미세먼지 대기오염과 건강영향

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미세먼지 대기오염과 건강영향

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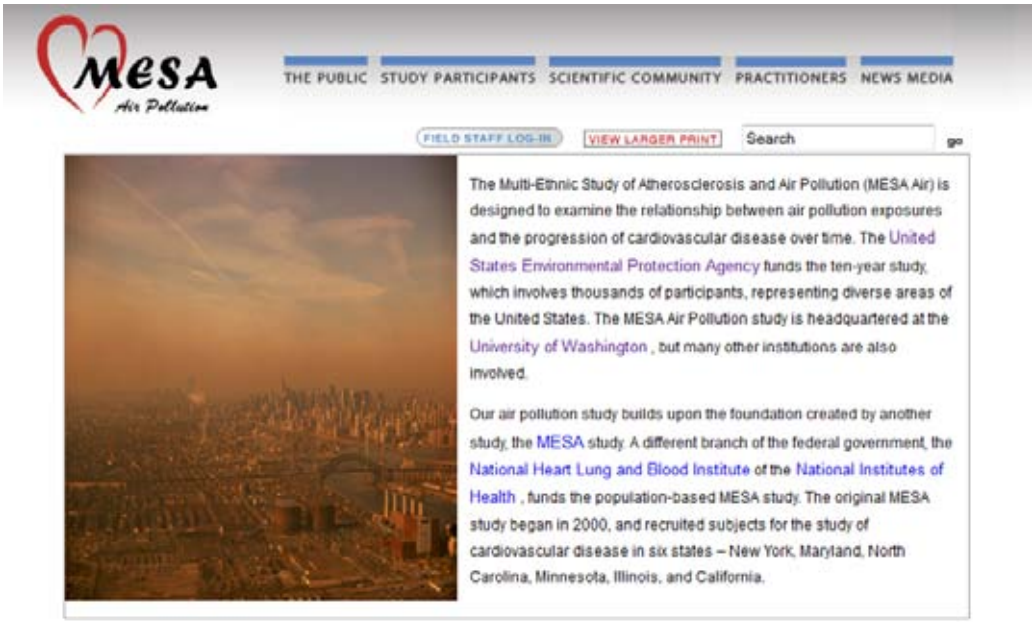
Association between fine particulate matter ($PM_{2.5}$) components and cardiovascular health in MESA

MESA Air study

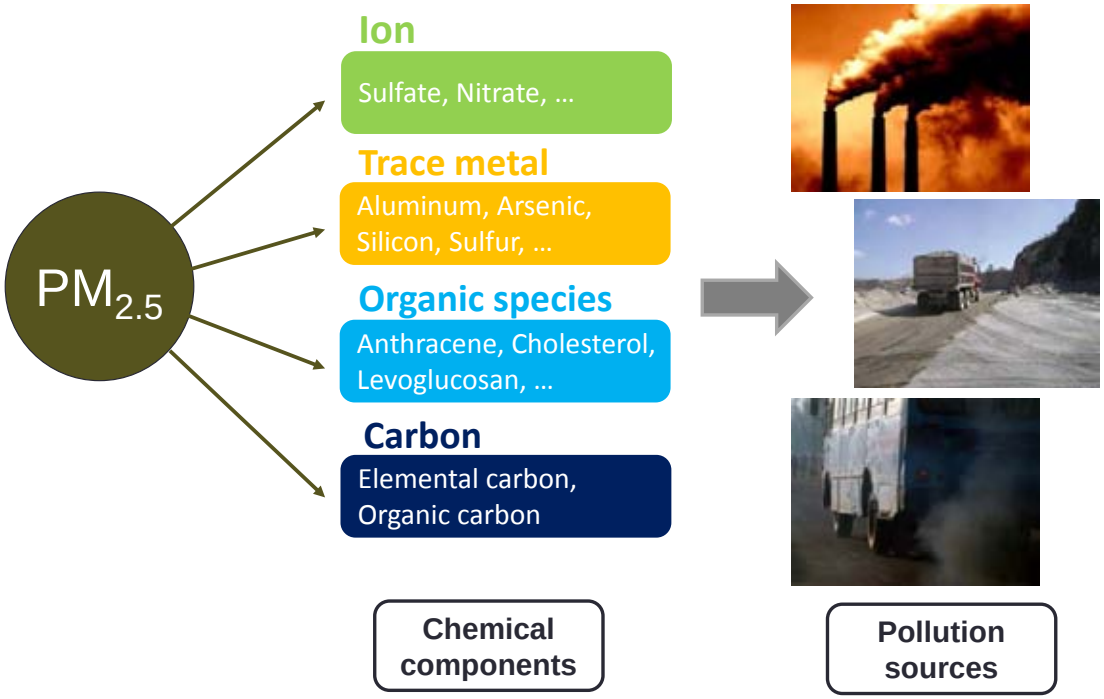


MESA cohort

- 6,814 participants in the Multi-Ethnic Study of Atherosclerosis (MESA)
- 6 cities: Los Angeles, Chicago,
  St. Paul, Baltimore,
  New York, and Winston-Salem
  in the U.S.

