PITT-PM

Design and Feasibility
Assessment for a Retrospective
Epidemiological Study of
Coal-Fired Power Plant Emissions in the
Pittsburgh,
Pennsylvania Region

(DE-FC26-05NT42302)

Rick Bilonick
Assistant Professor of Epidemiology
University of Pittsburgh, GSPH

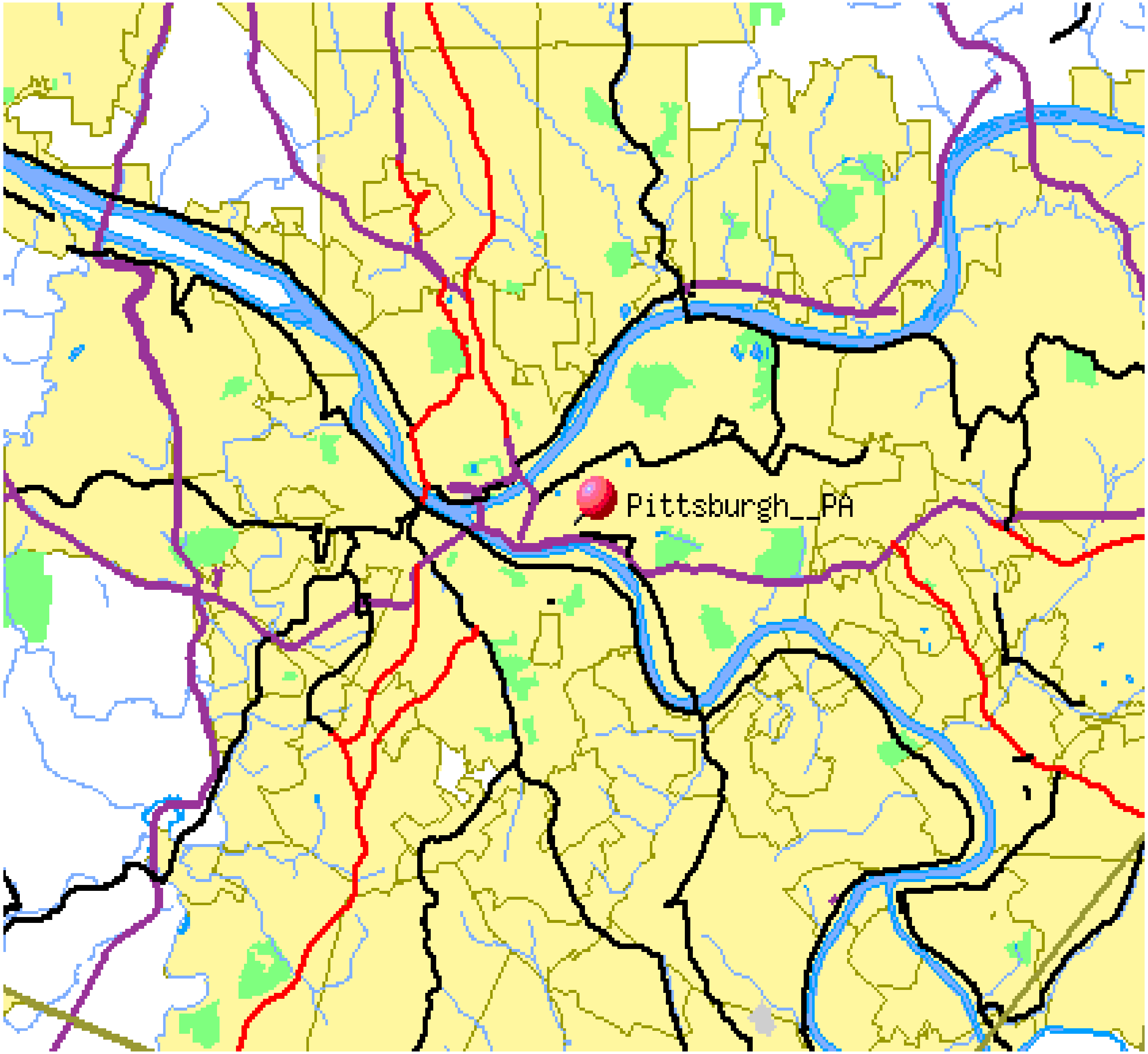
PITT-PM Research Team

- Rick Bilonick – Epidemiology
- Dan Connell – CONSOL Energy
- Kevin Crist – Ohio University
- Larry Keller – EOH
- Chris Myers - EOH
- Juley Rycheck - Epidemiology
- Sam Schlosberg – ACHD
- Nancy Sussman – EOH
- Evelyn Talbott – Epidemiology
- Steve Winter – CONSOL Energy
- Jeanne Zborowski - Epidemiology

Study Objectives

- Time period: ~1999 to 2004
- Make an inventory of health outcome databases
- Make an inventory of air monitoring databases
- Source apportionment
- Exposure with identification of $PM_{2.5}$ composition (e.g. speciation)
- Effects modeling
- Evaluate time-series methods for modeling effects
- Feasibility assessment of design

Pittsburgh Metropolitan Region



Particulate pollution has been studied in Pittsburgh since the 1970's.

The following is a brief description of some of these studies.

Pittsburgh and Pollution

Mazumdar S. and Sussman N.
Relationships of air pollution to health: results from the Pittsburgh study. (Archives of Environmental Health. 38(1):17-24, 1983 Jan-Feb.)

Methods: Time series models of health effects were determined using the air quality data for sulfur dioxide (SO_2) and particulates (TSP) as measured by the COH from three monitoring stations located within Allegheny County. The analysis was limited to the investigation of same day effects.

