CARB's Sensor Performance Evaluation Program

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Outline

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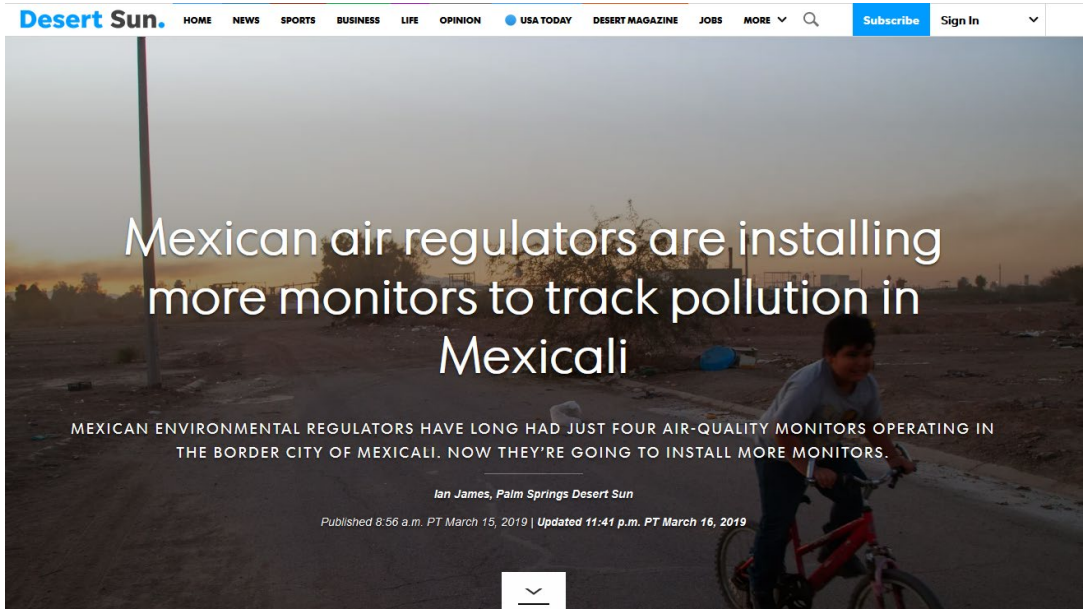
- Why conduct sensor evaluations
- CARB's role in assessing sensor performance
- Sensor evaluation and application examples
  - Collocation
  - Correlation and modeling
  - Smoke monitoring
- Developing resources and tools
- Summary

Background

- Low cost sensors
  - 1,600 operational Purple Air sensors in CA 2018
- AB617 Community Air Grants
  - 24 out of 28 Grants will use low-cost sensors (Mar/2019)
  - ~350 PM sensors (Dylos, PA-II, Airbeam, Clarity nodes)
  - Pollutants: PM, O_3, NO, NO_2, BC, VOC
- Increased media attention and public awareness



