Quality Assurance for Gas & PM Sensors Networks

2023 Air Sensors Quality Assurance Workshop

Section: QA for specific gas and PM sensor applications continued

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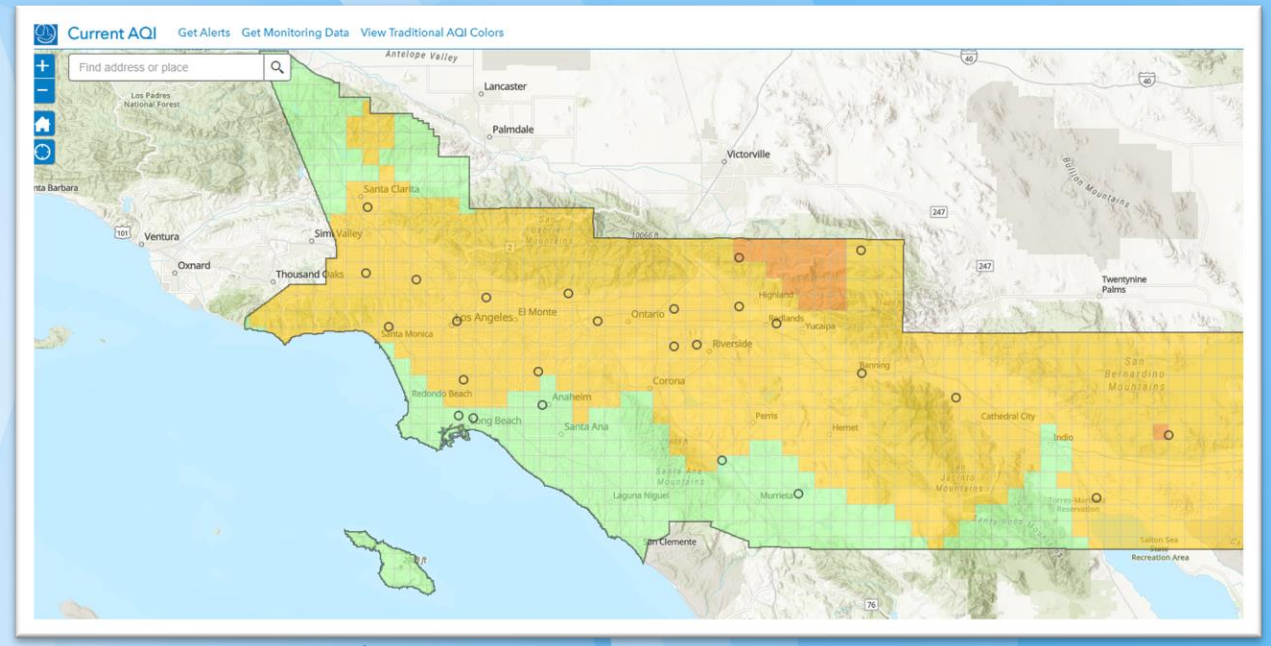
QA Objective = Data Usefulness and Timeliness

- Obtain data of known quality
  - Calibrated data in real-time
  - Validated in near-real-time with appropriate QC checks
- Obtain data fit for purpose
  - Displayed data – filter for QC checks.



www.aqmd.gov/aqimap

What have we been talking about so far?
How to apply the QA lifecycle to sensor data

