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Next-generation air measurement technologies: Development and application

Gayle Hagler, PhD
EPA Office of Research and Development
hagler.gayle@epa.gov



Foreward

Objective of this presentation:

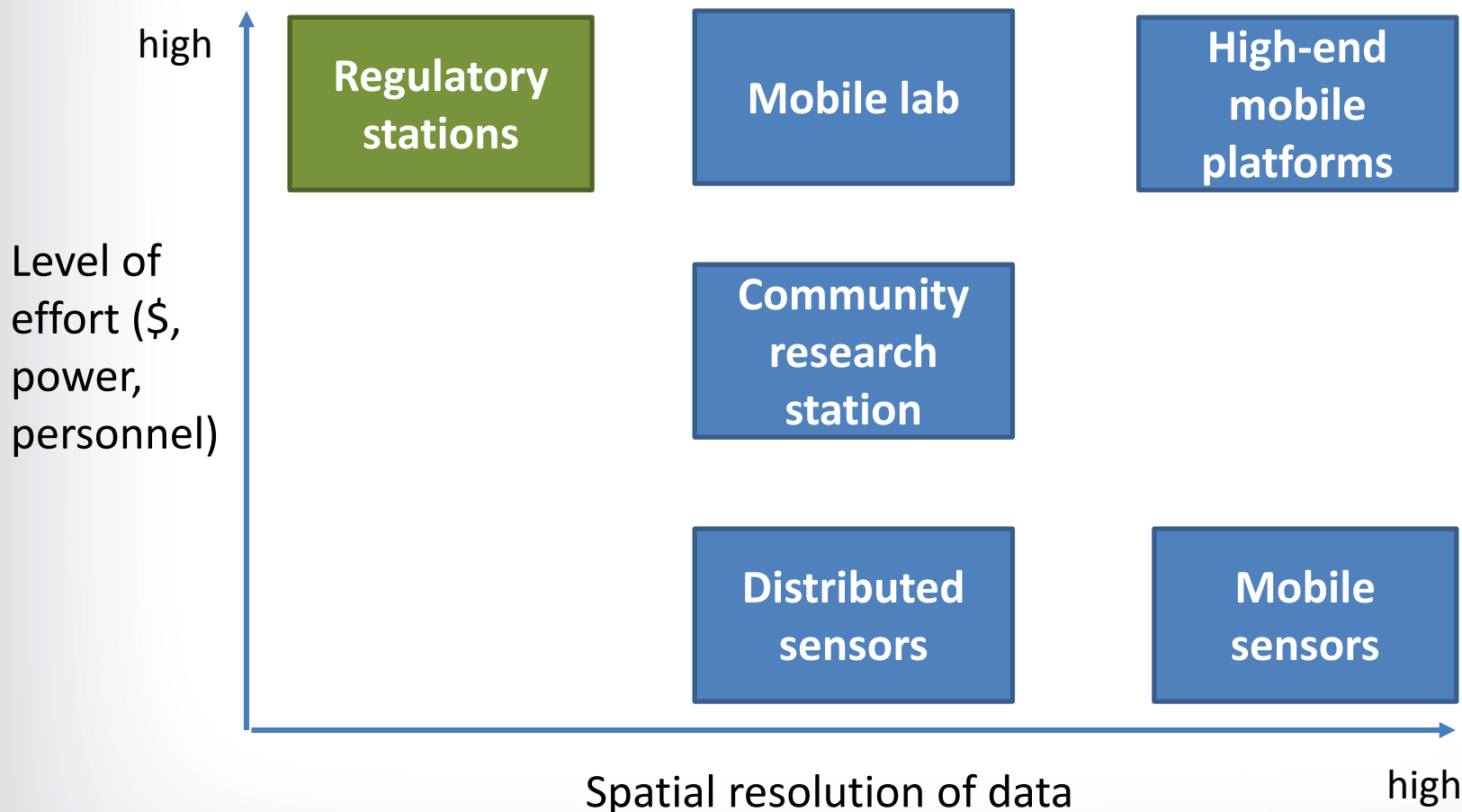
This presentation summarizes current and upcoming EPA ORD research projects related to using next-generation air measurement technologies (NGAM) in community environments.

Disclaimer:

While this presentation has been reviewed and cleared for publication by the U.S. Environmental Protection Agency, the views expressed here are those of the author and do not necessarily represent the official views or policies of the Agency.



