# APPENDIX K

## DRAFT AWMA PAPER, “EVALUATION OF MODELED IMPACT OF TEXAS CLEAN GASOLINE”

REGIONAL STRATEGY

APRIL 2000 REVISION

# Evaluation of Modeled Impact of Texas Clean Gasoline

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## ABSTRACT

Texas has moved forward with a standard for clean gasoline that will be required over the eastern part of the state. The purpose of the clean gasoline is to improve ozone air quality over a large part of the state. Texas has performed regional scale photochemical modeling with three episodes over a large domain that includes the whole state. One of the control strategies evaluated with the regional modeling was the impact of the clean gasoline regulation that was adopted in 1999. This paper will describe the base case development of the regional modeling, review model performance evaluation, cover the emission analyses used to determine the precursor reductions attributed to the clean gasoline, and describe the results of the modeling for the three regional scale episodes.

## INTRODUCTION

For areas that do not meet the National Ambient Air Quality Standards (NAAQS) for ozone, states are required to develop detailed plans that show how the standard will be attained by the attainment date defined in the Federal Clean Air Act Amendments of 1990. In ozone nonattainment areas that were classified as serious and above, states are required to use photochemical grid models such as the Urban Airshed Model (UAM) to develop these state implementation plans (SIPs). A number of different data sets are needed to run these photochemical models. In simple terms, these data sets include information on the meteorological data, emissions data, initial conditions, and boundary conditions. When this data is run in the model, this is usually called “base case” modeling. Once the model is run for the base case, a performance evaluation is conducted to determine how well the model predicted the ozone levels which actually occurred during selected historical episodes. Performance is evaluated using U.S. Environmental Protection Agency-approved evaluation criteria and performance limits. If the model performance is acceptable, then additional major modeling steps are performed. These include developing the “base future inventory” by projecting emissions to the future attainment date. Then the model is run using this base future inventory along with the meteorology from the base case episodes to determine if the existing state and federal regulations reduce ozone sufficiently for the area to meet the NAAQS by the attainment year. If the existing regulations are not sufficient, then ozone precursor reduction targets are determined from the modeling results.

In addition to local control in nonattainment areas, Texas has moved forward with regional control strategies to reduce the ozone levels over a large portion of the state. One of these

strategies applies clean gasoline over a large portion of the eastern part of the state. Clean gasoline is defined by reducing the Reid vapor pressure (RVP) and sulfur content of the gasoline marketed during the period from June 1 to October 1 of each year. Beginning in 2000, the RVP will be limited to 7.8 pounds per square inch (psi). Beginning in 2004, the sulfur content in gasoline will be limited to an average of 150 parts per million (ppm). The clean gasoline rule was adopted by the TNRCC on July 21, 1999. This paper will describe the modeling used to evaluate the impact of the clean gas.

## Regional Scale Modeling

As a part of ozone SIP development for the Houston/Galveston (HG) area, large scale regional photochemical modeling was performed to set boundary conditions for the urban scale photochemical modeling. This modeling was performed with an episode from September 6, 1993 to September 11, 1993 that was a part of the extensive database collected during the Coastal Oxidant Assessment for Southeast Texas (COAST) study. This modeling domain is shown in Figure 1. The original modeling was performed with version V of the UAM (UAM-V). In a similar fashion, regional scale modeling was performed over the same domain for the development of boundary conditions for use in the urban scale photochemical modeling for SIP development in the Dallas/Fort Worth (DFW) area. These episodes were from June 18, 1995 to June 22, 1995 and from June 30, 1996 to July 4, 1996.

