United States
Environmental Protection
Agency

EPA Tools and Resources Webinar: Air Quality Monitoring and Community Science

Rescheduled for June 29, 2016

3:00 – 4:00 PM ET

Ron Williams, EPA National Exposure Research Laboratory

Overview

- We have examined and continue to examine sensors as they become available.
- We are integrating these technologies into a variety of research projects.
- Investigating lower cost (< $2500) as well as mid-tier ($3000-$10000) sensors
- A wide range in capabilities are being observed. Cost is not necessarily the driver in how well any given device might function.
- Low cost sensor performance is as follows Ozone>PM> CO> NO2>SO2
- Fewer options available for air toxics. VOCs, ammonia, hydrogen sulfide, methane, etc limited in the low cost category.
- New data visualization tools like RETIGO are now available for use.
- Village Green Project giving EPA/regions/states and communities immediate access to continuous environmental data using sustainable technology.
- Demand to understand this technology sector is only increasing in intensity.
- Data messaging being pilot tested.
- Application requirements determine the data quality and sensor options for community needs.

Emerging Technologies Research Agenda

1. Investigate emerging technologies and potential to meet future air quality monitoring needs
2. Establish market surveys of commercially-available air quality sensors
3. Conduct extensive literature survey on the state of sensor technologies
4. Develop sensor user guides
5. Educate sensor developers and users on the state of low cost censors
6. Facilitate knowledge transfer to wide range of stakeholders
7. Work with sensor developers to speed up development
8. Support ORD's Sensor Roadmap by focusing on high priority issues (NAAQS, Air Toxics, Citizen Science)
9. Establish highly integrated research efforts across EPA
10. Apply knowledge gained in hands-on sensor deployment activities

*These areas will be highlighted in our discussion

Pollutants of Interest

Air Pollutant of Interest	Useful Detection Limits	Range to Expect	Level
Ozone (O_3)	10 ppb	0-150 ppb	70 ppb (8 hr)
Carbon monoxide (CO)	0.1 ppm	0-0.3 ppm	9 ppm (8 hr) 35 ppm (1 hr)
Sulfur dioxide (SO_2)	10 ppb	0-100 ppb	75 ppb (1 hr) 0.5 ppm (3 hr)
Nitrogen dioxide (NO_2)	10 ppb	0-50 ppb	100 ppb (1 hr) 53 ppb (1 yr)
Carbon dioxide (CO_2)	100 ppm	350-600 ppm	None
Volatile organic compounds (VOCs)	1 µg/m^3	5-100 µg/m^3 (total VOCs)	None
Benzene (an example of a VOC and air toxic)	0.01 – 10 µg/m^3	0-3 µg/m^3	None
Fine particulate matter ($PM_{2.5}$)	5 µg/m^3 (24-hr)	0-40 µg/m^3 (24-hr)	35 µg/m^3 (24 hr) 12 µg/m^3 (1 yr)
Particulate matter (PM_{10})	10 µg/m^3 (24-hr)	0-100 µg/m^3 (24-hr)	150 µg/m^3 (24 hr)
Black carbon (BC)	0.05 µg/m^3	0-15 µg/m^3	None

Select Quality Assurance Parameters Involving Continuous Monitoring

- Bias - is it routinely high or low with respect to the true value
- Precision - how repeatable is the measurement
- Calibration - does it respond in a systematic fashion as concentration changes
- Detection limit - how low and high will it measure successfully
- Response time - how fast does the response vary with concentration change
- Linearity of sensor response - what is the linear or multilinear range
- Measurement duration - how much data do you need to collect
- Measurement frequency - how many collection periods are needed
- Data aggregation - value in aggregating data (1 sec, 1 min, 1 hr, etc)
- Selectivity/specificity - does it respond to anything else
- Interferences - how does heat, cold, effect response
- Sensor poisoning and expiration - how long will the sensor be useful
- Concentration range - will the device cover expected highs and lows
- Drift - how stable is the response
- Accuracy of timestamp - what response output relates to the event
- Climate susceptibility - does RH, temp, direct sun, etc impact data
- Data completeness - what is the uptime of the sensor
- Response to loss of power - what happens when it shuts down

EPA/600/R-14/159 (June 2014)

Sensors and Health

- Sensors (personal, residential, outdoor, mobile) have been used in EPA panel study research examining health effects and pollutant exposure potentials (numerous health endpoints).
- Sensors can be used to define activity levels and activity patterns useful in reducing potential exposure patterns.
- Sensors can help you and your family learn about healthy versus unhealthy 'norms' or levels of air quality (Air Quality Awareness).
- Sensors can engage community groups, schools and others in environmental health, and they introduce students and community members to community science.
- Low cost sensors are now starting to be integrated into environmental justice, community advocacy groups, and citizen science-based research. EPA is awarding a number a community grants to integrate use of sensor technologies with the topics described above with its Air Pollution Monitoring for Communities grants:

(https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.rfatext/rfa_id/587)

Sensor Types

Metal Oxide (MOS)/Electrochemical and Light Scattering Sensors

- The most widely available of all gas sensor types
- Inexpensive ($15-$300)
- Available in a wide array of pollutants
- Often not specific to any one pollutant
- Co-factors often influence their output
- Response relational to some given parameter

- Light scattering sensors dominate market
- Cost varies ($50-6000)
- Sensitive to RH and stray light
- Size definition varies widely
- Unit output definition varies widely
- Aerosol composition influences response
- Not true mass measurement

Disclaimer: Mention of trade names or commercial products does not constitute endorsement or recommendation for use and are provided here solely for informational purposes

