Fred Lipfert, Brookhaven National Laboratory

"PM Monitoring: Issues and Objectives"

PM MONITORING: ISSUES AND OBJECTIVES

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PM MONITORING ISSUES

1. Precision: What is the lower limit for reliable determination of mass?

2. Accuracy: What biases may be present? (filter artifacts, loss of organics & nitrates, humidity effects, size cut)

3. Spatial density: Are fine particles really uniform in urban areas?

4. Frequency: Are daily data needed?

5. Personal exposure vs. outdoor ambient.

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SOME PM MONITORING OBJECTIVES

1. NAAQS Compliance
   (must use Reference Methods)

2. Source Apportionment Studies
   (requires source-specific tracers [Se?])

3. Support for Health Studies
   (requires a broader range of species;
   should include indoor & personal monitoring)

4. Monitoring Technology Development
   (requires side-by-side sampling)

UNRESOLVED HEALTH ISSUES

1. Recent time-series epi studies find less effect due to PM and more due to other pollutants.
2. PM data by size are sparse; coarse particles have been poorly measured.
3. SO4 is not an important factor in time-series studies, yet EPA has targeted power plants.
4. Recent epi studies point to traffic sources, yet soot and organics are not monitored in the U.S.
5. Personal PM exposures correlate poorly with outdoor data; how do we know who is exposed?
7. Urban PM never exists in isolation; how do indoor and outdoor inter-pollutant correlations compare?

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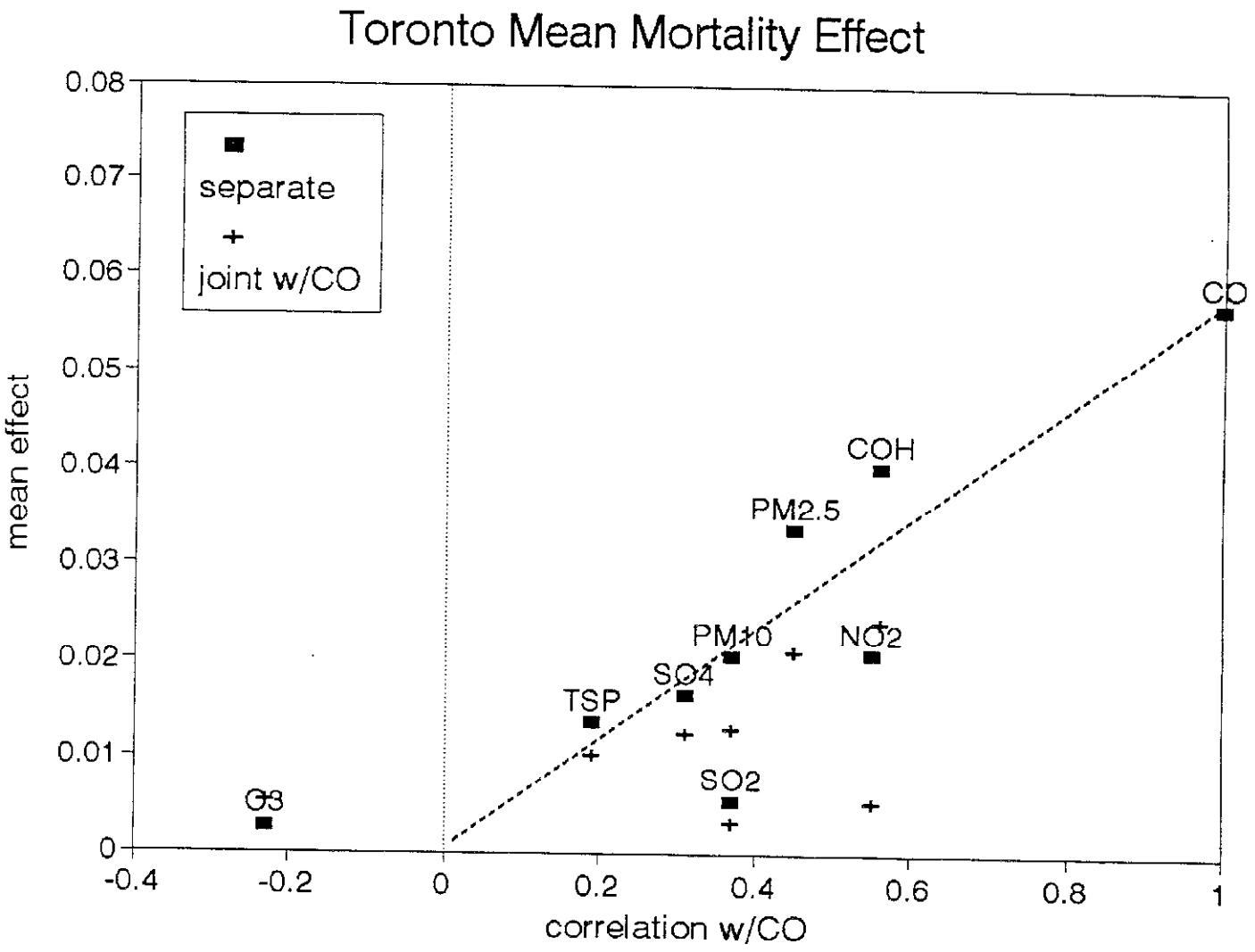
Toronto Mean Mortality Effect
separate
joint w/CO
mean effect
correlation w/CO
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
CO
COH
PM2.5
PM10
NO2
SO4
TSP
SO2
O3

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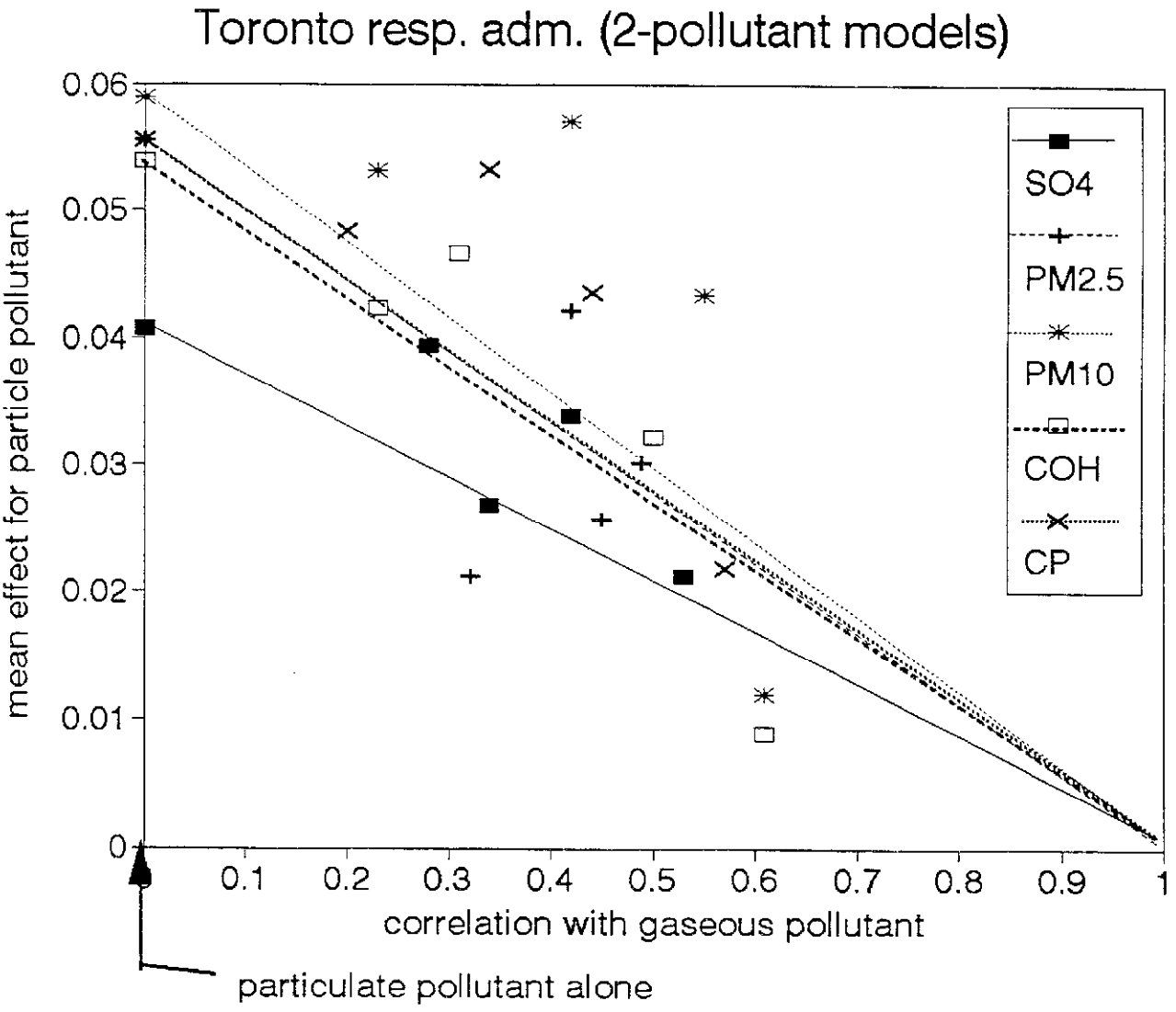
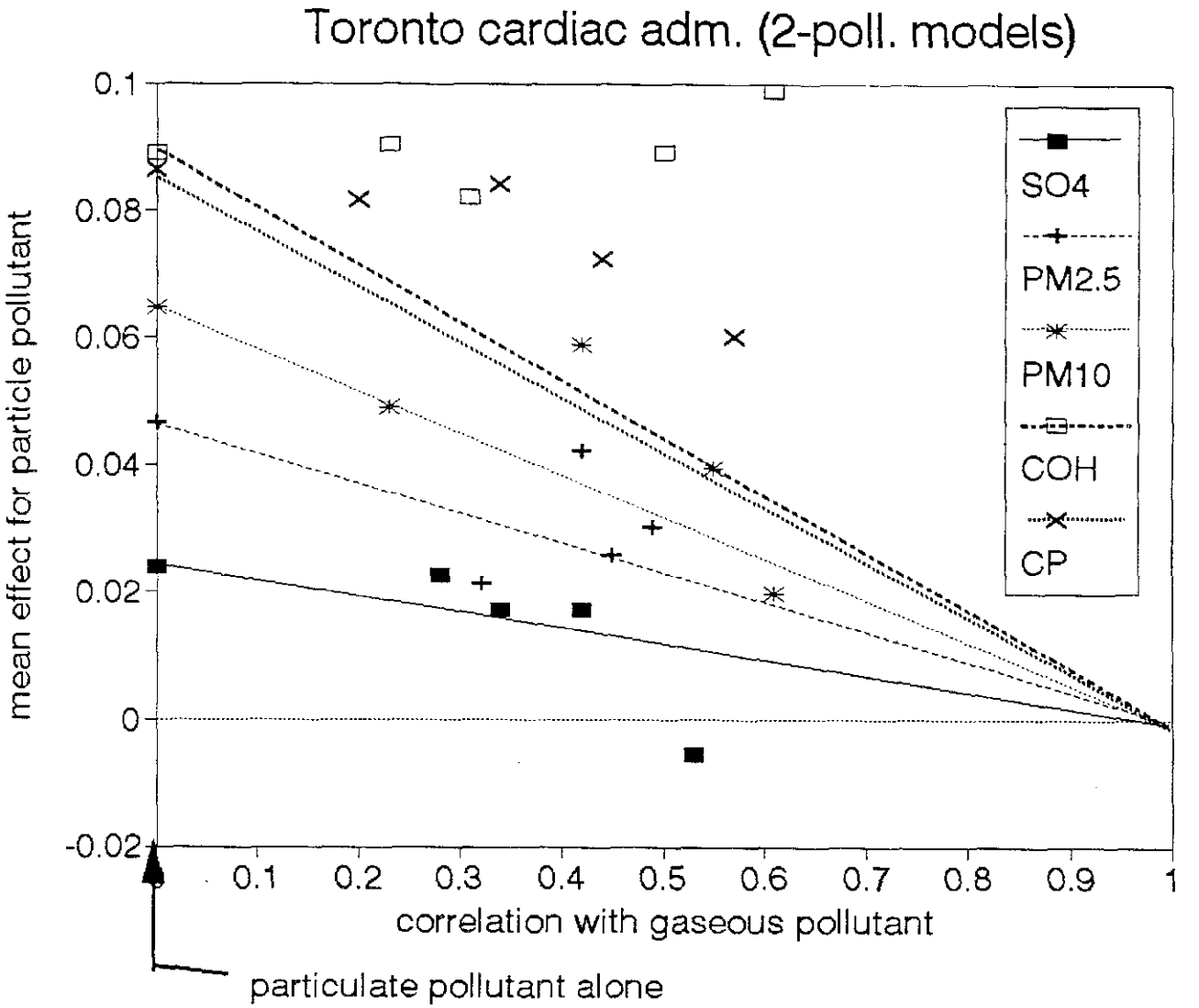

Toronto resp. adm. (2-pollutant models)
mean effect for particle pollutant
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
correlation with gaseous pollutant
SO4
PM2.5
PM10
COH
CP
particulate pollutant alone


Toronto cardiac adm. (2-poll. models)
mean effect for particle pollutant
0.1
0.08
0.06
0.04
0.02
0
-0.02
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
correlation with gaseous pollutant
SO4
PM2.5
PM10
COH
CP
particulate pollutant alone

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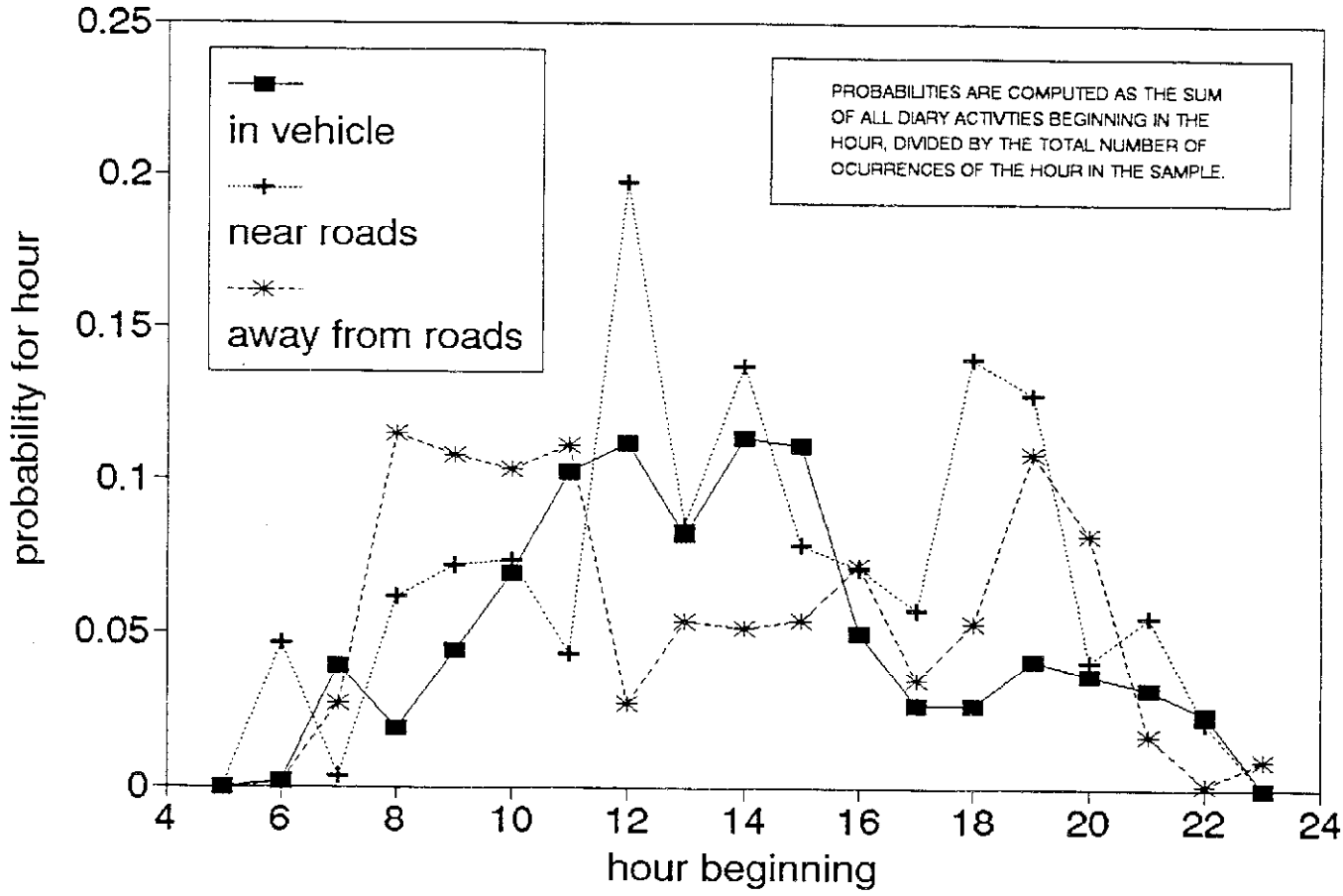
Cincinnati Diary Study (age 65+)

