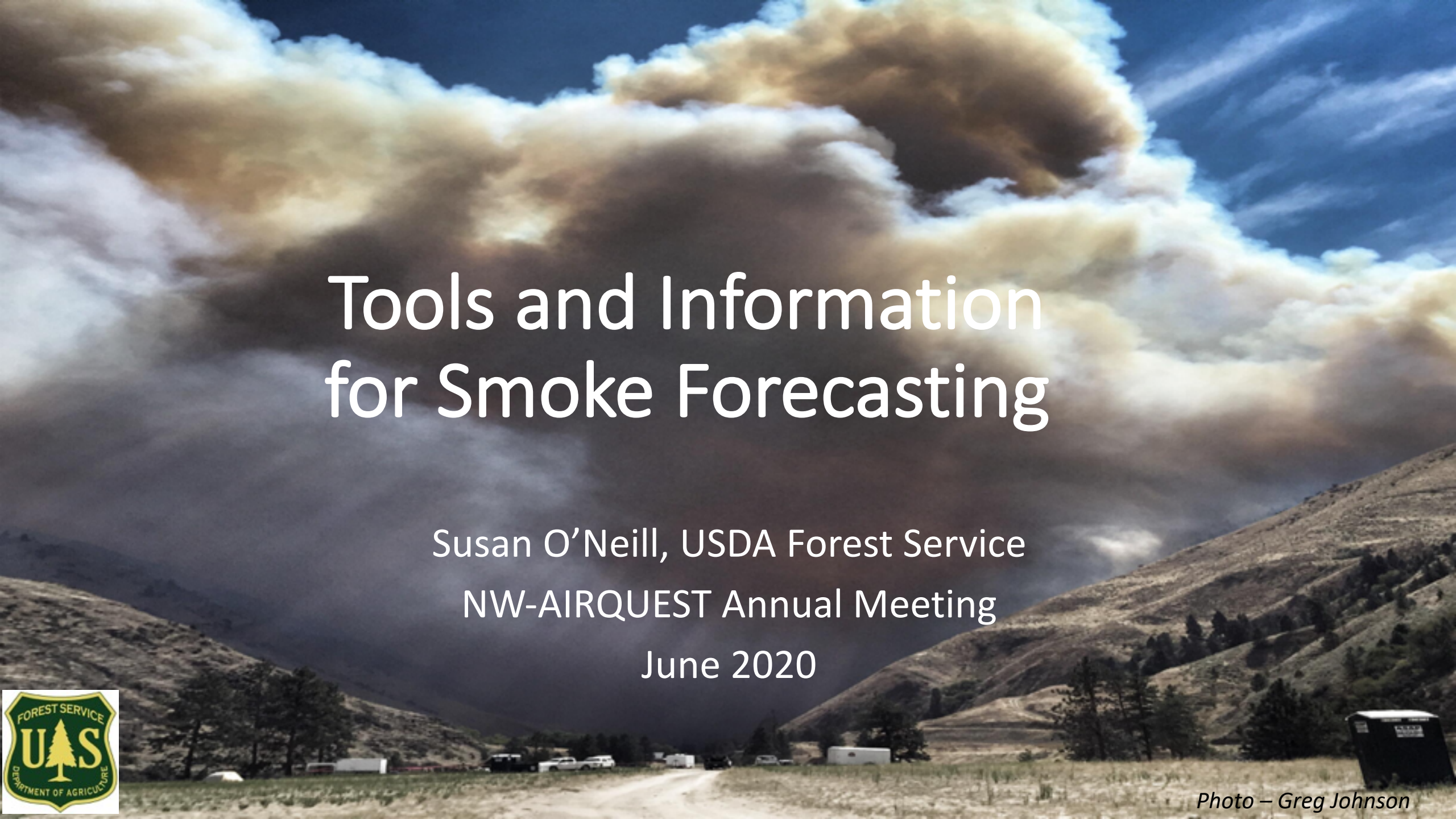


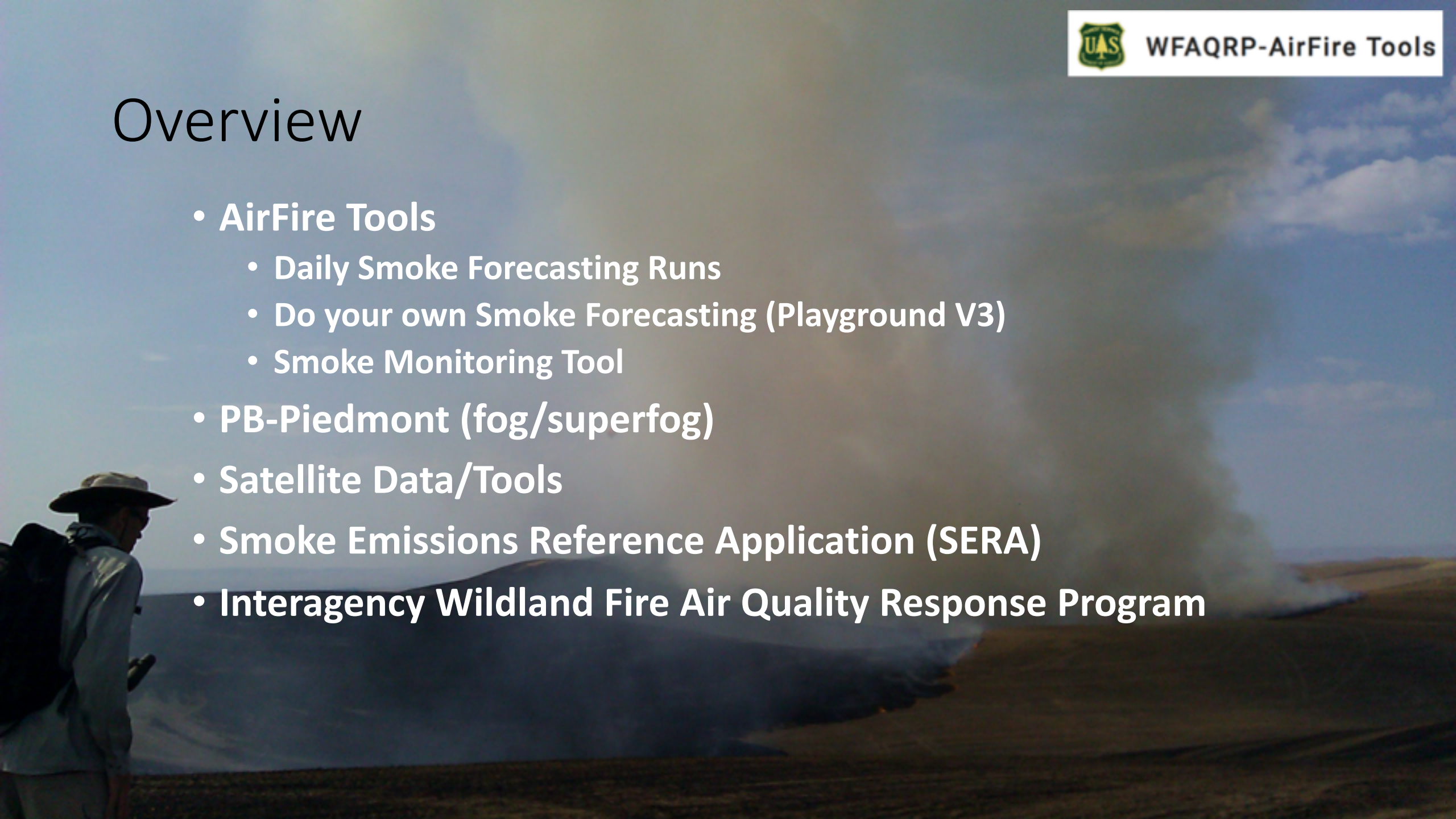
Tools and Information for Smoke Forecasting

Susan O'Neill, USDA Forest Service

NW-AIRQUEST Annual Meeting

June 2020

Photo – Greg Johnson



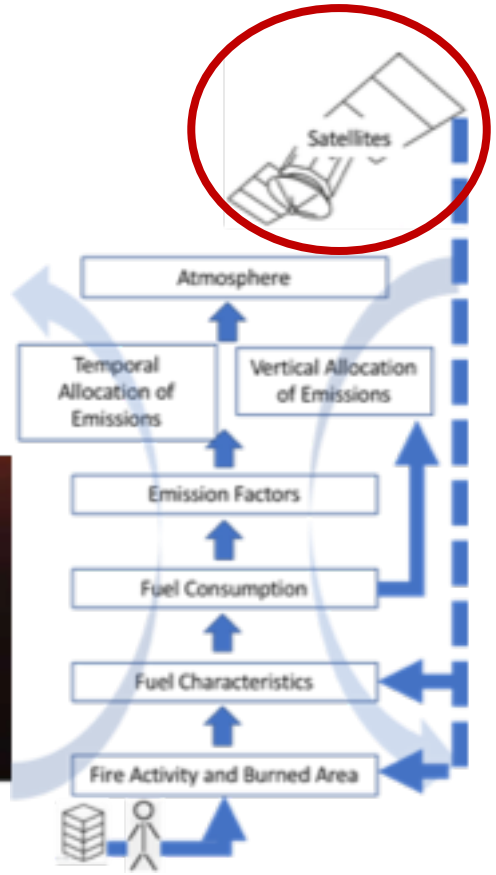
WFAQRP-AirFire Tools

Overview

- **AirFire Tools**
  - **Daily Smoke Forecasting Runs**
  - **Do your own Smoke Forecasting (Playground V3)**
  - **Smoke Monitoring Tool**
- **PB-Piedmont (fog/superfog)**
- **Satellite Data/Tools**
- **Smoke Emissions Reference Application (SERA)**
- **Interagency Wildland Fire Air Quality Response Program**

Tools for Wildfire and Rx Fire Smoke

https://tools.airfire.org/



Wildland Fire / Air Quality Tools

This page provides links to the most recent versions of tools produced by the U.S. Forest Service PNW Research Station's Pacific Wildland Fire Sciences Laboratory in support of wildland fire operations.

