Needs and Opportunities for High Spatial Resolution Measurements to Support Community-Focused Research

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Environmental Measurement Symposium
National Environmental Monitoring Conference

August 4, 2021

Community-Focused Research Needs

- Environmental Justice
- Community stakeholder perspective: science-informed action to solve problems
- EPA's National Environmental Justice Advisory Committee (NEJAC) (2004):
    - Promote a paradigm shift to community-based approaches, particularly community-based participatory research and intervention
    - Develop and implement efficient screening and targeting methods/tools to identify communities needing immediate intervention

Community-Focused Research

- Community-Relevant Research (examples)
  - Laboratory experiments
  - Development of measurement and analysis methods
  - Improved cumulative impact and cumulative risk assessment methods
- Community-Applied Research
  - Problem selection based on perceived risk or pollution in a community
  - Collecting real-world data in communities
  - Community-based participatory research (CBPR) – a research approach that features the direct involvement of the community at all stages in the research process

Community-Based Participatory Research

- **Community members** hold **formal leadership roles**
- Decision-makers and policy goals (**actions**) are at the center of the research design
- **Research questions** and **study design** are **informed** by members of the **local community**
- **Long-term partnerships** are sustained

Davis and Ramírez-Andreotta, 2021

Decision-Makers

Individuals

Communities

Companies

Local Government (City, County)

State Government

Federal Government

Mapping Tools and Environmental Justice

- Map communities in terms of a variety of characteristics simultaneously, including social factors (such as race and income) along with likely exposure risks
- EJ mapping tools can help address cumulative impacts
- An EJ tool should be:
  - Science-based
  - Informed by community experience
  - Endorsed and utilized by government
  - Available for all to use
  - Informed by public participation
  - Available as a third-party validator for local issues

Lee, 2020

What common questions do community members have?

Should I be concerned about air pollution in my community?

How do air pollution concentrations change from place to place in my community?

What are the causes of air pollution in my community?

Supplementing data collected in national air monitoring networks, a variety of monitoring strategies exist to provide answers to these common questions. Models can provide important complementary information. This presentation is primarily about monitoring.

Measurement considerations for these questions

Should I be concerned about air pollution in my community? → Measure air pollutant types of concern using methods that are accurate enough to compare against benchmark values

How do air pollution concentrations change from place to place in my community? → Measurements should be precise enough to determine changes in concentrations and support multi-location measurement

What are the causes of air pollution in my community? → Measurement strategy is needed, which could involve complementary modeling and combining ancillary data to explore local and distributed source contributions to air pollution concentrations

Common measurement research strategies to isolate local-scale impacts

Note: These two strategies can be used in combination

Strategy 1: Evaluate whether spatial differences exist for pollutant types of interest

Known source of interest | Measure here | Measure here | Measure here

Distance from source →

C_{loc} estimated by the difference between locations (downwind – upwind; near – far)

Conducted with:
Instruments onboard mobile platform
or
Multiple fixed monitoring stations

Strategy 2: Measure quickly to assess how pollutant concentrations change with wind

Known or unknown source | Measure here, quickly | Known or unknown source

Source location and C_{loc} estimated using wind and air pollutant data; supporting information if available (e.g., source activity data)

Conducted with:
One or multiple fixed monitoring stations; includes meteorological measurements

Example Spatial Gradient Near an Interstate Highway

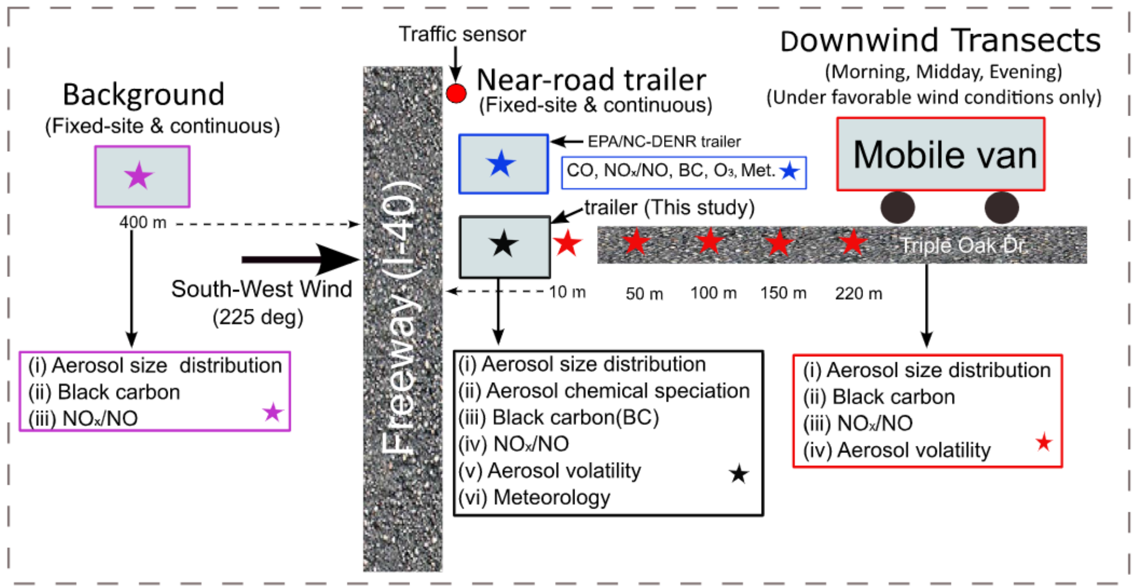


Fig. 1. Schematic of measurement sites and a list of measurements collected at each location.

Atmospheric Environment 177 (2018) 143–153

Contents lists available at ScienceDirect

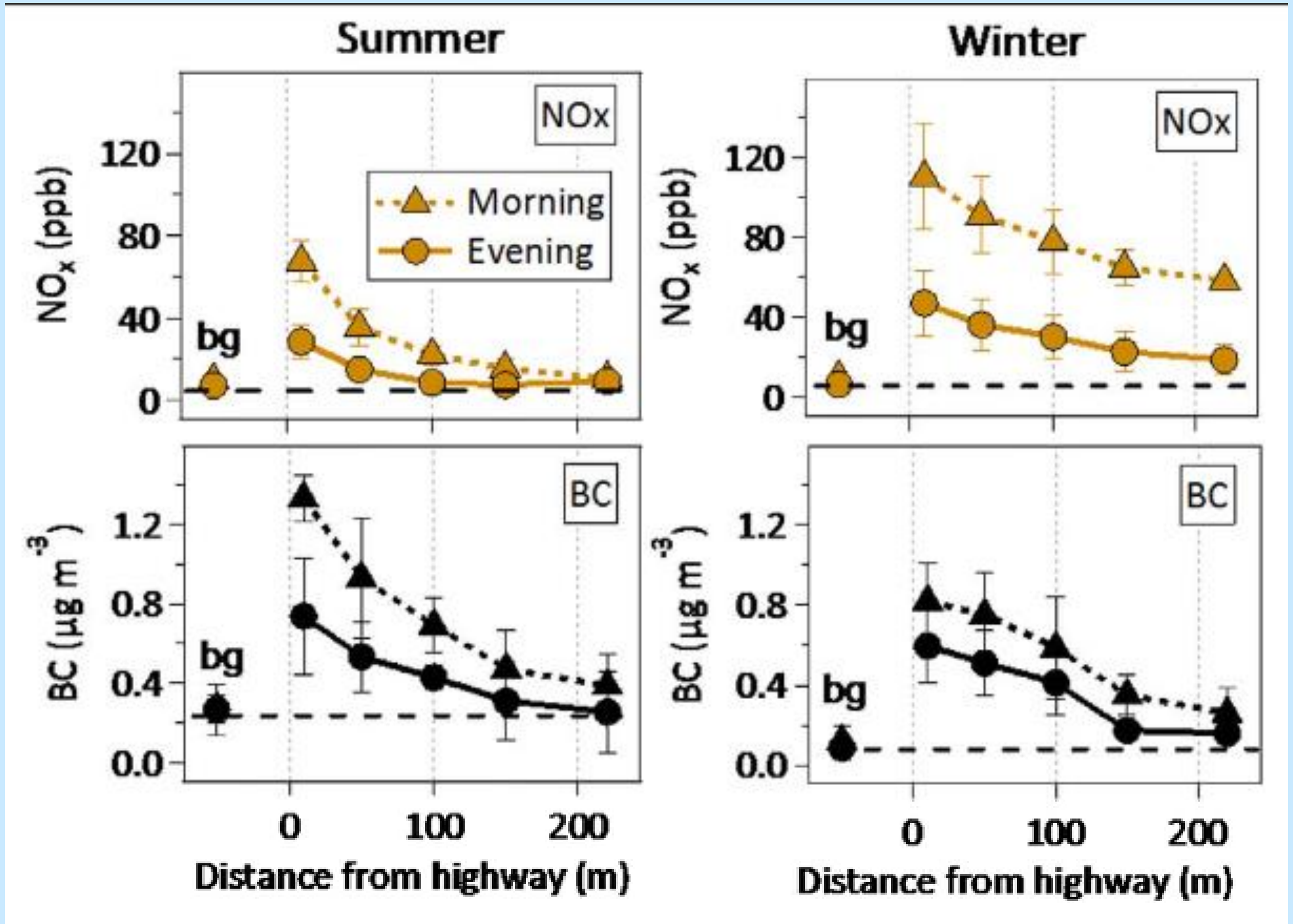
ELSEVIER

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

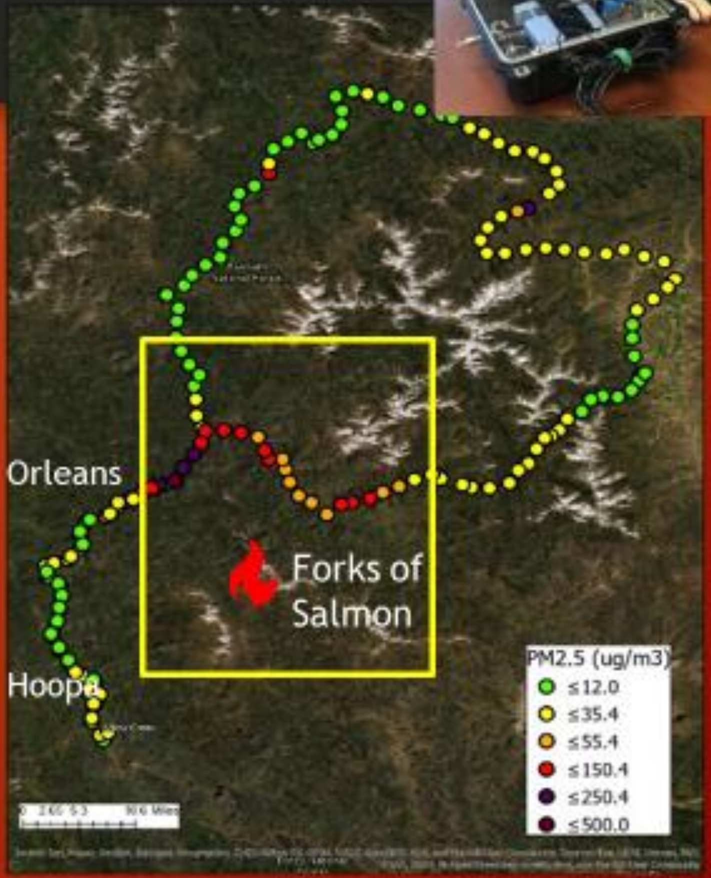
Characterization of air pollutant concentrations, fleet emission factors, and dispersion near a North Carolina interstate freeway across two seasons

Provat K. Saha[a], Andrey Khlystov[b], Michelle G. Snyder[c], Andrew P. Grieshop[a,*]



Vehicle Add-on Mobile Monitoring System (VAMMS)

- Highlighted in June 30 White House fact sheet on wildfires:
  - *"EPA is developing and expanding availability of the Vehicle Add-on Mobile Monitoring System (VAMMS) for use in heavy smoke impacted areas to provide ground truth on smoke plume and air quality models."*
- ORD/CEMM asked to develop 20 VAMMs units to provide to the Wildland Fire Air Quality Response Program and state, local, and tribal air quality agencies for use on wildfires



14

Air Pollution Mapping

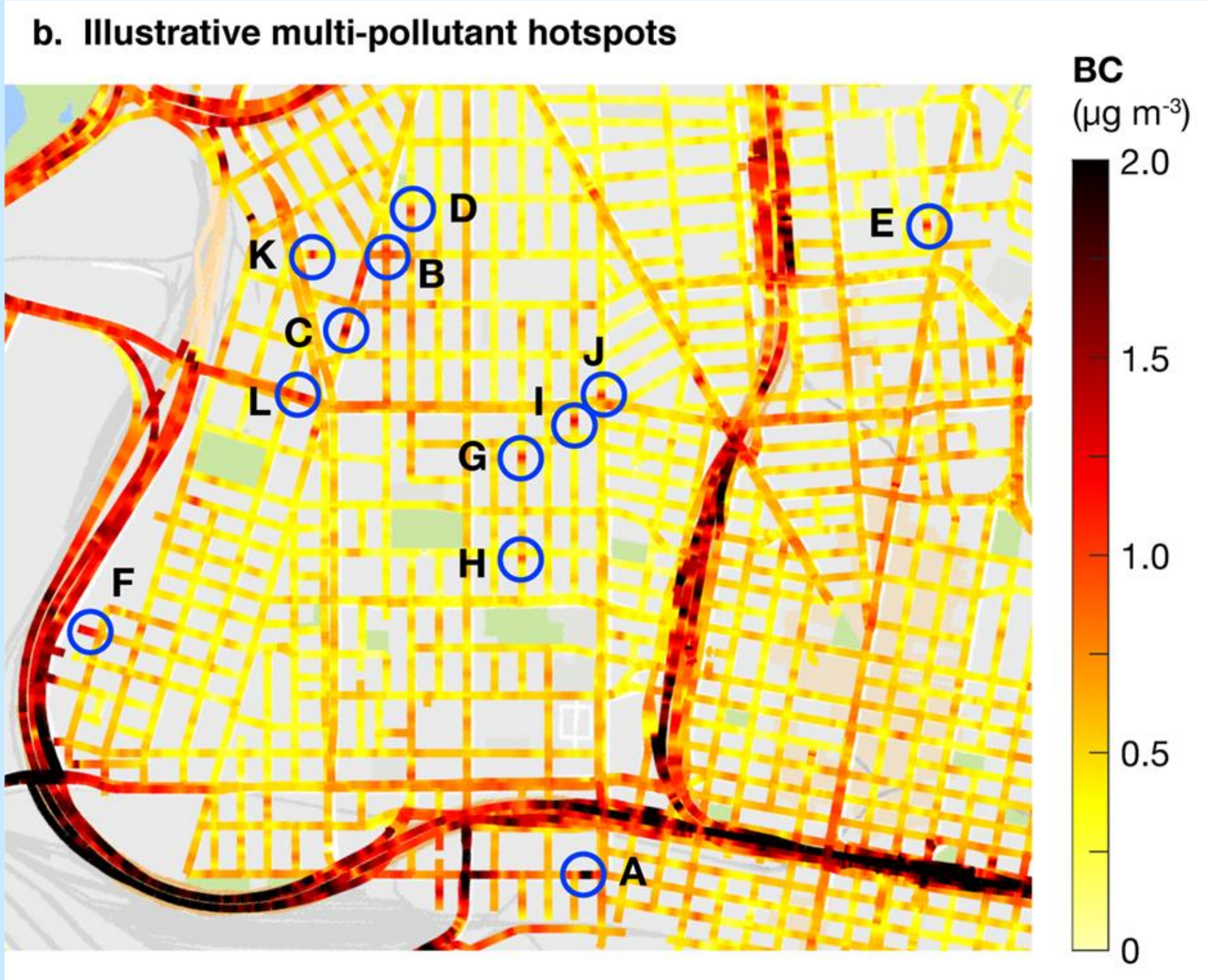
Environmental Science & Technology

Article

pubs.acs.org/est

High-Resolution Air Pollution Mapping with Google Street View Cars: Exploiting Big Data

