

Using Corrected Low-Cost Sensor Data in Local Air Quality Studies

Ronald Pope, PhD April 28, 2022

Phoenix as a Testbed for Air Quality Sensors (PTAQS)

Acknowledgements to the PTAQS team:

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 *Retired



PTAQS Overview

- Three phases (Nov 2018 Mar 2021)
- Phase 1: sensor collocation
- Phase 2: Larger field study using sensors in a distributive network
 - 20 PurpleAir sites, some with wind sensors
 - Mobile regulatory monitor for quality assurance
 - Four black carbon analyzers
- Phase 3: multi-sensor evaluation



Lessons Learned

- PM₁₀ data were unreliable.
- High quantity of data resulted in difficult QA.
- PM_{2.5} data had acceptable precision, but accuracy bias differed.
- Particle source affected data quality.
- PM_{2.5} data was significantly improved with correction factors.





Smoke Dominated
Stagnation
PMc Dominated
High Wind



Correction 1: Linear PM_{2.5}



| Correction | R^2 | RMSE (ug/m ³) | MAE (ug/m ³) |
|-------------------|--------|------------------------------|-----------------------------|
| None | 0.8649 | 8.74 | 4.54 |
| PM _{2.5} | 0.8649 | 4.59 | 2.65 |

Corrected PurpleAir (PA) $PM_{2.5} = 0.68 * PA PM_{2.5} + 2.42$



Correction 2: PM_{2.5} + Relative Humidity (RH)



| Correction | R^2 | RMSE (ug/m ³) | MAE (ug/m ³) |
|------------------------|--------|------------------------------|-----------------------------|
| None | 0.8649 | 8.74 | 4.54 |
| PM _{2.5} | 0.8649 | 4.59 | 2.65 |
| PM _{2.5} + RH | 0.8698 | 4.50 | 2.66 |

Corrected PA $PM_{2.5} = 0.70 * PA PM_{2.5} - 0.100 * PA RH + 4.74$



Correction 3: PM_{2.5} + RH + Season



Fall / Winter (October – March): Corrected PA $PM_{2.5} = 0.677 * PA PM_{2.5} - 0.1016 * PA RH + 4.8934$ Spring / Summer (April – September): Corrected PA $PM_{2.5} = 1.8965 * PA PM_{2.5} - 0.0778 * RH + 0.7519$



Correction 4: PM_{2.5} + RH + PM_{Coarse} (PM_c)



Corrected PA $PM_{2.5} = 0.6801 * PA PM_{2.5} - 0.0901 * PA RH + 0.049 * Non-col. PM_C + 3.79$

*Non-col. PMc = Average Regional PMcoarse as determined by the average concentration reported by regulatory monitors in the city.

Correction 5: PM_{2.5} + RH + PM_C + Season



| Correction | R^2 | RMSE (ug/m ³) | MAE (ug/m ³) |
|--|--------|------------------------------|-----------------------------|
| None | 0.8649 | 8.74 | 4.54 |
| PM _{2.5} | 0.8649 | 4.59 | 2.65 |
| PM _{2.5} + RH | 0.8698 | 4.50 | 2.66 |
| PM _{2.5} + RH + Season | 0.8553 | 4.78 | 2.91 |
| PM _{2.5} + RH + Non- col. PM _C | 0.884 | 4.35 | 2.50 |
| PM _{2.5} + RH + Non- col. PM _c + Season | 0.873 | 4.59 | 2.77 |

Fall / Winter (October – March):

Corrected PA $PM_{2.5} = 0.670 * PA PM_{2.5} - 0.094 * RH + 0.079 * PM_{C} + 3.872$ Spring / Summer (April – September): Corrected PA $PM_{2.5} = 1.589 * PA PM_{2.5} - 0.046 * RH + 0.186 * PM_{C} - 1.026$

Utilizing PTAQS Data for the 2019-2020 Winter Burn Study



PTAQS Monitoring Network for the 2019-2020 Study



★ Sites with only PurpleAir $PM_{2.5}$ sensors ★ Sites with permanent regulatory monitors and PurpleAir $PM_{2.5}$ sensors



Spatial Patterns of PM_{2.5} **Weekdays and Weekends**





Weekdays: Monday - Thursday Weekends: Friday - Sunday

Monthly PM_{2.5} Average by Time of Day

12:00 a.m. - 5:59 a.m.



12:00 p.m. - 5:59 p.m.



6:00 a.m. - 11:59 a.m.



6:00 p.m. - 11:59 p.m.





New Year's Eve 2019 and New Year's Day 2020



Legend





- Air Quality Index
- Symbolism corresponds to AQI thresholds from the 24-hour PM2.5 standard.
- The hazardous category (AQI >300) is further divided into two categories
 - Maroon (AQI 301 to 418)
 - Black (AQI > 418)

| Green | Good | 0 to 50 |
|--------|-----------------------------------|----------------------|
| Yellow | Moderate | 51 to 100 |
| Orange | Unhealthy for Sensitive Groups | 101 to 150 |
| Red | Unhealthy | 151 to 200 |
| Purple | Very Unhealthy | 201 to 300 |
| Maroon | Hazardous | 301 and higher |









































Thank you.

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