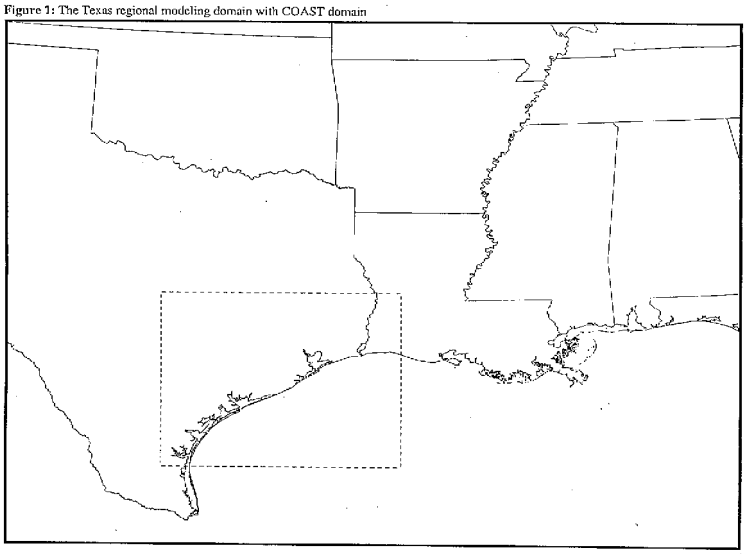


**Figure 1** Regional Modeling Domain

The Comprehensive Air Quality Model with extensions (CAMx) is an enhanced photochemical model with a file structure that is similar to that used by UAM-V and other enhanced photochemical models. The regional photochemical modeling discussed here was performed with the CAMx version 1 model using 16 kilometer x 16 kilometer grid cells.

## 1993 Episode

The modeling was performed with an episode that occurred from September 6-11, 1993 that included four consecutive exceedance days in the HG area beginning on September 8, 1993 to September 11, 1993. The databases used for photochemical modeling are summarized below, but specific details for the development of the emissions inventory and meteorological data preparation may be found in the February 1998 SIP for the HG area, the 1996 report on

developing boundary conditions, and the 1999 report on regional modeling.

Meteorological data for the modeling during this time period was part of the extensive COAST field study. Meteorological data files for the model were developed with the Regional Air Modeling System. This is a prognostic meteorological model. These files contained wind field values, temperatures, humidity, and cloud cover. The primary source of the base case emissions was the inventory developed for the Ozone Transport Assessment Group (OTAG) modeling. Day specific emissions were determined for biogenic and mobile sources, but point and area source emissions were determined for day of the week. The biogenic emissions were developed with the Biogenic Emissions Inventory System Version 2 (BEIS2) emission factors. Base case emissions were estimated for 1993, then projected to 2007. In 1993, a national standard for diesel fuel was implemented that limited the sulfur content to 0.05 percent and a minimum cetane level of 40. This rule was implemented in all states except Alaska. This rule is often referred to as the national diesel rule. The National Low-Emitting Vehicle (NLEV) rule became effective in 1998. Starting with model year 1999 in the northeastern states and model year 2001 nationally, all new cars and light-duty trucks up to 6,000 pounds gross vehicle weight will meet tailpipe standards that are more stringent than the U. S. Environmental Protection Agency could mandate prior to model year 2004. This rule will substantially reduce tailpipe emissions. For this modeling, the impact of national diesel and NLEV programs were applied to the base 2007 emissions.

## 1995 and 1996 Episodes

The modeling was performed with two episodes that occurred from June 18 to June 22, 1995 and June 30 to July 4, 1996. These episodes covered exceedance days in the DFW area. The data bases used for photochemical modeling are summarized below, but specific details for the development of the emissions inventory and meteorological data preparation may be found in "*Revisions to the State Implementation Plan for the Control of Ozone Air Pollution, Attainment Demonstration for the Dallas/Fort Worth Ozone Nonattainment Area, October 21, 1998*."

Meteorological data for the model were developed with the Systems Applications Incorporated Meteorological Model. This is a prognostic model and output was nudged with four dimensional data assimilation. Emission development focused on sources in the DFW nonattainment area. Point source emissions were developed using 1995 and 1996 emissions survey data in the TNRCC emissions inventory database. Where available, day specific emissions were based on continuous emissions monitoring data from the acid rain database. Day specific link-based mobile source emissions were used for the DFW area. Biogenic emissions were developed from biomass surveys and BEIS2 emission factors. For areas outside the DFW area, the emissions were developed following the procedures for the 1993 episode. Base case emissions were estimated for 1995 and 1996. For the 1995 and 1996 episodes, the future base 2007 emissions inventory was projected using the same projections used with the 1993 episode, and day specific temperatures and day of the week information.

## Model Performance Evaluation

Overall model performance for the 1993, 1995, and 1996 episodes appears to be acceptable for evaluation of regional controls, although there is a tendency for the model to over-predict ozone concentration. The performance varied, but generally was approximately as good as that obtained with other regional scale modeling such as that performed by OTAG. The model did not perform as well in urban areas as in rural areas. Its performance in the coastal areas was affected by the large size of the grid cells and the inability of the meteorological model to adequately resolve the complex meteorological conditions that occur in those areas. The model performance was adequate to have confidence in the relative results obtained from the modeling.

