ATTACHMENT 4

ALPINE
GEOPHYSICS
Atmospheric Sciences Division

Technical Report

Subregional Modeling Re-Assessment of the Contribution of West Texas Source Emissions to $PM_{2.5}$ Nonattainment Under EPA's CAIR Rule

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EXECUTIVE SUMMARY

At the request of Baker Botts, LLP, Alpine Geophysics, LLC performed advanced air quality modeling in connection with EPA's recent Clean Air Interstate Rule (CAIR). We examined the accuracy and reliability of the $PM_{2.5}$ air quality impacts attributed by EPA's modeling to manmade (anthropogenic) emissions from sources in Texas by essentially repeating key portions of the annual $PM_{2.5}$ CAIR Rule modeling over the continental U.S with particular attention paid to Texas. The aim of our modeling effort, beyond corroborating the CAIR Rule CMAQ model on an independent computer system, was to explore whether a more spatially refined modeling analysis of Texas emissions sources would alter EPA's findings of significant impacts at downwind receptors.

For a number of reasons -- political, legal, economic, historical and technical -- the State of Texas is commonly divided into east Texas and west Texas separated by the major north-south Interstate I-35 and Interstate I-37). This historical separation of east Texas and west Texas is consistent with the location and magnitude of emissions sources in the two regions, and the prevailing wind patterns linking Texas with the downwind St. Louis $PM_{2.5}$ nonattainment area.

Using EPA's CAIR rule modeling methods and data bases, we conducted refined sub-regional modeling of east Texas and west Texas emissions sources. The 'refinement' stems from our modeling of the state of Texas as distinct regions. In the CAIR Rule modeling, EPA conducted coarser state-by-state "zero-out" analysis to quantify a state's downwind impact on projected $PM_{2.5}$ nonattainment areas. Our refined modeling went a step further by exploring what the CAIR Rule modeling would have shown regarding had EPA considered the west Texas and east Texas separately.

To support the CAIR Rule, EPA used the CMAQ model and the annual 2001 period to perform zero-out simulations in which anthropogenic emissions from the entire state of Texas were eliminated. EPA's comparisons between the Texas 'zero-out' run and the 2010 Base Case run indicated that Texas' highest annual average PM2.5 contribution to any of the 113 year 2010 'modeled plus monitored' nonattainment sites in any other state was $0.29\mu g/m^3$ in Madison County, Illinois. Only one other impact above EPA's threshold criterion of $0.2\mu g/m^3$ was predicted and this was in adjacent St. Clair County, Illinois where a value of $0.28\mu g/m^3$ was modeled. At the Madison County monitor, the year 2010 Base Case $PM_{2.5}$ prediction was 16.66 $\mu g/m^3$. Implementation of the CAIR controls required by 2010 led to a lower annual average of 15.96 $\mu g/m^3$, representing a net reduction of 0.70 $\mu g/m^3$. The 2010 Base and 2010 CAIR $PM_{2.5}$ annual averages at St. Clair were 16.24 $\mu g/m^3$ and 15.54 $\mu g/m^3$, respectively, which constitutes an identical improvement of -0.70 $\mu g/m^3$ at that locale.

A concerted effort on the part of Alpine and EPA staff was made to corroborate proper operation of the CMAQ modeling system with the CAIR data bases on our computers. Using the CMAQ model input and output files plus the Speciated Model Attainment Test (SMAT) post processing software, we were able to reproduce the CMAQ results quite well. However, despite these efforts, some remaining corroboration issues remain. Though not detracting from the results presented here, they do signal the need for additional efforts with EPA to document key analysis methods (e.g. rounding procedures) and the authenticity of certain model input files.

From the Texas subregional zero-out simulations, we determined anthropogenic emissions sources within east Texas are estimated to contribute 0.26 $\mu g/m^3$ and 0.27 $\mu g/m^3$ $PM_{2.5}$ at the Madison and St. Clair counties, respectively. For west Texas, our subregional zero-out modeling shows contributions of 0.05 $\mu g/m^3$ in both Illinois counties. Due to the nonlinearities in atmospheric chemistry and the artifacts caused by zero-out runs, the sum of the west Texas and east Texas impacts at both counties is slightly larger than the total impact from the entire state of Texas, as determined in EPA's zero-out run. It is possible that the incremental impacts from east Texas and west Texas may be overestimated slightly but this has not been confirmed yet.

Using EPA's criterion of 0.20 $\mu g/m^3$ as the definition for a significant impact, we see that the states of Missouri, Illinois, Indiana, Texas, Iowa, Ohio and Kentucky would be declared as significant contributors. Had EPA modeled west Texas and east Texas as distinct regions, east Texas would have been demonstrated to be a significant contributor to downwind PM2.5 nonattainment, at least based on EPA's significance threshold definition. West Texas, on the other hand, would fall toward the bottom of the list non-contributors with impacts (0.05 $\mu g/m^3$) that are only one fourth of the EPA's threshold criterion. Indeed, west Texas contributes only about 15% of the total Texas impact to the Madison and St. Clair counties.

Monthly average $PM_{2.5}$ concentration isopleths across the 36 km CMAQ domain for the west Texas (left) and east Texas (right) simulations reinforce the statistical findings. The downwind plume from the west Texas region has less geographical coverage, involves lower concentrations, and does not show nearly the influence on the St. Louis region when compared with the east Texas plume.

Our overall findings are that:

> The EPA 2010 CAIR Base Case simulation has been corroborated on Alpine's computers;

> While EPA's SMAT post-processing software produces slightly different results on Alpine's machines compared with EPA's computers, these discrepancies are unimportant for this analysis since we use the same version of the software to compare 2010 base case with subregional zero-out runs;

> EPA's finding of Texas's significant contribution to $PM_{2.5}$ nonattainment in Illinois is the result of emissions sources in east Texas; and

> CAIR controls on sources in west Texas have no meaningful impact in $PM_{2.5}$ attainment in St. Clair and Madison Counties.

EPA's CAIR analysis considered Texas only as one region (indeed, Texas by itself is larger than many eastern states the EPA considered individually in the CAIR Rule). Our results show the clear need to examine west Texas and east Texas separately since the downwind $PM_{2.5}$ impacts from these two regions is decidedly different.

1.0 INTRODUCTION

At the request of Baker Botts, LLP, Alpine Geophysics, LLC performed advanced air quality modeling in connection with EPA's recent Clean Air Interstate Rule (CAIR), particularly as it pertains to the state of Texas. Baker Botts specifically requested Alpine to address the accuracy and reliability of the $PM_{2.5}$ air quality impacts attributed by EPA's modeling to manmade (anthropogenic) emissions from sources in Texas. Alpine essentially repeated portions of the annual $PM_{2.5}$ CAIR Rule modeling over the continental U.S. but we placed particular attention on the downwind $PM_{2.5}$ impacts ascribed to Texas by the EPA in their modeling analysis (EPA, 2005). The aim of our modeling effort, beyond corroborating the CMAQ modeling on an independent computer system, was to explore whether a more spatially refined modeling analysis of Texas emissions sources would alter EPA's findings of significant impacts at downwind receptors.

This technical report by Alpine Geophysics summarizes independent analyses, using EPA's CMAQ air quality model and CAIR Rule data bases, to calculate the impact of Texas anthropogenic emissions sources on annual average $PM_{2.5}$ nonattainment in two Illinois counties. Using EPA's CAIR rule modeling methods and data bases, we conducted refined sub-regional modeling of Texas emissions sources. The 'refinement' stems from our modeling of the state of Texas as two distinct emissions regions rather than as one. In the CAIR Rule modeling, EPA conducted coarser state-by-state "zero-out" analysis to quantify a state's downwind impact on projected $PM_{2.5}$ nonattainment areas. Our refined modeling goes a step further by exploring what the CAIR Rule modeling would have shown regarding Texas' impacts on downwind states had EPA considered the western and eastern Texas source regions separately.

1.1 Overview

On 12 May 2005, EPA published in the Federal Register the final CAIR Rule imposing controls on sulfur dioxide (SO_2) and oxides of nitrogen (NOx) to assist in achieving attainment of the 8-hour ozone and fine particulate ($PM_{2.5}$) standards in the eastern U. S. The CAIR Rule mandates the deepest cuts in SO2 and NOx emissions in more that a decade. It provides for the use of a regional cap-and-trade program aimed at achieving the substantial reductions SO_2 and NOx emissions in order to help attain the 8-hr ozone and $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS). The program applies to the 28 eastern states and the District of Columbia. Though the required emissions reductions could conceivably come from any collection of anthropogenic source categories, the CAIR Rule clearly reflects EPA's position that the mandated substantial emissions reductions should come from the electric generating unit (EGU) sector because, the agency argues, controls on these sources would be highly cost effective.

In support of the rule, EPA's technical analyses relied upon advanced one-atmosphere regional air quality models and recent annual meteorological and emissions data bases to assess which upwind states have a "significant" contribution to downwind 8-hour ozone and $PM_{2.5}$ nonattainment problems in the eastern U.S. The CAIR Rules Technical Support Document (EPA, 2005) also identifies those states that are subject to the ozone (NOx) and/or $PM_{2.5}$ (SO_2 and NOx) control provisions of the rule. As noted, the CAIR SO_2 and/or NOx controls would be applied mainly to EGUs in those states identified in EPA's CAMx/CMAQ modeling as having a significant contribution to nonattainment. Using these two regional modeling systems, EPA calculated that emissions from the State of Texas have a 'significant' contribution to $PM_{2.5}$ nonattainment in two western Illinois counties – Madison and St. Clair Counties just east of St. Louis (see Figure 1-1). The 8-hr ozone modeling with CAMx did not reveal that Texas contributes to downwind nonattainment problems in other states so the focus of the present analysis in on the annual $PM_{2.5}$ NAAQS.

EPA's CMAQ modeling, in which anthropogenic emissions from Texas were 'zeroed-out', suggested that the state's maximum annual average $PM_{2.5}$ contribution to any of the 113 year 2010 'modeled plus monitored" nonattainment sites in downwind states was $0.29\mu g/m^3$. Since EPA used a threshold criterion of $0.2\mu g/m^3$ as the basis for defining whether a state had a significant impact on a nonattainment site, the projected Texas contribution of $0.29\mu g/m^3$ led to the state being included in the CAIR Rules list of 28 States and the District of Columbia found to make a significant contribution to $PM_{2.5}$ nonattainment (EPA, 2005, pg. 43).

1.2 Study Approach

The firm of Baker Botts contracted with Alpine Geophysics to perform $PM_{2.5}$ modeling with the following objectives:

> Obtain the EPA CAIR Rule modeling data sets, model codes, run scripts, etc, and independently corroborate of EPA's modeling on Alpine's computer systems;

> Re-run the 2010 Base Case with Texas divided into two source regions; that is, run a 'zero-west Texas' emissions case and a 'zero-east Texas' emissions case, with all other inputs identical to EPA's modeling;

> Compare the downwind $PM_{2.5}$ impacts of the two subregional Texas runs with EPA's full Texas 'zero-out' modeling reported in the Technical Support Document (EPA, 2005).

Notwithstanding the very short timeframe for this analysis (i.e., six weeks), Alpine modelers were able to successfully perform the above CAIR Rule model investigations. This was feasible because Alpine modelers already had most of the modeling tools, data sets, and analysis software set up on our computers. As a result of Alpine's ongoing involvement with all five (5) of the Regional Planning Organizations (RPOs) that are addressing the Regional Haze Rule, we had a substantial body of information immediately available to support the refined CAIR Rule modeling. This included, for example: (a) substantial experience in past regional scale regulatory modeling studies (OTAG, NOx SIP Call, Tier II Sulfur, HDD rule), (b) previous work analyzing the IAQR and CAIR rules and their various Technical Support Documents, (c) ongoing regulatory use of the CAMx and CMAQ modeling systems and data sets employed by EPA for the CAIR rule, and (c) sufficient computer resources to meet the very significant demands imposed by the schedule.

