

# The DOE-NETL Air Quality Research Program

*U.S. Department of Energy*

*Office of Fossil Energy (FE)*

*National Energy Technology  
Laboratory (NETL)*



# Why DOE-FE is Concerned About Air Quality

- **Goal 1 of Strategic Plan, DOE Office of Fossil Energy:**
  - *“eliminate environmental issues as a barrier to fossil fuel production and use, while maintaining the availability and affordability of fossil fuels.”*
- **Coal is a vital, low-cost source of electricity**
  - Responsible for > 50% of U.S. power generation
  - Reserves available for 200+ years
- **Coal power emissions can adversely impact air quality**
  - Criteria pollutants (SO<sub>2</sub>, NO<sub>x</sub>) are also fine PM precursors
  - Primary fine PM; Acid Gases
  - Mercury



# FE's "Innovations for Existing Plants" Program

- **Air quality research (today's topic)**
- Mercury control technology
- PM/acid gas control technology
- NOx control technology
- Coal utilization byproducts research
- Energy-water initiatives

**NETL Product  
Manager:  
Tom Feeley**



# Regulatory/Legislative Drivers

- **National Ambient Air Quality Standards (NAAQS)**
  - SO<sub>2</sub>, NO<sub>x</sub>, O<sub>3</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>
- **1999 Regional Haze Rule**
  - Affects SO<sub>2</sub>; BART provisions for power plants
- **MACT for Air Toxics (Hg)**
- **Near-stack opacity**
  - Acid gases (SO<sub>3</sub>); Primary PM
- **Multipollutant legislation “Clear Skies Initiative”**
  - SO<sub>2</sub>, NO<sub>x</sub>, Hg
- **Greenhouse gas emission restrictions?**



# Current Emphasis in Air Quality Research: PM<sub>2.5</sub>

- **Complex issue**
- **Multiple regulatory/legislative drivers**
- **High stakes for electric power generation**



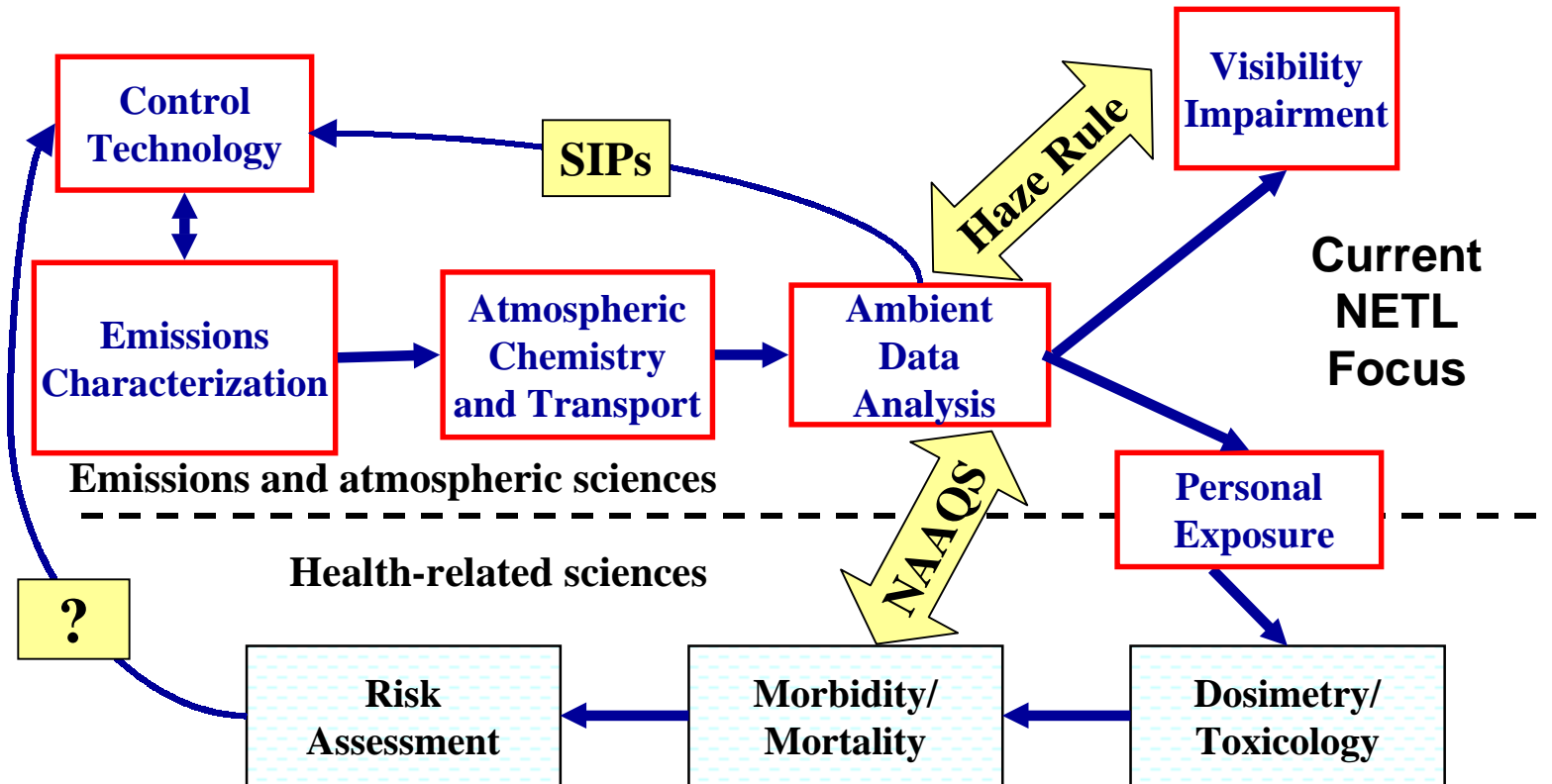
# Coal Power & PM<sub>2.5</sub> - Central Issues

- Power plant emissions contribute significantly to secondary PM<sub>2.5</sub> mass
- Effect of power plant emission reductions on PM<sub>2.5</sub> mass and regional haze is uncertain
- Effect of power plant emission reductions on human health is even less certain



# PM<sub>2.5</sub> Research Paradigm

*as applied to Power Plant Emissions*



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# DOE-NETL PM<sub>2.5</sub> Research Goals

- **Relate emissions from coal-based energy production to concentrations and composition of ambient PM<sub>2.5</sub>**
- **Inform decision-makers about energy management options for achieving PM<sub>2.5</sub> and related air quality standards**