Specific details may be found in "*Impacts of Regional Control Strategies on Air Quality in Eastern and Central Texas: Performance Evaluation*" by McDonald-Buller et al.

## Texas Clean Gas

Texas Clean Gas is to be marketed between June 1 and October 1 of each year. The RVP will be limited to 7.8 pounds psi and the sulfur content in gasoline will be limited to an average of 150 ppm. The impact of these controls on the 2007 base inventory was calculated with the Complex Model and Mobile5 model. The Complex model is used by petroleum refiners to determine if performance goals of gasoline are met relative to a baseline standard. It can be used to evaluate the impact of control strategies that limit various parameters of gasoline such as RVP, sulfur content, and methyl tertiary-butyl ether content. The model estimates the percentage change in volatile organic compounds (VOCs), carbon monoxide, nitrogen oxides ($NO_x$), and toxics for a given gasoline mixture compared to the baseline standard. These calculations were based on the fuel supplied to each area of the state. Phase I reformulated gasoline is already required in the HG and DFW nonattainment areas, so no additional reductions were modeled in those areas. For other areas, it was assumed that the RVP for gasoline was 9 psi and the sulfur content was 330 ppm. In these areas of the state, after the RVP and sulfur controls described above were applied, the reduction to the mobile source emissions were 14.3 percent for VOCs and 5 percent for $NO_x$.

## RESULTS

The results of the modeling were presented in the form of maps of ozone concentrations modeled over the modeling domain. For each day modeled, there were three different ozone concentration maps for one-hour concentrations and three for eight-hour concentrations. For each averaging time, there was a map of the results for the future base 2007 emissions, a map of the results after the reductions due to clean gasoline were applied to the base 2007 emissions, and a map that showed the difference in each grid cell between the first two maps. Figure 2 illustrates the one-hour map for the base 2007 emissions for September 8, 1993.

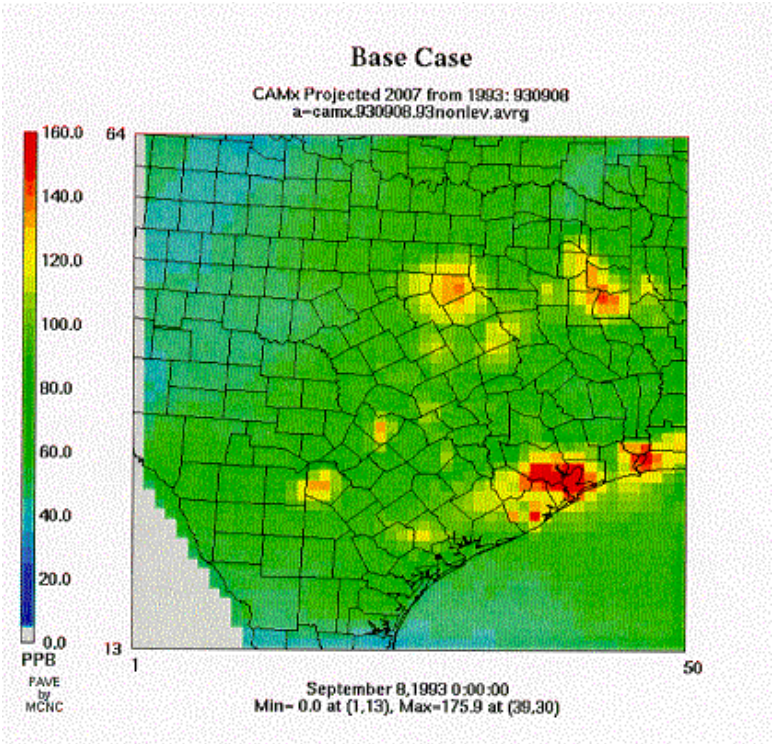


**Figure 2** Future Base 1-Hour Ozone (September 8, 1993)

Figure 3 illustrates the map of the difference between the base 2007 results and the results after applying the clean gas controls. Of special interest to Texas are the Austin, San Antonio, and Tyler/Longview areas since monitoring indicates that they exceed the proposed eight-hour ozone standard and have occasionally exceeded the one-hour ozone standard. Figure 3 indicates that over the modeling domain, the largest one-hour difference was 3.6 parts per billion (ppb) located in the vicinity of San Antonio. There were differences greater than 2.0 ppb over most of the San Antonio area. Figure 2 indicates that over the area of the largest reductions in San Antonio, the maximum one-hour concentrations were above the one-