Develop QA Documents

Data Collection

Systems & Performance Audits

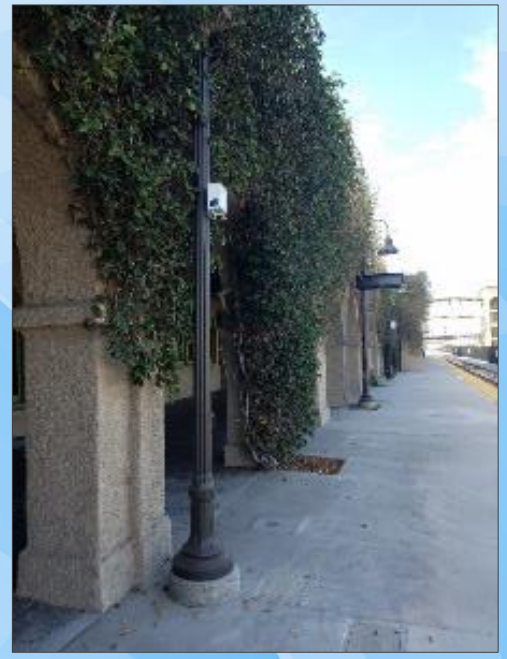
Corrective Action Improvements

Presentation Focus

- The Do's and Check's of Sensor Networks
  - Importance of proper siting and collecting meta data
  - Importance of tracking sensor health to manage sensor maintenance
  - Importance of choosing a calibration approach
  - Importance of developing QC metrics
  - Importance of auto alerting and auto flagging of data for real-time data displays
- Upcoming sensor network QA approaches
  - Sensor network evaluations
  - QA verifications