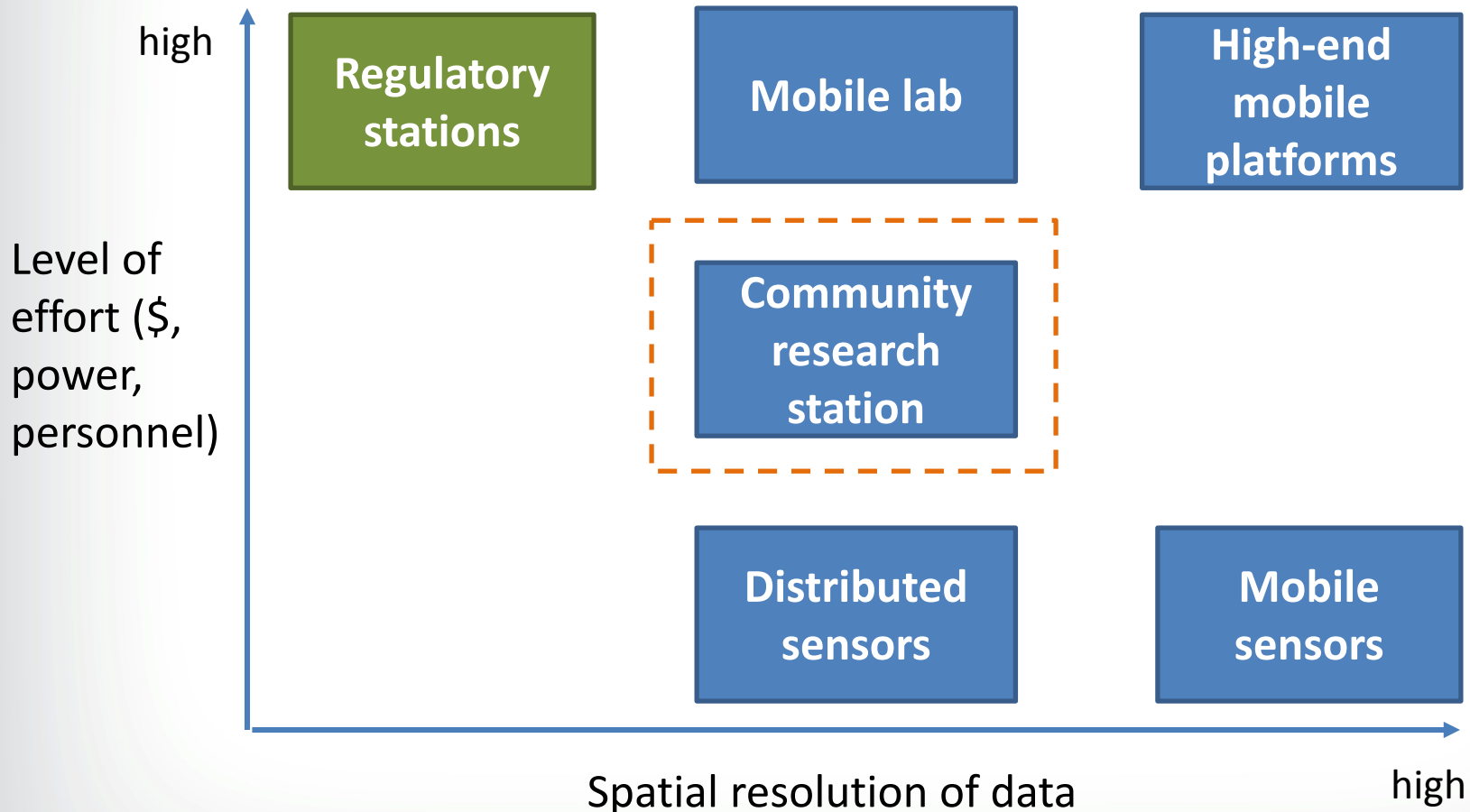
Next-generation air measurement (NGAM) technologies





Example projects:

I. Village Green Project (VGP)





Village Green Project - Vision

Conceptual
drawing



To develop a non-regulatory air monitoring system that would support measurements in more locations and increase engagement with community members.

