Spatial Investigation of Sources, Composition, and Long-Term Health Effects of Coarse PM

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Talk Overview

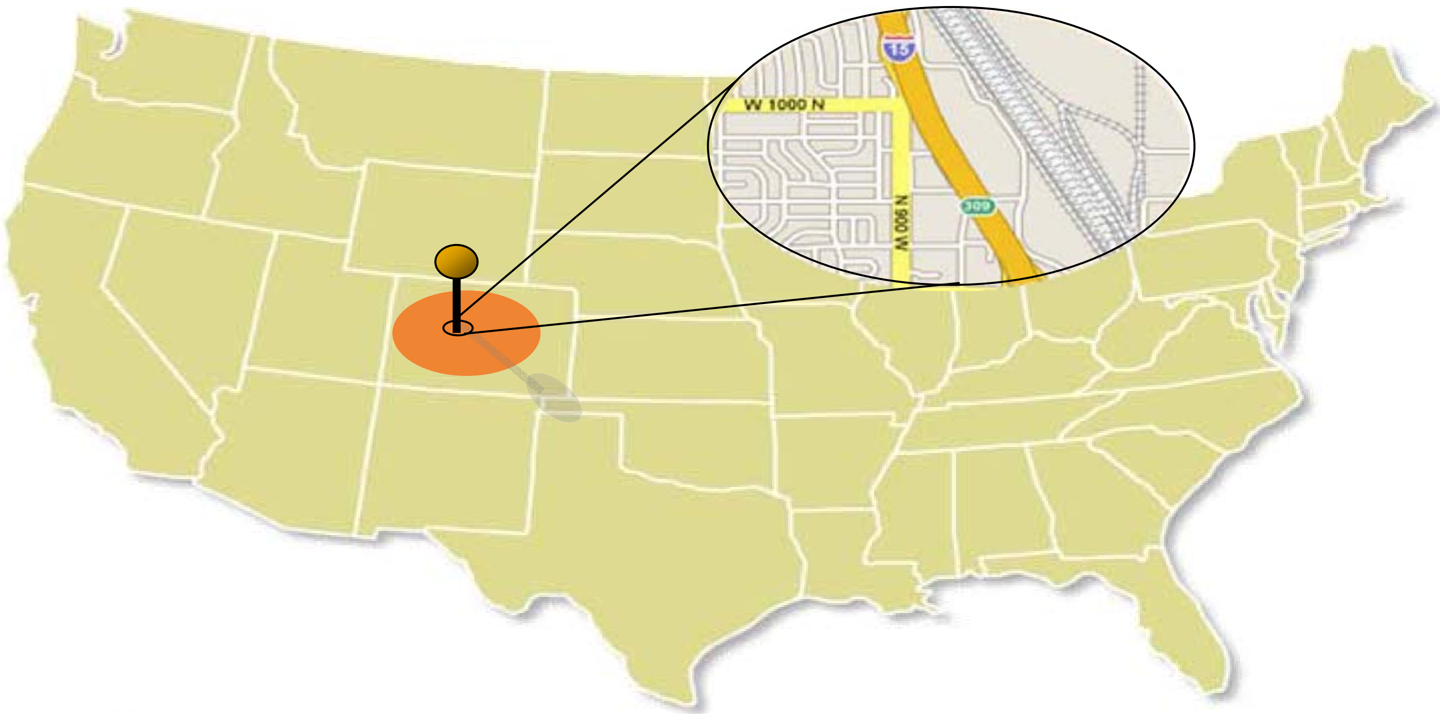
- Background
- Summary of Data Collected
- Exposure Modeling Progress
  - Mass Modeling
  - Species Modeling
- Preliminary Health Modeling
- Future Plans

Health Effects Not Well Characterized

- Past studies generally focused on PM_{10} or $PM_{2.5}$
- Some evidence of cardiovascular and pulmonary effects from coarse particles
- Research on chronic health effects of $PM_{10-2.5}$ mass and chemical components are very limited

Exposure Assignment for Chronic Health Effects Can Be Difficult

- Spatial variation of PM10-2.5 can be large due to local sources



Study Aims

1) Characterize spatial variability of $PM_{10-2.5}$ from natural and anthropogenic sources

2) Examine <u>chronic</u> health effects of $PM_{10-2.5}$ on the respiratory and cardiovascular systems

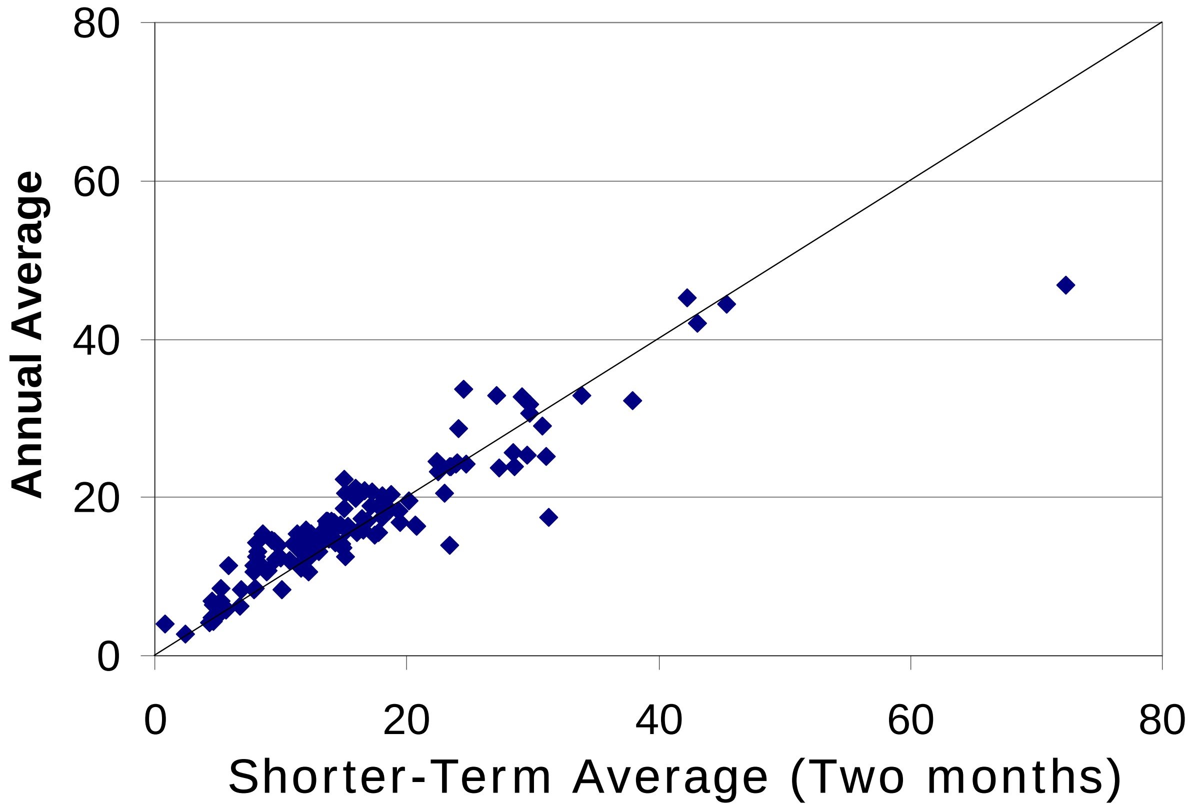
Nested in the Multi-Ethnic Study of Atherosclerosis and Air Pollution

- Population-based prospective cohort
- ~6,000 subjects (aged 45-84 yrs) without clinical CVD at baseline
  - White, African American, Hispanic, and Chinese
- Detailed characterization of PM2.5 through MESA Air

Repeated Spatial Snapshots Collected

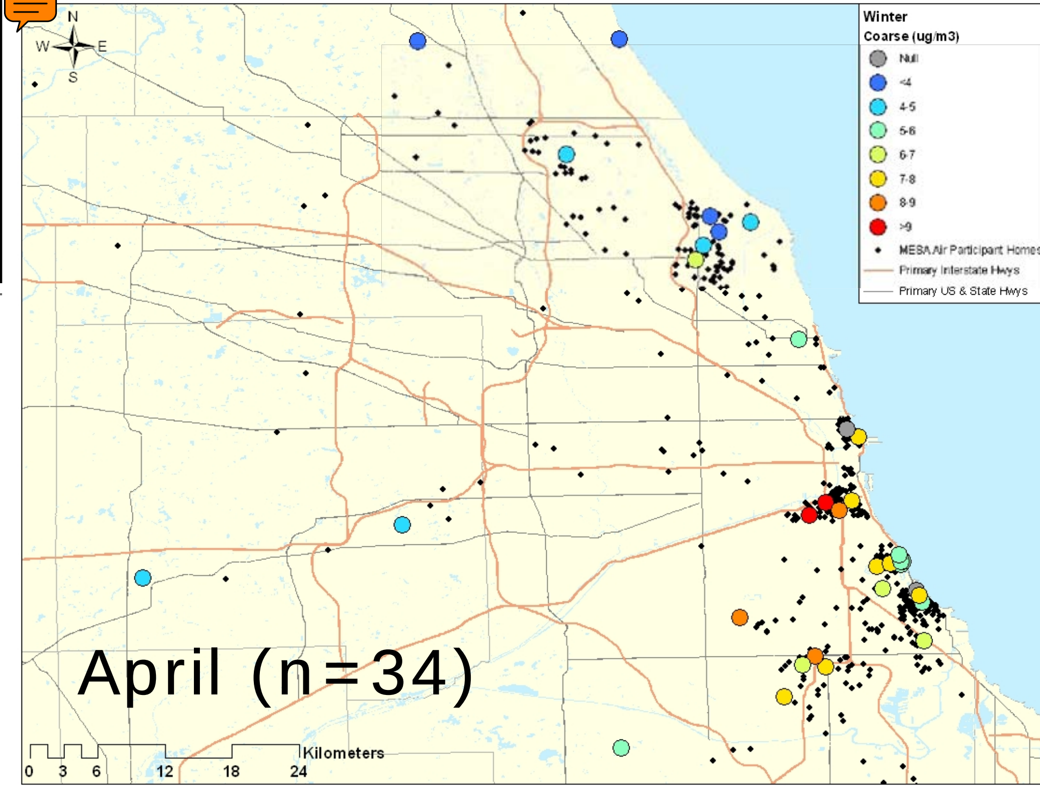
- Collected two-week snapshots of $PM_{10-2.5}$ outside homes of ~35 subjects (3 cities/2 seasons)
  - Cities to provide range in $PM_{10-2.5}$ and sources
  - Two seasons with some repeats
  - Mass , chemical species, and endotoxin analyzed and calculated by difference

