



Air Quality and Health Burden of 2017 Northern California Wildfires

Susan O'Neill, Minghui Diao
NASA HAQAST Tiger Team Update
7/10/2019, Pasadena, California



Co-Authors: 70+ HAQAST Members, Stakeholders, Contributors



HAQAST MEMBERS: Susan O'Neill (USDA Forest Service), Minghui Diao (San Jose State University - SJSU), Daniel Tong (George Mason University), Talat Odman (Georgia Tech), 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), Yiqin Jia (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), Jeffrey Williams (ARB), Jason Vargo (CDPH), Edmund Seto (UW), Keita Ebisu (OEHA), Gerda Albright (UC Davis), Eladio Knipping (EPRI), Michele Barbato (UC Davis)

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),

35 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

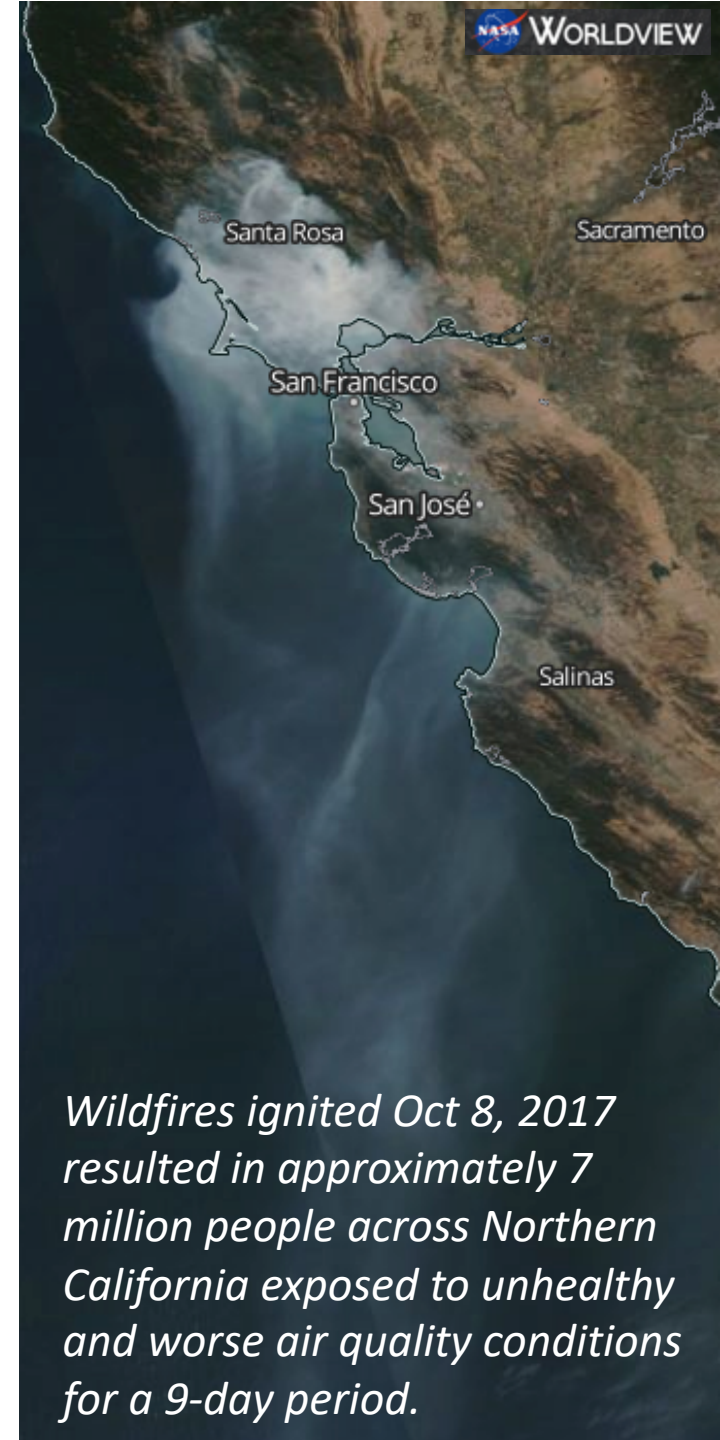
- EPA Region 9
- Bay Area Air Quality Management District
- Center for Disease Control
- California Air Resources Board
- California EPA
- Clark County Air Quality
- California Department of Public Health
- American Cancer Society
- Electric Power Research Institute
- NASA Jet Propulsion Lab
- NASA ARSET
- 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