Key attributes:

- Transparent data collection
- Easier to deploy and lower cost
- Data useful for research purposes
- Engage with community members
- Sustainable



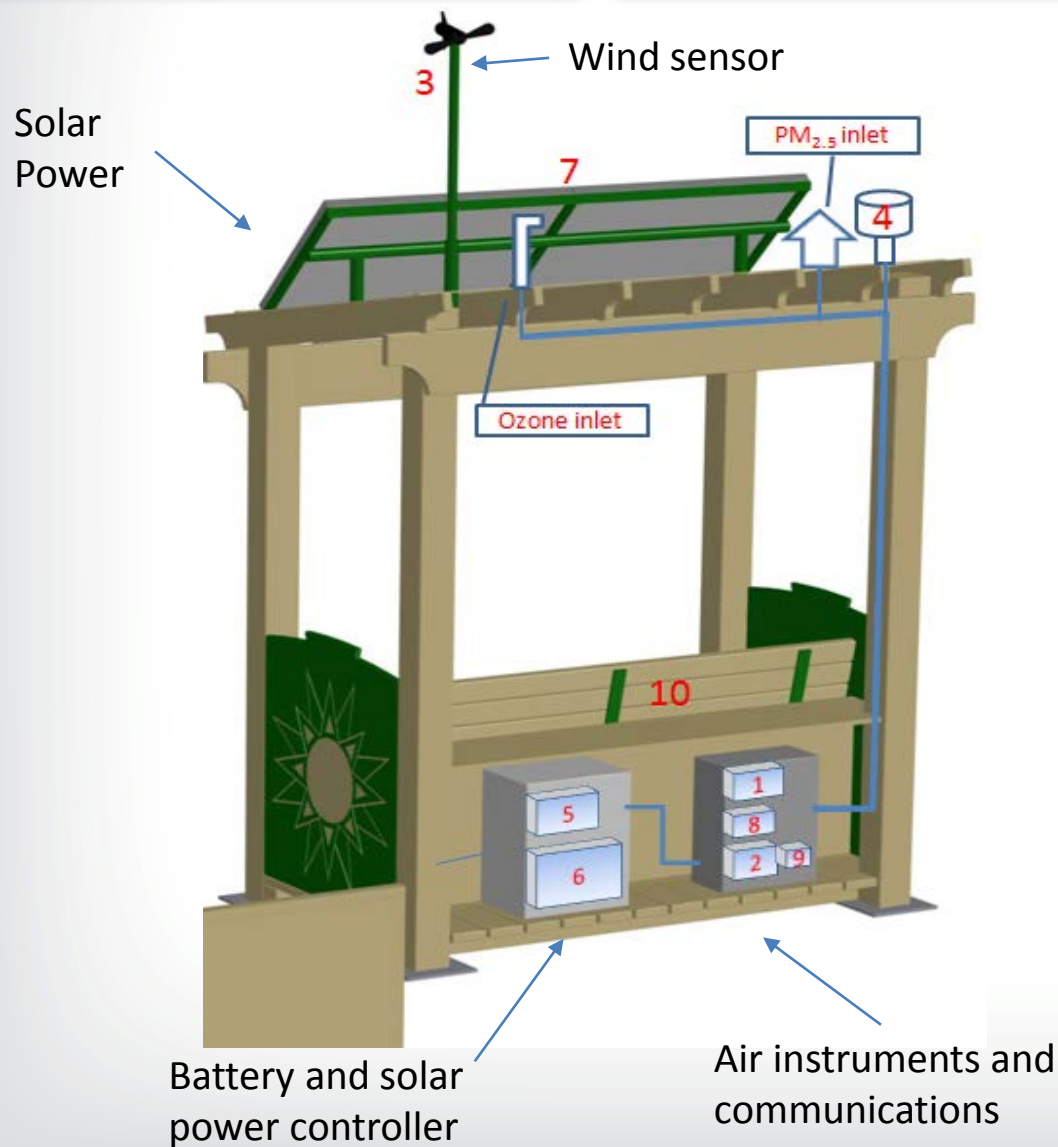
Village Green Project

- Prototype located in North Carolina, USA outside of a public library
- Measures two common air pollutants
 - **ozone** and **fine particulate matter (PM_{2.5}, particle diameter $\leq 2.5 \mu\text{m}$)**
- Measures **weather**
 - wind speed and direction
 - temperature and humidity
- Sampling rate – **every minute**
- Self-contained system incorporates
 - **power supply**: solar panels & battery
 - **microprocessor**
 - **cellular modem**





Village Green Project



- Data quality-checked using algorithms, new data values appear every minute on public website
- Data values also appear on a sign next to the bench





Village Green Project – test results

- Long-term prototype test in North Carolina (initiated June 2013)
- Sufficient Power from solar panel
 - Power sufficient for ~95% operation time over the first 10 months evaluated (June 2013 – March 2014)
- 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>



Jiao et al., ES&T, 2015.

