MONITORING, SAMPLING AND ANALYSIS OF FINE PARTICLES AT THE U.S. DEPARTMENT OF ENERGY - NATIONAL ENERGY TECHNOLOGY LABORATORY

$PM_{2.5}$ GOALS

- **Quantitatively relate the emissions from energy production (and use), particularly from coal-fired power plants, to ambient air $PM_{2.5}$ concentrations and human exposure at downwind receptors, and**

- **Develop management options applicable to coal-fired power generation to achieve the national $PM_{2.5}$ standards, integrating new knowledge of the origin and characteristics of airborne particles, their health and environmental effects, and the outlook for new or improved emission control technologies.**

NETL – OST's $PM_{2.5}$ PARTNERSHIPS

1) ADVANCED TECHNOLOGY SYSTEMS
2) ALLEGHENY COUNTY HEALTH DEPARTMENT
3) BRIGHAM YOUNG UNIVERSITY
4) CARNEGIE MELLON UNIVERSITY
5) CONSOL ENERGY
6) MINE SAFETY AND HEALTH ADMINISTRATION
7) NETL's ENVIRONMENTAL SAFETY AND HEALTH DIVISION
8) R. J. LEE GROUP, INC.
9) ARGONNE NATIONAL LABORATORY
10) OHIO UNIVERSITY
11) UNIVERSITY OF MARYLAND

- CO-LOCATE SAMPLING EQUIPMENT
- SHARE DATA
- TRADE SAMPLES FOR ANALYSIS
- CO-AUTHOR MANUSCRIPTS DESCRIBING OUR JOINT RESULTS

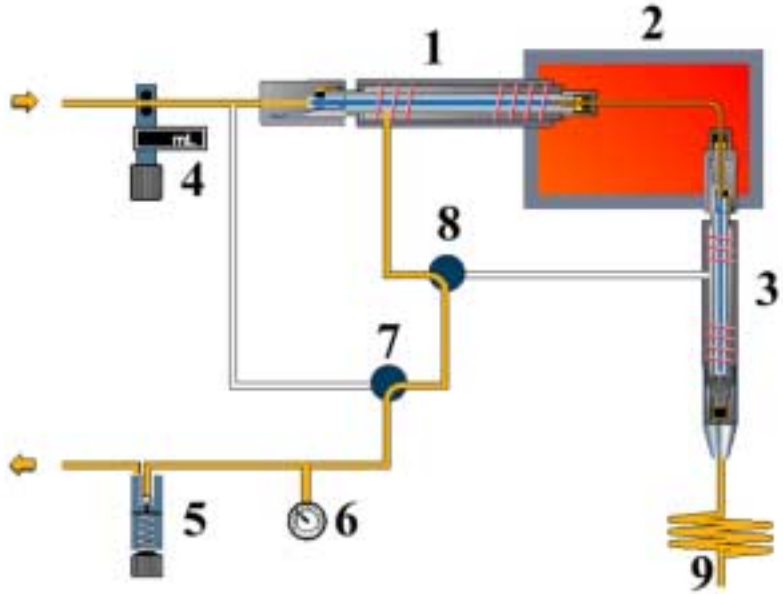
Experimental Approach

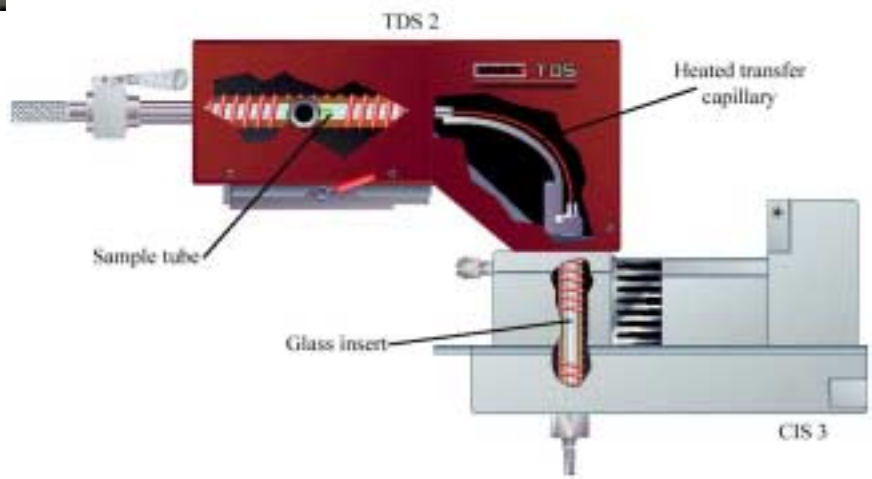
- **Collect Samples**
  - **Continuous and Filter Based Samplers for Gas Phase and Fine Particle Weight and Speciation**
- **Analyze Samples**
  - **Analysis Methods include PIXE, IC, EC/OC, LV-HRMS, GC-MS, and Microscopy**
- **Apply Models to Data**
  - **Examine variations in Fine PM Weight and Speciation as a function of Regional Meteorology**

Table 1. Monthly Average Concentrations of Monitored Species at the NETL Site During 18 October 1999 through 30 September 2000.