1.3 Rationale for Considering Texas Sub-Regions

For a number of reasons -- political, legal, economic, historical and technical -- the State of Texas is commonly divided into east and west portions separated by the major north-south Interstates I-35/I-37 (roughly depicted in Figure 1-1). Given the location and magnitude of west Texas emissions sources with respect to east Texas sources and the prevailing wind patterns linking Texas with the downwind St. Louis $PM_{2.5}$ nonattainment area, such a separation appears logical.

Texas is a large state both in terms of land mass area and population. This is easily shown in Figure 1-2 which contains two diagrams. The cartogram at the top of the figure shows a state's population in relationship to other states. States in the cartogram are drawn in mathematical proportion to their populations. The accuracy of specific boundaries of individual state land areas is sacrificed in favor of depicting the size of each state in proportion to the number of people who live there. The bottom diagram shows the standard U.S. state map which allows easy comparison of the relative land areas of each state. Collectively, these two diagrams reveal much about the 'size' of the 37 eastern CAIR Rule states in relation to their neighbors. New York, due to its large population, is shown much larger than it appears on the standard map. The geographically small state of Connecticut also looks much larger. Texas, which has both a very large land area and a large population, is shown more or less the same size as it appears on the standard map. Collectively, land mass size, population, and emissions density are important factors when considering one state's impact on another.

Rank-ordering of the size of each state by land area is illuminating, in part, because it reveals the widely variable number of CMAQ model grid cells that are needed to cover each state. Because the CAIR modeling zeroed-out anthropogenic NOx and SO2 emissions from each of the 37 eastern states in separate model simulations, this simple approach leads to wide variation in the number grid cells whose emissions were set to zero from one state run to another. Table 1-1 lists the CAIR rule states, their rank in terms of land mass size, and the approximate number of 36 km CMAQ grid cells covering each state.

Eastern Texas sources constitute by far the largest fraction of the statewide anthropogenic SO2 and NOx emissions inventory. Figure 1-3 presents the county-wide NOx emissions inventory for all anthropogenic sources in Texas. Figure 1-4 identifies the major stationary NOx point sources in the state while the major SO2 point sources are given in Figure 1-5. These graphical representations of the anthropogenic SO2 and NOx emissions categories show the predominant spatial patterns of Texas anthropogenic emissions. Much of the Texas emissions are located in the eastern portion of the state.

Owing to the east-west spatial separation of Texas emissions patterns, sources in western Texas may have different impact on annual fine particulate concentrations in St. Louis compared to sources in eastern Texas. This would be even more likely if one or the other portion of the state was more closely aligned with the climatologically wind transport corridor(s) linking Texas with the Midwest. To elucidate the prevailing wind trajectory paths, we accessed the long term climatic data from the NOAA-CIRES Climate Diagnostics Center (http://www.cdc.noaa.gov/HistData/). Based on the available surface and upper air data for the period 1980-2005, the NOAA climatic mean wind vector plots at two key levels (1000mb or 100 m agl; 850 mb or 250 m agl) were downloaded and are presented as Figures 1-6 and 1-7. Based on NOAA's climatologically records over the past quarter-century, eastern Texas sources are clearly aligned more closely along the prevailing wind transport corridor between Texas and St. Louis when compared to west Texas sources. Thus, for the purposes of this study we will use Figure 1-1 as our definition of east versus west Texas.

1.4 Outline of This Report

This report is organized as follows. In Chapter 2 we present a brief summary of the CAIR Rule modeling performed by EPA and the fine particulate results attributed to the state of Texas in the Technical Support Document. Then, we identify in Chapter 3 the technical approach we have taken in re-running the CMAQ modeling system for the 2010 Base Case and for the two sub-regional Texas 'zero-out simulations'. Highlights of the Texas subregional modeling are given in Chapter 4, followed by our findings and conclusions in Chapter 5.

Table 1-1. Ranking of CMAQ 'Zero-Out' States by Land Area Size. (Note: Texas alone covers as much of the CMAQ grid as the states grouped by color category and is larger than the aggregate of 14 of the other 36 CAIR States [ranks 36-50 below]).

Rank	CAIR State	Area (sq km)	CMAQ Cells
2	**Texas**	**678,051**	**523**
13	Kansas	211,900	164
14	Minnesota	206,189	159
15	Nebraska	199,099	154
16	South Dakota	196,540	152
17	North Dakota	178,647	138
18	Missouri	178,414	138
19	Oklahoma	177,847	137
21	Georgia	149,976	116
22	Michigan	147,121	114
23	Iowa	144,701	112
24	Illinois	143,961	111
25	Wisconsin	140,663	109
26	Florida	139,670	108
27	Arkansas	134,856	104
28	Alabama	131,426	101
29	North Carolina	126,161	97
30	New York	122,283	94
31	Mississippi	121,488	94
32	Pennsylvania	116,074	90
33	Louisiana	112,825	87
34	Tennessee	106,752	82
35	Ohio	106,056	82
36	Kentucky	102,896	79
37	Virginia	102,548	79
38	Indiana	92,895	72
39	Maine	79,931	62
40	South Carolina	77,983	60
41	West Virginia	62,361	48
42	Maryland	25,314	20
43	Vermont	23,956	18
44	New Hampshire	23,227	18
45	Massachusetts	20,306	16
46	New Jersey	19,211	15
48	Connecticut	12,548	10
49	Delaware	5,060	4
50	Rhode Island	2,706	2

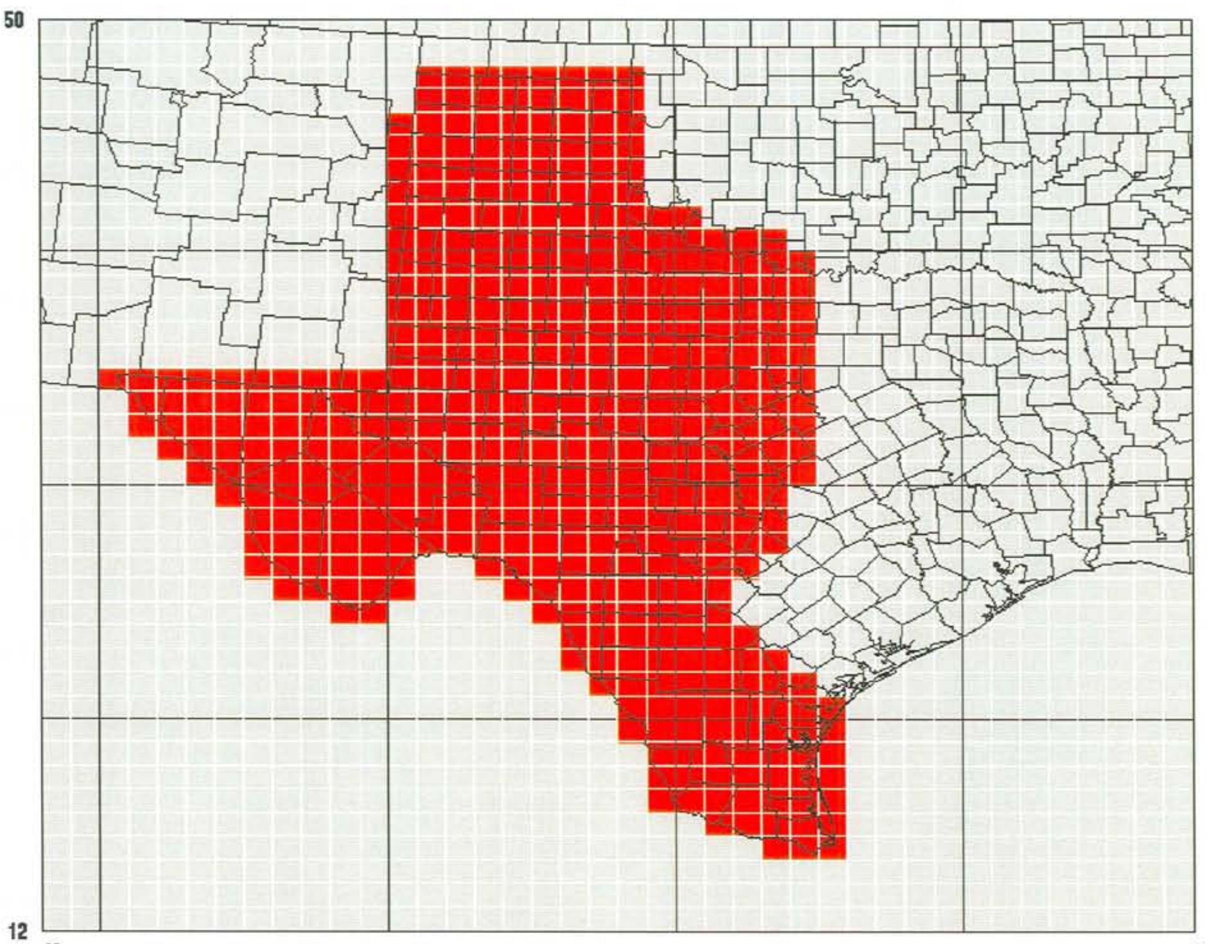
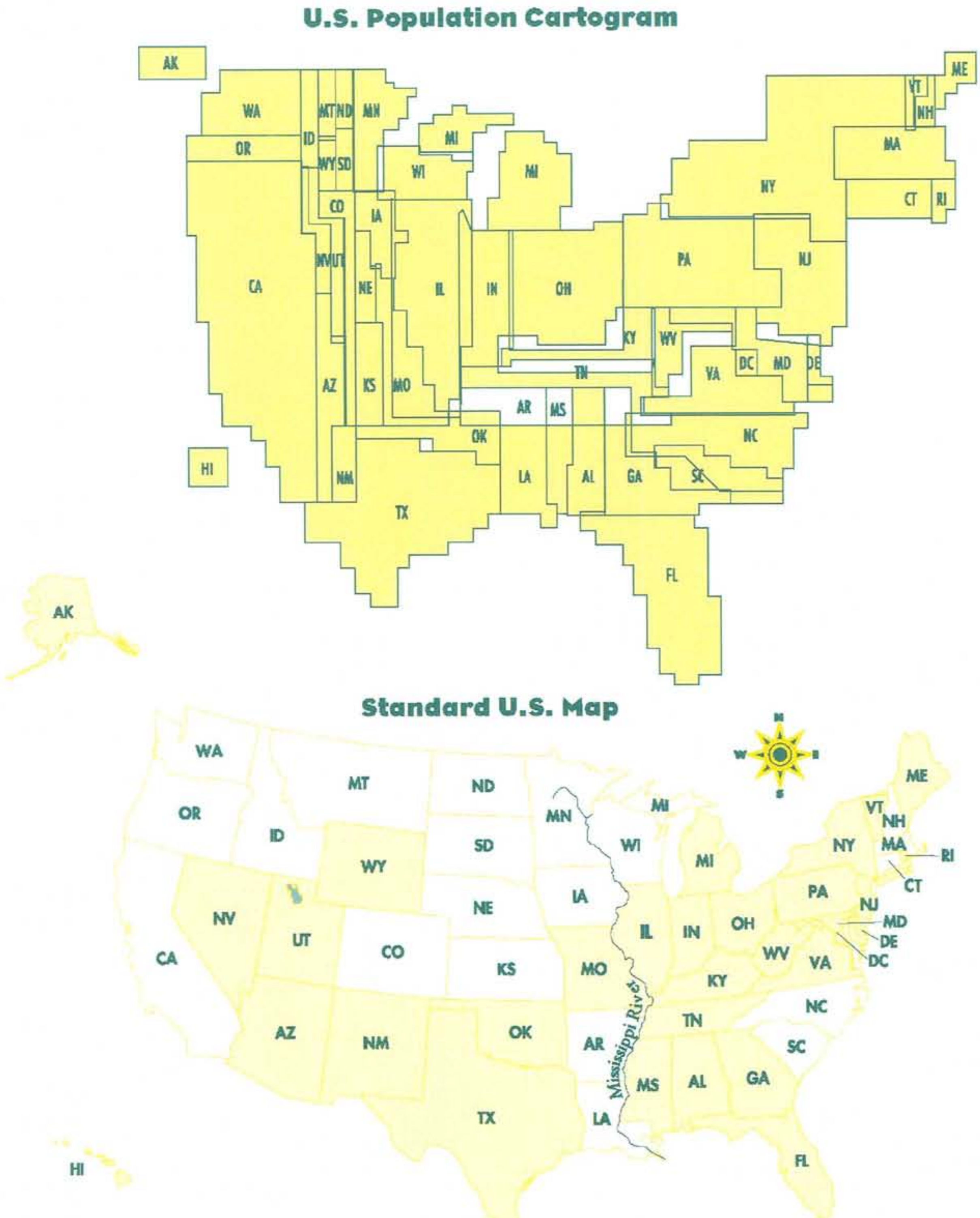


Figure 1-1. East and West Texas Division Approximately Defined By Interstates I-35/I-37.



