Where There's Smoke: (Application of) Satellite Data for Smoke and Fire

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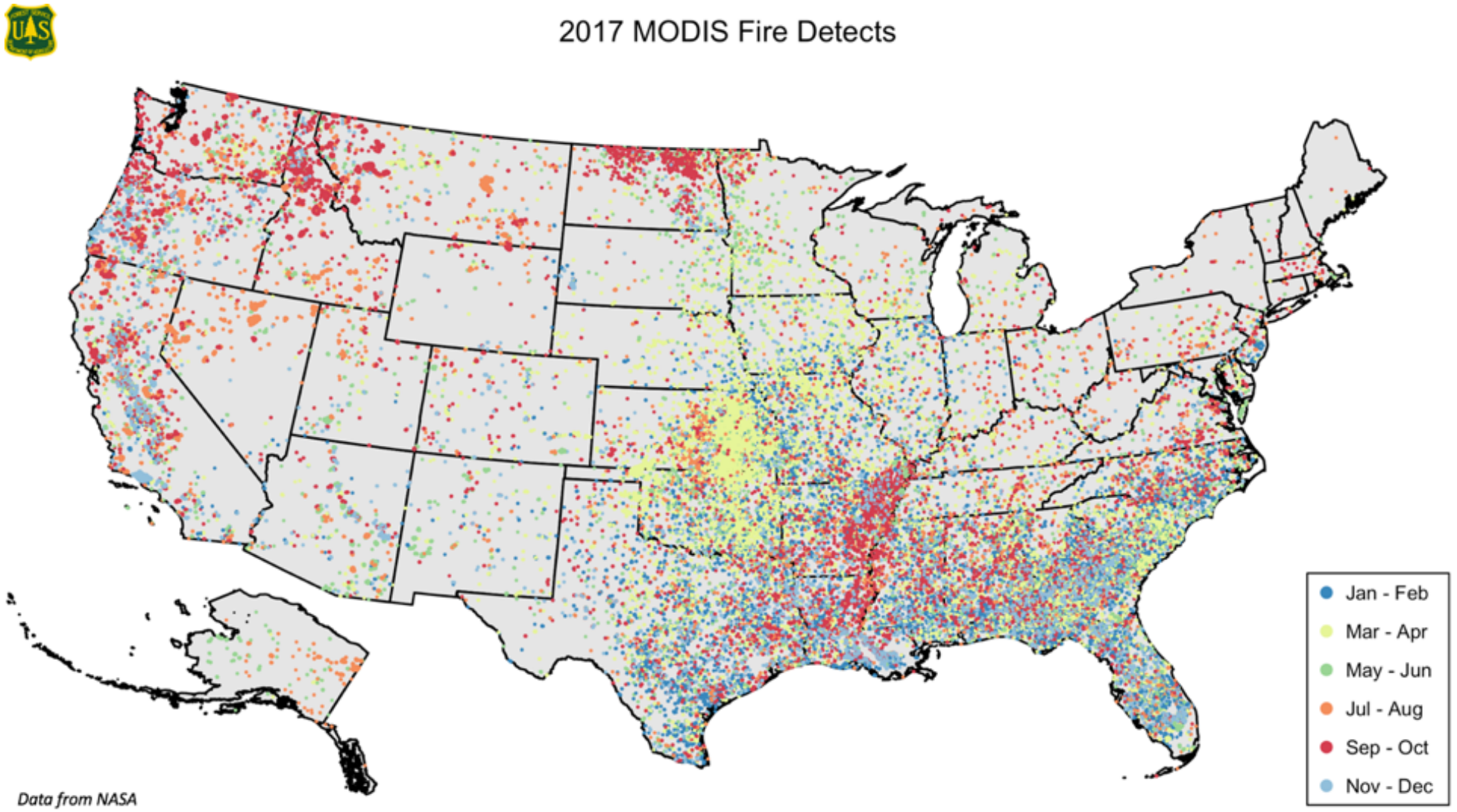
HAQAST2020
WEBINAR SERIES

Seasonality of Fire Occurrence



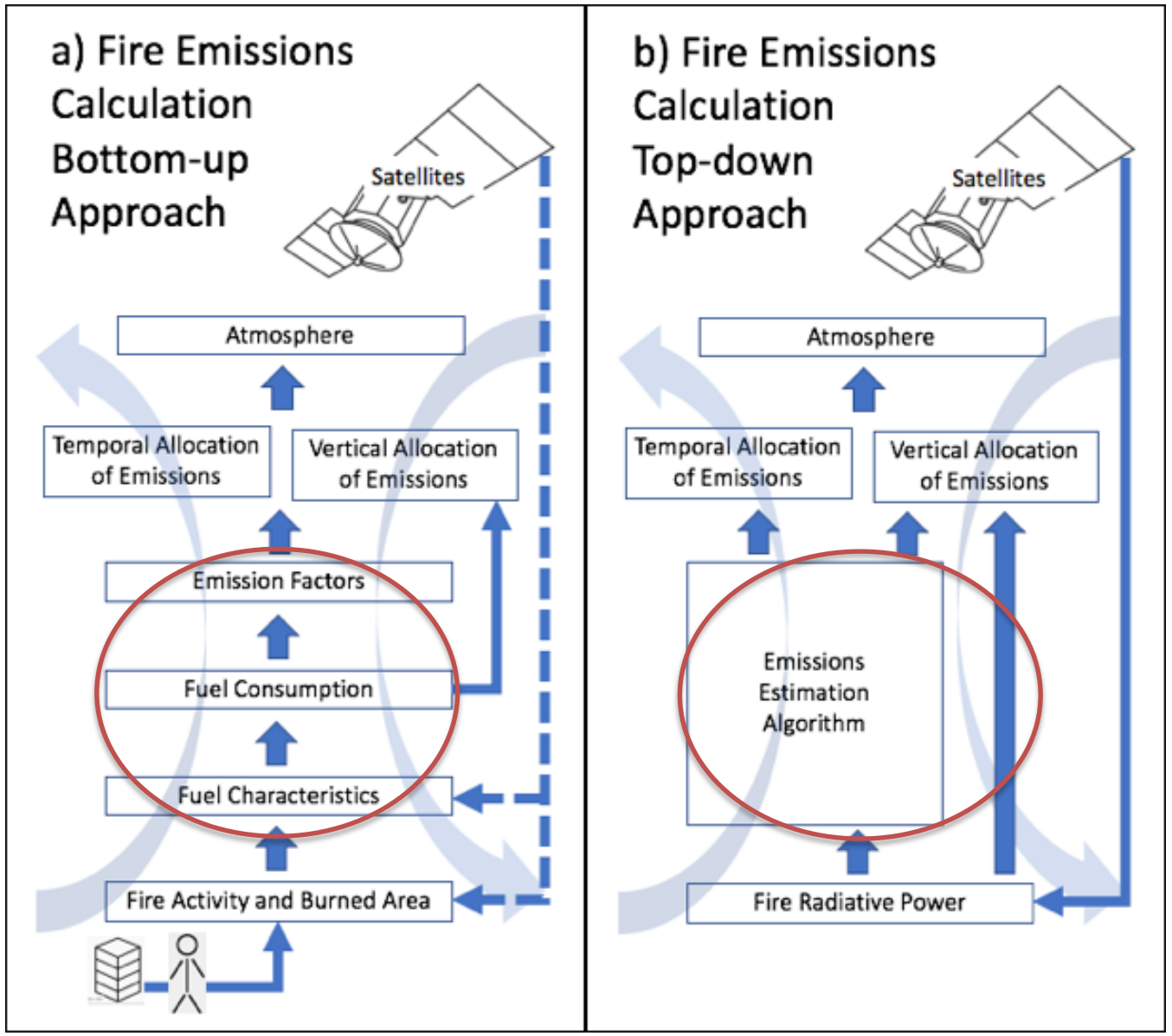
The 2017 Northern California Wildfires Tiger Team Project

