AIR QUALITY HEALTH MONITORING TASK FORCE MEETING

JANUARY 2025

Welcome!

This meeting is being recorded. The recording and meeting materials will be available on our website.

Please enter your name, title, and organization into the chat box for attendance.

Please make sure your microphones are muted during the presentations.

When asking a question, please utilize the Raise Your Hand feature and state your name and organization.

You may also utilize the chat box to ask questions.

Welcome!

Objective:

To bring together a group of government representatives, health officials, academic representatives, and air quality experts to evaluate data that may indicate a need for additional air quality improvement strategies to address concerns over localized air pollution, with a focus on transportation sources.

NCTCOG PRESENTATION

Monitoring Under the Rider 7 Local Air Quality Planning Grant

DANIELA TOWER | HEALTH & MONITORING TASK FORCE | 1.30.2025

Rider 7 Monitoring

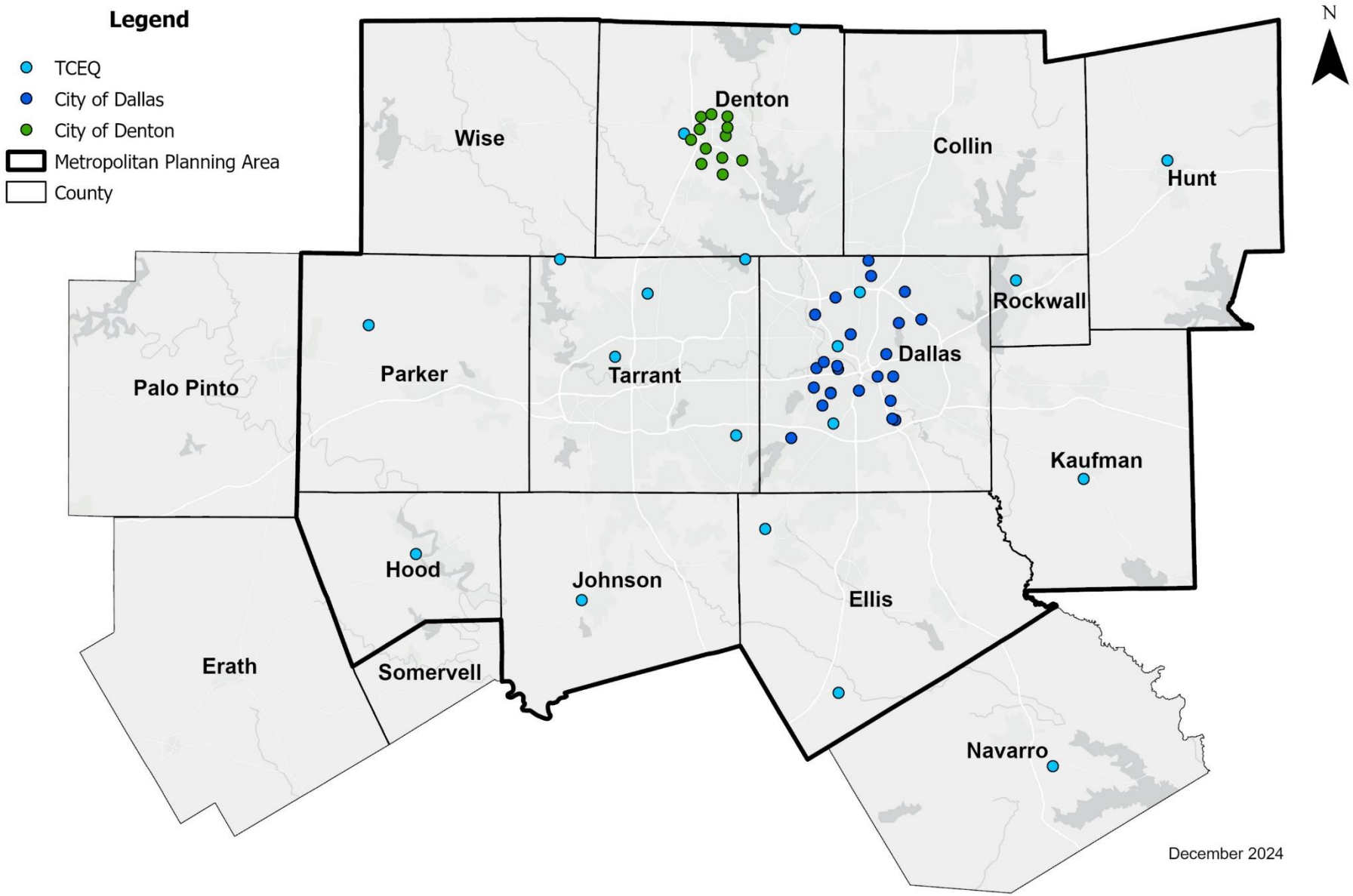
Rider 7 Local Air Quality Planning Grant exists for Ozone and PM2.5

Eligible activities are limited to:

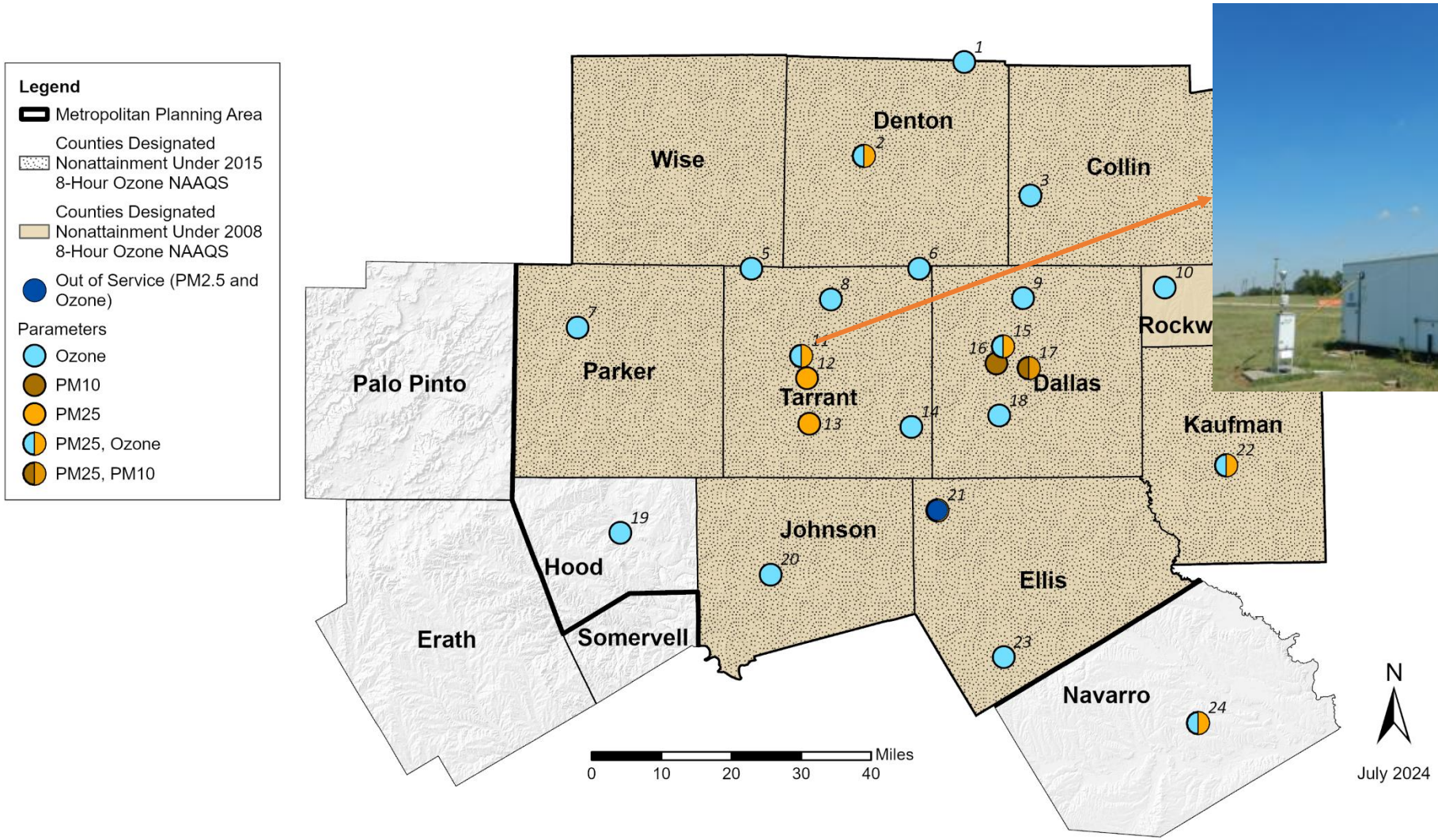
- Monitoring of Pollution Levels
- Emission Inventories
- Data Analysis
- Modeling - limited

Rider 7 Ozone funds are only eligible to be used in counties that are close to being in non-attainment, with a design value of between 60 and 70 ppb.

Current Ozone Monitors in North Central Texas

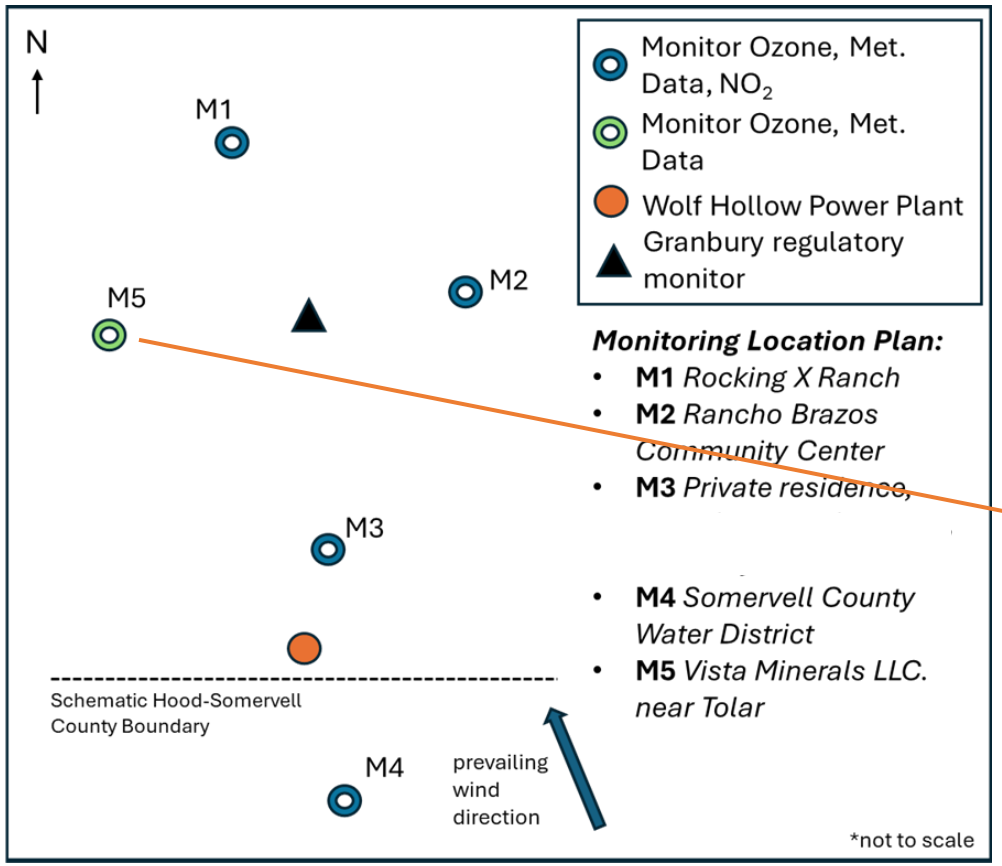


Regulatory Monitoring Network



14. Arlington Municipal Airport
15. Dallas Hinton Street
16. Earhart
17. Convention Center
18. Dallas Executive Airport
19. Granbury
20. Cleburne Airport
21. Midlothian
22. Kaufman
23. Italy
24. Corsicana Airport

Rider 7 Ozone – Monitoring Planning



Rider 7 – Monitoring Devices

FEM/ FRM Approved Devices: 2B Technologies (Ozone)

Dimensions (Height x Width x Depth): 8.7 × 4.0 × 3.0 in (22 × 10 × 7.6 cm)

Model 108-L Ozone Monitor | 2B Tech

Wind direction and speed: Atmos 41W (Meteorological Data)

ATMOS 41W - METER Group

Low-Cost-Monitors: Aeroqual AQY-R

Aeroqual AQY-R

Air quality monitoring system designed to provide real-time air quality data of ozone (0-200 ppb), **nitrogen dioxide (0-500 ppb)**, PM2.5 (0-1000 µg/m3) mass concentration, temperature and relative humidity.

Rider 7 Ozone – Monitoring Goals

Evaluate the influence of the Wolf Hollow Power Plant (Wolf Hollow II and planned III) - Bitcoin

Correlate meteorological conditions and ozone readings in the various locations

Track development of ozone readings

Compare precursors to ozone formation

Add to a better spatial coverage of pollution data in the DFW region

Although Rider 7 Ozone does aim for ozone and ozone precursor pollution, the Aeroqual also measures PM2.5 – more comprehensive pollution assessment.

Goal: The One-Stop-Shop Monitoring Network

MONITORING

Facilitate and create a more localized monitoring network, bundle access to the currently available monitoring stations and resources at one website, increase monitoring

HEALTH DATA

Collect and provide access to impersonalized health data with correlate to AQ data, facilitate the understanding of AQ impact on public health

COLLABORATION

Bring all interested parties together for information exchange, create an accessible public information platform, identify sources and mechanisms of AQ impacts

Health Data Tools

CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)

Web-based and Desktop Application

URL: https://www.epa.gov/cobra

- Allows you to see how changes in pollutants (PM2.5, SO2, NOx, VOC) impacts human health at county, state, regional, or national level
- Users can supply own baseline emissions, population, and incidence data; and health impact and valuation functions to customize the model in the Advanced Options tab in the desktop version

Source: CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) | US EPA

Health Data Tools

Regional Environmental Health Data Visualization Application (REHD)

Tool: https://edap.epa.gov/public/extensions/EHD_public/EHD_public.html

Webinar: https://www.youtube.com/watch?v=UhyK13qE374

- Compare health and environmental datasets from the Centers for Disease Control and Prevention (CDC) and EPA EJSCREEN: Environmental Justice Screening and Mapping Tool along with other data.
- For statistical reporting and analysis
- Contact: Sala Senkayi – Senkayi.Sala@epa.gov

Source: Exploring Environmental Health Data Using An Interactive Data Visualization Application | US EPA

FOR MORE INFORMATION

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https://www.nctcog.org/trans/quality/air

Downwinders at risk

Environmental Justice Cleaner Air Grassroots Power

Midlothian Cement Plants

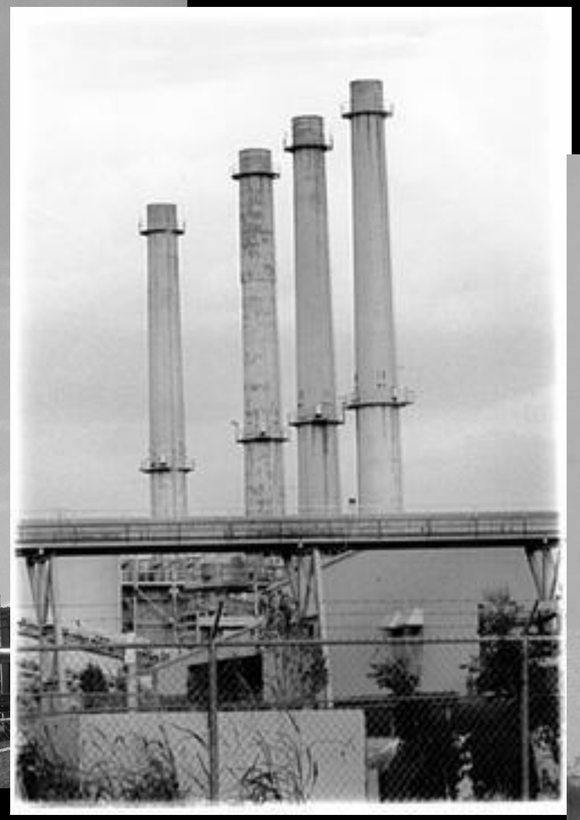
Our founding struggle was stopping the burning of hazardous wastes at three large old cement plants south of DFW

We worked for 13 years until we successfully:

Ended hazardous waste burning in Texas cement kilns

Replaced or modernized all three cement plants

Led a national campaign to reform EPA regulations for waste-burning cement kilns.



Frisco Lead Smelter

Downwinders helped
Frisco residents
close what turned out to be
an illegally operating
lead smelter
that was exceeding
national air pollution
standards
for lead.

FRISCO
UNLEADED

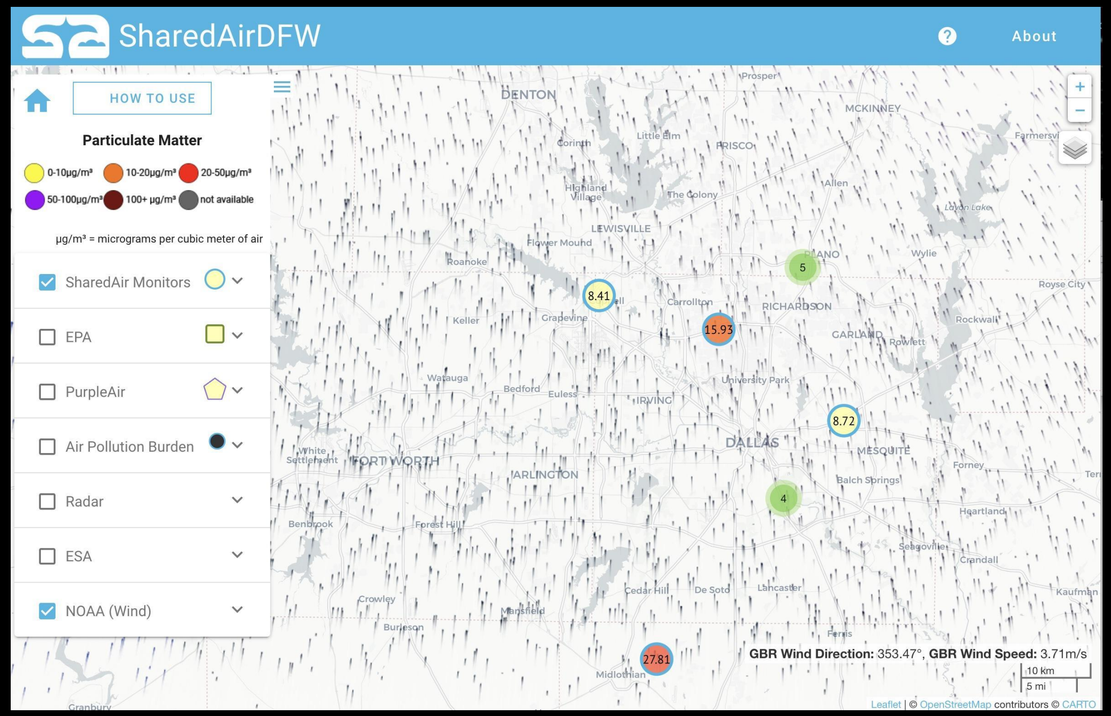
In less than a year
we won the closure and clean-up
of the smelter,
which previously had
the backing of EPA,
state government
and the City of Frisco.

Dallas Drilling Ordinance

Despite what the Dallas Mayor said was “a done deal”, we stopped and reversed gas drilling leases in city parks and floodplains.

Then we passed a tough drilling ordinance that effectively banned gas and oil drilling in Dallas City limits.

SharedAirDFW.com Network



Where does PM come from?

Vehicles with combustion engines:
Cars, Buses,Trucks, Trains, and Planes

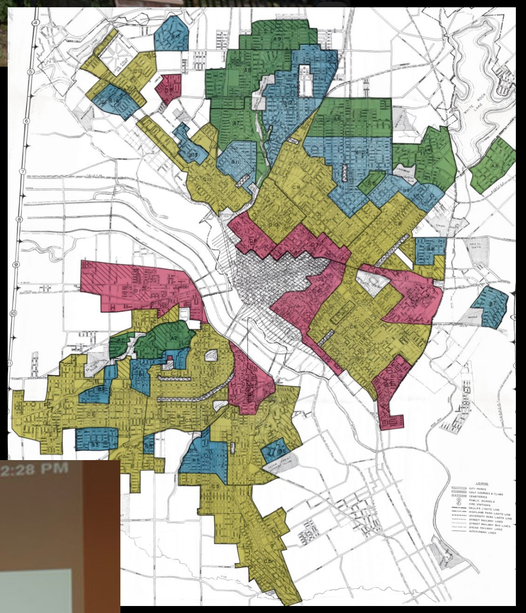
Industry with boilers, furnaces or other sources of combustion:utility plants, cement kilns, steel mills, natural gas compressors.

Small Businesses and homes with combustion restaurants, welding shops, stoves and fireplaces.

Black and Brown people are exposed to more and higher concentrations of air pollution than White people.

Why?

Proximity to polluters

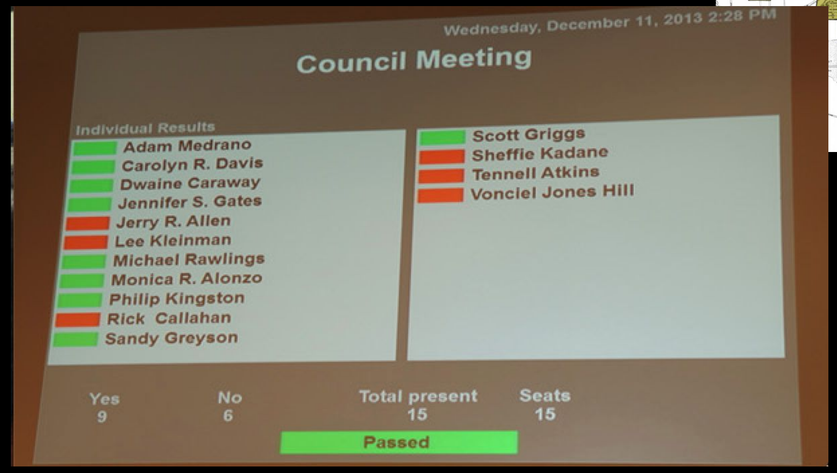


What determines proximity to polluters?

Zoning

How do you change Zoning?

Through local government



Black and Brown people are disproportionately exposed to higher concentrations of air pollution than White people.

EXHIBIT ES-3. CURRENT NATIONAL $PM_{2.5}$-ATTRIBUTABLE MORTALITY BURDEN BY RACE

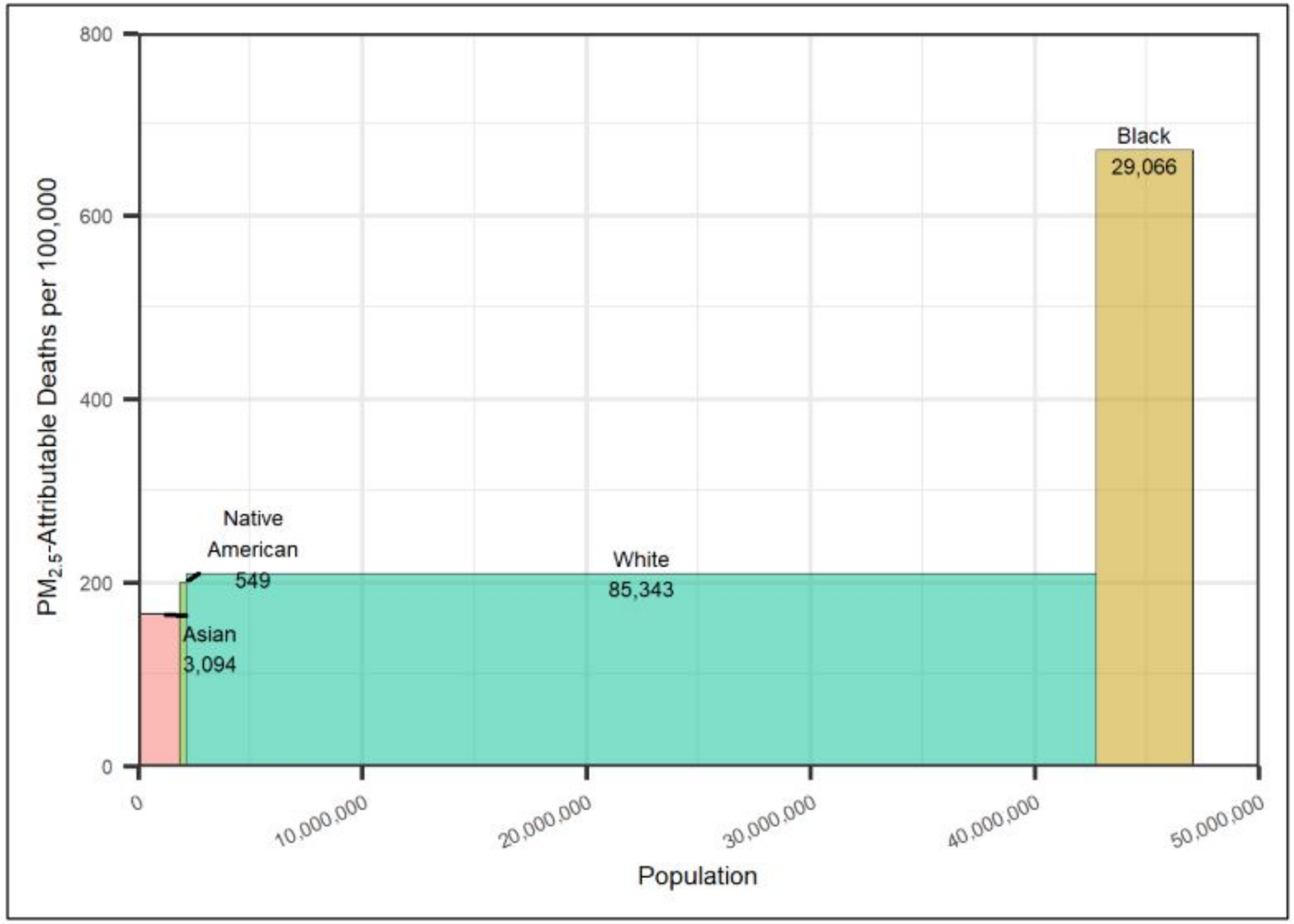


EXHIBIT ES-2. CURRENT $PM_{2.5}$-ATTRIBUTABLE MORTALITY RATE (PER 100,000)

RACE	PM-ATTRIBUTABLE MORTALITY (PER 100K)
Asian	170
Black	670
Native American	200
White	210
All	**300**

Source: Industrial Economics Incorporated, "Analysis of PM2.5-Related Health Burdens Under Current and Alternative NAAQS." 2022

The Joppa Environmental Health Project (JEHP) focused on two study questions to understand the health of the community regarding particulate matter (PM) air pollution:

1.

What is Joppa's actual exposure to $PM_{2.5}$ air pollution?

2.

Are there health problems among Joppa residents linked to $PM_{2.5}$ air pollution?

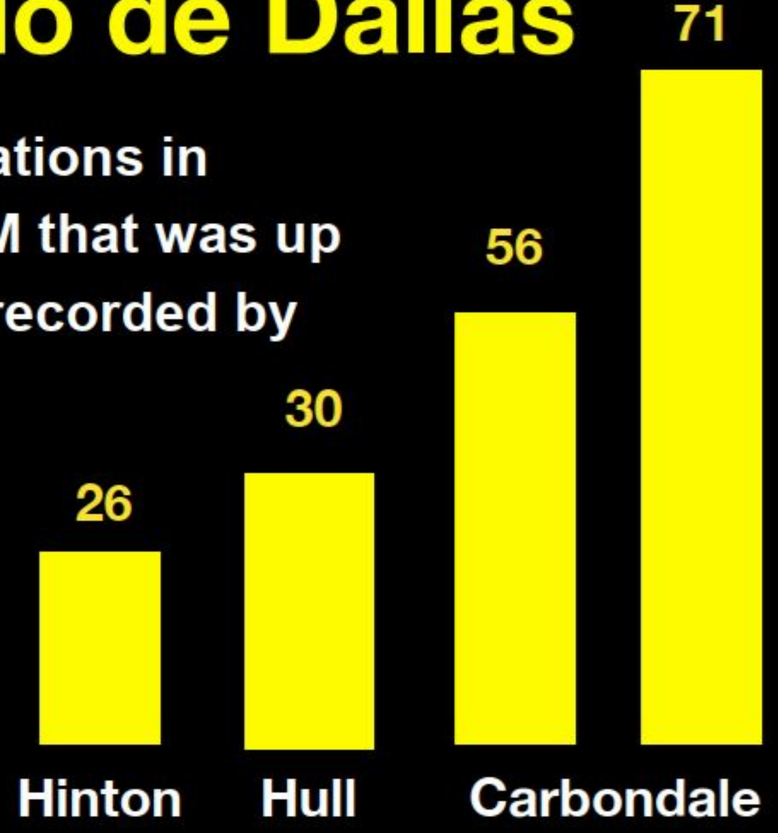

Community Survey:
Perceptions of Pollution
Encuesta Comunitaria: Percepciones de la Contaminación
La calidad del aire en Jope es mala o muy mala.
62%
Air quality in Joppa is poor or very poor.
La contaminación del aire en Jope tiene un efecto perjudicial para mi salud o la de mi familia.
83%
Air pollution in Joppa makes me and my family sick

Joppa Daily PM Burden = Up to 2-3X Dallas County Concentrations

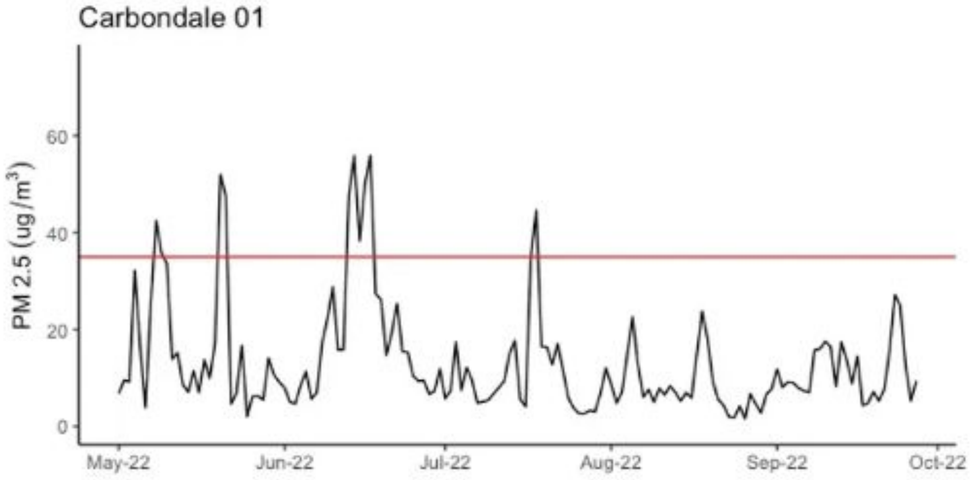
Carga de PM en Joppa = Hasta 2-3 Veces el Promedio del Condado de Dallas

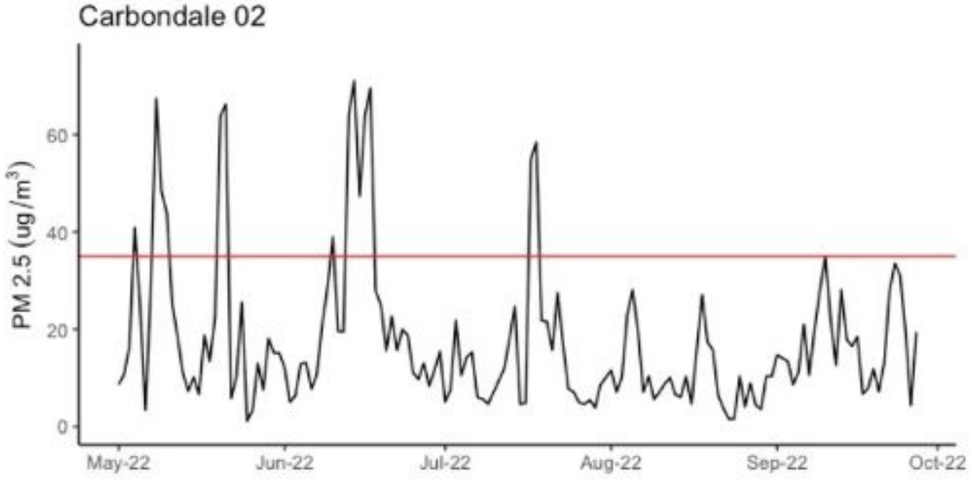
Data from the three SharedAirDFW.com monitor locations in Joppa showed an average daily exposure rate for PM that was up to approximately twice that of the Dallas County as recorded by the EPA PM monitor north of Downtown Dallas.

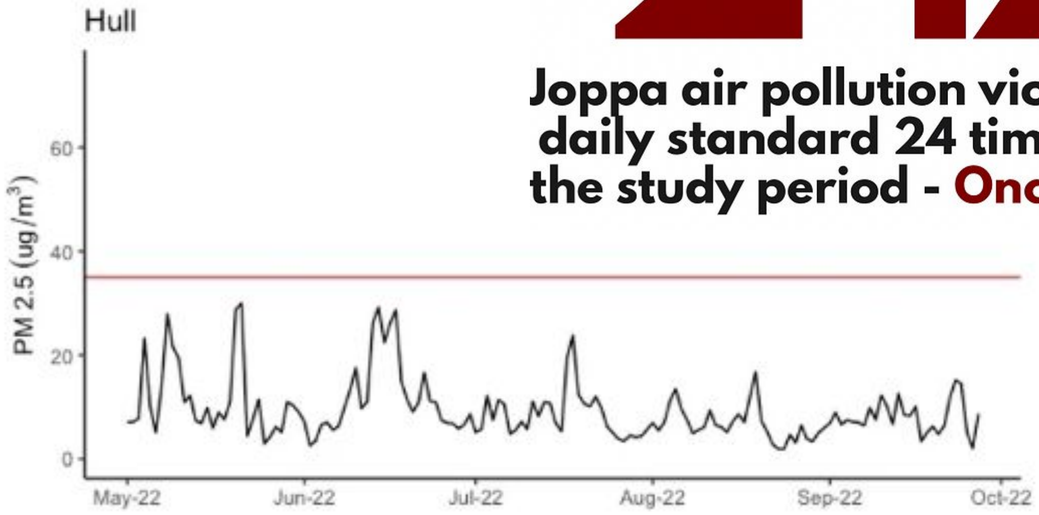
Los datos de las tres ubicaciones de monitores de SharedAirDFW.com en Joppa mostraron una tasa de exposición diaria promedio a PM que fue hasta aproximadamente el doble que el promedio del condado de Dallas, según lo registrado por el monitor de PM de la EPA al norte del centro de Dallas.