REAL TIME SMOKE TOOLS

PM2.5 Monitoring

Aggregated ground monitoring information More info

BlueSky Daily Run Viewer

Visualize daily smoke forecasts More info

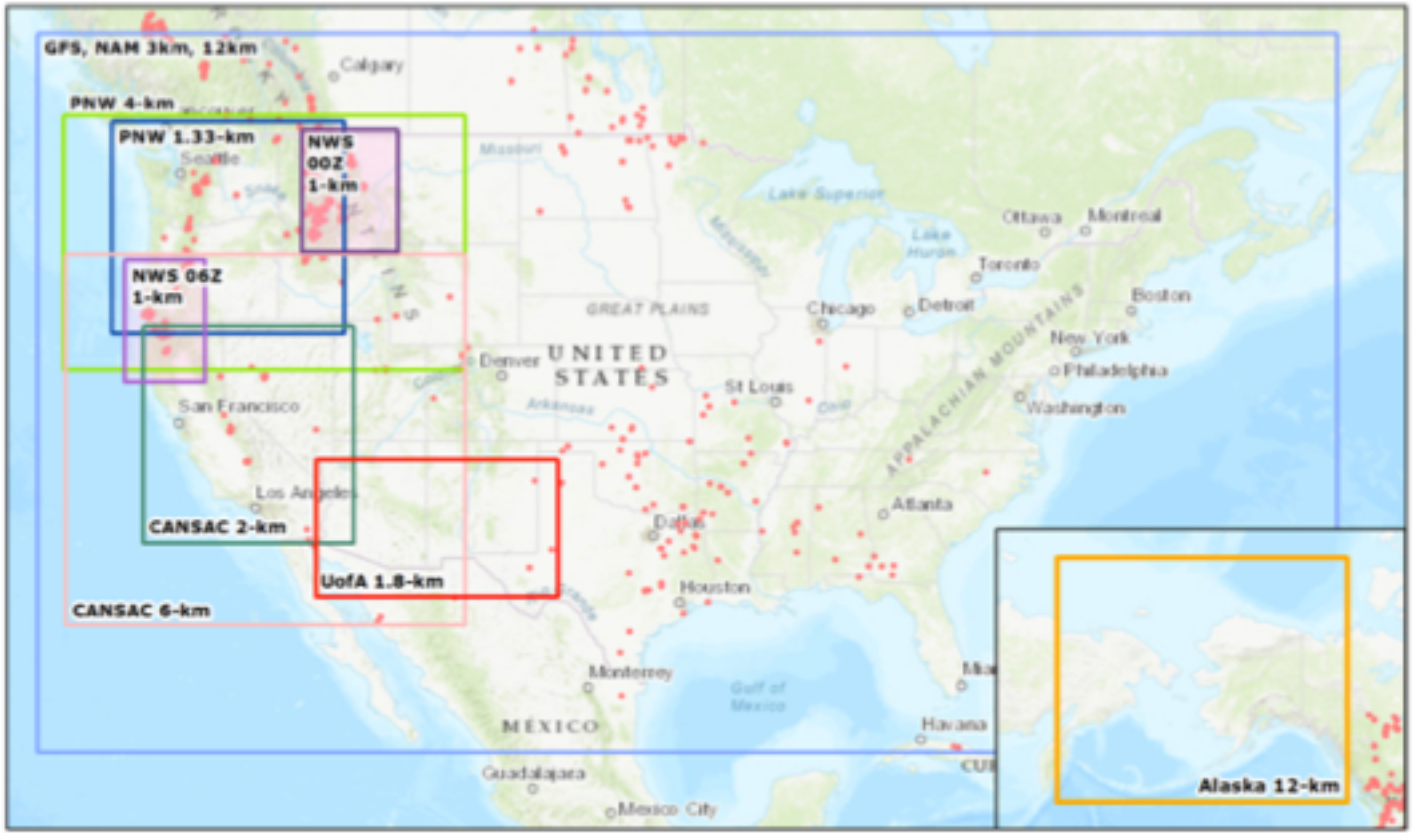
BlueSky Playground

Customized emissions and dispersion modeling More info

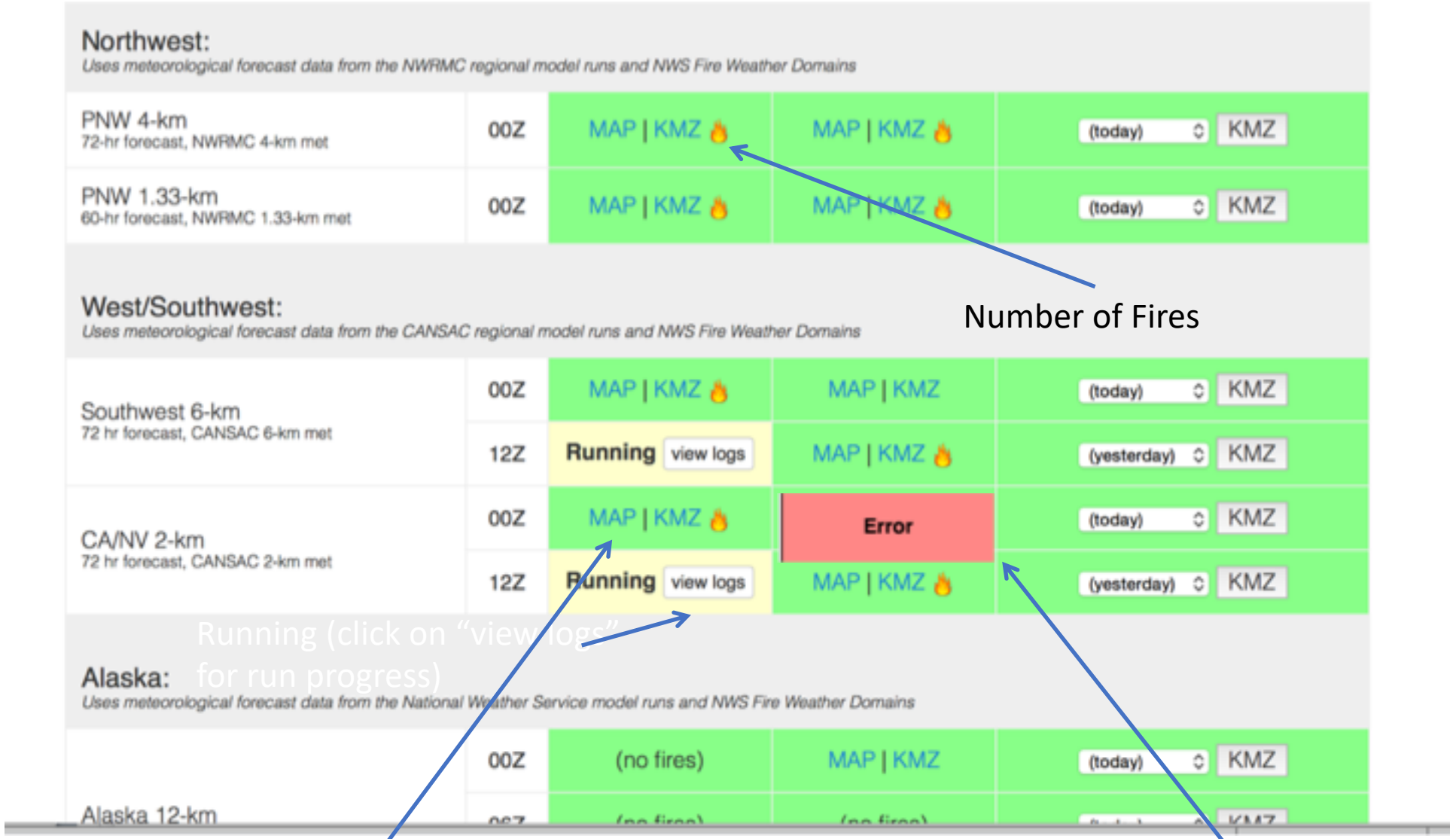
WFAQRP-AirFire Tools

Tailored Smoke Predictions Delivered to Incident Management Teams

- Domains
  - 1.33-km PNW
  - 4-km PNW
  - 1.33-km CA/NV
  - 4-km Western US
  - 12-km CONUS
  - 3-km CONUS
  - 12-km Alaska
  - 1.8-km AZ/NM
  - 1.27-km FW (moveable)
- Meteorology from: NWS, UW, DRI, UofA



- HYSPLIT – Primary near-surface 1-hr PM2.5



Number of Fires

Running (click on "view logs" for run progress)

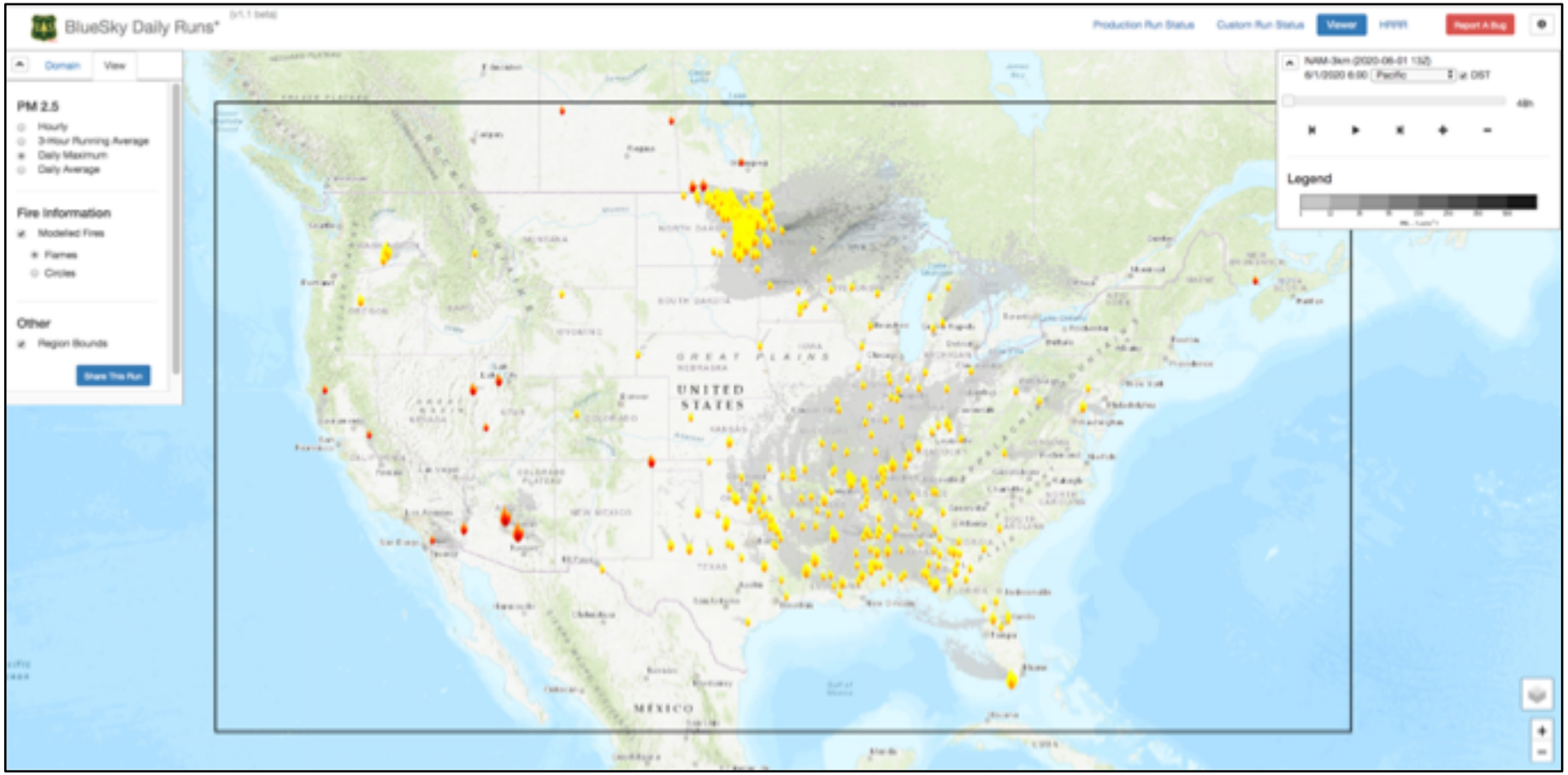
Successful!

Failures show up in red.

Website shows status of current runs

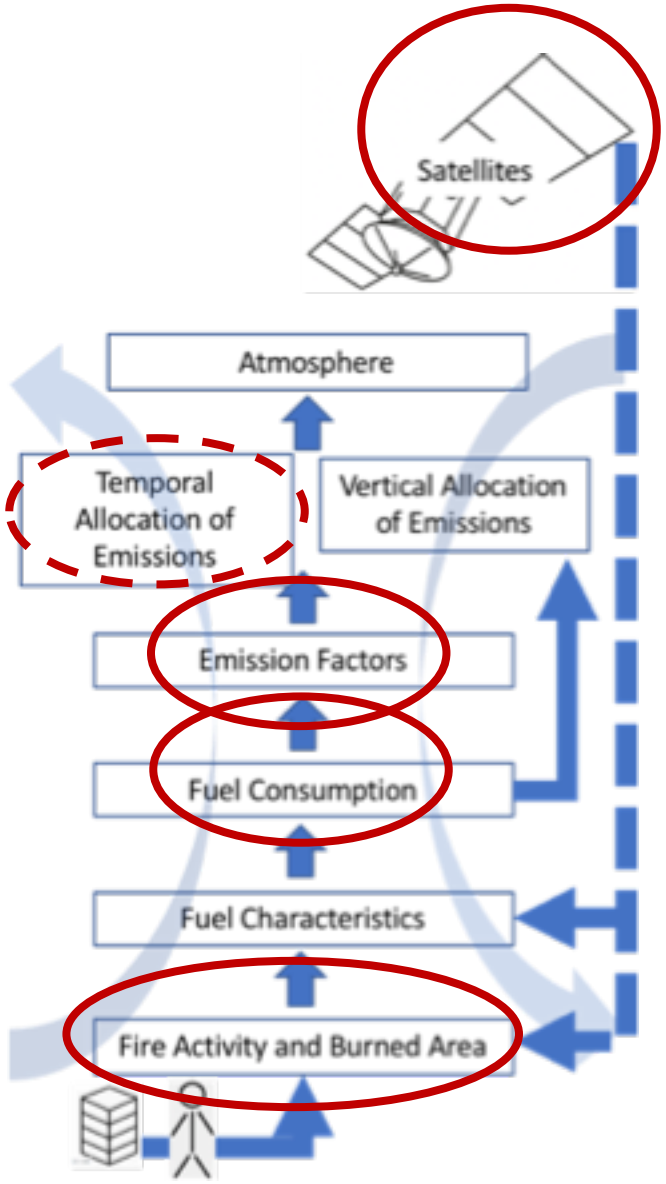
Tailored Smoke Predictions Delivered to Incident Management Teams