Result: EPA vision of expansion and enhancements



Village Green Project - pilot expansion

- USA expansion:
 - Partnership with state and local agencies
 - Competitive proposal opportunity (summer 2014): 22 proposals received, 5 selected for a new station
 - One additional station through EPA Region research project
- Significant improvements made to Village Green Project website and data management system through the AirNow program
- Continued technical development of the station:
 - Field-testing a variation of the station in a different range of air pollution through partnership between USEPA and Hong Kong Environmental Protection Department (HKEPD)
 - Testing addition of wind turbine and extra battery to increase system run-time in northern locations
 - Testing addition of new pollutant sensors



New Village Green Project stations in USA (FY15)

Partners: City of Philadelphia,
National Park Service



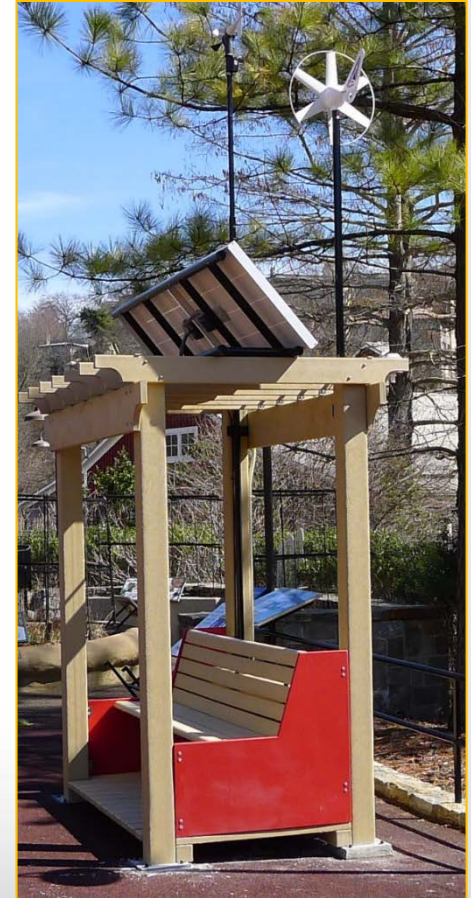
Partners: State of Oklahoma, Myriad
Botanical Gardens



Partners: State of
Kansas, Wyandotte
County, School
District



Partners: District
Department of the
Environment,
Smithsonian





Upcoming Village Green Project stations (FY16-17)

Hartford, Connecticut:

Partners: State of Connecticut, Connecticut Science Center

Chicago, Illinois:

Partners: EPA Region 5, Jane Addams Elementary School



Village Green Project: data website

Data website: airnow.gov/villagegreen



Welcome to the Village Green Project

a research effort to discover new ways of measuring air quality and weather conditions in community environments.



Measuring and communicating on-the-spot air quality and weather conditions for research and awareness



Developing small and rugged data collection systems that can be powered by the wind and sun

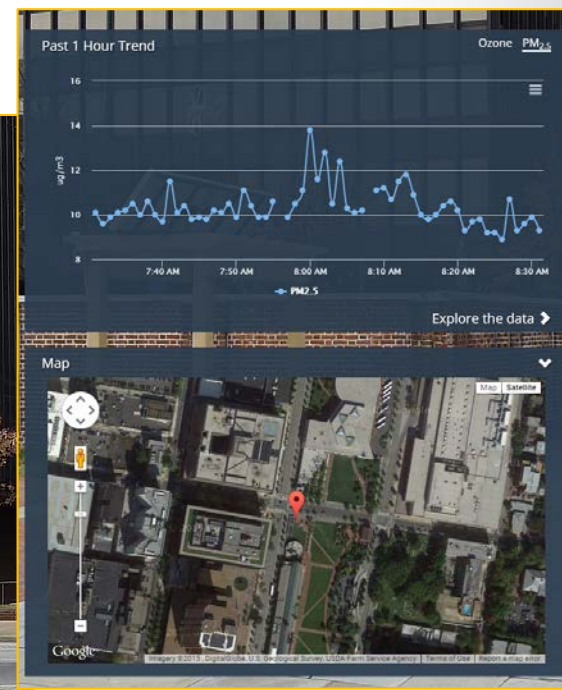


Partnering with communities to pilot test the new technology in outdoor community spaces.



