

# **Geospatial Associations of Air Pollutants and Asthma in Detroit and Windsor: The GeoDHOC Investigation**

**CURES New Perspectives Symposium:  
Addressing the Asthma and Allergy Epidemics**

**October 7, 2015**

**Lawrence D. Lemke**

**Department of Geology / Environmental Science Program**



# Acknowledgments

## Research Funding and In-kind Support:

- Wayne State University
- University of Windsor
- Health Canada
- Henry Ford Health System
- W.K. Kellogg Foundation
- Detroit Medical Center



## Essential Support:

- City of Detroit
- City of Windsor
- Great Lakes Institute for Environmental Research
- Michigan Department of Environmental Quality





# Presentation Outline

1. GeoDHOC project overview / study design

2. Summary of results in Detroit and Windsor

- Air sampling
- Air quality modeling
- Asthma associations

3. Present GeoDHOC initiatives

- Spatio-temporal air quality modeling in Detroit
- Birth outcome associations

# Urban Air Quality and Health

*Is our health  
connected to the air  
we breath?*

*Does air quality vary  
in different parts  
of a city?*

*Are some  
neighborhoods  
more vulnerable  
than others?*



USEPA My Air My Health

## GeoDHOC

**Geospatial  
Determinants of  
Health Outcomes  
Consortium**

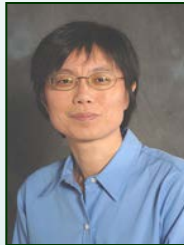


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# The GeoDHOC Team

*Geospatial Determinants of Health Outcomes Consortium*

**Team 1**  
**Air Sampling and  
Environmental  
Modeling**



Xu



Lemke



Graniero

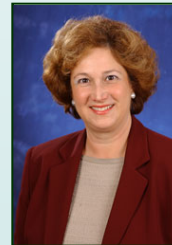
**Team 2**  
**Epidemiology  
and Health  
Outcomes**



Weglicki



Lamereto



Krouse



Raymond



Villeneuve



Reiners

**Team 3**  
**Data Integration  
and Geospatial  
Modeling**



Booza



Grgicak-Manion



Krajenta



# Detroit and Windsor share the same airshed...

...but have different:

- population demographics
- environmental regulations
- health care systems

Detroit

Windsor

## 2008 Pilot Study:

*Develop geospatial models to relate air quality and asthma in Detroit and Windsor.*





# Simultaneous Air Sampling

*September 2008 and June 2009*

- $\text{NO}_2$ ,  $\text{SO}_2$
- 26 Volatile Organic Compounds (VOCs)
  - BTEX, paint thinners, dry cleaning solvents
- 23 Polycyclic Aromatic Hydrocarbons (PAHs)
  - Anthracene c1ccc2cc3ccccc2c13
- Particulate Matter ( $\text{PM}_1$ ,  $\text{PM}_{2.5}$ ,  $\text{PM}_{10}$ )



# Two types of samplers

*PM and PAHs*



*NO<sub>2</sub> SO<sub>2</sub> and VOCs*



SAMPLER TYPE	Total	Detroit	Windsor
Passive Only	50	34	16
Active + Passive	50	34	16
TOTAL Locations	100	68	32



# Sampler Locations

## Key Considerations:

- **Geographic Distribution**
- **Prioritization** (land use, population density, prior AQ models)
- **Security**

**Detroit**

**Windsor**

**3x3 km grid**







# 2008 Air Sampling Campaign Sept 5-20, 2008

Question: How do you deploy 100 samplers  
across two cities in two days?



Answer: 20 Undergrads and 2 Grad Students from Geology,  
Environmental Science, and Civil & Environmental Engineering



# Training: SOP Manual

## TECHNICIAN MANUAL

### Detroit-Windsor Air Quality Study Spring 2009

By  
University of Windsor  
Health Canada  
Wayne State University  
May 2009

Revised May 22, 2009

#### Based on INSTRUCTIONS BY

1. SOP of Spatial Monitoring, 2005, Health Canada, Ottawa, ON, Canada
2. NO, NO<sub>2</sub>, NO<sub>x</sub> and SO<sub>2</sub> Sampling Protocol Using The Ogawa Sampler, Ogawa & Co., USA, Inc. <http://www.ogawausa.com/Protocol%20NO-NOx%20NO2%20SO2%20v.06.pdf>, Accessed July 2008.
3. 3M™ Organic Vapor Monitor 3500, 3510, 3520 or 3530. 3M Co. <http://multimedia.3m.com/mwa/mediaevalserver/656666/UuZieFSLXTnX&tNmM6EVnOEcuZgVt6EVv6E666666...>, Accessed July 2008.

1

## 5.0 Setup: Passive Samplers

Each passive sampler consists of a stainless steel rain shelter and a bracket. Rain shelters can also be attached to the outside of an active sampler case without using a bracket.

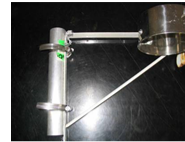


Figure 16. Passive only sampling unit

### 5.1 Installing passive only shelters

- 1) Park legally in a safe location that will not interfere with traffic flow.
- 2) Determine the most appropriate place and orientation to mount the shelter. Consider such issues as: overhanging trees, interference or vandalism, nearby parking lots, gas stations, dry cleaning shops, paint shops, and other factories.
- 3) Set up your ladder on even ground. Have someone hold the ladder securely in place while you attach the shelter 3m (8-10 feet) off the ground using hose clamps or zip ties. Never stand or climb onto the uppermost two rungs of your ladder.
- 4) Try to orient the bracket so that it runs parallel to the street or sidewalk. This will minimize its visibility to passersby.

### 5.2 Installing passive monitors

#### Ogawa Badge

- 1) The Ogawa badges are kept in a plastic Ziploc bag inside a brown plastic vial. The sampler itself is two-sided – it contains one NO<sub>x</sub> and one SO<sub>2</sub> filter loaded on opposite sides. Labels for both the NO<sub>x</sub> and one SO<sub>2</sub> filters will be affixed to the outside of the plastic bag.
- 2) Open the vial and remove the plastic bag. Remove one of each type of label from the plastic bag and affix it to the log sheet.
- 3) Remove the Ogawa sampler from the plastic bag. Gloves are not necessary for this procedure. DO NOT TOUCH THE DIFFUSER (the sides with many tiny holes). The moment the sampler is removed from the plastic bag is the start time of the sampling period. Record the time in military format to the nearest minute on the log sheet.



Figure 17. Ogawa NO<sub>x</sub>/SO<sub>2</sub> filter packaging

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## 4.5 Installing an active sampler on tripod

- o Assemble the tripod on wooden footings at a height of approximately 1.25 meters (4 feet) securing the base with rope to prevent the legs from spreading further than the desired angle.



Figure 14. Active tripod setup with rope and wooden footings

- o Assemble the mounting bracket hardware.
- o Bolt the mounting bracket to the tripod and attach the sampling unit to the mounting bracket as shown.



Figure 15. Mounting bracket hardware and assembly process for tripod setup

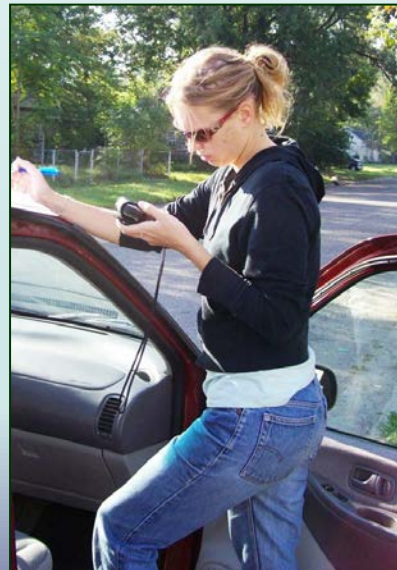
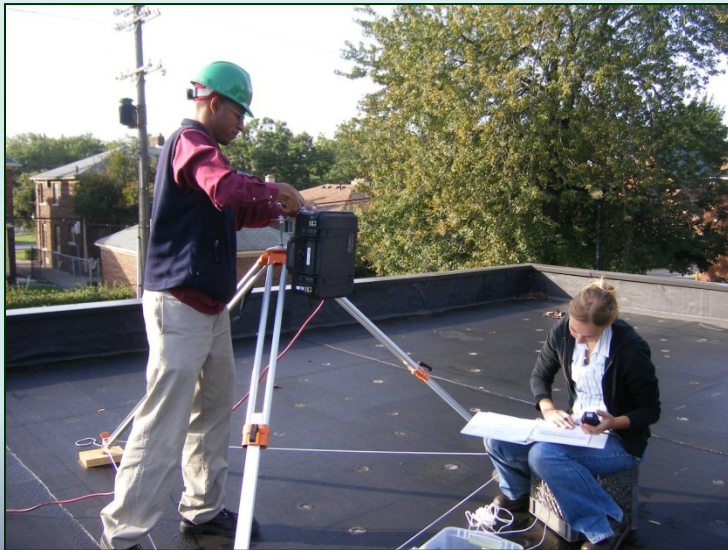
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# Air Sampling - Training





