ARIES Air Quality: Overview, 5-Year Trends and Spatial Variability

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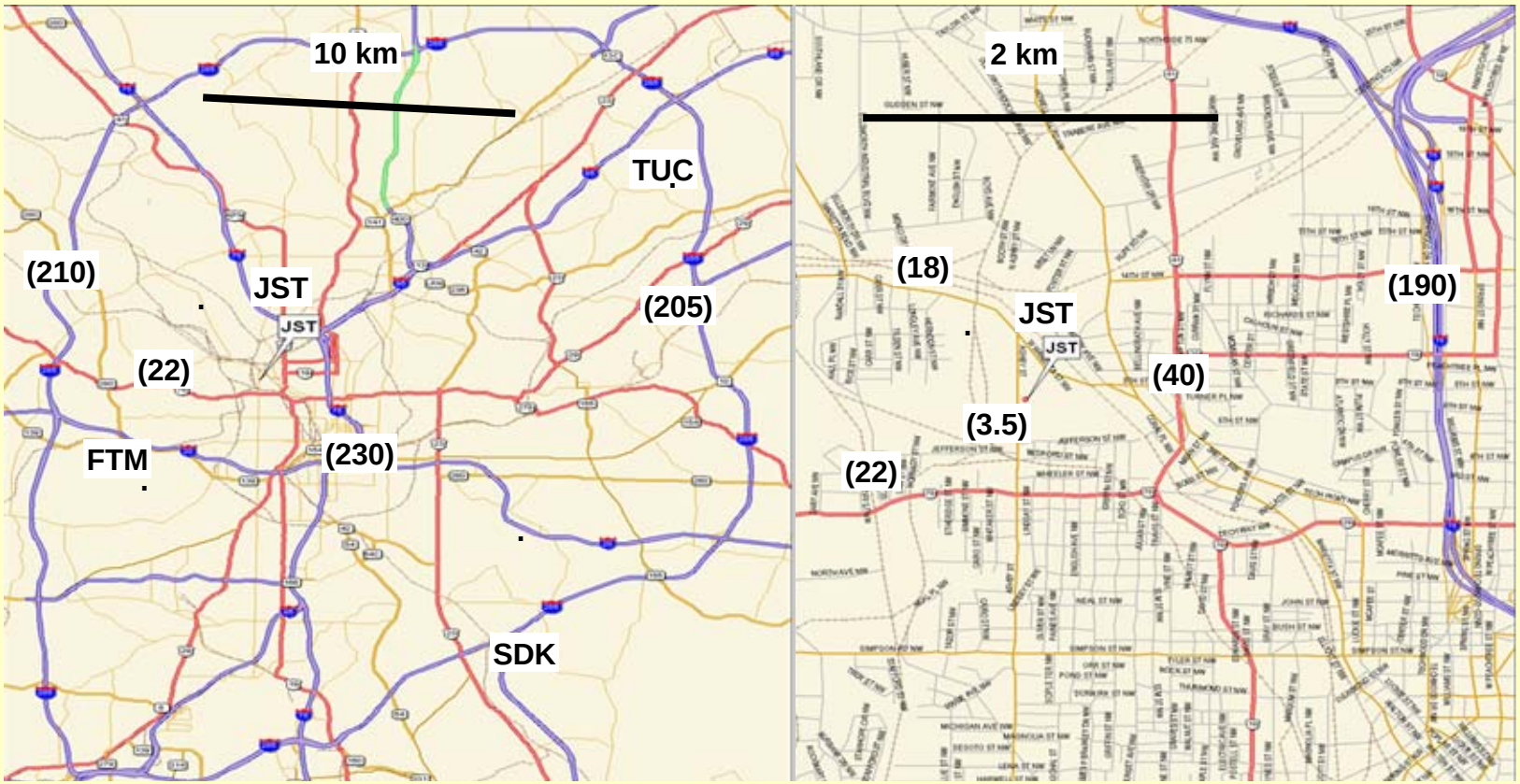
INTRODUCTION

