Now what have we gotten into?
(A brief look at data from the Southeast and a closer look at CTR)

Eric S. Edgerton

SOAS/SENEX/NOMMADS Science Coordination Meeting
Washington, DC
March 13, 2012

Outline

- Variability of PM and Trace Gases over Space and Time
- A Closer look at CTR Data (what might we expect in June-July 2013?)
  – Trace Gases
  – PM
  – Meteorology

The Southeastern Aerosol Research and Characterization (SEARCH) study: Temporal trends in gas and PM concentrations and composition, 1999–2010

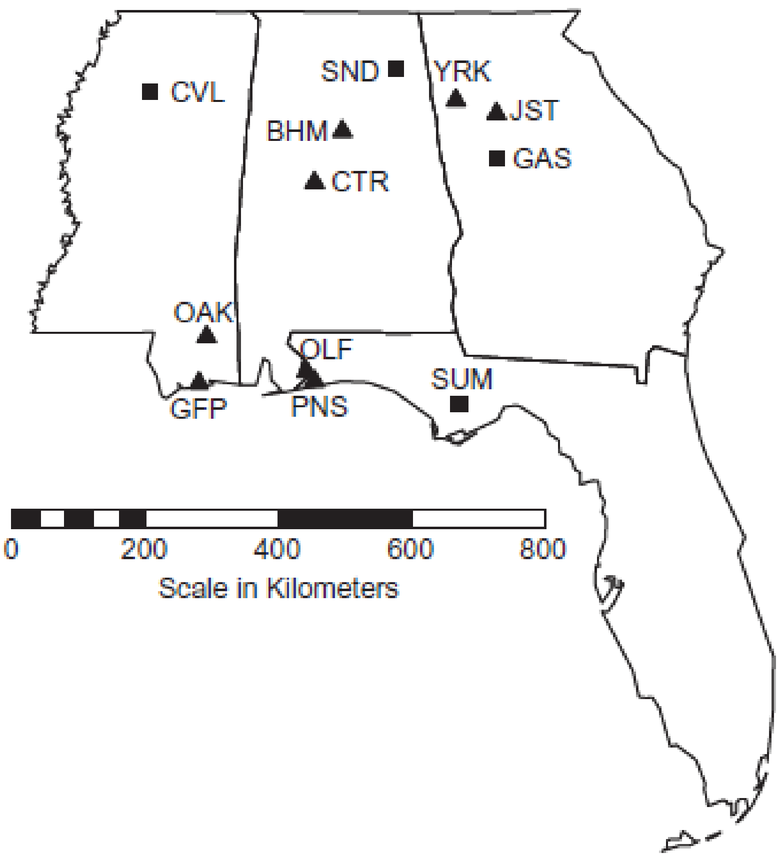
C.L. Blanchard,[1,*] G.M. Hidy,[2] S. Tanenbaum,[1] E.S. Edgerton,[3] and B.E. Hartsell[3]

[1] *Envair, Albany, California, USA*

[2] *Envair/Aerochem, Placitas, New Mexico, USA*

[3] *Atmospheric Research and Analysis, Cary, North Carolina, USA*

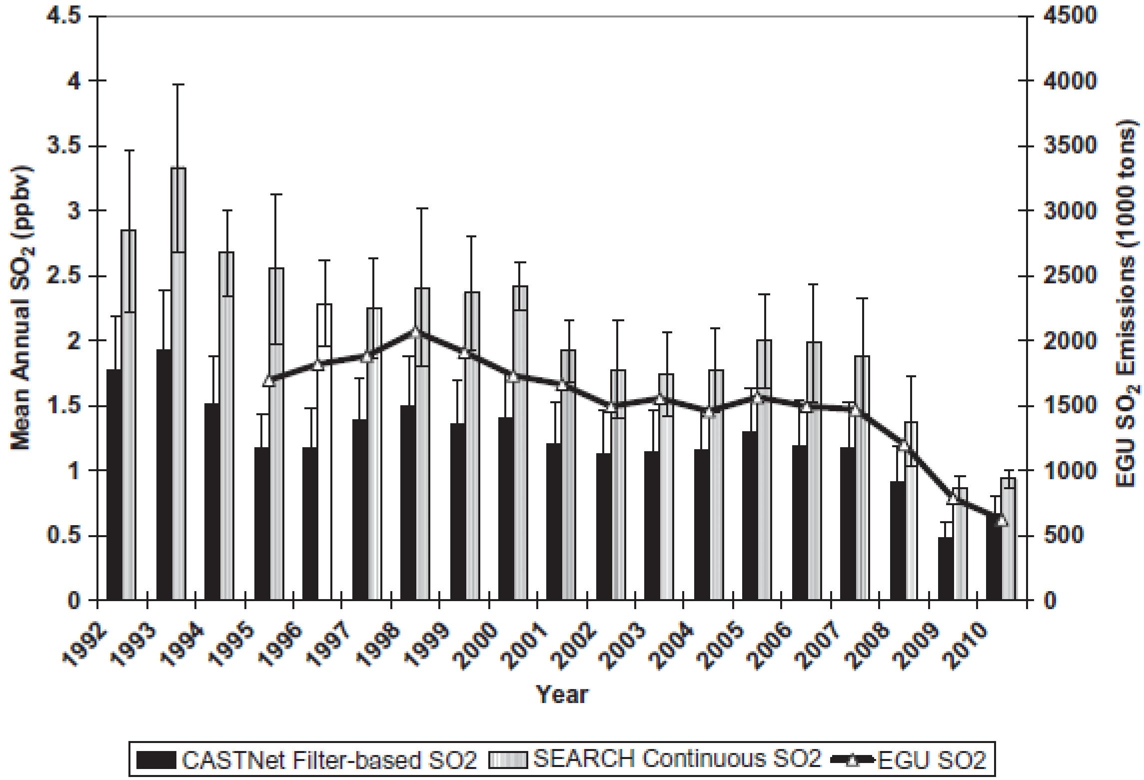
* *Please address correspondence to: C.L. Blanchard, Envair, 526 Cornell Avenue, Albany, CA 94706, USA; e-mail: cbenvair@pacbell.net*



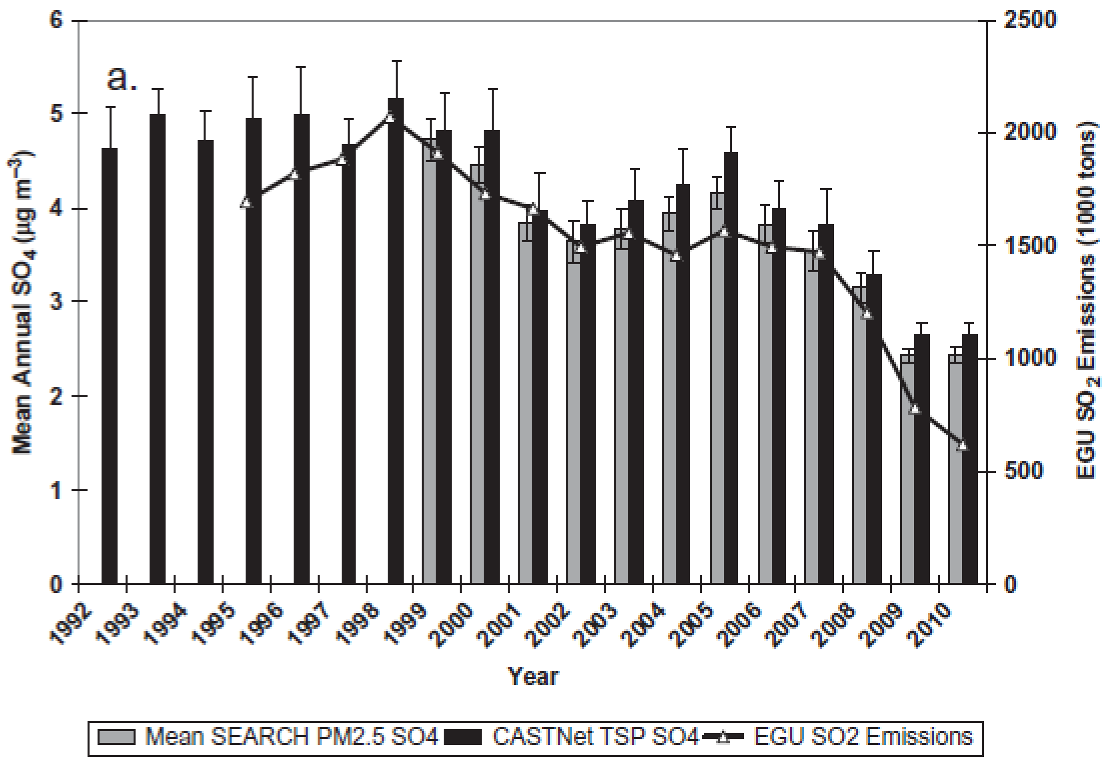
Emissions Trends

Year	CO	NH_3	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Mobile VOC[a]	On-road NO_x[a]	Nonroad NO_x[a]	EGU NO_x[b]	EGU SO_2[b]	EGU CO_2[b]
1990	18.22	0.34	2.62			2.80	2.59	1.69	1.25	0.40		2.17	
1991								1.62	1.23	0.41			
1992								1.56	1.21	0.42			
1993								1.49	1.19	0.43			
1994								1.42	1.17	0.43			
1995								1.35	1.15	0.44	0.72	1.70	274.6
1996	14.03	0.37	2.63	2.03	0.59	2.39	2.22	1.29	1.13	0.45	0.73	1.82	284.8
1997	13.72	0.37	2.66	2.12	0.61	2.46	2.20	1.23	1.14	0.45	0.73	1.88	298.8
1998	13.65	0.39	2.69	2.14	0.63	2.64	2.17	1.20	1.12	0.44	0.77	2.07	313.7
1999	15.99	0.36	2.70	2.66	1.03	2.46	2.42	1.17	1.09	0.44	0.73	1.91	316.1
2000	14.47	0.36	2.68	2.40	0.86	2.28	2.17	1.12	1.09	0.45	0.72	1.73	326.1
2001	15.16	0.32	2.62	2.39	0.88	2.23	2.19	1.06	1.01	0.44	0.68	1.66	318.8
2002	13.99	0.32	2.44	2.04	0.60	2.04	2.74	1.12	1.02	0.48	0.61	1.49	328.5
2003								1.07	0.96	0.50	0.56	1.56	335.8
2004								1.03	0.90	0.51	0.51	1.46	333.7
2005	12.48	0.33	2.25	2.12	0.68	2.11	2.66	0.98	0.84	0.52	0.50	1.57	349.8
2006								0.94	0.79	0.49	0.48	1.49	350.3
2007								0.90	0.74	0.45	0.46	1.47	361.0
2008[c]	9.22	0.30	1.75	1.75	0.43	1.46	1.54	0.86	0.69	0.42	0.42	1.20	339.0
2009								0.75	0.62	0.36	0.23	0.79	296.2
2010			1.33[d]			0.88[e]		0.63	0.56	0.31	0.24	0.62	338.6