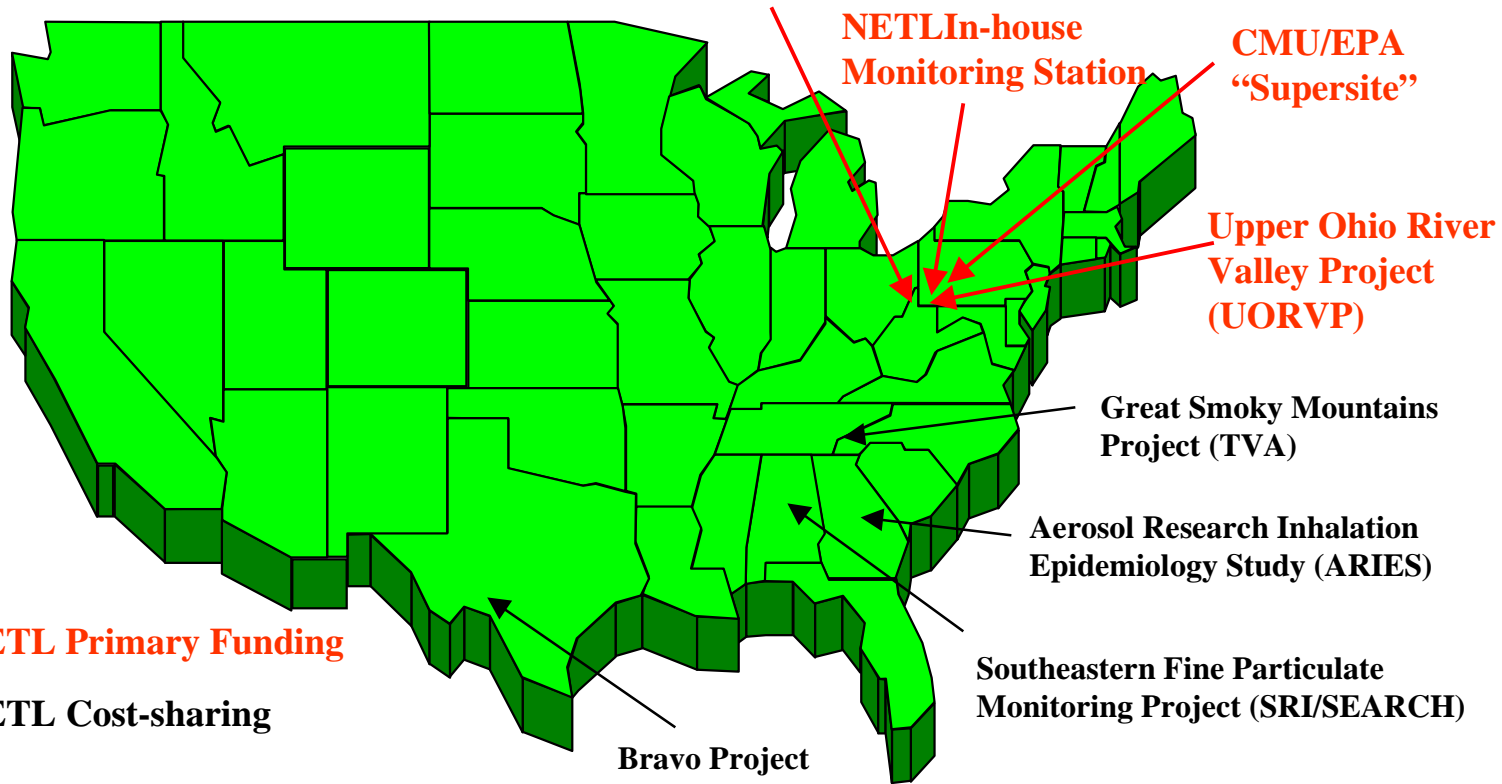




# Ambient Monitoring and Analysis

## *Current and Recently-completed Projects*

**Stuebenville Comprehensive Air Monitoring Project (SCAMP)**

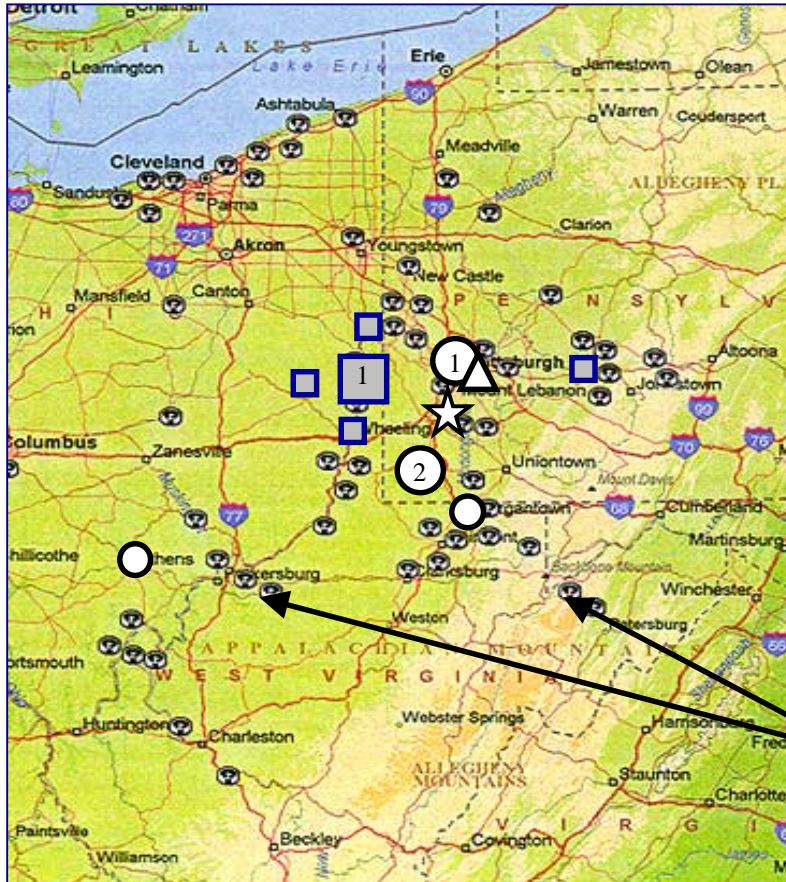


**DOE-NETL Primary Funding**

**DOE-NETL Cost-sharing**



# Ambient Monitoring Sites in Ohio River Valley



## UORVP Sites

- ① - Lawrenceville (Urban)
- ② - Holbrook (Rural)
- - Satellites

## SCAMP Sites

- 1 - Primary
- 2 - Satellites
- △ - CMU/EPA Supersite
- ☆ - NETL In-house site

Coal-fired power plants



# Upper Ohio River Valley Project

## *Monitoring Sites*

- **Contractor: Advanced Technology Systems, Inc.**
  - Sample Analysis: Desert Research Institute
  - Data Management: Ohio University
- **Main sites (PM filters & TEOMs; gases; met tower):**
  - Urban: Lawrenceville (Pittsburgh), PA (ACHD);
  - Rural: Holbrook, Greene County, PA (PADEP, NARSTO)
- **Satellite sites (FRM Only):**
  - Urban: Morgantown, WV (Airport)
  - Rural: Athens, OH (Gifford State Forest)