The Aerosol Research Inhalation Epidemiological Study (ARIES) is a long-term investigation of relationships between air quality and human health. Underpinning the study is a comprehensive set of air quality measurements at a central site (Jefferson Street), with supporting measurements at three satellite sites in and around Atlanta. This poster provides an introduction to the ARIES air quality measurements and the central air quality site. It summarizes data for the period 1999 through 2003 and compares observations to other sites in the Southeastern U.S. A first look at temporal trends and spatial variability across the City of Atlanta is also presented.

Figure 1. General and Detail Maps of ARIES Site Location (JST)



METHODS & SAMPLING SITES

ARIES measurements, PIs and period of record are shown in Table 1. In all, more than 100 variables were measured over the first 25 months of the study. Most measurements will continue through 2005, thus creating a comprehensive 7+ year record of air quality and meteorology. A number of measurements were discontinued in August 2000, after establishing a 25-month baseline.

The air quality site is one of 8 long-term research sites operated under the auspices of the Southeastern Aerosol Research and Characterization (SEARCH) study. It is located at 829 Jefferson St. NW, Atlanta (JST in Figure 1), about 4.5 km NW of city center. JST is in an industrial/commercial/residential part of the city, surrounded mostly by open ground and 1-story warehouses.

Local sources of interest include a coal-fired power plant and cement kiln (7 km NW), a metals recycling facility (700 m E), a bus maintenance facility (250 m SE) and area roads, thoroughfares and super-highways. The site is several km from major highways passing around and through Atlanta and about 600 m N of Bankhead Highway. Traffic count data in the vicinity of JST are depicted parenthetically in Figure 1 (units= 1000 vpd).

Also shown in Figure 1 are locations of three Assessment of Spatial Aerosol Comparability in Atlanta (ASACA) sites operated jointly by Georgia Institute of Technology and SEARCH. Measurements at these sites vary, but include, at a minimum, daily (24-hour average) PM2.5 composition and hourly PM2.5 mass (TEOMs) and black carbon (BC, aethelometers).

Table 1. ARIES Air Quality Measurements and Period of Record

Measurement	Resolution (Frequency)	PI	Period of Record 8/98-8/00	Period of Record 8/98-12/05
Trace Gases (O_3, NO, NO_2, NOx, NOy, HNO_3, SO_2, CO)	1-minute (continuous)	ARA	yes	yes
Trace Gases (NH_3)	24-hour (daily)	HSPH	yes	no
Meteorology (WS, WD, T, RH BP, Precip., SR)	1-minute (continuous)	ARA	yes	yes
$PM_{2.5}$ (Mass, ions, OC/EC, H_2O-soluble metals, trace elem.)	24-hour (daily)	ARA	yes	yes
$PM_{2.5}$ (Acidity)	24-hour (daily)	HSPH	yes	no
PM_{coarse} (mass, ions, H_20-soluble metals, trace elem.)	24-hour (daily)	ARA	yes	yes
Particle #, area, volume (3-1000nm)	10-minute (continuous)	Univ. Minn.	yes	no
VOCs/OVOCs (89 compounds)	24-hour (daily)	Oregon Grad. Inst.	yes	yes
Pollen/Spores	24-hour (daily)	HSPH	yes	no
Semi-volatile organics	24-hour (daily)	DRI	yes	no

Figure 2 illustrates the specific setting of JST. The equipment shelter is about 10 m above Lowery Boulevard (formerly Ashby Street) in a grass-covered clearing with excellent fetch for an urban site. Air quality measurements are made at reference heights of 5 m above ground level (particles) or 10 m above ground level (gases and meteorology) to minimize effects of surface emissions and activities.

