

Final Report

Ozone Impacts in DFW from Revised
Emission Controls in the 2009 Future Year

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EXECUTIVE SUMMARY

The August 13-22, 1999 episode was identified as being representative of a high 8-hour ozone episode in the Dallas/Fort Worth area. In 2006, numerous CAMx sensitivity tests established the DFW Combination 4 control package as the best scenario for reducing 8-hour ozone in the DFW NAA for the 2009 future year (Tai et al., 2006). This report evaluates 8-hour ozone from each refinement to the combination of controls before finalizing a run to be submitted for the DFW 8-hour ozone SIP.

The Combination 4 scenario applied controls to the DFW major and minor sources, DFW EGUs, Midlothian cement kilns, DFW on-road and off-road mobile sources, and East Texas engines. In each successive scenario from Combination 4 to Combination 8 (excluding Combination 6), the emission controls weakened, namely from mobile sources and East Texas engines. The 2009 future design values among the nine DFW sites increased an average of 0.5 ppb from the less-stringent controls, raising the number of sites over 85.0 ppb from two in Combination 4 to four in Combination 8.

When applying only the controls that could be expected to be phased in by 2009, the average DFW future design values increased another 0.5 ppb, raising the number of DFW sites over 85.0 ppb to six. If another year was available to implement the controls (Combination 10), future design values could be mitigated 0.2 to 0.3 ppb at all DFW sites, reducing the number of sites over 85.0 ppb to four. Frisco had the highest future design value at 89.3 ppb; the 9-site average was 84.7 ppb. This control package was selected for the DFW SIP.

DFW mobile sources were the leading contributors to 8-hour ozone in DFW, based on source apportionment analyses. If only one-third of the stricter 2010 on-road mobile source controls within the DFW NAA were incorporated into the Combination 10 control package, the DFW future design values would drop an average of 0.4 ppb. If all 2010 on-road mobile controls were incorporated throughout Texas, the future design values would drop an average of 1.0 ppb from Combination 10. In the latter scenario, the number of sites over 85.0 ppb dropped to two as most sites had future design values similar or slightly better than the Combination 4 scenario. Frisco (88.2 ppb) and Denton (87.5 ppb) remained above the 85.0 ppb threshold needed to achieve attainment for 8-hour ozone.

1. INTRODUCTION

The August 13-22, 1999 period was identified as being representative of a high 8-hour ozone episode in the Dallas/Fort Worth (DFW) area. In previous work for the Texas Commission on Environmental Quality (TCEQ), the Run 17b base case configuration examined the level of emission controls needed to reach attainment for 8-hour ozone in 2010 by applying a matrix of VOC and NO_x reductions inside the DFW 9-county non-attainment area (NAA) (Mansell et al., 2004). Numerous sensitivity runs performed for the Houston Advanced Research Council (HARC), project H35 (Tai et al, 2005a) tested different domain configurations, meteorology, and chemistry to optimize the 1999 base case. A new base case, Run 40, combined all components that improved model performance and was the basis for more control scenarios in the 2010 future year for TCEQ (Tai et al, 2005b).

In October, 2005, the EPA published new procedures for attainment demonstration, including the use of baseline emissions instead of base case emissions and an updated method for computing the baseline design values (EPA, 2005). In addition, the DFW attainment demonstration year was changed from 2010 to 2009. A new baseline (Run 46) was established for the DFW episode for TCEQ (Tai et al., 2006). Numerous DFW emission control scenarios were evaluated for the 2009 future year, leading to the DFW Combination 4 control package, which consisted of controls to DFW major and minor sources, DFW EGUs, Midlothian cement kilns, NCTCOG on-road and off-road mobile sources, and East Texas engines. This package generated the lowest future design values among all scenarios evaluated.

Commitment issues weakened some of the Combination 4 controls, leading to higher 8-hour ozone future design values in the runs performed for Lamar (Tai et al, 2007). A source apportionment run was also performed for Lamar, which identified local sources, particularly from on-road and off-road mobile sources, as the largest contributors to 8-hour ozone in DFW and could be targeted for further controls.

In this report, the DFW 2009 8-hour ozone is evaluated with further refinements to the control package before finalizing a run to be submitted for the DFW 8-hour ozone SIP. Section 2 analyzes the ozone impact when weakening the East Texas engine controls outside of the DFW NAA. Section 3 evaluates DFW 8-hour ozone when applying only the controls that could be implemented by 2009 and by 2010, if an extra year was allowed to phase in the proposed controls. The latter run was designated as the SIP run. Section 4 evaluates the ozone benefits when incorporating the stricter mobile source controls scheduled for 2010.

2. DFW COMBINATION CONTROLS WITH REVISED EAST TEXAS ENGINE CONTROLS

BACKGROUND

Numerous CAMx sensitivity tests established the DFW Combination 4 control package as the best scenario for reducing 8-hour ozone in the DFW NAA by the 2009 future year (Tai., 2006). The DFW Combination 4 control package, which consisted of controls to DFW major and minor sources, DFW EGUs, Midlothian cement kilns, NCTCOG on-road and off-road mobile sources, and East Texas engines, lowered NOx emissions by 46.5 tpd inside the DFW NAA and 40.9 tpd outside DFW. In Combination 6, the NCTCOG controls became less stringent while the East Texas engine controls increased the NOx reduction as more sources were identified for controls. The net impact was an average increase of 0.3 ppb to the 2009 future design values among the nine DFW sites (Tai, 2007).

In this section, two CAMx simulations examined the impacts to 8-hour ozone in DFW from further revisions to the East Texas engine controls that were originally applied to the DFW Combination 6 scenario. Combination 7 removed the engine controls in six of the 39 East Texas counties; Combination 8 eliminated controls applied to the lean-burning engines in the remaining 33 East Texas counties.

All runs in this report were based on the Run 46 configuration with CAMx version 4.31. The expanded 36 km modeling domain contained 12 km and 4 km nested grids over DFW; 20 vertical layers were applied with a model top near 15 km. Inputs included meteorology from MM5 Run 6, which was based on the ETA PBL scheme coupled with the Noah land surface model, with the kv100 patch applied to the vertical diffusivity. The boundary conditions assigned moderate conditions (22.3 ppbC VOC and 1.1 ppb NOx) in the mixed layer over land, and clean conditions (9.3 ppbC VOC and 1.1 ppb NOx) over the Gulf, Atlantic, and all areas aloft.

EMISSIONS

Table 2-1 shows the NOx reductions in Texas from each control for Combinations 6 to 8. Controls that were altered from the previous control scenario are shown in red. The top shows changes from the 2009.a2 baseline; the bottom shows differences from each successive run.

Combination 7 eliminated the controls applied to the spark-ignition engines in 6 of the 39 East Texas counties within 200 km of the DFW NAA, adding 10.3 tpd NOx mostly in Wise County. All six counties were west or north of DFW. The total NOx reduction from all controls in Texas was 85.4 tpd, of which 30.5 tpd was inside the DFW NAA.

In Combination 8, the revised East Texas engine controls also excluded controls to the lean-burning engines in the remaining 33 East Texas counties, increasing the NOx emissions by another 25.6 tpd. The total NOx increase of 35.9 tpd (compared to Combination 6) lowered the NOx reduction from the East Texas engine controls to 35.4 tpd NOx., close to the magnitude applied in Combination 5 (40.9 tpd). Combination 8 also incorporated a 1.1 tpd NOx reduction in TxLED fuel in locomotive switch engines within DFW; the net change was a 24.5 tpd NOx

increase compared to Combination 7. The NO_x reduction from all controls was 61.0 tpd, of which 31.6 tpd was inside the DFW NAA.

Summaries of the 2009 weekday NO_x emissions with the DFW Combination 7 and 8 controls are shown in Tables 2-2 and 2-3, respectively, by source region, as defined in Figures 2-1 and 2-2, and by emission group (biogenics, elevated points, Texas mobile, low points, area, and off-road, and non-Texas low-level anthropogenics). Differences from the 2009 a2 baseline and from the preceding combination of controls are shown in the two rightmost columns.

VOC emissions were unchanged from Combination 6 in both scenarios. VOCs were 2.9 tpd greater than in the 2009.a2 baseline.

Table 2-1. Change in weekday NO_x emissions by control group from the 2009.a2 baseline.

	DFW Combination 6	DFW Combination 7	DFW Combination 8
Change in NO_x from 2009.a2 baseline [tpd]			
Within DFW			
DFW major	-10.5	-10.5	-10.5
DFW minor	-4.5	-4.5	-4.5
DFW EGU	-2.0	-2.0	-2.0
Cement kilns	-11.0	-11.0	-11.0
On-road	-1.4	-1.4	-1.4
Off-road	-1.1	-1.1	-2.2
Total	-30.5	-30.5	-31.6
Outside DFW			
On-road	4.4	4.4	4.4
Off-road	1.7	1.7	1.7
East TX engines	-71.3	-61.0	-35.4
Total	-95.7	-85.4	-61.0
Change in NO_x [tpd]		Combo 7–Combo 6	Combo 8–Combo 7
Off-road		0.0	-1.1
East TX engines		+10.3	+25.6
TX Total		10.3	24.5

Table 2-2. Weekday NOx emissions [tpd] in 2009.a2 with DFW Combination 7 controls.

NOX [tpd]	Bio	TX Onroad	Elev Points	TX Low Points	TX Area	TX Offroad	Non-TX Low Anthro	All Anthro	Anthro Change from 2009.a2 baseline	Anthro change from Combo6
Collin Co	10	14	1	0	2	8	0	25	-0.5	0.0
Dallas Co	4	77	5	1	17	45	0	145	-4.1	0.0
Denton Co	8	17	1	0	11	9	0	38	-2.1	0.0
Tarrant Co	3	46	1	1	9	28	0	85	-3.4	0.0
Parker Co	1	6	0	0	1	2	0	8	-1.2	0.0
Johnson Co	5	5	3	0	0	5	0	13	-2.5	0.0
Ellis Co	15	8	20	0	0	6	0	35	-14.4	0.0
Kaufman Co	5	6	3	0	0	2	0	11	-1.4	0.0
Rockwall Co	2	3	0	0	0	1	0	5	-0.1	0.0
DFW 9-County	52	182	34	3	40	106	0	365	-29.7*	0.0
North Texas	31	24	13	3	17	15	0	72	-0.8	10.2
NE Texas	16	79	175	5	53	42	1	354	-39.5	0.0
Central TX	114	92	142	2	48	70	0	355	-18.7	0.0
Houston	21	179	226	11	53	63	0	532	4.3	0.0
South TX	229	189	261	21	75	100	0	646	-2.1	0.0
West TX	524	160	140	21	212	106	1	641	1.6	0.1
Texas	986	907	991	66	498	502	2	2965	-84.9	10.3
Gulf + Mexico	79	5	436	0	4	2	444	891	0.0	0.0
Oklahoma	227	1	256	0	2	3	661	924	0.0	0.0
Louisiana	106	1	715	1	2	1	1183	1903	-0.6	0.0
Arkansas	125	2	220	0	0	2	468	692	0.0	0.0
Mississippi	121	0	353	0	0	0	455	808	0.0	0.0
Alabama	75	0	442	0	0	0	491	932	0.0	0.0
Tennessee	118	0	244	0	0	0	662	906	0.0	0.0
Kentucky	145	0	289	0	0	0	770	1060	0.0	0.0
Georgia	110	0	408	0	0	0	823	1230	0.0	0.0
Florida	56	0	367	0	0	0	1206	1573	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	293	0	977	0	0	0	2332	3310	0.0	0.0
NE US	314	0	1302	0	0	0	5748	7051	0.0	0.0
Northern Plains	5238	0	3269	0	0	0	8623	11892	0.0	0.0
Total	7992	916	10270	67	507	510	23869	36138	-85.4	10.3
Change from baseline	0.0	3.0	-36.6	-16.3	-36.1	0.7	-0.2	-85.4		
Change from combo 6	0.0	0.0	5.0	2.1	3.1	0.0	0.0	10.3		

* Value may differ from Table 2-1 based on the way cells were defined for the DFW NAA.

Table 2-3. Weekday NOx emissions [tpd] in 2009.a2 with DFW Combination 8 controls.

NOX [tpd]	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non-TX Low Anthro	All Anthro	Anthro Change from 2009.a2 baseline	Anthro Change from Combo7
Collin Co	10	14	1	0	2	8	0	25	-0.6	-0.1
Dallas Co	4	77	5	1	17	44	0	144	-4.6	-0.5
Denton Co	8	17	1	0	11	9	0	38	-2.2	-0.1
Tarrant Co	3	46	1	1	9	27	0	85	-3.6	-0.3
Parker Co	1	6	0	0	1	2	0	8	-1.2	0.0
Johnson Co	5	5	3	0	0	5	0	13	-2.6	-0.1
Ellis Co	15	8	20	0	0	6	0	35	-14.4	-0.1
Kaufman Co	5	6	3	0	0	2	0	11	-1.4	0.0
Rockwall Co	2	3	0	0	0	1	0	5	-0.1	0.0
DFW 9-County	52	182	34	3	40	105	0	364	-30.8	-1.1
North Texas	31	24	13	3	17	15	0	72	-0.8	0.0
NE Texas	16	79	175	10	61	42	7	373	-21.1	18.4
Central TX	114	92	142	2	53	70	1	361	-12.5	6.3
Houston	21	179	226	11	53	63	0	532	4.3	0.0
South TX	229	189	261	21	75	100	0	647	-1.4	0.7
West TX	524	160	140	21	212	106	1	641	1.6	0.0
Texas	986	907	991	71	511	501	9	2990	-60.6	24.2
Gulf + Mexico	79	5	436	0	4	2	444	891	0.0	0.0
Oklahoma	227	1	256	0	2	3	661	924	0.0	0.0
Louisiana	106	1	715	1	2	1	1183	1903	-0.4	0.2
Arkansas	125	2	220	0	0	2	468	692	0.0	0.0
Mississippi	121	0	353	0	0	0	455	808	0.0	0.0
Alabama	75	0	442	0	0	0	491	932	0.0	0.0
Tennessee	118	0	244	0	0	0	662	906	0.0	0.0
Kentucky	145	0	289	0	0	0	770	1060	0.0	0.0
Georgia	110	0	408	0	0	0	823	1230	0.0	0.0
Florida	56	0	367	0	0	0	1206	1573	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	293	0	977	0	0	0	2332	3310	0.0	0.0
NE US	314	0	1302	0	0	0	5748	7051	0.0	0.0
Northern Plains	5238	0	3269	0	0	0	8623	11892	0.0	0.0
Total	7992	916	10270	72	520	509	23876	36163	-61.0	24.5
Change from baseline	0.0	3.0	-36.6	-11.2	-22.8	-0.4	7.0	-61.0		
Change from combo7	0.0	0.0	0.0	5.1	13.3	-1.1	7.1	24.5		

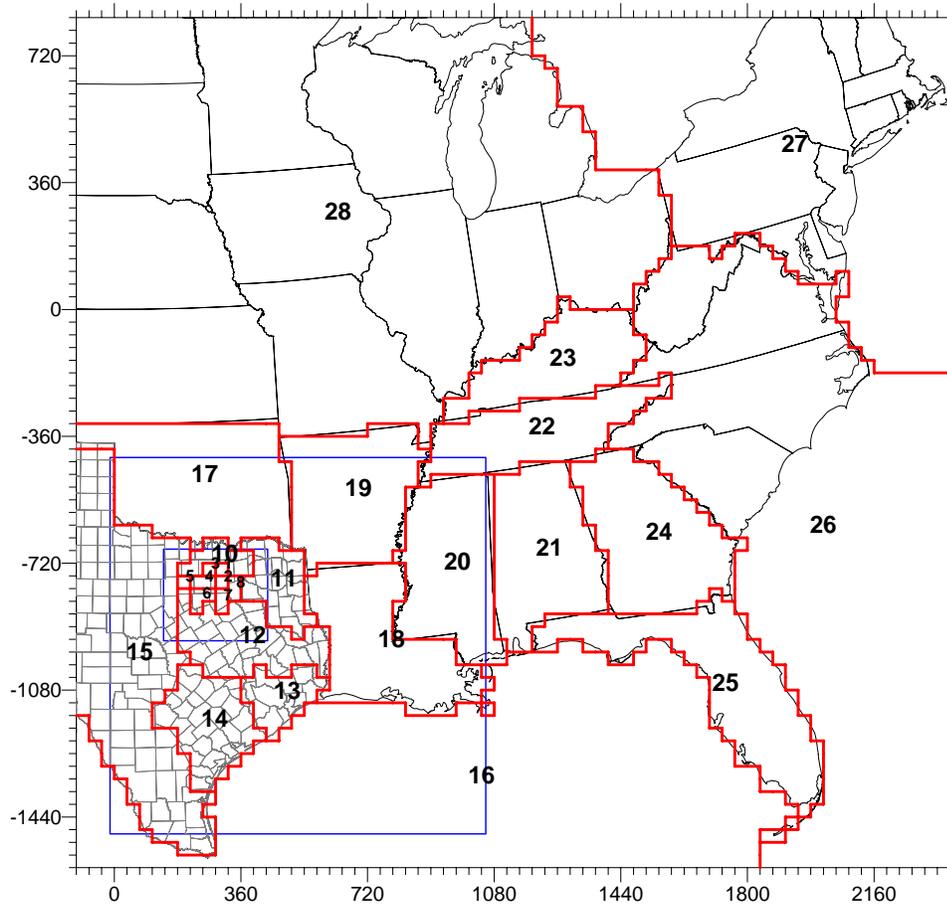


Figure 2-1. Map of source regions in the 36 km expanded domain.

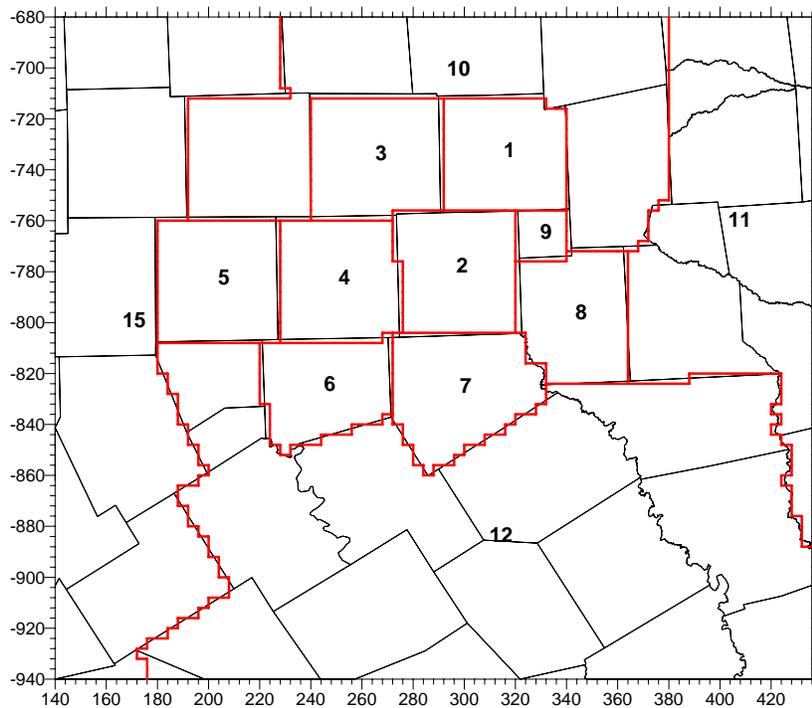


Figure 2-2. Map of source regions in the DFW 4 km domain.

MODELING RESULTS

Spatial plots of the daily maximum 8-hour ozone for Combinations 7 and 8 are displayed in Figure 2-3 for each episode date. Differences in the daily maximum 8-hour ozone are shown in Figure 2-4. The left column shows changes when removing engine controls from 6 counties to the north and west of DFW (Combination 7 – Combination 6); the middle column shows changes when removing lean-burning engine controls in the 33 East Texas counties (Combination 8 – Combination 7); the right column shows differences when removing the engine controls from both the 6 counties and from the lean-burning engines (Combination 8 – Combination 6).

The elimination of the engine controls in the six East Texas counties increased the daily maximum 8-hour ozone up to 2 ppb in northern Parker County, located south of Wise County, where most of the NO_x emissions were added, on the two dates with north winds (August 19 and 20). Combination 7 also added 0.25 to 0.50 ppb to the daily maximum 8-hour ozone in most areas of the DFW 4-county core on August 19. On all other episode dates, the impacts were less than 0.25 ppb throughout the DFW NAA as the six East Texas counties were downwind of DFW.

The removal of the lean-burning engine controls in East Texas added 0.5 to 1.0 ppb to the daily maximum 8-hour ozone across much of the DFW NAA on August 15 and 21. Impacts were lower on the other episode dates, particularly from August 17 to 20, when 8-hour ozone changed less than 0.25 ppb throughout the DFW core counties. The western DFW NAA counties were least impacted from the removal of lean-burning engine controls.

The ozone increases in DFW from the removal of the engine controls in the six East Texas counties usually were not co-located with the impacts from the removal of the lean-burning engine controls. The former had greater impacts in northwest DFW; the latter emphasized southern and eastern DFW.

The 2009 8-hour ozone future design value calculations for the DFW Combination 7 and 8 scenarios are shown in Tables 2-4 and 2-5, respectively, for all DFW monitoring sites using the 1999 baseline design value. Daily relative reduction factors are included at the bottom of each table. Table 2-6 compares the future design values with the 2009 baseline and Combination 6 scenario. Values at or over 85.0 ppb are listed in red.

In Combination 6, three of the nine DFW sites had 2009 future design values greater than or equal to 85.0 ppb – Frisco, Denton, and Dallas Hinton. Combination 7 added no more than 0.1 ppb to the future design values; however, the sites with increases were located at two exceedance sites – Frisco and Denton – and at Fort Worth C13, where the future design value increased from 84.9 ppb to 85.0 ppb.

Combination 8 added 0.1 ppb (Denton) to 0.3 ppb (Dallas North) to the future design values computed for Combination 7. Four DFW sites contained future design values exceeding 85.0 ppb – Frisco (88.9 ppb), Denton (88.5 ppb), Dallas Hinton (85.4 ppb), and Ft Worth C13 (85.1 ppb). These future design values were the same as in the Combination 5 scenario.

Table 2-7 shows the rate of future design value ozone responses to changes in the NO_x emissions. The average magnitude among the DFW sites when removing the lean-burning engine controls was comparable to the magnitude when identifying more East Texas engines for controls in Combination 6. Denton was the least responsive to the lean-burning engine controls; Dallas North was the most responsive. The average ozone response to the NO_x increase in the six East Texas counties was half as large as the response to the NO_x increase from lean-burning engines. Northern and western DFW monitors like Frisco and Denton were the most responsive to the engine controls in the six counties.

Tables 2-8 to 2-10 examine the 4-km grid cells in the DFW 9-county NAA in which the daily maximum 8-hour ozone exceeded 85 ppb. Table 2-8 lists the number of unique grid cells in DFW that exceed 85 ppb for each date in the 2009 baseline and in Combinations 6 to 8. For the episode, Combination 6 reduced the exceedance area by 10 %. Combinations 7 and 8 lowered the exceedance area by 9 % and 8 %, respectively.

Table 2-9 shows the number of baseline exceedance cells that were reduced at least 1 ppb from the combination of controls. In Combination 6, 38% of the 1158 exceedance cells were reduced at least 1 ppb from the controls. Combinations 7 and 8 lowered the reduction rate to 33 % and 29 %, respectively.

Table 2-10 sums the number of ppb's in the daily maximum 8-hour ozone that exceed 85 ppb. For example, if the daily maximum ozone in a grid cell is 90 ppb, the grid cell adds 5 ppb (90 – 85 ppb) to the sum of ozone exceedances. The number of exceedance ppb's among all episode dates was reduced 13% in Combination 6, and dropped to 12 % in both Combinations 7 and 8.

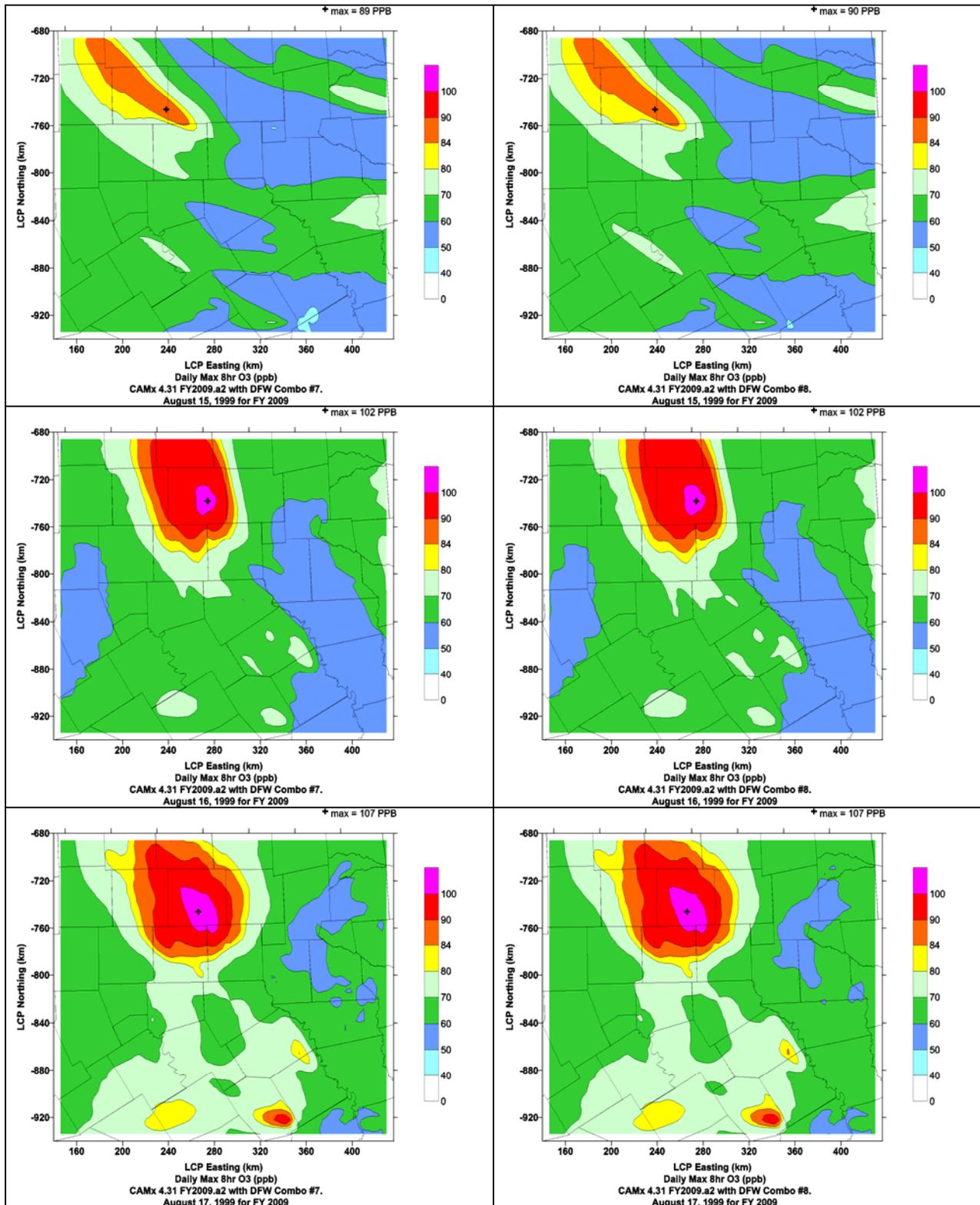


Figure 2-3. Spatial plots of the daily maximum 8-hour ozone in Combination 7 (left) and Combination 8 (right) for each episode date.

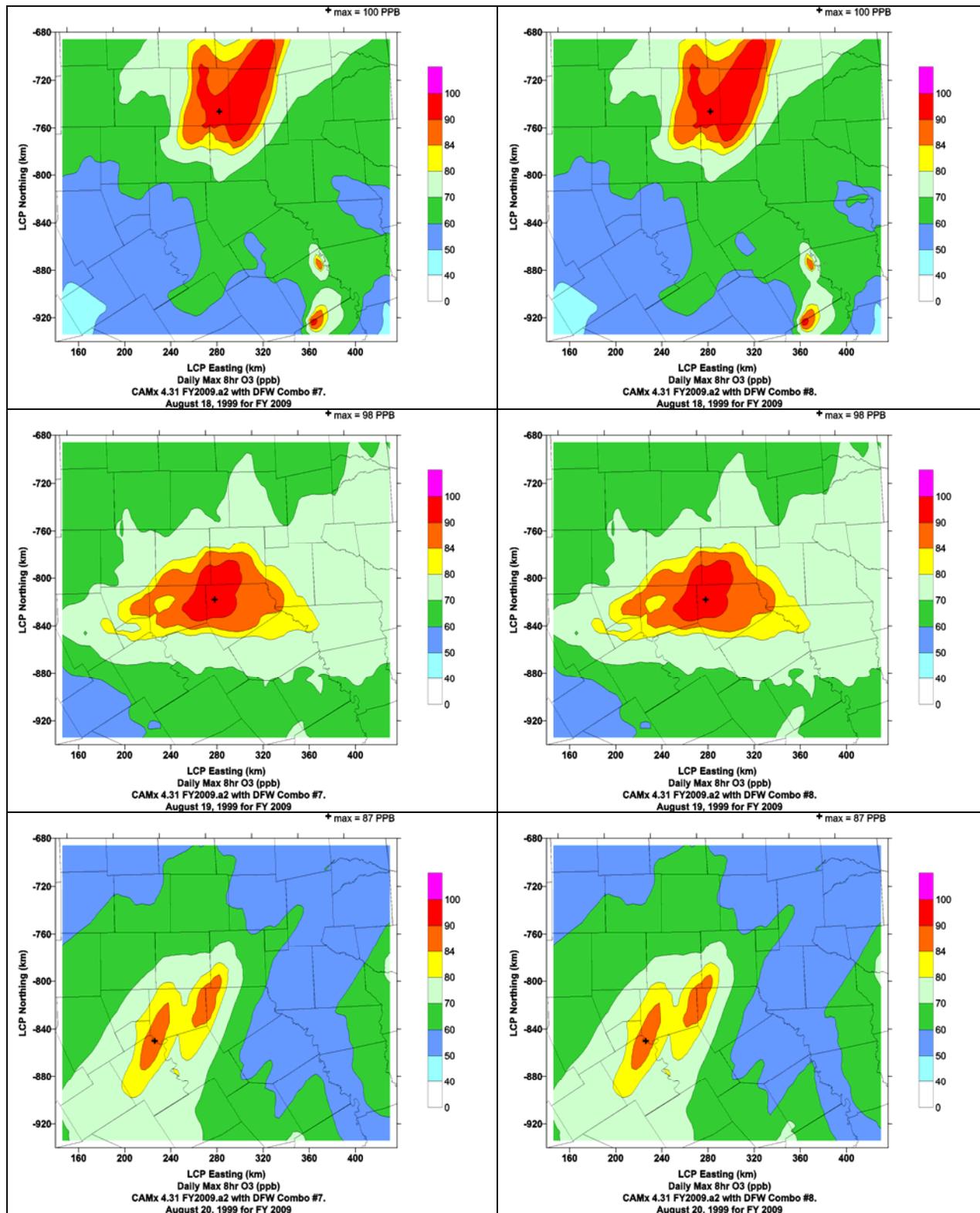


Figure 2-3 (continued). Spatial plots of the daily maximum 8-hour ozone in Combination 7 (left) and Combination 8 (right) for each episode date.

