



Citizen Science
and the
Internet of Things

The Cloud and the Crowd

- Clean Air Carolina's **history and initiatives**
- **AirKeepers** and the Citizen Science program
- Clean Air Carolina's **statewide partners and scope**
- **Success stories** through Citizen Science

Our Mission

TO ENSURE
CLEANER AIR QUALITY
FOR **ALL**
NORTH CAROLINIANS
THROUGH **EDUCATION**
AND **ADVOCACY**
AND BY WORKING WITH OUR PARTNERS
TO REDUCE SOURCES OF
POLLUTION



Our Programs

Medical Advocates for Healthy Air

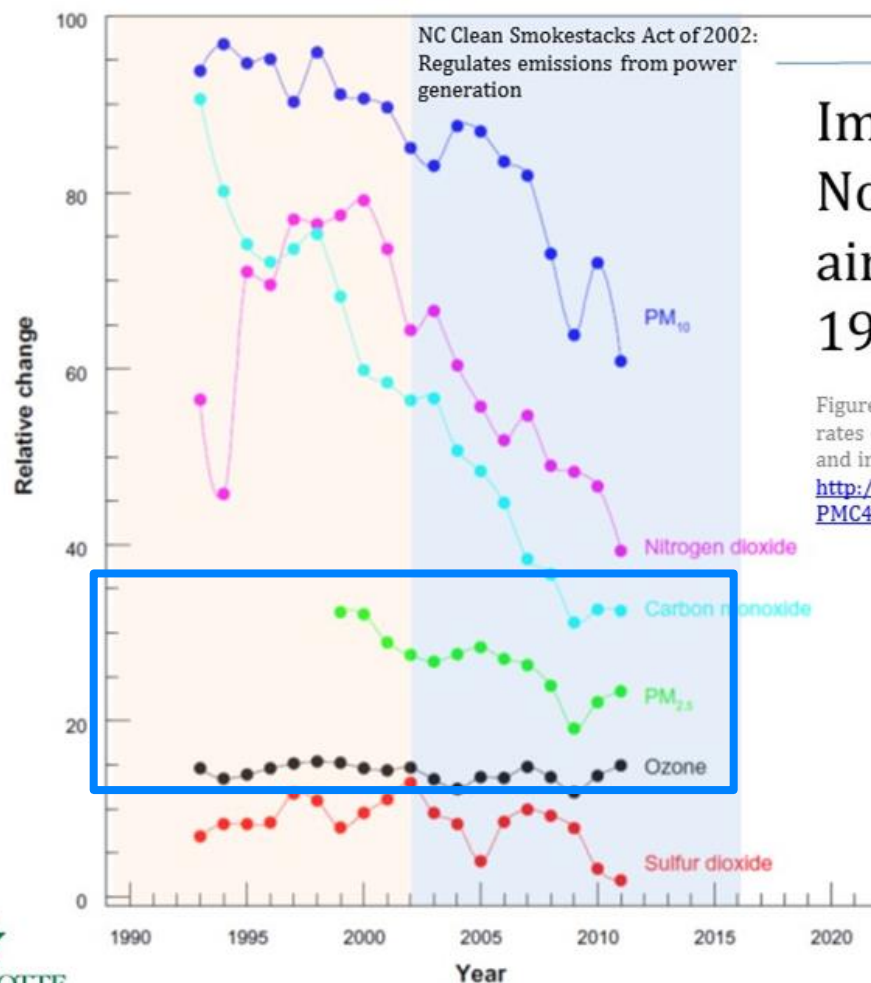


Clear the Air for the Kids!



Clean Construction

Federal Clean Air Act of 1970:
guarantees right to breathe healthy air

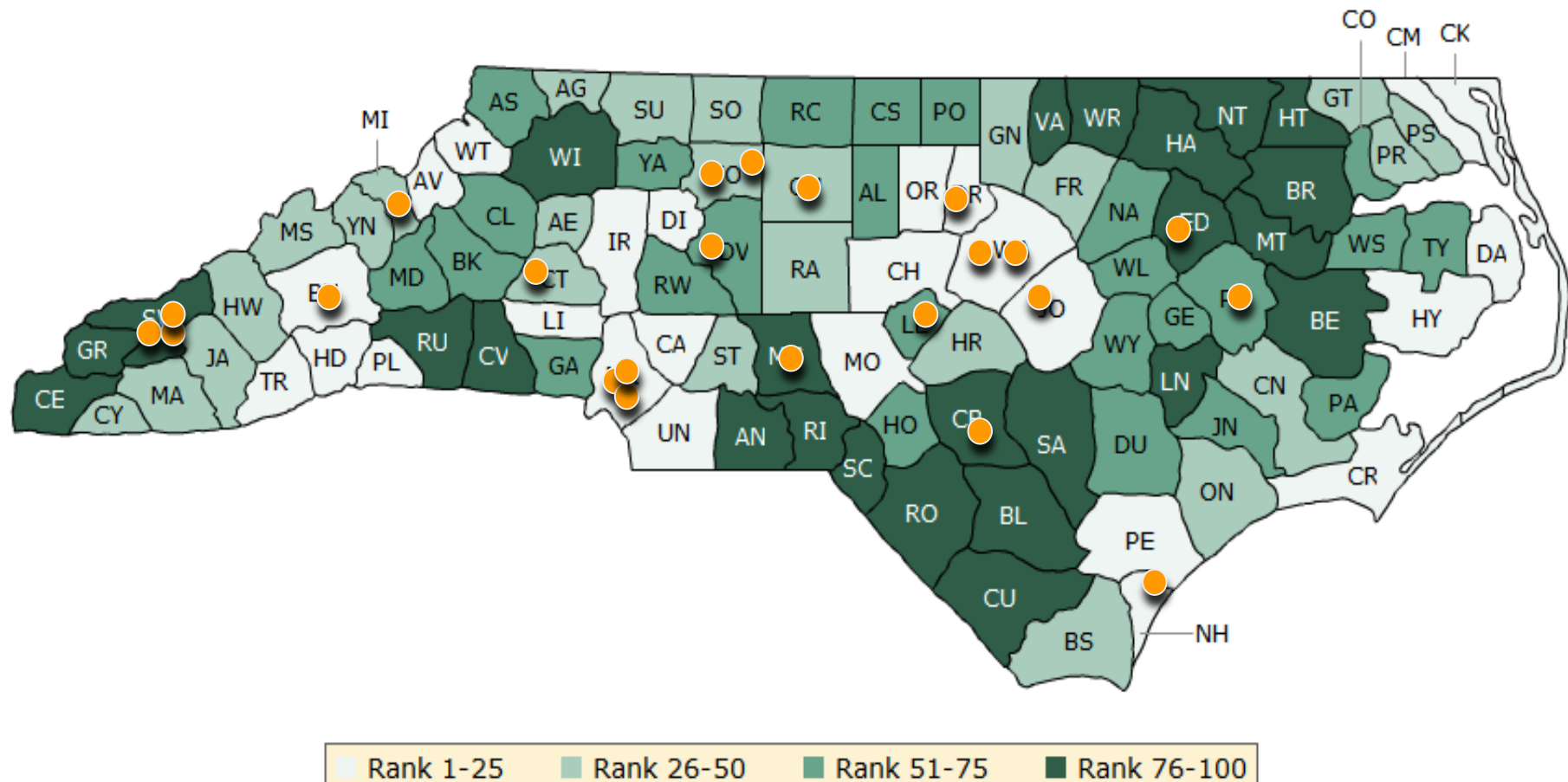


Improvements in North Carolina air quality since 1990s

Figure source: "Long-term dynamics of death
rates of emphysema, asthma, and pneumonia
and improving air quality"

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4075234/>

Our Challenge

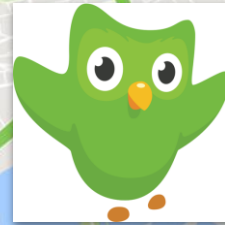




AirKeepers



Passive Examples



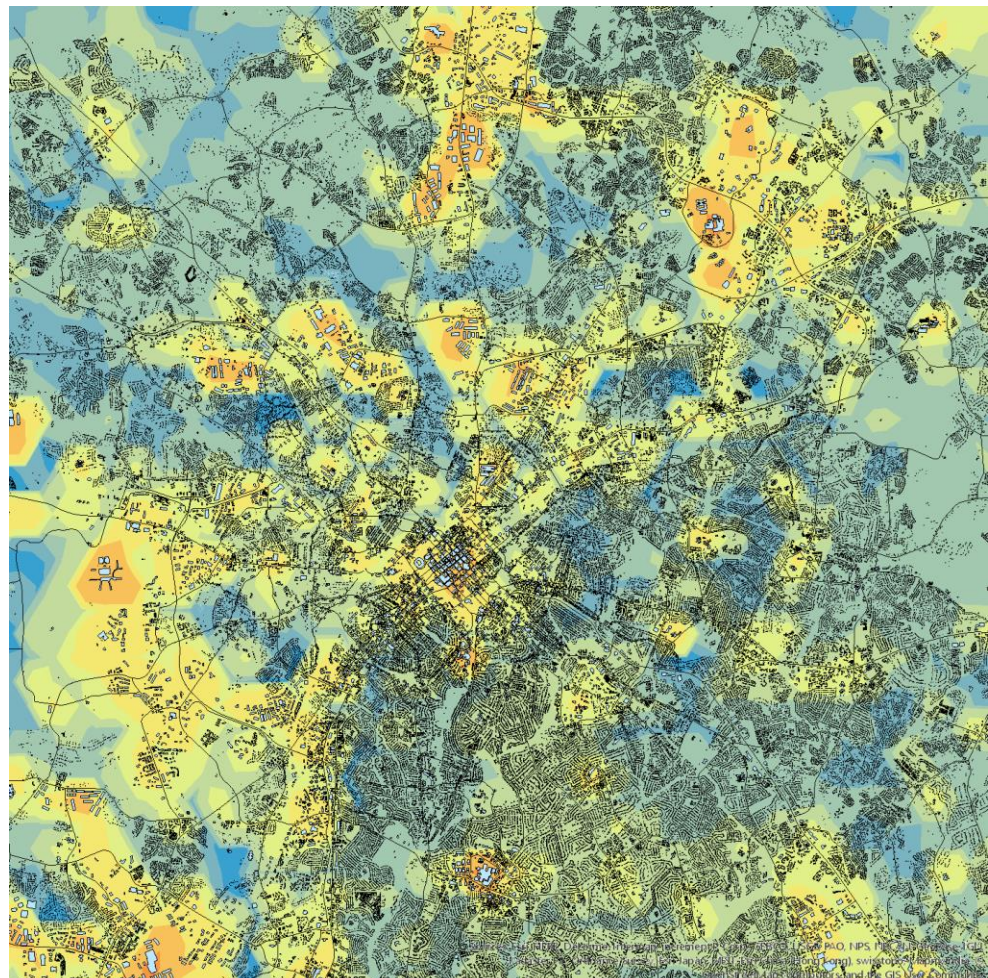
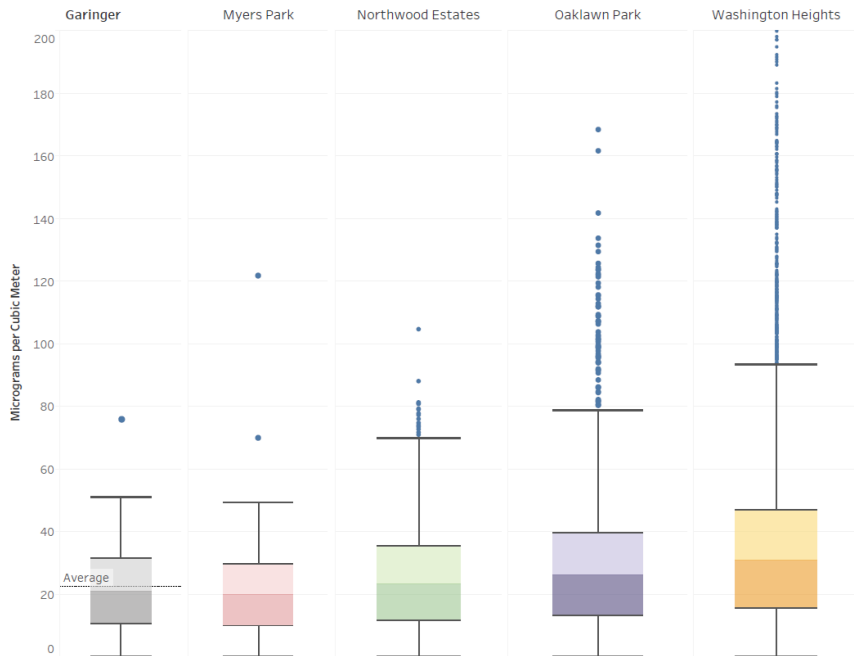
duolingo

PM 2.5 Monitors

- Fraction of the **Cost**
- **Compact** size
- **Relative Humidity**, and **Temperature**
- **Geotagged** data-points
- Web-based **mapping**



High Resolution **Modelling**



The most important part
of Crowdsourcing
is the Crowd

Monitoring on Campus



Fast Food vs. Forest Air: Fair or Foul?

Pragathi Quin and Christina Sawyer

Classmates of South Carolina at Charlotte
Charlotte, NC



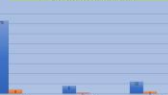
Introduction

Fast particulate air matter, also known as $PM_{2.5}$, is a form of air pollutant that is known to be a concern for people's health. $PM_{2.5}$ when inhaled can have negative effects on the eyes, ears, nose, and lungs causing irritation such as coughing, sneezing, runny nose, and shortness of breath.

Results

Our results established that there is a significant difference in the amount of air particulate matter present in the forest as compared to the inside of a populous building of the University. The forest had a significantly less amount of air particulate matter than the fast food environment did. When we ran the specifically that fast food environment in the Student Union had about 75 percent more air particulate matter present, the forest had about 4.75% more.

Particulate Matter Measurements



Method

We used a method of collecting data a few times a week between the afternoon hours of three and four o'clock in the same two locations: between two major fast food restaurants in the Student Union and a deep point in the forest on campus. At each location we used the air monitor and tablet provided by Cline, Air Carolina to record the amount of air particulate matter present at the times of recording.