Figure 2. Looking SE Towards Downtown **Looking NW** **Aerial View During SuperSite Expt.**

RESULTS & DISCUSSION

Descriptive statistics for a subset of ARIES measurements are shown in Table 2. Mean $PM_{2.5}$ mass is above the annual NAAQS(15 ug/m^3) and much of this can be explained by organic matter (OM=1.4*OC), sulfate and, to a lesser extent, by BC and ammonium. $PM_{2.5}$ is about 3 ug/m^3 higher than regionally representative rural sites in the area, and almost all of this difference can be explained by OM and BC. The xsNH4:SO4 ratio indicates that the aerosol is largely, but not completely, neutralized by ammonium. Trace gas data indicate that mean and maximum hourly ozone concentrations are significantly lower and higher, respectively, then rural sites. Ratios of CO:NOy and SO2:NOy show that most of the NOy and CO originates from gasoline vehicles, as opposed to diesel vehicles or point sources, and appear to reflect city-wide emissions.

Time series of annual average $PM_{2.5}$ for JST (Figure 3) show that there has been a significant decline in mass and composition from 1999 through 2003. This decline is on the order of 20% for mass and major components, and is observed to a greater or lesser extent at all SEARCH sites. It should be noted that the decline is not monotonic, but appears to be more of a step function between 1999-2000 and 2001-2003. Diurnal profiles for ozone (a secondary pollutant), PM2.5 (a mix of primary and secondary pollutants) and CO and NOy (primary pollutants) also show striking declines from 1999-2003. Reasons for these declines almost certainly involve both meteorology and emissions, but the interactions of these is unclear.

Table 2. Air Quality Data# for JST (1999-2003)

Component	Units	Mean	s.d.	Max	Min
$PM_{2.5}$ Mass	µg/m^3	16.9	8.2	68.8	1.9
" SO_4^{2-}	µg/m^3	4.8	3.4	21.5	0.5
" NO_3^-	µg/m^3	1.0	0.9	7.4	<0.1
" NH_4^+	µg/m^3	1.7	1.2	7.0	0.1
" OM	µg/m^3	6.1	3.5	36.3	0.5
" BC	µg/m^3	1.6	1.1	11.9	<0.1
$xsNH_4^+/SO_4^{2-}$	none	0.8	0.2	1.2	0.1
PM_{coarse} Mass	µg/m^3	9.1	5.3	50.4	0.5
" SO_4^{2-}	µg/m^3	0.3	0.3	4.2	<0.1
" NO_3^-	µg/m^3	0.5	0.4	2.7	<0.1
" NH_4^+	µg/m^3	<0.1	0.1	0.9	<0.1
" MMO	µg/m^3	3.5	2.6	21.7	0.1
O_3	ppb	24.1	22.7	167	<1
NO_y	ppb	52.4	67.9	642	1.9
CO	ppb	504	592	7700	70
SO_2	ppb	5.5	7.7	92.4	<0.1
NMHC	ppb-C	256	204	1520	42

 # selected variables

Figure 3. $PM_{2.5}$ Composition for SEARCH Sites (1999-2003)

