

Smoke Tools and Information for Prescribed Fire and Wildfire

Susan O'Neill, AirFire Team

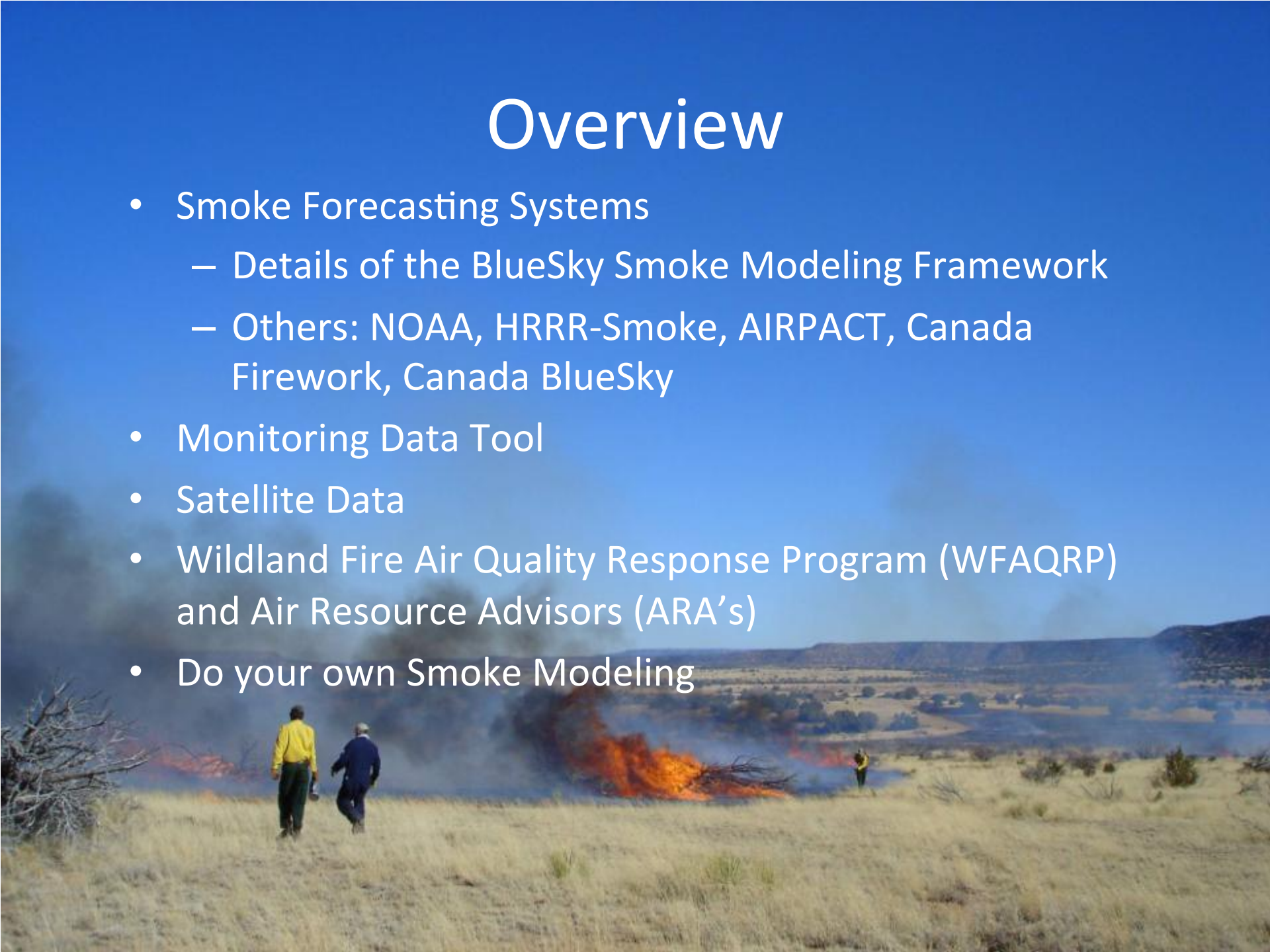
USDA Forest Service, PNW Research Station



Photo – Ted Grussing

Overview

- Smoke Forecasting Systems
 - Details of the BlueSky Smoke Modeling Framework
 - Others: NOAA, HRRR-Smoke, AIRPACT, Canada Firework, Canada BlueSky
- Monitoring Data Tool
- Satellite Data
- Wildland Fire Air Quality Response Program (WFAQRP) and Air Resource Advisors (ARA's)
- Do your own Smoke Modeling



Smoke Forecasting Systems

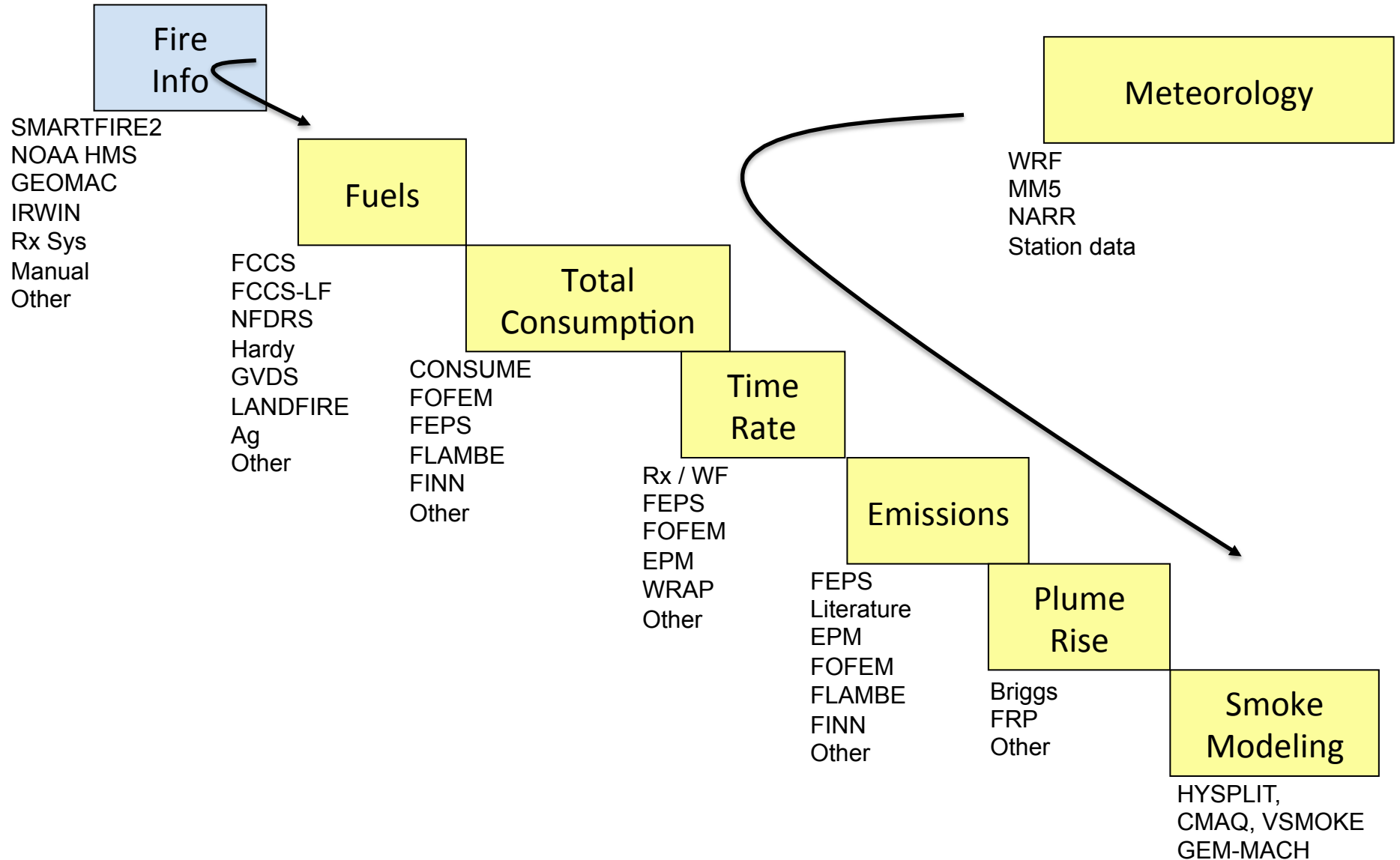
- BlueSky Daily Operational Runs
<http://www.airfire.org/data/bluesky-daily/>
- AIRPACT – Northwest US
<http://lar.wsu.edu/airpact/>
- High Resolution Rapid Refresh (HRRR) – Smoke
<https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/>
- NOAA Air Quality
<http://www.nws.noaa.gov/airquality/ww.shtml>
- Firework – Canada
https://weather.gc.ca/firework/index_e.html
- BlueSky – Canada
<http://firesmoke.ca/>

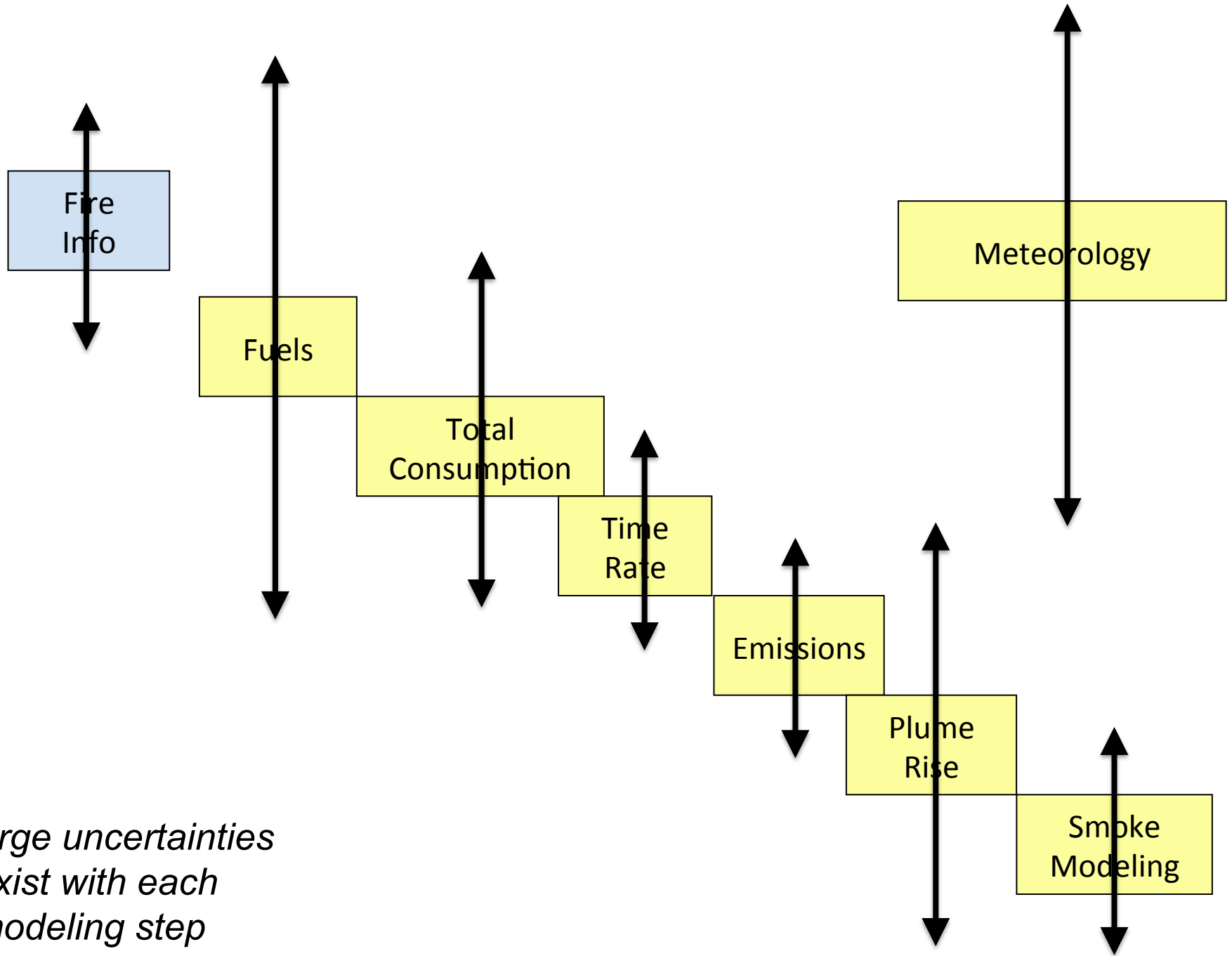
“Picking a model of choice for the day is a little like speed-dating: too little time/information to make up the mind leading to regrets by the end of the date/shift.”

