

Measurements and Modeling of Speciated Mercury in Coal-Fired Power Plant Plumes

John J. Jansen
Southern Company

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MERCURY

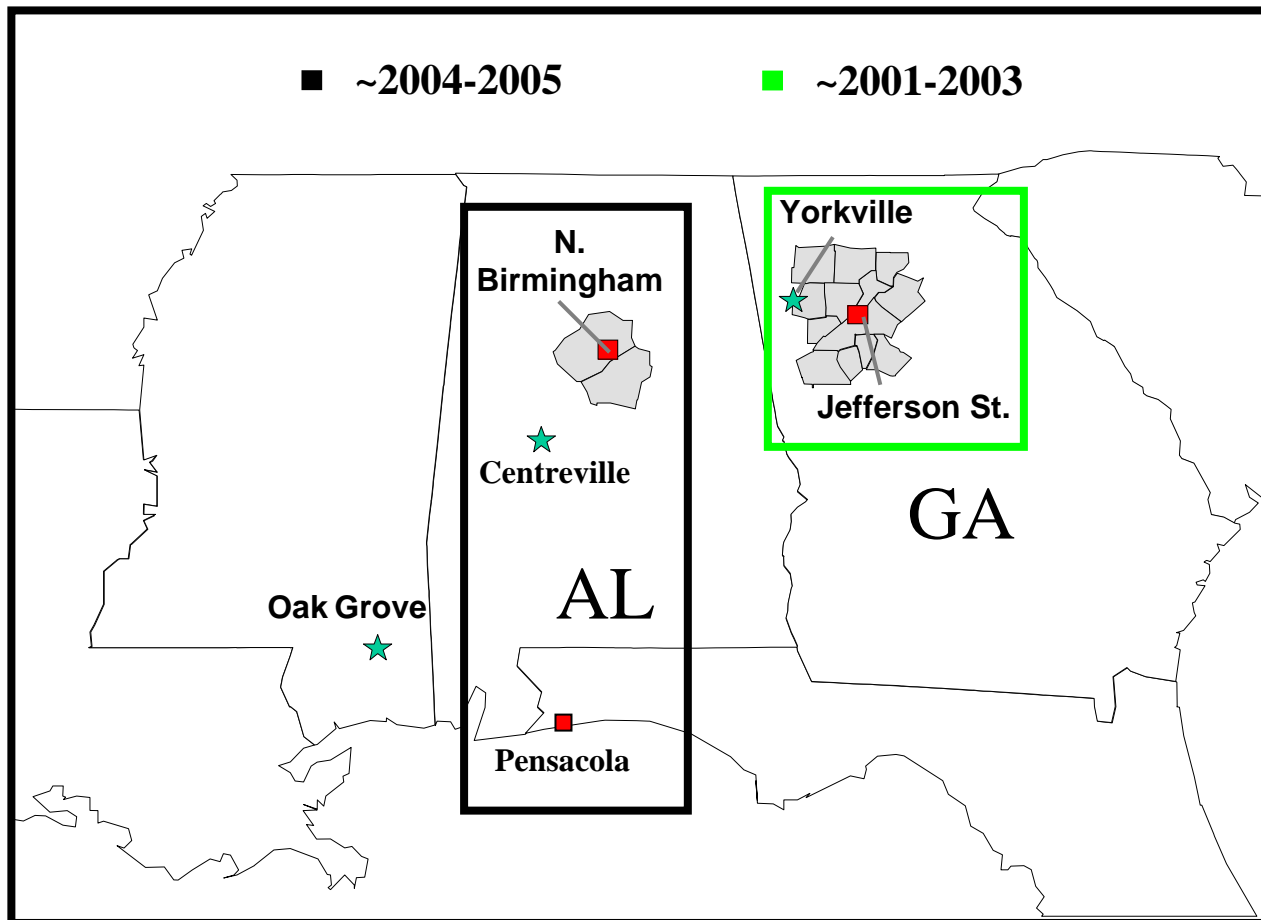
Objectives of Southern Company's **Atmospheric Hg** Research Program

- ◆ Participate in Mercury Deposition Network (MDN) with 3 rural sites for 5 years
- ◆ Characterize Seasonal/Annual Levels of Atmospheric Hg at Rural/Urban Sites
- ◆ Determine Partitioning Between Hg(0), RGM and Hg(p)
- ◆ Evaluate Sources (Plume Analyses)
- ◆ Obtain Data Sets for Model Evaluation

Atmospheric Hg Research Sites

★ MDN Sites - Weekly wet deposition, July 2000 to December 2005

Boxes - Sites with Tekran for hourly Hg(0), RGM, Hg (p); Daily Wet Dep.

