Phoenix as a Testbed for Air Quality Sensors (P-TAQS) An Evaluation of Low-Cost Sensors in an Extreme Environment

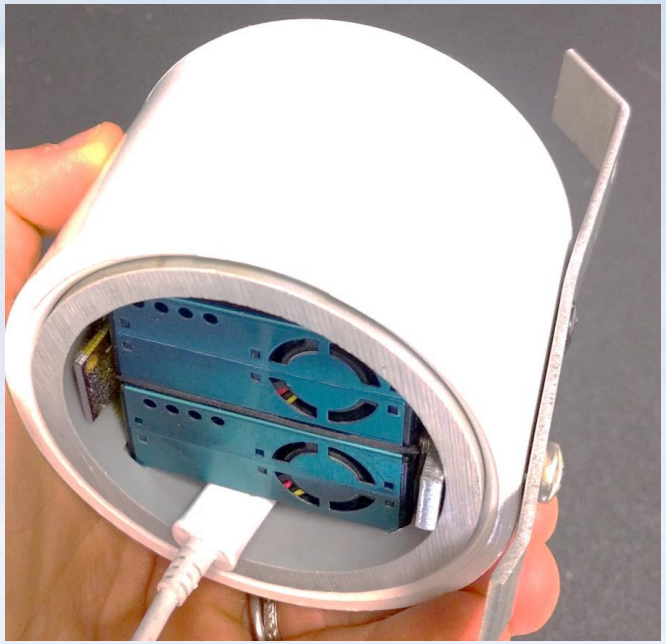
Ronald Pope, PhD
Atmospheric Scientist
Planning & Analysis Division

Phoenix as a Testbed for Air Quality Sensors (P-TAQS)

EPA Office of Research and Development: Center for Environmental Measuring and Modeling
Maricopa County Air Quality Department

- Science Questions and Drivers
  - What is the variance between sensors?
  - What is the long-term performance in extreme conditions?
  - How do sensors degrade over time?
  - What is optimal spatial scale and use of sensors?
- P-TAQS is running in 3 Phases

  (though Phase 3 is actually an intersection of the LTPP and PTAQS)



PurpleAir Sensor

- 2 Plantower PMS5003 optical particle counters (channels A & B)
- PM_{10}, **$PM_{2.5}$**, $PM_{1.0}$
- Temperature, Relative Humidity
- 2-minute resolution
- ~$250

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Phase 1: November 2018 - June 2019

- Collocation of PurpleAir sensors with FEM monitors (TEOM & T640) at three sites.
- MCAQD also conducted a winter fireplace smoke study in 2018-2019 in conjunction with Phase 1.
  - 10 PurpleAir sites
  - Focused on $PM_{2.5}$
  - Also collected PM_{10}

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Phase 2: July 2019 – ~March 2021

- Larger field study using sensors in a distributive network
  - 21 PurpleAir sites, some with solar
  - Mobile FEM (T640x) for QA

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Phase 3: August 2019 ~March 2021

- Phase 3 is an intersection with the EPA's Long-Term Performance Project (LTPP)
- Measures long-term performance of a variety of sensors
  - 6 different types of sensors operating at the same location
  - Focused on individual sensors, whereas Phase 2 is focused on the network

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Lessons Learned and Implications for Citizen Science

Setup Issues

- Large network operation poses the biggest challenges
- Proper siting and access
- Power
- Communications
- Security

Does the sensor have sufficient operating space? Are surrounding structures disrupting air flow? There are possible siting issues with the sensor in this photo.

(photo from Bakersfield.com).

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Lessons Learned and Implications for Citizen Science

Maintenance & Operation Issues

- Off-the-Shelf Equipment
- Wi-Fi Hotspots
- High temps in the field; we saw internal PurpleAir temps as high as 149.5 °F!

Failure/Replacement Rates in Phase 2

- 34% total replacement rate since beginning of study
- 17% replacement rate on sensors operating at least a year

A P-TAQS PurpleAir unit that has been exposed to the Phoenix sun for over a year.