- October 8-20, 2017. Five wildfires. 200K acres
- 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, 80 Stakeholders/Collaborators,
  - Co-leads: Susan O'Neill, Minghui Diao
  - 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

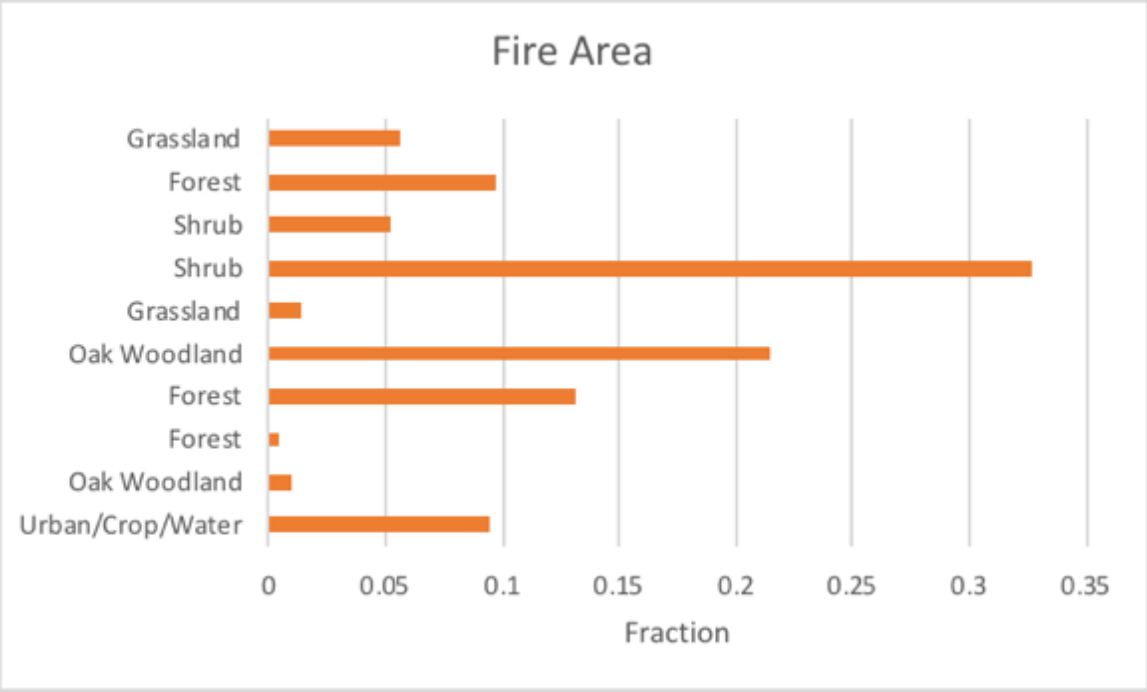
Wildfires ignited Oct 8, 2017 resulted in approximately 7 million people across Northern California exposed to unhealthy and worse air quality conditions for a 9-day period.

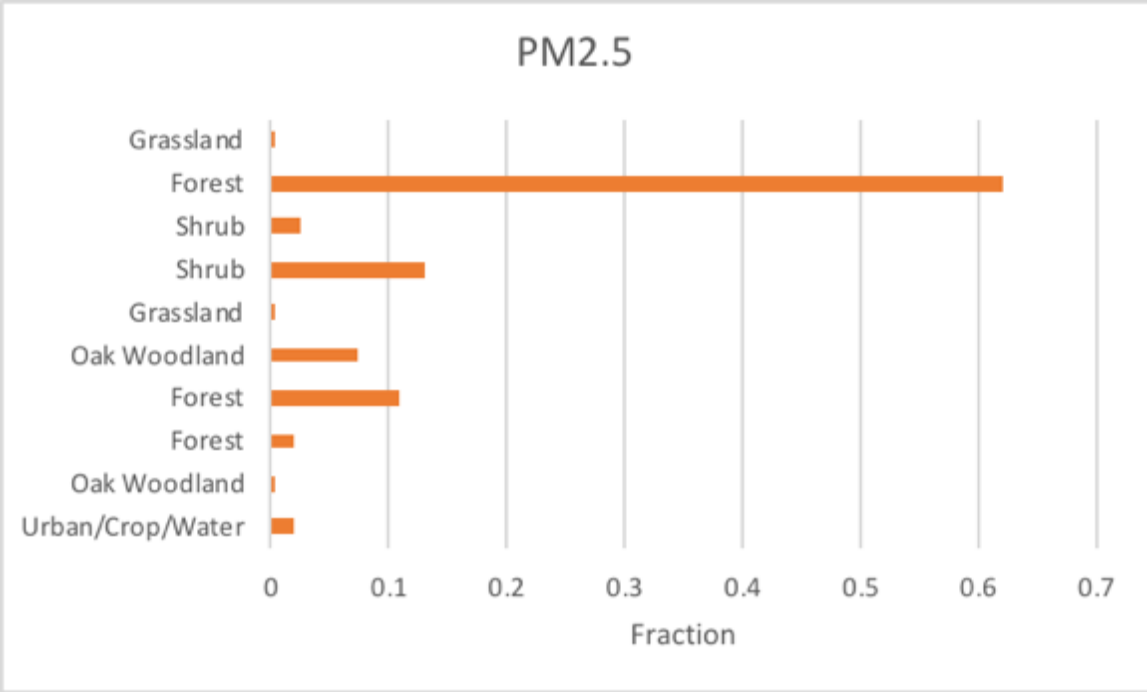
Calculating Emissions from Wildland Fire

- Vegetation/Land-based: BlueSky Framework
- Remotely-sensed based: NASA Fire Energetics and Emissions Research (FEER) Algorithm. Ichoku and Ellison (2014)
- The two methods share many similarities and make similar assumptions
- Every box is an area of research, with notable uncertainty/variability
- EPA NEI. Combining reported and remotely-sensed fire activity. Larkin et al. 2020