Joshua S. Apte,[*,†] Kyle P. Messier,[†,‡] Shahzad Gani,[†] Michael Brauer,[§] Thomas W. Kirchstetter,[∥] Melissa M. Lunden,[⊥] Julian D. Marshall,[#] Christopher J. Portier,[‡] Roel C.H. Vermeulen,[∇] and Steven P. Hamburg[‡]



Median Organic Aerosol Concentration from a Mobile Aerosol Mass Spectrometer

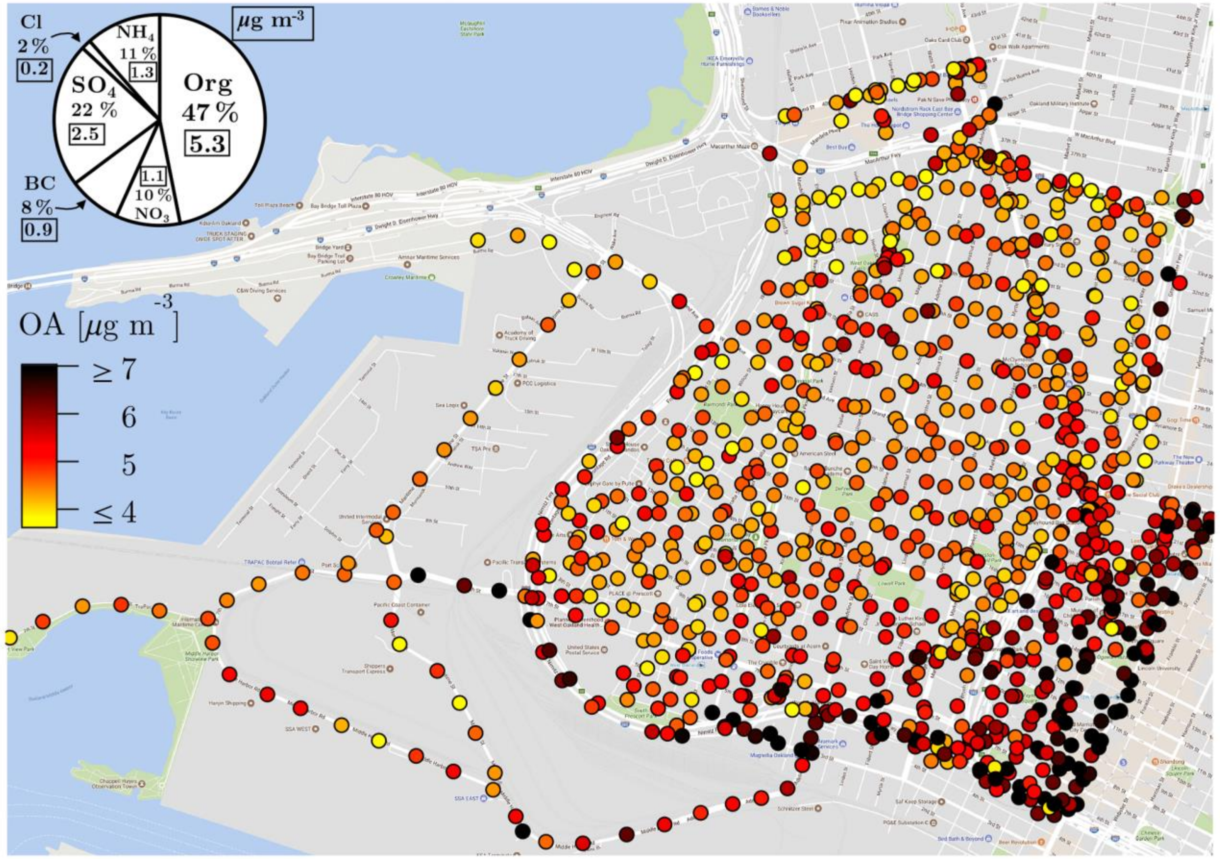
Atmos. Chem. Phys., 18, 16325–16344, 2018
https://doi.org/10.5194/acp-18-16325-2018

Atmospheric Chemistry and Physics
Open Access
EGU

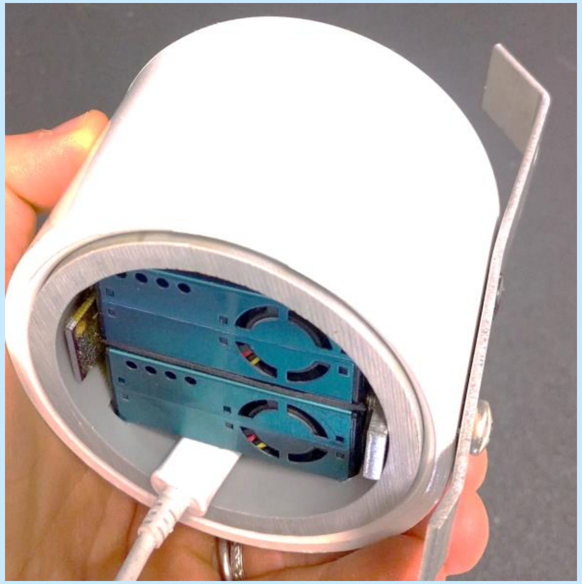
High-spatial-resolution mapping and source apportionment of aerosol composition in Oakland, California, using mobile aerosol mass spectrometry

Rishabh U. Shah[1,2], Ellis S. Robinson[1,2], Peishi Gu[1,2], Allen L. Robinson[1,2], Joshua S. Apte[3], and Albert A. Presto[1,2]

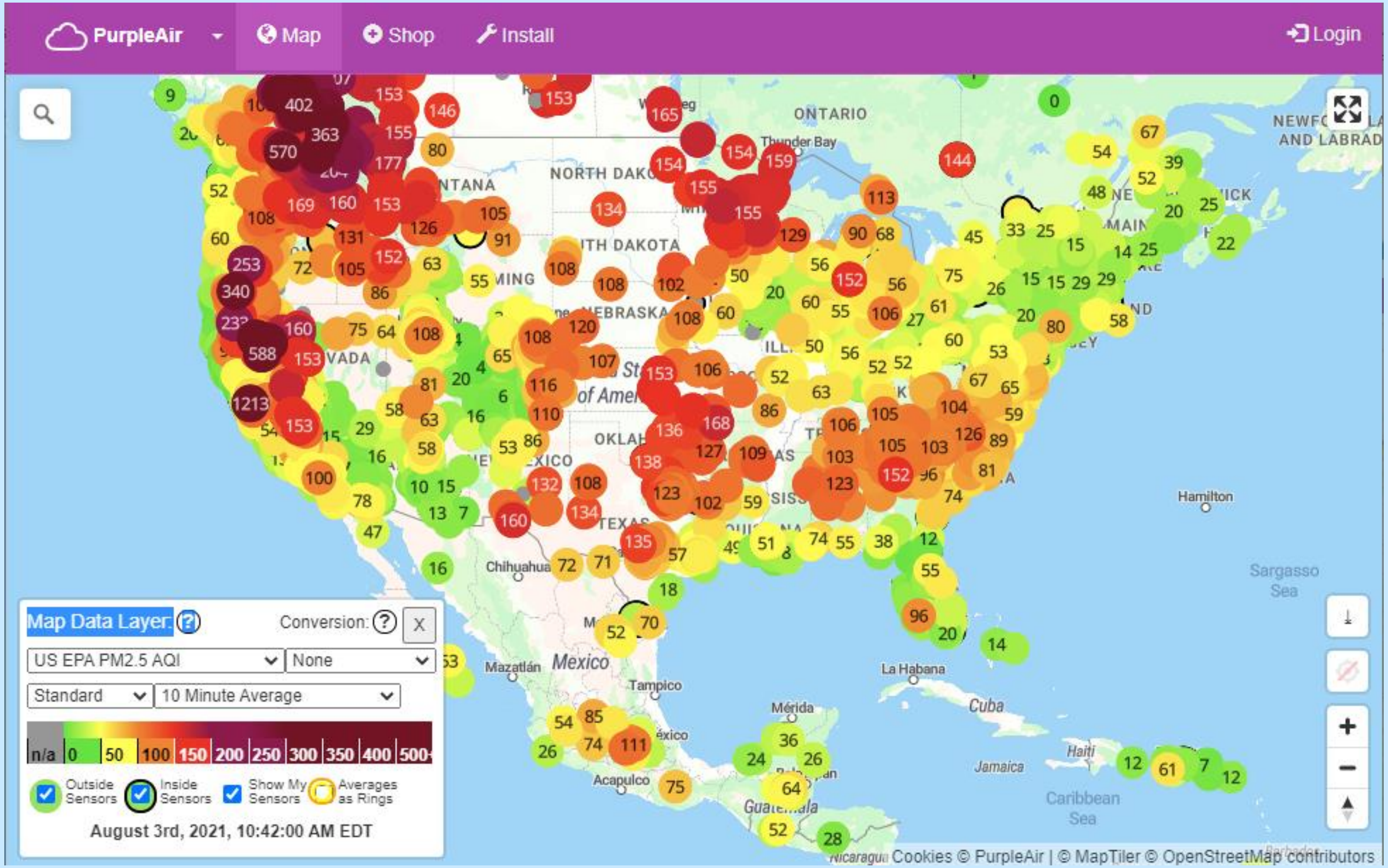
[1]Mechanical Engineering, Carnegie Mellon University, Pittsburgh, PA, USA
[2]Center for Atmospheric Particle Studies, Carnegie Mellon University, Pittsburgh, PA, USA
[3]Department of Civil, Architectural and Environmental Engineering, University of Texas at Austin, Austin, TX, USA



PM$_{2.5}$

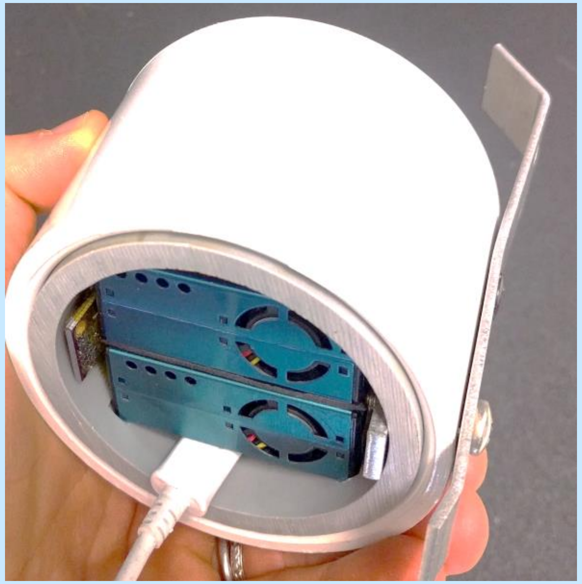


PurpleAir



Karoline (Johnson) Barkjohn, Amara Holder, Andrea Clements
Technical Overview of the Development and Performance Validation of U.S.-Wide Correction Equation for PurpleAir Sensor Data

$PM_{2.5}$



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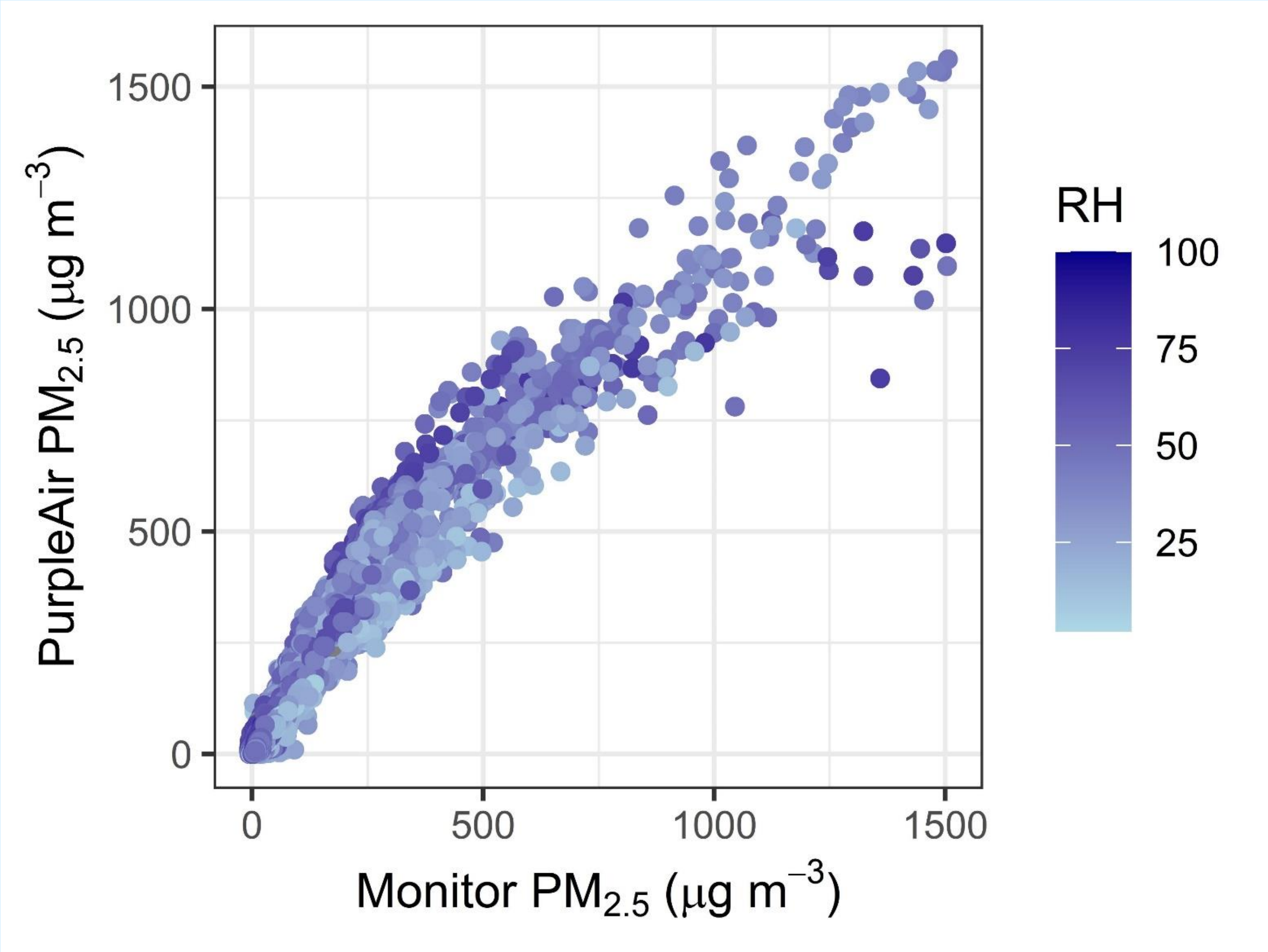