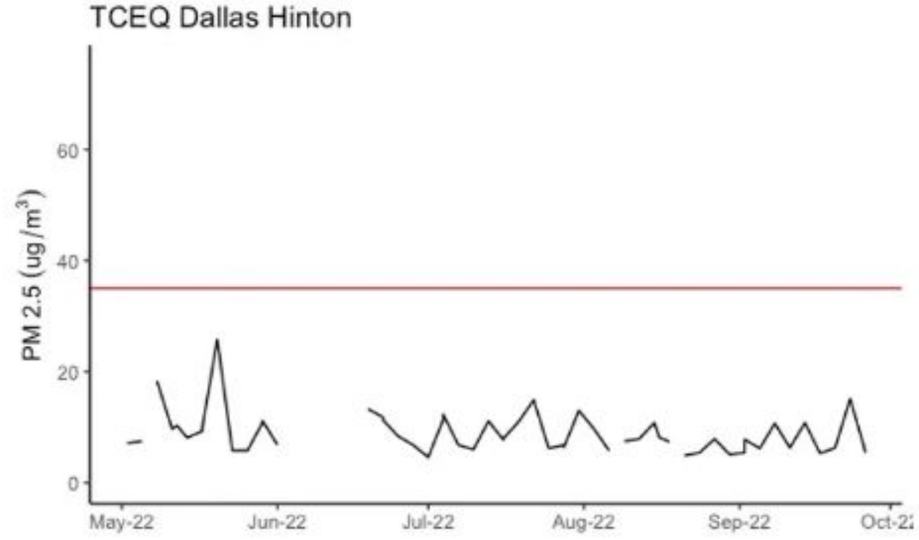


Air Monitor Results





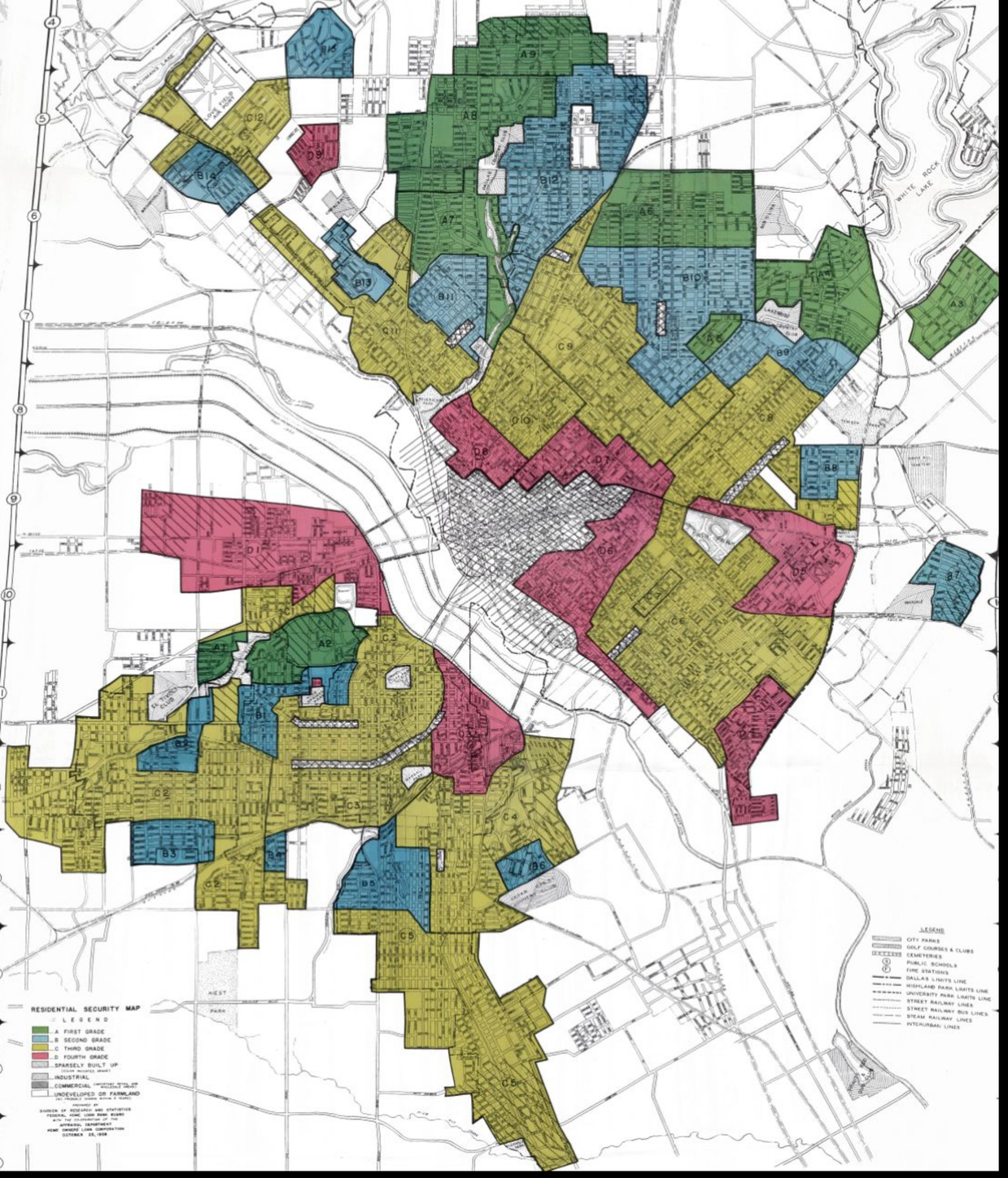


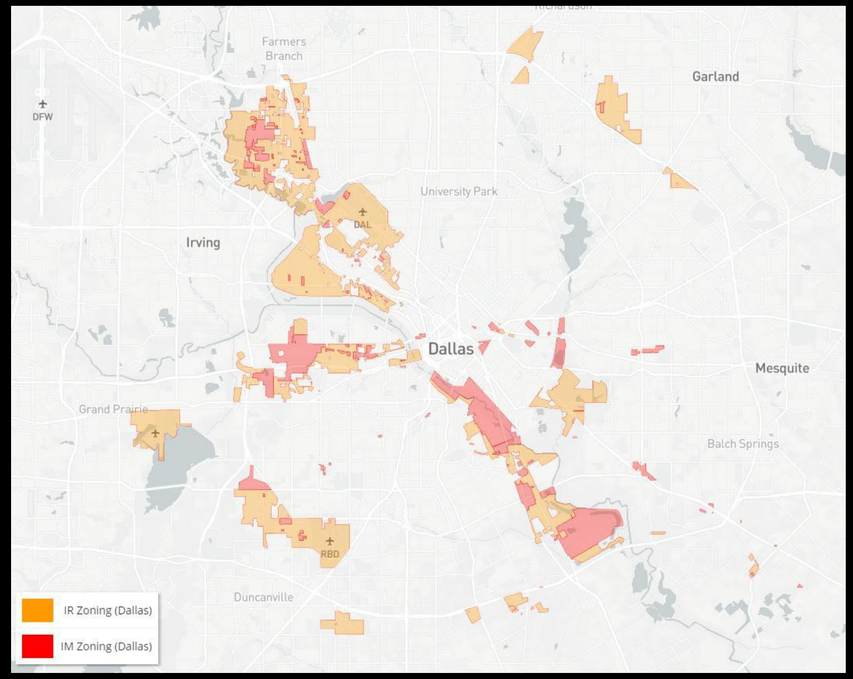


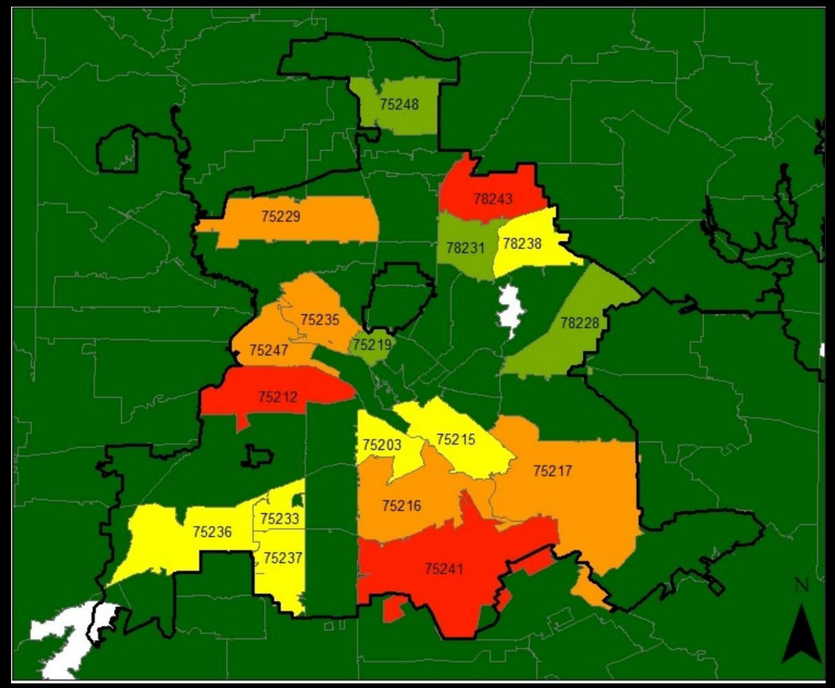
24X

Joppa air pollution violated EPA daily standard 24 times during the study period - Once a week.

Rolling Back Racist Zoning


RESIDENTIAL SECURITY MAP
LEGEND
A FIRST GRADE
B SECOND GRADE
C THIRD GRADE
D FOURTH GRADE
SPARSELY BUILT UP
INDUSTRIAL
COMMERCIAL
UNDEVELOPED OR FARMLAND
LEGEND
CITY PARKS
GOLF COURSES & CLUBS
CEMETERIES
PUBLIC SCHOOLS
FIRE STATIONS
DALLAS LIMITS LINE
HIGHLAND PARK LIMITS LINE
UNIVERSITY PARK LIMITS LINE
STREET RAILWAY LINES
STREET RAILWAY BUS LINES
STEAM RAILWAY LINES
INTERURBAN LINES
WHITE ROCK LAKE


Farmers Branch
Garland
DFW
University Park
DAL
Irving
Dallas
Mesquite
Grand Prairie
Balch Springs
RBD
Duncanville
IR Zoning (Dallas)
IM Zoning (Dallas)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NEIGHBORHOOD SELF—DEFENSE PROJECT

“Shingle Mountain”

ons

The Washington Post
Democracy Dies in Darkness

More Top Stories

Marsha Jackson, in her backyard in Dallas, is dwarfed by Shingle Mountain, an illegal toxic waste dump. (Allison V. Smith for The Post)

Race & Reckoning

Shingle Mountain: How a pile of toxic waste was dumped in a community of color

The manmade mountain of discarded roofing shingles stretches more than a city block in Dallas, where White leaders paved the way for the illegal toxic dump to rise up in a minority community.

By Darryl Fears

The Philadelphia Tribune

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'Shingle Mountain' casts towering threat over minority area in Dallas

Mollie Belt Oct 12, 2020 0

Marsha Jackson, founder of Southern Sector Rising, filed a lawsuit in July to prod action on removing the “Shingle Mountain” debris site in a predominately minority neighborhood in Dallas. — Photo from the Dallas Peace and Justice Center

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2020 Philadelphia's Most Influential African Americans


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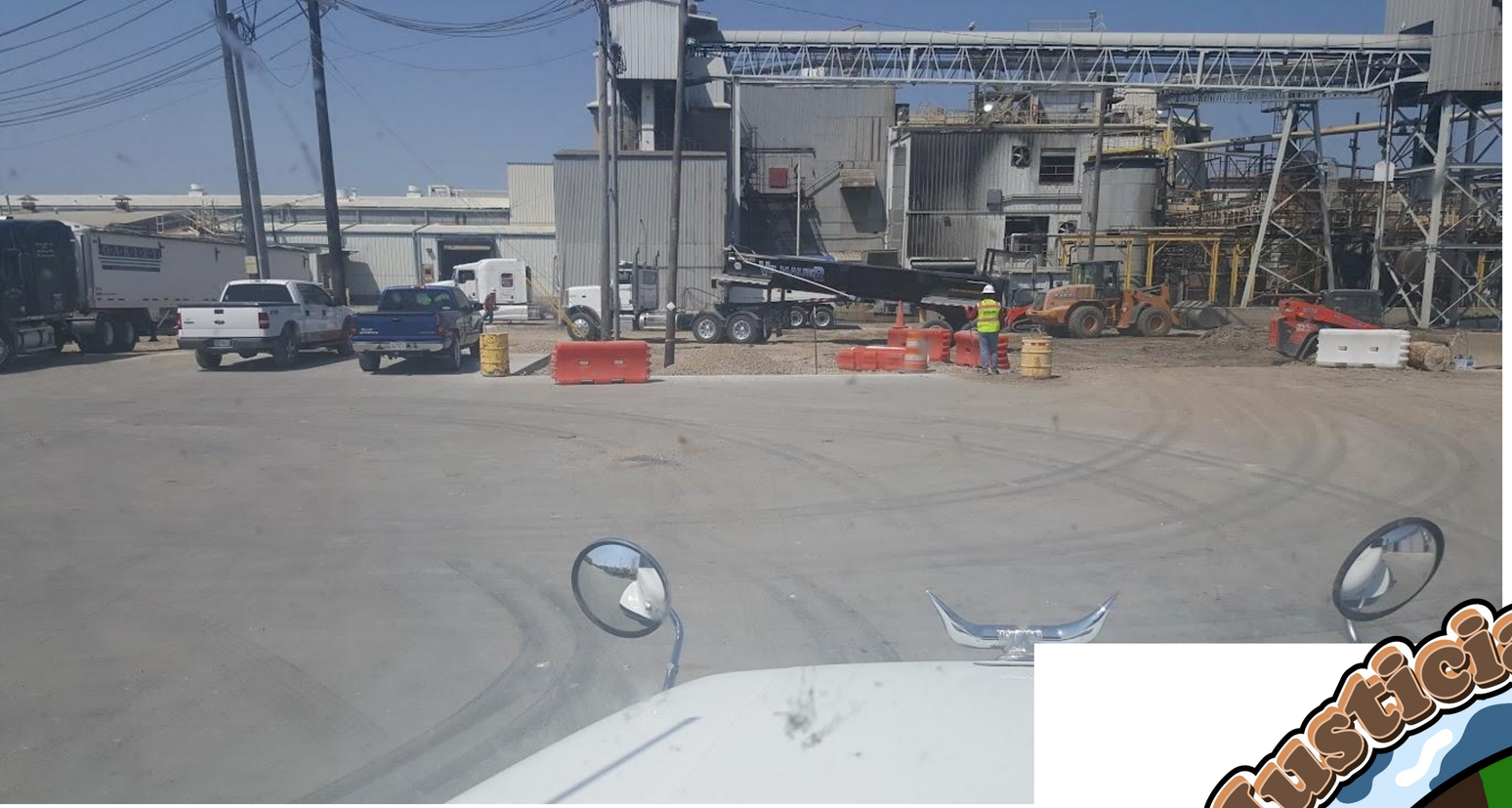
Ya
SINGLETON UNITED
GAFs
GOTTA GO
SMELL SOMETHING? CALL 311
www.GAFsGottaGo.com


Bedford
STOP



Tamko and Deindustrializing Joppa

Justicia Para Joppa

Justice For Joppa

Neighborhood Plan

RIBBON OF PLAY
CINTA DE JUEGO
(OPTION 3) (OPCION 3)

HKS

PARK FOR FLORAL FARMS

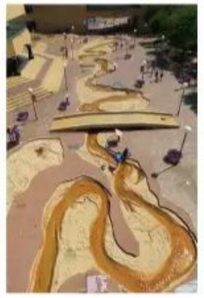
AUGUST 1, 2021 COMMUNITY ENGAGEMENT
21 DE AGOSTO DE 2021 COMPROMISO CON LA COMUNIDAD

KEY OF SITE ELEMENTS
ELEMENTOS DEL SITIO

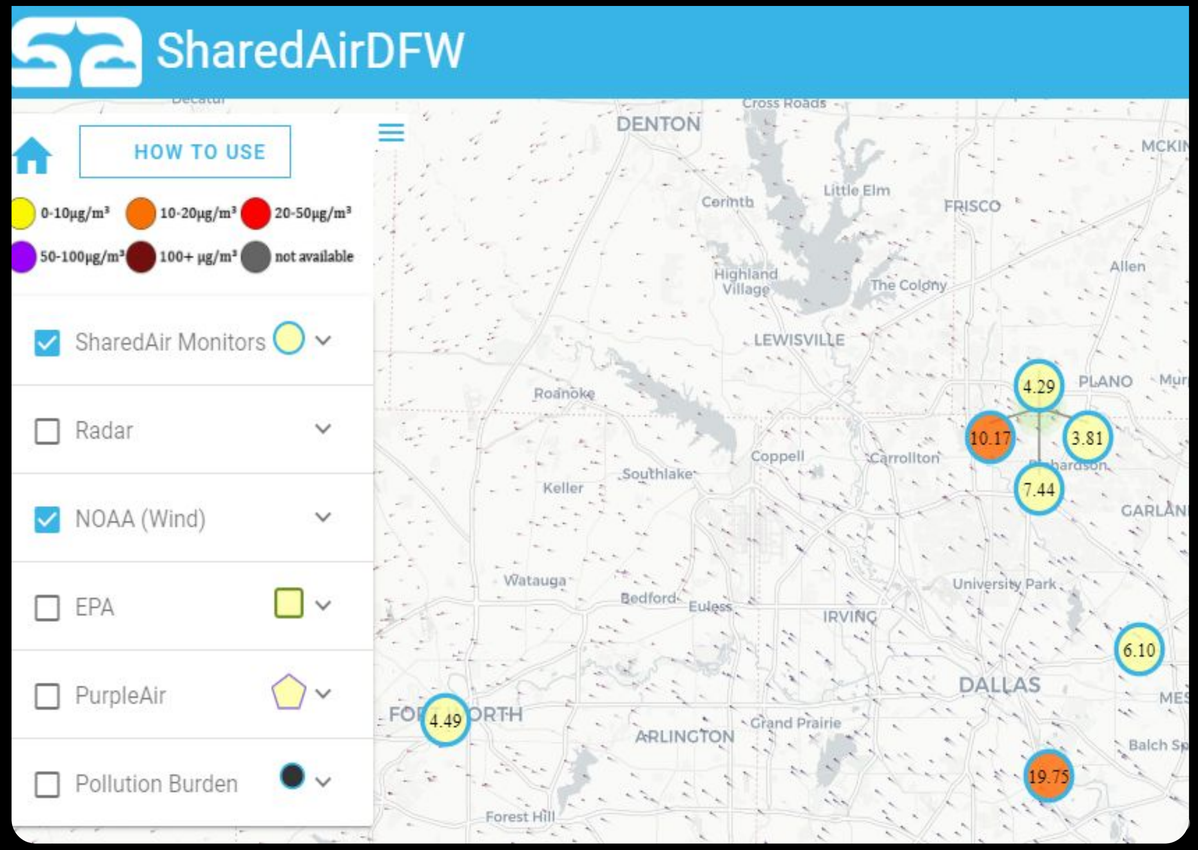
1. PHASE 1 ENTRANCE (ENTRADA FASE 1)
2. SPLASH PAD (ALMOHADILLA PARA SALPICADURAS))
3. TODDLER PLAY (JUEGO DE NIÑOS)
4. CHILDREN PLAY (LOS NIÑOS JUEGAN)
5. SOCCER FIELD (CAMPO DE FÚTBOL)
6. COMMUNITY GARDEN (JARDÍN COMUNITARIO)
7. RESTROOMS (BAÑOS)
8. AMPHITHEATER (ANFITEATRO)
9. REC CENTER (CENTRO DE RECREACIÓN)
10. HILL PLAY ((JUEGO DE COLINA)
11. RIBBON + PATH (CINTA + CAMINO)
12. FLORAL DISPLAY (EXHIBICIÓN FLORA)
13. BASKETBALL COURT (CANCHA DE BALONCESTO)
14. GATHERING SPACE (ESPACIO DE REUNIÓN)
15. TIER SEATING (ASIENTOS DE NIVEL)
16. BRIDGE (PUENTE)
17. PHASE 2 ENTRANCE (ENTRADA FASE 2)

Main Entry (Entrada Principal)

Hill Play (Juego de la Colina)



SharedAirDFW and EJCPS Grant



What Makes this Special

- SharedAirDFW is the only real time, second by second, hyperlocal air monitoring system in DFW
    - This is critical because neighborhood pollution can change block by block
- SharedAir is engineered by UTD's MINTS Team and used by groups like Texas A&M to complete health projects
- The EJCPS grant will expand the SharedAir system into new communities and upgrade current monitors hardware

West Dallas Environmental Health Project Proyecto de Salud Ambiental de West Dallas

Project Timeline

Q1 JAN—FEB

Connecting w/ Partners

Staff will touch base with each community partner listed in the EJCPS grant. We will verify that each group understands the grant and is willing to participate

Q1MAR—Q2APR

Create SharedAir Network

Work with each community partner to set a plan to hold a SharedAir Network meeting.

Q2 MAY—JUNE

Placing new monitors

Begin placing monitors based on need and a democratic process created from the Network meeting

Rest of the Year

Research Planning

Follow the calendar created in the EJCPS work plan and use network meetings to strategize on how to improve and expand the network

Meet the Team

Dr. Lary

UT-Dallas

Lakitha Wijeratne

UT-Dallas

Dr. Natalie Johnson

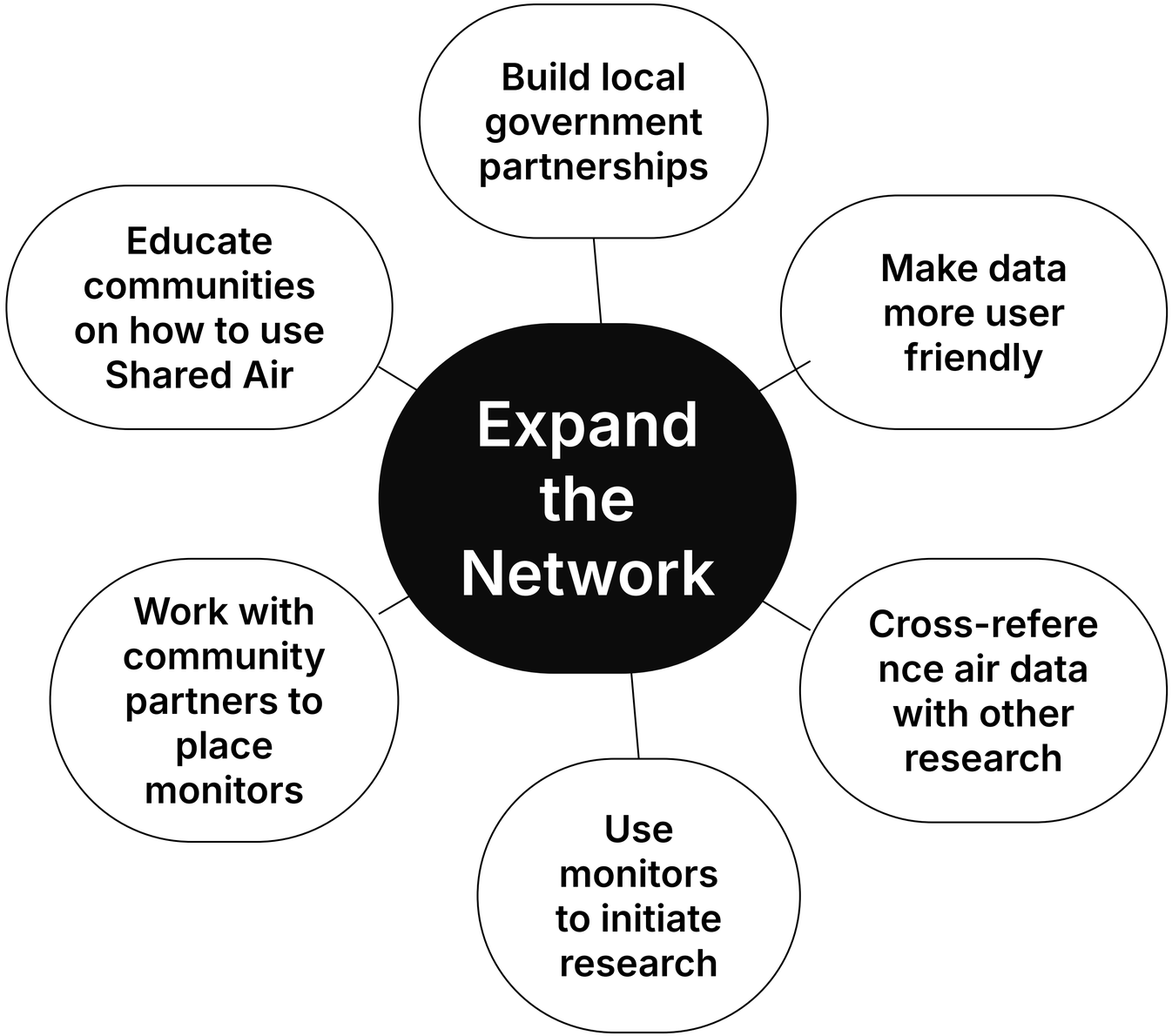
Texas A&M

Dr. Ping Ma

Texas A&M

Growth Strategy

SharedAirDFW is the most practical way for Downwinders to grow. If we can expand the network, we can connect more real time data to impacted communities

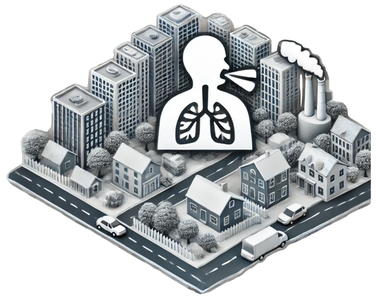


Downwinders at risk

Environmental Justice Cleaner Air Grassroots Power

MINTS-AI: Human Health and Sensing in Service of Society

Prof. David. J. Lary



Hyperlocal AQ
Health Outcomes

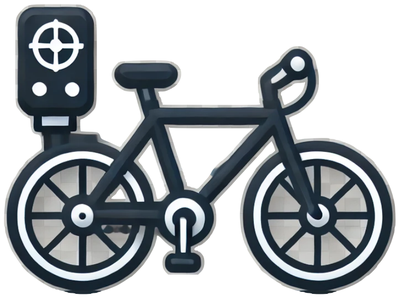
Hyperlocal AQ
Microenvironments

Humans as Sensors
for AQ with ML

Static AQ Monitors
Calibrated with ML

Remote Sensing
& AQ with ML

Mobile AQ Monitors on EVs
Calibrated with ML

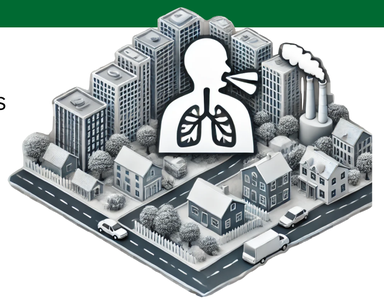


Mobile AQ Monitors on Bikes
Calibrated with ML

Humans as Sensors for AQ with ML

Exposome

Hyperlocal AQ Health Outcomes



Exposomics

Our environment — from the air we breathe, food we eat, and water we drink to the chemicals we ingest and stress we experience — influences health. Scientists strive to measure the exposome, which is the totality of these exposures and the body's response to them. The study of the exposome, called exposomics, will allow scientists to discover how exposure mixtures drive health and disease, so people can take steps to modify their individual exposures and improve their health.

Physical Environment

Air pollution, pesticides, water and soil contaminants, chemical exposures at home and work, as well as the surrounding natural environment.

Social Environment and Lifestyle

Diet, exercise, sleep habits, stress, smoking, and alcohol and drug use, along with socioeconomic conditions, are also examples of environmental exposures.

The Body's Response

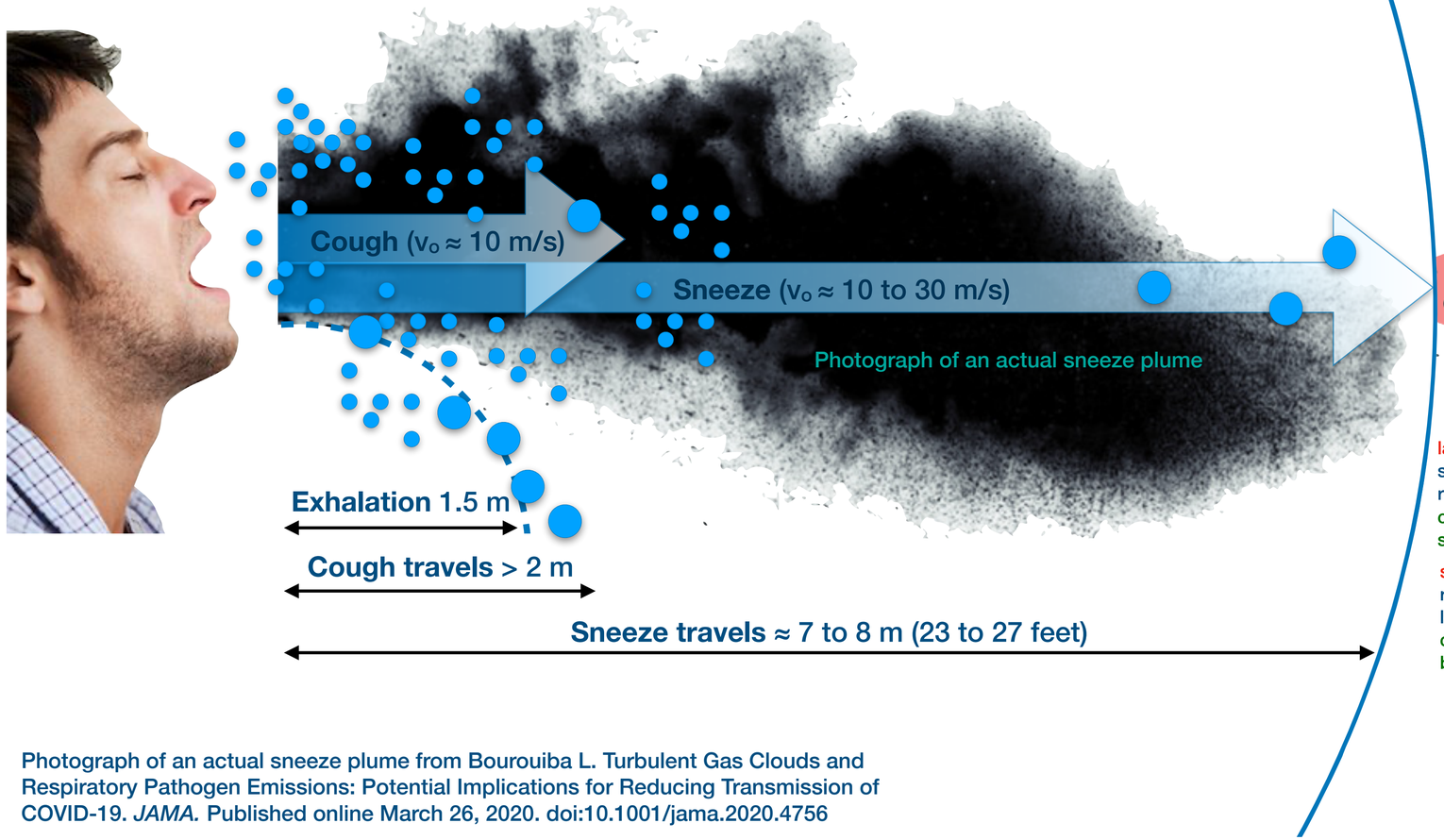
Some environmental exposures may cause biological changes that affect health. For example, these changes can affect DNA, protein levels, signaling pathways, and metabolism. However, a person's unique genetic makeup and environment influence how the body responds.

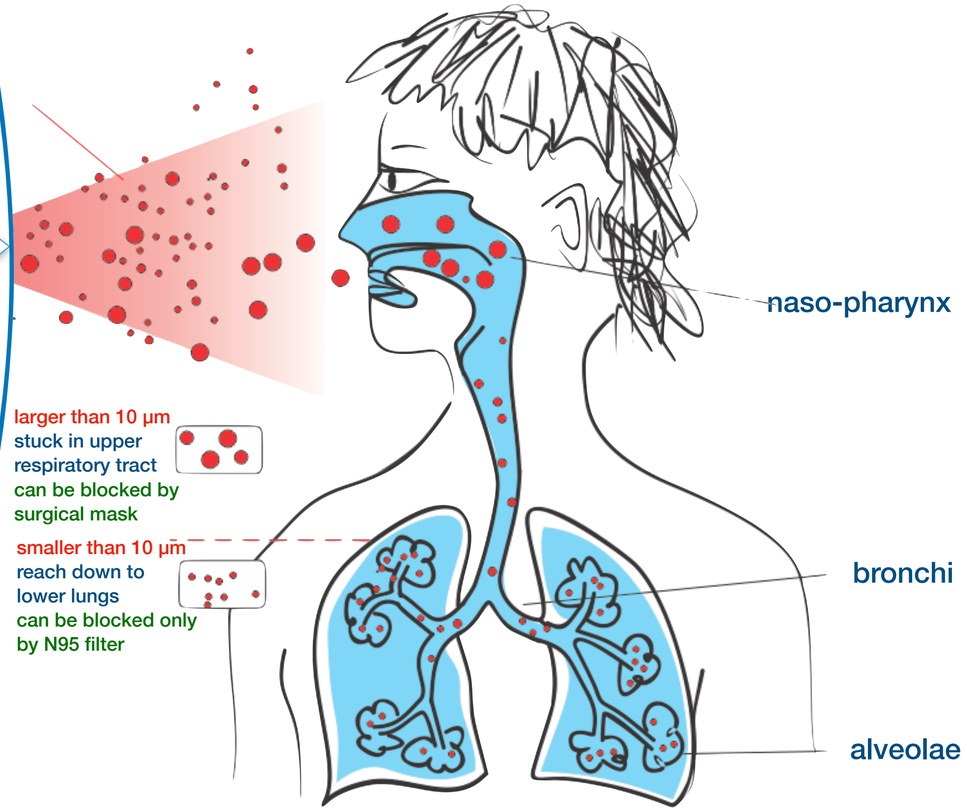
Hyperlocal AQ Microenvironments

The Ultra-Fine Size Fraction Penetrates Deeply into the Lungs and is Seldom Monitored

aerosols (< 10 μm)
will reach the lower lungs
blocked effectively only by N95 filter

large spray droplets (> 0.1 mm or 100 μm)
will get lodged in upper respiratory tract
can be blocked by surgical mask





Photograph of an actual sneeze plume from Bourouiba L. Turbulent Gas Clouds and Respiratory Pathogen Emissions: Potential Implications for Reducing Transmission of COVID-19. *JAMA.* Published online March 26, 2020. doi:10.1001/jama.2020.4756

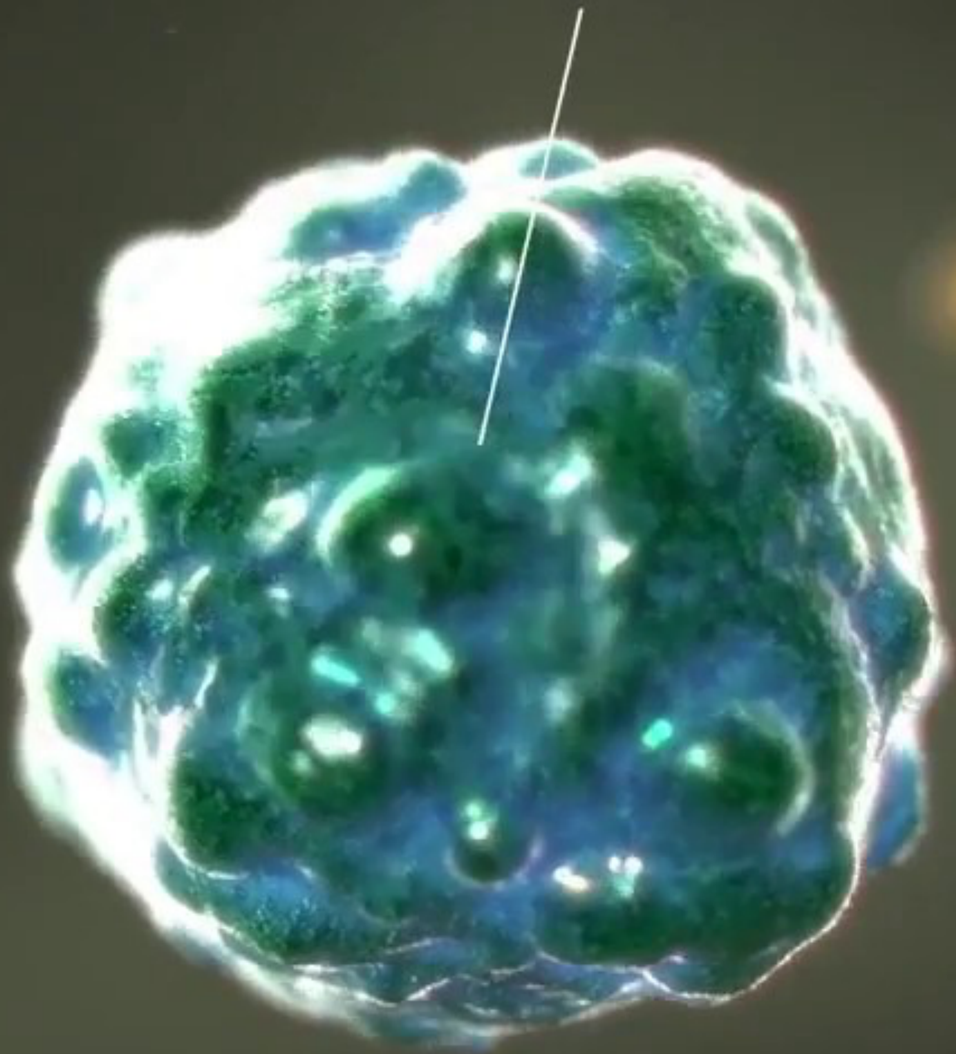
Size Matters

Fine and ultrafine particulate matter tends to circumvent the mechanisms that the body has to deflect, detain, and destroy unwelcome visitors.

Harmful ultrafine
0.1 micron particles

Ultrafine particles are like little Trojan horses, pretty much every metal known to humans can be found on them.

