Advancements in Source-to-Dose Analysis of Population Exposures to Ozone

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by

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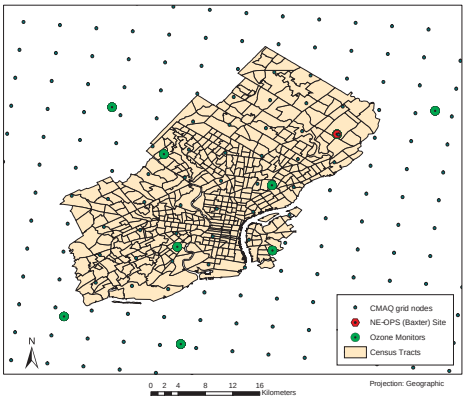
Modeling Steps in the MENTOR Source-to-Dose Analysis

Modeling ENvironment for TOtal Risk Studies (MENTOR) is an evolving open "support system" intended to facilitate consistent multiscale source-to-dose modeling of exposures to pollutants for individuals and populations

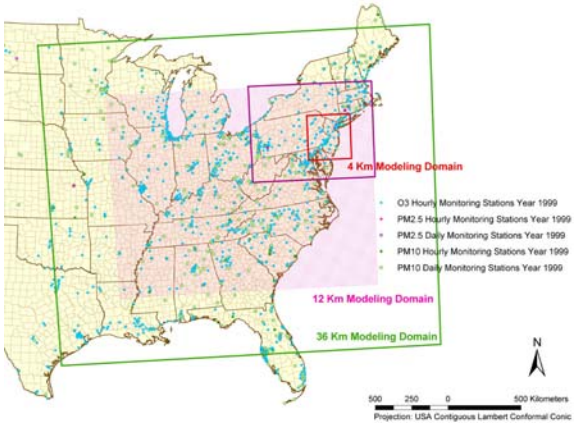
- Estimating regional ambient levels of ozone
  - Geostatistical analysis of fixed monitor data
  - Emission-based, regional air quality modeling (MM-5;SMOKE;Models-3/CMAQ)
- Linking regional ambient levels to local outdoor levels through spatiotemporal interpolation using Spatio-Temporal Random Fields (STRF) and Bayesian Maximum Entropy (BME) methods
- Population exposure and dosimetry modeling using Stochastic Human Exposure and Dose Simulation System (SHEDS)

The MENTOR Urban Philadelphia Case Study



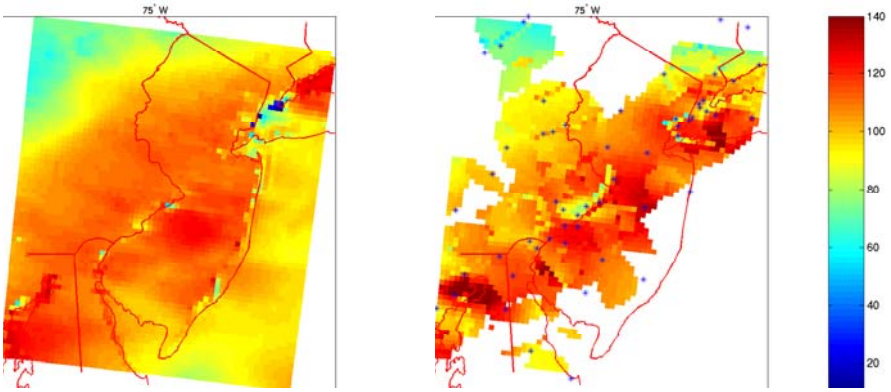
- The case study focuses on a two-week episode between 11 July 1999 and 24 July 1999
- 482 census tracts were selected in urban Philadelphia. Selection of the census tracts was based on population density and housing characteristics
- 1990 Census data were used to obtain demographic and housing characteristics

Domain for Regional Meteorological and Air Quality Modeling



- The modeling study used one-way nested grids with resolution of 36 km, 12 km, and 4km
- Outermost grid domain corresponds to the Ozone Transport and Assessment Group (OTAG) domain
- 14 layers in the vertical direction were used

Comparison of CMAQ O_3 Predictions to Observed Concentrations



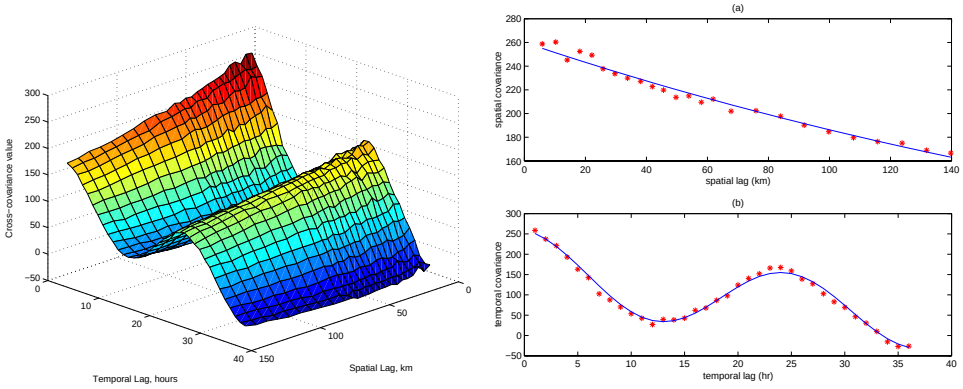
O_3 concentrations (ppb) at 1:00 PM EDT, 19 July 1999:

(left) CMAQ predictions for 4 km resolution domain,
(right) Observed Concentrations interpolated using STRF method

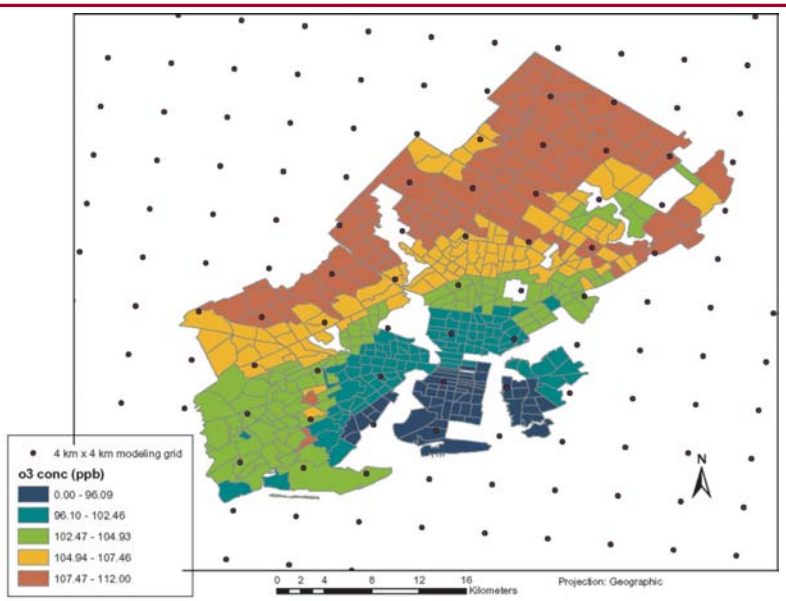
Spatiotemporal Interpolation for Obtaining Census-Tract Level Outdoor Concentrations

- The "Spatio-Temporal Random Field" (STRF) approach interpolates modeling output or monitor data in both space and time simultaneously
- The "Bayesian Maximum Entropy" (BME) method uses prior information of hard data (measurements or modeling outputs), probability law descriptions, interval information, and physical laws

Coavariance Analysis of CMAQ O_3 Predictions



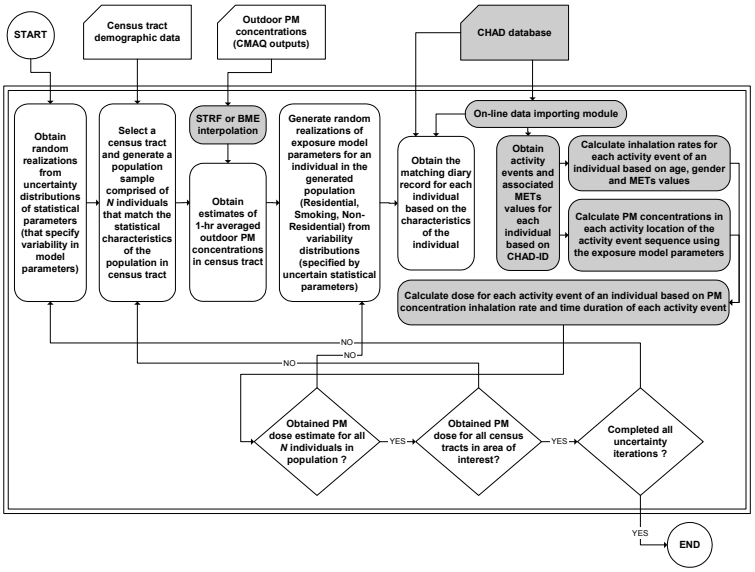
Interpolated O_3 Outdoor Concentrations for 482 Census Tracts in Urban Philadelphia for 1:00 PM EDT, 19 July 1999 (using the STRF method)



