Integration of Air Quality Sensor Data into the South Coast AQMD Real-Time Air Quality Index Map

Nico Schulte, Kyrstin Fornace, Ashley Collier-Oxandale, Brandon Feenstra, Vasileios Papapostolou, Scott A. Epstein

South Coast Air Quality Management District

Air Sensor International Conference

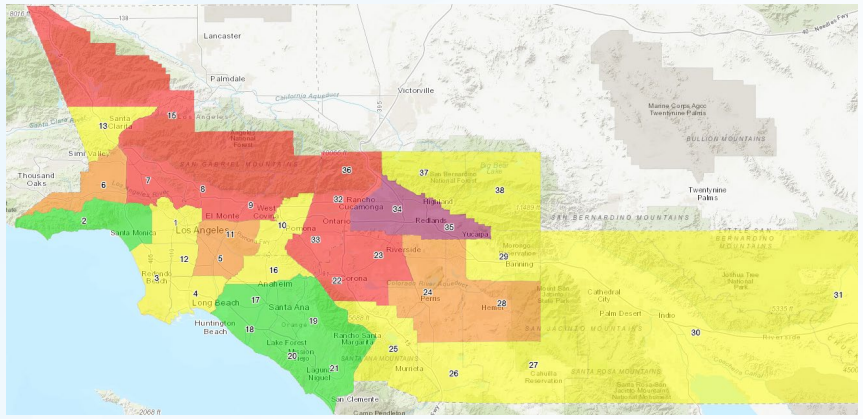
5/11/2022

Outline

- South Coast AQMD Current AQI Map
- Consumer Grade Sensors in the AQI Map
- Aeroqual AQY MOMA Calibration
- Map performance with AQY Data used in Calculations
- More accessible AQI colors

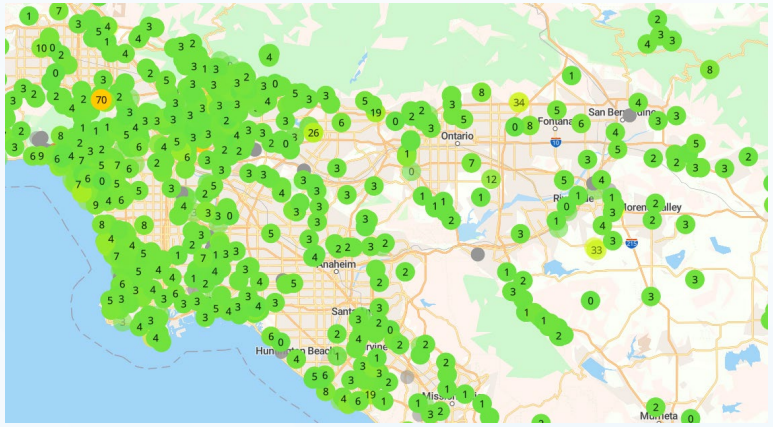
Methods of Displaying Real-Time Air Quality Data

Historical “Proxy Method”



