Sources of PM$_{2.5}$ in New York State

Philip K. Hopke

Center for Air Resources Engineering and Science

Clarkson University

Potsdam, NY

Introduction

- Areas of New York State have been determined to be in non-attainment of the National Ambient Air Quality Standard (NAAQS) for Particulate Matter.
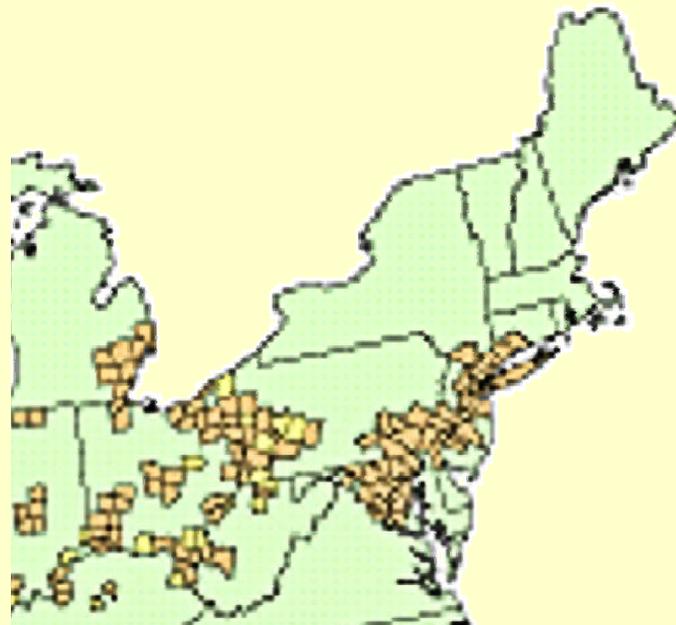
Introduction

- As a result of these designations, it will be necessary to prepare state implementation plans (SIPs) that outline an air quality management strategy to bring the areas in question into attainment

- New standards to be announced later this year are likely to put more areas of the state out of attainment if there are no changes in emissions across the region.

Introduction

- Even in areas that meet the National Ambient Air Quality Standard, there are regional haze problems that require planning to improve air quality, but on a much longer time scale.

Introduction

- To help inform the planning process, a number of studies of $PM_{2.5}$ have been made across New York State that have collected, analyzed the samples for chemical composition, and the data analyzed to investigate source/receptor relationships.

Prior Studies

- Application of Receptor Modeling to Atmospheric Constituents at Potsdam and Stockton, NY, W. Liu, P.K. Hopke,Y.-J. Han, S.-M. Yi, T.M. Holsen, S. Cybart, K. Kozlowski, and M. Milligan, *Atmospheric Environ.* 37: 4997-5007 (2003).

- Regional sources of particulate sulfate, SO2, PM2.5, HCl, and HNO3, in New York, NY, A. Bari, V.A. Dutkiewicz, C.D. J., Lloyd, R. Wilson, D. Luttinger, L. Husain, Atmospheric Environment 37: 2837–2844 (2003).

- Atmospheric Gaseous Mercury Concentrations in New York State: Relationships with Meteorological Data and Other Pollutants, Y.-J. Han, T.M. Holsen, S.-O. Lai, P.K. Hopke, S.-M. Yi, W. Liu, J. Pagano, L. Falanga, M. Milligan, and C. Andolina, *Atmospheric Environ.* 38: 6431-6446 (2004).

- Sources of Fine Particle Composition in New York City, Z. Li, P.K. Hopke, L. Husain, S. Qureshi, V.A. Dutkiewicz. J.J. Schwab, F. Drewnick, and K.L. Demerjian, *Atmospheric Environ.* 38: 6521–6529 (2004).

Prior Studies

- Spatial variation of PM2.5 chemical species and source-apportioned mass concentrations in New York City, K. Ito, N. Xue, G.D. Thurston, Atmospheric Environment 38: 5269–5282 (2004).

- Sources of fine particulate sulfate in New York, V.A. Dutkiewicz, S. Qureshi, A.R. Khan, V. Ferraro, J. Schwab, K. Demerjian, L. Husain, Atmospheric Environment 38: 3179–3189 (2004).

- Comparison between Back-Trajectory Based Modeling and Lagrangian Backward Dispersion Modeling For Locating Sources of Reactive Gaseous Mercury, Y.-J. Han, T.M. Holsen, P.K. Hopke, S.-M. Yi, *Environ. Sci. Technol.* 39: 1715-1723 (2005).

- Reconciling Trajectory Ensemble Receptor Model Results with Emissions, P.K. Hopke, L. Zhou, R.L. Poirot, *Environ. Sci. Technol.* (In press, 2005).

- The Sources of $PM_{2.5}$ in Metropolitan New York City, Y. Qin, E. Kim and P.K. Hopke, submitted to *Atmospheric Environment* (2005)

- Identifying and Quantifying Transported vs. Local Sources of New York City PM2.5 Fine Particulate Matter Air Pollution, R. Lall, G.D. Thurston, submitted to *Atmospheric Environment* (2005).