- Adults over age of 45 with ethnic diversity
- Baseline visit in 2000-2002 and five follow-up exams in 2003-2011

$PM_{2.5}$ chemical components



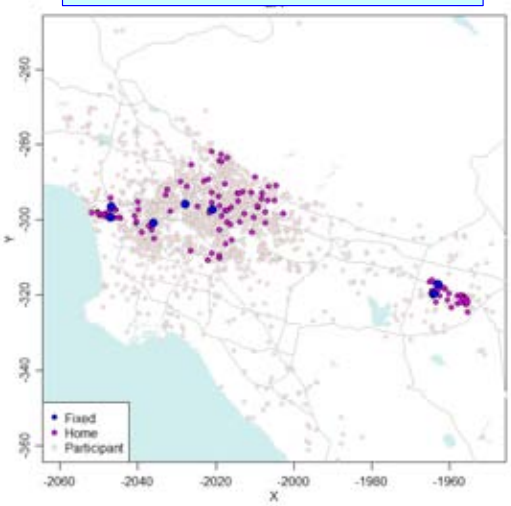
Purpose of the study

- To examine whether long-term exposures to four $PM_{2.5}$ components are associated with the extent and progression of subclinical atherosclerosis
- Four components: sulfur, silicon, and elemental and organic carbon (EC and OC)

$PM_{2.5}$ component monitoring data

- Dedicated to MESA cohort
- 2-week samples in 2005-2009
- 3-7 fixed sites and about 50 rotating home-outdoor sites in each of two seasons

MESA cohort and monitoring site locations in Los Angeles



Spatio-temporal model: ST residuals

$$C(s,t) = \beta_0(s) + \beta_1(s)f_1(t) + \varepsilon(s,t)$$

1) Long-term mean

- Land use regression + Kriging

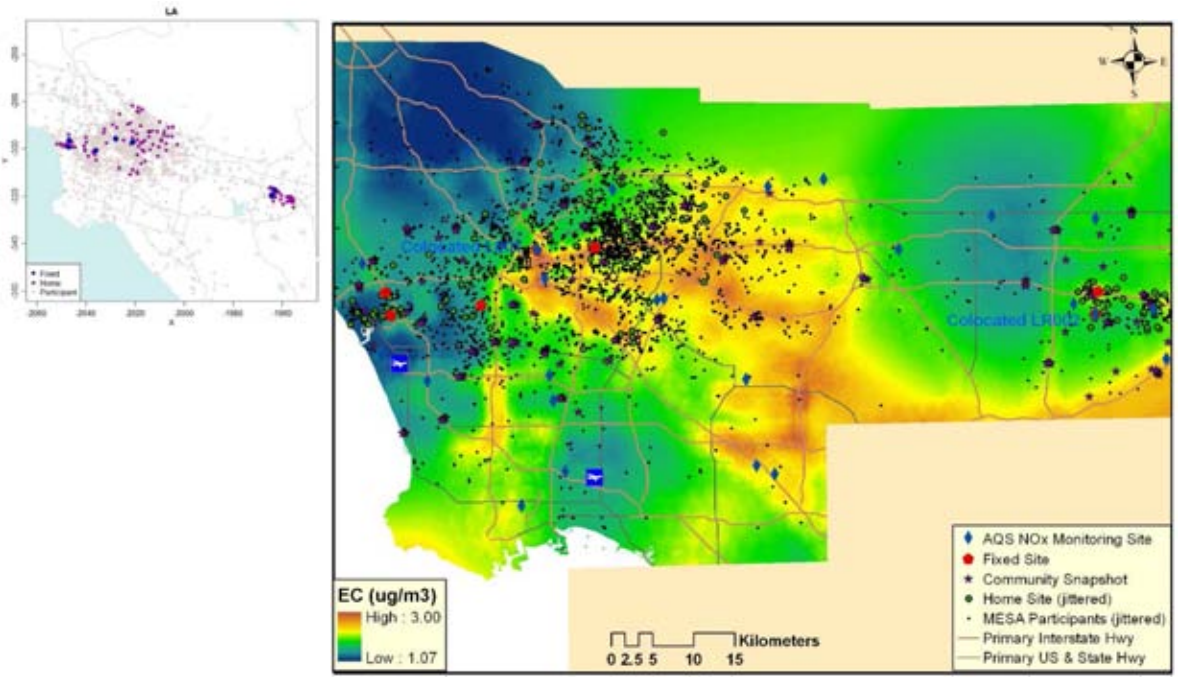
2) Temporal trend

- Temporal trend coefficient ($\beta_1(s)$) + Temporal trend function ($f_1(t)$)
- Temporal trend coefficient modeled with land use regression