Market Discovery – PM Sensors

DYLOS

SPECK

MET ONE

SHINYEI

AIRBEAM

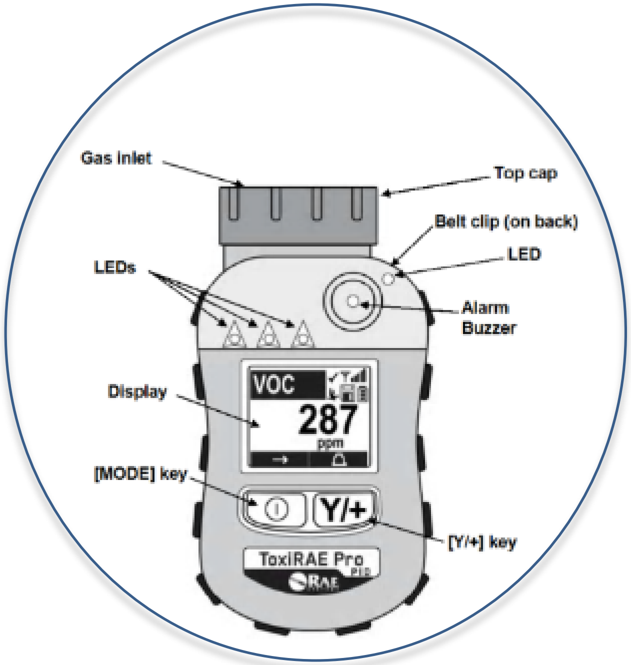
TZOA

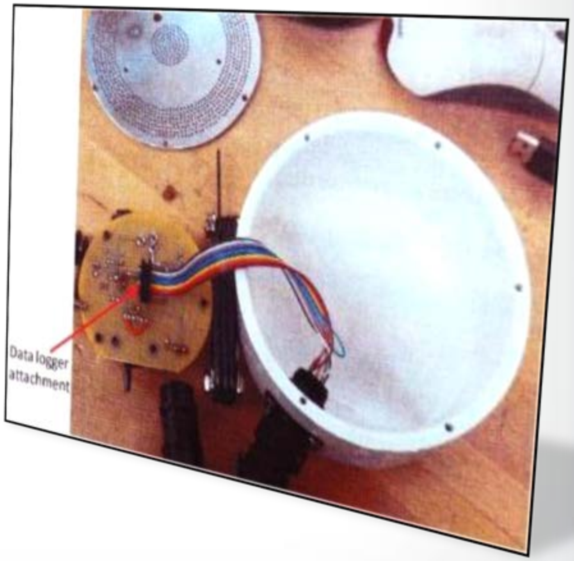
Market Discovery – VOC Sensors

ToxiRae

UniTech

EPA VOC





Market Discovery – Gas Sensors

SENSARIS

AIR CASTING

CAIRCLIP

AEROQUAL

AQ EGG

NODE

Example – Multipollutant Stations

ELM

HAZ-SCANNER

AQ MESH

EPA's Recent Community Air Monitoring Training Event

- **Goals**:
  - To share tools, best practices and resources from EPA's Air Sensor Toolbox for Citizen Scientists
  - To educate interested groups and individuals on how to conduct successful air monitoring projects
- 30 in-person attendees, 800+ via webinar
- Training videos now available on Air Sensor Toolbox website
- Ongoing follow-up with Regions/State/Tribal interests

Sensor Related Resources

Air Sensor
Measure · Learn · Share

Citizen Science Toolbox

EPA

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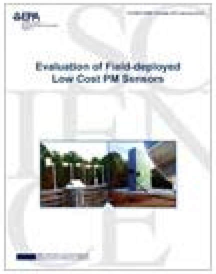
Online Resources Available at:
www2.epa.gov/air-research/air-sensor-toolbox-citizen-scientists

Air Sensor Guidebook

CSAM Operating Procedures

Mobile Sensors & Applications for Air Pollutants

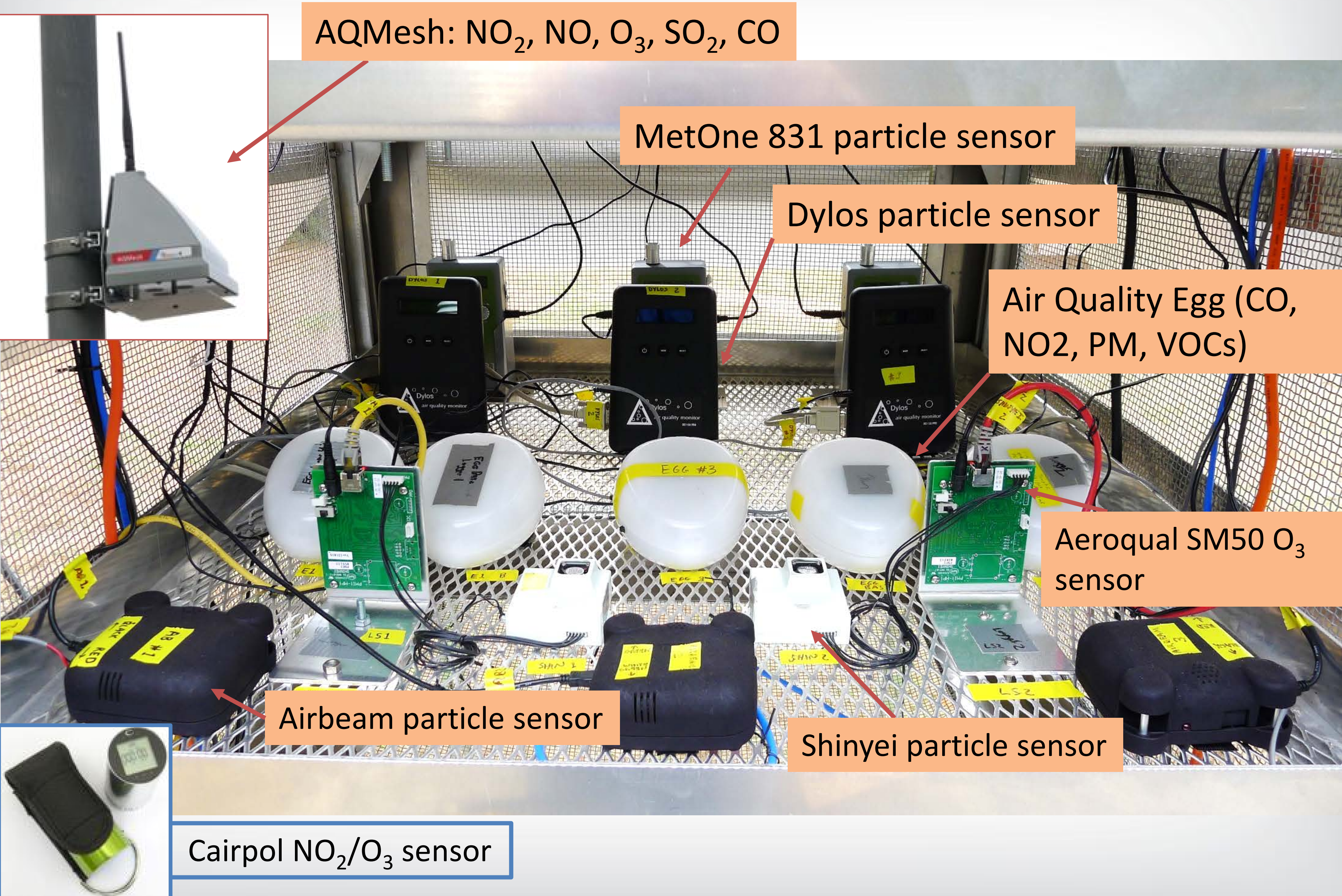
Citizen Science Air Monitor (CSAM): Quality Assurance Guidelines



