.3	1.14	1.14	1.28
SHWH	410	92.3	1.11	1.11	1.09
Average RRF	-	-	**1.141**	**1.138**	**1.186**

5 FUTURE CASE MODELING

5.1 Future Design Values

Table 8: *Comparison of Future Design Values Projected with Reg10 and Reg11_MVS* compares the RRFs and future design values (DV_Fs) for the modeling conducted with MOBILE6.2 (Reg10) for the 2010 HGB AD SIP Revision (abbreviated M6) with those from the current MOVES2010a (Reg11_MVS) modeling (abbreviated MVS). Both sets were based on the 2018 controls—not including the additional 25% reduction to highly reactive volatile organic compounds (HRVOC) emissions—that were part of the final control package. While some sites saw increased RRFs and DV_Fs, others saw the opposite. On average, the RRFs increased from 0.909 to 0.917, meaning that with MOVES2010a the model was slightly less responsive to the 2006-2018 emission reductions than was the case with MOBILE6.2. BAYP (CAMS 0053) saw a similar increase in its RRF, from 0.885 to 0.900, resulting in a 2018 DV_F increase from 85.5 ppb to 87.0 ppb. WALV (CAMS 617), on the other hand, saw its RRF decrease from 0.940 to 0.936, causing a decrease in its DV_F from 85.5 ppb to 85.2 ppb.

Table 8: Comparison of Future Design Values Projected with Reg10 and Reg11_MVS

Monitor Designation	Site Code	2006 DV_B (ppb)**	Reg10 RRF	Reg11_MVS RRF	Reg10 2018 DV_F (ppb)**	Reg11_MVS 2018 DV_F (ppb)**
Houston East (CAMS 1)	HOEA	80.3	0.935	0.943	75.1	75.8
Aldine (CAMS 8)	HALC	85.0	0.907	0.918	77.1	78.0
Channelview (CAMS 15)	HCHV	82.7	0.937	0.940	77.5	77.7
NW Harris County (CAMS 26)	HNWA	89.0	0.858	0.878	76.4	78.1
Galveston Airport (CAMS 34)	GALC	81.7	0.939	0.928	76.7	75.8
Deer Park (CAMS 35)	DRPK	92.0	0.940	0.937	86.5	86.2
S'brook Friendship Park (CAMS 45)	SBFP	85.3	0.926	0.925	79.0	78.9
Bayland Park (CAMS 53)	BAYP	96.7	0.885	0.900	85.5	87.0
Conroe Relocated (CAMS 78)	CNR2	83.0	0.866	0.878	71.9	72.9
Houston Regional Office (CAMS 81)	HROC	79.7	0.945	0.951	75.3	75.8
Manvel Croix Park (CAMS 84)	MACP	90.7	0.882	0.891	80.0	80.8
Clinton (CAMS 403)	C35C	79.0	0.938	0.949	74.1	75.0
North Wayside (CAMS 405)	HWAA	76.3	0.917	0.934	70.0	71.3
Swiss and Monroe (CAMS 406)	HSMA	90.3	0.911	0.919	82.3	83.0
Lang (CAMS 408)	HLAA	77.7	0.876	0.898	68.0	69.7
Croquet (CAMS 409)	HCQA	87.0	0.883	0.898	76.8	78.2
Shell Westhollow (CAMS 410)	SHWH	92.3	0.844	0.869	77.9	80.2
Houston Texas Avenue (CAMS 411)	HTCA	79.3	0.929	0.939	73.7	74.5
Haden Road (CAMS 603)*	H03H	84.0	0.939	0.945	78.9	79.4
Wallisville Road (CAMS 617)*	WALV	92.0	0.940	0.936	86.5	86.2
Danciger (CAMS 618)*	DNCG	80.3	0.880	0.882	70.7	70.8
Mustang Bayou (CAMS 619)*	MSTG	84.7	0.892	0.901	75.6	76.3

Monitor Designation	Site Code	2006 DV_B (ppb)**	Reg10 RRF	Reg11_MVS RRF	Reg10 2018 DV_F (ppb)**	Reg11_MVS 2018 DV_F (ppb)**
Texas City (CAMS 620)*	TXCT	84.3	0.925	0.922	78.0	77.7
Lynchburg Ferry (CAMS 1015)	LYNF	81.7	0.948	0.944	77.5	77.1
Lake Jackson (CAMS 1016)	LKJK	77.0	0.891	0.892	68.6	68.6
Average			0.909	0.917	76.78	77.4

* Non-regulatory, industry-sponsored monitor;
** Values 85 ppb or greater are shown in red.