Source: U.S. Census Bureau

Figure 1-2. U.S. Population Cartogram and Standard State Map.

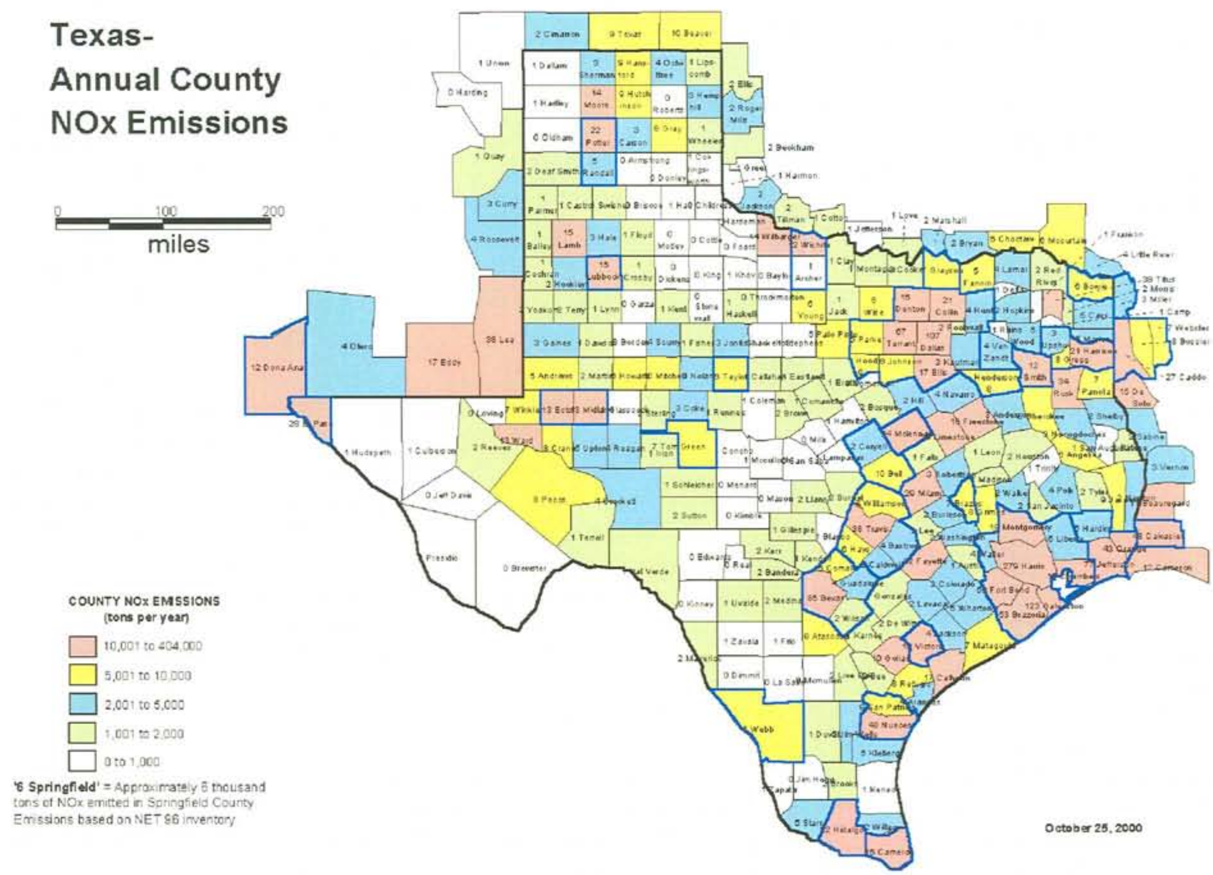


Figure 1-3. NOx Emissions from all Anthropogenic Sources in Texas.

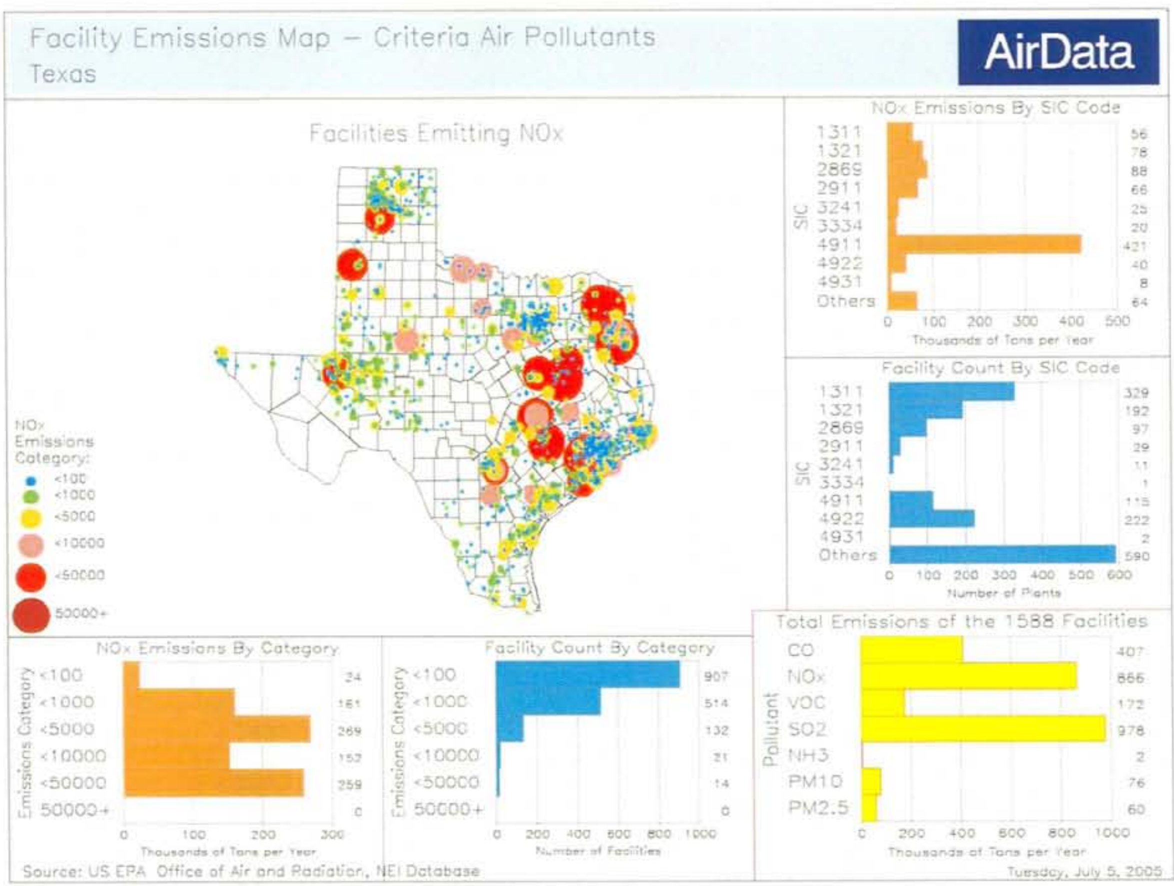


Figure 1-4. NOx Emissions from Stationary Point Sources in Texas.

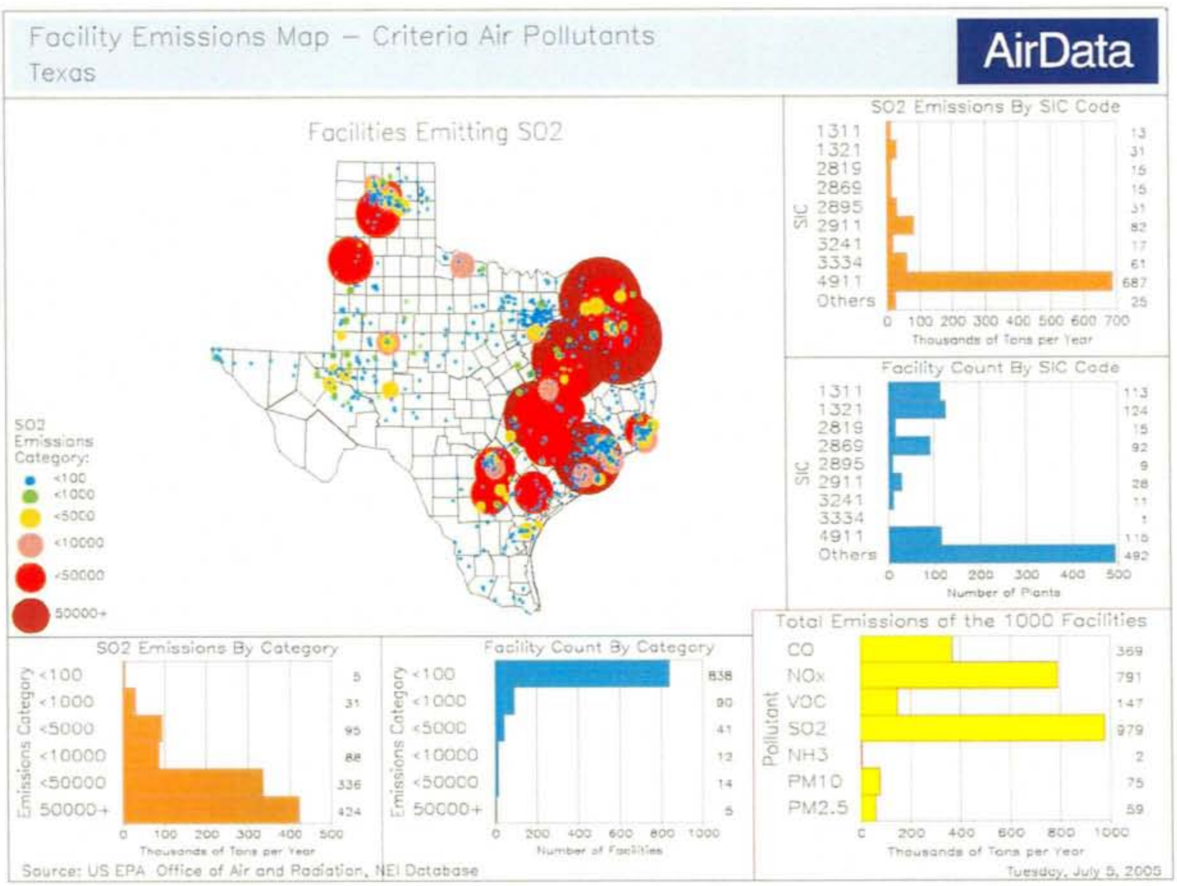


Figure 1-5. SO2 Emissions from Stationary Point Sources in Texas.