Village Green Project: data website

Data website: Interactive data exploration

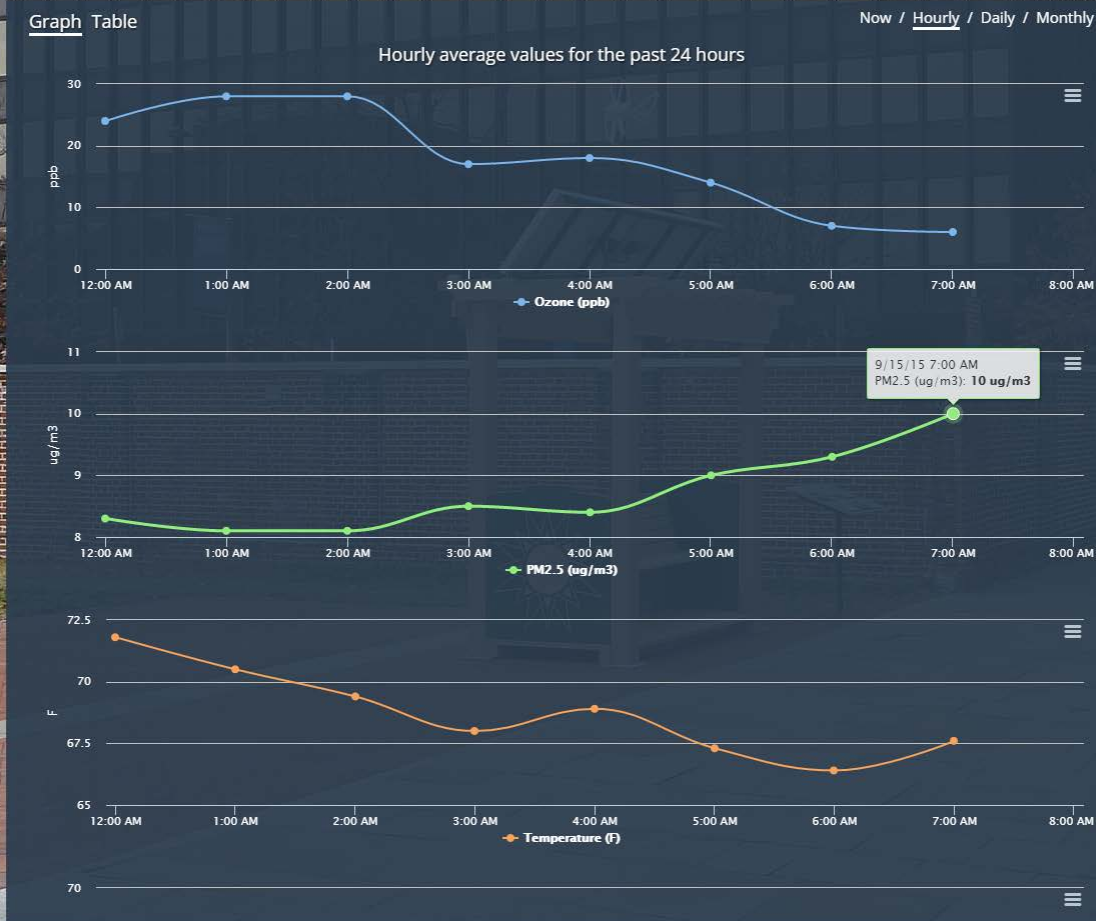


Graph Table

Hourly average values for the past 24 hours

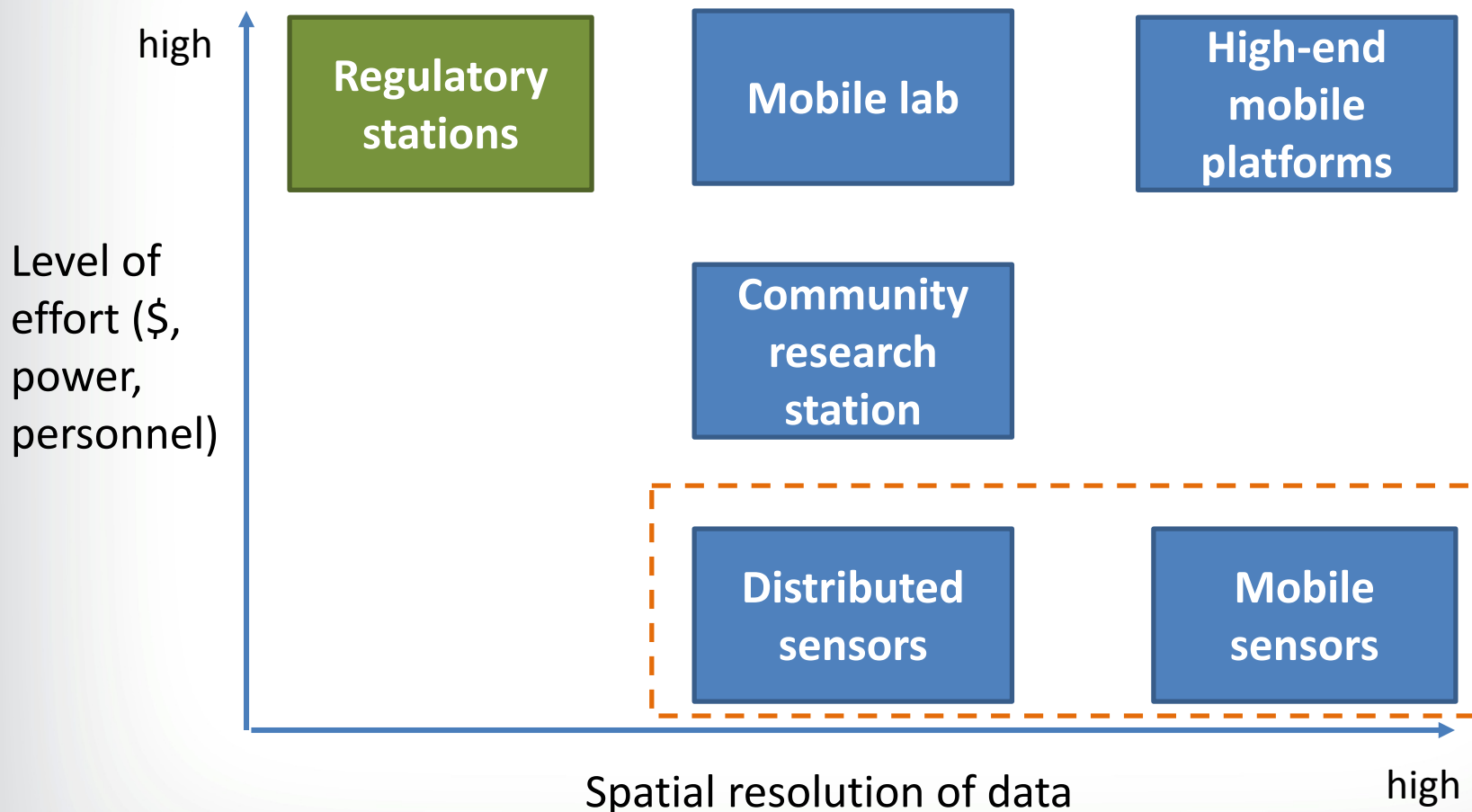
Now / Hourly / Daily / Monthly

Date EDT	O ₃ ppb	PM _{2.5} µg/m ³	Temp °F	RH %	W Spd mph
9/15 7:00 AM	6	10.0	67.6	61.8	0.7
9/15 6:00 AM	7	9.3	66.4	64.4	0.7
9/15 5:00 AM	14	9.0	67.3	62.0	0.9
9/15 4:00 AM	18	8.4	68.9	57.7	2.5
9/15 3:00 AM	17	8.5	68.0	59.5	1.1
9/15 2:00 AM	28	8.1	69.4	54.4	0.7
9/15 1:00 AM	28	8.1	70.5	52.4	0.7
9/15 12:00 AM	24	8.3	71.8	49.3	1.1
9/14 11:00 PM	20	11.7	72.0	48.9	0.7
9/14 10:00 PM	19	8.9	73.0	47.8	0.4
9/14 9:00 PM	21	8.2	75.2	42.8	1.3
9/14 8:00 PM	17	7.6	75.2	41.2	1.1
9/14 7:00 PM	25	7.4	76.5	37.8	0.7
9/14 6:00 PM	31	7.4	78.4	32.1	2.5
9/14 5:00 PM	31	6.8	79.3	30.2	3.4





