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Multiple Pollutants and Risk of Cardiac and Respiratory Emergency Department Visits in Atlanta – Air Quality Data

Annual Progress Report to Emory University, under EPA contract
Period of performance: January 1 – December 31, 2004

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Introduction

Air quality data and analysis were provided to support an Emory School of Public Health research team in the epidemiologic investigation of relationships between multiple pollutants and risk of cardiac and respiratory emergency department visits in Atlanta. The study expands an existing study to cover the period January 1, 1993 through December 31, 2002. Two air quality databases were used in this study. First, a database from the Atlanta super-station for the time period July 1, 1998 through December 31, 2002 was developed by Atmospheric Research & Analysis, Inc. (ARA) under Electric Power Research Institute (EPRI) sponsorship for the Aerosol Research Inhalation Epidemiological Study (ARIES). Second, a database of ambient air monitoring data from sources other than the super-station for the period January 1, 1993 through December 31, 2002 was developed by Georgia Tech researchers under this subcontract.

In this report, the development of the second database through December 31, 2002 is documented. Air quality measures and data sources are identified. Temporal and spatial patterns are described. Methods for interpolating missing hourly data and methods for imputing values for days when data are missing are described.

Air Quality Measures and Data Sources

Meteorological data were collected from the National Climatic Data Center (NCDC) network. Daily values of mean barometric pressure, maximum and minimum temperature, maximum and minimum relative humidity, total precipitation, mean dew point, average wind speed, average wind vector, and mean visibility were obtained from the Hartsfield Airport station. Ambient air quality data were collected from the EPA's Air Quality System (AQS), the Georgia Department of Natural Resources' Metro Atlanta Index (MAI), the Assessment of the Spatial Aerosol Composition in Atlanta (ASACA), and the SouthEastern Aerosol Research and Characterization Study (SEARCH) networks. Hourly values of the gaseous pollutants sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), nitrogen oxides (NO_x), and ozone (O_3) were obtained from several metro-Atlanta monitoring sites, as were measures of particulate matter mass (PM_{10} and $PM_{2.5}$) and composition. The locations of monitoring stations are listed in Table 1 and shown in Figure 1.

Table 1. Air quality monitoring stations in metro-Atlanta used in this study.

station	*measure(s)*	*longitude (W)*	*latitude (N)*
Hartsfield Int. Airport (HA) [a]	all met. data	-84.433	+33.633
Bolton Rd (BR) [a]	precipitation	-84.500	+33.833
Fulton County (FC) [a]	visibility	-84.517	+33.783
Roswell Rd (RR) [b]	CO	-84.3803	+33.8764
Dekalb Tech (DT) [b]	CO	-84.2358	+33.7892
Confederate Ave. (CA) [b]	SO_2, O_3	-84.3578	+33.7206
Stilesboro (St) [b]	SO_2	-84.9153	+34.1033
Georgia Tech (GT) [b]	NO_2, NO_x, SO_2, PM_{10}	-84.4008	+33.7758
S. Dekalb College (SD) [b,d]	NO_2, NO_x, O_3, $PM_{2.5}$	-84.2903	+33.6875
Conyers Monastery (Co) [b]	NO_2, NO_x, O_3	-84.0667	+33.5856
Tucker (Tu) [b,d]	NO_2, $PM_{2.5}$	-84.2142	+33.8472
Fire Station # 8 (FS8) [b]	PM_{10}, $PM_{2.5}$	-84.4358	+33.8017
Fulton County Health Dept. (FCHD) [c]	PM_{10}	-84.3828	+33.7517
Doraville Health Center (DHC) [b]	PM_{10}	-84.2789	+33.9031
Griffin (Gr) [b]	PM_{10}	-84.2850	+33.2647
Douglasville (Do) [b]	$PM_{2.5}$	-84.7789	+33.7433
E. Rivers School (ERS) [b]	$PM_{2.5}$	-84.3819	+33.8137
East Point Health Center (EPHC) [b]	$PM_{2.5}$	-84.4375	+33.6164
Forest Park (FP) [b]	$PM_{2.5}$	-84.3911	+33.6097
Kennesaw (Ke) [b]	$PM_{2.5}$	-84.6075	+34.0144
Fort McPherson (FM) [d]	$PM_{2.5}$	-84.4375	+33.7083
Jefferson St. (JS) [d,e]	CO, SO_2, O_3, NO, NO_2, NO_y, PM_c, $PM_{2.5}$, PM composition, MET	-84.4167	+33.7769
Yorkville (Yo) [b,e]	CO, SO_2, O_3, NO, NO_y, PM_c, $PM_{2.5}$, PM composition, MET	-85.0453	+33.9283

[a] NCDC network; [b] AQS network; [c] MAI network; [d] ASACA network; [e] SEARCH network

Using raw data collected from the air quality data networks, various daily averages were calculated and a master air quality database (master.xls) was created. Data files are organized as shown in Figure 2.

Composite files were constructed to provide values of air quality measures for a central site in metro-Atlanta. The stations chosen for this composite site are underlined in Table 2. Averages and ranges for each measure are also given in Table 2. A data summary table and plots of air pollutant trends by year, month, day-of-week, and hour-of-day are appended to this report.

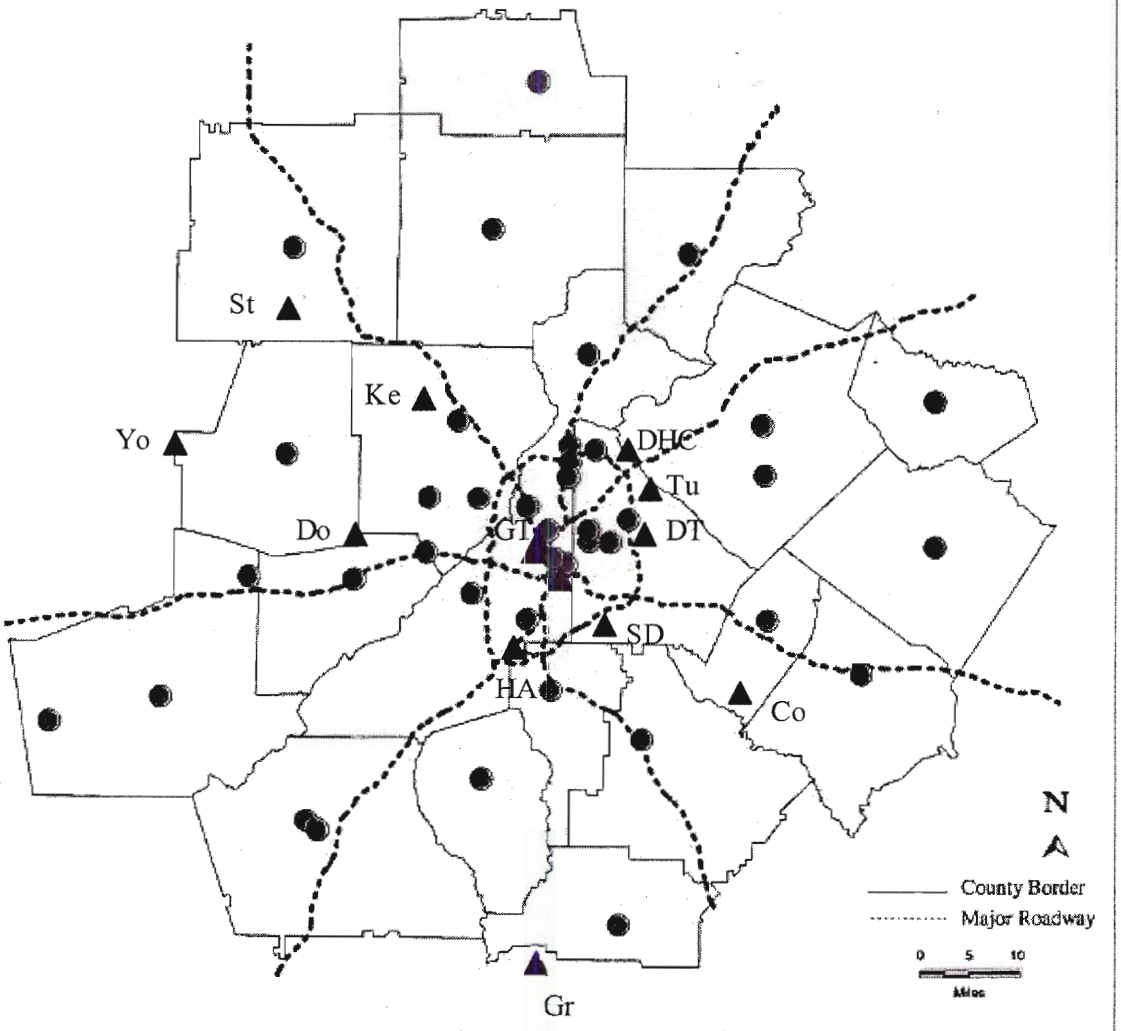


Figure 1. Location of selected air quality monitoring stations (triangles). Also shown are the locations of hospitals participating in the study (circles).

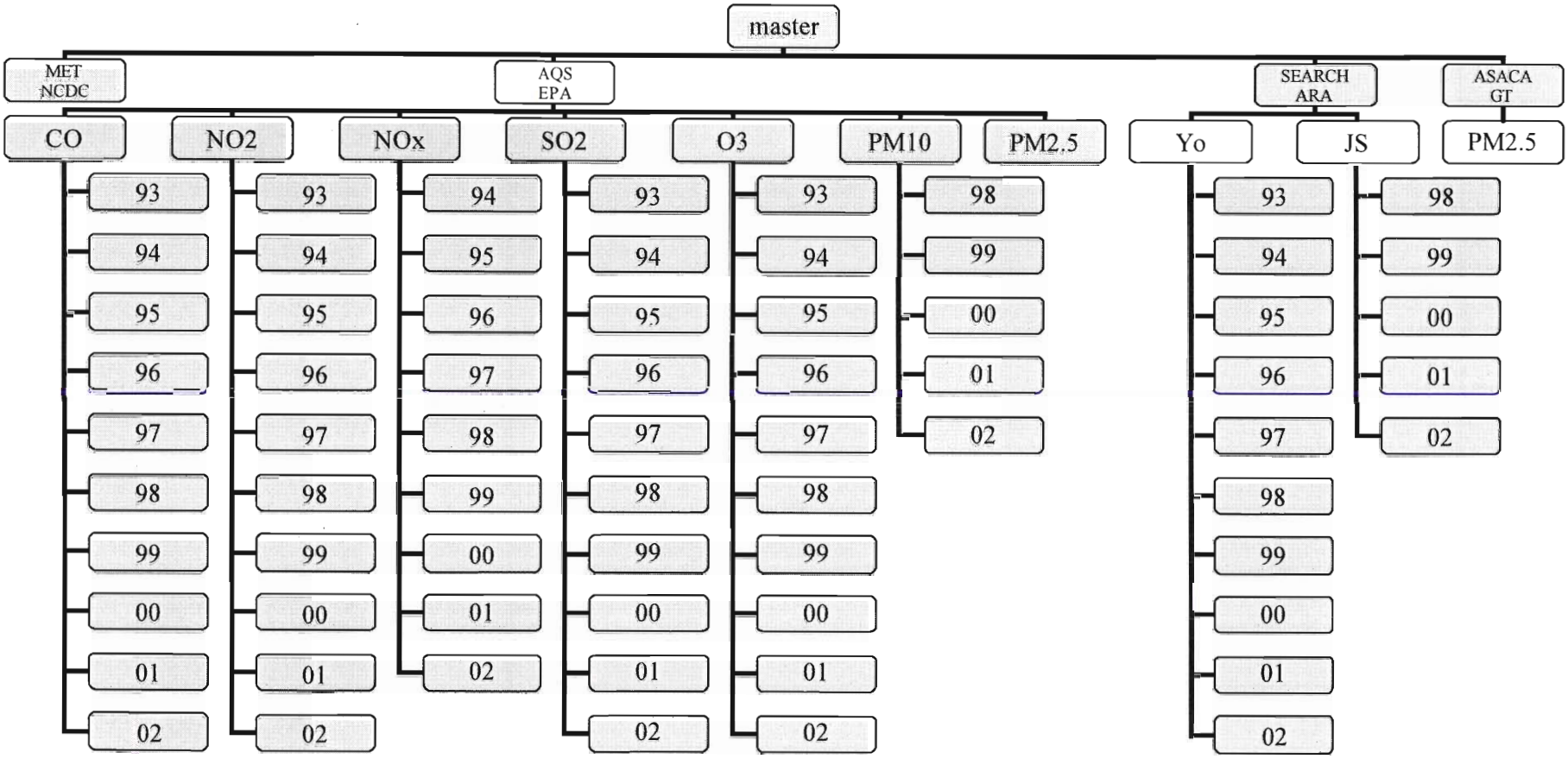


Figure 2. Organization chart for data files.

