PERCH Air Quality Study

Quarterly Report

November 7, 2003

Submitted to:
Professor Ranga Rao
Center for Environmental Diagnostics and Bioremediation
University of West Florida
11000 University Parkway
Pensacola, FL 32514-5754

Karsten Baumann¹, Mohan Turaga³, Rick Peltier¹, Yongtao Hu², Michael E. Chang¹, Ann Bostrom³, Armistead Russell²

¹ School of Earth & Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA 30332-0340
² School of Civil & Environmental Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0355
³ School of Public Policy, Georgia Institute of Technology, Atlanta, GA 30332-0345

GTRC Project #: 3506B35
PERCH Air Quality Study (PAQS)

Summary
The primary focus of the PAQS this quarter was the deployment of the Mobile Air Quality Laboratory (MAQL) for a pilot field study of particulate matter (PM), ozone \( (O_3) \), air toxics, and meteorology in the Pensacola, FL area. A Quality Assurance Project Plan (QAPP) was submitted to US EPA on 9 June 2003 and approved on 20 June 2003. Subsequently, the deployment was initiated the second week of July and data were collected 14 July – 15 August 2003. Herein is a description of the field site that was selected, the measurement techniques employed, and a preliminary analysis of the data collected during this period. The data are also examined relative to other measurements conducted by the FL DEP and the Southeastern Aerosol Research and Characterization (SEARCH) study. Included in this pilot study, a relatively new instrument was employed that allowed the observation of high frequency particle composition. This instrument and subsequent data are also described. See Sections 1 & 2 and appendices A & B.

Other efforts this quarter included the continuing work to make commensurate and quantify the relative risks associated with each of the three primary classes of pollutants that are the focus of this study: PM, \( O_3 \), and air toxics. Described and documented in this report are several different approaches to characterizing relative risk and a preliminary application of these techniques to quantify the potential risk from each of the three pollutants in the Pensacola, FL area. See Section 3 and appendix C.

Finally, a four-dimensional air quality model of ozone and particulate matter was run for a baseyear of 2000 and a future year of 2007 as part of another study funded by the state of Georgia – the Fall line Air Quality Study (FAQS). While this study is concerned with air quality in the Augusta, Macon, and Columbus, Georgia areas, the model domain actually includes much of the eastern U.S. including Pensacola. Here we briefly report on a re-analysis of the model runs from a Pensacola perspective. See Section 4 and appendix D.

Whereas, the following report describes the aforementioned activities, a meeting of all the PERCH investigators was held in Pensacola at the University of West Florida on 3 November 2003 at which all these activities were also described. These presentations are included here as appendices A – D.
1. PERCH AQS PILOT FIELD STUDY (KARSTEN BAUMANN)

1.1 Field Site Location

The sponsoring “Partnership for Environmental Research and Community Health” (PERCH) is focused on Escambia and Santa Rosa counties. Partners from the University of South Florida were “Assessing the Impact of Environmental Hazard Exposure on the Health Status of Geographically Defined Populations in Escambia and Santa Rosa Counties.” A preliminary analysis by zip code of black and total population mortality due to all cancer, birth defects, cardiac, lung cancer, and respiratory disease suggested that three areas may have significantly higher standardized mortality ratios for black or total populations. These were zip codes 32501, 32503, and 32570. Of these three, the USF team concluded that 32501 and 32503 “have a larger population and have a number of highly significant differences for the major cause of death Cancer and Heart Disease. Zip code 32570 has the most consistent pattern of poor outcomes but primarily in the less common diseases (birth defects, respiratory disease) and in a smaller population.” Based on these recommendations, the GA Tech team decided to deploy their Mobile Air Quality Laboratory (MAQL) at the OJ Semmes Elementary School (OJS), located at a highly residential area, ~2 miles south of the airport, and ~2 miles north of downtown Pensacola; see Figure 1 (Address: 1250 E Texar Drive, Pensacola, FL 32503, Latitude= 30.45111 N, Longitude= 87.20681 W). The active measurement period was from 15 July to 14 August (incl.), 2003.

![Figure 1: Field deployment site (OJS) of GA Tech’s Mobile Air Quality Laboratory (MAQL).](image)

1.2 Measurement Techniques

The MAQL is equipped with a variety of commercialized, prototype, and research grade instrumentation for the continuous and discrete analysis of an unusually wide range of primary and
secondary air pollutants, their tracers, and relevant meteorological conditions. These include the more common ozone (O$_3$), carbon monoxide (CO), fine particulate matter mass (PM$_{2.5}$), and sulfur dioxide (SO$_2$) measurements, but also the more important and difficult to measure pollutants like particulate matter composition, speciated oxides of nitrogen (NO, NO$_x$, NO$_y$), and volatile organic compounds (VOC). During the field deployment at OJS, Pensacola from 15 July to 14 August, 2003, continuous measurements of trace gas and indicator species NO, NO$_x$, NO$_y$, O$_3$, CO, and SO$_2$ and meteorological parameters were made utilizing a standard 10 m meteorological triangular Al tower mounted to the rear side of the MAQL, as depicted in Figure 2. The meteorological parameters measured, their units, the sensor height in m above ground (mag), the sensors’ specifications and accuracies are listed in Table 1.

![Figure 2: Top view dimensions and overview arrangements of AREC’s MAQL.](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>unit</th>
<th>height mag</th>
<th>sensor specifications</th>
<th>accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometric pressure</td>
<td>mbar</td>
<td>2</td>
<td>Vaisala PTB100A 800-1060 mbar</td>
<td>±0.3 mbar</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>%</td>
<td>10.4</td>
<td>Vaisala HMP45A 0-100 %</td>
<td>±1 % RH (0-90%)</td>
</tr>
<tr>
<td>Air temperature</td>
<td>C</td>
<td>10.4</td>
<td>aspirated RMYoung RTD1000 –40 - +60 C</td>
<td>±0.05 C</td>
</tr>
<tr>
<td>Air temperature</td>
<td>C</td>
<td>2.8</td>
<td>aspirated RMYoung RTD1000 –40 - +60 C</td>
<td>±0.05 C</td>
</tr>
<tr>
<td>Visible radiation</td>
<td>W/m$^2$</td>
<td>11.3</td>
<td>LICOR LI-200SA pyranometer 400-1100nm</td>
<td>±5 %</td>
</tr>
<tr>
<td>UV-B radiation</td>
<td>W/m$^2$</td>
<td>11.3</td>
<td>YES UVB-1 pyranometer 280-320 nm</td>
<td>±5 % (0-60zenith)</td>
</tr>
<tr>
<td>Wind direction</td>
<td>deg N</td>
<td>11.6</td>
<td>RM Young 05305AQ 0-360 deg</td>
<td>±3 deg</td>
</tr>
<tr>
<td>Wind speed</td>
<td>m/s</td>
<td>11.6</td>
<td>RM Young 05305AQ 0-40 m/s</td>
<td>±0.2 m/s</td>
</tr>
</tbody>
</table>

The sample gas for the measurement of ambient levels of NO, NO$_x$, NO$_y$, O$_3$, CO, and SO$_2$ was drawn through Teflon (PFA) tubing with inlets mounted on top of the tower, about 9-10 mag. All data were acquired at 1 Hz and reported as 1 min averages if not noted otherwise. Samples of O$_3$, CO, and SO$_2$ were tapped off a manifold inside the trailer at the base of the tower. O$_3$ was measured using a
pressure and temperature compensated commercial UV absorption instrument (model TEI 49-C, Thermo Environmental Instruments, Inc., Franklin, MA). The linearity and precision of the analyzer was checked on average once every 22 hours by a primary standard calibrator with active feedback control (model TEI 49C-PS) providing mixing ratios of 0, 40, 80, 120, and 160 ppbv. CO was measured by a highly modified analyzer (model TEI 48C-TL with a hand-selected PbSe detector matched with an optimal preamplifier, and an absorption cell with gold-plated mirrors) via the principle of gas filter correlation, nondispersive infrared absorption. The modifications included a zero trap kept at 180 °C that quantitatively oxidizes CO to CO$_2$ allowing frequent switching into zero modes and constant tracking of the analyzer’s drifting baseline. The analyzer’s overall performance and data quality had been further improved by implementing automated mass flow controlled standard addition and dynamic dilution at the instrument inlet. Similar modifications were applied to a commercial, pulsed UV fluorescence instrument (model TEI 43C-TL) that substantially improved the quality of the ambient SO$_2$ measurement, see Table 2 for a summary.