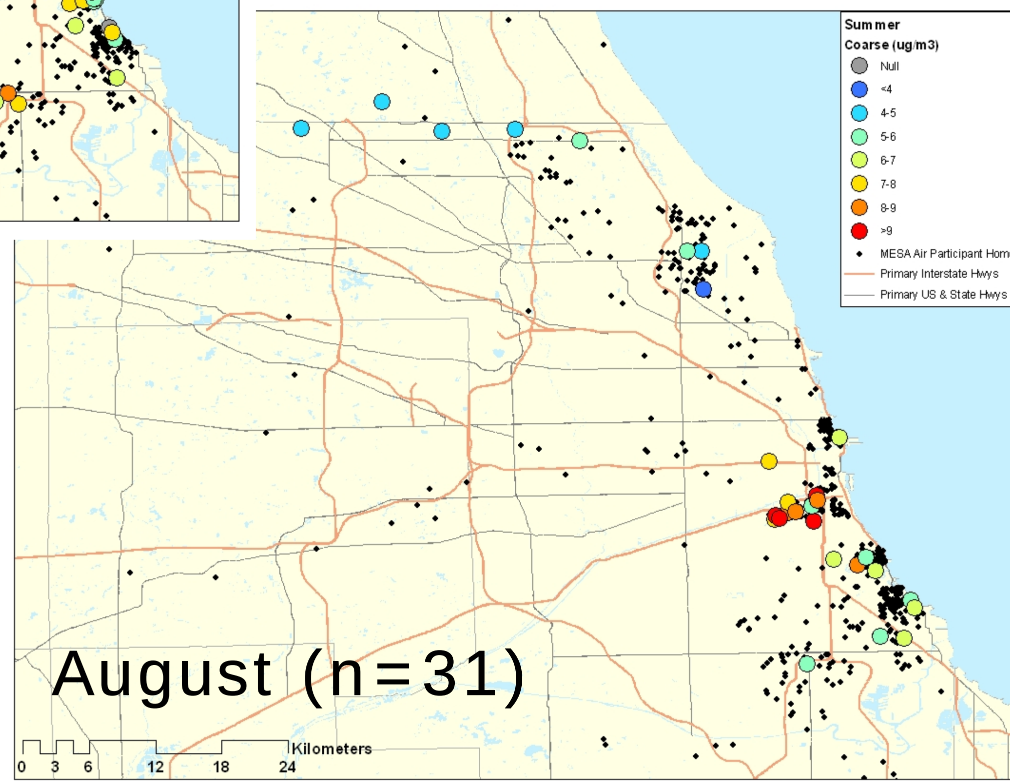
Short-Term Samples Reasonably Reflect Annual Averages



- Use spatial prediction procedures based on snapshots to assign long-term exposures

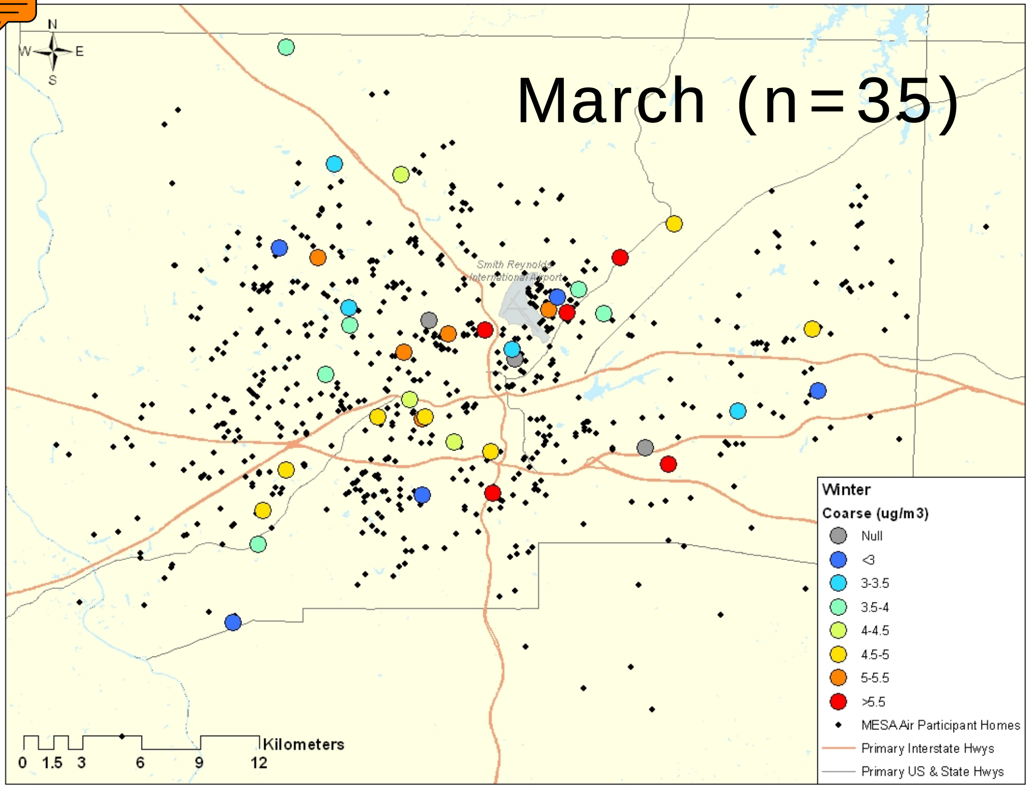
Chicago, IL

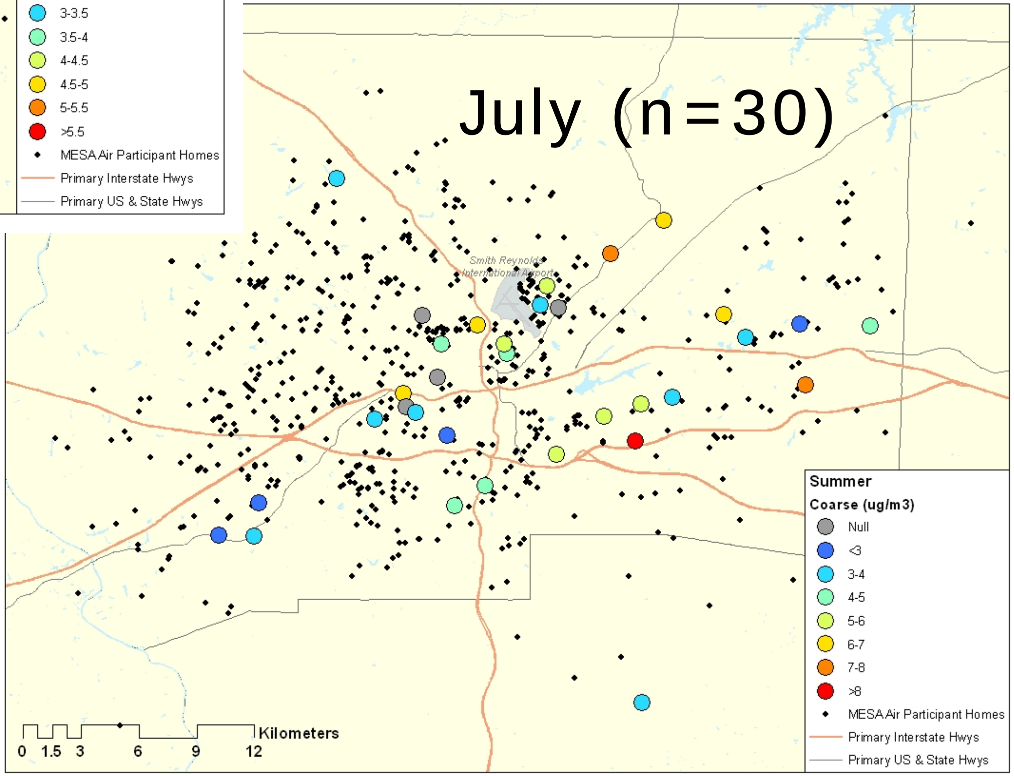




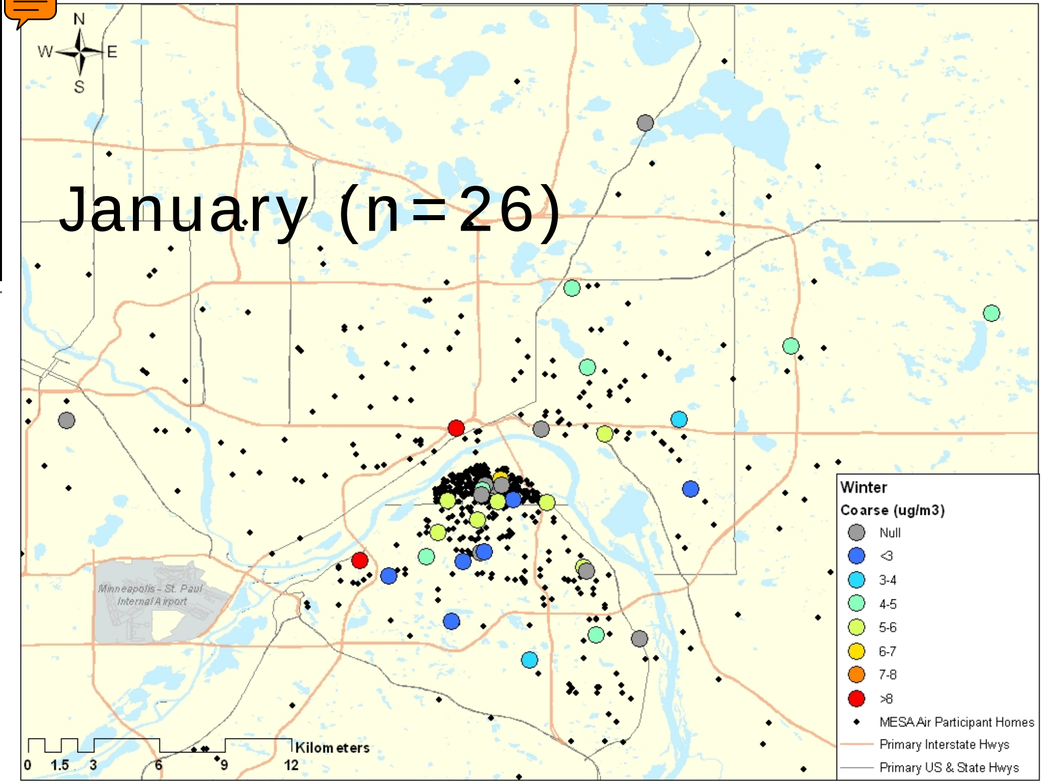
Homes targeted to capture geographic space and variation in local characteristics