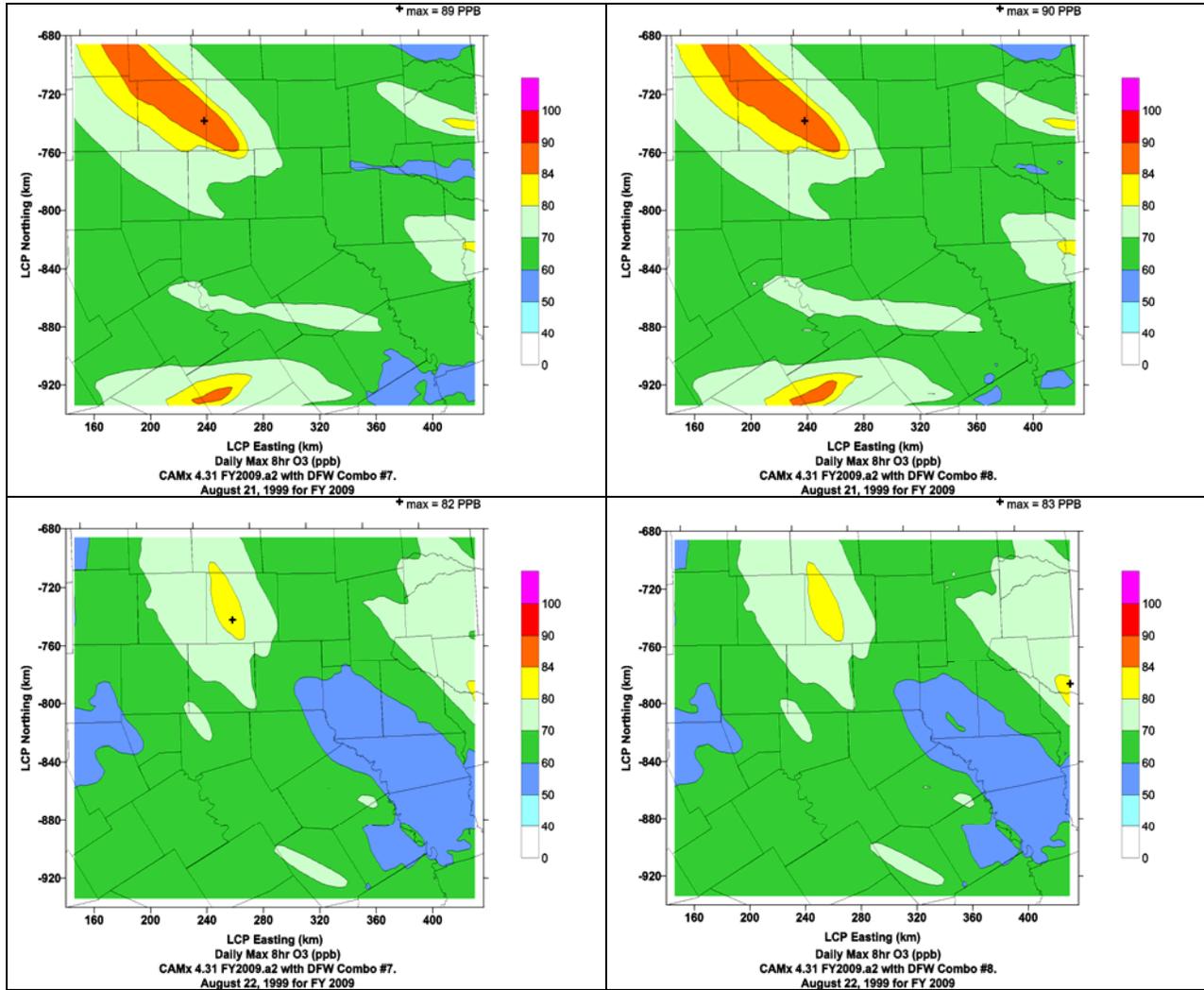


Figure 2-3 (concluded). Spatial plots of the daily maximum 8-hour ozone in Combination 7 (left) and Combination 8 (right) for each episode date.

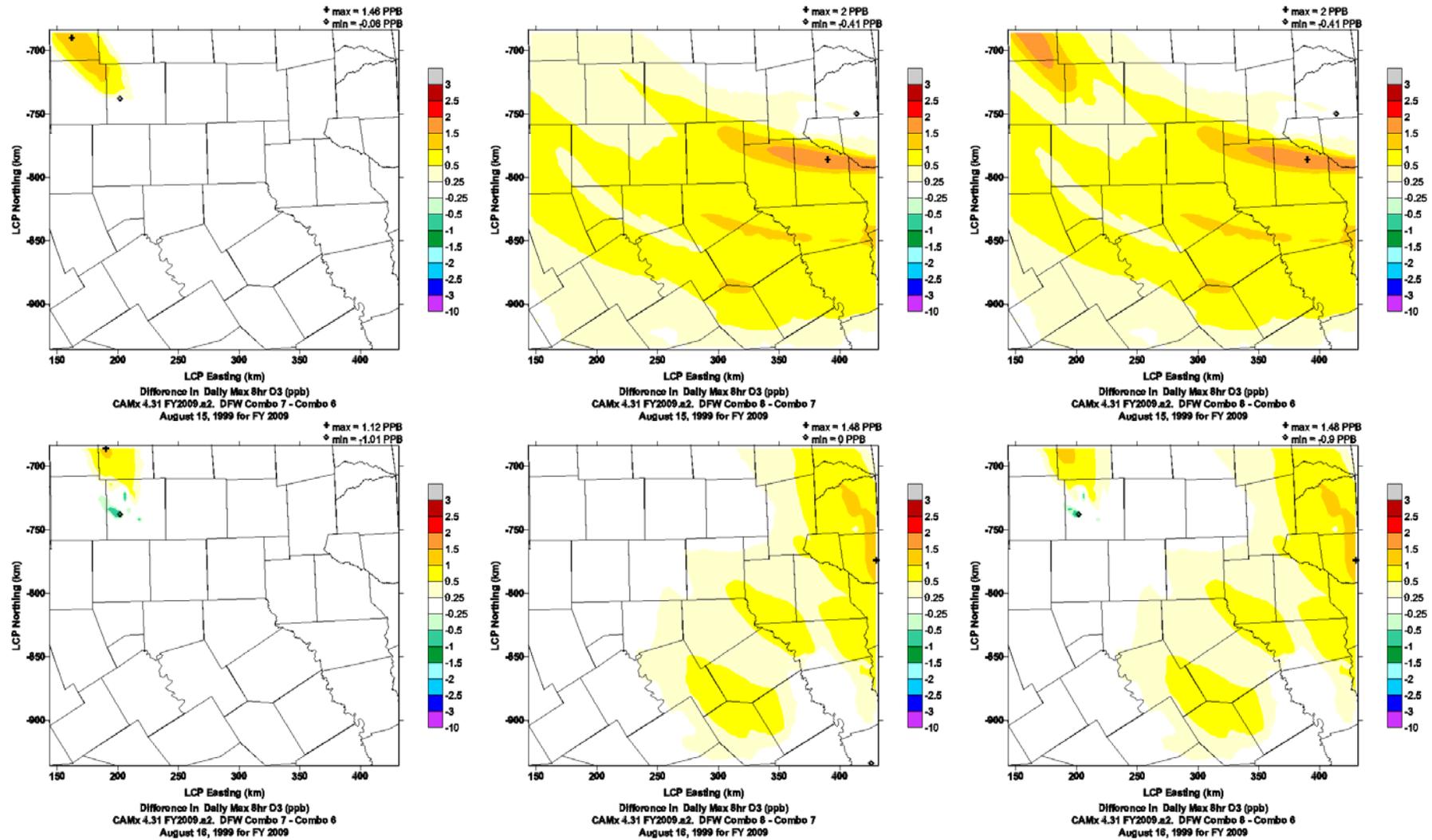


Figure 2-4. Spatial plots of differences in the daily maximum 8-hour ozone when removing all engine controls in six counties (Combination 7- Combination 6, left), when removing lean-burning engine controls (Combination 8 – Combination 7, center), and when removing both engine controls (Combination 8 – Combination 6, right).

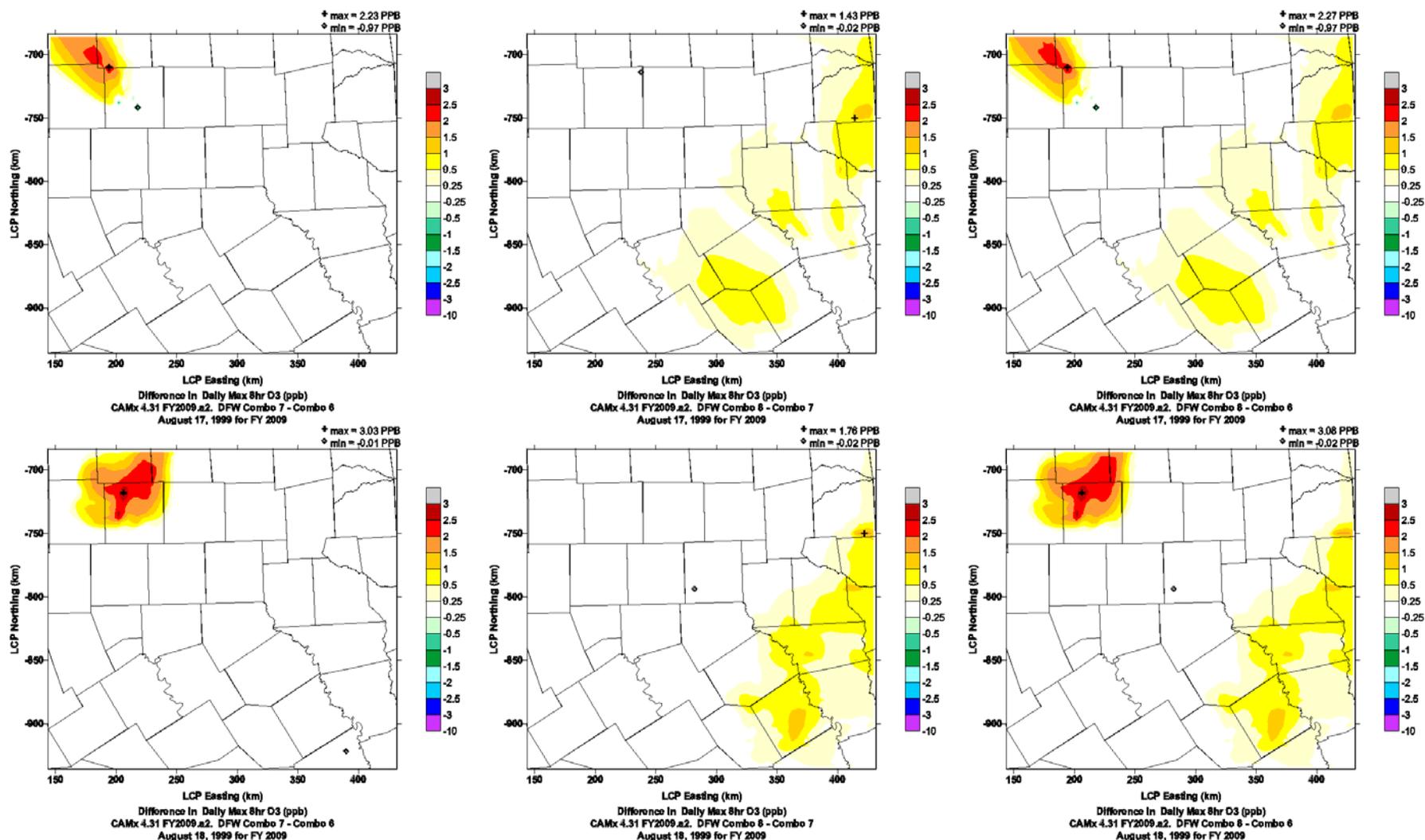


Figure 2-4 (continued). Spatial plots of differences in the daily maximum 8-hour ozone when removing all engine controls in six counties (Combination 7- Combination 6, left), when removing lean-burning engine controls (Combination 8 – Combination 7, center), and when removing both engine controls (Combination 8 – Combination 6, right).

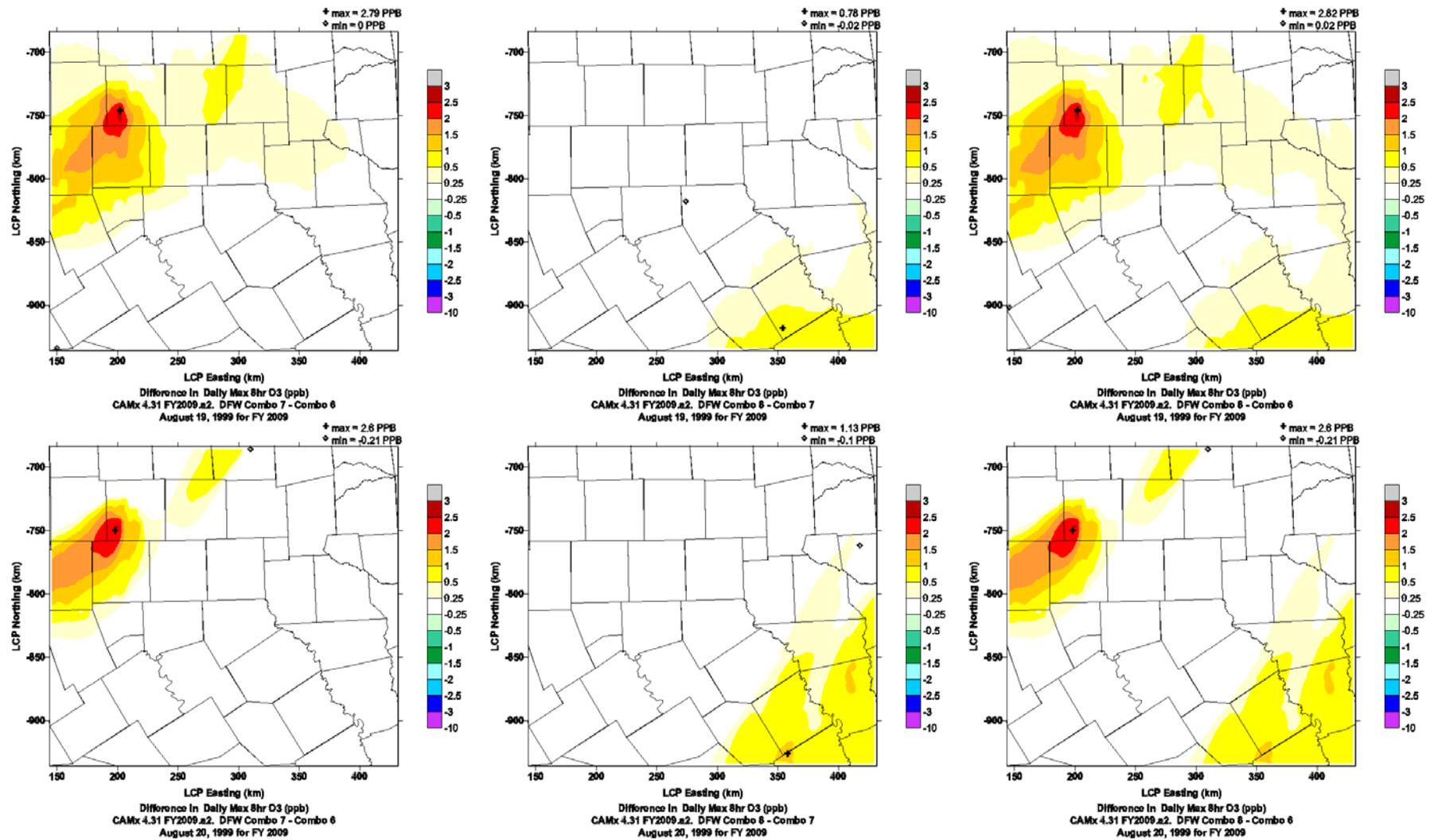


Figure 2-4 (continued). Spatial plots of differences in the daily maximum 8-hour ozone when removing all engine controls in six counties (Combination 7- Combination 6, left), when removing lean-burning engine controls (Combination 8 – Combination 7, center), and when removing both engine controls (Combination 8 – Combination 6, right).

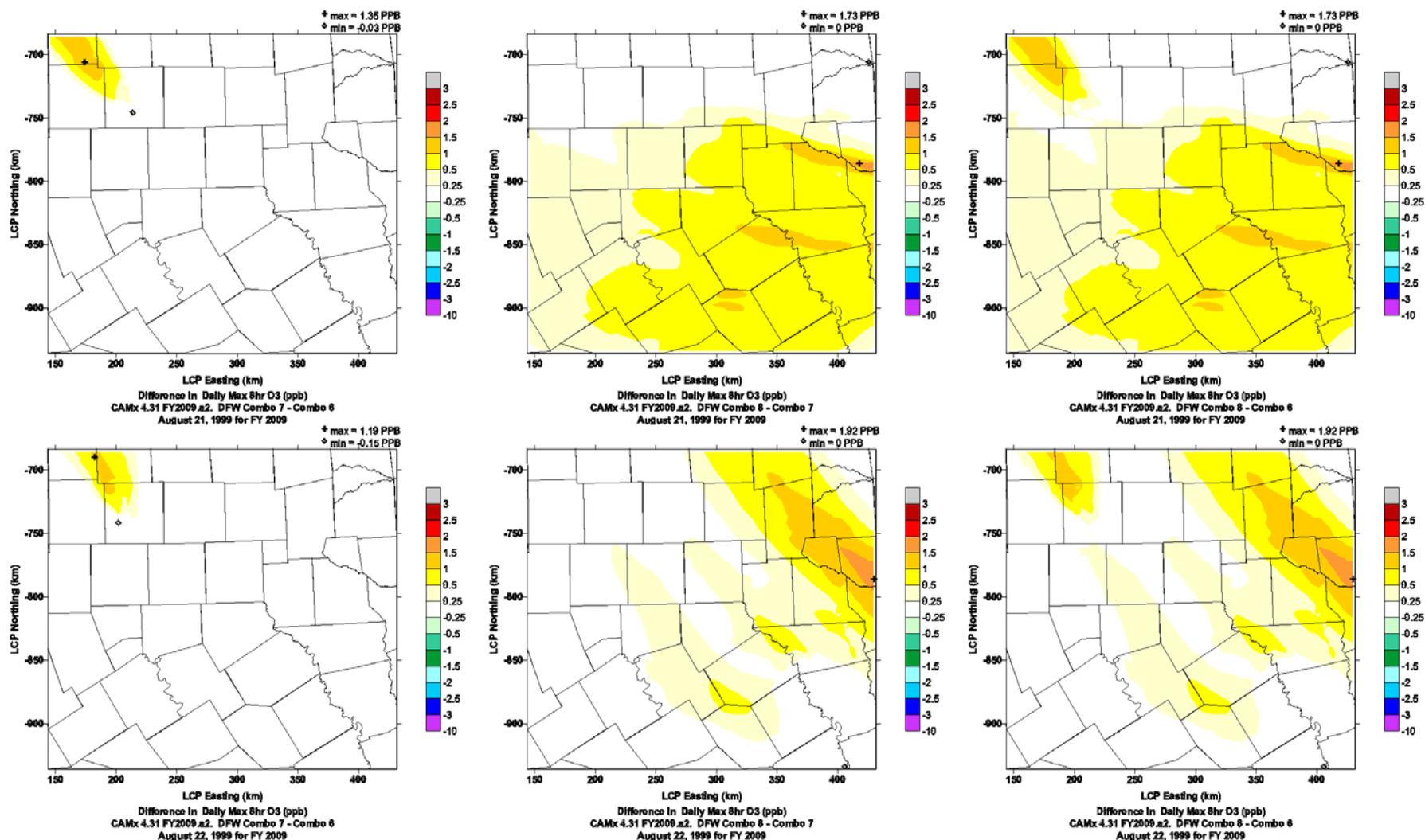


Figure 2-4 (concluded). Spatial plots of differences in the daily maximum 8-hour ozone when removing all engine controls in six counties (Combination 7- Combination 6, left), when removing lean-burning engine controls (Combination 8 – Combination 7, center), and when removing both engine controls (Combination 8 – Combination 6, right).

Table 2-4. Future design value scaling calculations [ppb] for the DFW Combination 7 control scenario.

Base Case: run46												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	#Days>70		
Frisco	81.3	107.0	102.6	109.2	86.0	69.9	87.1	89.5	94.7	7		
Dallas Hinton C60	83.1	99.8	103.4	103.8	99.2	78.0	85.5	85.3	92.3	8		
Dallas North C63	82.6	101.3	102.6	106.6	96.5	76.4	86.8	88.4	92.6	8		
Dallas Exec C402	77.0	93.3	98.5	96.6	107.4	83.7	79.4	79.5	89.4	8		
Denton	102.6	113.1	110.0	112.5	84.7	73.1	101.6	99.6	99.7	8		
Midlothian	78.3	86.1	85.9	76.2	114.0	88.8	75.7	76.7	85.2	8		
Arlington	86.2	98.4	100.2	95.2	106.9	83.1	81.9	86.7	92.3	8		
Ft Worth C13	93.8	105.5	104.3	106.0	96.0	80.1	89.8	92.0	95.9	8		
Ft Worth C17	101.1	111.1	110.4	108.3	92.4	78.6	95.9	94.9	99.1	8		
Future Year: run46.fy2009.a2.dfw_combo8												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	RRF ¹	BaseDV [ppb]	Future DV ² [ppb]
Frisco	65.5	99.9	101.3	99.9	72.8	63.9	73.4	73.1	83.7	0.884	100.3	88.67
Dallas HintonC60	70.8	91.8	102.9	97.0	91.1	80.8	76.5	72.7	85.4	0.926	92.0	85.19
Dallas North C63	68.9	94.6	101.3	98.9	84.0	77.4	74.6	72.7	84.1	0.907	93.0	84.35
Dallas Exec C402	65.0	80.5	88.4	83.6	96.3	85.1	69.0	68.9	79.6	0.890	88.0	78.32
Denton	86.7	102.3	107.5	91.4	71.1	64.4	88.9	82.3	86.8	0.871	101.5	88.41
Midlothian	68.6	75.3	78.2	70.4	98.0	85.3	67.5	69.2	76.6	0.899	92.5	83.16
Arlington	71.3	86.2	89.2	80.7	94.9	85.1	71.6	76.3	81.9	0.887	90.5	80.27
Ft Worth C13	77.0	91.9	93.0	87.3	83.0	75.6	77.9	78.0	82.9	0.865	98.3	85.03
Ft Worth C17	87.8	97.0	103.5	89.7	78.7	70.5	87.2	80.9	86.9	0.877	96.3	84.46
Daily RRFs ³												
Site	990815	990816	990817	990818	990819	990820	990821	990822				
Frisco	0.805	0.934	0.987	0.915	0.847	0.914	0.843	0.816				
Dallas HintonC60	0.852	0.919	0.996	0.934	0.918	1.037	0.895	0.852				
Dallas North C63	0.834	0.934	0.987	0.927	0.871	1.014	0.860	0.823				
Dallas Exec C402	0.845	0.862	0.897	0.866	0.897	1.016	0.870	0.867				
Denton	0.845	0.905	0.977	0.812	0.840	0.881	0.874	0.826				
Midlothian	0.876	0.875	0.911	0.923	0.860	0.961	0.892	0.903				
Arlington	0.827	0.876	0.890	0.848	0.888	1.024	0.874	0.880				
Ft Worth C13	0.821	0.871	0.891	0.823	0.865	0.943	0.868	0.848				
Ft Worth C17	0.869	0.874	0.938	0.829	0.852	0.897	0.909	0.853				

1. RRF = future year average / baseline average

2. Future DV = baseline DV * RRF

3. Daily RRFs are for information only. They are not used to calculate the future DV.

Table 2-5. Future design value scaling calculations [ppb] for the DFW Combination 8 control scenario.

Base Case: run46												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	#Days>70		
Frisco	81.3	107.0	102.6	109.2	86.0	69.9	87.1	89.5	94.7	7		
Dallas HintonC60	83.1	99.8	103.4	103.8	99.2	78.0	85.5	85.3	92.3	8		
Dallas North C63	82.6	101.3	102.6	106.6	96.5	76.4	86.8	88.4	92.6	8		
Dallas Exec C402	77.0	93.3	98.5	96.6	107.4	83.7	79.4	79.5	89.4	8		
Denton	102.6	113.1	110.0	112.5	84.7	73.1	101.6	99.6	99.7	8		
Midlothian	78.3	86.1	85.9	76.2	114.0	88.8	75.7	76.7	85.2	8		
Arlington	86.2	98.4	100.2	95.2	106.9	83.1	81.9	86.7	92.3	8		
Ft Worth C13	93.8	105.5	104.3	106.0	96.0	80.1	89.8	92.0	95.9	8		
Ft Worth C17	101.1	111.1	110.4	108.3	92.4	78.6	95.9	94.9	99.1	8		
Future Year: run46.fy2009.a2.dfw_combo8												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	RRF ¹	BaseDV [ppb]	Future DV ² [ppb]
Frisco	66.3	100.1	101.4	99.8	72.9	63.9	73.7	73.3	83.9	0.886	100.3	88.87
Dallas HintonC60	71.4	92.0	103.0	97.0	91.1	80.8	76.9	73.0	85.6	0.928	92.0	85.38
Dallas North C63	69.6	94.8	101.4	98.9	84.0	77.4	75.0	73.0	84.3	0.910	93.0	84.63
Dallas Exec C402	65.6	80.8	88.5	83.6	96.3	85.0	69.5	69.1	79.8	0.892	88.0	78.50
Denton	87.2	102.4	107.5	91.4	71.2	64.4	89.0	82.5	86.9	0.872	101.5	88.51
Midlothian	69.2	75.6	78.4	70.4	98.0	85.3	68.1	69.5	76.8	0.901	92.5	83.34
Arlington	71.9	86.4	89.2	80.7	94.9	85.0	72.0	76.5	82.1	0.889	90.5	80.45
Ft Worth C13	77.4	92.0	93.0	87.3	83.0	75.5	78.2	78.2	83.1	0.866	98.3	85.13
Ft Worth C17	88.2	97.2	103.5	89.8	78.7	70.5	87.4	81.1	87.1	0.879	96.3	84.65
Daily RRFs³												
Site	990815	990816	990817	990818	990819	990820	990821	990822				
Frisco	0.815	0.935	0.988	0.915	0.847	0.914	0.847	0.818				
Dallas HintonC60	0.859	0.921	0.996	0.934	0.918	1.037	0.899	0.855				
Dallas North C63	0.843	0.936	0.988	0.927	0.871	1.014	0.864	0.826				
Dallas Exec C402	0.853	0.865	0.898	0.866	0.897	1.016	0.876	0.869				
Denton	0.850	0.906	0.977	0.812	0.840	0.880	0.876	0.828				
Midlothian	0.884	0.878	0.912	0.924	0.860	0.961	0.899	0.906				
Arlington	0.833	0.878	0.890	0.848	0.888	1.024	0.879	0.882				
Ft Worth C13	0.826	0.872	0.892	0.824	0.865	0.943	0.871	0.850				
Ft Worth C17	0.873	0.875	0.938	0.829	0.852	0.897	0.911	0.855				

1. RRF = future year average / baseline average

2. Future DV = baseline DV * RRF

3. Daily RRFs are for information only. They are not used to calculate the future DV.

Table 2-6. Summary of future design values [ppb].

	run46.fy2009.a2	run46.fy2009.a2 dfw_combo6	run46.fy2009.a2 dfw_combo7	run46.fy2009.a2.df w_combo8
	2009 baseline version a2	2009.a2 with combo 6 controls	2009.a2 with combo 7 controls	2009.a2 with combo 8 controls
Future DVs [ppb]				
Frisco	89.8	88.6	88.7	88.9
Dallas Hinton	86.2	85.2	85.2	85.4
Dallas North C63	85.4	84.4	84.4	84.6
Dallas Exec C402	79.6	78.3	78.3	78.5
Denton	89.3	88.3	88.4	88.5
Midlothian	84.7	83.2	83.2	83.3
Arlington	82.1	80.3	80.3	80.5
Ft Worth C13	86.8	84.9	85.0	85.1
Ft Worth C17	85.4	84.5	84.5	84.7
Differences from 2009.a2 baseline [ppb]				
Frisco		-1.2	-1.1	-0.9
Dallas Hinton		-1.0	-1.0	-0.8
Dallas North C63		-1.0	-1.0	-0.7
Dallas Exec C402		-1.3	-1.3	-1.1
Denton		-1.0	-0.9	-0.8
Midlothian		-1.6	-1.6	-1.4
Arlington		-1.8	-1.8	-1.6
Ft Worth C13		-1.9	-1.8	-1.7
Ft Worth C17		-1.0	-1.0	-0.8
Other Differences [ppb]			Combo7-Combo6	Combo8- Combo7
Frisco			0.1	0.2
Dallas Hinton			0.0	0.2
Dallas North C63			0.0	0.3
Dallas Exec C402			0.0	0.2
Denton			0.1	0.1
Midlothian			0.0	0.2
Arlington			0.0	0.2
Ft Worth C13			0.1	0.1
Ft Worth C17			0.0	0.2

Table 2-7. Ozone responsiveness to changes in NOx emissions [ppb O3 / ton NOx].

	Combo 6 – Combo 5	Combo 7 – Combo 6	Combo 8 – Combo 7
Change in NOx	-30.4 outside DFW	+10.3 tpd outside DFW	+25.6 tpd outside DFW, -1.1 tpd inside DFW
Frisco	0.010	0.011	0.008
Dallas Hinton	0.006	0.000	0.008
Dallas North C63	0.006	0.000	0.011
Dallas Exec C402	0.006	0.000	0.007
Denton	0.007	0.010	0.004
Midlothian	0.009	0.000	0.007
Arlington	0.006	0.000	0.007
Ft. Worth C13	0.007	0.010	0.004
Ft. Worth C17	0.006	0.000	0.008
Average	0.007	0.003	0.007

Table 2-8. Exceedance Area (Number of 4-km grid cells in DFW with the daily max 8-hour ozone \geq 85 ppb).

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_lo_combo6	run46.fy2009.a2. dfw_lo_combo7	run46.fy2009.a2. dfw_lo_combo8
Scenario	2009.a2 baseline	2009 with DFW combo 6 controls	2009 with DFW combo #7 controls	2009 with DFW combo #8 controls
990815	18	12	12	12
990816	220	204	204	208
990817	291	278	278	280
990818	248	233	233	234
990819	323	277	288	289
990820	30	18	18	18
990821	28	21	21	22
990822	0	0	0	0
Totals	1158	1043	1054	1063
% Reduced		-10%	-9%	-8%

Table 2-9. Number of exceedance cells reduced at least 1 ppb.

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo6	run46.fy2009.a2. dfw_combo7	run46.fy2009.a2 dfw_combo8
990815	--	18	18	18
990816	--	169	169	134
990817	--	93	93	88
990818	--	31	31	31
990819	--	119	60	59
990820	--	4	4	4
990821	--	11	10	0
990822	--	0	0	0
Totals	--	445 (38%)	385 (33 %)	334 (29 %)

Table 2-10. Number of ppb's from grid cells in the daily maximum 8-hour ozone in excess of 85 ppb¹.

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo6	run46.fy2009.a2. dfw_combo7	run46.fy2009.a2 dfw_combo8
990815	47	24	24	29
990816	2269	1937	1938	1968
990817	2880	2626	2626	2640
990818	1634	1475	1475	1478
990819	1478	1193	1245	1250
990820	23	11	11	10
990821	69	45	45	49
990822	0	0	0	0
Totals	8400	7312	7364	7423
% Reduced		-13%	-12%	-12%

¹ $\Sigma(\max(O_3-85, 0.0))$ for all grid cells in DFW 9-county NAA.