- Wes Adkins, Meteorologist, National Weather Service, Juneau, AK

BlueSky Smoke Modeling Framework

Components to Calculating Fire Emissions





Meteorology

Fuels

Total Consumption

Time Rate

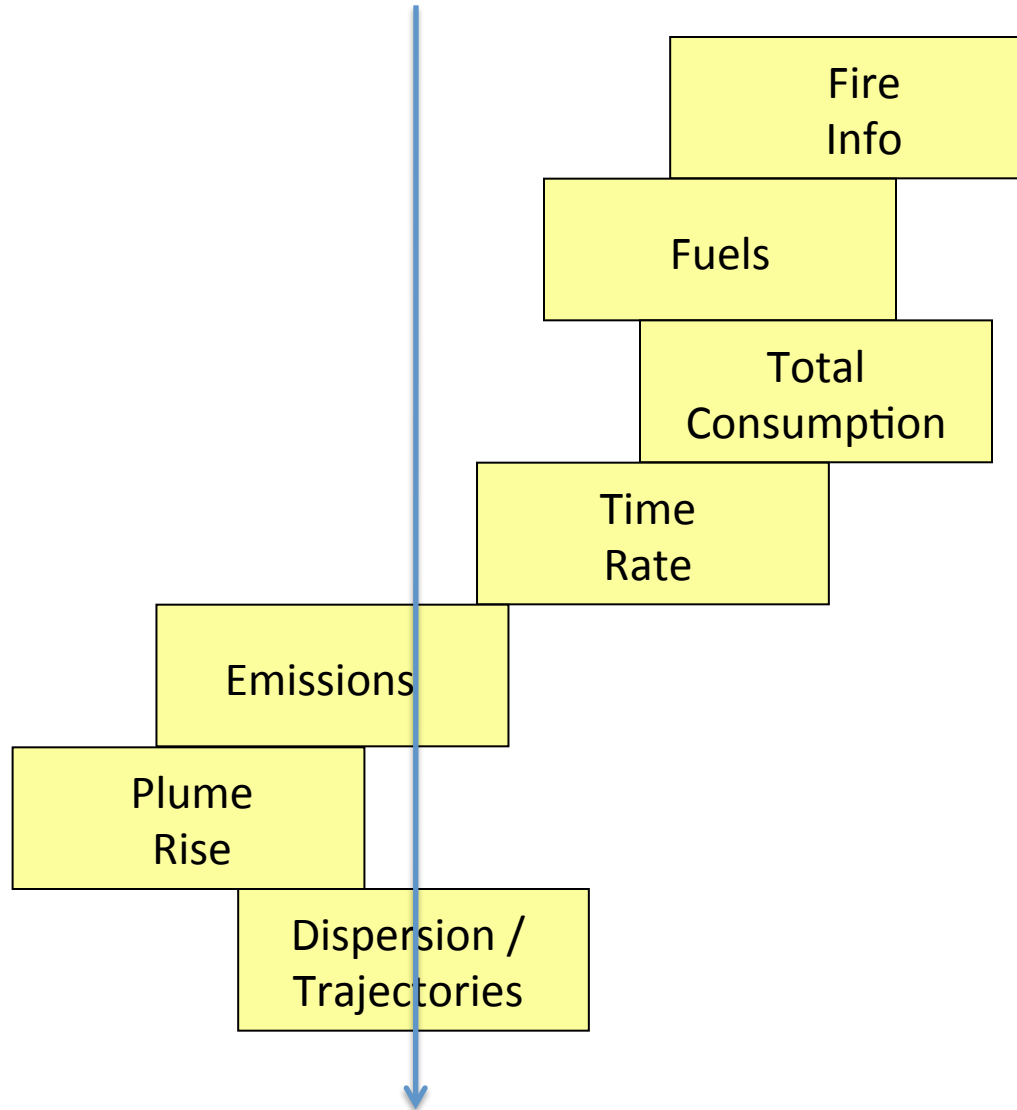
Emissions

Plume Rise

Smoke Modeling

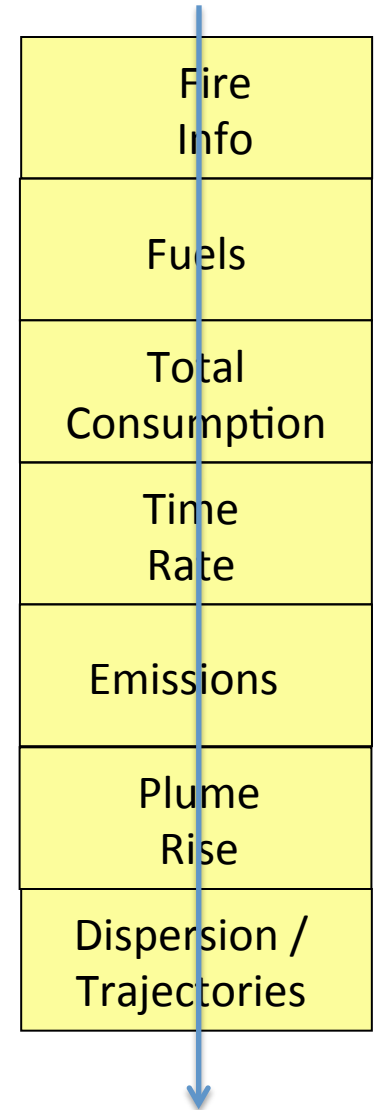
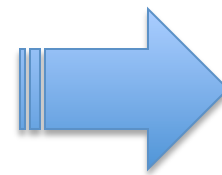
Large uncertainties exist with each modeling step

Reality



right answer, wrong reasons

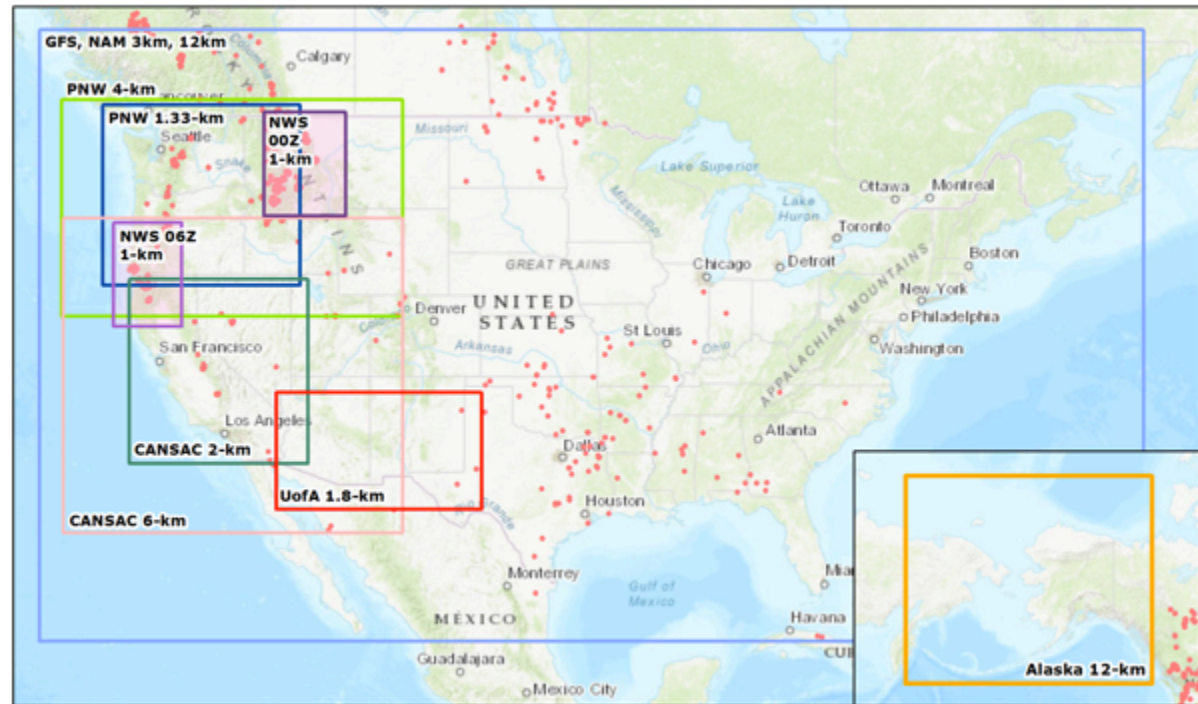
Reality



right answer, right reasons

Tailored Smoke Predictions Delivered to Incident Management Teams

- Domains
 - 2-km CA/NV
 - 6-km Western US
 - 1.33-km WA/ID
 - 4-km PNW
 - 12-km CONUS
 - 12-km Alaska
 - 3-km CONUS
 - 1.8-km AZ/NM
 - 1-km FW (moveable)
- Partnerships: NWS, UW, DRI, UofA

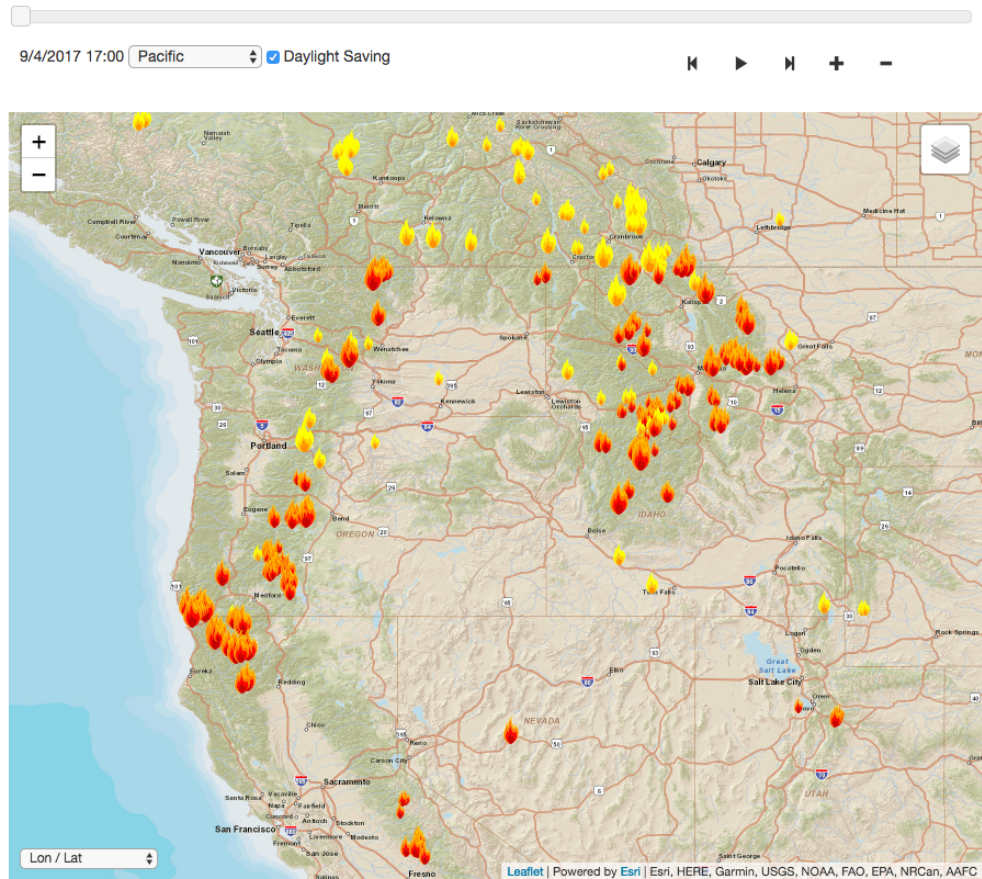


- HYSPLIT – Primary near-surface 1-hr PM_{2.5}

Tailored Smoke Predictions Delivered to Incident Management Teams

- Fire Activity Information
- NOAA Hazard Mapping System (HMS) Satellite Fire Detections
- SmartFire v2 (SF2) augments (fire type, fire size, aggregation)

CONUS 0.15deg 84hrs BlueSky Daily Run initialized at 2017-09-05 00Z and run for 72hours



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



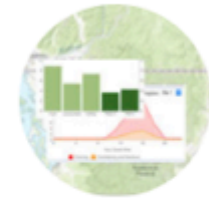
PM2.5 Monitoring

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](#)

Northwest:

http://www.airfire.org/data/bluesky-daily/

Uses meteorological forecast data from the NWRMC regional model runs and NWS Fire Weather Domains

PNW 4-km

72-hr forecast, NWRMC 4-km met

00Z

MAP | KMZ 🔥

MAP | KMZ 🔥

(today) ⌵ KMZ

PNW 1.33-km

60-hr forecast, NWRMC 1.33-km met

00Z

MAP | KMZ 🔥

MAP | KMZ 🔥

(today) ⌵ KMZ

West/Southwest:

Uses meteorological forecast data from the CANSAC regional model runs and NWS Fire Weather Domains

Number of Fires

Southwest 6-km

72 hr forecast, CANSAC 6-km met

00Z

MAP | KMZ 🔥

MAP | KMZ

(today) ⌵ KMZ

12Z

Running [view logs](#)

MAP | KMZ 🔥

(yesterday) ⌵ KMZ

CA/NV 2-km

72 hr forecast, CANSAC 2-km met

00Z

MAP | KMZ 🔥

Error

(today) ⌵ KMZ

12Z

Running [view logs](#)

MAP | KMZ 🔥

(yesterday) ⌵ KMZ

Running (click on "view logs"

Alaska:

Uses meteorological forecast data from the National Weather Service model runs and NWS Fire Weather Domains

Alaska 12-km

00Z

(no fires)

MAP | KMZ

(today) ⌵ KMZ

06Z

(no fires)

(no fires)

(today) ⌵ KMZ

Successful!

Failures show up in red.

Website shows status of current runs

Daily BlueSky Production Runs

12/10/2017 Satellite Fire Detections & PM2.5, 6-km

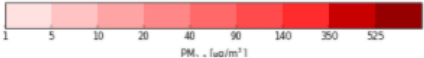
<http://www.airfire.org/data/bluesky-daily/>

Select Options

PM 2.5

- Hourly
- 3-Hour Running Average
- Daily Maximum
- Daily Average

Include Carry-Over Smoke



1 5 10 20 40 90 140 350 525
PM_{2.5} - µg/m³

**Experimental Research Output. Use at your own Risk.*

Fire Information

- Modelled Fires
 - Flames
 - Circles

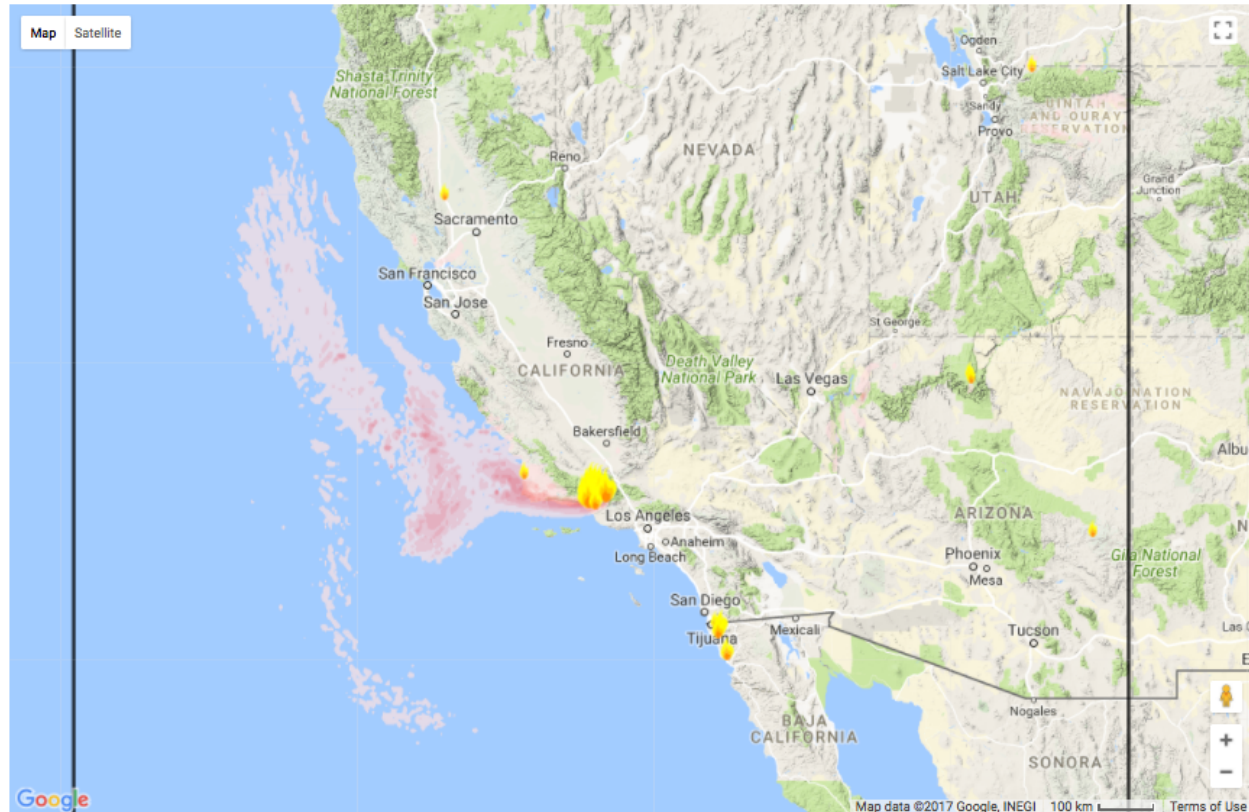
Other

- Region Bounds

Share This Run

WesternUS 6km 72hrs BlueSky Daily Run initialized at 2017-12-10 00Z and run for 71hours