Evaluation of Field-deployed Low Cost PM Sensors

Direct Collocation with FEMs

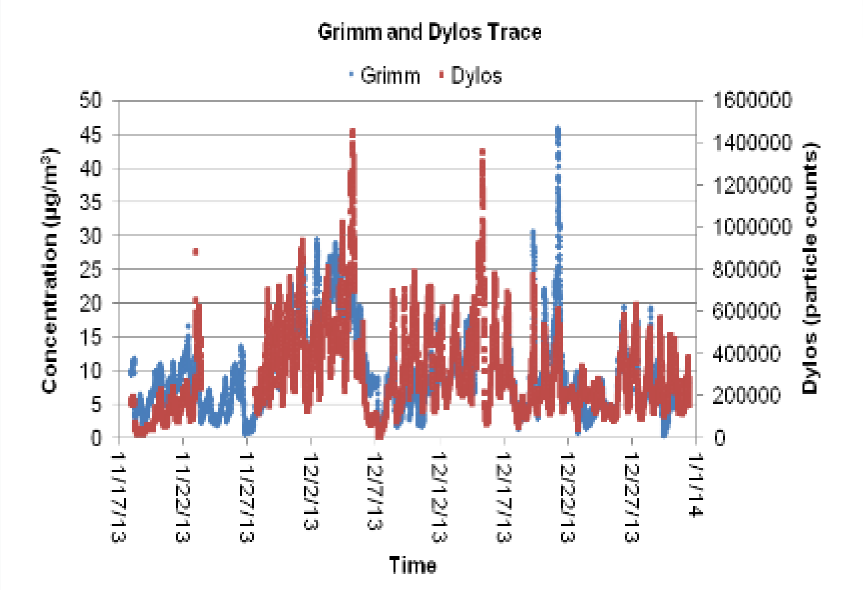
Ad-Hoc Testing

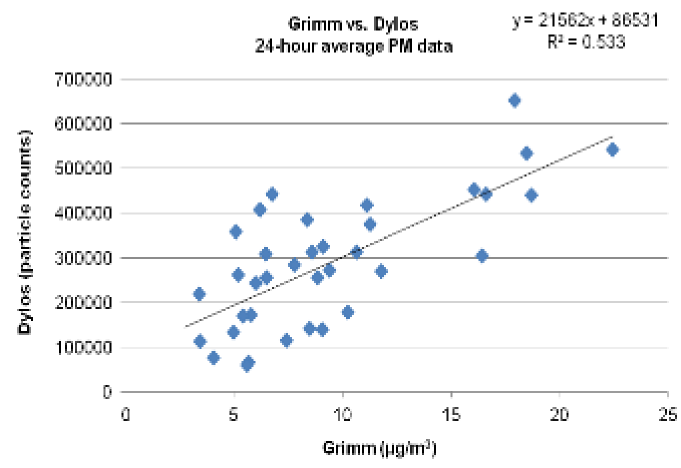


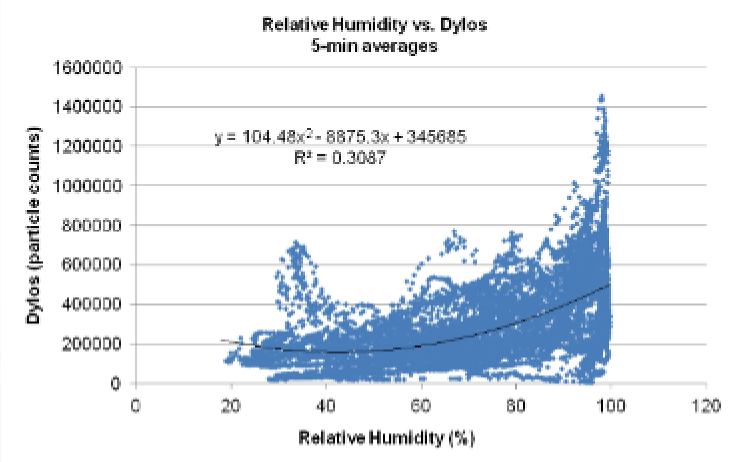
Atlanta and Denver- Climate Extremes

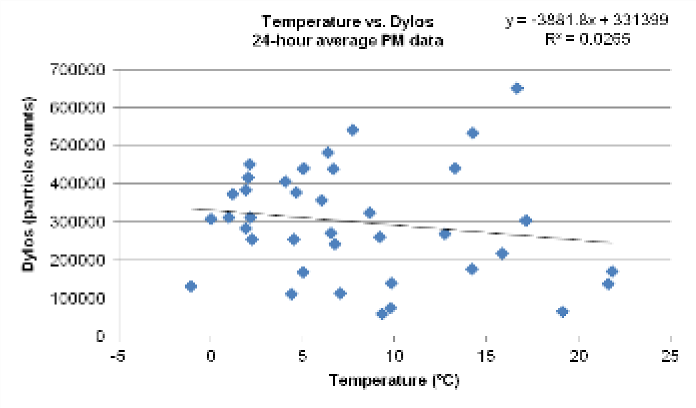
Opportunity to examine highly varying RH and temperature impacts upon sensor performance versus state-operated regulatory monitoring platforms