Know your locations and obtain meta data

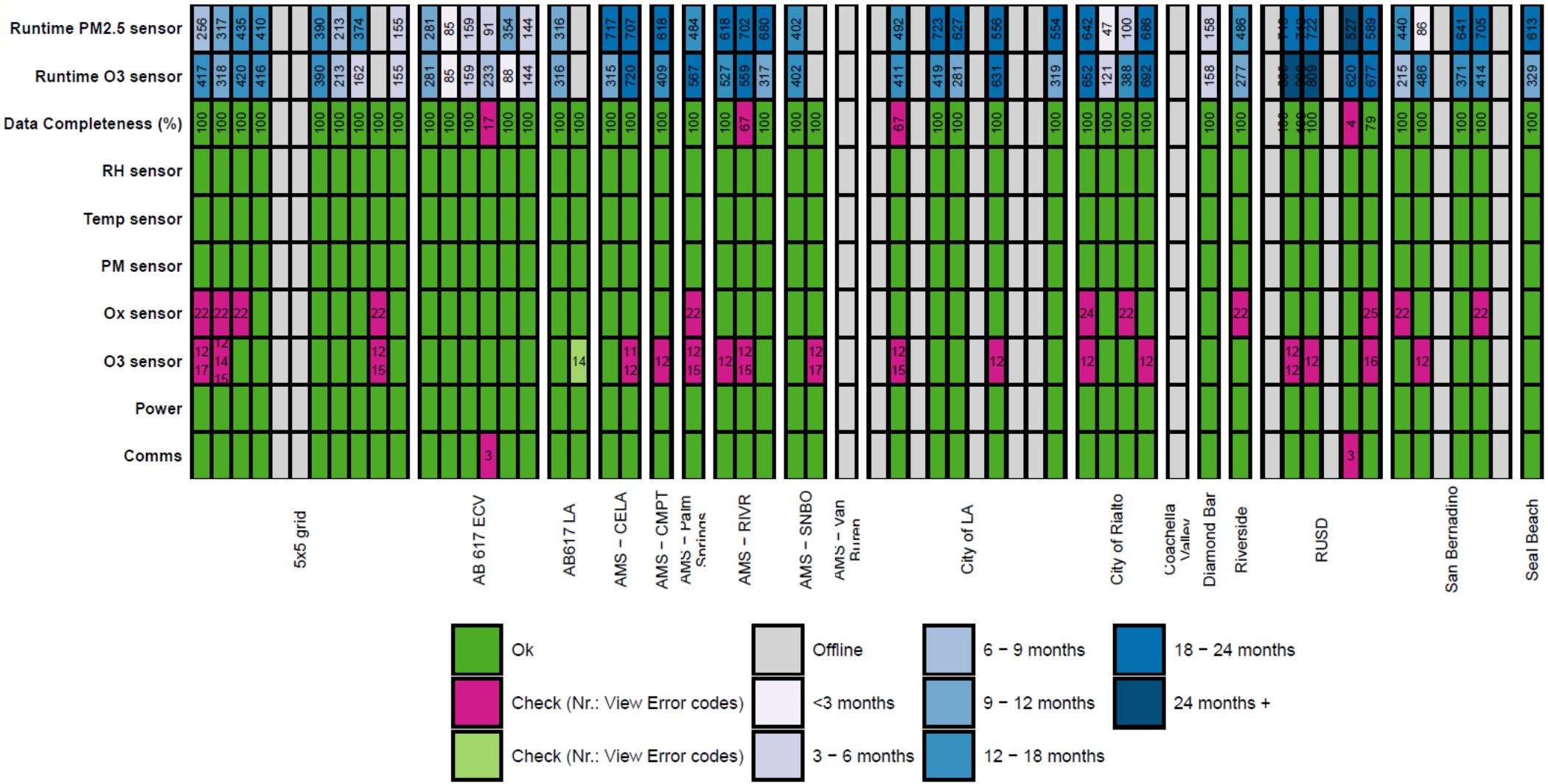




Recommendations:

- Locate sensors at breathing height or above and away from obstructions
- Verify sensor installations with collecting meta data and pictures via surveys
- Know your surroundings and annotate accordingly for data analysis
- Example survey: www.aqmd.gov/aq-spec/special-projects/star-grant

Device Management - Sensor Health Dashboard



Develop Quality Control Rules for Data

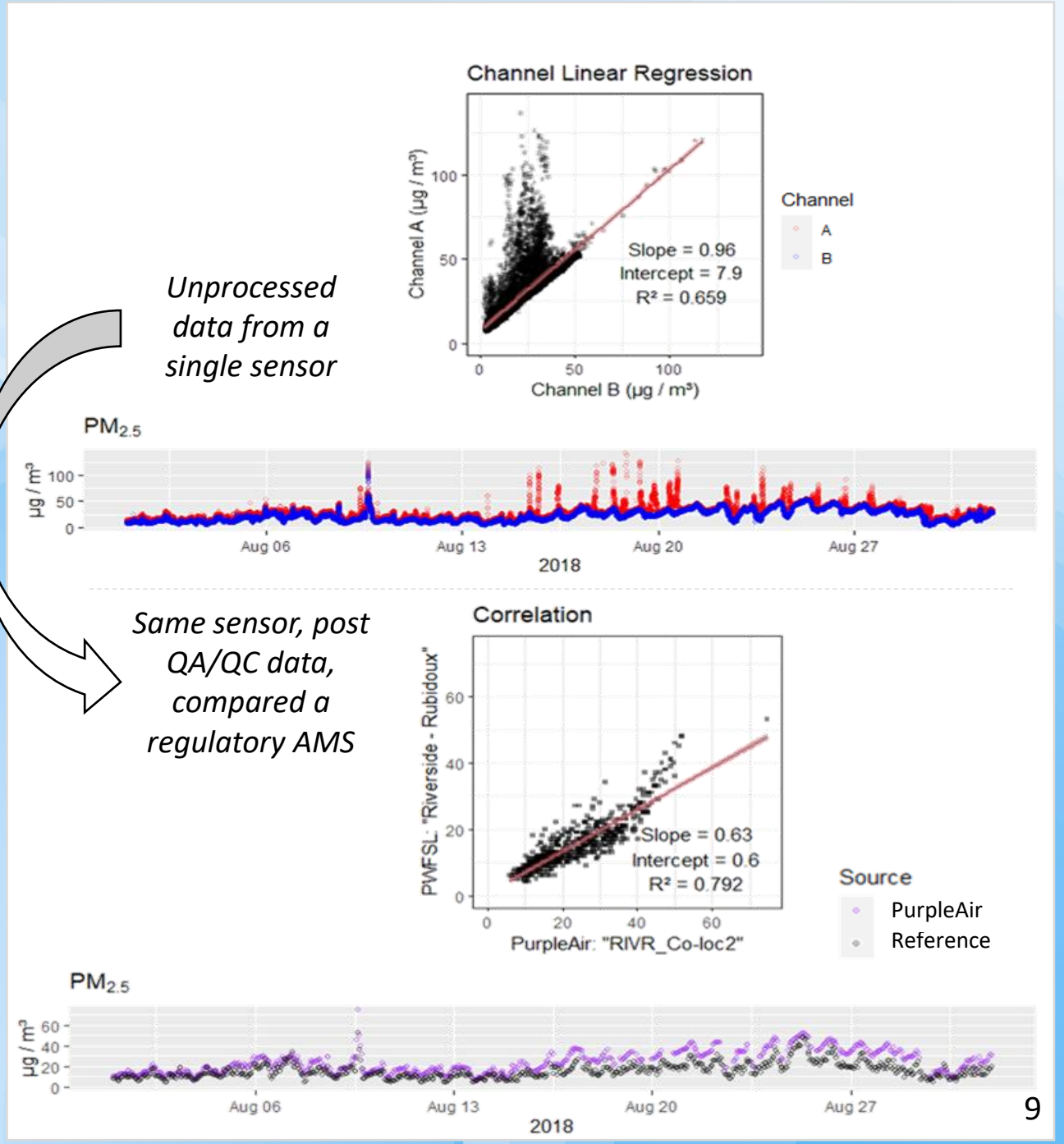
- **Sensor-specific**
  - Manufacturer-designated bounds
  - Environmental operating limits (temperature and humidity)
  - Unique features that can be leveraged
  - Common failure modes (e.g., “sticky values” or flatlining)
  - Behavior that may indicate a failure/drift or an actual air quality event, such as wildfires (e.g., extended elevated readings)
- **Pollutant-specific**
  - Typical ranges
  - Typical trends (e.g., diurnal trends)
- **Actions**
  - Invalidate –malfunctions
  - Flag – data indicating failure OR an air quality event of interest
  - Requirements – for criteria that must be met (e.g., for completeness)
  - Adjust value – in some cases values may be adjusted/calibrated (e.g., to zero)