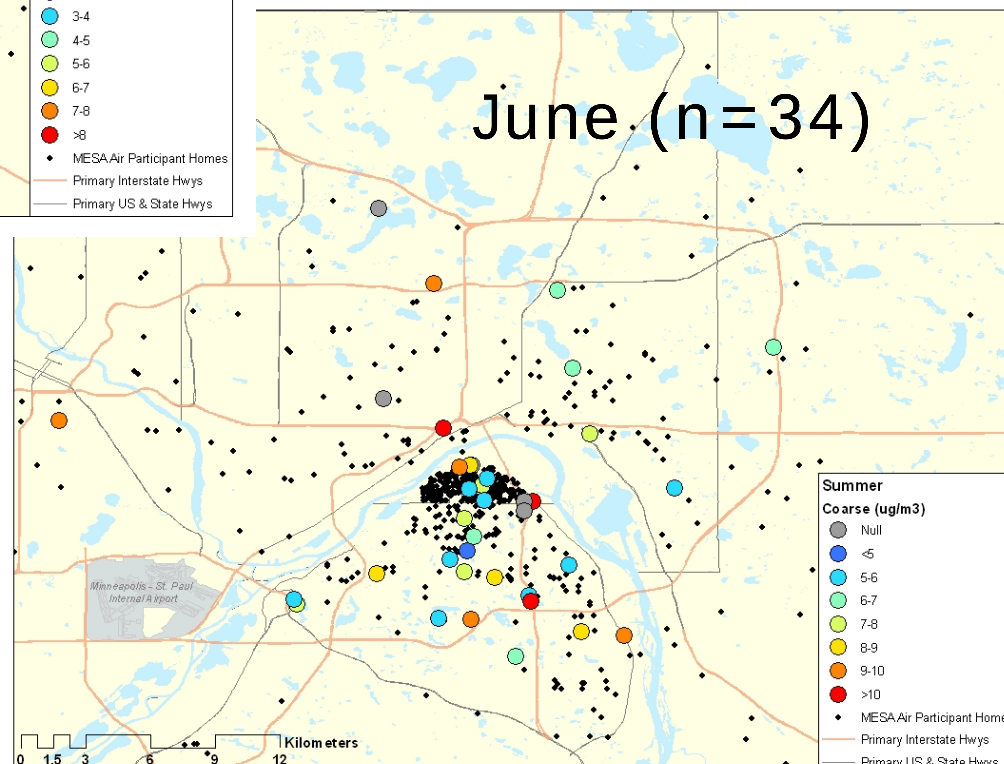
Winston Salem, NC



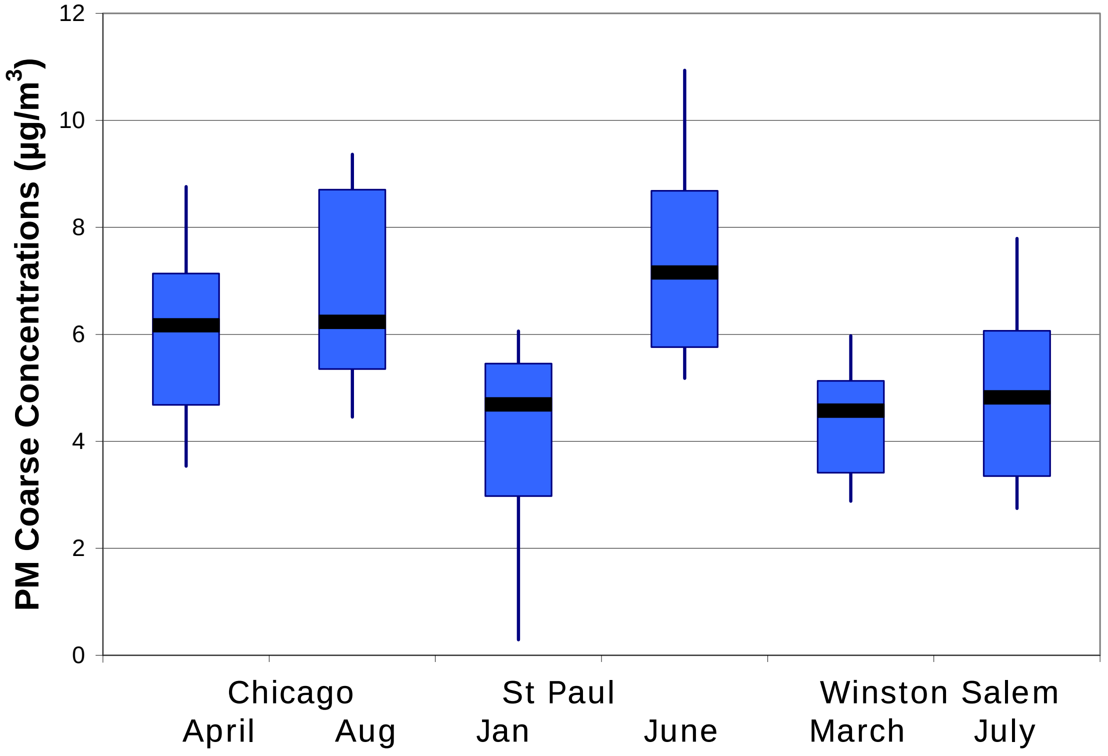


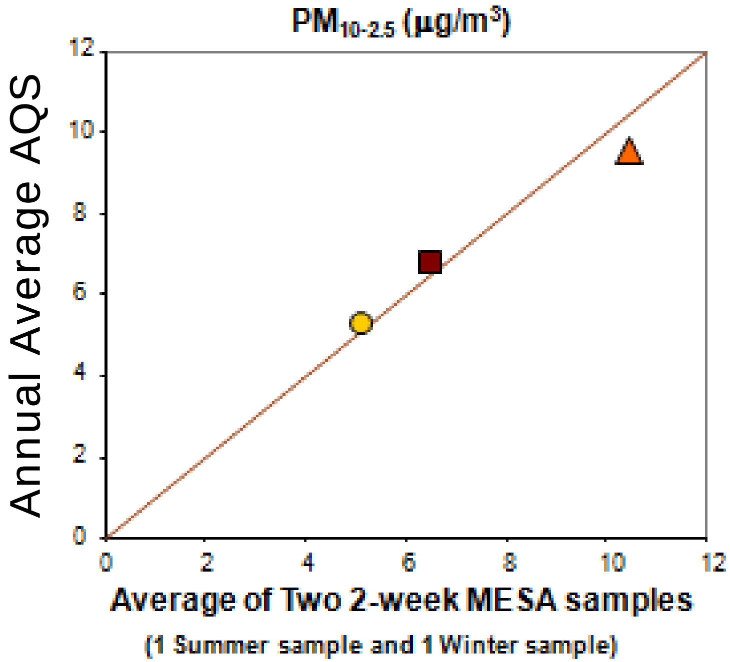
St Paul, MN


January (n=26)
N
W
E
S
Minneapolis - St. Paul International Airport
Kilometers
0 1.5 3 6 9 12
Winter
Coarse (ug/m3)
Null
<3
3-4
4-5
5-6
6-7
7-8
>8
MESA Air Participant Homes
Primary Interstate Hwys
Primary US & State Hwys


June (n=34)
Minneapolis - St. Paul International Airport
Kilometers
0 1.5 3 6 9 12
Summer
Coarse (ug/m3)
Null
<5
5-6
6-7
7-8
8-9
9-10
>10
MESA Air Participant Homes
Primary Interstate Hwys
Primary US & State Hwys

Within- and Between-City Differences





PM10-2.5 Can Be Predicted by Spatial Features : Chicago

Predictor	Partial R^2
A1 in 750m	0.24
Industry in 750m	0.18
Nearness to rail yard	0.14
Nearness to airport	0.05
Local PM10 emissions	0.04
Local PM2.5 emissions	0.02

- Other variables examined included A2, A3, NDVI, commercial land use, residential land use, population density, port, season
- Model selected based on consistency of predictors and CV RMSE