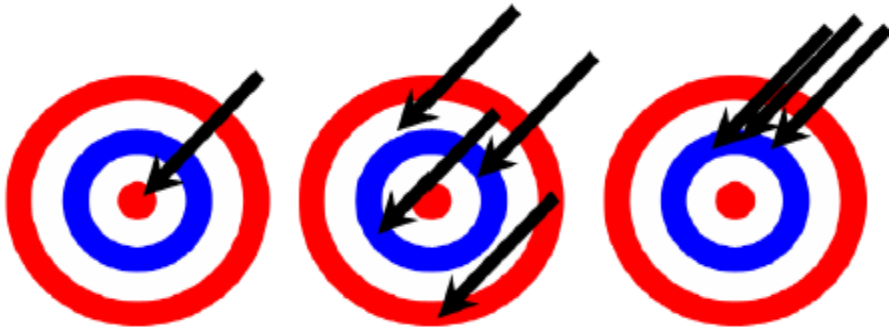
Mar/16 Desert Sun

Low cost sensors increased public awareness of local air quality

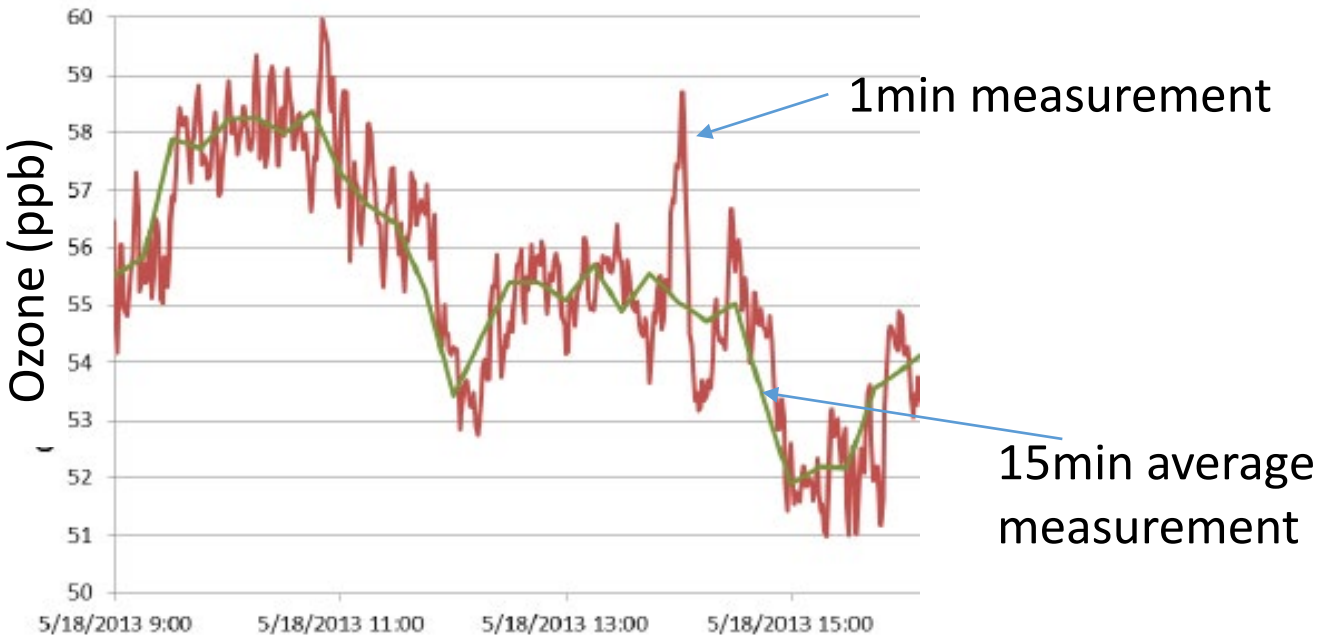
Sensor evaluation motivation

- Understanding performance is the key to interpreting data
- No established performance specifications

Sensor performance



Accuracy Precision Bias



Evaluating performance is key to interpreting sensor measurements

CARB's role in assessing sensor performance

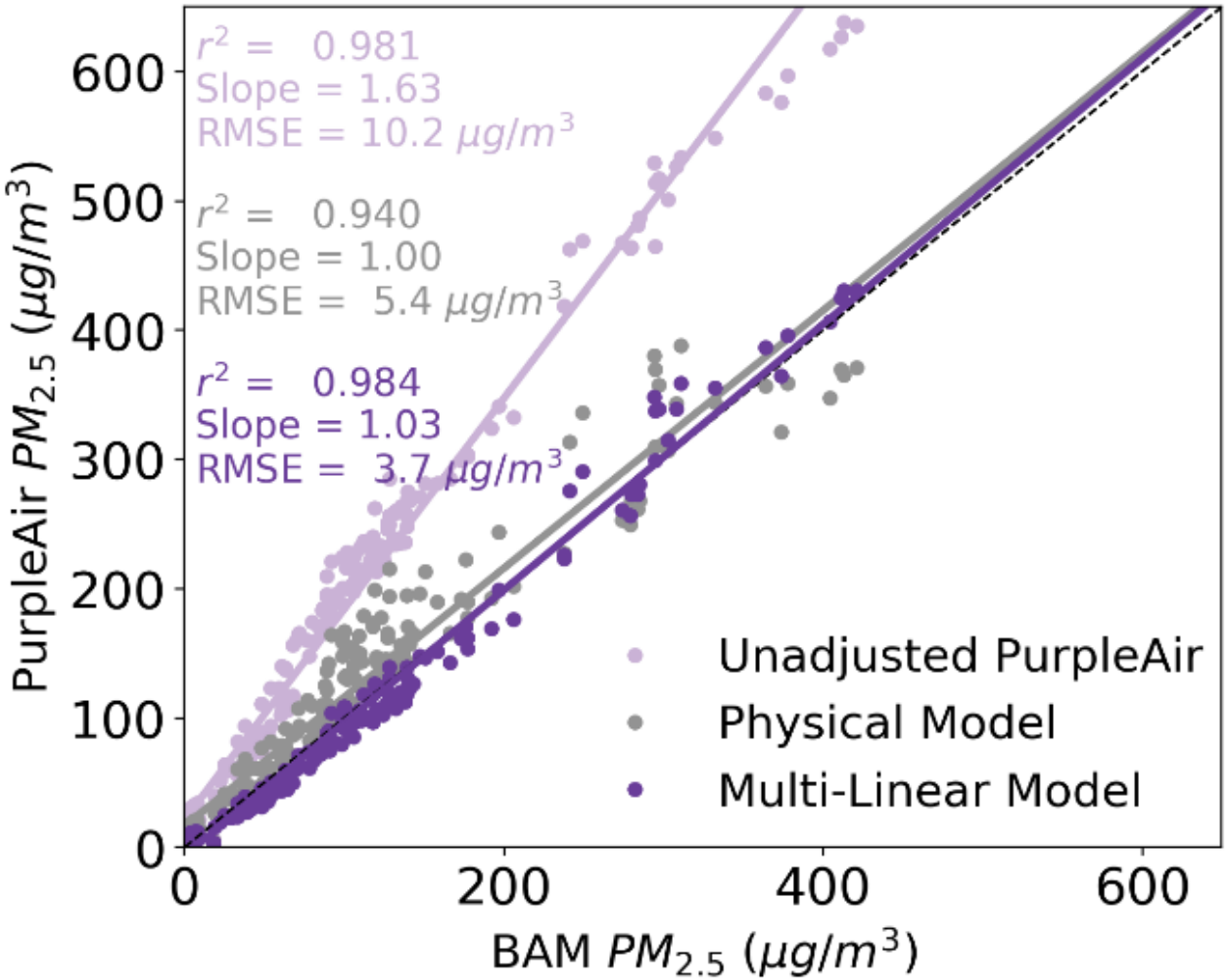
Sensor performance evaluations support CARB's and communities' monitoring programs

