Air Quality and Health Burden of 2017 Northern California Wildfires

Susan O'Neill, Minghui Diao

NASA HAQAST Tiger Team Update

1/3/2019, Phoenix, Arizona

Co-Authors: 67 HAQAST Members, Stakeholders, Contributors

HAQAST MEMBERS: Susan O'Neill (USDA Forest Service), Daniel Tong (George Mason University), Talat Odman (Georgia Tech), Minghui Diao (San Jose State University - SJSU), Jason West (University of North Carolina), Mark Zondlo (Princeton), Pat Kinney (Boston University), Brad Pierce (NOAA), Jessica Neu (NASA JPL), Mohammad Al-Hamdan (USRA), Akula Venkatram (UC Riverside), Sim Larkin (USDA Forest Service), Arlene Fiore (Columbia University), Daven Henze (University of Colorado), Tracey Holloway (University of Wisconsin).

STAKEHOLDERS: Saffet Tanrikulu (Bay Area Air Quality Management District - BAAQMD), Stephen Reid (BAAQMD), Jeff McQueen (NOAA), Pete Lahm (USDA Forest Service Fire & Aviation Management, Program Lead – Wildland Fire Air Quality Response Program), Trent Proctor (USDA Forest Service Air Program Lead, Region 5 – CA), Susan Stone (EPA, Office of Air Quality Planning and Standards (AQI Lead)), Ana Rappold (EPA, National Health and Environmental Effects Research Lab), Tesh Rao (EPA, Office of Air Quality Planning and Standards, National Emission Inventory Lead), Scott Bohning (EPA Region 9 Wildfire Smoke Team), Kathleen Stewart (EPA Region 9 Wildfire Smoke Team), Lauren Maghran (EPA Region 9 Wildfire Smoke Team), ShihMing Huang (Sonoma Technology Inc.), Mark Fitch (National Park Service, National Smoke Specialist), Ambarish Vaidyanathan (CDC), Cynthia Garcia (CARB), Dharshani Pearson (California EPA), Ho-Chun Huang (NOAA), Irva Hertz-Picciotto (UC Davis), Jeff Vukovich (EPA), Joe Wilkins (EPA), Kathleen Stewart (EPA R9), Kirk Baker (EPA), Lauren Maghran (EPA R9), Megan Bela (NOAA), Rachel Broadwin (California EPA), Ravan Ahmadov (NOAA), Rebecca J Schmidt (UC Davis), Stuart McKeen (NOAA), Thien Khoi Nguyen (EPA), Zheng Li (Clark County Air Quality), Paul English (CDPH), Jeff Wagner (CDPH), Bob Chatfield (NASA), Meytar Sorek Hamer (NASA), Sumi Hoshiko (CDPH), Leticia Nogueira (American Cancer Society), Centers for Disease Control and Prevention (CDC)

CONTRIBUTORS: Leland Tarnay (USDA Forest Service Region 5 Remote Sensing Lab – CA), Yasmeen Sands (USDA Forest Service, PNW Research Station Public Affairs Specialist), Rupa Basu (California EPA, Office of Environmental Health Hazard Assessment), Yufei Zou (University of Washington), Sean Raffuse (University of California, Davis), Pawan Gupta (NASA, ARSET), Ernesto Alvarado (University of Washington), Daegan Miller (University of Wisconsin), Elena Becerril (University of Washington), Emily Saunders (NASA), Gina Wing (USDA Forest Service), Greg Osterman (NASA JPL), Maggie McCallister (Princeton), Marlin Martinez (University of Washington), Rui Wang (Princeton), Stephanie Cleland (UNC)

34 Agencies and Universities

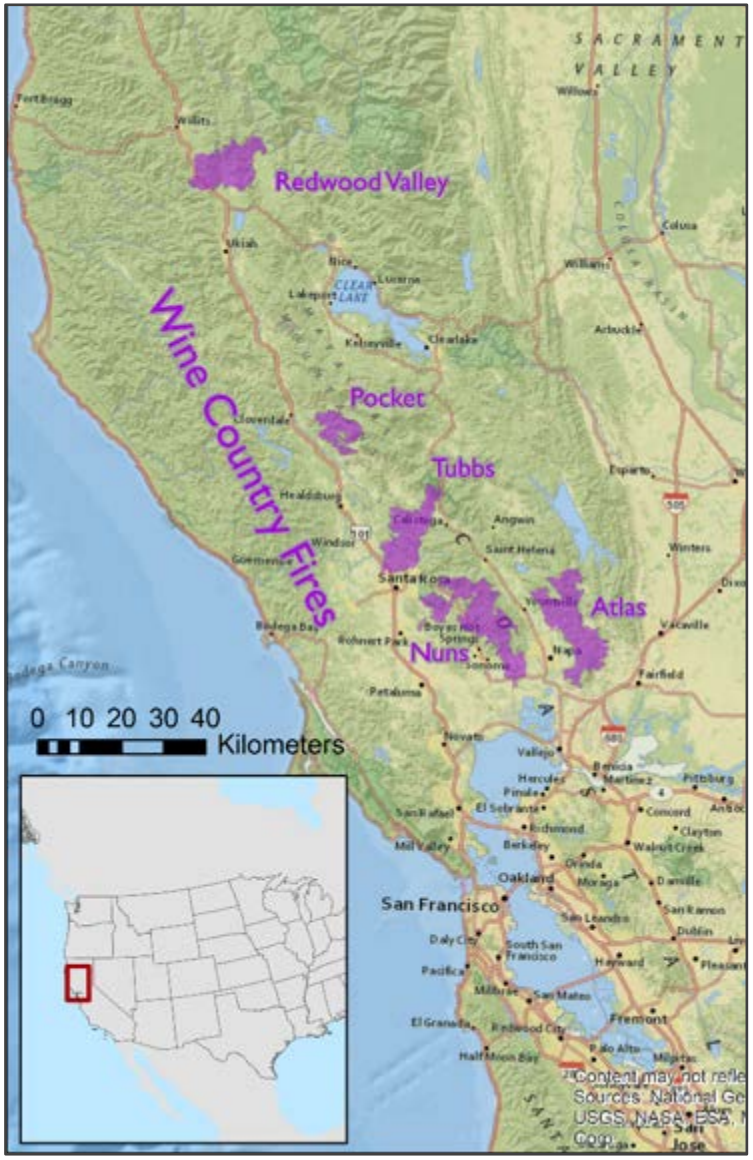
- George Mason University
- San Jose State University
- Georgia Tech
- Princeton
- Columbia University
- University of California, Riverside
- University of California, Davis
- University of Colorado
- University of North Carolina
- Boston University
- University of Wisconsin
- University of Washington
- NOAA National Weather Service
- NOAA Earth Systems Research Lab
- EPA Office of Air Quality Planning and Standards
- EPA Office of Research and Development
- EPA National Health and Environmental Effects Research Lab
- EPA Region 9
- Bay Area Air Quality Control District
- Center for Disease Control
- California Air Resources Board
- California EPA
- Clark County Air Quality
- California Department of Public Health
- American Cancer Society
- NASA Jet Propulsion Lab
- NASA ARSET
- NASA Ames Research Center
- NASA Marshall Space Flight Center
- USDA Forest Service PNW Research Station
- USDA Forest Service Fire & Aviation Management
- USDA Forest Service Region 5
- USDA Forest Service Remote Sensing Lab
- US DOI National Park Service