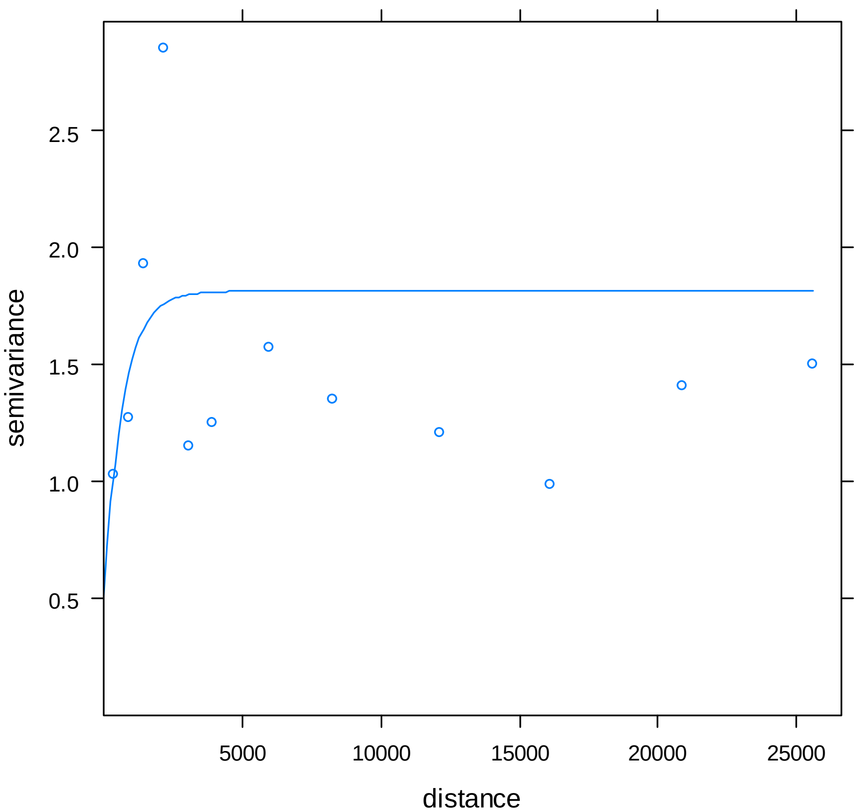
Model based R^2 = 0.68
CV R^2 = 0.61

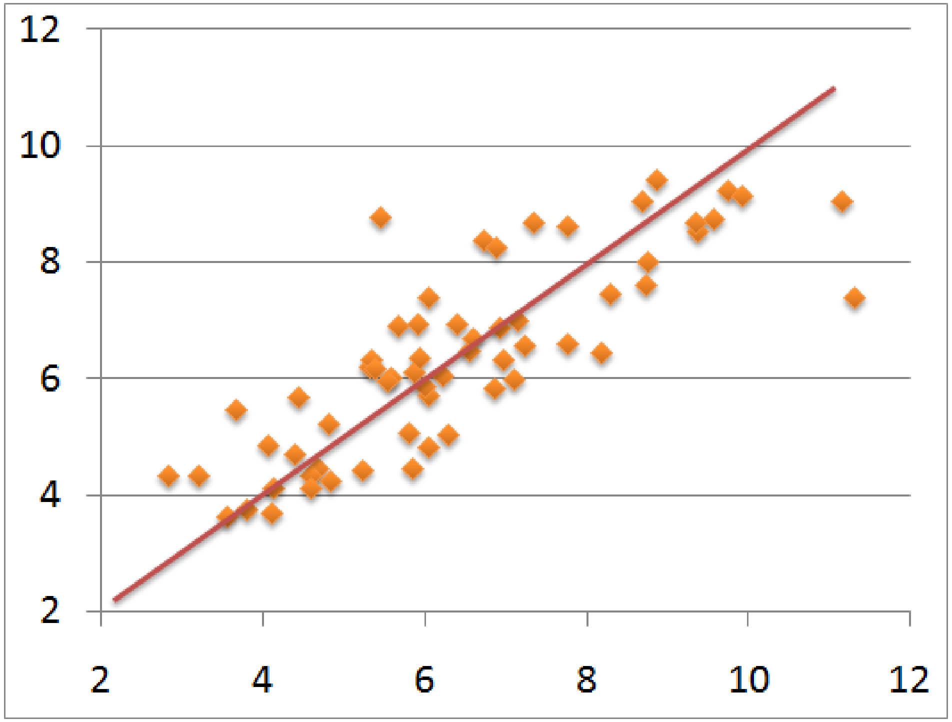
Modest Residual Spatial Structure

- Short spatial scale: Range ~600 meters

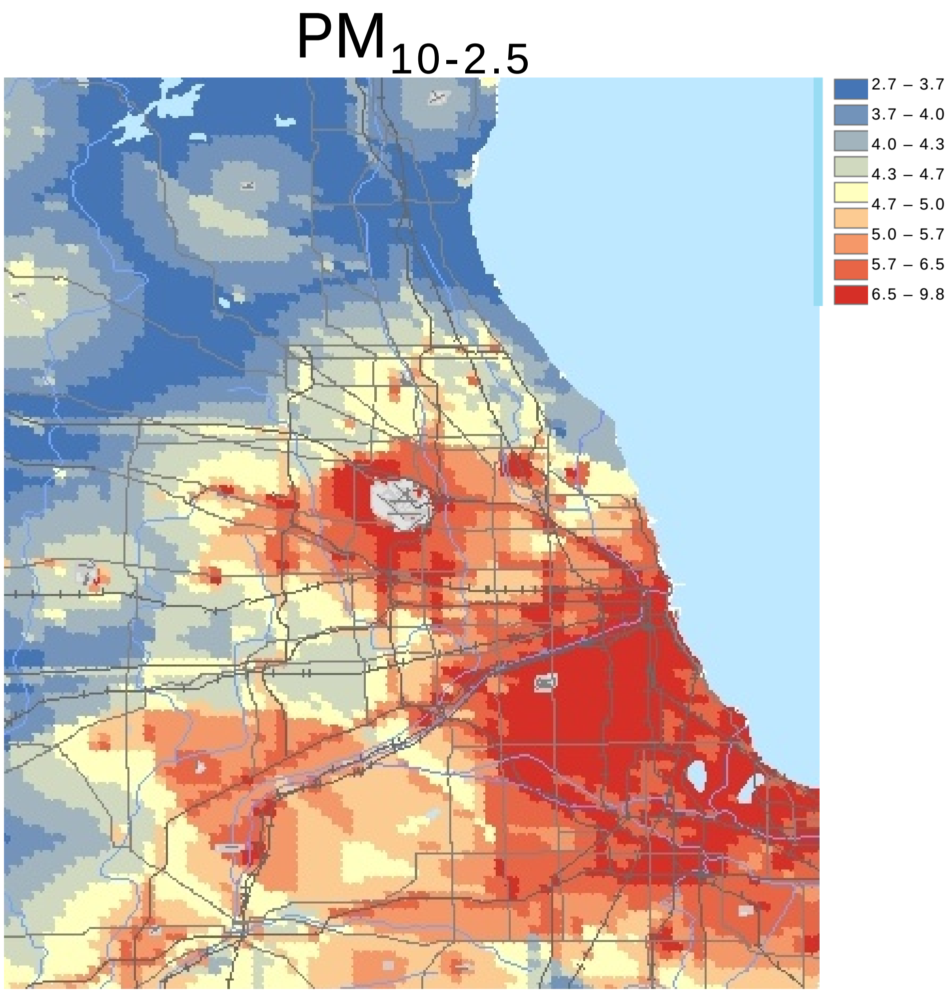
LUR: RMSE = 1.22 μg/m³ $R^2 = 0.61$

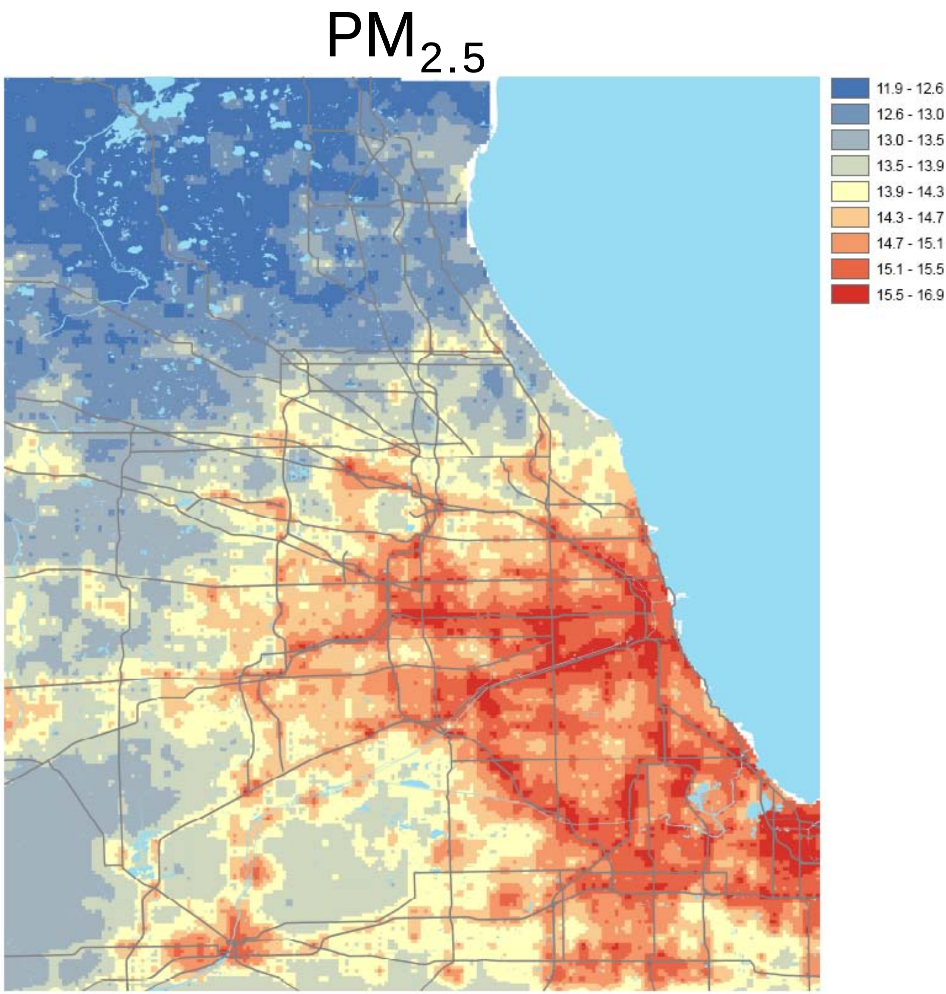
UK: RMSE = 1.11 μg/m³ $R^2 = 0.71$





Different Distribution Than PM2.5



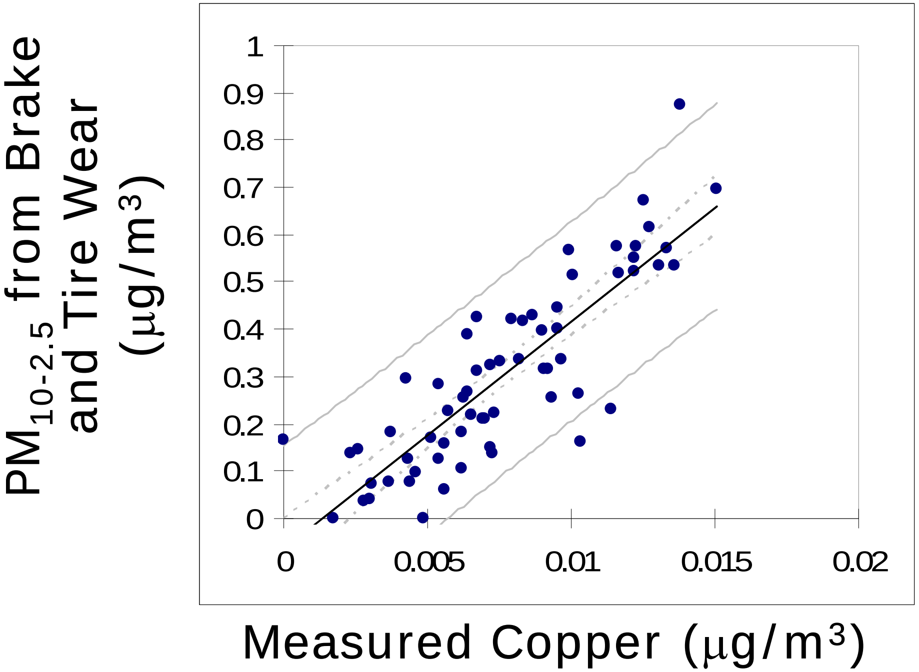


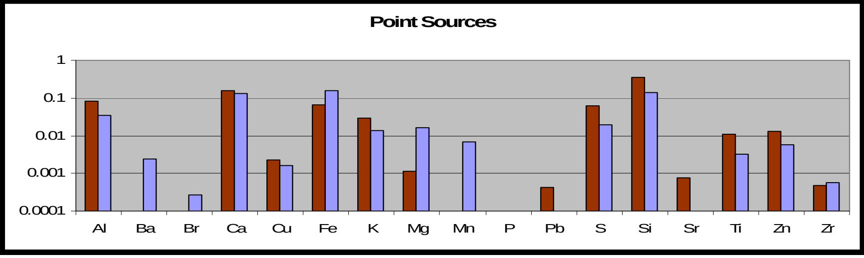
Identified Tracer of Road Dust

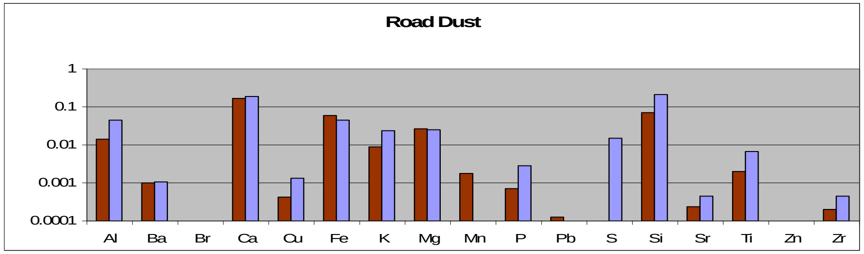
Species Mass Fraction

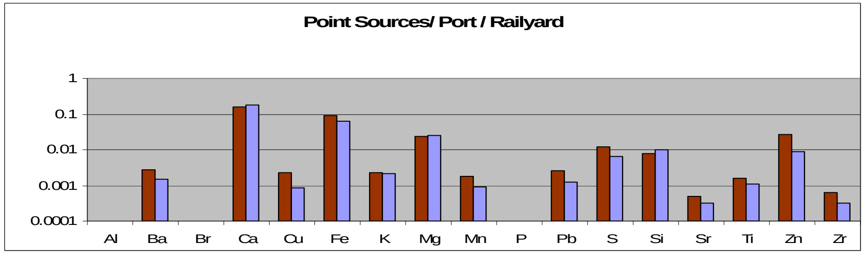
PMF 3.0

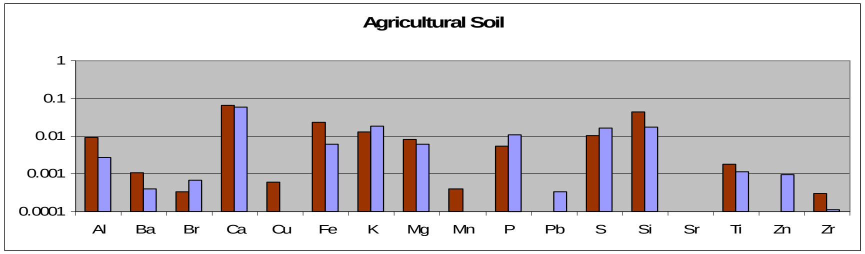
Enhanced ME-2 (constrained by spatial variables)