- Fire Activity Information
- NOAA Hazard Mapping System (HMS) Satellite Fire Detections
- Example: 3-km NAM meteorology 6/1/2020



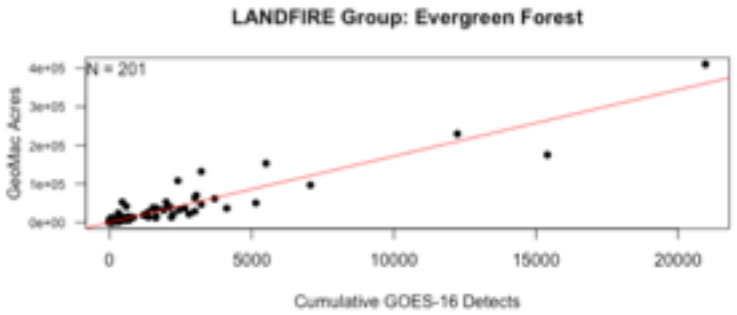
Recent Updates

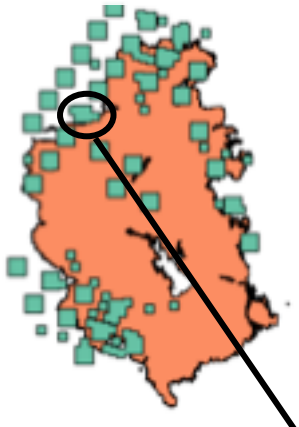
- Satellite and Ground-Based Fire Activity Information
- Major revision of underlying code
- CONSUME V5
  - *S.J. Prichard, M.C. Kennedy, C.S. Wright, J.B. Cronan, R.D. Ottmar. 2017. Predicting forest floor and woody fuel consumption from prescribed burns in southern and western pine ecosystems of the United States. Forest Ecology and Management, Volume 405, Pages 328-338, ISSN 0378-1127, https://doi.org/10.1016/j.foreco.2017.09.025.*
- Emission Factors
  - *Prichard, O'Neill, Eagle, Andreu, Drye, Dubowy, Urbanski, Strand. 2020. Wildland fire emission factors in North America: synthesis of existing data, measurement needs and management applications. IJWF https://doi.org/10.1071/WF19066*
- Current Research – Diurnal Profile(s)
  - *GOES-16: Custom profiles for Wildfires (O'Neill and Raffuse. 2020. High Temporal Resolution Satellite Fire Detection Data Provide Important Improvements in Smoke Forecasting for Large Wildfires. Eos. Submitted)*
  - *Li, F., X. Zhang, D. P. Roy, S. Kondragunta. 2019. Estimation of biomass-burning emissions by fusing the fire radiative power retrievals from polar-orbiting and geostationary satellites across the conterminous United States. Atmospheric Environment, Volume 211, Pages 274-287, ISSN 1352-2310. https://doi.org/10.1016/j.atmosenv.2019.05.017.*



Fire Information System (FIS) - Spider

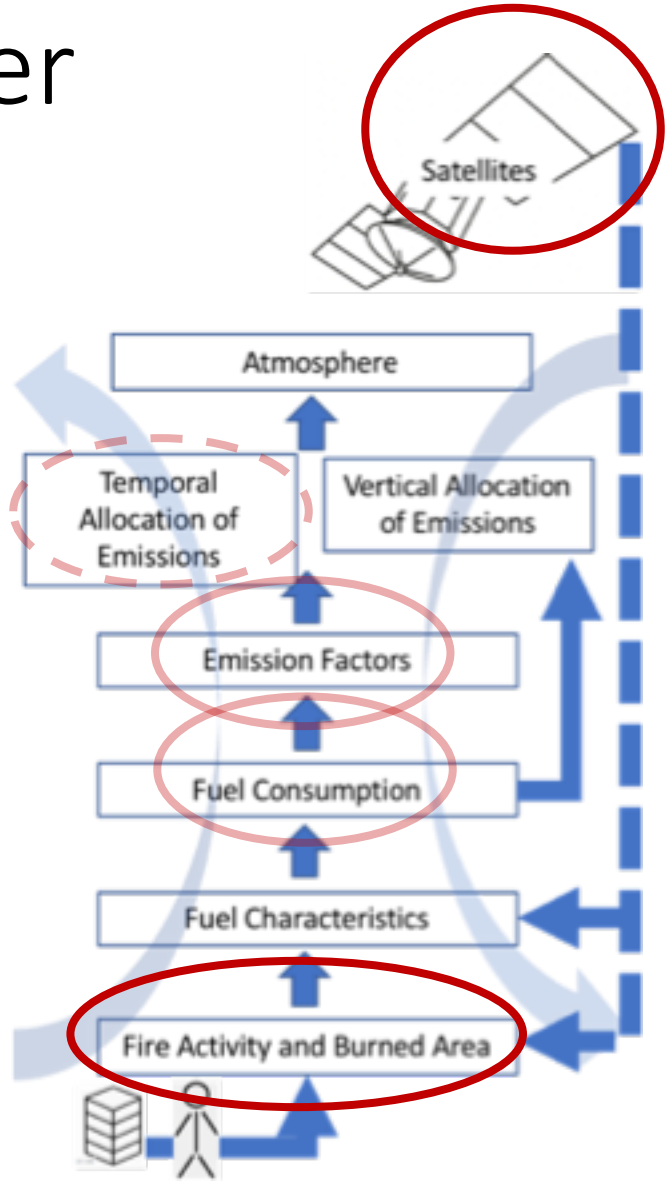
- Fire Information System
  - Aggregation of multiple satellite detection sources and fire information (perimeters)
  - Association of satellite data to known fires
  - Estimation of active burning area via statistical relationship per detection source and vegetation type
- Spider
  - GOES-16
  - Max area of other two options (VIIRS, MODIS-nominally)
- Using HMS
  - Direct datafeeds of GOES-16/17, MODIS, VIIRS





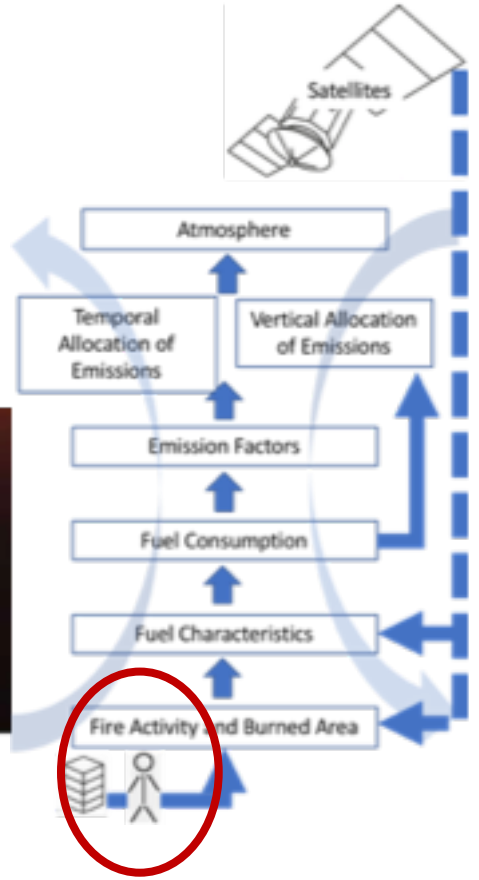
Carr Fire, 8/4/2018
Clustered detects from 8/4/2018

Landfire Vegetation Group: 7 (Evergreen Tree)
Number of GOES-16 detects: 23
Number of HMS detects: 8
Estimated area from GOES-16: 391 acres
Estimated area from HMS: 320 acres