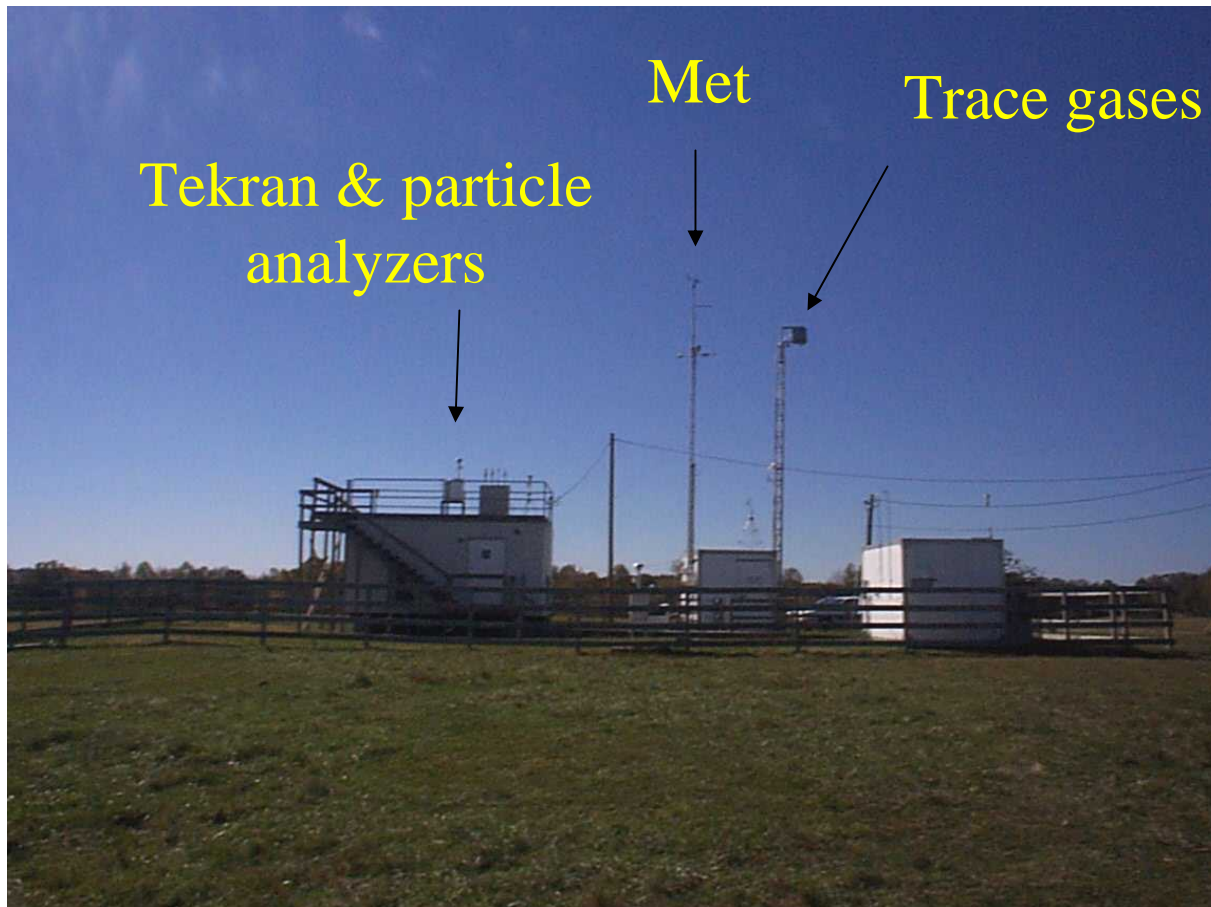


Power Plant Plume Analysis

Research Approach For Plume Analyses

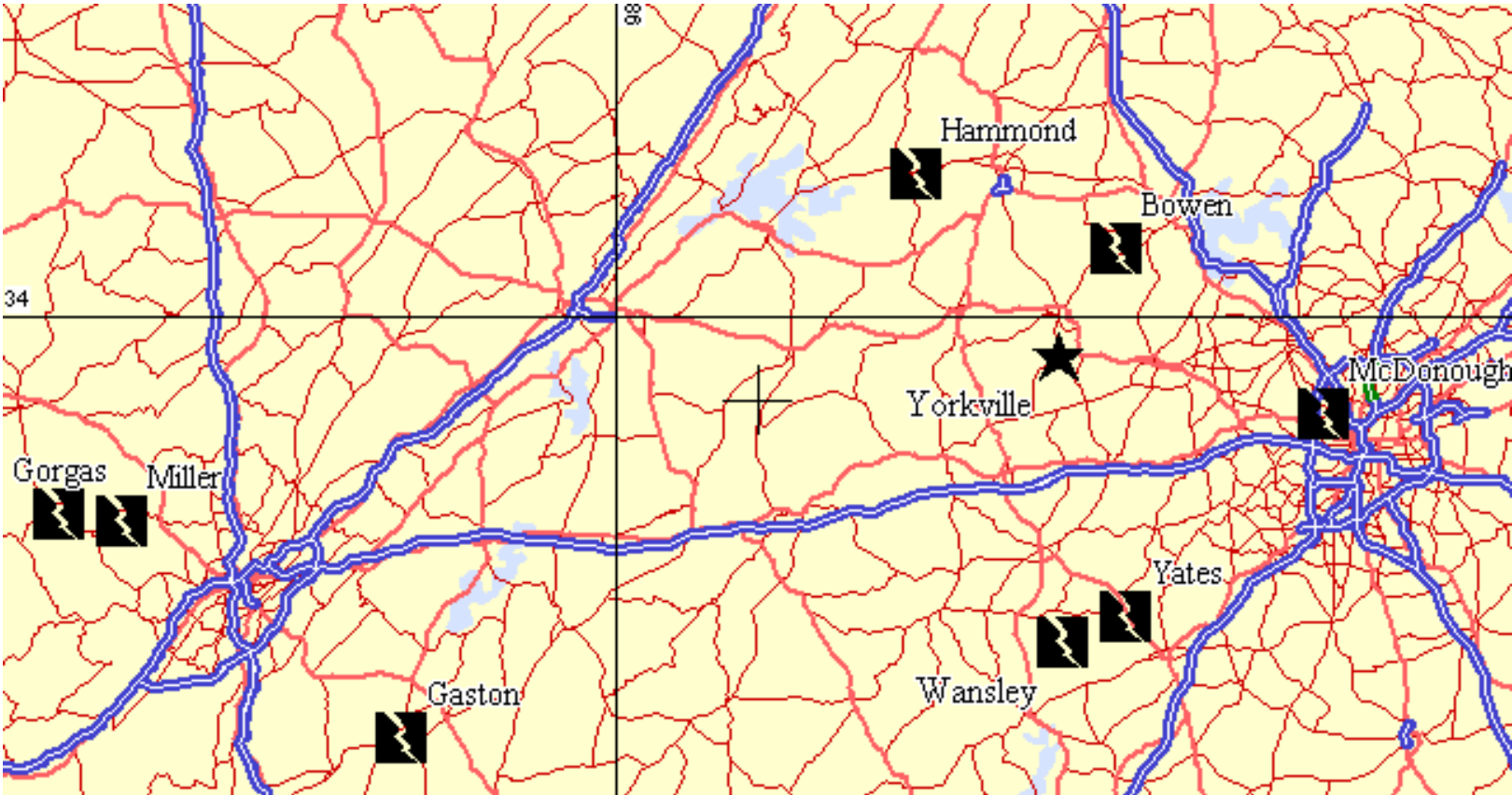
- ◆ Make precise, hourly measurements of speciated mercury
- ◆ Use **SEARCH** measurements, trajectory analyses, and other evidence to identify power plant (and other) plumes impacting site
- ◆ Measure the amount of speciated mercury, above ambient, attributable to the plume and calculate ratio
- ◆ Compare with expected emissions ratios
 - ◆ Based on event-specific coal analysis and EPRI empirical emissions model derived from ICR
- ◆ Attempt to explain observations with model