AirNow

PurpleAir

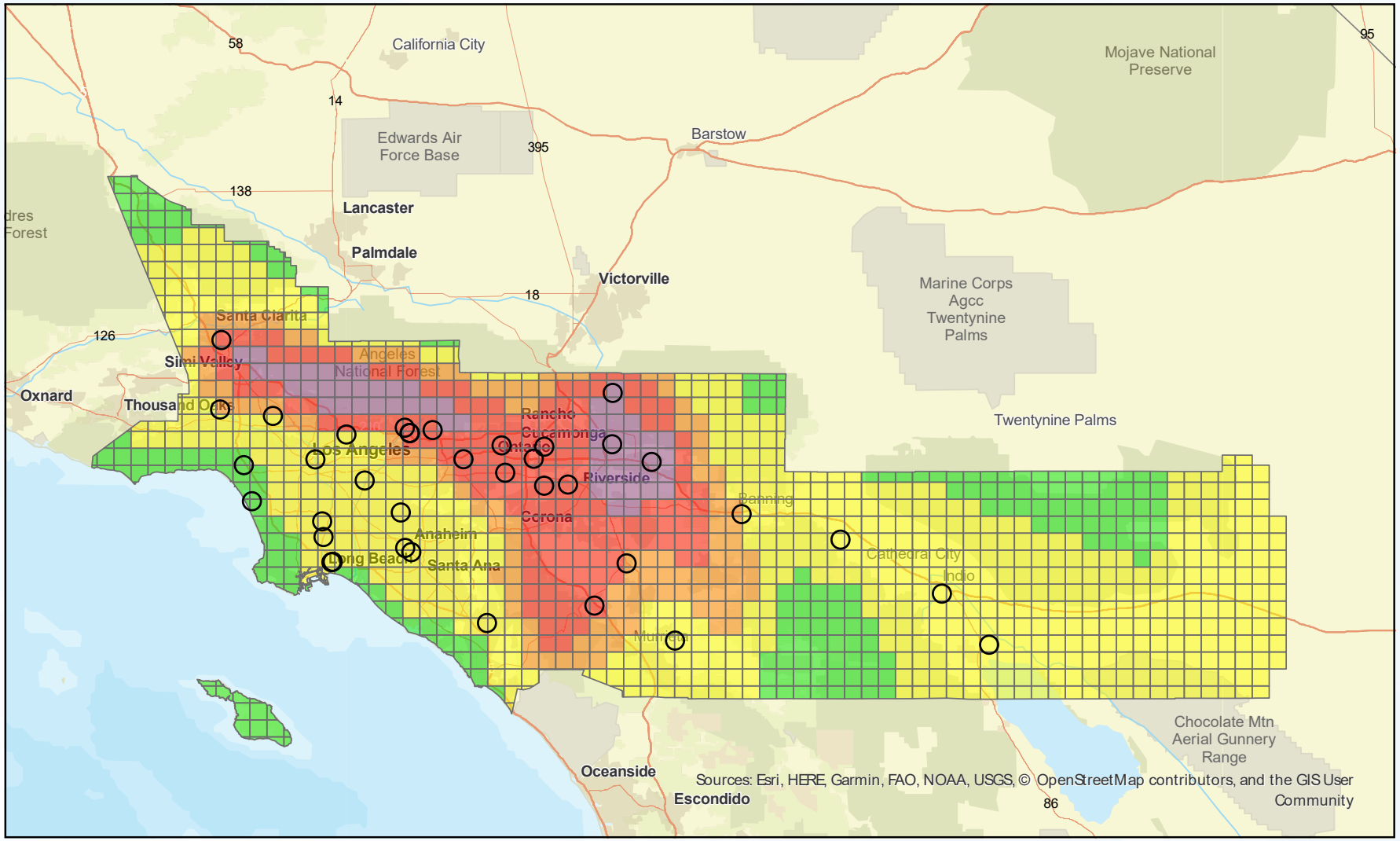


Limitations identified:

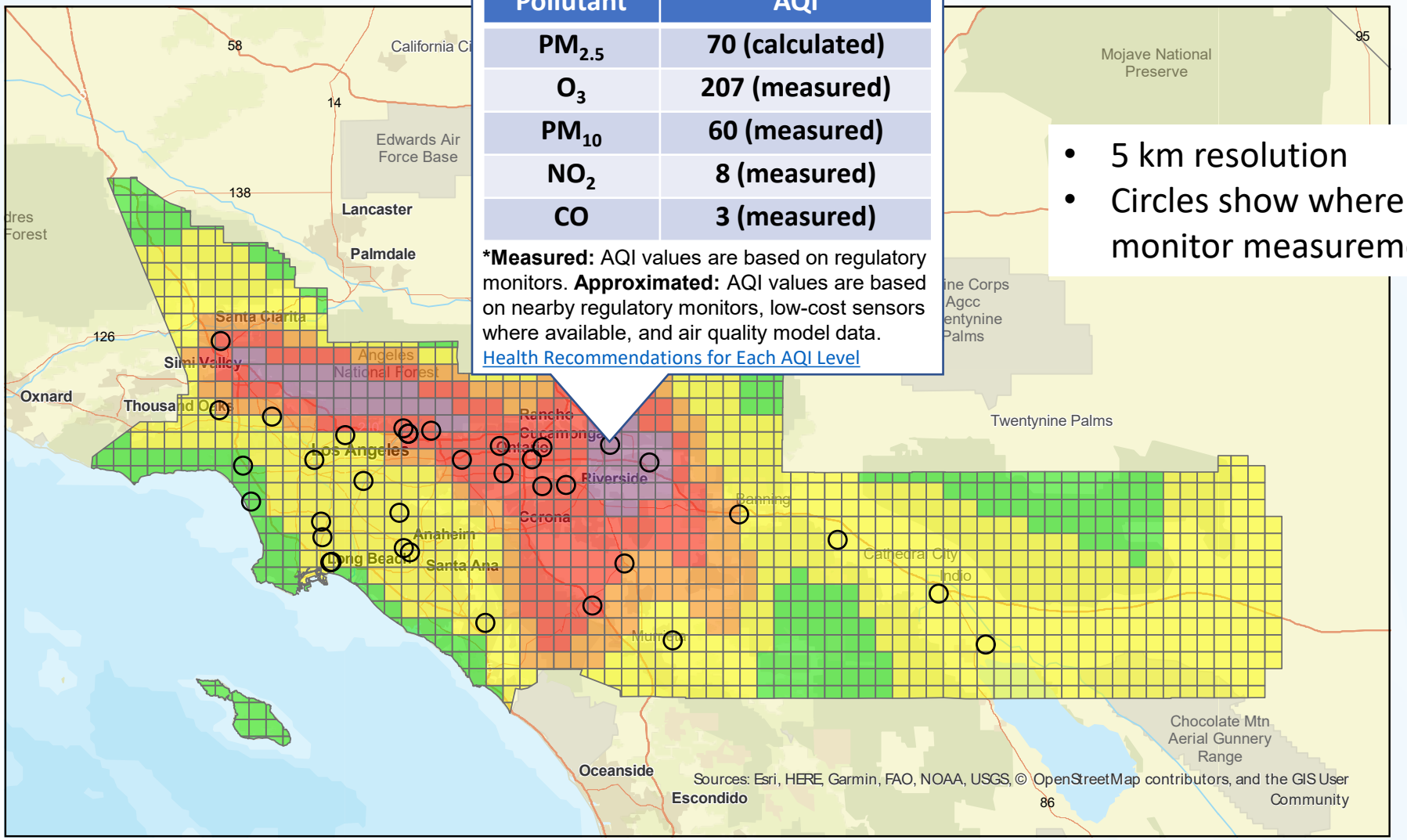
- Location of monitor that is driving an area’s current AQI is unclear
- Distance-weighted interpolation doesn’t account for complex terrain
- Public often looks at multiple maps to understand current air quality (PurpleAir map) and does not interpret consumer-grade sensor data appropriately
- Resolution 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

South Coast AQMD

Real-Time AQI Map (www.aqmd.gov/aqimap)