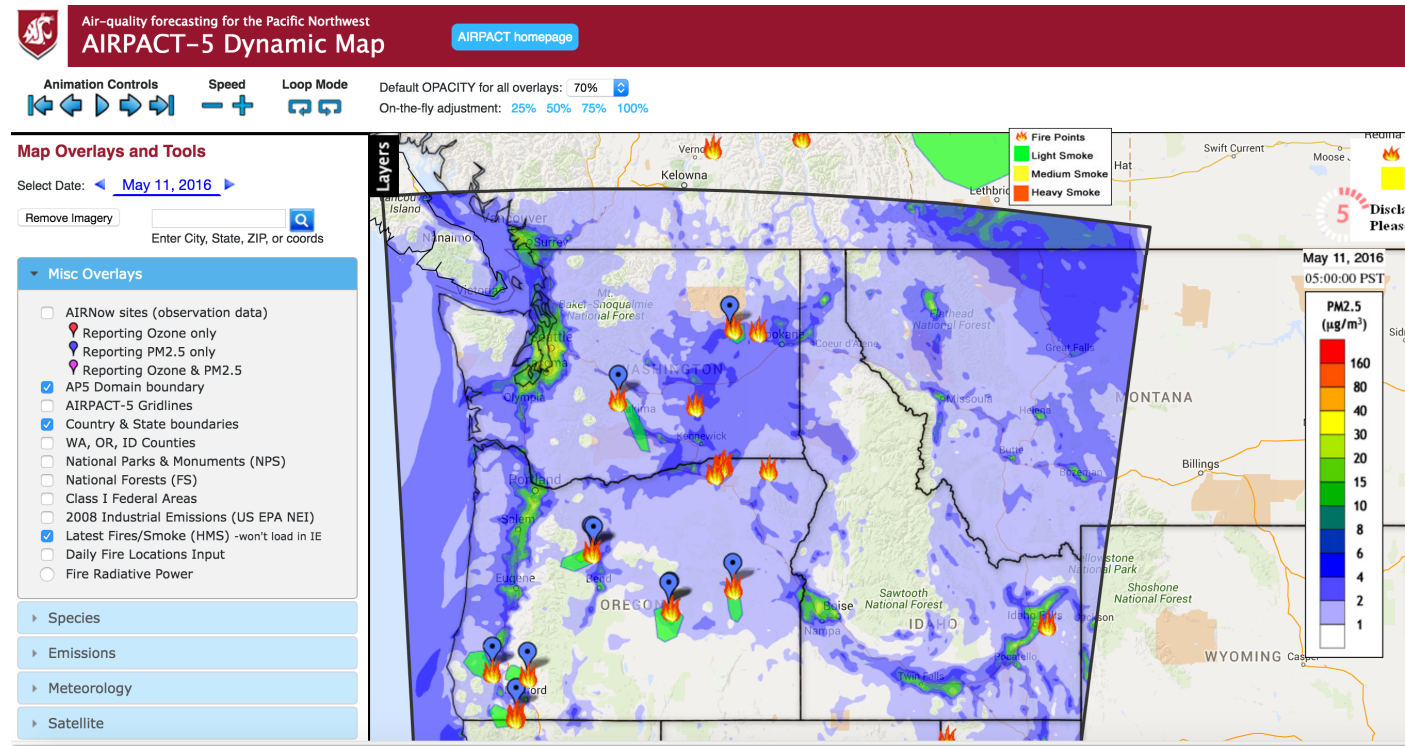
12/11/2017 3:00 Pacific Daylight Saving



Information provided for research purposes only. Modeling may be inaccurate for a variety of reasons. Use at own risk. Contact local public health agencies for air quality alerts.

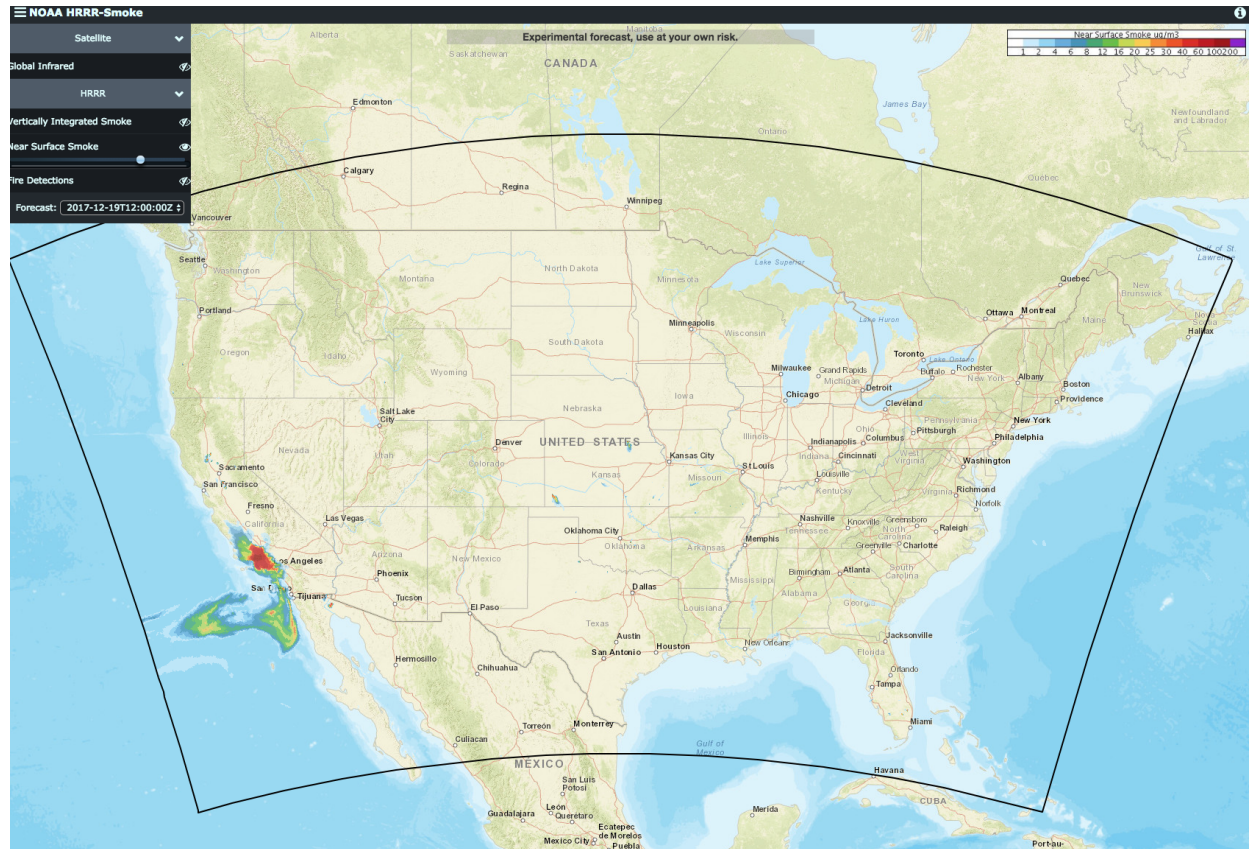
AIRPACT – Northwest

- CMAQ
- 4-km
- 72-hours
- Ozone, PM2.5
- BlueSky Fire Emissions



NOAA HRRR-Smoke (High Resolution Rapid Refresh)

- Coupled Meteorology/Smoke (WRF-Chem)
- 3-km, CONUS, Alaska
- Primary PM2.5
- Visible Infrared Imaging Radiometer Suite (VIIRS)
 - fire activity
 - fire radiative power (FRP)
- Plume Rise – FRP
- Emissions – FRP
- 00Z, 06Z, 12Z, 18Z
- 36-hrs



<https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/>

HRRR-Smoke Near-Surface PM2.5

NOAA HRRR-Smoke

Satellite

Global Infrared

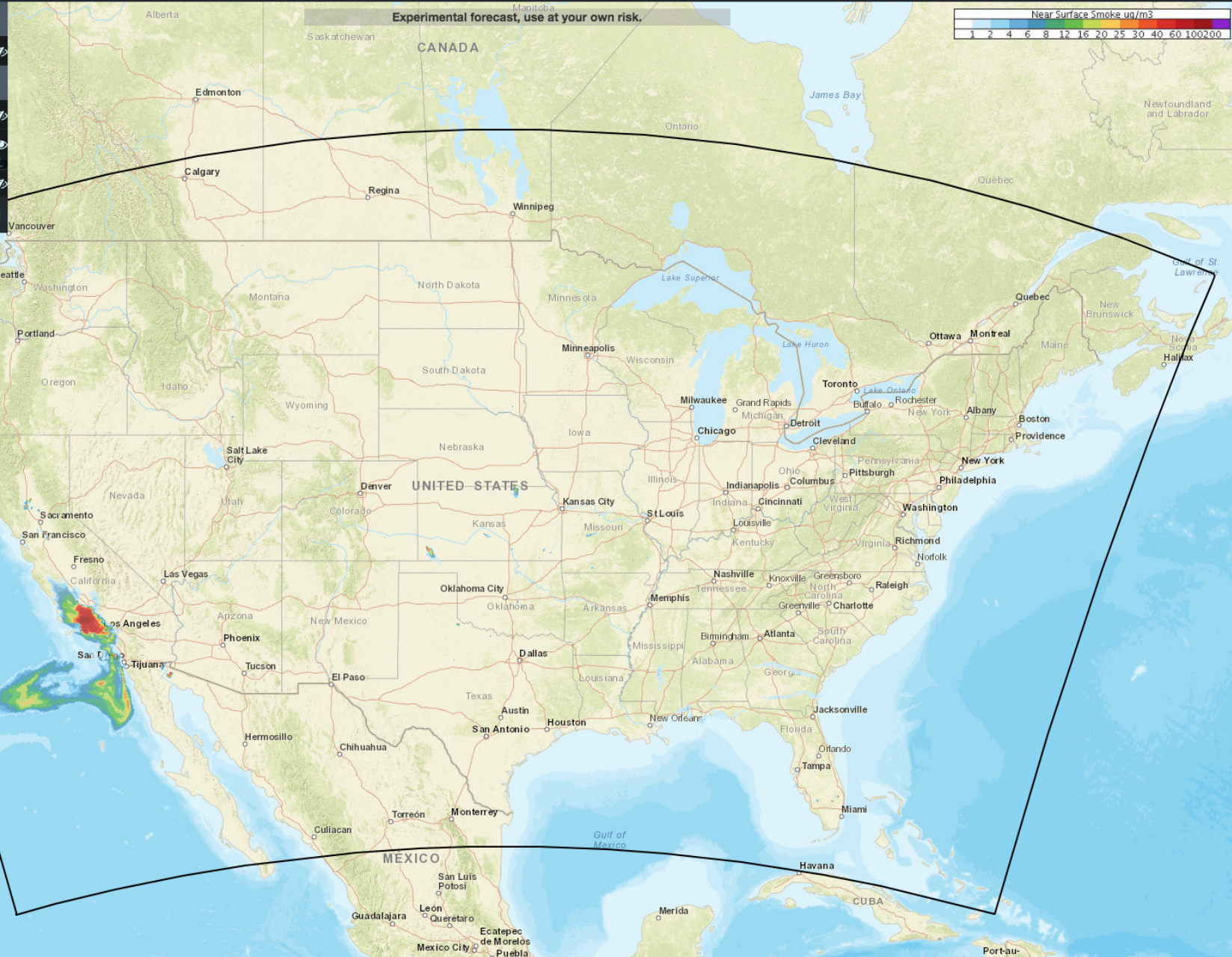
HRRR

Vertically Integrated Smoke

Near Surface Smoke

Fire Detections

Forecast: 2017-12-19T12:00:00Z



HRRR-Smoke Vertically Integrated PM2.5





National Weather Service

- HYSPLIT
- CMAQ
- Ozone, PM2.5
- 12-km
- 84-hours
- BlueSky Fire Emissions

Mouse over or click on the times below to change the above graphic.
 1 Hour Average Ozone Concentration:
 | 3pm | 4pm | 5pm | 6pm | 7pm | 8pm | 8pm | 9pm | 10pm | 11pm | 12am | 1am | 2am |

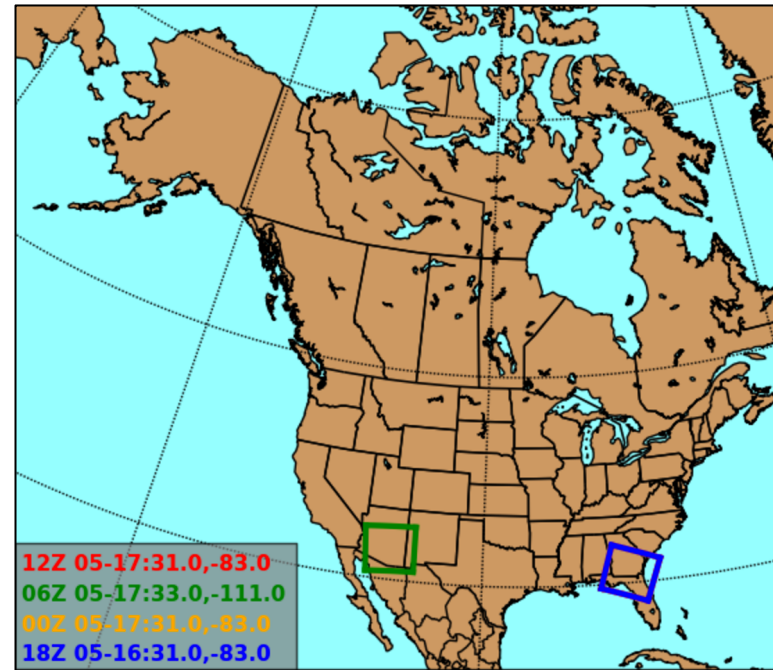
Additional Air Quality Forecast Guidance

1-Hr Average Ozone 	1-Hr Average Ozone 	1-Hr Average Ozone
8-Hr Average Ozone 	8-Hr Average Ozone 	8-Hr Average Ozone
Surface Smoke 	Surface Smoke 	Surface Smoke
Vertical Smoke Integration 	Vertical Smoke Integration 	Vertical Smoke Integration
Vertical Dust Integration 	Surface Dust 	

National Weather Service Fire Weather 1.27-km Domains

- 00Z, 06Z, 12Z, 18Z
- 36-hr
- Custom BlueSky Runs - 2-hr setup
- Meteorological Products available with the NWS 1km Domains

<http://www.emc.ncep.noaa.gov/mmb/mmbpll/firewx/>



BlueSky Daily Runs*

(v1.1 beta)