Develop QC Rules - Examples

QC Rule	Logic	Action
High/Low Value Check	If $PM_{2.5}$ concentration value > 300 µg/m^3 for > 4 hr	Flag
High/Low Value Invalid	If $PM_{2.5}$ concentration value > 900 µg/m^3 for > 24 hr If $PM_{2.5}$ concentration value < 0.5 µg/m^3 for > 24 hr	Invalidate
Out of Bounds	If value is out of range of sensor manufacture specs O_3 > 200 ppb; NO_2 > 500 ppb; $PM_{2.5}$ > 1000 µg/m^3; Temp < -10 or > 60 °C; or RH < 0 or > 100 %	Invalidate
Flatline	If rolling Std Dev < 1 for > 12 hours	Invalidate
Temperature Exceedances	If temp <-15 or >110 ° F, concentration data flagged as “High Temp”	Flag
Negative Data Filter	If concentration value < - 5 ppb for O_3	Invalidate
Negative value replacement	If concentration value > -5 ppb and < 0 for O_3 ; set to zero	Set to zero
Offline	No data from sensor > 12 hours	Flag
Data Averaging	Require 75% valid data recovery to generate time averages	Requirement
Correlation Check	Purple Air: If R^2 between A/B < 0.5 for 36 hour Community: If R^2 between sensor/community < 0.5 for 36 hour	Flag

