Emerging and novel measurement methods to support NAAQS enforcement and environmental justice

Albert Presto (apresto@andrew.cmu.edu)

Dept. of Mechanical Engineering

Center for Atmospheric Particle Studies

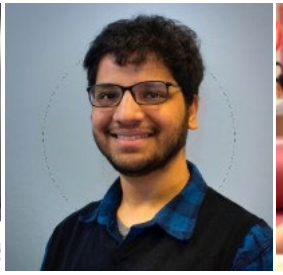
Carnegie Mellon University

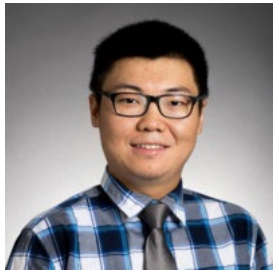
Acknowledgments

Really hard workers



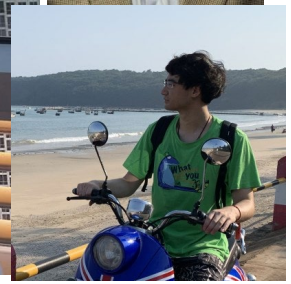








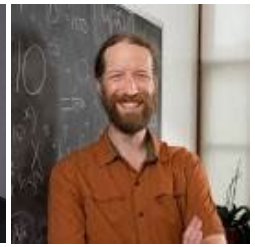
Collaborators










Funding Sources

EDF
ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

NSF

THE HEINZ ENDOWMENTS
HOWARD HEINZ ENDOWMENT • VIRA I. HEINZ ENDOWMENT

This research is funded by U.S. EPA - Science To Achieve

PEOPLES GAS
Keep Life Moving

ALLEGHENY COUNTY ACHD HEALTH DEPARTMENT

U.S. DEPARTMENT OF ENERGY

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

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Take home points

- We can use low-cost sensor networks and mobile monitoring to investigate local-scale variations in air pollution
- Low-cost sensors need to be carefully calibrated for local conditions
- Mobile monitoring enables detailed investigations of source impacts at the urban scale

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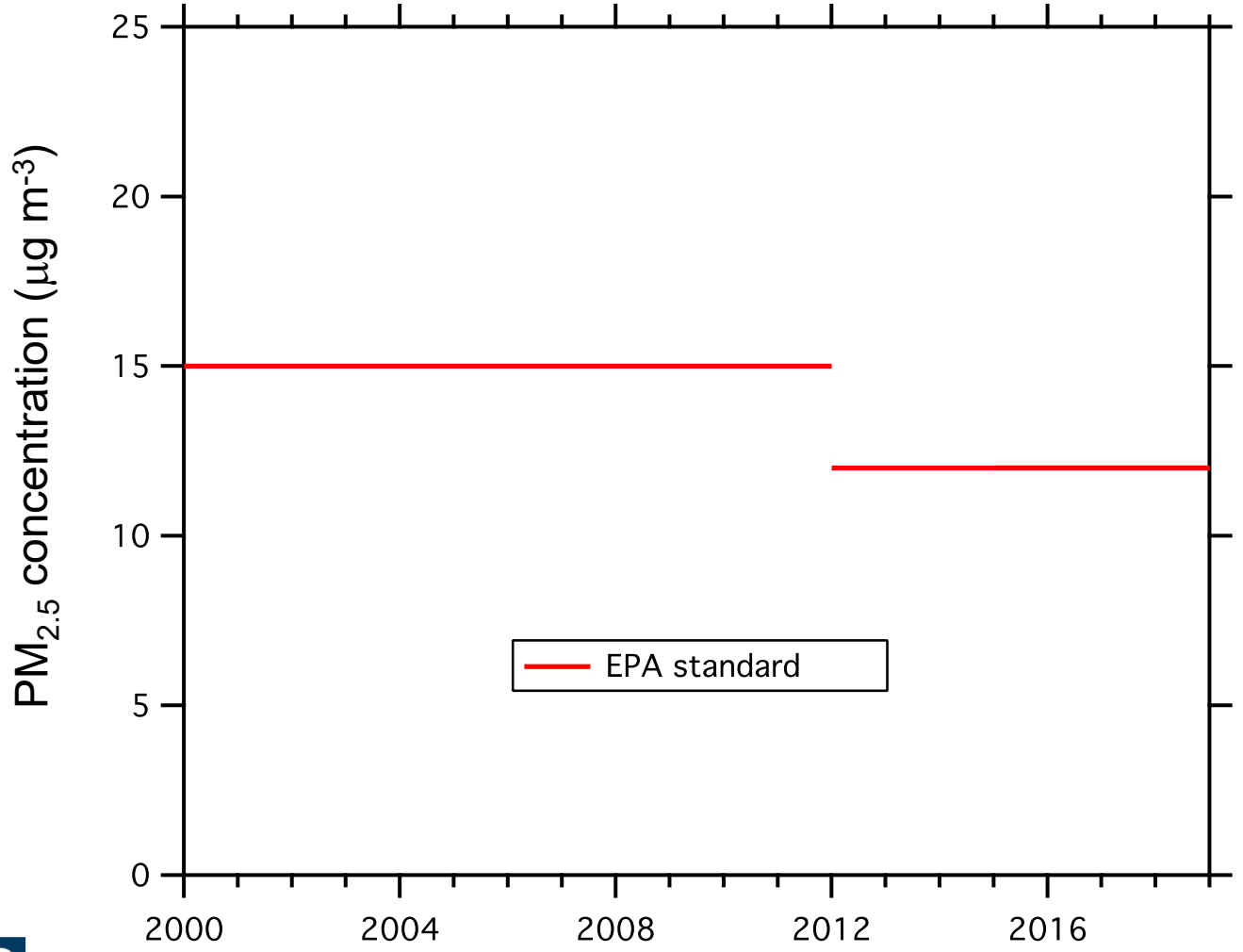
Most air quality monitoring in the US is to check compliance with the Clean Air Act



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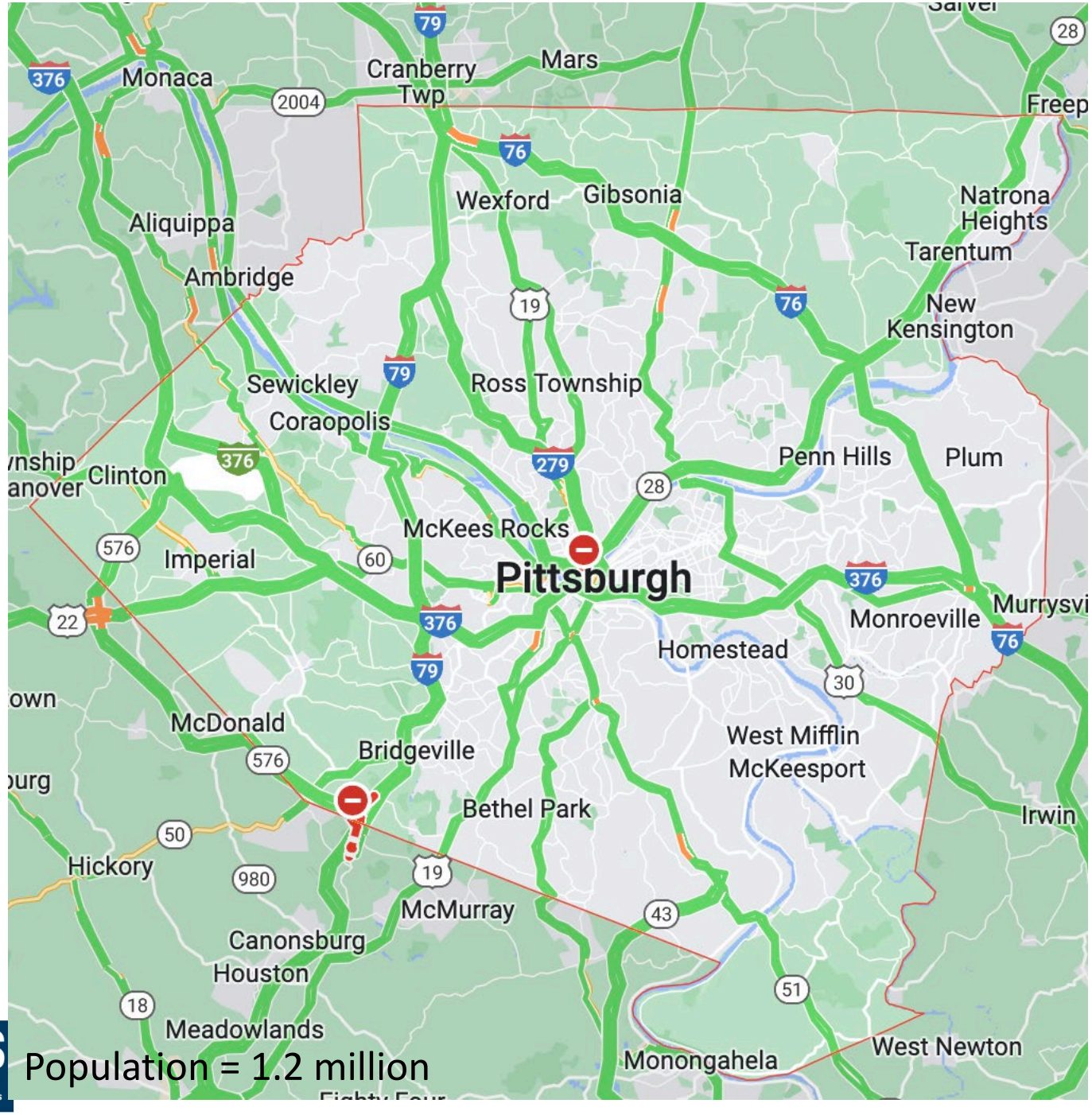

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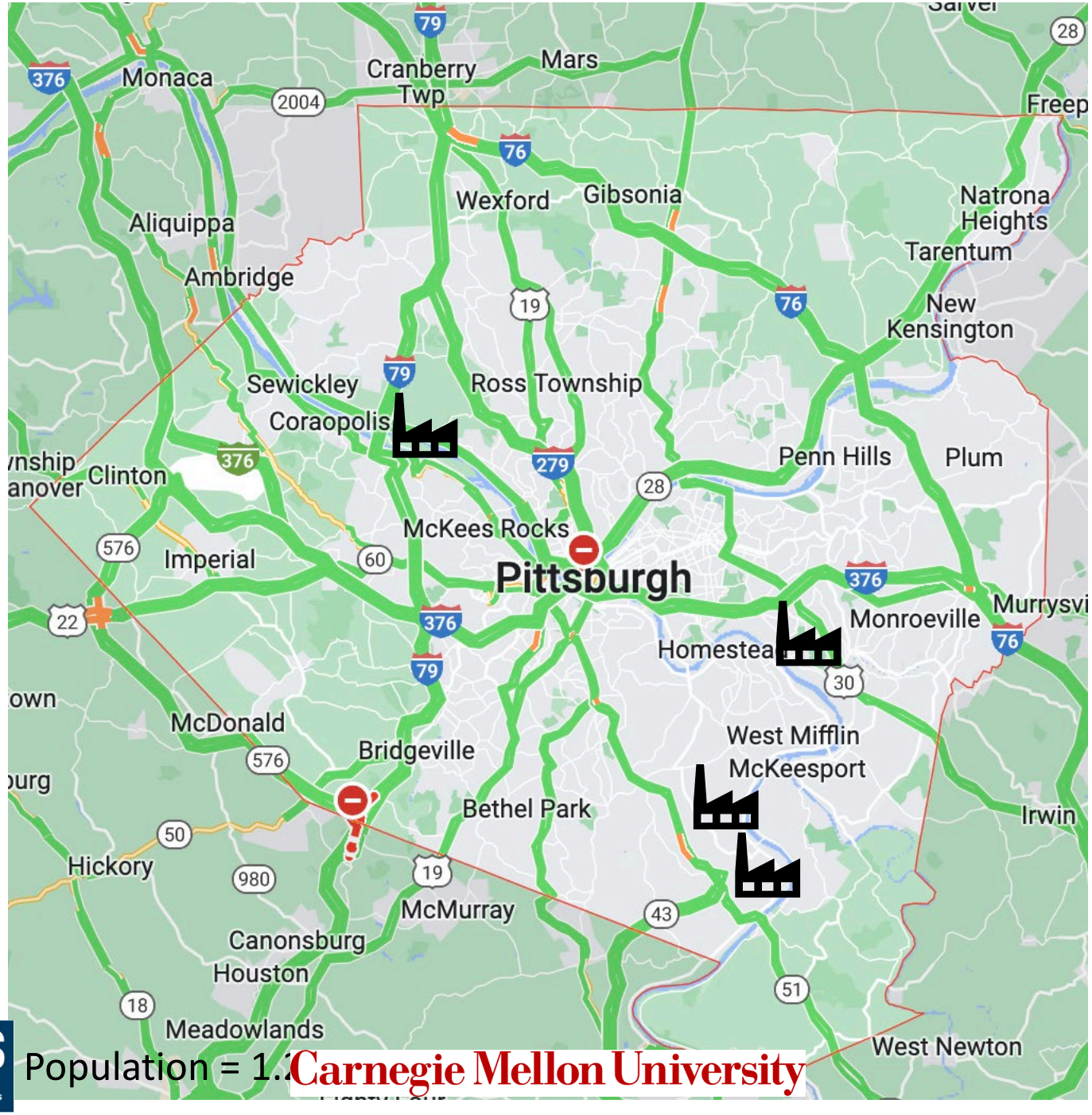
Population = 1.2 million



Population = 1.1

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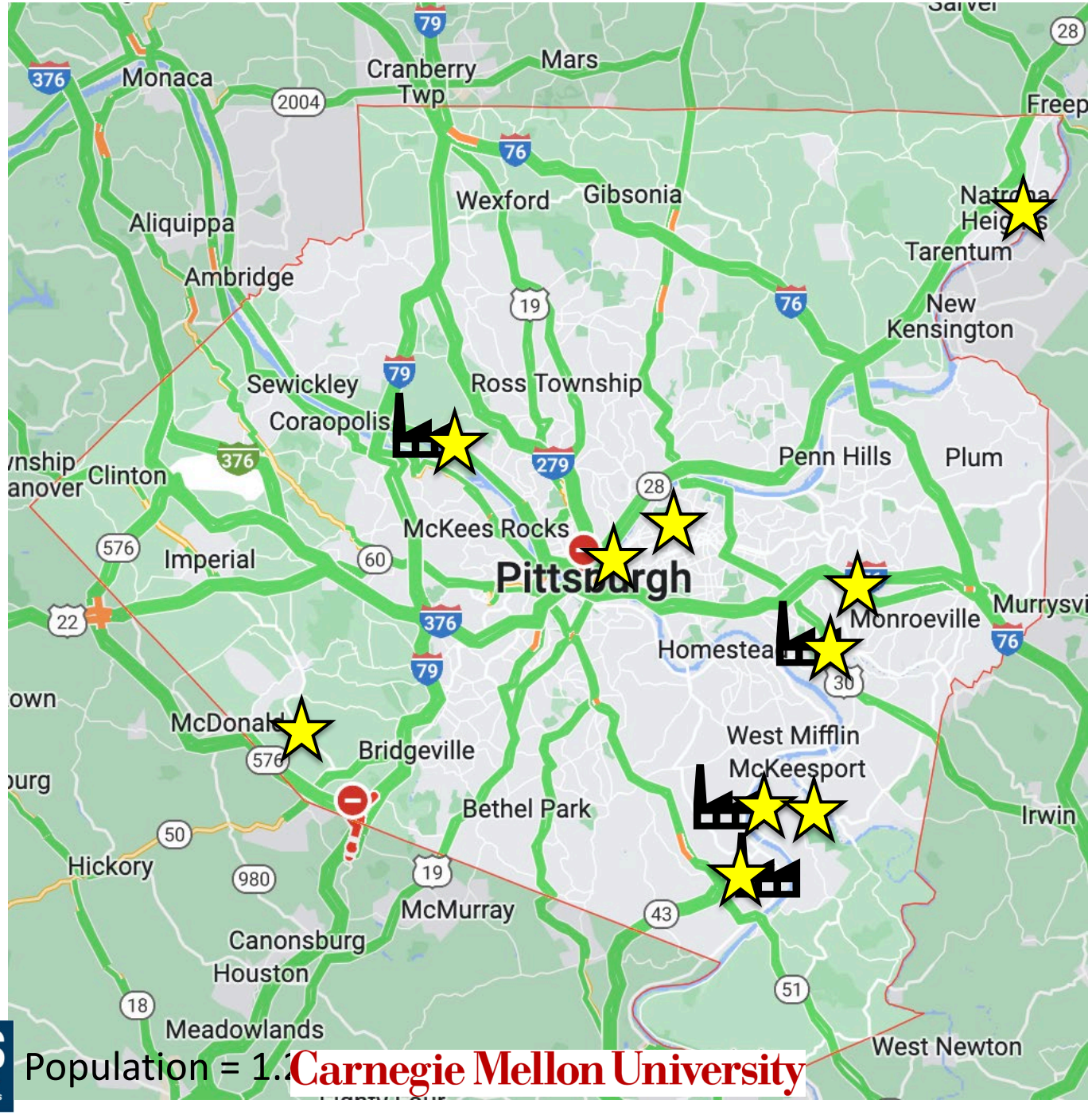

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Population = 1.