Measurement Sites
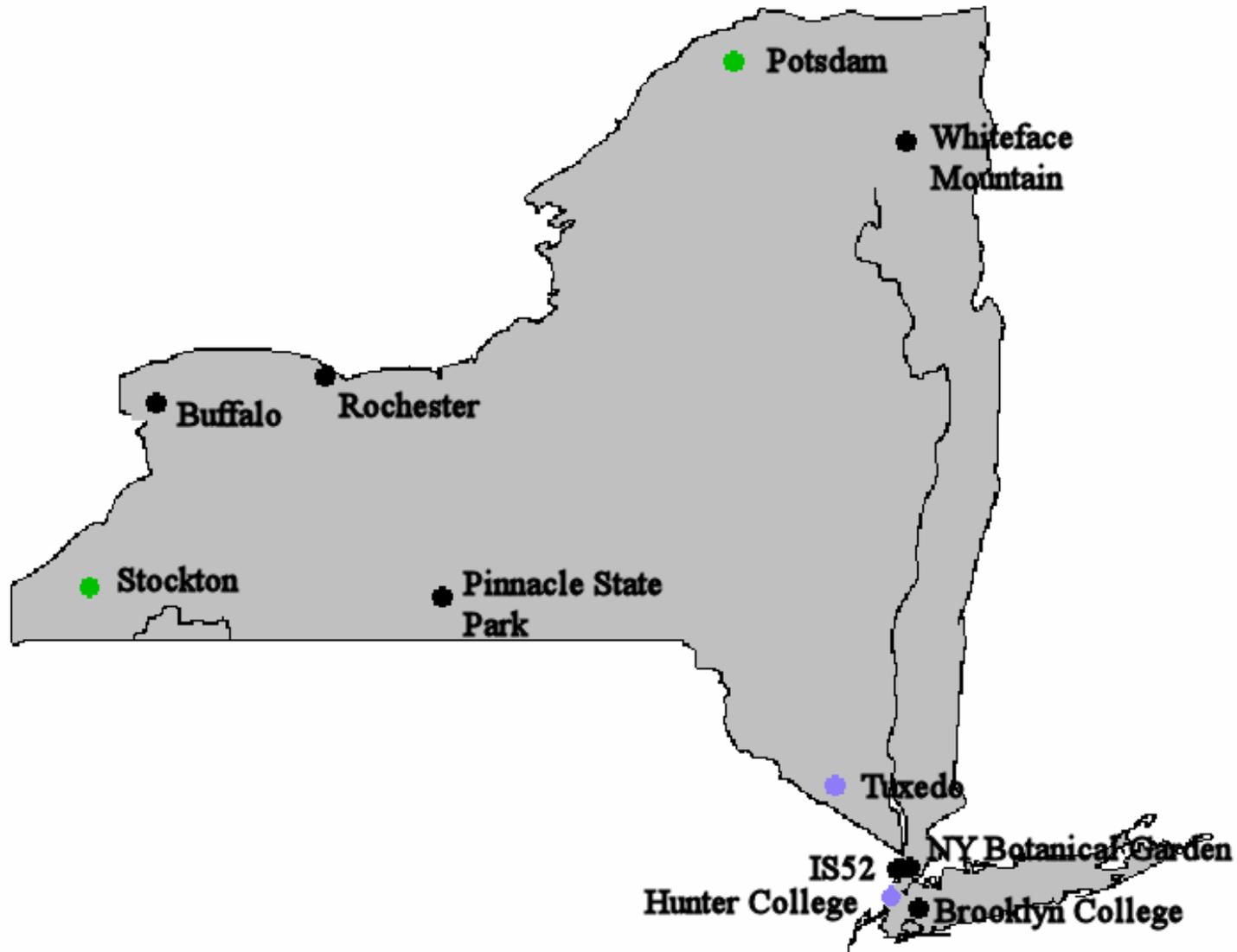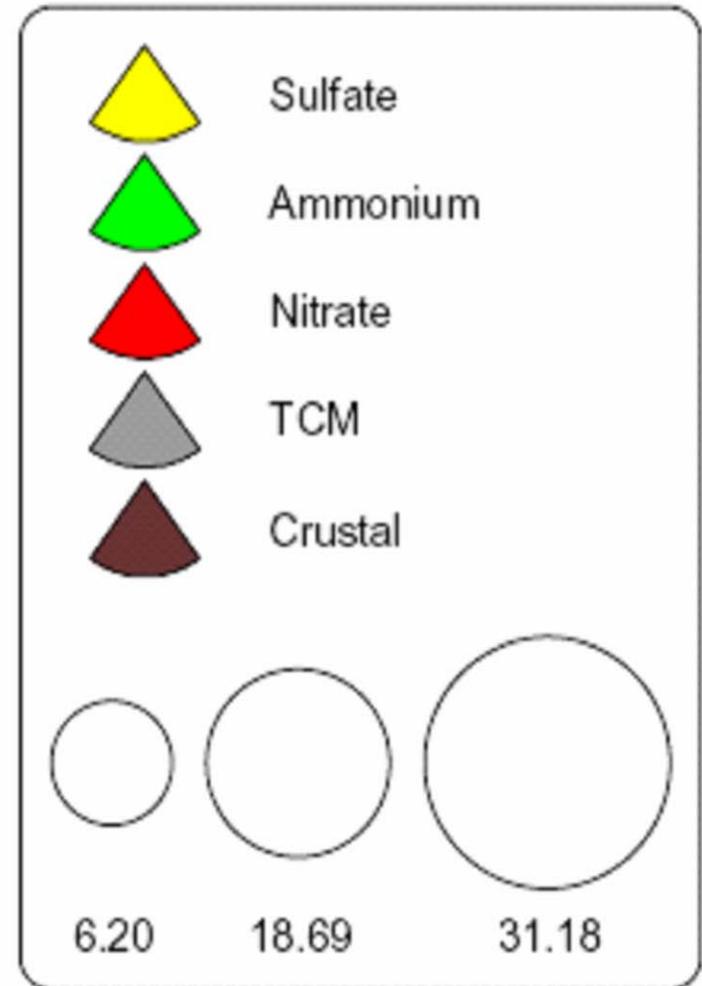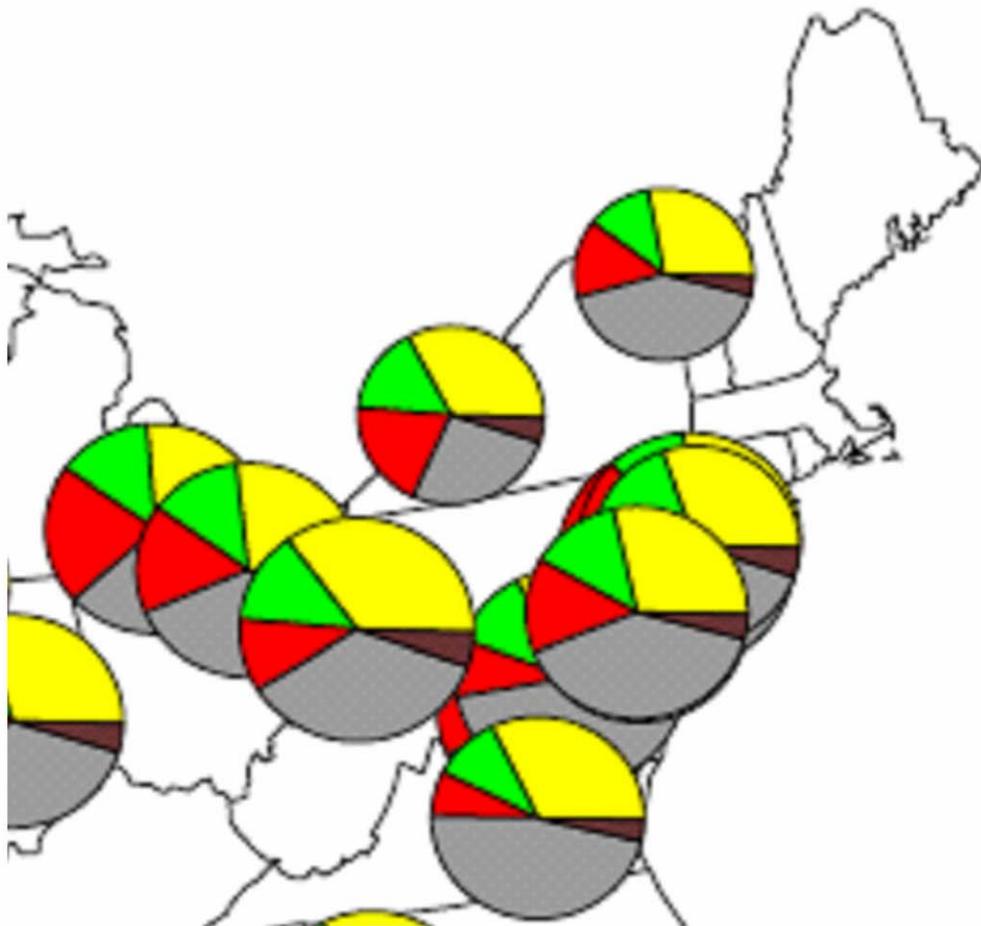
