Low-cost Air Pollution Monitors for Deployment in an Urban Setting

Kirsten Koehler, Misti Zamora - Johns Hopkins University
Drew Gentner, Lizi Xiong - Yale University
Branko Kerkez - University of Michigan

SEARCH
Solutions for Energy
Air, Climate & Health

This presentation was developed under Assistance Agreement No. RD835871 awarded by the US EPA to Yale University. It has not been formally reviewed by EPA. The views expressed in this document are solely those of the authors and do not necessarily reflect those of the agency. EPA does not endorse any products or commercial services mentioned in this presentation.

Objectives

Principal Hypothesis: A significant fraction of observed heterogeneity in regional air quality and personal exposure to air pollutants is due to energy-related factors

Objective 1: Develop novel online multipollutant monitors (stationary and portable models) to measure air pollutants and GHGs.

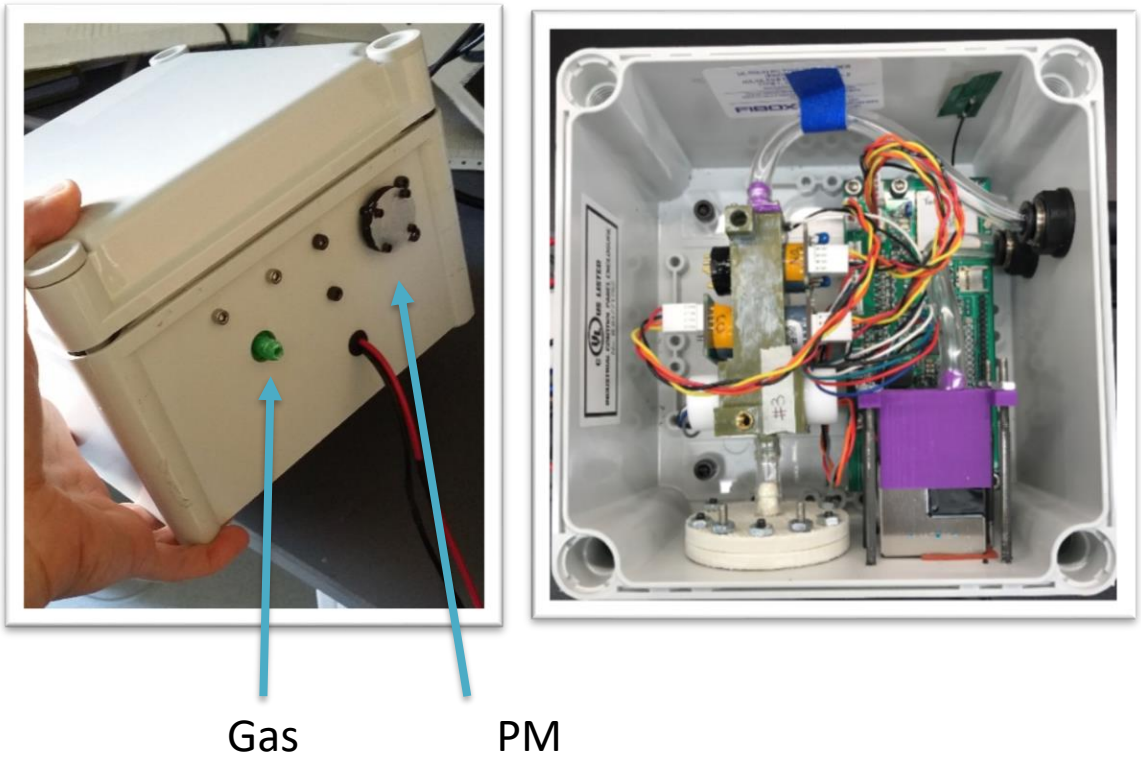
Objective 2: Measure pollutants with high spatiotemporal resolution using a multipollutant stationary monitoring network.

- ~50 monitors
- Source apportionment for energy-related sources

Objective 3: Measure temporally resolved personal exposures with detailed time-activity information.

