AQI Mapping Using Model, Regulatory Monitor, and Sensor Data in Real-Time

Scott A. Epstein, Ph.D.

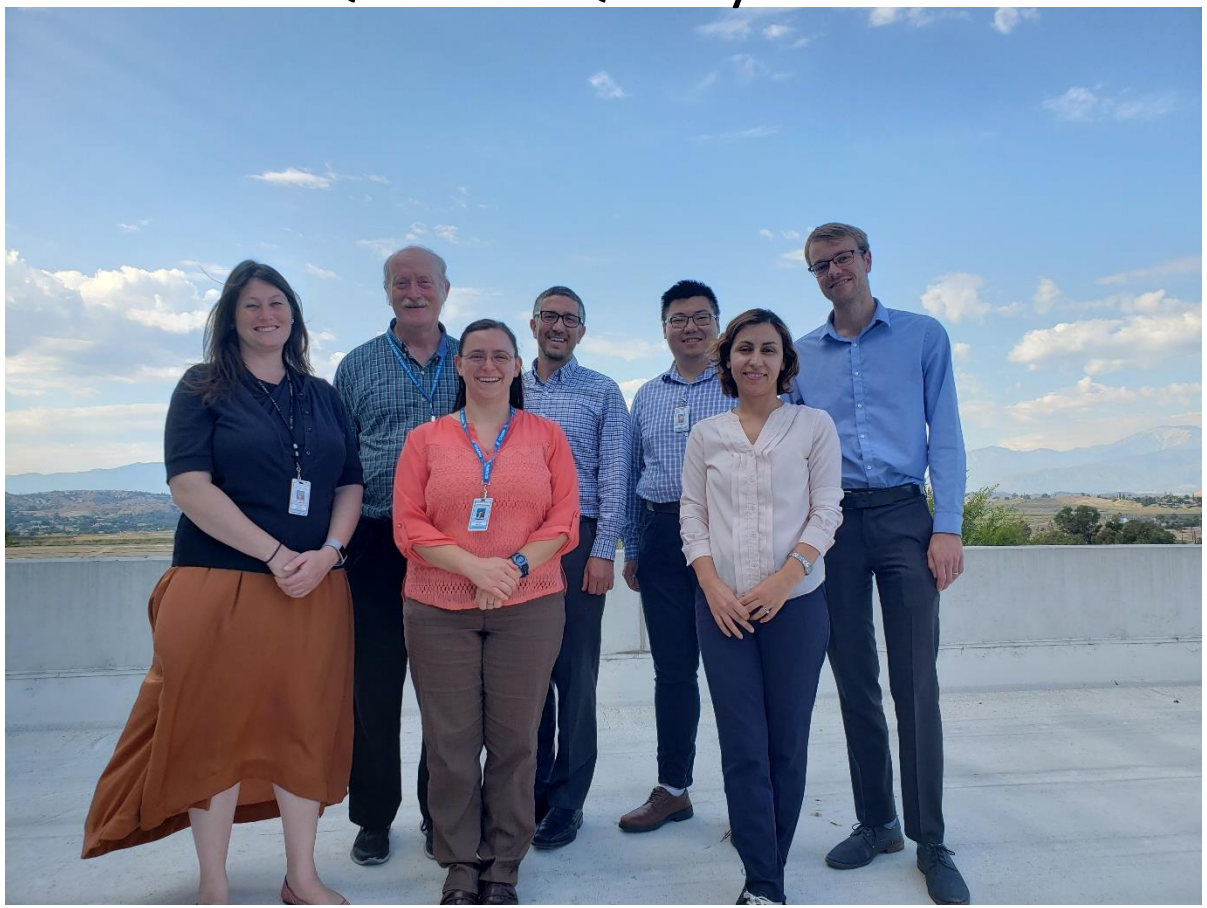
Program Supervisor, Air Quality Assessment

Planning, Rule Development and Area Sources

South Coast Air Quality Management District

Acknowledgements

South Coast AQMD Air Quality Assessment Group



Nico Schulte, PhD

Melissa Sheffer, *Senior Meteorologist*; Mark Bassett, PhD; Melissa Maestas, PhD;
Xiang Li, PhD; Elham Baranizadeh, PhD; Nico Schulte, PhD

South Coast AQMD

The South Coast AQMD

- Government Agency
- 17 million residents
- 4 counties
- 3 air basins:
  - South Coast, Salton Sea (Riverside County portion), Mojave Desert (Riverside County portion)
- Does not meet federal PM2.5, ozone, and PM10 standards
- Highest ozone levels in the U.S.
- Over 150 exceedances of federal air quality standards each year