Report a Bug

Production Run Status

Custom Run Status

Viewer

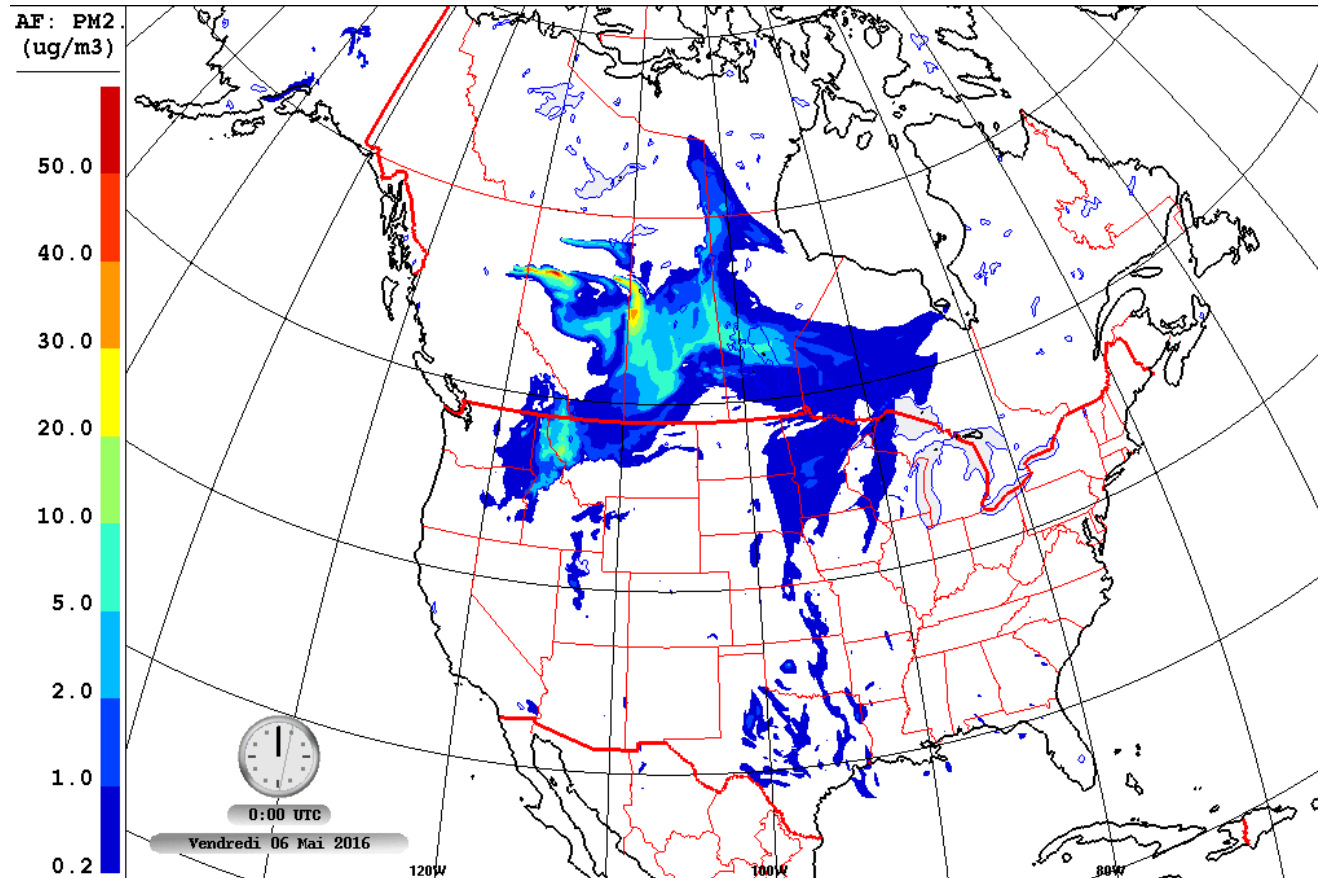
Configuration of all runs: SmartFire2 and BlueSky Framework version 3.5.1 with HYSPLIT v4.9.
The current date and time in UTC is: **20170516 19:32 Z. (All times listed in UTC.)**

Run	Starts	Today (20170516)	Yesterday (20170515)	Avail KMZs
Custom Runs <i>Uses meteorological forecast data from the various domains</i>				
Pinal Wildfire, FireWx 1-km (Arizona) 36-hr forecast, NWS 1-km met	06Z	MAP KMZ	MAP KMZ	(today) <input type="button" value="KMZ"/>

* Actual timing will vary depending on the number of fires modeled and other factors

Firework – Canada

- GEM-MACH
- 10-km
- 48-hrs
- PM2.5 from only fires
- CWFIS – Canadian Emissions
- BlueSky – US Emissions
- North America



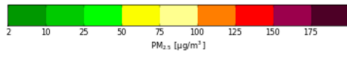
BlueSky Canada

- BlueSky – Emissions and HYSPLIT
- 4-km, 12-km
- 48-hrs
- CWFIS – Canadian Emissions
- PM2.5 from fires

Select Runs View Options

PM 2.5

HOURLY
 DAILY MAXIMUM
 DAILY AVERAGE



**Experimental Research Output. Use at your own Risk.*

Fire Information

MODELLED FIRES

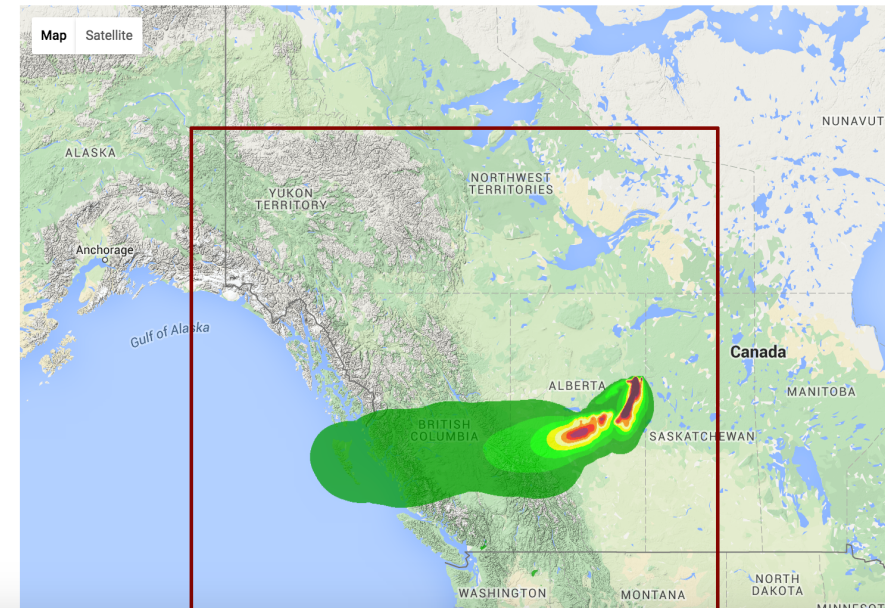
Other

REGION BOUNDS

Share This Run

BlueSky Daily Run initialized at 2016-05-11 08Z and run for 51hours

5/12/2016 5:00 Pacific Daylight Saving



Smoke Monitoring Tool (Permanent and Temporary Monitors)

<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



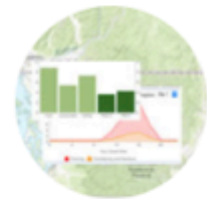
PM2.5 Monitoring

Aggregated ground monitoring information [More info](#)



BlueSky Daily Run Viewer

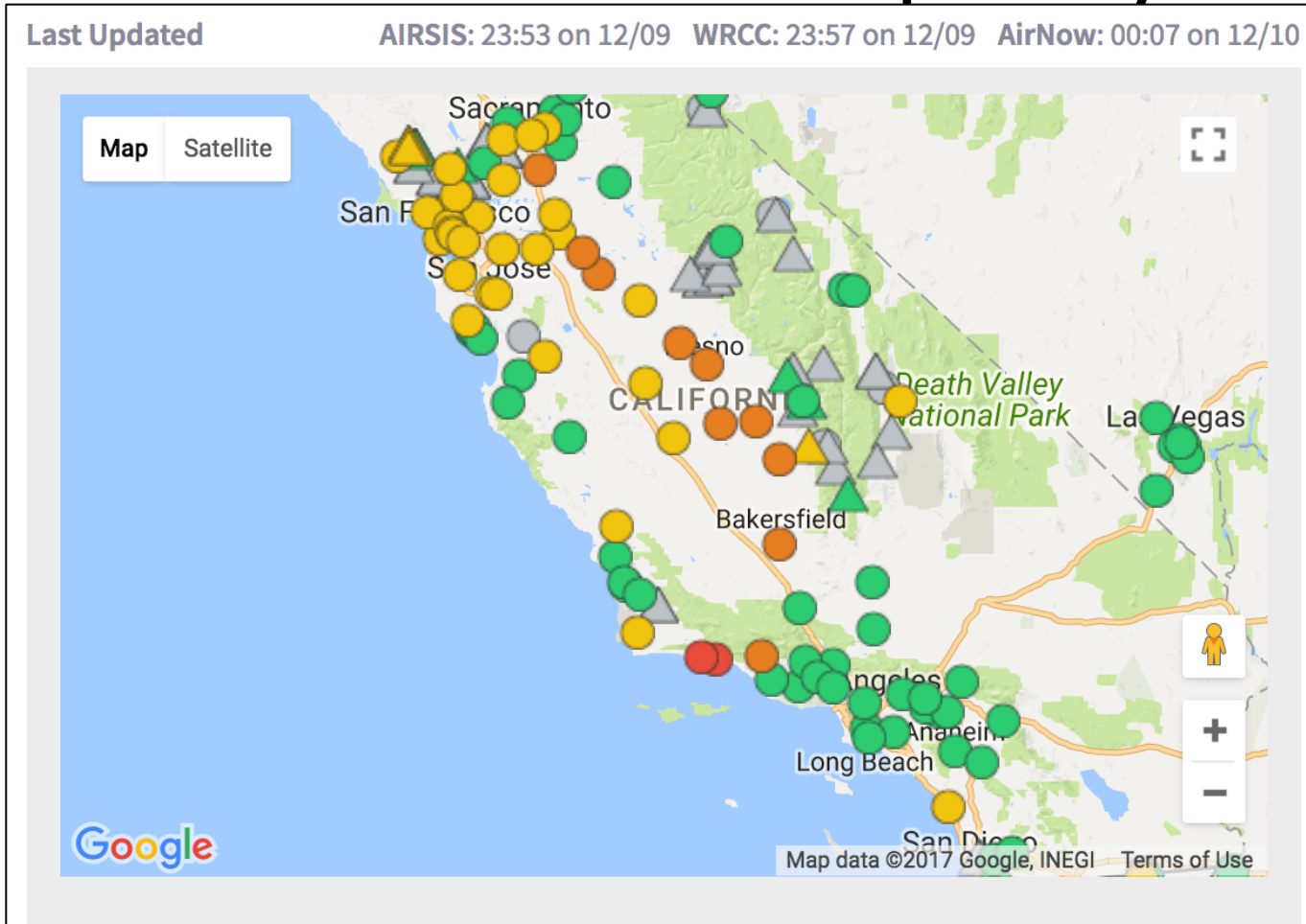
Visualize daily smoke forecasts [More info](#)



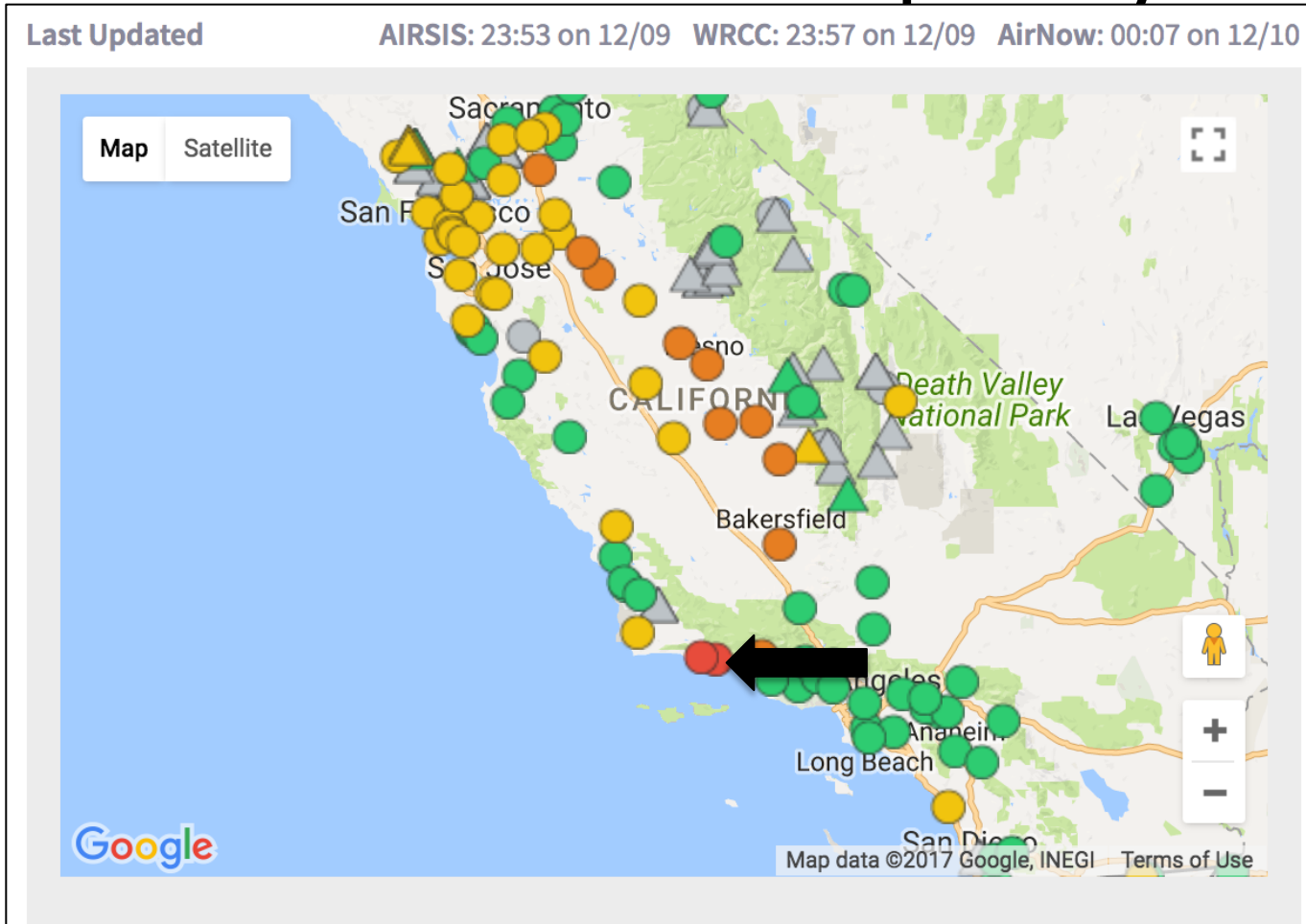
BlueSky Playground

Customized emissions and dispersion modeling [More info](#)