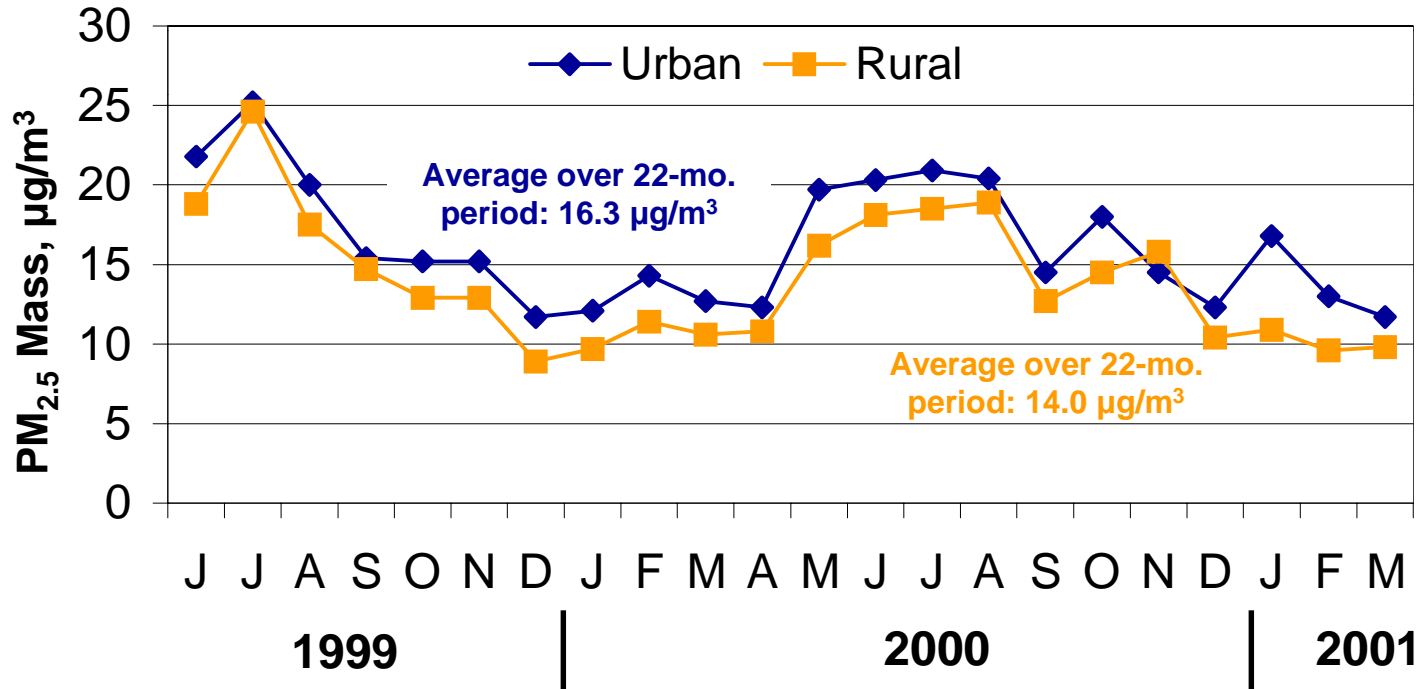
# Upper Ohio River Valley Project

## *PM Filter Sampling Schedule*

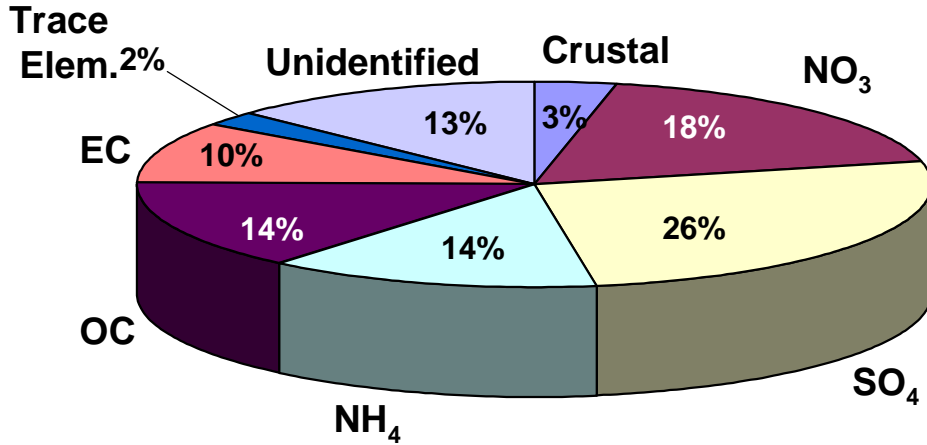
- **Baseline: 1-24h sample every 6th day at all sites**
- **Intensives:**
  - Approx. 1 month in length
  - Winter and Summer 1999, 2000 and 2002; Summer 2001
  - Lawrenceville: 4 samples daily
  - Holbrook: 1 sample daily
  - Satellites: 1 sample every 3rd day
- **Samples stored at DRI for chemical analysis**
  - Focus on key periods to reduce cost



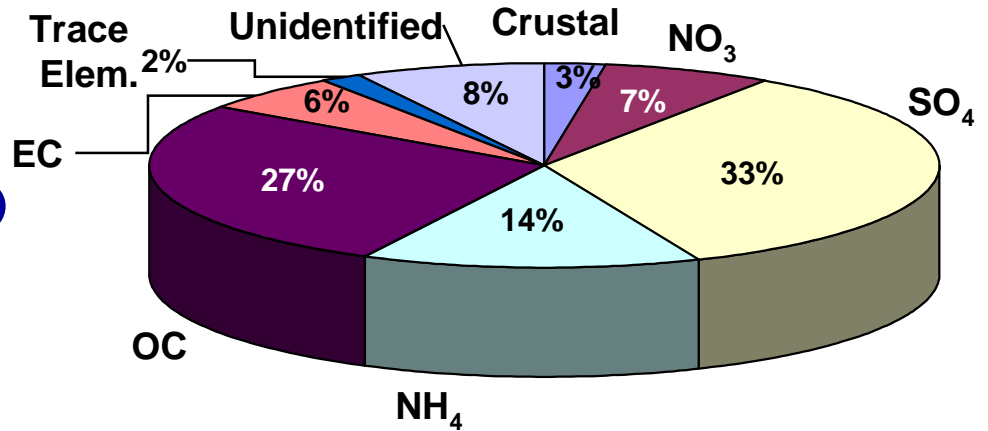
# Monthly Average TEOM PM<sub>2.5</sub>, UORVP Sites



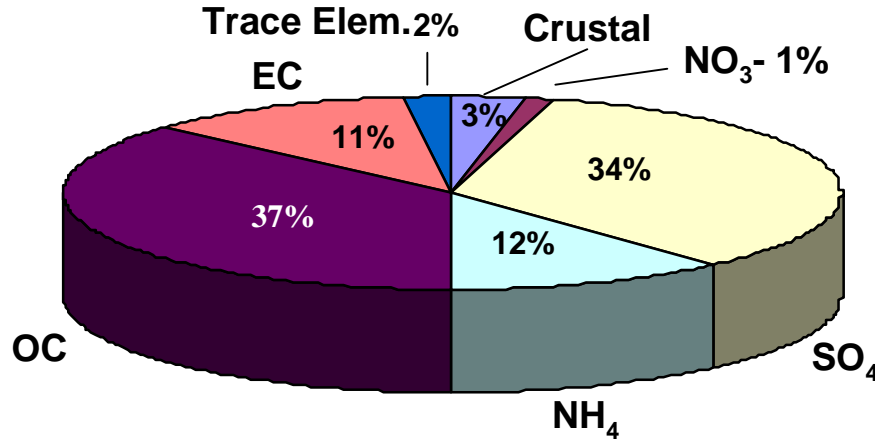
# Typical UORVP PM<sub>2.5</sub> Speciation (*Winter 1999*)



Rural Site  
(avg. of 9 samples)

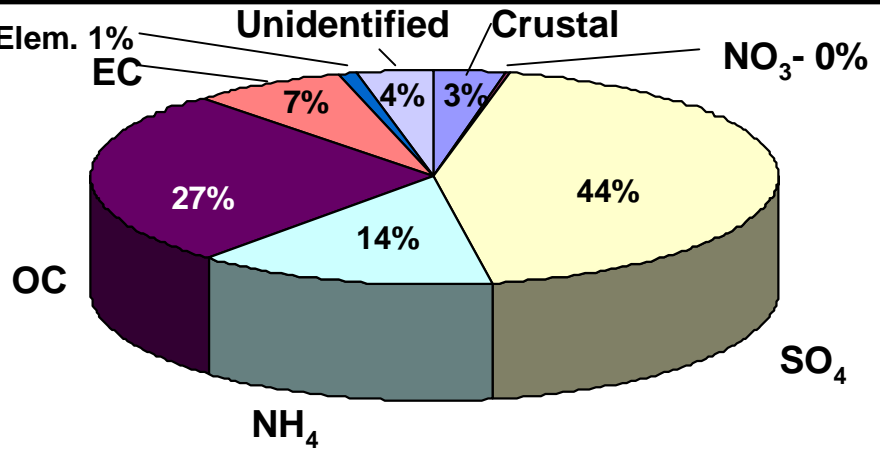


# Typical UORVP PM<sub>2.5</sub> Speciation (*Summer 1999*)



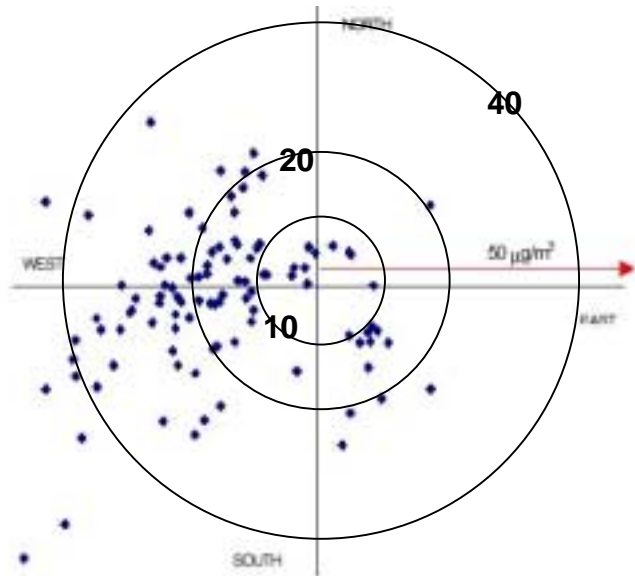
**Urban Site**  
(avg. of 39 samples)

