

CHAPTER 3 : PHOTOCHEMICAL MODELING

3.1 INTRODUCTION

This chapter describes the photochemical modeling conducted to demonstrate attainment of the 8-hour ozone standard in the BPA nonattainment area. Modeling of 1-hour ozone concentrations is also provided. The 1-hour modeling also provides background information that may be useful to the scientific community and other stakeholders. Modeling was conducted for two episodes, August 12 - 13, 2000 and August 19 - September 6, 2000. The latter episode occurred during the 2000 Texas Air Quality Study (TexAQS 2000) study, and included a robust collection of meteorological, aerometric, and emissions data. The former episode occurred just prior to the start of the study. This BPA modeling demonstration will include the effects of specific point source NO_x rules that were adopted in 1999, (TCEQ Chapter 117 rules) that will be implemented in the BPA area, as well as the effects of other local, regional, and national controls.

3.2 THE 2000 TEXAQS FIELD STUDY

From August 15 to September 15, 2000, approximately 250 investigators from more than 35 organizations joined the commission in the 2000 Texas Air Quality Study (TexAQS 2000) to carry out research to improve technical understanding of the factors affecting ozone and fine particle concentrations in the eastern half of Texas. TexAQS 2000 was based in Houston, and its work concentrated on the Houston region. TexAQS 2000 collected extensive data useful for supporting photochemical modeling of episodes that occurred during the study period.

3.2.1 Data Collection

The major components of the TexAQS 2000 were the following:

- Six research aircraft, four of which were based in Houston and performed multiple missions:
 1. The National Oceanic and Atmospheric Administration (NOAA) used a Lockheed Electra as a platform to collect regional chemistry and meteorological measurements to help define regional emissions, chemistry, and transport.
 2. The Department of Energy provided a Grumman Gulfstream 1 with instrumentation similar to the Electra's to measure both regional and local emission, chemistry, and transport.
 3. Baylor University operated a Twin Otter for the commission, carrying advanced air quality monitoring instruments similar to those at a Level 2 ground station along with canisters for sampling volatile organic compounds. The Twin Otter's ability to fly slowly made it well-suited to studying urban and industrial plumes.
 4. NOAA's Environmental Technology Laboratory provided a DC-3 aircraft to measure ozone and fine particles with a downward-looking LIDAR system well-suited to measuring the formation and movement of pollution plumes and to studying the effects of coastal meteorology, including the bay breeze.
 5. NASA provided two aircraft for use in thermal mapping to help define and evaluate urban and industrial heat-island effects.

- Additional meteorological monitoring to provide data to help describe and understand how wind flows are influenced by bay breezes, sea breezes, and urban and industrial heat islands:
 1. Six radar profilers to measure winds and virtual temperature aloft.
 2. Two advanced acoustic sounders for the same purpose.
 3. Three weather balloon launch sites to measure the temperature and moisture structure of the atmosphere, one of which also had geographic positioning system capability to measure winds aloft as well as the structure of the atmosphere.

- A Doppler LIDAR to aid in analysis of the interaction of the bay breeze and the Ship Channel area.

- To the approximately 50 routine, ground-based continuous ozone monitoring sites across the eastern half of Texas and neighboring states, the study added the following:
 1. Three Level 2 chemistry monitoring stations to provide detailed, high-sensitivity atmospheric chemistry information on ozone, sulfur dioxide, carbon monoxide, NO, and NO₂.
 2. A principal atmospheric chemistry and physics research site at La Porte Airport at which many researchers from universities and national laboratories operated state-of-the-science instruments to investigate atmospheric processes and measure pollutant concentrations.
 3. A smaller advanced research site high on the Williams Tower, about 850 feet above ground level.

- An hour-by-hour inventory of emissions from the HGB and BPA industrial areas reporting a much more detailed record of emissions than is normally required.

3.3 MODELING EPISODE SELECTION

Experience from previous modeling studies for both BPA and HGB indicated that there were substantial advantages in using episodes that occurred during intensive field studies. Enhanced monitoring and emissions inventory data, enabling a better analysis of model base case performance, and more confidence can be placed on ozone precursor controls based on the modeling are benefits of selecting an episode during an intensive field study. Consequently, previous modeling studies for the upper Texas Gulf Coast focused on the 1993 Coastal Oxidant Assessment for Southeast Texas (COAST) study. The TCEQ is currently modeling a set of high ozone days that occurred during TexAQS 2000.

EPA, in its *Guideline for Regulatory Application of the Urban Airshed Model*, establishes an approach to episode selection that includes identifying meteorological regimes associated with recent high ozone events and ranking them according to the magnitude of the observed ozone. For the 1-hour standard, EPA generally recommends that candidate episodes have monitored ozone greater than 0.12 ppm. Similarly, 8-hour candidate episodes should include monitored ozone values greater than 0.08 ppm. The *Guideline* also acknowledges that data quality and availability are extremely important considerations in episode selection. Previously, the robust, quality-assured COAST data aided the development of reliable wind fields, initial conditions, and boundary conditions. It also provided a large data set of ozone and ozone precursor measurements for evaluating model performance later in the modeling process. The

TexAQS 2000 study provides the same types of data and more. Discussions with EPA Region 6 led to an agreement that TCEQ would focus on more recent episodes.

Episode selection was made by a team of meteorologists who are familiar with the local and regional meteorological patterns occurring along the Texas Gulf Coast. Episode selection criteria were based on both 1-hour and 8-hour considerations, as follows:

- Episodes that occurred during the TexAQS 2000 study, with its robust data sets.
- Episodes with 1-hour ozone greater than 0.12 ppm.
- BPA episodes that occurred during other (HGB) modeled episodes (potential for transport analyses and conservation of modeling staff resources).
- Episodes that are described by the BPA conceptual model.
- Episodes with relatively high monitored 8-hour ozone (greater than 0.08 ppm).
- Episodes with meteorological regimes (wind flow patterns) representative of high ozone events.
- Closeness of monitored exceedances to 1-hour and 8-hour design values.

3.3.1 HGB Considerations

Due to the large amount of aerometric data collected during TexAQS 2000, episode selection for BPA included consideration of HGB ozone occurrences so that selected episodes would be useful to both nonattainment areas. Since hourly emissions data, as well as ozone and ozone precursor measurements, were collected for both BPA and HGB, it was important to select TexAQS 2000 episode days so that reliable emissions estimates could be generated. Ozone predicted using these estimates could be favorably compared to performance evaluation statistics over the entire modeling domain.

An additional consideration in BPA episode selection is the role of transported ozone and ozone precursors from the HGB area. During TexAQS 2000, there were episode-days for which there was ample evidence of transported pollutants from HGB. There will be further discussion of transport in subsequent sections of this document.

3.3.2 Beaumont-Port Arthur Conceptual Model

An important component for episode selection is the development of an area-specific conceptual model. Conceptual models are descriptions of the meteorological conditions, air quality values, and emissions data that describe high ozone events for a particular area of interest. The BPA conceptual model is found in a report generated by the University of Texas at Austin and ENVIRON International, *Conceptual Model of Ozone Formation in the Beaumont/Port Arthur Ozone Non-Attainment Area* (October 31, 2002). The BPA conceptual model report and BPA modeling protocol for this SIP are Appendices A and B.

Follow-up analyses by the commission for the BPA conceptual model also includes:

- Flow patterns (source-receptor relationships) for all 8-hour exceedance days from 1998-2002. A complete description of these analyses is Attachment 2 to the conceptual model. A list of all 8-hour exceedance days for 1998-2002 in BPA is shown in Table 3-1. Days considered for modeling are denoted as bold, underlined values.
- Design value trends. The results show that ozone 1-hour design values have been declining, but

ozone 8-hour design values have remained constant or increased.

- VOC canister reactivity - to answer questions of which compounds are most important in the formation of ozone in the BPA area and whether or not the contribution of certain compound groups to total reactivity has increased or diminished over the last five years.
- Analysis of some Baylor aircraft data.

This additional conceptual model analyses is provided in Appendix A.

Table 3-1: 8-hour episode days in BPA, 1998-2002

Episode Type	Date	Maximum 8-hr Ozone Concentration (ppb)
Transport from Houston	8/20/99	89
	10/22/99	92
	<u>8/30/00</u>	88
	<u>8/31/00</u>	105
	<u>9/01/00</u>	96
	<u>9/02/00</u>	86
	5/23/01	85
	8/05/01	104
	7/12/02	116
	9/14/02	121
Transport from Houston + Beaumont (local)	<u>8/21/00</u>	96
	7/24/02	87
Local - Beaumont Area Only	5/18/98	90
	5/19/98	92
	7/18/98	96
	8/05/98	86
	8/27/98	87

Episode Type	Date	Maximum 8-hr Ozone Concentration (ppb)
	8/28/98	93
	8/29/98	87
	8/30/98	99
	9/03/98	94
	9/04/98	97
	8/03/99	94
	8/06/99	91
	8/07/99	87
	8/28/99	112
	9/19/99	100
	2/14/00	86
	5/22/00	88
	7/24/00	90
	7/25/00	94
	7/26/00	90
	<u>8/12/00</u>	99
	<u>8/19/00</u>	92
	<u>9/04/00</u>	97
	8/04/01	102
	9/15/01	90
	6/15/02	92
	8/05/02	92
	9/12/02	95
	9/13/02	92
Beaumont (local) + Transport from Lake Charles Area	9/16/99	89
	9/18/99	101

Episode Type	Date	Maximum 8-hr Ozone Concentration (ppb)
	10/14/99	88
	8/13/00	89
	9/06/00	85
	9/18/00	85
	6/24/01	85
	9/11/02	95
Transport from Lake Charles Area	6/07/00	88
Maritime flow (long range, across the Gulf of Mexico)	10/01/98	98
	8/06/01	100
	8/23/01	87
	5/21/01	85
	5/22/01	91

3.3.3 1-hour TexAQS 2000 Candidate Episodes

Because the commission decided to select high ozone days from among those occurring during TexAQS 2000, the list of available candidate days is narrowed down considerably. Table 3-1a lists the BPA area's 1-hour exceedances that occurred during TexAQS 2000.

Table 3-1a: BPA 1-Hour Ozone Episode Days Occurring During TexAQS 2000

Date	1-hour Ozone Max (ppb)	Monitor Location	Number of hours over 124 ppb
August 30	134	CAMS2 (Beaumont)	1
August 30	133	CAMS9 (West Orange)	1
August 30	165	CAMS28 (Port Arthur West)	2
August 30	131	CAMS64 (Hamshire)	1
August 30	162	CAMS640 (Sabine Pass)	4
August 30	143	CAMS643 (Jefferson County Airport)	2

Date	1-hour Ozone Max (ppb)	Monitor Location	Number of hours over 124 ppb
August 31	152	CAMS640 (Sabine Pass)	2
September 1	160	CAMS28 (Port Arthur West)	2
September 1	144	CAMS64 (Hamshire)	2
September 1	145	CAMS643 (Jefferson County Airport)	2

August 30 - September 1, 2000 is a rare multi-day episode for the BPA area. This time period coincided with a high ozone event in the HGB area as well. In addition, this period is already being modeled by the commission for the HGB Mid Course Review Phase II SIP, meaning fewer resources would be needed to develop this episode for the BPA analysis. Analysis of back trajectories indicated that BPA was being affected by transport of ozone and ozone precursors from HGB on all three days.

A search of other BPA exceedance days found that another 1-hour exceedance day occurred on August 12, 2000, just prior to the start of TexAQS 2000. On this day, a 126 ppb maximum was recorded at CAMS28 (Port Arthur West). The commission's plume sequences indicated that the wind flow on this day had air parcels being moved south, over the BPA area, out into the Gulf briefly, and then returned back in with the sea breeze. The 126 ppb exceedance occurred at 1800 LST at Port Arthur West (CAMS28). The exceedance does not appear to have any influence from the HGB area and is considered a locally-generated exceedance. Another advantage for using this day is that, even though it does not actually occur during TexAQS 2000, inventories developed for the study period can be easily ported to August 12.

3.3.4 8-hour Considerations

Table 3-2 lists the high 8-hour ozone values for the August 12 and August 30 - September 1, 2000 1-hour episode days. The table also shows 8-hour exceedances for the "extended" TexAQS 2000 episode (August 19- 21 and September 2- 6, 2000). Since August 13, 2000 also had 8-hour exceedances, it is included as well.

Table 3-2: 8-hour Ozone Exceedances in BPA

Date	8-hour Ozone Max (ppb)	Monitor Location
August 12	99	CAMS28 (Port Arthur West)
August 12	85	CAMS64 (Hamshire)
August 12	88	CAMS640 (Sabine Pass)
August 13	85	CAMS2 (Beaumont)
August 13	89	CAMS64 (Hamshire)
August 19	85	CAMS2 (Beaumont)

Date	8-hour Ozone Max (ppb)	Monitor Location
August 19	92	CAM9 (West Orange)
August 21	96	CAMS2 (Beaumont)
August 30	88	CAMS2 (Beaumont)
August 30	94	CAMS9 (West Orange)
August 30	115	CAMS28 (Port Arthur West)
August 30	115	CAMS640 (Sabine Pass)
August 30	95	CAMS643 (Jefferson County Airport)
August 31	105	CAMS28 (Port Arthur West)
August 31	85	CAMS64 (Hamshire)
August 31	104	CAMS640 (Sabine Pass)
September 1	87	CAMS9 (West Orange)
September 1	96	CAMS28 (Port Arthur West)
September 1	91	CAMS64 (Hamshire)
September 1	90	CAMS643 (Jefferson County Airport)
September 2	86	CAMS28 (Port Arthur West)
September 4	97	CAMS28 (Port Arthur West)
September 4	97	CAMS640 (Sabine Pass)
September 6	85	CAMS28 (Port Arthur West)

3.3.5 Design Values

A final component used to evaluate the representativeness of an ozone episode day is the comparison of the day's highest monitored ozone to station-specific and area-wide design values. The 1-hour ozone design value is the highest 4th high 1-hour ozone concentration in an area, over a 3 consecutive year period. The 8-hour design value is defined as the highest 3-year average of each station's 4th-highest 8-hour ozone concentrations (for each of the three years). That is, for each station and each year, a fourth-highest ozone concentration is reported and a three year average for each station is computed. The highest of these averages is the area-wide 8-hour design value. Table 3-3 lists each BPA station's 1-hour and 8-hour design values for 1998 - 2000, with area-wide design values underlined.

Table 3-3: 1-hour and 8-hour BPA Area Design Values 1998 - 2000**

Station	1-hour design value (ppb)	8-hour design value (ppb)
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CAMS2 (Beaumont)	129	86
CAMS9 (West Orange)	120	75
CAMS28 (Port Arthur West)	118	87
CAMS640 (Sabine Pass)	<u>145</u>	<u>95</u>
CAMS642 (Mauriceville)	116	86
CAMS643 (Jefferson County Airport)	137	92

** Hamshire (CAMS64) is not included here because 2000 was the first year this station was in operation.

For 1-hour design values, and using ± 10 ppb as a criteria for a “close” or “preferred” exceedance day, the following combinations of days and site are preferred:

August 12 - 126 ppb at CAMS28 (DV=118)
 August 30 - 134 ppb at CAMS2 (129)
 August 30 - 143 ppb at CAMS643 (137)
 August 31 - 152 ppb at CAMS 640 (145)
 September 1 - 145 ppb at CAMS643 (137)

For the 8-hour design values, and using ± 5 ppb as the criteria for “close” or “preferred”, the following days/sites are considered exceedances that are “preferred”:

August 13 - 85 ppb at CAMS2 (DV=86)
 August 19 - 85 ppb at CAMS2 (86)
 August 30 - 88 ppb at CAMS2 (86)
 August 30 - 95 ppb at CAMS643 (92)
 September 1 - 90 ppb at CAMS643 (92)
 September 2 - 86 ppb at CAMS28 (87)
 September 4 - 97 ppb at CAMS640 (95)
 September 6 - 85 ppb at CAMS28 (87)

If the 8-hour “preferred” definition is relaxed to ± 10 ppb, additional days/sites would include:

August 12 - 88 ppb at CAMS640 (DV=95)
 August 21 - 96 ppb at CAMS2 (85)
 August 31 - 104 ppb at CAMS640 (95)
 September 1 - 96 at CAMS28 (87)
 September 4 - 97 ppb at CAMS28 (87)

Therefore, there are a substantial number of exceedances that are close to individual station’s 1-hour and/or 8-hour design values. For the period August 12 - 13 and August 19 - September 6, 2000, there are 5 “preferred” 1-hour exceedances found in the 4 1-hour exceedance days and 13 “preferred” 8-hour exceedances in the 10 exceedance days.

3.3.6 Episode Selection Summary

Candidate episode days were evaluated for magnitude of ozone concentration, the number of monitors recording exceedances, the number of hours of exceedance, and closeness to the station's design values. The availability of supplementary aircraft, canister, and continuous gas chromatograph data was also considered. Based on the fact that the August 19 - September 6, 2000 episode was: (1) a multiday episode; (2) already being modeled for HGB; (3) part of an intensive field campaign; (4) contains days when 1-hour and 8-hour exceedances are close to station design values; and (5) fit in with the BPA conceptual model (including episode days showing transport from HGB), it was chosen as one of the BPA episodes.

The August 12 - 13, 2000 episode was also selected for photochemical modeling because (1) it is temporally close to the start of TexAQS 2000 and the August 19 - September 6, 2000 episode, meaning the emissions inventory data already prepared for the TexAQS 2000 episode days were easily adjusted for use in the August 12 - 13, 2000 episode; (2) the 1-hour and 8-hour exceedances measured on the 12th and 13th are close to station design values; (3) the meteorology characterizing this episode fits within the BPA conceptual model; and (4) TCEQ plume sequences indicate no influence from the HGB area, such that this is a clearly representative local episode.

3.4 MODEL PARAMETERIZATION

3.4.1 Modeling Domain and Horizontal Grid Cell Size

Figure 3.4-1 shows the grid configuration for the BPA modeling. The CAMx modeling domain consisted of a 4 km × 4 km grid encompassing the HGB and BPA ozone nonattainment counties (light blue box), nested within a 12 km × 12 km grid covering the eastern part of Texas (green box). The outer 36 km × 36 km grid (blue box) was selected based on analyses using Hy-Split back trajectories, indicating that the domain as shown is sufficiently large to minimize the contributions of boundary conditions on the inner grid for the episode.

All grids are projected in a Lambert Conformal Projection (LCP) with origin at 100° W. and 40° N., and aligned with EPA's National Grid which was developed for nationwide modeling for haze and particulate matter. Choosing a grid system compatible with an existing large-scale grid system serves several functions, including providing ready-made regional inventory data which can be used directly, allowing the commission's modeling to be integrated into regional modeling projects, and promoting consistency among various regional and urban modeling applications in the central United States. Table 3-4 lists the grid dimensions for the CAMx domain and sub-grids.

Table 3-4: CAMx Modeling Domain Definition

Grid Name	Grid Cell Size	Dimensions (grid cells)	Lower left-hand corner ¹	Upper right-hand corner ¹
Coarse Grid	36 × 36 km.	45 × 46	(-108, -1584)	(1512, 72)
Intermediate Grid	12 × 12 km.	89 × 89	(-12, -1488)	(1056, -420)
Fine Grid	4 × 4 km.	83 × 65	(356, -1228)	(688, -968)

¹Grid corners are in kilometers (easting, northing) relative to grid origin at 100° W. and 40°N.



Figure 3.4-1: CAMx Modeling Domains, Grids Selected for Use in BPA Modeling Analysis

TCEQ has engaged in discussions with several stakeholders regarding the employment of grid scales finer than 4 km. The TCEQ has used the 4-km modeling to represent the ozone phenomena for which the model was designed and parameterized. Significant concerns have been raised by the academic community that while the CAMx model will “work” at a 1-km grid-scale, it has never been evaluated for correct performance at this scale, and the uncertainties associated with these concerns may undermine the credibility of the model runs upon which the control strategy was based. One of the parameters within CAMx which is suspect is horizontal diffusivity; i.e., it is uncertain whether the horizontal diffusion of emissions is replicated correctly. Another concern is that the assumptions within CAMx that apply to the hydrostatic equilibrium of horizontal and vertical transport may begin to break down at a finer grid resolution. Similarly, the vertical diffusive treatment of transport (otherwise referred to as the Kv’s) and vertical layer structure may not be consistent with 1- km horizontal scale.

However, prominent members of the academic community have stated that these uncertainties become relatively less important when evaluating short term releases. These same researchers have stated that high-resolution modeling is necessary to simulate the transient ozone events associated with highly localized short-term releases, since these phenomena are capable of causing concentration gradients much steeper than would normally occur from routine emissions. Since the photochemistry is driven by precursor concentrations within the individual grid cells, using superfine grids allows the model to more faithfully replicate chemical reactions which occur over small spatial and temporal scales. In these circumstances, the chemistry is believed to dominate the physical components of the Eulerian continuity equation. Therefore, superfine grid modeling is appropriate to evaluate discreet short term releases because the photochemistry effects associated with large emission events are so large that the uncertainties introduced through of a superfine grid are dwarfed in comparison. As the emission gradients are lessened; i.e., as the magnitude of the emission events is reduced, the residual uncertainties become relatively much more important and use of superfine grids is much less justifiable. Therefore, application of the superfine resolution may be more useful in Houston, where short term releases drive the extreme ozone events, but the effect is significantly lessened by the time HGB emissions reach BPA. Similarly, BPA does not seem to have the same type of high ozone events as seen in HGB, meaning that the aforementioned high ozone events, are neither observed nor need to be simulated. Continued evaluation and peer review of these uncertainties is necessary before the model can routinely be applied at a finer resolution to replicate all conditions of ozone formation.

3.4.2 Number of Vertical Layers

The number of vertical layers is a compromise between including enough detail to accurately characterize the vertical layering of the atmosphere and managing the amount of time required to run the model. The commission’s Silicon Graphics modeling computer makes it feasible to employ many more vertical layers than have been used in past modeling exercises. Ideally, CAMx would be run with the same vertical layering as MM5; but since the latter uses sigma coordinates while CAMx uses standard height-above-ground-level, it is not possible to match the layers exactly.

The unique meteorology induced by the land/sea/bay effects and the unique mixture of industrial sources, which release pollutants across a wide range of elevations, indicate the need for many vertical layers, particularly near ground level.

For this modeling, the modeling staff designed a new 24-layer vertical structure in which the first 21 layers correspond with their MM5 counterparts. Three additional layers each correspond with two MM5

layers. This 24-layer structure is used within the 4 × 4 km grid only. A new 15-layer vertical structure is being used in the intermediate and coarse grids. Tables 3-5 and 3-6 below show the new vertical layer structure for the fine and coarse grids respectively. Note that the new structure extends to a height of 5836 meters above ground level (AGL). The taller grid system helps to further insulate ground-level ozone concentrations from the top boundary conditions.

Table 3-5: CAMx Vertical Layer Structure for Fine Grid

CAMx Layer	MM5 Layers	Top (m AGL)	Center (m AGL)	Thickness (m)
24	26, 27	5835.9	5367.0	937.0
23	24, 25	4898.0	4502.2	791.6
22	22, 23	4106.4	3739.9	733.0
21	21	3373.5	3199.9	347.2
20	20	3026.3	2858.3	335.9
19	19	2690.4	2528.3	324.3
18	18	2366.1	2234.7	262.8
17	17	2103.3	1975.2	256.2
16	16	1847.2	1722.2	256.3
15	15	1597.3	1475.3	249.9
14	14	1353.4	1281.6	243.9
13	13	1209.8	1139.0	143.6
12	12	1068.2	998.3	141.6
11	11	928.5	859.5	137.8
10	10	790.6	745.2	90.9
9	9	699.7	654.7	90.1
8	8	609.5	564.9	89.3
7	7	520.2	476.0	88.5
6	6	431.7	387.8	87.8
5	5	343.9	300.4	87.0
4	4	256.9	213.7	86.3
3	3	170.5	127.7	85.6
2	2	84.9	59.4	51.0
1	1	33.9	16.9	33.9

Note: AGL - Above ground level.

Table 3-6: CAMx Vertical Layer Structure for Intermediate & Coarse Grids

CAMx Layer	MM5 Layers	Top (m AGL)	Center (m AGL)	Thickness (m)
15	24, 25, 26, 27	5835.9	4970.9	1730.0
14	21, 22, 23	4105.9	3565.9	1080.0
13	18, 19, 20	3025.9	2564.5	922.9
12	15, 16, 17	2103.0	1728.1	749.8
11	13, 14	1353.2	1210.6	285.2
10	11, 12	1068.2	929.3	277.5
9	9, 10	790.6	700.0	181.0
8	8	609.5	564.9	89.3
7	7	520.2	476.0	88.5
6	6	431.7	387.8	87.8
5	5	343.9	300.4	87.0
4	4	256.9	213.7	86.3
3	3	170.5	127.7	85.6
2	2	84.9	59.4	51.0
1	1	33.9	16.9	33.9

Note: AGL - Above ground level.

3.4.3 Initial and Boundary Conditions

The modeling domain was selected to be sufficiently large to help minimize model sensitivity to boundary conditions. In addition, the commission began the modeling three days prior to the first primary day of the episode to minimize the sensitivity to initial conditions. Although default initial and boundary condition concentrations have typically been used in CAMx modeling, recent modeling analyses conducted for the Dallas/Fort Worth and Tyler/Longview areas by ENVIRON showed an unexpectedly large sensitivity of ozone concentrations in that region to the lateral boundary conditions. ENVIRON consequently investigated the use of alternative boundary condition concentrations originally developed for an earlier regional modeling application. In the alternative boundary conditions, the default concentrations of some ozone precursors were replaced by values derived from other regional modeling applications (Ozone Transport Assessment Group, Minerals Management Service) and from measurements made at Kinterbish, Alabama, which is located near the eastern boundary of the modeling domain. After running a number of sensitivity analyses, ENVIRON adopted these alternative boundary conditions into the DFW modeling. We have adopted the DFW boundary conditions for use in both the BPA and the HGB MCR Phase II analyses because we believe these alternative boundary conditions better represent typical rural pollutant concentrations than EPA’s default “clean” boundary conditions, and to maintain consistency among modeling applications in Texas. Sensitivity analyses have shown some improvement in HGB model performance using these somewhat higher concentrations, but the sensitivity to boundary conditions in the HGB region appears to be considerably less than that seen in the DFW or Tyler/Longview modeling.

As discussed in the DFW modeling final report (available at ftp://ftp.tceq.state.tx.us/pub/OEPAA/TAD/Modeling/DFWAQSE/Modeling/Doc/DFW_1999_Basecase_Final_Report_20030831.pdf), the outer edge of the 36 km coarse grid was divided into three sections as shown in Figure 3.4-2 below (note that the Dallas/Fort Worth coarse grid is identical to the one we are

using for the HGB and BPA areas). Boundary conditions for each of these segments were set to the values listed in Table 3-7. Initial concentrations were set equal to the values in the last column of the

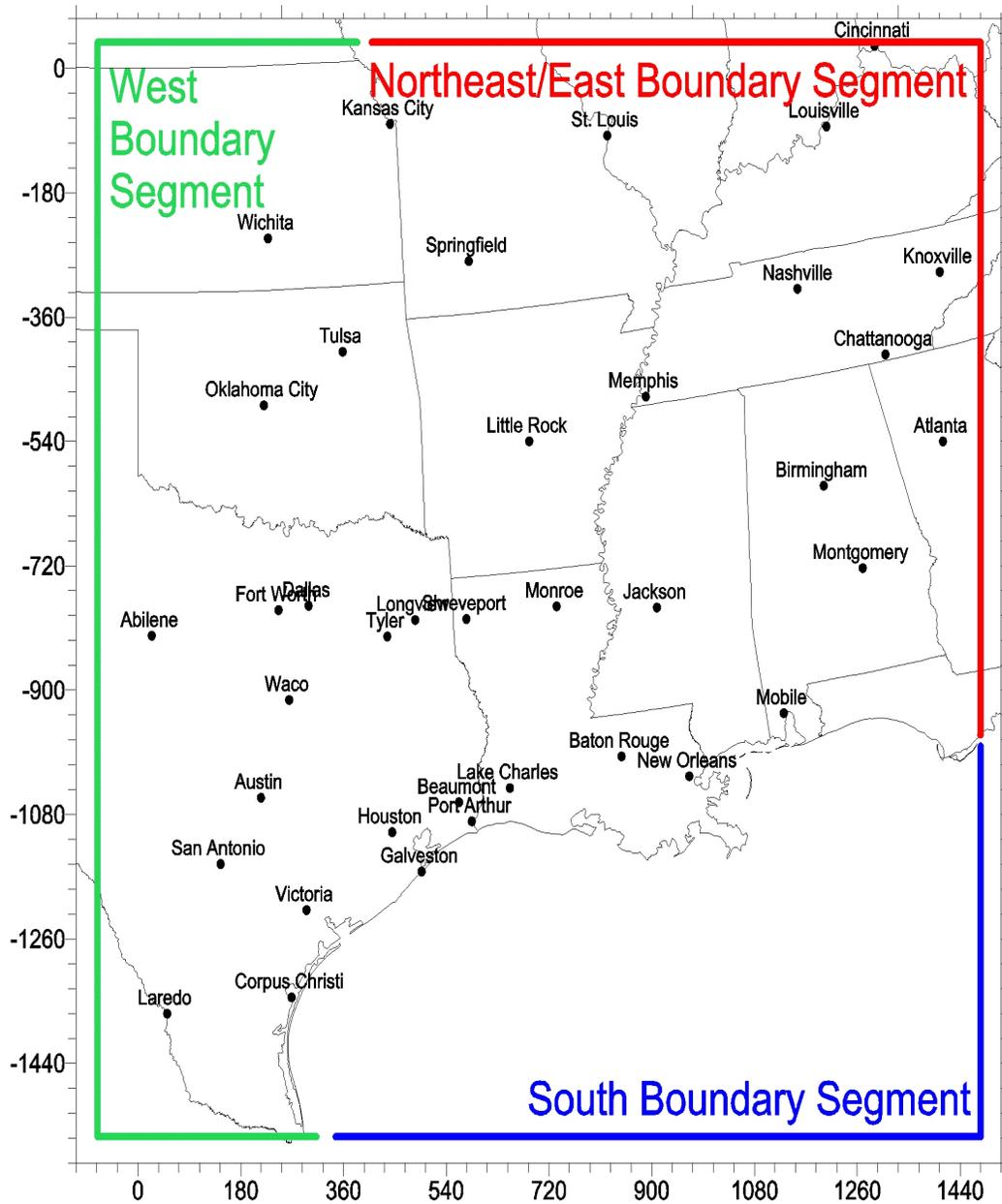


table.

Figure 3.4-2: Boundary Condition Segments Used to Define Lateral Boundary Conditions

Table 3-7: Boundary Conditions

Species	East/Northeastern Boundary Below 1700 m (ppb)	Western Boundary Below 1700 m (ppb)	Southern Boundary and Above 1700 m (ppb)
O3	40.0	40.0	40.0
NO	0.1	0.1	0.1
NO2	1.0	1.0	1.0
CO	200.0	200.0	100.0
PAR	14.9	14.9	14.9
HCHO	2.1	2.1	0.05
ETH	0.51	0.51	0.15
ALD2	0.555	0.555	0.05
TOL	0.18	0.18	0.0786
PAN	0.1	0.1	0.1
HNO2	0.001	0.001	0.001
HNO3	3.0	3.0	1.0
H2O2	3.0	3.0	1.0
OLE	0.3	0.3	0.056
XYL	0.0975	0.0975	0.0688
ISOP	3.6	0.1	0.001
MEOH	8.5	0.001	0.001
ETOH	1.1	0.001	0.001
Total NO_x	1.1	1.1	1.1
Total VOC (ppbC)	50.5	22.3	9.3

3.4.4 Plume-in-Grid Modeling

CAMx has an option to model selected point sources with a Plume-in-Grid (PiG) algorithm. PiG allows a model to simulate plume behavior of elevated point sources within one or more grid cells. That is, the PiG algorithm does not immediately dump a “PiGged” source’s emissions into the entire cell at once, but rather keeps the plume cohesive until it is no longer of a sub-grid scale size. With today's computer resources, combined with the efficient PiG algorithm built into CAMx, PiG selection does not have to be as carefully limited as it was historically. Modeling staff selected PiG sources based on magnitude of NO_x emissions (5 tons/day with a co-location distance of 1 meter). As with Phase 1 of the MCR, over 300 PiG sources across the entire modeling domain, mostly large power plants, were selected.

3.5 METEOROLOGICAL MODELING

3.5.1 Overview

As mentioned in previous sections, there are two basic types of BPA ozone events: those which are locally generated, and those which involve significant transport of ozone and precursors from other areas. In order to properly represent both types of events in the attainment demonstration, two different episode periods were identified and modeled. Periods of transport occurred during TexAQS 2000 study period. The local episode period of interest occurred before the TexAQS intensive period.

In subsequent discussions, for the purposes of meteorological modeling, we will refer to the period August 12 and 13 as the “local” episode. The period August 23 to September 6, 2000 will be referred to as the “extended TexAQS 2000 episode.” We refer to a period of transport (August 30 through September 1), which occurred during the TexAQS 2000 episode, as an “embedded BPA episode”. Although the physics options were the same in each of the periods, several different contractors worked on each of the episode segments to evaluate various different techniques to improve model performance. The Beaumont episode periods are summarized below.

BPA Episodes

<u>Dates</u>	<u>Episode Type</u>	<u>Name</u>	<u>Surface Parameters</u>
August 12-13, 2000	Local	Local	MM5 Default Surface Parameters
Aug 30-Sept 1, 2000	Transport	Embedded	GOES Satellite Data
September 2-6, 2000	Transport	Part of Extended	NOAH Land Surface Model

All of the BPA episodes were modeled using the same modeling grids, vertical layers, and physics options and in those respects were identical to the HGB modeling conducted for the 2000 episodes. The MM5 modeling domain used for these episodes is identical to the domain used for the December 2002 HGB SIP revisions (TCEQ, 2002). As described in the BPA modeling protocol, the nesting structure for MM5 modeling placed both HGB and BPA in a single four kilometer domain. The MM5 modeling configuration was consistent with what was used for the HGB modeling for the period between August 25 and September 6. The physics options for all the episodes are noted in Table 3-8 below, and details of each episode follow.

Table 3-8: MM5 Physics Options

MM5 Parameterization	Option Selected
Radiation	Rapid Radiative Transfer Model (RRTM)
Cumulus Parameterization	Grell (grids 1-3)
Explicit Moisture Physics	Simple ice

Planetary Boundary Layer (PBL)	Medium Range Forecast (MRF)
Nesting	Two-way
Nudging	Analysis nudging above Planetary Boundary Layer (PBL)

3.5.2 August 12-13, 2000 Episode (Local)

Unlike the well instrumented TexAQS 2000 study period which focused upon the HGB area, this episode did not have extra meteorological data from local rawinsonde launches or from radar profilers which could be used to evaluate predicted features such as the planetary boundary layer (PBL) or local winds aloft. However, the complications for meteorological modeling associated with some of the highest temperatures on record as well as dry conditions which were noted later in August were less prominent for August 12 and 13. Therefore, use of the default land use dependent parameters such as available soil moisture should be appropriate.

MM5's ability to replicate the meteorological fields was evaluated using a software package called METSTAT. Modeling statistics from METSTAT indicate reasonable performance. In this case, "typical" was defined by ENVIRON during a survey of meteorological modeling studies which was part of their development for the METSTAT program described here. The METSTAT plots for temperature and wind speed bias are shown in Figures 3-3 and 3-4.

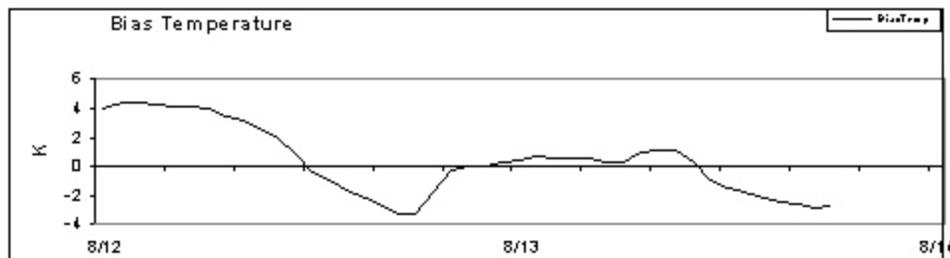


Figure 3-3: METSTAT Plots for Temperature Bias

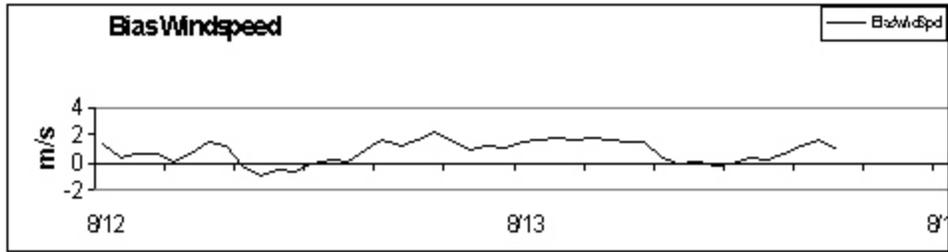


Figure 3-4: METSTAT Plots for Wind Speed Bias

These two figures represent statistics calculated over eleven sites extending between BPA and Louisiana. When the sites in the HGB area are included, the bias for temperature and wind speed are reduced further. A full set of METSTAT figures are available in this document's Appendix C.

One sensitivity study was performed to investigate the impact of observational nudging to three profilers in the HGB area which were coming on line in preparation for the TexAQS 2000 field study. The impact of the profiler data was not significant in the BPA area. Similar conclusions were reached by Dr. Craig Tremback of Atmospheric, Meteorological, and Environmental Technologies (ATMET) who conducted MM5 modeling across the August 30 - September 1 time frame.