# Air Sampling - Deployment





# Air Sampling - Retrieval



# Completed Log Sheet

Page 1 of 2

WSU/UW Air Quality Study Summer 2008

## LOG SHEET: PASSIVE

Site ID: D-A-26 Start Date (dd/mm/yyyy): 05/09/2008

Operator's initials Setup: RJ Takedown: 19/09/2008

Coordinates Setup	GPS Unit ID No: 1 Waypoint ID: <u>D-A-26-1</u>	UTM Coordinates: <u>17 T 0330294</u> <u>4699581</u> Estimated Accuracy: <u>6.9</u>
Coordinates Takedown	GPS Unit ID No: 1 Waypoint ID: <u>D-A-26-2</u>	UTM Coordinates: <u>17 T 0330285</u> <u>4699579</u> Estimated Accuracy: <u>10.4</u>
Street Address	<u>18601 Ryan</u>	
Description*	<u>Located on a down spout on the NW corner of the fire station within the fenced in parking lot.</u>	

\*Describe exact location so that it could easily be found by another technician, and take a few pictures

### Ogawa Passive Sample

Pollutant	Label ID	Start Time* (hh:mm)	Stop Date (dd/mm/yyyy)	Stop Time* (hh:mm)	Comments:
NO <sub>2</sub>	DWS08-NO2-071	18:11	<u>19/09/2008</u>	<u>13:10</u>	<u>good condition</u>
SO <sub>2</sub>	DWS08-SO2-071	18:11	<u>19/09/2008</u>	<u>13:10</u>	<u>good condition</u>

### VOC Sample

Sample ID	Start Time* (hh:mm)	Stop Date (dd/mm/yyyy)	Stop Time* (hh:mm)	Comments:
DWS08-VOC-046	<u>18:09</u> <u>18:10</u>	<u>19/09/2008</u>	<u>13:11</u> <u>13:11</u>	<u>good condition</u> <u>good condition</u>

\* DWS08-VOC-019 10, 14:00

### Blank IDs (as applicable)

VOC	Ogawa NO <sub>2</sub>	Ogawa SO <sub>2</sub>
<u>NA</u>	<u>NA</u>	<u>NA</u>

Page 2 of 2

WSU/UW Air Quality Study Summer 2008

## LOG SHEET: ACTIVE

Site ID: D-A-26 Start Date (dd/mm/yyyy): 05/09/2008

Operator's initials Setup: RJ Takedown: 19/09/2008

Height above ground 9 feet Height above roof —

Case No.	Pump No.	Flow Meter No.	Start Time (hh:mm)	Pump Display Time (min)	Stop Time (hh:min)	Pump Display Time (min)	Stop Date (dd/mm/yyyy)	Flow Meter No.
<u>5</u>	<u>21029</u>	<u>FM-1</u>	<u>17:54</u>	<u>0</u>	<u>13:16</u>	<u>19882</u>	<u>19/09/2008</u>	<u>FM-1</u>

Pollutant	Label ID	Start Split Flow (LPM)				End Split Flow (LPM)	
		Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
PM (5 LPM)*	DWS08-PM1-029	<u>5.291</u>	<u>5.284</u>	<u>5.205</u>	<u>5.205</u>	<u>5.022</u>	<u>5.016</u>
	DWS08-PUF1-029						
	DWS08-PUF2-029						
PAH (2 LPM)*	DWS08-PAH-004	<u>1.947</u>	<u>1.948</u>	<u>2.026</u>	<u>2.032</u>	<u>1.960</u>	<u>1.959</u>

\* ideal flow rate. Actual flow rate can be ±5%

### Blank IDs (as applicable)

PM	PAHS
DWS08-PM1-031	<u>NA</u>
DWS08-PUF1-032	
DWS08-PUF2-031	

Comments:  
 Plymo vent located about 25ft from sampling unit.  
 Sampling unit located in a parking lot, so cars drive by frequently. Bay door for fire engines located just around the corner of the building. Incinerator located at school about a block away, NW from fire station.  
 Air conditioning unit located about 30ft from sampling unit. Could not get estimated accuracy below 6.9, even in front of building

19/09/2008 cigarette smoking was occurring near unit when we came for take down

# Lab Analyses & QA/QC

## Detroit-Windsor Summer 2008 Filter Analyses

Analysis	Laboratory	Location
VOC	AirZOne Inc.	Mississauga, Ontario
NO <sub>2</sub> /SO <sub>2</sub>	Environment Canada	Egbert, Ontario
PAH	AirZOne Inc.	Mississauga, Ontario
PM	Alberta Research Council	Vegreville, Alberta

Sampler Type	Deployed	Passed QA/QC
Passive	100	98 (98%)
Active	50	38 (76%)



## VOC Species Exclusion

Criteria: Exclude analytes with fewer than 80% of sample sites registered values above variable MDL.

VOC Analytes	% Count >MDL
1 Toluene	100
2 (m+p)-Xylene	100
3 Dichloromethane (DCM)	100
4 Benzene	99
5 Ethylbenzene	99
9 o-Xylene	99
6 Hexane	99
7 1,2,4-Trimethylbenzene	99
10 n-Decane	98
8 Trichloroethylene	97
12 1,3,5-Trimethylbenzene	97
11 Chloroform	90
13 Tetrachloroethylene	81
14 Naphthalene	80
<hr/>	
15 1,4-Dichlorobenzene	69
17 a-Pinene	59
16 d-Limonene	48
18 1,2-Dichloroethane	27
19 p-Cymene	3
20 Cumene	2
21 Styrene	0
22 1,1,2,2-Tetrachloroethane	0
23 Pentachloroethane	0
24 1,3-Dichlorobenzene	0
25 Hexachloroethane	0
26 1,2,4-Trichlorobenzene	0

Excluded Species

## PAH Species Exclusion

Criteria: Exclude analytes with fewer than 80% of sample sites registered values above variable MDL.

PAH Analytes	% >MDL
1 Anthracene	100
2 Fluoranthrene	100
3 Fluorene	100
4 Phenanthrene	100
5 Pyrene	100
6 Acenaphthene	97
7 ortho-Phenylphenol*	84
<hr/>	
8 Diazinon*	66
9 Chrysene	58
10 Acenaphthylene	50
11 Benz(a)anthracene	21
12 Chlorpyrifos (Dursban)*	21
13 Benz(k)fluoranthene	3
14 Benzo(b)fluoranthrene	3
15 Benzo(a)pyrene	0
16 Benzo(ghi)perylene	0
17 cis-Permethrin*	0
18 Dibenz(a,h)anthracene	0
19 Indeno(123-cd)pyrene	0
20 Piperonyl butoxide*	0
21 Propoxur (Baygon)*	0
22 trans-Permethrin*	0
23 Naphthalene**	0

Excluded Species

\*pesticide



# Acute Asthma Events in 2008

- Hospital Admissions + Emergency Room Visits
  - primary diagnosis of asthma
    - ICD9-CM codes (493.xx) or ICD-10 code (J45)
  - HFHS: approximately 2800 events
  - CIHI: approximately 650 events
    - Discharge Abstract Database (DAD) for hospital admissions,
    - National Ambulatory Care Reporting System (NACRS) for emergency department visits
- Geocoded by residential address
  - assigned to postal code area
  - stratified by age and gender

