Environmental Information exchange Network

EN2015

Village Green–Demonstrating the Capabilities of Real-Time Monitoring

Dennis Sosna and Hallie Weiss

City of Philadelphia , Department of Public Health, Air Management Services

Kristen Benedict and Ron Evans

U.S. EPA, Office of Air Quality Planning and Standards

2015 Exchange Network National Meeting

Supporting the Business of Environmental Protection

September 29–October 1, 2015
Sheraton Philadelphia Society Hill Hotel
Philadelphia, Pennsylvania

http://www.exchangenetwork.net/en2015

ABSTRACT

The Village Green Project (VGP) is an example of using innovative technology to enable community-level, real-time air pollution measurements using low-cost sensor technologies. The VGP stations are air monitoring systems configured as park benches and are intended for research and educational purposes. Through partnerships with states, cities, and other organizations, these air monitoring systems are being installed across the country for use by the public. See the VGP webpage at:

http://www2.epa.gov/air-research/village-green-project

Outline

A. Village Green II (VGII) Project
   - Background
     - Technical Objective
     - Data Objective
   - State/local partnerships
   - Pictures
   - Philadelphia VG Station
     - Process
     - Hardware
     - Data
     - Metrics
- Interpretation and Communication of Data

Village Green Prototype

Park Bench

- Durham, NC Library
- Installed in June 2013
- Purpose: Research and educational outreach
- Air instruments ($PM_{2.5}$ & Ozone)
- Meteorological Instruments
- Solar-powered
- One-minute data uploaded to publically available website

Cite or Quote

Inside the bench

Power module:
Power inputs from solar and/or wind
Rechargeable battery

Instrumentation module
PM2.5 and ozone instruments
Microprocessor
Cellular modem
Internal temperature sensor
Heater (new stations)

Background: Village Green II Technical Objectives

- Prototype → Pilot expansion (one year)
  - Moved from research to development
  - Remain federal property
  - State/local/ partnerships
  - Continued research (e.g. introduce NO_2 sensor)
  - Enhanced station components (e.g. wind turbine & heater)
  - Public/Community outreach
  - Re-assess after one year with partners

Background: Village Green II Data Objectives

- Prototype → Pilot expansion (one year)
  - Expand transparency using Air-Now
  - Real time data to the public for communities in which air quality data is lacking
  - Revise AirNow to include VG data
    - Existing: One hour data
    - VG data: One minute data
  - Develop additional communication tools
    - Mobile app for smartphones
    - Data messaging
- Exceeds FY15 Agency Priority Goal of having 2 real-time data streams available to the public

2015: Village Green II Project

State/Local Partnerships – One-Year Pilot

- Funding from Next Generation Compliance
- State/local solicitation
  - 22 Proposal submitted
  - Five selected
- Selected Sites
    - Washington, DC – installed in February 2015
    - Philadelphia, PA – installed in March 2015
    - Kansas City, KS – installed in March 2015
    - Oklahoma City, OK – to be installed in Fall 2015
    - Hartford, CT – to be installed in Fall 2015