3.5.3 August 30 - September 1, 2000 Episode (Transport)

The transport episode of August 31 - September 1, 2000 was part of previous modeling conducted by Dr. Nielsen-Gammon (Texas A&M University and State Climatology) described in a series of reports to the TCEQ. A summary of documents attached as appendices to the 2002 HGB SIP revisions is presented below. At the same time, the commission was supporting an alternative development of MM5 being conducted by scientists at the University of Alabama Huntsville (UAH) and NASA Marshall Space Flight Center (MSFC) to assimilate Geosynchronous Operational Environmental Satellites (GOES) data. This version of MM5 has certain advantages which are described in the following sections, but the GOES data processed by MSFC for this version of MM5 were only available on the August 25 - September 1 episode days. TCEQ modeling staff selected this version of MM5 to provide the input meteorology for the CAMx modeling for August 30 - September 1, 2000.

The following reports provide a summary of the work provided by Dr. Nielsen-Gammon during the project period extending from August 31, 2001 through February 28, 2002 and were attached as appendices to the 2002 HGB SIP revisions. The MM5 modeling was confined to the core TexAQS 2000 episode of August 25 through September 1, 2002. Each of these reports is available from the Texas

A&M University website <http://www.met.tamu.edu/results> or from the TCEQ website http://www.tnrcc.state.tx.us/air/aqp/airquality_contracts.html#section3. The first report is titled *Initial Modeling of the August 2000 HGB Ozone Episode*, December 2001 (Nielsen-Gammon 2001). This document introduces the episode and has an initial discussion of the daily variations that need to be modeled correctly. Also included is the basic MM5 configuration and a preliminary assessment of how the model results are dependent on the model configuration. TexAQS 2000 data did not begin to become available until after the MM5 modeling in the first report. The second report is the *Evaluation and Comparison of Preliminary Meteorological Modeling for the August 2000 HGB Ozone Episode*, February 5, 2002 (Nielsen-Gammon 2002a). This document summarizes the status of special study data that was utilized in the intermediate series of model runs. Along with this data review, a further discussion of daily weather variations was included so that features which were part of model performance evaluation could be introduced. The last part of this report evaluated the location of precipitation, temperature biases, development of the planetary boundary layer (PBL), and winds with modeling performed to date. The final report in this series was *Meteorological Modeling for the August 2000 HGB Ozone Episode: PBL Characteristics, Nudging Procedure, and Performance Evaluation*, February 28, 2002 (Nielsen-Gammon 2001b). This document described in detail the ability of the MM5 model to capture those physical features which Dr. Nielsen-Gammon considered most relevant to the core TexAQS 2000 episode, and provided justification for the final configuration of MM5 used for the 2002 HGB SIP revision.

3.5.3.1 Description of GOES-MM5 Configurations

Dr. Nielsen-Gammon continued the evaluation of another version of MM5 using the data from GOES system. The purpose of this work was to investigate whether MM5, as configured by Nielsen-Gammon 2002b, could be improved by satellite data and predict the PBL with greater accuracy. This work is also distinguished by its attempts to validate the model output against microwave temperature profiler (MTP) which was deployed on NOAA aircraft during the TexAQS 2000. A preliminary report describing the preparation of MTP data for model validation purposes is described in the report *Application of Microwave Temperature Profiler (MTP) Data to MM5 Modeling of the August 2000 Houston-Galveston Ozone Episode* (August 30, 2002). This version of MM5 has the same physics options as the other MM5 runs described above and in Table 3-8. This GOES-MM5, however, utilized GOES satellite data to dynamically modify available soil moisture.

The MM5-GOES modeling system was developed by the University of Alabama, Huntsville (UAH) and staff at the Marshall Space Flight Center (MSFC). Previously published work (Carlson et.al 1981) realized that available soil moisture and thermal inertia were the primary sources of uncertainty in the surface energy budget when radiation could be well characterized. UAH staff focused on modifying MM5 to use solar insolation (incoming radiation) as provided by GOES data rather than using calculated solar insolation. A further key assumption is that during the mid-morning hours the primary difference between the surface energy budget calculated internally by MM5 subroutines and the surface energy budget calculated from GOES data is due to uncertainty of latent heat flux. GOES data provides measured surface temperature, and from these data the change of temperature with time (*tendencies*) can be calculated. By taking the difference between temperature tendencies derived from GOES data and from MM5 routines, using the GOES radiation data, and invoking the above assumptions, a correction for available soil moisture can be calculated. This analyses provides an alternative to the other adjustments of soil moisture described by Nielsen-Gammon 2001 or by using the NOAA land surface model. A more detailed discussion of GOES methodology can be found in McNider (1994). Sample METSTAT statistics are provide below in Figures 3.5 and 3.6.

The process of validating the MM5-GOES modeling system is still proceeding. A preliminary report of performance is titled *Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode: Mixing Depths in the GOES Skin Temperature Assimilation* August 30, 2003 (Nielsen-Gammon 2003). The conclusions available to date include:

- Comparison of GOES versus non-GOES MM5 runs, when evaluated against surface temperatures and rawinsonde data indicate that the GOES MM5 performs better during the morning hours, and not as well as the non-GOES during the afternoon hours. This performance is expected since the non-GOES MM5 had soil moisture adjusted by afternoon sounding data, and the GOES MM5 was nudged by morning temperature tendencies.
- The GOES-MM5 run still tended to overpredict PBL heights between August 25 and August 30, but less so than the non-GOES run. During the period of starting late in the afternoon of August 30 and running through September 1, the GOES-MM5 underpredicts PBL, and the non-GOES

run comes closer to the observed PBL. (See Nielsen-Gammon 2001 for discussions of the meteorological transition on August 30, 2000).

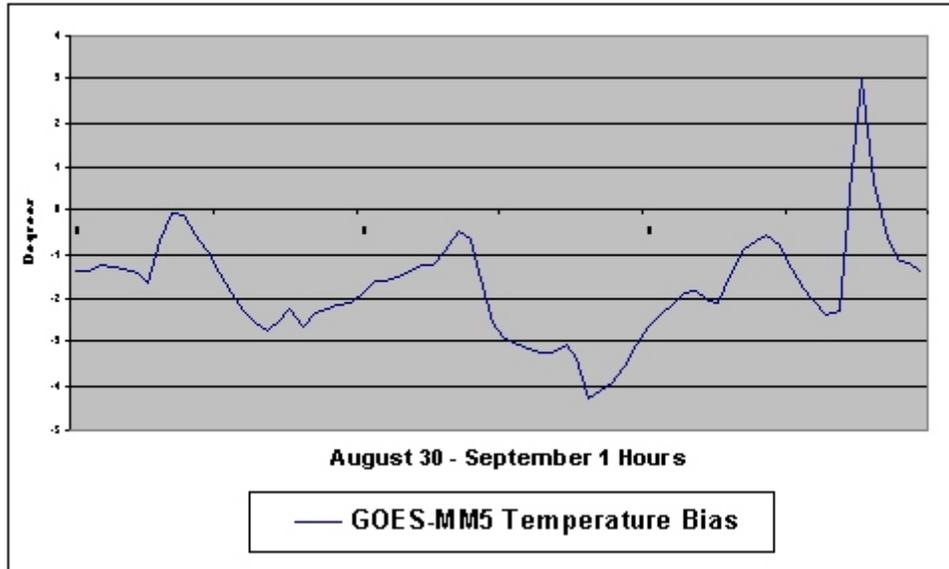


Figure 3.5: METSTAT Plot for GOES-MM5 Temperature Bias

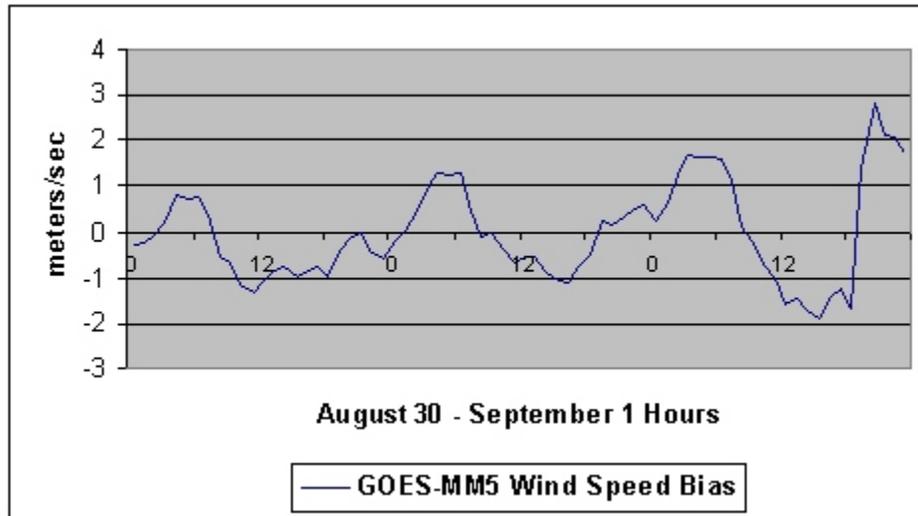


Figure 3.6: METSTAT Plot for GOES-MM5 Wind Speed Bias

One consequence of the GOES data assimilation into MM5 was to improve features of the wind field. For example, although the GOES-MM5 predicted PBL was no longer improved over the non-GOES MM5 for August 31 and September 1, CAMx model performance was still better on these two days than with either the original Nielsen-Gammon MM5 or the ATMET MM5.

3.5.4 September 2 through September 6 (Transport)

ATMET MM5 output was used between September 2 and September 6. The meteorological modeling for BPA proceeded along two parallel paths. The second part utilized an existing contract with ENVIRON Corporation to support improvements in HGB modeling. ENVIRON's contract with the commission included the subcontracting of meteorological work to ATMET. Since ENVIRON was already doing model sensitivity studies on behalf of the Houston Advanced Research Center (HARC), the commission was able to extend the HARC scope of work by entering into an agreement with the Geotechnology Research Institute (GTRI) affiliated with HARC which identified additional tasks which will be described in 3.5.4.1. The full set of statistics and other representative figures are provided in Appendix C. Meteorological model performance was not as good on September 2, 4, and 6 as for the

embedded episode, but statistics and wind field analysis suggest this output is suitable for regulatory modeling. CAMx model performance, described in Section 3.7 is also reasonable on these days.

3.5.4.1 Description of ATMET MM5 Configurations

The ATMET modeling used the physics options for the extended TexAQS 2000 episode summarized in Table 3-8 and match the MM5 configuration used previously for the core TexAQS 2000 episode. TCEQ and ATMET focused upon using the MM5 configuration developed and discussed in the appendices to the 2002 HGB SIP revision to provide consistency between the MM5 modeling of the extended TexAQS 2000 episode and the previous MM5 modeling of the core TexAQS 2000 episode.

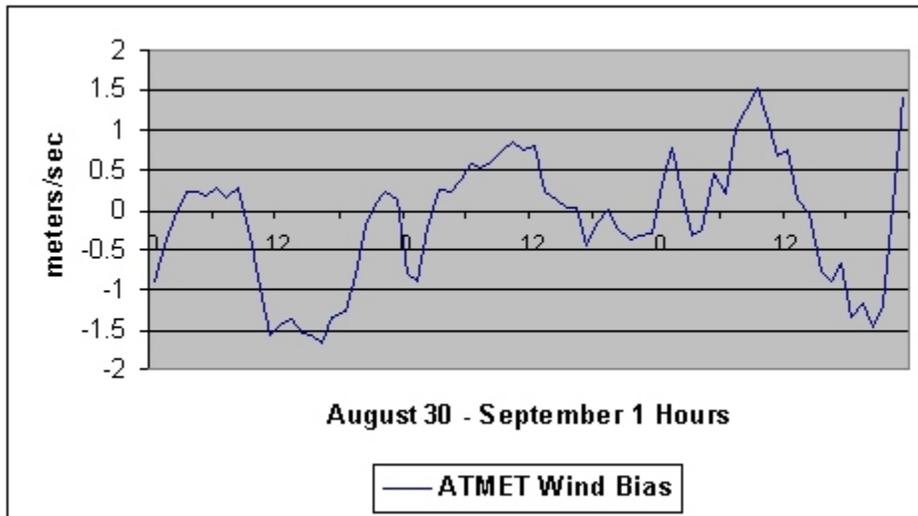
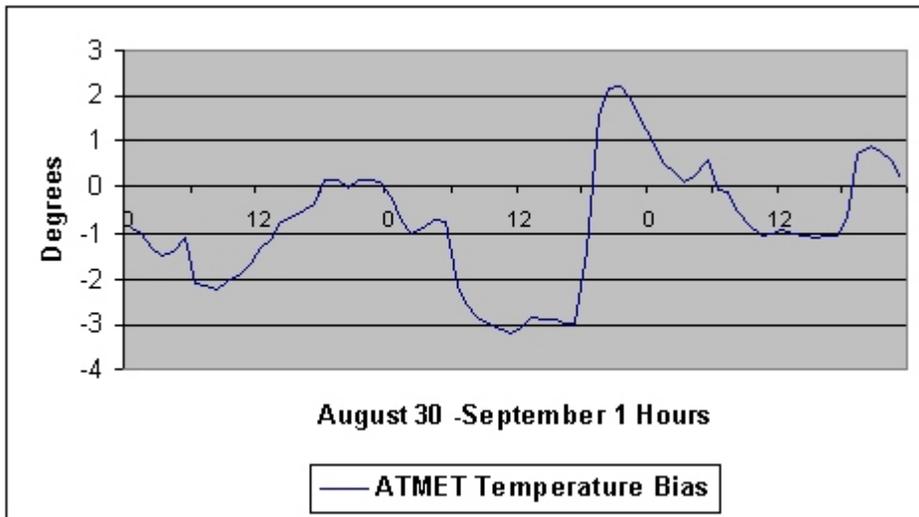
One of the key parameters affecting MM5 performance is the available soil moisture. This parameter can be set to default values dependent upon land use category, adjusted manually when data is available (see Nielsen-Gammon 2001) or set by a land surface model (LSM). The primary difference between the initial modeling performed by ATMET and the physics options in Table 3-8 was the choice to use a LSM to provide surface fluxes. The LSM which became available with MM5 version 3.6 was developed with support of the National Center for Environmental Prediction (NCEP), Oregon State University (OSU), the U.S. Air Force, and the Hydrologic Research Laboratory (NOAH).

The choice of PBL scheme was discussed at some length in Nielsen-Gammon 2002a and Nielsen-Gammon 2002b. The present modeling effort by ATMET is documented in a series of reports. The first report is titled *Final Report: MM5 Simulations for TexAQS 2000 Episode*, August 14, 2003. Additional attention was paid to model sensitivity to PBL schemes. ATMET, conducted investigations into the performance of PBL choices in their first report. A more detailed discussion followed in *Task 3: Sensitivities to modifications of the MRF PBL scheme*, September 30, 2003. This report documents modifications to the MRF code so that sensitivity studies could be explored. MM5 contains alternative PBL algorithms to the MRF which rely upon calculations of Turbulent Kinetic Energy (TKE). Comparisons between MM5 predictions using MRF and one of the alternative TKE PBL choices, called Gayno-Seaman, was a significant part of Nielsen-Gammon 2002b. Since ATMET has extensive familiarity with TKE-based PBL algorithms using the Regional Atmospheric Modeling System (RAMS), they were asked to evaluate the possibility of future TKE analyses with MM5. This summary of algorithm differences became *Task 4: Review of the TKE PBL schemes in MM5*. A portion of the METSTAT statistics are presented in Figures 3.5-7 and 3.5-8 for comparison to the other MM5 runs.

A partial summary of observations and conclusions from the present series of ATMET modeling reports referenced above is included here.

- The METSTAT statistics for surface temperatures indicates that the NOAH land surface model performed favorably when compared to the adjustments made to available soil moisture as described by Dr. Nielsen-Gammon in his reports.

- The initialization of the NOAH LSM by EDAS data contributed to the very low values of available soil moisture that characterized this period. These low values may have contributed to a large sensible heat flux and planetary boundary layer depth that was at least as deep as previously predicted.
- Removal of the convective velocity adjustment in the MRF PBL scheme removed a low daytime wind speed bias that had been observed previously by Dr. Nielsen-Gammon and in the initial ATMET runs. This change was incorporated into the MM5 modeling which comprised the final ATMET MM5 configuration.
- Other MRF PBL sensitivity tests adjusted two parameters which can affect the predicted PBL depth: the first is the value of the critical Richardson number, and the second test removed the virtual temperature excess. These tests support the observations of MRF developers that the algorithm is sensitive to these parameters. However, without a criterion for selected alternative values to the default parameters, these tests were not incorporated into the final MM5 runs.



**Figure 3.5-7:
METSTAT
Plot for
ATMET
Temperature
Bias**

Figure 3.5-8: METSTAT Plot for ATMET Wind Speed Bias

3.5.5 Influence of Doppler Lidar Data

An improvement in low level wind on August 25 when Doppler lidar data was included in the observational nudging file was noted. The reasoning [Nielsen-Gammon 2002b] was that MM5 responded as expected by nudging to the profiler data which is valid at 200 meters and above, but that without data between the surface and 200 meters, MM5 could not capture low level winds recorded by surface stations. The same observational nudging file was used for the ATMET runs but the commission concluded that the Doppler lidar played a smaller role for daily model performance when the NOAA land surface model was used. Even though MM5-GOES wind field were good on August 31 in Nielsen-Gammon 2003, a sensitivity test was conducted by including Doppler lidar data on this day to see if model performance improved. The conclusion was that the Doppler lidar data did not change model performance August 31, 2000.

3.5.6 Conclusions and Future Directions

The CAMx meteorological fields are derived from MM5 meteorology using the ENVIRON program MM5CAMX. In all cases, the O'Brien option in MM5CAMx was used to calculate the vertical diffusivities (Kv's) which determine vertical mixing in CAMx. An additional program called KVpatch provided corrections to layer one Kv's to reflect weighting of land-use categories in each CAMx grid cell. The unadjusted PBL heights were used whenever possible, and the present meteorology relies on MM5-GOES fields with no PBL adjustments on August 12 and 13 and between August 29 and September 1.

The only meteorological field which was post-processed was PBL height for the portion of the extended TexAQS episode of September 2 through September 6.

The focus of the GOES-MM5 work was to further investigate the impact of GOES data assimilation on MM5 predicted PBL height. As noted above, this version of MM5 produced PBL fields which were closer to observations than either the Nielsen-Gammon model runs of 2002 or the ATMET model runs of 2003. In addition to producing PBL fields which did not require adjustments based upon observed data, the characteristics of the wind field also attracted attention. The GOES-MM5 was used for the embedded BPA episode largely because wind fields seem to have been better represented. Figures comparing predicted versus observed winds are available in Appendix C. CAMx model performance was found to be better using the MM5-GOES meteorology with no PBL adjustments during the embedded BPA episode.

The next Texas field study scheduled for 2005 and 2006 is expected to provide more detailed meteorological data for the BPA area than is presently available. In addition, the commission expects to expand the operational capabilities of the MM5-GOES methodology so that it is available for future meteorological modeling studies. Use of the MM5-GOES modeling system is currently limited to those periods for which Marshall Space Flight Center has processed GOES data into a format suitable for MM5. At present, only data from August 25 through September 1, 2000 was processed for GOES sensitivity analyses.

References to reports in this section may be obtained on the TCEQ website.

http://www.tceq.state.tx.us/air/aqp/airquality_contracts.html#section3

3.6 EMISSIONS INVENTORY DEVELOPMENT

3.6.1 Point sources

3.6.1.1 Base Case Point Source Emissions Inventory Development

The point source emissions inventories are composed of information from several databases. The following sections describe the base case point source emission inventory development for the BPA August 28-September 6, 2000 modeling episode. Tables 3-9 and 3-10 summarize the base case point source emissions for August 30, 2000. Note that “CB-IV HC” represents tons of emissions after transformation to the Carbon Bond IV chemical mechanism, the simplified chemistry used by many photochemical models including CAMx. CB-IV mass typically differs from VOC mass by up to 20 percent. “Region 12 U/M” is the mass added from the TCEQ Region 12 Upset & Maintenance database (this is in addition to the emissions variability reported in the Special Inventory, which is already included in the EGU and NEGU emissions). Finally, “HGB Olefin Adjustment” is the mass added to the model by adjusting emissions of terminal olefins as described later in this document.

Table 3-9: BPA Point Source Emissions (Tons/Day) - August 30, 2000

	NO_x	VOC	CB-IV HC
EGU	34.90	0.82	0.72
NEGU	84.35	66.87	63.81
REGION 12 U/M	0.00	0.00	0.00
TOTALS	119.25	67.69	64.53

(EGU: Electric generating unit; NEGU: Non-Electric Generating Unit (point source);
U/M: Upset/maintenance)

Table 3-10: Domain Wide Point Source Emissions (Tons/Day) - August 30, 2000

	NO_x	VOC	CB-IV HC
TEXAS EGU	1348.26	19.63	19.24
TEXAS NEGU	866.39	500.67	458.37
REGION 12 U/M	0.00	3.01	3.32
HGB OLEFIN ADJUSTMENT	0.00	155.36	177.84
LOUISIANA EGU	404.04	3.29	3.31
LOUISIANA NEGU	630.90	218.79	197.25
OTHER EGU	5739.74	39.28	43.20
OTHER NEGU	2017.41	1769.35	1569.15
OFFSHORE POINTS	546.08	188.85	56.03
MEXICO POINTS	272.34	0.41	0.31
TOTALS	11825.16	2898.64	2528.02

Texas Point Sources

For Texas point sources, data from the TCEQ Point Source Data Base (PSDB) provided the basis for modeling the 2000 base case episode. As previously developed, the Texas EI was divided into Electric Generating Units (EGUs) and non-EGUs (NEGUs), which were processed as separate files. The EGU portion of the Texas point source EI was supplemented with hourly data from EPA's Acid Rain Program Database (ARPDB). Upon completion of a PSDB-to-ARPDB cross reference, ozone-season daily PSDB emission records were replaced with hourly ARPDB emission rates for each day of the modeled episode. The Texas inventory was also supplemented with hourly data obtained via the TexAQS 2000 Special Inventory and with additional information from the TCEQ Region 12 Upset/Maintenance Database.

Special Inventory

Episode-day and hour-specific point source emissions data were collected by surveying the largest sources of NO_x and VOC emissions in the HGB and BPA areas to account for specific operating conditions, upsets, start-ups, and shut-downs during the TexAQS 2000 study period. Sources emitting at least 250 tons per year of non-methane organic compounds (NMOC) or 1000 tons per year of NO_x were requested to participate in the survey. A total of 83 TCEQ accounts were queried. Special Inventory data have been incorporated into the base case modeling episode. See Appendix D, "Point Source Modeling Inventory Development" for more details.

Region 12 Upset/Maintenance Database

In addition to the TexAQS 2000 Special Inventory data, data submitted to the TCEQ Region 12 Upset/Maintenance Database were reviewed. All emission events reported during the modeling episode time period were examined and cross-referenced with the emission events reported to the Special Inventory. Events not already included in the Special Inventory were extracted from the database and processed as part of the base case modeling inventory. Only events with quantifiable amounts of CO, NO_x or VOC over the episode were considered for inclusion. Some examples of the data included are: a large CO upset of 885 lb/hr, NO_x upsets varying from 4 lb/hr to 295 lb/hr, and VOC upsets varying from 0.07 lb/hr to 295 lb/hr. A summary of these events is also included in Appendix D.

Louisiana Point Sources

The Louisiana Department of Environmental Quality (LDEQ) supplied a copy of its year 2000 point source emissions inventory in AIRS Facility Subsystem (AFS) format. The TCEQ and the LDEQ completed an AFS-to-ARPDB cross-reference list, which links Acid Rain Program boilers to their corresponding LDEQ stack identifiers. With this cross reference list completed, the LDEQ annual EGU emission records were replaced with hourly ARPDB emissions for each modeling episode day.

Regional Point Sources

For the states in the remainder of the modeling domain, beyond Texas and Louisiana, point source emission records in AFS format were obtained from ENVIRON. These 1999 National Emissions Inventory (NEI) v1 data were prepared for near-nonattainment modeling performed by ENVIRON for several areas of Texas. The AFS files were reviewed and Texas and Louisiana records were removed from the data to avoid double counting.

An AFS-to-ARPDDB cross-reference list was developed for boilers larger than 750 megawatts capacity that are subject to EPA's Acid Rain Program. This cross-reference list links these boilers to their corresponding NEI/AFS stack identifiers. With this cross-reference, the ozone-season daily emission records were replaced with corresponding hourly ARPDDB emissions for each hour of the modeled episode.

Offshore Point Sources

The TCEQ has been in contact with the Minerals Management Service (MMS) over the last several years to monitor the status of the 2000 Gulf-Wide Emission Inventory (GWEI). As of this writing, the data have not been made available to the public, so it was not used in the current round of modeling.

In Phase 1 of the HGB MCR, the 2000 offshore EI was generated by growing the 1992 MMS offshore EI, in-place, by a factor to account for the growth in offshore production platforms, based on a previous MMS report. Based on the recommendation of MMS, all point source offshore emissions were grown by 44%, assuming that the ancillary stationary point source equipment would grow at the same rate as the number of offshore platforms. An explanation of the 44% growth factor can be found in Appendix D.

Mexico Point Sources

The Desert Research Institute provided commission modeling staff with a 1999 Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study Emissions Inventory in Inventory Data Analyzer (IDA) format; see "Mexico Emissions Inventory - excerpt from Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study Emissions Inventory (November 16, 2001)" for more details. Modeling staff reviewed the inventory, subset out emissions from sources in Mexico, and converted the data to AFS format for processing. These emissions have been incorporated into current base case modeling.

A preliminary evaluation of the ERG July 2003 "1999 Mexico NEI" report was reviewed and there were no significant differences in point source emissions between the two inventories, therefore, the 1999 BRAVO inventory continues to be used.

PiG Selection

CAMx has an option to model selected point sources with a Plume-in-Grid (PiG) algorithm. PiG allows a model to simulate plume behavior of elevated point sources within one or more grid cells. That is, the PiG algorithm does not immediately dump a “PiGged” source’s emissions into the entire cell at once, but rather keeps the plume cohesive until it is no longer of a sub-grid scale size. With today's computer resources, combined with the efficient PiG algorithm built into CAMx, PiG selection does not have to be as carefully limited as it was historically. Modeling staff selected PiG sources based on magnitude of NO_x emissions (five tons/day with a co-location distance of one meter). As with Phase 1 of the MCR, over 300 PiG sources across the entire modeling domain, mostly large power plants, were selected.

3.6.1.2 Point Source VOC Speciation

Emissions from both the PSDB and the Special Inventory contain large amounts of information about specific hydrocarbons emitted by each source; however, some sources report little or no speciation of their hydrocarbon emissions.

In HGB Phase 1 MCR modeling, any source which reported less than 75% speciation was assigned either a Texas-specific Source Category Code (SCC)-average or an EPA default speciation profile. For sources reporting 75% or more speciation, the unspiciated emissions were assumed to have the same speciation as the reported emissions. This method is a significant improvement over simply assigning default speciation profiles based on SCCs, but it still has some drawbacks. Specifically, for any source whose emissions are less than 75% speciated, all reported speciation data would be ignored. See "Development of Source Speciation Profiles from the 2000 TCEQ Point Source Database", available electronically at ftp://ftp.tnrc.state.tx.us/pub/OEPAA/TAD/Modeling/HGAQSE/Contract_Reports/EI/DevelopmentOfSourceSpeciationProfilesFrom2000PSDB.pdf, for more details.

For the HGB Phase 2 MCR and BPA SIP Revision modeling analysis, a new process was developed which retains virtually all speciated hydrocarbon data reported to the PSDB, regardless of the completeness of the speciation of each point’s emissions. Also new is the exclusion of non-VOC species, as defined by EPA, from all point-source speciation profiles. These procedures are described in "Speciation of Texas Point Source VOC Emissions for Ambient Air Quality Modeling", available electronically at

ftp://ftp.tnrc.state.tx.us/pub/OEPAA/TAD/Modeling/HGAQSE/Modeling/EI/PointEI_VOC_Speciation_Report-GabrielCantu.pdf.

Companies supplied chemical speciation profiles for their hourly emissions as part of the TexAQS 2000 survey. When available, these data were used to develop the CB-IV speciation profiles used in the EPS2x preprocessor to CAMx. In cases where TexAQS-2000 speciation data

were incomplete or not available, the procedure described in the speciation report noted above was used.

3.6.1.3 HGB Point Source VOC Emissions Adjustment

One conclusion of the TexAQS 2000 study was that observed concentrations of certain compounds in the HGB area, especially light olefins, were much larger than represented in the reported emissions inventories. This conclusion has been reviewed and documented in numerous scientific journals. In HGB Phase 1 MCR modeling, the reported emissions resulted in a significant under prediction bias in modeled ozone concentrations; however, when a set of HRVOCs was adjusted and used, the model performance markedly improved. This adjustment served to increase the reactivity of the baseline modeling inventory, i.e., it increased the inventory's ozone yield potential.

The adjustment used in HGB Phase 1 modeling was a second point source emissions file containing all emission points for the largest HRVOC-emitting accounts in the 8-county nonattainment area (NAA). This file was used to provide the extra HRVOC emissions necessary to make the selected facilities' HRVOC emissions equal their individual NO_x emissions. This HRVOC-to-NO_x adjustment was based on the observation that airborne concentrations of light olefins measured aboard the Baylor University research aircraft in 2001 were frequently approximately equal to concurrently measured concentrations of NO_y (NO_x plus other nitrogen compounds which are typically products of photochemical reactions, such as nitric acid) when the aircraft passed through industrial plumes. For more details, see <http://www.tnrcc.state.tx.us/oprd/sips/dec2002hga.html#docs>.

Since the completion of HGB Phase 1 modeling, several additional studies have been conducted comparing reported inventories to ambient measurements, both airborne and at ground level. These studies generally agree that emissions of HRVOCs in the HGB area are significantly under-reported. The approach used in HGB Phase 1 modeling is supported by an independent study conducted for the Houston Advanced Research Center (HARC) by ENVIRON, Project No. H6E.2002, "Top-Down Evaluation of the Houston Emission Inventory using Inverse Modeling". This study used inverse modeling to assess various inventory components, and concluded that further modification of the inventory used in HGB Phase 1 was not warranted under the then-current model formulation.

For the HGB Phase 2 MCR analysis and BPA SIP Revision, an improved HRVOC adjustment was used. Considering the measurement instruments onboard the Baylor aircraft were primarily designed for isoprene detection, they theoretically also respond well to other "terminal olefins". Since an olefin is defined as any unsaturated hydrocarbon containing one or more pairs of carbon

atoms linked by a double bond, a terminal olefin is one in which a double bond resides at the end of the carbon chain. A study to determine the instruments' actual response to other olefin species is planned for the near future. Some data has been published regarding these instruments' olefin detection limits, this data can be found in *Eddy covariance measurement of isoprene fluxes*, (Journal of Geophysical Research, vol. 103, no. D11, June 20, 1998). Given this data, and the data available in PSDB, a set of terminal olefins was targeted for adjustment. A list of the olefins selected for imputation is provided in Table 3-11. The extra HRVOC emissions are explicitly speciated as individual compounds, as opposed to the "generic" HRVOC used in previous modeling. Overall, these enhancements change the modeled reactivity slightly from previous modeling.

Table 3-11: Terminal Olefins Selected for Imputation

SPECIES
Ethylene
Propylene
1-Butene
1,3-Butadiene
1,2-Butadiene
Pentene
2-Methyl-1-Butene
3-Methyl-1-Butene
Hexene
Isoprene
1-Decene
Propadiene
E-1,3-Pentadiene

Two types of adjustments were developed using this method, a non-varying adjustment similar to that used in previous modeling and an adjustment that incorporates Special Inventory daily and hourly emission fluctuations. The non-varying HRVOC adjustment adds 155 tons/day of VOC to the HGB 8-county area, as opposed to the 149 tons/day added in previous modeling, and the resulting reactivity is approximately 91% of the reactivity previously added to the model. The varying adjustment fluctuates from 163 to 203 tons/day. Details on how this adjustment was developed can be found in Appendix D.

The TCEQ plans to conduct additional studies comparing ambient concentrations of olefins to the inventory, and will work towards developing more targeted adjustments, especially now that several new automatic gas chromatographs (Auto-GCs) have been deployed in the industrial sectors of the HGB area. In addition to in-house analyses, TCEQ plans to use the results of other pertinent studies of ambient VOC measurements that have been or will be conducted by scientists and consultants using data from the HGB area. Specifically, TCEQ plans to use the findings of the following studies for guidance, if appropriate:

1. In-house studies of VOC/NO_x ratio measurements from the TCEQ and EISM auto-GC networks;
2. Advanced multivariate receptor modeling using trajectory analyses and matrix separation techniques, to be performed by Pacific Northwest National Lab researchers and their research colleagues;
3. Positive matrix factorization and other ambient/emissions inventory analyses that have recently been performed by consultants for HARC/TERC (Roberts, P., S. Brown, S. Reid, M. Buhr, T. Funk, P. Steifer, P. Hopke, E. Kim (2004). *Emission Inventory Evaluation and Reconciliation in the Houston-Galveston Area: Final Report*. STI-903640-2490-FR, HARC project H6C, prepared for: Houston Advanced Research Center, Texas Environmental Research Consortium, The Woodlands, TX, March 19, 2004);
4. Other studies that seem useful, such as
 - (a) Zhao W., P. Hopke, and T. Karl (2004). Source identification of volatile organic compounds in Houston, Texas. *Environ. Sci. Technol.* 38: 1338-1347;
 - (b) Karl, T., T. Jobson, W. C. Kuster, E. Williams, J. Stutz, R. Shetter, S. R. Hall, P. Goldan, F. Fehsenfeld, and W. Lindinger, (2003). Use of proton-transfer-reaction mass spectrometry to characterize volatile organic compound sources at the La Porte super site during the Texas Air Quality Study 2000, *J. Geophys. Res.*, 108(D16), 4508, doi:10.1029/2002JD003333, 2003.

Although HRVOC adjustments were made to HGB-area point sources, no such adjustments were made to BPA-area point sources. There were no aircraft or automated gas chromatograph measurements made in BPA during either modeling episode; therefore, no adjustments could be made. The adjustments made to the HGB inventory were the result of widely peer-reviewed analyses of the TexAQS 2000 data. However, TCEQ is continuing to study the issue of VOC

emissions in BPA, and a field study scheduled for 2005-2006 may provide more definitive information.

3.6.1.4 2007 Future Year Point Source Emissions Inventory Development – Growth

Table 3-12 summarizes the methods used to grow the point source inventory, the base case inventory upon which the growth was applied, and the computer filename of the modeling “growth packet.”

Table 3-12: 2007 Future Base Case Summary of Growth Methods

Geographic Area	Inventory Used	Growth Applied	File Name
Regional (Outside of Texas)	EGU (1999 NEI v1 w/ hourly 2000 Acid Rain Data)	EGAS 99-07	<i>RegionalEGASGrowthFactors99to07</i>
	NEGU (1999 NEI v1)	EGAS 99-07	<i>RegionalEGASGrowthFactors99to07</i>
Louisiana	EGU (LDEQ 2000 AFS EI w/ hourly Acid Rain)	EGAS 00-07	<i>LouisianaEGASGrowthFactors00to07</i>
	NEGU (LDEQ 2000 AFS EI)	EGAS 00-07	<i>LouisianaEGASGrowthFactors00to07</i>
Offshore	GMAQS points	assumed same as 2000 (grown 44% from 1992 GMAQS)	N/A
Mexico	1999 Mexico “NEI”	none	N/A
HGB	EGU	newly-permitted EGUs (additional AFS file)	<i>N/A (already included in the HGB Cap)</i>
	NEGU	Banked (ERCs and DERCs) NO _x and VOC	<i>grow.NAA_Banks_NEGU and TIPIEGASGrowthFactors00to07v3 (just grows CO, since bank takes care of NO_x and VOC)</i>
	HRVOC Cap	none	N/A

Geographic Area	Inventory Used	Growth Applied	File Name
BPA	EGU	newly-permitted EGUs (additional AFS file)	<i>afs.hgmcr2004.new_egu_TX-HG.lcp_v3</i> then apply 75% demand-to-capacity to the new EGUs: <i>control.075N.new_egu</i>
	NEGU	Banked (ERCs and DERCS) NO _x and VOC	<i>grow.NAA_Banks_NEGU</i> and <i>TIPIEGASGrowthFactors00to07v3</i> (just grows CO, since bank takes care of NO _x and VOC)
DFW	EGU	newly-permitted EGUs (additional AFS file)	<i>afs.hgmcr2004.new_egu_TX-HG.lcp_v3</i> then apply 75% demand-to-capacity to the new EGUs: <i>control.075N.new_egu</i>
	NEGU	Banked (ERCs and DERCS) NO _x and VOC	<i>grow.NAA_Banks_NEGU</i> and <i>TIPIEGASGrowthFactors00to07v3</i> (just grows CO, since bank takes care of NO _x and VOC)
East Tx	EGU	newly-permitted EGUs (additional AFS file)	<i>afs.hgmcr2004.new_egu_TX-HG.lcp_v3</i> then apply 75% demand-to-capacity to the new EGUs via <i>control.075N.new_egu</i>

Geographic Area	Inventory Used	Growth Applied	File Name
	Cement Kiln NO _x	newly-permitted units/modifications and TIPI 00-07 to existing kilns	<i>afs.MidloKilns._v5</i> then apply <i>ellis_kilns.TIPI.00-07</i>
	Agreed Orders and Consent Decree for East Texas	N/A	N/A (agreed reductions, not growth)
	all others	TIPI-EGAS 00-07	<i>TIPIEGASGrowthFactors00to07v3</i>
West Tx	EGU	newly-permitted EGUs (additional AFS file)	<i>afs.hgmcr2004.new_egu_TX-HG.lcp_v3</i> then apply 75% demand-to-capacity to the new EGUs via <i>control.075N.new_egu</i>
	NEGU	TIPI-EGAS 00-07	<i>TIPIEGASGrowthFactors00to07v3</i>

Regional Point Source Growth

EPA's 2007 regional point source inventory in AFS format was obtained from ENVIRON. This inventory included regional point source growth assumptions and NO_x SIP Call Controls.