- 100 participants (24-hr) with personal multipollutant monitor + GPS

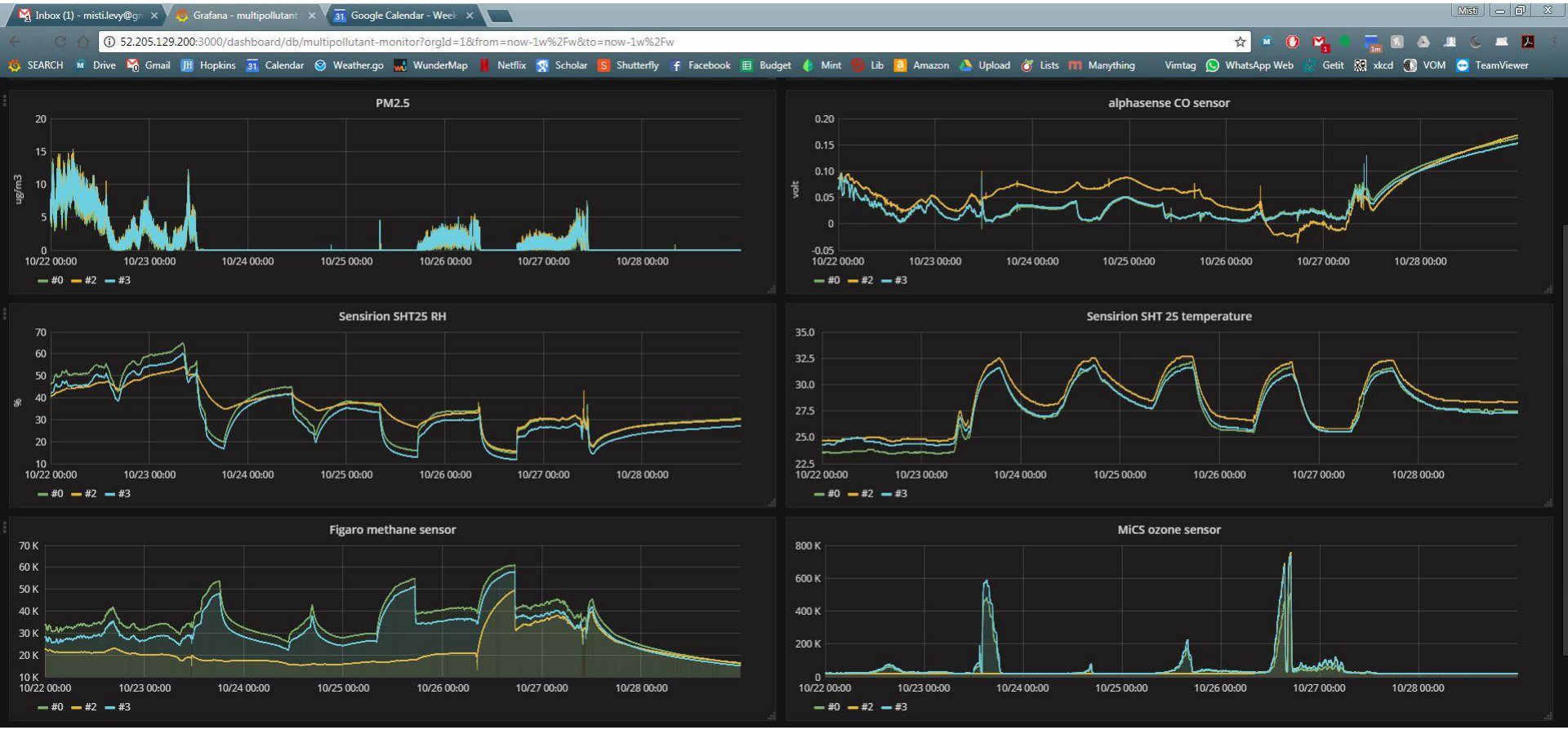
Stationary Custom Multi-pollutant Monitors: Baltimore Deployment



Measured Air Pollutants
Particulate Matter ($PM_{2.5}$)
Ozone (Tropospheric)
Nitrogen Dioxide (NO_2)
Nitric Oxide (NO)*
Carbon Monoxide (CO)
Methane (CH_4)
Carbon Dioxide (CO_2)*