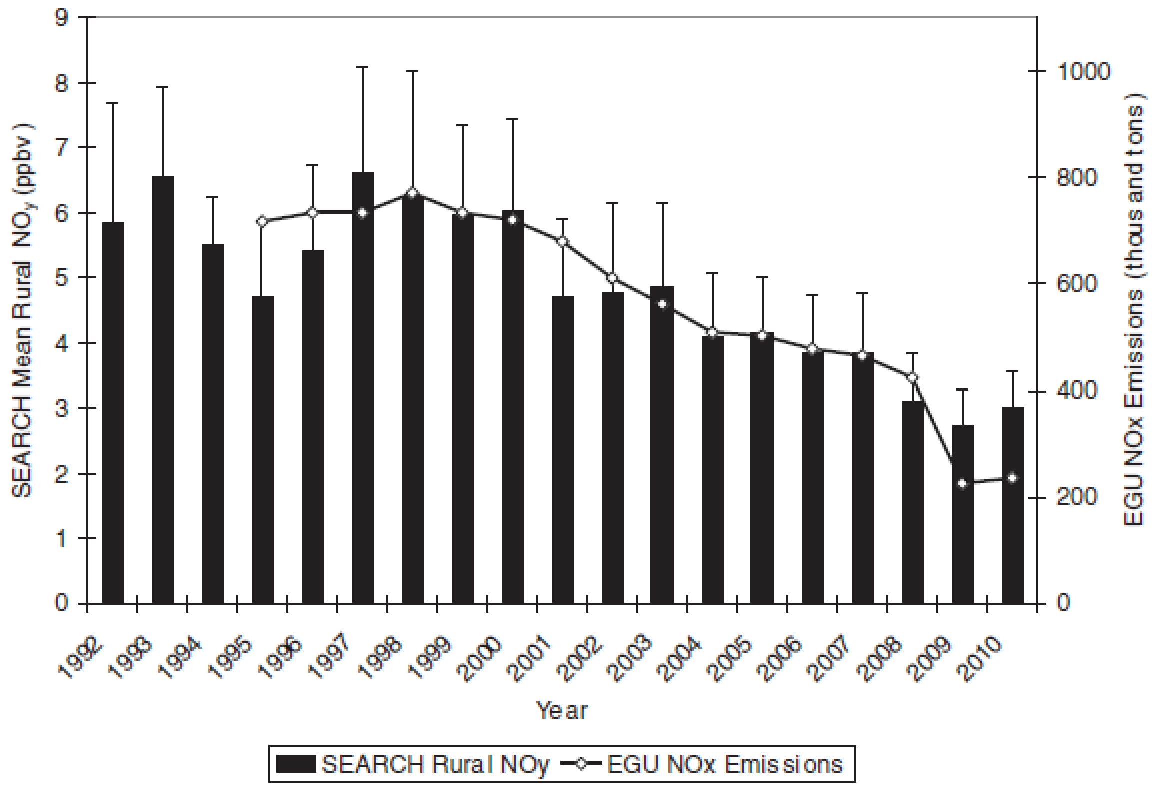
SO2 Emissions and Concentrations Trends



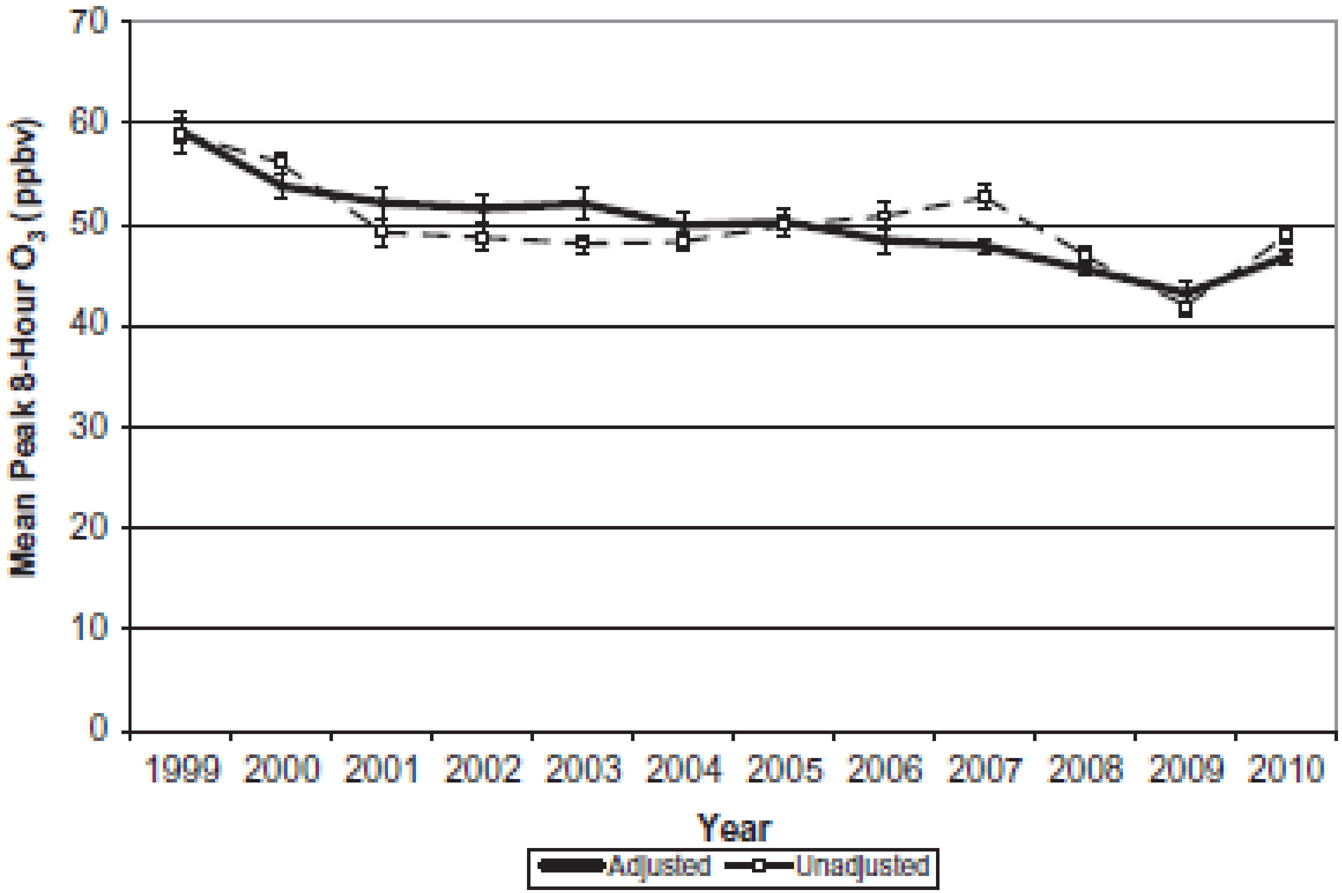
SO4 Concentrations and SO2 Trends



NOX and NOy Trends



Meteorologically adjusted Ozone

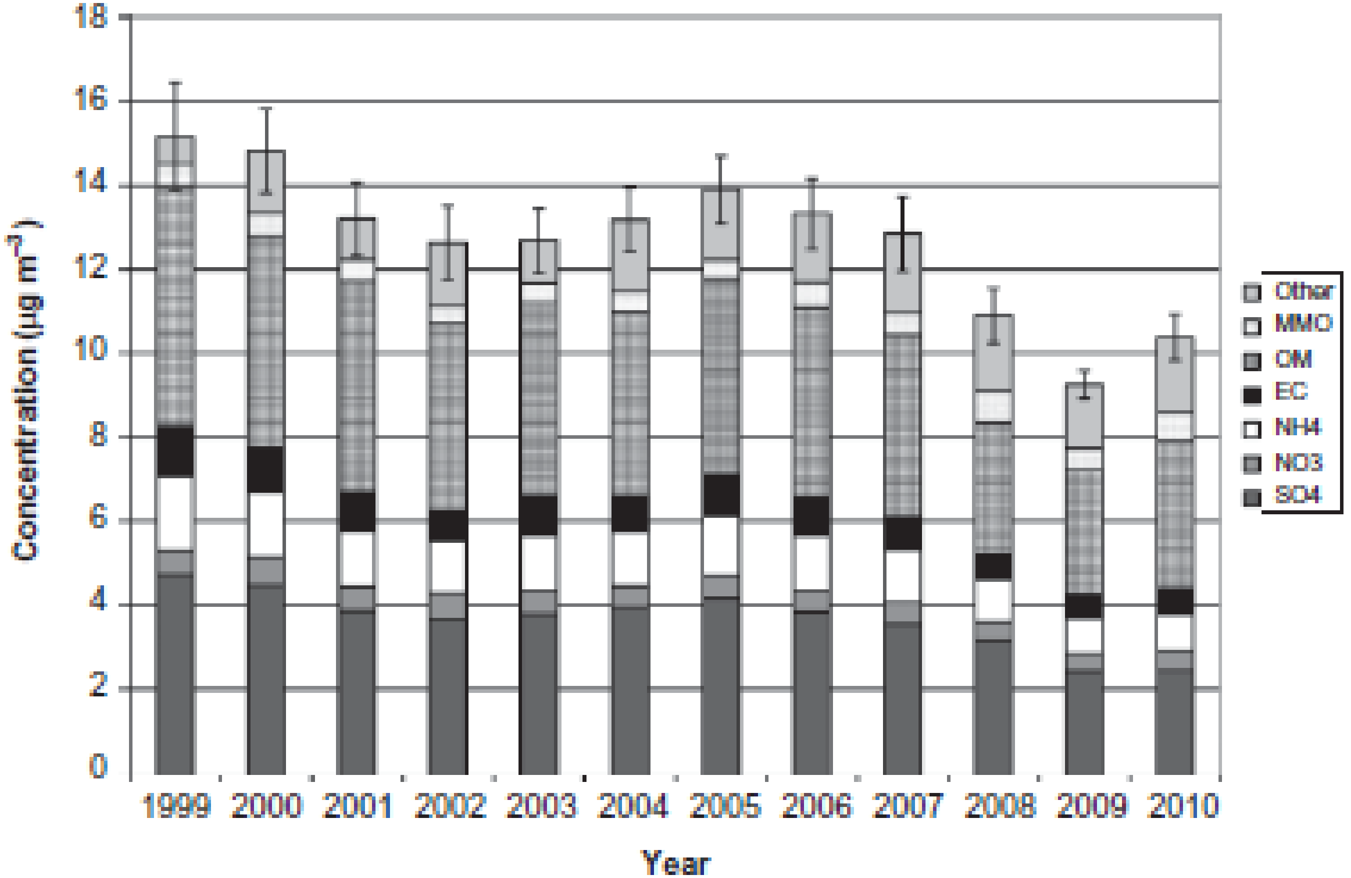


Annual Rate of Change for SEARCH Gases and $PM_{2.5}$ (%/yr)