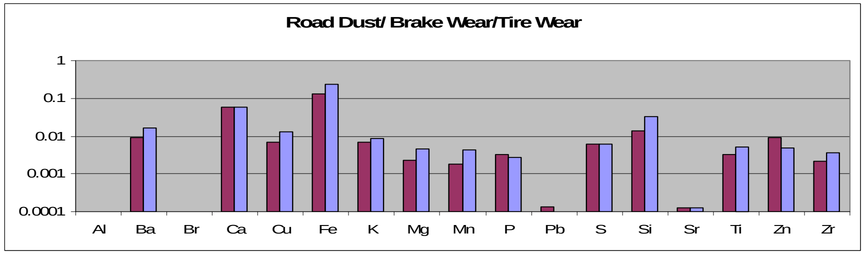








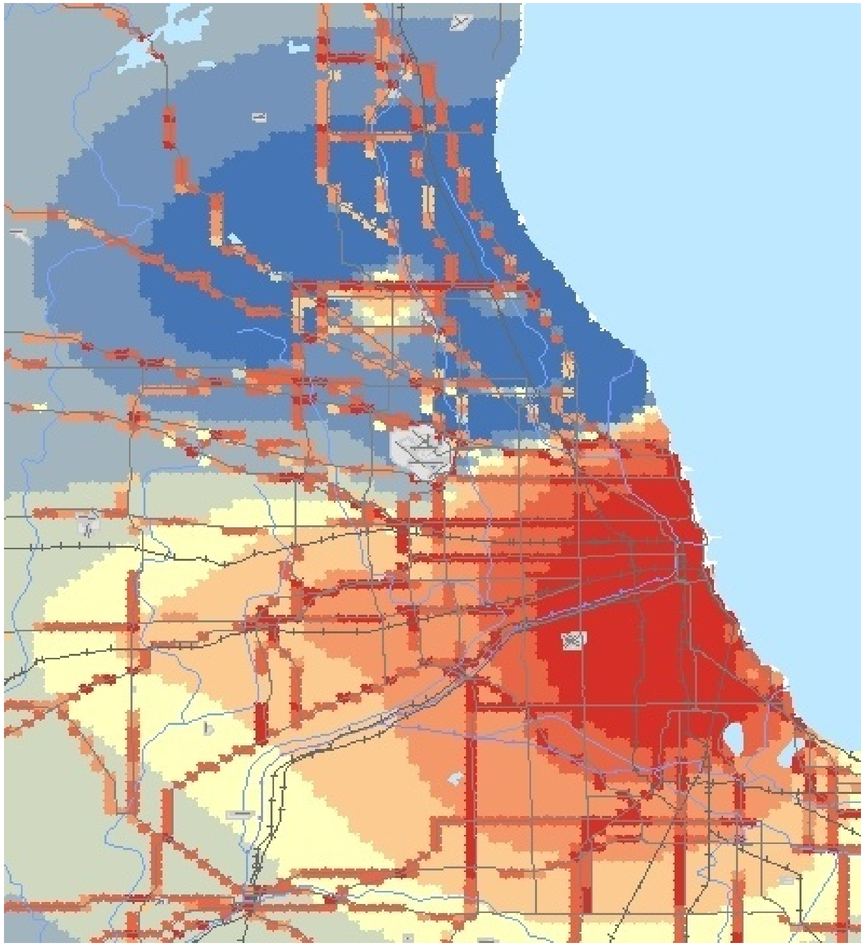




Copper Can Be Predicted by Spatial Features : Chicago

Predictor	R^2
A1 in 400m	0.38
A2 in 400m	0.05
Nearness to Large Port	0.05

UK: RMSE=2.6 ng/m^3 R^2 =0.64
LUR: RMSE=2.8 ng/m^3 R^2 = 0.47

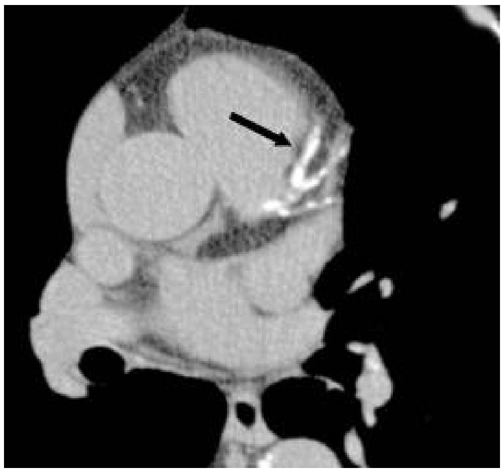


Exposure Assignment to be Completed for All Cities

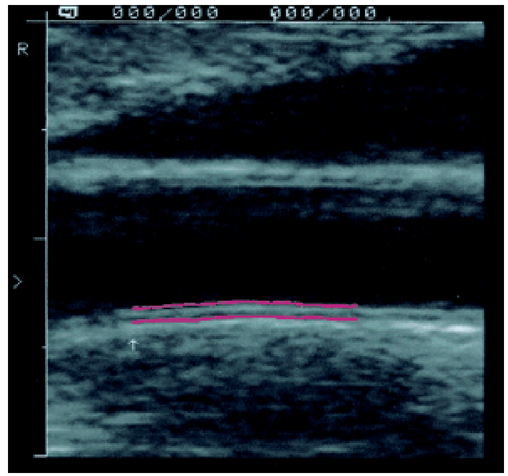
- Powered to focus on 3 metropolitan areas with model predictions but also aim to explore associations in 6 metropolitan areas
- To evaluate consistency across regions and ability of models to predict at regulatory monitors
- Assigning exposure based on AQS monitors or covariates

Incident / Progression of Cardiovascular and Pulmonary Outcomes

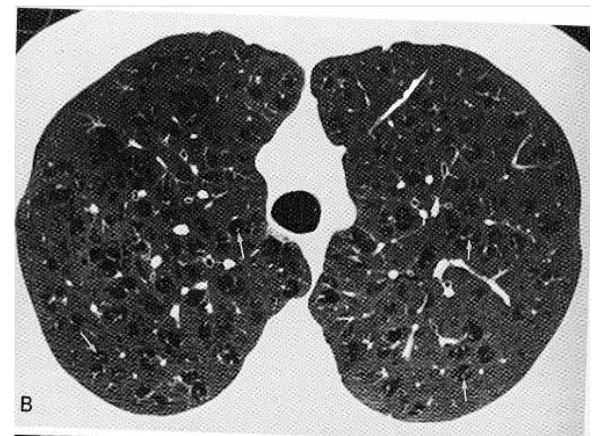
Coronary Artery Calcium



Intima-Medial Thickness



Lung Density



Clinical Disease/ Events

Other Interesting Outcomes

Retinal Microvasculature | Pulmonary Function

Systemic Inflammation | Blood Pressure

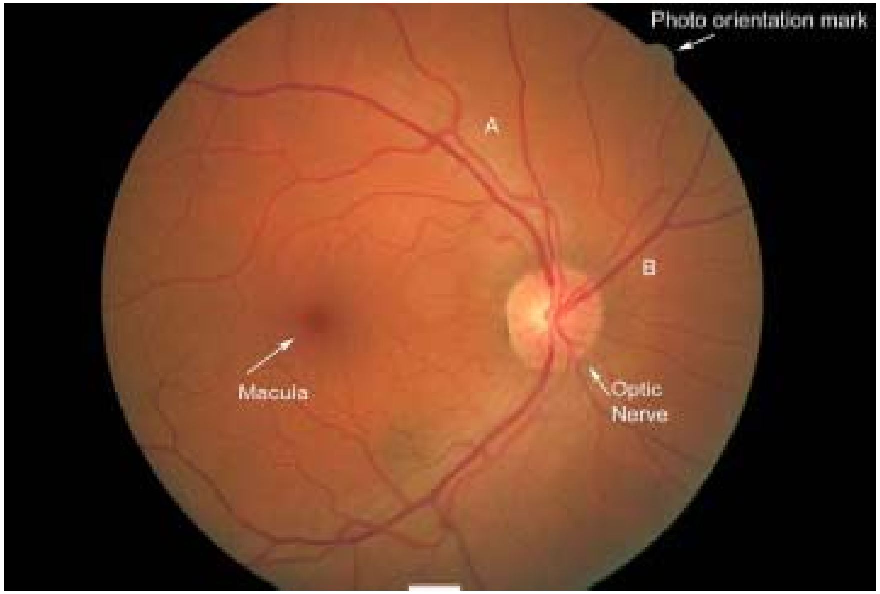
Left Ventricular Mass | Aortic Calcium

Flow Mediated Dilation | Heart Rate Variability

Genetic data also available for gene-environment interactions

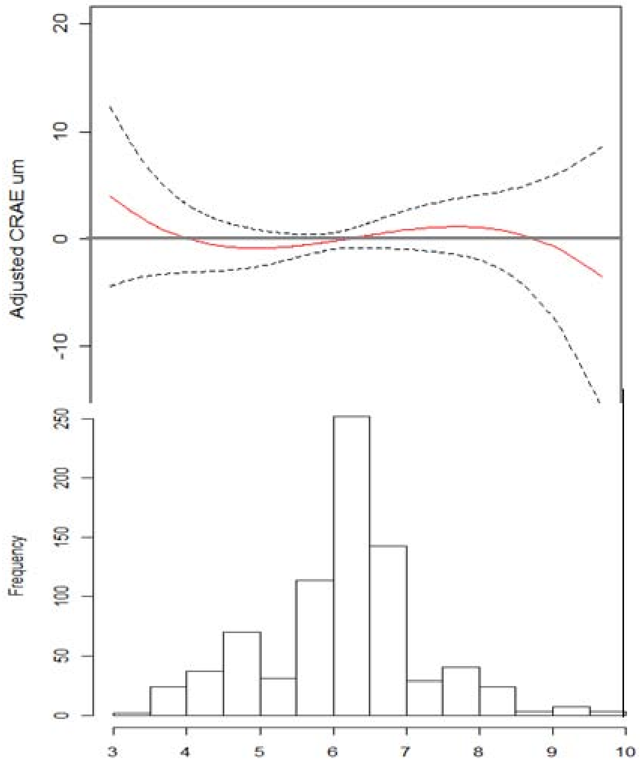
Retinal Photographs Provide Insight to Microvasculature

- Non invasive, *in vivo*, method to characterize human microvasculature
- Observes retinal vessels 100-300 um
- Hypothesize that PM10-2.5 is associated with narrowed arteriolar diameters

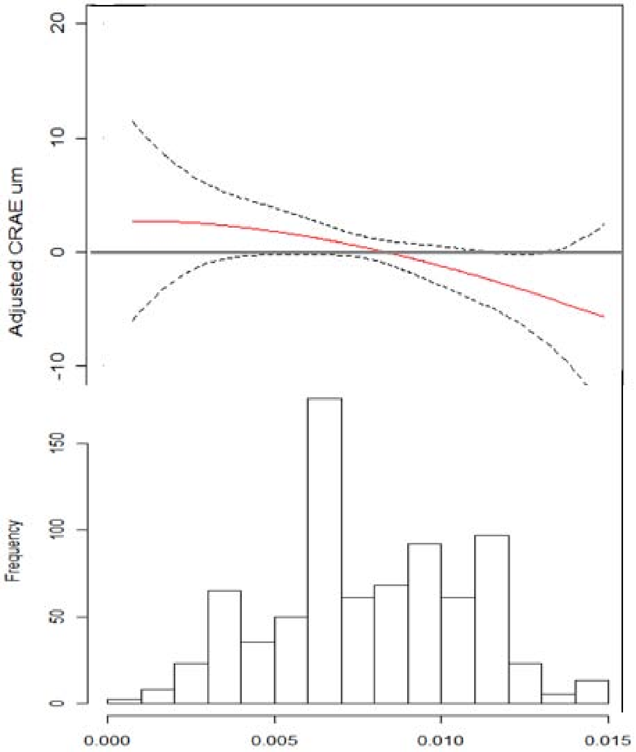


Chicago UK Results: Copper But Not Total Mass Associated with CRAE

Total $PM_{10\text{-}2.5}$



Copper $PM_{10\text{-}2.5}$



Controlled for traditional risk factors and $PM_{2.5}$ mass.
Independent negative association for copper and “near road” indicator.