PROBABILITY OF OUTDOOR ACTIVITY



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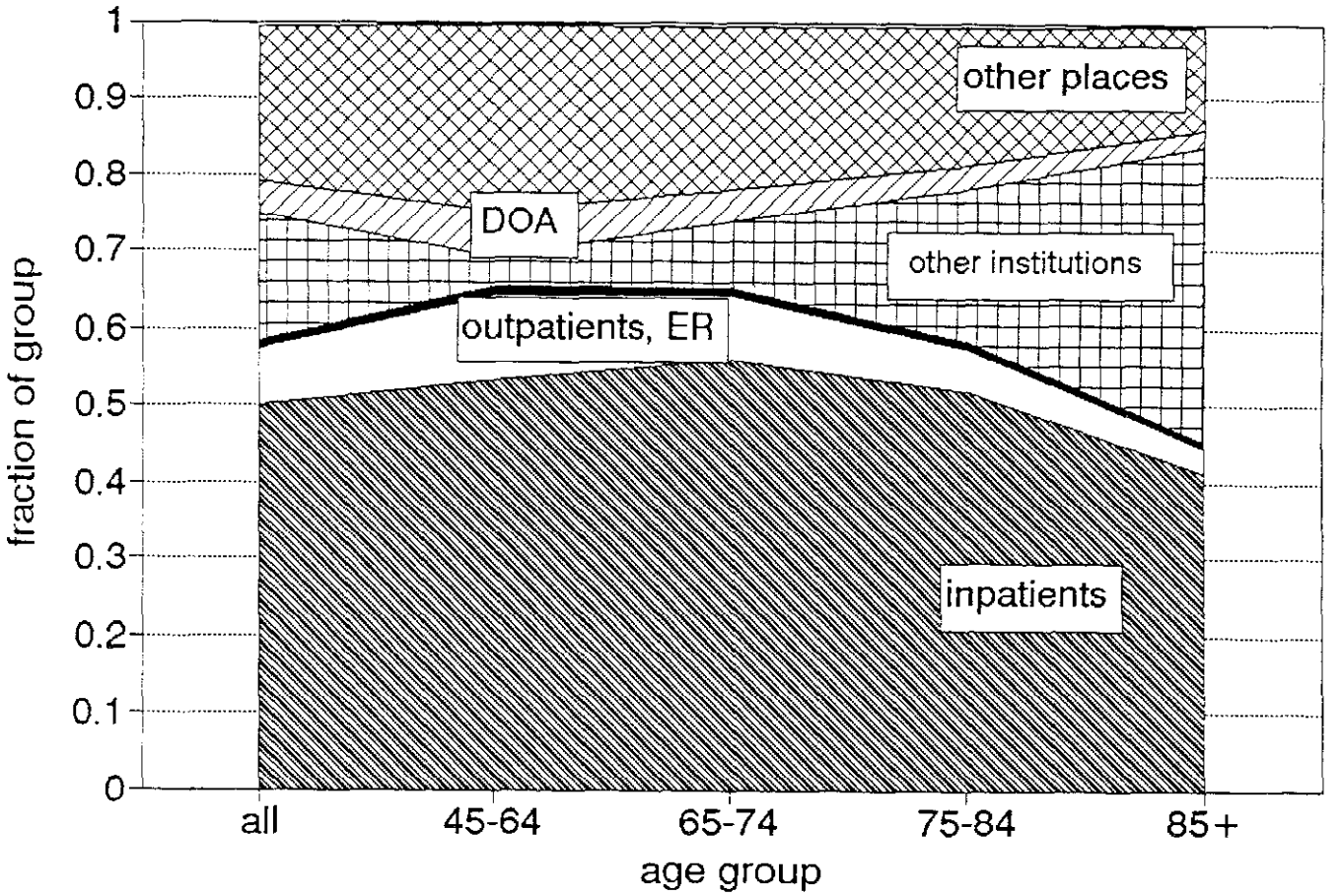
U.S. Mortality by Place of Death
(all causes)



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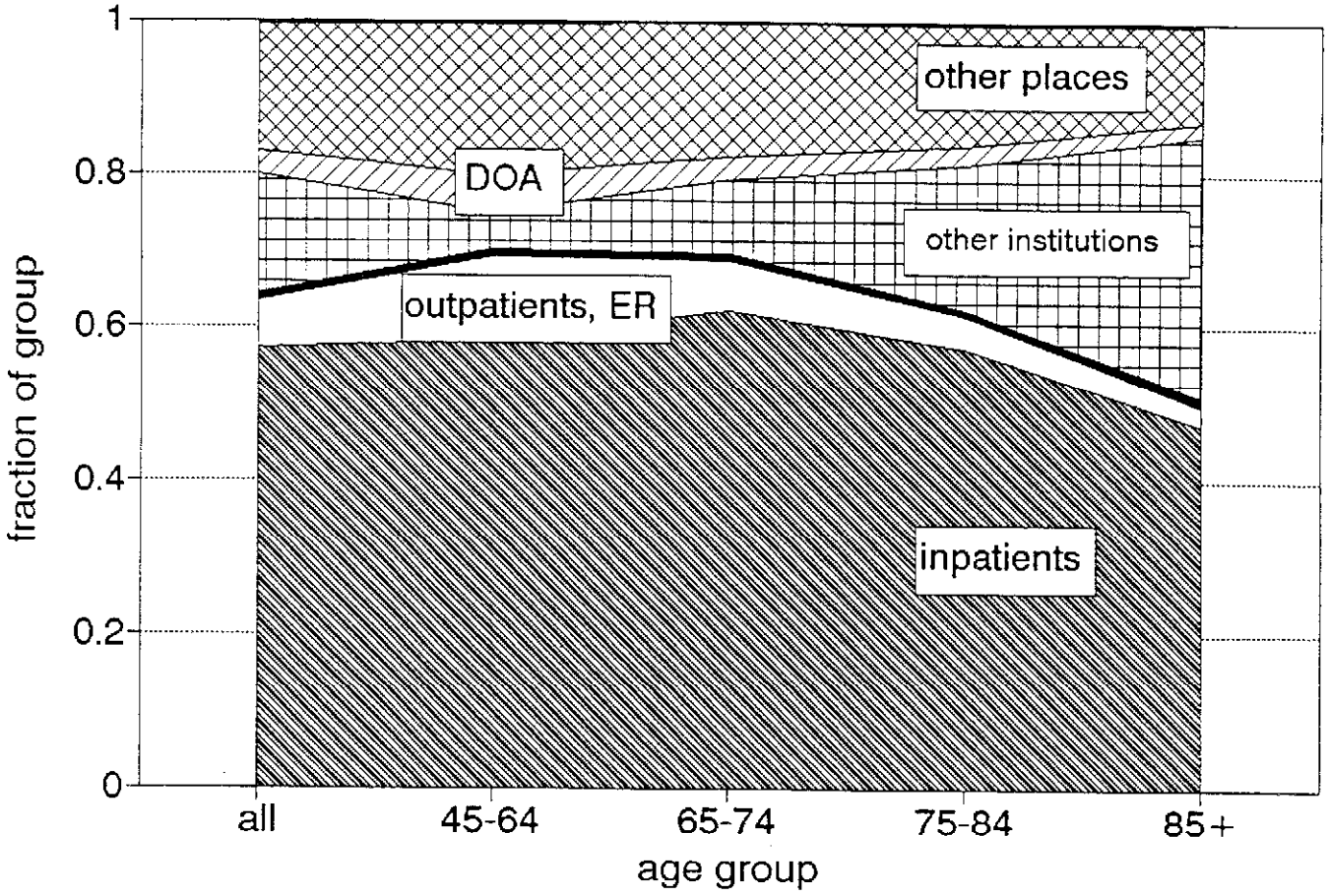
U.S. Mortality by Place of Death (1988)
(chronic obstructive pulmonary disease)



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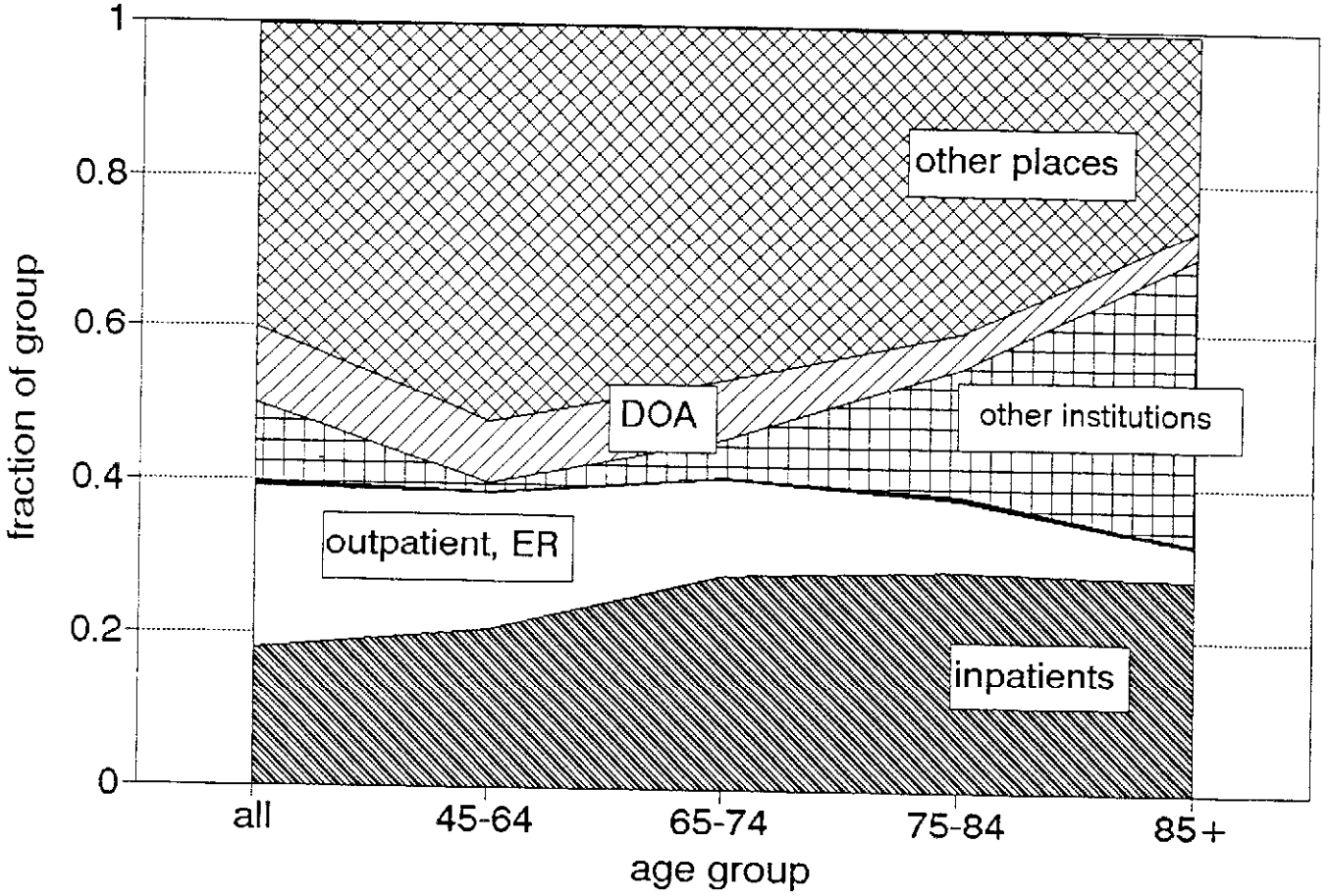
U.S. Mortality by Place of Death (1991)
("ill-defined" causes)



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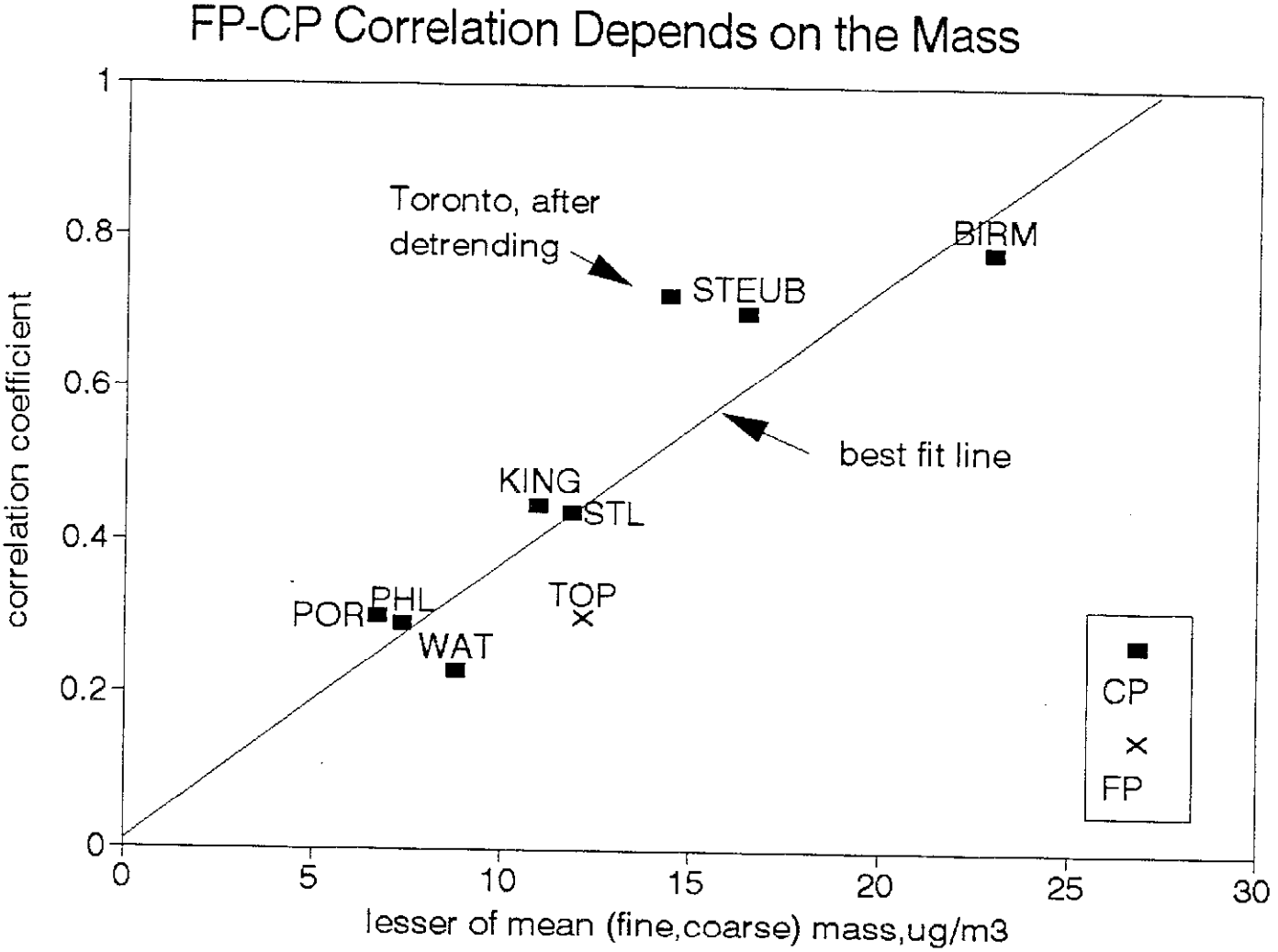
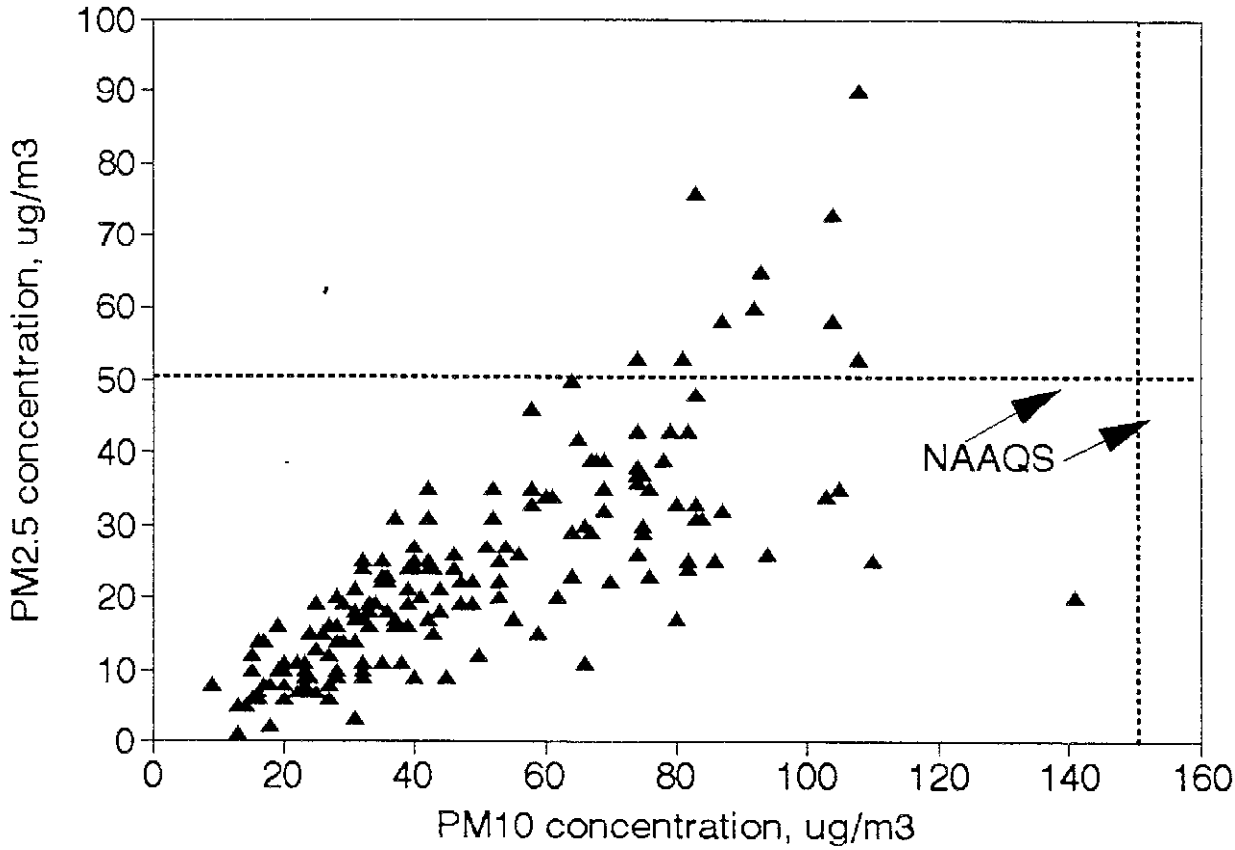
COMPONENTS OF EXPOSURE ERROR

- INSTRUMENT PRECISION AND ACCURACY
- NUMBERS, LOCATIONS OF MONITORS
- ACTIVITY PATTERNS OF SUBJECTS
- MICROENVIRONMENT CHARACTERISTICS
  - air conditioning?
  - windows open?
  - building condition?
  - indoor pollution sources?