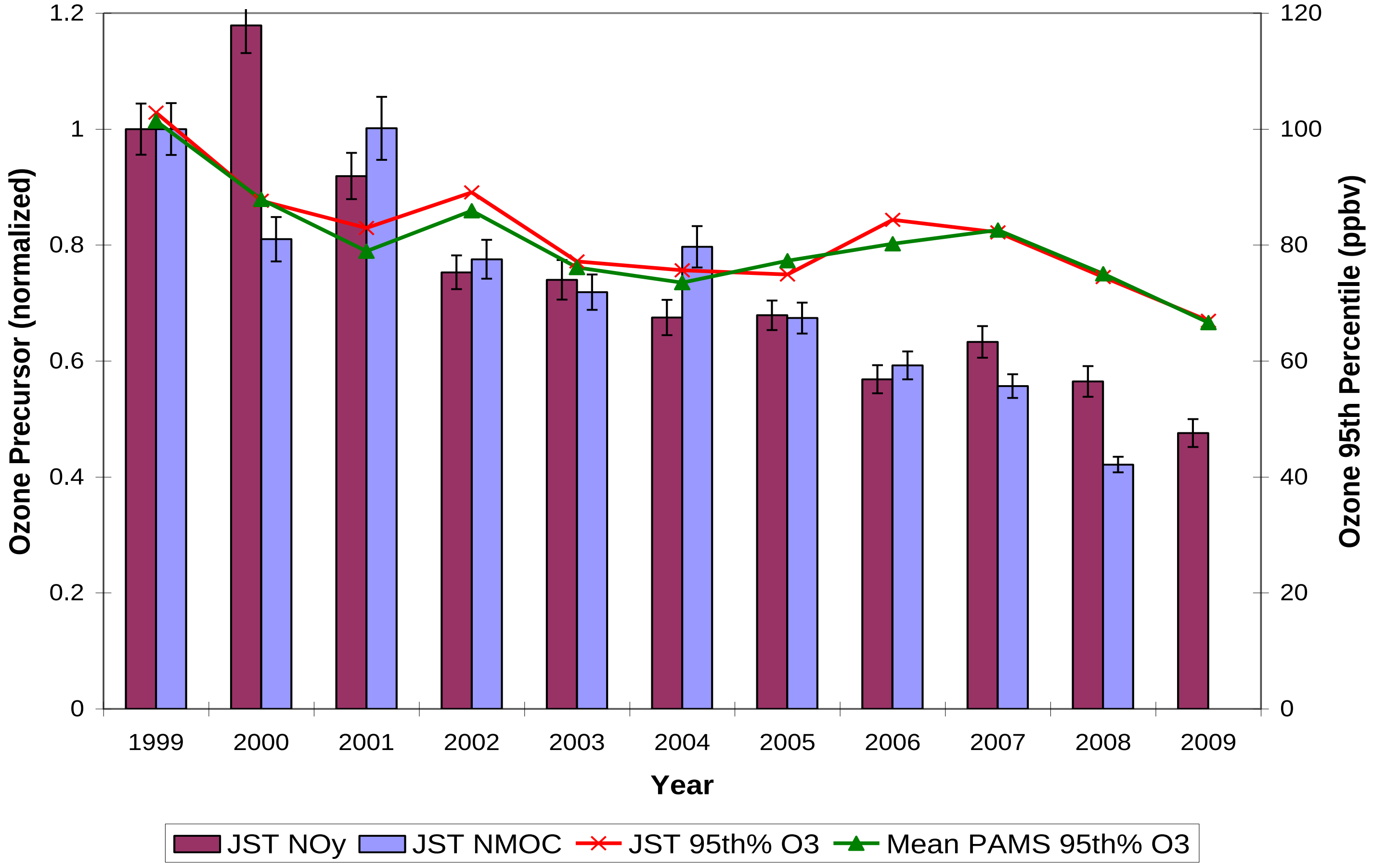
Site	SO_2	SO_4	NO_y	NO_3	O_3	CO	EC	OM
BHM	-5.1 ± 2.0	-5.2 ± 1.0	-6.6 ± 0.8	-5.8 ± 0.9	-1.9 ± 0.9	-6.0 ± 0.6	-6.6 ± 1.8	-6.1 ± 1.3
CTR	-6.8 ± 1.4	-6.2 ± 1.1	-6.1 ± 0.8	-3.3 ± 1.3	-3.1 ± 0.8	-1.6 ± 1.0	-1.3 ± 1.9	-3.3 ± 0.8
GFP	-7.1 ± 1.4	-4.6 ± 0.8	-7.4 ± 1.1	-0.6 ± 1.2	-1.5 ± 0.6	-5.0 ± 0.8	-5.5 ± 1.6	-4.1 ± 0.9
JST	-9.1 ± 1.7	-5.5 ± 1.1	-7.3 ± 0.8	-4.7 ± 0.6	-1.8 ± 0.7	-7.2 ± 0.4	-6.8 ± 1.3	-5.0 ± 1.0
OAK	-8.0 ± 1.5	-4.2 ± 0.8	-6.0 ± 0.9	-0.9 ± 1.2	-1.9 ± 0.4	-2.2 ± 0.7	-4.0 ± 1.6	-4.9 ± 1.2
OLF	-9.7 ± 1.8	-4.4 ± 0.9	-7.8 ± 0.7	-2.3 ± 1.1	-2.0 ± 0.5	-1.2 ± 0.4	-4.9 ± 1.3	-4.5 ± 1.2
PNS	-4.1 ± 8.4	-3.7 ± 1.1	-9.0 ± 1.3	-1.7 ± 0.8	-2.2 ± 0.6	-6.5 ± 0.5	-7.8 ± 0.7	-6.5 ± 0.3
YRK	-7.6 ± 2.3	-5.3 ± 1.3	-7.7 ± 0.7	-4.0 ± 0.9	-2.8 ± 0.5	-1.6 ± 0.7	-6.0 ± 1.8	-4.0 ± 1.3

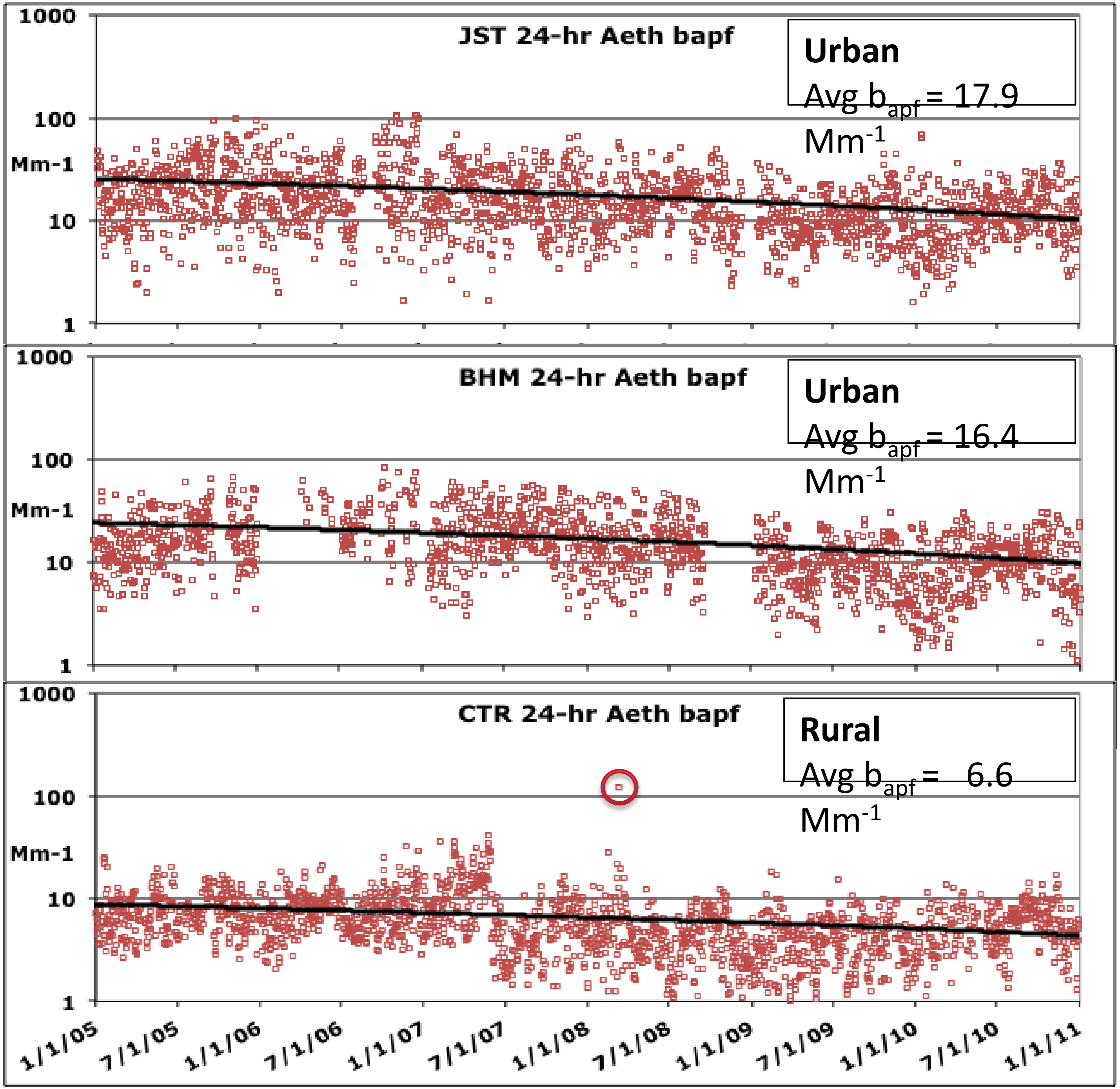
BLANCHARD, ET AL., 2012. THE SOUTHEASTERN AEROSOL RESEARCH AND CHARACTERIZATION (SEARCH) STUDY: TEMPORAL TRENDS IN GAS AND PM CONCENTRATIONS AND COMPOSITION, 1999-2010. SUBMITTED.

SEARCH-Average PM2.5 Mass and Composition



VOCs (JST only) and O_3 also decreasing





Dry b_{apf} Trends 2005-2010

Note: log scale

In 6 years, urban b_{apf} fell by ~45% and rural (CTR) by ~25%.

