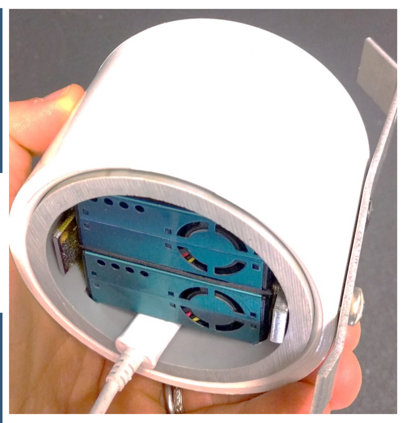
PurpleAir $PM_{2.5}$ U.S. Correction and Performance During Smoke Events

Karoline K. Johnson Barkjohn[1,2], Amara L. Holder[2], Samuel Frederick[2,3], Gayle S.W. Hagler[2], Andrea L. Clements[2]

[1]Oak Ridge Institute for Science Education Postdoctoral Fellow
[2]U.S. EPA Office of Research and Development, Center for Environmental Measurement & Modeling
[3]Oak Ridge Associated Universities

Research Questions

Can a single correction improve accuracy across the entire U.S. including during smoke episodes?



PurpleAir underside view

Procedures to Correct

1. Receive 2-minute raw PurpleAir data
2. Extract columns:
   - Time stamp
   - Channel A: PM2.5_CF1_ug/m3 (higher correction factor)
   - Channel B: PM2.5_CF1_ug/m3 (higher correction factor)
   - Temperature
   - Humidity*
3. Average each column to 1-hr average (e.g. 8:00-8:59= 8am average)
4. Exclude hour if less than 90% of the measurements are available in the hour average
5. Exclude hour if 1-hr A&B averages are different by BOTH: 5 μg m^{-3} & 70%†
6. Apply U.S. Correction:
   $PM_{2.5}$=0.541*PA_cf1(avgAB)-0.0618*RH +0.00534*T +3.634 §
7. Calculate NowCast based on past 12 hours of data

*If data is from offline sensor also save uptime column
†If data is from offline sensor also remove data when uptime resets (indicating searching for WiFi)
§ Developed based on a 24-hr averaged dataset of PurpleAir sensors collocated at regulatory sites across 8 states

Test Dataset

5 smoke impacted datasets– collocation with temporary monitors deployed to capture smoke impacts
- Alaska wildfire May-Aug 2019 (FEM BAM)
  - Anchorage, AK
- Alder wildfire Oct 20-27, 2018 (FEM BAM)
  - Pinehurst, CA
- Alpine prescribed fire and woodstove smoke Oct 31-Nov 4, 2019 (near-FEM E-Sampler)
  - Oakley, UT
- Natchez wildfire Aug 11-29, 2018 (near-FEM E-BAM)
  - Happy Camp, CA
- RTP prescribed burn Aug-Dec 2018 (FEM Grimm)
  - EPA-RTP, NC

7 typical ambient datasets-collocated at regulatory monitoring sites
- CO, DE, GA, NC, OK, WI (FEM T640x)
- AZ (FEM TEOM 1405-DF)

Evaluation using NowCast*
- AQI value generated **every hour** based on the previous 12-hours
- Weighted more heavily to the recent data when concentrations are changing quickly

C_{low}	C_{high}	I_{low}	I_{high}	Category
0	12.0	0	50	Good
12.1	35.4	51	100	Moderate
35.5	55.4	101	150	Unhealthy for Sensitive Groups
55.5	150.4	151	200	Unhealthy
150.5	250.4	201	300	Very Unhealthy
250.5	350.4	301	400	Hazardous
350.5	500.4	401	500	Hazardous

NowCast AQI categories

*Equation source: https://airnow.zendesk.com/hc/en-us/articles/212303417-How-is-the-NowCast-algorithm-used-to-report-current-air-quality-

This work would not have been possible without the data provided by the following organizations

AK: State of Alaska, Citizens for Clean Air
AZ: Maricopa County Air Quality Department
CA: San Luis Obispo County Air Pollution Control District, Mojave Desert Air Quality Management District, Antelope Valley Air Quality Managment District, California Air Resources Board, Santa Barbara County Air Pollution Control District, Air Quality Sensor Performance Evaluation Center, Ventura County Air Pollution Control District
CO: Colorado Department of Public Health and Environment
DE: Delaware Division of Air Quality
FL: Sarasota County Government
GA: Region 4, Georgia Environmental Protection Division
IA: Iowa Air Quality Bureau
MT: Missoula County, Montana Department of Environmental Quality
NC: Forsyth County Office of Environmental Assistance & Protection, Clean Air Carolina, UNC Charlotte, North Carolina Department of Environmental Quality
OH: Akron Regional Air Quality Management District
OK: Quapaw Nation, Oklahoma Department of Environmental Quality
UT: University of Utah, Utah Department of Environmental Quality
VA: Virginia Department of Environmental Quality
VT: State of Vermont
WA: Washington Department of Ecology, Puget Sound Clean Air Agency
WI: Wisconsin Department of Natural Resources
Federal: Forest Service, Wildland Fire Air Quality Response Program, National Park Service, Region 9, Region 10, Lauren Maghran