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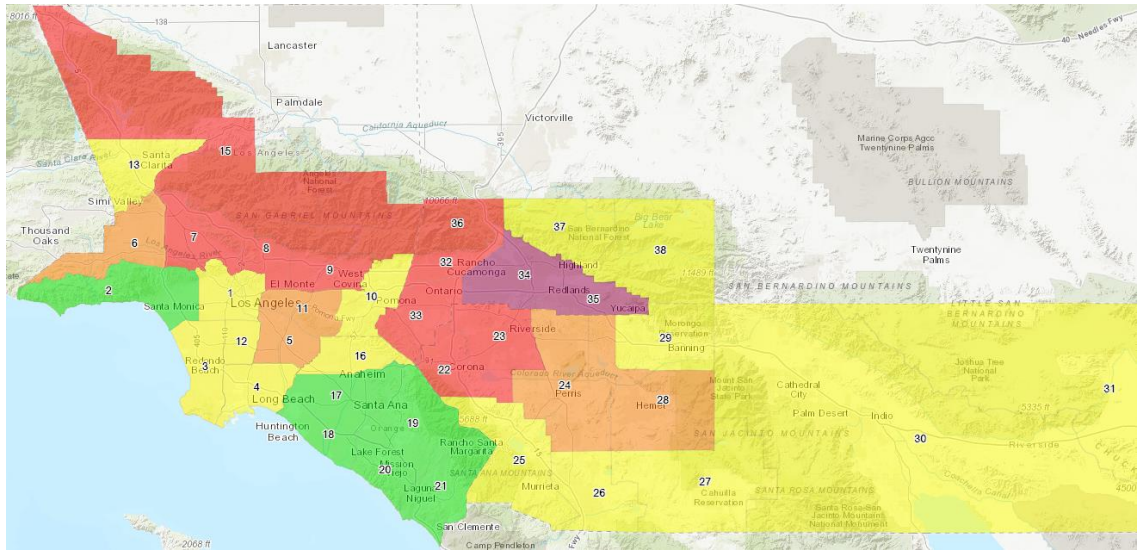
Methods of Displaying Real-Time Air Quality Data

South Coast AQMD "Proxy Method"



AirNow Inverse Distance Weighted Interpolation

Limitations identified:

- Location of monitor that is driving an area's current AQI is unclear
- Distance-weighted interpolation doesn't account for complex terrain
- Public often looks at multiple maps to understand current air quality (PurpleAir map) and does not interpret low-cost sensor data appropriately
- Resolution is too large to accurately represent localized events (i.e. "Proxy")
- For maps showing point-data, some locations may have AQI values that do not consider measurements from all relevant pollutants

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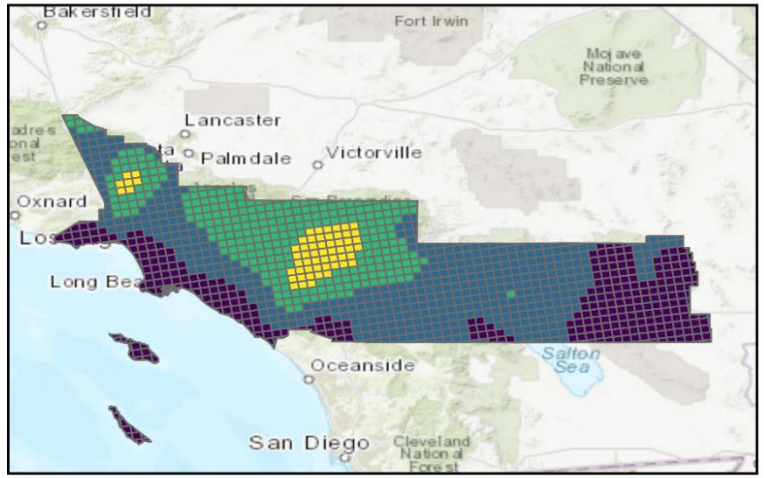
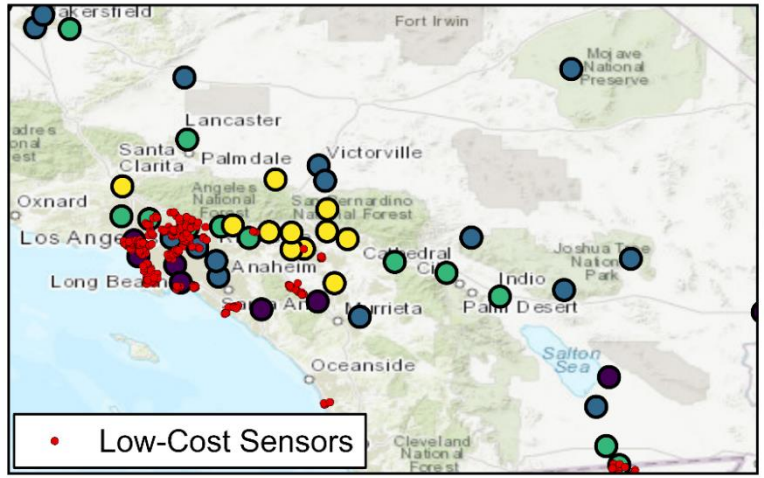
Monitor/Model/Sensor Blended Map