An Example of In-Depth PM Sensor Evaluation

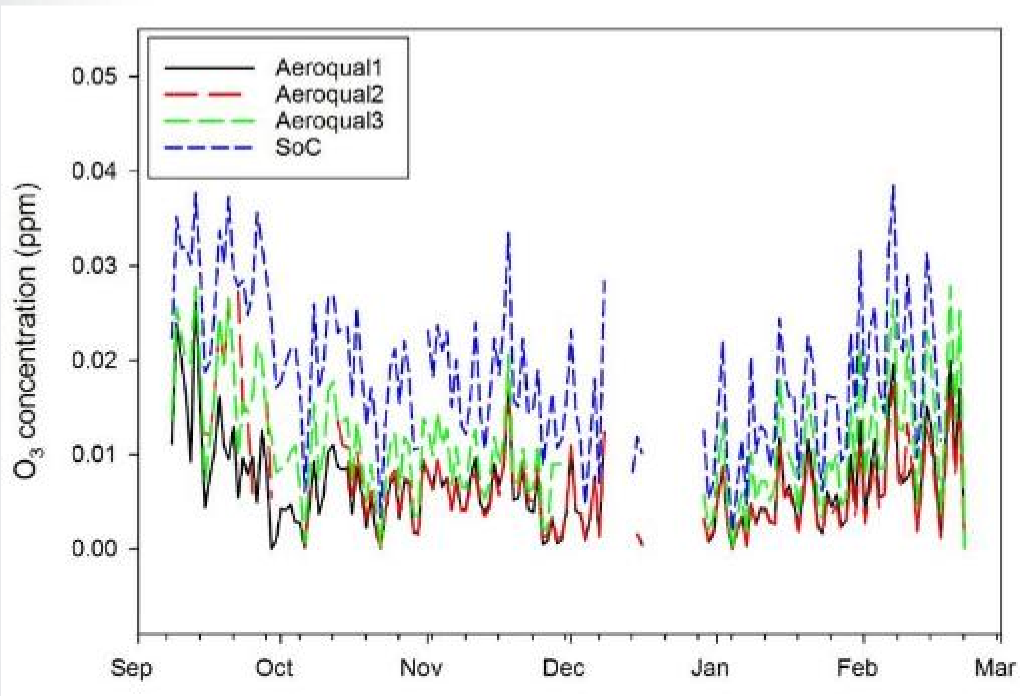


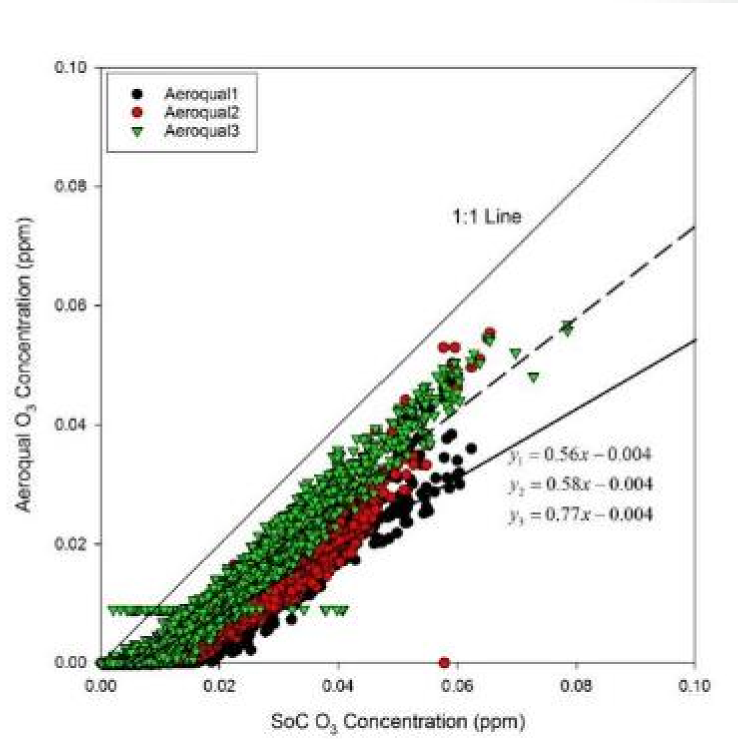






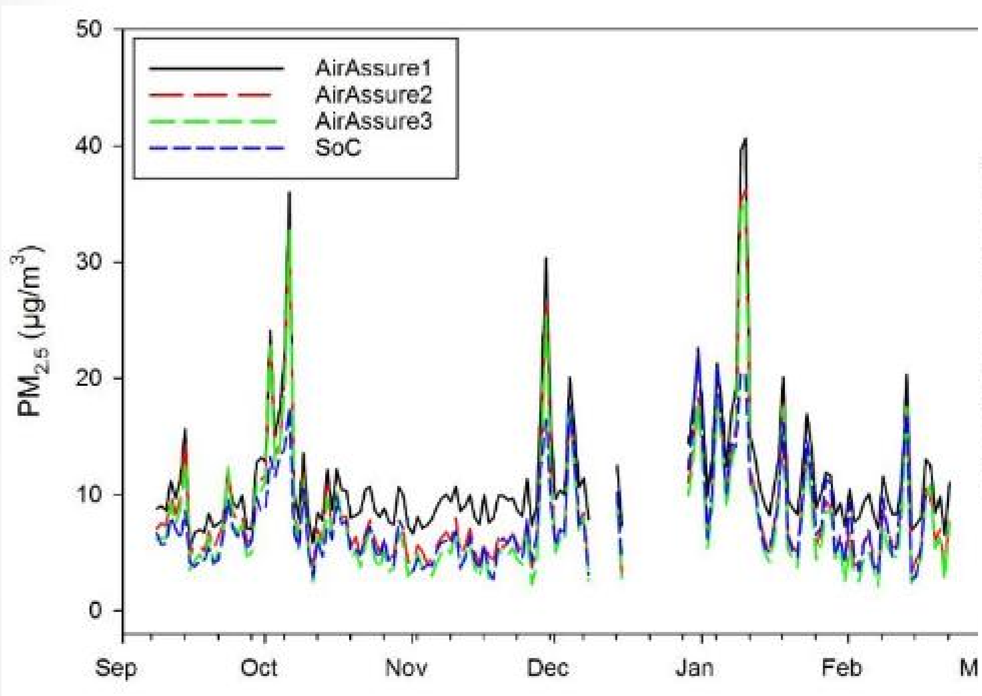
Aeroqual – O_3 (Preliminary Findings)