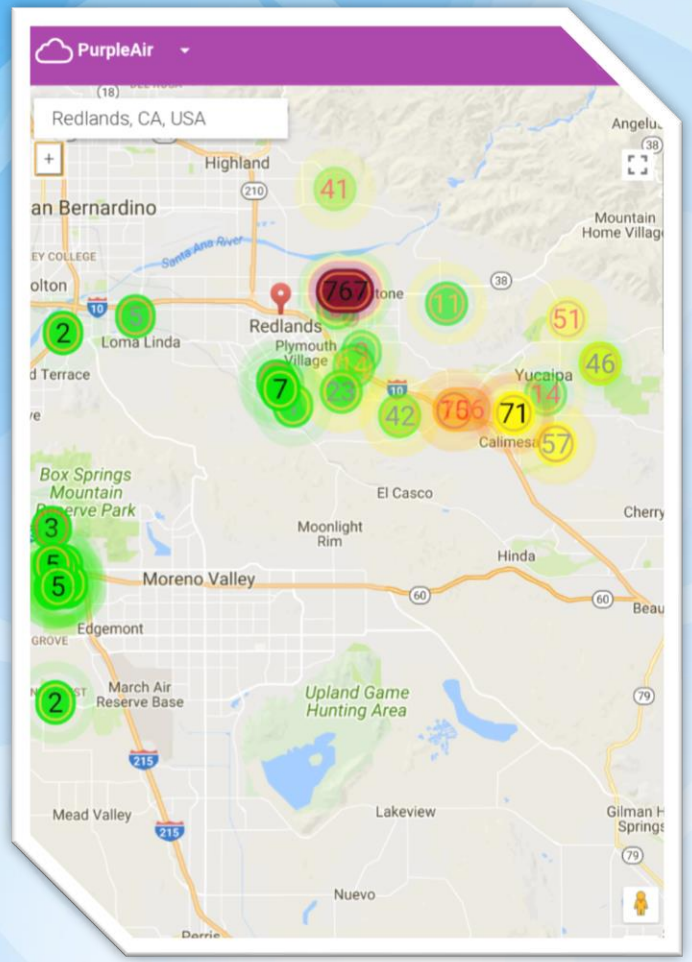
EXAMPLE: QA/QC Applied

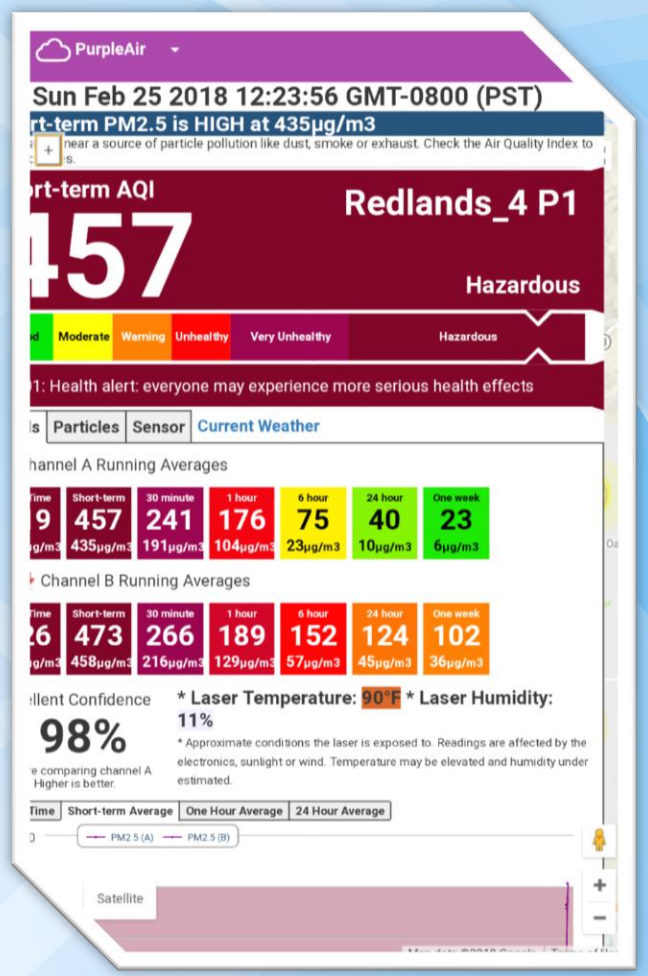
- The top plot depicts high-time resolution data from a sensor co-located at a regulatory air monitoring station
- Here there is disagreement between the duplicate channels (i.e., noise in the Channel A data, though in general trends agree)
- Filtering, applying a QA/QC Algorithm, and aggregating the data results in the processed data (bottom plot)
- The result is post-QA/QC data, for which trends agrees fairly well with the corresponding regulatory data

