Abstract 681, Paris 2006 ISEA-ISEE Conference

Spatial Analysis Of Air Pollution And Development Of A Land-Use Regression Model In An Urban Airshed

Shaibal Mukerjee[1]*, Luther Smith[2], Xiaojuan Liao[2], Lucas Neas[3], Casson Stallings[2], and Mary Johnson[3]

[1]U.S. EPA/ORD/NERL E205-02, RTP, NC, USA; [2]Alion Science & Technology, Durham, NC, USA; [3]U.S. EPA/ORD/NHEERL, RTP, NC, USA

Introduction

All sampling in Detroit, Michigan, USA area during Summer 2005. Passive sampling of VOC & NO_2 at 25 local elementary (PK-6) schools in Detroit and Dearborn Public Schools. Sampling also done at 2 State of Michigan regulatory (reg) sites. This poster presents the exposure component of the EPA/ORD Detroit Children's Health Study (DCHS). Overall spatial assessment & development of land-use regression (LUR) model will be discussed. Approach based on spatial approach in El Paso Children's Health Study (Smith et al., *Atmos Environ* **40** (2006) 3773-3787).

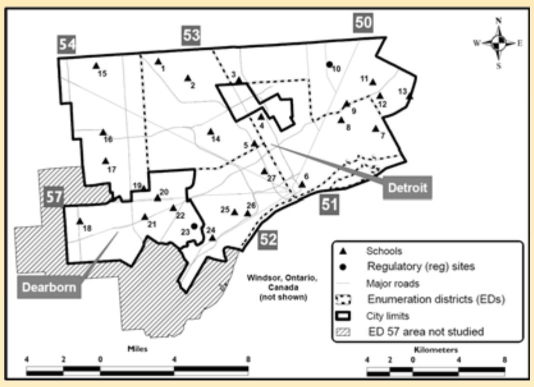
Methods

- VOCs: Carbopack X sorbent thermal desorption tubes (Supelco) (McClenny et al. *JEM* **8** (2006) 263-9)

- NO_2: Ogawa (Model 3300) (Mukerjee et al *JAWMA* **54** (2004) 307-19)

- Sampled 6 weeks during stable air masses & low winds
- Week-long sampling - mimic chronic exposures

Fig. 1. Schools and their Locations Relative to Enumeration Districts (EDs) in Detroit Area



Outline of Approach

1. Correlation analysis to determine ancillary (GIS) variables for prediction
2. Pattern analysis to select school sites
3. Comparison of EDs (first 2 digits of 2000 US Census tract number)
4. Comparison of regulatory (reg) sites with neighboring schools to assess representativeness of the regulatory sites for gaseous pollutants (**Fig.1**)
5. Development of LUR model for VOCs & NO_2

(Statistical programming in SAS® 8)

Potential Ancillary Variables

- Data from SE Michigan Council of Governments, National Center for Education Statistics, 2000 US Census, EPA TRI & NEI emissions inventories.
- Variable types (relative to schools) from GIS:
  - Distance (m) to nearest road of various traffic volumes (**Dist_90KP** = distance to road segment ≥ 90,000 cars/day)
  - Traffic intensity (vehicles per day/km) within set distances (**Int_1000** = intensity within 1000 m radius)
  - Housing unit density (units/km^2 in census block)
  - Population density (people/km^2 in census block; **Pop_Den500** = population density from census tract(s) within 500 m)
  - Distance (m) to large VOC, $PM_{2.5}$, Manganese point sources (**VOC_Big_Dist, PM25_Big_Dist, Mn_Big_Dist** – respectively)
  - Distance (m) to nearest **Border** X-ing

Choice of Variables & Selection of Schools for Monitoring

- Correlation analysis:
  - Same correlation structure desired for monitored & un-monitored schools
  - Avoided strong correlation among chosen ancillary variables
- Potential ancillary variables chosen:
  - Dist_50KP
  - Dist_90KP
  - Int_1000
  - Pop_Den500
  - VOC_Big_Dist
  - PM25_Big_Dist
  - Mn_Big_Dist
  - Distance to Border X-ing
- Schools chosen (see **Fig. 1**) based on their ancillary variables (above) and had to be representative of study area; 4 to 5 schools selected per ED

ED & Regulatory (reg)/School Comparisons of Air Pollutants

- ED Comparison Tests (5% level)
  - Overall Kruskal-Wallis test
  - Pairwise multiple comparisons (analogous to t-test) - Modified Dunn's test (Dunn *Technometrics* **6** (1964) 241-252)
- Reg/School Comparisons
  - Comparison of regulatory site data to corresponding range of school data
  - Dixon's r_{10} ratio (5% level) (Dixon *Ann Math Stat* **21** (1950) 488-506; **22** (1951) 68-78)

Results

- Based on distance & traffic intensity values, 25 schools chosen were generally representative of variability of study area & their ED.
- Similar correlation structure among ancillary variables between monitored & remaining schools.

Overall Spatial Analysis of Air Pollution Data from Chosen Schools

- Overall & pairwise comparisons of EDs suggested only NO_2 showed coarse spatial difference.
- For NO_2, ED 52 (high traffic/industrial impacted area) significantly higher than ED 54 (residential area) – see **Fig. 2**.