Particle Composition-Rural
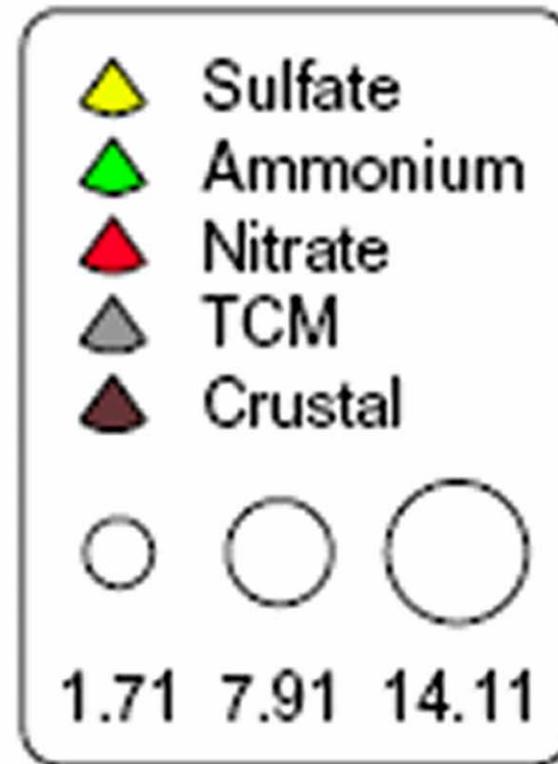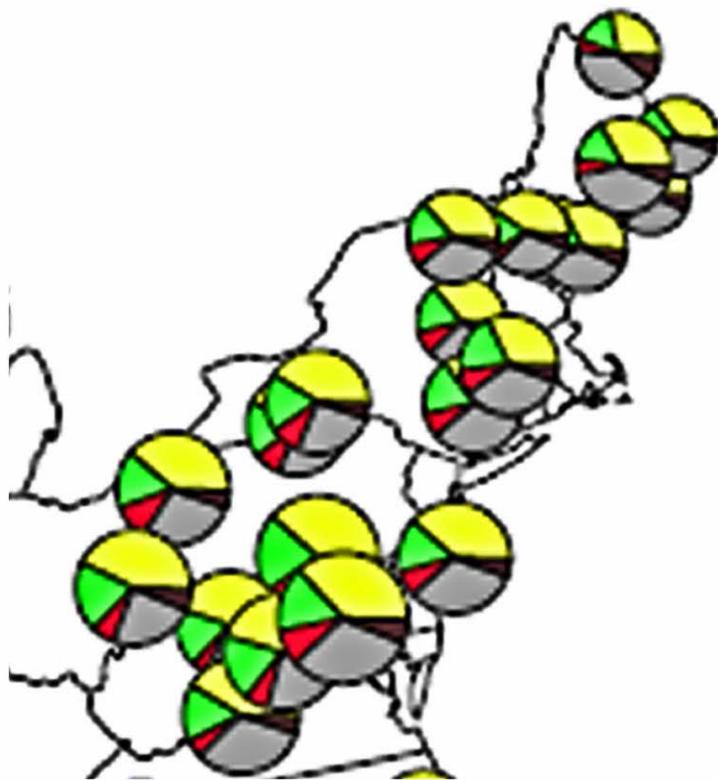
Particle Composition