Time and location: 1970s, Pittsburgh

Conclusion: Indicated a possible association between heart disease mortality/morbidity and same day particulate levels.

Pittsburgh and Pollution

Schwartz J.
The distributed lag between air pollution and daily deaths.
(Epidemiology. 11(3):320-6, 2000 May.)

Methods: Applied distributed lag models for daily deaths for each of ten cities as a function of PM_{10} while controlling for temperature, humidity, barometric pressure, day of the week, and seasonal patterns.

Time and location: New Haven, Birmingham, Pittsburgh, Canton, Detroit, Chicago, Minneapolis, Colorado Springs, Spokane, and Seattle

Conclusion: Health effects of PM_{10} were spread over five days.

Pittsburgh and Pollution

Chock D. P., Winkler S. L., Chen C.

A study of the association between daily mortality and ambient air pollutant concentrations in Pittsburgh, Pennsylvania.

(J. of the Air & Waste Man. Association. 50(8):1481-500, 2000 Aug.)

Methods: Looked at the problem of multi-collinearity among pollutants (PM10, CO, O_3, SO_2, NO_2, $PM_{2.5}$, coarse PM) and weather using seasonal and nonseasonal time series models of daily mortality for two age groups.

Time and location: 1989-1991, Pittsburgh

Conclusions: "The concern for the instability of the pollutant coefficients due to a small signal-to-noise ratio makes it impossible to ascertain credibly the relative associations of the fine- and coarse-particle modes with daily mortality."

Pittsburgh and Pollution

Braga A. L., Zanobetti A., Schwartz J.
Do respiratory epidemics confound the association between air pollution and daily deaths? (European Respiratory Journal. 16(4):723-8, 2000 Oct.)

Methods: Looked at potential for confounding of health effects of PM10 due to pneumonia epidemics.

Time and location: Chicago, Detroit, Minneapolis, Pittsburgh, Seattle

Conclusions: Effects due to pneumonia epidemics only account for a small downward change in the estimated effect of PM_{10}.

Pittsburgh and Pollution

Maisonet M., Bush T. J., Correa A., Jaakkola J. J.
Relation between ambient air pollution and low birth weight in the Northeastern United States. (Environmental Health Perspectives. 109 Suppl 3:351-6, 2001 Jun.)

Methods: Looked at term low birth weight (LBW) and its relation to CO, PM_{10}, and SO_2. Average trimester exposure to ambient levels was estimated.

Time and locations: 1994-1996, Boston, Hartford, Philadelphia, Pittsburgh, Springfield, MA, Washington, DC.

Conclusions: Exposure to CO and SO_2 were associated with increased risk of term LBW. No indication of a positive association with PM_{10}.

Pittsburgh and Pollution

Zanobetti A., Schwartz J.
Cardiovascular damage by airborne particles: are diabetics more susceptible? (Epidemiology. 13(5):588-92, 2002 Sep.)

Methods: Hierarchical model with Poisson regressions in each of four cities.

Time period and location: 1988-1994, Chicago, Detroit, Pittsburgh, Seattle

Conclusions: Diabetics have twice the risk of a PM_{10}-associated cardiovascular admission compared to non-diabetics. Persons 75 years of age and older had higher risk.

Pittsburgh and Pollution

Dominici F., McDermott A., Zeger S. L., Samet J. M.
Airborne particulate matter and mortality: timescale effects in four US cities. (American Journal of Epidemiology. 157(12):1055-65, 2003 Jun.)

Methods: Time series Poisson regression of daily mortality on Fourier decomposition of particulate air pollution time series to study time scale of effects.

Time period and location: 1987-1994, Pittsburgh, Minneapolis, Seattle, and Chicago

Conclusion: Larger relative rates of mortality for two-week to two-month time scale compared to 1-4 days. Particulate effect is more than just advancing death by a few days for frail individuals.

Pittsburgh and Pollution

Schwerha J. J., Talbott E. O., Zborowski J. V., Mazumdar S., Arena V. C., He S., Keller L., et al.
Allegheny County Air Pollution Study (ACAPS), Final Report (2003)

Methods: GAM (stringent convergent criteria) with LOESS and distributed lag hospital admissions time series models as a function of PM_{10} and SO_2 adjusting for weather and day-of week.

Time and location: 1995-2000, Allegheny County

Conclusion: 20 μg/m3 (one IQR) increase in PM_{10} was associated with a an elevated but n.s.s. change in hospital admissions while a 0.0068 ppm (one IQR) increase in SO_2 was associated with a s.s. increase.

Some Observations

- In observational studies, association does not necessarily imply causation.

- To the extent causation can be inferred, it can be attached either to types of particles or sources of particles.

- Monitoring site data by itself isn't enough for source determination so that either more information is needed and/or strong assumptions/modelling are needed.

- In addition to weather effects, there are many potential confounding factors.