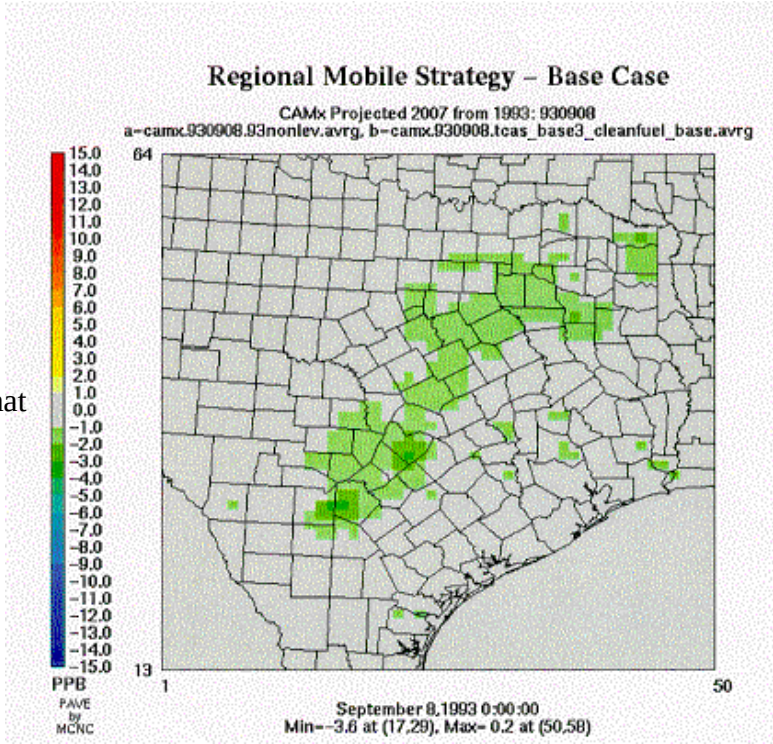


**Figure 3** Difference Plot For 1-Hour Ozone Showing the Benefits of the Regional Mobile Strategy in 2007

hour standard of 120 ppb. Similar results were found in the Austin and Tyler/Longview areas. The one-hour values for each day modeled are reported in Table 1. For the 11 days modeled in the Austin area, the one-hour difference was greater than 3.0 ppb on two days, greater than 2.0 ppb on three days, and greater than 1.0 ppb on five days. In the San Antonio area, the one-hour difference was greater than 3.0 ppb on one day, greater than 2.0 ppb on five days, and greater than 1.0 ppb on three days. Similarly, in the Tyler/Longview area, the one-hour difference was greater than 2.0 ppb on three days and greater than 1.0 ppb on seven days.