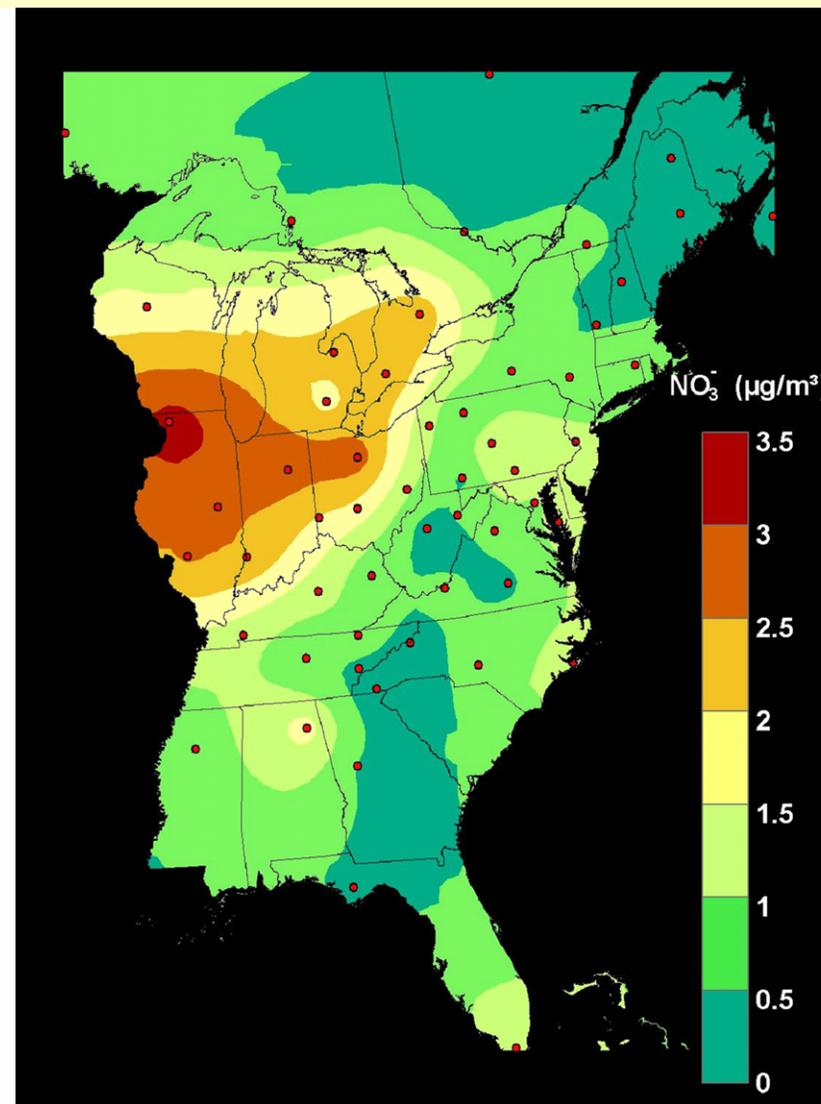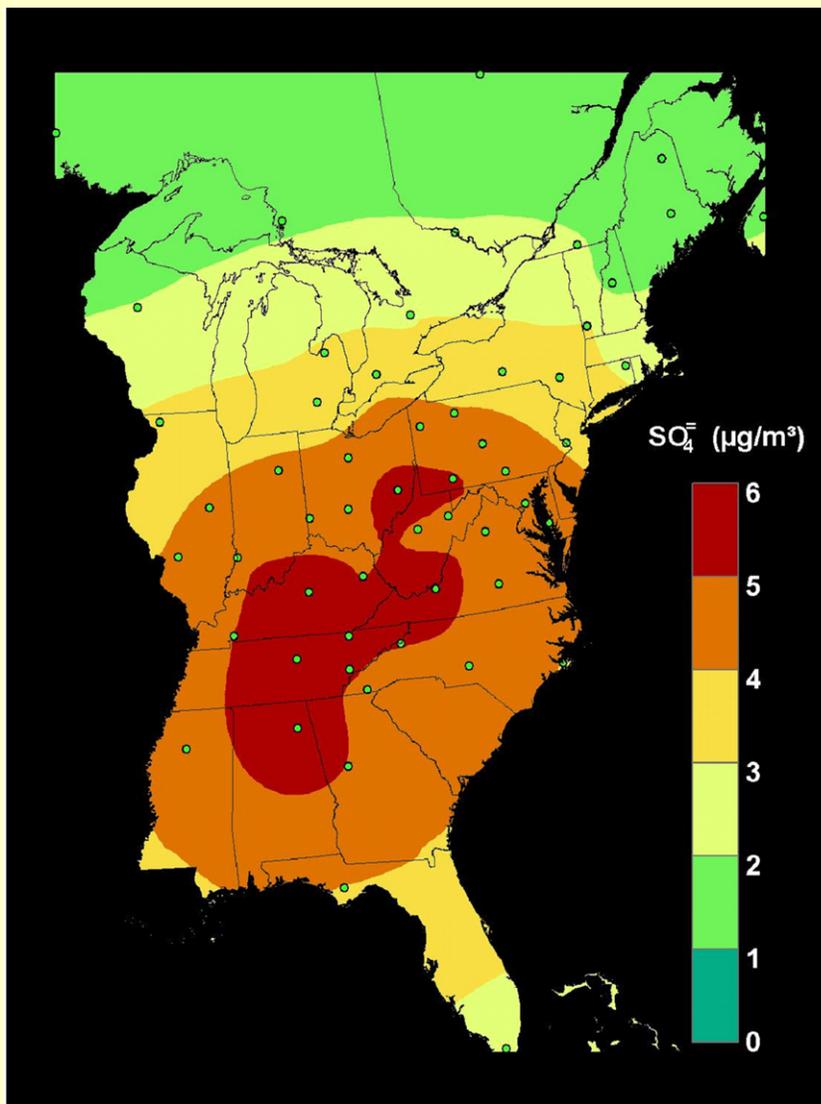
Sulfate
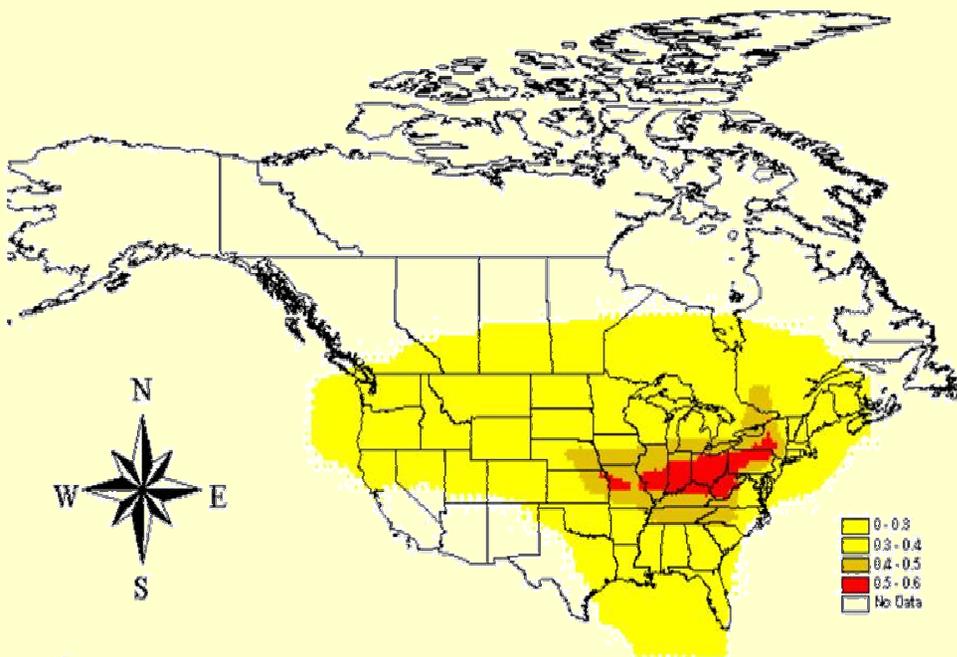
Potsdam