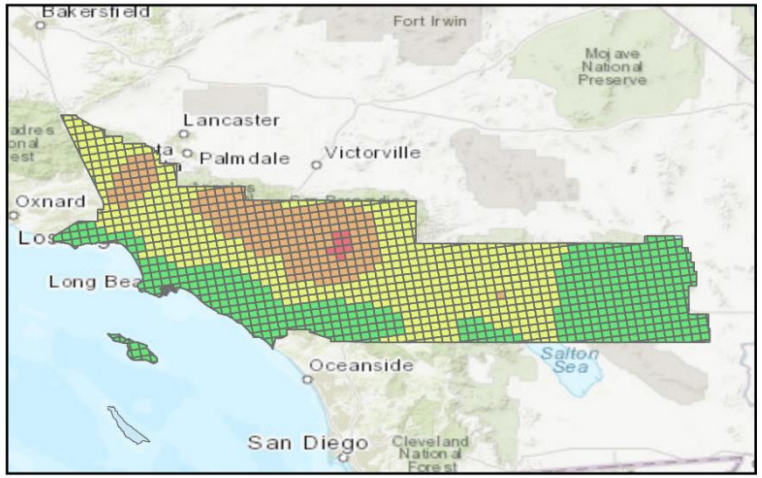
Gridded Model Data



Monitor and Low-Cost Sensor Data



Gridded AQI



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Pollutant	Method	Far from monitors	Near monitors
$PM_{2.5}$	Fill in gaps between monitors using model* and low-cost sensor data	Models and low-cost sensor data drive concentration	Monitor data drives concentration
O_3	Fill in gaps between monitors using model*	Models drive concentration	
PM_{10}, NO_2, CO	Natural neighbor interpolation	Monitor data drives concentration	

*NOAA NAQFC WRF-CMAQ

Schulte, N., Li, X., Ghosh, J.K., Fine, P.M., Epstein, S.A. **Responsive High-Resolution Air Quality Index Mapping Using Model, Regulatory Monitor, and Sensor Data in Real-Time**, *accepted in Environmental Research Letters*

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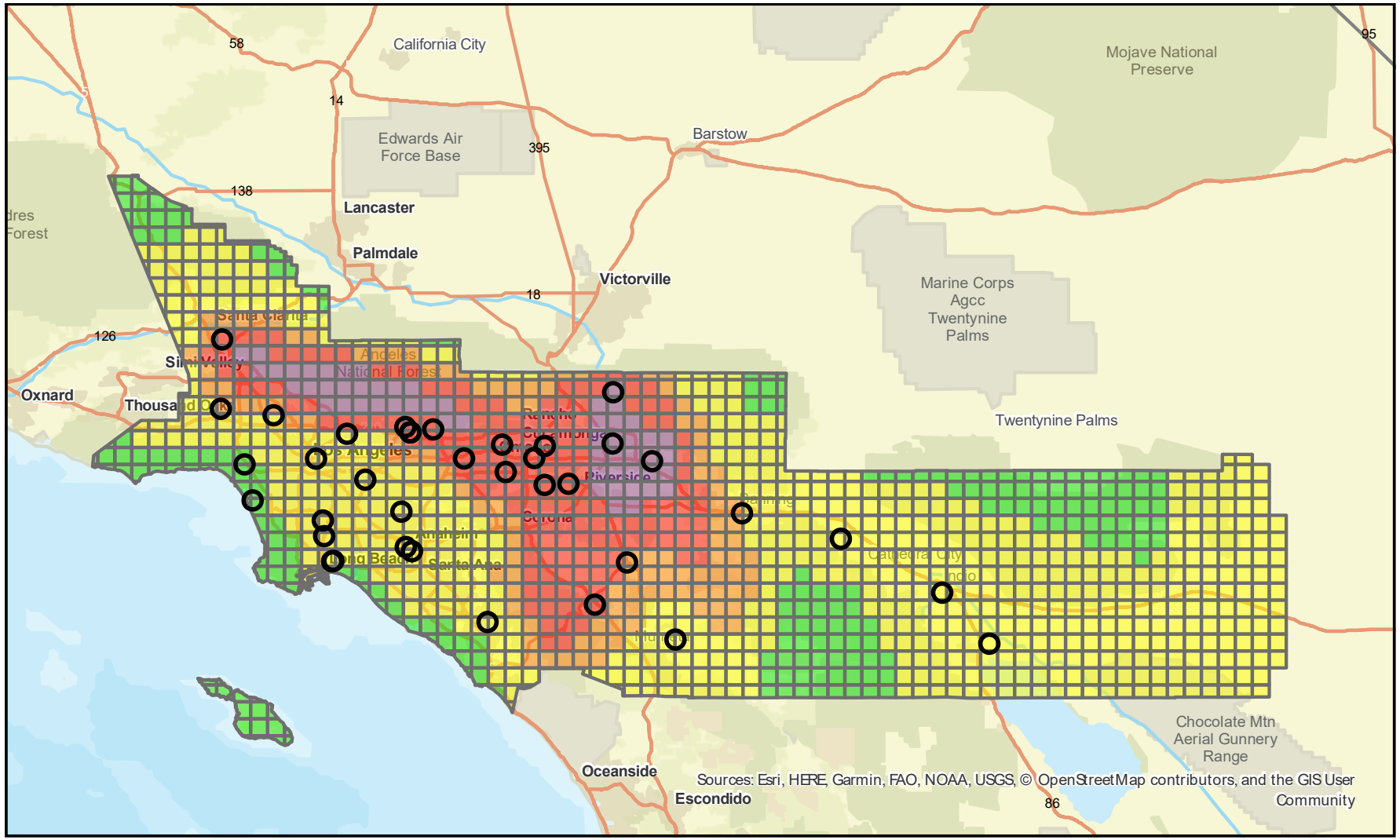
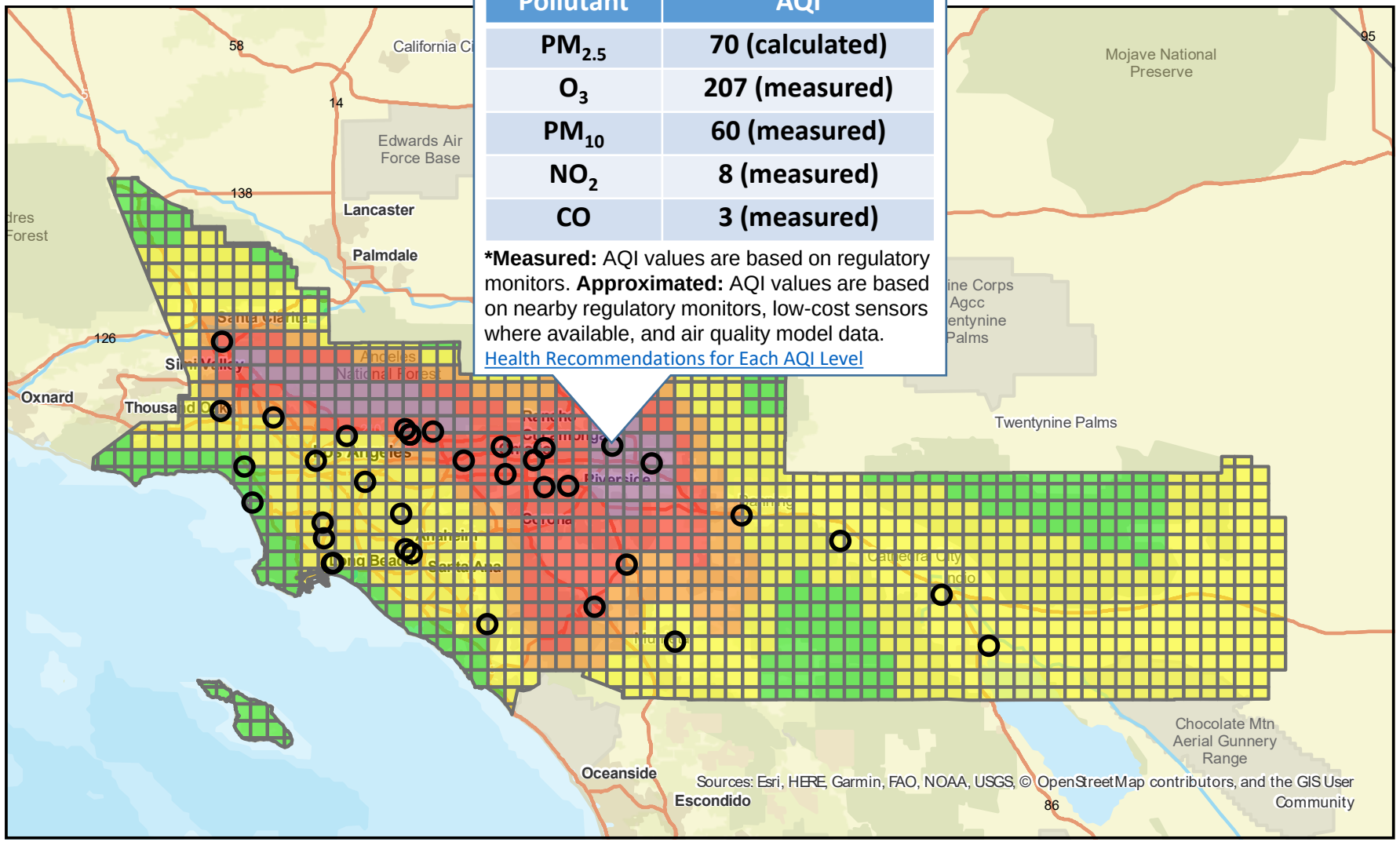
The User Experience (www.aqmd.gov/aqimap)



