Six years of the Pittsburgh RAMP network: Lessons learned and where we go from here

Albert Presto, R. Subramanian, Naomi Zimmerman, Carl Malings, Aliaksei Hauryliuk, Jiayu Li, Rose Eilenberg, Rebecca Tanzer-Gruener, Provat Saha, Sakshi Jain, Ruichen Song, and Hugh Li

Carnegie Mellon University

Take home points

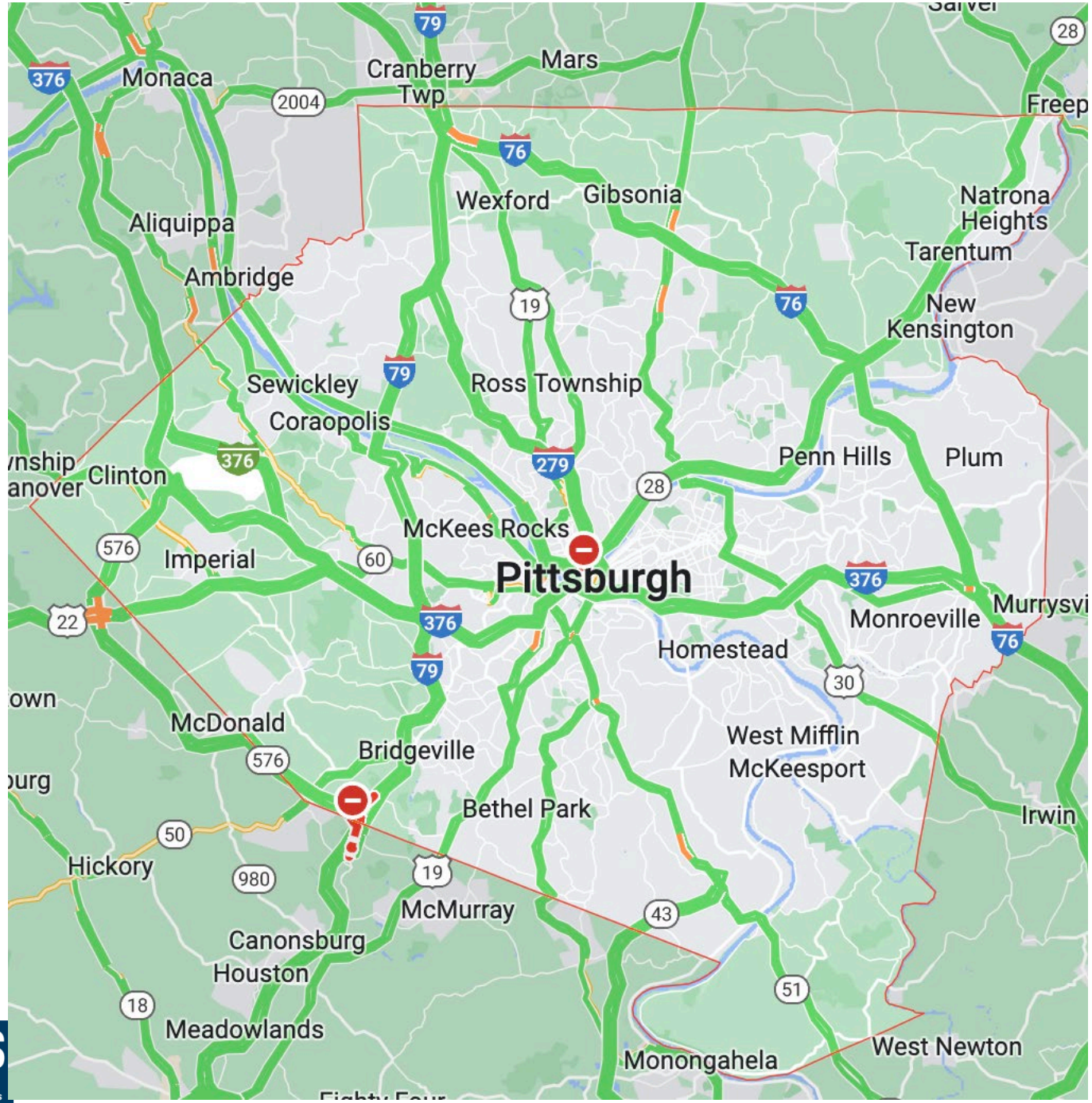
- We can use low-cost sensor networks to quantify both *chronic* and *acute* variations in local-scale air pollution
- We can do this because sensors are well calibrated and characterized
- Partnering with local communities allows us to communicate air pollution data in a way that is relevant and actionable