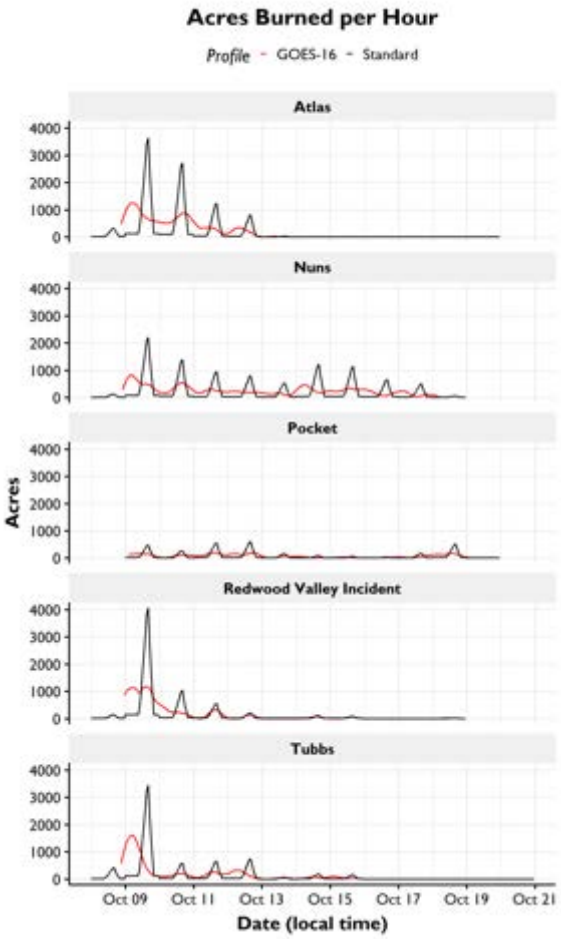
About the Project

- Major Components
  - Fire Emission Inventory (MODIS, VIIRS, GOES-16)
  - Air Quality Modeling (WRF/CMAQ/Dispersion)
  - Satellite Observations to Improve and Evaluate Model Predictions (AOD, CO, NH3)
  - Health Impact Analysis
- Project Organization – Seven sub-teams with Leads
  - Fire Emission Inventory & Modeling – Susan O'Neill (USDA FS)
  - Dispersion and Plume Rise – Joe Wilkins (EPA)
  - Satellite and Data Fusion – Mohammad Al-Hamdan (USRA)
  - Health Impacts – Jason West (UNC), Pat Kinney (Boston University)
- Communications
  - Monthly Stakeholder Calls
  - Sub-team calls more often
  - Google Docs, data storage, Webpage

Wildfires ignited Oct 8, 2017 resulted in approximately 7 million people across Northern California exposed to unhealthy and worse air quality conditions for a 9-day period.

Sub-team 1: Fire Emissions



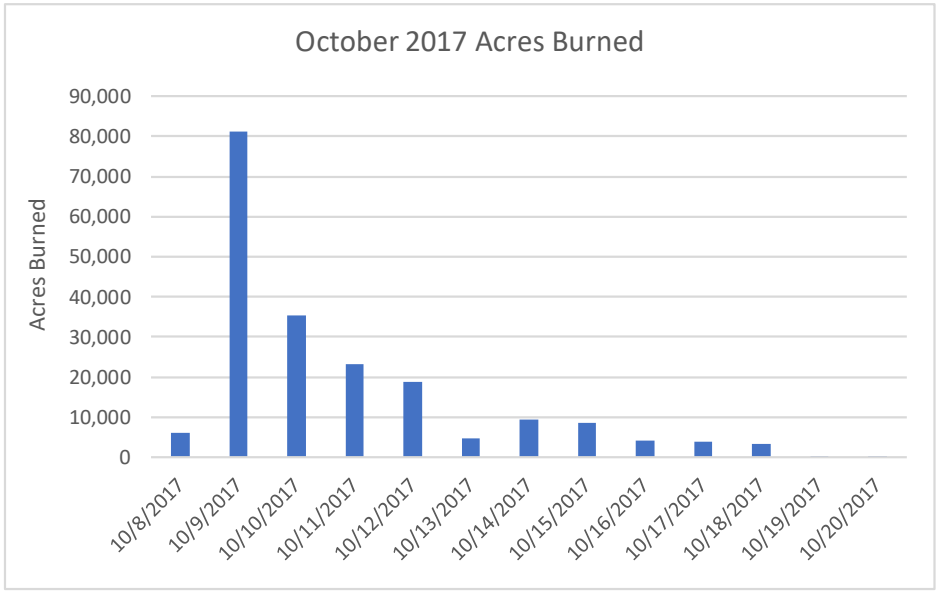


1) GOES-16 Based Time Profile
   - Allocate counts of GOES-16 five minute pixel detections within 2-km of each fire perimeter (from GeoMAC)
   - Aggregate by hour by fire
   - Apply loess smoothing
   - Assign resulting hourly fractional count to total area acquired from CalFire
2) Fire Emissions – BlueSky: Use the custom GOES-16 time profiles in the BlueSky Smoke Modeling Framework to calculate hourly fire emissions.

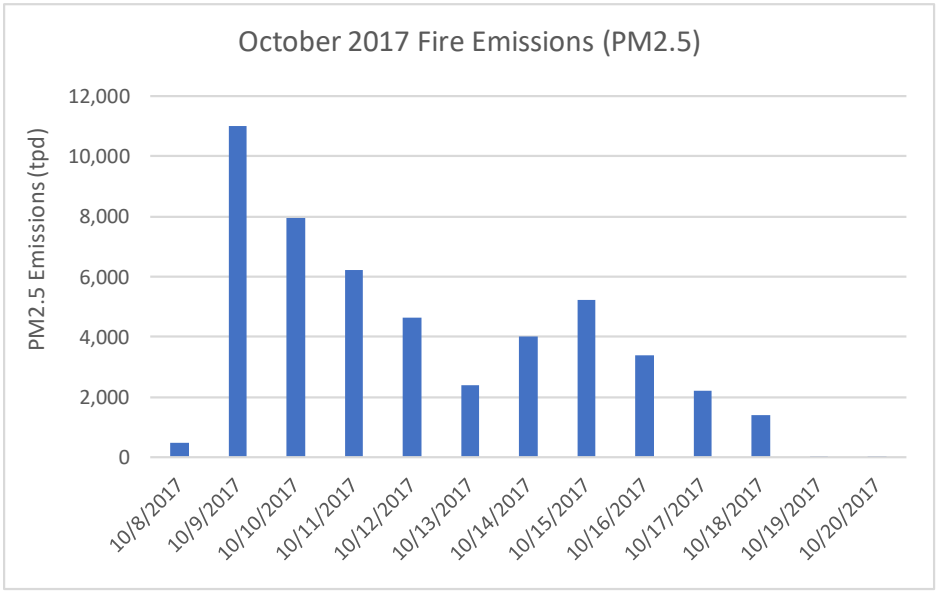
HAQAST Contributor: Sean Raffuse, UC Davis
HAQAST Member: Susan O'Neill, USDA Forest Service