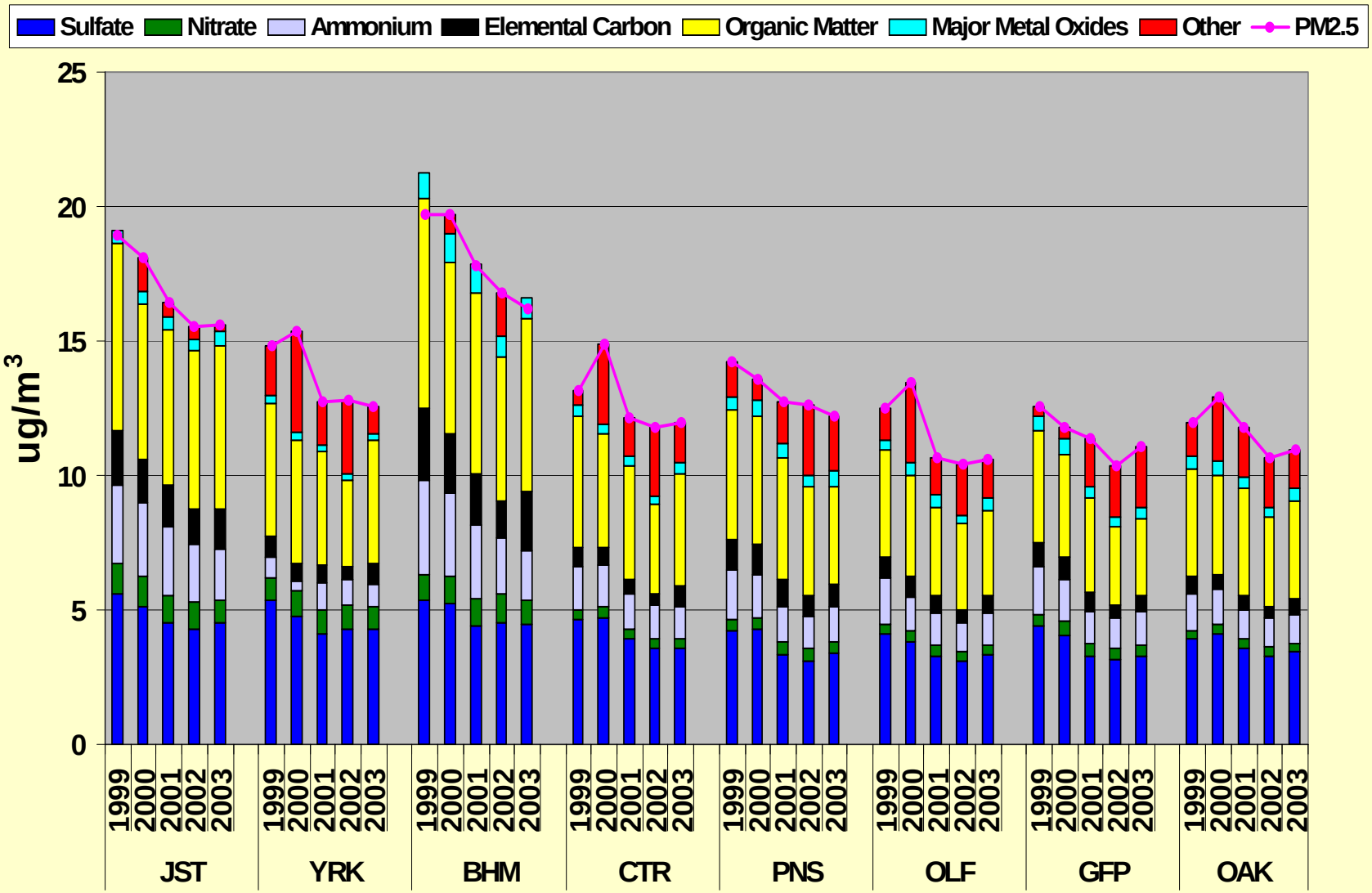


Figure 4. Annual Diurnal Profiles at JST (1999-2003)