5.2 Response Curves

Response curves of 2018 projected ozone design values were developed by reducing the future case NO_X, VOC, and combined NO_X and VOC emissions by 25% and 50%, then plotting the area-wide maximum future design value as a function of the emission reduction percentage for both the modeling scenarios using MOBILE6.2 and MOVES2010a. Note that the design value monitor in the 2010 HGB AD SIP Revision (MOBILE6.2) was WALV (CAMS 0617) while for this SIP revision (MOVES2010a) it is BAYP (CAMS 0053). Also note that the emissions in this SIP revision are larger than in the 2010 HGB AD SIP Revision, so a 25% reduction amounts to more tons per day than in the preceding revision.

Figure 34: *Comparison of 2018 Ozone Response Curves Generated Using MOBILE6.2 and MOVES2010a* compares the response curves developed using the two future cases for BAYP (CAMS 0053), DRPK (CAMS 0035), and WALV (CAMS 0617). In each of the three cases, the shapes of the response curves do not change much from MOBILE6.2 to MOVES2010a, but for the DRPK (CAMS 0035) and WALV (CAMS 0617) curves, the starting values (0% reduction) declined slightly from modeling with MOBILE6.2 to MOVES2010a, while BAYP (CAMS 0053), which is heavily influenced by local on-road mobile sources, shows an increase. Despite slightly differing starting points, the shapes of the curves based on MOBILE6 and those based on MOVES are quite similar to each other, indicating that the model's response is not changed much by switching to MOVES-based emissions.