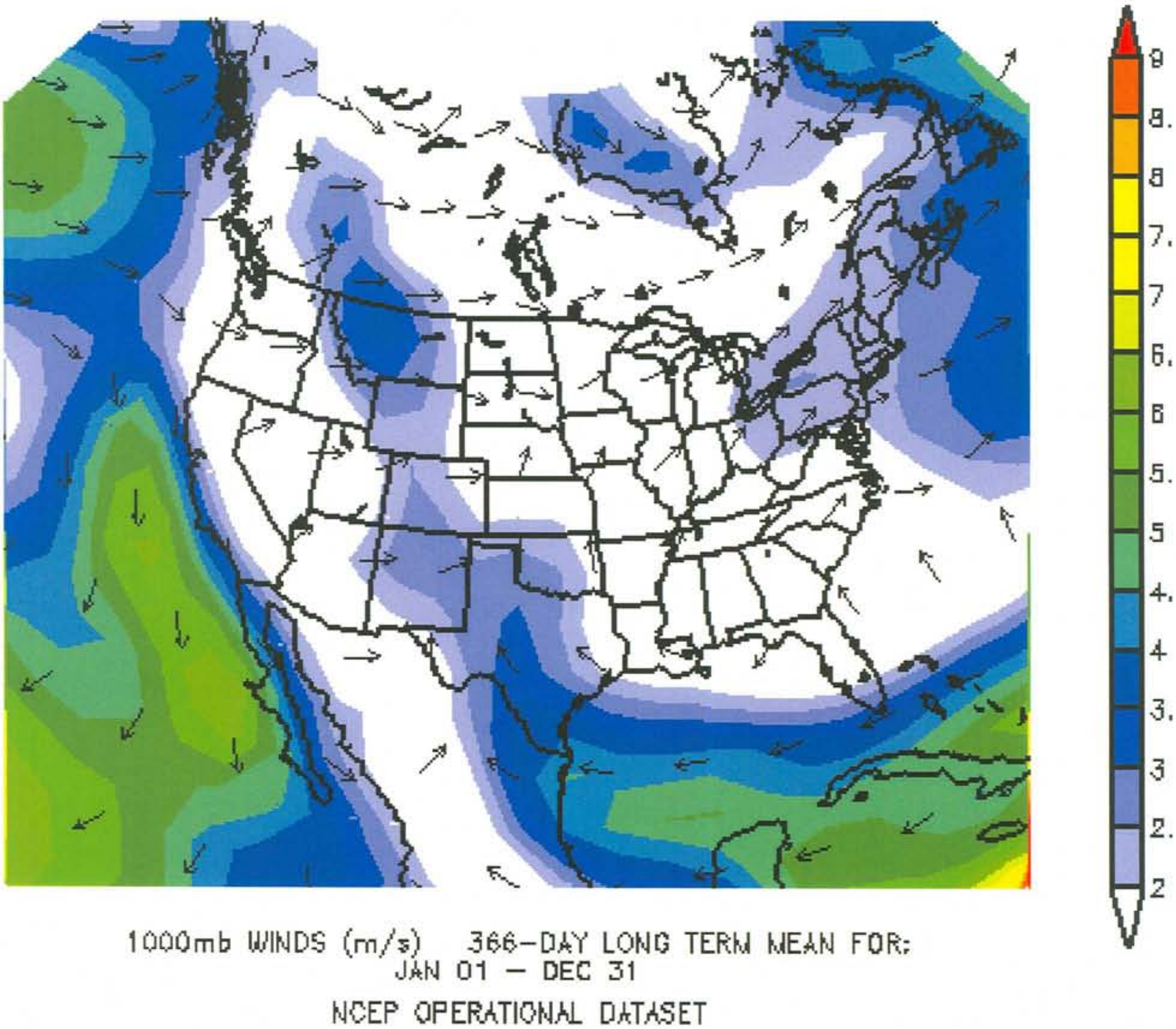


Figure 1-6. Twenty-Five Year Climatic Mean Wind Vector Fields at 1000m Over the U.S.

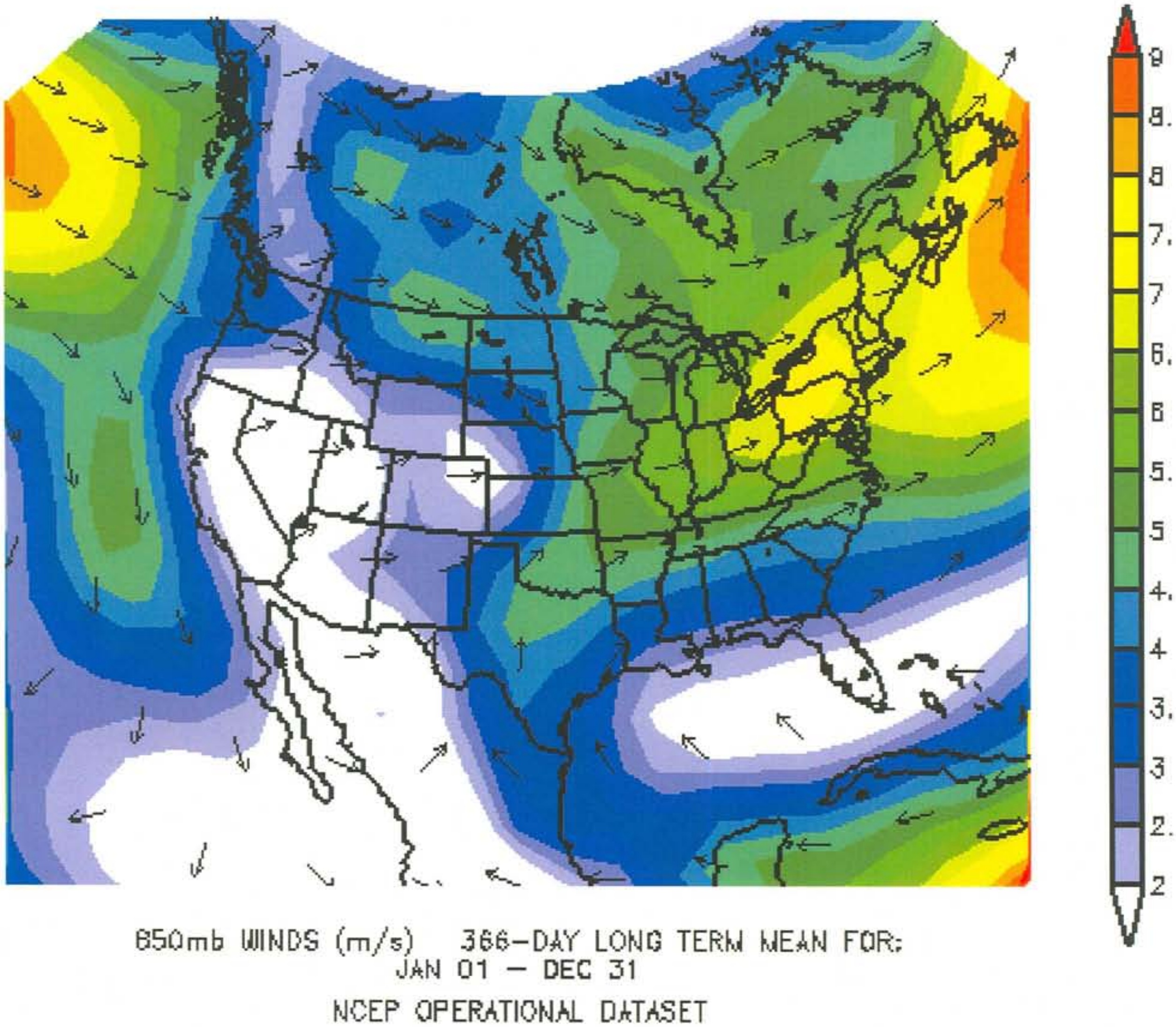


Figure 1-7. Twenty-Five Year Climatic Mean Wind Vector Fields at 250m Over the U.S.

2.0 CAIR RULE MODELING FOR TEXAS

The air quality modeling performed by EPA in support of the CAIR Rule included several inter-related tasks, namely (a) selection of air quality models, (b) development of model inputs, (c) evaluation of model performance, (d) projection of base year emissions to future year levels; (e) future year model impact projection, and (f) an assessment of the expected air quality improvements from the regional SO_2 and NOx emissions reductions in CAIR. In this section, we summarize very briefly the analyses contained in the final CAIR Rule Technical Support Document (TSD) to provide the context for our analyses. We focus on $PM_{2.5}$ since the CAIR Rule modeling demonstrated that Texas is not an upwind contributor to downwind 8-hr ozone nonattainment (Figure 2-1).

2.1 Overview of EPA's Approach

In the final CAIR Rule analyses, EPA addressed a number of concerns and criticisms with the technical support underpinning the agency's earlier proposed rule entitled "Rule to Reduce Interstate Transport of Fine Particulate Matter and Ozone (Interstate Air Quality Rule); Proposed Rule," 69 Fed. Reg. 4566 (January 30, 2004). On behalf of the Midwest Ozone Group (MOG)[1], Alpine Geophysics scientists prepared a detailed commentary on the IAQR modeling and made a number of recommendations (Tesche, Stella, and Morris, 2004) for ways to improve the modeling prior to the final rule. In particular, we recommended:

> *"What does not appear in the EPA IAQR Technical Support Documents is a plan for migration to more current emissions inventories, modeling periods, and public domain, truly state-of-science 'one atmosphere' regional models. Conceivably, this migration is underway at EPA and will be carried out prior to December 31, 2004. However; this has not been publicly released in a modeling protocol or similar document. Examples of the desirable improvements in the IAQR modeling support entail the use of the more recent 1999 NEI emissions inventory, a more recent modeling year such as 2001 (see for example, McNally, 2003), detailed performance evaluation of the meteorological modeling data base used for the episodic 8-hr ozone modeling, and the use of a more scientifically robust PM model such as CMAQ or CAMx (Morris et al., 2003)."*

In several areas, the EPA responded to suggestions such as these and indeed carried out more technically rigorous modeling with state-of-science models such as CAMx and CMAQ. However, not all concerns were fully addressed, particularly those related to the actual use of models to calculate state-by-state ozone and $PM_{2.5}$ impacts, the need for thorough documentation, and the procedures for assessing 'significance'. We address the implications of one of these issues, i.e., need for sub-regional modeling, in this study.

2.2 Emissions Inventories

The CAIR modeling inventories were developed for the 48 contiguous States, the District of Columbia, and portions of Canada and Mexico for a 2001 Base Year, for 2010 and 2015 future baseline scenarios, and for 2010 and 2015 regional control scenarios. The 2001 inventory is a

[1] MOG is an ad hoc affiliation of 16 companies and trade organizations representing more than 95,000 mw of fossil-fired electric generating capacity, largely in the Midwest.

combination of several different data sources including 2001 Continuous Emissions Monitoring (CEM) data for the EGUs, MOBILE6.2 estimates for on-road and nonroad mobile sources and draft NONROAD 2004 model estimates for nonroad mobile sources. Non-EGU and stationary area source emissions were developed in one of three ways: (a) projected from 1999 to 2001, (b) computed for 2001, or (c) based on the latest information available. The BEIS3.12 model was used to estimate biogenic emissions.

Data from existing and promulgated control programs were used to project the 2001 inventory to two 2010 and 2015. Enhancements to the future year inventory included the use of the MOBILE6.2, NONROAD, and IPM models to estimate 2010 and 2015 emissions from relevant source categories. The future control case scenarios developed for air quality modeling included: (a) CAIR controls in 2010 and 2015, (b) CAIR plus BART controls in 2015, and (c) BART-only controls in 2015. In each of these cases, only emissions from EGUs were controlled. Emissions from sources in all other sectors remained at the level of the corresponding 2010 or 2015 Base Case.

2.3 Annual MM5/CMAQ Modeling System

The CAIR modeling for $PM_{2.5}$ and visibility utilized EPA's CMAQ (ver 4.3) model, set up on a 36 km grid covering the continental U.S. CMAQ was exercised for the full calendar year of 2001 in order to estimate $PM_{2.5}$ concentrations and associated visibility for each CAIR emissions scenario. Unlike the episodic ozone modeling, the annual CMAQ modeling for $PM_{2.5}$ was based on meteorological modeling performed by Alpine staff. Specifically, under contract to EPA, Alpine set up, exercised, and evaluated the Mesoscale Meteorological Model (MM5) for the full year of 2001 (McNally, 2003). The MM5 domain consisted of a single 36 x 36 km grid with 165 by 129 cells and run on the same map projection as CMAQ.

Alpine's evaluation of the suitability of the 2001 MM5 results for use in the CAIR modeling was performed in accordance with an EPA-approved protocol (McNally and Tesche, 2002) and involved a combination of qualitative and quantitative analyses to assess the adequacy of the simulated fields. We found that the MM5 fields closely matched the observed synoptic patterns and in general, the bias and error values associated with the 2001 data were in the range of model performance found from other non-EPA regional meteorological model applications (ENVIRON, 1999; Tesche and McNally 2000). Initial and boundary conditions to CMAQ for the annual CAIR $PM_{2.5}$ modeling were derived from a global three-dimensional chemistry model, the GEOS-CHEM model. Linkage of the GEOS-CHEM model output to CMAQ was developed following the approach developed in the VISTAS Regional Haze Modeling Study (see, for example, Morris et al., 2005; Tesche et al., 2005) with support from researchers at the University of Houston.