**Rural Site**  
(avg. of 10 samples)

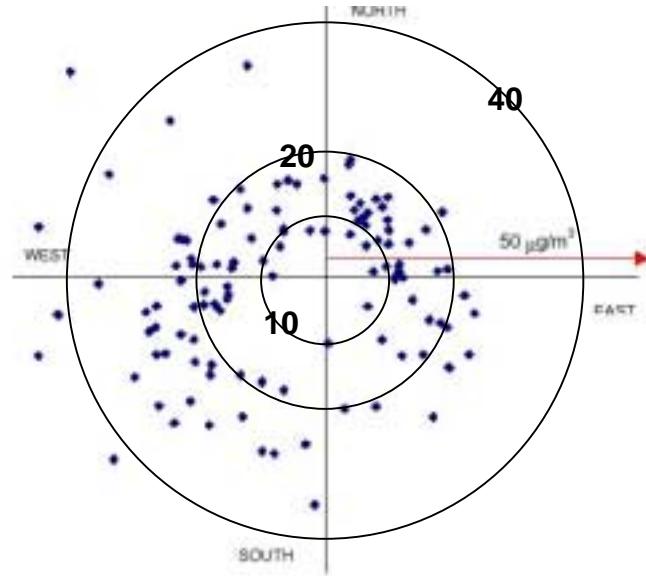


# PM<sub>2.5</sub> Mass vs. Wind Direction

July 1999



July 2000

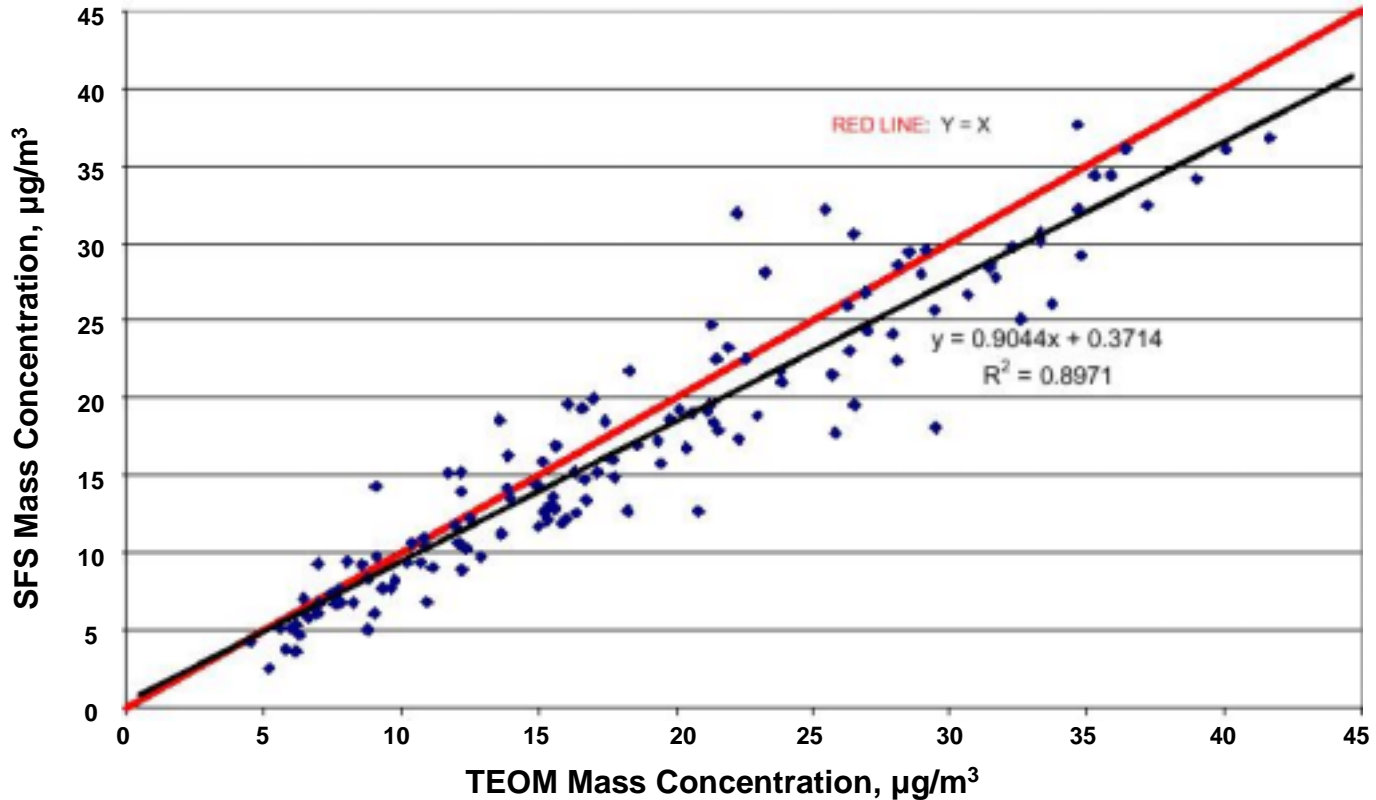


Urban site, 6-Hr TEOM Averages,  $\mu\text{g}/\text{m}^3$



# TEOM vs. Sequential Filter Sampler, PM2.5

6-Hour Samples, Summer 1999



# Summary of Interim Results - UORVP

- **PM<sub>2.5</sub> Mass:**
  - Urban site slightly higher than rural site
  - Higher levels, wider variations in during summer
  - Higher at urban site when winds from W, SW, NW
- **Sulfate is dominant component of PM<sub>2.5</sub> mass**
  - Higher nitrate at urban site
  - Higher OC at rural site
- **TEOMs and filter samplers give similar masses**
  - Less semi-volatile PM than in other regions



# Steubenville Comprehensive Air Monitoring Project (SCAMP)

- **Outdoor (Ambient) Study**

- Central monitoring site; four satellite sites
- Primary performer: CONSOL, Inc.
- Daily sampling of ambient PM<sub>2.5</sub> mass
  - 1 day in 4 chemical speciation
- Funding: DOE, EPA

- **Personal Exposure Study**

- Outdoor vs. indoor vs. personal PM<sub>2.5</sub> in Steubenville
- Primary Performer: Harvard School of Public Health
- Primary Funding: Ohio Coal Development Office (OCDO)
- Co-funding: EPRI, NMA, API, AISI, CONSOL



