Final Report

2007 FUTURE YEAR OZONE MODELING FOR THE DALLAS/FORT WORTH AREA

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Prepared for

Texas Commission on Environmental Quality
12118 Park 35 Circle
Austin, Texas 78753

Prepared by

ENVIRON International Corporation
101 Rowland Way, Suite 220
Novato, CA 94945

and

Texas Engineering Experiment Station
3000 TAMU
College Station, TX 77843

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TABLE OF CONTENTS

APPENDIX

TABLES

FIGURES

1.0 INTRODUCTION

This report describes the results of initial 2007 future year ozone modeling of the Dallas/Fort Worth (DFW) area using and August 1999 episode. The development of the August 13-22, 1999 episode by ENVIRON for the TCEQ was described previously by Mansell et al., (2003). The future year ozone results for 2007 described here will be used by the TCEQ in planning activities for the 1-hour ozone standard.

The TCEQ will be considering the 8-hour ozone standard using ozone modeling results for a 2010 future year when they become available. This report includes an 8-hour ozone analysis for 2007 as an indication of progress toward meeting the 8-hour ozone standard by 2007. The analysis of 8-hour ozone uses the "design value scaling" (DV scaling) method described by EPA in the draft 8-hour ozone modeling guidance (EPA, 1999). The DV scaling method looks at relative changes in modeled ozone from the base year to the future year and therefore is sensitive to any inconsistencies between the base and future year modeling, such as changes in emission inventory assumptions. The 8-hour ozone analysis presented here for 2007 is preliminary because: (1) The 8-hour analysis relies upon 1999 ozone modeling results that use an inventory that needs to be updated to match the 2007 inventory, and; (2) The final 8-hour ozone modeling will be for 2010 not 2007.

The 2007 future year ozone modeling described here used the latest version 4.03 of the CAMx model. The previous 1999 base case modeling (Mansell et al., 2003) was performed using CAMx version 4.02. The 1999 base case was re-run using CAMx version 4.03 to update the model performance evaluation and provide a consistent set of modeling results the base and future years. As just discussed, consistency between 1999 and 2007 modeling methods is particularly important for 8-hour ozone when the DV scaling method is used.

The modeling domain for this study, shown in Figure 1-1, provides a 4-km high-resolution grid in the DFW area nested within 12-km and 36-km grids covering much of the South, Southeast and Central US. This modeling domain was designed to provide high-resolution for all sources in the DFW area and also include all regional sources within a 2-3 day transport time of DFW.

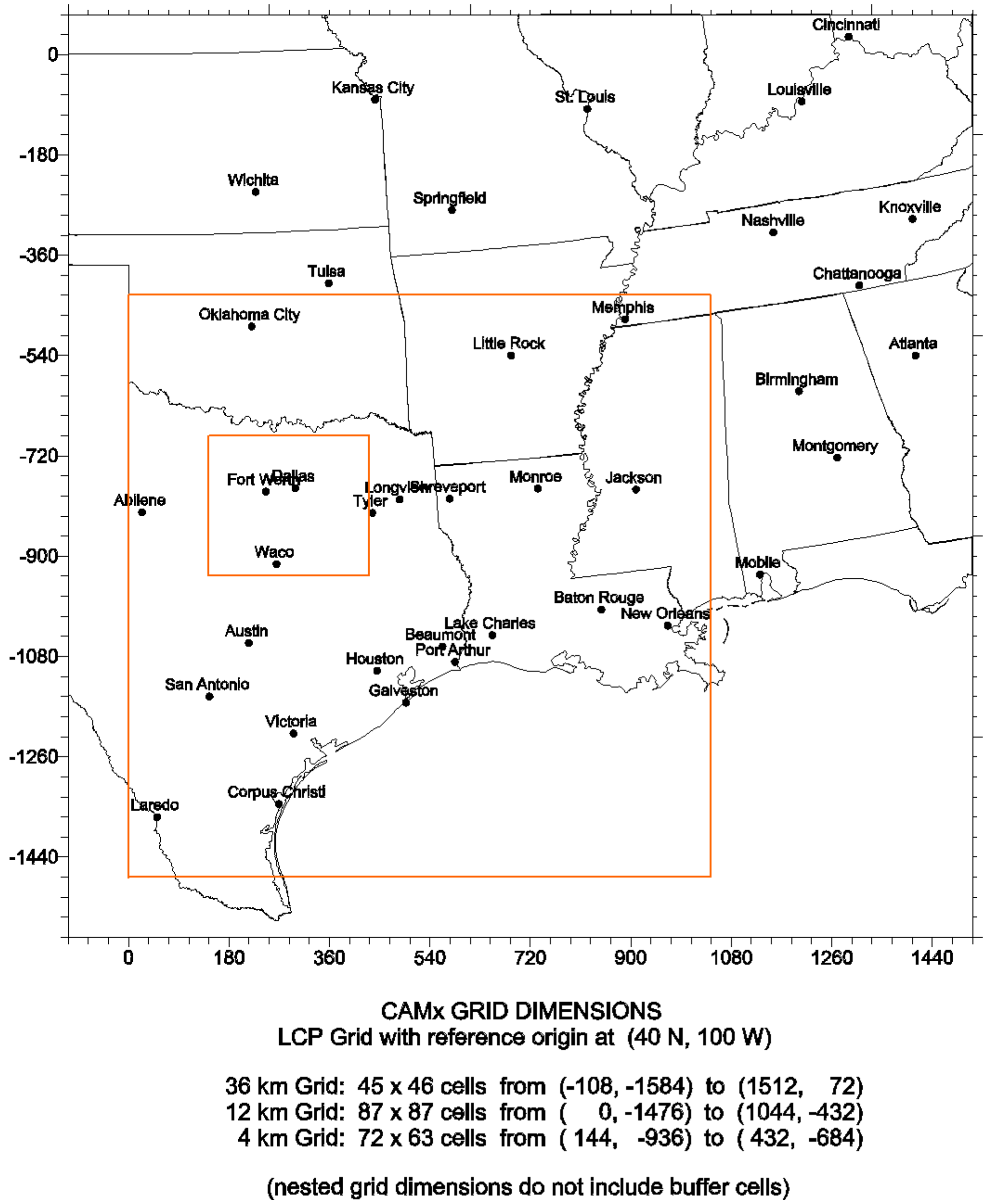


Figure 1-1. CAMx modeling domain for the August 1999 episode showing the 36-km regional grid and the nested 12-km and 4-km fine grids.

2.0 EMISSIONS PROCESSING

The August 13-22, 1999 DFW ozone episode, a Friday through Sunday, was modeled in CAMx using a Lambert Conformal Projection (LCP) nested grid configuration with grid resolutions of 36, 12 and 4-km (Figure 1-1). In CAMx, emissions are separated between surface (surface and low level point) emissions and elevated point source emissions. For the surface emissions, a separate emission inventory is required for each grid nest, i.e., three inventories. For elevated point sources, a single emission inventory is prepared covering all grid nests.

Two emissions modeling domains are used to generate the required CAMx ready inventories:

1. **Dallas/Fort Worth Non-Attainment Area 4-km Grid**. The DFW emissions grid has 72 x 63 cells at 4-km resolution and covers the same area as the CAMx 4-km nested grid shown in Figure 1-1.

2. **Regional Emissions Grid**. Emissions for the CAMx 36-km and 12-km grids are prepared together in a single emissions processing step for efficiency. The regional emissions grid has 135 x 138 cells at 12-km resolution and covers the full area shown in Figure 1-1. This emissions grid is used for the 12-km CAMx grid by "windowing out" emissions for the appropriate region. In contrast the regional emissions grid is aggregated from nine 12-km cells to one 36-km cell over the entire area to generate the CAMx 36-km grid.

DATA SOURCES FOR 1999

The development of emission inventories for the 1999 base year is documented in Mansell et al., 2003. Table 2-1 provides a summary of data sources used in the development of the 1999 inventory. Emission summaries for 1999 by source category and county were presented in Mansell et al., 2003.

Table 2-1. Summary of emissions data sources for 1999.

Category	Region	Data Source
Mobile	DFW	NCTCOG link-based, MOBILE6
	Texas major urban	TTI link-based, MOBILE6 via TCEQ
	Other Texas	TTI county level, MOBILE6 via TCEQ
	Outside Texas	EPA NEI99 Version 2, MOBILE6
Offroad	Texas	NONROAD 2002 model
	DFW	NCTCOG local data and NONROAD 2002 model
	Outside Texas	EPA NEI99 Version 2
Area	Texas	TCEQ
	Outside Texas	EPA NEI99 Version 2
Point	TX and LA EGU	EPA acid rain hourly data processed by TCEQ
	Texas other	1999 PSDB
	Louisiana other	LA DEQ provided to TCEQ
	OK EGU	EPA acid rain hourly data processed by ENVIRON
	OK other	EPA NEI99 Version 2 with ODEQ corrections
	Other	EPA NEI99 Version 2
Offshore	Texas	TCEQ offshore and shipping emissions
Biogenic	DFW	GloBEIS3.1 with TCEQ LULC data
	Outside DFW	GloBEIS2.2 with TCEQ and BELD3 LULC data

DATA SOURCES FOR 2007

The future year 2007 emission inventory was developed jointly by ENVIRON and TCEQ. The TCEQ developed gridded, model-ready emissions files for area and off-road mobile source for the entire state of Texas for both the 12-km regional and 4-km DFW emissions grids. On-road mobile source emissions for all areas were based on EPA's MOBILE6 model. Off-road mobile source emissions were based on the 2002 version of EPA's NONROAD model for most source categories. Point source emissions were based on data from TCEQ's point source database (PSDB) and EPA's National Emissions Inventory. Area source emissions for Texas were based on TCEQ data and other states were based on EPA's data developed for a rulemaking on heavy-duty diesel (HDD) engines. Biogenic emissions were unchanged from the 1999 base case inventory as described by Mansell, et al. (2003).

The data sources for the 2007 emissions inventories are described in more detail below followed by summary tables of gridded emissions by county and source category. Spatial plots of the 2007 NOx, VOC and CO emissions by source category for the August 17 episode day are presented for the 12-km and 4-km grids.

On-Road Mobile Sources

All on-road mobile source emissions were based on EPA's MOBILE6 model. Control measures for on-road mobile sources were modeled using MOBILE6.

DFW: On-road mobile source emissions were developed by NCTCOG for TCEQ using MOBILE6.2. The modeling files were downloaded from TCEQ's FTP server: ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/TXareaNR/files
The following files were provided:

- dfw_04km_07.18Fed2004.tar
- reg_12km.fy07e.regular_tx_os_mex.tar

The DFW on-road mobile emissions are based on a 5-day work week.

NE Texas: Link-based emissions from MOBILE6.2 for 4 day of week scenarios (Monday – Thursday, Friday, Saturday, Sunday) and 2007 vehicle miles traveled (VMT) and fleet turnover developed by TTI with day-specific adjustments for temperature and humidity.

Rest of Texas: County-level emissions from MOBILE6 for 4 day of week scenarios and 2007 VMT and fleet turnover developed by TTI with day-specific adjustments for temperature and humidity.

Other States: MOBILE6.2 county level emissions for typical summer day conditions (as used in the NEI999v2) with EPA data for 2007 VMT and fleet turnover.

Off-Road Mobile Sources

Off-road mobile source emissions for all categories except aircraft, commercial marine and locomotives were from EPA's 2002 version of the NONROAD model (NONROADv2002). The

TCEQ developed the NONROAD model input data for Texas and EPA's data were used elsewhere. Emissions for aircraft, commercial marine and locomotives are not included in NONROAD and so were estimated by TCEQ and EPA for 1999 and projected to other years using EPA data including the Economic Growth Analysis System (EGAS).

Texas: TCEQ provided gridded model-ready off-road mobile source emissions data. The modeling files were downloaded from TCEQ's anonymous FTP server: ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/TXareaNR/files
The following files were provided:

- dfw_04km_07.18Fed2004.tar
- reg_12km.fy07e.regular_tx_os_mex.tar

Other States: NONROADv2002 with default input data for 2007. Aircraft, commercial marine and railroad emissions for 2007 developed by EPA for a rulemaking on "heavy duty diesel" emissions.

Area Sources

Emissions for stationary sources that are not individually inventoried (area sources) were based on data developed for 1999 by TCEQ and EPA. Emissions for years later than 1999 were projected using EGAS and other data.

Texas: TCEQ provided gridded model-ready off-road mobile source emissions data. The modeling files were downloaded from TCEQ's FTP server: ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/file_transfer/TXareaNR/files
The following files were provided:

- dfw_04km_07.18Fed2004.tar
- reg_12km.fy07e.regular_tx_os_mex.tar

Other States: EPA 2007 emission inventory developed for a rulemaking on "heavy duty diesel" emissions.

Point Sources

Emissions for stationary sources that are inventoried individually (point sources) were based on data from TCEQ, EPA and the Louisiana DEQ (LDEQ). The TCEQ provided model-ready point source emissions data for the entire modeling domain. Gridded low-level point source emission files were provided for both the 12-km regional and 4-km DFW modeling domains. The data were downloaded from TCEQ's FTP server: ftp://ftp.tnrcc.state.tx.us/pub/OEPAA/TAD/Modeling/DFWAQSE/Modeling/EI/Points/2007.

The following files were provided:

- dfwmcr_2007_points.tar.gz

Biogenic Emissions

Biogenic emissions were prepared using both versions 2.2 and 3.1 of the GloBEIS model (Yarwood et al., 1999 a,b). The GloBEIS model was developed by the National Center for Atmospheric Research and ENVIRON under sponsorship from the TCEQ.

GloBEIS Version 2.2

GloBEIS version 2.2 was based on the EPA BEIS2 model algorithms with the following improvements:

- Updated emission factor algorithm (called the BEIS99 algorithm).
- Compatible with the EPA's Biogenic Emission Landcover Database – Version 3 (BELD-3).
- Compatible with the TCEQ's Texas specific landcover database which includes local surveys of DFW vegetation (Yarwood et al., 1999b).
- Ability to directly input solar radiation data for photosynthetically active radiation (PAR).

GloBEIS 2.2 requires input data for landuse/landcover (LULC), temperature and solar radiation. The TCEQ provided these data for the August 1999 episode period (Yarwood et al., 2001). Briefly, these data were:

- TCEQ LULC data for Texas and Mexico.
- EPA BELD-3 LULC data for all other U.S. States.
- Hourly temperature data from interpolated NWS observations.
- Hourly solar radiation (PAR) based on GOES satellite data as analyzed by the University of Maryland.

GloBEIS Version 3.1

GloBEIS, version 3.1, was released in 2002 (Guenther et al., 2002) and has the following changes from version 2.2:

- Options to model the impacts of drought and prolonged periods of high temperature.
- Optional leaf energy balance model.
- Optional direct input of leaf area index (e.g., from satellite data).
- Option to model effects of leaf age on emissions (seasonal effects).
- Chemical speciation for the SAPRC99 and CB4 mechanisms.
- Updated speciation of other VOC emissions.
- GloBEIS3 emission factor model (previously called BEIS99).

GloBEIS3.1 and GloBEIS2.2 codes calculate the same emissions when using the same input data. Using the options to model drought impacts and prolonged periods of high temperature requires input data for humidity and wind speed in addition to temperature. It is important for these humidity and temperature inputs to be consistent (e.g., from a meteorological model such as MM5).

Biogenic Inventory Preparation

GloBEIS was used to calculate day specific, gridded, speciated, hourly emissions of biogenic VOCs and NOx for each modeling grid (36-km, 12-km, 4-km). The model versions and input data were as follows.

DFW 4-km grid area: Biogenic emissions were calculated using GloBEIS3.1 with TCEQ LULC data, MM5 temperature data and GOES satellite PAR data.

Texas outside of the DFW 4-km grid area: Biogenic emissions were calculated using GloBEIS2.2 with TCEQ LULC data, interpolated observed temperature data and GOES satellite PAR data.

States outside of Texas: Biogenic emissions were calculated using GloBEIS2.2 with BELD-3 LULC data, interpolated observed temperature data and GOES satellite PAR data.

Mexico: Biogenic emissions were calculated using GloBEIS2.2 with TCEQ LULC data, interpolated observed temperature data and GOES satellite PAR data.

EMISSION SUMMARIES FOR 2007

The emission inventories for 2007 are summarized in Tables 2-2 through 2-5. These tables are:

- Table 2-2 shows the 2007 NOx emissions for DFW area counties by source category.
- Table 2-3 shows the 2007 VOC emissions for DFW area counties by source category.
- Table 2-4 shows the 2007 CO emissions for DFW area counties and day-of-week.
- Table 2-5 shows the 2007 NOx and VOC emissions for the entire modeling domain broken out by several geographic areas.

Tables 2-2 through 2-4 provide detailed information for the DFW area by day of week and source category. The days of week shown in Tables 2-2 through 2-4 are August 18^{th} (weekday), August (21 (Saturday) and August 22 (Sunday). Table 2-5 shows the emission inventories for the entire modeling domain in a concise format for just the August 17^{th} day (Tuesday). The geographic areas used in Table 2-5 are the same as used in previous ozone source apportionment modeling (Mansell et al., 2003) as defined in Figure 2-1. The source categories in Tables 2-5 through 2-7 are biogenic, on-road mobile, all point and area plus off-road mobile sources. Table 2-8 provides the definition of the source regions corresponding to the numbered regions in Figure 2-1.

Table 2-5 is prepared directly from model ready emissions files and this introduces some uncertainty into the emissions totals because: (1) County boundaries are approximated to the nearest grid-cell boundary, and; (2) The emissions processing provides CAMx with moles of emissions rather than tons of emissions. Therefore, in the case of minor differences between Tables 2-2 through 2-4 and Table 2-5, the former should be considered more accurate. Also, the weekday in Tables 2-2 through 2-4 is August 18^{th} whereas Table 2-5 is for August 17^{th}.

Table 2-6 shows the same information as Table 2-5 but for the 1999 base year rather than 2007 future year emission inventory. Comparing Tables 2-5 and 2-6 shows the trends in emissions from the base to future year resulting from the combined effects of activity growth and emission control strategies. Table 2-7 shows the ratio of the 2007 to 1999 emissions shown in Tables 2-6 and 2-5. In a few cases the ratios are large numbers because the 1999 emissions were very low, so care is needed in interpreting the ratios shown in Table 2-7. The following points are noted from the emissions trend analysis shown in Table 2-7:

- There are significant reductions in on-road mobile source NOx and VOC emissions in all regions from 1999 to 2007 resulting from cleaner vehicles and fuels.
- The on-road mobile source NOx emission reductions are influenced by new standards for heavy-duty diesel vehicles and therefore the overall on-road mobile source NOx reduction tends to be larger in areas with a high contribution from truck traffic.
- There are significant reductions in elevated point source NOx emissions in most regions from 1999 to 2007.
- The 2007 Point source NOx in the 4 core DFW counties is substantially reduced, but increases in the surrounding 12 counties.
- Point source NOx emissions are substantially lower in 2007 for the "Other" region (region 25 in Figure 2-1) due to EPA's NOx SIP call.
- Reductions in combined area plus off-road mobile source NOx emissions tend to be less than for on-road mobile or point sources.

The spatial distribution of the emissions is shown by source category in Figures 2-2 through 2-7. The 4-km grid model ready emissions for Tuesday August 17th are shown in Figures 2-2 through 2-4 for NOx, VOC and CO, respectively. Figures 2-5 through 2-7 show the corresponding information for the 12-km CAMx grid.

The dates shown in the PAVE legends in Figures 2-2 through 2-7 are sometimes different from August 17th, 1999. This does not indicate any problems with the emission inventory: rather, future year area, off-road and low-level point emissions were prepared for representative weekdays from a Houston modeling episode (Tuesday August 29, 2000 or Thursday August 31, 2000) and used for DFW future case weekdays.

Table 2-2. 2007 NOx emissions by source category for the DFW area counties.

2007 NOx emissions (tons/days)															
	Area			On-road Mobile			Off-road Mobile			Points			Total Anthropogenic		
County	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**
Colin	2.3	1.7	1.2	18.2	12.9	9.1	20.3	13.4	10.2	3.8	2.9	3.4	**44.5**	**30.8**	**24.1**
Cooke	0.2	0.2	0.2	2.9	2.1	1.6	2.9	2.8	2.7	0.0	0.0	0.0	**6.0**	**5.1**	**4.5**
Dallas	17.8	13.0	8.2	86.8	60.2	43.9	62.9	46.6	37.1	17.8	17.7	17.3	**185.4**	**136.3**	**106.5**
Denton	2.5	2.2	1.8	18.3	12.5	9.0	9.5	7.0	5.6	2.8	2.7	2.6	**33.1**	**24.3**	**19.1**
Ellis	0.3	0.3	0.2	10.0	7.7	7.0	11.2	8.0	6.5	72.4	72.4	72.4	**93.9**	**88.2**	**86.1**
Fannin	0.2	0.2	0.2	1.2	0.9	0.8	0.9	0.8	0.7	15.8	7.9	8.1	**18.2**	**9.8**	**9.8**
Grayson	0.4	0.4	0.4	5.2	3.7	3.1	4.7	4.5	4.3	1.3	1.3	1.3	**11.6**	**9.9**	**9.0**
Henderson	1.1	1.1	1.0	2.6	2.6	2.4	3.6	3.7	3.6	6.5	7.1	7.1	**13.8**	**14.4**	**14.2**
Hood	1.1	1.1	1.0	1.2	1.2	1.2	0.7	0.5	0.4	20.8	19.3	21.2	**23.7**	**22.0**	**23.8**
Hunt	0.3	0.2	0.2	5.4	4.7	4.3	2.5	2.2	1.9	0.3	0.3	0.1	**8.5**	**7.4**	**6.7**
Johnson	0.3	0.3	0.2	5.4	4.9	4.5	7.5	7.0	6.7	5.7	5.7	5.7	**19.0**	**17.7**	**17.2**
Kaufman	0.2	0.2	0.1	7.3	6.0	5.5	3.9	3.5	3.2	8.4	8.4	8.4	**19.8**	**18.0**	**17.3**
Parker	3.9	3.9	3.8	6.6	5.3	4.8	4.3	4.0	3.8	6.7	6.8	6.9	**21.5**	**19.9**	**19.2**
Rockwell	0.1	0.1	0.1	3.7	2.2	1.5	1.3	0.8	0.6	0.0	0.0	0.0	**5.2**	**3.1**	**2.2**
Tarrant	9.0	6.5	4.1	53.9	37.7	27.0	52.3	40.9	34.4	12.5	12.1	12.7	**127.7**	**97.3**	**78.4**
Wise	13.0	13.0	13.0	3.1	2.1	1.5	5.6	5.5	5.4	11.3	11.3	11.3	**33.1**	**31.9**	**31.2**
Total	**52.9**	**44.2**	**35.5**	**231.9**	**166.8**	**127.2**	**193.8**	**151.2**	**127.2**	**186.1**	**175.9**	**178.5**	**664.8**	**536.1**	**469.3**

Table 2-3. 2007 VOC emissions by source category for the DFW area counties.

