Gulf Coast Aerosol Research and Characterization Program (Houston Supersite)

FINAL REPORT

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Submitted by:

Dr. David Allen
(allen@che.utexas.edu)
512-471-0049

Center for Energy and Environmental Resources
The University of Texas at Austin
10100 Burnet Road, Bldg. 133
MS R7100
Austin, Texas 78758

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1. Introduction

The entire eastern half of Texas experiences annual average concentrations of fine particulate matter (specifically PM less than 2.5 μm in aerodynamic diameter, or $PM_{2.5}$) in the range of 10-12 $\mu g/m^3$. Superimposed on these background concentrations are regions in southeastern Texas in which industrial and urban emissions drive annual average concentrations of fine PM to approximately 15 $\mu g/m^3$. These high background concentrations, with local hot spots, located in a region of high population density (Houston is the fourth most populous city in the United States), result in high exposures to fine PM. At the time this program was initiated, a report performed under contract to the City of Houston estimated that approximately 2.5 million people in the Houston urban area in southeast Texas are exposed to annual average PM concentrations in excess of 15 $\mu g/m^3$ (Lurmann, et al., 1999).

In addition to being an area where $PM_{2.5}$ exposures are significant, southeastern Texas also has a unique mix of emission sources that influence $PM_{2.5}$ concentrations, including typical urban anthropogenic sources, biogenic sources, and significant industrial emissions. The Houston area is home to the largest concentration of petrochemical manufacturing facilities in the United States, and the strength of the industrial source signature in southeastern Texas is unique among large U.S. cities.

The Gulf Coast Aerosol Research and Characterization Study (GC-ARCH or the Houston PM Supersite) examined the spatial and temporal variability in fine PM source contributions and composition in Southeastern Texas, and the physical and chemical process that govern PM formation and transformation in Southeastern Texas. This was accomplished through the analysis of data collected in a 16-month field sampling program (August 2000 – November 2001). Three core sites and approximately 20 peripheral sites, jointly operated by the study team and the Texas Commission on Environmental Quality (TCEQ), were employed. The specific objectives of the study are summarized below and the hypotheses that were examined are listed in Table 1.

Objective 1: Collect physicochemical data on fine PM over a 16 month sampling period in Southeastern Texas; use the data to identify sources and to characterize spatial and temporal variability in fine PM source contributions and composition

Objective 2: Compare the spatial and temporal variability in fine PM source contributions and composition in southeastern Texas to variability throughout the United States

Objective 3: Examine the physical and chemical process that govern PM formation and transformation in Southeastern Texas

Objective 4: Develop a combined database on PM, gas phase air pollutants and meteorological variables, suitable for testing models of the formation and fate of fine PM; this objective was achieved by coordinating with a large, integrated ozone and PM field study conducted during the summer of 2000

Lurmann, F.W., Hall, J.V., Kleinman, M., Chinkin, L.R., Brajer, V., Meacher, D., Mummery, F., Arndt, R.L., Funk, T.H., Alcorn, S.H., and Kumar, N.. 1999. Assessment of the Health Benefits of Improving Air Quality in Houston, Texas, Final report by Sonoma Technologies to the City of Houston (STI-998460-1875-FR).

Table 1. Hypotheses examined through the Gulf Coast Aerosol Research and Characterization Study (GC-ARCH or the Houston PM Supersite)*

Objective 1: Collect physicochemical data on fine PM over a 16 month sampling period in Southeastern Texas; use the data to identify sources and to characterize spatial and temporal variability in fine PM source contributions and composition

Hypotheses:

- Source profiles, average mass concentrations, and average compositions of PM in an upwind site, a site downwind of a heavily industrialized region and a site downwind of the urban core are substantially different, and spatial gradients in fine PM concentrations are greatest in the Ship Channel (industrial) region. (Hypothesis 1a)
- Maximum fine PM concentrations in Southeast Texas are observed in the summer, when secondary PM generation peaks. (Hypothesis 1b)
- Variations in fine PM concentration and composition on an hourly time scale will be substantial and this temporal variability will be related to, but will not identically track, variability in ozone (and other gas phase pollutant) concentrations. (Hypothesis 1c)

Objective 2: Compare the spatial and temporal variability in fine PM source contributions and composition in southeastern Texas to variability throughout the United States

Hypotheses:

- Source profiles of PM in Southeastern Texas are substantially different than those in other parts of the U.S. . (Hypothesis 2a)
- Maximum fine PM concentrations are observed in the summer, when secondary PM generation peaks. (Hypothesis 2b)

Objective 3: Examine the physical and chemical process that govern PM formation and transformation in Southeastern Texas

Hypotheses:

- In regions of high PM concentration gradients, increases in PM mass are primarily due to condensation onto existing PM, rather than formation of new particles. (Hypothesis 3a)
- Rates of condensation of organics onto hydrophobic and hydrophilic PM will vary, and the condensation rates will depend on the hydrophobic surface area available for condensation. (Hypothesis 3b)
- Rates of PM growth are highly correlated with concentrations of semivolatiles, peroxides, and acid gases and gas/particle partitioning ratios for organics will depend on the hydrophobic surface area available for condensation. (Hypothesis 3c)

Objective 4: Develop a combined database on PM, gas phase air pollutants and meteorological variables, suitable for testing models of the formation and fate of fine PM; this objective was achieved by coordinating with a large, integrated ozone and PM field study conducted during the summer of 2000 (no hypotheses)

*These hypotheses are adapted from the original Houston Supersite proposal, and while many of the hypotheses were proven to be correct, some were proven to be incorrect (see Section 2, Key Findings, for details)

2. Scientific Key Findings

Scientific key findings will be divided into sections addressing objectives 1 and 3, and their associated hypotheses, and objective 4. The hypotheses associated with objective 2 (comparison of results from southeastern Texas with results from other regions) are currently being addressed through the development of collective Supersite synthesis findings.

Objectives 1 and 3 and associated hypotheses

Objective 1 was to characterize spatial and temporal variability in fine PM source contributions, and objective 3 was to examine physical and chemical processes that govern fine PM formation and transformation (secondary PM formation) in southeast Texas. Measurements designed to meet these objectives were conducted over a 16 month period, and were made in a variety of locations, including rural sites, urban sites, residential sites, and industrial-source dominated sites. The locations, and associated site names, are shown in Figure 1.

Findings associated with objectives 1 and 3 are separated into sections. The first section describes findings related to spatial and temporal variability in the concentrations, size and composition of the fine PM. The second and third describe findings related to primary sources, and secondary sources/photochemical processes.

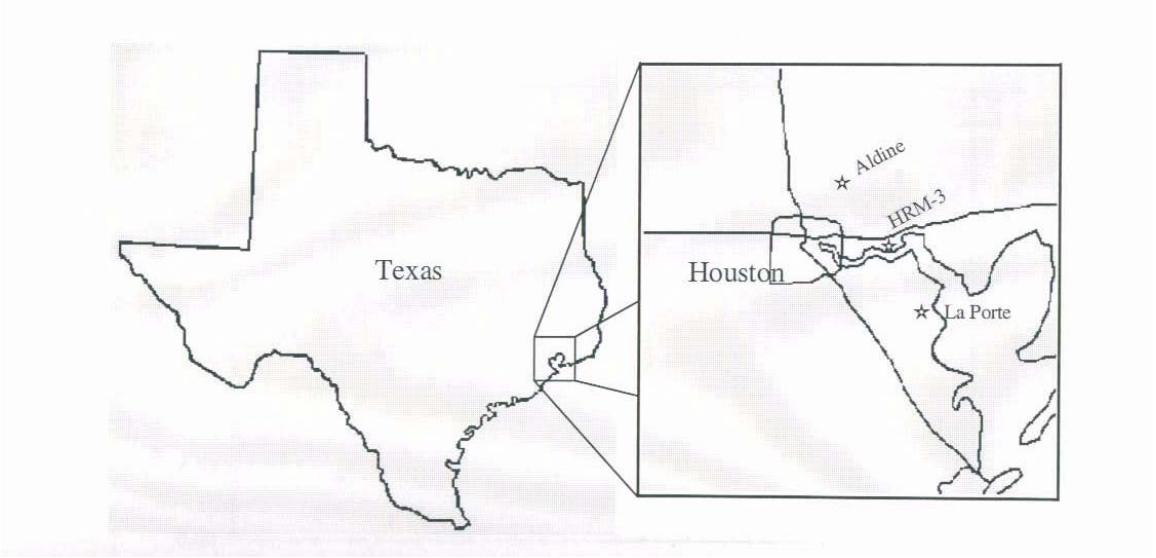

Figure 1. The primary sampling locations for the Houston Supersite were Aldine, HRM-3 and LaPorte. In La Porte, the sampling site was located on the grounds of a municipal airport located at the edge of the small residential community of La Porte. Industrial sources bordered this residential community on the north and east. The sampling site HRM-3 was located directly adjacent to the highly industrialized Houston Ship Channel. Finally, the sampling site Aldine was located on the grounds of a middle school in the suburban community of Aldine, approximately 20 kilometers from the industrial source region. Approximately 20 additional sites located in the inset area provided supporting data.

Key findings related to related to spatial and temporal variability in the concentrations, size and composition of the fine PM are summarized in Findings numbered 1-7.

1. On a seasonal and annual average basis, $PM_{2.5}$ mass concentrations are spatially homogeneous throughout southeast Texas (disproves parts of hypothesis 1a suggesting spatial variability in mass concentration)

Daily average fine particulate matter concentrations are remarkably consistent among sites in southeast Texas. Annual averages of daily average $PM_{2.5}$ concentrations range between 10 and 15 $\mu g/m^3$ (the National Ambient Air Quality Standard is 15 $\mu g/m^3$). While average concentrations show spatial homogeneity, the extreme values of $PM_{2.5}$ mass concentrations show more variability. Maximum daily average concentrations are typically 40 $\mu g/m^3$, with a few sites experiencing higher values (Russell, et al., 2004a).