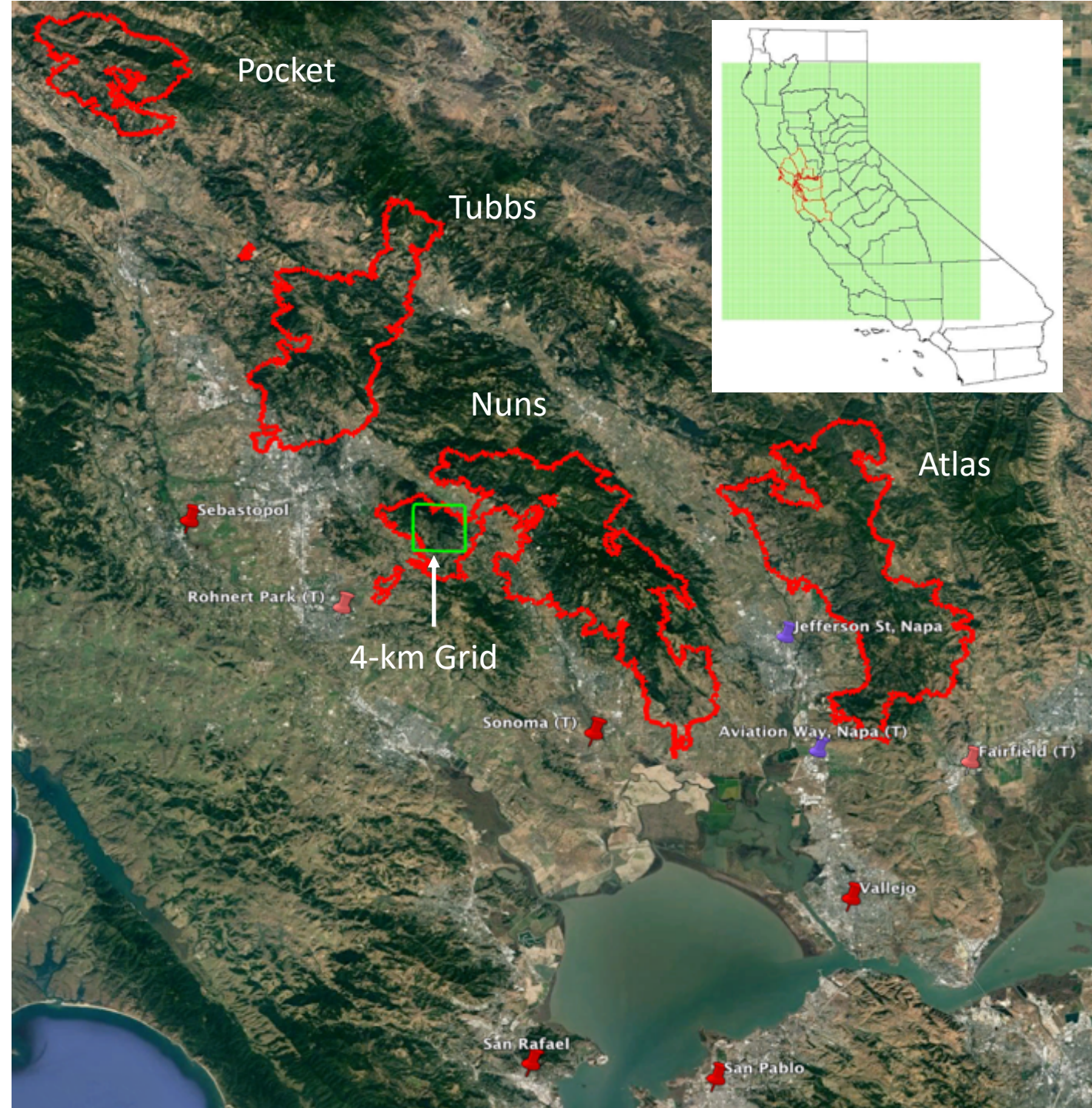
About the Project

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



2017 Northern California Wildfires Modeling Domain & Fire Information

- October 8-20, 2017
 - Pocket = 17,357 acres
 - Tubbs = 36,807 acres
 - Nuns = 56,556 acres
 - Atlas = 51,624 acres
 - Redwood Valley = 36,523 acres
- } 200,000 acres
- *Red = Fire Perimeters*
 - *Pins = Monitors (AQI)*
 - *Green Square = 4-km Modeling Grid Cell*



WRF and CMAQ Configurations

WRF_v3.8

- Morrison (two moments) microphysics
- RRTM short- and long-wave radiation
- Modified Kain-Fritsch cumulus scheme
- Pleim-Xiu Land Surface Model and ACM2 PBL scheme
- Surface-layer Revised MM5 Monin-Obukhov scheme
- Analysis and Observation FDDA were applied

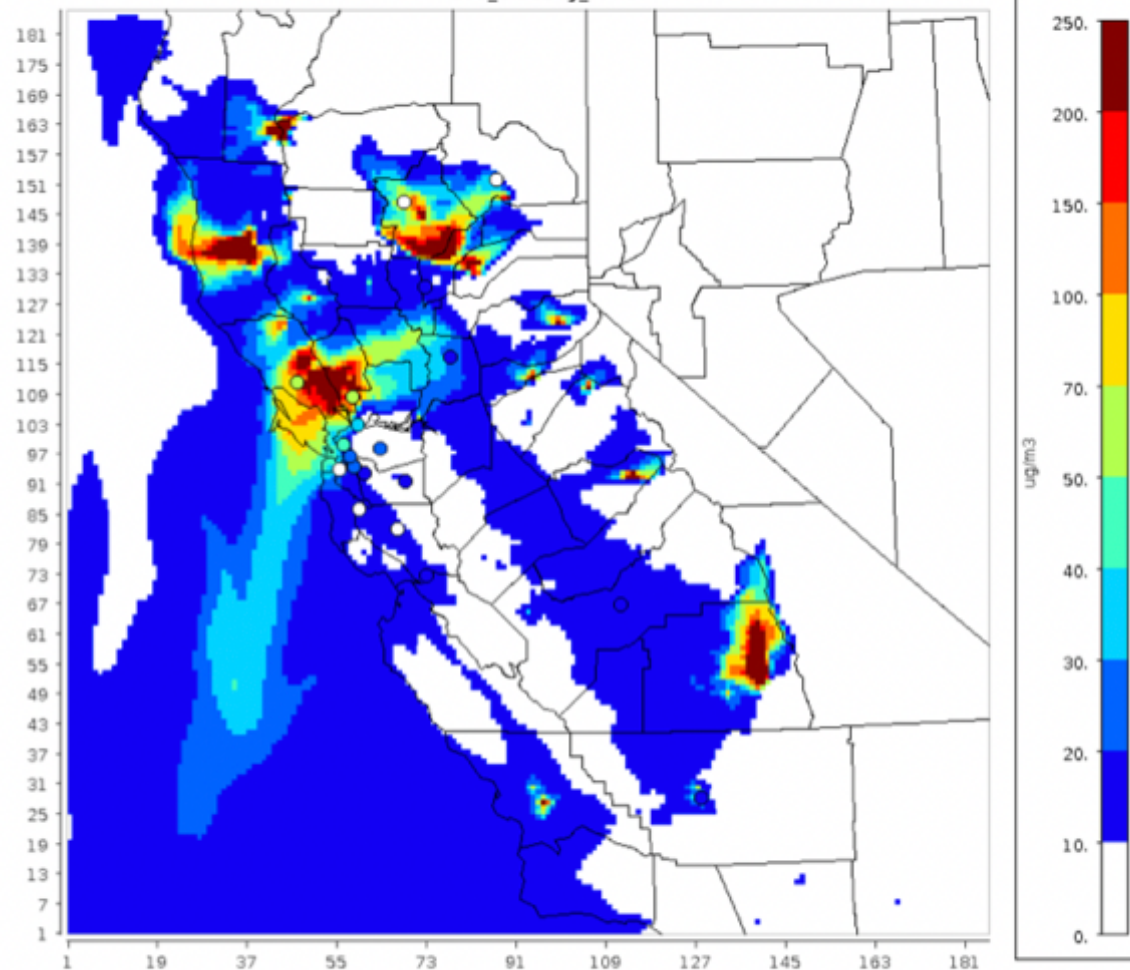
CMAQ_v5.2

- SAPRC07 Chemical Mechanism
- AERO6 Aerosol Module with nonvolatile POA
- CCTM Science Modules: Driver WRF; Horizontal advection YAMO; vertical advection WRF; horizontal diffusion MULTISCALE; vertical diffusion ACM2