The User Experie[illegible]md.gov/aqimap)



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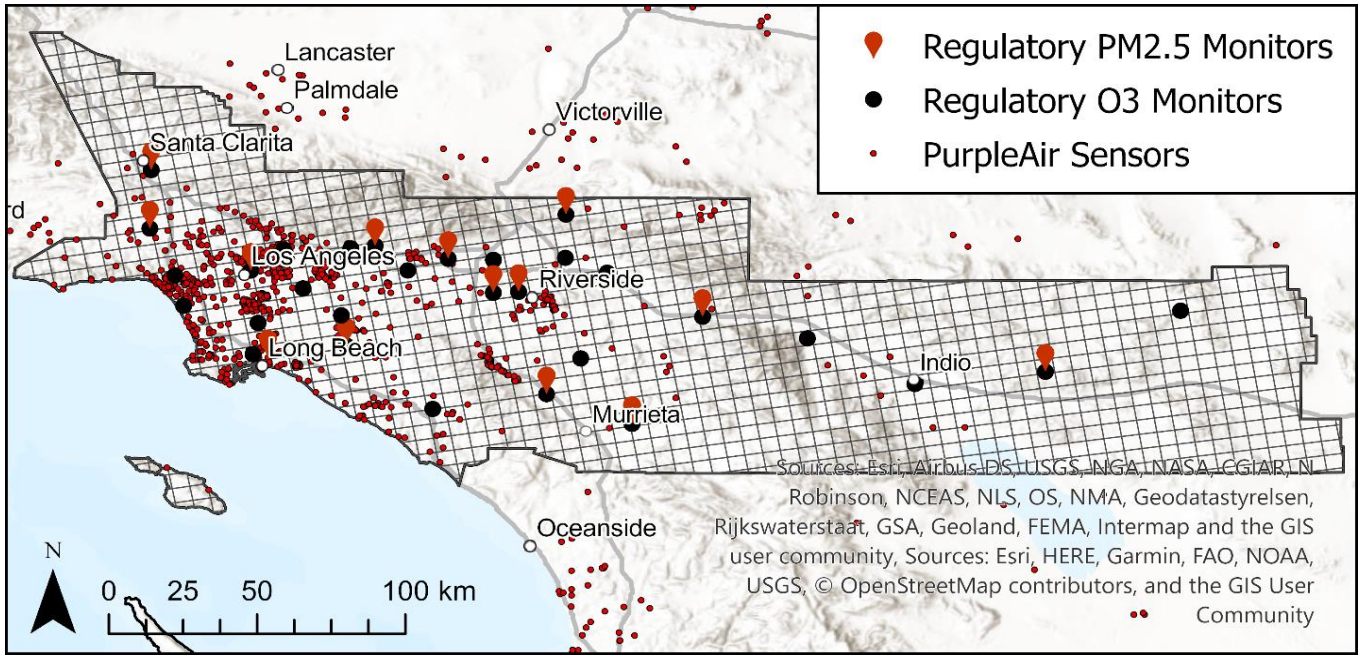
Treatment of Low-Cost Sensor PM2.5 Data