2015: Pilot Expansion of the Village Green Project

Station at Independence Mall National Park, Philadelphia, PA

Partners: City of Philadelphia, National Park Service

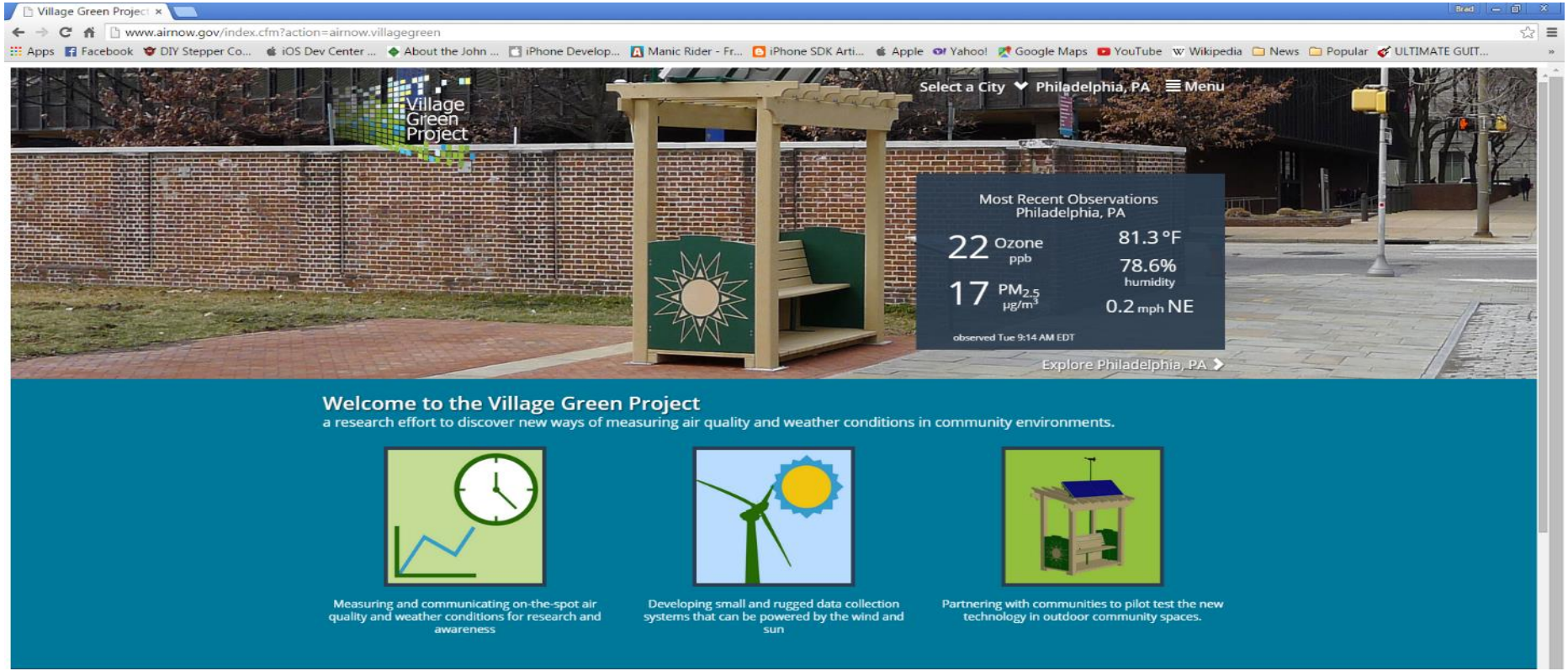
Timeline

- **September 2014** – Philadelphia Air Management Services awarded grant
- **October 2014** – Chose monitoring location/partner
- **November 2014** – Conference Calls with EPA
- **December 2014** – Meetings with Partner: National Parks Service (NPS)
- **January 2015** – EPA visits site location
- **February 2015** – Philadelphia AMS Staff become familiar with equipment manuals, Permit is in place
- **March 5, 2015** – EPA contractors install the Village Green equipment

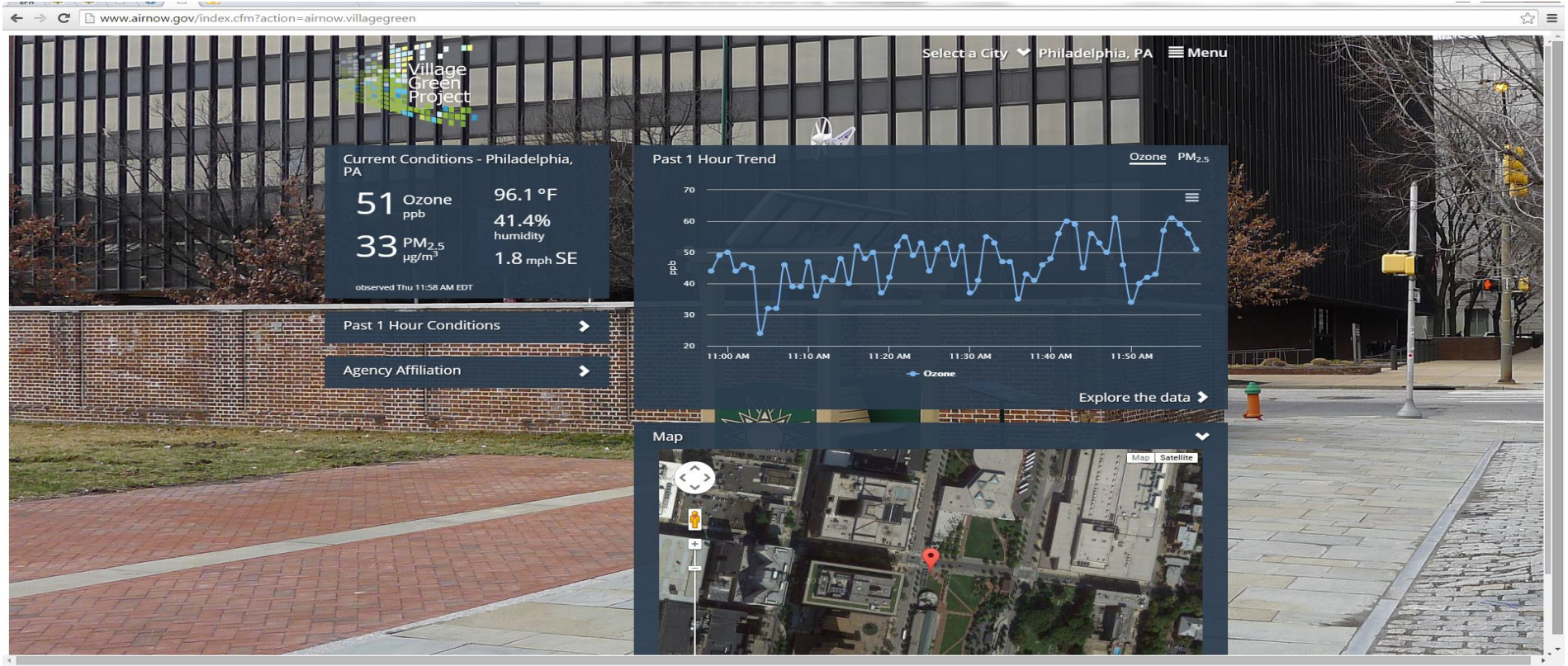
- **March 2015** – Training by webinar/person

