

# Mercury Deposition in the Great Lakes Region

Jerry Keeler

University of Michigan Air Quality Laboratory

Presented at the Mercury Workshop:  
What do we know about mercury deposition in the  
upper Midwest?  
February 22, 2006  
Chicago, Illinois



# Ohio Mercury Measurement and Receptor Modeling Study

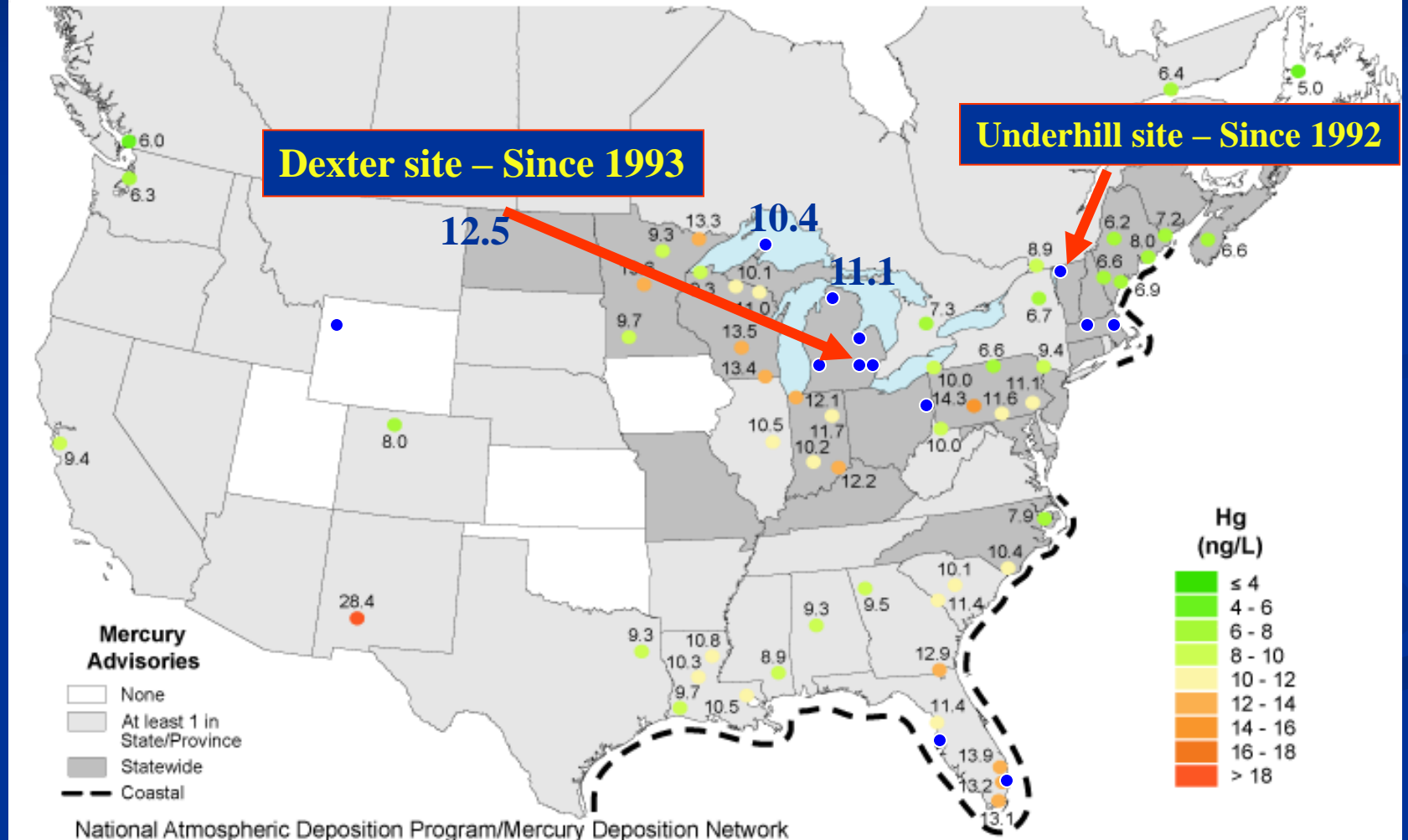
## Objective

Determine the impact of local/regional coal combustion sources on Hg deposition in the Ohio River Valley