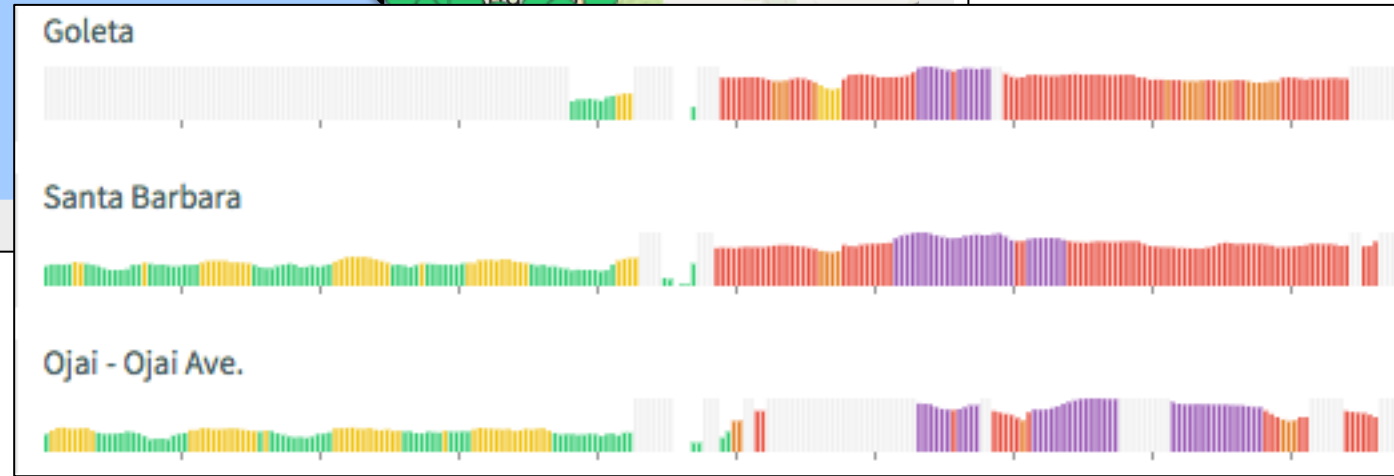
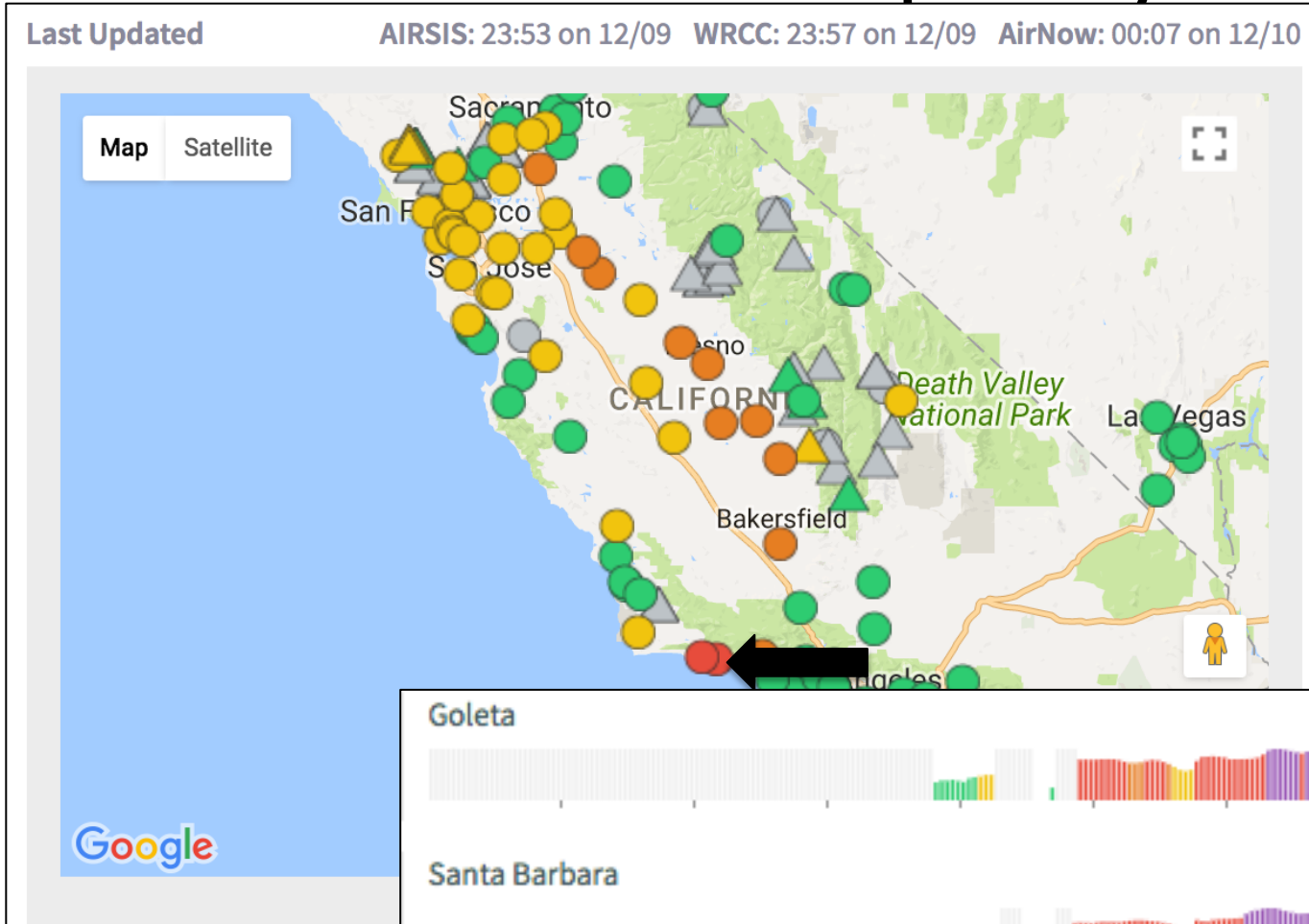
Monitoring Data Tool – Real-time PM2.5 Permanent and Temporary Monitors



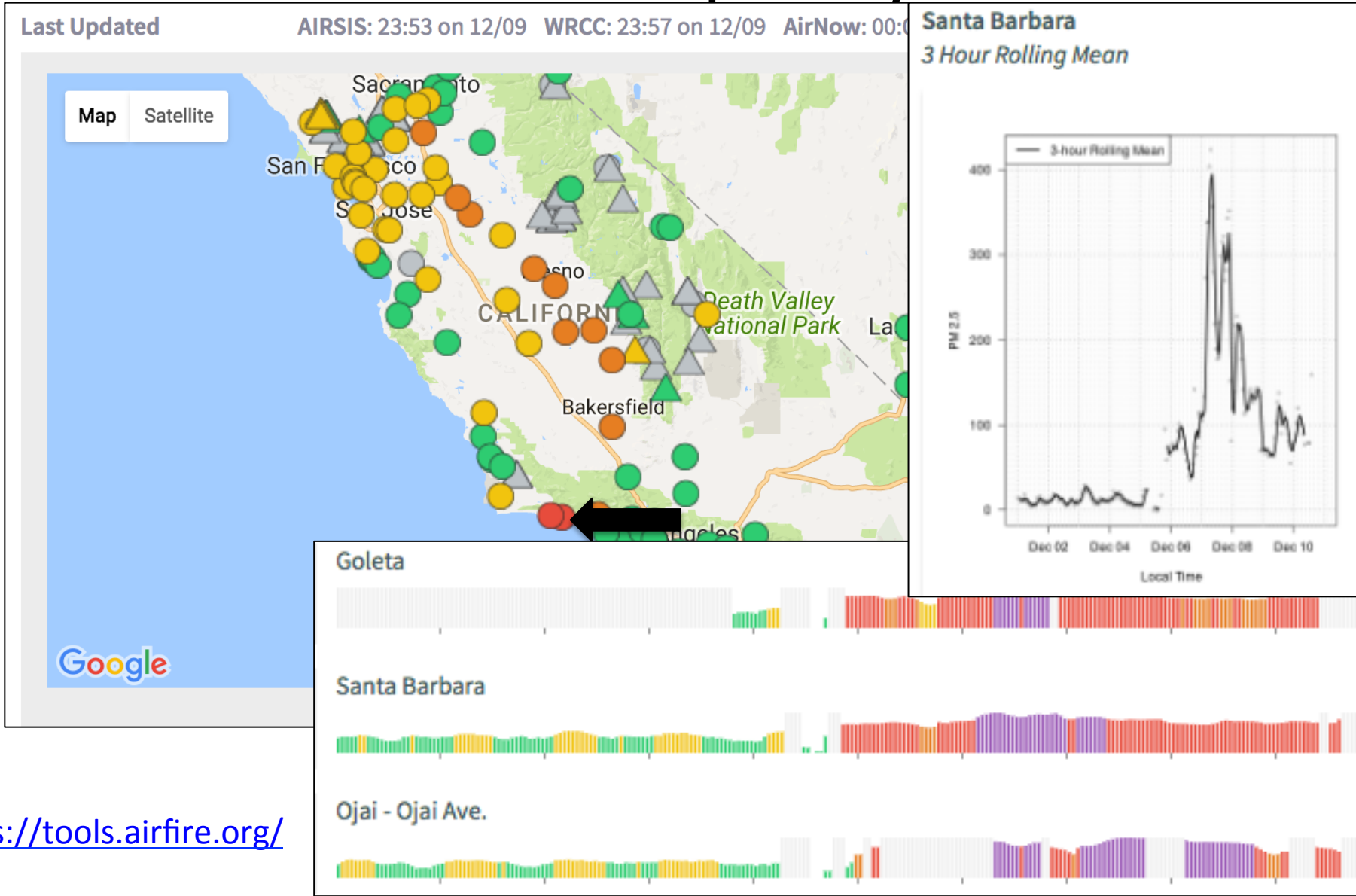
Monitoring Data Tool – Real-time PM2.5 Permanent and Temporary Monitors



Monitoring Data Tool – Real-time PM2.5 Permanent and Temporary Monitors



Monitoring Data Tool – Real-time PM2.5 Permanent and Temporary Monitors





Satellite Information

- Infusing Satellite Data into Environmental Applications (IDEAS)
<https://www.star.nesdis.noaa.gov/smcd/spb/aq/>
- Enhanced Infusing Satellite Data into Environmental Applications (eIDEAS)
<https://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/index.php>
- GOES-16
<http://rammb-slider.cira.colostate.edu/>
- NASA Worldview
<https://worldview.earthdata.nasa.gov/>
- Stay tuned for more
 - GOES-16 Launched 11/2016 – in GOES East Position
 - NOAA-20 Launched 11/18/2017
 - GOES-S Launched 03/2018 – will be GOES-17 in GOES-West Position

NASA WORLDVIEW

NASA WORLDVIEW

Layers Events Data

OVERLAYS

- Fires and Thermal Anomalies (Day, 375m)
Suomi NPP / VIIRS
- Fires and Thermal Anomalies (Night, 375m)
Suomi NPP / VIIRS
- Fires and Thermal Anomalies (Day and Night)
Terra and Aqua / MODIS
- Place Labels
© OpenStreetMap contributors, Natural Earth
- Coastlines / Borders / Roads
© OpenStreetMap contributors, Natural Earth
- Coastlines
© OpenStreetMap contributors

BASE LAYERS

- Corrected Reflectance (True)

+ Add Layers

2017 SEP 06

JUL AUG SEP

The main map displays a satellite view of North America with numerous red dots representing fire and thermal anomalies. State abbreviations are visible: B.C., Alta., Sask., Wash., Mont., N.D., S.D., Wyo., Nev., Utah, Idaho, Ore., Calif., San Jose, and Colo. The interface also features a top right corner with navigation icons and a bottom right corner with a menu icon.

GOES-16 9/4/2017 14:12 PDT

2017-09-04
21:12:15 UTC

(H)ide

Play (space) < >

(L)oop (R)ock Re(v)

Speed

Zoom (+) Zoom (-) Max (Z)oom

(M)aps Lat/Lo(n) Slid(e)r

Mouse (D)raw Clear Drawin(g)s

(S)atellite GOES-East (G...)

Se(c)tor CONUS

(P)roduct GeoColor (CIRA)

Add (O)verlay Add (O)verlay

of (I)mages 12

(T)ime Step 60 min

Fire Temperature (CIRA) Hide

GeoColor (CIRA) Hide

(A)rchived Imagery

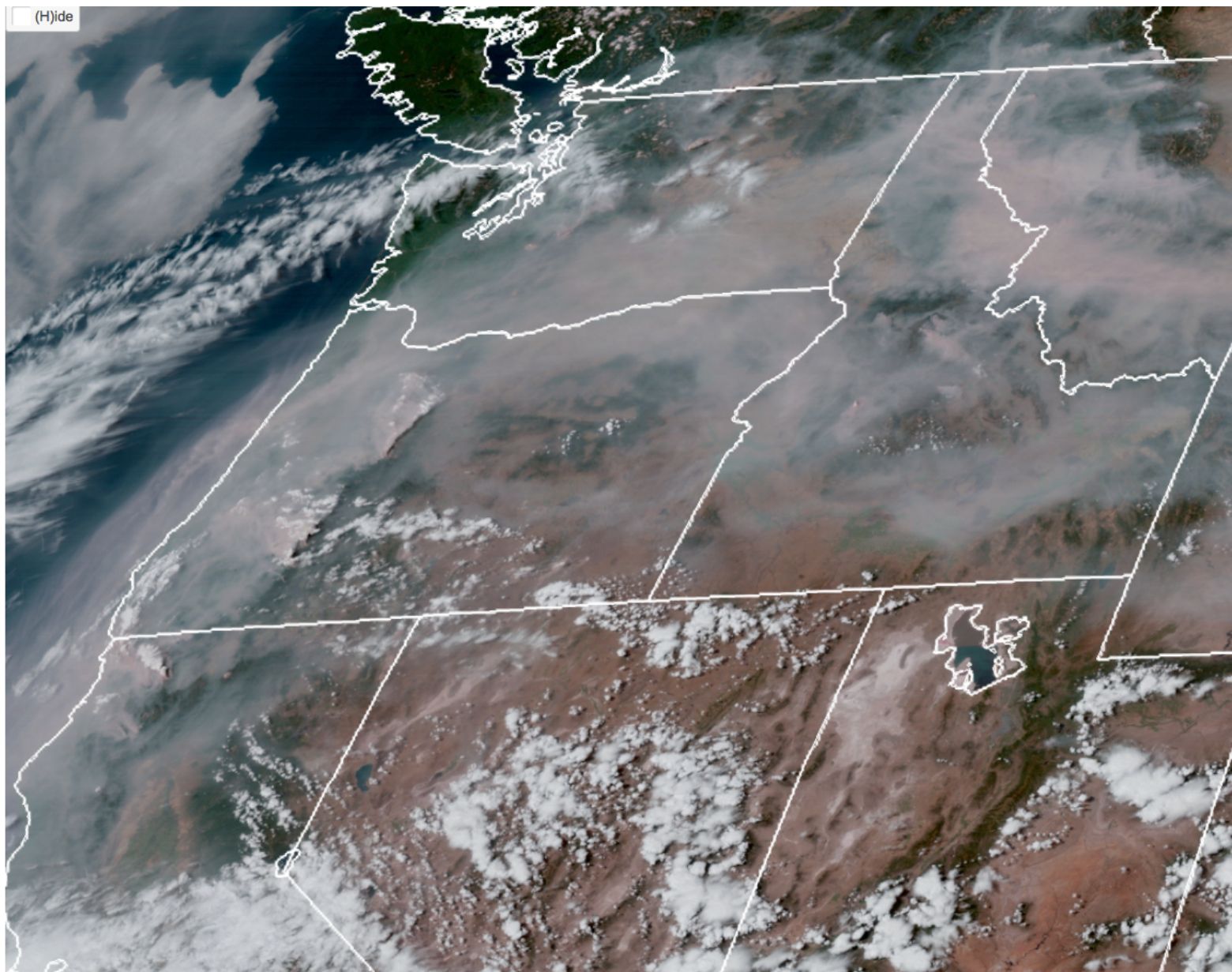
2017-09-04 17 17:02:15...