More Observations

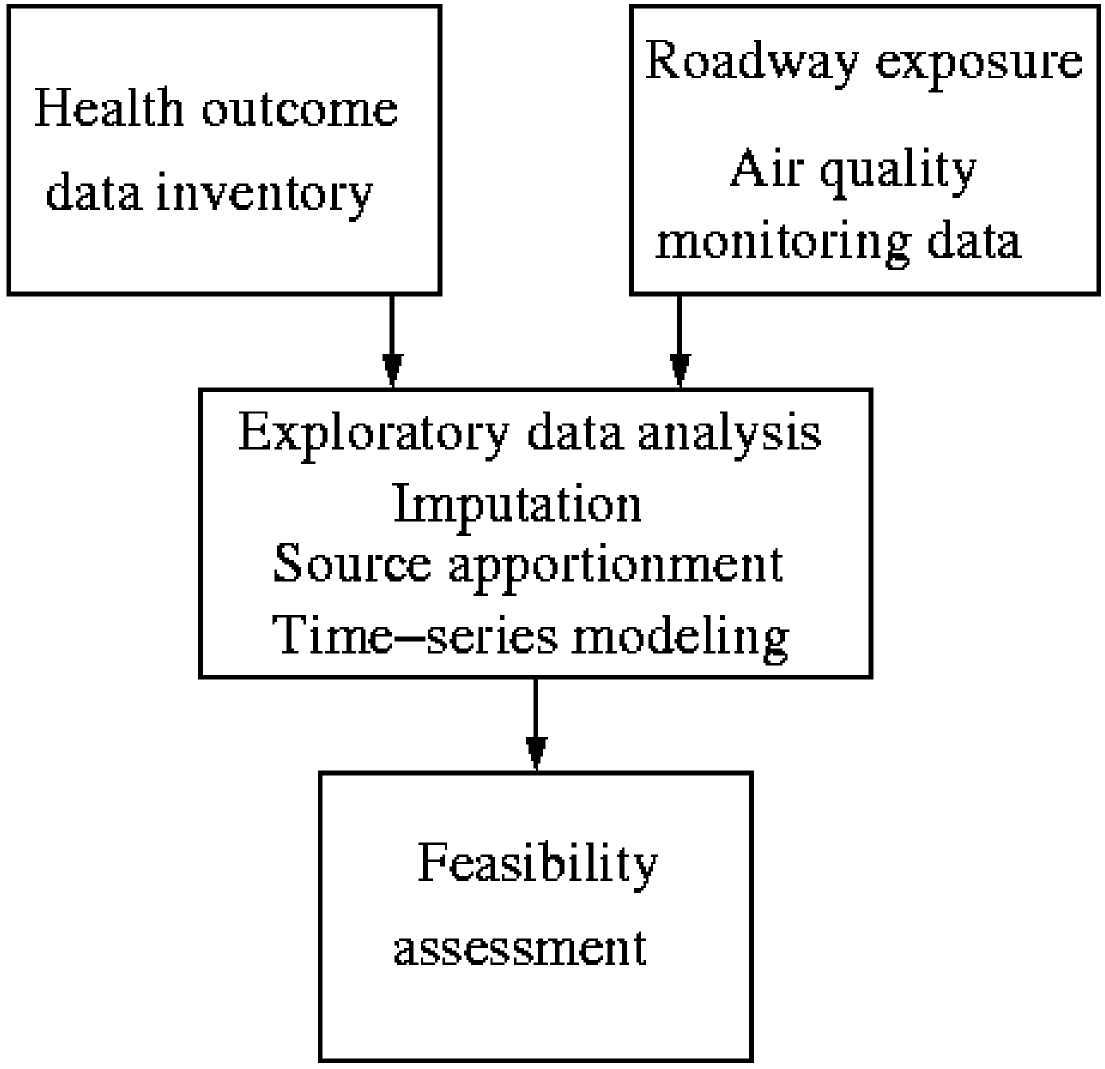
- Complex statistical modelling can sometimes be effectively used to adjust for some confounding factors.

- Exposure metrics are based on a variety of sources:

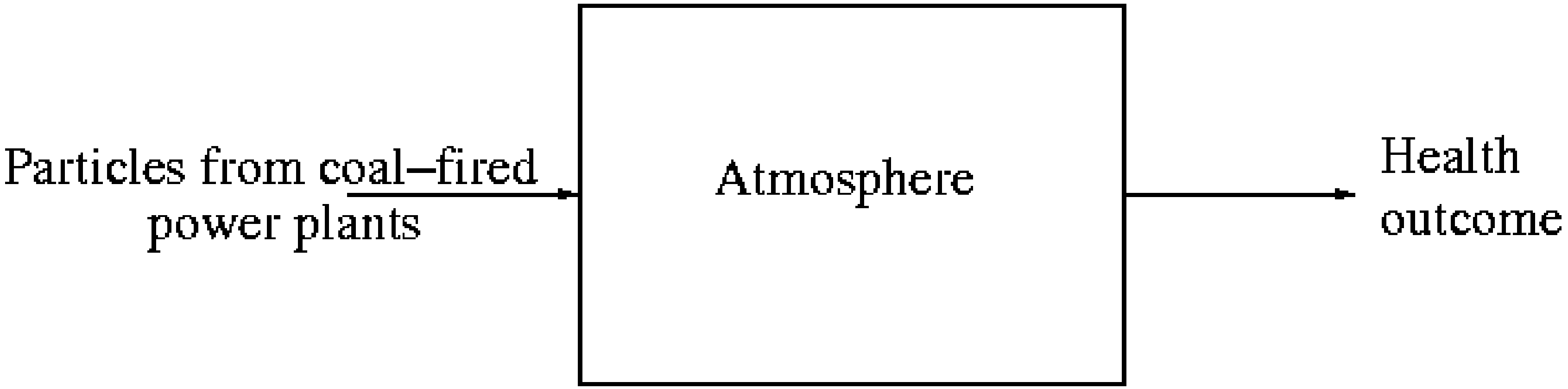
  single monitors, multiple monitors, personal monitors, etc.

- No extensive study of PM2.5 with or without speciation in the Pittsburgh area.