2. $PM_{2.5}$ mass concentrations peak in late summer when photochemical activity is highest and in early winter, when mixing heights are low; this seasonality is strongest when concentrations at the 90th percentile are examined. (proves parts of hypothesis 1b suggesting temporal variability in mass concentration)

When all $PM_{2.5}$ concentrations are averaged, there are subtle increases in fine particulate matter concentrations in the late summer and winter; this trend is enhanced if only the highest $PM_{2.5}$ concentrations are examined (Russell, et al., 2004a)

3. A consistent and strong morning peak in $PM_{2.5}$ mass concentrations is observed throughout the region and a weaker and slightly less consistent peak in mass concentration is observed in the late afternoon to early evening (proves part of hypothesis 1c suggesting temporal variability in PM concentrations, but disproves part of hypothesis 1c suggesting PM diurnal variability would be related to ozone concentrations)

Average $PM_{2.5}$ mass concentrations, as a function of time of day, show consistent patterns at multiple sites. There is a strong maximum in average concentration in the morning, and a weaker maximum in the late afternoon to early evening. Several hypotheses have been put forward, and are currently being investigated, to explain the morning maximum. These hypotheses include a strong traffic source, low mixing heights, and bursts of photochemical activity associated with sunrise. In evaluating these hypotheses, it should be noted that the morning maximum is observed at both rural and urban sites, sites close to roadways and far from roadways, and sites near the coast and inland. (Russell, et al., 2004a)

4. Sulfate, ammonium, organic carbon and elemental carbon are the major constituents of $PM_{2.5}$ in southeast Texas and the relative concentrations of these components are, on average, spatially homogeneous and show modest temporal variability. (disproves parts of hypothesis 1a suggesting spatial variability in mass concentration and proves parts of hypothesis 1b suggesting temporal variability in mass concentration)

Average composition is relatively homogeneous over all sites and is not sensitive to overall particle concentration. Concentrations of sulfate are slightly higher in the spring and late fall than in the summer and carbon concentrations are highest in the late summer and late fall. (Russell, et al., 2004a)

5. High organic to elemental carbon ratios suggest that much of the carbonaceous material is due to secondary organic aerosol and secondary organic aerosol concentrations peak in late summer. (proves part of Hypothesis 1b suggesting secondary aerosol production peaks in late summer)

The ratio of organic to elemental carbon is often used to distinguish the relative importance of primary and secondary organics. It is generally assumed that soot-like EC is only emitted by primary (combustion) sources, and that these primary emissions have some characteristic ratio of OC to EC. If observed ratios of OC/EC are higher than those assumed to occur in primary emissions (a ratio between 2 and 5 is generally assumed for OC/EC in primary emissions) then the excess OC is assumed to be due to secondary organic aerosol formation. OC to EC ratios in southeast Texas are generally well above the value assumed for primary emissions, suggesting that much of the OC may be due to secondary organic aerosol formation. The contribution of secondary organic aerosol peaks in late summer. (Russell, et al., 2004b)

6. Sulfate is the dominant source of acidity in fine particulate matter in southeast Texas; not all of the acidity is neutralized by cations; ammonium is the primary cation responsible for neutralizing particulate matter acidity, but sodium can also play a role

Nitric acid is not a significant source of acidity or inorganic salts in southeast Texas, so sulfate is the dominant anion in fine PM. Chloride concentrations are small but frequently observed. Ammonium is the dominant cation, but sodium is also frequently present; because samples with high sodium concentration frequently contain little chloride, it can be inferred that sulfate is displacing chloride from sea salt particles, which initially contain NaCl. (Russell, et al., 2004a)

7. Particle size distributions are not spatially homogeneous throughout southeast Texas (proves part of hypothesis 1a suggesting spatial variability in particulate matter characteristics, and proves part of hypothesis 3a that particle growth be more significant than new particle formation)

Industrial sites, such as HRM-3, have higher concentrations of freshly emitted, primary mode particles than more residential sites. Because the freshly emitted particles are small (approximately 0.1 μm) they do not have as large an impact on $PM_{2.5}$ mass or bulk composition as they have on the number density of fine particles (Gasparini, et al., 2004).

Key findings related to primary emissions are summarized in Table 2 and in Findings numbered 8-12. Since hypotheses regarding individual source contributions were not suggested in the original proposal, these findings are not tied to specific hypotheses.

The estimates of the relative magnitudes of emission sources have been based on both "top-down" and "bottom-up" approaches, where top-down approaches rely on ambient observations and bottom-up approaches rely on emission factors and activity data; the results of the two approaches are generally consistent.

Table 2. Summary of inventory data and source strengths for primary sources of fine particulate matter in southeast Texas (Allen, 2003)

Source category	*"Bottom-up" approach*	*"Top-down" approach*	*Overall assessment of source strength*
Wildfires and controlled burns of biomass	Estimates of acreage burned, fuel loading per acre and emissions per ton of fuel burned	Molecular markers of cellulose combustion	Approximately 1-2% of fine PM on an annual average basis; considerable yearly and daily variability
Dust (geological)	Not available	Use of silica and alumina tracers	Generally less than 1% of fine PM on an annual average basis; some possibility of higher source strength in the Ship Channel region (up to 2% of fine PM mass), but this measurement may be subject to interferences
Point sources	Data on individual point sources for PM_{10}	Spatial distributions of PM mass	Data for $PM_{2.5}$ emissions from point sources are not yet available. Data for PM_{10} emissions suggest that point sources are a measurable, but not dominant contributor to $PM_{2.5}$ mass. This is consistent with the spatial distribution of $PM_{2.5}$ concentrations, which are marginally higher in source regions. It should be noted, however, that number concentrations of PM are a factor of 2 higher in regions dominated by point sources, suggesting that point sources are a significant source of ultra-fine particles.
Mobile sources	Data on fuel consumption and emission factors from tunnel studies	Molecular markers of diesel/gasoline engine combustion products	Approximately a quarter to a third of fine PM on an annual average basis, depending on the site; roughly half from diesel engines and half from gasoline engines, again, dependent on site.
Cooking	Inventories done for Los Angeles scaled by population	Molecular tracers of meat cooking	Approximately 10-15% of fine PM on an annual average basis; highest in residential areas

8. Fires are a sporadic, but significant source of $PM_{2.5}$ emissions in Texas.

Estimates based on measurements of levoglucosan (a molecular marker of wood smoke) and on estimates of fire acreage and land cover burned, are consistent in indicating that wildfires and contolled burns of biomass contribute of order 1-2% of the total fine particulate matter mass in the Houston-Galveston area (Fraser and Yue, 2001; Dennis, et al., 2002).

Fires do not occur with the same frequency throughout the year, however, and on specific days at specific locations, fire emissions can dominate total fine particulate matter concentrations. For example, Fraser (2002) made measurements of levoglucosan concentrations during August and September 2000. The average concentration over 2 months of samples, at multiple sites, was approximately five times the annual average for 1997-1998. These data suggest the need to consider temporal variability and year-to-year variability in fine particulate matter emissions associated with fires.

9. Geological sources of fine particulate matter (dust) are a relatively minor contributor to total fine PM mass in the urban Houston-Galveston area.

Geological sources of fine particulate matter include road dust, construction dust, farming dust and windblown dust. These dust sources tend to be found in the coarse mode (>10 μm) of atmospheric particles, but this mode extends to particles below 2.5 μm in aerodynamic diameter, so these sources do contribute to fine particulate matter concentrations.

In urban areas, the major geological contributor to emissions is road dust. Fraser (2002) has estimated that road dust accounted for an average of 0.3 $\mu g/m^3$ of fine particulate matter mass in August and September 2000, at a Ship Channel area site (HRM-3). Other sites had much lower contributions from dust. It should be noted, however, that for the Ship Channel site, Phares, et al (2002) found very small silica particles atypical of normal dust particle sizes. These particles, with diameters of less than 100 nm, may be from a source other than road dust. Therefore, even the relatively modest contribution from dust estimated for the HRM-3 site may be an upper bound.

10. Primary point source emissions of fine particulate matter have not yet been estimated.

Estimates of point source emissions of fine particulate matter ($PM_{2.5}$) are not yet available for most regions in Texas; primary emissions of PM_{10} are significant (of order 10,000 tons/yr), however. Thus, additional studies should characterize the size distributions and compositions of primary point source emissions.

11. Primary mobile source emissions are significant; these emissions account for approximately a quarter to a third of fine PM mass.

Mobile sources of fine particulate matter include direct emissions of particulate matter from diesel and gasoline engines operated on-road, direct emissions of particulate matter from non-road engines (primarily diesel), and particulate matter generated by tire and brake wear. With the exception of emissions due to tire and brake wear, which is a relatively minor contributor to emissions, mobile source emissions tend to be found in the primary mode (approximately 0.1 μm in aerodynamic diameter), and tend to be major sources in most urban areas.

Fraser has estimated the magnitude of primary particulate matter emissions from on-road diesel and gasoline engines in southeast Texas, based on both top-down (Fraser, 2002) and bottom-up (Fraser, et al., 2002) approaches. The top down approach relied on measurements of the concentrations of molecular tracers of diesel sources (EC, hopanes, alkanes and PAHs) and gasoline vehicles operating with catalytic converters (hopanes, alkanes and PAHs). The bottom-up approach was based on dynamometer and fuel consumption data. The analyses are

consistent and suggest that mobile source emissions contribute 3-6 μg/m^3 to seasonal/annual average PM concentrations, depending on the site. The contributions were lowest at LaPorte (approximately 2.6 μg/m^3), intermediate at Aldine (5 μg/m^3), and highest at HRM3 (6 μg/m^3). At Aldine and HRM3, the fine PM mass due to mobile sources accounts for approximately a quarter to a third of total annual average fine PM mass. Of these emissions, approximately half is due to diesel emissions and half is due to emissions from gasoline engines with catalytic converters, although there is some variation from site to site.

12. Primary emissions from cooking are significant; these emissions account for approximately 10-15% of fine PM mass.

Fine particulate matter is emitted during charbroiling and frying of meat, and emission inventory data suggest that these emissions may make a significant contribution to total particulate matter concentrations in urban areas. In Los Angeles, Rogge, et al. (1991) estimated that approximately 6000 kg/day of fine particulate matter is emitted from cooking operations. If these emissions scale with population, then the emissions in southeast Texas would be expected to be several thousand kilograms per day, comparable to the primary emissions from mobile sources.

No detailed inventories of emissions from cooking operations has been performed in southeast Texas, however, a number of molecular markers of cooking emissions have been identified. Fraser (2002) has measured the concentrations of these molecular markers in fine particulate matter in southeast Texas and has estimated that 1.4 to 2.6 μg/m^3 of fine particulate matter observed in southeast Texas can be attributed to emissions from cooking. The concentrations are highest in residential areas (Aldine) and lowest in industrialized areas (HRM3, LaPorte). The fine particulate matter concentrations attributed to cooking represent 10-20% of the observed, annual average fine particulate matter concentrations, making cooking a significant source.

Table 3 and Findings 13-18 summarize data on the relative strengths of secondary fine particulate matter precursor emission sources for southeast Texas. The estimates of the relative magnitudes of emission sources have been based on both "top-down" and "bottom-up" approaches, and the results of the two approaches are generally consistent.