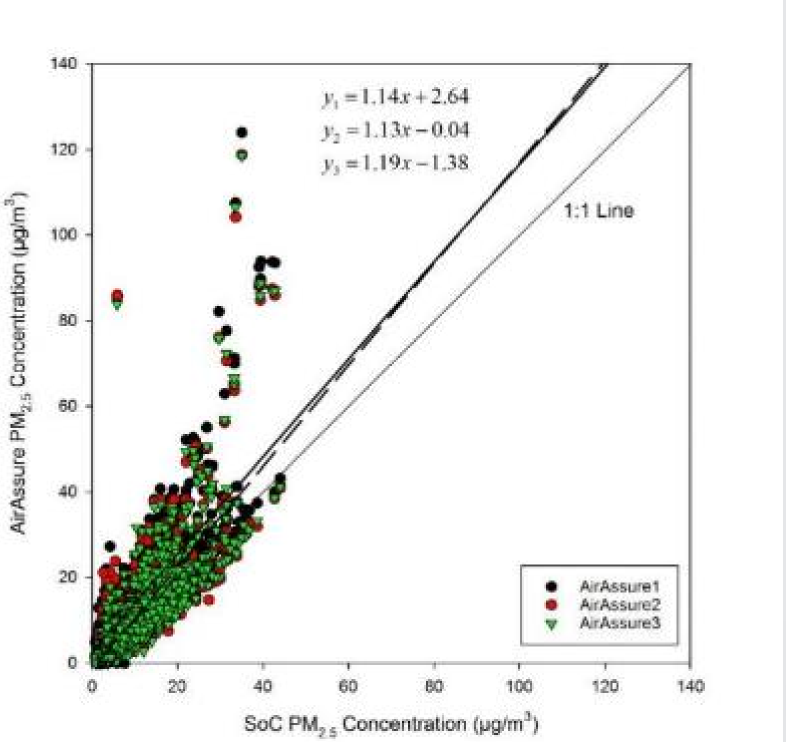




- Underreports regulatory monitor O_3
- Consistent across seasons
- Appears to have strong correlation

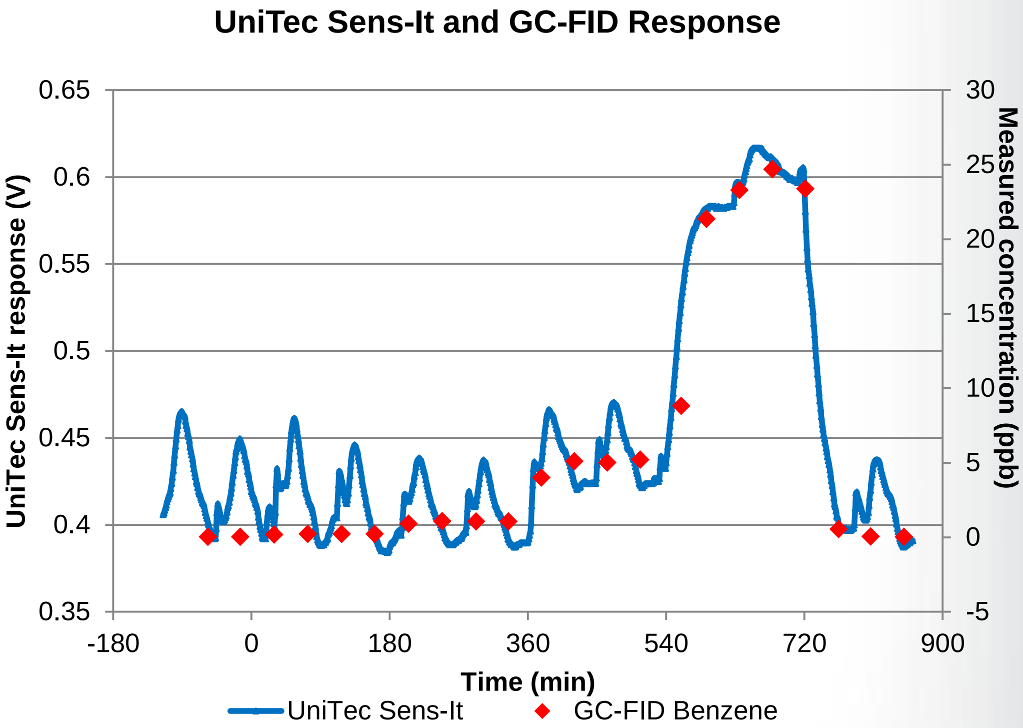
AirAssure – $PM_{2.5}$ (Preliminary Findings)





- Few over-responding events
- Strong agreement between units 2 and 3
- Appears to have strong correlation with monitor