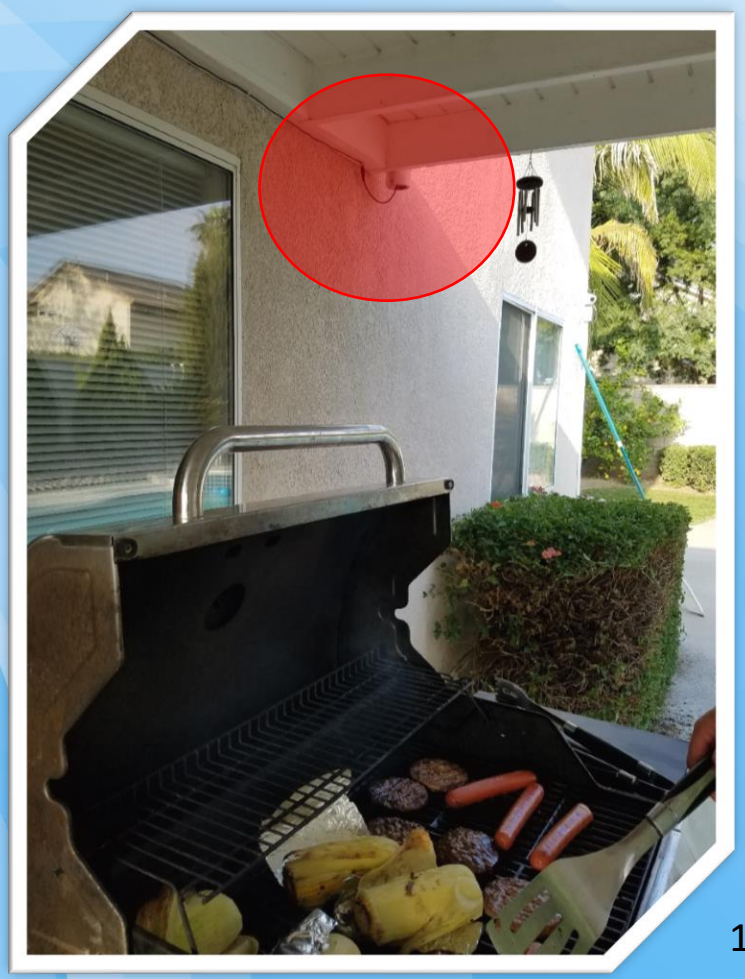


Correlation check: Sensor to community

Hyper-local effects







Develop a Calibration Approach

Types	Overview	Pros	Cons
Factory Calibration	High throughput batch calibrations, resulting in correction factors (often linear)	All sensors in a batch calibrated under the same conditions	Occurs once by manufacturer

Upcoming Approaches for QA of Sensor networks

- Sensor Network Performance Evaluations
  - How well do calibration approaches work?
  - How well do QC measures / approaches work in real-time?

- Alternative options for obtaining QC verifications
  - Park and verify with mobile monitoring platform
  - Drive-by verification with mobile monitoring platform
  - Hierarchal co-locations / buddy checks

Key Takeaways

- Collect meta data on sensor deployments and obtain pictures of install
- Develop device management dashboard to direct network maintenance scheduling and track sensor lifetime
- Develop QC metrics to flag data to be filtered from real-time visualizations if not pass QC rules
- Choose and implement a calibration approach
- Develop additional QC checks to verify performance and collect QC data

Thank you!

Contact information

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