Table 2. Daily air quality measures, January 1, 1993 through December 31, 2002 (3652 days).

	station	*frequency*	*average (range)*
MET: mean pressure	HA	daily	981 millibar (959-1001)
maximum temperature	HA	daily	72.4 °F (18 – 102)
minimum temperature	HA	daily	53.3 °F (6 – 80)
maximum relative humidity	HA	daily	88.3 % (40 – 100)
minimum relative humidity	HA	daily	48.0 % (7 – 100)
mean dew point	HA	daily	50.7 °F (-2.4 – 74.7)
total precipitation	HA,BR	daily	0.13 inches (0 – 6.7)
mean wind speed	HA	daily	8.1 mph (0.3 – 28.1)
mean wind vector	HA	daily	1.4 mph (0.1 – 23.9); 313°
mean visibility	HA,FC	daily	9.3 miles (0.3 – 21.3)
SO_2 (1-hr max, 24-hr avg)	GT	hourly	15.3 ppb (1 – 149)
	CA	hourly	12.5 ppb (1 – 136)
	JS	hourly, since 8/1/98	18.6 ppb (0.05 – 101)
	St	hourly	12.4 ppb (1 – 273)
	Yo	hourly	11.6 ppb (0.2 – 158)
CO (1-hr max, 8-hr max; 24-hr avg)	DT	hourly	1.68 ppm (0.1 – 7.7)
	RR	hourly, since 8/5/94	2.00 ppm (0.2 – 9.5)
	JS	hourly, since 8/1/98	1.37 ppm (0.20 – 7.69)
	Yo	hourly	0.30 ppm (0.08-1.05)
NO_2 (1-hr max, 24-hr avg)	GT	houly	44.6 ppb (7 – 181)
	JS	hourly, since 8/1/98	52.9 ppb (0.1 – 200)
	SD	hourly	33.4 ppb (1 – 139)
	Tu	hourly, since 4/6/95	32.7 ppb (1 – 100)
	Co	hourly, since 4/1/94	14.7 ppb (1 – 80)
	Yo	hourly, since 1/25/96	11.7 ppb (1 – 70)
NO_x (1-hr max, 24-hr avg)	GT	hourly, since 4/1/98	133 ppb (5 – 996)
	JS	hourly, since 8/1/98	153 ppb (6 – 671)
	SD	hourly, since 4/1/94	158 ppb (1 – 930)
	Tu	hourly, since 4/6/95	64.7 ppb (1 – 387)
	Co	hourly, since 4/1/94	27.2 ppb (1 – 187)
	Yo	hourly, since 1/25/96	13.8 ppb (1 – 148)
O_3 (1-hr max; 8-hr max, 24-hr avg)	CA	hourly (93-95: 3/1–11/30)	54.0 ppb (3 – 147)
	SD	hourly (96: 3/1–10/31)	49.7 ppb (2 – 138)
	Co	hourly (97-02: 4/1–10/31)	54.5 ppb (5 – 133)
	JS	hourly, since 8/1/98	44.3 ppb (1 – 131)
	Yo	hourly	51.5 ppb (3 – 133)
PM_{10} mass (24-hr avg)	GT	daily, since 1/9/96	26.0 $\mu g/m^3$ (4 – 98)
	JS	daily, since 7/15/98	27.8 $\mu g/m^3$ (4 – 100)
	FCHD	5 dy/wk, 1/1/93–1/3/96	29.8 $\mu g/m^3$ (0 – 151)
	FS8	6th day	32.0 $\mu g/m^3$ (0 – 80)
	DHC	6th day	24.8 $\mu g/m^3$ (0 – 74)
	Yo	daily, since 7/25/98	21.2 $\mu g/m^3$ (5 – 62)
	Gr	6th day	23.4 $\mu g/m^3$ (0 – 82)
$PM_{2.5}$ mass (24-hr avg)	JS	daily, since 7/10/98	18.0 $\mu g/m^3$ (3 – 66)
	FM	daily, since 3/1/99	19.2 $\mu g/m^3$ (3 – 75)
	Tu	daily, since 3/1/99	19.8 $\mu g/m^3$ (3 – 52)
	SD	daily, since 1/1/99	18.1 $\mu g/m^3$ (5 – 47)
	DHC	daily, since 1/1/99	18.4 $\mu g/m^3$ (0.7 – 89)
	ERS	daily, since 1/1/99	18.0 $\mu g/m^3$ (2 – 140)
	FS8	3rd day, since 1/1/99	20.1 $\mu g/m^3$ (0.8 – 79)
	EPHC	3rd day, since 1/1/99	18.3 $\mu g/m^3$ (0.4 – 77)
	FP	3rd day, since 1/1/99	18.2 $\mu g/m^3$ (0.7 – 74)
	Ke	3rd day, since 1/1/99	18.0 $\mu g/m^3$ (2 – 94)
	Yo	3rd day, since 5/6/98	14.3 $\mu g/m^3$ (2 – 65)

Temporal Patterns

Features of the temporal profiles of selected meteorological measures, SO_2, CO, NO_2, NO_x, O_3, PM_{10}, and $PM_{2.5}$ are highlighted in Table 3 and described below for the January 1, 1993 through December 31, 2002 period.

Table 3. Features of temporal patterns for selected air quality measures (1/1/93 – 12/31/02).

	peak year	*peak month*	*peak day-of-wk*	*peak hours*	*R-value*[a]	*R-value*[b]
temperature	1994	July-August				
precipitation	1994	Jan-March				
wind speed	1994	Jan-March				
1-hr SO_2, GT	1993	Oct-March	Wednesday	10am – 5pm	0.27	0.11
1-hr CO, DT	1993	Oct-Feb	Wednesday	7am/9pm	0.47	0.17
1-hr NO_2, GT	1996	March-May	Wednesday	7am/9pm	0.53	0.22
1-hr NO_x, GT	1999	Oct-March	Wednesday	7am	0.49	0.16
8-hr O_3, CA	1999	July-August	Saturday	12pm – 5pm	0.72	0.54
24-hr PM_{10}, GT	1993	July-August	Wednesday	7am	0.69	0.45
24-hr $PM_{2.5}$, DHC	*1999*	*July-August*	*Thursday*	*9am*	*0.56*	*0.35*

[a] Correlation with value on previous day.
[b] Correlation with value two days previous.

Meteorological conditions in Atlanta in 1994 were unusual. This year had the highest total precipitation, average wind speed, and average daily temperature of any year during the study period. High rainfall resulted in much flooding in Georgia that year. In general, ambient air pollutant concentrations were low.

Annual average daily one-hour maximum SO_2 concentration was highest in 1993 at about 20 ppb at the Georgia Tech monitoring station. It decreased in 1994 and 1995, then held mostly constant at about 10 ppb through 2002. The decrease in SO_2 concentration is likely due to installation of scrubbers at Georgia coal-fired power plants. SO_2 concentrations are highest in winter. In July, SO_2 concentrations are also high, consistent with periods of high energy consumption. SO_2 concentrations are highest mid-week and lowest on weekends. Peak SO_2 concentrations typically occur between the hours of 10am and 5pm (EST). Occasional spikes of SO_2 concentration are observed during mid-day fumigation events.

Annual average daily one-hour maximum CO concentration was highest in 1993 at 2.1 ppm at the Dekalb Tech monitoring station. It has decreased since, to less than 1.3 ppm in 2002. CO levels are highest in fall and winter, peaking in November. By day-of-week, peak CO levels are observed mid-week. Two peaks in the diurnal pattern of CO are observed, at 7am and at 9pm. This pattern is consistent with mobile sources as a major source, with overnight levels higher than mid-day levels due to atmospheric mixing height.

Annual average daily one-hour maximum NO_2 concentration at the Georgia Tech monitoring station in mid-town Atlanta fluctuated between 40 and 50 ppb during the study period. At the more suburban South Dekalb College and Tucker sites, as well as at the monitoring stations in Conyers and Yorkville which are farther from Atlanta, NO_2 concentration increased during the study period, likely due to increased motor vehicle traffic. NO_2 levels are lowest in summer, and

highest in spring (April) and fall (October). NO_2 concentrations are lowest on weekends and highest mid-week. As with CO, the NO_2 diurnal patterns have two peaks. In the case of NO_2, the evening peak occurs between 8pm and 11pm and the morning peak occurs between 7am and 8am. These patterns are consistent with mobile sources as the major NO_2 source in the metro-Atlanta area.

The annual average daily one-hour maximum NO_x concentration is about 130 ppb at the Georgia Tech monitoring station. Like NO_2 and CO, NO_x levels are lowest in summer, peaking between November and February. By day-of-week, NO_x levels are highest mid-week and lowest on weekends. Levels peak at 7am on average.

Annual average daily eight-hour maximum O_3 concentration was highest in 1999, which was hot and dry, and lowest in 1994, when rainfall was high. O_3 levels are highest in the hottest months, July and August. On average, highest levels are observed on Saturdays, and lowest values on Monday, evidence of the slow conversion of precursors prior to the clearing out of primary pollutants on the weekend. Levels are highest between 1pm and 4pm (i.e., 2pm and 5pm DST).

Average PM_{10} values range from 25 to 35 $\mu g/m^3$ in downtown Atlanta from 1993 through 2002. Like ozone, PM_{10} is highest in mid-summer (July and August). Levels are lowest on weekends and highest mid-week. Peak values occur at 7am. Average $PM_{2.5}$ values range from 18 to 20 $\mu g/m^3$ in downtown Atlanta from 1998 through 2002. Like PM_{10}, $PM_{2.5}$ is highest in July and August. $PM_{2.5}$ is lowest on Mondays and highest on Fridays. It is lowest during the afternoons and peaks between 8am and 10am. These trends suggest a significant secondary formation component of particulate matter in metro-Atlanta.

Spatial Patterns

In Table 4, information is given on differences in the magnitude of the air pollutant levels and the correlation of air pollutant concentrations between the central monitoring location and stations farther from the Atlanta city center for the January 1, 1993 through December 31, 2002 period.

Table 4. Correlation coefficients for selected air pollutants at different metro Atlanta monitoring sites (1/1/93 – 12/31/02).

	station (primary listed first)	*R-value*[a]
1-hr max. SO_2	GT vs. JS/CA/St/Yo	0.67/0.70/0.11/0.04
1-hr max. CO	DT vs. JS/RR/Yo	0.72/0.65/0.16
1-hr max. NO_2	GT vs. JS/Tu/SD/Co/Yo	0.59/0.76/0.68/0.43/0.06
1-hr max. NO_x	GT vs. JS/Tu/SD/Co/Yo	0.88/0.82/0.84/0.70/0.20
8-hr max. O_3	CA vs. JS/SD/Co/Yo	0.98/0.97/0.91/0.84
24-hr avg PM_{10}	GT vs. JS/FCHD/FS8/DHC/Gr/Yo	0.86/0.67/0.66/0.63/0.70/0.80
24-hr avg $PM_{2.5}$	DHC vs. JS/Tu/FM/ERS/SD/FP/FS8/EPHC/Ke/Yo	0.82/0.72/0.76/0.78/0.72/0.84/0.79/0.79/0.75/0.77

[a] Correlation of value at secondary station to that at primary station (underlined).

SO_2 concentration is higher at the Georgia Tech monitoring station in mid-town Atlanta than at the Confederate Ave. station in downtown Atlanta and the station in Stilesboro. One-hour

maximum values at the Atlanta stations have a correlation coefficient of 0.70, and are not correlated to the Stilesboro and Yorkville values.

CO concentration is higher at the Roswell Rd station than the Dekalb Tech station, located farther from Atlanta city center. The Dekalb Tech station data are used as the primary values in this study because the Roswell Rd site is located nearer major roads and may be influenced more by local sources. The one-hour maximum CO data at the two stations have a correlation coefficient of 0.65.

NO_2 concentration is higher at the Jefferson St and Georgia Tech monitoring stations than at the suburban sites of Tucker and South Dekalb College, which are higher than the more rural sites of Conyers to the southeast and Yorkville to the west. NO_x concentration at the South Dekalb College station is higher than that at Georgia Tech and Jefferson St. Correlation coefficients for both NO_2 and NO_x concentrations decrease with increasing distance from the Georgia Tech station.

Eight-hour maximum ozone levels are slightly higher in downtown Atlanta (Confederate Ave station) and in Conyers (to the southeast) than at South Dekalb College. The lower levels at South Dekalb College are likely due to the higher NO concentrations, resulting in higher rates of O_3 consumption. The levels at the three sites are highly correlated.

Like O_3, PM_{10} and $PM_{2.5}$ concentrations do not decrease significantly until far outside metro-Atlanta area (e.g. Griffin and Yorkville). Like ozone, the levels are highly correlated over this wide area.

Interpolation of Missing Hourly Values

A program was written to linearly interpolate values for hours where air pollutant data are missing. The maximum number of consecutive hours for which data are missing and values are interpolated must be specified. The interpolation is performed prior to averages being calculated. Cells in which values have been interpolated are highlighted so that they can be identified. Alternative interpolation schemes were considered. Linear interpolation was found to be the best method for a limited number of consecutive missing hourly data over the range of situations encountered. Due to the air pollutant diurnal patterns, this procedure was found to yield more accurate averages than ignoring missing hourly values.

Imputation of Missing Daily Values

Statistical models were developed to impute missing daily values of air pollutant measures. These models utilize both temporal and spatial patterns, as well as correlations of the imputed measure with meteorological data and other air pollutant measures. R-values for correlations of air pollutant measures over time (i.e., with values of one day and two days previous) are listed in Table 3. R-values for correlations of air pollutant measures over space (i.e., with different

monitoring sites) are listed in Table 4. In Table 5 below, R-values are listed for correlations between air quality measures, including meteorological measures.

Table 5. R-values for correlations of air quality measures (1/1/93 – 12/31/02).