SUMMARY

Two CAMx simulations examined the impacts to 8-hour ozone in DFW when applying revisions to the East Texas engine controls. One run (Combination 7) removed all engine controls from 6 of the 39 East Texas counties, resulting in a 10.3 tpd NO_x increase, mostly in Wise County. A second run (Combination 8) removed controls applied to the lean-burning engines in the remaining 33 East Texas counties, adding another 25.6 tpd NO_x; the second run also incorporated a 1.1 tpd NO_x reduction from TxLED in locomotive switch engines within DFW for a net increase of 24.5 tpd NO_x.

Combination 7 added no more than 0.1 ppb to the 2009 future design values at any DFW ozone monitoring site. One of the sites was Fort Worth C13, whose future design value increased from 84.9 ppb to 85.0 ppb. Combination 8 added an additional 0.1 to 0.3 ppb to the future design values. Four DFW sites exceeded 85.0 ppb – Frisco, Denton, Dallas Hinton, and Fort Worth C13; their future design values were the same as in the Combination 5 control scenario.

3. DFW CONTROLS EXPECTED TO BE PHASED IN BY 2009 AND 2010

INTRODUCTION

This section evaluates 8-hour ozone in DFW when incorporating only the controls in the Combination 8 scenario that are expected to be phased in by June, 2009 (Combination 9), and controls scheduled for 2010 but are assumed to take place in 2009 (Combination 10).

EMISSIONS

The NO_x and VOC reductions from each control group are listed in Tables 3-1 and 3-2, respectively, for DFW Combinations 8, 9 and 10. Controls that were altered from the previous control scenario are shown in red. The top shows changes within the DFW 9-county NAA; the bottom shows changes outside the DFW NAA.

Combination 9, which incorporated controls that are expected to be in place by 2009, reduced 24.0 tpd NO_x inside the DFW NAA, but added 6.1 tpd NO_x outside DFW; the total NO_x reduction was 17.9 tpd. Compared to Combination 8, NO_x emissions were 7.6 tpd higher inside DFW due to adjustments in controls applied to the DFW major and minor sources, DFW EGUs, and cement kilns; outside DFW, NO_x emissions increased 35.4 tpd because the East Texas engine controls cannot be installed by 2009.

Combination 10, which applied controls scheduled for 2010, reduced 26.4 tpd NO_x within the DFW NAA and 16.3 tpd outside DFW. The total NO_x reduction of 42.7 tpd was 18.3 tpd lower than in Combination 8, but 24.8 tpd higher than in Combination 9 mainly due to more East Texas engine controls.

Tables 3-3 and 3-4 show the 2009 weekday NO_x emissions for the DFW Combination 9 and 10 control scenarios, respectively, broken down by source region, as defined in Figures 2-1 and 2-2, and by emission group (biogenics, elevated points, Texas mobile, low points, area, and off-road, and non-Texas low-level anthropogenics). Differences from the 2009 a2 baseline and from the Combination 8 scenario are shown in the two rightmost columns; these differences may vary slightly from those in Table 3-1 based on the way cells were assigned to each source region.

VOC emissions were unchanged from Combination 8 in both new scenarios. VOCs were 2.9 tpd higher than the 2009.a2 baseline. Table 3-5 shows the weekday VOC emissions separated by the same source regions and emission groups as in Tables 3-3 and 3-4.

Table 3-1. Change in weekday NOx emissions [tpd] by control group from the 2009.a2 baseline.

	DFW Combination 8	DFW Combination 9	DFW Combination 10
Within DFW NAA			
DFW major	-10.5	-8.4	-9.0
DFW minor	-4.5	-1.3	-3.0
DFW EGU	-2.0	-0.4	-0.4
Cement kilns	-11.0	-10.4	-10.4
On-road	-1.4	-1.4	-1.4
Off-road	-2.2	-2.2	-2.2
DFW Total	-31.6	-24.0	-26.4
Outside DFW NAA			
On-road	4.4	4.4	4.4
Off-road	1.7	1.7	1.7
East TX engines	-35.4	0.0	-22.4
Outside DFW Total	-29.3	+6.1	-16.3
Total	-61.0	-17.9	-42.7

Table 3-2. Change in weekday VOC emissions [tpd] by control group from the 2009.a2 baseline.

	DFW Combination 8	DFW Combination 9	DFW Combination 10
Within DFW NAA			
DFW major	0.0	0.0	0.0
DFW minor	0.0	0.0	0.0
DFW EGU	0.0	0.0	0.0
Cement kilns	0.0	0.0	0.0
On-road	-0.5	-0.5	-0.5
Off-road	+0.5	+0.5	+0.5
Surface coating	-0.1	-0.1	-0.1
DFW Total	-0.1	-0.1	-0.1
Outside DFW NAA			
On-road	+1.0	+1.0	+1.0
Off-road	+1.9	+1.9	+1.9
East TX engines	0.0	0.0	0.0
Outside DFW Total	+2.9	+2.9	+2.9
Total	+2.9	+2.9	+2.9

Table 3-3. Weekday NOx emissions [tpd] for 2009.a2 with Combination 9 controls.

NOx	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non-TX Low Anthro	All Anthro	Anthro Change from 2009.a2 Baseline	Anthro Change from Combo 8
Collin Co	10	14	1	0	2	8	0	25	-0.3	0.3
Dallas Co	4	77	5	1	18	44	0	146	-3.1	1.5
Denton Co	8	17	1	0	11	9	0	38	-1.4	0.9
Tarrant Co	3	46	1	1	10	27	0	86	-3.0	0.6
Parker Co	1	6	0	0	1	2	0	9	-0.5	0.7
Johnson Co	5	5	4	0	0	5	0	14	-1.9	0.7
Ellis Co	15	8	22	0	0	6	0	36	-12.8	1.6
Kaufman Co	5	6	4	0	0	2	0	12	-0.4	1.0
Rockwall Co	2	3	0	0	0	1	0	5	-0.1	0.0
DFW 9-County	52	182	38	3	43	105	0	371	-23.4¹	7.4
North Texas	31	24	13	3	18	15	0	73	-0.6	0.1
NE Texas	16	79	186	16	71	42	1	394	0.0	21.1
Central TX	114	92	147	3	60	70	0	373	0.0	12.5
Houston	21	179	226	11	53	63	0	532	4.4	0.1
South TX	229	189	261	22	75	100	0	648	0.0	1.5
West TX	524	160	140	21	212	106	1	641	1.6	0.0
Texas	986	907	1011	79	532	501	2	3032	-17.9	42.7
Gulf + Mexico	79	5	436	0	4	2	444	891	0.0	0.0
Oklahoma	227	1	256	0	2	3	661	924	0.0	0.0
Louisiana	106	1	715	1	2	1	1183	1904	0.0	0.4
Arkansas	125	2	220	0	0	2	468	692	0.0	0.0
Mississippi	121	0	353	0	0	0	455	808	0.0	0.0
Alabama	75	0	442	0	0	0	491	932	0.0	0.0
Tennessee	118	0	244	0	0	0	662	906	0.0	0.0
Kentucky	145	0	289	0	0	0	770	1060	0.0	0.0
Georgia	110	0	408	0	0	0	823	1230	0.0	0.0
Florida	56	0	367	0	0	0	1206	1573	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	293	0	977	0	0	0	2332	3310	0.0	0.0
NE US	314	0	1302	0	0	0	5748	7051	0.0	0.0
Northern Plains	5238	0	3269	0	0	0	8623	11892	0.0	0.0
Total	7992	916	10291	80	542	509	23869	36206	-17.9	43.0
Change from 2009 baseline	0.0	3.0	-16.1	-3.1	-1.3	-0.4	-0.1	-17.9		

¹ Values may differ from Table 3-1 based on how cells were assigned to each region.

Table 3-4. Weekday NOx emissions for DFW 2009.a2 with Combination 10 controls.

	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non-TX Low Anthro	All Anthro	Anthro Change from 2009.a2 Baseline	Anthro change from Combo 8
Collin Co	10	14	1	0	2	8	0	25	-0.3	0.3
Dallas Co	4	77	5	1	18	44	0	145	-3.5	1.1
Denton Co	8	17	1	0	11	9	0	38	-2.1	0.1
Tarrant Co	3	46	1	1	10	27	0	86	-3.2	0.4
Parker Co	1	6	0	0	1	2	0	8	-1.1	0.1
Johnson Co	5	5	3	0	0	5	0	13	-2.2	0.4
Ellis Co	15	8	22	0	0	6	0	36	-12.8	1.6
Kaufman Co	5	6	4	0	0	2	0	12	-0.4	1.0
Rockwall Co	2	3	0	0	0	1	0	5	-0.1	0.0
DFW 9-County	52	182	37	3	41	105	0	369	-25.7¹	5.1
North Texas	31	24	13	3	17	15	0	72	-0.7	0.1
NE Texas	16	79	181	10	68	42	1	380	-13.5	7.6
Central TX	114	92	143	2	58	70	0	366	-7.6	4.9
Houston	21	179	226	11	53	63	0	532	4.4	0.0
South TX	229	189	261	21	75	100	0	647	-1.2	0.3
West TX	524	160	140	21	212	106	1	641	1.6	0.0
Texas	986	907	1001	72	525	501	2	3008	-42.6	18.0
Gulf + Mexico	79	5	436	0	4	2	444	891	0.0	0.0
Oklahoma	227	1	256	0	2	3	661	924	0.0	0.0
Louisiana	106	1	715	1	2	1	1183	1903	-0.1	0.2
Arkansas	125	2	220	0	0	2	468	692	0.0	0.0
Mississippi	121	0	353	0	0	0	455	808	0.0	0.0
Alabama	75	0	442	0	0	0	491	932	0.0	0.0
Tennessee	118	0	244	0	0	0	662	906	0.0	0.0
Kentucky	145	0	289	0	0	0	770	1060	0.0	0.0
Georgia	110	0	408	0	0	0	823	1230	0.0	0.0
Florida	56	0	367	0	0	0	1206	1573	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	293	0	977	0	0	0	2332	3310	0.0	0.0
NE US	314	0	1302	0	0	0	5748	7051	0.0	0.0
Northern Plains	5238	0	3269	0	0	0	8623	11892	0.0	0.0
Total	7992	916	10281	73	534	509	23869	36181	-42.7	18.3
Change from 2009 baseline	0.0	3.0	-26.1	-10.2	-8.92	-0.4	-0.1	-42.7		

¹ Values may differ from Table 3-1 based on how cells were assigned to each region.

Table 3-5. Weekday VOC emissions [tpd] for DFW 2009.a2 with Combination 10 controls.

	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non-TX Low Anthro	All Anthro	Anthro Change from 2009.a2 baseline
Collin Co	27	7	0	1	12	4	0	23	0.0
Dallas Co	50	42	4	8	72	17	0	144	0.0
Denton Co	65	8	1	1	15	4	0	29	0.0
Tarrant Co	64	25	2	7	54	9	0	96	0.0
Parker Co	121	2	0	0	5	1	0	8	0.0
Johnson Co	111	2	0	0	6	1	0	9	0.0
Ellis Co	89	2	3	2	6	2	0	15	0.0
Kaufman Co	112	2	0	0	7	1	0	11	-0.1
Rockwall Co	3	1	0	0	2	1	0	4	0.0
DFW 9-County	642	91	10	20	180	38	0	340	-0.1
North Texas	601	8	24	2	29	5	1	69	0.0
NE Texas	4917	27	14	41	82	14	1	179	0.2
Central TX	6393	35	20	20	91	23	1	191	0.2
Houston	1683	81	91	215	247	42	0	676	1.7
South TX	2069	78	20	48	217	46	0	408	0.5
West TX	6198	59	10	28	215	52	3	367	0.3
Texas	22503	381	188	374	1060	221	6	2230	2.8
Gulf + Mexico	658	3	32	0	10	4	329	378	0.0
Oklahoma	7940	1	3	0	5	1	481	490	0.0
Louisiana	9941	0	47	3	4	1	546	601	0.0
Arkansas	13925	0	23	0	2	0	441	466	0.0
Mississippi	14818	0	35	0	0	0	548	583	0.0
Alabama	13954	0	39	0	0	0	655	695	0.0
Tennessee	8678	0	66	0	0	0	895	961	0.0
Kentucky	3753	0	34	0	0	0	622	656	0.0
Georgia	12198	0	53	0	0	0	869	922	0.0
Florida	9793	0	42	0	0	0	1594	1636	0.0
Mid Atlantic (SC, NC, VA, WV)	31294	0	67	0	0	0	2836	2903	0.0
NE US	20472	0	248	0	0	0	5407	5655	0.0
Northern Plains	40144	0	226	0	0	0	8224	8450	0.0
Total	210073	385	1104	377	1080	227	23453	26625	2.9
Change from 2009 baseline	0.0	0.5	0.0	-0.1	0.0	2.4	0.0	2.9	

MODELING RESULTS

Spatial plots of the daily maximum 8-hour ozone in the Combination 9 and 10 scenarios are displayed in the left and right columns of Figure 3-1, respectively, for each episode date. Three sets of difference plots for Combination 9 (left) and Combination 10 (right) are shown in Figure 3-2 to highlight differences between the controls. The top plots show differences from Combination 8; the center plots show differences from the 2009.a2 baseline; the bottom plots show changes from the 1999 baseline. The latter uses a color scale 10 times the magnitude of the others.

The Combination 9 NO_x controls were 43 tpd less effective than Combination 8, resulting in 8-hour ozone increases of at least 0.5 ppb across much of the DFW NAA on August 15, 16, 21, and 22. The largest increase occurred on August 15, when ozone was more than 2 ppb higher in southern DFW. Compared to the 2009.a2 baseline, the ozone benefits were greatest in the western DFW NAA, particularly in Tarrant County, where the Combination 9 controls lowered the daily maximum 8-hour ozone at least 2 ppb on four episode dates.

In Combination 10, the NO_x controls were 18 tpd less effective than Combination 8, adding up to 1.0 ppb to the daily maximum 8-hour ozone within the DFW NAA on each episode date. On half of the episode dates, the largest 8-hour ozone increase in the 4 km domain was in Dallas County, where local increases of 0.7 to 1.0 ppb were found. Compared to the 2009.a2 baseline, the Combination 10 ozone benefits were more widespread across DFW than in Combination 9 as some of the East Texas engine controls were reintroduced in Combination 10. Tarrant County continued to benefit the most from the combination of controls.

The 2009 8-hour ozone future design value calculations for the DFW Combination 9 and 10 scenarios are shown in Tables 3-6 and 3-7, respectively, for all DFW monitoring sites using the 1999 baseline design values. Daily relative reduction factors are included at the bottom of each table. Table 3-8 compares the future design values with the 2009.a2 baseline and Combination 8. Values greater than or equal to 85.0 ppb are listed in red.

In the 2009 baseline, six of the nine DFW sites had future design values greater than or equal to 85.0 ppb – Frisco, Denton, Dallas Hinton, Fort Worth C13, Dallas North, and Fort Worth C17. In Combination 8, the latter two sites dropped below 85.0 ppb leaving four of the six sites above 85 ppb. In Combination 9, all six sites were over 85.0 ppb as the future design values increased 0.4 to 0.7 ppb from Combination 8. Frisco had the largest increase, adding 0.7 ppb to 89.6 ppb, putting its future design value only 0.2 ppb less than in the 2009.a2 baseline.

If the controls scheduled for 2010 were phased in (Combination 10), future design values at each DFW site would be 0.2 to 0.3 ppb lower than in Combination 9, but still 0.2 to 0.4 ppb higher than in Combination 8. The Combination 10 scenario had four sites with future design values over 85.0 ppb – Frisco, Denton, Dallas Hinton, and Fort Worth C13; these are the same four sites over 85.0 ppb in Combination 8. Frisco had the highest future design value at 89.3 ppb followed by Denton at 88.7 ppb; these values were 0.5 and 0.6 ppb lower than in the 2009.a2 baseline, respectively. The largest reduction from the Combination 10 controls was at Fort Worth C13, where the future design value dropped 1.4 ppb to 85.4 ppb.

Table 3-9 lists the future design value responsiveness at each DFW site, calculated from the ozone response to NO_x emission changes relative to Combination 8. For Combination 9, the average response rate of 0.012 ppb O₃ per ton of NO_x was higher than the responses seen previously for NO_x changes between Combinations 5 through 8. Combinations 6, 7 and 8 involved NO_x emissions changes outside of the DFW NAA and produced average response rates of 0.003 to 0.007 ppb O₃ per ton of NO_x. Combination 9 had 18 percent of the NO_x emissions changes within the DFW NAA. Combination 10 was slightly more responsive than Combination 9 because Combination 10 had 29 percent of the NO_x emission changes within DFW.

Tables 3-10 to 3-12 examine the 4-km grid cells in the DFW 9-county NAA in which the daily maximum 8-hour ozone exceeded 85 ppb. Table 3-10 lists the number of unique grid cells in DFW that exceed 85 ppb for each date in the 2009 baseline and in Combinations 8 to 10. For the

episode, Combination 8 reduced the exceedance area by 8 %. Combinations 9 and 10 only lowered the exceedance area by 5 % and 6 %, respectively.

Table 3-11 shows the number of baseline exceedance cells that were reduced at least 1 ppb from the combination of controls. In Combination 8, 344 of the 1158 exceedance cells (29 %) were reduced at least 1 ppb from the controls. In Combination 9, half as many cells were reduced at least 1 ppb (13 %); Combination 10 reduced 17 %.

Table 3-12 sums the number of ppb's in the daily maximum 8-hour ozone that exceed 85 ppb. For example, if the daily maximum ozone in a grid cell is 90 ppb, the grid cell adds 5 ppb (90 – 85 ppb) to the sum of ozone exceedances. The number of exceedance ppb's among all episode dates was reduced 12% in Combination 8, and dropped to 7 % and 9 % in Combinations 9 and 10.

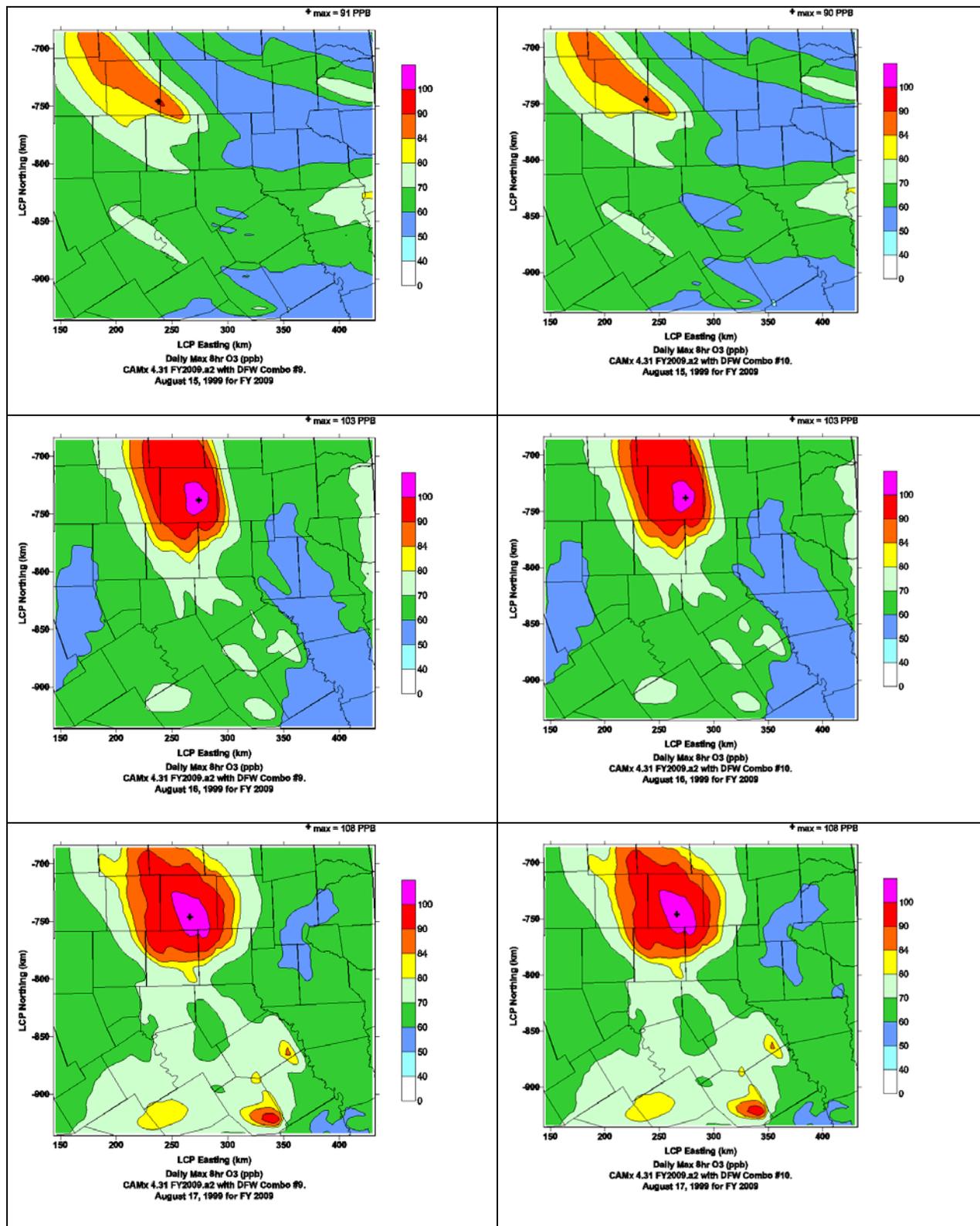


Figure 3-1. Spatial plots of the daily maximum 8-hour ozone for each episode date in the DFW Combination 9 (left) and Combination 10 (right) scenarios.

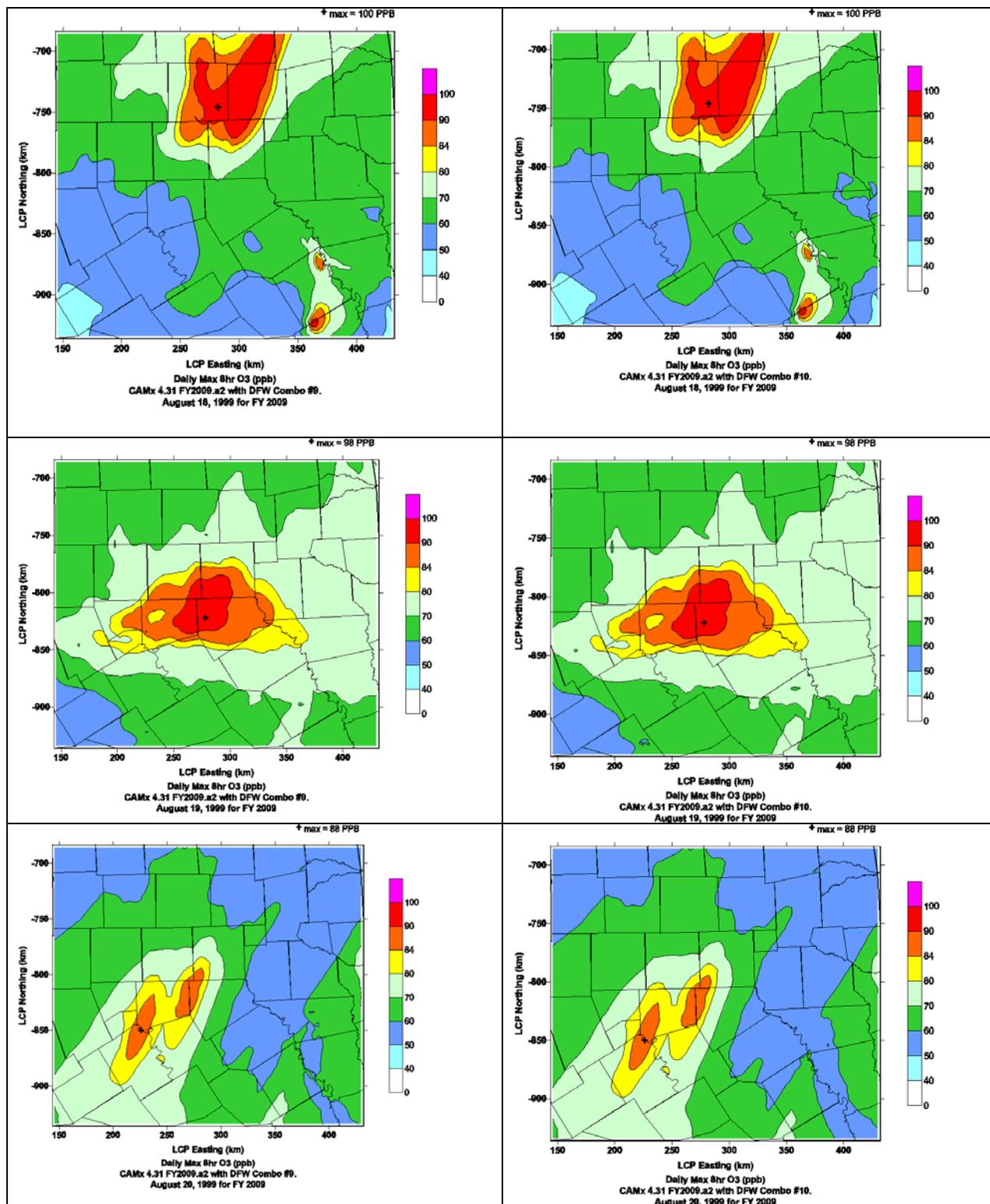


Figure 3-1. Continued. Spatial plots of the daily maximum 8-hour ozone for each episode date in the DFW Combination 9 (left) and Combination 10 (right) scenarios.

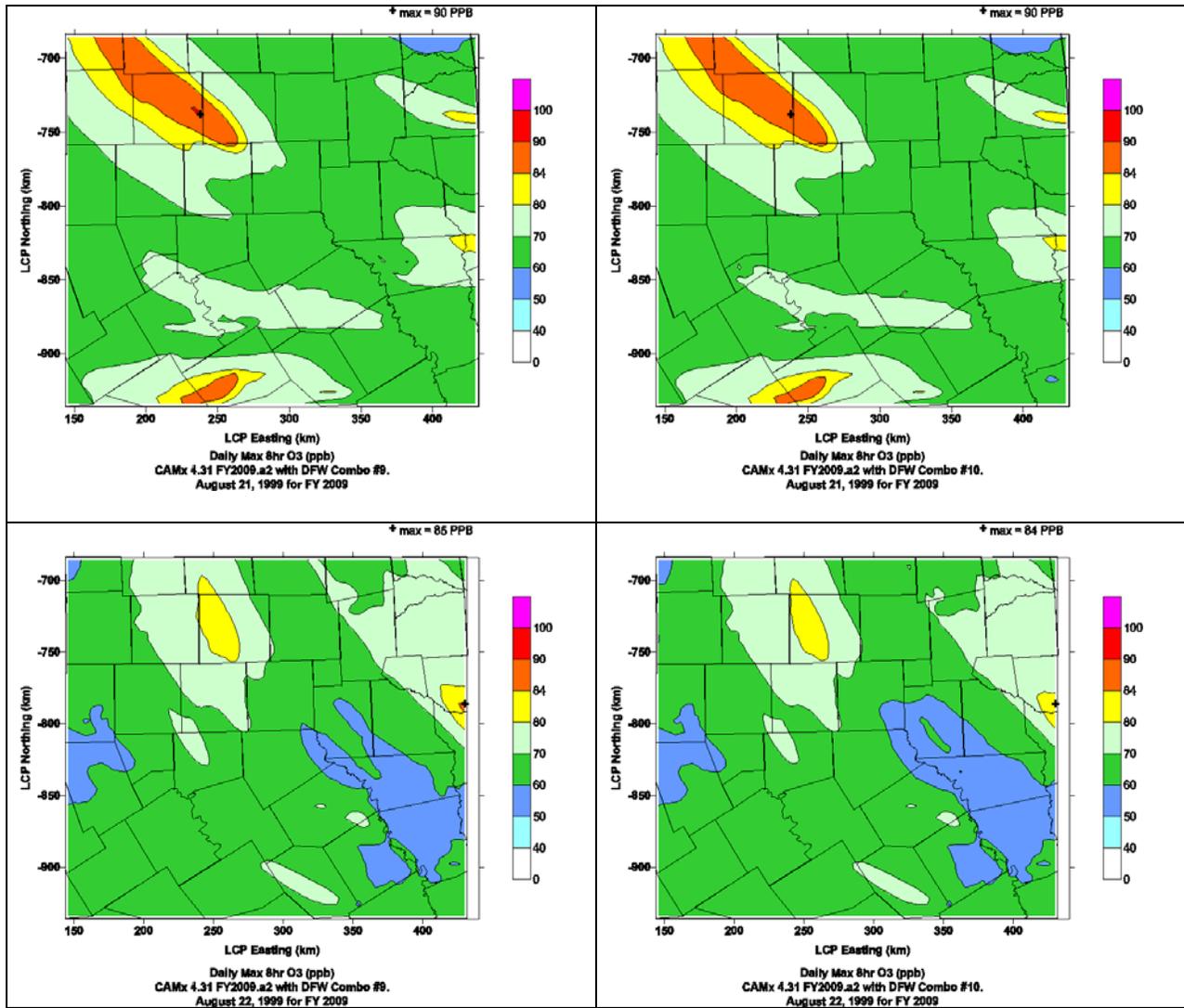


Figure 3-1. Concluded.

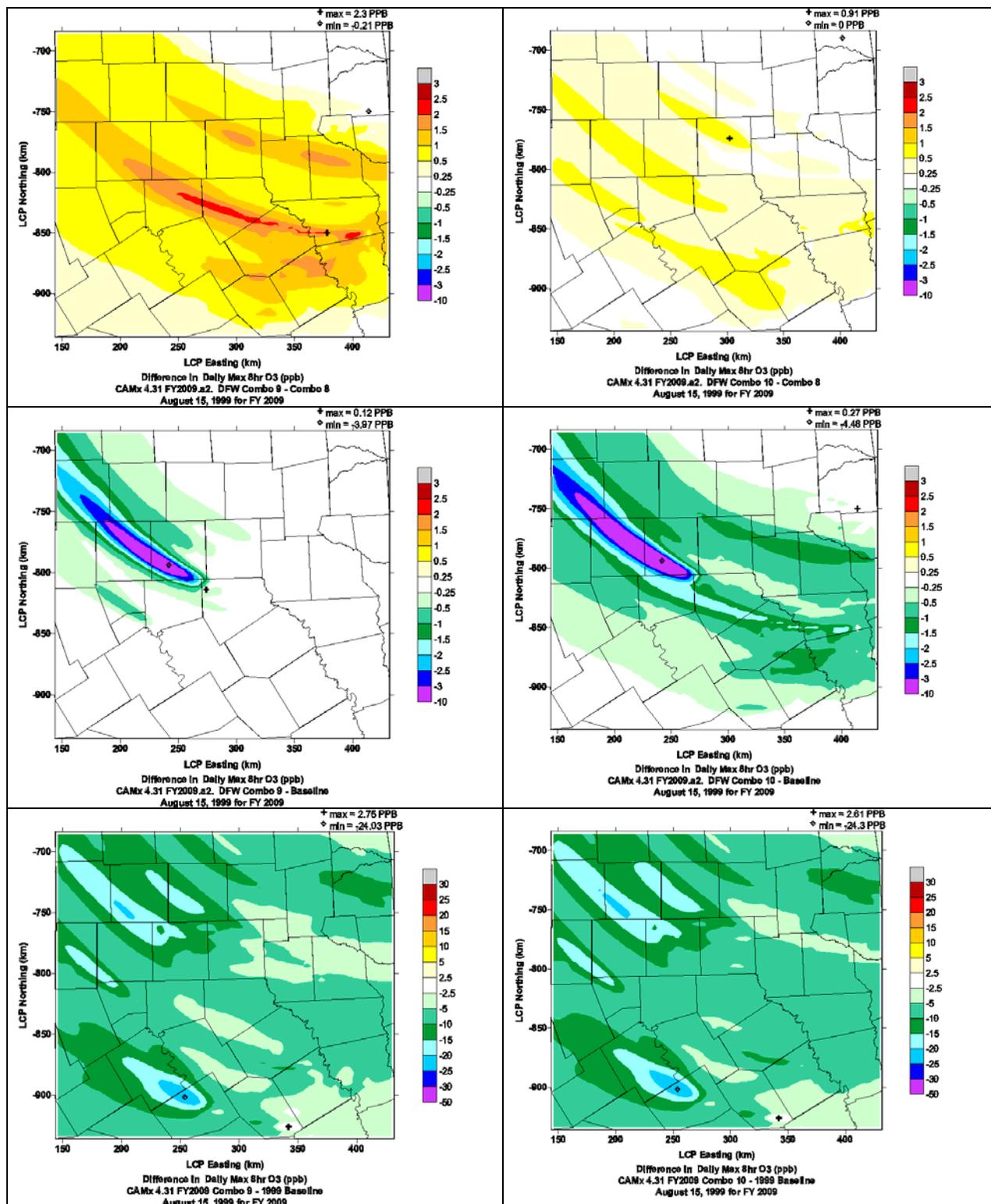


Figure 3-2. Spatial plots of differences in the daily maximum 8-hour ozone for Combination 9 (left) and Combination 10 (right) showing changes from Combination 8 (top), from the 2009.a2 baseline (middle), and from the 1999 baseline (bottom – note difference in color scale).