Species	Measure -ment	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Avg
$PM_{2.5}$ Mass, ìg/m^3	TEOM	11.2	10.9	8.0	7.9	9.8	8.7	8.8	15.7	16.3	14.5	15.7	11.0	11.5
$PM_{2.5}$ Mass, ìg/m^3	TEOM[a]	11.2	10.7	8.0	7.8	9.8	8.6	9.0	16.5	17.0	14.6	16.6	11.3	11.8
$PM_{2.5}$ Mass, ìg/m^3	FRM[a]	13.8	14.3	12.1	12.4	14.2	11.0	11.1	17.4	19.7	17.6	20.2	14.0	14.8
$PM_{2.5}$ OM, ìg/m^3	R&P C	3.8	4.1	4.2	3.5	3.8	3.0	4.9	5.8	4.4	5.9	4.6	2.8	4.2
$PM_{2.5}$ EC, ìg/m^3	R&P C	0.6	0.6	0.7	0.5	0.6	0.4	0.6	0.6	0.7	0.8	0.9	0.7	0.8
$PM_{2.5}$ PAH, fA/m^3	EcoChem				4.7	4.9	4.1	3.5	2.6	2.8	3.4	4.1	5.0	3.9
SO_2, ppb	API	11.1	10.6	10.5	12.2	10.1	9.2	8.2	6.4	8.1	5.2	6.8	8.5	8.9
NO_X ppb	API	36.7	24.3	32.8	23.6	25.6	19.8	16.0	10.5	9.7	10.6	12.9	14.6	19.9
NO_2, ppb	API	18.7	14.9	16.6	16.7	17.0	13.2	12.2	8.9	8.1	8.6	9.8	9.9	12.9
O_3, ppb	API	16.4	21.9	13.5	19.2	23.9	28.1	31.1	39.1	39.5	31.0	24.8	19.8	25.7