Sub-team 1: Fire Emissions

Daily Acres Burned and PM2.5 Emissions



198,867 acres burned for the 5 major Northern CA fires

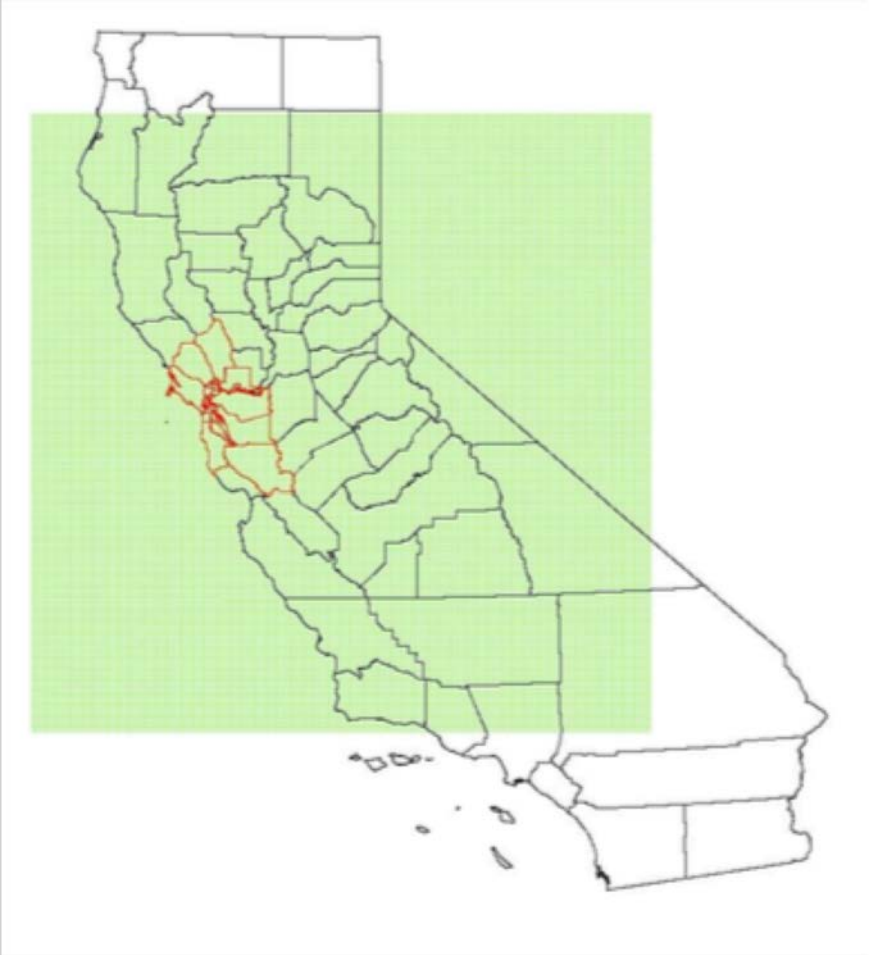


48,938 tons of PM2.5 emissions

HAQAST Contributor: Sean Raffuse, UC Davis
HAQAST Member: Susan O'Neill, USDA Forest Service
HAQAST Stakeholder/Contributor: BAAQCD

Sub-team 1: Fire emission modeling CMAQ Air Quality Modeling

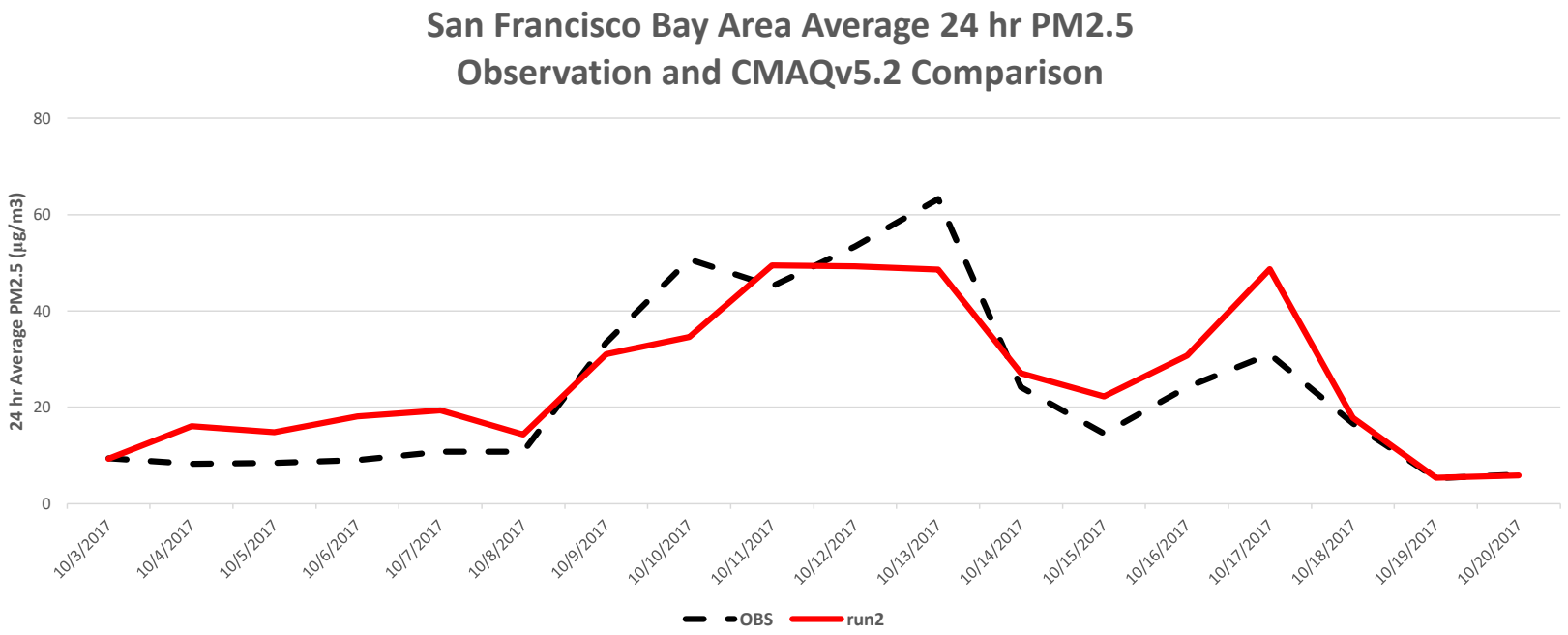
- Fire emissions processed through SMOKE and combined with existing anthropogenic emissions estimates for 2016
- WRF and CMAQ run for a 4-km resolution modeling domain



HAQAST Stakeholder/Contributor: Bay Area Air Quality Control District

CMAQ Air Quality Modeling Results

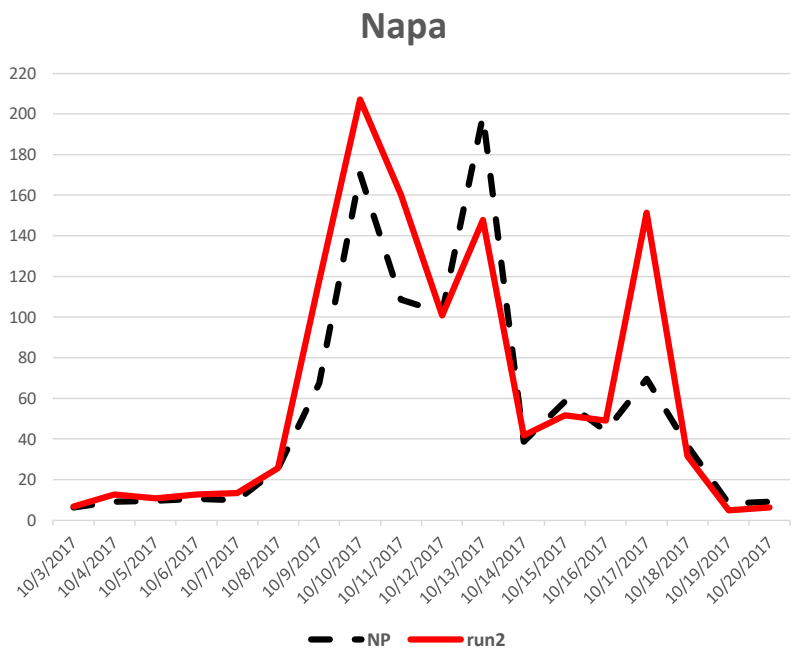
Daily Average PM2.5 for 16 Bay Area Sites

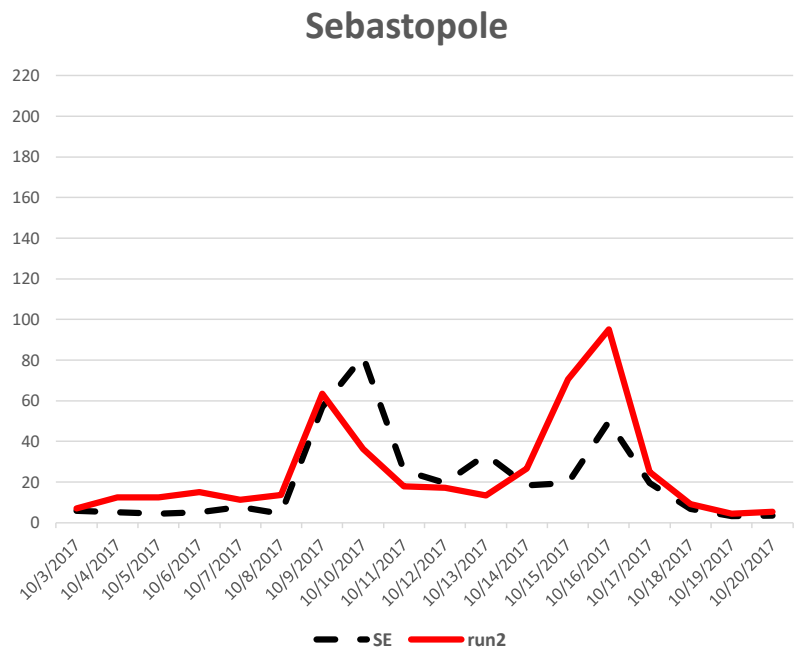


HAQAST Stakeholder/Contributor: Bay Area Air Quality Control District

CMAQ Air Quality Modeling Results

CMAQ and observed 24-hour PM2.5 at representative sites.