Relationship of PM2.5 Emissions to Fuel Type & Fire Area

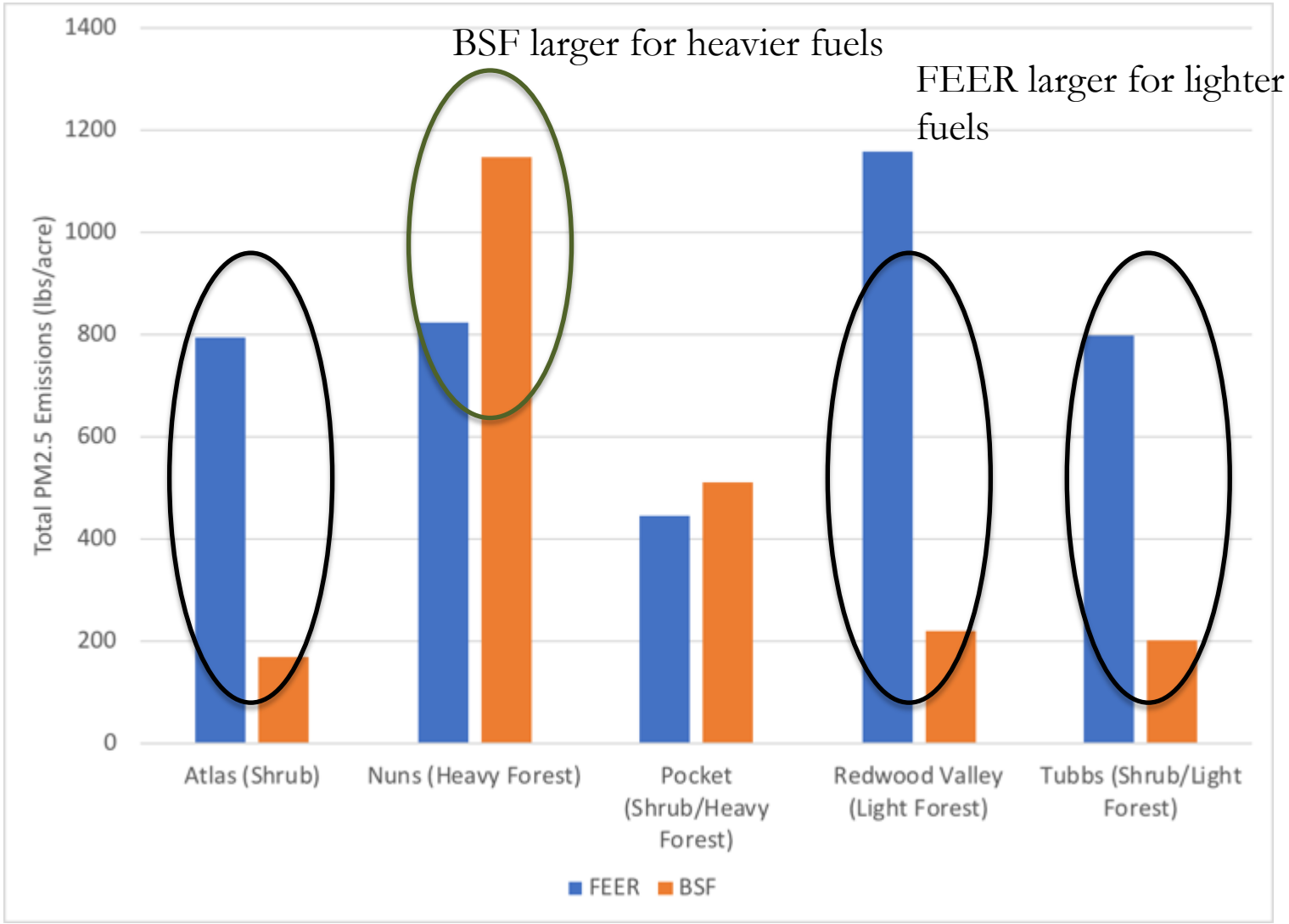




- 2017 Northern California Wildfires, 10 fuel types
- 10% of the area burned responsible for 62% of the PM2.5 emissions
- Fire Area and PM2.5 emissions not necessarily directly related – need to account for fuel type

Comparison of Fire Emission Methods

- Five 2017 Northern California wildfires
- Blue – NASA FEER Emissions Estimate (FRP-based)
- Orange – BlueSky Emissions Estimate (bottom up approach)



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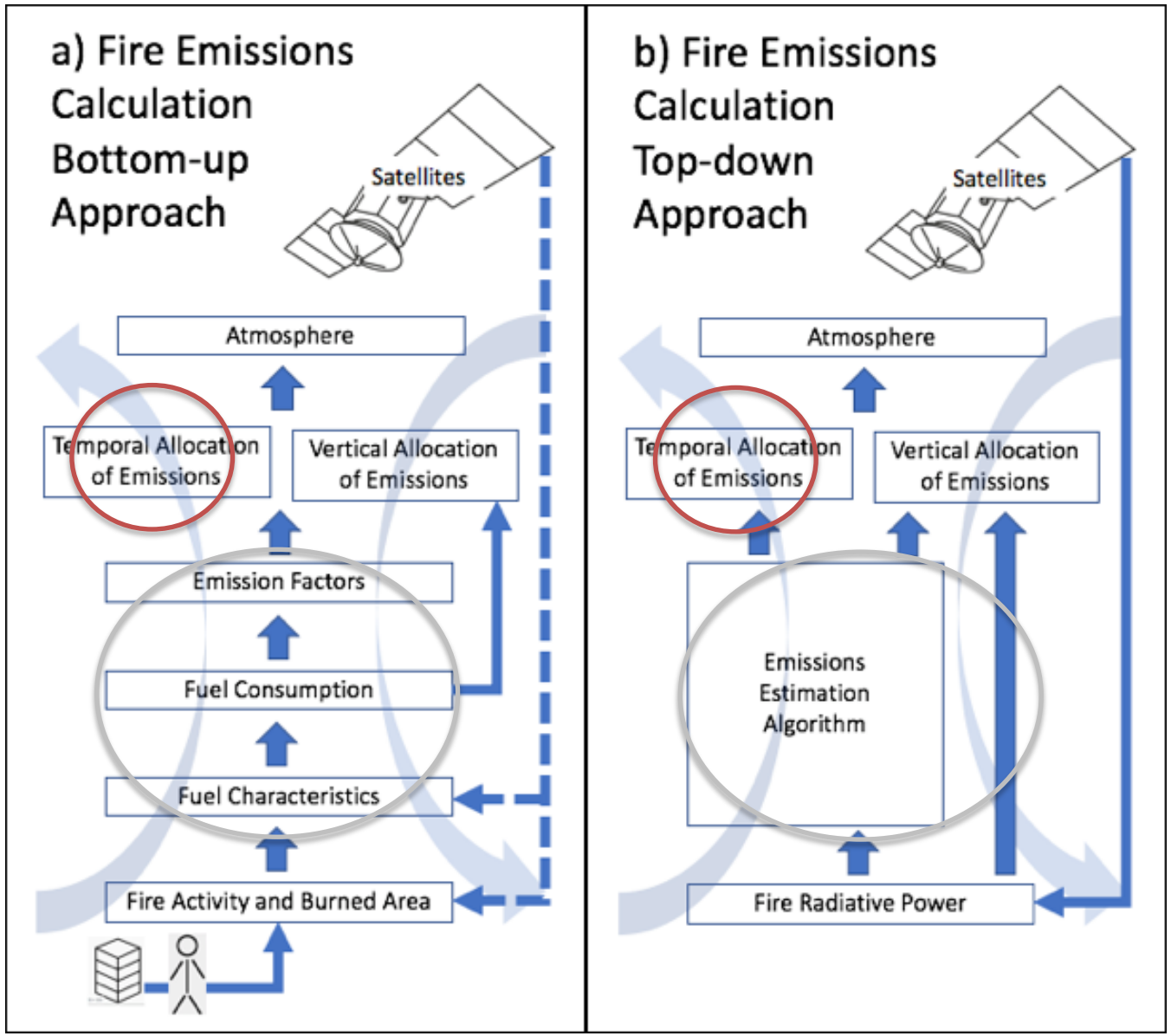
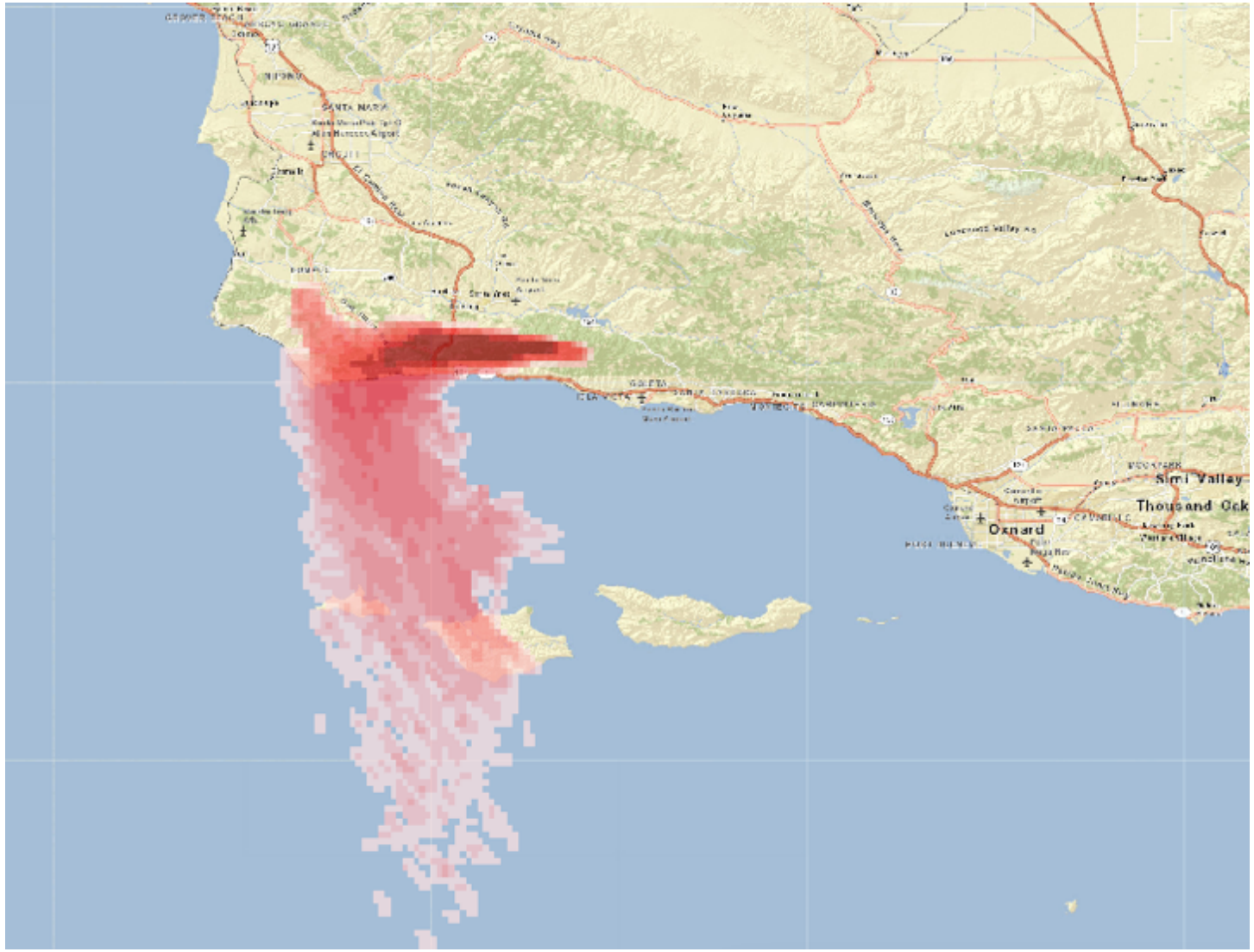