3) Spatio-temporal residual

- Temporally independent but spatially correlated
- Kriging

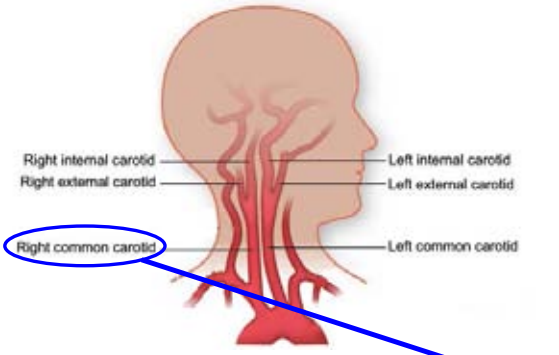
Prediction surface of EC

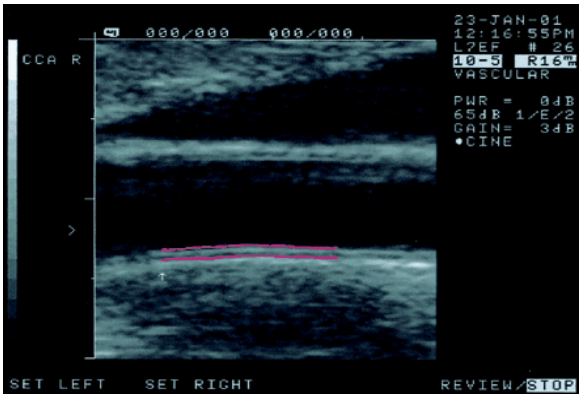


Kim et al. 2014, *in preparation*

Outcome: sub-clinical atherosclerosis

- Far wall right common carotid intima-media thickness (CIMT)





Health analysis model

$$\mathrm{CIMT}_{it} = \textbf{Cross Sectional}_i + \sum_{t'=1}^{t} \textbf{Longidinal}_{it} \times \left(\mathrm{time}_{it'} - \mathrm{time}_{i(t'-1))}\right) + \varepsilon_{it}$$

$$\textbf{Cross Sectional}_i = \alpha_0 + \alpha_1 \mathrm{PM}_{2.5}\mathrm{component}_i + \alpha_2 \mathrm{covariate}_{i0} + a_i$$

$$\textbf{Longitudinal}_{it} = \beta_0 + \beta_1 \mathrm{PM}_{2.5}\mathrm{component}_i + \beta_2 \mathrm{covariate}_{it\prime} + b_i$$

- Parameters of interest
  - β_1: longitudinal effect
  - α_1: cross-sectional effect

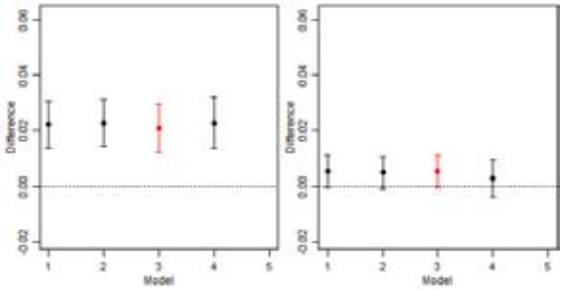
Health model

- Statistical analysis: linear regression for $PM_{2.5}$ component concentrations adjusting for individual covariates

- Covariate adjustment
  - Model 1 (minimally adjusted): + age, gender, race
  - Model 2 (moderately adjusted): + education, income, waist, body surface area
  - **Model 3 (primary): + DBP, hypertension, statin**
  - Model 4 (fully adjusted): + extended set of variables
  - Model 5 (city adjusted): Model 3 + city

Health effect: sulfur and silicon

Sulfur Silicon EC OC

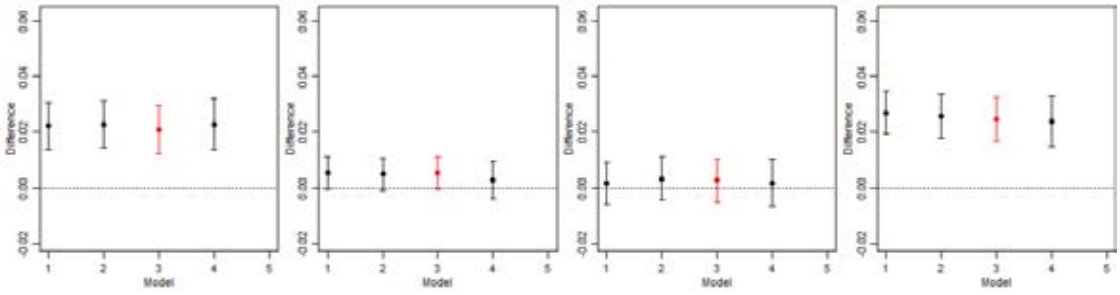


Kim et al. 2014. *AJE (in press)*

- Interquartile increases of 0.51 and 0.02 μg/m^3 in sulfur and silicon were associated with 0.021 mm (95% CI: 0.012 – 0.029) and 0.005 mm (0.000 – 0.011) increases in CIMT, respectively
- The association of Sulfur was consistent with adjustment for extended covariates

Health effect: EC and OC

Sulfur Silicon EC OC



- Interquartile increase of 0.69 μg/m^3 in OC was associated with 0.025 mm (0.017 – 0.033) increase in CIMT
- The association of OC was consistent with adjustment for extended covariates

Summary and discussion

- Sulfur, silicon, and OC were associated with the extent of CIMT
  - Findings were consistent with adjustment for covariates
  - OC is considered as traffic-related pollutant, although secondary organic aerosol also contributes to OC
- No evidence for progression of CIMT

- Future studies
  - Longitudinal analysis using the extended follow-up data

Acknowledgements

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  - Health Effects Institute
  - U.S. Environmental Protection Agency
  - National Institute of Environmental Health Sciences