	SO_2	CO	NO_2	NO_x	O_3	PM_{10}	$PM_{2.5}$
1-hr max SO_2, GT	1						
1-hr max CO, DT	0.24	1					
1-hr max NO_2, GT	0.25	0.63	1				
1-hr max NO_x, GT	0.23	0.74	0.76	1			
8-hr max O_3, CA	0.15	0.16	0.44	0.15	1		
24-hr PM_{10}, GT	0.13	0.41	0.56	0.45	0.56	1	
24-hr $PM_{2.5}$, DHC	0.07	0.33	0.38	0.31	0.54	0.69	1
maximum T, HA	- 0.03	0.10	0.16	- 0.07	0.64	0.53	0.34
minimum RH, HA	- 0.24	- 0.27	- 0.49	- 0.34	- 0.46	- 0.21	- 0.02
average WSP, HA	- 0.08	- 0.44	- 0.46	- 0.46	- 0.31	- 0.44	- 0.34

Pollutants that are most correlated with each other are PM_{10} and $PM_{2.5}$ (R = 0.69) and NO_2 and NO_x (R = 0.76). NO_2 and $PM_{2.5}$ are components of NO_x and PM_{10}, respectively. CO and NO_x are also correlated (R = 0.74), likely because a major source of these pollutants is transportation. O_3 and $PM_{2.5}$ are correlated (R = 0.54), likely because O_3 and a significant fraction of $PM_{2.5}$ are secondary pollutants, produced by atmospheric reactions. O_3 is more strongly correlated with daily maximum temperature (R = 0.64) than the other pollutants, as expected. All pollutants are inversely correlated with minimum relative humidity and average wind speed, indicating highest pollutant levels occur on dry, still days. SO_2 is least correlated with other air pollutants and meteorological measures, likely due to periodic high concentration events caused by fumigation of power plant plumes.

Identification of Outlying Values

Statistical criteria were used to identify (and flag) outlying values for pollutants. This analysis provides an indication of potential measurement error and/or local effects on pollutant measures.

Summary

An air quality database has been extended to cover the period from January 1, 1993 through December 31, 2002 for use in epidemiologic study of multiple pollutants and risk of cardiac and respiratory emergency department visits in Atlanta. This database supplements the data collected under the ARIES program at a mid-town Atlanta site. Temporal and spatial patterns in the data have been studied to better understand how these ambient air pollutant measures might be used in the epidemiologic studies, and how the study findings might be interpreted. Electronic files have been transferred to the Emory School of Public Health researchers.

Appendix

Master Data File Summary, 1993-2002

1993-2002 summary

MET	pressure Hartsfield NCDC 24hr avg (millibar)	temp. Hartsfield NCDC max (deg F)	temp. Hartsfield NCDC min (deg F)	temp. Hartsfield NCDC .5max+min (deg F)	sunshine Hartsfield NCDC 24hr tot (minutes)	precip. Bolton Rd NCDC 24hr tot (inches)	precip. Hartsfield NCDC 24hr tot (inches)	RH Hartsfield NCDC min (%)	RH Hartsfield NCDC max (%)	dew point Hartsfield NCDC 24hr avg (deg F)	WSP Hartsfield NCDC 24hr avg (mph)	wind vec. Hartsfield NCDC 24hr avg (mph)	wind dir. Hartsfield NCDC 24hr avg (degrees)	visibility Hartsfield NCDC 24hr avg (miles)	visibility Fulton Co NCDC 24hr avg (miles)
avg	981.3	72.45	53.34	63.10	459.10	0.139	0.128	48.01	88.33	50.73	8.15	6.59		9.26	8.51
max	1001.4	102	80	90.5	860	5.05	6.68	100	100	74.7	28.1	23.9	360	21.3	19.2
min	959.0	18	6	13	0	0	0	7	40	-2.4	0.3	0.1	1	0.3	0.6
count	3652	3652	3652	3652	2398	3651	3651	3652	3652	3652	3652	3647	3647	3451	3245
missing	0	0	0	0	1254	1	1	0	0	0	0	5	5	201	407

NO2	Georgia Tech AQS 1hr max (ppb)	Georgia Tech AQS 24hr avg (ppb)	S. Dekalb College AQS 1hr max (ppb)	S. Dekalb College AQS 24hr avg (ppb)	Conyers AQS 1hr max (ppb)	Conyers AQS 24hr avg (ppb)	Tucker AQS 1hr max (ppb)	Tucker AQS 24hr avg (ppb)	Yorkville AQS 1hr max (ppb)	Yorkville AQS 24hr avg (ppb)	Jefferson St SEARCH 1hr max (ppb)	Jefferson St SEARCH 24hr avg (ppb)	composite (GT/SD/Tu avg) 1hr max (ppb)	composite (GT/SD/Tu avg) 24hr avg (ppb)
avg	44.6	23.5	33.4	16.0	14.7	7.1	32.7	16.6	11.7	5.3	52.9	34.2	36.8	18.7
max	181.0	74.4	139.0	66.7	80.0	26.3	100.0	50.2	70.0	31.6	200.0	199.4	113.7	56.8
min	7.0	1.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.1	0.1	8.1	2.9
count	3223	3223	3269	3269	3052	3052	2456	2456	2249	2249	1003	1003	3625	3625
missing	429	429	383	383	600	600	1196	1196	1403	1403	2649	2649	27	27

NOx	Georgia Tech AQS 1hr max (ppm)	Georgia Tech AQS 24hr avg (ppm)	S. Dekalb College AQS 1hr max (ppm)	S. Dekalb College AQS 24hr avg (ppm)	Conyers AQS 1hr max (ppm)	Conyers AQS 24hr avg (ppm)	Tucker AQS 1hr max (ppm)	Tucker AQS 24hr avg (ppm)	Yorkville AQS 1hr max (ppm)	Yorkville AQS 24hr avg (ppm)	Jefferson St SEARCH 1hr max (ppm)	Jefferson St SEARCH 24hr avg (ppm)	composite (GT/SD/Tu avg) 1hr max (ppm)	composite (GT/SD/Tu avg) 24hr avg (ppm)
avg	0.133	0.082	0.158	0.104	0.027	0.016	0.065	0.038	0.014	0.009	0.153	0.049	0.116	0.073
max	0.996	0.776	0.930	0.702	0.187	0.106	0.387	0.289	0.148	0.120	0.671	0.347	0.726	0.596
min	0.005	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.006	0.002	0.003	-0.003
count	1677	1677	2693	2693	2889	2889	2452	2452	2225	2225	994	994	2974	2974
missing	1975	1975	959	959	763	763	1200	1200	1427	1427	2658	2658	678	678

SO2	Confederate Ave. AQS 1hr max (ppb)	Confederate Ave. AQS 24hr avg (ppb)	Georgia Tech AQS 1hr max (ppb)	Georgia Tech AQS 24hr avg (ppb)	Stilesboro AQS 1hr max (ppb)	Stilesboro AQS 24hr avg (ppb)	Yorkville SEARCH 1hr max (ppb)	Yorkville SEARCH 24hr avg (ppb)	Jefferson St SEARCH 1hr max (ppb)	Jefferson St SEARCH 24hr avg (ppb)	composite (CA/GT avg) 1hr max (ppb)	composite (CA/GT avg) 24hr avg (ppb)
avg	12.51	3.72	15.30	4.44	12.36	3.09	11.58	3.21	18.61	6.13	14.03	4.13
max	136.00	31.60	149.00	36.25	273.00	45.58	157.91	29.27	100.78	39.57	102.67	30.03
min	1.00	0.04	1.00	0.25	1.00	1.00	0.18	0.06	0.05	0.05	1.99	0.81
count	3481	3481	3378	3378	3554	3554	2904	2904	1145	1145	3628	3628
missing	171	171	274	274	98	98	748	748	2507	2507	24	24

CO	Dekalb Tech AQS 1hr max (ppm)	Dekalb Tech AQS 8hr max (ppm)	Dekalb Tech AQS 24hr avg (ppm)	Roswell Rd AQS 1hr max (ppm)	Roswell Rd AQS 8hr max (ppm)	Roswell Rd AQS 24hr avg (ppm)	Yorkville SEARCH 1hr max (ppm)	Yorkville SEARCH 8hr max (ppm)	Yorkville SEARCH 24hr avg (ppm)	Jefferson St SEARCH 1hr max (ppm)	Jefferson St SEARCH 8hr max (ppm)	Jefferson St SEARCH 24hr avg (ppm)	composite (DT/RR avg) 1hr max (ppm)	composite (DT/RR avg) 8hr max (ppm)	composite (DT/RR avg) 24hr avg (ppm)
avg	1.678	1.096	0.744	2.002	1.335	0.978	0.297	0.246	0.210	1.369	0.861	0.557	1.850	1.220	0.865
max	7.700	6.138	3.721	9.600	5.163	3.667	1.060	0.951	0.599	7.666	6.389	3.379	7.502	4.155	3.247
min	0.100	0.013	0.004	0.200	0.125	0.083	0.076	0.071	0.071	0.196	0.175	0.149	0.397	0.231	0.165
count	3333	3333	3333	3039	3039	3039	2766	2766	2766	1133	1133	1133	3608	3608	3608
missing	319	319	319	613	613	613	886	886	886	2519	2519	2519	44	44	44

O3	Confederate Ave. AQS 1hr max (ppb)	Confederate Ave. AQS 8hr max (ppb)	Confederate Ave. AQS 24hr avg (ppb)	S. Dekalb College AQS 1hr max (ppb)	S. Dekalb College AQS 8hr max (ppb)	S. Dekalb College AQS 24hr avg (ppb)	Conyers AQS 1hr max (ppb)	Conyers AQS 8hr max (ppb)	Conyers AQS 24hr avg (ppb)	Yorkville SEARCH 1hr max (ppb)	Yorkville SEARCH 8hr max (ppb)	Yorkville SEARCH 24hr avg (ppb)	Jefferson St SEARCH 1hr max (ppb)	Jefferson St SEARCH 8hr max (ppb)	Jefferson St SEARCH 24hr avg (ppb)	composite (CA/SD/Co avg) 1hr max (ppb)	composite (CA/SD/Co avg) 8hr max (ppb)	composite (CA/SD/Co avg) 24hr avg (ppb)
avg	62.99	53.78	30.16	59.22	49.58	24.77	62.70	54.54	30.73	57.14	51.60	40.29	53.53	44.29	24.42	54.06	46.03	26.36
max	180.00	147.60	80.71	174.00	138.25	63.75	166.00	133.25	69.50	159.21	133.06	90.21	167.19	130.81	72.28	158.12	127.24	64.05
min	3.00	2.88	2.29	3.00	2.25	2.08	9.00	5.36	3.13	3.32	2.82	1.75	2.15	1.25	0.86	3.32	2.82	1.75
count	2396	2396	2396	2349	2349	2349	2414	2414	2414	2926	2926	2926	1173	1173	1173	3465	3465	3465
missing	1256	1256	1256	1303	1303	1303	1238	1238	1238	726	726	726	2479	2479	2479	187	187	187

PM10 mass	FCHD MAI-DNR 24hr avg (ug/m3)	GT MAI-DNR 24hr avg (ug/m3)	GT AMP-DNR 24hr avg (ug/m3)	GT AQS 24hr avg (ug/m3)	FCHD AQS 24hr avg (ug/m3)	DHC AQS 24hr avg (ug/m3)	FS8 AQS 24hr avg (ug/m3)	Griffin AQS 24hr avg (ug/m3)	East River AQS 24hr avg (ug/m3)	Douglasvil AQS 24hr avg (ug/m3)	Yorkville SEARCH 24hr avg (ug/m3)	Jefferson S SEARCH 24hr avg (ug/m3)	FCHD/GT composite 24hr avg (ug/m3)
avg	30.83	29.46	26.18	26.03	29.83	24.81	32.02	23.43	19.50	24.83	21.21	27.77	27.17
max	105.00	70.00	77.00	98.38	151.00	74.00	80.00	62.00	79.00	59.00	61.53	100.14	105.00
min	2.00	7.00	3.00	4.21	0.00	0.00	0.00	0.00	0.00	4.00	4.81	3.85	2.00
count	714	1230	609	1771	540	546	560	528	149	72	321	1347	3285
missing	2938	2422	3043	1881	3112	3106	3092	3124	3503	3580	3331	2305	367

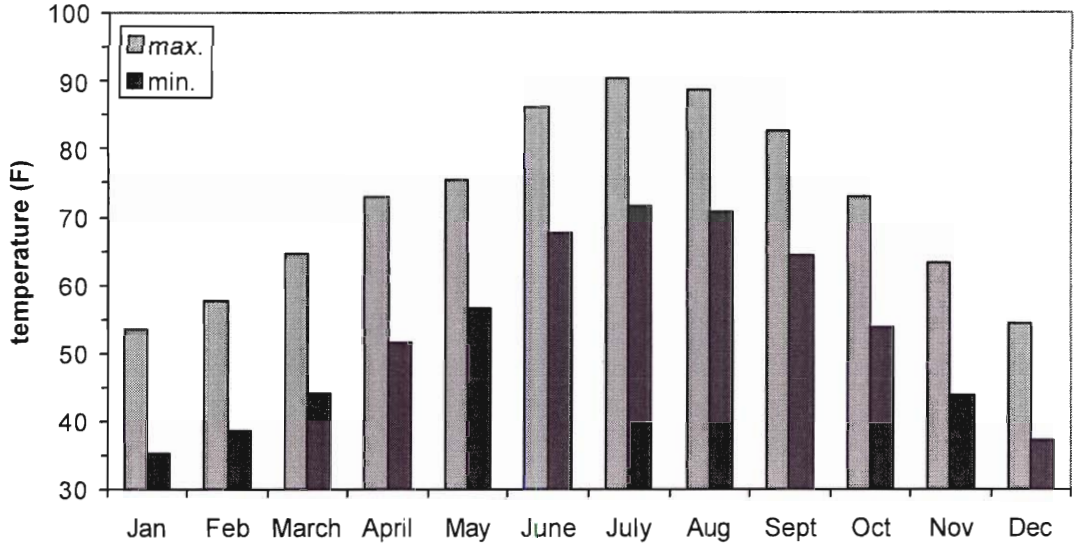
PM2.5 mass	Doraville AQS 24hr avg (ug/m3)	H.E. Rivers AQS 24hr avg (ug/m3)	S.South Dek AQS 24hr avg (ug/m3)	Fire Sta #8 AQS 24hr avg (ug/m3)	East Point AQS 24hr avg (ug/m3)	Forest Park AQS 24hr avg (ug/m3)	Kennesaw AQS 24hr avg (ug/m3)	Yorkville AQS 24hr avg (ug/m3)	S. Dekalb AQS 24hr avg (ug/m3)	Ft.McPh. ASACA 24hr avg (ug/m3)	JSt-ARIES ASACA 24hr avg (ug/m3)	Tucker ASACA 24hr avg (ug/m3)	S. Dekalb ASACA 24hr avg (ug/m3)	DHC/ERS/SD avg composite 24hr avg (ug/m3)
avg	18.44	17.97	17.70	20.12	18.25	18.22	18.01	15.85	15.84	19.21	19.95	19.79	18.09	18.53
max	89.40	140.00	140.00	76.80	77.10	73.80	94.10	130.00	40.00	74.77	72.07	51.82	47.20	66.83
min	0.70	1.60	1.00	0.80	0.40	0.70	1.60	0.60	4.70	3.00	0.00	2.69	5.04	5.42
count	1248	1234	1206	432	306	426	423	431	119	614	1166	1008	601	1613