Yorkville Research Site

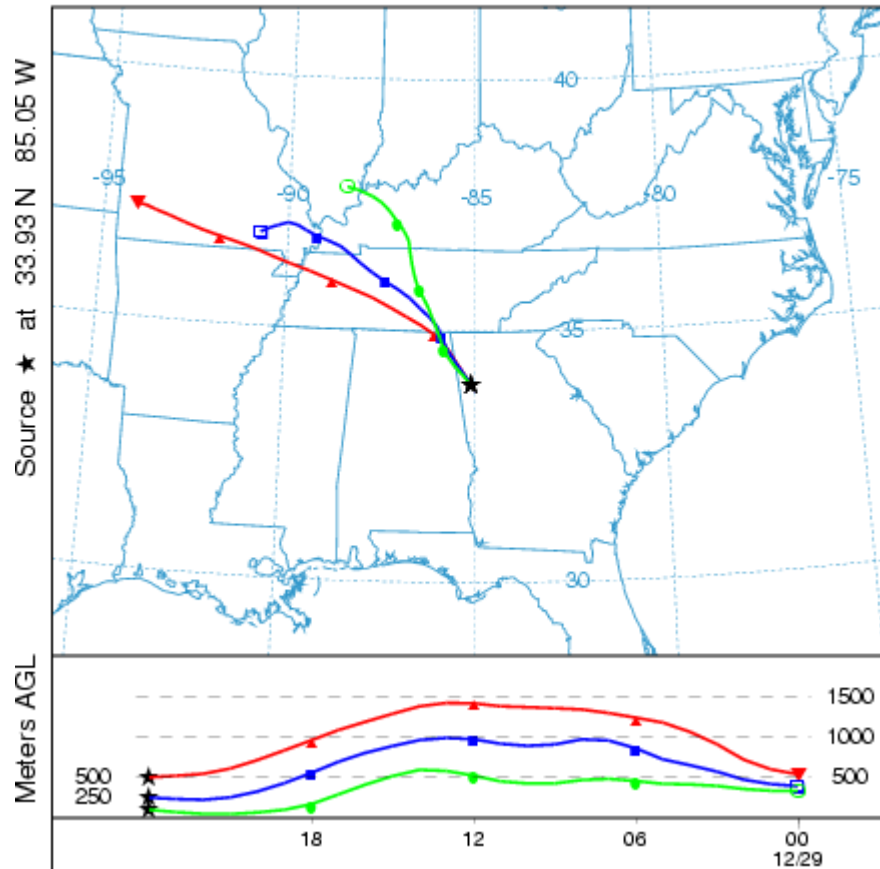


Lat. 33.95 N
Long. 85.01 W
Elev. 390 m

Major Power Plants Near Yorkville

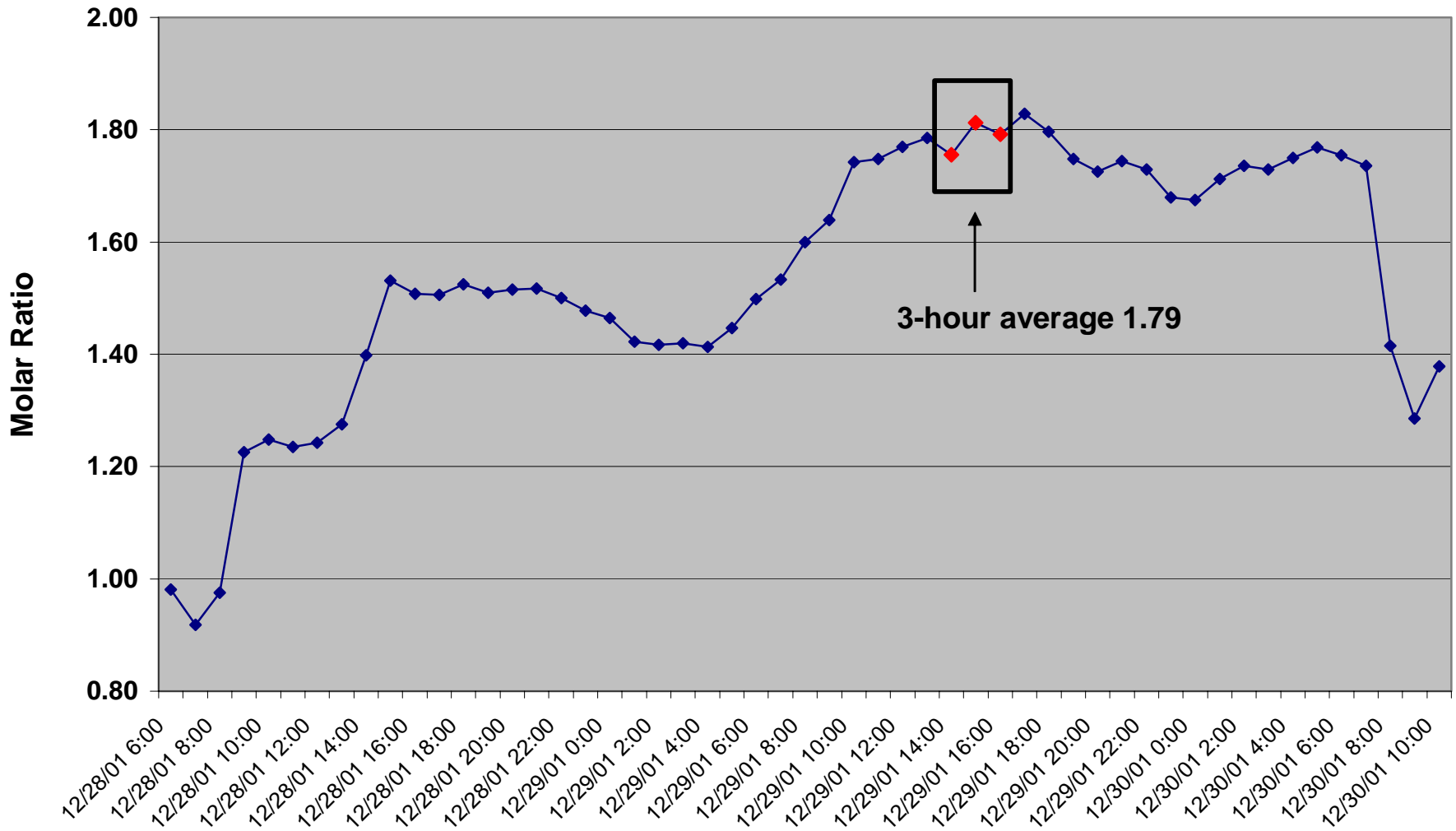