Tools for Wildfire and Rx Fire Smoke

https://tools.airfire.org/



Wildland Fire / Air Quality Tools

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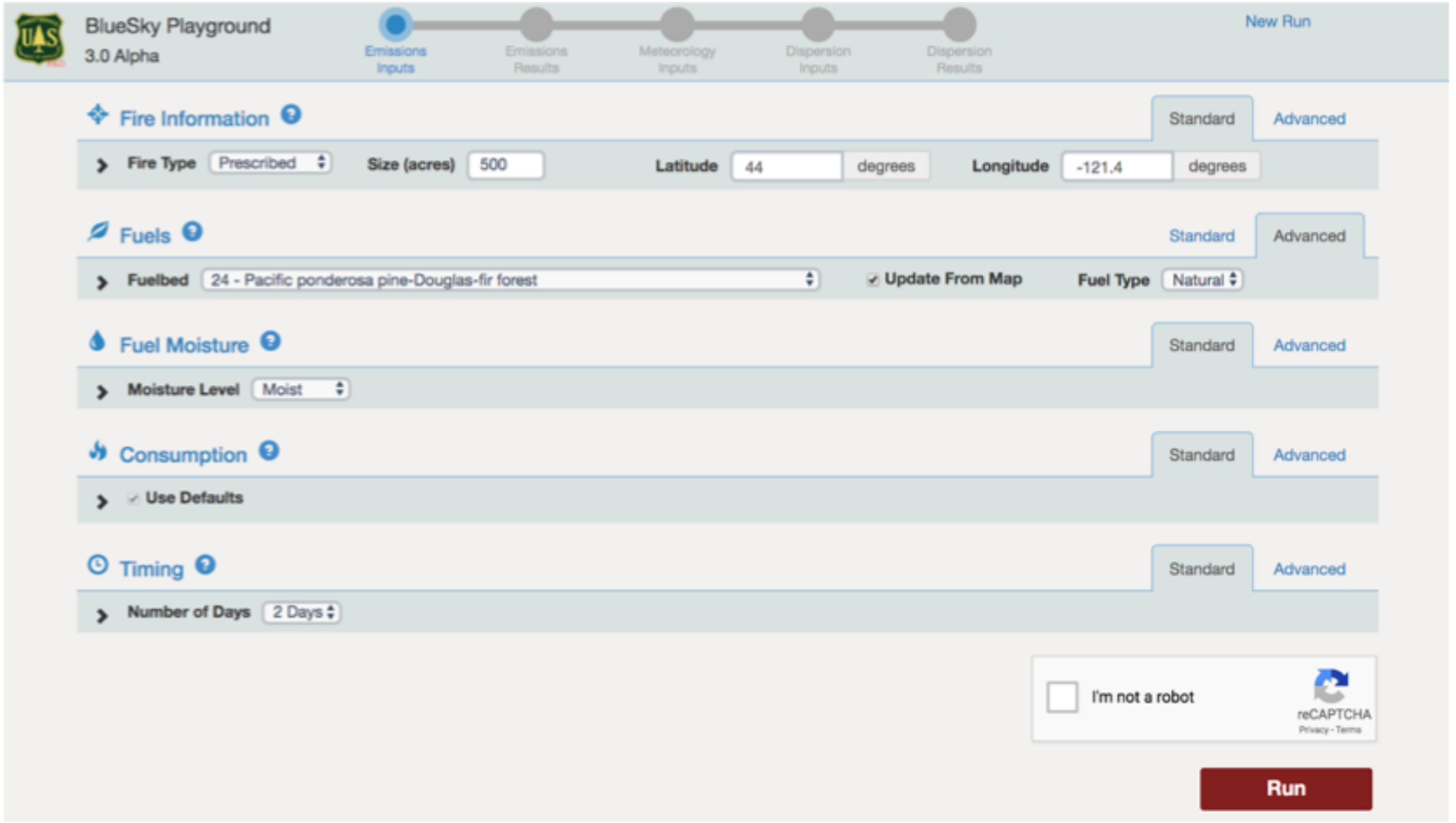
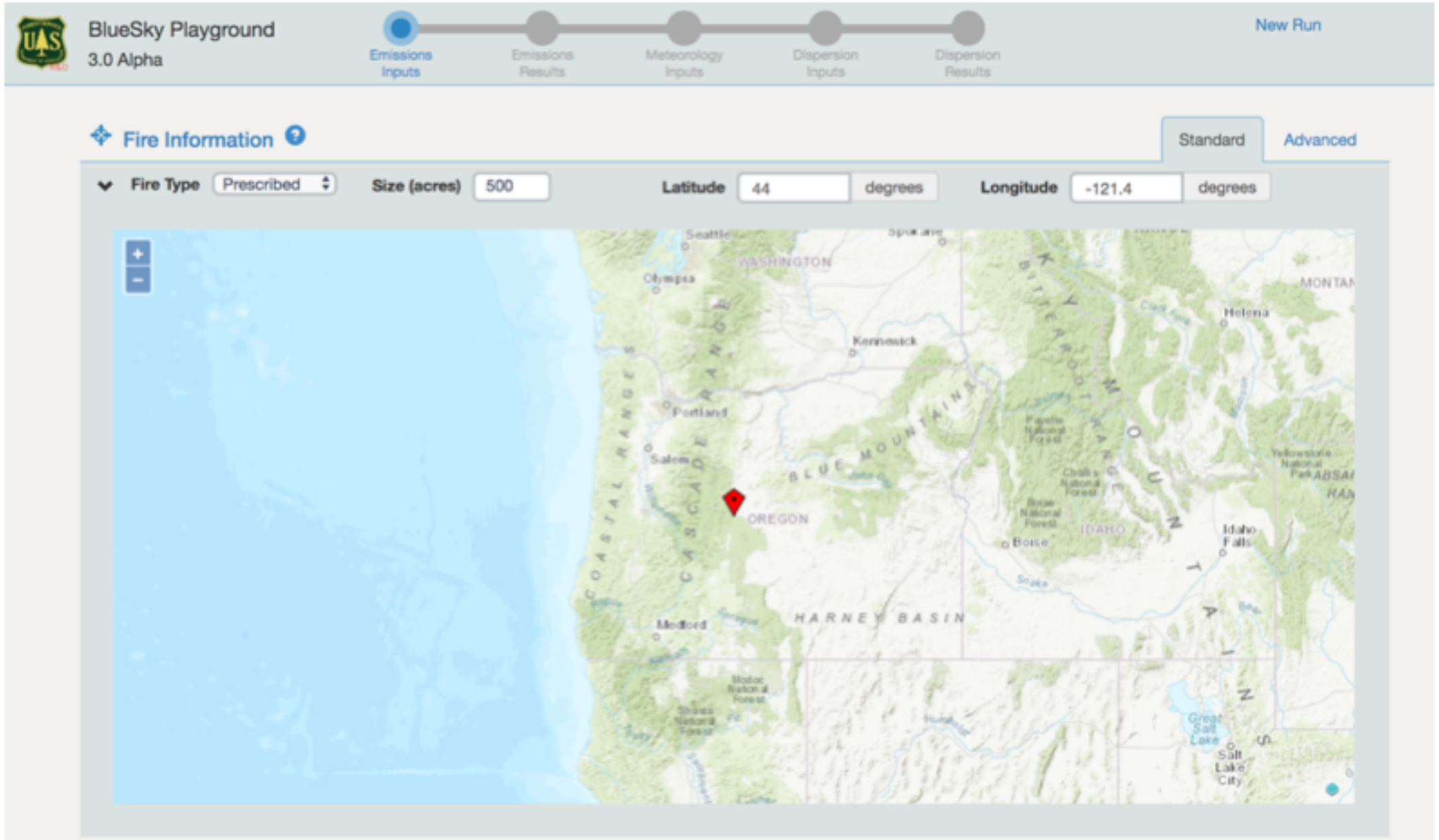
WFAQRP-AirFire Tools

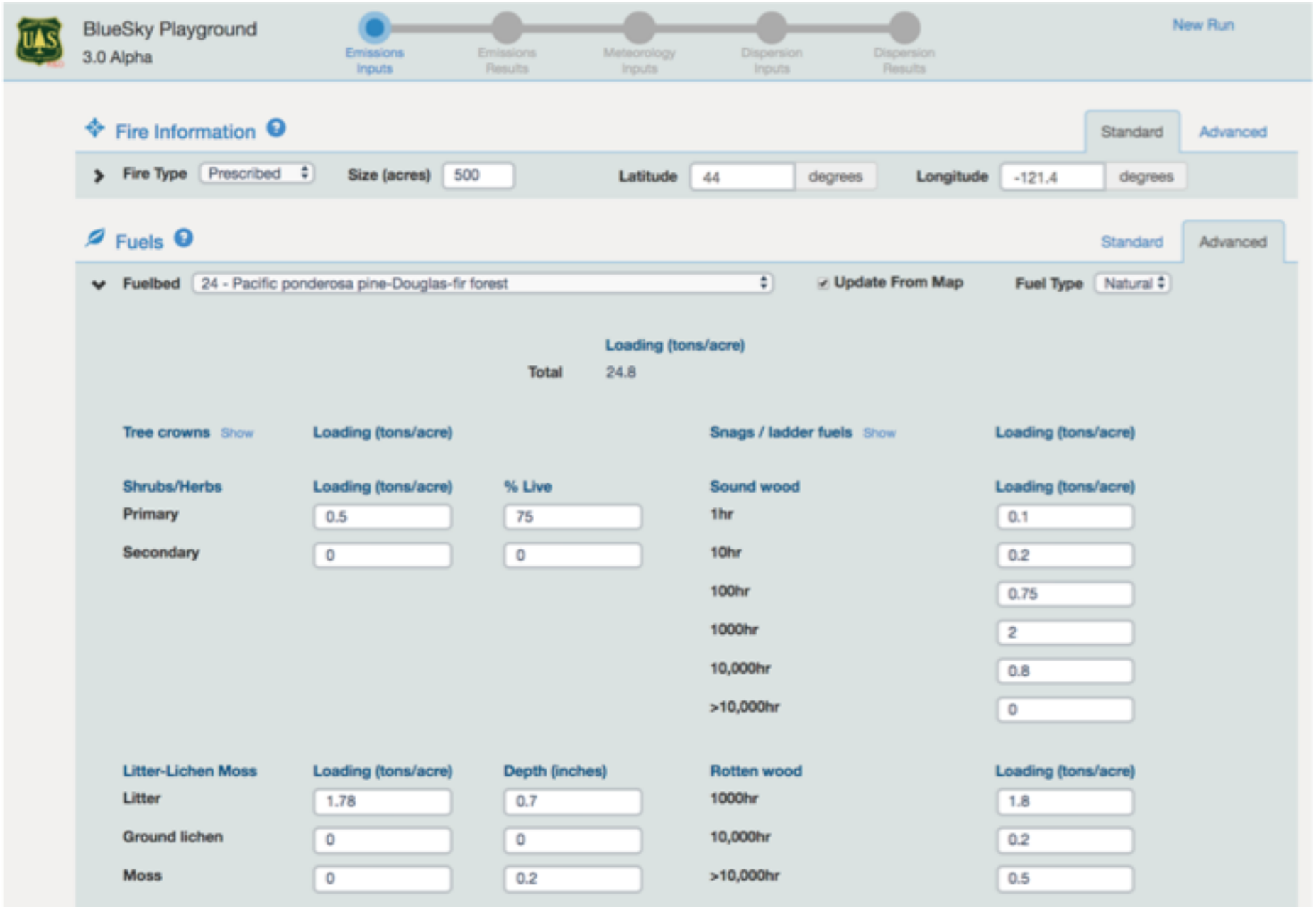
BlueSky Playground V3 (PGV3)