Diagram of Fast Food Locations



UNIVERSITY of NORTH CAROLINA
PEMBROKE



THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

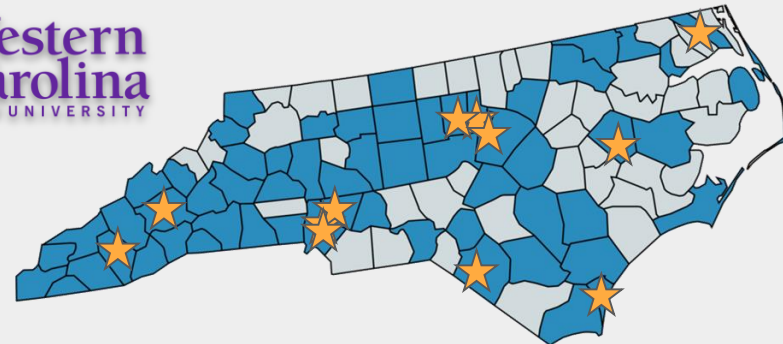


Johnson C. Smith University
Become yourself. Change our world.

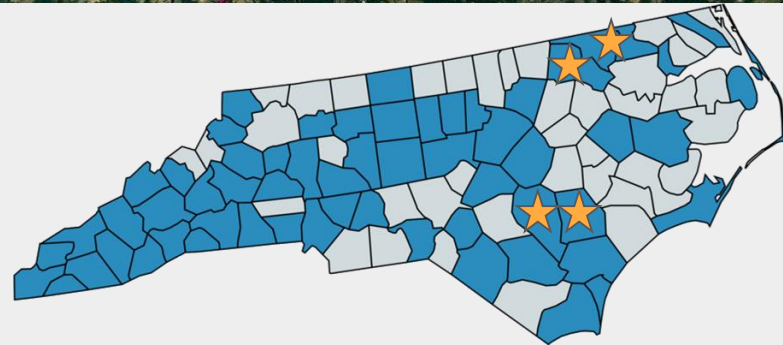


CENTRAL PIEDMONT
COMMUNITY COLLEGE

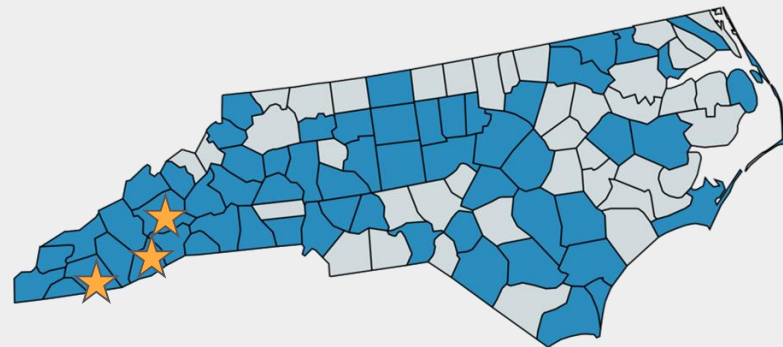
LENOIR-RHYNE
UNIVERSITY



EJ issues in the east

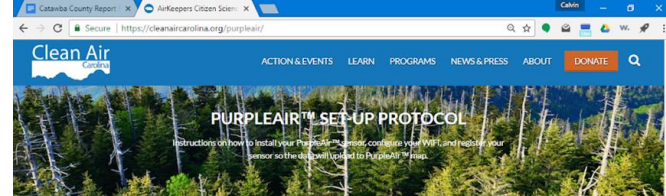
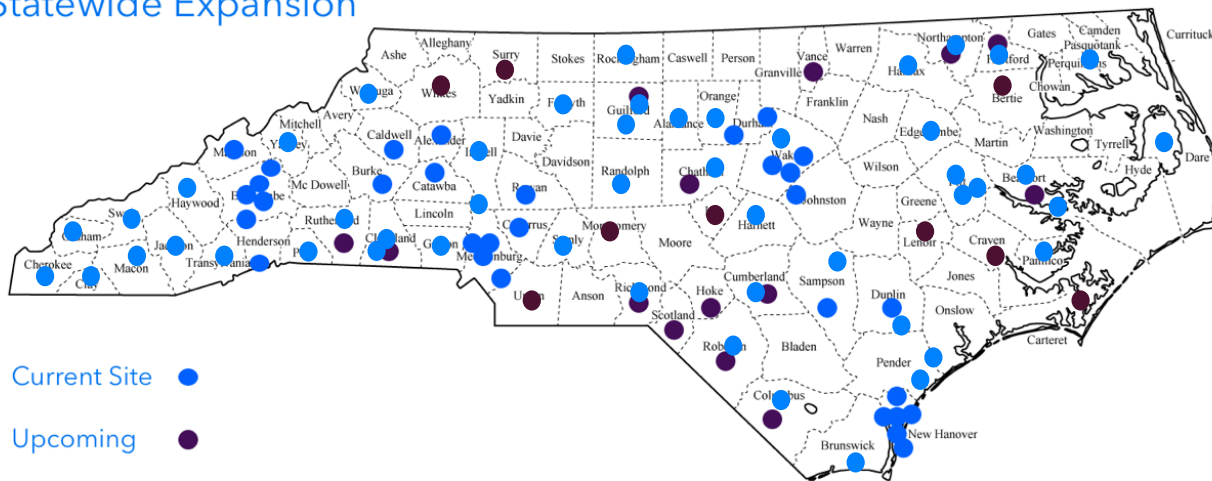


STEM Outreach in the West



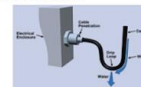
Statewide Platform

Statewide Expansion



INSTALLATION TIPS

1. The PurpleAir™ enclosure is designed to let air flow freely while protecting the electronics from the elements.
2. Although the power supply is waterproof, it should be mounted so that it will not be submerged in water or covered by snow.
3. Use a drip loop with wires to prevent water from running directly down wires into the device, power supply, or power outlet.



4. It is best to mount the sensor in a shady spot under the eave of the roof (usually the north-facing part of the house).
5. To produce better data, it is best to mount it away from vents or anything that might affect the readings, such as a charcoal grill.
6. The power cord is only 33 feet long, so you will need a power outlet within 33 feet of the sensor. (make sure you're in WiFi range as well)



INSTALLATION GUIDE

*Note: all screenshots are meant to provide a general guideline as screens for other devices may look different.



INSTALL YOUR PURPLEAIR™ SENSOR

- Step 1
- Step 2
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CONFIGURE WIFI

- Step 1
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Connect your phone, tablet, or computer to a WiFi network called "AirMonitor_XXXX". The "XXXX" is specific to your sensor.



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Locate your sensor's MAC address.



CONGRATULATIONS!

You have installed and registered your PurpleAir™ sensor. It may take a couple of days for the data from your sensor to appear on the PurpleAir™ Map.

NC BREATHE Conference



March 8 2018

The **Message**

No one cares
how much you know
until they know
How much you care

Questions?

AirKeepers





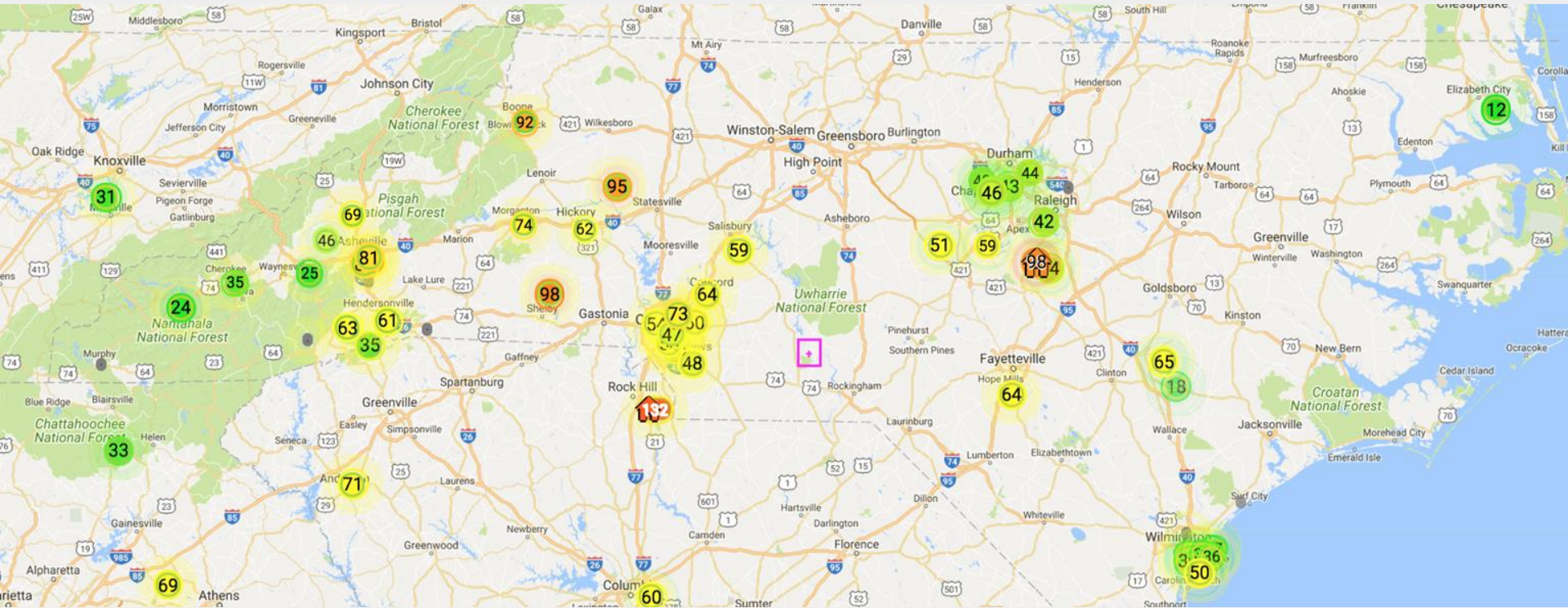
Thank you!