CMAQ Air Quality Modeling Results, 10/9/2017

CMAQ 24hr Average PM25_FRM with AQS Observation

FIRE08_BlueSky_run2

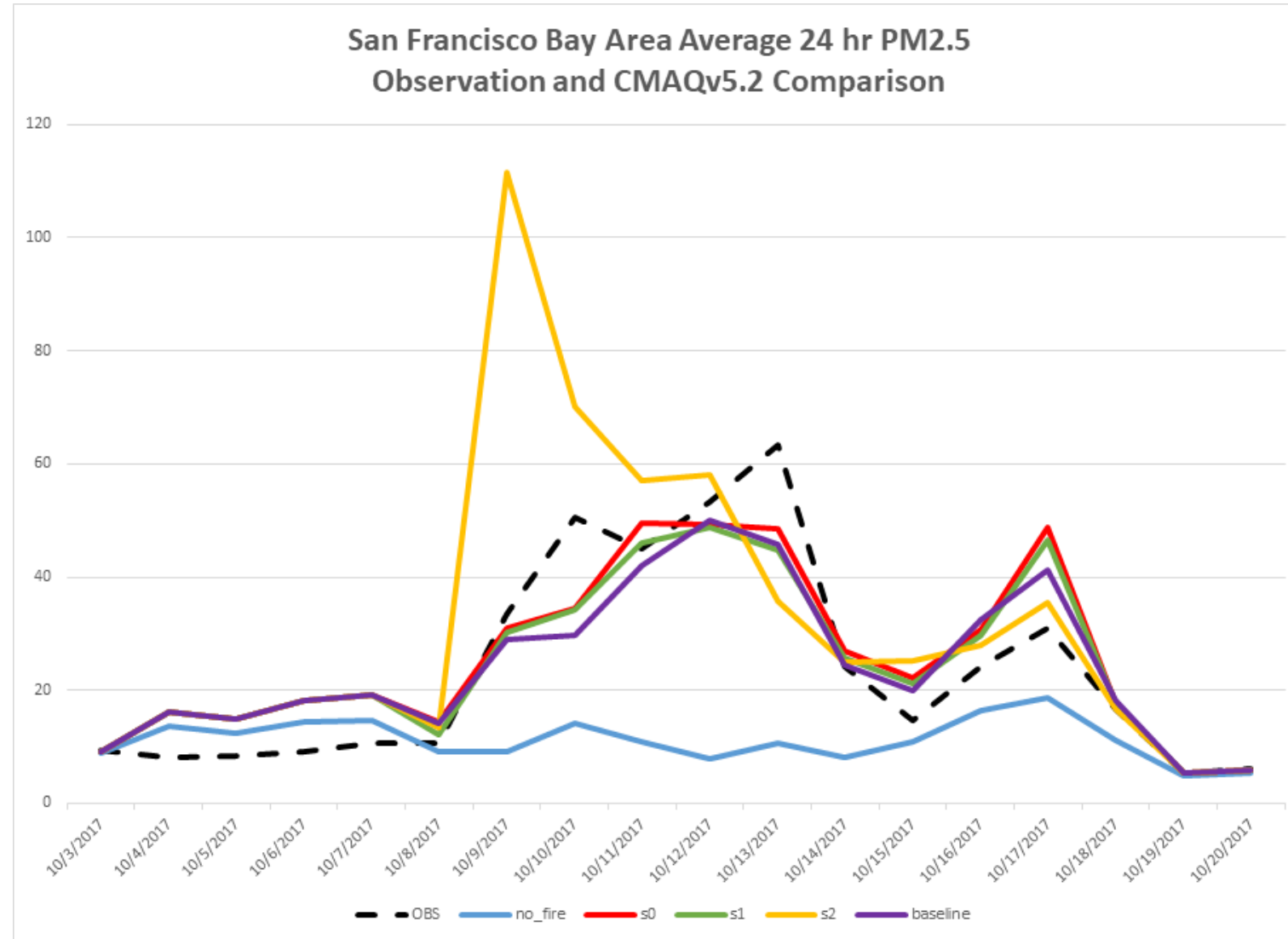


October 09, 2017 00:00:00 UTC Min (140, 96) = 2., Max (36, 138) = 8816.



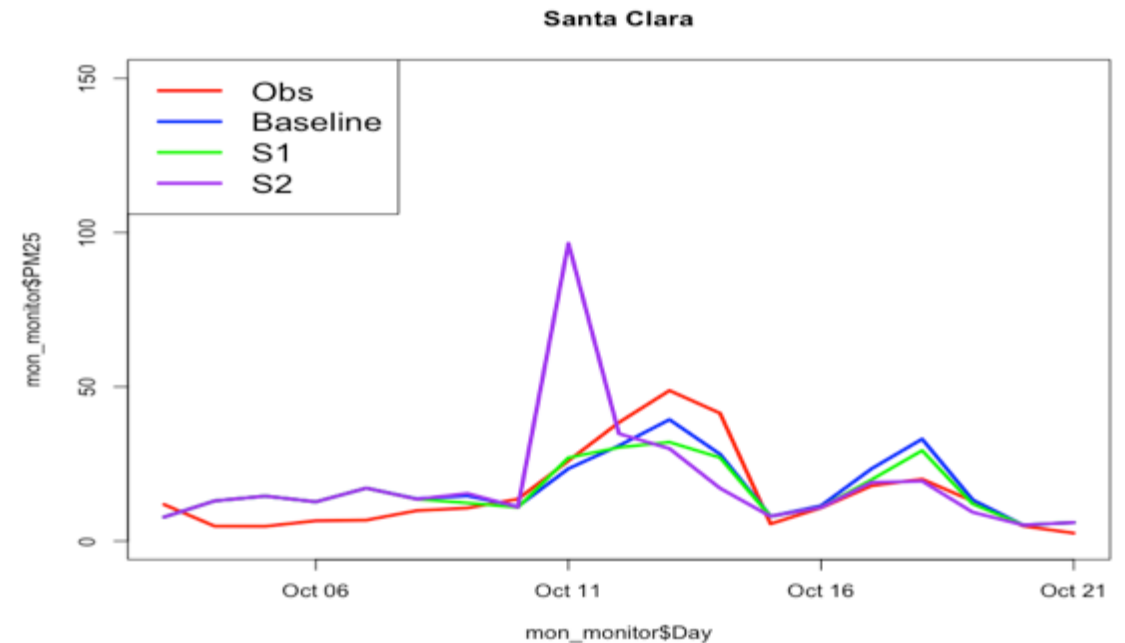
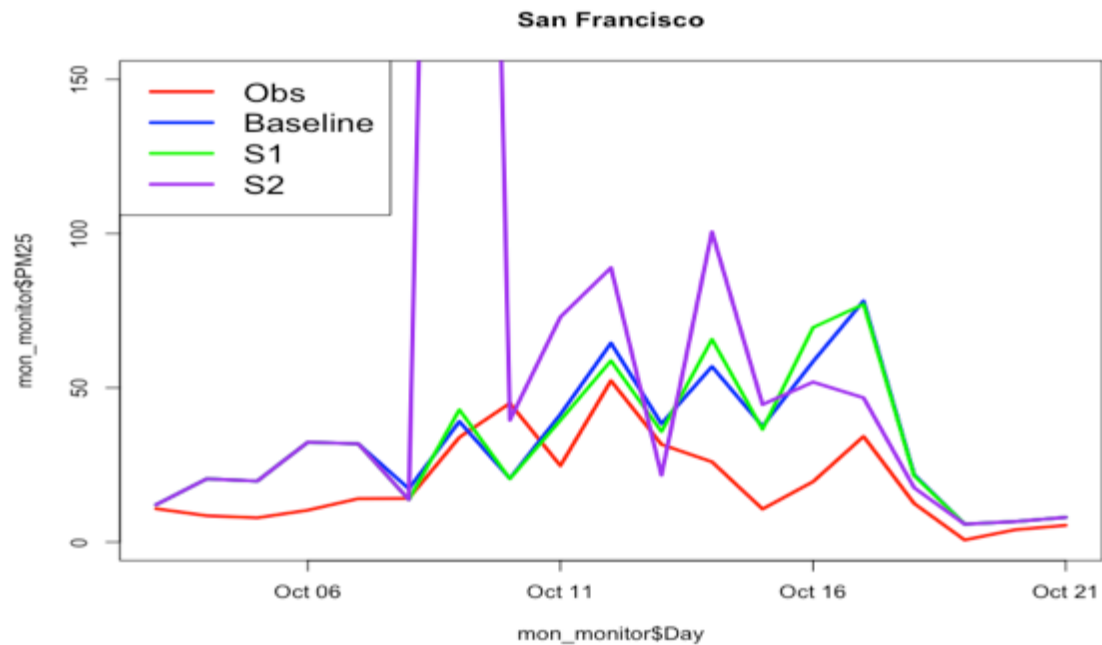
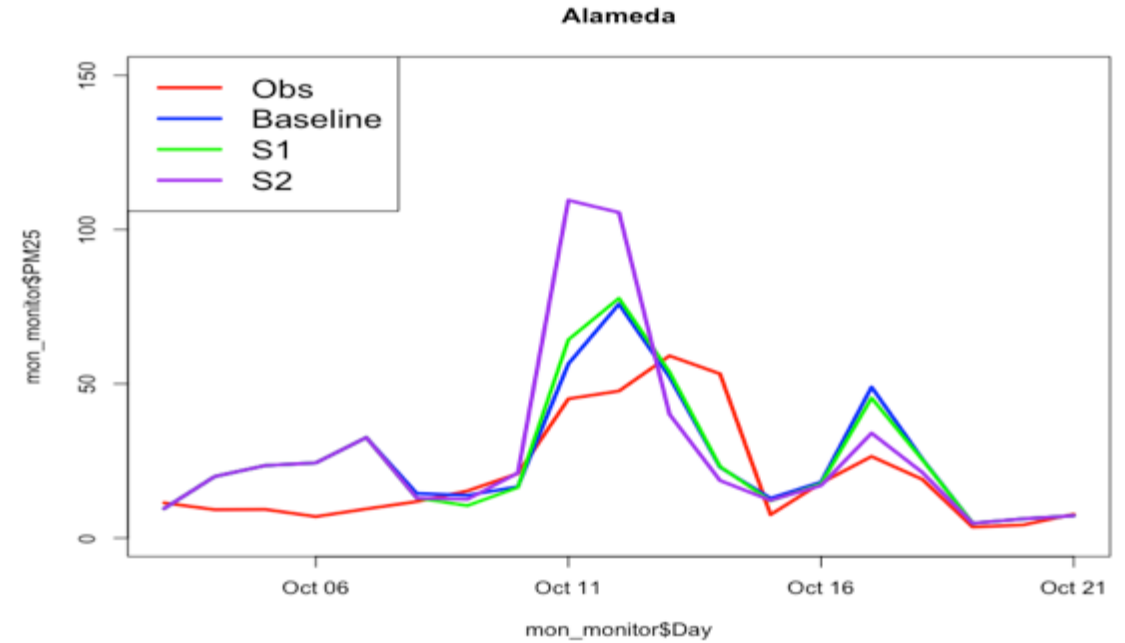
CMAQ Air Quality Modeling Results