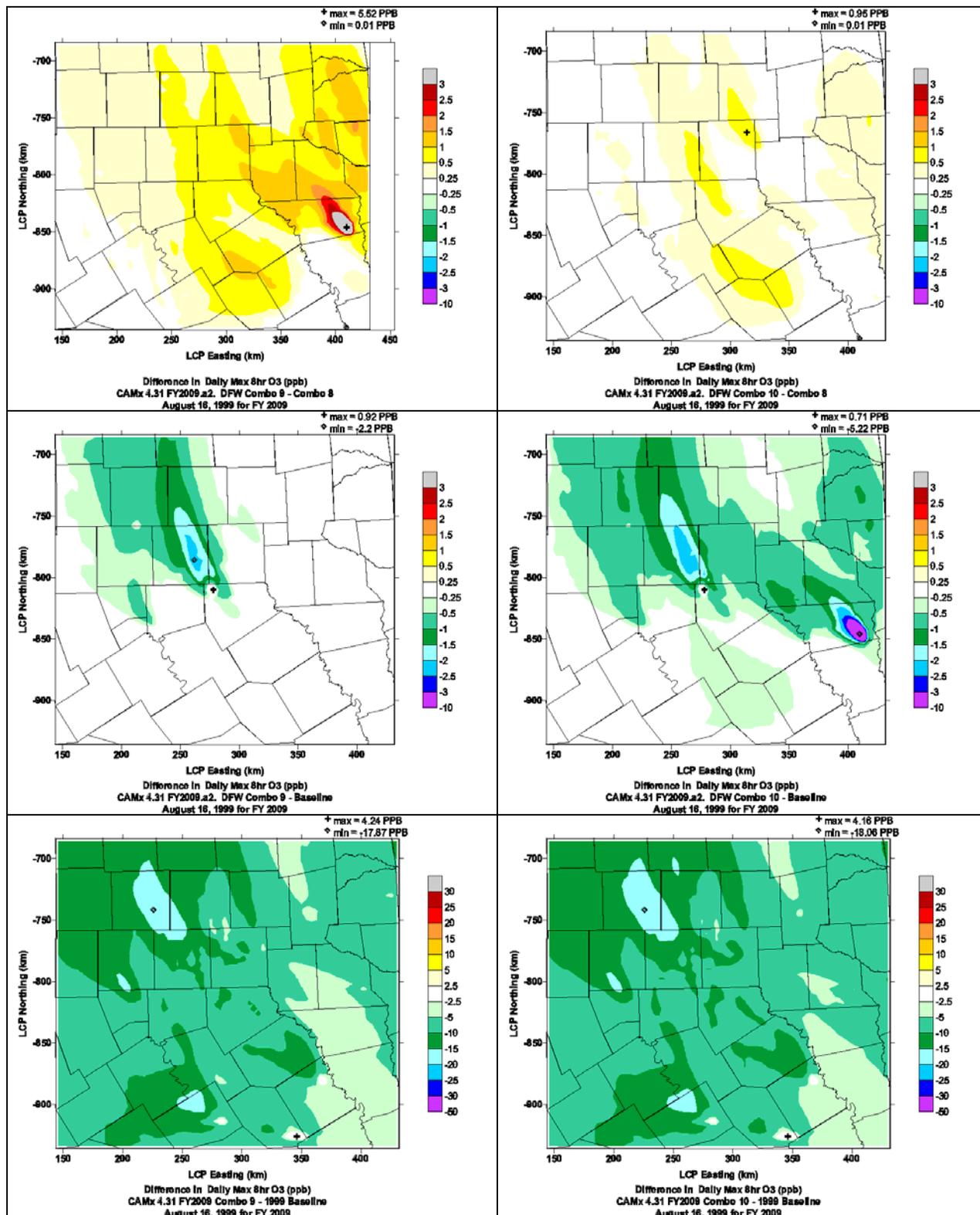


Figure 3-2. Continued. Spatial plots of differences in the daily maximum 8-hour ozone for Combination 9 (left) and Combination 10 (right) showing changes from Combination 8 (top), from the 2009.a2 baseline (middle), and from the 1999 baseline (bottom – note difference in color scale).

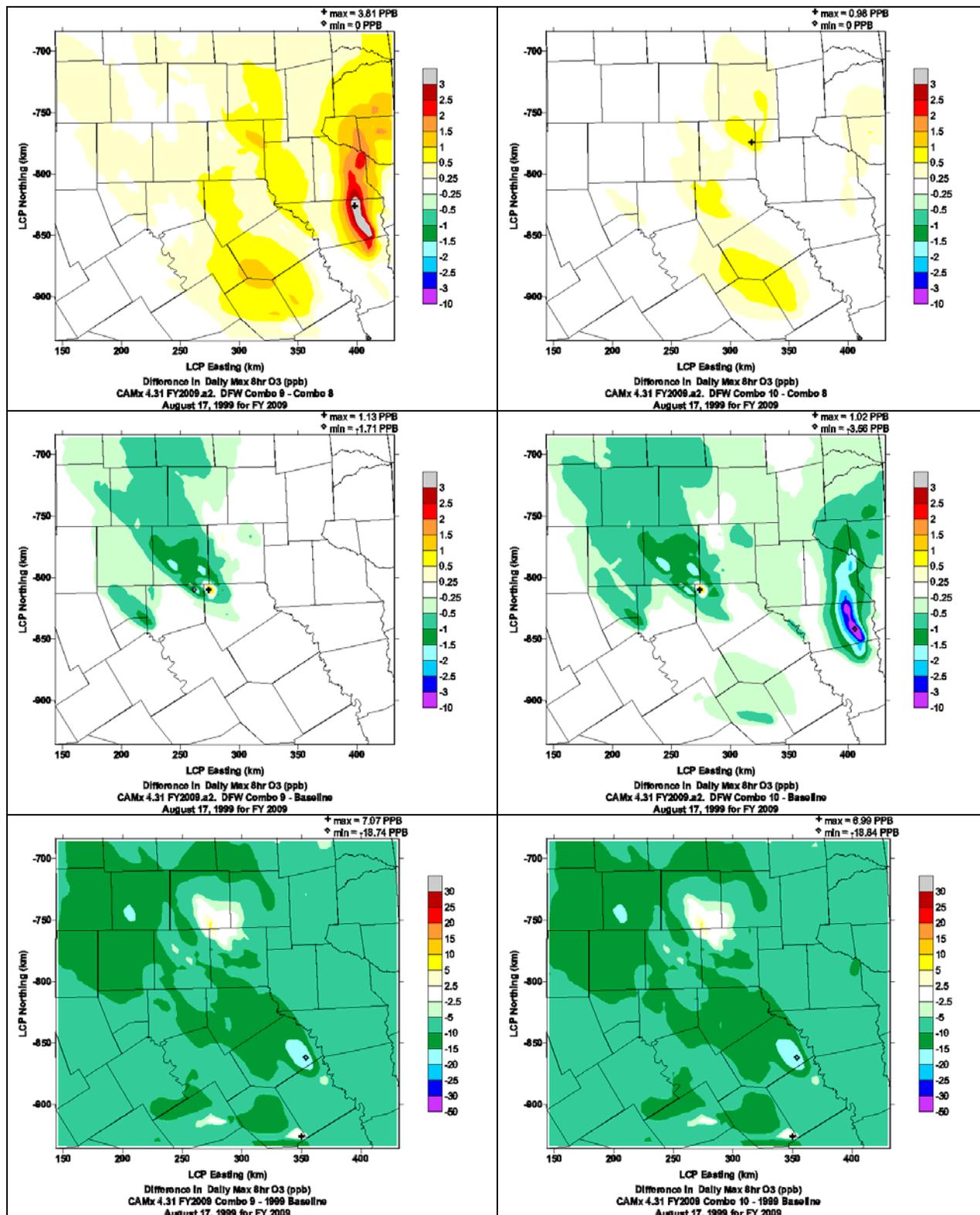


Figure 3-2. Continued. Spatial plots of differences in the daily maximum 8-hour ozone for Combination 9 (left) and Combination 10 (right) showing changes from Combination 8 (top), from the 2009.a2 baseline (middle), and from the 1999 baseline (bottom – note difference in color scale).

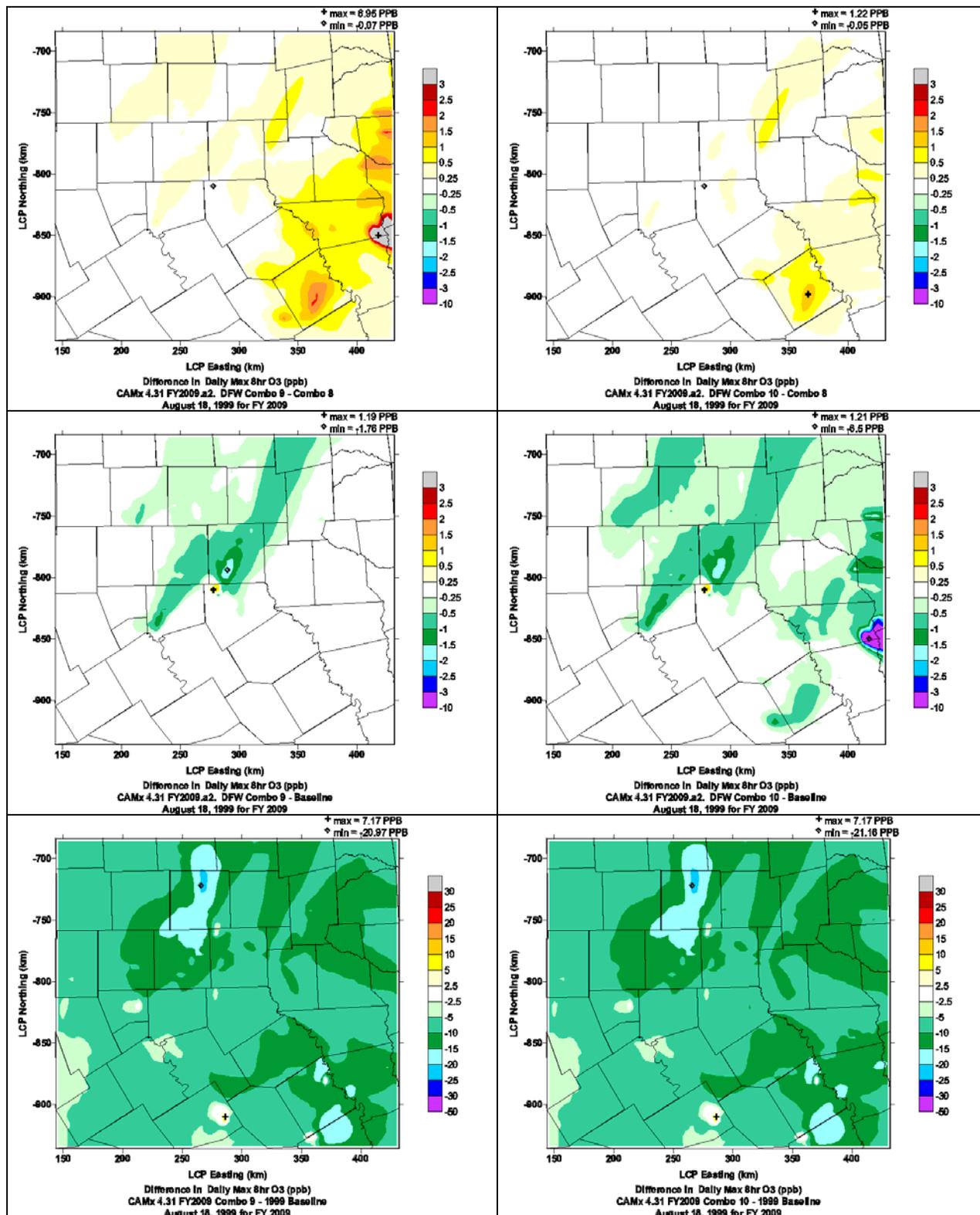


Figure 3-2. Continued. Spatial plots of differences in the daily maximum 8-hour ozone for Combination 9 (left) and Combination 10 (right) showing changes from Combination 8 (top), from the 2009.a2 baseline (middle), and from the 1999 baseline (bottom – note difference in color scale).

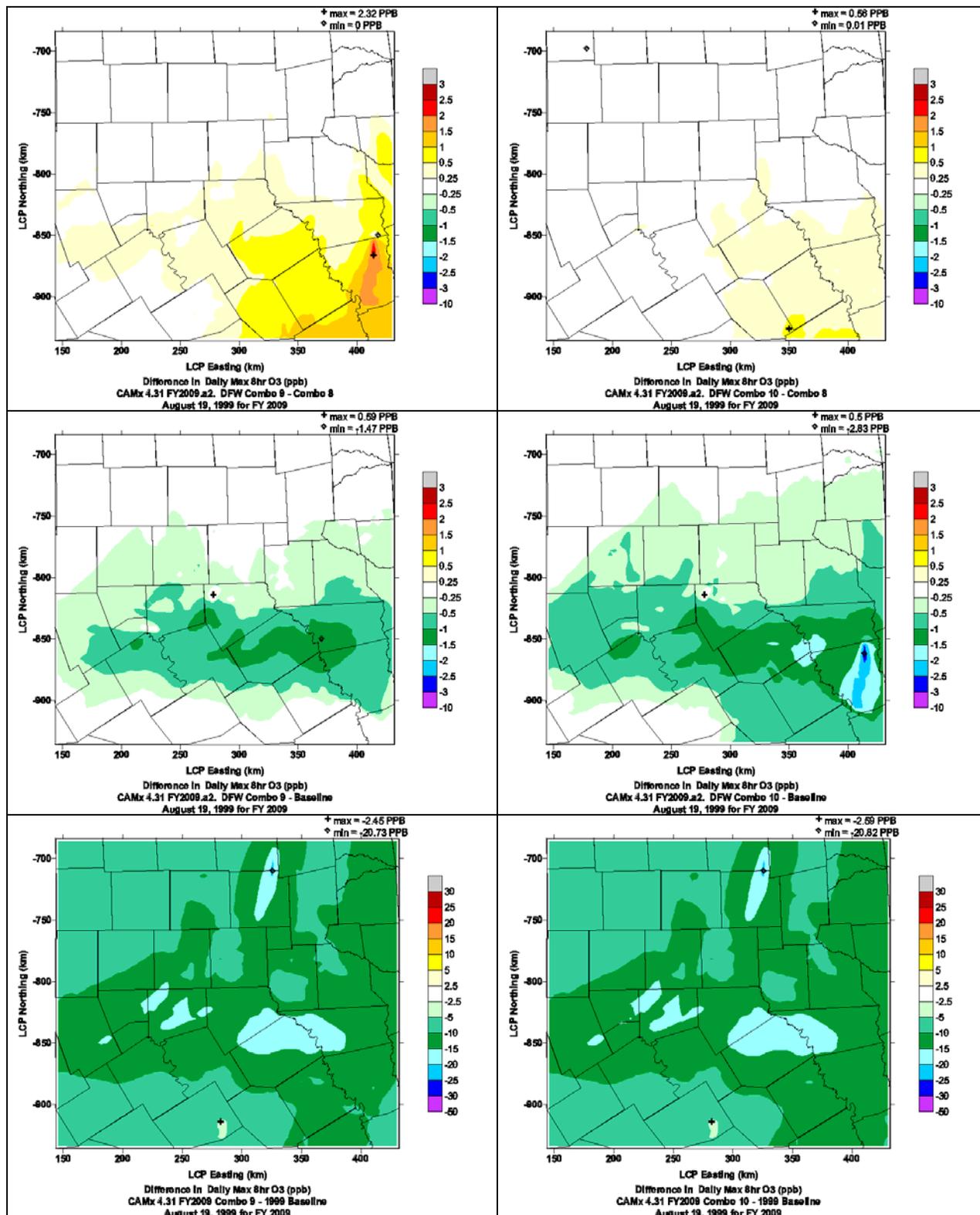


Figure 3-2. Continued. Spatial plots of differences in the daily maximum 8-hour ozone for Combination 9 (left) and Combination 10 (right) showing changes from Combination 8 (top), from the 2009.a2 baseline (middle), and from the 1999 baseline (bottom – note difference in color scale).

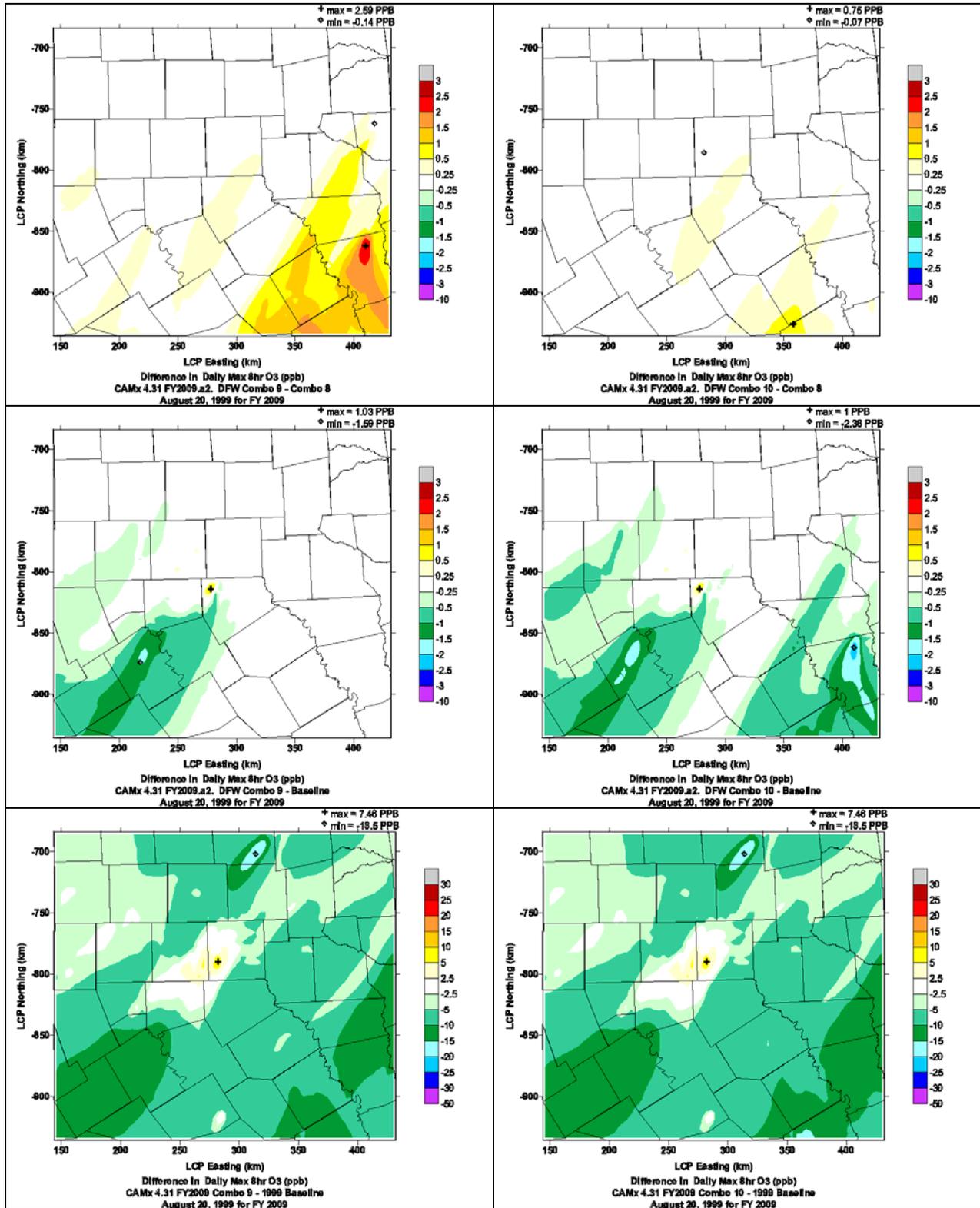


Figure 3-2. Continued. Spatial plots of differences in the daily maximum 8-hour ozone for Combination 9 (left) and Combination 10 (right) showing changes from Combination 8 (top), from the 2009.a2 baseline (middle), and from the 1999 baseline (bottom – note difference in color scale).

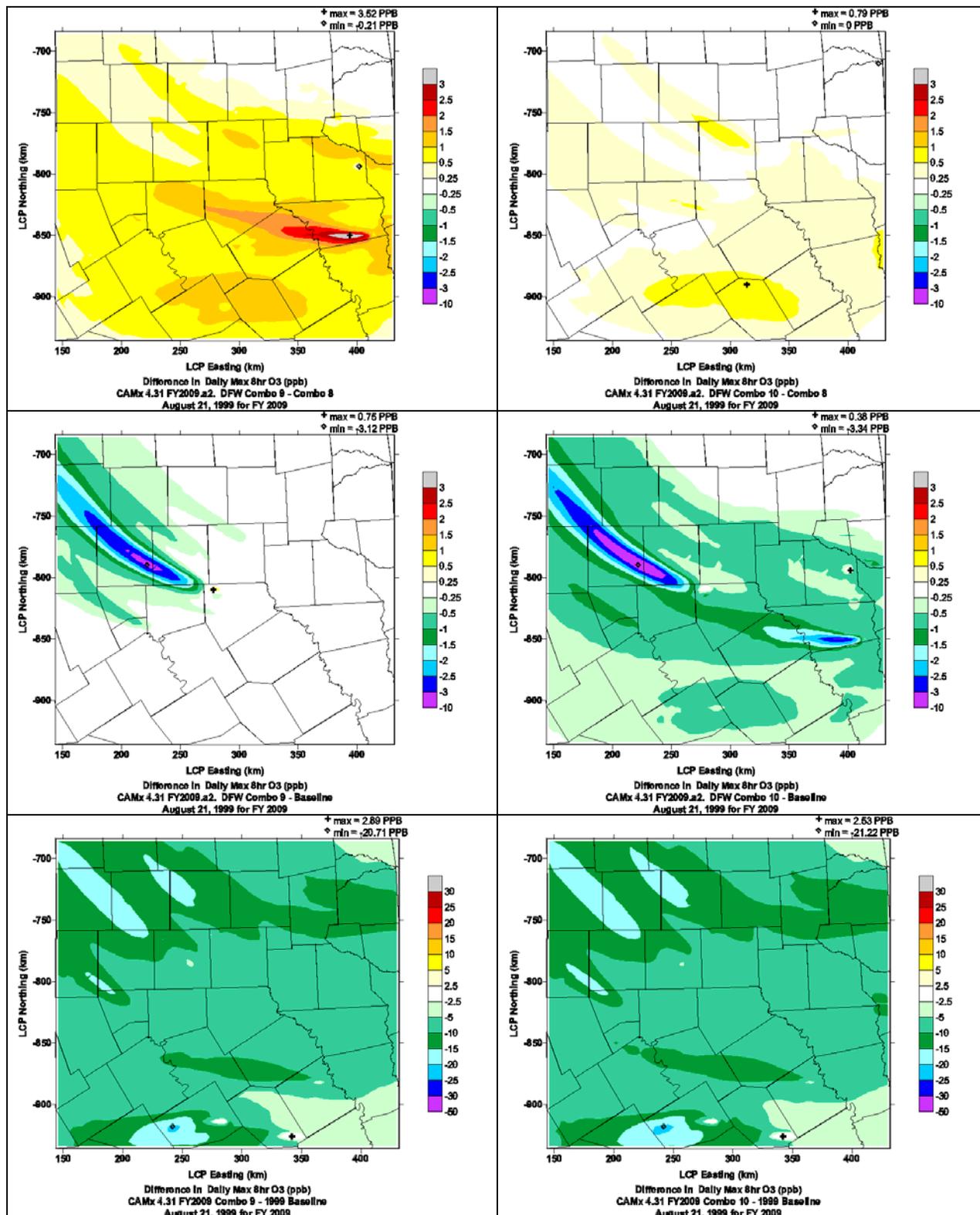


Figure 3-2. Continued. Spatial plots of differences in the daily maximum 8-hour ozone for Combination 9 (left) and Combination 10 (right) showing changes from Combination 8 (top), from the 2009.a2 baseline (middle), and from the 1999 baseline (bottom – note difference in color scale).

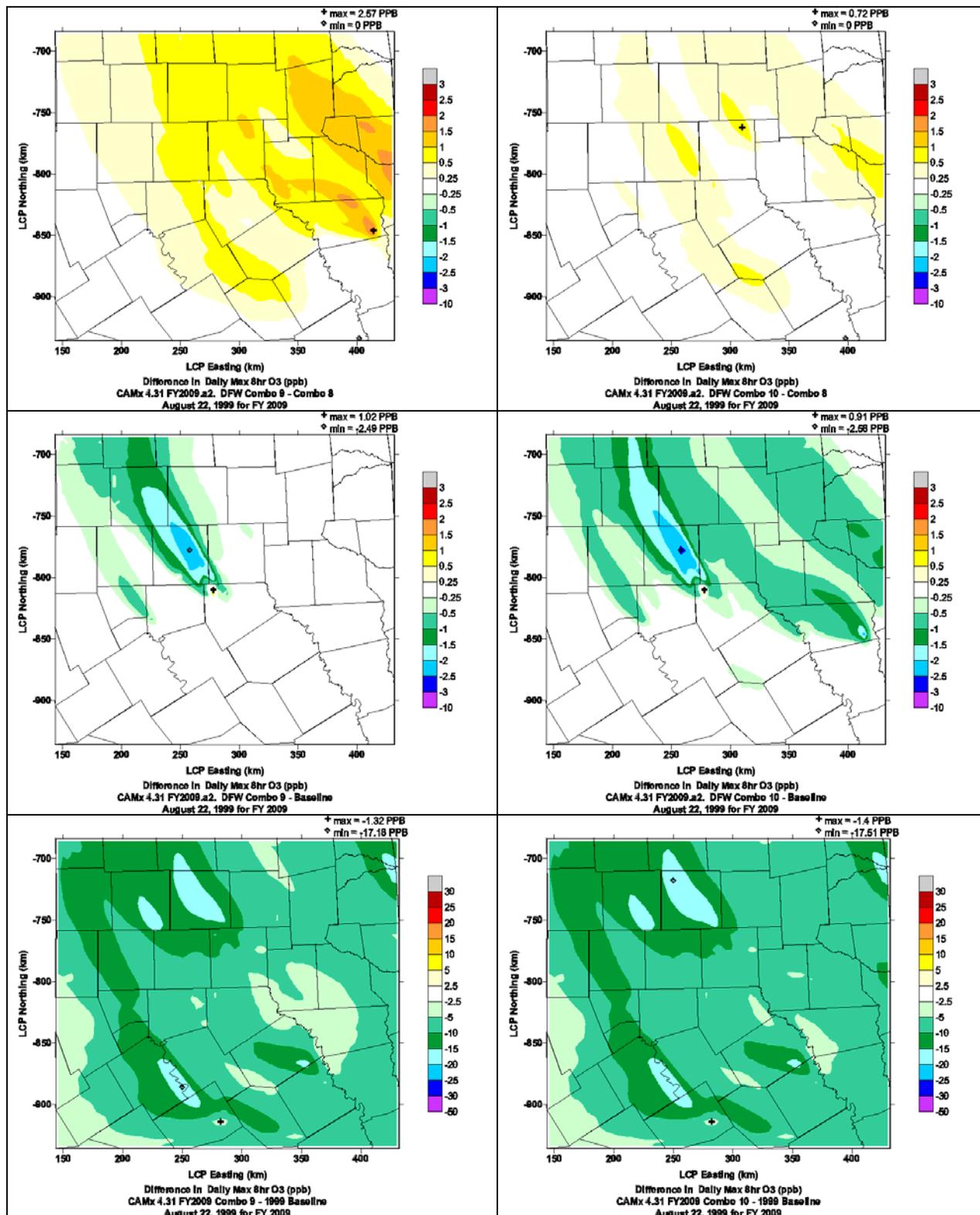


Figure 3-2. Concluded. Spatial plots of differences in the daily maximum 8-hour ozone for Combination 9 (left) and Combination 10 (right) showing changes from Combination 8 (top), from the 2009.a2 baseline (middle), and from the 1999 baseline (bottom – note difference in color scale).

Table 3-6. Future design value scaling calculations for 2009.a2 with Combination 9 controls.

Base Case: run46												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	#Days>70		
Frisco	81.3	107.0	102.6	109.2	86.0	69.9	87.1	89.5	94.7	7		
Dallas HintonC60	83.1	99.8	103.4	103.8	99.2	78.0	85.5	85.3	92.3	8		
Dallas North C63	82.6	101.3	102.6	106.6	96.5	76.4	86.8	88.4	92.6	8		
Dallas Exec C402	77.0	93.3	98.5	96.6	107.4	83.7	79.4	79.5	89.4	8		
Denton	102.6	113.1	110.0	112.5	84.7	73.1	101.6	99.6	99.7	8		
Midlothian	78.3	86.1	85.9	76.2	114.0	88.8	75.7	76.7	85.2	8		
Arlington	86.2	98.4	100.2	95.2	106.9	83.1	81.9	86.7	92.3	8		
Ft Worth C13	93.8	105.5	104.3	106.0	96.0	80.1	89.8	92.0	95.9	8		
Ft Worth C17	101.1	111.1	110.4	108.3	92.4	78.6	95.9	94.9	99.1	8		
Future Year: run46.fy2009.a2.dfw_combo9												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	RRF ¹	BaseDV	Future DV ² [ppb]
Frisco	67.4	100.6	101.8	100.0	73.0	63.9	74.5	74.2	84.5	0.893	100.3	89.57
Dallas HintonC60	72.8	92.6	103.3	97.2	91.3	80.7	77.8	73.6	86.1	0.934	92.0	85.93
Dallas North C63	70.8	95.3	101.8	99.2	84.2	77.4	76.0	73.8	84.8	0.916	93.0	85.19
Dallas Exec C402	66.4	81.6	88.9	83.9	96.6	85.2	70.2	69.6	80.3	0.898	88.0	79.02
Denton	88.2	102.9	107.7	91.7	71.4	64.5	89.6	83.0	87.4	0.877	101.5	89.02
Midlothian	70.3	76.2	78.9	70.6	98.2	85.5	69.1	70.0	77.3	0.908	92.5	83.99
Arlington	72.7	87.0	89.7	81.0	95.2	85.2	72.6	77.1	82.6	0.894	90.5	80.91
Ft Worth C13	78.2	92.6	93.4	87.5	83.2	75.6	78.7	78.8	83.5	0.871	98.3	85.62
Ft Worth C17	89.0	97.9	103.8	90.0	78.9	70.5	87.9	81.7	87.5	0.883	96.3	85.03
Daily RRFs ³												
Site	990815	990816	990817	990818	990819	990820	990821	990822				
Frisco	0.828	0.940	0.992	0.917	0.849	0.914	0.856	0.828				
Dallas HintonC60	0.876	0.927	0.999	0.936	0.919	1.036	0.909	0.863				
Dallas North C63	0.858	0.941	0.992	0.930	0.873	1.013	0.876	0.835				
Dallas Exec C402	0.862	0.874	0.902	0.869	0.899	1.017	0.884	0.876				
Denton	0.859	0.910	0.978	0.815	0.843	0.882	0.881	0.833				
Midlothian	0.898	0.885	0.919	0.925	0.862	0.963	0.912	0.913				
Arlington	0.843	0.885	0.894	0.851	0.891	1.025	0.886	0.889				
Ft Worth C13	0.833	0.878	0.895	0.826	0.867	0.944	0.877	0.857				
Ft Worth C17	0.880	0.881	0.940	0.831	0.855	0.897	0.917	0.861				

(1) RRF = future year average / baseline average

(2) Future DV = baseline DV * RRF

(3) Daily RRFs are for information only. They are not used to calculate the future DV

Table 3-7. Future design value scaling calculations for 2009.a2 with Combination 10 controls.