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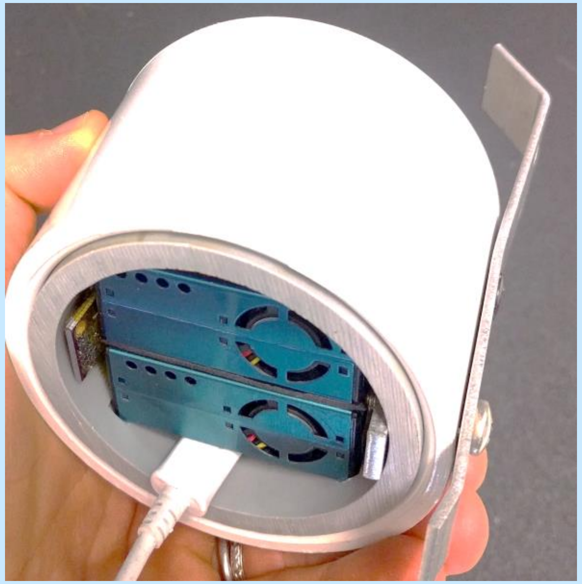

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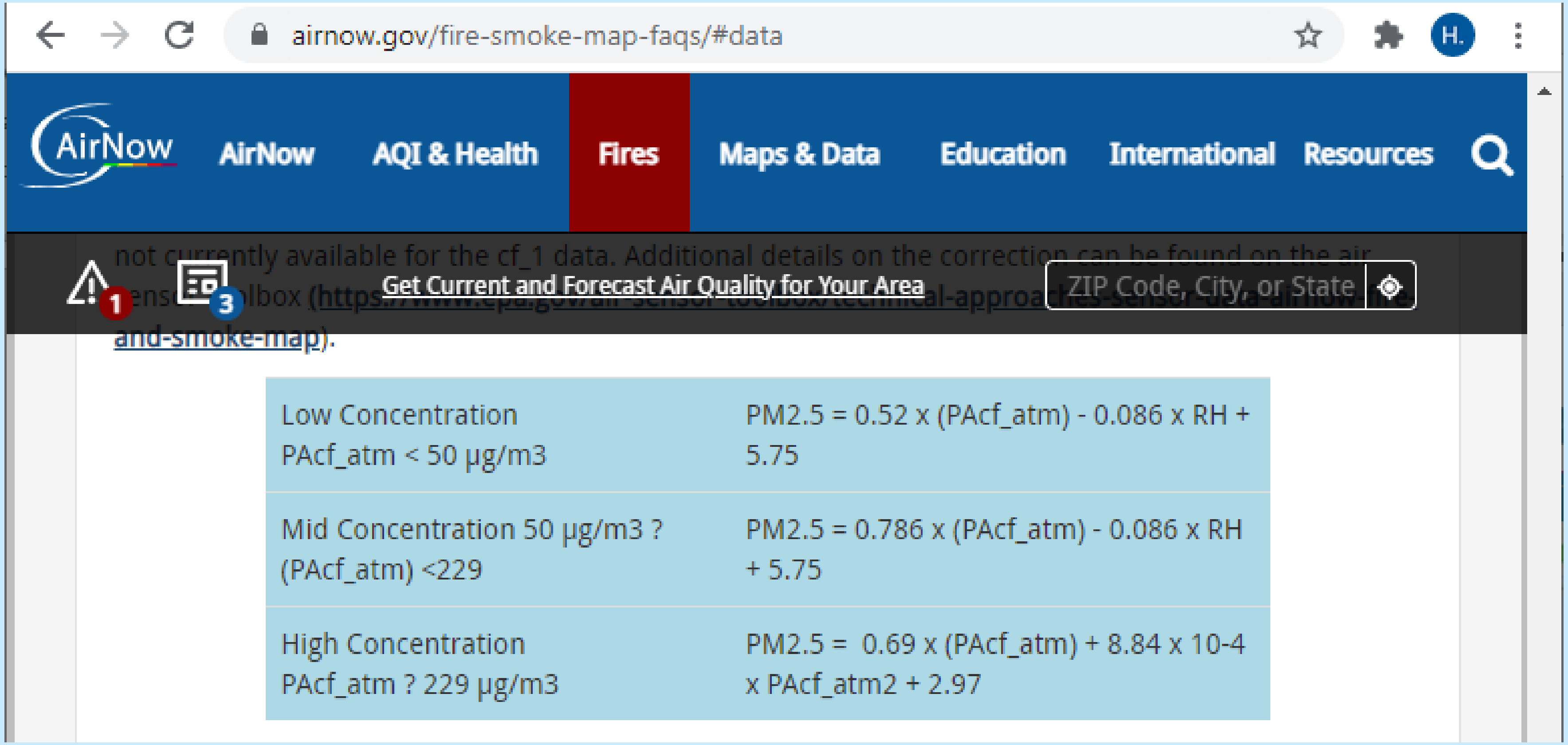
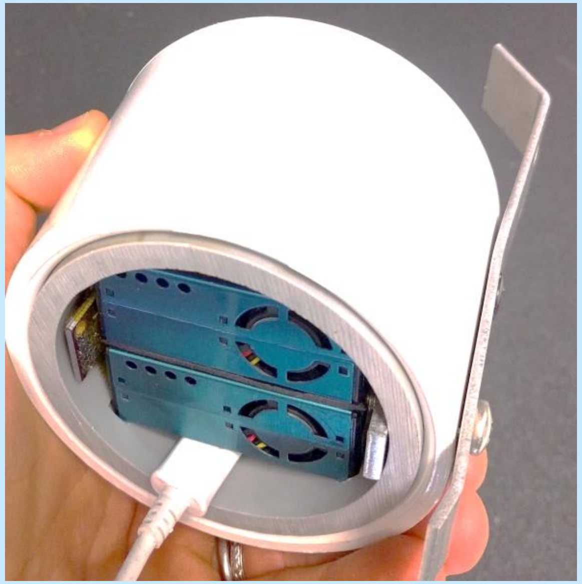


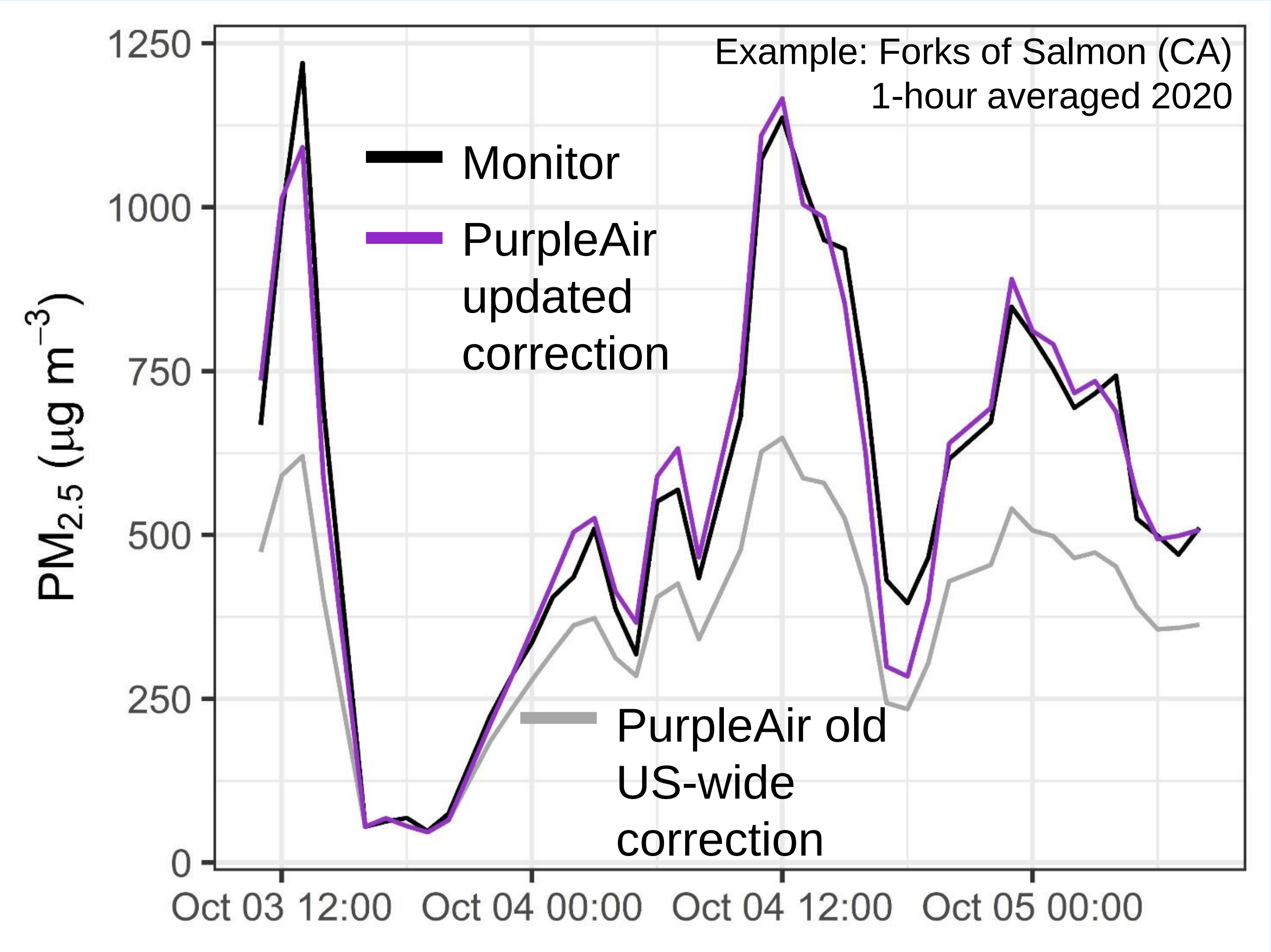
Low Concentration PAcf_atm < 50 µg/m3	PM2.5 = 0.52 x (PAcf_atm) - 0.086 x RH + 5.75
Mid Concentration 50 µg/m3 ? (PAcf_atm) <229	PM2.5 = 0.786 x (PAcf_atm) - 0.086 x RH + 5.75
High Concentration PAcf_atm ? 229 µg/m3	PM2.5 = 0.69 x (PAcf_atm) + 8.84 x 10-4 x PAcf_atm2 + 2.97

Karoline (Johnson) Barkjohn, Amara Holder, Andrea Clements
Technical Overview of the Development and Performance Validation of U.S.-Wide Correction Equation for PurpleAir Sensor Data

$PM_{2.5}$



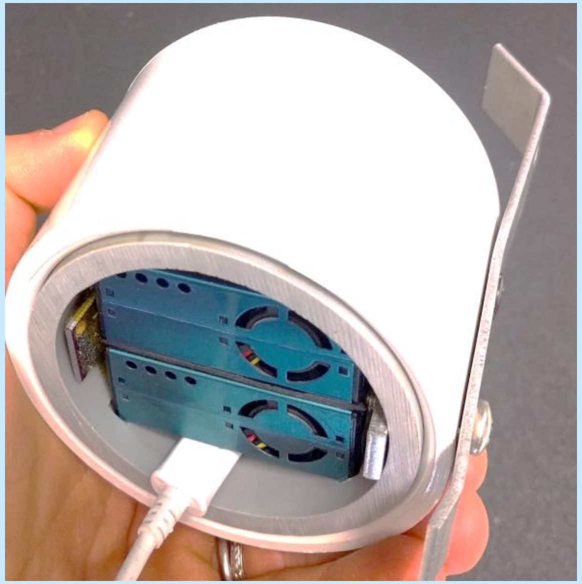
PurpleAir



Simple correction based on relative humidity

Karoline (Johnson) Barkjohn, Amara Holder, Andrea Clements
Technical Overview of the Development and Performance Validation of U.S.-Wide Correction Equation for PurpleAir Sensor Data