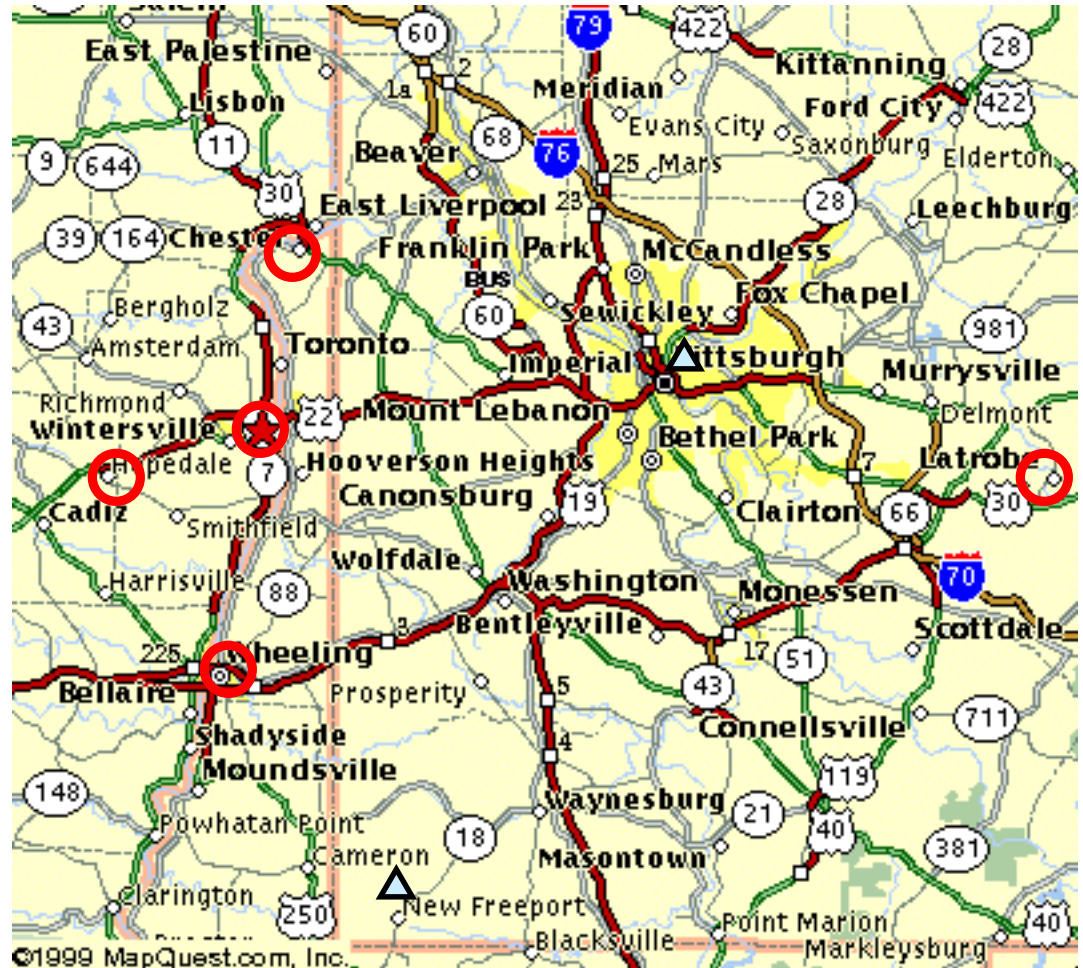
# SCAMP Outdoor Study - Status

- **Sampling May 2000 - May 2002**
- **Ambient data analysis “complete” through Dec. 2000**
  - Except for OC/EC/Crustal Speciation
- **Not yet integrated with Personal Exposure Study**

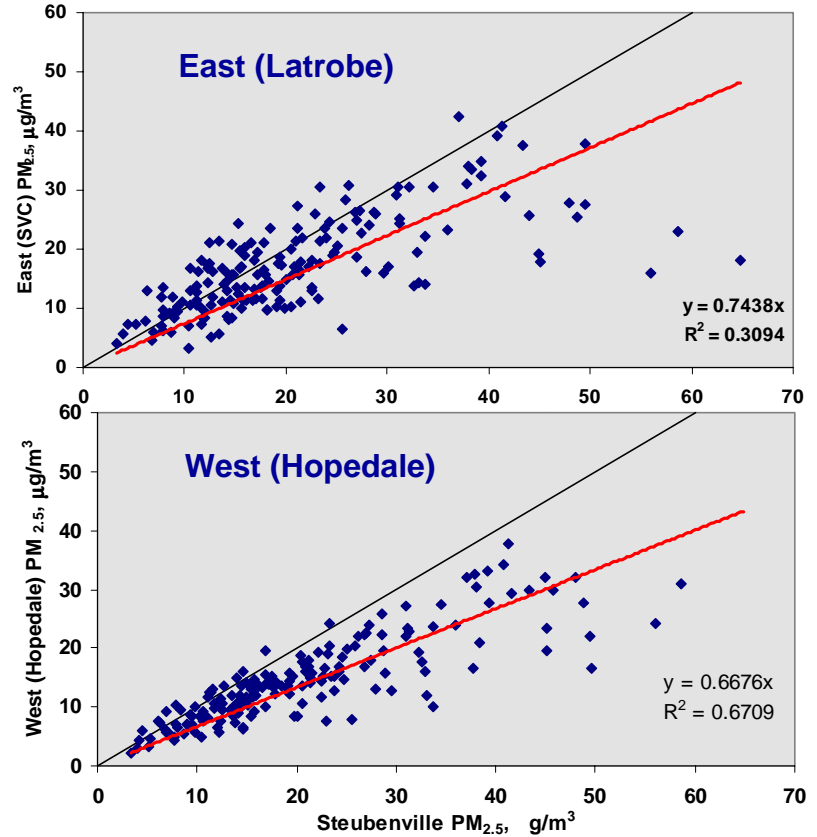
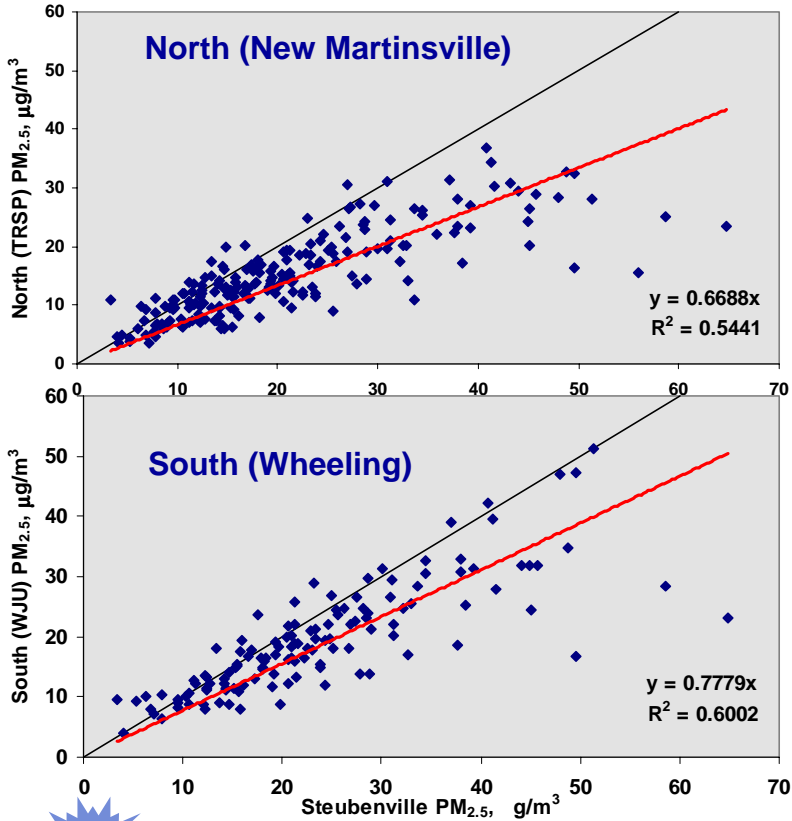


# SCAMP Monitoring Sites

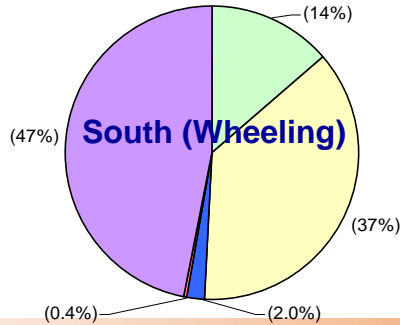
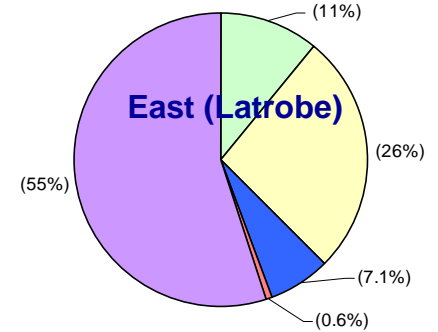
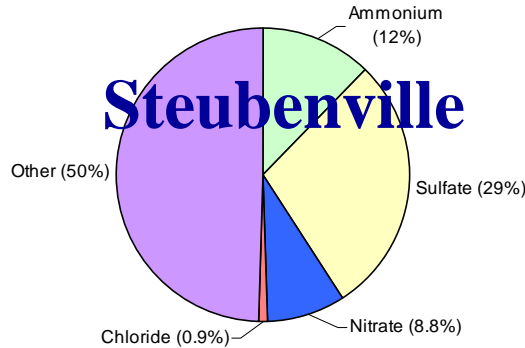
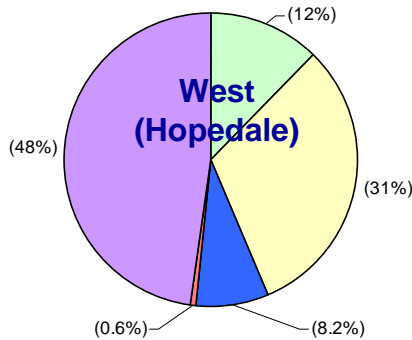
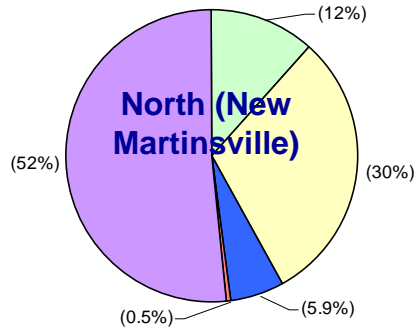
- Steubenville, OH
- New Manchester, WV
- Hopedale, OH
- Wheeling, WV
- Latrobe, PA