2017-09-06 23 23:57:16...

Home (y) Share (U)RL Help (?)

SLIDER by RAMMB / CIRA @ CSU

[Experimental Products Disclaimer](#)



GOES-16 9/4/2017 14:12 PDT

2017-09-04
21:12:15 UTC

(H)ide

Play (space) < >

(L)oop (R)ock Re(v)

Speed

Zoom (+) Zoom (-) Max (Z)oom

(M)aps Lat/Lo(n) Slid(e)r

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of (I)mages 12

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Fire Temperature (CIRA) Hide

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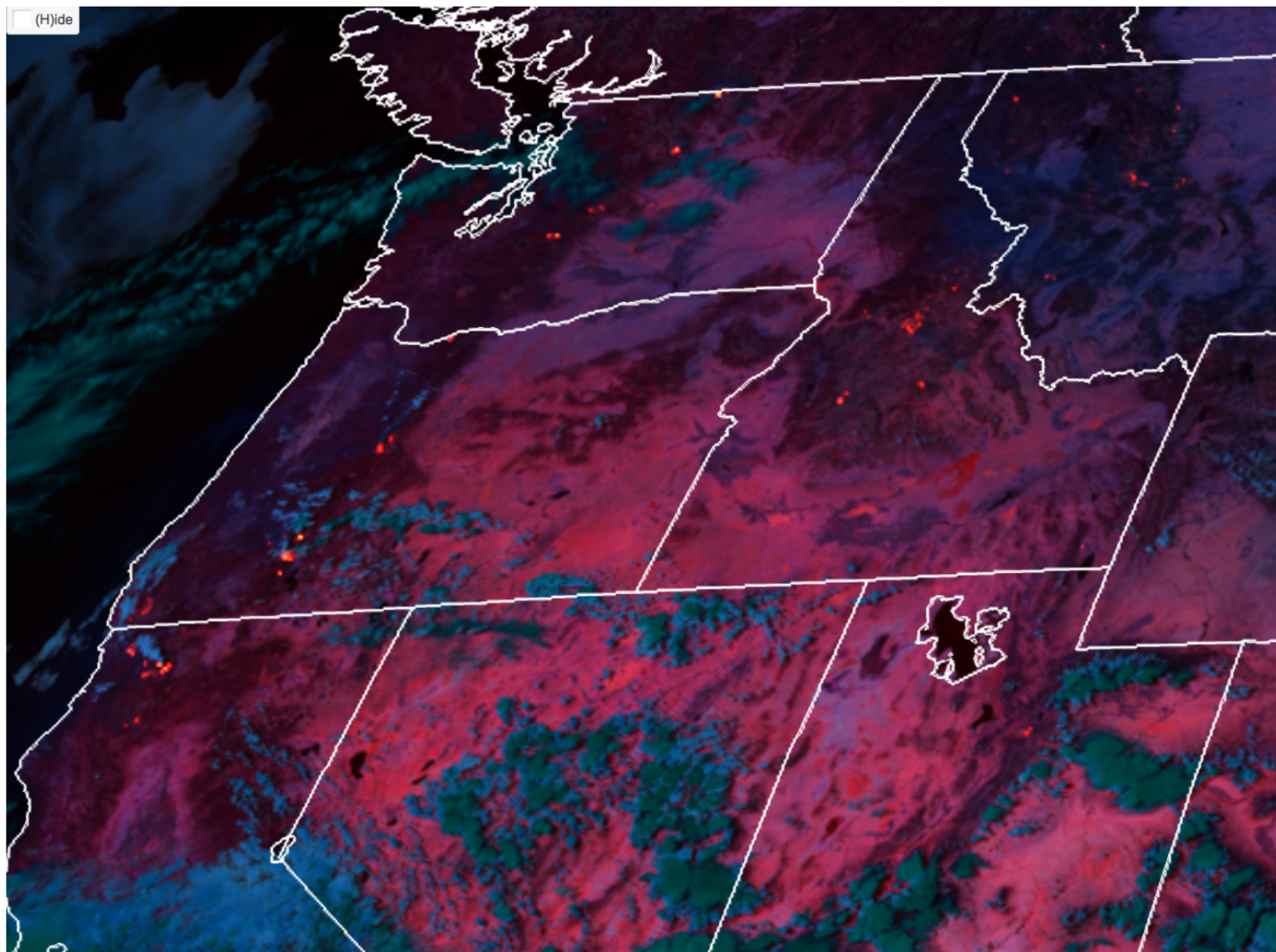
(A)rchived Imagery

2017-09-04 17 17:02:15...

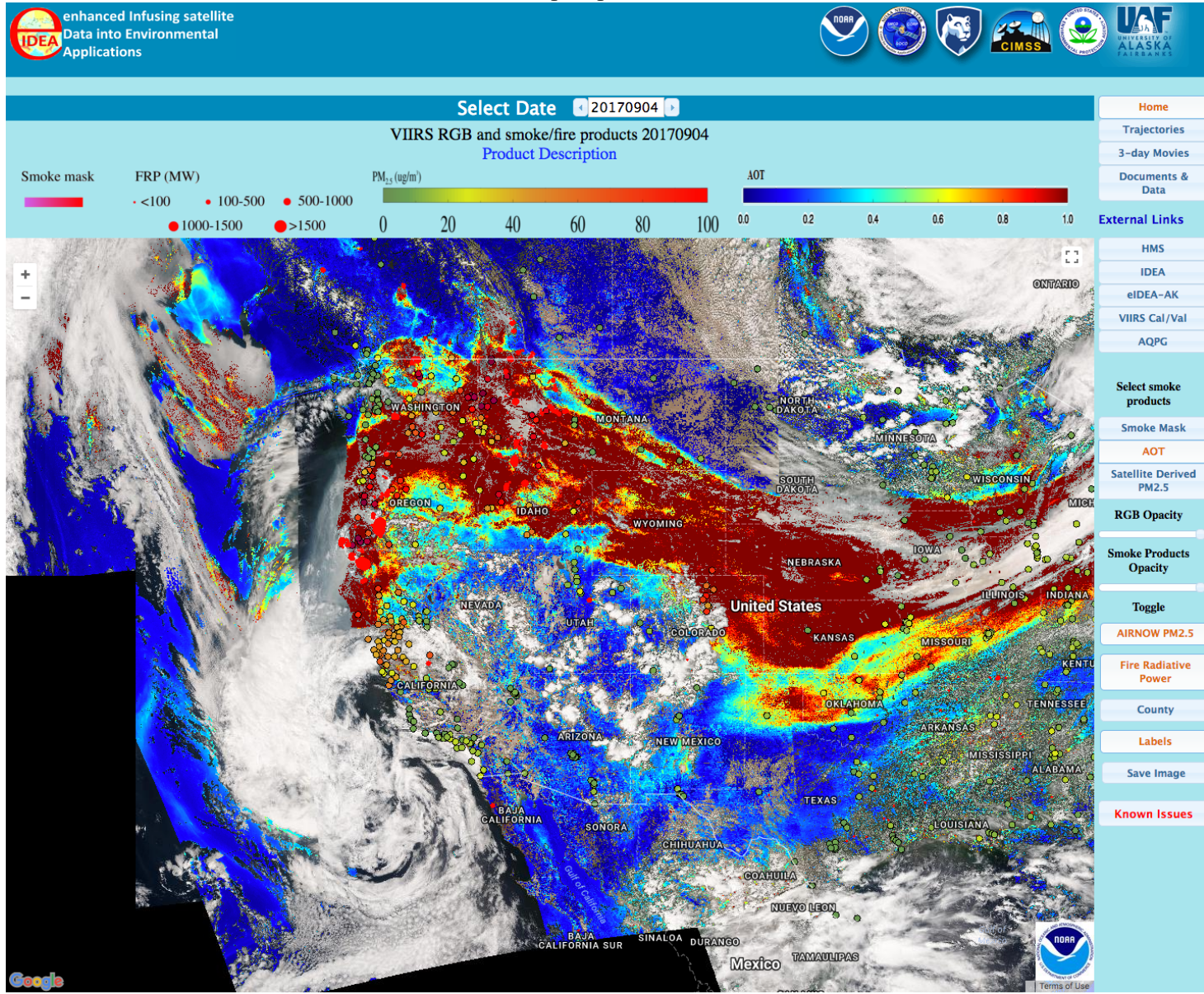
2017-09-06 23 23:57:16...

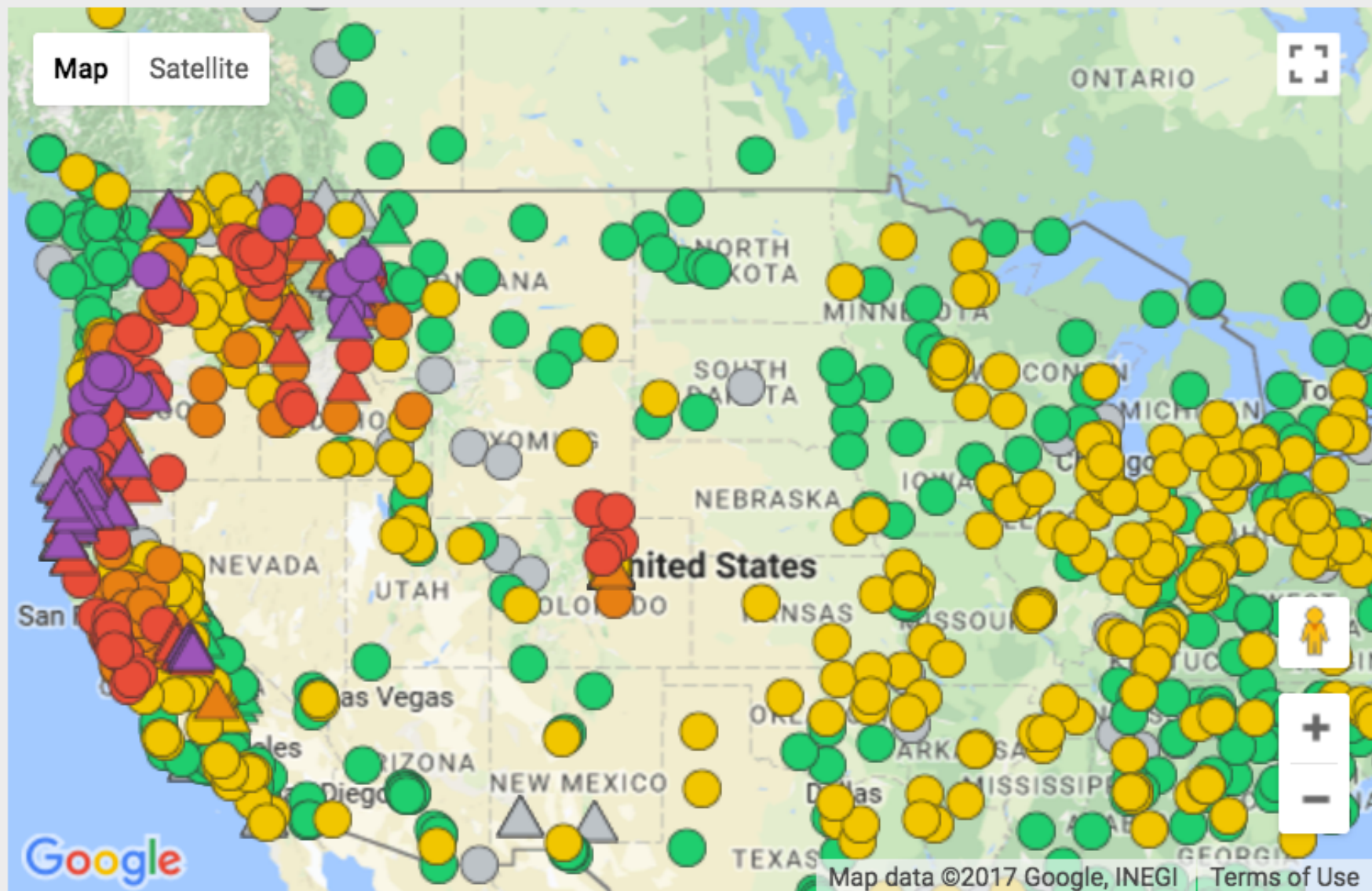
Home (y) Share (U)RL Help (?)