Table 2: Average trace gas DQIs typically achieved in MAQL’s field deployments.

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>O$_3$</th>
<th>CO</th>
<th>SO$_2$</th>
<th>NO</th>
<th>NO$_x$</th>
<th>NO$_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tau</td>
<td>s</td>
<td>10</td>
<td>20</td>
<td>45</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>DL$_{1min}$</td>
<td>ppbv</td>
<td>0.5</td>
<td>100</td>
<td>1.2</td>
<td>0.003</td>
<td>0.01</td>
<td>0.5</td>
</tr>
<tr>
<td>DL$_{30min}$</td>
<td>ppbv</td>
<td>0.1</td>
<td>18</td>
<td>0.2</td>
<td>0.0005</td>
<td>0.001</td>
<td>0.1</td>
</tr>
<tr>
<td>Precision</td>
<td>%</td>
<td>±5</td>
<td>±10</td>
<td>±6</td>
<td>±10</td>
<td>±15</td>
<td>±15</td>
</tr>
<tr>
<td>Accuracy</td>
<td>%</td>
<td>±5</td>
<td>±17</td>
<td>±15</td>
<td>±15</td>
<td>±20</td>
<td>±25</td>
</tr>
</tbody>
</table>

Proto-type and research grade NO/NO$_x$ and NO/NO$_y$ analyzers (Air Quality Design - AQD, Golden, Colorado) were deployed for the measurement of NO, NO$_x$, and total reactive nitrogen oxides (NO$_y$) that include NO, NO$_2$, NO$_3$, N$_2$O$_5$, HONO, HNO$_3$, aerosol nitrate, PAN, and other organic nitrates. These measurements are based on the principal method of metal-surface induced reduction of the more highly oxidized species to NO [Fahey et al. 1985; 1986; Fehsenfeld et al. 1987; Atlas et al. 1992; Parrish et al. 1993; etc.], and its subsequent chemiluminescence detection (CLD) with excess ozone [Ridley and Howlett 1974; Kley and McFarland 1980; Bollinger 1982; Fehsenfeld et al. 1990]. The quality of the measured data is added to Table 2, in terms of data quality indicators (DQI) such as response time, detection limit, precision and accuracy, with Tau being the instrument’s response time in reaching 90 % of its end value signal. More details on the technical aspects of these measurements can be found at www.cure.gatech.edu/faqs.asp.

A Particle Composition Monitor (PCM) was deployed for discrete measurements of PM$_{2.5}$ mass and composition including relevant gas-phase species, see Figure 3. The PCM is equipped with 3 separate mass flow controlled channels for the discrete sampling of airborne PM$_{2.5}$, operated initially for periods between 6 and 9 hours, switched to 12 hour daytime versus nighttime intervals for the second half of the field study period. Prior to collection of PM$_{2.5}$ on filter media, important inorganic and organic gas species such as NH$_3$, SO$_2$ and HNO$_3$, as well as semi-volatile polycyclic aromatic compounds (PAH), pesticides, and halogenated species are effectively removed from the sample stream by means of specially coated diffusion tubes (denuders). The main species quantified and reported are the particle phase sodium (Na$^+$), calcium (Ca$^{2+}$), ammonium (NH$_4^+$), chloride (Cl$^-$), nitrate (NO$_3^-$), sulfate (SO$_4^{2-}$), formate (HCOO$^-$), acetate (CH$_3$COO$^-$), and oxalate (C$_2$O$_4^{2-}$), as well as elemental and organic carbon (EC, OC). In addition to the particle-bound species, the PCM also measures the important gas-phase species NH$_3$, HCl, HONO, HNO$_3$, SO$_2$, and the light organic acids (LOA) HCOOH, CH$_3$COOH, and (COOH)$_2$; see Baumann et al., 2002, for more details.
The GA Tech team operates an analytical laboratory for the determination of the above PM$_{2.5}$ quantities. Gravimetric mass concentrations are determined in a separate clean room. The soluble ion content of the individual discrete sample extracts is determined via a dual-channel Dionex DX-500 ion chromatograph (IC) with two separate EG40 eluent generators; KOH for anions, methane-sulfonic acid (MSA) for cations, controllable to within 0.5 and 50 mM, and IonPac analytical columns AG11-HC for anions and CS12A for cations, both in the 2 mm ID microbore format. Each channel operates a self-regenerating SRS-ULTRA suppressor in external DDW regeneration mode, a CD20 conductivity detector, and a GP50 gradient pump. The applied micro-bore system allows economical analyte flow rates of 0.25 ml/min for cations, and 0.35 ml/min for anions. DDW is supplied by a Barnstead E-Pure at a resistivity of $18.0 \pm 0.2$ M$\Omega$ and fed directly to the EG40. Degassing is performed on-line immediately after the eluent is added to the DDW well upstream of the injector. Quantitative analysis of EC and OC content of the PM$_{2.5}$ samples is performed using the thermal optical transmittance (TOT) method of Birch and Cary (1996).
Figure 3: Three-channel PCM for discrete measurement of PM$_{2.5}$ mass and composition.

C… Carbon monolith (Novacarb$^\text{TM}$, Mast Carbon Ltd., UK) extruded from phenolic resin to ~10 cm long, ~3 cm dia. cylinder with <200 channels, controlled microporosity of ~1 nm and specific surface area of ~1,000 m$^2$/g.

GF… Gelman Type AE (PN 61631) glass fiber filter, pre-baked for ~3 h at 500°C.

IC… Ion Chromatography

P… Whatman 41 cellulose [paper] filter

pa… phosphorous acid coating solution: 10%/90% DDW/MeOH by volume, with 1g of PA per 100ml of solution, yielding a 122 mM solution.

Q… Pallflex #2500 QAT-UP Quartz fiber filter, pre-baked for ~2 h at 600°C.

sc… sodium carbonate coating solution: 8g of Na$_2$CO$_3$ dissolved in 400ml DDW, 600 ml methanol added, yielding a 75.5mM solution.

T… Zeflour$^\text{TM}$ P5PJ047, unringed Teflon membrane, 2µm pore size.

xad… XAD-4, a porous macroreticular, non-polar, polystyrene-divinyl-benzene resin (725m$^2$/g$^{-1}$) applied onto a backup Q.

XRF… Wavelength dispersive X-Ray Fluorescence spectroscopy for main trace elements (Fe, Co, Ni, V, Cd, Cr, Cu, Mn, Ti, Zn, As, Pb, Mo, Ag, Sn, Sb, Ba)
A picture of the fully operational MAQL at the OJS site is presented in Figure 4.

Figure 4: The MAQL fully deployed and operational at the OJ Semmes ES site on July 18, 2003.

1.3 Results Summary

Conditions at OJ Semmes Elementary School

The period July 15 to August 14, 2003 was characterized by frequent showers and thunderstorms predominantly in late mornings and early afternoons, with only exception being the four day period from August 8th to 12th. Since rainfall is the most effective loss mechanism for atmospheric PM, the PM$_{2.5}$ mass concentration averaged 29.6 ±6 µg/m$^3$ for the short dry period, and 11.6 ±4 µg/m$^3$ for the longer wet period. The statistical details for PM$_{2.5}$ and other quantities measured at OJS are summarized in Table 3. The unseasonable wetness extended over the entire Southeastern United States, leading to relatively clean conditions region-wide. For example, the average PM$_{2.5}$ concentrations measured at the Georgia FAQS sites Macon, Columbus, and Augusta for the period July 15 to August 8 were 13.9 ±6, 13.0 ±5, and 15.0 ±7 µg/m3, respectively. The increase in [PM$_{2.5}$] at the beginning of the dry period on August 8th occurred also region-wide, since the three FAQS sites recorded average PM$_{2.5}$ mass concentrations of 29.6 ±9, 25.6 ±6, and 25.7 ±9 µg/m$^3$, respectively, indicating influx of polluted continental air masses from northerly directions. Isentropic trajectory analysis would potentially reveal the origin of those air masses in more detail. Note, that the air mass with high PM levels reached Augusta about one day later than all other sites, which makes this case very interesting for a detailed trajectory analysis.
Table 3: Statistical summary, i.e. minima, lower/upper 67- and 90-percentiles, medians, means, and maxima of measured quantities based on 30 min averages; npts is number of 30 min averages, and 1444 represents 100 % completeness. Note that the difference in npts between wind speed and direction (513) reflects the occurrence of calm conditions (36%).