FP-CP Correlation Depends on the Mass
correlation coefficient
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
lesser of mean (fine,coarse) mass,ug/m3
Toronto, after detrending
STEUB
BIRM
best fit line
KING
STL
TOP
POR
PHL
WAT
CP
FP

PM2.5 vs. PM10

Wayne Co., (MI), Sites 32,33



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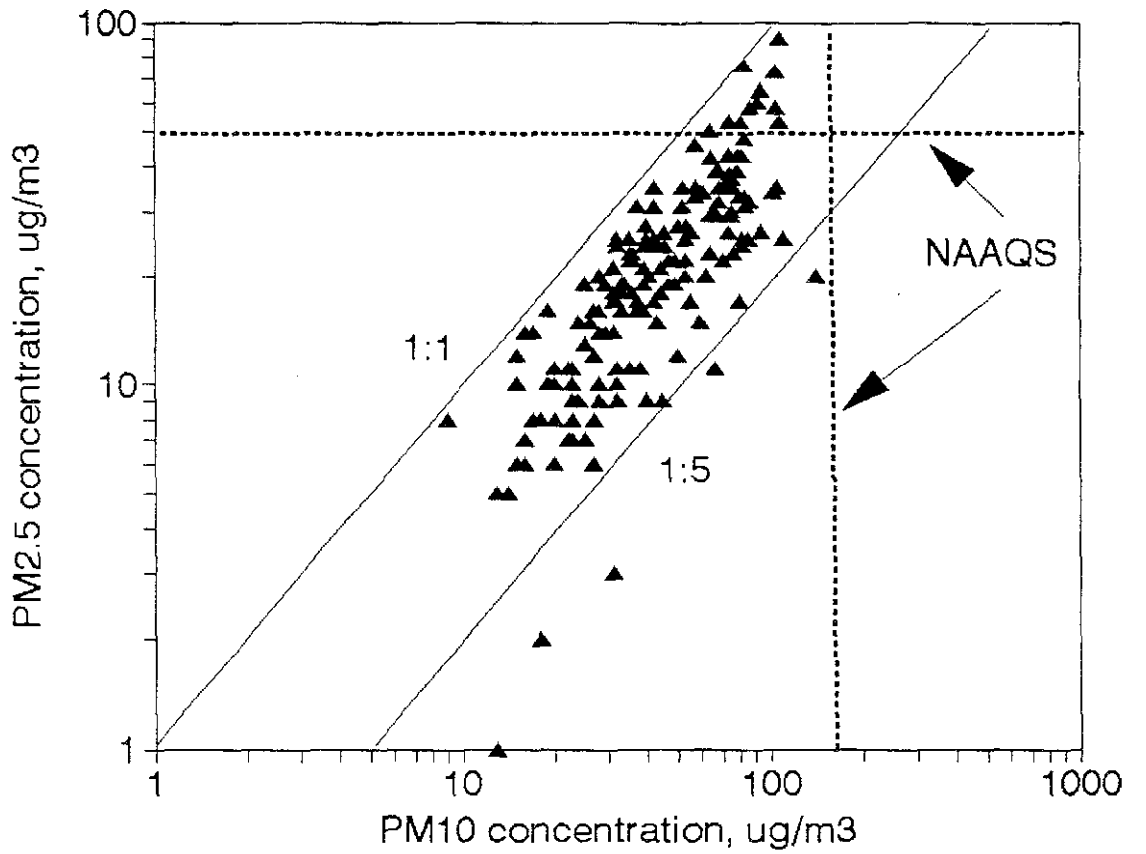
PM2.5 vs. PM10

Wayne Co.(MI) Sites 32,33



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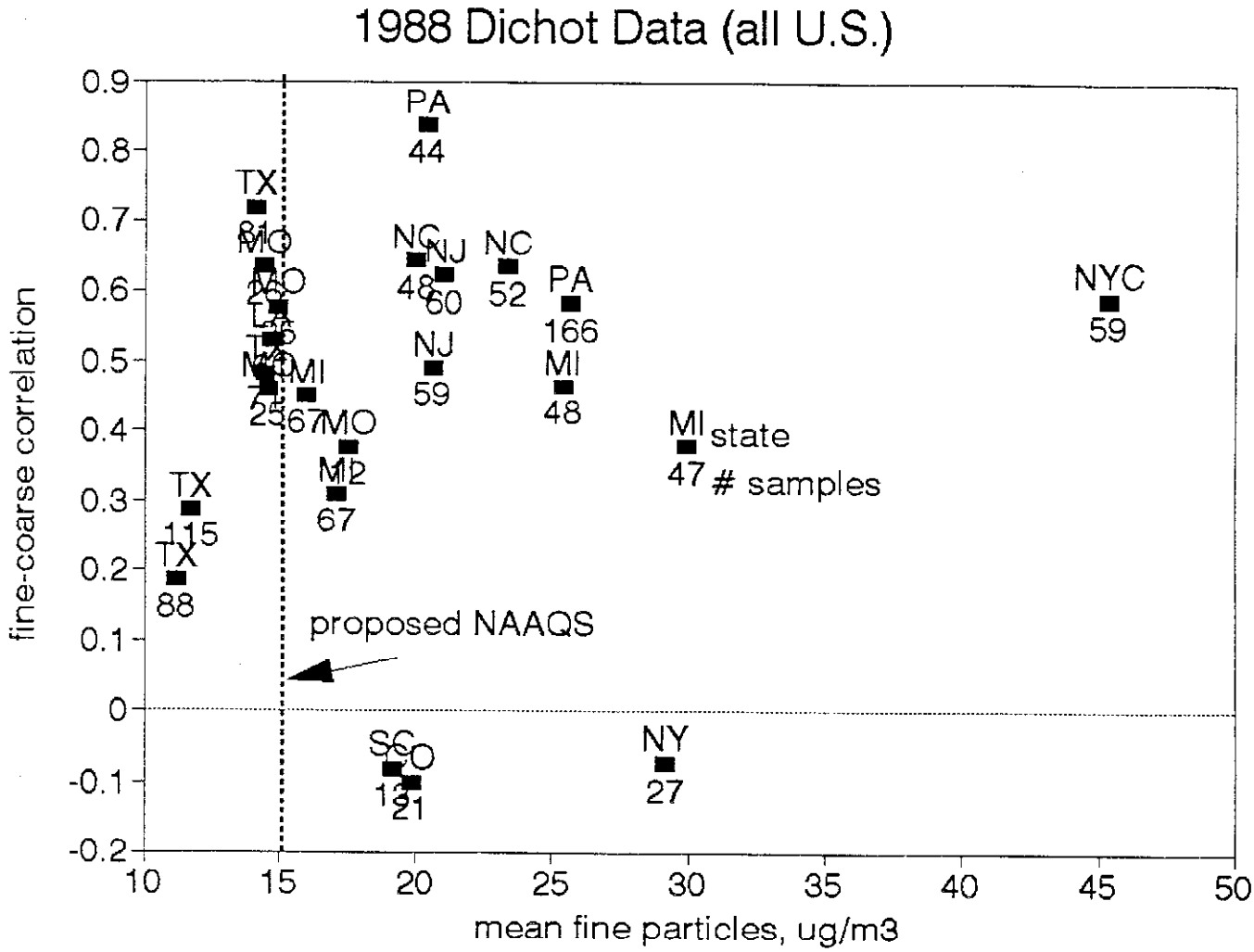
1988 Dichot Data (all U.S.)
fine-coarse correlation
mean fine particles, ug/m3
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
10
15
20
25
30
35
40
45
50
PA
44
TX
81
MO
NC
48
NJ
60
NC
52
PA
166
NYC
59
NJ
59
MI
48
MI
67
MO
MI
47
state
samples
TX
115
TX
88
MI
67
proposed NAAQS
SC
21
NY
27

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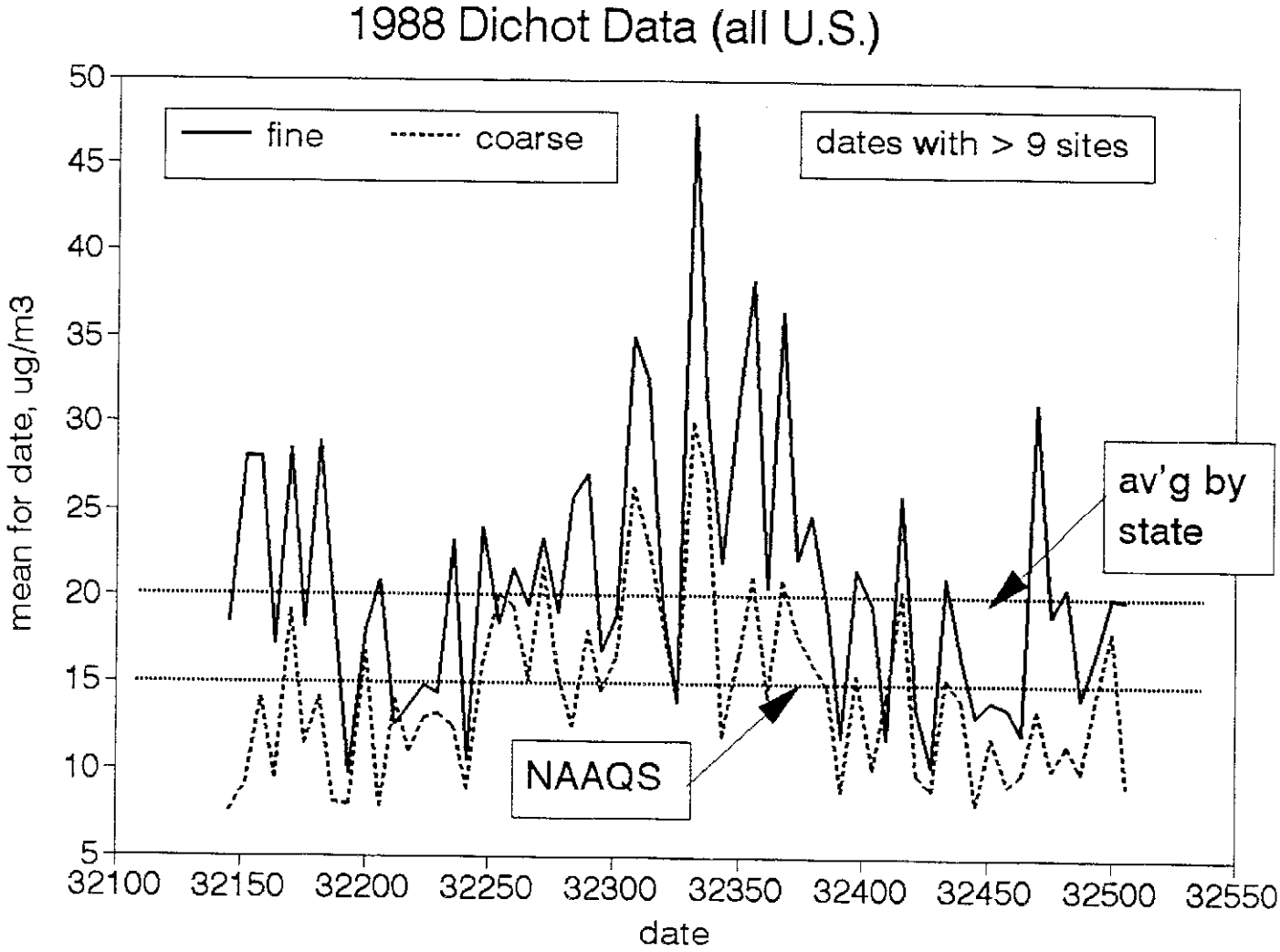
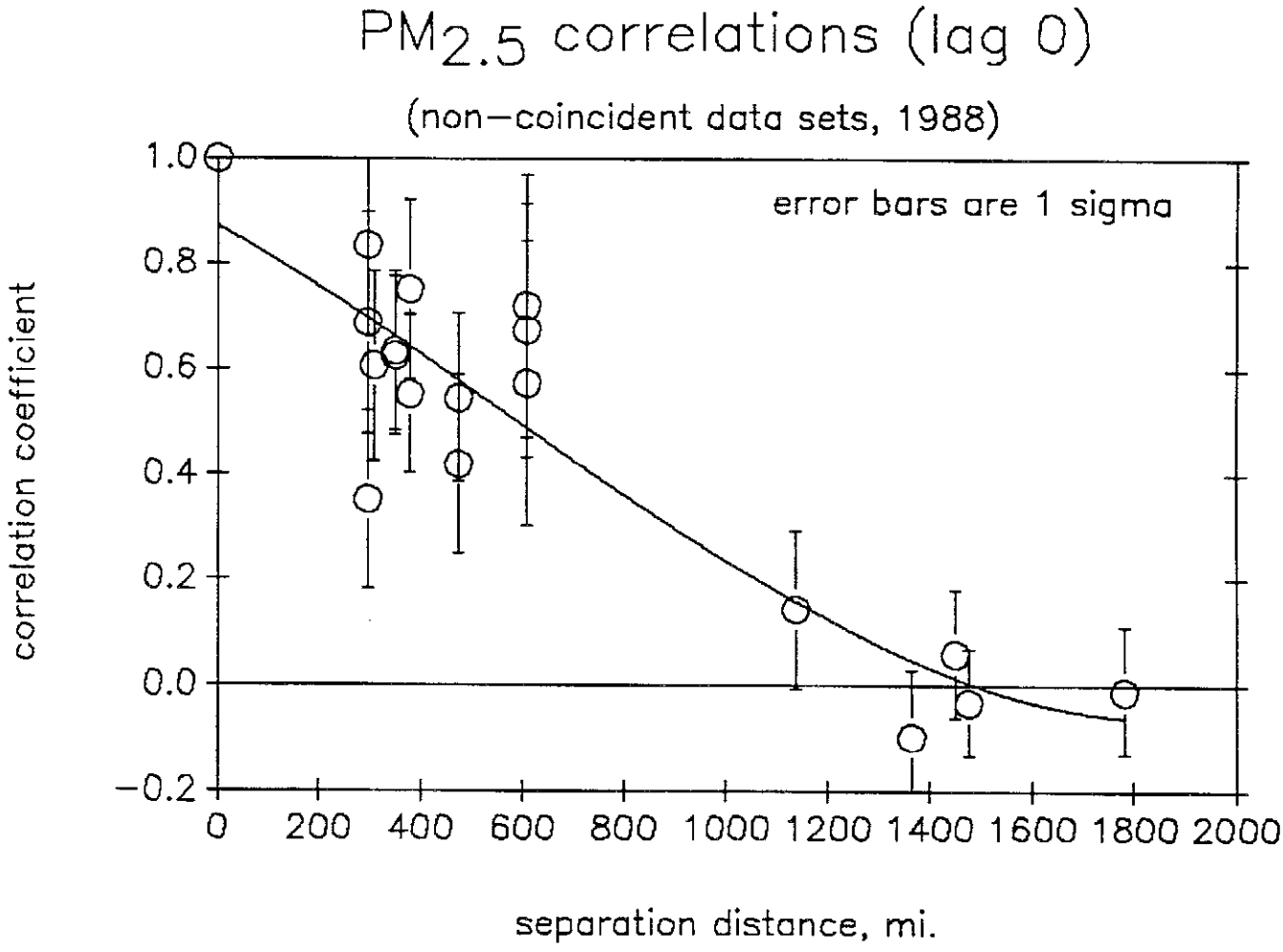
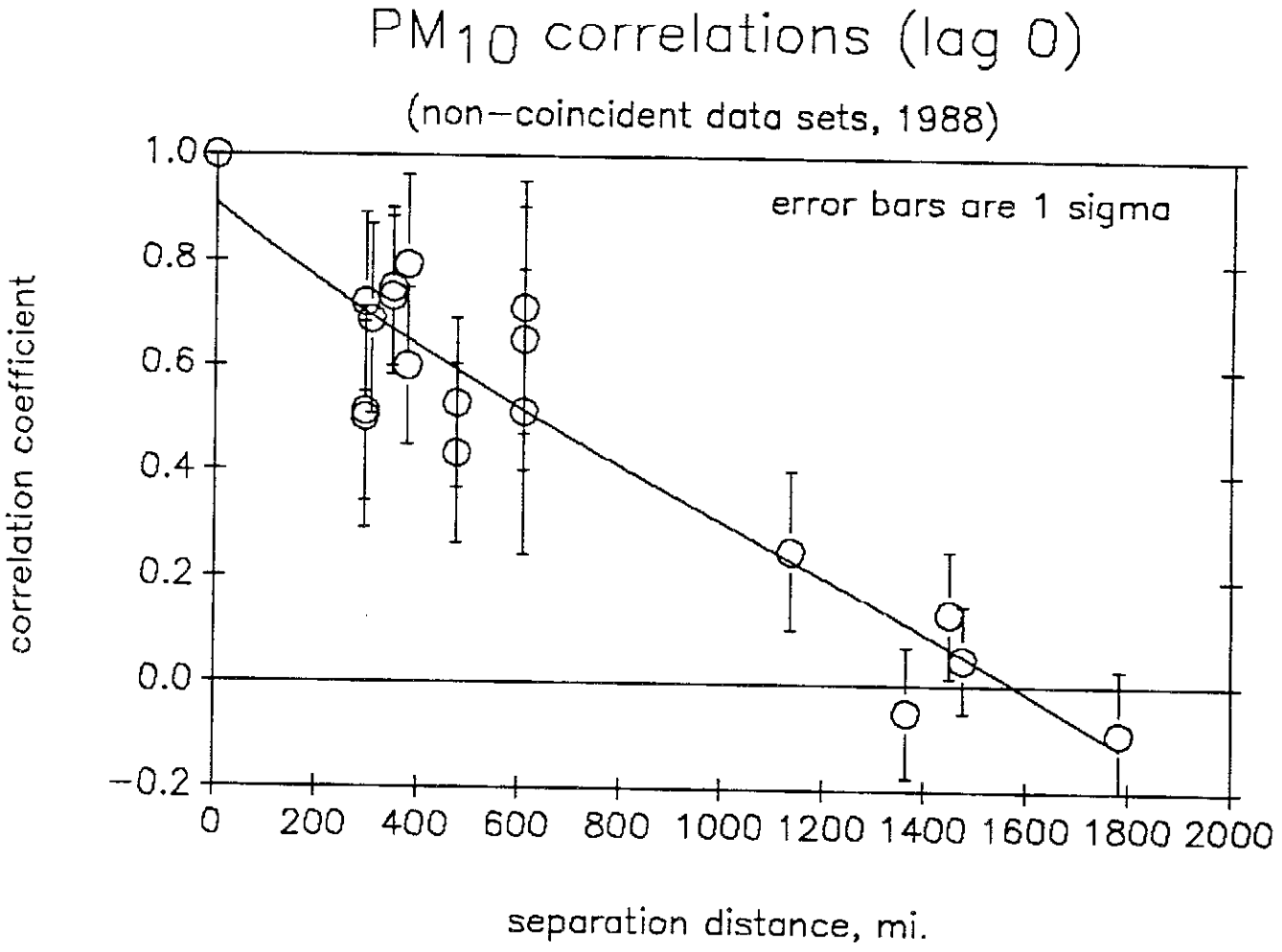