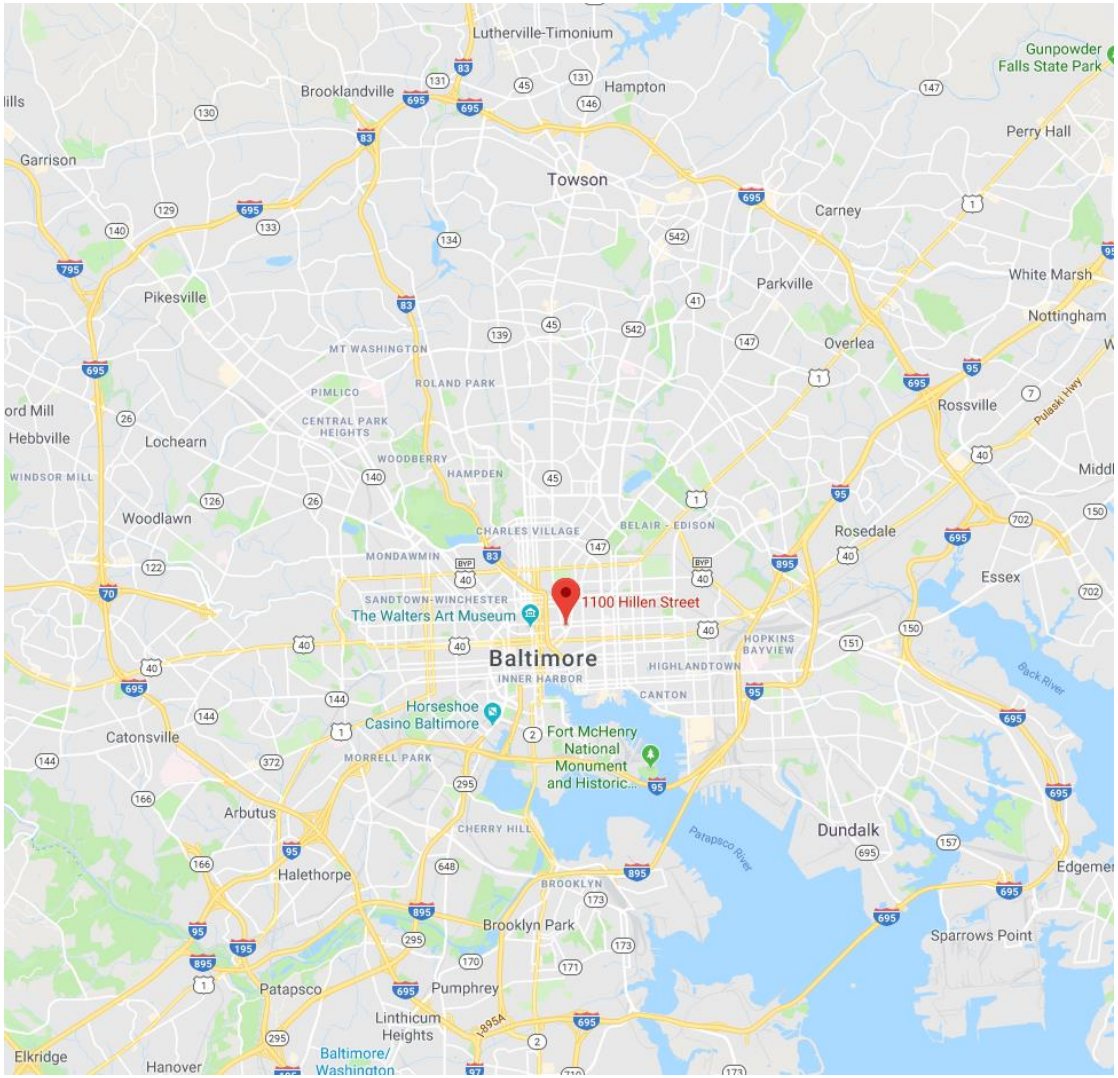
SEARCH
Solutions for Energy
Air, Climate & Health

Online Monitoring



