

Gulf Coast Aerosol Research and Characterization Program (Houston Supersite)

PROGRESS REPORT

EPA Contract No. R-82806201

between the Environmental Protection Agency and the
University of Texas at Austin

Submitted by:

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Title: Gulf Coast Aerosol Research and Characterization Study

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Institutions: University of Texas and Rice University

Research Category: Air Quality/Fine Particulate Matter

Project Period: 01/15/00-11/30/03

Objective of Research: Characterize fine particulate matter and fine particulate matter formation processes in Southeast Texas

Progress Summary/Accomplishments:

Analysis of data collected during the Houston Supersite field program is transitioning from descriptive analysis of the data to source resolution. This quarterly report expands on the work reported in a previous quarterly report on anthropogenic sources of secondary organic aerosol.

Overview

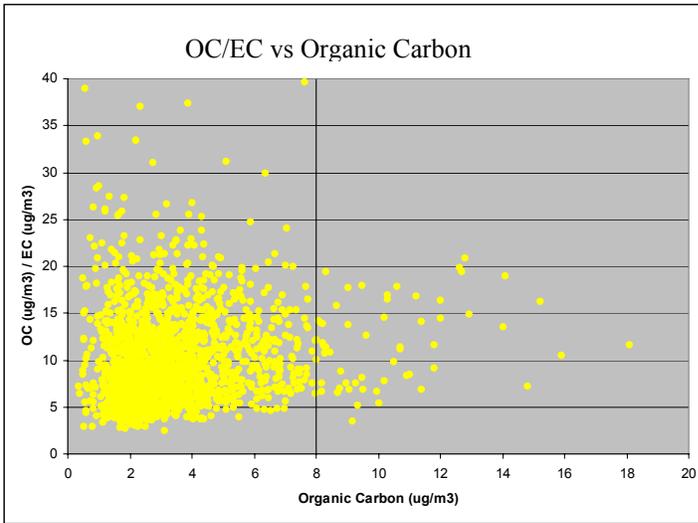
In a previous quarterly report, Secondary Organic Aerosol (SOA) formation due to precursor emissions from anthropogenic sources in the Houston/Galveston (HG) area was estimated by multiplying the anthropogenic emissions of SOA precursors by fractional aerosol coefficients (FAC). The analysis indicated that emissions of terpenes from pulp and paper processing and emissions of aromatics, especially toluene, xylenes and trimethylbenzenes are significant SOA precursors in the Houston-Galveston (HG) area. Estimated SOA formation rates were consistent with average concentrations of particle phase organic carbon in the Houston-Galveston area. In this quarterly report, emission mappings of the anthropogenic SOA precursors, and a summary of inventory data on SOA precursors is provided.

Background

Annual average fine particulate matter concentrations over much of the Houston-Galveston area in Texas approach the National Ambient Air Quality Standard of 15 $\mu\text{g}/\text{m}^3$. On average, approximately 25% of the mass is carbonaceous (Tropp, et al, 1998), and most of the carbonaceous material is characterized as organic carbon (OC), where OC is defined as carbon containing materials that volatilize below approximately 850°C in a thermogravimetric analysis. Only a small fraction of the carbon is in light-absorbing, soot-like structures, commonly referred to as elemental carbon, or EC. The sources of OC in fine particulate matter can be either direct emissions to the atmosphere (primary organics), or secondary organic aerosol (SOA) formation. SOA is formed in the atmosphere through the reactions of gas phase organics, which produce low volatility reaction products.

The ratio of OC to EC 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. A ratio between 2 and 5 is generally assumed for OC/EC in primary emissions (Strader, et al., 1999). If observed ratios of OC/EC are higher than those assumed to occur in primary emissions then the excess OC is assumed to be due to secondary organic aerosol formation. Figure 1 shows that 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.

Figure 1. Daily average OC to EC ratios in fine particulate matter (PM_{2.5}) in southeast Texas; measurements are at multiple sites for the period 1999-2001 (Russell, et al., 2002)



Estimates of SOA formation can also be based on emission rates of SOA precursors and predicted yields of SOA from those precursors. In the models most commonly used to estimate SOA formation, the extent of hydrocarbon reaction and the selectivity of gas phase reactions to SOA is assumed to be constant. These overall yields of SOA are referred to as fractional aerosol coefficients (FACs), and FACs have been estimated for a large number of hydrocarbons (Grosjean and Seinfeld, 1989; Grosjean, 1992).

In a previous quarterly report, the emission rates of SOA precursors from anthropogenic sources in the Houston/Galveston area were estimated and SOA yields were estimated using FACs. In this quarterly report, emission mappings of the anthropogenic SOA precursors, and a summary of inventory data on SOA precursors is provided.

Spatial distribution of SOA precursor emissions

The spatial distribution of emissions for secondary organic aerosol precursors in southeast Texas is shown in Figures 2-4 (Dechapanya, 2002). The data are shown as emission rates of SOA, calculated using fractional aerosol coefficients (FACs). As is evident from the Figures, the spatial distribution of SOA precursor emissions varies significantly among source categories.