2007 VOC emissions (tons/days)															
	Area			On-road Mobile			Off-road Mobile			Points			Total Anthropogenic		
County	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**
Colin	15.8	11.2	7.7	10.7	8.0	6.5	6.0	8.0	7.1	1.4	1.4	1.4	**33.9**	**28.7**	**22.7**
Cooke	7.8	6.5	5.5	1.6	1.4	1.2	1.0	2.6	2.5	0.1	0.1	0.1	**10.5**	**10.6**	**9.3**
Dallas	73.6	40.8	27.7	49.1	36.6	30.0	29.3	36.2	32.4	13.2	13.2	13.2	**165.1**	**127.2**	**103.2**
Denton	19.0	12.1	9.3	10.0	7.5	6.1	4.8	9.9	9.3	1.9	1.9	1.9	**35.7**	**31.5**	**26.6**
Ellis	10.3	6.9	4.0	2.8	3.1	3.2	2.2	3.3	3.0	8.6	8.6	8.6	**23.9**	**21.9**	**18.9**
Fannin	3.5	2.4	1.7	0.7	0.7	0.6	0.3	0.3	0.3	0.4	0.2	0.2	**4.8**	**3.6**	**2.7**
Grayson	7.0	4.8	3.0	2.7	2.5	2.4	1.5	2.6	2.5	0.1	0.1	0.1	**11.2**	**10.1**	**8.0**
Henderson	8.0	6.2	4.8	2.0	2.2	2.4	2.1	6.6	6.5	0.7	0.7	0.7	**12.7**	**15.8**	**14.3**
Hood	3.1	2.6	1.9	0.9	1.0	1.1	0.4	1.2	1.2	0.7	0.7	0.7	**5.1**	**5.5**	**4.9**
Hunt	9.6	4.8	2.2	2.6	3.0	3.1	2.0	5.0	4.9	0.1	0.1	0.1	**14.3**	**13.0**	**10.3**
Johnson	8.7	5.3	2.9	2.6	2.9	3.0	0.9	1.4	1.2	0.8	0.8	0.8	**13.0**	**10.3**	**7.9**
Kaufman	10.7	4.6	2.7	2.9	3.2	3.4	1.0	2.1	2.0	2.2	2.2	2.2	**16.7**	**12.1**	**10.2**
Parker	8.9	7.3	5.6	2.3	2.5	2.7	1.0	1.8	1.6	1.1	1.1	1.1	**13.3**	**12.7**	**11.0**
Rockwell	2.5	1.6	1.0	1.0	0.8	0.6	0.7	1.7	1.6	0.0	0.0	0.0	**4.2**	**4.1**	**3.2**
Tarrant	58.1	27.9	19.1	29.5	22.2	18.1	18.0	24.2	21.6	10.0	9.9	10.0	**115.5**	**84.4**	**68.7**
Wise	18.4	17.1	16.2	1.9	1.5	1.2	1.0	2.3	2.2	2.2	2.2	2.2	**23.5**	**23.1**	**21.8**
Total	**264.8**	**162.1**	**115.2**	**123.3**	**99.1**	**85.6**	**72.1**	**109.1**	**99.9**	**43.4**	**43.1**	**43.2**	**503.5**	**414.5**	**343.6**

Table 2-4. 2007 CO emissions by source category for the DFW area counties.

2007 CO emissions (tons/days)															
	Area			On-road Mobile			Off-road Mobile			Points			Total Anthropogenic		
County	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**	**Wkd**	**Sat**	**Sun**
Colin	7.7	6.0	4.4	149.8	120.1	101.3	100.5	123.0	103.1	2.9	2.9	2.9	**260.9**	**253.4**	**210.2**
Cooke	1.6	1.5	1.4	21.2	20.6	18.1	8.6	15.8	14.2	0.0	0.0	0.0	**31.4**	**38.0**	**33.7**
Dallas	32.1	18.2	4.6	679.7	543.4	454.8	562.6	669.2	584.9	15.8	15.8	16.2	**1290.2**	**1257.1**	**1057.6**
Denton	5.5	4.7	4.0	142.8	116.5	98.1	61.0	96.0	82.3	1.6	1.6	1.6	**210.9**	**220.2**	**185.1**
Ellis	3.5	2.5	1.5	40.0	46.7	50.9	24.4	34.3	29.2	66.1	66.1	66.1	**134.0**	**150.5**	**147.5**
Fannin	2.5	2.3	2.1	8.7	8.8	8.2	5.2	7.2	5.7	5.4	2.5	2.5	**21.9**	**20.7**	**18.5**
Grayson	2.9	2.7	2.5	33.3	33.3	31.1	13.2	20.5	17.5	0.2	0.2	0.2	**49.6**	**56.7**	**51.3**
Henderson	2.1	1.7	1.3	22.9	26.2	28.3	15.6	35.9	33.0	4.7	4.9	4.9	**45.4**	**69.1**	**67.2**
Hood	1.6	1.4	1.3	11.1	12.3	13.4	6.1	12.0	10.6	8.7	8.7	8.7	**27.5**	**34.7**	**34.1**
Hunt	2.1	1.7	1.3	32.7	38.2	41.4	16.3	29.9	26.5	0.1	0.1	0.1	**51.2**	**70.4**	**68.8**
Johnson	1.8	1.2	0.7	32.2	36.0	39.4	15.2	23.4	19.0	6.2	6.2	6.2	**55.4**	**67.6**	**65.1**
Kaufman	1.3	0.9	0.5	37.2	42.8	46.5	16.7	26.4	23.7	6.3	6.3	6.3	**61.4**	**77.0**	**76.4**
Parker	5.4	5.1	4.8	28.9	32.9	36.3	14.2	23.4	20.5	5.5	5.5	5.5	**54.0**	**67.5**	**67.0**
Rockwell	0.8	0.7	0.5	16.6	13.4	11.1	9.3	13.9	12.3	0.0	0.0	0.0	**26.6**	**28.1**	**23.9**
Tarrant	17.8	10.1	2.6	422.2	339.6	284.8	276.8	366.0	306.0	13.7	12.8	13.7	**730.4**	**732.3**	**606.5**
Wise	16.5	16.3	16.2	25.0	21.7	17.0	9.9	16.5	14.9	9.2	9.2	9.2	**60.7**	**63.7**	**57.3**
Total	**105.2**	**77.2**	**49.7**	**1704.3**	**1452.5**	**1280.5**	**1155.4**	**1513.5**	**1303.5**	**146.5**	**142.8**	**144.2**	**3111.4**	**3207.1**	**2770.0**

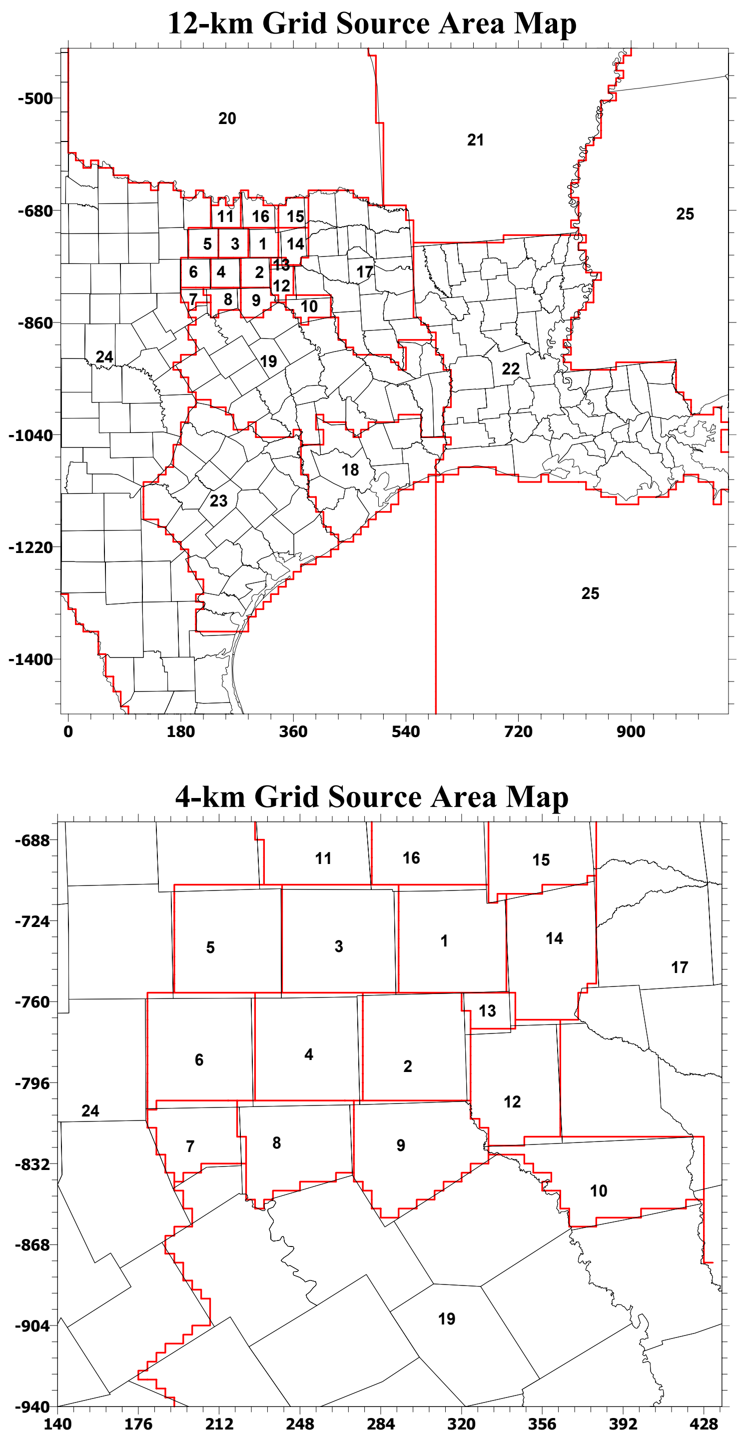


Figure 2-1. Emissions source areas used to prepare the emission summary tables by geographic area. The areas are described in Table 2-8.

Table 2-5. Summary of 2007 model ready emissions for Tuesday August 17th by source region and category.

	Biogenic		On-Road Mobile		All Points		Area + Off-Road Mobile	
Source Region	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**
Collin	11.2	29.0	16.4	8.7	3.1	1.2	20.9	21.4
Dallas	4.2	56.2	89.2	44.3	18.0	12.2	79.0	104.7
Denton	8.1	66.4	19.8	9.3	2.7	1.7	12.1	23.1
Tarrant	2.9	65.5	60.0	28.8	13.0	9.7	63.8	80.3
Core	**26.4**	**217.2**	**185.4**	**91.0**	**36.8**	**24.8**	**175.9**	**229.6**
Wise	2.3	149.5	3.1	1.7	11.3	2.0	18.0	18.7
Parker	0.6	130.9	7.2	2.3	6.8	1.1	8.2	10.2
Hood	0.2	34.5	1.2	0.8	20.8	0.6	1.9	3.8
Johnson	4.8	108.3	6.3	2.7	4.2	0.2	9.1	11.0
Ellis	14.3	89.7	10.0	2.6	72.4	7.5	11.4	13.0
Henderson	0.7	275.5	3.3	2.1	6.5	0.6	5.1	11.5
Cooke	3.7	88.5	3.1	1.6	0.0	0.2	3.0	10.1
Kaufman	5.0	105.8	7.1	2.6	8.4	1.9	3.8	11.1
Rockwall	1.6	3.6	3.3	0.9	0.0	0.0	1.3	3.0
Hunt	6.8	77.2	5.7	2.4	0.3	0.1	2.9	11.5
Fannin	7.1	120.9	1.1	0.6	0.0	0.0	1.5	4.4
Grayson	9.1	144.8	8.3	4.1	17.4	0.5	7.9	13.5
Perimeter 12	**56.3**	**1329.3**	**59.7**	**24.3**	**148.0**	**14.7**	**74.0**	**121.8**
Central Texas	**111.2**	**5430.8**	**77.9**	**36.1**	**240.8**	**43.7**	**113.6**	**169.9**
Northeast Texas	**16.4**	**4348.6**	**78.6**	**31.7**	**255.2**	**60.1**	**92.2**	**156.2**
South Texas	**220.4**	**1851.7**	**194.8**	**113.5**	**345.2**	**69.8**	**190.1**	**402.6**
HGBPA	**19.6**	**1548.8**	**161.2**	**85.3**	**324.1**	**342.8**	**146.2**	**267.7**
West Texas	**508.4**	**5370.8**	**128.1**	**74.1**	**264.1**	**46.1**	**331.7**	**559.6**
AR	**133.6**	**12293.3**	**198.0**	**114.9**	**354.6**	**110.9**	**325.3**	**358.5**
LA	**108.3**	**8378.3**	**265.0**	**151.0**	**1029.6**	**236.9**	**977.3**	**390.8**
OK	**224.1**	**6866.5**	**265.4**	**173.4**	**655.4**	**149.2**	**260.9**	**300.7**
Other States	**1977.8**	**64264.8**	**2549.3**	**1488.7**	**6212.4**	**1621.4**	**3466.9**	**3853.4**
Total	**3402.4**	**111900.1**	**4163.4**	**2384.0**	**9866.1**	**2720.2**	**6154.0**	**6810.8**

Table 2-6. Summary of 1999 model ready emissions for Tuesday August 17th by source region and category.

	Biogenic		On-Road Mobile		All Points		Area + Off-Road Mobile	
Source Region	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**	**NOx**	**VOC**
Collin	11.2	29.0	29.2	13.7	5.2	0.7	24.1	23.9
Dallas	4.2	56.2	177.9	76.0	60.7	11.7	82.9	118.0
Denton	8.1	66.4	36.5	15.0	5.2	2.7	18.7	20.0
Tarrant	2.9	65.5	117.5	47.6	40.1	12.5	64.4	82.4
Core	**26.4**	**217.2**	**361.0**	**152.4**	**111.3**	**27.6**	**190.1**	**244.2**
Wise	2.3	149.5	8.1	3.2	11.6	2.0	33.1	20.2
Parker	0.6	130.9	15.0	4.3	4.1	0.9	16.6	11.7
Hood	0.2	34.5	2.0	1.2	30.1	0.3	3.8	4.6
Johnson	4.8	108.3	11.4	4.7	6.0	0.5	9.2	11.1
Ellis	14.3	89.7	19.6	4.7	29.9	6.0	7.8	10.2
Henderson	0.7	275.5	5.8	3.5	5.5	0.6	8.9	12.0
Cooke	3.7	88.5	5.7	2.0	0.0	0.2	3.2	11.6
Kaufman	5.0	105.8	13.4	4.6	0.9	0.8	4.2	10.2
Rockwall	1.6	3.6	4.6	1.7	0.0	0.0	0.9	2.9
Hunt	6.8	77.2	10.9	4.0	0.6	0.1	3.3	10.3
Fannin	7.1	120.9	2.8	1.4	0.0	0.0	1.9	4.7
Grayson	9.1	144.8	16.0	5.7	23.5	0.5	9.9	14.2
Perimeter 12	**56.3**	**1329.3**	**115.1**	**41.2**	**112.1**	**11.9**	**102.6**	**123.6**
Central Texas	**111.2**	**5430.8**	**152.3**	**55.6**	**332.3**	**40.6**	**149.0**	**180.3**
Northeast Texas	**16.4**	**4348.6**	**184.7**	**79.2**	**355.6**	**52.4**	**143.2**	**173.2**
South Texas	**220.4**	**1851.7**	**382.2**	**161.9**	**457.0**	**64.3**	**255.2**	**431.4**
HGBPA	**19.6**	**1548.8**	**387.1**	**158.7**	**704.8**	**254.0**	**252.0**	**296.7**
West Texas	**508.4**	**5370.8**	**282.4**	**112.2**	**285.3**	**38.4**	**427.8**	**598.8**
AR	**133.6**	**12293.3**	**232.0**	**139.6**	**428.4**	**93.8**	**339.1**	**477.0**
LA	**108.3**	**8378.3**	**377.3**	**217.8**	**1177.1**	**235.9**	**1023.4**	**581.6**
OK	**224.1**	**6866.5**	**358.2**	**240.9**	**668.0**	**97.2**	**397.4**	**420.7**
Other States	**1977.8**	**64264.8**	**3369.8**	**2071.2**	**11844.3**	**2148.2**	**3278.5**	**5170.5**
Total	**3402.4**	**111900.1**	**6202.2**	**3430.5**	**16476.4**	**3064.2**	**6558.3**	**8698.0**

Table 2-7. Ratio of 2007 to 1999 model ready emissions for Tuesday August 17th by source region and category.

Source Region	Biogenic		On-RoadMobile		All Points		Area + Off-Road Mobile	
	NOx	VOC	NOx	VOC	NOx	VOC	NOx	VOC
Collin	1.00	1.00	0.56	0.63	0.59	1.58	0.87	0.90
Dallas	1.00	1.00	0.50	0.58	0.30	1.04	0.95	0.89
Denton	1.00	1.00	0.54	0.62	0.52	0.65	0.65	1.16
Tarrant	1.00	1.00	0.51	0.60	0.32	0.78	0.99	0.98
Core	**1.00**	**1.00**	**0.51**	**0.60**	**0.33**	**0.90**	**0.93**	**0.94**
Wise	1.00	1.00	0.38	0.53	0.98	0.97	0.54	0.93
Parker	1.00	1.00	0.48	0.53	1.67	1.17	0.50	0.87
Hood	1.00	1.00	0.62	0.66	0.69	1.98	0.51	0.84
Johnson	1.00	1.00	0.55	0.57	0.70	0.42	0.99	1.00
Ellis	1.00	1.00	0.51	0.54	2.42	1.26	1.46	1.28
Henderson	1.00	1.00	0.57	0.60	1.18	0.96	0.57	0.96
Cooke	1.00	1.00	0.55	0.77	1.36	1.25	0.95	0.87
Kaufman	1.00	1.00	0.53	0.56	9.79	2.28	0.92	1.09
Rockwall	1.00	1.00	0.72	0.52	0.00	0.00	1.44	1.02
Hunt	1.00	1.00	0.52	0.60	0.41	1.10	0.87	1.12
Fannin	1.00	1.00	0.41	0.44	0.00	0.00	0.81	0.94
Grayson	1.00	1.00	0.52	0.73	0.74	0.92	0.79	0.94
Perimeter 12	**1.00**	**1.00**	**0.52**	**0.59**	**1.32**	**1.23**	**0.72**	**0.99**
Central Texas	**1.00**	**1.00**	**0.51**	**0.65**	**0.72**	**1.08**	**0.76**	**0.94**
East Texas	**1.00**	**1.00**	**0.43**	**0.40**	**0.72**	**1.15**	**0.64**	**0.90**
South Texas	**1.00**	**1.00**	**0.51**	**0.70**	**0.76**	**1.09**	**0.74**	**0.93**
HGBPA	**1.00**	**1.00**	**0.42**	**0.54**	**0.46**	**1.35**	**0.58**	**0.90**
West Texas	**1.00**	**1.00**	**0.45**	**0.66**	**0.93**	**1.20**	**0.78**	**0.93**
AR	**1.00**	**1.00**	**0.85**	**0.82**	**0.83**	**1.18**	**0.96**	**0.75**
LA	**1.00**	**1.00**	**0.70**	**0.69**	**0.87**	**1.00**	**0.95**	**0.67**
OK	**1.00**	**1.00**	**0.74**	**0.72**	**0.98**	**1.53**	**0.66**	**0.71**
Other States	**1.00**	**1.00**	**0.76**	**0.72**	**0.52**	**0.75**	**1.06**	**0.75**
Total	**1.00**	**1.00**	**0.67**	**0.69**	**0.60**	**0.89**	**0.94**	**0.78**

Table 2-8. Emissions source area definitions.

Area Number	Area Abbreviation	Area Definition
1-4	Core	Dallas Core Counties (Collin, Dallas, Denton, Tarrant)
5-16	Perimeter12	12 Counties surrounding Dallas Core (Wise, Parker, Hood Johnson, Ellis, Henderson, Cooke, Kaufman, Rockwall, Hunt, Fannin, Grayson)
17	Northeast Texas	Northeast Texas
18	HGBPA	Houston/Galveston/Beaumont/Port-Arthur (11 Counties)
19	Central Texas	East Central Texas
20	OK	Oklahoma
21	AR	Arkansas
22	LA	Louisiana
23	South Texas	Near Non-attainment areas (Austin, San Antonio, Victoria, Corpus Christi)
24	West Texas	Texas (excluding area 1-19 and 23
25	Other States	Other areas