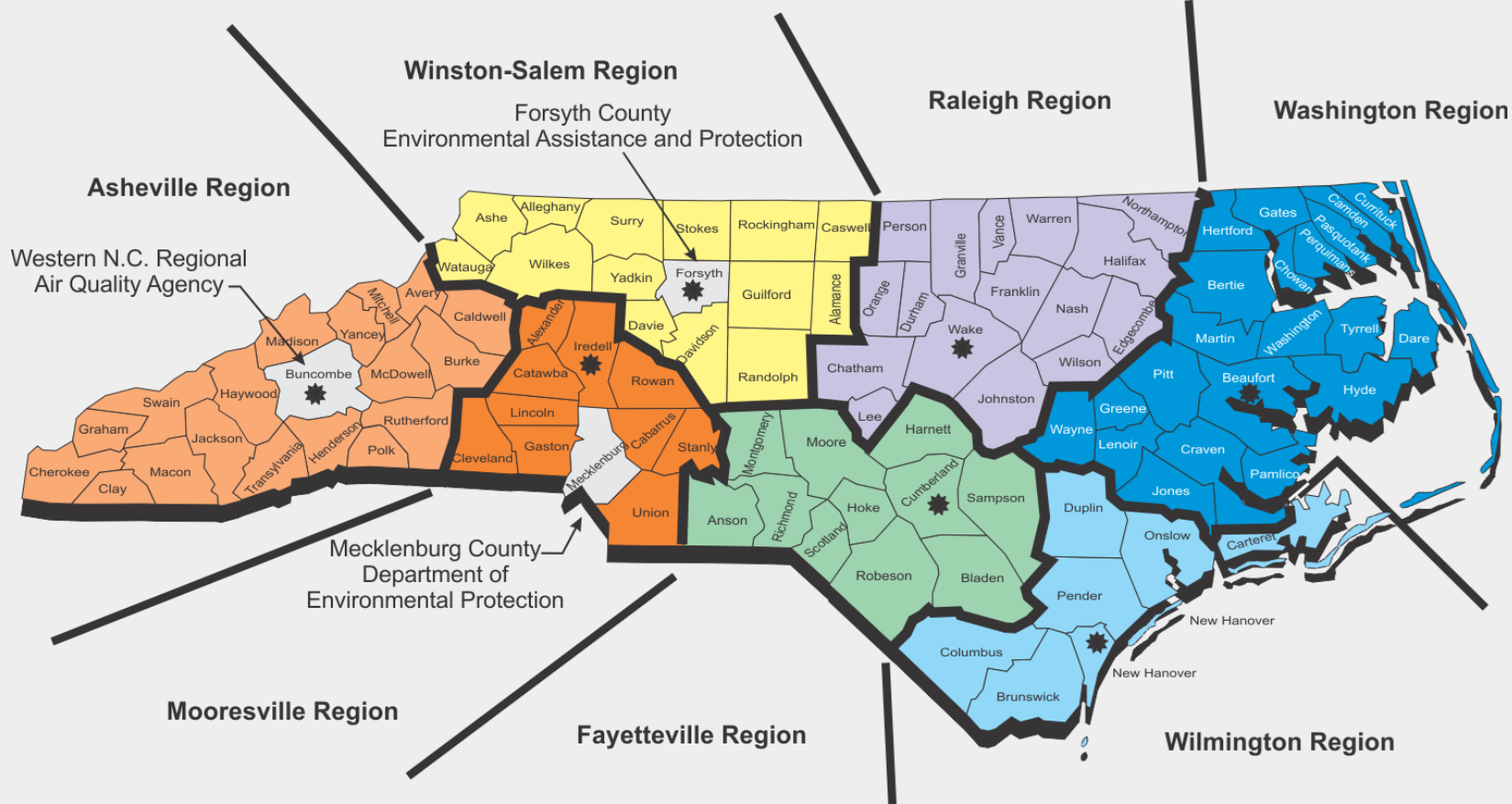
Calvin A. Cupini

Citizen Science Program Manager
Calvin@CleanAirCarolina.org



Monitoring Network



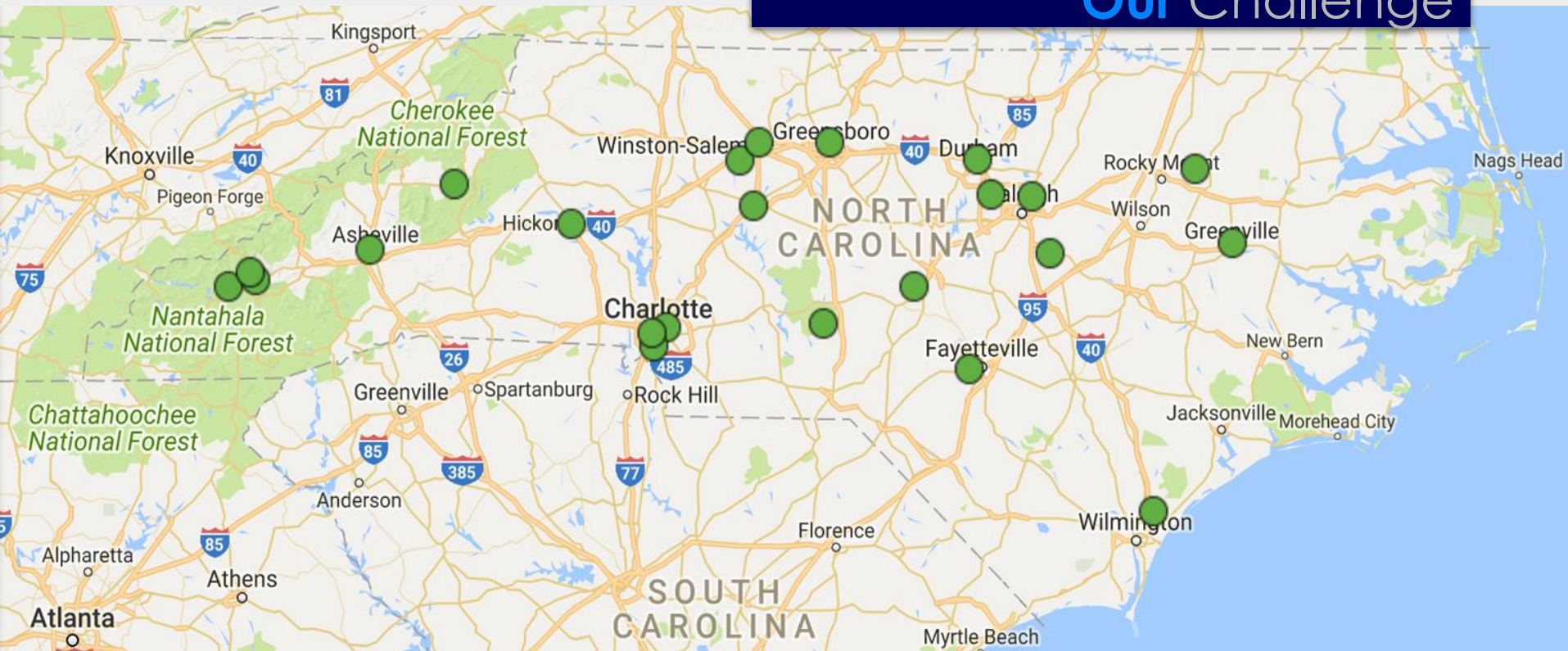


Statewide Reach

Atrium Health

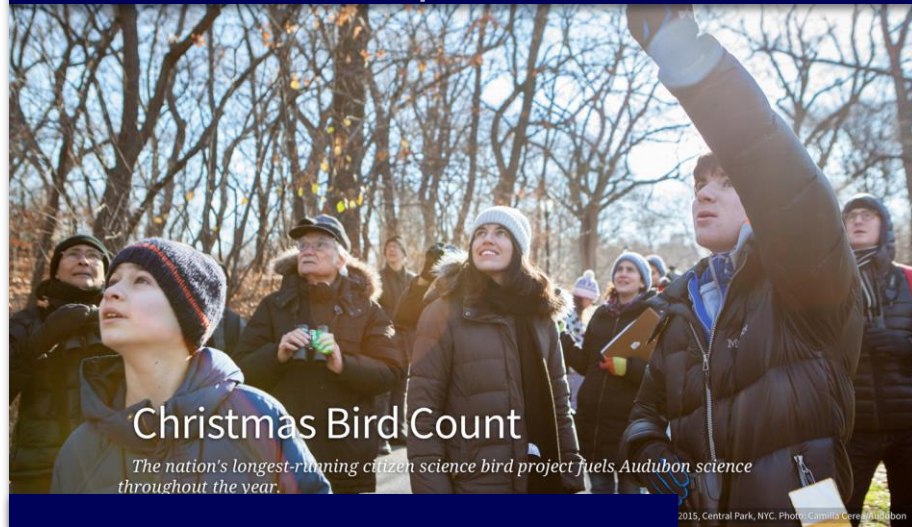


Our Challenge



PM Reference Monitors

Active Examples



Audubon Society

Geo Tag - X



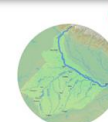
Ebola response



Emergency Shelter
Assessment in the
Middle East



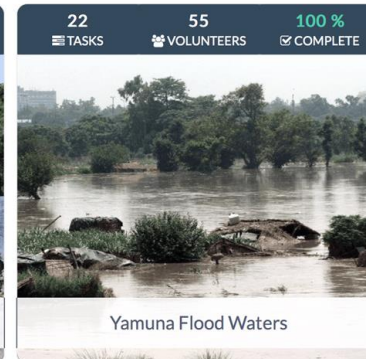
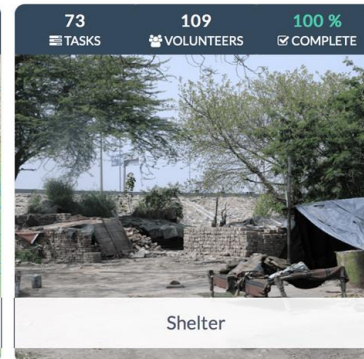
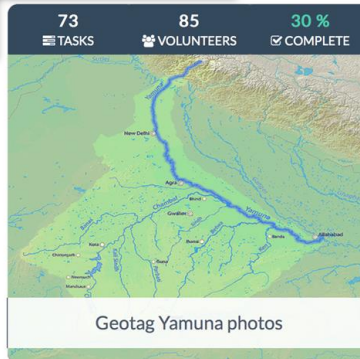
Yemeni Cultural
Heritage at Risk



Yamuna Monsoon
Flooding 2013



Somali Drought



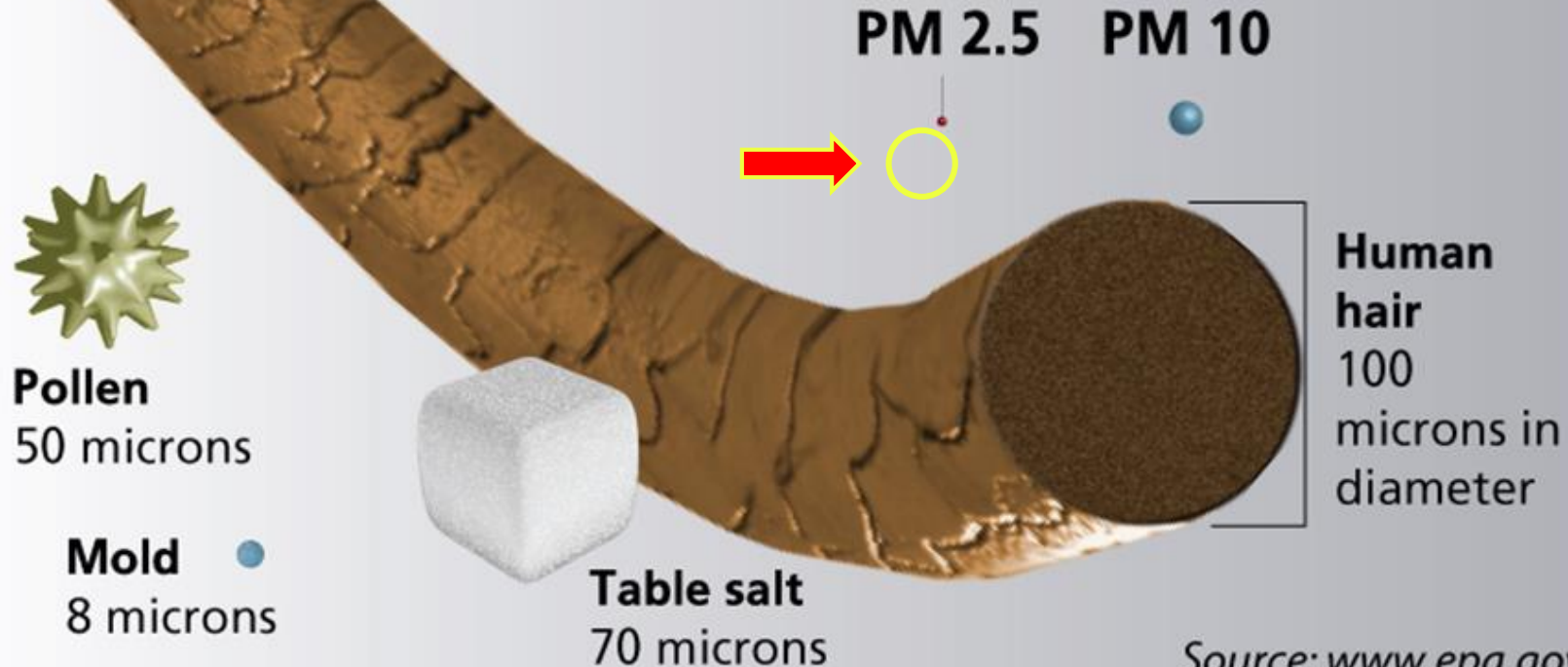
Cannon School STEM



WHAT IS PM2.5?

Health & PM 2.5

PM2.5 refers to dangerous particles of pollutants that are less than 2.5 microns in diameter. At 1/20th the width of a human hair, they lodge deep in lung tissue and are linked to many diseases, from cancer to asthma, and even autism.



Source: www.epa.gov

PM 2.5 and Your Health

- Fine particle pollution has long been linked to **heart disease** which is the leading cause of death in the US
- PM 2.5 can trigger **heart attacks and stroke**
- There is **no safe level of exposure**--even short-term exposure can impact lung function and increase emergency room visits & hospitalization for children with asthma
- Every 10 micrograms per cubic meter of PM2.5 **reduces life expectancy** by 5-10 months

Our Mission

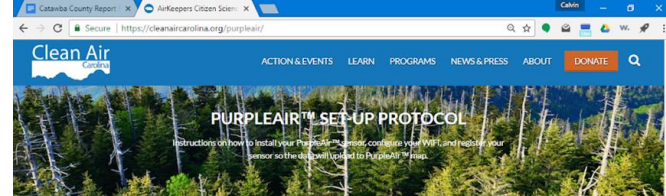
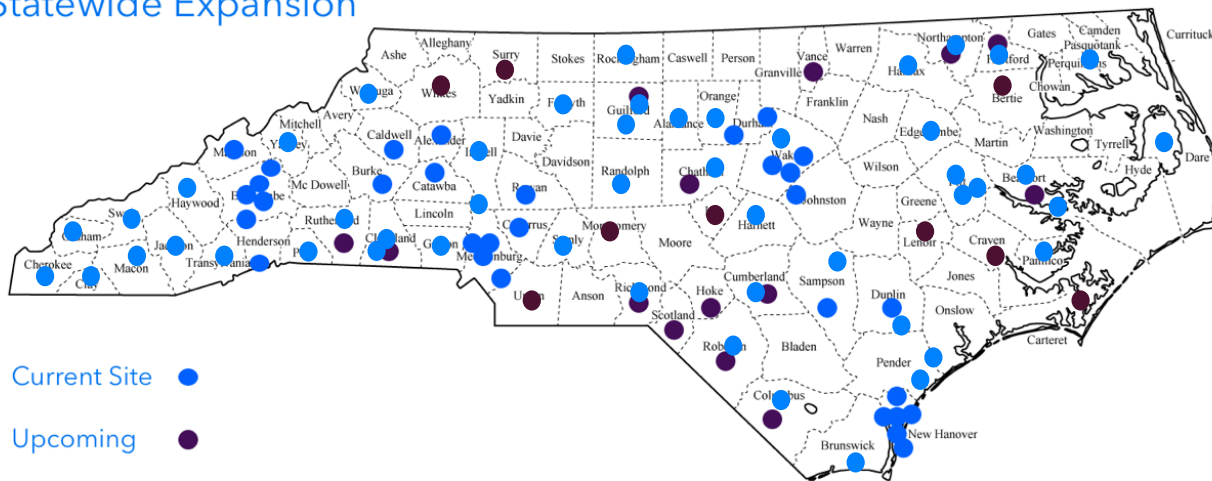
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Clean Air
Carolina
Your advocates for healthy air



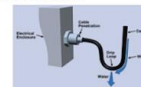
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- 23 toxic air emissions permits, including three Title V permits
- Traffic proximity higher than 67% of North Carolina counties
- 50% of Richmond County residents are economically disadvantaged
- High rates of respiratory-related illness and death

Due to the lack of air monitors in Richmond County, air pollution levels are currently unknown. However, large quantities of air pollution are emitted from industrial facilities and high-traffic roads, particularly in Rockingham and Hamlet.

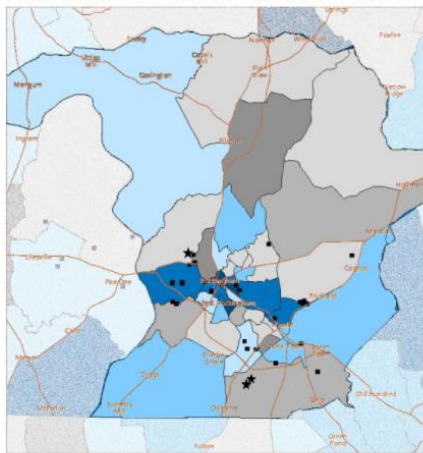
A. Industrial facilities

- Proximity to facilities using extremely hazardous substances for residents of Richmond County ranks higher than 80% of NC counties.
- 23 facilities have toxic air emissions permits (black squares in Figure 1) — 115% the state average.
- Three facilities have Title V permits, meaning they emit more than 100 tons of air pollutants annually (black stars in Figure 1). In 2017, a biomass company called Enviva acquired a Title V permit to build a large wood pellet production facility in Hamlet. This will push Richmond County past the state average for Title V permits.

- Traffic proximity is higher than 67% of North Carolina counties. In Rockingham, individuals are exposed to traffic-related air pollution levels higher than 80-90% of North Carolinians.
- Traffic-related air pollutants include diesel particles, NOx, and ozone.

- Low-income communities, children, the elderly, and individuals with respiratory illness are more susceptible to the negative health effects of air pollution.
- 50% of Richmond County is economically disadvantaged, and 20% of the population is elderly.
- Particularly in Hamlet and Rockingham, child routes are more likely to be exposed to unhealthy air quality.