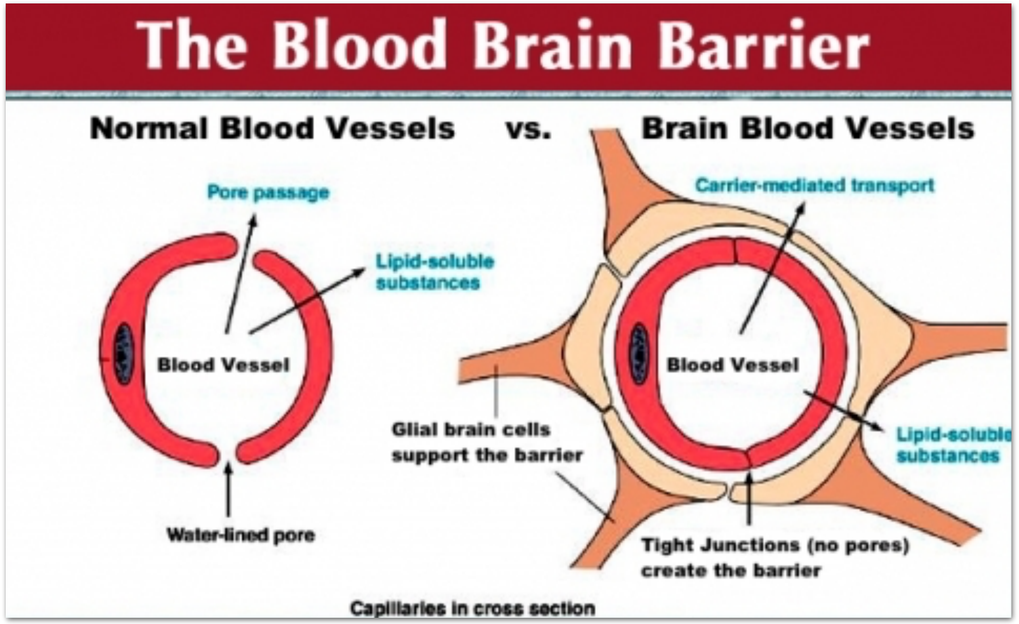
Airborne
pollutants

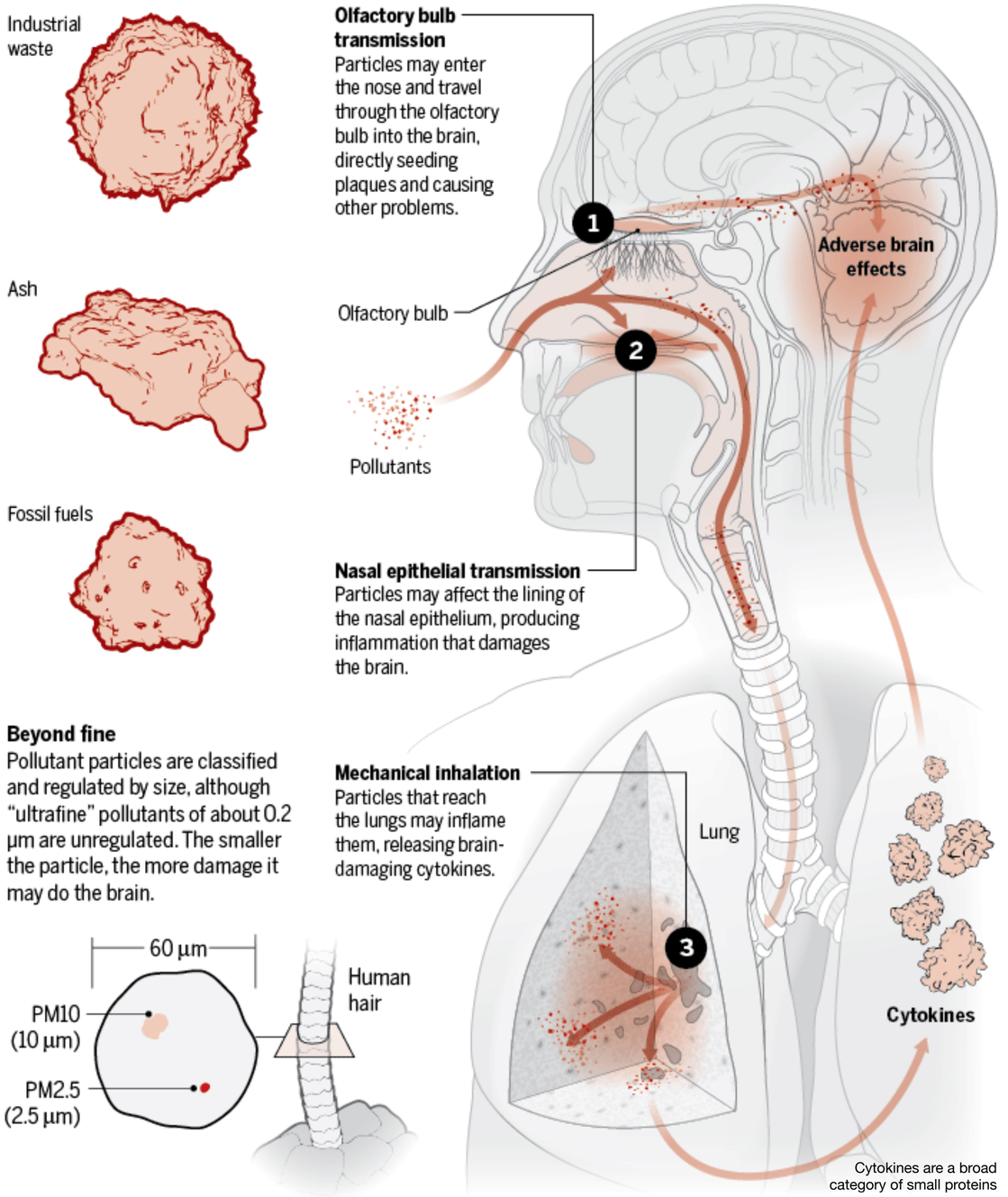


Studies suggest that the tiny pollutant particles can go up the nose and be **carried straight to the brain via the olfactory nerve**— bypassing the blood–brain barrier.

The **particles don't travel alone**. On their surfaces these particles carry contaminants, from dioxins and other chemical compounds to metals such as iron and lead.

Particulate Matter acts as a vector, transporting any number of chemicals into the brain, chemicals that may act in different ways to cause damage.



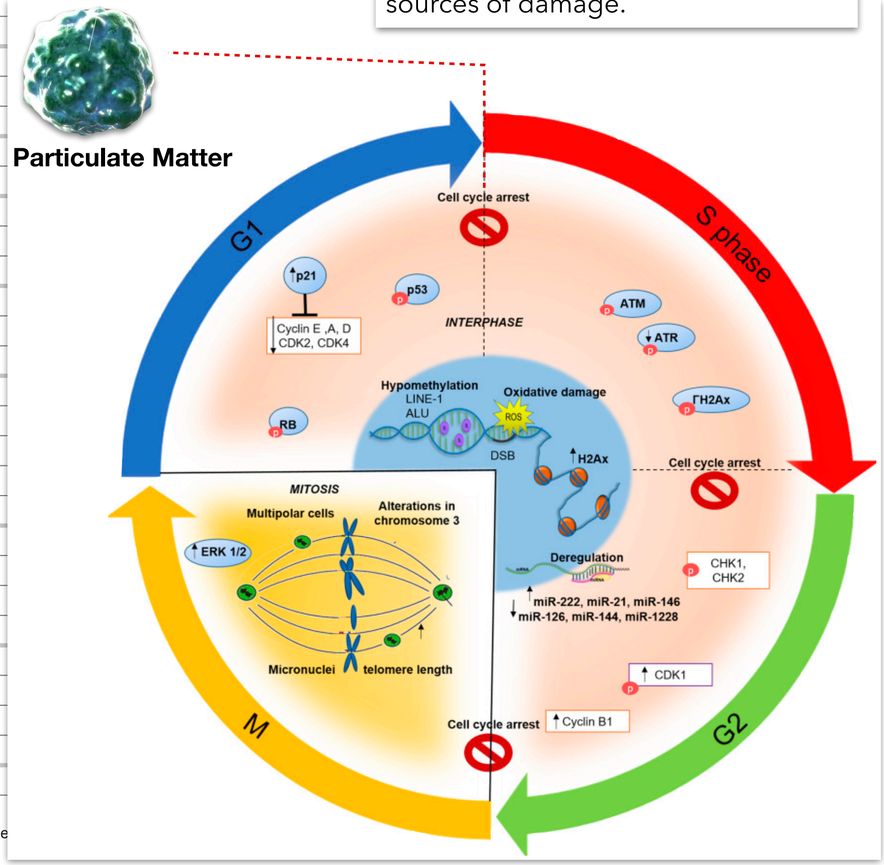


Human Health Impacts

HEALTH OUTCOMES	SHORT-TERM STUDIES			LONG-TERM STUDIES		
	PM_{10}	$PM_{2.5}$	UFP	PM_{10}	$PM_{2.5}$	UFP
Mortality						
All causes	XXX	XXX	X	XX	XX	X
Cardiovascular	XXX	XXX	X	XX	XX	X
Pulmonary	XXX	XXX	X	XX	XX	X
Pulmonary effects						
Lung function, eg, PEF	XXX	XXX	XX	XXX	XXX	
Lung function growth				XXX	XXX	
Asthma and COPD exacerbation						
Acute respiratory symptoms		XX	X	XXX	XXX	
Medication use			X			
Hospital admission	XX	XXX	X			
Lung cancer						
Cohort						
Hospital admission						
Cardiovascular effects						
Hospital admission	XXX	XXX				
ECG-related endpoints						
Autonomic nervous system	XXX	XXX	XX			
Myocardial substrate and vulnerability		XX	X			
Vascular function						
Blood pressure	XX	XXX	X			
Endothelial function	X	XX	X			
Blood markers						
Pro-inflammatory mediators	XX	XX	XX			
Coagulation blood markers	XX	XX	XX			
Diabetes	X	XX	X			
Endothelial function	X	X	XX			
Reproduction						
Premature birth	X	X				
Birth weight	XX	X				
IUR/SGA	X	X				
Fetal growth						
Birth defects	X					
Infant mortality	XX	X				
Sperm quality	X	X				
Neurotoxic effects						
Central nervous system		X	XX			

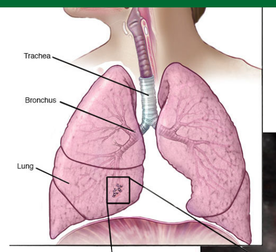
Notes: X, few studies. XX, many studies. XXX, large number of studies.
Abbreviations: UFP, ultrafine particle; PEF, peak expiratory flow; COPD, chronic obstructive pulmonary disease for gestational age.

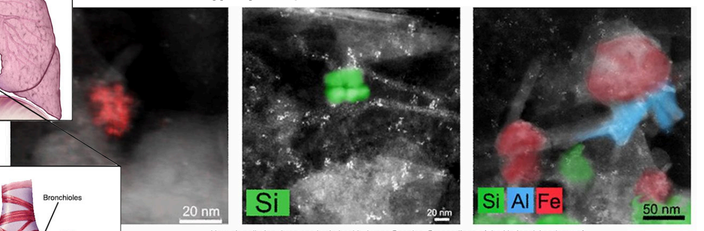
The epidemiological and toxicological evidence suggest that particulate matter acts as a carcinogenic factor in humans, causing **high rates of genomic alterations**. Particulate matter is capable of inducing genomic instability during the carcinogenic process and our genetic background influences the response to the sources of damage.



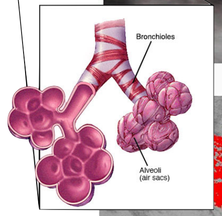
Particles May Enter the Brain via the Bloodstream

Small particles can slip through the plasma membrane of alveoli—the tiny air sacs in the lungs—and get picked up by capillaries. The particles are then distributed around the body in the blood. Although some of these particles may eventually **breach the blood–brain barrier**, but a pollutant need not enter the brain to cause trouble there. The immune system can react to particles in the lung or bloodstream, too, triggering **widespread inflammation** that affects the brain.

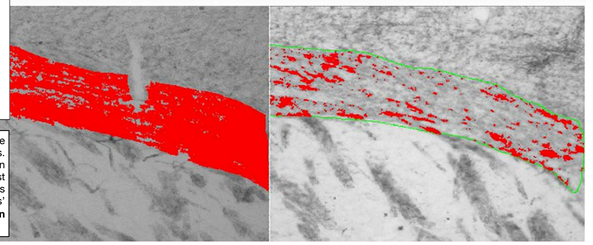




How air pollution threatens brain health, Lynne Peeples, Proceedings of the National Academy of Sciences Jun 2020, 117 (25) 13856-13860; DOI: 10.1073/pnas.2008940117



Cory-Slechta received a surprising request from some University of Rochester environmental medicine colleagues. Typically, the group researched the effects of air pollution on the lungs and hearts of adult animals. But they had just exposed a group of newborn mice and asked Cory-Slechta's team to look at the brains. When she examined the animals' tissue. "It was eye-opening. **I couldn't find a brain region that didn't have some kind of inflammation."**

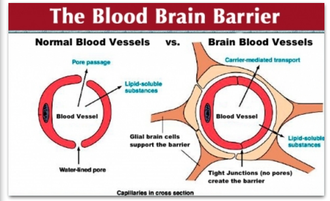


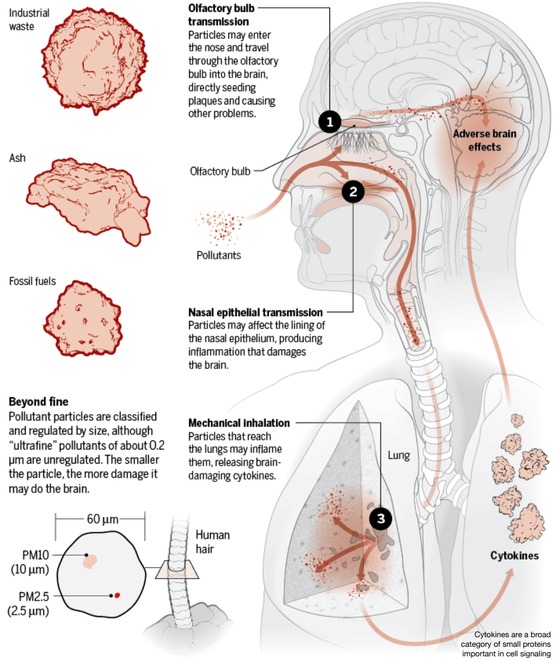
After 14 days of exposure to pollutants during the gestational period, researchers found deposits of trace elements silica (Si), iron (Fe), and aluminum (Al) in rat brains (*Top Right*). They also found a loss of myelin—the insulating sheath around nerve fibers—in the corpus callosum of male rat brains (*Bottom Right*). Image credit: Uschi M. Graham (University of Kentucky, Lexington, KY) (*Top*) and Deborah Cory-Slechta (*Bottom*).

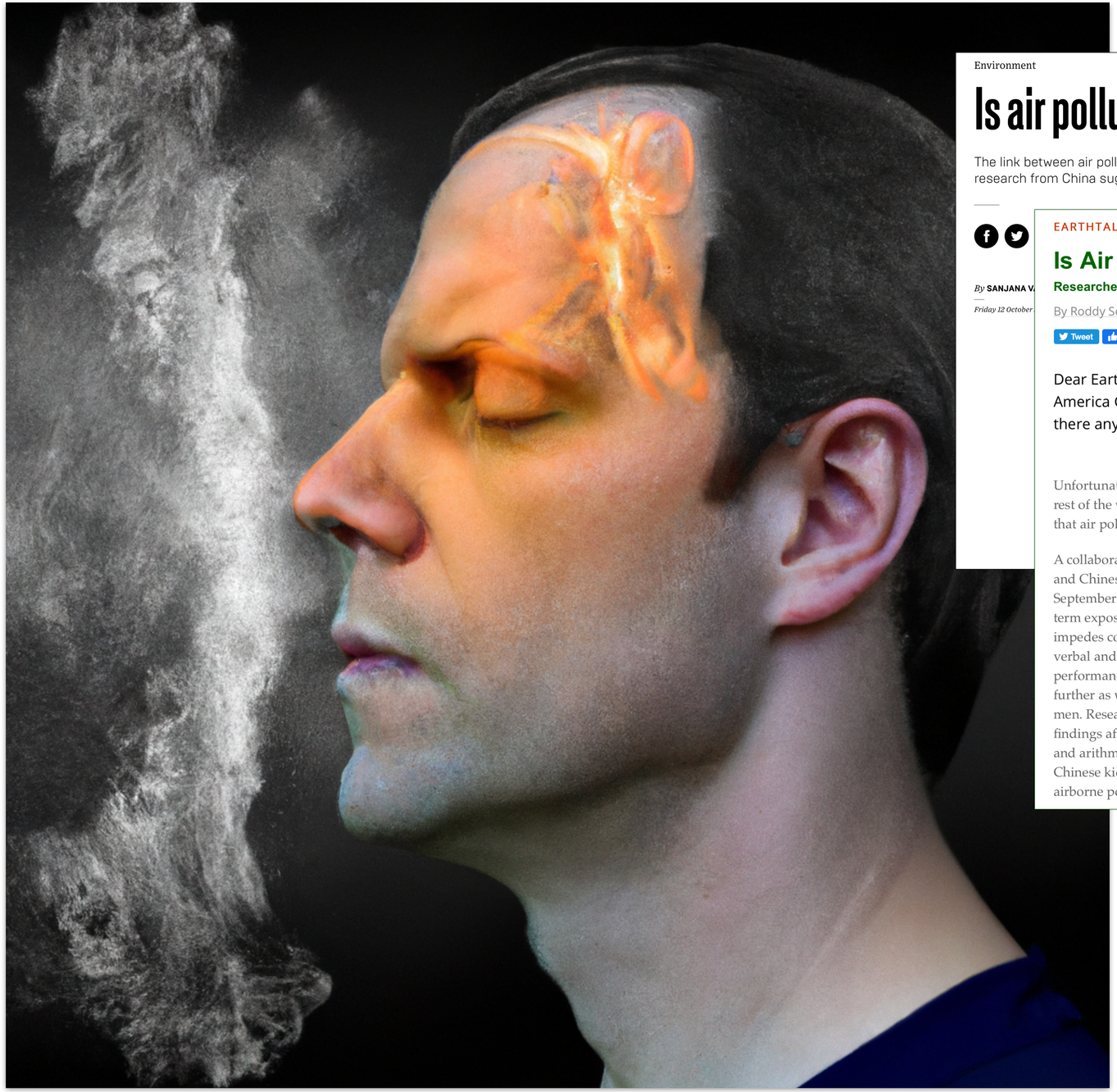
Studies suggest that the tiny pollutant particles can go up the nose and be **carried straight to the brain via the olfactory nerve**—bypassing the blood–brain barrier.

The **particles don't travel alone**. On their surfaces these particles carry contaminants, from dioxins and other chemical compounds to metals such as iron and lead.

Particulate Matter acts as a vector, transporting any number of chemicals into the brain, chemicals that may act in different ways to cause damage.







Environment

Is air pollution making you dumb?

The link between air pollution and our general health is well proven. Large-scale research from China suggests that it may be affecting our brains too

By SANJANA V.

Friday 12 October

EARTHTALK Q&A

Is Air Pollution Making Us Dumber?

Researchers Uncover Links Between Bad Air Quality And Lower IQ Scores

By Roddy Scheer and Doug Moss February 23, 2019

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Dirty Air Makes You Dumb

Air pollution causes health hazards, but a recent study says it also affects human intelligence.

BusinessToday.In | Print Edition: October 7, 2018

https://www.businesstoday.in/magazine/the-break-out-zone/dirty-air-makes-you-dumb/story/282438.html

PNAS

The impact of exposure to air pollution on cognitive performance

Xin Zhang[a,1], Xi Chen[b,c,1], and Xiaobo Zhang[d,e,2]

[a]School of Statistics, Beijing Normal University, Beijing 100875, China; [b]Department of Health Policy and Management, Yale School of Public Health, New Haven, CT 06520; [c]Department of Economics, Yale University, New Haven, CT 06511; [d]National School of Development, Peking University, Beijing 100871, China; and [e]Division of Development Strategy and Governance, International Food Policy Research Institute, Washington, DC 20005

. Hauser, Center for Demography of Health and Aging, Madison, WI, and approved July 23, 2018 (received for review June 8, 2018)

nes the effect of both cumulative and transitory pollution for the same individuals over time on nance by matching a nationally representative ey and air quality data in China according to nd geographic locations of the cognitive tests. g-term exposure to air pollution impedes cogni- in verbal and math tests. We provide evidence air pollution on verbal tests becomes more pro- le age, especially for men and the less educated. the aging brain by air pollution likely imposes h and economic costs, considering that cognitive ical for the elderly for both running daily errands

nce | China

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Second, we have matched exposure to local environmental stressors with individual cognitive performance according to the exact time of test taking. This is more precise than in previous studies, for instance, that of Ham et al. (8), who match yearly air pollution with average standardized test scores at the school-grade level. Third, most existing studies consider either the effects of transitory or cumulative exposure to air pollution, but rarely both effects simultaneously, except for Marcotte (13). For example, Ham et al. (8) and Ebenstein et al. (10) focus on contemporaneous exposure; Bharadwaj et al. (14), Molina (15), and Sanders (16) examine the effect of cumulative exposure. We are among the first to examine the cognitive impact of cumulative exposure to air pollution while controlling for contemporaneous exposure. By controlling for the latter, we can evaluate the relative importance of transitory and accumulative effects. We find that the accumulative effect dominates.

Given that cognitive ability shapes human behavior and decision making, our result provides supporting evidence on the findings about the negative effect of air pollution on decision making (7, 17), risk attitude (11), and behavior (11, 18). The damage on cognitive ability by air pollution also likely impedes the development of human capital. In fact, a few studies have found that exposure to air pollution lowers educational attainment (10, 16) and results in lower labor productivity (19–22).

Air pollution is a ubiquitous problem in developing countries. According to the global ambient air pollution database compiled

Significance

Most of the population in developing countries live in places with unsafe air. Utilizing variations in transitory and cumulative air pollution exposures for the same individuals over time in China, we provide evidence that polluted air may impede cognitive ability as people become older, especially for less educated men. Cutting annual mean concentration of particulate matter smaller than 10 μm (PM10) in China to the Environmental Protection Agency's standard (50 μg/m^3) would move people from the median to the 63rd percentile (verbal test scores) and the 58th percentile (math test scores), respectively. The damage on the aging brain by air pollution likely imposes substantial health and economic costs, considering that cognitive functioning is critical for the elderly for both running daily errands and making high-stake decisions.

Author contributions: X.C. and Xiaobo Zhang designed research; Xin Zhang, X.C., and Xiaobo Zhang performed research; Xin Zhang analyzed data; and Xin Zhang, X.C., and Xiaobo Zhang wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

[1]Xin Zhang and X.C. contributed equally to this work.

[2]To whom correspondence should be addressed. Email: x.zhang@nsd.pku.edu.cn.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1809474115/-/DCSupplemental.

Published online August 27, 2018.

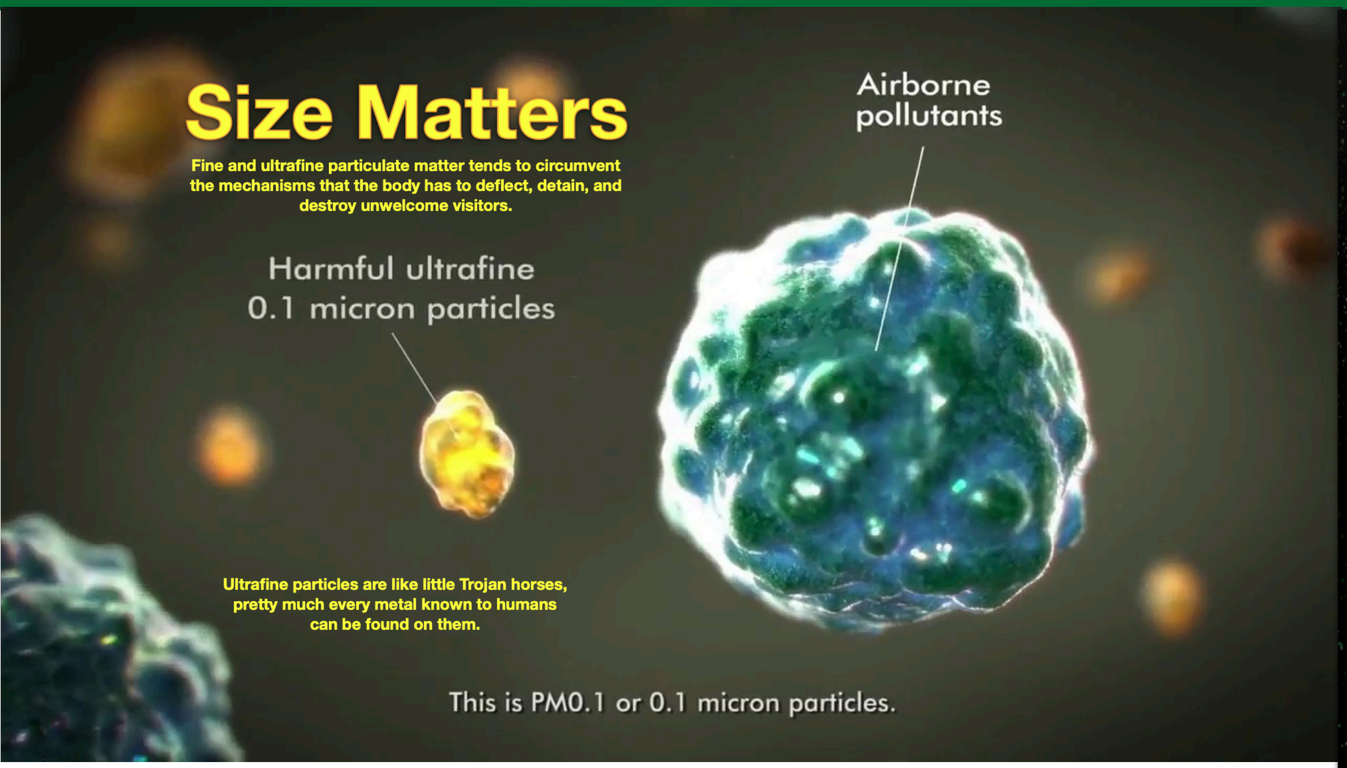
PSYCHOLOGICAL AND COGNITIVE SCIENCES

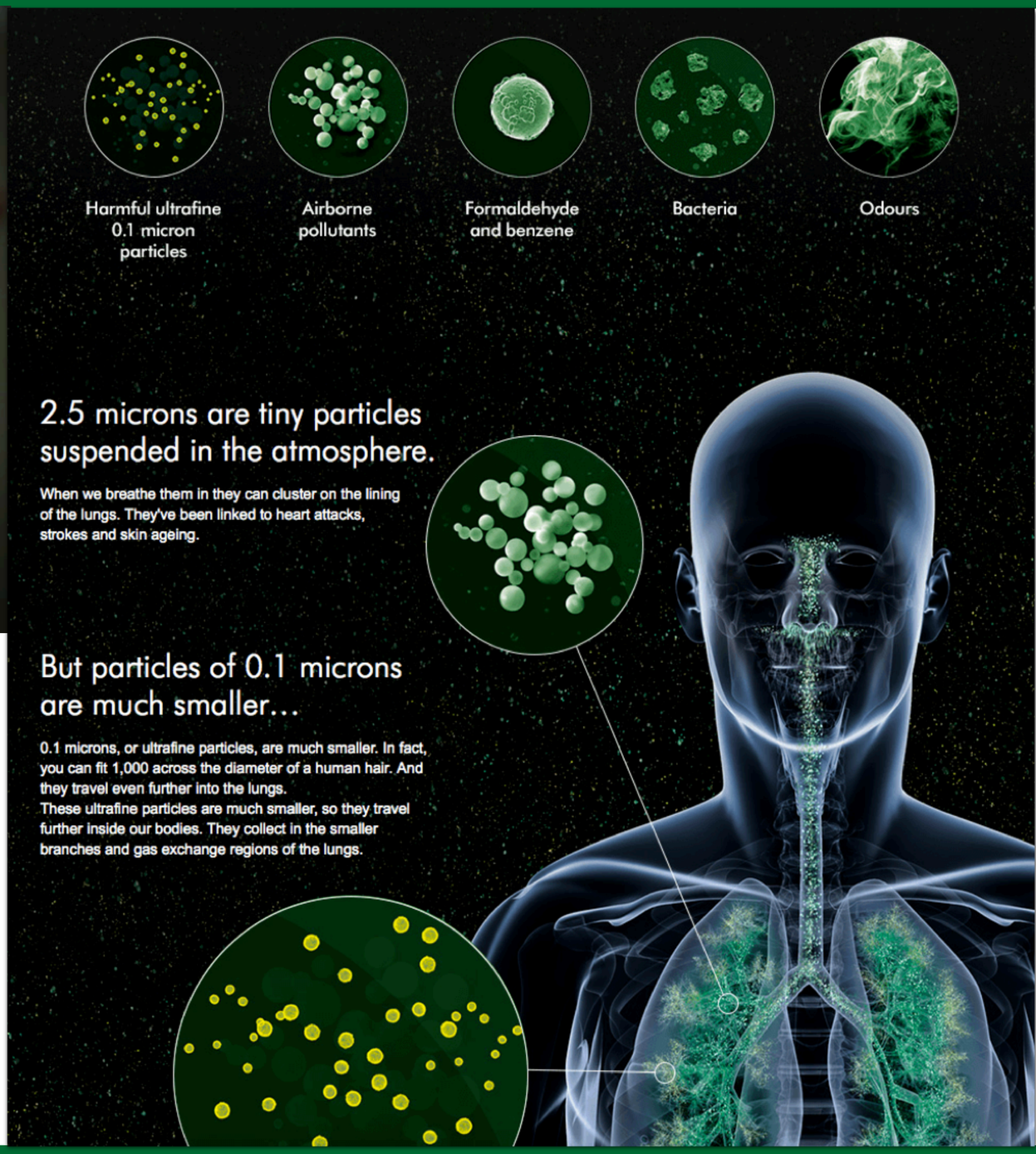
SUSTAINABILITY SCIENCE

Cognitive Performance Impacts

DALL·E generated image

a brain scan of a man inhaling polluted air visibly entering his nostrils which can be seen reaching his brain degrading his cognitive performance, photorealistic



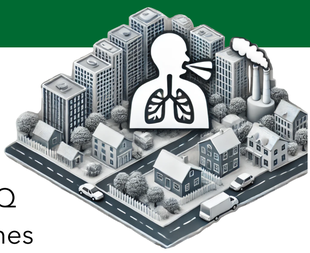


Fine and ultrafine particulate matter tends to circumvent the mechanisms that the human body has to deflect, detain, and destroy unwelcome visitors.

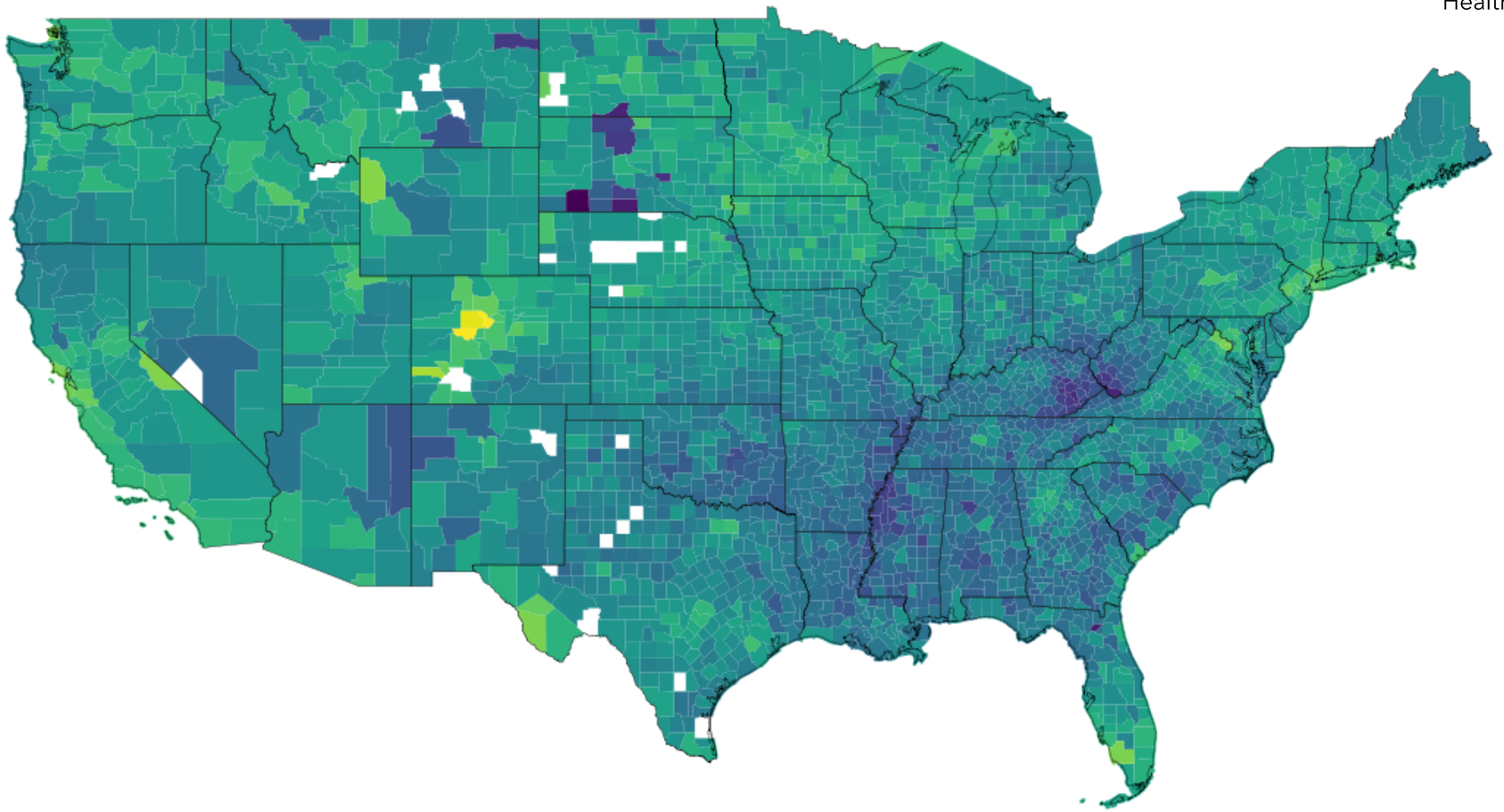
The health effects of air pollution are strongly influenced by particle size.