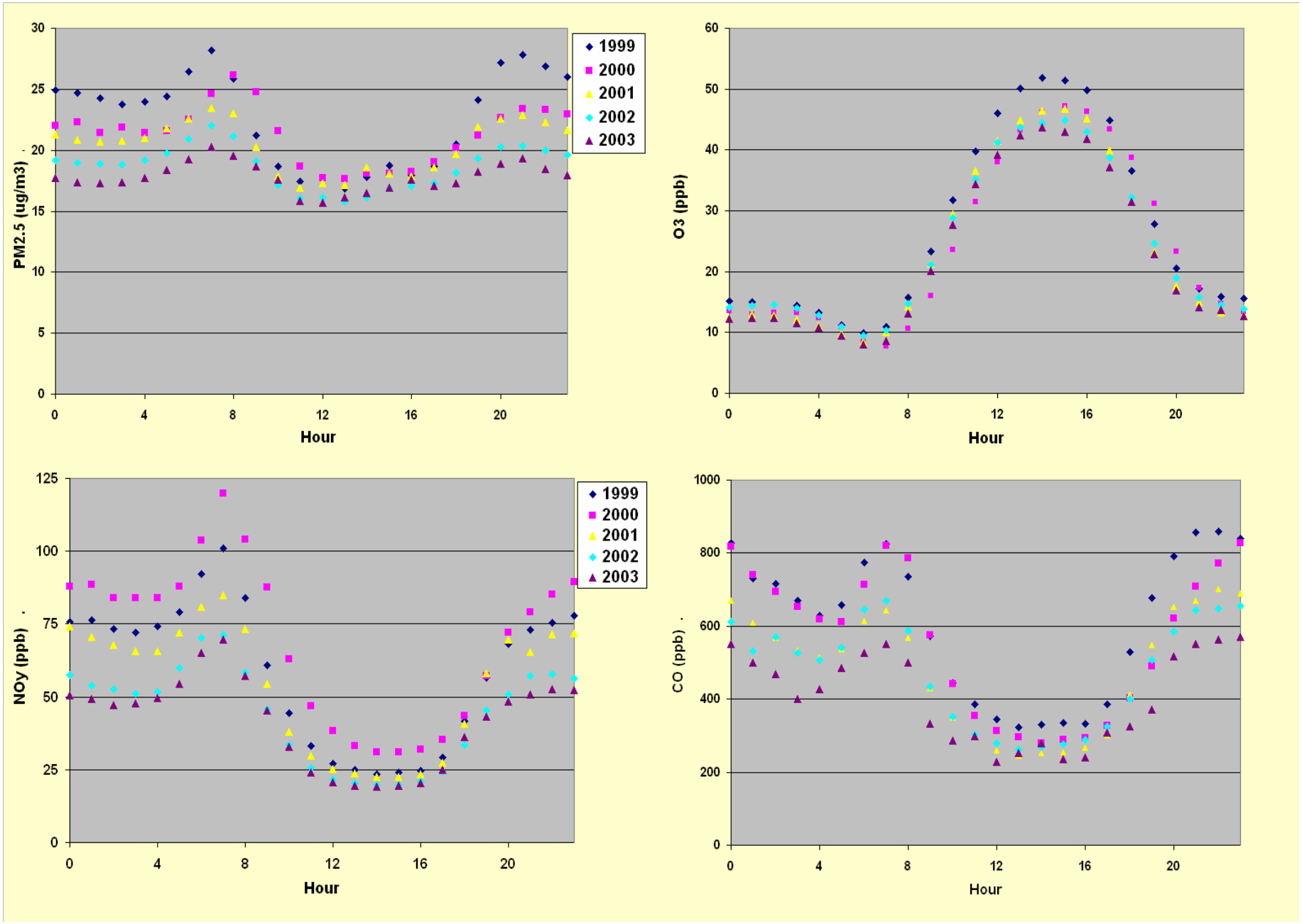
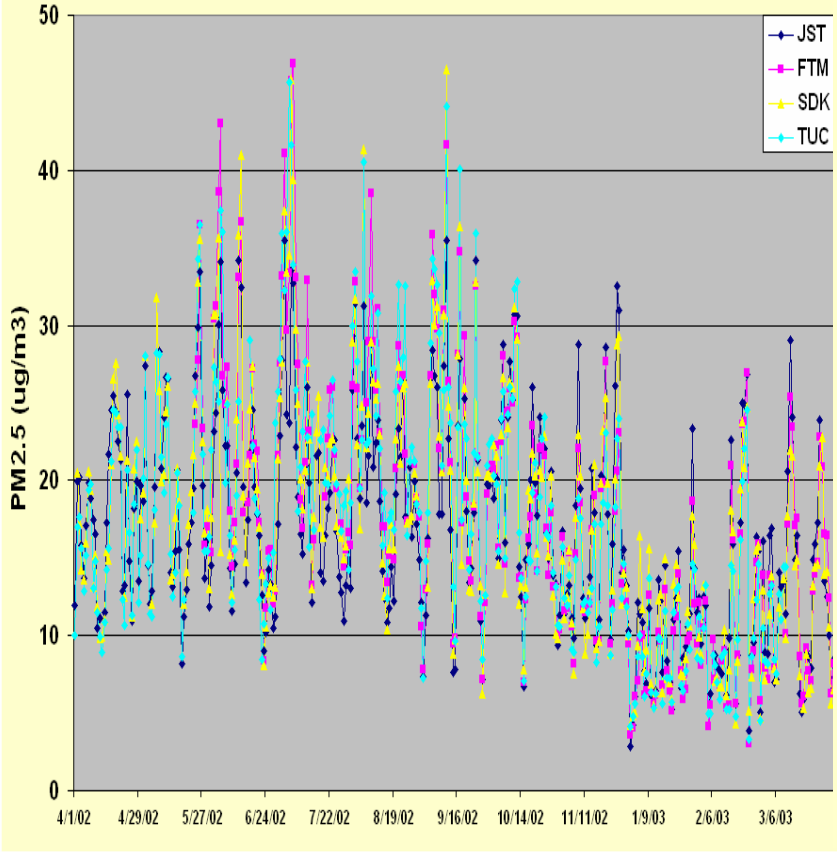