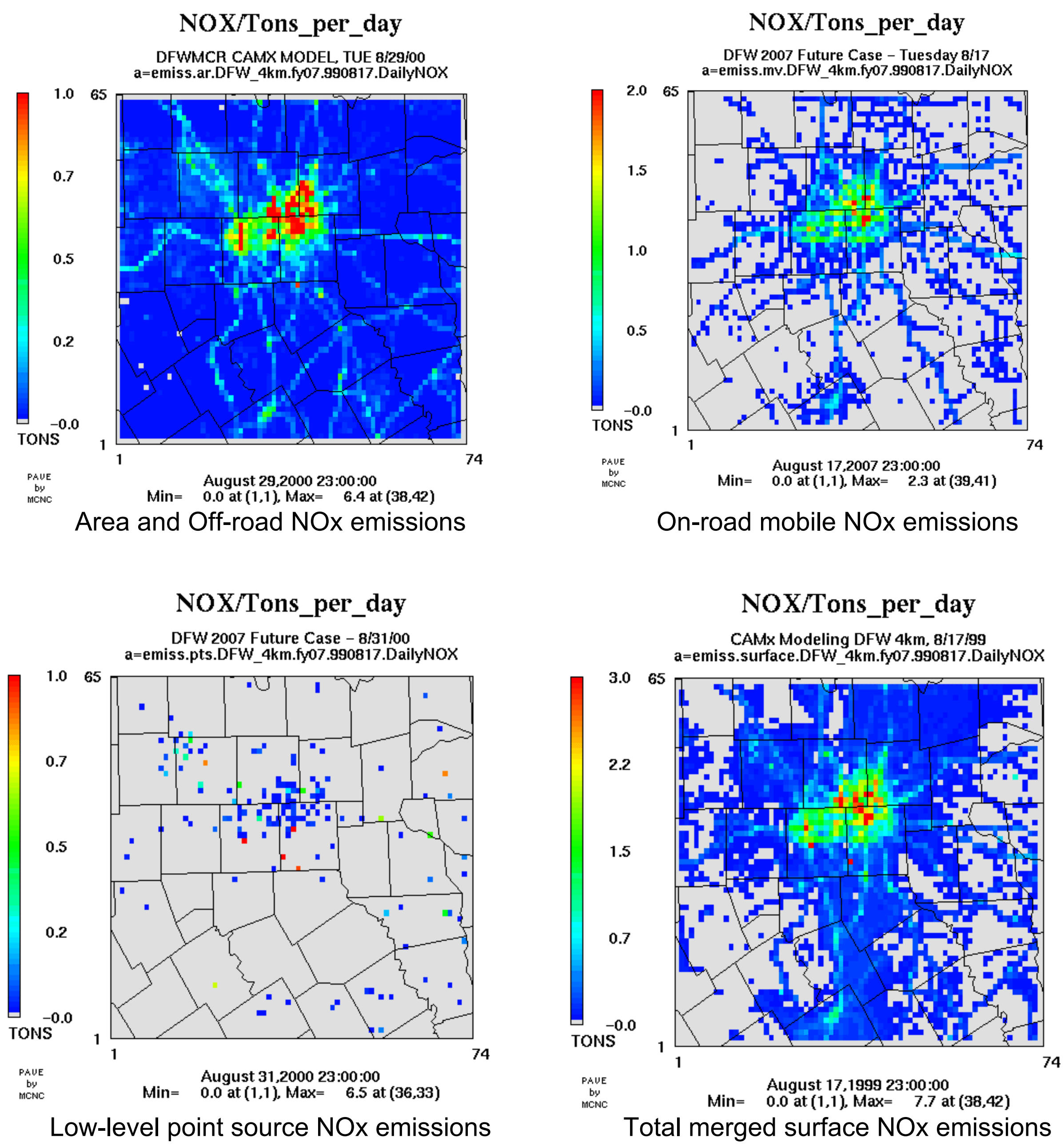
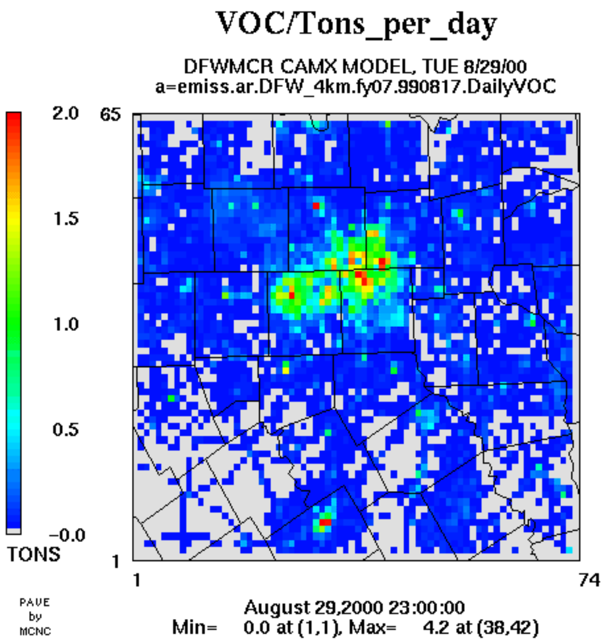
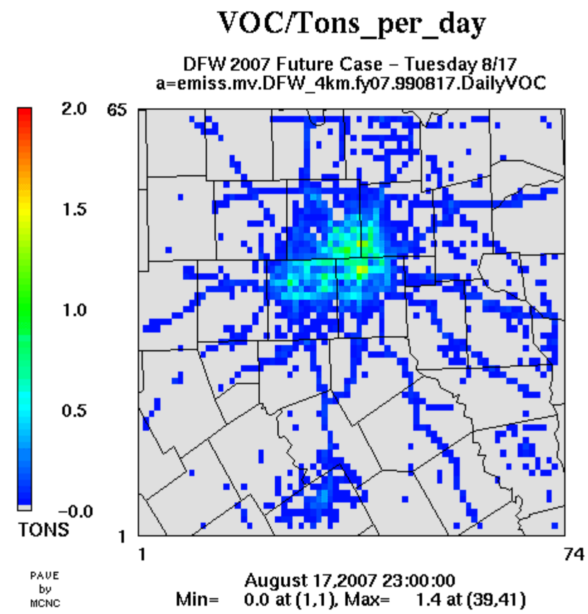


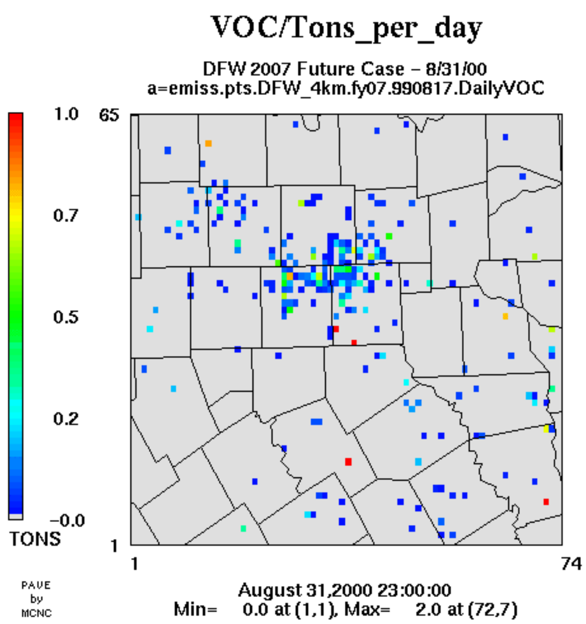
Figure 2-2. 2007 NOx emissions for Tuesday August 17th on the 4-km grid.



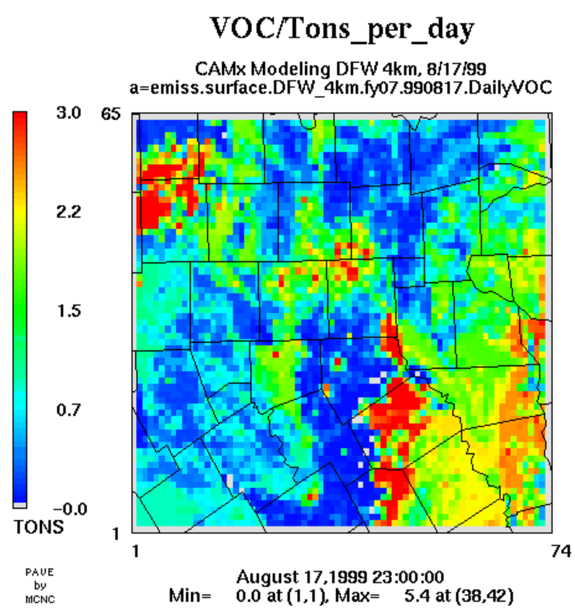
Area and Off-road VOC emissions



On-road mobile VOC emissions



Low-level point source VOC emissions



Total merged surface VOC emissions

Figure 2-3. 2007 VOC emissions for Tuesday August 17th on the 4-km grid.

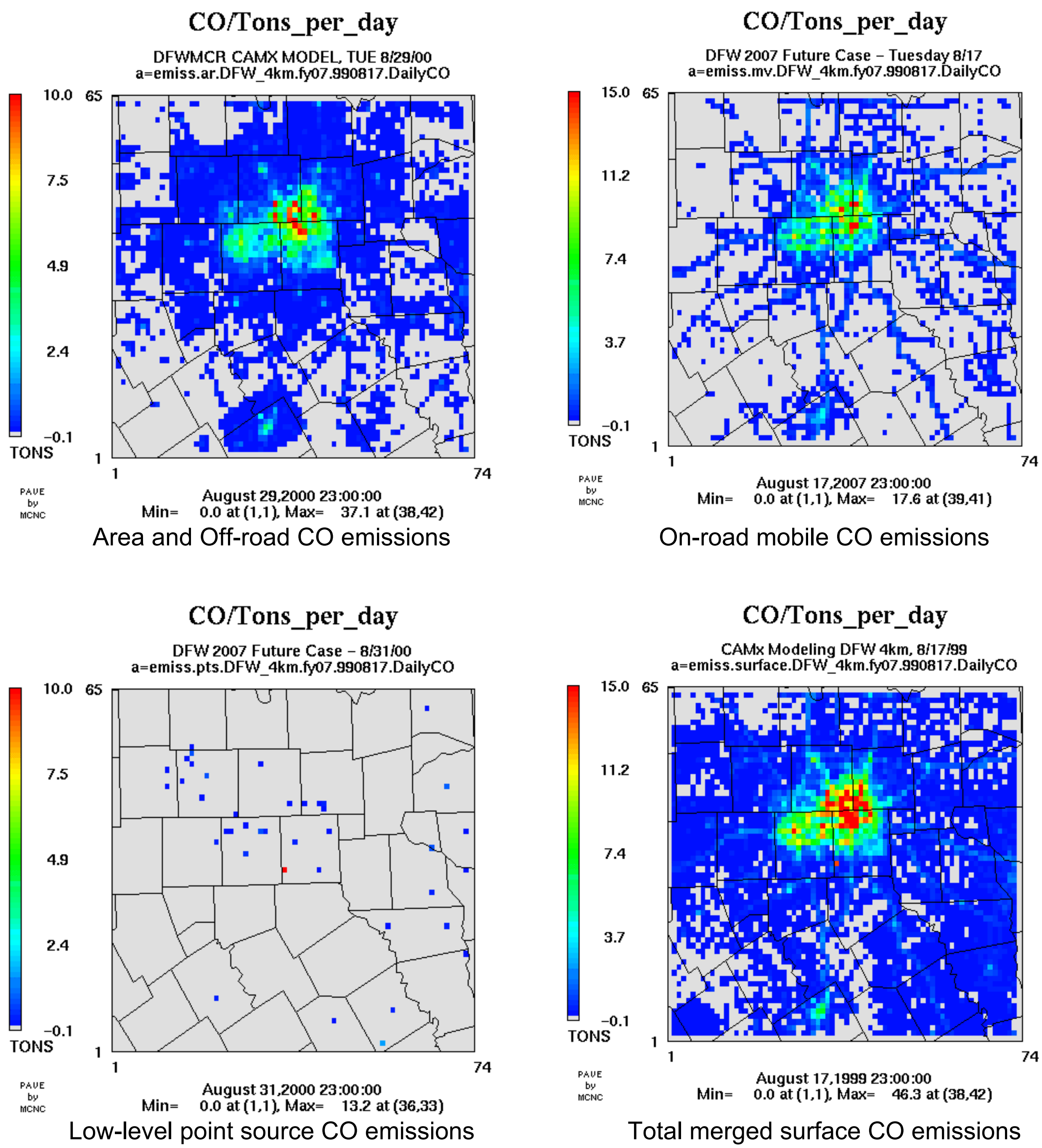


Figure 2-4. 2007 CO emissions for Tuesday August 17th on the 4-km grid.

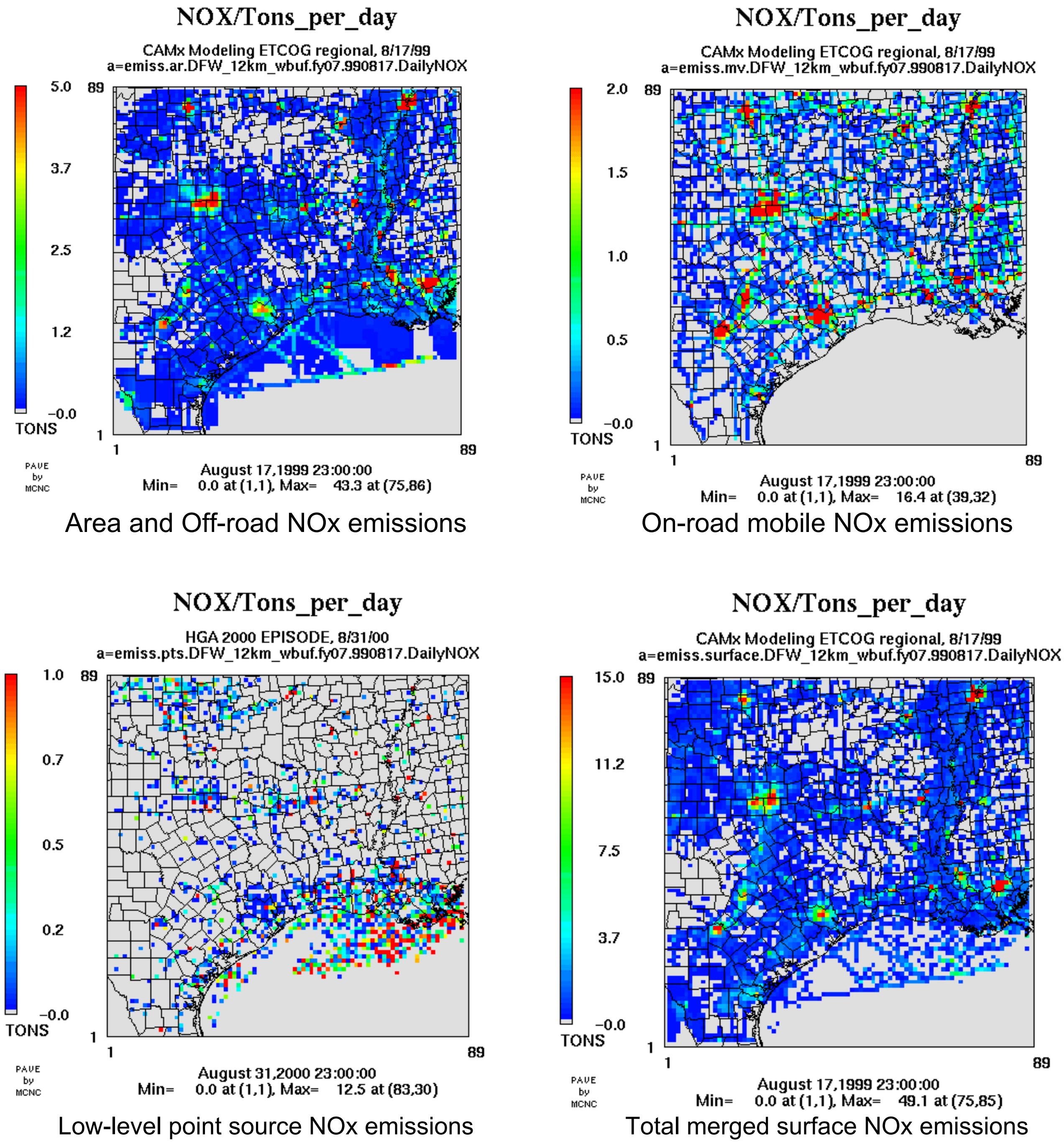


Figure 2-5. 2007 NOx emissions for Tuesday August 17^{th} on the 12-km emissions grid.

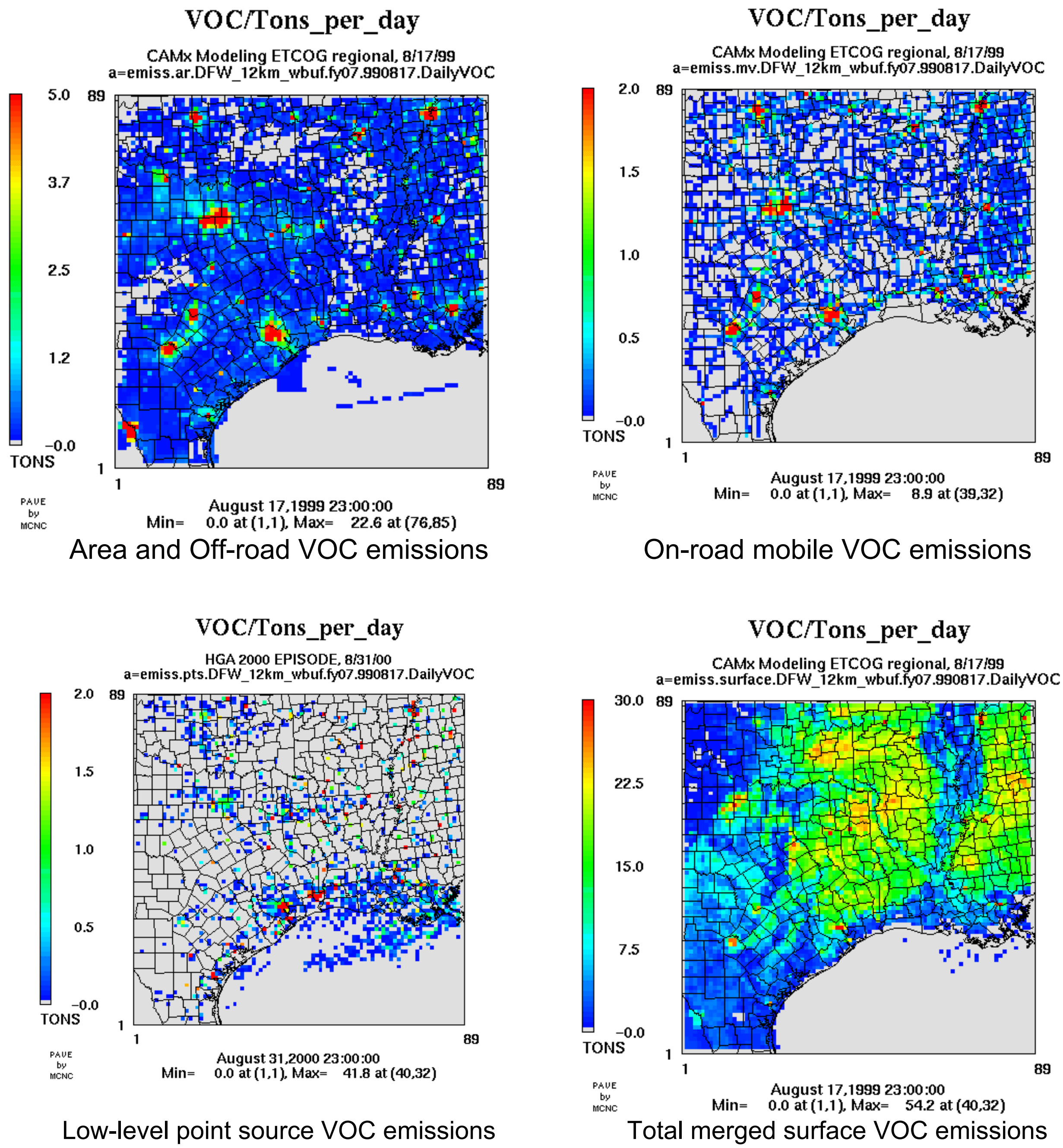


Figure 2-6. 2007 VOC emissions for Tuesday August 17th on the 12-km emissions grid.

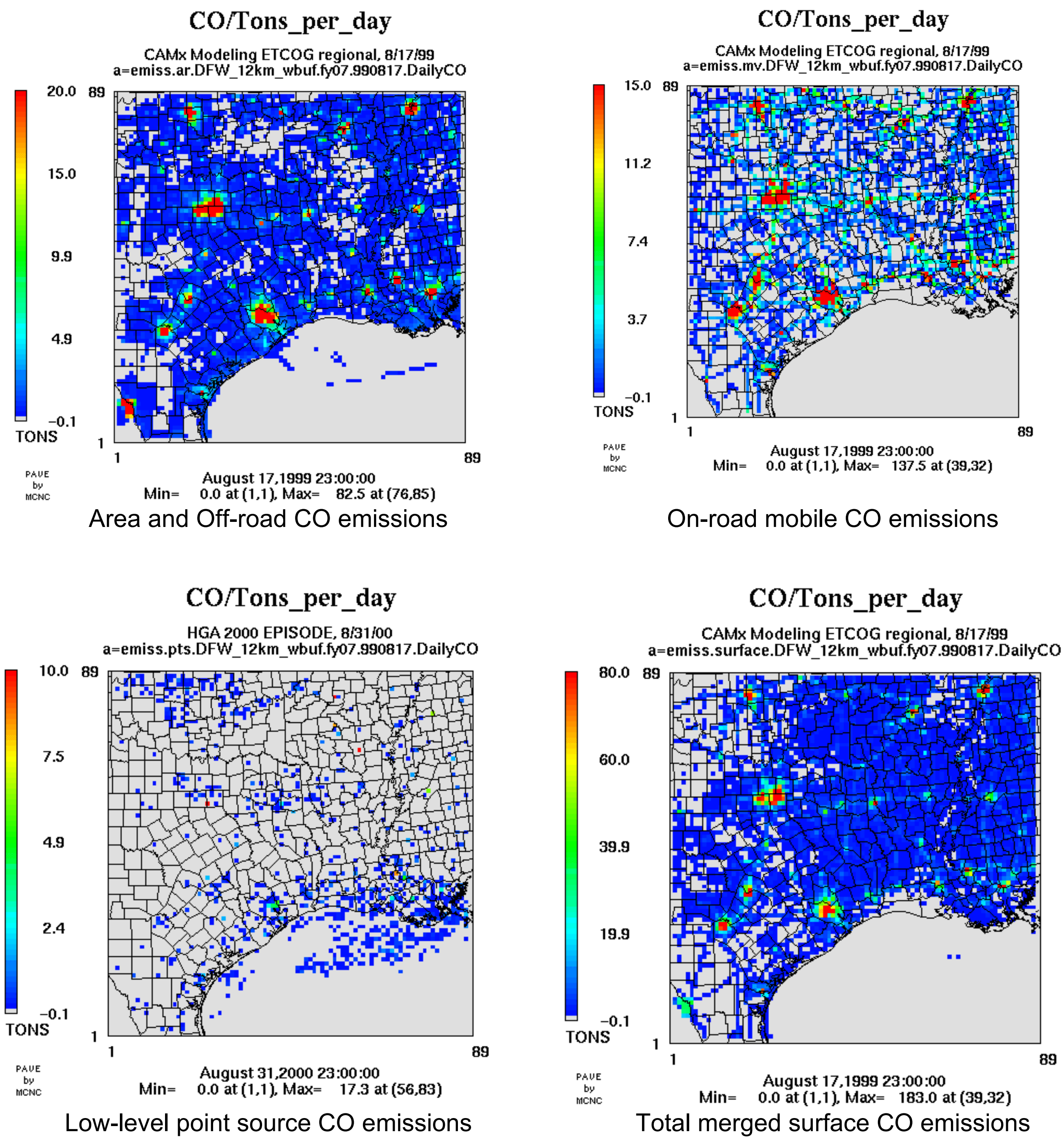


Figure 2-7. 2007 CO emissions for Tuesday August 17th on the 12-km emissions grid.

3.0 OZONE MODELING

CAMx MODEL CONFIGURATION AND INPUTS

Previous CAMx modeling of the Dallas/Fort Worth August 1999 ozone episode described by Mansell et al. (2003) used version 4.02 of the CAMx model. The current 2007 future year modeling uses CAMx version 4.03. CAMx 4.03 includes only a few changes from CAMx 4.02 (see the model release notes posted at http://www.camx.com), but one change corrects an error in the calculation of dry deposition velocities and results in slightly lower ozone levels (a few ppb) with CAMx 4.03 than CAMx 4.02 for the DFW modeling. The 1999 base year modeling was re-run with CAMx 4.03 to provide consistent base and future year simulation results for subsequent analysis. The input data requirements are the same for CAMx versions 4.02 and 4.03 so that updating the 1999 modeling to the new CAMx version does not require any changes to input data or files.

All of the CAMx meteorological input data were derived from the Fifth Generation Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model (MM5; Duhdia, 1993). The MM5 modeling used nested 108-km, 36-km, 12-km and 4-km grids and 28 vertical layers. An analysis of the final MM5 run used for air quality modeling of the DFW 1999 episode (denoted Run3), is documented in ENVIRON, 2003, and Mansell et al., (2003).

CAMx has several user-selectable options that are specified for each simulation through the CAMx control file. Most of these options follow naturally from other choices about model inputs. There are four model options that must be decided for each project: the choice of the chemical mechanism, the chemistry solver, advection scheme, and the plume-in-grid scheme. The selection for each option is decided at the stage of the base case model performance evaluation and then held fixed for the evaluation of any future year emission scenarios. The CAMx model configuration and inputs used for both the 1999 and 2007 modeling were documented in Mansell, et al., (2003), and briefly summarized below.