<table>
<thead>
<tr>
<th></th>
<th>npts</th>
<th>min</th>
<th>l67</th>
<th>l90</th>
<th>med</th>
<th>mean</th>
<th>u67</th>
<th>u90</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>ambP mbar</td>
<td>1444</td>
<td>1007.4</td>
<td>1009.0</td>
<td>1011.0</td>
<td>1013.8</td>
<td>1014.0</td>
<td>1016.9</td>
<td>1019.5</td>
<td>1021.7</td>
</tr>
<tr>
<td>soilT °C</td>
<td>1333</td>
<td>29.5</td>
<td>30.4</td>
<td>31.5</td>
<td>33.3</td>
<td>34.3</td>
<td>37.6</td>
<td>40.3</td>
<td>45.7</td>
</tr>
<tr>
<td>T3m °C</td>
<td>1444</td>
<td>21.4</td>
<td>22.6</td>
<td>23.9</td>
<td>26.0</td>
<td>26.6</td>
<td>29.6</td>
<td>31.7</td>
<td>34.0</td>
</tr>
<tr>
<td>T11m °C</td>
<td>1444</td>
<td>21.6</td>
<td>22.9</td>
<td>23.9</td>
<td>26.1</td>
<td>26.5</td>
<td>29.3</td>
<td>30.9</td>
<td>34.5</td>
</tr>
<tr>
<td>dTdz K/m</td>
<td>1308</td>
<td>-0.36</td>
<td>-0.20</td>
<td>-0.09</td>
<td>-0.01</td>
<td>-0.03</td>
<td>0.04</td>
<td>0.07</td>
<td>0.18</td>
</tr>
<tr>
<td>dewT °C</td>
<td>1444</td>
<td>19.9</td>
<td>21.8</td>
<td>22.5</td>
<td>23.7</td>
<td>23.7</td>
<td>24.8</td>
<td>25.5</td>
<td>29.2</td>
</tr>
<tr>
<td>RH %</td>
<td>1444</td>
<td>46</td>
<td>62</td>
<td>73</td>
<td>89</td>
<td>86</td>
<td>98</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>H2O %v</td>
<td>1444</td>
<td>2.35</td>
<td>2.65</td>
<td>2.77</td>
<td>2.98</td>
<td>2.99</td>
<td>3.19</td>
<td>3.35</td>
<td>4.20</td>
</tr>
<tr>
<td>VIS W/m²</td>
<td>1305</td>
<td>11</td>
<td>14</td>
<td>15</td>
<td>39</td>
<td>200</td>
<td>519</td>
<td>815</td>
<td>1083</td>
</tr>
<tr>
<td>UVB W/m²</td>
<td>1305</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.04</td>
<td>0.62</td>
<td>1.57</td>
<td>2.91</td>
<td>4.25</td>
</tr>
<tr>
<td>WS m/s</td>
<td>1444</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
<td>0.6</td>
<td>0.7</td>
<td>1.3</td>
<td>2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>WD degN</td>
<td>931</td>
<td>1</td>
<td>57</td>
<td>152</td>
<td>241</td>
<td>225</td>
<td>301</td>
<td>346</td>
<td>360</td>
</tr>
<tr>
<td>CO ppbv</td>
<td>1444</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.39</td>
<td>1.87</td>
<td>2.52</td>
<td>9.11</td>
<td>43.36</td>
</tr>
<tr>
<td>NO ppbv</td>
<td>1435</td>
<td>0.2</td>
<td>1.0</td>
<td>2.4</td>
<td>8.0</td>
<td>10.4</td>
<td>18.3</td>
<td>28.7</td>
<td>55.8</td>
</tr>
<tr>
<td>NOx ppbv</td>
<td>1185</td>
<td>0.5</td>
<td>2.1</td>
<td>4.8</td>
<td>10.8</td>
<td>13.3</td>
<td>21.6</td>
<td>33.3</td>
<td>56.2</td>
</tr>
<tr>
<td>NOy ppbv</td>
<td>1389</td>
<td>0.0</td>
<td>0.1</td>
<td>0.5</td>
<td>1.4</td>
<td>1.8</td>
<td>3.2</td>
<td>4.8</td>
<td>8.0</td>
</tr>
<tr>
<td>NOz ppbv</td>
<td>1165</td>
<td>0.1</td>
<td>1.3</td>
<td>8.1</td>
<td>25.1</td>
<td>27.3</td>
<td>46.2</td>
<td>62.1</td>
<td>89.4</td>
</tr>
<tr>
<td>O₃ ppbv</td>
<td>1440</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.36</td>
<td>1.17</td>
<td>1.63</td>
<td>4.46</td>
<td>39.38</td>
</tr>
<tr>
<td>PM₂.₅ µg/m³</td>
<td>1437</td>
<td>1.1</td>
<td>5.2</td>
<td>7.3</td>
<td>11.5</td>
<td>13.7</td>
<td>19.6</td>
<td>31.6</td>
<td>44.3</td>
</tr>
</tbody>
</table>

Figure 5: Average diurnal cycles of wind speed and UVB radiation (left, with 30 min wind direction data), and dew, soil and vertical gradient air temperatures, relative humidity, and average rainfall duration in percent time (right). Note, that few southeasterly component winds occurred at night; on some days easterly flow occurred with sunrise, veering to southerly and westerly flow during the course of the day.
The relatively clean conditions were also indicated by lower than expected daytime maxima of photochemical products, such as ozone and the oxidation products of nitrogen oxides (NOz), as illustrated in Figure 6. Under conditions of intense photochemical activity during mid-summer stagnation periods in the SE-US, daytime maxima of ozone and NOz would be clearly higher. Hence, the observed diurnal behaviour of O3 is largely driven by nighttime titration from primary pollutants, e.g. such as NOx. Both NOy and NOx are bimodal, correlating with CO, thus indicating the influence from mobile sources and other sources of incomplete combustion.

The linear regression of all 30 min CO and NOy data yields a slope of 12.4 ±0.2, which is significantly more than what would be considered typical mobile source emissions. Hence, the OJS site seems to be influenced by mixed emissions from multiple sources. The intercept of 125 ppbv can be considered regional background level for CO. The linear regression of O3 versus NOz for midday periods only, yields a slope of 7.8 ±0.5, which would be high if interpreted as ozone production efficiency (OPE) in an urban environment.