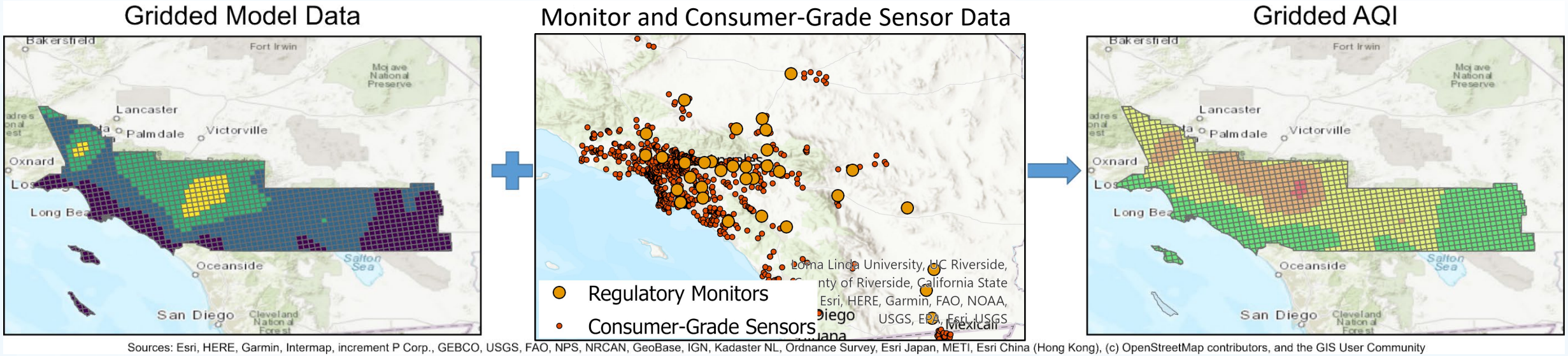


Real-Time AQI M d.gov/aqimap)



- 5 km resolution
- Circles show where regulatory monitor measurements are made

How the AQI Map Works

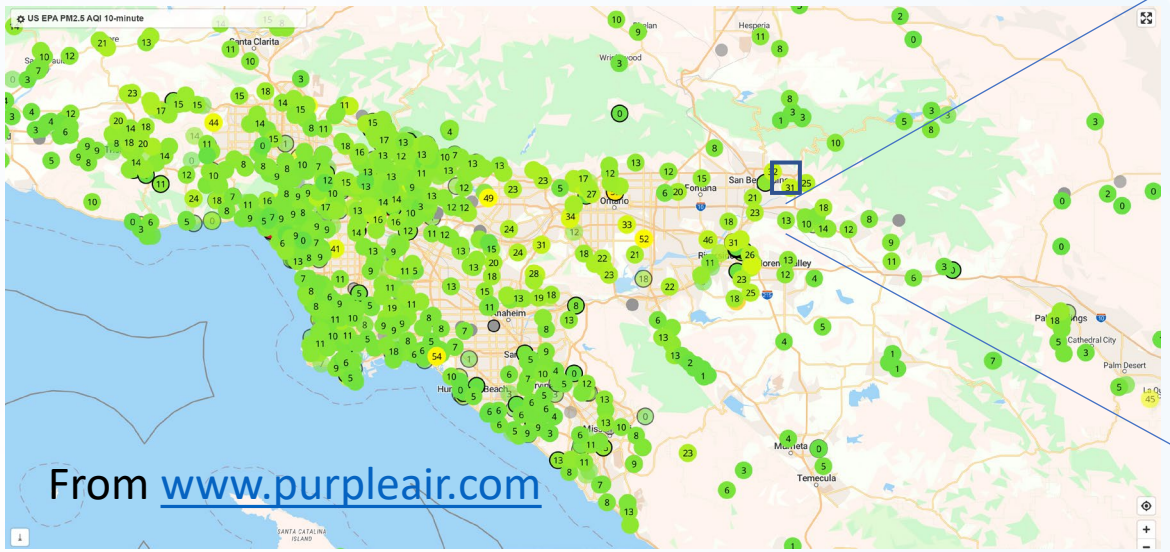


Pollutant	Method	Far from monitors	Near monitors
$PM_{2.5}$	Fill in gaps between monitors using model and consumer-grade sensor data	Models and consumer-grade sensor data drive concentration	Monitor data drives concentration
O_3	Fill in gaps between monitors using model	Models drive concentration	
PM_{10},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

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**, 2020, *Environmental Research Letters,* **15** 1040a7

Consumer-Grade Sensors

- About 700 PurpleAir $PM_{2.5}$ sensors in 2021; Great spatial coverage
- AQI Map uses sensor data to fill in gaps between monitor
- PurpleAir sensors more concentrated near the coast and downtown LA
- South Coast AQMD deploying sensors for community monitoring, wildfire monitoring, current AQI map, fill in data gaps
  - 350+ PurpleAir Sensors through EPA STAR grant funding, 60+ Aeroqual AQY v1.0 deployed
- We are integrating Aeroqual AQY $PM_{2.5}$, PM_{10}, and O_3, data into AQI map