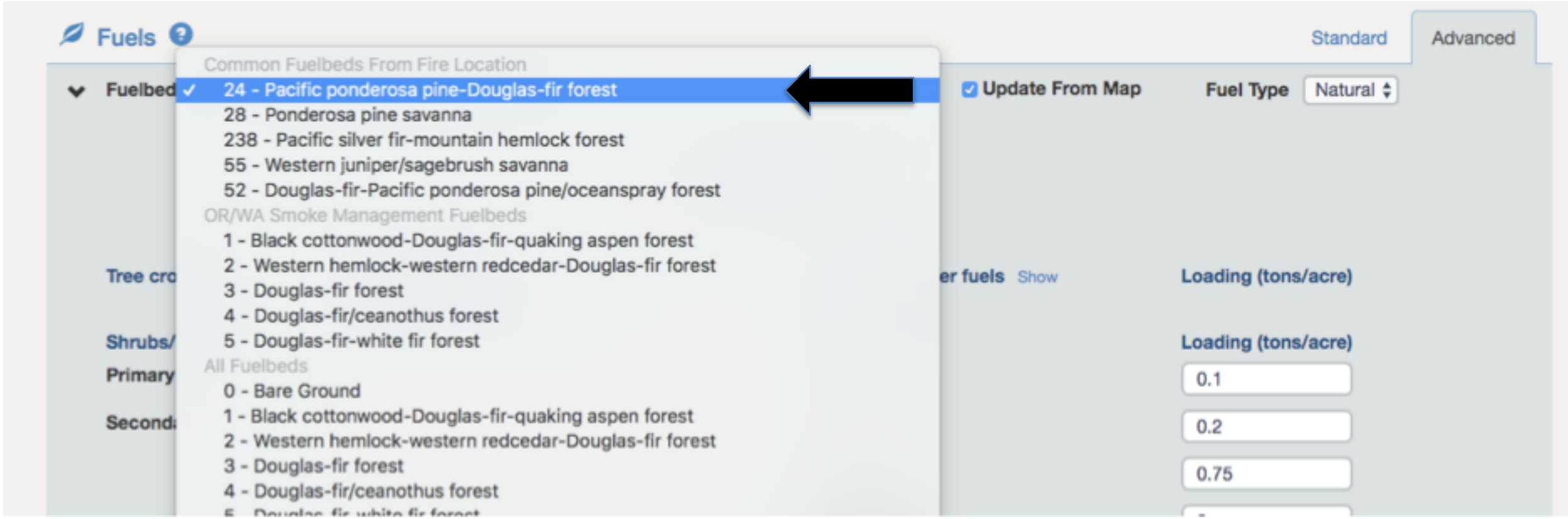
PGV3 – Fire Location



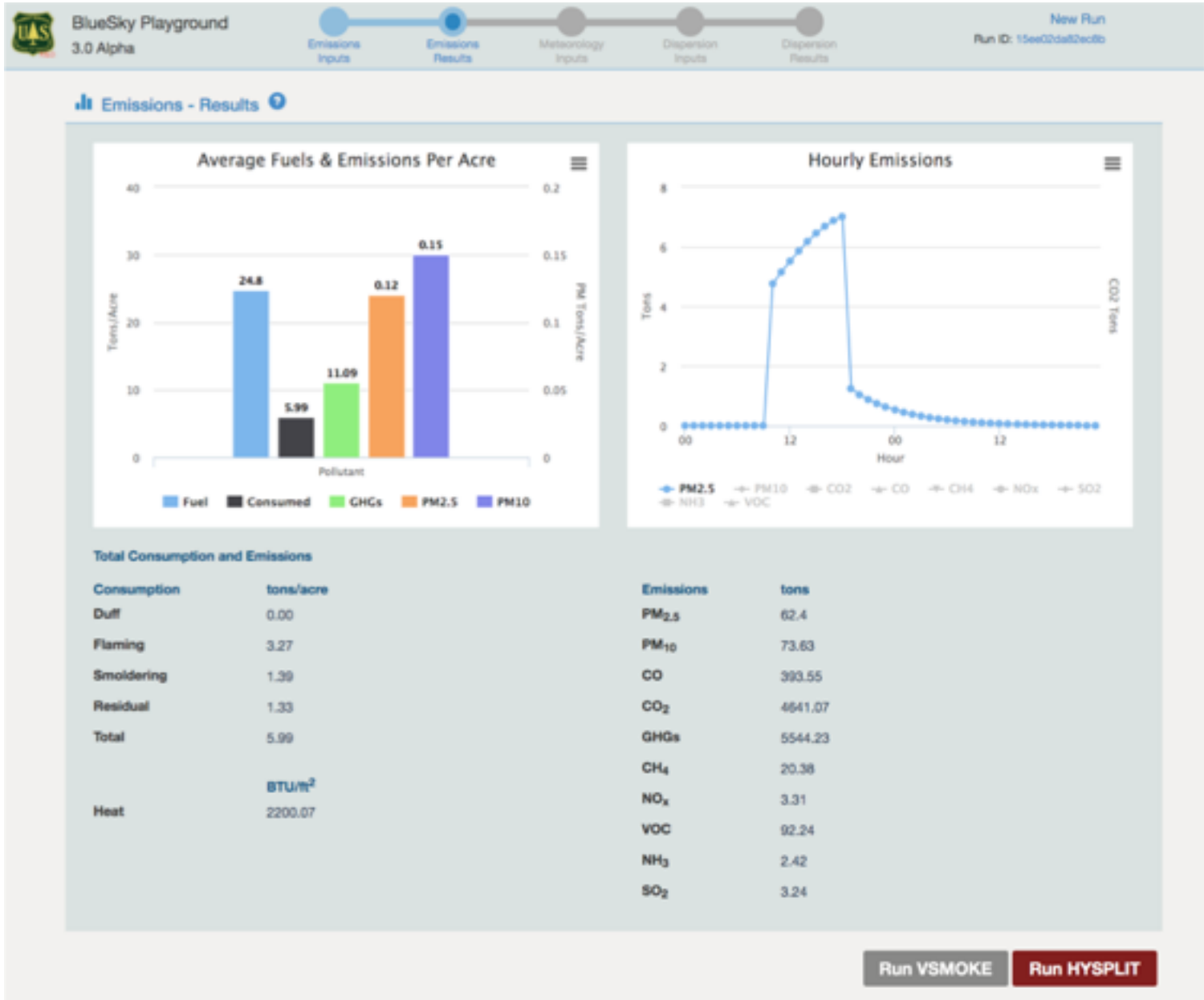
PGV3 – Fuels Inputs



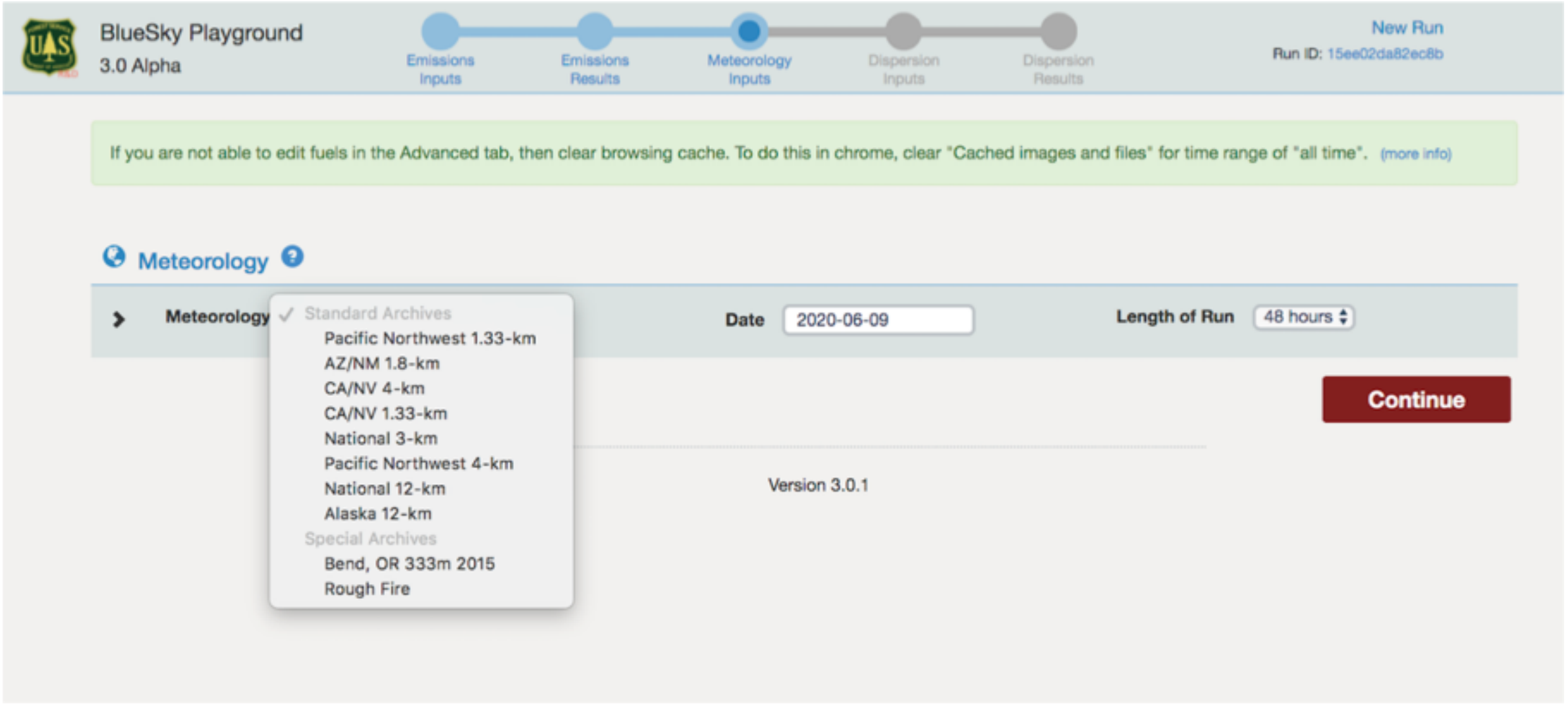
PGV3 – Fuelbed Selection



PGV3 – Emissions and Consumption Summary

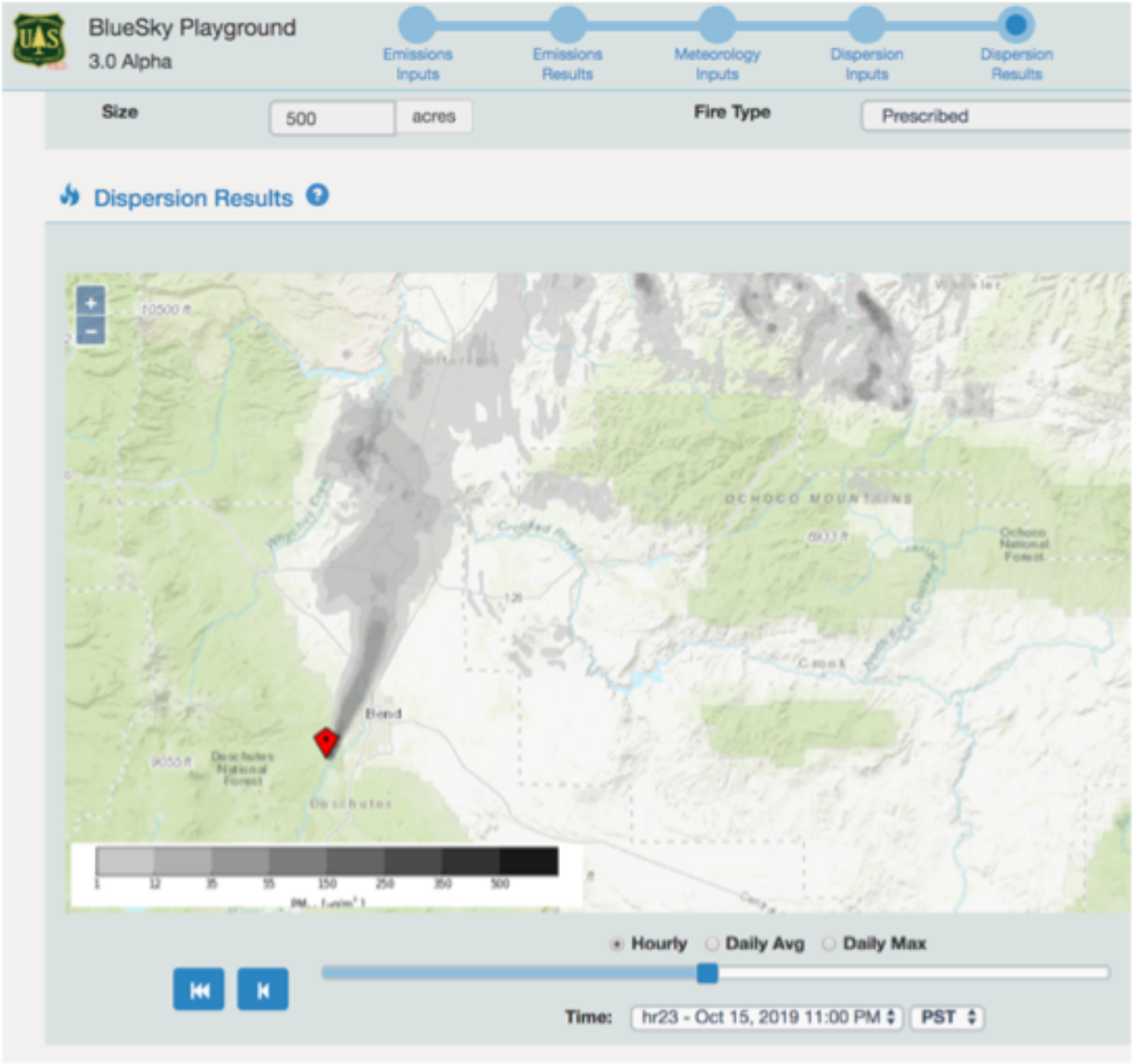


PGV3 – Meteorology Selection



BlueSky Playground V3
Do-your-own-smoke-modeling

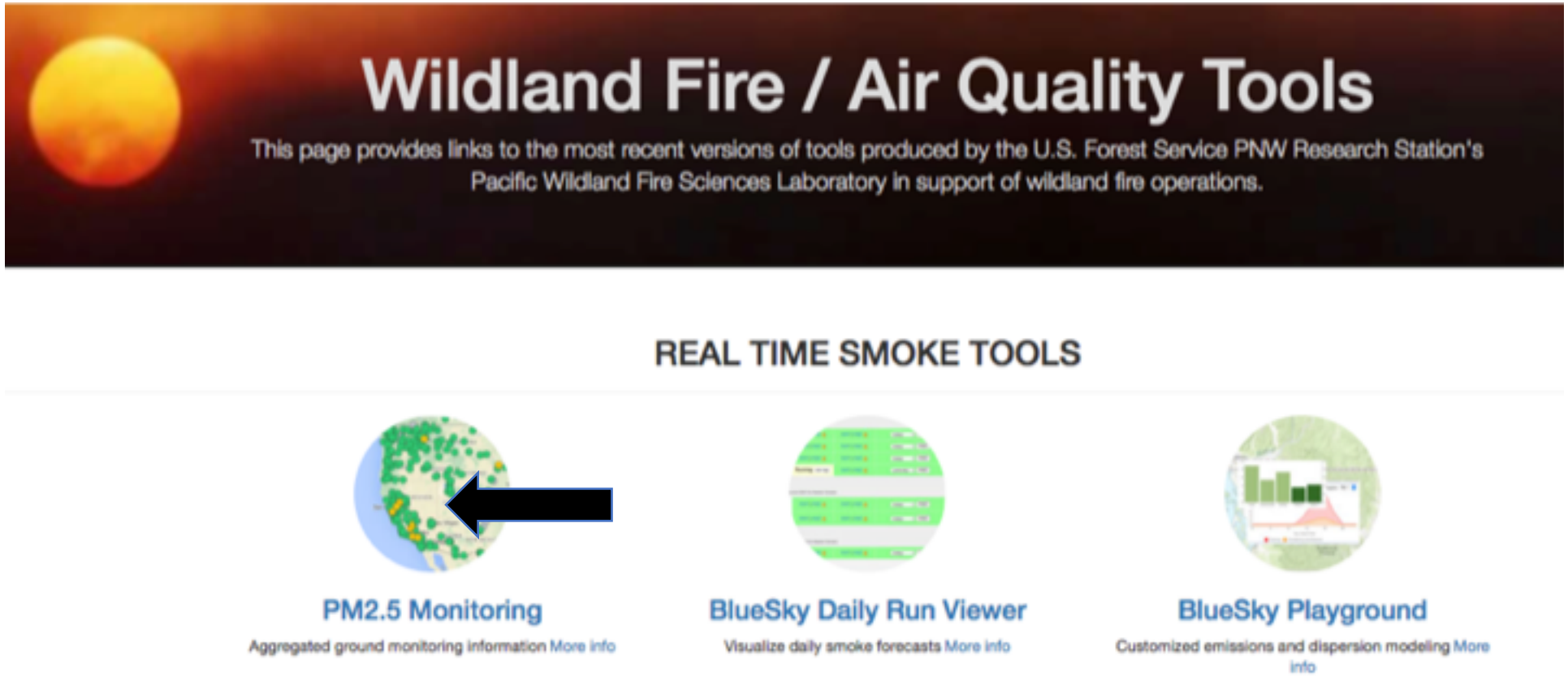
- Near surface 1-hr average PM2.5 Concentrations
- HYSPLIT Dispersion Model