- Four Runs
 - No Fires
 - Baseline – Business as usual
 - Sensitivity 1 – GOES-16 Time Profile, BlueSky Emissions
 - Sensitivity 2 – GOES-16 Time Profile, Sofiev (FRP) Plume Rise, NASA FEER Emissions (See Sean Raffuse's Talk)

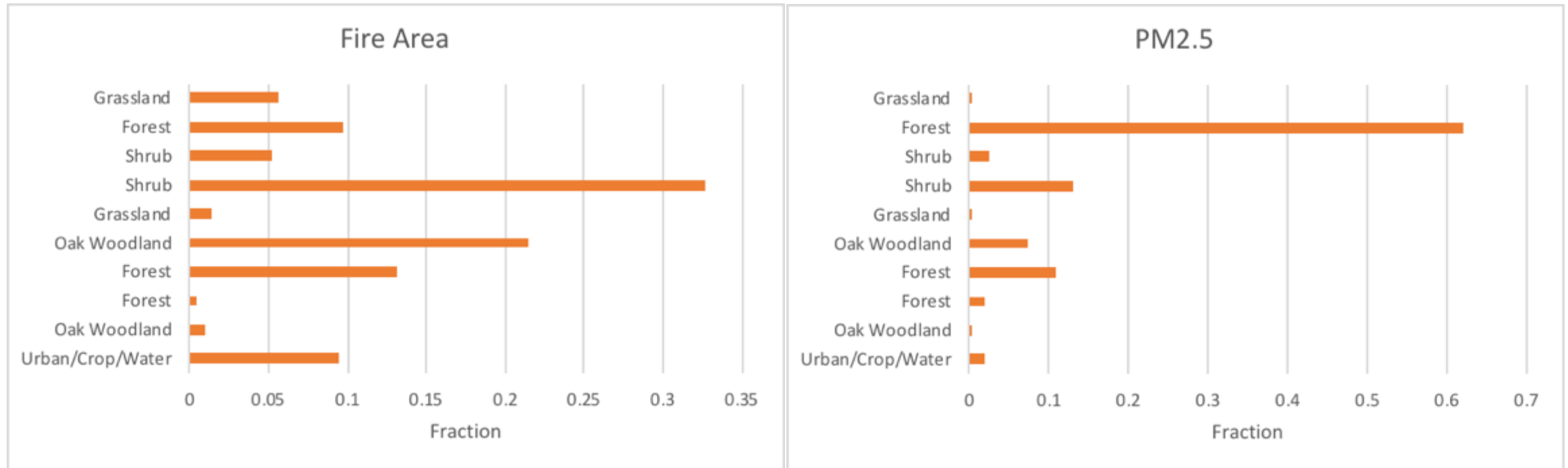


HAQAST Stakeholder/Contributor: Bay Area Air Quality Management District

CMAQ Air Quality Modeling Results



Fuel Types, Fire Area and PM2.5 Emissions

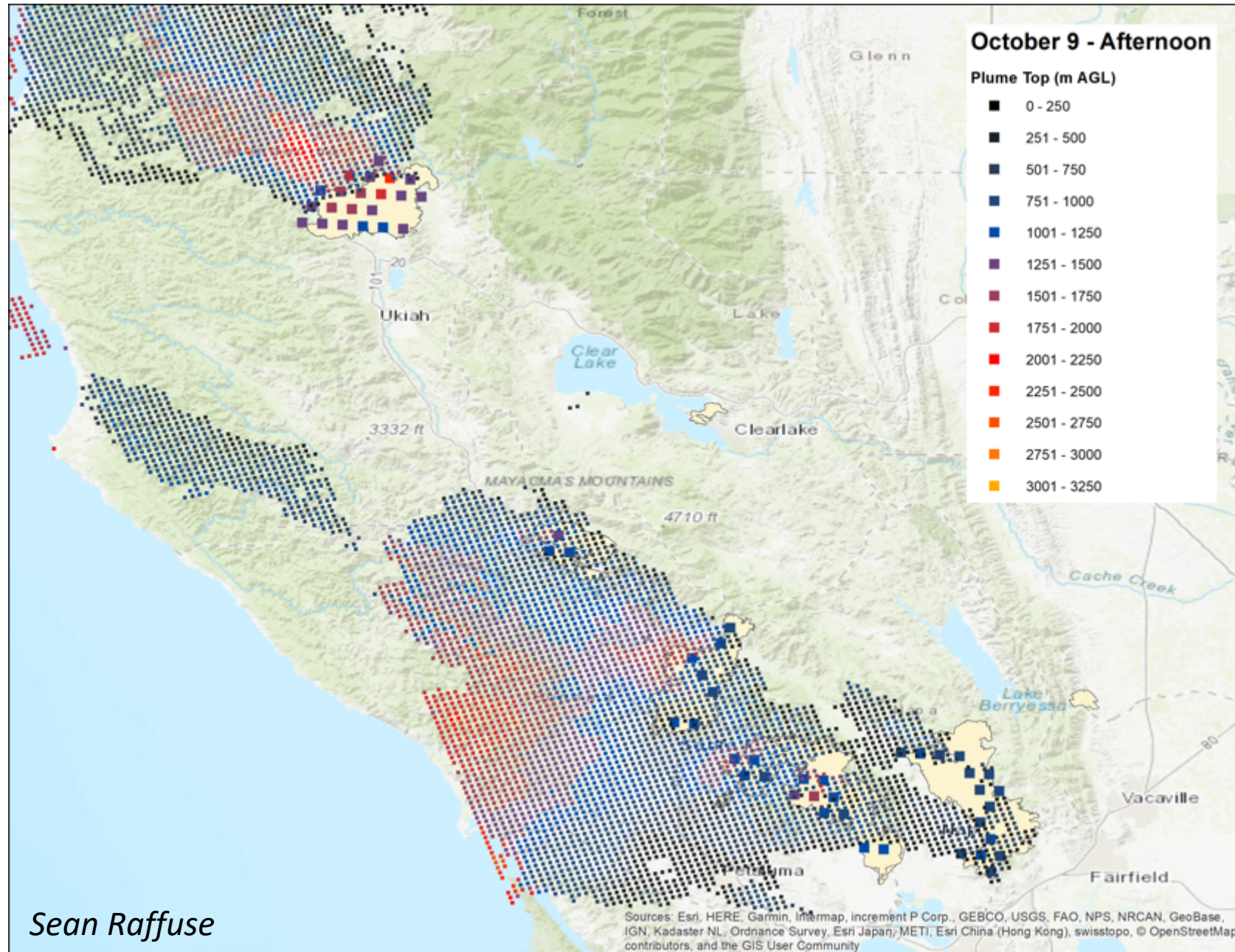


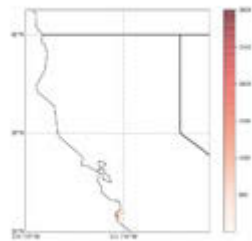
- 10% of the area burned responsible for 62% of the PM2.5 emissions
- Nuns and Pocket – heavy forest

- 10% of the area burned in the Urban/Crop/Water
- Relating FRP to fuels & fuel consumption

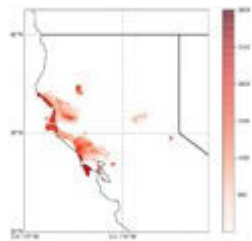
Plume Rise

- Small Dots: MAIAC Plume Injection Height
- Large Dots: Sofiev Plume Rise (GOES-16, FRP)
- To Do: MISR (10/12), CALIPSO, Briggs
- *Joe Wilkins Talk*
- *Sean Raffuse Talk (time profile)*