Base Case: run46												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	#Days>70		
Frisco	81.3	107.0	102.6	109.2	86.0	69.9	87.1	89.5	94.7	7		
Dallas HintonC60	83.1	99.8	103.4	103.8	99.2	78.0	85.5	85.3	92.3	8		
Dallas North C63	82.6	101.3	102.6	106.6	96.5	76.4	86.8	88.4	92.6	8		
Dallas Exec C402	77.0	93.3	98.5	96.6	107.4	83.7	79.4	79.5	89.4	8		
Denton	102.6	113.1	110.0	112.5	84.7	73.1	101.6	99.6	99.7	8		
Midlothian	78.3	86.1	85.9	76.2	114.0	88.8	75.7	76.7	85.2	8		
Arlington	86.2	98.4	100.2	95.2	106.9	83.1	81.9	86.7	92.3	8		
Ft Worth C13	93.8	105.5	104.3	106.0	96.0	80.1	89.8	92.0	95.9	8		
Ft Worth C17	101.1	111.1	110.4	108.3	92.4	78.6	95.9	94.9	99.1	8		
Future Year: run46.fy2009.a2.dfw_combo10												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	RRF ¹	BaseDV	Future DV ² [ppb]
Frisco	66.8	100.4	101.7	99.9	72.9	63.9	74.2	73.7	84.2	0.890	100.3	89.27
Dallas HintonC60	72.1	92.3	103.2	97.1	91.2	80.7	77.4	73.1	85.9	0.931	92.0	85.65
Dallas North C63	70.2	95.1	101.7	99.1	84.1	77.4	75.6	73.3	84.6	0.913	93.0	84.91
Dallas Exec C402	65.9	81.3	88.8	83.8	96.5	85.1	69.7	69.5	80.1	0.895	88.0	78.76
Denton	87.7	102.7	107.6	91.5	71.2	64.4	89.4	82.6	87.1	0.874	101.5	88.71
Midlothian	69.8	76.1	78.9	70.6	98.1	85.5	68.5	69.9	77.2	0.905	92.5	83.71
Arlington	72.3	86.9	89.6	80.9	95.1	85.1	72.3	77.0	82.4	0.892	90.5	80.73
Ft Worth C13	77.8	92.5	93.3	87.4	83.1	75.6	78.5	78.7	83.3	0.869	98.3	85.42
Ft Worth C17	88.5	97.6	103.7	89.9	78.8	70.5	87.7	81.3	87.3	0.881	96.3	84.84
Daily RRFs ³												
Site	990815	990816	990817	990818	990819	990820	990821	990822				
Frisco	0.821	0.938	0.991	0.916	0.848	0.914	0.852	0.823				
Dallas HintonC60	0.868	0.924	0.998	0.936	0.919	1.036	0.905	0.857				
Dallas North C63	0.850	0.939	0.991	0.929	0.872	1.013	0.872	0.829				
Dallas Exec C402	0.856	0.871	0.901	0.868	0.898	1.017	0.879	0.874				
Denton	0.855	0.908	0.978	0.813	0.841	0.881	0.879	0.829				
Midlothian	0.891	0.884	0.918	0.926	0.861	0.962	0.905	0.912				
Arlington	0.838	0.883	0.894	0.849	0.890	1.025	0.882	0.888				
Ft Worth C13	0.829	0.877	0.894	0.825	0.866	0.943	0.874	0.856				
Ft Worth C17	0.876	0.879	0.940	0.830	0.853	0.897	0.914	0.857				

1. RRF = future year average / baseline average

2. Future DV = baseline DV * RRF

3. Daily RRFs are for information only. They are not used to calculate the future DV

Table 3-8. 2009 future design value summary [ppb].

	run46.fy2009.a2 (2009 baseline)	run46.fy2009.a2. dfw_combo8	run46.fy2009.a2. dfw_combo9	run46.fy2009.a2. dfw_combo10
Frisco	89.8	88.9	89.6	89.3
Dallas Hinton C60	86.2	85.4	85.9	85.7
Dallas North C63	85.4	84.6	85.2	84.9
Dallas Exec C402	79.6	78.5	79.0	78.8
Denton	89.3	88.5	89.0	88.7
Midlothian	84.7	83.3	84.0	83.7
Arlington	82.1	80.5	80.9	80.7
Ft Worth C13	86.8	85.1	85.6	85.4
Ft Worth C17	85.4	84.7	85.0	84.8
Differences from the 2009 a2 baseline				
Frisco		-0.9	-0.2	-0.5
Dallas Hinton C60		-0.8	-0.3	-0.5
Dallas North C63		-0.7	-0.2	-0.5
Dallas Exec C402		-1.1	-0.6	-0.9
Denton		-0.8	-0.3	-0.6
Midlothian		-1.4	-0.7	-1.0
Arlington		-1.6	-1.2	-1.3
Ft Worth C13		-1.7	-1.2	-1.4
Ft Worth C17		-0.8	-0.4	-0.6
Differences from DFW Combination 8				
Frisco			0.7	0.4
Dallas Hinton C60			0.6	0.3
Dallas North C63			0.6	0.3
Dallas Exec C402			0.5	0.3
Denton			0.5	0.2
Midlothian			0.6	0.4
Arlington			0.5	0.3
Ft Worth C13			0.5	0.3
Ft Worth C17			0.4	0.2

Table 3-9. Ozone responsiveness to changes in NO_x emissions [ppb O₃/ton NO_x].

	Combo 9 – Combo 8	Combo 10 – Combo 8
Change in NO _x	+7.6 tpd inside DFW, +35.4 tpd outside DFW	+5.2 tpd inside DFW, +13.0 tpd outside DFW
Frisco	0.016	0.022
Dallas Hinton	0.013	0.015
Dallas North C63	0.013	0.015
Dallas Exec C402	0.012	0.014
Denton	0.012	0.011
Midlothian	0.015	0.020
Arlington	0.011	0.015
Ft Worth C13	0.011	0.016
Ft Worth C17	0.009	0.010
Average	0.012	0.015

Table 3-10. Exceedance Area (Number of 4-km grid cells in DFW with the daily max 8-hour ozone \geq 85 ppb).

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo8	run46.fy2009.a2. dfw_combo9	run46.fy2009.a2. dfw_combo10
Scenario	2009 baseline	2009 with DFW combo 8 controls	2009 with DFW combo 9 controls	2009 with DFW combo 10 controls
990815	18	12	16	13
990816	220	208	210	210
990817	291	280	287	284
990818	248	234	239	235
990819	323	289	301	297
990820	30	18	22	20
990821	28	22	27	25
990822	0	0	0	0
Total	1158	1063	1102	1084
% Reduced		-8.2 %	-4.8 %	-6.4 %

Table 3-11. Number of exceedance cells reduced at least 1 ppb.

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo8	run46.fy2009.a2. dfw_combo9	run46.fy2009.a2. dfw_combo10
990815	--	18	0	0
990816	--	134	97	106
990817	--	88	33	51
990818	--	31	4	6
990819	--	59	20	31
990820	--	4	1	3
990821	--	0	0	0
990822	--	0	0	0
Total	--	334 (29 %)	155 (13 %)	197 (17 %)

Table 3-12. Number of ppb's from grid cells in the daily maximum 8-hour ozone in excess of 85 ppb¹.

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo8	run46.fy2009.a2. dfw_combo9	run46.fy2009.a2. dfw_combo10
990815	47	29	41	34
990816	2269	1968	2084	2039
990817	2880	2640	2732	2706
990818	1634	1478	1535	1510
990819	1478	1250	1331	1299
990820	23	10	13	12
990821	69	49	62	56
990822	0	0	0	0
Total	8400	7423	7798	7656
% Reduced		-12 %	-7 %	-9 %

¹ $\Sigma(\max(O_3-85, 0.0))$ for all grid cells in DFW 9-county NAA.

SUMMARY

Two CAMx simulations examined the impacts to 8-hour ozone in DFW when applying only the Combination 8 controls that could be phased in by 2009 (Combination 9), and controls that could be phased in by 2010, but are assumed to be in place by 2009 (Combination 10). Combination 9 reduced 24.0 tpd NO_x inside the DFW NAA, but added 6.1 tpd outside DFW (17.9 tpd total NO_x reduction). Combination 10 reduced 26.4 tpd NO_x within DFW and 16.3 outside DFW (42.7 tpd total NO_x reduction).

Combination 9 added 0.4 to 0.7 ppb to each of the DFW future design values when compared to Combination 8. Six of the nine sites had future design values of at least 85 ppb. Frisco had the highest future design value at 89.6 ppb, and was only 0.2 ppb lower than the 2009.a2 baseline. The future design values at each DFW site in Combination 10 were 0.2 to 0.3 ppb lower than in Combination 9, but 0.2 to 0.4 ppb higher than in Combination 8. The four DFW sites with future design values greater than 85 ppb in Combination 8 were the same four in Combination 10 (Frisco, Denton, Dallas Hinton, and Fort Worth C13). Frisco was highest at 89.3 ppb.

4. COMBINATION 10 WITH 2010 MOBILE CONTROLS

INTRODUCTION

Two CAMx simulations examined the 8-hour ozone benefits in the DFW NAA when incorporating the stricter mobile controls scheduled for 2010 into the Combination 10 package. Combination 11 added one-third of the anticipated on-road mobile emission reductions between 2009 and 2010 inside the DFW NAA; Combination 12 applied the full 2010 on-road mobile controls throughout Texas. Both runs included further emission reductions from TERP.

EMISSIONS

The NO_x and VOC reductions from each control group in DFW Combinations 10 through 12 are listed in Tables 4-1 and 4-2, respectively. Controls that were altered from the Combination 10 scenario are listed in red. The top shows changes within the DFW 9-county NAA; the bottom shows changes outside the DFW NAA.

The Combination 11 controls applied stricter on-road mobile NO_x controls than in Combination 10. The additional 12.6 tpd NO_x reduction was all inside the DFW NAA, of which 6.0 tpd NO_x was from TERP and the rest was attributed to one-third of the anticipated on-road reductions between 2009 and 2010. The NO_x reduction from all controls within DFW was 38.9 tpd; outside DFW, the 16.3 tpd NO_x reduction was unchanged from Combination 10. The total NO_x reduction across Texas was 55.3 tpd.

VOC emissions were reduced 1.6 tpd inside the DFW NAA from the Combination 11 control package, up from the 0.1 tpd reduction in Combination 10 due to stricter on-road controls. Outside DFW, VOC emissions were 2.9 tpd higher than the 2009.a2 baseline, just like in Combination 10. The net change across Texas was a 1.4 tpd VOC increase.

Tables 4-3 and 4-4 show the 2009 weekday NO_x and VOC emissions, respectively, for the DFW Combination 11 control scenario, broken down by source region, as defined in Figures 2-1 and 2-2, and by emission group (biogenics, elevated points, Texas mobile, low points, area, and off-road, and non-Texas low-level anthropogenics). Differences from the 2009.a2 baseline and from the Combination 10 scenario are shown in the two rightmost columns; these differences may vary slightly from those in Tables 4-1 and 4-2 based on the way cells were assigned to each source region. Similar tables of weekday NO_x and VOC emissions for the Combination 12 scenario are displayed in Tables 4-5 and 4-6, respectively.

The Combination 12 scenario was similar to Combination 10 except the full set of on-road mobile controls scheduled for 2010 was applied throughout Texas, and an additional 6.4 tpd NO_x was reduced from off-road mobile sources inside the DFW NAA from TERP. The 2010 on-road mobile source controls lowered NO_x emissions by 21.5 tpd inside DFW and 108.5 tpd outside DFW when compared to the 2009.a2 baseline. The total NO_x reduction from all controls in Combination 12 was 52.9 tpd inside the DFW NAA – twice as large as the NO_x reduction inside DFW in Combination 10; outside DFW, NO_x was reduced 129.3 tpd – eight times greater than in Combination 10. Statewide, Combination 12 lowered NO_x emissions by 182.2 tpd compared to 42.7 tpd in Combination 10.

VOC controls in Combination 12 were the same as Combination 10 except from on-road mobile sources. Inside the DFW NAA, Combination 12 lowered VOC emissions by 4.6 tpd; outside DFW, VOC emissions were 14.1 tpd lower. Statewide, VOC emissions were reduced 18.7 tpd.

Table 4-1. Change in weekday NOx emissions [tpd] by control group from the 2009.a2 baseline.

	Combination 10	Combination 11	Combination 12
Within DFW NAA			
DFW major	-9.0	-9.0	-9.0
DFW minor	-3.0	-3.0	-3.0
DFW EGU	-0.4	-0.4	-0.4
Cement kilns	-10.4	-10.4	-10.4
On-road	-1.4	-14.0	-21.5
Off-road	-2.2	-2.2	-8.6
DFW Total	-26.4	-38.9	-52.9
Outside DFW NAA			
On-road	4.4	4.4	-108.5
Off-road	1.7	1.7	1.7
East TX engines	-22.4	-22.4	-22.4
Outside DFW Total	-16.3	-16.3	-129.3
Total	-42.7	-55.3	-182.2

Table 4-2. Change in weekday VOC emissions [tpd] by control group from the 2009.a2 baseline.

	DFW Combination 10	DFW Combination 11	DFW Combination 12
Within DFW			
DFW major	0.0	0.0	0.0
DFW minor	0.0	0.0	0.0
DFW EGU	0.0	0.0	0.0
Cement kilns	0.0	0.0	0.0
On-road	-0.5	-2.0	-5.0
Off-road	+0.5	+0.5	+0.5
Surface coating	-0.1	-0.1	-0.1
DFW Total	-0.1	-1.6	-4.6
Outside DFW			
On-road	+1.0	+1.0	-16.0
Off-road	+1.9	+1.9	+1.9
East TX engines	0.0	0.0	0.0
Outside DFW Total	+2.9	+2.9	-14.1
Total	+2.9	+1.4	-18.7

Table 4-3. Weekday NOx emissions [tpd] for 2009.a2 with Combination 11 controls.

	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non-TX Low Anthro	All Anthro	Anthro Change from 2009.a2 baseline	Anthro change from combo 10
Collin Co	10	13	1	0	2	8	0	24	-1.3	-1.0
Dallas Co	4	72	5	1	18	44	0	140	-8.8	-5.3
Denton Co	8	16	1	0	11	9	0	37	-3.3	-1.2
Tarrant Co	3	43	1	1	10	27	0	82	-6.4	-3.2
Parker Co	1	5	0	0	1	2	0	8	-1.4	-0.4
Johnson Co	5	4	3	0	0	5	0	13	-2.5	-0.3
Ellis Co	15	8	22	0	0	6	0	36	-13.3	-0.6
Kaufman Co	5	6	4	0	0	2	0	12	-0.8	-0.4
Rockwall Co	2	3	0	0	0	1	0	4	-0.3	-0.2
DFW 9-County	52	170	37	3	41	105	0	356	-38.2	-12.5
North Texas	31	24	13	3	17	15	0	72	-0.7	0.0
NE Texas	16	79	181	10	68	42	1	380	-13.5	0.0
Central TX	114	92	143	2	58	70	0	366	-7.6	0.0
Houston	21	179	226	11	53	63	0	532	4.4	0.0
South TX	229	189	261	21	75	100	0	647	-1.2	0.0
West TX	524	160	140	21	212	106	1	641	1.6	0.0
Texas	986	894	1001	72	525	501	2	2995	-55.2	-12.6
Gulf + Mexico	79	5	436	0	4	2	444	891	0.0	0.0
Oklahoma	227	1	256	0	2	3	661	924	0.0	0.0
Louisiana	106	1	715	1	2	1	1183	1903	-0.1	0.0
Arkansas	125	2	220	0	0	2	468	692	0.0	0.0
Mississippi	121	0	353	0	0	0	455	808	0.0	0.0
Alabama	75	0	442	0	0	0	491	932	0.0	0.0
Tennessee	118	0	244	0	0	0	662	906	0.0	0.0
Kentucky	145	0	289	0	0	0	770	1060	0.0	0.0
Georgia	110	0	408	0	0	0	823	1230	0.0	0.0
Florida	56	0	367	0	0	0	1206	1573	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	293	0	977	0	0	0	2332	3310	0.0	0.0
NE US	314	0	1302	0	0	0	5748	7051	0.0	0.0
Northern Plains	5238	0	3269	0	0	0	8623	11892	0.0	0.0
Total	7992	903	10281	73	534	509	23869	36168	-55.3	-12.6
Total change from baseline	0.0	-9.5	-26.1	-10.2	-8.92	-0.4	-0.1	-55.3		

Table 4-4. Weekday VOC emissions [tpd] for 2009.a2 with Combination 11 controls.

	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non-TX Low Anthro	All Anthro	Anthro Change from 2009.a2 baseline	Anthro change from combo 10
Collin Co	27	7	0	1	12	4	0	23	-0.1	-0.1
Dallas Co	50	42	4	8	72	17	0	143	-0.7	-0.7
Denton Co	65	8	1	1	15	4	0	29	-0.1	-0.1
Tarrant Co	64	24	2	7	54	9	0	96	-0.4	-0.4
Parker Co	121	2	0	0	5	1	0	8	0.0	0.0
Johnson Co	111	2	0	0	6	1	0	9	0.0	0.0
Ellis Co	89	2	3	2	6	2	0	15	0.0	0.0
Kaufman Co	112	2	0	0	7	1	0	11	-0.1	0.0
Rockwall Co	3	1	0	0	2	1	0	4	0.0	0.0
DFW 9-County	642	90	10	20	180	38	0	338	-1.6	-1.5
North Texas	601	8	24	2	29	5	1	69	0.0	0.0
NE Texas	4917	27	14	41	82	14	1	179	0.2	0.0
Central TX	6393	35	20	20	91	23	1	191	0.2	0.0
Houston	1683	81	91	215	247	42	0	676	1.7	0.0
South TX	2069	78	20	48	217	46	0	408	0.5	0.0
West TX	6198	59	10	28	215	52	3	367	0.3	0.0
Texas	22503	379	188	374	1060	221	6	2229	1.3	-1.5
Gulf + Mexico	658	3	32	0	10	4	329	378	0.0	0.0
Oklahoma	7940	1	3	0	5	1	481	490	0.0	0.0
Louisiana	9941	0	47	3	4	1	546	601	0.0	0.0
Arkansas	13925	0	23	0	2	0	441	466	0.0	0.0
Mississippi	14818	0	35	0	0	0	548	583	0.0	0.0
Alabama	13954	0	39	0	0	0	655	695	0.0	0.0
Tennessee	8678	0	66	0	0	0	895	961	0.0	0.0
Kentucky	3753	0	34	0	0	0	622	656	0.0	0.0
Georgia	12198	0	53	0	0	0	869	922	0.0	0.0
Florida	9793	0	42	0	0	0	1594	1636	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	31294	0	67	0	0	0	2836	2903	0.0	0.0
NE US	20472	0	248	0	0	0	5407	5655	0.0	0.0
Northern Plains	40144	0	226	0	0	0	8224	8450	0.0	0.0
Total	210073	383	1104	377	1080	227	23453	26624	1.4	-1.5
Change from baseline	0.0	-1.0	0.0	-0.1	0.0	2.4	0.0	1.4		

Table 4-5. Weekday NOx emissions [tpd] for 2009.a2 with Combination 12 controls.

	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non- TX Low Anthro	All Anthro	Anthro Change from 2009.a2 baseline	Anthro change from combo 10
Collin Co	10	13	1	0	2	8	0	23	-2.4	-2.1
Dallas Co	4	69	5	1	18	42	0	134	-14.5	-11.0
Denton Co	8	15	1	0	11	9	0	35	-4.6	-2.5
Tarrant Co	3	40	1	1	10	26	0	78	-10.5	-7.3
Parker Co	1	5	0	0	1	2	0	8	-1.8	-0.7
Johnson Co	5	4	3	0	0	5	0	13	-2.9	-0.7
Ellis Co	15	8	22	0	0	5	0	35	-13.8	-1.0
Kaufman Co	5	6	4	0	0	2	0	12	-1.1	-0.7
Rockwall Co	2	3	0	0	0	1	0	4	-0.6	-0.5
DFW 9-County	52	162	37	3	41	98	0	343	-52.1	-26.5
North Texas	31	20	13	3	17	15	0	68	-5.2	-4.5
NE Texas	16	66	181	10	68	42	1	367	-27.2	-13.7
Central TX	114	80	143	2	58	70	0	353	-20.2	-12.6
Houston	21	157	226	11	53	63	0	510	-18.3	-22.7
South TX	229	160	261	21	75	100	0	618	-30.2	-29.0
West TX	524	131	140	21	212	106	1	612	-27.4	-29.0
Texas	986	775	1001	72	525	494	2	2870	-180.6	-138.0
Gulf + Mexico	79	4	436	0	4	2	444	891	-0.6	-0.6
Oklahoma	227	1	256	0	2	3	661	923	-0.2	-0.2
Louisiana	106	1	715	1	2	1	1183	1903	-0.4	-0.3
Arkansas	125	1	220	0	0	2	468	692	-0.5	-0.5
Mississippi	121	0	353	0	0	0	455	808	0.0	0.0
Alabama	75	0	442	0	0	0	491	932	0.0	0.0
Tennessee	118	0	244	0	0	0	662	906	0.0	0.0
Kentucky	145	0	289	0	0	0	770	1060	0.0	0.0
Georgia	110	0	408	0	0	0	823	1230	0.0	0.0
Florida	56	0	367	0	0	0	1206	1573	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	293	0	977	0	0	0	2332	3310	0.0	0.0
NE US	314	0	1302	0	0	0	5748	7051	0.0	0.0
Northern Plains	5238	0	3269	0	0	0	8623	11892	0.0	0.0
Total	7992	783	10281	73	534	502	23869	36041	-182.2	-139.5
Change from 2009 baseline	0.0	-130.0	-26.1	-10.2	-8.92	-6.9	-0.2	-182.2		
Change from combo 10	0.0	-133.0	0.0	0.0	0.0	-6.5	0.0	-139.5		

Table 4-6. Weekday VOC emissions [tpd] for 2009.a2 with Combination 12 controls.

	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non-TX Low Anthro	All Anthro	Anthro Change from 2009.a2 Baseline	Anthro Change from Combo 10
Collin Co	27	7	0	1	12	4	0	23	-0.2	-0.3
Dallas Co	50	40	4	8	72	17	0	142	-2.0	-2.0
Denton Co	65	8	1	1	15	4	0	28	-0.4	-0.4
Tarrant Co	64	23	2	7	54	9	0	95	-1.8	-1.8
Parker Co	121	2	0	0	5	1	0	8	-0.1	-0.1
Johnson Co	111	2	0	0	6	1	0	9	0.0	0.0
Ellis Co	89	2	3	2	6	2	0	15	0.1	0.0
Kaufman Co	112	2	0	0	7	1	0	11	-0.1	0.0
Rockwall Co	3	1	0	0	2	1	0	4	0.0	0.0
DFW 9-County	642	87	10	20	180	38	0	335	-4.54	-4.5
North Texas	601	8	24	2	29	5	1	68	-0.4	-0.5
NE Texas	4917	26	14	41	82	14	1	178	-1.3	-1.5
Central TX	6393	33	20	20	91	23	1	189	-1.9	-2.2
Houston	1683	75	91	215	247	42	0	670	-4.8	-6.4
South TX	2069	75	20	48	217	46	0	406	-2.0	-2.6
West TX	6198	55	10	28	215	52	3	364	-3.4	-3.7
Texas	22503	359	188	374	1060	221	6	2209	-18.4	-21.2
Gulf + Mexico	658	3	32	0	10	4	329	378	-0.3	-0.3
Oklahoma	7940	1	3	0	5	1	481	490	0.0	0.0
Louisiana	9941	0	47	3	4	1	546	601	0.0	0.0
Arkansas	13925	0	23	0	2	0	441	466	0.0	0.0
Mississippi	14818	0	35	0	0	0	548	583	0.0	0.0
Alabama	13954	0	39	0	0	0	655	695	0.0	0.0
Tennessee	8678	0	66	0	0	0	895	961	0.0	0.0
Kentucky	3753	0	34	0	0	0	622	656	0.0	0.0
Georgia	12198	0	53	0	0	0	869	922	0.0	0.0
Florida	9793	0	42	0	0	0	1594	1636	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	31294	0	67	0	0	0	2836	2903	0.0	0.0
NE US	20472	0	248	0	0	0	5407	5655	0.0	0.0
Northern Plains	40144	0	226	0	0	0	8224	8450	0.0	0.0
Total	210073	363	1104	377	1080	227	23453	26604	-18.7	-21.6
Change from 2009 baseline	0.0	-21.0	0.0	-0.1	0.0	2.4	0.0	-18.7		
Change from combo 10	0.0	-21.5	0.0	0.0	0.0	0.0	0.0	-21.6		

MODELING RESULTS

The top row of Figure 4-1 shows spatial plots of the daily maximum 8-hour ozone for each episode date in DFW Combinations 11 (left) and 12 (right). Differences from the 2009.a2 baseline and from Combination 10 are displayed in the center and bottom rows, respectively.

The largest ozone reduction from the additional on-road mobile controls applied in Combination 11 was located in Denton County on six of the eight episode dates, where the peak reduction was between 0.6 and 0.7 ppb. On the other two dates (August 19 and 20), north winds transported the peak ozone reduction of comparable magnitude south of the DFW NAA.

The more stringent emission controls in Combination 12 lowered the daily maximum 8-hour ozone up to 1.3 to 1.7 ppb on most dates when compared to Combination 10. Like Combination 11, the peak reduction was found in Denton County on a majority of the episode dates. The DFW peak daily maximum 8-hour ozone dropped at least 1.0 ppb from the additional controls in Combination 12 on all dates except August 20.

Compared to the 2009.a2 baseline, Tarrant County benefited the most from the Combination 11 and 12 controls because on a majority of the episode dates, Tarrant County was downwind of the Midlothian cement kilns, whose NO_x emissions were reduced by 10 tpd. The daily maximum 8-hour ozone was almost 5 ppb lower than the 2009 baseline on August 15 in both scenarios.

The 2009 8-hour ozone future design value calculations for the DFW Combination 11 and 12 scenarios are shown in Tables 4-7 and 4-8, respectively. Daily relative reduction factors (RRF) are included at the bottom of the table. Table 4-7 lists the nine DFW monitoring sites with baseline design values available in 1999; Table 4-8 lists 19 monitors in the DFW 4 km domain, including the original nine DFW sites, plus Temple. When baseline design values were not available, only the RRF's were computed.

The average RRF from 1999 to 2009 with Combination 12 controls for the original nine DFW sites was 0.885. Among the newer sites, three sites had RRFs higher than the nine site average – Sunnyvale, Grapevine and Temple. Grapevine had the highest episode averaged daily maximum 8-hour ozone in the 2009 Combination 12 scenario.

Table 4-9 compares the future design values of the 2009.a2 baseline with Combinations 10, 11, and 12. Values at or over 85.0 ppb are listed in red. In Combination 10, four DFW sites had future design values over 85 ppb – Frisco, Denton, Dallas Hinton, and Fort Worth C13. In Combination 11, the number of sites over 85 ppb dropped to three as the additional on-road mobile controls lowered the future design values at most DFW sites by 0.4 to 0.5 ppb. Fort Worth C13 dropped from 85.4 ppb to 84.9 ppb. Frisco continued to have the highest future design value at 88.8 ppb – 1.0 ppb less than in the 2009.a2 baseline; its future design value dropped 0.5 ppb from all controls in Combination 10 and another 0.5 ppb from the additional DFW on-road controls. The other sites over 85 ppb were Denton (88.3 ppb) and Dallas Hinton (85.2 ppb), both with future design values 1.0 ppb less than in the 2009.a2 baseline.

In Combination 12, only two of the nine DFW sites had future design values over 85.0 ppb – Frisco (88.2 ppb) and Denton (87.5 ppb). Compared to the 2009.a2 baseline, future design values dropped between 1.4 and 2.6 ppb. The largest reductions were at Fort Worth C13 and Arlington, both in Tarrant County. When compared to Combination 10, the future design values at sites exceeding 85 ppb in the 2009.a2 baseline were 0.9 to 1.2 ppb lower in Combination 12; at all other sites, future design value reductions were smaller. The Combination 12 future design values at most DFW sites were slightly lower than in Combination 4, which was the best control package evaluated in 2006 for the 2009 future year. Frisco and Denton were 0.1 ppb and 0.4 ppb lower, respectively, in Combination 12 than in Combination 4.

Table 4-10 lists the future design value responsiveness at each DFW site when applying more NOx controls in relation to Combination 10. In Combination 11, the average response among the nine DFW sites was 0.033 ppb O₃/ton NO_x. This response was comparable to the ozone response from the NO_x adjustments from Combination 4 to Combination 5, which revised the NCTCOG on-road and off-road mobile controls; in both scenarios, most changes to the NO_x emissions were within the DFW NAA. Ozone was 2 to 10 times more responsive to the local on-road mobile NO_x reductions than any of the other recent scenarios, which evaluated the ozone response to changes in NO_x mainly outside of the DFW NAA. Frisco was the most responsive to the local on-road mobile NO_x changes among the nine DFW sites.

In Combination 12, the average response from the 139.5 tpd NO_x reduction added on top of the Combination 10 controls was relatively low at 0.007 ppb O₃ per ton of NO_x. In this case, less than 20 % of the additional NO_x controls were inside the DFW NAA.

Tables 4-11 to 4-13 examine the 4-km grid cells in the DFW 9-county NAA in which the daily maximum 8-hour ozone exceeded 85 ppb. Table 4-11 lists the number of unique grid cells in DFW that exceed 85 ppb for each date in the 2009.a2 baseline and in Combinations 10 through 12. In the 2009.a2 baseline, there were 1158 grid cells in the DFW NAA at or over 85 ppb spanning the eight day episode. The Combination 10 controls reduced the exceedance area by 6 % during the episode. Combinations 11 and 12 reduced the exceedance area by 11 % and 18 %, respectively.

Table 4-12 shows the number of baseline exceedance cells that were reduced at least 1 ppb from the combination of controls. In Combination 10, 197 of the 1158 exceedance cells (17 %) were reduced at least 1 ppb from the controls. In Combination 11, 764 (66 %) grid cells were reduced at least 1 ppb – nearly four times as many as in Combination 10. On August 15 and 16, almost every exceedance cell was at least 1 ppb lower than in the 2009.a2 baseline. In Combination 12, the percentage of exceedance cells reduced at least 1 ppb increased to 97 %.