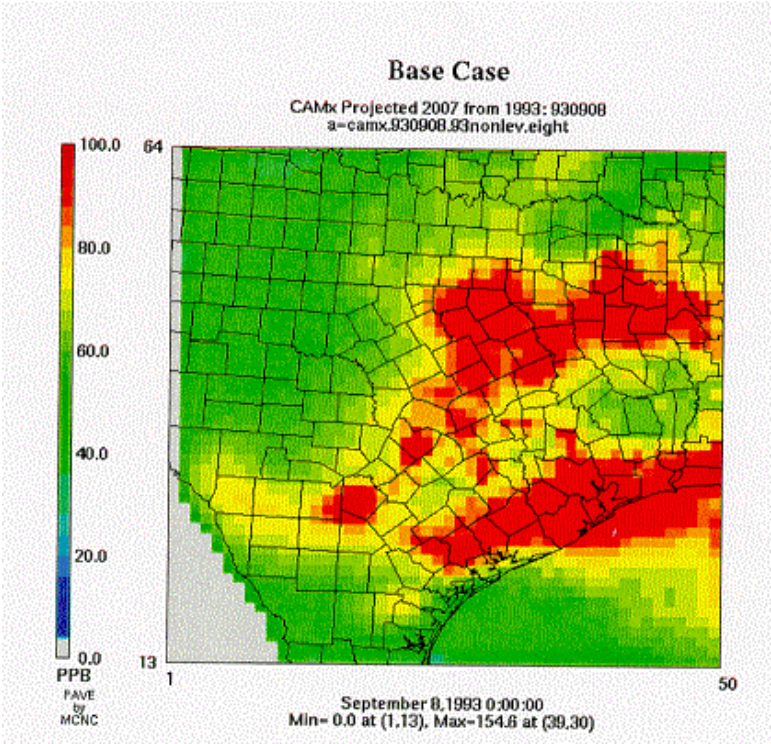


**Figure 4** Future Base 8-Hour Ozone (September 8, 1993)

Figure 4 shows eight-hour ozone concentrations for the base 2007 emissions for September 8, 1993. Figure 5 shows the map for differences between the base 2007 results and the results after applying the clean gas controls. From the results in Figure 5, the largest eight-hour difference was 2.9 ppb found in the Austin area. There was a significant area where the difference was greater than 2.0 ppb and the whole county was covered by a difference of greater than 1.0 ppb. Figure 4 indicates that most of the county is well above 85 ppb, the proposed eight-hour standard. Figure 6 indicates that the largest differences occur where some of the largest concentrations were predicted. Since the current design value for Austin is 87 ppb, the differences predicted for implementing clean gasoline will play a significant role

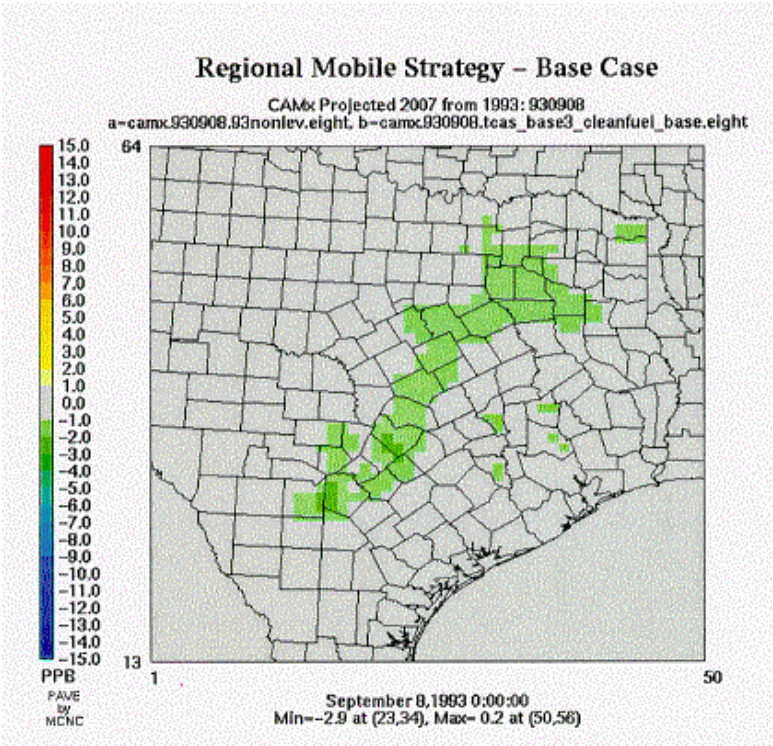


**Figure 5** Difference Plot For 8-Hour Ozone Showing Benefits of the Regional Mobile Strategy in 2007

in moving the area closer to the proposed eight-hour standard. Similar results are found for the San Antonio and Tyler/Longview areas. The eight-hour values for each day modeled are reported in Table 2.

**Table 1. Reductions in One-Hour Ozone Concentrations with Application of Clean Gas**

| Day | Maximum Difference ppb | Difference Austin Area ppb | Difference San Antonio Area ppb | Difference Corpus Christi Area ppb | Difference Tyler-Longview ppb |
|---|---|---|---|---|---|
| 9/7/93 | 2.8 | 2.0 to 3.0 | 2.0 to 3.0 | < 1.0 | 1.0 to 2.0 |
| 9/8/93 | 3.6 | 3.0 to 4.0 | 3.0 to 4.0 | 1.0 to 2.0 | 2.0 to 3.0 |
| 9/9/93 | 3.6 | 3.0 to 4.0 | 2.0 to 3.0 | < 1.0 | 1.0 to 2.0 |
| 9/10/93 | 3.2 | 2.0 to 3.0 | 3.0 to 4.0 | <1.0 | 1.0 to 2.0 |
| 9/11/93 | 1.8 | 1.0 to 2.0 | < 1.0 | < 1.0 | < 1.0 |
| 6/20/95 | 1.8 | <1.0 | 1.0 to 2.0 | <1.0 | 1.0 to 2.0 |
| 6/21/95 | 1.8 | 1.0 to 2.0 | 1.0 to 2.0 | <1.0 | 1.0 to 2.0 |
| 6/22/95 | 2.8 | 1.0 to 2.0 | 2.0 to 3.0 | < 1.0 | 2.0 to 3.0 |
| 7/2/96 | 2.2 | 1.0 to 2.0 | 2.0 to 3.0 | 1.0 to 2.0 | 1.0 to 2.0 |
| 7/3/96 | 2.7 | 2.0 to 3.0 | 2.0 to 3.0 | < 1.0 | 2.0 to 3.0 |
| 7/4/96 | 1.5 | 1.0 to 2.0 | 1.0 to 2.0 | < 1.0 | 1.0 to 2.0 |