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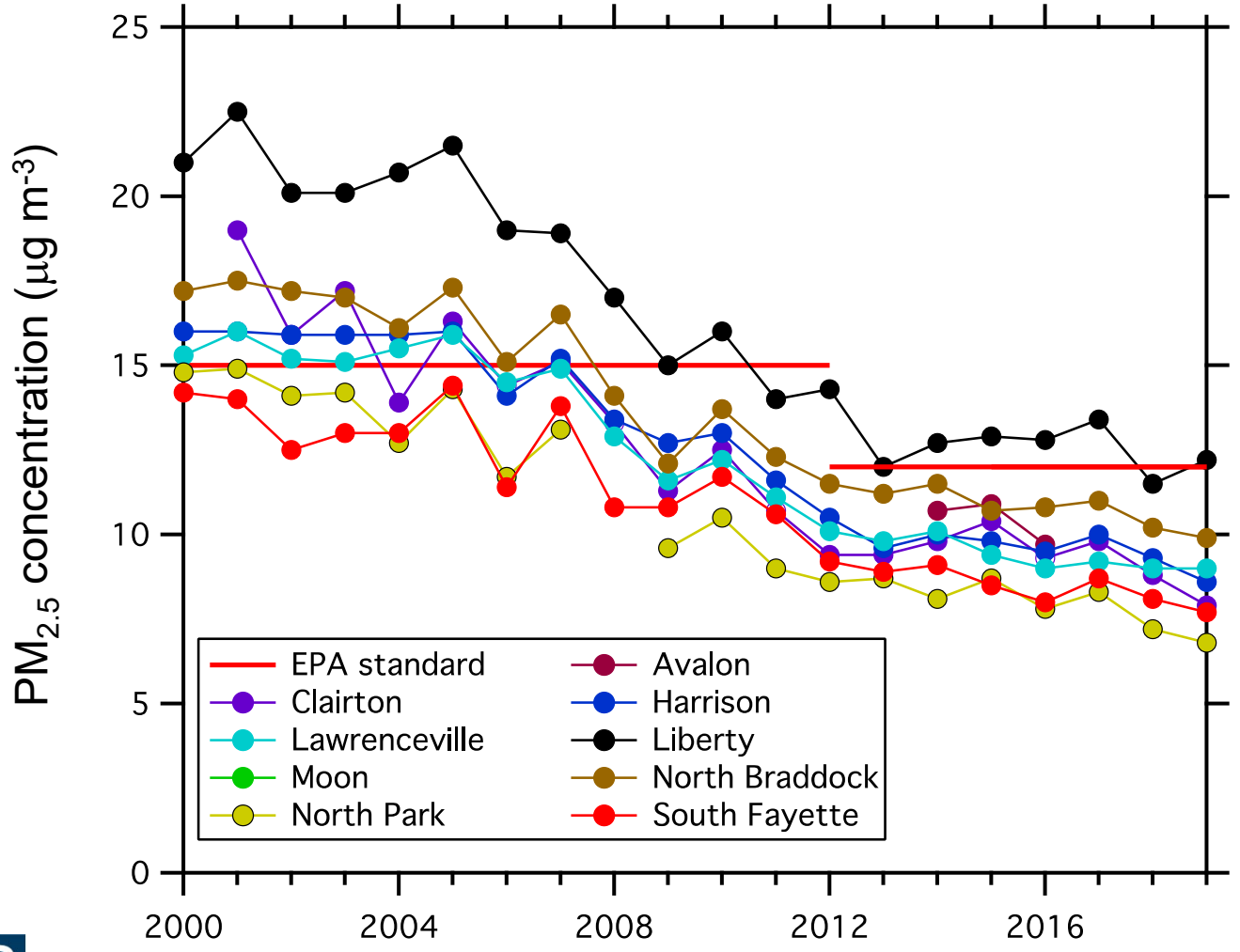
Most air quality monitoring in the US is to check compliance with the Clean Air Act



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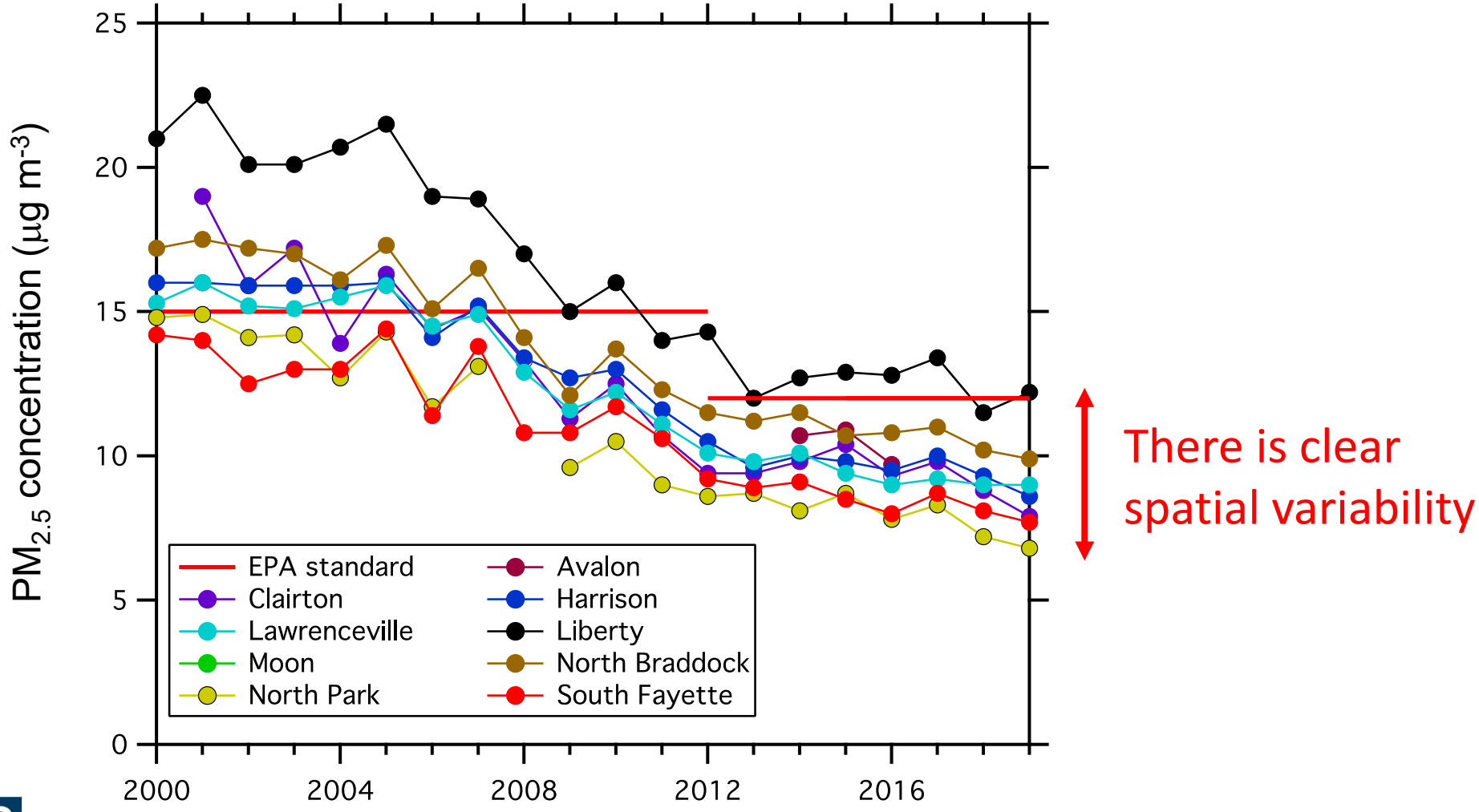

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How much does air pollution vary at the neighborhood level?

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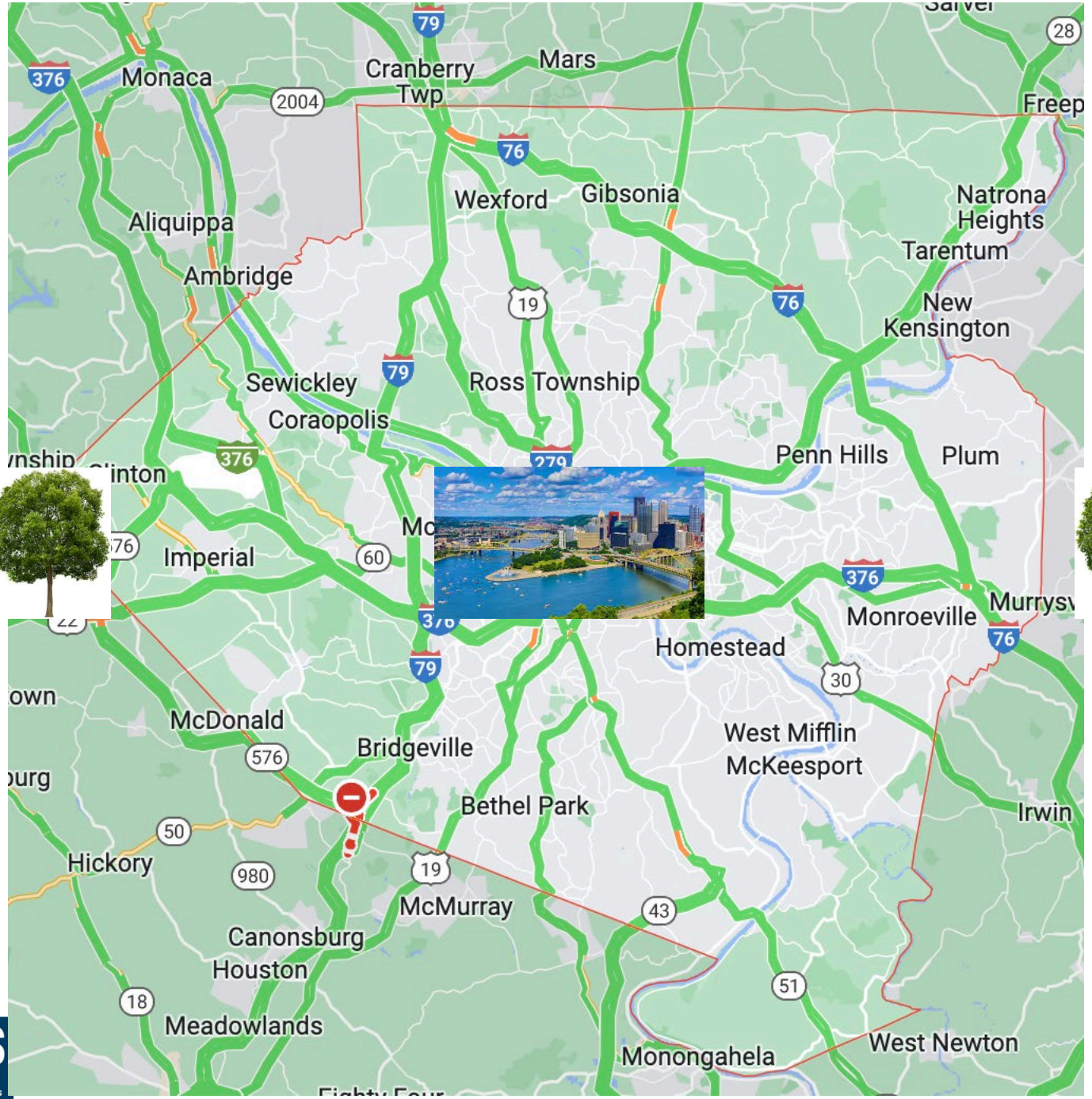

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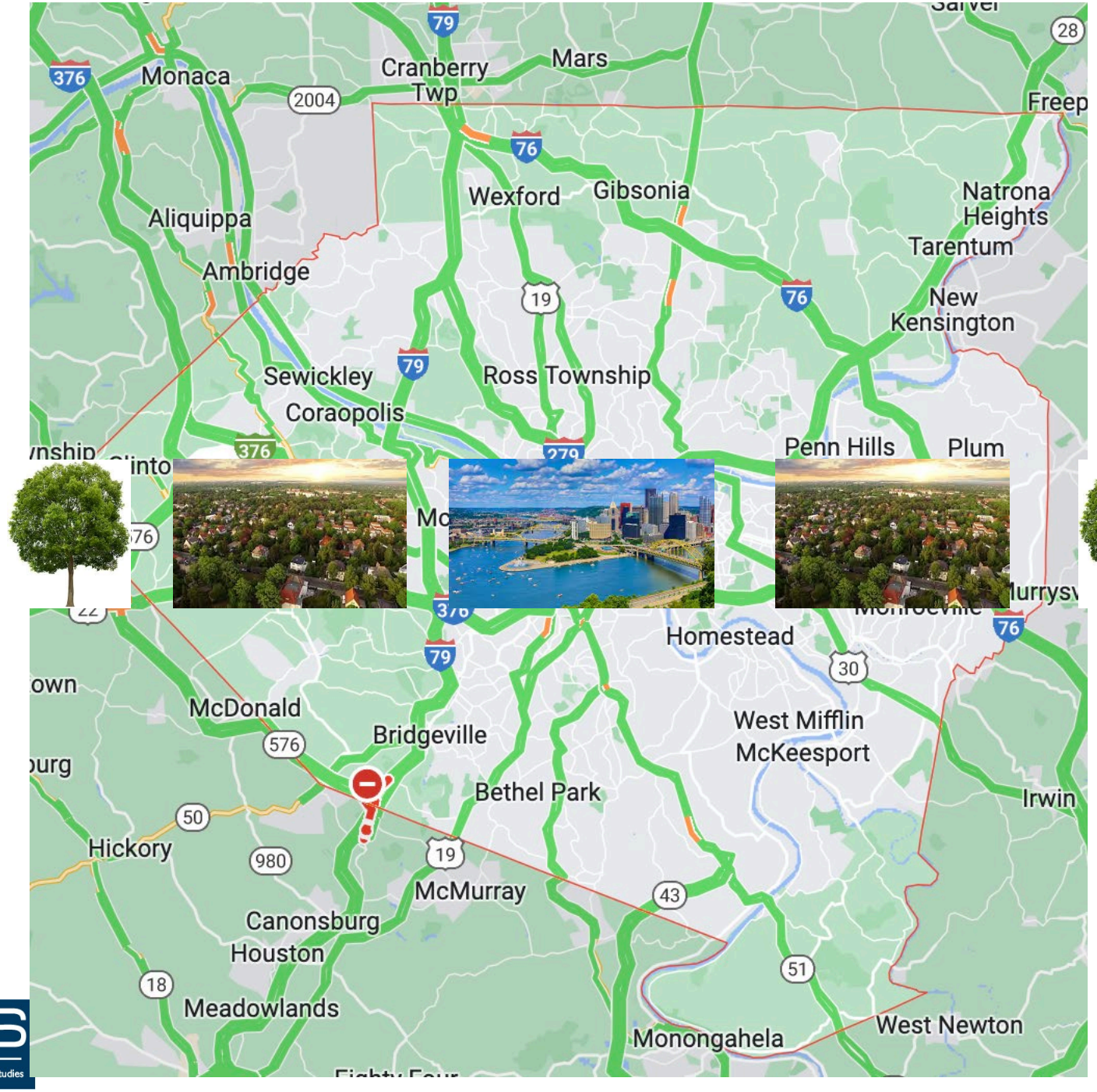

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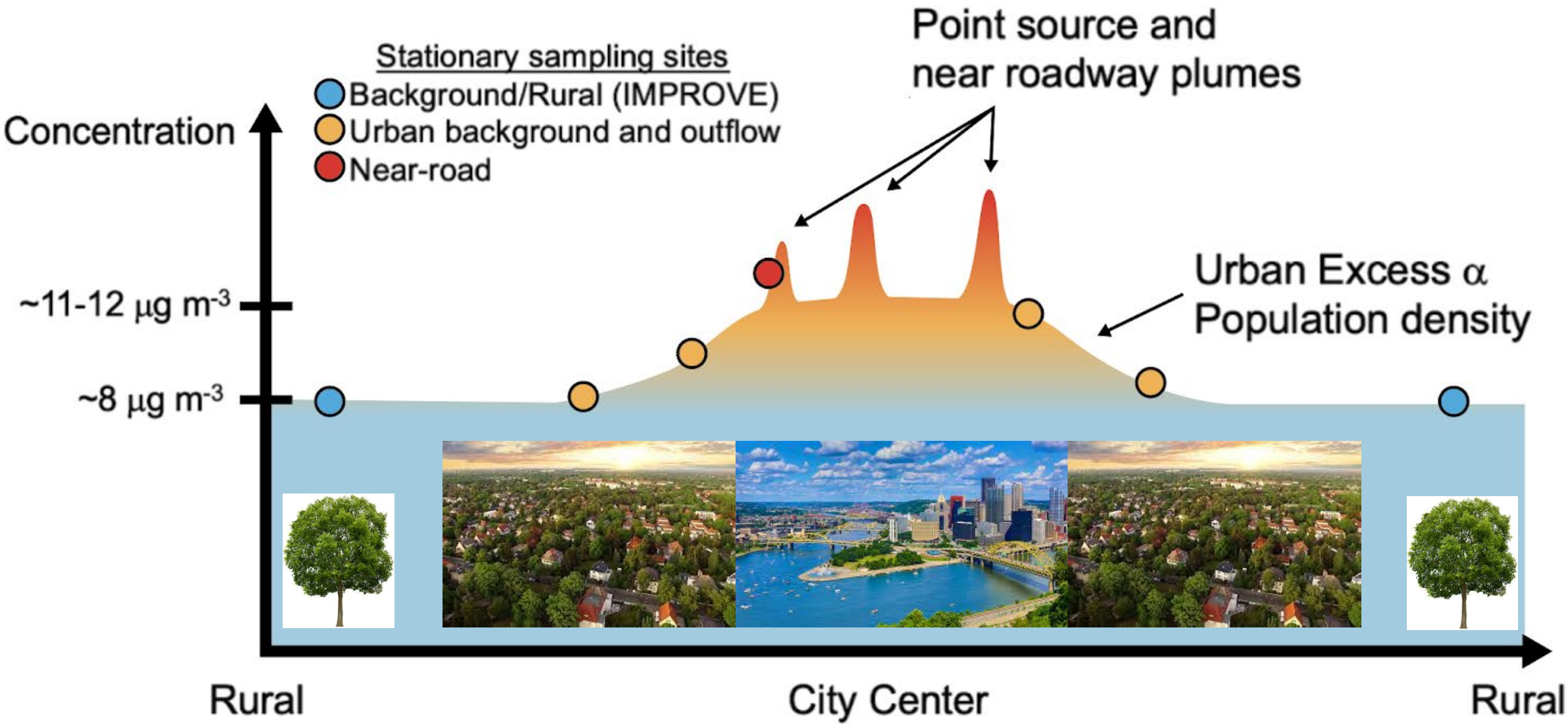
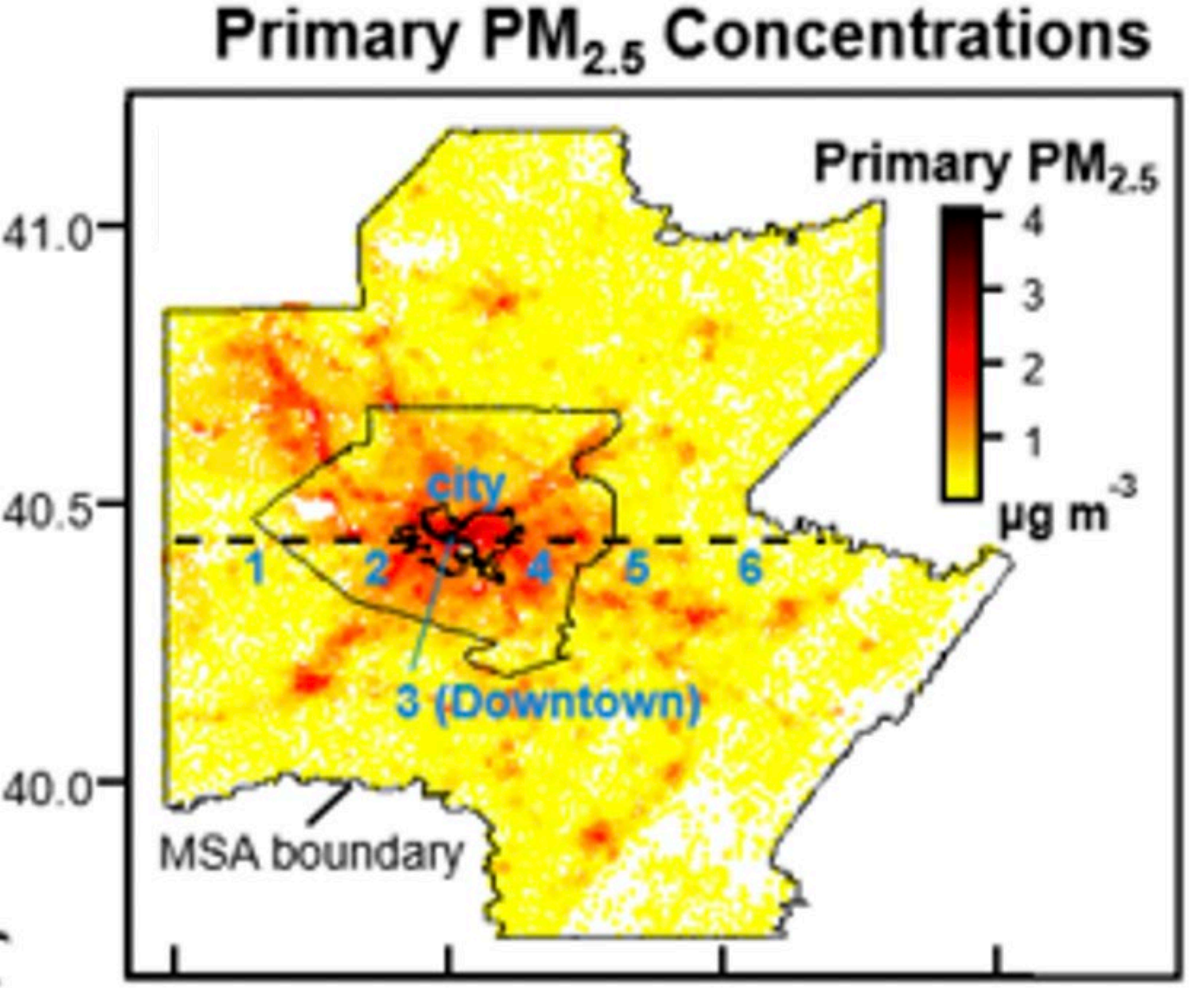


Adapted from Lenschow et al, 2001

Urban areas have an air pollution “hump” with spikes on top of it



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Saha et al, *submitted*, 2022