Anomaly on 3/12/08

Mean Gas and PM Concentrations

	Coastal sites				Inland sites			
	Nonurban		Urban		Nonurban		Urban	
Species	OAK[a]	OLF	GFP[a]	PNS[b]	CTR	YRK	BHM[c]	JST
$PM_{2.5}$ ($\mu g\ m^{-3}$)								
Mass	11.06	10.69	10.93	12.28	11.51	12.89	16.53	15.46
SO_4	3.26	3.22	3.28	3.42	3.50	4.11	4.31	4.27
NO_3	0.32	0.36	0.42	0.42	0.33	0.76	0.83	0.87
NH_4	0.98	1.04	1.06	1.12	1.12	1.62	1.55	1.67
EC	0.50	0.60	0.62	0.78	0.58	0.57	1.76	1.34
OM	3.71	3.41	3.35	3.96	4.22	4.31	6.17	5.88
MMO	0.49	0.44	0.50	0.59	0.38	0.32	1.02	0.51
$PM_{10\text{-}2.5}$ ($\mu g\ m^{-3}$)								
Mass	6.10	6.59	8.08	9.06	5.25	5.23	14.38	8.28
SO_4	0.21	0.26	0.30	0.29	0.19	0.21	0.34	0.24
NO_3	0.45	0.56	0.72	0.64	0.37	0.37	0.48	0.41
NH_4	0.03	0.03	0.03	0.03	0.04	0.05	0.02	0.03
MMO	1.58	1.41	2.02	2.39	1.33	1.34	4.91	3.03
Gases (ppbv)								
O_3	34.81	32.95	32.54	29.12	35.18	37.68	24.66	24.47
CO	160.39	181.95	218.21	262.11	165.64	178.73	397.67	417.25
SO_2	1.29	1.76	1.62	2.30	1.66	2.31	4.20	4.33
NO	0.15	0.86	2.24	3.59	0.29	0.46	13.52	21.21
NO_2	1.36	4.22	5.68	7.29	2.23	3.8	15.34	18.84
HNO_3	0.39	0.32	0.31	0.23	0.62	0.86	0.54	1.03
NO_y	2.64	6.49	9.76	11.72	4.00	6.12	30.66	42.75
NH_3[d]	0.31	0.47	0.76	0.82	0.32	2.67	2.53	1.40

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Source Contributions to Atmospheric Gases and Particulate Matter in the Southeastern United States

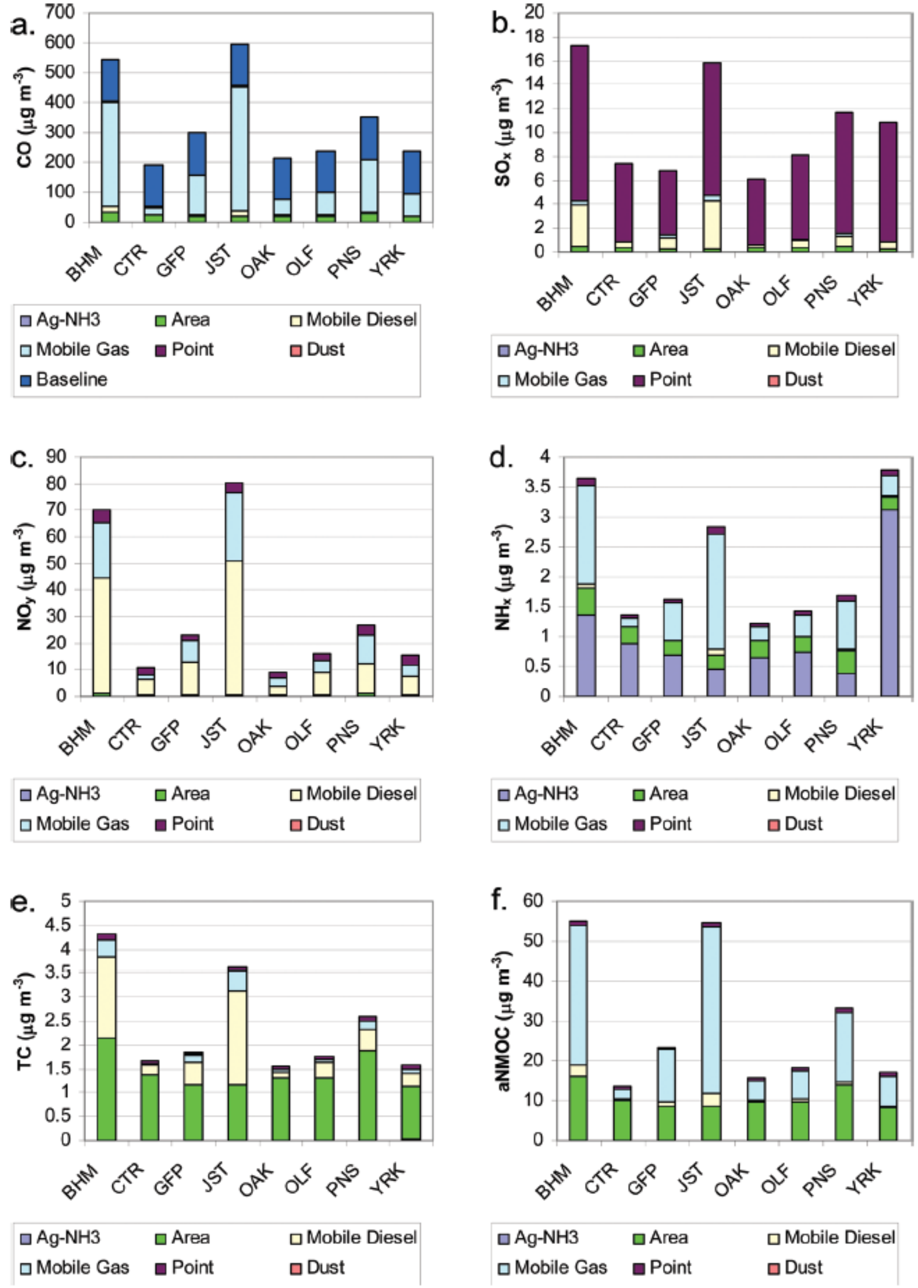
Charles L. Blanchard,* Shelley Tanenbaum, and George M. Hidy

- Chemical Mass Balance Approach

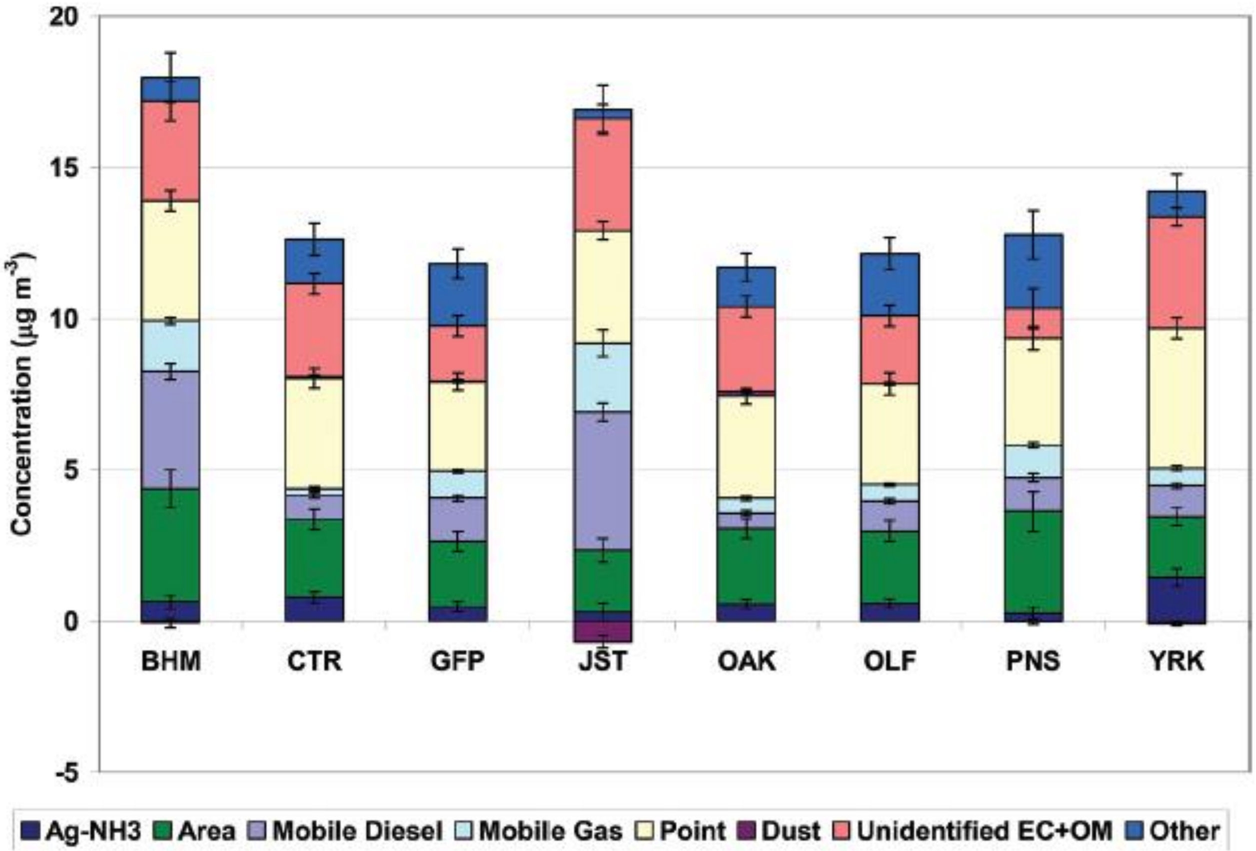
$$
\begin{aligned}
[PM_{2.5}]_i = {} & [SO_x]_i (SO_4/SO_x) + [NO_y]_i (NO_3/NO_y) \\
& + [NH_x]_i (NH_4/NH_x) + [MMOx]_i + [K_2O]_i \\
& + [EC]_i + 1.6^* [OC]_i
\end{aligned}
$$