2.4 Interstate Annual $PM_{2.5}$ Impact Modeling

EPA used CMAQ for modeling $PM_{2.5}$, visibility, and nitrogen/sulfur deposition across a national domain consisting of a 36 x 36 km grid with 14 vertical layers. Boundary conditions were obtained from a global chemistry model (GEOSCHEM). CMAQ was evaluated for the full 2001 annual period with fourteen (14) particulate species, gaseous precursor species, and wet deposition species obtained from the IMPROVE, CASTNet, STN, NDAP, AIRS, and SEARCH ambient monitoring networks. In general, for summer sulfate and winter nitrate the CAIR model evaluation results compare favorably with other ongoing regional modeling (e.g., VISTAS, MRPO, WRAP).

This evaluation demonstrated the utility of the CMAQ modeling and associated data sets for use in exploring the merits of the CAIR Rule.

To set the stage for assessing a state's significant contribution to $PM_{2.5}$ nonattainment, EPA carried out a three step process:

> Identify the counties in the East that are expected to be nonattainment in 2010 under projected future baseline emissions levels;

> Perform State-by-State modeling to quantify the contribution from 2010 baseline emissions in each State to nonattainment counties in other States; and

> Evaluate the upwind State-to-downwind nonattainment contributions from Step 2 using significance metrics and criteria.

The actual determination of a whether a state has a significant contribution to ozone or $PM_{2.5}$ was based on three rules: (a) states that contribute amounts which exceed the significance criterion for $PM_{2.5}$ are covered for annual SO2 and NOx emissions reductions, (b) states that contribute amounts which exceed the significance criteria for 8-hour ozone are covered for summer season NOx emissions reductions, and (c) states that do not contribute in excess of our significance criteria for either $PM_{2.5}$ or 8-hour ozone are not covered for regional controls as part of CAIR. For $PM_{2.5}$, EPA chose a single bright-line criterion based on the magnitude of the contribution from an upwind State to downwind nonattainment receptor. That is, a State is significant if it contributes 0.2 ug/m3 or more to annual average $PM_{2.5}$ nonattainment in another State. For 8-hour ozone, a multi-factor test which considers the magnitude, frequency, and relative amount of contribution. (This is the same approach EPA used in the NOx SIP Call). Thus, a State is significant if it contributes large and/or frequent amounts of ozone to 8-hour ozone nonattainment in another State. Based in these notions, EPA developed the maps shown in Figures 2-1 and 2-2 which depict the states to be included in the CAIR ozone and/or $PM_{2.5}$ control programs. As shown in Figure 2-1, only three states (TX, GA, MN) are identified for $PM_{2.5}$ only.

2.5 Summary of CAIR Modeling Results for Texas

The TSD (EPA, 2005) lists those states that are subject to the ozone (NOx) and/or $PM_{2.5}$ (SO_2 and NOx) control provisions of the rule. CAIR SO_2 and/or NOx controls would be applied mainly to EGUs in those states that identified in EPA's CAMx/CMAQ modeling as having a significant contribution to nonattainment. Using these two regional modeling systems, EPA calculated that emissions from the State of Texas do not produce a 'significant' contribution to 8-hour ozone nonattainment in any downwind counties. However CMAQ results for the 2001 annual simulation produced 'significant' $PM_{2.5}$ impacts in Madison and St. Clair Counties in Illinois. These two counties are within the St. Louis Metropolitan Statistical Area (see Figure 2-3).

EPA's annual CMAQ modeling indicated that the maximum Texas downwind contribution of $PM_{2.5}$ to any nonattainment county in the eastern U.S. was 0.29 $\mu g/m^3$. Specifically, the non-attainment counties impacted by Texas *anthropogenic emissions* were Madison and St. Clair Counties in Illinois. In Madison County, the annual average $PM_{2.5}$ based on the 1999-2003 period of record was 17.40 $\mu g/m^3$. In St. Clair County, IL the 1999-2003 average $PM_{2.5}$ concentration was 16.87 $\mu g/m^3$. These values exceed that annual the $PM_{2.5}$ NAAQS of 15.0 $\mu g/m^3$. Projected nonattainment in these two counties in 2010 ("Modeled + Monitored"), together with the expected $PM_{2.5}$ reductions calculated as the result of CAIR controls required by 2010 (EPA, 2005) are as follows:

> Madison County, IL
>
> - 2010 Base = 16.66 $\mu g/m^3$
> - 2010 CAIR = 15.96 $\mu g/m^3$
> - Improvement = -0.70 $\mu g/m^3$

> St. Clair County, IL
>
> - 2010 Base = 16.24 $\mu g/m^3$
> - 2010 CAIR = 15.54 $\mu g/m^3$
> - Improvement = -0.70 $\mu g/m^3$

Finally, EPA's modeling estimated that the six upwind states contributing to the "modeled + monitored" nonattainment in Madison and St. Clair counties were Indiana, Iowa, Kentucky, Missouri, Ohio and Texas. Of course, Illinois sources are also implicated in the exceedances in these two counties.

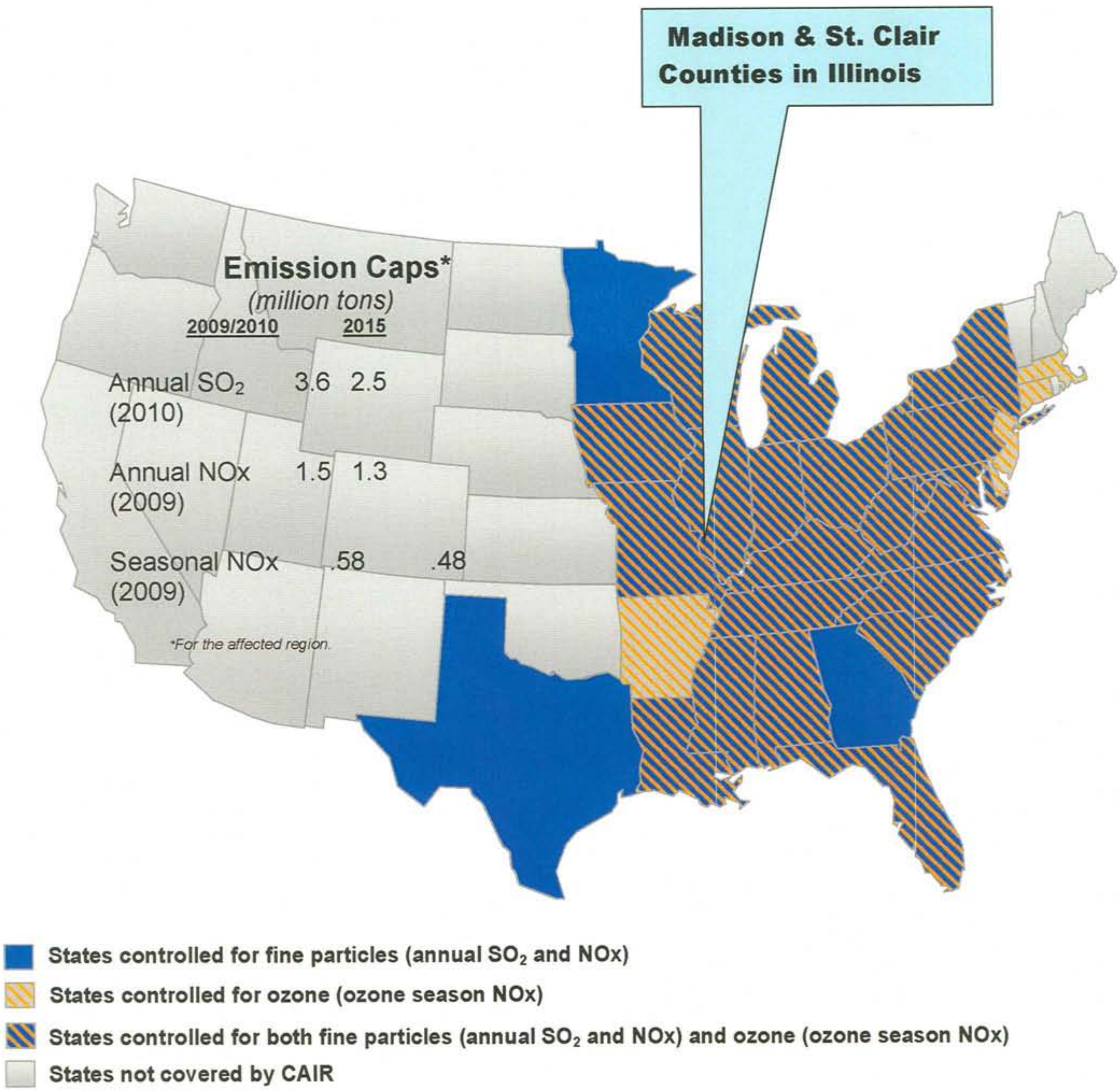


Figure 2-1. EPA Assignment of CAIR Rule States. (Source: Possiel, 2005).

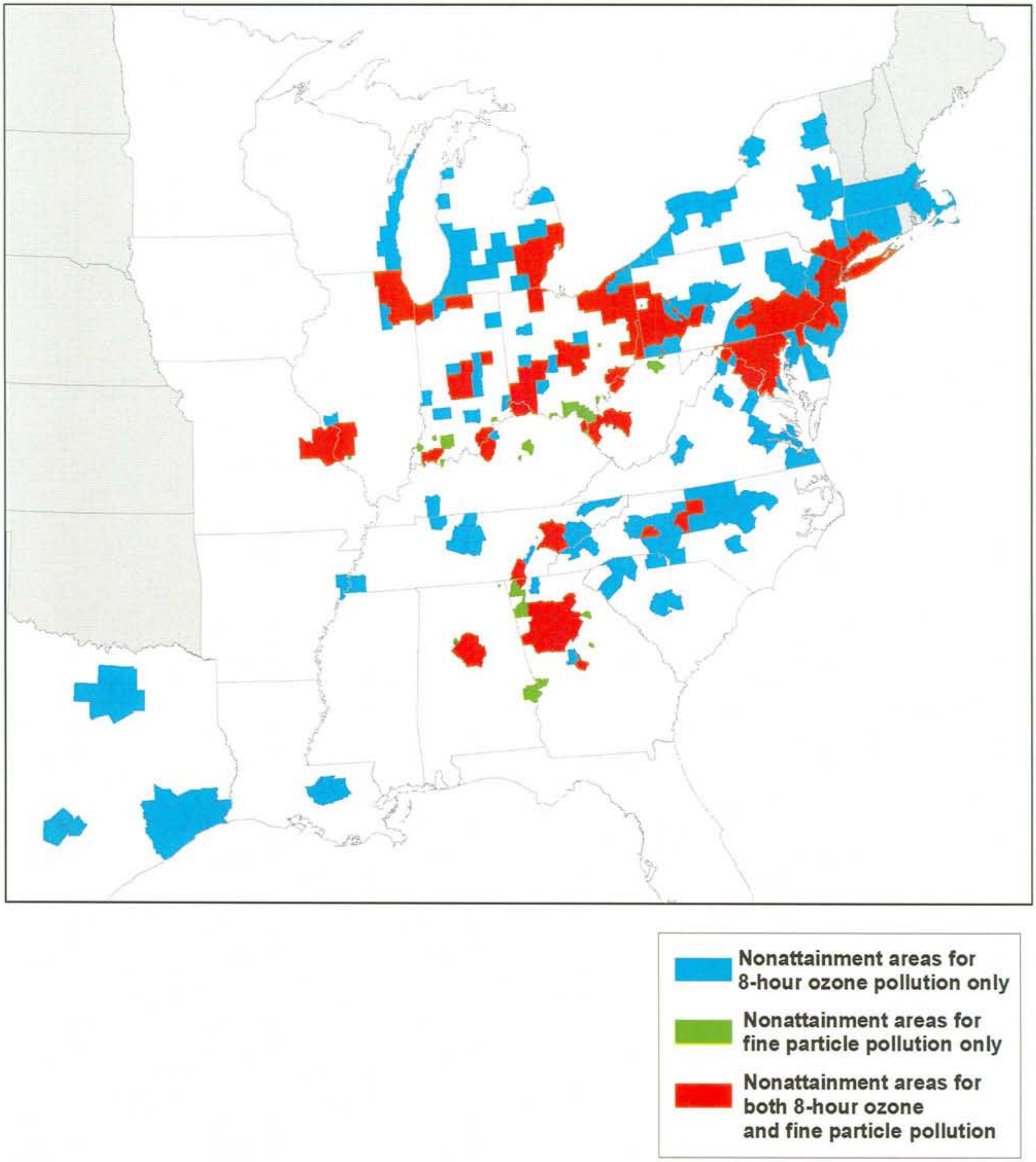


Figure 2-2. EPA Modeled Impacts of CAIR Rule and Other Clean Air Programs on PM2.5 and 8-hr Ozone Nonattainment in the Eastern U.S. by 2010. (Source: Possiel, 2005).