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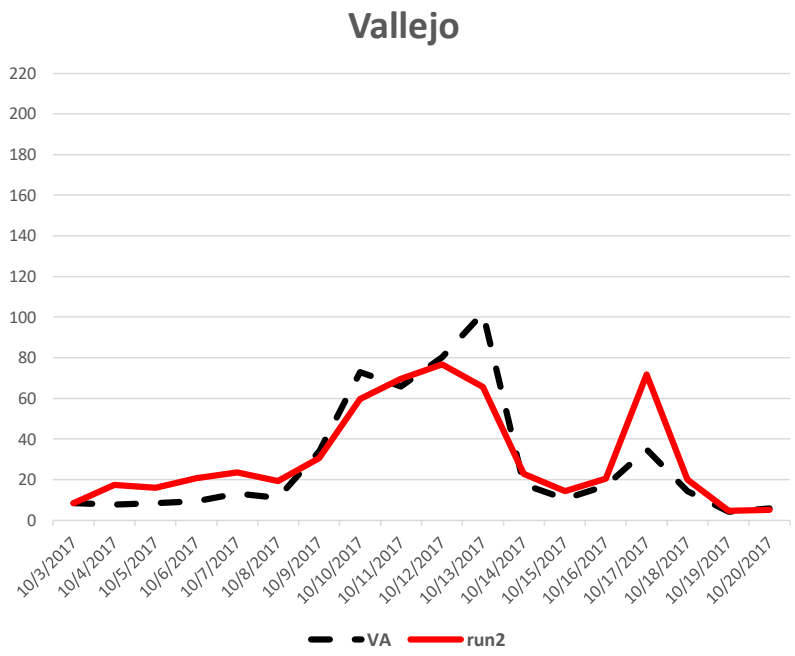
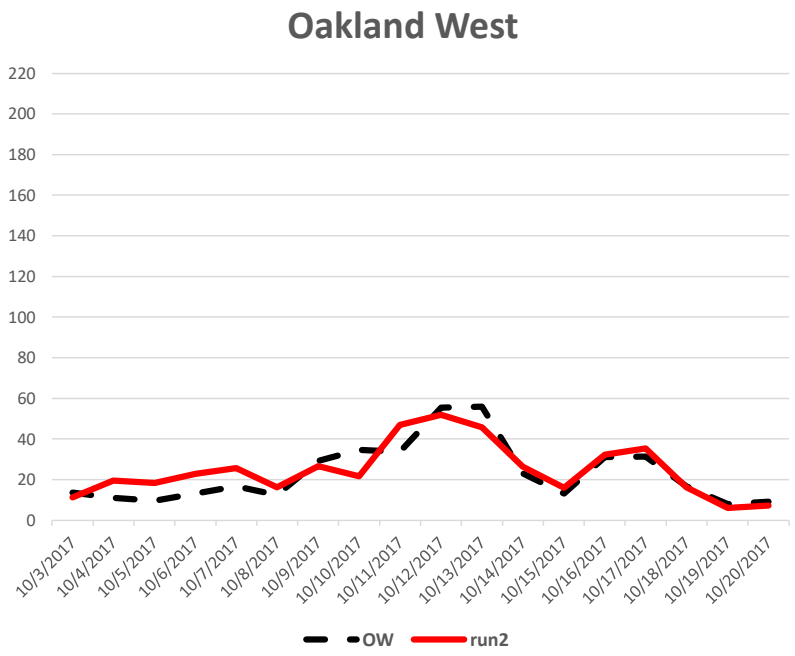
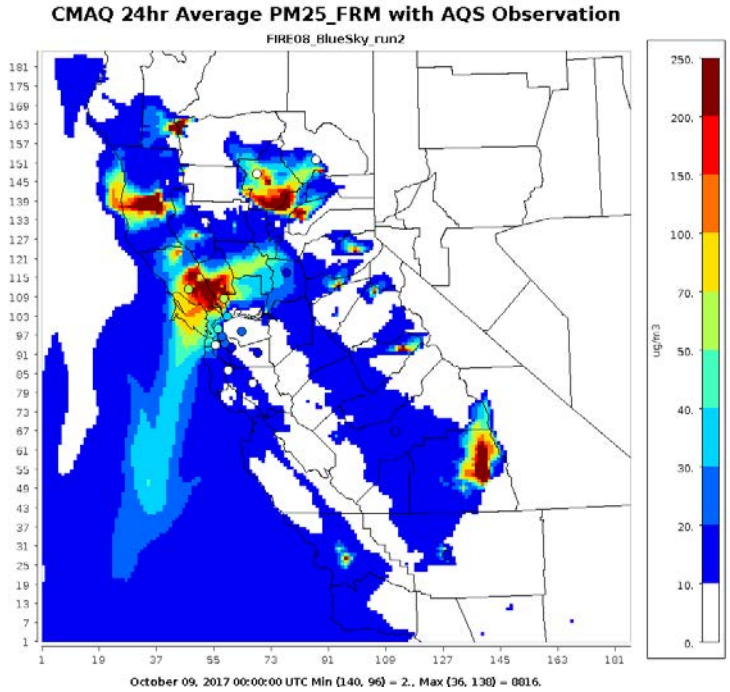




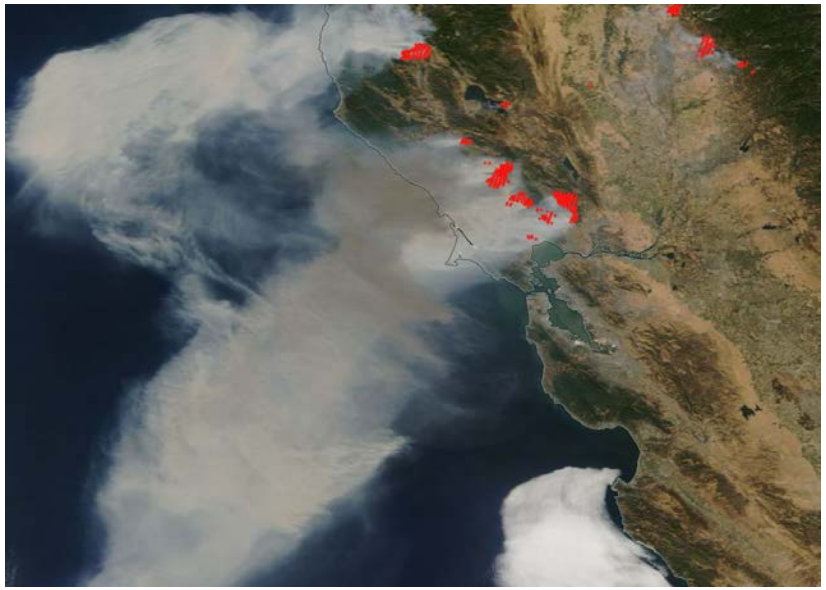
HAQAST Stakeholder/Contributor: Bay Area Air Quality Control District