Example projects: 2. Upcoming sensor studies





ORD-Region research projects using sensors (FY15-16)

Project / Year	Regional Partner(s)	Measurements	Location
CAIRSENSE (FY15)	Region 1 Region 4 Region 5 Region 7 Region 8	PM, ozone, nitrogen dioxide – four sensor nodes	Atlanta, GA
CSAM (FY15)	Region 2	PM, NO ₂ , temperature, humidity – portable stations	Ironbound community, NJ
<i>CitySpace (FY16)</i>	<i>Region 4 Region 6 Region 7</i>	<i>PM – up to 20 stationary nodes</i>	<i>Memphis, TN</i>
<i>AirMapper (FY16)</i>	<i>Region 5 Region 10</i>	<i>PM, noise, temperature, humidity – portable units</i>	<i>Chicago, IL Portland, OR</i>
<i>Puerto Rico EJ (FY16)</i>	<i>Region 2</i>	<i>Tentative: PM, VOCs, NO₂ – portable units</i>	<i>Puerto Rico</i>



ORD-Region research projects using sensors (FY15-16)

Project / Year	Regional Partner(s)	Measurements	Location
CAIRSENSE (FY15)	Region 1 Region 4 Region 5 Region 7 Region 8	PM, ozone, nitrogen dioxide – four sensor nodes	Atlanta, GA

Goal: Test feasibility of using low-cost sensor network in suburban setting



- Solar-powered
- Daisy-chained data communication via ZigBee communication
- PM sensor: Shinyei PM sensor
- NO₂ sensor: Cairclip NO₂/O₃ sensor
- O₃ sensor: Aeroqual SM50





ORD-Region research projects using sensors (FY15-16)

Project / Year	Regional Partner(s)	Measurements	Location
CSAM (FY15)	Region 2	PM, NO ₂ , temperature, humidity – portable stations	Ironbound community, NJ

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



- Designed for temporary use by citizens in multiple locations (on tripod)
- Battery-powered
- Local data storage
- PM sensor: personal DataRAM nephelometer
- NO₂ sensor: Cairclip NO₂