Thorough evaluation of these files and inventory development methods revealed multiple issues. Through the process of attempting to resolve these issues it was discovered that the original HDD database files were no longer available from EPA's website. Therefore, the HDD as a future case inventory was not pursued. Instead, the existing 1999 NEI v1 EGU and NEGU files, that had been supplemented with hourly 2000 Acid Rain data, were grown using EGAS 4.0 on a 2-digit SIC basis. The reader is referred to the EGAS 4.0 Reference Manual, which is available on EPA's CHIEF website. Table 3-13 is a summary of the "grown" Regional inventory.

Table 3-13: Regional 2007 Modeled Growth for August 30

Regional source	1999/2000 NO _x (tpd)	1999/2000 VOC (tpd)	2007 NO _x (tpd)	2007 VOC (tpd)	% NO _x Growth	% VOC Growth
EGU	5565.3	39.3	5710.7	42.3	3%	8%
NEGU	1862.2	1769.3	1945.6	2172.9	4%	23%
Total	7427.5	1808.6	7656.3	2215.2	3%	22%

Louisiana Point Source Growth

The 2000 Louisiana point source inventory was grown to 2007 with EGAS 4.0 projection factors. This NO_x and VOC growth in Louisiana is represented in Table 3-14.

Table 3-14: Louisiana 2007 Modeled Growth for August 30

Louisiana source	2000 NO _x (tpd)	2000 VOC (tpd)	2007 NO _x (tpd)	2007 VOC (tpd)	% NO _x Growth	% VOC Growth
EGU	404.1	3.3	449.6	3.6	11%	9%
NEGU	631.0	218.8	647.4	234.0	3%	7%
Total	1035.1	222.1	1097.0	237.6	6%	7%

Offshore Point Source Growth

As noted in the Base Case Point Source Emissions Inventory Development Section, the 2000 GWEI, which may provide guidance for growth of the Offshore points beyond 2000, is unavailable. While it was indicated by MMS that an assumption of 44% growth of point source emissions from 2000 to 2007 might be appropriate, it was also indicated that it would not be appropriate to model that growth in-place, since the platforms built after 2000 have typically been erected beyond the 50-100 mile point from the coastline. As a result of these unknowns, offshore emissions from the base case were not grown. TCEQ plans to incorporate GWEI data in future modeling, when the data becomes available.

Mexico Point Source Growth

Due to a lack of data and the trend toward slowing economic growth in northern Mexico, no growth was applied to point sources in Mexico; hence, the emissions are the same as those used in the base case.

Texas Nonattainment Area Point Source Growth

Growth in NO_x and VOC emissions in the Texas NAAs, HGB, BPA, and DFW, was partially accounted for through the emissions banked in the Emissions Banking and Trading (EBT) database. ERC and DERC totals for each of the NAAs, as of October 9, 2003 were used. These banked emissions could return to the airshed as actual emissions in the future; this growth was applied to the NEGUs, in the respective NAAs. A summary of the emissions is presented as Table 3-15.

Table 3-15: Banked Emissions as of October 9, 2003

NAA	NO_x (tpd)	VOC (tpd)
HGB	1.2	13.2
BPA	13.9	1.4
DFW	11.4	0.7

Chapter 101 requires that an ERC must be surplus to any federal, state or local rule. The credits that are in the bank have been devalued to show surplus using the Chapter 117 ESADs. Also, the Chapter 101 MECT DERC use restrictions were incorporated in the NO_x total in Table 3-15. Therefore, the bank in HGB has shown a substantial decrease from previous estimates. The totals in Table 3-15 for DFW and BPA incorporate offset ratios and Chapter 101 10% environmental contributions.

In addition, growth in the NAAs was accounted for by the inclusion of newly-permitted EGUs. It is expected that existing EGUs in the state will not grow. Rather, much of the existing EGU capacity in the state is being replaced by new, cleaner, more efficient combined-cycle (typically) EGUs, reflected in Table 3-16. With a few exceptions, this growth has not been occurring in the nonattainment counties, because of strict nonattainment New Source Review (NSR) requirements. Permit applications for these

new EGUs throughout the state permitted prior to November 5, 2003 were examined. These permits were then cross-referenced against sources in the 2000 base case EI, to ensure no double-counting occurred. These new sources were assembled into a single “new EGU” AFS file of permit allowable emission rates and permitted stack parameters.

It is likely an overestimate of projected demand (and hence, emissions) to assume that these newly-permitted EGUs in the state will all be operating at their permitted levels. Given that permits typically represent full load (capacity) conditions of the equipment, modeling staff adjusted the modeled new EGU emissions downward to more accurately represent future demand on these new EGUs. An analysis of trend data from an Electric Reliability Council of Texas (ERCOT) report, that included future projections, indicates that demand has typically been, and is expected to be in 2007, 75% of capacity. Hence, the new EGUs were ultimately modeled at 75% of their permit allowable emission rates. Table 3-16 is a summary of these newly-permitted EGUs in the NAAs.

Table 3-16: Newly-Permitted EGUs in NAAs as of November 5, 2003

NAA	NO _x (tpd)	VOC (tpd)	CO (tpd)
HGB	0	0	0
BPA	5.9	1.7	22.2
DFW	0.3	0.1	0.7

Table 3-16 demonstrates that there is no new EGU growth in the HGB NAA. Chapter 101 MECT rules required companies to have an administratively complete permit application prior to January 2, 2001. These accounts obtained allowances based on permit allowables as a result of the MECT Level of Activity certification. Accounts which obtain permit authorization after January 2, 2001 are required to obtain allowances from an account that was allocated allowances or from a broker. Therefore, any NO_x increases at existing or new sources, which are subject to Chapter 117 ESADs in HGB, are already accounted for in the MECT cap; no NO_x growth can occur in HGB for those source types (pieces of equipment) for which Chapter 117 ESADs exist.

CO from NEGU combustion sources is also expected to grow as burner modifications are implemented, because of the inherent off-stoichiometric ratio of air-to-fuel required to achieve low-NO_x combustion. Therefore, NEGU CO was grown from 2000 to 2007 via factors derived from the Texas Industrial Production Index (TIPI), discussed below. Where TIPI SIC factors were unavailable, EGAS 4.0. growth factors were used.

East Texas Point Source Growth

As with the NAAs, newly-permitted EGUs in East Texas were added to the inventory as growth, at 75% of their permitted emissions, due to the demand vs. capacity trend discussed above. A summary of the emissions is provided in Table 3-17.

Table 3-17: Newly-Permitted EGUs in East Texas as of November 5, 2003

Sources	NO _x (tpd)	VOC (tpd)	CO (tpd)
EGU	70.7	13.6	149.8

As in the base case, the future 2007 case Ellis County cement kilns were modeled at their 2000 actual emissions, except that seven years of TIPI growth were applied to all existing 2000 kilns. A separate file of the 2000 emissions for Ellis County cement kilns was created. This file also included one new TXI kiln (EPN E2-22) that became operational since 2000; it was included at its permit allowable emission rates. A permit condition of that permit stated that this new kiln cannot operate simultaneously with two of the older kilns, so we created a file, *ellis_kilns.TIPI.00-07*, that zeros-out two of TXI's kilns. TIPI growth for the cement industry was also applied via the file *ellis_kilns.TIPI.00-07*.

All other sources in East Texas were grown using the TIPI-derived factors, where available, and supplemented with EGAS 4.0 factors where necessary. TIPI was used where possible, because its data are more recent than those in the EGAS 4.0 model. The EGAS model was last updated on January 26, 2001, and uses data and data models which date from the early 1980s to 1999. The REMI model, which is the economic basis of EGAS 4.0 uses economic data which date from 1969 to 1996. Also, EGAS uses historical emissions data from the NEI ranging from 1972 to 1992. (See the EGAS 4.0 Reference Manual, available on EPA's CHIEF website). TIPI uses more recent economic data (November 2003). TIPI-EGAS is the combination of these two databases, as described below.

TIPI data from January 1967 through November 2003 was used in a linear regression analysis to project emissions from 2000 to 2007. A list of the 2-digit SICs for which TIPI data is available is included in Appendix D.

According to the Federal Reserve Bank of Dallas, TIPI is a value-added index (based on a weighted average of employment, man hours, and some production data). The underlying process to derive TIPI data is the same as the Bureau of Economic Analysis gross-state product. A better surrogate would have been local survey data based on production. However, no such data currently exist for the state of Texas. For further information on the TIPI see <http://www.dallasfed.org/data/data/mi5000.tab.htm>.

For those categories in Texas, not covered by TIPI, EGAS factors were used. The categories for which EGAS was used are listed in Appendix D. Table 3-18 presents the growth projections for East Texas based on TIPI-EGAS factors.

Table 3-18: East Texas 2007 TIPI-EGAS Growth for August 30

Source	2000 NO _x (tpd)	2000 VOC (tpd)	2007 NO _x (tpd)	2007 VOC (tpd)	% NO _x Growth	% VOC Growth
NEGU	382.6	160.1	408.2	178.5	7%	11%

As stated above, new permits have been used to account for changes in emissions where such data are readily available and where resources were available to extract the data from permits (EGUs and cement kilns).

West Texas Point Source Growth

As with the rest of the Texas inventory, newly-permitted EGUs in West Texas were added to the inventory as growth at 75% of their permit allowable emissions. A summary of the emissions from the newly-permitted EGUs is provided in Table 3-19.

Table 3-19: Newly-Permitted EGUs in West Texas as of November 5, 2003

Sources	NO _x (tpd)	VOC (tpd)	CO (tpd)
EGU	6.2	2.5	17.8

Some of these emissions are actually outside of the modeling domain; therefore, other modeling summaries may be inconsistent with these totals. All other sources in West Texas were grown using the same TIPI-EGAS procedure used for the rest of the state. Table 3-20 represents the growth projections for West Texas based on TIPI-EGAS factors

Table 3-20: West Texas 2007 TIPI-EGAS Growth for August 30

Source	2000 NO _x (tpd)	2000 VOC (tpd)	2007 NO _x (tpd)	2007 VOC (tpd)	% NO _x Growth	% VOC Growth
NEGU	116.6	41.1	117.8	43.3	1%	5%

3.6.1.5 2007 Future Year Point Source Emissions Inventory Development – Controls

In addition to the application of growth projections, as described above, Table 3-21 summarizes the controls applied to arrive at the future base case point source inventory. The future base case includes all of the controls for which rules have already been written, and have ultimate compliance dates prior to the

8-hour ozone attainment date. Appendix D contains more details. The subsections that follow describe the controls applied to the various parts of the point source inventory to arrive at the future base case point source emission inventory for the BPA August 28-September 6, 2000 modeling episode.

The Special Inventory that was modeled in the 2000 base case was considered to be specific to the summer of 2000; hence, it was not carried into the future base cases. The hourly ARPDB-enhanced EGU emissions were projected and controlled in the future, because they represent the typical temporal pattern of baseline, intermediate, or peaking power plants.

Table 3-21: 2007 Future Base Case Summary of Controls Applied

Geographic Area	Base Inventory	Controls Applied	File Name
Regional (Outside of Texas)	EGU (1999 NEI v1 w/ hourly 2000 Acid Rain Data)	NO _x SIP Call (Feb. 2002 Federal Register)	<i>control.NO_xSIPCall_EGU</i>
	NEGU (1999 NEI v1)	none	none
Louisiana	EGU (LDEQ 2000 AFS EI w/ hourly Acid Rain)	Baton Rouge 9-parish NO _x reductions from LDEQ 12/01 SIP (controlled to tpd level in SIP and then grown)	<i>control.la.9parish.EGU_NEGU</i>
	NEGU (LDEQ 2000 AFS EI)	Baton Rouge 9-parish NO _x reductions from LDEQ 12/01 SIP (controlled to tpd level in SIP and then grown)	<i>control.la.9parish.EGU_NEGU</i>
Offshore	grown GMAQS	none	none
Mexico	1999 Mexico "NEI"	none	none
HGB	EGU	2007 NO _x Cap	<i>control.HG_NO_xCap_EGU</i>
	NEGU	2007 NO _x Cap	<i>control.HG_07NO_xCap_NEGU</i>
	HRVOC Cap	Revised Speciation and Cap Cutoff Levels	<i>control.new_hga_hrvoc_cap.to2n2_negu and then apply control.new_hga_hrvoc_cap.less20inharris</i>

Geographic Area	Base Inventory	Controls Applied	File Name
BPA	EGU	Ch. 117 controls; assuming no VOC controls	<i>control.07TX-HG_egu</i> (already applied the 75% demand-to-capacity to the new EGUs)
	NEGU	Ch. 117 controls via Emission Factor Survey; assuming no VOC controls	<i>control.2007.BPA.NEGU</i>
DFW	EGU	Ch. 117 controls; assuming no VOC controls	<i>control.07TX-HG_egu</i> (already applied the 75% demand-to-capacity to the new EGUs)
	NEGU	Ch. 117 controls via Emission Factor Survey; assuming no VOC controls	<i>control.2007.dfw.negu</i>
East Tx	Existing EGUs	SB7 or Ch. 117 controls; assuming no VOC controls	<i>control.07TX-HG_egu</i>
	Newly-Permitted EGUs	none (added as growth)	<i>control.midlothian.energy</i> (already applied the new EGU file and the 75% demand-to-capacity of the new EGUs via <i>control.075N.new_egu</i>)
	Cement Kiln NO _x	permit modifications	already applied permit modifications to <i>afs.MidloKilns._v5</i> via <i>ellis_kilns.TIPI.00-07</i>
	Agreed Orders and Consent Decree for East Texas	specific reductions at ALCOA and Eastman	<i>AgreedOrdersControlFactors00to07</i>
	all others	none	none

Geographic Area	Base Inventory	Controls Applied	File Name
West Tx	Existing EGUs	SB7 or Ch. 117 controls; assuming no VOC controls	<i>control.07TX-HG_egu</i>
	Newly-Permitted EGUs	none	none
	NEGU	none	none

Regional Point Source Controls

The only Regional control strategy modeled was the federal NO_x SIP Call. The latest reductions, as obtained from the Federal Register, dated February 2, 2002, were assumed indicating EGU NO_x reductions of:

- 27% in Illinois
- 32% in Indiana and Kentucky
- 33% in Ohio
- 23% in Tennessee
- 29% in northern counties of Alabama
- 28% in Northern counties of Georgia
- 34% in Eastern counties of Missouri

These controls were applied to the 1999 NEI v1 EGU file that had been supplemented with hourly 2000 Acid Rain data and grown as described above. No controls were modeled for NEGUs outside of Texas and Louisiana and no VOC reductions were modeled. Table 3-22 represents the 2007 controlled emissions summary for the Regional Point Sources.

Table 3-22: Modeled Regional NO_x Emissions Summary for August 30

Source	1999 NO _x w/2000 Acid Rain (tpd)	2007 NO _x w/EGAS Growth (tpd)	2007 NO _x w/Growth and NO _x SIP Call Controls (tpd)
EGU	5565.3	5711.8	4540.2
NEGU	1862.2	1946.0	1937.9
Total	7427.5	7657.8	6478.1

Louisiana Point Source Controls

Based on guidance from the LDEQ, the NO_x SIP control strategy information from LDEQ's December 2001 Baton Rouge attainment demonstration was applied. Specifically, reductions of 34% in EGU and non-EGU NO_x in the Baton Rouge 9-parish area were applied to the LDEQ-supplied 2000 point source inventory. No VOC reductions were modeled. Table 3-23 represents the modeled emissions summary for Louisiana Point Sources.

Table 3-23: Louisiana Modeled NO_x Emissions Summary for August 30

Source	2000 NO_x w/Acid Rain (tpd)	2007 NO_x w/EGAS Growth (tpd)	2007 NO_x w/Growth and LDEQ SIP Controls (tpd)
EGU	404.0	449.6	403.5
NEGU	630.9	647.4	596.7
Total	1034.9	1097.0	1000.2

Offshore Point Source Controls

As discussed in the Offshore Point Source Growth section of this document, the offshore inventory was not grown from the 2000 base case, nor have controls been applied to existing offshore point sources because the information is unavailable.

Mexico Point Source Controls

As with the offshore inventory, it is conservatively being assumed that no controls will be applied to Mexican point sources between 1999 and 2007. Therefore, no controls were applied to Mexican point sources for 2007 modeling.

Texas Nonattainment Area (HGB, BPA, DFW) Point Source Controls

HGB

In HGB, the Chapter 101 Mass Emissions Cap and Trade (MECT) program was applied. It incorporates all of the ESADs from Chapter 117 and provides annual NO_x allowances that accounts can emit in each year subsequent to 2002. A summary of the emissions that would be allowed in 2007 was generated and summed:

1. MECT allowances (see Table 3-24);
2. Part of the banked NO_x emissions that can be used in MECT (2.1 tpd EGU and 2.1 tpd NEGU);
3. Estimate of the total tons per day from sources that are exempt from ESADs (too small or not a controlled category) (17.1 tpd NEGU); and
4. Estimate of the sources which are subject to ESADs but were not included in MECT (and take 80% off of those, since ESADs apply) (4.1 tpd NEGU).

This sum became an estimate of the NO_x emissions in 2007 for the HGB 8-county area. Trading is allowed within the NAA, since this area is under the MECT program. Reductions were spread across the entire area where future emissions could occur or reoccur. Thus, a simple ratio of future allowance to base case emissions was calculated to give the reductions in Table 3-24. The numbers in Table 3-24 represent the NO_x cap values for a generic ozone day, as opposed to a specific modeled episode day.

Table 3-24: HGB 8-County Ozone Season Daily (OSD) NO_x Cap Summary

HGB sources	2000 NO _x OSD (tpd)	2000 NO _x w/Acid Rain (tpd) ¹	2007 MECT NO _x Cap (tpd)	2008 MECT NO _x Cap (tpd)	2007 Modeled NO _x (tpd) ²
EGU	192	203	23	23	25
NEGU	283	283	113	104	135
Total	475	486	136	127	160

¹ average day of the hourly Acid Rain data over 20-day episode

² includes all 4 of the summed estimates above; excludes non-MECT bank and newly-permitted EGUs

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

This table shows that the EGUs in HGB maintain the same level of NO_x emissions from 2007 to 2008, yet the NEGUs receive another 3% reduction from 2007 to 2008. This is due to the phased-in approach of the MECT program for HGB. The compliance date for the ESADs in Chapter 117 for EGUs is 2005, so all of the reductions for EGUs should be completed by 2005. The last phase of MECT for 1-Hour ozone attainment for HGB NEGUs occurs in April 2008, so the capped NO_x sources will remain unchanged after April 2008.

The NO_x values for the year 2000, in Table 3-25, represent the emissions modeled for August 30, 2000. These emissions include the Special Inventory and Acid Rain variations. The emissions shown for 2007 do not include the SI emissions, for the reasons discussed above, but do include the growth (non-MECT banked emissions and the newly-permitted EGUs).

Table 3-25: HGB 8-County Modeled NO_x Emissions Summary for August 30

HGB sources	2000 NO _x w/SI and Acid Rain (tpd)	2007 Modeled NO _x w/Cap Controls (tpd)	2007 Modeled NO _x w/Cap Controls and Growth (tpd)
EGU	225.9	27.1	42.5
NEGU	266.0	130.4	131.6
Total	491.9	157.5	174.1

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

Modeling the HRVOC Rules in HGB

Table 3-26 summarizes the VOC species targeted for regulation in the Chapter 115 rules. These species are a subset of the terminal olefins that were adjusted, as described in the base case modeling inventory section previously presented.

Table 3-26: HRVOC Regulated by Chapter 115 Rules by Area

HGB source	Species
Harris County	Ethylene Propylene 1,3-Butadiene All Butenes
Seven Surrounding Counties	Ethylene Propylene

The HGB HRVOC cap specifically targets flares, cooling towers, and vents, while fugitive emissions are regulated separately. Because there is limited information contained in STARS (and its predecessor database, PSDB) on specific emission point classifications, e.g., flares, fugitives, cooling towers, and vents, it is not possible for modeling staff to explicitly model controls for specific source types. An early attempt at emission point classification, prior to December 2002, led TCEQ staff to consider that a certain percentage of emissions in each portion of HGB should be subject to site-wide caps. This classification scheme is reflected in the current HGB HRVOC cap and was the best available at the time. More refined attempts at emission point classification have been made since then, and the Commission has expanded the emission point classifications beginning with the 2003 Emission Inventory Questionnaires.

In the interim, staff modeled the HRVOC totals for each area (Harris County and the Seven Surrounding Counties), as summarized by the cap rules and other fugitive reductions. Due to fundamental changes in modeling inventory speciation and inventory adjustment methodology, both described previously in this document, along with limited information on emission point types, it is not possible for staff to explicitly model the site-specific caps as published in Tables 6-2.1 and 6-2.2 of the *Post-1999 Rate-of-Progress and Attainment Demonstration Follow-up SIP for the Houston/Galveston Ozone Nonattainment Area* adopted on December 13, 2002. Therefore, modeling staff developed a method similar to that used in the published Dec. 2002 tables to approximate reductions for the areas using the current modeling inventory and terminal olefin adjustment.

Under this method, the adjusted modeling inventory was screened for account-level HRVOC totals greater than 10 tons/year. These totals were then split into what is assumed to be capped sources and non-capped sources (fugitives) according to the percentages published in the aforementioned Tables 6-2.1 and 6-2.2 (80.7% for Harris and 88.7% for the seven surrounding counties). “Control Levels” were then assigned to each account’s capped source totals according to the method used in Tables 6-2.1 and 6-2.2, i.e. 70% control for accounts with totals greater than 500 lb/hr HRVOC, 68% control for accounts with totals between 125 and 500 lb/hr HRVOC, 60% control for accounts with totals between 10 and 125 lb/hr HRVOC, and 50% control for accounts with totals less than 10 lb/hr HRVOC. A 64% reduction was applied uniformly to all remaining non-capped sources. Additionally for Control Strategy 06 (CS-06), 20 tons/day of HRVOC was removed uniformly from adjusted Harris County totals.

This method of modeling area-wide totals is similar in theory to that used to model the Chapter 101 MECT program, in which, reductions were spread over the entire geographical area since it is unknown where emissions may occur/reoccur under a system in which trading is allowed. Twenty four hour rolling average site-wide HRVOC allocations are not allowed in the HRVOC Cap and Trade system. Table 3-27 summarizes the additional HRVOC added to the modeling inventory. All reductions are from the 2000 adjusted base case modeling inventory.

Table 3-27: HGB 8-County Modeled “Extra” HRVOC Summary

HGB source	2000 Unadjusted Modeling Inventory Ozone Season Daily HRVOC (tpd)¹	2000 Adjusted Modeling Inventory Ozone Season Daily HRVOC (tpd)²	2007 Adjusted Modeling Inventory Ozone Season Daily HRVOC (tpd)
Harris County	20.6	94.4	2
Seven Surrounding Counties	10.0	46.3	12

¹Ozone season daily totals do not include Special Inventory or Region 12 Upset/Maintenance data. These totals are adjusted upward slightly due to commission application of rule effectiveness estimates.

²The “2000 Additional HRVOC” total is a subset of the additional terminal olefins included in the base case inventory non-varying adjustment, as described in the section above, and does not contain Special Inventory data fluctuations.

BPA

In the BPA 3-county area, Chapter 117 NO_x rules affect EGUs and NEGUs, with separate and distinct control packets applied to simulate these rules. No VOC controls were applied to BPA. The emission factor (EF), e.g., lb/MMBtu, for a piece of equipment is dictated by Chapter 117. In order to determine the reduction to apply to the unit from 2000, EFs from the 2000 point source inventory were needed. This information is only sometimes supplied by a company representative when completing their annual EIQ. For EGUs that are Acid Rain units, the EF can be found in the ARPDB. The third quarter 2000 (2000Q3) ARPDB was used as the basis for the EGU EFs. The simple formula

$$EF_{2007} / EF_{2000} = CF$$

provides the control factor (CF) that can be found in the control packet that was applied. See Table 3-21 for the file name. The 2007 emission rate is calculated by multiplying the 2000 emission rate (or the grown 2000 emissions) by the CF. The reduction factor (RF) from 2000 to 2007 is then

$$1 - (EF_{2007} / EF_{2000}) = RF$$

For BPA NEGUs, a similar process was used, yet there is no ARPDB for NEGUs. Instead a survey was conducted of all of the BPA NEGU units reporting more than 25 tpy of NO_x in their 2000 EIQ. These units represented 92% of the total BPA NEGU NO_x. This survey included email requests to company/account representatives for EF information for these units. Where no response was provided by a company representative, the hardcopy EIQ was searched for information that may have lead to an inferred EF. See Table 3-21 for the file name of the control packet developed as the result of this survey project. Table 3-28 is a summary of BPA NO_x reductions to estimate 2007 future year emissions. All existing Chapter 117 rule compliance dates for BPA are prior to 2007, so all 2007 CFs based on those Chapter 117 compliance EFs were modeled. No VOC reductions were modeled.

Table 3-28: BPA 3-County Modeled NO_x Emissions Reduction Summary for August 30

BPA sources	2000 NO_x OSD (tpd)¹	2000 NO_x w/SI and Acid Rain (tpd)²	2007 Modeled NO_x w/Growth (tpd)³	2007 Modeled NO_x w/Growth and Controls (tpd)
EGU	26.4	34.9	42.7	27.4
NEGU	96.6	84.3	98.2	81.9
Total	123.0	119.2	140.9	109.3

¹ typical ozone season day (emissions directly from PSDB/STARS)

² This day includes a 12 tpd NO_x NEGU decrease due to Special Inventory reporting.

³ includes the banked emissions (put into NEGU) and the newly-permitted EGUs

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

DFW

For the DFW 4-county area, a procedure very similar to the BPA approach was used to arrive at future case point source inventories. As with BPA, an EF survey was performed. Table 3-29 summarizes the 2007 DFW NO_x emissions. No VOC reductions were modeled.

Table 3-29: DFW 4-County Modeled NO_x Emissions Reduction Summary for August 30

DFW sources	2000 NO_x OSD (tpd)¹	2000 NO_x w/Acid Rain (tpd)	2007 Modeled NO_x w/Growth (tpd)²	2007 Modeled NO_x w/Growth and Controls (tpd)
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EGU	72.9	107.0	107.4	23.8
NEGU	6.9	6.9	18.3	13.1
Total	79.8	113.9	125.7	36.9

¹ typical ozone season day (emissions directly from PSDB/STARS)

² includes the banked emissions (put into NEGU) and the newly-permitted EGUs

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

East Texas Point Source Controls

EGUs were controlled (1) in the 95 attainment counties of East Texas with SB7 reductions if they have SB7 allowances, or (2) in the 31 Chapter 117 “named affected counties” with Chapter 117 NO_x reductions, if they do not have SB7 allowances. The appropriate reduction method was determined for each of the EGU accounts in Texas. The list of EGUs with SB7 allowances can be found in Appendix D and at <http://www.tnrc.state.tx.us/permitting/airperm/banking/allowreg.htm>.

For East Texas SB7 accounts, an average reduction necessary to comply with the 2007 EF was calculated and modeled, since SB7 allows trading among all of the East Texas accounts that have SB7 allowances. This East Texas average SB7 reduction from the year 2000, based on 2000Q3 ARPDB, was calculated and modeled to be 45%. The non-SB7 accounts in East Texas required reductions between 31% and 60%. Overall, the reductions in East Texas EGUs total 373.6 tpd. The reductions are represented in the control packet listed in Table 3-21. Table 3-30 represents the overall reductions modeled for East Texas.

Table 3-30: East Texas Attainment Counties Modeled NO_x Emissions Reduction Summary for August 30

E Tx sources	2000 NO _x OSD ¹ (tpd)	2000 NO _x w/ Acid Rain (tpd)	2007 Modeled NO _x w/Growth ² (tpd)	2007 Modeled NO _x w/ Growth and Controls ³ (tpd)
EGU	776.1	835.9	930.2	556.5
NEGU	382.5	382.5	408.2	413.3
Total	1158.6	1218.4	1338.4	969.8

¹ typical ozone season day (emissions directly from PSDB/STARS)

² includes TIPI-EGAS projections (put into NEGU) and the newly-permitted EGUs

³ includes the SB7/Ch117 EGU controls, the Midlothian kiln NEGU “controls”, and NEGU Agreed Orders

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

As noted in the growth discussion subsection above, the EGUs in East Texas were grown through the addition of newly-permitted EGUs. At least one EGU source reported only partial emissions in its 2000 EIQ, because the source was newly operational in 2000. Since these emissions would not be

representative of the emissions a source would be emitting in the future, the 2000 EIQ emissions were zeroed out, via the control packet, “control.midlothian.energy”, as represented in Table 3-21. Then the permit allowable emissions were modeled via the new EGU AFS file identified in Table 3-21.

Recent agreed orders and consent decrees were reviewed and Table 3-31, below, shows the sources that were affected. Control packets and an AFS file reflecting the changes dictated by these Agreed Orders and the Consent Decree are presented in Appendix D. These reductions totaled 23 tpd in East Texas and are also accounted for in Table 3-30, above.

Table 3-31: Sources Affected by Agreed Orders and Consent Decrees

Source	Number	Date	Implementation	Link
Eastman Chemical Co.	2000-0033-SIP	2000	Apr 2000-July 2002	http://www.tnrc.state.tx.us/oprdrule_lib/4regapb.pdf
Eastman Chemical Co.	2001-0880-RUL	2001	Apr 2002-May 2003	http://www.tnrc.state.tx.us/oprdr/sips/01026sip-eastman.pdf
Alcoa	Consent Decree fr24ap03-81	2003	2006 - 2007	http://www.epa.gov/compliance/resources/cases/civil/caa/alcoafs.pdf http://www.epa.gov/fedrgstr/EPA-AIR/2003/April/Day-24/a10081.htm http://www.usdoj.gov/opa/pr/2003/April/03_enrd_215.htm

West Texas Point Source Controls

As with East Texas, in the attainment counties of West Texas, EGUs were controlled with (1) SB7 reductions if they have SB7 allowances, or (2) Chapter 117 NO_x reductions, if they do not have SB7 allowances. The list of EGUs in West Texas with SB7 allowances can also be found in Appendix D and at <http://www.tnrc.state.tx.us/permitting/airperm/banking/allowreg.htm>.

For West Texas SB7 accounts, an average reduction necessary to comply with the 2007 EF was calculated and modeled, since SB7 allows trading among all of the West Texas accounts with SB7 allowances. This West Texas average SB7 reduction from the year 2000, based on 2000Q3 ARPDB, was calculated and modeled to be 49%. The non-SB7 accounts in West Texas required reductions between 28% and 43%. Overall, the reductions in the West Texas EGUs in the modeling domain total 62.9 tpd. The reductions are represented in the control packet listed in Table 3-21. No other reductions were modeled for West Texas. Table 3-32 represents the overall reductions modeled for West Texas.

Table 3-32: West Texas Attainment Counties (within the Modeling Domain) Modeled NO_x Emissions Reduction Summary for August 30

W Tx sources	2000 NO _x w/ Acid Rain (tpd)	2007 Modeled NO _x w/Growth ¹ (tpd)	2007 Modeled NO _x w/ Growth and Controls (tpd)
EGU	144.7	149.0	86.1
NEGU	116.6	117.7	117.7

Total	261.3	266.7	203.8
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¹ includes TIPI-EGAS projections (put into NEGU) and the newly-permitted EGUs

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

3.6.2 Area and Non-Road Mobile Sources

Area and Non-Road mobile source emissions were primarily derived from the 1999 periodic emissions inventory (area sources) and the 2002a version of the NONROAD model with many Texas-specific input files. The 1999 Texas PEI has been updated to incorporate many improvements developed in recent years, including use of survey-based emissions for shipping, construction, lawn and garden, locomotive, and recreational boating activities. Spatial allocation for most categories used updated LCP 2km surrogates.

Special treatment was accorded to ships, by treating them as pseudo-stacks spaced along the major waterways within the Galveston Bay region (as described in the December 6, 2000 HGB SIP revision) and now in the BPA region. New data on wildfires, also treated as point sources were used for the August 28 - September 6, 2000 modeling. This wildfire data was developed by the University of Texas at Austin. Emissions from states outside of Texas were obtained from ENVIRON, who developed 1999 and 2007 inventories for their modeling of near-nonattainment areas in Texas. The ENVIRON data was based on the NEI and NONROAD model.

During the course of EI/Ambient studies it was determined that the toluene levels in the modeling inventory were too high. Using updated speciation profiles from California Air Resources Board for solvents, and updated gasoline profiles from ENVIRON corrected this discrepancy. These new profiles reflect changes in the composition of solvents and gasoline over the years since the default profiles were developed.

When they become available, offshore emissions will be obtained from the Gulf Coast Ozone Study. Until that time, the emissions developed for the 1992 Gulf of Mexico Air Quality Study are being used. The GMAQS-based emissions will be projected to 2000 and 2007 using data obtained from the Minerals Management Service where available. Spatial surrogates for shipping lanes, developed by modeling staff, allowed offshore shipping emissions to be spatially allocated more accurately.

The primary QA method, as outlined in the QA Section of the *Photochemical Modeling QA/QC Plan*, was to divide the inventory into its separate constituents and separately process each constituent through EPS2x. Tables below summarize the data for each emissions category on a typical 2000 ozone season weekday for HGB and BPA. Each category was individually plotted to check emissions totals, as well as temporal and spatial distribution for both the 2000 base case and the 2007 future case (Tables 3-33 and 3-34).

The 2007 emissions reflect a future case before SIP controls were applied. The projections of the emissions to 2000 and 2007 for most categories were performed using NONROAD for categories covered by the model, and EGAS for most others. The projected data include both future growth in activity and federal controls in place at this time. The HGB 8-county elevated shipping files use 1997 data for 2000 and are the result of a detailed shipping emissions project reported in previous SIPs. The 2007 HGB shipping emissions are from the same contract. A new, similar set of data for 2000 and 2007 was used for the shipping in the three BPA counties (see Figure 3-9).

Table 3-33: 2000 Nonroad Category BPA 3-County Totals for a Weekday

BPA_NR00_b3b (tons/day)	BPA Non-Road Mobile NO_x	BPA Non-Road Mobile VOC
Agriculture	0.38	0.06
Aircraft	0.04	0.08
Commercial	0.36	0.53
Construction	3.71	0.69
GSE*	0	0
Industrial	1.69	0.45
Commercial Lawn+Garden	0.13	0.91
Residential Lawn+Garden	0.12	1.3
RR Maintenance	0.01	0
Logging	0.1	0.06
Locomotives	6.55	0.27
Oil+Gas	0.35	0.07
Recreational Equipment	0.03	0.82
Recreational Boating	0.19	3.56
Ships	10.75	0.31
BPA 3-County Total	24.41	9.11

*Airport Ground Support Equipment

Table 3-34: 2000 Area Source Category BPA 3-County Totals for a Weekday

BPAarea00_b2c (tons/day)	BPA Area Source NO_x	BPA Area Source VOC
Architectural Coating	0	1.57
Asphalt Paving	0	0.91
Auto Refinishing	0	0.16
Bakeries+Breweries	0	0
Drycleaning	0	0.38
Graphic Arts	0	0.03
Industrial Fuel Use	0.72	0.03
Leaking Underground ST	0	0.48
Oil+Gas Production	4.81	8.21
Open Burning	0.04	0.2
Pesticide Use	0	0.34

Petro Transport+Refueling	0	5.7
Residential Fuel Use	0.23	0.01
Solvent Use	0	4.61
Surface Cleaning	0	1.14
Surface Coating	0	1.83
Traffic Marking	0	0.06
Waste Treatment	0	0.23
BPA 3-County Total	5.8	25.89

3.6.2.1 Base Case Modeling Emissions Summary

Tileplots depicting the low-level 2000 base case input modeling files covering the 4-km domain for area and nonroad are shown in Figures 3.6-9 and 3.6-10. Note that the totals in the plots do not exactly match the tables. The plots show CB-IV Hydrocarbons, not VOC, as in the data tables. Carbon-Bond IV emissions are used internally in CAMx and differ in mass from the originally reported VOCs. In most cases, the difference is less than five percent. While the map total numbers are accurate, the county total numbers are only approximate. Second, tile plot county emission totals are based on a summing of county cell fractions and are subject to some error since the county area plots are generally limited to land area. Although emissions from lake areas are included, some emissions in the bays, which can be significant for sources such as ships, are not yet incorporated into the plotting routine. Further, a concentration of emissions near county borders also leads to some inaccuracy in the county totals on these plots as emissions in a grid cell are allocated to counties based on relative area. For example, a grid cell may be divided evenly across two counties. For the plotting routine, emissions would be allocated as if they were evenly distributed between the two counties when in reality, they might actually all be located in only one of the counties. The use of shipping lanes in the Gulf is also evident in these plots. Table 3-35 summarizes the modeled base case (Base5b) area, non-road, and shipping NO_x and VOC emissions.