$PM_{2.5}$



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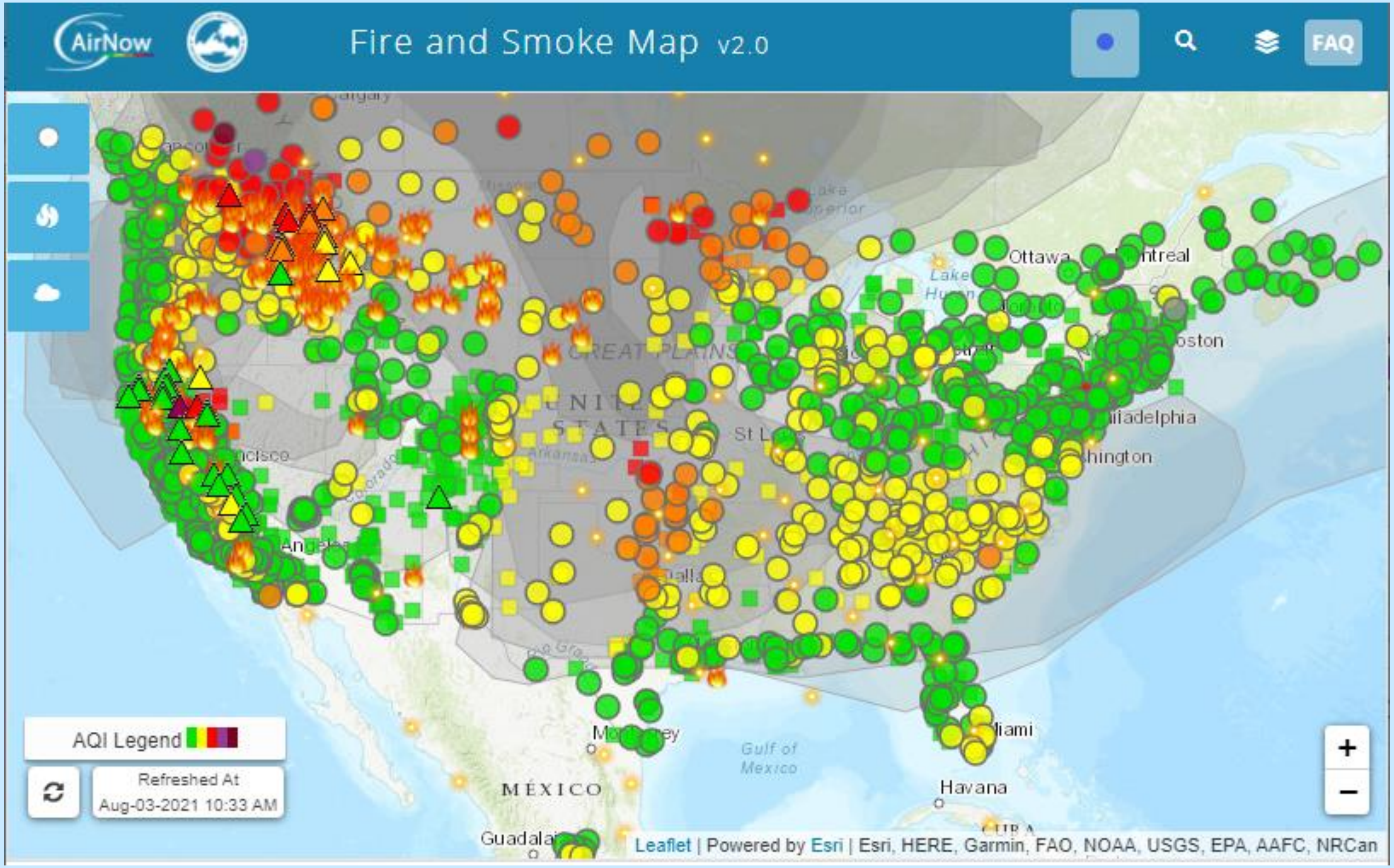
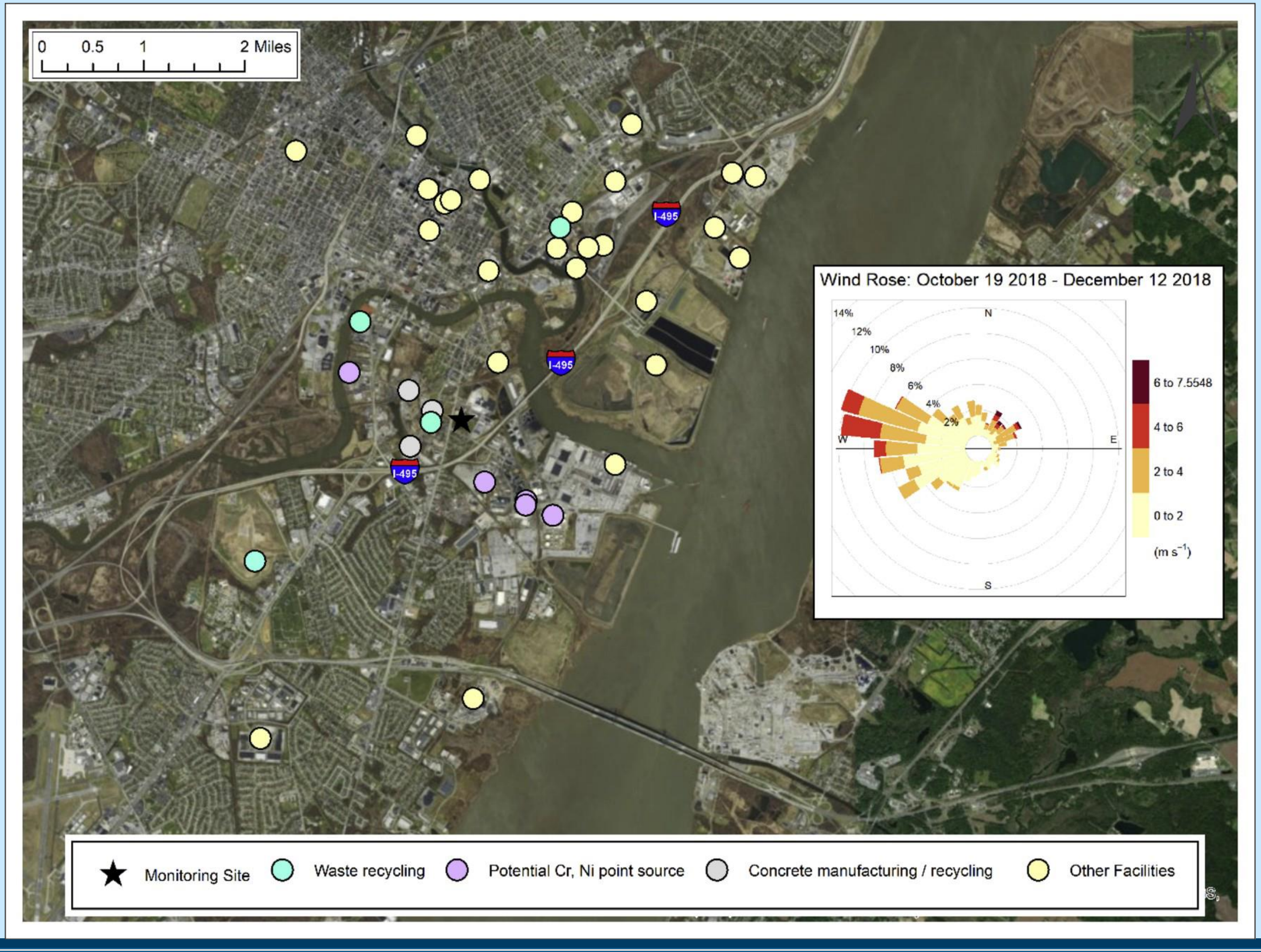
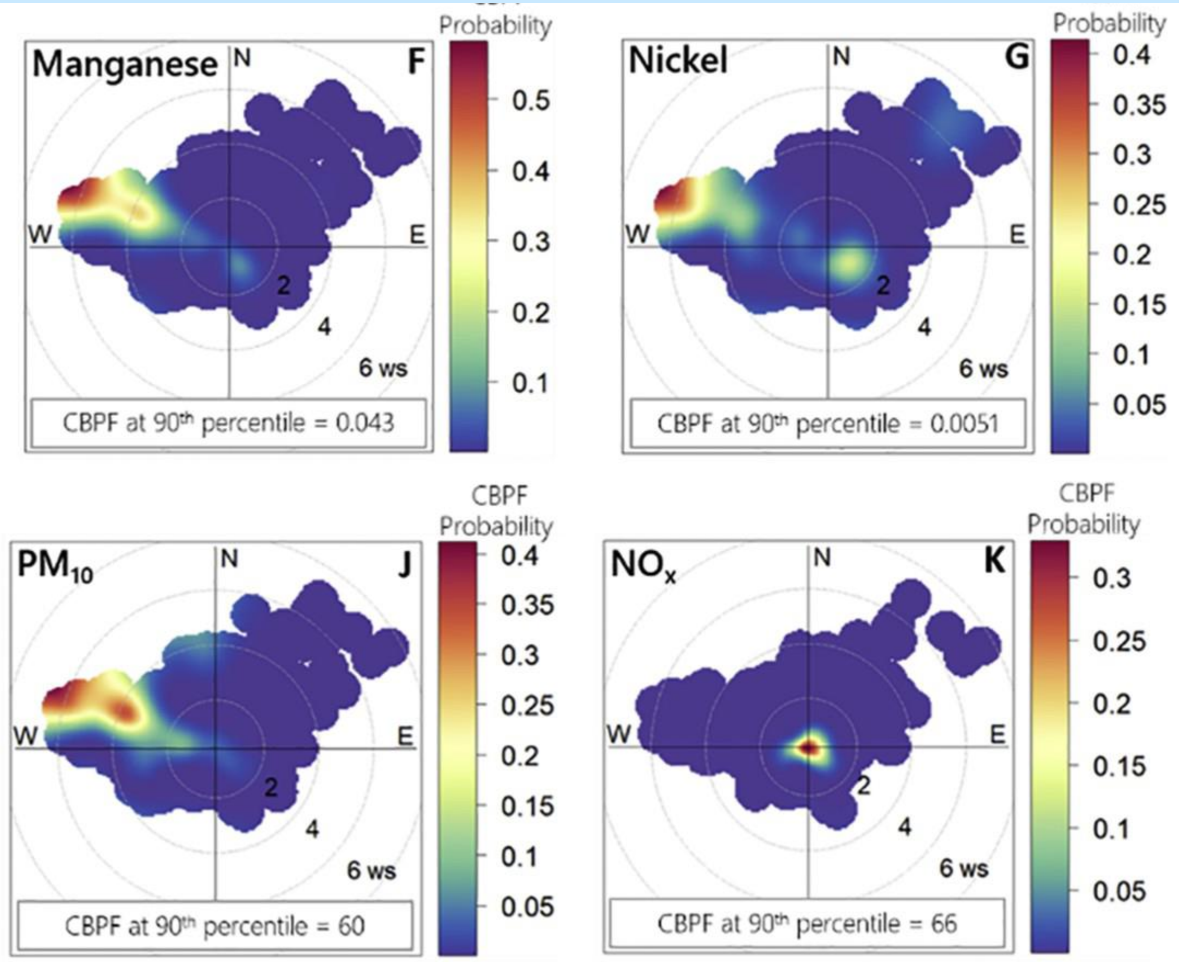


Karoline (Johnson) Barkjohn, Amara Holder, Andrea Clements
Technical Overview of the Development and Performance Validation of U.S.-Wide Correction Equation for PurpleAir Sensor Data

Single Monitoring Site





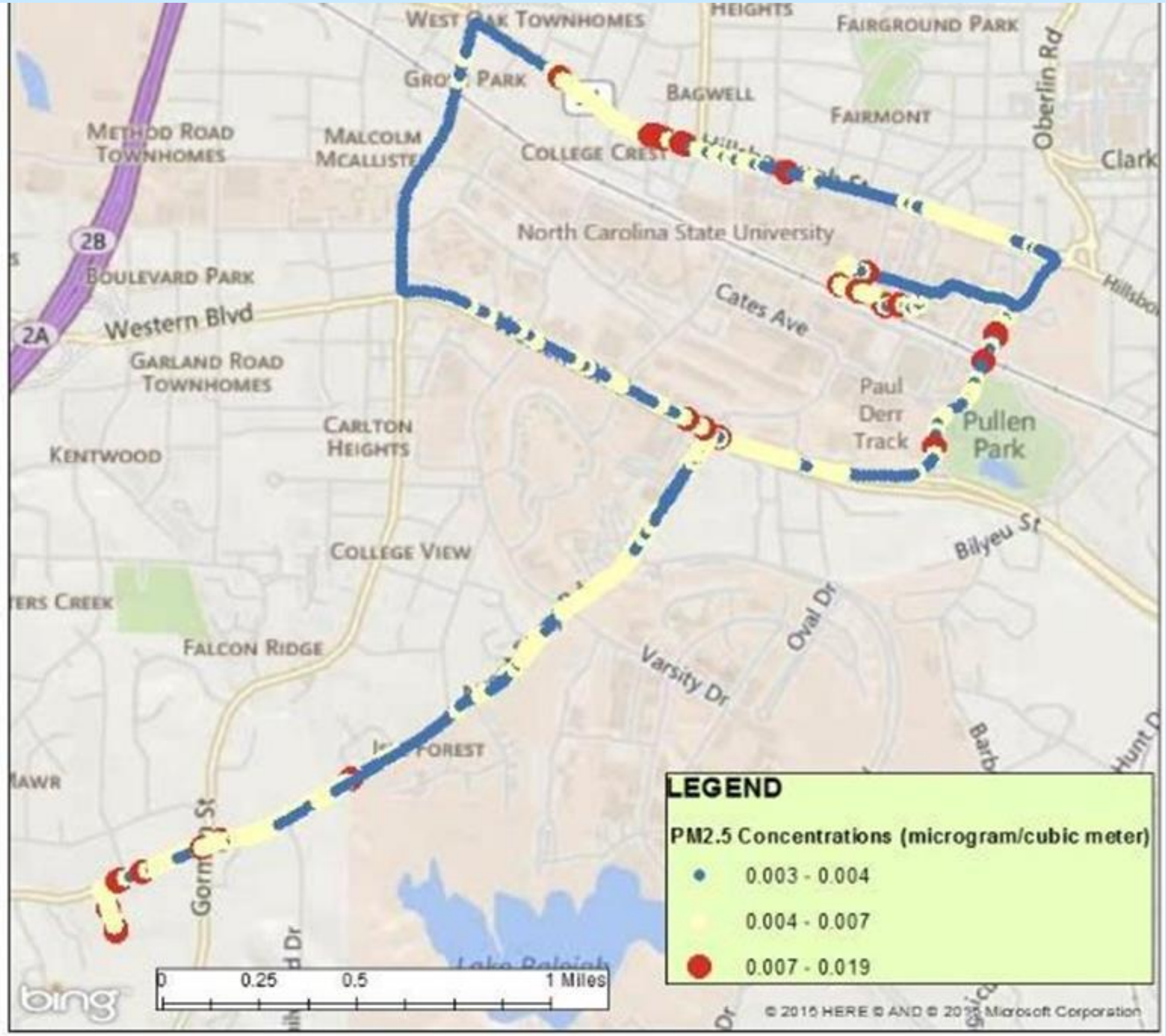
O S. Ryder, J. L. DeWinter, S. G. Brown, K. Hoffman, B. Frey, A. Mirzakhalili
Assessment of particulate toxic metals at an Environmental Justice community
ATMOSPHERIC ENVIRONMENT: X 6 (2020) 100070

Quantification of Sources of Variability of Air Pollutant Exposure Concentrations among Selected Transportation Microenvironments

Transportation Research Record
2020, Vol. 2674(9) 395–411

DOI: 10.1177/0361198120929336
journals.sagepub.com/home/trr
SAGE

H. Christopher Frey[1], Disha Gadre[2], Sanjam Singh[3], and Prashant Kumar[4]



Vehicle Exhaust Emissions Measurement Methods

- Chassis dynamometer
- Engine dynamometer
- Tunnel studies
- Remote sensing
- Chase vehicles
- **Portable emission measurement systems**
- Mobile emissions laboratories
- Automotive sensors
- Twin site ambient measurements
- Inverse modeling
- Evaporative emissions
- Low cost sensors

Elements of Real-World Measurements

Purpose

- How will the data be used?
- What data are needed?