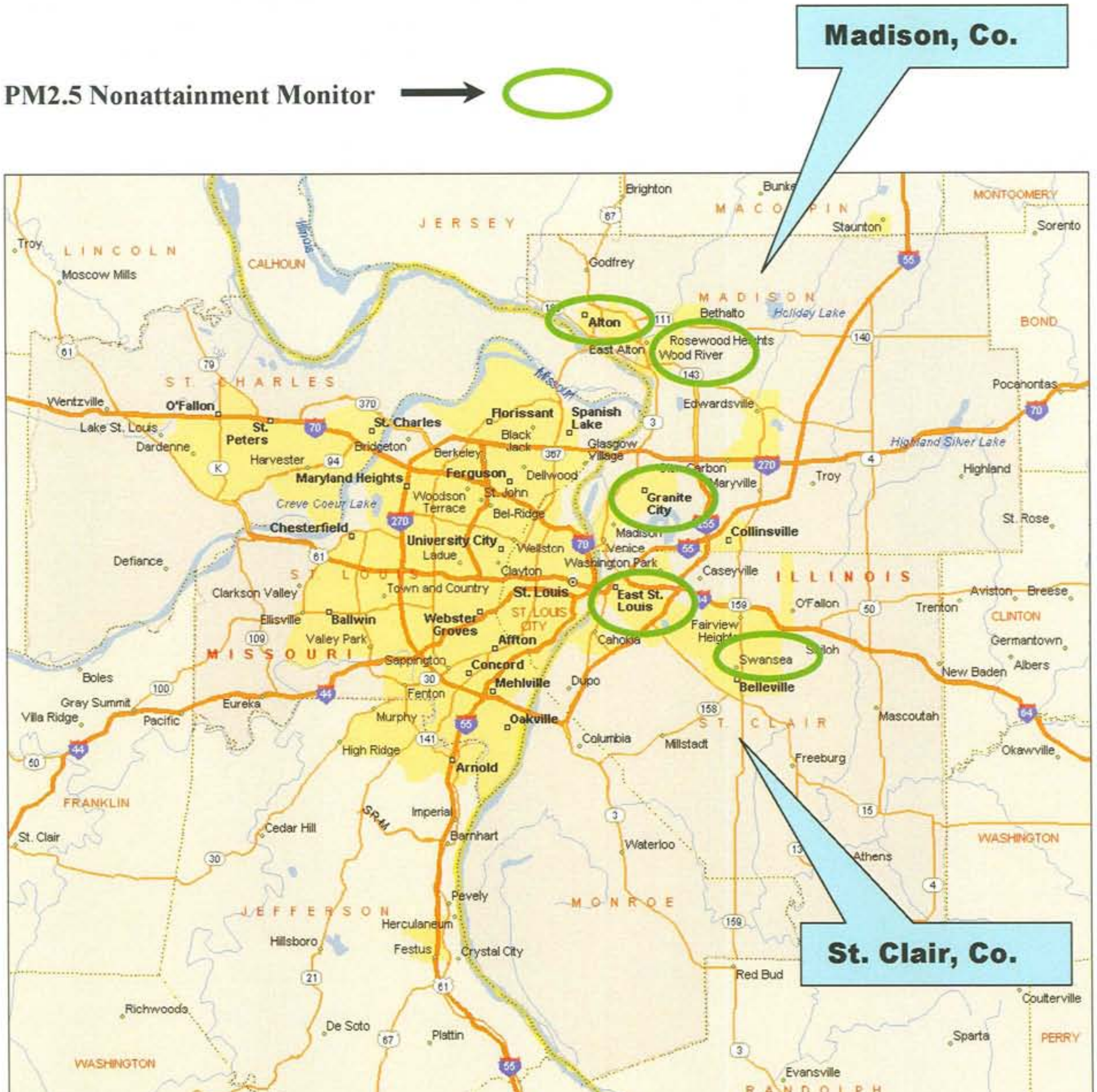


Figure 2-3. Location of Madison and St. Clair Counties in Illinois, East of the St. Louis Metropolitan Area. (Circles enclose the six SLAM $PM_{2.5}$ Monitors Used to Estimate Monitored $PM_{2.5}$ Nonattainment).

3.0 TECHNICAL APPROACH

The central aim of this study was to quantify whether the CAIR Rule modeling of Texas as a single source region produces unrealistic estimates of the potential impact of sources within the state on downwind PM2.5 nonattainment areas. EPA's modeling of the 2010 Texas anthropogenic emissions zero-out case produced maximum annual average $PM_{2.5}$ contributions in excess of the $0.20 \mu g/m^3$ threshold criterion at two downwind monitors in Illinois. It is unclear to what extent these impacts are influenced by the sheer size of the region zeroed out. As indicated in Table 1-1, The Texas zero-out region by itself is equivalent in size to the combined area of as many as 14 other eastern states for whom zero-out modeling was performed separately. In our view, treating an area of this magnitude as a single source region in zero-out modeling is an unnecessarily simplification. Moreover, it does not achieve the level of reliability potentially available with the CAIR data sets and the state-of-science CMAQ system when the source regions are appropriately chosen. Accordingly, we performed annual CMAQ $PM_{2.5}$ modeling with the EPA's CAIR Rule data bases for west Texas and east Texas separately in order to quantify their respective $PM_{2.5}$ impacts in downwind Madison and St. Clair counties.

3.1 Elements of the Modeling Study

This modeling study began on 25 May 2005 at the request of Baker Botts, LLP. Our initial activities centered on developing a work plan to guide the project through the mid-July 2005 completion date. The work plan consisted of three main elements.

Data Base Acquisition and Model Setup: The purpose of this activity was to obtain pertinent CAIR modeling databases needed to corroborate satisfactory model adaptation to an independent computer system, and perform annual CMAQ zero-out $PM_{2.5}$ modeling simulations. Among the data requested and obtained from EPA were the following:

- 2001 CMAQ Base Case (used to confirm model performance)
- 2010 CMAQ Base Case (used to establish 2010 Baseline conditions)
- For each simulation, input data sets (e.g., pre-merged SMOKE emissions files, MCIP2.2gv, ICON, BCON, JPROC)
- For each simulation, run scripts and ancillary files needed for exercising CCTM
- Model output files for each run (e.g., ACONC, AEROVIS, DRYDEP, and WETDEP)
- Software used to conduct SMAT analysis of the $PM_{2.5}$ impacts of the State of Texas on each of the 113 downwind FRM receptor sites
- Data sets and processing software used to perform calculated steps 1-5 (pgs 20-21) that lead to the projected future $PM_{2.5}$ concentrations for a future case CMAQ modeling scenario.
- 1999-2003 design values calculated at the FRM sites in 433 eastern counties for $PM_{2.5}$.

Verify Correct Model/Data Base Adaptation to Alpine Computers: Once the CMAQ 2010 Base Case simulation was received from EPA and installed on Alpine's computers, we ran the full annual 2010 CAIR Base Case run to compare with EPA's 2010 Base Case simulation. These comparisons were designed to corroborate proper installation of the CAIR modeling system as well as the SMAT post-processing software programs used by EPA to calculate $PM_{2.5}$ impacts.

Perform East and West Texas Sub-Regional CAIR Rule Modeling Once the CMAQ 2010 Base Case simulation was corroborated, we developed new SMOKE emissions files for input to CMAQ for the west Texas and east Texas zero-out cases. After making the two annual CMAQ simulations, we calculated the downwind $PM_{2.5}$ from west Texas and east Texas anthropogenic sources using the same two-step process used by EPA in the CAIR Rule technical support modeling. Specifically, these two steps were taken:

- Apply the SMAT technique to the 2010 west Texas and east Texas zero-out runs to calculate $PM_{2.5}$ concentrations at the St. Clair and Madison, IL sites; and

- For each, calculate the difference between the 2010 Base $PM_{2.5}$ concentration and the $PM_{2.5}$ concentrations for the west Texas and east Texas zero-out runs.

Using the 'maximum contribution' metric defined by EPA, we identified the maximum contribution of west Texas and east Texas anthropogenic emissions sources to downwind $PM_{2.5}$ non-attainment. These results were then compared with the full state zero-out simulation in the EPA (2005) Technical Support Document. The results of this modeling are presented in the following chapter.

3.2 EPA Responsiveness to Modeling Data Requests

The data sets required to perform this modeling were substantial (exceeding 4 TB, or over 6000 CD-ROMs) and required the formatting, data transfer and express shipping of over a dozen 300 Gb external disk drives between the Alpine and EPA offices. Especially in view of the very tight schedule, we commend the timeliness and quality of the EPA staff' work efforts in assisting with this transfer. In large modeling studies of this type, one expects that some files will be found to be misplaced, corrupted, or incorrectly labeled. In the few instances in which this occurred, EPA staff were swift to assess the situation and provide the technical assistance so that we could continue with the analyses. Notwithstanding this degree of cooperation by EPA staff, there remain some data sets that have still not been received or whose authenticity (in terms of their actual use in the *final* CAIR modeling) is uncertain. Also, some modeling procedures (e.g., the use of SMAT and rounding procedures) require further documentation in order for Alpine to exactly reproduce EPA's post-processing methods. While these issues do not affect the findings and conclusions presented in this report, they nonetheless represent areas where further work with EPA to strengthen the agreement between the agency's and Alpine's base case modeling results is warranted.

4.0 $PM_{2.5}$ MODELING RESULTS

This Chapter presents a presentation and discussion of the subregional CMAQ Modeling performed by Alpine Geophysics. First we present results demonstrate that satisfactory corroboration of EPA's published CMAQ modeling results has been achieved (at least for the purposes of this study). Subsequently, we present the results for the west Texas and east Texas zero-out modeling. Output from these runs are then compared with EPA's significant impact criterion.

4.1 Corroboration of EPA's CAIR Rule Base Case

A concerted effort on the part of Alpine and EPA staff was made to corroborate proper operation of the CMAQ modeling system with the CAIR data bases on our computers. Using the CMAQ model input and output files plus the Speciated Model Attainment Test (SMAT) post processing software, we were able to reproduce the CMAQ results quite well. This corroboration effort is summarize in Table 4-1.

The table lists the various projected "modeled + monitored" counties within the modeling region as defined in the TSD (EPA, 2005, pg. 22). The second column reproduces the modeled annual $PM_{2.5}$ impacts in each county for the 2010 Base Case. (Note that this 2010 Base Case does not include implementation of the CAIR rule controls stipulated by 2010 but rather is the 2010 baseline simulation from which CAIR controls were later added.) To compare our CMAQ results with EPA's, we obtained the SMAT processor code, implemented it on our system, and then processed both the EPA and Alpine 2010 baseline simulations with it. The last two columns reveal very close agreement between the EPA and Alpine CMAQ simulations when compared with the identical version of the SMAT software. On average, these results agree to within 0.0002 $\mu g/m^3$ across the full set of counties. Larger differences were encountered when attempting to compare the results of our implementation of SMAT with the results reported by EPA in the CAIR TSD. In discussions with EPA staff, we attribute these minor discrepancies to result from different assumptions made in rounding procedures between EPA (not yet fully documented) and those we employed. Also, there were some minor differences in some of the model input files (JPROC on the first few days of the annual run) that contributed to the differences. Overall, however, the results in Table 4-1 demonstrate quite acceptable corroboration of the EPA modeling system on Alpine's computers. In the comparisons made with the zero-out simulations we base them upon the annual CMAQ simulation performed on our machines in order to remove issues associated with rounding assumptions.