# Asthma Study Findings

1. Neighborhood scale variability of air pollutants in Detroit and Windsor

2. Asthma-Air Pollution Associations

- NO<sub>2</sub>, VOCs and PM<sub>10</sub> in Windsor
- BTEX and VOCs in Detroit

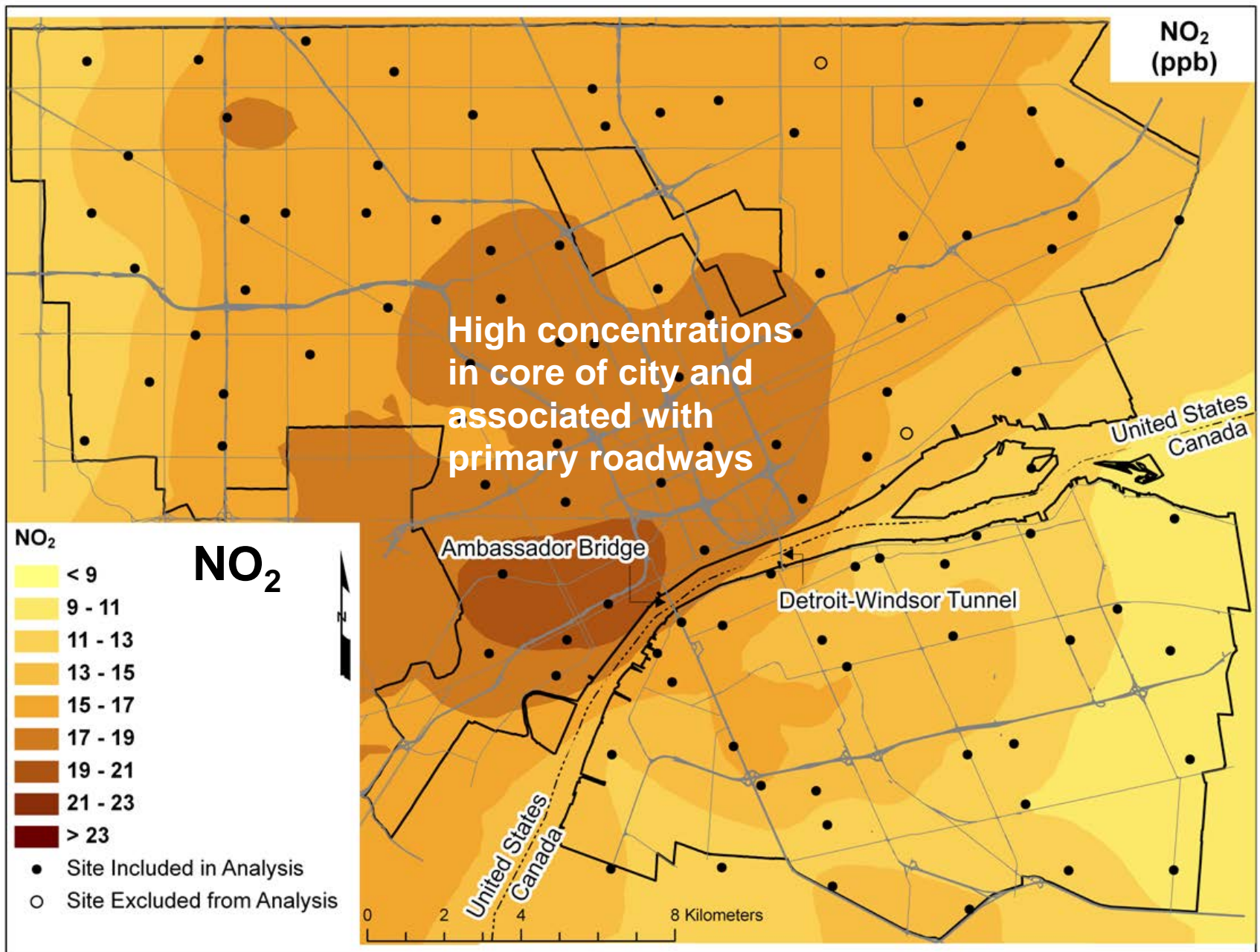
3. Population-normalized asthma events

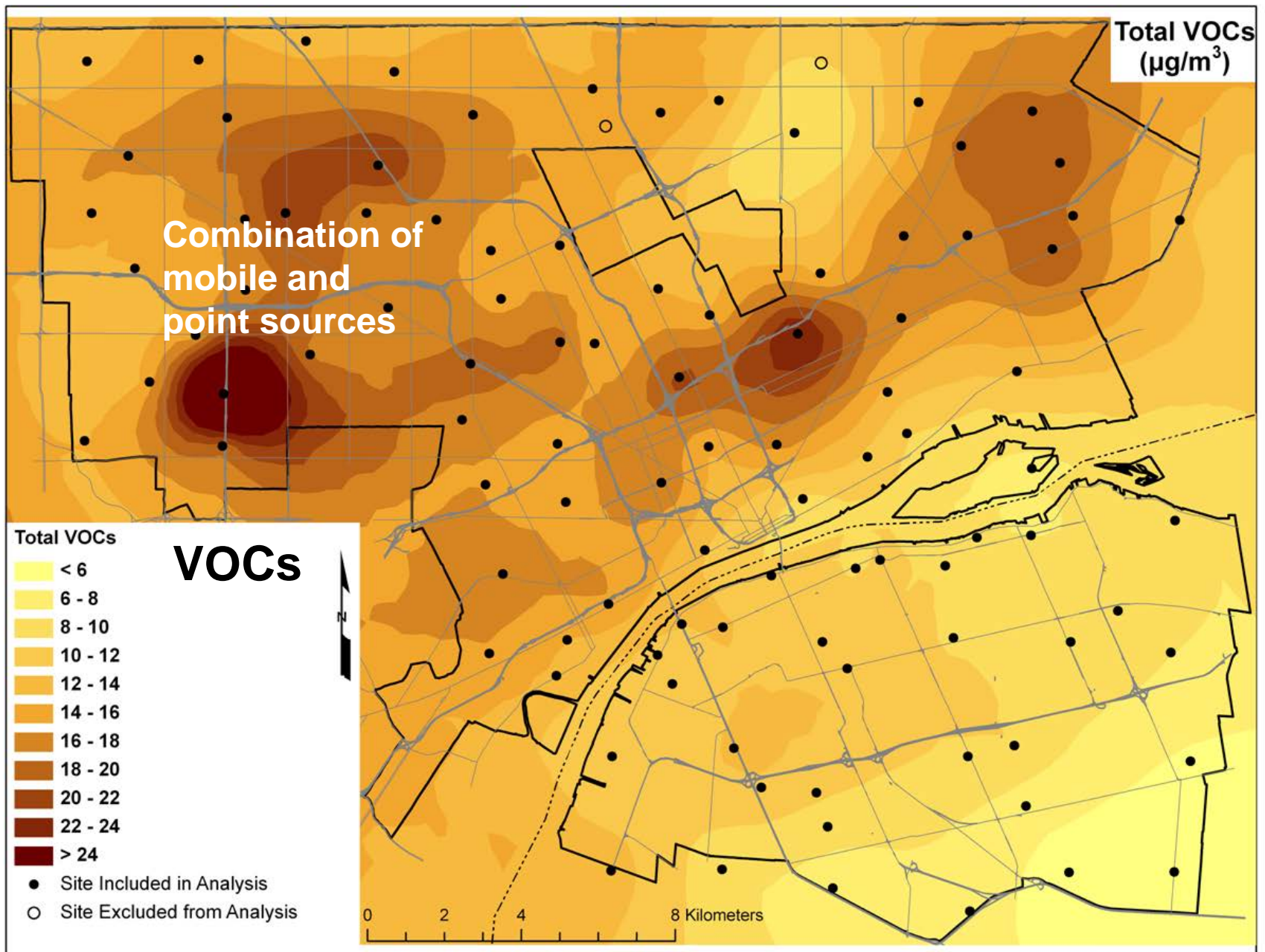
- Detroit ~ 10 times greater than Windsor