CMAQ Air Quality Modeling Results

October 9, 2017



CMAQ 24 hr average FRM_PM2.5 overlaid with AQS observations

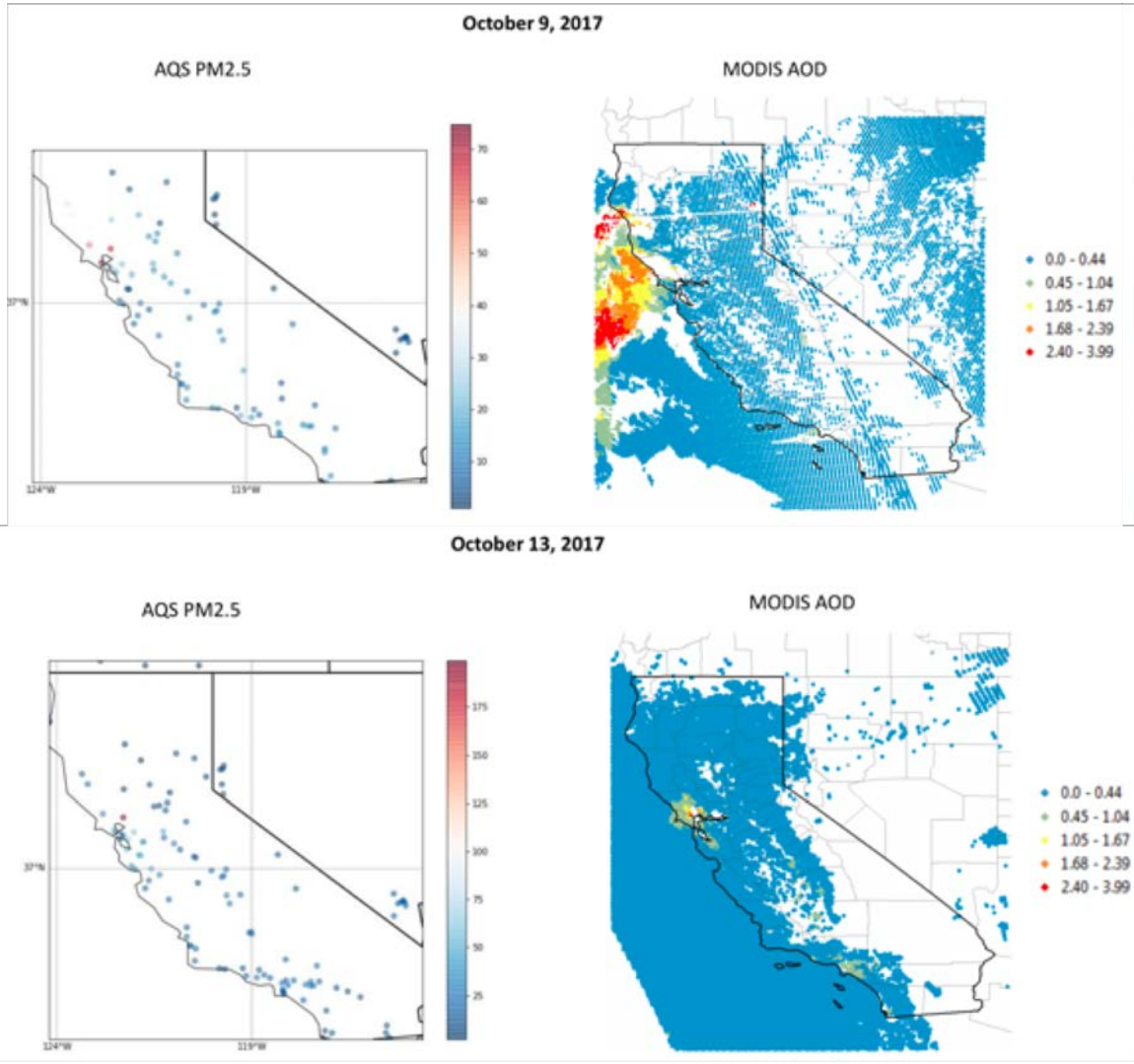


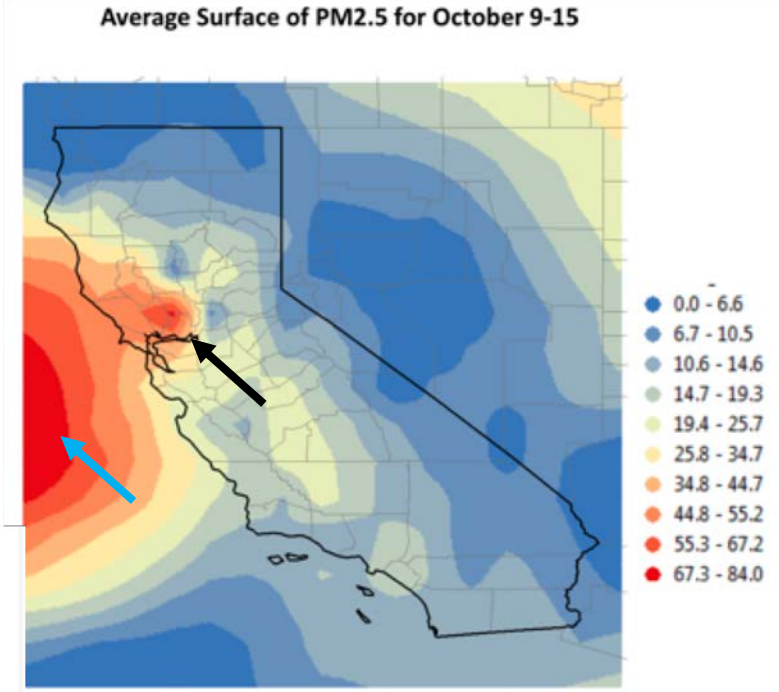
Satellite imagery from Worldview

HAQAST Stakeholder/Contributor: Bay Area Air Quality Control District

Slide Prepared by:
Dr. Mohammad Al-Hamdan
USRA at NASA/MSFC
mohammad.alhamdan@nasa.gov

Sub-team 2: Satellite and data fusion MODIS AOD and Surface PM2.5

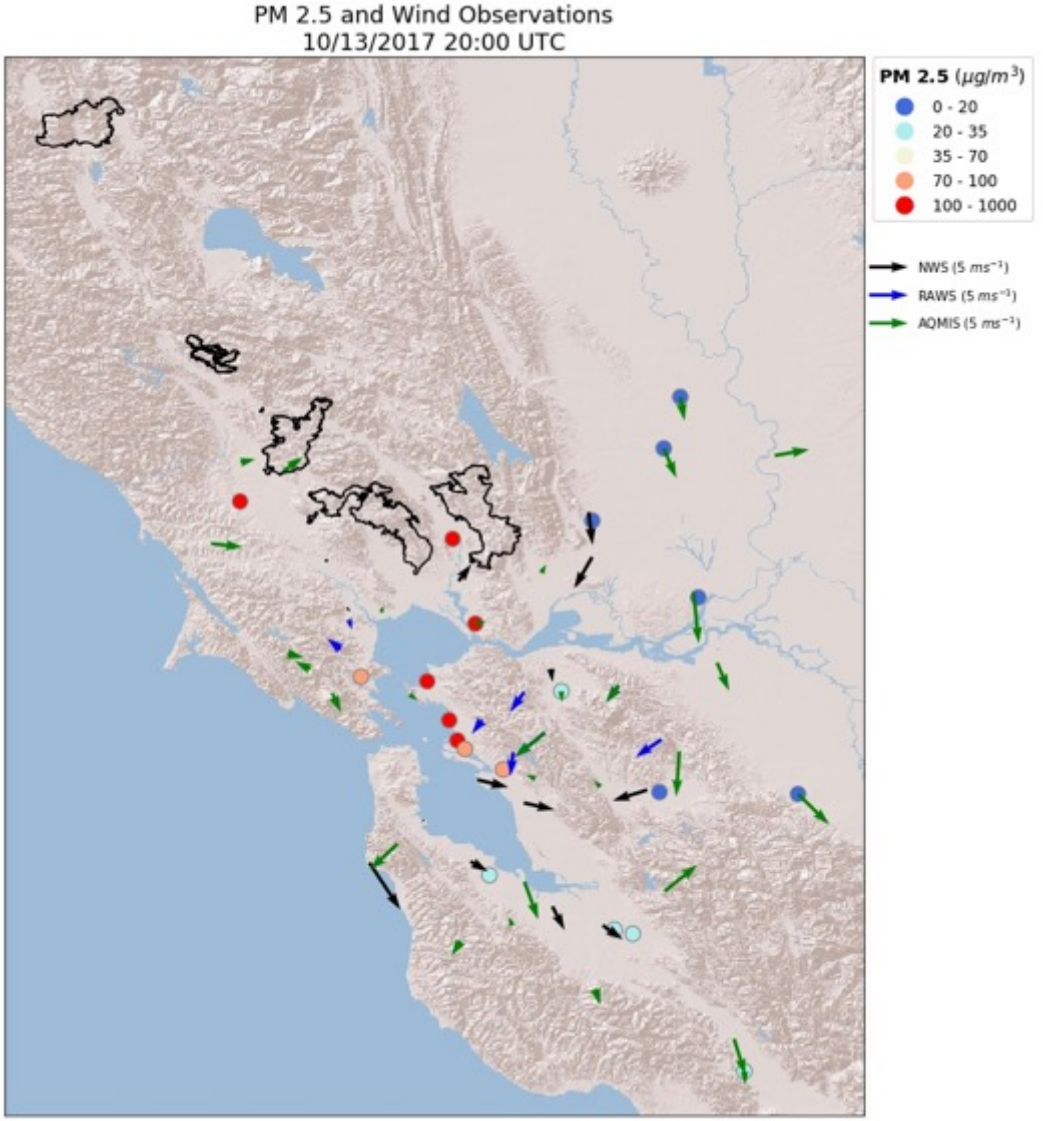




- MODIS AOD data can be used to identify high PM2.5 surface concentrations from the wildfire event
- Issues over the ocean are due to B-spline smoothing algorithm, and next step will examine other smoothing algorithms