Philadelphia Village Green up and running!

SNAPSHOT OF AIR NOW WEBSITE



SNAPSHOT OF AIR NOW WEBSITE



SNAPSHOT: Now/Hourly/Daily/Monthly Data

SNAPSHOT: Hourly Average Values (24 hrs)

Date EDT	O_3 ppb	$PM_{2.5}$ µg/m³	Temp °F	RH %	W Spd mph
9/3 4:00 PM	51	32.4	97.9	36.6	2.0
9/3 3:00 PM	51	32.4	99.3	33.7	2.2
9/3 2:00 PM	49	32.1	99.3	33.6	2.2
9/3 1:00 PM	47	31.8	98.4	36.8	2.2
9/3 12:00 PM	47	35.9	96.8	40.9	2.5
9/3 11:00 AM	46	42.4	94.8	45.6	2.5
9/3 10:00 AM	33	47.2	92.7	48.6	2.0
9/3 9:00 AM	28	50.3	89.8	51.0	1.6
9/3 8:00 AM	18	52.8	85.1	58.9	1.6
9/3 7:00 AM	15	52.8	81.7	65.7	1.6
9/3 6:00 AM	17	52.2	80.2	69.1	1.3
9/3 5:00 AM	22		80.6	68.0	1.1
9/3 4:00 AM	28		81.1	67.0	1.1
9/3 3:00 AM	31		81.3	66.4	0.9
9/3 2:00 AM	33		82.2	64.0	1.1
9/3 1:00 AM	30		82.6	66.5	0.7

Timeline

- **April 21, 2015 –** Ribbon-Cutting Ceremony

Operation since April 2015

- **Maintaining the station** – Keeping a daily log

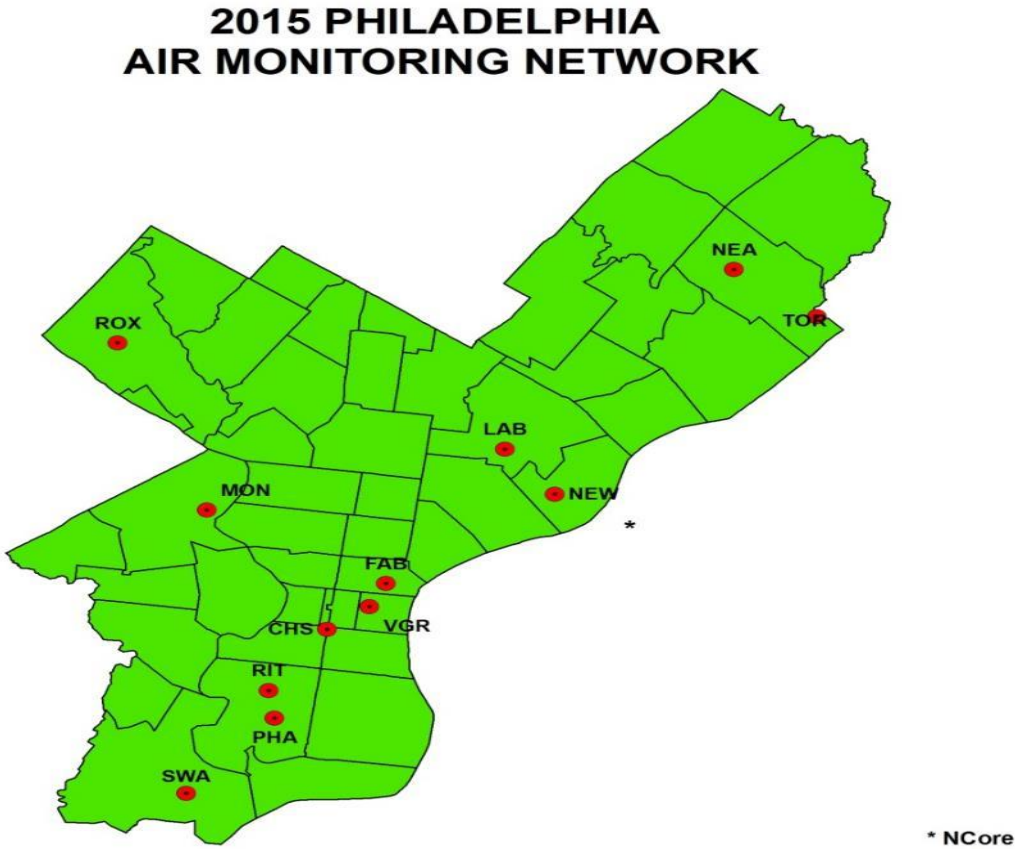
DATE	COMMENTS
1-Jun	Checked online, both pages looked fine. All parameters are up with once in a while (about every 10- 15 minutes), O3 cell P, diode
2-Jun	Checked online, both pages looked fine. All parameters are up with once in a while (about every 10- 15 minutes), O3 cell P, diode
3-Jun	Checked both pages; they look fine. All parameters are up. Battery appears little bit low in voltage, perhaps due to weather; it's be
4-Jun	Checked both pages; they look fine. All parameters are up.
5-Jun	Checked both pages; they look fine. All parameters are up.
6-Jun	Checked data pages and no missing hours occurred; hourly data appear fine.
7-Jun	Checked data pages and no missing hours occurred; hourly data appear fine.
8-Jun	Checked the data page for 6/8 (Monday), the hourly data for O3 appear fine, while the hourly 8-hr O3 seem having insufficient data for the past 5 hrs (1 AM – 5 AM), will have to check data from GH to confirm.
9-Jun	Checked Village Green websites and both webs appear fine except on the datapage (http://vgapi.sonomatechdata.com/datafilter.aspx), components of O3 such as O3_CellP, O3_Diode, O3_Flow and O3_Temp have
10-Jun	Checked online, both pages appeared fine. All parameters are up. The O3 components that were blank in every 2-3 minutes the day before, have been back up since Tuesday (6/9) evening hours. Will verify if the cal check was done yesterday.
11-Jun	Checked both pages; they look fine. All parameters are up. O3 had some downtime (~ 3 hrs) due to cal check. As of 3:07 pm, O3
12-Jun	Checked the data page for Friday, the hourly PM2.5 looks good, no insufficient hourly data or missing data, but there were insufficient hourly data for hourly O3 from 10 AM – 9 PM. Will need to check the minute data when it's available.