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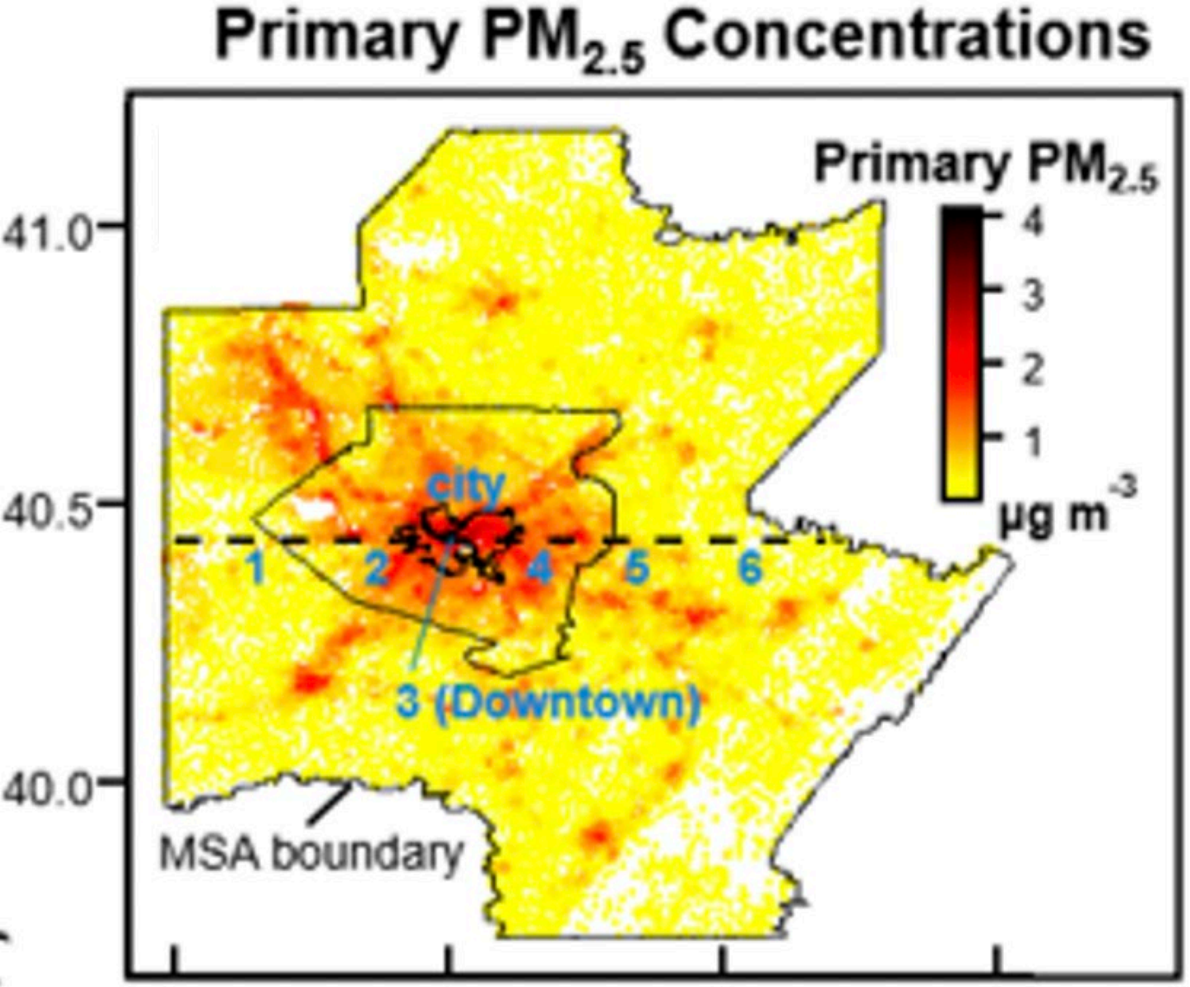

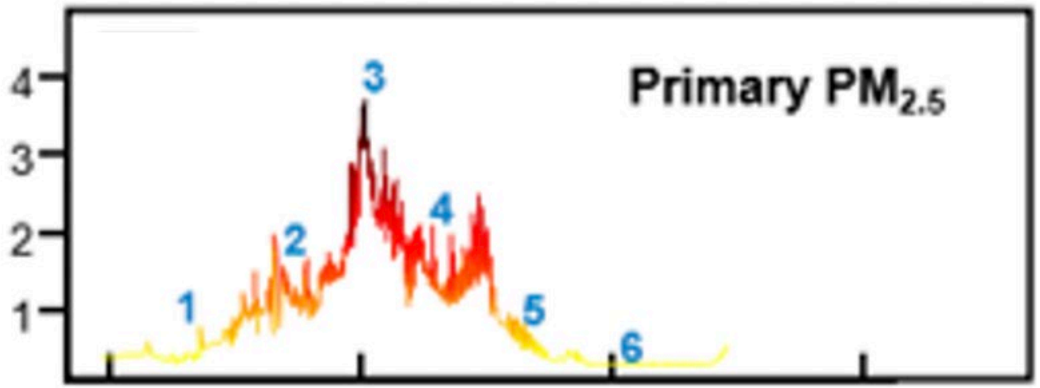

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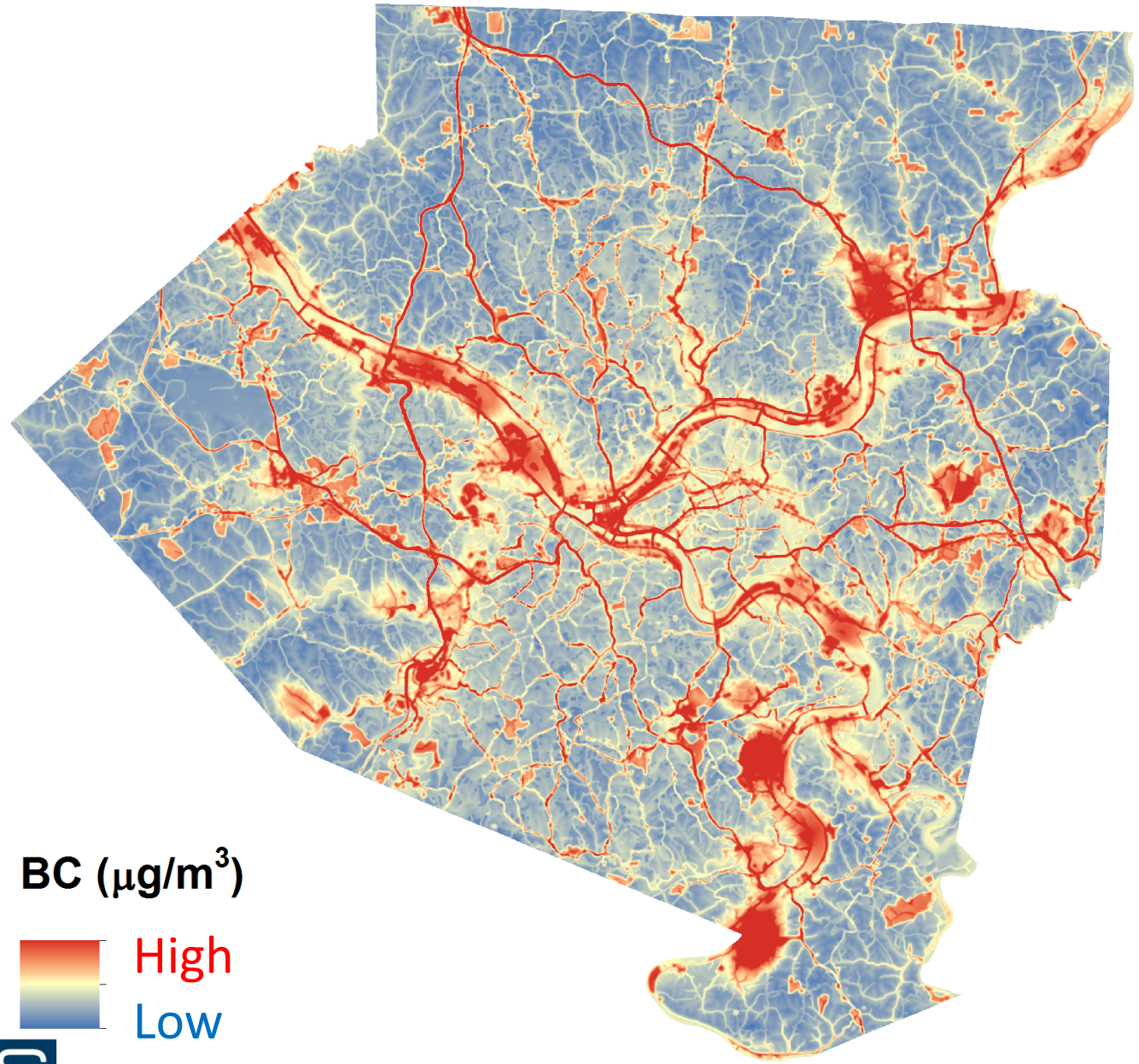

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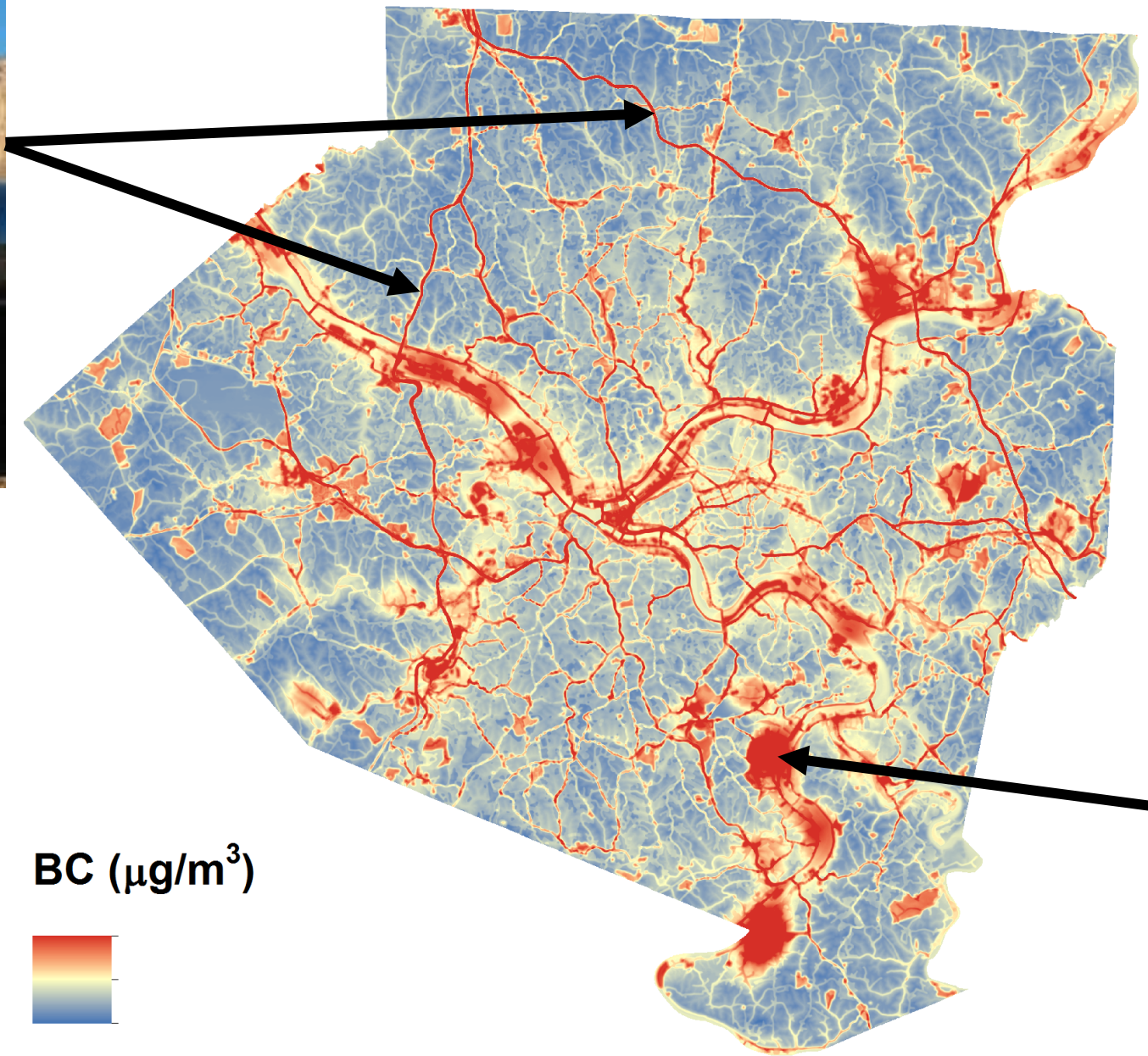
Tan et al, *Atmos. Environ.*, 2016



Tan et al, *Atmos. Environ.*, 2016

How can novel sampling methods be used to quantify neighborhood scale spatial variations?

Dense network of **fixed sites**

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Dense network of **fixed sites**

Real-Time Affordable Multi-Pollutant Sensor (RAMP)

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Low-cost gas sensors are cross sensitive to T, RH, and other pollutants

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Low-cost $PM_{2.5}$ sensors can be influenced by RH, T, particle composition, and particle morphology

Low-cost gas sensors are cross sensitive to T, RH, and other pollutants

Low-cost $PM_{2.5}$ sensors can be influenced by RH, T, particle composition, and particle morphology

Laboratory calibrations are insufficient because we cannot cover the entire relevant phase space

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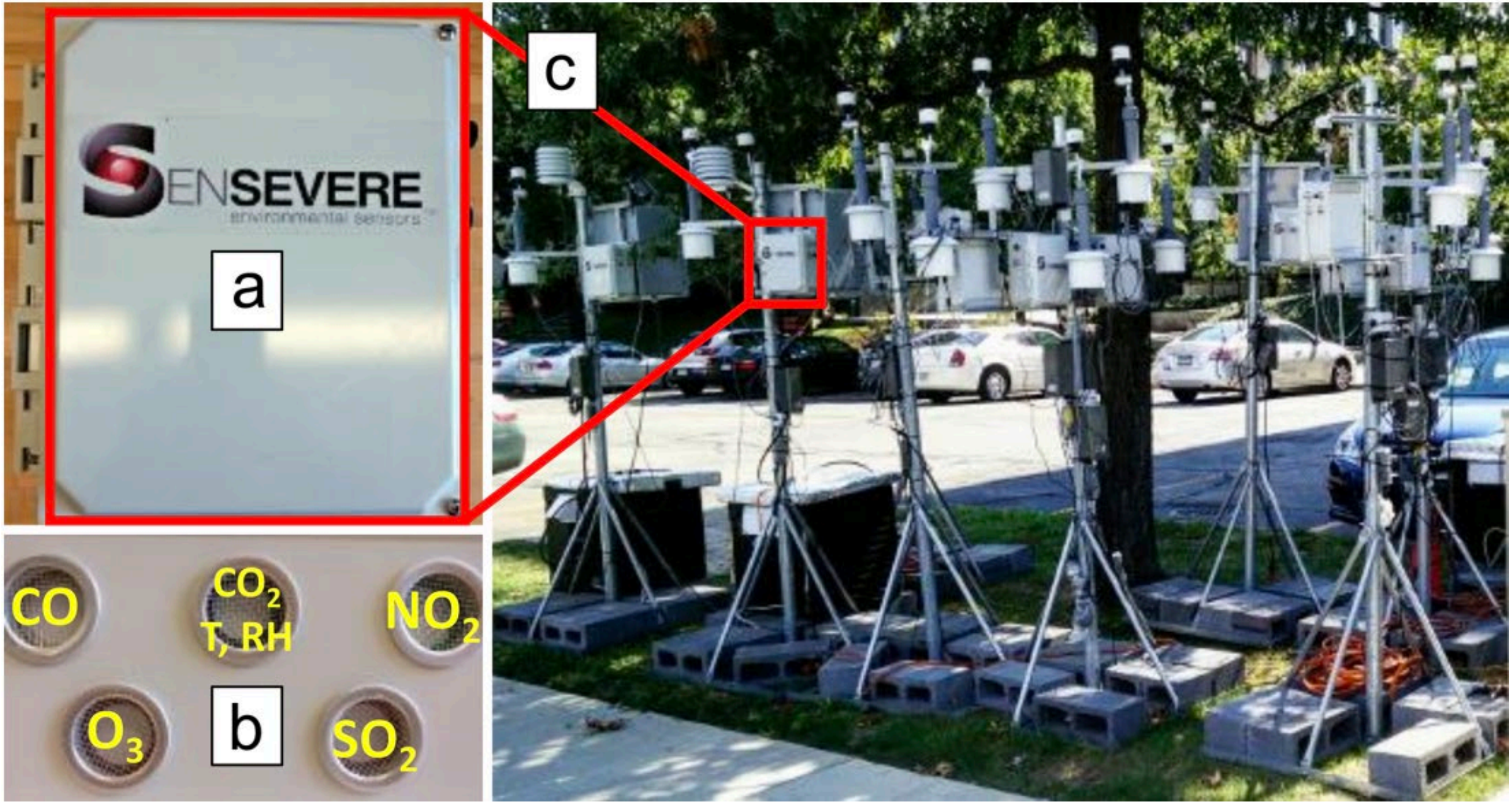
Zimmerman et al, *AMT*, 2018
Giordano et al, *J. Aerosol Sci.*, 2021