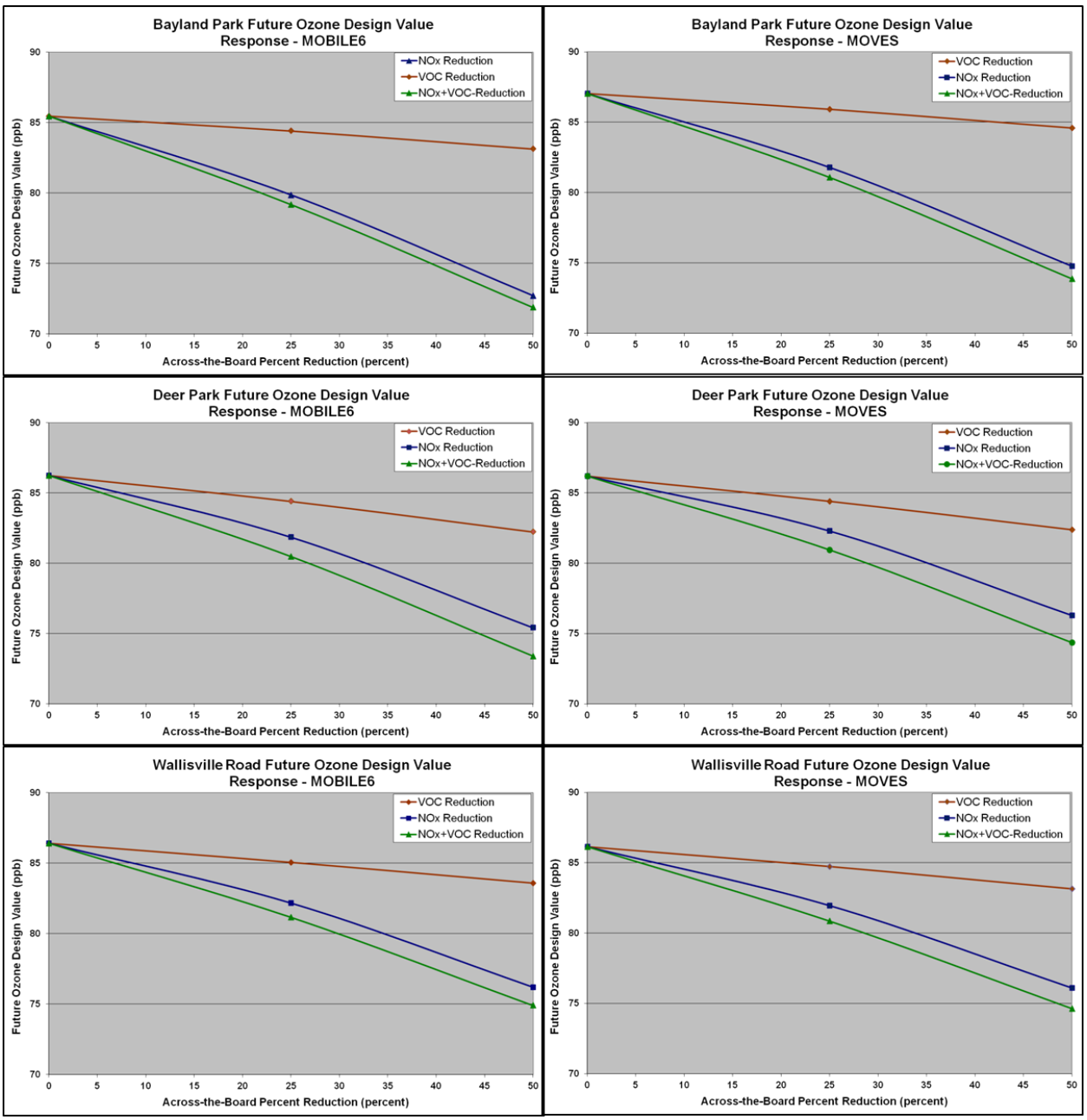

Figure 34: Comparison of 2018 Ozone Response Curves Generated Using MOBILE6.2 and MOVES2010a

5.3 Future Case Modeling with Controls

Both the 2010 HGB AD SIP Revision and this revision included modeling of a redistribution and reduction of the current total allocated point source HRVOC emissions by 25%, 2.69 tpd from HRVOC Emissions Cap and Trade (HECT) applicable sources in Harris County. Table 9: *HECT Modeling Sensitivity Results* compares the projected future design values at BAYP (CAMS 0053), DRPK (CAMS 0035), and WALV (CAMS 0617) monitors using the MOBILE6.2 and MOVES2010a-based future cases. Compared with the MOBILE6.2 modeling, both DRPK (CAMS 0035), and WALV (CAMS 0617) DV_F decreased by 0.28 ppb and 0.34 ppb, respectively using MOVES2010a, while BAYP (CAMS 0053) DV_F increased by over 1.5 ppb.

Table 9: HECT Modeling Sensitivity Results

Site	Site Code	Baseline DV_F (ppb)	MOBILE6.2 HECT DV_F (ppb)	MOVES2010a HECT DV_F (ppb)
Bayland Park (CAMS 53)	BAYP	87.04	85.44	86.95
Deer Park (CAMS 35)	DRPK	86.20	86.36	86.08
Wallisville Road (CAMS 619)	WALV	86.15	86.32	85.98

Note: WALV (CAMS 0617) is a non-regulatory, industry-sponsored monitor.

5.4 Unmonitored Area Analysis

The final comparison between MOBILE6.2-based modeling and MOVES2010a-based modeling is between the future design values interpolated across the nonattainment area using the TCEQ Attainment Test for Unmonitored areas (TATU). Figure 35: *Comparison of Spatially-Interpolated Baseline and Future Case Design Values Using MOBILE6.2 and MOVES2010a* compares the spatially-interpolated baseline and future-case design values, with MOBILE6.2 on top and MOVES2010a on bottom. The baseline figures (left column) are quite similar, both showing the highest projected ozone concentrations forming an annulus surrounding the urban core, with the highest concentrations near BAYP (CAMS 0053). The MOBILE6.2 case shows a slightly more concentrated peak, but the MOVES2010a case shows the higher ozone concentrations spread around a slightly broader area. The future cases have the same annular feature, but the predicted concentrations are much lower, with MOVES2010a-based future case concentrations generally slightly higher than their MOBILE6.2 counterparts. In the MOVES2010a future case, the maximum concentration moves from near WALV (CAMS 0617) to the other side of the city near BAYP (CAMS 0053), as in the baseline.