**Figure 6:** Average diurnal variation of main pollutants measured at OJS from July 15 – August 14, 2003.

**Figure 7:** Linear regressions of CO vs NOy (left) and O3 vs NOz (right) scaled by day of time.
Comparison with other measurements

<table>
<thead>
<tr>
<th>Site name</th>
<th>Type</th>
<th>Setting</th>
<th>Lat</th>
<th>Lon</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>UWF</td>
<td>suburb-NAMS</td>
<td>Commercial</td>
<td>30.5444</td>
<td>-87.2161</td>
<td>FL-DEP</td>
</tr>
<tr>
<td>ELY</td>
<td>Ellyson</td>
<td>suburb-SLAMS</td>
<td>30.5250</td>
<td>-87.2043</td>
<td>FL-DEP</td>
</tr>
<tr>
<td>WAR</td>
<td>Warrington</td>
<td>suburb</td>
<td>30.3986</td>
<td>-87.2764</td>
<td>FL-DEP</td>
</tr>
<tr>
<td>NAS</td>
<td>Naval Air Station</td>
<td>suburb-NAMS</td>
<td>Mobile</td>
<td>30.3681</td>
<td>-87.2708</td>
</tr>
<tr>
<td>NVR</td>
<td>Navarre</td>
<td>suburb</td>
<td>30.4077</td>
<td>-86.8902</td>
<td>FL-DEP</td>
</tr>
<tr>
<td>OLF</td>
<td>Old Land. Field #8</td>
<td>suburb</td>
<td>Forest-Grass</td>
<td>30.551</td>
<td>-87.376</td>
</tr>
<tr>
<td>PNS</td>
<td>Pensacola</td>
<td>urban</td>
<td>30.437</td>
<td>-87.256</td>
<td>SEARCH</td>
</tr>
<tr>
<td>OJS</td>
<td>OJ Semmes ES</td>
<td>urban</td>
<td>30.4511</td>
<td>-87.2068</td>
<td>GIT-EAS</td>
</tr>
</tbody>
</table>

**Figure 8:** Names and locations of other monitoring stations operated by the Florida Dept. of Environmental Protection and the SouthEastern Aerosol Research and Characterization Study.
Figure 8: Average diurnal cycles (bold) and standard deviations (thin) of wind speed, SO$_2$, NOy, O$_3$, CO and PM$_{2.5}$ mass concentrations from OJS in comparison with OLF, UWF, Ellyson, PNS, Warrington, NAS, and NVR; see Fig. 7.

Figure 8 shows that the winds are driven mostly convectively in the region of investigation. With the increased convective turbulence after sunrise, SO$_2$ is occasionally being mixed down from the reservoir layers that were decoupled from the near-surface layer the previous night, as indicated by the SO$_2$ average diel cycle but even more so by the standard deviations observed at all sites; the magnitude of the level is largest at UWF, which is the site closest to the Gulf Power coal-fired power plant (see Fig. 7). The bimodal character of CO and NOy is pronounced at the PNS site, which is to the west of I-110, but less visible (esp. for CO) at the distant OLF site. The O$_3$ maxima are very similar and statistically indistinguishable among all sites. The only significant difference is that O3 seems less titrated away from primary pollutants at the NAS shoreline site. The [PM$_{2.5}$] seems to show a trend of
higher concentrations towards sites closer to the shore, which is, however, insignificant considering the standard errors.

The VOC snapshot measurements from morning, noon, afternoon, and late evening whole-air canister samples, show a diurnal variability similar to CO and NOy for n-pentane, which is a tracer for gasoline fuel evaporation, hence indicative of vehicular traffic. Figure 9 shows this trend, along with the averages for isoprene, a biogenic hydrocarbon species emitted from plants during photosynthesis. Note that each hourly VOC average is based on 22 can sample measurements, i.e a total of 88 cans were sampled during this study.

![Figure 9: Diurnal trends of isoprene and n-pentane based on 4 x 22 canister samples.](image)

A comparative analysis of the wind speeds and directions by means of Figure 10, indicates that the land-sea breeze is most pronounced at the two shore sites NAS and NVR, with southerly component flow at daytime, and predominantly northerly component flow at night. The land-sea breeze circulation seems to weaken and become less influential at the sites further inland. The observed “veering” over south to westerly directions may be indicative of a converging flow with westerly gradient flow, that is likely to be more dominant at the sites farthest to the north and away from the coastline.

Correlations of primary pollutants with wind direction (wind rose plots) indicate that i) the sporadic occurrences of high [SO₂] is associated with northerly flow at the ELV, OJS, and PNS sites, but with SE and NE directions at OLF; ii) the bimodal appearance of CO and NOy is governed by local sources, i.e from traffic on I-110 for PNS and OJS (situated to the west and east, respectively), and from traffic on I-10 and state route 90 for OLF, which is located to the south and west from these line sources.
The ozone wind roses individually determined for all sites are depicted in Figure 11, overlaying the map shown previously. Considering the diurnal behaviour of the wind circulation established above, ozone-rich air is associated with daytime southerly flow, whereas northerly nighttime flow carries higher levels of primary pollutants and therefore ozone-poor (titrated) air masses. Continuous measurements of PM$_{2.5}$ mass were made only at OLF, ELY, PNS, and OJS, hence the PM$_{2.5}$ wind rose plots showed an average high from northerly directions, which were attributed to the continental air mass transport during the dry period mentioned earlier.
Figure 11: Ozone wind rose plots for each monitoring site overlayed with the regional map.

Air toxics from VOC can samples
The following halogenated hydrocarbons F-114, F-11, F-113, CCl4, and aromatic compounds benzene, toluene, ethylbenzene, m-xylene, p-xylene, o-xylene, 1,3-butadiene, 4-ethyltoluene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene were quantitatively measured from the can samples via GC-MS/ECD/FID. Note, that the individual benzenes, toluenes and xylenes were grouped together.

Table 4: Toxic aromatics and halogenated HCs measured on 22 days at given time intervals; n-pentane and isoprene are tracers for gasoline evaporation and biogenic emissions, and listed for comparison.
Figure 12: Diurnal trend of toxic halogenated HCs (left) and aromatics (right) from VOC can samples collected on 22 days at given times; averages are bold, standard deviations in thin lines.

Preliminary PM$_{2.5}$ mass and composition data

PM$_{2.5}$

- [K$^+$]
- [Na$^+$]
- [NH$_4^+$]
- [Cl$^-$]
- [NO$_3^-$]
- [SO$_4^{2-}$]
- Acetate
- Formate
- Oxalate
- Organic C
- Elemental C
- OOE
- Unidentified

1,3-Butadiene (pptv)

B, T, X (pptv)

Figure 13: PM$_{2.5}$ mass balance from discrete PCM measurements. Assuming that the unidentified mass is largely due to the underestimation of the other organic elements (OOE) needed to convert organic carbon (OC) to organic mass, then total organics make up almost 60% of the total average PM$_{2.5}$ mass concentration, and sulfate ranks second with about 25%. These are very preliminary data, that need to undergo further qa/qc. Furthermore, these data span only until the end of July, i.e. data from the second half of the campaign are still being analysed, therefore no statements can be made yet about the potential contribution from secondary organic aerosols.

See Appendix A.
2. SEMI-CONTINUOUS INORGANIC SPECIATION MEASUREMENTS DURING PERCH FIELD CAMPAIGN – SUMMER 2003 (RICK PELTIER)

A Particle-Into-Liquid-Sampler (PILS) system was deployed as part of the instrument suite of the Georgia Institute of Technology’s Mobile Air Quality Laboratory during the field campaign of the Partnership for Environmental Research and Community Health (PERCH). The instrument was coupled with Metrohm® dual-channel ion chromatographs, and operated over a four-minute sample and integration period. Measurements began at approximately 1200 on 14Jul, and ended at approximately 0730 on 13Aug. The PILS/IC system was restricted to a PM$_{2.5}$ cut-size and measured the following 11 ions and inorganic acids:

<table>
<thead>
<tr>
<th>Ammonium</th>
<th>Sodium</th>
<th>Calcium</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>Sulfate</td>
<td>Nitrate</td>
<td>Nitrite</td>
</tr>
<tr>
<td>Chloride</td>
<td>Oxalate</td>
<td>Formate</td>
<td></td>
</tr>
</tbody>
</table>

Since the termination of the field campaign, the researchers have been analyzing and processing the collected data. Verification and validation of data has been conducted according to the QA/QC protocols outlined at the beginning of this study. Erroneous or unreliable data points have been sequestered and removed from the dataset.

Currently, the researchers are utilizing statistical analytical techniques to put together a better picture of the important air quality issues. While still in the early stages of this process, summary information has been generated that illustrates the initial findings of this research.