Laboratory VOC Sensor Evaluation



ORD-Region example research projects using sensors

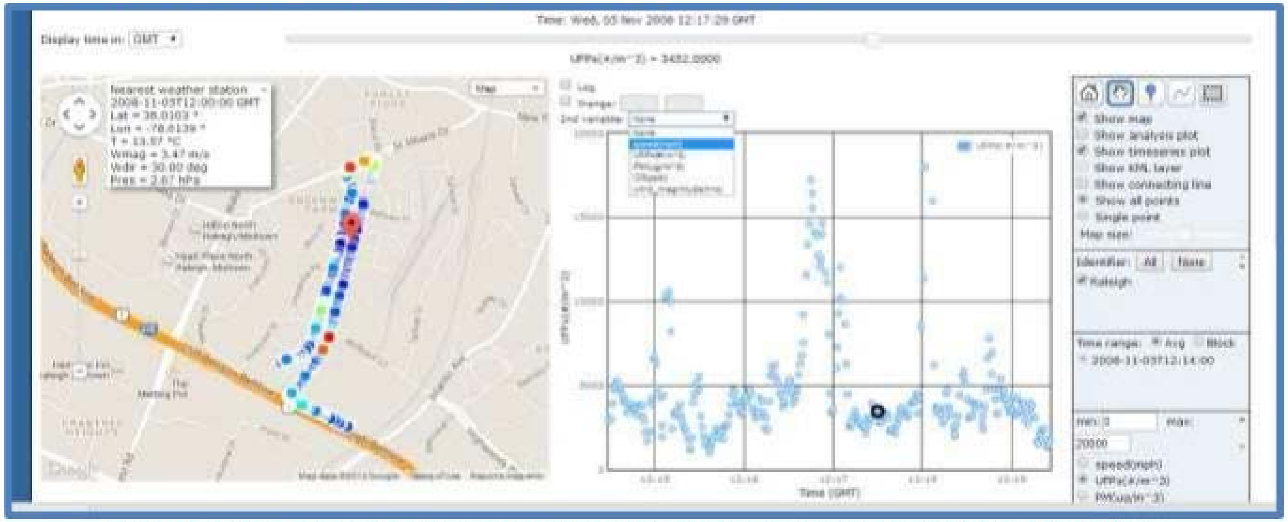
Goal: Support community group in using low-cost sensors to explore their air quality

- Designed for use by citizens/students
- Local (on-board) data storage
- Designed for ease of use by non-professionals
- Lessons learned from ORD evaluations integrated into design function (e.g., technology selected /data visualization tools employed)

Data Visualization Tools-RETIGO

REAL-TIME GEOSPATIAL DATA VIEWER (RETIGO)

AN EPA-DEVELOPED WEB-BASED TOOL FOR RESEARCHERS AND CITIZEN SCIENTISTS TO EXPLORE THEIR AIR MEASUREMENTS



Screenshot showing RETIGO in action, where data are displayed on a map and in one of the chart options.

- Free, on-line data visualization tool for spatially resolved air quality measurements
- Designed for plug and play data handling scenarios
- Provides time and spatial features of your dataset
- On-line tutorials provide step by step user instructions
- Available at **https://www.epa.gov/research/real-time-geospatial-data-viewer-retigo**

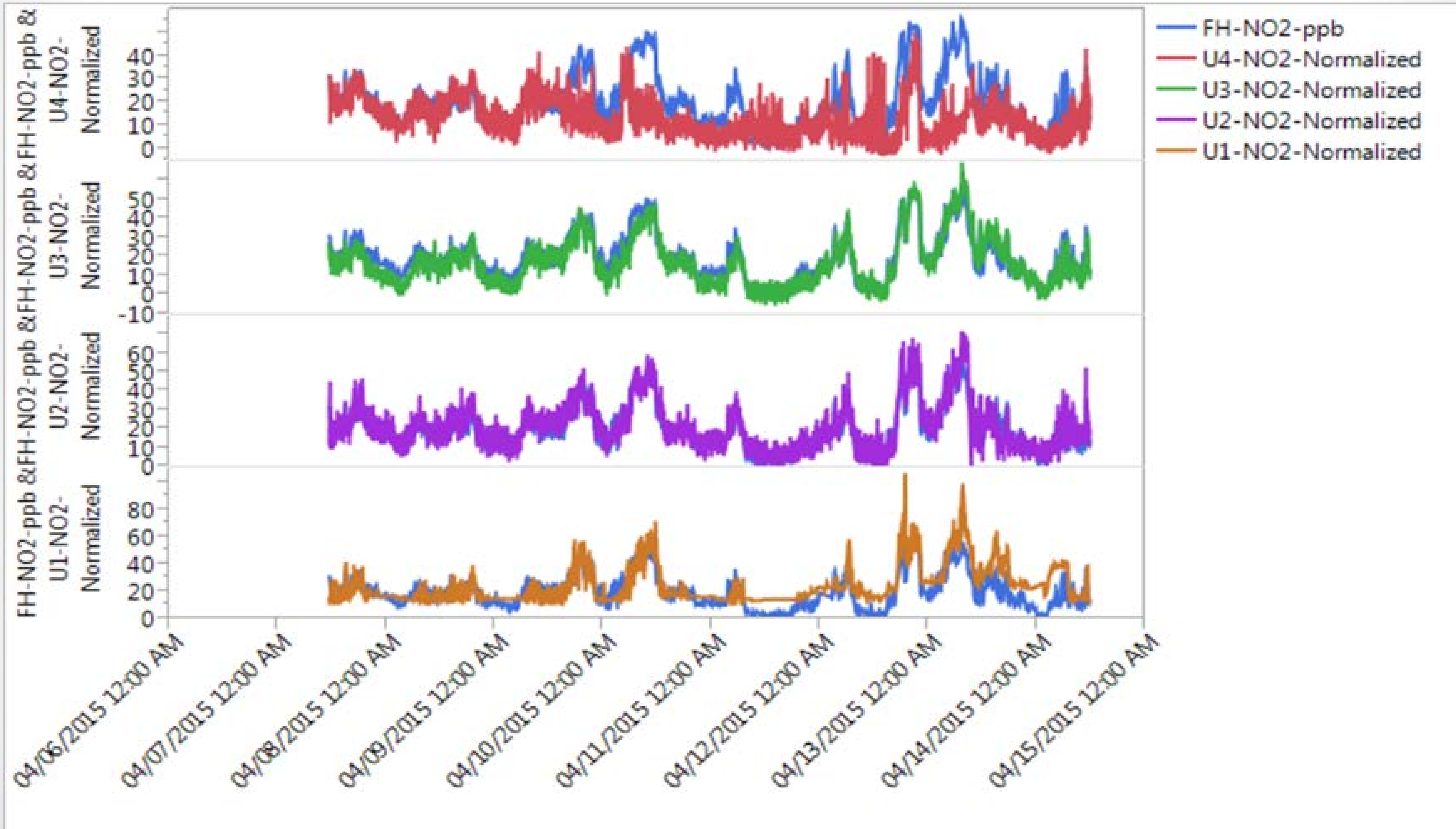
AirMapper Data Integration with RETIGO

AIRMAPPER – UNIT 4, Second File

ORD-Region research projects using sensors (FY15-17)