PurpleAir sensor

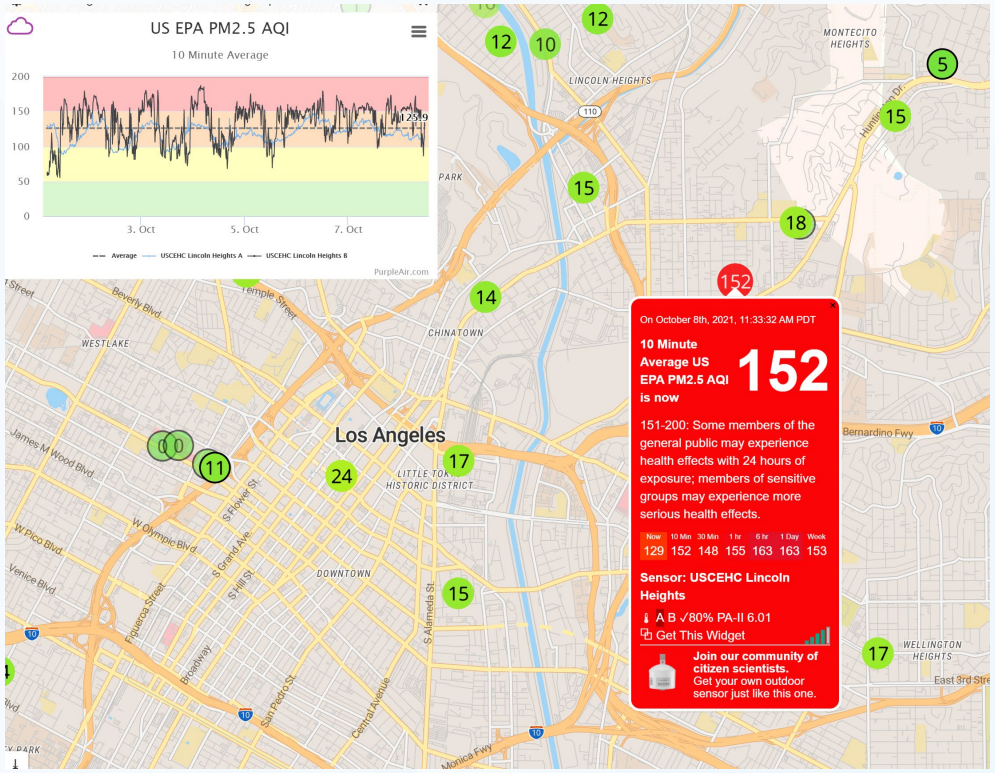
South Coast AQMD

Interpreting Consumer-Grade Sensor Data

- Sensor data should be:
  - Representative (place sensor away from local pollution sources)
  - Reliable (remove broken sensors)
  - Averaged (1-hour averages for NowCast AQI)
  - Calibrated/corrected (often based on colocation with regulatory monitors)

- **South Coast AQMD AQI map handles these issues in real-time**

Example: This sensor is broken



From www.purpleair.com

AQY Moment Matching (MOMA)

(PM2.5, PM10, O3, NO2)
aeroqual.com

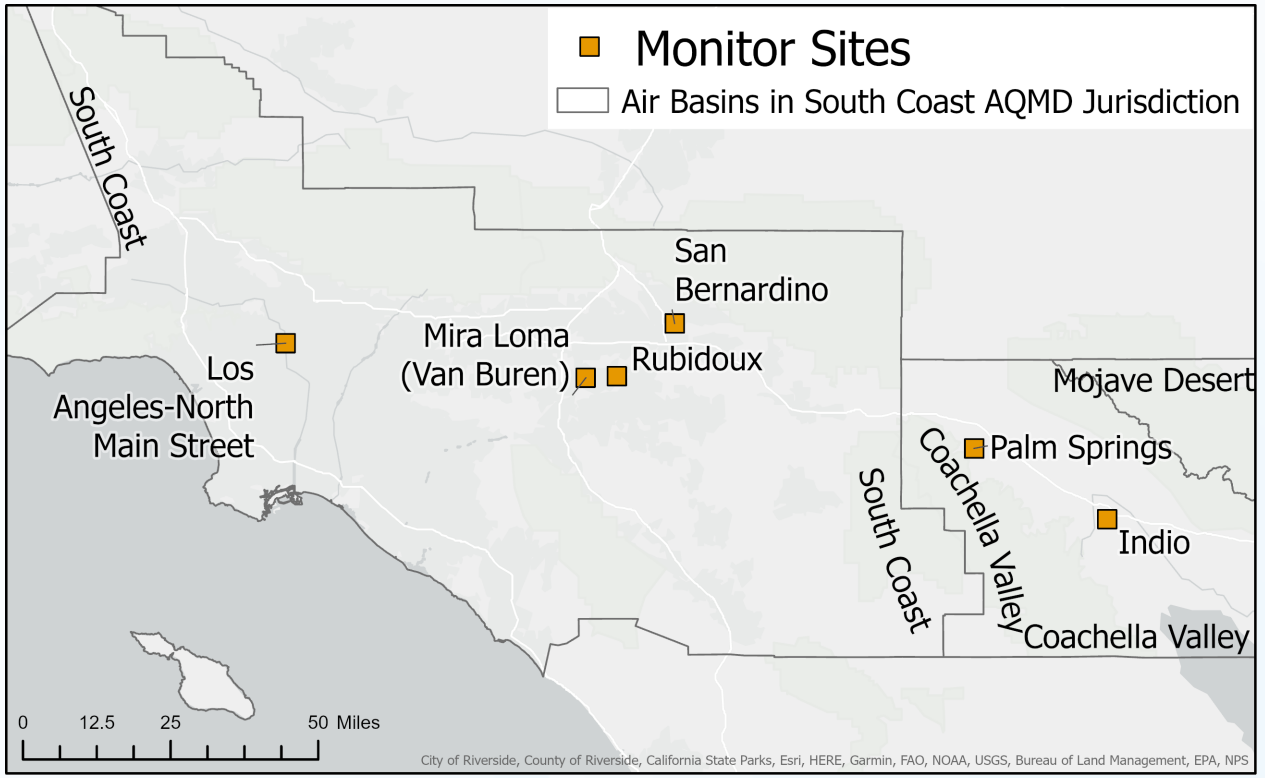
- MOMA is an algorithm that corrects the real-time AQY data
- MOMA applies a linear adjustment to AQY sensor measurements
  - $Corrected = a_0 + a_1 SENSOR$
- To determine a_0 and a_1:
  - Assign a **proxy*** regulatory monitor to each AQY sensor
  - Every hour, calculate $a_1 = \sqrt{\frac{var(PROXY)}{var(SENSOR)}}$, $a_0 = avg(PROXY) - a_1 avg(SENSOR)$
  - where $var()$ is the variance and $avg()$ is the average over the past 3 days
- For details see: A real-time calibration and device management system for air quality sensors deployed in hierarchical networks May 13th 9:50 AM Session 5D