Temporal PM$_{2.5}$ relationships show a slight diurnal variation throughout the study period. While the first portion of the data show relatively low PM levels, the time period surrounding August 10$^{th}$ shows significant PM level elevations. This data warrants deeper investigation by the researchers. The inorganic profile of Pensacola’s PM$_{2.5}$ mass consists of domination by sulfate (approximately 70% of inorganic mass) and ammonium (approximately 25%). The researchers expect to have all of the data (including meteorology, atmospheric gases, etc.) verified soon, and can begin to analyze the specific chemistry that occurred during the study period.

The State of Florida Department of Environmental Protection (DEP) air quality data has been collected from all sites within the Pensacola region. FRM data requests may be extended to additional air quality monitoring sites (e.g. Mobile Bay, AL). This data has been collected in an effort for the researchers to make spatial and temporal correlations and relationships with the surrounding air quality monitors.

It is expected that the data analysis portion (specifically, spatial relationship correlations) will extend for at least the next two quarters.

See Appendix B.
3. HUMAN HEALTH RISK ASSESSMENT FOR PENSACOLA REGION (MOHAN TURAGA AND ANN BOSTROM)

3.1 Objective
The main objective of risk assessment is to assess the human health risks associated with air toxics in Pensacola region and to compare these risks with the health risks posed by two criteria pollutants: ozone and particulate matter (PM 2.5).

3.2 Approach and Methodology
We assessed the health risks from air toxics using the data from National Air Toxics Assessment (NATA), 1996. We obtained information on cancer as well as non-cancer risks from 32 toxic air pollutants assessed under NATA for Escambia and Santa Rosa counties in Pensacola region. Region IV of Environmental Protection Agency (EPA) prepared a risk screening scheme (US EPA, 2002) to rank the 736 counties with Region IV based on the risks posed by toxic air pollutants. We used this report to compare Escambia and Santa Rosa counties with other counties in the region with respect to health risks from air toxics. Specifically, we compared the risks in these two counties with counties considered as peer counties by Pensacola Chamber of Commerce.

We compared the relative risks associated with ozone and PM 2.5 at three different levels. First, we assessed the status of Escambia county with respect to attainment of National Ambient Air Quality Standards (NAAQS) for ozone and PM 2.5 based on the ambient air quality data collected by Florida Department of Environmental Protection (DEP) for the years 1999-2002. Second, we compared the number of days Air Quality Index (AQI) fell under different health risk categories for ozone and PM 2.5. Finally, we estimated the health costs associated with each pollutant to compare health risks not only between ozone and PM 2.5 but also across PM 2.5, ozone, and air toxics. We used cost coefficients found in literature (Shih et al. 2003) to estimate the costs of ozone and PM 2.5 pollution and used value of statistical life approach for air toxics.

3.3 Findings
The following are the preliminary findings from our work so far:

- Data from NATA, 1996 shows that there is a 42 in a million cancer risk associated with 32 air toxics (assessed under NATA) in Escambia county and a 37 in a million cancer risk in Santa Rosa county.
- Escambia is in the top 6% of the 736 Region IV counties in terms of health risks from air toxics based on the relative risk screening analysis of EPA Region IV.
- Both ozone and PM 2.5 are in attainment of NAAQS during the two most recent years.
- Comparison based on AQI as well as health costs indicates that PM 2.5 poses greater health risks than ozone in Escambia.
- Preliminary health cost estimations associated with the three pollutants – ozone, PM 2.5, and air toxics – indicate that PM2.5 imposes the highest per person per year costs, followed by ozone, and then air toxics.
3.4 Limitations of Findings

Our analysis is a preliminary effort to compare the human health risks associated with the three pollutants in Escambia and should be interpreted recognizing certain limitations involved in our analyses. Some of the limitations are listed below:

- Due to lack of more recent information, the assessment of risk (including the assessment of health costs) from air toxics is based on a national assessment (NATA) conducted in 1996 and it is limited to 32 out of the 188 air toxics listed under the Clean Air Act.
- In our view, the risk ranking scheme developed by EPA for ranking air toxic risks in Region IV is rather arbitrary in terms of the parameters used for assessing risks as well as the weights assigned to various parameters. However, our sensitivity analysis shows that the rankings are reasonably robust and not too sensitive to the weighting scheme adopted.
- In calculating AQIs and estimating health costs, we assumed that data from a single monitoring station (Ellyson Industrial Park) in Escambia are representative of exposures to the whole population in the county.
- The methodology used to derive the cost coefficients for PM 2.5 and ozone is not fully known to us yet. Information on these coefficients will help in reducing the uncertainty in interpreting the health costs.

3.5 Future Research

- A full-scale health cost analysis for PM 2.5 and ozone on the lines of nationally developed assessment (e.g., benefit estimation of Clean Air Act) methodologies and associated uncertainty analysis.
- Comparison of air toxic exposures modeled under NATA, 1996 with data from our field monitoring conducted during the summer of 2003 to assess the changes in air toxic exposures in Escambia and possibly relate the changes to changes in emissions of air toxics (using toxic release inventory (TRI) data).
- Assessment of spatial differences in health risks based on a comparison of summer monitoring data with the data from existing monitors in Escambia.
- Over a longer term, a survey on perceptions of air quality risk in Escambia to compare the perceptual risks with scientific estimates of risk.

See Appendix C.
4. INCIDENTAL MODEL RESULTS RELEVANT TO PENSACOLA FROM THE FALL LINE AIR QUALITY STUDY (YONGTAO HU, TED RUSSELL, AND MICHAEL CHANG)

A four-dimensional air quality model of ozone and particulate matter was run for a baseyear of 2000 and a future year of 2007 as part of another study funded by the state of Georgia – the Fall line Air Quality Study (FAQS). Model inputs were prepared according to US EPA guidance and utilized in the Community Multiscale Air Quality (CMAQ) model. The episode studied was a high ozone event that occurred between 10-20 August 2000. While this study is concerned with air quality in the Augusta, Macon, and Columbus, Georgia areas, the model domain actually includes much of the eastern U.S. including Pensacola. Here we briefly report on a re-analysis of the model runs from a Pensacola perspective. Results suggest that national and regional controls that are already scheduled to be in place by 2007, may result in a 5% to 10% net decrease in peak ozone concentrations in the Pensacola area, but may have little effect on particulate matter concentrations. The effect on air toxics was not assessed. See Appendix D.
5. REFERENCES


U.S. EPA Region 4 Air Toxics Relative Risk Screening Analysis, September 27, 2002.
PERCH Air Quality Study – PAQS

Special thanks to
Carl Mohrherr
Alan Knowes
Staff of OJSES
FL-DOH
FL-DEP
SEARCH
Air Quality Experience

Karsten Baumann
Michael Bergin
Ann Bostrom
Carlos Cardelino
Bill Chameides
Michael Chang
Talat Odman
Rick Peltier
Mohan Turaga
Ted Russell
Rodney Weber

- Southern Oxidants Study
- Fall line Air Quality Study
- Atlanta Supersite
- Texas Air Quality Study 2000
- Southern Appalachian Mountain Initiative
- Atlanta Ozone Forecasting
- Southern Center for the Integrated Study of Secondary Air Pollutants
- Air Resources Engineering Center
What’s the problem?
Is there a problem?

PERCH Mission: to determine if a connection exists between elevated levels of illness in Northwest Florida and the levels of toxic pollutants in the area.

Could the air be making people sick or causing premature death?
PERCH Air Quality Study – Phase I

✓ Scope: air toxics, ozone, and particulate matter.
✓ Identify, compile, and assess existing emissions and ambient air data from US EPA, FL DEP, and private (e.g. SEARCH).
✓ Review existing studies (particularly National Air Toxics Assessment and Gulf Coast Ozone Study). Any gaps?
✓ Complete a health impacts literature search.
✓ Screen for potential health risks due to realized and potential ambient exposures.
• **Design and conduct field pilot study in Phase II.**
Deployment of GA Tech’s Mobile Lab
Period: 15 July - 14 August, 2003
Pollutants in the Region

SO$_2$, O$_3$, NO$_y$, PM$_{2.5}$, CO

Time (CST)
Pollutants in the Region Around August 9-10 Weekend
Diurnal Characteristics: Averages, Std.Dev.