# UMAQL EVENT SAMPLING SITES

Total Mercury Concentration, 2001



# Ohio Mercury Study

- **Sate-of-the-art measurement & analyses**
  - Aerosols - Integrated and Continuous
  - Wet Deposition - Daily Event
  - Criteria Gases - Continuous
  - Meteorology - Continuous
- **Receptor Modeling**
  - UNMIX, and PMF
  - Hybrid Modeling (Regional Transport)



# Steubenville EPA PMF

## Apportionment Results 2003-2004

Analyte	Factor 1 (Iron/Steel)	Factor 2 (P Source)	Factor 3 (Coal)	Factor 4 (Crustal)	Factor 5 (Metals)	Factor 6 (Oil/Incineration)
Mg	187.14	95.11	*	<b>539.31</b>	29.58	*
Al	49.19	*	75.71	<b>346.68</b>	34.67	52.20
P	*	<b>64.36</b>	*	*	*	*
S	*	172.33	<b>11187.00</b>	363.19	*	*
Cl	257.26	*	602.59	186.41	647.79	<b>1745.00</b>
V	<b>2.82</b>	*	*	*	*	<b>1.26</b>
Cr	<b>2.40</b>	*	*	*	*	0.62
Mn	<b>53.93</b>	14.02	*	33.01	*	*
Fe	<b>337.11</b>	15.32	22.52	12.40	*	136.26
Ni	*	0.53	*	*	*	<b>3.93</b>
Cu	*	2.29	19.90	*	8.23	14.38
Zn	3.31	4.20	*	*	13.78	<b>44.79</b>
As	*	0.04	0.70	0.09	0.27	0.60
Se	*	*	<b>2.39</b>	*	1.25	0.26
Rb	*	0.26	0.23	0.14	0.08	0.20
Sr	0.51	1.53	1.77	<b>5.54</b>	*	2.19
Mo	*	*	*	*	<b>3.60</b>	*
Cd	0.09	*	0.33	*	0.25	0.25
La	*	*	*	<b>0.61</b>	0.01	0.07
Ce	0.02	*	*	<b>1.19</b>	*	*
Hg	0.011	0.003	0.136	*	*	*
Pb	0.91	*	3.83	*	*	6.26
NO <sub>3</sub>	*	216.00	<b>5993.80</b>	1325.70	*	5296.70
% Hg	4 ± 3	2 ± 1	<b>67 ± 14</b>	*	*	*