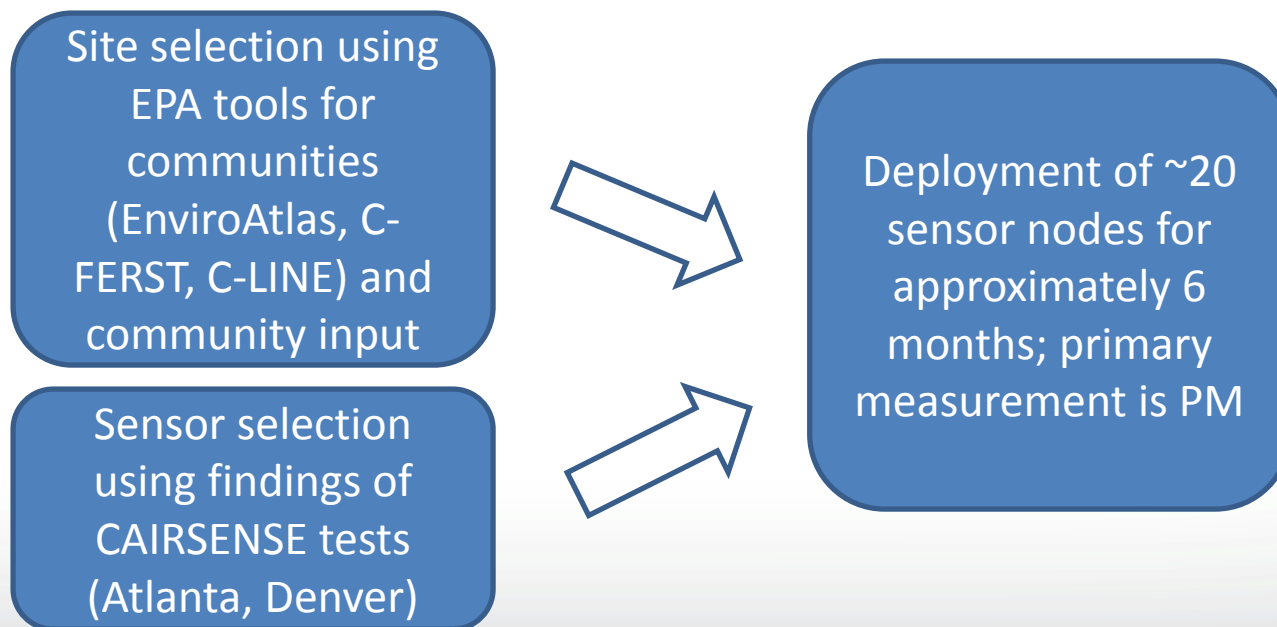




ORD-Region research projects using sensors (FY15-16)

Project / Year	Regional Partner(s)	Measurements	Location
<i>CitySpace (FY16)</i>	<i>Region 4 Region 6 Region 7</i>	<i>PM – up to 20 stationary nodes</i>	<i>Memphis, TN</i>

Goal: Test use of low-cost sensors to explore spatial variability of PM





ORD-Region research projects using sensors (FY15-16)

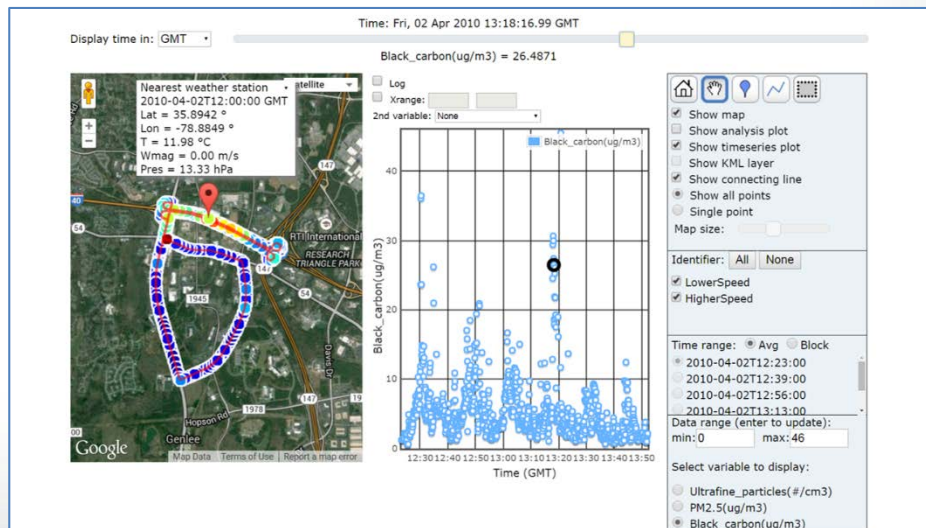
Project / Year	Regional Partner(s)	Measurements	Location
AirMapper (FY16)	Region 5 Region 10	PM, noise, temperature, humidity	Chicago, IL Portland, OR

Goal: Develop portable monitoring system to measure geospatial patterns of PM, that is user-friendly for students and adults.

RETIGO data viewer: www.epa.gov/retigo



- Measurements at rate of 1-10 s
- Target parameters: PM, noise, temperature, humidity, location





ORD-Region research projects using sensors (FY15-16)

Project / Year	Regional Partner(s)	Measurements	Location
<i>Puerto Rico EJ (FY16)</i>	<i>Region 2</i>	<i>Tentative: PM, VOCs, NO₂ – portable units</i>	<i>Puerto Rico</i>

Goal: Apply low-cost sensors to explore air quality trends in environmental justice community, with participation of the community.



Other upcoming research

- Black carbon sensor: FY16 project to develop a low-maintenance and compact sensor for long-term field use.
- Air Pollution Monitoring for Communities Grant (EPA-G2014-STAR-K1): STAR funding to universities to be announced, up to \$4.5 million.



Summary

- ORD heavily involved in evaluating, developing, and conducting exploratory research with air sensors.
- Significant interest in multiple EPA Regions and states to pilot the use of NGAM technologies in their communities.
- The research and educational outreach potential is significant, and this technology is developing quickly. Data quality and appropriate use of sensors remains the largest question and concern.

For more information:

Ron Williams: williams.ronald@epa.gov

Gayle Hagler: hagler.gayle@epa.gov