- Convective winds
- Sporadic SO$_2$ events
- Bimodal CO and NO$_y$
- Similar daytime O$_3$ maxima at all sites
- Less nighttime O$_3$ titration at NAS shoreline
- Trend to higher PM$_{2.5}$ mass in southern part
Diurnal Characteristics of Winds

OLF ELY PNS OJS NAS NVR

- Indications for land-sea breeze circulation at shore sites NAS and NVR, with southerly component flow at daytime, northerly at night.
- Land-sea breeze influence weakens further inland.
- Indications for “convergence” with synoptic westerlies.
Transport from Local and Distant Sources
Wind Frequency Distributions
Transport from Local and Distant Sources

Wind Speed
Transport from Local and Distant Sources
Sulfur Dioxide (SO₂)
Transport from Local and Distant Sources
Carbon Monoxide (CO)
Transport from Local and Distant Sources
Nitrogen Oxides (NOx & NOy)
Transport from Local and Distant Sources

Ozone (O$_3$)
Transport from Local and Distant Sources
Fine PM Mass (PM$_{2.5}$)
Air Toxics from VOC can samples

Halogenated HCs
- F-114
- F-11
- F-113
- CCl₄

Aromatics
- Benzene
- Toluene
- Ethylbenzene
  - m-xylene
  - p-xylene
  - o-xylene
- 1,3-butadiene
- 4-ethyltoluene
- 1,3,5-trimethylbenzene
- 1,2,4-trimethylbenzene

Graphs showing concentration of various compounds over time (CST).
Photochemical Processes Leading to $O_3$ and PM


Figure 3.9 Schematic of the photochemical pathways leading to the production of $O_3$ (red lines) and the termination steps that dominate under NO$_x$-limited (blue line) and VOC-limited (green line) regimes.
Photochemical Activity

Source – Receptor Considerations: \( \text{O}_3/\text{NO}_2 \) as “OPE”

Elevated regional \( \text{O}_3 \) background reflected in regression’s intercept: higher in Aug ’99! At JST higher intercept and slope during Aug ’99 (OPE = 4 vs 3): more efficient \( \text{P}(\text{O}_3) \).

OPE in air mass arriving at Griffin is likely larger given by upper and lower limits. Lower limit assumes 1st order loss of \( \text{HNO}_3 \) due to surface deposition at \( k \approx 0.22 \text{ h}^{-1} \).

---

**Graphs**

- **Atlanta JST**
  - Sunny daytimes
  - August 1999
    - slope = \( 3.6 + 0.14 \)
    - intercept = \( 59 + 1.5 \)
    - \( r = 0.59 \)
  - July 2001
    - slope = \( 2.7 + 0.28 \)
    - intercept = \( 38 + 2.7 \)
    - \( r = 0.50 \)
  - December 2001
    - slope = \( -0.6 + 0.09 \)
    - intercept = \( 33 + 1.1 \)
    - \( r = -0.42 \)

- **Griffin**
  - July 2001
    - Sunny daytimes
    - Northerly flow
    - slope = \( 13.7 + 0.59 \)
    - intercept = \( 34 + 1.5 \)
    - \( r = 0.86 \)
    - incl “lost” \( \text{HNO}_3 \)
    - slope = \( 2.9 + 0.21 \)
    - intercept = \( 34 + 2.4 \)
    - \( r = 0.72 \)

---

**Legend**

- \( \text{O}_3 \) (ppbv)
- \( \text{NO}_2 \) (ppbv)
OPE Considerations for Pensacola

Crude midday OPE is very similar for both sites, indicating moderate OPE.

A much more refined analysis is required for true OPE.

Intercept indicating relatively low background O$_3$ level.
Secondary organic aerosol (SOA):
Organic compounds, some highly oxygenated, residing in the aerosol phase as a function of atmospheric reactions that occur in either gas or particle phases.

SOA formation mainly depends on:
Emissions & forming potential of precursors
  aromatics (BTX, aldehydes, carbonyls)
  terpenes (mono-, sesqui-)
  other biogenics (aldehydes, alcohols)
Presence of other initiating reactants
  $O_3$, OH, NO$_3$, sunlight, acid catalysts

Mechanisms (with half hr to few hr yields):
Gas-to-particle conversion/partitioning
  e.g. terpene oxidation
Heterogeneous reactions
  aldehydes via hydration and polymerization, forming hemiacetal/acetal in presence of alcohols
Particle-phase reactions
  acetal formation catalytically accelerated by particle sulfuric acid (Jang and Kamens, ES&T, 2001)
Particle Composition Monitor “PCM”

**Channel 1:**
- NH₃
- Na⁺, K⁺, NH₄⁺, Ca²⁺

**Channel 2:**
- HF, HCl, HONO, HNO₃, SO₂, HCOOH, CH₃COOH, (COOH)$_₂$
- F⁻, Cl⁻, NO₃⁻, SO₄²⁻
- HCOO⁻, CH₃COO⁻, C₂O₄²⁻

**Channel 3:**
- EC, OC, WSOC, “SVOC”

Additional higher resolution
- CO, NO, NOₓ, O₃, PM-mass, and basic meteorology
Preliminary PM$_{2.5}$ Mass and Composition Data
Preliminary Findings and Outlook

- Period 7/15-8/14 characterized by frequent precipitation
- Period has been unseasonably wet for SE-US
- Leading to low [O₃] and [PM₂.₅] region-wide
- Land-sea breeze circulation most prominent at shore sites
- Sea breeze (southerly flow) converging with westerlies on middays
- Highest [O₃] associated with southerly component flow at all sites
- Highest [PM₂.₅] with continental air mass during dry period at end
- OJS predominantly influenced by mobile sources
- Sporadic SO₂ events during morning BL evolution
- Integrate, further evaluate PILS-IC, VOC, FLDEP, SEARCH data
- Relate air toxics to other compounds/sources
- Complete fine PM mass and composition analyses
- Find resources for transition metals analyses (ICP-MS)
- Analyze back trajectories for certain episodes
- Analyze P(O₃)/OPE for late episode of regionally high PM
- Assess fraction of SOA from mass balance
- Help integrate data for comprehensive exposure/health risk analysis
- Listen to what is needed!!
Questions, comments, suggestions?

• Dr. Karsten Baumann  kb@eas.gatech.edu
• Dr. Michael Chang   chang@eas.gatech.edu
• Dr. Ranga Rao       rrao@uwf.edu

Georgia Institute of Technology
University of West Florida
Appendix B.

High Frequency Observation of Particle Composition During the Summer of 2003 in Pensacola, FL

November 3, 2003
High Frequency Observations of Particle Composition During Summer of 2003 - Pensacola, FL

Rick Peltier
November 3rd, 2003
PILS/IC System
PILS/IC System - Description

- Capable of semi-continuous speciation of inorganic particles.
- Designed for aircraft measurements, but suitable for health effect studies.
- Roughly 18,000 data points.
- LOD: 10–40 nmol/m³ ($4 \text{ pg/m}^3 \text{ SO}_4^{2-}$).
- Diurnal measurements; transient events → source apportionment*. 