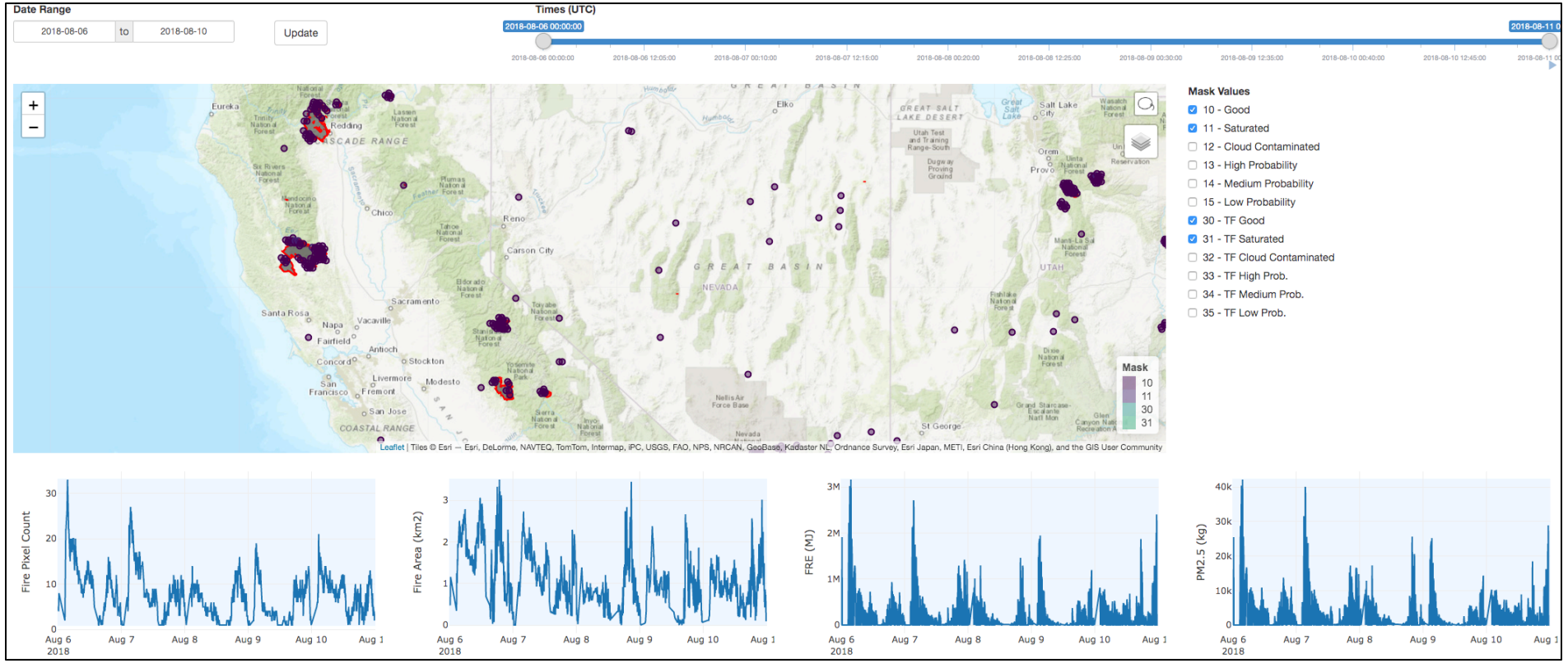
Diurnal Profile (Fire Behavior/Emissions)

- Motivation – Sundowner winds and nighttime fire activity
- Whittier Wildfire July 16, 2017 0400 PDT
- GOES-16 data newly available
- Working one on one with the Air Resource Advisor deployed on the fire doing smoke forecasting