Table 3-35: Base5b Model Run 2000 Weekday BPA 3-County Weekday Summary

	NO_x (tons/day)	VOC (tons/day)
Low-Level Non-Road Mobile (NR00_b3b)	12.58	8.79
2000 BPA Ships	10.75	0.31
Area Sources (area_base2c)	5.79	25.88
BPA 3-County Total	29.12	34.98

b00_3b Area Source NO_x Emissions, 08/31/2000

(2x2 Km Grid Cells)

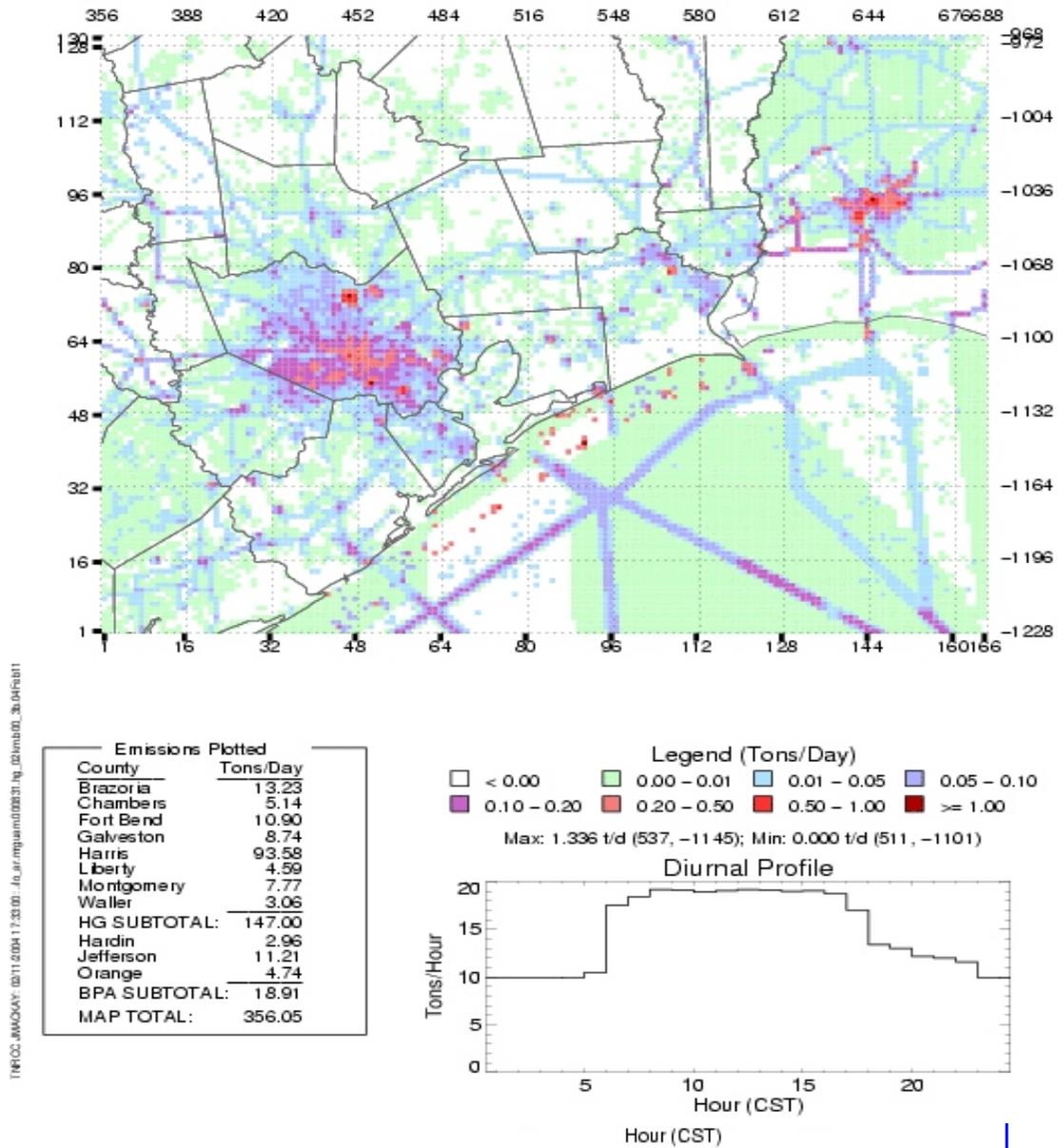


Figure 3.6-9: 2000 Low-Level Area and Nonroad NO_x Emissions Tileplot

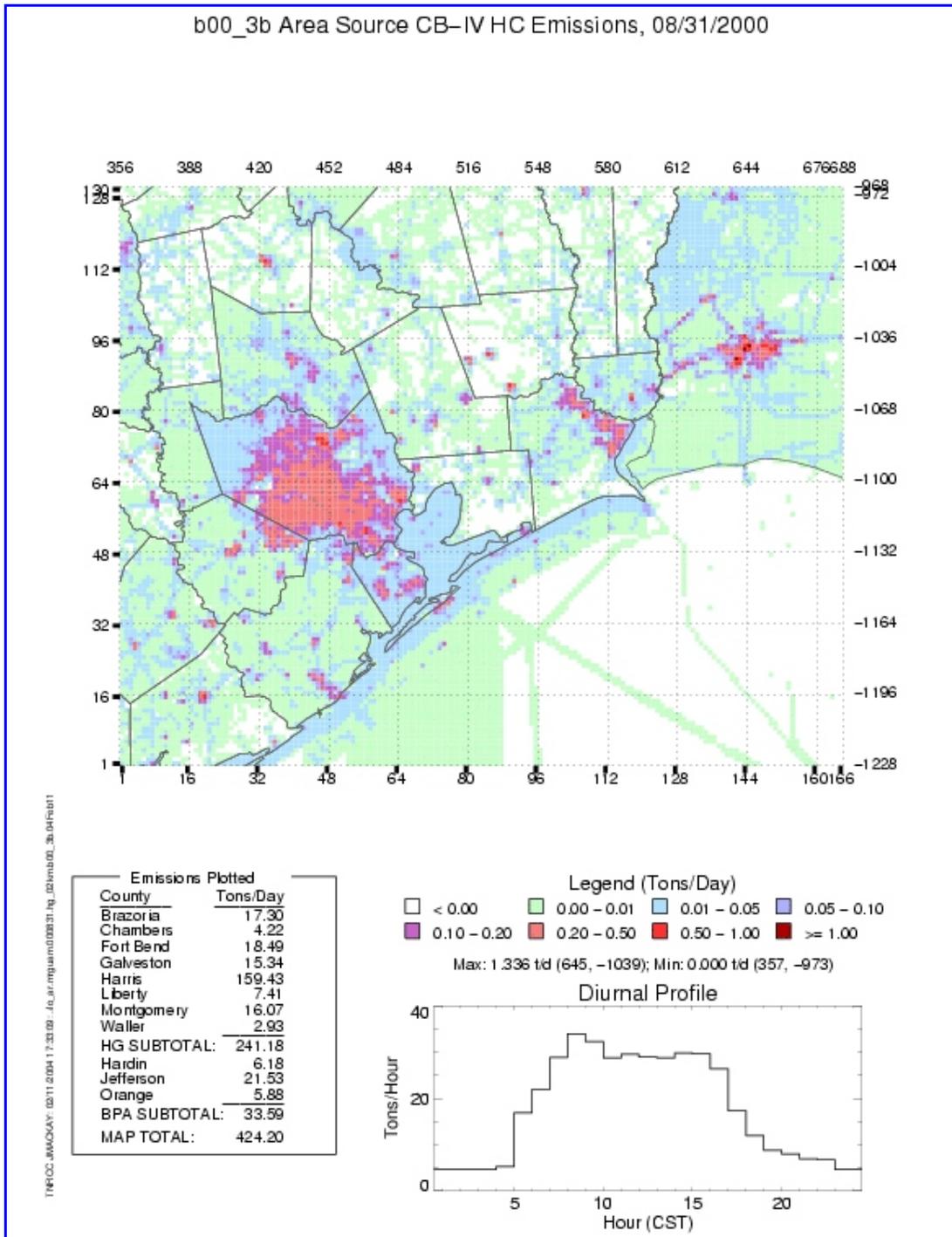


Figure 3.6-10: 2000 Low-Level Area and Nonroad VOC Emissions Tileplot

3.6.2.2 Future Case Modeling Emissions Summary

The future totals in Table 3-38 reflect the base 2007 emissions in Tables 3-36 and 3-37, the additional SIP control measures that follow and emissions to account for construction at the Golden Pass LNG facility. Low-emission diesel fuel, clean gas, and California large spark ignition rules were modeled using conventional control packets that applied to appropriate area source categories (ASC) and counties. The 2.75 tpd NO_x benefit for TERP was applied by using BPA 3-County-based factors to remove the proper total NO_x tons across the non-road section of the modeling inventory. The gas can rule was modeled statewide using a factor applied to VOC emissions for gasoline-powered equipment in the Lawn and Garden category. The Golden Pass LNG facility construction activities are included as 1.99 tpd NO_x and 0.26 tpd of VOC. In addition, 0.52 tpd of NO_x and 0.05 tpd of VOC emissions from construction at the Freeport (Brazoria County) LNG facility and 1.25 tpd of NO_x and 0.15 tpd of VOC emissions from construction at the Cheniere, Louisiana LNG facility were added.

Table 3-36: 2007 Nonroad Category BPA 3-County Totals for a Weekday Before SIP Controls

BPA07_b4b (tons/day)	BPA Non-Road Mobile NO_x	BPA Non-Road Mobile VOC
Agriculture	0.34	0.04
Aircraft	0.05	0.1
Commercial	0.39	0.43
Construction	3.24	0.46
GSE	0.01	0.01
Industrial	1.85	0.44
Commercial Lawn+Garden	0.17	0.57
Residential Lawn+Garden	0.11	0.89
RR Maintenance	0.01	0
Logging	0.06	0.04
Locomotives	7.21	0.29
Oil+Gas	0.35	0.07
Recreational Equipment	0.03	1.23
Recreational Boating	0.24	2.54
Ships	12.64	0.37
BPA 3-County Total	26.7	7.48

Table 3-37: 2007 Area Source Category BPA 3-County Totals for a Weekday Before SIP Controls

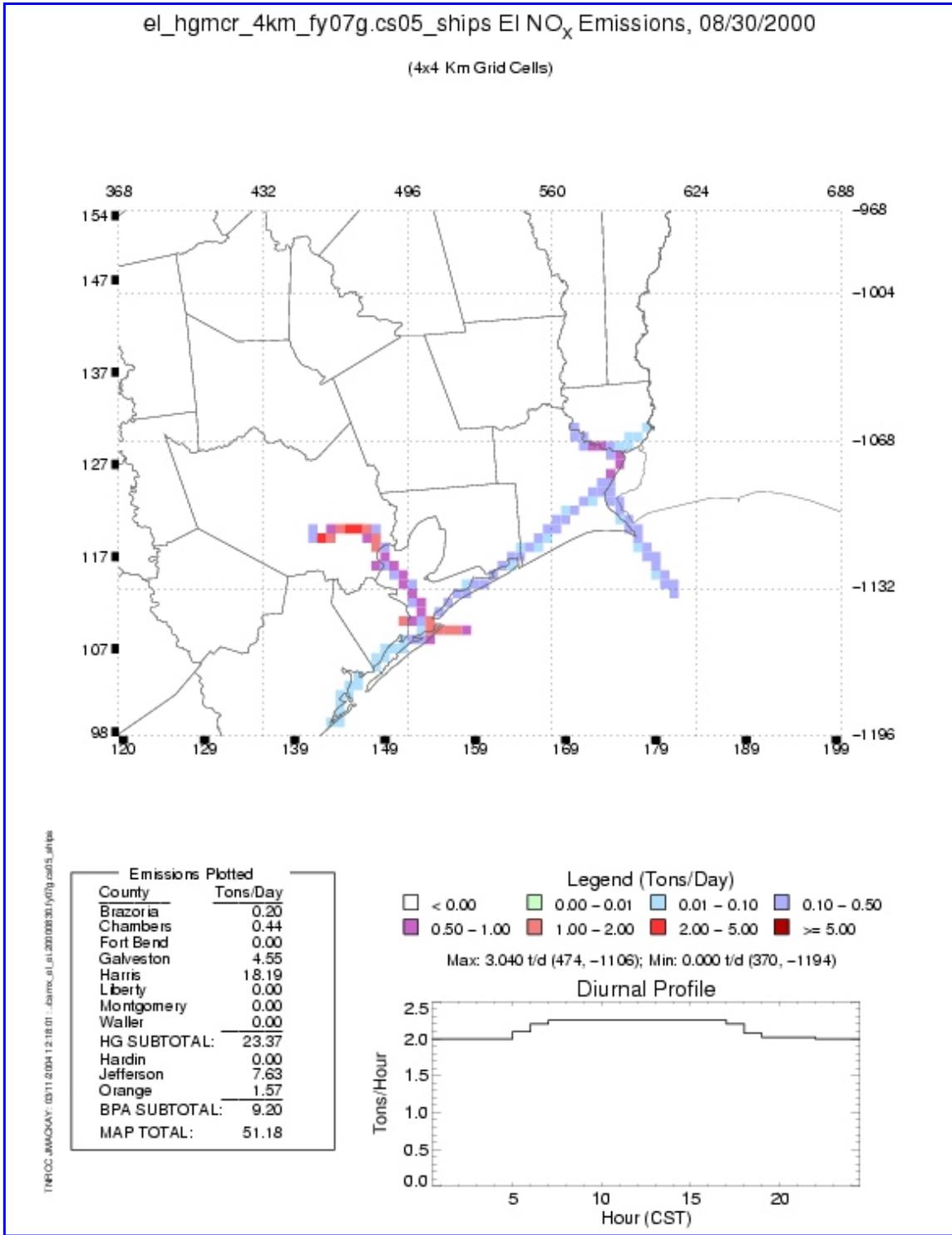
BPA07_b3 3 (tons/day)	BPA Area Source NO_x	BPA Area Source VOC
Architectural Coating	0	1.49
Asphalt Paving	0	0.96
Auto Refinishing	0	0.19
Bakeries+Breweries	0	0
Drycleaning	0	0.43
Graphic Arts	0	0.03
Industrial Fuel Use	0.81	0.03
Leaking Underground ST	0	0.56
Oil+Gas Production	8.31	7.33
Open Burning	0.04	0.27
Pesticide Use	0	0.35
Petro Transport+Refueling	0	5.43
Residential Fuel Use	0.21	0.01
Solvent Use	0	4.81
Surface Cleaning	0	1.62
Surface Coating	0	2.91
Traffic Marking	0	0.05
Waste Treatment	0	0.27
BPA 3-County Total	9.37	26.74

Table 3-38: fy07m Model Run (All SIP Controls) 2007 Weekday BPA 3-County Summary

	NO_x (tons/day)	VOC (tons/day)
Low-Level Non-Road Mobile (NR07_b4_gc)	9.92	6.42
2007 BPA ships	12.64	0.37
Area Sources (area07_b3)	9.37	26.74
Golden Pass LNG Facility	1.99	0.26
BPA 3-County Total	33.92	33.79

Figure 3.6-11, on the following page, shows the 2007 shipping emissions in the HGB/BPA domain. Note that the elevated shipping is not included in this plot.

Figure 3.6-11: Future Case Elevated Shipping NO_x Emissions Tileplot for HGB and BPA



3.6.3 On-road Mobile Sources

The purpose of this section is to provide a brief overview of the 3-county BPA nonattainment area onroad mobile source emission inventory data which were input into the photochemical model for both the 2000 base case and the 2007 future case. These inventory data were developed under contract to TCEQ by the Texas Transportation Institute (TTI). TTI couples MOBILE6.2 emission rate output with travel demand model vehicle miles traveled (VMT) data. The net result is referred to as a “link-based” inventory due to the fact that both hourly VMT and emissions estimates are developed for each roadway segment or “link”. For the 2000 base case, onroad inventories were developed in June of 2003 for Weekday, Friday, Saturday, and Sunday “day types”. For the 2007 future case, separate inventories were developed in February of 2004 for each of the following ozone episode time periods from 2000:

- August 10th to August 13th;
- August 18th to August 21st; and
- August 29th to September 6th.

Greater detail covering both the development and processing of these inventory data can be found in the following references:

- *Summary of Development and Processing of Onroad Mobile Source Inventories Used for Photochemical Modeling Efforts in Texas* (Appendix G);
- *2000 On-Road Mobile Source Modeling Emissions Inventories for the Beaumont/Port Arthur Ozone Nonattainment Area*, TTI Report (June 2003)(Appendix H); and
- *2007 On-Road Mobile Source Modeling Emissions Inventories for the Beaumont/Port Arthur Ozone Nonattainment Area*, TTI Report (February 2004) (Appendix I).

Tables 3-39 and 3-40 provide summaries of the total vehicle miles traveled (VMT), NO_x, VOC, and CO MOBILE6.2 emissions for the entire 3-county BPA area for both the 2000 base case and the 2007 future case, respectively. For the 2007 future case, the Monday-Thursday episode days have the very same VMT totals and are considered to be “average weekdays”. As expected, the Friday episodes have the highest total VMT of the week, with the Saturday and Sunday episodes having the least amount of VMT. Due to the fact that Labor Day occurred on Monday, September 4th in 2000, this holiday episode does not have a typical Weekday VMT. Instead, its overall VMT is similar to that for a typical Sunday. Even though the Friday episodes have the highest VMT of the week, the estimated NO_x emissions are actually lower on Fridays than on weekdays. This difference is due to the fact that the relative contribution of VMT from the “18-wheeler” categories (i.e., HDDV8a and HDDV8b classes from MOBILE6.2) is lower on Fridays than on weekdays. As expected for onroad mobile source inventories, total emissions decrease from 2000 to 2007. This decrease is a result of the increased penetration of tighter emissions

standards into the onroad fleet, coupled with simultaneous attrition of older more higher-emitting vehicles. Consistent with current State rules, the onroad inventories from TTI for 2007 include the benefits of Texas Low Emission Diesel (LED) fuel.

Table 3-39: VMT, NO_x, VOC, & CO Summary for 2000 MOBILE6.2 3-County BPA Inventory

Day Type	3-County VMT Total	Total Emissions (tons per day)		
		NO _x	VOC	CO
Weekday	11,963,973	54.07	20.03	258.16
Friday	13,921,965	49.46	21.89	284.73
Saturday	11,796,603	32.23	16.78	232.65
Sunday	10,095,432	22.78	14.77	209.41

Table 3-40: VMT, NO_x, VOC, & CO Summary for 2007 MOBILE6.2 3-County BPA Inventory

Day of Week	Episode Day	3-County VMT Total	Total Emissions (tons per day)		
			NO _x	VOC	CO
Thursday	August 10, 2000	11,885,906	25.27	10.03	130.42
Friday	August 11, 2000	14,106,027	23.86	11.91	156.59
Saturday	August 12, 2000	11,780,788	16.37	9.09	127.32
Sunday	August 13, 2000	9,825,913	12.05	7.54	107.44
Friday	August 18, 2000	14,106,027	24.30	12.17	158.25
Saturday	August 19, 2000	11,780,788	16.21	8.96	126.19
Sunday	August 20, 2000	9,825,913	11.57	7.59	109.56
Monday	August 21, 2000	11,885,906	25.10	9.95	131.28
Tuesday	August 29, 2000	11,885,906	25.31	10.13	131.65
Wednesday	August 30, 2000	11,885,906	25.74	10.56	132.94
Thursday	August 31, 2000	11,885,906	25.90	10.88	134.47
Friday	September 1, 2000	14,106,027	24.32	12.38	161.00
Saturday	September 2, 2000	11,780,788	16.31	9.31	127.81
Sunday	September 3, 2000	9,825,913	11.74	7.89	111.48
Monday	September 4, 2000	9,825,913	12.00	8.23	111.60
Tuesday	September 5, 2000	11,885,906	25.86	10.73	133.53
Wednesday	September 6, 2000	11,885,906	25.66	9.99	129.28

For onroad inventory descriptive purposes, Wednesday, August 30th was selected as the most representative “average weekday”. For both the 2000 and 2007 Wednesday, August 30th

inventories, Tables 3-41 and 3-42 present respective summaries of the VMT, NO_x, VOC, and CO MOBILE6 emissions for each of the three counties in the BPA area. As expected, Jefferson County accounts for roughly 60-65% of the estimated VMT, NO_x, VOC, and CO from the entire BPA nonattainment area.

Table 3-41: Summary of 2000 BPA Onroad Wednesday August 30th Inventory by County

County	VMT		Total Emissions (tons per day)		
	Total	Distribution	NO _x	VOC	CO
Hardin	1,417,616	11.85%	4.22	2.43	31.10
Jefferson	7,626,266	63.74%	36.33	12.72	163.22
Orange	2,920,091	24.41%	13.51	4.88	63.84
Total	11,963,973	100.00%	54.07	20.03	258.16

Table 3-42: Summary of 2007 BPA Onroad Wednesday August 30th Inventory by County

County	VMT		Total Emissions (tons per day)		
	Total	Distribution	NO _x	VOC	CO
Hardin	1,521,745	12.80%	2.37	1.34	16.74
Jefferson	7,388,358	62.16%	16.58	6.52	81.64
Orange	2,975,803	25.04%	6.80	2.70	34.55
Total	11,885,906	100.00%	25.74	10.56	132.94

The onroad emissions inventory data provided by TTI were prepared for input into the photochemical model using the 2x version of the Emissions Preprocessor System (EPS2x). When input into the EPS2x system, the inventory data are in a “readable” text-based format. However, once within the EPS2x system, the emissions data are in a binary format. Table 3-43 summarizes the EPS2x modules which were used to process the 3-county BPA link-based inventories.

Table 3-43: EPS2x Modules Used to Process 3-County BPA Onroad Emissions Data

EPS2x Module	Description
LBASE	“Link-Base” - Spatially allocate link emissions among grid cells
PREPNT	“Pre-Point” - Prepare stationary extended idling emissions for further processing

CHMSPL	“Chemistry Split” - Speciate emissions into NO, NO2, Paraffins, Olefins, etc.
TMPRL	“Temporal” - Apply temporal profile to extended idling emissions
CNTLEM	“Control Emissions” - Apply controls to model strategies, adjustments, etc.
CNTLHR	“Control Hourly” - Apply adjustments that vary by hour per vehicle type
GRDEM	“Grid Emissions” - Sum emissions by grid cell for photochemical model input
MRGUAM	Merge and adjust multiple gridded emission files for photochemical model input

As described above in Table 3-43, adjustments to the inventory are made with either the CNTLEM or CNTLHR modules. The CNTLEM module was used to:

- Remove 3.4% of the HDDV8a and HDDV8b (“18-wheeler”) emissions for separate processing as “extended idling” emissions in accordance with the January 2004 EPA Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity; and
- Apply benefits to accrue from January 15, 2004 EPA *Final Rule for Control of Emissions From Highway Motorcycles*.

According to the January 15, 2004 motorcycle rule referenced above, new NO_x and VOC emission standards for motorcycles are scheduled to take place beginning with the 2006 model year. According to EPA staff, these benefits have not been included in MOBILE6.2, but are expected to yield a 3.47% NO_x reduction and 2.61% VOC reduction from the 2007 motorcycle (MC) emission rate output from MOBILE6.2. Due to the fact that total motorcycle emissions are relatively low, the overall NO_x and VOC benefits for 2007 from this motorcycle rule are in the 1-2 pound range for both NO_x and VOC. Impacts due to the motorcycle are shown in Table 3-44.

Table 3-44: 3-County BPA NO_x & VOC Benefits from New Motorcycle Rule for August 30th

Calendar Year	Units Reported	NO_x Emissions	VOC Emissions
2007	Tons Per Day	0.0005	0.0011
	Pounds Per Day	1.0	2.2

The MOBILE6.2 model accounts for the effects that changes in hourly temperature and humidity have on NO_x emissions for only 6 of the 28 total vehicle types. These vehicle types are the MOBILE6.2 LDGV, LDGT1-4, and MC classes. There is no temperature/humidity NO_x correction for the remaining 22 vehicle classes, which include all 13 of the diesel-powered vehicles and the 9 heavy-duty gasoline vehicle classes. Under contract to HARC, ENVIRON worked with the Southwest Research Institute (SwRI) to develop temperature/humidity NO_x correction equations to apply to both the 13 diesel and 9 heavy-duty gasoline vehicle classes in MOBILE6.2. These equations reflect the fact that as ambient temperature increases, tailpipe NO_x emissions increases. However, as ambient humidity increases, tailpipe NO_x emissions decrease. Greater detail on the development of these correction equations can be found in the following references:

- *Humidity and Temperature Correction Factors for NO_x Emissions From Diesel Engines*, Environ/SwRI Report (June 2003) (Appendix J); and
- *Humidity and Temperature Correction Factors for NO_x Emissions From Spark Ignited Engines*, Environ/SwRI Report (October 2003) (Appendix K).

Part of ENVIRON's work was to develop the CNTLHR module referenced above in Table 3-43, which allows the user to apply a different NO_x, VOC, and/or CO correction for each different hour, episode day, county, and vehicle type combination. TCEQ staff developed custom software code which calculates the appropriate CNTLHR adjustment factors for each vehicle type by obtaining hourly inputs for temperature, relative humidity, and barometric pressure data for each county and episode day combination. The hourly temperature, relative humidity, and barometric pressure inputs used by the SAS code are the same ones used by TTI in its development of both the 2000 and 2007 BPA onroad inventories. These meteorological data were obtained from National Weather Service and TCEQ monitors in the BPA area during the August 10 - September 6, 2000 time period.

Tables 3-45 and 3-46 are 2000 and 2007 summaries, respectively, of this correction procedure by county for the Wednesday August 30th episode day. (This correction factor was actually applied to all episode days.) Within each county, more NO_x is reduced during the overnight and early morning hours when the temperature is at its minimum and the relative humidity is at its maximum. However, during the hottest hours of the afternoon when the relative humidity is at its lowest, the temperature/humidity NO_x correction either decreases NO_x very slightly or increases it somewhat, depending upon the specific conditions for that hour. Overall, the temperature/humidity NO_x correction procedure allows not only for improved estimates of the total onroad NO_x emissions, but also for improved spatial and temporal allocation of those emissions. Greater detail on this correction procedure can be found in Appendix G.

Table 3-45: Summary of Temperature/Humidity NO_x Correction by County for 2000 Inventory

County	NO _x Emissions (tons per day)			
	Input	Output	Difference	Change
Hardin	4.22	4.03	-0.19	-4.46%
Jefferson	36.31	34.13	-2.18	-6.01%
Orange	13.51	12.63	-0.88	-6.51%
3-County Total	54.04	50.79	-3.25	-6.02%

Table 3-46: Summary of Temperature/Humidity NO_x Correction by County for 2007 Inventory

County	NO _x Emissions (tons per day)			
	Input	Output	Difference	Change
Hardin	2.33	2.24	-0.09	-3.99%
Jefferson	16.42	15.54	-0.89	-5.40%
Orange	6.97	6.54	-0.43	-6.18%
3-County Total	25.73	24.32	-1.41	-5.48%

Based on a September 27, 2001 EPA Memorandum entitled *Texas Low Emission Diesel (LED) Fuel Benefits*, a 4.8% NO_x LED benefit should be claimed for 2002-and-newer diesel vehicles, while a 6.2% NO_x LED benefit should be claimed for 2001-and-older diesel vehicles. In order to determine the specific LED adjustment factors which should apply to each of the 13 diesel vehicle types from MOBILE6.2, TCEQ staff performed MOBILE6.2 runs for the BPA area to determine both VMT and NO_x emission rates by model year. By using these data, the 4.8% and 6.2% reduction factors were weighted according to NO_x model year contributions for each vehicle type. The resulting LED adjustment factors and benefits for 2007 are summarized in Table 3-47. These LED factors were incorporated by TTI into the onroad inventories by post-processing the MOBILE6.2 diesel NO_x emission rates. Please note that the LED rule does not go into effect until 2005 and thus, does not apply to the 2000 onroad inventory.

Table 3-47: LED Fuel NO_x Adjustments Applied to 2007 Onroad BPA Inventory

Diesel Vehicle Type	2007 LED Adjustments		
	NO _x Reduction	Adjustment Factor	Benefit (tons per day)
LDDV	6.11%	0.9389	0.0004
LDDT12	6.20%	0.9380	0.0002
HDDV2b	5.43%	0.9457	0.0208
HDDV3	5.05%	0.9495	0.0106
HDDV4	5.28%	0.9472	0.0075
HDDV5	5.47%	0.9453	0.0053
HDDV6	5.37%	0.9463	0.0263

HDDV7	5.50%	0.9450	0.0185
HDDV8a	5.67%	0.9433	0.0823
HDDV8b	5.99%	0.9401	0.6862
HDDBT	5.57%	0.9443	0.0146
HDDBS	5.82%	0.9418	0.0185
LDDT34	5.82%	0.9418	0.0006
Total Diesel	5.59%	0.9441	0.8918

EPA issued a document in January 2004 entitled *Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity*. This EPA guidance states that “extended idling” emissions account for 3.4% of the total emissions calculated with MOBILE6.2 for the HDDV8a and HDDV8b vehicle classes. As previously stated, TCEQ used the CNTLEM module to remove 3.4% of the hourly NO_x, VOC, and CO emissions from the link-based “running” emissions prepared for photochemical model input from the HDDV8a and HDDV8b classes. Using a combination of custom written SAS and UNIX code, these extended idling emissions from each hour were grouped into a BPA 3-County 24-hour total and spatially assigned to known truck stop locations. The extended idling emissions were then processed through EPS2x as if they were stationary low-level point sources. The emissions were temporally allocated as the inverse of HDDV8a/HDDV8b VMT. Consequently, more of the extended idling emissions were allocated during overnight hours rather than daytime hours. The extended idling emissions were also run through the CNTLHR module to receive a temperature/humidity NO_x correction. Provided in Tables 3-48 and 3-49 are summaries of the total NO_x, VOC, and CO extended idling emissions for both the 2000 and 2007 Wednesday, August 30th episode days, respectively.

Table 3-48: 2000 HDDV8a & HDDV8b “Extended Idling” Emissions for 3-County BPA Area

County	Total Emissions (tons per day)		
	NO _x	VOC	CO
Hardin	0.00	0.00	0.00
Jefferson	0.38	0.01	0.03
Orange	0.66	0.01	0.05
3-County Total	1.04	0.02	0.08

Table 3-49: 2007 HDDV8a & HDDV8b “Extended Idling” Emissions for 3-County BPA Area

County	Total Emissions (tons per day)		
	NO _x	VOC	CO
Hardin	0.00	0.00	0.00
Jefferson	0.15	0.01	0.03
Orange	0.26	0.01	0.05
3-County Total	0.41	0.02	0.08

Provided in Tables 3-50 and 3-51 are summaries of the Wednesday, August 30th onroad emissions inventories input into the photochemical model for both 2000 and 2007, respectively. These onroad

inventories are combinations of both idling emissions (as summarized above in Tables 3-48 and 3-49 and “running” emissions. The temperature/humidity NO_x correction has been applied as summarized in Tables 3-50 and 3-51.

Table 3-50: 2000 Onroad Mobile Source Inventory for Wednesday, August 30th Episode Day

3-County BPA Area	Total Emissions (tons per day)		
	NO _x	VOC	CO
Hardin	4.03	2.43	31.09
Jefferson	34.13	12.71	163.15
Orange	12.63	4.88	63.83
3-County Total	50.79	20.02	258.08

Table 3-51: Final 2007 Onroad Inventory by County for Wednesday, August 30th Episode Day

3-County BPA Area	Total Emissions (tons per day)		
	NO _x	VOC	CO
Hardin	2.24	1.34	16.74
Jefferson	15.54	6.51	81.63
Orange	6.54	2.70	34.60
3-County Total	24.32	10.55	132.98

For the 2007 inventory, additional post-processing adjustments were necessary to model the on-road inventory benefits to accrue from TERP. The TERP program benefit was 0.25 tpd NO_x for the 3-county BPA area.

3.6.4 Biogenic Sources

3.6.4.1 Input Data for Biogenic Emissions Modeling

Land Cover Data

Land cover and vegetation data for the biogenic emissions modeling was developed by a study described in Wiedinmyer et al., 2001.

Temperature Data

Temperature measurements were obtained from several different monitoring networks. Networks were chosen if they had acceptable QA procedures in place, and data were available for the time period of interest. Differences in sensor height among the temperature networks are usually not an issue during hot summer days, when vigorous mixing leads to small temperature gradients, but they might be an issue during dry, cool, still conditions when larger temperature gradients might occur near the ground.

Data from the following networks were used: TCEQ network, Aerometric Information Retrieval System, National Weather Service network, Texas Crop Weather Program, Conrad Blucher Institute Texas Coastal Observation Network, and National Automated Buoy Data network. Overall, data from over 100 stations were used.

The statistical technique of kriging was used to interpolate temperature measurements, thus creating a temperature field for each hour of the chosen episode. Vizuete et al. (2002) found that kriging is one of the most effective temperature interpolation methods for the purpose of creating biogenic emission model inputs. Kriging takes into account the tendency of neighboring observations to be more alike than those that are far apart. The function that describes the average similarity of any two observations as a function of distance is called the semivariogram. Because there was considerable variability in the semivariograms calculated for different times of day, unique semivariograms were estimated for each hour. Specifically, a power function was fitted to each hourly semivariogram, and the fitted power function was used in the kriging algorithm. Therefore, each hour had a different semivariogram as the basis of the interpolation. The SAS© software kriging algorithm was used in this application. Temperature fields were calculated for each hour at three different spatial resolutions: 4 km x 4 km grid cells, 12 km x 12 km, and 36 km x 36 km. The different grids were nested within each other, and were configured to match the photochemical modeling domains.

Data from a temperature site not used in the interpolations were compared to the temperature field values at that location. The Soil Climate Analysis Network (SCAN) site used in the comparison was located at Prairie View A&M University, in Waller County, Texas (Natural Resource Conservation Service, 2004). The Prairie View site is operated by the Soil Climate Analysis Network, and collects data on behalf of the National Water and Climate Center, an agency within the Natural Resource Conservation Service in the U.S. Department of Agriculture. Figure 3.6-12 shows a time series of the interpolated temperatures and the measured temperatures. The time series indicates that the interpolated temperatures generally depict the diurnal variation of temperature at the site reasonably well. It also shows that the overnight temperatures were generally overestimated, and the maximum temperatures, especially on very hot days, were sometimes underestimated. A scatterplot of the same data (Figure 3.6-13) shows a high degree of correlation ($r^2 = 0.94$) between the measured and modeled values. The 1:1 line indicates that the interpolation overestimates temperatures on the low end, but generally depicts the higher temperatures (i.e., $>30^\circ\text{C}$) relatively well. Since the higher temperatures are more important in biogenic emissions, the temperature interpolation seems to be a sound method for estimating temperatures for biogenic emissions modeling.

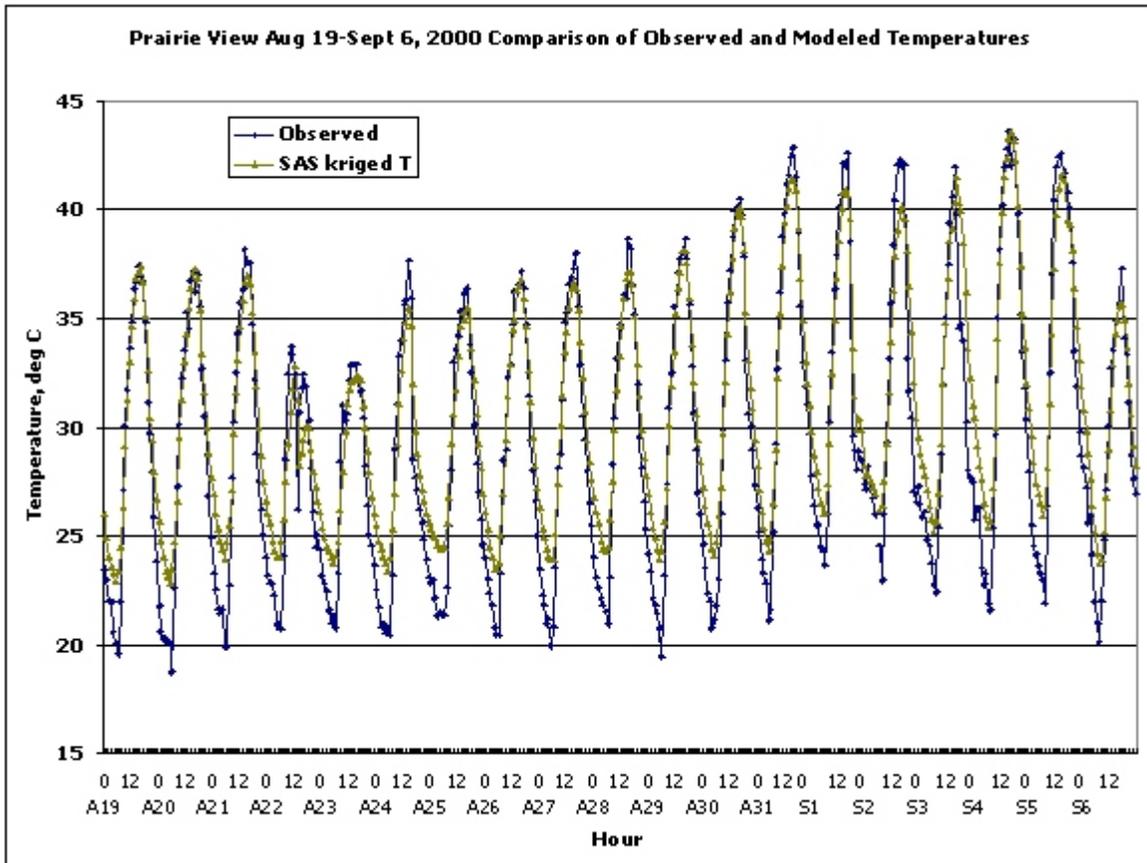


Figure 3.6-12: Time Series Comparison of Observed and Interpolated Temperatures (The Prairie View site was not included in the data set used to create the interpolated temperature field)

Photosynthetically-active Solar Radiation Data

Photosynthetically-active solar radiation (PASR) is defined as visible radiation with wavelengths between 400 nm - 700 nm. Biogenic emissions modeling requires input of hourly PASR fields that extend over large domains. Interpolation of surface measurements is unlikely to yield a satisfactory field, given the heterogeneous nature of clouds, and the comparative rarity of PASR measurements.