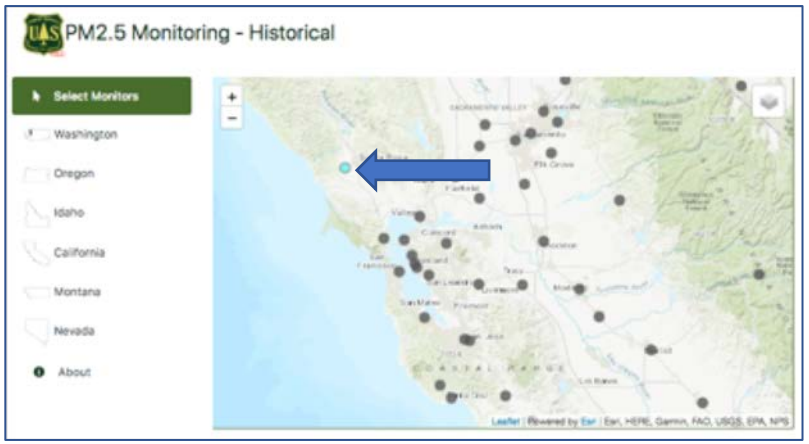
Sub-team 3: Meteorological Analysis & High Resolution Dispersion Modeling

- Complex Terrain
- HRRR 3-km wind field
- Using hourly maps, the measured PM2.5 Concentration field (hour-by-hour) follows well with the 10-meter flow pattern
- In this figure of Oct 13 2017, high concentrations are associated with weak winds, indicating that smoke may remain in the area for a few days after being blown into those areas from fires.



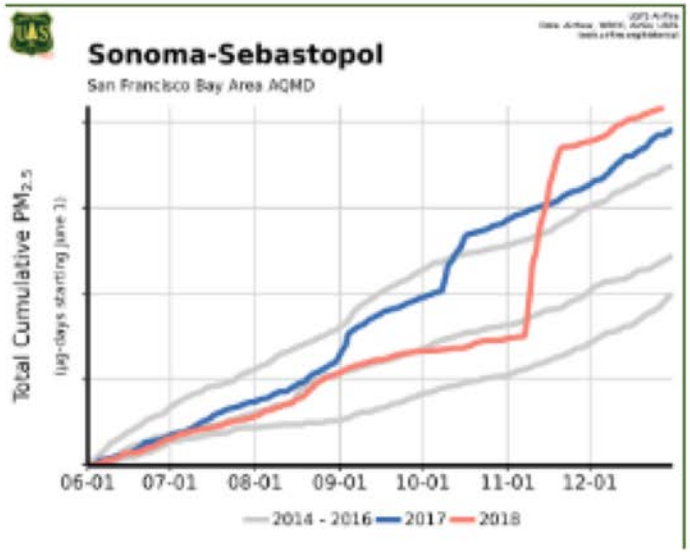
HAQAST Member: Frank Freedman, SJSU

PM2.5 Monitoring Data – Historical Tool

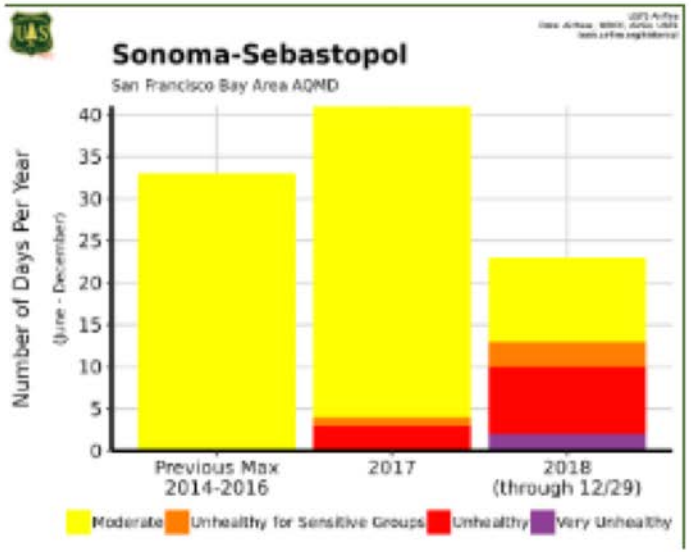


- Stakeholder Request: California EPA and others
  - How does 2017 compare to other years?
  - How do PM2.5 concentrations vary with location?
- Cumulative PM2.5 per year
  - Blue = 2017
  - Red = 2018
  - Gray = 2005-2016 (depending on data availability)
- Number of Days in AQI Category
- **Interactive Tool**: https://tools.airfire.org/historical/
- In-depth analysis for northern California: https://haze.airfire.org/bluesky-daily/output/temp_susan/HAQAST/ObservationalDataAnalysis/

Cumulative PM2.5:

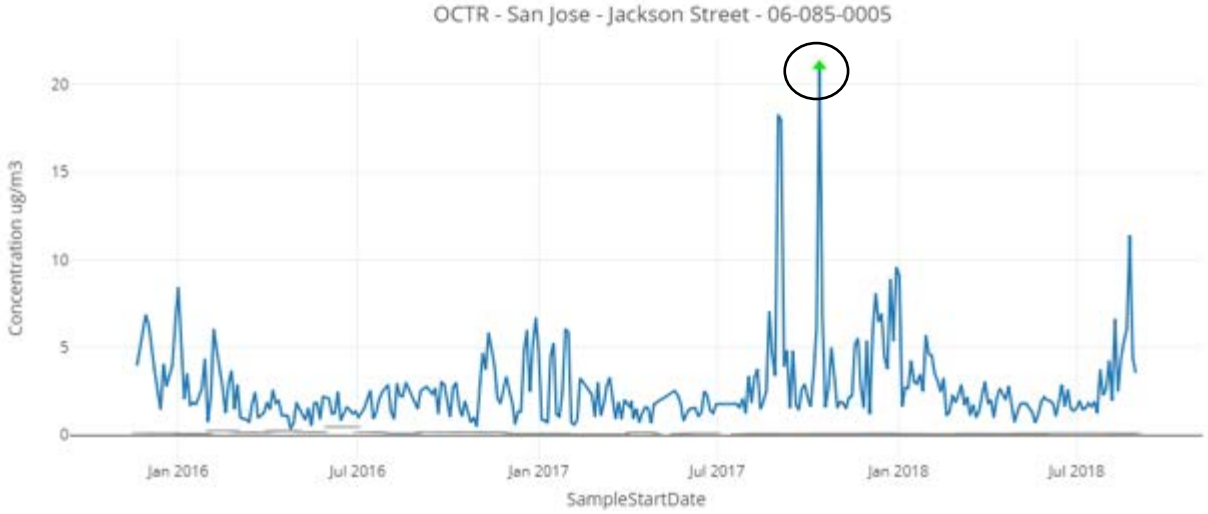


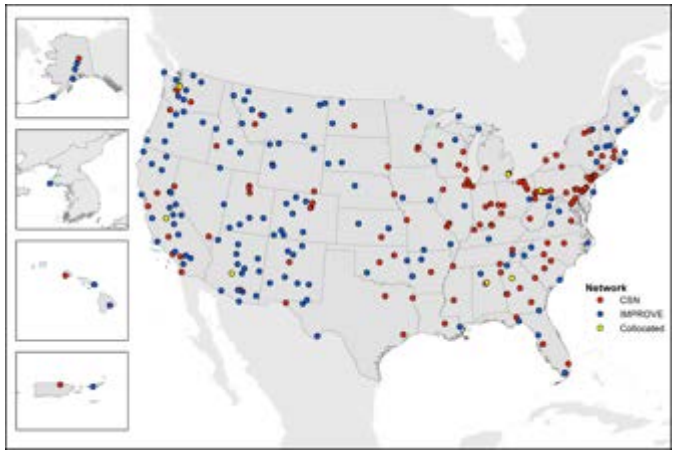
Days with PM2.5 in each AQI Category:

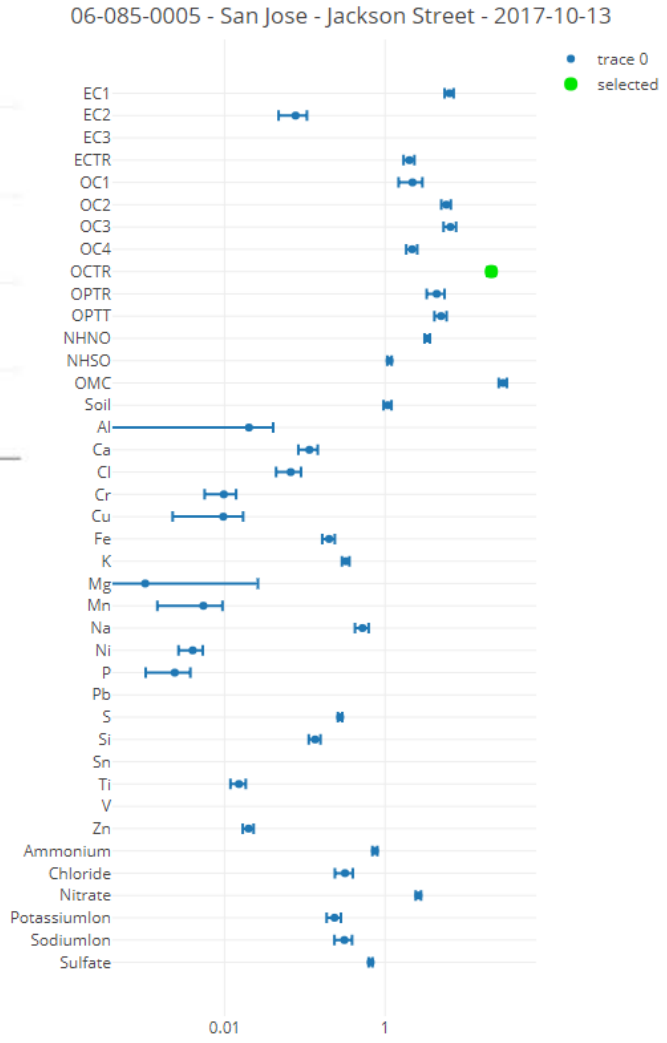


HAQAST Member: USDA Forest Service, AirFire Team

IMPROVE/Chemical Speciation Network (CSN): San Jose, California 1/2016 – 9/2018, Peak 10/13/2017





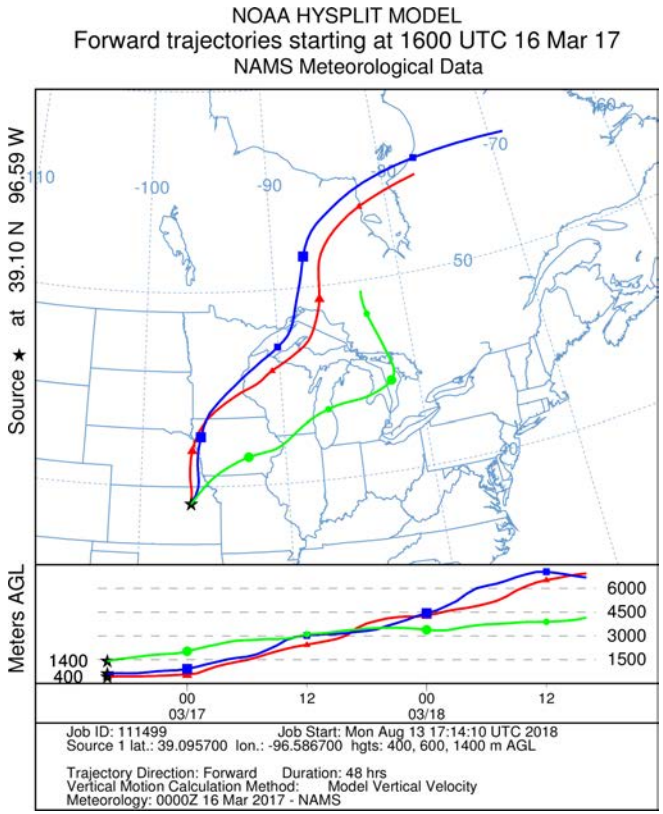


HAQAST Contributor: UC Davis

Sub-team 4: Plume Rise

- Plume Rise sub-team
- Lead: Joe Wilkins, EPA
- Opportunity to bring together multiple remotely-sensed and modeled datasets
  - CATS, CALIOP, MAIAC, MISR, FRP
  - Briggs, Sofiev, Frietas
- See Joe Wilkins talk (this session)

Example Flint Hills 16 March 2017 boundary layer height importance

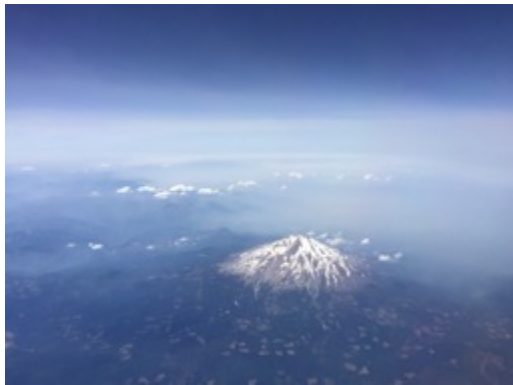


Above PBL – Green
Below PBL – Red & Blue

NOTE: Model run and figure generated using on-line NOAA Air Resources Laboratory HYSPLIT model (Rolph, 2003).