**Table 2. Reductions in Eight-Hour Ozone Concentrations with Application of Clean Gas**

| Day | Maximum Difference ppb | Difference Austin Area ppb | Difference San Antonio Area ppb | Difference Corpus Christi Area ppb | Difference Tyler-Longview ppb |
|---|---|---|---|---|---|
| 9/7/93 | 2.3 | 1.0 to 2.0 | 1.0 to 2.0 | < 1.0 | 1.0 to 2.0 |
| 9/8/93 | 2.9 | 2.0 to 3.0 | 2.0 to 3.0 | < 1.0 | 1.0 to 2.0 |
| 9/9/93 | 3.0 | 2.0 to 3.0 | 2.0 to 3.0 | < 1.0 | 1.0 to 2.0 |
| 9/10/93 | 2.6 | 2.0 to 3.0 | 2.0 to 3.0 | < 1.0 | 1.0 to 2.0 |
| 9/11/93 | 1.6 | 1.0 to 2.0 | 1.0 to 2.0 | < 1.0 | < 1.0 |
| 6/20/95 | 1.6 | < 1.0 | < 1.0 | < 1.0 | 1.0 to 2.0 |
| 6/21/95 | 1.7 | 1.0 to 2.0 | < 1.0 | < 1.0 | 1.0 to 2.0 |
| 6/22/95 | 2.6 | 1.0 to 2.0 | 1.0 to 2.0 | < 1.0 | 2.0 to 3.0 |
| 7/2/96 | 1.8 | 1.0 to 2.0 | 1.0 to 2.0 | < 1.0 | 1.0 to 2.0 |
| 7/3/96 | 2.4 | 1.0 to 2.0 | 1.0 to 2.0 | < 1.0 | 2.0 to 3.0 |
| 7/4/96 | 1.5 | 1.0 to 2.0 | 1.0 to 2.0 | < 1.0 | 1.0 to 2.0 |

Figure 6 is the map of the base 2007 one-hour ozone concentrations for June 22, 1995, and Figure 7 is the corresponding map showing the differences in one-hour concentrations between the base 2007 results and the results after applying the clean gas controls. Figure 7 shows that the largest one-hour difference was 2.8 ppb in the Tyler/Longview area. In the same area, there was a significant area with differences larger than 2.0 ppb and a large area where the difference was greater than 1.0 ppb. Figure 6 indicates that the maximum one-hour ozone concentration over the area of largest reductions was near or above the one-hour ozone standard. The Tyler/Longview area currently violates the one-hour ozone standard, so the clean gas controls would be effective in reducing one-hour concentrations in this area.