Meteorological models can generate PASR fields, but sometimes generate spurious clouds, which would greatly affect the PASR field. Therefore, hourly PASR fields were created using algorithms developed by Pinker et al., 2003, and input data from the GOES8 satellite. Cloud cover estimates from satellite imagery were fed into the radiation balance algorithm(s) to create a large-scale field of PASR. High resolution PASR fields were created from $0.0625^\circ \times 0.0625^\circ$ solar field data for August 28 - September 6, 2000, but lower resolution $0.5^\circ \times 0.5^\circ$ solar data was used for August 10 - 13, 2000, because the higher resolution data were not available.

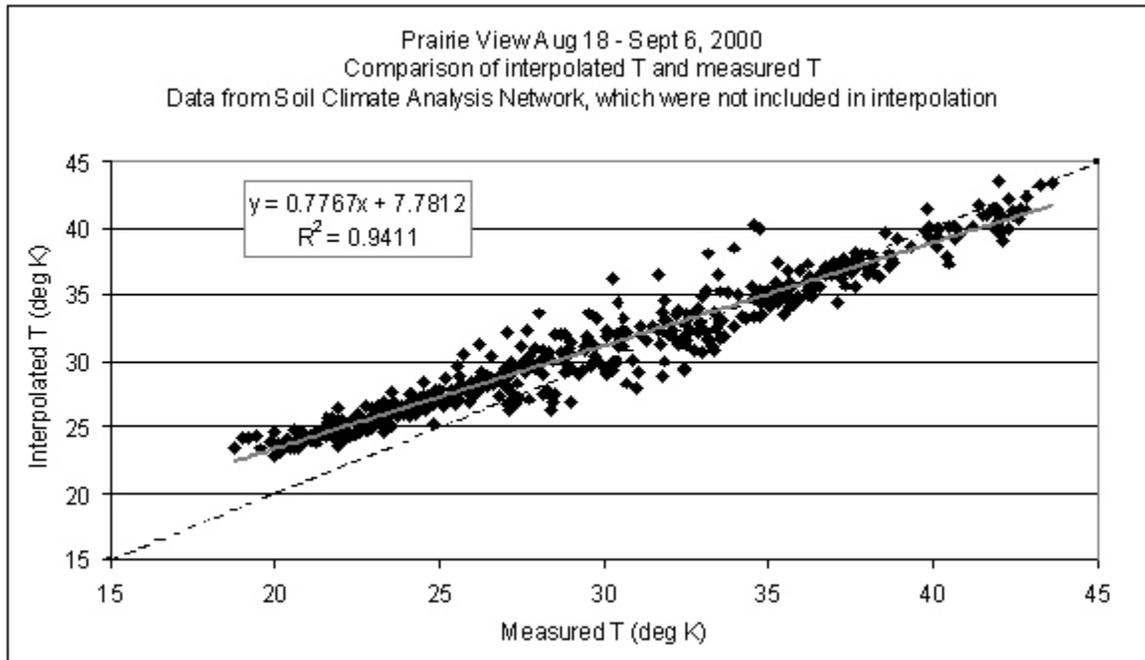


Figure 3.6-13: Scatterplot of Observed and Interpolated Temperature Data for the Prairie View Site (Dashed line represents the 1:1 line; grey line is the regression line)

Comparisons between GOES-derived PASR fields and ground-based broadband solar radiation measurements found very high degrees of correlation. Correlations for TCEQ sites ranged from 0.94 to 0.97, with slopes ranging from 0.47 to 0.53, indicating that PASR comprised approximately 50% of broadband solar radiation (i.e., 20 nm - 2000 nm). Figures 3.6-14 and 3.6-15 show an example of the time

series and scatterplot comparisons between the GOES-derived PASR values and broadband solar radiation measurements at the TCEQ Bayland Park monitoring site.

The nearest direct measurements of PASR at a ground station were at Goodwin Creek, Mississippi, at a NOAA monitoring site. Since that site is located outside the 4 km modeling domain, the comparisons of GOES-derived data and ground observations for that site are not very useful.

3.6.4.2 Biogenic Emissions Model

The model used in the current scenario is GloBEIS. GloBEIS was originally developed by Alex Guenther at the National Center for Atmospheric Research (Guenther et al., 1995; Guenther et al., 1997; Guenther et al., 1999). Guenther et al. developed the original algorithms for the BEIS family of biogenic emissions models (Guenther et al., 1993; Geron et al., 1994), and developed GloBEIS originally as a research-grade model. TNRCC commissioned Guenther and the model developers at ENVIRON in 1999 to adapt this model for photochemical grid modeling, so that the latest developments in the field of biogenic emissions could be swiftly incorporated into TNRCC's ozone episode modeling. Since then, the model has been revised several times to incorporate new features, and to update the VOC speciation.

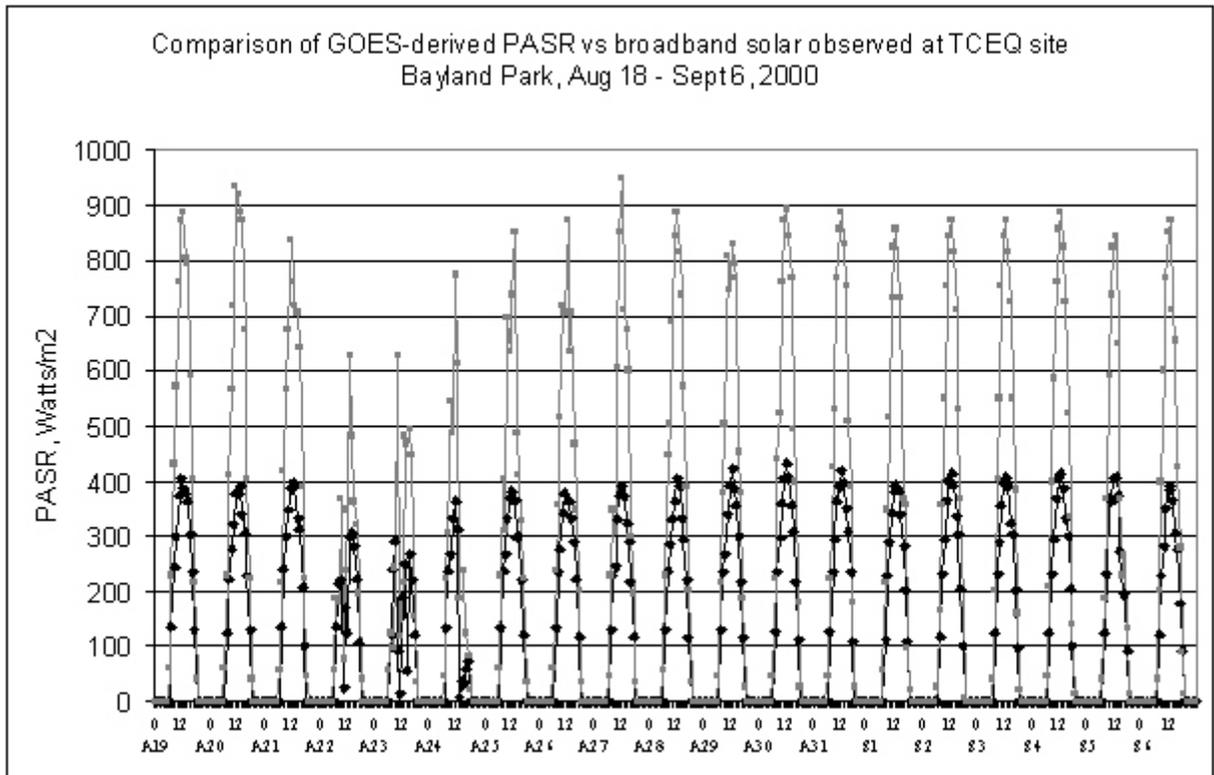


Figure 3.6-14: Time Series Comparison of Satellite-derived Photosynthetically-active Solar Radiation Data and Observed Broadband Solar Data at the TCEQ Bayland Park Monitoring Site in Houston

For the base case modeling runs, TCEQ has run the model in default model, using the GloBEIS3 algorithms. None of the special algorithms (variable leaf area index, variable leaf age, drought index, leaf temperature, or antecedent temperature) have been invoked for the standard runs.

Figure 3.6-16 shows how the biogenic emissions vary among the episode days. Emissions are presented in their form before they have been converted to Carbon Bond 4. The speciation process usually changes the mass, which is why the subsequent tileplot figures show different values. Figure 3.3-17 shows the spatial distribution of biogenic VOCs emitted during August 25, the temporal variation in emissions, and the daily total for each county in southeast Texas. Figure 3.6-17 shows only the 4km domain. Figure 3.6-18 shows the same for biogenic NO_x. Figures 3.6-19 and 3.6-20 show the spatial distribution for the 12km domain for August 25. Additional tileplots can be found at the TCEQ website, and in Appendix L.

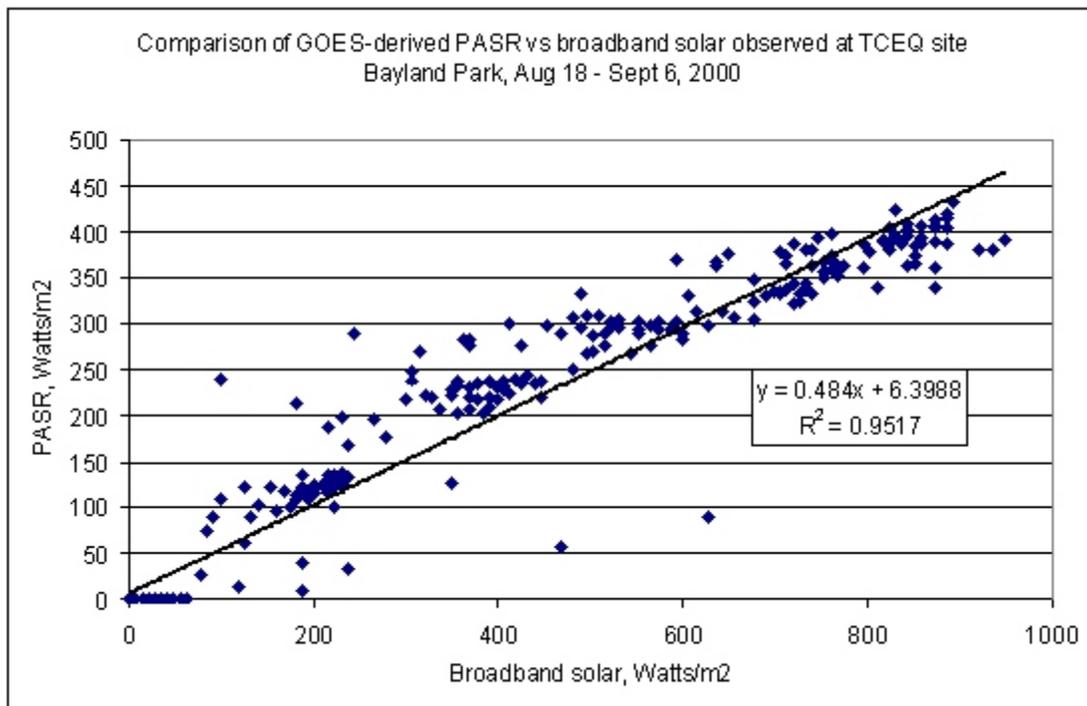


Figure 3.6-15: Scatterplot of Satellite-derived Photosynthetically-active Solar Radiation (PASR) vs. Observed Broadband Solar Radiation

hgba_04km Biogenic CB-IV HC Emissions, 08/25/2000

(4x4 Km Grid Cells)

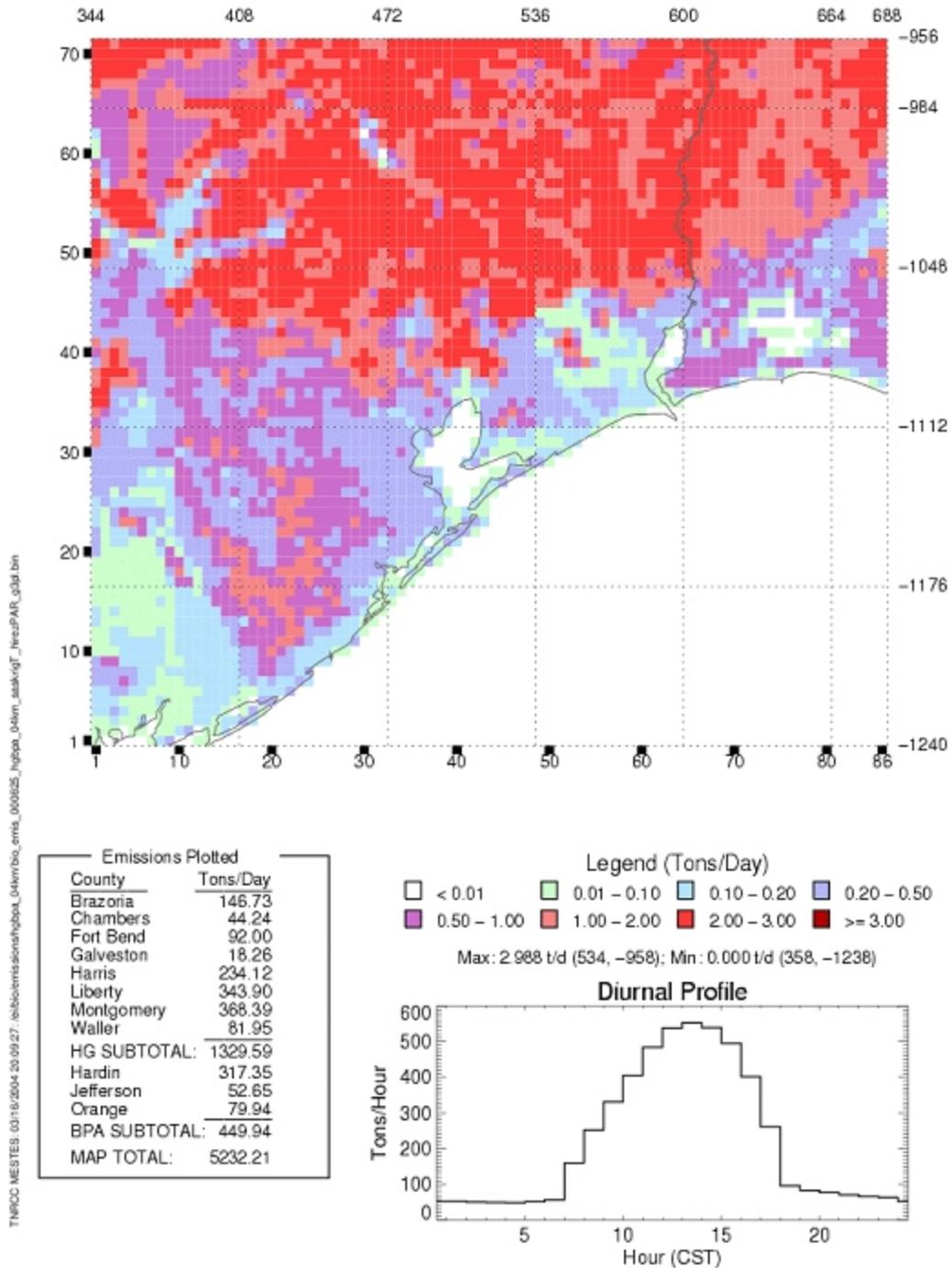


Figure 3.6-17: Spatial Distribution of Biogenic VOC Emissions, August 25, 2000, 4km Domain

hgba_04km Biogenic NO_x Emissions, 08/25/2000

(4x4 Km Grid Cells)

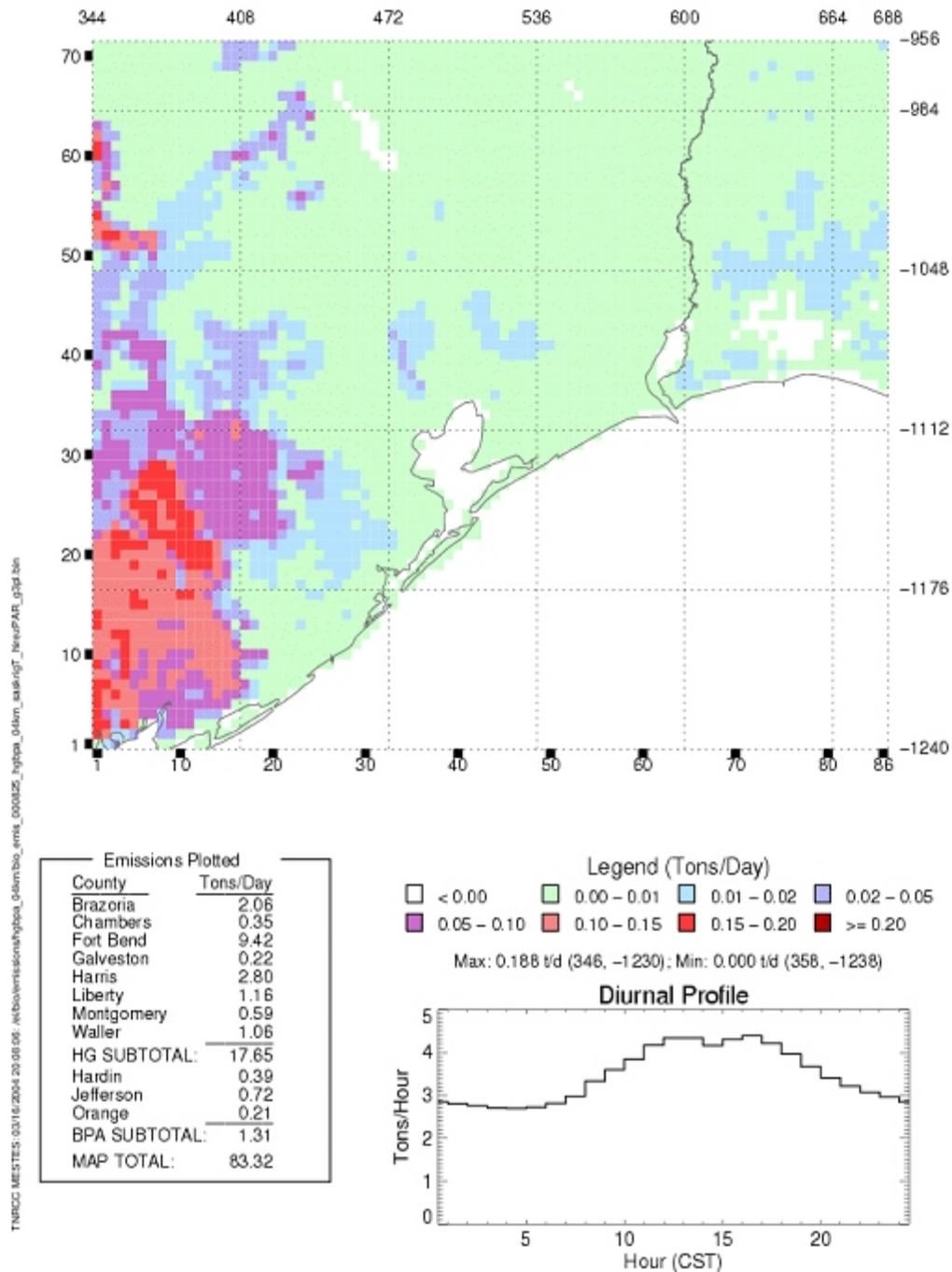


Figure 3.6-18: Spatial Distribution of Biogenic NO_x Emissions, August 25, 2000, 4km Domain

etx_12km Biogenic CB-IV HC Emissions, 08/25/2000

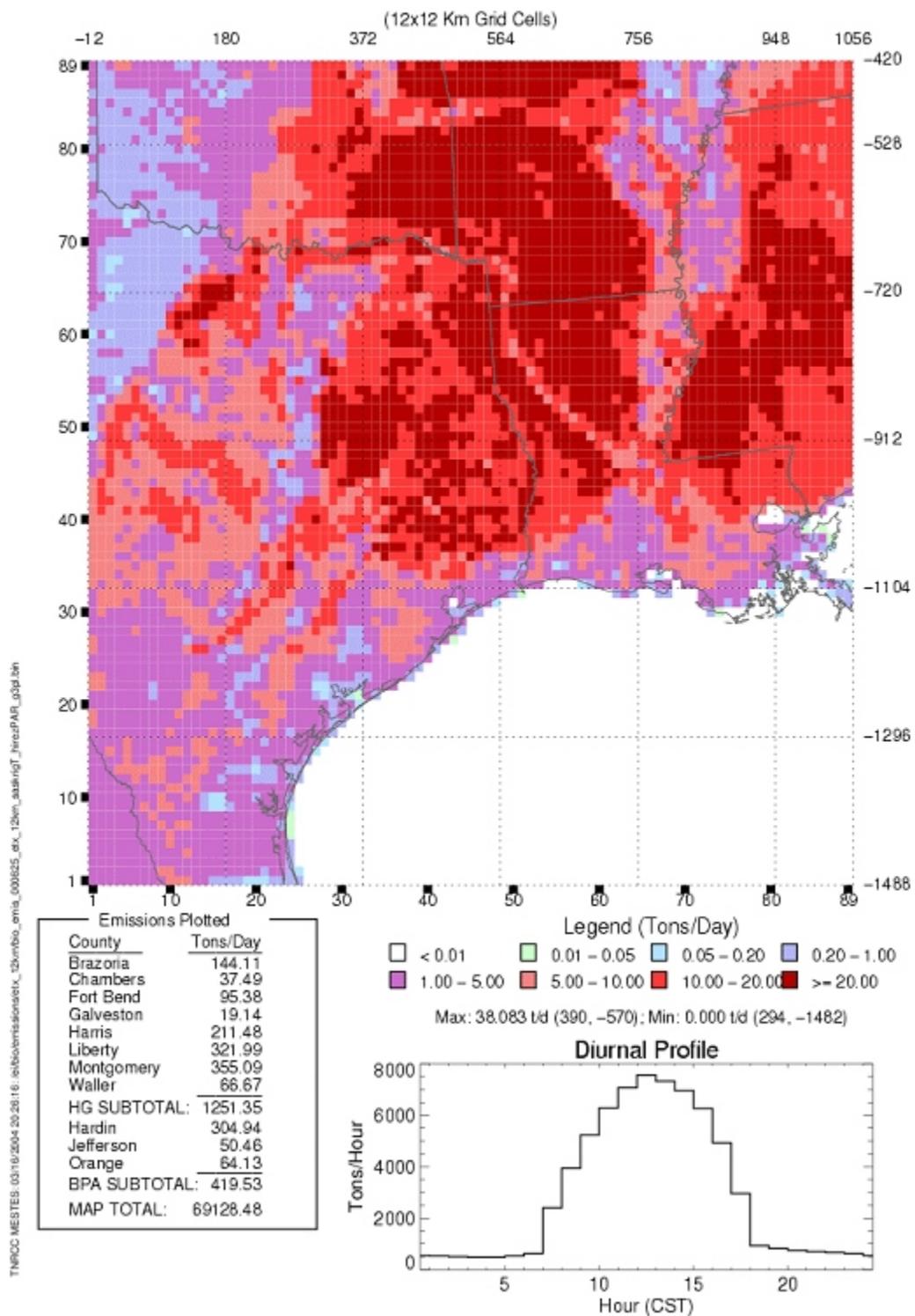


Figure 3.6-19: Spatial Distribution of Biogenic VOC Emissions, August 25, 2000, for 12km Domain

etx_12km Biogenic NO_x Emissions, 08/25/2000

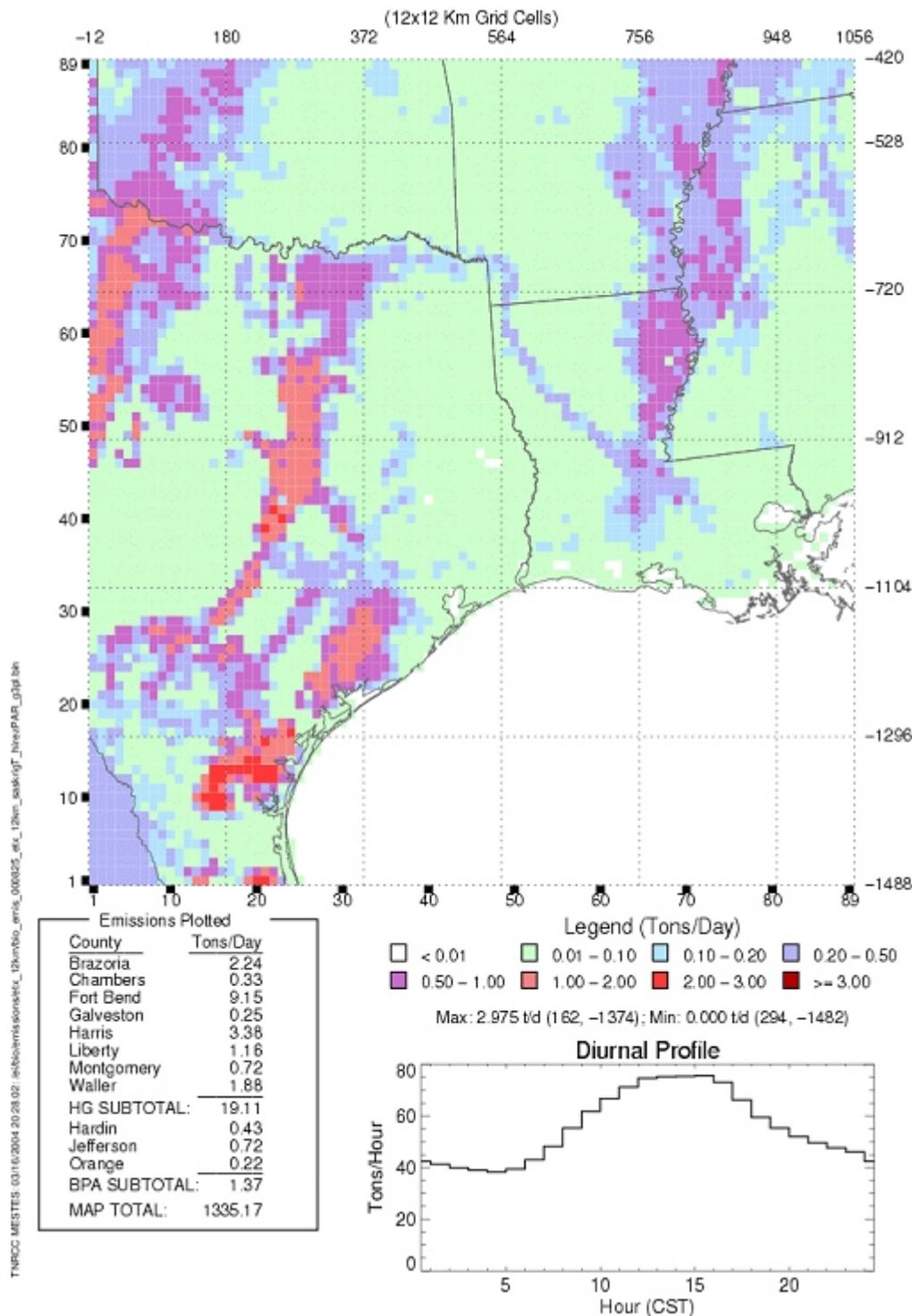


Figure 3.6-20: Spatial Distribution of Biogenic NO_x Emissions, August 25, 2000, for 12 Km Domain

Note: It should be noted that there are uncertainties associated with the development of biogenic emissions estimates. However, every component of these estimates, from the enhanced land use data, to the improved photosynthetically active solar radiation data, to the GloBEIS3 model is current state of the science and goes well beyond traditional, default methods of biogenic emissions estimates. Nevertheless, TCEQ is still committed to improving knowledge of biogenics, and will certainly study this issue in more detail during the Texas Air Quality Study II, scheduled for 2005-2006.

3.7 BASE CASE MODEL PERFORMANCE EVALUATION

After the development of the meteorological fields and gridded emissions inventory, both components were fed into CAMx in order to assess the model's ability to replicate ozone measured during each episode. The model must show reasonable performance for each base case episode before the meteorological data for the episode are used with the future year emissions inventory to assess future control strategies.

The photochemical model predicts a volumetric 1-hour average over the whole grid cell. Monitoring data provides a measure of air quality at a specific point in space. To provide an accurate comparison with model predictions, the monitoring data would have to be transformed into volumetric 1-hour averages over the same grid cells used in the model. However, monitoring networks are not dense enough to provide this information even for the most intensive studies that have been performed. Thus, comparison between the model's volumetric predictions and the monitored point measurements are the only recourse. This comparison can provide insight into model prediction trends but does not provide precise measures of model performance. Additional information on specific procedures is found in EPA's UAM modeling guidelines (U. S. EPA, 1991), and in EPA's draft 8-hour modeling guidance which is available at EPA's Support Center for Regulatory Air Models (SCRAM) website (U. S. EPA, 1999).

It should be noted that for the assessments of 8-hour and 1-hour predictions for future years, discussed in Section 3.8, we employ the use of "relative reduction factors", a procedure that accounts for underpredictions and overpredictions in base case modeling. Draft EPA 8-hour modeling guidance requires that the model be used in a relative fashion, and we use this technique for both 8-hour and 1-hour modeling. Ratios of base case to future case model response, called relative reduction factors, are tied to station design values, and the model is used to determine the relative response of the model to control scenarios. Again, this is more fully discussed in Section 3.8.

3.7.1 Graphical Methods

Graphical displays comparing predicted to observed concentrations can provide information on model performance. The following techniques were used for days subsequent to the ramp-up day(s):

- Time-Series Plots - For each monitoring station in the domain and for each hour in the episode, the monitored concentration was compared with the modeled concentration (interpolated from the four grid cell centers nearest the monitor). This comparison determined whether the model predicted the peak concentrations and if the timing of ozone generation in the model agreed with that found with the monitoring. Modeled concentrations are compared with data from monitoring sites, which are specific points in space; therefore, it should not be expected that agreement would be excellent. Time series plots including the nine-cell minimum and maximum modeled concentrations were produced to account for some of the inherent incommensurability between measurements and modeled concentrations;
- Surface-Level Isopleths - For selected hours, surface-level isopleths (lines of equal concentration) were developed. This approach shows how the model is predicting the extent, location, and magnitude of ozone formation. This information, too, can be compared to monitoring results;
- Scatter Plots - Scatter plots of predictions compared to observations depict the extent of bias in the ensemble of hourly data pairs. Systematic positioning of data points around the perfect correlation line indicates bias. The distribution of points over the area is an indication of error. This procedure also indicates outlier pairs; and
- Animations - Model output was rendered into an animated sequence showing the formation and transport of ozone (and its precursors) throughout each episode. These animations were compared to the conceptual model developed for both episodes to assure that the model replicated the commission's understanding of the process. These animations are not part of this Chapter, but may be seen by contacting the commission.

3.7.2 Statistical Methods

These methods can provide a quantitative measure of model performance. The results must be considered carefully, especially in cases where there are not a large number of monitors. EPA recommends the following statistics for use in evaluating performance of the model for 1-hour analyses (U. S. EPA, 1991):

- Unpaired Highest-Prediction (Peak Domain Maximum) Test - This measure compares the difference between the highest observed value and the highest predicted value found over all hours and over all monitoring stations. This comparison was made for both 1-and 8-hour peak ozone concentrations. EPA guidance indicates that the acceptability benchmark for this test should be $\pm 15\text{-}20\%$;
- Normalized Bias Test - This test measures the model's ability to replicate observed patterns. Since there are many time periods when relatively low levels of ozone are predicted and statistics from these periods are not very meaningful, this test was limited to 1-hour data pairs where the

observed concentration was greater than 0.060 parts per million (ppm). This threshold is notably above the naturally occurring ozone background value of 0.040 ppm. The acceptability benchmark for this test is $\pm 5-15\%$; and

- Gross Error Test - This test compared the differences between all pairs of predictions and observations that are greater than 0.060 ppm. This examination is a measure of model precision. For gross error, the acceptability benchmark is 30-35%.

3.7.3 Base Case Performance Evaluation Results

3.7.3.1 August 10-13, 2000 Episode - 1-hour Performance

For the August 10 - 13, 2000 episode, statistics and graphics were developed to evaluate model performance. Table 3-52 shows results for the statistical criteria, while Figures 3-21 through 3-23 show the graphical analyses.

Table 3-52: 1-hour Performance Statistics for August 10 - 13, 2000 Episode

Date	Unpaired peak accuracy (± 15-20%)	Bias (± 5-15%)	Gross error (30-35%)	Max observed ozone (ppb)	Max predicted ozone (ppb)
8/10/2000	-30.1	-13.4	14.8	120.0	83.9
8/11/2000	5.2	-3.6	18.2	107.0	112.5
8/12/2000	-4.3	-6.0	16.3	126.0 (CAMS28)	120.6
8/13/2000	-7.9	-8.3	14.6	102.0	93.9

Although the unpaired peak benchmark was not met on August 10, this was a ramp-up day and not an episode day. Otherwise, the model meets EPA statistical benchmarks on August 12 and 13, which are the primary days of interest. Although CAMx was not able to replicate the 1800 spike on August 12, it did replicate the rise and fall of ozone at Port Arthur West. Scatter plots of predicted vs observed ozone for CAMS28 show that although predictions overall were low, the correlation is acceptable. The time series at CAMS28 for this episode is shown in Figure 3.7-21 and the scatter plot is Figure 3.7-22. A modeled ozone isopleth plot for August 12, shown in Figure 3.7-23, indicates the model performance produced higher ozone over Sabine Lake, and along the coast.

It should be noted that the maximum predicted ozone listed in the performance statistics tables may not agree with the maximum predicted ozone shown in the tile plots. This is because the ozone values shown in tables are “masked out” of the grid cells found within the 3 county area, while the tile plots show ozone (and the maximum ozone) over the entire plot “domain.”