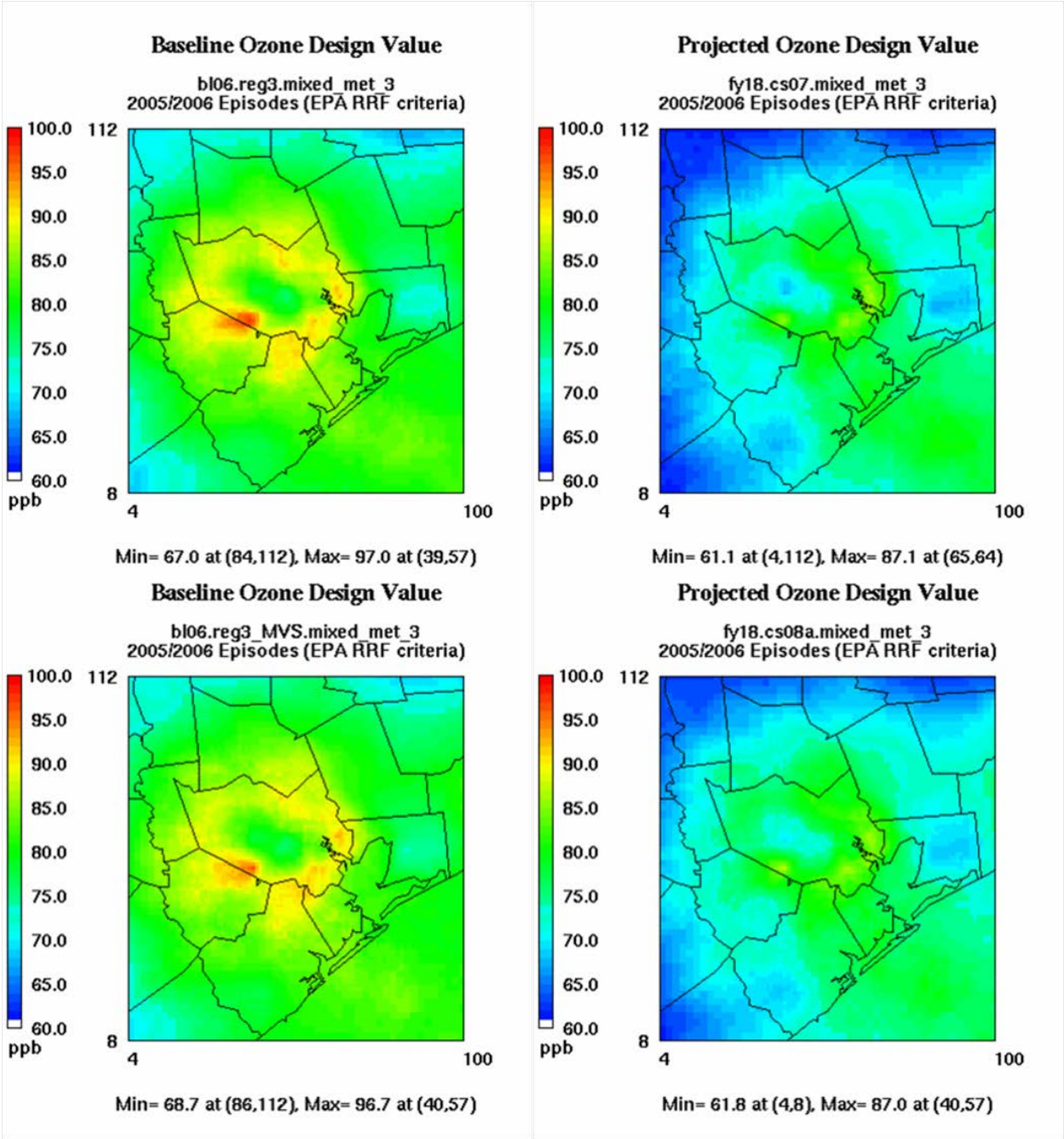

Figure 35: Comparison of Spatially-Interpolated Baseline and Future Case Design Values Using MOBILE6.2 and MOVES2010a

6 MODEL PERFORMANCE SUMMARY

Overall, the effects of replacing MOBILE6.2 (in Reg10) with MOVES2010a (in Reg11_MVS) were significant, but not overwhelming. Concentrations of NO_X almost universally increased, particularly at BAYP (CAMS 0053) where increases of up to 20 ppb were seen during morning peak periods. Concentration differences for VOC were very modest, and the two base cases were virtually undistinguishable on time series plots (not shown). The additional NO_X emissions in Reg11_MVS increased overall ozone concentrations, as shown in the Episodic Model

Performance Assessment, but in some cases actually caused the daily ozone peak concentrations to drop, particularly in areas where fresh NO_X from motor vehicles is prevalent.

The weekday to weekend analysis indicated that, at least for on-road mobile sources, the model using MOVES2010a may be even less responsive than it was using MOBILE6.2, but the retrospective analysis showed very little difference between the modeling cases.