- Identify appropriate applications
- Best practices to develop and maintain sensor networks
- Make information available via AB617 resource center

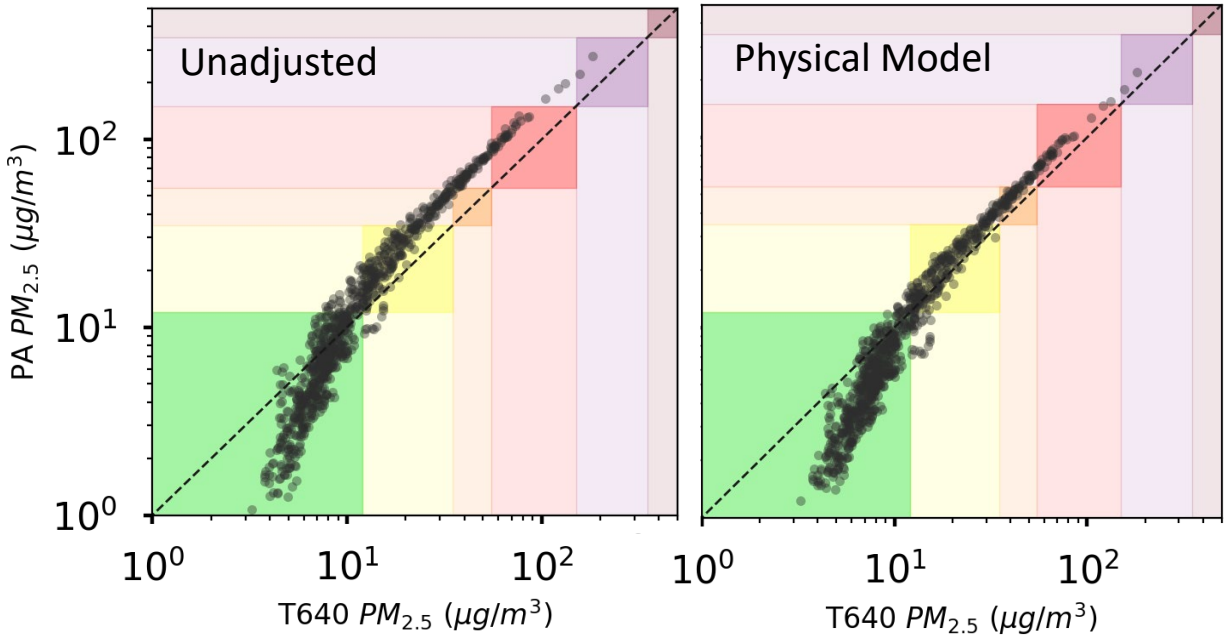
Sensor collocation

Collocating with regulatory instruments to evaluate basic sensor performance

Modeling and adjustment development



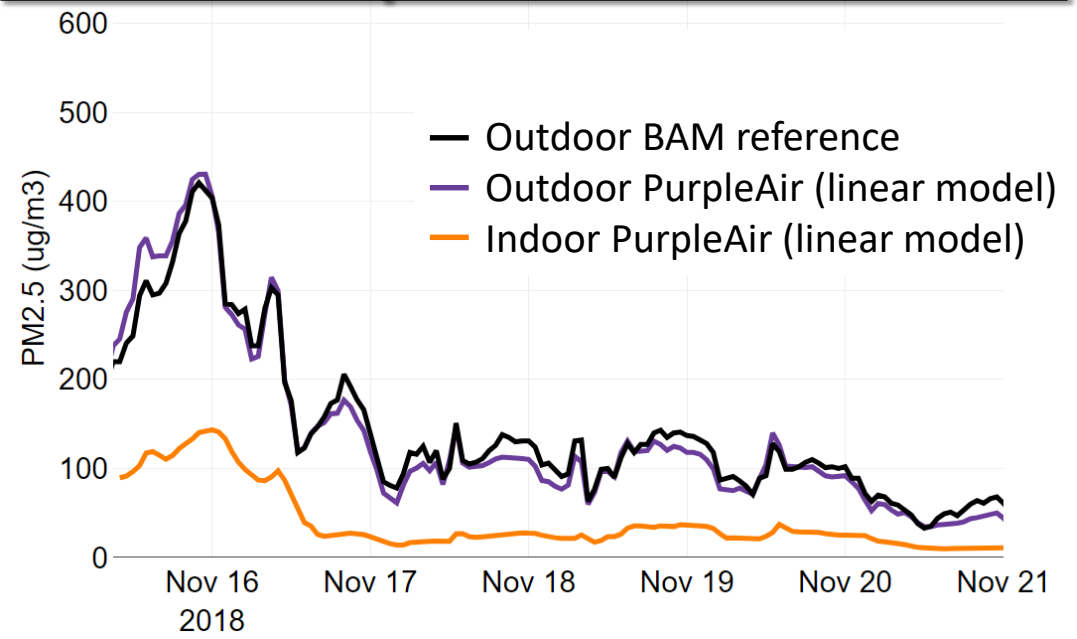
PA overestimates PM2.5 ~1.6 of BAM (FEM) with high r^2