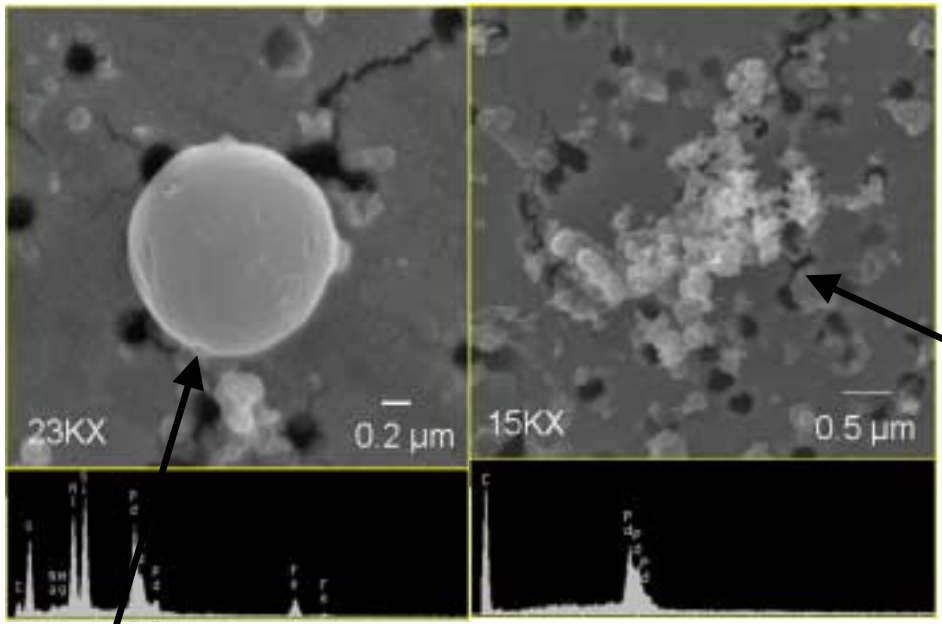
Methodology





Organic Analysis

SEM / EDX Source Markers of $PM_{2.5}$ Particles

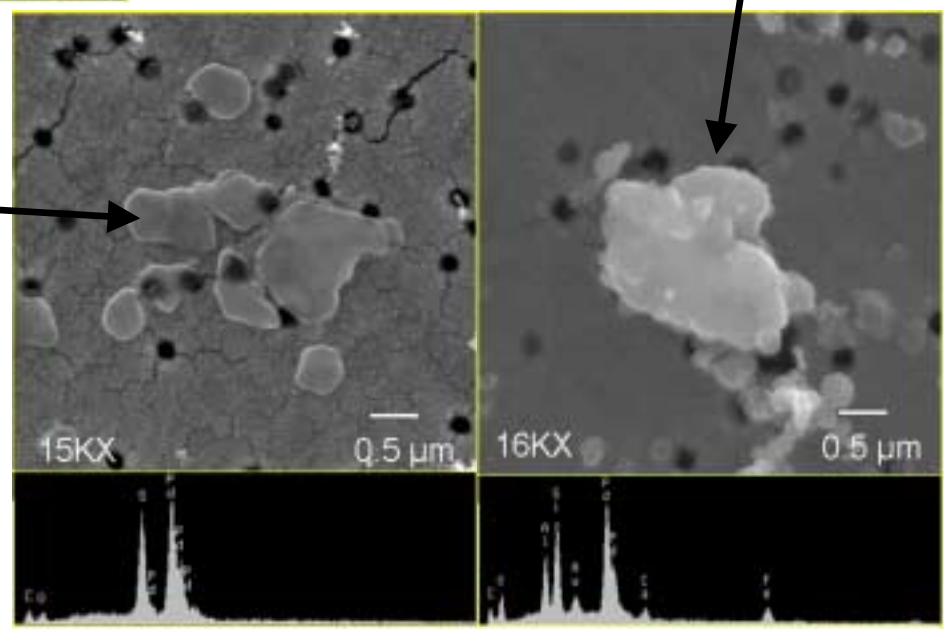


Carbon Chain Agglomerates

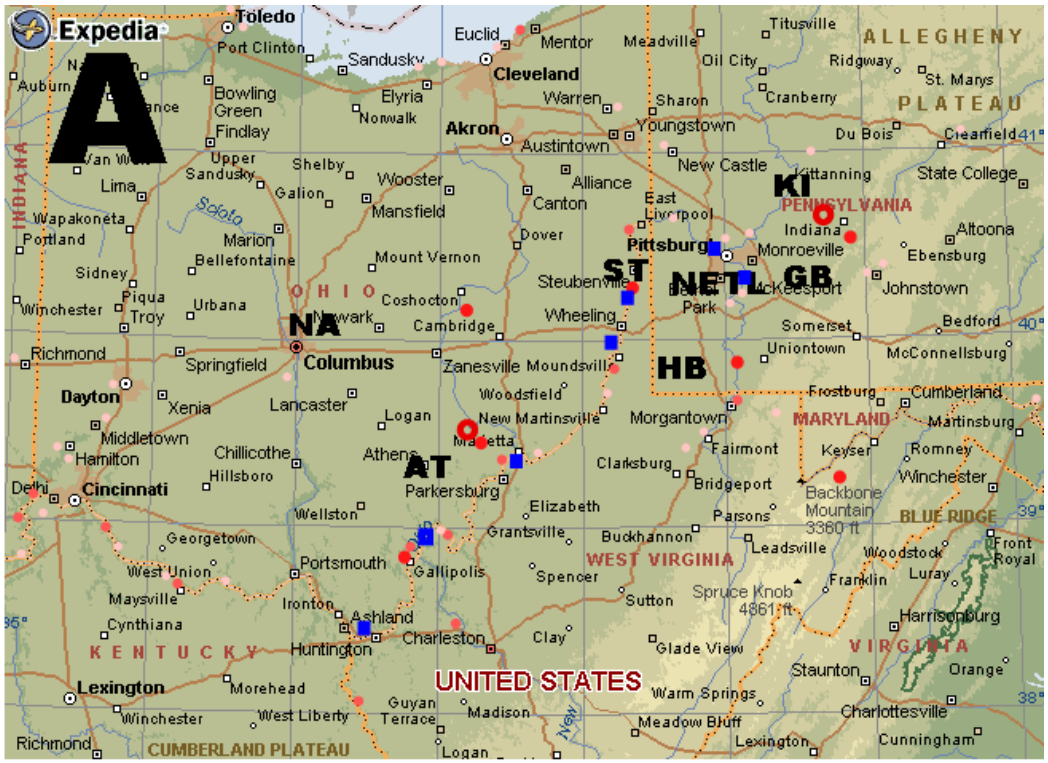
Spherical Alumino-Silicate

Ammonium-Sulfate

Crustal



Regional TEOM Sampling Sites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Expedia
Toledo
Cleveland
Akron
Columbus
Dayton
Cincinnati
Pittsburgh
Youngstown
Wheeling
Charleston
Huntington
Lexington
Richmond
Morgantown
Parkersburg
Clarksburg
Bridgeport
Harrisburg
Staunton
Charlottesville
Cumberland
Altoona
Johnstown
State College
Indiana
Kittanning
Monroeville
McKeesport
Steubenville
Marietta
Athens
Zanesville
Mansfield
Wooster
Lima
Toledo
Sandusky
Mentor
Meadville
Titusville
Oil City
Ridgway
St. Marys
Cranberry
Du Bois
Clearfield
Warren
Sharon
New Castle
Alliance
Canton
Dover
Mount Vernon
Coshocton
Cambridge
Newark
Springfield
Xenia
Lancaster
Logan
Chillicothe
Hillsboro