Humans as Sensors
for AQ with ML

Life Expectancy (2019)



Hyperlocal AQ
Health Outcomes



Humans as Sensors
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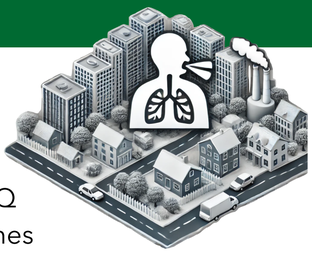
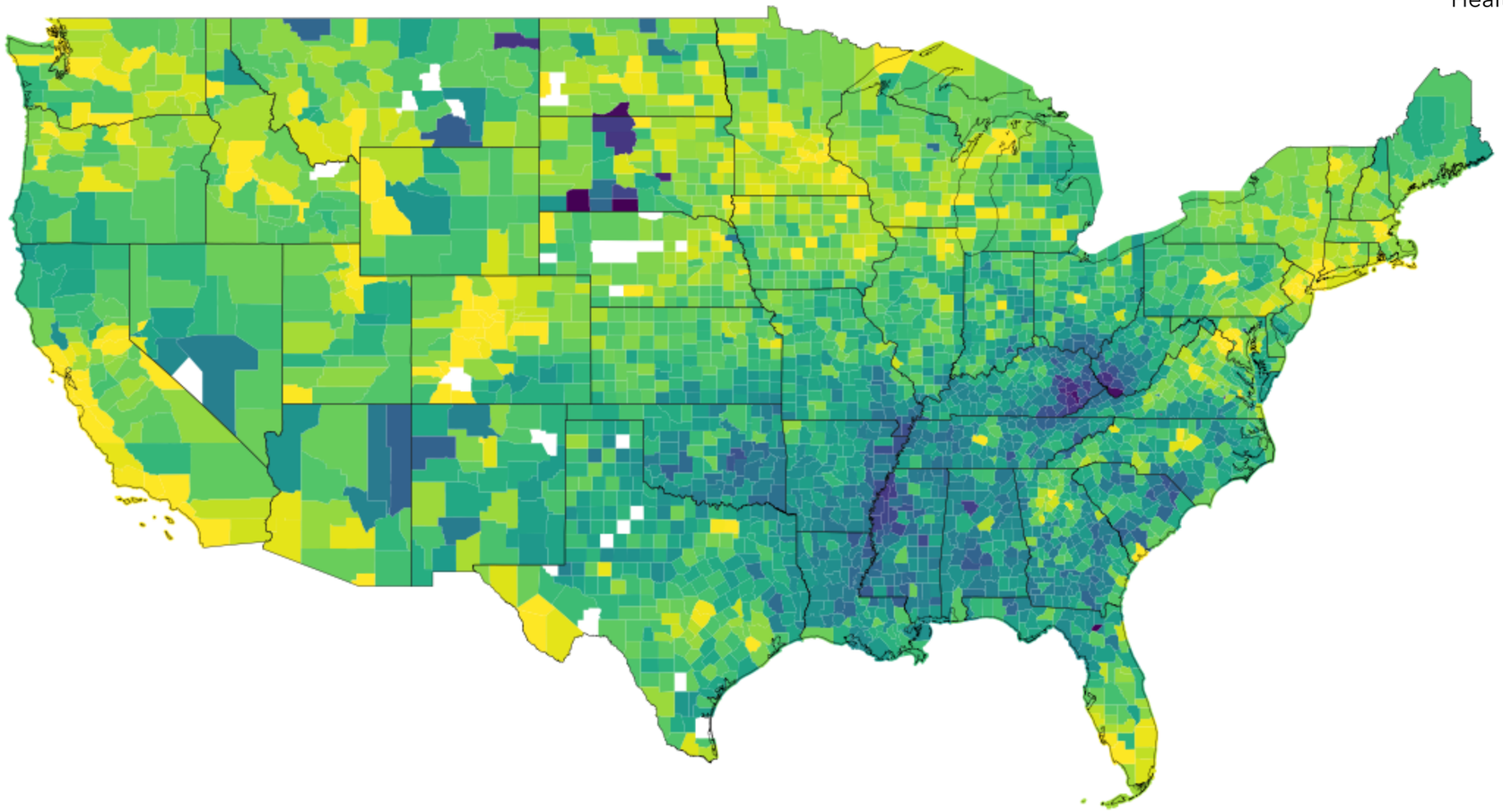
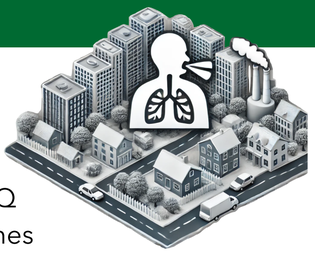


Hyperlocal AQ
Health Outcomes

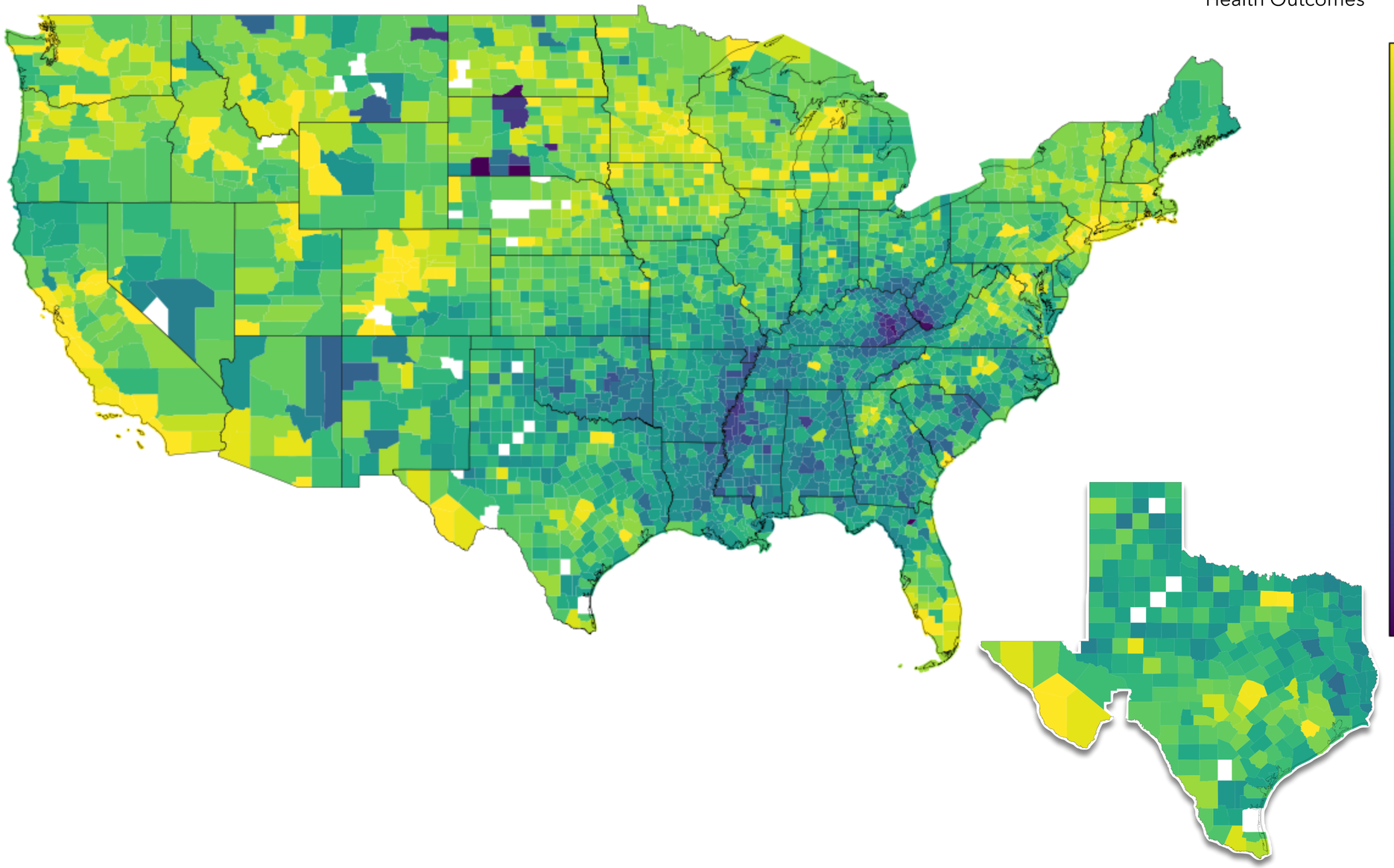


Humans as Sensors
for AQ with ML

Life Expectancy (2019)

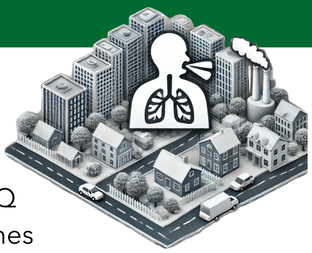


Hyperlocal AQ
Health Outcomes

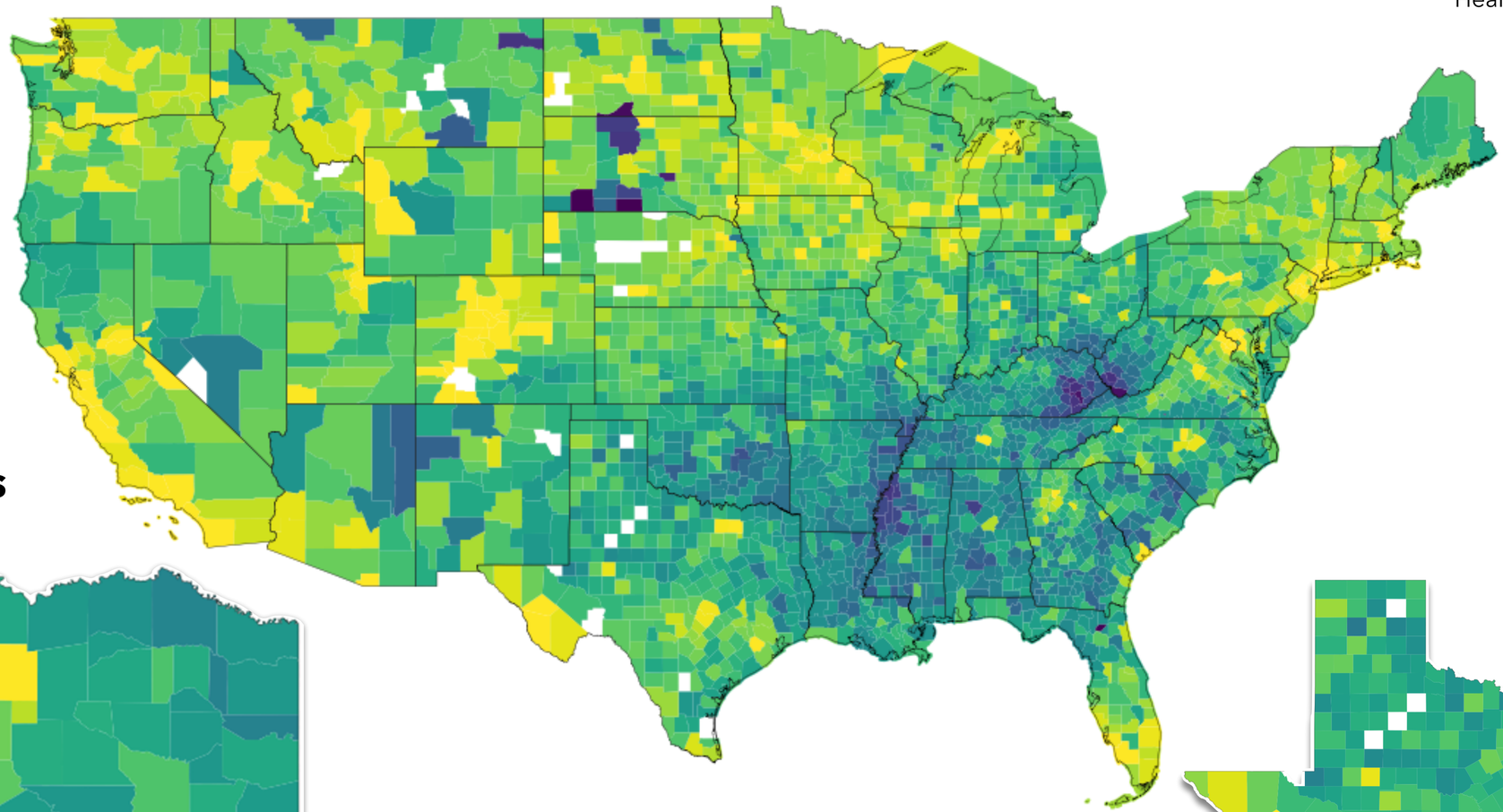


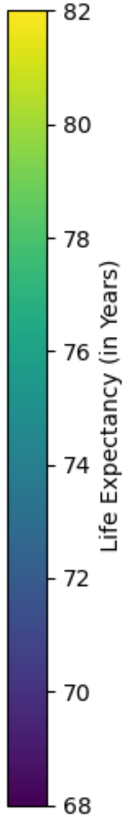
Humans as Sensors
for AQ with ML

Life Expectancy (2019)

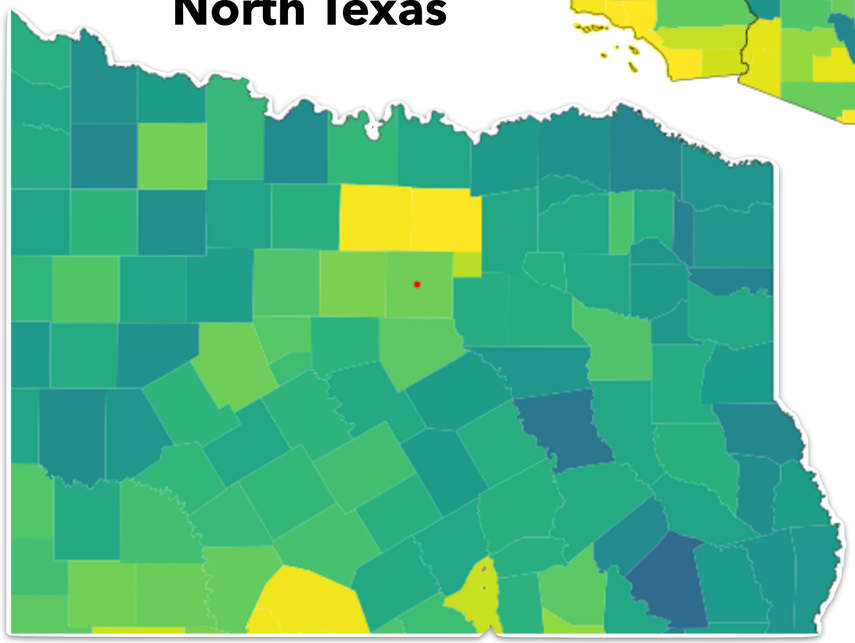


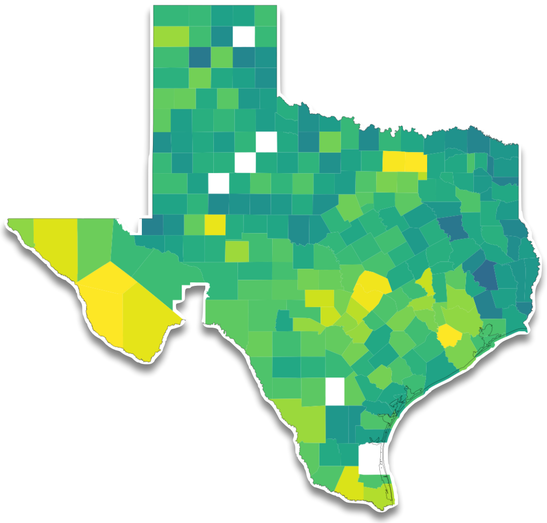
Hyperlocal AQ
Health Outcomes





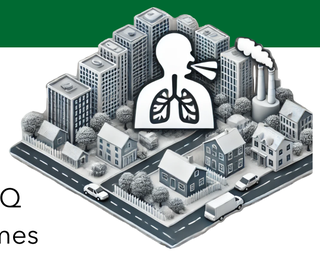
North Texas



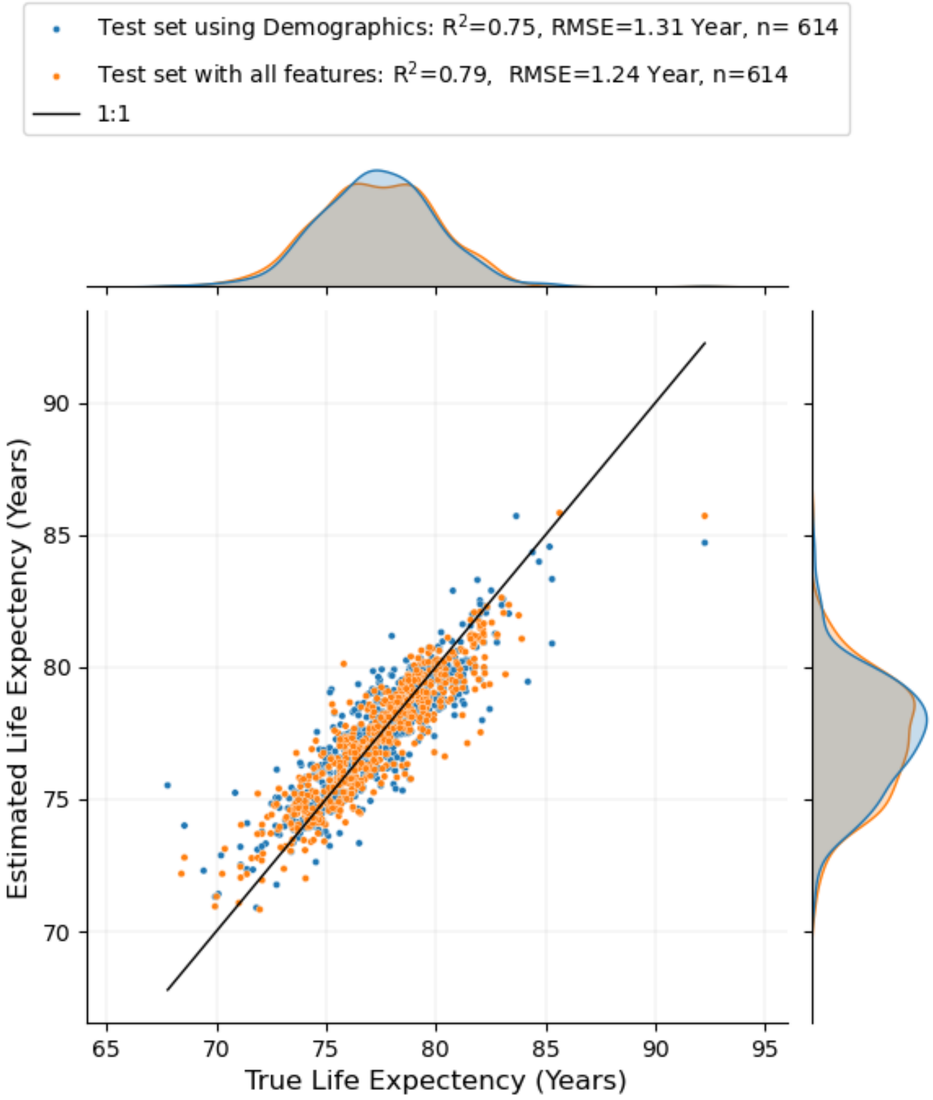


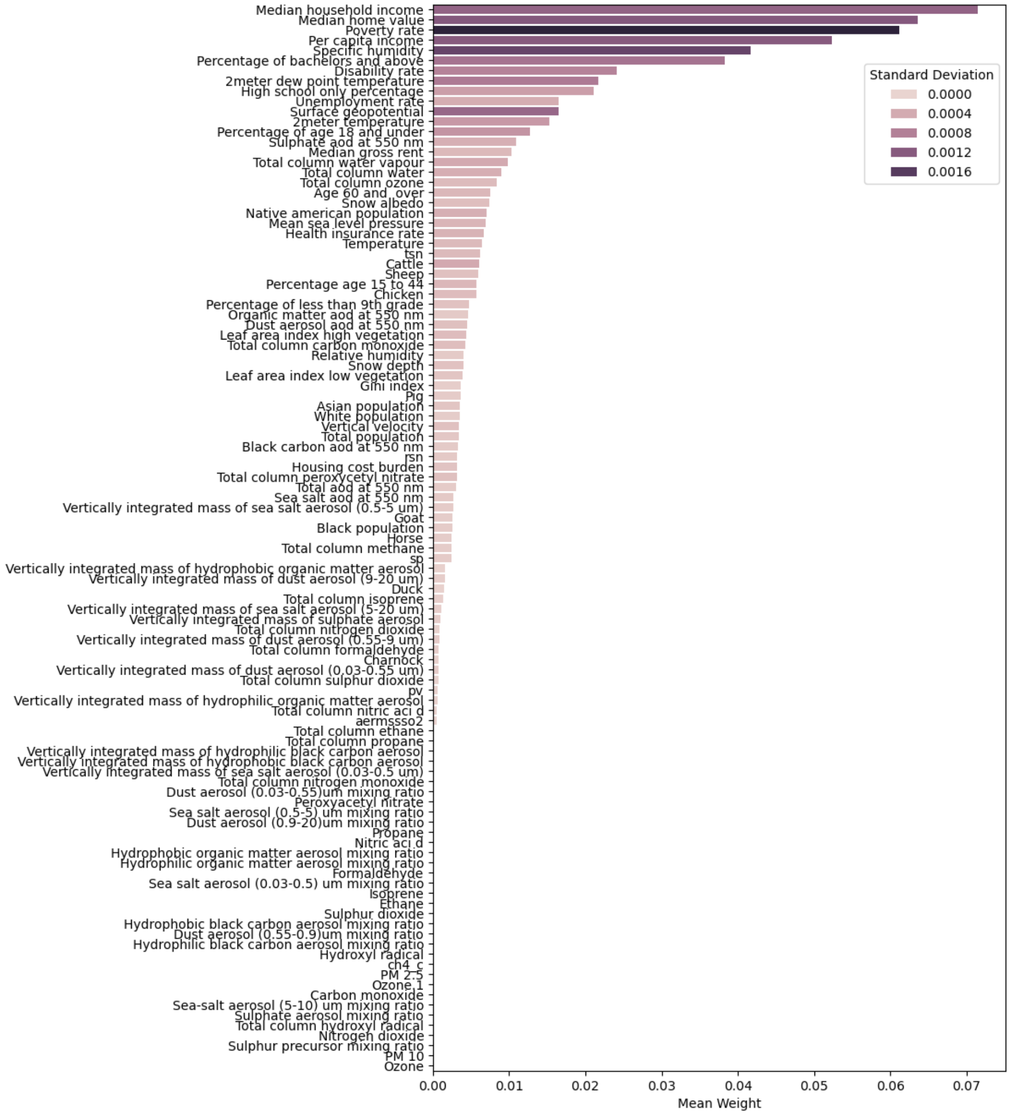
Humans as Sensors for AQ with ML

Life Expectancy (2019)

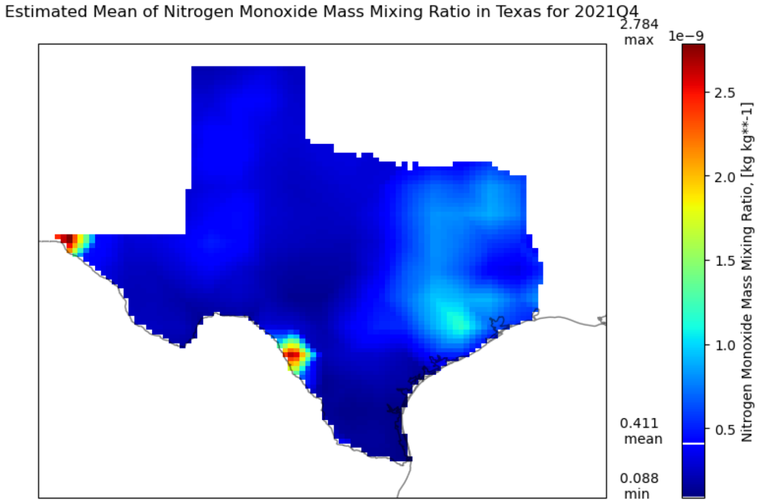


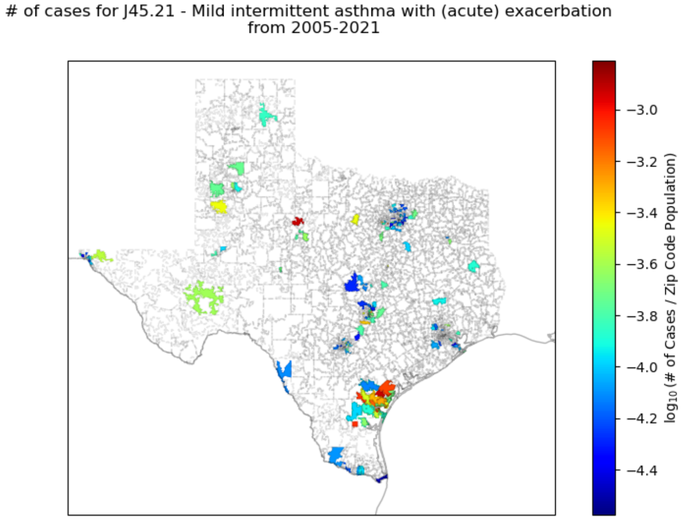
Hyperlocal AQ Health Outcomes

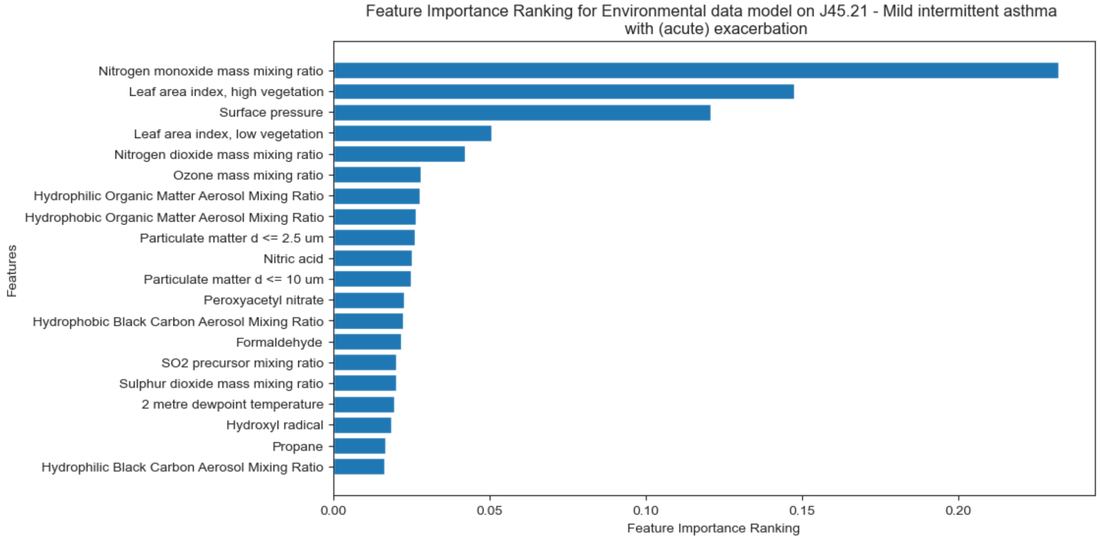




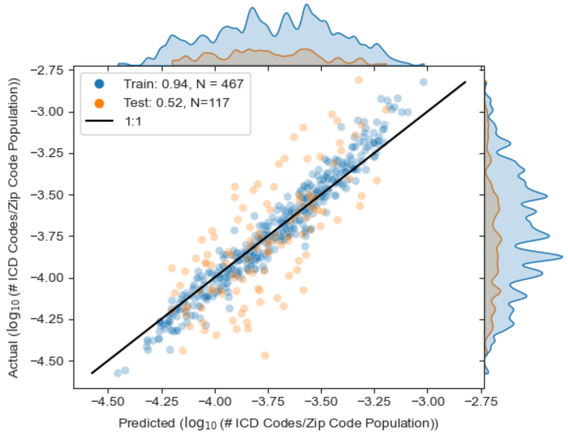
Emergency Room Admissions



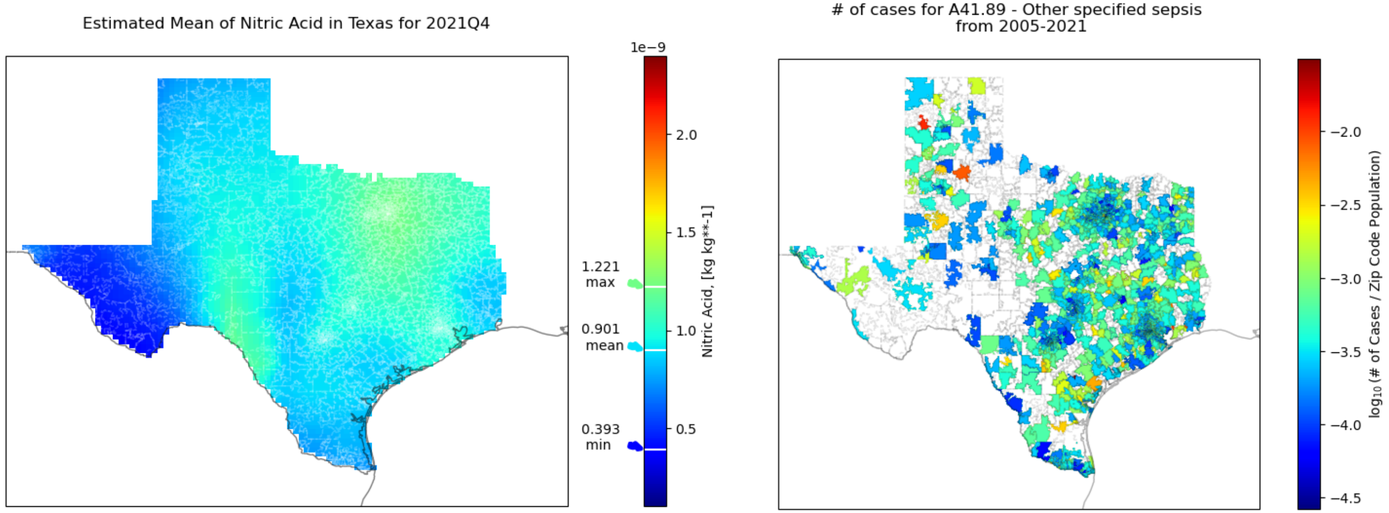


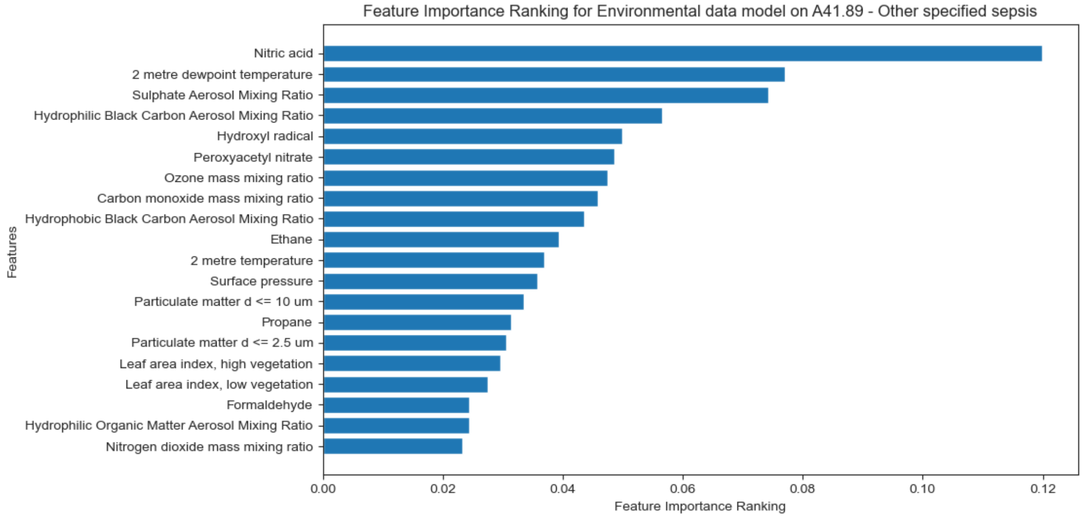


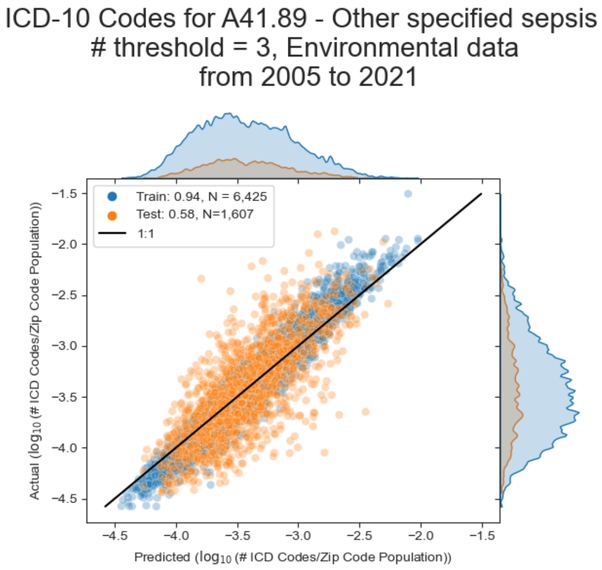
ICD-10 Codes for J45.21 - Mild intermittent asthma with (acute) exacerbation
threshold = 3, Environmental data from 2005 to 2021



Emergency Room Admissions







Social & Environmental Observatory

Software Defined Sensors

Platform

App Store

Sentinel

Cyber Physical Observatory

Demographics

Disease Incidence

Mortality Rate

Prescriptions

Lab Results

Mobility Data

Diet

Crime & Accident Statistics

School Absenteeism

Emergency Room Admissions

Citizen Tips & Feedback

In Patient

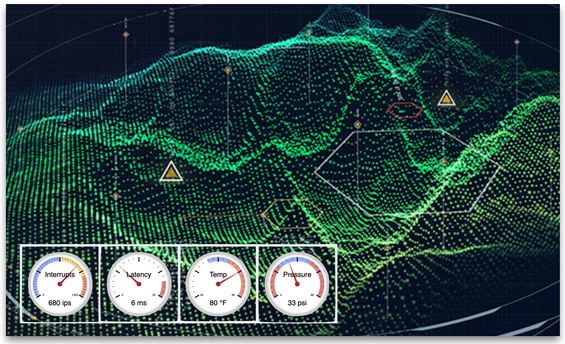
Social Observatory

App Store

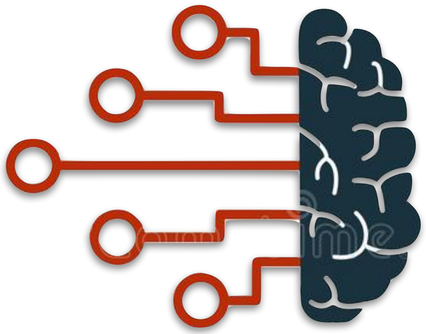
(CPSO) Cyber Physical Social Observatory

Sentinel = Software Defined Sensor + Platform

Autonomic Biometric Sensing



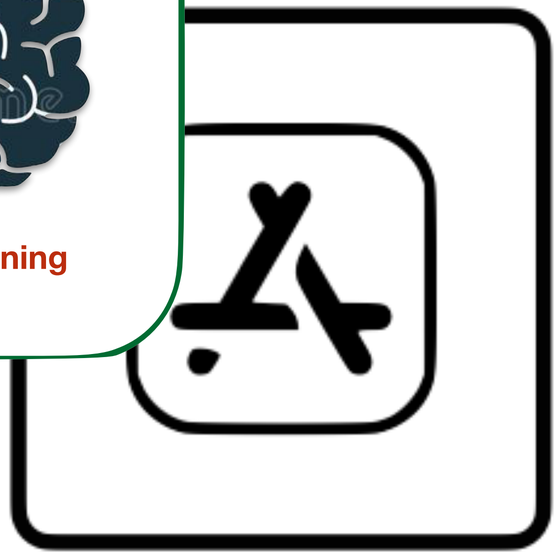
Environmental Sensing



Machine Learning

Software Defined Sensors

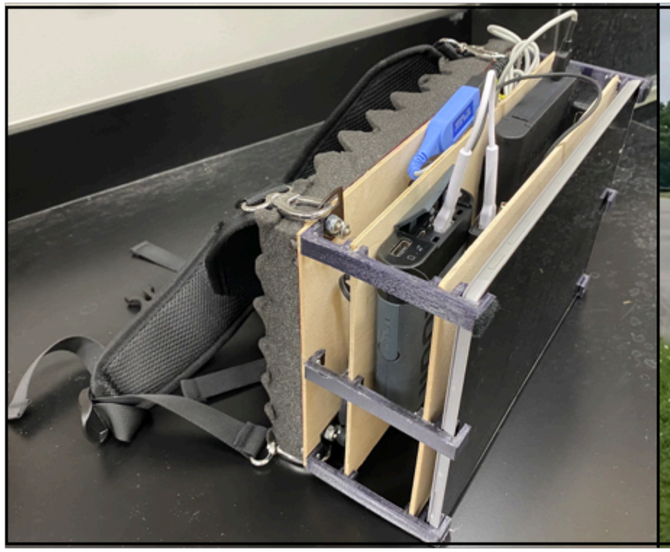
Platform



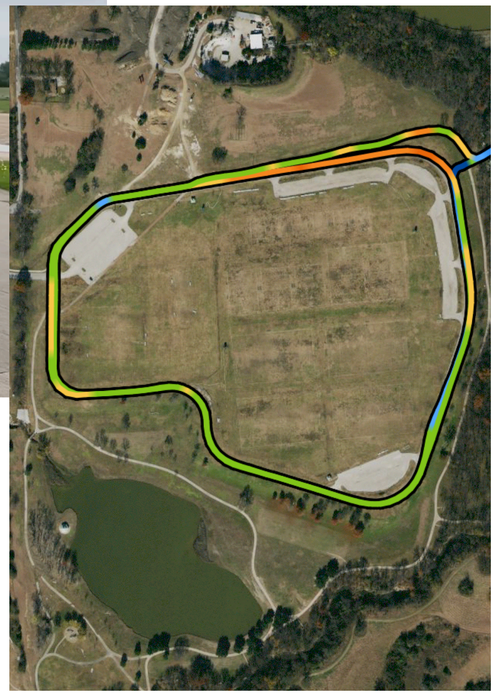
App Store

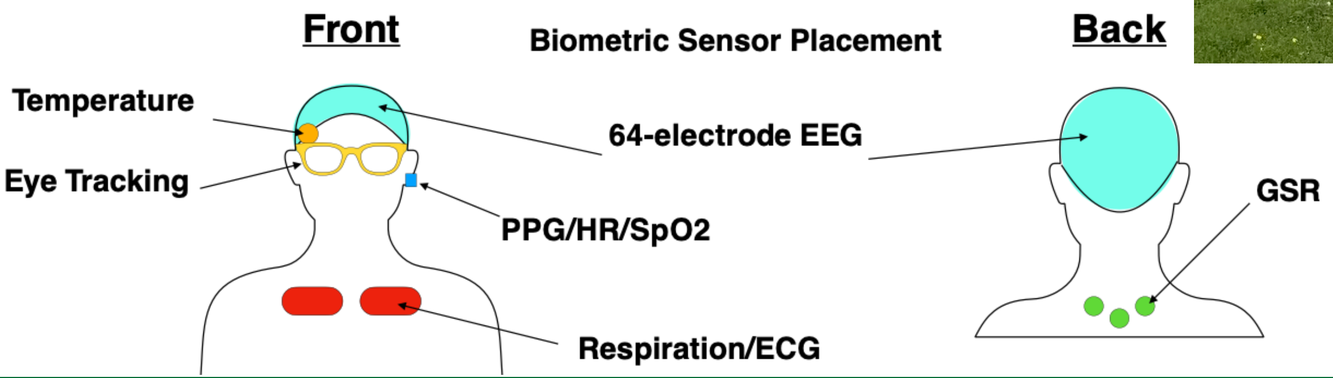
Sentinel

MINTS-AI

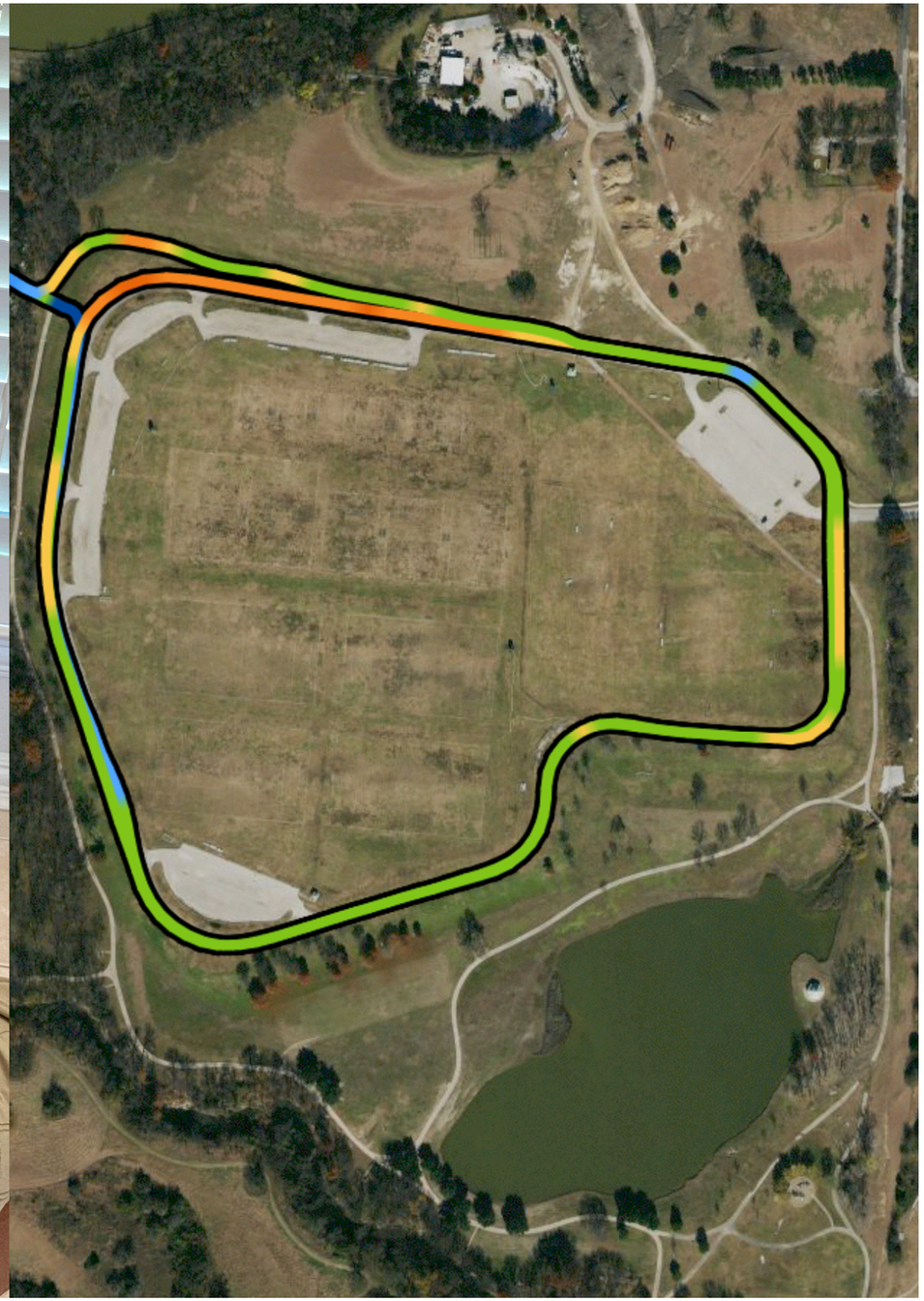


Humans as Sensors
for AQ with ML

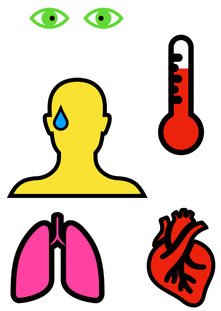




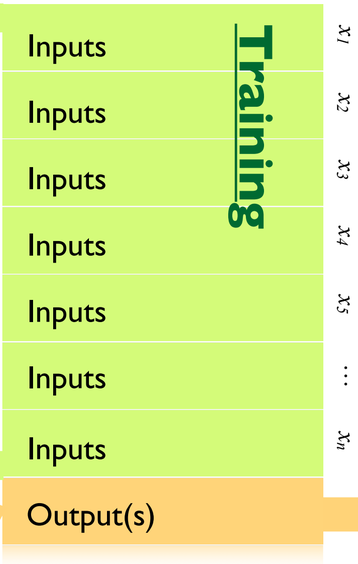
MINTS-AI

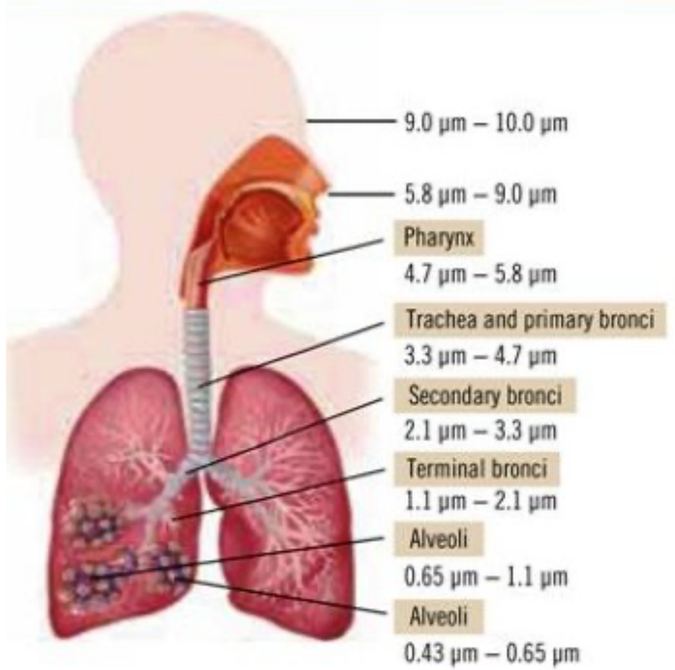


Wearable Sensors Decoding Autonomic Physiological Responses Using Machine Learning