\* = Not Significant at 95% confidence interval

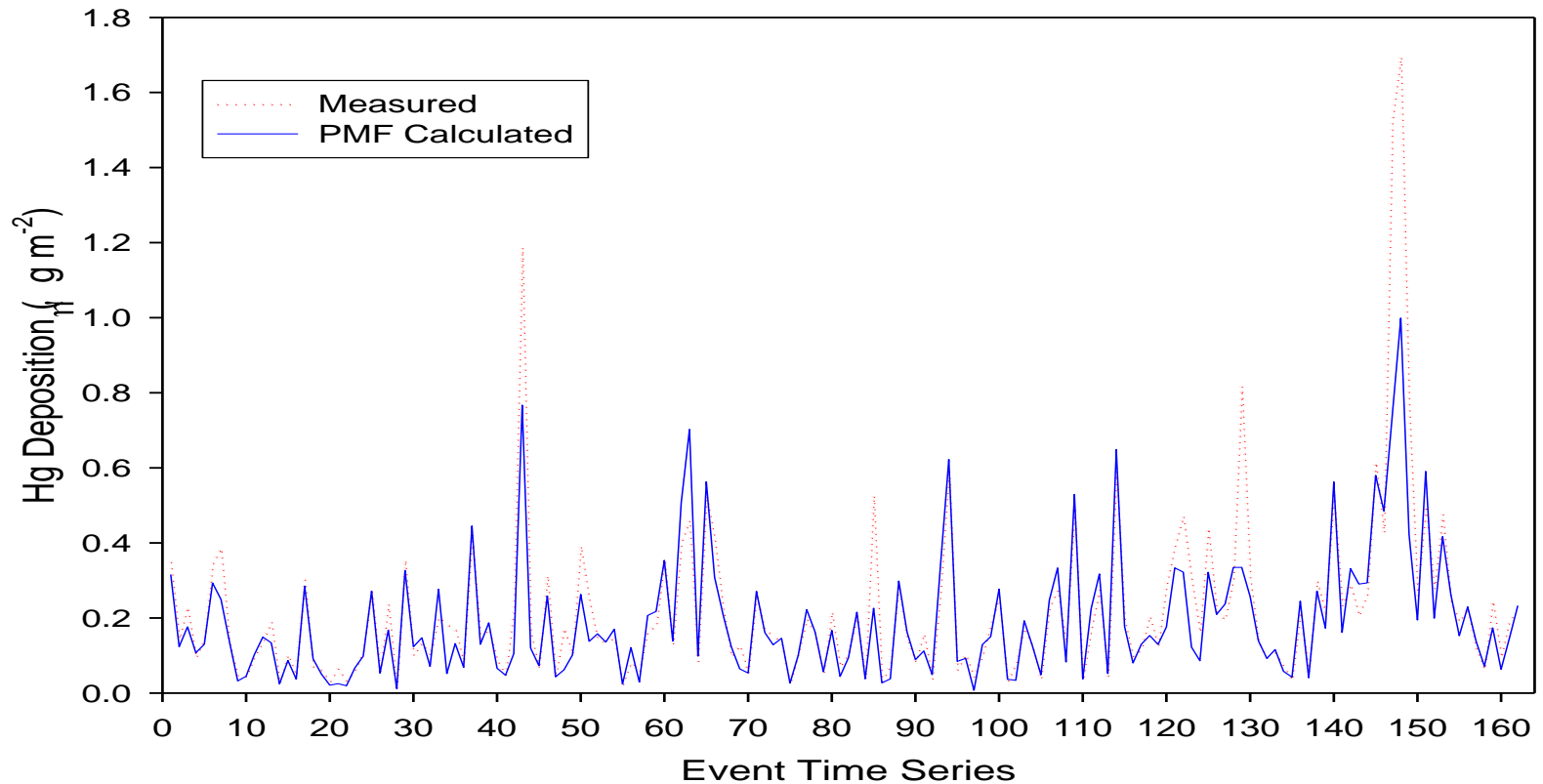
# Source Apportionment Results Steubenville, Ohio

	Measured	PMF Estimated CFUB* Contribution	UNMIX Estimated CFUB* Contribution
2003	13.2	Mean = 9.5 (5-95% CI <sup>Ω</sup> ) = (7.2 – 15.8)	Mean = 9.9 (5-95% CI <sup>Ω</sup> ) = (4.9 – 14.9)
2004	19.8	Mean = 12.0 (5-95% CI <sup>Ω</sup> ) = (9.0 – 19.8)	Mean = 15.4 (5-95% CI <sup>Ω</sup> ) = (7.7 – 23.1)