Adjustment algorithm reduces misclassification of AQI

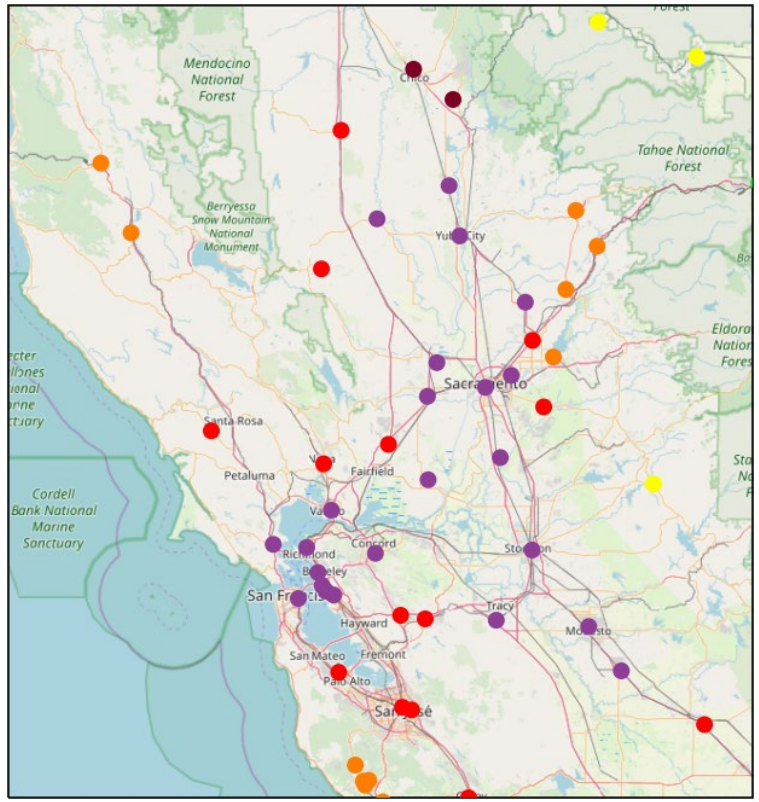
Indoor air monitoring

- Indoor air quality during the Camp Fire
- Linear model adjustment to improve PM measurements
- Useful for indoor air quality estimate (small, low power, quiet)