Association between predicted particulate matter air pollution and health in Korea

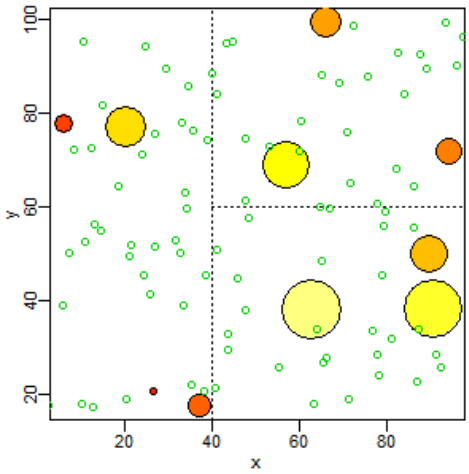
예측된 미세먼지 노출이 건강에 미치는 영향

:공간 노출예측모형에 대한 가상 및 역학 연구

Previous studies of PM and health in Korea

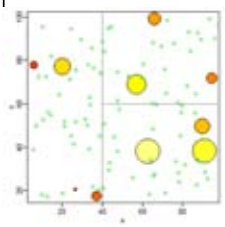
- Evidence based on time series studies for associations of PM_{10} and health since 2000
- Recent cohort studies since 2005
- Exposure prediction modeling approach
  - Ordinary kriging or land use regression
  - Model development limited to a few cities
  - Research need for incorporating expanded source-oriented variables and combining land use regression and kriging into exposure prediction models

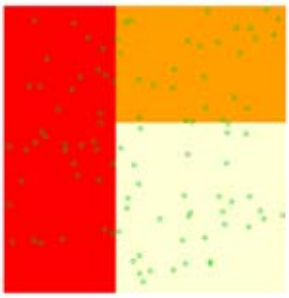
Exposure prediction



Prediction of $PM_{2.5}$ concentrations at 100 subject homes in 3 administrative areas using $PM_{2.5}$ data at monitoring sites

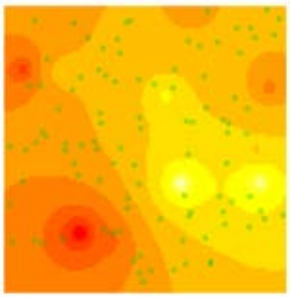
Exposure prediction models



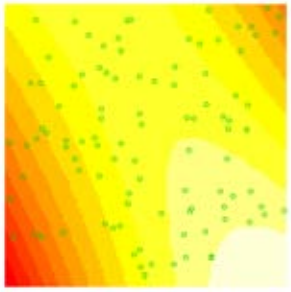


Area-averaging

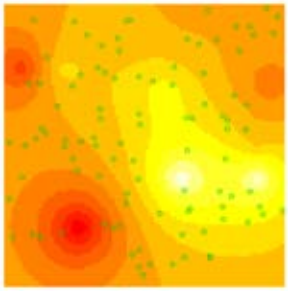
Nearest-monitor



Inverse-distance-weighting

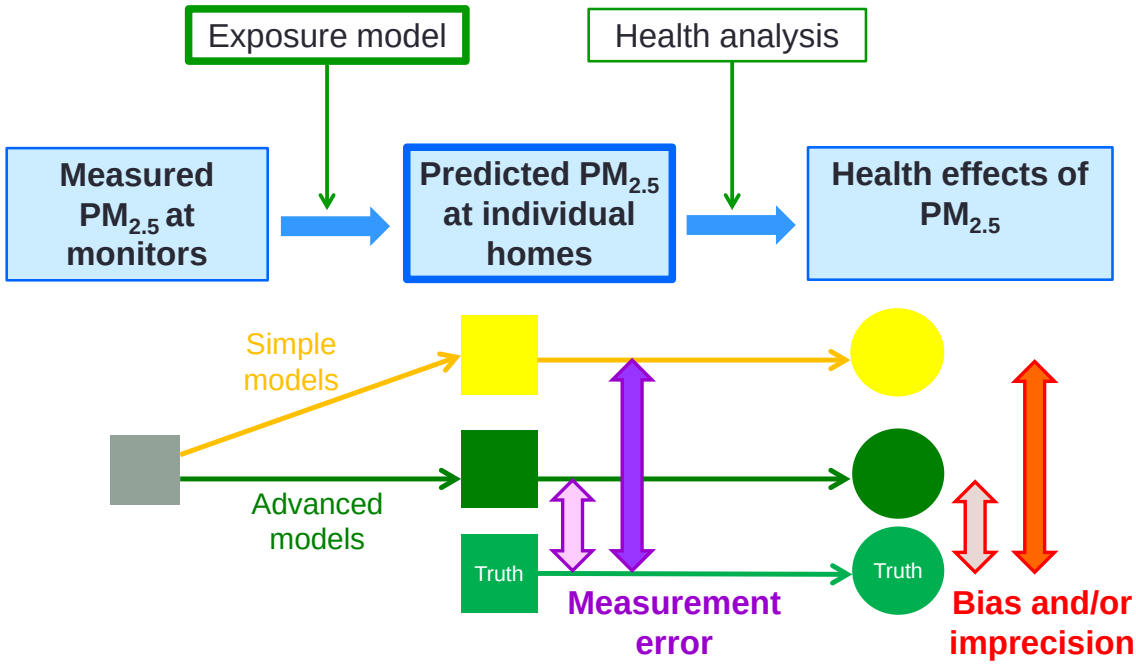


Ordinary kriging



Universal kriging

Exposure prediction and health analysis



Aim

1. **To develop exposure prediction models** for long-term exposures to particulate matter air pollution in Seoul and South Korea (PM_{10}, $PM_{2.5}$, and $PM_{2.5-10}$)