Fig.1 Distribution of Low Income Population (State Percentile)



July 10, 2017

— Highways
□ Counties
■ Air permits ★ Title V permits

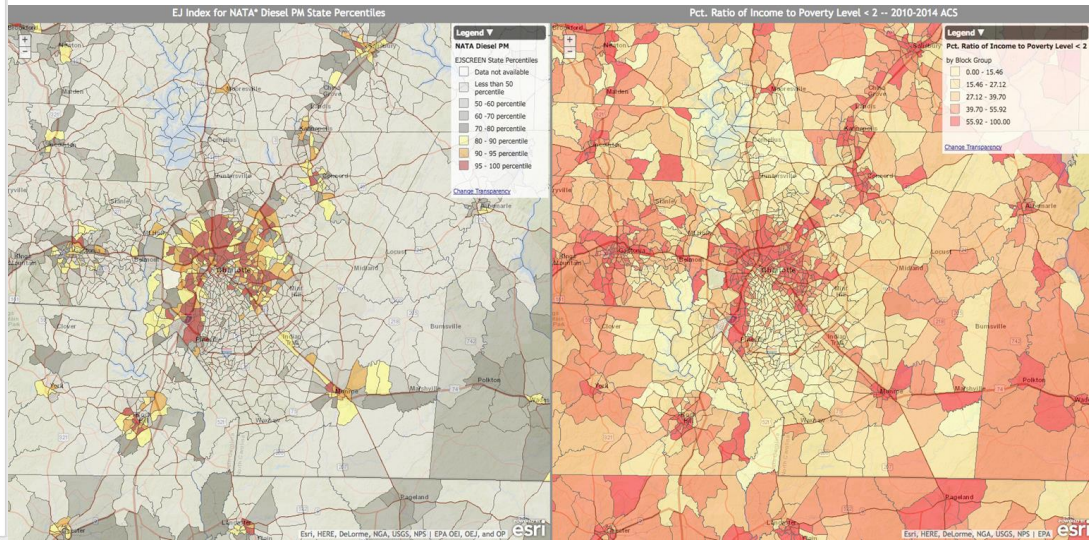
EJSCREEN State Percentiles

□ Data not available
■ Less than 50 percentile

50 - 60 percentile
60 - 70 percentile
70 - 80 percentile
80 - 90 percentile
90 - 95 percentile
95 - 100 percentile

HCOT GIS User
SRA OE, OE, and OP
SRI HERE, Oculina, Inagynia, & Oculina's contributors, and the
GIS user community
SRA OE

Rank 1-25 Rank 26-50 Rank 51-75 Rank 76-100



Modular Protocols



THE POWER OF MONITORING

Clean Air Carolina is reaching out to individuals and organizations across that state who want to participate in the next revolution in understanding our environment through citizen science. We need your help to build a network that addresses environmentally impacted communities across the state, particularly those located near sources of pollution. We are interested in locating monitors in communities whose health is disproportionately affected by air pollution (communities of color, low-income, children, and seniors).

HOW TO GET A MONITOR

Clean Air Carolina has set a goal to deploy monitoring sites in every single county in North Carolina in 2018. Monitors will be provided **free of charge** for eligible sites in uncovered counties.



WHAT IS POSSIBLE?

- Real-time high-resolution mapping of air quality at a far greater density than regulatory monitors
- fence-line monitoring to detect emissions events
- community monitoring to assess hot spots
- personal monitoring
- applications to collect data in remote places, and access it from anywhere.



WHAT IS THE DEVICE?

The PurpleAir™ sensor is a device that uses two laser particle counters to capture and record data about microscopic particulate matter (PM_{2.5}) suspended in the air. It then calculates the mass of the particles in micrograms per cubic meter (µg/m³). The sensor uses Wi-Fi connectivity to report real-time air quality readings to the web, where data can be shared with scientists and the public.



WHAT IS REQUIRED?

- The sensor needs 3 things:
- Access to an outdoor power source, that is not too close to a source of emissions like a grill, or exhaust pipe.
 - A location in range of a Wi-Fi network that is reliable, and on 24/7.
 - A position about 6-15ft off the ground, with as much fresh air as possible.



WHERE IS THE DATA GOING?

The data collected by the sensors is going directly to our AirKeepers page where it can be viewed anytime (CleanAirCarolina.org/AirKeepers). The data is also being shared with researchers, public health experts, and other stakeholders to advance our understanding of air quality concerns around the state.

¹ D. Qian, Wang Y, Zanobetti A, Wong, Y, Koutroski, P., et al. "Air Pollution and Mortality in the Medicare Population". *New England Journal of Medicine*, June 30, 2017.

Clean Air

Carolina

Your advocates for healthy air

Citizen Science Worksheet

1. List your Group Members:

2. Create a Session Name:

School	Team Name	Date	Session Title
Example: NWSA	Eagles	9/8/16	NWSA Eagles 9/8/16

3. Collect Environmental Conditions (Wait and complete this outside to observe conditions.)

Using the data below, complete the following chart to get your AirCasting "Session Notes"

Landscape:

- "U" Dense urban areas surrounded by taller buildings, with roughly 1,000 people or more per square mile.
- "S" Sparse suburban city areas, surrounding a city. Primarily houses and mixed use.
- "R" Areas of mostly natural surroundings, including forests, farmland, and large undeveloped area.

Cloud Cover:

- "100%" If no sky is visible through clouds. Completely overcast.
- "75%" If there is less blue sky visible than clouds. Mostly Cloudy.
- "50%" If there is equal amounts of cloud and sky. Lightly Cloudy.
- "25%" If only few clouds are visible, or most clouds are very small.
- "0%" If the sky is clear.

Wind:

- "H" Heavy gusts of wind.
- "M" Moderate levels of wind.
- "L" Light wind, steady breeze.
- "C" Calm conditions. Little to no noticeable wind.

Most Recent Rain:

- Count the number of days since rainfall at the testing location. "1" if rain fell the previous day, "2" if two days ago, "3" if three days ago, "3+" if longer than three days since last rainfall. Do not record during the rain.

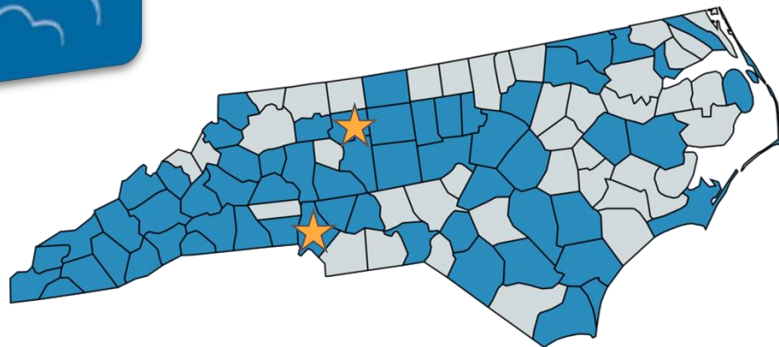
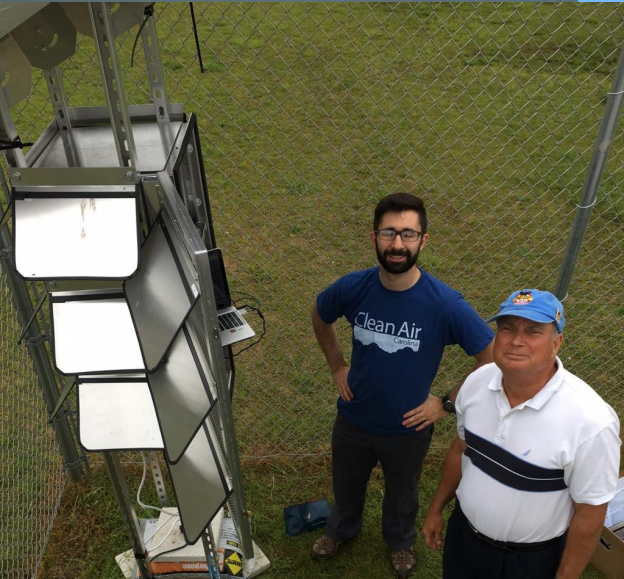
Landscape	Cloud Cover	Wind	Most Recent Rain	Session Notes
Example: U	75%	L	2	U75%L2

4. Preliminary questions before AirCasting. Discuss as a group and answer.

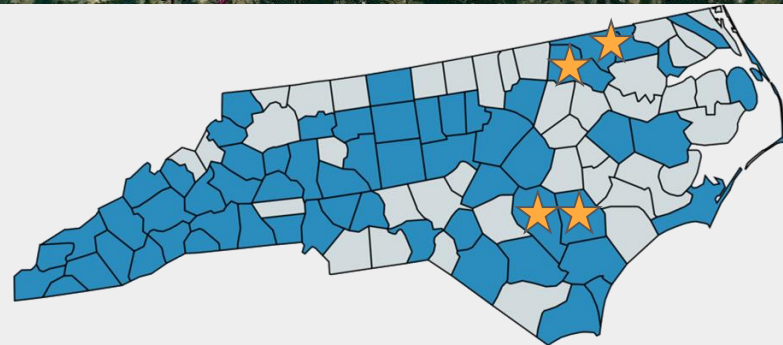
- 1) What is the air like where you live and go to school?

- a. Can you see air pollution, like exhaust, smog, or smoke?

- b. Are there busy roads, trains, or airports nearby?



EJ issues in the east





Particle Falls

Communication Successes

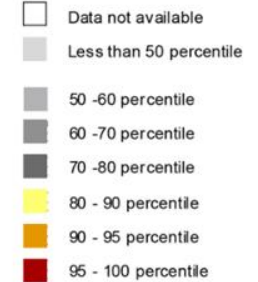
Environmental Justice in North Carolina

Major issues facing North Carolina

The biggest issues facing most developed countries, such as the United States, are pollution from traffic and industrial facilities.

The map shows levels of PM 2.5 and ozone, two of the major pollutants related to these issues.

EJSCREEN NATIONAL PERCENTILE

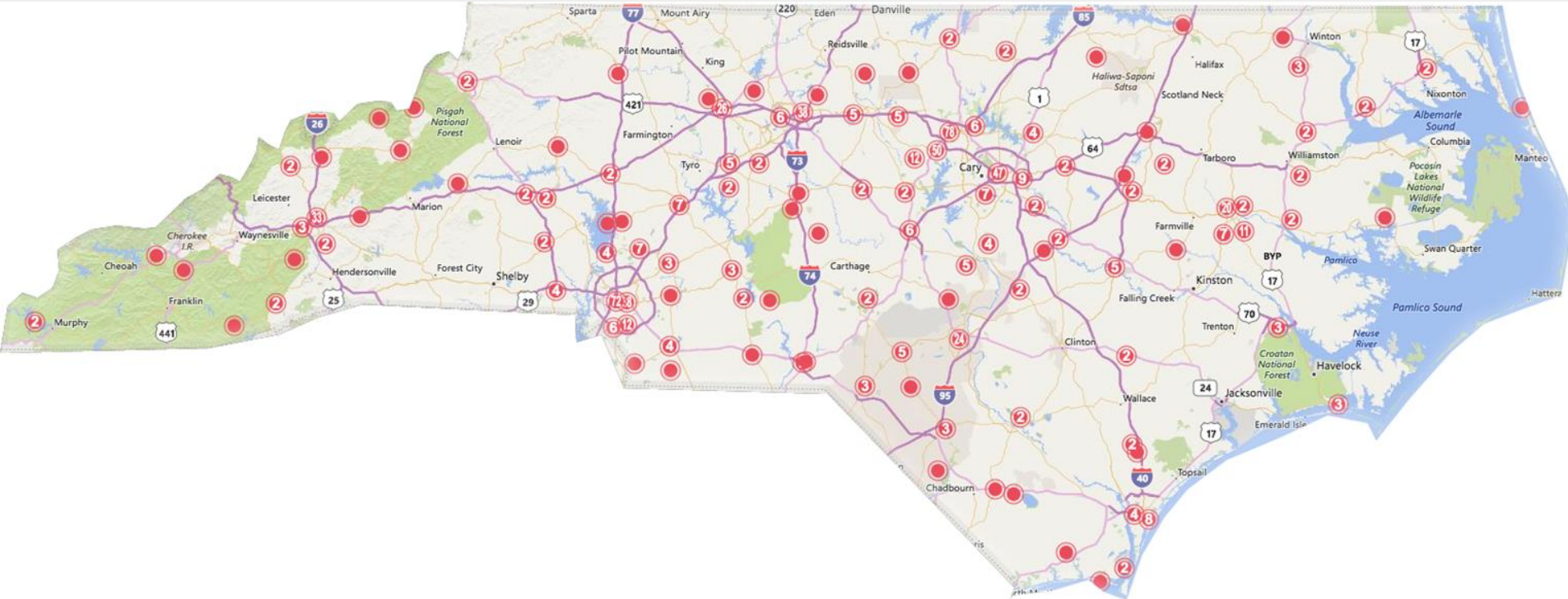


Each section of the county or state is classified based on emissions of PM 2.5 and ozone per census block group, with red being the most heavily polluted.

Communication Successes

Action Network

More than 900 members across NC



NC BREATHE Conference



Late March 2019

Thank You

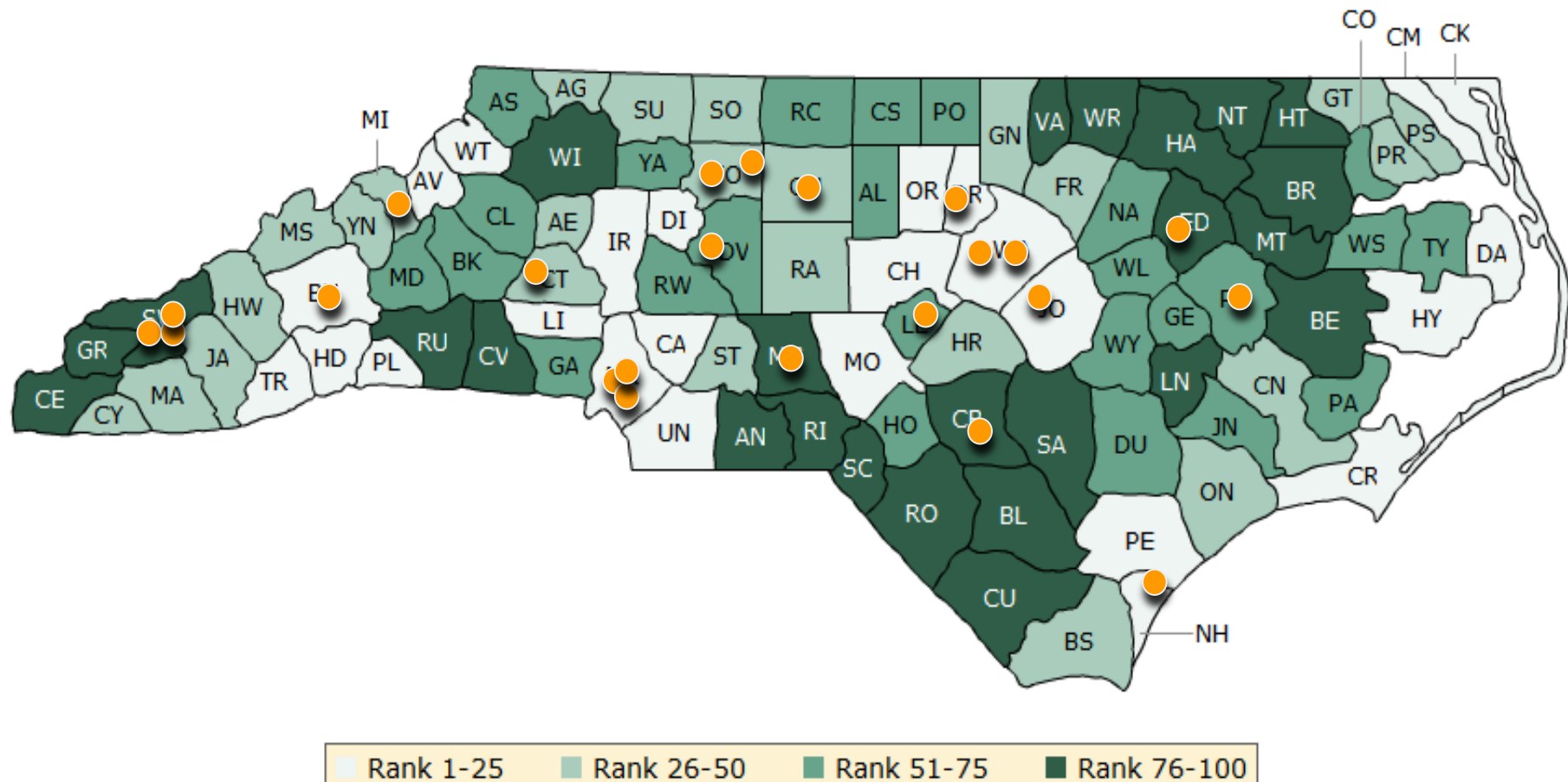
Calvin A. Cupini
Calvin@CleanAirCarolina.org