NOAA HY-SPLIT Back Trajectory Ending at YRK 12/29/01 @ 1900



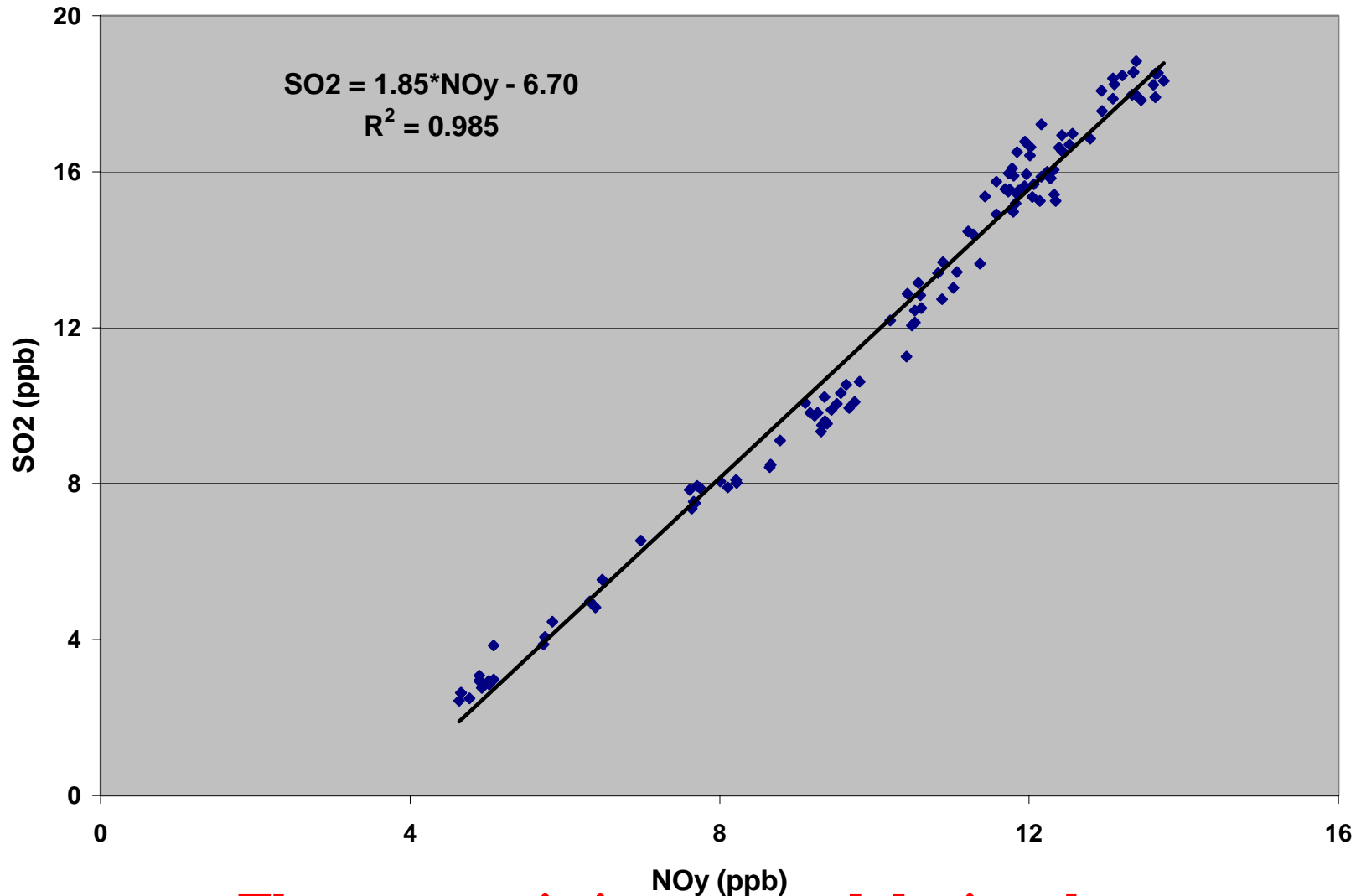
Trajectory analyses help to locate source and estimate travel time.