1988 Dichot Data (all U.S.)
fine
coarse
dates with > 9 sites
av'g by state
NAAQS
mean for date, ug/m3
date
50
45
40
35
30
25
20
15
10
5
32100
32150
32200
32250
32300
32350
32400
32450
32500
32550

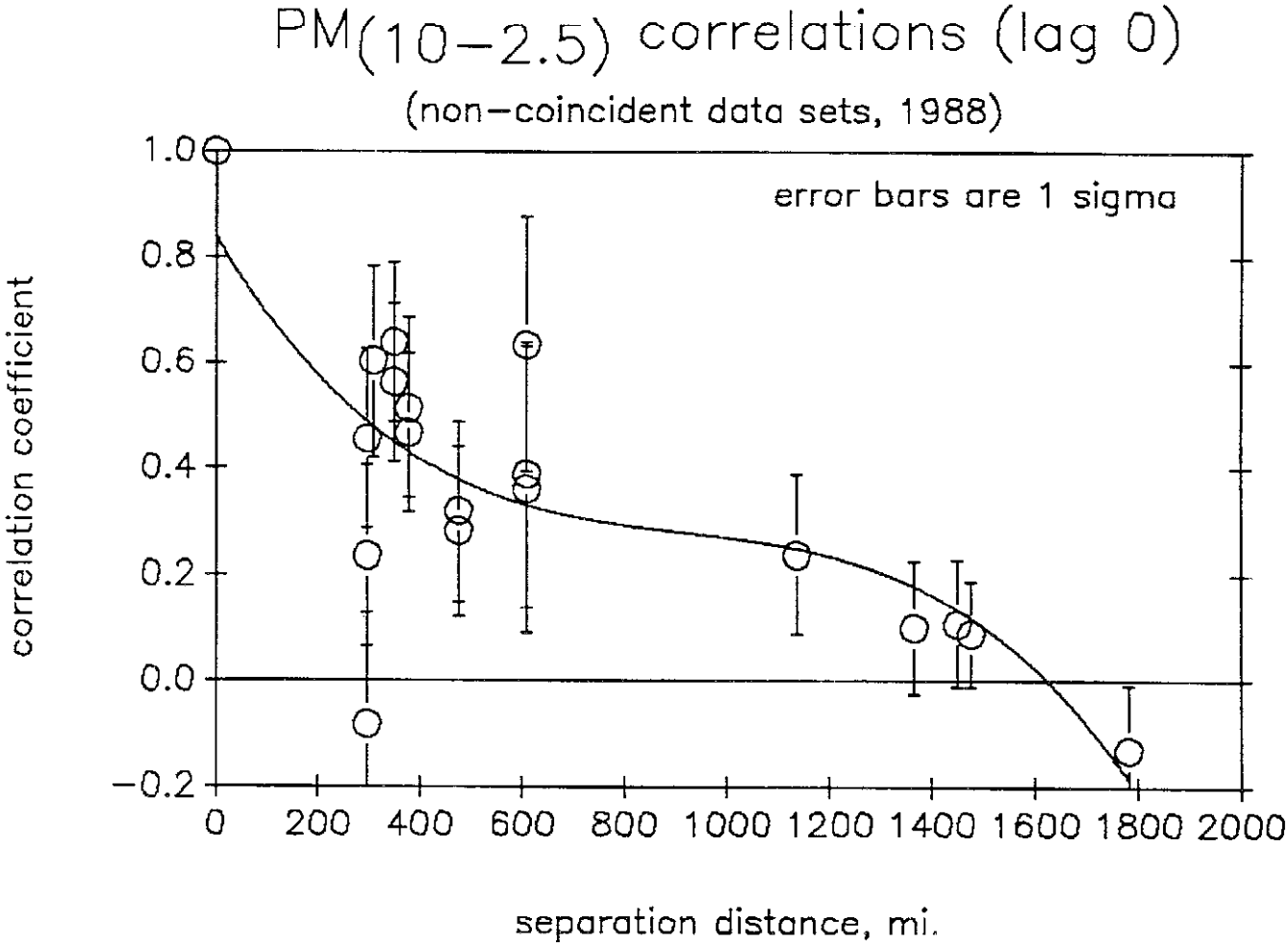
BNL
FWL


PM2.5 correlations (lag 0)
(non–coincident data sets, 1988)
error bars are 1 sigma
correlation coefficient
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0
200
400
600
800
1000
1200
1400
1600
1800
2000
separation distance, mi.

BNL
FWL


PM10 correlations (lag 0)
(non–coincident data sets, 1988)
error bars are 1 sigma
correlation coefficient
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0
200
400
600
800
1000
1200
1400
1600
1800
2000
separation distance, mi.

BNL
FWL


PM(10–2.5) correlations (lag 0)
(non–coincident data sets, 1988)
error bars are 1 sigma
correlation coefficient
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
0
200
400
600
800
1000
1200
1400
1600
1800
2000
separation distance, mi.

1988 Site-Site Fine Particle Correlations

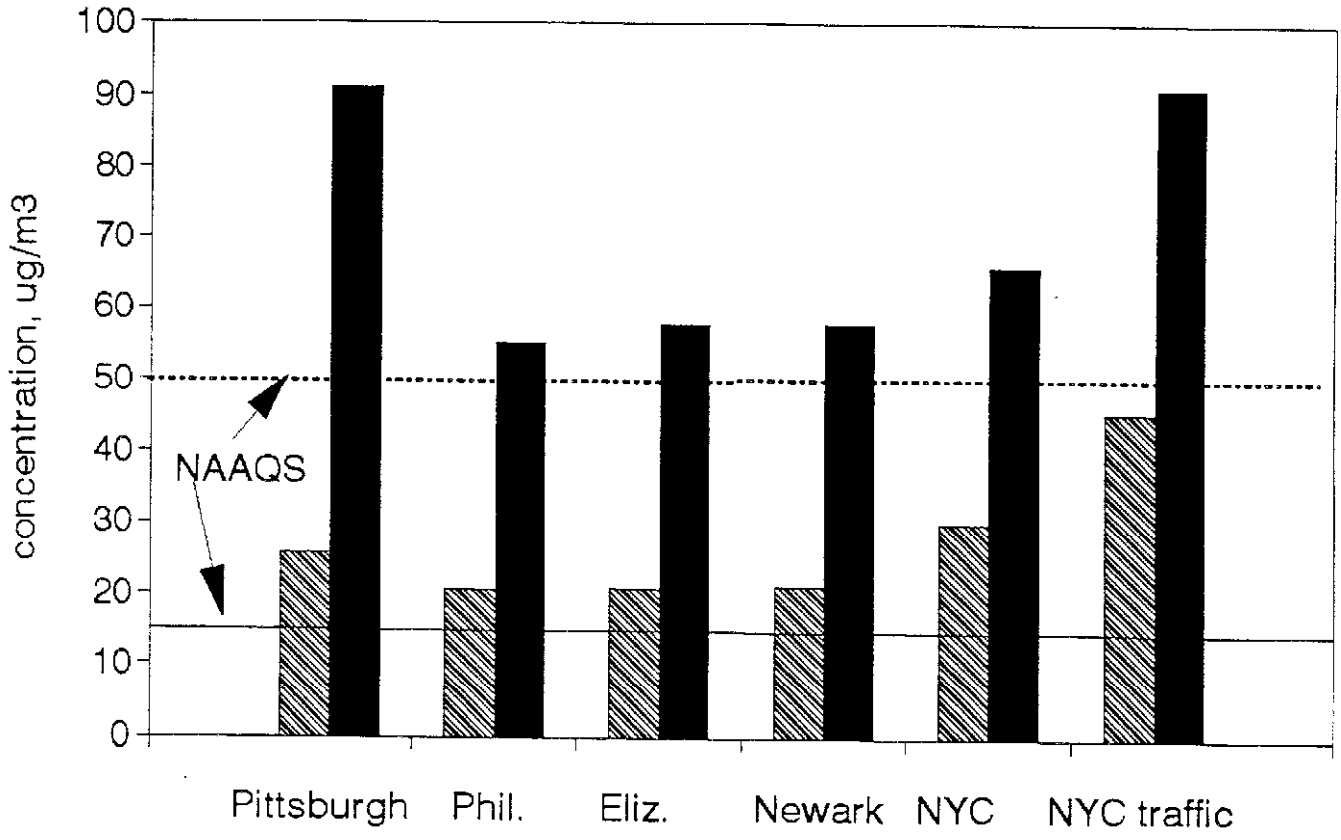
(top: correlations; bottom: no. of samples)

	Pittsburgh	Philadelphia	Elizabeth,	Newark,	New York City urban	New York City traffic
Pittsburgh	1	0.606	0.625	0.635	0.750	0.553
Philadelphia	35	1	0.712	0.761	0.757	0.703
Elizabeth,N	47	43	1	0.863	0.822	0.773
Newark,NJ	49	44	58	1	0.928	0.836
New York Ci	38	33	45	47	1	0.792
NYC, traffic	47	43	57	58	46	1

standard error of correlations: 0.13 to 0.18

1988 Fine Particle Data

mean and maximum concentrations



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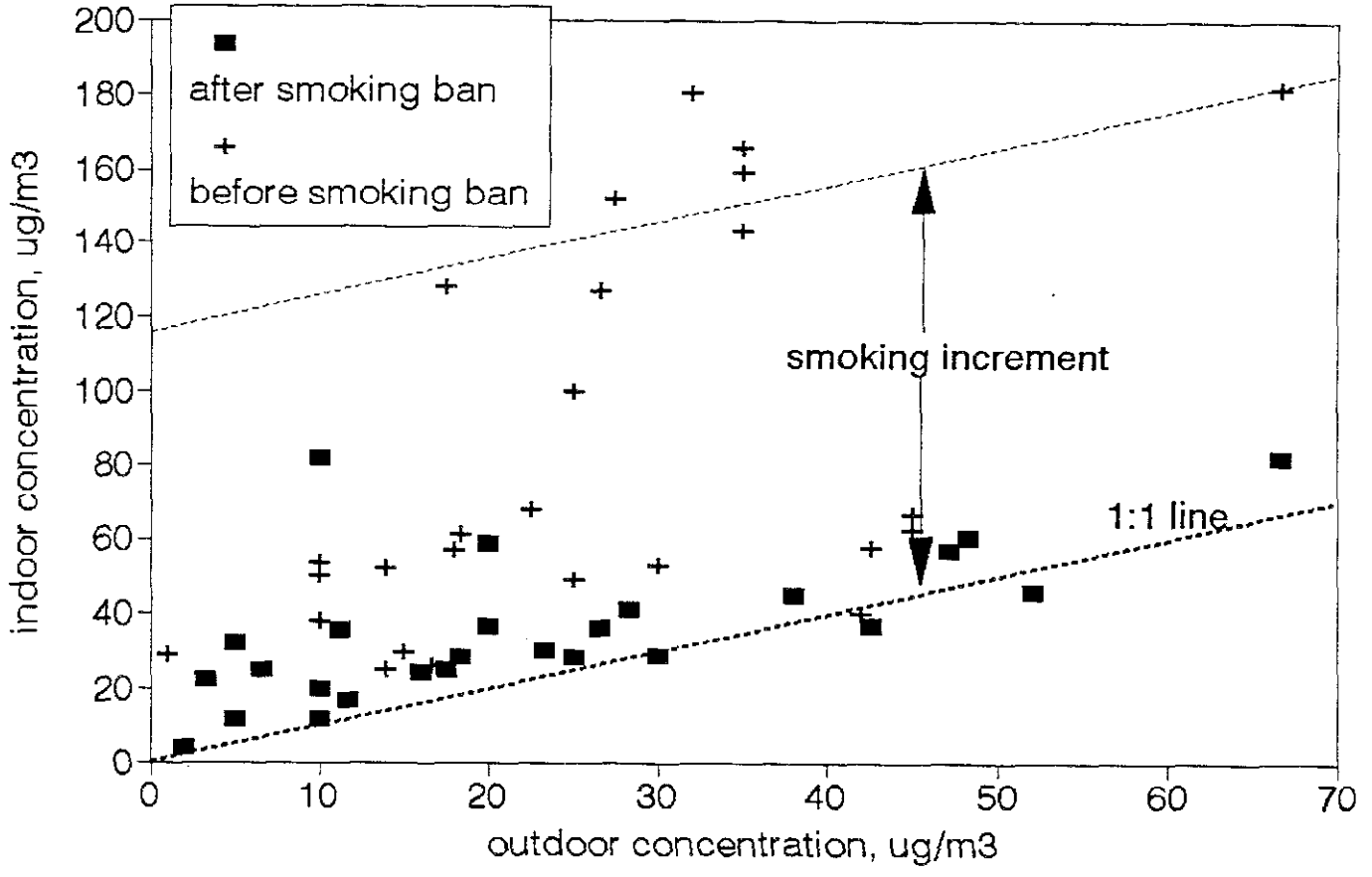
Indoor vs. Outdoor RSP (ca. 1-hr)

data from a tavern (Ott et al., 1996)



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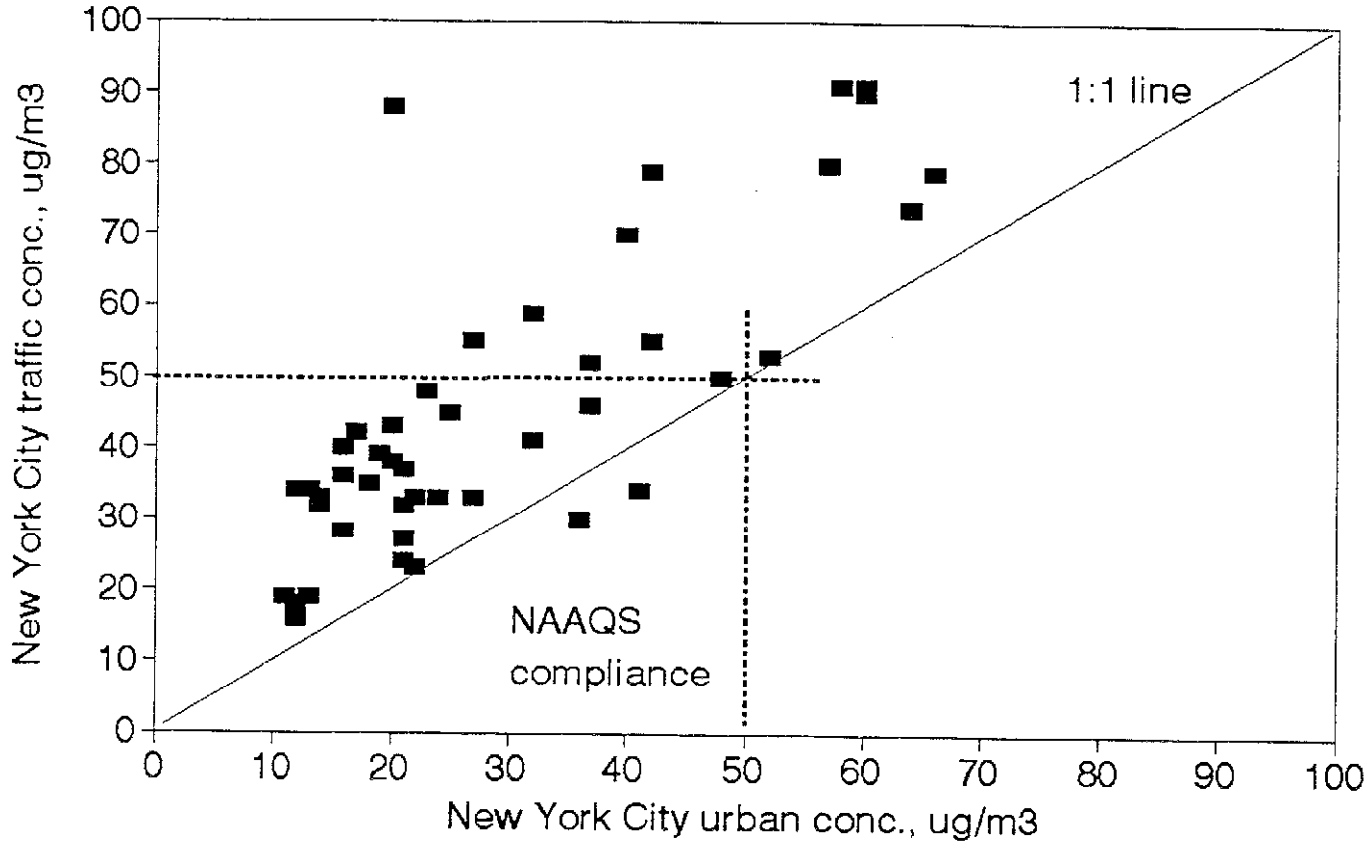
1988 Fine Particle Comparison