PM2.5 mass	Yorkville SEARCH 24hr avg (ug/m3)	Yorkville SEARCH 24hr avg (ug/m3)	Yorkville SEARCH 24hr avg (ug/m3)	JSt SEARCH 24hr avg (ug/m3)	JSt SEARCH 24hr avg (ug/m3)	JSt SEARCH 24hr avg (ug/m3)
avg	14.35	14.74	14.16	16.05	16.08	16.53
max	64.85	37.41	68.95	65.81	49.26	68.04
min	2.22	1.83	0.81	3.35	1.93	1.68
count	1108	506	1363	1436	673	1209

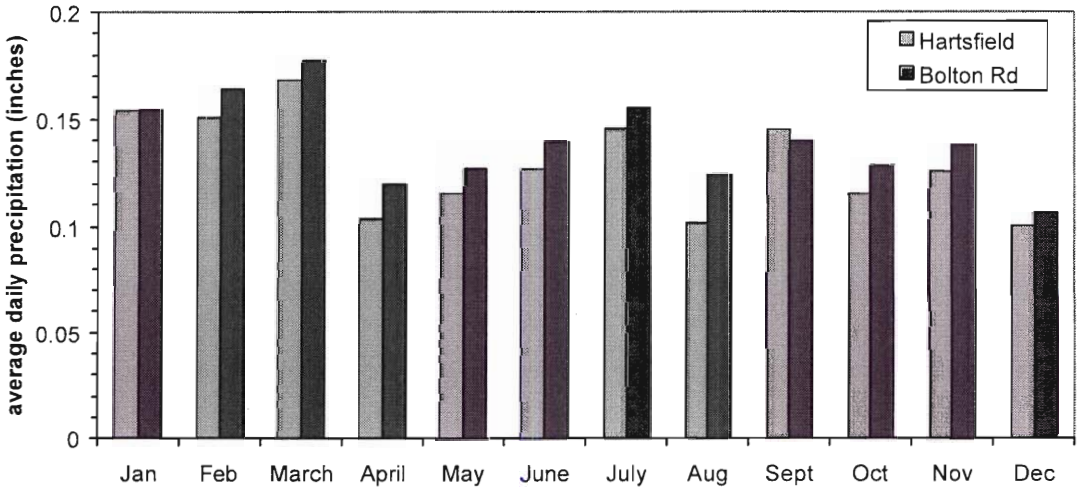
TSP mass	FCHD AQS 24hr avg (ug/m3)
avg	45.53
max	93.00
min	15.00
count	160
	3492

Selected Meteorological Data, 1993-2002

(a) Maximum and minimum daily temperatures, by month

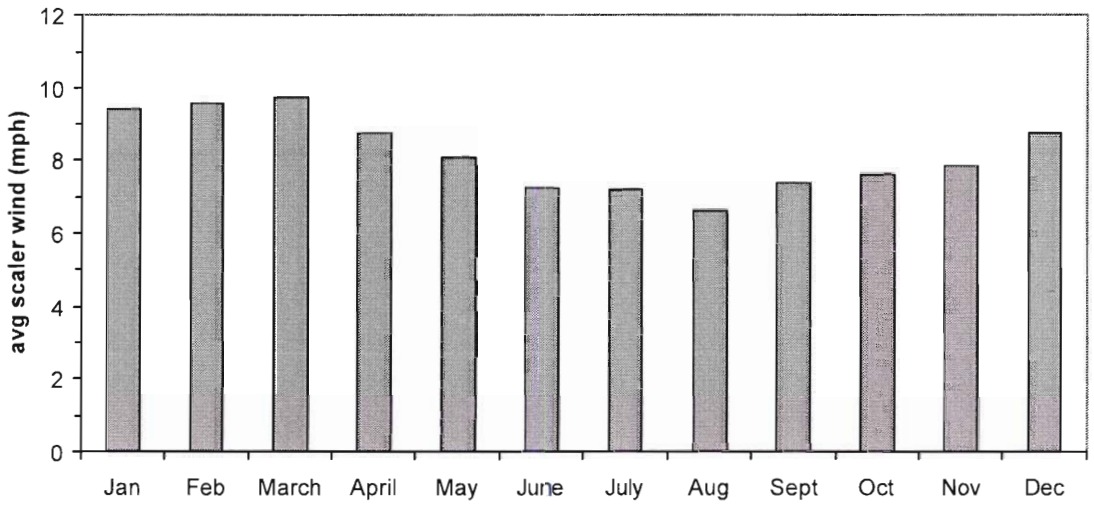


(b) Daily average precipitation, by month

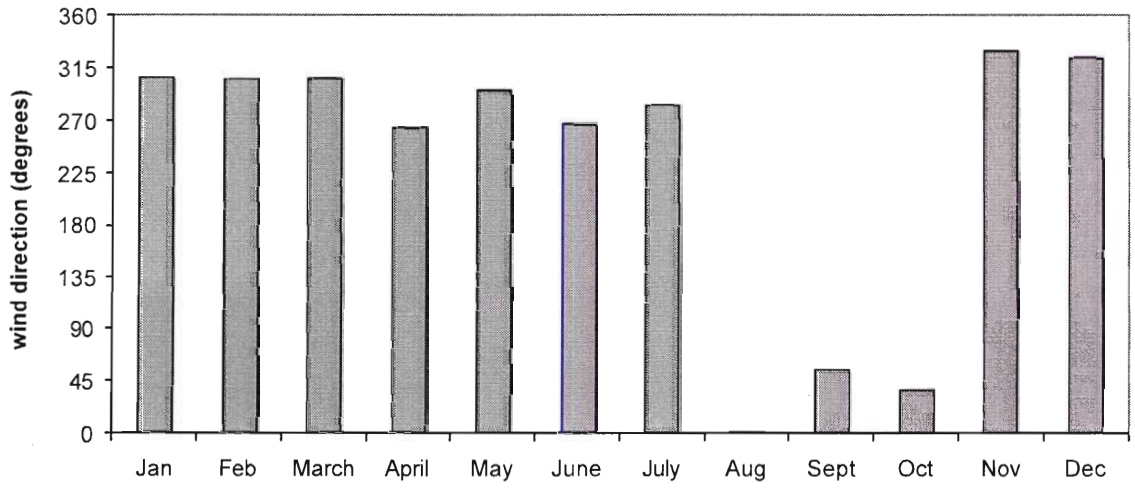


Selected Meteorological Data, 1993-2002

(c) Average wind speed, by month

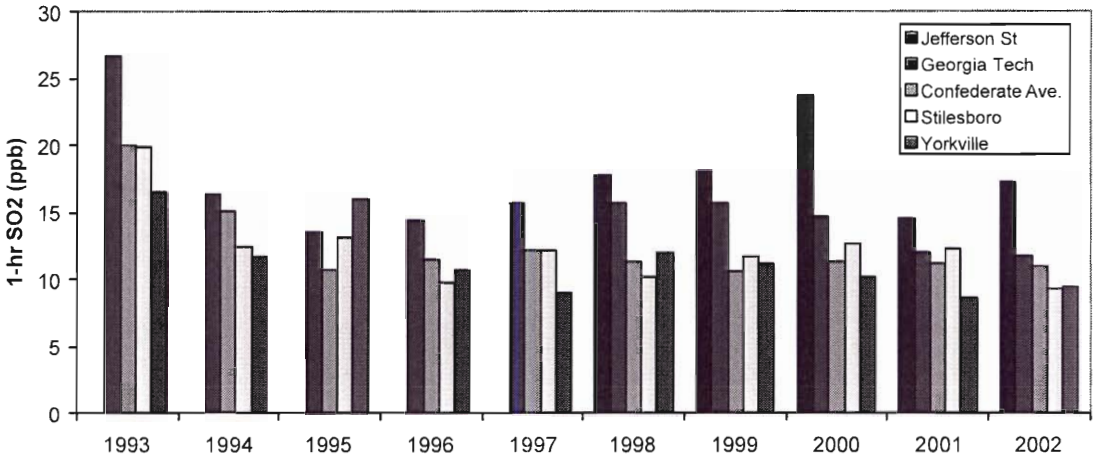


(d) Average wind vector direction, by month

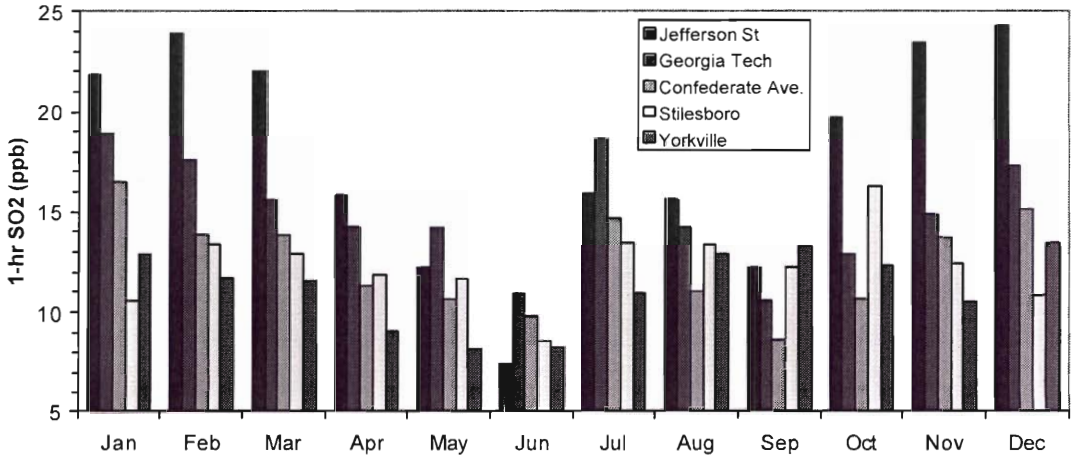


SO_2 Data Summary, 1993-2002

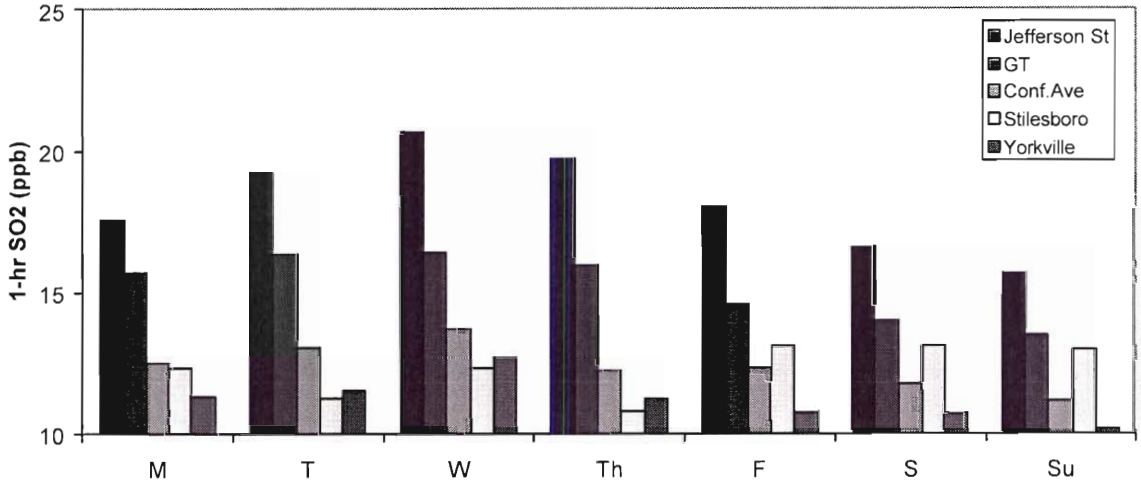
(a) Average daily one-hour maximum SO_2 concentration, by year