Philosophy

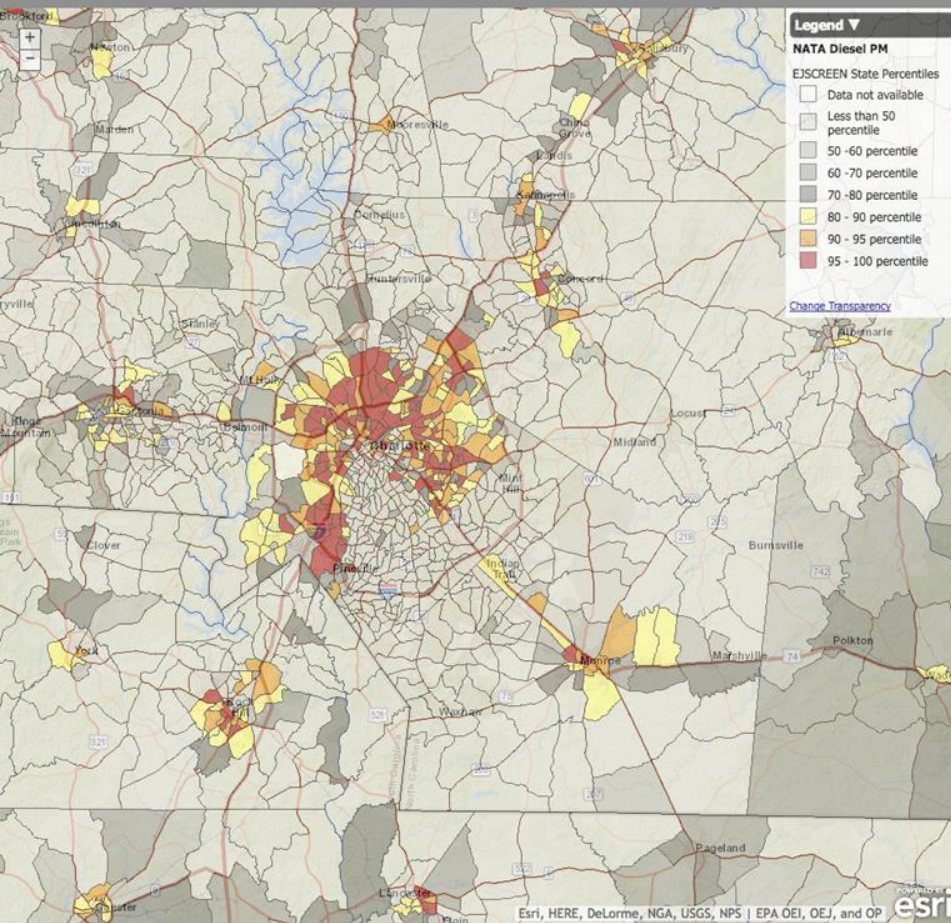


Our Challenge

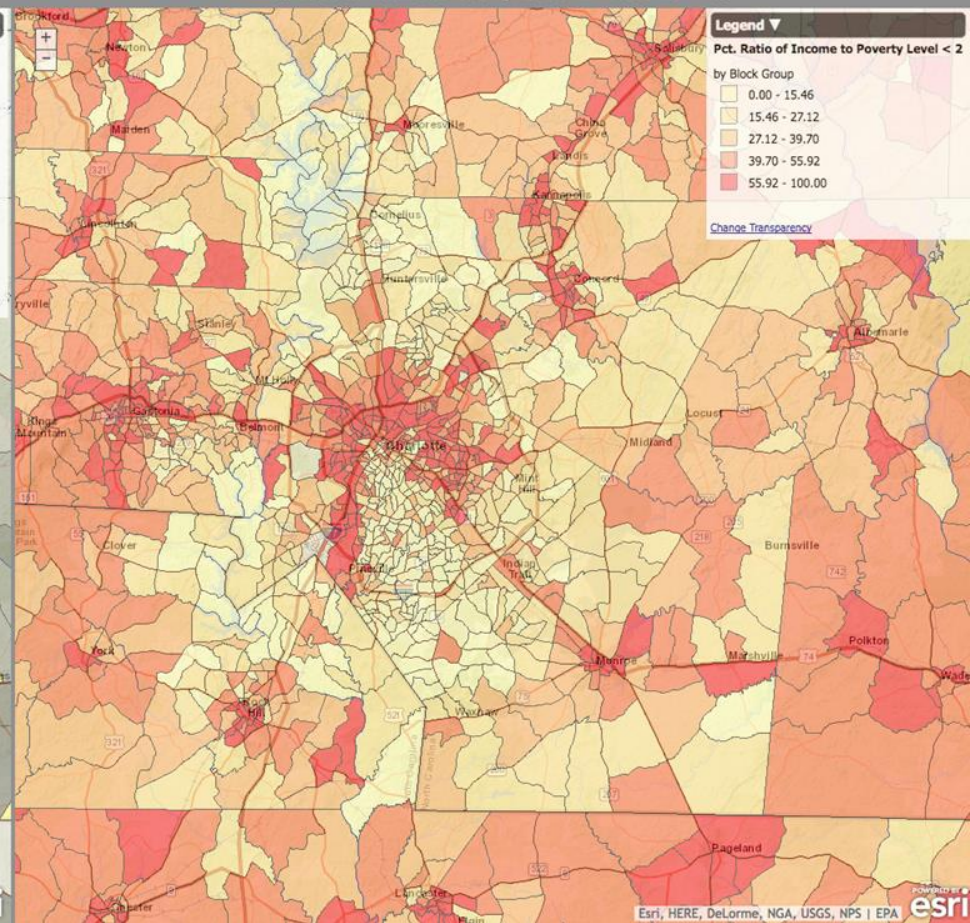


Environmental Disparities

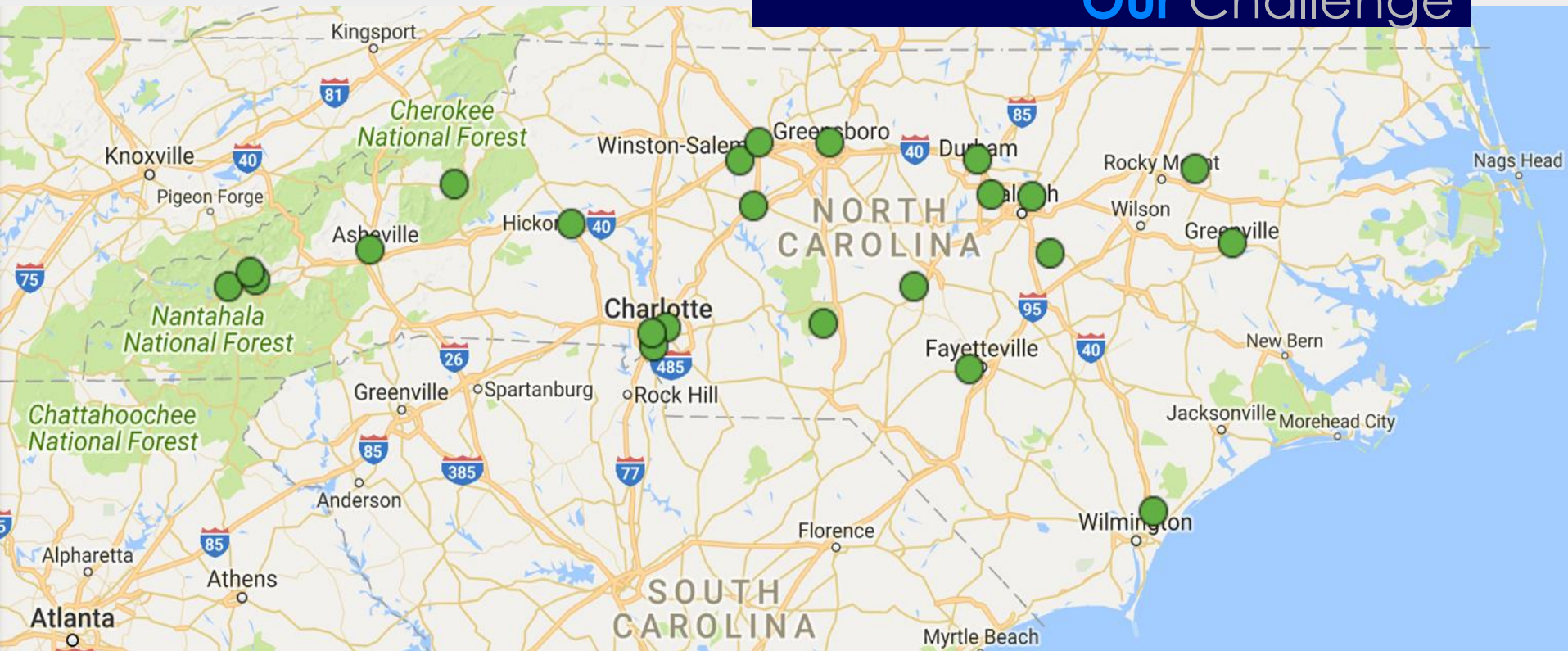
EJ Index for NATA* Diesel PM State Percentiles