Biometrics



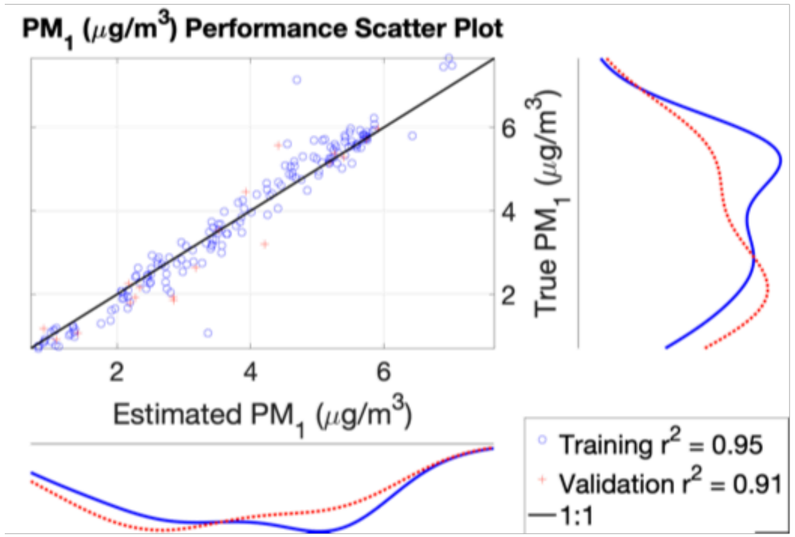


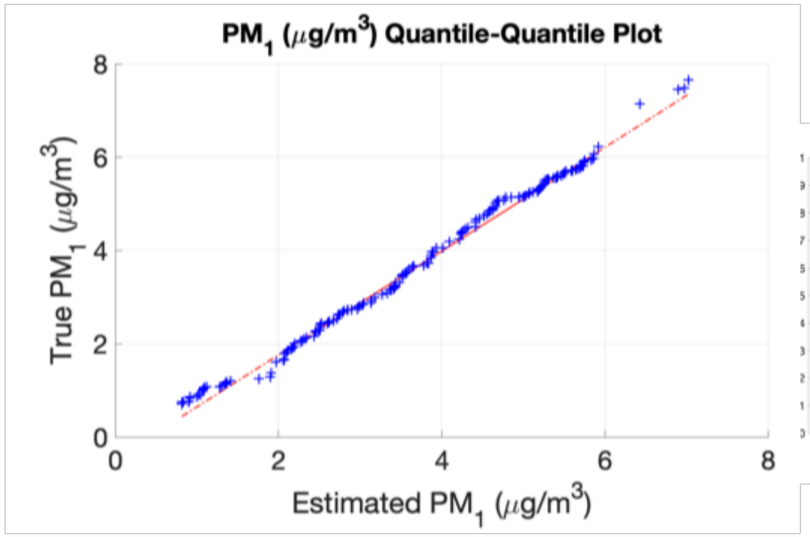
$$y = f(x_1, x_2, x_3, x_4, x_5, \ldots x_n)$$

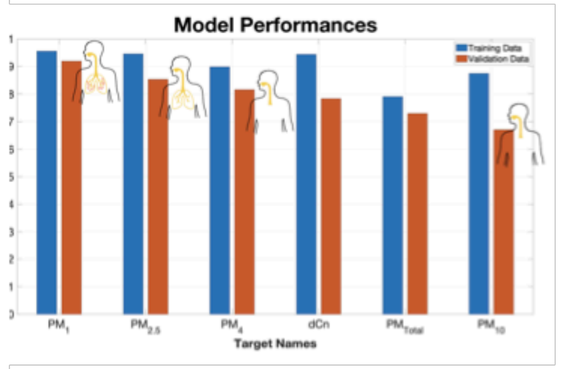
Imagine x_1 through x_n and y tabulated in a spreadsheet

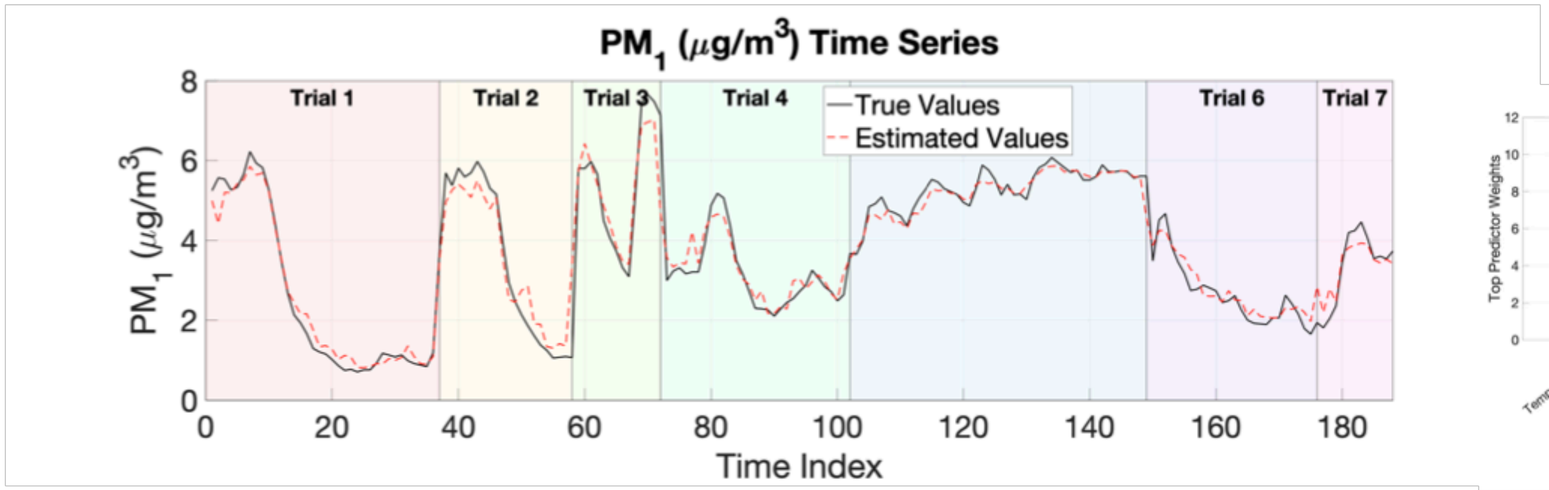
Multi-Variate Machine Learning Regression

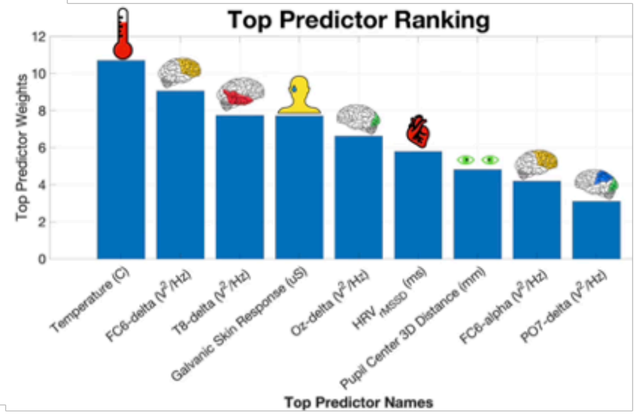
The Composition of the Air Impacts our Performance





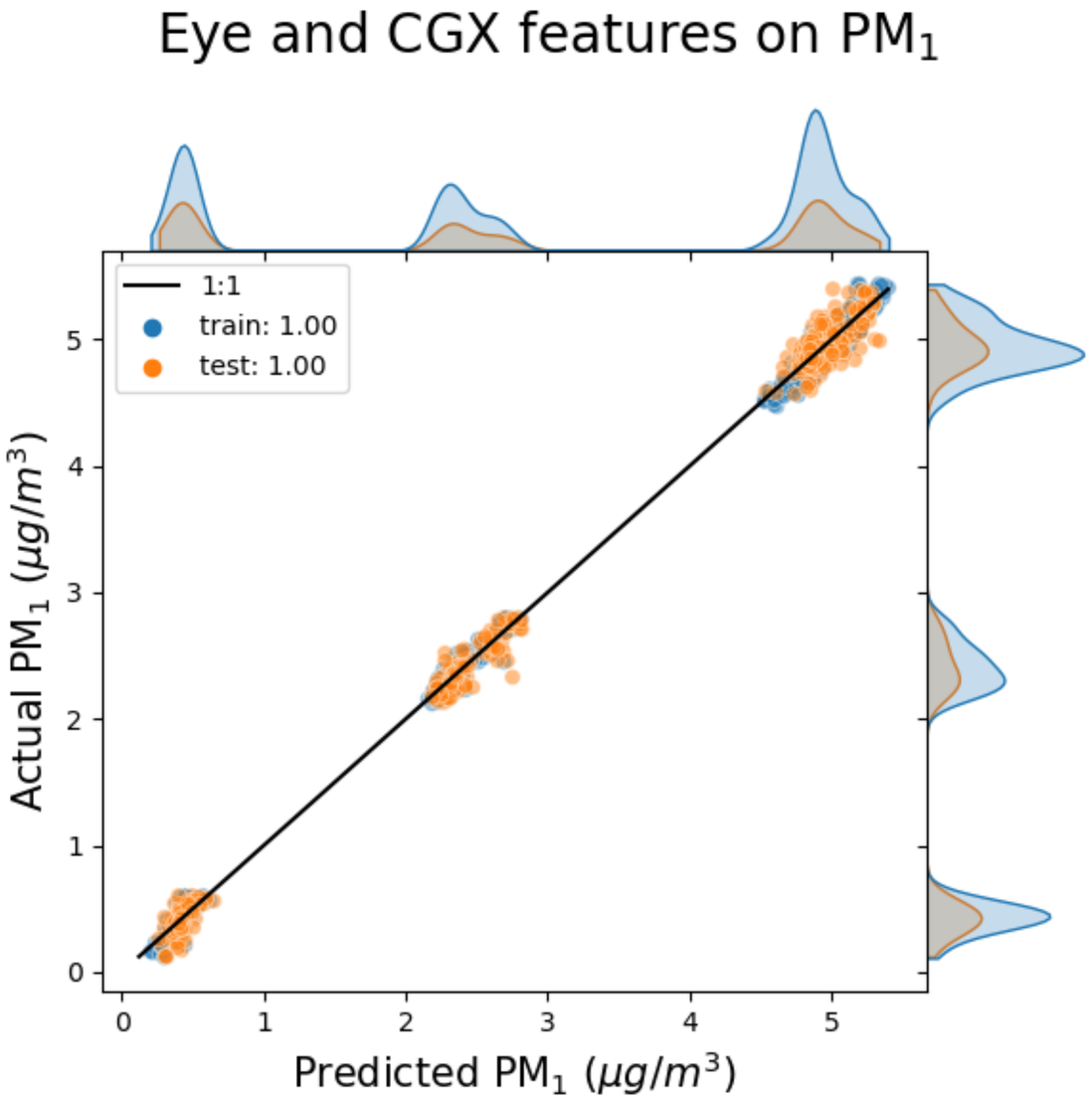


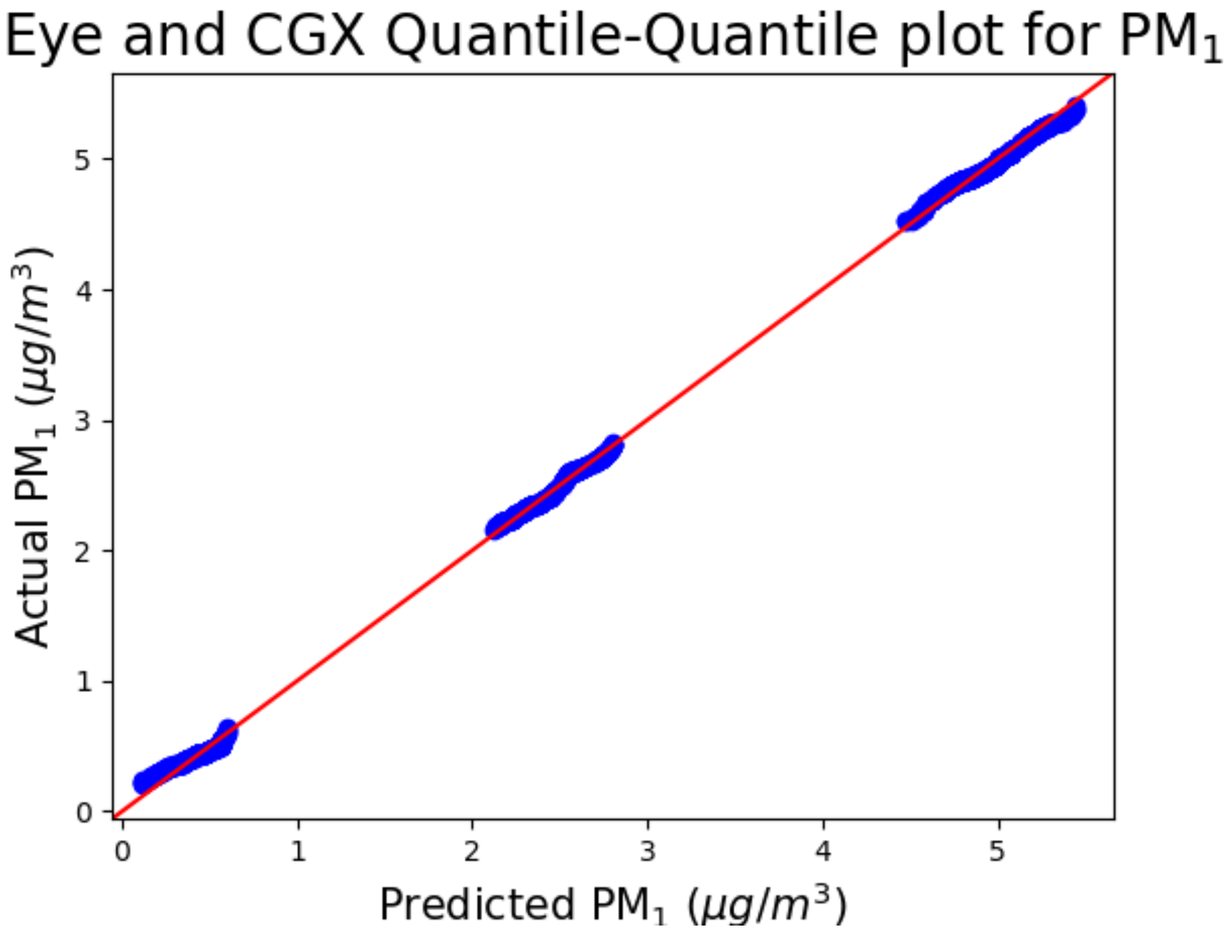




DUEDARE Multiple Riders

Model for PM_1 Concentrations





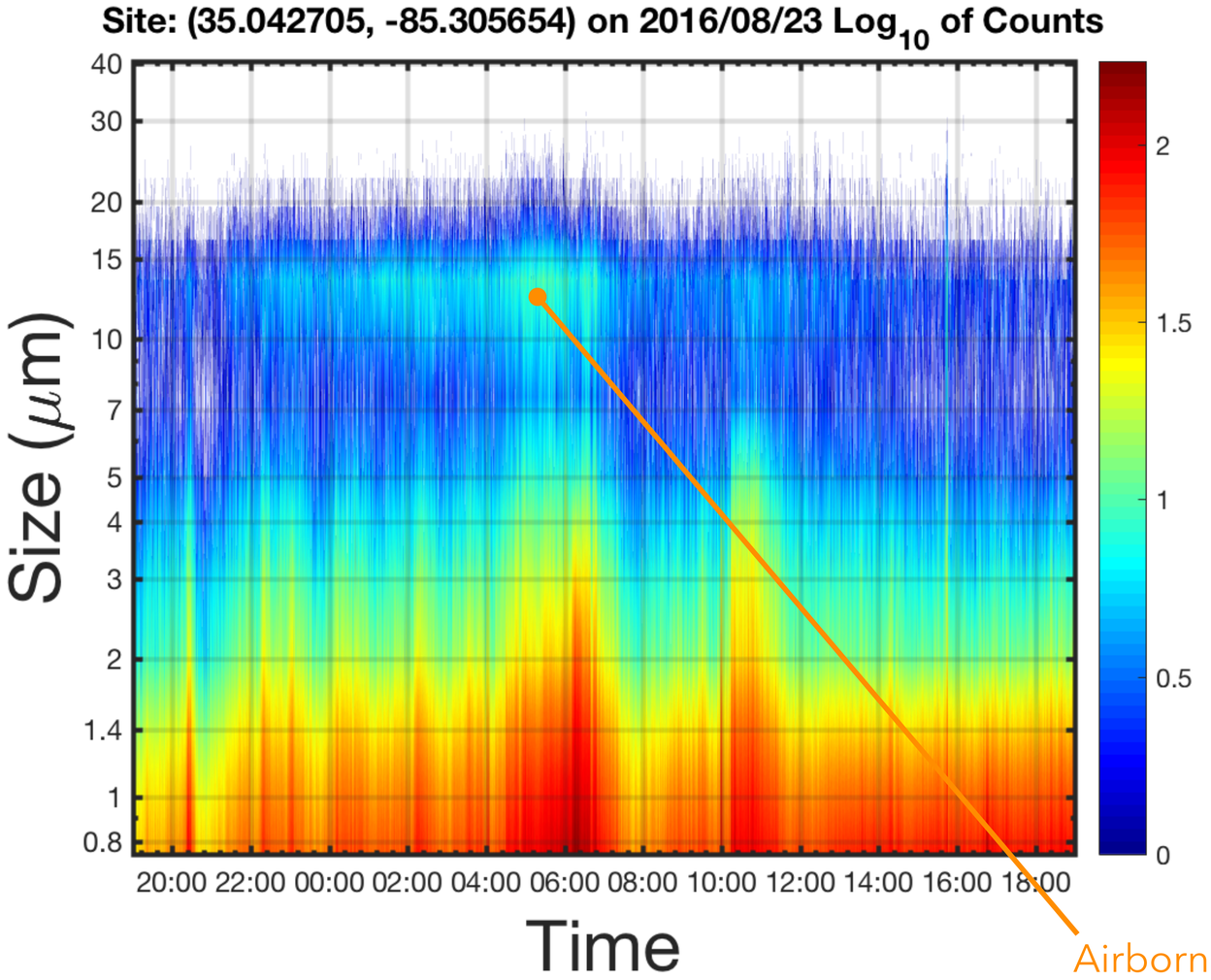
The Goals of the MINTS-AI AQ Monitors

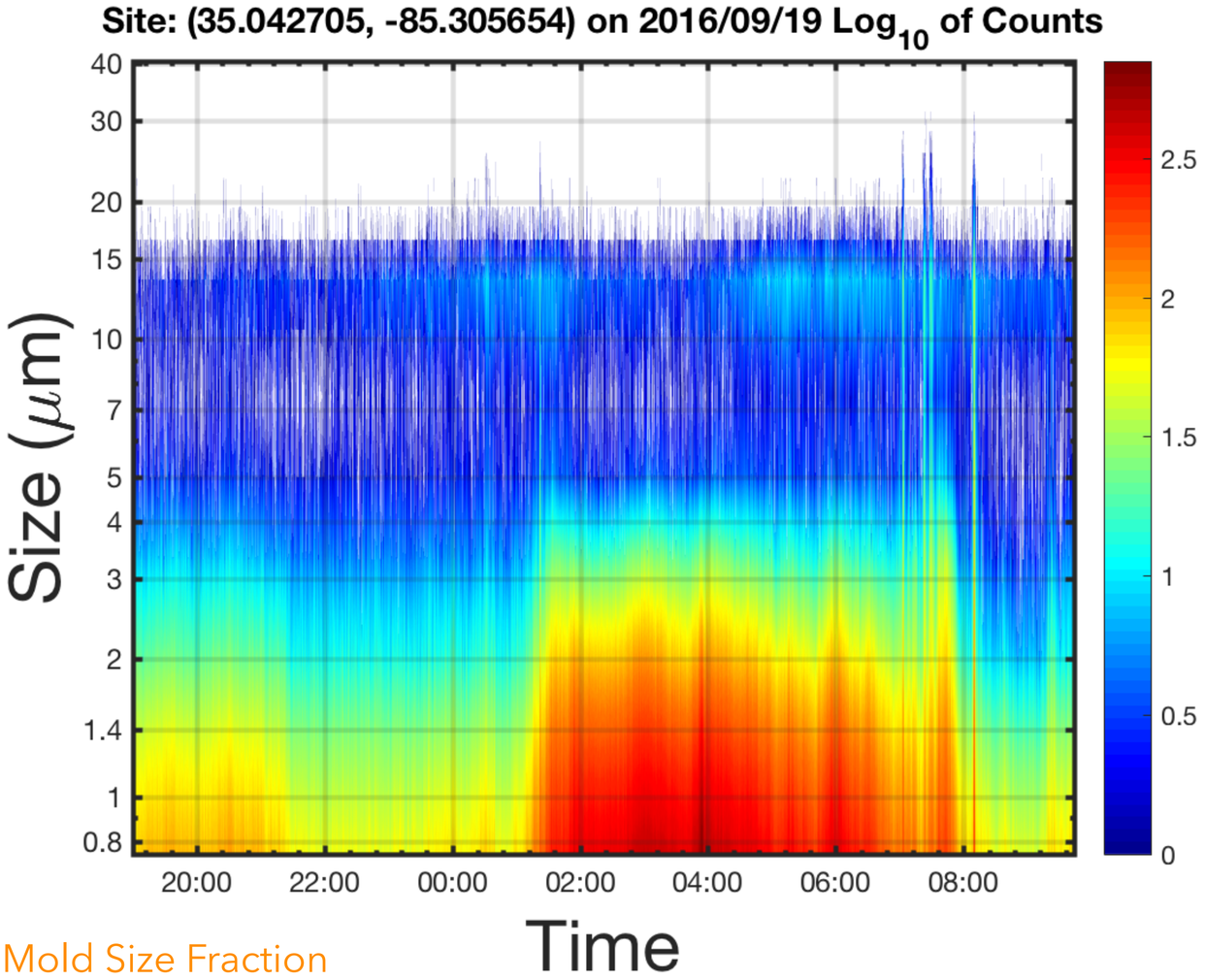
- Provide a real-time aerosol size distribution.
- Provide measurements of the **ultra-fine size** fraction most impactful for human health and generally overlooked.
- Provide observations on the appropriate temporal (and spatial) timescales.
- Provide real time meteorological context from an accurate rain gauge and ultra-sonic wind speed and direction.
- Provide real-time measures of biodiversity.

Static AQ Monitors
Calibrated with ML

Real-time Size Distribution

Mold & Pollen Size Fractions

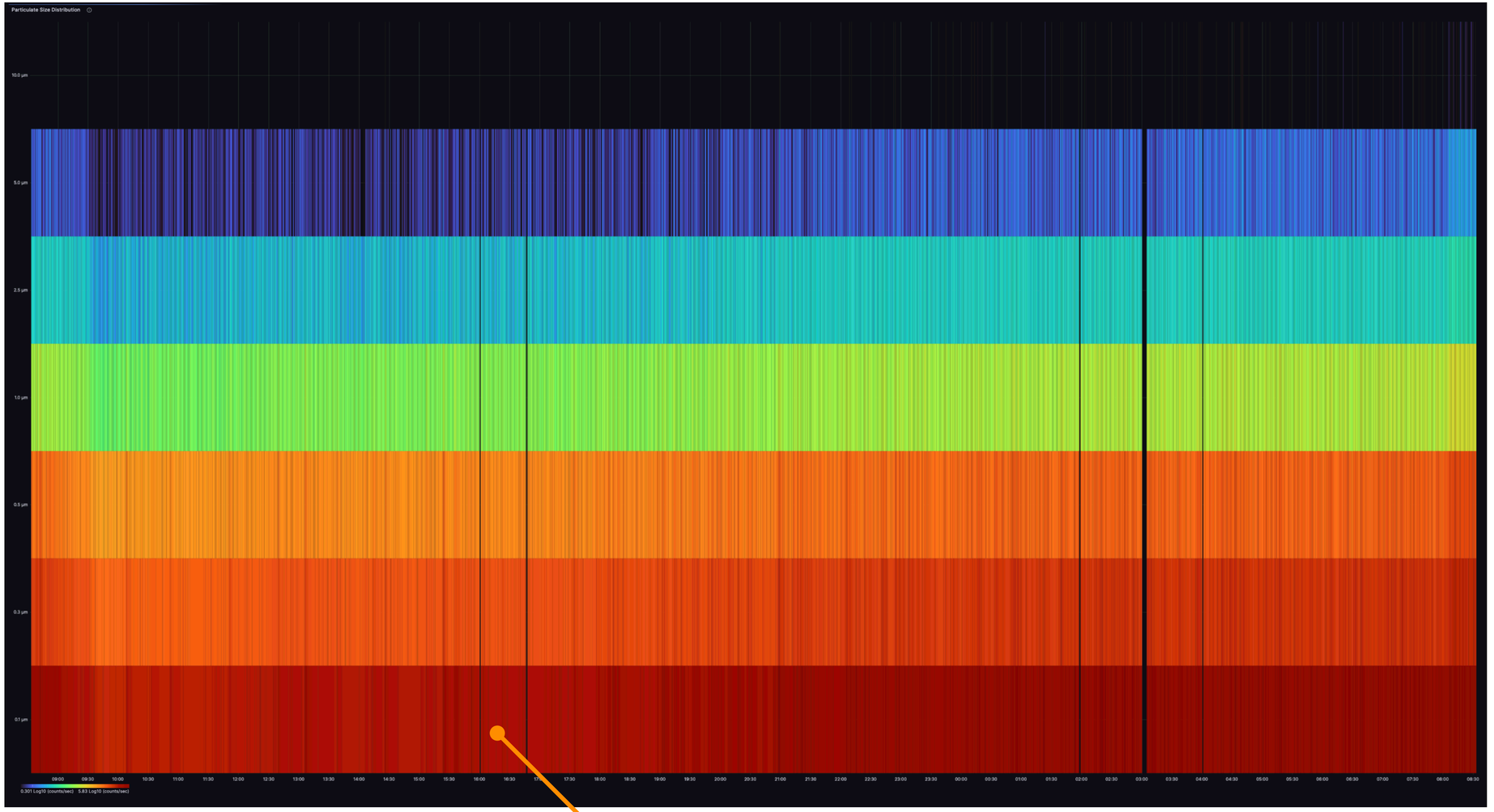




Airborne Mold Size Fraction

Real-time Size Distribution

10 µm	~ 1-5 / litre
5 µm	~ 10-15 / litre
2.5 µm	~ 100 – 200 / litre
1 µm	~ 1,000 / litre
0.5 µm	~ 30,000 / litre
0.3 µm	~ 90,000 / litre
0.1 µm	>300,000 / litre



Ultra-fine Size Fraction

Example Software Defined Sensor

Application Workflow

Low cost sensors calibrated against high end reference sensors can be distributed at scale

Low Cost Sensor

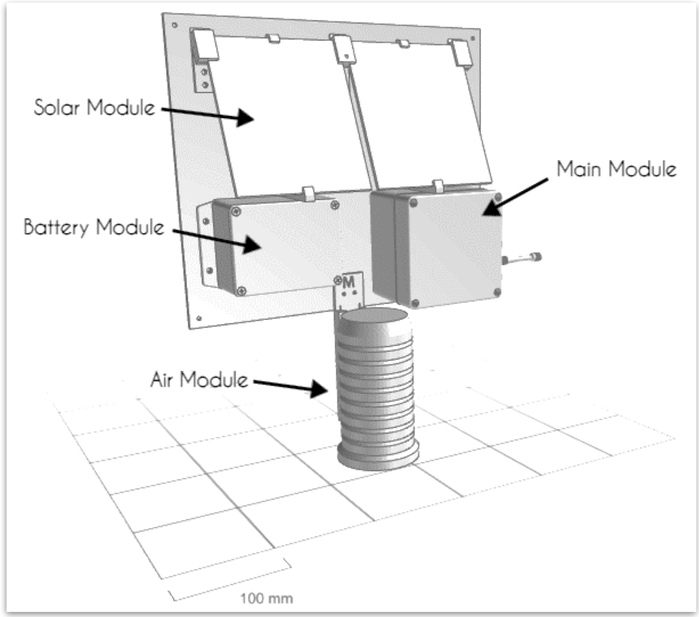
Reference Sensor

On-board App Store

Machine Learning Calibration

Software Defined Sensors

Live Machine Learning System



Sensor Calibration

sensors

MDPI

Article

Using Machine Learning for the Calibration of Airborne Particulate Sensors

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Received: 7 November 2019; Accepted: 10 December 2019; Published: 23 December 2019

check for updates

Abstract: Airborne particulates are of particular significance for their human health impacts and their roles in both atmospheric radiative transfer and atmospheric chemistry. Observations of airborne particulates are typically made by environmental agencies using rather expensive instruments. Due to the expense of the instruments usually used by environment agencies, the number of sensors that can be deployed is limited. In this study we show that machine learning can be used to effectively calibrate lower cost optical particle counters. For this calibration it is critical that measurements of the atmospheric pressure, humidity, and temperature are also made.

Keywords: optical particle counter; airborne particulates; machine learning

1. Introduction

Airborne atmospheric aerosols are an assortment of solid or liquid particles suspended in air [1]. Aerosols, also referred to as particulate matter (PM), are associated with a suite of issues relevant to the global environment [2–8], atmospheric photolysis, and a range of adverse health effects [9–15]. Atmospheric aerosols are usually formed either by direct emission from a specific source (e.g., combustion) or from gaseous precursors [16]. Although individual aerosols are typically invisible to the naked eye, due to their small size, their presence in the atmosphere in substantial quantities means that their presence is usually visible as fog, mist, haze, smoke, dust plumes, etc. [17]. Airborne aerosols vary in size, composition, origin, and spatial and temporal distributions [14,18]. As a result, the study of atmospheric aerosols has numerous challenges.

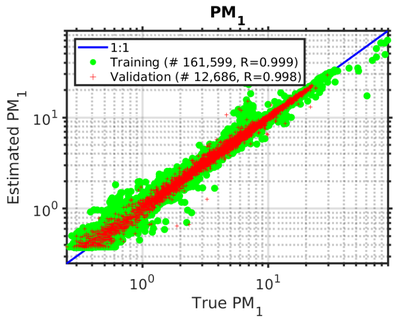
1.1. Motivation for This Study

Low cost sensors that can also be accurately calibrated are of particular value. For the last two decades we have pioneered the use of machine learning to cross-calibrate sensors of all kinds. This was initially done for very expensive orbital instruments onboard satellites (awarded an IEEE paper prize, and specially commended by the NASA MODIS team) [19]. We are now using this approach operationally for low-cost sensors distributed at scale across dense urban environments as part of our smart city sentinels. The approach can be used for very diverse sensors, but as a useful illustrative example that has operational utility, we describe here a case for accurately calibrated, low-cost sensors measuring the abundance and size distribution of airborne particulates, with the implicit understanding that many other sensor types could easily be substituted. These sensors can be readily deployed at scale at fixed locations; be mobile on various robotic platforms (walking, flying, etc) or vehicles; be carried; or deployed autonomously as a mesh network, either by operatives or by robots (walking, flying, etc.).