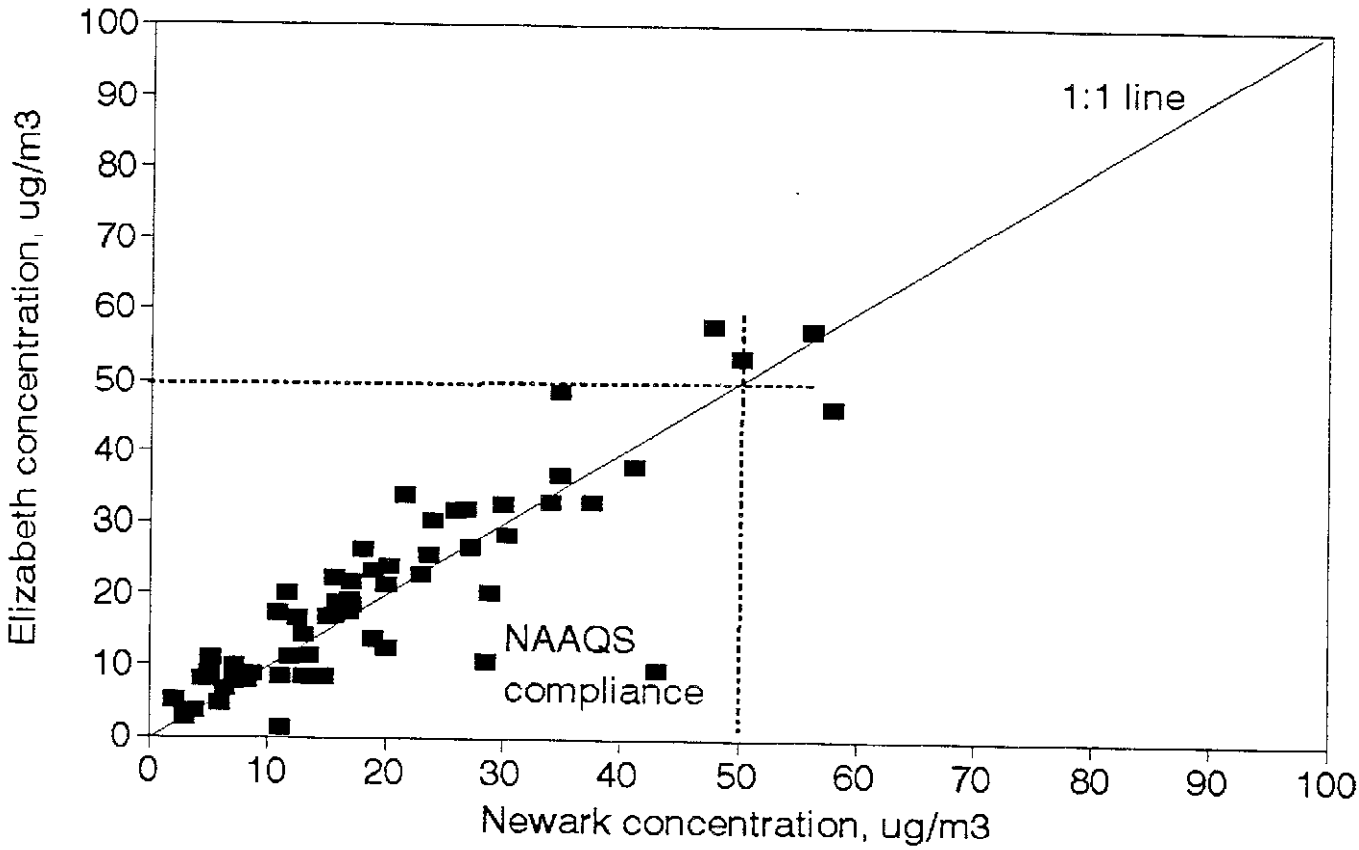
New York City, traffic vs. urban sites



BNL
FWL

1988 Fine Particle Comparison

New Jersey sites



BNL
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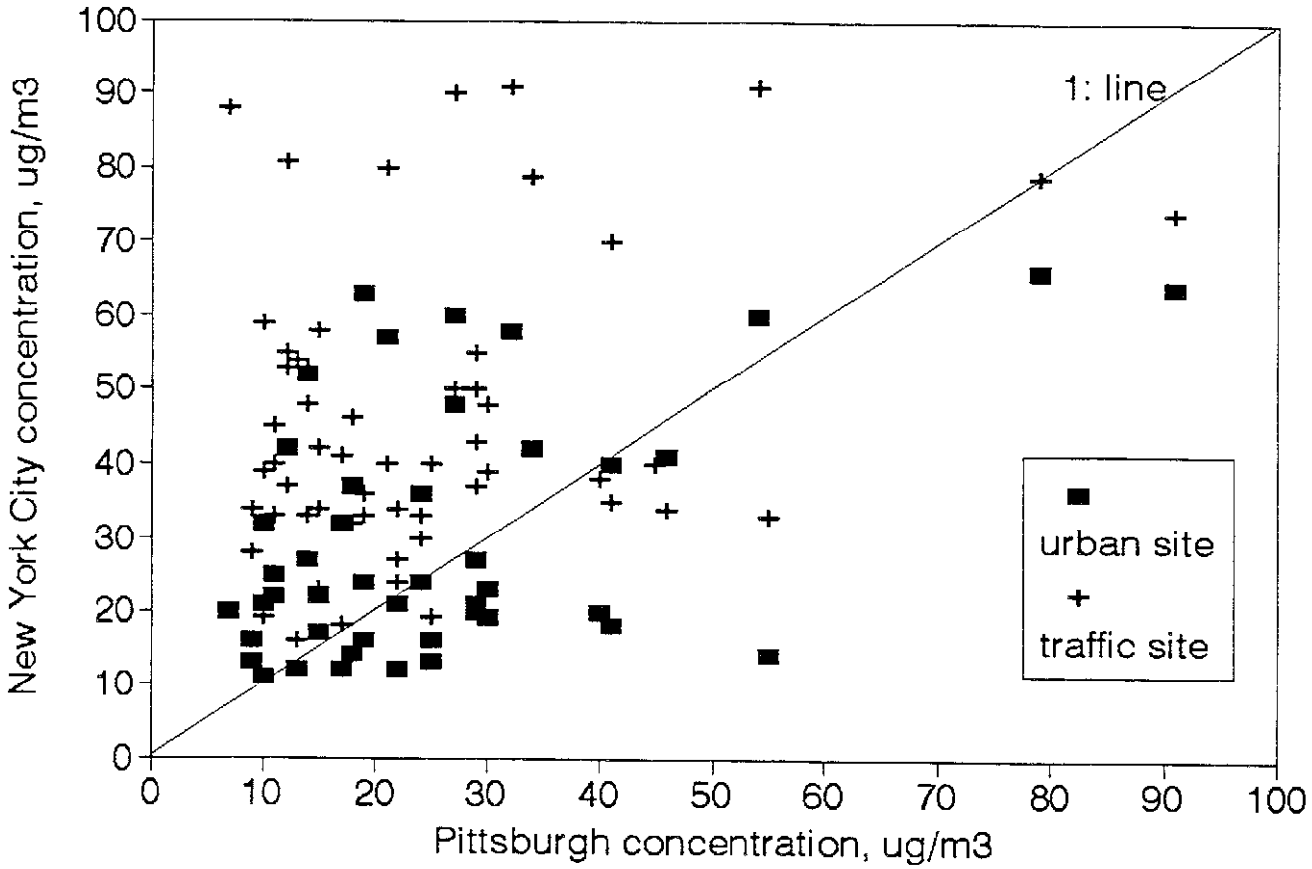
1988 Fine Particle Comparison

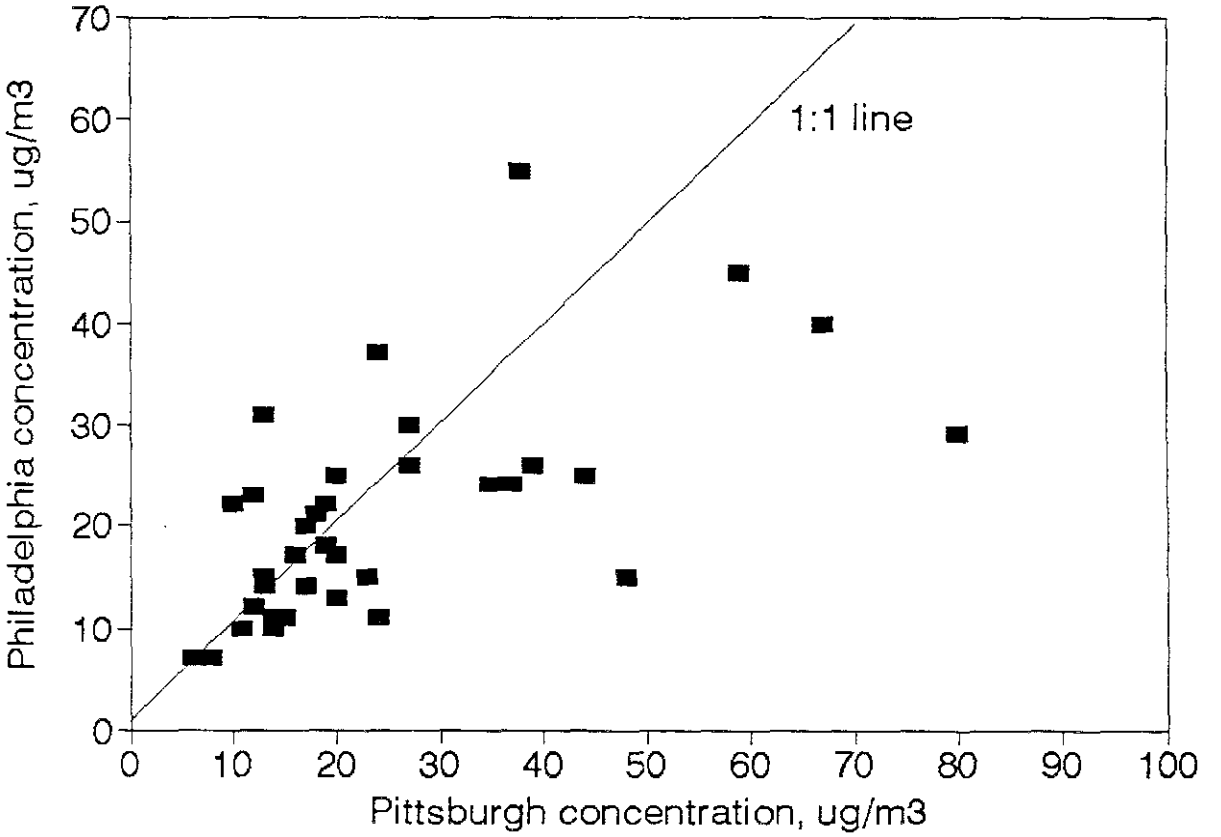
New York City vs.Pittsburgh (2-day lag)



BNL
FWL

1988 Fine Particle Comparison

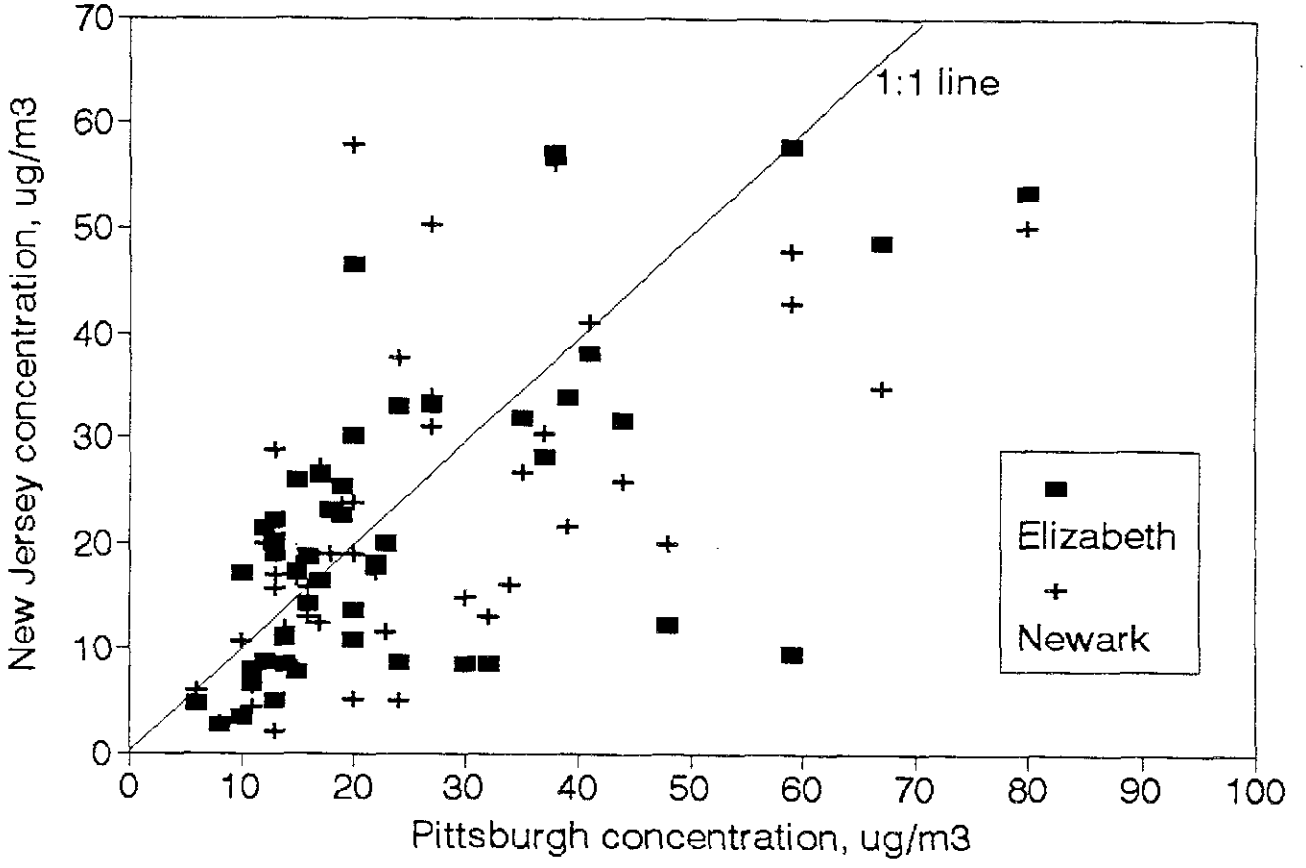
Philadelphia vs. Pittsburgh



BNL
FWL

1988 Fine Particle Comparison

New Jersey vs. Pittsburgh



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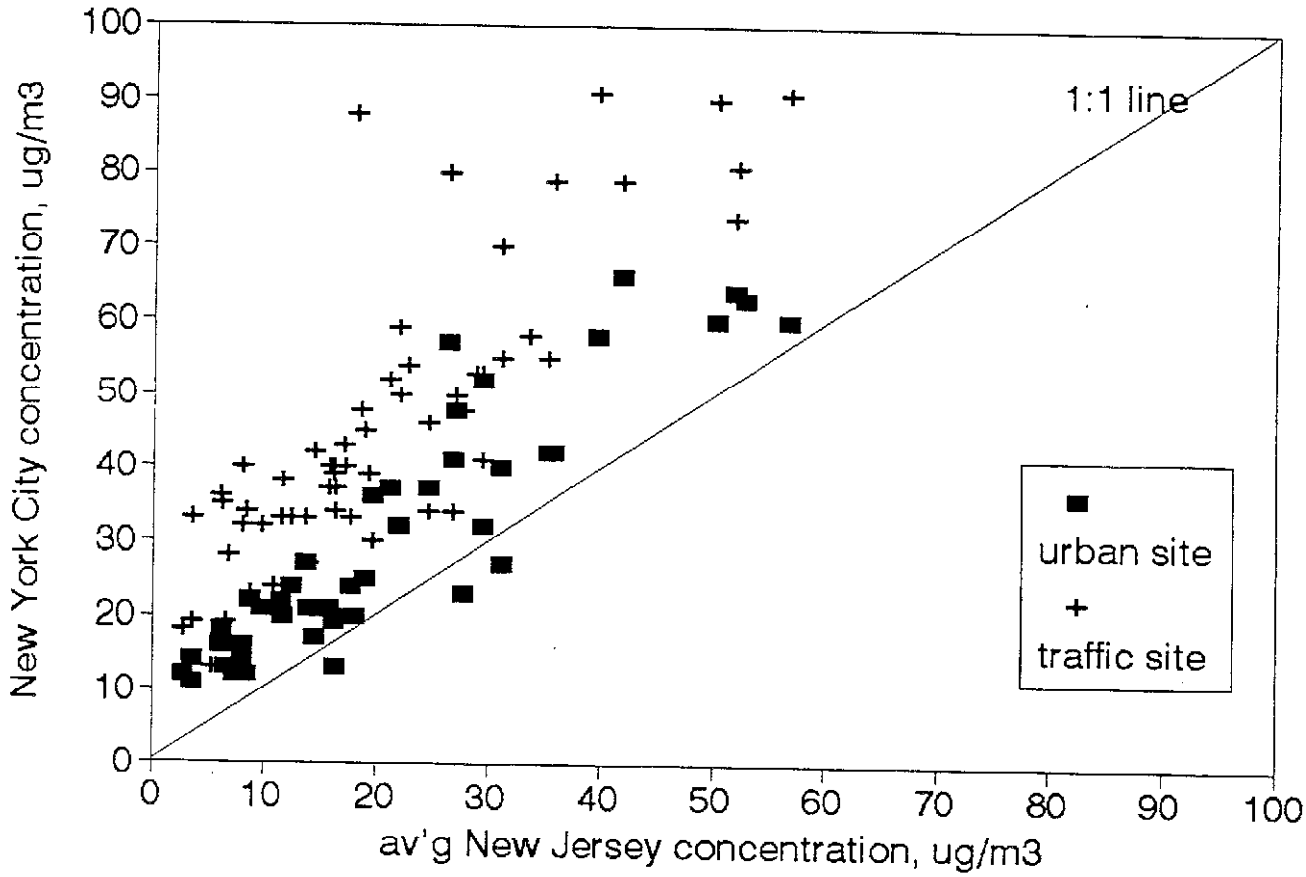
1988 Fine Particle Comparison