*For this implementation, the proxy is chosen as the closest regulatory monitor

AQY Collocation with Regulatory Monitors

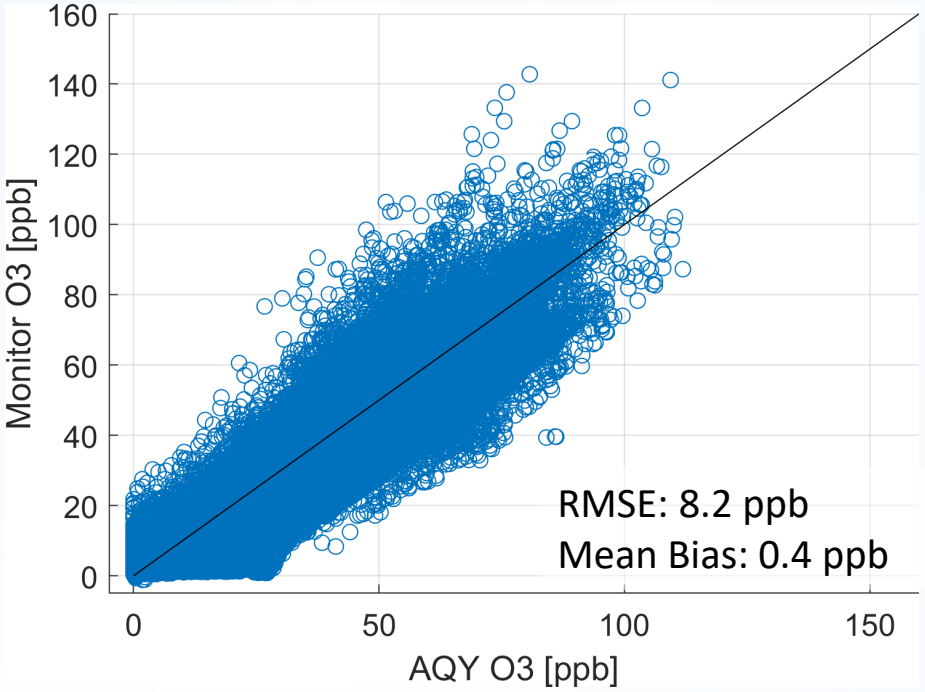
- Data used to analyze MOMA calibration performance
- January 1 – December 31, 2021
- Hourly data at six sites

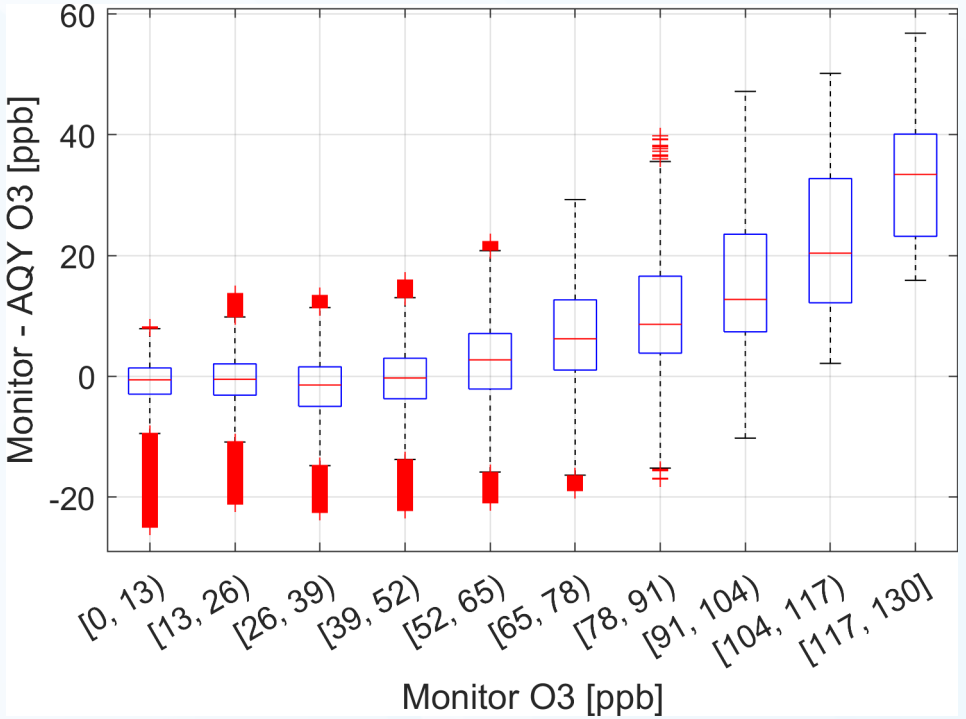
Pollutant	Regulatory Monitor Instruments
O3	Thermo 49i, Teledyne T400, Teledyne T500U
PM2.5	Met One BAM 1020
PM10	Met One BAM 1020, Thermo 5014i



Ozone Correction Performance

- High correlation between corrected AQY and monitor
- AQY underestimates at higher O_3 concentration
- We use the RMSE as an estimate of standard uncertainty in the AQI calculations