Hammond SO₂/NO_x Emission Ratio 12/28/01-12/30/01



Based on trajectory information, the emissions
MERCURY ratio for the relevant time period can be obtained.

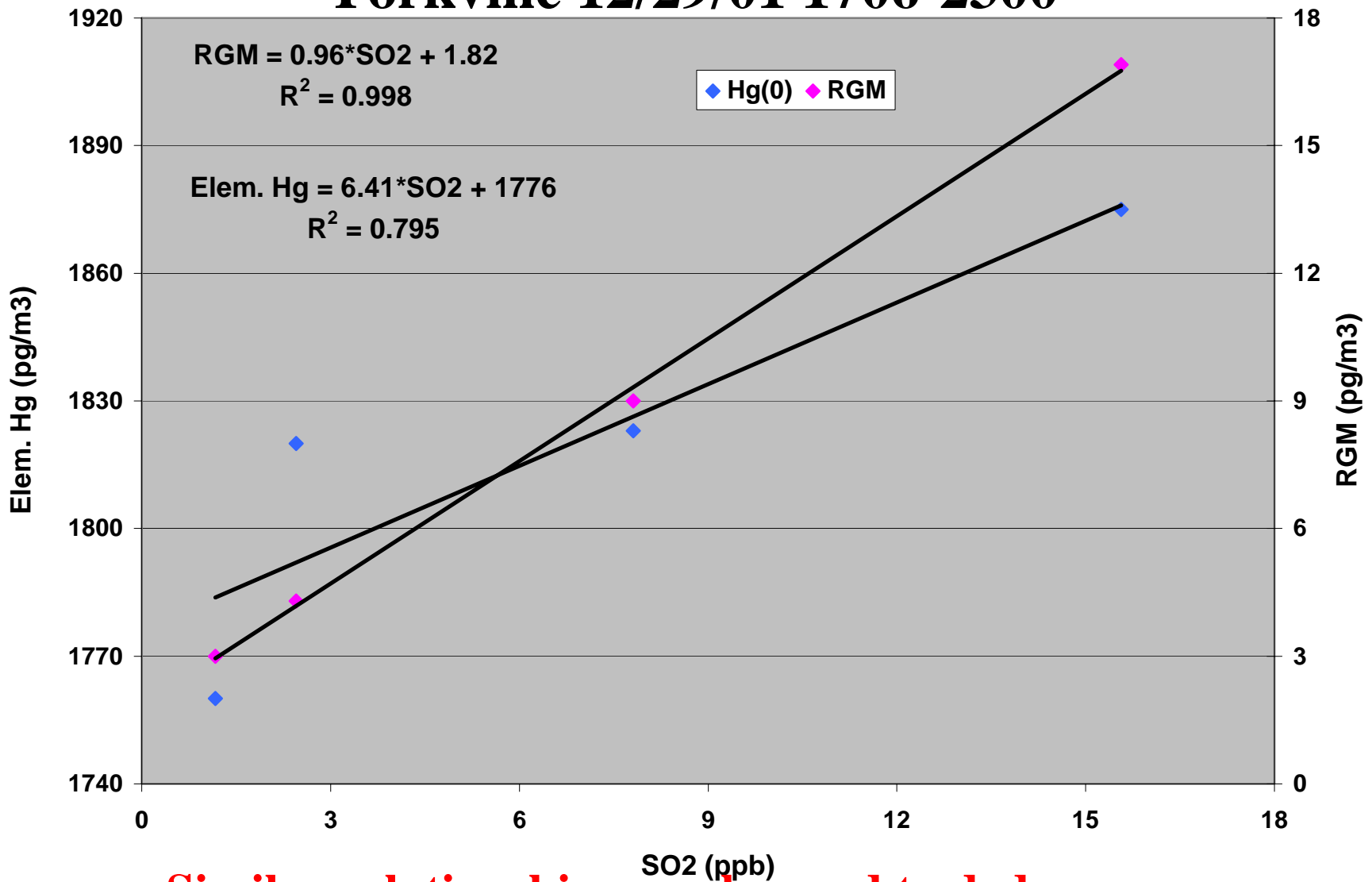
Observed SO₂ and NO_y at Yorkville 12/29/01 1800-2000



The same ratio is measured during the plume event and corroborates the source.

Scattergrams of RGM and Hg(0) vs. SO2

Yorkville 12/29/01 1706-2300



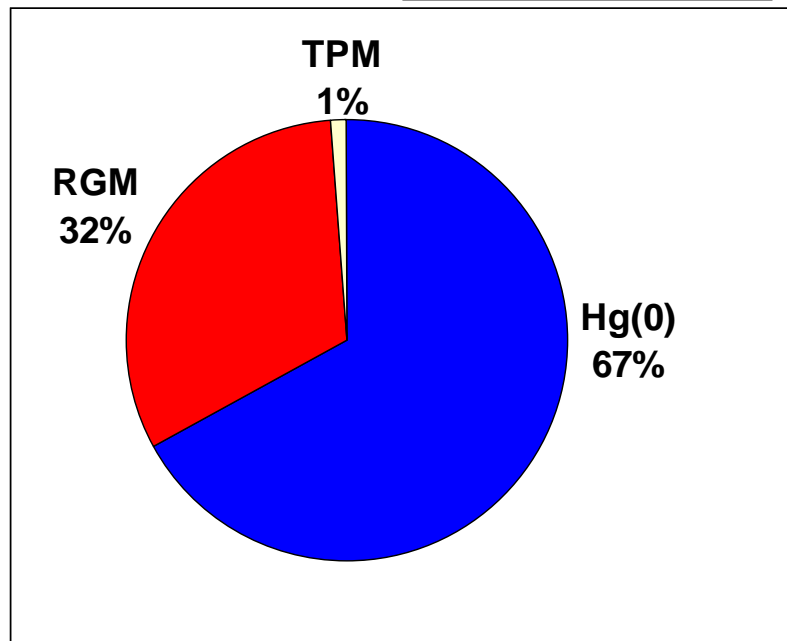
Similar relationships can be used to deduce source