2. **To compare the health effect estimates of predicted long-term PM concentrations** between exposure prediction approaches in a simulation study using Korean birth cohort data in Seoul

3. **To assess the association between predicted long-term PM concentrations and health** in a cohort study (project-based cohort or cohort based on administrative health databases)

Research plan

Year 1: Geodatabase

Year 2: Exposure prediction models for PM_{10}

Year 3: Simulation study

Year 4: Exposure prediction models for $PM_{2.5}$ and $PM_{2.5-10}$

Year 5: Epidemiological study

Geodatabase (year 1)

- PM data
  - 2001-2013 hourly data across about 300 monitoring sites
- Geographical variables
  - Traffic: road network and density
  - Population density: census data
  - Land use
  - Sources: railroad, bus route, subway route
  - Altitude
  - Emission
  - Parcel data
  - And other factors?

Exposure models for PM_{10} (year 2)

- PM_{10} long-term averages for 2010
- Six exposure prediction models
  1) Area-averaging
  2) Nearest-monitor
  3) Inverse-distance weighting
  4) Land use regression (LUR)
  5) Ordinary kriging
  6) Universal kriging

Simulation study (year 3)

- Aim: to compare effect estimates of predicted PM_{10} on infant mortality between different exposure modeling approaches in Seoul, Korea
- Korean birth cohort data
  - 225 infant deaths out of 359,459 births for 2004-2008 in Seoul
  - RR= 1.65 (1.18-2.31) for PM_{10} in a previous study (Son et al. 2010)

Exposure models for $PM_{2.5}$ and $PM_{2.5-10}$ (year 4)

- $PM_{2.5}$ annual averages in 2010
- $PM_{2.5-10}$ based on PM_{10} and $PM_{2.5}$ data

- Six exposure prediction models

Epidemiological study (year 5)

- Cohort created from administrative health databases
  1) Korean birth cohort
     - Outcome: infant mortality, low birth weight
     - Limited address (‘Gu’ level) and individual covariate data
     - Random assignment of addresses within each lowest administrative unit proportional to population density

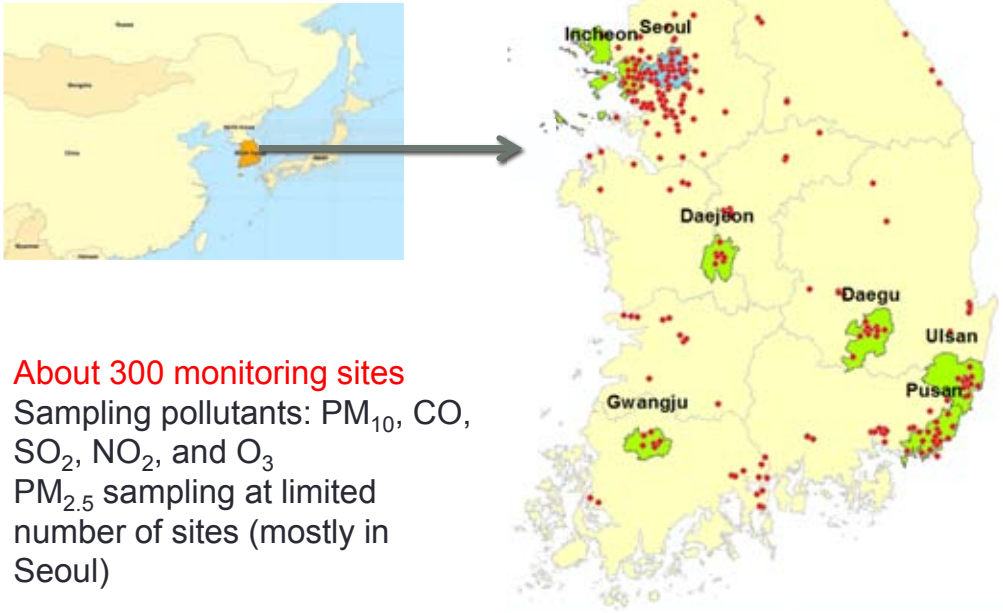
  2) Korean health insurance cohort
     - Outcome: mortality, disease incidence
     - Limited address (‘Gu’ level) and individual covariate data