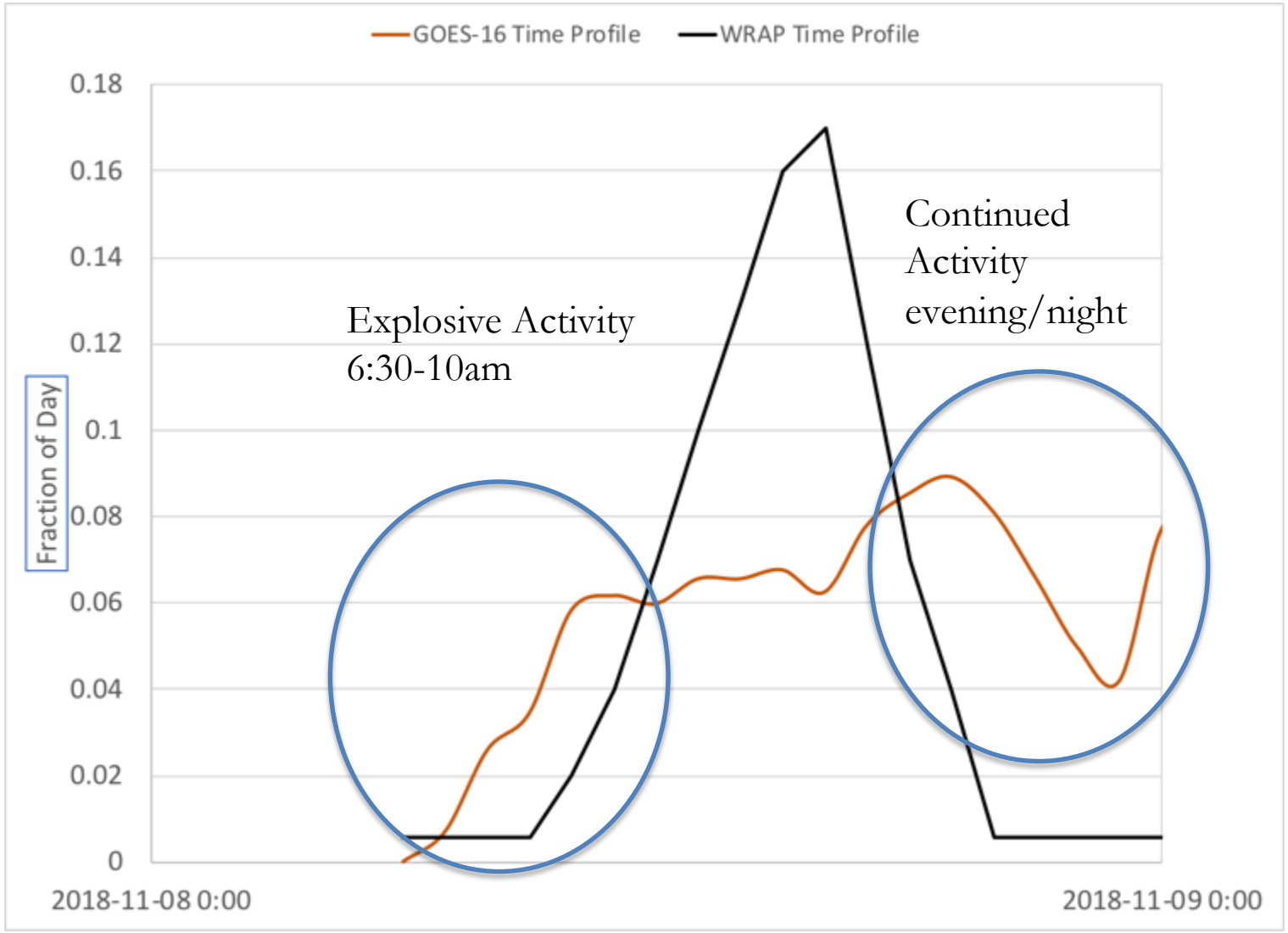
The GOES Fire And Smoke Tool (GoFAST)

- Using GOES-16 to create a diurnal profile of fire emissions
- Sean Raffuse



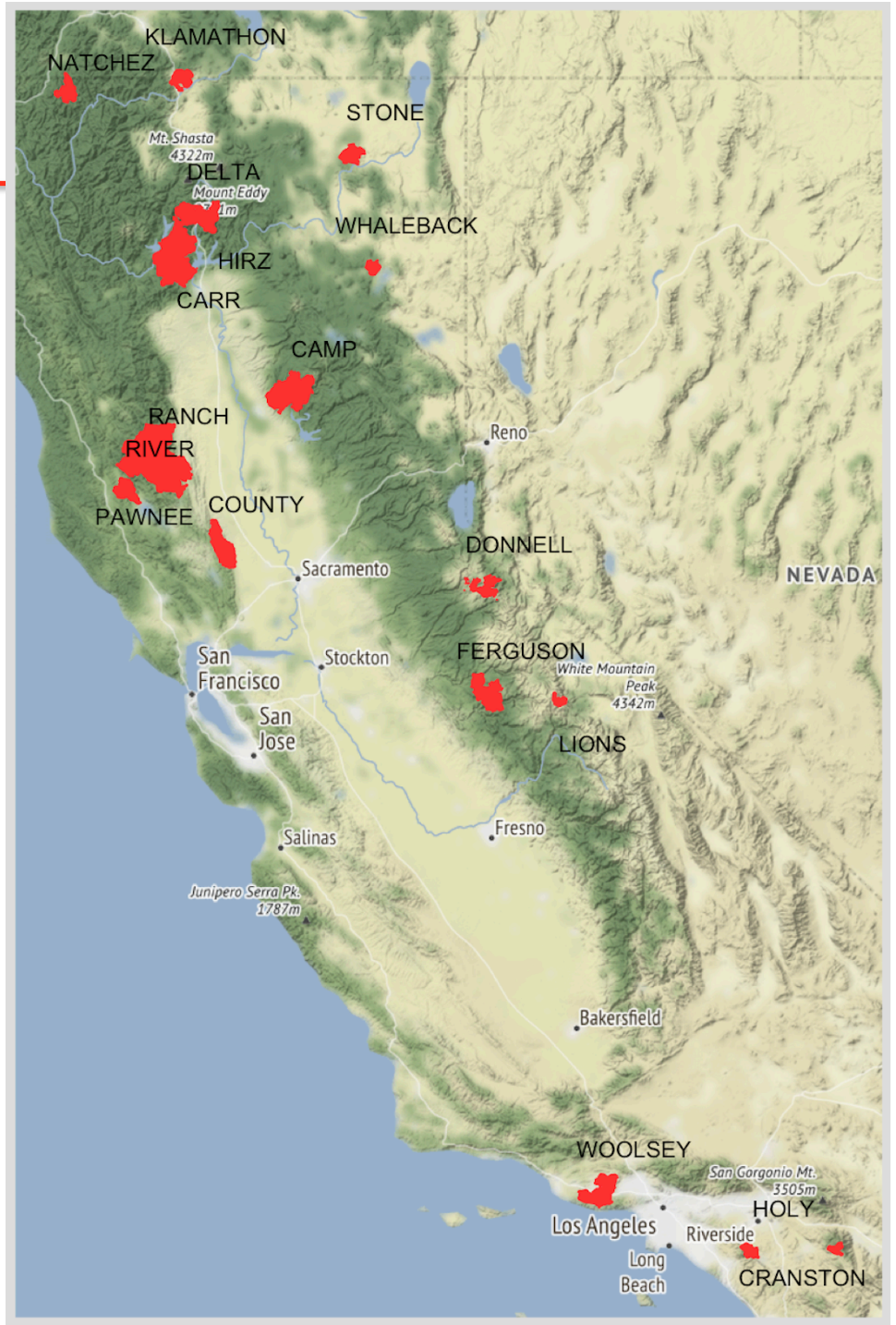
Diurnal Profile (Fire Behavior/Emissions)

- Camp wildfire November 8, 2018
- Figure: 24-hr diurnal profile of emissions
- Motivation: The default diurnal profile obviously does not apply
- Smoke forecasting systems failed



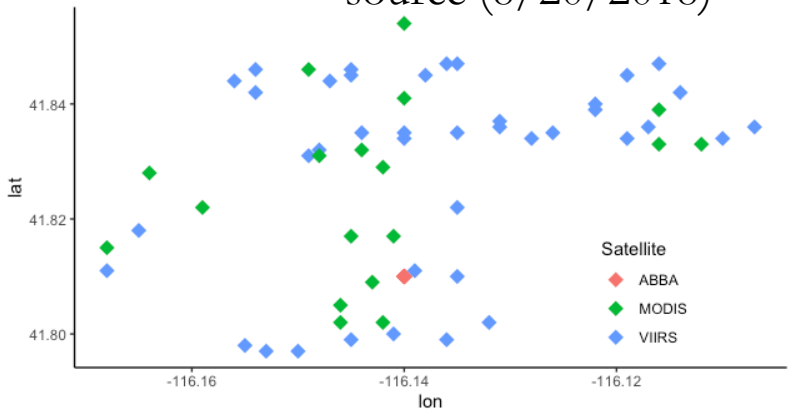
Product: June-November 2018 Fire Emissions Inventory California

- GOES-16 Detections for 18 Wildfires greater than 12K acres
  - Mendocino, Carr, Camp, Woolsey, Ferguson, Lions, Delta etc.
  - 1.48 million acres total