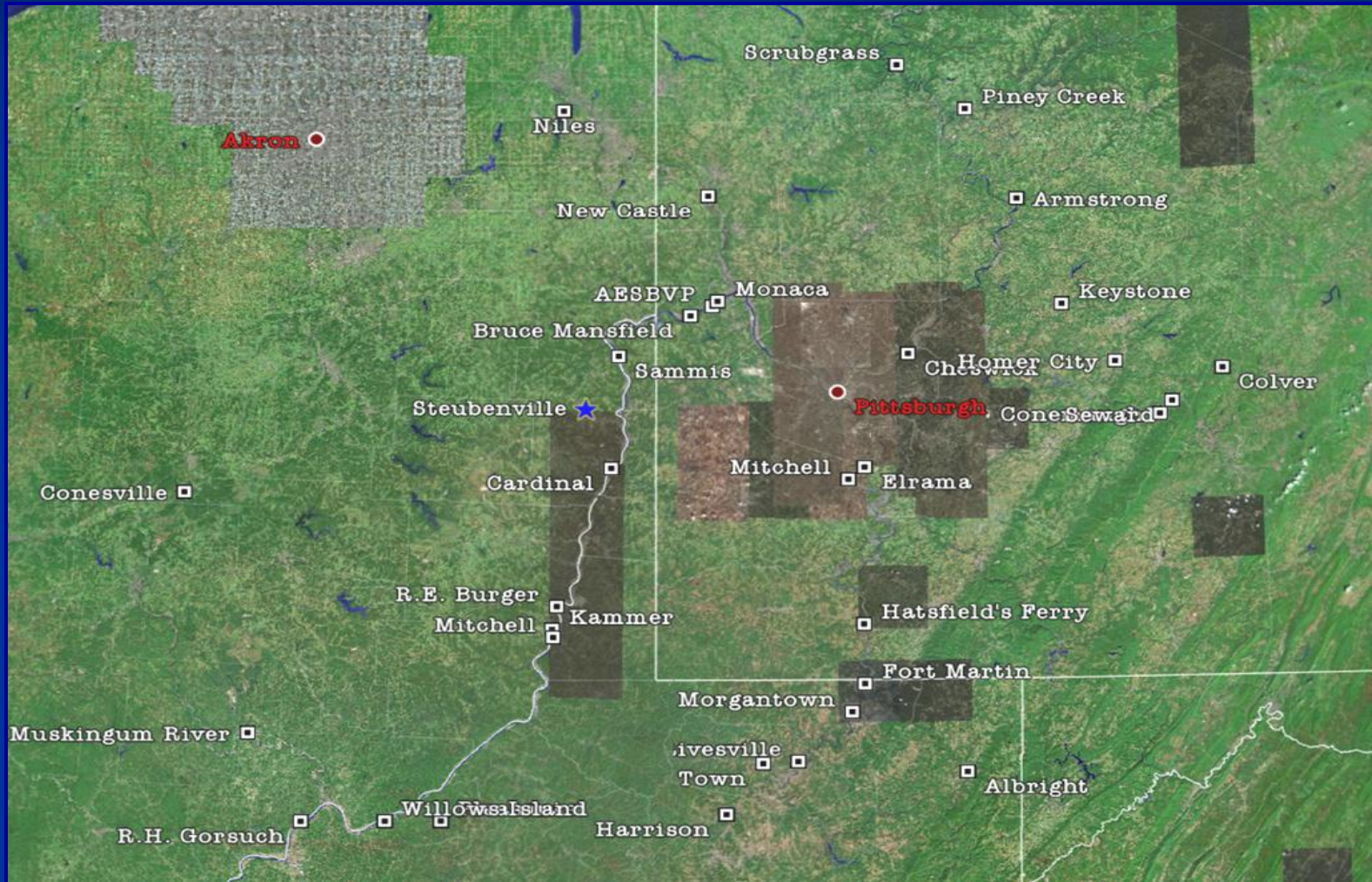
\*Coal-fired Utility Boiler

<sup>Ω</sup> Confidence Interval

# Estimated versus Measured Mercury Deposition

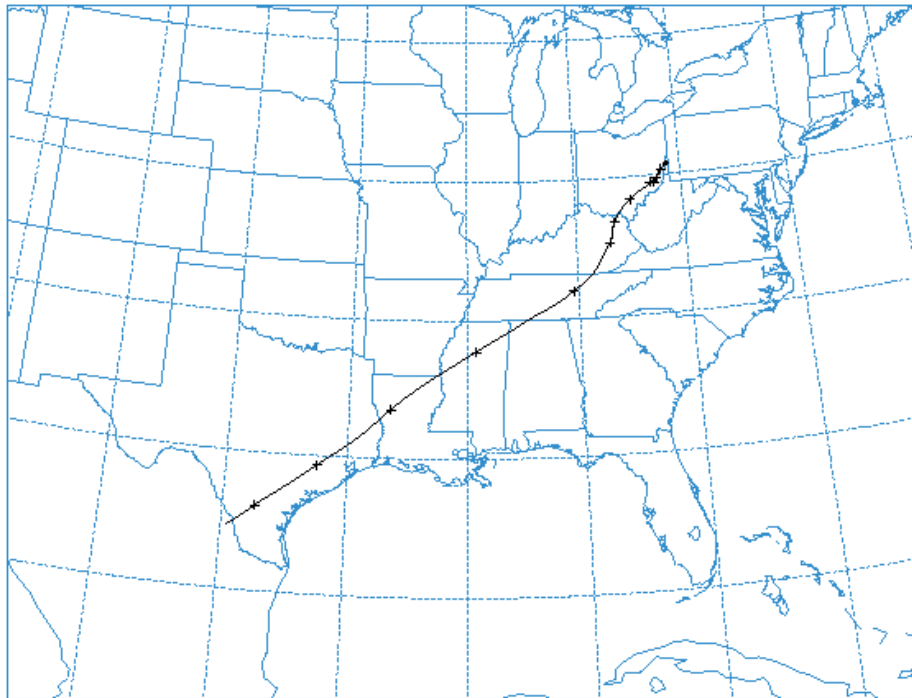


# Steubenville Site



# HY-SPLIT Back Trajectories

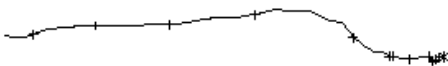
U OF M AIR QUALITY LABORATORY  