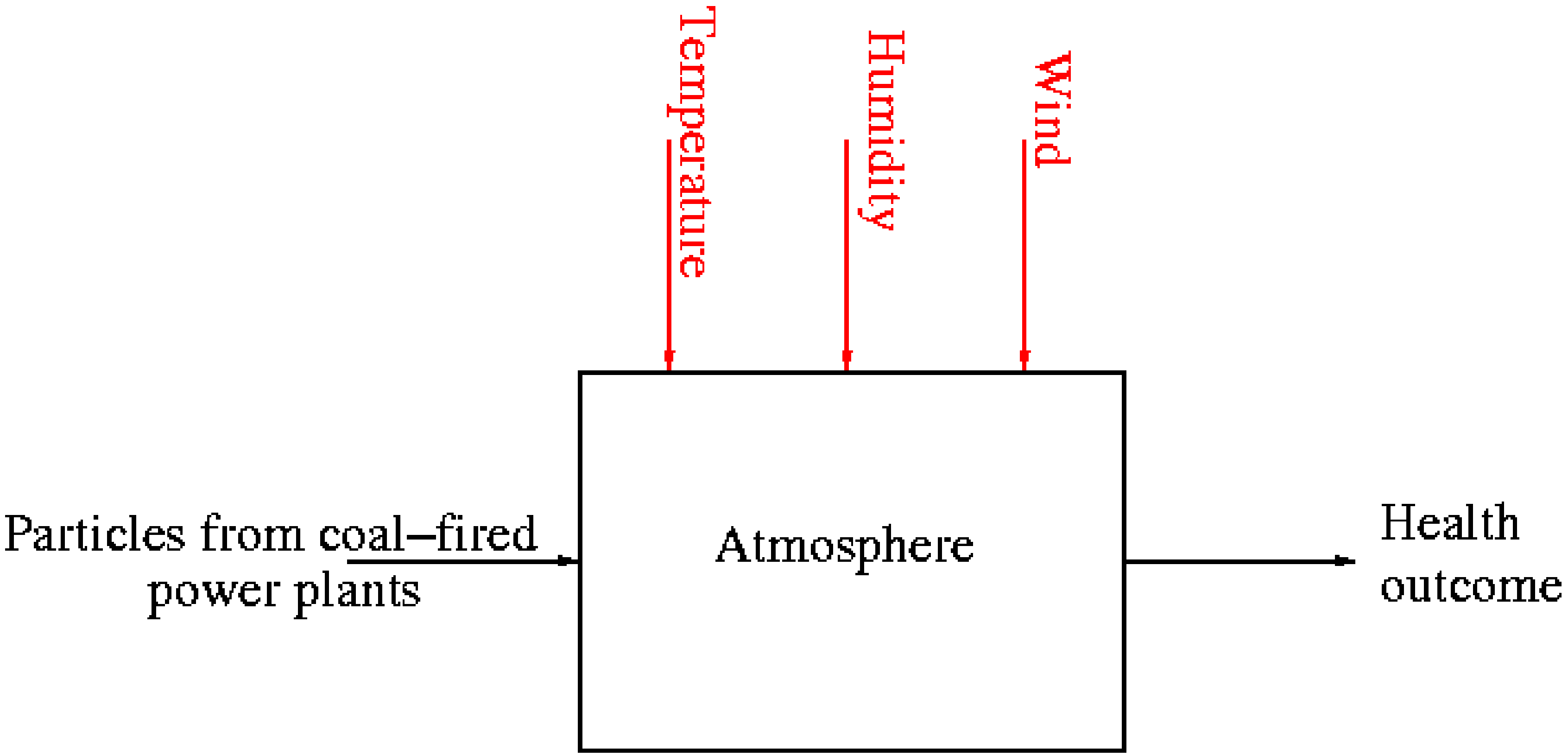
Designing the Retrospective Study



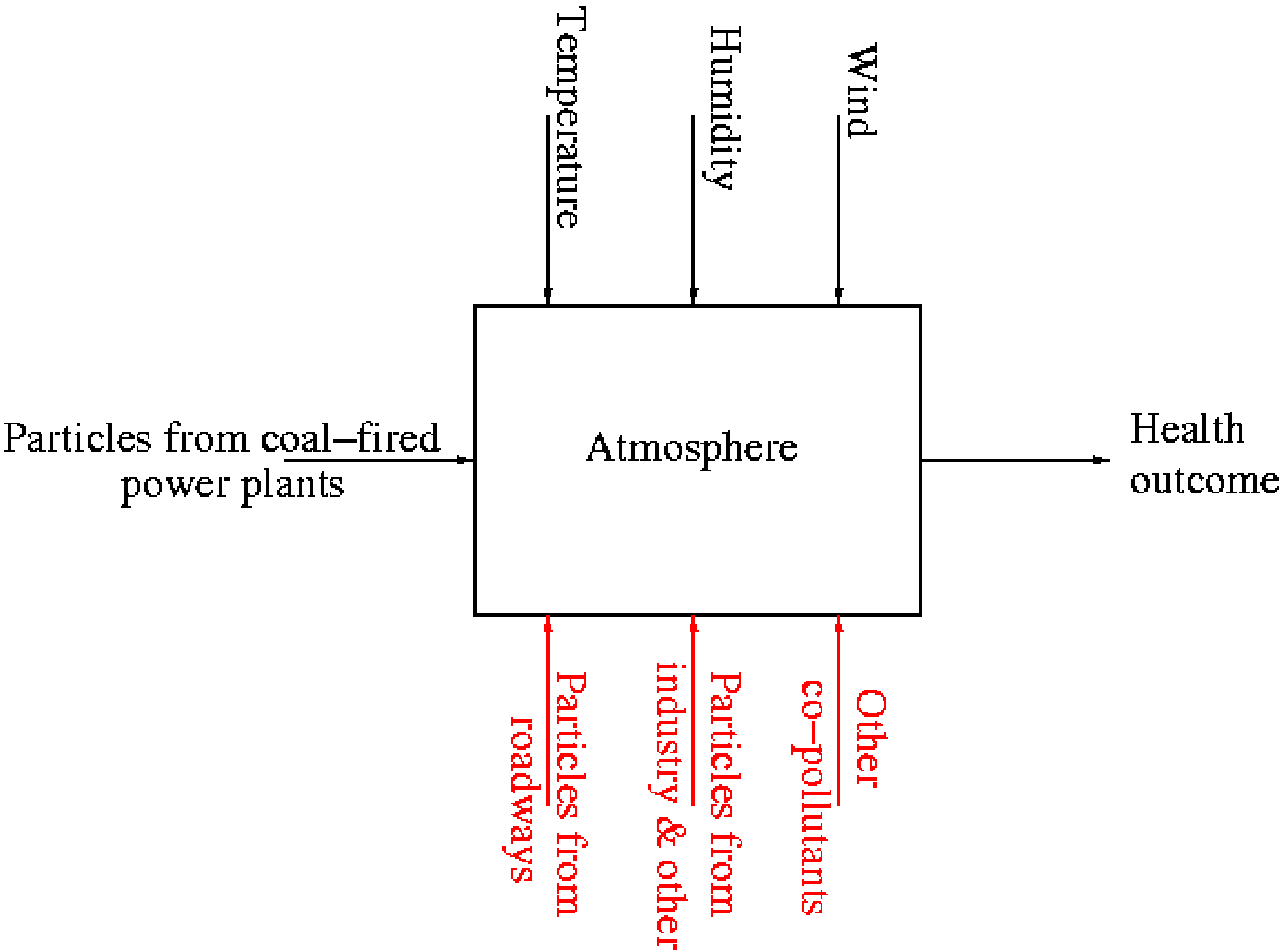
Connecting Inputs to Outputs



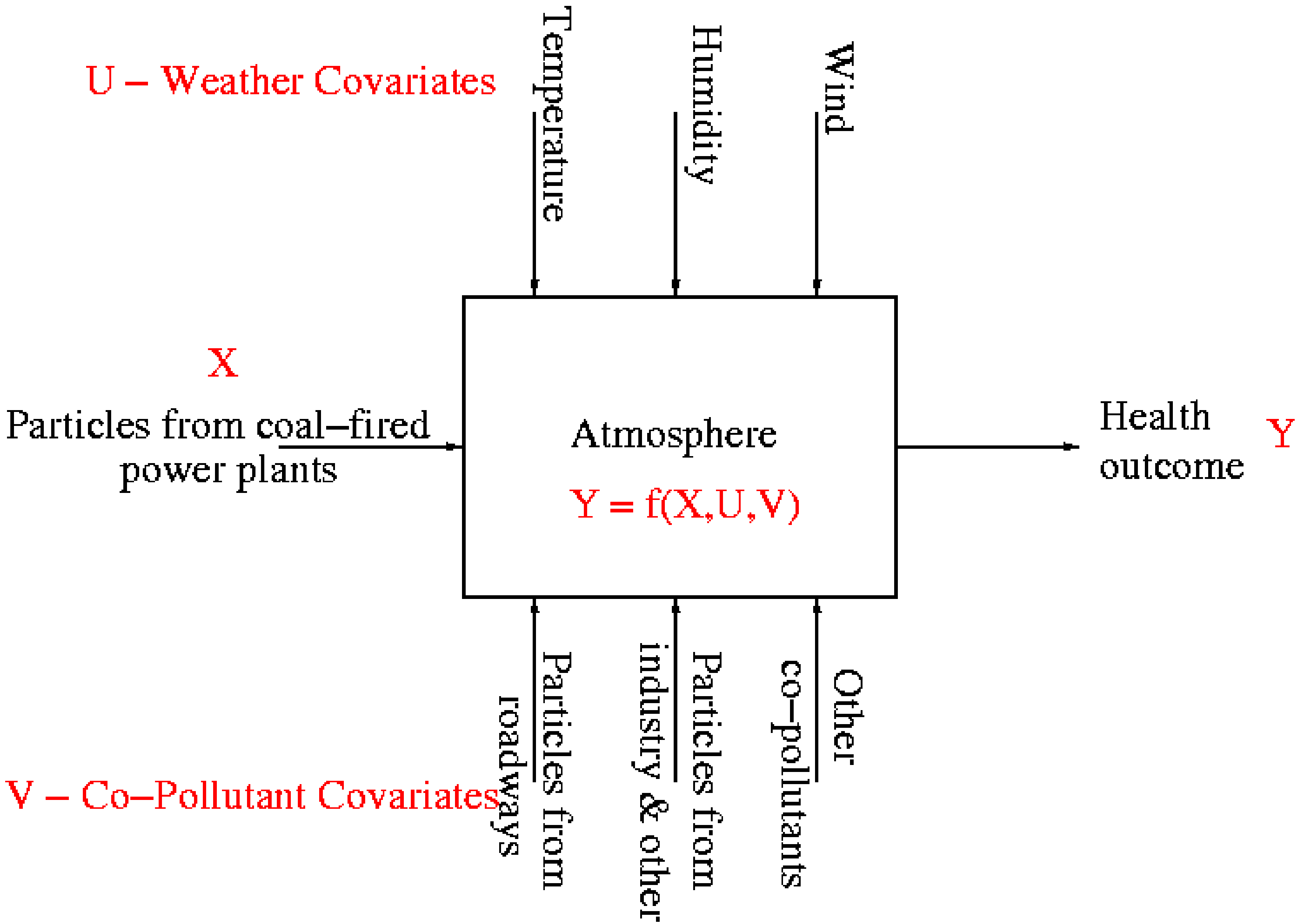
Connecting Inputs to Outputs



Connecting Inputs to Outputs



Connecting Inputs to Outputs



Other Complications

Trends over time exhibit autocorrelation between adjacent observations.