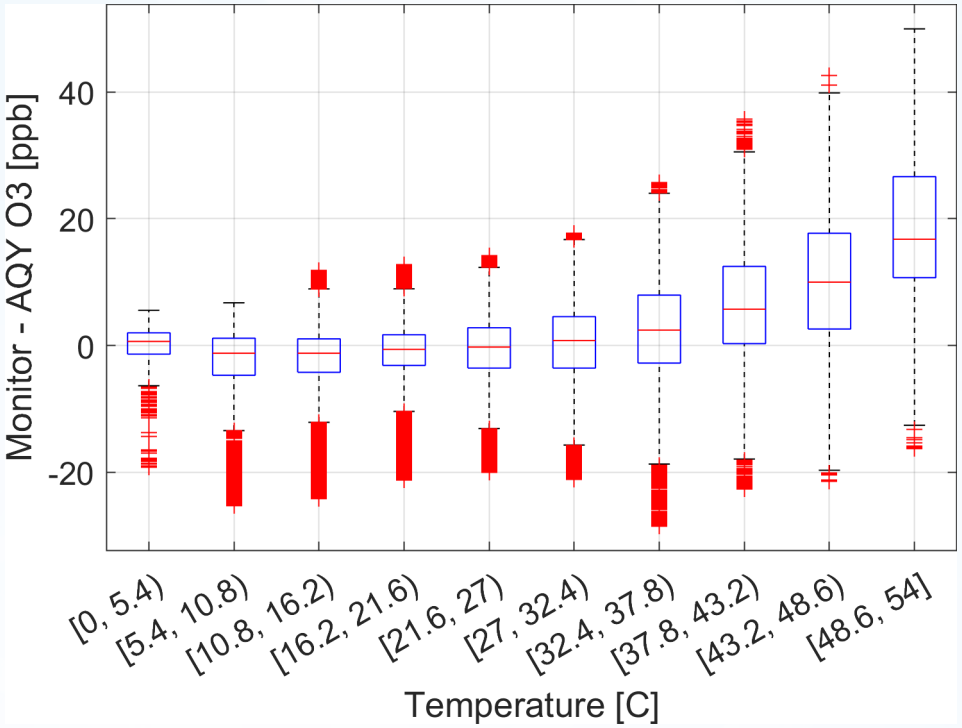


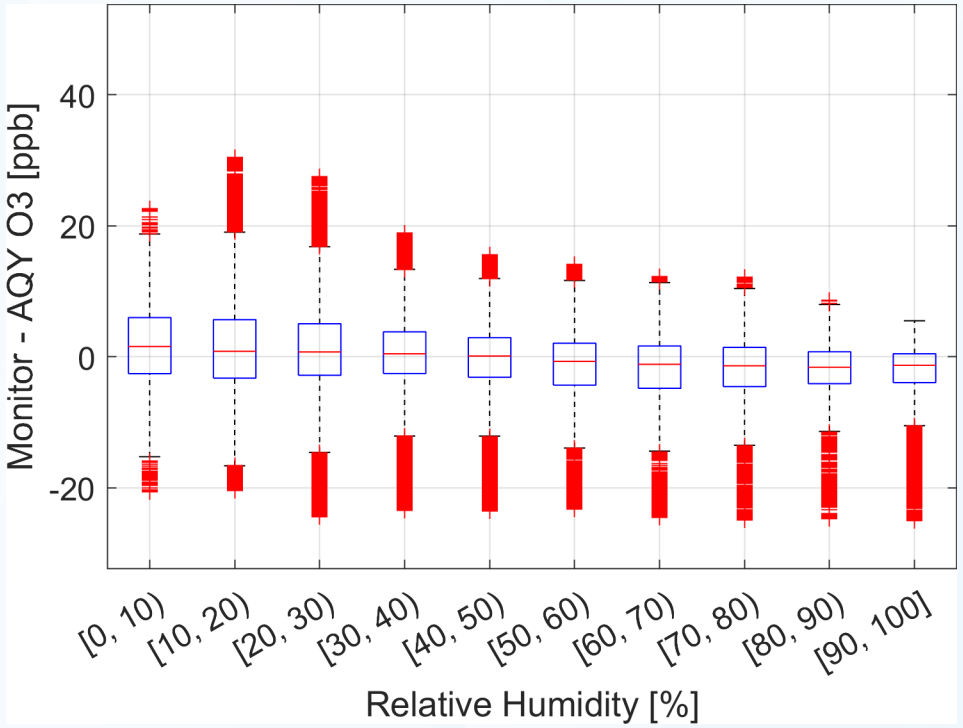
Using Corrected AQY data (1-hour average)
Lower and upper 1% of residuals have been removed from box plot. Boxes show median, 25th, and 75th percentiles. Whiskers are at 1.5 times interquartile range

South Coast AQMD

Ozone Temperature and Humidity Influence

- AQY underestimates at higher temperature (and higher ozone concentration)
- AQY bias has little relative humidity dependence