- Project-based cohort

OUTLINE

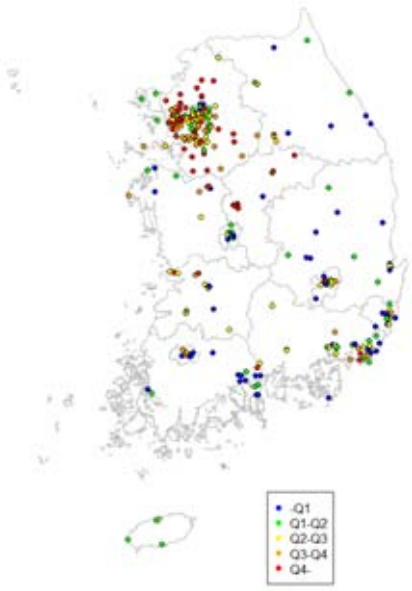
- Association between fine particulate matter ($PM_{2.5}$) components and cardiovascular health in the Multi-Ethnic Study of Atherosclerosis
- Association between particulate matter (PM) air pollution and health in Korea
  - Study overview
  - Preliminary analysis

Maps of monitoring sites



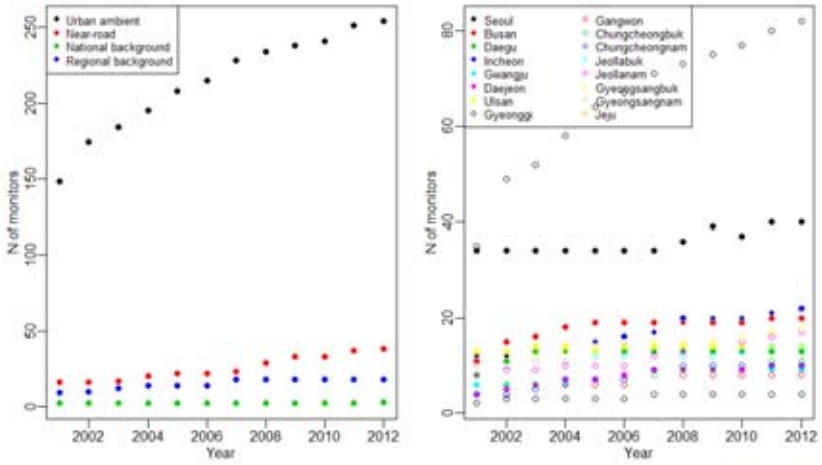
- About 300 monitoring sites
- Sampling pollutants: PM_{10}, CO, SO_2, NO_2, and O_3
- $PM_{2.5}$ sampling at limited number of sites (mostly in Seoul)

PM_{10} monitoring sites (283) in South Korea



- Higher concentrations in Seoul, Incheon, and Gyeonggi province

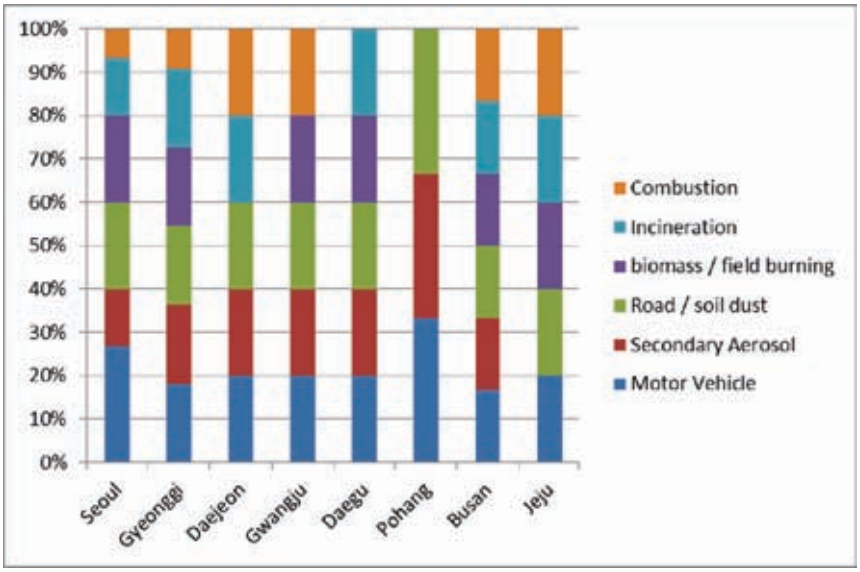
PM_{10} data exploration



Lee et al. *KOSEHT 2014 poster presentation*

- Available monitoring data since 2001
- Large number of sites for 2009-2012 than early years
- Four types of monitoring sites
- Much more sites in Seoul and Gyeonggi province

PM_{10} sources in Korea



Ryou et al. *KOSEHT 2014 poster presentation*

Geographical variables

Data category	Geographical variable	Data source
Traffic	Distance to closet road	Korea Transport Database (Korean Transport Institute)
	Sum of road lengths	
Transportation	Distances to subway and train stations, and bus stop	Statistics and Geography Database (National Statistical Office)
Population	Sum of population	Statistics and Geography Database
	Sum of households	
Demography	Sum of housing facilities by housing type	
	Sum of housing facilities by construction year	
	Sum of businesses by category	
	Sum of employees by business category	
Land use	Percent of each land use characteristics	Environment and Geography Database
Location	Coordinates	National Institute of Environmental Research
Geography	Distances to river and coastline	Statistics and Geography Database
NDVI	Annual summaries of MODIS images	Institute of Industrial Science, University of Tokyo
Elevation	Absolute and relative elevation	Statistics and Geography Database