DEP Daily PM$_{2.5}$

FL DEP 24 Hour Averaged PM$_{2.5}$ Measurements
Sulfate is Major Constituent of PM

FL DEP 24 Hour Averaged PM$_{2.5}$ Measurements

FL DEP 24 Hour Average SO$_4^{2-}$ Measurement

PM$_{2.5}$ (ug/m$^3$)

12:00 AM  6:00 AM  12:00 PM  6:00 PM
7/26/2003

Hour of Day, 26 Jul 03
PILS/IC Sulfate Measurement Measures Up

FL DEP 24 Hour Averaged PM$_{2.5}$ Measurements

PILS/IC 24 Hour Average SO$_4^{2-}$ Measurement (blue)

FL DEP 24 Hour Average SO$_4^{2-}$ Measurement (red)

12:00 AM  6:00 AM  12:00 PM  6:00 PM
7/26/2003  7/26/2003

Hour of Day, 26 Jul 03
Variability in Hourly Sulfate

FL DEP 24 Hour Averaged PM$_{2.5}$ Measurements

PILS/IC 24 Hour Average SO$_4^{2-}$ Measurement (blue)

PILS Hourly Averaged SO$_4^{2-}$ Measurement

FL DEP 24 Hour Average SO$_4^{2-}$ Measurement (red)

Hour of Day, 26 Jul 03

12:00 AM 6:00 AM 12:00 PM 6:00 PM

7/26/2003
Greater Resolution = Greater Variability
The Bigger Picture

FL DEP 24 Hour Average PM$_{2.5}$ Measurement (red)

PILS/IC Hourly Averaged SO$_4^{2-}$ Measurements (blue)

FL DEP 24 Hour Average SO$_4^{2-}$ Measurement (green)
Diurnal Patterns: Sulfate and SO₂
Where do we go from here?

Continue data analysis. Obtain SEARCH data, FL DEP data, etc. Examine chemistry.

Interface with health community for follow-up field study (increase spatial resolution, etc.). Continue refining exposure studies.

Spatial intercomparison, refine speciated results w.r.t. spatial distribution.
Insights to Exposure

Ambient Air Quality

Exposure

Health Outcomes

University of South Florida

Georgia Tech
Ambient Air Quality

Health Outcomes

Exposure

Risk Assessment/Management

University of South Florida

Georgia Tech
Molar Ratios

Molar Ratio - NH₄/SO₄

0  5  10  15  20

GIT TEOM and PILS/IC

PM$_{2.5}$ One Hour Average by GIT TEOM

Inorganic PM$_{2.5}$ One Hour Average by PILS/IC

Date

PM$_{2.5}$ (µg/m$^3$)

Pseudo-Mass Closure

FL DEP PM<sub>2.5</sub> 24-Hour Filter Measurement

PILSAC Ion Mass
Appendix C.

Health Risk Comparison of Air Pollutants in Pensacola

November 3, 2003
Health Risk Comparison of Air Pollutants in Pensacola

Rama Mohana Turaga
PERCH PIs Meeting
November 2003
The Problem

- What are the human health risks posed by air pollutants – Particulate Matter (PM2.5), Ozone, or Air Toxics - in Escambia? Are some air pollutants worse than others?
Framework – Comparative Health Effects Valuation

- Emissions Inventory
- Air Quality Modeling
- Concentration-Response Functions
- Willingness to Pay

- Emissions Estimations
- Ambient Concentrations
- Quantification of Health Outcomes
- Valuation of Health Outcomes
Overview of Presentation

- Assessment of air toxics risk in Escambia and Santa Rosa and comparison with peer counties
- Comparison of PM2.5 and Ozone based on annual ambient concentrations and air quality index (AQI)
- Comparison of PM2.5, ozone, and air toxics based on valuation of health effects
- Future Research
Data and Methodology

• Air Toxics
  – Air toxics risk assessment using data from National Air Toxics Assessment, 1996
  – Analysis of EPA Risk Screening Analysis (2002) for peer county comparisons

• PM2.5 and Ozone
  – Daily ambient concentrations data of ozone and PM from EPA monitors
  – Calculation of daily AQI’s for three years and AQI comparison between ozone and PM

• Valuation of Health Costs
  – Cost coefficients from literature for PM and ozone
  – Value of statistical life approach for cancer risks from toxics
### Air Toxics – Risk in Escambia

<table>
<thead>
<tr>
<th>Source</th>
<th>Risk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cancer* ($x10^{-6}$)</td>
</tr>
<tr>
<td>Major</td>
<td>1.06</td>
</tr>
<tr>
<td>Area and other</td>
<td>5.85</td>
</tr>
<tr>
<td>Onroad mobile</td>
<td>10.6</td>
</tr>
<tr>
<td>Nonroad mobile</td>
<td>4.84</td>
</tr>
<tr>
<td>Estimated background</td>
<td>20.0</td>
</tr>
<tr>
<td>Total</td>
<td>42.4</td>
</tr>
</tbody>
</table>

*Probability of developing cancer due to inhalation over lifetime (70 years)*  
**Hazard Quotient, the ratio of ambient concentration to reference concentration**  
Source: National Air Toxics Assessment, 1996
### Air Toxics – Risk in Santa Rosa

<table>
<thead>
<tr>
<th>Source</th>
<th>Risk Score</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cancer* (x10^-6)</td>
<td>Non-cancer**</td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>1.17</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>Area and other</td>
<td>6.66</td>
<td>2.41</td>
<td></td>
</tr>
<tr>
<td>Onroad mobile</td>
<td>4.06</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Nonroad mobile</td>
<td>5.26</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>Estimated background</td>
<td>19.9</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>37.1</td>
<td>3.59</td>
<td></td>
</tr>
</tbody>
</table>

*Probability of developing cancer due to inhalation over lifetime (70 years)

* *Hazard Quotient, the ratio of ambient concentration to reference concentration

Source: National Air Toxics Assessment, 1996
### EPA Risk Screening Scheme

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
<th>Weighted Score Escambia</th>
<th>Weighted Score Santa Rosa</th>
</tr>
</thead>
<tbody>
<tr>
<td>NATA cancer risk</td>
<td>10%</td>
<td>0.014</td>
<td>0.008</td>
</tr>
<tr>
<td>NATA non-cancer risk</td>
<td>10%</td>
<td>0.040</td>
<td>0.035</td>
</tr>
<tr>
<td>NATA diesel particulate matter</td>
<td>5%</td>
<td>0.028</td>
<td>0.027</td>
</tr>
<tr>
<td>1999 relative hazard ranking</td>
<td>25%</td>
<td>0.056</td>
<td>0.001</td>
</tr>
<tr>
<td>Total respiratory mortality</td>
<td>5%</td>
<td>0.023</td>
<td>0.024</td>
</tr>
<tr>
<td>Total cardiovascular mortality</td>
<td>5%</td>
<td>0.028</td>
<td>0.025</td>
</tr>
<tr>
<td>Total cancer morbidity</td>
<td>5%</td>
<td>0.025</td>
<td>0.023</td>
</tr>
<tr>
<td>Total population density</td>
<td>15%</td>
<td>0.022</td>
<td>0.006</td>
</tr>
<tr>
<td>Population density of people under 18 years of age</td>
<td>10%</td>
<td>0.009</td>
<td>0.002</td>
</tr>
<tr>
<td>Population density of people over 65 years of age</td>
<td>10%</td>
<td>0.016</td>
<td>0.005</td>
</tr>
<tr>
<td>Total Relative Risk Score</td>
<td>100%</td>
<td>0.262</td>
<td>0.155</td>
</tr>
</tbody>
</table>

Source: U.S. EPA Region 4 Air Toxics Relative Risk Screening Analysis, September 27, 2002
## Peer County Comparison