Strong seasonal trends have the same effect.

Even after trends are accounted for, autocorrelation usually remains.

To keep this from being too easy, we don't know which particles are from coal-fired plants!

Important Questions

Does enough speciated exposure data exist spatially? Temporally?

What are the sources of the responsible constituents?

Are there enough health outcomes to construct a study capable of detecting important health effects?

Important Questions

Are health effects due primarily to:

- mass of particles?
- particular subspecies?
- other co-pollutants?

Key Issue

Within the available data bases, is there sufficient

overlap between health effect data and

and exposure data for a retrospective analysis?

Assessment of Existing Morbidity and Mortality Databases

- Create inventory and assess quality and quantity of information
- Mortality, hospital admissions, emergency room visits, etc.
- Evaluate data for completeness and quality
- Develop a plan to construct appropriate databases

Health Outcomes and Fine Particulates

- Given the trends in improved treatments for disease, mortality alone is not a sensitive enough indicator to capture all potential effects of changes in air quality on health.

- Ideally, daily or even hourly medical information would be available to capture all health-related outcomes in the population potentially related to variations in $PM_{2.5}$ concentrations and/or its components.

- Information would include but not be limited to deaths, hospital admissions, emergency room visits, physicians’ office visits, prescriptions, and medication use, all preferably in electronic format.

Mortality and Morbidity Databases

Mortality

Allegheny County Health Department (ACHD)

Pennsylvania Department of Health Statistics

Ohio Department of Health

West Virginia Department of Health

Mortality and Morbidity Databases

Morbidity

Daily Hospital Admissions

Pennsylvania Health Care Cost Containment Council   Ohio Hospital Association

West Virginia Hospital Association

Emergency room visits

Medical Archival System (MARS) (UPMC)

Real-time Outbreak Disease Surveillance (RODS) Lab.

Individual Local and Regional Hospital Databases

Medicare billing information, the Scott-Levin pharmaceutical use database, UPMC Health Plan Pharmaceutical Database, and others

Exposure Data

- Create an inventory of speciated $PM_{2.5}$ data, gaseous co-pollutants, and meteorological data available in the Pittsburgh region
- Create an inventory of archived filters for potential speciation
- Determine availability of data related to population density, traffic density, proximity to roadways, mileage of paved roads, etc. (GIS)
- Assess the quality and comparability
- Develop a plan for construction of an exposure database

Allegheny County Air Monitoring Sites

PM $_{2.5}$ Sites

	SO2	CO	NOx	O3	H2S	Bnz	PM10	PM2.5	TSP	Pb	Dst	SO4	B(a)P	Total
PITTSBURGH														
DOWNTOWN		C												1
FLAG PLAZA		C					C							2
HAZELWOOD	C						C	I						3
MANCHESTER							I							1
LAWRENCEVILLE			C	C				I						3
OTHER SITES														
NORTH PARK								I						1
STOWE	C						C	I						3
NEVILLE											I			1
NEVILLE 2											I			1
AVALON*	C				C		CI		I	I		I	I	8
NATRONA 8											I			1
NATRONA 9											I			1
SPRINGDALE								I						1
HARRISON			C	C										2
HARRISON 2								I						1
NORTH BRADDOCK							I	I						2
NORTH BRADDOCK 7											I			1
BRADDOCK							CI		I	I	I	I	I	7
FORWARD							I	I			I			3
LIBERTY*	C				C	C	CI	I					I	7
GLASSPORT	C													1
GLASSPORT 4							C							1
LINCOLN							C							1
CLAIRTON 4							I	I						2
SOUTH FAYETTE*	C			C			I	I					I	5
COLLIER											I			1
MOON							I	I						2
Total:	6	2	2	3	2	1	17	12	2	2	8	2	4	