- 2004-2007 SEARCH Data
- 2005 NEI

Source Contributions to Mean Concentrations



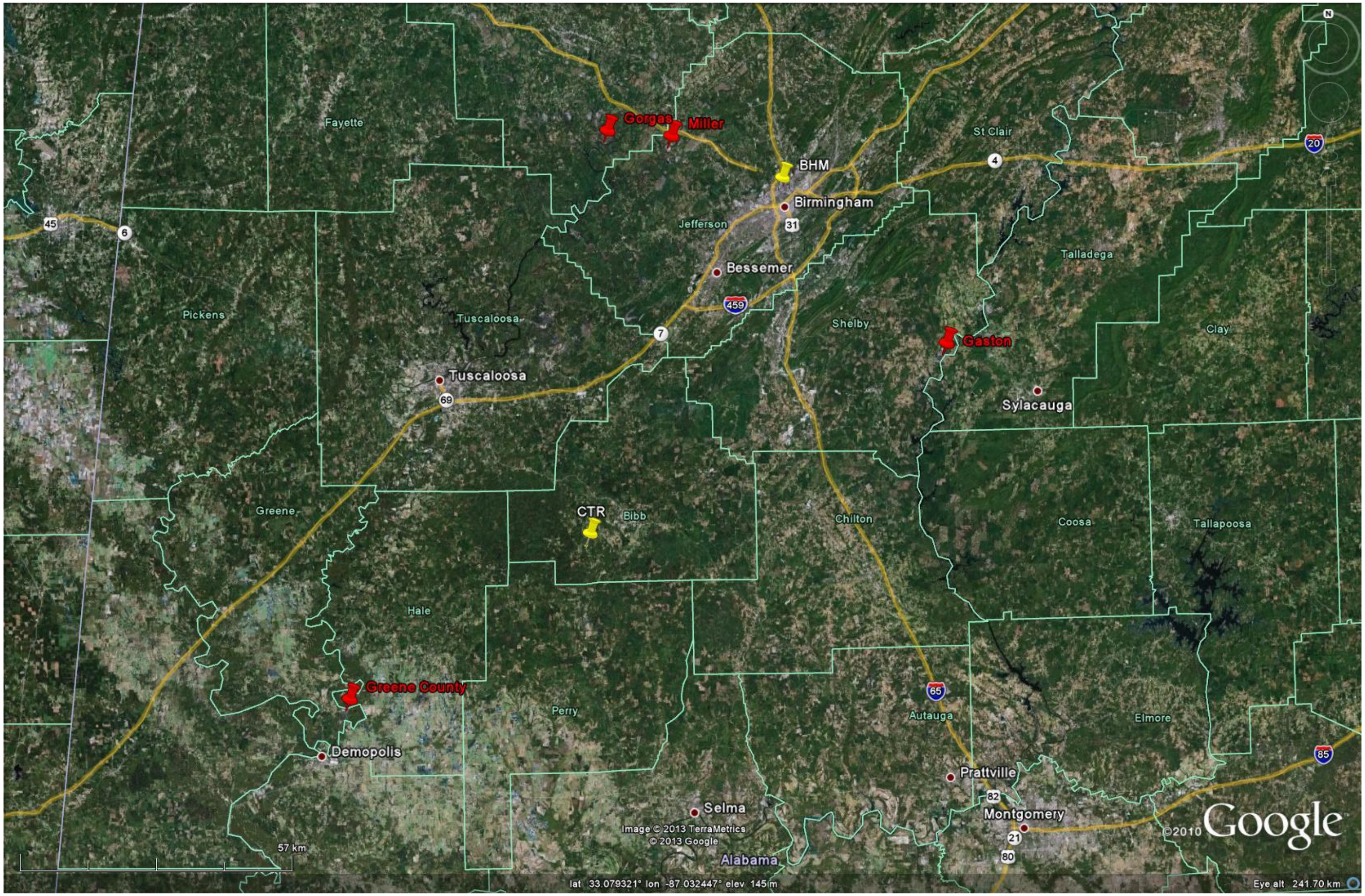
Source Contributions to $PM_{2.5}$



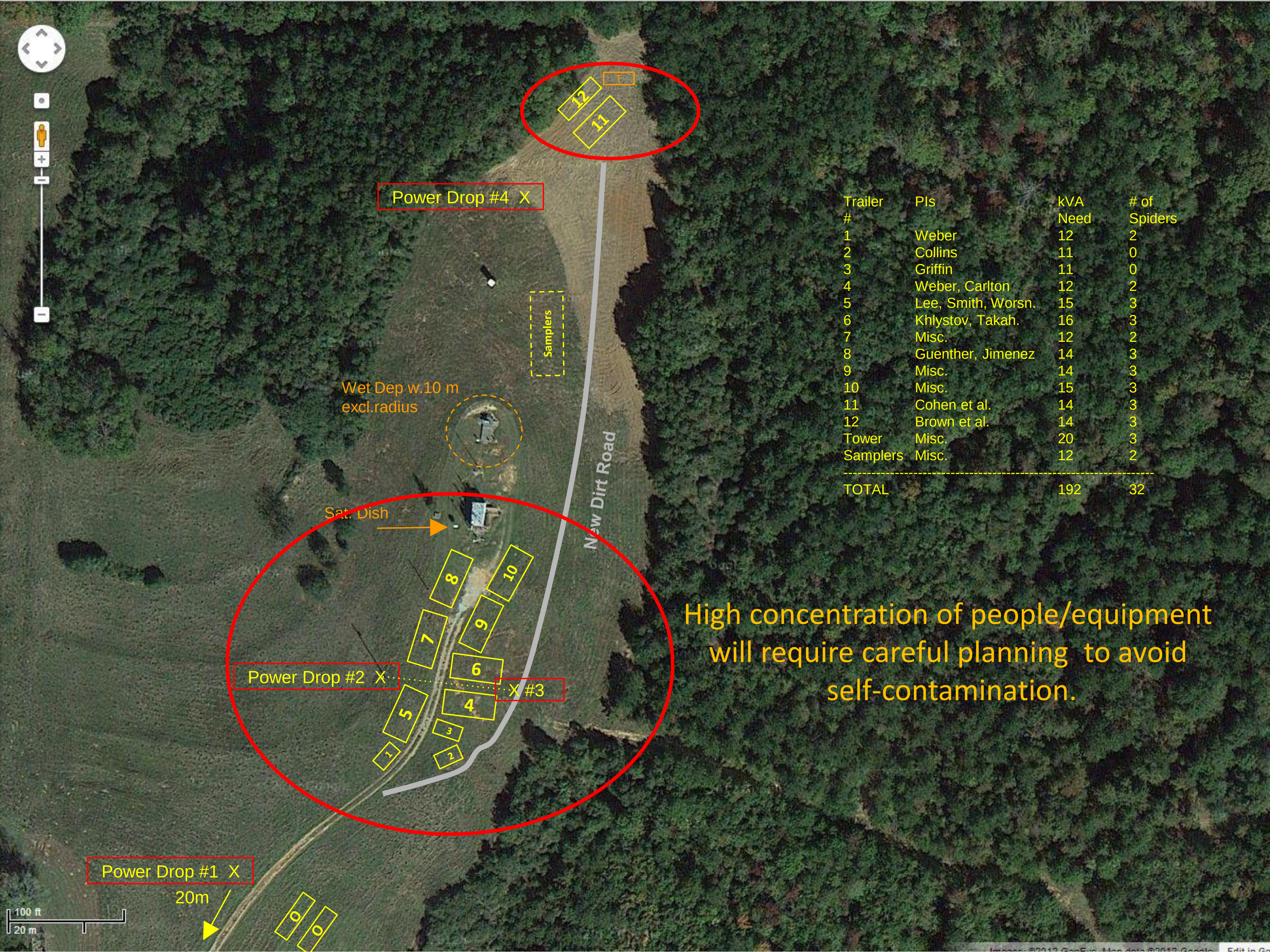
Multiple sources contribute to PM2.5 mass at all SEARCH sites.
Large unidentified EC+OM component likely dominated by SOA.

Recent Observations at CTR

General Location of Centreville SEARCH Site

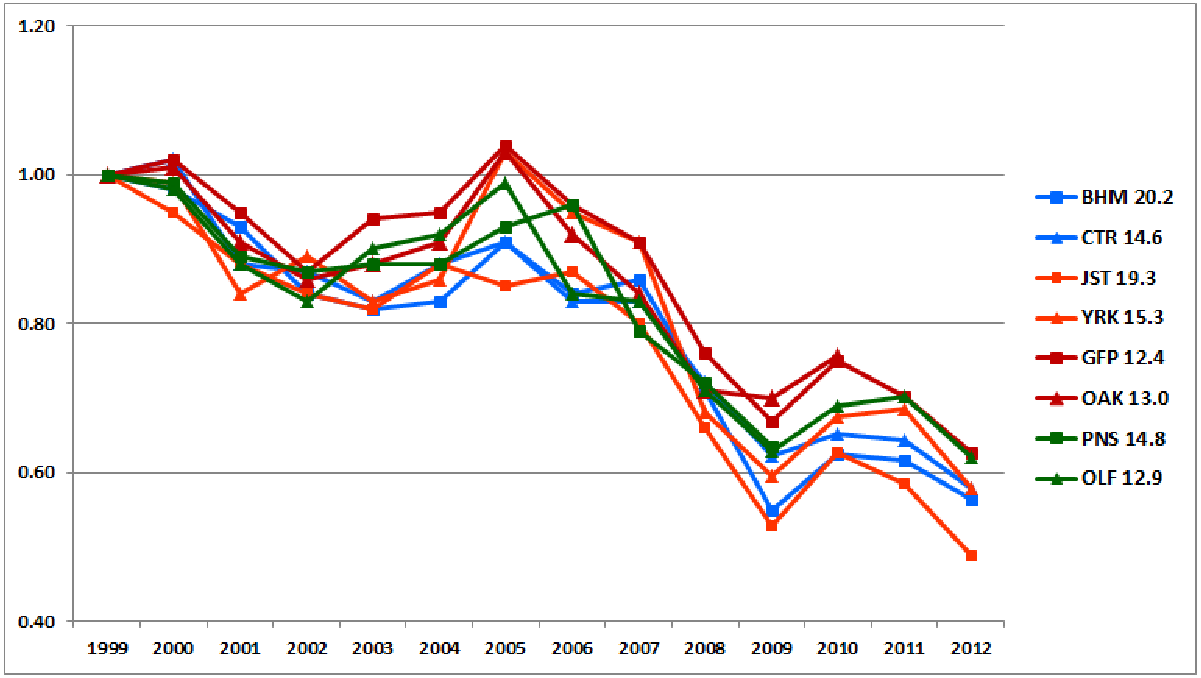


EGU	Size (MW)	D (km)	City	Population	D (km)	POI	D (km)
Green County	1,220	60	Tuscaloosa	222,000	45	Starbucks	51
Gaston	1,880	81	Birmingha	1,128,000	80	Fresh Mark	68
Miller	2,640	82	Montgome	375,000	105	Whole Foo	82
Gorgas	1,221	83					

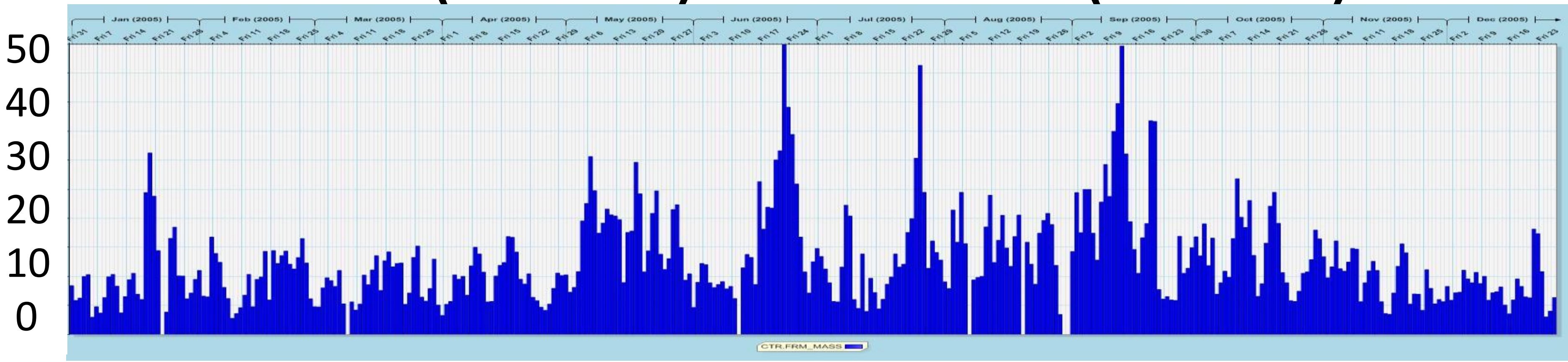


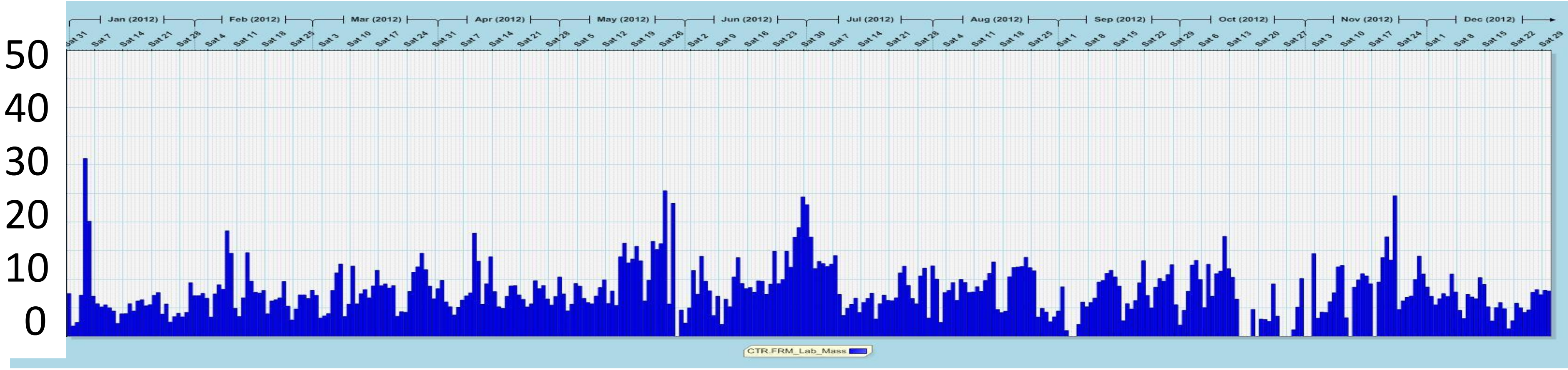
Trailer #	PIs	kVA Need	# of Spiders
1	Weber	12	2
2	Collins	11	0
3	Griffin	11	0
4	Weber, Carlton	12	2
5	Lee, Smith, Worsn.	15	3
6	Khlystov, Takah.	16	3
7	Misc.	12	2
8	Guenther, Jimenez	14	3
9	Misc.	14	3
10	Misc.	15	3
11	Cohen et al.	14	3
12	Brown et al.	14	3
Tower	Misc.	20	3
Samplers	Misc.	12	2
TOTAL		192	32