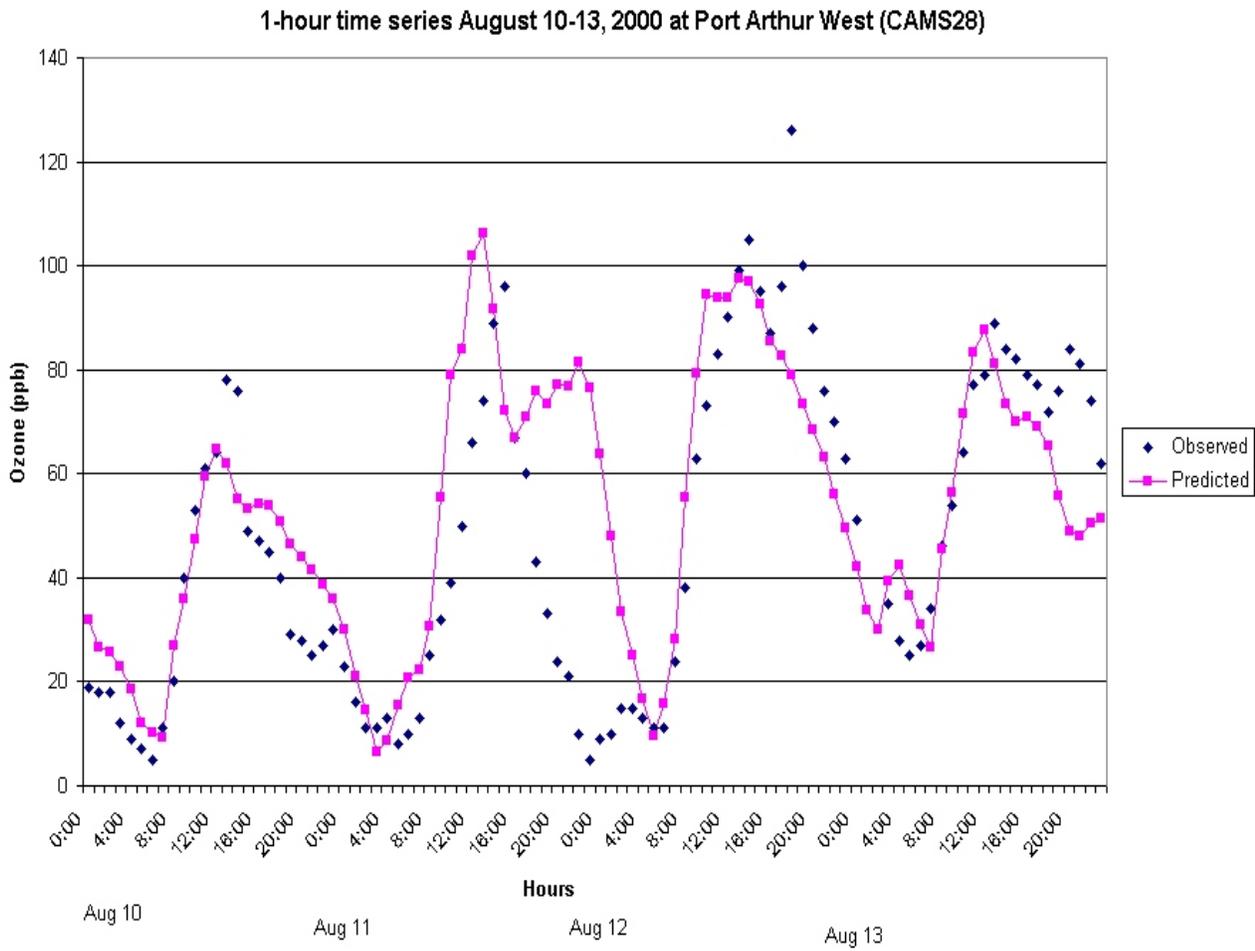


Figure 3.7-21: 1-hour Time Series of Ozone Predictions vs Observations at Port Arthur West (CAMS28)

1-hour scatter August 10-13, 2000 at Port Arthur West (CAMS28)

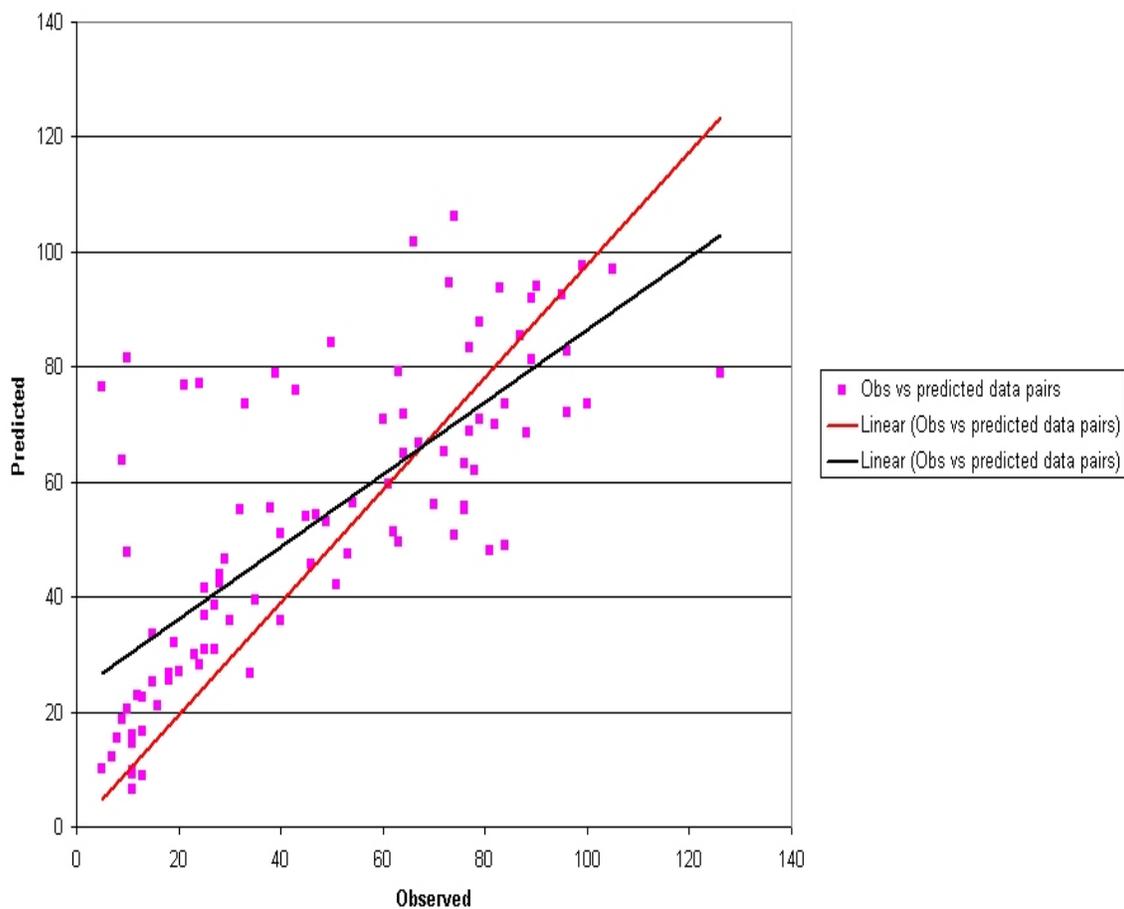


Figure 3.7-22: Scatter Plot of Observed vs Predicted 1-hour Data for August 10 - 13, 2000 at CAMS28

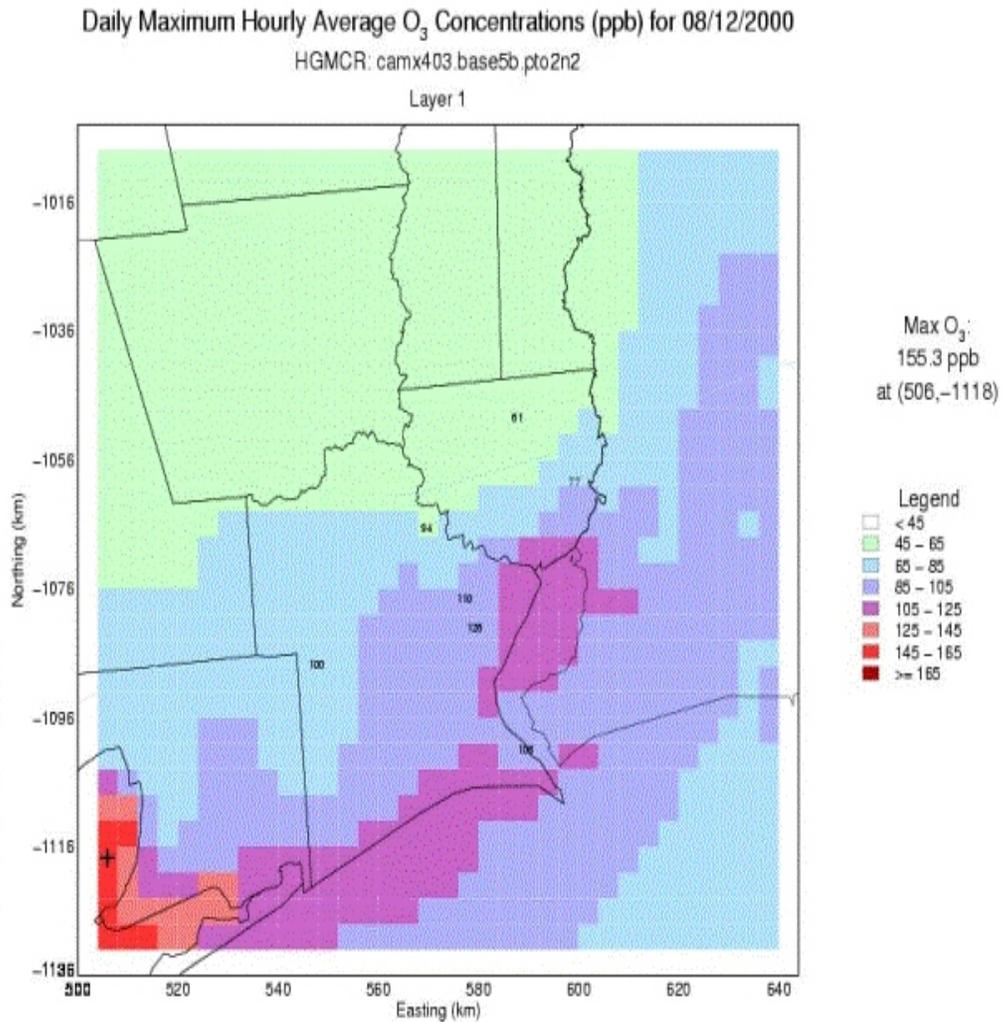


Figure 3.7-23: Maximum Predicted 1-hour Ozone Over BPA Domain for August 12, 2000

3.7.3.2 August 10 - 13, 2000 Episode - 8-hour Performance

Similar performance measures and graphics are shown here for 8-hour ozone (Tables 3-53 and Figures 3-24 through 3-30).

Table 3-53: 8-hour Performance Statistics for August 10 - 13, 2000 Episode

Date	Unpaired peak accuracy (± 15-20%)	Bias (± 5-15%)	Gross error (30-35%)	Max observed ozone (ppb)	Max predicted ozone (ppb)
8/10/2000	-3.7	2.1	11.1	74.6	71.9
8/11/2000	39.5	21.1	23.6	72.2	100.8
8/12/2000	5.6	4.5	15.0	99.8 (CAMS28)	105.3
8/13/2000	-5.6	0.1	11.5	89.0 (CAMS64)	84.0

Except for August 11, this episode had remarkably good 8-hour statistical performance although time series show that peaks were not reached at some stations, and overpredicted at others. This episode performs well enough to go forward with for future case modeling. This episode is important because this episode is considered the local episode and will be a good indicator of the effects of BPA controls upon BPA ozone. Time series are shown in Figures 3.7-24 through 3.7-27, a scatter plot for all stations is Figure 3.7-28, and 8-hour ozone isopleth plots are shown in Figures 3.7-29 and 3.7-30.

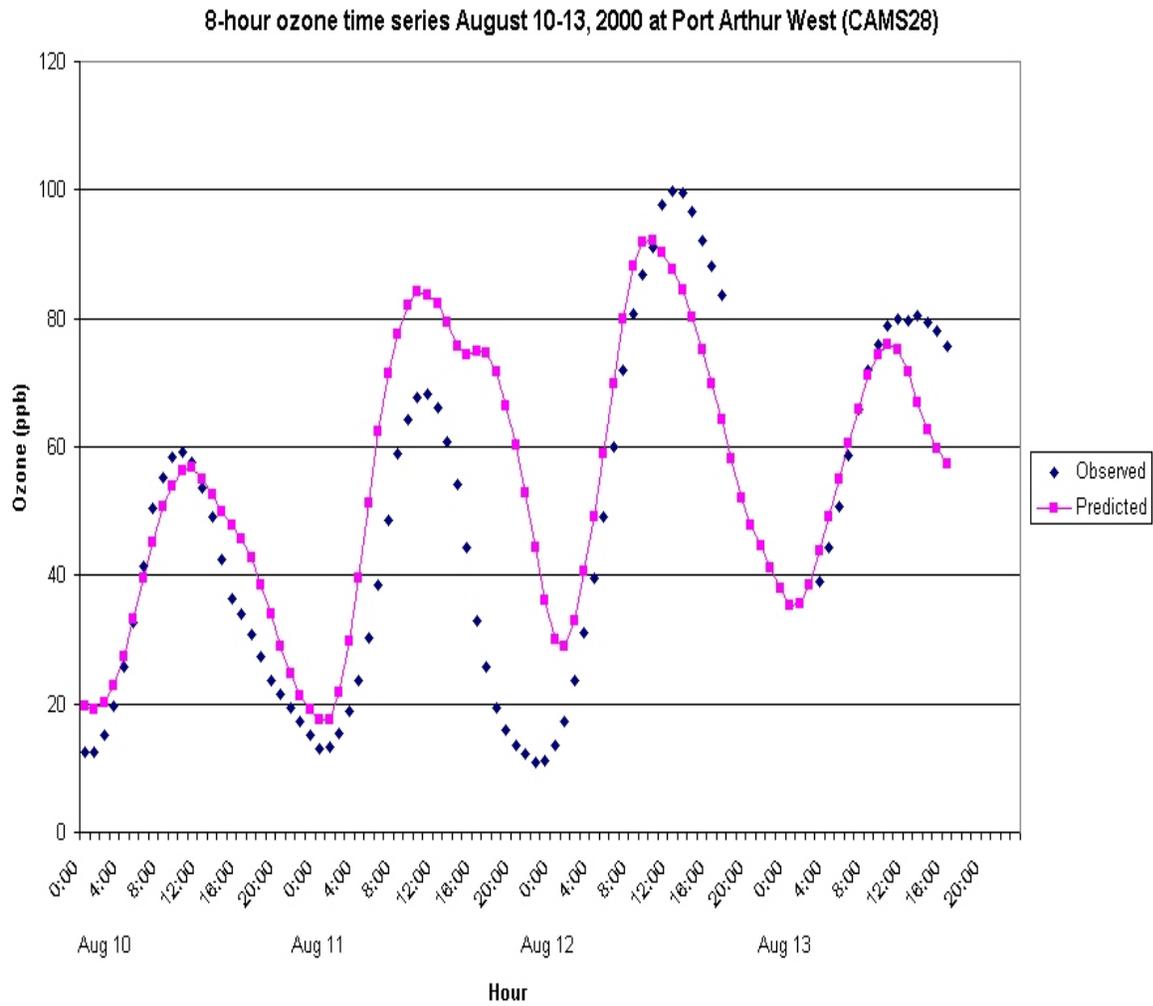


Figure 3.7-24: 8-hour Time Series for August 10 - 13, 2000 at Port Arthur West (CAMS28)

8-hour Ozone time series August 10-13, 2000 at Hamshire (CAMS64)

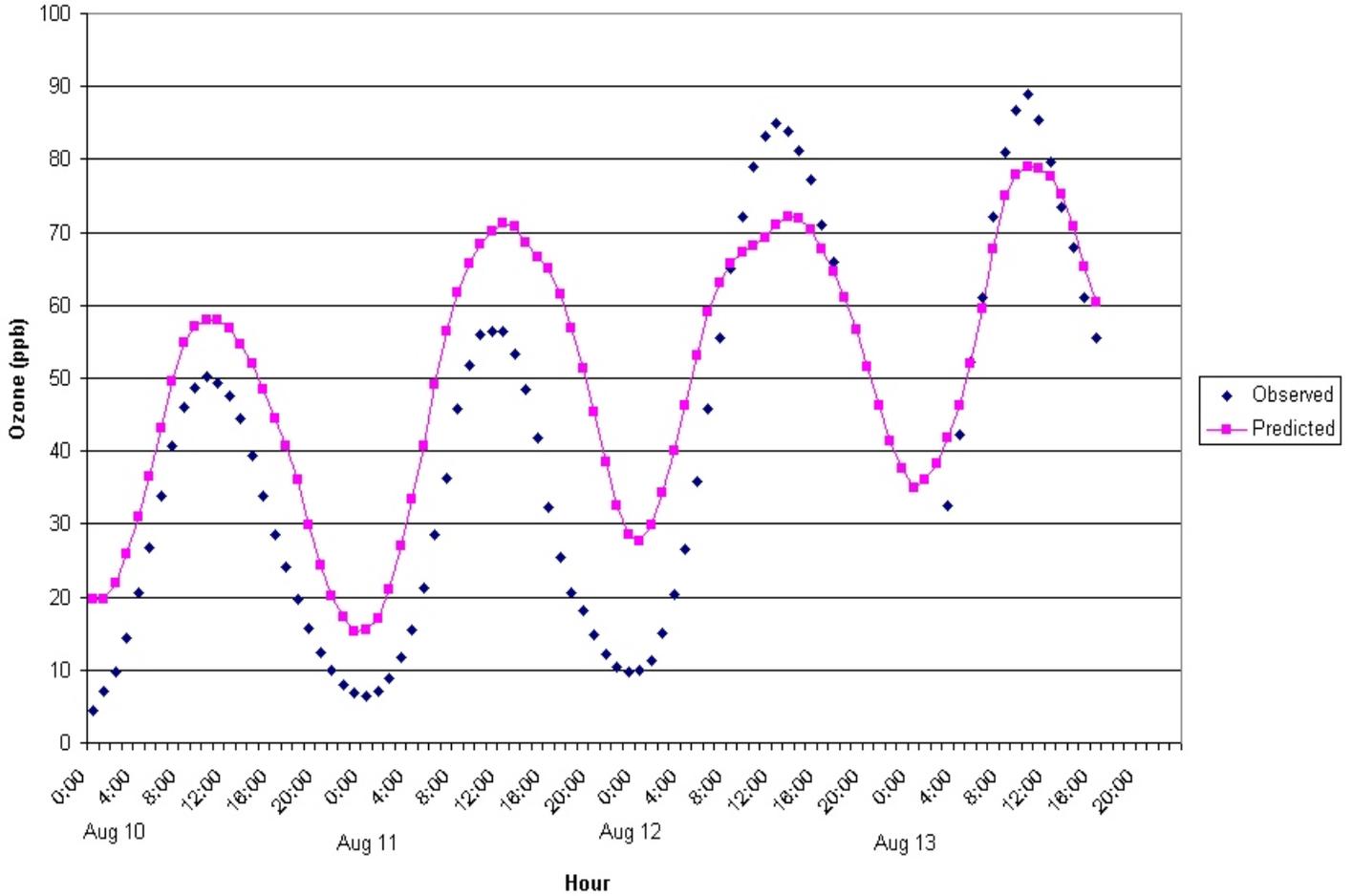


Figure 3.7-25: 8-hour Time Series for August 10-13, 2000 at Hamshire (CAMS64)

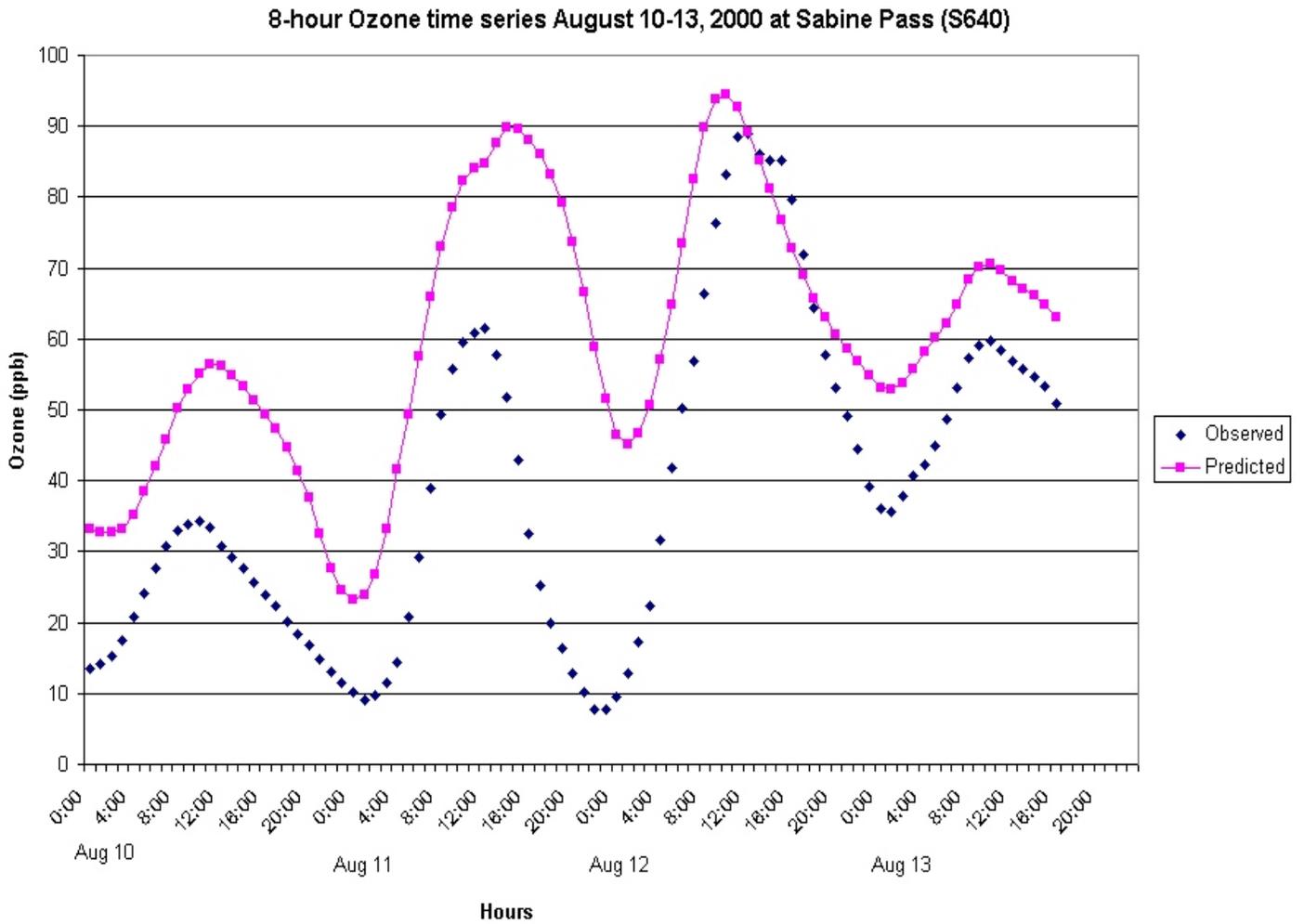


Figure 3.7-26: 8-hour Time Series for August 10 - 13, 2000 at Sabine Pass

8-hour ozone time series August 10-13, 2000 at Beaumont (CAMs2)

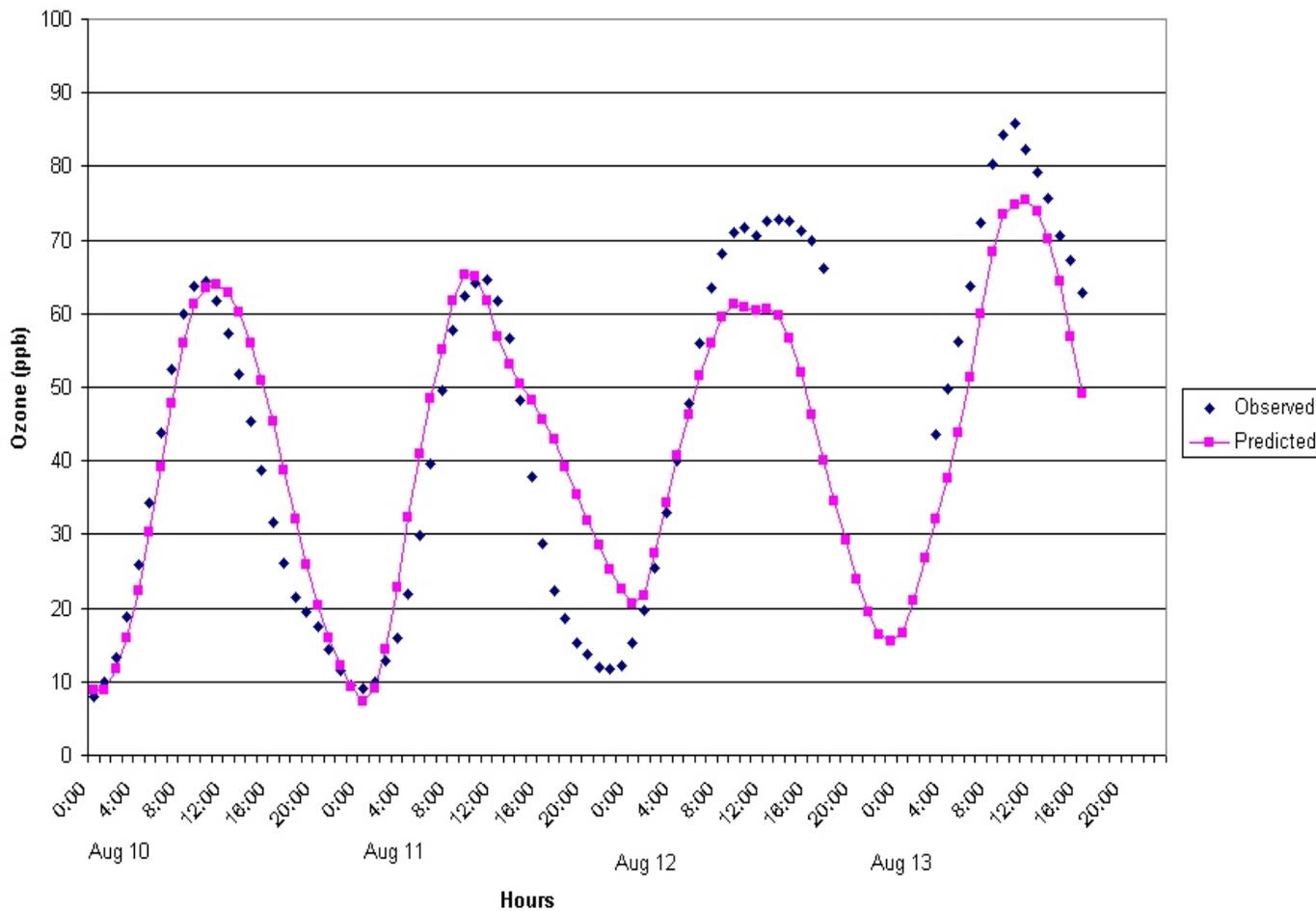


Figure 3.7-27: 8-hour Time Series for August 10 - 13, 2000 at Beaumont (CAMs2)

8-hour scatter August 10-13, 2000 all stations

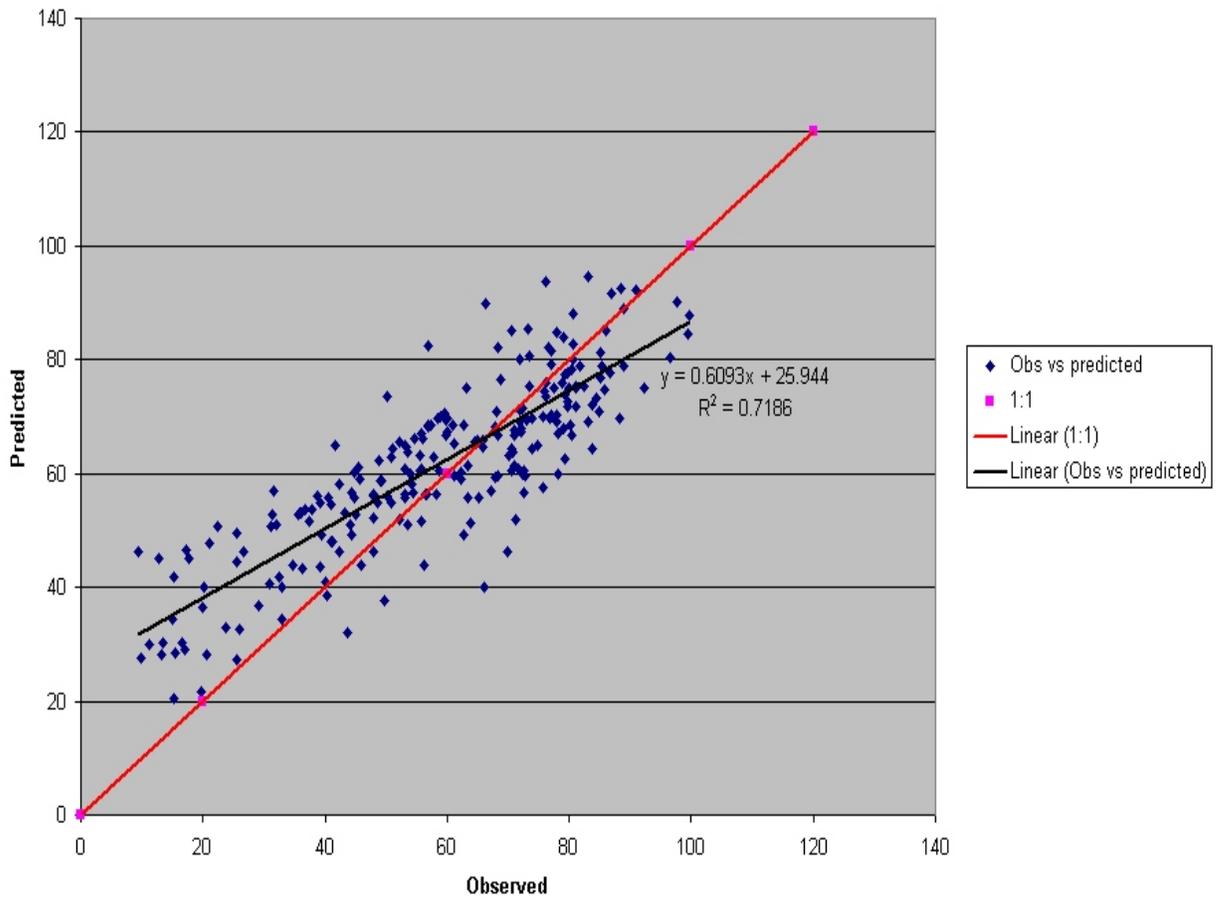


Figure 3.7-28: 8-hour Scatter for All Stations, August 10 - 13, 2000

Daily Maximum 8-Hour Moving Average O₃ Concentrations (ppb) for 08/12/2000

HGMCR: camx403.base5b.pto2n2

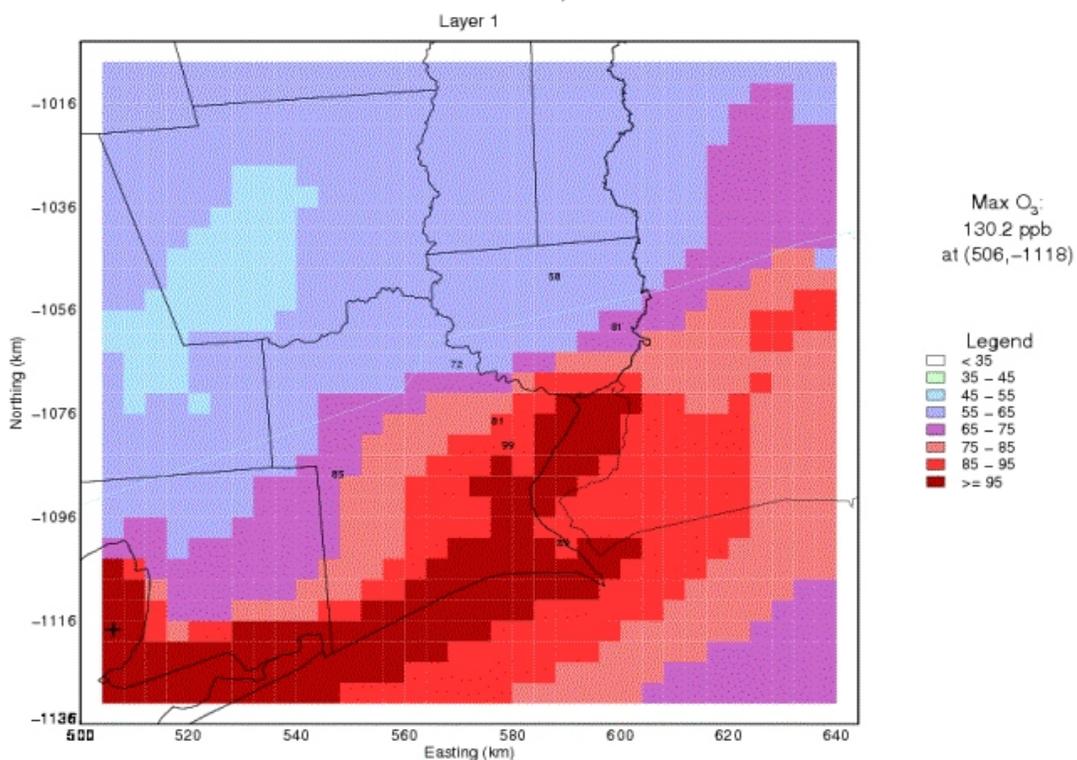


Figure 3.7-29: Maximum Daily 8-hour Ozone Over BPA Subdomain for August 12, 2000

Daily Maximum 8-Hour Moving Average O₃ Concentrations (ppb) for 08/13/2000

HGMCR: camx403.base5b.pto2n2

Layer 1

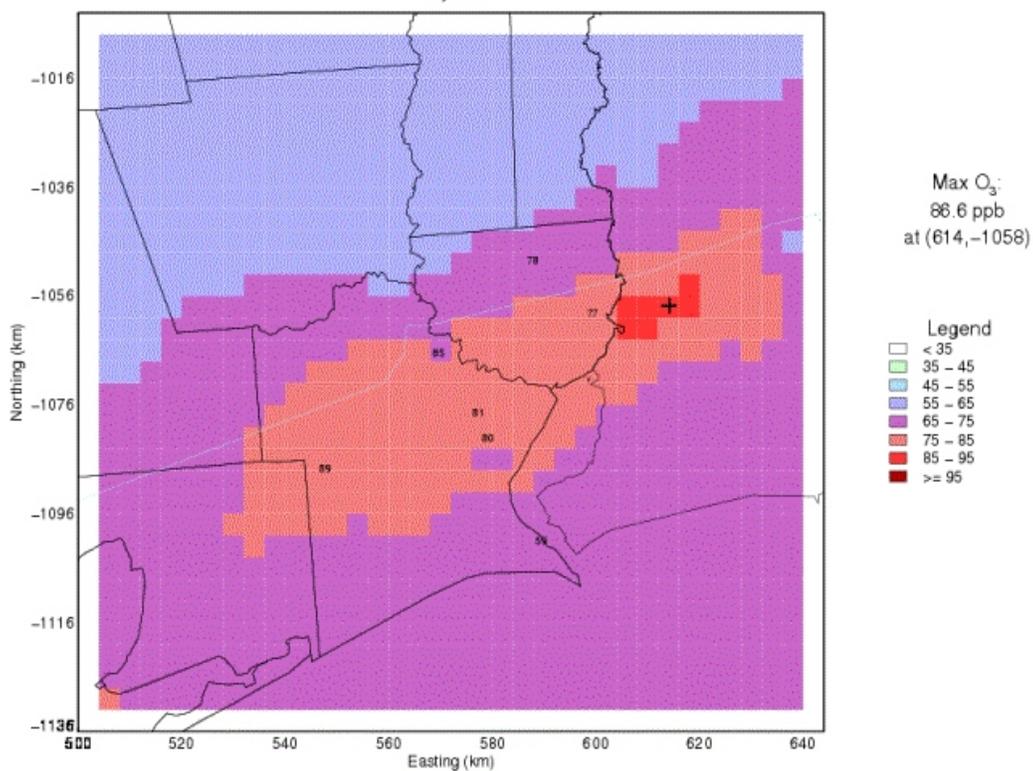


Figure 3.7-30: Maximum Daily 8-hour Ozone Over BPA Subdomain for August 13, 2000

3.7.3.3 August 28 - September 6, 2000 Episode - 1-hour Performance

A complete description of the performance evaluation for this episode may be found in Chapter 3 of the 2004 HGB ozone SIP revision. A short summary of base case performance for BPA is discussed here. The most recent version of the BPA base case for this episode is referred to as Base5b. Table 3-54 shows the statistical performance of CAMx for the three 1-hour episode days for case Base5b.

Table 3-54: Statistical Measures for August 30 - September 1, 2000

Date	Unpaired peak accuracy (± 15-20%)	Bias (± 5-15%)	Gross error (30-35%)	Max observed ozone (ppb)	Max predicted ozone (ppb)
8/30/2000	-25.1	-5	19.2	165 (CAMS28)	123
8/31/2000	-1.4	7	15.6	152 (S640)	149
9/1/2000	-19.1	16.9	31.2	160 (CAMS28)	129

Model performance is statistically acceptable for all criteria only on August 31, and that some of the underprediction features are also seen in HGB for this episode. On August 30, CAMx misses the peak in BPA by over 40 ppb. A similar situation was seen in HGB, where the monitored peak ozone was 199 ppb, yet the model could only generate 137 ppb. Since this day was a classic example of transport from HGB to BPA, this underprediction in BPA is understandable. Most of the high ozone measured during these three 1-hour exceedance days is due to transport from HGB. This finding is borne out by the fact that large scale winds on these three days are westerly. A discussion of the analyses done of the TexAQS ambient data for this day, as well as the rest of the episode is found in the HGB MCR Phase II report.

Figures 3.7-31 through 3.7-36 show 1-hour time series for these days at several BPA monitoring stations. Scatter plots may be found, along with all time series in Appendix M, Base Case Performance Evaluation. Figures 3.7-37 through 3.7-39 show predicted ozone isopleths.

The time series indicate that CAMx did a somewhat reasonable job with the rising ozone, it was not able to predict the magnitude of the ozone as the HGB plume swept on-shore late in the day at Sabine Pass on August 30. Ozone animations showed that CAMx had the “shape” of the plume correct, impacting first at Sabine Pass at 4 - 5 pm, then advecting northward over other stations in Jefferson, and later Orange counties. Absent any additional HGB emissions that could increase predicted ozone in BPA, performance of the model is otherwise acceptable.

On August 31, CAMx generates a 149 ppb, which is good unpaired peak accuracy (vs 152 ppb). Overall, the model is biased low, and both bias and gross error are within EPA criteria. This analysis is borne out by time series review which shows CAMx did best on the August 31 at Beaumont, Jefferson County Airport, Hamshire, and West Orange. At Sabine Pass, the model captures the rise of ozone until early-afternoon when the HGB plume begins moving on-shore and measured ozone jumps 27 ppb from 125 to 152 ppb.