CAPS Center for Atmospheric Particle Studies

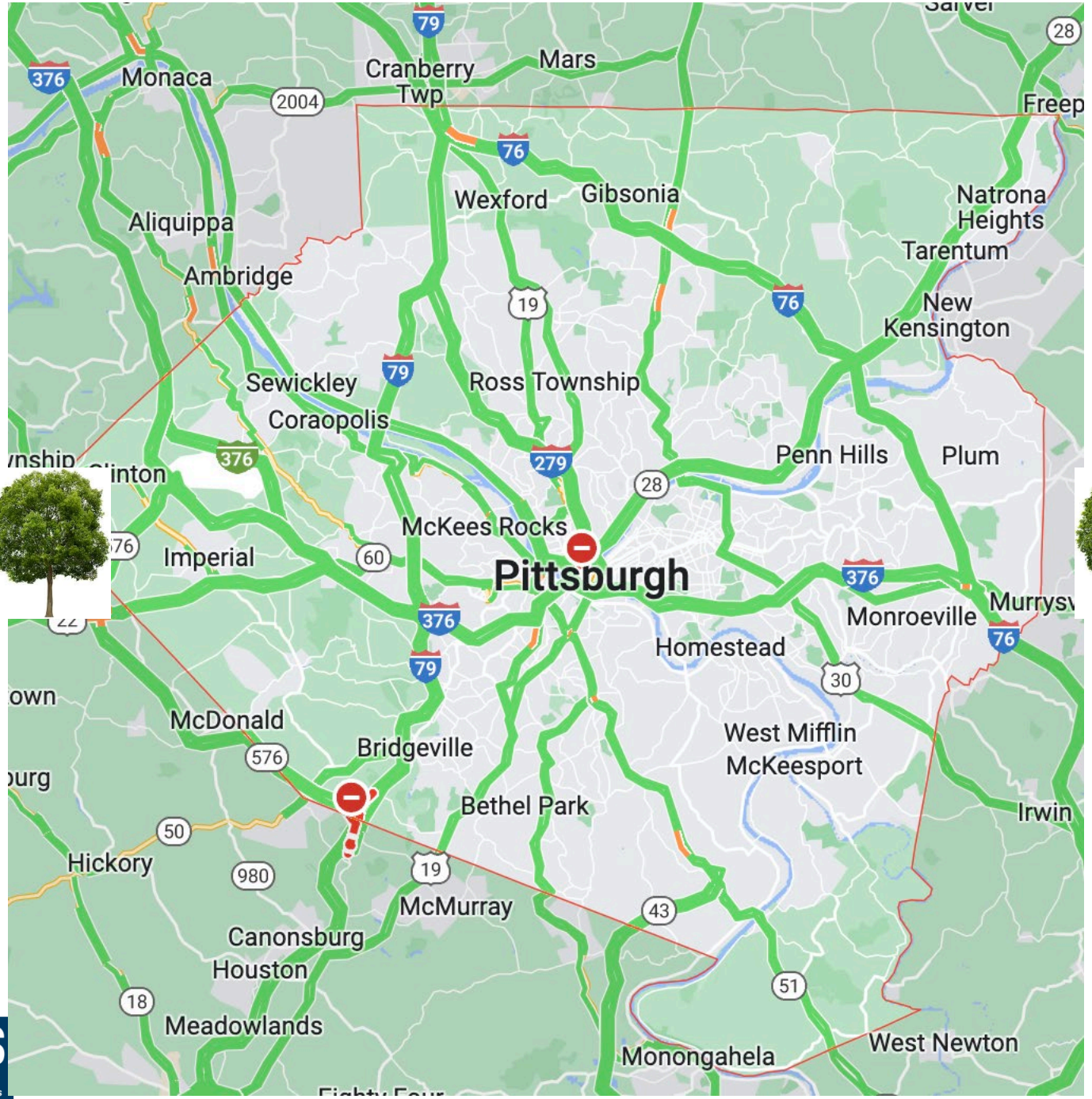
Carnegie Mellon University

CAPS Center for Atmospheric Particle Studies

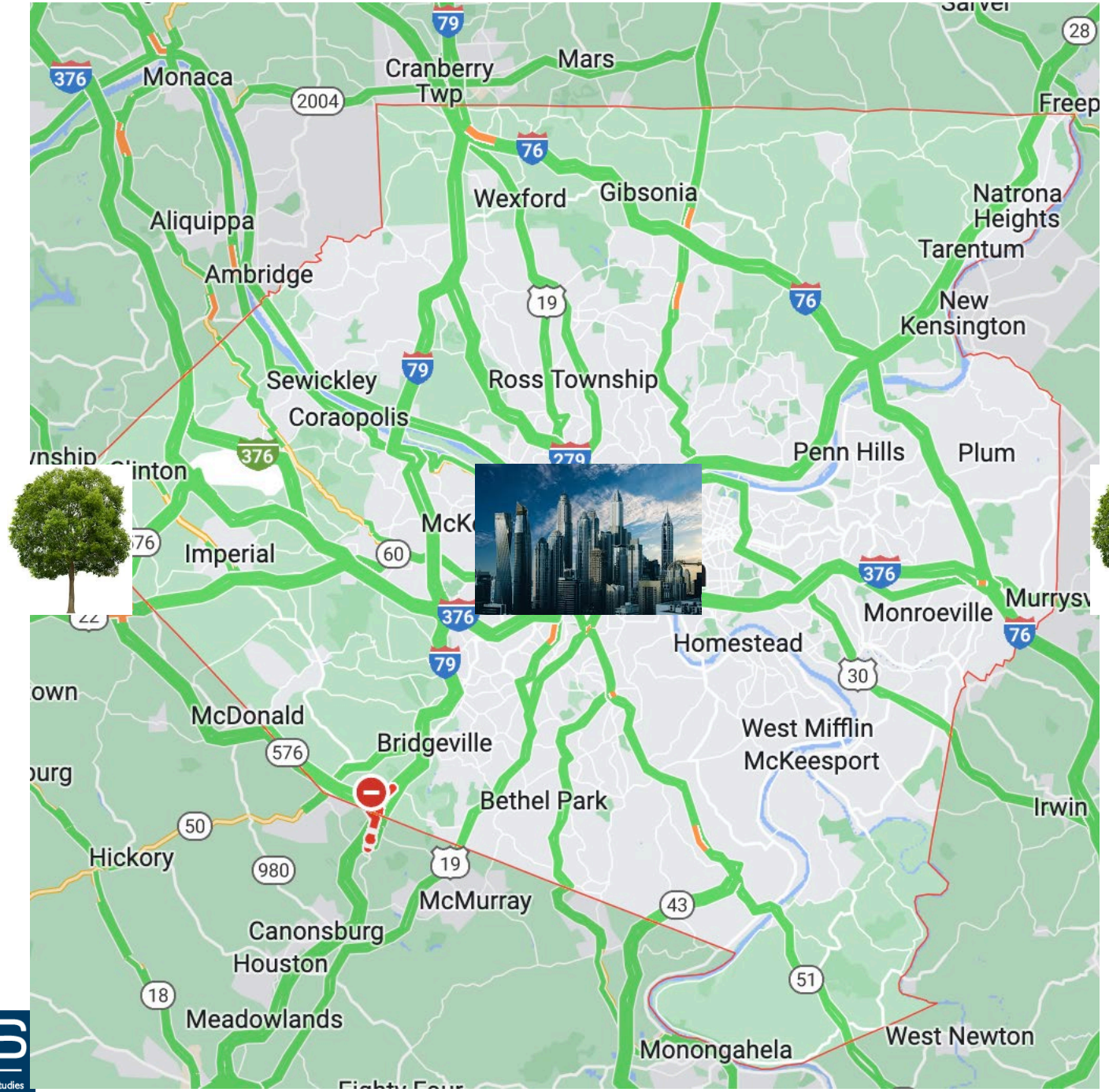
Carnegie Mellon University



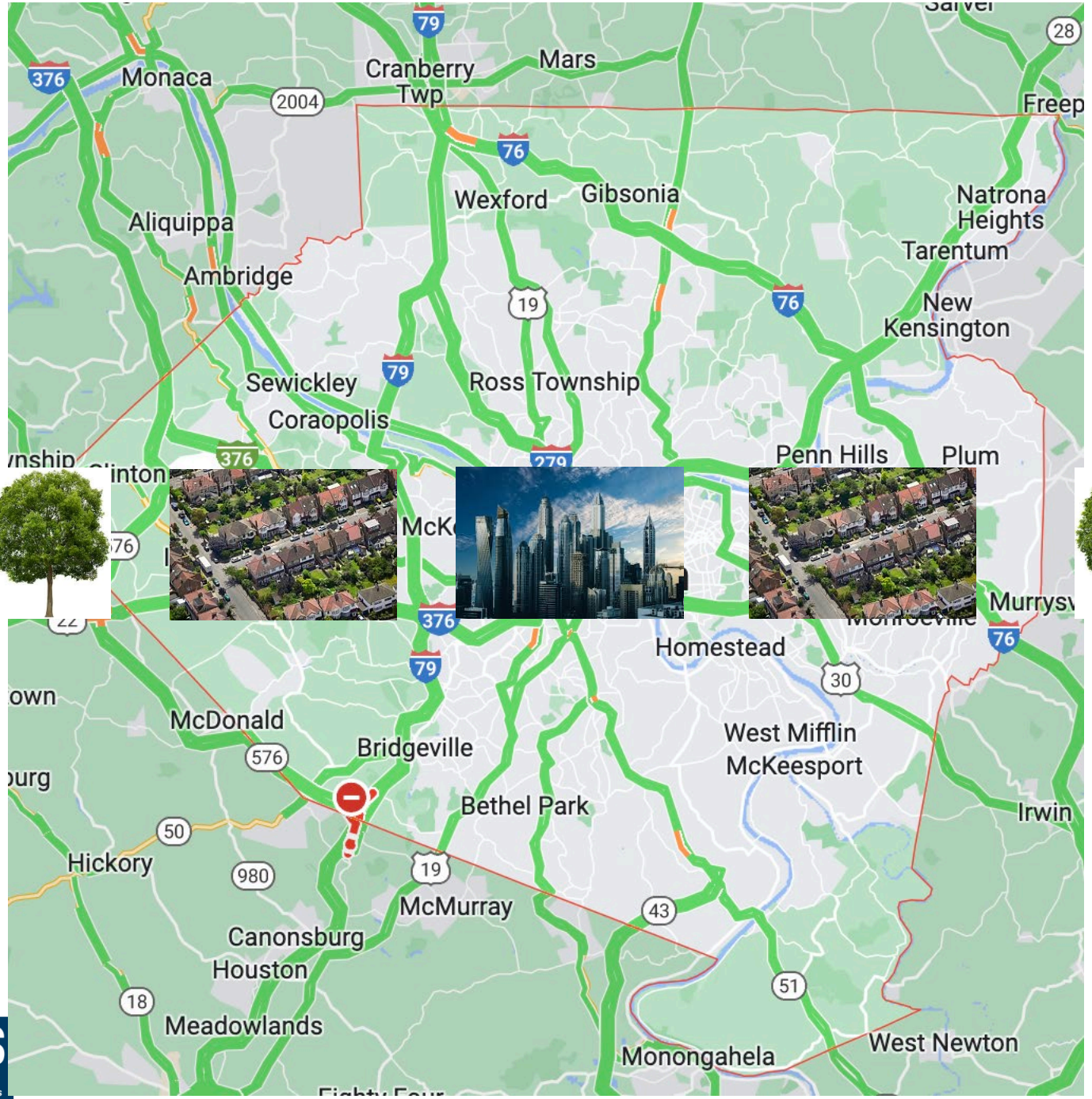
CAPS
Center for Atmospheric Particle Studies