- **July 31, 2015** – 1st Quarterly Report Provided to EPA
  - Data Completeness
  - Quality Checks
  - Corrective Action/Comments

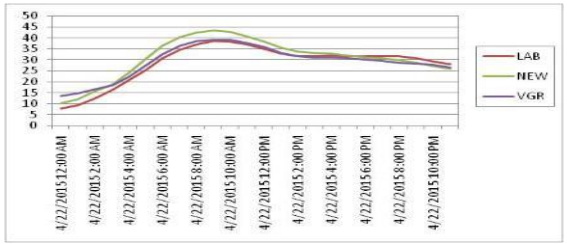
Experiences with Equipment

- **Maintaining the station**
  - **General maintenance:**
    - 15 Hours were spent conducting quarterly quality checks
    - Observations: Setting ozone flow rate to 1300 ccm helped keep it within the automatic quality check range
    - Aimed to avoid air quality action days for any onsite maintenance that would interrupt data collection.
    - AMS purchased back-up air instruments with grant funding to minimize downtime.
    - NPS grounds crew notifies Philadelphia AMS if there is any lawn maintenance at the station.
  - **Troubleshooting**
    - Remote restarts allowed us to correct some minor issues – interruption in $PM_{2.5}$ data reporting, clock drift. EPA and Philadelphia AMS both have remote-connect capability.
    - EPA contractor replaced wind sensor data interface (RS232 converter).
- **System performance**
  - 96% and greater completeness for April 1 through July 1, 2015.

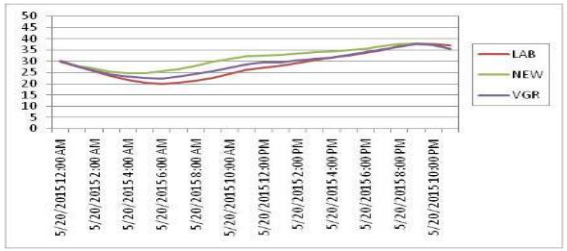
Philadelphia Air Monitoring Network



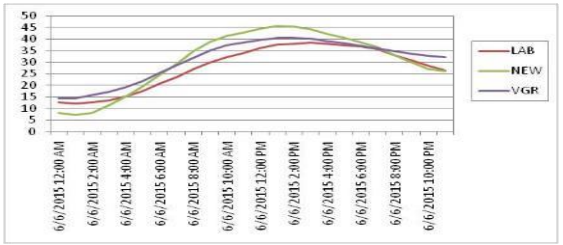
Ozone (PPB) and PM2.5 (µg/m³)