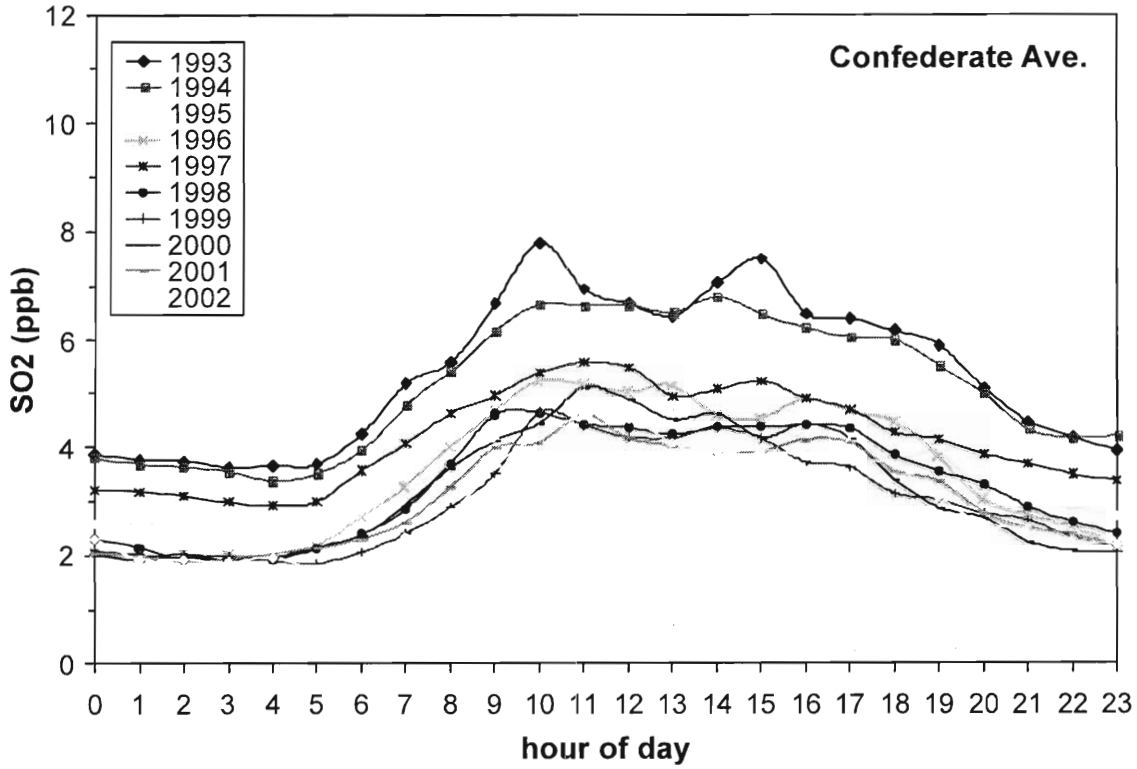
(b) Average daily one-hour maximum SO_2 concentration, by month



(c) Average daily one-hour maximum SO_2 concentration, by day-of-week

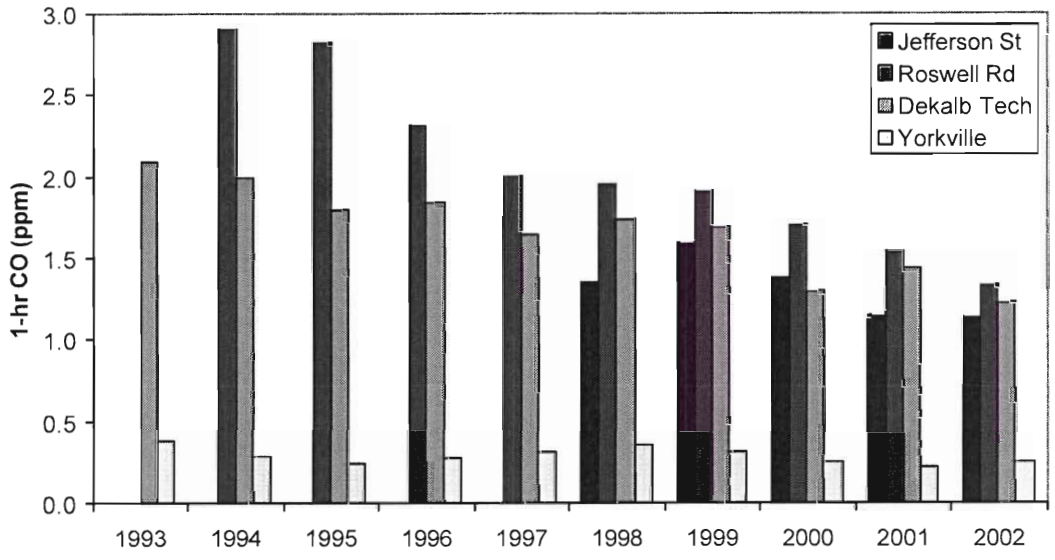


(d) Average diurnal SO_2 concentration, by year

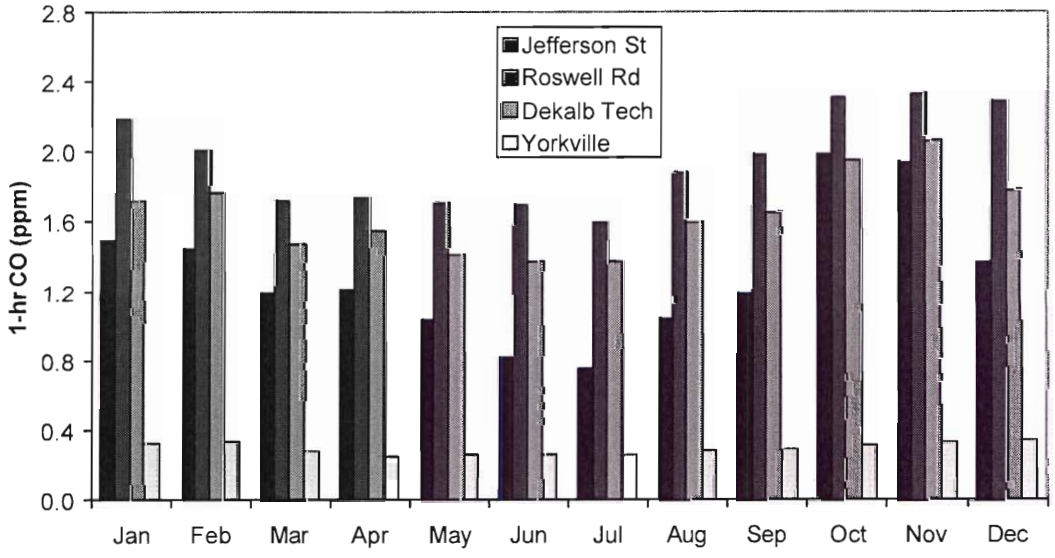


CO Data Summary, 1993-2002

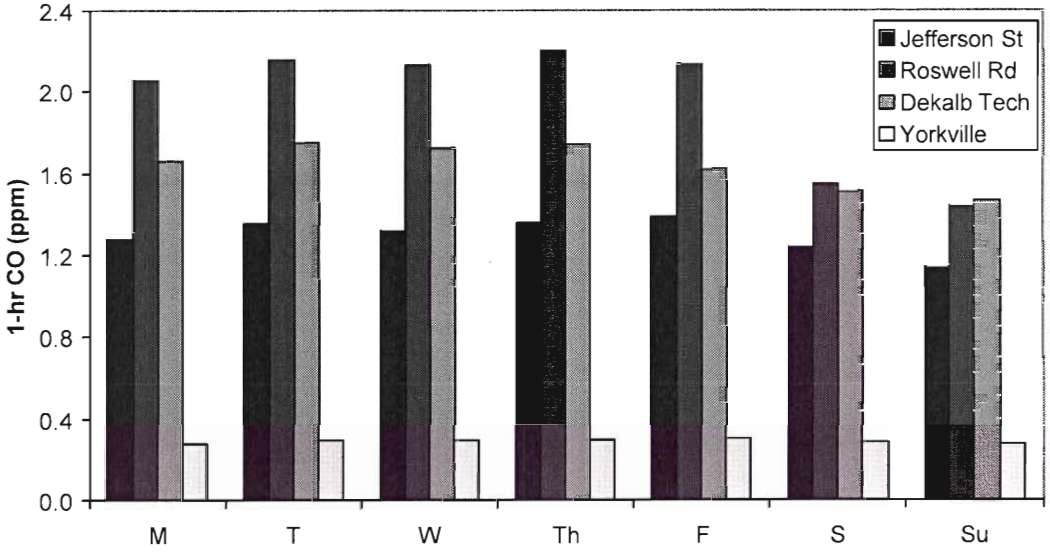
(a) Average daily one-hour maximum CO concentration, by year



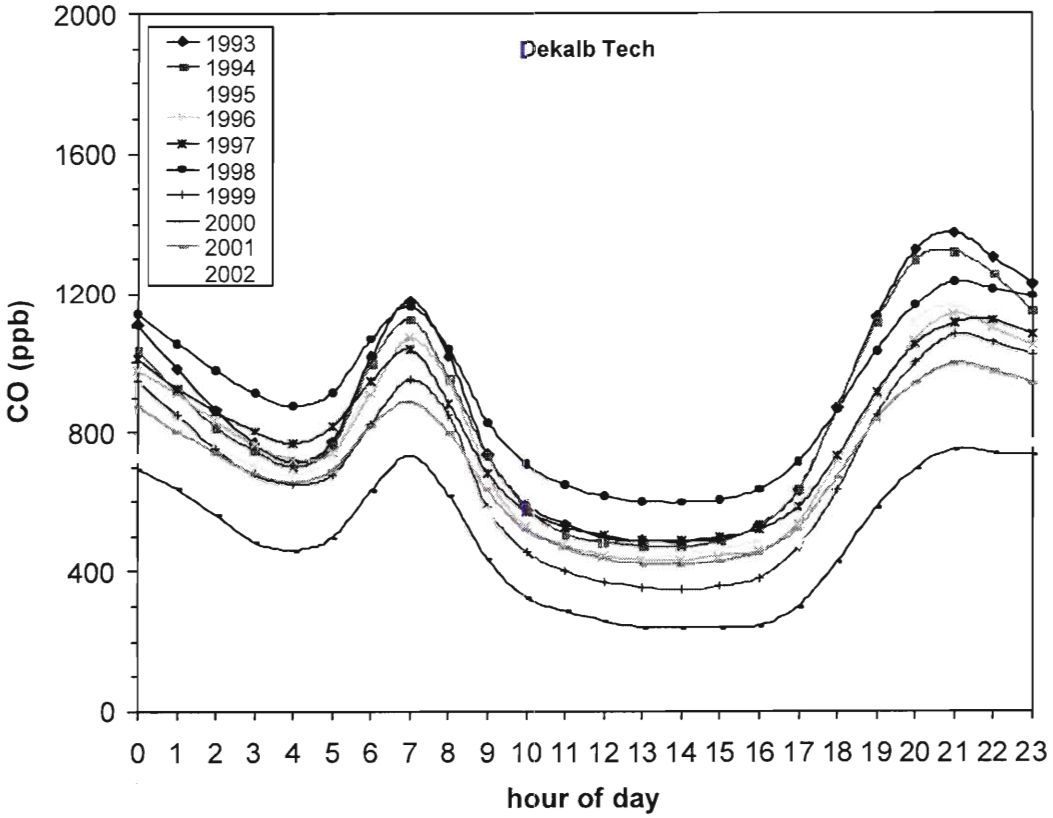
(b) Average daily one-hour maximum CO concentration, by month