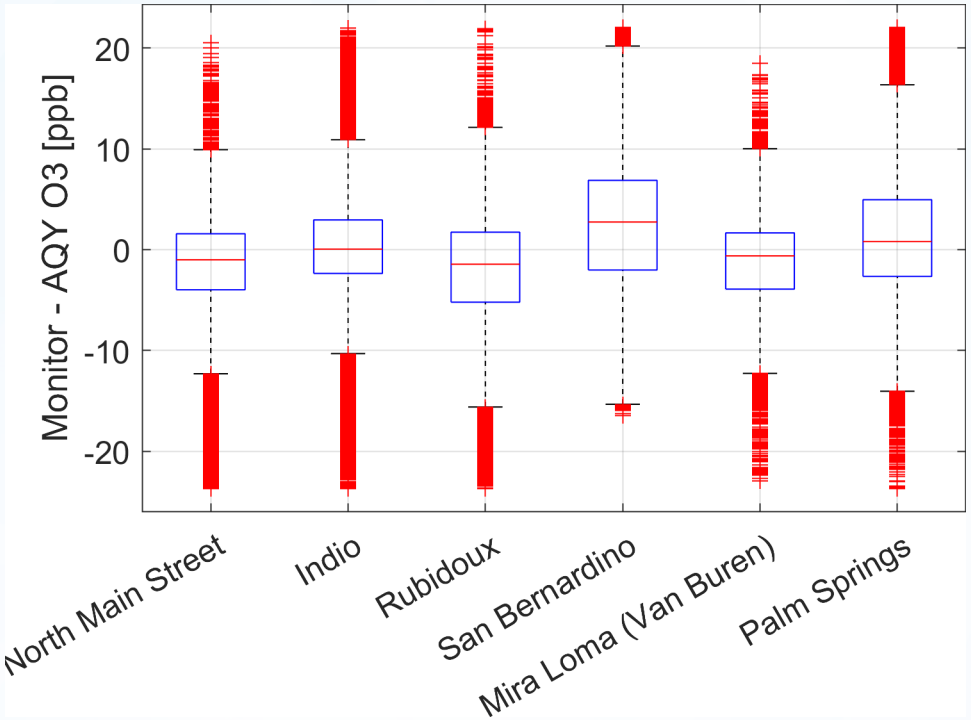


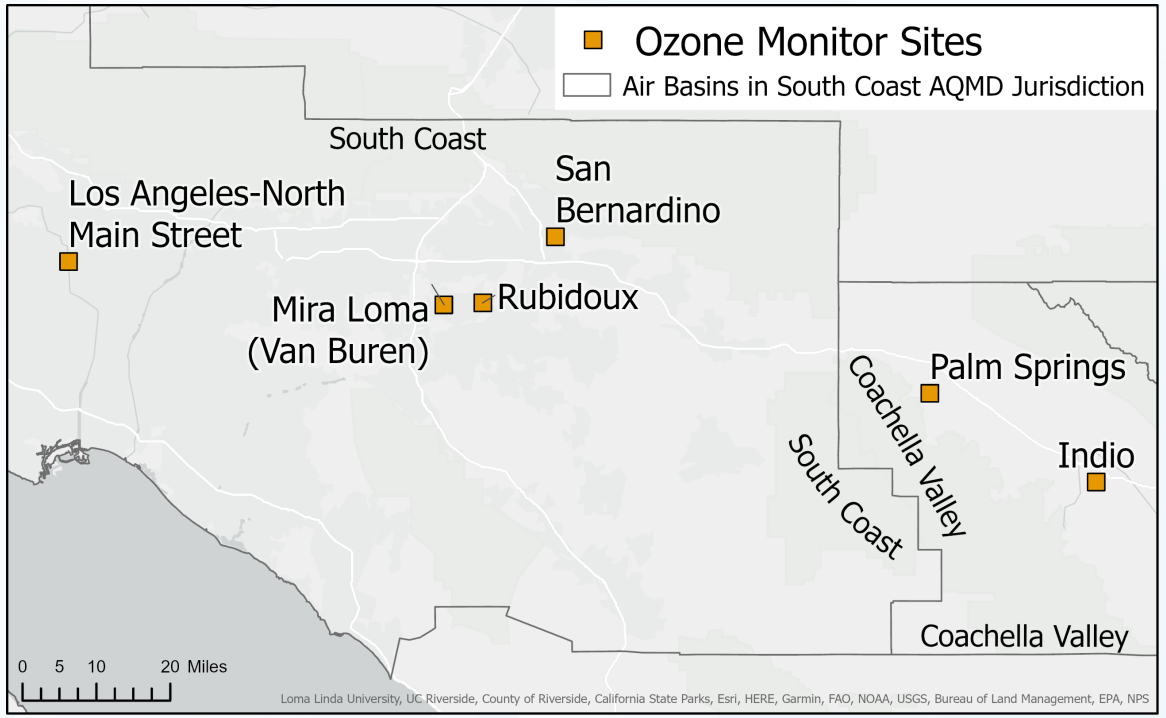


Using Corrected AQY data (1-hour average); Lower and upper 1% of residuals have been removed from box plot. Boxes show median, 25th, and 75th percentiles. Whiskers are at 1.5 times interquartile range

Ozone – Location Variation

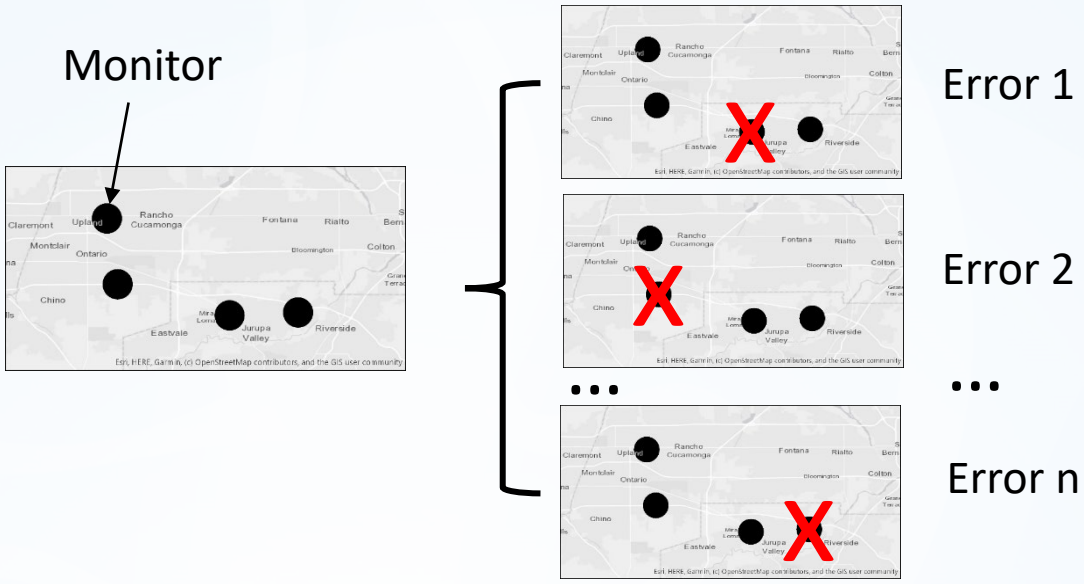
- AQY measurement bias has little variation by location