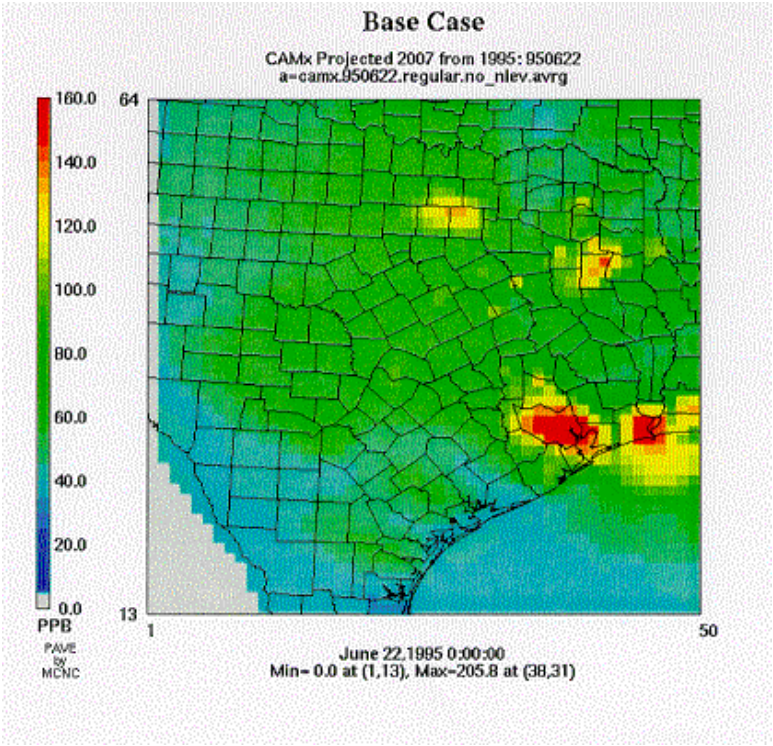


**Figure 6** Future Base 1-Hour Ozone (June 22, 1995)

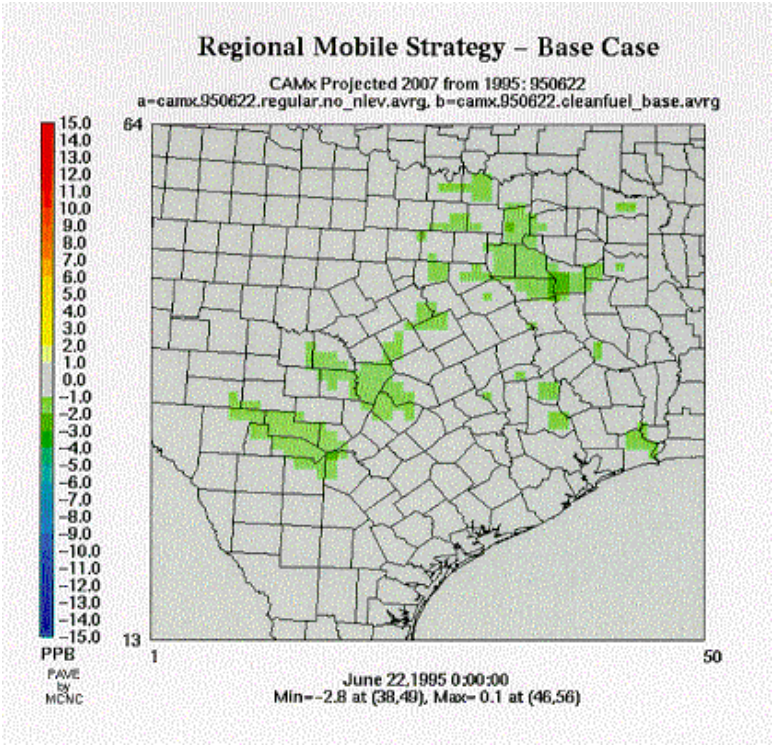


**Figure 7** Difference Plot for 1-Hour Ozone Showing the Benefits of the Regional Strategy in 2007

Figure 8 is the map of the base 2007 eight-hour concentrations for June 22, 1995, and Figure 9 is the corresponding map showing the differences in eight-hour concentrations between the base 2007 results and the results after applying the clean gas controls. Figure 9 shows that the largest difference in eight-hour concentrations is 2.6 ppb in the Tyler/Longview area. Figure 8 indicates that there is a large area in the Tyler/Longview area where the eight-hour ozone concentration exceeds 85 ppb. This indicates that the clean gasoline control would be effective in reducing eight-hour ozone concentrations in an area that exceeds the eight-hour proposed ozone standard.