Eum et al. *KOSEHT 2014 poster presentation*

Association between traffic and PM_{10}

Selected Variables	coefficients	p-value
The shortest distance from monitoring site to 101road	-0.0022496	0.005531 **
The shortest distance from monitoring site to 105road	-0.0011527	0.085740 .
The shortest distance from monitoring site to 106road	-0.0015758	0.010842 *
Sum of 103road length within buffer 5000m	0.0007587	6.12e-06 ***
Sum of 104road length within buffer 100m	0.0211769	0.007402 **
Sum of 104road length within buffer 300m	0.0053875	0.019543 *
Sum of 104road length within buffer 1000m	-0.0014849	3.70e-05 ***
Sum of 104road length within buffer 5000m	0.0001161	0.000172 ***
Sum of 107road length within buffer 5000m	-0.0003616	0.000877 ***
Sum of 108road length within buffer 100m	0.1333061	0.228813
Sum of 108road length within buffer 5000m	-0.0007295	3.46e-06 ***

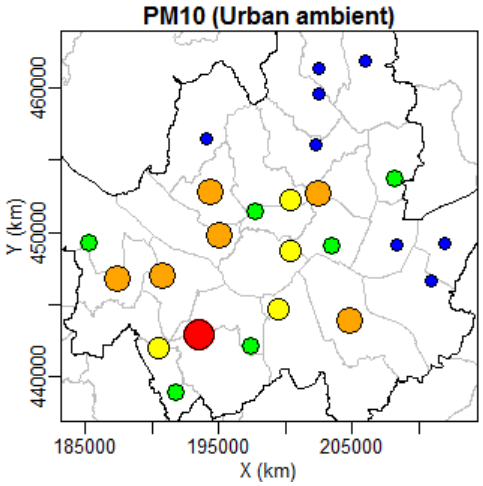
Choi et al. *KOSEHT 2014 poster presentation*

- 2010 PM10 averages
- Traffic variables: distance to the closet roads and sums of road lengths 25-5000 m buffers
- Variable selection based on stepwise method

Preliminary PM exposure model

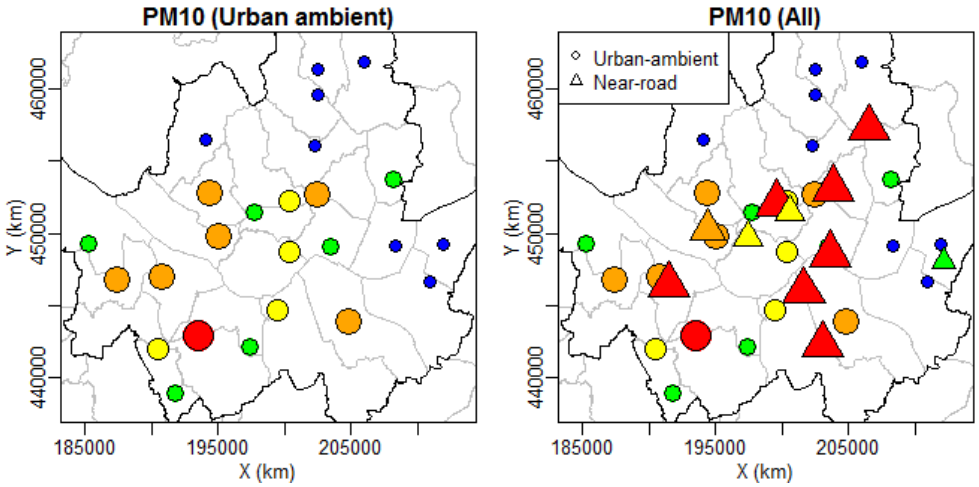
- Data
  - 2010 annual averages for PM_{10} and $PM_{2.5}$ in Seoul
  - Limited GIS variables: road network variables, population density, coordinates, and building height
- Variable selection using LASSO (15) and exhaustive search (5)
  - Mostly traffic variables in the final set
- Comparison between land use regression and universal kriging models

2010 PM_{10} annual averages in Seoul



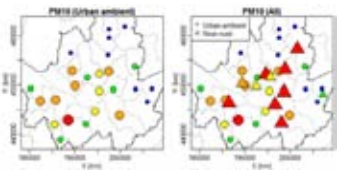
- One site in each district
- Higher concentrations in the western area of Seoul

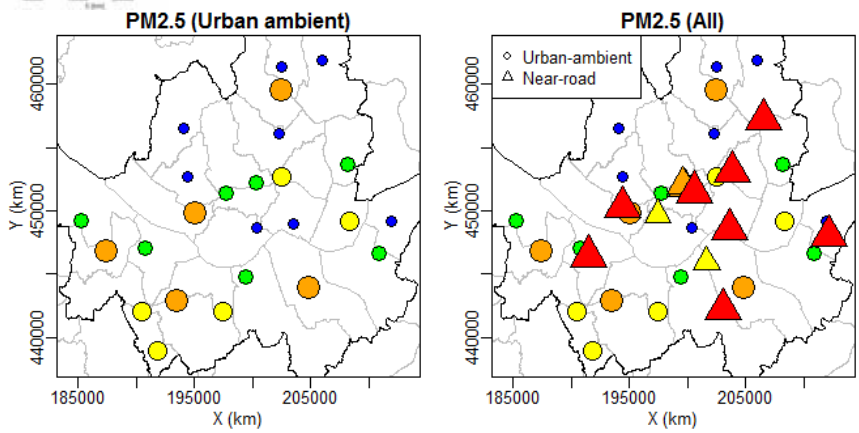
2010 PM_{10} annual averages in Seoul



- One site in each district
- Higher concentrations in the western area of Seoul
- Higher concentrations at near-road sites