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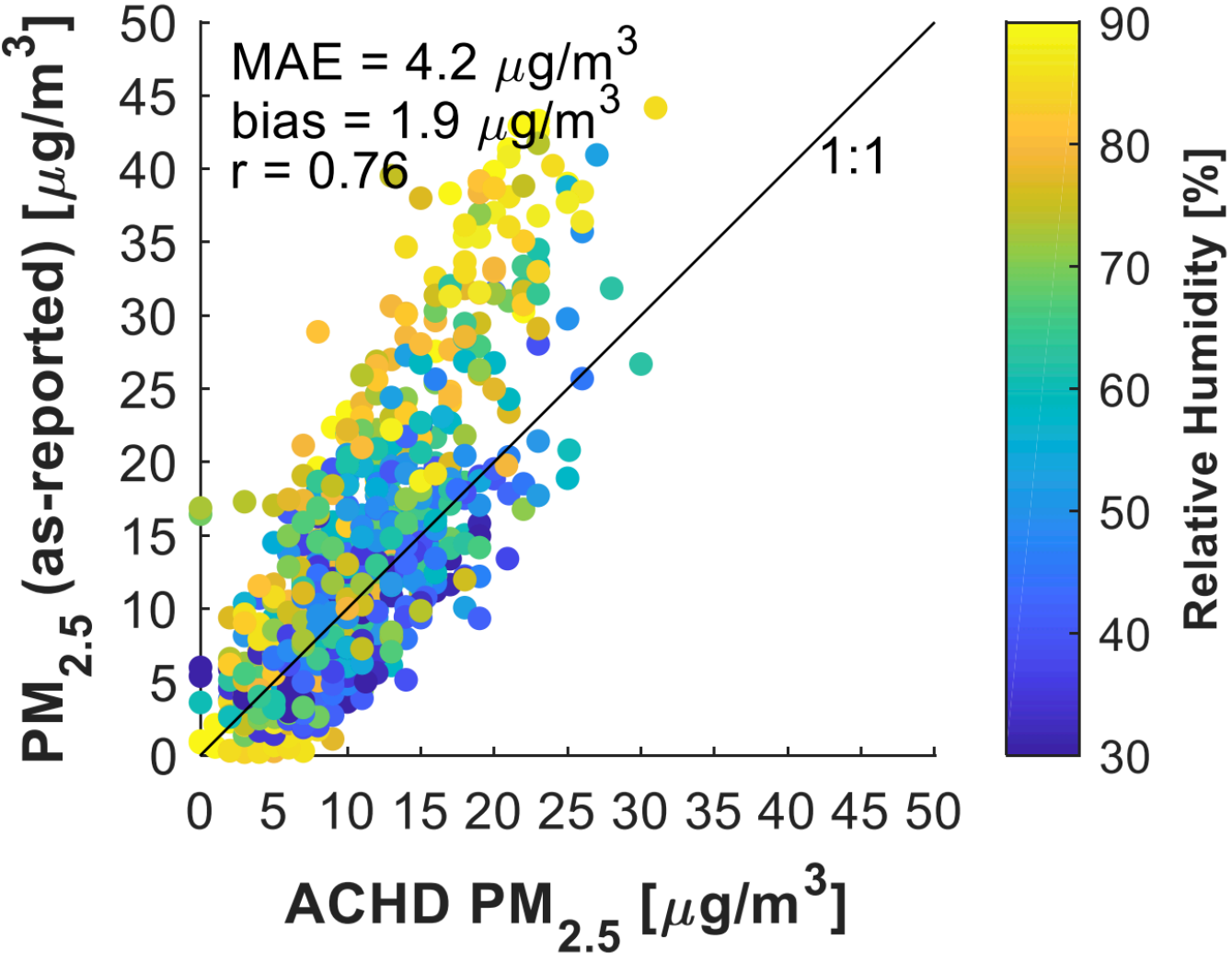
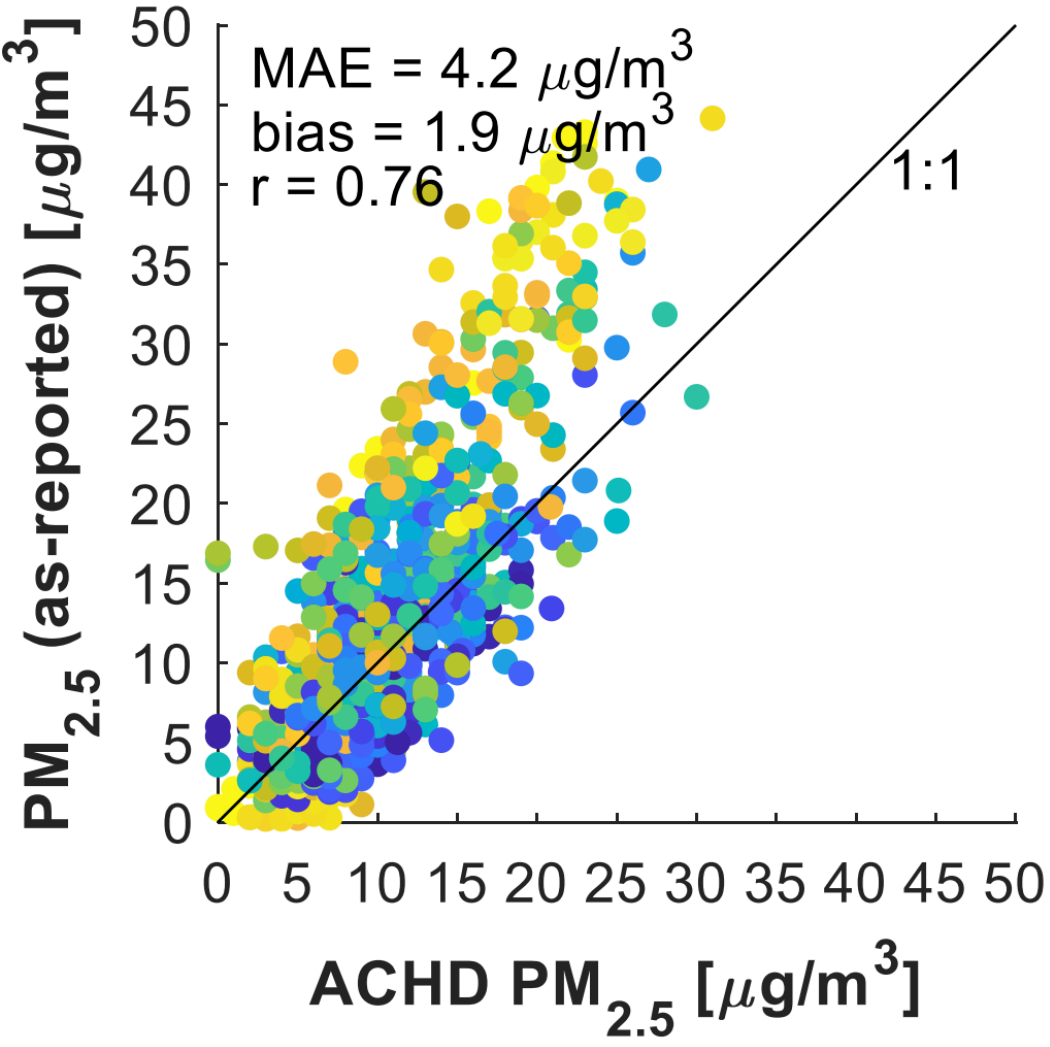
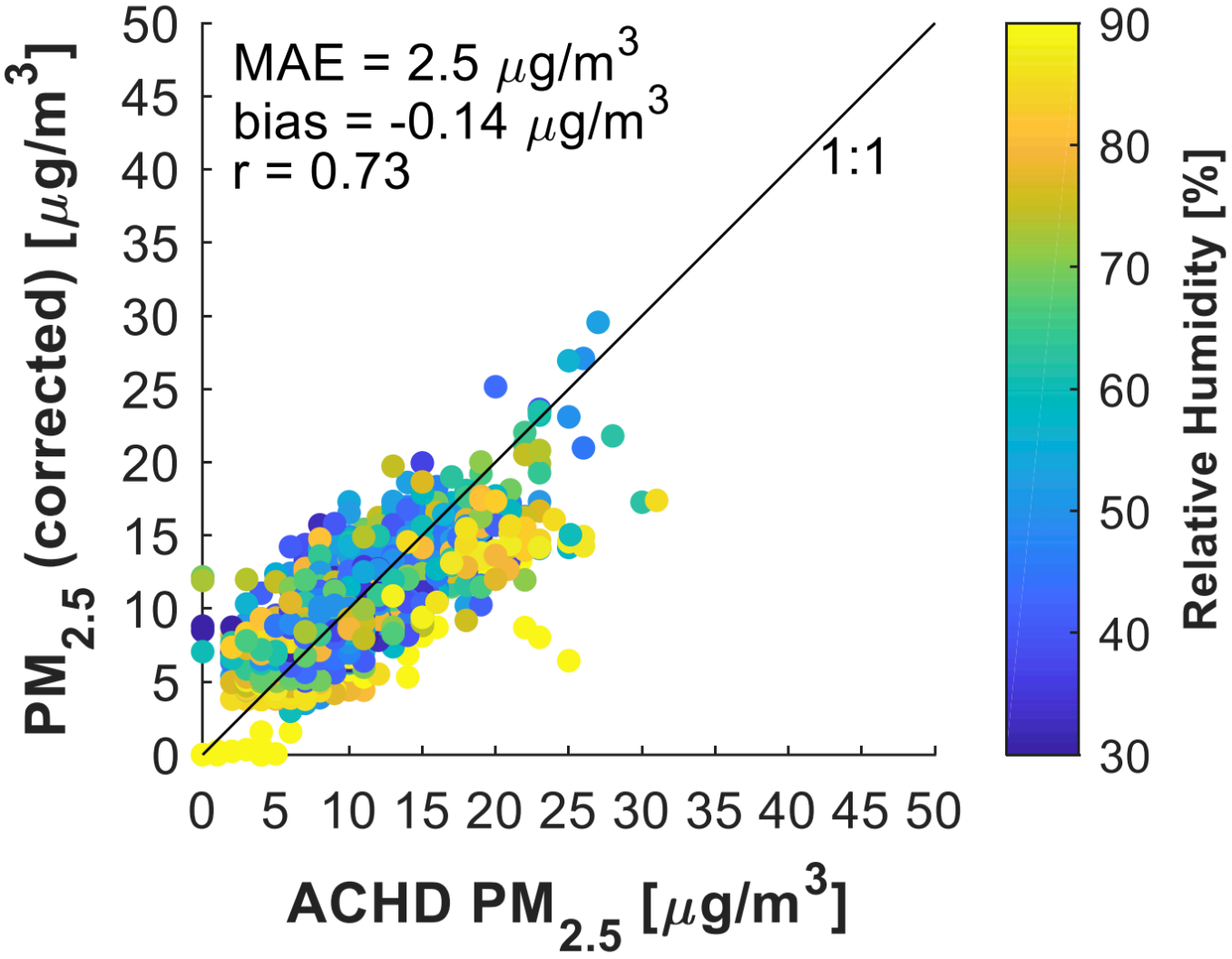
Raw Purple Air output shows humidity bias

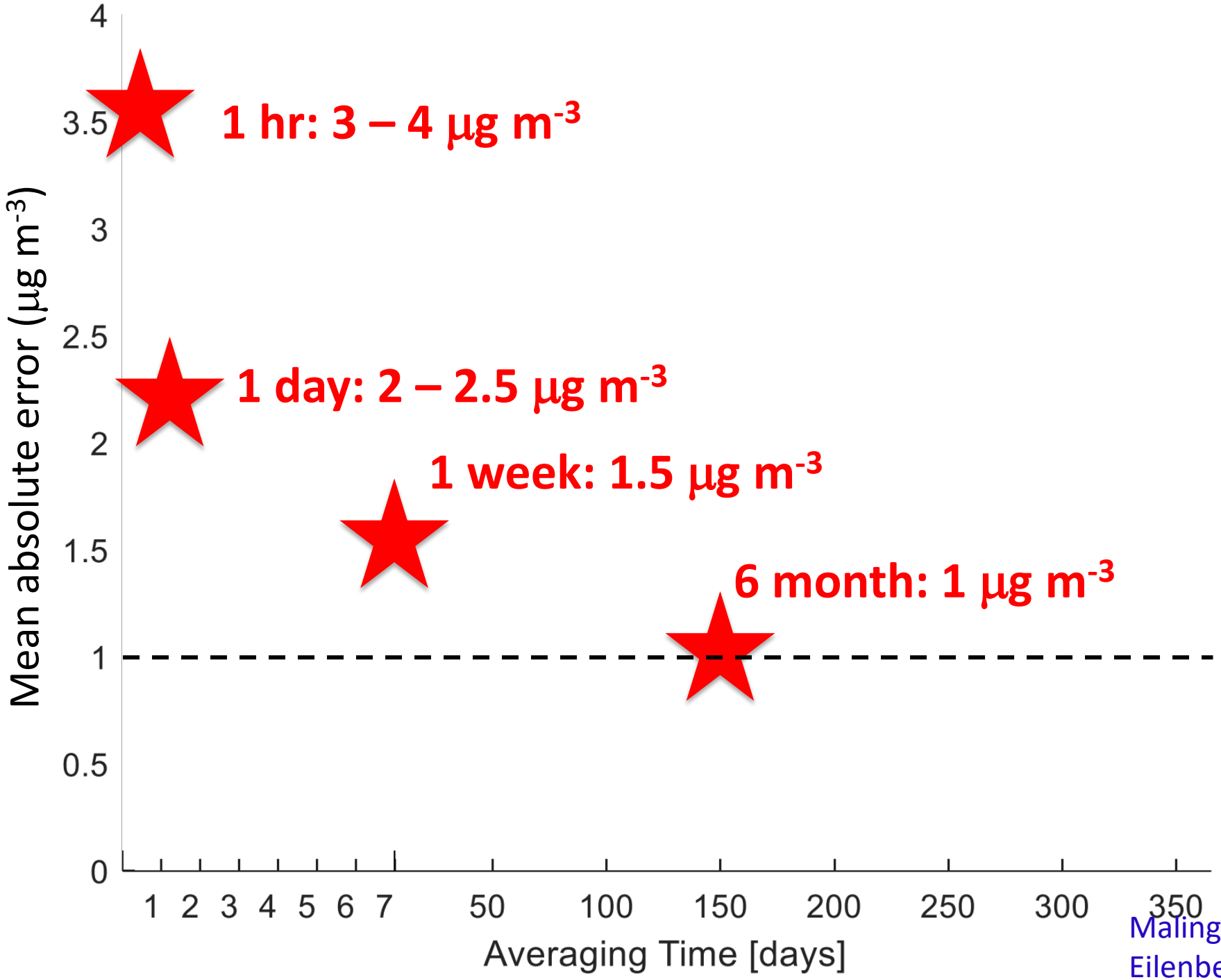


Malings et al, *AS&T*, 2020

Humidity correction removes the bias; hourly data are still scattered

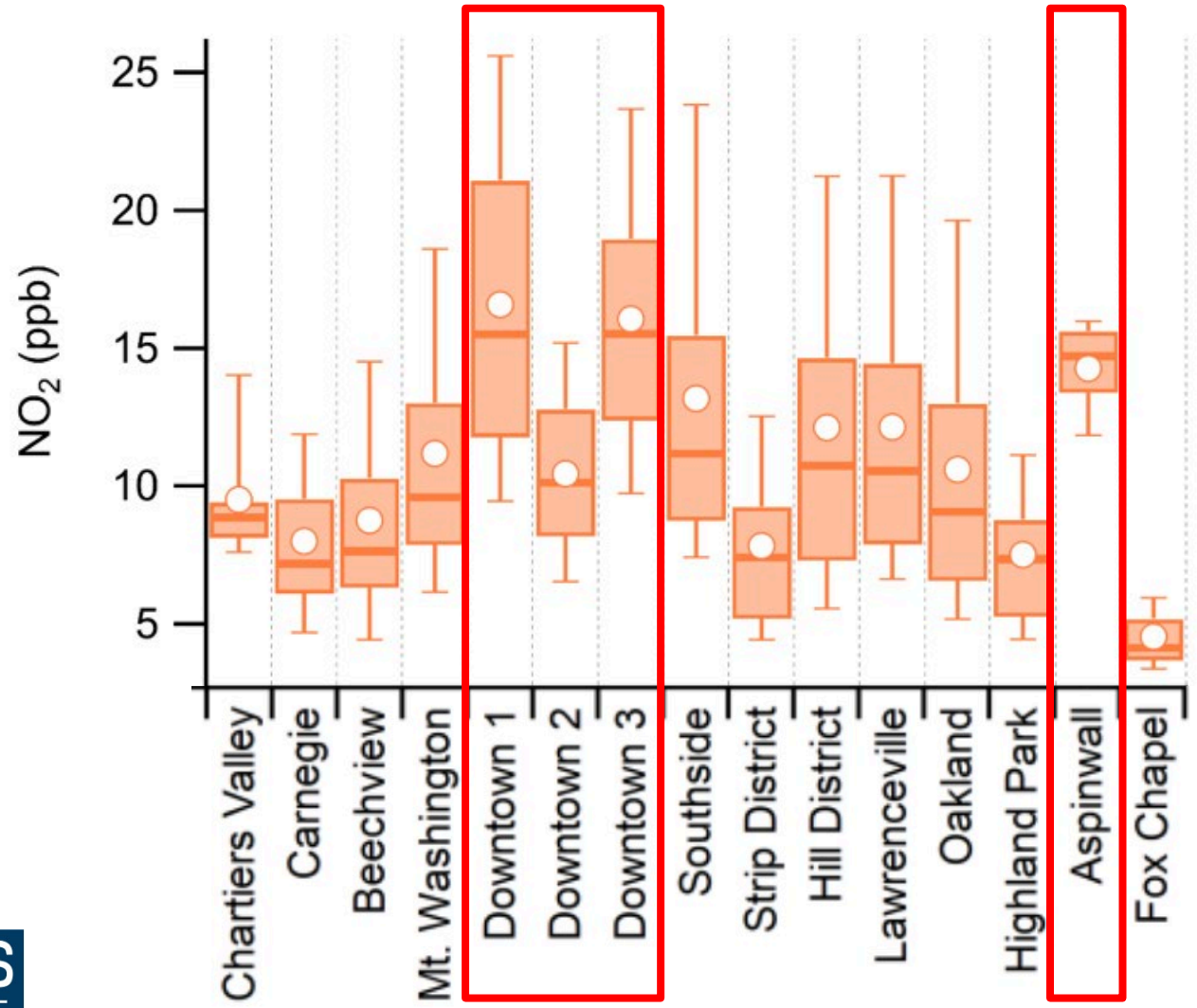






Malings et al, *AS&T*, 2020
Eilenberg et al, *JESEE*, 2020

Calibrations allow us to resolve differences between sites



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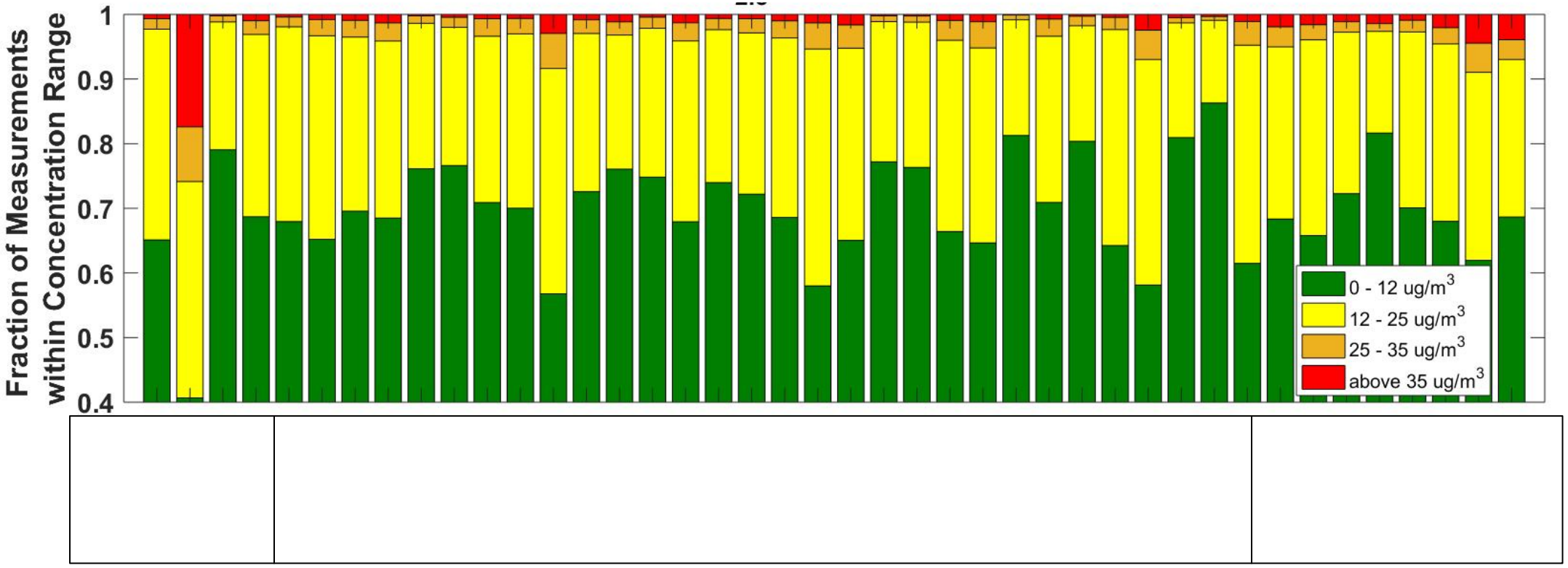
Zimmerman et al, *AAQR*, 2019