Miller et al., 2010, *Atmospheric Environment*

Lemke et al., 2013, *Journal of Exposure Science and Environmental Epidemiology*

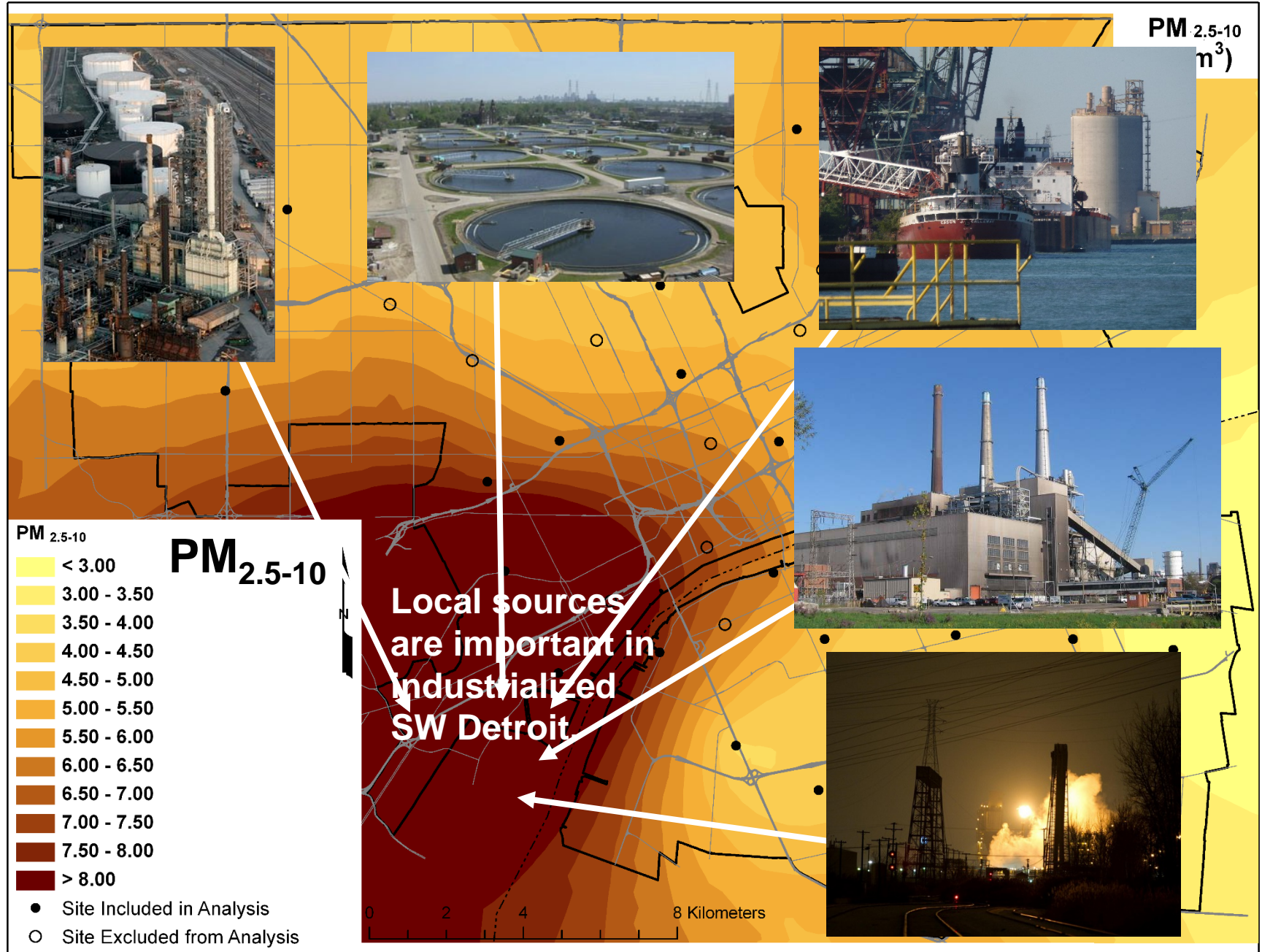








PM<sub>2.5-10</sub> (μg m<sup>-3</sup>)



PM<sub>2.5-10</sub>

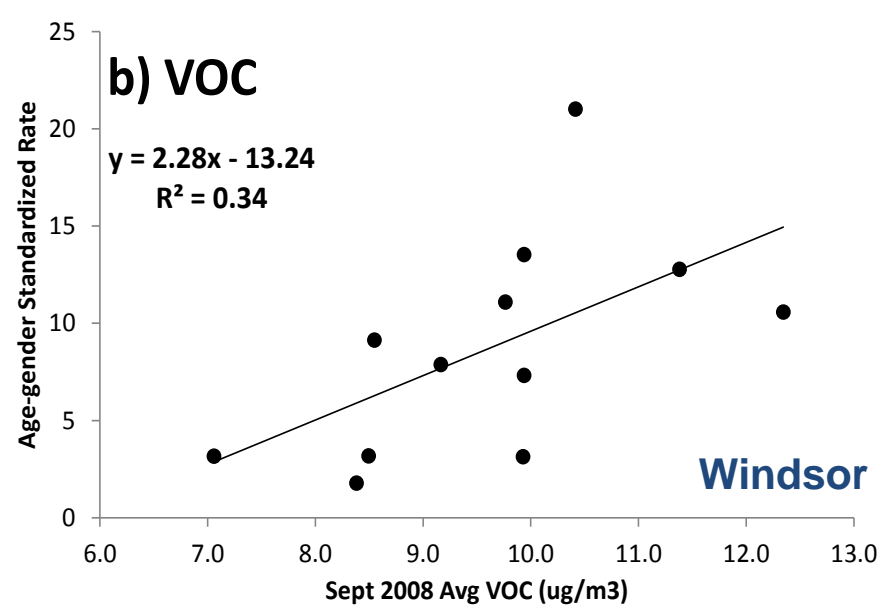
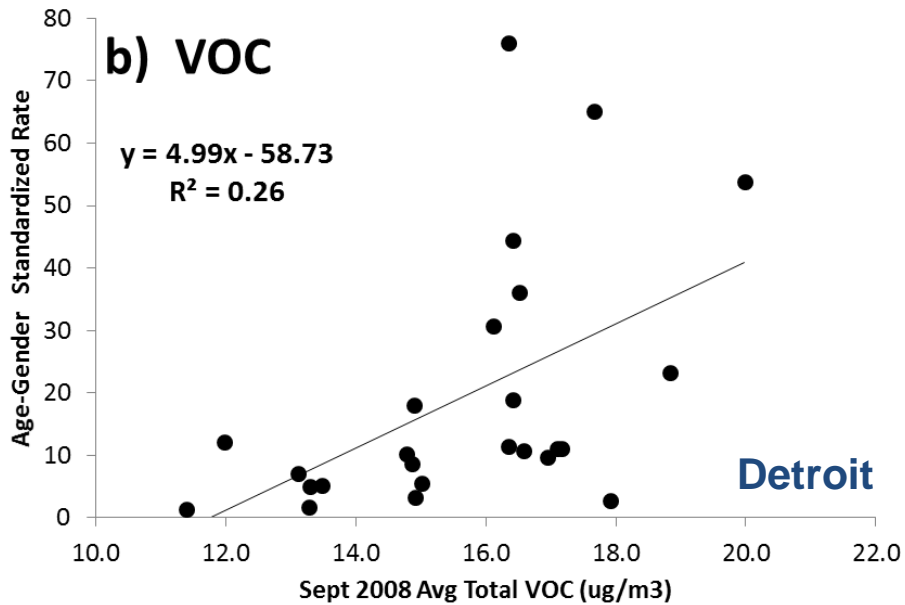
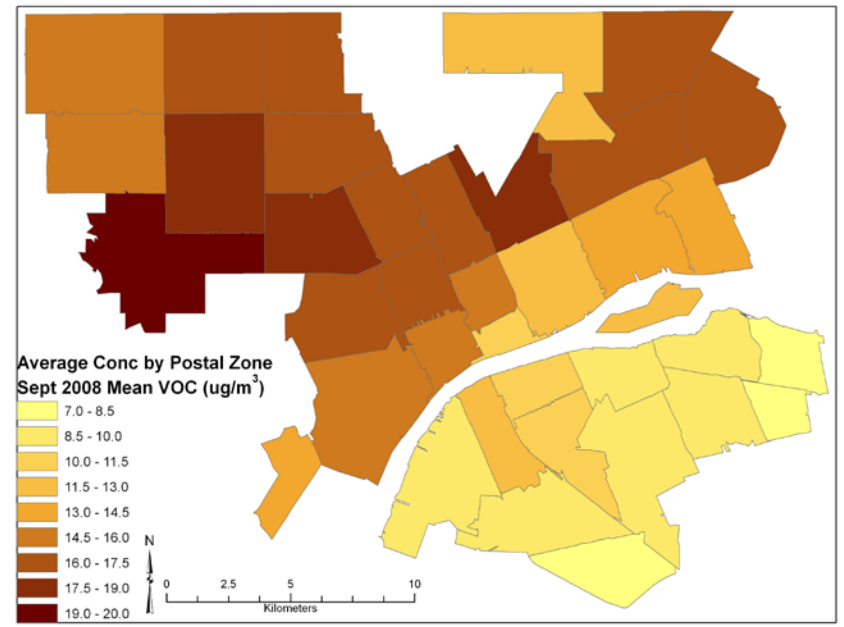
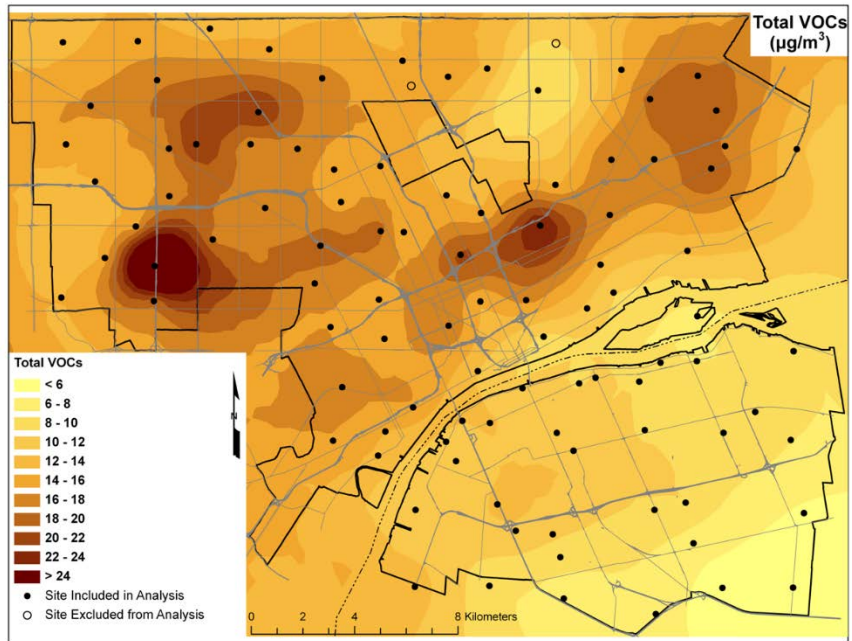
- < 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- 4.00 - 4.50
- 4.50 - 5.00
- 5.00 - 5.50
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- > 8.00