U.S. Environmental Protection Agency
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$PM_{2.5}$ NowCast category correctly reported by PurpleAir **90%** of the time* even during smoke events

*after U.S. Correction (always within 1 category)

Natchez Fire (Happy Camp, CA)
Photo Credit: Lauren Maghran

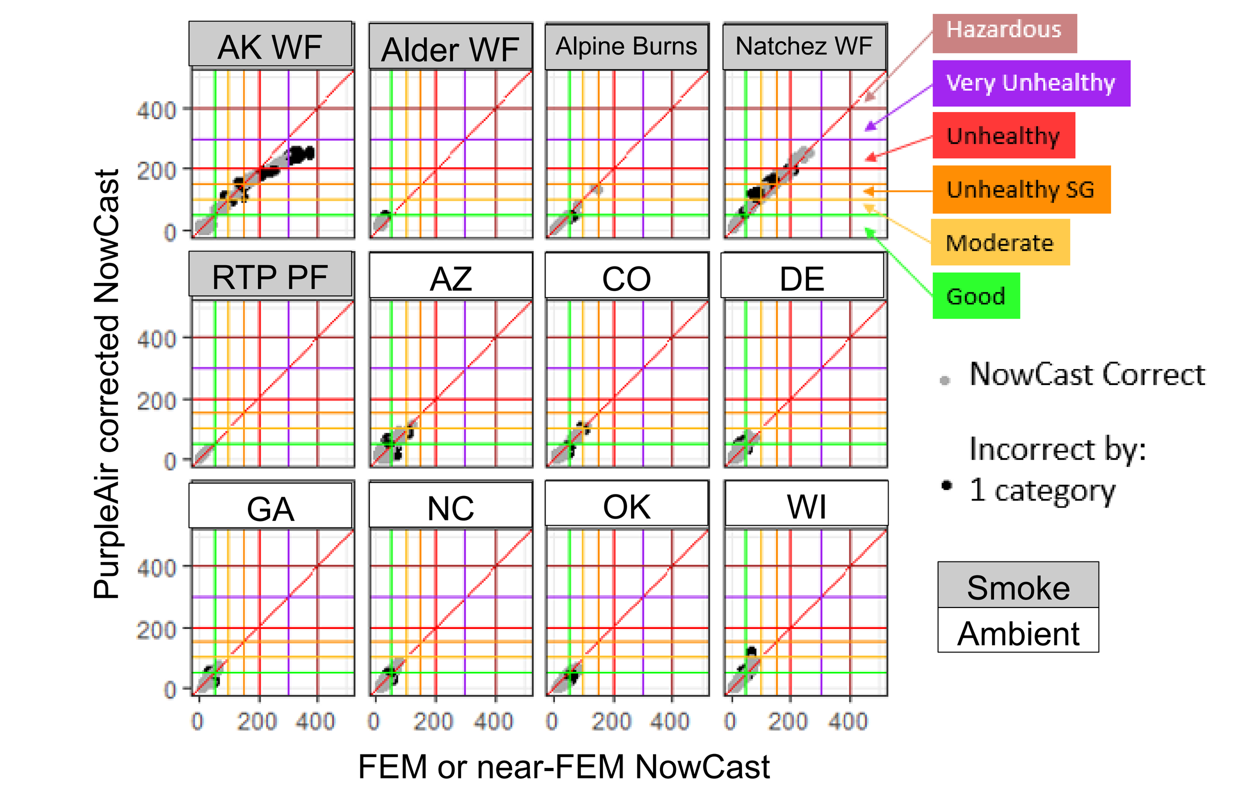
Contacts: Johnson.Karoline@epa.gov, Holder.Amara@epa.gov, Frederick.Samuel@epa.gov, Hagler.Gayle@epa.gov, Clements.Andrea@epa.gov