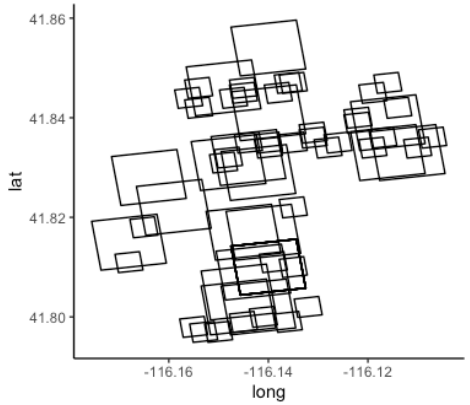


Product: June-November 2018 Fire Emissions Inventory California

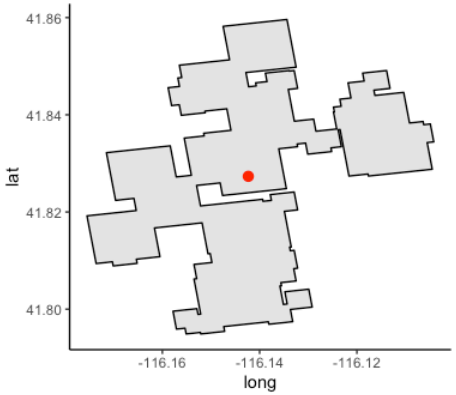
Daily satellite detects by source (8/20/2018)



Create 'box' around each detect. Size based based on source



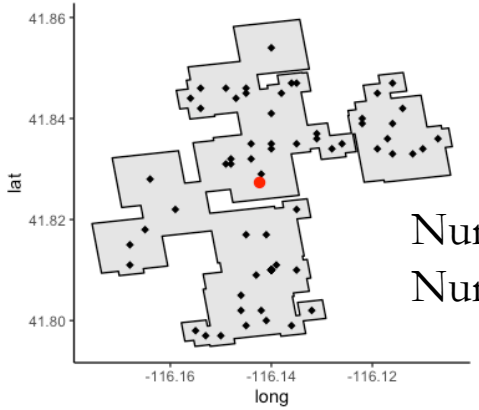
Dissolve each box, resulting in a fire 'location'



Now that we have a fire location, need a size (acres) estimate

Using the number of detects…

… and a reduced number of detects based on 1 km grid



Number of detects: 59
Number of reduced detects: 21

A size (acre) estimate is applied to each reduced detection. The size is based on vegetation type, e.g. 200 acres for grassland, 50 acres forest.

For modeling purposes, detections are aggregated up until a threshold value. Currently 5000 acres.

Approximately 300K acres total

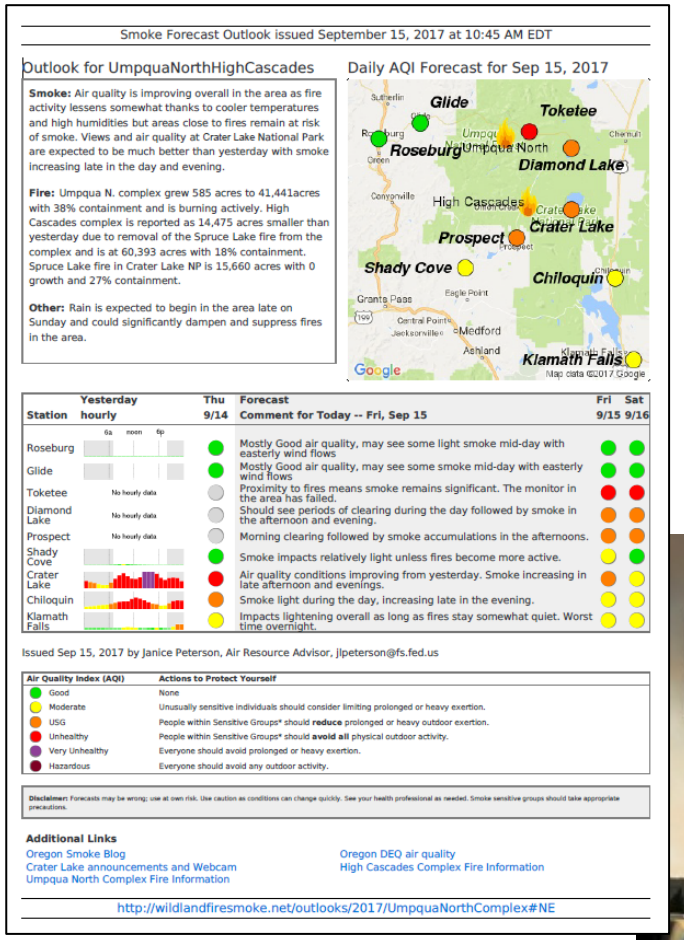
Stakeholder: Interagency Wildland Fire Air Quality Response Program (IWFAQRP)

CONGRESS.GOV

S.47 - John D. Dingell, Jr. Conservation, Management, and Recreation Act

116th Congress (2019-2020) | Get alerts

- Deployment of Air Resource Advisors (ARA) with Incident Management Teams (IMT) or Geographic Area Coordination Centers (GACC)
- Provide: Modeling, Monitoring, Messaging
- MODIS statistical method to initialize the Smoke Outlooks for "today". Marsha and Larkin, 2019.



Smoke Forecast Outlook issued September 15, 2017 at 10:45 AM EDT

Outlook for UmpquaNorthHighCascades

Smoke: Air quality is improving overall in the area as fire activity lessens somewhat thanks to cooler temperatures and high humidities but areas close to fires remain at risk of smoke. Views and air quality at Crater Lake National Park are expected to be much better than yesterday with smoke increasing late in the day and evening.

Fire: Umpqua N. complex grew 585 acres to 41,441acres with 38% containment and is burning actively. High Cascades complex is reported as 14,475 acres smaller than yesterday due to removal of the Spruce Lake fire from the complex and is at 60,393 acres with 18% containment. Spruce Lake fire in Crater Lake NP is 15,660 acres with 0 growth and 27% containment.

Other: Rain is expected to begin in the area late on Sunday and could significantly dampen and suppress fires in the area.

Daily AQI Forecast for Sep 15, 2017

Station	Yesterday hourly	Thu 9/14	Forecast Comment for Today -- Fri, Sep 15	Fri 9/15	Sat 9/16
Roseburg			Mostly Good air quality, may see some light smoke mid-day with easterly wind flows		
Glide			Mostly Good air quality, may see some smoke mid-day with easterly wind flows		
Toketee	No hourly data		Proximity to fires means smoke remains significant. The monitor in the area has failed.		
Diamond Lake	No hourly data		Should see periods of clearing during the day followed by smoke in the afternoon and evening.		
Prospect	No hourly data		Morning clearing followed by smoke accumulations in the afternoons.		
Shady Cove			Smoke impacts relatively light unless fires become more active.		
Crater Lake			Air quality conditions improving from yesterday. Smoke increasing in late afternoon and evenings.		
Chiloquin			Smoke light during the day, increasing late in the evening.		
Klamath Falls			Impacts lightening overall as long as fires stay somewhat quiet. Worst time overnight.		

Issued Sep 15, 2017 by Janice Peterson, Air Resource Advisor, jlpeterson@fs.fed.us

Air Quality Index (AQI)	Actions to Protect Yourself
Good	None
Moderate	Unusually sensitive individuals should consider limiting prolonged or heavy exertion.
USG	People within Sensitive Groups* should **reduce** prolonged or heavy outdoor exertion.
Unhealthy	People within Sensitive Groups* should **avoid all** physical outdoor activity.
Very Unhealthy	Everyone should avoid prolonged or heavy exertion.
Hazardous	Everyone should avoid any outdoor activity.