Chemistry Data

The chemistry parameters file specifies the photochemical mechanism used to model ozone formation as well as the rates for all thermo-chemical reactions associated with the chemical mechanism.

- CAMx was run with an updated version of the Carbon Bond 4 mechanism (CB4), referred to as mechanism 3 in CAMx, which is described in the CAMx User's Guide (ENVIRON, 2002). Mechanism 3 is the CB4 mechanism with updated radical-radical termination reactions and updated isoprene mechanism as used for the OTAG modeling and other TCEQ modeling studies.

- CAMx has two options for the numerical scheme used to solve the chemical mechanism. The first option is the CMC fast solver that has been used in every prior version of CAMx. The second option is an IEH solver. The CMC solver is faster and more accurate than most chemistry solvers used for ozone modeling. The IEH solver is even more accurate than the CMC solver, but slower. The CMC solver was used for this study.

- The CB4 mechanism also includes several "photolysis" reactions that depend upon the presence of sunlight. The photolysis rates input file determines the rates for chemical reactions in the mechanism that are driven by sunlight. Photolysis rates were calculated using the Tropospheric visible Ultra-Violet (TUV) model developed by the National Center for Atmospheric Research (Madronich, 1993 and 2002). TUV is a state-of-the-science solar radiation model that is designed for photolysis rate calculations. TUV accounts for environmental parameters that influence photolysis rates including solar zenith angle, altitude above the ground, surface UV albedo, aerosols (haze), and stratospheric ozone column.

Advection Scheme

CAMx version 4.03 has three optional methods for calculating horizontal advection called Smolarkiewicz, Bott and Piecewise Parabolic Method (PPM). Although the Smolarkiewicz scheme has been used for many years, and was used in the previous modeling for Northeast Texas (ENVIRON, 1999), the scheme has been criticized for causing too much artificial diffusion of pollutants, tending to "smear out" features and artificially overstate transport. The Bott and PPM schemes are newer and have less artificial diffusion than the Smolarkiewicz scheme. The PPM scheme was used for this study as it has been determined to be the least numerically diffusive, runs at speeds similar to Smolarkiewicz, and does not exhibit certain "noisy" features near sharp gradients that are apparent with the Bott approach.

Plume-in-Grid

CAMx includes an optional sub-grid scale plume model that can be used to represent the dispersion and chemistry of major NOx point source plumes close to the source. We used the Plume-in-Grid (PiG) sub-model for major NOx sources (i.e., point sources with episode average NOx emissions greater than 2 tons per day in the 4-km grid and 2.5 tons per day outside the 4-km grid).

Surface Characteristics

CAMx requires gridded landuse data to characterize surface boundary conditions, such as surface roughness, deposition parameters, vegetative distribution, and water/land boundaries. CAMx land use files provide the fractional contribution (0 to 1) of eleven land use categories to the surface area of grid cell. Gridded land cover data were developed from the same landuse databases that were used in the generation of spatial emission surrogates for the 36-km and 12-km grids. The development of surface characteristics data was documented in Mansell et al. (2003)

Initial and Boundary Conditions

The initial conditions (ICs) are the pollutant concentrations specified throughout the modeling domain at the start of the simulation. Boundary conditions (BCs) are the pollutant concentrations specified at the perimeter of the modeling domain. Conventional wisdom dictates that the boundary conditions should have little impact on the model results for the DFW area because regional modeling is being performed. One of the reasons for performing regional scale modeling rather than urban scale modeling is to minimize the importance of ICs and BCs. Using a large regional domain moves the boundaries far away (in distance and transport time) from the study area.

However, the base case modeling and sensitivity tests (Mansell et al., 2003) showed that the boundary conditions do influence the modeling results for DFW non-attainment area. In particular, the amount of background VOC in air entering the modeling domain from the Midwest and Southeast influences the regional background ozone levels transported into DFW. The VOC boundary conditions are mainly influenced by biogenic emissions and so there is no reason to reduce the VOC boundary conditions from 1999 to 2007. The ozone boundary condition was set to 40 ppb for 1999 which is the commonly assumed default background level for ozone. The NOx boundary condition for 2007 was set to 1.1 ppb which is a low value representative of rural areas. Therefore, the 2007 boundary and initial conditions were not changed from the 1999 values described in Mansell et al. (2003).

UPDATED 1999 BASE CASE

Version 4.03 of the CAMx air quality model was run for the August 1999 Dallas/Ft. Worth ozone episode using the model configuration and input described above. Both the 1999 base and 2007 future years were simulated. The 1999 base year was re-run with CAMx 4.03 to provide a consistent set of modeling results for the design value scaling analysis.

OZONE MODELING RESULTS FOR 1999 AND 2007

Table 3-1 presents the one-hour ozone model performance statistics for the 1999 base year simulation (99run7c V4.03). The previous 1999 base case results (99run7c V4.02) are also shown for comparison. Model performance was slightly degraded from the CAMx 4.02 model results as discussed in more detail below. Also included in Table 3-1 are the observed and predicted daily maximum 1-hour ozone concentrations for the 1999 base case as well as the predicted daily maximum 1-hour ozone concentrations for the 2007 future year simulations (07run02). The results presented in Table 3-1 are for the DFW 4-km modeling domain.

Table 3-1. One-hour ozone model performance statistics on the DFW 4-km modeling domain.

		Episode Day							
		8/15/99	8/16/99	8/17/99	8/18/99	8/19/99	8/20/99	8/21/99	8/22/99
Peak Observed (ppb)									
		107.0	127.0	150.0	131.0	128.0	108.0	111.0	100.0
Peak Predicted (ppb)									
	99Run 7c (V4.02)	128.8	119.1	143.5	151.1	137.5	109.1	126.1	124.0
	99Run 7c (V4.03)	126.3	116.5	140.6	148.6	135.9	106.2	123.7	121.8
	07Run 02	105.8	120.9	138.5	138.3	125.4	96.4	105.7	94.0
Unpaired Accuracy of Peak (%) (EPA Goal ± 20%)									
	99Run 7c (V4.02)	20.4	-6.3	-4.3	15.3	7.5	1.0	13.6	24.0
	99Run 7c (V4.03)	18.0	-8.3	-6.3	13.4	6.2	-1.7	11.5	21.8
Normalized Bias (%) (EPA Goal ± 15%)									
	99Run 7c (V4.02)	-6.0	-14.3	-24.2	2.1	-5.4	-16.2	-21.9	-7.1
	99Run 7c (V4.03)	-10.1	-17.8	-27.1	-0.7	-7.7	-19.8	-25.6	-10.3
Normalized Gross Error (%) (EPA Goal 30 - 35%)									
	99Run 7c (V4.02)	19.4	16.6	27.0	11.8	14.0	17.1	22.8	19.6
	99Run 7c (V4.03)	20.0	19.1	29.1	10.9	14.5	20.1	26.1	19.9

Figures 3-1 and 3-2 present the spatial distribution of predicted 1-hour ozone concentrations within the DFW 4-km and regional 12-km modeling domains, respectively. Results for both the 1999 base and 2007 future year simulations are shown. Only the August 15 – 22 episode days are shown, as the first two days of the episode are considered "spin-up" days.

Corresponding displays for the predicted daily maximum 8-hour ozone concentrations are presented in Figures 3-3 and 3-4.

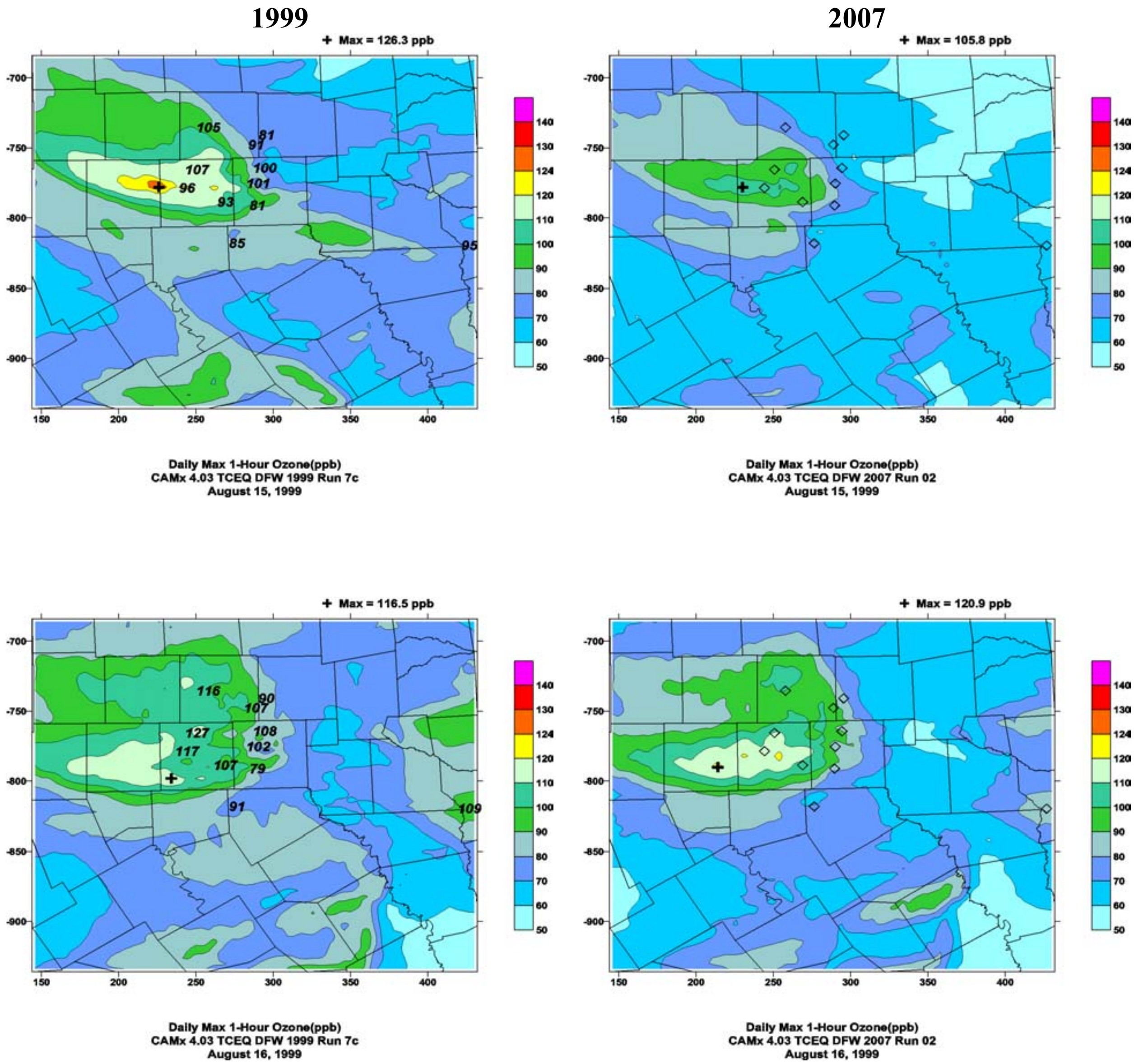


Figure 3-1. Daily maximum 1-hour ozone in the DFW 4-km domain for 1999 and 2007.

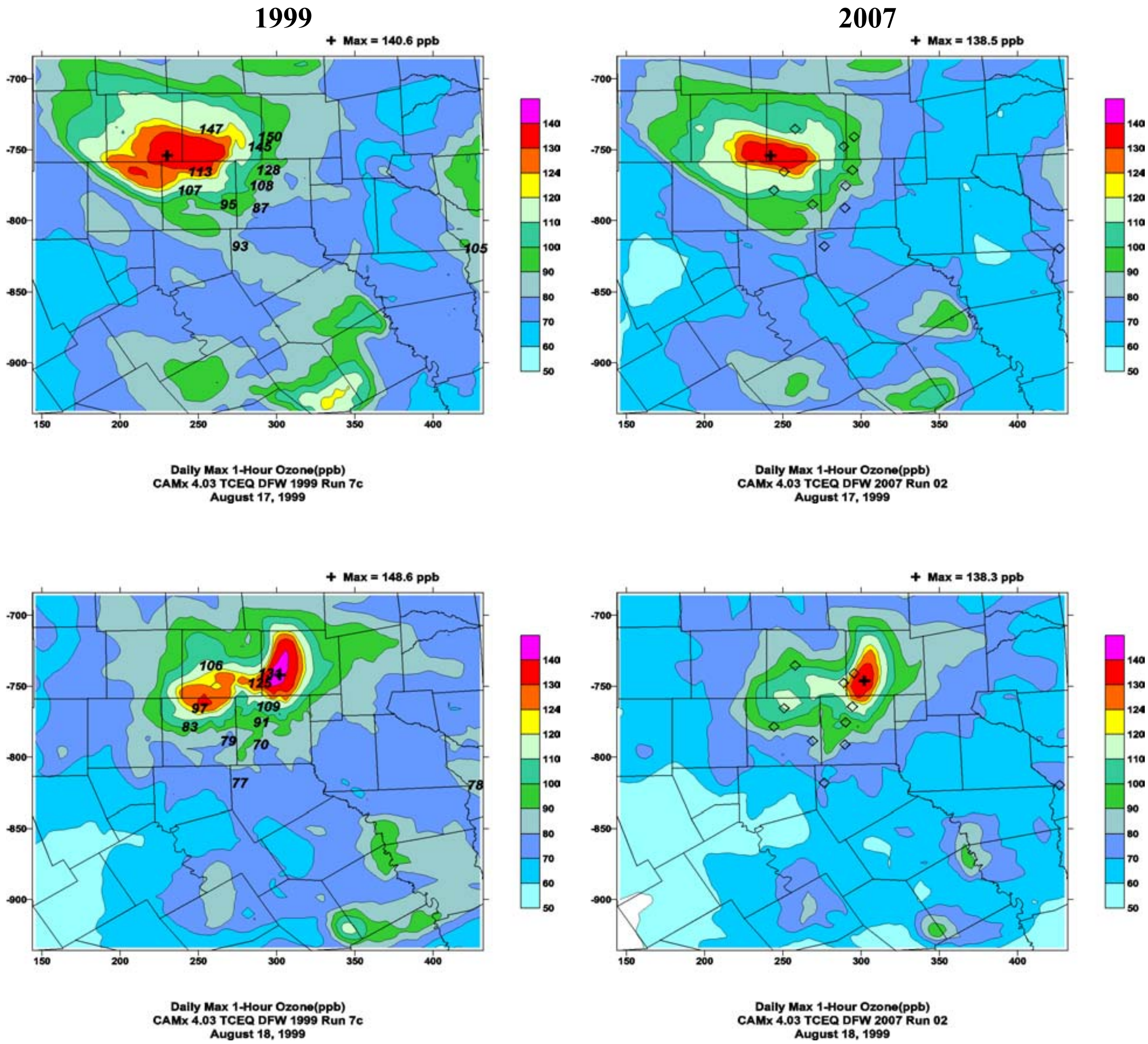


Figure 3-1 (cont). Daily maximum 1-hour ozone in the DFW 4-km domain for 1999 and 2007.

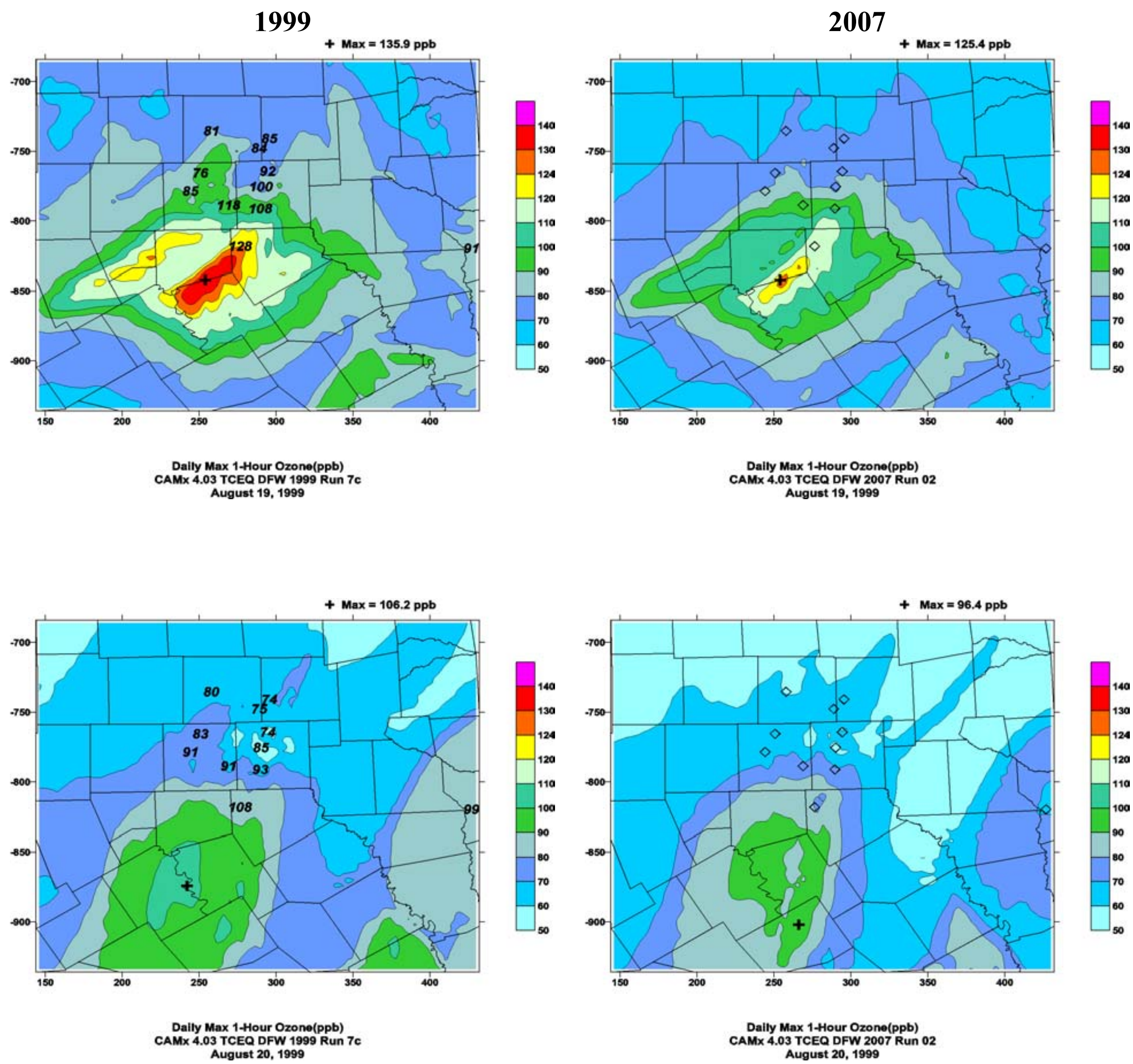


Figure 3-1 (cont). Daily maximum 1-hour ozone in the DFW 4-km domain for 1999 and 2007.

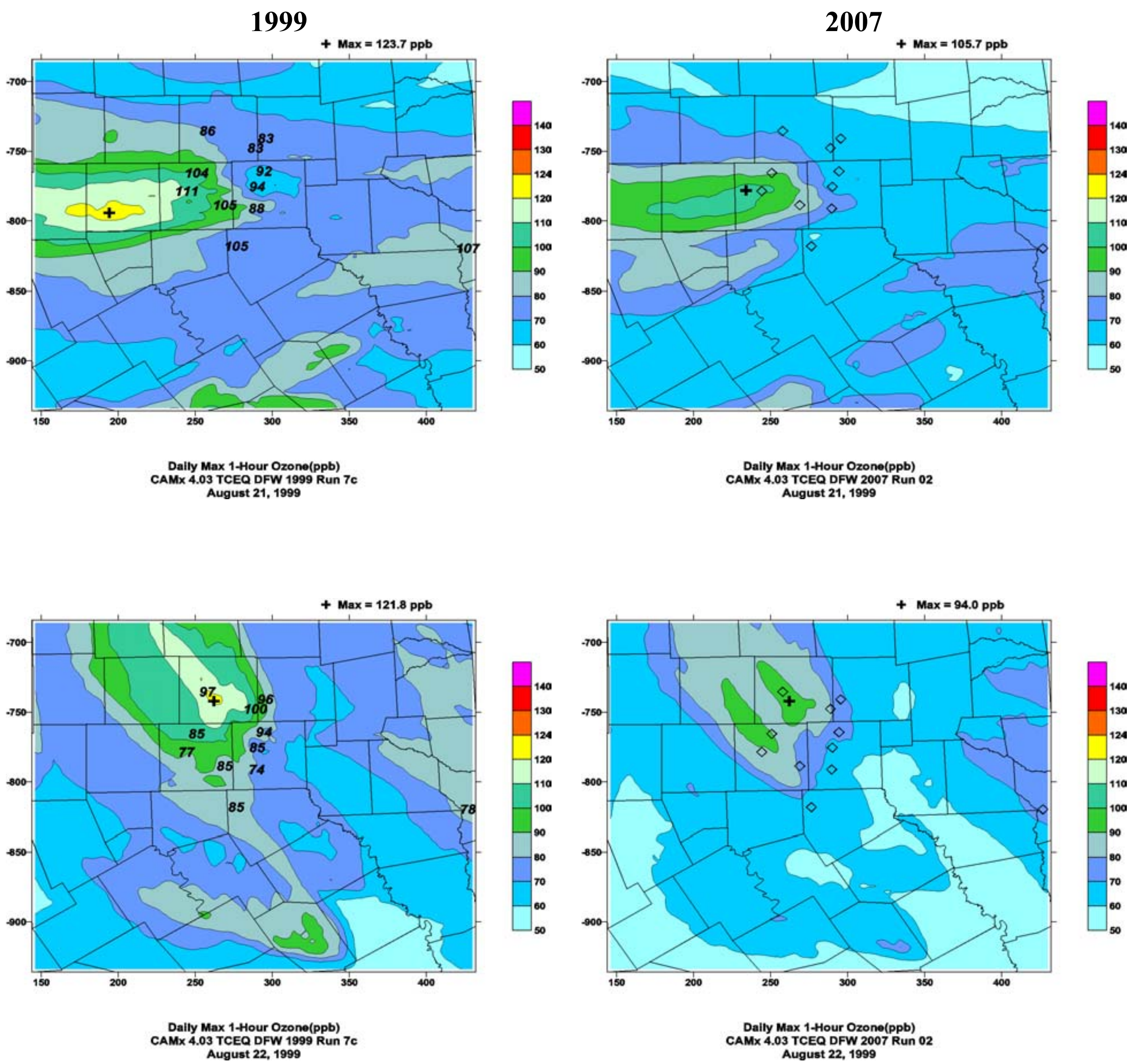


Figure 3-1 (concluded). Daily maximum 1-hour ozone in the DFW 4-km domain for 1999 and 2007.

