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

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

EPA Office of Research and Development: Center for Environmental Measuring and Modeling
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- **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
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)
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.
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.

Hourly PurpleAir data
Phoenix, AZ
Outliers in red

A comparison of A & B channels with outliers flagged.
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.
Thank You!

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