BACKWARD ENDING - 08Z 08 MAY 3 (UTC)  
EDAS METEOROLOGICAL DATA



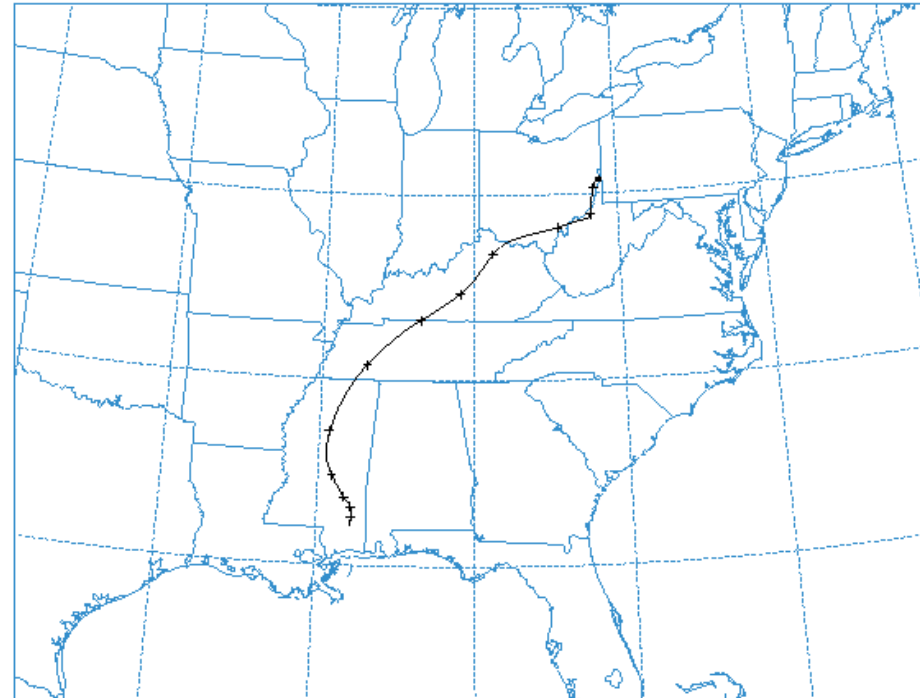
VERTICAL MOTION METHOD - OMEGA

HPA

700  
900



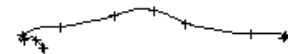
U OF M AIR QUALITY LABORATORY  
BACKWARD ENDING - 03Z 29 AUG 4 (UTC)  
EDAS METEOROLOGICAL DATA