Study Design

- Controllable
- Observable but not controllable
- Not observable

Instruments	Data collection
Calibration	QA/QC
Maintenance	Data analysis
Repair	People
Deployment	Training

Examples of Portable Emission Measurement Systems

SEMTECH-DS
CFR 1065 Compliant
NDIR: CO_2, CO, HC
FID: THC
NDUV: NO, NO_2
Heated Sample Line
Heavy (~50 lbs)
High Power Demand

Axion
NDIR: CO_2, CO, HC
Electrochemical: NO, O_2
Light-scattering: PM
Water separation bowl
Portable (~30 lbs)
Low Power Demand

ParSYNC
"micro-PEMS"
Electrochemical:
CO_2, NO, NO_2
PM: light-scattering, opacity, ionization
Water separation
Portable (~10 lbs)
Low Power Demand

Tailor Study Design to Purpose: Examples for Onroad Vehicle Tailpipe Emissions

- Real-world effectiveness of
  - Emission standards
  - Emissions controls
- Trends over time
- Source categories
- Fuels
- Operating modes (e.g., cold starts)
- Road functional class
- Level of service, congestion
- Effect of road grade
- Identification of emissions hotspots
- Roundabout vs. signalized intersections
- Signal timing and coordination
- Idle reduction
- Driver behavior and driving cycles
- Alternative routes for an Origin/Destination pair
- Siting of remote sensing locations
- Comparison of transport modes (e.g., rail vs. passenger car)

Spatial Variation in Real-World Light Duty Vehicle Exhaust Emission Rates

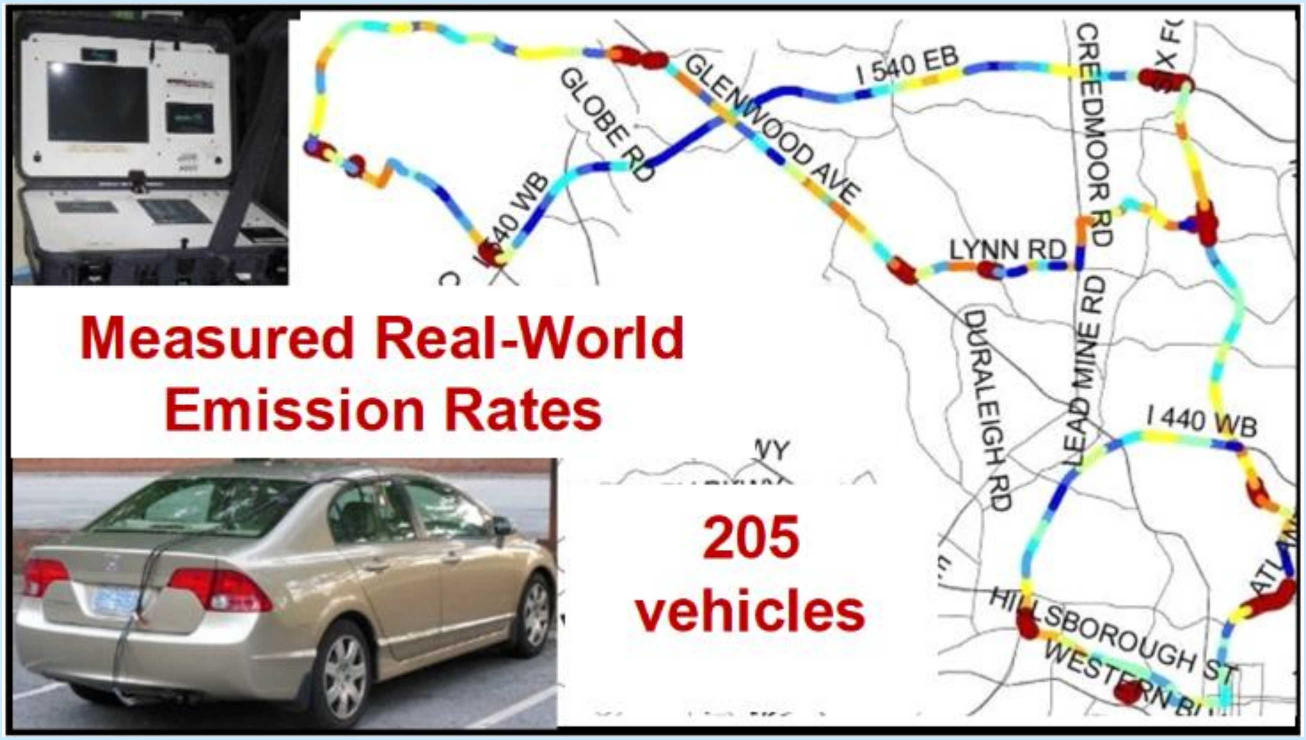

Environmental Science & Technology

pubs.acs.org/est Article

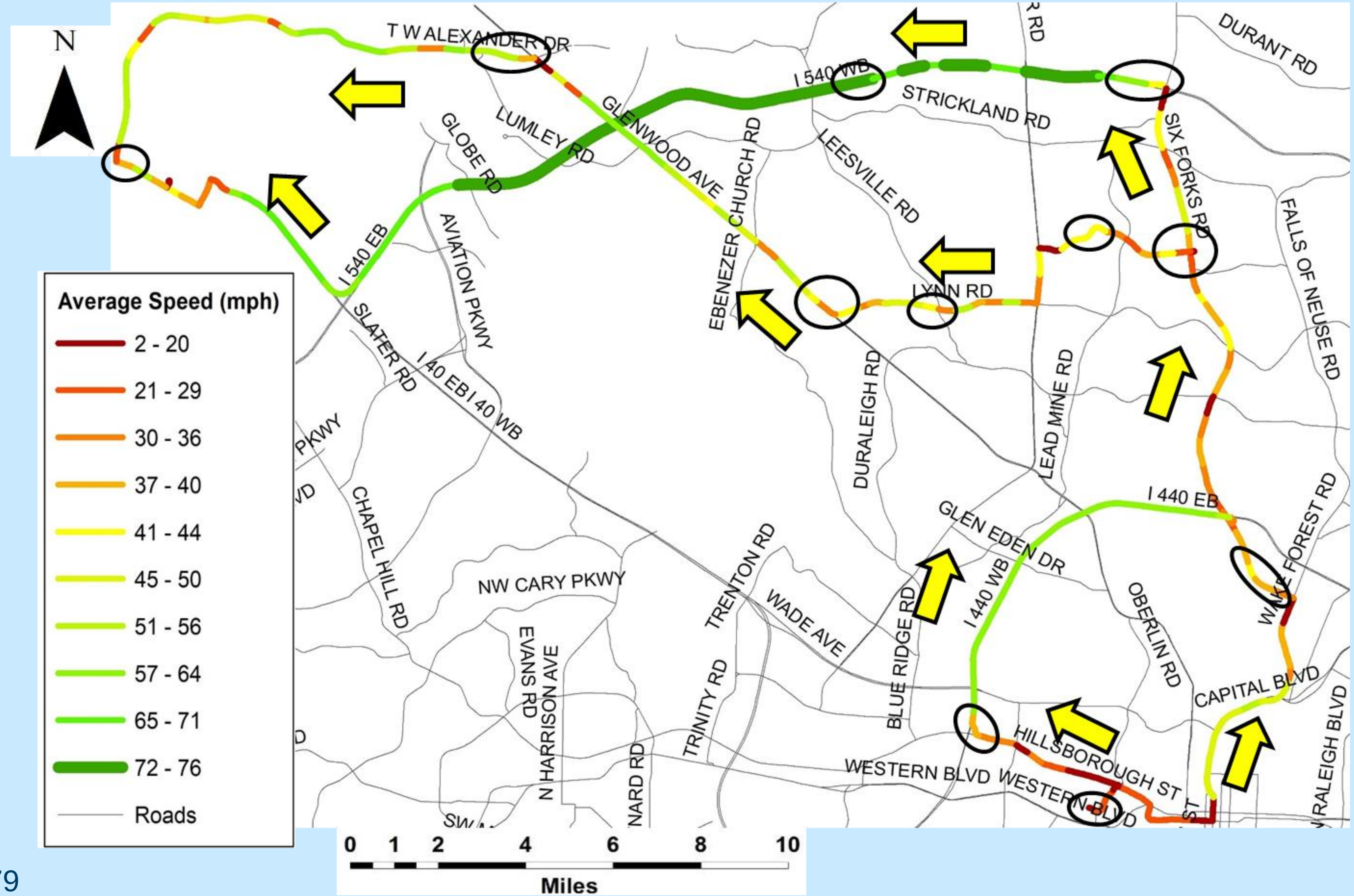
Geospatial Variation of Real-World Tailpipe Emission Rates for Light-Duty Gasoline Vehicles

Tanzila Khan, H. Christopher Frey,* Nikhil Rastogi, and Tongchuan Wei

Cite This: *Environ. Sci. Technol.* 2020, 54, 8968–8979 Read Online



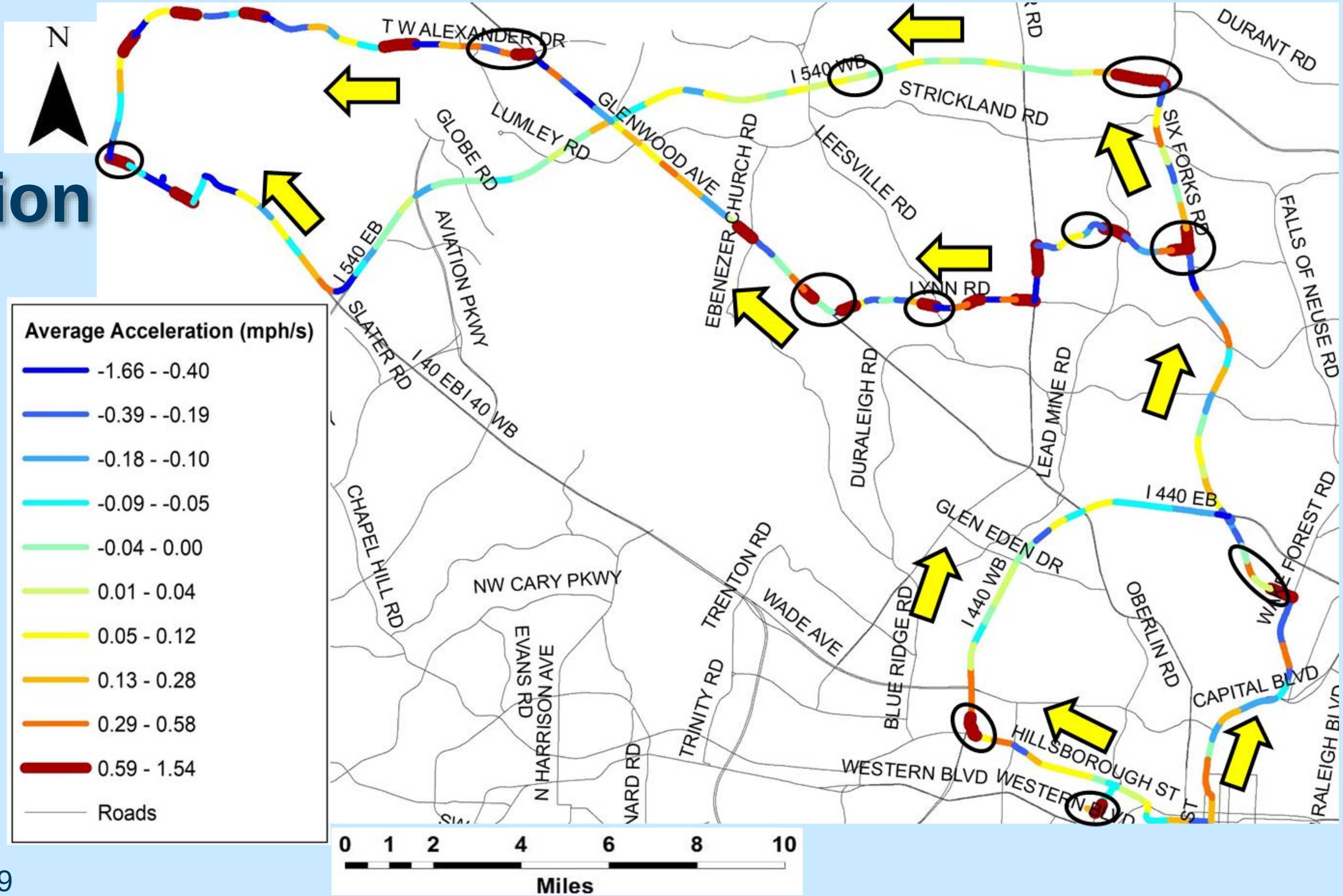
Speed



Khan et al. (2020)