Pct. Ratio of Income to Poverty Level < 2 -- 2010-2014 ACS

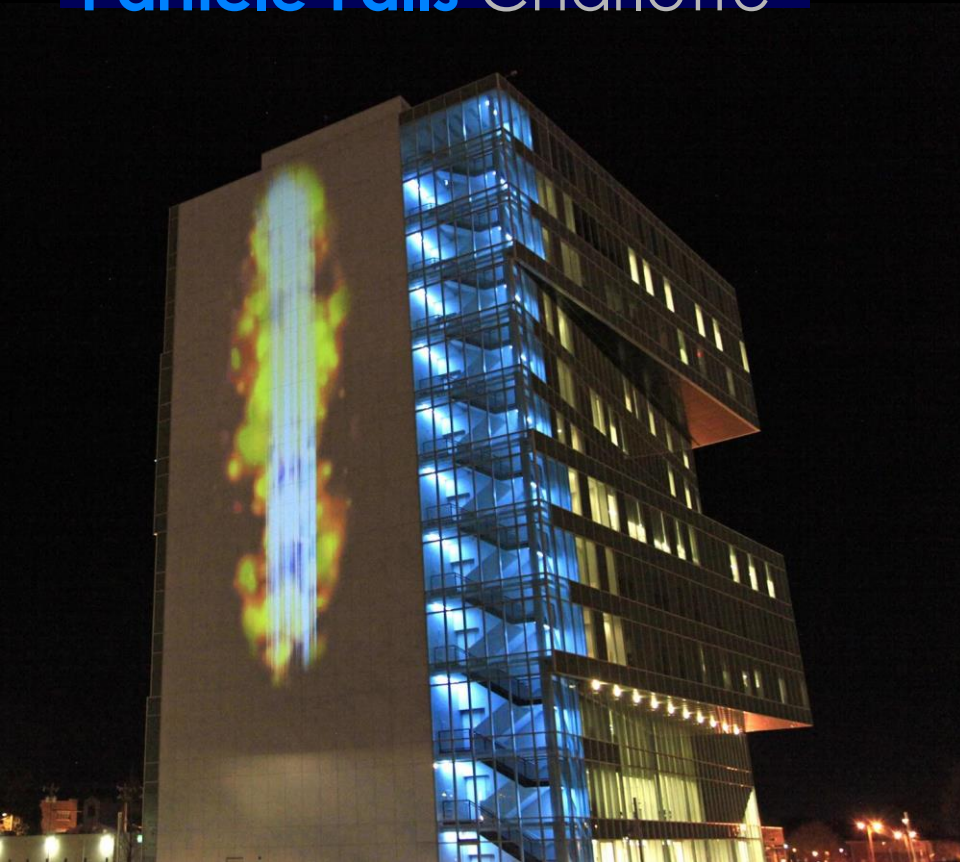


Our Challenge



PM Reference Monitors

Particle Falls Charlotte



Particle Falls Raleigh

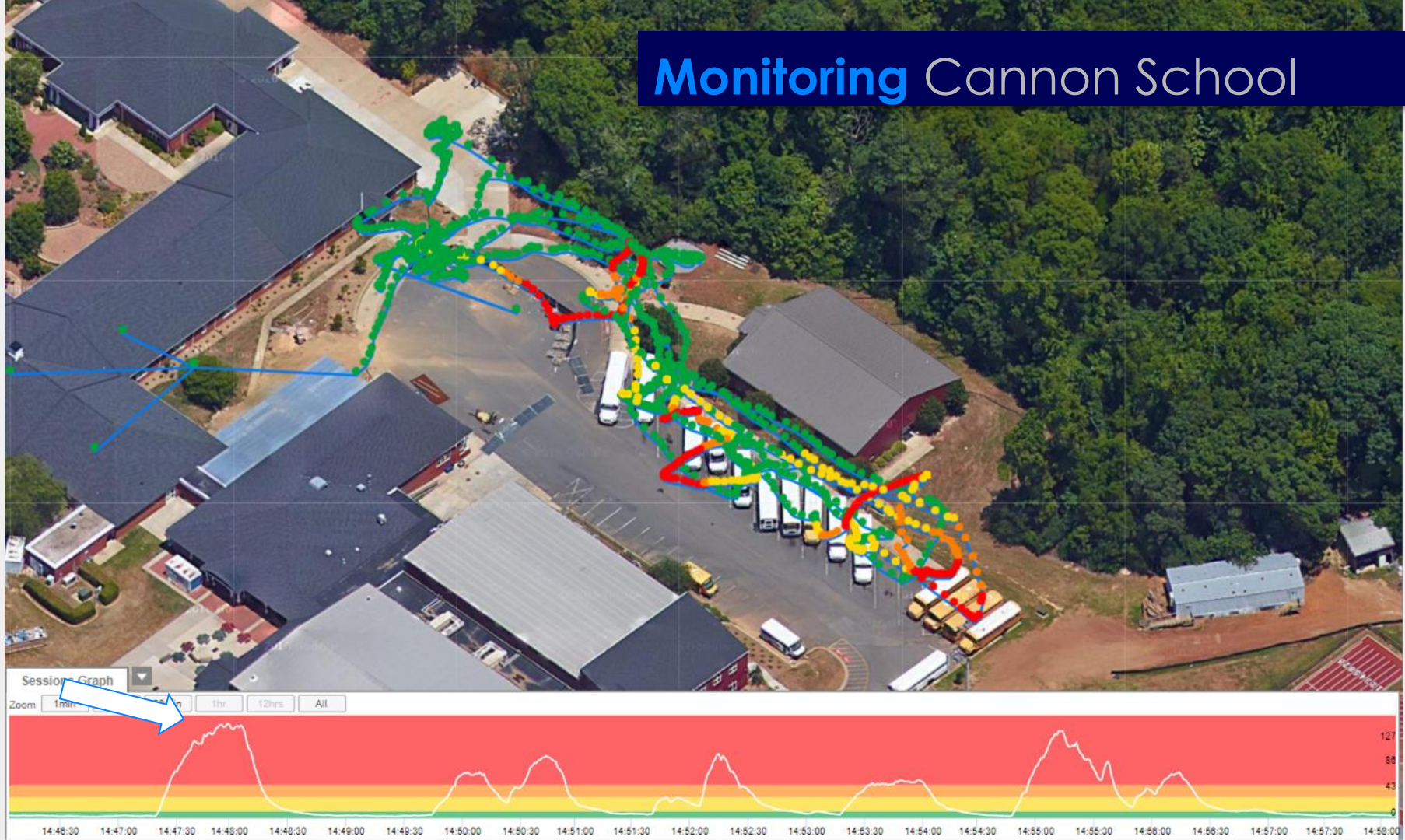
PM 2.5 Monitors

- Fraction of the **Cost**
- **Compact** size
- **Relative Humidity**,
and **Temperature**
- **Geotagged** data-points
- Web-based **mapping**

NOT a replacement of professional tools



Monitoring Cannon School



Citizen Science

- Interested members of the general public **contributing** to the collection or analysis of data
- Participating **actively or passively**.
- Citizen Science can provide **expanded capacity and scope** to projects with limited resources.
- The projects offer **STEM learning** opportunities
- **Direct public outreach** through hands on learning, and communication

Carolinas HealthCare System

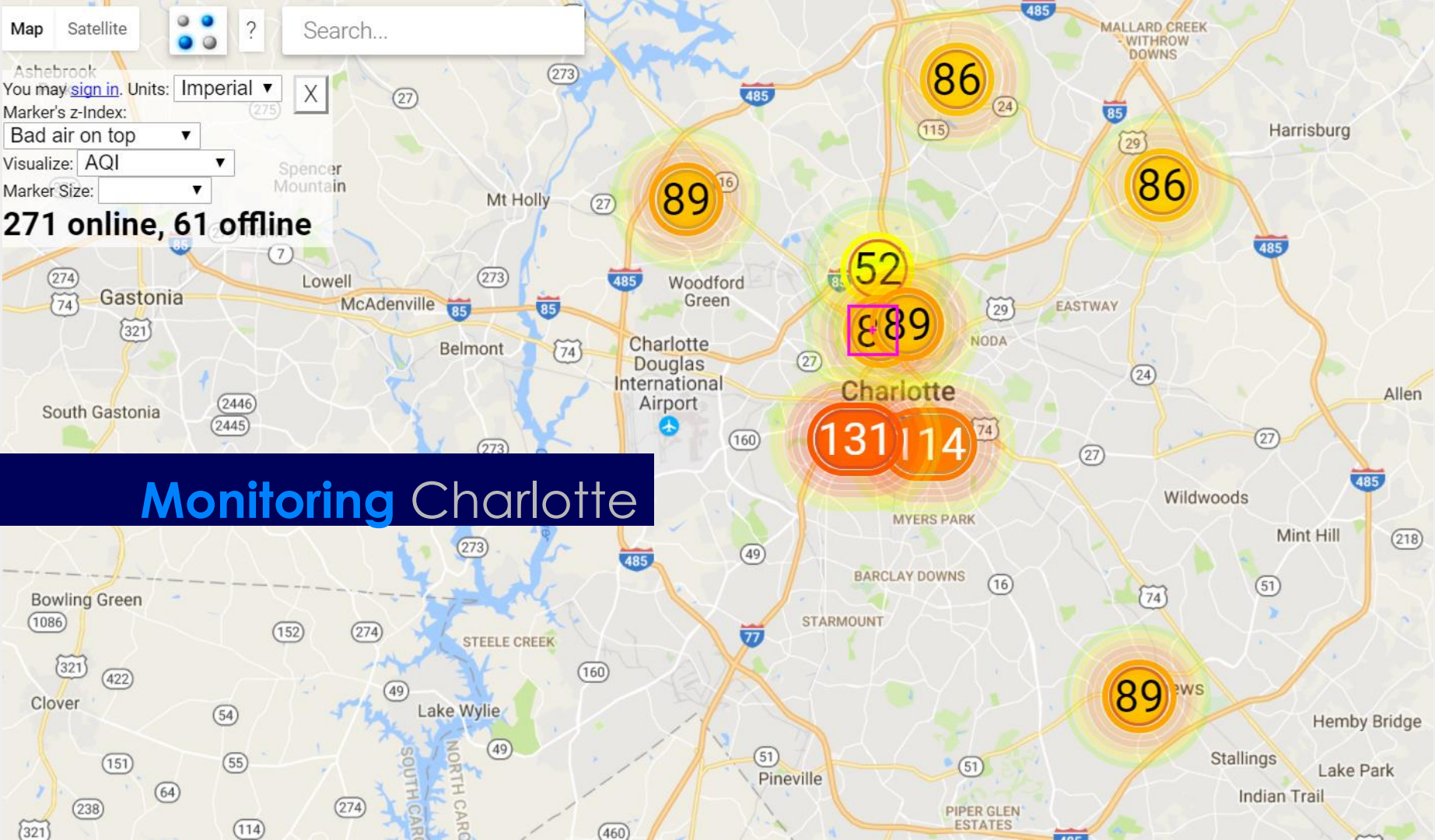


Cannon School

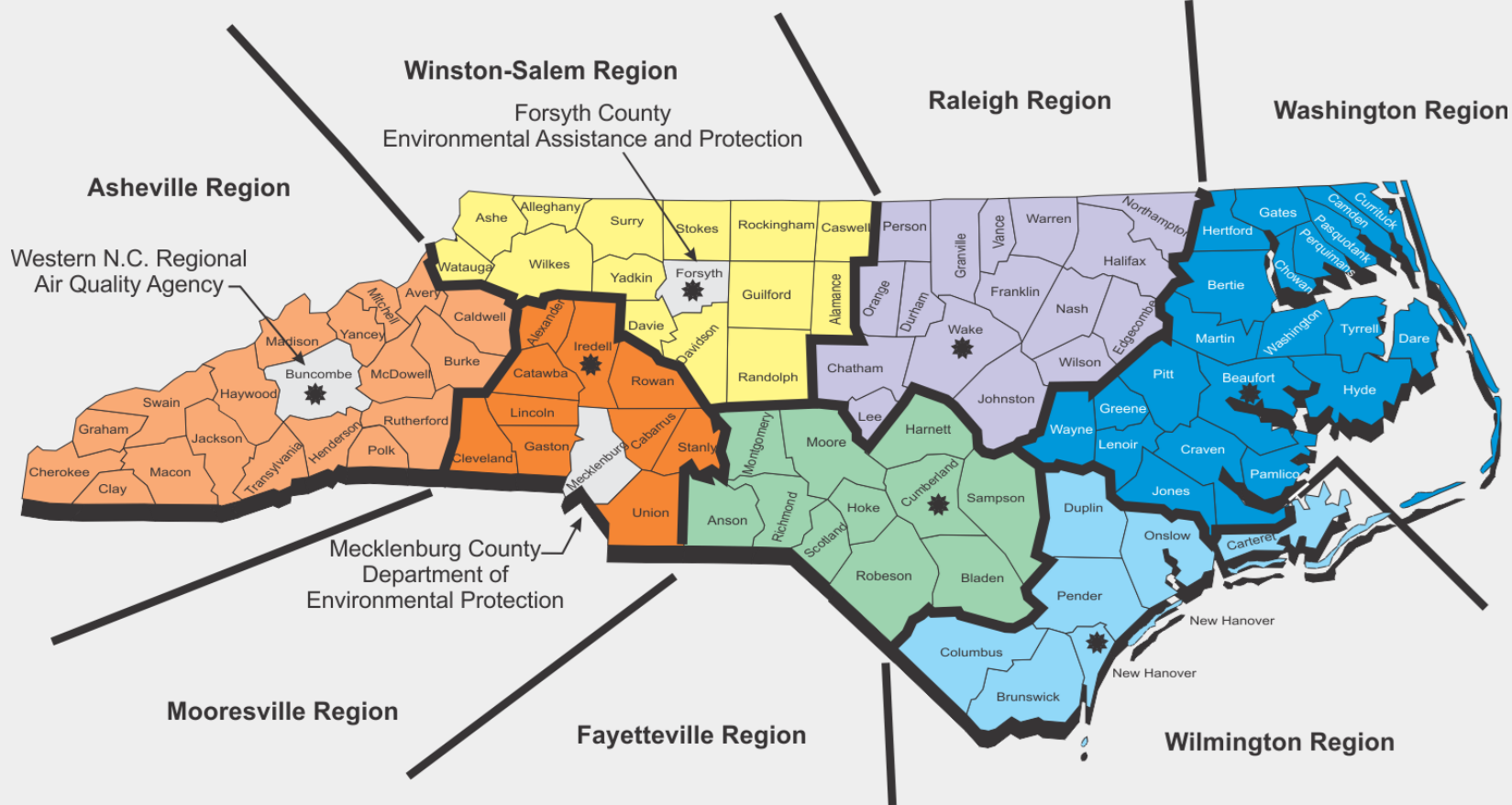


Ashebrook
You may [sign in](#). Units: Imperial
Marker's z-Index:
Bad air on top
Visualize: AQI
Marker Size:

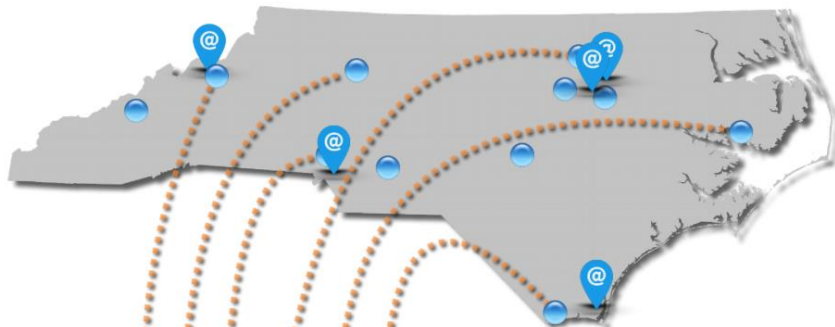
271 online, 61 offline



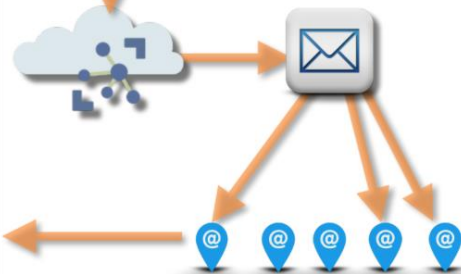
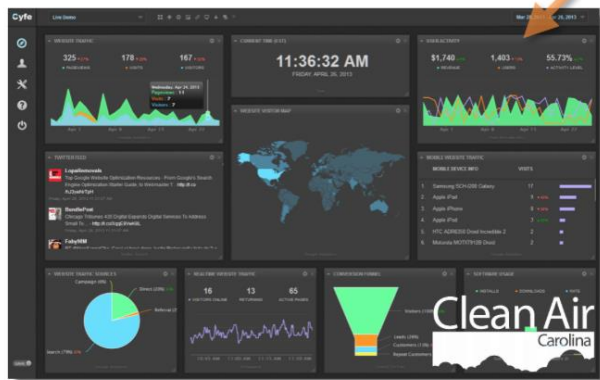
Monitoring Charlotte



Monitoring NC



IoT Platform



Low Cost Sensor Validation



Collocation

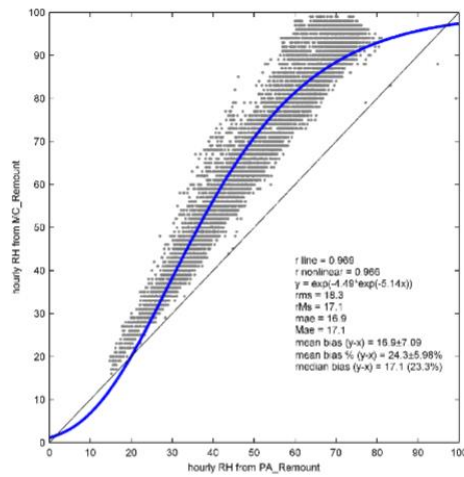
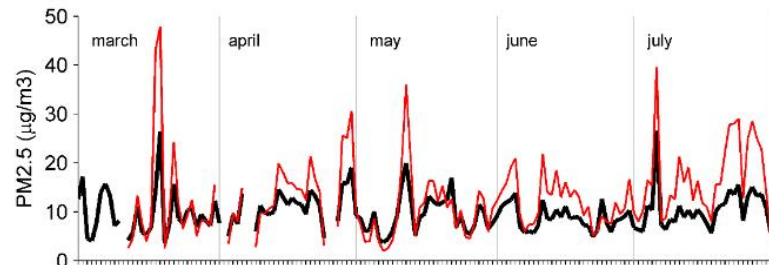


Figure 3: Daily comparison of PA-II with BAM



MAHA Initiative Clean Construction Partnership



N ■ **NOVANT**
■ **HEALTH**



Atrium Health

Citizen Science Presentations



2019 Strategy



IoT Revolution

[illegible]

Topics

- Clean Air Carolina's programs
- North Carolina's monitor network
- Crowdsourced Citizen Science
- Who are AirKeepers?
- Low cost monitors
- Crowdsourcing in Air Quality

Community-focused air monitoring collaborations between multiple stakeholders.