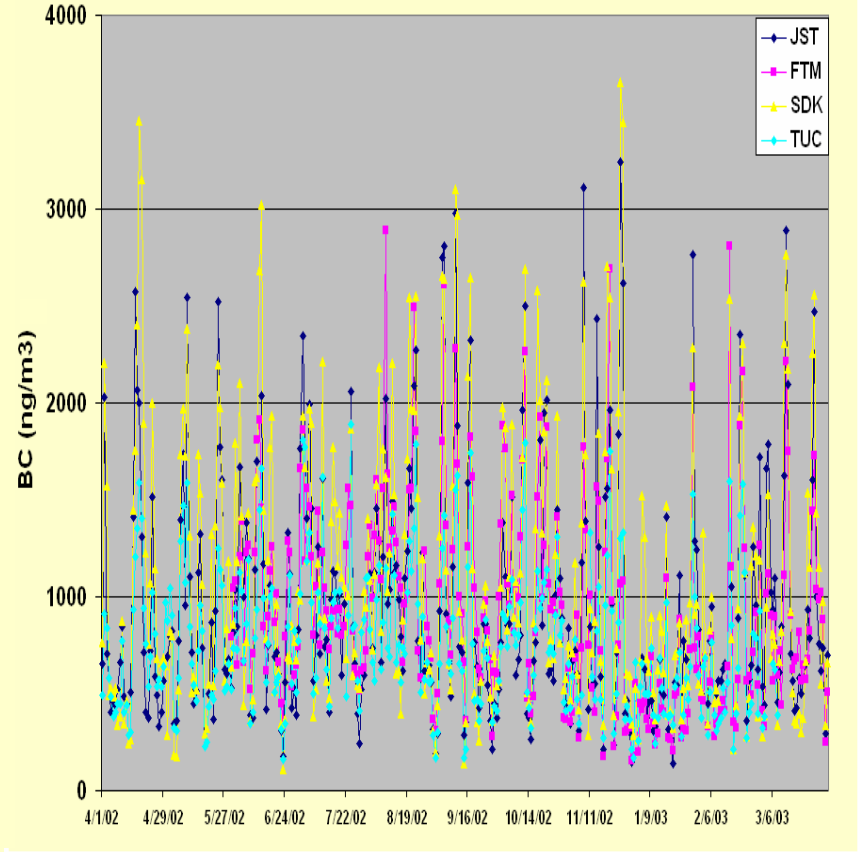