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Table 3. Summary of inventory data and source strengths for sources of the precursors of secondary fine particulate matter in southeast Texas (Allen, 2003)

Source category	*"Bottom-up" approach*	*"Top-down" approach*	*Overall assessment of source strength*
Inorganic sulfate and ammonium			
Sources of SO_2	Data on individual point sources for SO_2; other, non-point sources are negligible compared to point sources	Sulfate measurements	Approximately 30-40% of fine PM on an annual average basis is due to sulfate; considerable yearly and daily variability; much of the observed sulfate is likely due to transport from the continental US
Sources of ammonia	Data on animal husbandry, fertilizer use, soil types, population density, vehicle use and emission factors	Ammonium measurements	Generally ammonium is almost sufficient to neutralize sulfate and accounts for 5-8% of fine PM mass on an annual basis
Secondary organic aerosol (SOA)			
Point sources	Data on VOC emissions for individual point sources and Fractional Aerosol Coefficients	OC/EC ratios	SOA formation rates of approximately 1500-2000 kg/day, leading to 2-3 $\mu g/m^3$; these emissions of precursors are localized and the subsequent SOA formation may also be confined to the Ship Channel region and regions near other sources of SOA precursors (e.g., Polk county)
Mobile sources	Data on fuel consumption and emission factors from tunnel studies	OC/EC ratios	SOA formation rates of approximately 200-300 kg/day, leading to 0.2-0.3 $\mu g/m^3$; these emissions of precursors are broadly distributed
Area/non-road sources	Inventories done for State of Texas	OC/EC ratios	SOA formation rates of approximately 1000 kg/day, leading to 1 $\mu g/m^3$; these emissions of precursors are broadly distributed
Biogenic sources	Land cover data, leaf biomass densities and emission factors	$^{14}C/\ ^{13}C$ ratios	SOA formation rates likely in excess of 10,000 kg day, mostly in the forested areas north of Houston; little biogenic SOA formation in the urban area; high estimated biogenic SOA formation rates are in qualitative agreement with radiocarbon data

13. Point sources of SO_2 emissions are the dominant source of locally generated sulfate

Sulfate typically makes up roughly 40% of fine particulate matter mass in southeast Texas (an average of about 6 $\mu g/m^3$ at many sites). This fine particulate matter mass has both regional (eastern U.S.) and local components, and while the precise allocation of regional and local contributions varies daily, a comparison of annual average data from sites near Texas' eastern border with urban Houston measurements suggest that roughly 2/3 of the total sulfate contribution is regional.

Of the local contributions, emissions leading to sulfate formation may come from point sources burning sulfur containing fuels and mobile and non-road sources burning sulfur-containing fuels. Sulfur oxide emissions from mobile sources can be based on the sulfur content of fuels. Fraser (reported in Dennis, et al., 2002) estimated that 1,000,000 kg of diesel fuel is consumed per day in the Houston area. If that fuel contains 500 ppm sulfur, then 1000 kg/day of SO_2 will be emitted. Similarly, if 10-20 million kg of gasoline is consumed per day in the Houston-Galveston area and that gasoline contains an average of 300 ppm sulfur, then 10,000 kg/day of SO_2 will be emitted. These emissions are relatively small compared to the point source emissions of approximately 300,000 kg/day reported in point source inventories from 2000.

14. The sulfate in fine particulate matter in southeast Texas is often not completely neutralized; ammonia emissions therefore influence total fine particulate matter mass.

The dominant source of ammonia in the state is cattle and other livestock; in most of the state's urban areas, on-road sources, domestic activities (use of cleaning products, human persperation and respiration, human wastes and pet wastes) dominate ammonia emissions (Russell, et al., 2004).

15. Sulfate in fine particulate matter in southeast Texas can be produced by heterogeneous reactions on wood smoke

During an August and September wildfire episode, significant enhancements of sulfate formation were observed and these enhancements were tied to heterogeneous oxidation of SO_2 on wood smoke particles (Buzcu, et al., 2005)

16. Primary emissions are the dominant source of carbonaceous fine PM during most seasons; in the summer, secondary organics are also a significant fraction of total PM mass. (proves part of Hypothesis 1b suggesting secondary aerosol production peaks in late summer)

Organic carbon and elemental carbon make up approximately 25-30% of the total, annual average, fine particulate matter mass in southeast Texas. While some of the carbonaceous material found in fine particulate matter in southeast Texas is likely the result of transport from the eastern continental U.S., there is also evidence for significant local sources. Primary emissions are the dominant source of carbonaceous fine PM during most seasons; in the summer, secondary organics are also a significant fraction of total PM mass. The mass of secondary organics in fine particulate matter peaks at most sites in September (Russell, et al., 2004b).

17. At some suburban and rural locations in southeast Texas, secondary organic aerosol formation is dominated by the reactions of biogenic emissions. These locations are primarily north and southwest of the urban core.

Ratios of organic carbon to elemental carbon suggest that much of the carbonaceous material during the summer at rural sites is due to secondary organic aerosol, formed in the atmosphere as the result of the reactions of gas phase VOC emissions. Radiocarbon dating ($^{14}C/^{13}C$ ratios) indicates that at some suburban and rural locations in southeast Texas, secondary organic aerosol formation is dominated by the reactions of biogenic VOC emissions (Lemire, et al., 2002). These findings are supported by bottom-up inventory assessments, which indicate that during the summer, emissions of biogenic secondary organic aerosol (Vizuete, et al., 2004) overwhelm anthropogenic precursor emissions (Dechapanya, et al., 2004) except in Houston's urban core.

18. The dominant route to formation of biogenic secondary organic aerosol is the reaction of terpenes with ozone; the spatial distribution of this secondary organic aerosol formation is tied more to the distribution of terpene emissions than the distribution of ozone concentrations or the distribution of existing organic aerosol. (partly proves hypothesis 3c suggesting that rates of PM growth would be related to precursor concentrations, but partly disproves hypothesis 3b suggesting that secondary organic aerosol formation would be sensitive to hydrophobic surface area available for condensation)

The reactions of pinenes with ozone dominate secondary organic aerosol formation from both biogenic and anthropogenic precursors during summer months in southeast Texas. These reactions occur in regions that have substantial pinene emissions, as opposed to regions where ozone concentrations are highest (Russell and Allen, 2005).

Objective 4

Objective 4 was to develop a combined database on PM, gas phase air pollutants and meteorological variables, suitable for testing models of the formation and fate of fine PM; this objective was achieved by coordinating with a large, integrated ozone and PM field study conducted during the summer of 2000. Ambient data have been submitted to the NARSTO data archive and a modeling episode has been developed (NARSTO, 2005). Inputs for three-dimensional, gridded photochemical models for the modeling episode have been developed jointly with the Texas Commission on Environmental Quality and are available from the TCEQ (TCEQ, 2005).

KEY CITATIONS:

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3. Knowledge gaps

This report summarizes current information available on fine particulate matter concentrations, compositions and sources in southeast Texas. Critical uncertainties and knowledge gaps remain, however, as summarized below.

Sources of fine particulate matter in Southeast Texas

1. Based on ambient data, in can be concluded that point sources, mobile sources and cooking are the dominant contributors to primary emissions of fine particulate matter in southeast Texas. Detailed inventories of $PM_{2.5}$ emissions from these source categories, using localized information (rather than national defaults) are not yet available. Inventories should be assembled using currently available methods.
2. Based on ambient data and emission inventories, it can be concluded that point source emissions of SO_x, ammonia emissions, and biogenic, point and area source emissions of secondary organic aerosol precursors are all important contributors to fine particulate matter formation in southeast Texas. Although preliminary inventories have been performed for these source categories, more detailed information on SO_3/SO_2 ratios, spatial distribution of ammonia emissions and emissions of semi-volatiles is needed.

Potential impacts of control strategies

3. Among the control strategies that will be implemented in Texas is reduction of SO_x emissions. Since the SO_3/SO_2 ratios for emissions in southeast Texas may be different than in other regions, and because experience in southern California has shown that reductions in SO_x emissions may lead to increases in ammonium nitrate formation, detailed modeling of inorganic aerosol formation in southeast Texas should be performed as soon as the necessary emission inventory data have been assembled.
4. Reductions in emissions that will lead to reduced ozone formation will also likely lead to reduced rates of secondary organic aerosol formation (both inorganic and organic). Detailed modeling of secondary organic aerosol formation in southeast Texas should be performed as soon as the necessary emission inventory data have been assembled.

4. Technical and Economic Feasibility (Technical feasibility of control strategies)
The findings presented in the previous sections have significant implications for reducing $PM_{2.5}$ concentrations in southeast Texas. Summarized below, for each source category, are likely responses of fine PM concentrations to control strategies.

Burning Emissions from fires of various types are a relatively small contributor to annual average concentrations of fine particulate matter; fires contribute on the order of 1-2% of fine particulate matter mass in the Houston-Galveston area. Many of the emissions are due to wildfires and therefore are difficult to control; however, the majority of the emissions associated with fires state wide are associated with prescribed burns, especially rangeland clearing. Control strategies for these emissions can be devised, but the strategies would result in relatively small reductions in fine particulate matter concentrations.

Geological sources Geological sources of fine particulate matter (dust) are a relatively minor contributor to fine particulate matter concentrations in southeast Texas, with the possible exception of certain sites in the Ship Channel area. Dust control measures are relatively simple to implement, but the strategies would result in relatively small reductions in fine particulate matter concentrations.

Point sources Thousands of tons per year of PM_{10} are emitted from point sources in the Houston-Galveston area. It is not clear what fraction of those PM_{10} emissions are $PM_{2.5}$ emissions, but an upper bound would be to assume that all of the reported emissions are $PM_{2.5}$. Even if this upper bound is assumed, however, the emission rate from primary sources is at most comparable to the expected rate of secondary organic formation from anthropogenic sources, a few metric tons per day. This would be a measurable, but not dominant contribution to fine particulate matter mass concentrations in the Houston-Galveston area. Thus, the direct contribution of primary particulate emissions from point sources to total $PM_{2.5}$ concentrations is likely to be small. The assumption of relatively small primary emissions from point sources is consistent with the general observation of only marginally higher annual average concentrations of $PM_{2.5}$ in source-dominated areas.

While the contribution of primary emissions from point sources to $PM_{2.5}$ concentrations is likely small, the contribution to number concentrations is significant. Number concentrations of ultrafine particles at HRM3, measured over a five-month period, were more than double the number concentrations observed at a residential receptor site. It is not clear whether the presence of these particles could play a role in catalyzing or otherwise promoting gas to particle conversion processes, but it is possible that the primary emissions of ultrafine particles from point sources is having an impact on total $PM_{2.5}$ concentrations, albeit indirect.

Mobile sources Mobile sources are the most significant contributor to primary $PM_{2.5}$ emissions. Based on the concentrations of molecular tracers associated with mobile sources, mobile sources contribute 3-6 $\mu g/m^3$ to seasonal/annual average PM concentrations, depending on the site. Of these emissions, approximately half is due to diesel emissions and half is due to emissions from gasoline engines with catalytic converters, although there is some variation from site to site. Mobile source emission controls are likely to be among the most effective strategies for reducing $PM_{2.5}$ concentrations in southeast Texas.

5. Comprehensive Bibliography

This bibliography is presented in two parts. The first part is a bibliography of publications resulting from the Houston Supersite. The second part is a comprehensive bibliography of recent publications related to air quality in southeast Texas.

Part 1: Houston Fine Particulate Matter Supersite Bibliography

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Part 2.

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*an extension of the bibliography compiled by Mark Estes of the Texas Commission on Environmental Quality, http://www.tnrcc.state.tx.us/air/aqp/airquality_techcom.html#topic2b3

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Observations of total alkyl nitrates during TexAQS-2000. R. S. Rosen, E. C. Wood, P. J. Wooldridge, J. A. Thornton,*, D. A. Day, W. Kuster, E. J. Williams, B. T. Jobson, and R. C. Cohen

The Relationship of the Vertical Distribution of Ozone to Boundary Layer Structure in an Urban Environment**.** Guangfeng Jiang, William J. Shaw, and Christoph Senff

An Intercomparison of Ozone Measurements from In Situ and Remote Sensors during the Texas Air Quality Study 2000**.** William J. Shaw, Elaine G. Chapman, Christoph Senff, David Parrish, Stephen Springston, Kenneth Rozacky, Chester Spicer

A Bad Air Day in Houston. R. M. Banta, C. J. Senff, T. B. Ryerson, J. Nielsen-Gammon, L. S. Darby, R. J. Alvarez, S. P. Sandberg, and M. Trainer

Retrieval of model grid scale heat capacity using geostationary satellite products. R. T. McNider, A. Biazar, X Shi, W. Lapenta, and J. Pleim.