PM<sub>2.5-10</sub>

Local sources are important in industrialized SW Detroit

- Site Included in Analysis
- Site Excluded from Analysis

0 2 4 8 Kilometers





# Asthma Correlations

	Detroit			Windsor	
	r	p		r	p
NO <sub>2</sub>	0.17	0.40		<b>0.63</b>	<b>0.03</b>
BTEX	<b>0.53</b>	<b>0.01</b>		0.43	0.16
VOC	<b>0.51</b>	<b>0.01</b>		<b>0.58</b>	<b>0.05</b>
PAH	0.09	0.68		0.38	0.23
PM <sub>1</sub>	0.19	0.38		0.04	0.90
PM <sub>2.5</sub>	-0.04	0.84		0.31	0.33
PM <sub>10</sub>	0.000	1.00		<b>0.61</b>	<b>0.04</b>

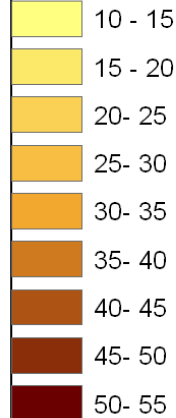
# Why are asthma exacerbations 10 times higher in Detroit?



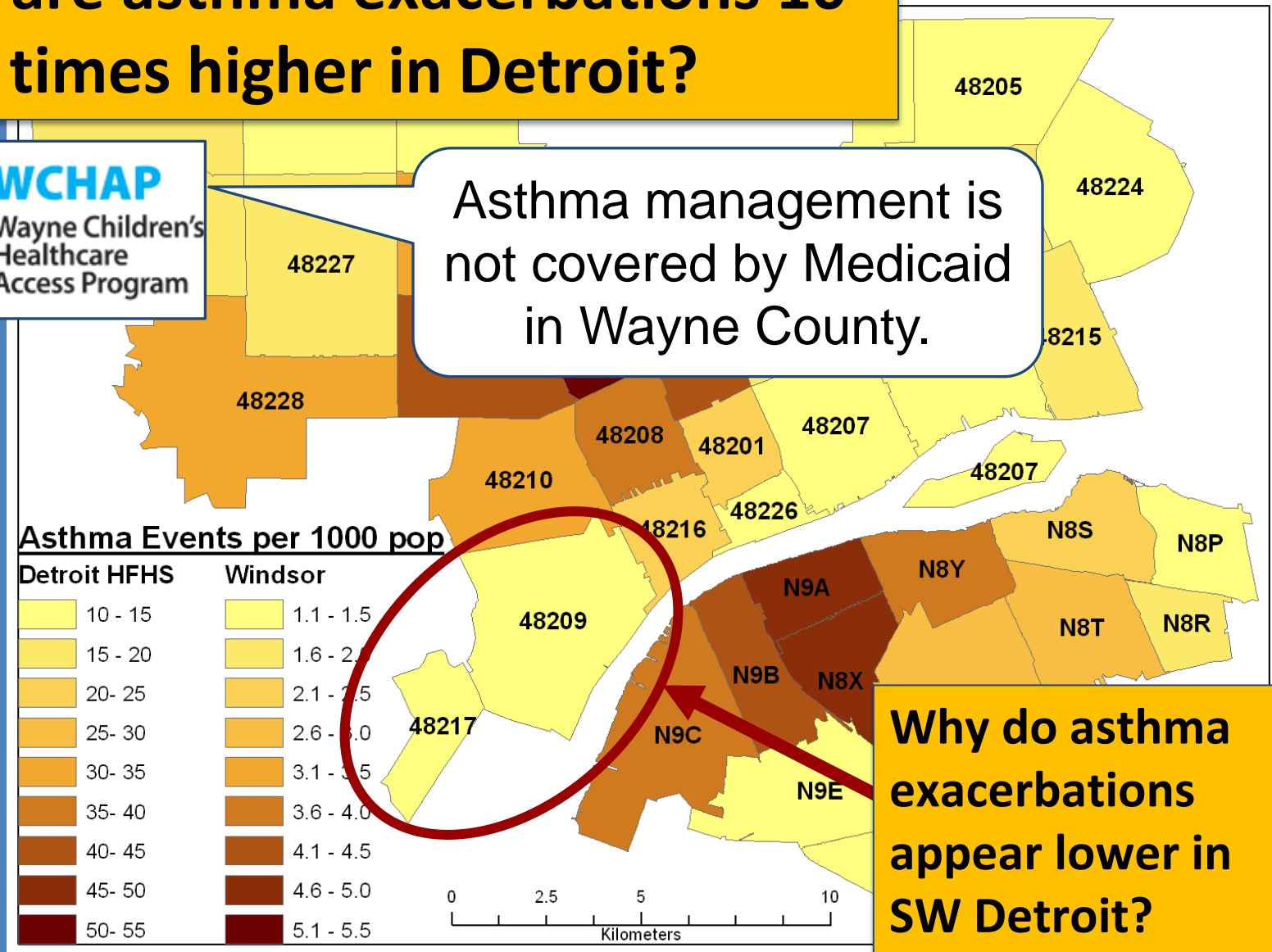
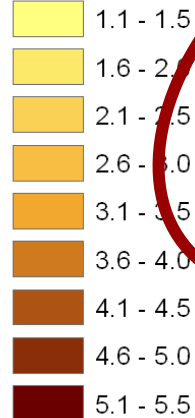
Asthma management is not covered by Medicaid in Wayne County.