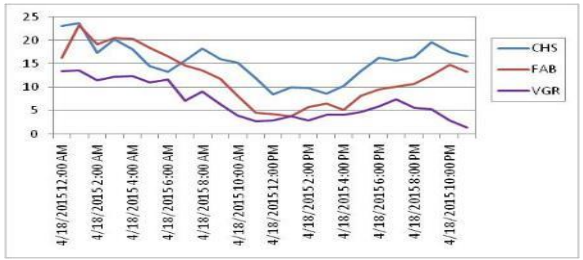
(4/22/2015)



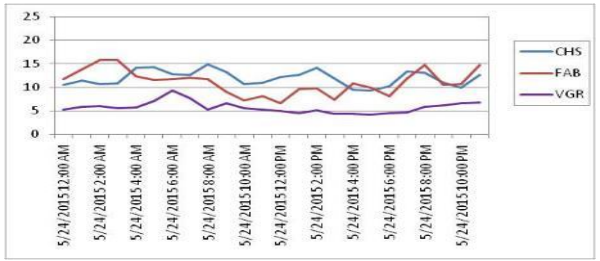
(5/20/2015)



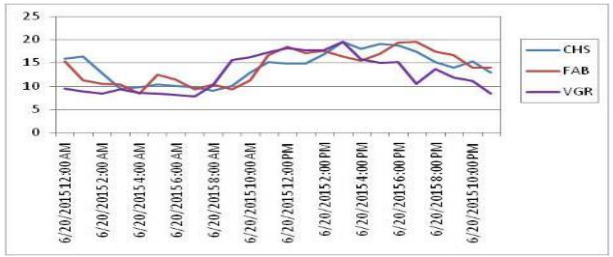
(6/6/2015)



(4/18/2015)



(5/24/2015)



(6/6/2015)

Collected Data Thoughts

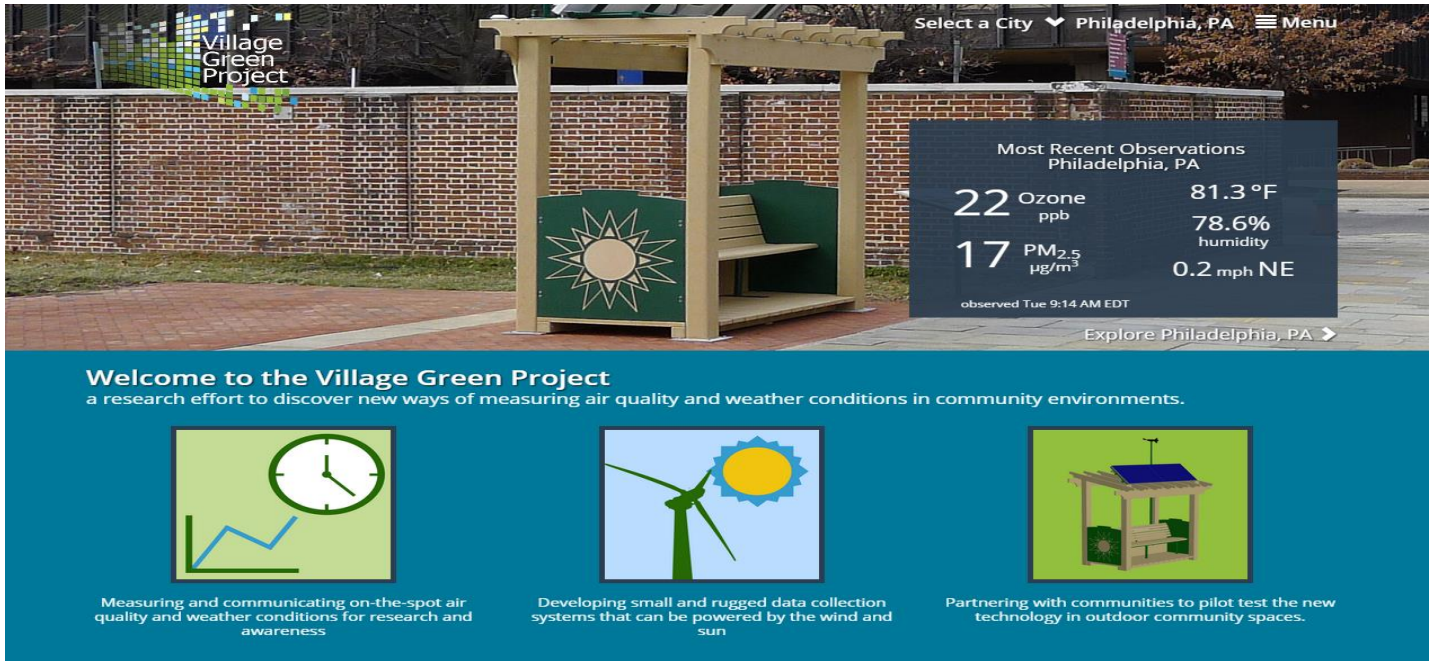
- Initial assessment in Durham, NC indicated agreement within ~15% with nearby reference instruments (Jiao et al., 2015).
- Ozone from both the Village Green (VGR) monitor and the reference monitor (LAB) have been in close agreement towards each other from the time Village Green started.
- Particulate Matter ($PM_{2.5}$): Comparison of the station (VGR) against nearby stations (CHS and LAB) for one day selected per month had disagreement in values for April and May, but close agreement in June.
- Met data looks fine.
- With only one quarter so far, we need further investigation. To prepare a comparison of daily averages for the full time span.