Smoke Monitoring Tool (Permanent and Temporary Monitors)

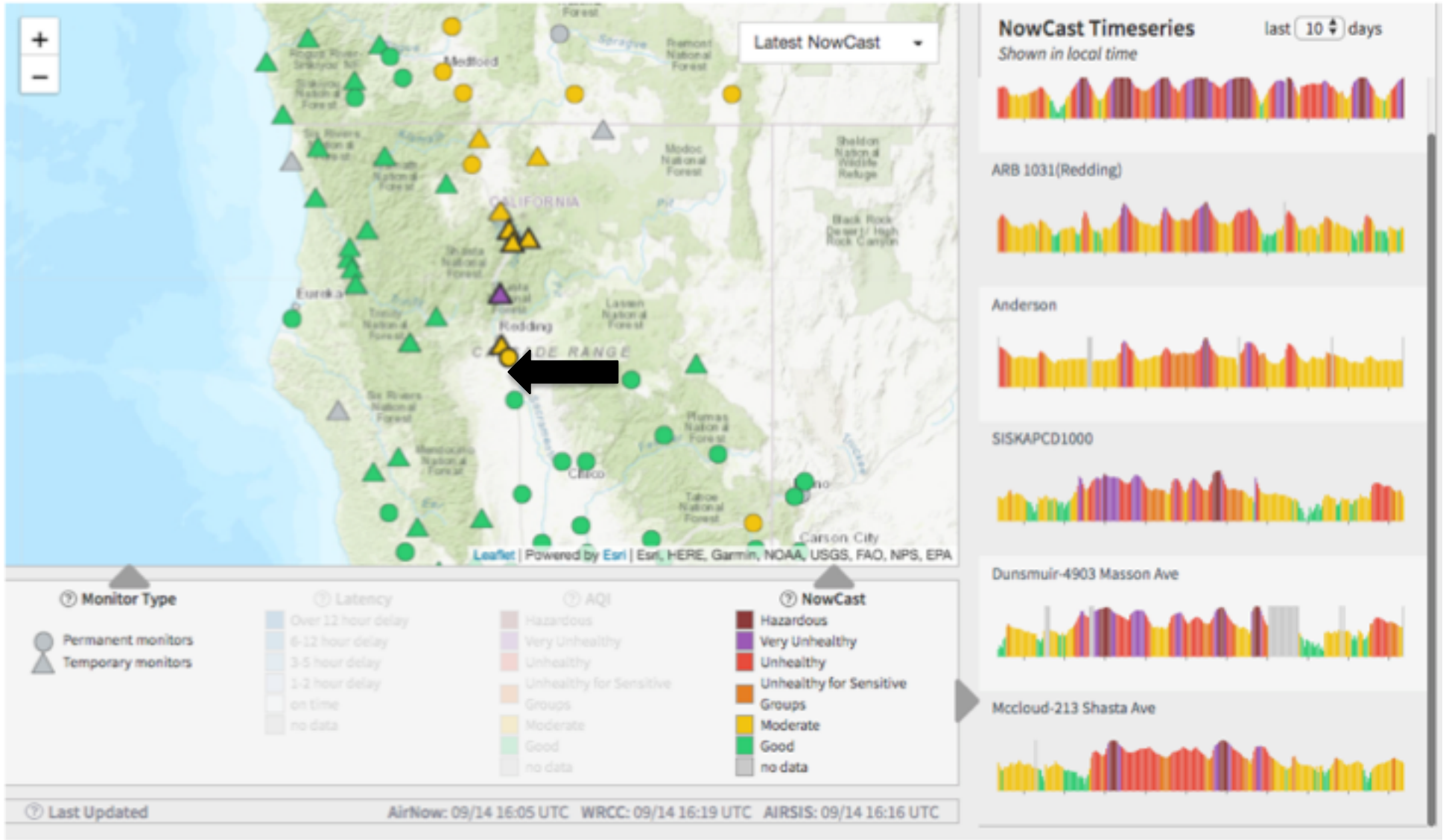
WFAQRP-AirFire Tools

https://tools.airfire.org/



Monitoring V4

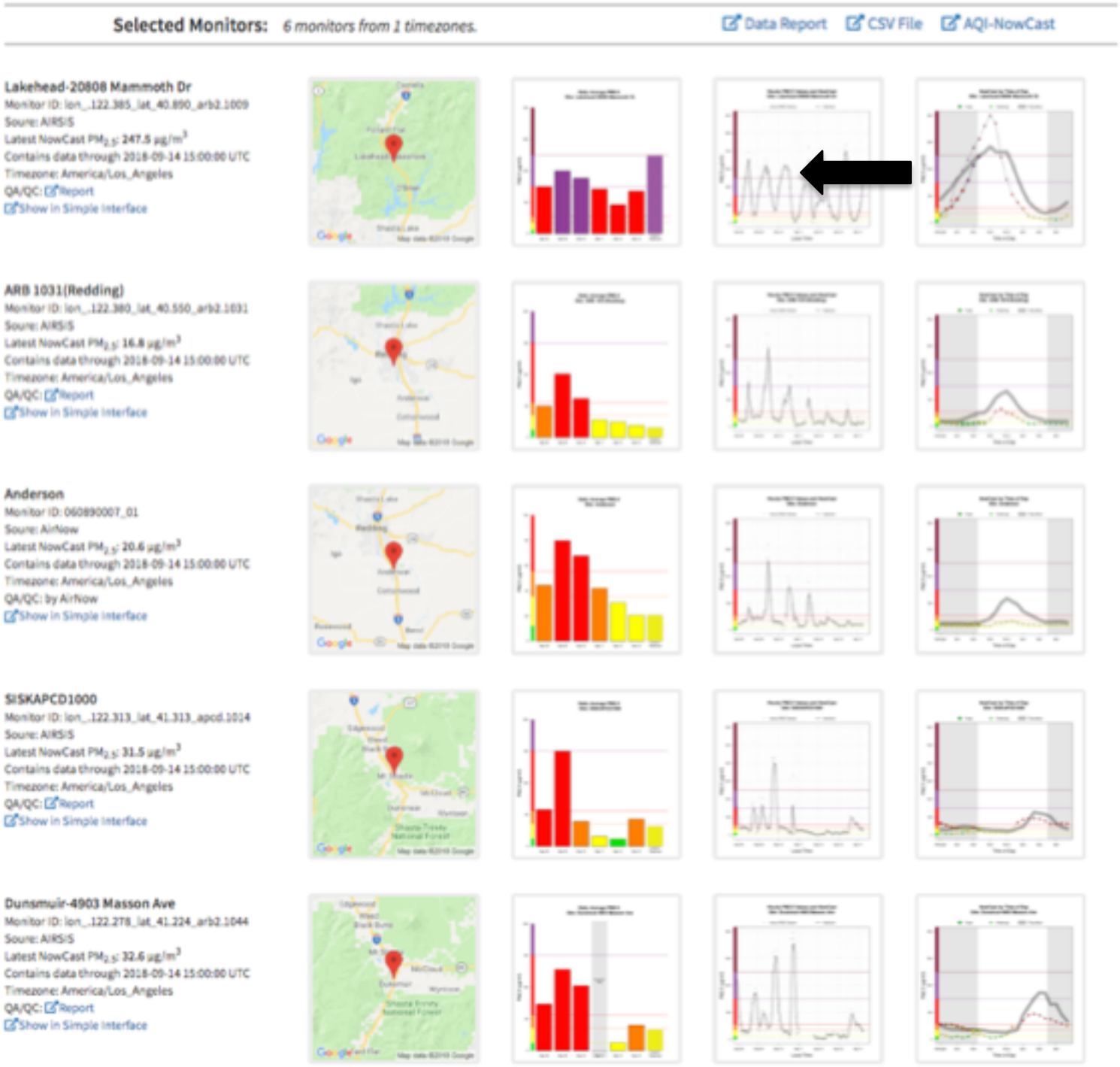
Circles - Permanent Monitors
Triangles - Temporary Monitors



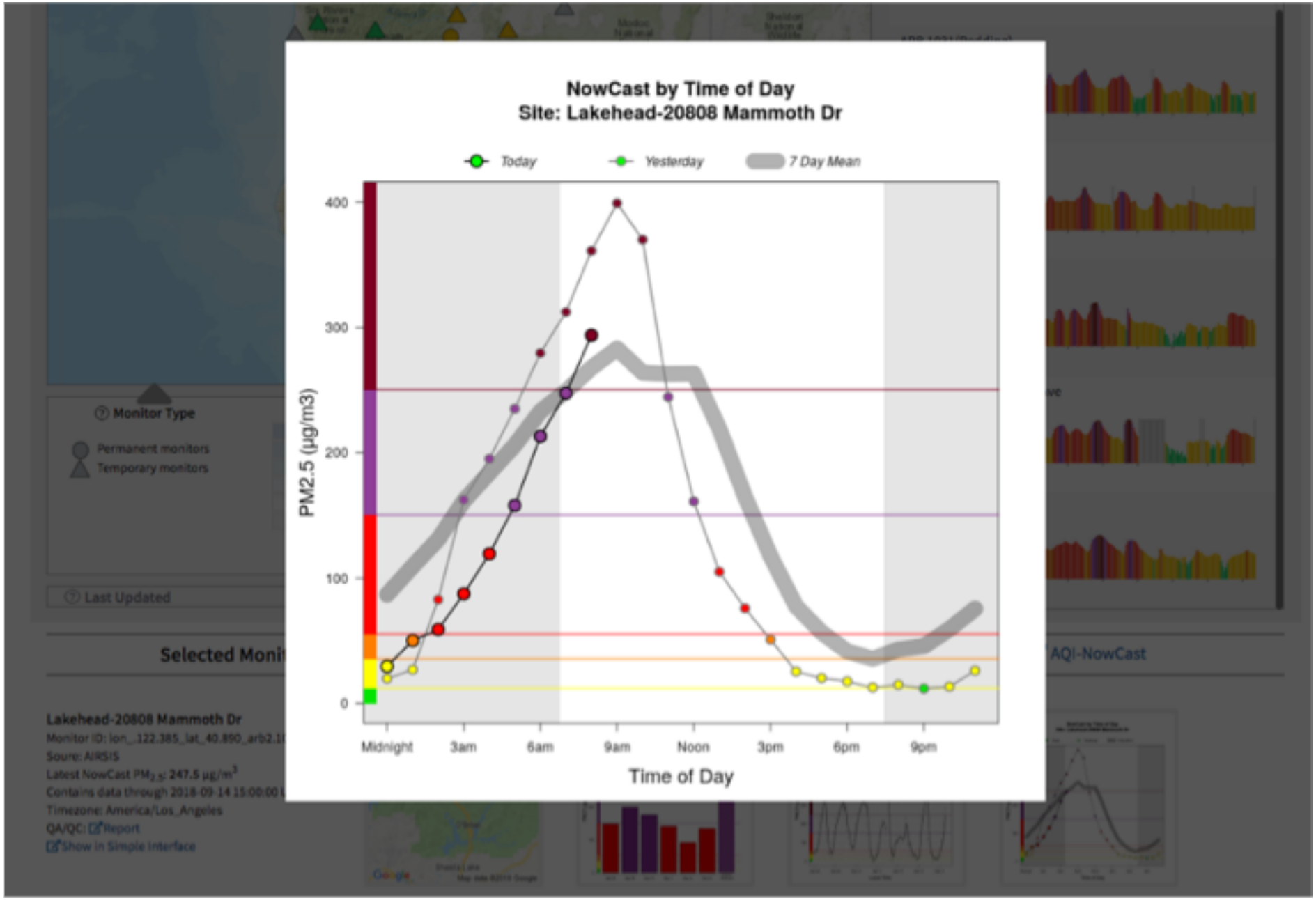
https://github.com/MazamaScience/PWFSLSmoke