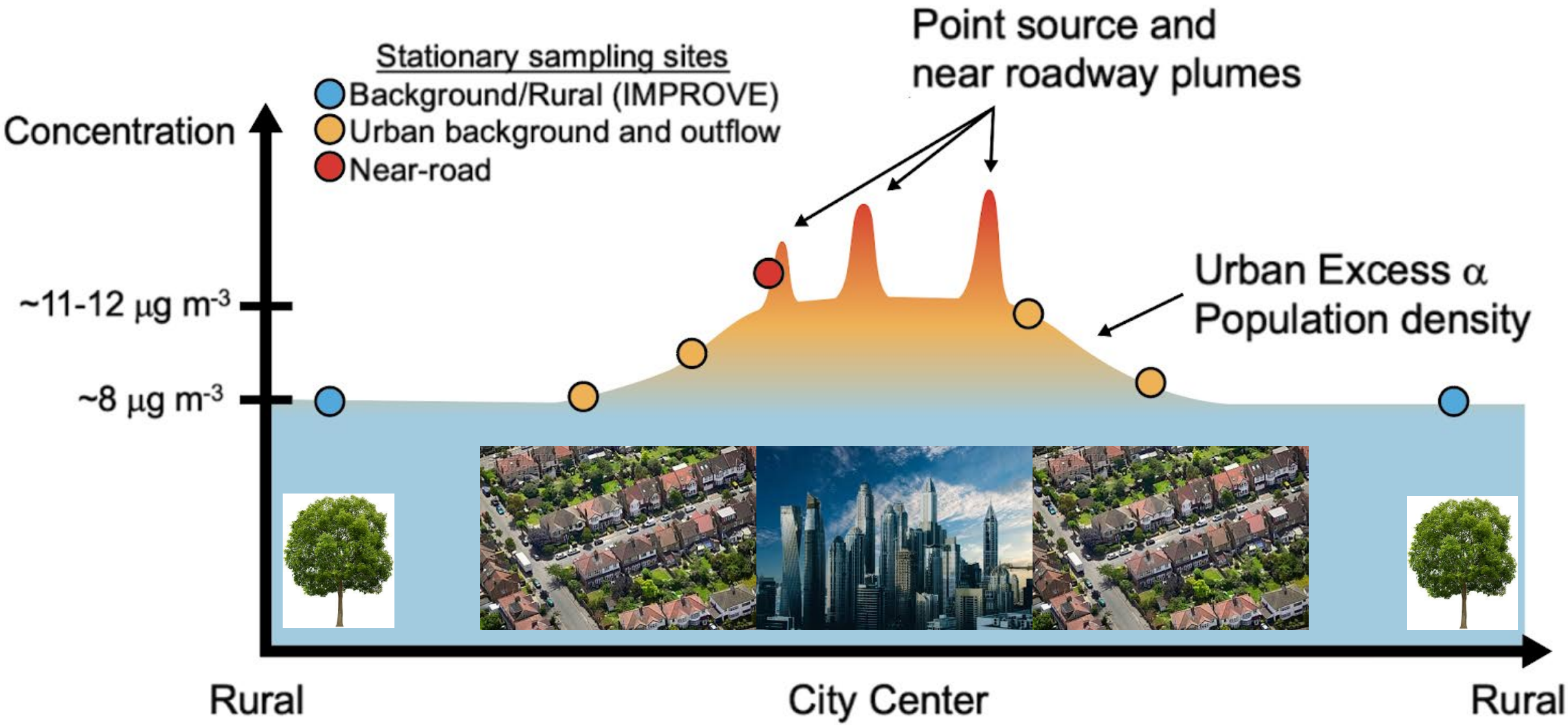
CAPS
Center for Atmospheric Particle Studies



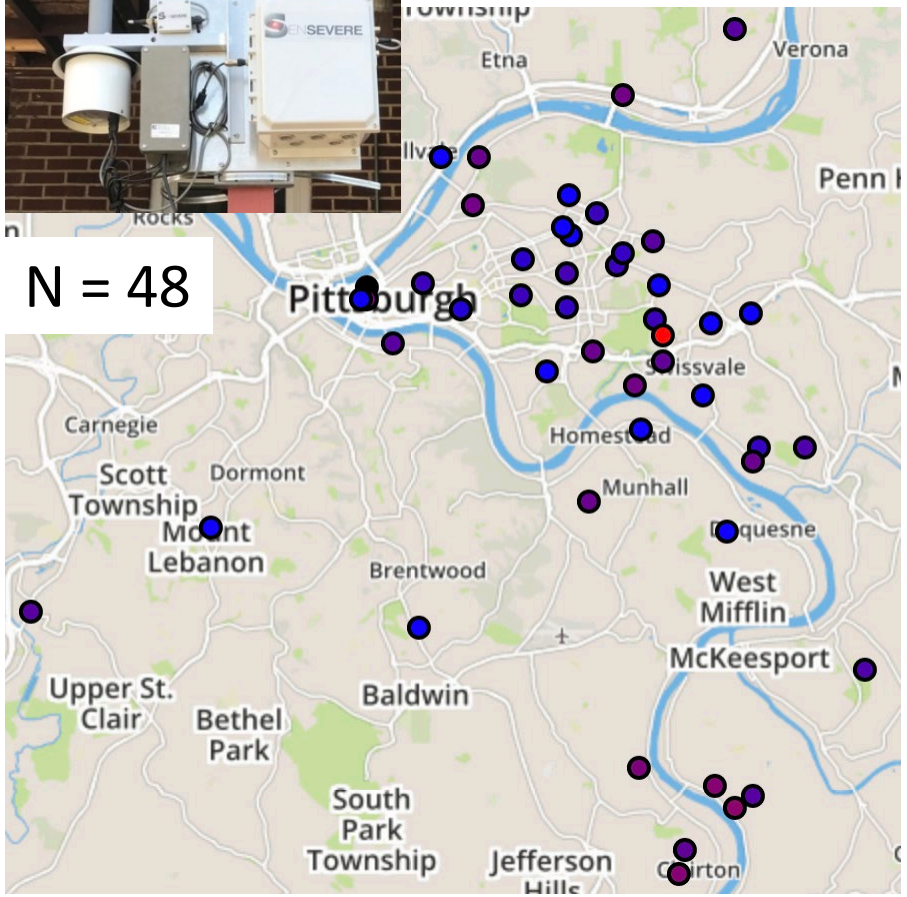
CAPS
Center for Atmospheric Particle Studies