General Experience

- The efforts of our cooperative partner, the National Parks Service, in keeping the Philadelphia Village Green site clean, deserve note. Their team has demonstrated great experience in outreach to the public.
- EPA has been very helpful and responsive, providing good support to the operation.
- Philadelphia AMS has been getting some good traffic on the website for the project.
- Equipment looks dependable; all calibration checks have passed so far.
- Next Steps
  - One Year Pilot Study
  - Future discussions with NPS/EPA
  - Mobil App
  - Additional Outreach

Interpretation & Communication

Philadelphia VG Station



http://www.airnow.gov/index.cfm?action=airnow.villagegreen

Interpretation & Communication

Studies do not support short term (e.g. 1-minute) ***health effects*** messaging

Interpretation & Communication

The Air Quality Index

(*Not for use to interpret sensor data)*

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

AQI focuses on health effects experienced within a few hours or days

Interpretation & Communication

Sensor Concentration ≠ Air Quality Index

Sensor Reading
Concentration
Short term (e.g. 1 minute)
Data Quality Unknown

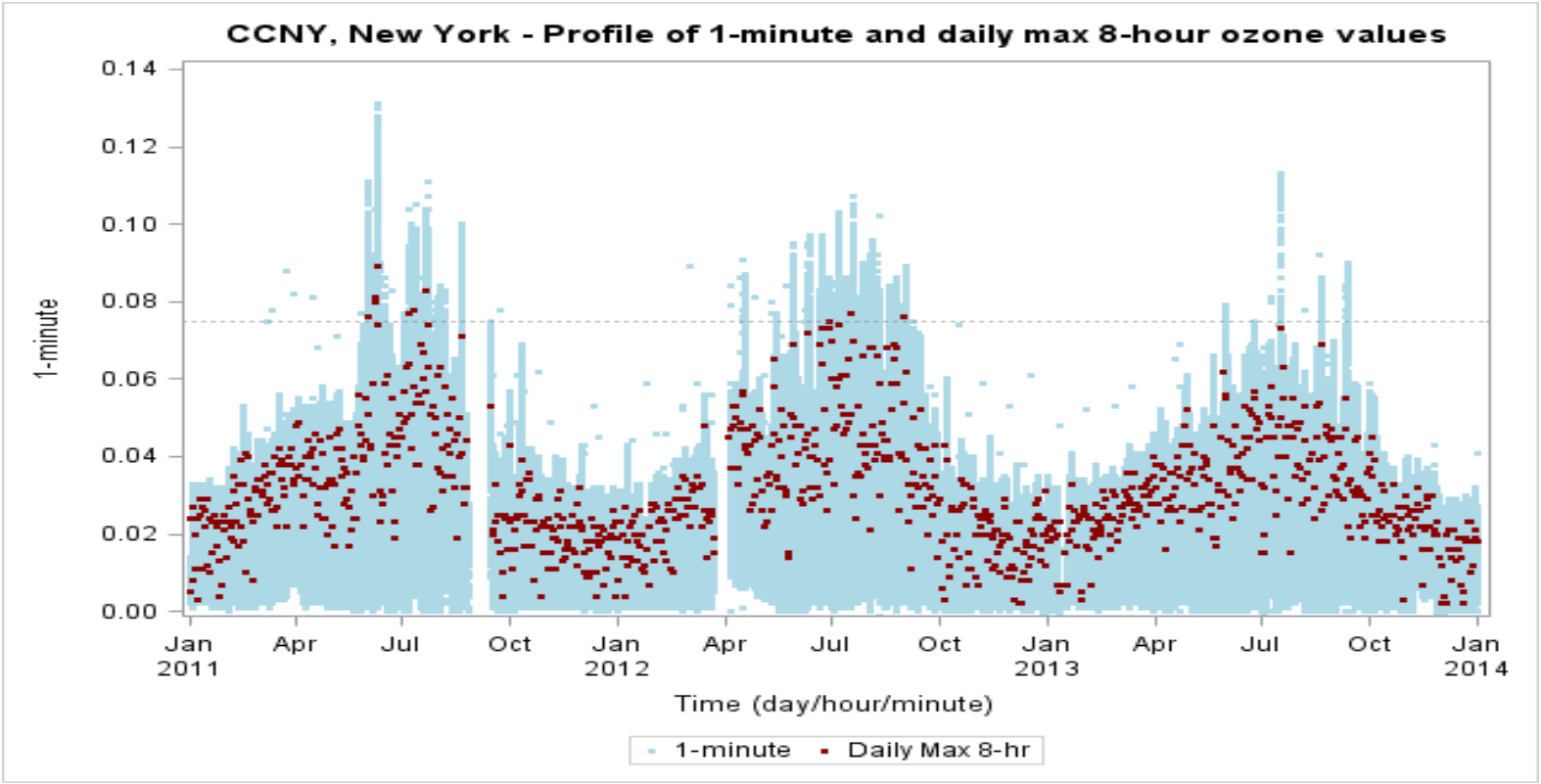
Air Quality Index
Index Color
Averaged (e.g. 8-hour, 24-hour)
Data Quality Assured