Stockton
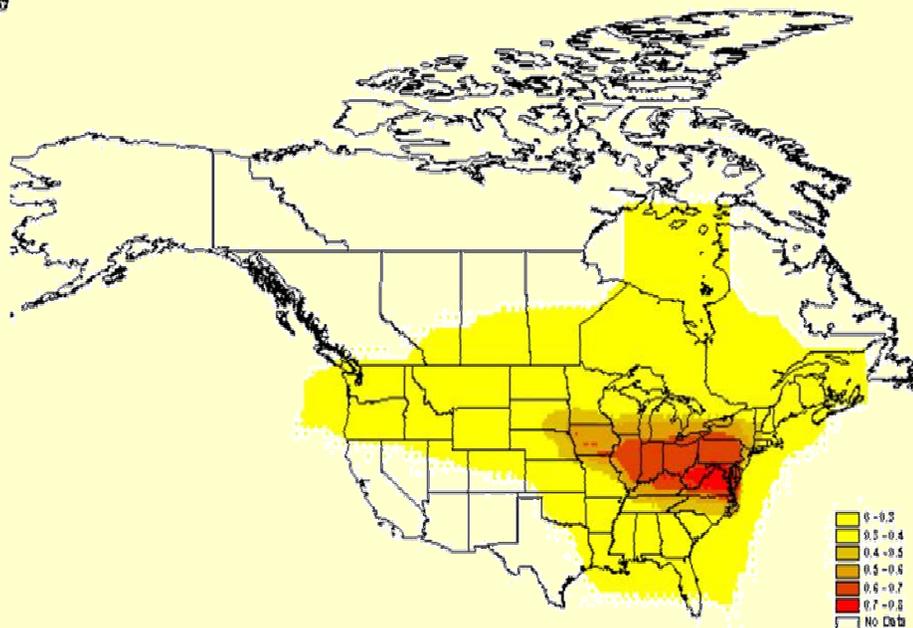
Sulfate

Combining back trajectory analyses from Underhill, VT and Brigantine, NJ permits triangulation of the source regions (Hopke et al, 2005) for sulfate that is attributed to coal-fired power plants and Ni and V-related particles assigned to residual oil combustion.