Measured PM2.5

- Meta Data
- Map location
- 24-hr Average
- 10-day 1-hr & 3-hr
- Diurnal Profile



Mazama Science R Package



- MazamaCoreUtils -- Utilities to help write production R code
- MazamaSpatialUtils -- Harmonized spatial datasets and spatial search functions
- MazamaLocationUtils -- A system for managing spatial metadata associated with known locations
- PWFSLSmoke -- Utilities for working with federal air quality monitoring data
- AirMonitorPlots -- Plotting functions for the PWFSLSmoke package
- AirSensor — Utilities for working with data from air quality sensors (e.g. Purple Air)

https://github.com/MazamaScience/PWFSLSmoke

Smoke Modeling
Superfog – PB-Piedmont

Click on map above to select location of ignition

Location of ignition: +38.65200° latitude -112.01800° longitude time zone: America/Denver

Fire start (in fire's time zone) & duration

confidence ranges (relative to latest available NAM forecasts): past data 0-6 hours 7-12 hours 13-24 hours 25-36 hours

Local start date: Feb 6, 2020 Local start time: 1200 Duration: 18 hours

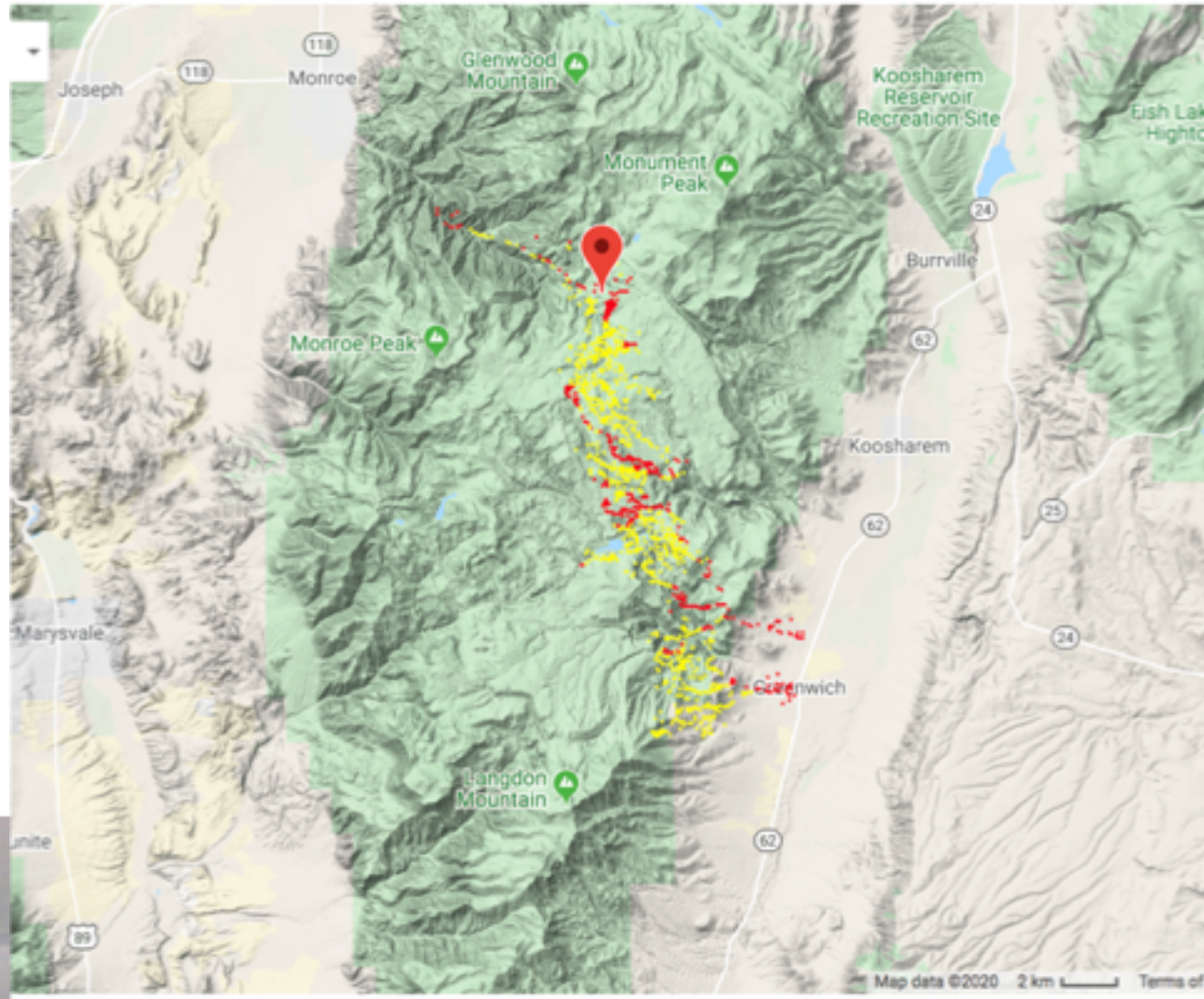
Terrain parameters

Area burned: 3000 acres Grid spacing: 120 meters Sample radius: 10 miles

Fuel parameters

Fuel type: trees

Modeling Results for +38.559303° latitude, -112.004372° longitude
starting at Feb 5, 2020 1400 (America/Denver), and lasting for 6 hours
400 acres burned 120 meters grid spacing 10 miles sample radius



Feb 5, 2020 1400: +0 hours +1 hours +2 hours +3 hours +4 hours +5 hours

animation loop: ▶ ⏸ per-image delay: 1.0 secs smoke fog

Download KML output (zip file)

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

- JPSS JSTAR Mapper
  https://www.star.nesdis.noaa.gov/jpss/mapper
  - Suomi NPP, NOAA-20, Sentinal 5P (CO, NO2)

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

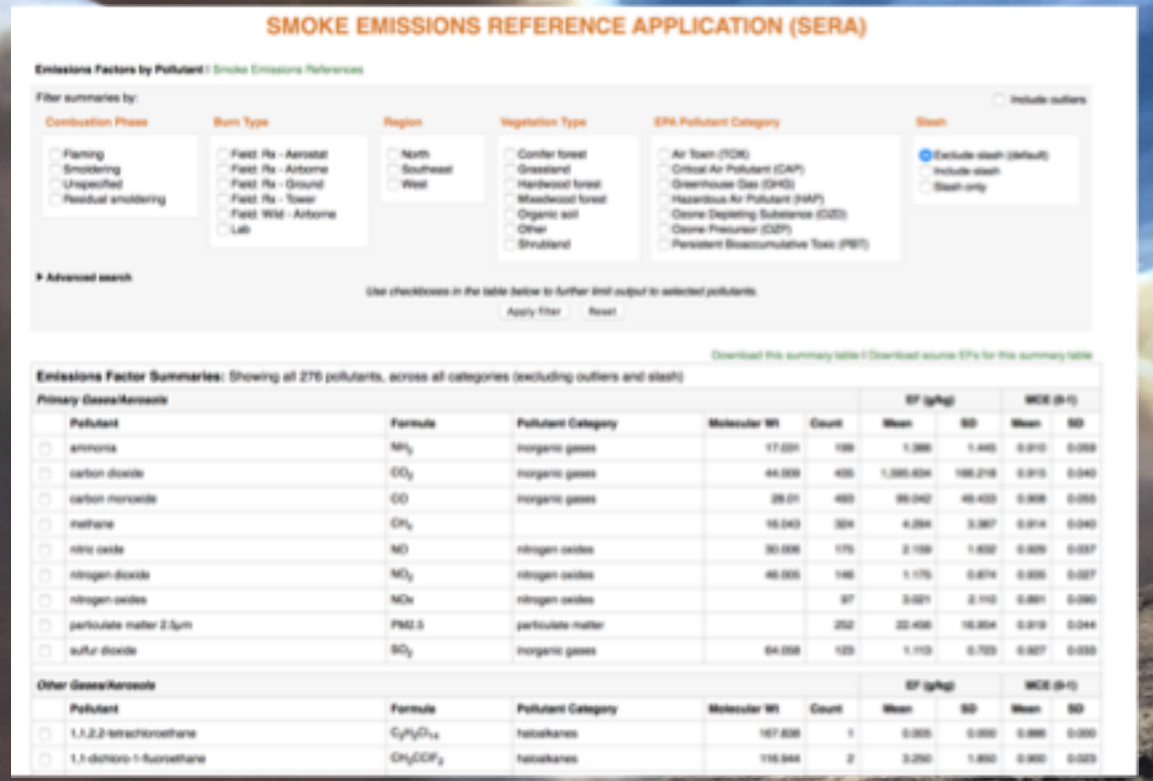
(discussed at the end of video Part 2)

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

The 15 minute online training is at:

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

Wildland Fire Emissions Factors in North America The new Smoke Emissions Reference Application (SERA)



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

Susan O'Neill, USDA Forest Service

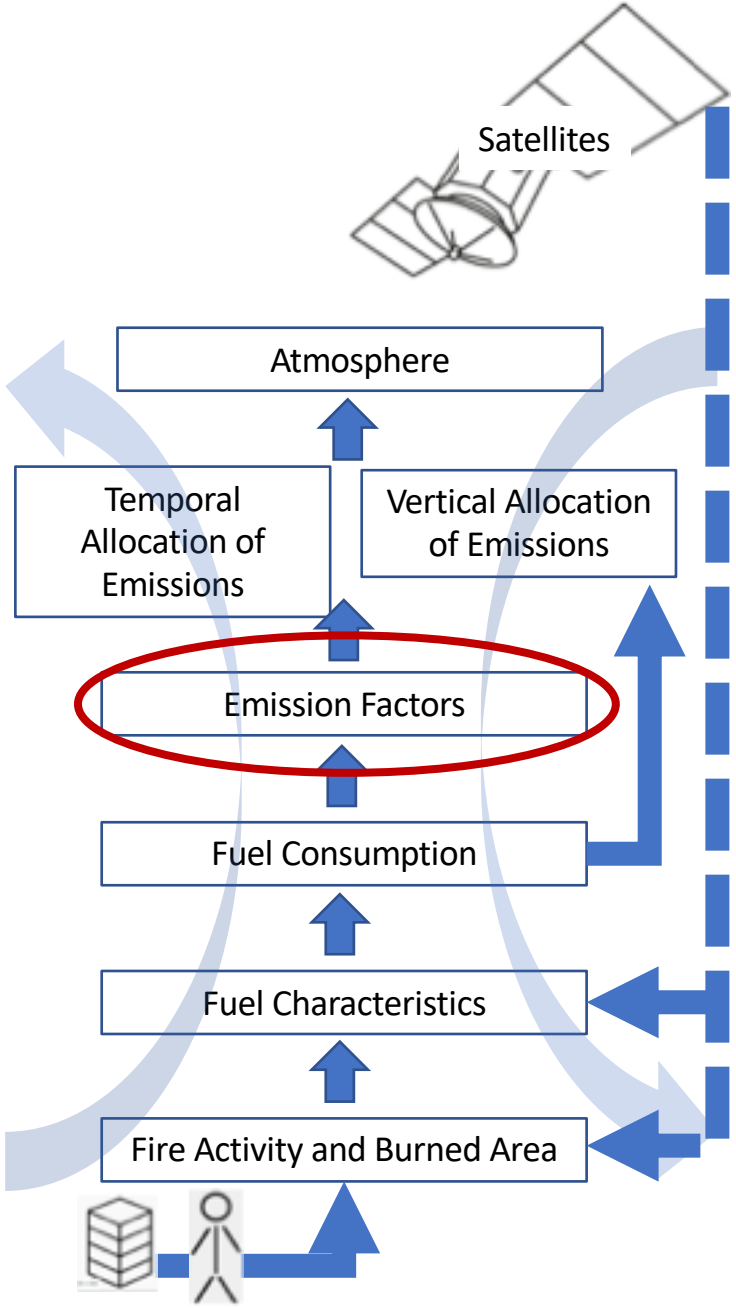
Susan Prichard, University of Washington