CAPS
Center for Atmospheric Particle Studies



Adapted from Lenschow et al, 2001



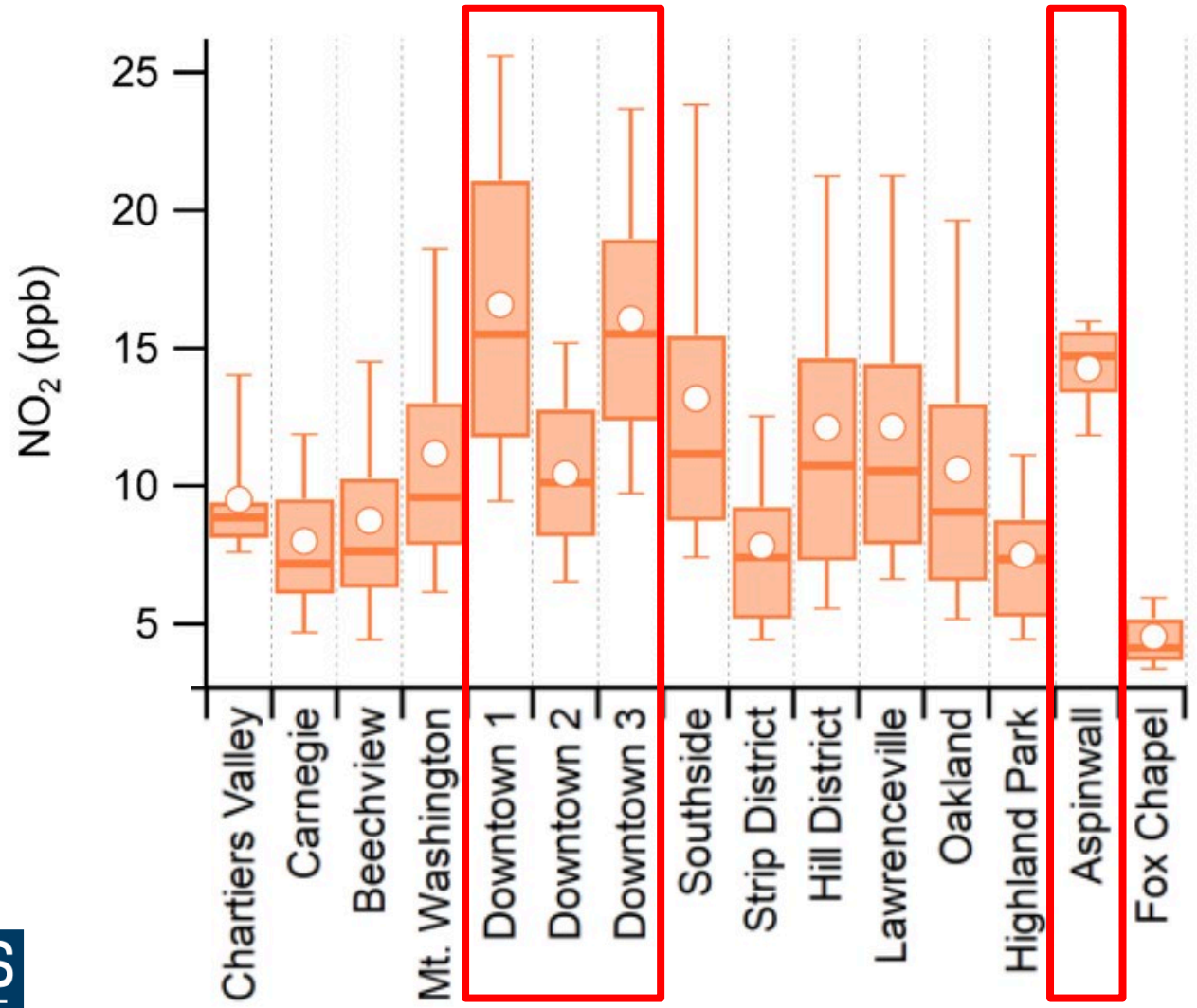
Dense network of **fixed sites**

Real-Time Affordable Multi-Pollutant Sensor (RAMP)