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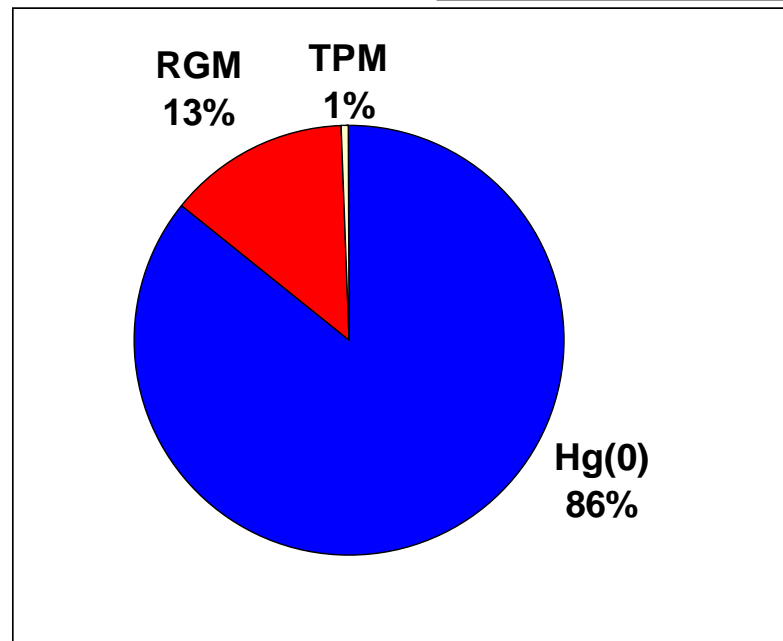
signatures (or emission factor) for mercury species.

Expected and Observed Hg Speciation Hammond Event – December 29, 2001

Expected Total-Hg = 7.5 pg/m³/ppb SO₂



Observed Total-Hg = 7.6 pg/m³/ppb SO₂



Clearly, what is observed is different that what is expected suggesting reduction of RGM to elemental mercury.

Summary Information for Mercury Events at Yorkville, GA

Summary Information for Mercury Events at Yorkville, GA									
Date	Time of Max. SO2	Max. SO2 (ppb)	Probable Source	Transit Time (hrs.)	SO2/NOy Ratio (molar)		Local Meteorology		
					Source*	Observed#	clouds	rain	max. T
6/27/01	1600	12.7	Bowen	6	3.58	3.76	scattered	none	36.5
7/20/01	0900	27.0	Bowen	4	3.26	3.19	scattered	none	25.2
10/20/01	2000	17.0	Wansley	8	2.31	1.96	clear	none	18.6
10/22/01	1300	22.9	Bowen	4	2.68	2.69	scattered	none	21.7
11/16/01	1400	40.0	Bowen	4	3.01	2.39	scattered	none	21.2
11/17/01	1900	35.0	Bowen	5	2.79	2.85	clear	none	21.0
12/7/01	1100	10.0	Gaston	???	???	2.74	clear	none	9.8
12/13/01	1000	30.0	Bowen	3	2.51	2.59	heavy	light	16.0
12/15/01	1400	27.8	Bowen	4	2.84	2.89	scattered	none	18.9
12/19/01	0500	7.5	Hammond	5	1.29	1.14	scattered	none	9.6
12/26/01	1000	10.7	Hammond	5	1.48	1.33	clear	none	3.2
12/28/01	1800	12.2	Gaston	8	3.46	2.98	scattered	none	15.0
12/29/01	1900	15.6	Hammond	4	1.79	1.85	clear	none	8.8
12/31/01	1700	28.5	Hammond	3	1.54	1.39	heavy	moderate	4.9
1/3/02	1800	21.8	Hammond	4	1.26	1.17	scattered	none	3.5
* from CEM data (est. time of emission)									

Population of events span multiple power plants and seasons.

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Summary of Yorkville Plume Events

June 2001-January 2002 (n=15)

Date	Probable Source	Observed RGM/SO2*	Observed Hg(0)/SO2*	Observed % Hg(0)	Expected % Hg(0) [#]	Apparent RGM Red. Rate (%/hr)
6/27/01	Bowen	1.2	9.7	89	46	15
7/20/01	Bowen	0.75	12	94	39	23
10/20/01	Wansley	0.85	6.3	88	48	8
10/22/01	Bowen	4.7	6.8	59	44	5
11/16/01	Bowen	4.6	nd	nd	43	nd
11/17/01	Bowen	6.3	nd	nd	41	nd
12/7/01	Gaston	0.59	12.4	94	61	6
12/13/01	Bowen	0.93	12.3	93	38	23
12/15/01	Bowen	3.5	nd	nd	42	nd
12/19/01	Hammond	0.36	11.3	97	42	24
12/26/01	Hammond	1.6	9.2	85	40	20
12/28/01	Gaston	1.3	13.9	92	58	5
12/29/01	Hammond	1	6.4	87	63	11
12/31/01	Hammond	0.56	10.4	95	60	18
1/3/02	Hammond	2.9	9.9	78	58	11
Mean		2.1	10.1	87.6	48.2	14.0
Lower 95% CI		1.1	8.8	81.7	43.6	9.9
Upper 95% CI		3.0	11.3	93.5	52.8	18.2