[SLIDER by RAMMB / CIRA @ CSU](#)
[Experimental Products Disclaimer](#)



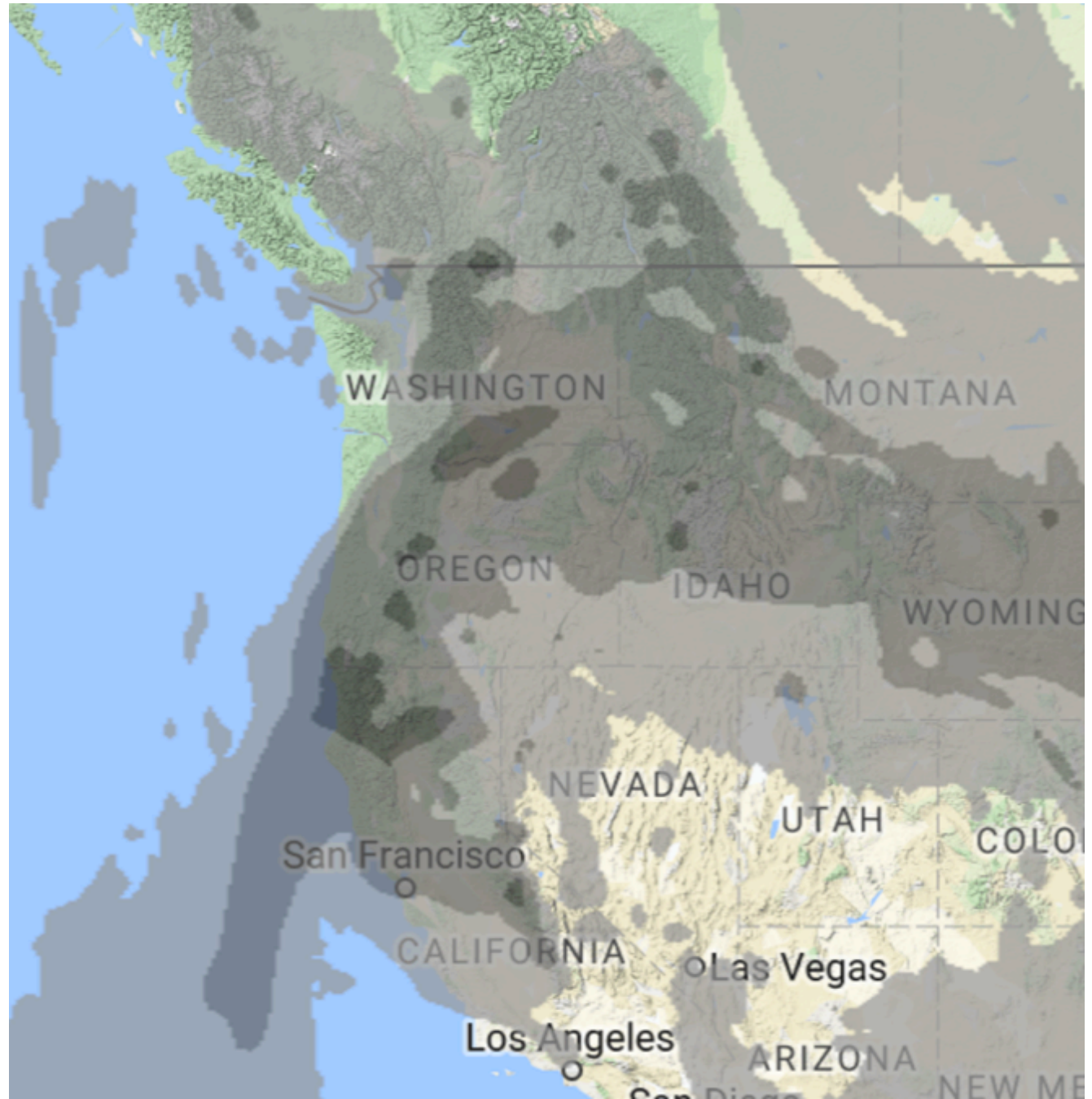
Enhanced Infusing Satellite Data for Environmental Applications (eIDEAS)



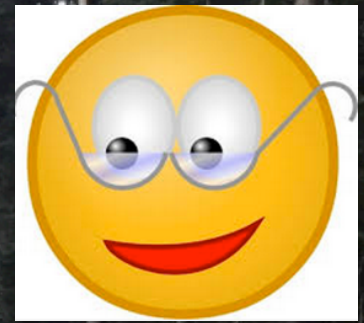


9/4/2017
13:00 PDT

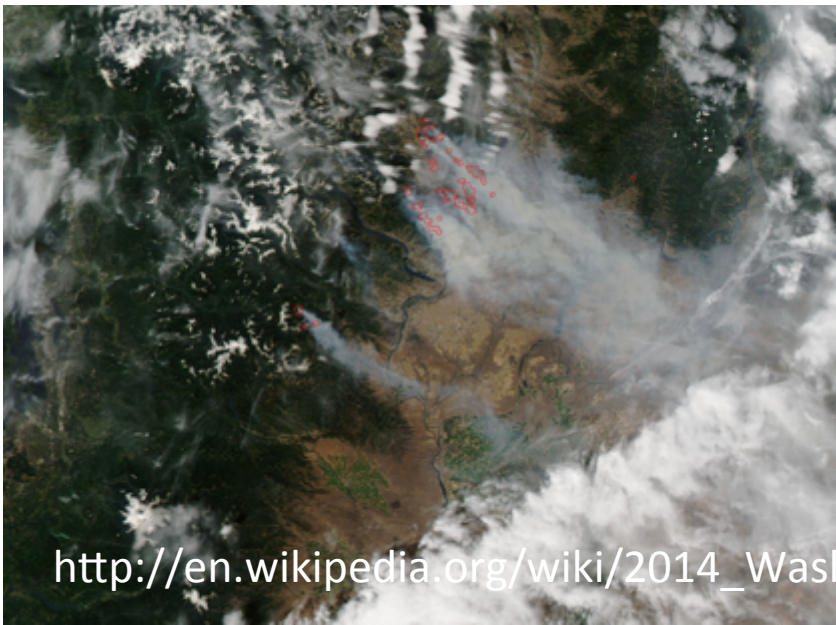
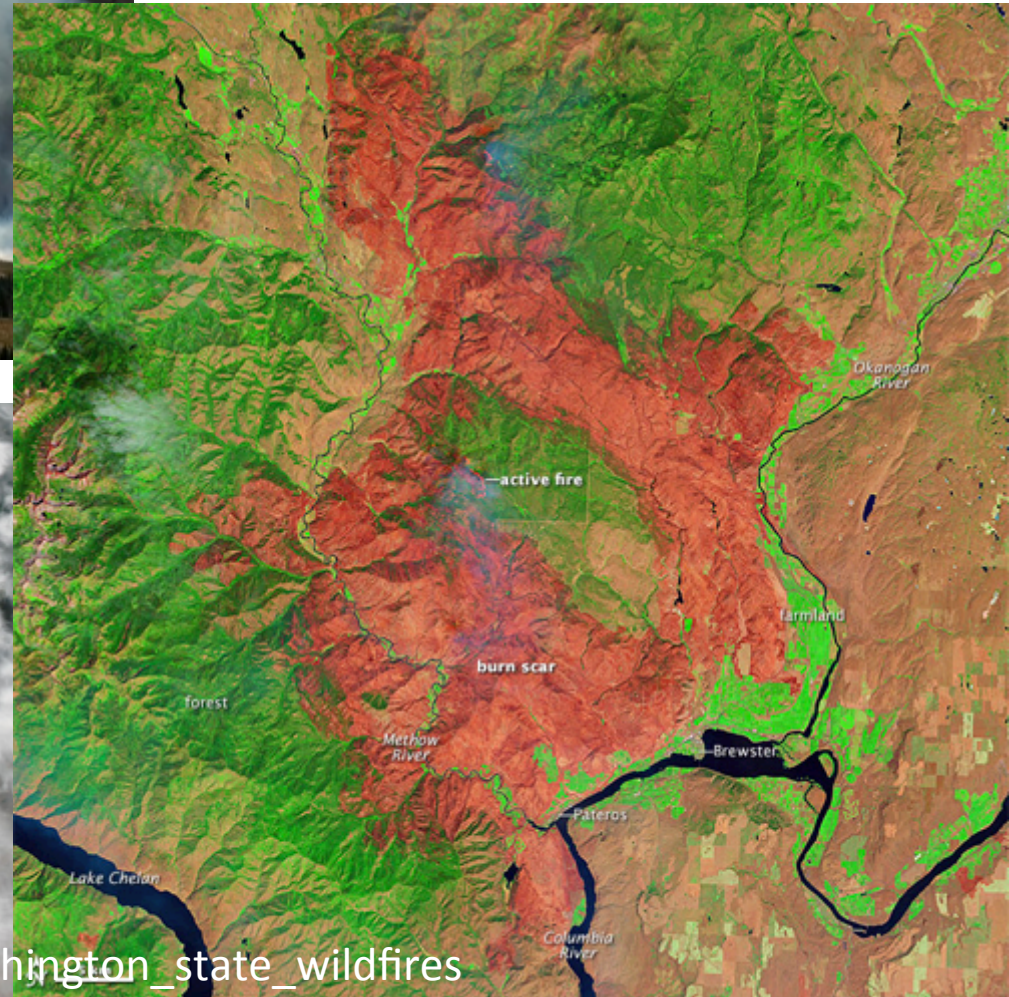
- BlueSky
- Global Forecast System (GFS)
- Column Average



Putting on Your Smoke Glasses



Carlton Complex Washington State 2014 250,000 acres



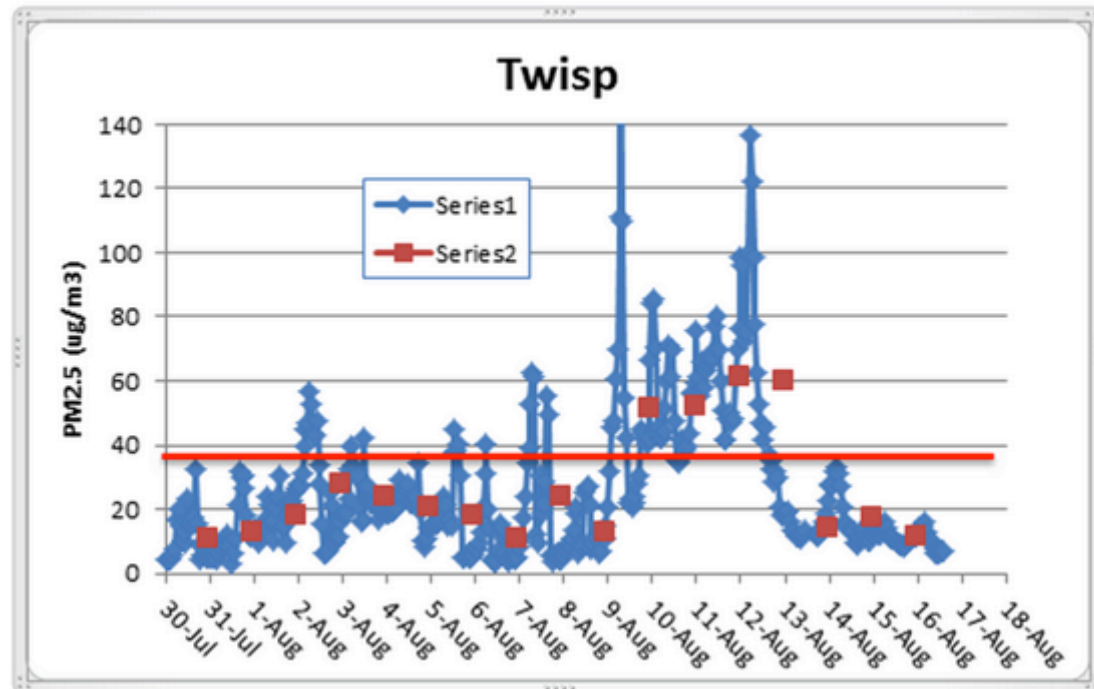
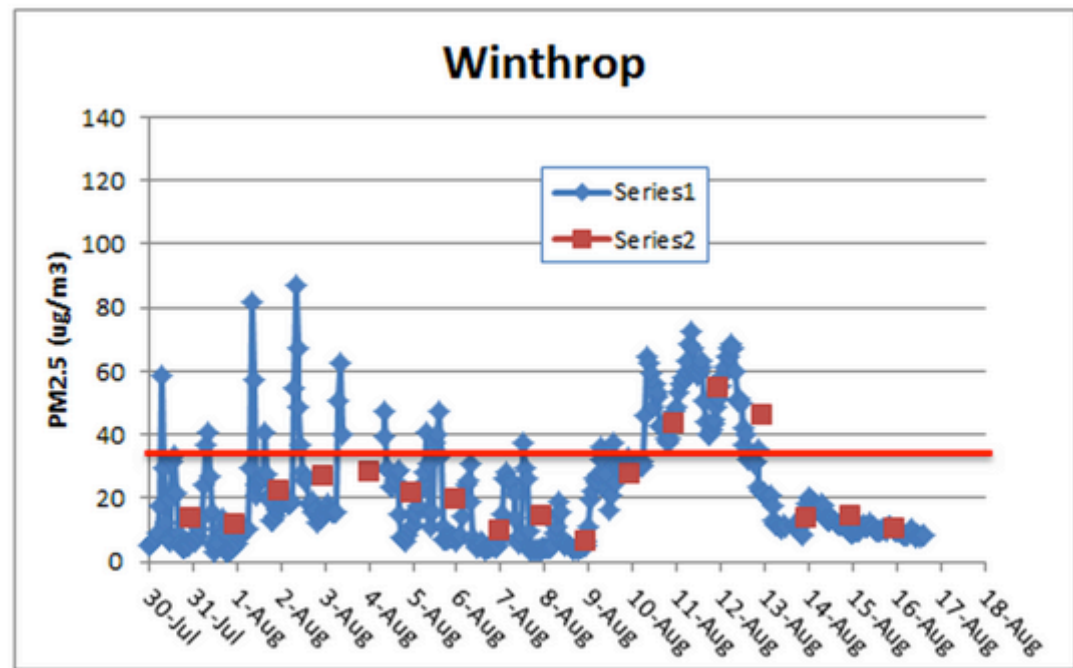
http://en.wikipedia.org/wiki/2014_Washington_state_wildfires

Carlton Complex August 2014

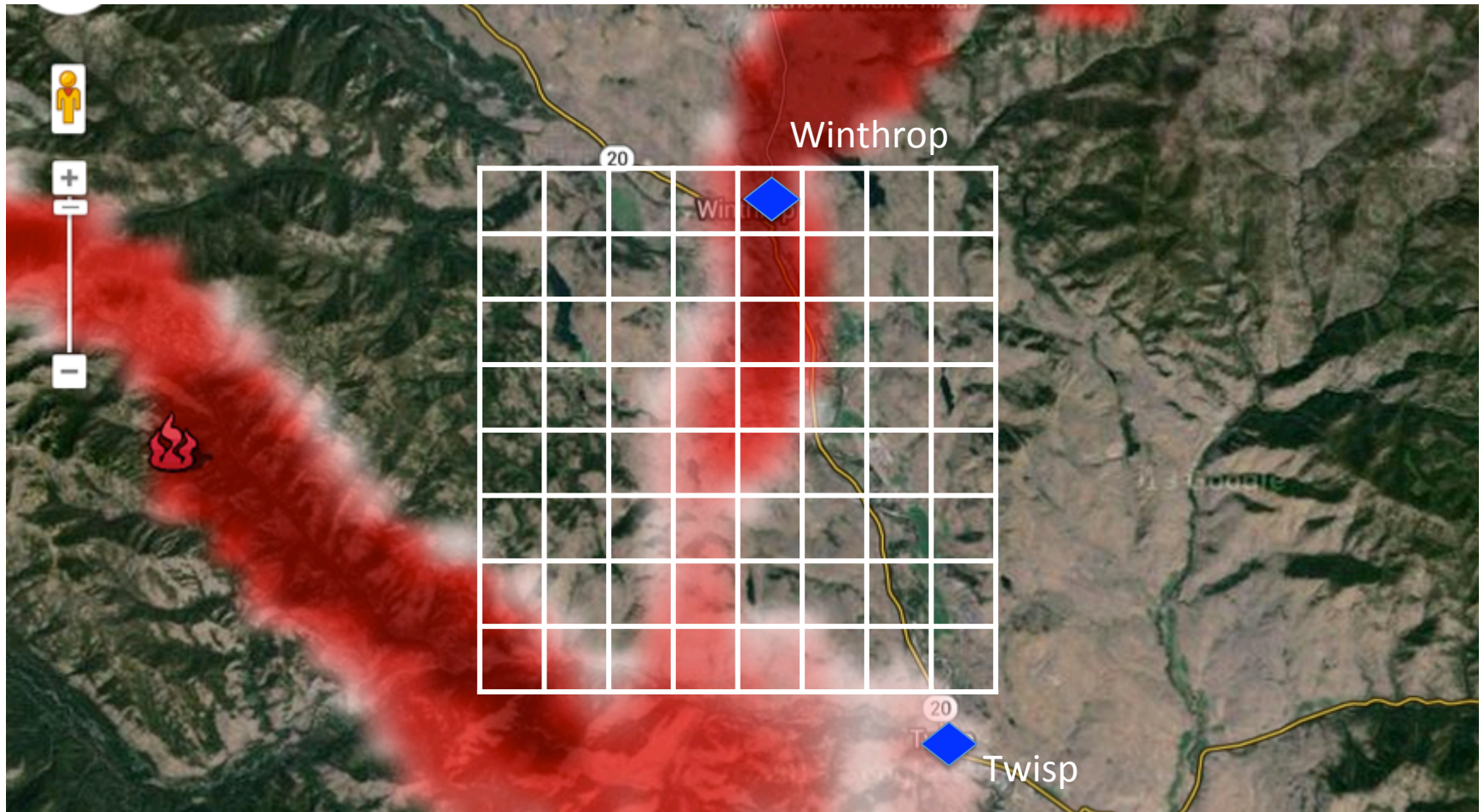
Washington Smoke Blog

On this gorgeous, clear day with no smoke, let's take a look at the differences between two air quality monitors located less than 9 miles apart in the same Methow Valley. The blue graphs indicate 1-hr average concentrations of PM2.5 while the red data points are 24-hr averages. Note that while the 24-hr values trended rather similar for the two sites (expected as they are spatially close) the peak 1-hr values differed greatly!