(c) Average daily one-hour maximum CO concentration, by day-of-week

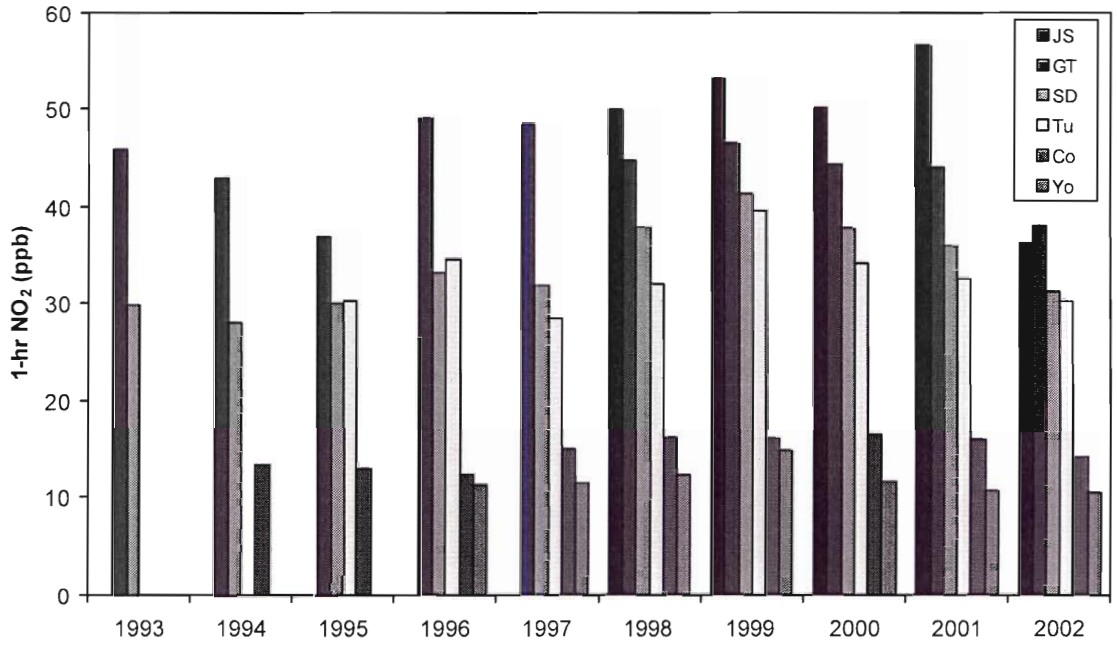


(d) Average diurnal CO concentration, by year

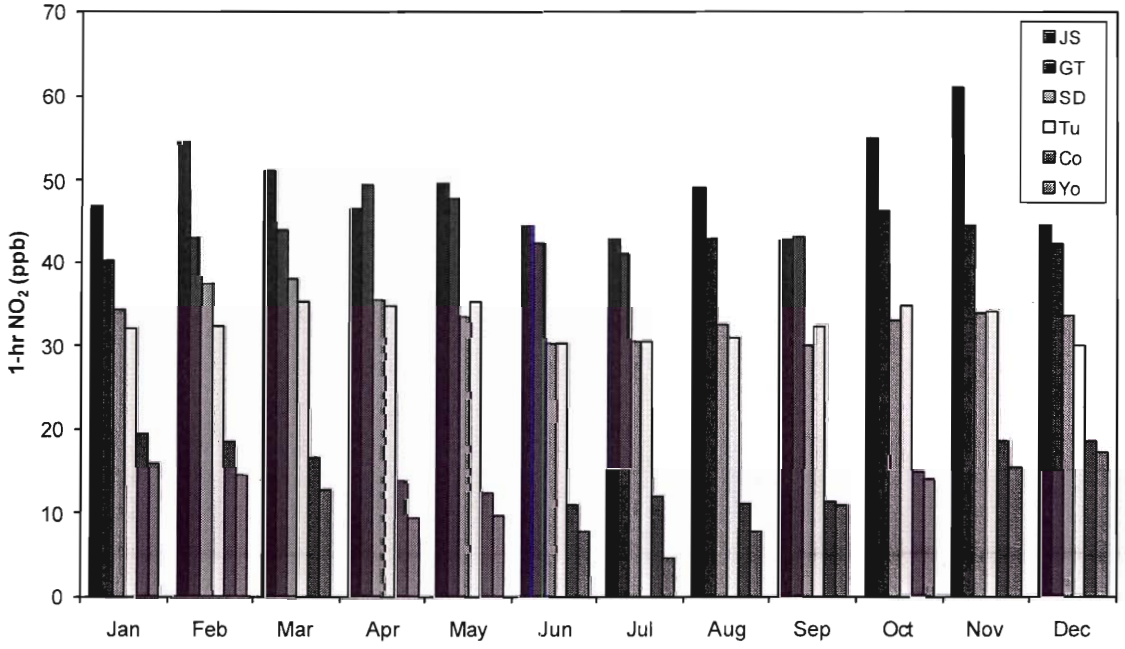


NO_2 Data Summary, 1993-2002

(a) Average daily one-hour maximum NO_2 concentration, by year

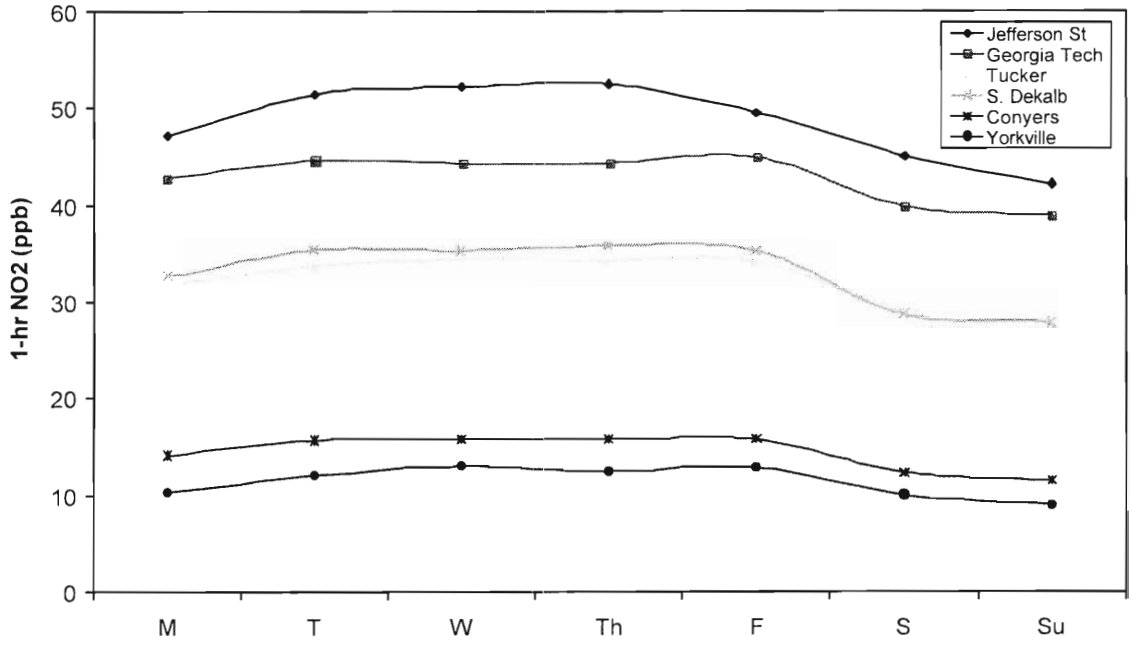


(b) Average daily one-hour maximum NO_2 concentration, by month

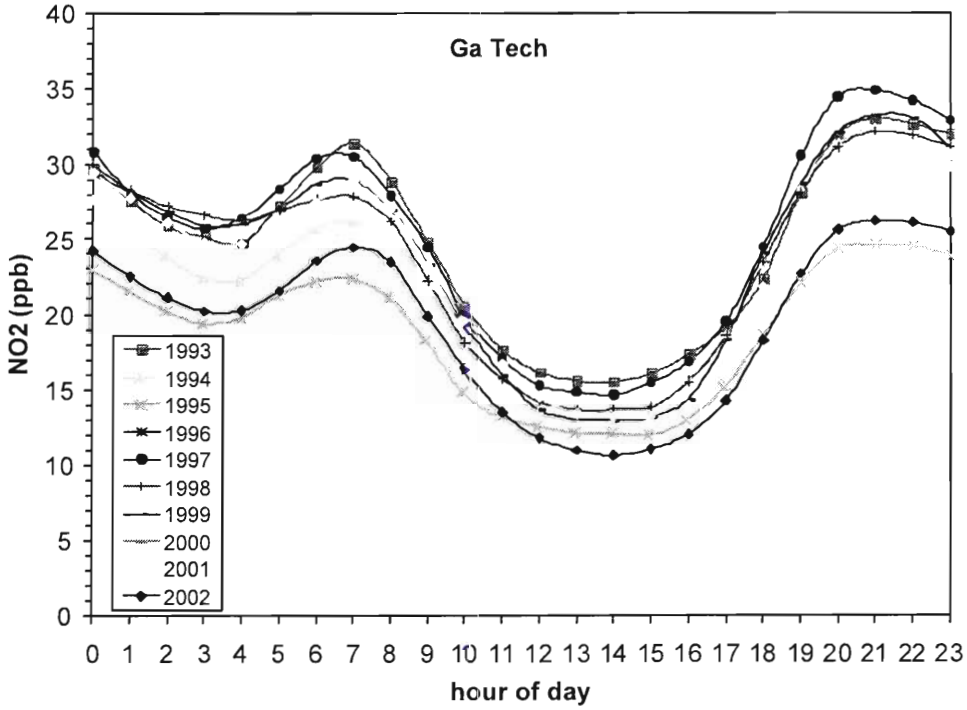


NO_2 Data Summary, 1993-2002

(c) Average daily one-hour maximum NO_2 concentration, by day-of-week

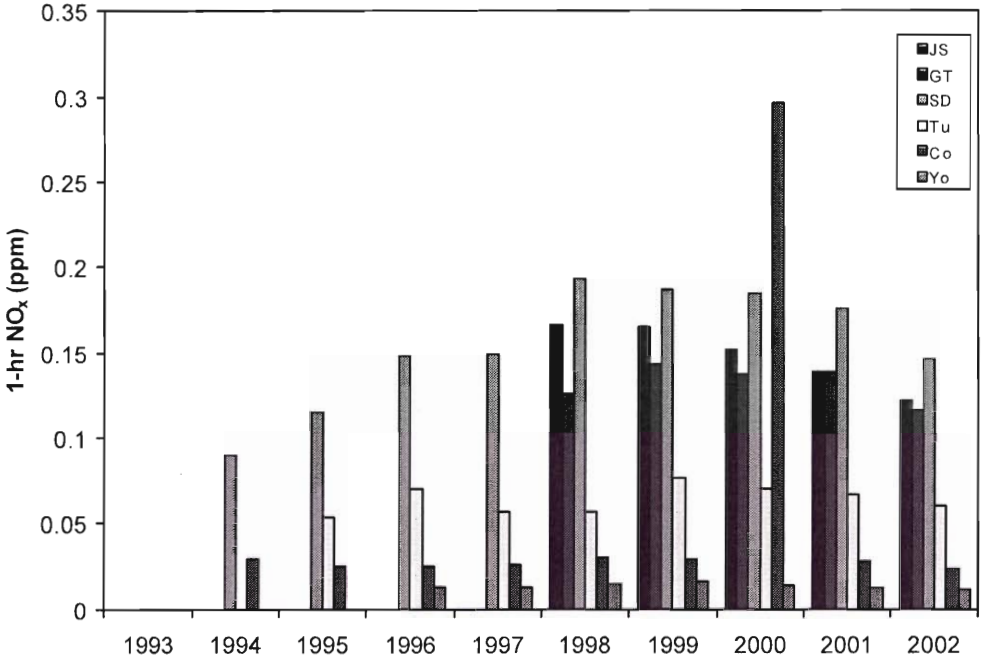


(d) Average diurnal NO_2 concentration, by year

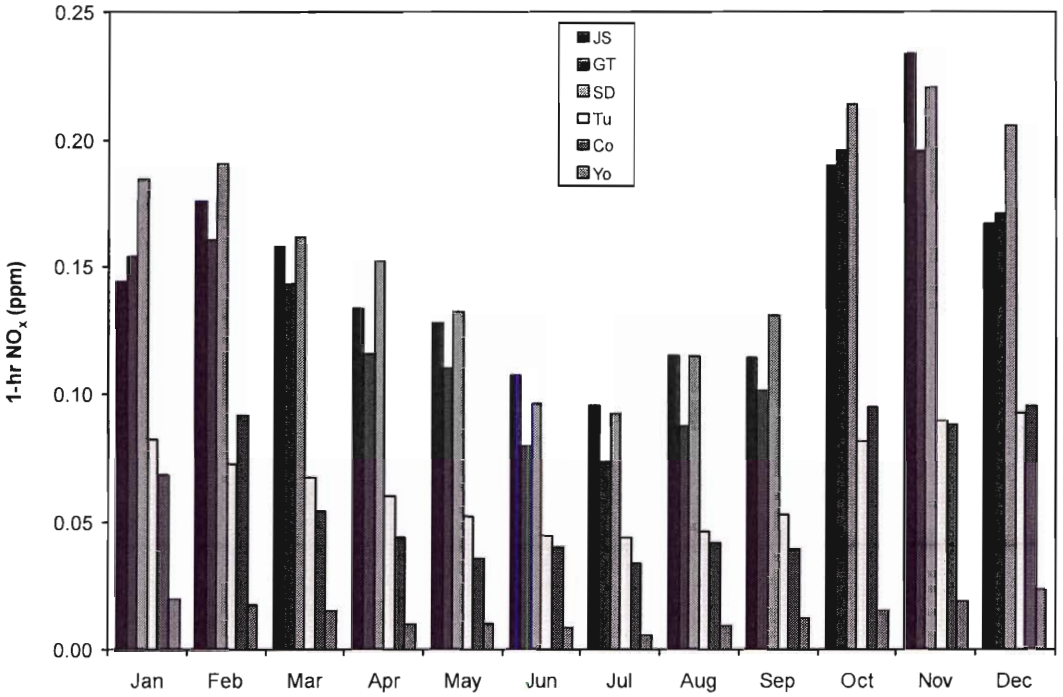


NO_x Data Summary, 1993-2002

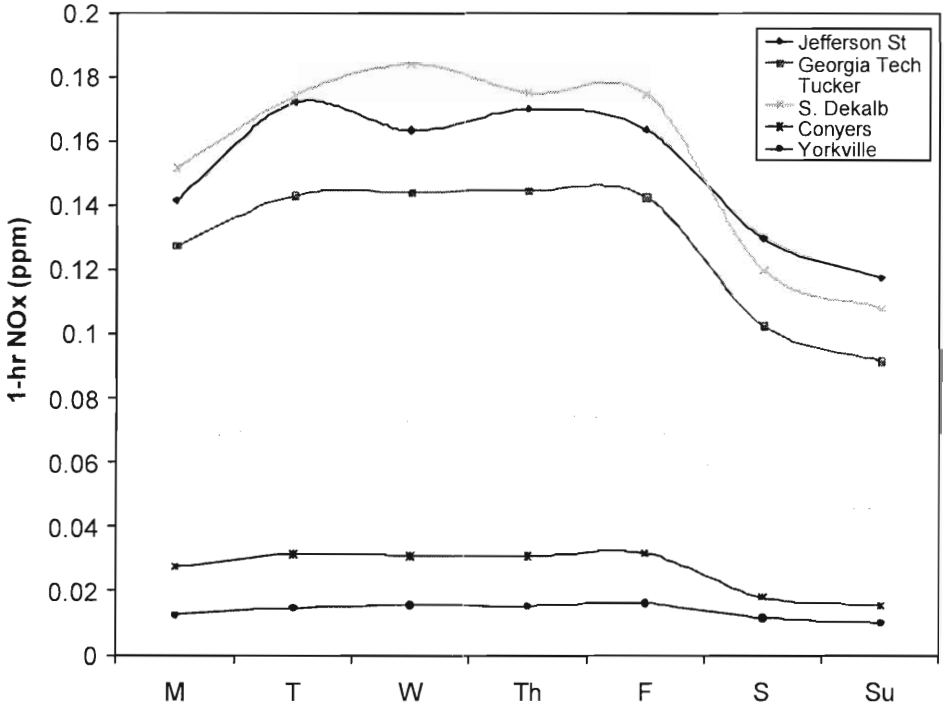
(a) Average daily one-hour maximum NO_x concentration, by year