The downward march of $PM_{2.5}$ has continued since Blanchard et al. analysis



Daily $PM_{2.5}$ Time Series at CTR 2005 (above) and 2012 (below)

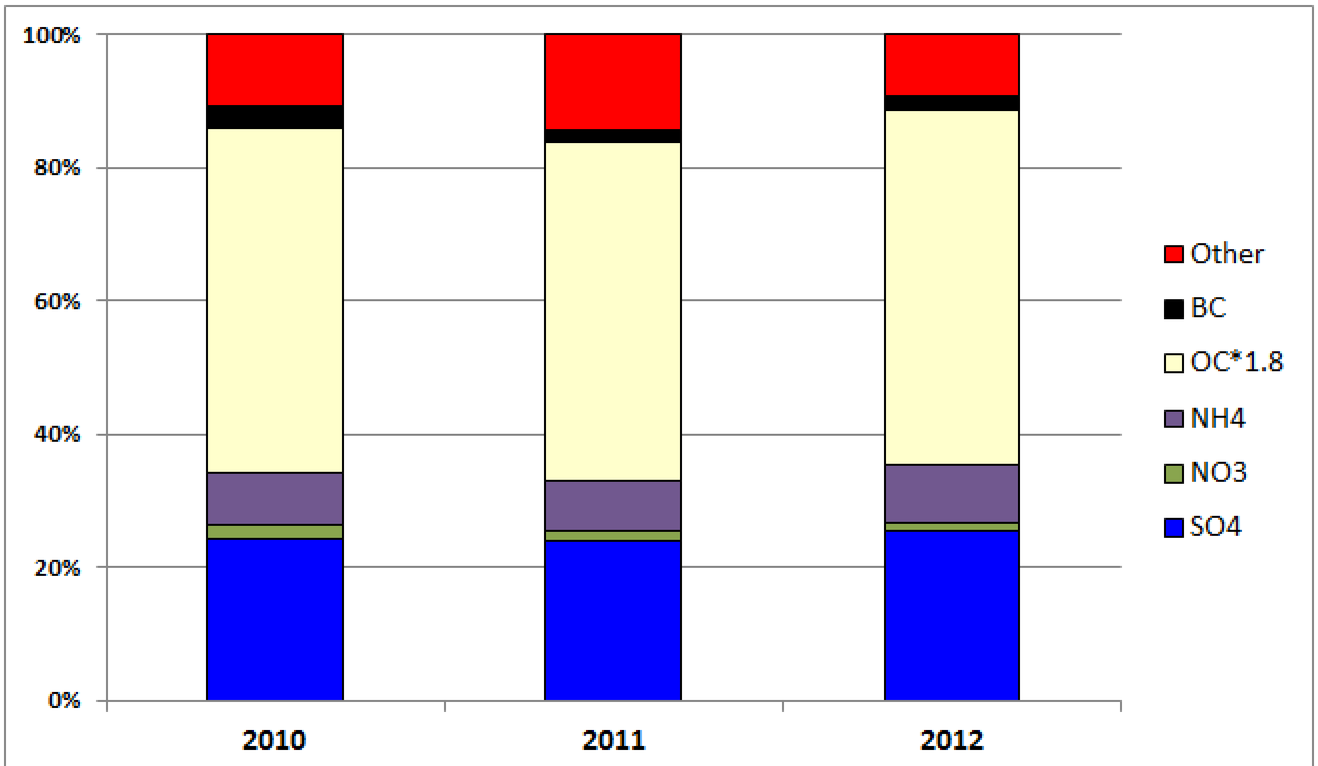




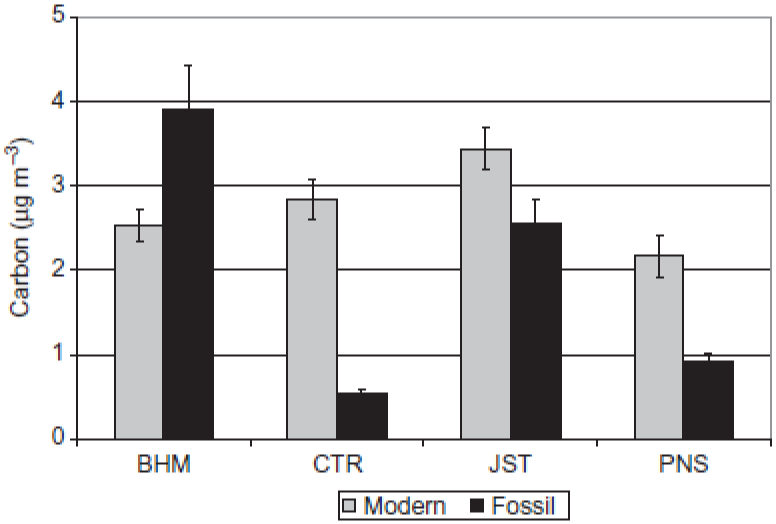
Major summertime excursions of $PM_{2.5}$ mass have largely disappeared.

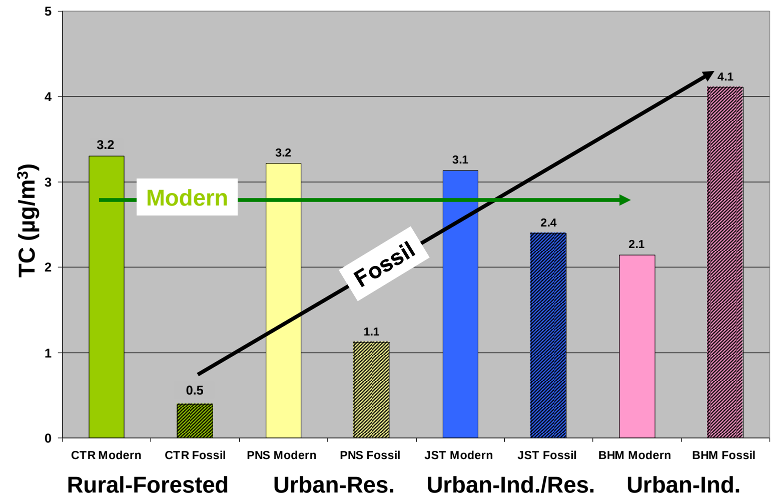
PM2.5 Mass and Components June-July 2010-2012

Year	$PM_{2.5}$[ug/m^3] Mean	Max. 24-Hr.	Max 1-Hr.	SO_4[ug/m^3] Mean	Max. 24-Hr.	Max 1-Hr.	NO_3[ug/m^3] Mean	Max. 24-Hr.	Max 1-Hr.	NH_4[ug/m^3] Mean	Max. 24-Hr.	Max 1-Hr.	OC[ug/m^3] Mean	Max. 24-Hr.	Max 1-Hr.	BC [ug/m^3] Mean	Max. 24-Hr.	Max 1-Hr.
2010	10.79	18.2	34.3	2.60	4.8	12.7	0.23	0.5	1.6	0.87	2.4	4.9	3.09	5.4	5.8	0.38	0.6	1.6
2011	13.29	33.5	68.1	3.17	7.8	11.2	0.22	0.8	2.0	0.99	2.4	3.4	3.76	11.6	36.0	0.24	1.0	3.1
2012	9.28	23.9	31.1	2.44	6.1	9.8	0.14	0.4	1.0	0.82	2.6	3.8	2.84	6.9	10.8	0.22	0.4	0.9



^{14}C Measurements: 2003-2005

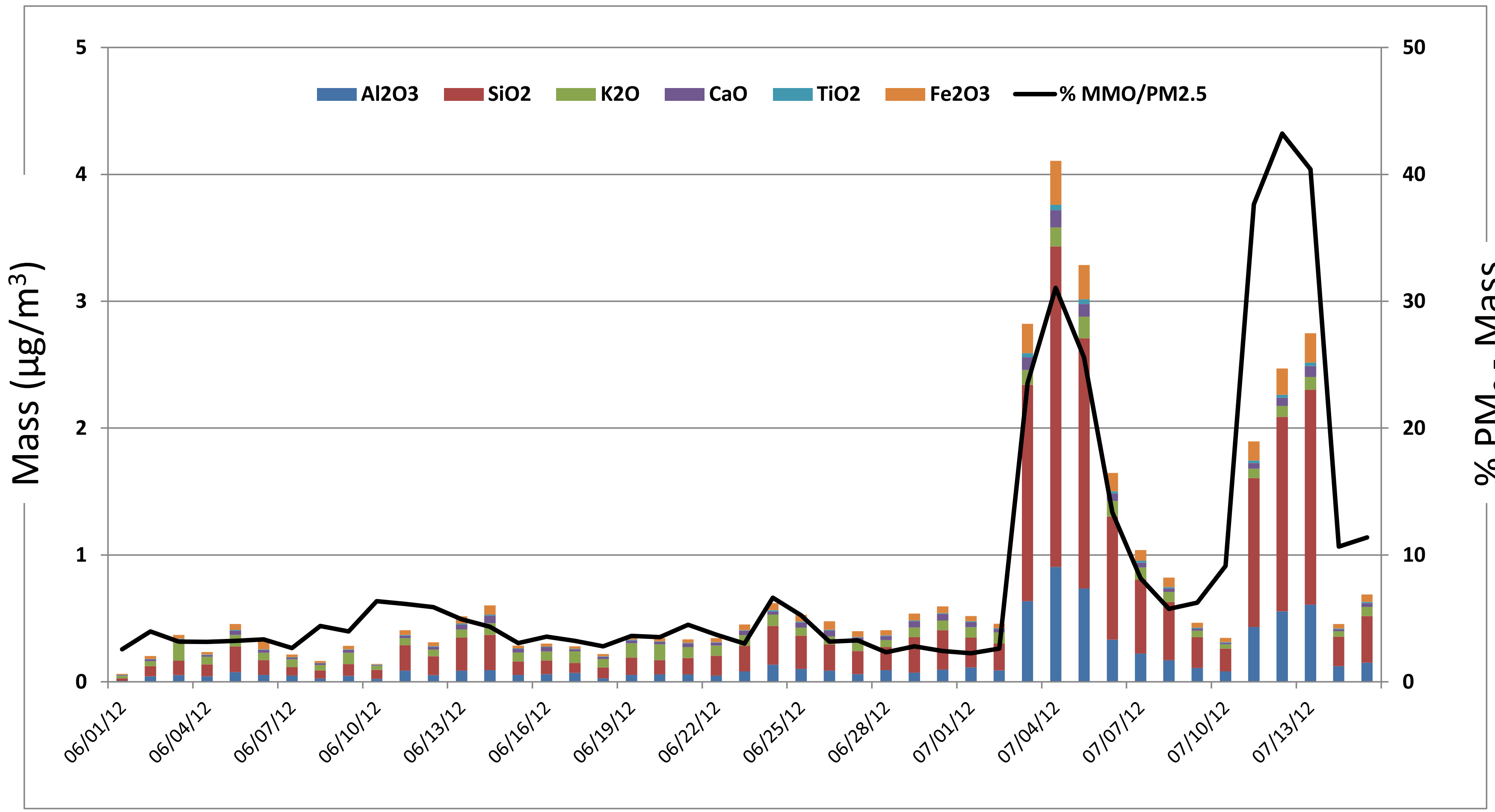




Qtr	n	Fmodern	C-weighted Fmodern	Modern TC	Fossil TC
1	19	0.83	0.90	3.94	0.41
2	27	0.87	0.87	2.59	0.38
3	18	0.83	0.88	3.95	0.55
4	19	0.83	0.82	2.91	0.62
All	**83**	**0.84**	**0.86**	**3.24**	**0.53**