Table 4-13 sums the number of ppb's in the daily maximum 8-hour ozone that exceed 85 ppb. For example, if the daily maximum ozone in a grid cell is 90 ppb, the grid cell adds 5 ppb (90 – 85 ppb) to the sum of ozone exceedances. The number of exceedance ppb's among all episode dates was reduced 9 % in Combination 10, 15 % in Combination 11, and 25 % in Combination 12.

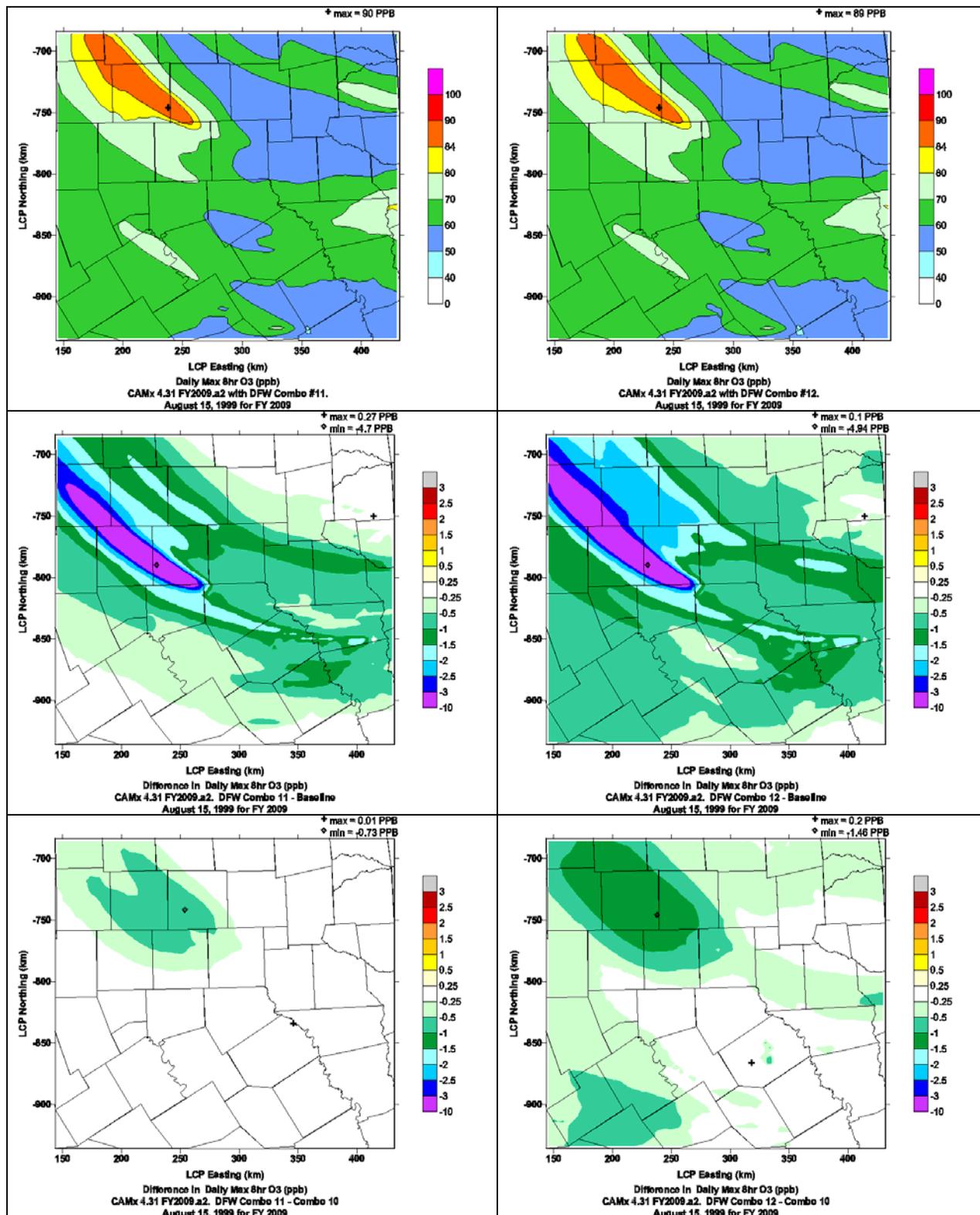


Figure 4-1. Spatial plots of the daily maximum 8-hour ozone (top) in Combination 11 (left) and Combination 12 (right), and their differences from the 2009.a2 baseline (center row) and from Combination 10 (bottom).

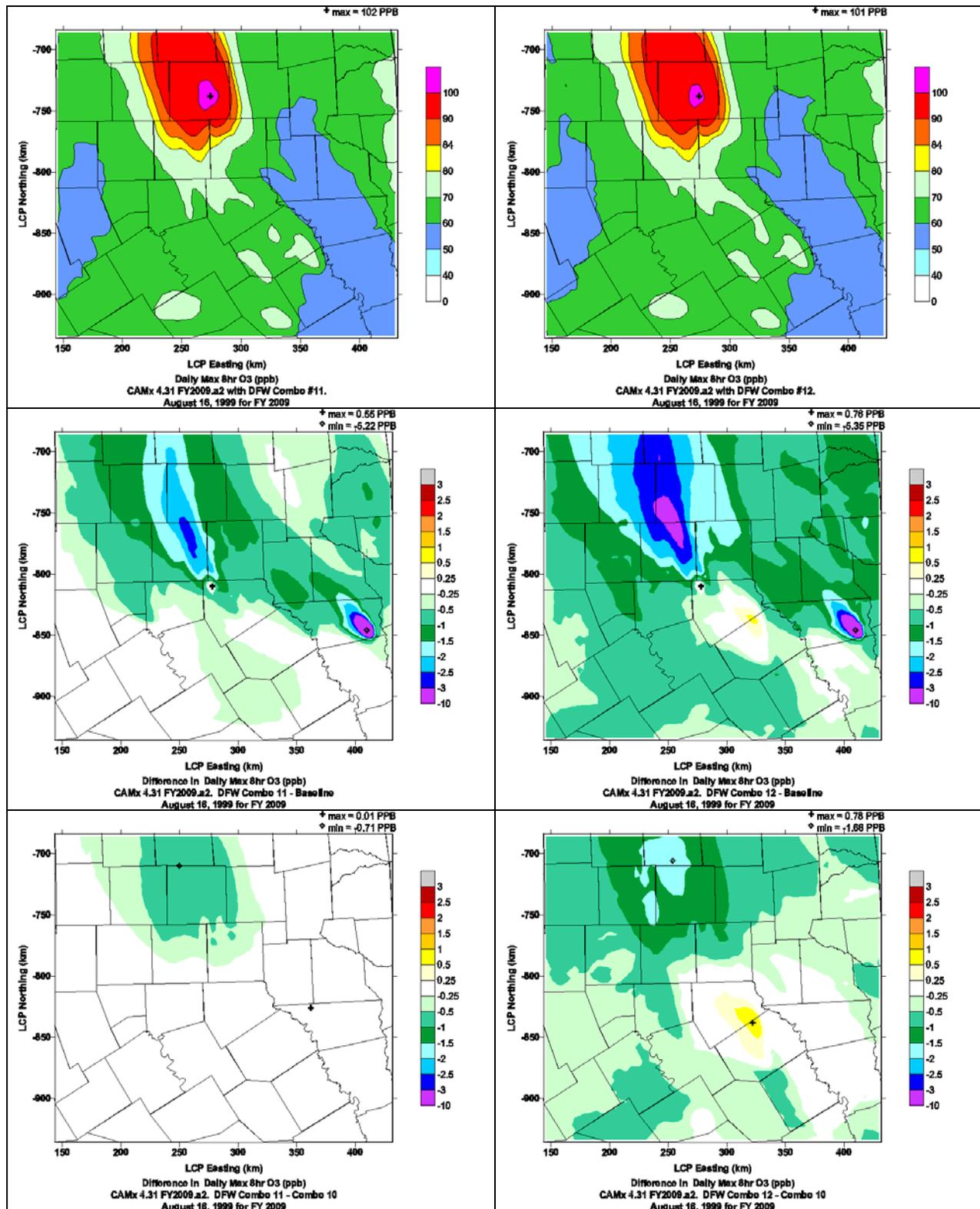


Figure 4-1 (continued). Spatial plots of the daily maximum 8-hour ozone (top) in Combination 11 (left) and Combination 12 (right), and their differences from the 2009.a2 baseline (center row) and from Combination 10 (bottom).

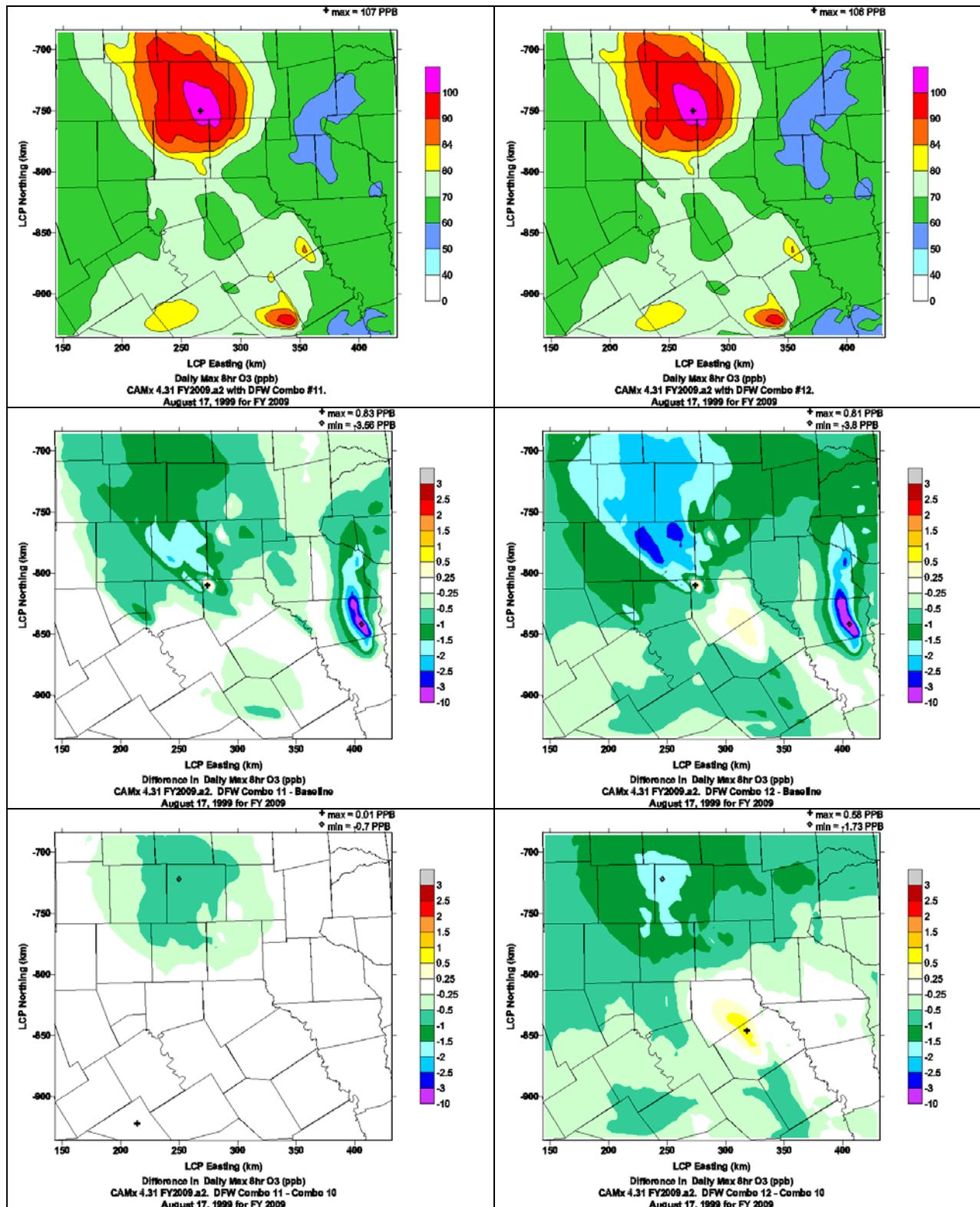


Figure 4-1 (continued). Spatial plots of the daily maximum 8-hour ozone (top) in Combination 11 (left) and Combination 12 (right), and their differences from the 2009.a2 baseline (center row) and from Combination 10 (bottom).

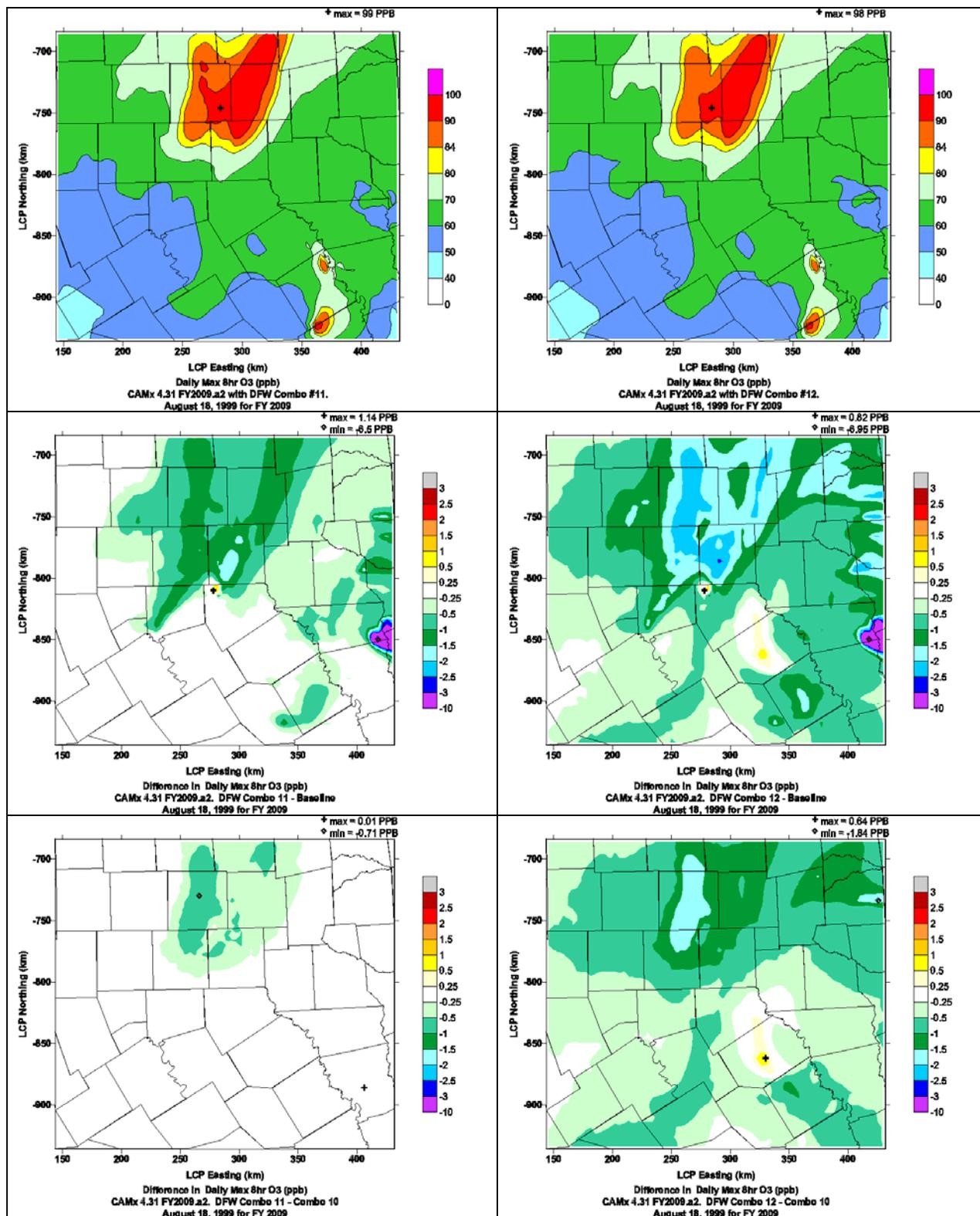


Figure 4-1 (continued). Spatial plots of the daily maximum 8-hour ozone (top) in Combination 11 (left) and Combination 12 (right), and their differences from the 2009.a2 baseline (center row) and from Combination 10 (bottom).

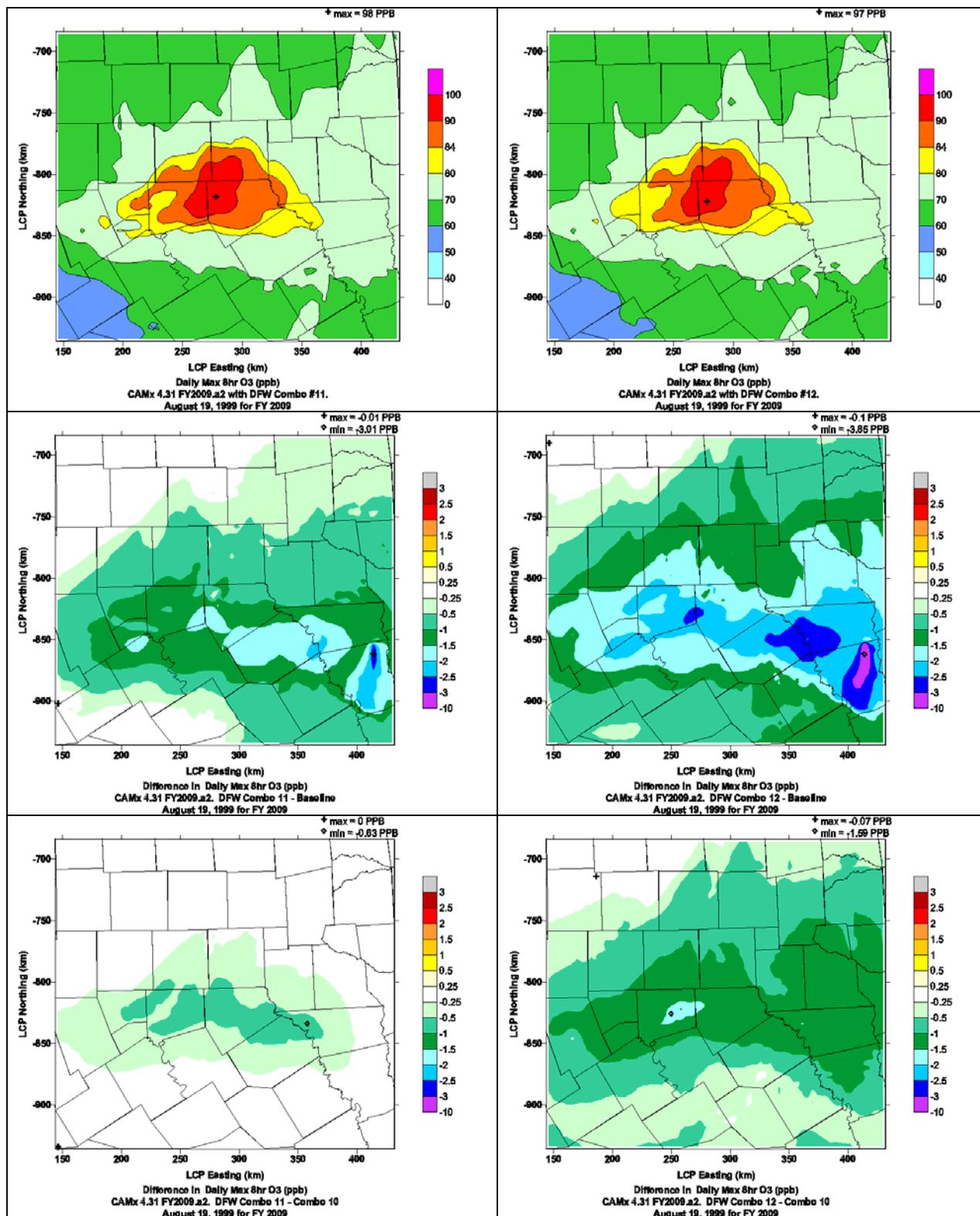


Figure 4-1 (continued). Spatial plots of the daily maximum 8-hour ozone (top) in Combination 11 (left) and Combination 12 (right), and their differences from the 2009.a2 baseline (center row) and from Combination 10 (bottom).

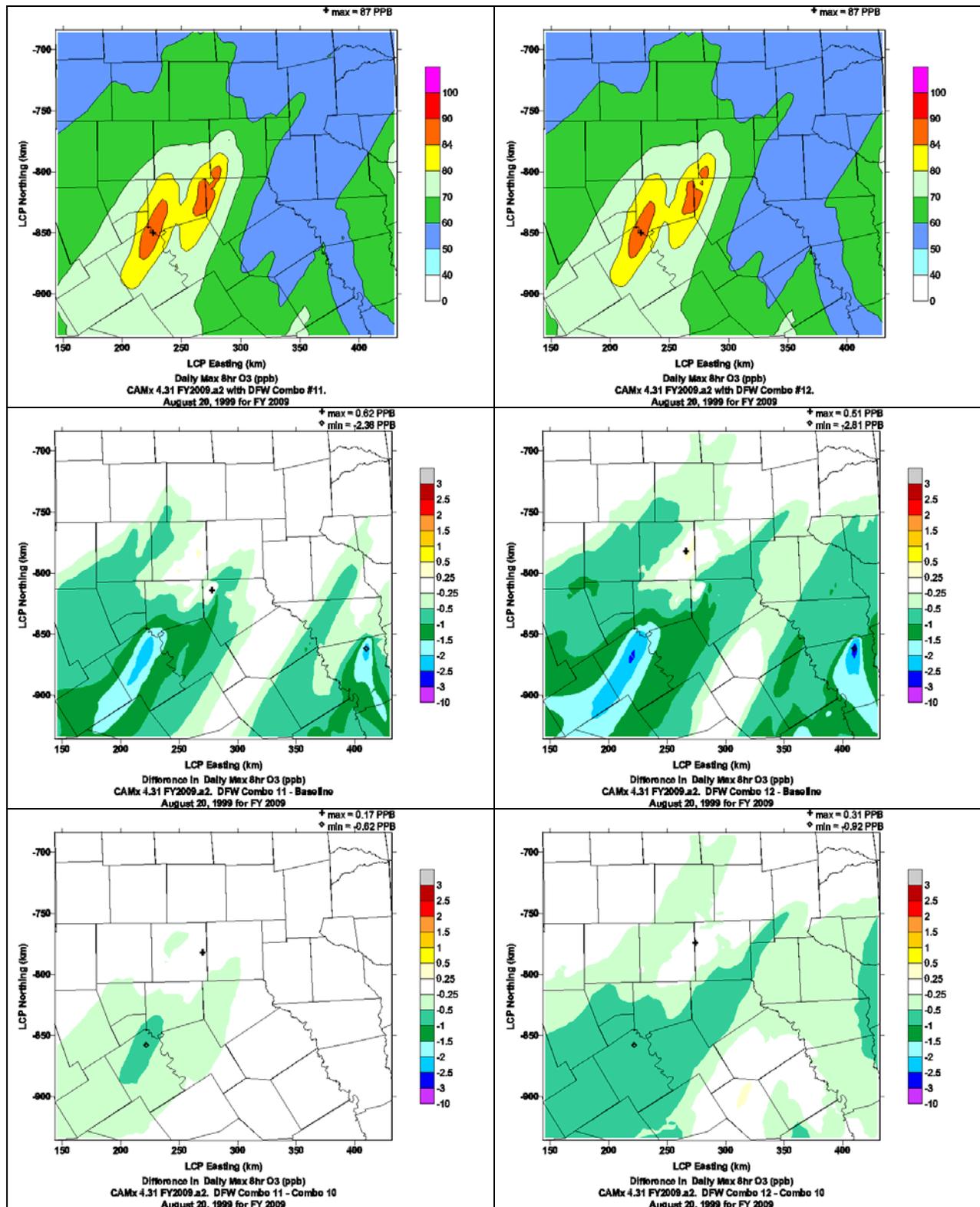


Figure 4-1 (continued). Spatial plots of the daily maximum 8-hour ozone (top) in Combination 11 (left) and Combination 12 (right), and their differences from the 2009.a2 baseline (center row) and from Combination 10 (bottom).

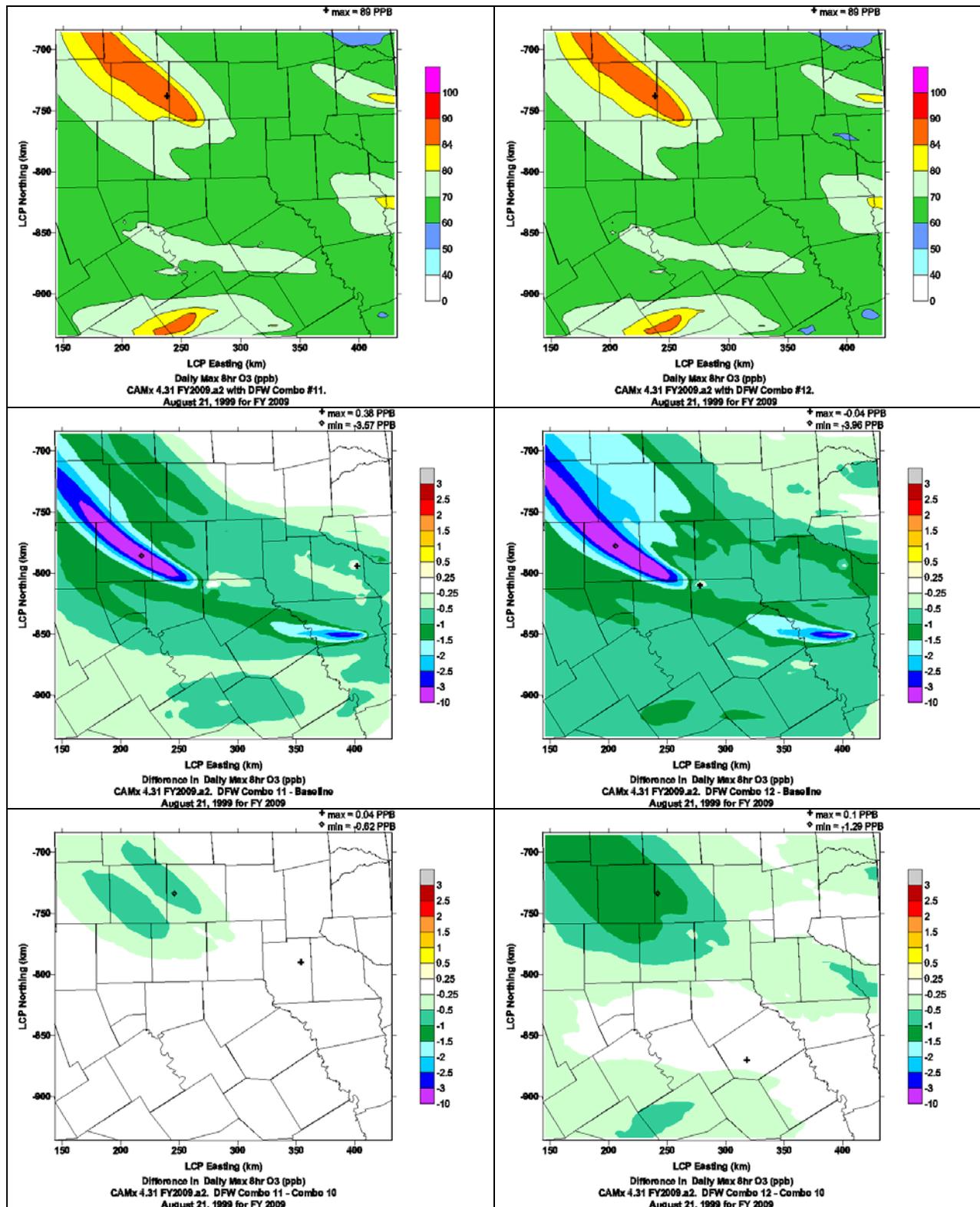


Figure 4-1 (continued). Spatial plots of the daily maximum 8-hour ozone (top) in Combination 11 (left) and Combination 12 (right), and their differences from the 2009.a2 baseline (center row) and from Combination 10 (bottom).

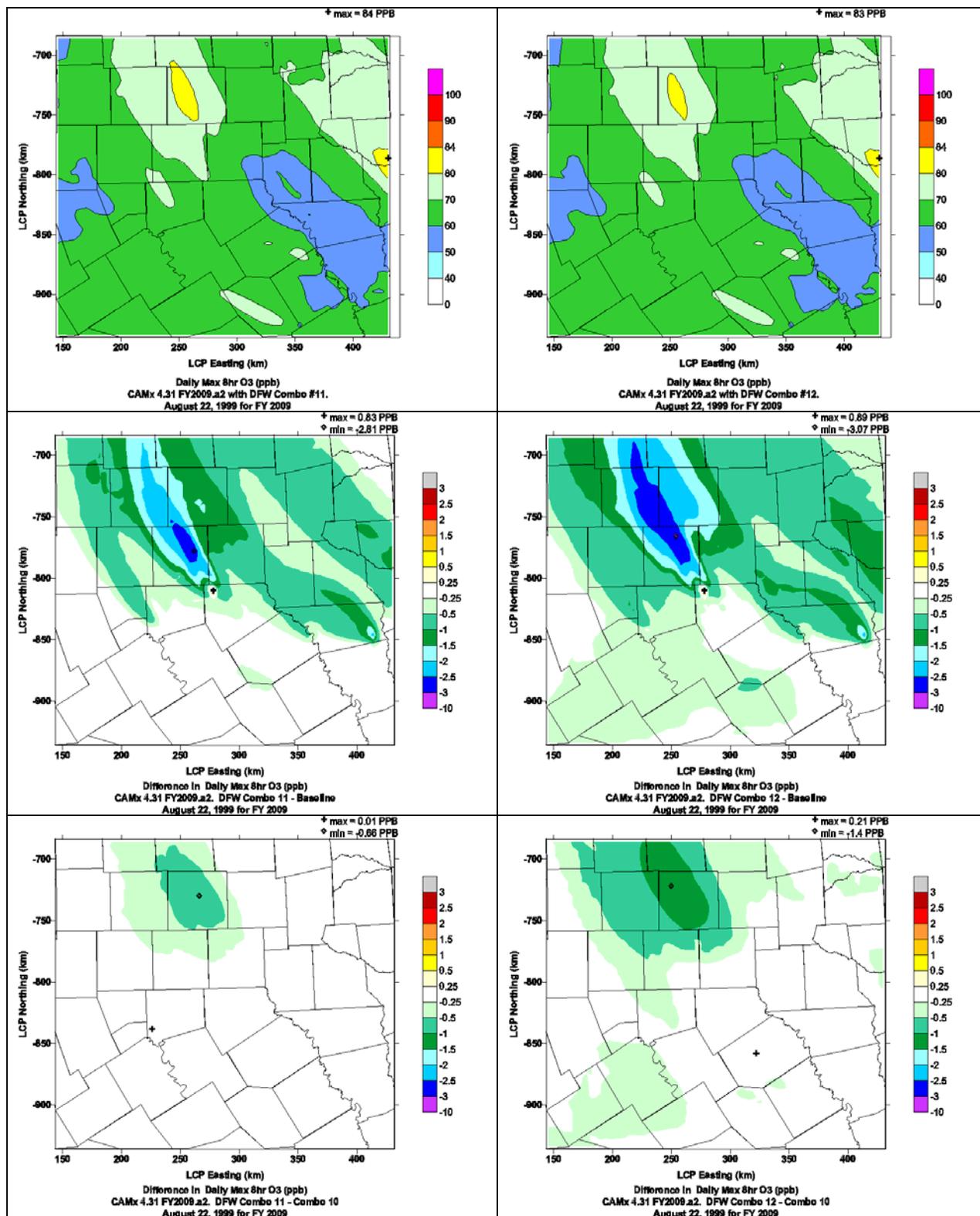


Figure 4-1 (concluded). Spatial plots of the daily maximum 8-hour ozone (top) in Combination 11 (left) and Combination 12 (right), and their differences from the 2009.a2 baseline (center row) and from Combination 10 (bottom).