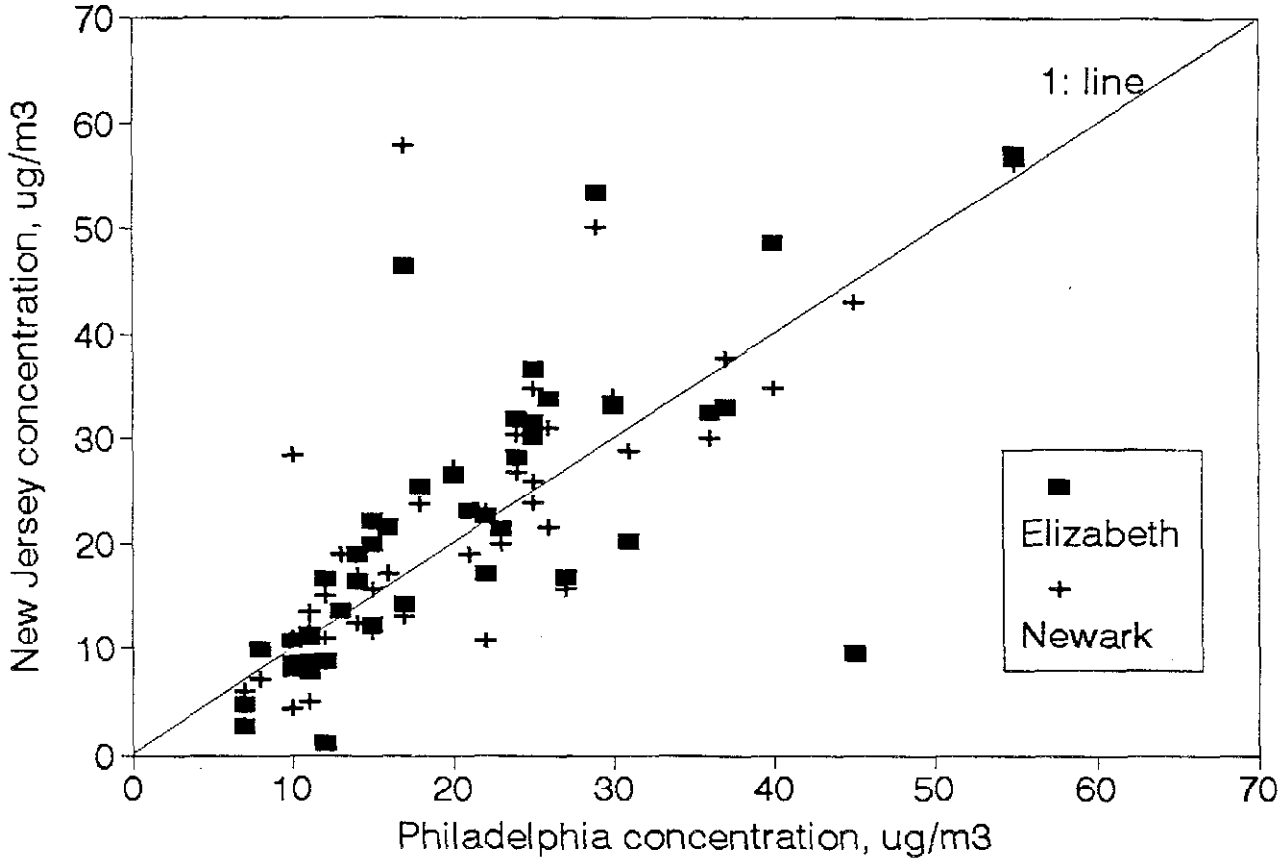
New York City vs. New Jersey average



BNL
FWL

1988 Fine Particle Comparison

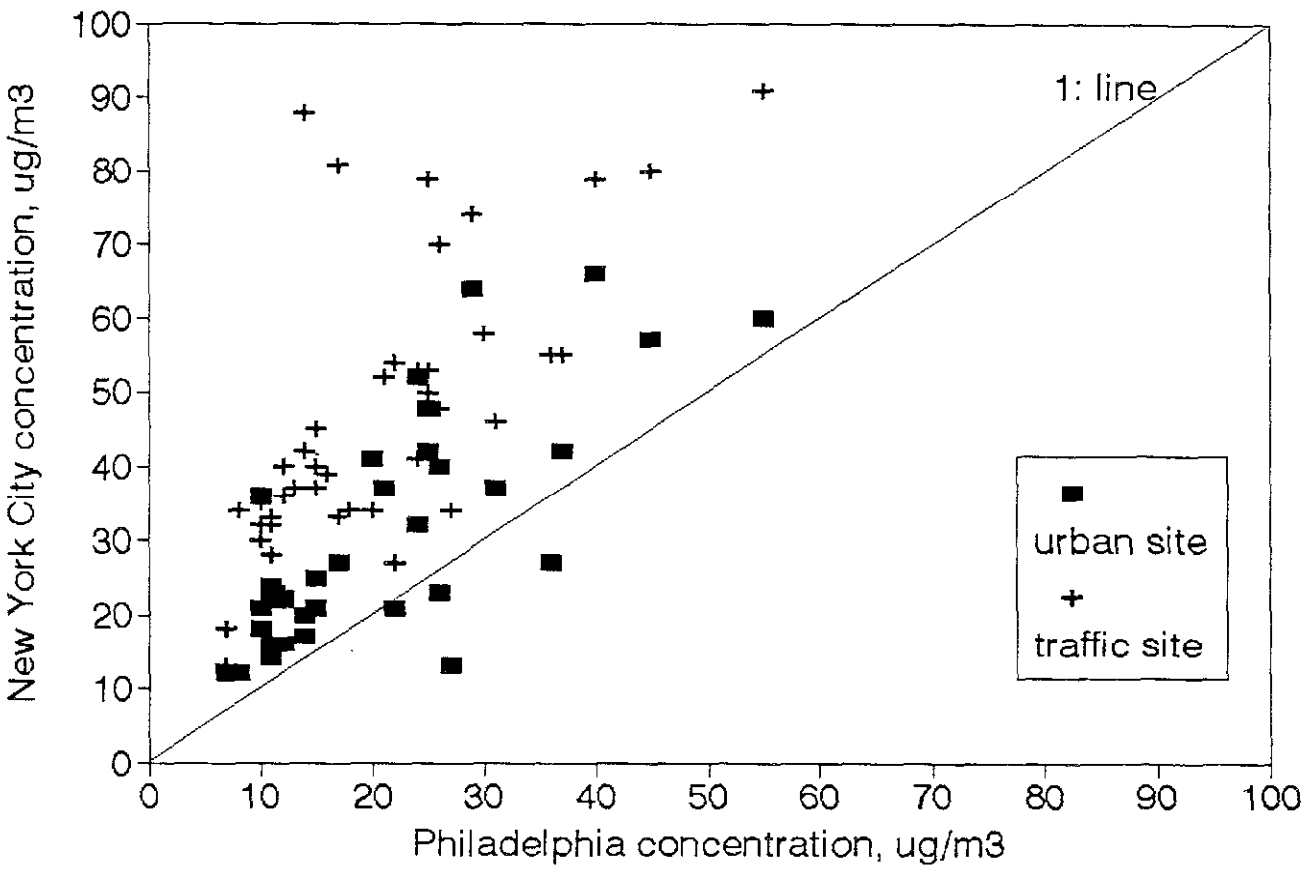
New Jersey vs. Philadelphia



BNL
FWL

1988 Fine Particle Comparison

New York City vs. Philadelphia



BNL
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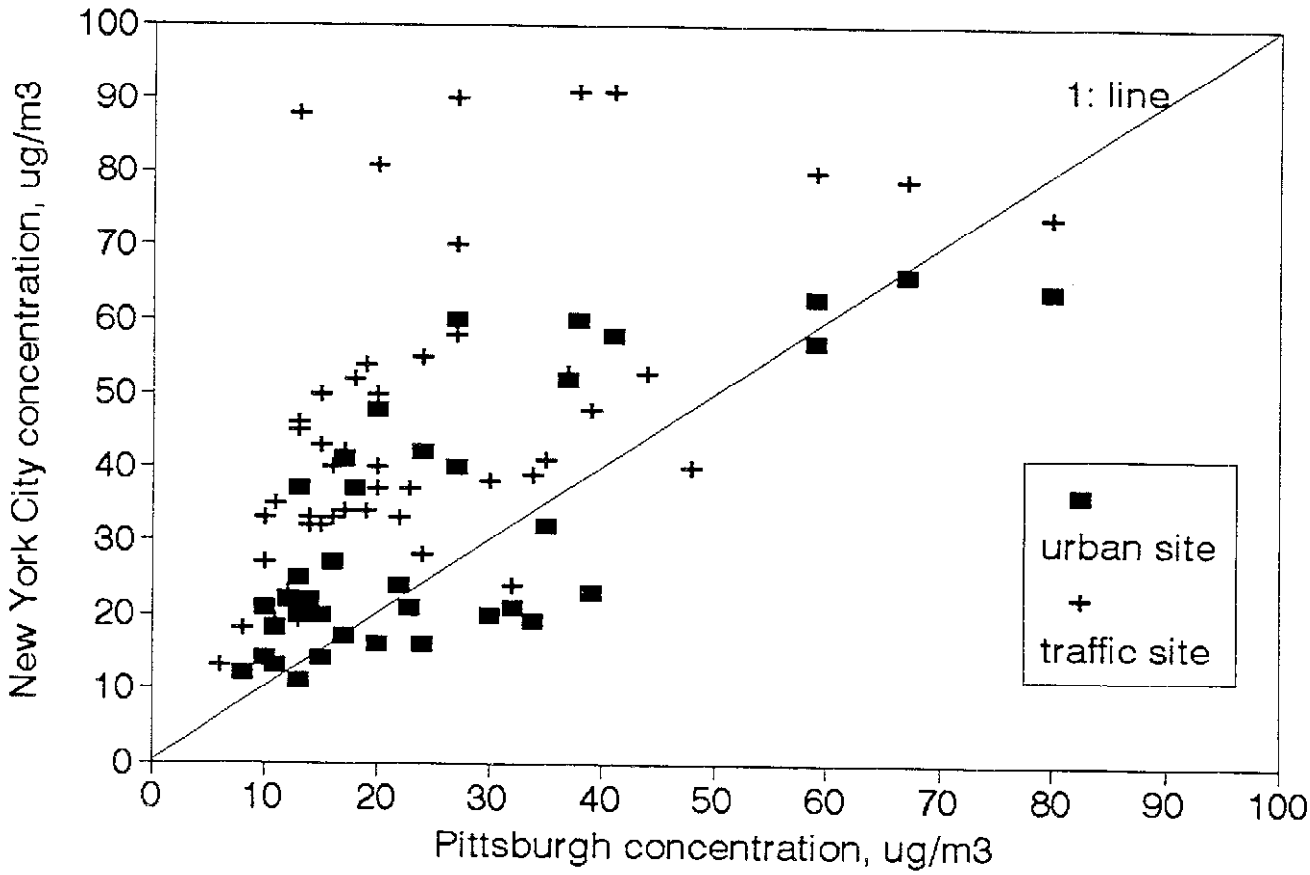
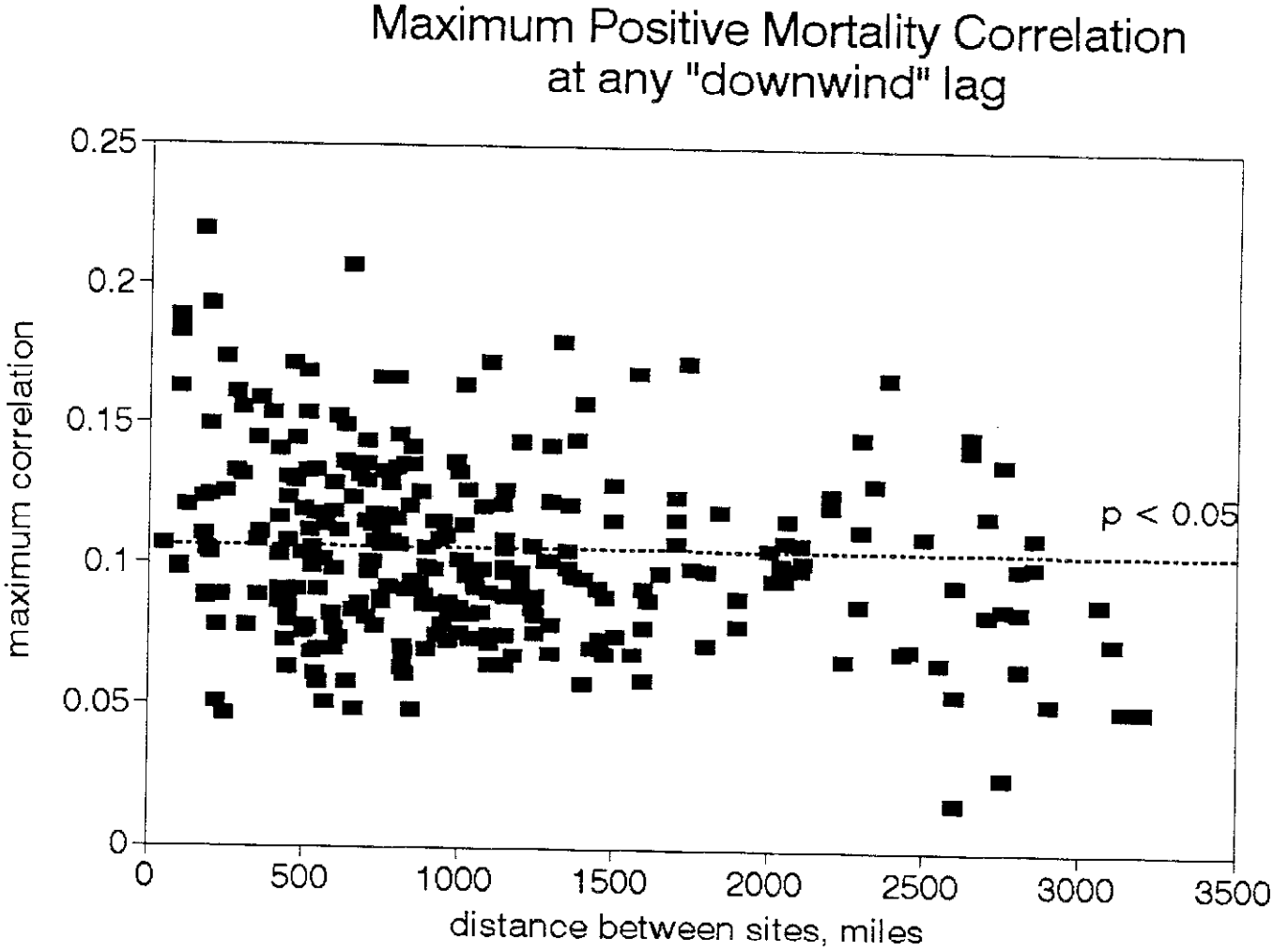
1988 Fine Particle Comparison

New York City vs. Pittsburgh (same day)



BNL
FWL


Maximum Positive Mortality Correlation
at any "downwind" lag
maximum correlation
0.25
0.2
0.15
0.1
0.05
0
p < 0.05
0
500
1000
1500
2000
2500
3000
3500
distance between sites, miles

