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

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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”

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

San Bernardino
AQI: 207
AQI Category: Very Unhealthy
Dominant Pollutant: Ozone | Updated: 4 PM

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>AQI</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{2.5}$</td>
<td>70 (calculated)</td>
</tr>
<tr>
<td>O$_3$</td>
<td>207 (measured)</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td>60 (measured)</td>
</tr>
<tr>
<td>NO$_2$</td>
<td>8 (measured)</td>
</tr>
<tr>
<td>CO</td>
<td>3 (measured)</td>
</tr>
</tbody>
</table>

*Measured: AQI values are based on regulatory monitors. Approximated: AQI values are based on nearby regulatory monitors, low-cost sensors where available, and air quality model data.

Health Recommendations for Each AQI Level

- **5 km resolution**
- **Circles show where regulatory monitor measurements are made**
How the AQI Map Works

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Method</th>
<th>Far from monitors</th>
<th>Near monitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{2.5}$</td>
<td>Fill in gaps between monitors using model and consumer-grade sensor data</td>
<td>Models and consumer-grade sensor data drive concentration</td>
<td>Monitor data drives concentration</td>
</tr>
<tr>
<td>O$_3$</td>
<td>Fill in gaps between monitors using model</td>
<td>Models drive concentration</td>
<td>Monitor data drives concentration</td>
</tr>
<tr>
<td>PM$_{10}$, NO$_2$, CO</td>
<td>Natural neighbor interpolation</td>
<td>Monitor data drives concentration</td>
<td>Monitor data drives concentration</td>
</tr>
</tbody>
</table>

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

From [www.purpleair.com](http://www.purpleair.com)
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)

• MOMA is an algorithm that corrects the real-time AQY data
• MOMA applies a linear adjustment to AQY sensor measurements
  • Corrected = \( a_0 + a_1 \text{SENSOR} \)
• To determine \( a_0 \) and \( a_1 \):
  • Assign a proxy* regulatory monitor to each AQY sensor
  • Every hour, calculate \( a_1 = \frac{\text{var(PROXY)}}{\text{var(SENSOR)}} \), \( a_0 = \text{avg(PROXY)} - a_1 \text{avg(SENSOR)} \)
  • where \( \text{var()} \) is the variance and \( \text{avg()} \) 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

<table>
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<tr>
<th>Pollutant</th>
<th>Regulatory Monitor Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>O3</td>
<td>Thermo 49i, Teledyne T400, Teledyne T500U</td>
</tr>
<tr>
<td>PM2.5</td>
<td>Met One BAM 1020</td>
</tr>
<tr>
<td>PM10</td>
<td>Met One BAM 1020, Thermo 5014i</td>
</tr>
</tbody>
</table>
Ozone Correction Performance

• High correlation between corrected AQY and monitor
• AQY underestimates at higher O₃ 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
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

<table>
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<th>Pollutant</th>
<th>With AQY</th>
<th>Without AQY</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{2.5}$ [μg m$^{-3}$]</td>
<td>10.17</td>
<td>10.18</td>
</tr>
<tr>
<td>O$_3$ [ppb]</td>
<td>7.91</td>
<td>7.94</td>
</tr>
<tr>
<td>PM$_{10}$ [μg m$^{-3}$]</td>
<td>29.4</td>
<td>29.6</td>
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Prepared by: South Coast AQMD
More Accessible AQI Colors

- 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
• 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

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

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