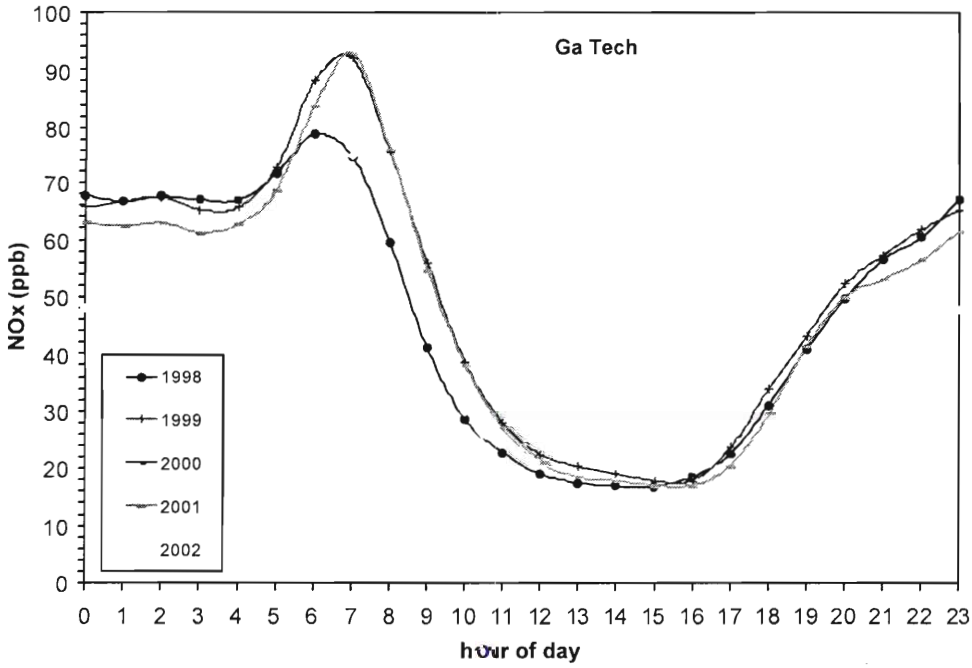
(b) Average daily one-hour maximum NO_x concentration, by month



(c) Average daily one-hour maximum NO_x concentration, by day-of-week

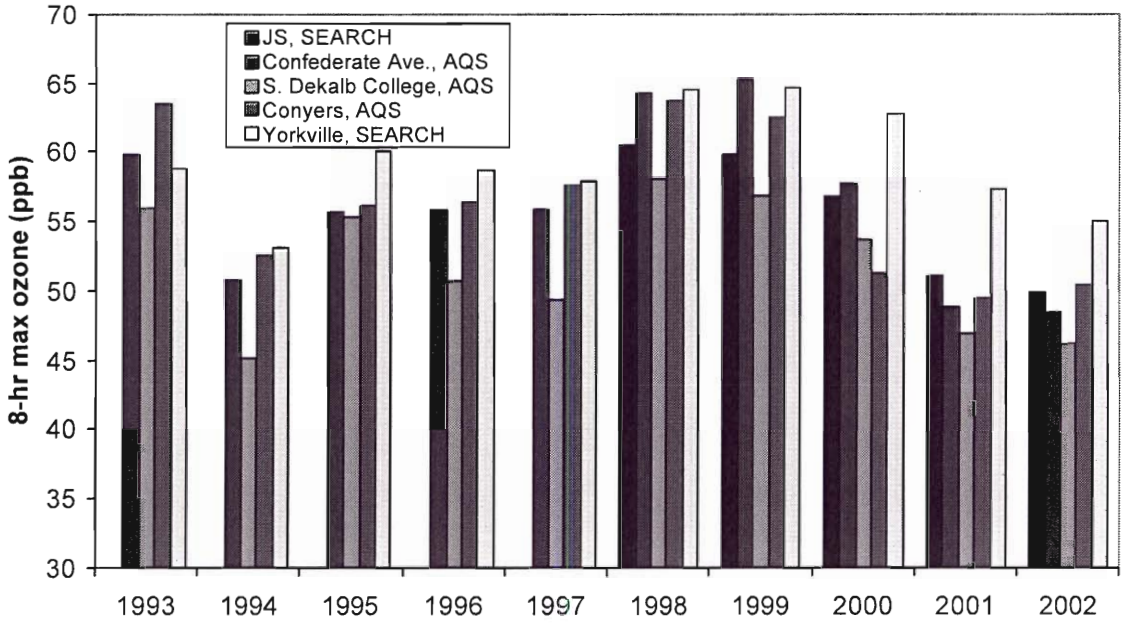


(d) Average diurnal NO_x concentration, by year

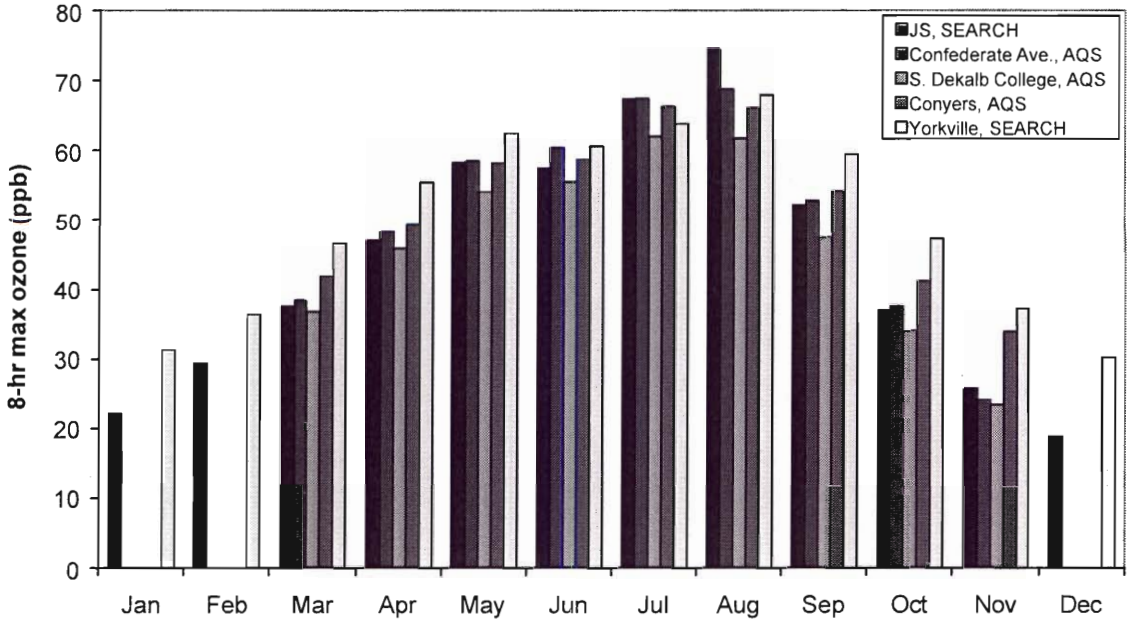


O_3 Data Summary, 1993-2002

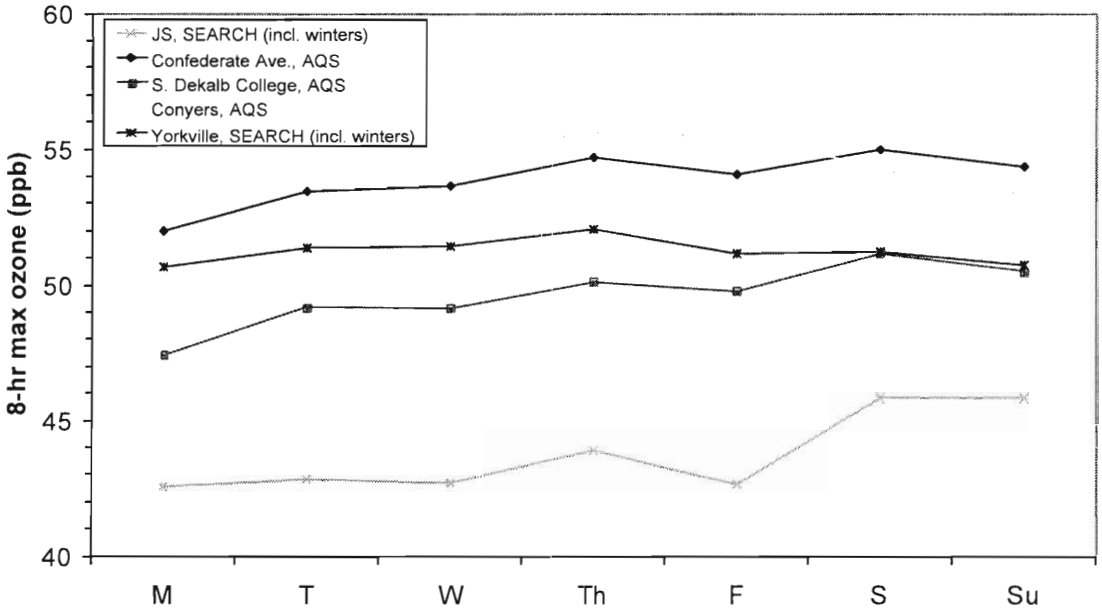
(a) Average daily eight-hour maximum O_3 concentration, by year



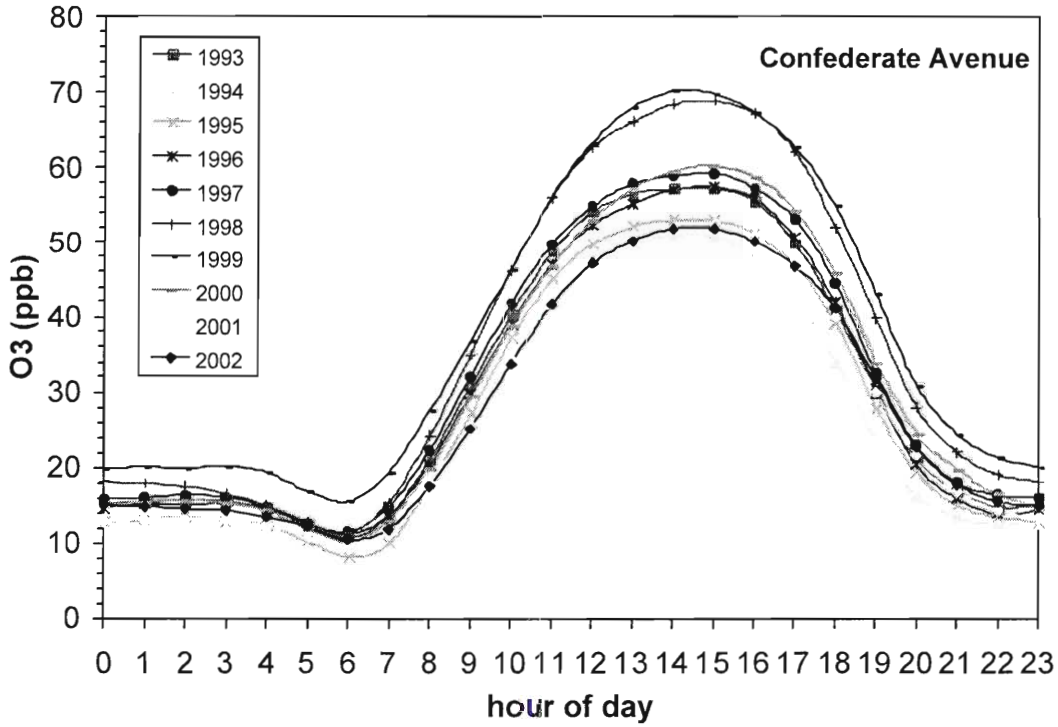
(b) Average daily eight-hour maximum O_3 concentration, by month