# Steubenville PM<sub>2.5</sub> Mass vs. Satellites (FRM Data)



# Average PM<sub>2.5</sub> Composition Sept.-Dec. 2000



# Average PM<sub>2.5</sub> Composition, wt %

	NH <sub>4</sub> <sup>+</sup>		SO <sub>4</sub> <sup>2-</sup>		NO <sub>3</sub> <sup>-</sup>		Cl <sup>-</sup>		Other (by difference)	
	May-Aug	Sep-Dec	May-Aug	Sep-Dec	May-Aug	Sep-Dec	May-Aug	Sep-Dec	May-Aug	Sep-Dec
Steubenville	12.0	12.2	35.7	28.6	3.3	8.8	0.9	0.9	48.1	49.5
North	11.7	11.7	36.4	30.2	2.1	5.9	1.2	0.5	48.6	51.6
South	13.1	13.7	39.7	37.1	2.7	2.0	0.8	0.4	43.7	46.8
East	11.9	10.9	35.8	26.5	2.6	7.1	1.0	0.6	48.7	55.0
West	12.3	12.3	38.1	31.3	2.5	8.2	1.0	0.6	46.1	47.6



Decrease



Increase





# SCAMP Personal Exposure Study - Status

- **Completed data collection for panel studies of 2 “susceptible” populations**
- **Older Adults: Summer 2000; Fall 2000**
  - Companion cardiovascular health study (NIEHS)
- **Children: Winter 2001; Summer 2001**
- **Preliminary data analysis for older adult panel**
  - PM<sub>2.5</sub> mass concentrations



# Pittsburgh Air Quality Study

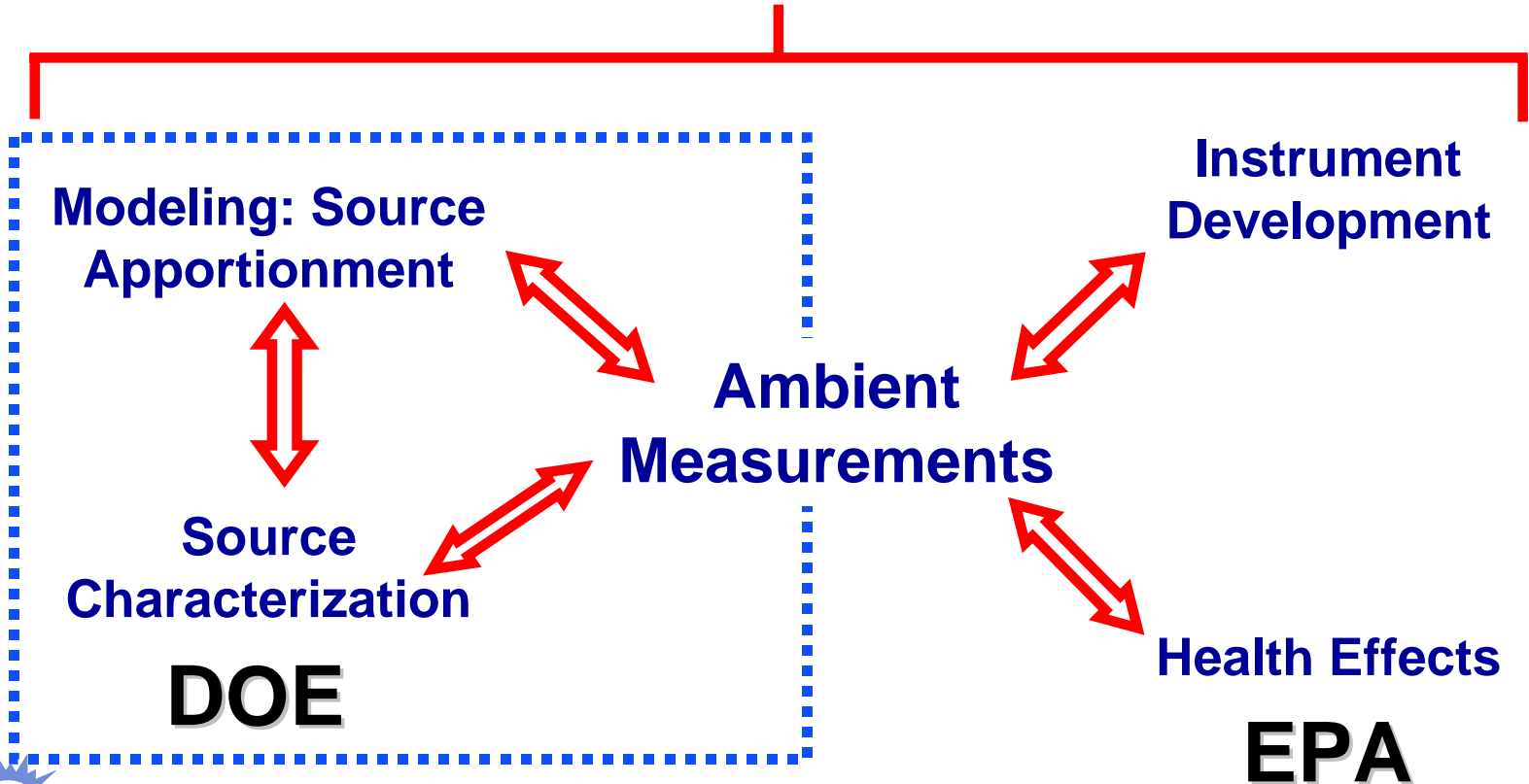
## *Carnegie-Mellon University*

- **Leveraged with CMU/EPA Supersite**
- **DOE Project Title: “Atmospheric Aerosol Source-Receptor Relationships: The Role of Coal-fired Power Plants”**
- **3 components:**
  - Advanced ambient monitoring at EPA “Supersite”
  - Source characterization/profiling in Pittsburgh area
  - Comprehensive regional modeling and data analysis