CAPS Center for Atmospheric Particle Studies

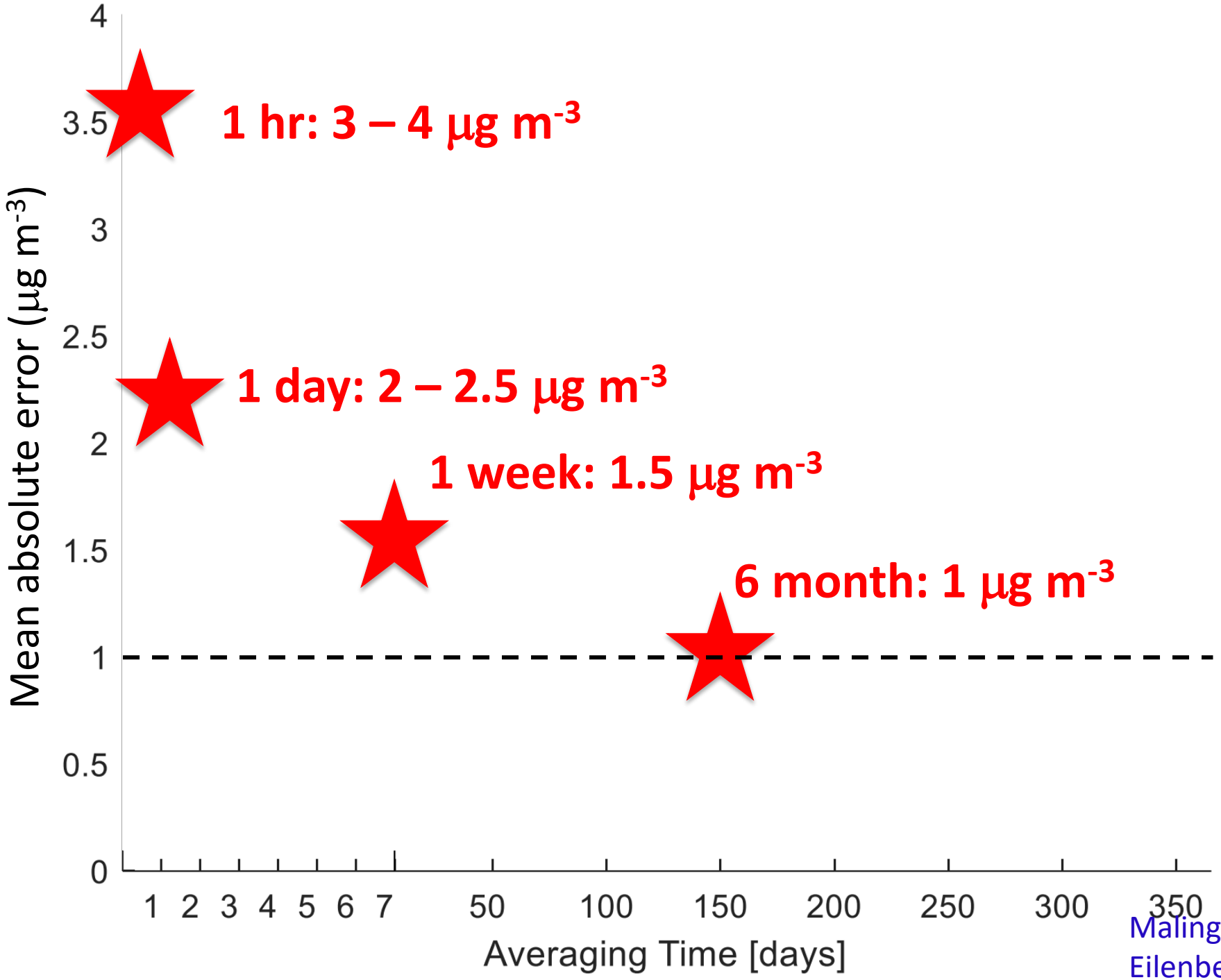
Carnegie Mellon University

Evidence of the urban excess



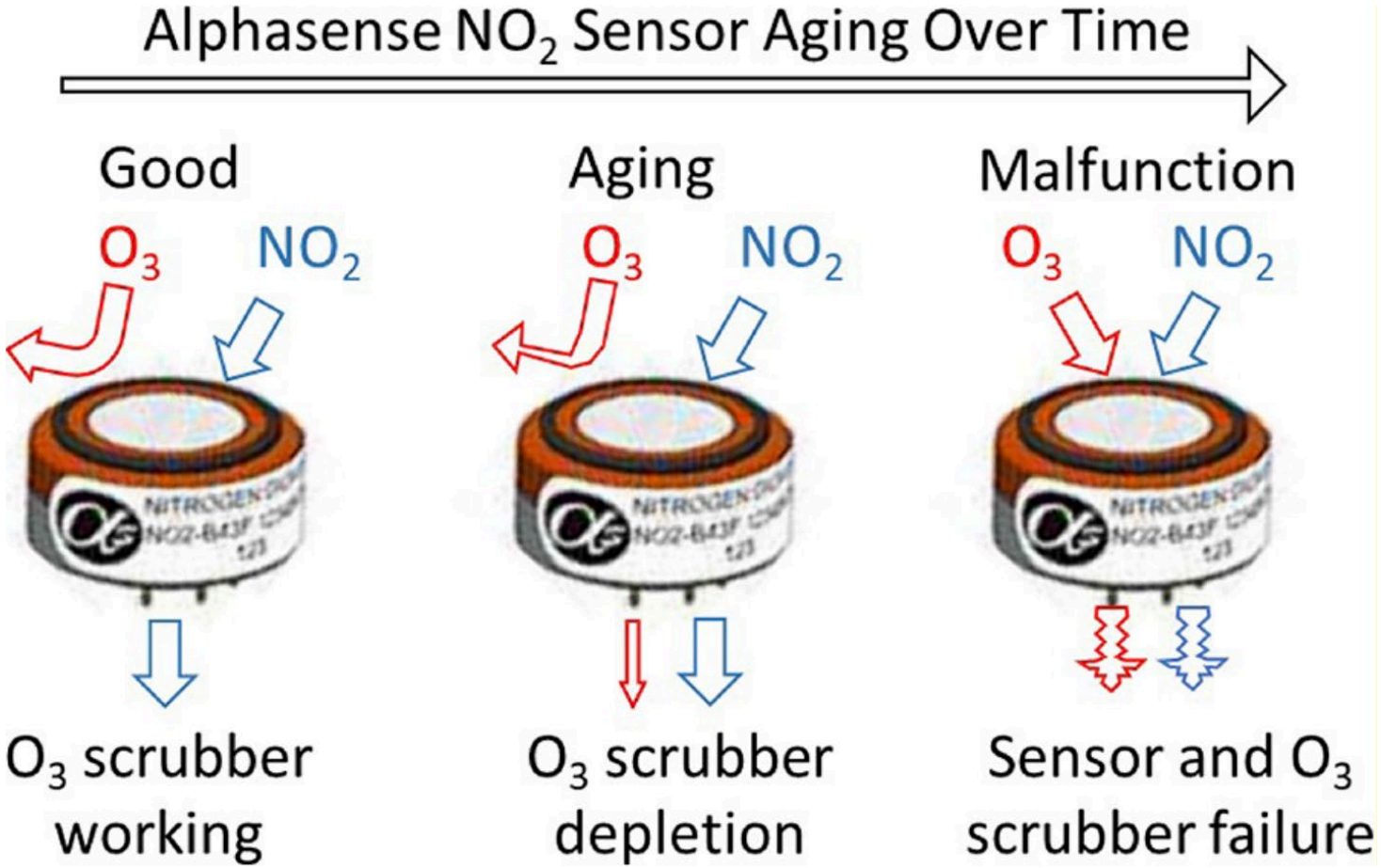
CAPS
Center for Atmospheric Particle Studies