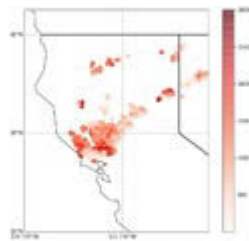




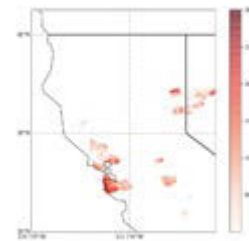
DOY 278



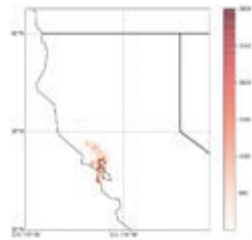
DOY 282



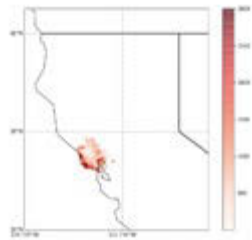
DOY 283



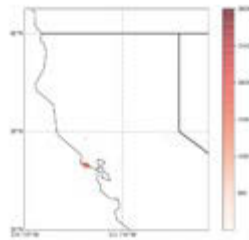
DOY 284



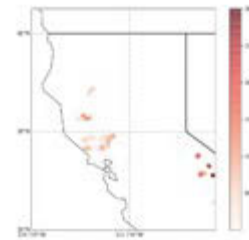
DOY 285



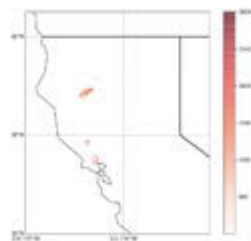
DOY 286



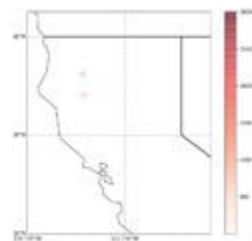
DOY 287



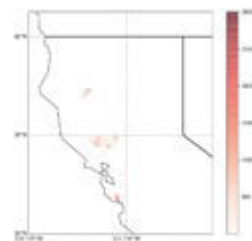
DOY 288



DOY 289

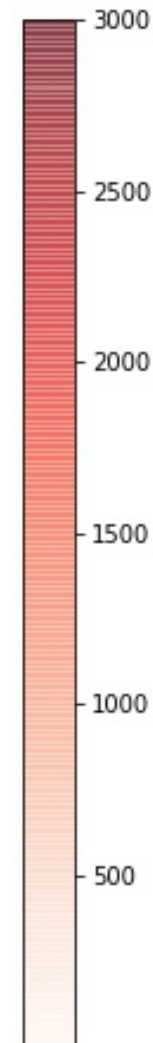


DOY 290



DOY 291

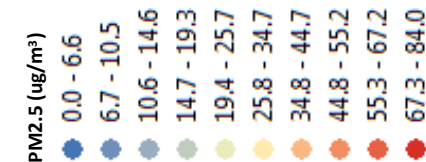
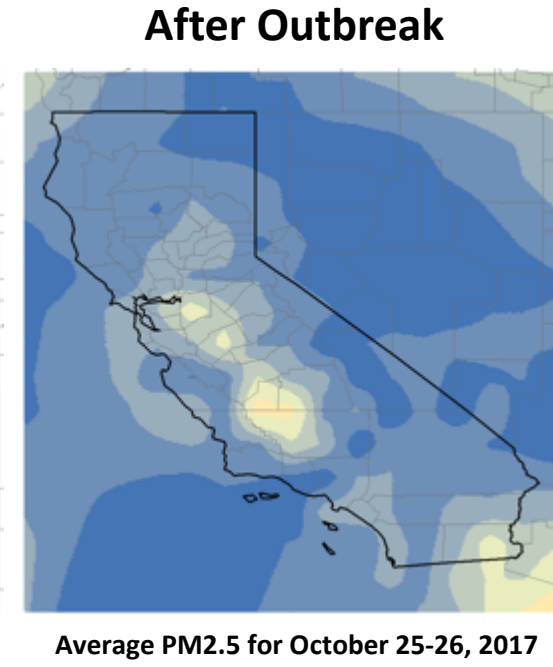
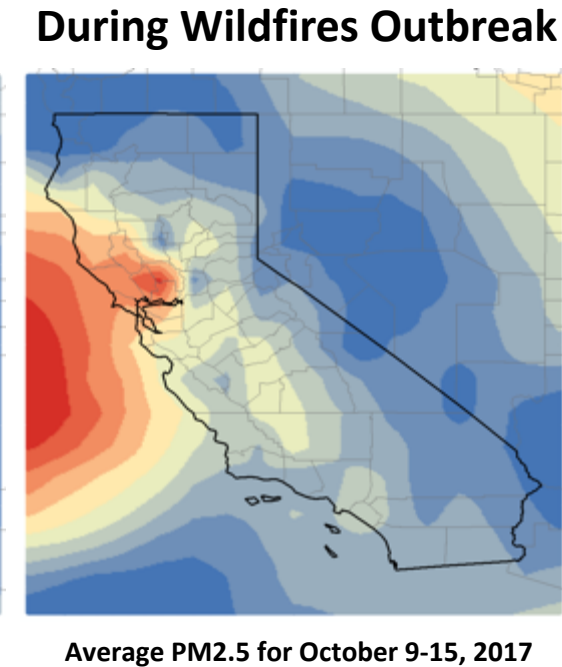
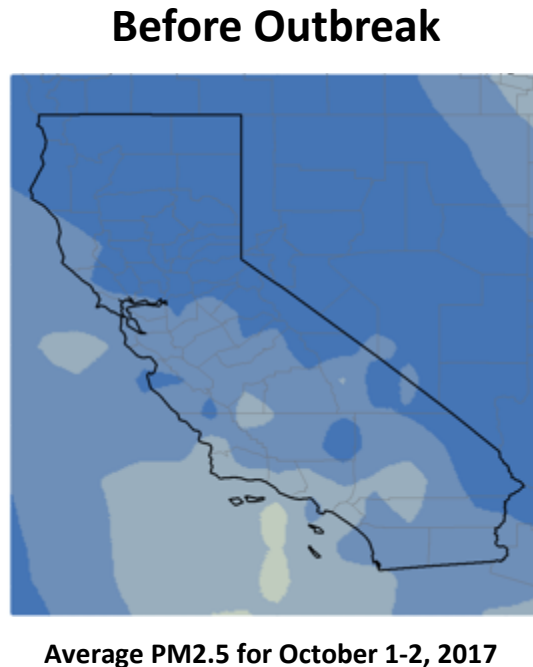
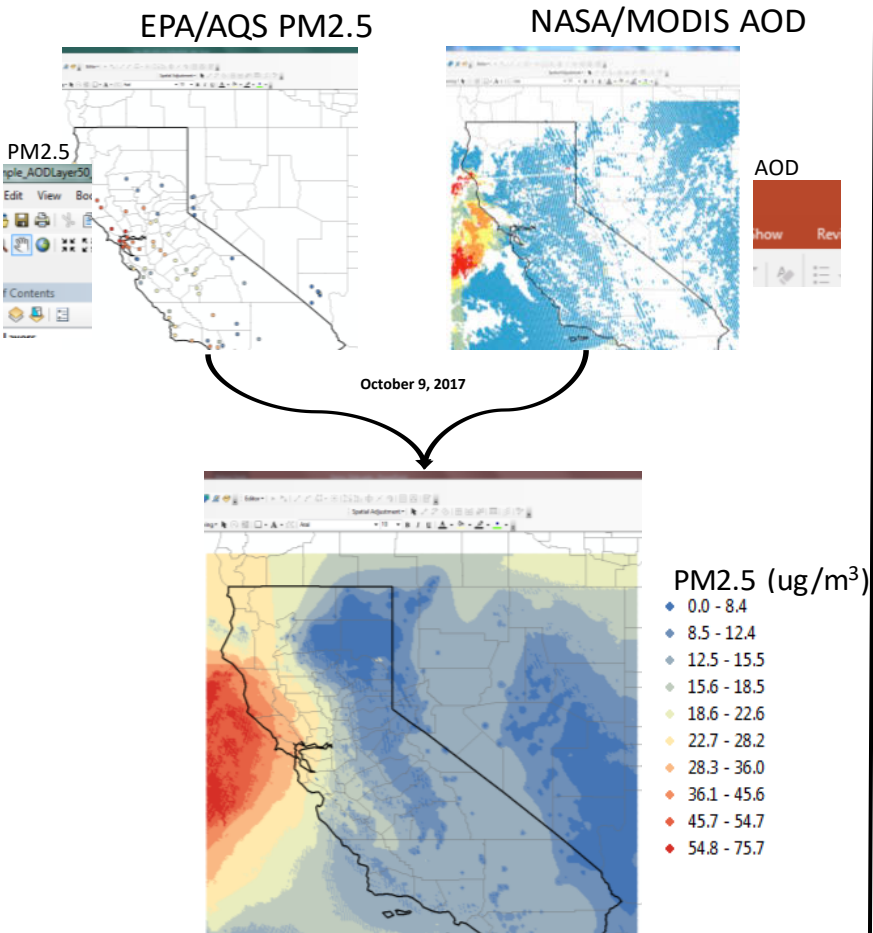
**Smoke Plume
Injection Height
(meters above
ground)**



**MAIAC
MODIS/AQUA
1:30 PM**

Daily PM_{2.5} Estimates and Wildfire Events

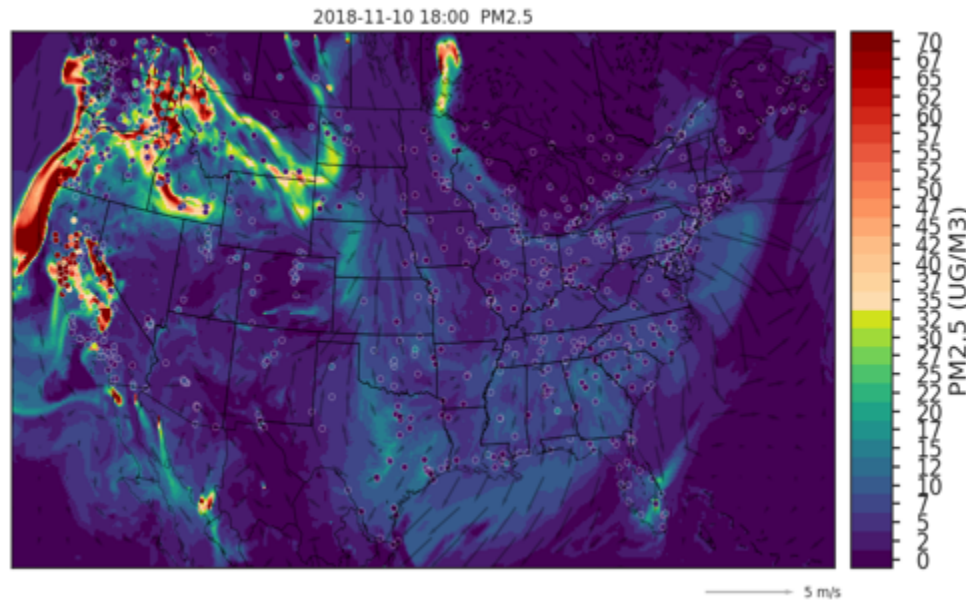
We used a modified version of the Al-Hamdan et al. (2009, JAWMA) geostatistical surfacing algorithm to provide daily estimates of PM_{2.5} for days prior to, during and after the Northern California Wildfires Outbreak of October 9-15, 2017. This algorithm combines data from NASA satellites and EPA ground monitors to provide daily estimates of PM_{2.5} on a 3-km grid (surface).



Improving Fire Emissions with National Air Quality Forecast

Objectives

1. Simulating air quality and exposure impacts of 2018 Camp Fire;
2. Extending TT knowledge to improve national air quality forecasting.



Satellite Products:

- MODIS Fire Detection;
- MODIS Fire Radiative Power (FRP);
- VIIRS Fire Detection;
- VIIRS Fire Radiative Power (FRP);
- MODIS AOD;
- VIIRS AOD;

Ongoing Activities:

- Testing different satellite-based emission products;
- Comparing plume-rise schemes;
- Supporting the FIREX-AQ campaign.