## Asthma Events per 1000 pop

### Detroit HFHS

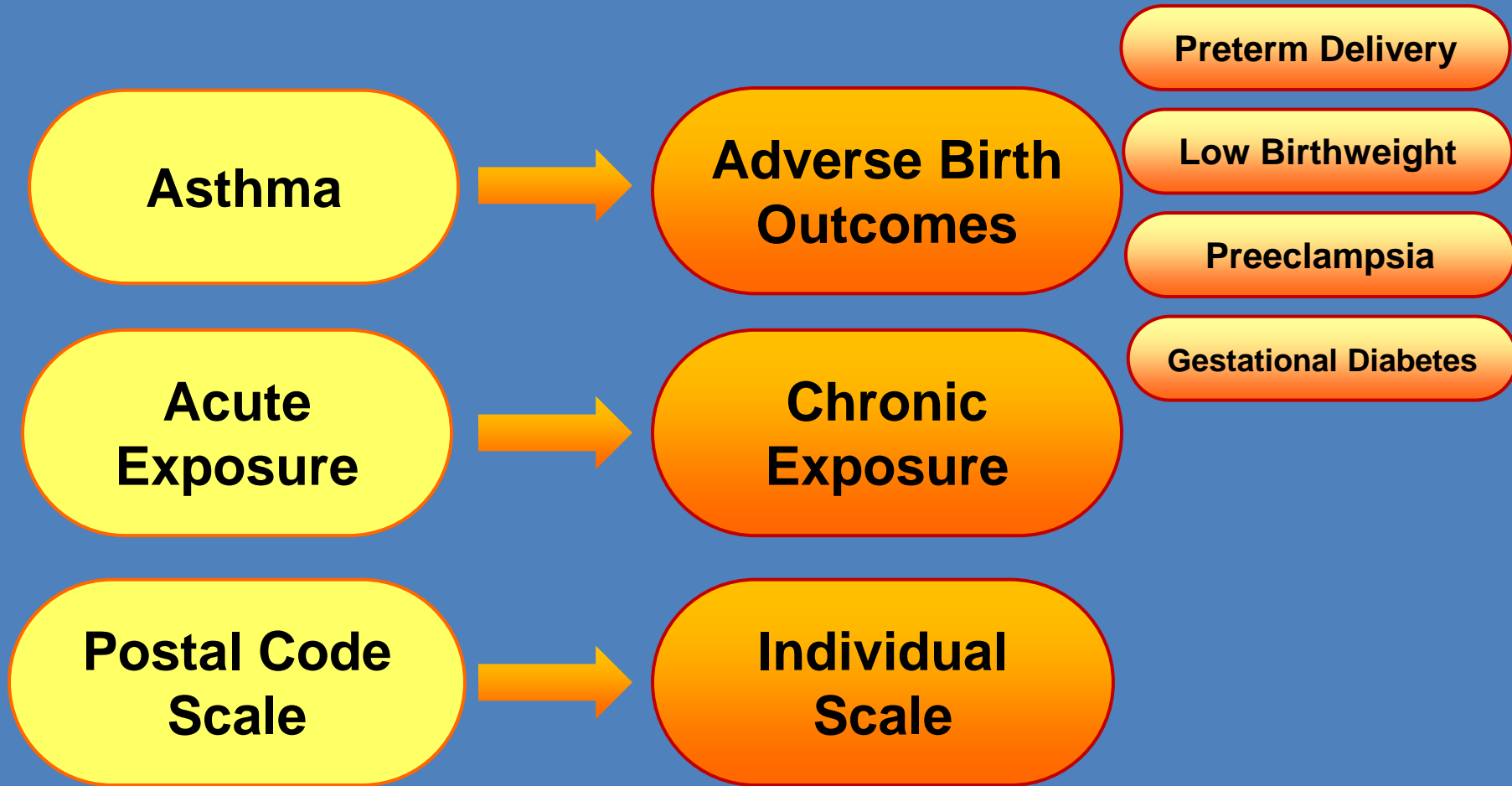


### Windsor



Why do asthma exacerbations appear lower in SW Detroit?