The low-cost sensor network lets us examine details of certain locations



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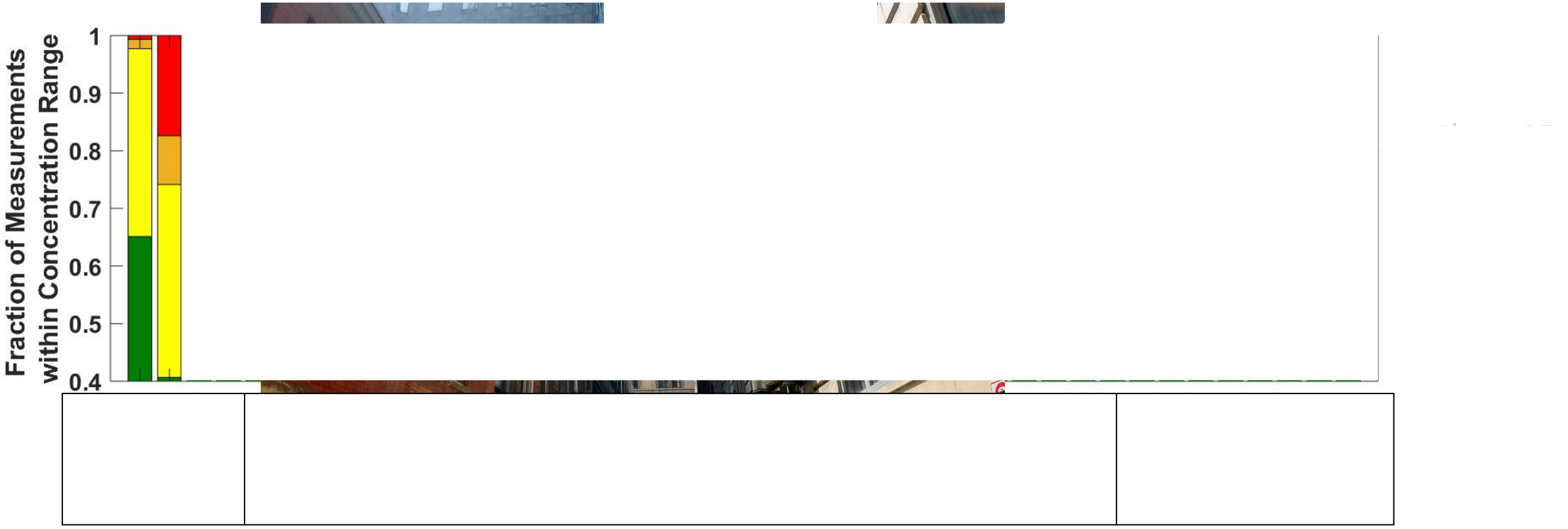
Tanzer et al, *IJERPH*, 2019

$PM_{2.5}$ spatial variability is largely driven by emissions spikes



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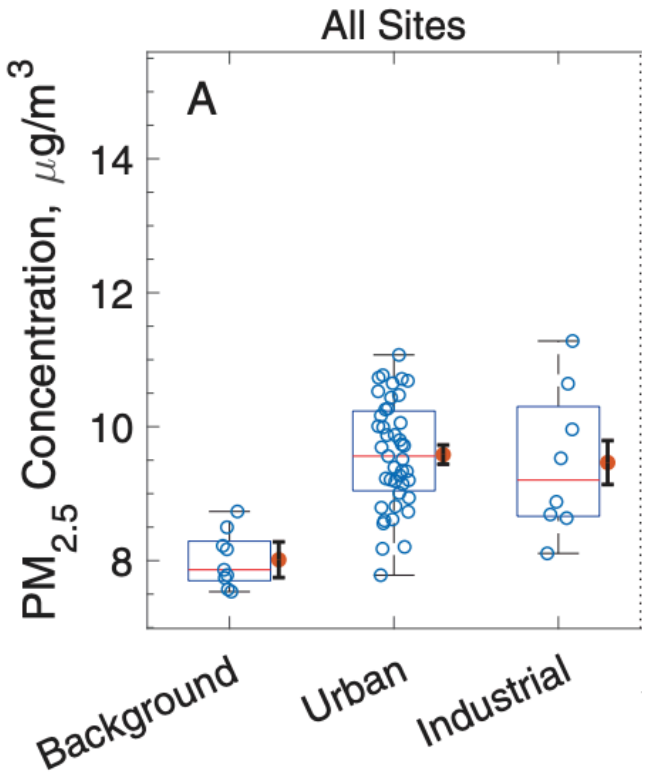
We quantified the impacts of industrial emissions and urban sources



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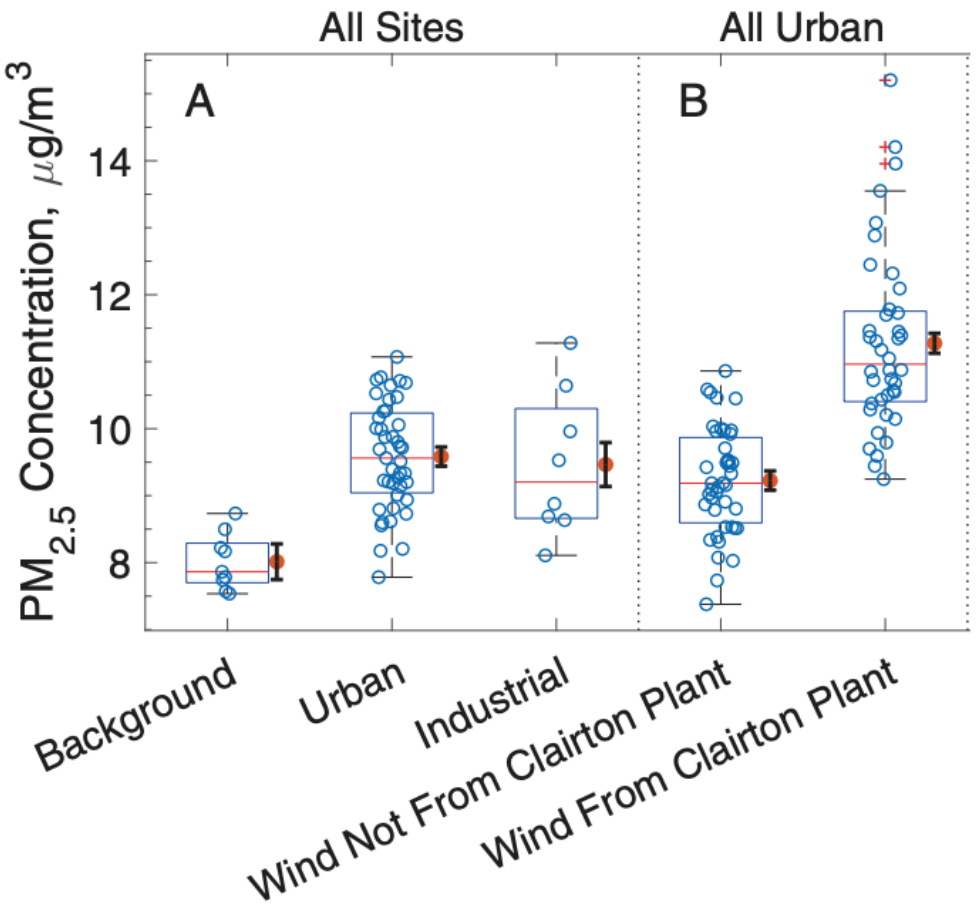

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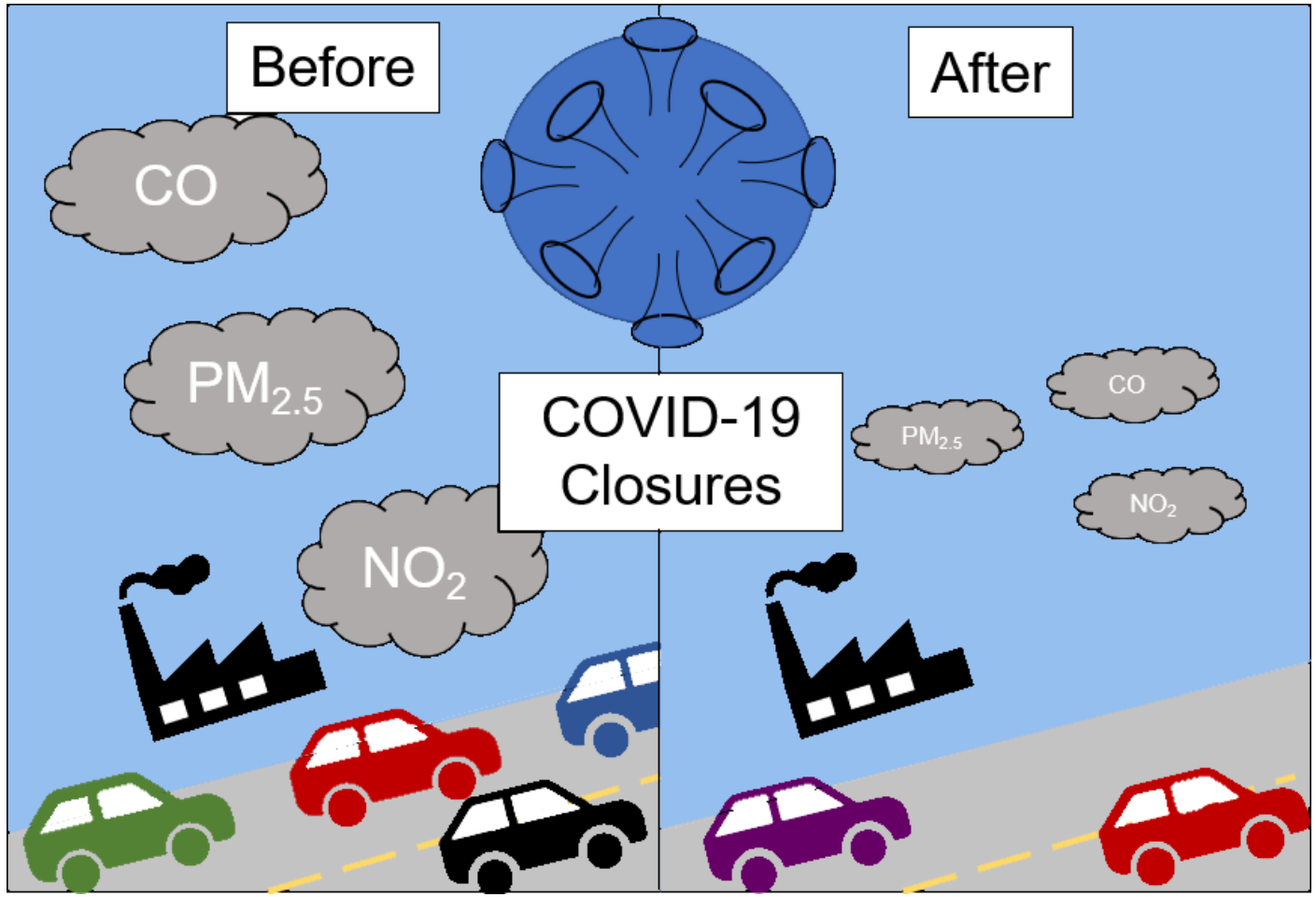
Eilenberg et al, *JESEE*, 2020



Impacts of Modifiable Factors on Ambient Air Pollution: A Case Study of COVID-19 Shutdowns

Rebecca Tanzer-Gruener, Jiayu Li, S. Rose Eilenberg, Allen L. Robinson, and Albert A. Presto*

Cite this: *Environ. Sci. Technol. Lett.* 2020, 7, 8, 554–559
Publication Date: June 23, 2020
https://doi.org/10.1021/acs.estlett.0c00365

Dense network of **fixed sites**

Mobile sampling to quantify block by block ***sources*** and ***exposure***.

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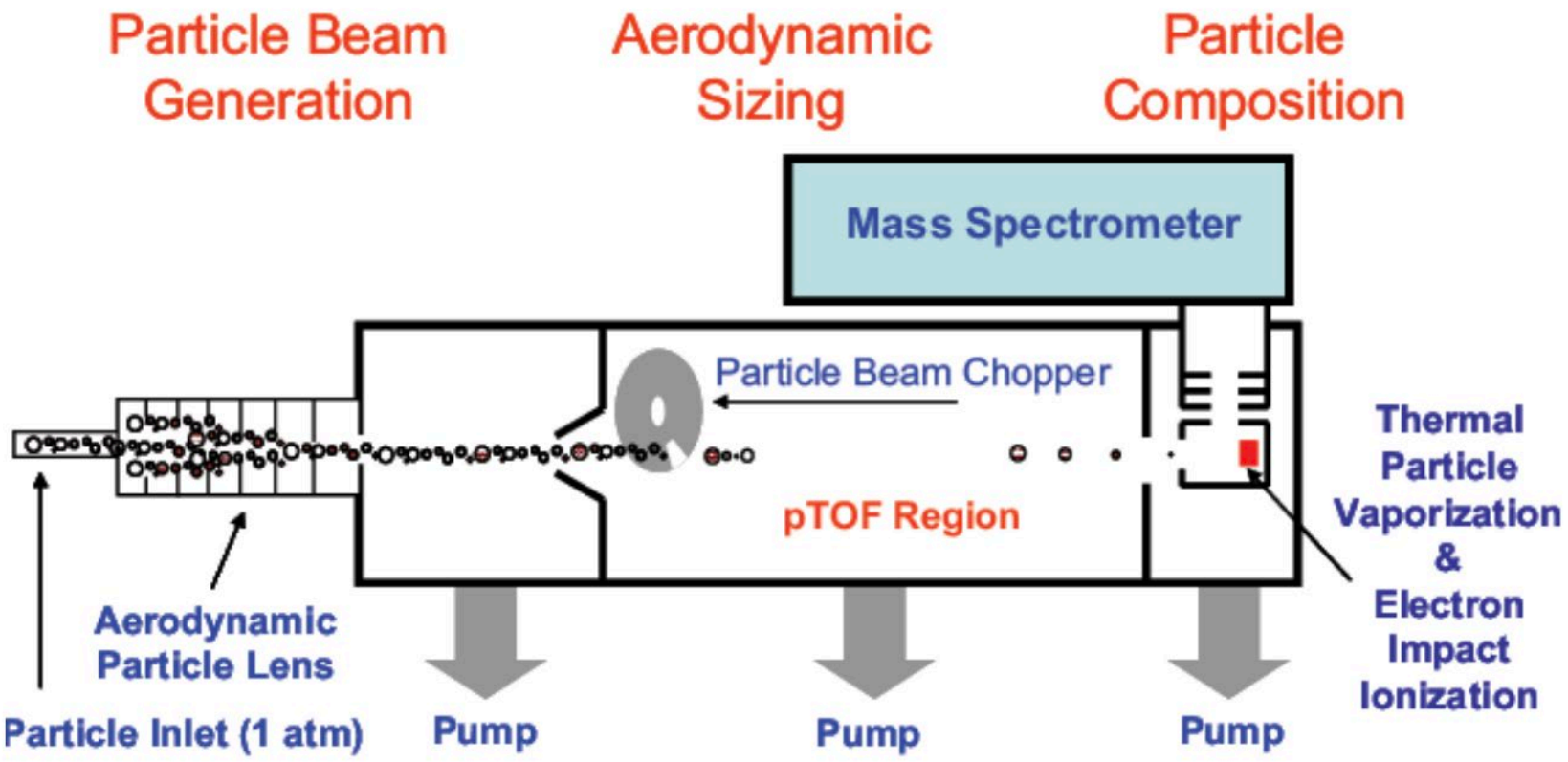
Mobile sampling with an Aerosol Mass Spectrometer (AMS)



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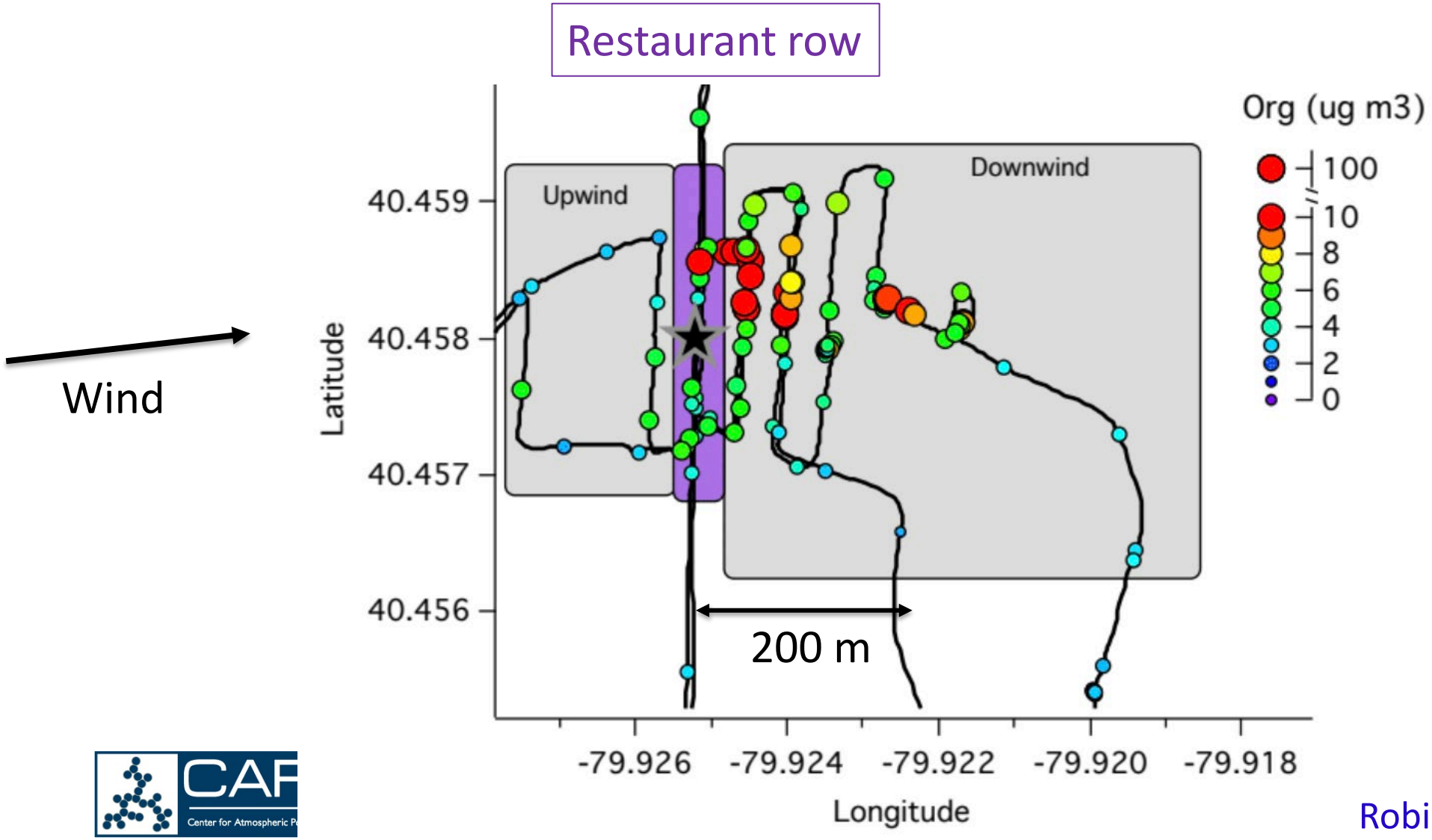
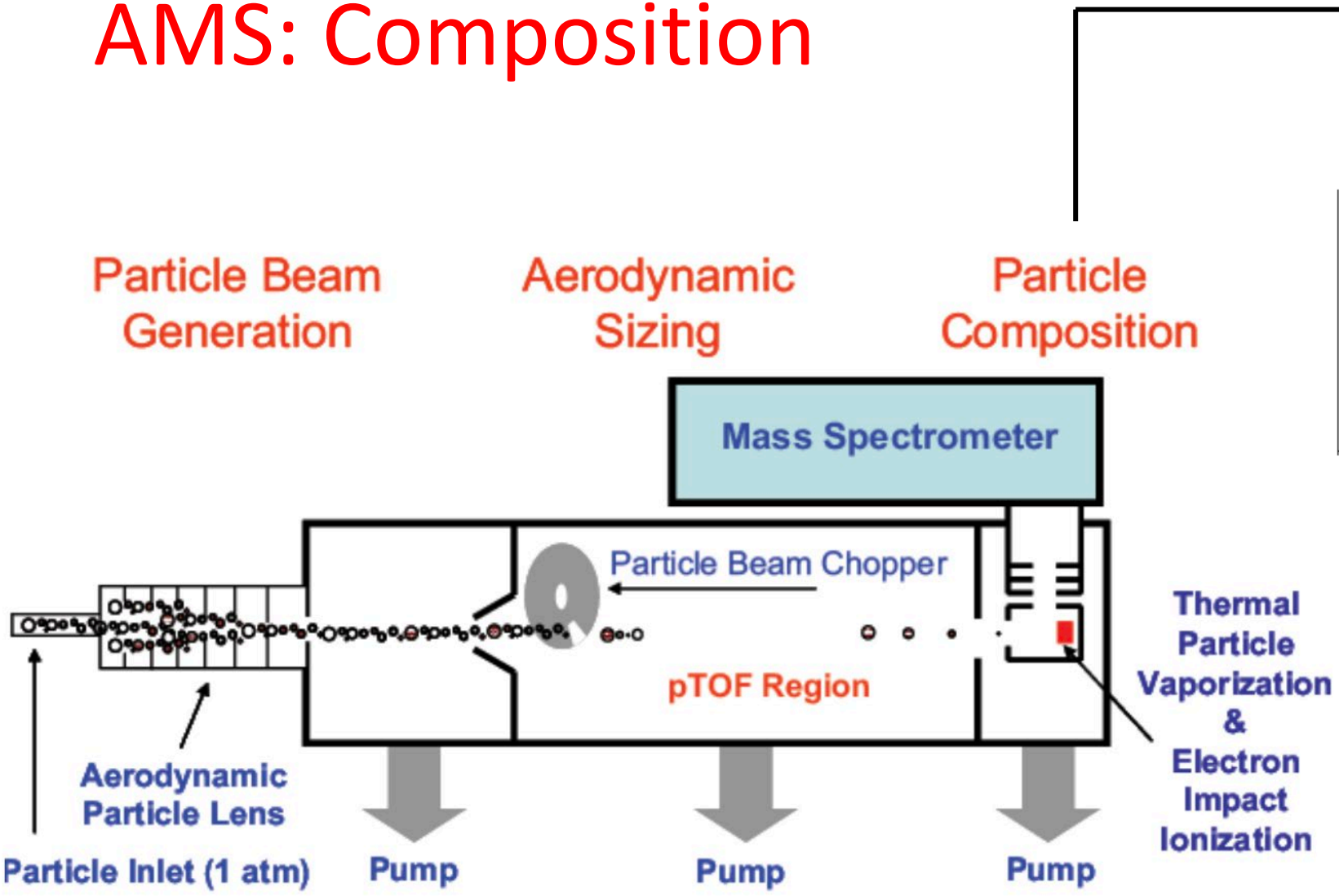
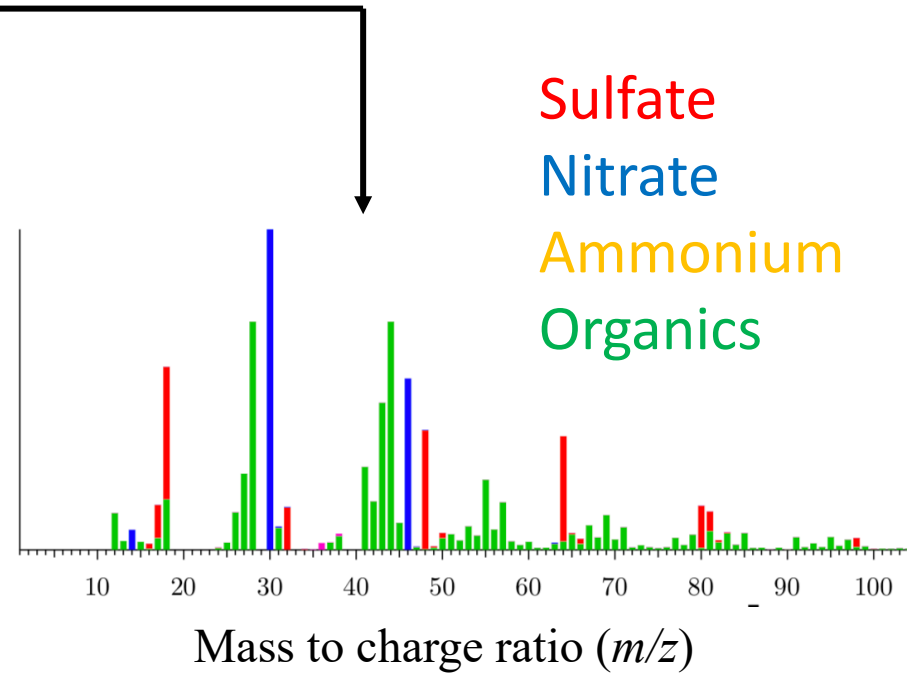
Cooking sources generate large plumes