Accelerated Science Review

Documents that summarize recent findings relevant to air quality policy in Houston and Texas: http://www.utexas.edu/research/ceer/texaqsarchive/accelerated.htm

- Overview (version 1.0, 9/13/01)
- Emission Inventories (02/05/03)
- Atmospheric Chemistry (5/26/02)
- Meteorology (5/30/02)
- Photochemical Air Quality Modeling (2/17/02)
- Executive Summary (11/13/02)
- Evaluacion Cientifica Acelerada de la Formacion

De Ozono En El Area De Houston-Galveston, 18 de febrero de 2002

TCEQ Air Pollution Events web page.

This web page presents preliminary analyses of each significant air pollution event that occurs in Texas, back to 2000.http://www.tnrcc.state.tx.us/updated/air/monops/airpollevents/2000/sigevents_2000.html

Selected Dallas-Fort Worth Papers and Studies

Tombach, Ivar, et al. Prepared by ENSR for Electric Power Research Institute. "Dallas-Fort Worth Winter Haze Project." EPRI TR-106775-V1. Project 9019. July 1996

MacKay, James; Thomas, Ronald; Mai, Saadia; Rae, Scott; Ross, Charlotte; Sattler, Melanie; Schoonmacher, Scott; Sims, Mike; and Troy Stuckey. "Hierarchical Emissions Inventory Development for Nested Photochemical Modeling. Part 4: Area and Nonroad Mobile Sources." *Emissions Inventory: Living in a Global Environment '98*. Air & Waste Management Association specialty conference. December 1998.

North Central Texas Council of Governments. "1996 Nonroad Mobile and Area Source Periodic Emission Inventories for the Dallas-Fort Worth Modeling Domain." December 1997.

North Central Texas Council of Governments. "1995 and 1996 Episodic Non-Road Mobile and Area Source Emission Inventories for the Dallas-Fort Worth Modeling Domain." September 1997.

TCEQ-sponsored projects related to Houston ozone. The reports can be found at: http://www.tnrcc.state.tx.us/air/aqp/airquality_contracts.html#section3 unless otherwise noted.

These projects are organized by the following topics:

* Independent Peer Review of Photochemical Modeling

* Meteorological Modeling Projects
* Emissions Inventory Projects
* Air Quality Modeling Projects
* Data Analysis Projects
* Other Contract Projects

Independent Peer Review of Photochemical Modeling

A team of ozone photochemical modeling experts lead by Steven Reynolds of Envair performed an independent peer review of photochemical modeling being carried out by TCEQ. The peer review team assesses the appropriateness of the procedures used and their implementation. The review covers four key areas of the modeling work: rapid ozone formation events, emissions modeling, meteorological modeling and air quality modeling.

* Final Report
* Supplementary Document: Response to Comments

Staff Contact: Jim Smith, jismith@tceq.state.tx.us, 512/239-1941.

Meteorological Modeling Projects

MM5 Simulations for TexAQS 2000 Episode - Final Report. ATMET, LLC., 101 pp. (14 Aug 2003) - This report, provided by ATMET, LLC, describes MM5 modeling for the extended TexAQS 2000 episode of August 18 - September 6. It covers the topics on basic modeling configuration, use of the NOAH land surface model, and experimental modeling results. Also included is discussion of modeling sensitivity runs that addressed the questions of wind speed bias during daytime hours.

Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1478

MM5 Simulations for TexAQS 2000 Episode - Task 3: Sensitivities to modifications of the MRF PBL scheme. ATMET, LLC., 37 pp. (30 Sep 2003) - This report, provided by ATMET, LLC, documents modifications to the MRF PBL scheme and a sereis of sensitivity simulations of TexAQS 2000 Episode.

Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1478

MM5 Simulations for TexAQS 2000 Episode - Task 4: Review of the TKE PBL schemes in MM5. ATMET, LLC., 15 pp. (30 Sep 2003) - This report, provided by ATMET, LLC, assesses the possibility of future TKE analyses using available MM5 options.

Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1478

Application of Microwave Temperature Profiler (MTP) Data to MM5 Modeling of the August 2000 Houston-Galveston Ozone Episode. J. W. Nielsen-Gammon, 4 pp. (30 Aug 2002) - This report, provided by Dr. Nielsen-Gammon of Texas A&M University, attempts to validate the model output against microwave temperature profiler (MTP) that was deployed on NOAA aircraft during the TexAQS 2000. This is the preliminary report describing the preparation of MTP data for model validation purposes.

Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1478

Evaluation of the 4-km Coupled MM5/TOPLATS/SSATS Modeling System for the August 1998 Houston-Galveston Area Ozone Exceedance Episode. J. N. McHenry and C. D. Peters-Lidard, 254 pp. (7 Oct 2002) - This report, provided by John McHenry of MCNC and Christa Peters-Lidard of Georgia Institute of Technology, eveluates the application of the coupled meteorological-hydrological-emission-air quality modeling system - Advanced Texas Air Quality Model (ATAQM) - to the August 1998 Ozone Exceedance Episode in Houston-Galveston Area.

Staff Contact: James Red, jred@tceq.state.tx.us, 512/239-1465

MM5 Forecast Validation. ATMET, LLC., 8 pp. (informal note, undated). Available from http://bridge.atmet.org/texaqs.shtml.

RAMS Simulations for TexAQS 2000 Episode. ATMET, LLC., 64 pp. (31 Aug 2002). Available from http://bridge.atmet.org/texaqs.shtml.

RAMS Meteorological Modeling For the September 6-11, 1993 Houston Ozone Episode. ENVIRON Intl. Corp. and ASTER Div., Mission Research Corp., 42 pp. (16 Feb 2001) – This report, provided by Environ, describes the initial RAMS meteorological modeling of the September 6-11, 1993 Houston ozone episode. Following development of the meteorological fields, CAMx sensitivities were done with the RAMS modeling results.
Staff Contact: James Red, jred@tceq.state.tx.us, 512/239-1465

Evaluation of Houston Sea Breeze and Circulation of Pollutants. L. Darby, C. Senff, R. Banta, B. Orr, and J. George, 55 pp. (undated, ca. 2002) - This report, provided by NOAA Environmental Technology Laboratory, evaluates data from two lidars sited at La Porte during the TexAQS study to review development of the Bay/Sea Breeze, (strength, timing, direction and depth) and how the Bay/Sea Breeze is affects ozone concentrations. The report discusses several key, typical days during TexAQs. The report integrates data from several types of surface and hi-tech instruments.
Staff Contact: Pete Breitenbach, pbreiten@tceq.state.tx.us, 512/239-1968

Spatial and Temporal Variations in Mixing Height in Houston. C. Senff, R. Banta, L. Darby, W. Angevine, A. White, C. Berkowitz, and C. Doran, 58 pp. (undated, ca. 2002) - This report, provided by University of Colorado and NOAA, compares rawinsonde, profiler and aircraft data on Mixing Height during the TexAQS modeling period (Aug. 23 - Sep. 1, 2000) and includes wind flow patterns calculated from the profiler data. All three data types give fairly consistent results. The most interesting part of this report is that the aircraft data allow us to evaluate mixing heights over the water, whereas the sounder and profiler data only give data over the land areas. Mixing heights over the Gulf of Mexico average 500-600 meters, and 1000-1200 meters over Galveston Bay.
Staff Contact: Pete Breitenbach, pbreiten@tceq.state.tx.us, 512/239-1968

Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode: Mixing Depths in the GOES Skin Temperature Assimilation. J. W. Nielsen-Gammon, 6 pp. (30 Aug 2003) – This is the seventh report from John Nielsen-Gammon of Texas A&M University regarding the MM5 modeling of the August 2000 ozone episode. It examines the mixing depths in the GOES simulation and considers sources of mixing depth error.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode: Implementation and Initial Evaluation of GOES Skin Temperature Assimilation. J. W. Nielsen-Gammon and S.-O. Han, 46 pp. (3 Jun 2003) – This is the sixth report from John Nielsen-Gammon of Texas A&M University regarding the MM5 modeling of the August 2000 ozone episode. It describes the GOES satellite data assimilation technique and its implementation for the ozone episode modeling. The report includes a comparison with Microwave Temperature Profiler (MTP) data, a preliminary evaluation of mixing height performance, and a statistical evaluation.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

Development of a Conceptual Model for Meteorology and Ozone Formation in the Houston-Galveston Metropolitan Area. J. W. Nielsen-Gammon, 9 pp. (30 Aug 2002) – This preliminary report, by Texas A&M University, discusses the sea-breeze dominated meteorology in the Houston-Galveston area and its relationship to ozone formation as discerned from surface winds, profiler data, and buoy observations. Available at http://www.met.tamu.edu/results.

Trajectory Analysis of Meteorological Simulations of the August 2000 Houston-Galveston Ozone Episode. T. Erukhimova, J. Nielsen-Gammon, and K. Bowman, 179 pp. (27 Aug 2002) – This report, by Texas A&M University, presents and discusses trajectory patterns from major emissions sources as simulated

by the MM5 model during the August 2000 ozone episode. Available at http://www.met.tamu.edu/results.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode: Improved Data Assimilation and Statistical Evaluation. J. W. Nielsen-Gammon, 30 pp. (29 Aug 2002) – This is the fifth report from John Nielsen-Gammon of Texas A&M University regarding the MM5 modeling of the August 2000 ozone episode. It describes and performs statistical validation on model runs with corrected profiler nudging and added Doppler lidar nudging. It also discusses issues related to the downward extrapolation of MM5 model output to instrument level.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode: METSTAT Statistical Evaluation and Model Runs from March-June 2002. J. W. Nielsen-Gammon, 23 pp. (21 Jun 2002) – This is the fourth report from John Nielsen-Gammon of Texas A&M University regarding the MM5 modeling of the August 2000 ozone episode. It describes minor corrections to the final driver run to ensure a consistent set of nested grids, additional tests of the nudging scheme and PBL parameterization, and statistical evaluation of the surface meteorological model output.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode: PBL Characteristics, Nudging Procedure, and Performance Evaluation. J. W. Nielsen-Gammon, 109 pp. (28 Feb 2002) - This is the third report from John Nielsen-Gammon of Texas A&M regarding the MM5 modeling of the August 2000 ozone episode. It documents the final preparation of meteorological modeling. Key topics include the development of the planetary boundary layer during the TexAQS 2000 study period, the appropriate nudging of the model towards observations, and performance evaluation of the modeling results.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

Evaluation and Comparison of Preliminary Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode. J. W. Nielsen-Gammon, 83 pp. (5 Feb 2002) - This is the second report from John Nielsen-Gammon of Texas A&M University regarding the MM5 modeling of the August 2000 ozone episode. It evaluates the quality of MM5 simulations of the episode to help guide the final selection of a model configuration. The report also evaluates the viability of MCNC's real-time forecasting system as an alternative meteorological model for regulatory work.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

Initial Modeling of the August 2000 Houston-Galveston Ozone Episode. J. Nielsen-Gammon, 71 pp. (19 Dec 2001) - This report from John Nielsen-Gammon of Texas A&M University describes the initial MM5 modeling of the August 2000 ozone episode. It covers the topics on meteorological conditions, procedures for developing MM5 simulations, basic modeling setup, and experimental modeling results.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

Assessment of Meteorological Conditions during TexAQS 2000 - Through a contract work order, Texas A&M University developed a Web site to provide meteorological condition details, including upper air charts, profiler charts, satellite images, surface plots, radar images, and ozone data, for August 15 - September 19, 2000 of the TexAQS 2000 field study. The Web site's address is http://www.met.tamu.edu/t2k/tnrcc/metdata.html.