VERTICAL MOTION METHOD - OMEGA

PLT

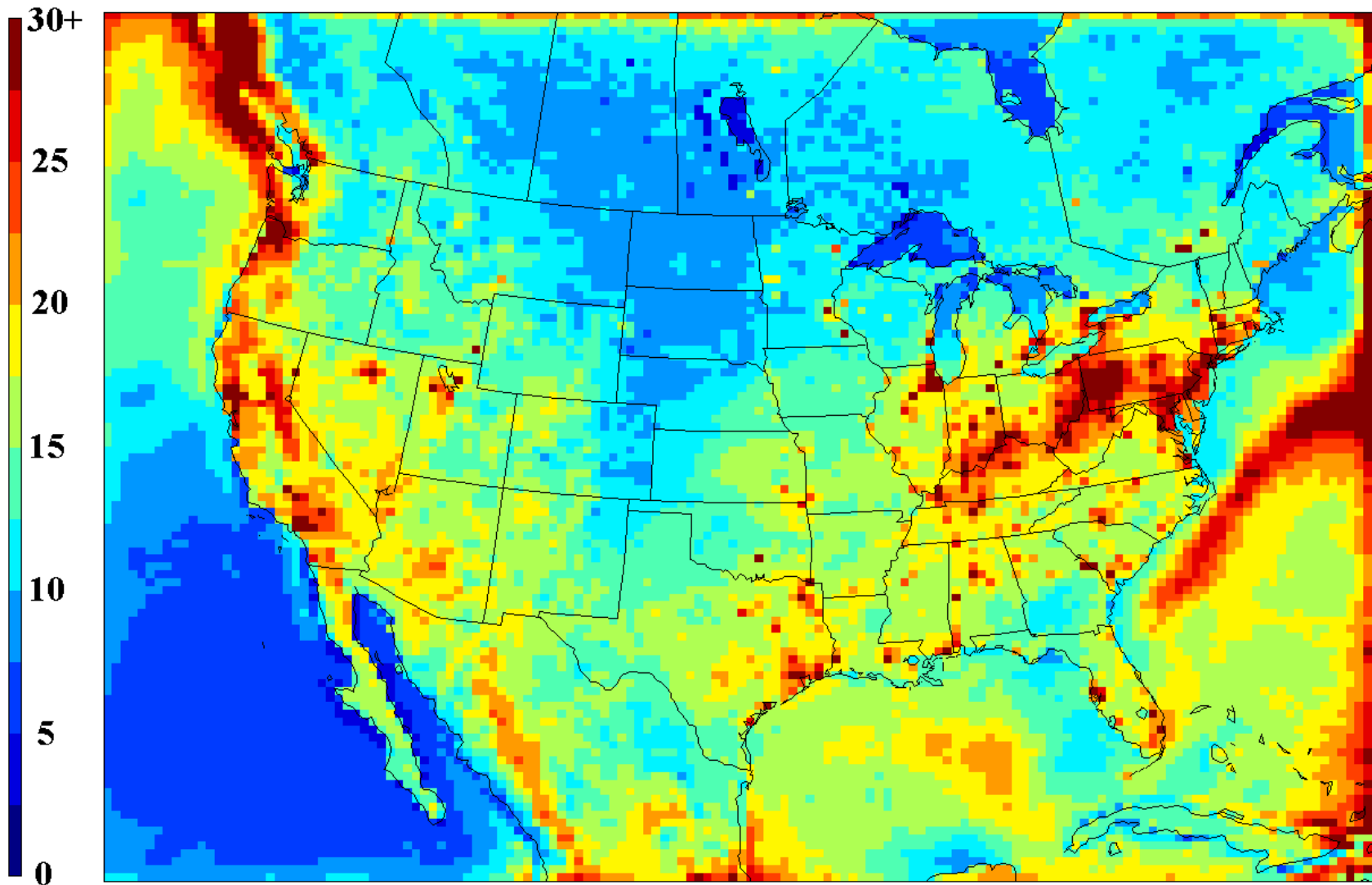
800  
900  
1000



# Summary of Ohio Receptor Modeling 2003-2004

- **Hg wet deposition at Steubenville**
  - ~ 80% attributable to local/regional anthropogenic sources
  - ~ 70% is attributable to coal combustion
  - ~ 20% from reemission/global background
- **A significant portion of total Hg wet deposition is driven by a few local coal combustion dominated precipitation events**
  - In 2004, >8% of Hg wet deposition occurred during 1 event
- **Hybrid-receptor Modeling results being completed.**

# CMAQ-simulated total mercury deposition for 2001 (micrograms per square meter)



**Base case**

# Comparison of CMAQ Model Results to Measured Mercury Wet Deposition at Steubenville

	Hg Deposition ( $\mu\text{g m}^{-2}$ )	CFUB Contribution (%)
CMAQ 2001	13.6	43
PMF & UNMIX 2003 & 2004	15.6	~70

CMAQ Simulations performed by CSC for EPA (6FEB04)