Regional TC is about 85% F_{modern} implying roughly 3 µg/m^3 modern carbon at CTR and other sites.

North African Dust Excursions



N. African (mineral) dust events normally occur in August, but sometimes in July as in 2012.

Selected Trace Gases June-July 2010-2012

	O3[ppb]			CO[ppb]			SO2[ppb]			NH3[ppb]			H20 [%]	
Year	**Mean**	**Max 1-Hr**	**Max. 5-min**	**Mean**	**Max 1-Hr**	**Max. 5-min**	**Mean**	**Max 1-Hr**	**Max. 5-min**	**Mean**	**Max 1-Hr**	**Max. 5-min**	**Mean**	**Max 1-Hr**
2010	30.6	76.7	79.2	141	248	336	0.62	9.7	18.6	n.a.	n.a.	n.a.	3.0	3.6
2011	32.6	91.0	92.9	167	886	1266	0.61	11.7	17.6	n.a.	n.a.	n.a.	2.8	3.7
2012	34.0	84.4	87.0	162	268	397	0.47	31.7	41.6	0.41	1.59	1.71	2.6	3.6

Average concentrations for O_3, CO, SO_2 and NH_3 are relatively low, but short-term maxima indicate interesting excursions.

Water vapor, both a friend (reactant and medium) and enemy (condensation), is abundant. Be prepared!

Dry(blue) and ambient (red) light scattering at 530 nm

Scattering data show lots of water associated with particles, even in winter.

VOC data at CTR are very limited, but indicate significant mid-afternoon isoprene in June and July

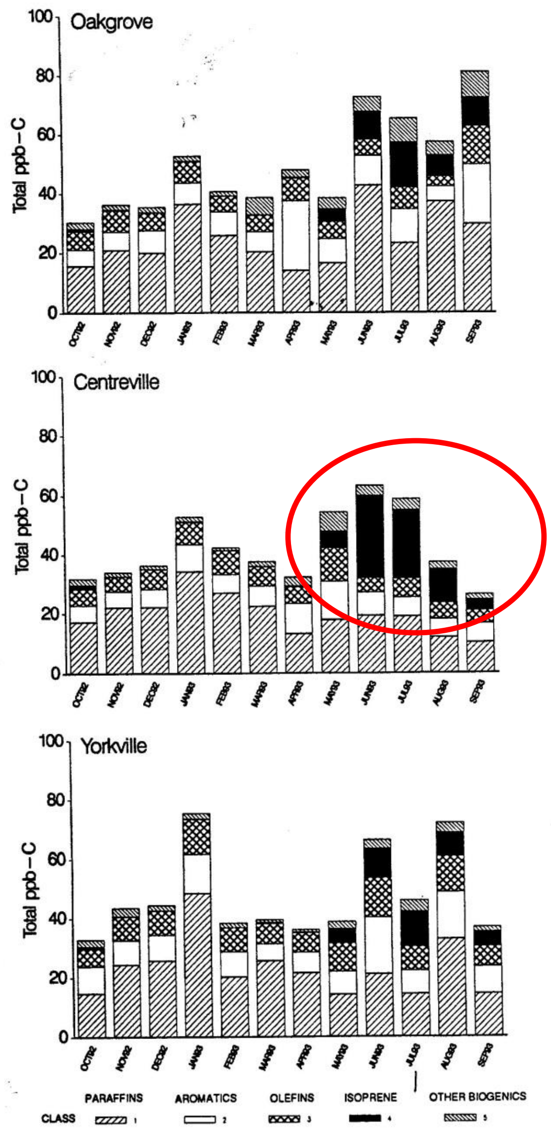
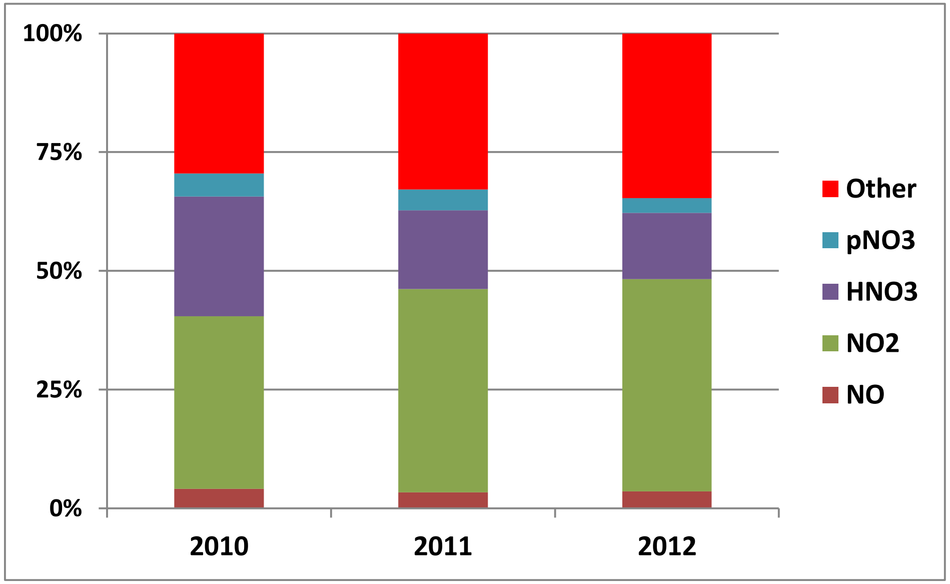


Figure 5-1. Monthly Mean Hydrocarbon Concentration, by Class, for Three SCION Sites

SOS-SCION data
October 1992-September 1993

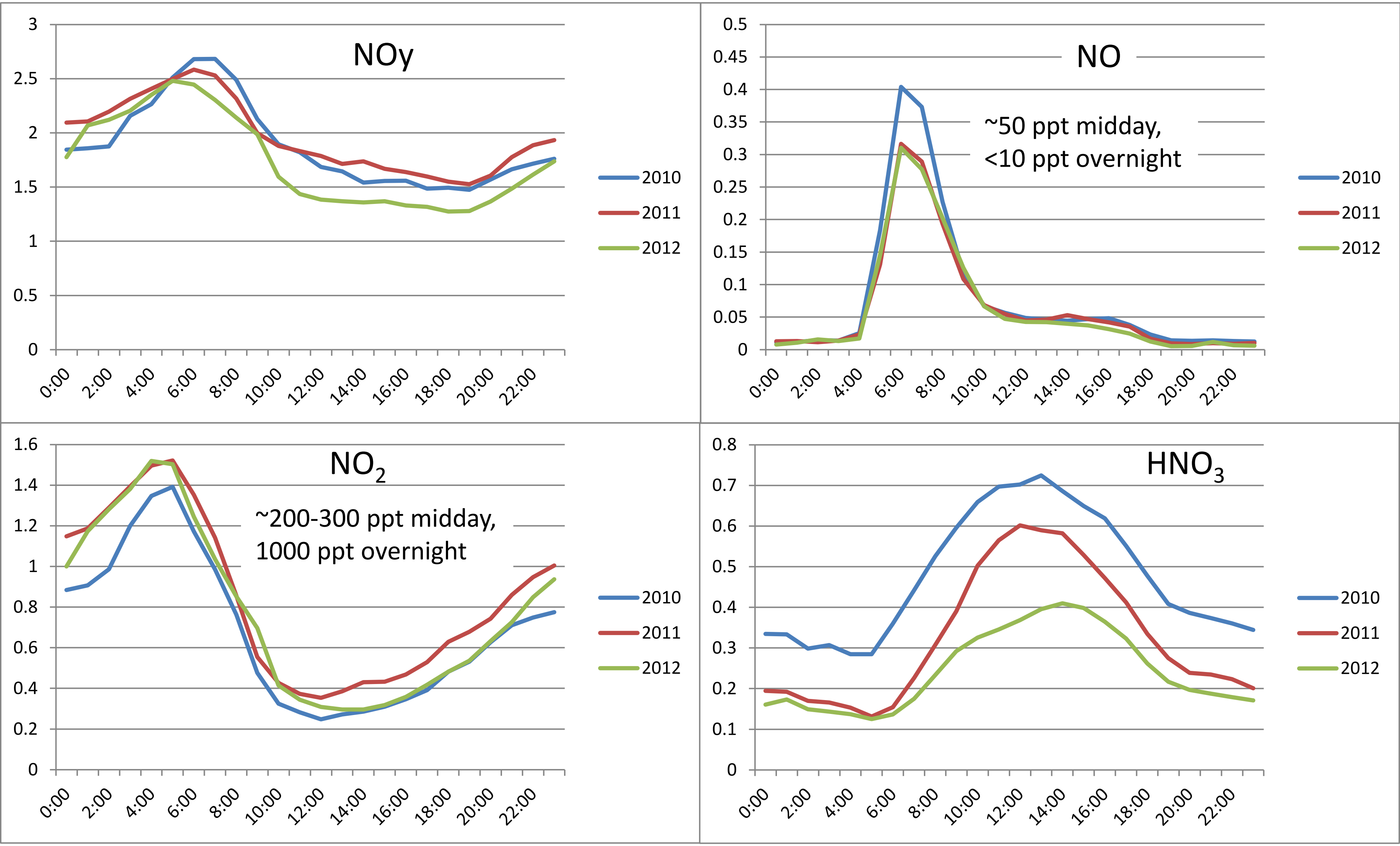
NOy, NOx and NOz
June-July 2010-2012

Year	NOy[ppb] Mean	NOy Max 1-Hr	NOy Max. 5-min	NO[ppb] Mean	NO Max 1-Hr	NO Max. 5-min	NO2[ppb] Mean	NO2 Max 1-Hr	NO2 Max. 5-min	HNO3[ppb] Mean	HNO3 Max 1-Hr	HNO3 Max. 5-min	pNO3[ppb] Mean	pNO3 Max 1-Hr	pNO3 Max. 5-min
2010	1.89	8.9	11.8	0.08	2.2	3.0	0.69	6.2	7.3	0.48	1.8	3.0	0.09	0.7	1.0
2011	1.97	10.3	11.4	0.07	1.5	4.2	0.84	6.9	7.7	0.33	1.4	1.5	0.09	0.8	1.2
2012	1.74	16.8	23.5	0.06	1.8	3.1	0.78	9.8	15.4	0.24	1.3	1.4	0.05	0.4	0.8



Lots of highly oxidized NOy, in addition to HNO_3.