# GeoDHOC Today



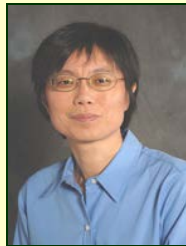


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# The GeoDHOC Team

## *Asthma – Detroit and Windsor*

### Team 1 Environmental Modeling



Xu



Lemke



O'Leary

### Team 2 Epidemiology and Health Outcomes



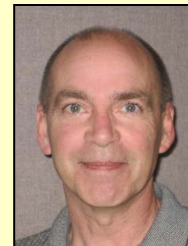
Villeneuve



Reiners



Lamerato



Larkin



Mathieu



Cassidy



Burmeister

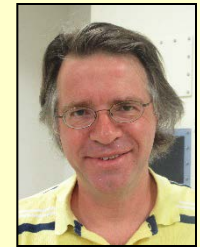
### Team 3 Geospatial Modeling

## *Perinatology - Detroit*

### *Low Birth Weight Preterm Delivery*



Sperone

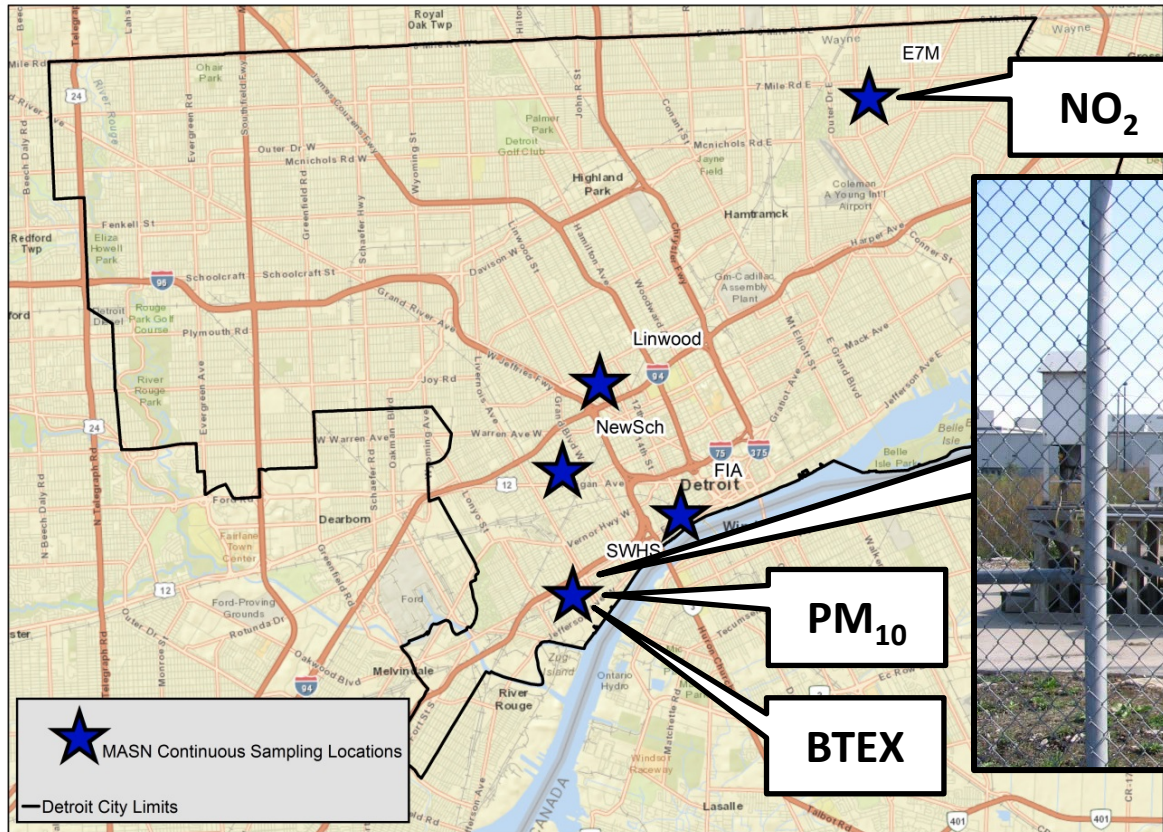


Goovaerts

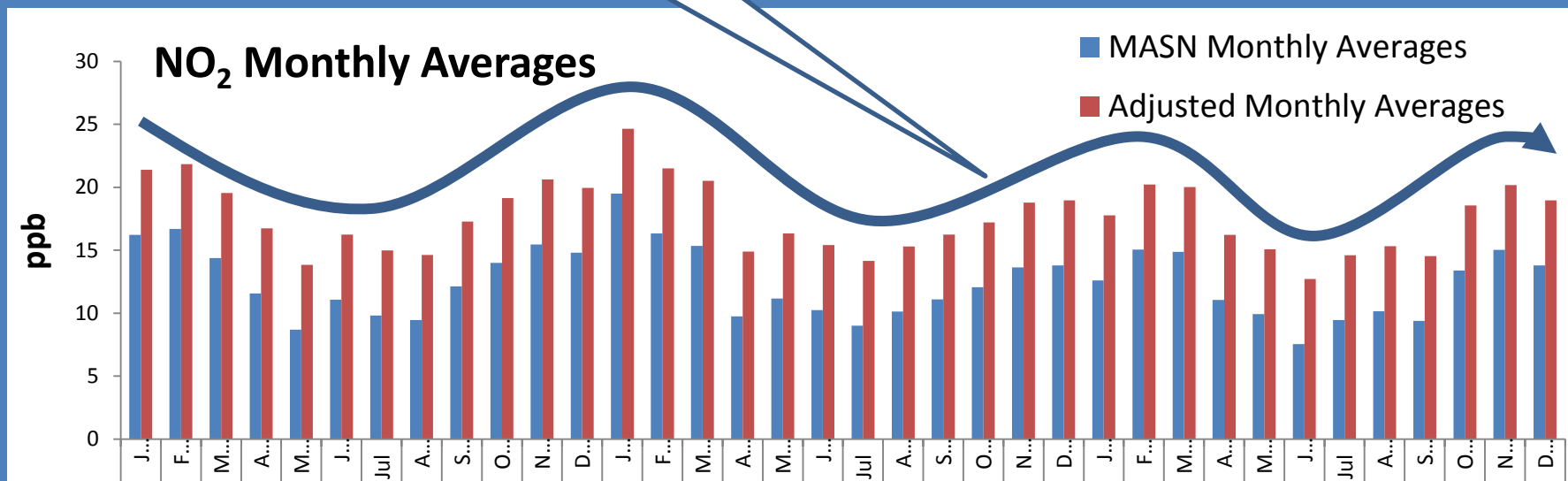
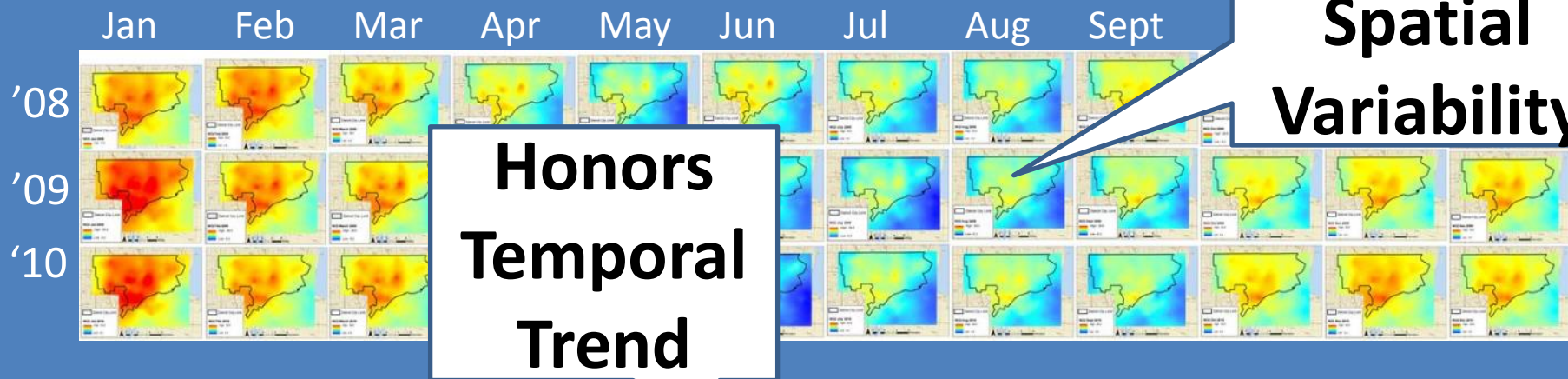
# Michigan Air Sampling Network (MASN)

Analytes	East 7 Mile	FIA	Newberry	Linwood	SWHS
NO <sub>2</sub>	X				
BTEX					X
PM 10					X
PM 2.5	X	X	X	X	X