Project / Year	Regional Partner(s)	Measurements	Location
CAIRSENSE (Data summarization stage)	Region 1 Region 4 Region 5 Region 7 Region 8	PM, ozone, nitrogen dioxide – four sensor nodes	Atlanta, GA/Denver CO
CSAM (Report just released)	Region 2	PM, NO_2, temperature, humidity – portable stations	Ironbound community, NJ
CitySpace *(Under development)*	*Region 4* *Region 6* *Region 7*	*PM – up to 20 stationary nodes*	*Memphis, TN*
AirMapper *(Under development)*	*Region 5* *Region 10*	*PM, noise, temperature, humidity – highly portable units*	*Chicago, IL* *Portland, OR*
Puerto Rico EJ *(Under development)*	*Region 2*	*PM, VOCs, NO_2 stationary nodes*	*Puerto Rico*

Integration of Sensor Research and Citizen Science
Sensor Normalization (NO_2)
CSAM vs FEM



Village Green Project

- Prototype located in Durham, NC outside of a public library
- Self-contained system incorporates
  - **power supply**: solar panels & battery
  - **microprocessor**
  - **cellular modem**
- Measures two common air pollutants
  - **ozone** and **fine particulate matter ($PM_{2.5}$, particle diameter ≤ 2.5 µm)**
- Measures **weather**
  - wind speed and direction
  - temperature and humidity
- Sampling rate – **every minute**
- Comparable results
  - Instruments agreed within 10-20 % of reference monitors located nearby
- Prototype design made available: http://pubs.acs.org/doi/suppl/10.1021/acs.est.5b01245

Village Green Pilot Project

Partners: City of Philadelphia, National Park Service

Partners: State of Oklahoma, Myriad Botanical Gardens

Partners: State of Kansas, Wyandotte County, School District

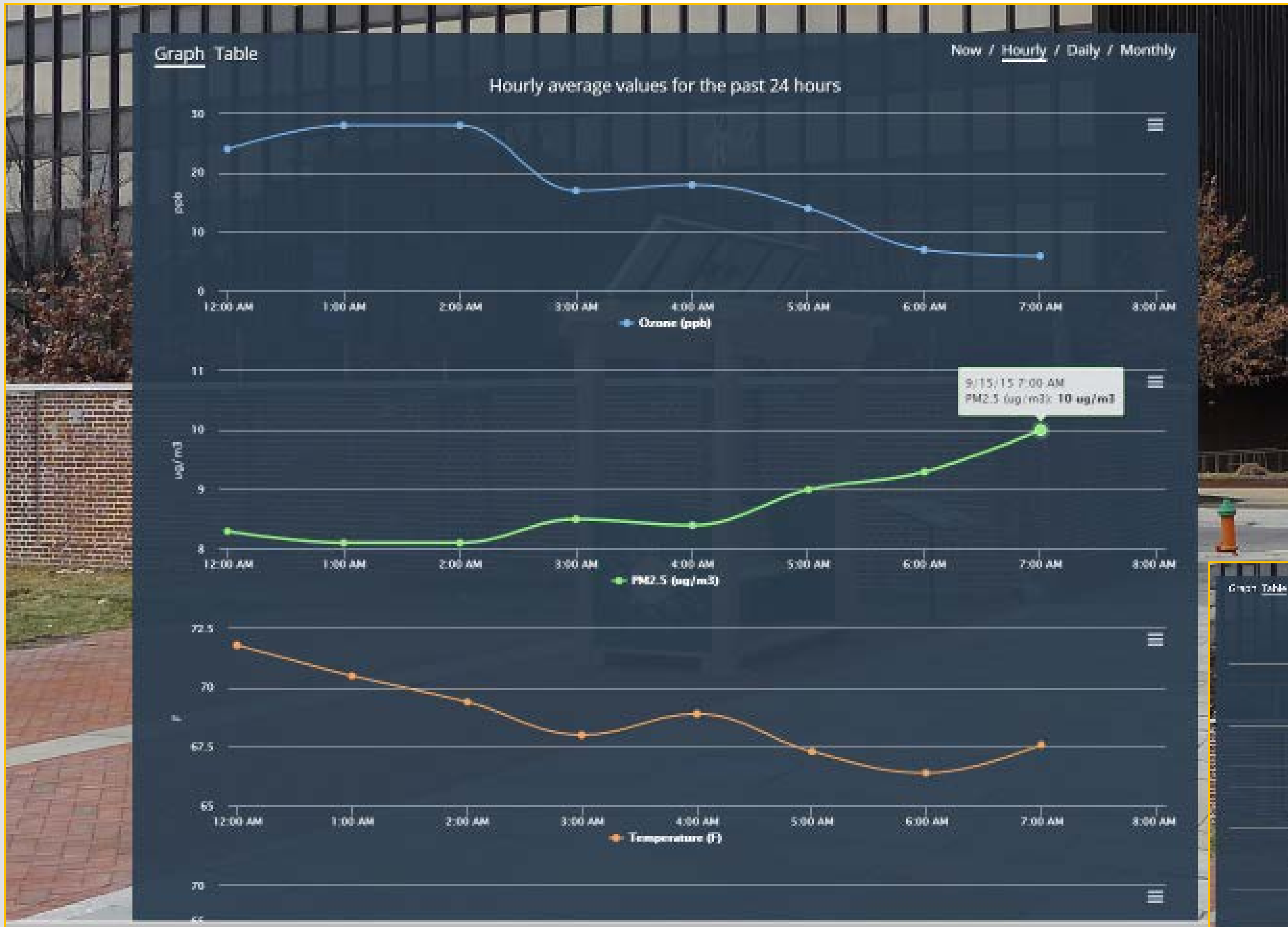
Partners: District Department of the Environment, Smithsonian