Portsmouth
Gallipolis
Ironton
Ashland
Huntington
Charleston
Morehead
Winchester
Maysville
Georgetown
Middletown
Hamilton
Sidney
Piqua
Troy
Urbana
Marion
Bellefontaine
Wapakoneta
Portland
Findlay
Bowling Green
Elyria
Norwalk
Galion
Shelby
Upper Sandusky
Van Wert
Auburn
Port Clinton
Euclid
Warren
Youngstown
Austintown
Steubenville
Wheeling
Moundsville
Woodsville
New Martinsville
Morgantown
Fairmont
Clarksburg
Bridgeport
Parsons
Elizabeth
Grantsville
Buckhannon
Leadsville
Spencer
Sutton
Clay
Glade View
Warm Springs
Meadow Bluff
Lexington
Cunningham
Charlottesville
Madison
Guyan Terrace
West Liberty
Morehead
Winchester
Richmond
Lexington
Staunton
Harrisonburg
Franklin
Luray
Woodstock
Front Royal
Orange
Frostburg
Keyser
Romney
Winchester
Martinsburg
Somerset
Uniontown
McConnellsburg
Bedford
Johnstown
Ebensburg
Indiana
Kittanning
Pittsburgh
Monroeville
McKeesport
Park
Dover
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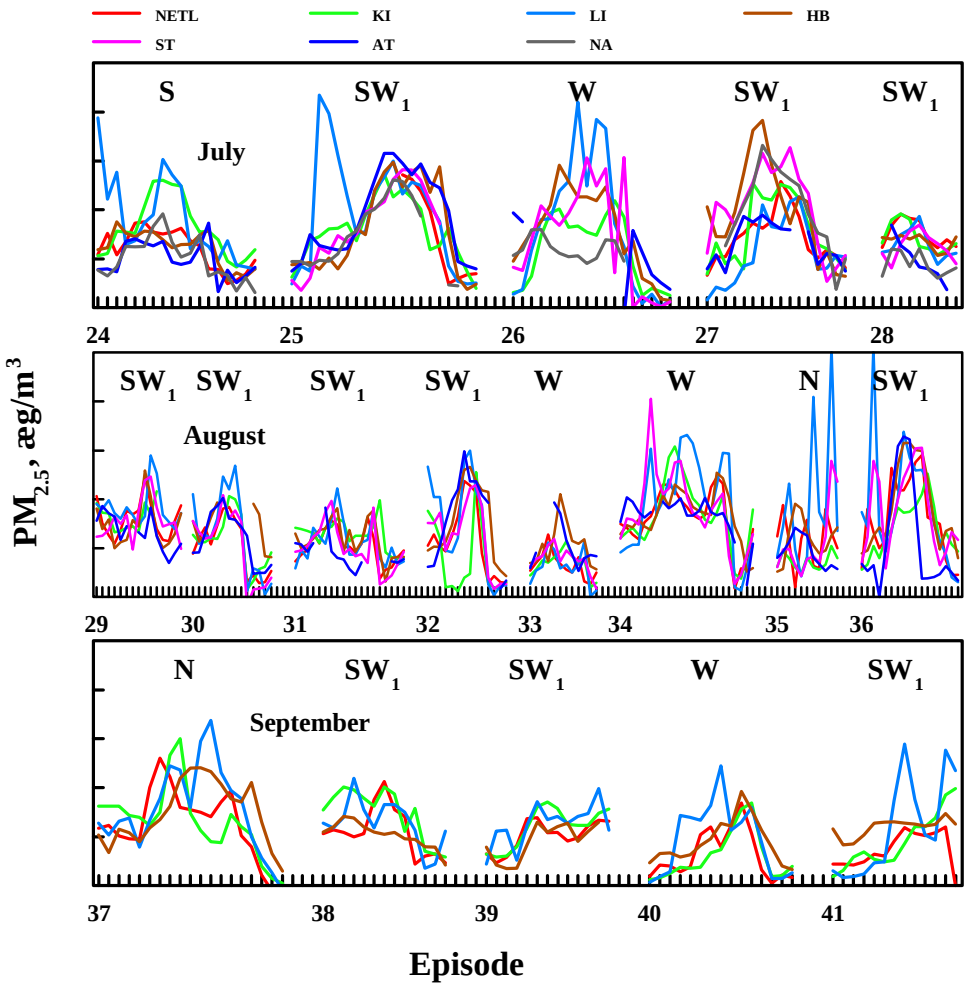
Cleveland