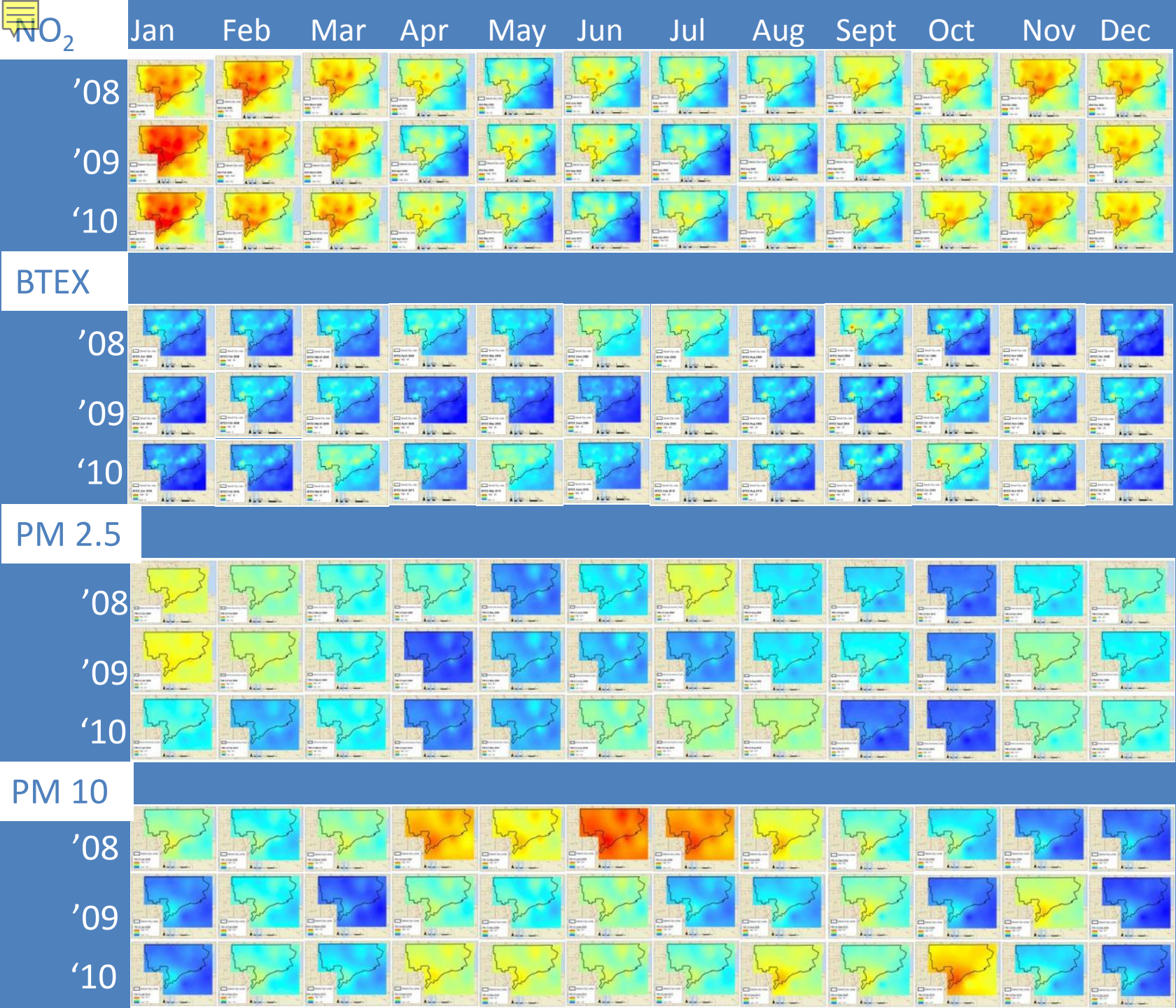
MASN Sampler Locations in Detroit



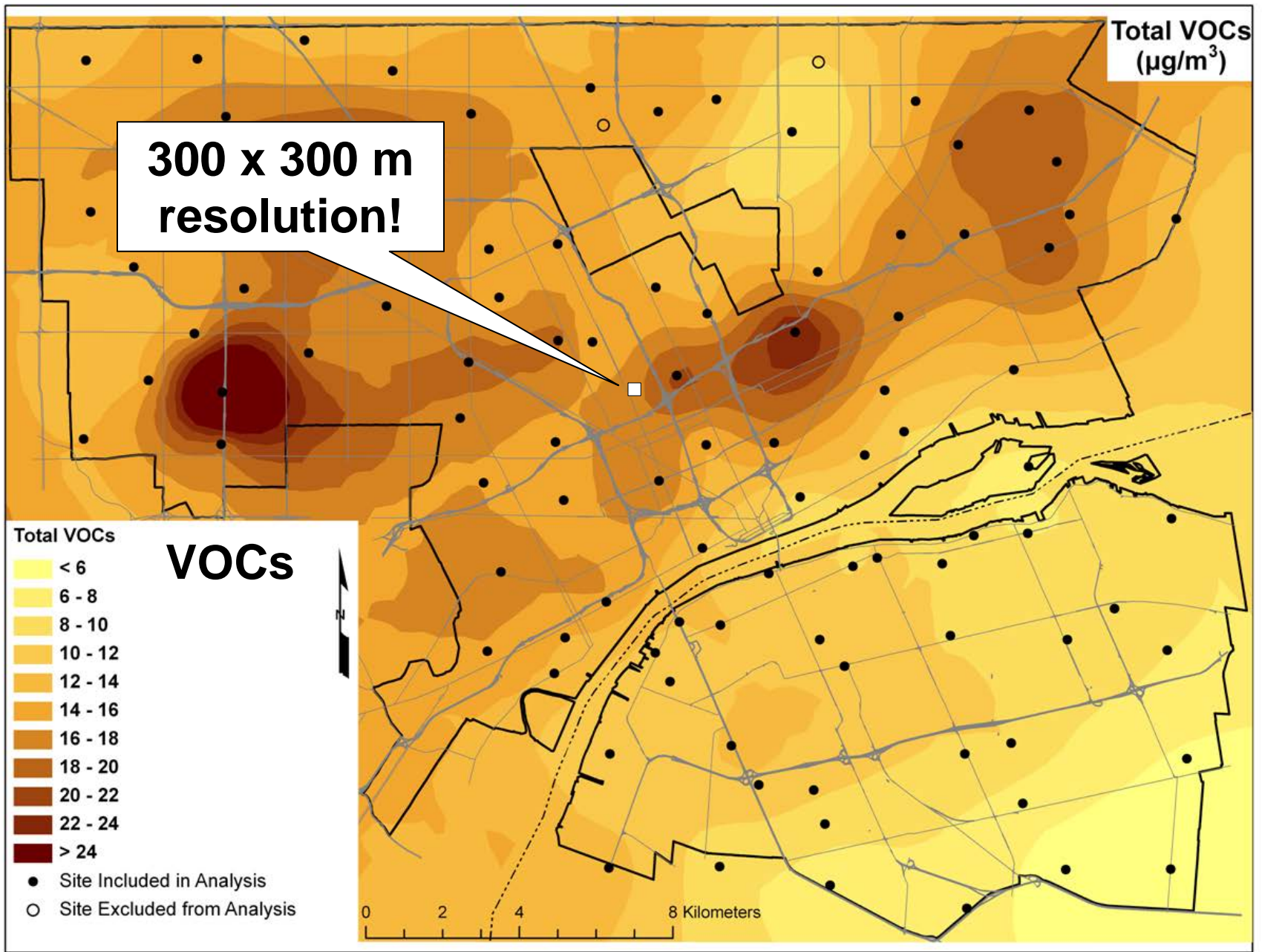
# Monthly Concentration Maps



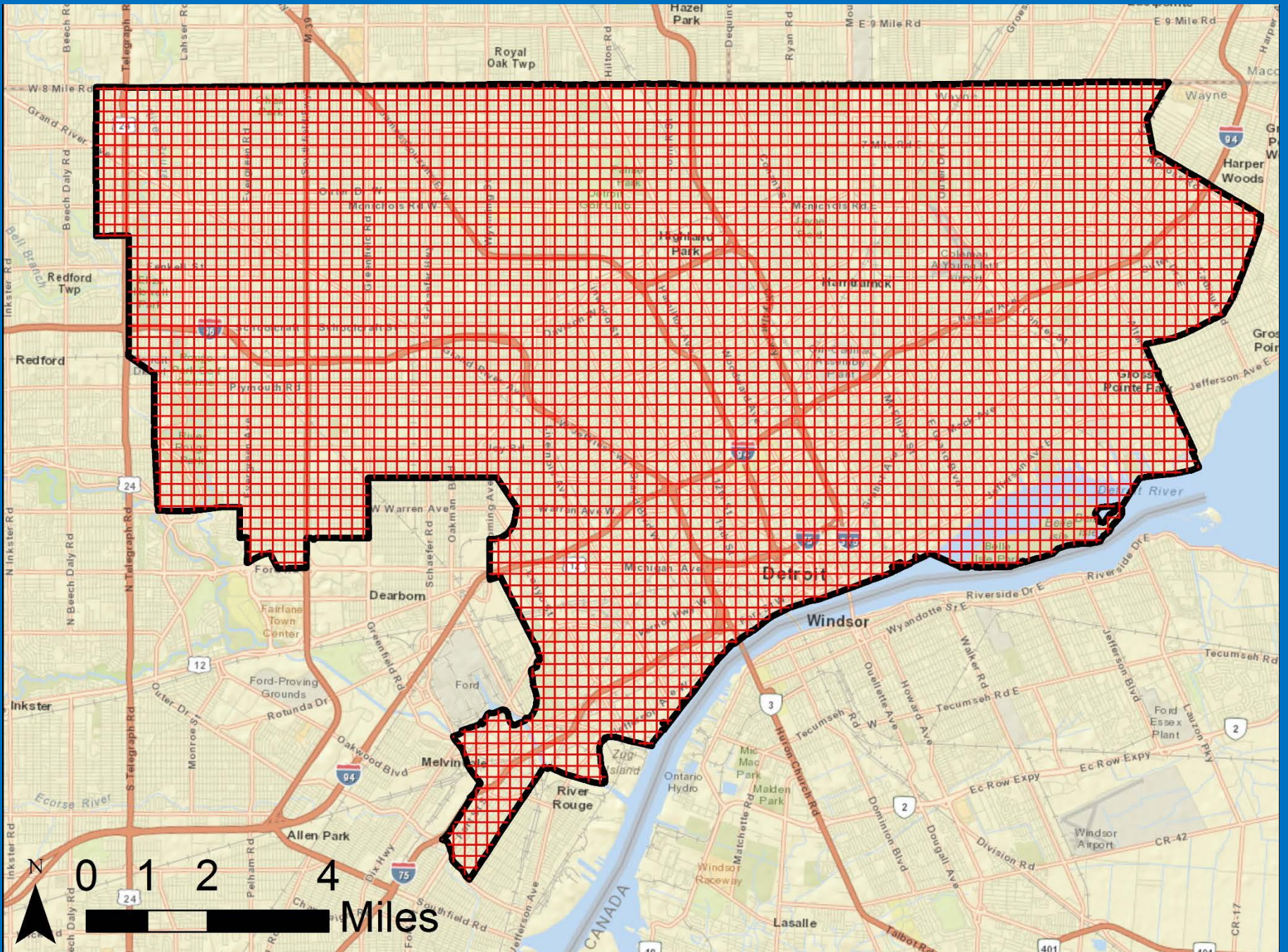














Fisher

Individual level exposure estimates based on residential address

I-BIO

E17  
L7

Next Energy

HFHS





# Merits of Geospatial Environmental Health Analysis

- **High resolution air quality models**

- Spatial Detail (GeoDHOC)
- Temporal Detail (MASN)

- **Health Outcome Investigations**

- Asthma
- Birth Conditions
- Maternal Complications
- Allergies?

- **Science and Public Policy**

- Spatial and temporal associations
- Visualization for effective communication

**Neighborhood  
Scale  
Variability  
is Essential in  
Urban Areas**