Progress Report for Modeling Bay/Sea Breeze. J. NIelsen-Gammon, A. Odins, and C. Reed, 4 pp. (undated, Aug 2001) - This report, from Texas A&M University, provides information on selection of vertical layers in the MM5 modeling for accurate simulation of bay/sea breeze.
Staff Contact: Bright Dornblaser, bdornbla@tceq.state.tx.us, 512/239-1978

High Resolution (1.33 km) MM5 Modeling of the September 1993 COAST Episode: Sensitivity to Model Configuration and Performance Optimization. ENVIRON Intl. Corp. and ATMET, LLC., 60 pp. (15 Feb 2002) - This report, from Environ and ATMET, provides the information on over 20 different MM5 simulations performed in the sensitivity tests for the Sep. 1993 COAST episode. These tests investigated the effects of modeling grid resolutions (down to 12km, 4km, and 1.33km respectively), microphysical parameterizations, PBL parameterizations, and FDDA grid nudging.
Staff Contact: James Red, jred@tceq.state.tx.us, 512/239-1465

MM5/RAMS Fine Grid Meteorological Modeling for September 8-11, 1993 Ozone Episode. ENVIRON Intl. Corp. and Mission Research Corp./ASTER Div., 37 pp. (31 Aug 2001) - This report from Environ International Corp. provides information on a project to produce new wind fields for the referenced episode using RAMS at about a 1 km grid resolution and to compare those results with equivalent simulations from the Penn State/NCAR MM5.
Staff Contact: James Red, jred@tceq.state.tx.us, 512/239-1465

Enhanced Meteorological Modeling and Performance Evaluation for Two Texas OzoneEpisodes. C. Emery, E. Tai, and G. Yarwood, 235 pp. (31 Aug 2001) - This report from Environ International Corp. provides results from their study to develop a quantitative objective assessment capability of the performance of the meteorological model, similar to the techniques employed for air quality modeling over the past ten years.
Staff Contact: Pete Breitenbach, pbreiten@tceq.state.tx.us, 512/239-1468

Emissions inventory projects

Evaluation of MOBILE for Application to Houston, TX - This study report developed through a work order with Environ International Corp, provides the result of evaluating MOBILE by comparing ratios of species in emissions inventories prepared using MOBILE with corresponding ratios in ambient data. In the study Environ compared estimates of emission ratios of non-methane hydrocarbon (NMHC) and carbon monoxide (CO) to nitrogen oxides (NOx) in a detailed, MOBILE6-based inventory that was developed for Houston with NMHC/NOx and CO/NOx ratios observed at several Houston area monitoring sites for the 1999-2001 summer ozone season.
Staff Contact: Chris Kite, ckite@tceq.state.tx.us, 512/239-1959

Ground Truth Verification of Emissions in the Houston Ship Channel Area (Revised) – This report, provided by Sonoma Technology, Inc., summarizes the work conducted and the findings based on site visits to eight facilities that represent an array of reactive volatile organic compound (VOC) emission sources for petrochemical facilities of varying sizes near the Houston Ship Channel area. It includes (a) a description of the on-site truth activities conducted during winter 2001-2002, (b) statistical summaries of emission discrepancies, and (c) recommendations to improve emission estimation and/or reporting procedures.
Staff Contact: Kathy Pendleton, kpendlet@tceq.state.tx.us, 512/239-1936

Development of Gridded Spatial Allocation Factors for the State of Texas (Updated) – This report from Sonoma Technology Inc. provides details of a project to develop gridded spatial allocation factors for the state of Texas. The factors will be used to geographically distribute area and non road mobile source emissions which were developed from spatial surrogate data. Gridded spatial factors for a 2000 base-year were developed for the entire state as well as portions of Louisiana, Arkansas, and Oklahoma.This report has a companion data file in Comma Separated Values format (CSV).
Staff Contact: Jim Smith, jismith@tceq.state.tx.us, 512/239-1941

Development of Source Speciation Profiles from the 2000 TCEQ Point Source Database – This report, from Pacific Environmental Services, Inc. under a subcontract to Environ International Corp., provides detail

on a project that reviewed existing data from the 2000 TCEQ Point Source Database (PSDB) and developed source specific and SCC specific volatile organic compound speciation profiles that may be used to improve the point source speciation of these emissions for futuremodeling episodes.
Staff Contact: Jocelyn Mellberg, jmellber@tceq.state.tx.us, 512/239-0164

Development of Source Speciation Profiles from the 2000 TCEQ Point Source Database -Memo - This memo, provided by Pacific Environmental Services, Inc, summarizes the development of point source emissions profile based on the TCEQ's 2000 Point Source Database (PSDB).
Staff Contact: Jocelyn Mellberg, jmellber@tceq.state.tx.us, 512/239-0164

Development of Source Speciation Profiles from the 1999 TCEQ Point Source Database – This report, from Pacific Environmental Services, Inc. under a subcontract to Environ International Corp., provides detail on a project that reviewed existing data from the 1999 TCEQ Point Source Database (PSDB) and developed source specific and SCC specific volatile organic compound speciation profiles that may be used to improve the point source speciation of these emissions for future modeling episodes. This report has a set of Microsoft Access database files, compressed in a single zip file.
Staff Contact: Jim Neece, jneece@tceq.state.tx.us, 512/239-1524

2007 On-Road Mobile Source Episode Specific Emissions Inventories for the Beaumont-Port Arthur Ozone Nonattainment Area - This report, provided by Texas Transportation Institute, summarizes the development of link-based on-road mobile source inventories utilizing MOBILE6 in the Beaumont-Port Arthur nonattainment area for the 2007 future case projection of the August 22 -September 1, 2000 ozone episode. A discussion of the MOBILE6 55 mph speed limit benefits for 2007 is included in the report.
Staff Contact: Chris Kite, ckite@tceq.state.tx.us, 512/239-1959

2000 On-Road Mobile Source Episode Specific Emissions Inventories for the Beaumont-Port Arthur Ozone Nonattainment Area - This report, provided by Texas Transportation Institute, summarizes the development of link-based on-road mobile source inventories utilizing MOBILE6 in the Beaumont-Port Arthur nonattainment area from August 22 - September 1, 2000.
Staff Contact: Chris Kite, ckite@tceq.state.tx.us, 512/239-1959

2007 On-Road Mobile Source Episode Specific Emissions Inventories for the Houston-Galveston Ozone Nonattainment Area - This report, provided by Texas Transportation Institute, summarizes the development of link-based on-road mobile source inventories utilizing MOBILE6 in the 8-County Houston/Galveston nonattainment area for the 2007 future case projection of the August 22 - September 1, 2000 ozone episode. A discussion of the MOBILE6 55 mph speed limit benefits for 2007 is included in the report.
Staff Contact: Chris Kite, ckite@tceq.state.tx.us, 512/239-1959

2000 On-Road Mobile Source Episode Specific Emissions Inventories for theHouston-Galveston Ozone Nonattainment Area - This report, provided by Texas Transportation Institute, summarizes the development of link-based on-road mobile source inventories utilizing MOBILE6 in the 8-County Houston/Galveston nonattainment area from August 22 - September 1, 2000.
Staff Contact: Chris Kite, ckite@tceq.state.tx.us, 512/239-1959

TexAQS On-Road Mobile Source Emissions Estimation - This report, provided by Texas Transportation Institute, summarizes the development of link-based on-road mobile source inventories utilizing MOBILE5b in the 8-County Houston/Galveston nonattainment area from August 15 - September 7, 2000.
Staff Contact: Chris Kite, ckite@tceq.state.tx.us, 512/239-1959

High Resolution Solar Radiation Data for Biogenic Emissions Modeling for 2000 Ozone Episodes in the Houston Area - This report, from the University of Maryland, provides the results of a study undertaken to produce high-resolution fluxes of photosynthetically active radiation over the Houston area. The report describes the development of the high resolution data, appropriate support information and a discussion of the data sources, analysis and quality assurance procedures. The data developed by this project include shortwave downward radiation, photosynthetically active solar radiation, and cloud cover at hourly, daily, and instantaeous averaging times, at 1/8 degree and 1/16 degree (4-km) spatial resolution, for the period August 15 - Sept 18, 2000. The 1/8 degree data include the entire US; the 1/16 degree data include the extended Texas area. These data are available upon request.
Staff Contact: Mark Estes, mestes@tceq.state.tx.us, 512/239-6049

High Resolution Solar Radiation Data for Biogenic Emissions Modeling for 1998 Ozone Episodes in the Houston Area - This report from the University of Maryland provides the results of a study undertaken to produce high-resolution fluxes of photosynthetically active radiation over the Houston area. The report describes the development of the high resolution data, appropriate support information and a discussion of the data sources, analysis and quality assurance procedures.
Staff Contact: Mark Estes, mestes@tceq.state.tx.us, 512/239-6049

Biogenic VOC Emission Estimates for the TexAQS 2000 Emission Inventory: Estimating Emissions during Periods of Drought and Prolonged High Temperatures and Developing GloBEIS3 - This report, provided by ENVIRON Inc., describes the development of Globeis3, which includes modules that will help account for biogenic emission changes due to drought and prolonged high temperatures. TCEQ commissioned this revision to Globeis in order to apply the best available information to the biogenic inventory for the drought-stricken summer of 2000. The model itself and its User's Guide are available from Environ's GloBEIS Web Site .
Staff Contact: Mark Estes, mestes@tceq.state.tx.us, 512/239-6049

Review of the Effects of Drought and High Temperatures on Biogenic Emissions, and Future Biogenic Research Efforts in Texas - This report, written by written by Alex Guenther of the National Center for Atmospheric Research, covers two topics. The first topic is a literature review of journal articles and other studies that focussed on how drought and high temperatures affect biogenic organic compound emissions from vegetation. After reviewing the available evidence, the author recommends methods for modifying GLOBEIS that will take into account drought and high temperature effects, as they are currently understood. The second topic is a discussion of research approaches that could be used to validate biogenic emissions modeling in Texas.
Staff Contact: Mark Estes, mestes@tceq.state.tx.us, 512/239-6049