Previous Work

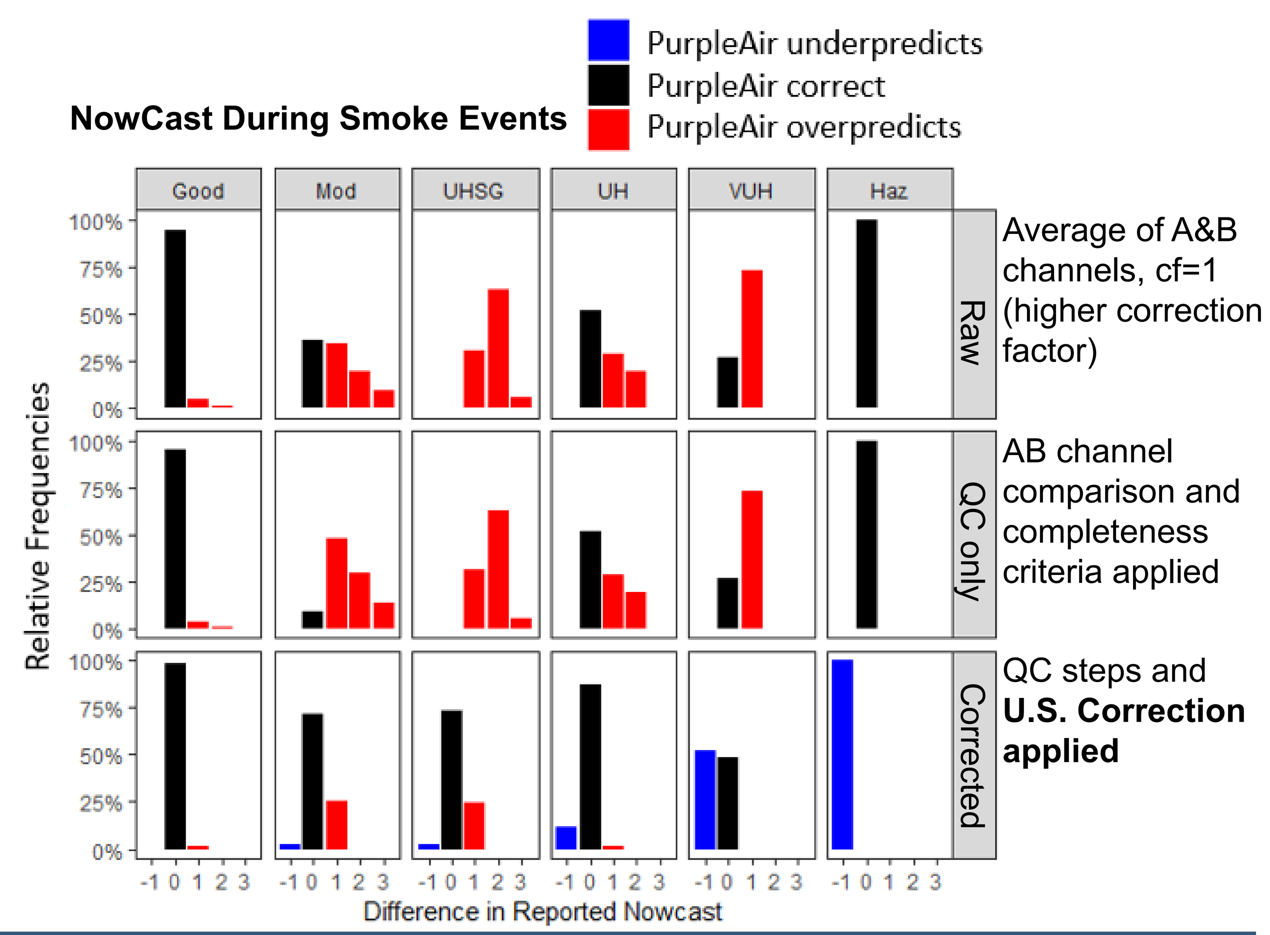
- Previous work has characterized the PurpleAir monitors:
  - At single outdoor sites[1-5]
    - North Carolina, Pennsylvania, Utah, California
  - In lab settings[5-7]
  - Typically using 1-3 devices[1,3-7] but up to 9 [2]
- Our results are comparable to previous work:
  - With raw $PM_{2.5}$ values often over estimating[1-7] though sometimes underestimating depending on site, season, source, and concentration range[3, 6, 7]
  - Typically with influences from RH and temperature[1, 2, 4-6] though not always[3]
  - And typically moderate to strong correlations depending on location r=0.64-0.98 (R^2= 0.41-0.97)[1-6]

Performance Under Typical Ambient and Smoke Events

- With correction, PurpleAir reports NowCast within 1 category across all datasets
- Most disagreement is at break points



- U.S. Correction reduces over-reporting
- Some under-reporting at high NowCast categories
- Behavior modifications may be similar above unhealthy NowCast
- Similar to full dataset results



Conclusions

PurpleAir NowCast AQI can be improved by a U.S. Correction.
With correction, the NowCast category reports:
- Correctly: 92% of the time (smoke only: also 92%)
- Within 1 category: 100% of the time (smoke only: also 100%)

Remaining considerations:
- QC procedures: likely not imperative but may be helpful for "problem sensors"
- Additional validation data will be considered as it becomes available
- Minor adjustments may be made to the U.S. Correction equation as the analysis is finalized for publication
  - Target publication submission: summer 2020

Citations:
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