Health Impacts: Compilation of Wildfire Health Studies

Current Studies

- Health and Air Quality Applied Sciences Team (HAQAST) - 2017 Northern California Wildfires Tiger Team: Health Impacts Subgroup
- Chemical composition of 2018 wildfire smoke in SF Bay Area relevant to potential human health effects
- SF-Bay Area 2017 Wildfire Health Study
- Extreme wildfire smoke days and hospitalizations in California from 2004 - 2009
- B-SAFE Wildfire Pregnancy Study
- Linkage Study of Potential Developmental Effects of Wildfire Exposures
- WHAT-Now -CA (Wildfires and Health: Assessing the Toll in Northern California)

Related Studies

- Fire and Smoke Model Evaluation Experiment (FASMEE)
- Western Wildfire Experiment for Cloud Chemistry, Aerosol Absorption and Nitrogen (WE-CAN)
- Fire Influence on Regional and Global Environments Experiment (FIREX)
- Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ 2019)

Reference Compilation of Past Studies

Sub-team Leads: Jason West, Pat Kinney

<https://docs.google.com/spreadsheets/d/1KNX32KwtCfjzao-0XUsw3guJDtxs9yqlgkoHTIfFeg/edit#gid=0>

MAPPING THE AIR QUALITY & HEALTH IMPACTS OF THE 2017 CALIFORNIA WILDFIRES

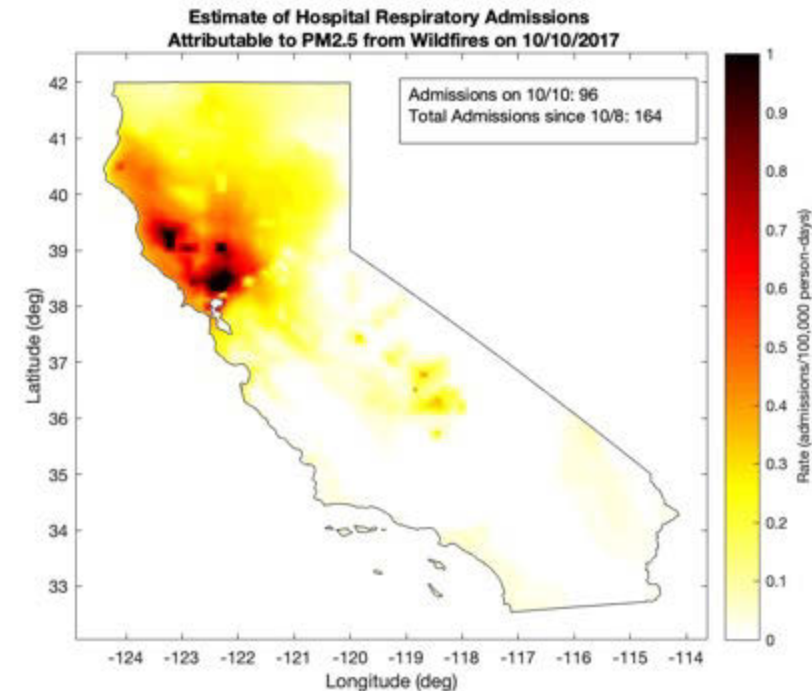
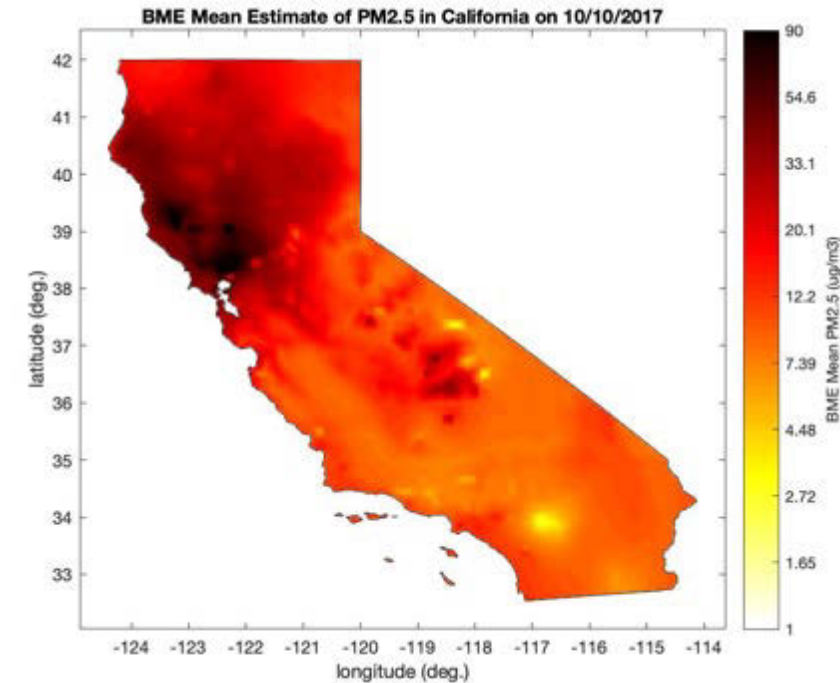


Stephanie Cleland, Marc Serre, Jacob Becker, Marissa DeLang, & Jason West

Two primary goals:

1. **Map $PM_{2.5}$ during the Oct. 2017 wildfires**, fusing together observed & modeled $PM_{2.5}$ concentrations
 - Surface observation data from both FRM/FEM & temporary monitoring stations
 - Model data from BAAQMD CMAQ run
2. Use the $PM_{2.5}$ map to **estimate the acute health impact of the Oct. 2017 wildfires**, specifically the attributable respiratory hospital admissions

Future work will extend this approach to more health endpoints and pollutants.



Communications – Project Website



CMAQ Air Quality Modeling Results (BAAQMD) - Four Planned Runs

Figure: [Modeling Domain](#)

1. [No Fires \(Anthropogenic and Biogenic Emissions\)](#)
2. [Baseline \("Business as usual"\)](#): BlueSky Fire Emissions, CMAQ Time Profile and Plume Rise (Briggs-based)
3. [Sensitivity 1 \(hourly ground-based, remotely-sensed time profile\)](#): BlueSky Fire Emissions & Plume Rise (Briggs-based posted 6/10/2019)
4. [Sensitivity 2 \(100% remotely-sensed\)](#): Fire Emissions (GOES-16 FRP, NASA FEER algorithm), Time Profile (GOES-16 F (GOES-16 FRP, Sofiev algorithm)

Inventory of Fire Emissions (USFS, UCD)

Figure: [GOES-16 Derived Acres Burned per Hour](#)

[Baseline \("Business as usual"\)](#): BlueSky Fire Emissions, CMAQ Time Profile and Plume Rise (Briggs-based)

[Sensitivity 1](#): BlueSky Fire Emissions & Plume Rise (Briggs-based), GOES-16 Time Profile (new files 6/3/2019)

[Sensitivity 2](#): GOES-16 Fire Emissions (NASA FEER), GOES-16 Time Profile, GOES-16 Plume Rise (Sofiev)

[Other Fires Dataset](#): All fires, excluding the 5 Major Northern California Fires

PM2.5 and Wind Observations Analysis (SJSU, UCR)

[Animated gif](#)

[HTML Animation](#)

Python code, observational data (PM2.5, winds, fire perimeters), and hourly png figures at:
https://haze.airfire.org/webaccess/susan/HAQAST/Wildfires_TT/PM2.5_and_Wind_Obs/