Robinson et al, *ES&T*, 2018

AMS: Composition





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PM composition helps inform sources

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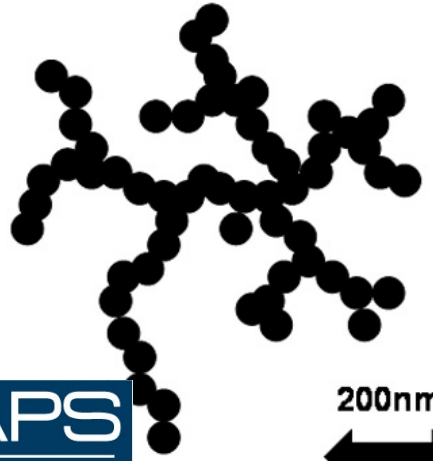
What are these particles made from?



200nm

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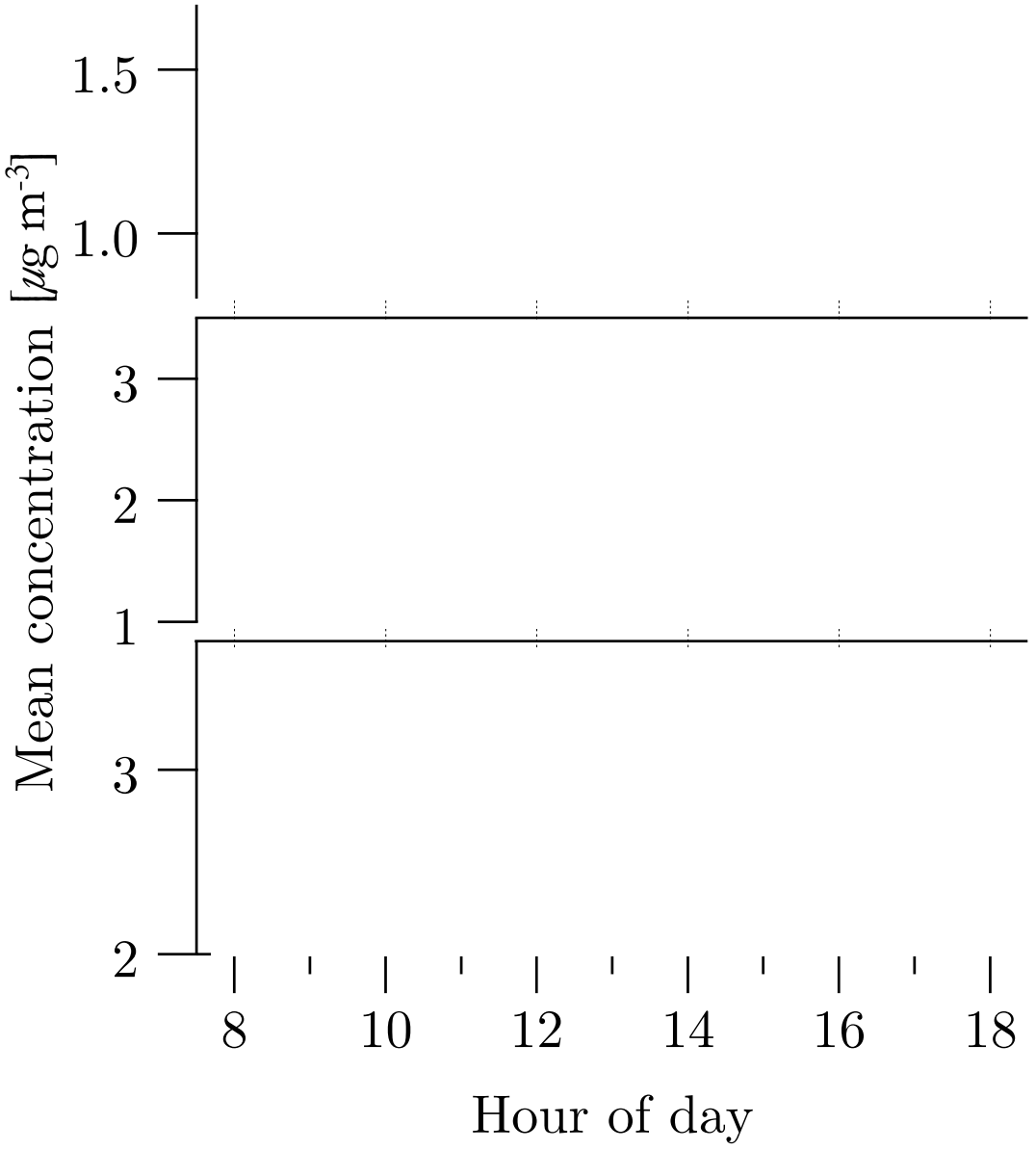
There are three main factor types



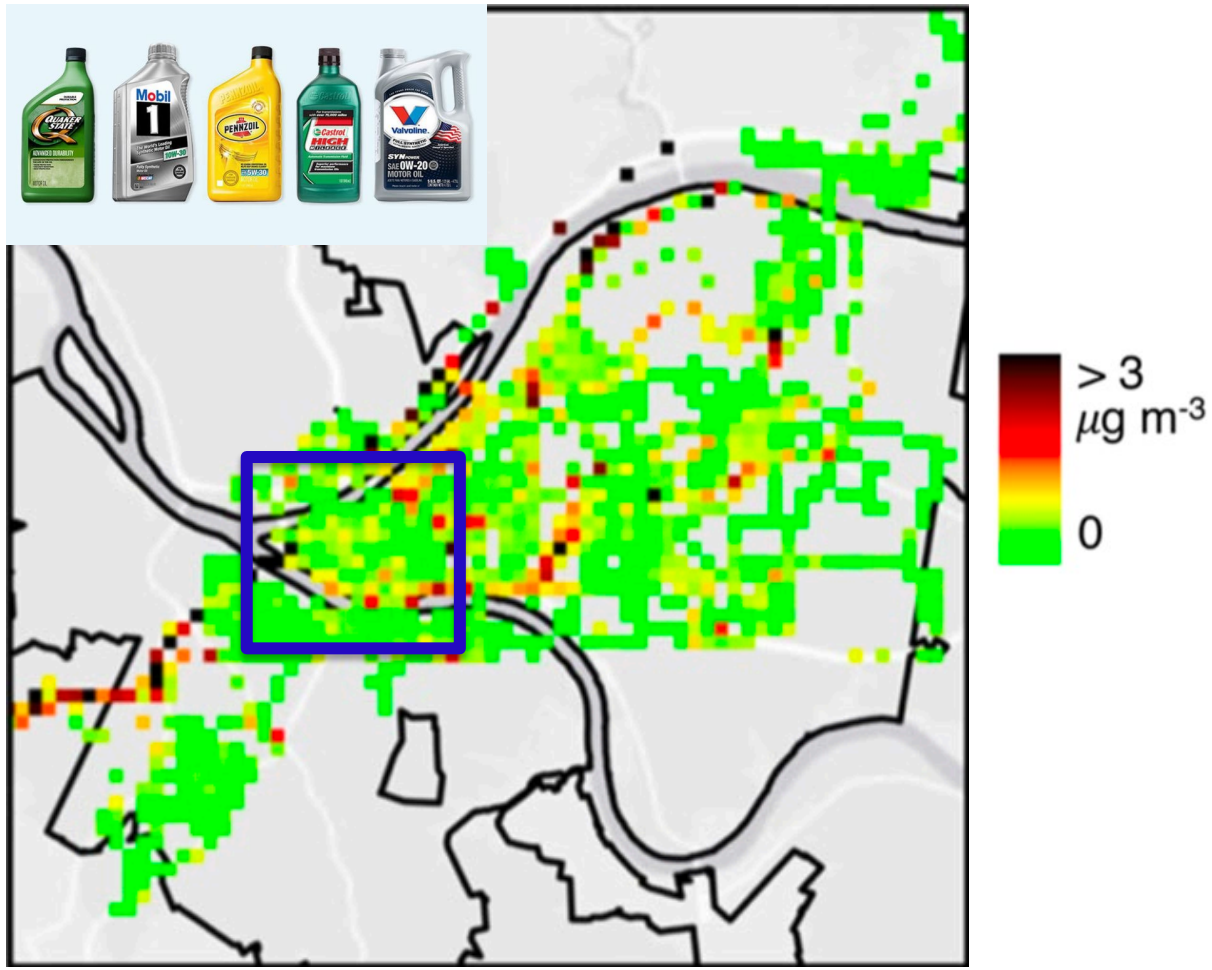
Primary OA from vehicle exhaust

Primary OA from cooking

Secondary OA formed upon processing of primary OA

Shah et al, *ACP*, 2018

Source-resolved PM varies spatially



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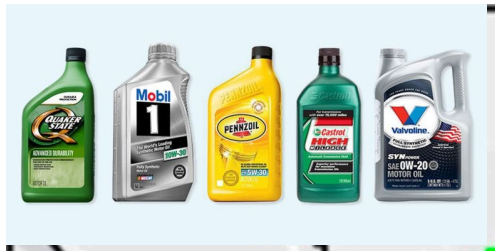
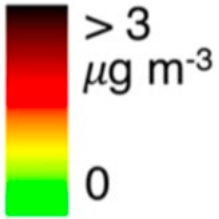
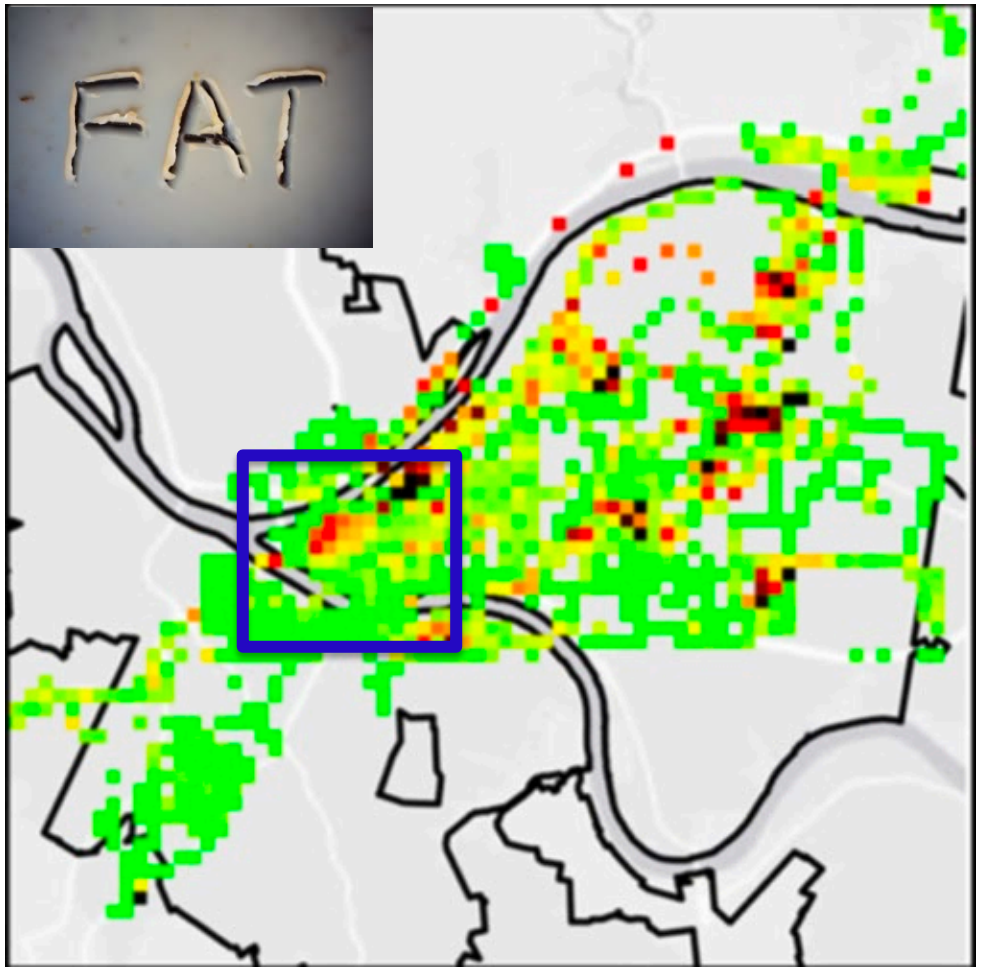
Gu et al, *ES&T*, 2018

Cooking hotspots are more intense than traffic hotspots







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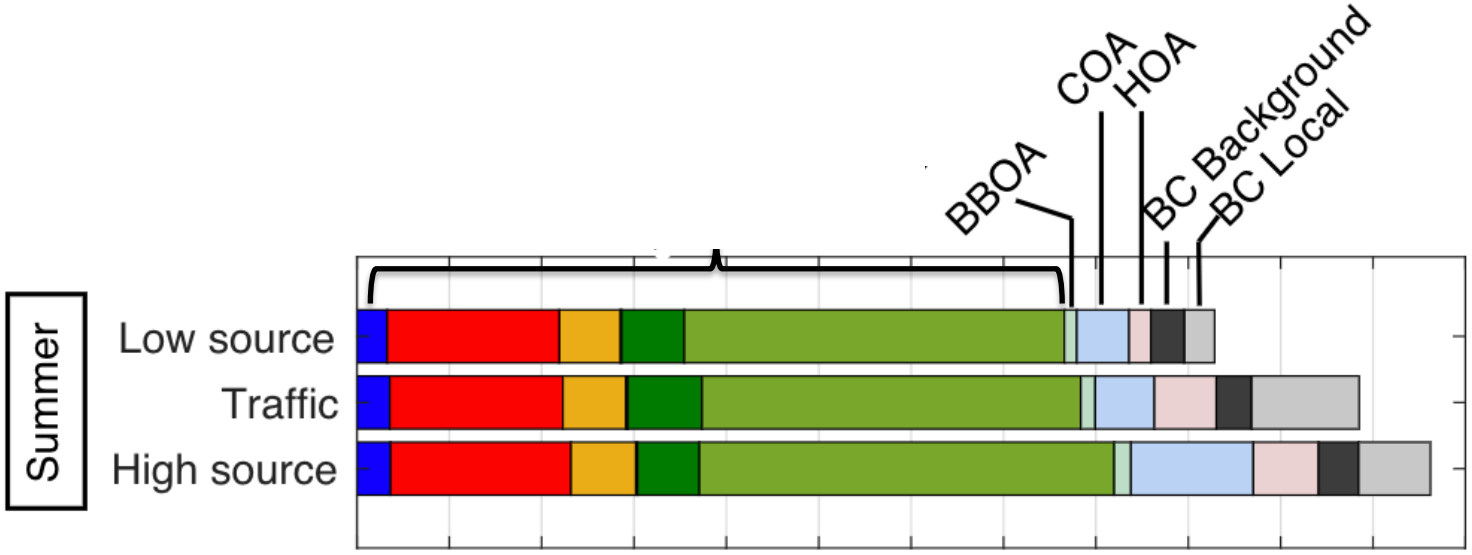
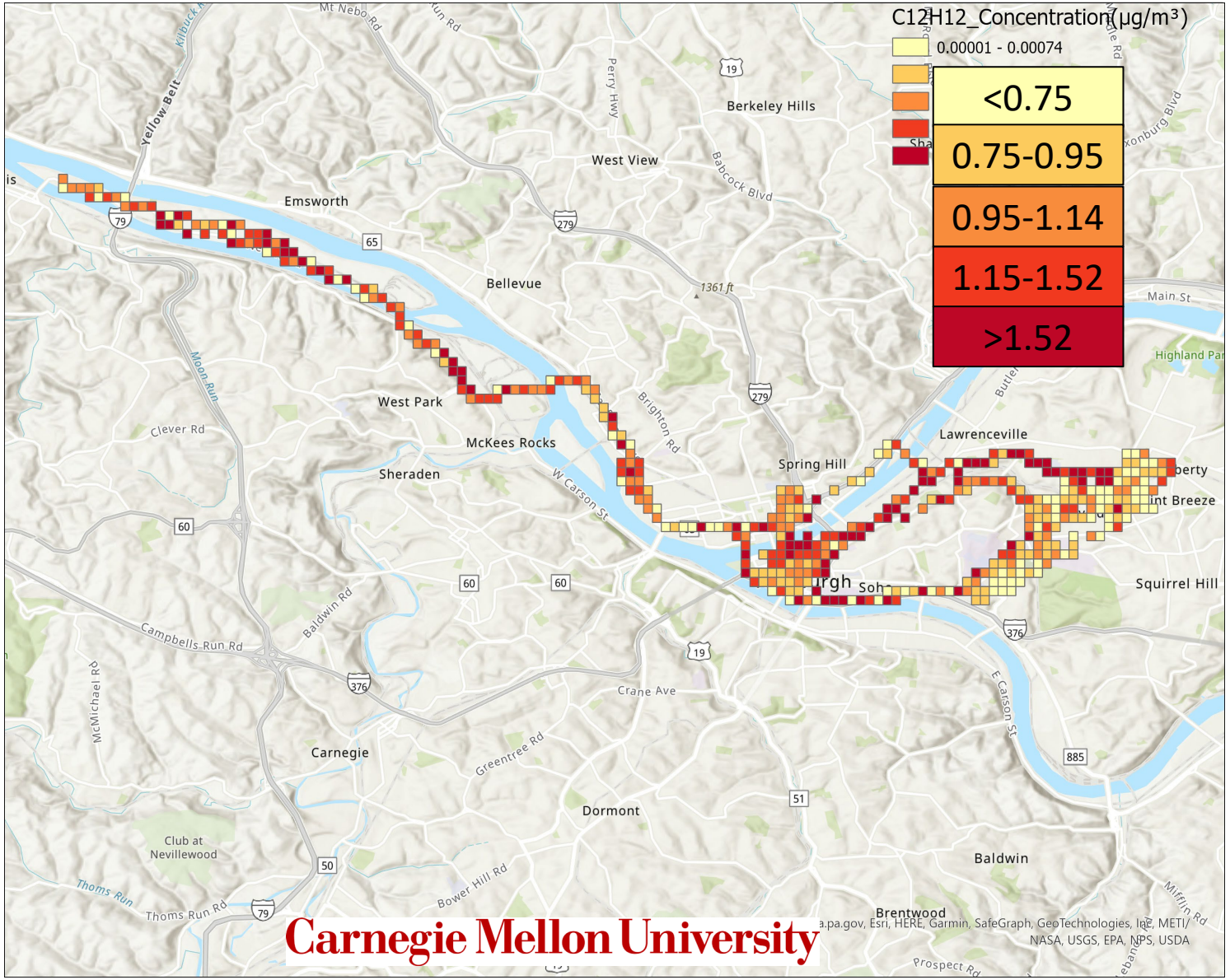
Gu et al, *ES&T*, 2018