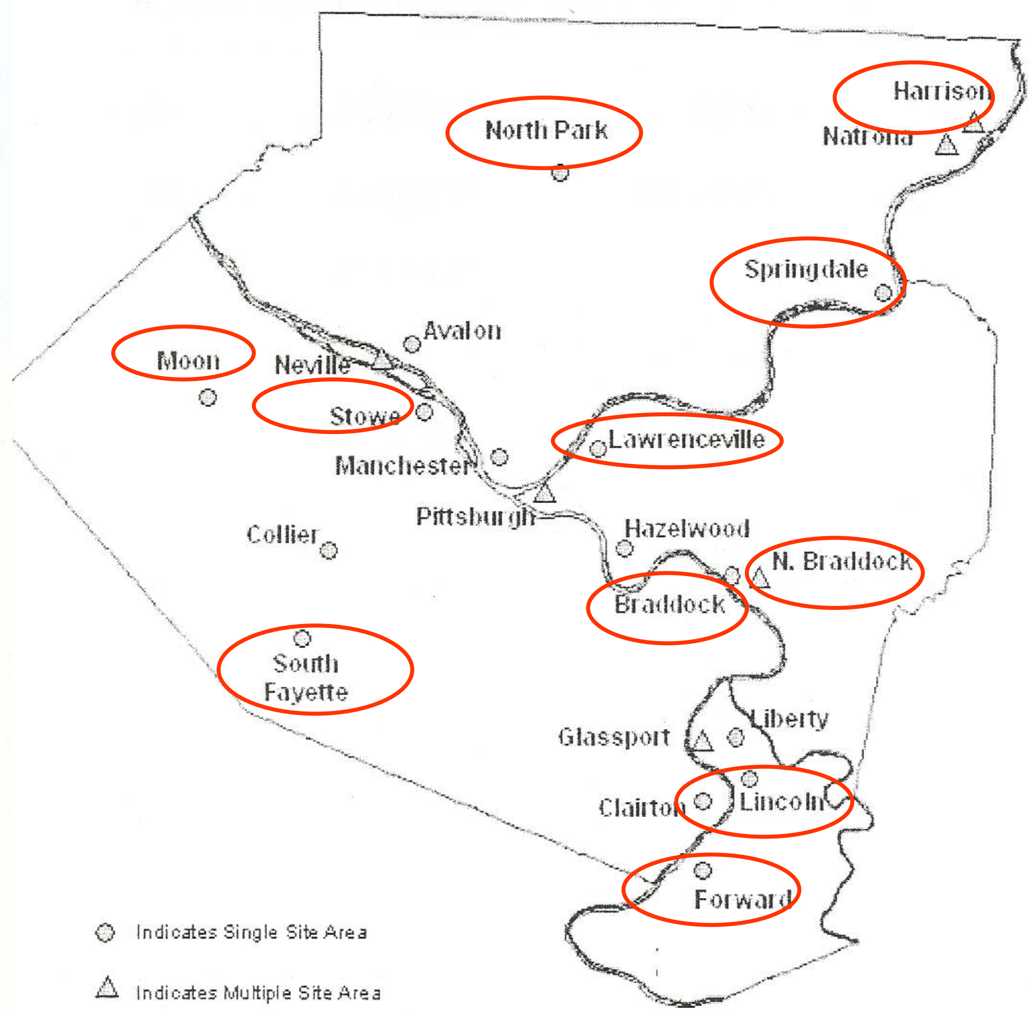
Grand Total = 63

[C]ontinuous monitors

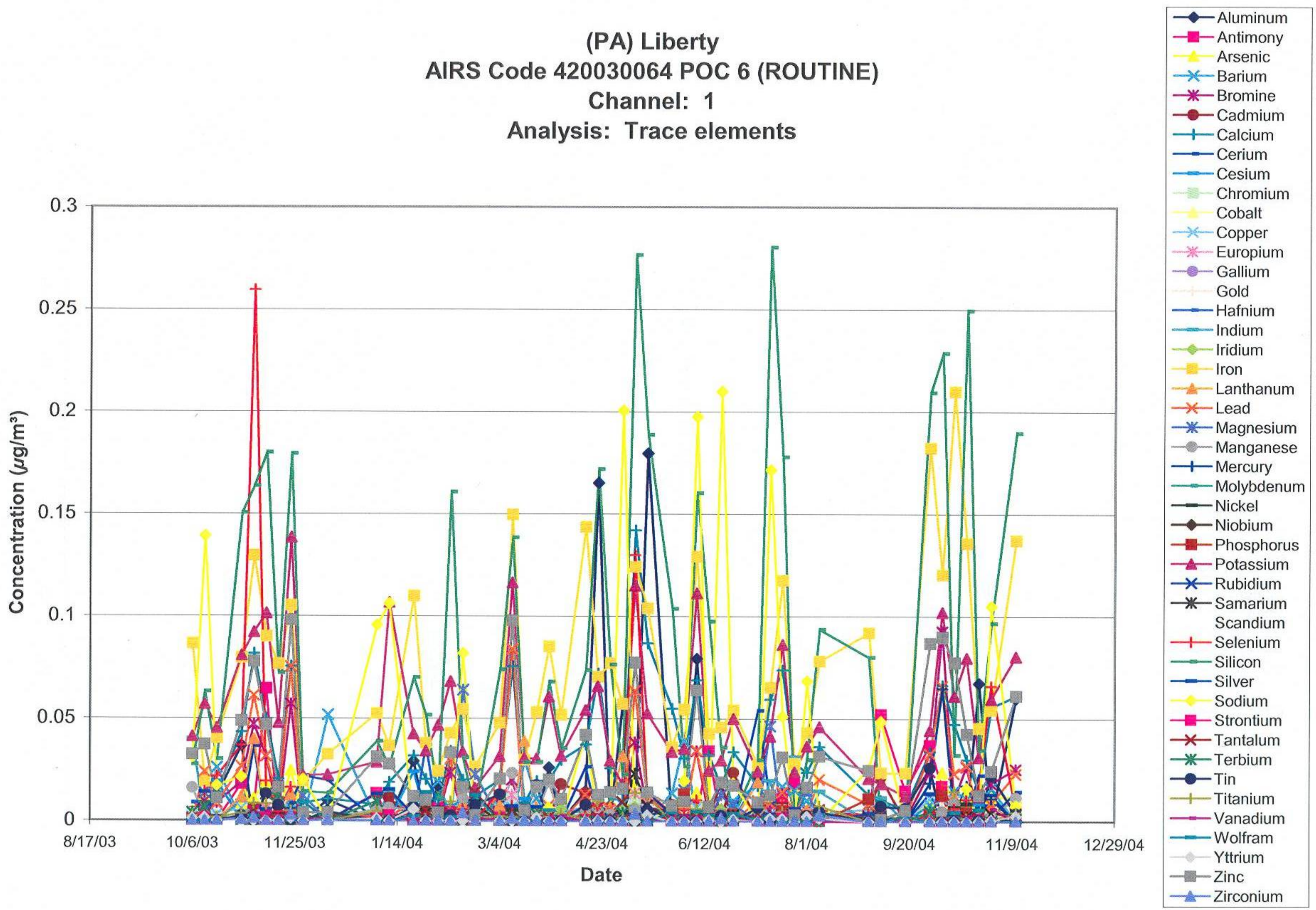
[I]ntermittent monitors

SO2 = sulfur dioxide
CO = carbon monoxide
NOx = nitrogen oxides
O3 = ozone
H2S = hydrogen sulfide
Bnz = benzene
PM10 =inhalable particulates(10u)
PM2.5 = inhalable particulates(2.5u)
TSP = total suspended particulates
Pb = lead
SO4 = sulfates
Dst = dustfall
B(a)P=benzo(a)pyrene