Calvin A. Cupini
Calvin@cleanaircarolina.org
App State University
Monday October 21, 2018

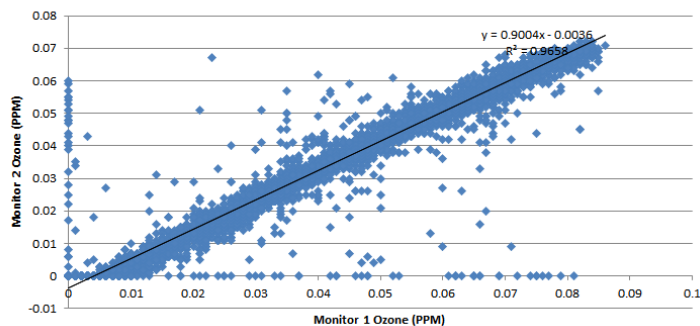
Atmos(here)



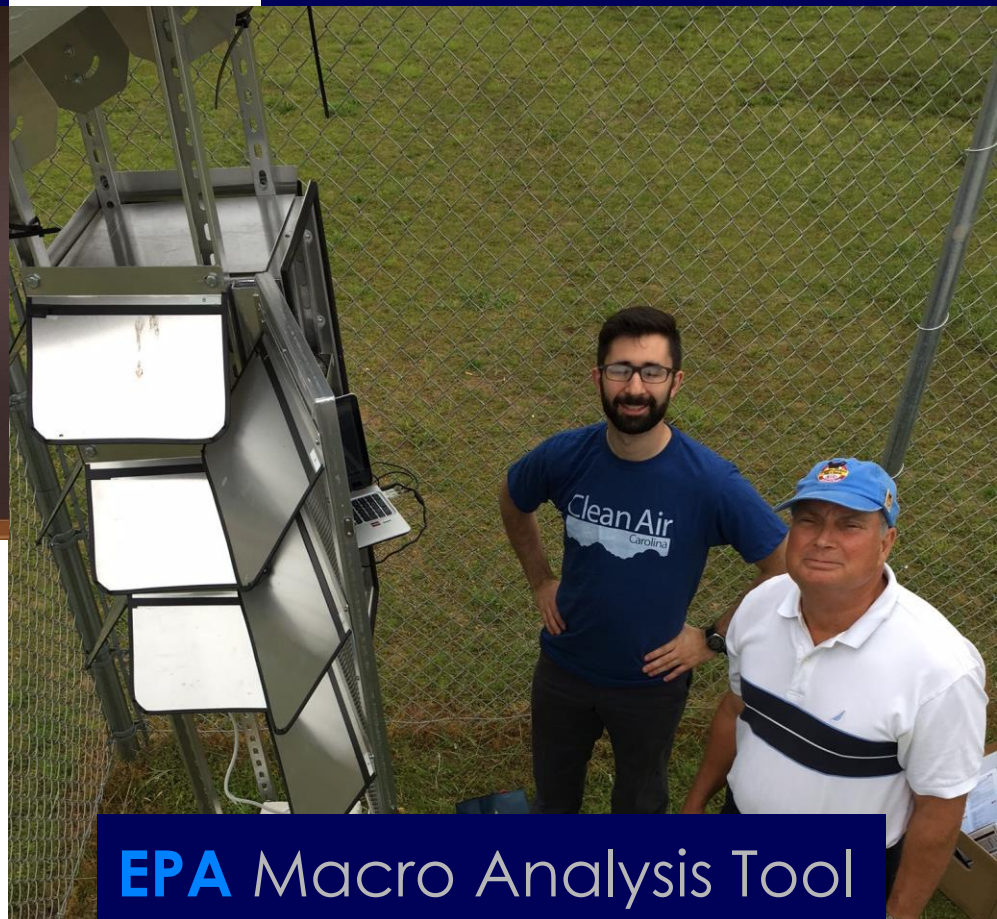
Citizen Science Partnerships



Monitor 1 vs Monitor 2 Ozone Levels



Air Sensor Toolbox



EPA Macro Analysis Tool

Low Cost Sensor Validation



Collocation

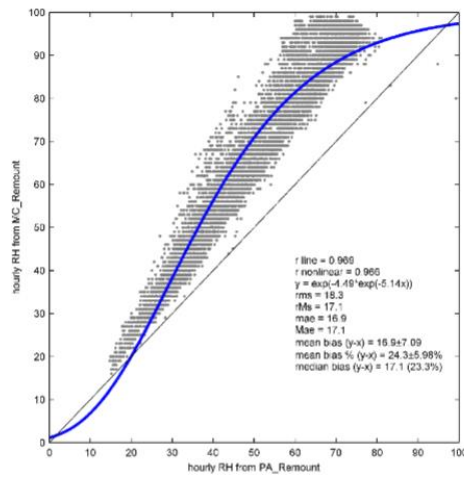
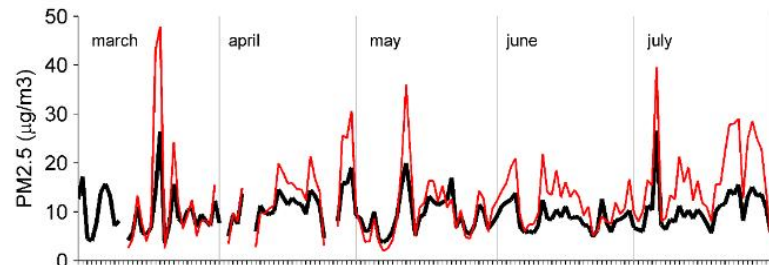


Figure 3: Daily comparison of PA-II with BAM



Modular Protocols



THE POWER OF MONITORING

Clean Air Carolina is reaching out to individuals and organizations across that state who want to participate in the next revolution in understanding our environment through citizen science. We need your help to build a network that addresses environmentally impacted communities across the state, particularly those located near sources of pollution. We are interested in locating monitors in communities whose health is disproportionately affected by air pollution (communities of color, low-income, children, and seniors).

HOW TO GET A MONITOR

Clean Air Carolina has set a goal to deploy monitoring sites in every single county in North Carolina in 2018. Monitors will be provided **free of charge** for eligible sites in uncovered counties.



WHAT IS POSSIBLE?

- Real-time high-resolution mapping of air quality at a far greater density than regulatory monitors
- fenceline monitoring to detect emissions events
- community monitoring to assess hot spots
- personal monitoring
- applications to collect data in remote places, and access it from anywhere.



WHAT IS THE DEVICE?

The PurpleAir™ sensor is a device that uses two laser particle counters to capture and record data about microscopic particulate matter (PM_{2.5}) suspended in the air. It then calculates the mass of the particles in micrograms per cubic meter (µg/m³). The sensor uses Wi-Fi connectivity to report real-time air quality readings to the web, where data can be shared with scientists and the public.



WHAT IS REQUIRED?

- The sensor needs 3 things:
- Access to an outdoor power source, that is not too close to a source of emissions like a grill, or exhaust pipe.
 - A location in range of a Wi-Fi network that is reliable, and on 24/7.
 - A position about 6-15ft off the ground, with as much fresh air as possible.



WHERE IS THE DATA GOING?

The data collected by the sensors is going directly to our AirKeepers page where it can be viewed anytime (CleanAirCarolina.org/AirKeepers). The data is also being shared with researchers, public health experts, and other stakeholders to advance our understanding of air quality concerns around the state.

¹ D. Qian, Wang Y, Zanobetti A, Wong, Y, Koutroski, P., et al. "Air Pollution and Mortality in the Medicare Population". *New England Journal of Medicine*, June 30, 2017.

Clean Air

Carolina

Your advocates for healthy air

Citizen Science Worksheet

1. List your Group Members:

2. Create a Session Name:

School	Team Name	Date	Session Title
Example: NWSA	Eagles	9/8/16	NWSA Eagles 9/8/16

3. Collect Environmental Conditions (Wait and complete this outside to observe conditions.)

Using the data below, complete the following chart to get your AirCasting "Session Notes"

Landscape:

- "U" Dense urban areas surrounded by taller buildings, with roughly 1,000 people or more per square mile.
- "S" Sparse suburban city areas, surrounding a city. Primarily houses and mixed use.
- "R" Areas of mostly natural surroundings, including forests, farmland, and large undeveloped area.

Cloud Cover:

- "100%" If no sky is visible through clouds. Completely overcast.
- "75%" If there is less blue sky visible than clouds. Mostly Cloudy.
- "50%" If there is equal amounts of cloud and sky. Lightly Cloudy.
- "25%" If only few clouds are visible, or most clouds are very small.
- "0%" If the sky is clear.

Wind:

- "H" Heavy gusts of wind.
- "M" Moderate levels of wind.
- "L" Light wind, steady breeze.
- "C" Calm conditions. Little to no noticeable wind.

Most Recent Rain:

- Count the number of days since rainfall at the testing location. "1" if rain fell the previous day, "2" if two days ago, "3" if three days ago, "3+" if longer than three days since last rainfall. Do not record during the rain.

Landscape	Cloud Cover	Wind	Most Recent Rain	Session Notes
Example: U	75%	L	2	U75%L2

4. Preliminary questions before AirCasting. Discuss as a group and answer.

- 1) What is the air like where you live and go to school?

- a. Can you see air pollution, like exhaust, smog, or smoke?

- b. Are there busy roads, trains, or airports nearby?

Search...

X

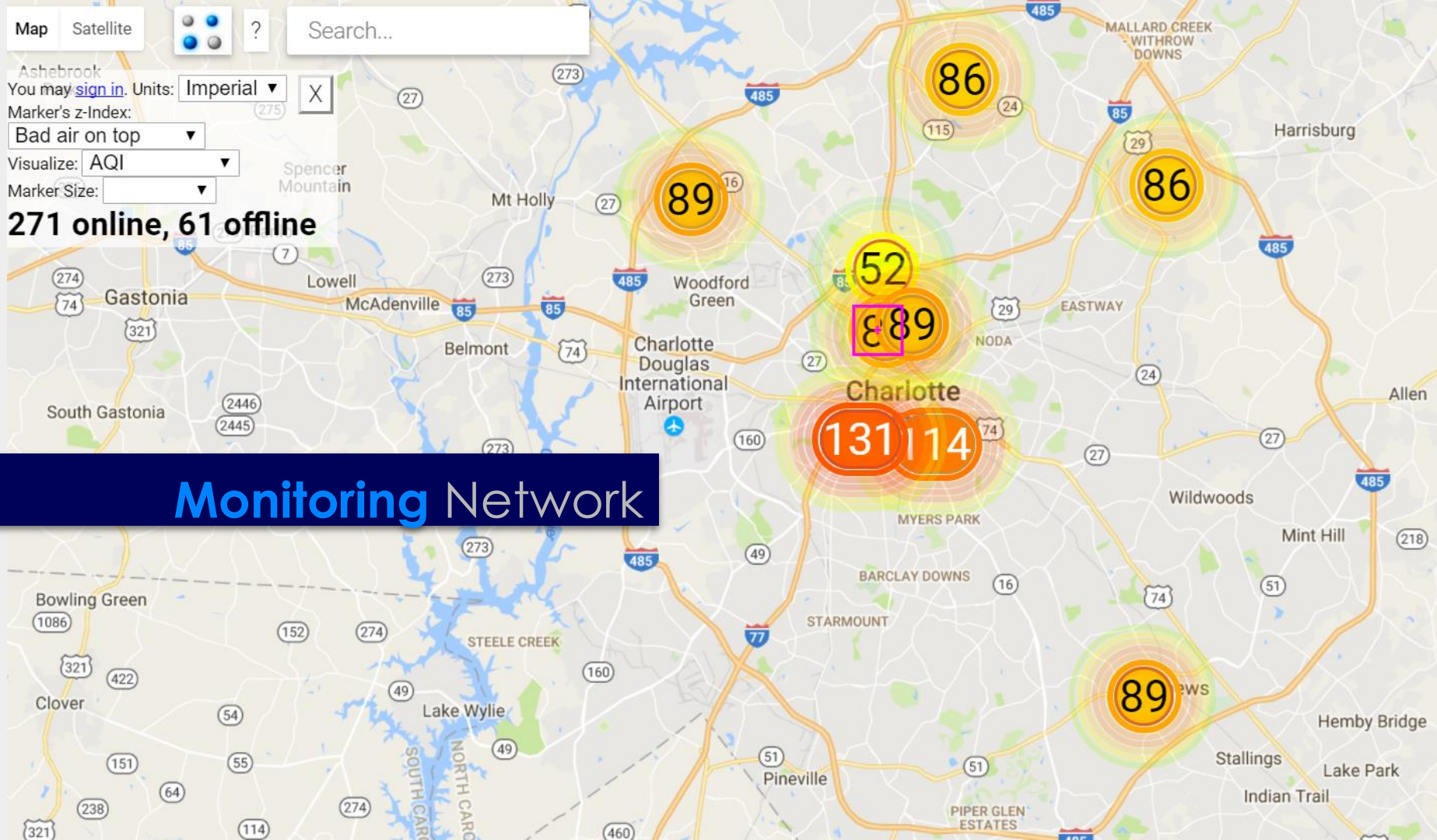
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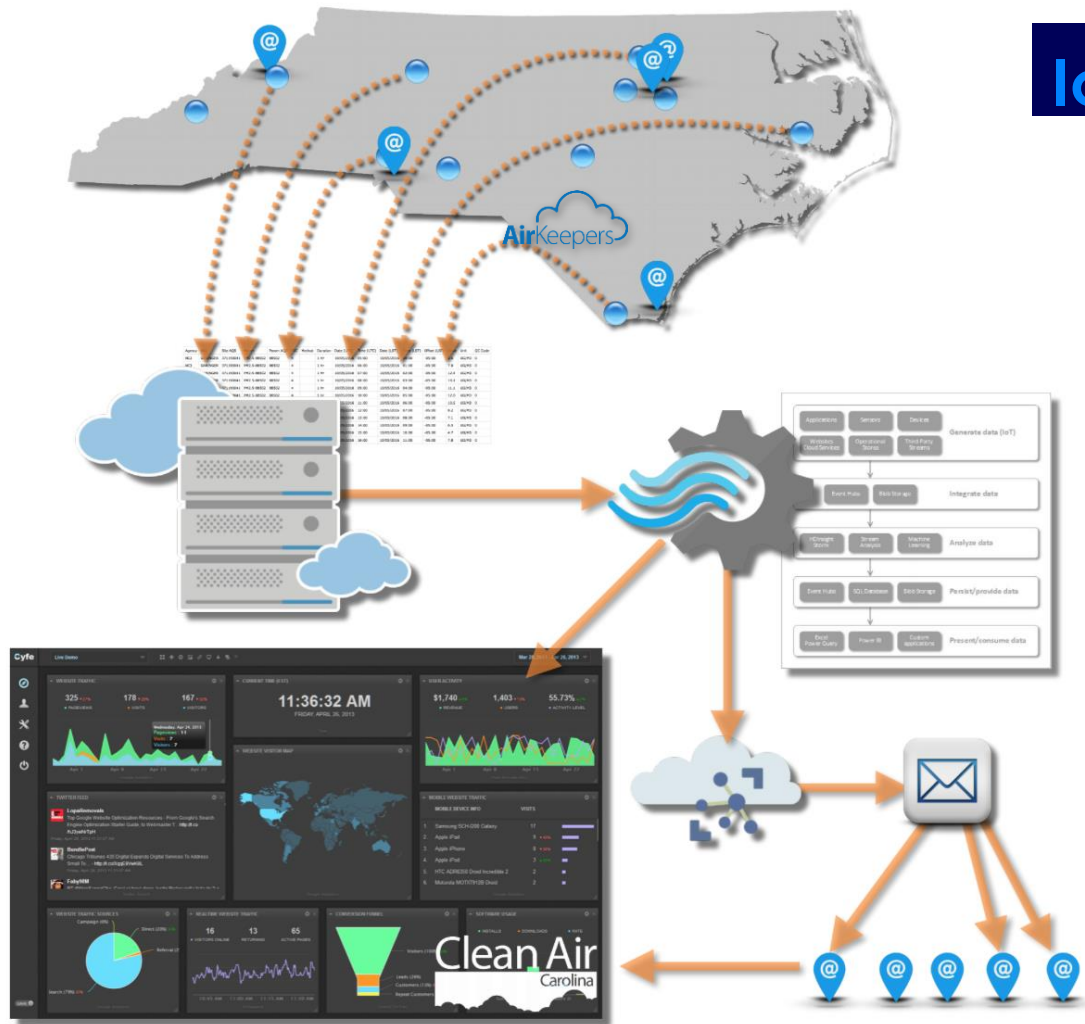
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Monitoring Network