Lagrangian Modeling of Industrial Point-source Plumes in the Houston-Galveston Area – This report, provided by Noor Gillani and Yuling Wu of the University of Alabama at Huntsville, describes Lagrangian reactive plume modeling performed for the Harris-Galveston-Brazoria county area for August 28, 2000. The purpose of this modeling was to simulate the observed ozone and ozone precursors with a different type of model (other than a photochemical grid model which TCEQ uses in its regulatory ozone modeling). The report describes the modeling in detail, including the TexAQS 2000 data used to initialize the model's meteorological parameters. The report also provides an inferred point source emissions inventory for the industrial facilities in the greater Houston area.
Staff Contact: Mark Estes, mestes@tceq.state.tx.us, 512/239-6049

Meteorological and Ozone Characteristics in the Houston Area from August 23 through September 1, 2000. C. P. MacDonald and P. T. Roberts, 231 pp. (30 Aug 2002) - This report, from Sonoma Technology, Inc., provides a day-specific conceptual models of ozone formation in the Houston-Galveston-Brazoria area for each day of the Texas Air Quality Study. Each of these daily conceptual models provides a holistic picture of the processes leading to ozone formation (or lack thereof) throughout that day. Overall

model performance for any day can then be assessed through comparing the modeled processes with the processes in that day's conceptual model.
Staff Contact: Jim Smith, jismith@tceq.state.tx.us, 512/239-1941

Exploratory Source Apportionment of Houston's Clinton Drive Auto-GC 1998-2001 Data -This project was an exploratory investigation into the use of receptor-based models with Auto GC data in the Houston Ship Channel area. STI developed a database of Auto-GC data from Clinton Drive site (years 1998-2001) for use in Positive Matrix Factorization. Fifteen different source types were found by their composition fingerprints, temporal characteristics, and wind-direction dependencies.
Staff Contact: Erik Gribbin, egribbin@tceq.state.tx.us, 512/239-2590

TexAQS 2000 Phase II, Analysis of NOAA Data - This final report developed by the National Oceanic and Atmospheric Administration (NOAA) Aeronomy Laboratory provides an analysis of data taken during the TexAQS 200 field study to determine the efficiency of production of ozone and fine particles from urban and industrial plumes in the Houston area.
Staff Contact: Pete Breitenbach, pbreiten@tceq.state.tx.us, 512/239-1468

TexAQS 2000 Wind Profiler and GPS Sounding Quality Control. D. E. White and A. B. White, 136 pp. (undated, ca. 2002) - This report, from NOAA Environmental Technology Laboratory, provide information on the quality control of wind profiler and GPS sounding data collected during the TexAQS 2000.
Staff Contact: Dave Harper, dharper@tceq.state.tx.us, 512/239-1463

Acquisition, Review, and Analysis of AutoGC VOC Data in the Houston Area 1998-2001 – This report from Sonoma Technology Inc., provides the final results of analyses structured to explore overall characteristics of the auto-GC data, episode versus non-episode differences, composition/concentration differences with respect to wind quadrant, and combinations of these investigations.
Staff Contact: Erik Gribbin, egribbin@tceq.state.tx.us, 512/239-2590

Baylor Aircraft Flight Summary Data: 1997 - 2001 (MS Excel) - This is a MS Excel spreadsheet file containing summary information on Baylor aircraft flights for the years 1997 - 2001. Individuals wishing to obtain data for a particular year on CD-ROM should send an e-mail to the Staff Contact.
Staff Contact: Erik Gribbin, egribbin@tceq.state.tx.us, 512/239-2590

Preliminary Analyses of Houston Auto-GC 1998-2001 Data: Episode/Non-episode Differences - This report, from Sonoma Technology Inc., provides the preliminary results of analyses structured to explore overall characteristics of the auto-GC data, episode versus non-episode differences, composition/concentration differences with respect to wind quadrant, and combinations of these investigations.
Staff Contact: Erik Gribbin, egribbin@tceq.state.tx.us, 512/239-2590

Summary of Data Validation of 2001 Auto-GC Data - This report, from Sonoma Technology Inc., provides the information on validation of the auto-GC data collected during 2001 in Houston area.
Staff Contact: Erik Gribbin, egribbin@tceq.state.tx.us, 512/239-2590

TCEQ/Baylor University Airborne Sampling Data from TexAQS 2000 on CD-ROM – Flight sampling data by Baylor University's Twin Otter aircraft during the TexAQS 2000 field study are now available on CD-ROM disks. These data includes “real-time” measurements of a variety of pollutants, hydrocarbon canister measurements, flight notes and summaries, and data validation information. The data files are in ASCII and Rich Text Format (RTF). To obtain a CD-ROM disk of the data, please submit a request to Erik Gribbin (egribbin@tceq.state.tx.us).

Assistance with Twin Otter Data Manipulation, Quality Checking, and processing for the TexAQS 2000 Air Measurement Data Set - This report, from Sonoma Technology Inc., provides the information on the

improvement of the quality and confidence level of the Baylor University Twin Otter air measurement data set and preparation of a self-consistent data set for the flights conducted during TexAQS 200 for subsequent analysis.
Staff Contact: Erik Gribbin, egribbin@tceq.state.tx.us, 512/239-2590

Characterization of Auto-GC Data in Houston - This report, from Sonoma Technology Inc., provides the extended outline of analyses of auto-GC data to identify relationship of VOCs to Ozone events in Houston, blending the analyses (and their documentations) previously performed by TCEQ with more recent analyses.
Staff Contact: Jim Price, jprice@tceq.state.tx.us, 512/239-1803

Airborne Pollution Monitoring Services - Year 2000 Project Summary - This report, from the Central States Air Resources Agencies (CenSARA) and Baylor University, provides information on the aircraft flights and measurements taken during 2000.
Staff Contact: Erik Gribbin, egribbin@tceq.state.tx.us, 512/239-2590

Analysis of Year 2000 Air Quality Data Collected by the Baylor University Aircraft – This report from Sonoma Technology, Inc. provides characterization and review of the Baylor Aircraft flights and addresses some technical questions regarding ozone pollution in the Houston-Galveston area.
Staff Contact: Erik Gribbin, egribbin@tceq.state.tx.us, 512/239-2590

Data Mining of the Relationship Between Volatile Organic Components and Transient High Ozone Formation - This interim report, developed through a grant and provided by staff of the Department of Chemical Engineering, Clarkson University, describes the use of data mining method to environment data. The aim is to identify the relationships between volatile organic components and transient high ozone formation in the Houston area. The report notes that in Houston, short-term (1 hour) sharp increases are observed followed by a rapid decrease back to typical concentrations. Some components, such as ethylene, propylene etc., are thought to be the cause of the transient high ozone formation based on some measurements from automatic gas chromatographs (GC) Data mining is considered a reasonable method to extract from historic GC data. As huge historic GC data is available, the goal is to design a DM process to extract the information from the data set.
Staff Contact: Jim Price, jprice@tceq.state.tx.us, 512/239-2590

Ozone Production Rate and Hydrocarbon Reactivity in Five Urban Areas: A Cause of High Ozone in Houston - This paper, written by staff at Brookhaven National Laboratory, discusses observations of ozone and ozone precursors taken from aircraft flights over Houston, Nashville, Phoenix, New York, and Philadelphia. The paper notes the significant differences in high concentrations of reactive volatile organic compounds in the Houston area that leads to ozone production rates that are 2 to 5 times higher than in the other 4 cities even though Nox concentrations are comparable. The conclusions address the question of VOC observations being consistent with emission inventory estimates.
Staff Contact: Jim Price, jprice@tceq.state.tx.us, 512/239-2590

Chlorine Chemistry Studies - **The following reports are received from contractors involving a seriesof projects to address chlorine chemistry:**

Spatial and Temporal Impacts of Chlorine Chemistry on Ozone Formation in Southeastern Texas - This report from University of Texas Center for Energy and Environmental Resources describes of the Houston/Galveston non-attainment area using chlorine chemistry and the emission inventory described above. Results show chlorine chemistry can enhance ozone formation as much as 16 ppb in the morning, but only increases the afternoon peak ozone a few ppb, even in the presence of VOC upsets.

Impact of Chlorine on Ozone Modeling for the Houston Area - This report from Environ International Corp. provides results from a project to develop an improved version of the model that can be used to

investigate the role of reactive chlorine emissions; test the improved model using current TCEQ modeling data bases and use the results to evaluate the potential impact of reactive chlorine emissions on ozone formation in the Houston area.

Confirming the Presence and Extent of Oxidation by CI in the Houston Texas Urban Area Using Specific Isoprene Oxidation Products as Tracers - This report from the University of Miami provides the results of a series of experiments to determine the presence and extend of chlorine chemistry in the Houston Area. This report has a companion data file in Comma Separated Values format (CSV).

Impact of Molecular Chlorine Emissions on Ozone Formation in Southeast Houston – This report, from the University of Texas at Austin, Department of Chemical Engineering and Center for Energy and Environmental Resources, provides results of a project to determine the effect of chlorine on the kinetics of ozone formation in a mixture representing the atmosphere of a coastal urban center and to identify hydrocarbon maker species that can assist in characterizing the extent of chlorine reaction in the gas phase, using a smog chamber.

Incorporation of Chlorine Reactions into the Carbon Bond IV Mechanism - This report supplements the above referenced study.

* *Incorporation of Chlorine Reactions into the Carbon Bond IV Mechanism: Mechanism Updates and Preliminary Performance Evaluation* - This report provided by the University of Texas provides details on the updating of the mechanism for the above project.

* *Emission Inventory for Atomic Chlorine Precursors in Southeast Texas* - This report from Center for Energy and Environmental Resources describes spatial and temporal allocations of the chlorine emissions from significant sources in Houston/Galveston and Beaumont/Port Arthur areas, including volatilization of biocides from cooling towers, volatilization of disinfecting agents from swimming pools, and point sources.

Staff Contact: Jim Neece, jneece@tceq.state.tx.us, 512/239-1524

TCEQ Appendices and Attachments to the Mid-Course Review Phase I Technical Support Document

TCEQ Technical Analysis Division prepared modeling and data analyses in support of the December 2002 revision to the State Implementation Plan. The technical attachments describe the development of the emissions inventory, development of conceptual models of Houston ozone, the results of CAMx photochemical modeling simulations of the Aug 25 - Sept 1, 2000 ozone episode, testing of control strategies using the photochemical model CAMx, analyses of airborne VOC canisters and TCEQ auto-GC data, and development of an observation-based method of estimating VOC emissions. These reports are available at: http://www.tnrcc.state.tx.us/air/aqp/airquality_photomod.html#tsd2

Following are the appendices and attachments to the Technical Support Document of the TCEQ Executive Director Recommendation for Changes to Chapter 115/117/101 Rules. All files are in PDF format.