Regional Episodes



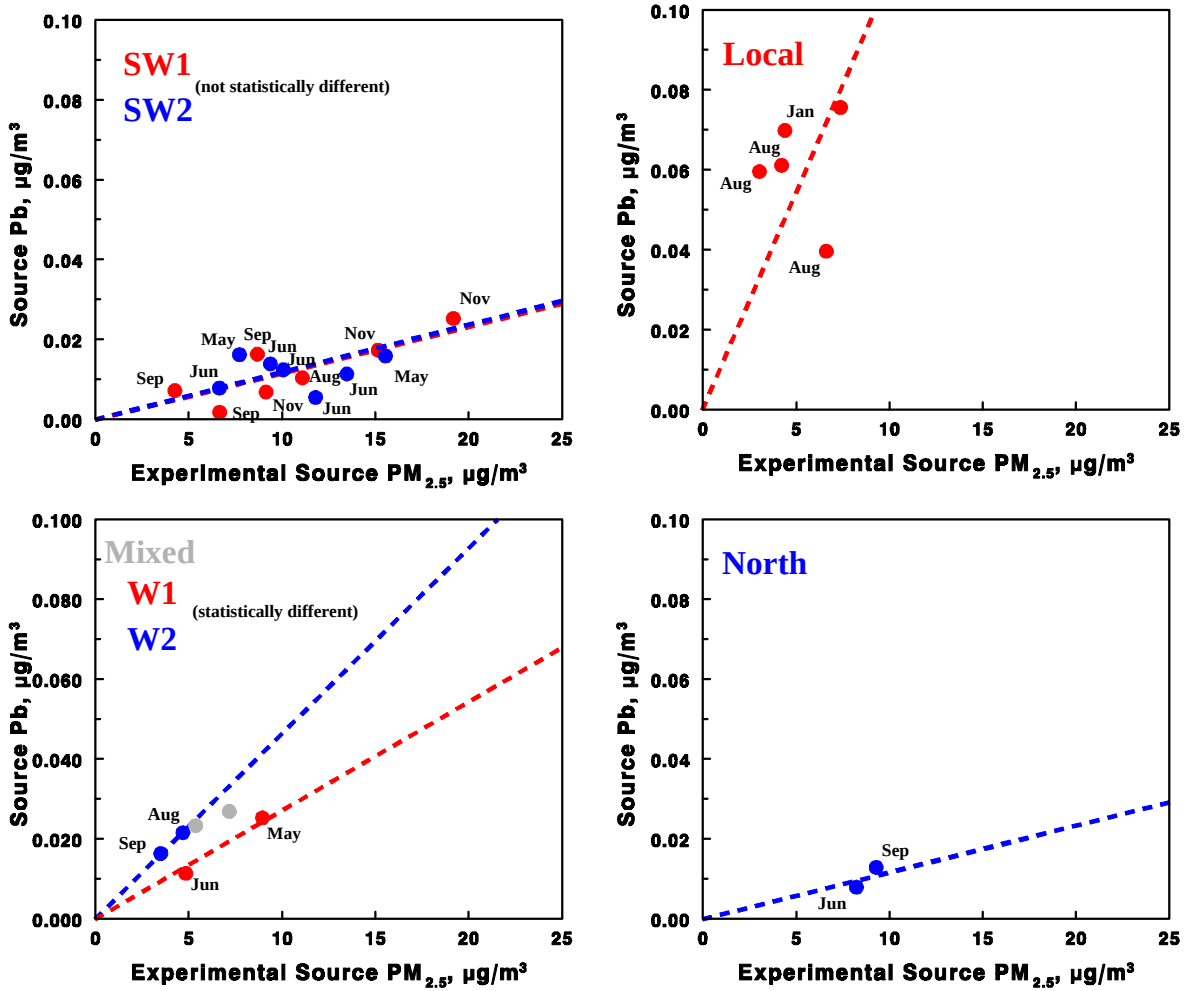
Findings

- **Relationships observed between levels of Fine PM and predominant geographic weather direction**
  - **High $PM_{2.5}$ episodes associated with transport during passage of frontal systems from Ohio River Valley to west and southwest of sampling sites**
  - **High $PM_{2.5}$ episodes associated with transitions from locally high pressure to lower pressure**
  - **Concentrations of $PM_{2.5}$ during high pressure periods were generally low throughout the study region**
  - **After episodes as pressure increased, concentrations of $PM_{2.5}$ often sharply decreased at all sites**

Quantitative Modeling

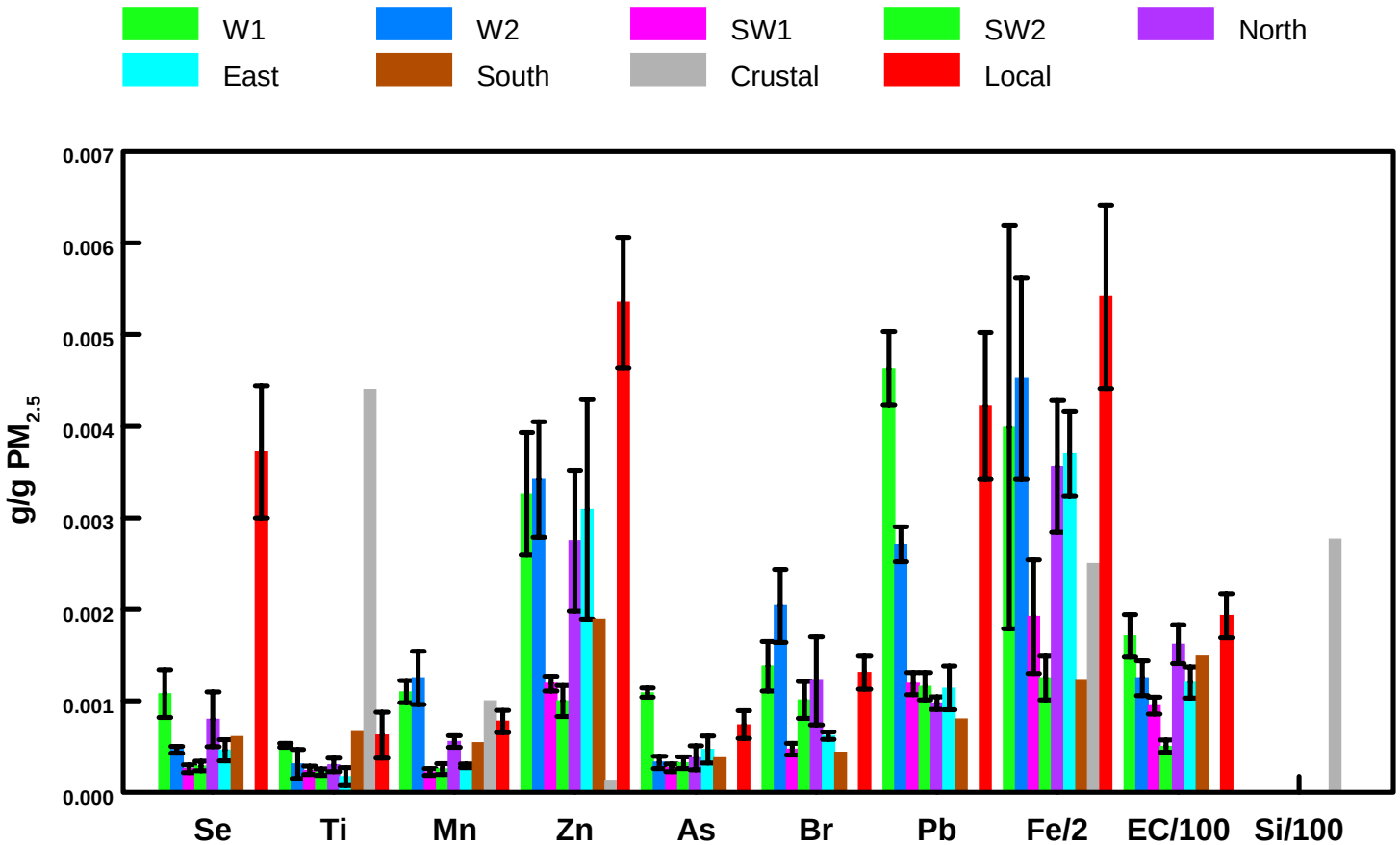
- **Apply EPA / DRI CMB8 model to test hypothesis that directional source profiles can be developed to determine directional apportionment of $PM_{2.5}$ transported into the region**
  - Develop directional source composition profiles for $PM_{2.5}$
  - Use combination of inorganic PIXE and EC / OC analysis data from NETL $PM_{2.5}$ samples, August 2000
  - NOAA Hysplit meteorological back-trajectory model used to determine predominant geographic origin of 24 hour sampled air masses
  - For each characteristic source direction, individual background crustal corrected elemental inorganic or EC component mass regressed against primary $PM_{2.5}$ mass
  - Plot Directional Source Profiles developed from regression slopes