Disclaimer: Forecasts may be wrong; use at own risk. Use caution as conditions can change quickly. See your health professional as needed. Smoke sensitive groups should take appropriate precautions.

Additional Links

Oregon Smoke Blog
Crater Lake announcements and Webcam
Umpqua North Complex Fire Information
Oregon DEQ air quality
High Cascades Complex Fire Information

http://wildlandfiresmoke.net/outlooks/2017/UmpquaNorthComplex#NE

The Basics of Satellite Data for Smoke and Fire

Online Training (15 min)

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)

What is a polar orbiting versus geostationary satellite?
What are the instruments on commonly used satellites?
What are the products from these instruments?

Required training for Air Resource Advisors
https://sites.google.com/firenet.gov/wfaqrp-airfire/projects/haqast/2017NorthernCAWildfiresTT/training

Name	Instrument	Products	Temporal Resolution, Overpass Time	Spatial Resolution	Polar/Geo	Launch Date	Operational Date
GOES-16	ABI	Visible, FRP, AOD, Fire Hot Spot, Smoke Mask	5-min CONUS, 10/15-min Full Disk	0.5 – 2-km	Geo	November 2016	December 2017
GOES-17	ABI	Visible, FRP, AOD, Fire Hot Spot, Smoke Mask	5-min CONUS, 10/15-min Full Disk	0.5 – 2-km	Geo	November 2018	February 2019
Terra	MODIS	Visible, FRP, AOD, Fire Hot Spot	Equator Overpass 10:30 am local time	250-m, 500-m, 1-km	Polar	December 1999	November 2000
Aqua	MODIS	Visible, FRP, AOD, Fire Hot Spot	Equator Overpass 13:30 pm local time	250-m, 500-m, 1-km	Polar	May 2002	July 2002
Suomi-NPP	VIIRS	Visible, FRP, AOD, 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, AOD, Fire Hot Spot, Smoke Mask	Equator Overpass 12:40 pm local time	375-m, 750-m	Polar	November 2017	May 2018
Landsat (note: there are 8 current Landsat satellites)	Variable, depending on satellite. For Landsat 8, OLI and TIRS	Visible, surface temp	Equator Overpass 10:00am local time	30-m	Polar	Feb, 2013	April, 2013

Satellite Information for Smoke

- NASA Worldview
  https://worldview.earthdata.nasa.gov/
  - VIIRS, MODIS
  - Visible smoke imagery, AOD, Fire Detections
  - Easy to add many layers
  - LOTS more

- College of Dupage https://weather.cod.edu/satrad/
  - GOES-16 (fast)

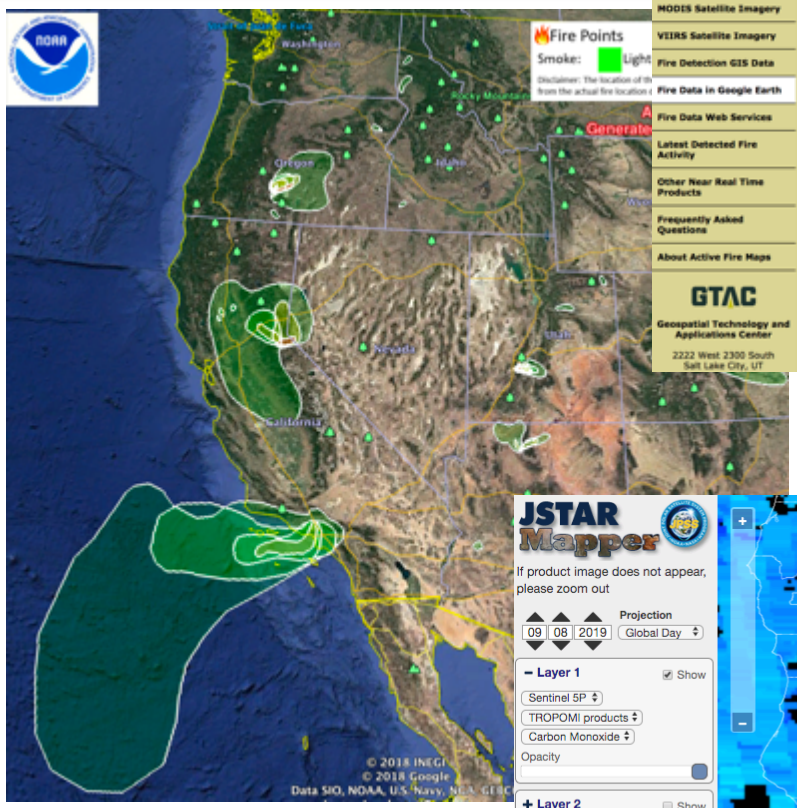
- CSU CIRA http://rammb-slider.cira.colostate.edu/
  - GOES-16, GOES-17 (be patient)

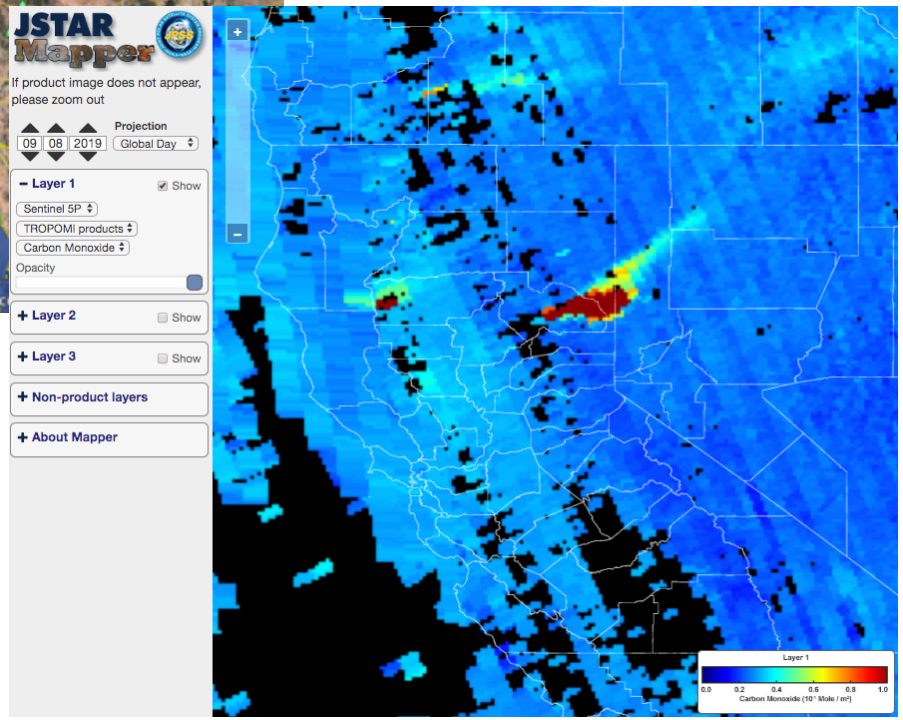
- NOAA AerosolWatch
  https://www.star.nesdis.noaa.gov/smcd/spb/aq/AerosolWatch/
  - GOES-16/17, VIIRS
  - AOD, Fire Detections, Surface Monitors

Satellite Information for Smoke

- NOAA Hazard Mapping System
  https://www.ospo.noaa.gov/Products/land/hms.html
- USFS Geospatial Technology and Applications Center
  https://fsapps.nwcg.gov/afm/googleearth.php
  - VIIRS, MODIS Fire Detections
  - Google Earth
- JPSS JSTAR Mapper
  https://www.star.nesdis.noaa.gov/jpss/mapper
  - Suomi NPP, NOAA-20, Sentinal 5P (CO, NO2)
- University of Wisconsin RealEarth
  https://realearth.ssec.wisc.edu
- NASA ARSET Training
  https://arset.gsfc.nasa.gov/

