Integration of satellite observations with low-cost air quality monitors: A Citizen Science project

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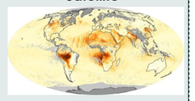
Scientific/Project Objectives

- ✓What is the relationship between the spatial/temporal variabilities of satellite-retrieved column aerosol optical depths (AOD) and surface fine particulate matter (PM2.5) concentrations?
- ✓Are low-cost sensors useful to generate reliable, good-quality, cost-effective ground-based data that can inform current (MODIS, VIIRS, GOES-R) and future (e.g., TEMPO, MAIA) NASA missions for monitoring surface PM and AQ?
- ✓Can we connect with and utilize citizen scientists? Access to data in real time, training and social media

Science and Technology

Satellite



Satellite data - Global spatial coverage, freely available, column metric

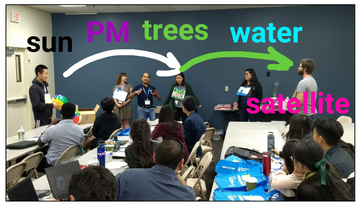
Surface/FRM/FEM

"Reference" methods - Point measurements, spatially sparse, expensive, "gold standard"

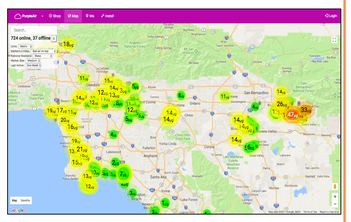
Surface/low-cost

"Low-cost Sensors" - Point measurements, relatively cheap, potential for broader spatial coverage, less accurate

Citizen Science Training



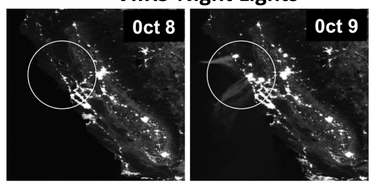
Citizen Science Network



Some Science Results

VIIRS-RGB

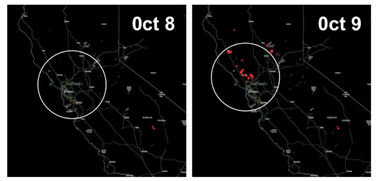
VIIRS-Night Lights



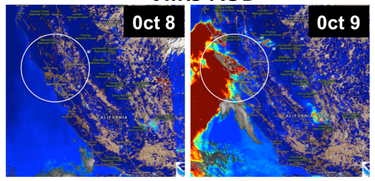
Satellite View of Fires in CA, October 2017

Satellites observe fires and emissions. Here we show imagery (Red/Green/Blue bands during daylight and DayNight Bands at night) along with retrievals of fires and aerosol optical depth (AOD) from the Visible Infrared Radiometer Suite (VIIRS) aboard the Suomi-NPP satellite.

VIIRS-Fire Detection



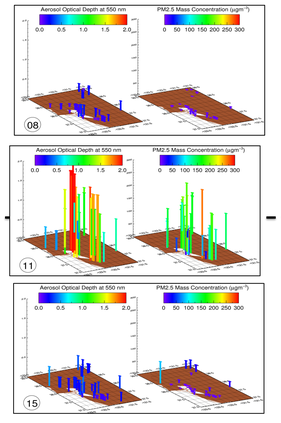
VIIRS-AOD



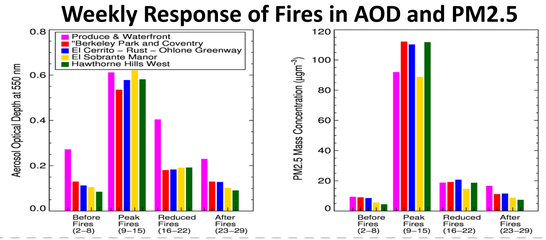
Satellite and Surface Measurements Respond to Change in Air Quality During Fires in CA (October 2017)

AODs were extracted over PurpleAir stations in the Bay Area. The three dimensional bar charts show retrieved AODs (left) and hourly mean $PM_{2.5}$ (right) on a day before the fire started (Oct 8), during the peak fires (Oct 11) and after the fires (Oct 15). There is spatial and temporal correlations to the variability,

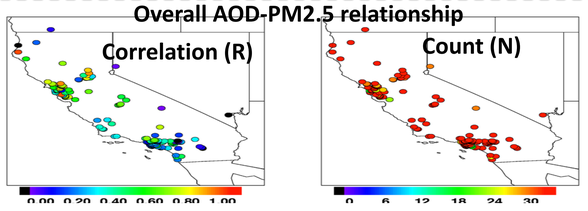
However, without other information, one cannot directly infer surface $PM_{2.5}$ from AOD.