Lead Data, CMB8 Directional Profile Development

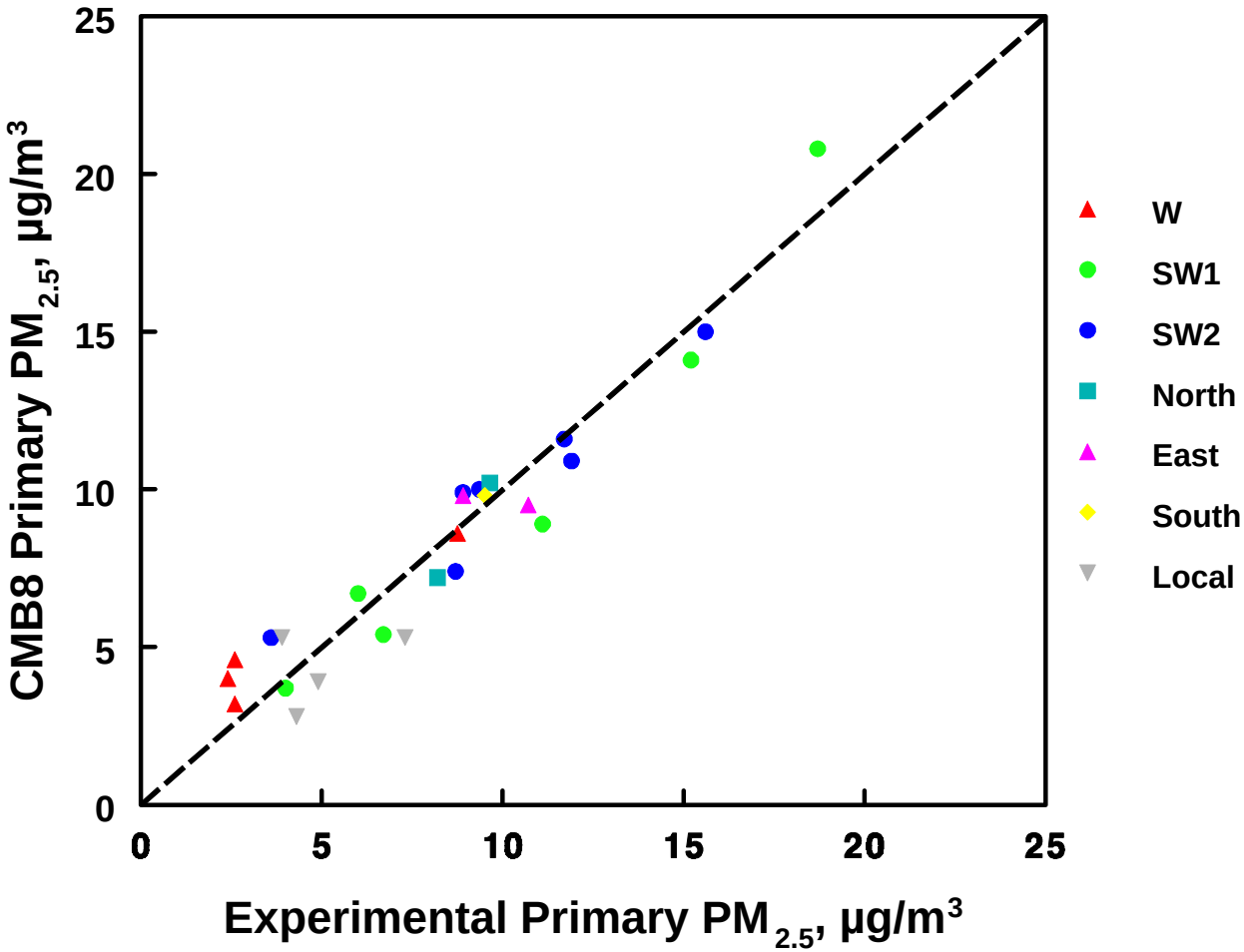


Crustal Corrected Directional Profiles

CMB8 Regional Profiles

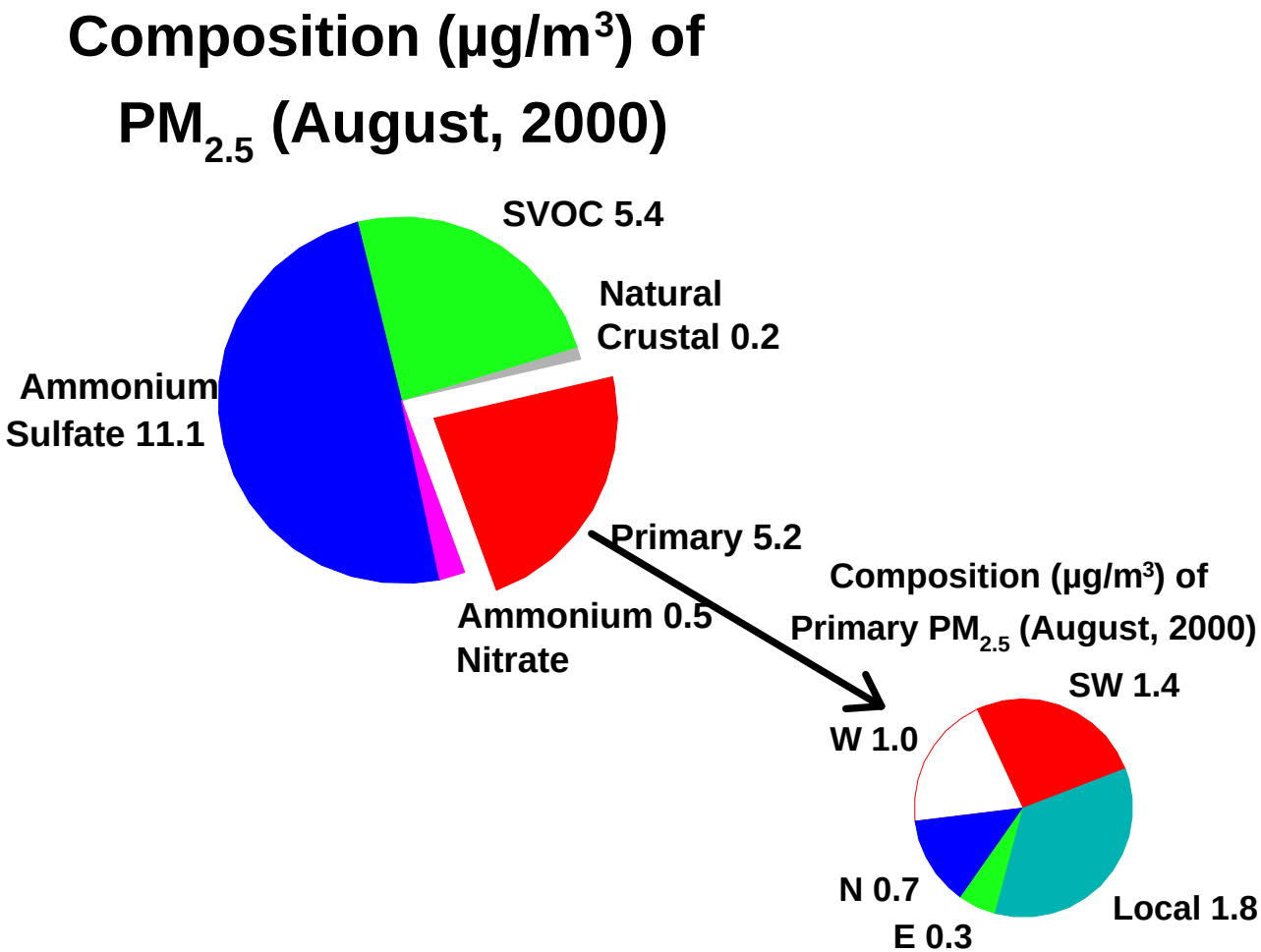


CMB8 versus Hysplit Observations



Y =0.9422x + 0.4305, R^2 =0.9122 unconstrained correlation

$PM_{2.5}$ Directional Compositions for Primary Particles
(EC and PIXE)



$PM_{2.5}$ Sampling and Analysis Team would like to thank the following people for their technical assistance

$PM_{2.5}$ Sampling and Analysis Team Partners

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