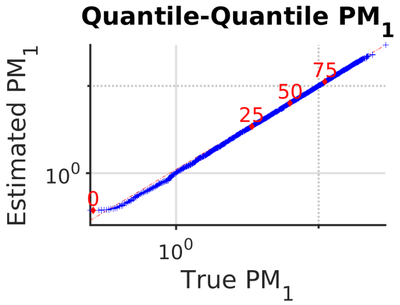
Building in calibration will enable consistent data to retrieved from all the low-cost nodes deployed/thrown. Otherwise the data will always be under some suspicion as the inter-sensor

Sensors **2020**, *20*(1), 99; https://doi.org/10.3390/s20010099

PM_1

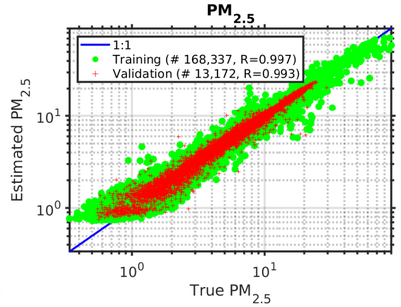


(a)

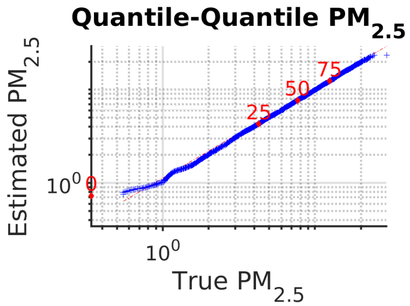


(b)

$PM_{2.5}$

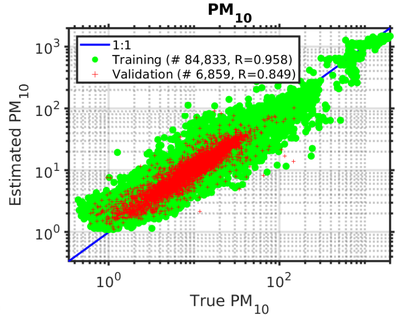


(d)

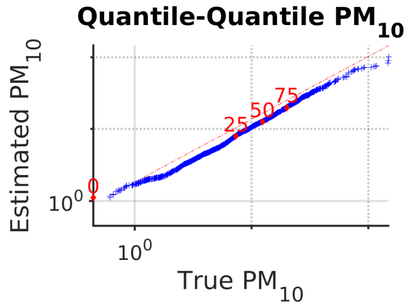


(e)

PM_{10}

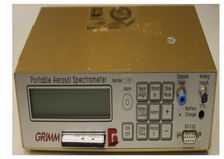


(g)



(h)

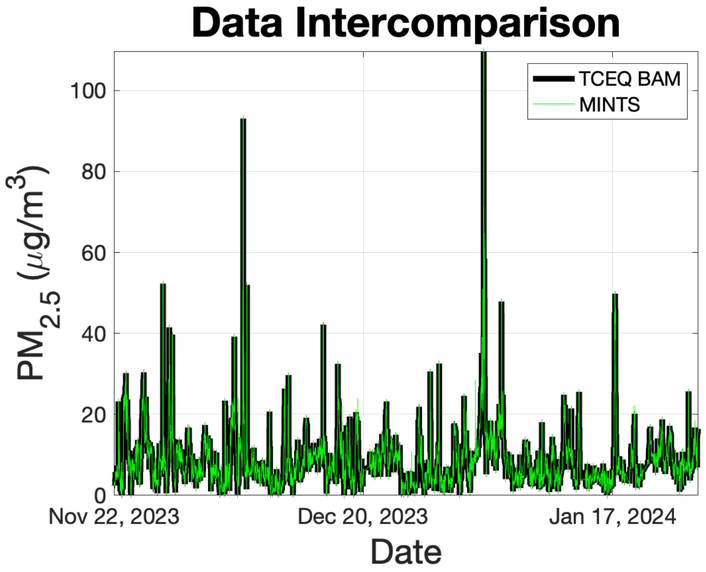
Research Grade Sensor

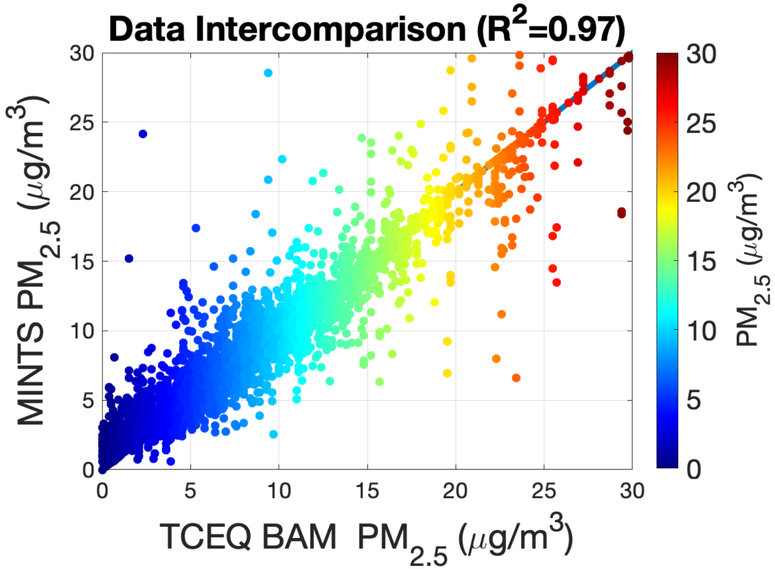


Low Cost Sensor

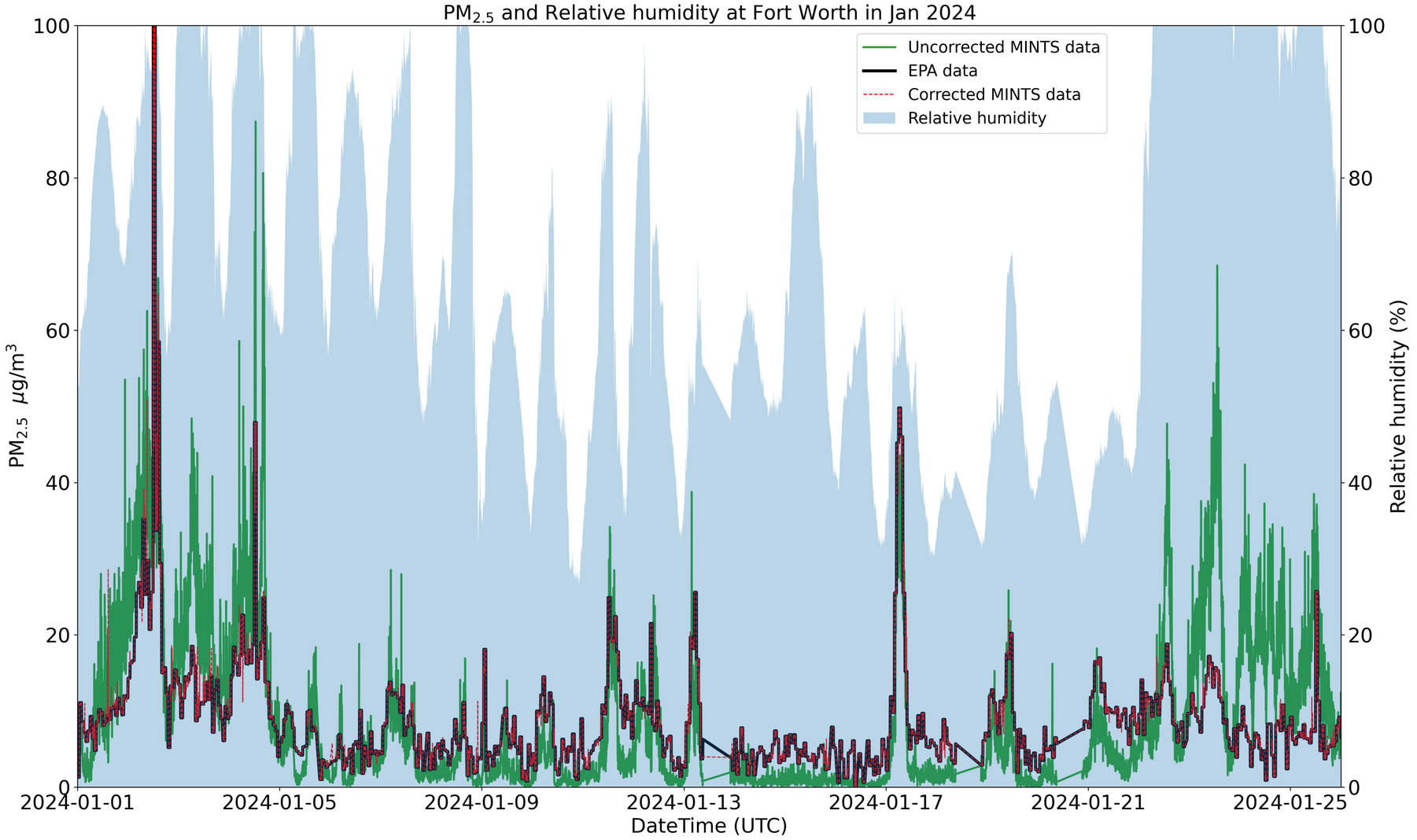
Calibration of low cost sensor against research grade sensor using machine learning.

Further ML Correction





Humidity Correction



Correction is applied live to all sensor streams.

PHYSICAL SENSING OF AIRBORNE PARTICULATES USING COMPLEMENTARY IN-SITU AND REMOTE SENSING APPROACHES

by

Prabuddha Madusanka Hathurusinghe Dewage

APPROVED BY SUPERVISORY COMMITTEE:

David J. Lary, Chair

Robert Glosser

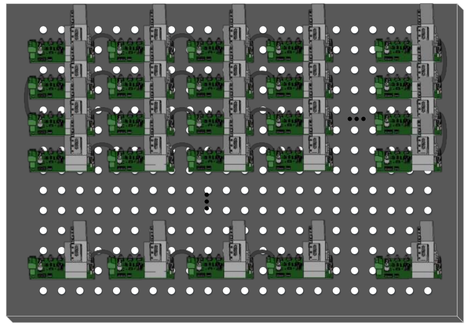
Lindsay J. King

Lloyd Lumata

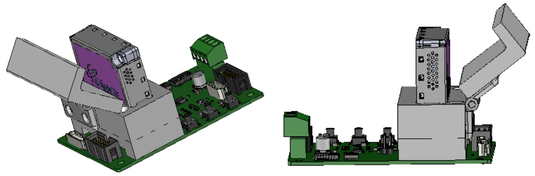
David Lumley

Precalibrated IPS

Fully Automated Calibration System Configuration



IPS Test Jig
(To be completed by Aug. 27)

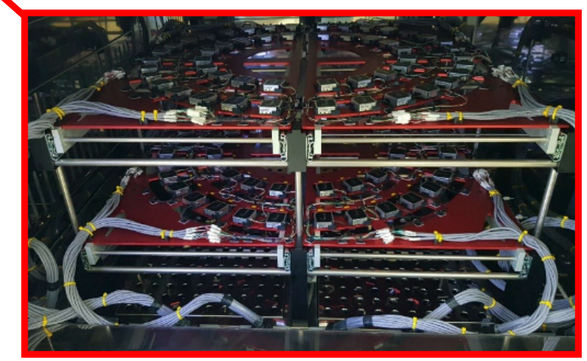


Calibration Chamber ADT-1786

Automated Calibration Controller
(To be completed by Aug. 18)

Ethernet TCP/IP

Data cables



Fully-Automated Process

Base firmware download

↓

Test chamber and jig setup/Initialization

↓

Automatic calibration/Inspection

↓

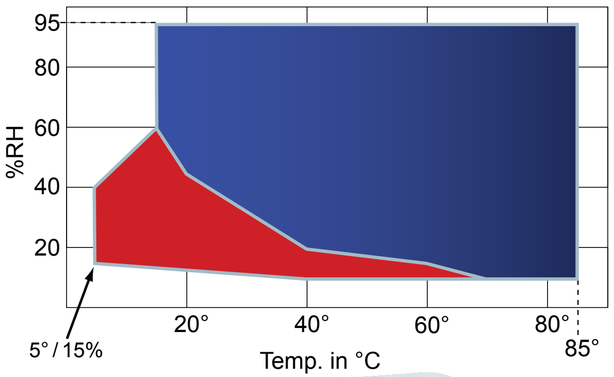
Packaging

↓

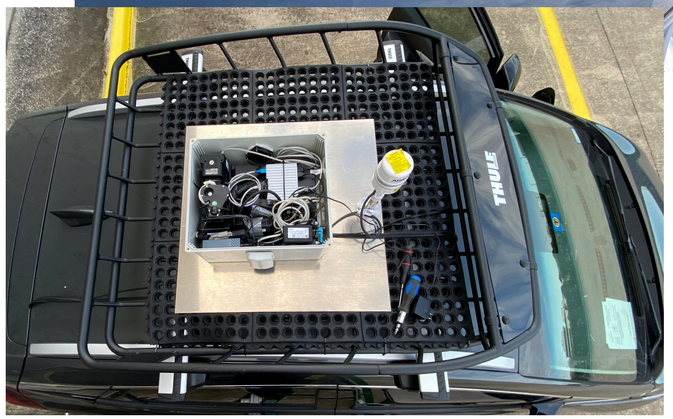
Shipping

Next Generation Calibration

Controlled humidity range for BTL-433 & BTX-475 models (without live load). Optional low humidity range shown in red.

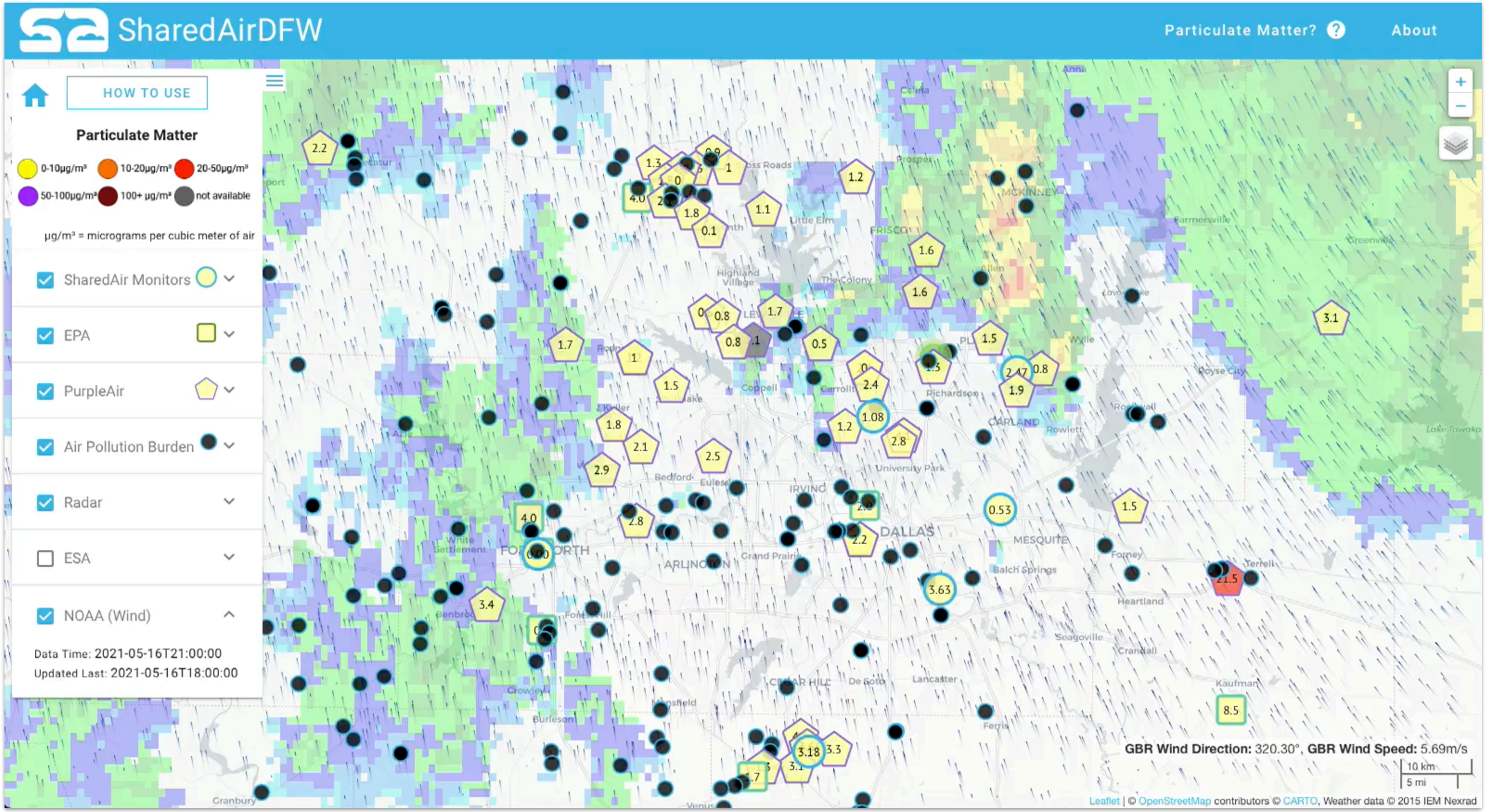


ESPEC BTL-433 Temperature/Humidity Chamber

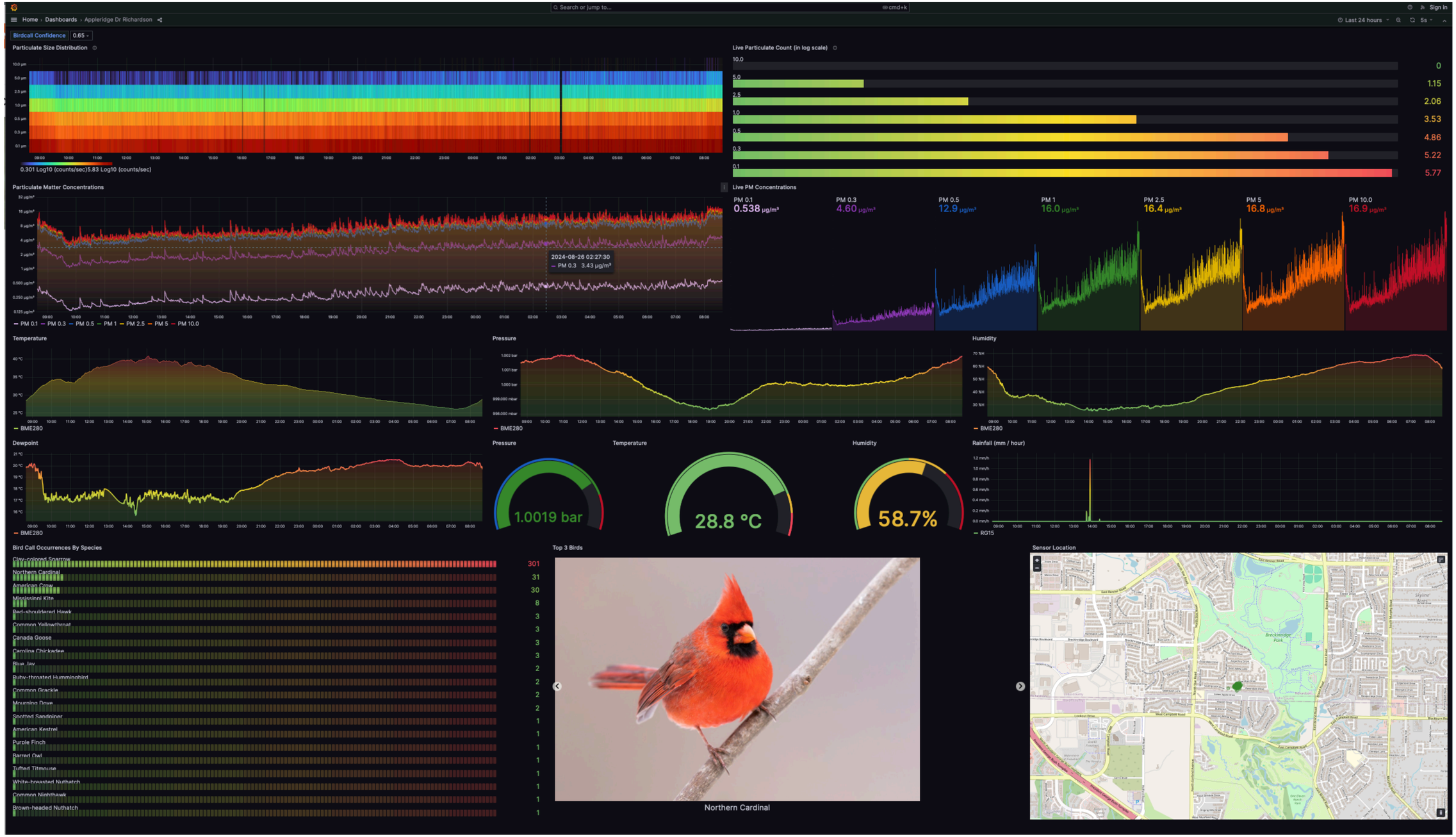


- Chamber Calibration
- Mobile Calibration across DFW

MINTS-AI


SharedAirDFW
Particulate Matter?
About
HOW TO USE
Particulate Matter
0-10µg/m³
10-20µg/m³
20-50µg/m³
50-100µg/m³
100+ µg/m³
not available
µg/m³ = micrograms per cubic meter of air
SharedAir Monitors
EPA
PurpleAir
Air Pollution Burden
Radar
ESA
NOAA (Wind)
Data Time: 2021-05-16T21:00:00
Updated Last: 2021-05-16T18:00:00
GBR Wind Direction: 320.30°, GBR Wind Speed: 5.69m/s
10 km
5 mi
Leaflet | © OpenStreetMap contributors © CARTO, Weather data © 2015 IEM Nexrad

MINTS-AI

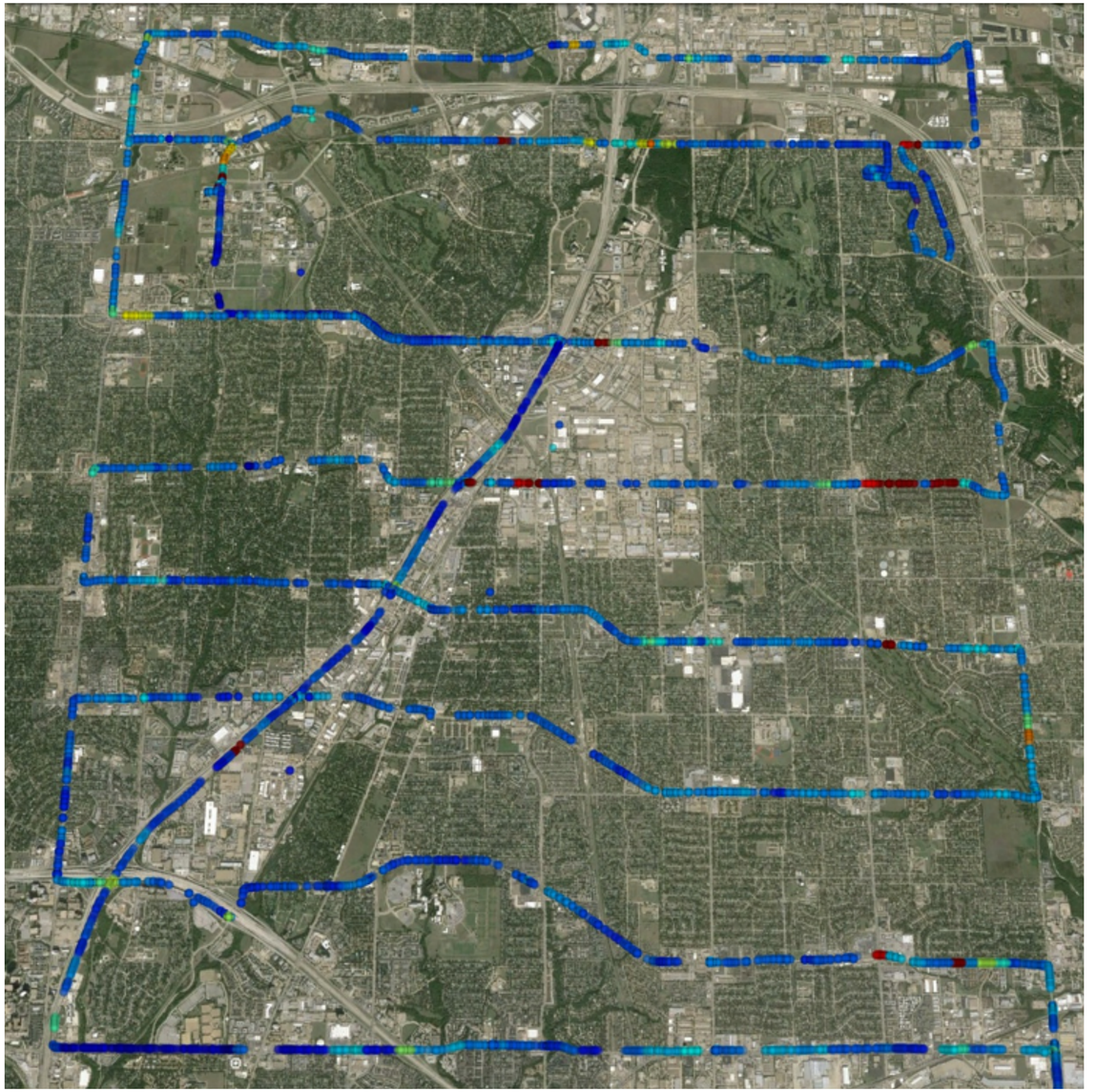


http://mdash.circ.utdallas.edu:3000/d/eeb35d4f-57b9-4a9d-8a71-2fe1f9685aa5/appleridge-dr-richardson?orgId=1&refresh=5s&from=now-24h&to=now

Hyperlocal AQ
Microenvironments

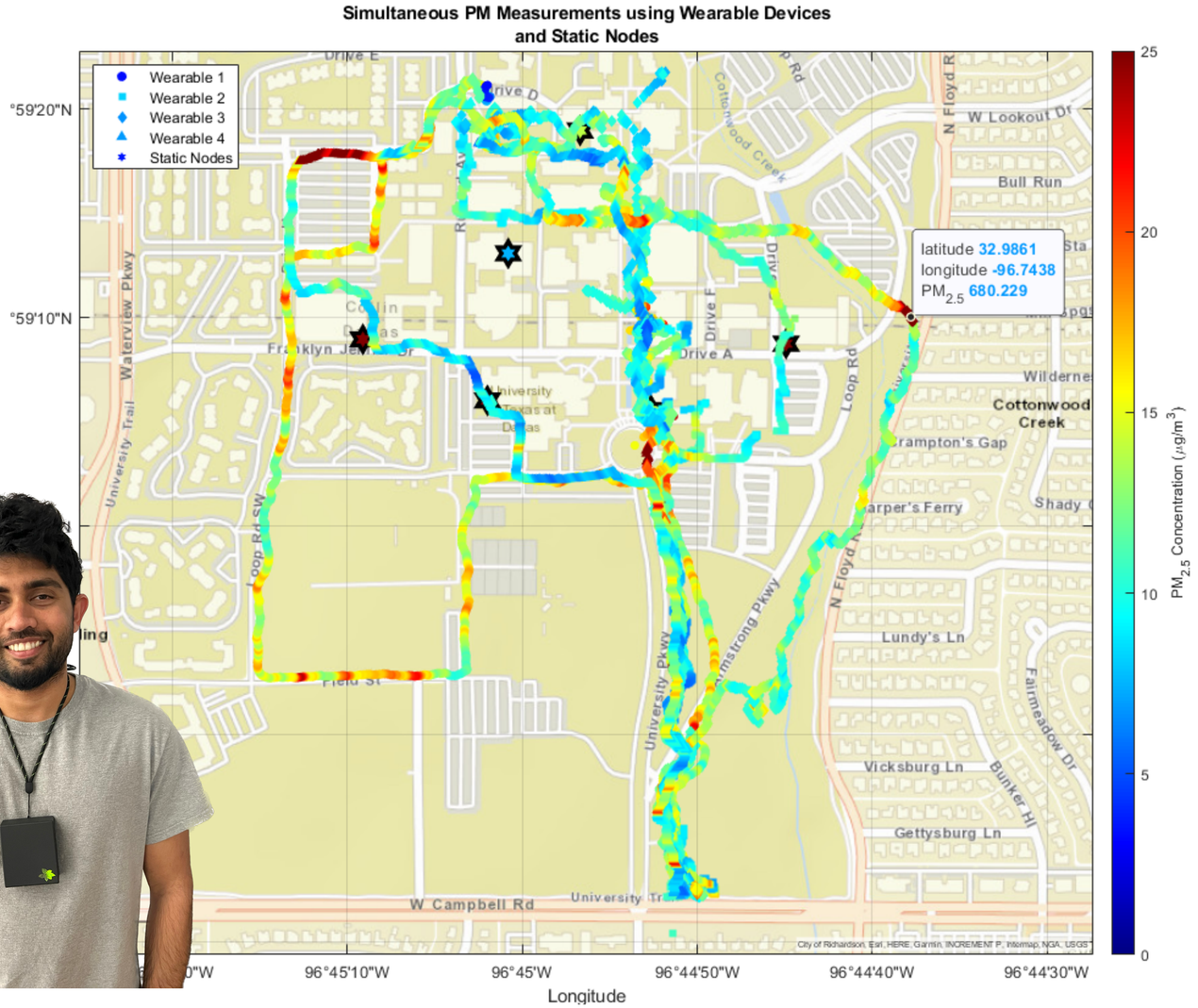
Hyper-Local Micro Environments

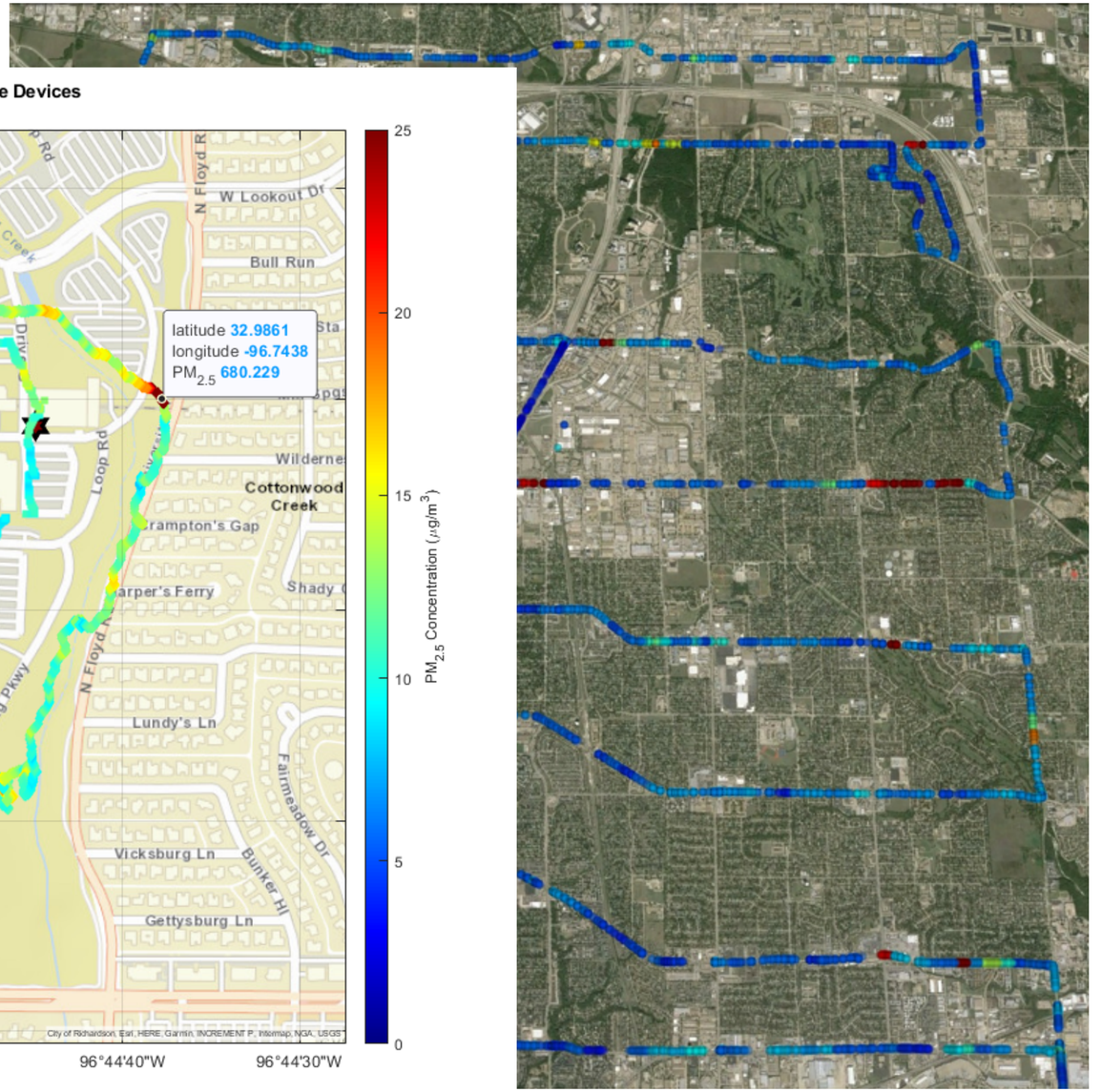
Ideal Spatial resolution is at least 0.5 km



Hyper-Local Micro Environments

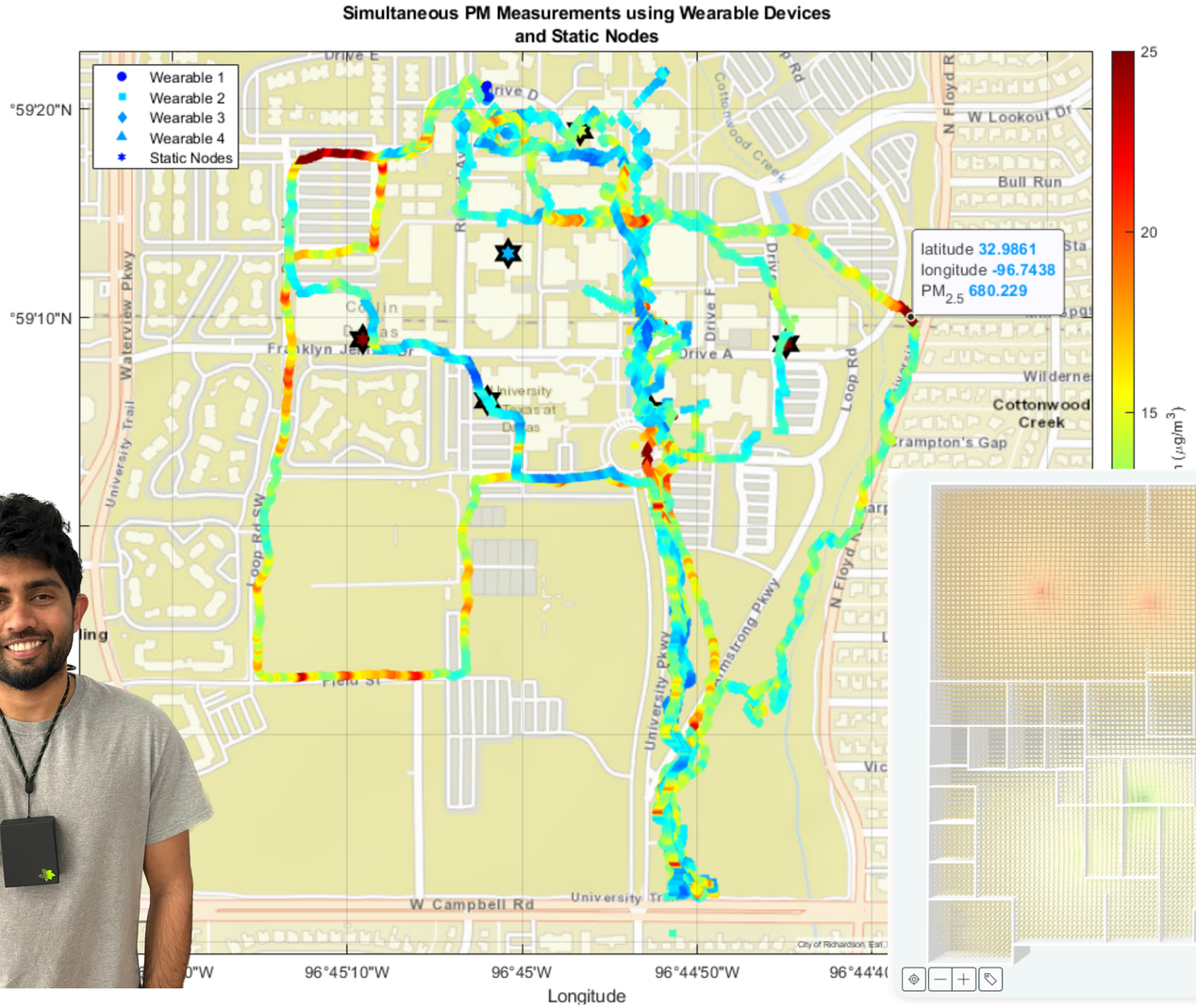
Ideal Spatial resolution is at least 0.5 km