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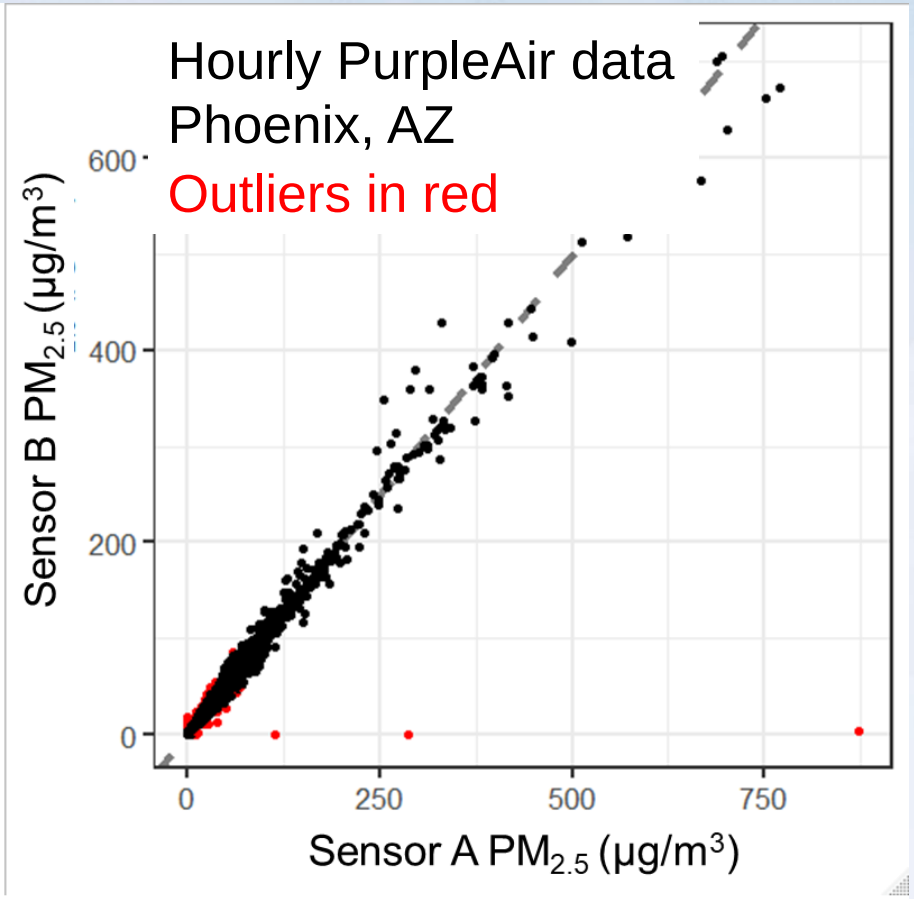
Lessons Learned and Implications for Citizen Science

Data Issues

- Continuous Data Quality/Validation Checks of Network
  - Are there Connectivity issues?
  - Malfunctions in equipment?
- PurpleAir Data Cleaning/Formatting
  - Formatting irregularities removed.
  - A & B channels checked; outliers flagged.
  - Raw data might need to be averaged to longer time interval.



A comparison of A & B channels with outliers flagged.

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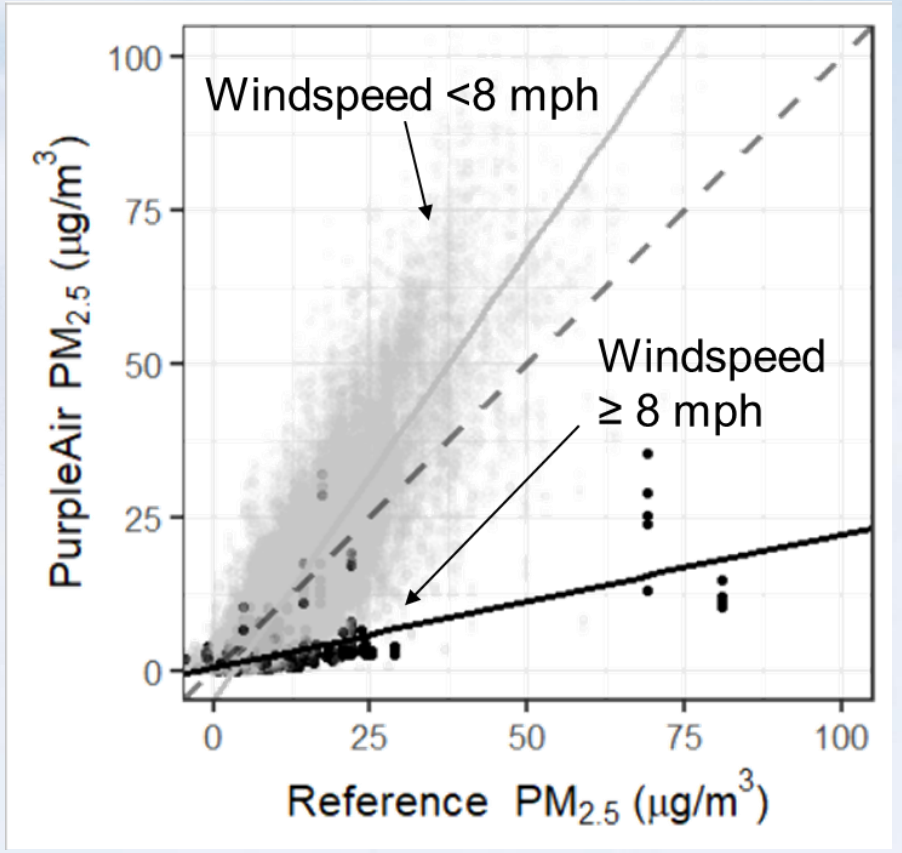
Lessons Learned and Implications for Citizen Science

Sensor Performance

- PM_{10} data has poor precision & accuracy
- $PM_{2.5}$ data has acceptable precision, but accuracy was typically biased high
  - Aerosol composition affects performance
  - Meteorology, especially windspeed, affects sensor performance
- PurpleAir $PM_{2.5}$ data can be significantly improved with correction factors.



Windspeed affects PurpleAir performance. Literature found that windspeeds >18 mph overpower sensor intake fans.

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Thank You!

Ron Pope
ron.pope@maricopa.gov

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