For September 1, CAMx is biased low for the unpaired peak accuracy. The best performance was at Hamshire, although CAMx could not hit the peak measured at that site, and at West Orange (but no

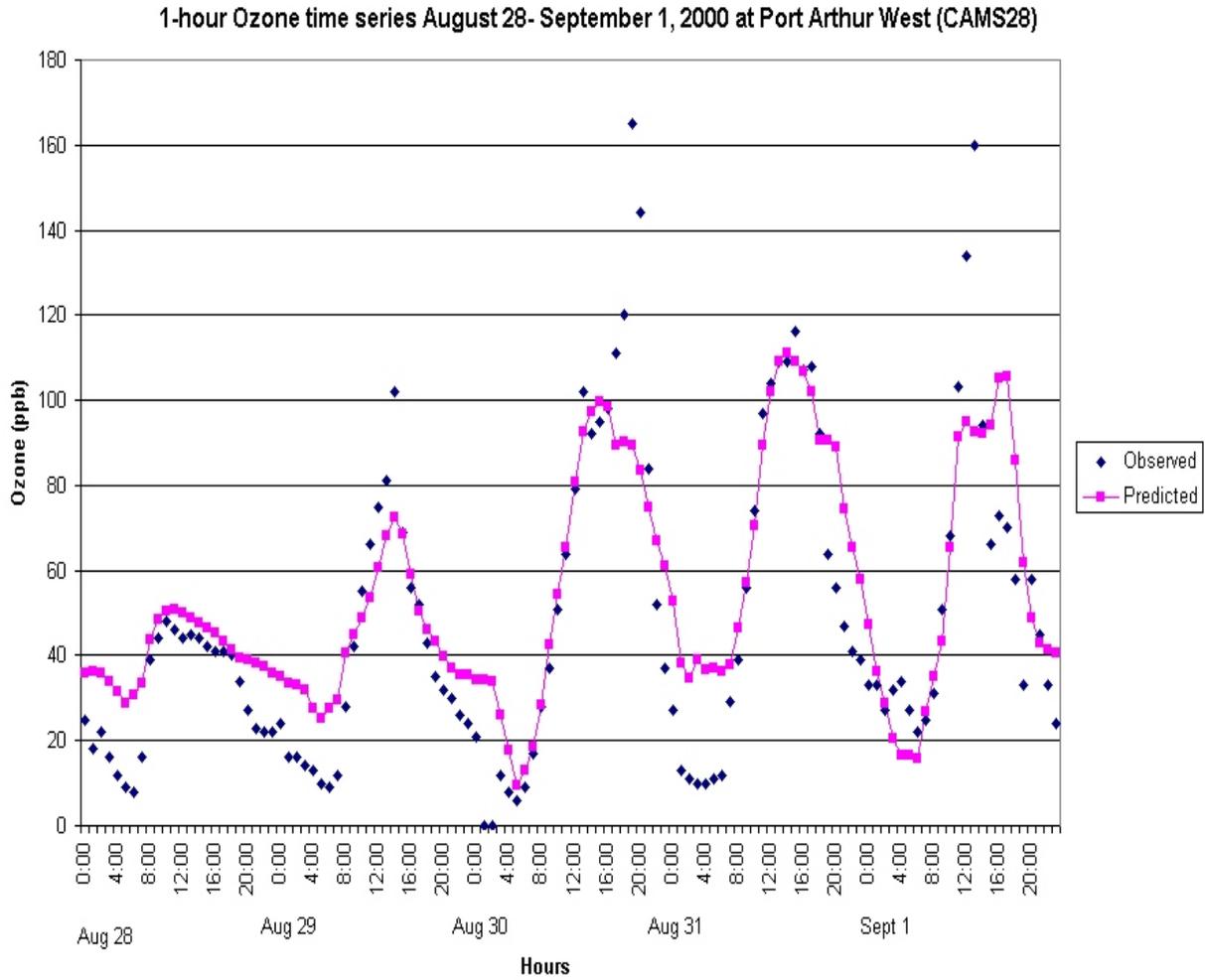
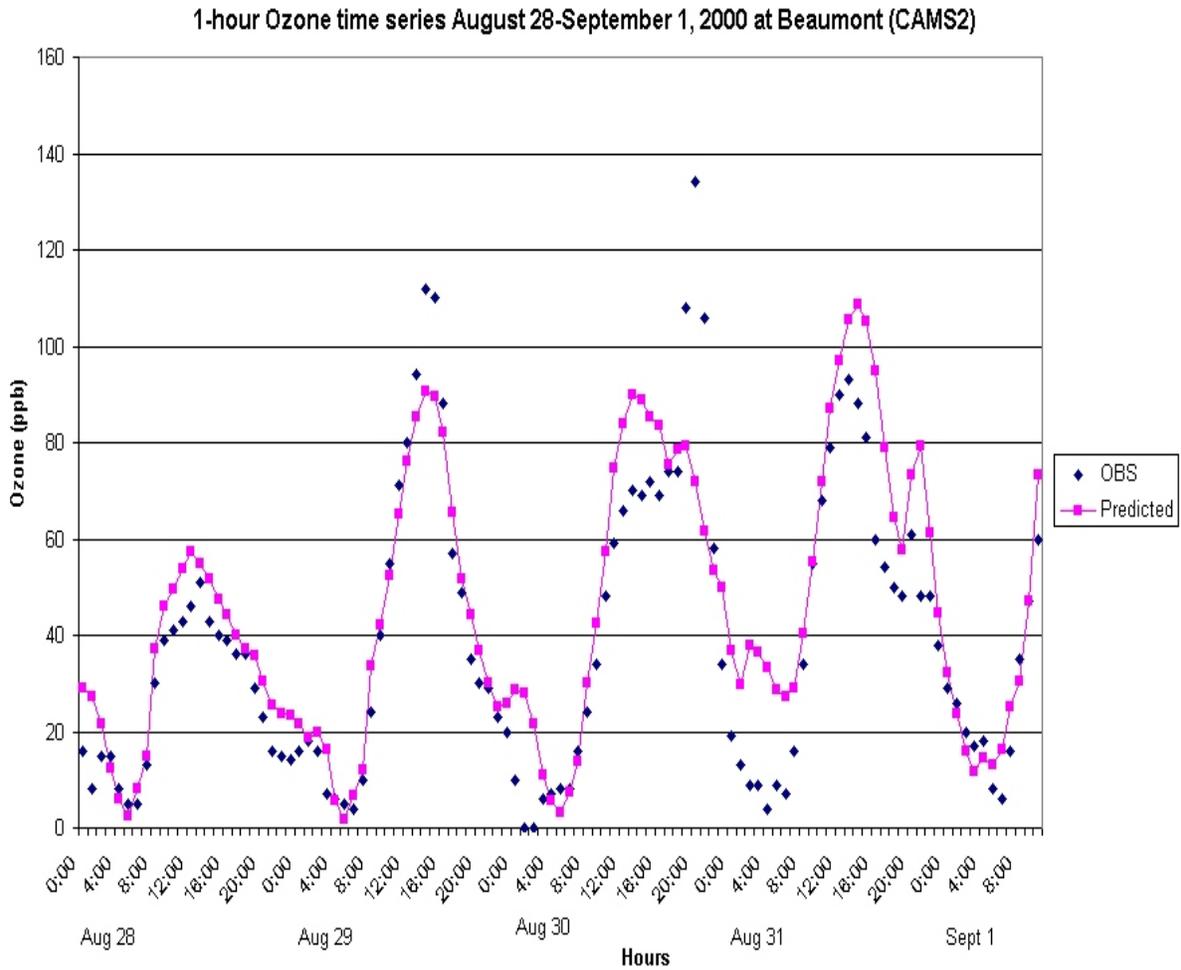


Figure 3.7-31: 1-hour Time Series August 28 - September 1, 2000 at Port Arthur West

exceedance at that station). Plume sequence movies indicate westerly winds blowing HGB ozone and precursors into BPA for the entire day.



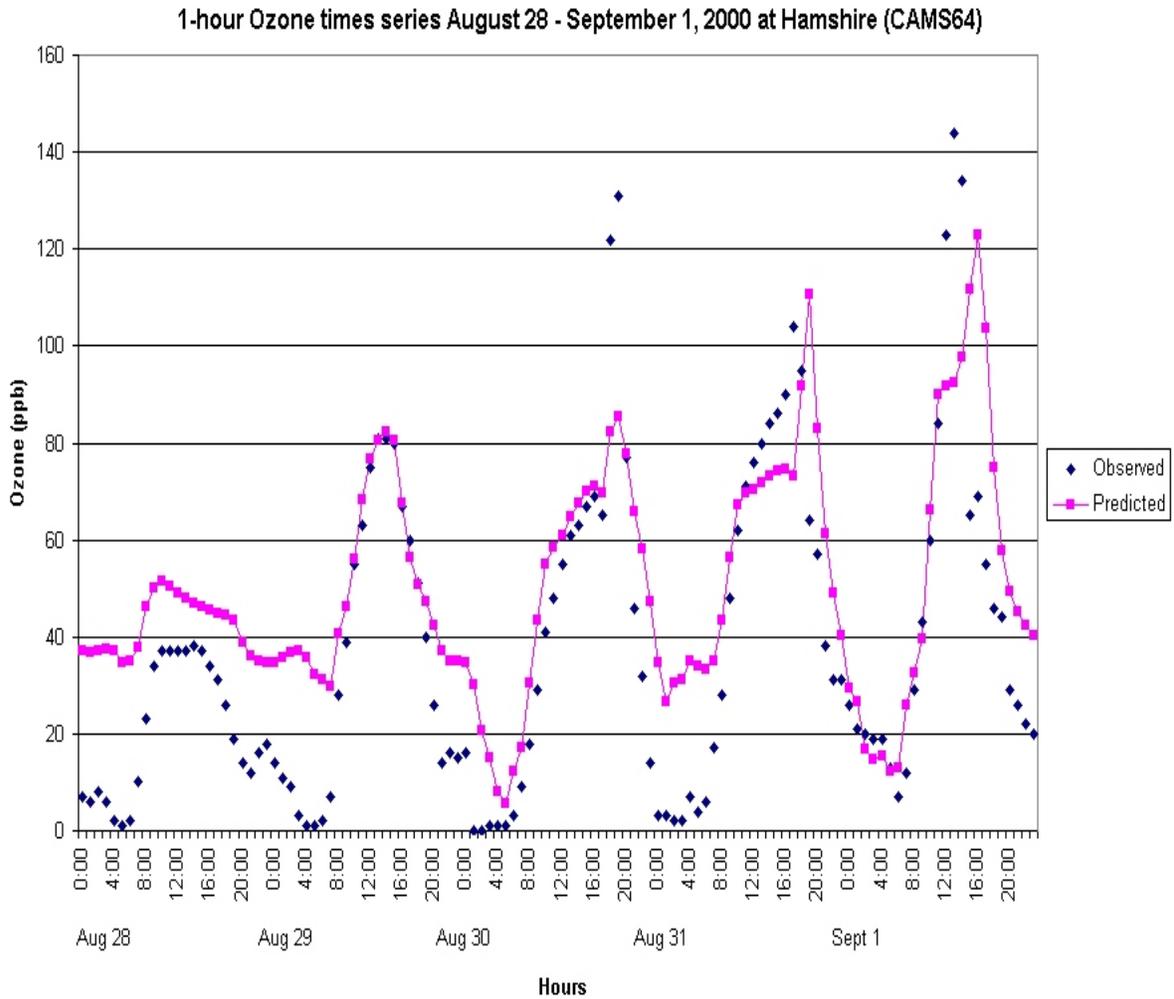


Figure 3.7-33: 1-hour Time Series August 28 - September 1, 2000 at Hamshire (CAMS64)

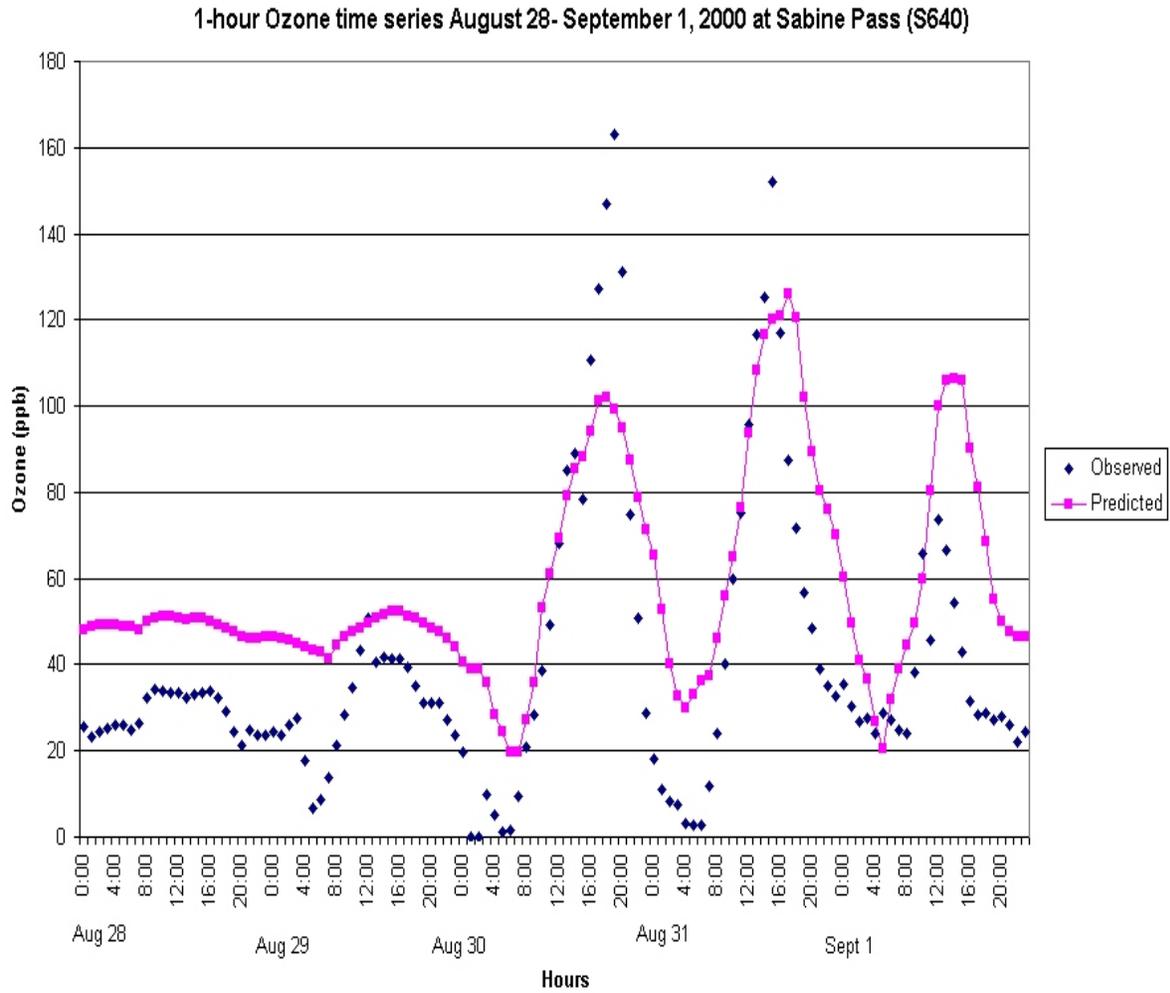


Figure 3.7-34: 1-hour Time Series August 28 - September 1, 2000 at Sabine Pass (S640)

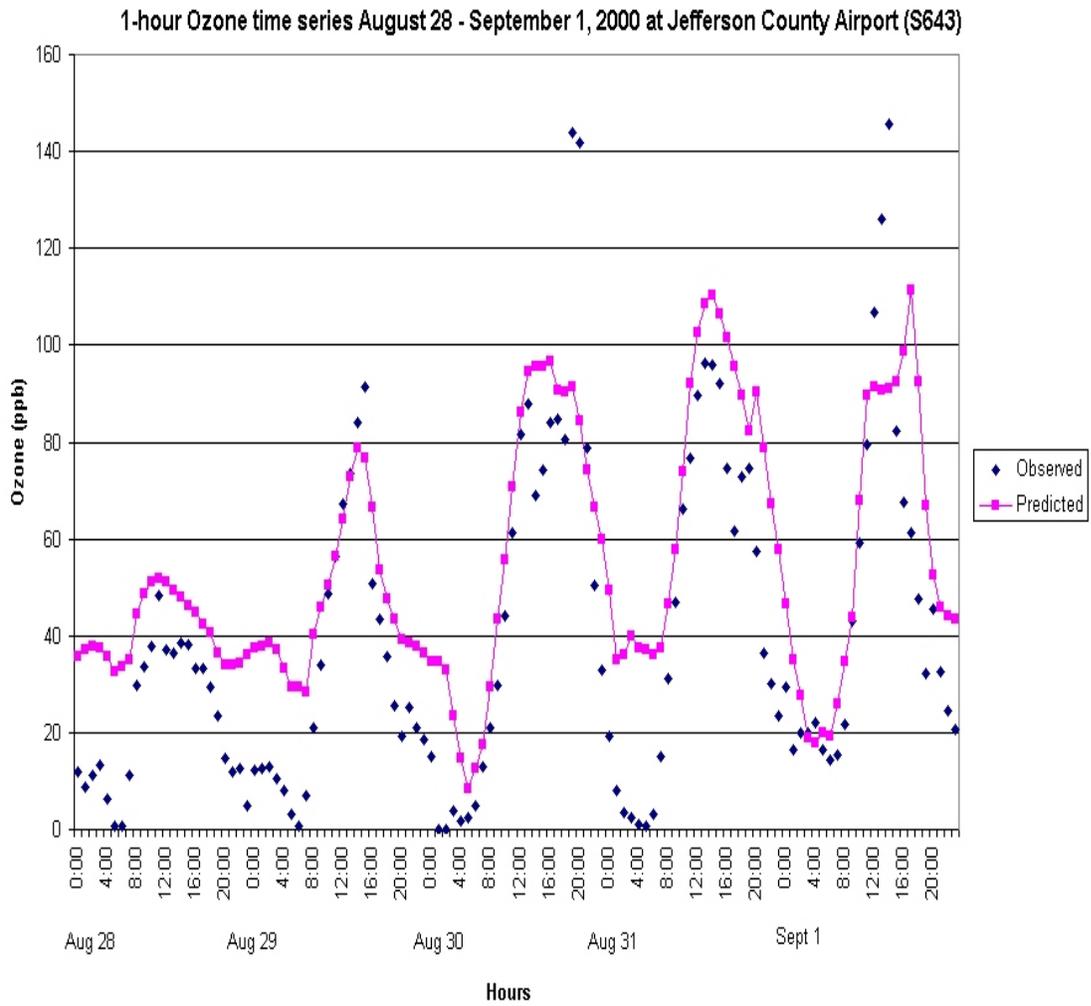


Figure 3.7-35: 1-hour Time Series August 28 - September 1, 2000 at Jefferson County Airport (S643)

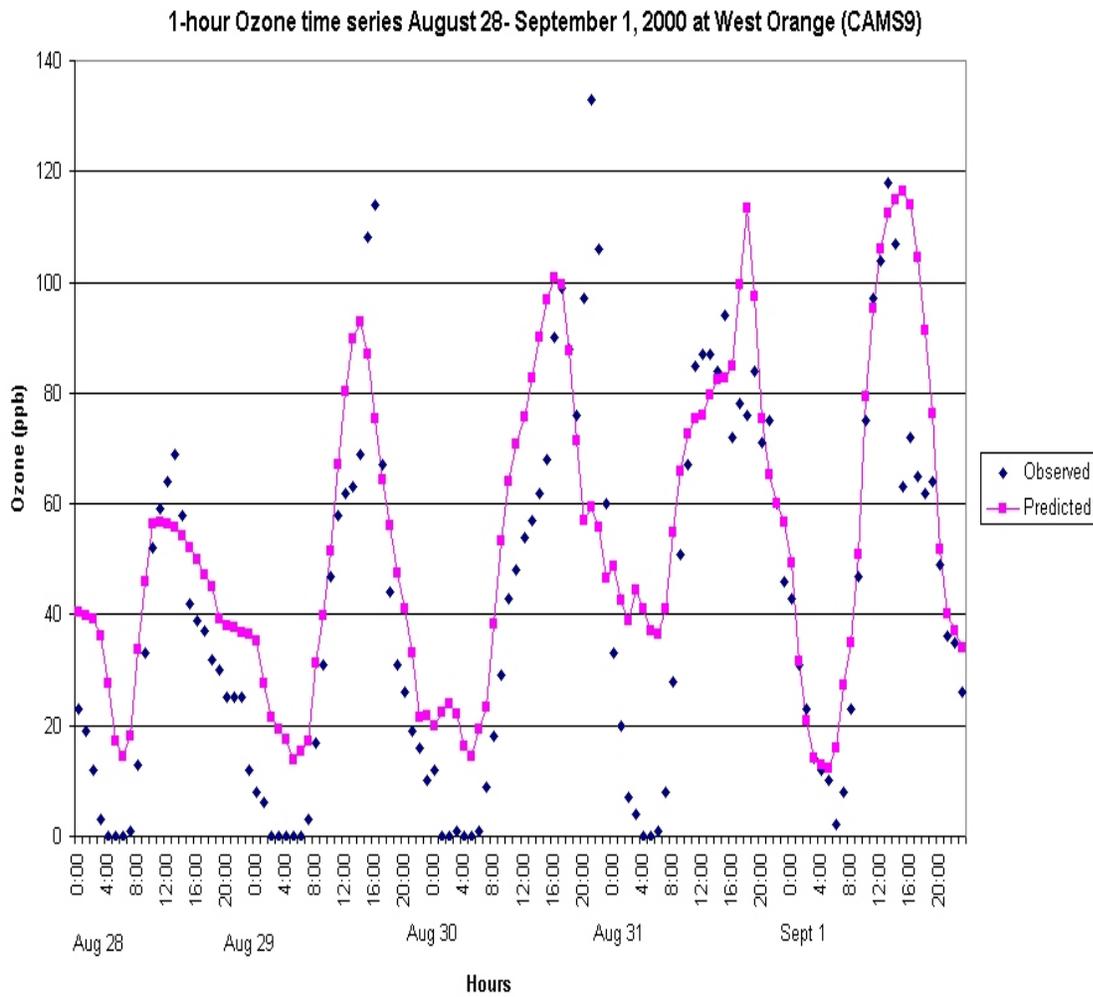


Figure 3.7-36: 1-hour Time Series August 28 - September 1, 2000 at West Orange (CAM9)

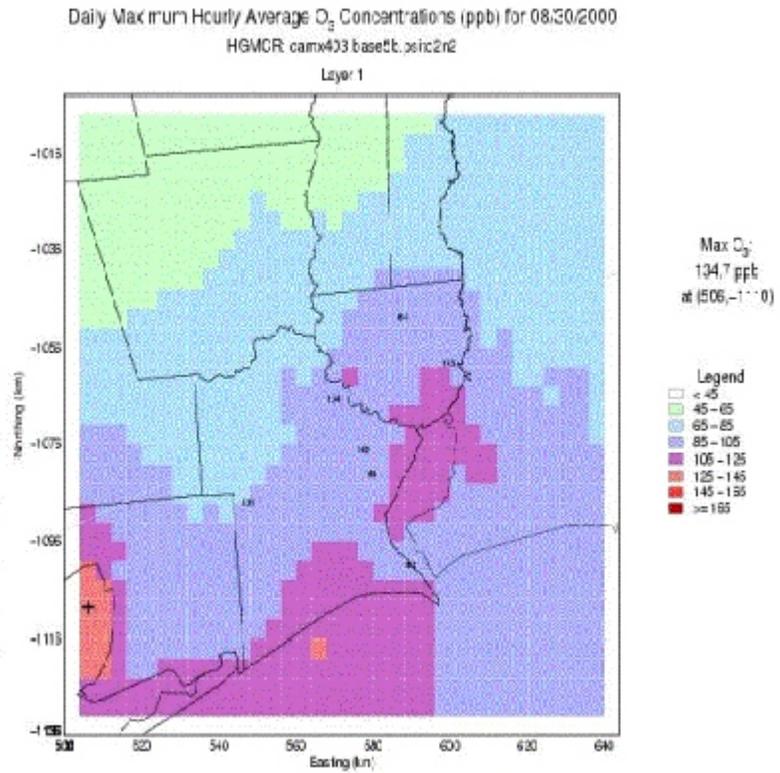


Figure 3.7-37: Daily Maximum Hourly Average O₃ Concentration (ppb) for August 30, 2000

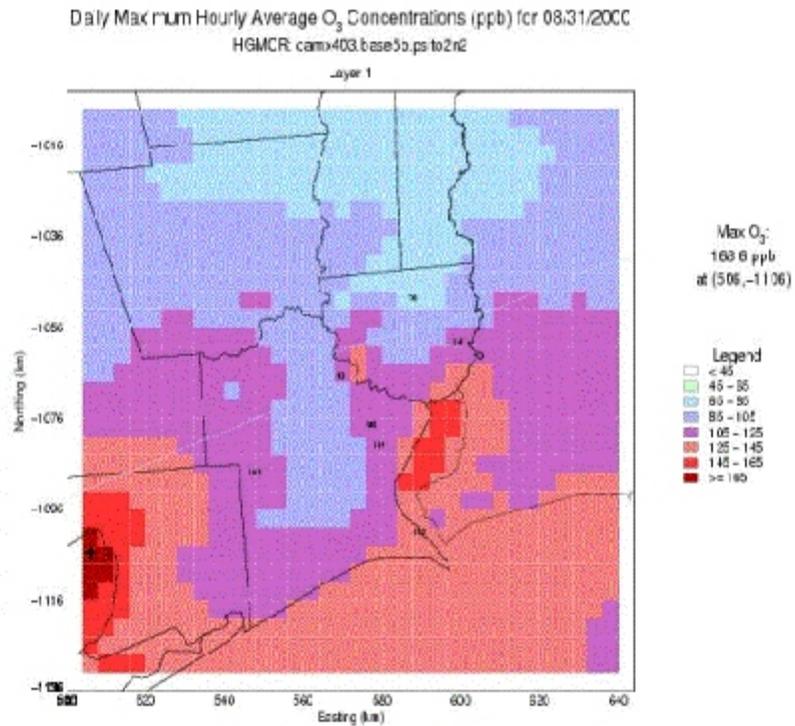


Figure 3.7-38: Daily Maximum Hourly Average O₃ Concentration (ppb) for August 31, 2000

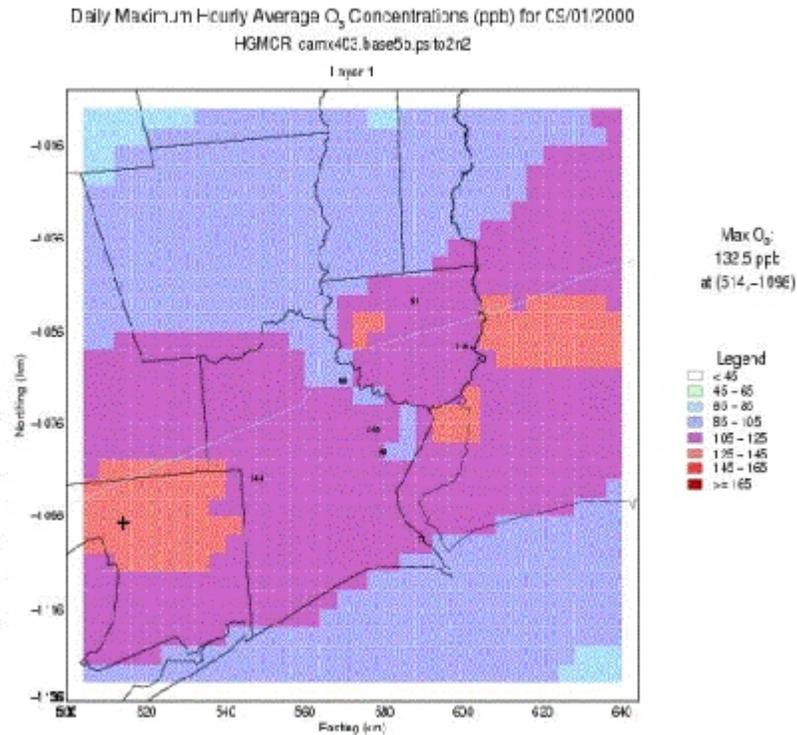


Figure 3.7-39: Daily Maximum Hourly Average O₃ Concentration (ppb) for September 1, 2000

3.7.3.4 August 30 - September 6, 2000 - 8-hour Model Performance

Similarly, Table 3-55 describes 8-hour model performance for the August 30 - September 6, 2000 episode. Table 3-55 focuses only on days in which 8-hour exceedances were recorded in BPA.

Table 3-55: 8-hour Model Performance Statistics for August 30 - September 6, 2000 Episode

Date	Unpaired peak accuracy (± 15-20%)	Bias (± 5-15%)	Gross error (30-35%)	Max observed ozone (ppb)	Max predicted ozone (ppb)
8/30/2000	-10.3	-3.3	26.8	116.4	104.4
8/31/2000	3.0	-5	8.7	105.2	108.4
9/1/2000	14.0	13.8	17.8	96.0	109.4
9/2/2000	14.8	6.8	15.1	86.8	99.6
9/4/2000	7.1	7.0	12.8	105.3	98.3
9/6/2000	17.6	21.9	23.0	85.8	100.9

As the episode progresses, CAMx develops a tendency to bias predictions high, although within statistical bounds (except for high bias on September 6). As EPA points out in its 1999 draft 8-hour modeling guidance, these bounds for unpaired peak accuracy, bias, etc. should be considered performance goals, rather than absolute criteria. This factor is because the goal in 8-hour modeling is not to absolutely model all grid cells below 85 ppb, but rather use the model in a relative sense to estimate the change to 8-hour ozone design values. Graphical measures are also intended by EPA to be indicators of 8-hour model performance. These are shown below in Figures 3.7-40 through 3.7-53, which show time series and, ozone isopleths. Scatter plots are not produced here, but may be found in Appendix M, Base Case Performance Evaluation. The time series graphs are broken out in two parts, August 28 - September 1, and September 2 - 6 for readability. Time series are only shown for days/stations which had 8-hour exceedances. Isopleth plots are for each of the 8-hour exceedance days, as well.

Time series show that the model replicates ozone well during August 28 - September 1, especially on August 30 at Hamshire; August 31 at Beaumont, Jefferson County Airport, and Sabine Pass; and September 1 at Jefferson County Airport. The latter third of the time series show that the model only performed well on September 4 at Port Arthur West, and to a lesser degree at Sabine Pass. Although September 5 was neither a 1-hour or 8-hour exceedance day in BPA, it is interesting to note that CAMx dramatically overpredicts ozone on this day. Similar performance situations have been noted in the HGB domain, this maybe due to MM5 moving a convergence zone too far inland. In BPA, the zone bisected Jefferson County, leading to overpredictions in CAMx.

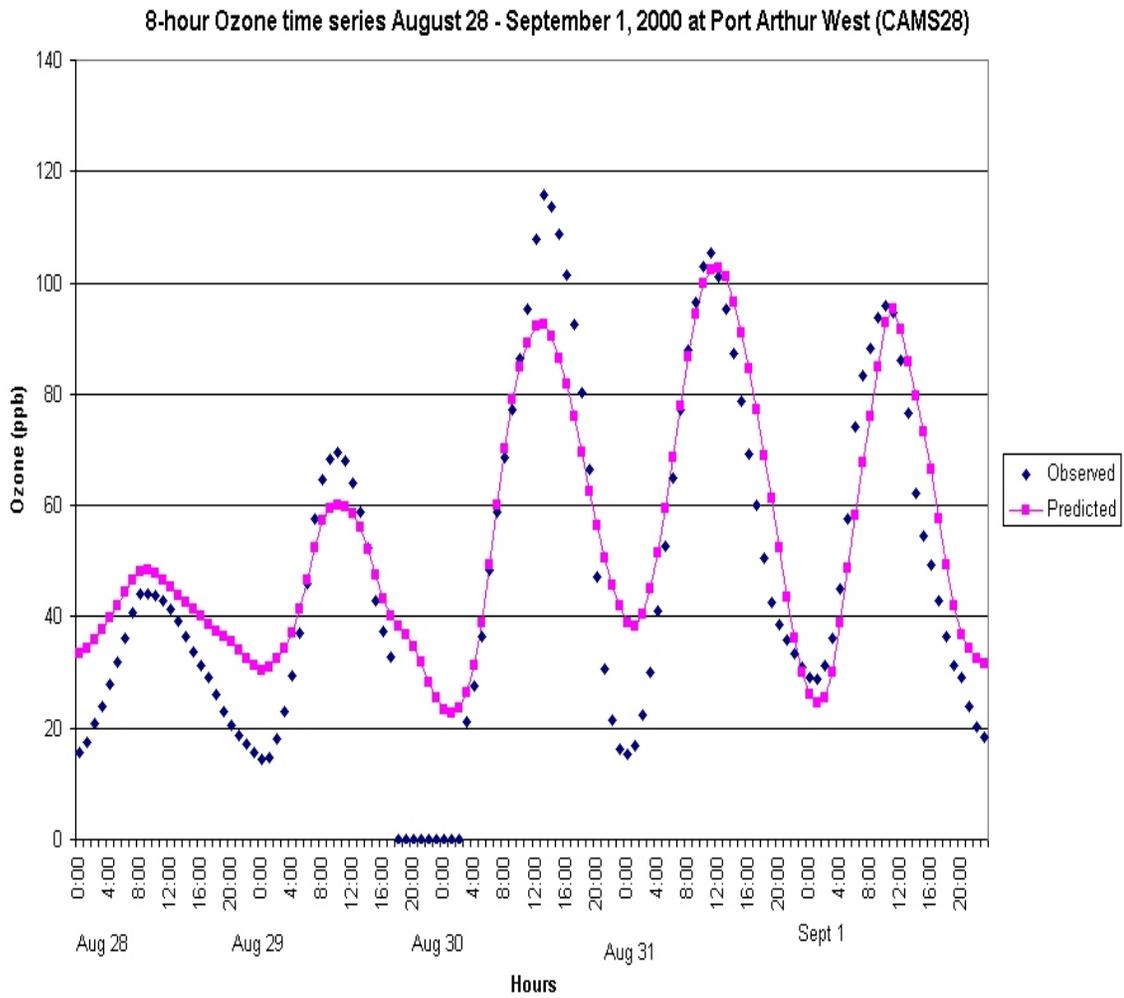


Figure 3.7-40: 8-hour Time Series August 28 - September 1, 2000 at Port Arthur West (CAMS28)

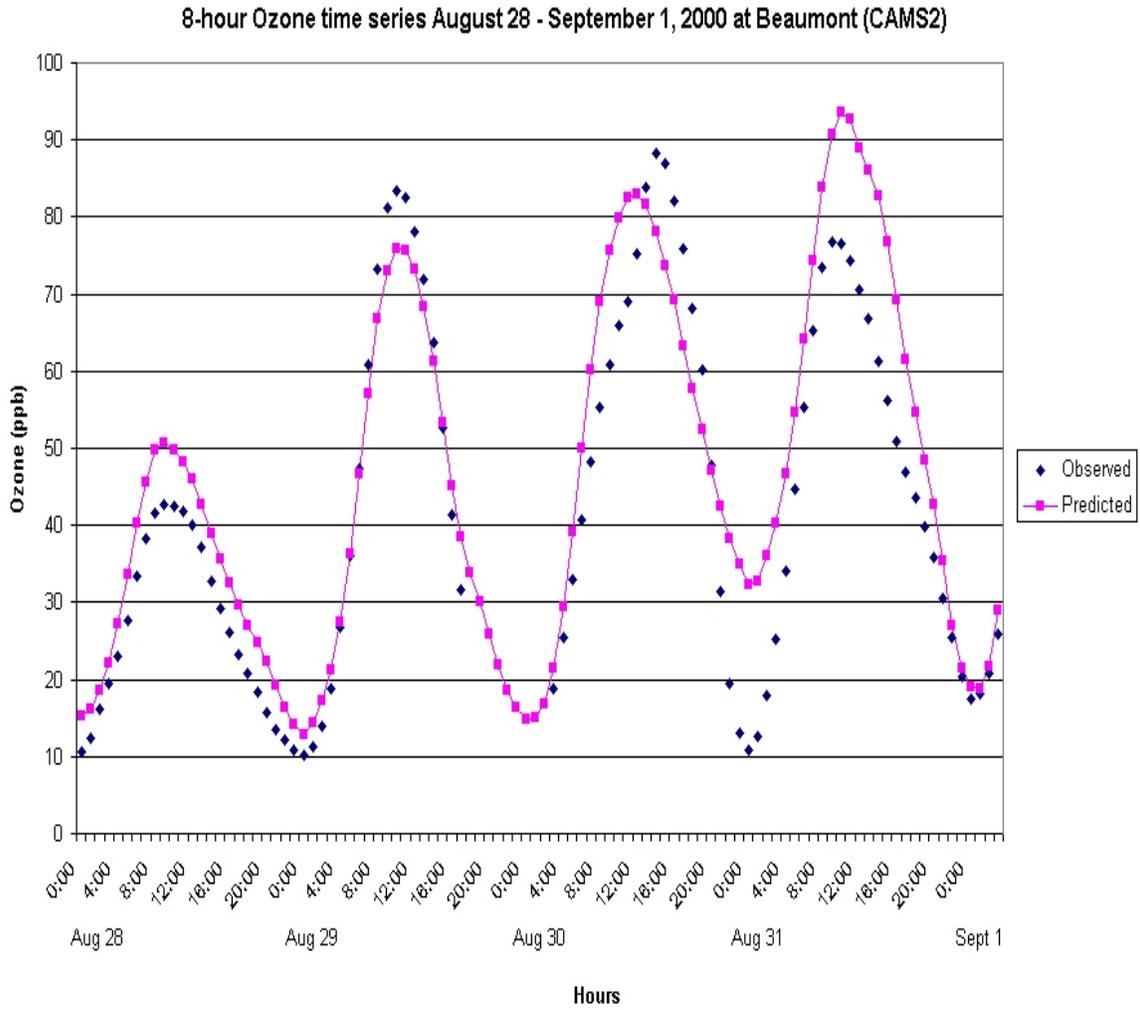


Figure 3.7-41: 8-hour Time Series August 28 - September 1, 2000 at Beaumont (CAM2)