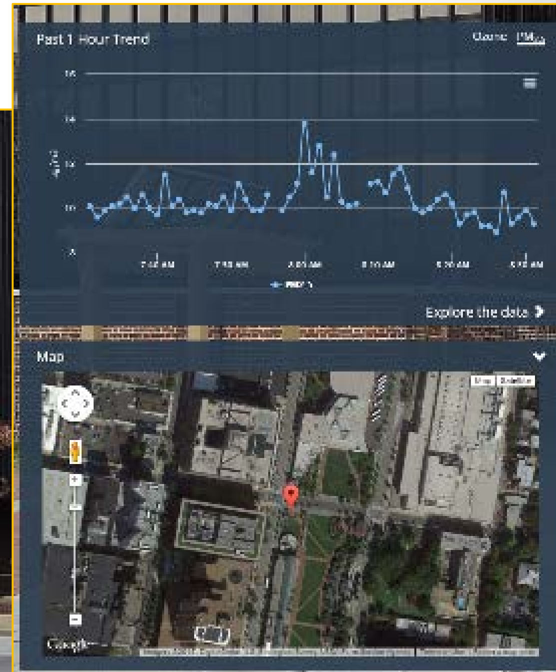
Latest Village Green Station

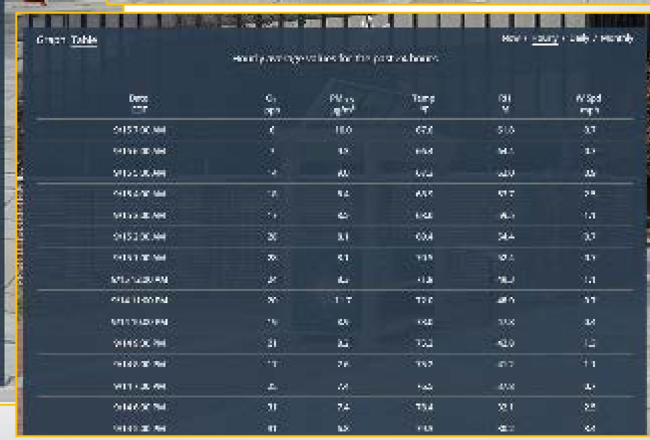
Location: Connecticut Science Center outdoor pavilion, Hartford, CT
Partners: State of Connecticut, Connecticut Science Center

Village Green Project: data website

Data website: Interactive data exploration







New Village Green Data Messaging Tool

Data Messaging Pilot- On the Village Green and Air Sensors Toolbox Websites

Communicating Instantaneous Air Quality Data: Pilot Project

EPA is launching a pilot project to test a new tool for making instantaneous outdoor air quality data useful for the public. The new "sensor scale" is designed to be used with air quality sensors that provide data in short time increments – often as little as one minute. EPA developed the scale to help people understand the 1-minute data the stations provide and how to use those data as an additional tool for planning outdoor activities.

EPA is testing the scale using data from the community-based Village Green stations, which provide 1-minute ozone and particle pollution data for seven U.S. cities. We're seeking feedback through the end of August.

Once the pilot is complete, EPA will make any necessary improvements to the scale and messages and determine our next steps. Our goal is to make the scale available for use with other sensors later in 2016. Read the documents below to learn more, and send us feedback.

FAQs: Pilot "Sensor Scale" Project to Communicate Instantaneous Air Quality Data

Provide Feedback

You will need Adobe Reader to view some of the files on this page. See EPA's About PDF page to learn more.

- Sensor Scale Pilot Project: Fact Sheet (PDF) (2 pp, 174 K)
- Interpretation and Communication of Short-term Air Sensor Data A Pilot Project (PDF) (4 pp, 198 K)
- Ozone short-term measurement analysis: report (PDF) (7 pp, 622 K)
- Particle pollution short-term measurement analysis: report (PDF) (7 pp, 508 K)

Contact Us to ask a question, provide feedback, or report a problem.

Take Home Messages

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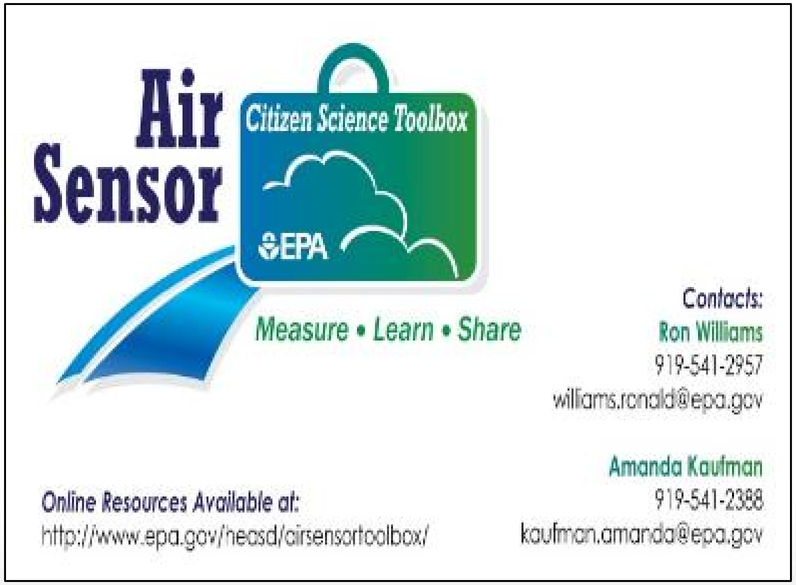
Thank You

One resource for you is the following website:

(http://www2.epa.gov/air-research/air-sensor-toolbox-citizen-scientists)



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