# CMU-Pittsburgh Air Quality Study

## *Objectives*



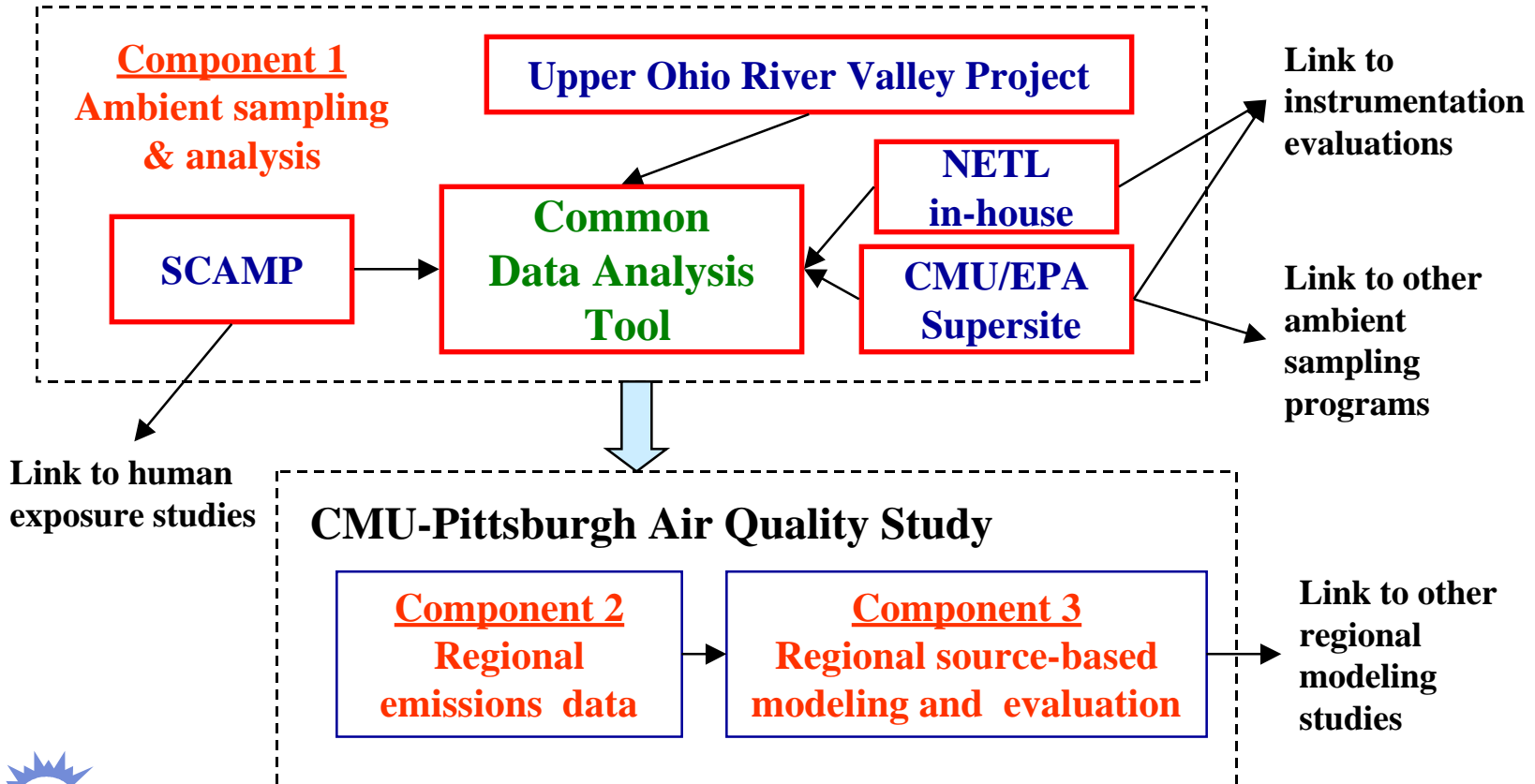


# Integrated Database and Analytical Tool

- **New Award to Advanced Technology Systems, Inc.**
  - Expected start: May 2002
- **Integrate data from UORVP, SCAMP, CMU, and NETL In-house monitoring sites**
  - Include EPA, State, local site data if possible
  - Database structure coordinated with EPA, NARSTO, etc.
- **Web-based querying, sorting, graphing, mapping downloading capabilities**
  - Stakeholder group to define analytical capabilities

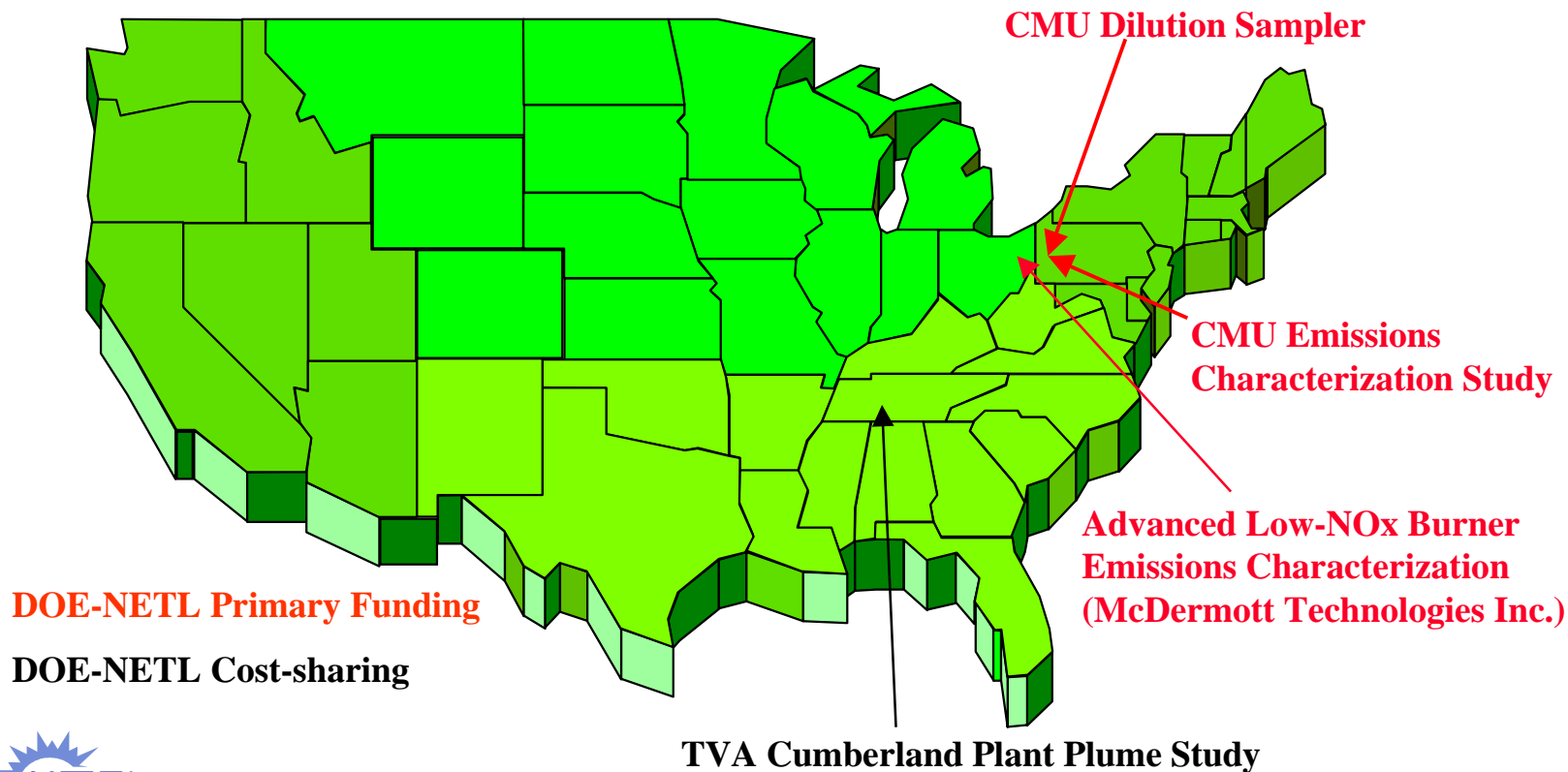


# Integration of Air Quality Research Components



# Emissions Characterization

*Current and Recently-completed Projects*



# Characterization of Primary PM<sub>2.5</sub> Emissions from Low-NO<sub>x</sub> Burners (*McDermott Technology Inc.*)

- **Higher unburned carbon in ultra-low NO<sub>x</sub> PM**
  - Overall ash LOI: 4.3% vs. 1.3%
  - PM<sub>2.5</sub> carbon: 45% vs. 7%
- **Slight decrease in ESP efficiency with ultra-low NO<sub>x</sub>**
  - 99.3% vs 99.9%
  - Associated with greater rapping re-entrainment
- **Most volatile trace elements (As, Se) enriched in finest particles**