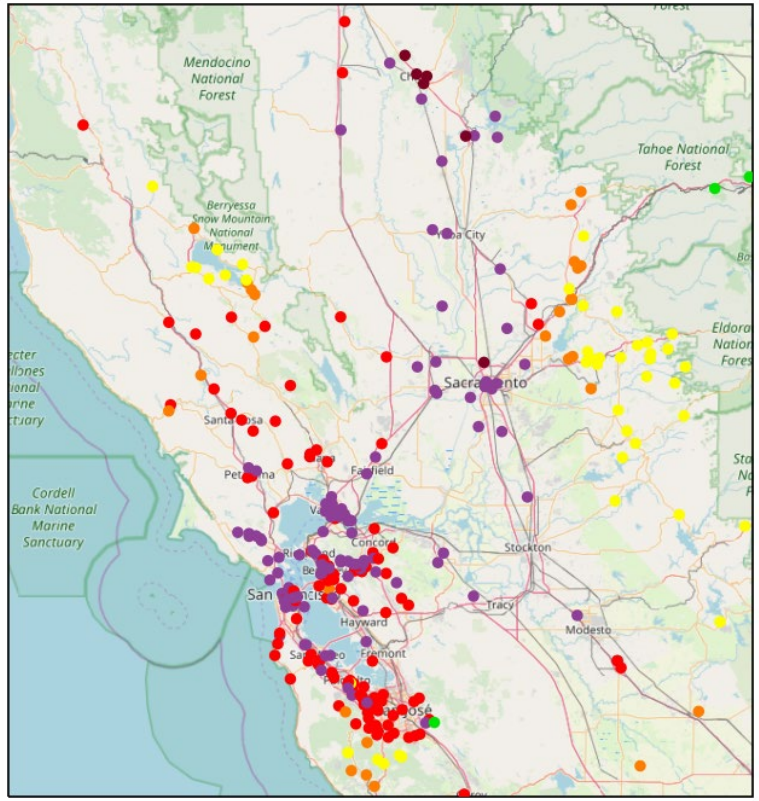


Smoke monitoring program

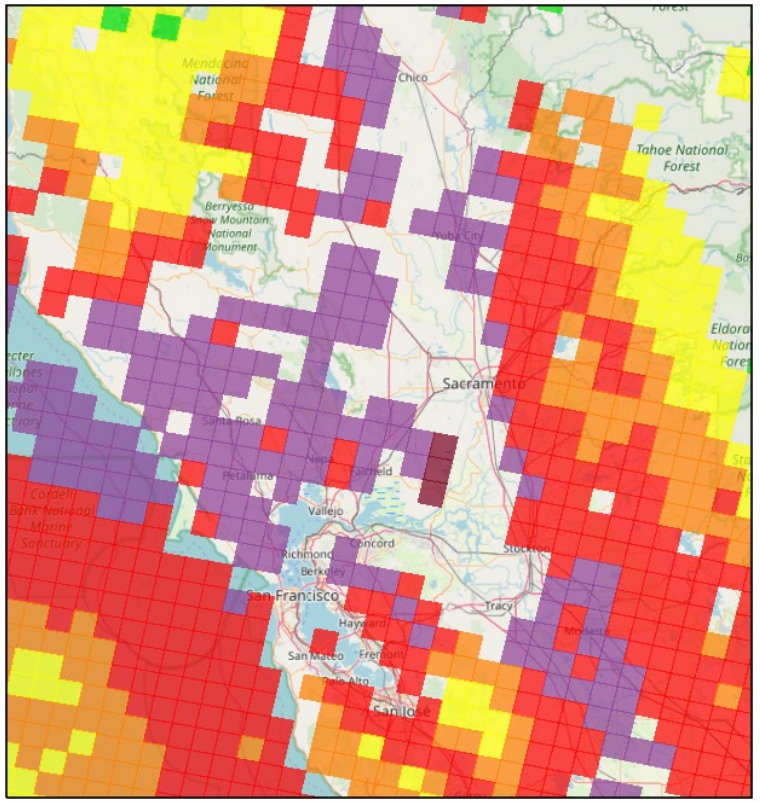
AQI, 16th November2018



Regulatory sites: Hourly averages



Sensors: Minute-to-minute



Satellite : Daily snapshot

Satellite measurements provide wider coverage but requires modeling and in-situ data to constrain the surface $PM_{2.5}$

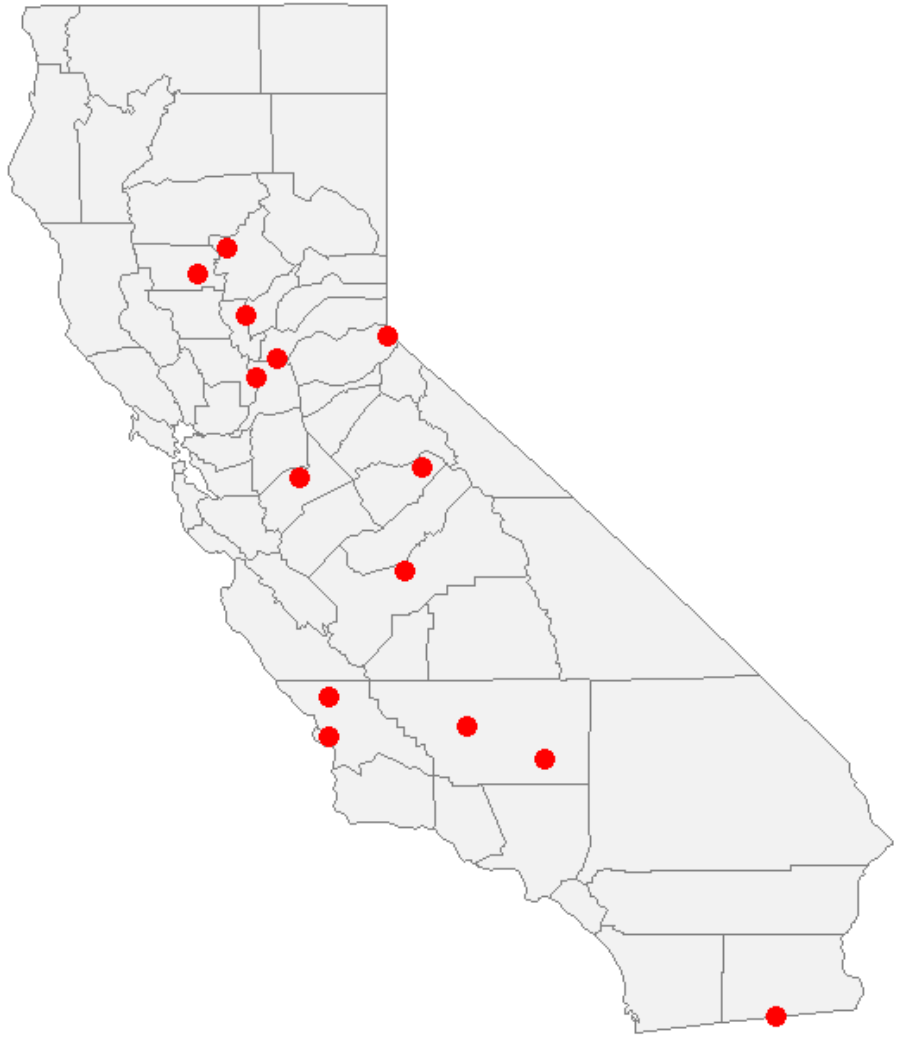
Can we leverage sensors for smoke monitoring?

Developing resources and tools

- Sensor performance evaluation
  - Field study
  - Chamber
- Sensor network adjustment protocol
  - Network modeling
- Data visualization
  - Dashboard examples

Field sensor evaluation

- Characterize environmental impacts on sensor performance
- 12 sites selected to represent various environments and range of conditions
    - Regional groups
    - Temperature/RH
    - Wind speed
    - $PM_{2.5}$ / PM_{10}
    - Aerosol type



Can we generalize our sensor adjustment to different environments?