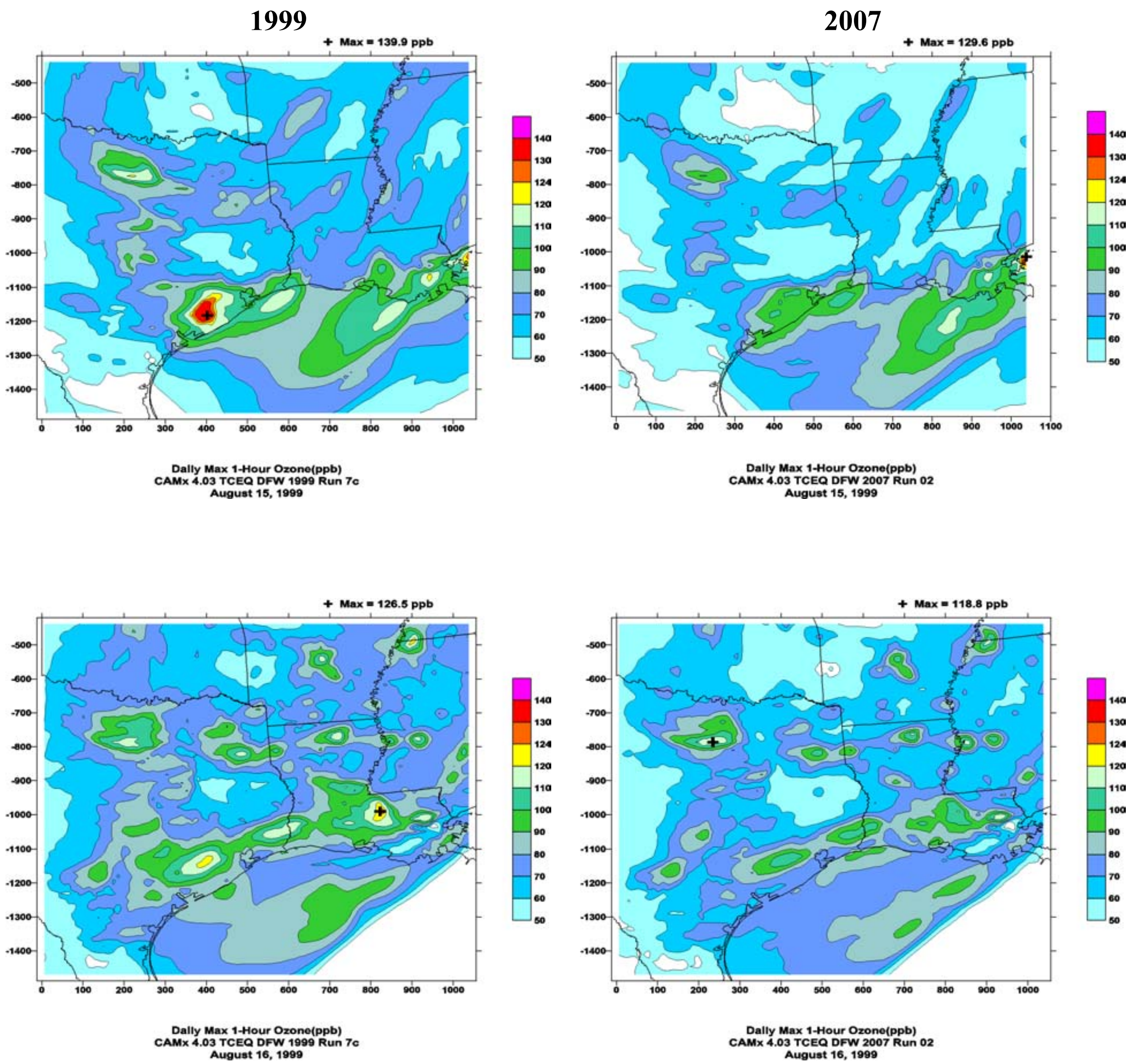


Figure 3-2. Daily maximum 1-hour ozone in the regional 12-km domain for 1999 and 2007.

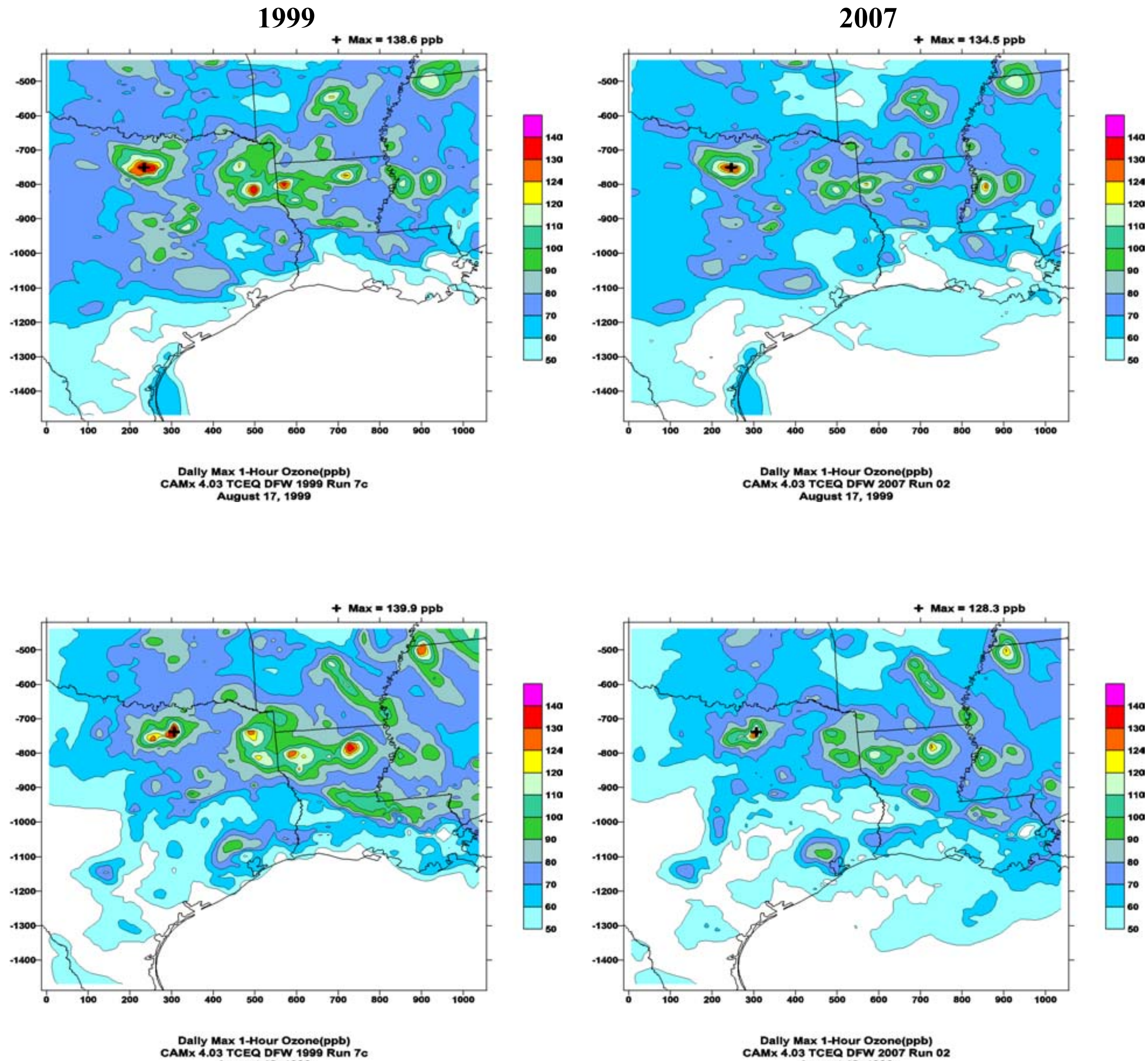


Figure 3-2 (cont.) Daily maximum 1-hour ozone in the regional 12-km domain for 1999 and 2007.

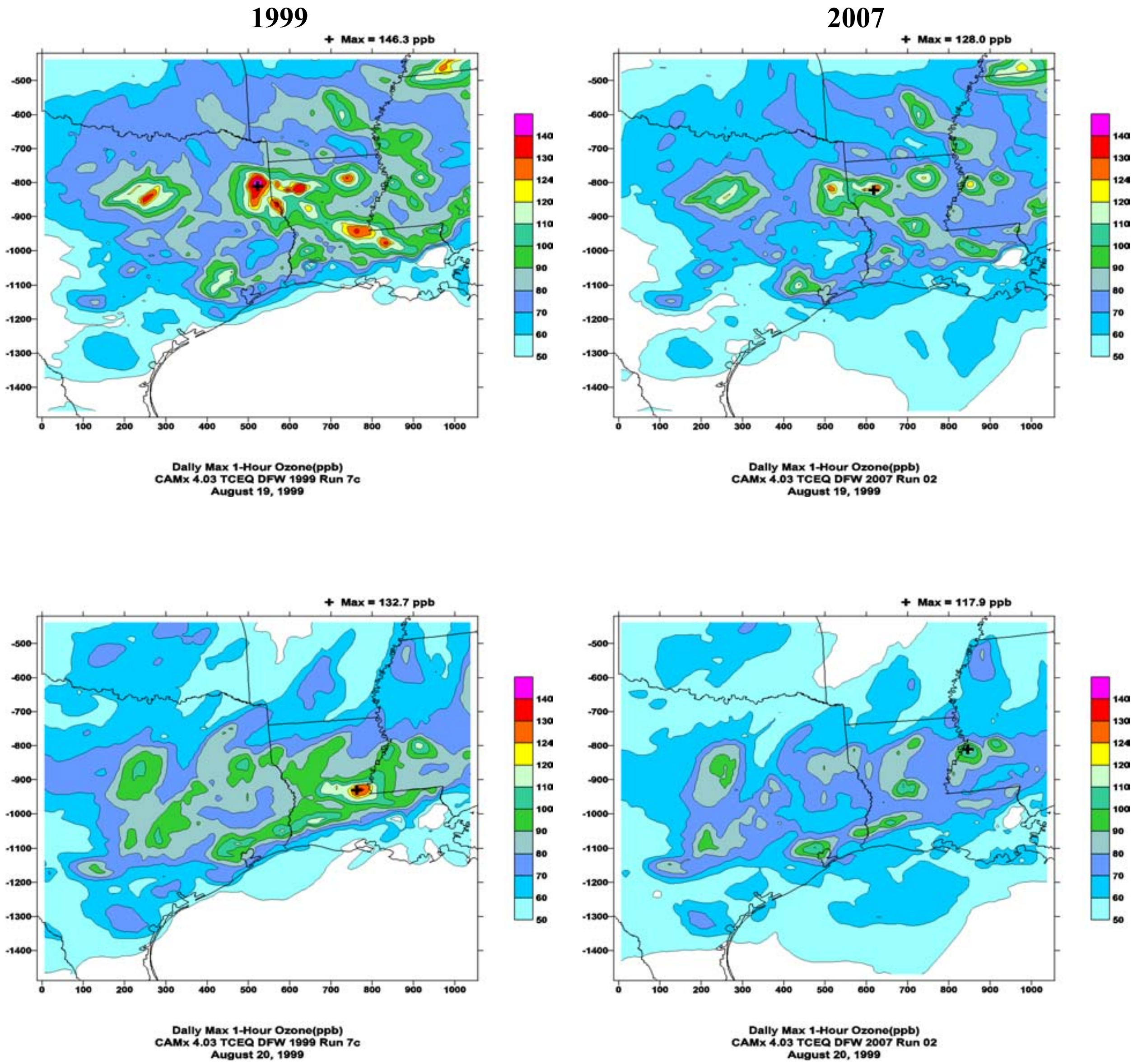


Figure 3-2 (cont.) Daily maximum 1-hour ozone in the regional 12-km domain for 1999 and 2007.

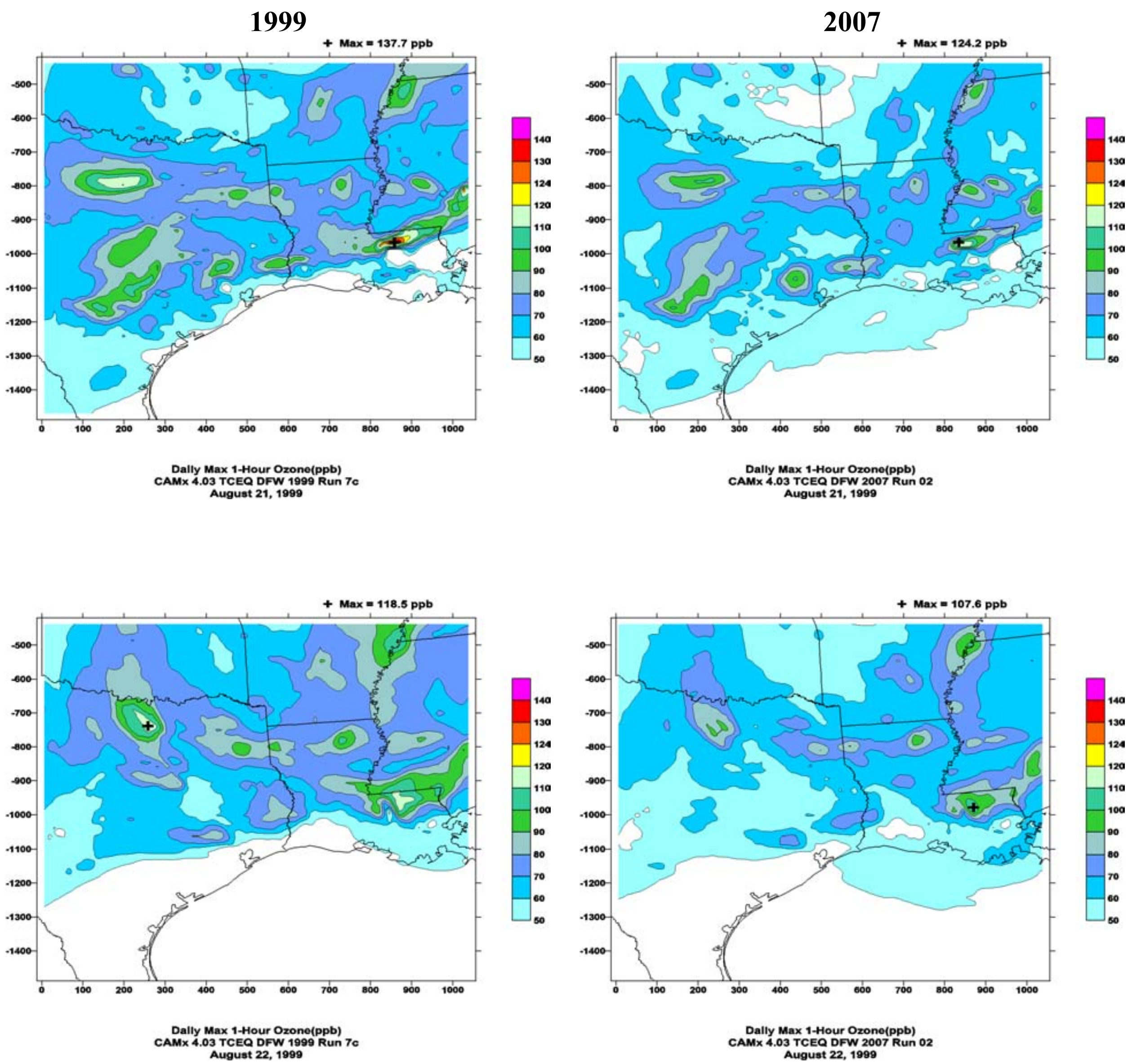


Figure 3-2 (concluded). Daily maximum 1-hour ozone in the regional 12-km domain for 1999 and 2007.

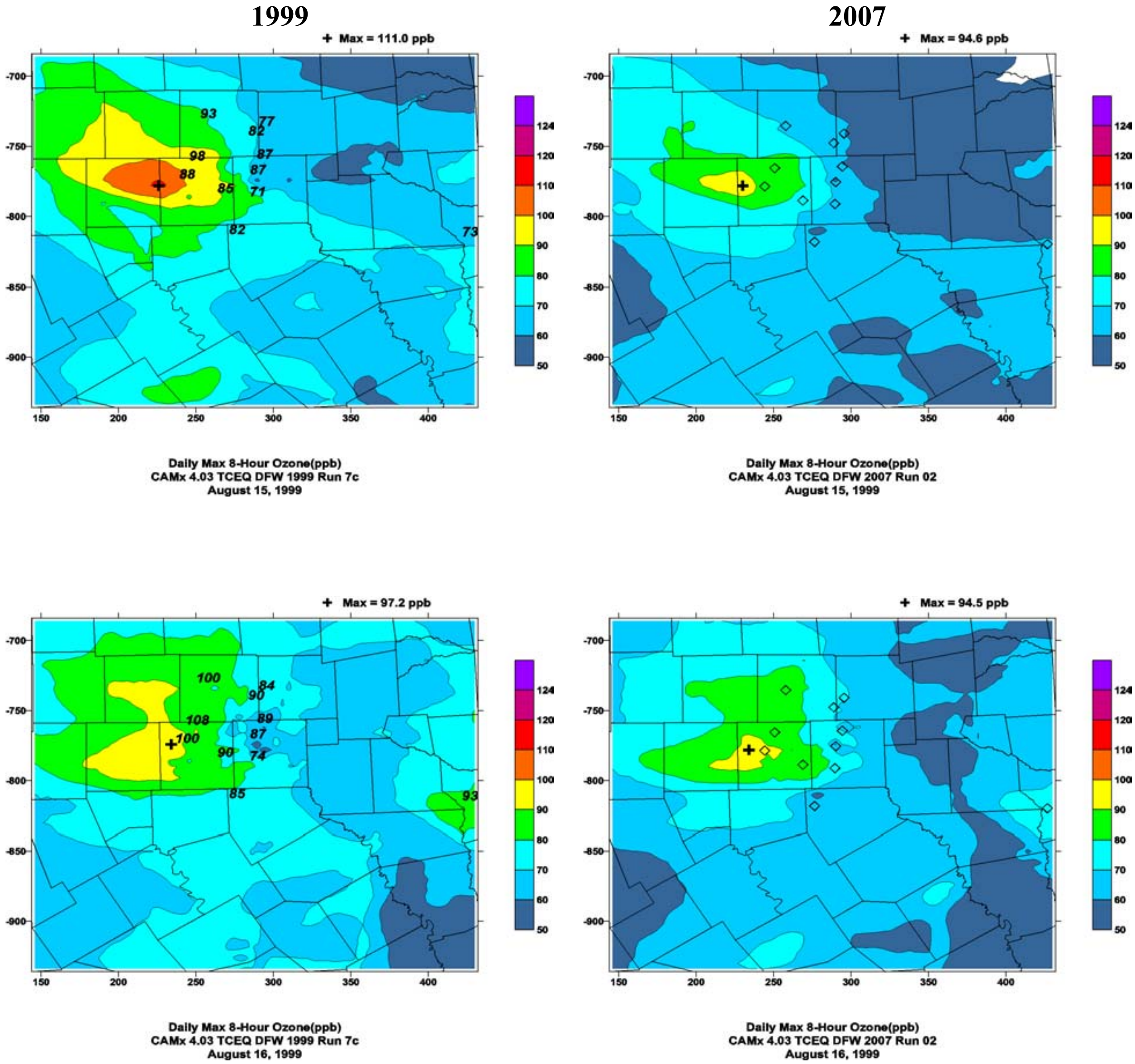


Figure 3-3. Daily maximum 8-hour ozone in the DFW 4-km domain for 1999 and 2007.

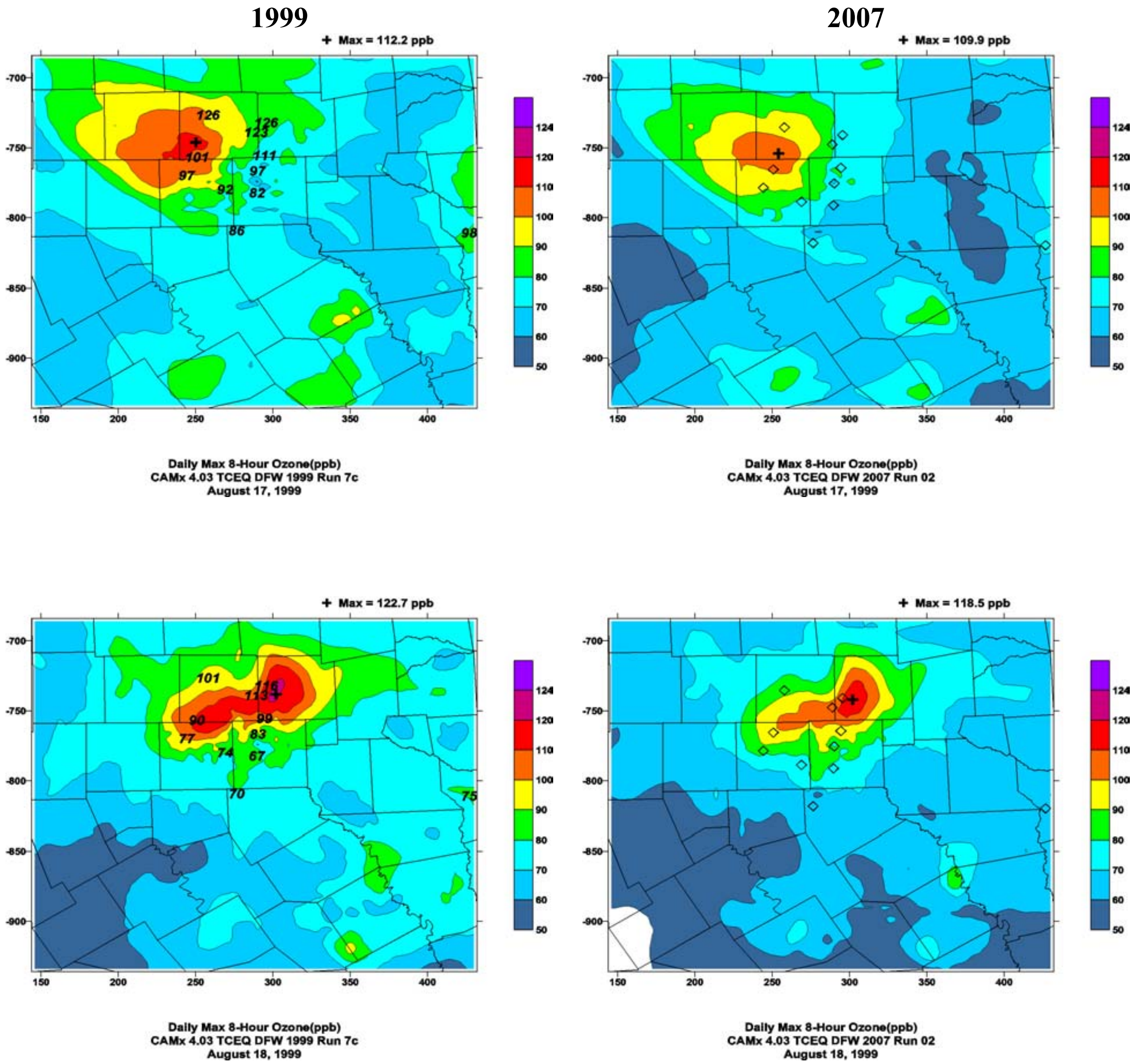


Figure 3- (cont.) Daily maximum 8-hour ozone in the DFW 4-km domain for 1999 and 2007.