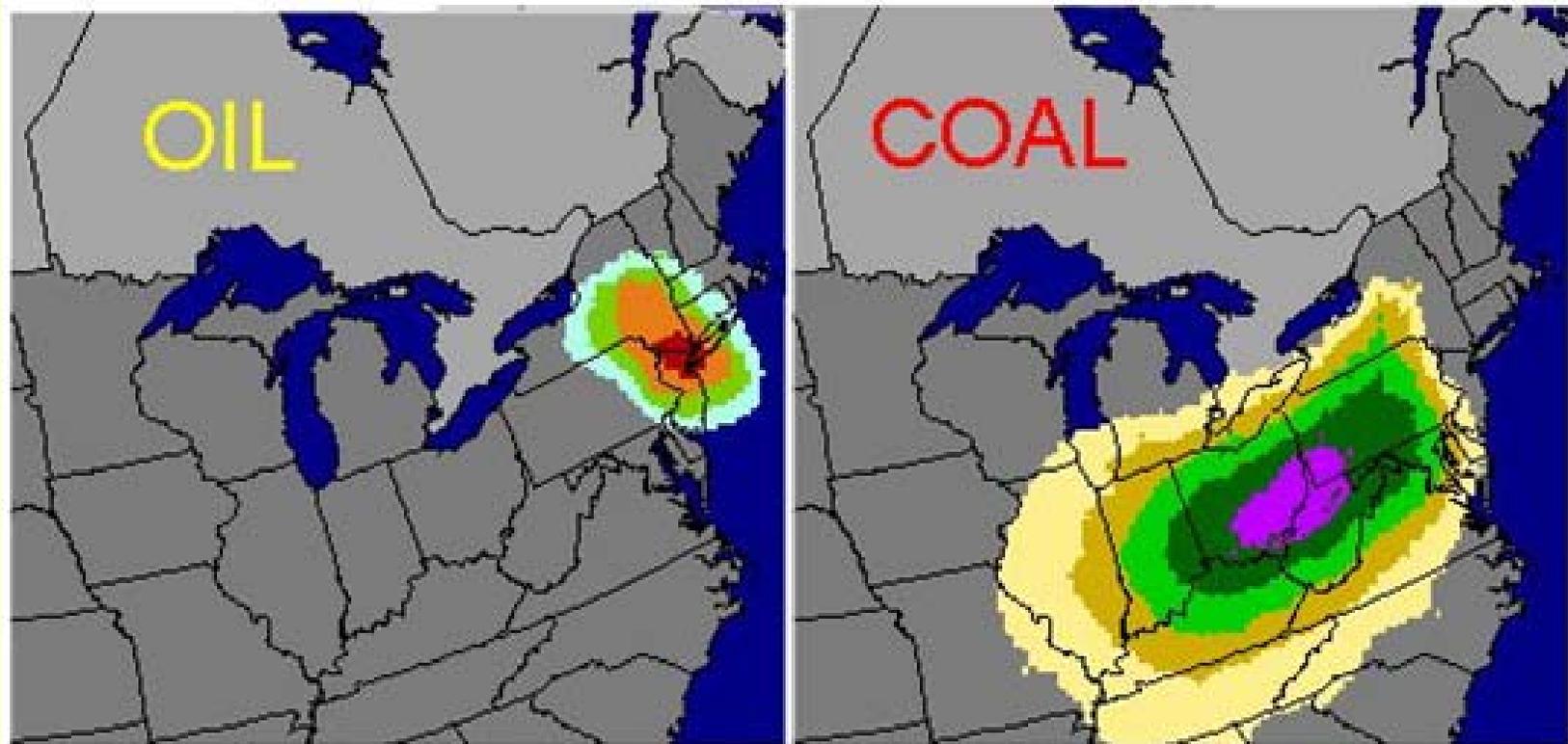
Sulfate

Examination of the emissions inventories for coal-fired power plants and residual oil combustion can be presented as contour plots of the average annual emissions.
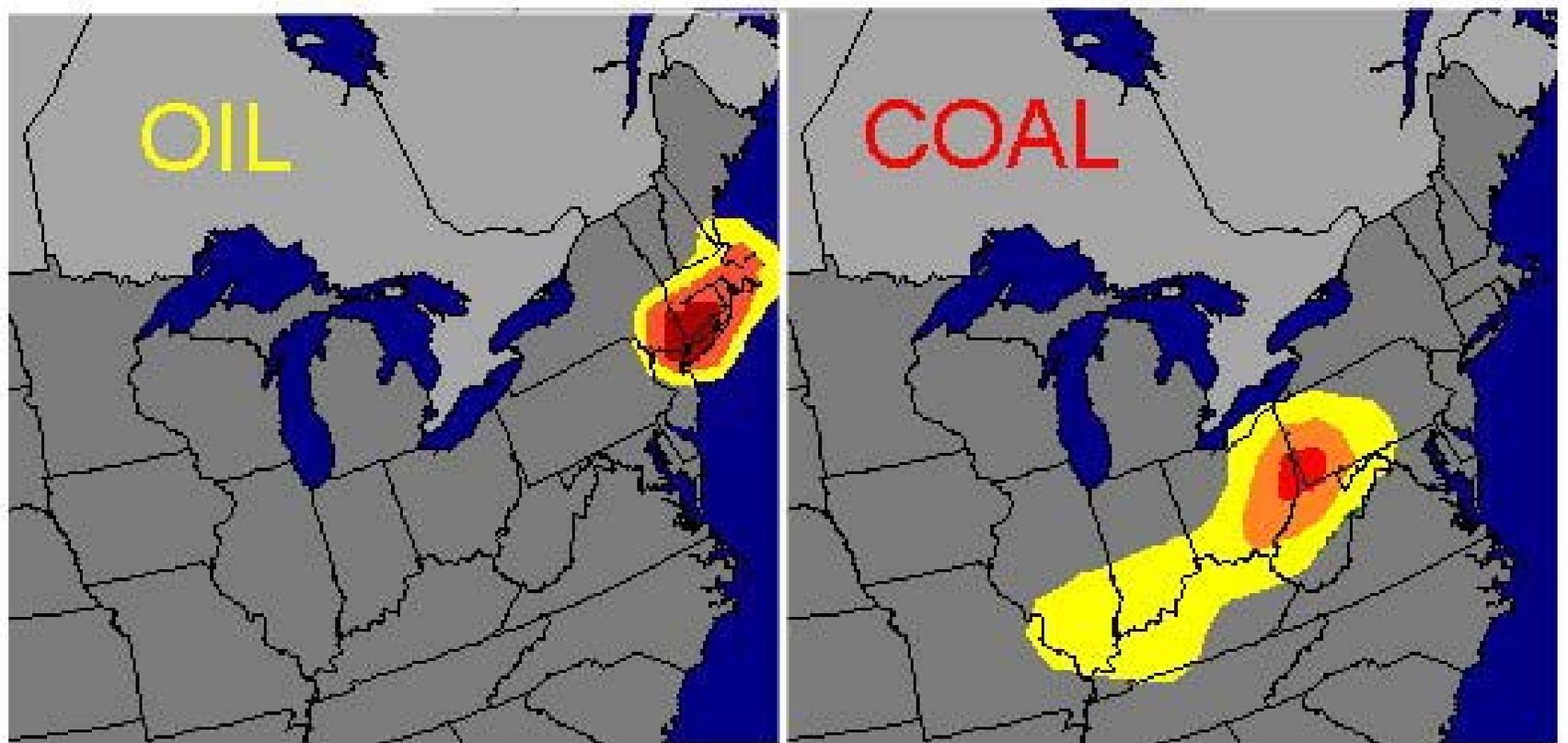
Sulfate