Chamber sensor evaluation

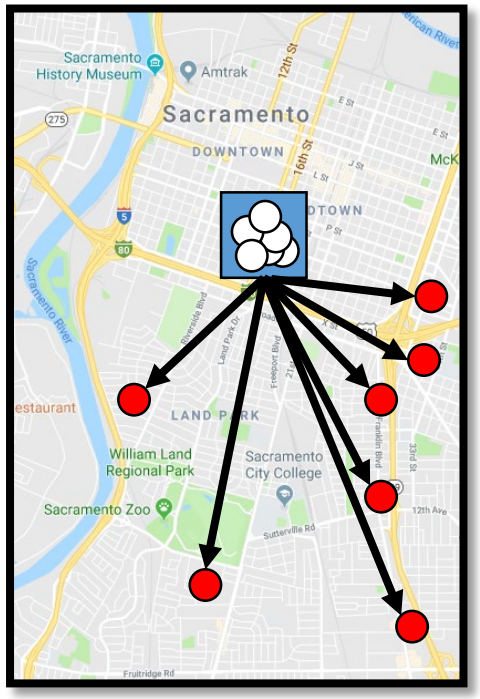
- Research-grade instrumentation
  - TSI Optical Particle Sizer
  - TSI Laser Aerosol Spectrometer
  - Ecophysics 855Y CLD –$NO/NO_2/NO_X$
  - Picarro Methane/H2S
  - Aeris Pico Mobile Spectrometer Methane/Ethane
  - Aethlabs MA300 BC
  - Licor 850 CO_2
  - Teledyne T640 PM
  - Teledyne T100 SO_2
  - Teledyne T200 $NO/NO_2/NO_X$
  - Teledyne T300 CO
  - Teledyne T400 Ozone
- Explore sensor degradation

Controlled environment for more detailed sensor performance characterization

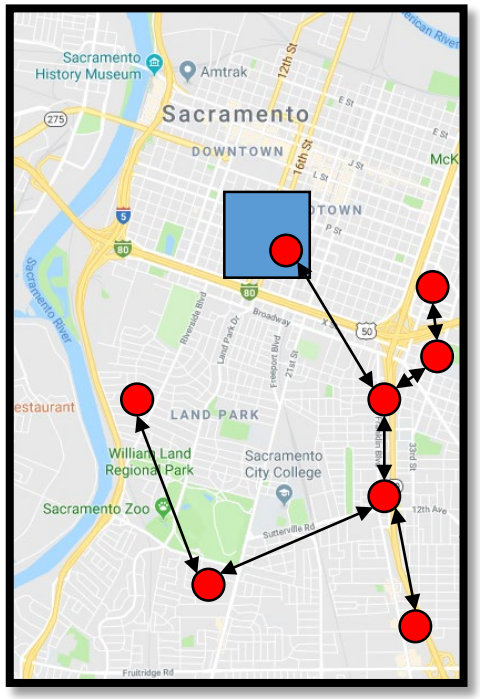
Sensor network quality

- Evaluating different network calibration methods
- Sensor-to-sensor “buddy-checking” to flag faulty sensors