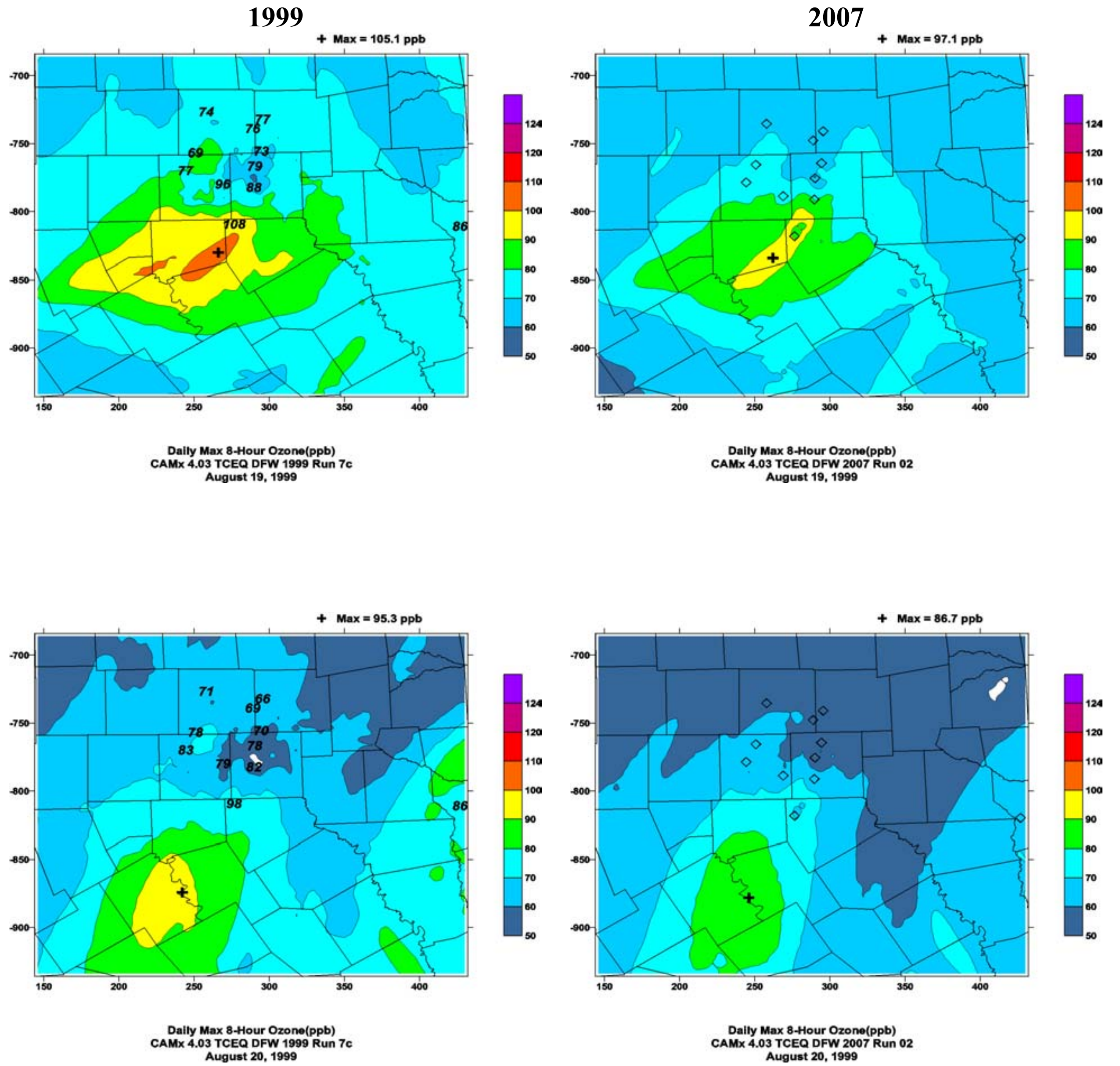


Figure 3-3 (cont.) Daily maximum 8-hour ozone in the DFW 4-km domain for 1999 and 2007.

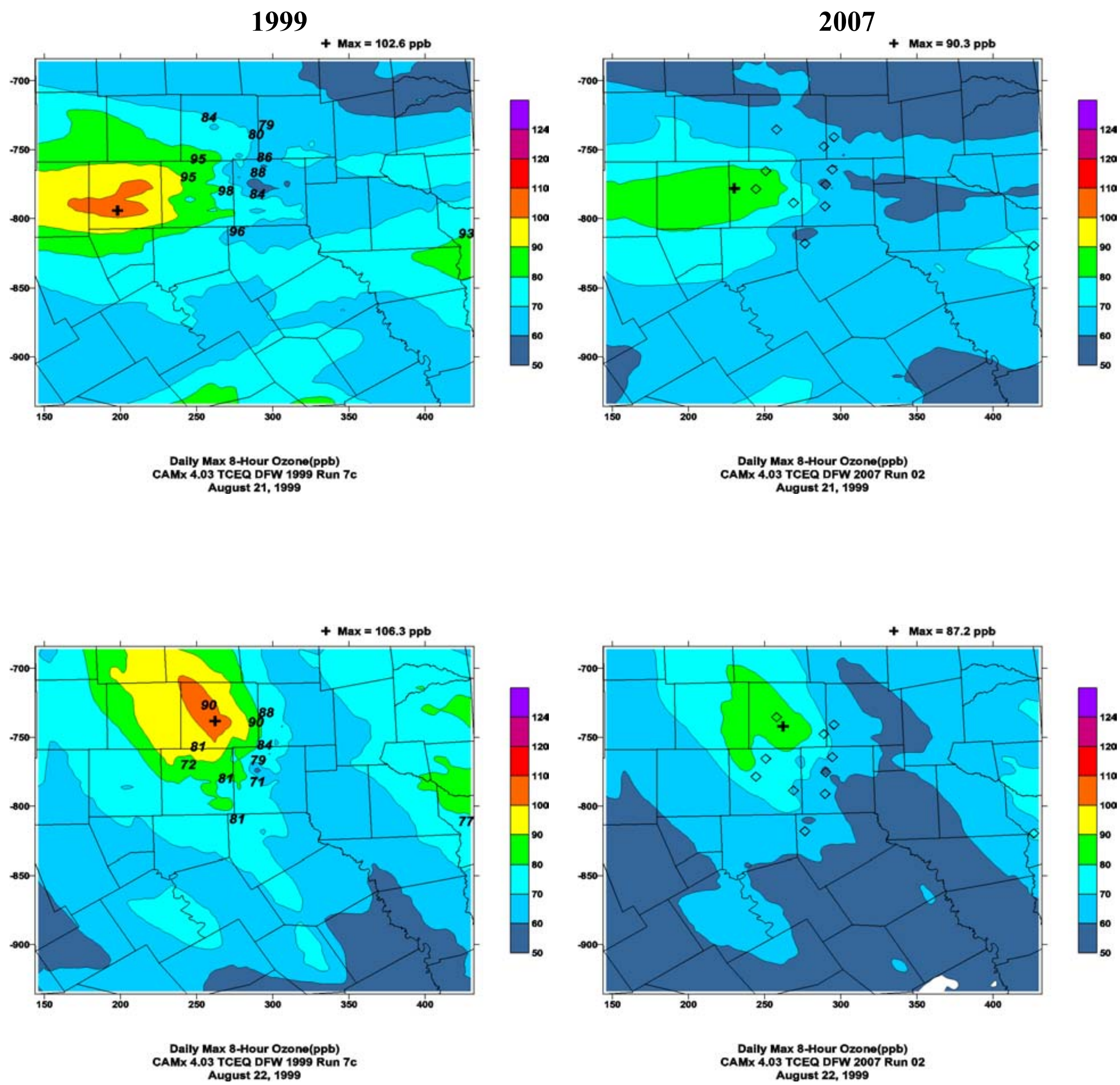


Figure 3-3 (concluded). Daily maximum 8-hour ozone in the DFW 4-km domain for 1999 and 2007.

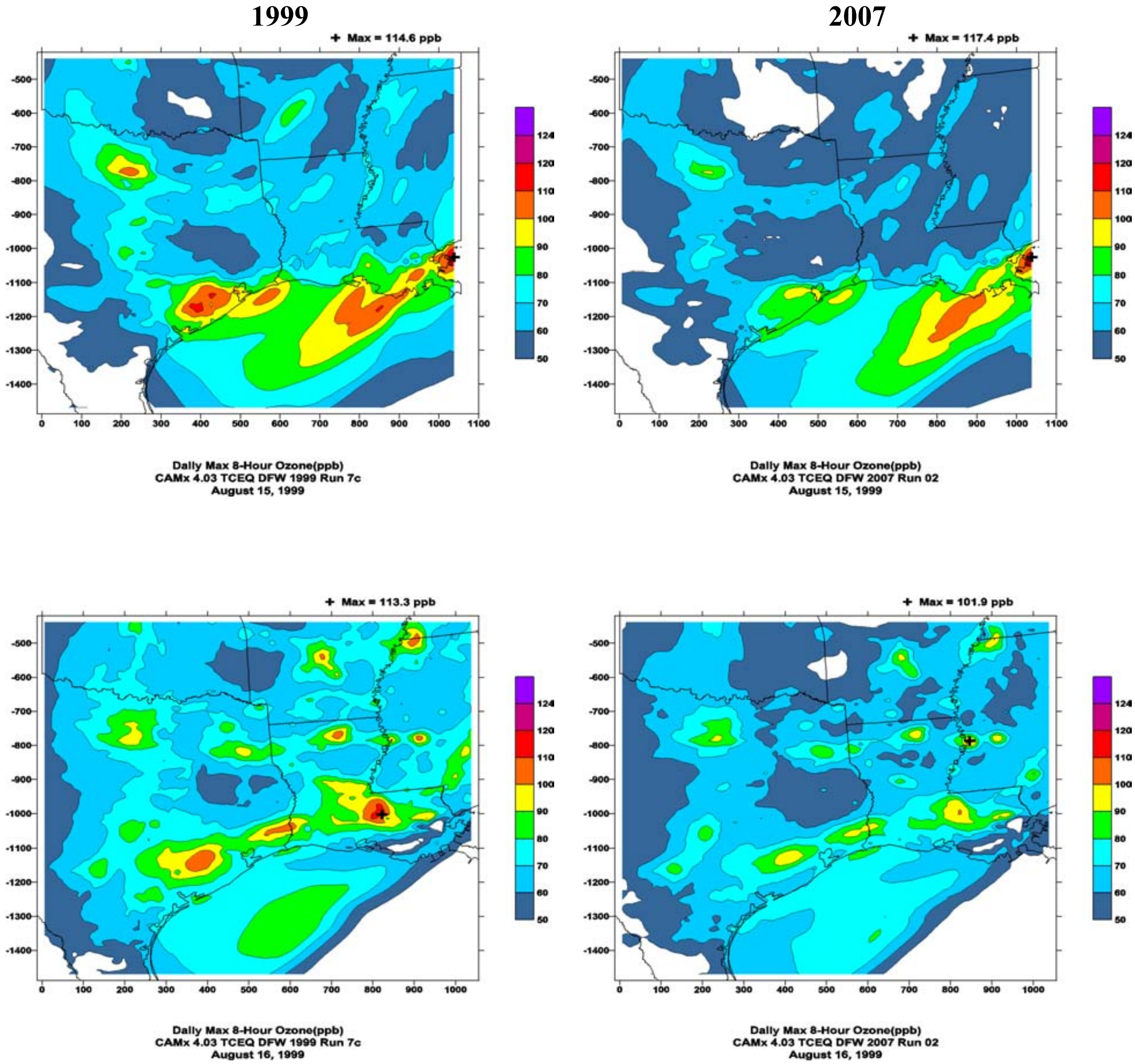


Figure 3-4. Daily maximum 8-hour ozone in the regional 12-km domain for 1999 and 2007.

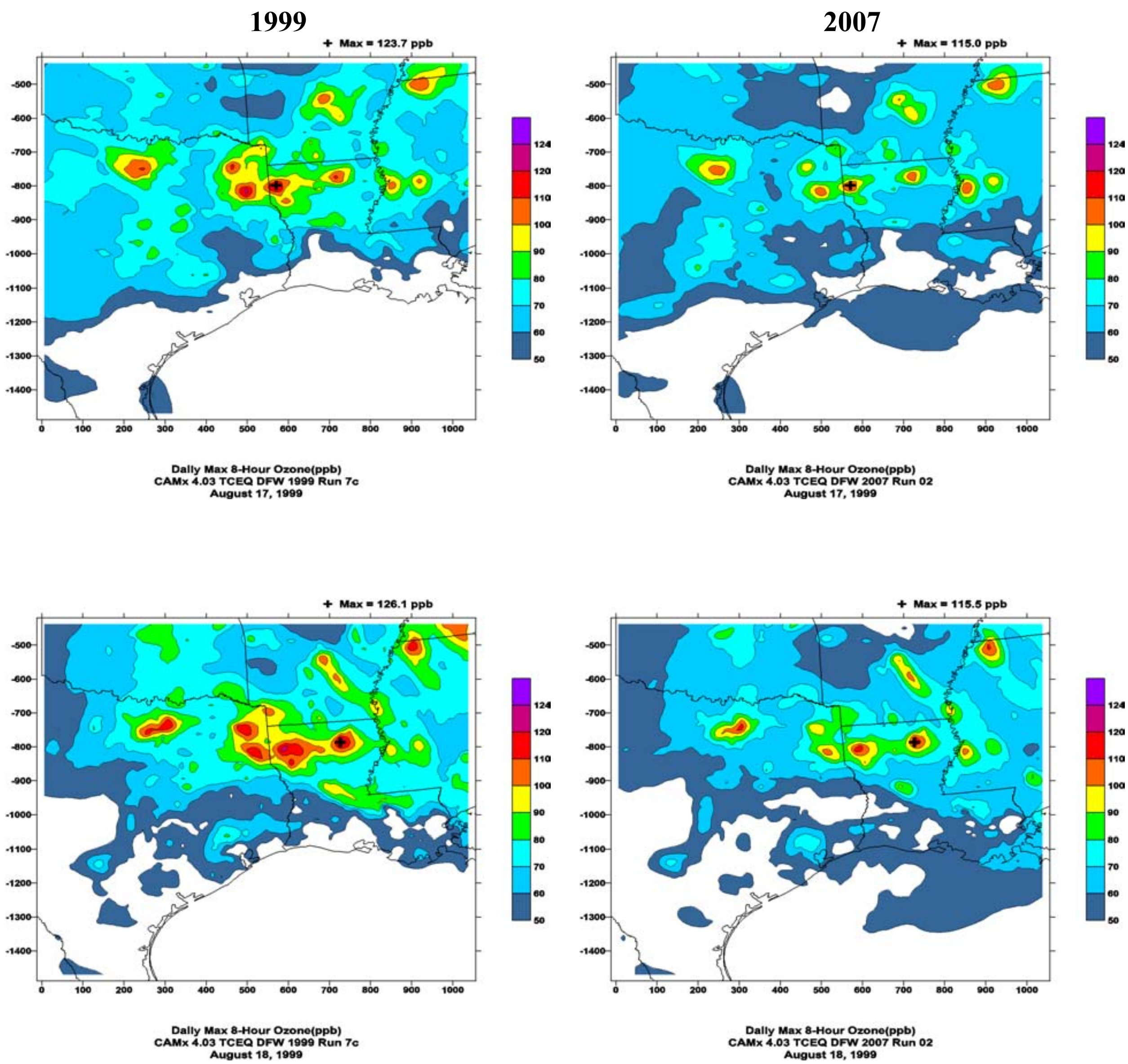


Figure 3-4 (cont.) Daily maximum 8-hour ozone in the regional 12-km domain for 1999 and 2007.

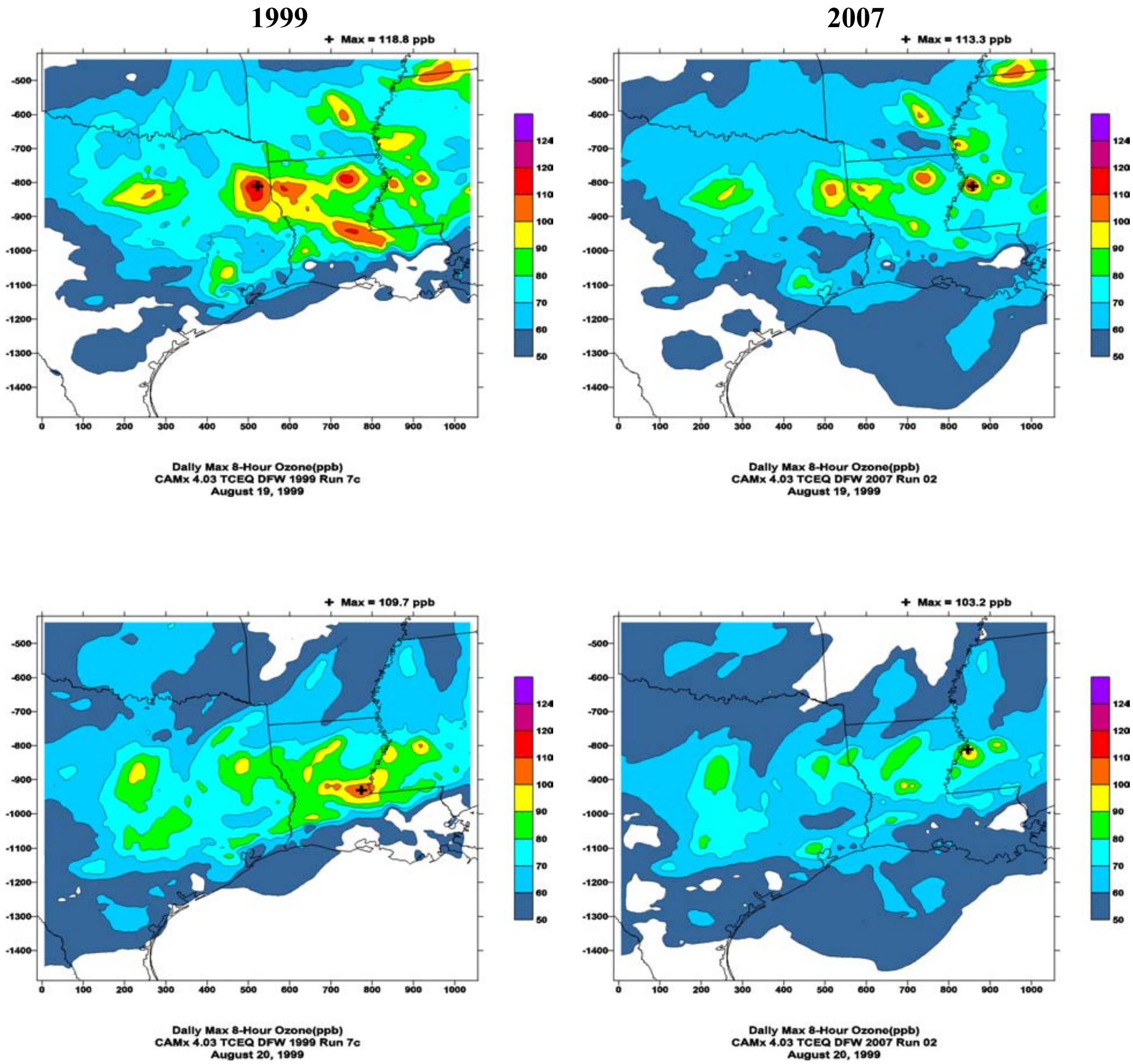


Figure 3-4 (cont.) Daily maximum 8-hour ozone in the regional 12-km domain for 1999 and 2007.

1999 **2007**

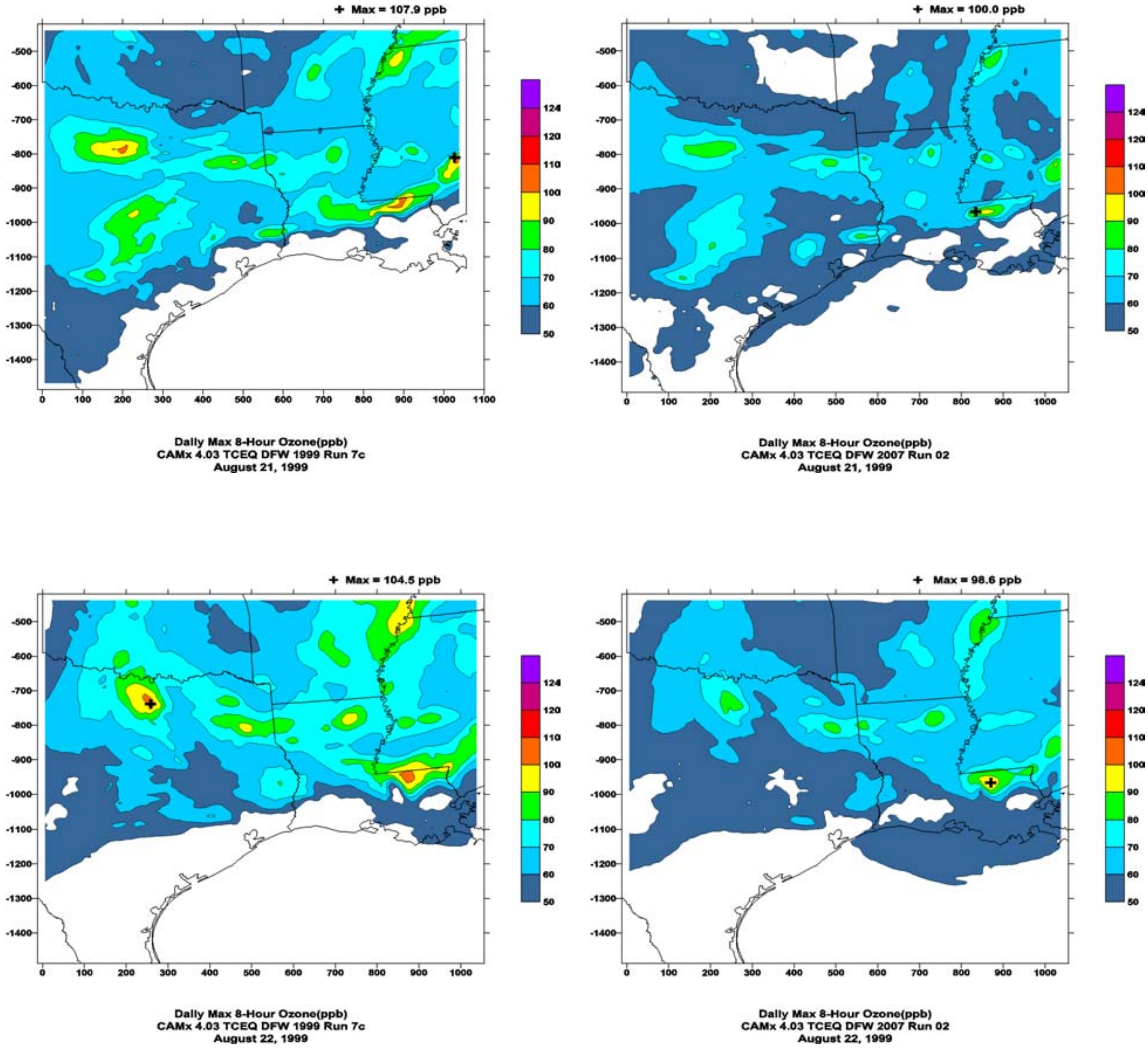


Figure 3-4 (concluded). Daily maximum 8-hour ozone in the regional 12-km domain for 1999 and 2007.