Zimmerman et al, *AAQR*, 2019



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

Alphasense NO_2 sensors last about 1 year

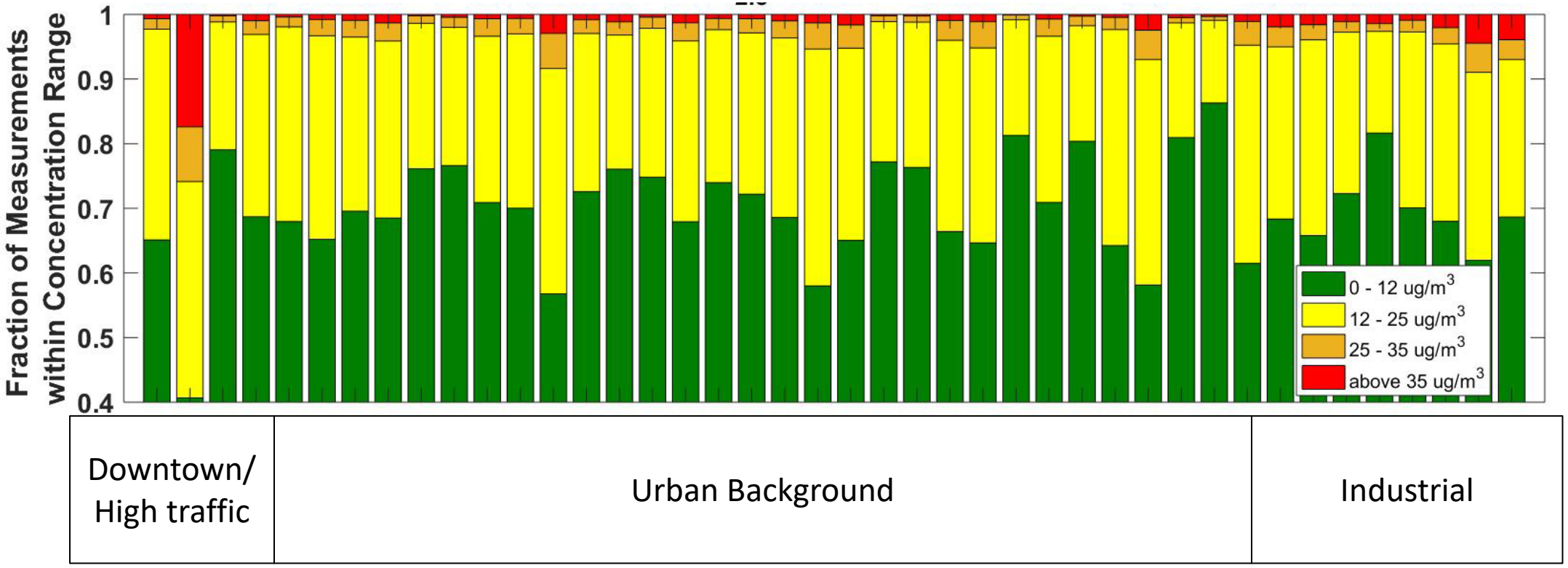


CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University

Li et al, *ACS Sensors*, 2021

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



CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University

Tanzer et al, *IJERPH*, 2019

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

CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University

Tanzer et al, *IJERPH*, 2019

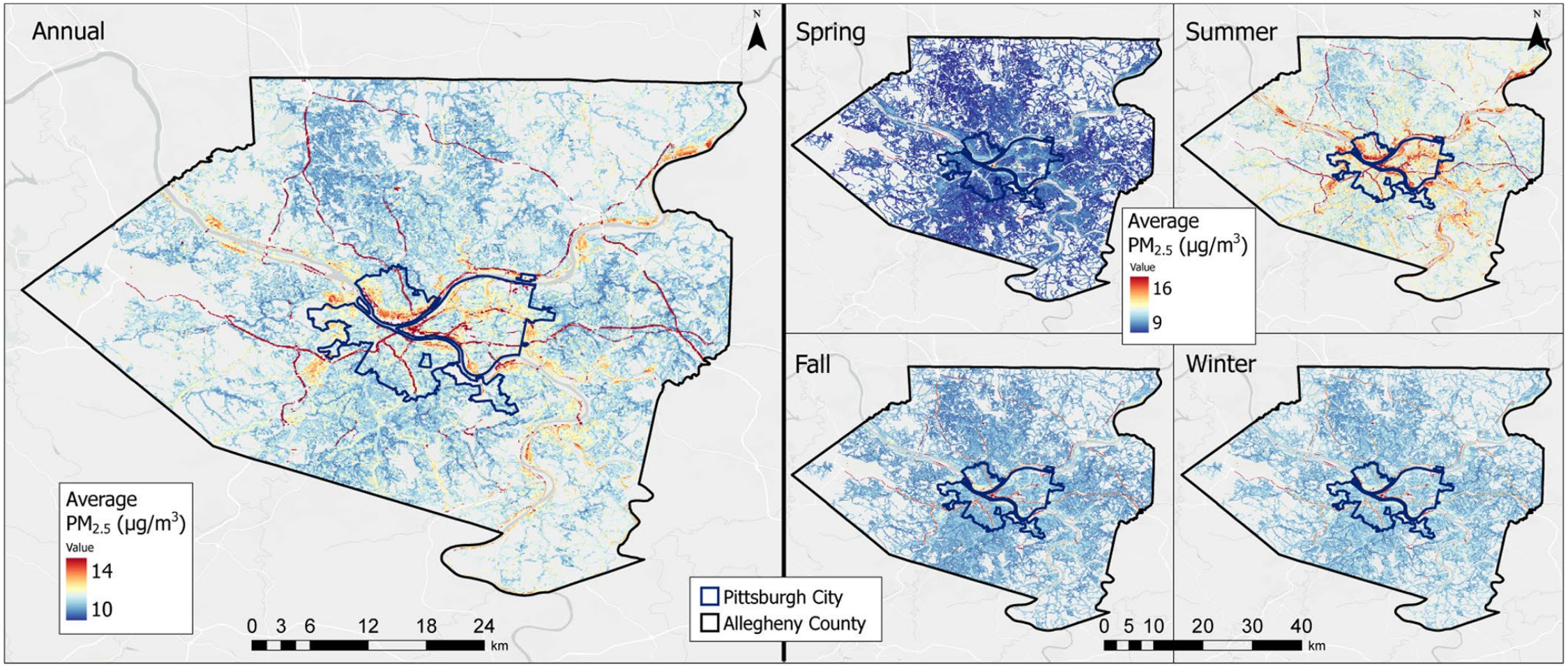
$PM_{2.5}$ spatial variability is largely driven by emissions spikes

CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University

Tanzer et al, *IJERPH*, 2019

We built empirical models of long-term PM2.5 across the network

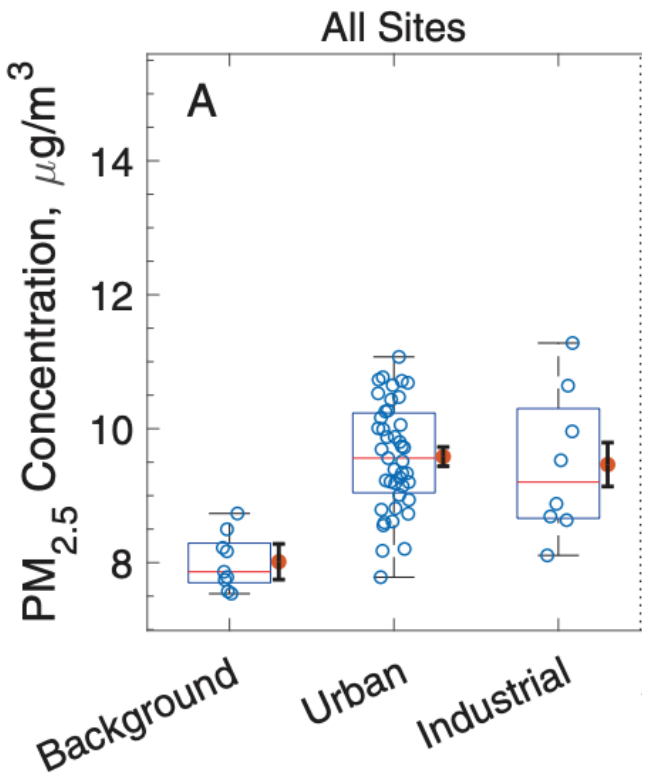


CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University

Jain et al, *ES&T*, 2021

We quantified the impacts of industrial emissions and urban sources

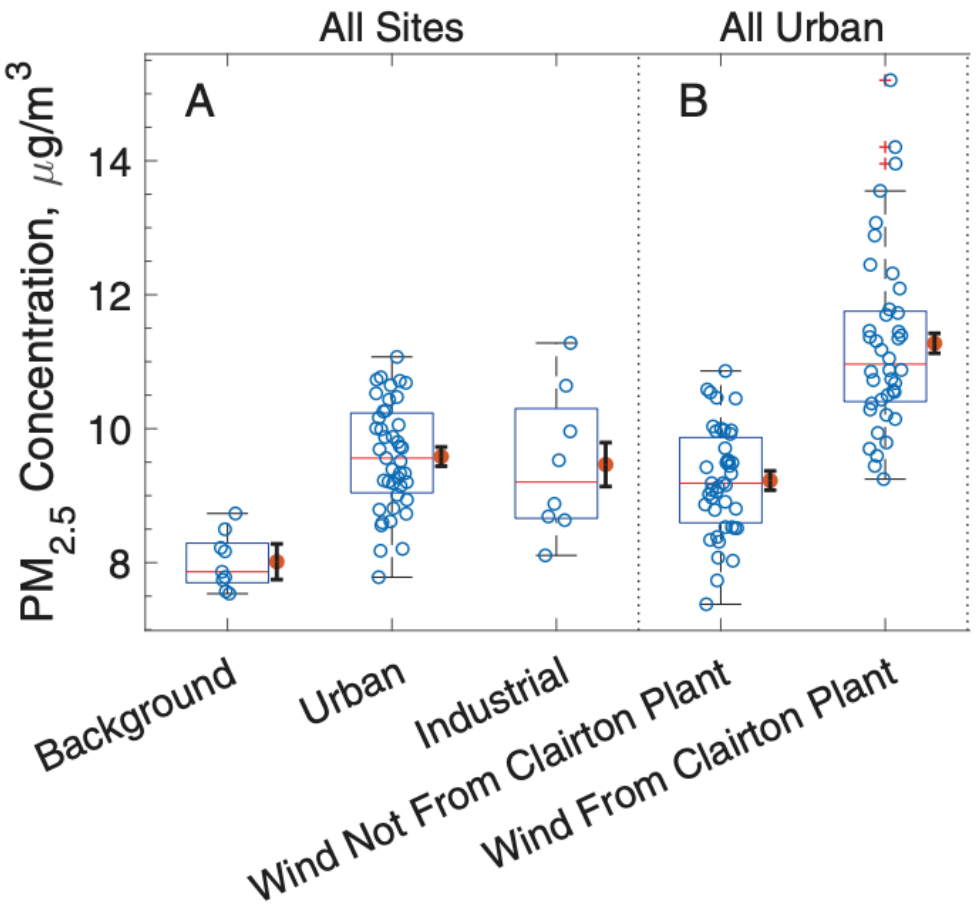


CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University

Eilenberg et al, *JESEE*, 2020

We quantified the impacts of industrial emissions and urban sources



CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University

Eilenberg et al, *JESEE*, 2020

Wildfires are another example of acute events

Western wildfire smoke is contributing to New York City's worst air quality in 15 years

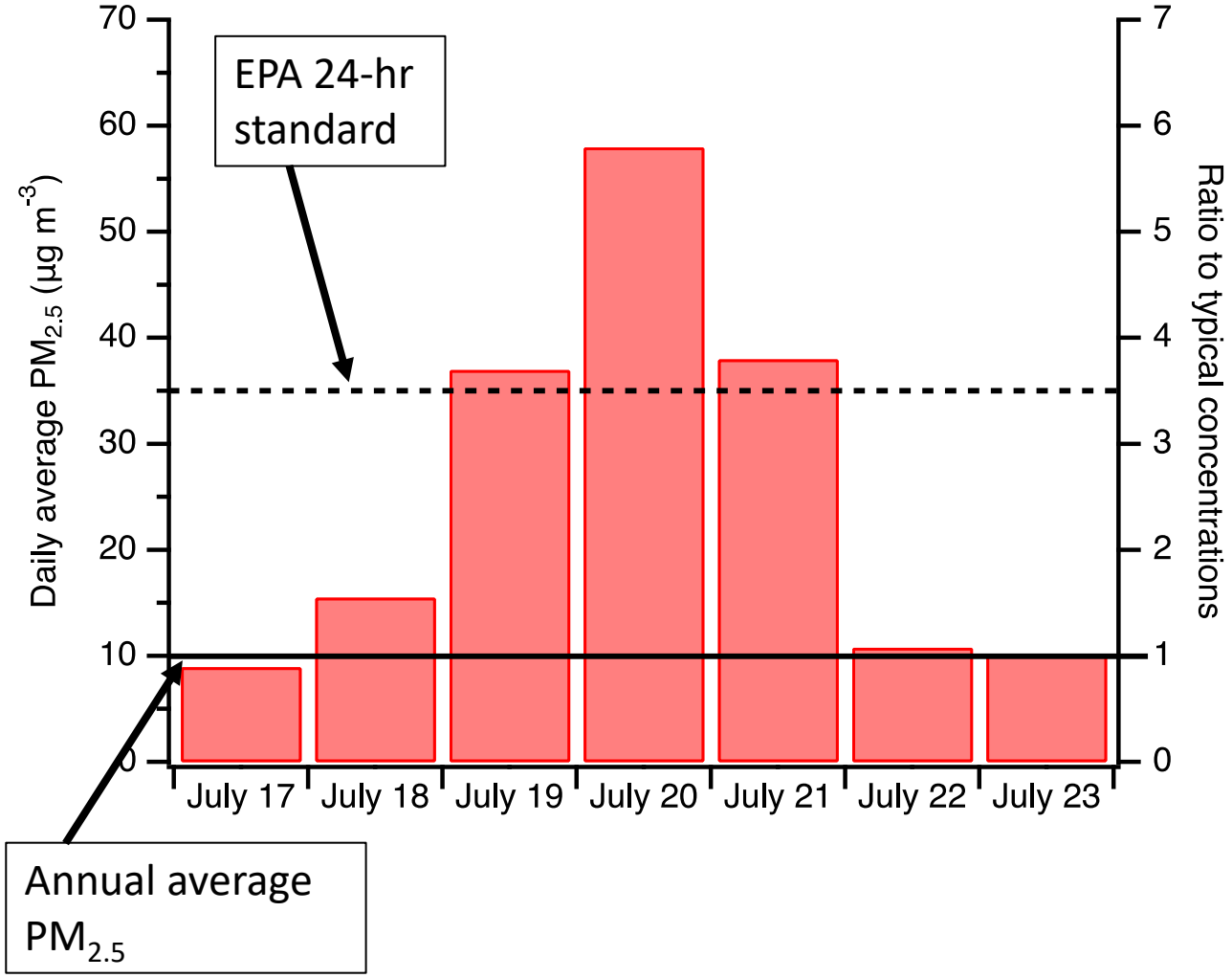
By Hollie Silverman, Michael Guy and Joe Sutton, CNN

Updated 10:30 PM ET, Wed July 21, 2021

https://www.cnn.com/2021/07/21/weather/us-western-wildfires-wednesday/index.html


https://www.earthcam.com/
July 20, 2021
HEINZ
Pittsburgh was hazy from high $PM_{2.5}$ due to fire plumes
EarthCam