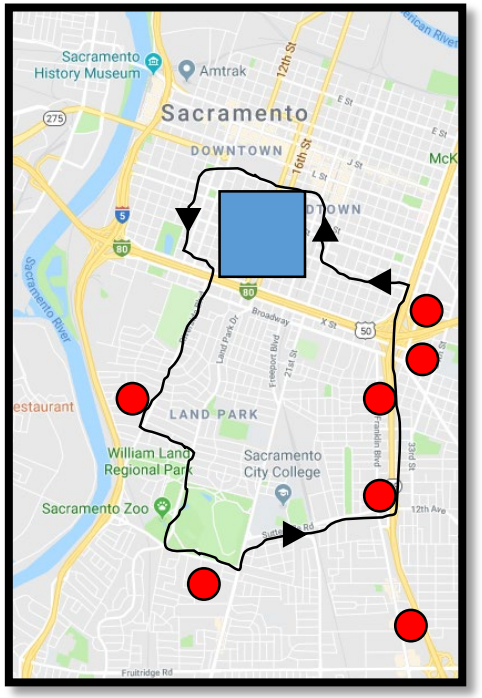
Colocation & dispatch



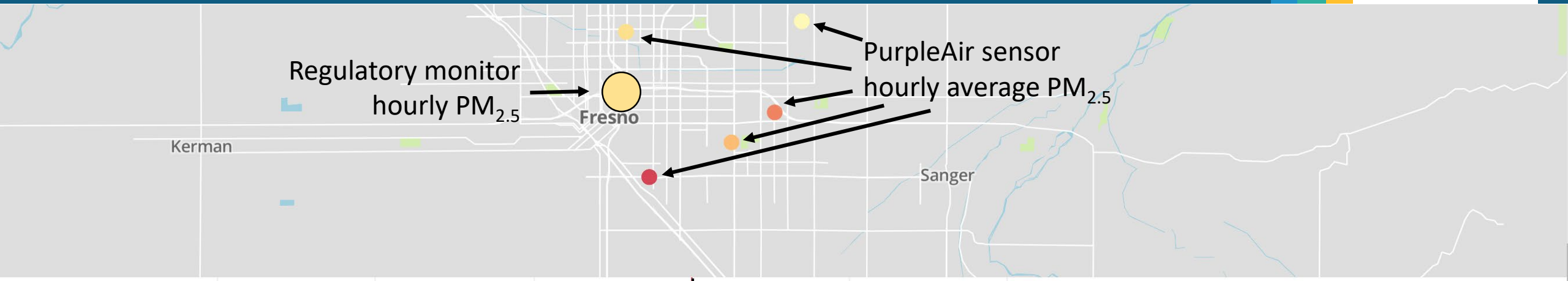
Colocation & propagate

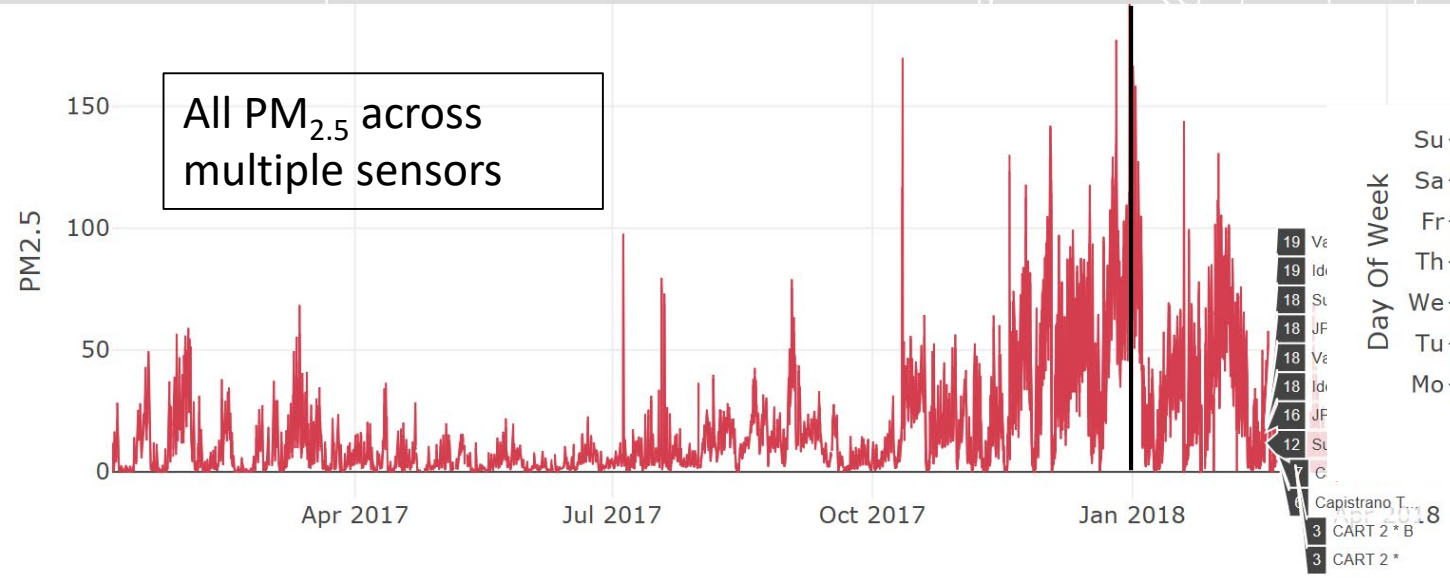


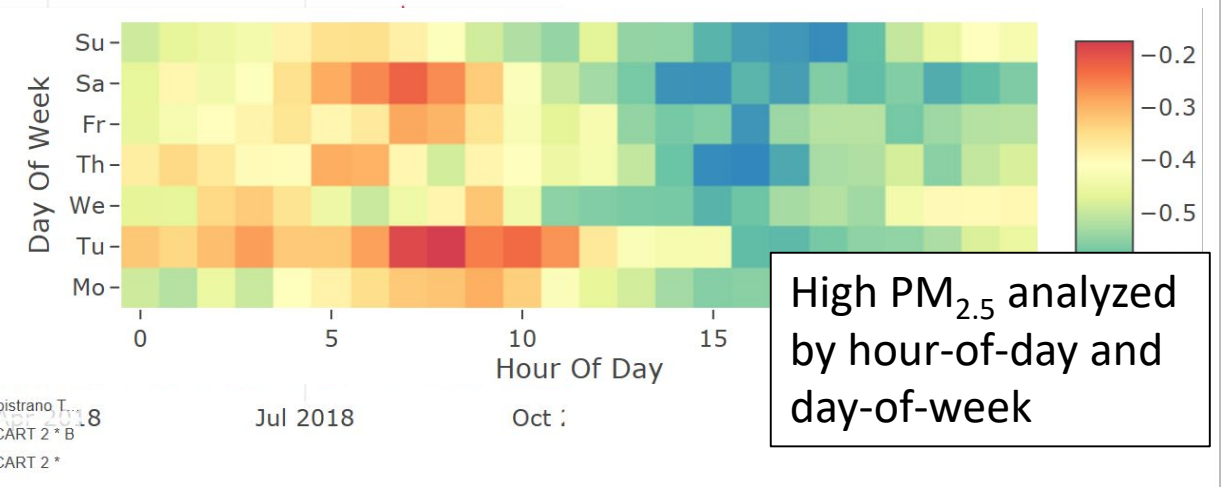
Mobile Colocation



Data visualization





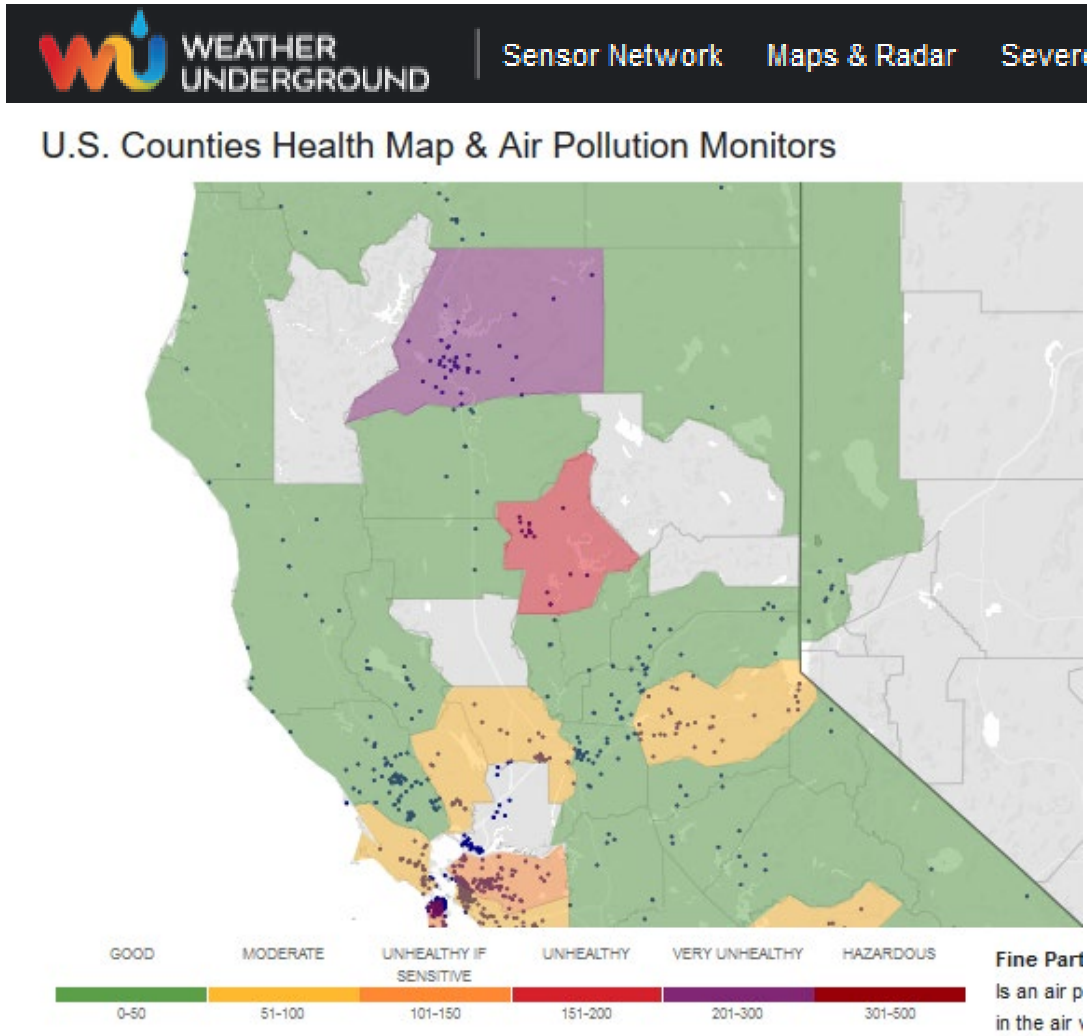


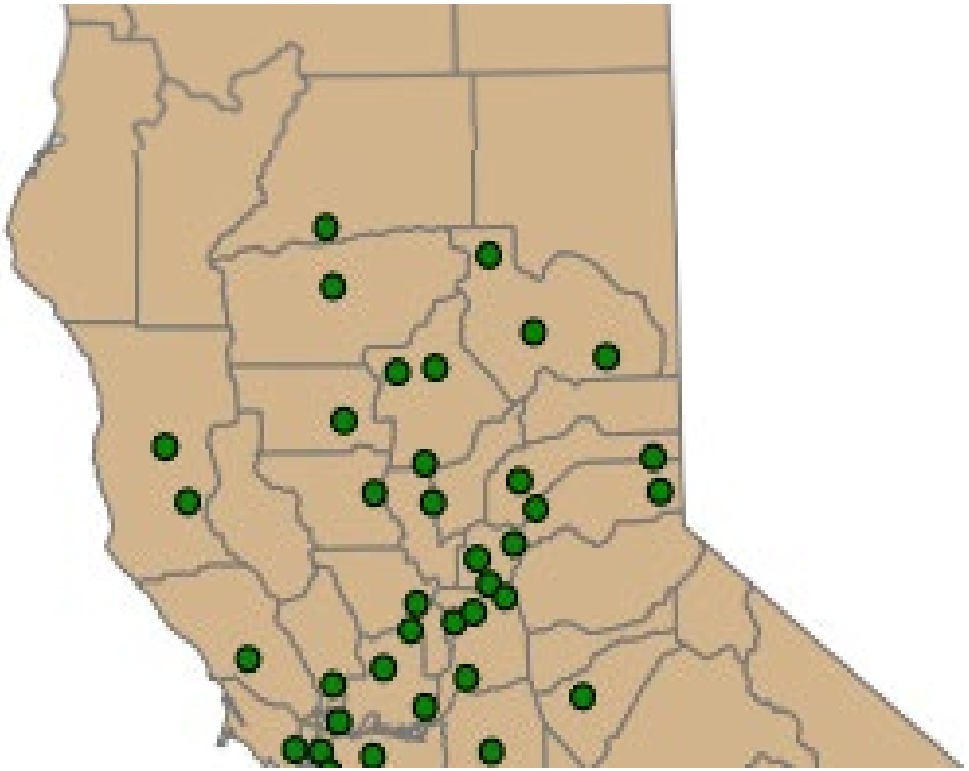
- Visualize the wealth of data
- Evaluate agreement with regulatory monitors
- Understand spatial and temporal variability
- Explore calibration methods

Summary

- Field and chamber evaluations help understand environmental impacts on sensor performance and product life
- Sensor networks can enhance spatial and temporal coverage once QA/QC'ed
- Analytical tools must keep up with new technologies
- Understanding performance improves messaging…

Data interpretation and messaging





Understanding sensor performance and appropriately visualizing information improves messaging

Backup