PROJECTED 2007 8-HOUR OZONE DESIGN VALUES

Design Value Scaling Methodology for 8-Hour Ozone

The methodology for the 8-hour ozone attainment test was described in draft modeling guidance issued by EPA (EPA, 1999). The methodology calls for scaling base year design values (DVs) using relative reduction factors (RRFs) from a photochemical model in order to estimate future design values using the following equations:

Future Year DV = Base Year DV × RRF

RRF = Future Year Modeled Ozone / Base Year Modeled Ozone

This methodology is conceptually simple, but the implementation is complicated and is described in detail below. This methodology was implemented in a computer program to automate the calculation for efficiency and reliability.

<u>Calculating RRFs</u>

RRFs are calculated for each monitor location. In addition, since high ozone can also occur away from monitor locations, a screening calculation is also carried out to identify grid cells with consistently high ozone. If any screening cells are identified, RRFs are then calculated for the screened grid cells. The idea behind the screening cells is to account for any areas with consistently high modeled ozone that are not captured by the monitoring network. Since there is no base year DV for a screening cell, the DV from a nearby representative monitor must be used. The attainment test is passed when all the future year scaled DVs are 84 ppb or less.

Figure 3-5 shows a schematic outline of the calculations and identifies the input data required to complete the calculation. These are:

1. A monitor list – the list of monitors along with base year DVs for each monitor.
2. A screening cell list – the list of cells to be considered in the screening cell calculation along with the monitors that are considered to be associated with that grid cell. This list may be a sub-set of the modeling grid covering just the area for which controls are being developed. The significance of associating monitors with each grid cell is in the selection of an appropriate base year DV for the grid cell and in setting concentration thresholds for including the grid cell in the screening calculation, discussed below. There are no firm criteria for deciding how to associate monitors with grid cells.
3. Base case ozone – gridded 8-hour daily maximum ozone for the base year.
4. Future case ozone – gridded 8-hour daily maximum ozone for the future year.

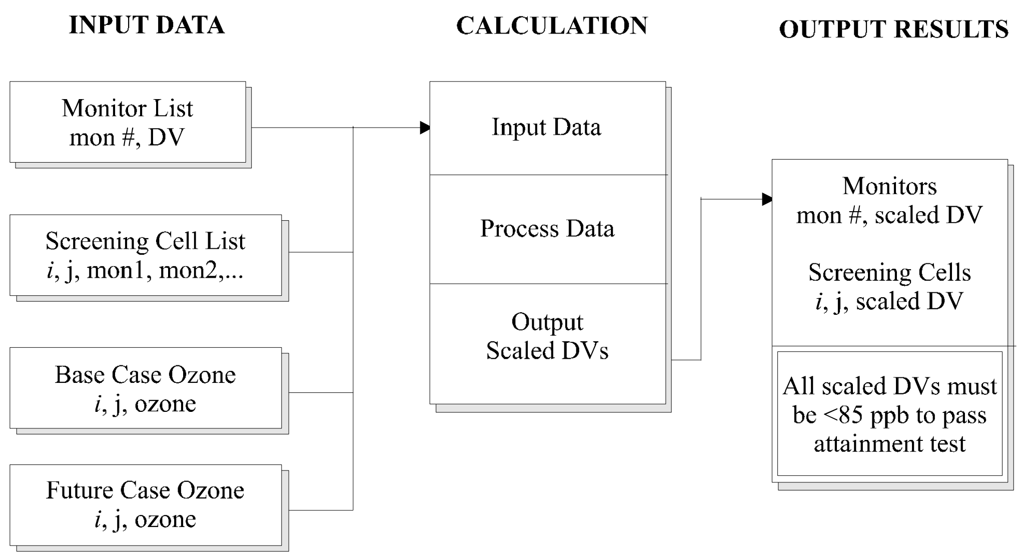


Figure 3-5. Overview of the 8-hour ozone attainment test methodology.

The details of the calculations are as follows:

- Monitor DV Scaling

1. For each monitor, find the daily maximum 8-hour ozone in an *n* x *n* block of cells around the monitor for both the base and future case. Repeat for each modeling day being used for control strategy development. For a 4 km grid, *n*=7 or 9 are consistent with the guidance.
2. Exclude days when the base case daily maximum 8-hour ozone was below 70 ppb.
3. Average the daily maximum 8-hour ozone across days for the base and future year.
4. Calculate the RRF = (average future daily max) / (average base daily max).
5. Calculate the scaled DV = base year DV x RRF and truncate to nearest ppb.
6. Repeat 1-5 for each monitor

- Screening Cell DV Scaling

7. For each grid cell on the screening cell list, count the number of days where the modeled daily maximum 8-hour ozone is at least 5% greater than the modeled daily maximum 8-hour ozone at any "associated" monitor, and at least 70 ppb.
8. If the number of days is 50% or greater of the total days, treat this cell as if it were a monitor – this is a "screened cell."
9. The base year DV to be used for a screened cell is the maximum of the base year DVs for any "associated" monitor.
10. Calculated the scaled DV for each screened cell as if it were a monitor (steps 1-5 above).
11. Repeat 7-10 for each grid cell on the screening cell list.

We make two deviations from EPA's draft guidance (EPA, 1999). First, in Step 4 the draft guidance says to round the average base and future daily maximum 8-hour ozone concentrations to the nearest ppb before calculating the RRFs, whereas we use the full precision of the modeled values. Rounding the average daily maximum 8-hour ozone concentrations in Step 4 doesn't make sense at this point in the calculations as it looses precision and will result in "stepfunction" RRFs that are illogical. The second deviation from EPA's draft guidance is that they recommend rounding the RRFs to 2 digits to the right of the decimal point, whereas again we use full precision. Again we believe this is an unnecessary loss of precision, however in this case it has little effect.

Dallas/Ft. Worth 8-Hour Design Values

The current 8-hour design values for the Dallas/Ft. Worth non-attainment area are presented in Table 3-3. The 8-hour design value for an individual monitor is defined as the fourth highest monitored 8-hour ozone value averaged over the most recent three years of data. EPA will use the 2000-2003 design values for 8-hour ozone attainment designations. However, because the modeling episode is for 1999, the EPA modeling guidance (EPA, 1999) says that the design value scaling must consider the higher of the design values corresponding to the base year (1998-2000) and the attainment designation (2001 to 2003) at each monitor.

Table 3-3 shows the base year (1998-2000) and attainment designation (2001-2003) design values for monitors in the DFW area. Also presented in Table 3-3 is the maximum design value over these two periods. Figure 3-6 displays the location of ozone monitors within the DFW nonattainment area. The specific period for which the maximum design occurs is also denoted in Figure 3-6.

Table 3-3. DFW 8-Hour O3 Design Values.

County	City	CAMS	1998-2000	2001-2003	Max DV	Ending Year of Max DV
Collin	Frisco	C31	101	88	101	2000
Collin	Anna	C68		80	80	2003
Dallas	Dallas	C60, C401	93	90	93	2000
Dallas	Dallas	C63		86	86	2003
Dallas	Dallas	C402	88	83	88	2000
Dallas	Sunnyvale	C74		83	83	2003
Denton	Denton	C56	102	97	102	2000
Ellis	Midlothian	C94	97	82	97	2000
Hood	Granbury	C73		84	84	2003
Johnson	Cleburne	C77		90	90	2003
Kaufman	Kaufman	C71		73	73	2003
Parker	Weatherford	C76		89	89	2003
Rockwall	Rockwall	C69		81	81	2003
Tarrant	Arlington	C57	95		95	2000
Tarrant	Eagle Mountain Lake	C75		96	96	2003
Tarrant	Fort Worth	C13	99	96	99	2000
Tarrant	Fort Worth	C17	97	100	100	2003
Tarrant	Grapevine	C70		100	100	2003

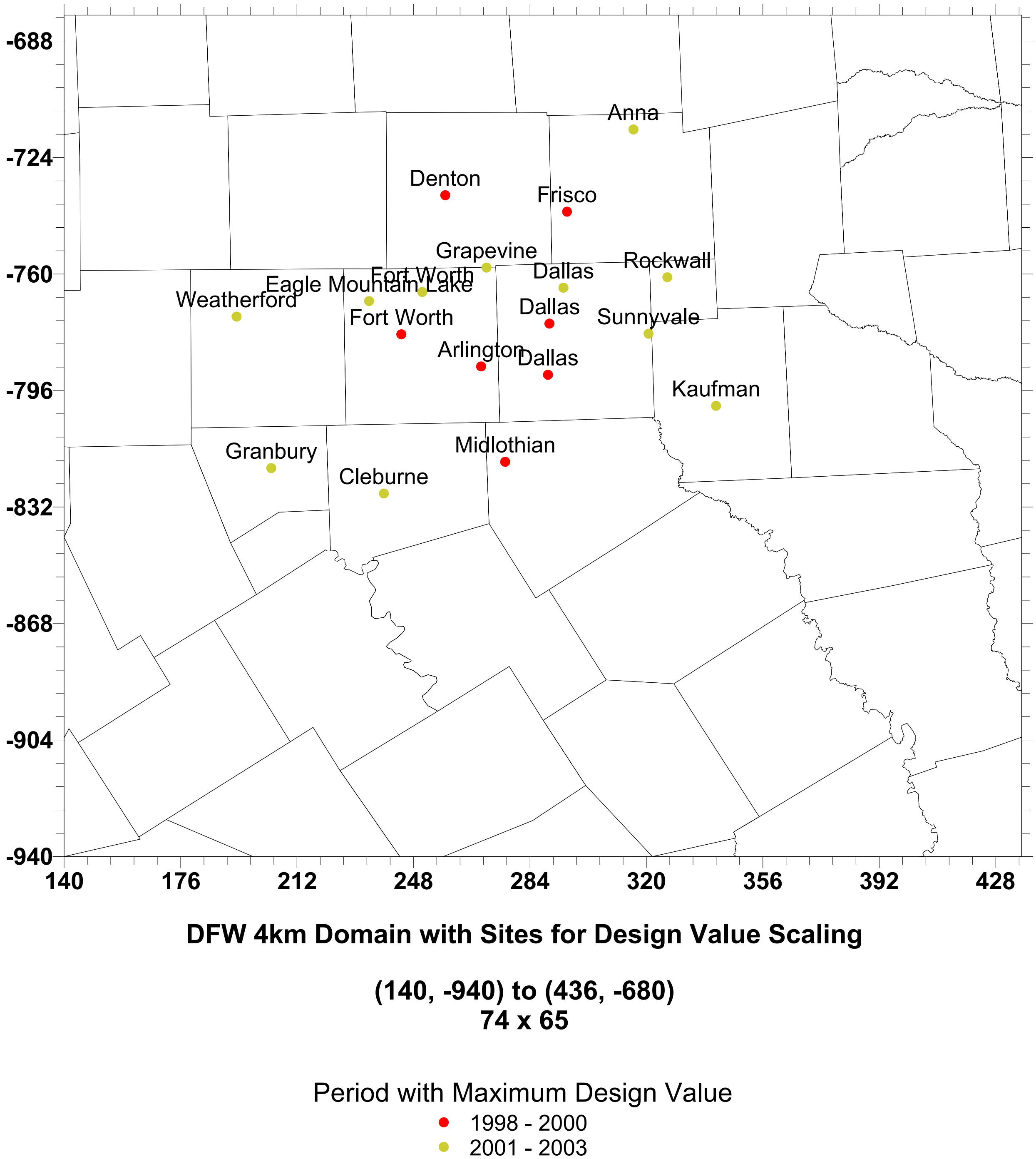


Figure 3-6. DFW ozone monitors and maximum design value periods.

The results of the design value scaling analysis are presented in Table 3-3. Yellow shaded values in the right hand column of the lower panel indicate monitors that fail the attainment test (8-hour O_3 < 85.0) for 2007.

Table 3-3. Preliminary 2007 8-hour ozone design value scaling analysis for monitors in the DFW area. The scaled 2007 design values are in the right hand column of the lower panel.

Base Case: run7c.403			Base Case Max 8-Hr Ozone (ppb)											#Days above 70 ppb
Site	Max DV	DV year	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	Avg	
Frisco	101	2000	57.5	64.8	76.3	80.8	92.5	122.7	75.2	66.3	72.8	93.9	87.7	7
Anna	80	2003	53.9	62.6	67.2	72.4	84.6	119.5	74.4	64.6	64.7	71.0	84.3	5
Dallas C60	93	2000	55.0	69.5	88.8	80.5	89.9	102.2	80.9	65.7	73.9	85.4	85.9	7
Dallas C63	86	2003	50.1	67.2	82.4	74.3	86.2	108.8	79.0	63.9	71.4	89.3	84.5	7
Dallas C402	88	2000	57.1	80.5	88.8	86.4	89.9	89.0	93.3	73.1	78.4	85.4	85.0	9
Sunnyvale	83	2003	62.8	65.9	71.6	71.4	78.0	89.9	81.5	66.5	70.2	69.1	77.1	6
Denton	102	2000	55.1	71.4	87.9	88.9	112.2	114.1	79.8	68.0	79.4	106.3	92.5	8
Midlothian	97	2000	55.6	79.7	79.4	79.8	79.7	79.5	105.1	80.1	73.2	77.9	81.6	9
Granbury	84	2003	48.8	101.1	85.6	84.4	77.3	76.0	97.8	78.0	94.1	72.5	85.2	9
Cleburne	90	2003	51.3	93.3	82.0	78.1	78.8	72.9	102.1	86.6	79.9	75.1	83.2	9
Kaufman	73	2003	54.0	64.8	75.5	68.3	71.7	73.1	82.1	65.4	71.6	65.3	74.8	5
Weatherford	89	2003	56.2	85.5	106.0	95.0	99.8	76.4	78.3	66.7	100.9	76.2	89.8	8
Rockwall	81	2003	62.2	65.9	65.4	72.1	80.3	106.5	81.5	64.7	71.9	70.0	82.5	5
Arlington	95	2000	57.1	87.8	97.5	89.7	94.8	91.7	93.3	73.2	85.1	85.8	88.8	9
Eagle Mt Lake	96	2003	56.0	85.2	111.0	97.2	110.8	109.1	84.3	70.7	99.9	94.3	95.8	9
Ft Worth C13	99	2000	56.4	82.6	108.2	97.2	106.0	109.8	84.1	72.5	95.5	91.6	94.2	9
Ft Worth C17	100	2003	57.6	79.0	104.3	94.5	111.7	116.5	82.9	72.5	91.7	100.0	94.8	9
Grapevine	100	2003	58.3	76.0	97.4	89.0	110.1	119.8	82.8	72.5	84.0	102.5	92.7	9

Future Year: 07run02.dfw			Future Case Max 8-Hr Ozone (ppb)												2007 DV
Site	Max DV	DV year	8/13	8/14	8/15	8/16	8/17	8/18	8/19	8/20	8/21	8/22	Avg	RRF	
Frisco	101	2000	52.8	61.9	67.2	78.6	89.3	118.5	69.4	60.2	65.8	79.0	81.1	0.9246	**93.4**
Anna	80	2003	51.0	55.0	59.0	65.5	77.2	107.7	68.5	59.7	58.5	61.4	76.1	0.9017	72.1
Dallas C60	93	2000	57.1	73.1	77.9	84.2	88.9	100.2	80.0	67.4	73.5	75.0	82.8	0.9639	**89.6**
Dallas C63	86	2003	56.3	66.2	75.1	80.0	86.5	110.9	76.3	63.9	69.2	78.0	82.3	0.9739	83.8
Dallas C402	88	2000	57.1	75.9	77.9	84.9	88.1	91.5	93.1	76.7	73.5	71.1	81.4	0.9580	84.3
Sunnyvale	83	2003	64.8	59.0	62.1	68.6	75.2	89.0	75.3	61.0	64.0	63.3	72.4	0.9388	77.9
Denton	102	2000	51.3	61.4	74.4	83.7	106.5	101.8	71.2	61.0	68.7	87.2	81.8	0.8847	**90.2**
Midlothian	97	2000	53.7	71.7	69.6	74.1	74.3	71.3	97.0	77.8	66.7	68.3	74.5	0.9133	**88.6**
Granbury	84	2003	48.7	88.7	78.1	76.6	71.6	70.8	87.3	73.0	81.4	66.3	77.1	0.9050	76.0
Cleburne	90	2003	48.5	81.1	75.1	73.2	73.4	65.3	93.1	82.8	75.4	63.7	75.9	0.9120	82.1
Kaufman	73	2003	53.2	55.4	60.6	63.2	64.1	66.3	76.9	57.5	63.8	58.0	66.4	0.8872	64.8
Weatherford	89	2003	49.7	75.5	91.6	89.1	90.4	67.4	70.6	61.2	89.0	67.1	80.1	0.8921	79.4
Rockwall	81	2003	64.8	59.0	57.7	67.0	74.3	100.6	75.3	59.5	62.8	62.9	76.0	0.9214	74.6
Arlington	95	2000	55.4	83.4	82.5	90.1	93.6	91.5	93.1	76.7	82.2	78.1	85.7	0.9653	**91.7**
Eagle Mt Lake	96	2003	51.6	79.3	94.6	94.5	107.5	95.3	75.9	64.7	90.3	82.6	87.2	0.9096	**87.3**
Ft Worth C13	99	2000	52.5	83.4	93.7	94.5	103.5	98.8	81.9	68.6	90.1	81.5	88.5	0.9394	**93.0**
Ft Worth C17	100	2003	52.7	77.0	90.5	93.7	109.9	102.4	77.4	64.8	88.3	84.2	87.6	0.9241	**92.4**
Grapevine	100	2003	54.0	73.1	85.0	87.9	109.7	107.6	74.6	64.8	81.1	86.1	85.6	0.9234	**92.3**

Note: Yellow shaded values are 85 ppb or higher.

4.0 SUMMARY AND CONCLUSIONS

The CAMx air quality model was applied for the August 13 –22, 1999 Dallas/ Ft. Worth ozone episode. Version 4.03 of the CAMx air quality model was run for the 1999 base year and the 2007 future year. The development of the input databases for 1999 was documented in Mansell et al., 2003. Emission inventories for the 2007 future year were developed jointly by ENVIRON and TCEQ as described above. The main points from the ozone modeling results for 1999 and 2007 are summarized below.

Model Performance Evaluation

Model performance statistics for 1-hour ozone are shown in Table 3-1.

- The model performance for 1999 was slightly degraded by the change from CAMx 4.02 to CAMx 4.03.
- There was a reduction in regional ozone levels in the DFW area of a few ppb due the change in CAMx version.
- The 1999 episode peak 1-hour ozone was reduced from 151.1 ppb with CAMx 4.02 to 148.6 ppb with CAMx 4.03. These modeled values compare with an observed episode 1-hour peak ozone of 150 ppb.
- The normalized bias statistic was slightly more negative (by about 3 percentage points) on all days with CAMx 4.03 than CAMx 4.02.
- There was little change in the normalized gross error statistic between CAMx versions 4.02 and 4.03.

1-Hour Ozone for 2007

Peak 1-hour ozone levels for 2007 are shown in Table 3-1.

- Peak 1-hour ozone levels exceeded the level of the 1-hour ozone standard (124 ppb) on three days from August 17th to 19th.
- The 1-hour ozone peak on August 17th was 138.5 ppb for 2007 compared to 140.6 ppb for 1999. This peak value occurred downwind of DFW to the west and was not very responsive to the emissions reductions in the DFW area from 1999 to 2007. The observed peak ozone on 17 August 1999 was 150 ppb to the north of Dallas.
  - August 17th is the day with the poorest model performance due to a bias in the MM5 wind field (Mansell et al., 2003). The normalized bias for 17 August 1999 was –27%, which is outside the EPA goal of +/- 15%.

- Because the modeled and observed peaks are in different locations, it is difficult to estimate whether a "relative reduction factor" analysis would find that 1-hour ozone levels are more responsive to emission reductions than the peak ozone.

- The 1-hour ozone peak on August 18th was 138.3 ppb for 2007 compared to 148.6 ppb for 1999. This peak value occurred to the north of DFW and was very close to the observed peak of 131 ppb for 1999.
    - Because the modeled peak is responsive to emission reductions and is located close to the observed peak, a "relative reduction factor" analysis is likely to suggest that 1-hour ozone levels would attain the standard on this day.

- The 1-hour ozone peak on August 19th was 125.4 ppb for 2007 compared to 135.9 ppb for 1999. This peak value occurred to the south of DFW. The observed peak for this day in 1999 was 128 ppb at the monitor closest to the observed peak, about 25 km away.
    - Because the modeled and observed peaks are in different locations, it is difficult to estimate whether a "relative reduction factor" analysis would find that 1-hour ozone levels are more responsive to emission reductions than the peak ozone.

8-Hour Ozone for 2007

Design values for 8-hour ozone in 2007 are shown in Table 3-3.

- A preliminary analysis was completed for 8-hour ozone levels in 2007 using EPA's design value (DV) scaling methodology. The analysis is preliminary because:
    - The final analysis will be for a 2010 future year.
    - The DV scaling method is sensitive to consistency between the base and future year modeling, and the base year inventory needs to be updated.

- The projected 8-hour design values for 2007 exceeded the target level of 84 ppb (after truncation) at 9 of 18 sites considered in the DFW area.

- The relative reduction factor analysis projected that four monitors (Dallas CAMS402, Dallas CAMS63, Cleburne CAMS77 and Weatherford CAMS76) would come into attainment of the 8-hour ozone standard by 2007.

- The highest projected 8-hour design values for 2007 was 93.4 ppb at the Frisco monitor.

5.0 REFERENCES

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Appendix A.

OZONE SOURCE APPORTIONMENT (APCA) ANALYSIS

OZONE SOURCE APPORTIONMENT (APCA) ANALYSIS

An ozone source apportionment analysis was completed for the 2007 base case to help understand which geographic areas and categories of emissions contribute to high ozone in the DFW area for the 2007 future case. A similar analysis was completed for the 1999 base case as described by Mansell et al., (2003). The source apportionment analysis used a technique called APCA, which stands for Anthropogenic Precursor Culpability Assessment. The next section discusses how APCA results relate to other modeling methods, and the important points to realize are:

- Because ozone formation involves non-linear interactions between VOC and NOx emissions there is no unique source apportionment for ozone.
- Consequently, neither the APCA results nor any other modeling or ambient data analysis can provide a unique answer to the question "which emissions caused this ozone."
- We recommend considering all available information (modeling, inventories, data analysis) in developing a conceptual model of which sources cause high ozone and therefore how to approach control strategy design.

METHODS FOR EVALUATING SOURCE CONTRIBUTIONS IN CAMx

Ambient measurements and ozone models both provide information on total ozone levels. Since ozone is formed from VOC and NOx precursor emissions it is useful to understand which emissions are causing high ozone levels so that effective emission control strategies can be designed. In other words, we would like to apportion the total ozone among all of the sources that participated in forming the ozone. Unfortunately, ozone source apportionment is difficult because ozone formation involves the interaction between emissions that likely came from different sources, e.g., anthropogenic NOx interacting with biogenic VOC. There is no one unique or "correct" way to apportion ozone among sources, but there are several approaches that can be used with CAMx:

- Ozone Source Apportionment Technology (OSAT).
- Anthropogenic Precursor Culpability Assessment (APCA).
- Zero-out differences.