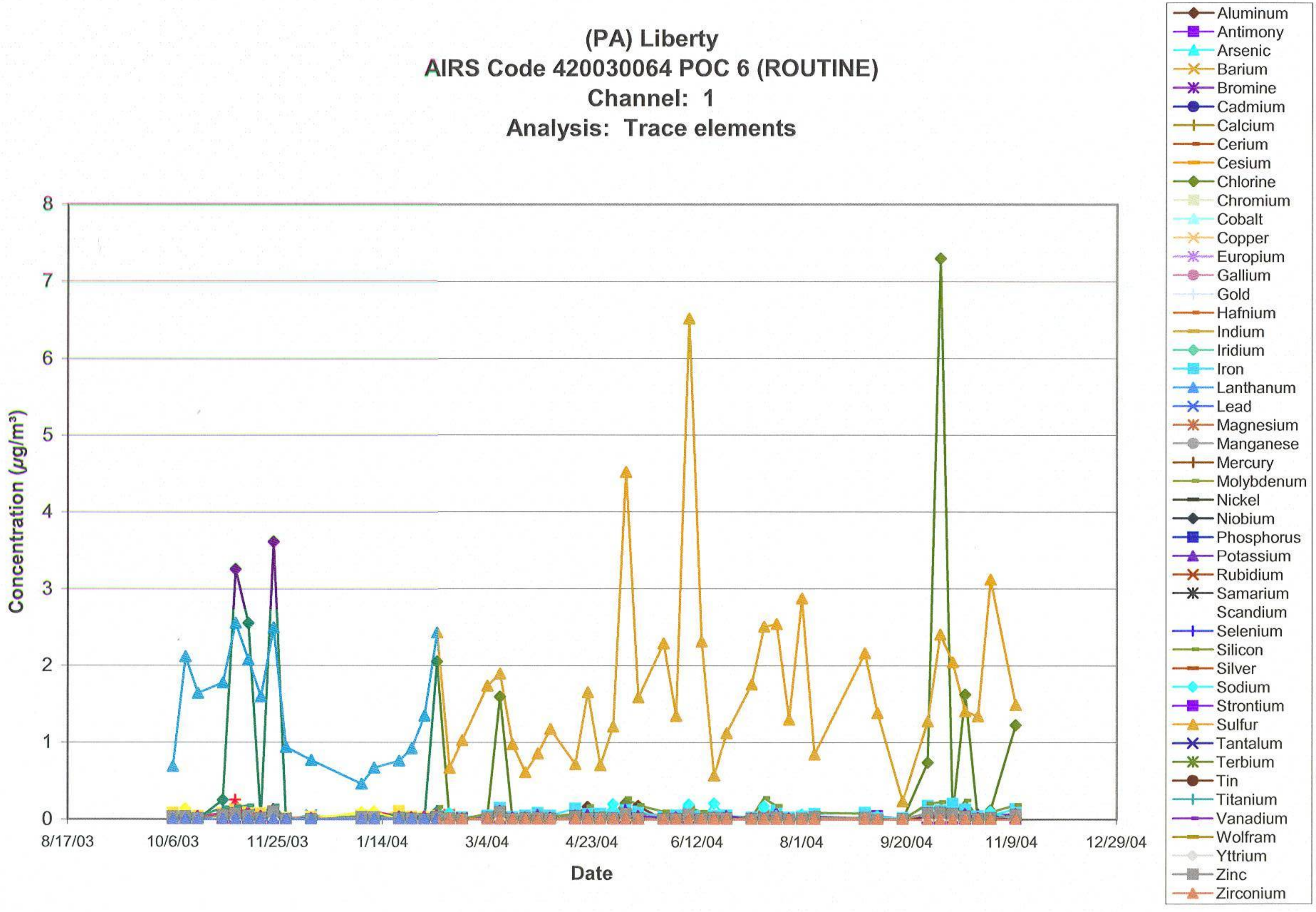
Allegheny County Health Department
Air Quality Monitoring Sites



ACHD Speciation



ACHD Speciation



Statistical Analysis and Effects Modeling

- Evaluate methods for exploratory data analysis and GIS modeling (roadway sources)
- Evaluate individual site information versus spatial/temporal averaging of emissions and explanatory variables
- Evaluate methods for apportioning emissions to sources
- Develop and evaluate statistical methods for modeling health effects as a function of source emissions while controlling for potential confounding explanatory factors

Identifying Sources

- Speciation
- Source profiles
- Chemical mass balance

Possible Methods

- Exploratory factor analysis
- Confirmatory factor analysis
- Bayesian factor analysis
- Regression and measurement error models
- Nested block bootstrapping

Connecting Health Outcomes to Changes in $PM_{2.5}$

- GAM
- GLM
- Time series methods (ARIMA, GARIMA, GLARMA)
- Explore, compare, and contrast these methods using simulation and available data for potential application to Pittsburgh data

Power Issues

We will investigate how the probability of detecting health effects can be enhanced by:

- using a large enough region size

- using a sufficiently long time period