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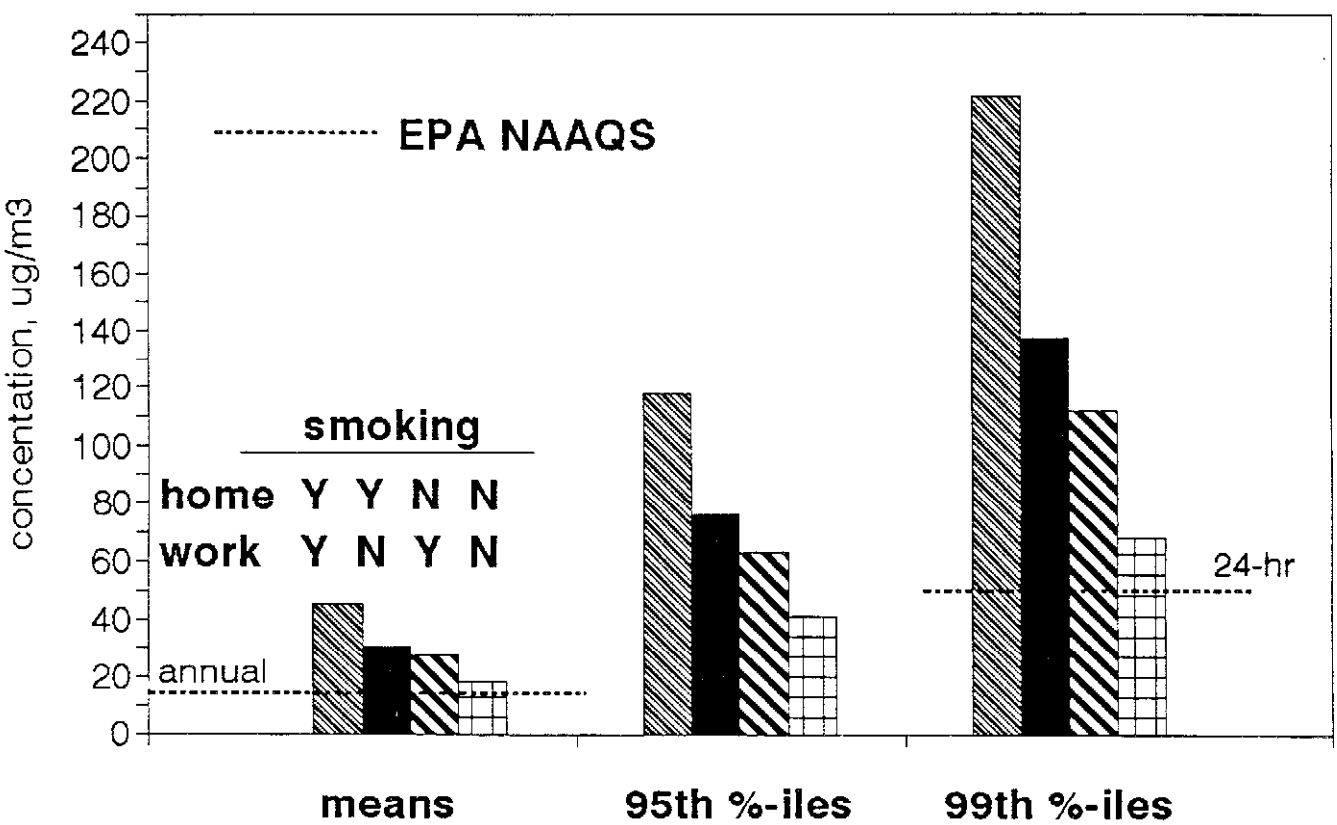
Time-wtd. Personal RSP Exposures

data from Jenkins et al. (1996), n=1480



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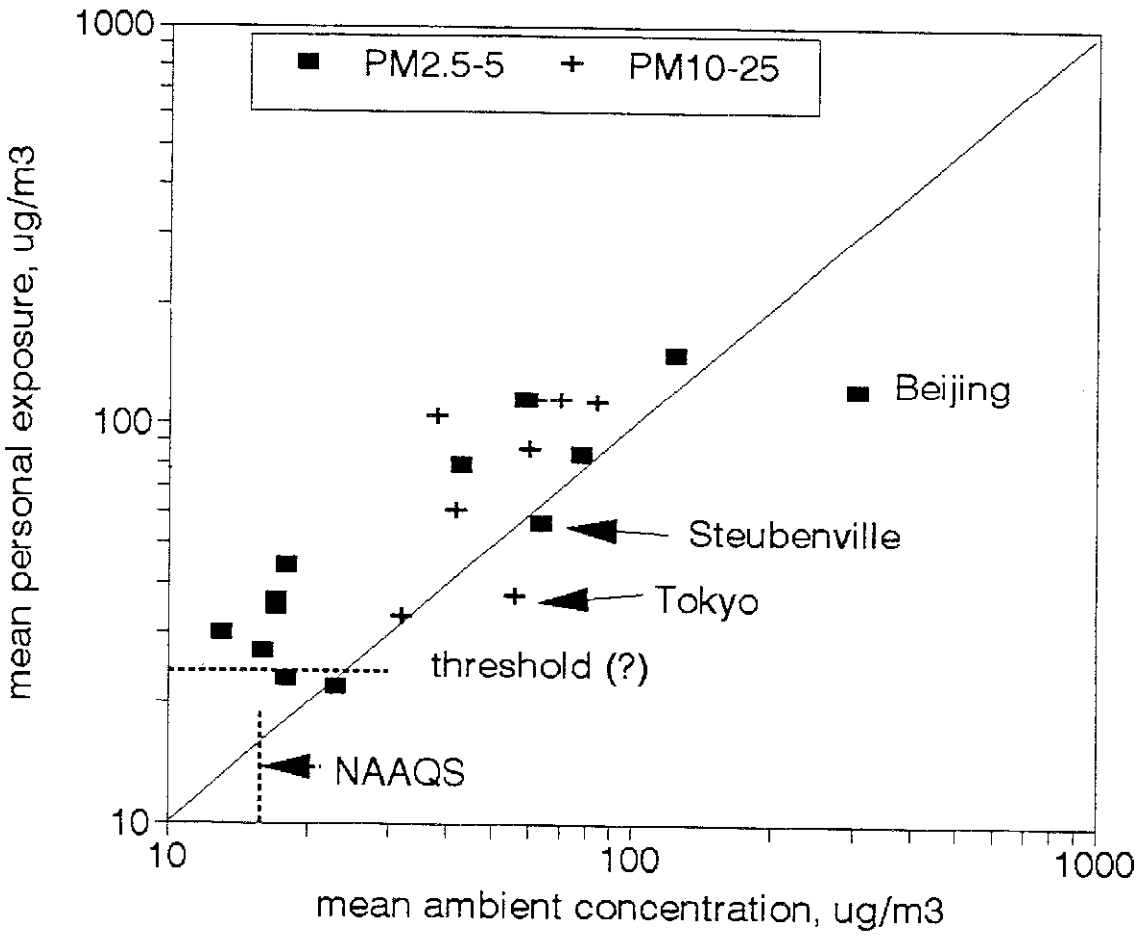
EPA Personal Exposure Data
(Table 7-34, CD)



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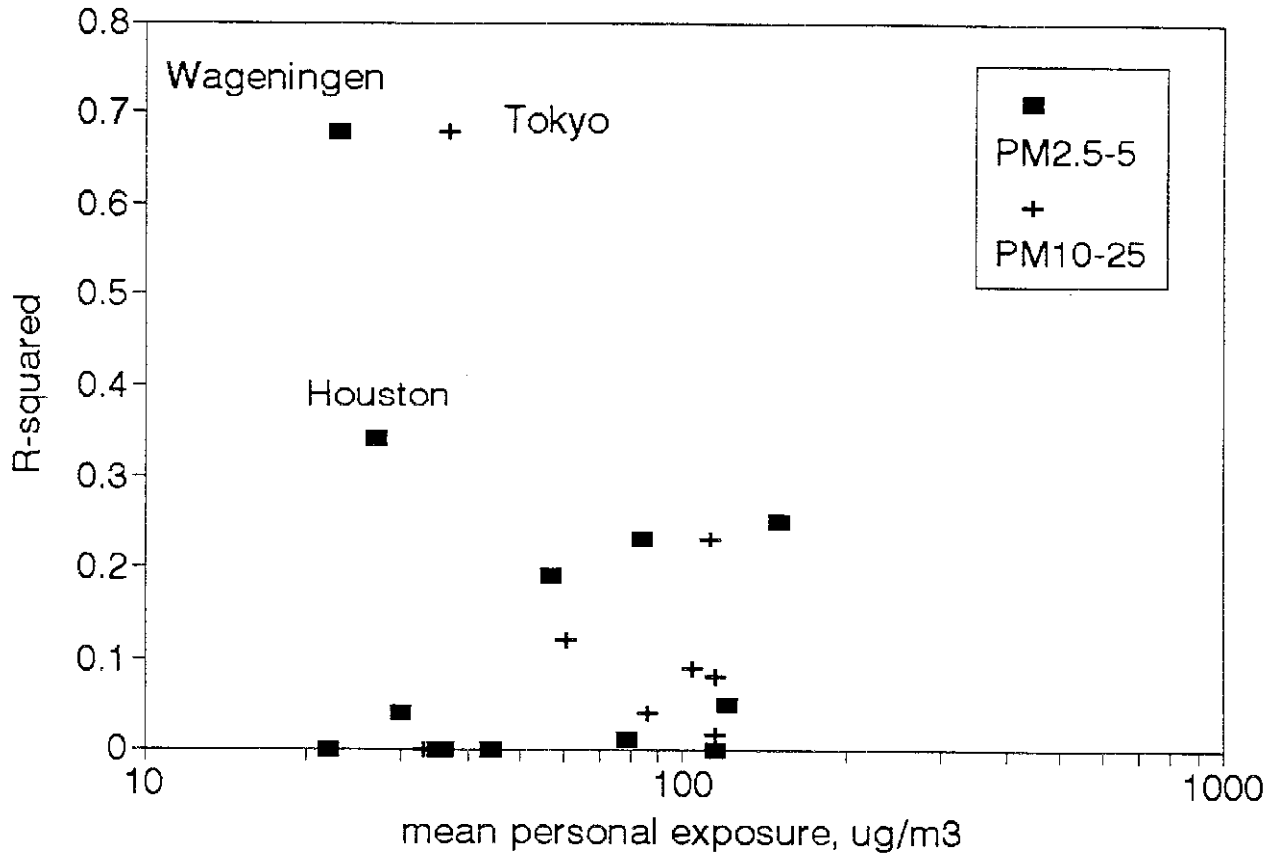
EPA Personal Exposure Data

Personal-Outdoor Correlations (Rsq)



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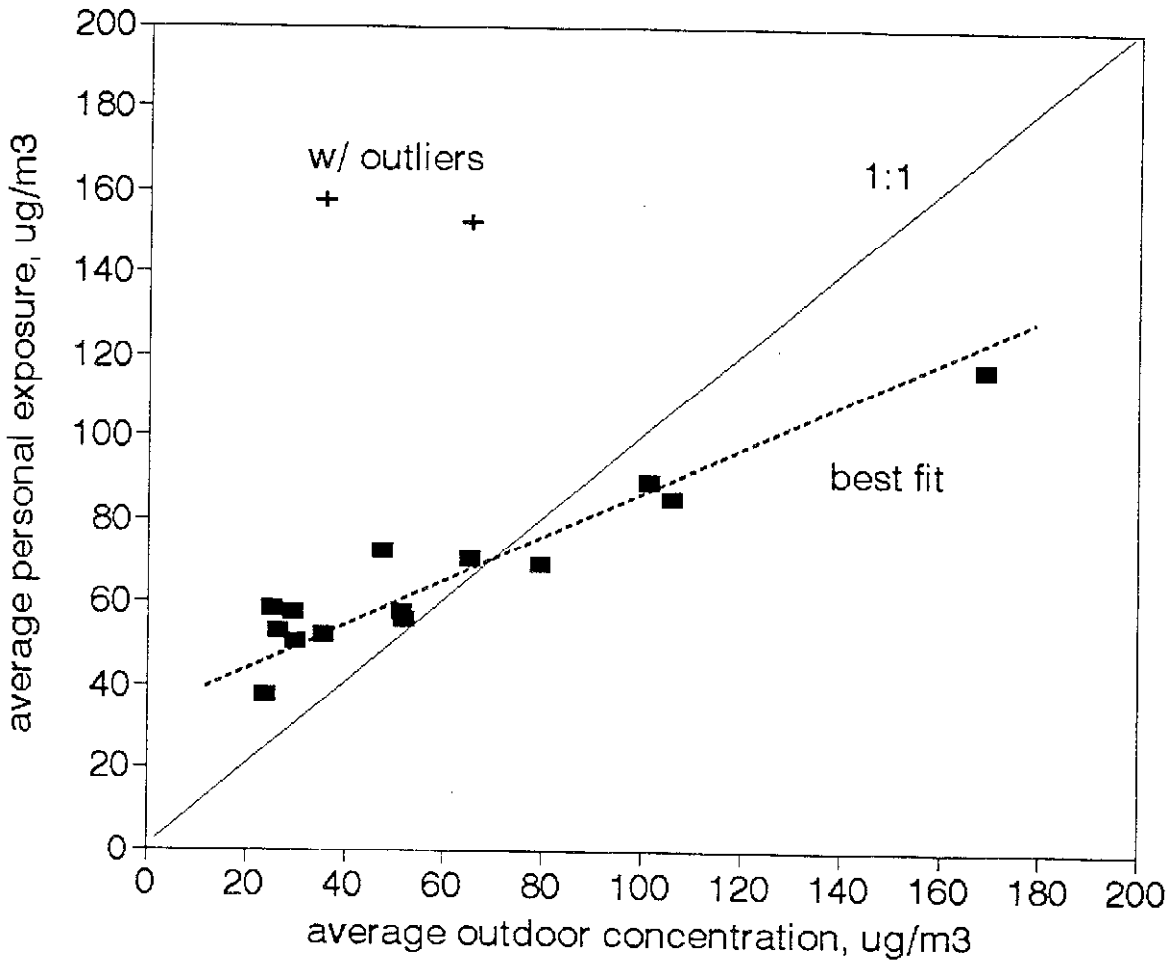
Phillipsburg PM10 (Lioy et al., 1990)

average personal vs. average outdoor



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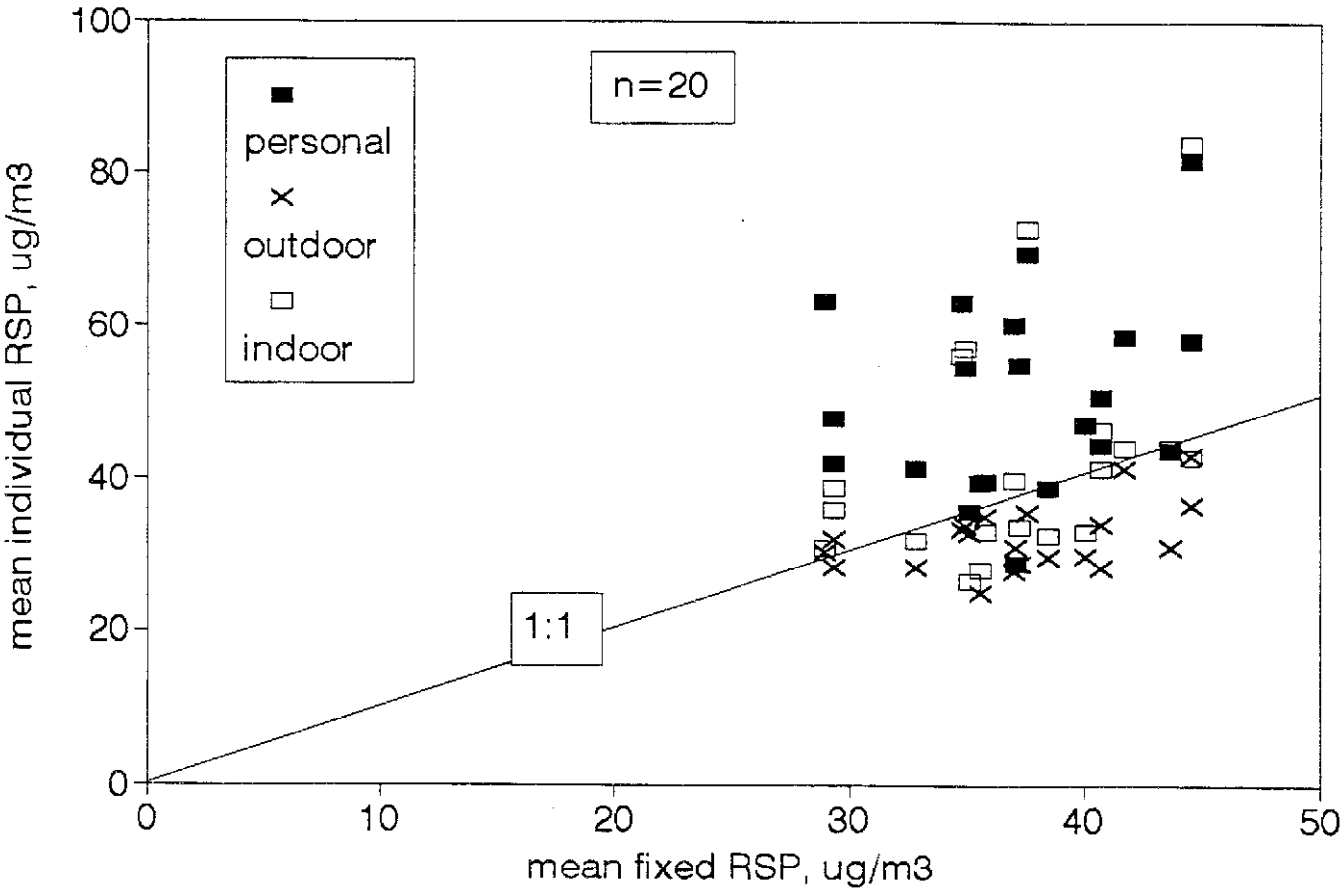
Toronto Asthmatics' RSP

Individual data (Gage Res. Inst.)