Summary

- Successful monitoring campaign
  - Approximately 200 homes sampled across 3 cities and 2 seasons
  - Analyzed for mass, species, and endotoxin
- Preliminary modeling shows that coarse mass and components can be predicted using covariates and spatial structure
- Early health analyses suggest that there might be impacts of coarse mass, especially from traffic sources

Next Steps

- Finalize spatial modeling
  - Create predictions for St Paul and Winston Salem
  - Evaluate other species and source profiles
  - Identify indicators of $PM_{10-2.5}$ mass and species
  - Evaluate performance in unmeasured areas
- Examine associations with various health endpoints

Anticipated Contributions

- Unique characterization of within-city variation of $PM_{10-2.5}$ and its sources
  - Spatial prediction models
  - Supplements existing MESA Air exposure assessment
- Explore chronic health effects
  - Clinical and subclinical
  - Ability to evaluate potentially sensitive subpopulations

Thank you for your attention.
Any questions?

Acknowledgements

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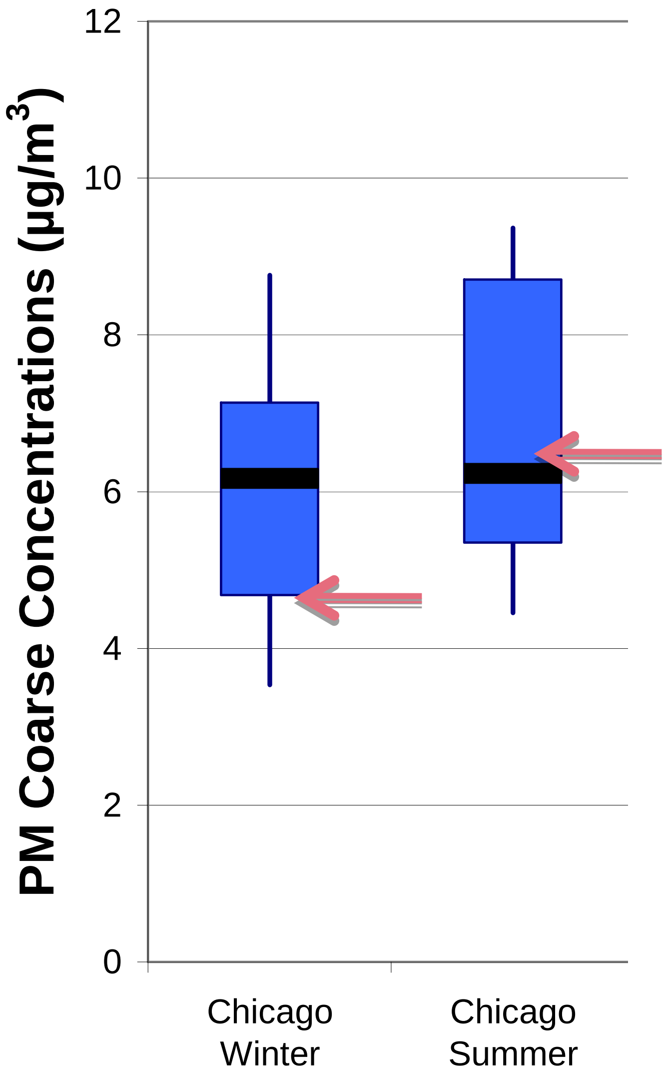
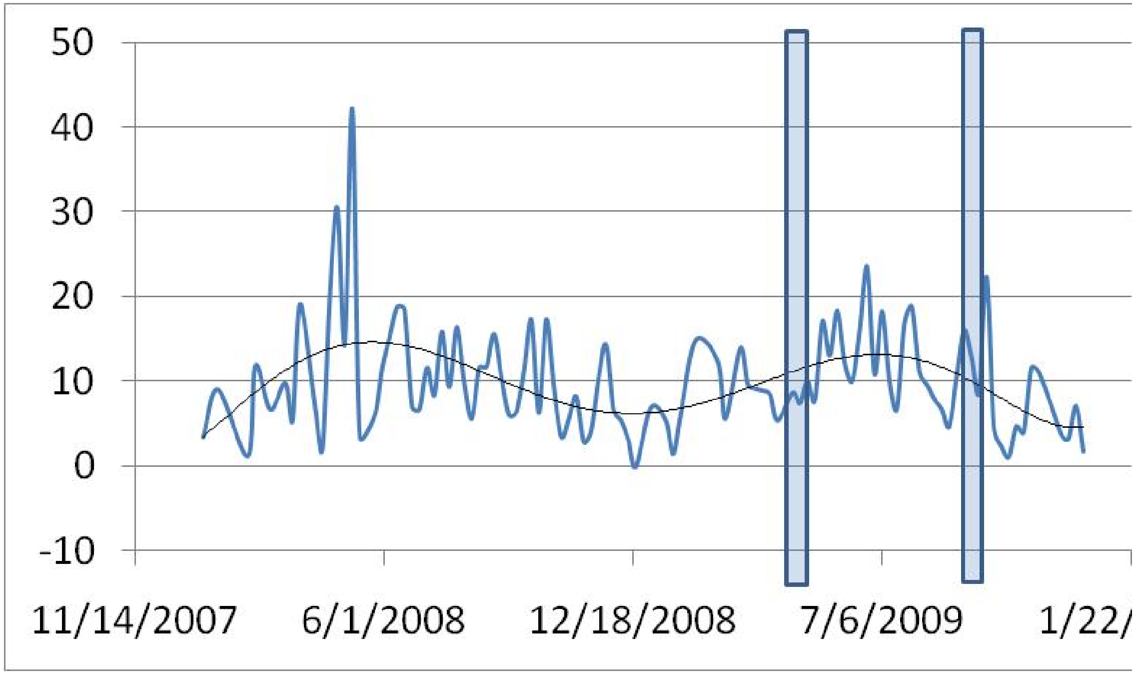
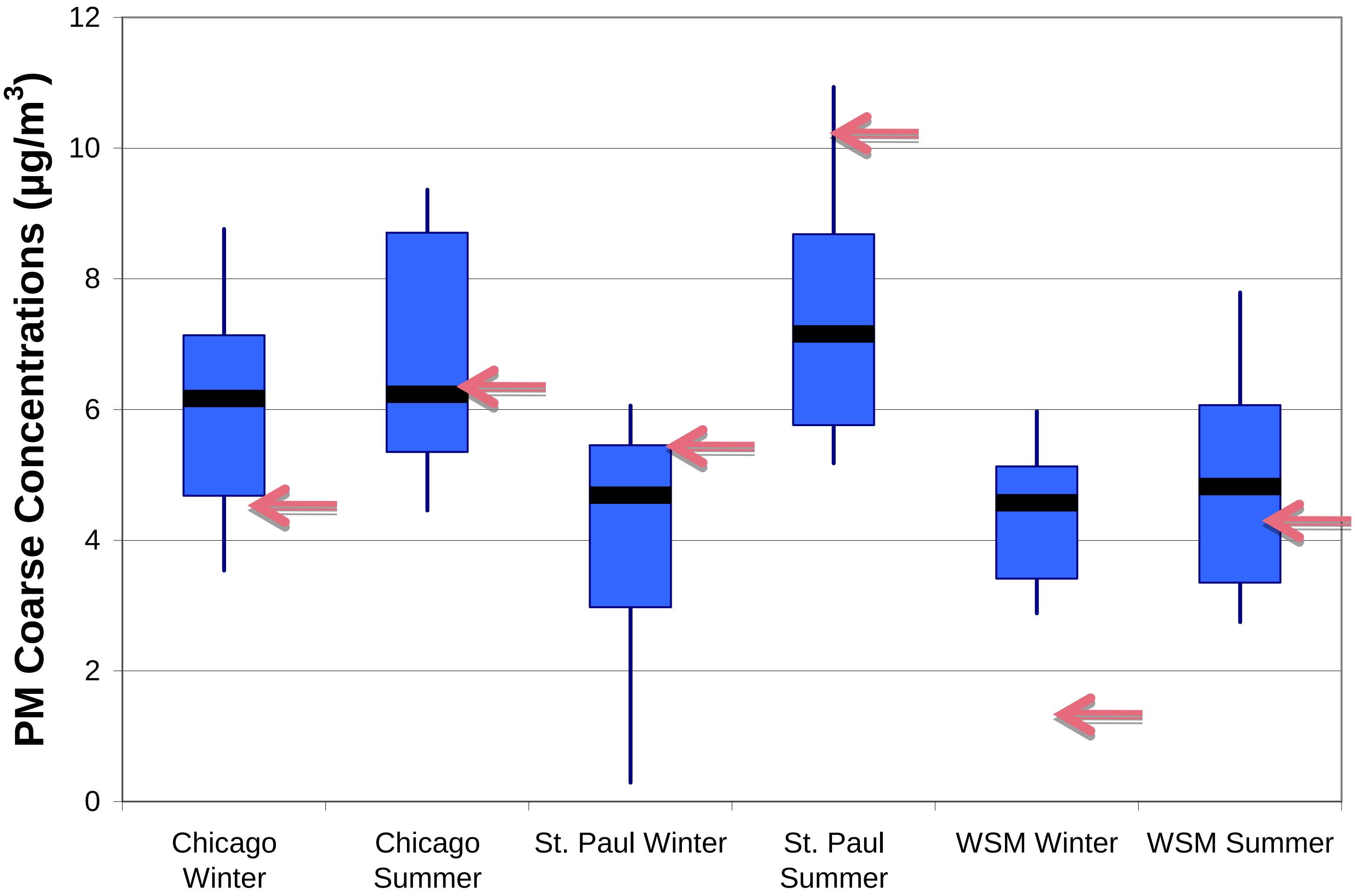
Consistent with AQS Data