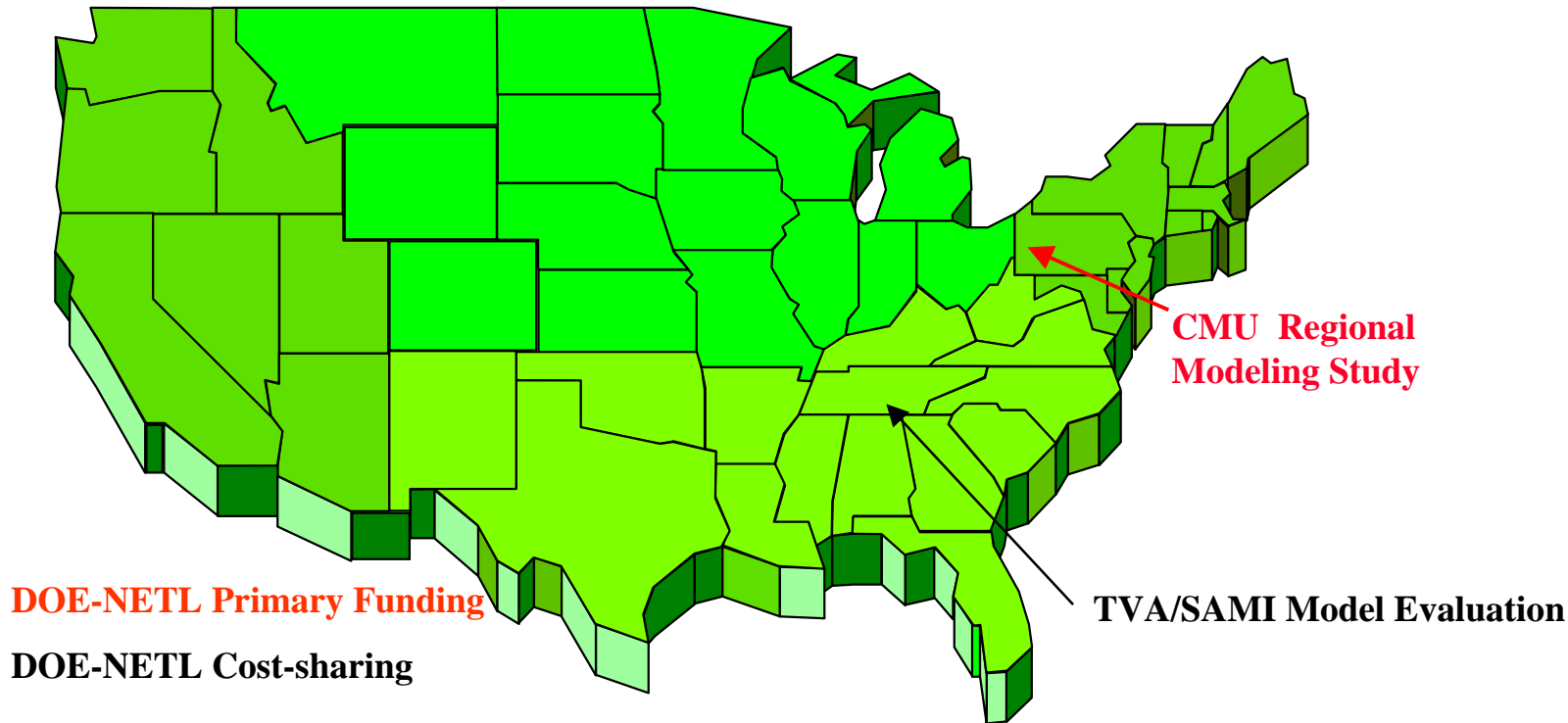
# TVA Cumberland Plume Studies - Key Results

- **Helicopter flights through plume before & after FGD**
  - Difficult to detect post-FGD plume with particle-based instruments
- **Conversion rate of  $\text{SO}_2$  to  $\text{SO}_4$  ~ 4%/hr (gas-phase only)**
  - Heterogeneous conversion not measured
- **Production of  $\text{SO}_4$  occurs primarily at plume edges**



# Modeling and Evaluation

*Current and Recently-completed Projects*



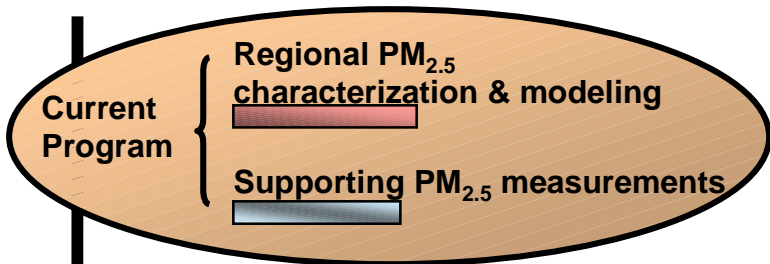
# TVA/SAMI Model Evaluation

## *Key Results*

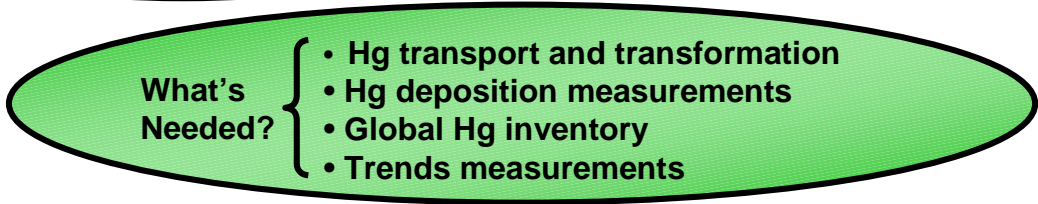
- **Modeled the changes in PM<sub>2.5</sub> expected to result from reduced SO<sub>2</sub> emissions in SAMI region**
  - Slight regional net decreases in overall PM<sub>2.5</sub> mass
  - Urban areas now exceeding 15 µg/m<sup>3</sup> is may not benefit from the decline in sulfate because of increases in OC
  - Rural areas already in attainment are likely to remain that way through 2010
- **Small benefits to visibility in Class 1 areas**
  - Not enough benefit to meet regional haze goals



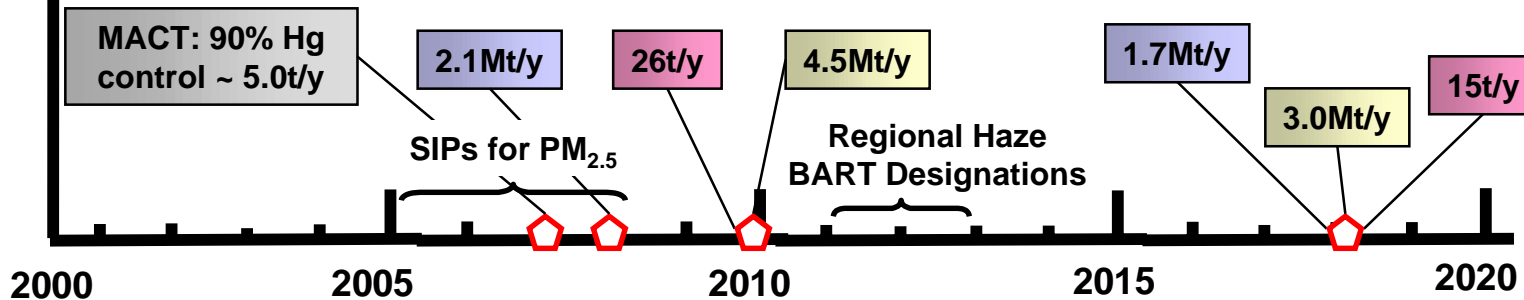
# Air Quality Research Program



Goal: Provide high-quality scientific information for use in future policy & regulatory decisions



- CSI SO<sub>2</sub> caps
- CSI NO<sub>x</sub> caps
- CSI Hg caps



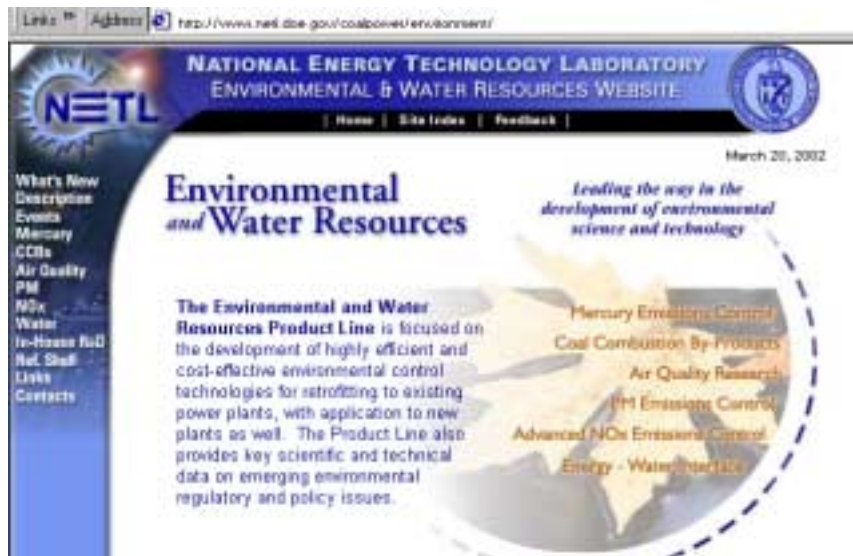
How will changes in power plant emissions affect our air quality?



# For Further Information

- **NETL Environmental & Water Resources Website**

- <http://www.netl.doe.gov/coalpower/environment/>



- **NETL Conference - April 9-10, 2002**

- *“PM<sub>2.5</sub> and Electric Power Generation: Recent Findings and Implications”*