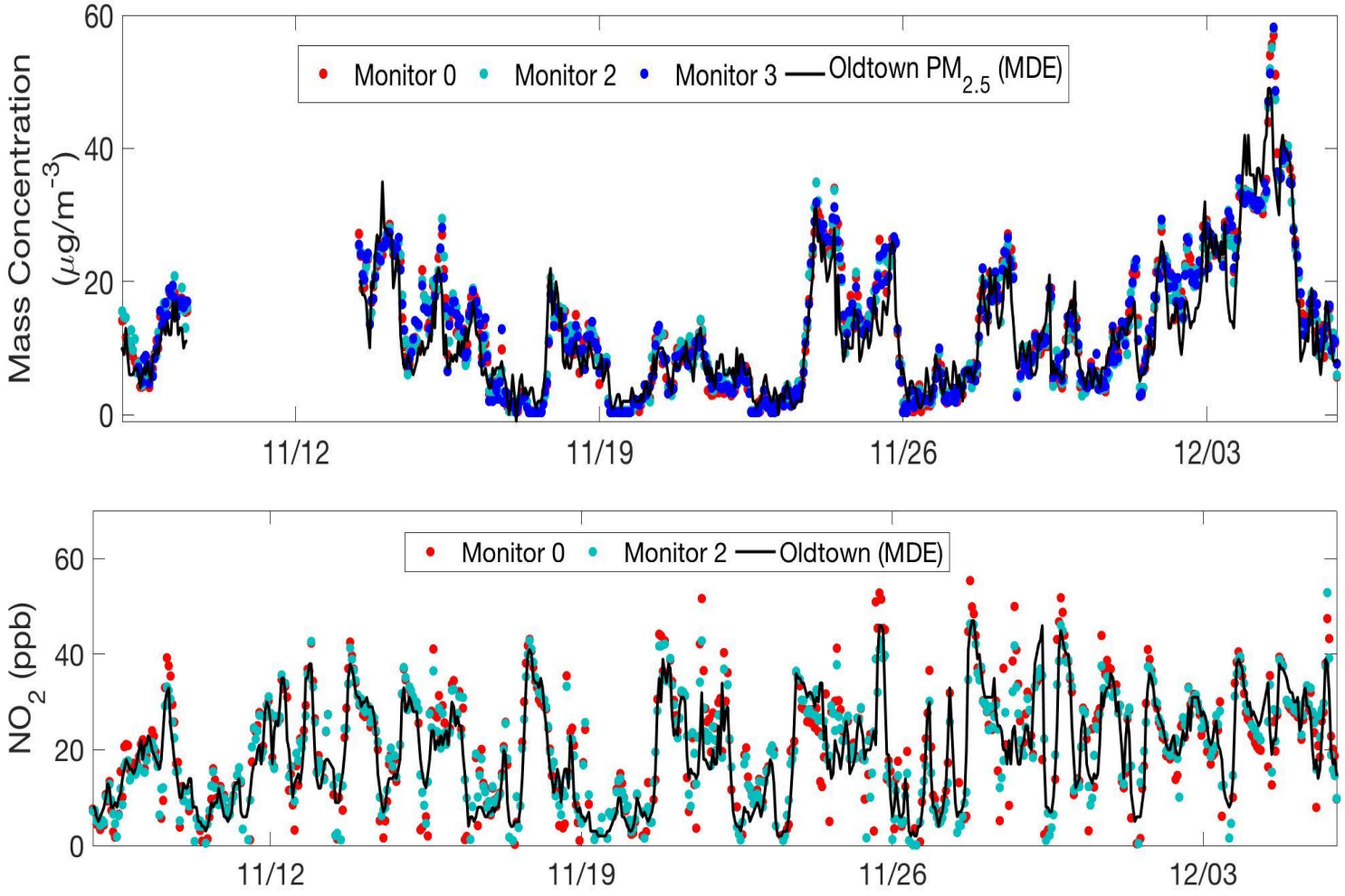
- Grafana online Platform
- Password protected
- Updates every 5 seconds
- SD card back up