The sensor network also captured the impacts of wildfire smoke in Pittsburgh



CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University

We publish RAMP reports

2022-01.pdf

2021-Metallico Fire.pdf

2021-Fireworks.pdf

2021-Fire smoke.pdf

2021-12.pdf

2021-11.pdf

2021-10.pdf

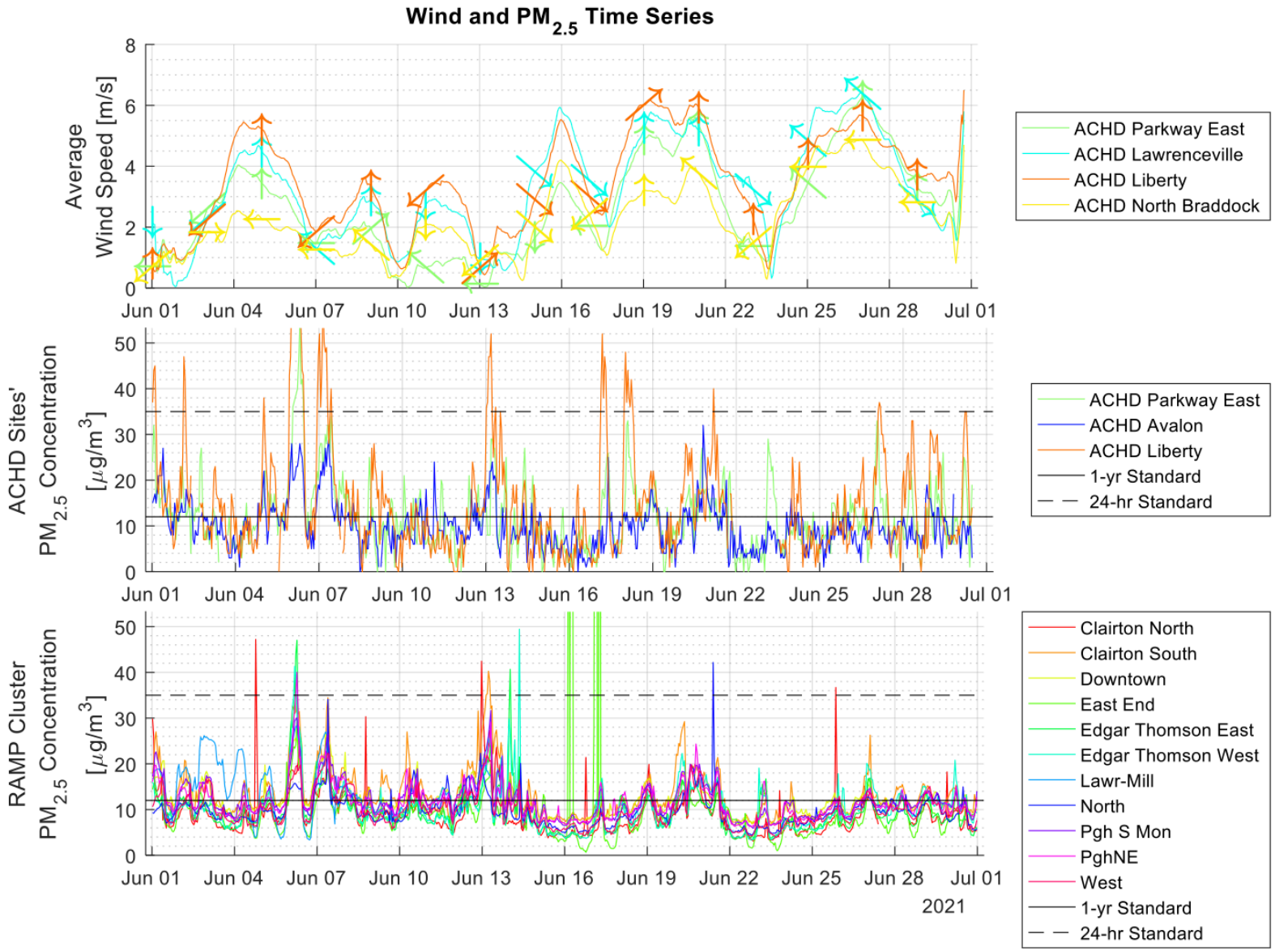
2021-09.pdf

We publish monthly reports for the RAMP network

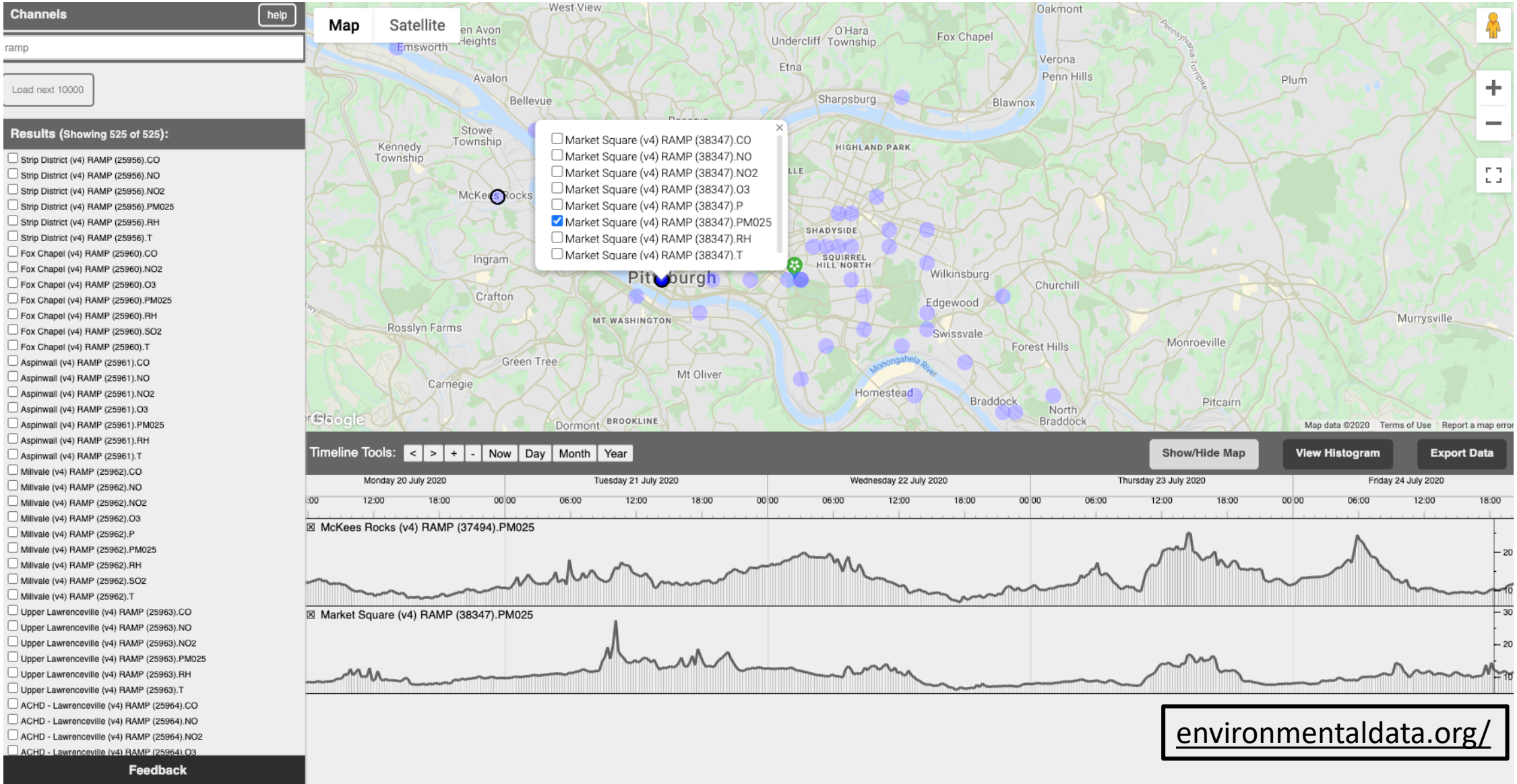
The top plot shows the 6-hour average wind speed in m/s as well as its bearing, normalized to eight cardinal directions.

The bottom two plots show $PM_{2.5}$ levels at ACHD stations (recorded hourly) and averaged across RAMP clusters. The horizontal lines represent annual and daily EPA limits on $PM_{2.5}$.

Maximum Hourly $PM_{2.5}$ Levels				
	Max. µg/m³	**Site**	**Time**	**Wind from**
ACHD site	75	Liberty	Jun-06 4:30 AM	3.7 m/s SE
RAMP Cluster	232	East End	Jun-17 3:30 AM	1.8 m/s E



We also make data available in real time



environmentaldata.org/

What next?

- Additional focus on Environmental Justice
- Monitoring of new and novel sources
- Better partnering with local regulators

Take home points

- We can use low-cost sensor networks to quantify both *chronic* and *acute* variations in local-scale air pollution
- We can do this because sensors are well calibrated and characterized
- Partnering with local communities allows us to communicate air pollution data in a way that is relevant and actionable

CAPS Center for Atmospheric Particle Studies

Carnegie Mellon University