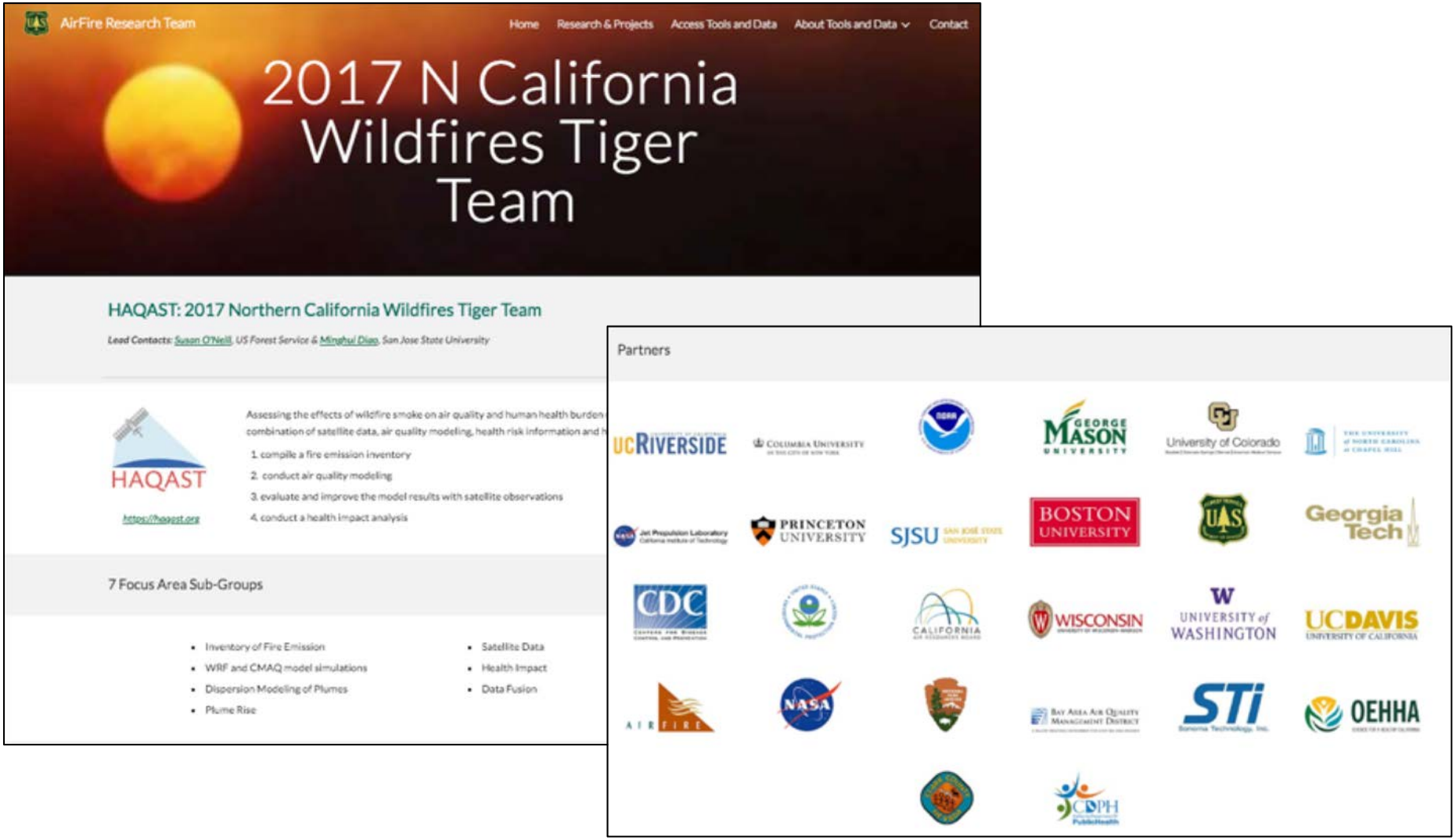
Sub-team 5: Health Impacts

- Stakeholder Communication & Outreach
  - California EPA
  - American Cancer Society
  - California Department of Public Health
  - EPA, National Health and Environmental Effects Research Lab
  - UC Davis, School of Medicine
- Hospital health records – California EPA



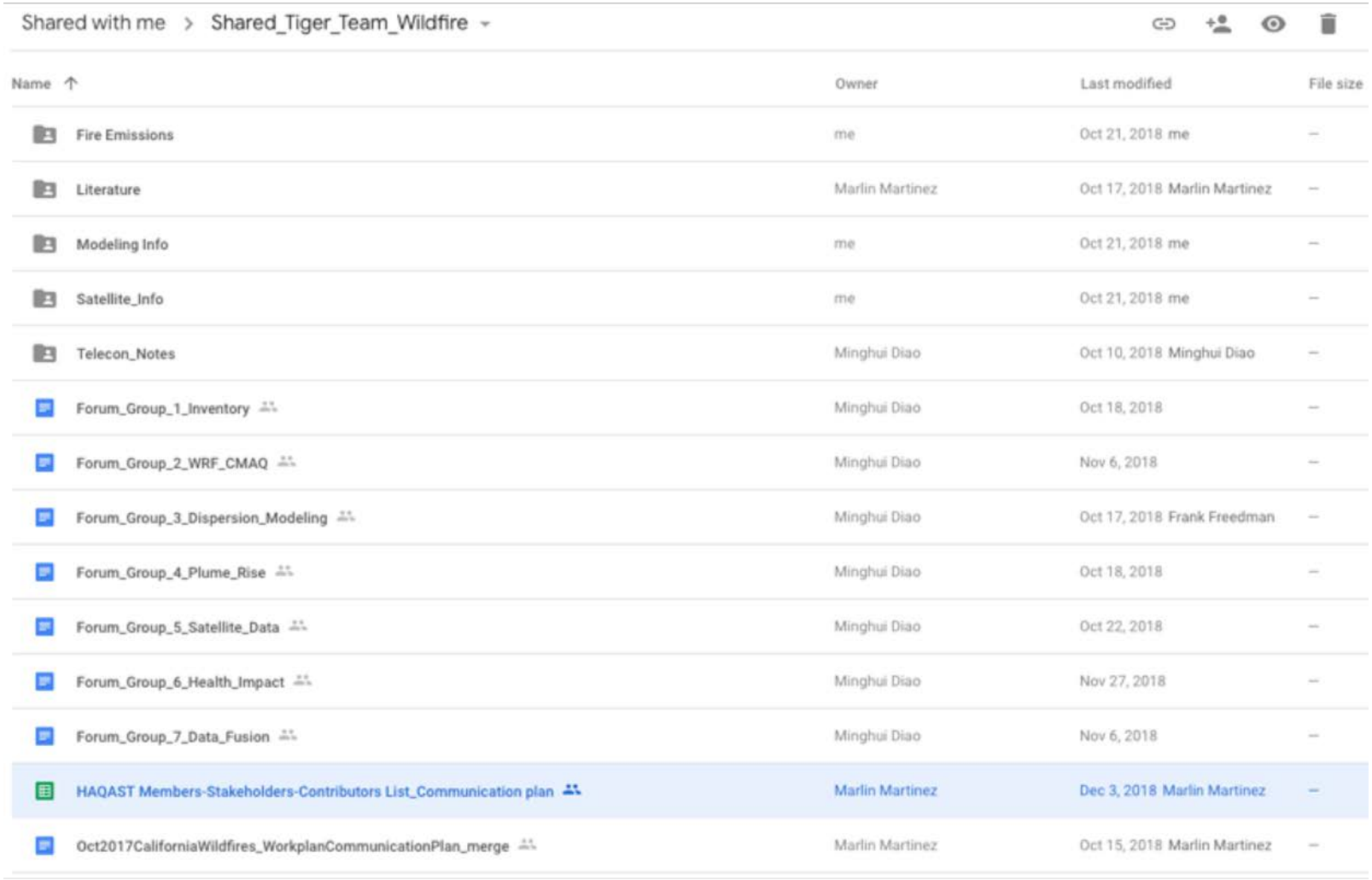
Photos: Kat Navarro, Rob Elleman, Janice Peterson

Communications – Project Website



https://sites.google.com/firenet.gov/wfaqrp-airfire/projects/haqast/2017NorthernCAWildfiresTT

Communications – Google Share



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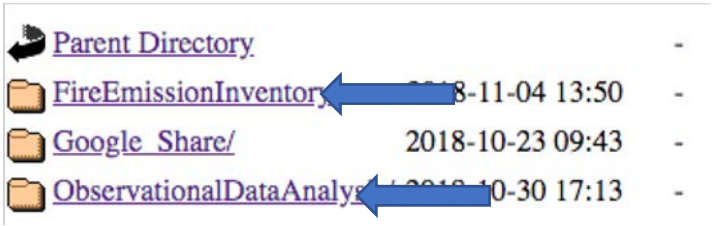
Communications – Datasets



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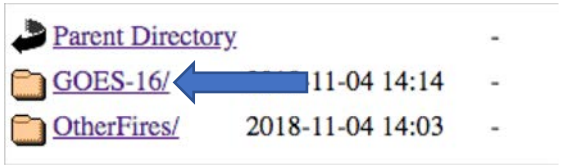

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https://haze.airfire.org/bluesky-daily/output/temp_susan/HAQAST/

Continuing Work

- 4 Months into the project
- Continued work on all project components
- Online Satellite Training Module for Smoke Forecasters Deployed with Incident Management Teams
- Conferences
  - International Association Wildland Fire, Fire Safety and Human Dimensions, Asheville, NC, December 2018
  - International Association Wildland Fire, Fire Behavior and Fuels Conference, Boise, Idaho, April 2019
  - Air Waste Management Association, Wildfires and Air Quality, Santa Rosa, CA, February 2019 https://www.awma.org/wildfires

Thank you!

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