Structure of MENTOR-SHEDS Module

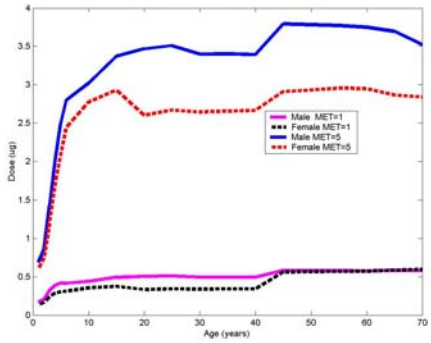
- Estimation of ozone levels in microenvironments
  - Observed indoor/outdoor relationships
  - Microenvironmental modeling through mass-balance model
- Activity event sequences for each member of the sample population
  - Matching CHAD database with essential demographics
  - Study-specific information
- Calculation of appropriate inhalation rates for the members of the sample population
- Combination of inhalation rates and microenvironmental concentrations for each activity event to assess exposures
- Aggregation of exposure estimates over time scales characterizing the exposure metric of concern

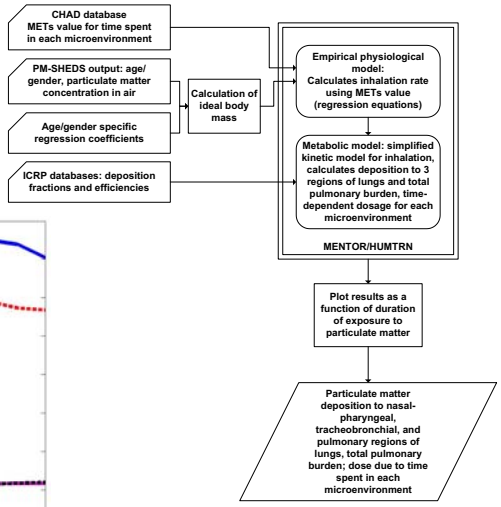
Flow-Chart of MENTOR-SHEDS Module



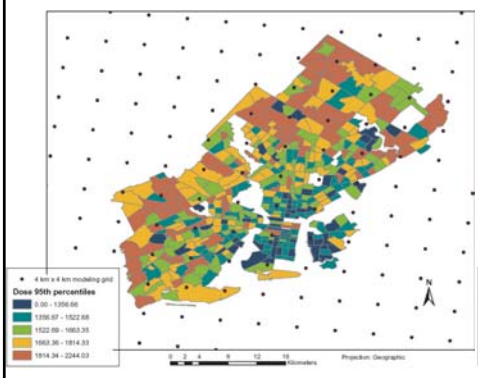
Inhalation Dosimetry in MENTOR-SHEDS

Level C: Semiempirical (Population-Oriented) Module

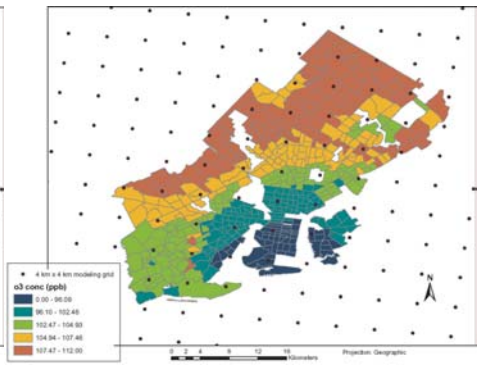




Comparison of 24 Hour Aggregated O_3 Doses from Time Spent Outdoors with Interpolated Outdoor O_3 Concentrations

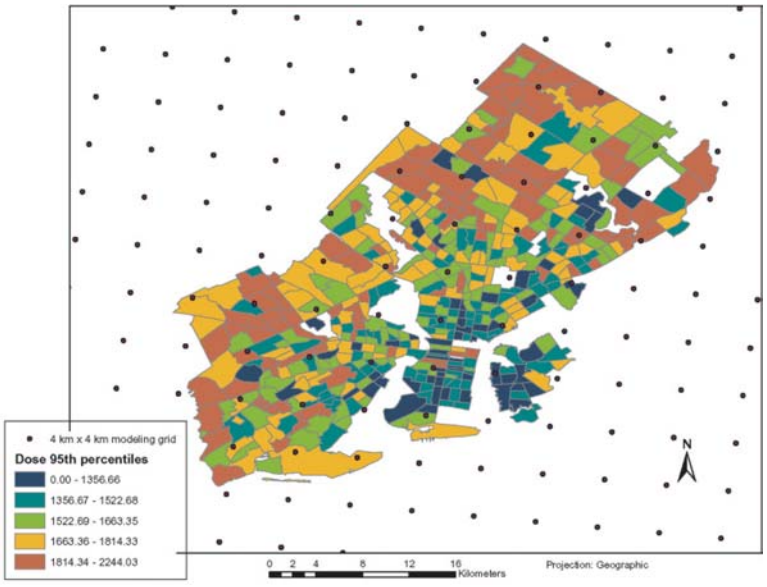


95th percentiles of 24 hour aggregated O3 doses from time spent outdoors for 19 July 1999