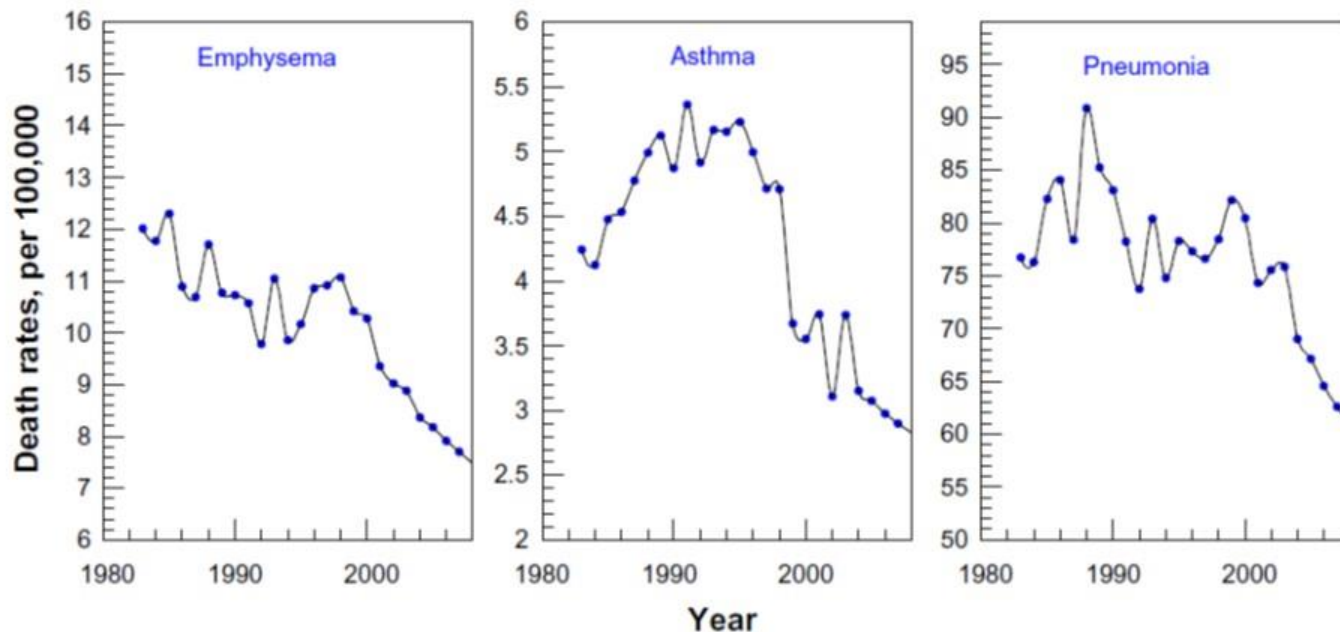


IoT Platform



Smoke Sense





Associated health trends in North Carolina since 1990s

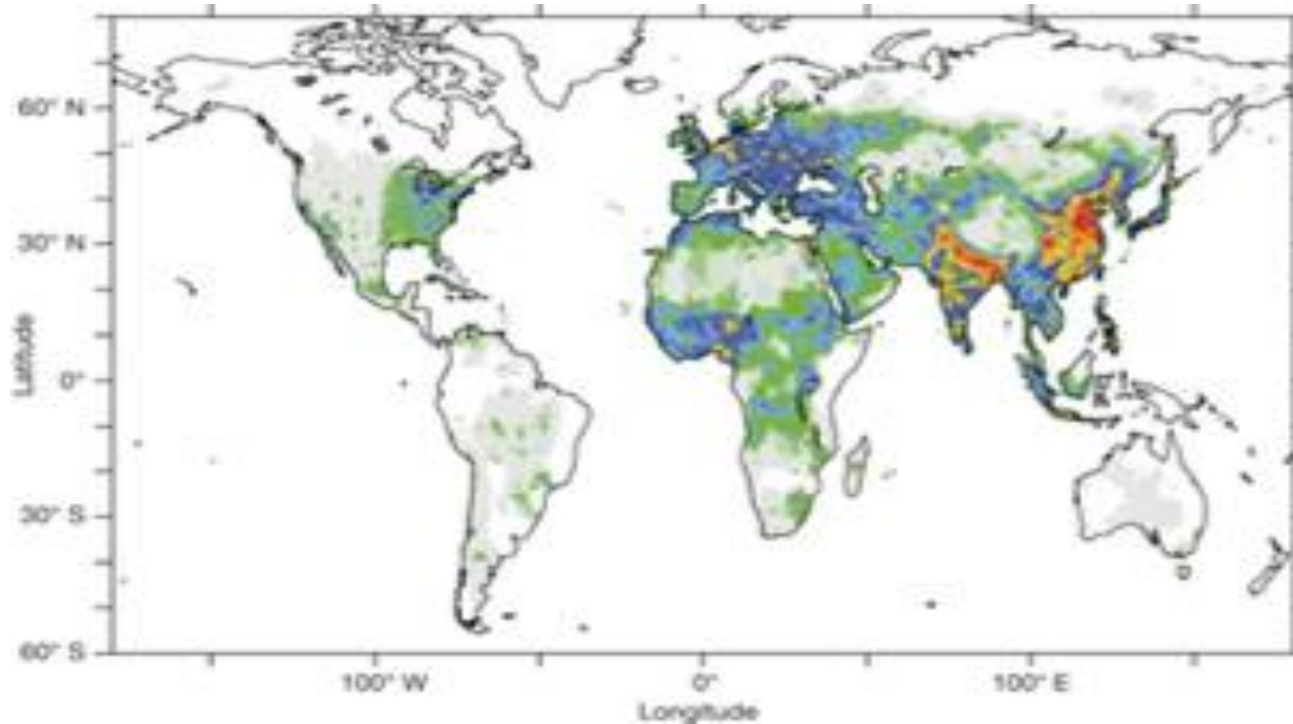
Figure source: "Long-term dynamics of death rates of emphysema, asthma, and pneumonia and improving air quality" <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4075234/>

Our Challenge

6.1 million premature deaths worldwide in 2010 attributed to air pollution – **double by 2050**.

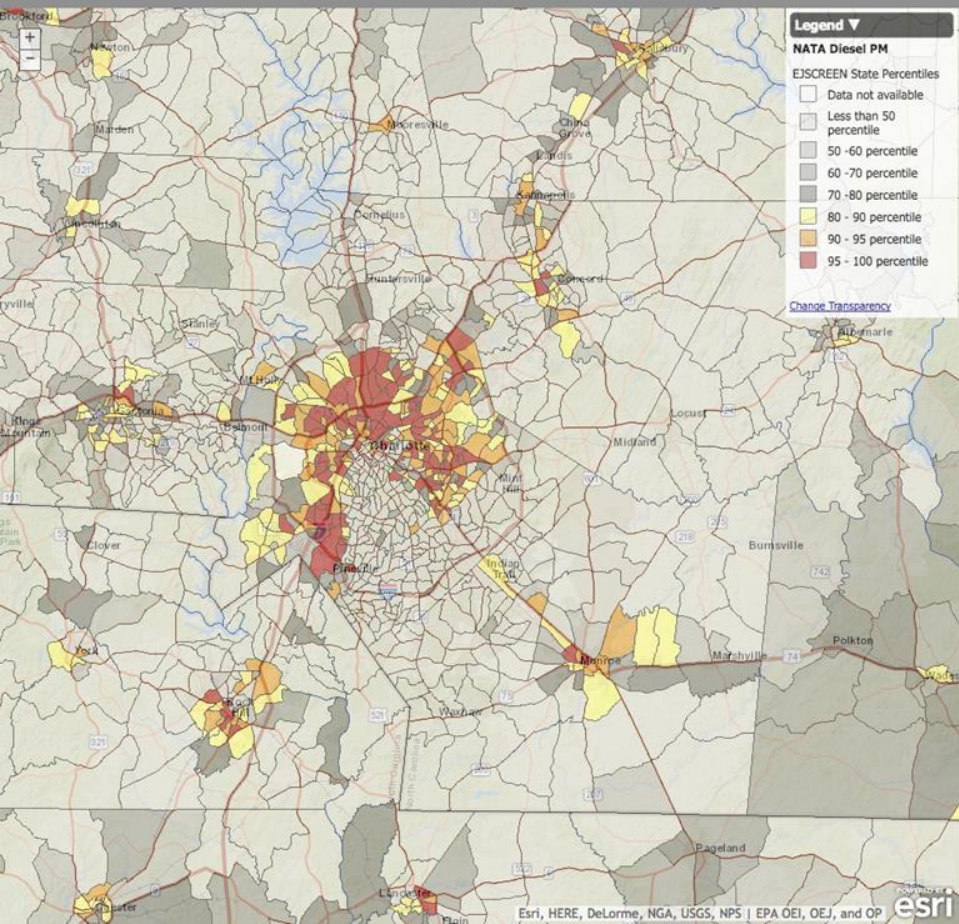
210,000 premature deaths in the **US** annually due to air pollution.

(Global Burden of Disease Study 2016 *The Lancet*, Vol. 390, No. 10100, p1345–1422 Published September 16, 2017).

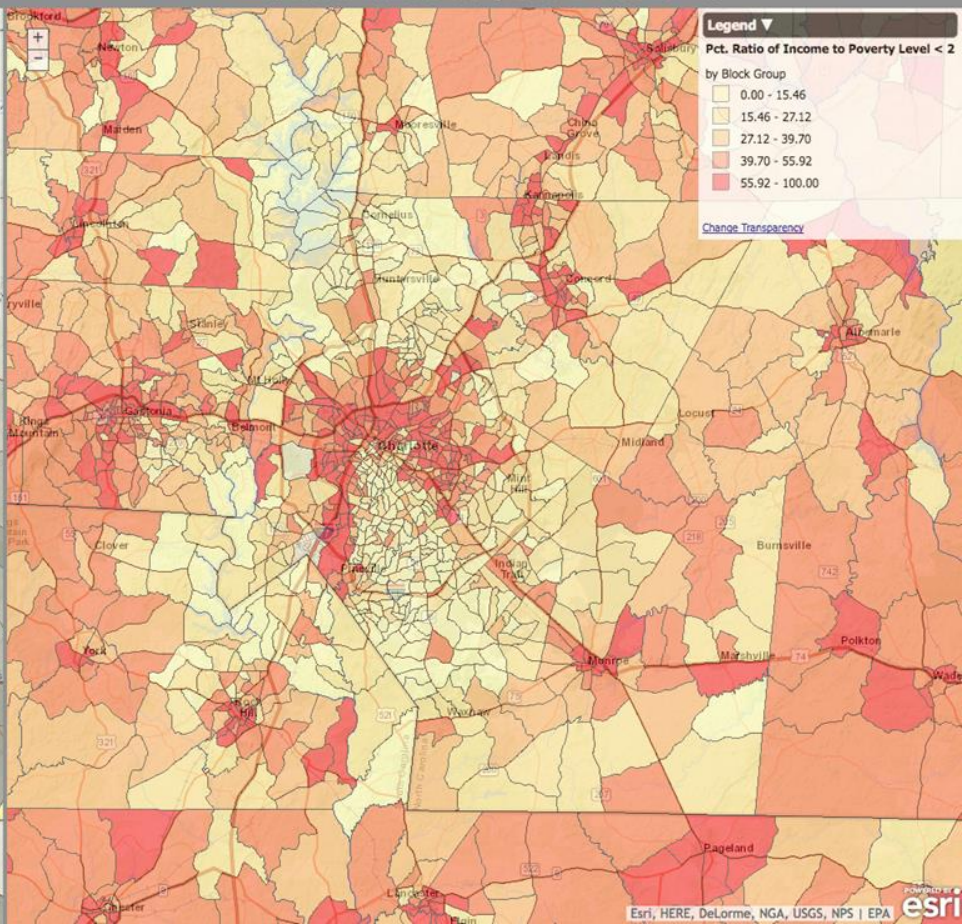


Environmental Disparities

EJ Index for NATA* Diesel PM State Percentiles



Pct. Ratio of Income to Poverty Level < 2 -- 2010-2014 ACS



Citizen Science

- Interested members of the general public **contributing** to the collection or analysis of data
- Participating **actively or passively**.
- Citizen Science can provide **expanded capacity and scope** to projects with limited resources.
- The projects offer **STEM learning** opportunities
- **Direct public outreach** through hands on learning, and communication



Particle Falls