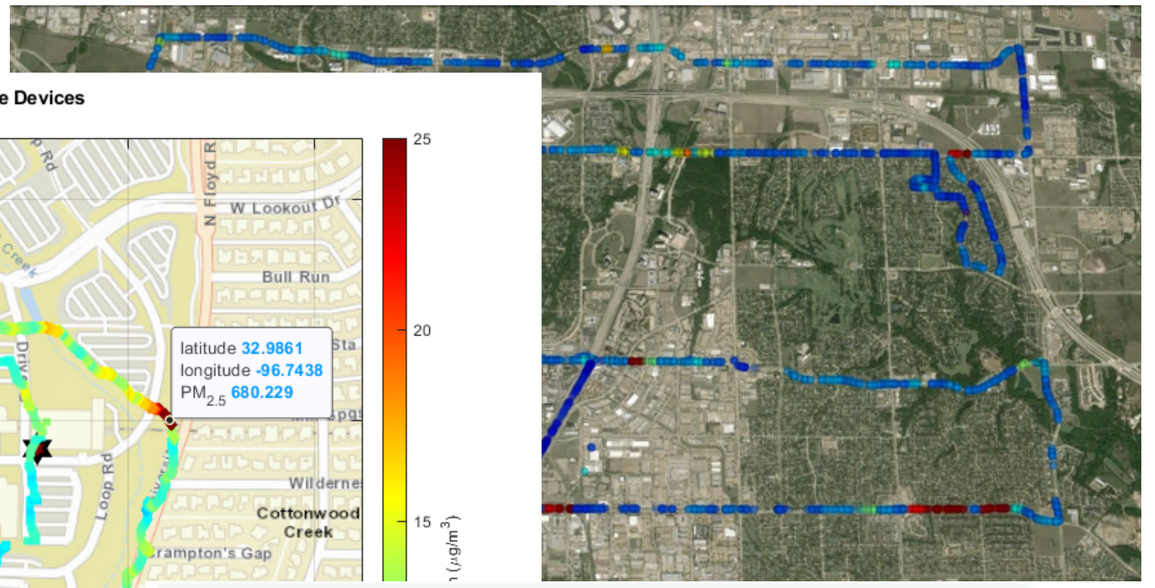


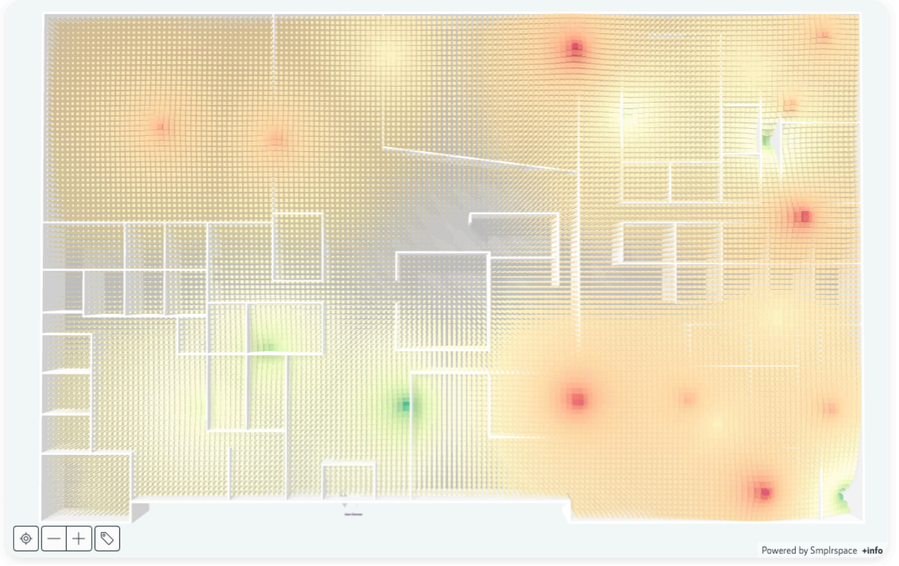


Hyper-Local Micro Environments

Ideal Spatial resolution is at least 0.5 km



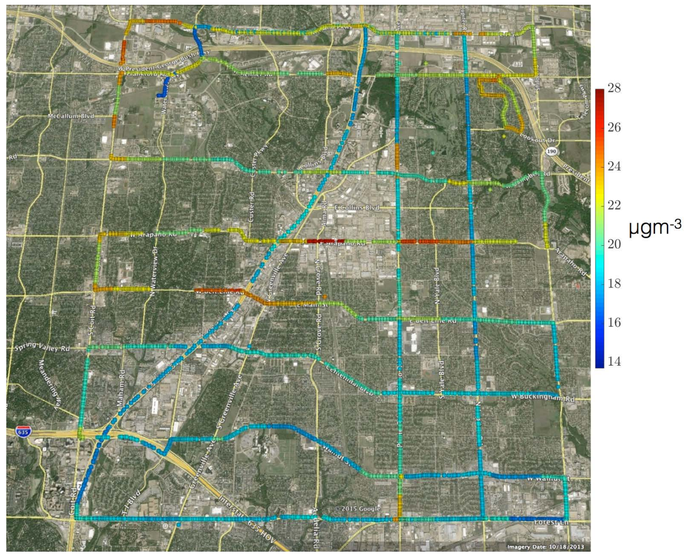


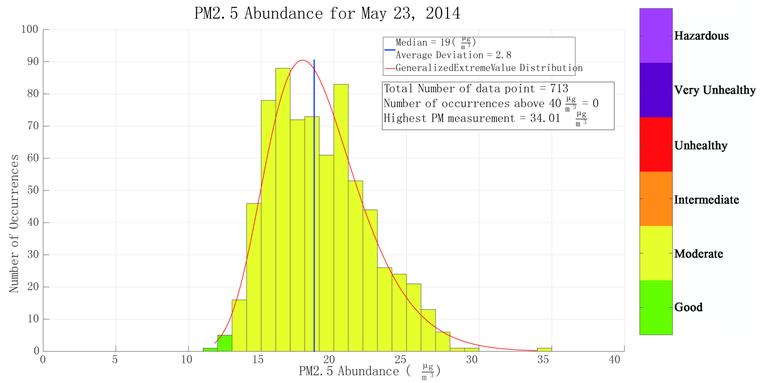


Hyperlocal AQ
Microenvironments

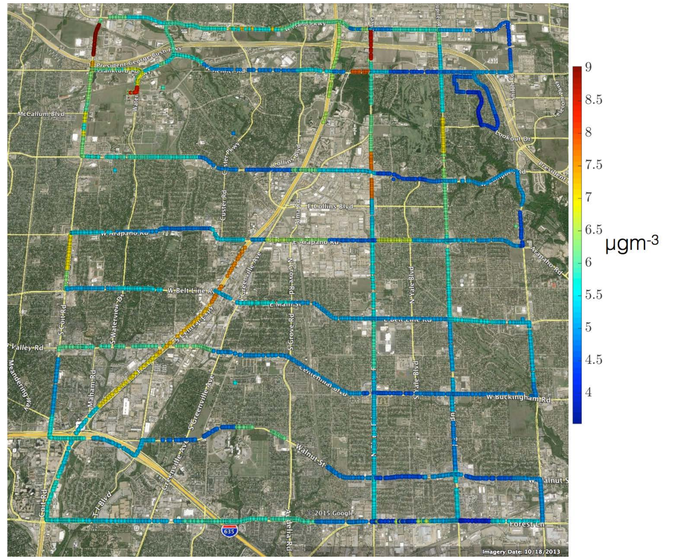
Hyper-Local Micro Environments

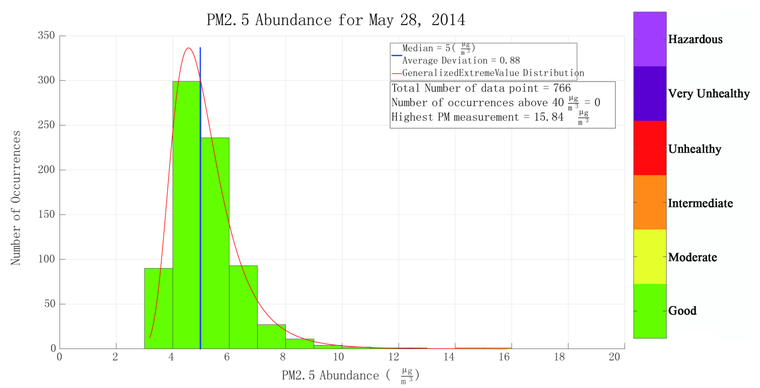
May 23, 2014





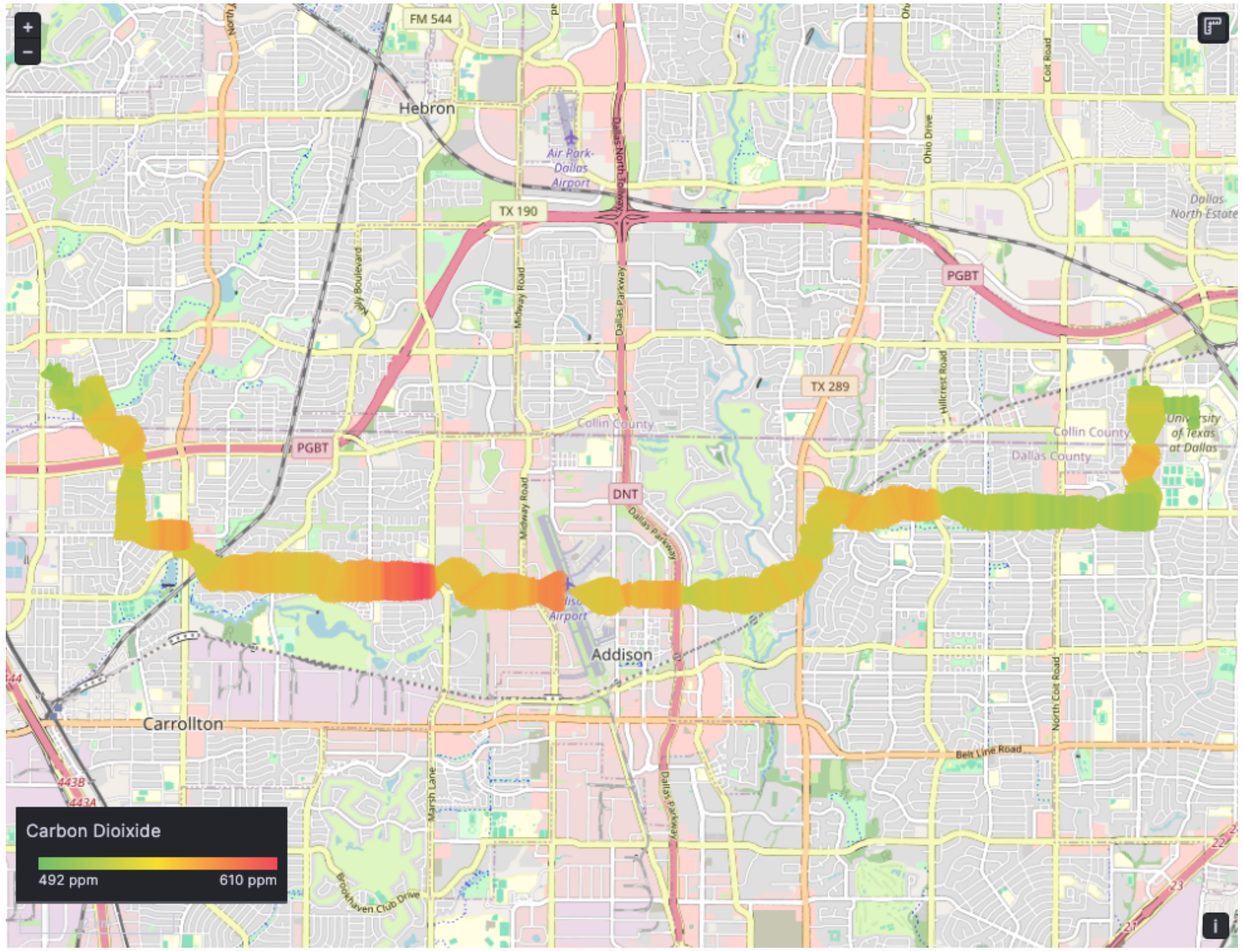
May 28, 2014

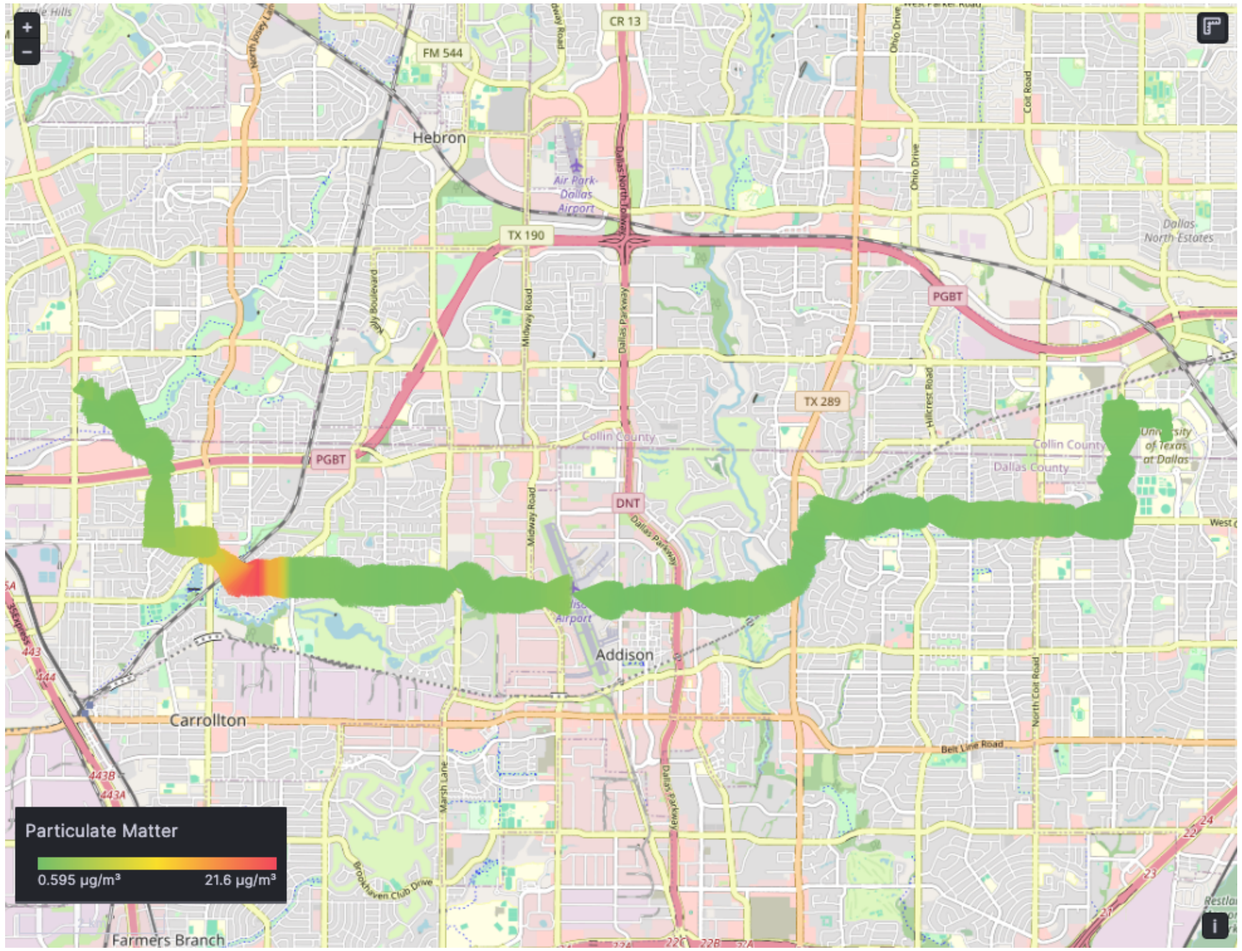




Hyper-Local Micro Environments

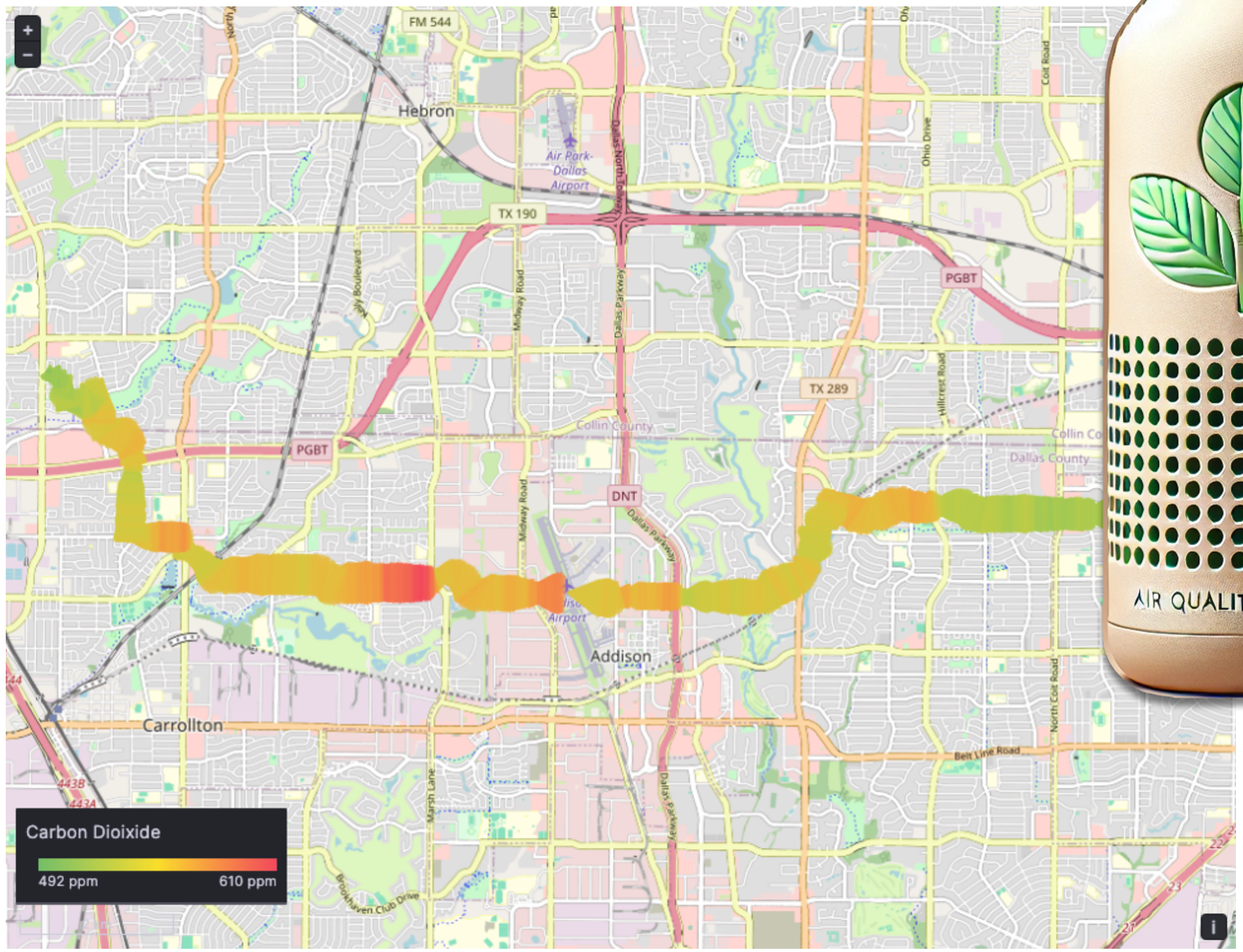
Hyperlocal AQ
Microenvironments

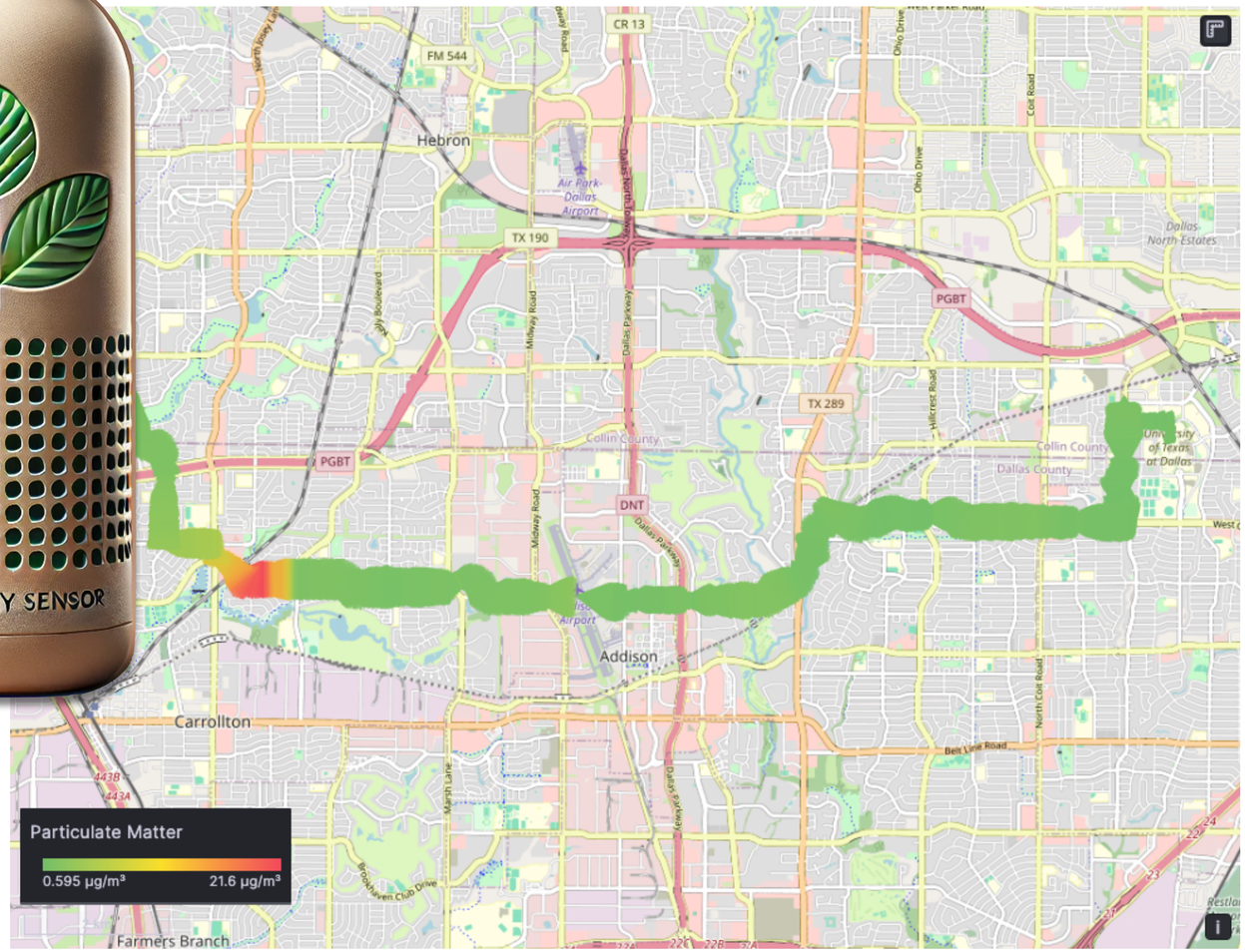




Hyper-Local Micro Environments

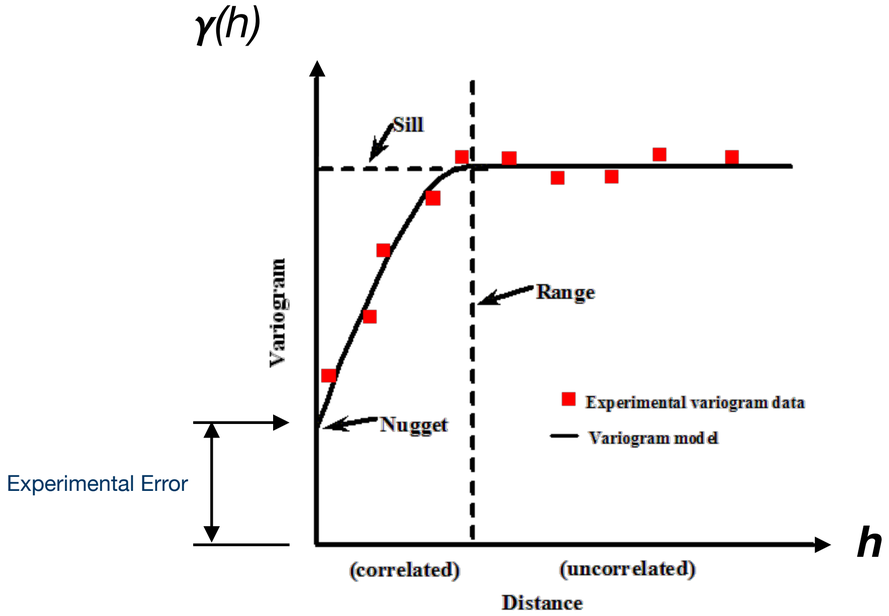
Hyperlocal AQ
Microenvironments





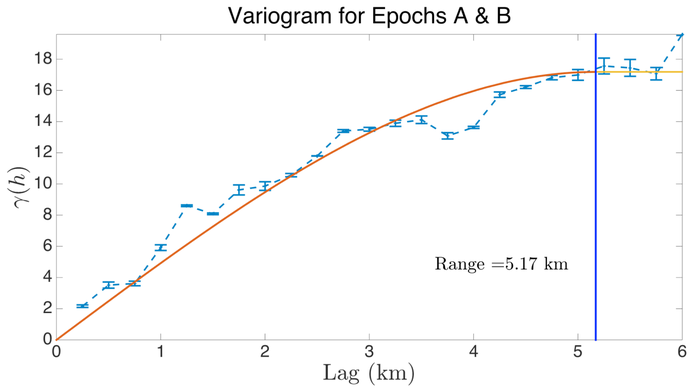
Hyperlocal AQ Microenvironments

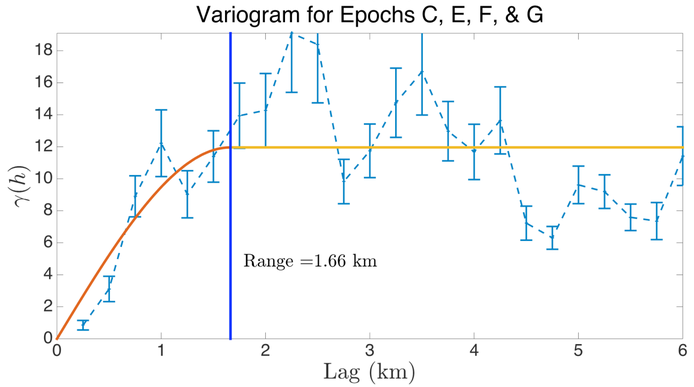
Hyper-Local Micro Environments

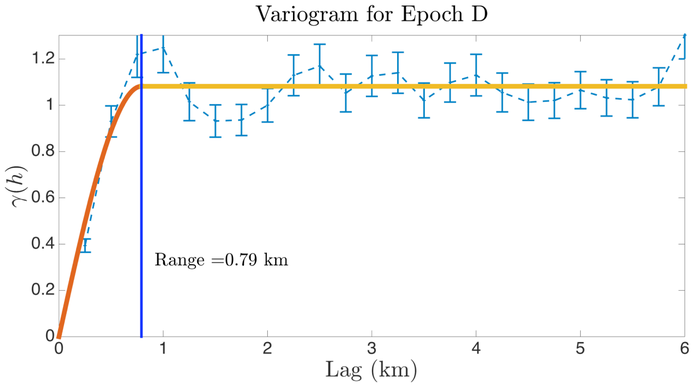


$$\gamma(h) = \frac{\sum\left(y\left(x_i + h\right) - y\left(x_i\right)\right)^2}{2N}$$

Half of the variance







Hyperlocal AQ
Microenvironments

Hyper-Local Micro Environments

https://www.scirp.org/html/6-6702595_56216.htm

Journal of Environmental Protection, 2015, 6, 464-476
Published Online May 2015 in SciRes. http://www.scirp.org/journal/jep
http://dx.doi.org/10.4236/jep.2015.65045

Scientific Research Publishing

The Neighborhood Scale Variability of Airborne Particulates

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Received 26 February 2015; accepted 8 May 2015; published 11 May 2015

Abstract

Airborne particulates play a central role in both the earth's radiation balance and as a trigger for a wide range of health impacts. Air quality monitors are placed in networks across many cities globally. Typically these provide at best a few recording locations per city. However, large spatial variability occurs on the neighborhood scale. This study sets out to comprehensively characterize a full size distribution from 0.25 - 32 μm of airborne particulates on a fine spatial scale (meters). The data are gathered on a near daily basis over the month of May, 2014 in a 100 km² area encompassing parts of Richardson, and Garland, TX. Wind direction was determined to be the dominant factor in classifying the data. The highest mean $PM_{2.5}$ concentration was 14.1 ± 5.7 μg·m⁻³ corresponding to periods when the wind was out of the south. The lowest $PM_{2.5}$ concentrations were observed after several consecutive days of rainfall. The rainfall was found to not only "cleanse" the air, leaving a mean $PM_{2.5}$ concentration as low as 3.0 ± 0.5 μg·m⁻³, but also leave the region with a more uniform $PM_{2.5}$ concentration. Variograms were used to determine an appropriate spatial scale for future sensor placement to provide measurements on a neighborhood scale and found that the spatial scales varied, depending on the synoptic weather pattern, from 0.8 km to 5.2 km, with a typical length scale of 1.6 km.

Keywords

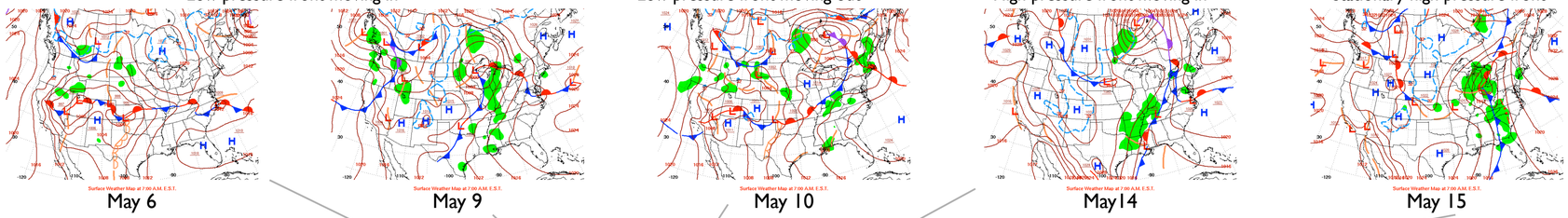
$PM_{2.5}$, Variograms, Neighborhood Scale, Spatial Length

1. Introduction

Multiple studies have established a strong link between aerosols and health issues [1]-[4]. Several illnesses have been attributed to long-term exposure of aerosols [5]-[7]. However, even short term exposure can have an effect on cardiovascular/cardiopulmonary or respiratory health [1] [8]. Aerosols and particulates have even been

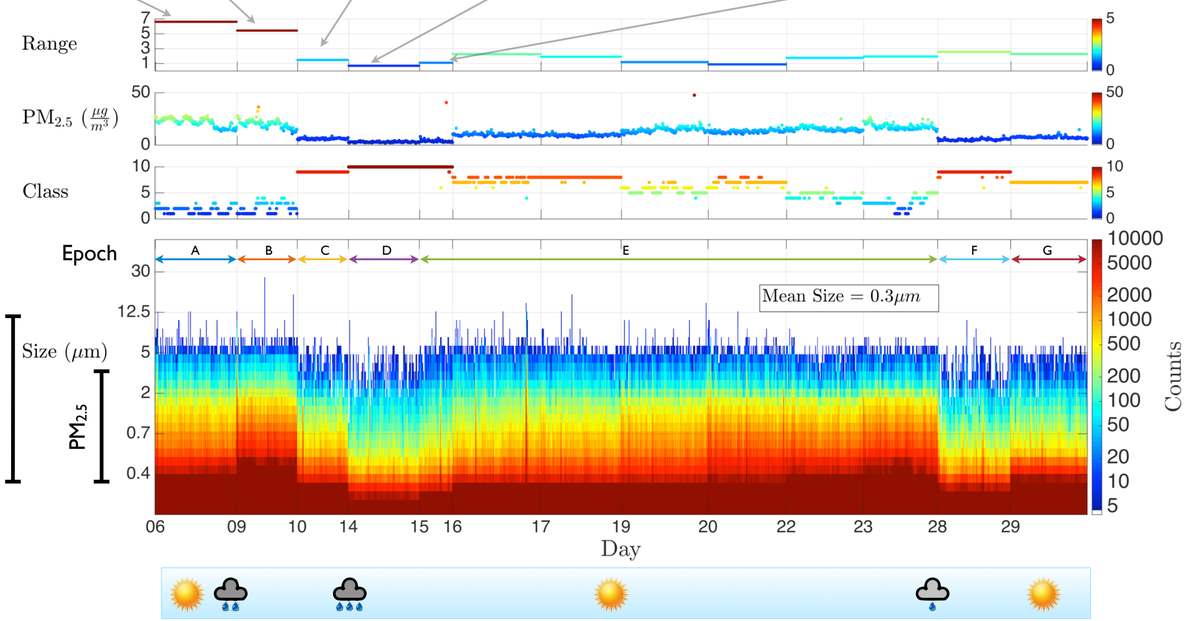
How to cite this paper: Harrison, W.A., Lary, D., Nathan, B. and Moore, A.G. (2015) The Neighborhood Scale Variability of Airborne Particulates. *Journal of Environmental Protection*, **6**, 464-476. http://dx.doi.org/10.4236/jep.2015.65045

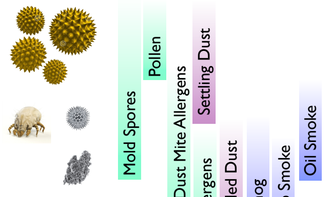
Low pressure front moving in | Low pressure front moving in | Low pressure front moving out | High pressure front moving in | Stationary high pressure front

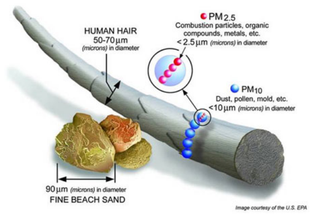


May 6 | May 9 | May 10 | May14 | May 15

May 2014





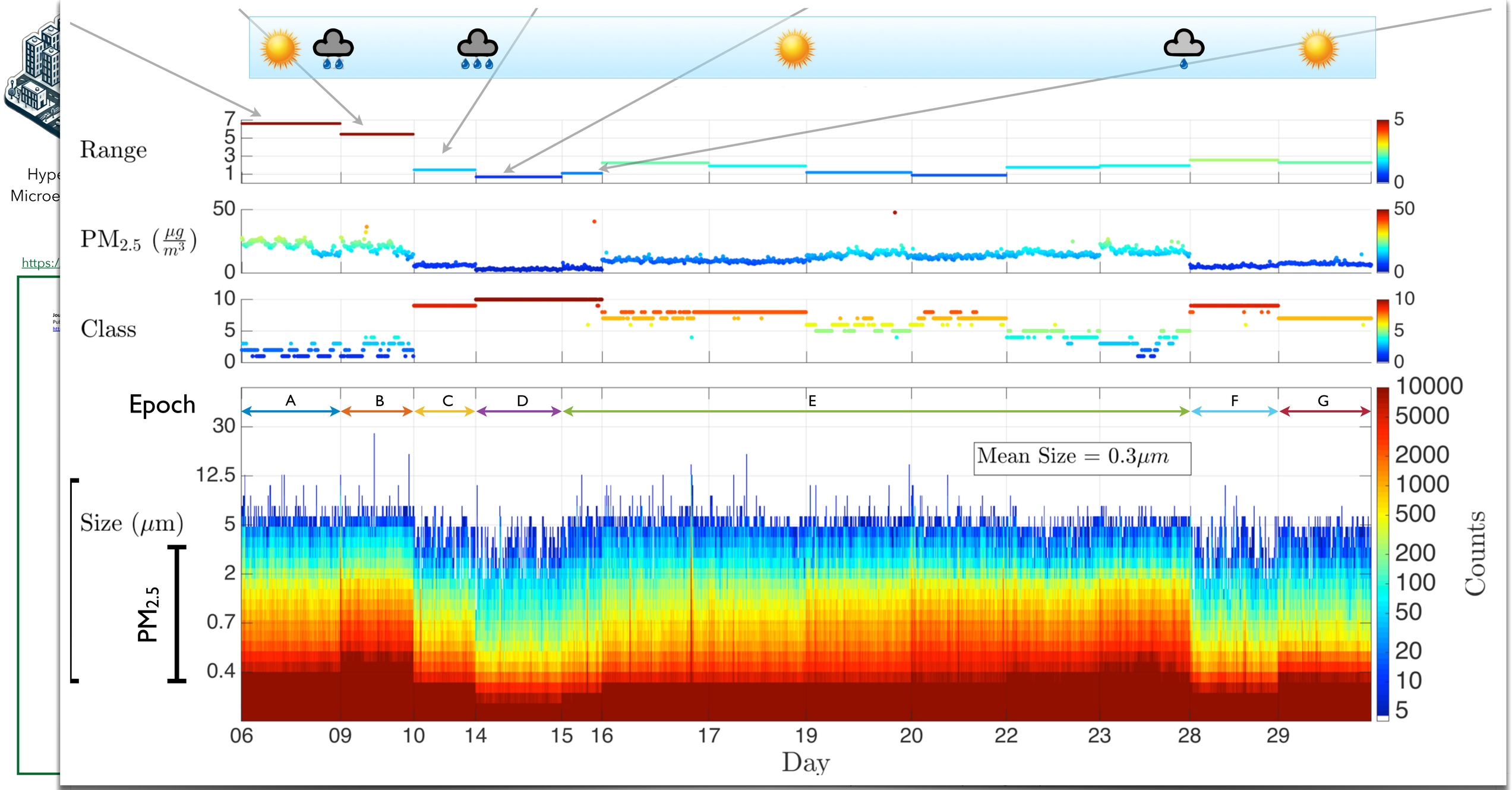


No significant rain in 16 days

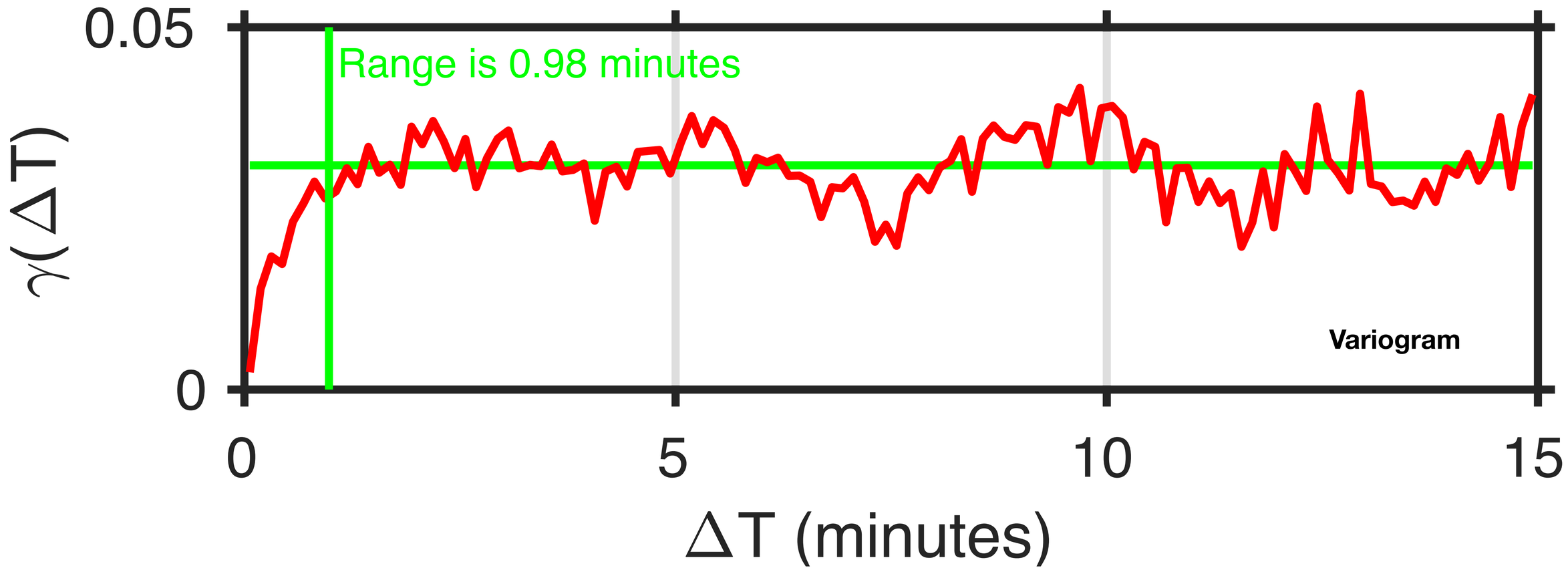
0.56" of rain on May 8

0.91" of rain for May 12, 13, and early morning on May 14 combined

0.27" of rain for May 25, 26, and 27 combined


Range
PM2.5 (μg/m³)
Class
Epoch
A
B
C
D
E
F
G
Size (μm)
PM2.5
Mean Size = 0.3μm
Counts
Day
06
09
10
14
15
16
17
19
20
22
23
28
29