* Units are pg/m³/ppb

Based on coal analysis for day of event

Summary of JST Plume Events

January-April, 2003 (n=17)

Date (mm/dd/yy)	Time (EST)	Probable Source	RGM pg/m ³	RGM/SO2 pg/m ³ /ppb
01/06/03	1157	McD	22.5	1.49
01/06/03	1245	McD	31.8	0.85
01/11/03	1235	BCC	50.5	1.08
01/13/03	1212	McD/BCC	51.4	0.75
01/13/03	1357	McD	37.0	1.00
01/13/03	1915	BCC/McD	65.1	1.47
01/17/03	1207	McD	48.2	1.24
01/17/03	1445	McD/BCC	47.4	1.95
01/17/03	1602	BCC	59.8	1.03
02/24/03	1315	BCC/McD	82.8	1.66
02/25/03	740	BCC	31.3	1.21
02/25/03	1205	McD/BCC	64.3	0.97
03/10/03	1447	McD	35.5	1.24
03/26/03	1617	McD	27.6	0.58
04/02/03	1605	BCC	28.9	1.68
04/12/03	1247	McD	34.0	1.37
04/22/03	1625	McD	30.6	1.89
Mean			44.0	1.26
s.d.			16.6	0.39

McD = McDonough CFPP
BCC = Blue Circle Cement

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Comparison of Expected, Modeled and Measured Hg Partitioning

Seigneur et. al., 2001, 2002.

Event	% Total-Hg	Source	Model Calculations			Meas.
			Actual Met.	w/clouds	V _d x10	
Bowen (7/20/01)	Hg(0)	39	41	42	52	94
	RGM	60	59	58	48	6
Hammond (12/29/01)	Hg(0)	64	67	nc	nc	87
	RGM	35	32	nc	nc	13

w/clouds simulation assumes clouds from 400m to 2000m; V_d = deposition velocity; nc - not calculated

Our current understanding of atmospheric mercury chemistry as represented in models cannot reproduce the observations.

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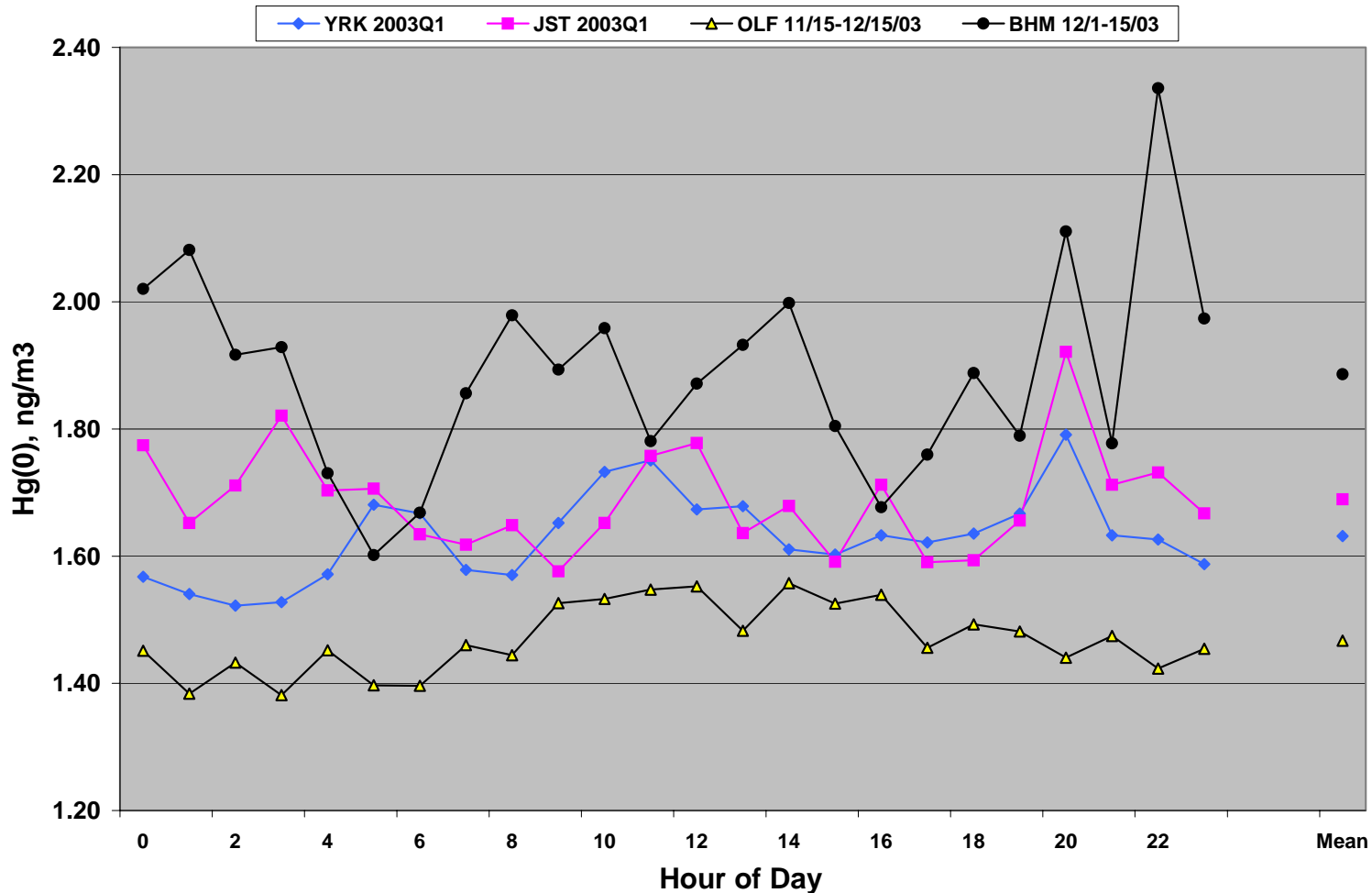
Interannual Variability of Hg(0)