Monitor Testing: Ambient Air



- 1-month at OldTown MDE Site
  - Continuous PM2.5
  - CO
  - NOx
  - Air toxics

How well do the sensors work?

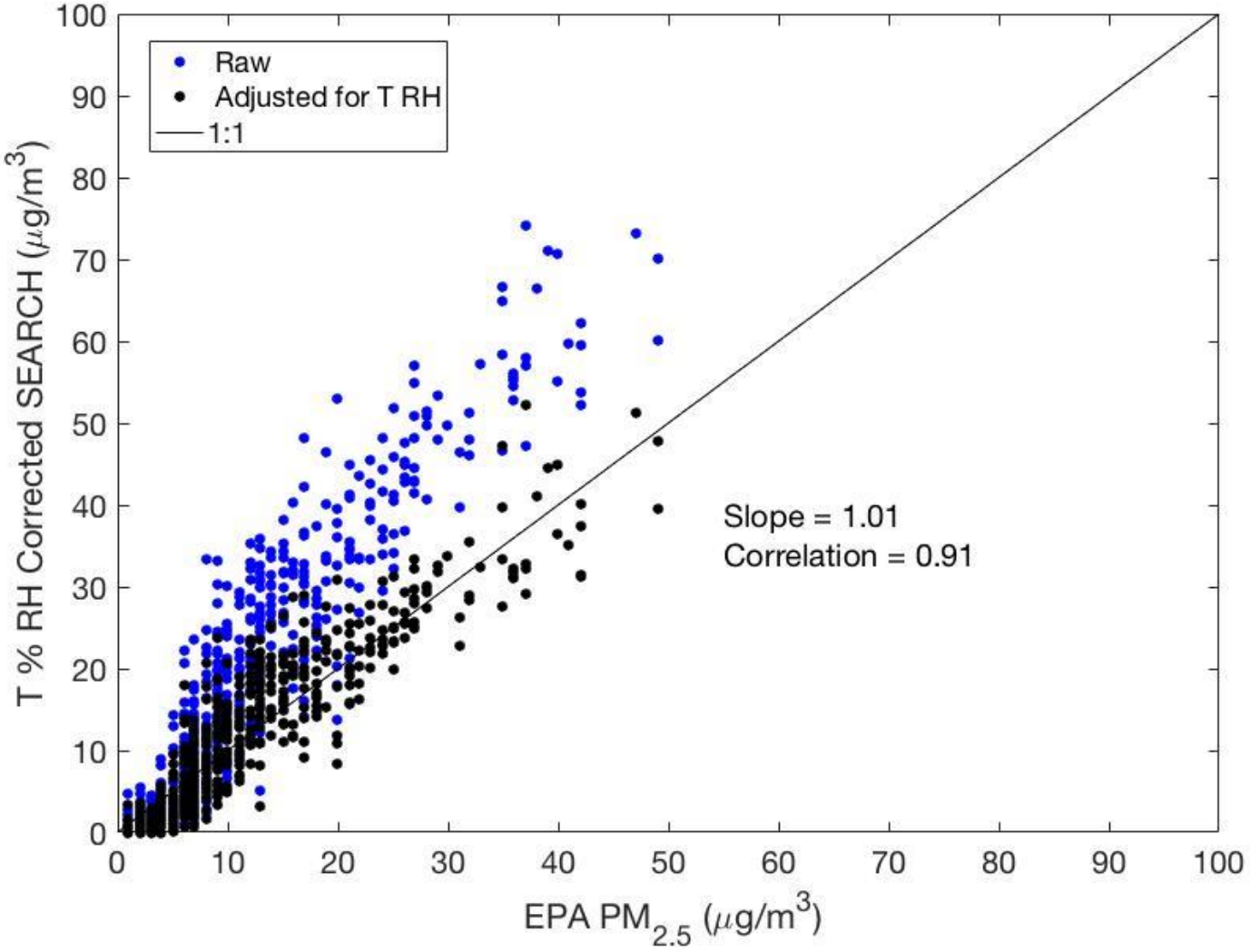


Raw data

Co-located at MDE Site in Central Baltimore

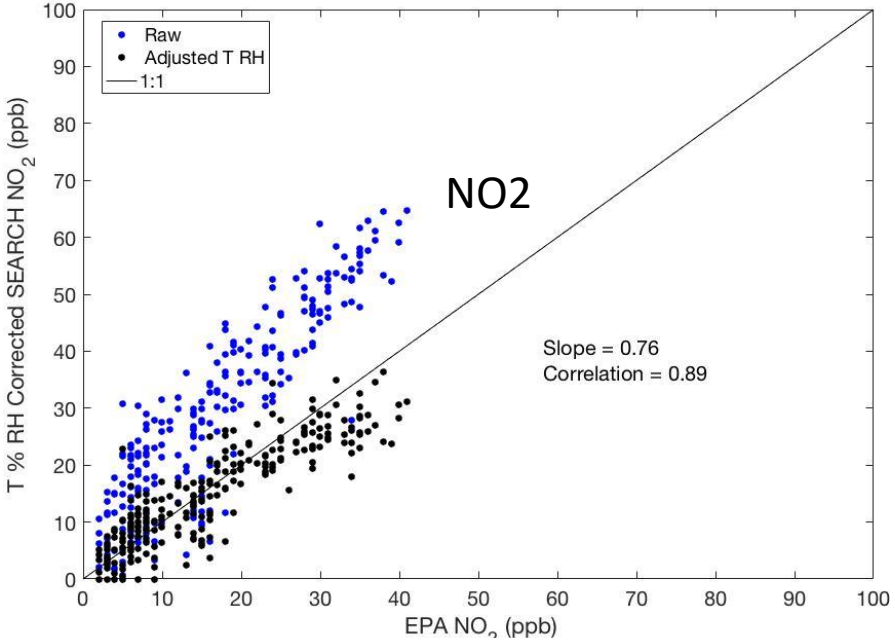
SEARCH
Solutions for Energy
Air, Climate & Health

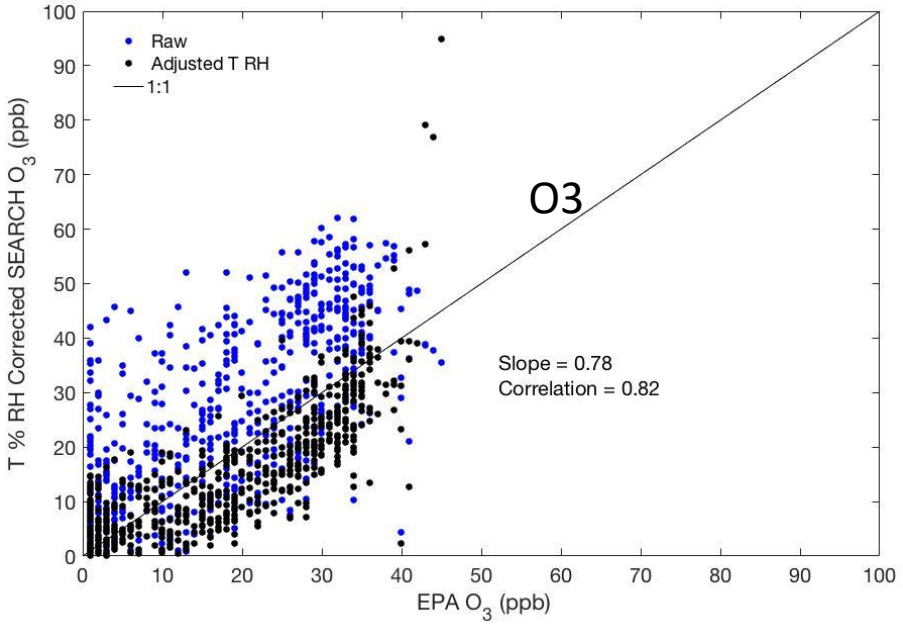
Adjusted PM in good agreement with MDE Site