- Quality Control PurpleAir Data
  - By comparing the simultaneous measurements from the two channels within each sensor and applying statistical criteria
- Calibrate PurpleAir Data
  - Using collocated BAM data and correction for relative humidity
- Combine individual sensors to estimate the average concentration in a grid cell
  - To “smooth” variation from local source impacts, we average at least 3 sensors in each grid cell



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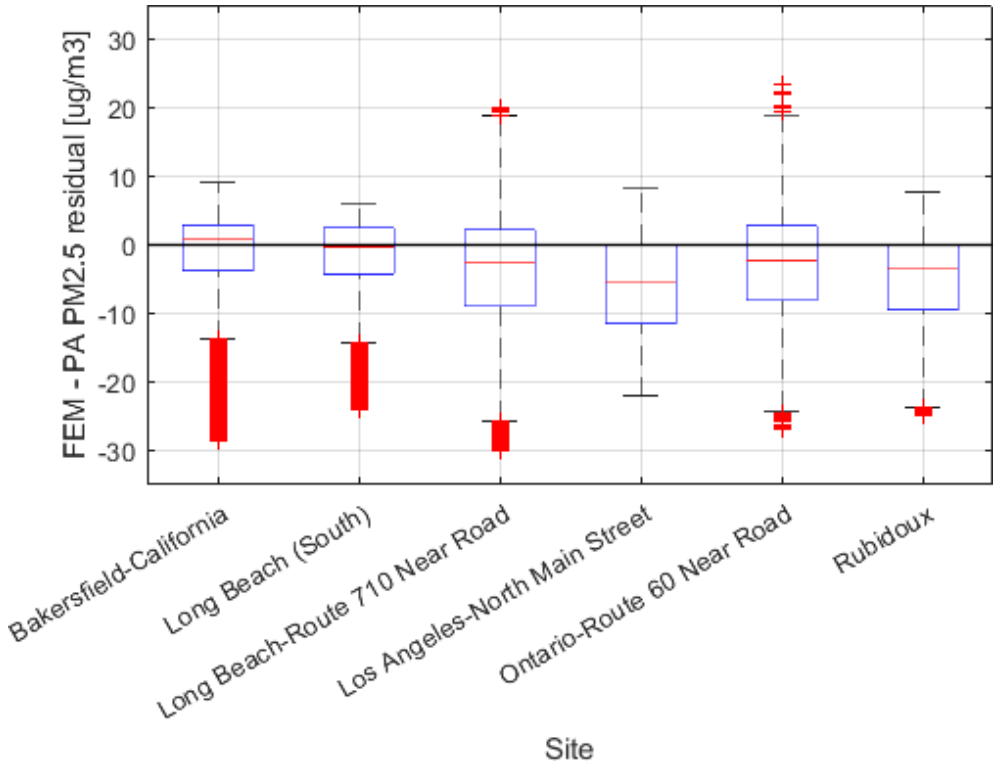
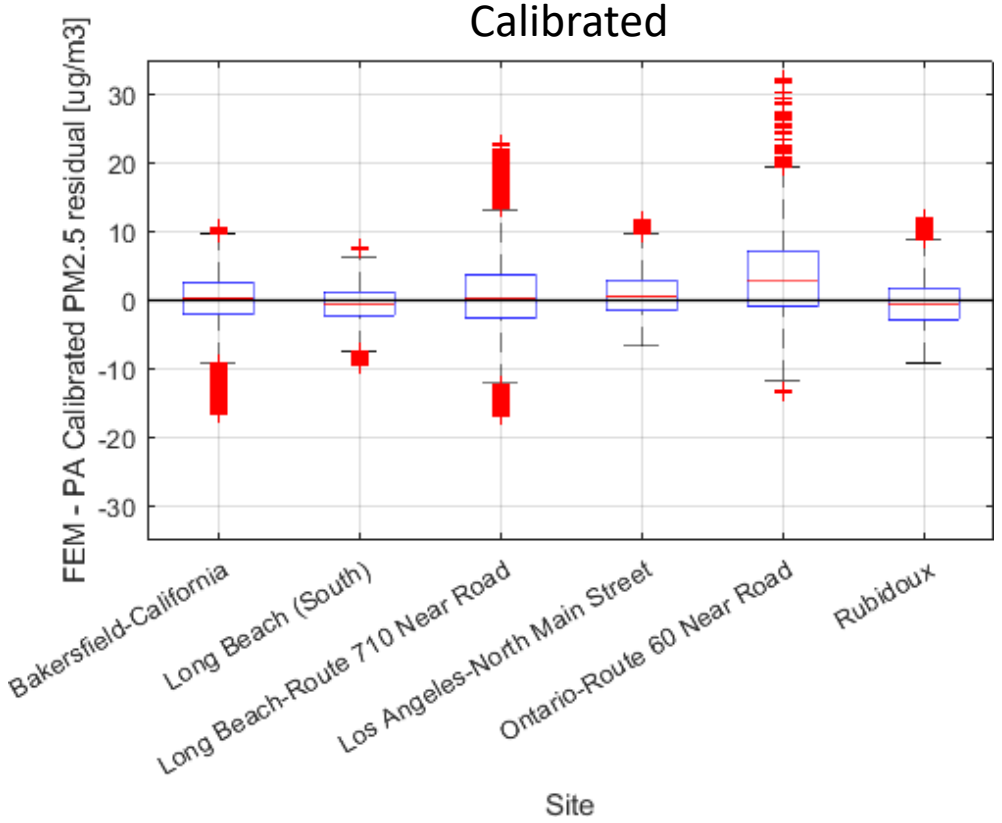
Sensor Calibration Performance