(c) Average daily eight-hour maximum O_3 concentration, by day-of-week

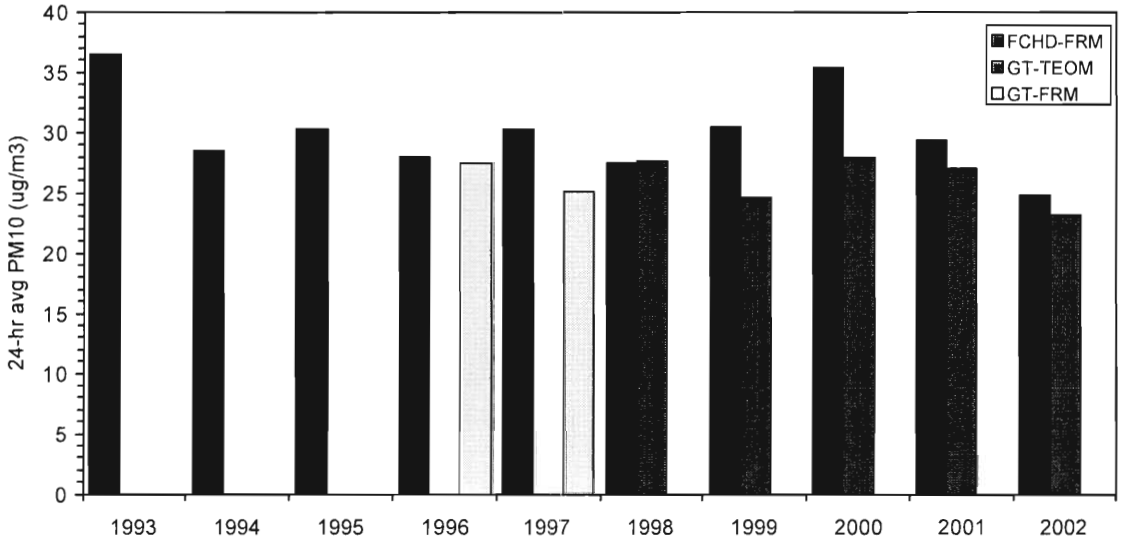


(d) Average diurnal O_3 concentration, by year

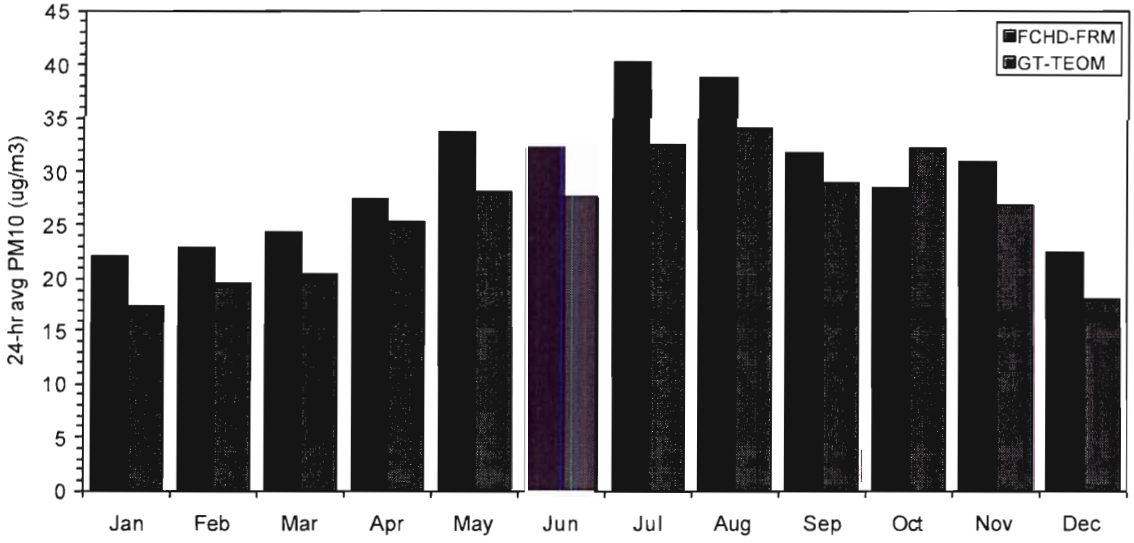


PM Data Summary, 1993-2002

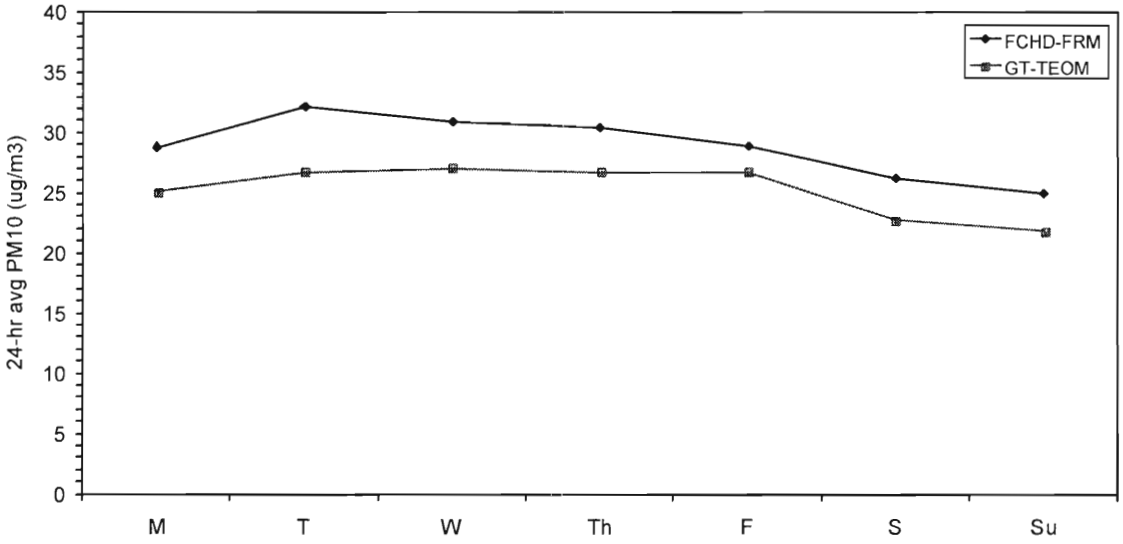
(a) Average daily PM_{10} concentration, by year



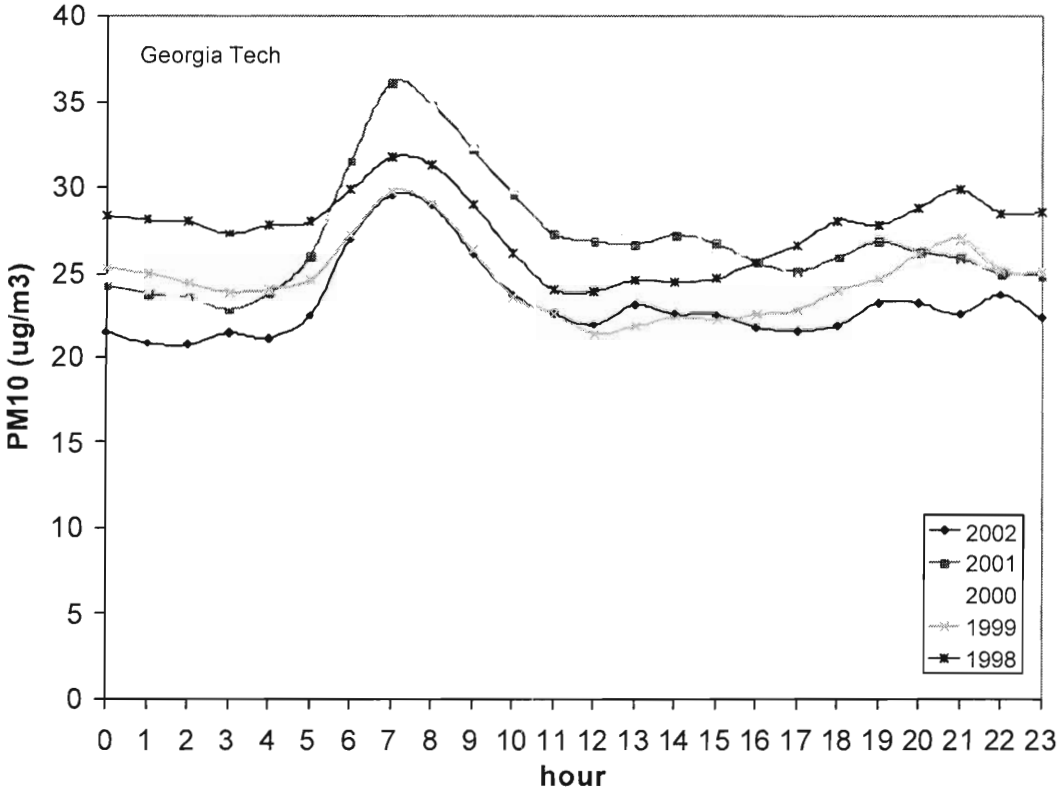
(b) Average daily PM_{10} concentration, by month



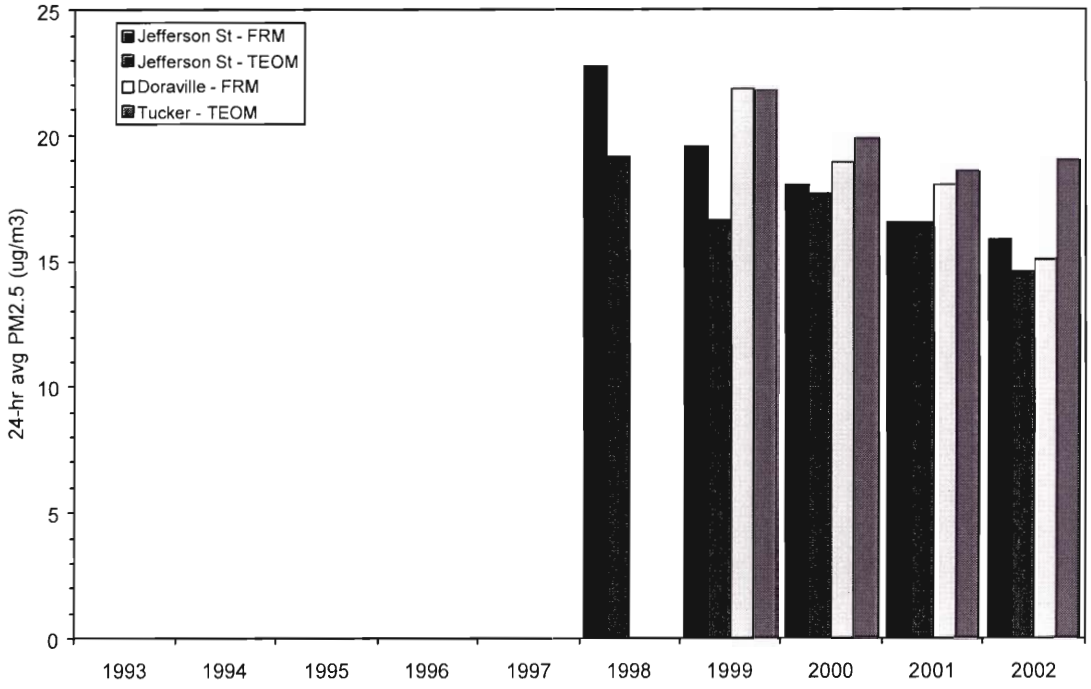
(c) Average daily PM_{10} concentration, by day-of-week



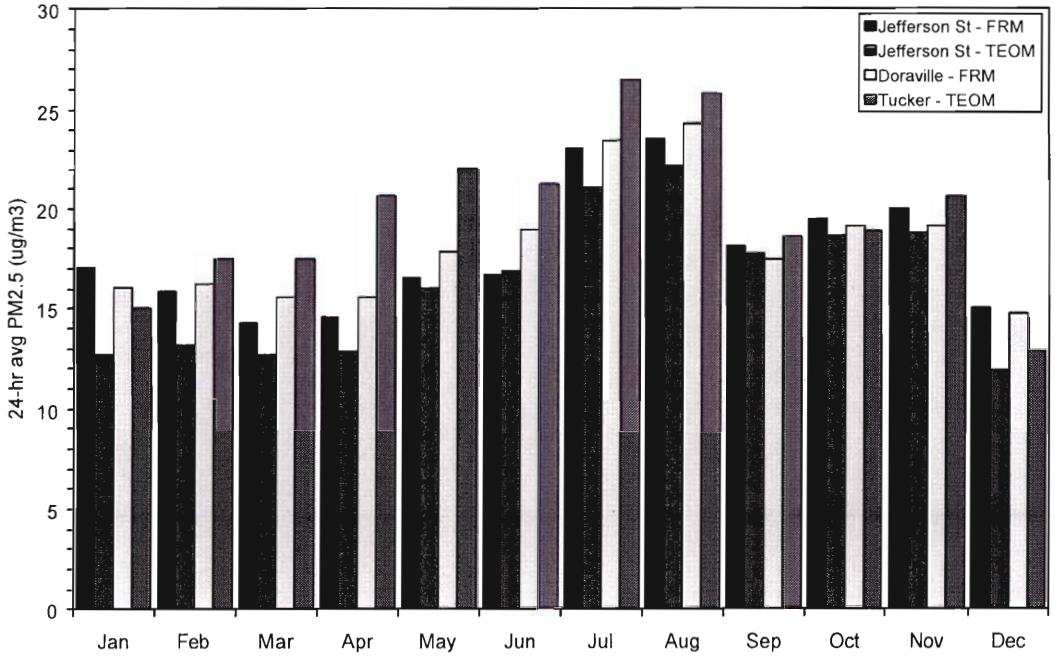
(d) Average diurnal PM_{10} concentration, by year



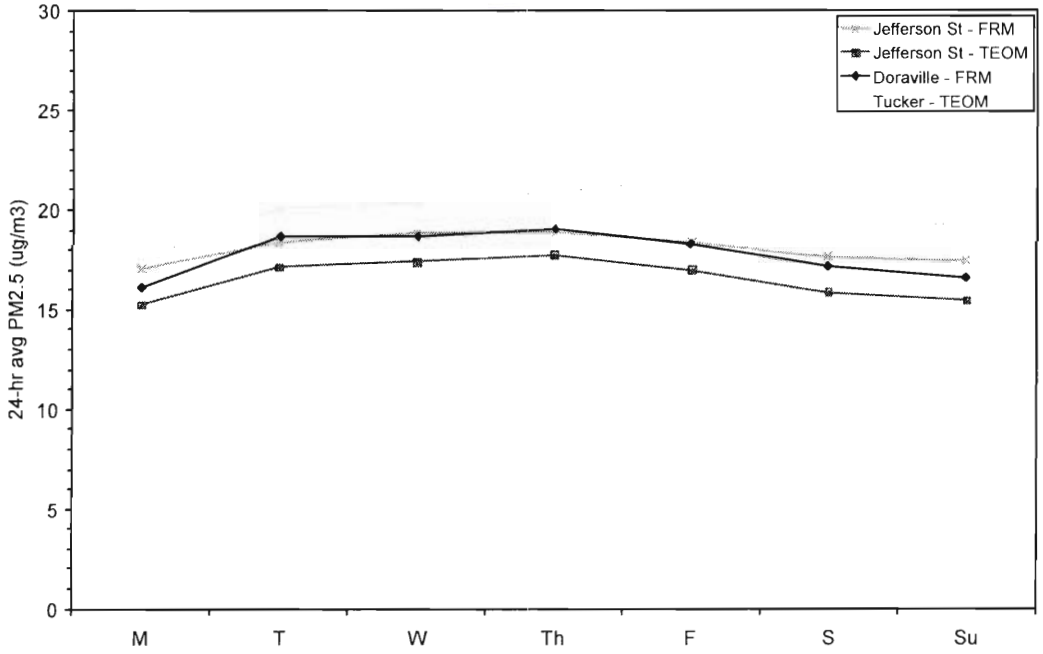
(e) Average daily $PM_{2.5}$ concentration, by year



(f) Average daily $PM_{2.5}$ concentration, by month



(g) Average daily $PM_{2.5}$ concentration, by day-of-week



(h) Average diurnal $PM_{2.5}$ concentration, by year