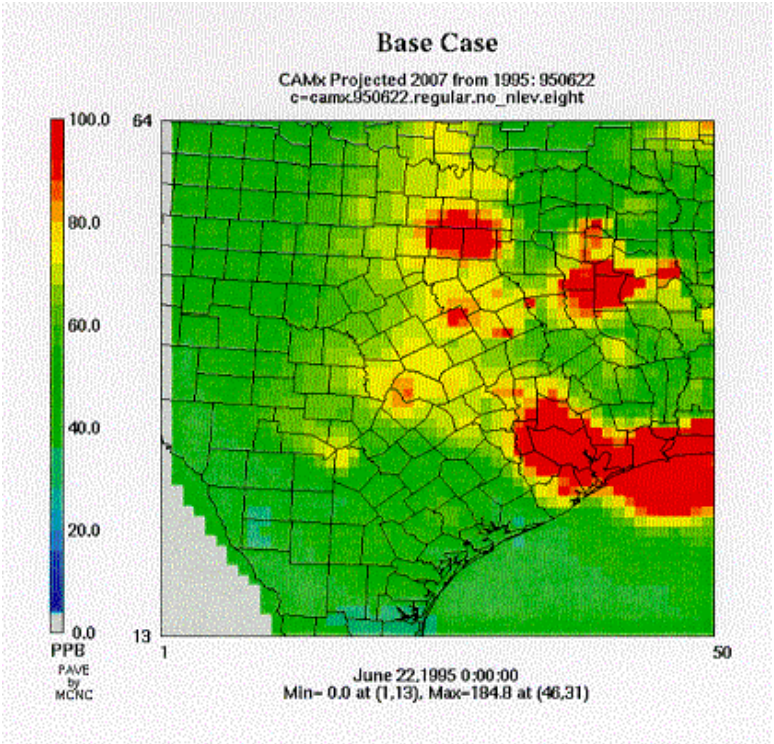


**Figure 8** Future Base 8-Hour Ozone (June 22, 1995)

## CONCLUSIONS

Regional scale photochemical grid modeling has been conducted with three episodes from 1993, 1995, and 1996 to evaluate the implementation of cleaner burning gasoline, Stage I vapor recovery, and NLEV. These controls will reduce one-hour ozone averages from 1.0 to 3.6 ppb over large areas of east and southeast Texas including the Austin, San Antonio, and Tyler/Longview areas. Reductions in eight-hour ozone averages would be slightly lower, but of the same magnitude over the same areas. When it is considered that the current eight-hour ozone design value for Austin and San Antonio is 87 ppb, and that a

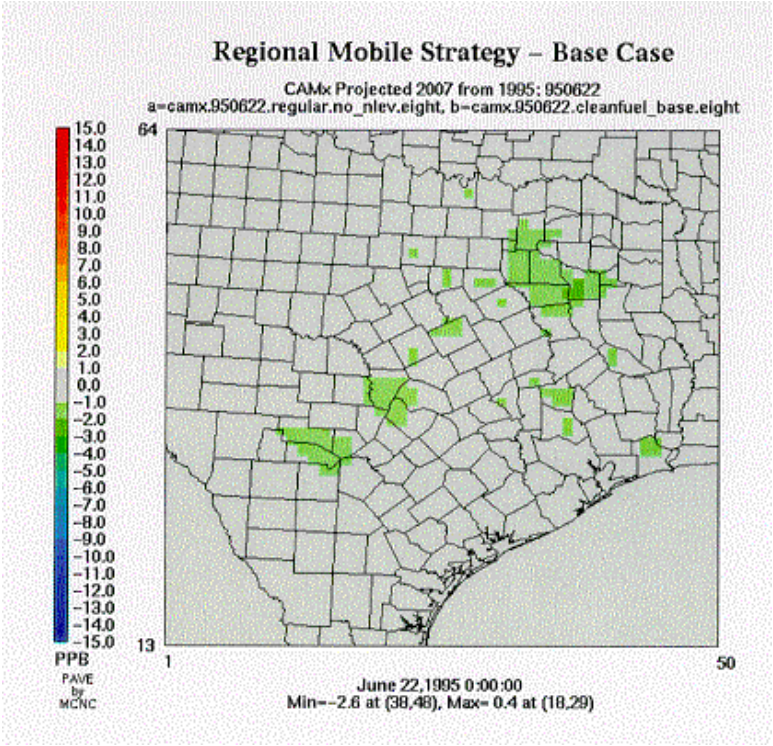


**Figure 9** Difference Plot for 8-Hour Ozone Showing the Benefits of the Regional Strategy in 2007

reduction of only 2 ppb is sufficient to meet the proposed 8-hour standard, then the implementation of these mobile source controls is significant.

## REFERENCES


1. TNRCC, *Revisions to the State Implementation Plan for the Control of Ozone Air Pollution, Attainment Demonstration for the Houston/Galveston Ozone Nonattainment Area, February 20, 1998*.
2. TNRCC, *Final Report, Future-Year Boundary Conditions for Urban Airshed Modeling for the State of Texas, August 30, 1996*.
3. TNRCC, *Impacts of Regional Control Strategies on Air Quality in Eastern and Central Texas, August, 1999*.
4. TNRCC, *Revisions to the State Implementation Plan for the Control of Ozone Air Pollution, Attainment Demonstration for the Dallas/Fort Worth Ozone Nonattainment Area, October 21, 1998*.
5. McDonald-Buller E, Eusebi A, Russell M, Quigley C, Hill A, Allen D, *Impacts of Regional Control Strategies on air Quality in Eastern and Central Texas: Performance Evaluation*, August 1999.