Not calibrated



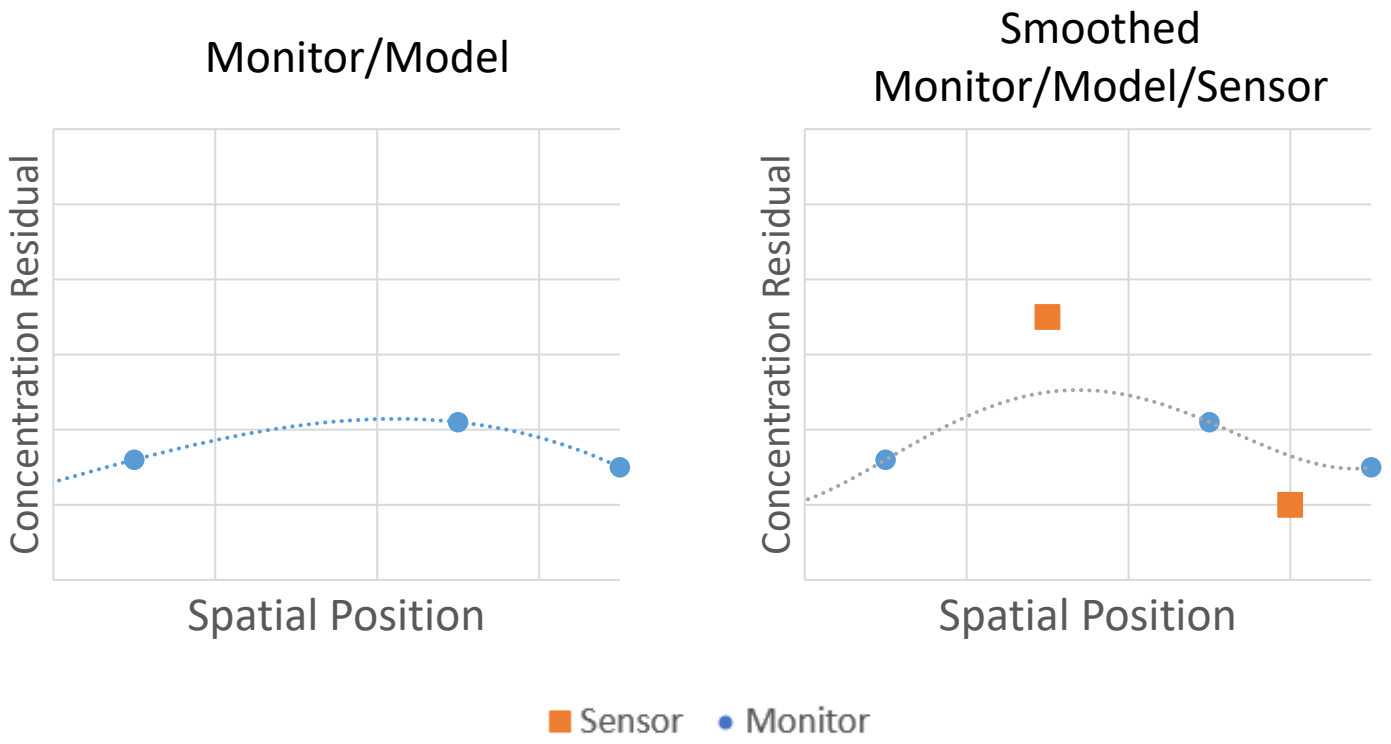
Calibrated



645,000 hourly data points (Purple Air with collocated FEM) are used to derive a calibration equation

Calibration equations adapted from: Malings et al, 2019. Aerosol Science & Technology

Blending Monitor/Model/Sensor Data



Concentration “surface” is fixed to regulatory monitors. Between monitors, model and low-cost sensor data modifies the concentration surface based on their relative uncertainties.