[California Health Studies \(Draft Summary Table\)](#)

[ber 12, 2017 \(NASA\)](#)

haze.airfire.org/webaccess/susan/HAQAST/Wildfires_TT/MISR/

[n PM2.5 Surfaces \(MODIS, Surface Monitors\) \(NASA MSFC\)](#)

haze.airfire.org/webaccess/susan/HAQAST/Wildfires_TT/DataFusionPM2.5/

[g Data Output](#)

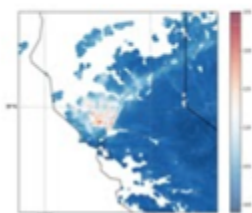


HAQAST: 2017 Northern California Wildfires Tiger Team

Lead Contacts: [Susan O'Neill](#), US Forest Service & [Minghui Diao](#), San Jose State University

Short url: <http://bit.ly/haqasttiger>

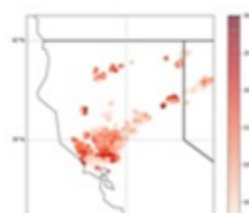
MAIAC AOD and Plume Injection Height (NASA)



AOD

[Terra Tabular Data](#) | [Terra Maps](#)

[Aqua Tabular Data](#) | [Aqua Maps](#)



Plume Injection Height

[Terra Tabular Data](#) | [Terra Maps](#)

[Aqua Tabular Data](#) | [Aqua Maps](#)

Video – The Basics of Satellite Data for Smoke and Fire

Part 1: The Basics of Satellite Data for Smoke and Fire



Part 2: The Basics of Satellite Data for Smoke and Fire



Summary Table of Satellites, Satellite Instruments, and Products for Smoke and Fire

(discussed at the end of video Part 2)

Name	Instrument	Products	Temporal Resolution, Overpass Time	Spatial Resolution	Polar/Geo	Launch Date	Operational Date
G01S-M	SAR	Visible, FRP, ACES, Fire Hot Spot, Smoke Mask	1 min, CCN/S, 10/10 min Full Disk	0.1 – 2 km	Geo	November 2014	December 2017
G01S-I	SAR	Visible, FRP, ACES, Fire Hot Spot, Smoke Mask	1 min, CCN/S, 10/10 min Full Disk	0.1 – 2 km	Geo	November 2014	February 2018
Terre	MODIS	Visible, FRP, ACES, Fire Hot Spot	Equator Overpass 10:30 am local time	250-m, 500-m, 1 km	Polar	December 1998	November 2000
Aqua	MODIS	Visible, FRP, ACES, Fire Hot Spot	Equator Overpass 13:30 pm local time	250-m, 500-m, 1 km	Polar	May 2002	July 2002
Satellite NPP	VIIRS	Visible, FRP, ACES, Fire Hot Spot, Smoke Mask	Equator Overpass 13:30 pm local time	375-m, 750-m	Polar	October 2011	November 2011
NOAA-20	VIIRS	Visible, FRP, ACES, Fire Hot Spot, Smoke Mask	Equator Overpass 12:45 pm local time	375-m, 750-m	Polar	November 2017	May 2018
Landat (note: there are 4 Chinese Landat satellites)	Vegetation, depending on satellite: Fire, Landat 8, GLI and TRIS	Visible, surface temp	Equator Overpass 10:00 am local time	30-m	Polar	Feb. 2013	April, 2013

- What is a polar orbiting versus geostationary satellite?
- What are the instruments on commonly used satellites?
- What are the products from these instruments?
- Required pre-work for Air Resource Advisor Training
- Went out to NWCG Smoke Managers Subcommittee
- NASA ARSET, NOAA, Land Manager Collaborations
- Daegan Miller – Thank you!
- First in a series

Manuscript – Draft Outline

- 1. Introduction, motivation of wildfire emission research
- 2. Input data used in the development of PM_{2.5} products (Table). Include tools for data analysis
 - 2.1 Fire detections, FRP (remotely sensed point data)
 - 2.2 AOD (remotely sensed grid data)
 - 2.3 plume injection height (MISR, CATS, MAIAC, CALIPSO)
 - 2.4 surface monitoring data (PM_{2.5}, PM_{2.5} composition)
- 3. Inter-comparison showcase of 2017 California wildfire
 - Figure, Maps of PM_{2.5} in October 2017 Northern California, satellite map, CMAQ map (CMAQ PM_{2.5} concentration with monitor observations)
 - 3.1 fire emissions calculations
 - 3.2 air quality modeling (description of the modeling system: WRF/CMAQ configurations; simulation results and evaluation), WRF
 - 3.3 Plume injection height differences in four model simulations
 - 3.3 High-resolution dispersion modeling
 - 3.4 Data fusion products
- 4. Discussions, challenges and future outlook. Link in what is in process with the health impact analysis/applications



Year 3 Progress Update, PI Susan O'Neill

Facilitating the Integration and Adoption of Satellite Products for Decision Support during Wildland Fire Smoke Episodes

- Earth Observation Information Synthesis, Dissemination and Delivery
 - Data Fusion – MAIAC AOD, Smoke Forecasting Model Runs, surface observations. Two case study demonstrations; one published paper (Zou et al. 2019a); one paper in draft (Zou et al. 2019b).
 - Incorporation of remotely sensed data into discussions at the National Smoke Assessment. Whitepaper in draft.
- Earth Observations for Smoke Model Evaluation
 - Used MAIAC AOD and CATS/CALIPSO aerosol cross sections to evaluate modeling and data fusion results.
 - Exploring how to access and process the TROPOMI carbon monoxide (CO) data and deliver in real-time.
- Earth Observations to Improve the Science of Smoke Modeling
 - Related work by Martinez et al. (2019) shows that the fire activity persistence assumption performs well when atmospheric conditions are trending similarly day to day.
 - A new aggregation and fire size assignment system was tested with the first round of Tiger Teams and is now poised for operational implementation with this 2019 wildfire season (Aqua, Terra, Suomi-NPP, NOAA-20, GOES-16).
- 6+ academic talks; 3 Land Manager/Air Resource Advisor trainings

Tiger Team Participation

- Co-Lead with Minghui Diao. Air Quality and Health Burden of 2017 California Wildfires
 - Completed training video “The Basics of Satellite Data for Smoke and Fire”. NASA ARSET will use. Required pre-work for Air Resource Advisor (ARA) Training as part of the Wildland Fire Air Quality Response Program.
 - Draft paper outline
 - Demonstrated utility of GOES-16 fire detections as a data calculation stream. R package developed (goesfire, S. Raffuse)
 - Extrapolating to 2018 – Camp Wildfire. Initial results show the potential to dramatically improve smoke forecasting.
 - Webpage – Communications and hosting of all project data/products
 - 3 conference talks.

1 paper published

1 paper accepted

1 paper submitted

3 in prep



International
Association
of Wildland Fire

UCDAVIS

**AIR QUALITY
RESEARCH CENTER**



The 3rd International Smoke Symposium (#ISS#3) will bring together researchers from the atmospheric sciences, the ecological sciences, health sciences, mathematicians, computer sciences, climatologists, social scientists, and others to discuss the complex issues of smoke and identify knowledge gaps and opportunities for innovation and development.

**The Symposium will be held in
Raleigh, North Carolina and UC Davis, California,
April 20-24, 2020.**

The Symposium will be a hybrid, which combines in-person and streaming presentations.