Restaurant and traffic lead to an increase of 2 μg m^{-3} to PM_1 concentration in Pittsburgh



Gu et al, *ES&T*, 2018

We are also applying mobile sampling for air toxics



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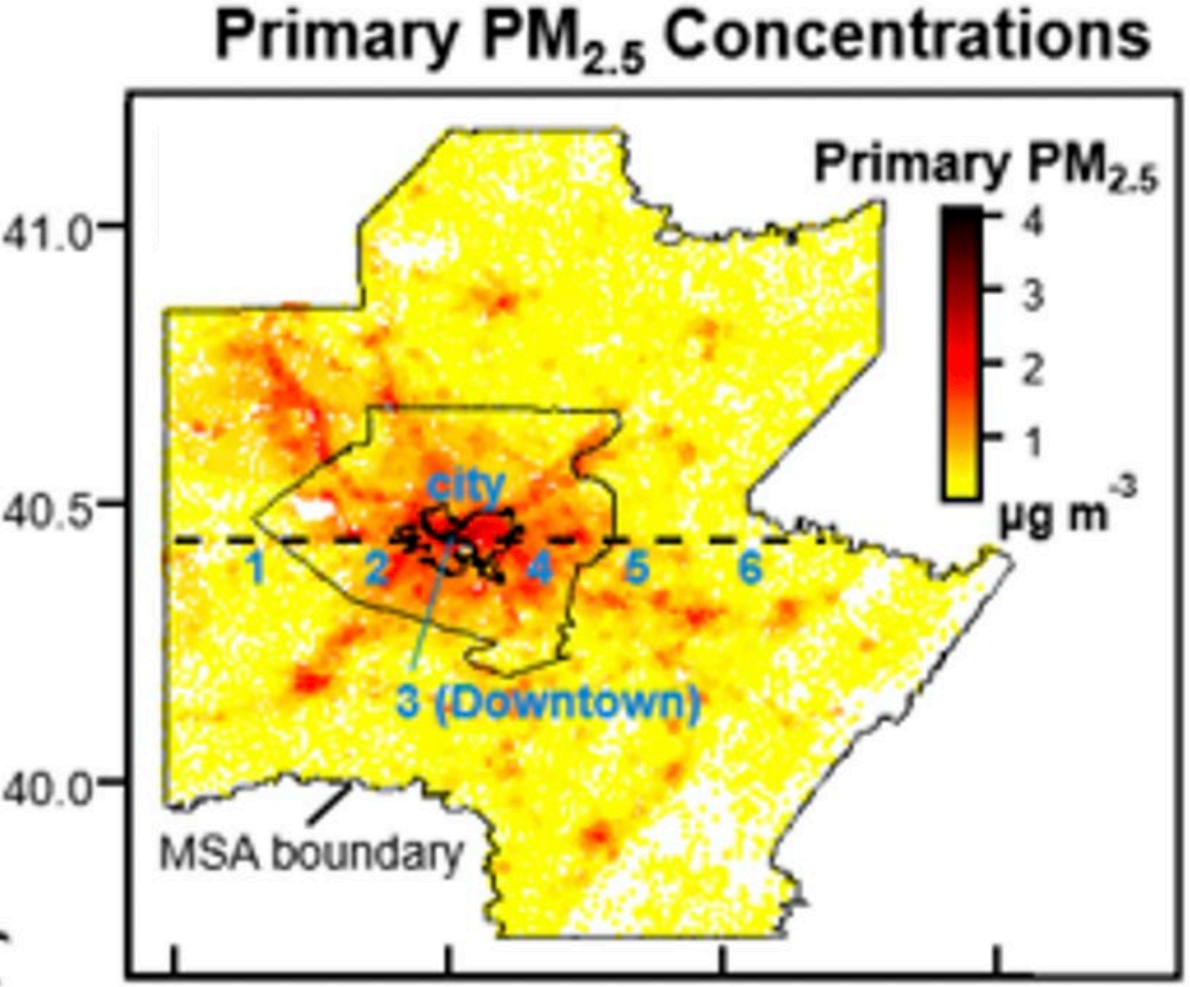
Environmental Justice

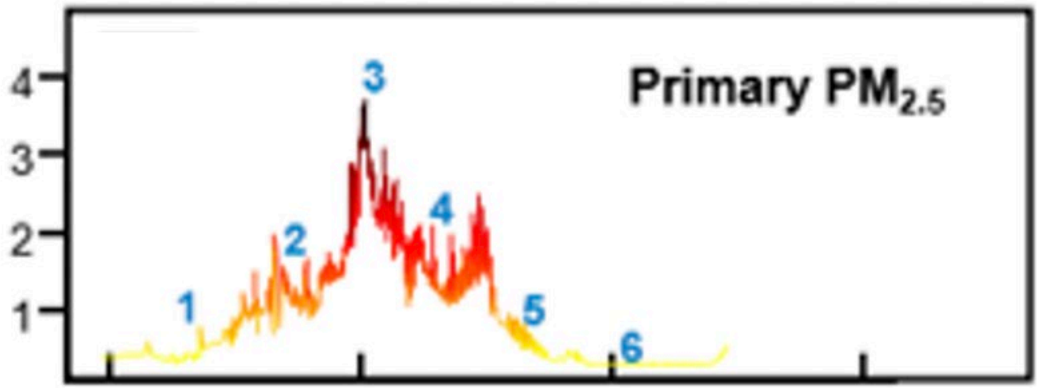
"We don't all breathe the same air"

Kids play basketball in the shadow of a petrochemical plant in Port Arthur, TX

Photo: readersupportednews.org

Urban areas have an air pollution “hump” with spikes on top of it





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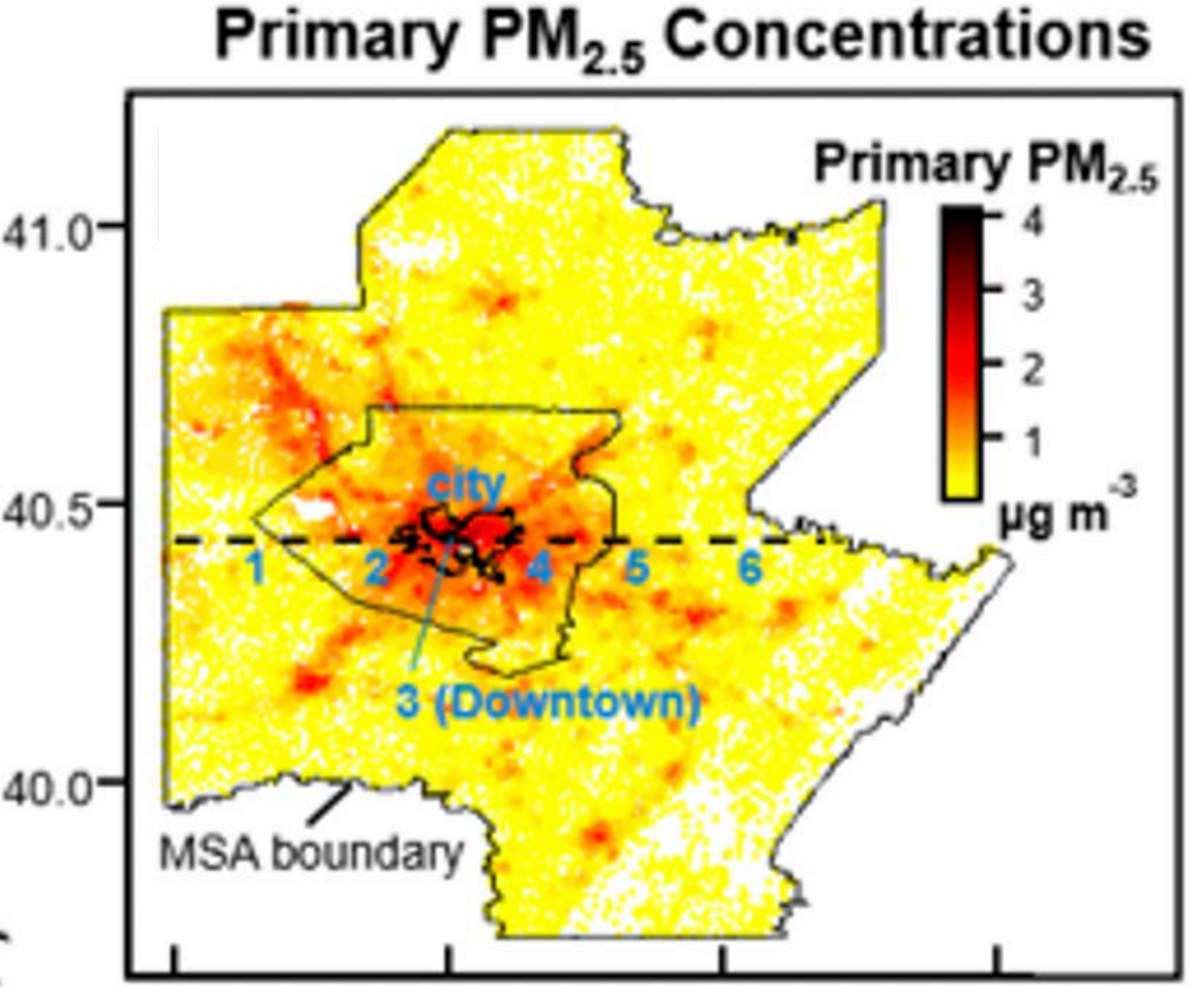
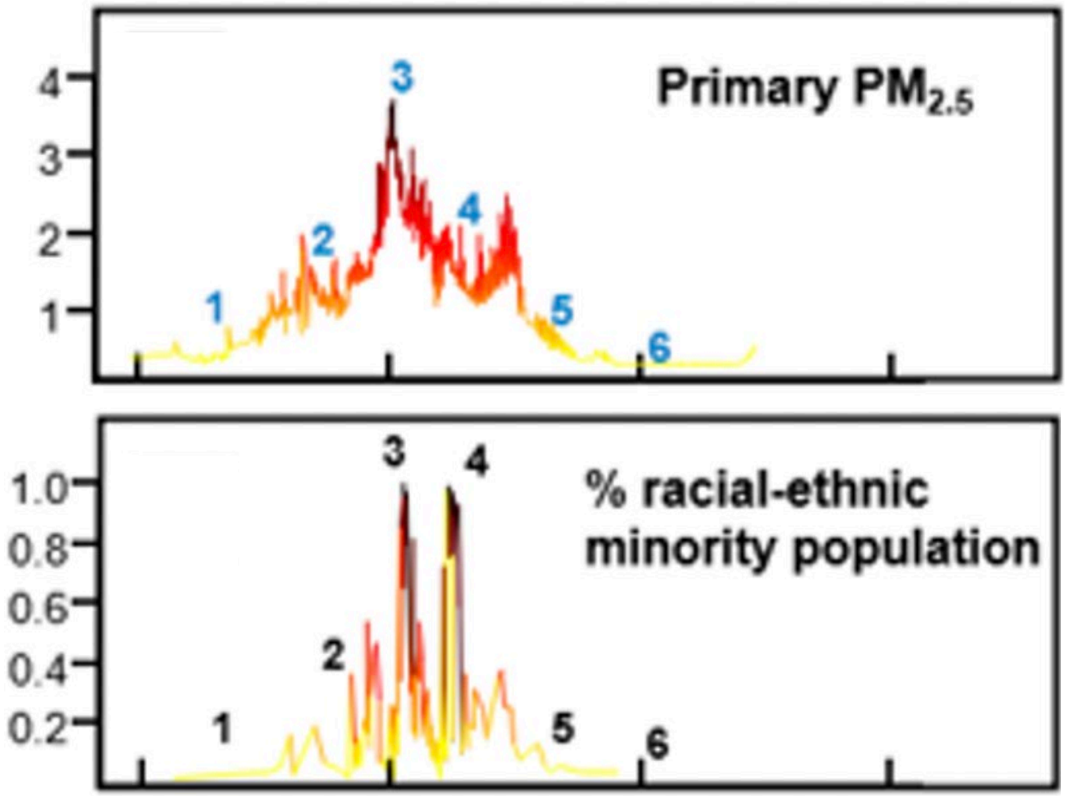
Saha et al, *submitted*, 2022

Demographics and $PM_{2.5}$ are correlated





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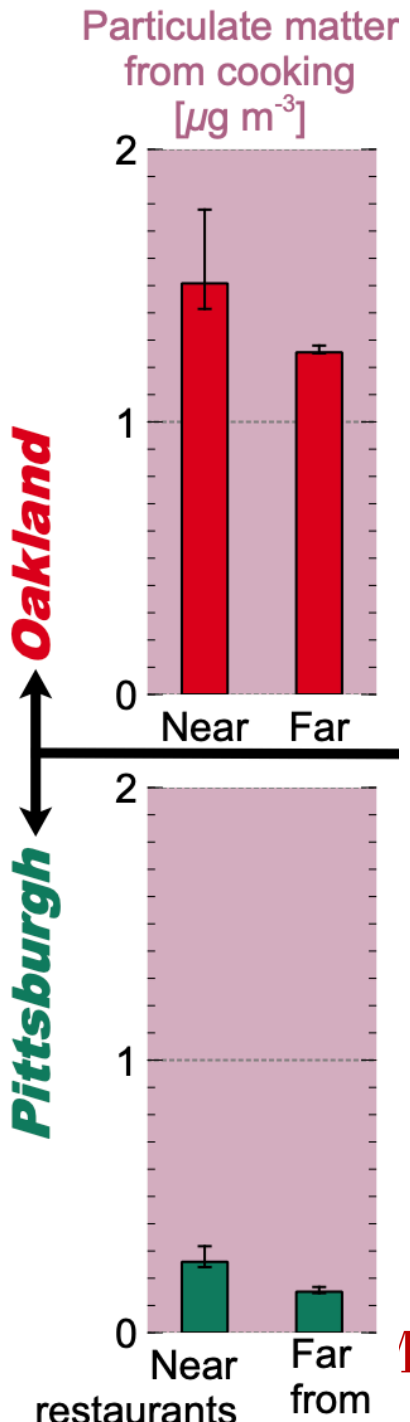
Saha et al, *submitted*, 2022

People living near urban emissions sources are more likely to be People of Color



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Mellon University

Shah et al, *ERL*, 2020

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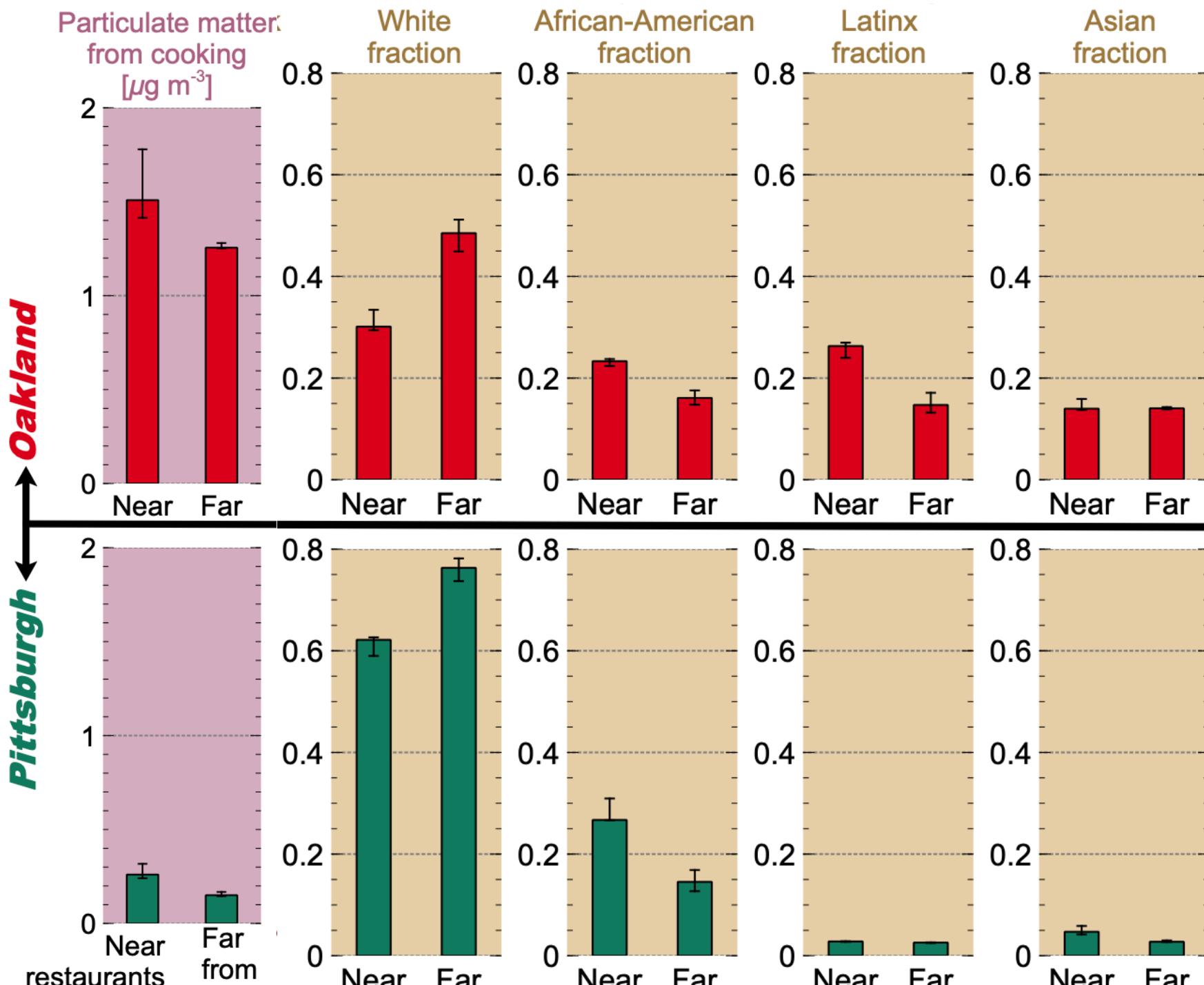