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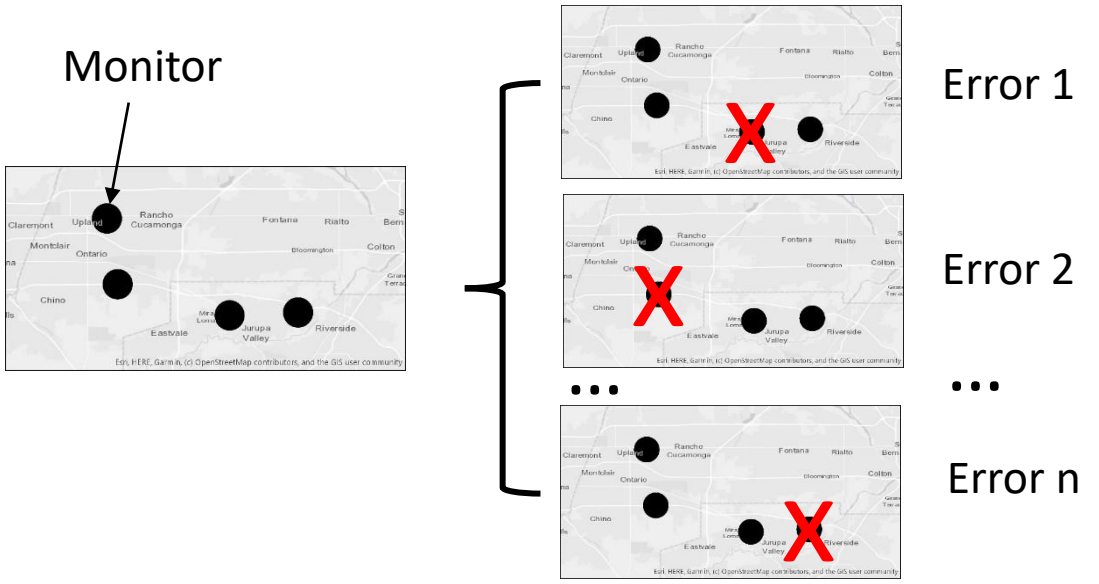
Evaluating Performance Compared to Other Methods

- Leave one out cross validation used for all pollutants



Root Mean Square Error (all pollutants)

Pollutant	Proxy	IDW	Blended
$PM_{2.5}$ [µg m^{-3}]	7.6	7.73	5.94
O_3 [ppb]	10.2	8.75	7.12
PM_{10} [µg m^{-3}]	34.7	36.1	33.6
CO [ppm]	0.171	0.191	0.163
NO_2 [ppb]	7.57	6.94	6.22

Blended map has lower errors than Proxy and IDW approach for all pollutants used in AQI calculation

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IDW – Inverse distance weighting as used by AirNow maps

Additional Evaluation of PM2.5 Performance with Monitoring Data from Independent Data Sets

- 24-hour Average Gravimetric Data (June 30, 2018 – March 31, 2020)
  - Performed analysis at 11 sites that do not have collocated continuous PM2.5 monitors
- North Hollywood Hourly PM2.5 (Oct 11, 2019 – March 31, 2020)
- Mission Viejo Hourly PM2.5 (Oct 29, 2019 – March 31, 2020)

$PM_{2.5}$ Root Mean Square Error [$\mu g\ m^{-3}$]

Method	Proxy	IDW	Blended
Gravimetric	4.64	4.07	3.59
North Hollywood	8.91	9.07	7.51
Mission Viejo	8.83	7.31	8.87

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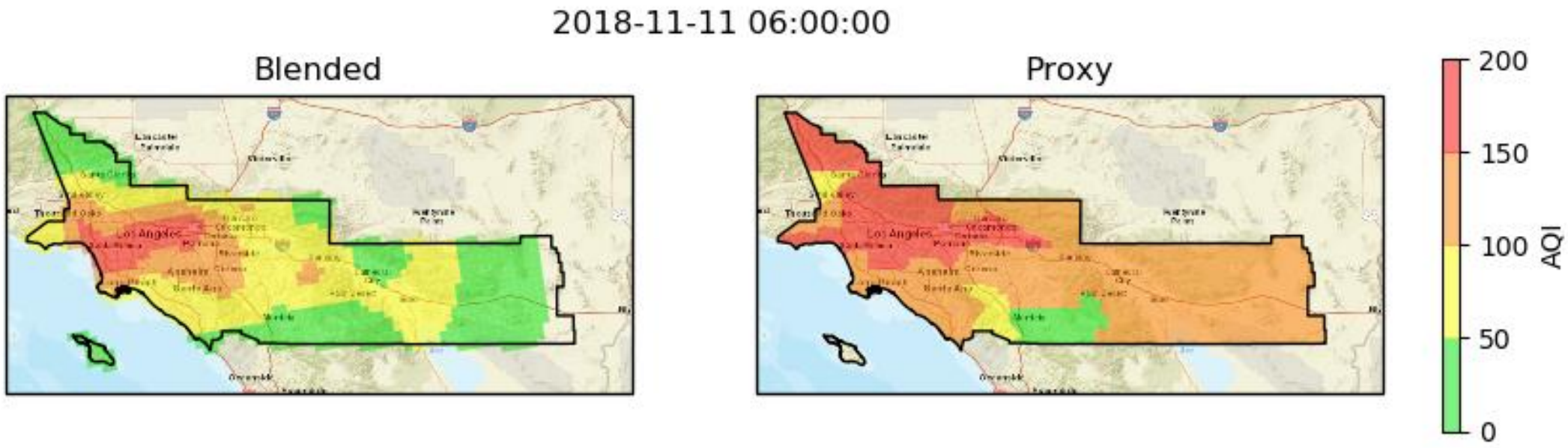
Gravimetric, North Hollywood, and Mission Viejo monitor data are not used by interpolation or by NOAA model