Data Analysis

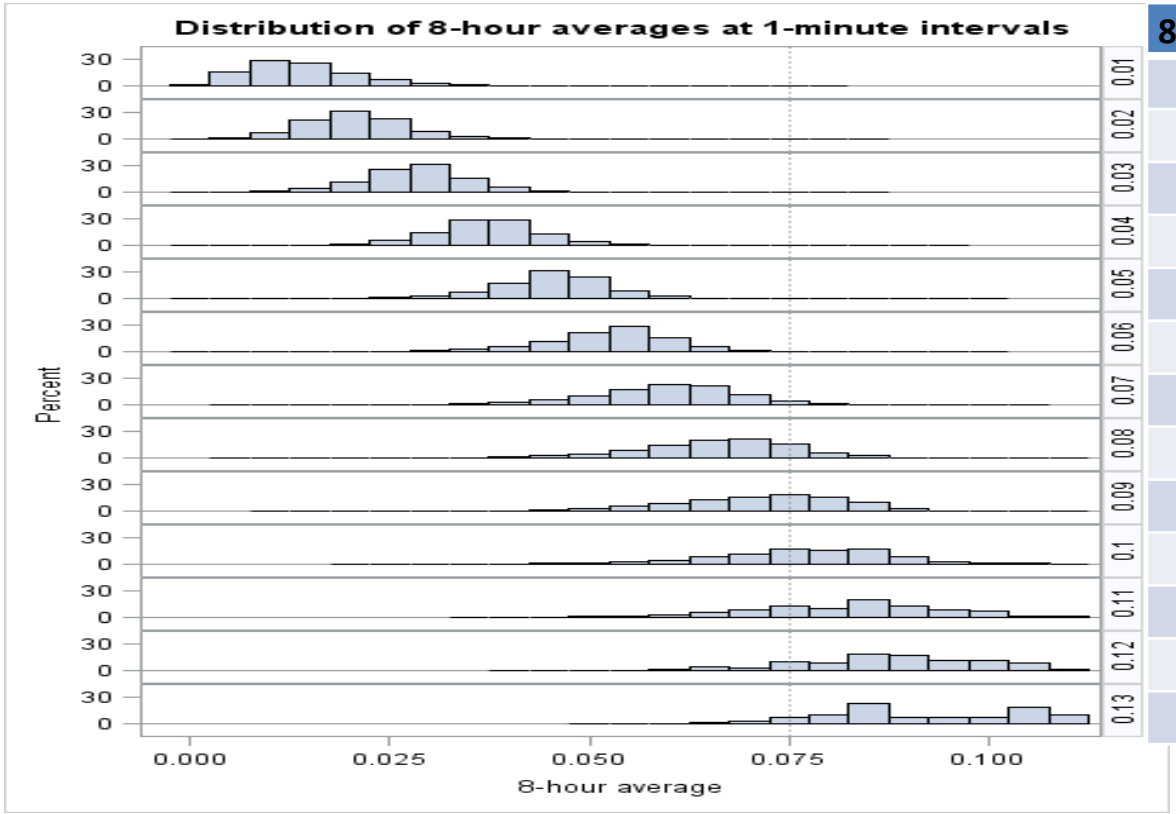
Ozone and $PM_{2.5}$ 1-minute Analysis

- **Analysis covers 12 sites in 5 cities:**
  - San Francisco – 2 sites, 2013 (ozone only)
  - Baltimore – 4 sites, 2011-2013 (ozone only)
  - Boston – 2 sites, 2011-2013 (ozone only)
  - New York – 2 sites, 2011-2013 (ozone and $PM_{2.5}$)
  - Denver – 2 sites, 2012-2014 (ozone and $PM_{2.5}$)
- **13 million FRM 1-minute values altogether**
- **Cities were chosen based on data availability and geographical diverseness**
- **Each city has at least one "higher" concentration site and one "lower" concentration site**

Data Analysis



Data Analysis



8-hr averages > .075 ppm (%)
~ 0
~ 0
~ 0
~ 0
~ 0
0.5%
5%
19%
37%
56%
70%
84%
89%

Interpretation & Communication

- Four Groups ~10 people (2 in DC, 2 in Oakland, CA)
- Moderators Guide
  - Air Quality Awareness
  - Definition of Sensors
  - Review of Messages
  - Mobile Website