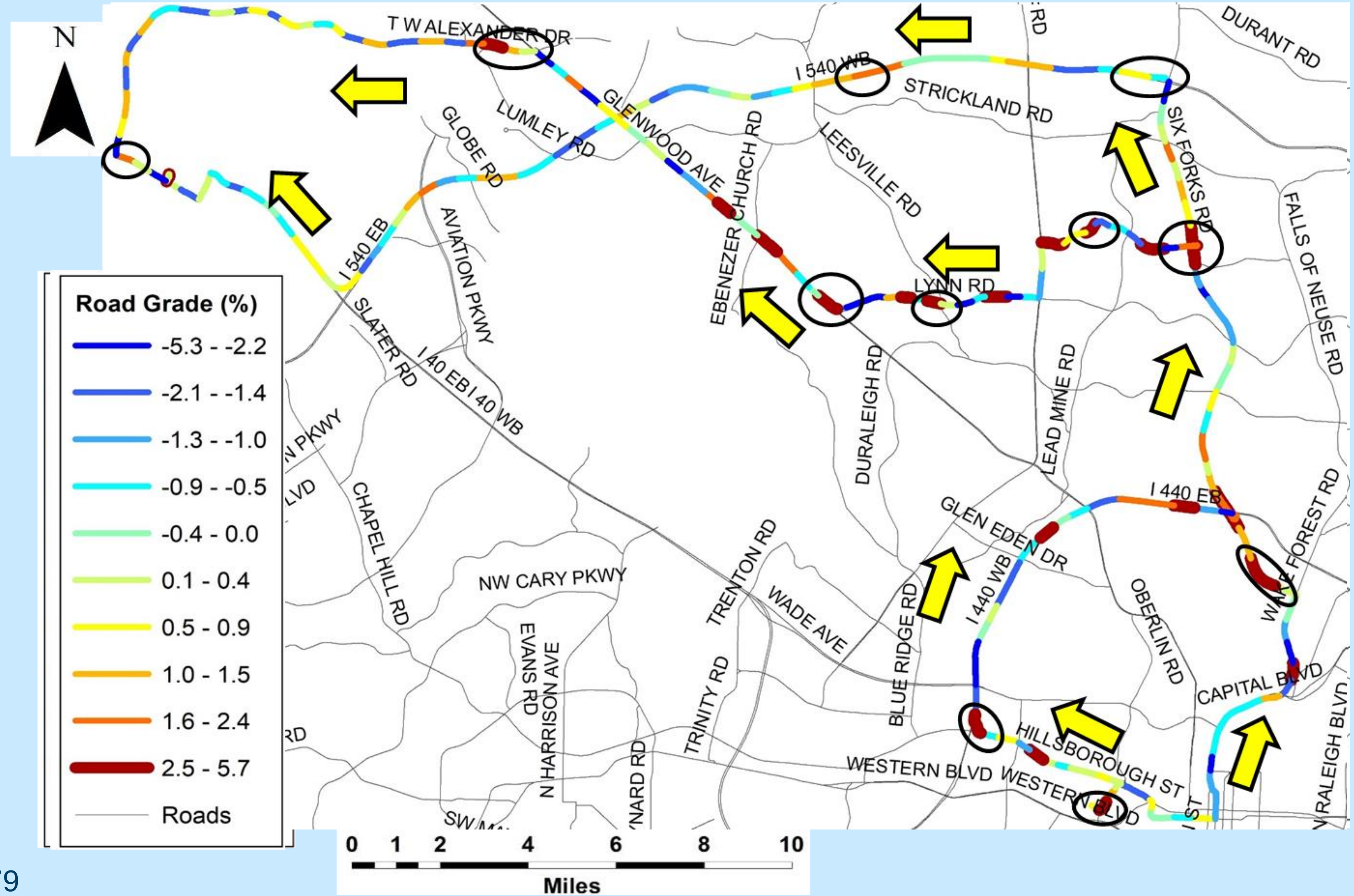
Environ. Sci. Technol. 2020, 54, 14, 8968–8979

Acceleration



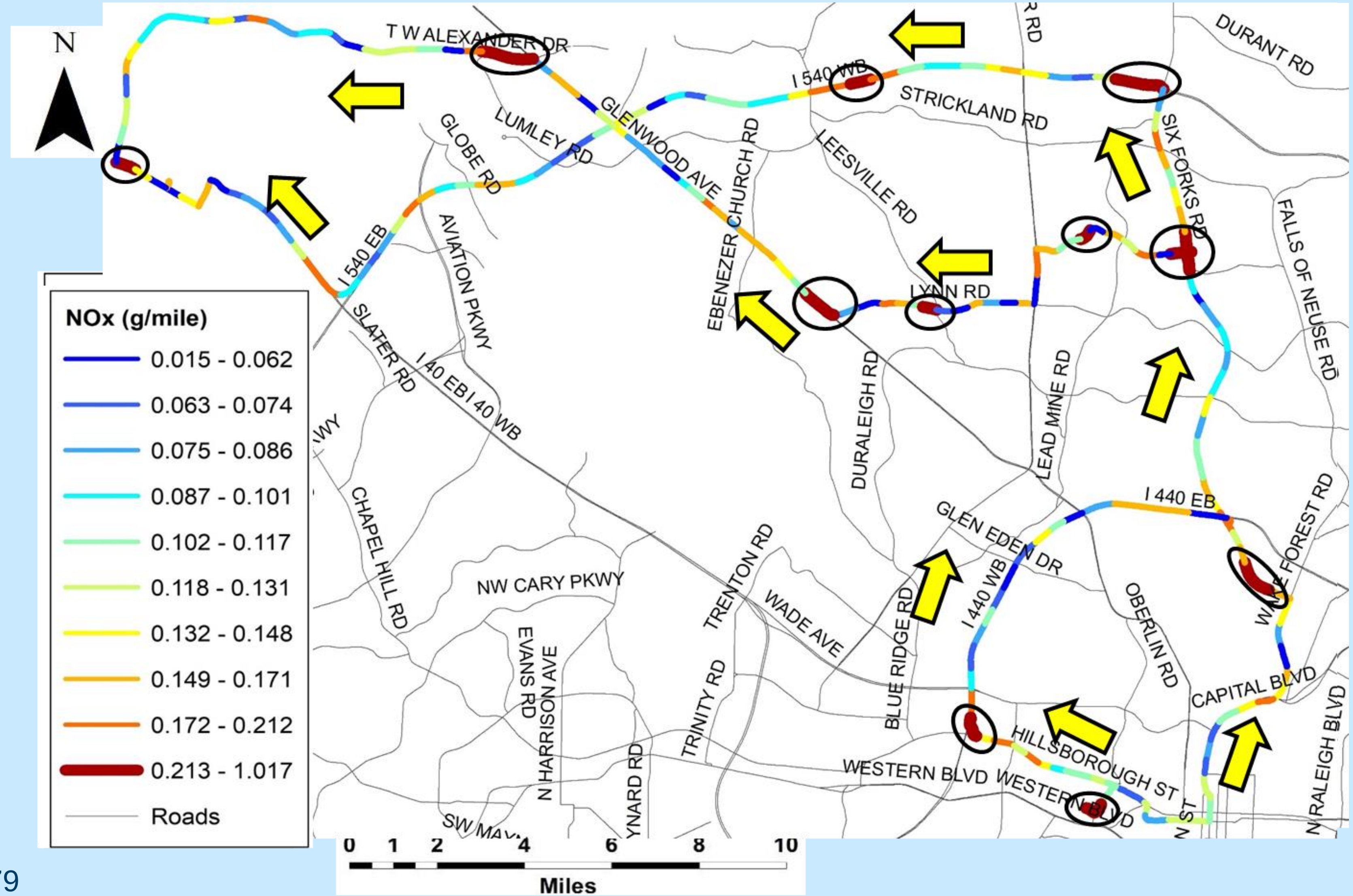
Khan et al. (2020)
Environ. Sci. Technol.
2020, 54, 14, 8968–8979

Grade



Khan et al. (2020)
Environ. Sci. Technol.
2020, 54, 14, 8968–8979

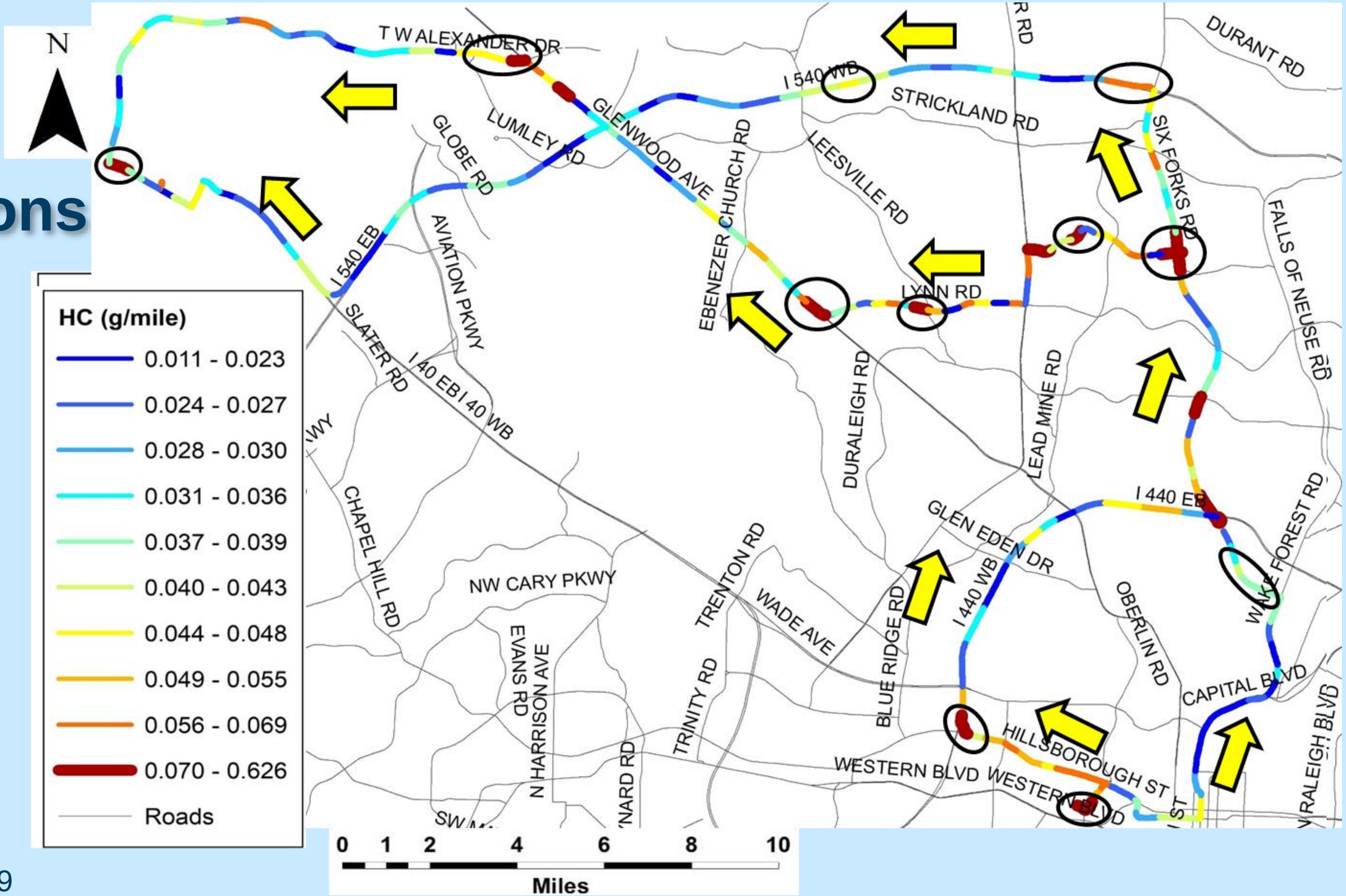
NO_x



Khan et al. (2020)