Table 4-7. Future design value scaling calculations for the 2009.a2 with Combination 11 control scenario.

Base Case: run46												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	#Days>70		
Frisco	81.3	107.0	102.6	109.2	86.0	69.9	87.1	89.5	94.7	7		
Dallas HintonC60	83.1	99.8	103.4	103.8	99.2	78.0	85.5	85.3	92.3	8		
Dallas North C63	82.6	101.3	102.6	106.6	96.5	76.4	86.8	88.4	92.6	8		
Dallas Exec C402	77.0	93.3	98.5	96.6	107.4	83.7	79.4	79.5	89.4	8		
Denton	102.6	113.1	110.0	112.5	84.7	73.1	101.6	99.6	99.7	8		
Midlothian	78.3	86.1	85.9	76.2	114.0	88.8	75.7	76.7	85.2	8		
Arlington	86.2	98.4	100.2	95.2	106.9	83.1	81.9	86.7	92.3	8		
Ft Worth C13	93.8	105.5	104.3	106.0	96.0	80.1	89.8	92.0	95.9	8		
Ft Worth C17	101.1	111.1	110.4	108.3	92.4	78.6	95.9	94.9	99.1	8		
Future Year: run46.fy2009.a2.dfw_combo11												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	RRF ¹	BaseDV [ppb]	FutureDV ² [ppb]
Frisco	66.3	99.8	101.2	99.4	72.7	63.7	73.8	73.1	83.8	0.885	100.3	88.77
Dallas HintonC60	71.6	91.7	102.7	96.7	90.8	80.6	77.0	72.7	85.5	0.926	92.0	85.19
Dallas North C63	69.8	94.6	101.2	98.5	83.7	77.3	75.3	72.8	84.1	0.908	93.0	84.44
Dallas Exec C402	65.5	80.8	88.3	83.5	95.9	84.8	69.5	69.4	79.7	0.891	88.0	78.41
Denton	87.1	102.1	107.1	90.8	71.0	64.3	88.9	82.1	86.7	0.870	101.5	88.31
Midlothian	69.6	75.9	78.7	70.5	97.5	85.1	68.4	69.8	76.9	0.903	92.5	83.53
Arlington	71.8	86.5	89.1	80.3	94.6	84.8	71.9	76.8	82.0	0.888	90.5	80.36
Ft Worth C13	77.2	92.0	92.6	86.7	82.6	75.3	77.9	78.3	82.8	0.864	98.3	84.93
Ft Worth C17	88.0	97.0	103.2	89.2	78.4	70.4	87.3	80.8	86.8	0.876	96.3	84.36
Daily RRFs ³												
Site	990815	990816	990817	990818	990819	990820	990821	990822				
Frisco	0.815	0.932	0.986	0.911	0.846	0.912	0.848	0.816				
Dallas HintonC60	0.862	0.919	0.994	0.931	0.915	1.034	0.901	0.852				
Dallas North C63	0.846	0.934	0.986	0.924	0.867	1.012	0.867	0.823				
Dallas Exec C402	0.851	0.866	0.896	0.864	0.893	1.013	0.875	0.873				
Denton	0.849	0.903	0.973	0.807	0.839	0.879	0.874	0.824				
Midlothian	0.889	0.882	0.916	0.925	0.856	0.958	0.903	0.911				
Arlington	0.833	0.880	0.888	0.844	0.885	1.021	0.878	0.886				
Ft Worth C13	0.823	0.872	0.888	0.819	0.861	0.940	0.868	0.852				
Ft Worth C17	0.870	0.874	0.935	0.824	0.849	0.895	0.910	0.852				

1. RRF = future year average / baseline average

2. Future DV = baseline DV * RRF

3. Daily RRFs are for information only. They are not used to calculate the future DV

Table 4-8. Future design value calculations for the DFW Combination 12 control package.

Base Case: run46												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	#Days>70		
Frisco	81.3	107.0	102.6	109.2	86.0	69.9	87.1	89.5	94.7	7		
Dallas HintonC60	83.1	99.8	103.4	103.8	99.2	78.0	85.5	85.3	92.3	8		
Dallas North C63	82.6	101.3	102.6	106.6	96.5	76.4	86.8	88.4	92.6	8		
Dallas Exec C402	77.0	93.3	98.5	96.6	107.4	83.7	79.4	79.5	89.4	8		
Denton	102.6	113.1	110.0	112.5	84.7	73.1	101.6	99.6	99.7	8		
Midlothian	78.3	86.1	85.9	76.2	114.0	88.8	75.7	76.7	85.2	8		
Arlington	86.2	98.4	100.2	95.2	106.9	83.1	81.9	86.7	92.3	8		
Ft Worth C13	93.8	105.5	104.3	106.0	96.0	80.1	89.8	92.0	95.9	8		
Ft Worth C17	101.1	111.1	110.4	108.3	92.4	78.6	95.9	94.9	99.1	8		
Anna	69.2	79.5	90.7	105.2	89.3	73.8	77.4	75.1	84.4	7		
Sunnyvale	65.5	77.7	84.4	93.2	97.0	70.5	75.7	71.0	81.4	7		
Granbury	84.1	80.1	81.8	75.4	100.5	86.2	83.7	77.3	83.6	8		
Cleburne	73.1	79.8	83.0	70.9	106.8	95.8	76.7	80.3	83.3	8		
Kaufman	68.6	68.3	74.5	74.2	96.1	65.1	73.2	66.3	79.5	4		
Weatherford	96.7	78.8	88.3	75.5	80.5	70.5	92.8	77.9	82.6	8		
Rockwall	63.6	77.3	87.0	99.9	91.6	69.4	74.6	71.1	83.6	6		
Eagle Mt Lake	98.7	108.4	101.9	95.9	90.2	78.8	95.8	92.7	95.3	8		
Grapevine	97.7	110.5	110.4	109.5	89.8	75.8	97.2	97.9	98.6	8		
Waco	87.3	87.5	92.9	72.8	75.3	84.0	104.0	83.3	85.9	8		
Temple ¹	72.5	79.4	89.5	57.7	71.9	86.3	85.9	70.4	79.4	7		
Future Year: run46.fy2009.a2.dfw_combo12												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	RRF²	BaseDV	FutureDV³
Frisco	66.0	99.1	100.5	98.4	72.1	63.6	73.4	72.7	83.2	0.879	100.3	88.16
Dallas HintonC60	71.2	91.1	102.1	95.9	90.1	80.6	76.6	72.2	85.0	0.921	92.0	84.73
Dallas North C63	69.4	94.0	100.5	97.7	82.9	77.3	74.9	72.4	83.6	0.903	93.0	83.98
Dallas Exec C402	65.2	80.5	87.7	82.8	95.0	84.7	69.1	69.4	79.3	0.887	88.0	78.06
Denton	86.3	101.4	106.2	89.7	70.4	64.0	88.2	81.3	85.9	0.862	101.5	87.49
Midlothian	69.5	76.0	78.6	70.3	96.6	84.9	68.2	69.9	76.8	0.901	92.5	83.34
Arlington	71.4	86.2	88.4	79.4	93.7	84.7	71.5	76.7	81.5	0.883	90.5	79.91
Ft Worth C13	76.6	91.4	91.7	85.7	81.8	75.2	77.4	78.1	82.2	0.857	98.3	84.24
Ft Worth C17	87.1	96.3	102.3	88.1	77.6	70.3	86.8	80.2	86.1	0.869	96.3	83.68
Anna	62.6	67.5	82.1	95.0	71.1	58.2	67.3	69.5	73.0	0.864		
Sunnyvale	59.0	70.2	76.4	84.0	84.8	65.5	65.8	63.3	72.9	0.895		
Granbury	69.1	64.4	69.3	62.4	84.0	80.3	69.1	66.6	70.7	0.845		
Cleburne	66.9	70.3	71.8	61.0	88.7	85.2	68.9	71.4	73.0	0.877		
Kaufman	61.8	60.9	63.7	63.6	84.7	58.2	65.6	60.1	69.4	0.873		
Weatherford	79.1	67.8	73.8	63.6	70.6	65.0	76.5	68.4	70.6	0.854		
Rockwall	57.6	67.5	76.9	88.5	77.7	63.1	64.9	62.8	73.0	0.874		
Eagle Mt Lake	82.2	90.0	91.4	79.5	77.7	71.7	79.9	78.1	81.3	0.853		
Grapevine	84.1	100.5	106.4	98.4	76.3	71.6	86.0	80.9	88.0	0.893		

Table 4-8. concluded.

Waco	65.7	73.2	82.4	64.2	66.2	75.7	84.5	67.7	72.5	0.844		
Temple	62.8	68.9	80.5	53.0	63.9	74.3	76.4	65.0	70.3	0.885		
Daily RRFs⁴												
Site	990815	990816	990817	990818	990819	990820	990821	990822				
Frisco	0.811	0.926	0.980	0.902	0.838	0.910	0.843	0.811				
Dallas HintonC60	0.857	0.913	0.987	0.924	0.908	1.034	0.896	0.846				
Dallas North C63	0.841	0.928	0.980	0.916	0.859	1.011	0.863	0.818				
Dallas Exec C402	0.847	0.863	0.889	0.857	0.885	1.011	0.871	0.874				
Denton	0.841	0.897	0.965	0.797	0.832	0.875	0.868	0.816				
Midlothian	0.888	0.883	0.916	0.922	0.848	0.956	0.901	0.911				
Arlington	0.828	0.876	0.882	0.834	0.876	1.019	0.873	0.884				
Ft Worth C13	0.817	0.866	0.879	0.808	0.853	0.938	0.861	0.849				
Ft Worth C17	0.862	0.868	0.927	0.814	0.840	0.895	0.905	0.845				
Anna	0.904	0.849	0.905	0.903	0.796	0.789	0.870	0.925				
Sunnyvale	0.900	0.904	0.905	0.901	0.874	0.930	0.869	0.891				
Granbury	0.822	0.804	0.847	0.828	0.836	0.932	0.826	0.861				
Cleburne	0.916	0.881	0.865	0.860	0.831	0.890	0.899	0.889				
Kaufman	0.901	0.891	0.855	0.858	0.881	0.894	0.896	0.907				
Weatherford	0.818	0.860	0.835	0.842	0.877	0.922	0.824	0.878				
Rockwall	0.905	0.873	0.885	0.886	0.848	0.910	0.869	0.883				
Eagle Mt Lake	0.833	0.830	0.897	0.829	0.862	0.910	0.834	0.842				
Grapevine	0.860	0.910	0.964	0.899	0.849	0.944	0.884	0.827				
Waco	0.753	0.836	0.887	0.882	0.879	0.901	0.812	0.813				
Temple	0.867	0.868	0.899	0.918	0.888	0.861	0.890	0.924				

1. Temple is outside the DFW 4 km domain. Its daily maximum values are based on the highest value in the 3x3 12 km grid cells surrounding it.

All other sites use the max value in their surrounding 7x7 4-km cells.

2. RRF = future year average / baseline average

3. Future DV = baseline DV * RRF

4. Daily RRFs are for information only. They are not used to calculate the future DV

Table 4-9. Future design value summary [ppb].

	run46.fy2009.a2 (2009 baseline)	run46.fy2009.a2. dfw_combo10	run46.fy2009.a2. dfw_combo11	run46.fy2009.a2 dfw_combo12
2009 future design values				
Frisco	89.8	89.3	88.8	88.2
Dallas Hinton C60	86.2	85.7	85.2	84.7
Dallas North C63	85.4	84.9	84.4	84.0
Dallas Exec C402	79.6	78.8	78.4	78.1
Denton	89.3	88.7	88.3	87.5
Midlothian	84.7	83.7	83.5	83.3
Arlington	82.1	80.7	80.4	79.9
Ft Worth C13	86.8	85.4	84.9	84.2
Ft Worth C17	85.4	84.8	84.4	83.7
Differences from the 2009 a2 baseline				
Frisco		-0.5	-1.0	-1.6
Dallas Hinton C60		-0.5	-1.0	-1.5
Dallas North C63		-0.5	-0.9	-1.4
Dallas Exec C402		-0.9	-1.2	-1.6
Denton		-0.6	-1.0	-1.8
Midlothian		-1.0	-1.2	-1.4
Arlington		-1.3	-1.7	-2.2
Ft Worth C13		-1.4	-1.9	-2.6
Ft Worth C17		-0.6	-1.1	-1.7
Differences from DFW Combination 10				
Frisco			-0.5	-1.1
Dallas Hinton C60			-0.5	-0.9
Dallas North C63			-0.5	-0.9
Dallas Exec C402			-0.4	-0.7
Denton			-0.4	-1.2
Midlothian			-0.2	-0.4
Arlington			-0.4	-0.8
Ft Worth C13			-0.5	-1.2
Ft Worth C17			-0.5	-1.2

Table 4-10. Ozone responsiveness to changes in NOx emissions [ppb O3/ton NOx].

	Combo 11 – Combo 10	Combo 12 – Combo 10
Change in NOx	-12.6 tpd inside DFW	-26.5 tpd NOx inside DFW, -113.0 tpd outside DFW
Frisco	0.040	0.008
Dallas Hinton	0.037	0.007
Dallas North C63	0.037	0.007
Dallas Exec C402	0.028	0.005
Denton	0.032	0.009
Midlothian	0.014	0.003
Arlington	0.029	0.006
Ft Worth C13	0.039	0.008
Ft Worth C17	0.038	0.008
Average	0.033	0.007

Table 4-11. Exceedance Area (Number of 4-km grid cells in DFW with the daily max 8-hour ozone \geq 85 ppb).

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo10	run46.fy2009.a2. dfw_combo11	run46.fy2009.a2 dfw_combo12
Scenario	2009 baseline	2009 with DFW combo 10 controls	2009 with DFW combo 11 controls	2009 with DFW combo 12 controls
990815	18	13	12	11
990816	220	210	205	200
990817	291	284	279	269
990818	248	235	229	216
990819	323	297	275	230
990820	30	20	11	6
990821	28	25	20	19
990822	0	0	0	0
Totals	1158	1084	1031	951
% Reduced		-6.4 %	-11.0 %	-17.9 %

Table 4-12. Number of exceedance cells reduced at least 1 ppb.

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo10	run46.fy2009.a2. dfw_combo11	run46.fy2009.a2 dfw_combo12
990815	--	0	18	18
990816	--	106	217	220
990817	--	51	183	265
990818	--	6	138	248
990819	--	31	186	322
990820	--	3	11	19
990821	--	0	11	28
990822	--	0	0	0
Totals	--	197 (17 %)	764 (66 %)	1120 (97 %)

Table 4-13. Number of ppb's from grid cells in the daily maximum 8-hour ozone in excess of 85 ppb¹.

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo10	run46.fy2009.a2. dfw_combo11	run46.fy2009.a2 dfw_combo12
990815	47	34	27	18
990816	2269	2039	1919	1775
990817	2880	2706	2563	2354
990818	1634	1510	1392	1206
990819	1478	1299	1158	951
990820	23	12	4	3
990821	69	56	46	34
990822	0	0	0	0
Total	8400	7656	7109	6340
% Reduced		-9 %	-15%	-25%

¹ $\Sigma(\max(O_3-85, 0.0))$ for all grid cells in DFW 9-county NAA.

SUMMARY

Two CAMx simulations examined the impacts to 8-hour ozone in DFW when assuming more 2010 controls in the 2009 future year. Combination 11 added stricter on-road mobile controls within DFW from TERP and from one-third of the anticipated on-road reductions between 2009 and 2010. NO_x and VOC emissions were 12.6 and 1.5 tpd less than in the Combination 10 scenario, respectively. The NO_x reduction from all controls was 38.9 tpd within DFW and 16.3 tpd outside DFW.

Combination 12 applied the full 2010 on-road mobile controls in Texas with additional off-road mobile controls from TERP, yielding a 52.9 tpd NO_x reduction inside the DFW NAA and a 129.3 tpd NO_x reduction outside DFW.

The number of sites with future design values over 85 ppb dropped from four in Combination 10 to three in Combination 11, to two in Combination 12 (Frisco and Denton). The on-road controls in Combination 11 reduced the future design values at most DFW sites by an additional 0.4 to 0.5 ppb. If all 2010 on-road controls in Texas were applied, future design values at the critical DFW sites would be reduced an extra 0.9 to 1.2 ppb. Combination 12 lowered the future design values at Frisco by 1.6 ppb to 88.2 ppb, and at Denton by 1.8 ppb to 87.5 ppb; both values were a few tenths of a ppb lower than in Combination 4.

5. SUMMARY AND CONCLUSIONS

In 2006, numerous CAMx sensitivity tests established the DFW Combination 4 control package as the best scenario for reducing 8-hour ozone in the DFW NAA by the 2009 future year (Tai et al., 2006). Since then, adjustments were made to the control package before finalizing a run to be submitted for the DFW 8-hour ozone SIP. CAMx runs showing the impacts from each change in controls are documented in this report.

Table 5-1 displays the change in NO_x emissions from the 2009 a2 baseline for each control group and scenario evaluated. For completeness, emissions from Combinations 4 to 6 are also included. Controls that were altered from the previous control scenario are shown in red. The top shows changes within the DFW 9-county NAA; the bottom shows changes outside the DFW NAA.

Table 5-2 displays the 2009 future design values for all runs and for all DFW sites with baseline design values available in 1999. Values exceeding 85.0 ppb are listed in red. In the 2009 a2 baseline, six of the nine sites exceeded 85.0 ppb. Frisco had the highest future design value at 89.8 ppb; the nine-site average was 85.5 ppb. Combination 4 reduced the number of sites over 85.0 ppb to two – Frisco (88.3 ppb) and Denton (87.9 ppb).

The relaxation of controls progressing from Combination 4 to Combination 8 (excluding Combination 6) reversed some of the ozone benefits achieved with the Combination 4 controls, adding on average 0.5 ppb to the future design values. The reductions included weaker NCTCOG mobile controls, the elimination of engine controls from six counties located north and west of the DFW NAA, and the elimination of lean-burning engine controls in the remaining East Texas counties.

Combination 9, which incorporated only the Combination 8 controls expected to be phased in by 2009, added another 0.5 ppb to the future design values; the average future design value of 84.9 ppb was 1.0 ppb greater than in Combination 4. Combination 9 accounted for only half of the NO_x reductions applied in Combination 4 within the DFW NAA and none of the NO_x reductions outside DFW. The number of sites with future design values over 85.0 ppb returned to six, of which many sites had future design values only a few tenths of a ppb less than the 2009 a2 baseline. Fort Worth C13 was the only exceedance site to be reduced more than 1.0 ppb as it benefited from being downwind of the Midlothian cement kilns, whose large NO_x controls remained mostly intact in all of the runs.

If another year was available to implement the controls (Combination 10), future design values could be 0.2 to 0.3 ppb lower than Combination 9 at all DFW sites, lowering the number of sites over 85.0 ppb from six to four. Frisco had the highest future design value at 89.3 ppb; the 9-site average was 84.7 ppb. Combination 10 was selected as the DFW SIP run.

Two additional runs examined ways to further reduce DFW 8-hour ozone beyond the Combination 10 scenario. Source apportionment runs showed that the largest contributors to 8-hour ozone in DFW were from local on-road mobile sources, followed by local off-road mobile sources (Tai et al., 2007). By adding one-third of the additional DFW on-road mobile controls between 2009 and 2010 plus an extra 6 tpd NO_x reduction from TERP to the Combination 10 scenario, Combination 11 lowered the average DFW future design values by 0.4 ppb. Sites with

future design values over 85.0 ppb tended to have larger reductions. The number of exceedance sites dropped from four in Combination 10 to three in Combination 11.

Combination 12 incorporated the entire 2010 on-road mobile controls throughout Texas with additional off-road controls from TERP. The NO_x controls both inside and outside of the DFW NAA were the largest compared to any other control package evaluated. NO_x emissions were reduced 52.9 tpd inside DFW and 129.3 tpd outside DFW. Future design values dropped to the same level or were even lower than those in Combination 4 at all sites; the number of sites over 85.0 ppb returned to two – Frisco (88.2 ppb) and Denton (87.5 ppb). The future design values among the nine DFW sites averaged 1.0 ppb less than the Combination 10 scenario, and 1.8 ppb less than the 2009 a2 baseline. The largest reductions were at sites with the highest future design values, suggesting that the additional mobile controls, particularly inside the DFW NAA, would be highly beneficial in reducing DFW 8-hour ozone if they could be incorporated into the control package.

Table 5-1. Change in weekday NOx emissions from the 2009 a2 baseline by control group.

	Combo 4	Combo 5	Combo 6	Combo 7	Combo 8	Combo 9	Combo 10	Combo 11	Combo 12
Main Changes to Controls		Relaxing NCTCOG mobile controls	Identifying more engines for controls	Eliminating engine controls in 6 East TX counties	Excluding lean-burning engines in East TX	Combo 8 controls expected to be in place by 2009	Combo 8 controls expected to be in place by 2010	Adding 1/3 of the additional DFW on-road controls expected for 2010	Adding all 2010 on-road controls in Texas
Within DFW NAA									
DFW major	-12.7	-10.5	-10.5	-10.5	-10.5	-8.4	-9.0	-9.0	-9.0
DFW minor	-4.5	-4.5	-4.5	-4.5	-4.5	-1.3	-3.0	-3.0	-3.0
DFW EGU	-2.0	-2.0	-2.0	-2.0	-2.0	-0.4	-0.4	-0.4	-0.4
Cement kilns	-11.0	-11.0	-11.0	-11.0	-11.0	-10.4	-10.4	-10.4	-10.4
On-road	-9.4	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-14.0	-21.5
Off-road	-6.9	-1.1	-1.1	-1.1	-2.2	-2.2	-2.2	-2.2	-8.6
DFW Total	-46.5	-30.5	-30.5	-30.5	-31.6	-24.0	-26.4	-38.9	-52.9
Outside DFW NAA									
On-road	0.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	-108.5
Off-road	0.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
East TX engines	-40.9	-40.9	-71.3	-61.0	-35.4	0.0	-22.4	-22.4	-22.4
Outside DFW Total	-40.9	-34.8	-65.2	-54.9	-29.3	+6.1	-16.3	-16.3	-129.3
Total	-87.4	-65.3	-95.7	-85.4	-61.0	-17.9	-42.7	-55.3	-182.2

Table 5-2. 2009 future design values from all runs.

	2009.a2 baseline	Combo 4	Combo 5	Combo 6	Combo 7	Combo 8	Combo 9	Combo 10	Combo 11	Combo 12
Frisco	89.8	88.3	88.9	88.6	88.7	88.9	89.6	89.3	88.8	88.2
Dallas Hinton	86.2	84.8	85.4	85.2	85.2	85.4	85.9	85.7	85.2	84.7
Dallas North C63	85.4	84.1	84.5	84.4	84.4	84.6	85.2	84.9	84.4	84.0
Dallas Exec C402	79.6	78.1	78.5	78.3	78.3	78.5	79.0	78.8	78.4	78.1
Denton	89.3	87.9	88.5	88.3	88.4	88.5	89.0	88.7	88.3	87.5
Midlothian	84.7	83.1	83.4	83.2	83.2	83.3	84.0	83.7	83.5	83.3
Arlington	82.1	80.0	80.5	80.3	80.3	80.5	80.9	80.7	80.4	79.9
Ft Worth C13	86.8	84.6	85.1	84.9	85.0	85.1	85.6	85.4	84.9	84.2
Ft Worth C17	85.4	84.1	84.7	84.5	84.5	84.7	85.0	84.8	84.4	83.7
Average	85.5	83.9	84.4	84.2	84.2	84.4	84.9	84.7	84.3	83.7

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APPENDIX

INTRODUCTION

A CAMx sensitivity run examined the 8-hour ozone benefits in the DFW NAA when zeroing out the Midlothian cement kilns. The emission reductions were applied to the Combination 10 package.

EMISSIONS

Combination 13 zeroed out the cement kilns in Ellis County from the Combination 10 scenario. The NO_x and VOC reductions from each control group are listed in Tables 1 and 2, respectively, for Combinations 10 and 13. Controls that were altered from the Combination 10 scenario are listed in red. The top shows changes within the DFW 9-county NAA; the bottom shows changes outside the DFW NAA.

The Combination 10 controls reduced 10.4 tpd NO_x from the cement kilns; Combination 13 removed an additional 16.4 tpd NO_x for a total reduction of 26.8 tpd from the cement kilns. The NO_x reduction from all controls within the DFW NAA increased to 42.8 tpd, or 59.1 tpd across Texas. There were no VOC controls applied to the cement kilns in Combination 10. Combination 13 reduced 1.7 tpd VOC from the kilns.

Tables 3 and 4 show the 2009 weekday NO_x and VOC emissions, respectively, for the DFW Combination 13 control scenario, broken down by source region, as defined in Figures 2-1 and 2-2, and by emission group (biogenics, elevated points, Texas mobile, low points, area, and off-road, and non-Texas low-level anthropogenics). Differences from the 2009.a2 baseline and from the Combination 10 scenario are shown in the two rightmost columns.

Table 1. Change in weekday NO_x emissions [tpd] by control group from the 2009.a2 baseline.

	DFW Combination 10	DFW Combination 13
Within DFW NAA		
DFW major	-9.0	-9.0
DFW minor	-3.0	-3.0
DFW EGU	-0.4	-0.4
Cement kilns	-10.4	-26.8
On-road	-1.4	-1.4
Off-road	-2.2	-2.2
DFW Total	-26.4	-42.8
Outside DFW NAA		
On-road	4.4	4.4
Off-road	1.7	1.7
East TX engines	-22.4	-22.4
Outside DFW Total	-16.3	-16.3
Total	-42.7	-59.1

Table 2. Change in weekday VOC emissions [tpd] by control group from the 2009.a2 baseline.

	DFW Combination 10	DFW Combination 13
Within DFW		
DFW major	0.0	0.0
DFW minor	0.0	0.0
DFW EGU	0.0	0.0
Cement kilns	0.0	-1.7
On-road	-0.5	-0.5
Off-road	+0.5	+0.5
Surface coating	-0.1	-0.1
DFW Total	-0.1	-1.8
Outside DFW		
On-road	+1.0	+1.0
Off-road	+1.9	+1.9
East TX engines	0.0	0.0
Outside DFW Total	+2.9	+2.9
Total	+2.9	+1.1

Table 3. Weekday NOx emissions [tpd] for 2009.a2 with Combination 13 controls.

	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non- TX Low Anthro	All Anthro	Anthro Change from 2009.a2 baseline	Anthro change from combo 10
Collin Co	10	14	1	0	2	8	0	25	-0.3	0.0
Dallas Co	4	77	5	1	18	44	0	145	-3.5	0.0
Denton Co	8	17	1	0	11	9	0	38	-2.1	0.0
Tarrant Co	3	46	1	1	10	27	0	86	-3.2	0.0
Parker Co	1	6	0	0	1	2	0	8	-1.1	0.0
Johnson Co	5	5	3	0	0	5	0	13	-2.2	0.0
Ellis Co	15	8	5	0	0	6	0	20	-29.1	-16.4
Kaufman Co	5	6	4	0	0	2	0	12	-0.4	0.0
Rockwall Co	2	3	0	0	0	1	0	5	-0.1	0.0
DFW 9-County	52	182	21	3	41	105	0	353	-42.1	-16.4
North Texas	31	24	13	3	17	15	0	72	-0.7	0.0
NE Texas	16	79	181	10	68	42	1	380	-13.5	0.0
Central TX	114	92	143	2	58	70	0	366	-7.6	0.0
Houston	21	179	226	11	53	63	0	532	4.4	0.0
South TX	229	189	261	21	75	100	0	647	-1.2	0.0
West TX	524	160	140	21	212	106	1	641	1.6	0.0
Texas	986	907	985	72	525	501	2	2991	-59.0	-16.4
Gulf + Mexico	79	5	436	0	4	2	444	891	0.0	0.0
Oklahoma	227	1	256	0	2	3	661	924	0.0	0.0
Louisiana	106	1	715	1	2	1	1183	1903	-0.1	0.0
Arkansas	125	2	220	0	0	2	468	692	0.0	0.0
Mississippi	121	0	353	0	0	0	455	808	0.0	0.0
Alabama	75	0	442	0	0	0	491	932	0.0	0.0
Tennessee	118	0	244	0	0	0	662	906	0.0	0.0
Kentucky	145	0	289	0	0	0	770	1060	0.0	0.0
Georgia	110	0	408	0	0	0	823	1230	0.0	0.0
Florida	56	0	367	0	0	0	1206	1573	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	293	0	977	0	0	0	2332	3310	0.0	0.0
NE US	314	0	1302	0	0	0	5748	7051	0.0	0.0
Northern Plains	5238	0	3269	0	0	0	8623	11892	0.0	0.0
Total	7992	916	10264	73	534	509	23869	36164	-59.1	-16.4
Change from 2009 baseline	0.0	3.0	-42.5	-10.2	-8.92	-0.4	-0.1	-59.1		
Change from combo 10	0.0	0.0	-16.4	0.0	0.0	0.0	0.0	-16.4		

Table 4. Weekday VOC emissions [tpd] for 2009.a2 with Combination 13 controls.

-----	Bio	TX Mobile	Elev Points	TX Low Points	TX Area	TX Offroad	Non- TX Low Anthro	All Anthro	Anthro Change from 2009.a2 baseline	Anthro change from Combo 10
Collin Co	27	7	0	1	12	4	0	23	0.0	0.0
Dallas Co	50	42	4	8	72	17	0	144	0.0	0.0
Denton Co	65	8	1	1	15	4	0	29	0.0	0.0
Tarrant Co	64	25	2	7	54	9	0	96	0.0	0.0
Parker Co	121	2	0	0	5	1	0	8	0.0	0.0
Johnson Co	111	2	0	0	6	1	0	9	0.0	0.0
Ellis Co	89	2	1	2	6	2	0	14	-1.7	-1.7
Kaufman Co	112	2	0	0	7	1	0	11	-0.1	0.0
Rockwall Co	3	1	0	0	2	1	0	4	0.0	0.0
DFW 9-County	642	91	8	20	180	38	0	338	-1.8	-1.7
North Texas	601	8	24	2	29	5	1	69	0.0	0.0
NE Texas	4917	27	14	41	82	14	1	179	0.2	0.0
Central TX	6393	35	20	20	91	23	1	191	0.2	0.0
Houston	1683	81	91	215	247	42	0	676	1.7	0.0
South TX	2069	78	20	48	217	46	0	408	0.5	0.0
West TX	6198	59	10	28	215	52	3	367	0.3	0.0
Texas	22503	381	187	374	1060	221	6	2229	1.1	-1.7
Gulf + Mexico	658	3	32	0	10	4	329	378	0.0	0.0
Oklahoma	7940	1	3	0	5	1	481	490	0.0	0.0
Louisiana	9941	0	47	3	4	1	546	601	0.0	0.0
Arkansas	13925	0	23	0	2	0	441	466	0.0	0.0
Mississippi	14818	0	35	0	0	0	548	583	0.0	0.0
Alabama	13954	0	39	0	0	0	655	695	0.0	0.0
Tennessee	8678	0	66	0	0	0	895	961	0.0	0.0
Kentucky	3753	0	34	0	0	0	622	656	0.0	0.0
Georgia	12198	0	53	0	0	0	869	922	0.0	0.0
Florida	9793	0	42	0	0	0	1594	1636	0.0	0.0
Mid Atlantic (SC, NC, VA, WV)	31294	0	67	0	0	0	2836	2903	0.0	0.0
NE US	20472	0	248	0	0	0	5407	5655	0.0	0.0
Northern Plains	40144	0	226	0	0	0	8224	8450	0.0	0.0
Total	210073	385	1102	377	1080	227	23453	26624	1.1	-1.7
Change from baseline	0.0	0.5	-1.8	-0.1	0.00	2.4	0.0	1.1		
Change from Combo 10	0.0	0.0	-1.7	0.0	0.0	0.0	0.0	-1.7		

MODELING RESULTS

Spatial plots of the daily maximum 8-hour ozone are displayed in the left column of Figure 1 for each episode date. Differences from the 2009.a2 baseline and from Combination 10 are shown in the center and right columns, respectively.