Diurnal behavior of NOy, NO, NO_2 and HNO_3

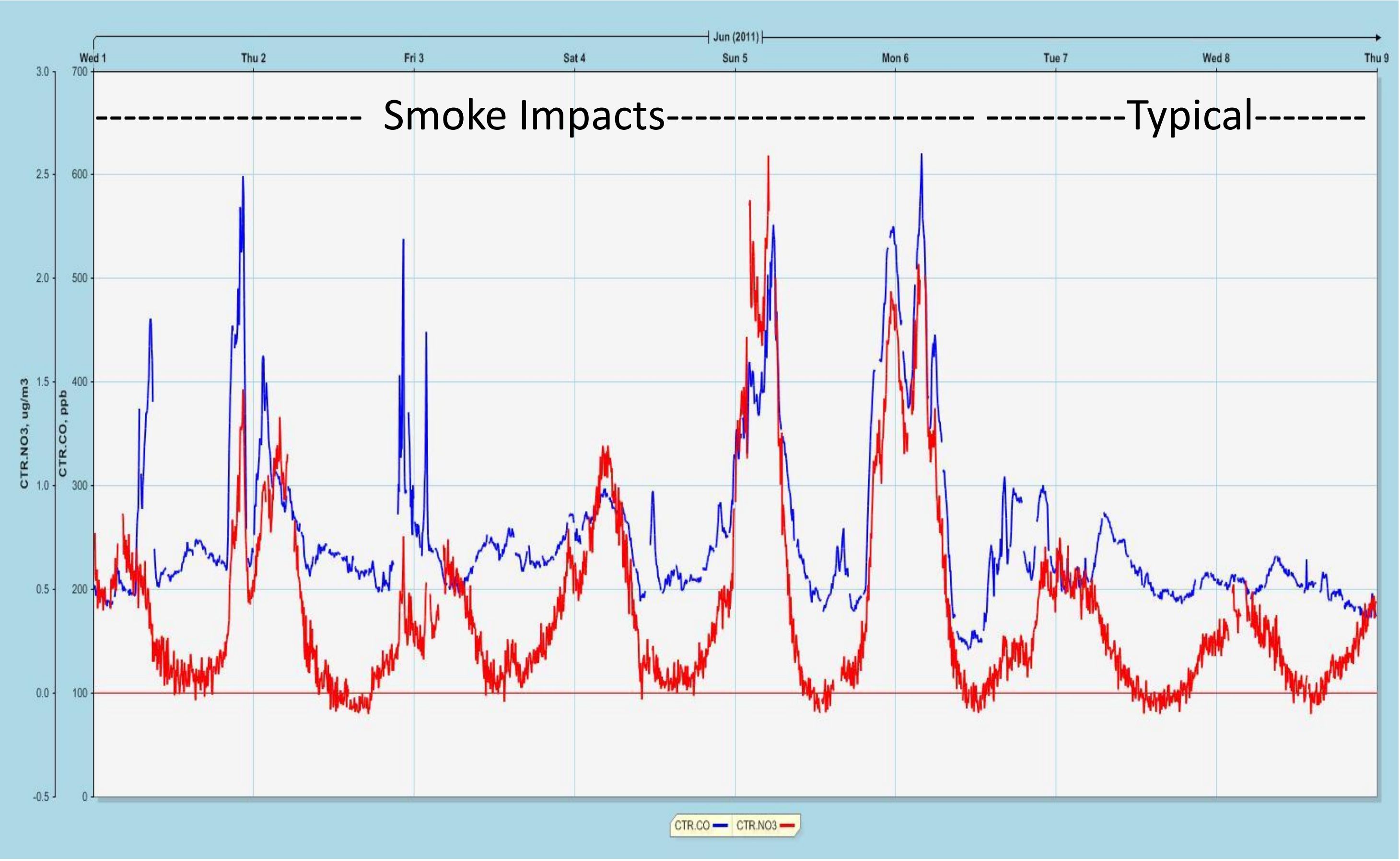


Typical HNO_3 Behavior

Strong daytime production, rapid removal by precipitation (green trace), interesting overnight excursions.

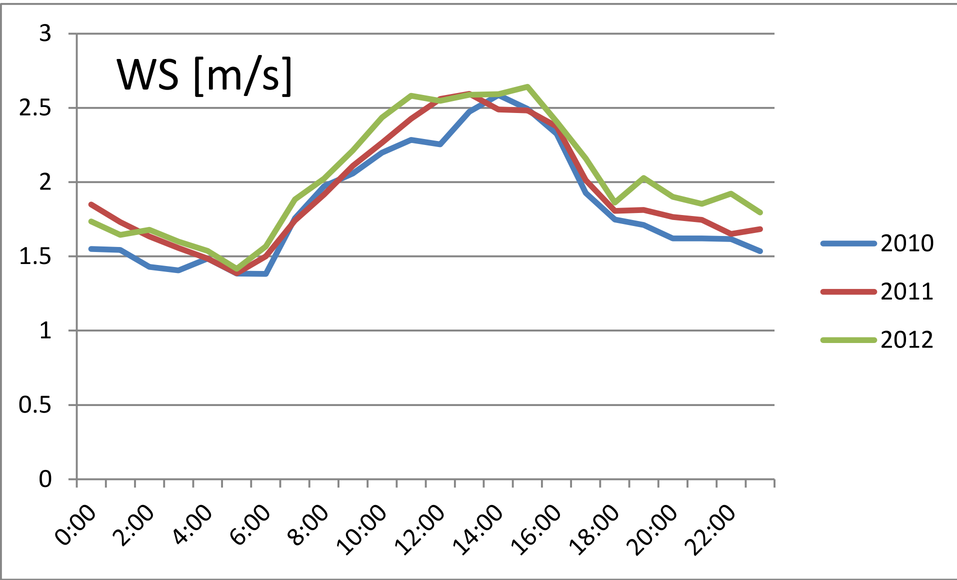
CO (blue) and pNO_3^- (red)

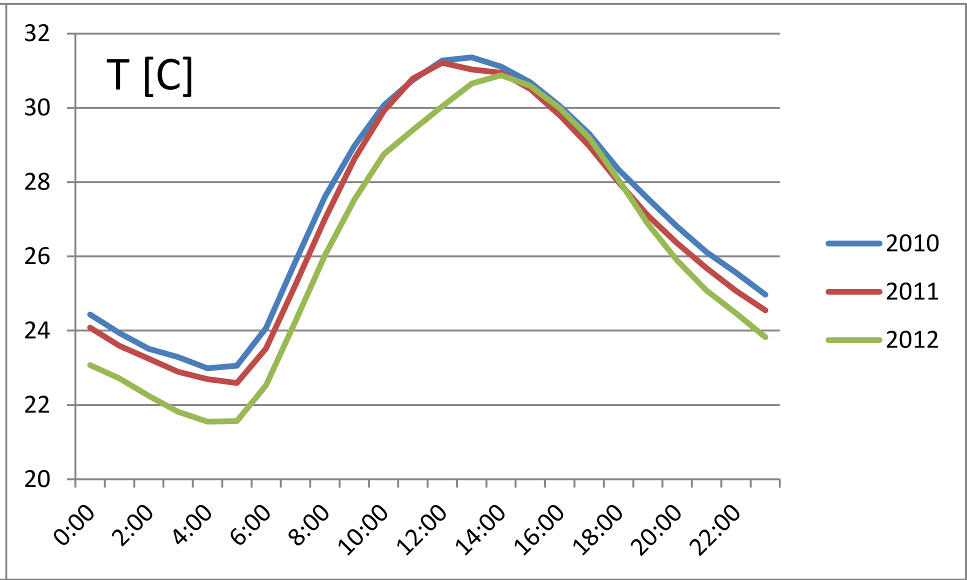
June 1-7, 2011

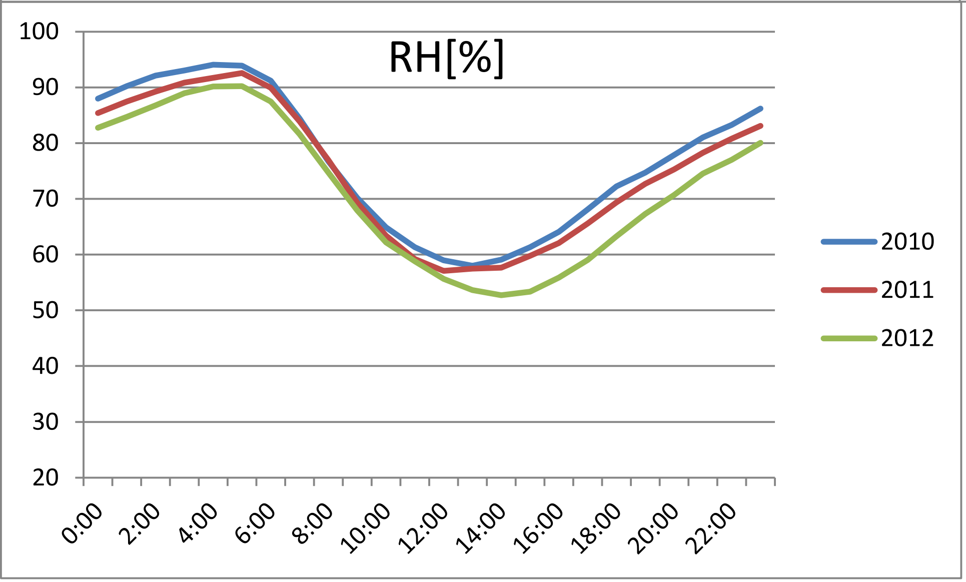


Particulate-nitrate (red) a minor component of NOy, but always forms overnight. Significant excursions occur, even in summer, when smoke impacted.

Meteorological Data for CTR







2012 was windier, cooler and drier than 2010, with 2011 in between.

Overnight winds (10m agl) rarely calm.

Bulk Formula for Fine OC

$$(CHN_{0.02*}S_{0.01\#}O_{0.15\text{-}0.65})\cdot nH_2O$$

- Oxygen is the big player
- Multiple groups, both real-time and filter-based
- ARA to estimate org.-S and org.-O on 24-hour filters
- Contribute to understanding OM/OC (mass closure)
- Contribute to understanding f(RH) for OC (Bscat closure)

*** Filterable water-soluble organic nitrogen in Fine particles over the southeastern USA during summer**
Neeraj Rastogi, Xiaolu Zhang, Eric S. Edgerton, Ellery Ingall, Rodney J. Weber

 # Contribution of organosulfur compounds to organic aerosol mass
Michael P. Tolocka, and Barbara J. Turpin