Environ. Sci. Technol. 2020, 54, 14, 8968–8979

Hydrocarbons



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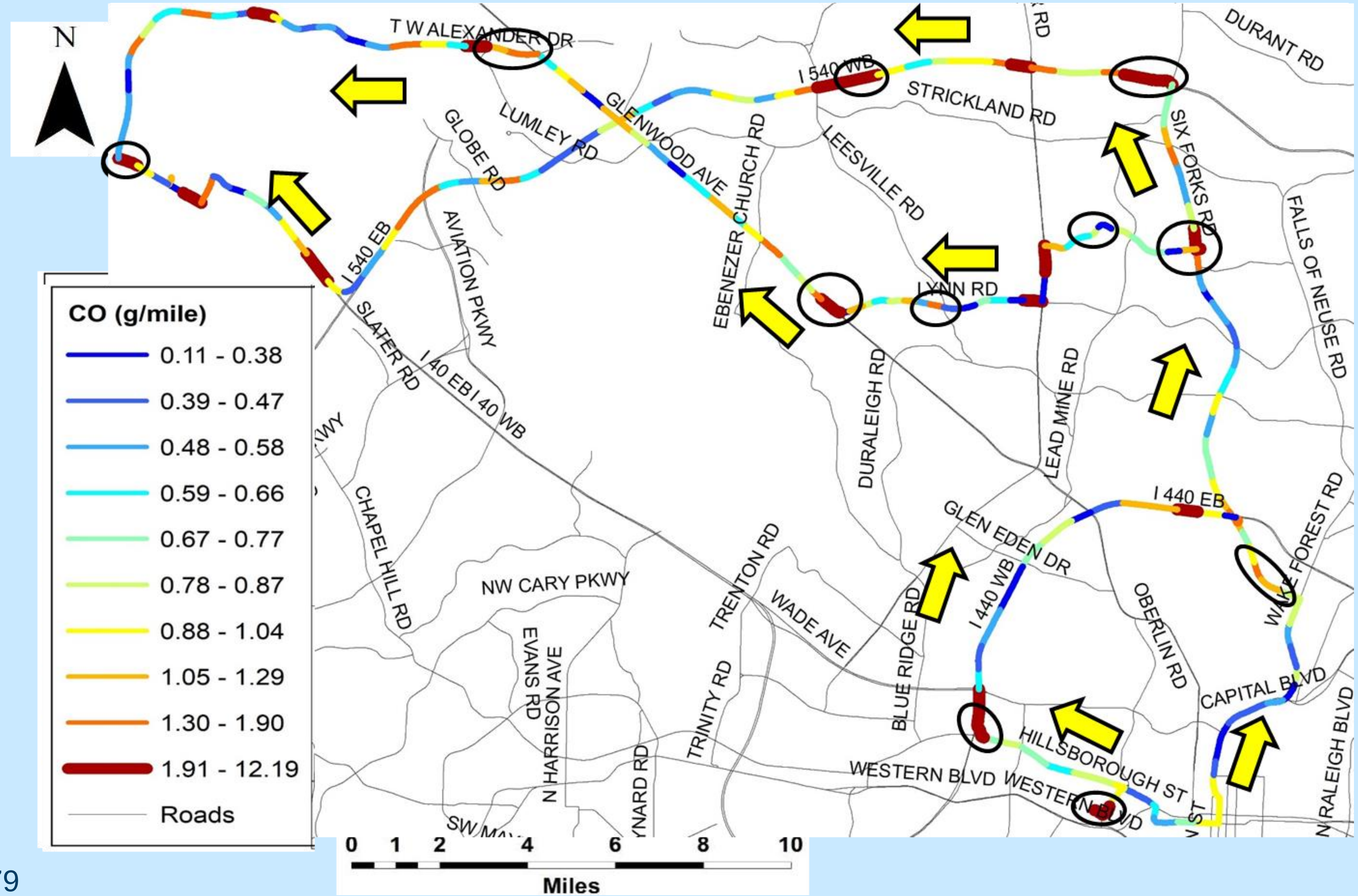
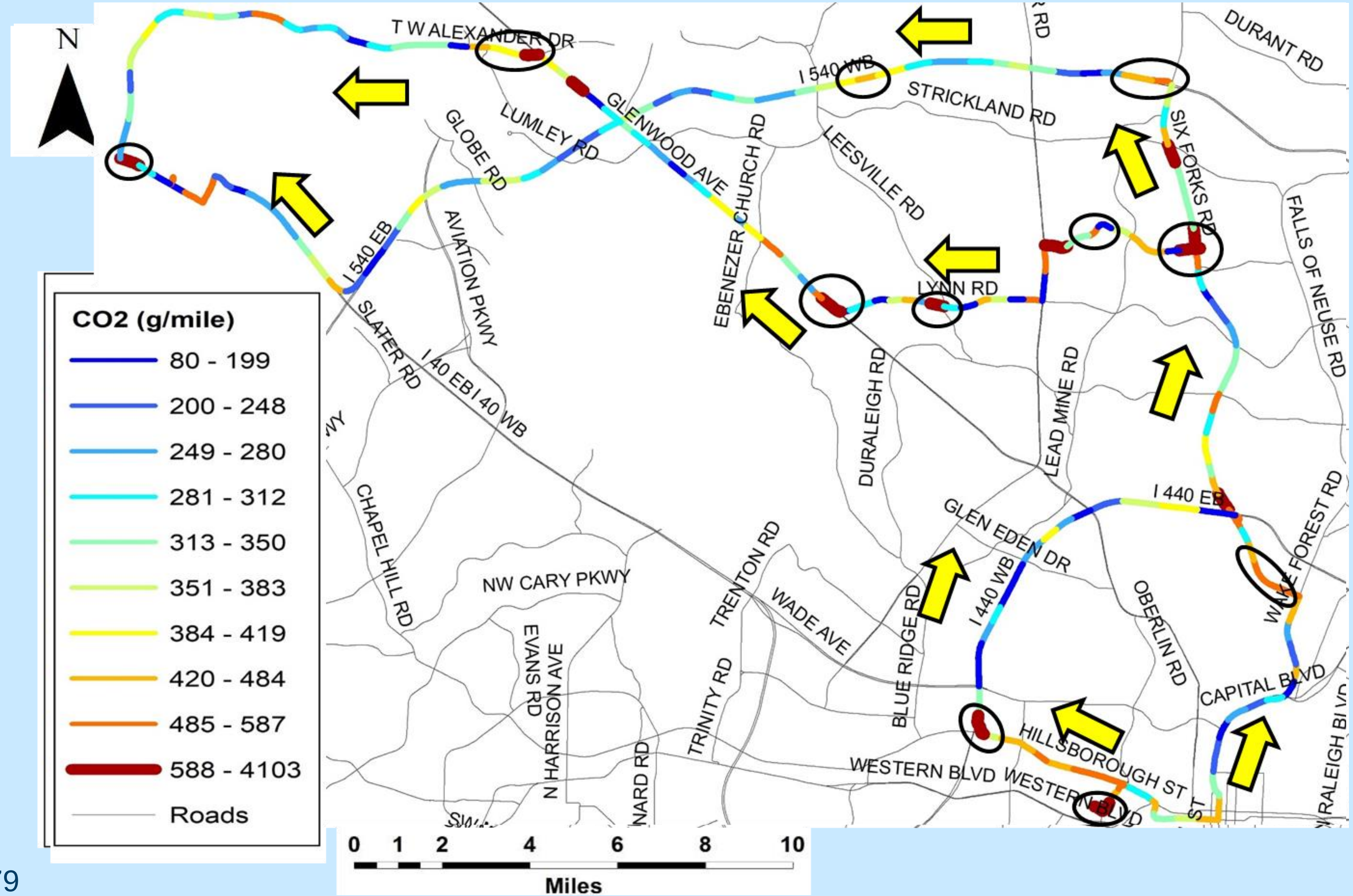
CO



Khan et al. (2020)

Environ. Sci. Technol. 2020, 54, 14, 8968–8979

CO_2



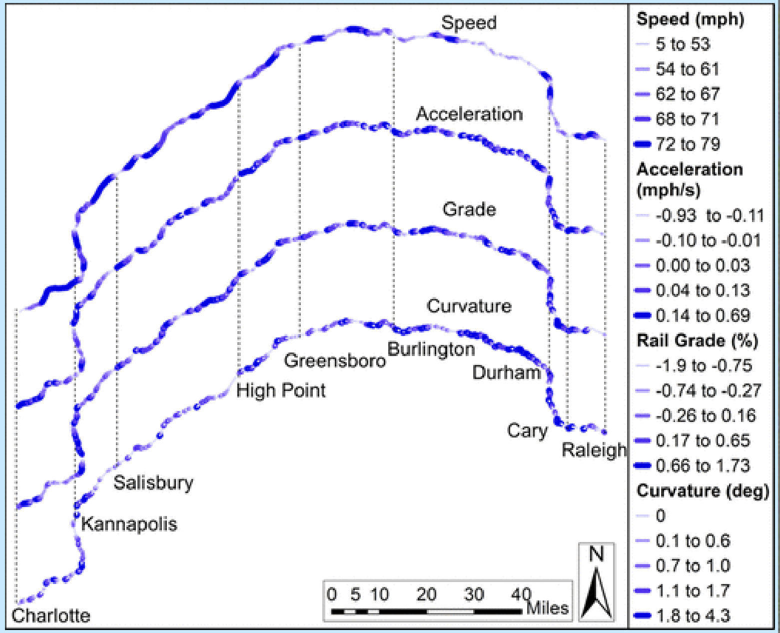
Khan et al. (2020)
Environ. Sci. Technol.
2020, 54, 14, 8968–8979

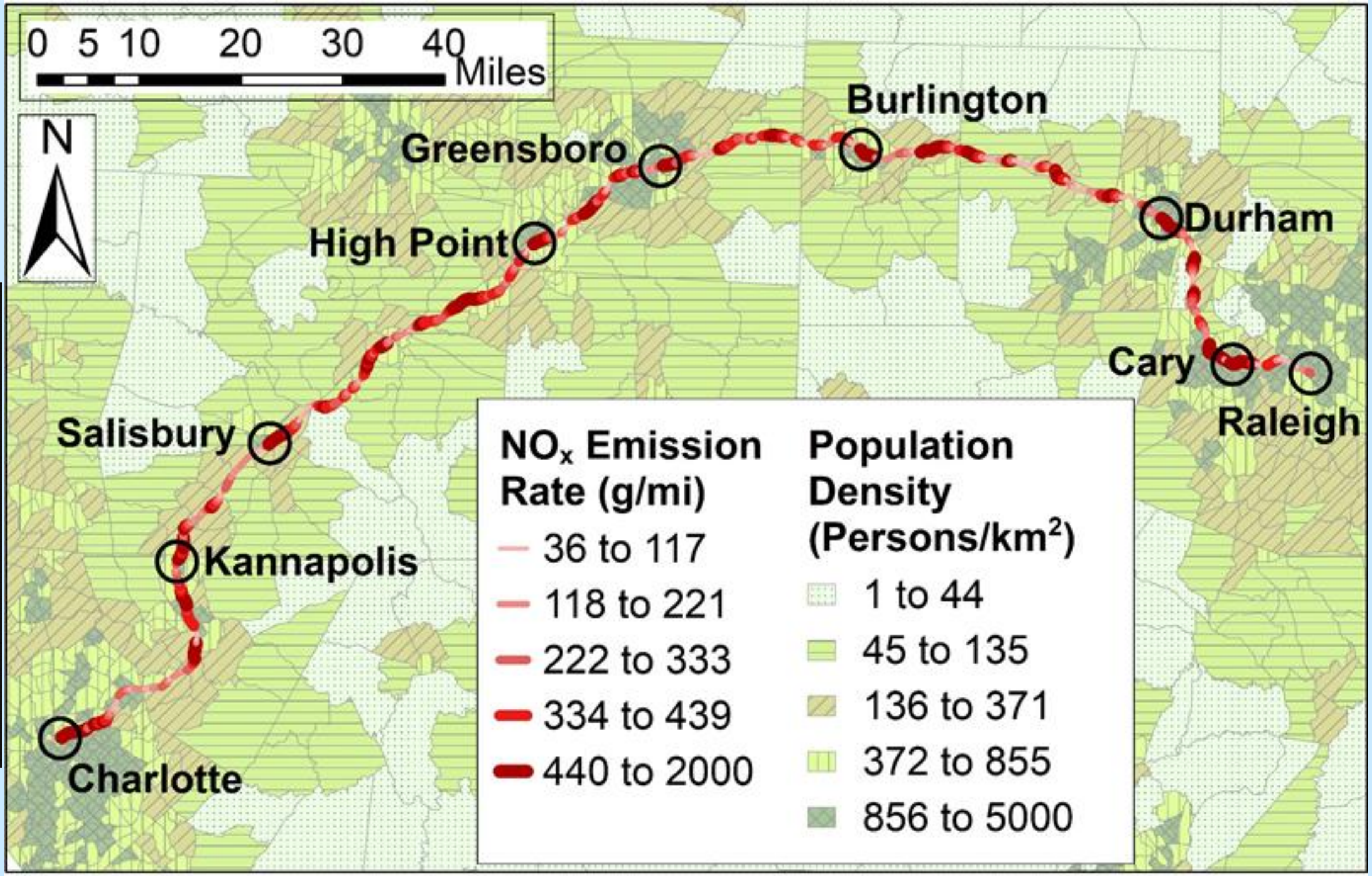
Environmental Science & Technology

Get e-Alerts

Characterizing Fuel Use and Emission Hotspots for a Diesel-Operated Passenger Rail Service

Nikhil Rastogi and H. Christopher Frey*



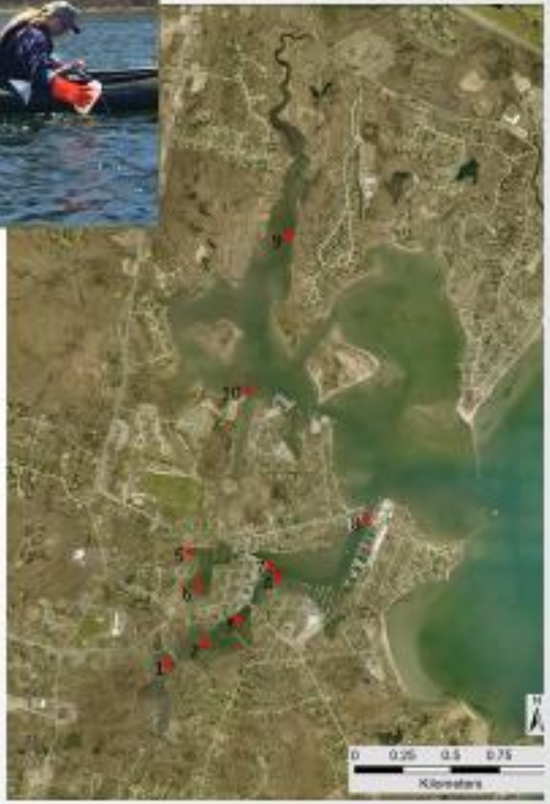


Using environmental measurements to assess the effect of sewering on local water quality

- **Purpose:** The waters around North Kingstown, RI are impacted by excess nutrients. The town is encouraging local residents to hook up to the new sewers they are constructing to help improve the water quality in the adjacent harbor and coves.

- **Data:** Measurements will be made in both groundwater and surface water, before and after sewer hookups are completed. Parameters to be measured include: algal cover on the sediment surface, nutrients, and dissolved oxygen.

- **Community Focus:** ORD has teamed up with USEPA Region 1, the USGS, and the town of North Kingstown to assess the impact of reducing the use of septic systems in the area.

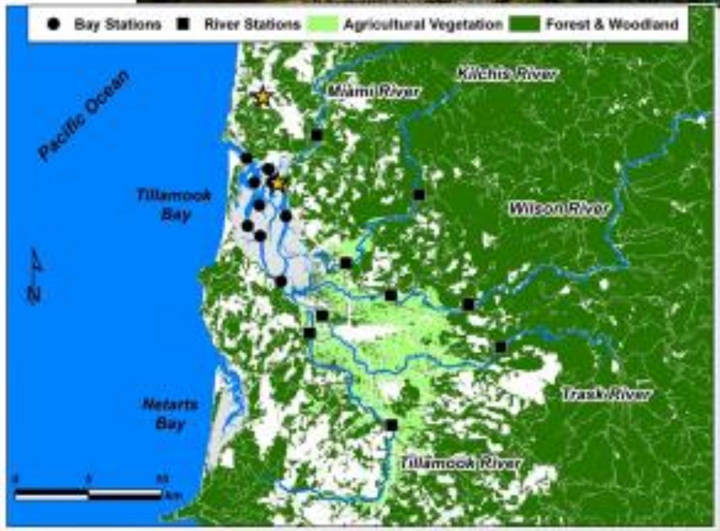


POC: Walter Berry

Characterizing nutrient-enhanced acidification and hypoxia (NECAH) in Tillamook Bay, OR

- **Purpose:** Characterize timing, location, and magnitude of acidification in Tillamook Estuary and characterizing roles of local nutrient pollution sources & land use practices on NECAH
- **Data**:
  - Continuous biogeochemical monitoring - SAMI pCO2, SeapHOx (SeaFET pH, O2), YSI EXO
  - Targeted bay cruises and river sampling –
    - 10 cruises from 7/17-7/18, 8 bay stations and 1 "ocean" station, Upriver and downriver sampling
    - CO2/DIC – calculated Ω and pHT, Dissolved oxygen
- **Community Focus**: Important for local recreational and commercial fisheries, as well as water quality management.