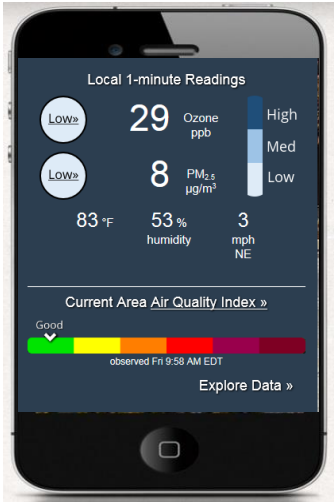
  24.104.117.6
  - Messaging Static Website

Interpretation & Communication

- Confusion on whether ozone is good or bad
- Include AQI in application/undesirable to click to another website
  - User wants immediate information
- Mixed reviews on color scale, red is a “panic” color
- Messaging $PM_{2.5}$
  - What does “reduce” mean (e.g. walk instead of run)?
  - How far do you move, what is the radius?
- Instructions on how to check sensor (portable versus stationary)

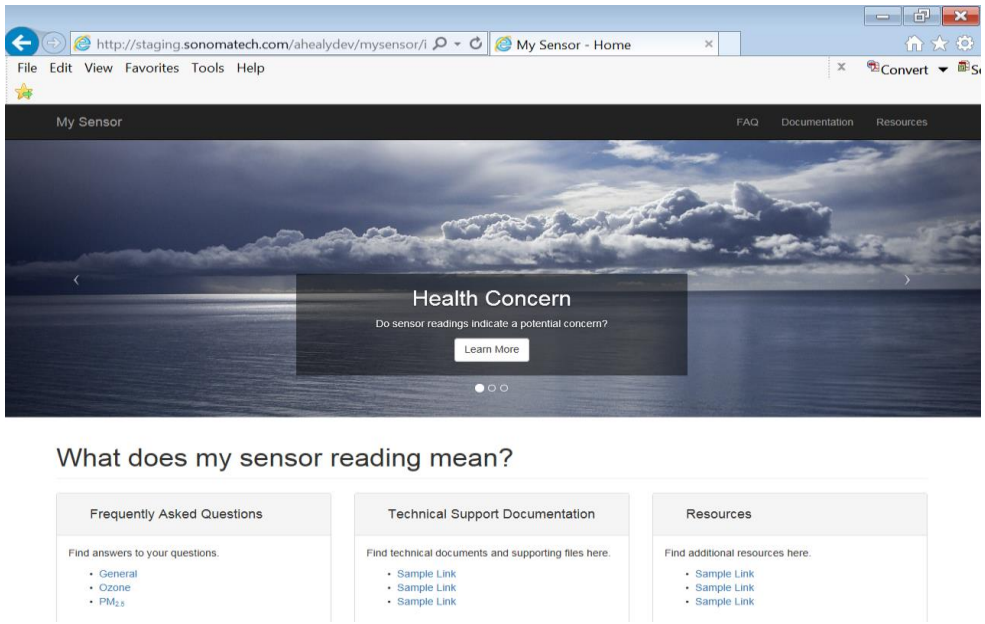
Interpretation & Communication

- Application is intuitive, easy to navigate
- Mixed reviews on actual text, concentration readings, additional messages, color scale, and legend
- Location
  - Desired a map of all data to compare with personal readings
  - Device should be location specific
  - Like the AQI bar at the bottom
- Buzz or sound alert for high readings, personalize
- What action should the user take, what can be done, how do I affect change? Is long term or cumulative exposure an issue? Actionable health messages (e.g. symptoms) desired
- Does this messaging work indoors?



Interpretation & Communication

- Need steps to check sensor
- Define “sustained” or “prolonged” exposure
- Need clear connection for the end-user between 1-minute readings and 8-hour or 24-hour averages regarding health risk



Acknowledgements

EPA VGTeam

- Gayle Hagler
- Esteban Herrera
- Ronald Williams
- Kristen Benedict
- Ann Brown
- Phil Dickerson
- Lewis Weinstock
- Ron Evans
- Brad Johns
- John White

Philadelphia VG Team

- Hallie Weiss
- Alison Riley
- Dennis Sosna
- Elizabeth Gaige
- Howard Schmidt
- Meyliana Wu
- Paresh Mehta
- Philipose Cheriyan
- Kyle Robinson
- Paul Policarpo

EPA Messaging Team

- Alison Davis
- Phil Lorang
- Nicholas Swanson
- Mike Papp
- Chris Chapman
- Bryan Hubbell
- Melissa Payne
- Elizabeth Mannshardt
- Jesse McGrath
- Susan Stone
- David Mintz
- Melissa Dreyfus
- Michelle Wayland
- Richard Wayland
- Michael Stewart
- Holly Wilson