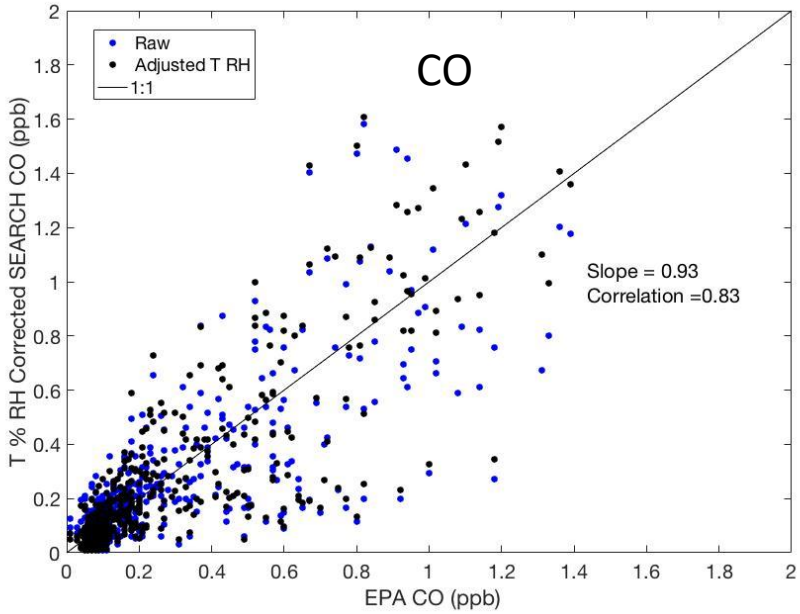


SEA
Solutions
Air, Climat

Preliminary Results: NO2, O3, CO

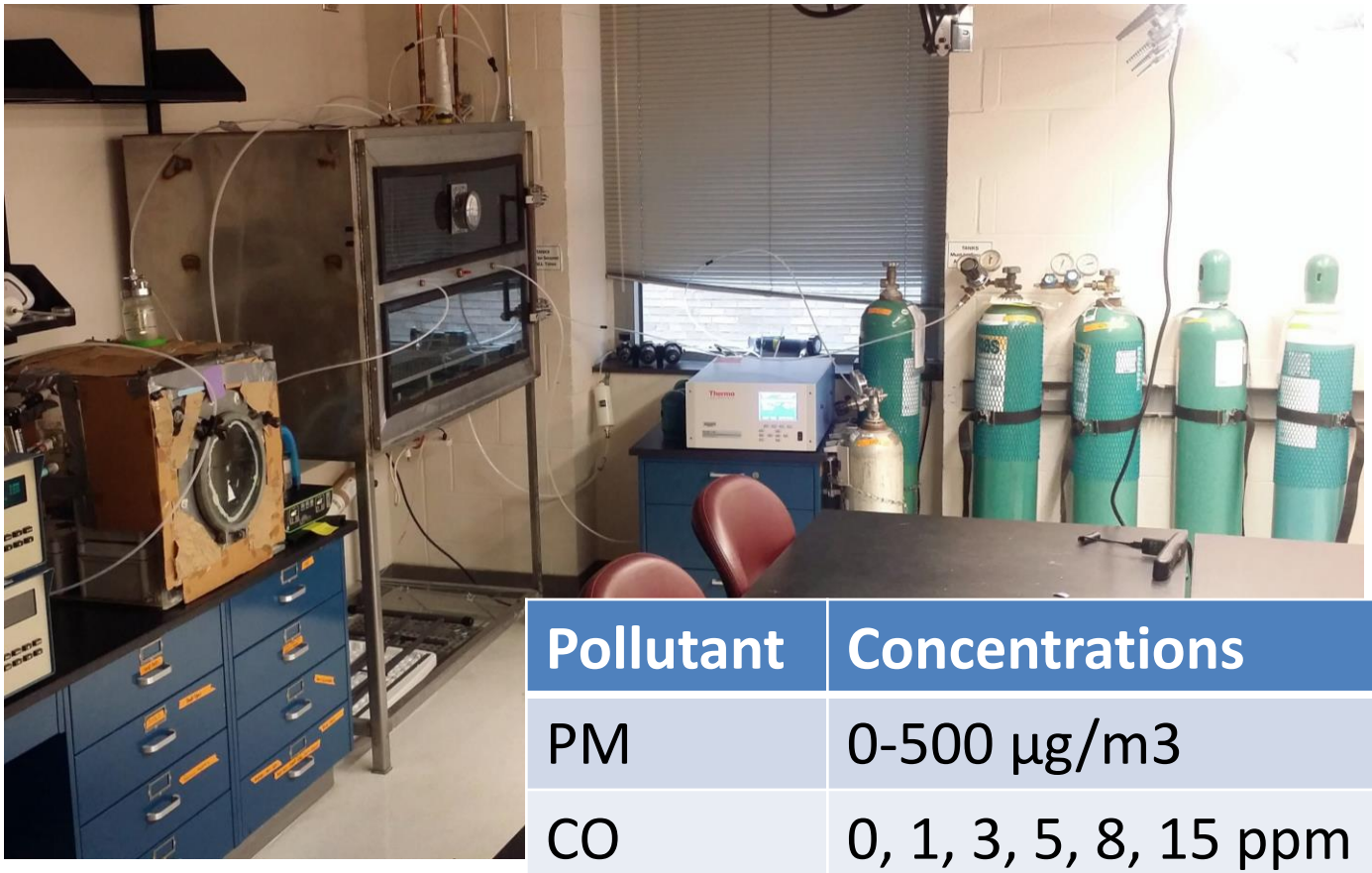






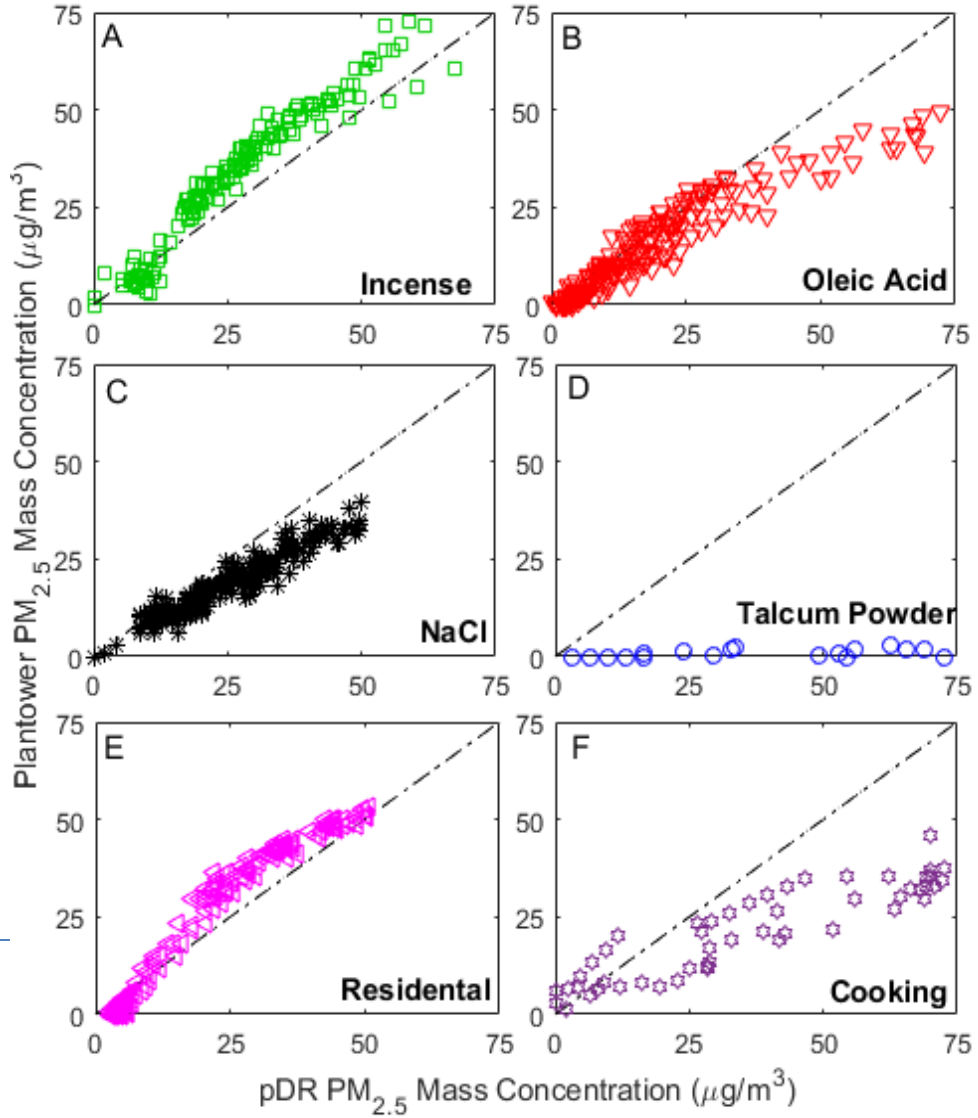
- Strong improvement of NO2
- Weaker correlation for O3 and CO, even after adjustment
- Minimal T/RH corrections for CO sensor

Lab Experiments



Pollutant	Concentrations
PM	0-500 µg/m3
CO	0, 1, 3, 5, 8, 15 ppm
O3	3, 11, 25, 41, 61, 78, 88, 100 ppb
NO2	0, 9, 22, 37, 57, 73, 101 ppb
CH4	0, 0.5, 1, 1.5, 2, 3, 5 ppm