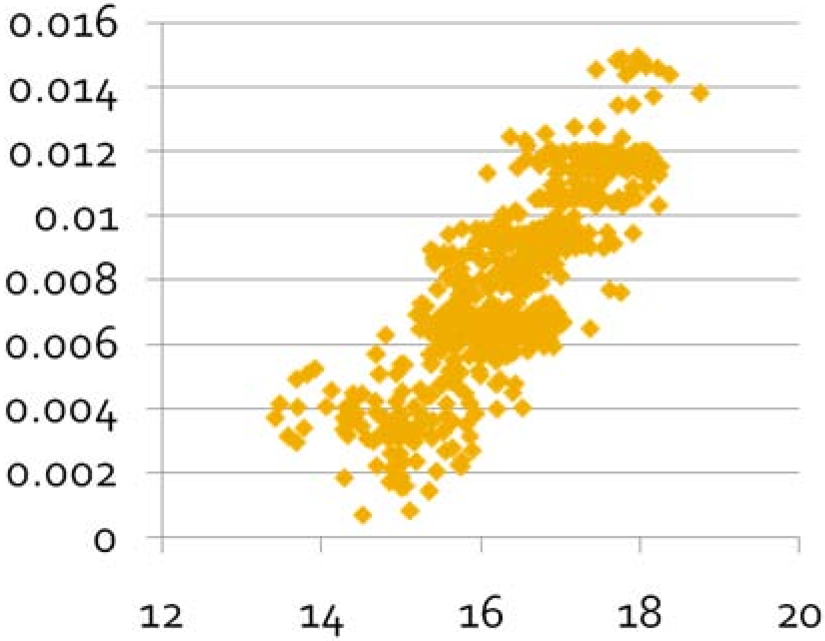


Good Agreement with AQS

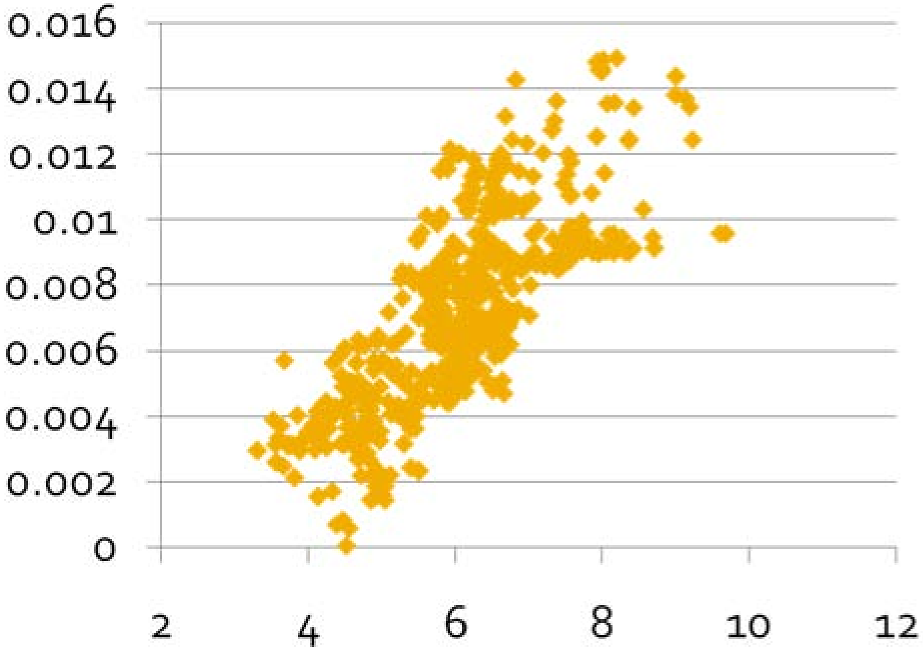


Copper Highly Correlated with Mass

Copper vs. $PM_{2.5}$
(ρ = 0.82)



Copper vs. $PM_{10-2.5}$
(ρ = 0.70)



Clinical Events Power

- 80% power to detect RR =1.15 among all cities and RR =1.28 among three cities

	Relative Risk Per 10μg/m^3 (95% CI)	Sex
Total		
Six Cities Study ($PM_{15-2.5}$)[3]	1.43 (0.83 to 2.48)	
Veteran's Cohort ($PM_{10-2.5}$)[15]	1.07 (1.01 to 1.13)	M
AHSMOG ($PM_{10-2.5}$)[16]	1.05 (0.92 to 1.20)	M
ACS ($PM_{15-2.5}$)[17]	1.00 (0.99 to 1.02)	
Coronary Heart Disease		
AHSMOG ($PM_{10-2.5}$)[18]	1.38 (1.07 to 1.77)	F
Non-Malignant Respiratory		
AHSMOG ($PM_{10-2.5}$)[16]	1.19 (0.88 to 1.62)	M

Sub-clinical Change Power

IMT

- 80% power to detect 2.5% of statin effect in all areas and 3% of effect in 3 areas

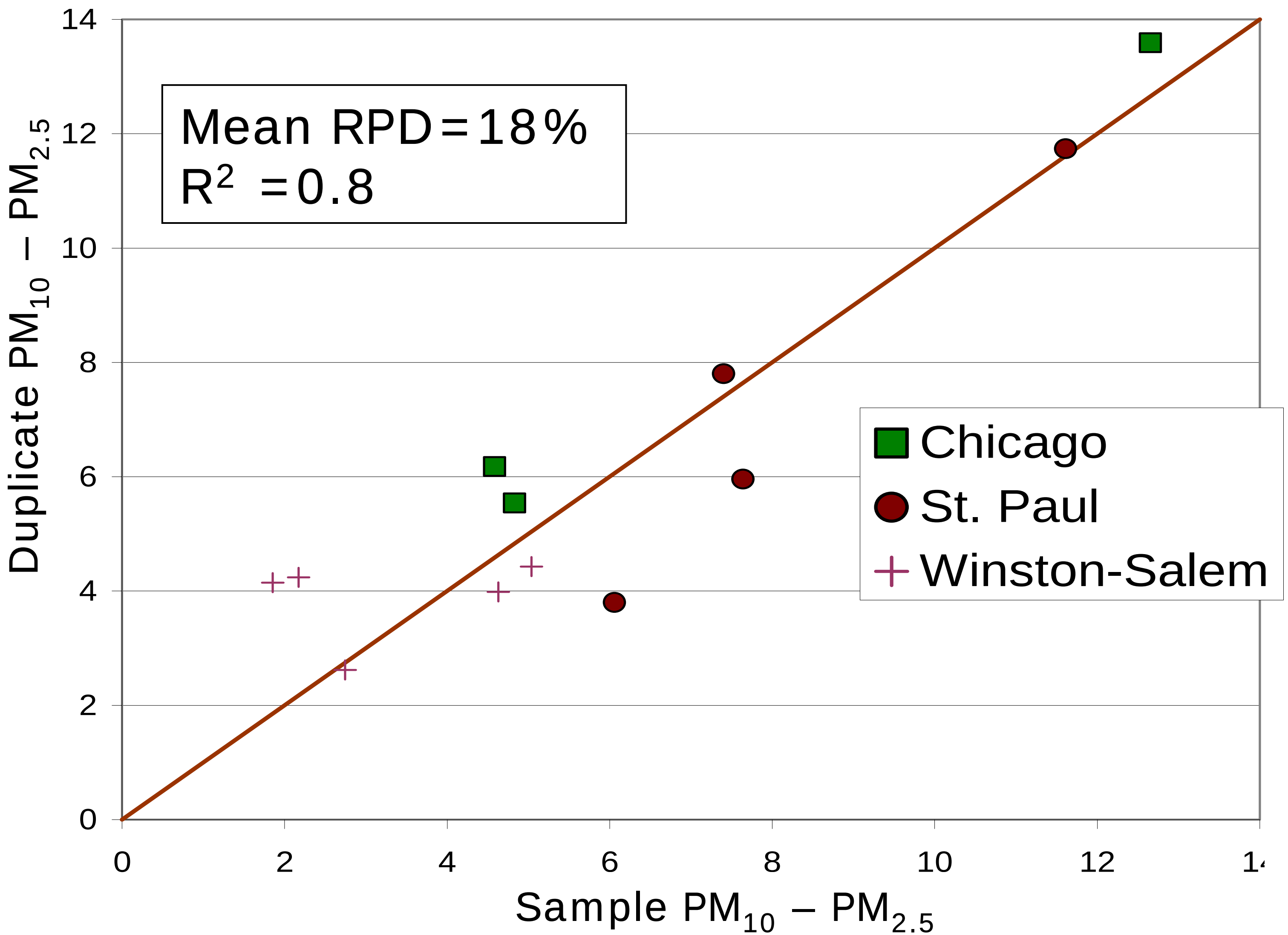
Lung Density

- 99% power to detect 1% of total change in MESA in all areas and 80% power to detect 1% change in 3 areas

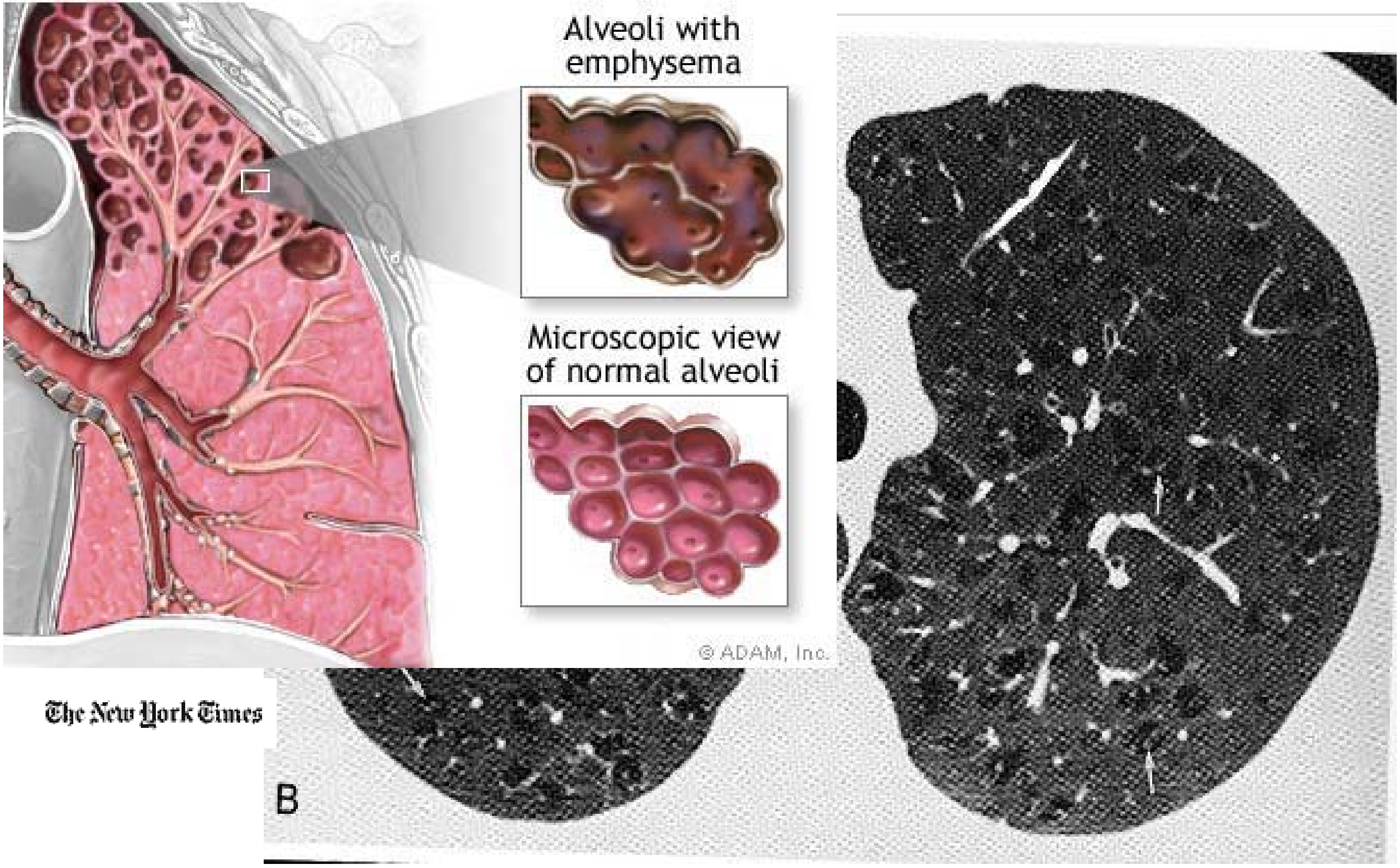
Good Variation in Geographic Features

	Baltimore	Chicago	Los Angeles	New York	St Paul	Winston -Salem
Mean NDVI (SD) USGS Reports NDVI $*10^4$	5900 (1600)	2500 (2100)	3200 (1400)	3900 (2100)	6200 (800)	7500 (390)
Mean Meters to Subjects from Major Road (SD)	230 (220)	140 (120)	230 (200)	60 (65)	160 (140)	390 (490)
Rural Land Use (%in Zip Code)	9	26	26	8	66	69
Comm/ Industr (% in Zip Code)	13	29	21	34	8	2