Additional Advantages of Blended Map During Wildfires

- Integration of PurpleAir and NOAA model data helps capture localized smoke plumes that are between regulatory monitors
- Higher resolution blended map better represents wildfire plumes
- Blended map automatically integrates temporary e-BAM monitoring data



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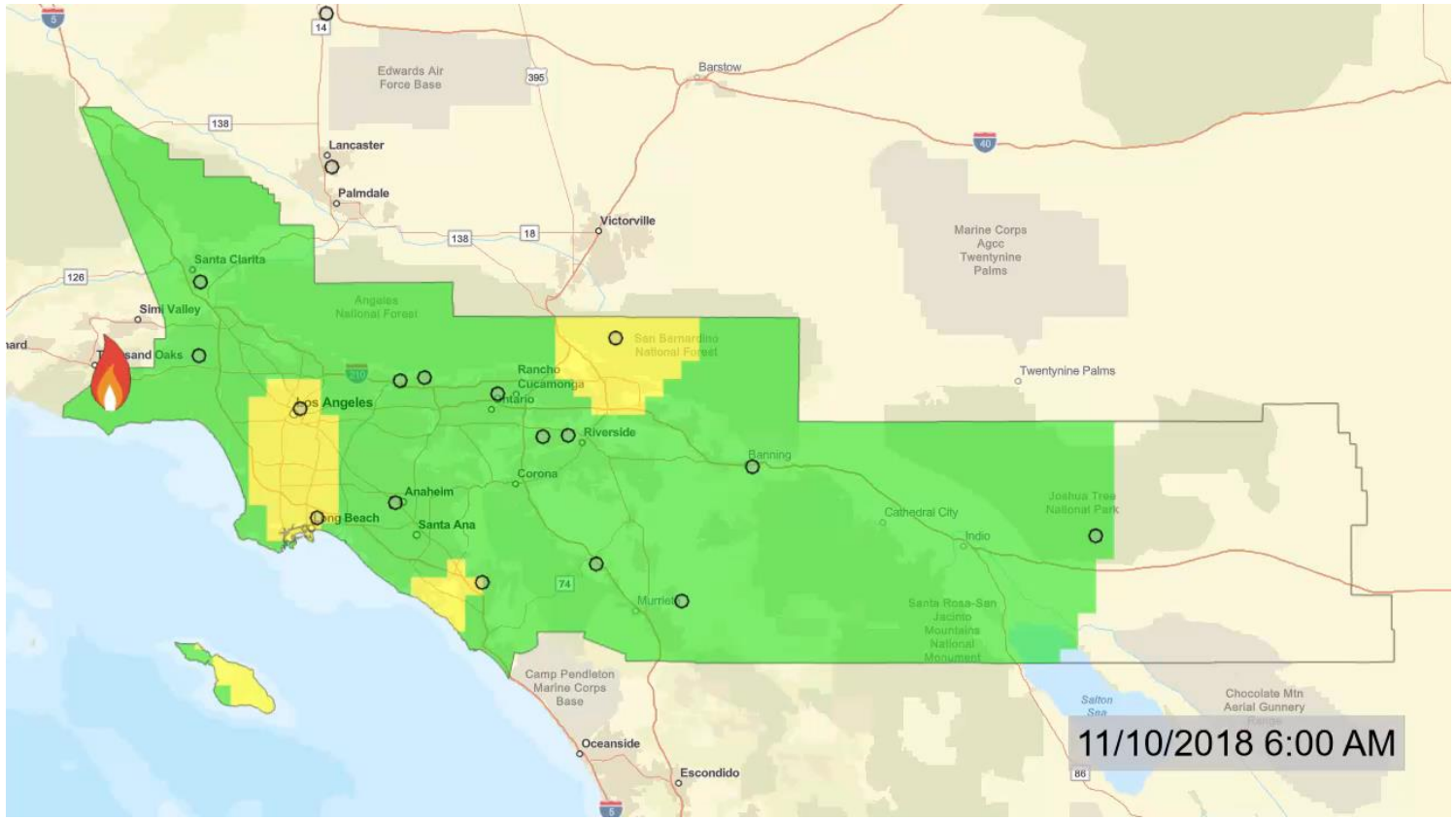
Map Performance Excels During Wildfires



$PM_{2.5}$ RMSE [$\mu g\ m^{-3}$] on fire days

Method	Proxy	IDW	Blended
Leave One Out Cross Validation	7.04	6.62	6.01
Gravimetric validation dataset	5.68	4.39	3.35
North Hollywood validation dataset	19.2	16.8	9.15

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Conclusions

- AQI map has high level of accuracy and avoids common public misunderstandings
- Clearly describes recommended measures to minimize exposure
- Data displayed on South Coast AQMD homepage and mobile app (www.aqmd.gov/mobileapp)
  - App can push notifications during periods of poor air quality
- Working closely with the AQ-SPEC Group to deploy additional PurpleAir PA-II & Aeroqual AQY v1.0 sensors to fill gaps in the monitoring network

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