Winter 2002 vs. Winter 2003

	JST (ng/m³)	YRK (ng/m³)
2002	2.10 +/- 0.27	1.94 +/-0.21
2003	1.52 +/-0.24	1.46 +/-0.22
'03/'02	0.72	0.75

Wintertime Hg(0) concentrations were substantially lower at YRK and JST in 2003 compared to 2002

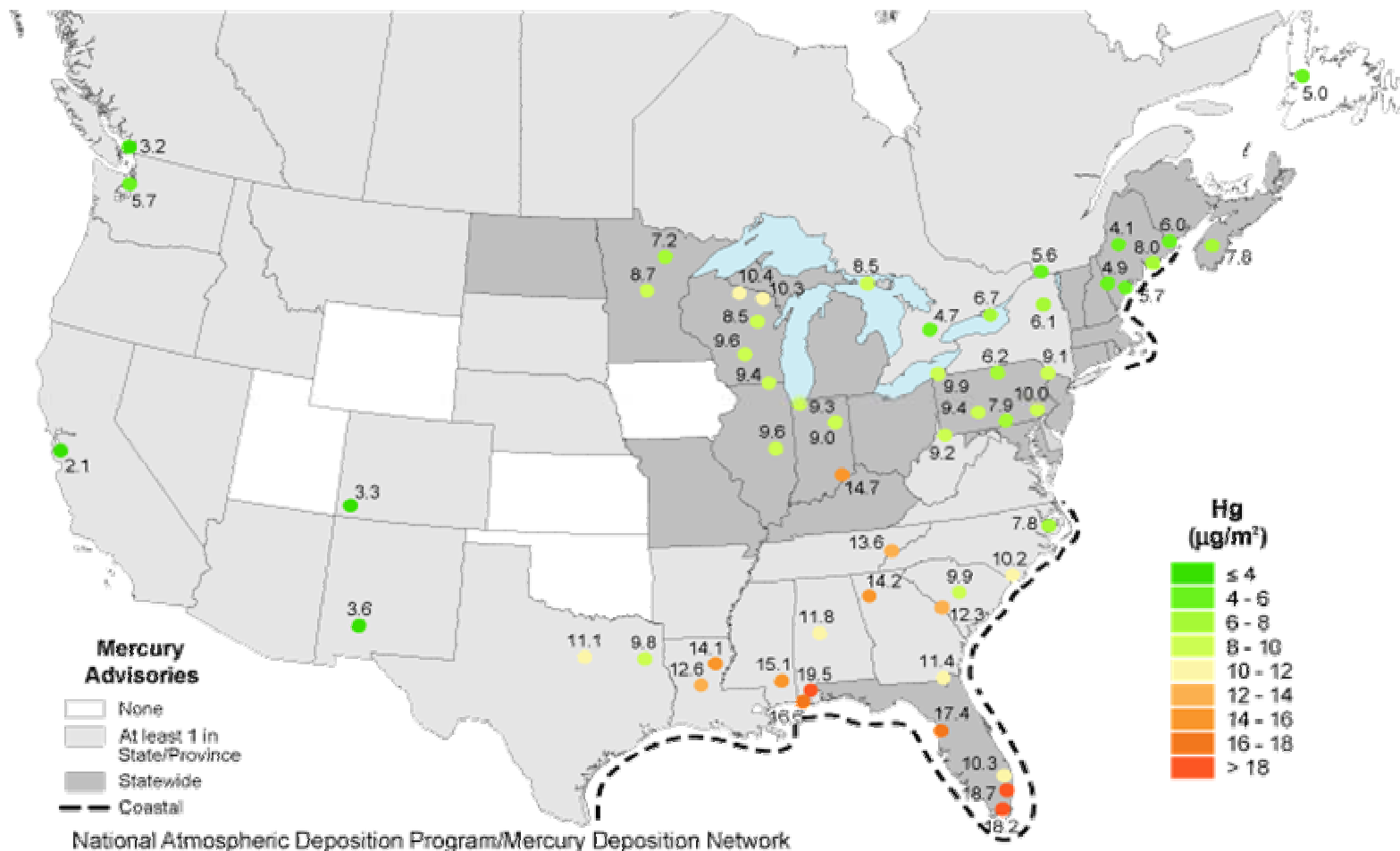
Diurnal Profiles of Elemental Hg at SEARCH Sites



Preliminary data on Hg(0) suggest levels in Pensacola are lower and in Birmingham, higher than in and near Atlanta

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Total Mercury Wet Deposition, 2002



**Inter-annual changes can be significant but
are not consistent spatially**

Summary and Conclusions

- ◆ High temporal resolution speciated Hg and trace gas measurements were made at Yorkville and Jefferson Street during 2001-2003.
- ◆ Numerous episodes of elevated RGM and SO₂ were identified at each site (15 at YRK, 17 at JST). In many cases, likely sources also identified.
- ◆ For YRK, RGM/SO₂ ratios substantially lower than expected, based on coal analysis and mass balance considerations.
- ◆ Similar RGM/SO₂ also observed at JST.
- ◆ These observations suggest that RGM is much less abundant in coal fired power plant plumes than expected.

Summary and Conclusions

- ◆ Current models cannot reproduce these observations.
- ◆ For unknown reasons, wintertime Hg(0) concentrations were substantially lower at YRK and JST in 2003 compared to 2002.
- ◆ Preliminary data on Hg(0) suggest levels in Pensacola are lower and in Birmingham, higher than in and near Atlanta.
- ◆ MDN data show substantial, but not spatially consistent, inter-annual changes.