CAMx also includes the decoupled direct method (DDM) method for sensitivity analysis (Dunker et al., 2002a). The DDM accurately calculates the sensitivity of model concentrations to emissions and is better suited to evaluating the effects of emissions changes (control strategies) than evaluating source contributions (source apportionment). The difference between source sensitivity and source apportionment is discussed further below.

Ozone Source Apportionment Technology (OSAT)

The OSAT method provides information about the relationships between ozone concentrations and sources of precursors in the form of ozone source apportionments. Source apportionment requires that the sum of all source contributions add up to exactly 100% of the total ozone so all of the ozone is accounted for. OSAT satisfies this requirement by attributing all new ozone production to precursors that are present at the point where the ozone is formed in CAMx. The OSAT attribution considers all potential sources of ozone in the simulation, i.e., emissions, boundary conditions and initial conditions. The emissions attribution can be broken out by geographic area and/or source category. The OSAT attribution of ozone production to the precursors that were present when the ozone was formed takes account of whether the ozone chemistry was sensitive to VOCs or NOx, and VOC reactivity differences. The OSAT methods are described in the CAMx User's Guide (ENVIRON, 2004) and in Dunker et al., (2002b).

Anthropogenic Precursor Culpability Assessment (APCA)

The APCA method is closely related to the OSAT method described above. The difference between the OSAT and APCA schemes can be summarized as follows. OSAT apportions ozone formation based solely on what precursors were present when the ozone is formed. APCA modifies the OSAT method to account for the fact that biogenic emissions are not considered to be controllable, and therefore APCA attributes ozone to controllable (anthropogenic) emissions whenever possible. The differences between OSAT and APCA are discussed in more detail below when results from the two methods are compared.

Zero-Out Differences

In the zero-out method the emissions for a particular source or group of sources are removed from the inventory (zeroed out), CAMx is re-run, and the change in ozone is measured relative to the base case. This zero-out ozone difference is a measure of the ozone contribution of the source, and the procedure can be repeated for several or all sources to build up a picture of relative source contributions to ozone. As discussed below, there are difficulties in interpreting the zero-out differences as source apportionments because the sum of the zero-out differences over all sources does not equal the total ozone. Nevertheless, the zero-out method has been widely used to evaluate source contributions to ozone.

STRENGTHS AND LIMITATIONS OF OSAT, APCA AND ZERO-OUT

As discussed above, there is no "correct" way to quantify the contribution of different source categories to ozone in a model like CAMx or in the real world. The OSAT, APCA and zero-out methods used with CAMx have different strengths and limitations that should be taken into account. The OSAT and APCA methods are discussed together because they are closely related.

The OSAT and APCA methods have several strengths:

- OSAT and APCA source contributions always sum to 100% of the modeled ozone so that all of the ozone is exactly accounted for and OSAT/APCA are directly interpretable as source apportionments.
- The OSAT and APCA apportionments are based on precursors from a specific source being present at the time and place where ozone was formed in the model.
- OSAT attributes ozone production based on whether the chemistry is VOC or NOx sensitive.
- The advantage of APCA over OSAT is taking account of the non-controllable nature of biogenic emissions. APCA seeks to minimize the contribution of biogenic sources (usually VOCs) by attributing ozone to the anthropogenic emissions (usually NOx) that interacted with the biogenic emissions.
- A practical advantage of OSAT and APCA is high computational efficiency, which means that more detailed source contributions (more geographic resolution, more source categories) can be identified with a set amount of project resources.

Limitations of OSAT and APCA are:

- Because ozone formation is non-linear, the OSAT and APCA source apportionments cannot be used to predict the effects of a specific strategy or calculate what emission reductions are needed to achieve a specific target ozone level.
- A limitation of OSAT can be attributing large amounts of ozone production to biogenic emission sources that are not controllable.

The strengths of the zero-out method are:

- The method is easy to explain and many people find the approach intuitively obvious and reasonable.
- The zero-out differences are directly related to the participation of emissions in ozone formation.
- The method is simple to apply with any model.

Limitations of the zero-out method are:

- The zero-out method requires changing the emissions, which in turn changes the chemistry of ozone formation.
- The sum of the zero-out differences over all sources will not necessarily add up to 100% of the modeled ozone.
- Zero-out differences may be negative for some sources. This makes sense in terms of source sensitivity, but does not make sense as source apportionment.
- For the three reasons listed above, zero-out results can be difficult to interpret as source apportionments. In this study, we refer to the zero-out results as differences rather than apportionments.
- A limitation of zero-out can be attributing large amounts of ozone production to biogenic emission sources that are not controllable.
- Because ozone formation is non-linear, the zero-out differences cannot be used to predict the effects of a specific strategy or calculate what emission reductions are needed to achieve a specific target ozone level. In particular, zeroing out all anthropogenic emissions represents an unrealistic control strategy which produces results that cannot be interpolated to correspond to a more modest (and realistic) strategy.

Source Apportionment vs. Source Sensitivity

An important limitation noted above that is common to OSAT, APCA and zero-out is that the results cannot be used to predict the effects of a specific strategy or calculate what emission reductions are needed to achieve a specific target ozone level. This is the difference between source apportionment and source sensitivity, which is an important technical issue that requires more explanation.

The amount of ozone formed by precursor emissions (NOx or VOC) is related to the amount of precursor emissions multiplied by the production efficiency i.e., ozone produced per precursor emitted. The ozone production efficiency is not a constant factor but depends upon many things, such as the type of emissions (NOx vs. VOC, specific type of VOC), the meteorological conditions, and the other precursors present in the atmosphere (e.g., the VOC/NOx ratio). As emissions are reduced, the ozone production efficiency also changes, and so the effect of emission controls may be greater or lesser than expected simply on the basis of the fraction of emissions reduced. In other words, a 10% emissions reduction will not necessarily lead to a 10% reduction in ozone contribution.

SOURCE AREAS AND EMISSIONS CATEGORIES

The geographic areas for the 2007 APCA analysis are the same as for the previously reported 1999 analysis (Mansell et al., 2003). The modeling domain was divided into 25 source areas described in Table 1 and shown in Figure 1. The emission inventory was divided into 4 source categories:

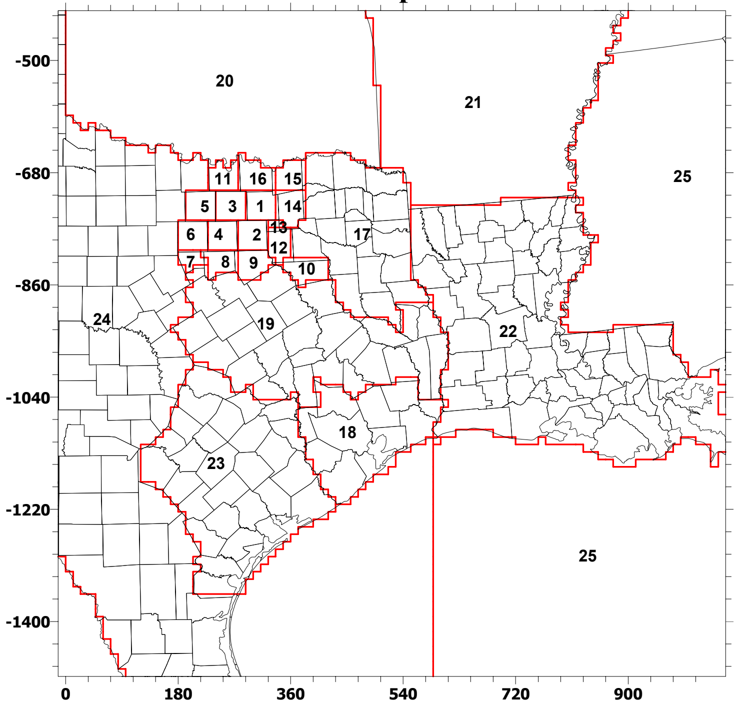
1. Biogenic sources
2. On-road mobile sources
3. All point sources (elevated plus low-level points)
4. Area plus off-road mobile sources.

This means that APCA attributed ozone to 100 different sectors of the emission inventory (25 areas times 4 categories) plus the CAMx initial and boundary conditions (6 categories). Emission totals for the source categories and geographic areas used in the APCA analysis are given in Section 2 for 2007 and 1999 (Tables 2-5 to 2-7).

Table 1. Emissions source area definitions.

Area Number	**Area Abbreviation**	**Area Definition**
1-4	Core	Dallas Core Counties (Collin, Dallas, Denton, Tarrant)
5-16	Perimeter12	12 Counties surrounding Dallas Core (Wise, Parker, Hood Johnson, Ellis, Henderson, Cooke, Kaufman, Rockwall, Hunt, Fannin, Grayson)
17	Northeast Texas	Northeast Texas
18	HGBPA	Houston/Galveston/Beaumont/Port-Arthur (11 Counties)
19	Central Texas	East Central Texas
20	OK	Oklahoma
21	AR	Arkansas
22	LA	Louisiana
23	South Texas	Near Non-attainment areas (Austin, San Antonio, Victoria, Corpus Christi)
24	West Texas	Texas (excluding area 1-19 and 23
25	Other States	Other areas

12-km Grid Source Area Map



4-km Grid Source Area Map

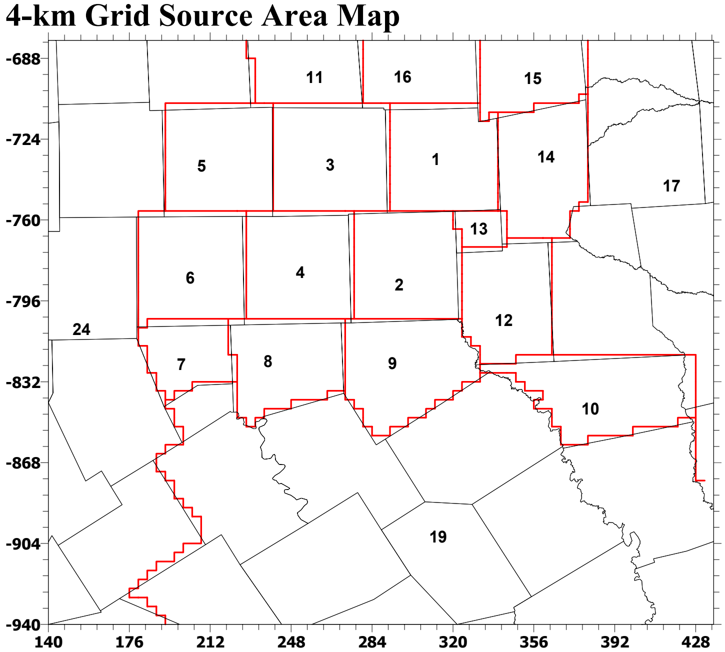


Figure 1. Geographic source areas for the 2007 APCA analysis. The areas are described in Table 1.

APCA RESULTS

The APCA analysis focused on identifying the anthropogenic emission sources that contribute to modeled 8-hour ozone levels of 85 ppb or higher in the four core DFW Counties. The methodology was as follows:

1. Identify grid cells and hours in the four core DFW counties that had 1999 8-hour ozone levels of 85ppb or higher. There were 4412 grid cell-hours meeting these criteria on the August 15-22 modeling days (i.e., excluding two spin-up days).

2. Analyze the APCA results for 1999 and 2007 to calculate the average source contributions over these 4412 grid cell-hours.

This methodology was chosen to make the 1999 and 2007 results directly comparable because the averages are calculated over the same grid cells and hours in both years.

The average 8-hour ozone contributions in the four core DFW counties are shown in ppb units in Table 2 for 2007 and Table 3 for 1999. The difference between the 2007 and 1999 contributions is shown in Table 4.

The APCA analysis was performed using CAMx version 4.03 for the 2007 base case (07run02) and an updated 1999 base case run17a (run7c with revised mobile source emissions for the 4 km grid and revised point source emissions for Louisiana non-EGU point sources). The 1999 run 17a is described by Emery et al. (2004).

Table 2. Average 2007 8-hour ozone contributions (ppb) to the four core DFW counties where 1999 8-hour ozone exceeded 85 ppb.

Source Region	Source Category IC	BC East	BC North	BC South	BC Top	BC West	Biogenic	Area + Off-Road	On-Road	All Points	# cells = 4412 Grand Total	Area Total
Collin							0.15	0.97	0.72	0.08	**1.92**	
Dallas							0.18	6.26	5.92	1.31	**13.67**	
Denton							0.33	1.17	1.81	0.20	**3.51**	
Tarrant							0.15	5.90	4.94	0.70	**11.69**	**30.79**
Wise							0.01	0.08	0.01	0.03	**0.13**	
Parker							0.01	0.05	0.05	0.05	**0.16**	
Hood							0.00	0.01	0.01	0.16	**0.18**	
Johnson							0.06	0.24	0.15	0.06	**0.51**	
Ellis							0.14	0.32	0.21	2.08	**2.75**	
Henderson							0.01	0.05	0.02	0.05	**0.13**	
Cooke							0.01	0.01	0.01	0.00	**0.03**	
Kaufman							0.14	0.15	0.24	0.38	**0.91**	
Rockwall							0.04	0.07	0.11	0.00	**0.22**	
Hunt							0.03	0.02	0.04	0.00	**0.09**	
Fannin							0.01	0.00	0.00	0.00	**0.01**	
Grayson							0.03	0.03	0.03	0.04	**0.13**	**5.25**
Central Texas							0.63	0.55	0.36	0.85	**2.39**	
Northeast Texas							0.20	0.60	0.39	1.20	**2.39**	
South Texas							0.19	0.17	0.14	0.20	**0.70**	
HGBPA							0.09	0.23	0.21	0.37	**0.90**	
West Texas							0.03	0.05	0.01	0.03	**0.12**	**6.50**
AR							0.22	0.58	0.35	0.59	**1.74**	
LA							0.31	1.57	0.54	1.42	**3.84**	
OK							0.05	0.09	0.10	0.16	**0.40**	
Other States							0.41	1.04	0.62	1.37	**3.44**	**9.42**
Boundary Conditions		0.27	9.99	0.38	0.83	21.11					**32.58**	
Initial Conditions	0.70										**0.70**	**33.28**
Grand Total	**0.70**	**0.27**	**9.99**	**0.38**	**0.83**	**21.11**	**3.43**	**20.21**	**16.99**	**11.33**	**85.24**	**85.24**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

Table 3. Average 1999 8-hour ozone contributions (ppb) to the four core DFW counties where 1999 8-hour ozone exceeded 85 ppb.

Source Region	Source Category										# cells = 4412	
	IC	BC East	BC North	BC South	BC Top	BC West	Biogenic	Area + Off-Road	On-Road	All Points	Grand Total	Area Total
Collin							0.12	1.04	0.98	0.13	**2.27**	
Dallas							0.12	6.18	8.35	2.79	**17.44**	
Denton							0.23	1.52	2.26	0.29	**4.30**	
Tarrant							0.10	4.95	6.51	1.19	**12.75**	**36.76**
Wise							0.01	0.13	0.03	0.03	**0.20**	
Parker							0.01	0.07	0.09	0.01	**0.18**	
Hood							0.00	0.01	0.01	0.23	**0.25**	
Johnson							0.05	0.24	0.24	0.07	**0.60**	
Ellis							0.13	0.23	0.41	0.85	**1.62**	
Henderson							0.01	0.07	0.03	0.04	**0.15**	
Cooke							0.01	0.01	0.02	0.00	**0.04**	
Kaufman							0.12	0.18	0.37	0.02	**0.69**	
Rockwall							0.03	0.05	0.14	0.00	**0.22**	
Hunt							0.03	0.03	0.06	0.00	**0.12**	
Fannin							0.01	0.00	0.01	0.00	**0.02**	
Grayson							0.04	0.05	0.09	0.12	**0.30**	**4.39**
Central Texas							0.59	0.70	0.68	1.10	**3.07**	
Northeast Texas							0.19	0.86	0.75	1.69	**3.49**	
South Texas							0.18	0.24	0.28	0.24	**0.94**	
HGBPA							0.08	0.33	0.47	0.56	**1.44**	
West Texas							0.03	0.07	0.03	0.04	**0.17**	**9.11**
AR							0.21	0.62	0.31	0.74	**1.88**	
LA							0.29	1.71	0.61	1.60	**4.21**	
OK							0.06	0.19	0.14	0.16	**0.55**	
Other States							0.35	0.91	0.58	1.97	**3.81**	**10.45**
Boundary Conditions		0.26	9.87	0.37	0.79	20.32					**31.61**	
Initial Conditions	0.65										**0.65**	**32.26**
Grand Total	**0.65**	**0.26**	**9.87**	**0.37**	**0.79**	**20.32**	**3.00**	**20.39**	**23.45**	**13.87**	**92.97**	**92.97**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

Table 4. Difference (2007 - 1999) in average 8-hour ozone contributions (ppb) to the four core DFW counties where 1999 8-hour ozone exceeded 85 ppb.

	Source Category										# cells = 4412	
Source Region	**IC**	**BC East**	**BC North**	**BC South**	**BC Top**	**BC West**	**Biogenic**	**Area + Off-Road**	**On-Road**	**All Points**	**Grand Total**	**Area Total**
Collin							0.03	-0.07	-0.26	-0.05	**-0.35**	
Dallas							0.06	0.08	-2.43	-1.48	**-3.77**	
Denton							0.1	-0.35	-0.45	-0.09	**-0.79**	
Tarrant							0.05	0.95	-1.57	-0.49	**-1.06**	**-5.97**
Wise							0	-0.05	-0.02	0	**-0.07**	
Parker							0	-0.02	-0.04	0.04	**-0.02**	
Hood							0	0	0	-0.07	**-0.07**	
Johnson							0.01	0	-0.09	-0.01	**-0.09**	
Ellis							0.01	0.09	-0.2	1.23	**1.13**	
Henderson							0	-0.02	-0.01	0.01	**-0.02**	
Cooke							0	0	-0.01	0	**-0.01**	
Kaufman							0.02	-0.03	-0.13	0.36	**0.22**	
Rockwall							0.01	0.02	-0.03	0	**0**	
Hunt							0	-0.01	-0.02	0	**-0.03**	
Fannin							0	0	-0.01	0	**-0.01**	
Grayson							-0.01	-0.02	-0.06	-0.08	**-0.17**	**0.86**
Central Texas							0.04	-0.15	-0.32	-0.25	**-0.68**	
Northeast Texas							0.01	-0.26	-0.36	-0.49	**-1.1**	
South Texas							0.01	-0.07	-0.14	-0.04	**-0.24**	
HGBPA							0.01	-0.1	-0.26	-0.19	**-0.54**	
West Texas							0	-0.02	-0.02	-0.01	**-0.05**	**-2.61**
AR							0.01	-0.04	0.04	-0.15	**-0.14**	
LA							0.02	-0.14	-0.07	-0.18	**-0.37**	
OK							-0.01	-0.1	-0.04	0	**-0.15**	
Other States							0.06	0.13	0.04	-0.6	**-0.37**	**-1.03**
Boundary Conditions		0.01	0.12	0.01	0.04	0.79					**0.97**	
Initial Conditions	0.05										**0.05**	**1.02**
Grand Total	**0.05**	**0.01**	**0.12**	**0.01**	**0.04**	**0.79**	**0.43**	**-0.18**	**-6.46**	**-2.54**	**-7.73**	**-7.73**

Note: # Cells is the number of grid cells and hours where 1999 ozone exceeded 85 ppb in the four core DFW counties.

Contributions to High 8-hour Ozone in the Four Core DFW Counties

- The largest emissions contributions to high 8-hour ozone in the DFW 4-county area come from nearby emissions sources. Nearby means primarily emissions from within the 4-county DFW area, followed by surrounding counties (11 perimeter DFW counties), followed by neighboring parts of Texas (Central Texas and Northeast Texas).

- The relative importance of different emission source categories varies by region and year. For the 4 DFW core counties, on-road mobile sources and area plus off-road sources are the largest contributors, well ahead of point sources. For the surrounding 11 counties, these three anthropogenic source categories are more comparable with on-road mobile the largest contributor in 1999 and point sources the largest contributor in 2007.

- The contribution to high 8-hour ozone in the DFW 4-county area from emissions in the 4 Counties was 36.8 ppb in 1999 and 30.8 ppb in 2007. The reduction of 6 ppb was due to reduced contributions from on-road mobile and point sources offset partially by an increased contribution from area plus off-road sources. The increase in ozone contribution from area plus off-road sources was not due to higher emissions but, rather, due to more efficient ozone formation from area plus off-road source emissions as other sources (on-road and point) were reduced more aggressively in the DFW 4-county area.

- The contribution to high 8-hour ozone in the DFW 4-county area from emissions in the surrounding 11 counties was 4.4 ppb in 1999 and 5.3 ppb in 2007. The 0.9 ppb increase was due mostly to higher contributions from point sources in Ellis County (1.2 ppb increase) and Kaufman County (0.4 ppb increase). The contributions of on-road and area plus off-road sources from the surrounding 11 counties decreased from 1999 to 2007.

- The contribution to high 8-hour ozone in the DFW 4-county area from Northeast Texas was 3.5 ppb in 1999 and 2.4 ppb in 2007. The 1.1 ppb decrease was due to decreased contributions from point, on-road and area plus off-road sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from Central Texas was 3.1 ppb in 1999 and 2.4 ppb in 2007. The 0.7 ppb decrease was due to decreased contributions from on-road, point and area plus off-road sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from HGBPA was 1.4 ppb in 1999 and 0.9 ppb in 2007. The 0.5 ppb decrease was due to decreased contributions from on-road, point and area plus off-road sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from South Texas was 0.9 ppb in 1999 and 0.7 ppb in 2007.

- The contribution to high 8-hour ozone in the DFW 4-county area from West Texas was 0.2 ppb in 1999 and 0.1 ppb in 2007.

- The contribution to high 8-hour ozone in the DFW 4-county area from Louisiana was 4.2 ppb in 1999 and 3.8 ppb in 2007. The Louisiana contributions were mainly from area plus off-road and point sources ahead of mobile sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from Arkansas was 1.9 ppb in 1999 and 1.7 ppb in 2007. The Arkansas contributions were mainly from area plus off-road and point sources ahead of mobile sources.

- The contribution to high 8-hour ozone in the DFW 4-county area from Oklahoma was 0.6 ppb in 1999 and 0.4 ppb in 2007.

- The contribution to high 8-hour ozone in the DFW 4-county area from other states (i.e., outside of Texas, Louisiana, Arkansas and Oklahoma) was 3.8 ppb in 1999 and 3.4 ppb in 2007.

- The contribution of model boundary conditions to high 8-hour ozone in the DFW 4-county area was about 32 ppb in both 2007 and 1999. This is consistent the value of 40 ppb used for the ozone boundary condition and shows that control strategy development will not be overly influenced by boundary conditions.

- The contribution of model initial conditions to high 8-hour ozone in the DFW 4-county area (after two spin-up days) was less than 1 ppb in both 2007 and 1999 which shows that control strategy development will not be influenced by the initial conditions.