POC: Stephen Pacella



2

SARS-CoV-2 Wastewater Monitoring - Network of Weekly Sampling

- OH Coronavirus Wastewater Monitoring Network
  - 36 sites, more will be added
  - Sample 1-2 times per week
  - ORD-Cincinnati = 10 sites

- Sewershed Scale
  - MSD
  - Mill Creek
    - Large flow, high dilution, high industrial input
  - Taylor Creek
    - Small flow, little dilution, little industrial input
  - Lick Run
    - Subsewershed of Mill Creek

POC: Jay Garland

https://coronavirus.ohio.gov/wps/portal/gov/covid-19/dashboards/wastewater 31

Geo-Crowdsourced Data: Example for Noise

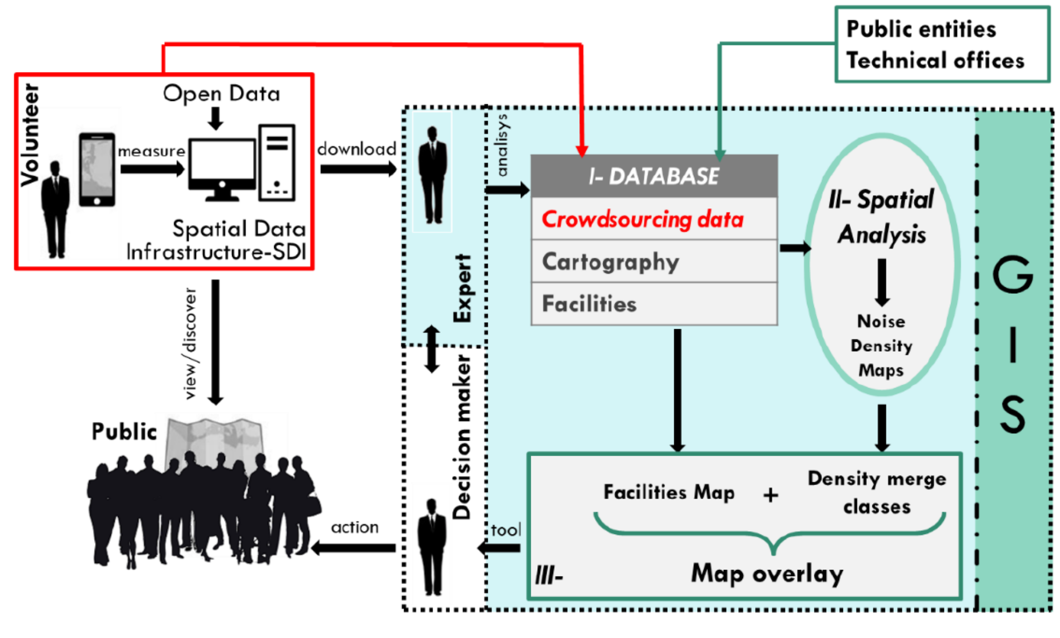


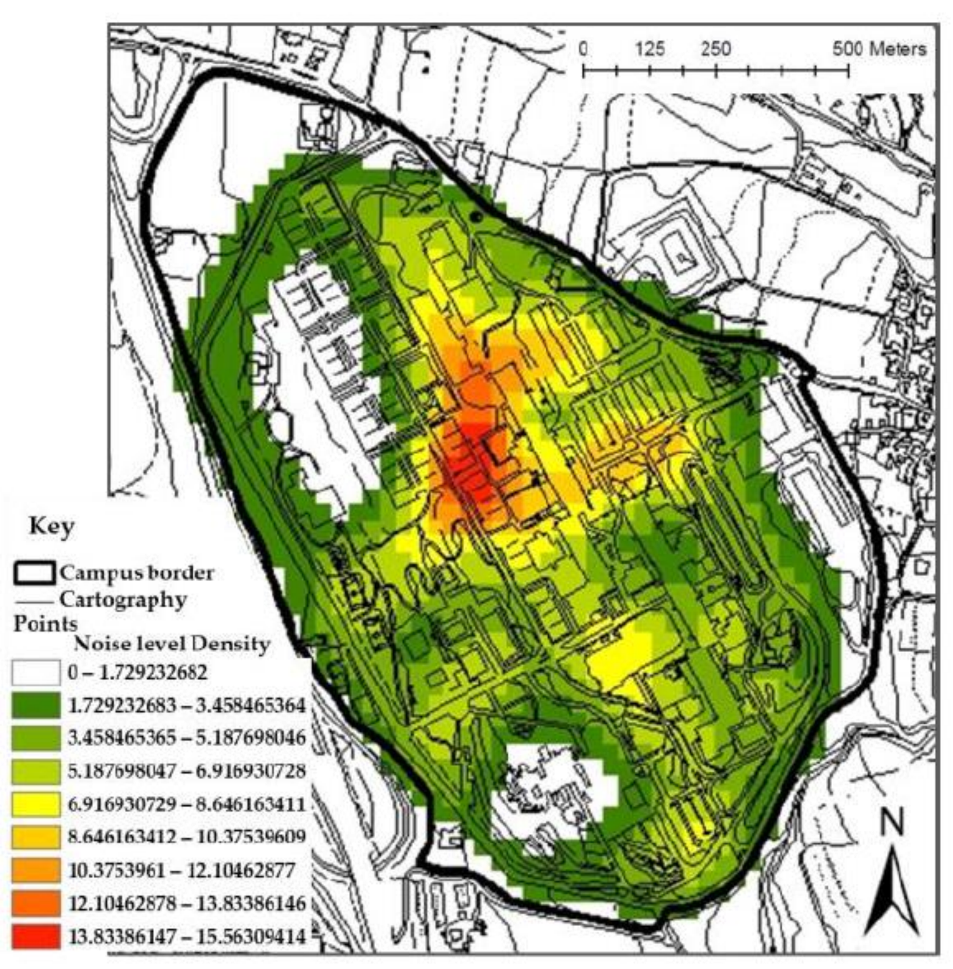
Figure 2. The 3–phases noise analysis model.

sustainability MDPI

Article

Geo-Crowdsourced Sound Level Data in Support of the Community Facilities Planning. A Methodological Proposal

Gabriella Graziuso [1], Simona Mancini [2], Antonella Bianca Francavilla [1], Michele Grimaldi [1] and Claudio Guarnaccia [1,*]



Community Engaged Participatory Air Monitoring

- Partnership of a university and community-based organization
- Trained local youth
- Incorporated community members into data collection
- Temporal as well as spatial variability

Articles

Fine Particulate Matter and Polycyclic Aromatic Hydrocarbon Concentration Patterns in Roxbury, Massachusetts: A Community-Based GIS Analysis

Jonathan I. Levy,[1] E. Andres Houseman,[2] John D. Spengler,[1] Penn Loh,[3] and Louise Ryan[2]

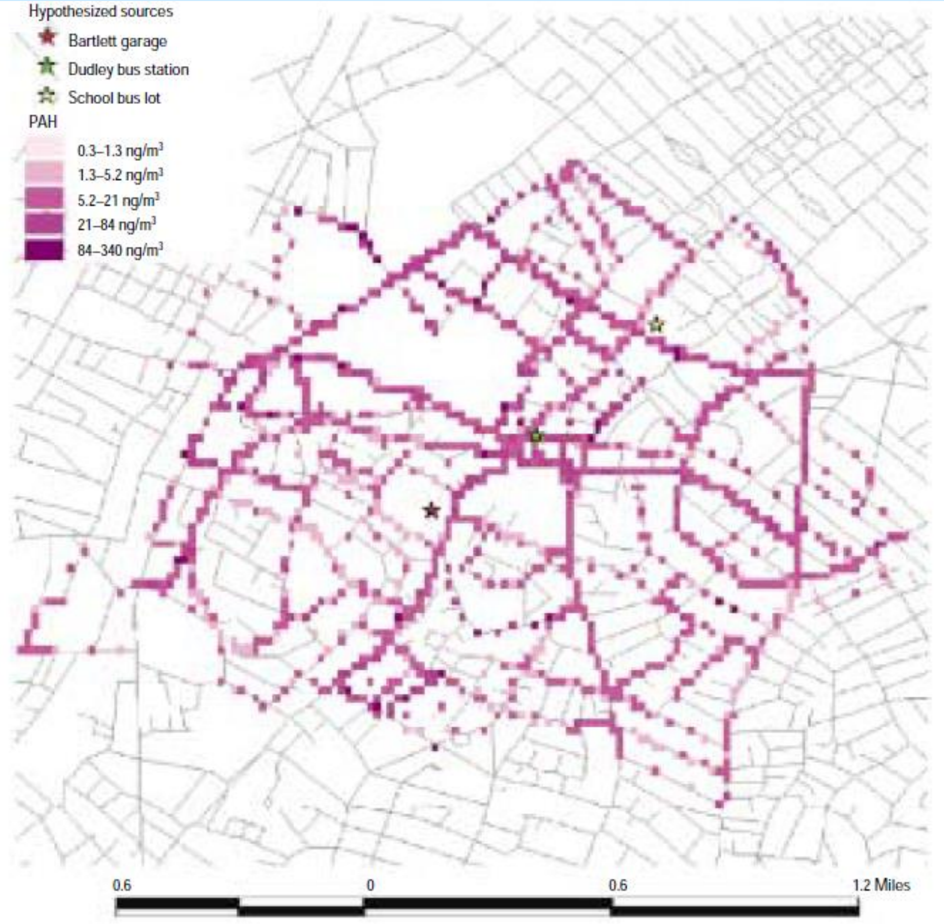


Figure 4. GIS representation of cell-averaged, 1-min average PAH concentrations near Dudley Square, derived from mobile PAS 2000CE monitoring in July/August 1999 (ng/m^3).

Youth Engaged Participatory Air Monitoring

"With all of this new information, I want to educate my community on how harmful these particulates are, and how change should begin with personal choices people make throughout their day"

International Journal of
Environmental Research and Public Health

MDPI

Article

Youth Engaged Participatory Air Monitoring: A 'Day in the Life' in Urban Environmental Justice Communities

Jill E. Johnston [1,*], Zully Juarez [1], Sandy Navarro [2], Ashley Hernandez [3] and Wendy Gutschow [1]

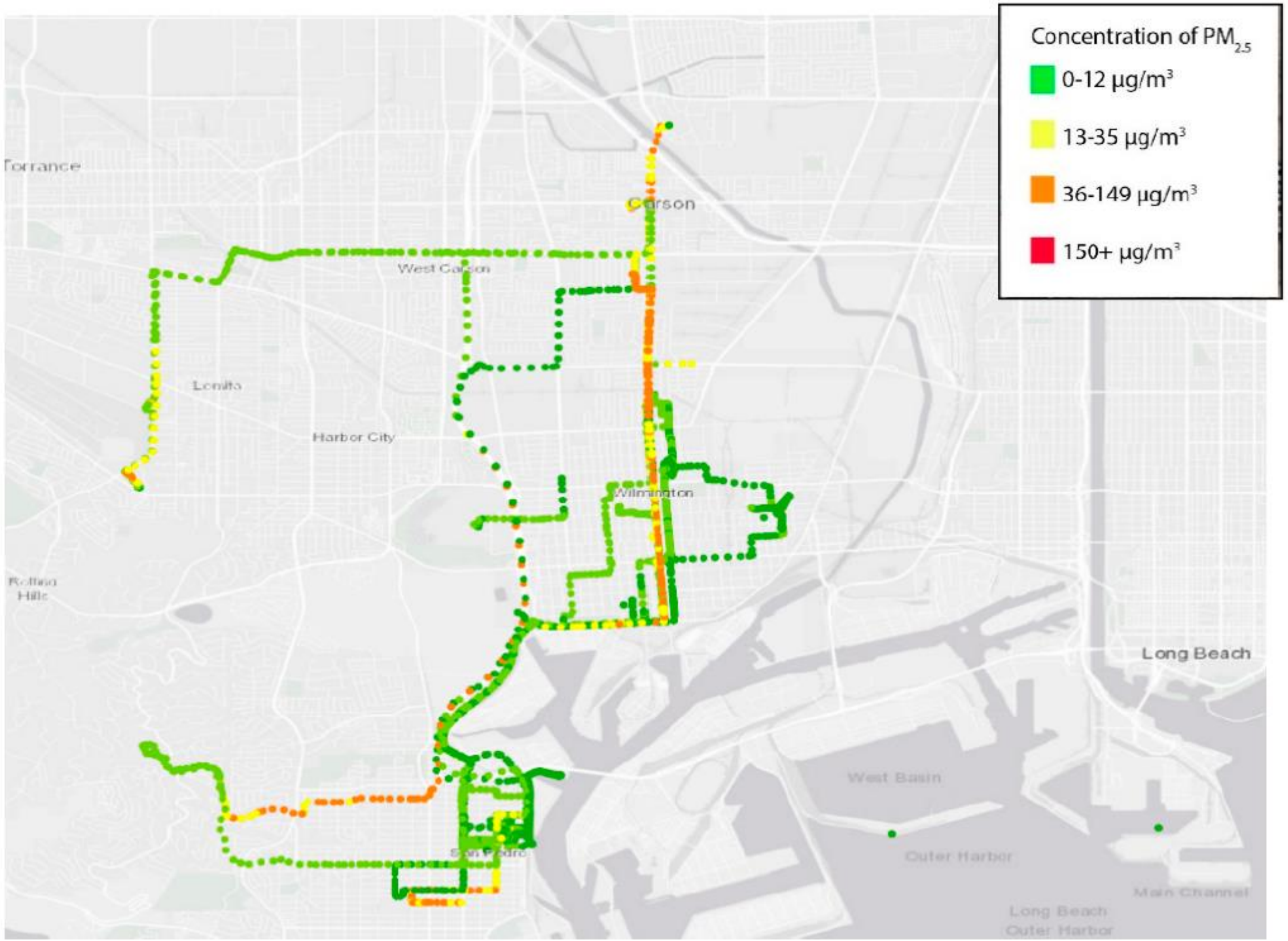


Figure 2. Map of $PM_{2.5}$ air monitoring exposure measurements from all CBE youth participants.

Discussion

What is the problem, and who decides?

Who are the decision-makers?

What information is needed to inform decisions and solve problems?

Study design can be adapted and tailored

Potential explanatory variables and uncontrollable factors – Observable? Measurable? Quantitative? Qualitative?

Other stressors?

Needs

Identify problems that matter to communities

Work with communities to characterize the problems and potential solutions

Fit-for-purpose measurements

Solutions-driven research

"Bias toward action"

Opportunities

Improve technology and techniques

Solving problems that are adversely affecting many people

Spark engagement and interest in science

Works Cited

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