<table>
<thead>
<tr>
<th>County</th>
<th>EPA Risk Screening Rank* (Percentile Rank)</th>
<th>County</th>
<th>EPA Risk Screening Rank* (Percentile Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mecklenburg, NC</td>
<td>12 (1.6)</td>
<td>Rowan, NC</td>
<td>114 (15.5)</td>
</tr>
<tr>
<td>Gaston, NC</td>
<td>22 (3.0)</td>
<td>Orange, NC</td>
<td>137 (18.6)</td>
</tr>
<tr>
<td>Durham, NC</td>
<td>40 (5.4)</td>
<td>Madison, AL</td>
<td>140 (19.0)</td>
</tr>
<tr>
<td>Escambia, FL</td>
<td>42 (5.7)</td>
<td>Lincoln, NC</td>
<td>151 (20.5)</td>
</tr>
<tr>
<td>Wake, NC</td>
<td>45 (6.1)</td>
<td>Union, NC</td>
<td>232 (31.5)</td>
</tr>
<tr>
<td>Chatham, GA</td>
<td>51 (6.9)</td>
<td>Chatham, NC</td>
<td>252 (34.2)</td>
</tr>
<tr>
<td>Lee, FL</td>
<td>67 (9.1)</td>
<td>Santa Rosa, FL</td>
<td>290 (39.4)</td>
</tr>
<tr>
<td>Cabarrus, NC</td>
<td>75 (10.2)</td>
<td>Limestone, AL</td>
<td>299 (40.6)</td>
</tr>
<tr>
<td>Berkeley, SC</td>
<td>76 (10.3)</td>
<td>Johnston, NC</td>
<td>314 (42.7)</td>
</tr>
<tr>
<td>York, SC</td>
<td>88 (12.0)</td>
<td>Effingham, GA</td>
<td>371 (50.4)</td>
</tr>
<tr>
<td>Charleston, SC</td>
<td>90 (12.2)</td>
<td>Bryan, GA</td>
<td>381 (51.8)</td>
</tr>
<tr>
<td>Dorchester, SC</td>
<td>98 (13.3)</td>
<td>Franklin, NC</td>
<td>492 (66.8)</td>
</tr>
</tbody>
</table>

Source: U.S. EPA Region 4 Air Toxics Relative Risk Screening Analysis, September 27, 2002

Note: Peer communities as identified by the Pensacola Chamber of Commerce

* Rank out of 736 counties in Region 4
## Criteria Pollutants – Ambient Concentrations of Ozone

<table>
<thead>
<tr>
<th>County</th>
<th>Site / Standard</th>
<th>3-yr avg of annual 4th highest daily 8-hour average ozone (ppbv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escambia</td>
<td>Ellyson Industrial Park</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Warrington Elementary</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>Naval Air Station</td>
<td>88</td>
</tr>
<tr>
<td>Santa Rosa</td>
<td>Navarre Beach Middle School</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>NAAQS</td>
<td></td>
</tr>
</tbody>
</table>

Source: Florida Department of Environment
# Criteria Pollutants – Ambient Concentrations of PM 2.5

<table>
<thead>
<tr>
<th>County</th>
<th>Site / Standard</th>
<th>Annual average</th>
<th>98th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escambia</td>
<td>Ellyson Industrial Park (3-day filter)</td>
<td>11.4 11.4 11.0</td>
<td>13.8 22.0 22.4</td>
</tr>
<tr>
<td></td>
<td>Ellyson Industrial Park (continuous)</td>
<td>15.0 12.3 11.5</td>
<td>NA 25.0 22.0</td>
</tr>
<tr>
<td>Santa Rosa</td>
<td>Gulf Breeze (3-day filter)</td>
<td>NA  NA 9.3</td>
<td>NA  NA 18.9</td>
</tr>
<tr>
<td></td>
<td>NAAQS</td>
<td>15.0</td>
<td>65.0</td>
</tr>
</tbody>
</table>

*Source: Florida Department of Environment*
PM and Ozone Comparison – Air Quality Index (AQI)

- AQI is an indicator of potential health effects associated with air pollution in a community.
- AQI index is presented in six color-coded categories ranked by the level of health risk posed.
- AQI can be calculated for each criteria pollutant based on its average daily ambient concentration.
- AQI in a community for a given day is the highest of the individual AQIs calculated for the six criteria pollutants in that community.
Air Quality Index in Escambia

- Good (0-50)
- Unhealthy for Sensitive Groups (101-150)
- Unhealthy (151-200)
- Very Unhealthy (201-300)
- Hazardous (301-500)

Legend:
- 2001 8-hr Ozone
- 2001 PM2.5
Preliminary Estimation of Health Costs

- Steps
  - Average ambient concentrations from monitored data from Florida DEP
  - Coefficients for economic valuation of health in \$/day/unit conc. (Shih et al., 2003)
  - Estimation of total health costs associated with PM and Ozone
  - Calculation of cancer risks for air toxicities and estimation of health costs using value of statistical life (VSL) approach
## Preliminary Estimated Health Cost in Escambia in 2000 - PM 2.5

<table>
<thead>
<tr>
<th>Average Ambient Concentration (µg/m³)</th>
<th>Cost Coefficient* ($/day/µg/m³/person)</th>
<th>($/year/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.9</td>
<td>0.338</td>
<td>1838.2</td>
</tr>
</tbody>
</table>

Values are in 2000 $  
* Coefficients from Shih et al., 2003
Preliminary Estimated Health Cost in Escambia in 2000 - Ozone

<table>
<thead>
<tr>
<th>Average Ambient Concentration (ppb)</th>
<th>Cost Coefficient ($/day/ppb/person)</th>
<th>($/year/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60.7</td>
<td>0.0043</td>
<td>95.3</td>
</tr>
</tbody>
</table>

Values are in 2000 $  
* Coefficients from Shih et al., 2003
## Preliminary Estimated Health Cost in Escambia in 2000 – Air Toxics

<table>
<thead>
<tr>
<th>Lifetime Cancer Risk*</th>
<th>Value of Statistical Life (2000 $)</th>
<th>($/year/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$45.1 \times 10^{-6}$</td>
<td>6.1 million</td>
<td>3.9</td>
</tr>
</tbody>
</table>

*Lifetime Cancer Risk is based on exposures to 32 air toxics for 70 years*
# Preliminary Estimated Health Cost Comparison

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>$/year/person</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM 2.5</td>
<td>1838.2</td>
</tr>
<tr>
<td>Ozone</td>
<td>95.3</td>
</tr>
<tr>
<td>Air Toxics</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Preliminary Findings

- All comparisons suggest that PM2.5 is a worse problem than ozone.

- Preliminary analysis of health costs due to morbidity and mortality suggests that
  - PM2.5 imposes the highest per person per year costs, followed by
  - ozone, then
  - air toxics

  with an order of magnitude difference between them
Current Work – Comparative Health Effects Valuation

1. Emissions Inventory
2. Air Quality Modeling
3. Ambient Concentrations
   - Concentration - Response Functions
4. Quantification of Health Outcomes
5. Willingness to Pay
6. Economic Valuation of Health Outcomes

Key Uncertainties:
- Average ambient concentrations from existing monitors
- Using nationally developed C-R functions (not from Pensacola)
- Benefit transfer – using willingness to pay values elicited outside Pensacola
Future Research

- Previous research suggests that risk management resources are applied based on risk perceptions
  - Refine estimates and comparisons of health risks from air pollutants in 32503.
  - Conduct a environmental health risk perception survey in Pensacola.
  - Study local air quality risk management strategies to see if they address the above
Appendix D.

2000 and 2007 air quality in Pensacola
Incidental Results from the Fall line Air Quality Study (FAQS)

November 3, 2003
2000 and 2007 air quality in Pensacola

Incidental Modeling (FAQS)

Incidental Implications (NOx SIP Call, Tier 2 Standards, National Low-Sulfur Fuels, Heavy Duty Diesel Engine Manufacturing)
Impact of Controls: 2000 (new) vs. 2007

Aug. 17th, 2000

2007 with clean fuels, Tier II, Utility NOx & SOx reductions

Currently: Most large cities and Much of the SE states over NAAQS ozone and PM standards

Significant reductions in ozone and PM, However Atlanta and a few other cities in SE still over NAAQS Ozone and PM

Georgia Institute of Technology
2000 vs. 2007 Pensacola 1: 1hr O3 & 8hr O3

Georgia Institute of Technology
2000 vs. 2007 Santa Rosa: 1hr O3 & 8hr O3
2000vs.2007 Pensacola 1: 1hr & 24hr PM2.5
2000vs.2007 PNS: Speciated 24hr PM2.5
2000vs.2007 OLF: Speciated 24hr PM2.5
2000 vs. 2007 Pensacola 1: 24hr PM10
Summary

- Controls already “on the books” may decrease peak ozone concentrations in Pensacola area by 5 to 10%.
- Same controls appear to have little impact on PM.
- Sulfate constitutes a large fraction of PM.

- To check on:
  - Does modeling include changes at Gulf Power Facility?