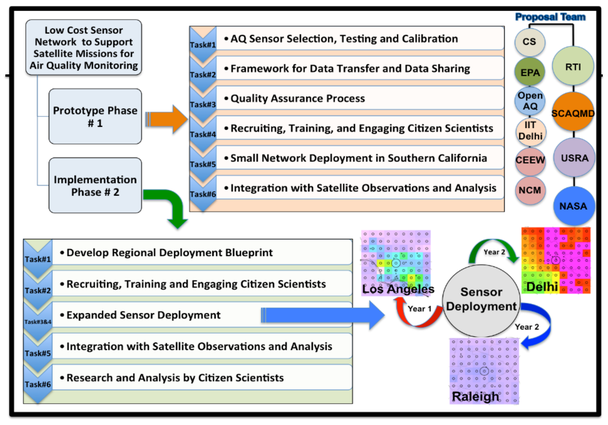
Weekly Response of Fires in AOD and PM2.5



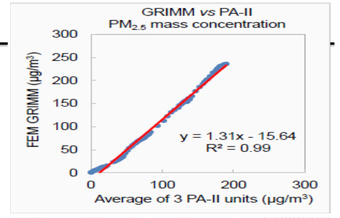
Overall AOD-PM2.5 relationship



Project Framework



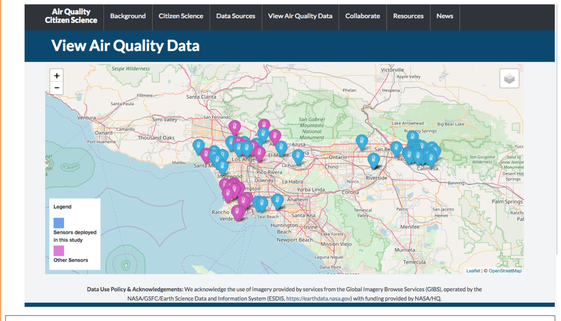
Phase 1: Sensor Testing



AQ-SPEC Air Quality Sensor Performance Evaluation Center

We tested different sensors in the laboratory (SCAQMD) and in the field against US EPA's FRM and FEM measurements. PurpleAir sensors were best in for accuracy and dynamic range, but still showed biases and uncertainties. Nonetheless, the ~$200 PurpleAir sensors were chosen for our project.

Phase 1: Initial Deployment



The Citizen Science Network has been initially set up in southern California (near LA) . https://aqcitizenscience.rti.org/

Phase 2: Expanding the Networks

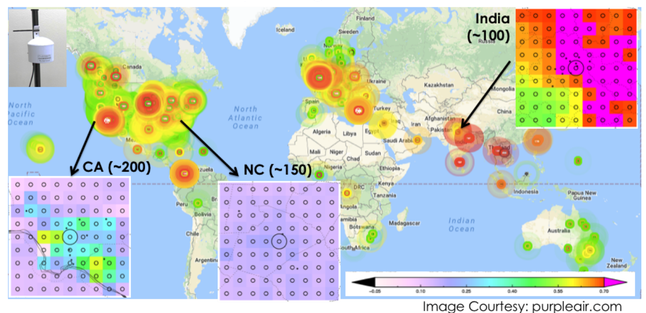
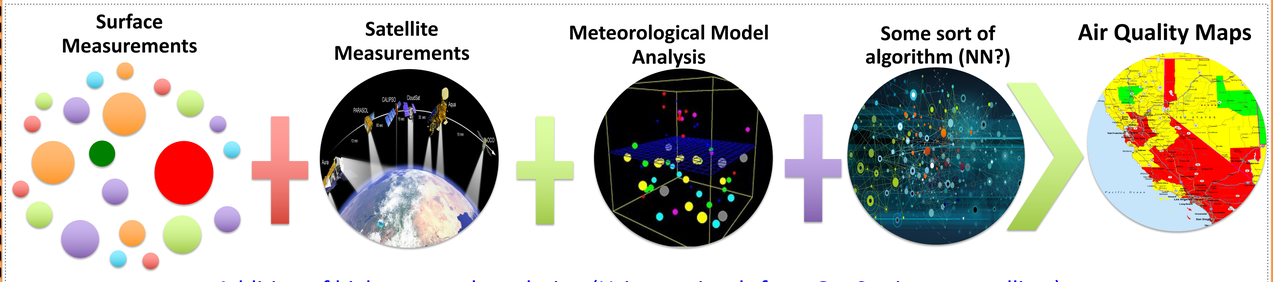


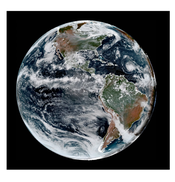
Image Courtesy: purpleair.com

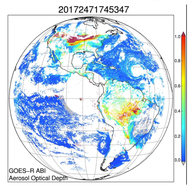
Over the next few years, we will be expanding the CitSci network to look at AQ in India (extreme pollution) and North Carolina (not usually extreme)

Satellite, Surface and Model Data Integration to map Air Quality



Addition of high temporal resolution (Using retrievals from GeoStationary satellites)





Since the advent of this project in 2017, NOAA's GOES-16 satellite has become operational. The current Advanced Imagers on GOES-16, GOES-17, Himwari-8 (Japan), GEO-KOMPSAT (Korea), are future sensors in Geostationary (GEO) orbit provide temporal resolution to the once or twice daily observations from sensors in Low Earth Orbit (LEO). Retrieval on the left is from Sep 7, 2017, highlighting biomass burning events in British Columbia (Canada) and Brazil.