Temporal Scales

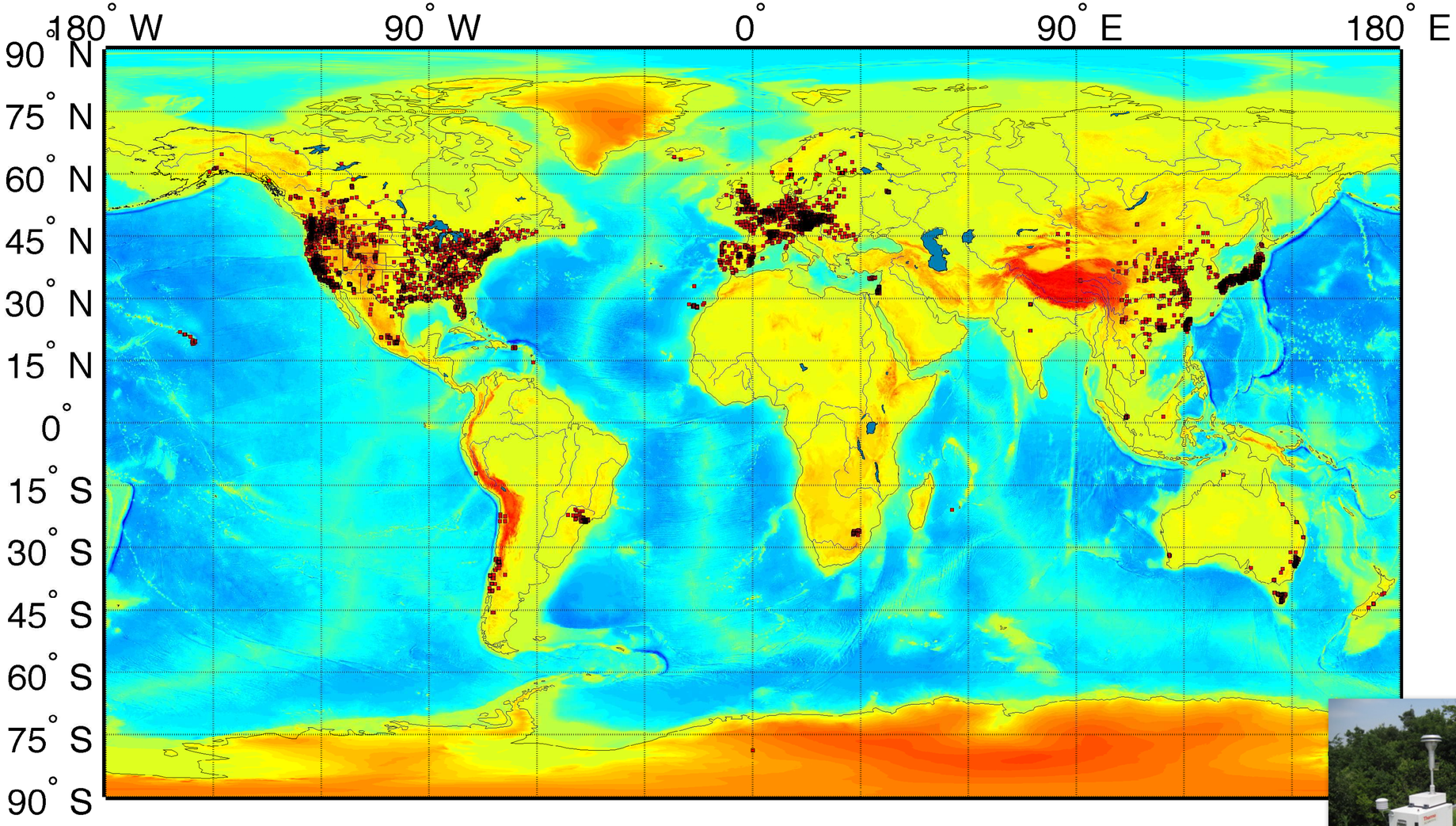


When collecting data over time, a **temporal variogram** can guide the design of efficient sampling strategies by identifying the optimal time intervals for data collection, ensuring that the data captures the relevant temporal variability.

$$\gamma(\Delta T) = \frac{1}{2N(\Delta T)} \sum_{i=1}^{N(\Delta T)} \left[Z(t_i) - Z(t_i + \Delta T) \right]^2$$

Remote Sensing
& AQ with ML

Remote Sensing & AQ with ML



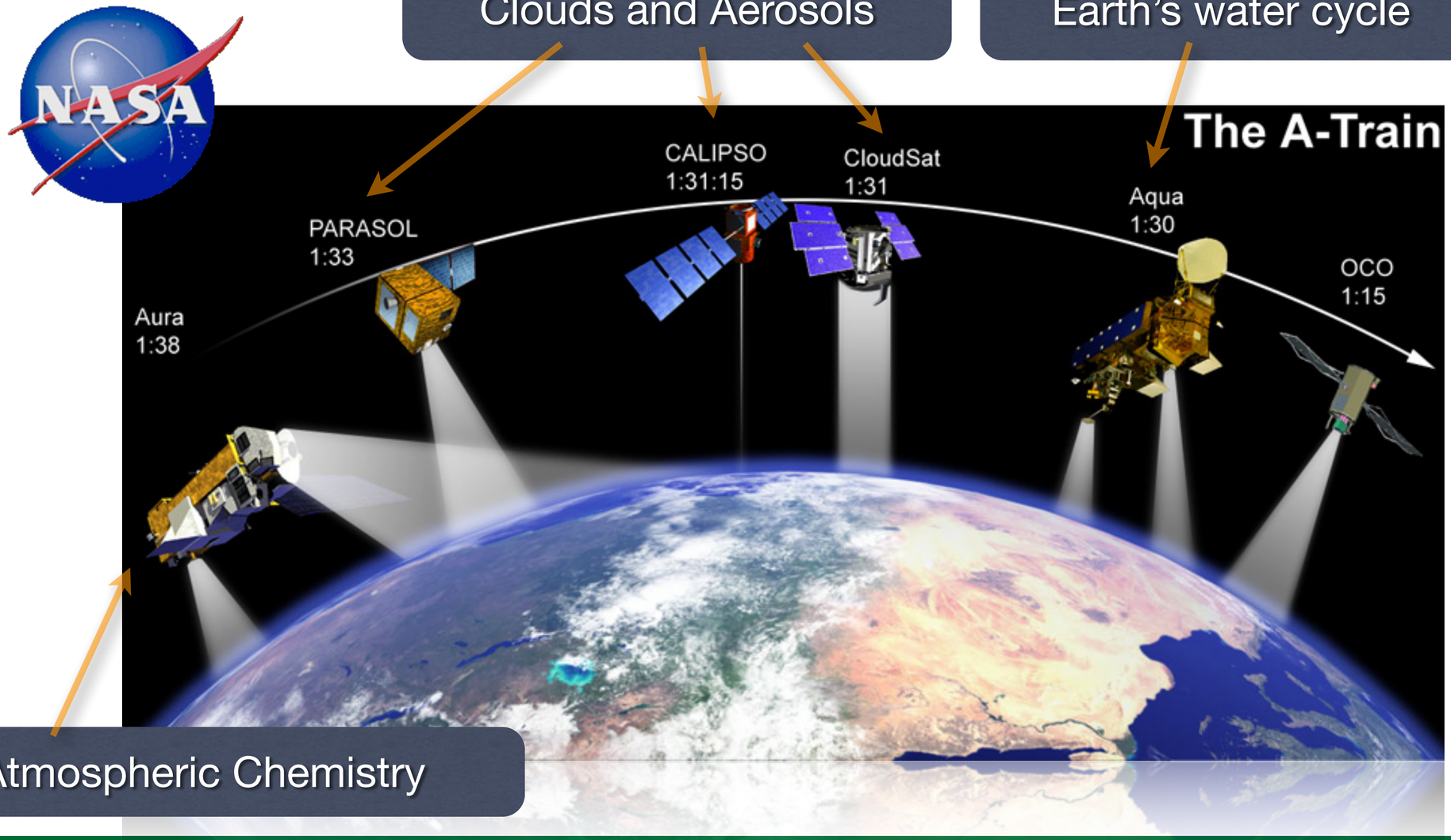
Hourly Measurements from 55 countries and more than 8,000 measurement sites from 1997-present

Remote Sensing
& AQ with ML

Remote Sensing & AQ with ML

Clouds and Aerosols

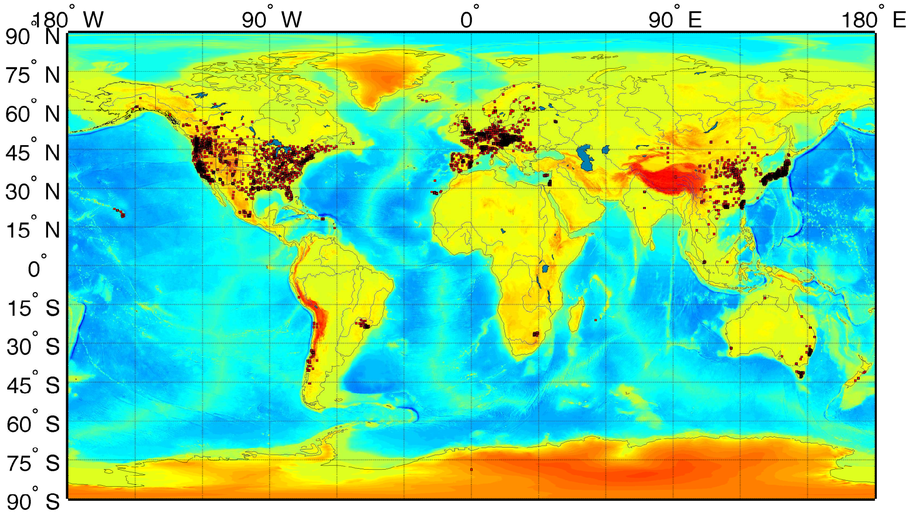
Earth’s water cycle



Atmospheric Chemistry

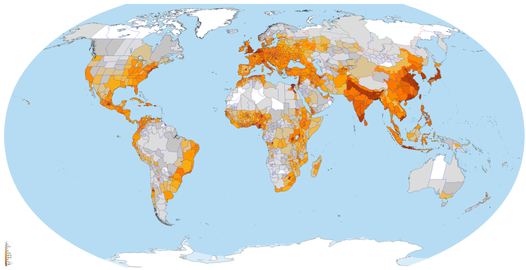
Remote Sensing & AQ with ML

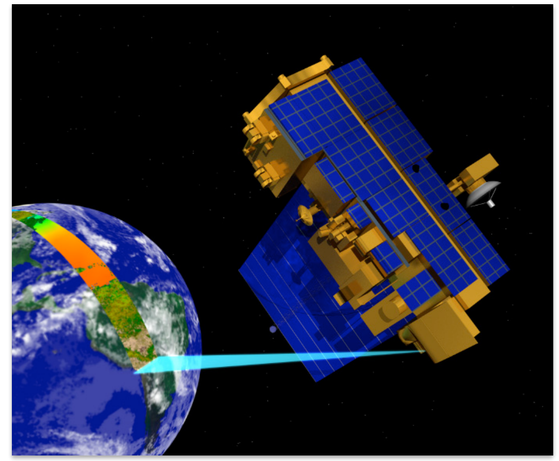
Remote Sensing
& AQ with ML



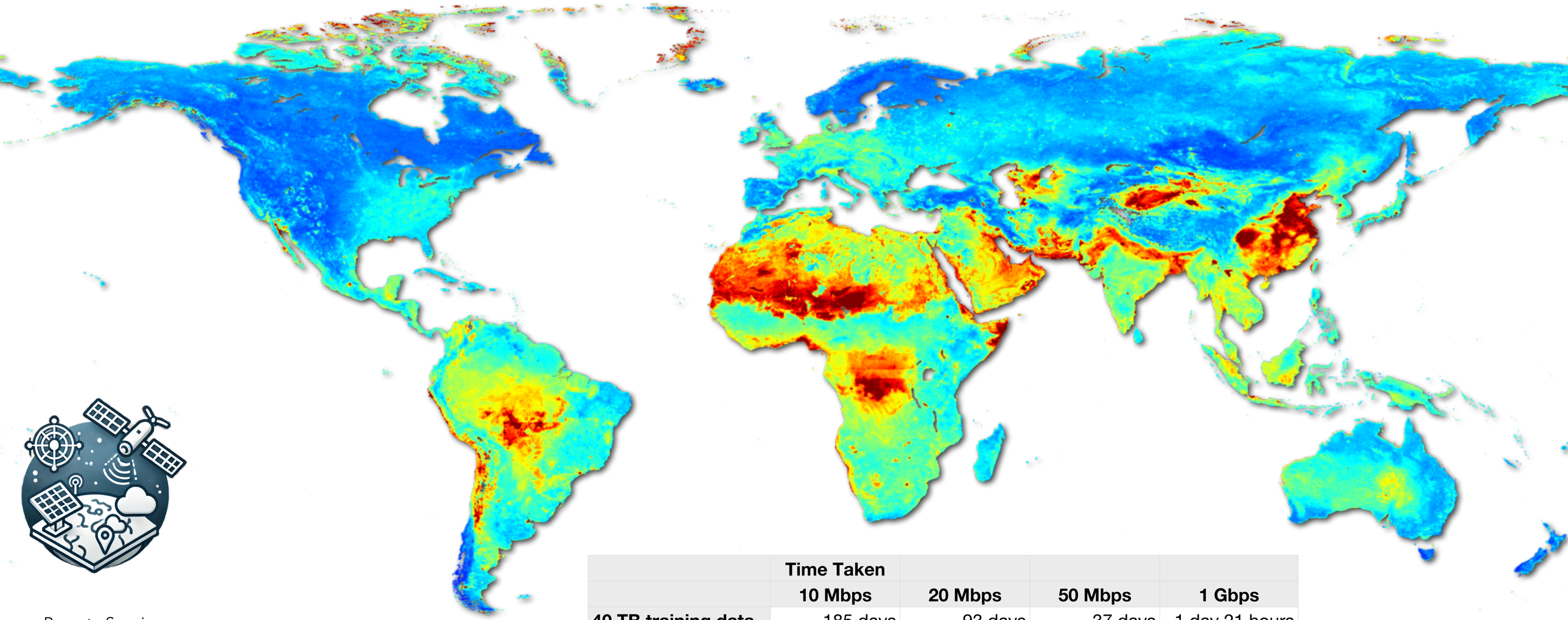
Aqua DeepBlue

Rank	Source	Variable	Type
1	Satellite Product	Tropospheric NO_2 Column	Input
2	Satellite Product	Solar Azimuth	Input
3	Meteorological Analyses	Air Density at Surface	Input
4	Satellite Product	Sensor Zenith	Input
5	Satellite Product	White-sky Albedo at 470 nm	Input
6		Population Density	Input
7	Satellite Product	Deep Blue Surface Reflectance 470 nm	Input
8	Meteorological Analyses	Surface Air Temperature	Input
9	Meteorological Analyses	Surface Ventilation Velocity	Input
10	Meteorological Analyses	Surface Wind Speed	Input
11	Satellite Product	White-sky Albedo at 858 nm	Input
12	Satellite Product	White-sky Albedo at 2,130 nm	Input
13	Satellite Product	Solar Zenith	Input
14	Meteorological Analyses	Surface Layer Height	Input
15	Satellite Product	White-sky Albedo at 1,240 nm	Input
16	Satellite Product	Deep Blue Surface Reflectance 660 nm	Input
17	Satellite Product	Deep Blue Surface Reflectance 412 nm	Input
18	Satellite Product	White-sky Albedo at 1,640 nm	Input
19	Satellite Product	Sensor Azimuth	Input
20	Satellite Product	Scattering Angle	Input
21	Meteorological Analyses	Surface Velocity Scale	Input
22	Satellite Product	Cloud Mask Qa	Input
23	Satellite Product	White-sky Albedo at 555 nm	Input
24	Satellite Product	Deep Blue Aerosol Optical Depth 550 nm	Input
25	Satellite Product	Deep Blue Aerosol Optical Depth 660 nm	Input
26	Satellite Product	Deep Blue Aerosol Optical Depth 412 nm	Input
27	Meteorological Analyses	Total Precipitation	Input
28	Satellite Product	White-sky Albedo at 648 nm	Input
29	Satellite Product	Deep Blue Aerosol Optical Depth 470 nm	Input
30	Satellite Product	Deep Blue Angstrom Exponent Land	Input
31	Meteorological Analyses	Surface Specific Humidity	Input
32	Satellite Product	Cloud Fraction Land	Input
	In-situ Observation	**$PM_{2.5}$**	**Target**



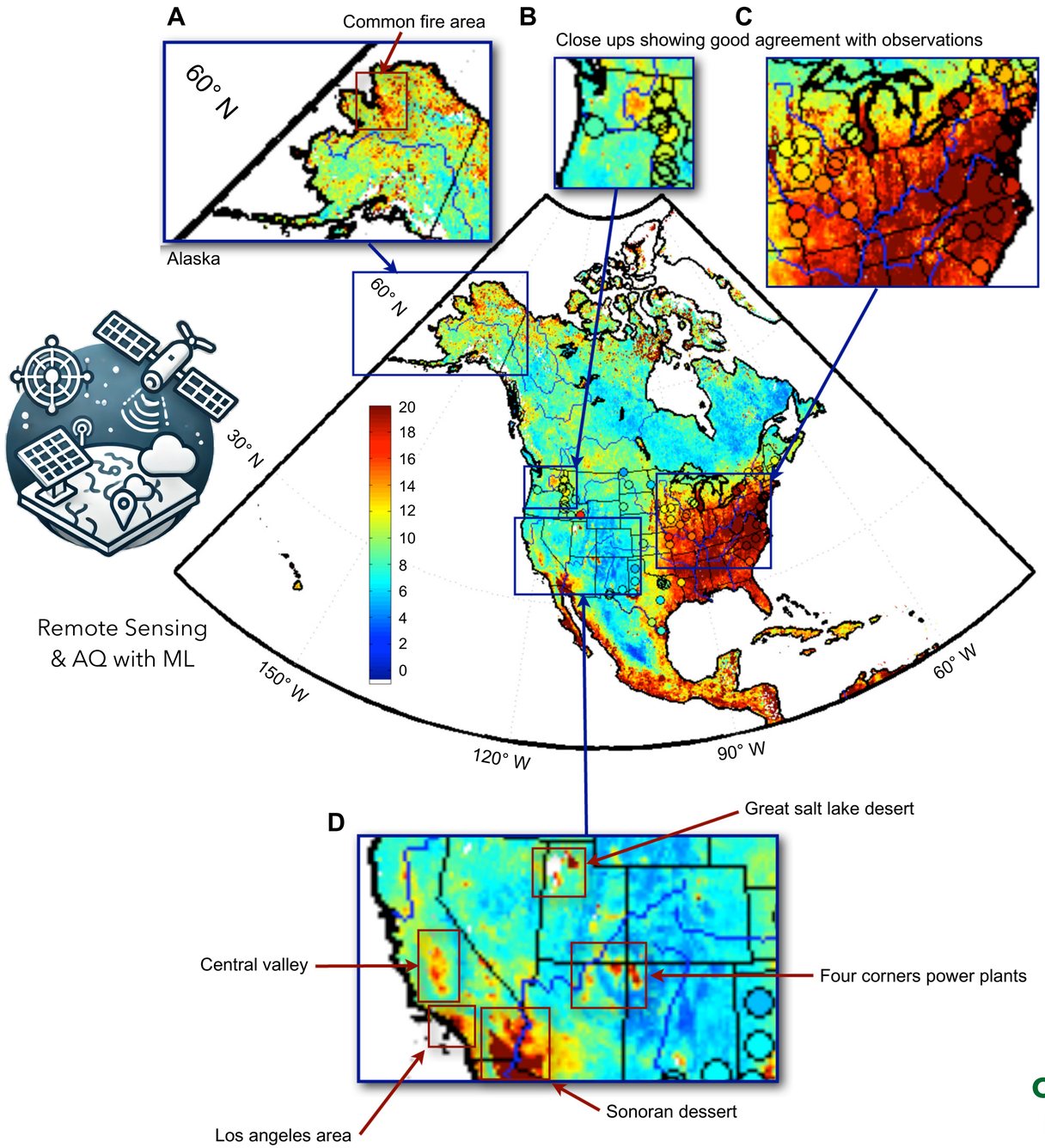


Remote Sensing & AQ with ML



Remote Sensing
& AQ with ML

	Time Taken			
	10 Mbps	**20 Mbps**	**50 Mbps**	**1 Gbps**
40 TB training data	185 days	93 days	37 days	1 day 21 hours
4 Gb update	54m	27m	11m	32s

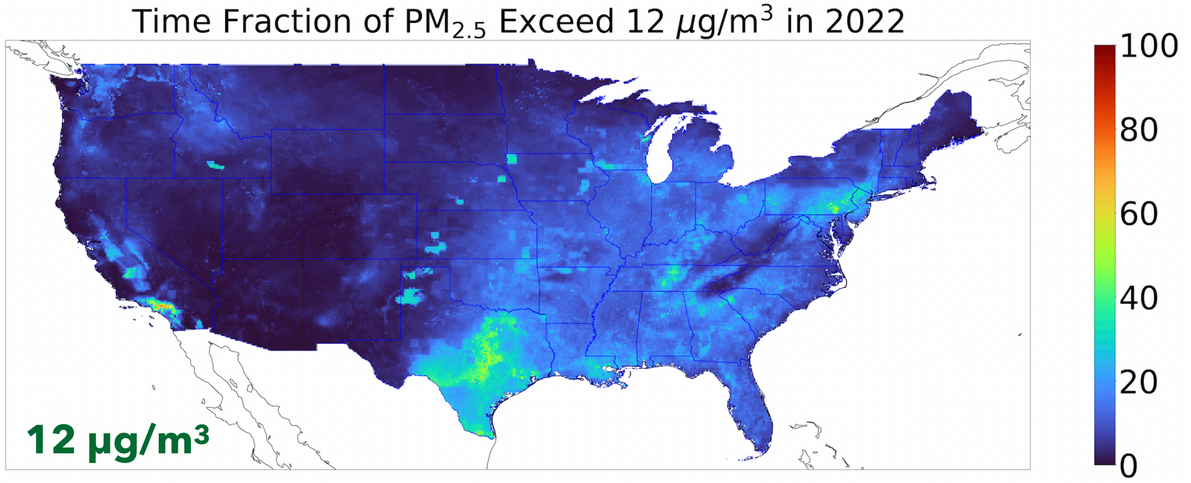


Remote Sensing & AQ with ML

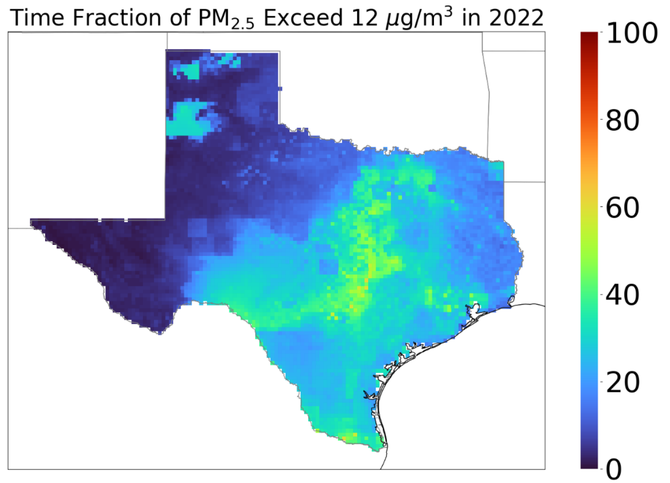
The monthly average of our machine learning $PM_{2.5}$ product (g m^{-3}) for August 2001. The average of the observations at a given site is overlaid as color filled circles when observations were available for at least a third of the days. Notice the good agreement between the $PM_{2.5}$ product and the observations. Also, as would be expected, in summer, the eastern US has much higher $PM_{2.5}$ abundance than the western US. Central Valley and LA are clearly visible in California. Inset panel (**A**) is of Alaska and highlights common fire areas associated with elevated $PM_{2.5}$. Insets (**B**) and (**C**) show the good agreement between our product and observations. Inset (**D**) shows the elevated $PM_{2.5}$ with the heavily agricultural Central Valley in California, the highly populated Los Angeles metro area, the Sonoran desert (one of the most active dust source regions in the US), and the Four Corners power plants (some of the largest coal-fired generating stations in the US), and the Great Salt Lake Desert. Note the fine scaled features visible in this product, which are in marked contrast to the AirNow product.

CITATION: Lary et al. Using Machine Learning to Estimate Global PM2.5 for Environmental Health Studies. *Environmental Health Insights* 2015:9(S1) 41–52 doi: 10.4137/EHI.S15664.

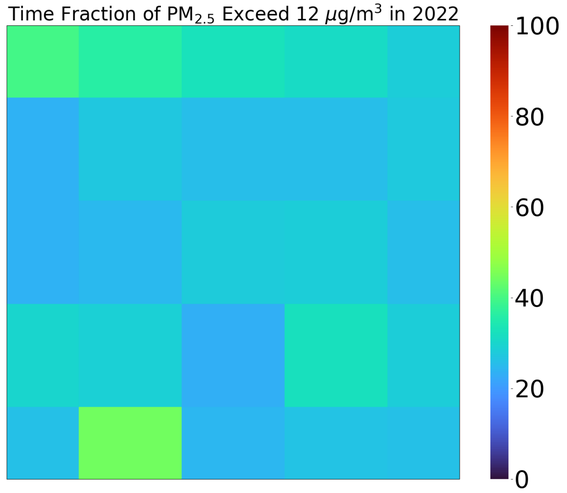
Fraction of the Time There is an Exceedance



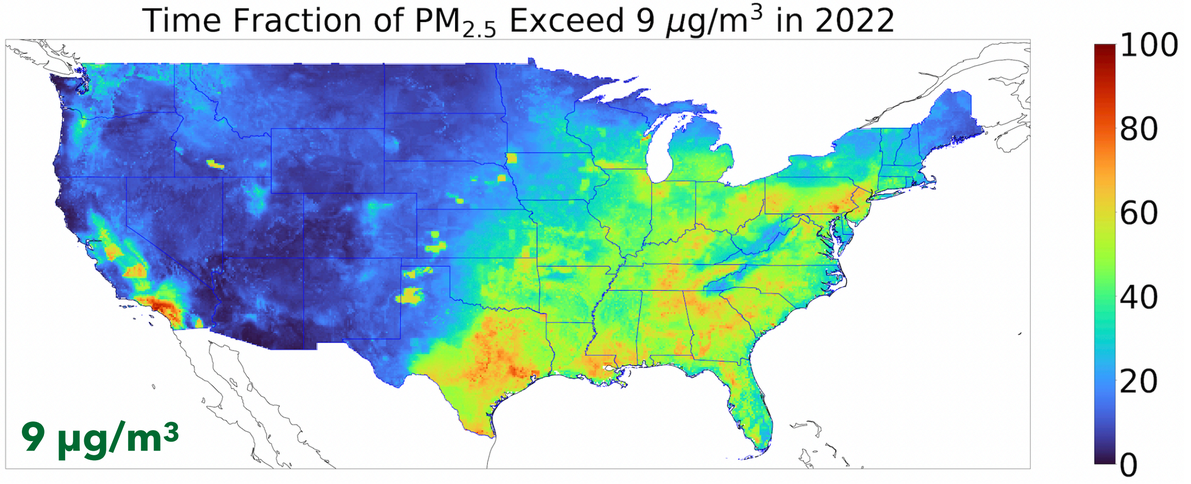
USA

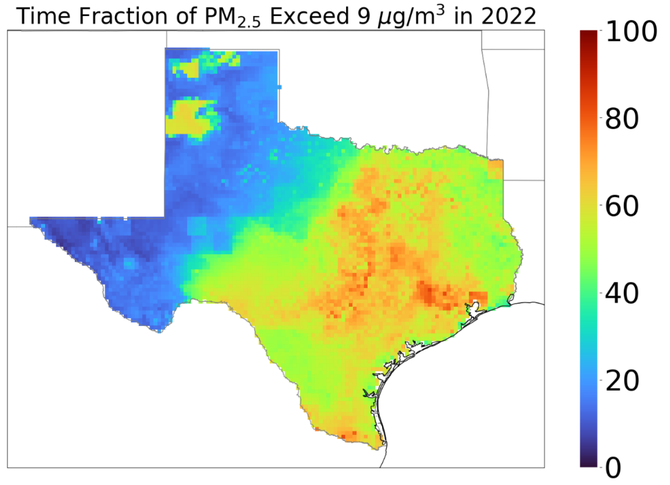


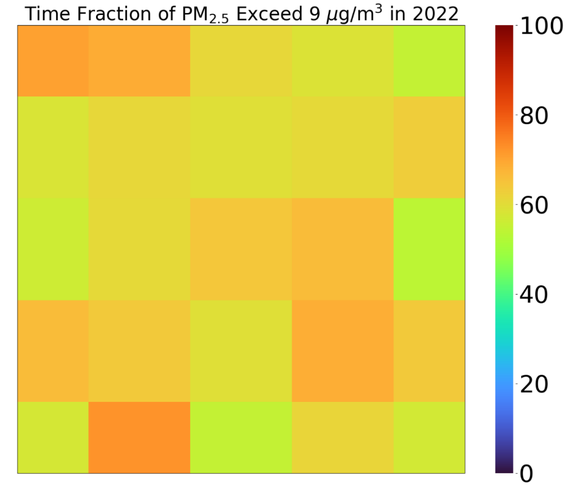
Texas



Dallas County

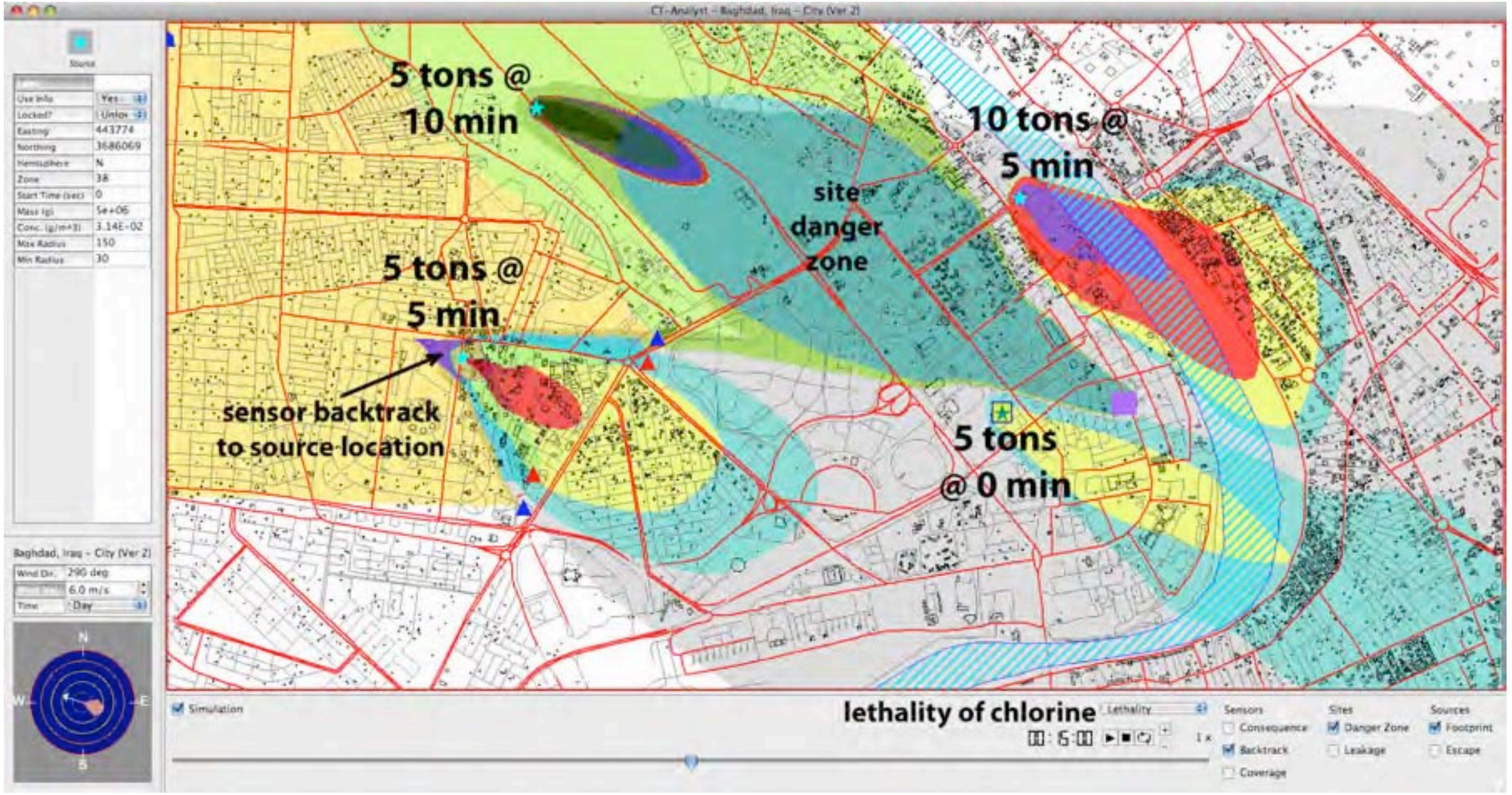






Plots by Prabuddha Dewage

Predicting Lethality

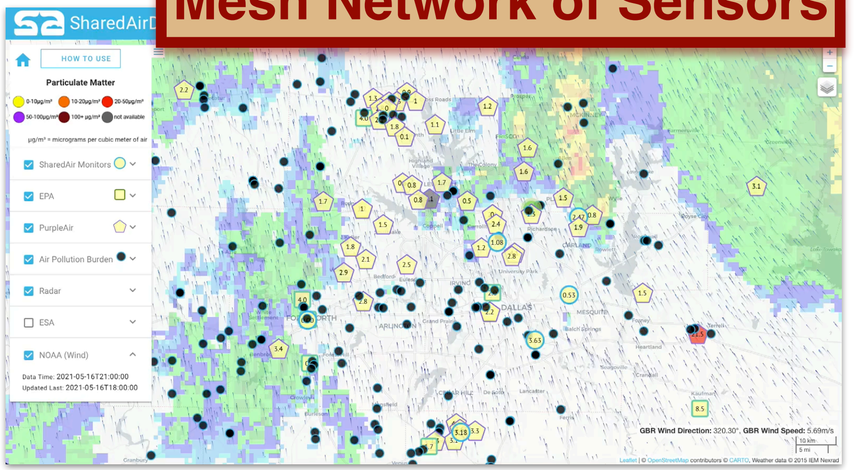


The entire CT-Analyst GUI display predicting lethality for a scenario involving four separate chlorine releases in downtown Baghdad. Notations have been added giving the amounts and release times of the four sources. Sensor fusion for a backtrack computation and a site danger zone are also shown. Computation for this composite display takes about 0.1 second.

Wearables

Simulation

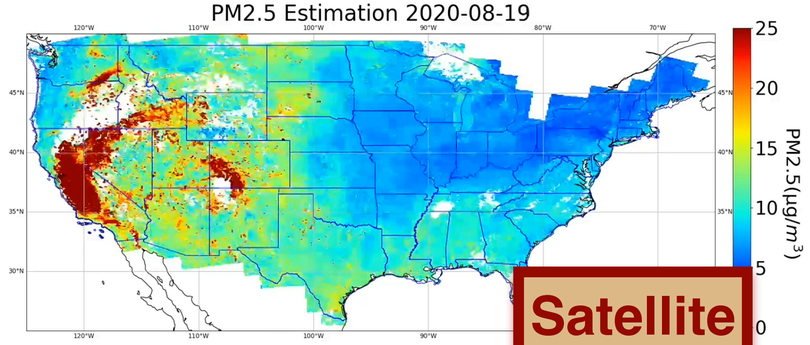
Mesh Network of Sensors



MINTS-AI

Forewarned is forearmed;
to be prepared is half the victory.

Satellite



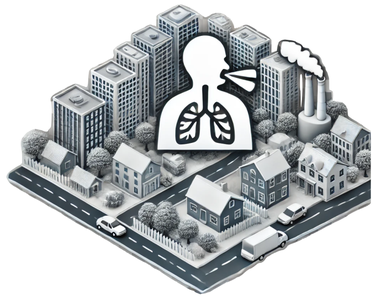
Co-operating Robot Team

Each Platform Has Multiple Payloads

Maritime

MINTS-AI: Human Health and Sensing in Service of Society

Prof. David. J. Lary



Hyperlocal AQ
Health Outcomes

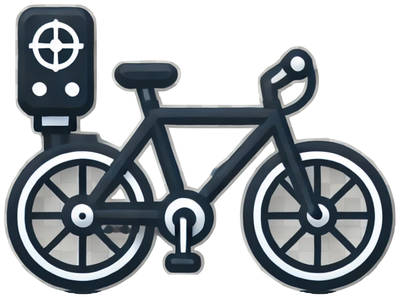
Hyperlocal AQ
Microenvironments

Humans as Sensors
for AQ with ML

Static AQ Monitors
Calibrated with ML

Remote Sensing
& AQ with ML

Mobile AQ Monitors on EVs
Calibrated with ML



Mobile AQ Monitors on Bikes
Calibrated with ML

Thank you!

Next Meeting: April 24, 2025

Recap email and next meeting details to follow.

Please reach out to Analisa Garcia with any questions.

Email: agarcia@nctcog.org

Phone: (817) 695-9170