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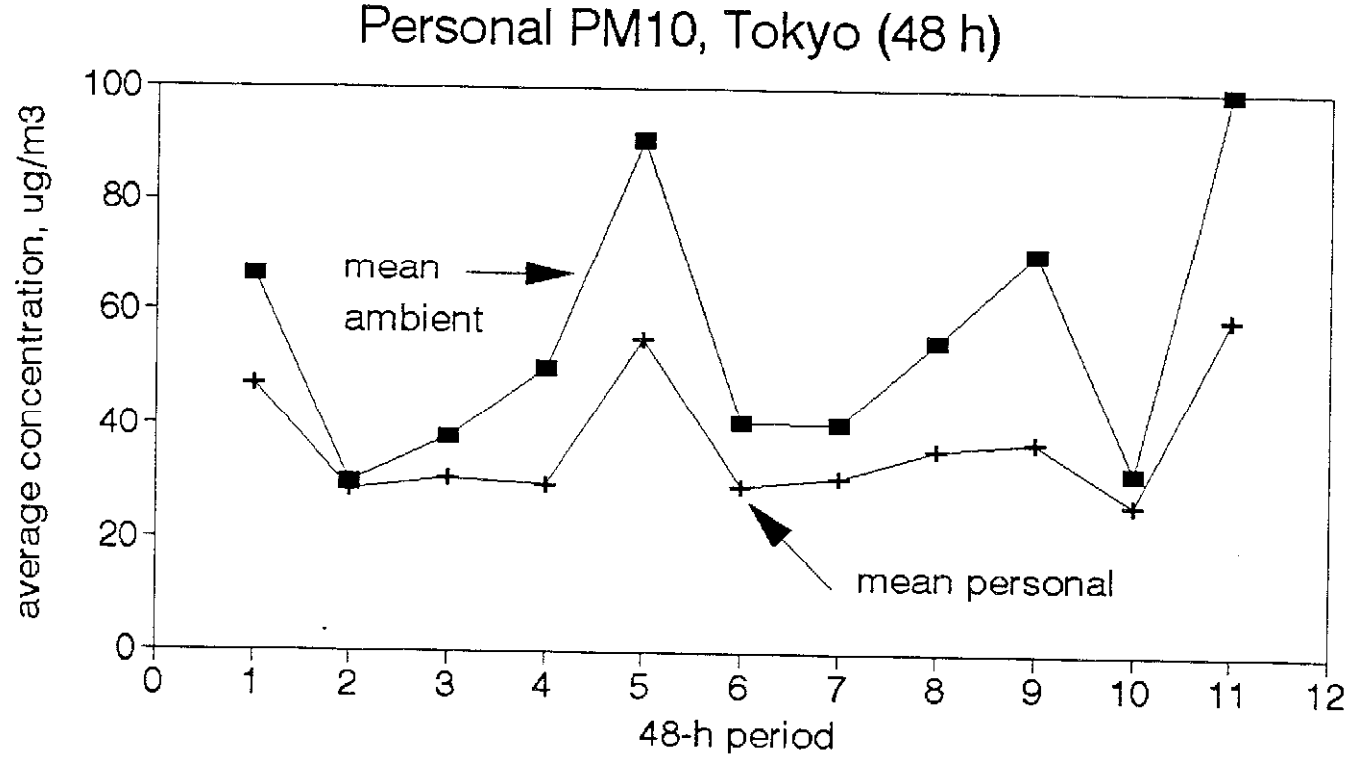
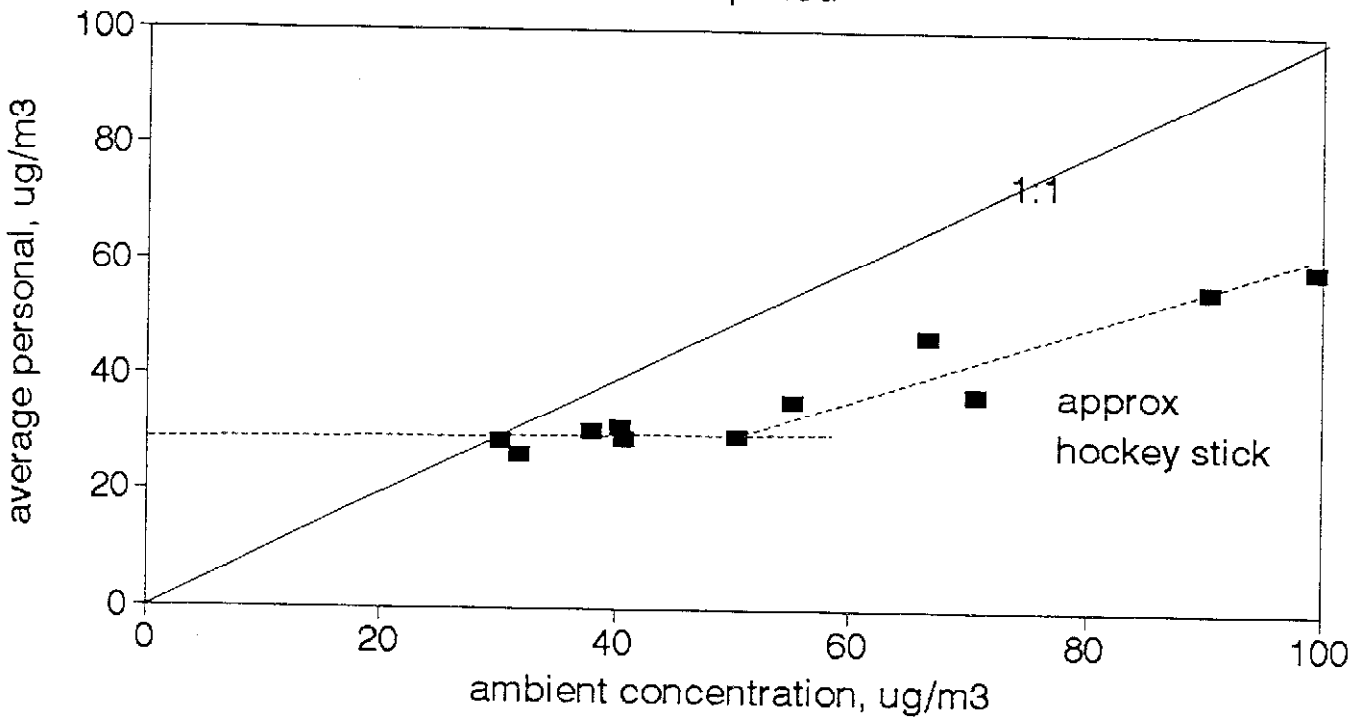

Personal PM10, Tokyo (48 h)
average concentration, ug/m3
100
80
60
40
20
0
mean
ambient
mean personal
0
1
2
3
4
5
6
7
8
9
10
11
12
48-h period


average personal, ug/m3
100
80
60
40
20
0
1:1
approx
hockey stick
0
20
40
60
80
100
ambient concentration, ug/m3

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SOME MONITORING "UNIT PROBLEMS"

1. A FETC-based monitor "proving ground" (side-by-side sampling platform)
2. Intensive local spatial characterization (vert. & horiz. gradients, by season & size)
3. Intensive temporal characterization (indoor/outdoor sampling by time of day)
4. Long-term indoor AQ characterization (How does IAQ respond to meteorology?)
5. Long-range transport correlation studies (parallel sampling w/ ~ 500 km separation)
6. Assimilation, synthesis of existing data (including non-governmental sources).

A PM MONITORING SITE AT BNL

1. No "local" PM sources. PM contributions expected from:
   New York metropolitan area
   mid-western coal burning
   natural sources (sea salt, vegetation).

2. Comprehensive criteria pollutant and met data are available.

3. Can coordinate with residential indoor air quality and ventilation monitoring.

4. Experienced staff available.

THE BNL HOUSE AS A PERSONAL EXPOSURE LABORATORY

1. Building air exchange characteristics are well known and controllable.

2. House is occupied intermittently, which allows studies of personal PM sources.

3. Other pollutants can be monitored indoors on an episodic basis.

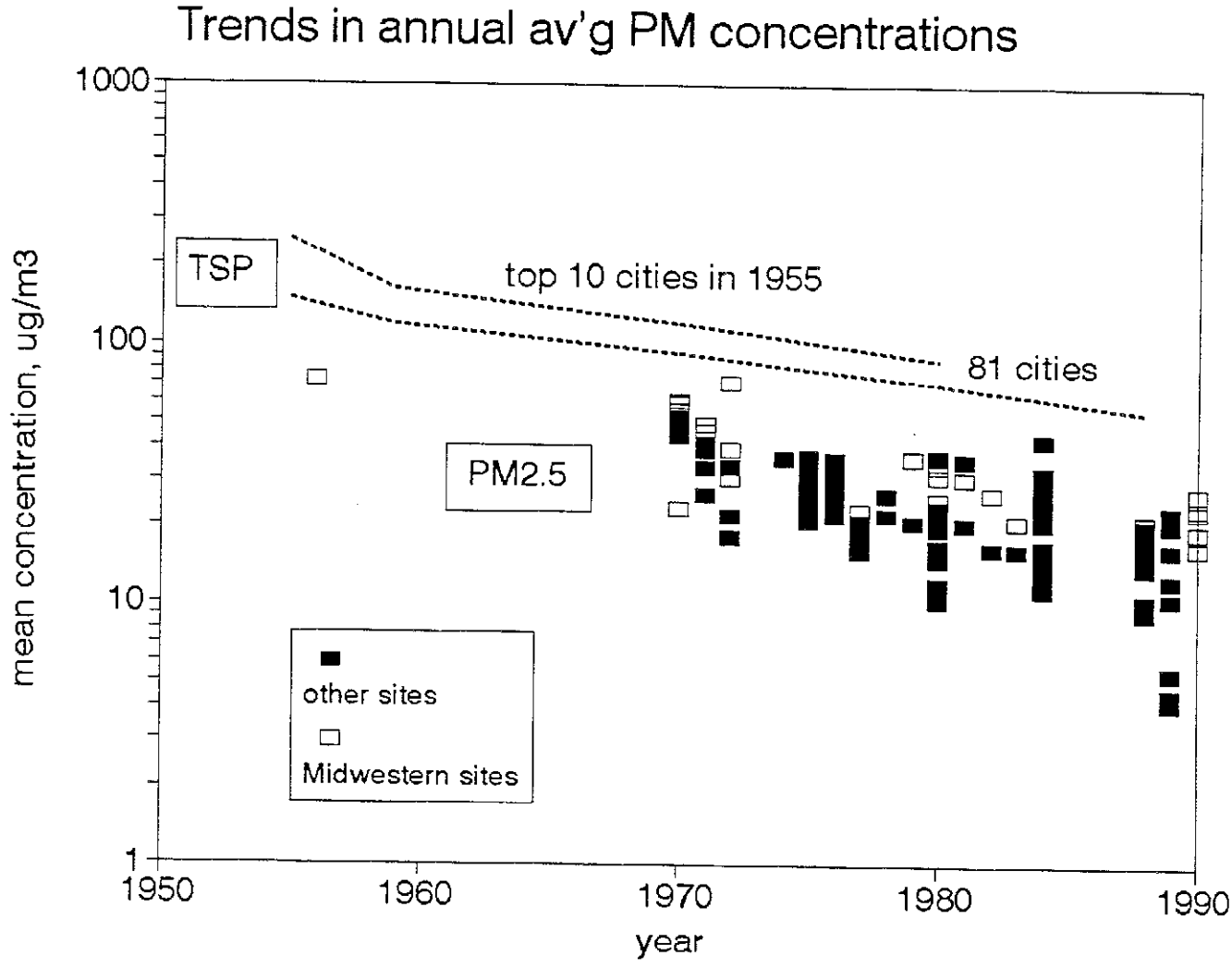
4. Source attribution studies can be done on indoor air quality.

WHAT CAN BE LEARNED FROM EXISTING DATA?

1. Trends in ambient concentrations and major source contributions (as acid rain controls take effect).
2. Temporal and spatial characteristics (time of day, day of week, meteorological effects, urban vs. rural, fugitive dust).
3. Archived filters could be analyzed for source tracers.
4. Synthesize indoor air quality data.
5. Synthesize personal exposure data.

WHAT CAN BE LEARNED FROM EXISTING DATA (cont'd)?

6. Examine how coefficient of haze data can be used (it works in Canada!).
7. Merge available data bases for more convenient access.
8. Develop correlations between species and with meteorological conditions.
9. Extend the PM trend analysis and correlate with emissions.
10. All of the above should take particle size into account.


Trends in annual av'g PM concentrations
1000
100
10
1
mean concentration, ug/m3
TSP
top 10 cities in 1955
81 cities
PM2.5
other sites
Midwestern sites
1950
1960
1970
1980
1990
year

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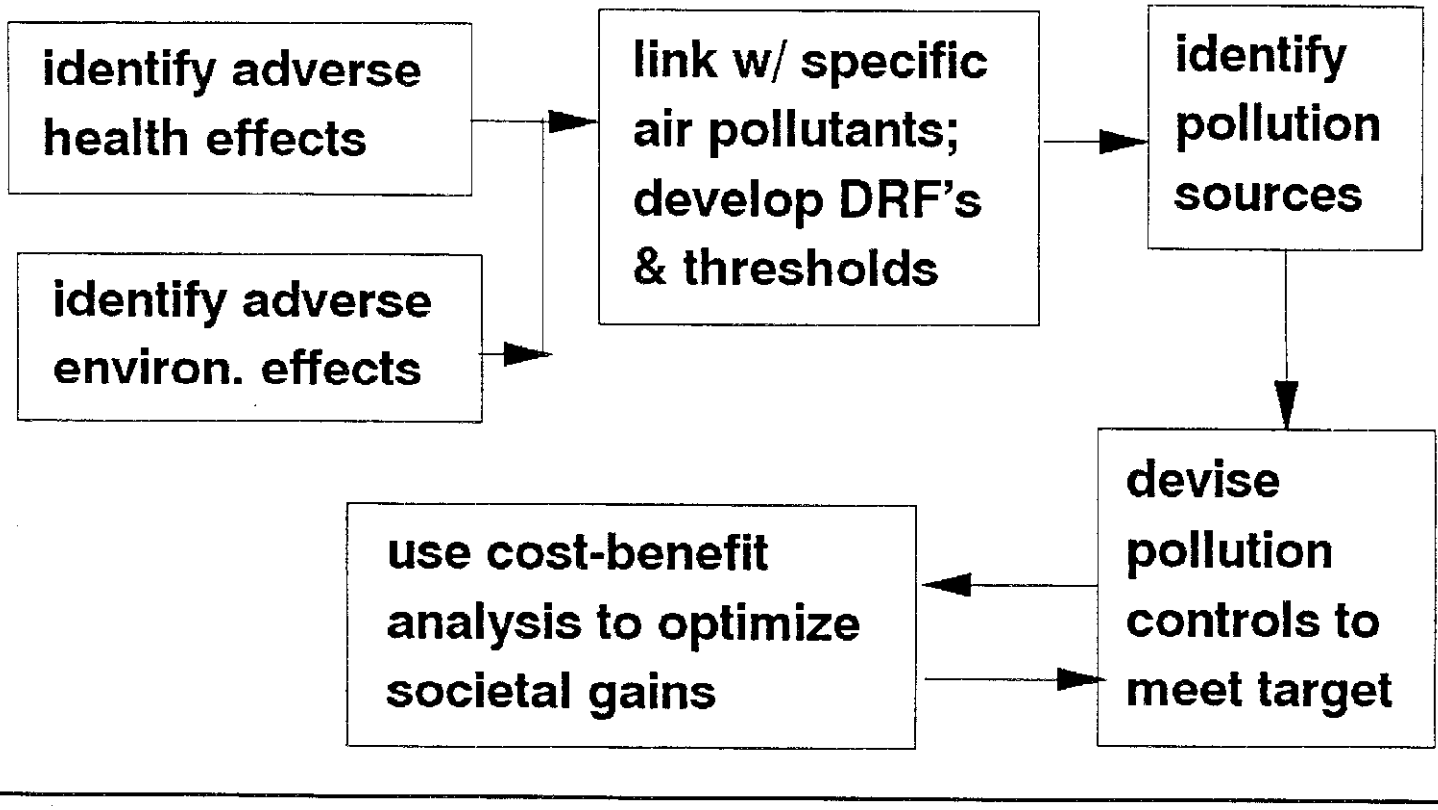
THE AIR POLLUTION ABATEMENT OPTIMIZATION PROCESS



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CONCLUSIONS: WHAT SHOULD DOE'S ROLE BE IN PM MONITORING?

1. Independent. Checks and balances are needed within the Federal establishment.

2. Comprehensive. DOE should take on tasks that EPA can't or won't. We need to know more about all types of PM, not just PM2.5. Existing data bases should be fully explored.

3. Integrative. There are many different stake-holders in PM regulation. We will learn more by working together.

The next EPA CD cycle will start soon; research must be published by May 2000 to be considered.

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