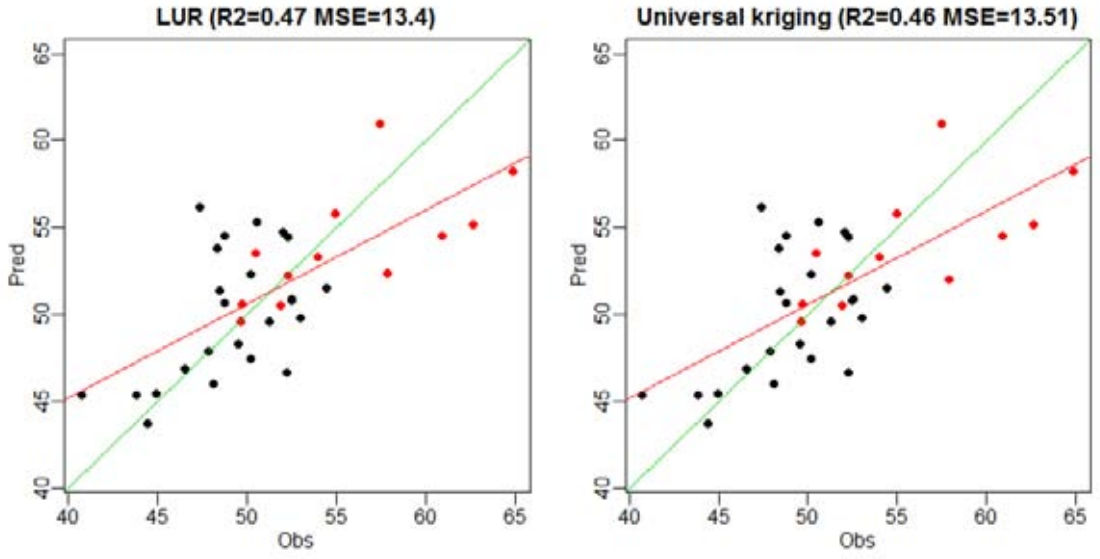
2010 $PM_{2.5}$ annual averages in Seoul





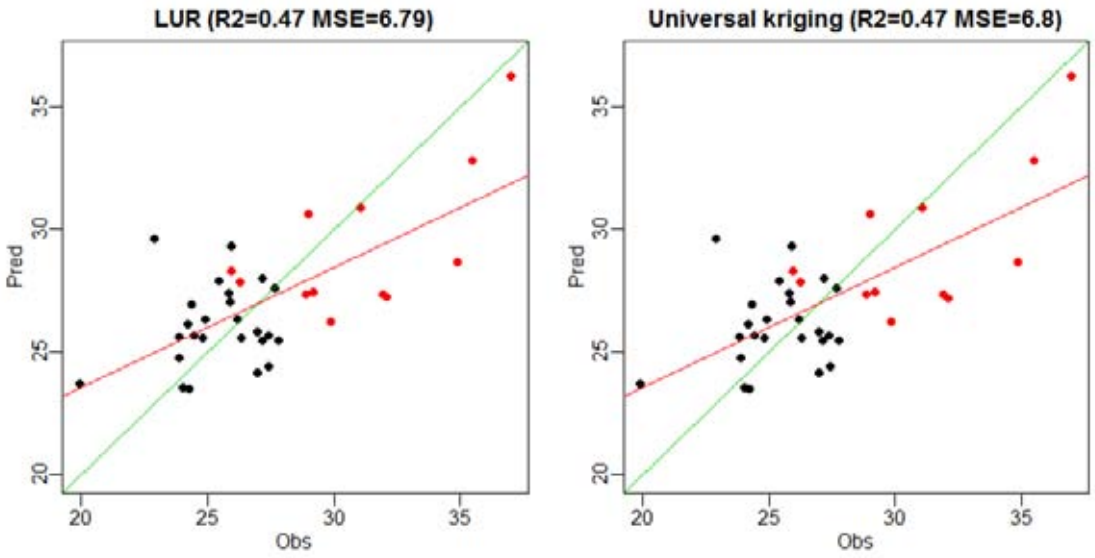
- Annual averages of hourly $PM_{2.5}$ measured by BAM
- Consistent trend of $PM_{2.5}$ with that of PM_{10}

LUR vs. universal kriging for PM_{10} in Seoul



- Moderate model performance
- Little contribution of kriging

LUR vs. universal kriging for $PM_{2.5}$ in Seoul



- Consistent results to those of PM_{10}

Summary and discussion

- Construction of geo-database
  - Progress in data acquisition and geographical variable computation
- Preliminary analysis
  - Less satisfying model performance of land use regression and universal kriging models using road-network and population variables in Seoul
- Future study
  - Inclusion of a large set of geographical variables
  - Application of modeling approaches to other areas and pollutants

Acknowledgements

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  - Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (900-20130078)