4.2 Results of Texas Sub-Regional Zero-Out Modeling

Table 4-2 presents the main results of the west Texas and east Texas zero-out simulations. The states are ordered in this table on the basis of size (km^2). Included in the table is the number of CMAQ grid cells required to cover the state. The last two columns identify EPA's modeled $PM_{2.5}$ impacts at the Madison County and St. Clair County monitors based on the state-by-state zero-out modeling. The last two rows include our west Texas and east Texas zero-out results. Anthropogenic emissions sources within east Texas are estimated to contribute 0.26 $\mu g/m^3$ and 0.27 $\mu g/m^3$ PM2.5 at the Madison and St. Clair counties, respectively. For west Texas, the CMAQ zero-out modeling shows contributions of 0.05 $\mu g/m^3$ in both Illinois counties. Note that due to the nonlinearities in atmospheric chemistry and the perturbation on the chemical system in the model when large areas are zeroed-out, the sum of west Texas and east Texas impacts at both Illinois counties is slightly larger than the impact from the entire state of Texas estimated in EPA's CAIR Rule zero-out run. It is possible that the incremental impacts from west Texas and east Texas may be overestimated slightly from the values shown in Table 4-2, but this has not been confirmed yet.

Table 4-3 presents the west Texas and east Texas zero-out simulation results ordered by decreasing $PM_{2.5}$ impacts in the two Illinois counties. Using EPA's criterion of 0.20 $\mu g/m^3$ as the definition for a significant impact, we see that the states of Missouri, Illinois, Indiana, Texas, Iowa, Ohio and Kentucky would be declared as significant contributors. Had EPA modeled the two regions separately, east Texas would have been shown to be a significant contributor to downwind $PM_{2.5}$ nonattainment at the same two Illinois counties. West Texas, on the other hand, would be determined 'insignificant' by EPA's criterion, falling near the bottom of the list non-contributors since west Texas' annual $PM_{2.5}$ impacts (0.05 $\mu g/m^3$) that are only one fourth of the threshold criterion.

Table 4-4 compares our results of the west Texas and east Texas zero-out simulations for Madison and St. Clair counties compared with EPA's full Texas zero-out run from a slightly different perspective. In the top table, we use four significant figures to present the results; two significant figures are used in the bottom table. These results show that west Texas contributes only about 15% of the total Texas impact to the Madison and St. Clair counties.

Finally, Figure 4-1 shows monthly average $PM_{2.5}$ concentration isopleths across the 36 km CMAQ domain for the west Texas (left) and east Texas (right) simulations for the months of April, July, and November, plus the full annual cycle. These graphical displays reinforce the statistical summaries presented in Tables 4-2 through 4-4. The downwind plume from the west Texas region has less geographical coverage, involves lower concentrations, and does not show nearly the influence on the St. Louis region when compared with the east Texas results.

Table 4-1. Results of EPA-Alpine Corroboration Analysis of the CMAQ Modeling of the 2010 Base Case and Application of the Speciated Model Attainment Test (SMAT) Post-Processor.

Nonattainment County	EPA 2010 Base		AG 2010 Base
	EPA SMAT	AG SMAT	AG SMAT
Alabama DeKalb Co	15.23	15.2716	15.2718
Alabama Jefferson Co	18.57	18.5911	18.5912
Alabama Montgomery Co	15.12	15.1541	15.1542
Alabama Morgan Co	15.29	15.3251	15.3253
Alabama Russell Co	16.17	16.1959	16.1959
Alabama Talladega Co	15.34	15.3662	15.3663
Delaware New Castle Co	16.56	16.5973	16.5974
District of Columbia	15.84	15.8744	15.8748
Georgia Bibb Co	16.27	16.2840	16.2841
Georgia Clarke Co	16.39	16.4077	16.4078
Georgia Clayton Co	17.39	17.4132	17.4133
Georgia Cobb Co	16.57	16.5950	16.5951
Georgia DeKalb Co	16.75	16.7658	16.7659
Georgia Floyd Co	16.87	16.8985	16.8985
Georgia Fulton Co	18.02	18.0454	18.0455
Georgia Hall Co	15.60	15.6235	15.6236
Georgia Muscogee Co	15.65	15.6770	15.6770
Georgia Richmond Co	15.68	15.7006	15.7006
Georgia Walker Co	15.43	15.4584	15.4587
Georgia Washington Co	15.31	15.3287	15.3287
Georgia Wilkinson Co	16.27	16.2906	16.2905
Illinois Cook Co	17.52	17.5616	17.5617
Illinois Madison Co	16.66	16.6871	16.6869
Illinois St. Clair Co	16.24	16.2752	16.2749
Indiana Clark Co	16.51	16.5469	16.5474
Indiana Dubois Co	15.73	15.7606	15.7607
Indiana Lake Co	17.26	17.3176	17.3178
Indiana Marion Co	16.83	16.8560	16.8564
Indiana Vanderburgh Co	15.54	15.5756	15.5755

Kentucky Boyd Co	15.23	15.2795	15.2800
Kentucky Bullitt Co	15.10	15.1496	15.1500
Kentucky Fayette Co	15.95	16.0093	16.0098
Kentucky Jefferson Co	16.71	16.7622	16.7627
Kentucky Kenton Co	15.30	15.3289	15.3295
Maryland Anne Arundel Co	15.26	15.2873	15.2877
Maryland Baltimore city	16.96	16.9854	16.9857
Michigan Wayne Co	19.41	19.4692	19.4690
Missouri St. Louis city	15.10	15.1287	15.1285
Montana Lincoln Co	15.05	15.9601	15.9596
New York New York Co	16.19	16.2196	16.2199
North CaroCatawba Co	15.48	15.5131	15.5135
North CaroDavidson Co	15.76	15.7931	15.7936
North CaroMecklenburg Co	15.22	15.2457	15.2461
Ohio Butler Co	16.45	16.5020	16.5025
Ohio Cuyahoga Co	18.84	18.8950	18.8953
Ohio Franklin Co	16.98	17.0250	17.0251
Ohio Hamilton Co	18.23	18.2759	18.2763
Ohio Jefferson Co	17.94	17.9984	17.9987
Ohio Lawrence Co	16.10	16.1620	16.1625
Ohio Mahoning Co	15.39	15.4243	15.4245
Ohio Montgomery Co	15.41	15.4602	15.4608
Ohio Scioto Co	18.13	18.1948	18.1954
Ohio Stark Co	17.14	17.1950	17.1952
Ohio Summit Co	16.47	16.5163	16.5165
Ohio Trumbull Co	15.28	15.3295	15.3300
PennsylvanAllegheny Co	20.55	20.6070	20.6072
PennsylvanBeaver Co	15.78	15.8221	15.8223
PennsylvanBerks Co	15.89	15.9261	15.9267
PennsylvanCambria Co	15.14	15.2080	15.2082
PennsylvanDauphin Co	15.17	15.2079	15.2082
PennsylvanDelaware Co	15.61	15.6407	15.6408
PennsylvanLancaster Co	16.55	16.5778	16.5780
PennsylvanPhiladelphia Co	16.65	16.6768	16.6769
PennsylvanWashington Co	15.23	15.2592	15.2595

PennsylvanWestmoreland Co	15.16	15.1966	15.1968
PennsylvanYork Co	16.49	16.5315	16.5319
Tennessee Davidson Co	15.36	15.4123	15.4124
Tennessee Hamilton Co	16.89	16.9218	16.9220
Tennessee Knox Co	17.44	17.4792	17.4794
Tennessee Sullivan Co	15.32	15.3607	15.3615
West VirgiBerkeley Co	15.69	15.7552	15.7557
West VirgiBrooke Co	16.63	16.6802	16.6805
West VirgiCabell Co	17.03	17.0842	17.0846
West VirgiHancock Co	17.06	17.1270	17.1273
West VirgiKanawha Co	17.56	17.6207	17.6212
West VirgiMarion Co	15.32	15.3858	15.3865
West VirgiMarshall Co	15.81	15.8598	15.8602
West VirgiOhio Co	15.14	15.1894	15.1899
West VirgiWood Co	16.66	16.7208	16.7211
Average	**16.30**	**16.3520**	**16.3522**

Note: Differences in Columns 2 and 3 are due to undisclosed rounding procedures used by EPA.

Table 4-2. Results of Texas Sub-Regional Zero-Out Simulations. (Unshaded rows are EPA results of state-by-state zero-out runs, including Texas. Bottom two rows shaded yellow are the Alpine 2010 Base Case simulations of west Texas and east Texas as separate source regions. Note that due to nonlinearities in atmospheric chemistry and the approximations inherent in zero-out simulations, the sum of the west Texas and east Texas zero-out results do not exactly match EPA's full Texas impacts at Madison and St. Clair).

Rank	CAIR State	Area (sq km)	CMAQ Cells	State Impact	
				Madison	St. Clair
2	**Texas**	678,051	**523**	**0.29**	**0.28**
13	Kansas	211,900	164		
14	Minnesota	206,189	159	0.13	0.13
15	Nebraska	199,099	154		
16	South Dakota	196,540	152		
17	North Dakota	178,647	138		
18	Missouri	178,414	138	1.05	1.07
19	Oklahoma	177,847	137		
21	Georgia	149,976	116	0.09	0.08
22	Michigan	147,121	114	0.13	0.13
23	Iowa	144,701	112	0.27	0.28
24	Illinois	143,961	111	0.80	0.83
25	Wisconsin	140,663	109	0.16	0.16
26	Florida	139,670	108	<0.05	<0.05
27	Arkansas	134,856	104		
28	Alabama	131,426	101	0.13	0.12
29	North Carolina	126,161	97	<0.05	<0.05
30	New York	122,283	94	<0.05	<0.05
31	Mississippi	121,488	94	0.09	0.08
32	Pennsylvania	116,074	90	<0.05	<0.05
33	Louisiana	112,825	87	0.18	0.18
34	Tennessee	106,752	82	0.18	0.17
35	Ohio	106,056	82	0.21	0.21
36	Kentucky	102,896	79	0.21	0.20
37	Virginia	102,548	79	<0.05	<0.05
38	Indiana	92,895	72	0.47	0.48
39	Maine	79,931	62		
40	South Carolina	77,983	60	<0.05	<0.05
41	West Virginia	62,361	48	0.05	<0.05
42	Maryland	25,314	20	<0.05	<0.05
43	Vermont	23,956	18		
44	New Hampshire	23,227	18		
45	Massachusetts	20,306	16		
46	New Jersey	19,211	15		
48	Connecticut	12,548	10		
49	Delaware	5,060	4		
50	Rhode Island	2,706	2		
WT	**West Texas**	418,154	323	**0.05**	**0.05**
ET	**East Texas**	259,897	200	**0.26**	**0.27**

Table 4-3. Results of Texas Sub-regional Zero-Out Simulations, Ordered by Decreasing Impacts in Madison and St. Clair Counties.