Figure 2. Spatial distribution of emissions of SOA precursors from point sources, weighted by FACs

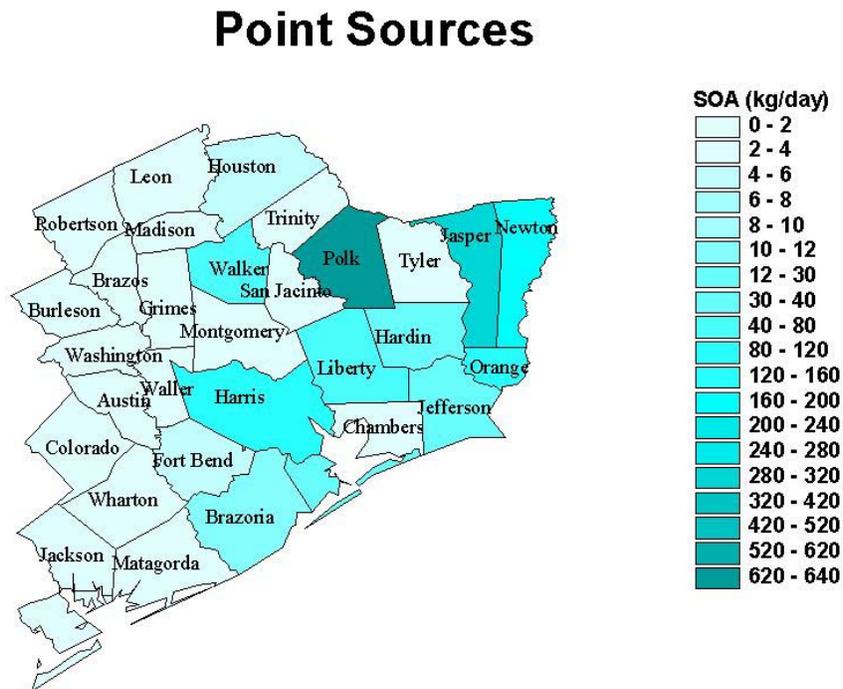


Figure 3. Spatial distribution of emissions of SOA precursors from area and non-road sources, weighted by FACs

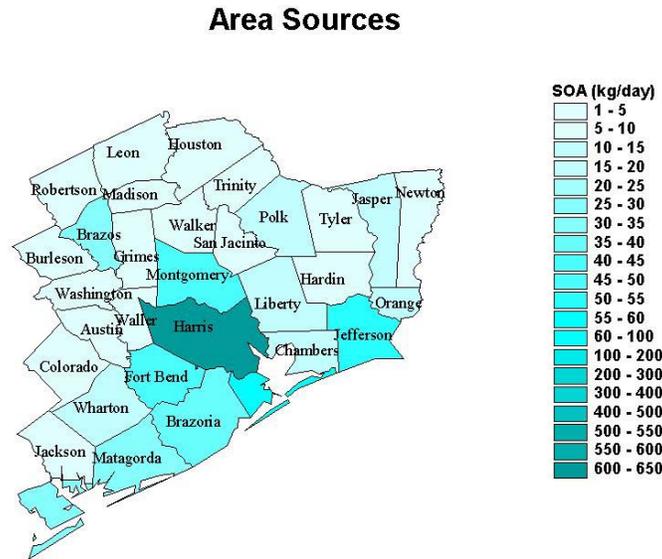
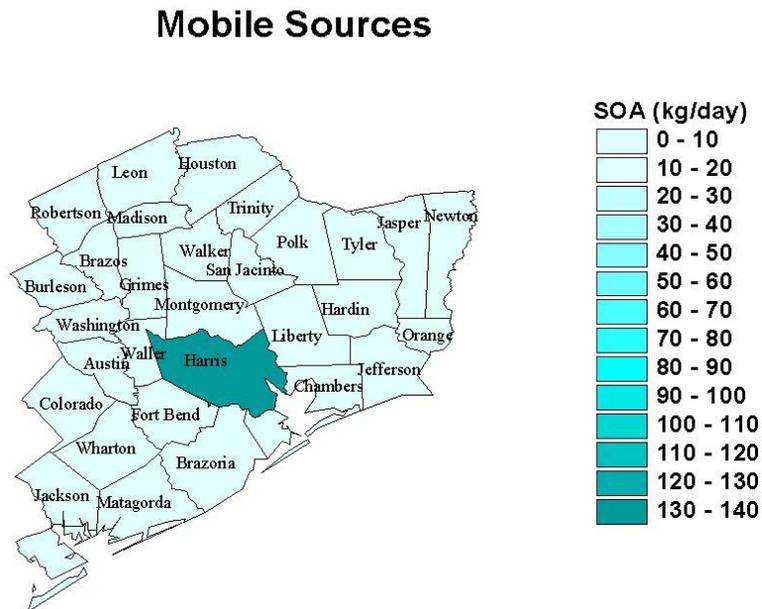


Figure 4. Spatial distribution of emissions of SOA precursors from on-road sources, weighted by FACs



Summary of SOA precursor emission analysis for anthropogenic sources

The rate of formation of secondary fine particulate matter from anthropogenic sources has been estimated based on inventory data and those estimates have been compared to observations made during the Supersite program. The results are summarized below.

Table 1. Summary of inventory data and source strengths for anthropogenic sources of the precursors of secondary organic aerosol

<i>Source category</i>	<i>Emission inventory method</i>	<i>Observational data</i>	<i>Overall assessment of source strength</i>
<i>Secondary organic aerosol (SOA)</i>			
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 $\mu\text{g}/\text{m}^3$; 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 $\mu\text{g}/\text{m}^3$; 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 $\mu\text{g}/\text{m}^3$; these emissions of precursors are broadly distributed

REFERENCES

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