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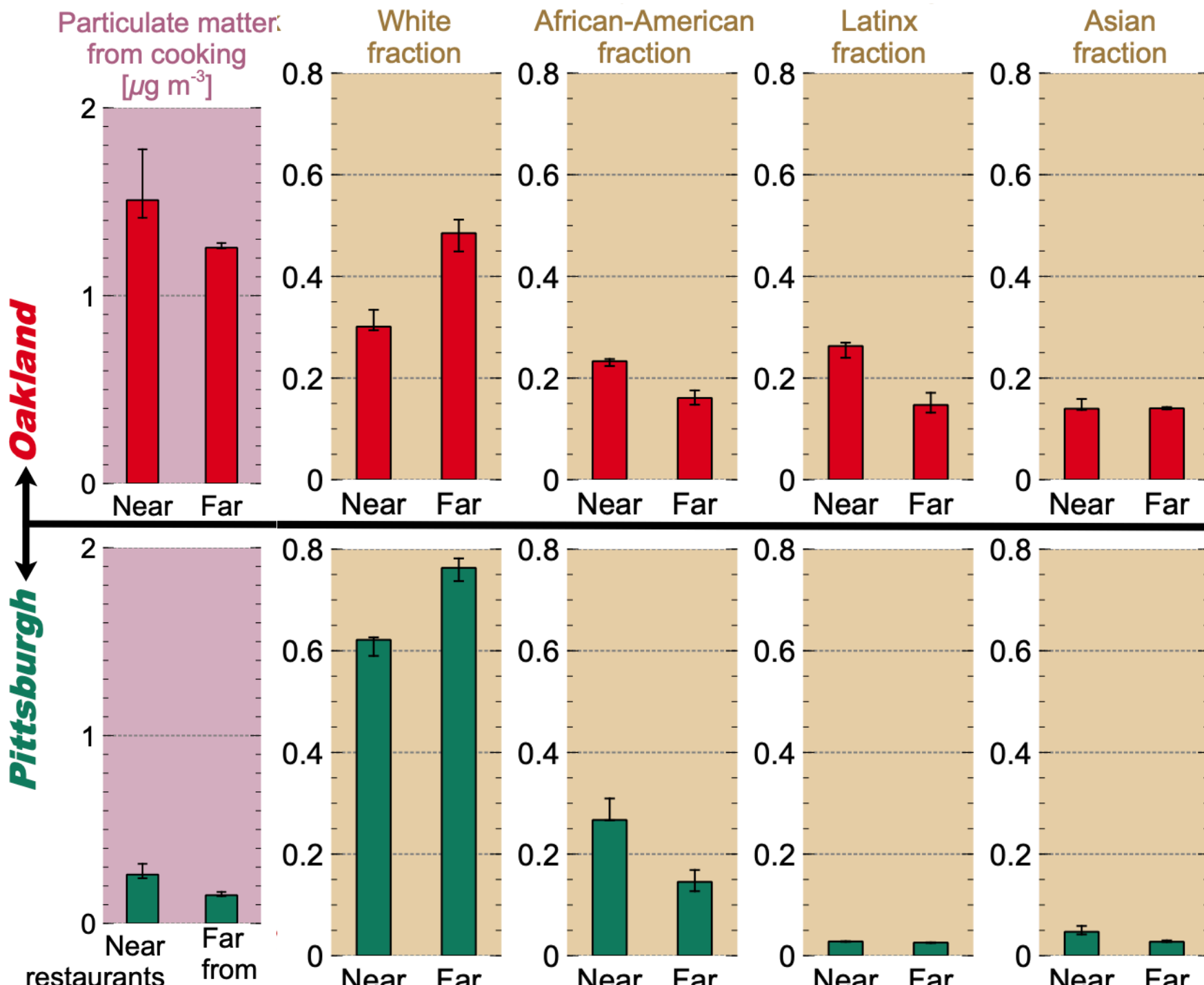
People living near urban emissions sources are more likely to be People of Color



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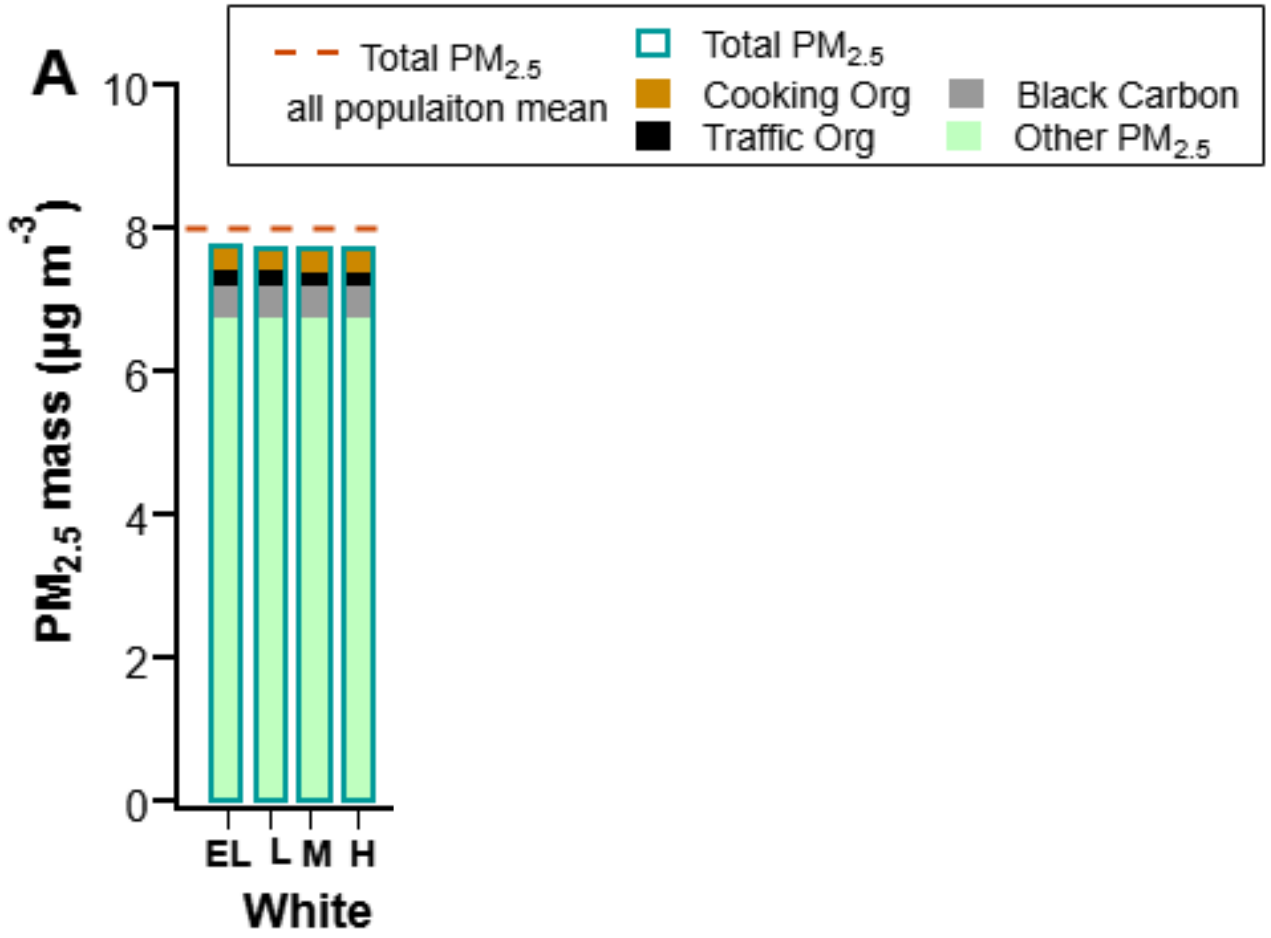
EJ: Race-ethnicity is a stronger factor than income



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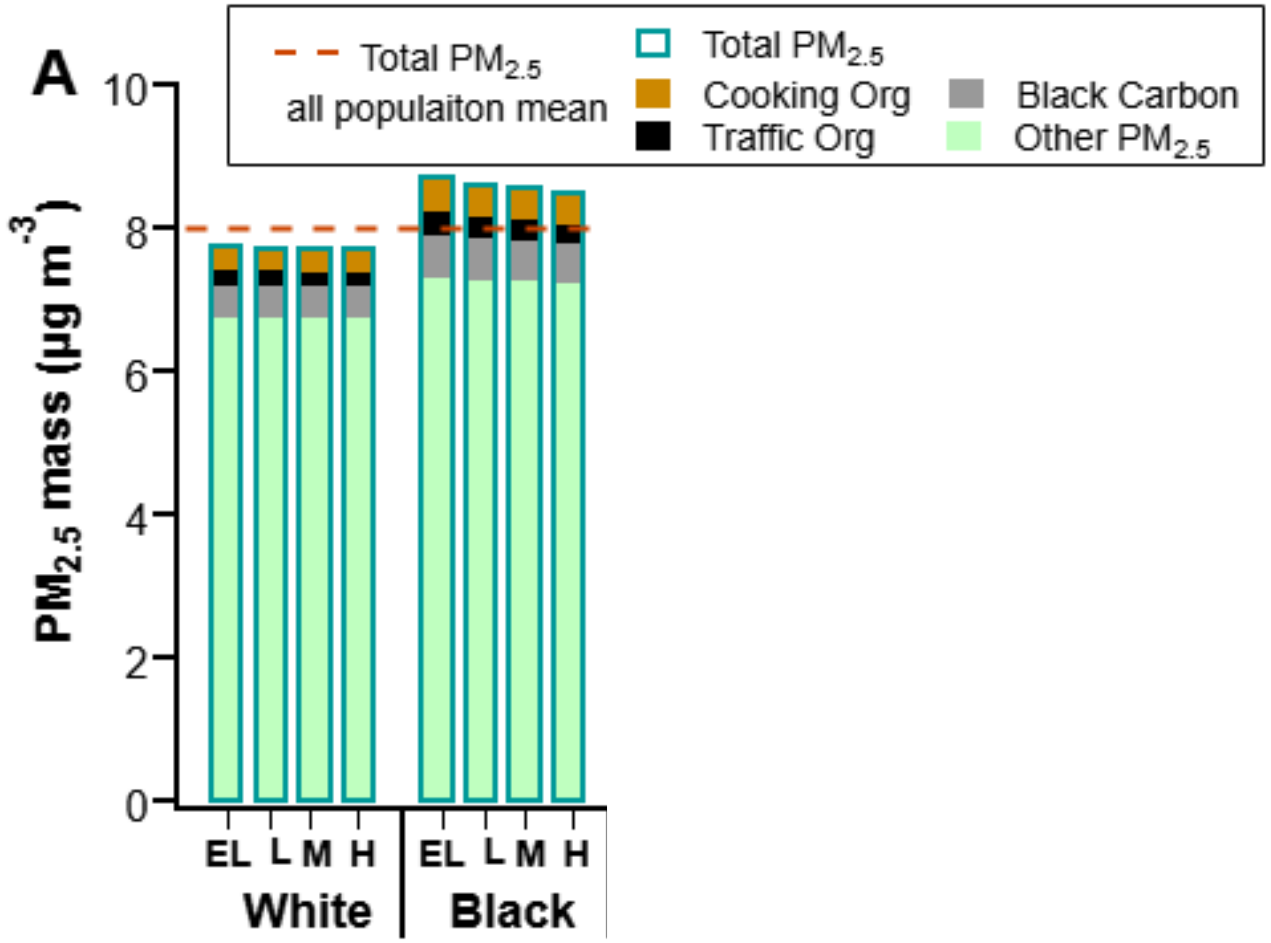

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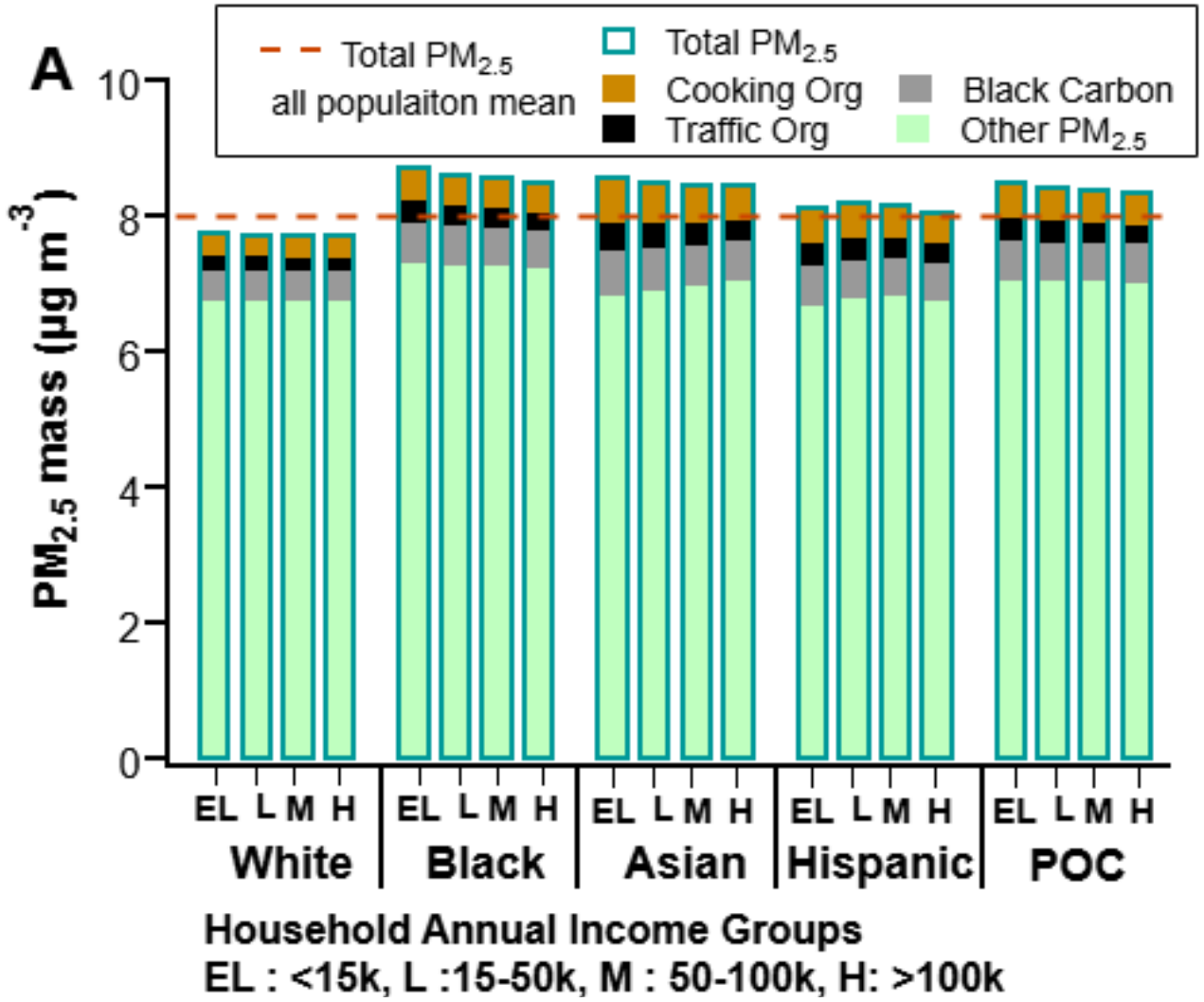

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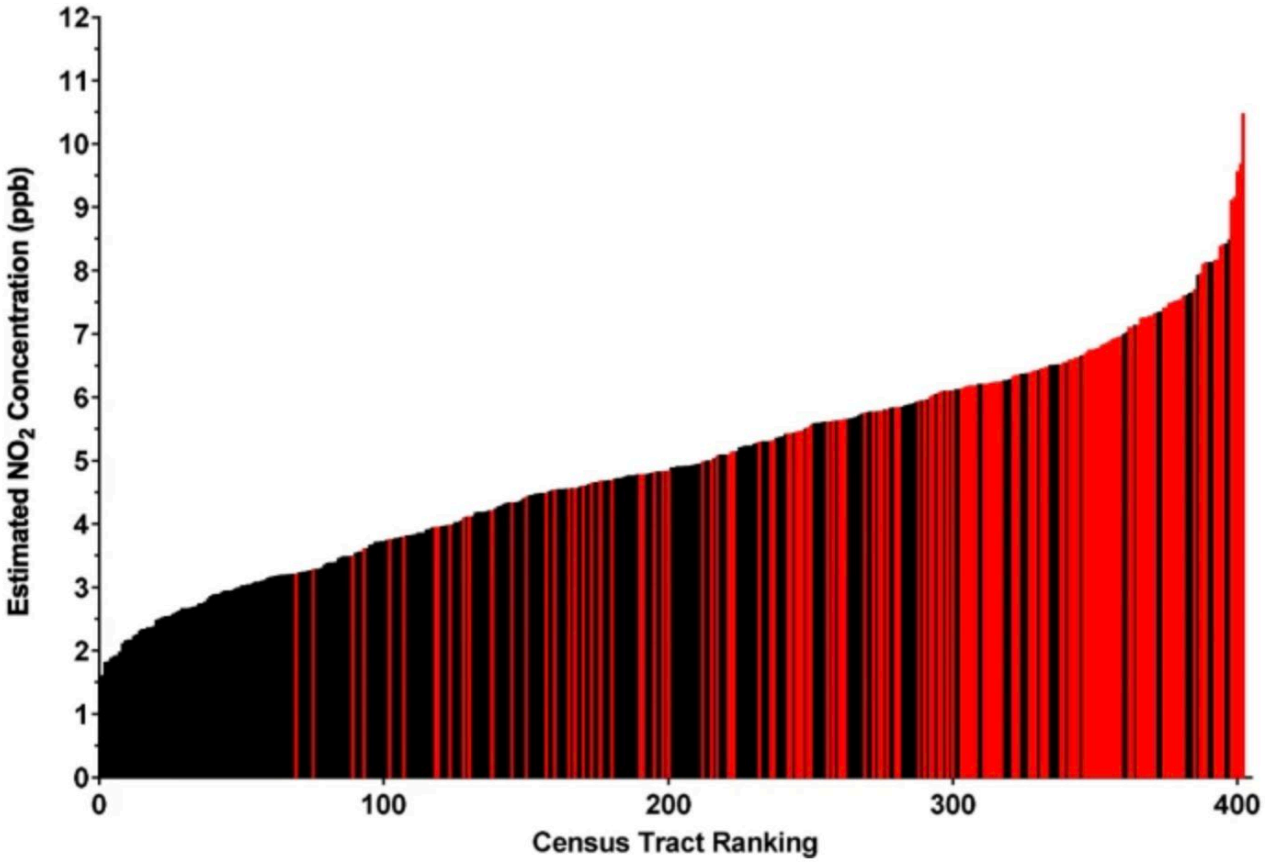
There is strong NO_2 environmental injustice in Allegheny County

A risk-based model to assess environmental justice and coronary heart disease burden from traffic-related air pollutants

James P. Fabisiak ✉, Erica M. Jackson, LuAnn L. Brink & Albert A. Presto



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Take home points

- We can use low-cost sensor networks and mobile monitoring to investigate local-scale variations in air pollution
  - Both allow for higher spatial density of sampling than regulatory monitoring
- Low-cost sensors need to be carefully calibrated for local conditions
  - After calibration, data are usable to quantify local-scale variations
- Mobile monitoring enables detailed investigations of source impacts at the urban scale
  - Enables detailed mapping of source impacts at the neighborhood scale