Rank	CAIR State	Area (sq km)	CMAQ Cells	State Impact	
				Madison	St. Clair
18	Missouri	178,414	138	1.05	1.07
24	Illinois	143,961	111	0.80	0.83
38	Indiana	92,895	72	0.47	0.48
2	Texas	678,051	523	0.29	0.28
23	Iowa	144,701	112	0.27	0.28
ET	East Texas	259,897	200	0.26	0.27
35	Ohio	106,056	82	0.21	0.21
36	Kentucky	102,896	79	0.21	0.20
33	Louisiana	112,825	87	0.18	0.18
34	Tennessee	106,752	82	0.18	0.17
25	Wisconsin	140,663	109	0.16	0.16
14	Minnesota	206,189	159	0.13	0.13
22	Michigan	147,121	114	0.13	0.13
28	Alabama	131,426	101	0.13	0.12
21	Georgia	149,976	116	0.09	0.08
31	Mississippi	121,488	94	0.09	0.08
26	Florida	139,670	108	0.05	0.05
29	North Carolina	126,161	97	< 0.05	< 0.05
30	New York	122,283	94	< 0.05	< 0.05
32	Pennsylvania	116,074	90	< 0.05	< 0.05
37	Virginia	102,548	79	< 0.05	< 0.05
40	South Carolina	77,983	60	< 0.05	< 0.05
41	West Virginia	62,361	48	0.05	< 0.05
42	Maryland	25,314	20	< 0.05	< 0.05
WT	West Texas	418,154	323	0.05	0.05

Table 4-4. **Results of Texas Sub-Regional Zero-Out Simulations for Madison and St. Clair Counties Compared with EPA Full Texas Zero-Out Run. (Alpine Results presented with four significant figures [top] and two significant figures [bottom]).**

PM2.5 Impacts in East St. Louis from East vs. West Texas Zero-out Runs--Four Significant Figures								
	EPA CMAQ	Alpine Geophysics CMAQ Results						
Annual PM2.5 Nonattainment County (Illinois)	Full Texas Zero-out (μg/m³)	2010 Base Case (μg/m³)	E. Texas Zero-out (μg/m³)	Diff (mg/m3) (μg/m³)	W. Texas Zero-out (μg/m³)	Diff (mg/m3) (μg/m³)	E+W Tex Combined (μg/m³)	W. Texas Fraction (%)
Madison Co.	0.29	16.6869	16.4236	0.2633	16.6398	0.0471	0.31	15%
St. Clair Co.	0.28	16.2749	16.0074	0.2675	16.2271	0.0478	0.32	15%

PM2.5 Impacts in East St. Louis from East vs. West Texas Zero-out Runs--Two Significant Figures								
	EPA CMAQ	Alpine Geophysics CMAQ Results						
Annual PM2.5 Nonattainment County (Illinois)	Full Texas Zero-out (μg/m³)	2010 Base Case (μg/m³)	E. Texas Zero-out (μg/m³)	Diff (mg/m3) (μg/m³)	W. Texas Zero-out (μg/m³)	Diff (mg/m3) (μg/m³)	E+W Tex Combined (μg/m³)	W. Texas Fraction (%)
Madison Co.	0.29	16.69	16.42	0.26	16.64	0.05	0.31	15%
St. Clair Co.	0.28	16.27	16.01	0.27	16.23	0.05	0.32	15%

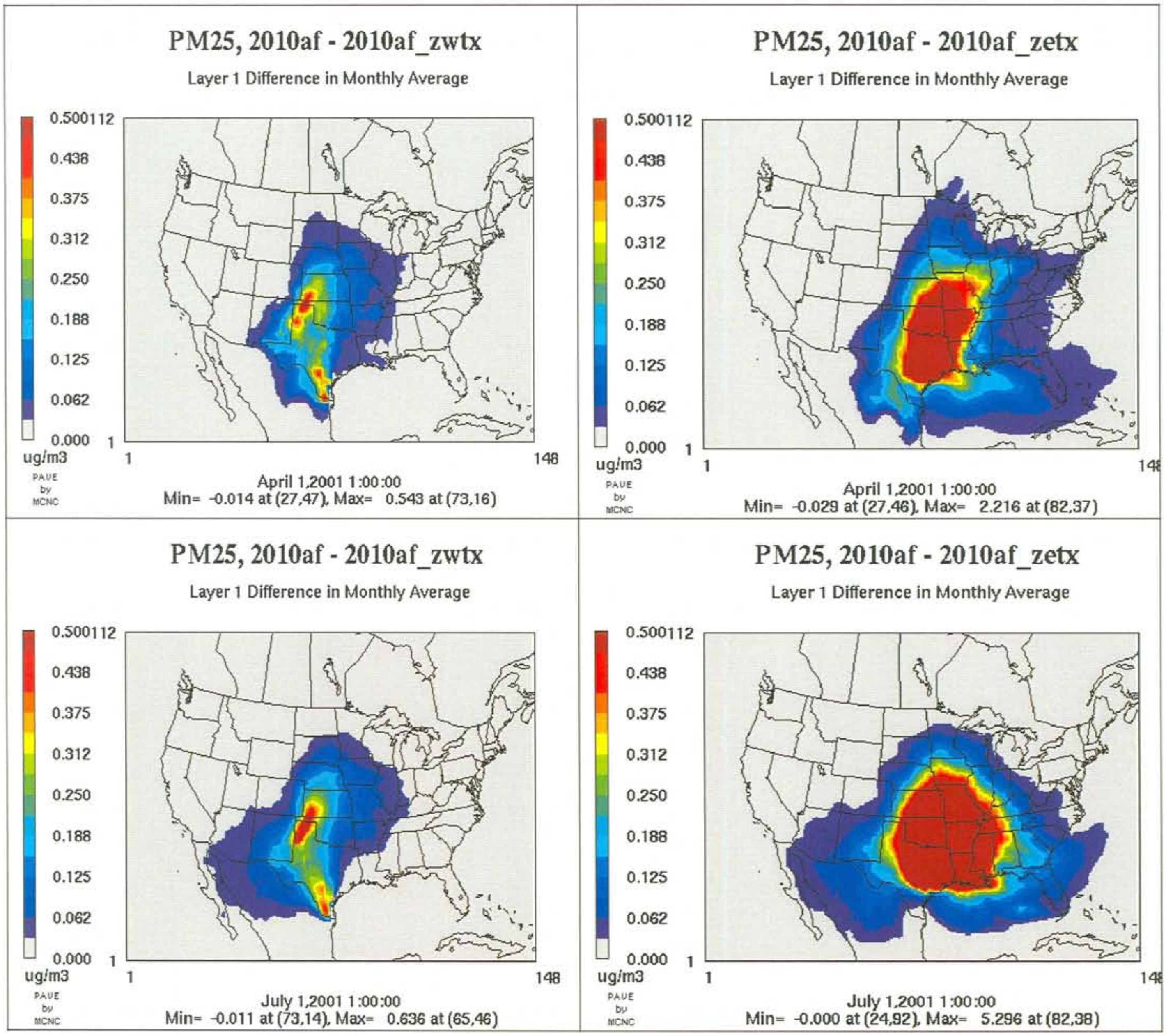


Figure 4-1a. Monthly and Annual Average $PM_{2.5}$ Impacts from 2010 Base Case West Texas Zero Out (left) and East Texas Zero Out Simulations: April (top), July (bottom).

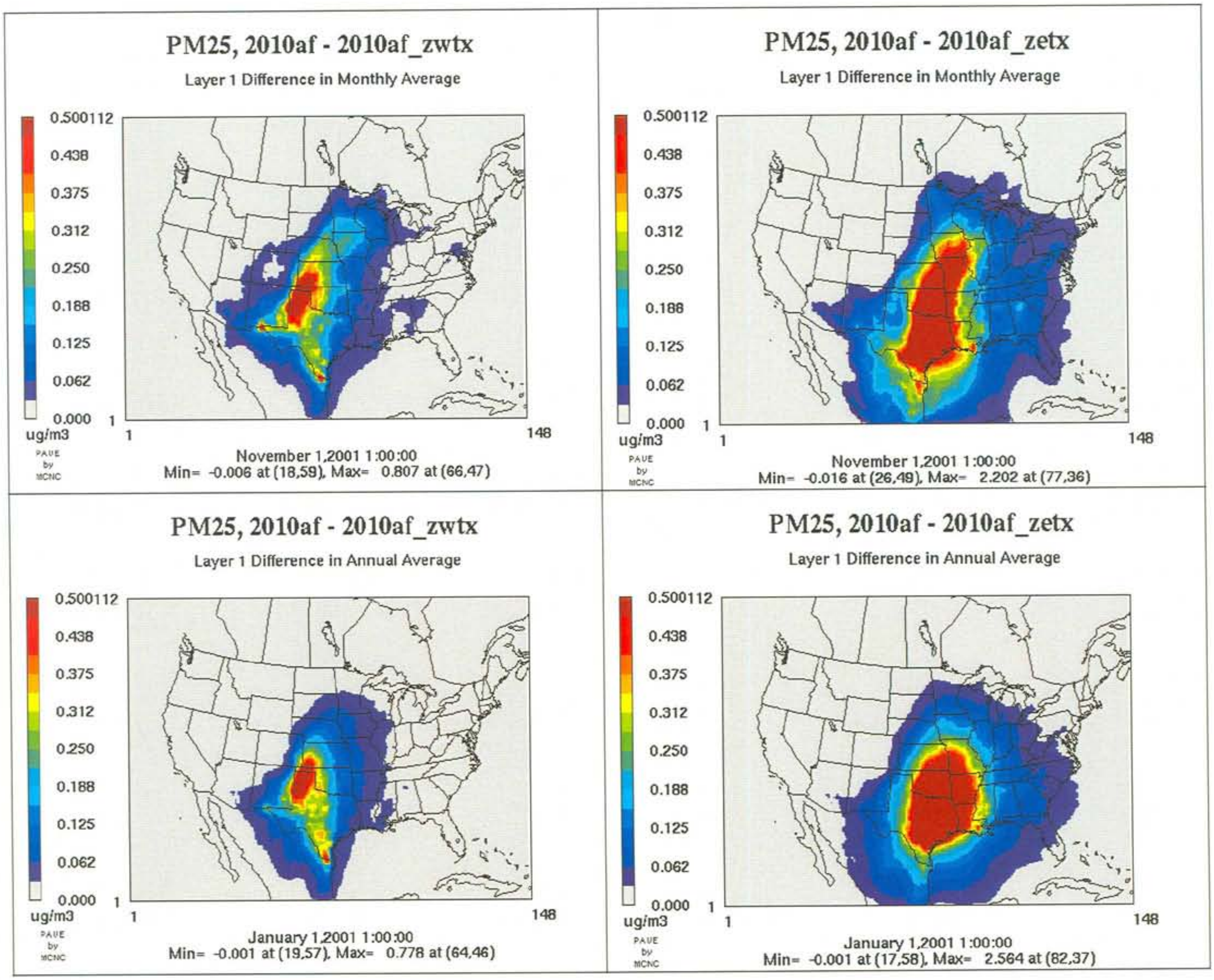


Figure 4-1b. Monthly and Annual Average $PM_{2.5}$ Impacts from 2010 Base Case West Texas Zero Out (left) and East Texas Zero Out Simulations: November (top), 2001 Annual Average (bottom).

5.0 SUMMARY AND CONCLUSIONS

5.1 Summary

This report by Alpine Geophysics summarizes independent CMAQ one-atmosphere modeling results of the impact of anthropogenic NOx and SO2 emissions from west Texas and, separately, from east Texas on annual average $PM_{2.5}$ nonattainment in two Illinois counties. Using EPA's 2010 CAIR Rule modeling codes and data bases, we conducted sub-regional modeling of west Texas and east Texas emissions sources as a notable refinement of the coarse state-by-state "zero-out" analysis performed by EPA in support of the CAIR Rule. Using EPA's significant impact criterion of 0.20, our modeling results indicate that emission sources in east Texas indeed contribute to modeled downwind $PM_{2.5}$ nonattainment in St. Clair and Madison Counties. However, sources in west Texas are 'insignificant' with respect to modeled $PM_{2.5}$ exceedances in Illinois.

5.2 Conclusions

Since EPA's CAIR analysis considered Texas only as one region (indeed, Texas by itself is larger than many eastern states the EPA considered individually in the CAIR Rule), there is a clear need to examine the state on a subregional basis. We conclude that:

> The EPA 2010 Base Case simulation has been corroborated on Alpine's computers;

> While EPA's SMAT post-processing software produces slightly different results on Alpine's machines compared with EPA's computers, these discrepancies are unimportant for this analysis since we use the same version of the software to compare 2010 base case with subregional zero-out runs;

> EPA's finding of Texas's significant contribution to $PM_{2.5}$ nonattainment in Illinois is the result of emissions sources in east Texas; and

> Based on our modeling of year 2010 emissions, west Texas sources have no meaningful impact on $PM_{2.5}$ attainment in St. Clair and Madison Counties.

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