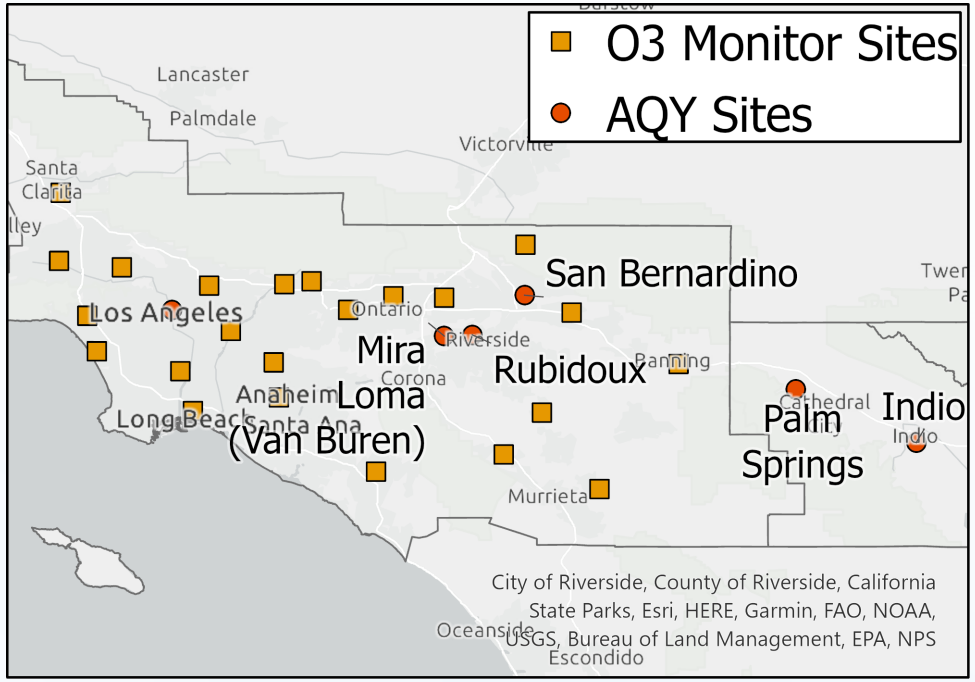




Evaluating Performance of AQI Map

Leave one out cross validation holds out one monitor at a time to estimate error





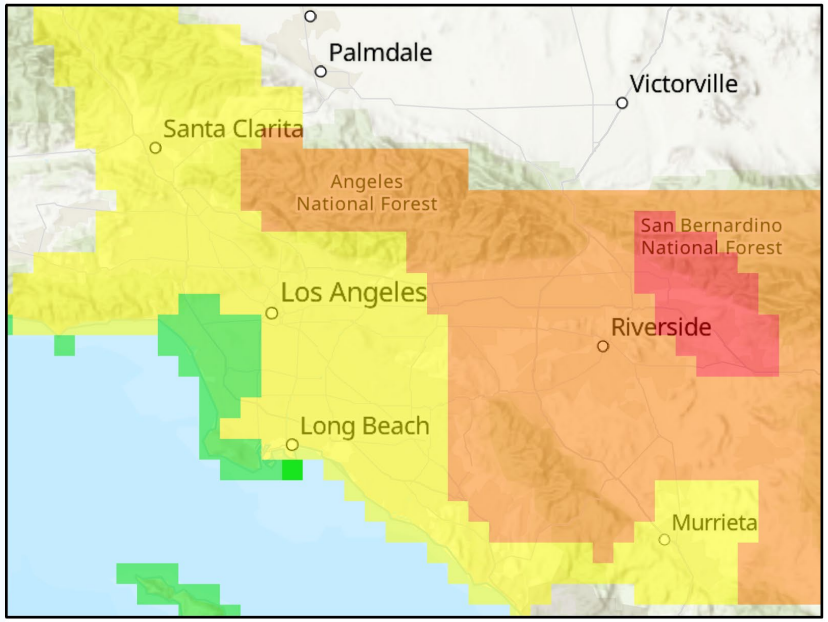
Root Mean Square Error

Pollutant	With AQY	Without AQY
$PM_{2.5}$ [µg m^{-3}]	10.17	10.18
O_3 [ppb]	7.91	7.94
PM_{10} [µg m^{-3}]	29.4	29.6

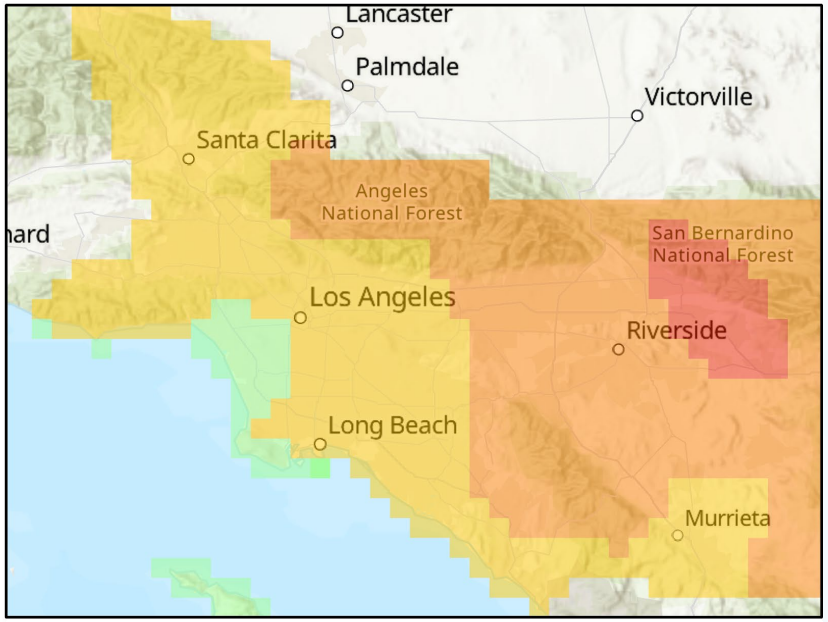
South Coast AQMD

More Accessible AQI Colors

Traditional AQI



More Accessible AQI



Esri, CGIAR, USGS, City of West Covina, County of Los Angeles, California State Parks, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS

- Available as option in current AQI map
- Modified colors improve accessibility for people with eight types of colorblindness
- Color lightness changes uniformly with AQI
- Can be used for continuous color scale

South Coast AQMD

Conclusion

AQI data displayed on South Coast AQMD homepage and mobile app (www.aqmd.gov/mobileapp)

- Sensors are useful to supplement regulatory data in real-time AQI map
- South Coast AQMD siting PurpleAir PA-II and Aeroqual AQY sensors to help fill data gaps
- MOMA calibration reduces bias due to AQY sensor drift
- AQY ozone, $PM_{2.5}$, and PM_{10} data was successfully integrated in the AQI map
- Performance improvements are small – likely because small number of AQY sensors were used (map already integrates hundreds of PurpleAir sensors and modeled data fields)
- We plan to evaluate performance again after integrating 60+ AQY that South Coast AQMD has deployed

Questions?

Nico Schulte

nschulte@aqmd.gov

South Coast Air Quality Management District