* Appendix A - Conceptual Model for Ozone Formation in the Houston/Galveston Area
* Appendix B - Updated Houston/Galveston Mid-Course Review CAMx Modeling Domain
* Appendix C - CAMx Modeling Matrix of the August 25-September 1, 2000 Episode
* Appendix D - Bibliography of Technical Support Information Reviewed and Considered
* Attachment 1 - Episode Selection
* Attachment 2 - Meteorological Modeling for the August 25, 2000 - September 1, 2000 Episode
* Attachment 3 - Emissions Inventory Development and Modeling for the August 25 – September 1, 2000 Episode
* Attachment 3.1 - TexAQS 2000 On-Road Mobile Source Emissions Estimation (MOBILE5) (Contract Report by TTI, August 31, 2001)

* Attachment 3.2 - 2000 On-Road Mobile Source Episode Specific Emissions Inventories for the Houston-Galveston Ozone Nonattainment Area (Contract Report by TTI, March 2002)
* Attachment 3.3 - 2007 On-Road Mobile Source Episode Specific Emissions Inventories for the Houston-Galveston Ozone Nonattainment Area (Contract Report by TTI, March 2002)
* Attachment 3.4 - Special Inventory Development
* Attachment 3.5 - Development of Source Speciation Profiles from the 2000 TCEQ Point Source Database (Contract Report by PES, August 30, 2002)
* Attachment 3.6 - Biogenic VOC Emission Estimates for the TexAQS 2000 Emission Inventory: Estimating Emissions During Periods of Drought and Prolonged High Temperatures and Developing GloBEIS3 (Contract Report by NCAR and Environ, April 11, 2002)
* Attachment 3.7 - 2000 On-Road Mobile Source Episode Specific Emissions Inventories for the Beaumont-Port Arthur Ozone Nonattainment Area (Contract Report by TTI, August 2002)
* Attachment 3.8 - 2007 On-Road Mobile Source Episode Specific Emissions Inventories for the Beaumont-Port Arthur Ozone Nonattainment Area (Contract Report by TTI, August 2002)
* Attachment 3.9 - Mexico Emissions Inventory - excerpt from Big Bend Regional Aerosol and Visibility Obervational (BRAVO) Study Emissions Inventory (November 16, 2001)
* Attachment 4 - CAMx Model Performance Evaluation for the August 25 - September 1, 2000 Episode
* Attachment 5 - Analysis of TexAQS 2000 Airborne Canisters
* Attachment 6 - Analysis of AutoGC Data from 1996-2001 to Determine VOCs with Largest Ozone Formation Potential
* Attachment 7 - Preliminary Emission Adjustment Factors Using Automated Gas Chromatography Data
* Attachment 8 - Allocation of Emissions of HRVOCs to Source Types

Houston Advanced Research Center Air Quality Project Reports

Reports from completed projects are available at: http://www.harc.edu/harc/Projects/AirQuality/

H1.2002 *Meteorological and Emissions Sensitivity Modeling Study of Rapid Ozone Formation Events in the Houston-Galveston Airshed*, Report Available, ENVIRON International Corp. (lead); ATMET LLC, University of California at Riverside CE-CERT

H3.2002 *Air Pollutant Emissions Associated with Forest, Grassland, and Agricultural Burning in Texas During the 2000 Texas Air Quality Study*, Report Available, The University of Texas at Austin

H4.2002 *Preparation of Strategic Research Plan and Science Synthesis Reports*, Report Available

H5.2002 *Measurement and Assessment of Equipment Leak Fugitives and Vent Emissions in Industrial Ethylene and Other Chemical Sources*, Report Available, ENVIRON International Corp.

H6A.2002 *Quantification of Fugitive Reactive Alkene Emissions from Petrochemical Plants with Perfluorocarbon Tracers*, Brookhaven National Laboratory - Environmental Sciences Department/Atmospheric Sciences Division

H6B.2002 *Top-down Emissions Verification for the Houston-Galveston Industrial Point Sources based on TexaAQS Data*, Report Available, University of Alabama in Huntsville

H6E.2002 *Top-Down Emissions Inventory*, Report Available, ENVIRON International Corporation/ Air Sciences Group

H7A.2003 *Compilation of Information on Cooling Towers, Equipment Leak Fugitives and Flares*, URS Corporation

H8B.2003-MOD *Modeling and MOBILE6: High emitter fraction and Mileage accumulation rate*, Report Available, Eastern Research Group

H8B.2003-T/H *Modeling and MOBILE6: Humidity and Temperature Effects on On-Road and Off-Road Diesel Emissions and Ozone Formation*, Report Available, ENVIRON International Corporation

H8B.2003-SPA *Modeling and MOBILE6: Spatial Allocation of Mobile Source Emissions*, Report Available, ENVIRON International Corporation

H8C.2003-AGR *Revised Agricultural Emission Estimates*, Report Available, ENVIRON International Corporation

H8C.2003-MAR *Improving Non-Road Mobile Sources Emissions Inventories*, Report Available, Eastern Research Group, Inc.

H9.2003 *Assessment of Incentives for Alternative Transportation Measures,* NuStats Partners, L.P.
H10.2003 *Estimates of Emission for Small Scale Diesel Generators,* Report Available, ENVIRON International Corporation
H13.2003 *Inventories of HR VOC Emissions & Impact of Emission Magnitude & Variability on Ozone Formation in H/G Area,* The University of Texas at Austin
H14.2002 *The importance of maintaining a proper state implementation plan (SIP) to address air quality issues in Texas: An economic and fiscal impact assessment,* Report Available, The Perryman Group
H17.2003 *Modeling the Effects of Land Use/ Land Cover Modifications on the Urban Heat Island Phenomena in Houston, Texas,* University of Houston
H19.2003 *Real-Time Trajectory Analysis Operation and Tool Development,* The University of Houston
H20.2003 *Texas Emission Reduction Plan Assessment in the Houston-Galveston-Brazoria Region,* Environ
H22.2003 *VOC and NOx Release Level Permits,* Final Report, URS Corporation

Nov 21-22, 2002 TexAQS workshop at University of Houston-Clear Lake

Presentations delivered at this workshop are available at TCEQ's website:
http://www.tnrcc.state.tx.us/air/aqp/airquality_workshop.html#ws07

1. Emission Loading at the Williams Tower Carl Berkowitz, et al
2. EI Verification using the 2001 Olefin Data - Comparing Olefin:NOx/y Ratios, Doug Boyer, et al
3. Characterization of 2001 Ozone Event-Triggered VOC and Carbonyl Samples in Houston Steven Brown, et al
4. Houston Air Quality with EPA NET96 vs. TCEQ 2000 Emissions Data, Daewon Byun, et al
5. How Can Meteorological Conditions at LaPorte, Texas be Used to Estimate Ozone Behavior across the TCEQ Network? Lisa Darby, et al
6. Reactivity of VOCs Measured by Automated Gas Chromatography in Houston, 1996-2001 Mark Estes, et al
7. Meteorological-Chemical Modeling of High Ozone Episodes during the 2000 TexAQS Jerome Fast, et al
8. Model-Measurement Comparisons of [OH], [HO2], and O3 Production Rate at La Porte Airport G. J. Frost, et al
9. Top-Down Verification of Emissions from Industrial Point Sources Noor Gillani, et al
10. Analysis of Auto-GC VOC Data in the Houston Area Hilary Hafner, et al
11. Comparison of VOC/NOx Emission Ratios with Ambient Measurements, Albert Hendler, et al
12. Data Mining of the Relationship between VOCs and Transient High Ozone Formation Philip Hopke, et al
13. Aircraft Observations vs CAMx Predictions for Houston August 25-30, 2000 Harvey Jeffries, et al
14. Comparison of High-Resolution Air Quality Model Simulations with Measurements Made during the TexAQS 2000 Field Study and two QuickTime animations of wind and Noy: Aug. 26-28, 2000 and Aug. 30, 2000 Stu McKeen
15. Update on Conceptual Model of the Gulf Breeze and on MM5 Modeling of the 2000 EpisodeJohn Nielsen-Gammon
16. Emission Quantification Projects Karen Olson
17. Comparison of Ozone Precursor Relationships in Four U.S. Urban Areas, D. Parrish, et al
18. Future Efforts to Improve Fugitive Emissions Estimates Kathy Pendleton
19. Episode Analysis of EPA-Sponsored VOC Canister Monitoring Data in Houston, Summer 2001 Mark Sather, et al
20. Spatial and Temporal Variations in Mixing Height during TexAQS 2000 and their Impact on Ozone Concentrations Christoph Senff, et al
21. Relationship of Boundary Layer Structure to Ozone Concentrations during TexAQS 2000 W.J. Shaw, et al
22. TCEQ Regulatory Modeling Jim Smith
23. Measurement and Assessment of Equipment Leak Fugitive Emissions in Ethylene Facilities Mike Smylie, et al
24. Flare Efficiency By Passive FTIR Bob Spellacy

Ozone and Particulate Research Presentations (August 28-29, 2002)

Presentations were held at the TCEQ complex in Austin to discuss ozone research results (August 28, 2002) and particulate matter research results (August 29, 2002). The presentations came from contract work and university work in Texas.

Acquisition, Review and Analysis of Auto-GC Data in the Houston Area Hilary Main, et al
Progress Report: Analysis of Texas 2000 Air Quality Study Data
Carl Berkowitz, et al Reactivity of VOCs Measured by Auto-GC in Houston: 1996-2001 Mark Estes, et al
2000 NOAA Canister Samples Doug Boyer
2000 DOE Canister Samples Doug Boyer
2000 Baylor Canister Samples Doug Boyer
Overview of EPA-Sponsored VOC Canister Monitoring Data in Houston: Summer, 2001 Mark Sather, et al
Characterization of 2001 Ozone Event-Triggered VOC and Carbonyl Samples Paul Roberts, et al
What Are the VOCs that Are Causing Houston's Peak Ozone Problems? and Where Do They
Come from? Harvey Jeffries, et al
TCEQ Regulatory Modeling Jim Smith
Grid Modeling in Houston Jim Smith
Conceptual Model of the Gulf Breeze and on MM5 Modeling of the 2000 Episode John Nielsen-Gammon

Simulation of Houston Air Quality with EPA's CMAQ with CAMx Emissions Data Daewon Byun, et al
Initial Application of a Coupled LES-Photochemical Model to Examine Near-Source Ozone
Production from Industrial Emissions Jerold Herwehe, et al
Evaluation of the NOAA Coupled Weather-Chemistry Model J-W. Bao, et al
Box Model Simulations to Assess Ozone Formation Potential of Large Releases of VOCs and/or NOx into an Air Parcel with a Composition Typical of Houston Yosuke Kimura, et al
Update on Laser Imaging of Fugitive Ethylene Emissions Kathy Pendleton Flare Project Update Karen Olson
Analysis of Vehicle Emissions in the Washburn Tunnel Gary McGaughey, et al
Texas Environmental Research Consortium (TERC) - Overview Dave Allen, et al
TERC Strategic Research Plan John Hall, et al

Fine Particulate Matter and Regional Haze (Aug. 29, 2002)

PM2.5 and Regional Haze Gerry Wolfe, et al Seasonal, Daily and Spatial Variability in Fine PM Composition and Concentration in Southeast Texas Matt Russell, et al Size Distributions of Fine PM in Southeast Texas Roberto Gasparini, et al

Organic Speciation and Source Apportionment of Fine PM during TexAQS 2000 M.P. Fraser, et al

Fine Particulate Matter Source Attribution for Southeast Texas Using 14C/13C Ratios Kenneth R. Lemire, et al

Biogenic Secondary Organic Aerosol Formation in Southeast Texas Victoria Junquera, et al Mechanistic Models of Secondary Organic Aerosol Formation and Their Application to Houston Conditions Wipawee Dechapanya, et al