… others





Upcoming Conferences and HAQAST2020

HAQAST2020 Webinars

- **Brad Pierce**. 2/25/2020. The Brightest Idea: New Capabilities for Infusing Satellite Data into Environmental Applications–International (IDEA-I)

13th Fire and Forest Meteorology Symposium

Track on Santa Ana, Diablo, Sundowner Winds

12-14 May 2020, Palm Springs, CA

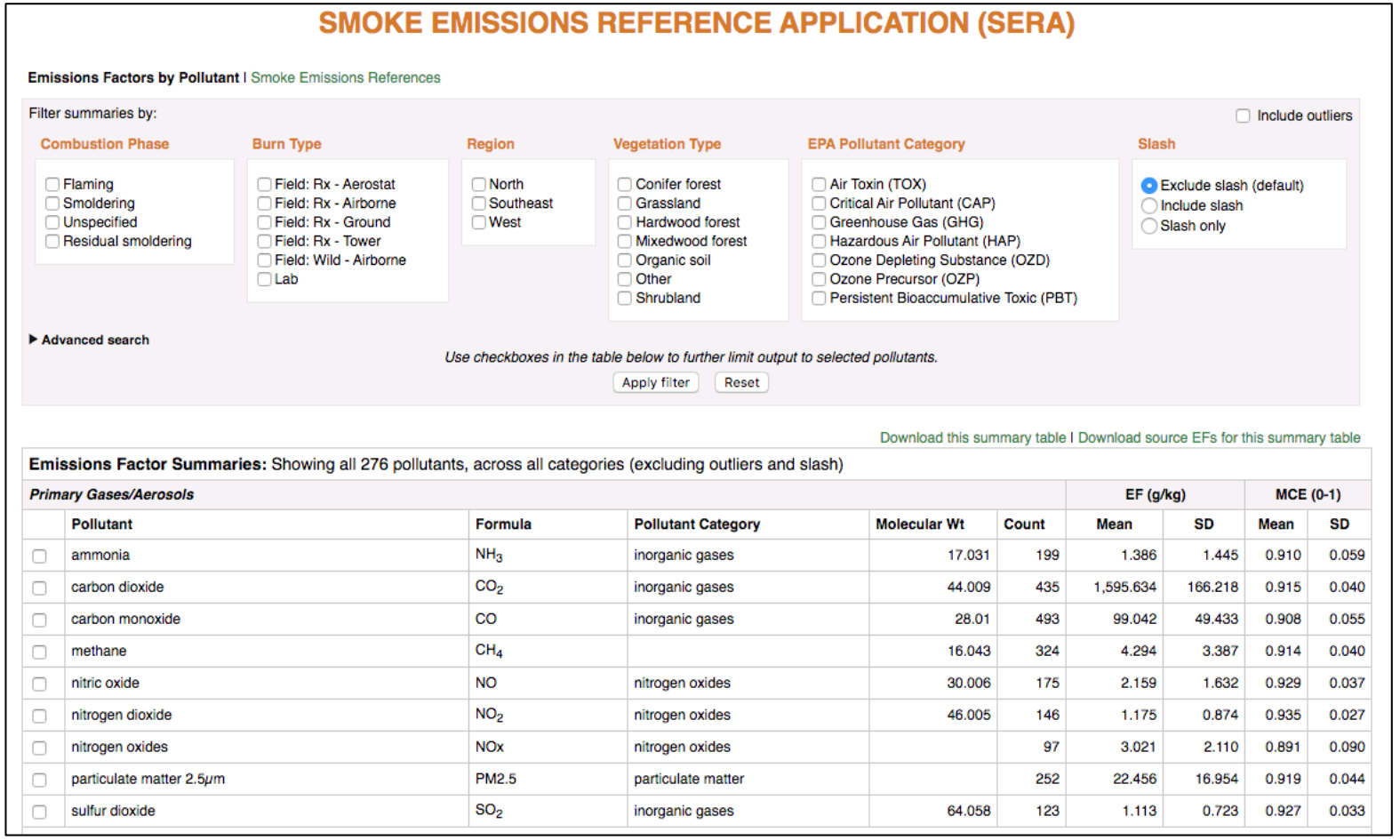
HAQAST2020 Webinars

- **Jason West**. 3/5/2020. Pollutant Concentration Mapping to Support Health Impact Assessment: Global Ozone Concentrations, and PM from California Wildfires
- **Minghui Diao**. 3/10/2020. The Air in Your Community: Estimating Surface PM2.5 in California with a Fusion of Monitor Data, Satellite Observations, and Downscale Modeling

Smoke Emissions Reference Application (SERA)

https://depts.washington.edu/nwfire/sera/index.php

- North American Emission Factor (EF) Standardization Project
- Emission factors are a critical component in calculating fire emissions
- Update systems such as CONSUME, FOFEM, BlueSky
- Significant literature review.
- Approximately 300 trace gas and aerosol species. Over 12K records in database.
- User Interface. Sort and summarize EF data by:
  Combustion Phase
  Burn Type (Wildfire, Rx, Lab)
  Region
  Vegetation Type
  Pollutant Category
- Download raw data.
- NWCG and SERDP funded work.



SMOKE EMISSIONS REFERENCE APPLICATION (SERA)

Emissions Factors by Pollutant | Smoke Emissions References

Filter summaries by: Include outliers

Combustion Phase: Flaming; Smoldering; Unspecified; Residual smoldering

Burn Type: Field: Rx - Aerostat; Field: Rx - Airborne; Field: Rx - Ground; Field: Rx - Tower; Field: Wild - Airborne; Lab

Region: North; Southeast; West

Vegetation Type: Conifer forest; Grassland; Hardwood forest; Mixedwood forest; Organic soil; Other; Shrubland

EPA Pollutant Category: Air Toxin (TOX); Critical Air Pollutant (CAP); Greenhouse Gas (GHG); Hazardous Air Pollutant (HAP); Ozone Depleting Substance (OZD); Ozone Precursor (OZP); Persistent Bioaccumulative Toxic (PBT)

Slash: Exclude slash (default); Include slash; Slash only

▶ Advanced search

Use checkboxes in the table below to further limit output to selected pollutants.

Apply filter Reset

Download this summary table | Download source EFs for this summary table

Emissions Factor Summaries: Showing all 276 pollutants, across all categories (excluding outliers and slash)

Primary Gases/Aerosols					EF (g/kg)		MCE (0-1)	
Pollutant	Formula	Pollutant Category	Molecular Wt	Count	Mean	SD	Mean	SD
ammonia	NH_3	inorganic gases	17.031	199	1.386	1.445	0.910	0.059
carbon dioxide	CO_2	inorganic gases	44.009	435	1,595.634	166.218	0.915	0.040
carbon monoxide	CO	inorganic gases	28.01	493	99.042	49.433	0.908	0.055
methane	CH_4		16.043	324	4.294	3.387	0.914	0.040
nitric oxide	NO	nitrogen oxides	30.006	175	2.159	1.632	0.929	0.037
nitrogen dioxide	NO_2	nitrogen oxides	46.005	146	1.175	0.874	0.935	0.027
nitrogen oxides	NOx	nitrogen oxides		97	3.021	2.110	0.891	0.090
particulate matter 2.5µm	PM2.5	particulate matter		252	22.456	16.954	0.919	0.044
sulfur dioxide	SO_2	inorganic gases	64.058	123	1.113	0.723	0.927	0.033

Prichard, S.J., S.M. O'Neill, P. Eagle, A.G. Andreu, B. Drye, J. Dubowy, S. Urbanski, and T.M. Strand. 2020. Wildland fire emissions factors in North America: synthesis of existing data, measurement needs and management applications. *International Journal of Wildland Fire*. https://doi.org/10.1071/WF19066.

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