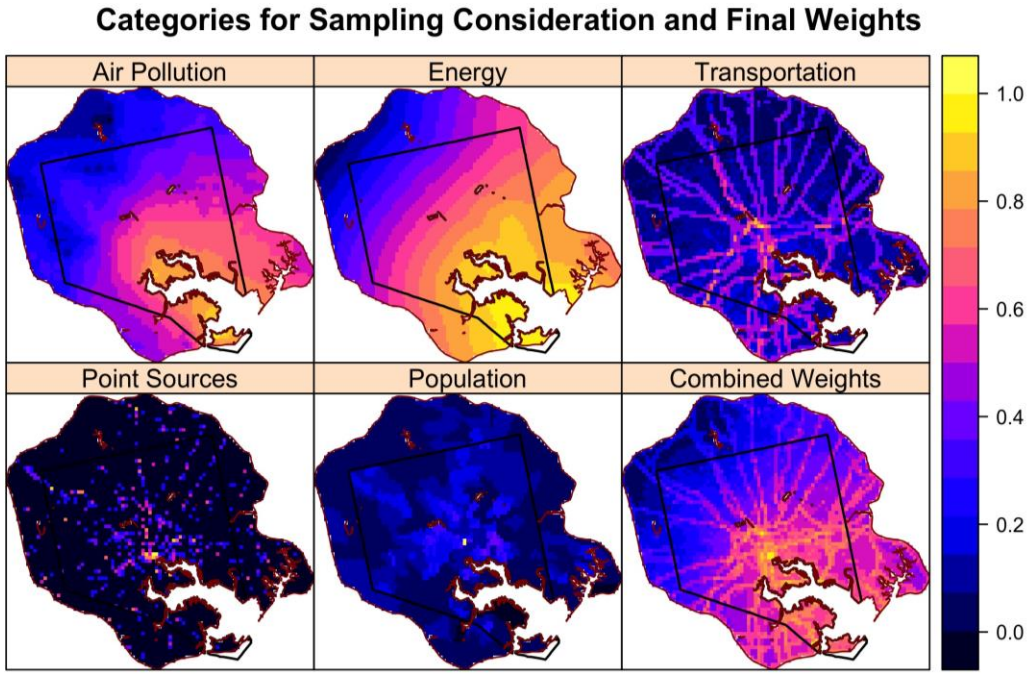
PM Sensor: Compositional Dependence



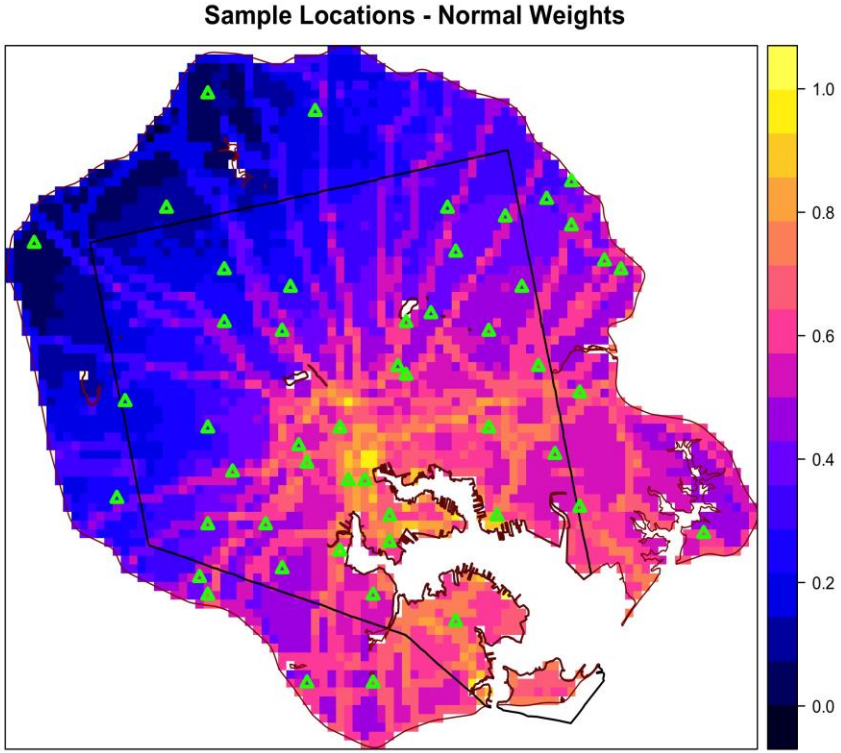
Aspiration problems for large particles?

Where do we put them?

- Characterize intra-urban air pollution variation



Weighted random sample locations



SEARCH
Solutions for Energy
Air, Climate & Health

Custom multi-pollutant monitors for SEARCH

Portable model: Wearable multi-pollutant monitors

Measured Air Pollutants	
Ozone (Tropospheric)	Carbon Monoxide (CO)
Particulate Matter ($PM_{2.5}$)	Carbon Dioxide (CO_2)
Nitrogen Dioxide (NO_2)	T/RH/Light/GPS

Battery life: 24+ Hours

Personal Monitoring

100 PARTICIPANTS
4 SAMPLING DAYS

2X → CAR

2X → ALTERNATE MODE

Key Research Questions:

1. Influence of Mode
2. Source apportionment
3. Time-activity information to reduce misclassification
4. Impact of modifiable factors on exposure
   - Socioeconomic
   - Built environment
   - Sustainability

SEARCH
Solutions for Energy
Air, Climate & Health

Conclusions and Future Work

- Preliminary results are encouraging for collection of high spatial- and temporal-resolution air quality information using low-cost sensor technology
- A siting strategy has been developed to place ~50 monitors in Baltimore City
- Long-term deployment begins this month.