Overlaying these two sets of maps shows the congruence between the areas that were identified as being important emissions regions from the data analysis and those that are known to be emissions areas from the emissions inventories.
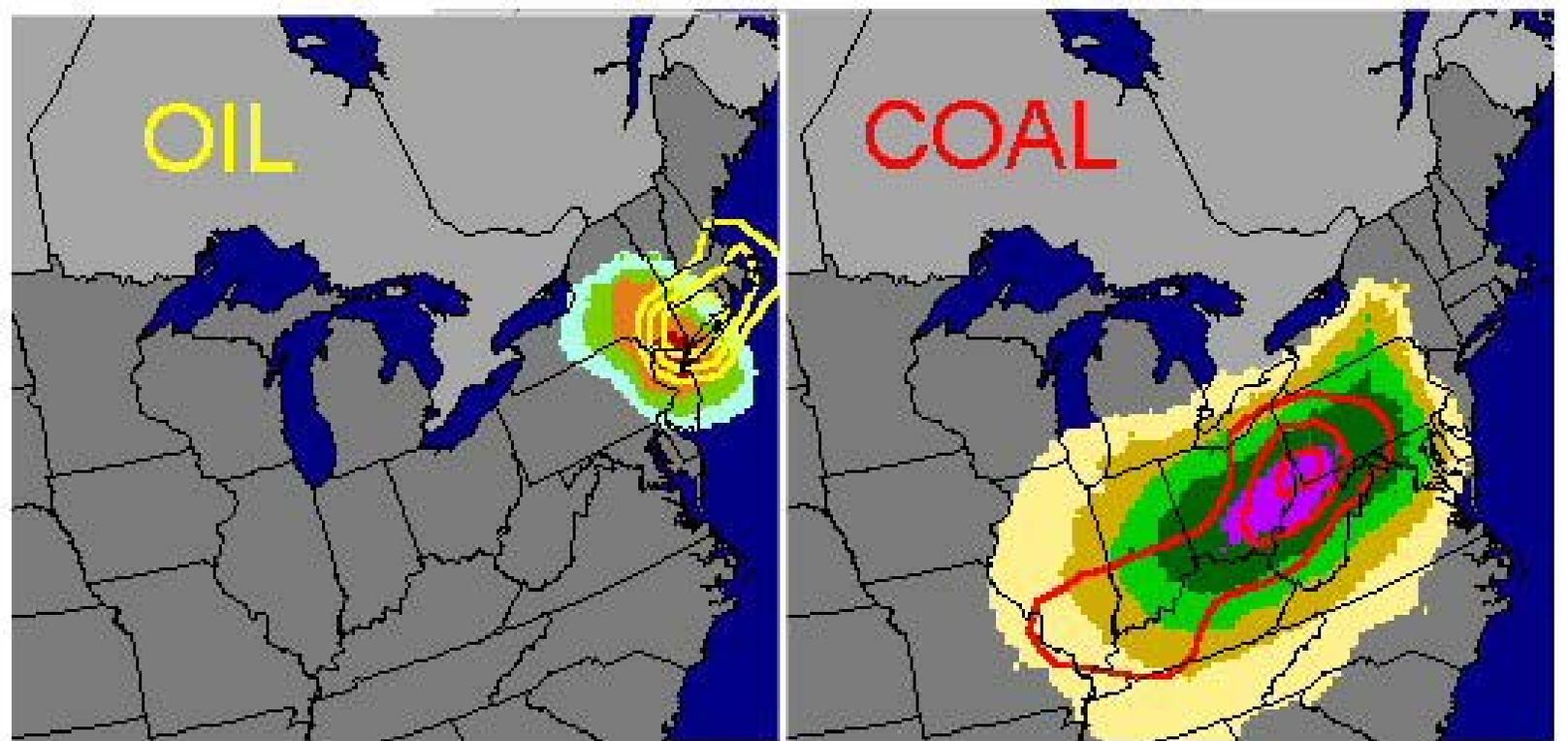
Sulfate in NYC Area

- Several groups have estimated the relative influence of upwind sources on the amount of sulfate in NYC.