Figure 5. Time Series of 24-hr Avg. $PM_{2.5}$ (L) and BC (R) for ASACA Sites





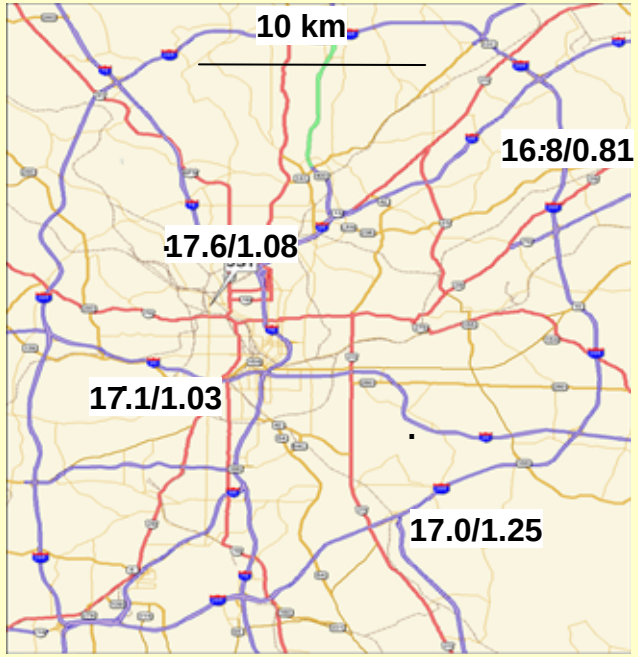
Measurements at JST and ASACA sites were undertaken, in part, to examine spatial variability in Atlanta, and detailed analyses of patterns and trends are currently underway. Time series of 24-hour $PM_{2.5}$ mass and BC (Figure 5) show very similar behavior across all four sites. Maximum and minimum concentrations generally line up, and no one site appears to be routinely higher or lower than others. This is true for 24-hour averages as well as 1-hour averages, and suggests that concentrations are in many ways governed by meteorological factors (e.g., nocturnal stagnation and daytime ventilation) which affect the city as a whole. Average $PM_{2.5}$ and BC values for the period March 2001-February 2003 also show limited variability across the city (see Figure 6).

Table 3. Pearson r for $PM_{2.5}$ Components

Component	FTM	SDK	TUC	YRK
Mass (1-hr)	0.85	0.78	0.71	0.66
" (24-hr)	0.92	0.89	0.81	0.88
SO_4^{2-}	0.88	0.91	0.92	0.91
NO_3^-	0.73	0.84	0.85	0.59
NH_4^+	0.85	0.91	0.85	0.79
BC (1-hr)	0.67	0.71	0.65	0.21
" (24-hr)	0.65	0.70	0.65	0.44

Mar. 2001-Feb. 2003

Figure 6. Mean $PM_{2.5}$ Mass and BC (µg/m³)



Mar. 2001-Feb. 2003

Pearson correlation coefficients for the ASACA sites, plus a rural SEARCH site outside Atlanta (YRK), show highly significant correlations across the area (see Table 3). Correlation coefficients are highest for sulfate (a secondary species) and PM2.5 (mixture of primary and secondary) and lowest, but surprisingly high nonetheless, for BC (a primary species).

SUMMARY & CONCLUSIONS

Comprehensive air quality measurements at JST are in their 5th year and are scheduled to continue through 2005. Results to date show:

1) Average PM2.5 exceeds the annual NAAQS and is composed largely of OM, sulfates, BC and ammonium.

2) There has been a significant, but unexplained, decline in PM2.5, including its major components, and trace gases between 1999 and 2003. Similar declines in PM2.5 have been observed throughout SEARCH.

3) PM2.5 mass, secondary inorganic species and BC (a primary pollutant) exhibit very strong coherence across Atlanta, both on hourly and 24-hour time scales, indicating that measurements at JST are broadly representative of Atlanta air quality.