The additional 16.4 tpd NO_x reduction from the cement kilns reduced the daily maximum 8-hour ozone up to 5 ppb on six of the eight episode dates. The peak reduction was in Tarrant County

on five of the six dates (August 15-17 and August 21-22) and in Dallas County on August 18, but the ozone benefits were confined to a small area downwind of Midlothian on each date. Compared to the 2009.a2 baseline, the Combination 13 controls lowered the daily maximum 8-hour ozone up to 10 ppb on August 15 in Tarrant County.

The 2009 8-hour ozone future design value calculations for the DFW Combination 13 scenario is shown in Table 5. Daily relative reduction factors (RRF) are included at the bottom of the table. All 19 sites in the 4 km domain (plus Temple) are listed. Table 6 compares the future design values between the 2009.a2 baseline, and Combinations 10 and 13 for the nine DFW sites that were operational in 1999.

The Combination 13 future design values improved 0.1 to 2.9 ppb from Combination 10. The largest reductions were at the southern DFW sites – Midlothian (-2.9 ppb) and Arlington (-1.1 ppb), both which were already in attainment in the 2009.a2 baseline. Fort Worth C13's future design value dropped 0.9 ppb from 85.4 ppb in Combination 10 to 84.5 ppb in Combination 13, reducing the number of sites over 85.0 ppb from four to three. The other three sites over 85.0 ppb in Combination 10 – Frisco, Denton, and Dallas Hinton – continued to exceed the 85.0 ppb threshold as each saw no more than a 0.2 ppb reduction in future design values. Frisco remained the site with the highest future design value at 89.2 ppb.

Table 7 lists the future design value responsiveness at each DFW site to the additional NO_x reduction applied to the Midlothian cement kilns. The average response of 0.041 ppb O₃ per ton of NO_x reduced was the highest evaluated because of the great response at Midlothian (0.174 ppb O₃/ton NO_x). Although all changes to the emissions were within the DFW NAA, the ozone benefits were only found in a small area. Frisco was less responsive to the kiln emission reductions compared to any other scenario recently evaluated.

Compared to Combination 11, which reduced 12.6 tpd NO_x from on-road mobile sources inside the DFW NAA, the ozone response was greater at the three DFW sites that were already in attainment in the 2009.a2 baseline, and weaker at five of the six DFW sites that exceeded 85.0 ppb in the 2009.a2 baseline.

Tables 8 to 10 examine the 4-km grid cells in the DFW 9-county NAA in which the daily maximum 8-hour ozone exceeded 85 ppb. Table 8 lists the number of unique grid cells in DFW that exceed 85 ppb for each date in the 2009.a2 baseline and in Combinations 10 and 13. In the 2009.a2 baseline, there were 1158 grid cells in the DFW NAA at or over 85 ppb spanning the eight day episode. The Combination 10 controls reduced the exceedance area by 6 % during the episode. Combinations 13 reduced the exceedance area by 10 %.

Table 9 shows the number of baseline exceedance cells that were reduced at least 1 ppb from the combination of controls. Combination 10 reduced 197 (17 %) of all exceedance cells by at least 1 ppb; Combination 13 reduced twice as many (400 exceedance cells, or 35 %).

Table 10 sums the number of ppb's in the daily maximum 8-hour ozone that exceed 85 ppb. For example, if the daily maximum ozone in a grid cell is 90 ppb, the grid cell adds 5 ppb (90 – 85 ppb) to the sum of ozone exceedances. The number of exceedance ppb's among all episode dates was reduced 9 % in Combination 10 and 15 % in Combination 13.

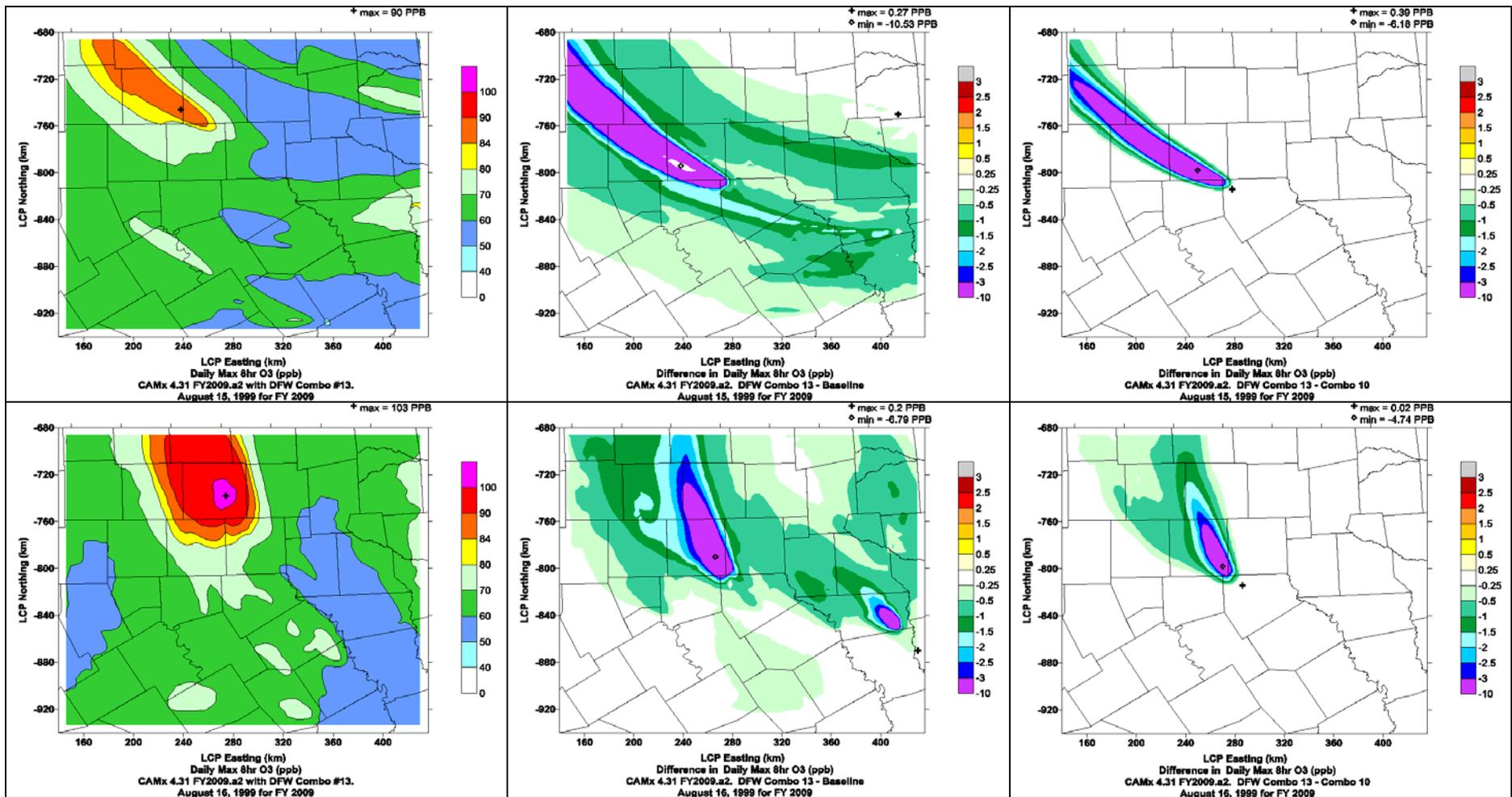


Figure 1. Spatial plots of the daily maximum 8-hour ozone in Combination 13 (left), and differences from the 2009.a2 baseline (center) and from Combination 10 (right).

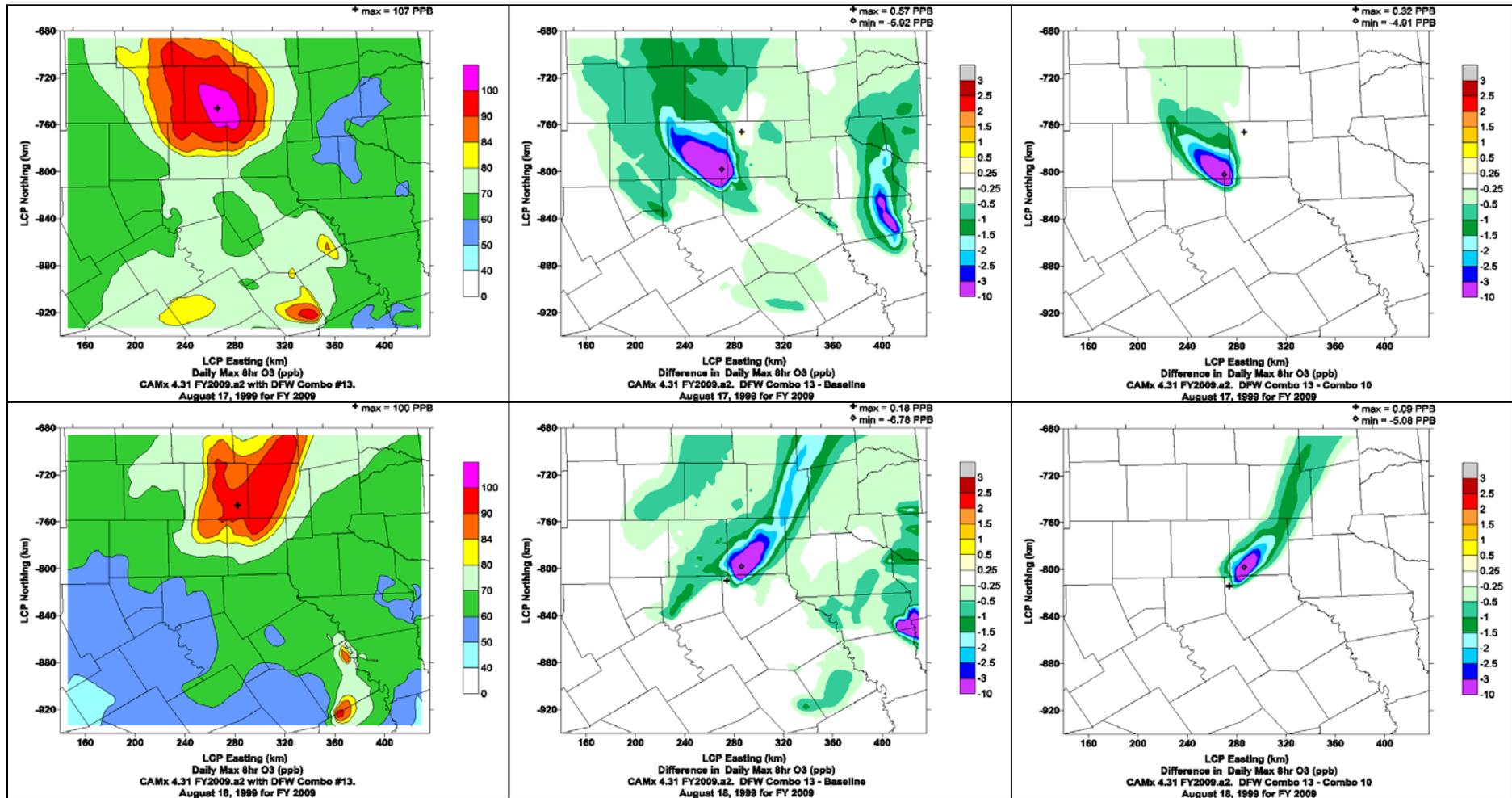


Figure 1. continued. Spatial plots of the daily maximum 8-hour ozone in Combination 13 (left), and differences from the 2009.a2 baseline (center) and from Combination 10 (right).

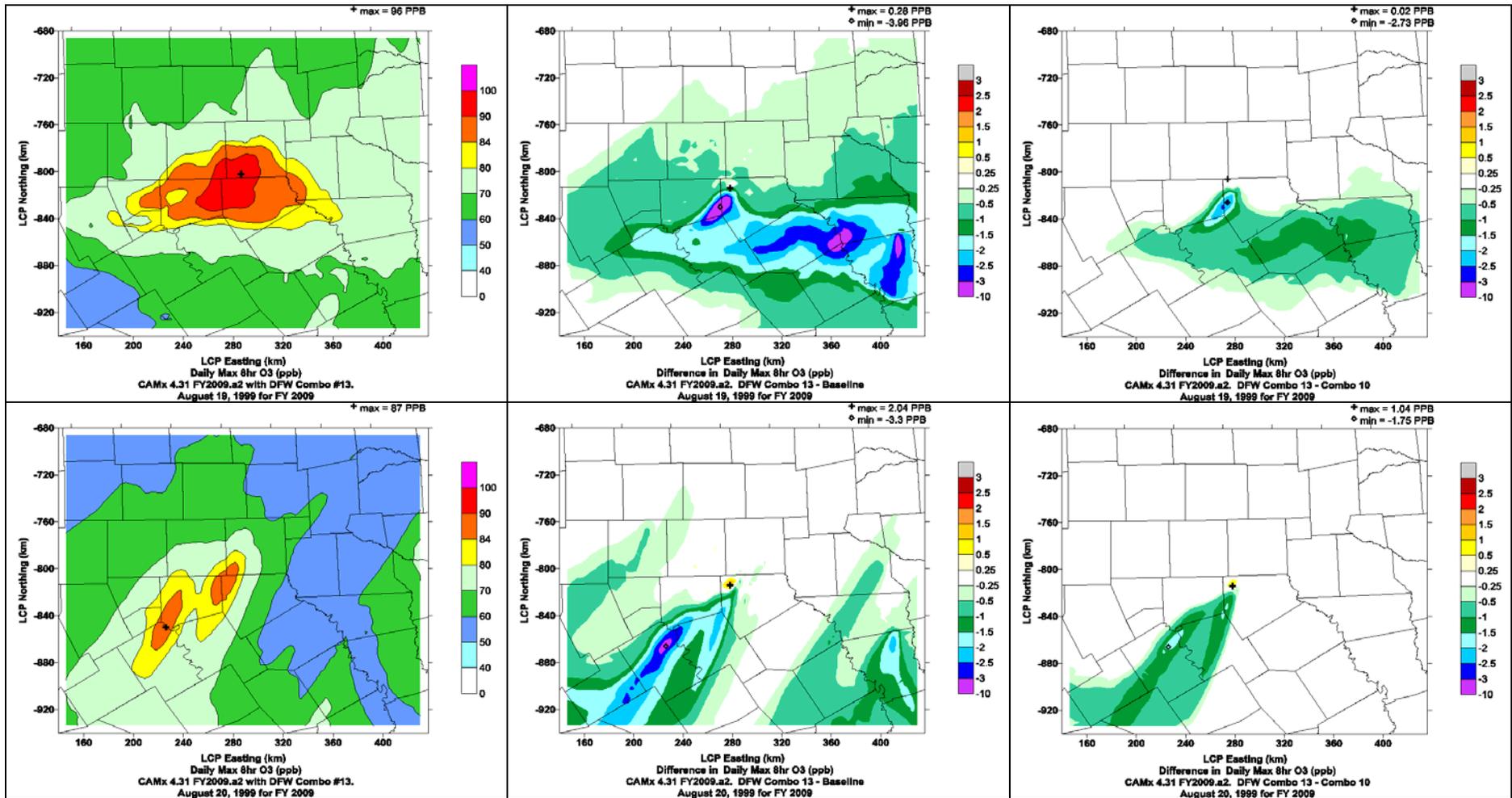


Figure 1. continued. Spatial plots of the daily maximum 8-hour ozone in Combination 13 (left), and differences from the 2009.a2 baseline (center) and from Combination 10 (right).

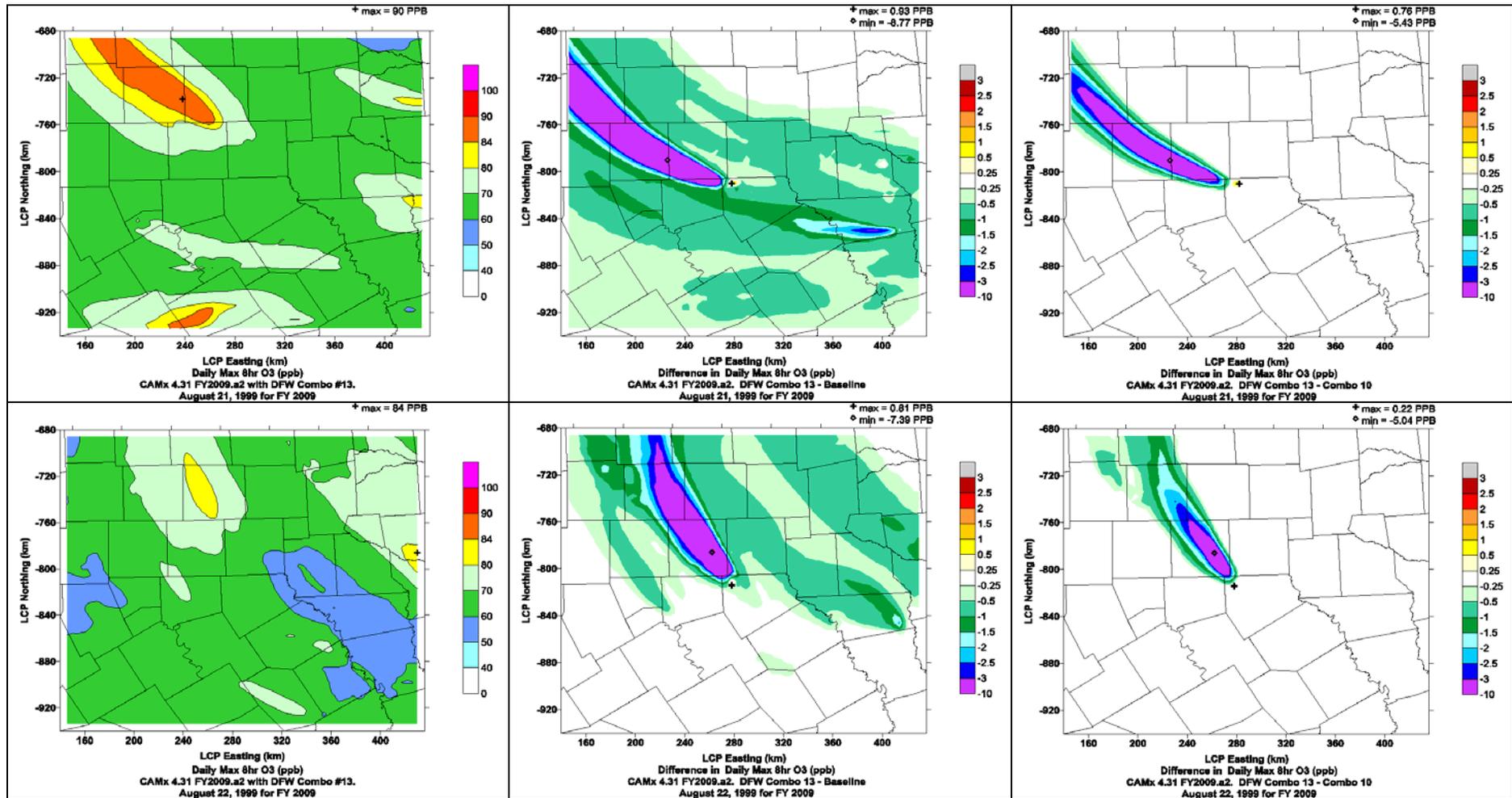


Figure 1. concluded. Spatial plots of the daily maximum 8-hour ozone in Combination 13 (left), and differences from the 2009.a2 baseline (center) and from Combination 10 (right).

Table 5. Future design value calculations for the DFW Combination 13 control package.

Base Case: run46												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	#Days>70		
Frisco	81.3	107.0	102.6	109.2	86.0	69.9	87.1	89.5	94.7	7		
Dallas HintonC60	83.1	99.8	103.4	103.8	99.2	78.0	85.5	85.3	92.3	8		
Dallas North C63	82.6	101.3	102.6	106.6	96.5	76.4	86.8	88.4	92.6	8		
Dallas Exec C402	77.0	93.3	98.5	96.6	107.4	83.7	79.4	79.5	89.4	8		
Denton	102.6	113.1	110.0	112.5	84.7	73.1	101.6	99.6	99.7	8		
Midlothian	78.3	86.1	85.9	76.2	114.0	88.8	75.7	76.7	85.2	8		
Arlington	86.2	98.4	100.2	95.2	106.9	83.1	81.9	86.7	92.3	8		
Ft Worth C13	93.8	105.5	104.3	106.0	96.0	80.1	89.8	92.0	95.9	8		
Ft Worth C17	101.1	111.1	110.4	108.3	92.4	78.6	95.9	94.9	99.1	8		
Anna	69.2	79.5	90.7	105.2	89.3	73.8	77.4	75.1	84.4	7		
Sunnyvale	65.5	77.7	84.4	93.2	97.0	70.5	75.7	71.0	81.4	7		
Granbury	84.1	80.1	81.8	75.4	100.5	86.2	83.7	77.3	83.6	8		
Cleburne	73.1	79.8	83.0	70.9	106.8	95.8	76.7	80.3	83.3	8		
Kaufman	68.6	68.3	74.5	74.2	96.1	65.1	73.2	66.3	79.5	4		
Weatherford	96.7	78.8	88.3	75.5	80.5	70.5	92.8	77.9	82.6	8		
Rockwall	63.6	77.3	87.0	99.9	91.6	69.4	74.6	71.1	83.6	6		
Eagle Mt Lake	98.7	108.4	101.9	95.9	90.2	78.8	95.8	92.7	95.3	8		
Grapevine	97.7	110.5	110.4	109.5	89.8	75.8	97.2	97.9	98.6	8		
Waco	87.3	87.5	92.9	72.8	75.3	84.0	104.0	83.3	85.9	8		
Temple ¹	72.5	79.4	89.5	57.7	71.9	86.3	85.9	70.4	79.4	7		
Future Year: run46.fy2009.a2.dfw_combo13												
Site	990815	990816	990817	990818	990819	990820	990821	990822	Average	RRF ²	BaseDV	FutureDV ³
Frisco	66.8	100.3	101.6	99.9	72.9	63.9	74.2	73.7	84.2	0.889	100.3	89.17
Dallas HintonC60	72.1	92.1	102.9	96.6	91.1	80.7	77.4	73.1	85.8	0.929	92.0	85.47
Dallas North C63	70.2	95.0	101.6	98.7	84.1	77.4	75.6	73.3	84.5	0.912	93.0	84.82
Dallas Exec C402	65.9	80.9	87.9	82.2	96.4	85.2	69.7	68.0	79.5	0.889	88.0	78.23
Denton	87.7	102.4	107.3	91.5	71.2	64.4	89.4	82.6	87.1	0.873	101.5	88.61
Midlothian	65.6	73.4	74.1	66.7	96.3	85.5	67.5	67.1	74.5	0.874	92.5	80.85
Arlington	72.3	83.3	88.2	80.7	95.0	85.2	72.3	73.2	81.3	0.880	90.5	79.64
Ft Worth C13	77.8	89.2	92.4	87.4	83.0	75.6	78.5	75.9	82.5	0.860	98.3	84.54
Ft Worth C17	88.5	96.2	103.1	89.9	78.7	70.5	87.7	81.3	87.0	0.878	96.3	84.55
Anna	62.9	68.3	83.1	95.9	72.1	58.5	67.7	69.8	73.6	0.872		
Sunnyvale	59.4	70.9	77.2	83.7	85.8	66.0	66.2	63.6	73.4	0.901		
Granbury	69.4	64.9	70.0	62.8	85.3	81.0	69.3	66.9	71.2	0.851		
Cleburne	67.2	70.8	72.4	61.6	90.2	86.0	69.1	71.8	73.6	0.884		
Kaufman	62.1	61.2	63.9	64.0	85.8	58.7	65.9	60.3	69.9	0.879		
Weatherford	77.1	67.7	75.0	64.3	71.2	65.3	76.6	68.9	70.8	0.856		
Rockwall	57.9	68.0	77.8	88.6	78.5	63.6	65.2	63.0	73.5	0.880		
Eagle Mt Lake	83.5	89.4	91.9	80.9	78.8	72.1	80.9	76.0	81.7	0.857		
Grapevine	85.2	101.4	107.3	99.9	77.2	71.8	86.9	82.2	89.0	0.902		

Table 5. concluded.

Waco	66.0	73.8	83.0	64.9	66.8	75.3	85.0	67.9	72.8	0.848		
Temple	63.3	69.6	81.0	53.4	64.4	74.8	76.9	65.2	70.7	0.891		
Daily RRFs⁴												
Site	990815	990816	990817	990818	990819	990820	990821	990822				
Frisco	0.821	0.938	0.990	0.916	0.848	0.914	0.852	0.823				
Dallas HintonC60	0.868	0.923	0.995	0.930	0.918	1.036	0.905	0.857				
Dallas North C63	0.850	0.938	0.990	0.926	0.871	1.013	0.872	0.829				
Dallas Exec C402	0.856	0.867	0.892	0.851	0.897	1.018	0.879	0.856				
Denton	0.855	0.906	0.975	0.813	0.841	0.881	0.879	0.829				
Midlothian	0.838	0.852	0.862	0.874	0.845	0.963	0.892	0.875				
Arlington	0.838	0.847	0.880	0.848	0.889	1.025	0.882	0.844				
Ft Worth C13	0.829	0.846	0.886	0.825	0.865	0.943	0.874	0.825				
Ft Worth C17	0.876	0.867	0.935	0.830	0.852	0.897	0.914	0.857				
Anna	0.908	0.859	0.917	0.912	0.807	0.792	0.875	0.929				
Sunnyvale	0.906	0.913	0.915	0.898	0.884	0.936	0.874	0.896				
Granbury	0.826	0.810	0.855	0.833	0.849	0.939	0.829	0.865				
Cleburne	0.919	0.887	0.872	0.868	0.844	0.898	0.901	0.893				
Kaufman	0.905	0.896	0.858	0.863	0.892	0.902	0.900	0.909				
Weatherford	0.798	0.858	0.849	0.851	0.884	0.927	0.825	0.884				
Rockwall	0.911	0.880	0.894	0.887	0.857	0.917	0.874	0.886				
Eagle Mt Lake	0.846	0.825	0.902	0.844	0.873	0.916	0.844	0.819				
Grapevine	0.872	0.917	0.972	0.913	0.859	0.947	0.893	0.840				
Waco	0.756	0.844	0.894	0.891	0.887	0.897	0.817	0.816				
Temple	0.873	0.876	0.906	0.925	0.896	0.866	0.895	0.926				

1. Temple is outside the DFW 4 km domain. Its daily maximum values are based on the highest value in the 3x3 12 km grid cells surrounding it

2. RRF = future year average / baseline average

3. Future DV = baseline DV * RRF

4. Daily RRFs are for information only. They are not used to calculate the future DV

Table 6. Future design value summary [ppb].

	run46.fy2009.a2 (2009 baseline)	run46.fy2009.a2. dfw_combo10	run46.fy2009.a2. dfw_combo13
2009 future design values			
Frisco	89.8	89.3	89.2
Dallas Hinton C60	86.2	85.7	85.5
Dallas North C63	85.4	84.9	84.8
Dallas Exec C402	79.6	78.8	78.2
Denton	89.3	88.7	88.6
Midlothian	84.7	83.7	80.9
Arlington	82.1	80.7	79.6
Ft Worth C13	86.8	85.4	84.5
Ft Worth C17	85.4	84.8	84.6
Differences from the 2009 a2 baseline			
Frisco		-0.5	-0.6
Dallas Hinton C60		-0.5	-0.7
Dallas North C63		-0.5	-0.6
Dallas Exec C402		-0.9	-1.4
Denton		-0.6	-0.7
Midlothian		-1.0	-3.9
Arlington		-1.3	-2.4
Ft Worth C13		-1.4	-2.3
Ft Worth C17		-0.6	-0.9
Differences from DFW Combination 10			
Frisco			-0.1
Dallas Hinton C60			-0.2
Dallas North C63			-0.1
Dallas Exec C402			-0.5
Denton			-0.1
Midlothian			-2.9
Arlington			-1.1
Ft Worth C13			-0.9
Ft Worth C17			-0.3

Table 7. Ozone responsiveness to changes in NOx emissions [ppb O3/ton NOx].

	Combo 13 – Combo 10
Change in NOx	-16.4 tpd inside DFW
Frisco	0.006
Dallas Hinton	0.011
Dallas North C63	0.005
Dallas Exec C402	0.032
Denton	0.006
Midlothian	0.174
Arlington	0.066
Ft Worth C13	0.054
Ft Worth C17	0.018
Average	0.041

Table 8. Exceedance Area (Number of 4-km grid cells in DFW with the daily max 8-hour ozone >= 85 ppb).

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo10	run46.fy2009.a2. dfw_combo13
Scenario	2009 baseline	2009 with DFW combo 10 controls	2009 with DFW combo 13 controls
990815	18	13	13
990816	220	210	200
990817	291	284	274
990818	248	235	231
990819	323	297	287
990820	30	20	16
990821	28	25	25
990822	0	0	0
Totals	1158	1084	1046
% Reduced		-6.4 %	-9.7 %

Table 9. Number of exceedance cells reduced at least 1 ppb.

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo10	run46.fy2009.a2. dfw_combo13
990815	--	0	0
990816	--	106	132
990817	--	51	127
990818	--	6	57
990819	--	31	71
990820	--	3	13
990821	--	0	0
990822	--	0	0
Totals	--	197 (17 %)	400 (35 %)

Table 10. Number of ppb's from grid cells in the daily maximum 8-hour ozone in excess of 85 ppb¹.

Run	run46.fy2009.a2	run46.fy2009.a2. dfw_combo10	run46.fy2009.a2. dfw_combo13
990815	47	34	34
990816	2269	2039	1856
990817	2880	2706	2564
990818	1634	1510	1457
990819	1478	1299	1202
990820	23	12	9
990821	69	56	56
990822	0	0	0
Total	8400	7656	7178
% Reduced		-9 %	-15 %

¹ $\sum(\max(O_3-85, 0.0))$ for all grid cells in DFW 9-county NAA.

SUMMARY

Combination 13 examined the impacts to 8-hour ozone in DFW from zeroing out the Midlothian cement kilns. NO_x and VOC emissions were reduced an additional 16.4 and 1.7 tpd, respectively, from the Combination 10 scenario.

The additional cement kiln controls reduced the daily maximum 8-hour ozone up to 5 ppb, but on most episode dates, the ozone benefits were confined to a narrow band downwind of Midlothian. Future design values were reduced 0.1 to 2.9 ppb. Ozone benefits were greatest at sites that were already in attainment, such as Midlothian (-2.9 ppb) and Arlington (-1.1 ppb) and lowest at sites that needed it the most, like Frisco and Denton (-0.1 ppb each). Combination 13 lowered the number of sites over 85.0 ppb from four in Combination 10 to three as Fort Worth C13's future design value dropped 0.9 ppb to 84.5 ppb.