EPA Wildland Fire Research Focus Group, April 2020

Photo Greg Johnson

Emission Factors

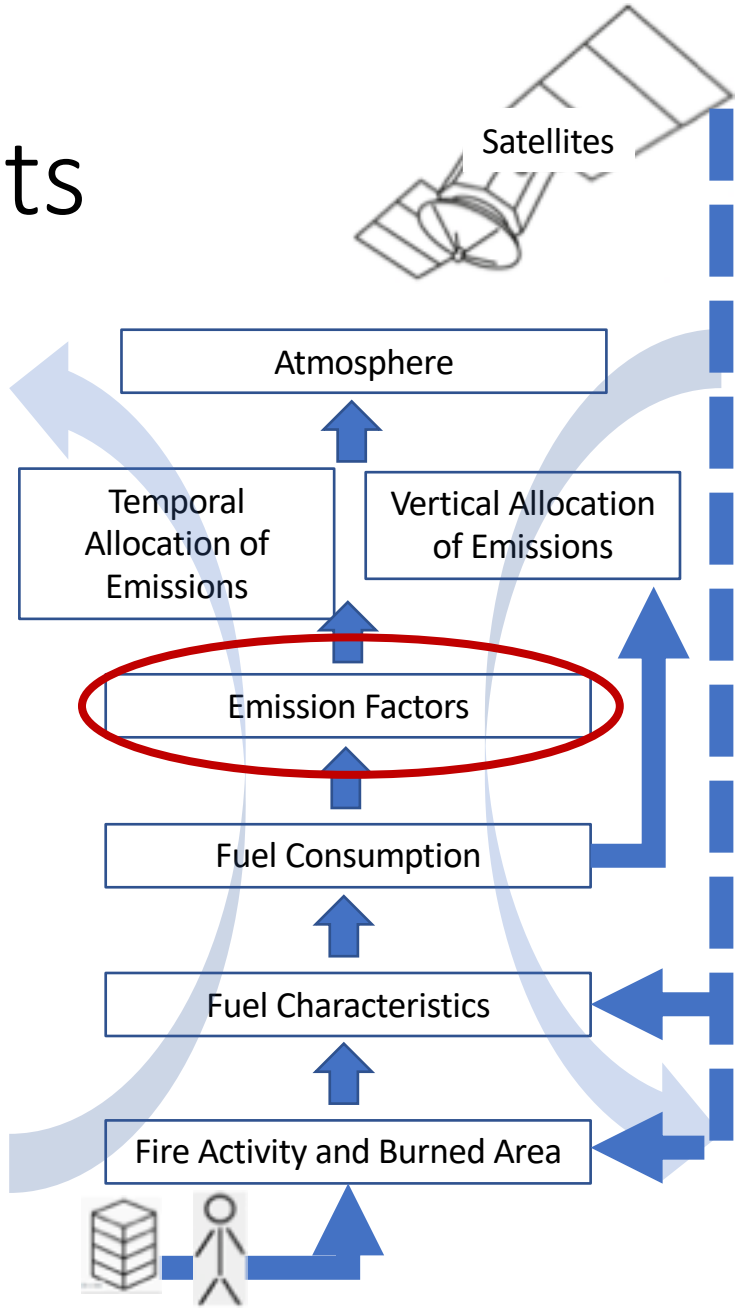
- Emission Factor (EF): mass pollutant released per mass fuel consumed (e.g. g/kg)
- Represents the chemical & physical processes of the air sample from the combustion release point to sampling point
- Important component in many fire emission calculation systems (e.g. BlueSky, CONSUME, FOFEM, FFT, NEI)
- Many years of research



Emission Factor Synthesis Projects

- Department of Defense Strategic Environmental Research and Development Program
  - Extensive literature review through 2010
  - Spreadsheet compilation of EF data
  - Lincoln et al. 2014. https://www.fs.usda.gov/rds/archive/Product/RDS-2014-0012
- National Wildfire Coordinating Group (NWCG) Smoke Committee (SmoC)
  - Update the SERDP work (add data since 2010)
  - Purpose: Update CONSUME, FOFEM, BlueSky models
  - Create a web interface and database
  - *Prichard, O'Neill, Eagle, Andreu, Drye, Dubowy, Urbanski, Strand. 2020. IJWF https://doi.org/10.1071/WF19066*

➔ The Smoke Emissions Reference Application (SERA)



SERA

- 276 Trace gases & aerosol
- 12,533 records
- Filter by:
  - Combustion Phase
  - Burn Type
  - Region
  - Vegetation Type
  - Pollutant Category
  - Logging Slash
- Mean, Std Dev
- Download the underlying data
- Fast!
- Simple to Use

SMOKE EMISSIONS REFERENCE APPLICATION (SERA)

Emissions Factors by Pollutant | Smoke Emissions References

Filter summaries by:

Include outliers

Combustion Phase	Burn Type	Region	Vegetation Type	EPA Pollutant Category	Slash
Flaming	Field: Rx - Aerostat	North	Conifer forest	Air Toxin (TOX)	Exclude slash (default)
Smoldering	Field: Rx - Airborne	Southeast	Grassland	Critical Air Pollutant (CAP)	Include slash
Unspecified	Field: Rx - Ground	West	Hardwood forest	Greenhouse Gas (GHG)	Slash only
Residual smoldering	Field: Rx - Tower		Mixedwood forest	Hazardous Air Pollutant (HAP)	
	Field: Wild - Airborne		Organic soil	Ozone Depleting Substance (OZD)	
	Lab		Other	Ozone Precursor (OZP)	
			Shrubland	Persistent Bioaccumulative Toxic (PBT)	

▸ 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

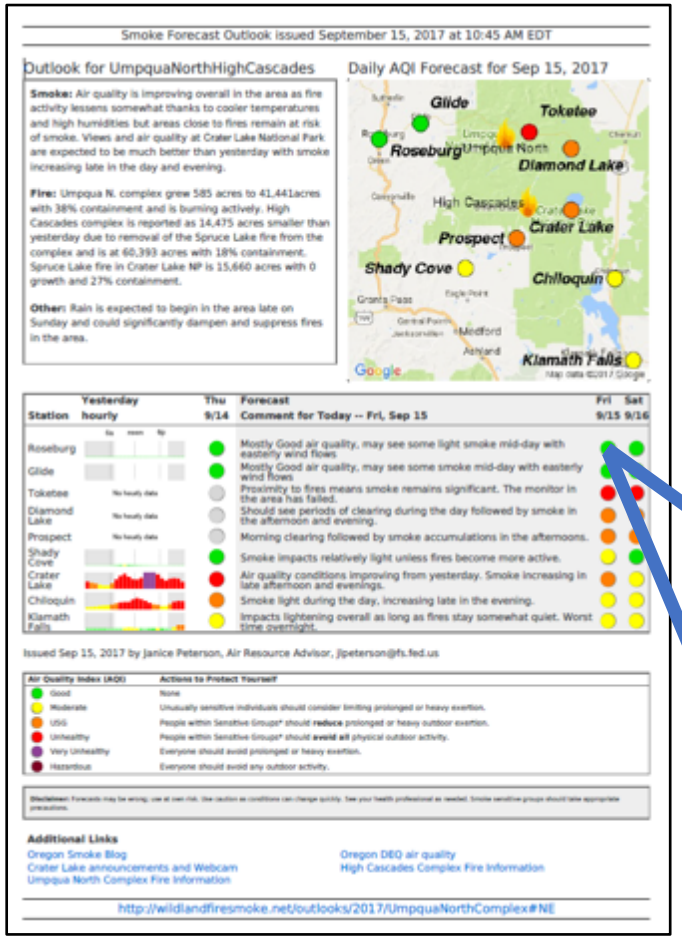
Emissions Factor Summaries: Showing all 276 pollutants, across all categories (excluding outliers and slash)

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

Other Gases/Aerosols					EF (g/kg)		MCE (0-1)	
Pollutant	Formula	Pollutant Category	Molecular Wt	Count	Mean	SD	Mean	SD
1,1,2,2-tetrachloroethane	$C_2H_2Cl_{14}$	haloalkanes	167.838	1	0.005	0.000	0.886	0.000
1,1-dichloro-1-fluoroethane	CH_3CCIF_2	haloalkanes	116.944	2	3.250	1.850	0.900	0.023

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

Interagency Wildland Fire Air Quality Response Program (IWFAQRP)

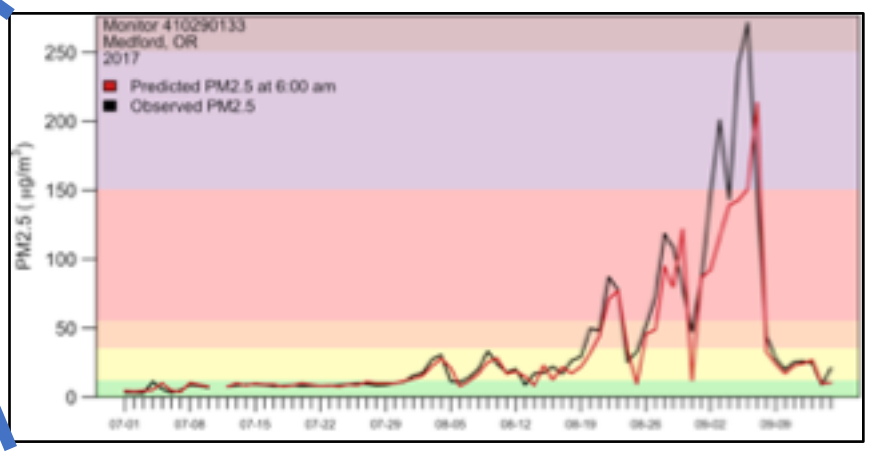


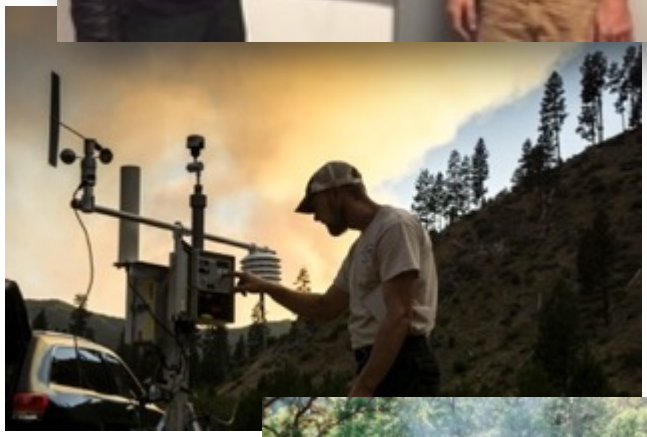
CONGRESS.GOV

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





Marsha, A., and N.K. Larkin (2019) A statistical model for predicting $PM_{2.5}$ for the Western United States. J. Air Waste Manage. 69(10): 1215-1229

Thank you!

- AirFire Team
- Mazama Science
- US Forest Service – F&AM, FERA, R6
- National Park Service
- National Weather Service, NOAA
- Environmental Protection Agency
- Joint Fire Science Program
- NASA
- Environment and Climate Change Canada
- Natural Resources Canada
- University of Washington
- Desert Research Institute
- University of Arizona
- *many others*

Susan O'Neill
susan.oneill@usda.gov