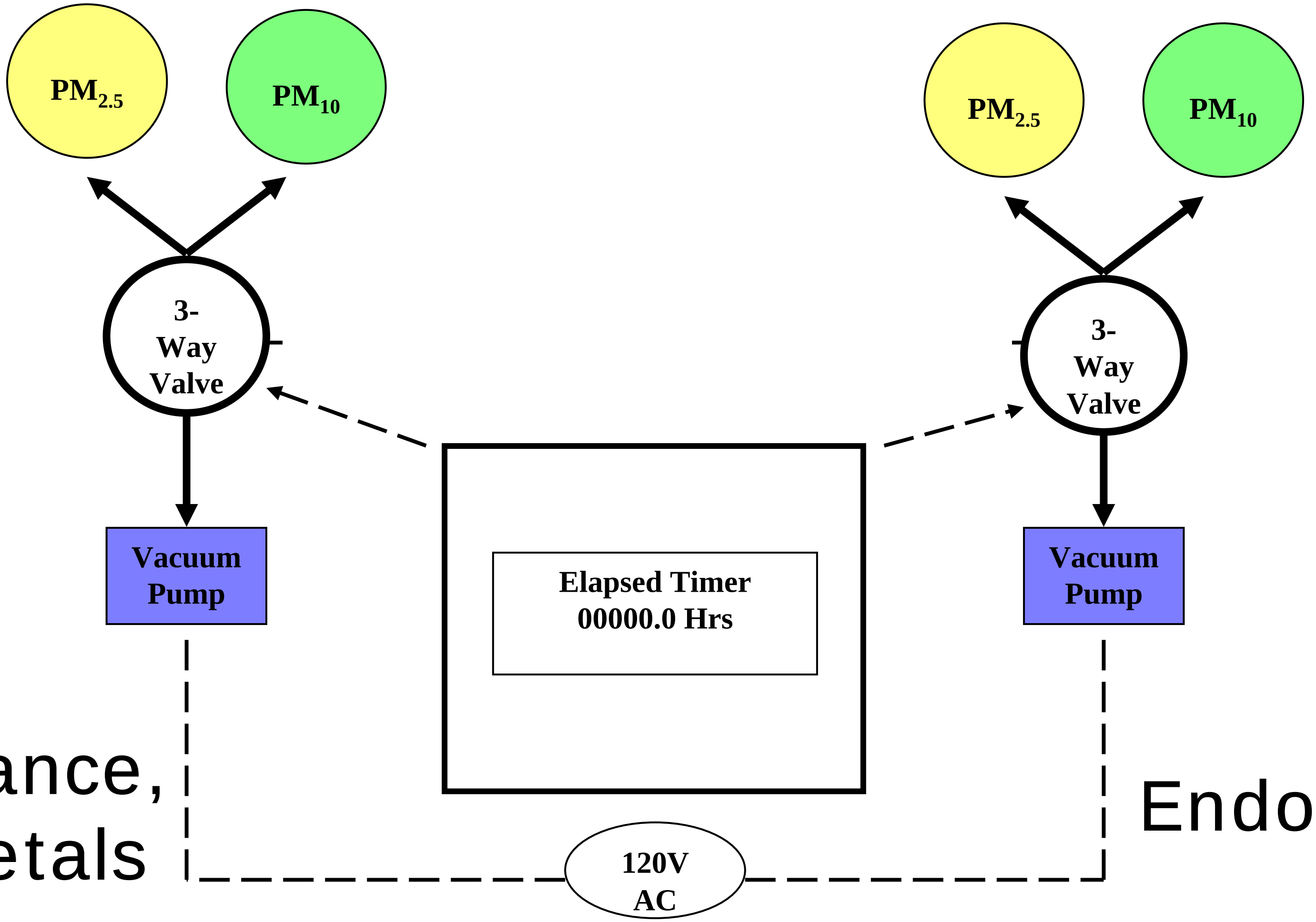
Reproducible Results



Subclinical Respiratory Outcomes



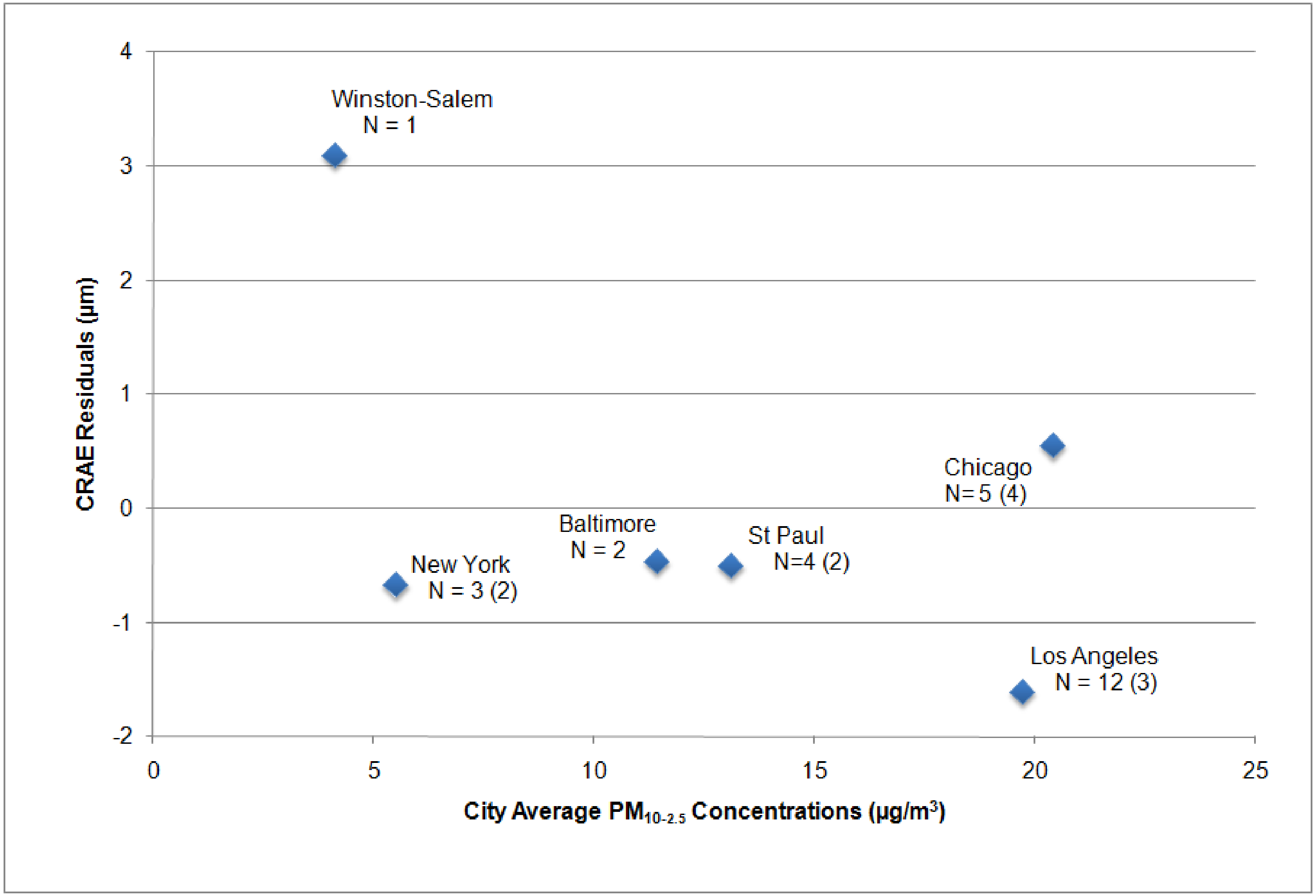
Analyzed for Mass and Components



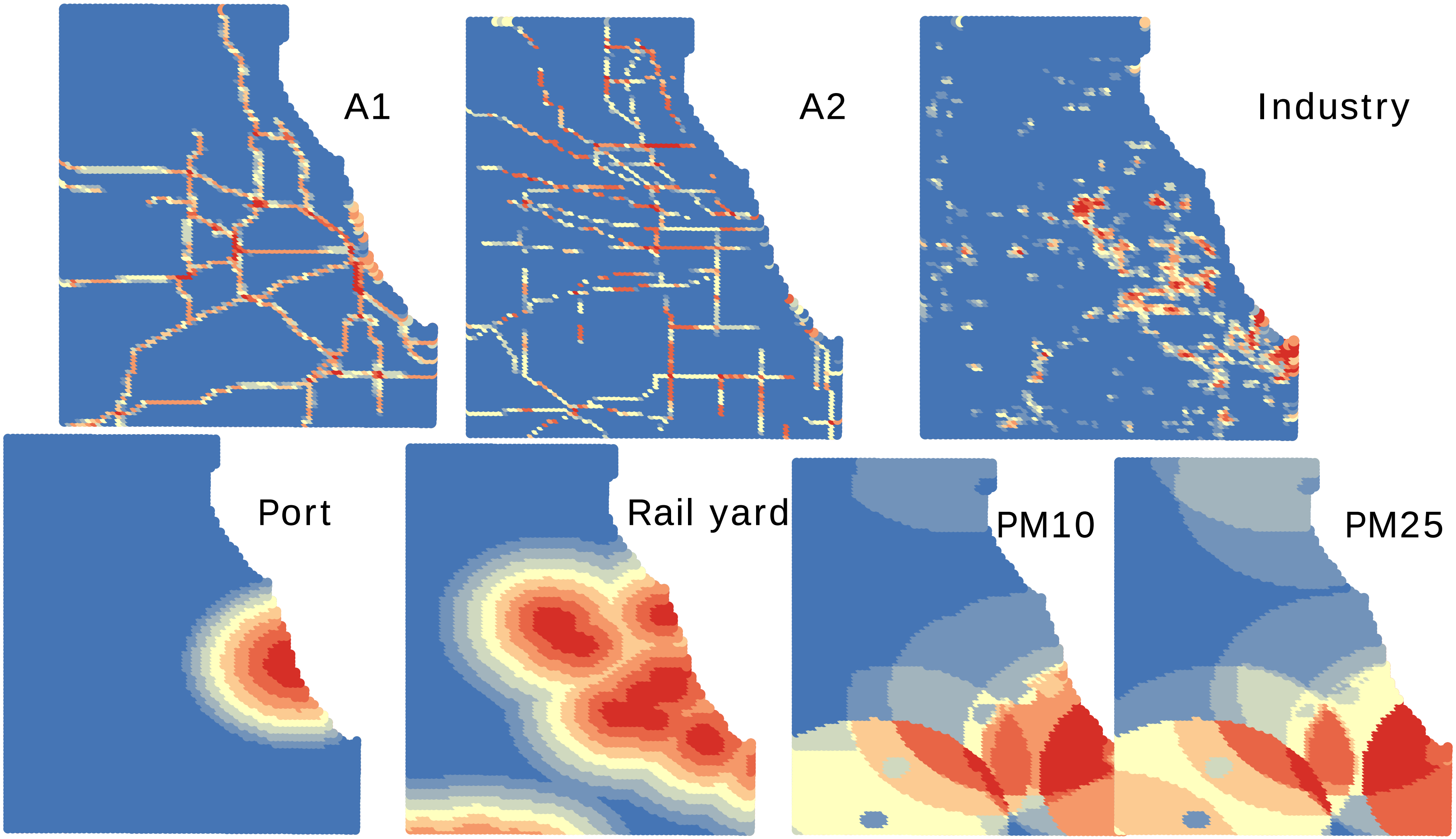
Mass, reflectance, and metals

Endotoxin

Nearest Monitor Approach: Results Driven by Winston-Salem



Spatial Features



Some Differences at Cohort Locations