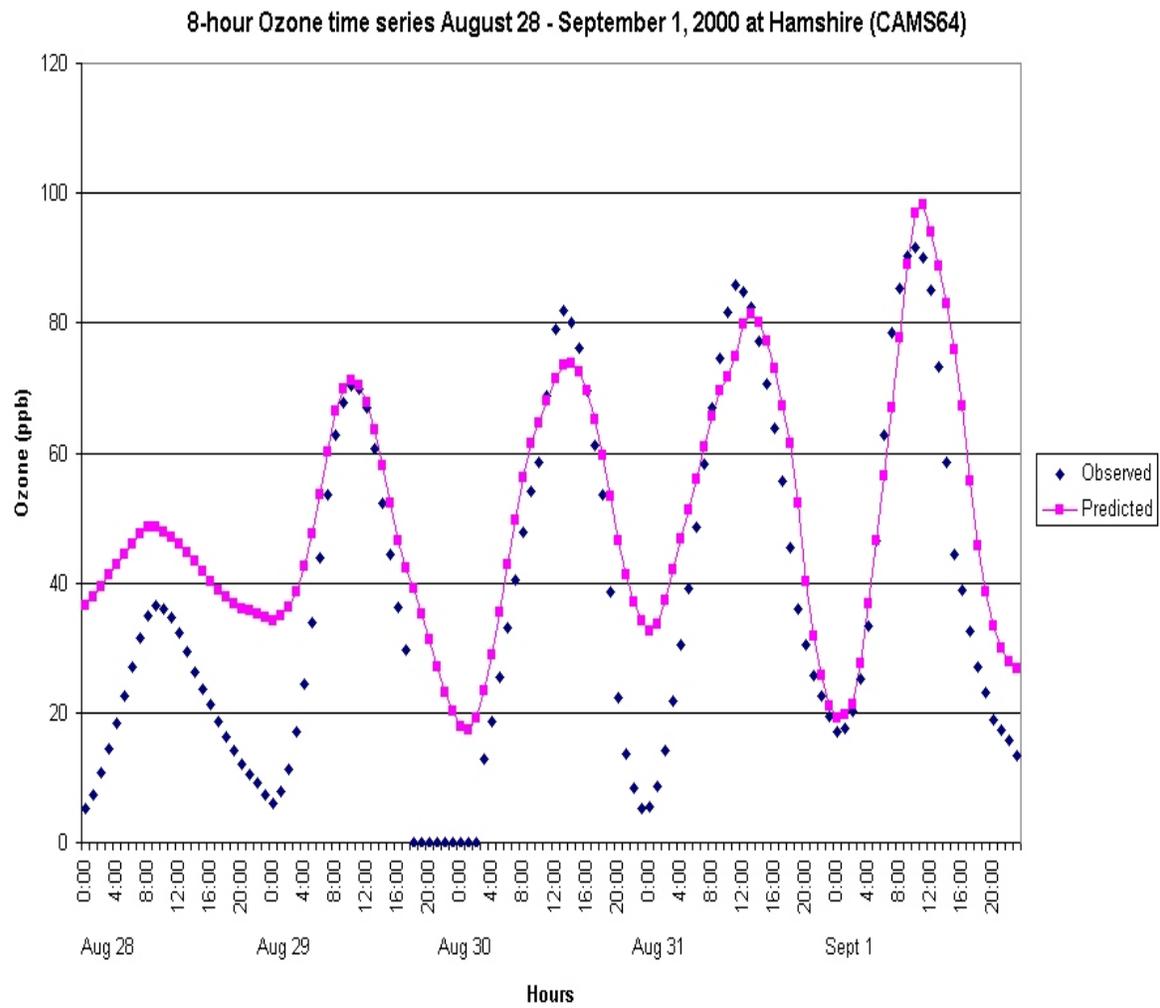


Figure 3.7-42: 8-hour Time Series August 28 - September 1, 2000 at Hamshire (CAMS64)

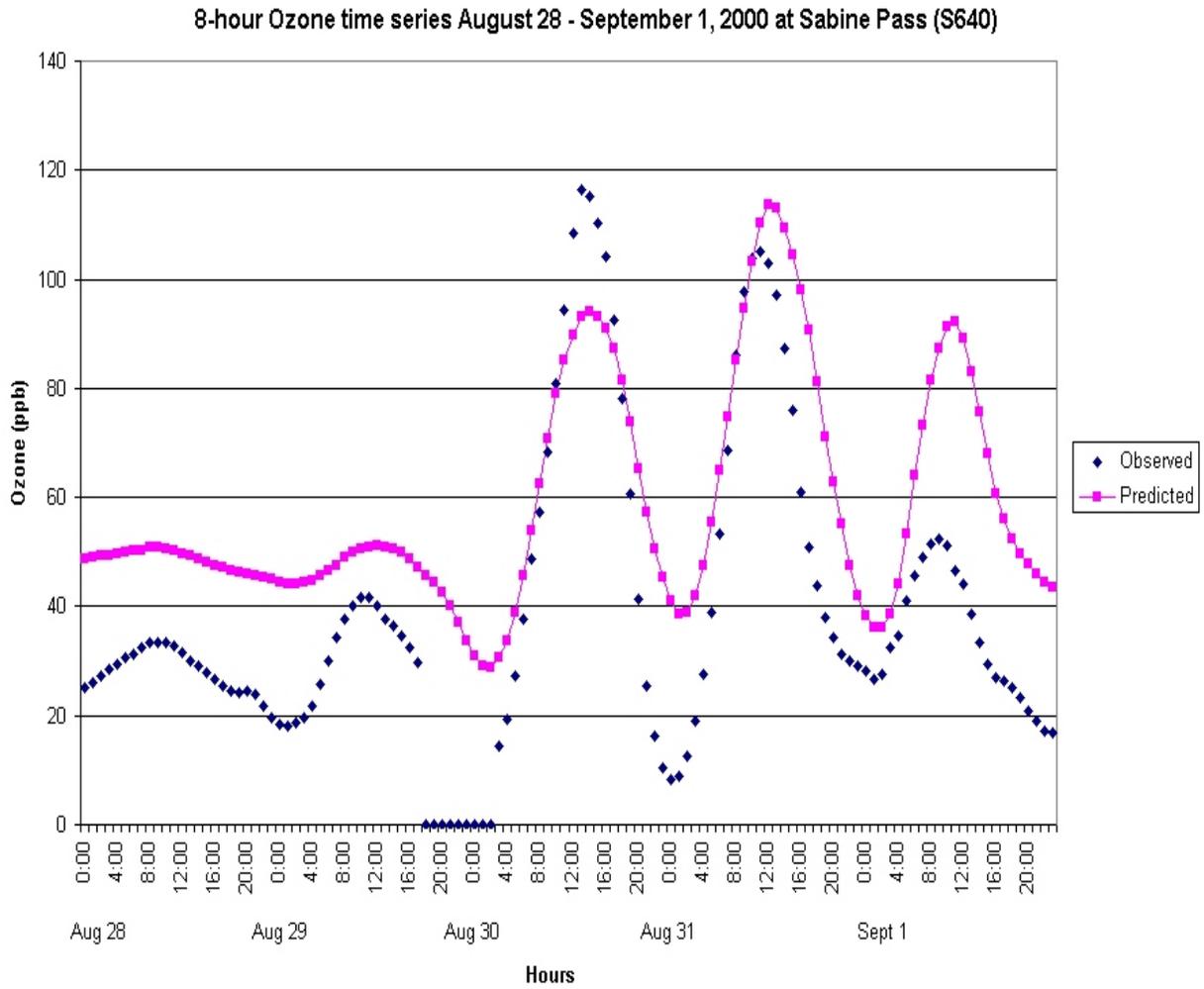


Figure 3.7-43: 8-hour Time Series August 28 - September 1, 2000 at Sabine Pass (S640)

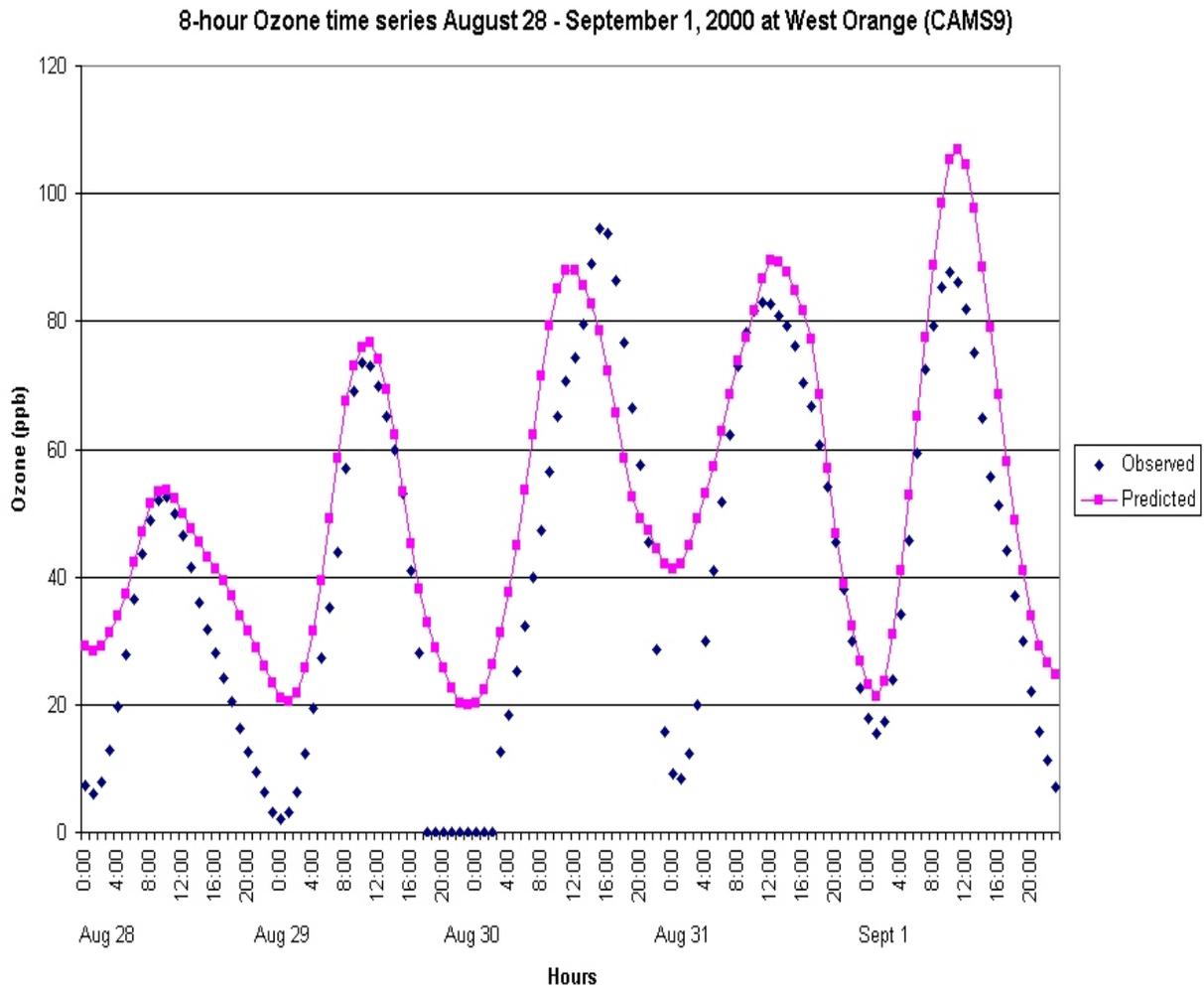


Figure 3.7-44: 8-hour Time Series August 28 - September 1, 2000 at West Orange (CAMS9)

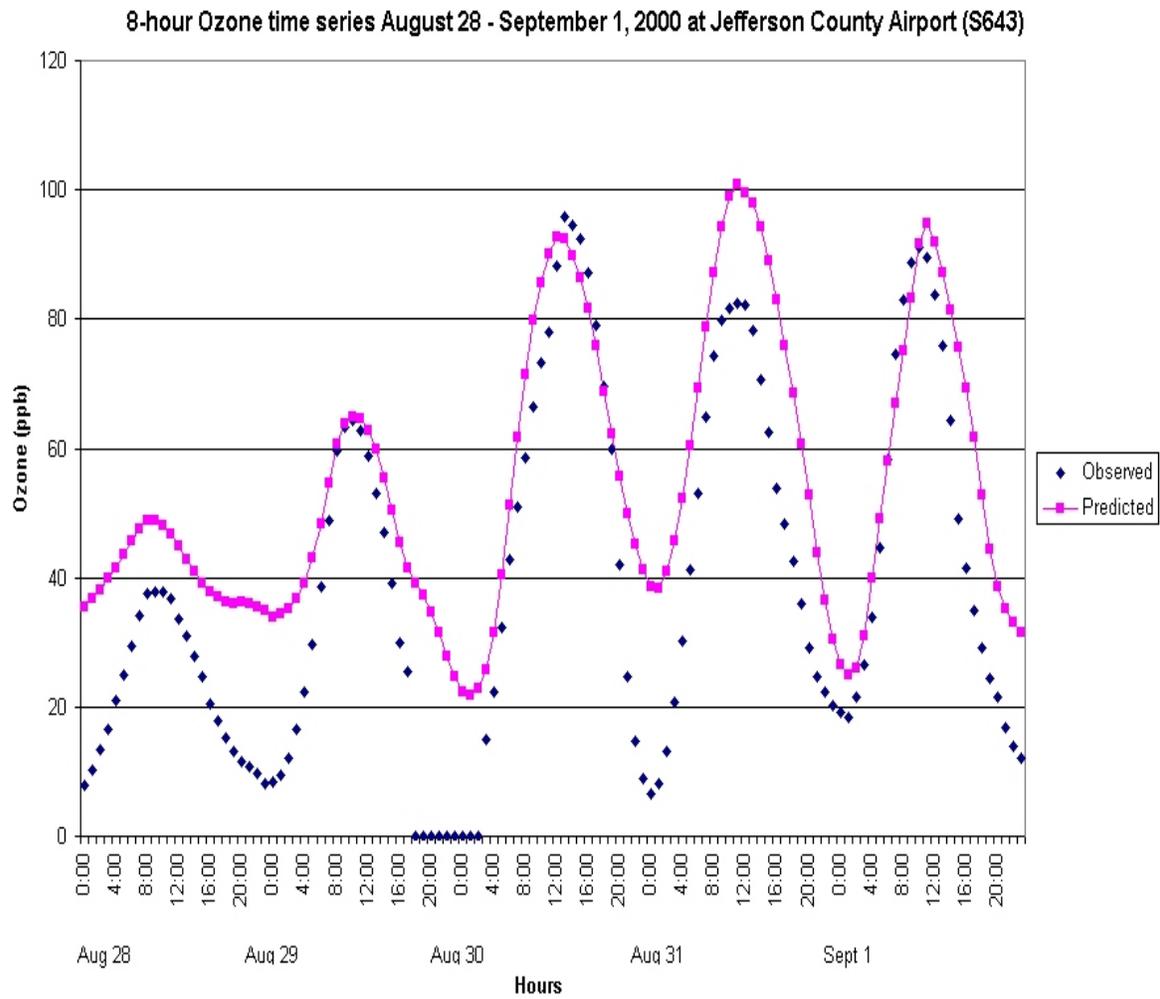


Figure 3.7-45: 8-hour Time Series August 28 - September 1, 2000 at Jefferson County Airport (S643)

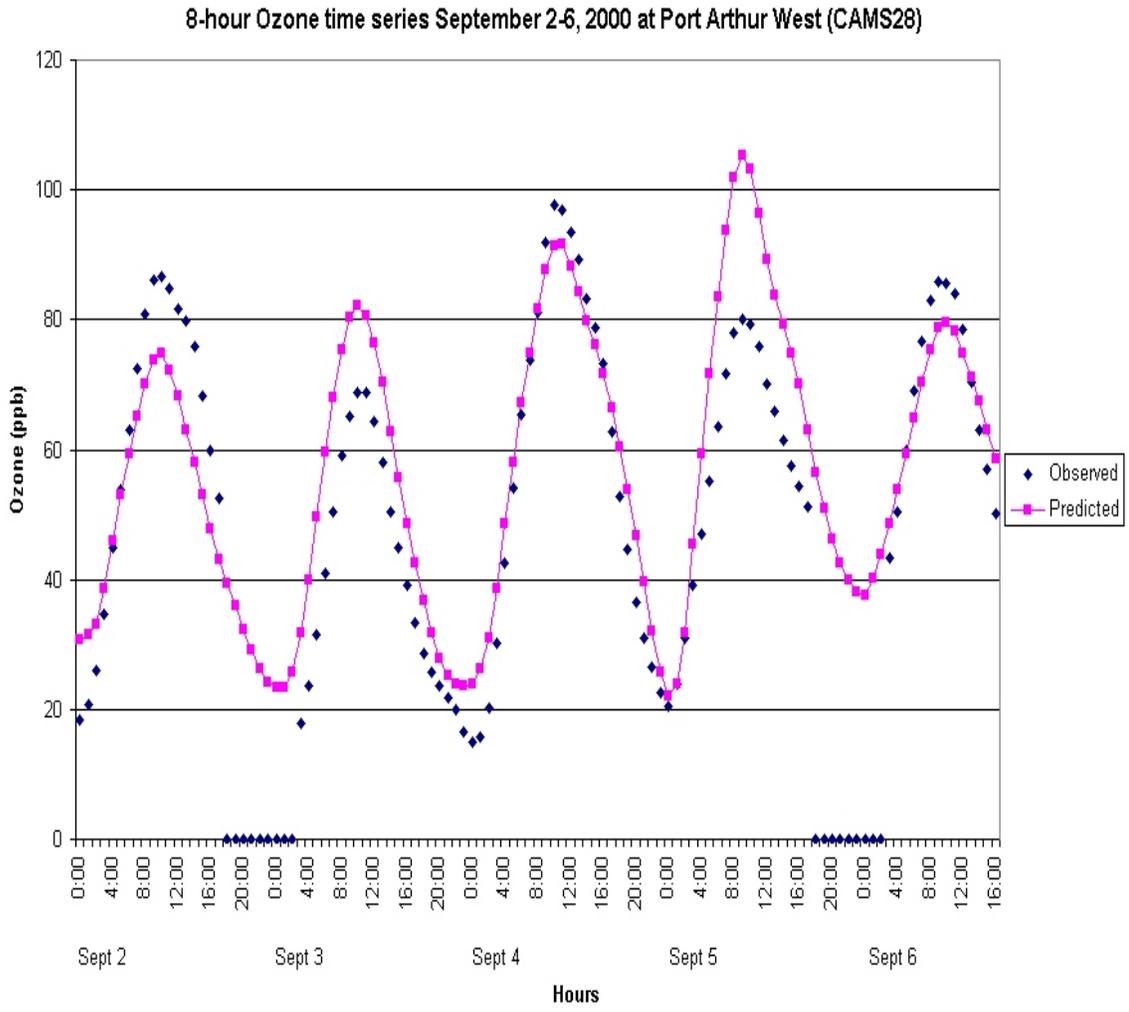


Figure 3.7-46: 8-hour Time Series September 2 - 6, 2000 at Port Arthur West (CAMS28)

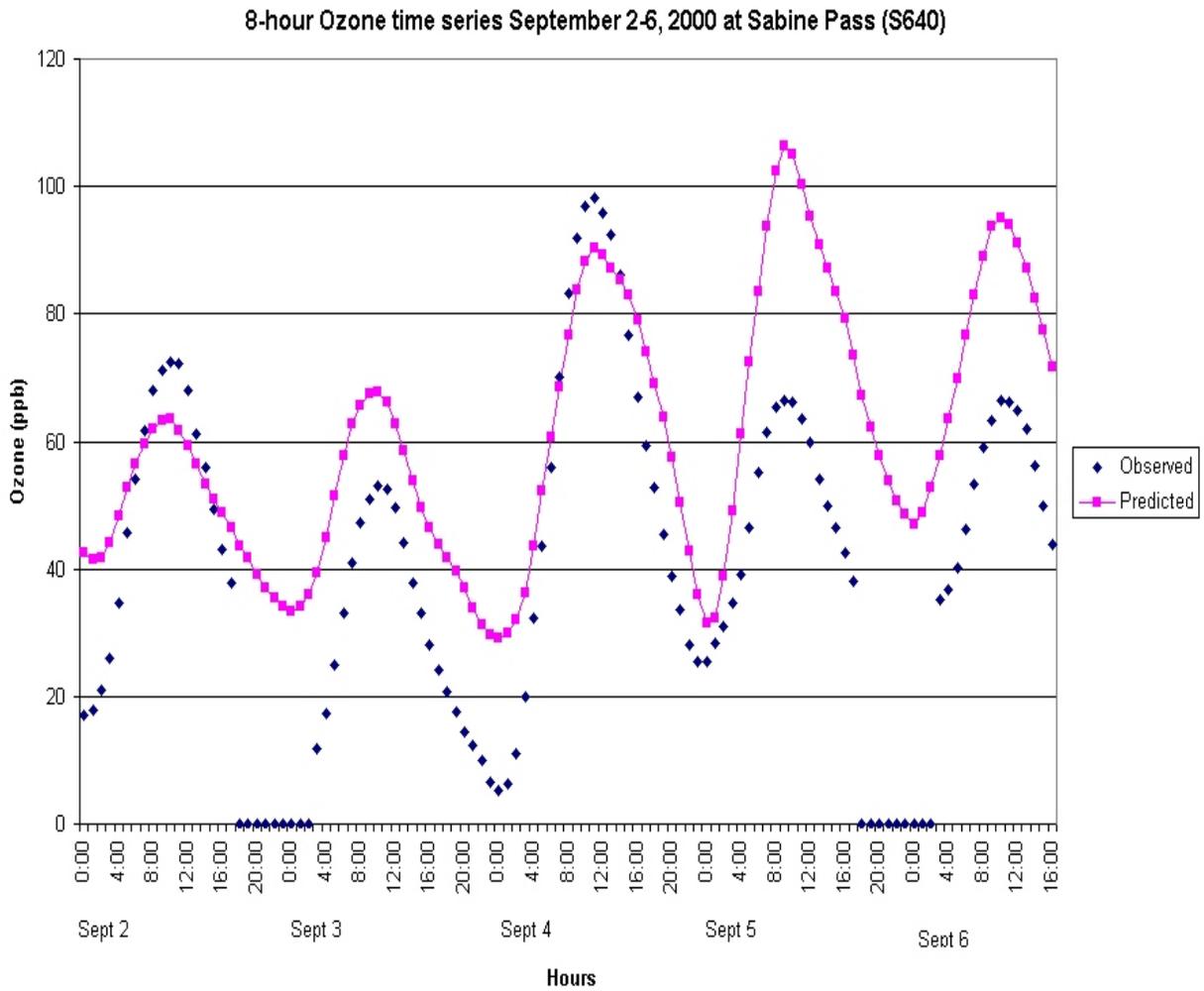


Figure 3.7-47: 8-hour Time Series September 2 - 6, 2000 at Sabine Pass (S640)

Daily Maximum 8-Hour Moving Average O₃ Concentrations (ppb) for 08/30/2000

HGMCR: camx403_base5b_psi02n2

Layer 1

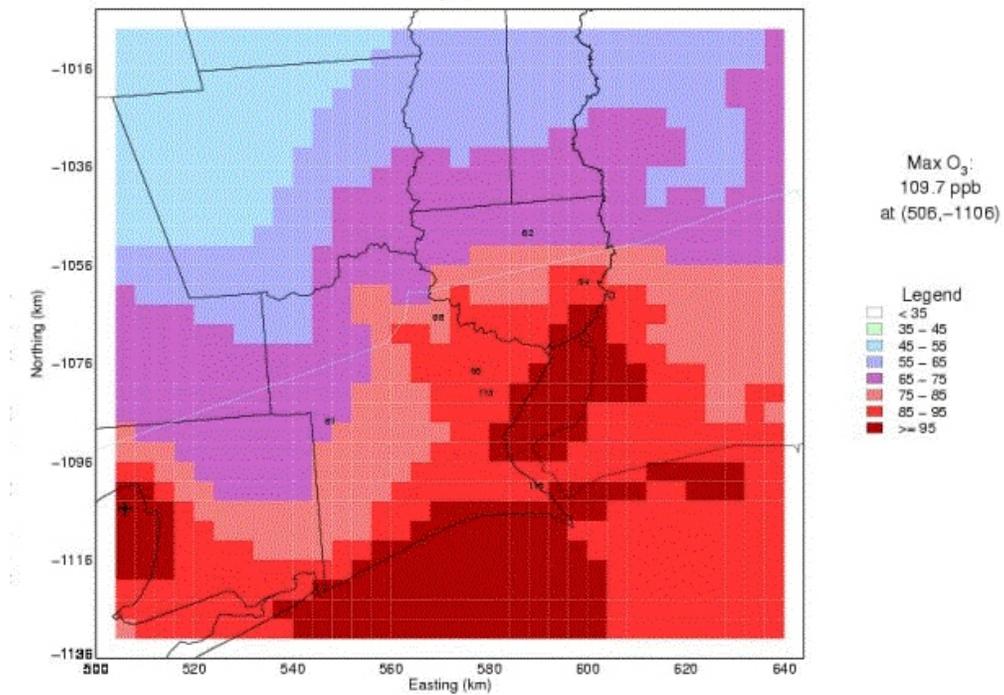


Figure 3.7-48: 8-hour Predicted Ozone Isopleth August 30, 2000

Daily Maximum 8-Hour Moving Average O₃ Concentrations (ppb) for 08/31/2000

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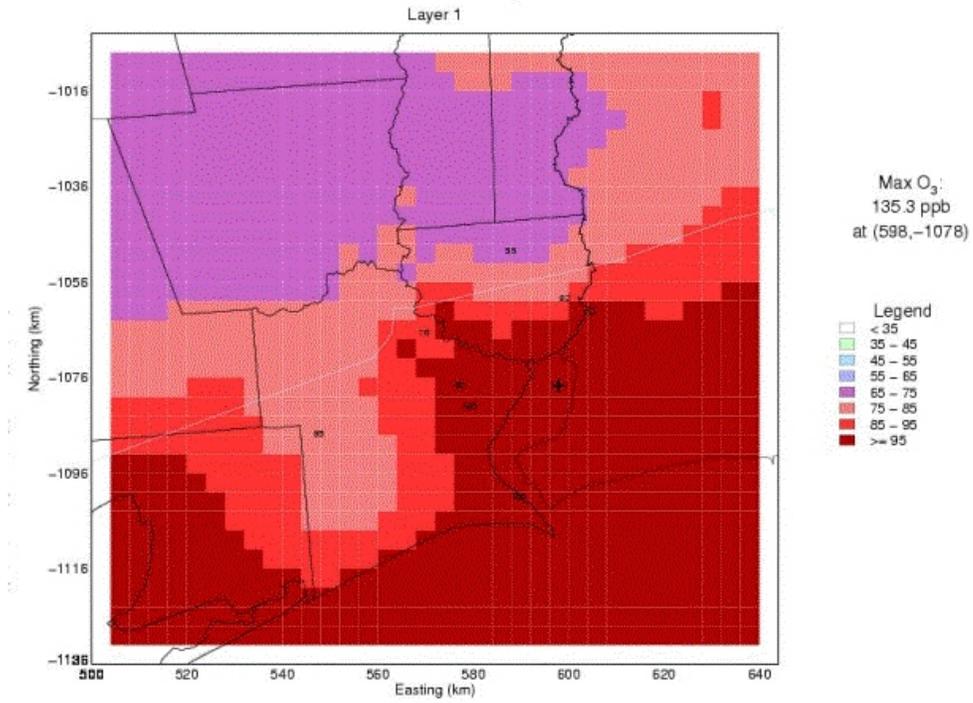


Figure 3.7-49: 8-hour Predicted Ozone Isoleth August 31, 2000

Daily Maximum 8-Hour Moving Average O₃ Concentrations (ppb) for 09/01/2000

HGMCR: camx403.base5b.psit02n2

Layer 1

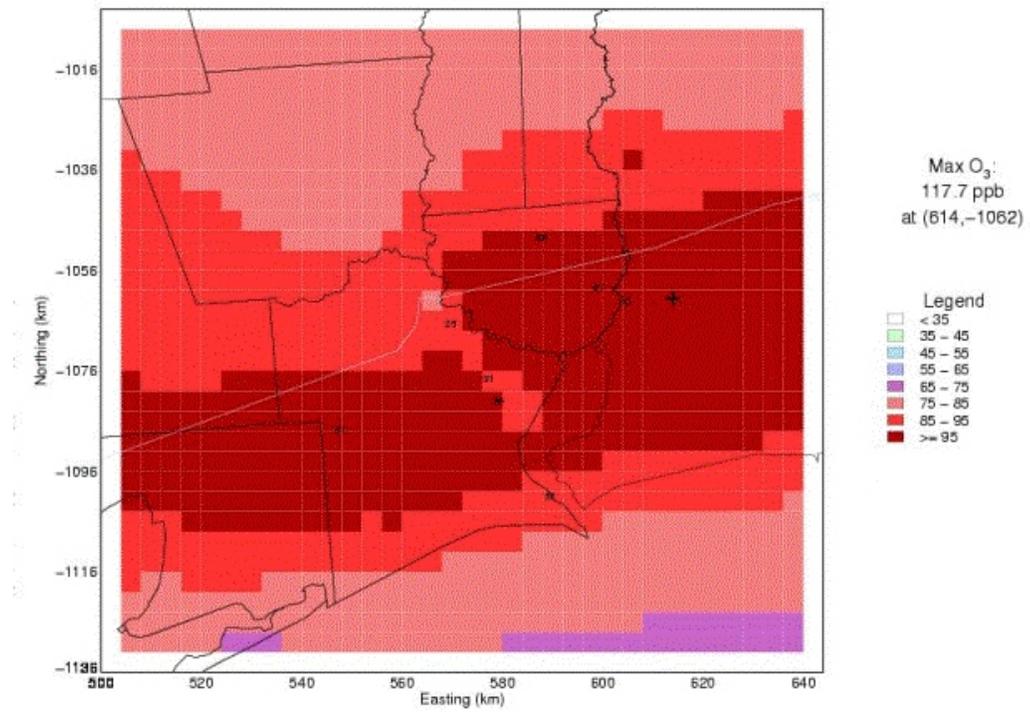


Figure 3.7-50: 8-hour Predicted Ozone Isopleth September 1, 2000

Daily Maximum 8-Hour Moving Average O₃ Concentrations (ppb) for 09/02/2000

HGMCR: camx403_base5b_psiso2n2

Layer 1

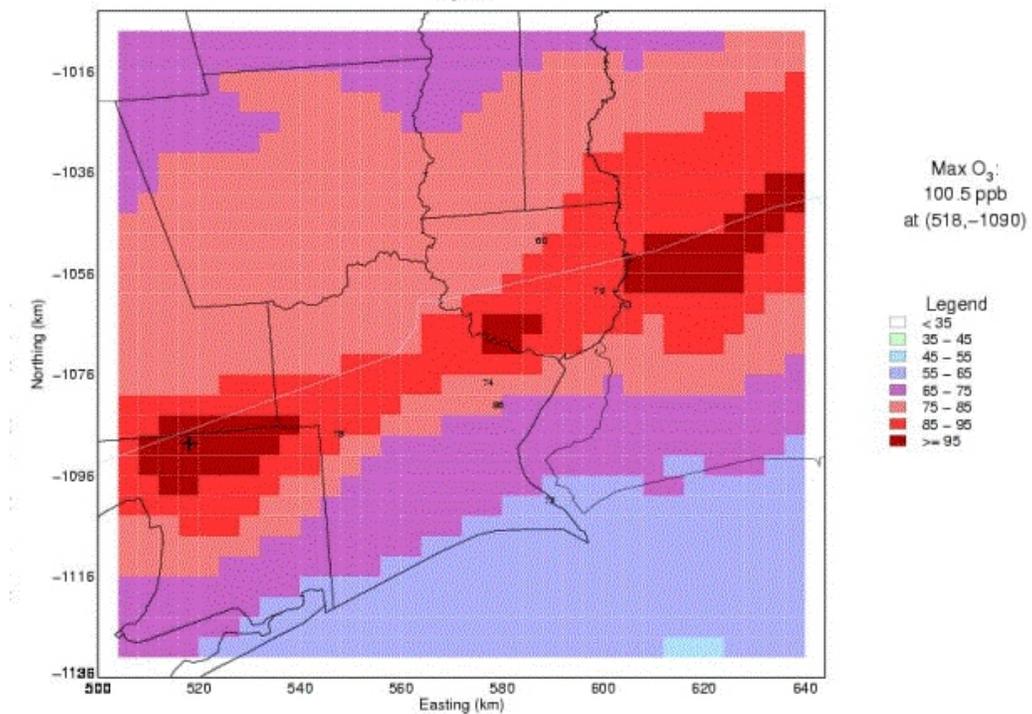


Figure 3.7-51: 8-hour Predicted Ozone Isopleth September 2, 2000

Daily Maximum 8-Hour Moving Average O₃ Concentrations (ppb) for 09/04/2000

HGMCR: camx403_base5b_psite2n2

Layer 1

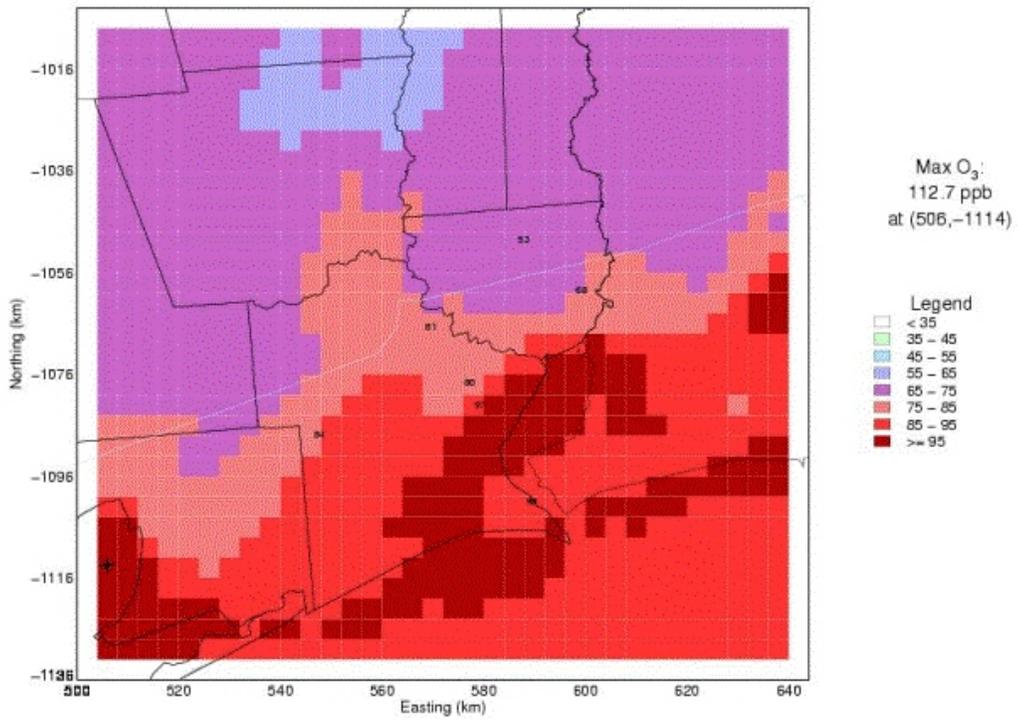


Figure 3.7-52: 8-hour Predicted Ozone Isoleth September 4, 2000

Daily Maximum 8-Hour Moving Average O₃ Concentrations (ppb) for 09/06/2000

HGMCR: camx403 base5b psito2n2

Layer 1

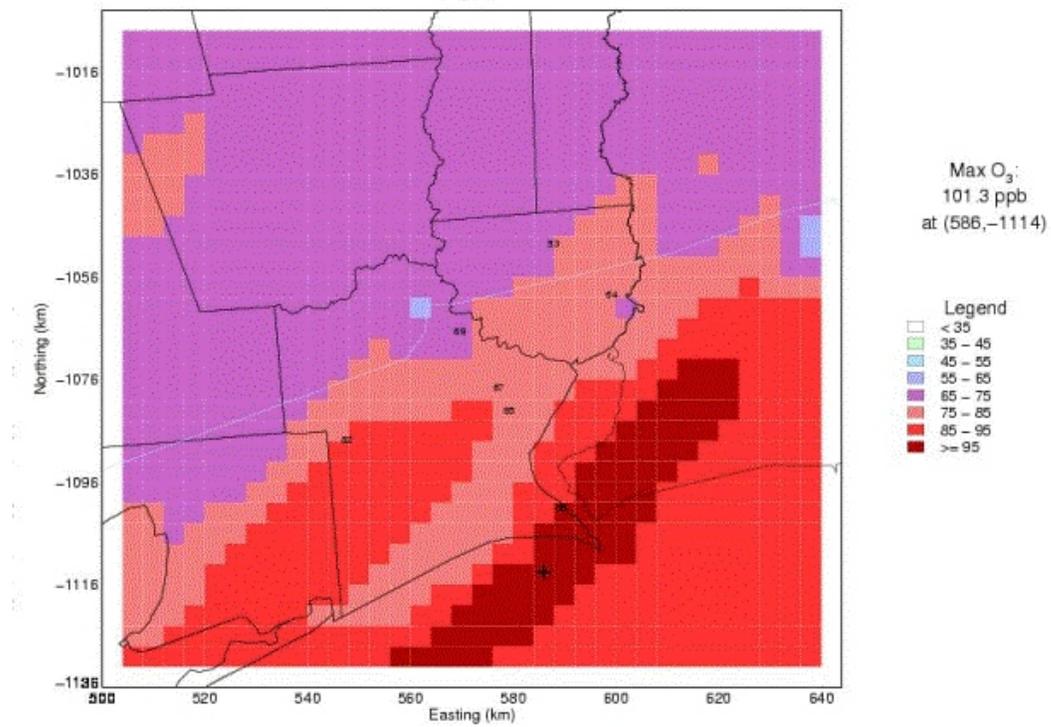


Figure 3.7-53: 8-hour Predicted Ozone Isopleth September 6, 2000