Poster session dedicated to TexAQS 2000 at AGU Fall Meeting, 2002

Abstracts available at: http://www.agu.org/cgi-bin/sessionsf?meeting=fm02&part=A12D&maxhits=100

Characterization of VOC Sources during the Texas Air Quality Study 2000 Using Proton-Transfer-Reaction Mass Spectrometry *T Karl, T Jobson, K William, E Williams, J Stutz, P Goldan, R Fall, F Fehsenfeld, W Lindinger,

The Behavior of the Hydroxyl and Hydroperoxyl Radicals During TexAQS2000 *M Martinez, H Harder, W Brune, P Di Carlo, E Williams, D Hereid, T Jobson, W Kuster, J Roberts, M Trainer, F Fehsenfeld, S Hall, R Shetter, E Apel, D Riemer, A Geyer, J Stutz, K Baumann

An Intercomparison of Airborne VOC and PAN Measurements A Hansel, *A Wisthaler, F Flocke, A Weinheimer, R Fall, P Goldan, G Hübler, F C Fehsenfeld

Chemical and Meteorological Characteristics Leading to the Major Ozone Exceedences ($>$150 ppb) Observed in Houston, TX During TEXAQS 2000 *K K Perkins, T B Ryerson, M Trainer, D K Nicks Jr.J A Neuman, J S Holloway, R O Jakoubek, D D Parrish, D T Sueper, G J Frost, W C Kuster, P D Goldan, R W Dissly, G Hubler, W M Angevine, F C Fehsenfeld, S G Donnelly, S Schauffler, V Stroud, E L Atlas, A J Weinheimer, F Flocke, B P Wert, W T Potter, A Fried, C Wiedinmyer, C J Senff, R M Banta, L S Darby, R J Alvarez

Emissions of NOx, SO2 and CO2 From Power Plants: Evaluating Continuous Emissions Monitoring Systems (CEMS) Data Using Airborne Field Measurements. *D Nicks Jr., T Ryerson, J Holloway, M Trainer, D Parrish, G Frost, G Hubler, C Wiedinmyer, D Sueper, F Fehsenfeld

First direct observations of daytime NO$_{3}$ during TEXAQS 2000 *A Geyer, B Alicke, R Ackermann, J Stutz, M Martinez, H Harder, W Brune, E Williams, T Jobson, R Shetter, S Hall

A COMPARATIVE STUDY OF O3 FORMATION IN THE HOUSTON URBAN AND INDUSTRIAL PLUMES DURING THE TexAQS 2000 STUDY *P H Daum, L I Kleinman, S R Springston, L J Nunnermacker, Y Lee, J Weinstein-Lloyd Formation of Nitrous Acid, HONO, in the Polluted Urban Atmosphere *J Stutz, A Geyer, S Wang, J

Value comparison with measurement and models in Houston *R Jakoubek, C Brock, F Fehsenfeld, G Frost, S Hall, J Holloway, S McKeen, D Nicks Jr.D Parrish, T Ryerson, R Shetter, D Sueper, M Trainer

Intercomparisons of Chemical Trace Species Measured on the Electra During TexAQS 2000 *D Sueper, T Ryerson, J Holloway, D Parrish, D Nicks Jr.A Neuman, G Hubler, M Trainer, E Williams, J Meagher, F Fehsenfeld, A Fried, B Wert, Y Lee, S Donnelly, S Schauffler, V Stroud, E Atlas, F Flocke, A Weinheimer, P Daum, S Springston, L

A Box-Model Analysis of Ozone Production Potential as a Function of Source Region in the Houston/Galveston Area *C M Berkowitz, P V Doskey, C W Spicer, R A Zaveri

Chemical Evolution of an Isolated Power-Plant Plume *S R Springston, L I Kleinman, F Brechtel, L J Nunnermacker, J Weinstein-Lloyd

Houston Rural vs. Urban Ozone and Carbon Dioxide Concentrations and Air-Surface Exchange Rates *R L Gunter, T P Meyers

Comparisons of the Surface Energy Balance and Turbulence During Houston 2000 *T P Meyers, R L Gunter

Single Particle Composition Measurements During TexAQS 2000 on Williams Tower: Visual Data Mining with Interactive Dendogram *A Zelenyuk, D G Imre, K Mueller, P Imrich, W Zhu, R Mugno

PAN, Nitrogen Dioxide, and Ozone Measurements at Deer Park, Texas, during TexAQS 2000 *J S Gaffney, N A Marley

A Comparison of NOy Budgets from the NOAA P3 during SOS99 and TexAQS 2000 *J W Peischl, G Huey, E L Atlas, R W Dissly, S G Donnelly, F Fehsenfeld, F Flocke, G Frost, P Goldan, J Holloway, G Hubler, R Jackoubek, W Kuster, B Lefer, E Leibrock, J Meagher, A Neuman, D Nicks Jr.D Parrish, J Roberts, T Ryerson, S Schauffler, R Shetter, D Sueper, M Trainer, A Weinheimer

Performance of the University of Denver Low Turbulence, Airborne Aerosol Inlet in PELTI, TexAQS2000 and ITCT *J C Wilson, W R Seebaugh, B G Lafleur, D Gesler, J Mullen, H Hilbert, J M Reeves, C A Brock, T Bertran, B Huebert, S Howell

Analysis of Motor Vehicle Emissions in a Houston Tunnel during the Texas Air Quality Study 2000 *G R McGaughey, N R Desai, D T Allen, R L Seila, W A Lonneman, M P Fraser, R A Harley, J M Ivy, J H Price

Observations of Total Alkyl Nitrates During TEXAQS-2000 *R S Rosen, E C Wood, P J Wooldridge, J A Thornton, R C Cohen, E J Williams, J M Roberts, T B Jobson, W Kuster

Aerosol Mass Spectrometer Measurements of Ambient Aerosol During the Texas 2000 Study *M R Canagaratna, J L Jimenez, P Silva, A Delia, K Purvis, H Boudries, J T Jayne, C Kolb, D Worsnop

Urban and Rural-Background Concentrations of Ozone near Houston during TexAQS 2000 *R M Banta, C J Senff, L S Darby

Observations and Modeling of Ozone Photochemistry in Plumes from Petrochemical Facilities near Houston, TX. *M Trainer, W Angevine, E Atlas, R Dissley, S Donnelly, F Fehsenfeld, F Flocke, A Fried, P Goldan, A Hansel, J Holloway, G Huebler, A Neuman, D Nicks, D Parrish, T Ryerson, S Schauffler, A Weinheimer, B Wert, A Wisthaler

Aerosol Chemical Composition Characterization During the 2000 Texas Air Quality Study *Y Lee, Z Song, R Weber, D Orsini, L Kleinman, S Springston, L Nunnermacker, J Hubbe, V Morris, N Laulainen, Y Liu, P Daum, J Rudolf

Hydroperoxide Measurements During the Texas 2000 Air Quality Study *J Zheng, J B Weinstein-Lloyd, S R Springston, L J Nunnermacker, Y Lee, F Brechtel, L I Kleinman, P H Daum

Comparison of Meteorology from a Weather-Chemistry Forecast Model with Observations During the TEXAQS-2000 Field Study *J Bao, S A Michelson, G A Grell, S A McKeen, A B White

Presentation session dedicated to TexAQS 2000 at AGU Fall Meeting 2002

Abstracts available at: http://www.agu.org/cgi-bin/sessionsf?meeting=fm02&part=A21F&maxhits=100

The Southern Oxidants Study Texas Air Quality Study (TexAQS 2000) II Presiding: P Daum, Brookhaven National Laboratory; J Meagher Ph.D, NOAA Aeronomy Laboratory

The Impact of TexAQS 2000 on Air Quality Planning in Houston *J W Thomas, J H Price

AN OVERVIEW OF OBSERVATIONS MADE FROM THE G-1 AIRCRAFT DURING TexAQS 2000 *L I Kleinman, P H Daum, F Brechtel, G Buzorius, Y Lee, L J Nunnermacker, S R Springston, J Weinstein-Lloyd, J Zheng

An overview of results from the Electra aircraft during the Texas 2000 study *T Ryerson, M Trainer, D Nicks Jr.J Neuman, J Holloway, C Brock, R Jakoubek, D Parrish, D Sueper, J Roberts, G Frost, W Kuster, P Goldan, R Dissly, G Huebler, S McKeen, K Perkins, W Angevine, F Fehsenfeld, S Donnelly, S Shauffler, V Stroud, E Atlas, A Weinheimer, F Flocke, B Wert, W Potter, A Fried, C Wiedinmyer, C Senff, R Banta, L Darby, R Alvarez

Ozone Distribution and Transport in the Houston Area: Insights Gained by Airborne Lidar *C J Senff, R M Banta, L S Darby, R J Alvarez, S P Sandberg, R M Hardesty, W M Angevine

An Overview of Photochemical Gas-phase Measurements at the La Porte Municipal Airport During TexAQS-2000 *E J Williams

Observations from the Williams Tower measurement site during TexAQS 2000: an Overview *D Imre, F Brechtel, A Zelenyuk, P Doskey, C Spicer, D Joseph, C Berkowitz, M Alexander, J Cowin, J Weinstein-Lloyd, K Baumann

Fine Particulate Matter Composition and Sources during the Texas Air Quality Study *D T Allen

Meteorological Modeling of a Houston Ozone Episode *J W Nielsen-Gammon

Comparisons of Air Quality Observations Collected During TEXAQS-2000 with Results of an Air Quality Forecast Model *S A McKeen, G A Grell, J Bao, S A Michelson, G J Frost

The Effect of Ethene and Propene Emissions on Ozone Production in Houston during the TexAQS 2000 Field Campaign. *J D Fast, G Jiang

Model-Measurement Comparisons of [OH], [HO2], and P(O3) in Houston *G J Frost, E Williams, D Hereid, B T Jobson, W Kuster, J Roberts, M Trainer, F C Fehsenfeld, M Martinez, H Harder, W Brune, P Di Carlo, S Hall, R Shetter, T Karl, E Apel, D Riemer, A Geyer, J Stutz, K Baumann

Particle Growth in Urban and Industrial Plumes in the Houston Metropolitan Area *C A Brock, M Trainer, T B Ryerson, J A Neuman, D D Parrish, J S Holloway, J C Wilson, J M Reeves, E L Atlas, V F Stroud

2004 AMS meeting, TexAQS and other Houston-related presentations

Abstracts available at: http://ams.confex.com/ams/84Annual/techprogram/programexpanded_190.htm

J2.7 Mixing height variations in a coastal megacity inferred from lidar, profiler, sonde, microwave temperature profiler, and aircraft Christina Smith, Texas A&M University, College Station, TX; and C. Senff, J. Nielsen-Gammon, A. White, W. Angevine, C. Berkowitz, M. Mahoney, S.-O. Han, and C. Doran

J2.8 Study of the Photochemical Processes in the Houston-Galveston Metropolitan Airshed Daewon W. Byun, University of Houston, Houston, TX

J2.9 Photochemical Production Rates in Western Houston Carl M. Berkowitz, PNNL, Richland, WA; and C. W. Spicer and P. V. Doskey