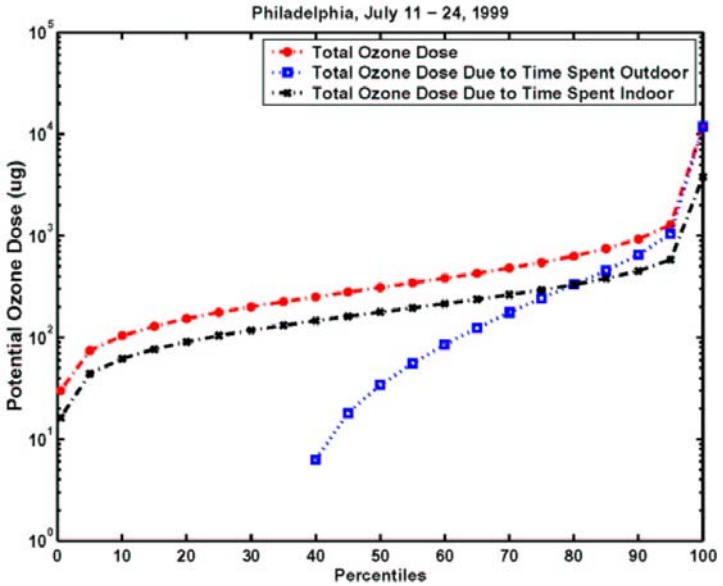


Interpolated O3 outdoor concentrations by using the STRF method for 1:00 PM EDT, 19 July 1999

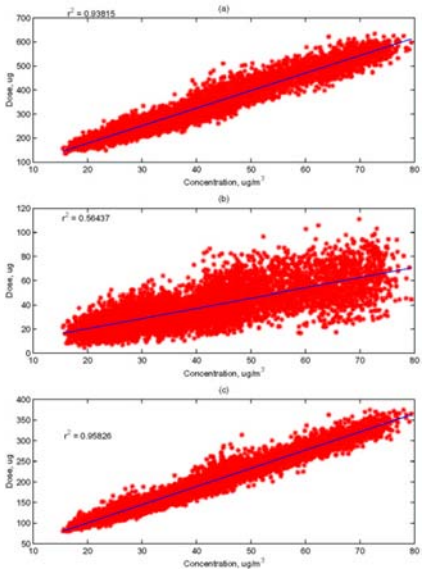
95th Percentiles of 24 Hour Aggregated Total O_3 Doses for 19 July 1999 (based on CMAQ outputs and STRF interpolation)



Cumulative Distribution of O_3 Doses for 482 Census Tracts in Philadelphia



Regression Between 50th Percentiles of O_3 Doses and Outdoor Concentrations for 482 Census Tract Data in Philadelphia

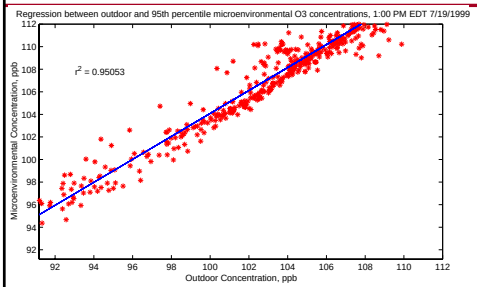


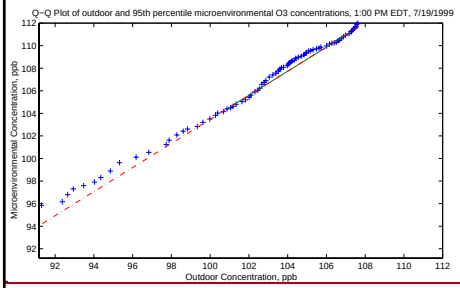
(a) total doses vs. outdoor concentrations

(b) doses from time spent outdoors vs. outdoor concentrations

(c) doses from time spent indoors vs. outdoor concentrations

Relationship between CMAQ Predictions and Microenvironmental Concentrations





O_3 outdoor concentrations (ppb) interpolated from CMAQ predictions for 1:00 PM EDT, 19 July 1999 and the 95th percentiles of corresponding O_3 microenvironmental concentrations (ppb) computed using MENTOR-SHEDS.

(top) Regression (r^2 = 0.95)

(bottom) Q-Q plot

Ongoing Work

- Incorporation of results from studies conducted by UPA collaborators into the MENTOR-SHEDS framework
- Use of geostatistical methods for investigation of co-occurrence of ozone and PM outdoor concentrations and exposures
- Investigation of vulnerability of areas with a high proportion of physically vulnerable or economically disadvantaged sub-populations
- Extension of SHEDS to incorporate commuting patterns
- Development of a GUI interface for SHEDS

Acknowledgments

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