- Bari et al. (2003) suggest that on an annual basis 43% of sulfate, 14% of the sulfur dioxide, 30% of the PM2.5 mass, 27% of HCl, and 24% of HNO3 were attributed to upwind emissions, with the remaining amounts due to emissions in the metropolitan New York.

Sulfate in NYC Area

- Dutkiewicz et al. (2004) attribute 44–55% of the sulfate at Queens on an annual basis is transported into the region.

- Lall and Thurston (2005) conclude that nearly half of the total PM2.5 reported in NYC is attributable to transport into the city on annual basis, and more than half (nearly two-thirds) of the PM2.5 in the summertime. For sulfate, the transported percentage is much greater, reaching approximately 90% of all the sulfate impacting the site considered in downtown Manhattan.

Sulfate in NYC Area

- Qin et al. (2005) report that 63% of the sulfate is transported into the region (see related poster at this meeting)

- Although there are a variety of estimates of the extent of local versus regional sulfate, all of the studies suggest a very large fraction are not local in origin suggesting that a substantial contributor to the NYC $PM_{2.5}$ non-attainment is not under NYS control

Nitrate in NYC Area

- Qin et al. (2005) find secondary nitrate was a major component of $PM_{2.5}$. It contributes about 8-18% of concentration for $PM_{2.5}$.

- About 54 to 65% of the ammonium nitrate measured in metropolitan area of New York City is the result of transport based on the Chester concentrations.

NYC Sources

- Lall and Thurston (2005) have examined the $PM_{2.5}$ composition data from samples collected at Hunter College and Tuxedo in 2001. A World Trade Center aerosol was also identified after September 11.

	Sulfate	Traffic	Residual Oil	Soil & Dust	Fe-Mn
Annual Average	8.3	6.8	3.6	0.5	0.4
Winter	6.6	4.4	8.6	0.2	0.2
Summer	12.9	9.1	0.9	0.6	0.4

NYC Sources

- Qin et al. (2005) analyzed the STN data from three STN sites in NYC (IS52, NY Botanical Gardens, and Brooklyn College).

Table 1. Average contributions of identified sources to $PM_{2.5}$ concentrations

	NYBG	IS52	QCII
Secondary sulfate	5.77±5.26	7.20±5.88	4.87±4.47
Secondary nitrate	2.10±2.45	2.57±2.44	1.81±2.55
Soil dust	1.48±1.06	1.07±0.76	0.75±0.64
Aged sea salt	0.68±0.69	0.49±0.61	0.44±0.61
Oil combustion	0.52±0.43	1.36±1.30	1.25±1.27
Traffic			2.55±2.09
Spark Ignition	2.14±1.65	1.11±0.91	
Diesel	0.43±0.34	0.45±0.34	

NYC Source Apportionment and Emissions Inventory

- Based on the results of Qin et al. (2005), soil dust contributes 6-11% of the $PM_{2.5}$ in the NYC area.

- According to EPA's National Emission Inventories, fugitive dust is the most important primary $PM_{2.5}$ emission source in this area. It supposedly accounts about 38-57% of local emissions of PM2.5 in the Bronx and Queens.

- However, it does not appear that there is sufficient concentrations of the crustal elements (Al, Si, Ca, Ti, Fe) to support the emissions estimates.

NYC Source Apportionment and Emissions Inventory

- Oil combustion contributes about 4-11% of concentration for PM2.5 at these four sites. It is much higher than the EPA estimated contribution of oil burning to primary emission sources of $PM_{2.5}$.
- The source contributions of spark ignition vehicles are 8 to 22%. They are higher than EPA highway vehicle contribution to primary emission sources of $PM_{2.5}$.

NYC Source Apportionment and Emissions Inventory

- Wood burning is listed by EPA as an import primary emission source for Queens supposedly accounting for 16.7% of primary PM2.5 emissions.
- However, there does not seem to be sufficient measured potassium concentrations that such emissions would be expected to generate (Watson *et al.*, 2001) and thus, wood burning could be identified at any of the sites.
- These and the other results can then be used to refine the emissions estimates so that they can provide more accurate inputs into the models used for developing the SIP for the non-attainment areas.

Source Apportionment and Health Effects

- While the association between exposure to ambient fine particulate matter mass (PM2.5) and human mortality is well established, the most responsible particle types/sources are not yet certain.

- In May 2003, the U.S. Environmental Protection Agency's Particulate Matter Centers Program along with NYSERDA sponsored the "Workshop on the Source Apportionment of PM Health Effects".

Source Apportionment and Health Effects

- The goal was to evaluate the consistency of the various source apportionment methods in assessing source contributions to daily PM2.5 mass-mortality associations. Seven research institutions, using varying methods, participated in the estimation of source apportionments of PM2.5 mass samples collected in Washington, DC and Phoenix, AZ.

- Apportionments were evaluated for their respective associations with mortality using Poisson regressions, allowing a comparative assessment of the extent to which variations in the apportionments contributed to variability in the source-specific mortality results.

- A poster describing this workshop is being presented at this meeting.

Conclusions

- Good tools are available to help with the source identification and apportionment

- Method development continues and better tools can be expected in the near future

- Apportionment can assist in SIP development, and

- Potentially can be used to assist in health effects epidemiology