Fig. 2. Median Values of NO_2, Total BTEX, & Styrene Over All Schools and By Each ED

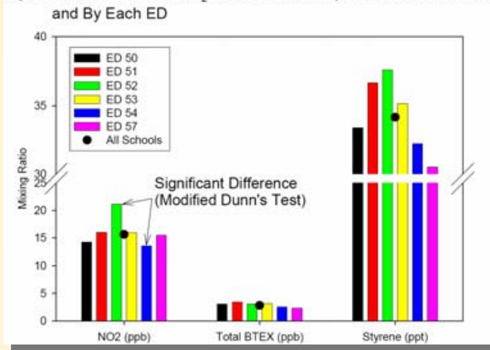
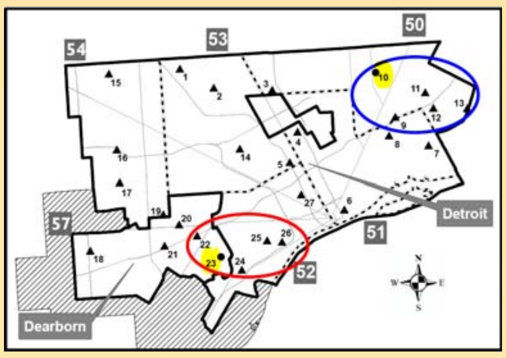


Fig. 4 – Comparison of NO_2 & VOCs from reg sites (yellowed) and respective schools (red and blue regions). Pollutants at reg sites within range of their schools. If outside of range, no significant difference (Dixon's r_{10} ratio, 5% level).



Initial Regression Results

- Natural log transformation applied for all pollutant and some ancillary variables.
- Only ancillary variables that behaved linearly used.
- Weighted regressions used.

Table 1. Initial regression models. Only significant (5% level) coefficients reported.

Pollutant	Intercept	Dist_50KP	Dist_90KP	Int_1000	Pop_Den500	VOC_Big_Dist	PM25_Big_Dist	Mn_Big_Dist	Border	R^{2*} (%)
Ln NO_2	4.43	-.052 (Ln)**	.023 (Ln)				-.095 (Ln)	-0.082 (Ln)	-1.5 x10^{-5}	82
Ln Benzene	6.23	-5.04 x10^{-5}			5.99 x10^{-5}			-3.8 x10^{-5}	1.23 x10^{-5}	43
Ln Toluene	7.42							-4.17 x10^{-5}	1.92 x10^{-5}	31
Ln Ethyl benzene	10.0							-.458 (Ln)	1.79 x10^{-5}	63
Ln o-xylene	6		-2.34 x10^{-5}		.239 (Ln)		.092 (Ln)	-.345 (Ln)		60
Ln m,p-xylene	8.43	-1 x10^{-4}	-2.81 x10^{-5}	-1.51 x10^{-6}			.166 (Ln)	-.215 (Ln)		55
Ln 1,3-butadiene	4.56				1 x10^{-4}			-2.95 x10^{-5}		43
Ln Styrene	3.75		-2.47 x10^{-5}					-2.03 x10^{-5}		43

*R^2 from original scale; ** Ln=natural logarithm of variable

Discussion

Overall spatial analysis results suggested mobile source effect throughout study area for VOCs. Only NO_2 exhibited coarse spatial difference between traffic/industrial-dominated city district versus a more residential district (see **Fig. 2**). In this study, regulatory sites were representative of neighboring locations (see **Fig. 3**).

Regressions (in **Table 1**) were not as successful as hoped *a priori*. Highest R^2 values obtained for NO_2. The relatively poor R^2 values (and the overall spatial results) may be due to the fact that the hourly winds were found to be blowing in roughly equal proportions from each compass quadrant during each week of the study. Winds were almost always light to calm for the entire six-week period. Thus, the sites were subjected to multiple influences for every measurement period. Siting issues may have also contributed to these findings.

Collinearity present in some of the regressions; suggested by coefficient values and collinearity diagnostics. Next efforts will address collinearity and cross-validation will be applied to the final predictive equations.

Based on above tabulated results, traffic influences were important predictor variables for the Detroit/Dearborn area. In El Paso, traffic intensity (Int_1000) was only important for predicting NO_2 (Smith et al., *Atmos Environ* **40** (2006) 3773-3787). In addition, distance from border crossing showed a consistent decline with increasing distance in El Paso; in Detroit, this was only the case for NO_2. These preliminary findings from the Detroit area suggest possible local differences should be factored in when attempting to derive common exposure metrics from data collected in different urban air sheds.

Suggestions for Future Research

- Additional monitoring to assess seasonal variability
- Additional monitoring for PM probably would indicate better local spatial variability
- Epidemiological study relating results to health data pending

Acknowledgements and Disclaimer – We thank Felicia Venable, Mathew Sam, and Priscilla Morris of the Detroit Public Schools Department of Environmental Health & Safety and Don Ball of Dearborn Public Schools as well as school principals and staff for access to the schools. We also thank the technical support of Dr. Hunter Daughtrey, Karen Oliver, Herb Jacumin, Chris Fortune, Mike Wheeler, and Dennis Williams all from Alion Science and Technology. The United States Environmental Protection Agency through its Office of Research and Development funded and managed the research described here under contract EP-D-05-065 to Alion Science and Technology, Inc. It has been subjected to Agency review and approved for publication.