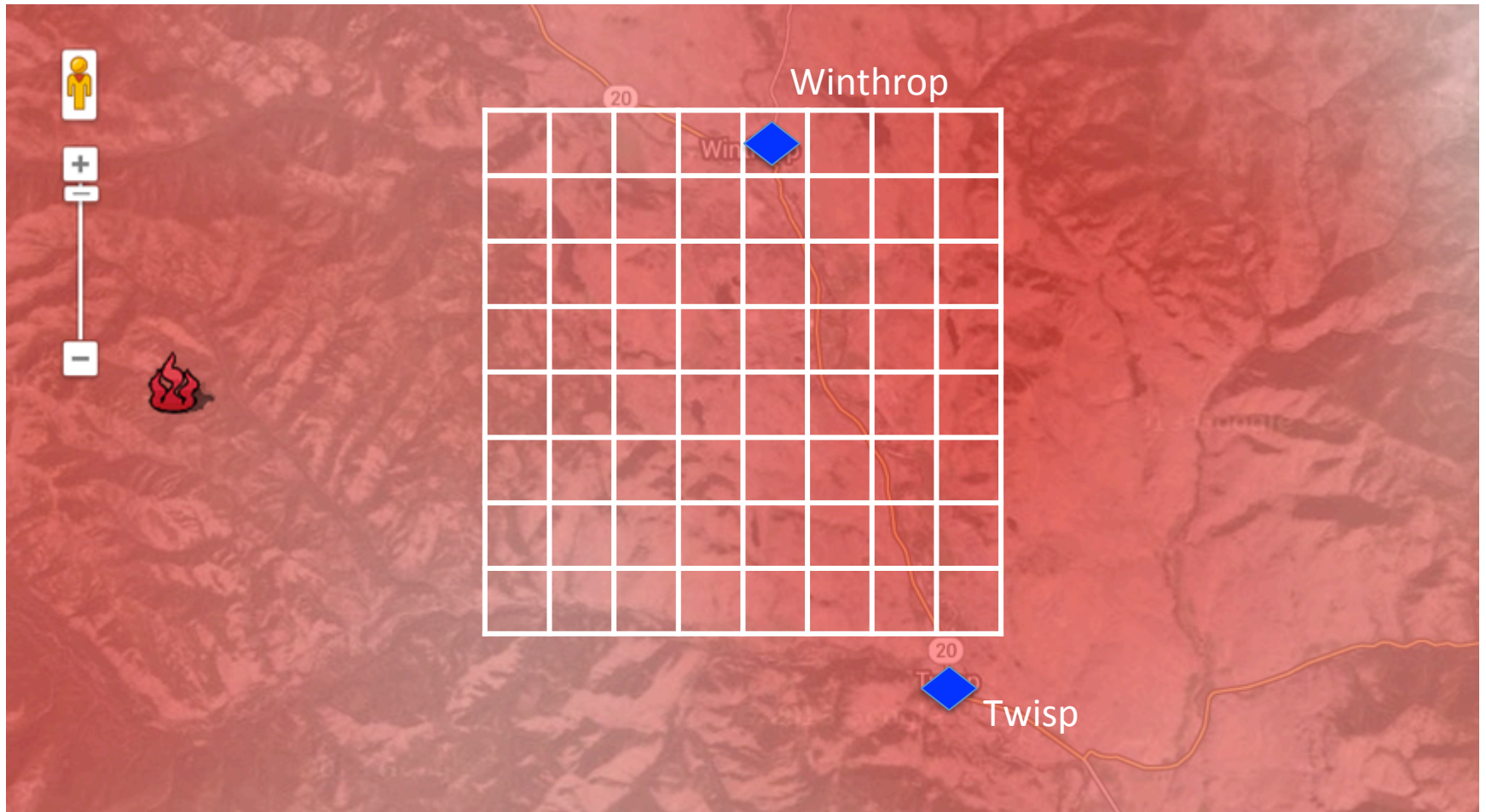
Posted by Mike Broughton, FWS, ARA



Carlton Complex, 8/4/2014 6am, 1.33 km Domain



Carlton Complex, 8/4/2014 6am, 12 km Domain



Wildland Fire Air Quality Response Program



<http://www.wildlandfiresmoke.net/>

- Air Resource Advisors
- Deployed to Incident Management Teams & Geographic Area Commands
- Modeling, Monitoring, Messaging

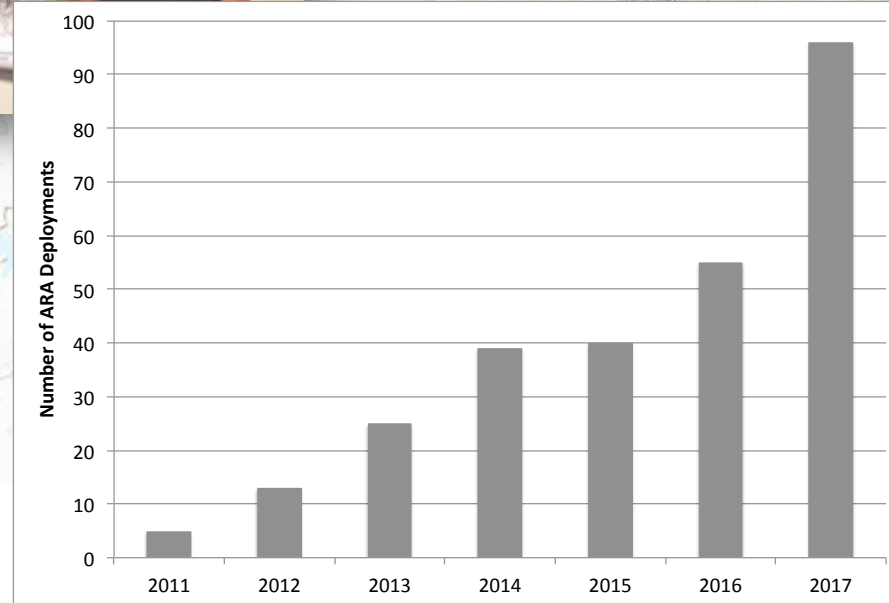
Deployments



- Smoke Monitoring Cache:
20 E-Samplers
6 EBAMS
Carbon Monoxide
- Trainings: 2013 – 2017

***Pete Lahm, USFS WO,
Coordinator***

Air Resource Advisors



Smoke outlook for next 2 days

1-2 pages

Aimed for public dissemination/posting:

- Smokeblogs
- Public Meetings
- Public bulletin boards
- AQ/Health agencies email lists & daily coordination calls

Outlook for Pier Fire

Smoke: Today's weather will be characterized by instability in the atmosphere providing good dispersion conditions. Smoke from today's planned aerial ignitions is expected to loft high and move north. Bishop may see impacts this afternoon with possible Moderate conditions through tonight. Communities along western foothills should generally see clearing this evening.

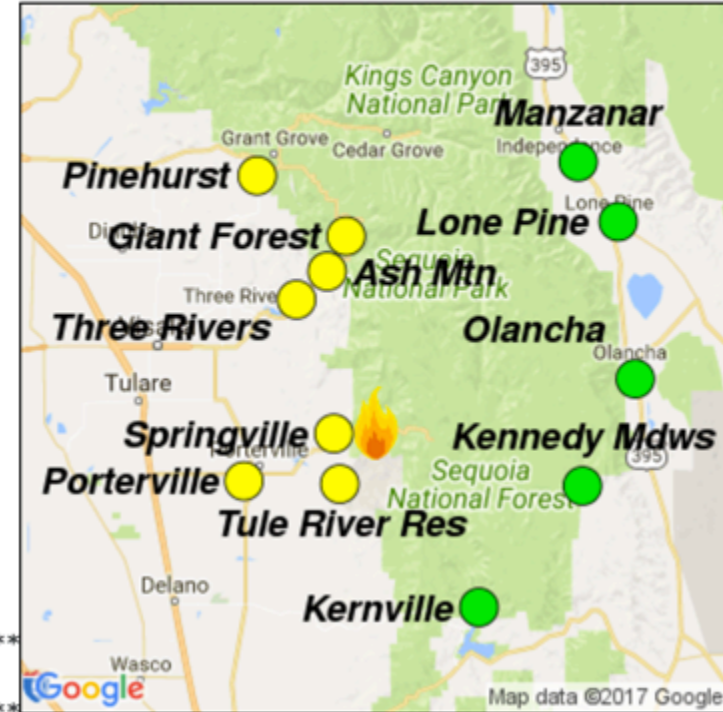
Fire: Aerial firing is expected to begin generally south of the Black Mountain/Solo Peak ridge line today. Fuels in that area range from dense forests with dead standing trees at the higher elevations to brush and grass at the lower elevations. Weather will moderate today's fire activity elsewhere.

Other: Forecasts reflect particulate matter only - not ozone. For information on real time air quality conditions related to smoke see: <https://tinyurl.com/yd7ngvd8>

CA Smoke Blog: <http://californiasmokeinfo.blogspot.com>

Protect Yourself from Wildfire Smoke:
<https://www.cdc.gov/features/wildfires/index.html>

Daily AQI Forecast for Sep 12, 2017



Station	Yesterday hourly	Mon 9/11	Forecast Comment for Today -- Tue, Sep 12	Tue 9/12	Wed 9/13
Springville		Yellow circle	Concentrations will rise into Unhealthy range this morning, clearing after noon	Yellow circle	Yellow circle
Tule River Reservation		Yellow circle	Concentrations will rise into USG this morning, clearing after noon	Yellow circle	Yellow circle
Porterville		Yellow circle	Mostly Moderate.	Yellow circle	Yellow circle
Three Rivers		Yellow circle	Concentrations may rise to USG this morning, clearing afternoon	Yellow circle	Yellow circle
Ash Mtn		Yellow circle	Concentrations may rise to USG this morning, clearing after noon	Yellow circle	Yellow circle
Giant Forest		Green circle	Concentrations may rise to USG this morning, moving to Moderate in afternoon	Yellow circle	Green circle
Pinehurst		Green circle	Mostly Moderate this morning, clearing this afternoon	Yellow circle	Green circle
Manzanar		Green circle	Good air quality	Green circle	Green circle
Lone Pine		Green circle	Good air quality	Green circle	Green circle

Smoke Blogs

Aug 14, 2017 – Sep 12, 2017



Pageviews today	5,512
Pageviews yesterday	10,543
Pageviews last month	599,337
Pageviews all time history	2,239,743
Followers	7


- <http://wasmoke.blogspot.com/>
- <http://oregonsmoke.blogspot.com/>
- <http://californiasmokeinfo.blogspot.com/>
- <http://idsmoke.blogspot.com/>

Figure: Janice Peterson

BlueSky Playground

<https://tools.airfire.org>

Do your own Smoke Modeling



playground 2.0 beta

Home | My Emissions | My Dispersions | Feedback | Help | Credits

Logged in as **susan** | Log Out

Home » My Emissions » **tst (Broadcast)**


Size and Location | Fuels | Moisture | Consumption | Timing | Emissions | Notes

Daily Size (growth) in acres

Day 1

Total Size: **500 acres**

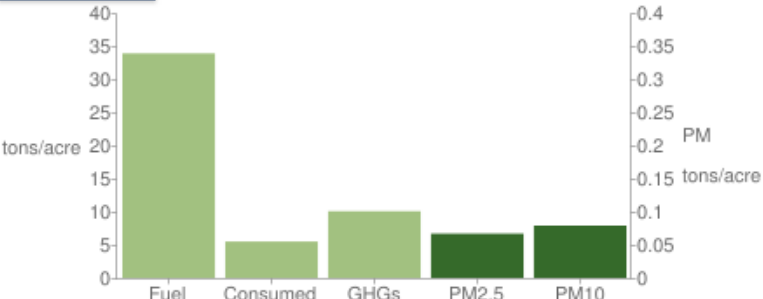
[Add a Day](#)



Latitude:
Longitude:

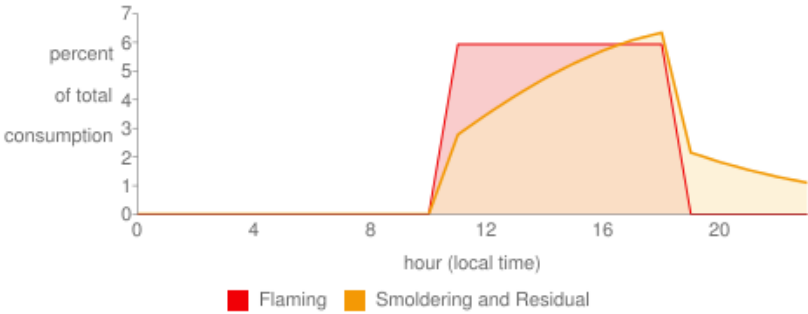
Discard Changes **Apply**

View Totals **Fuels and Emissions per Acre**



Category	Value (tons/acre)
Fuel	34
Consumed	5
GHGs	10
PM2.5	7
PM10	8

Diurnal Profile of % Total Consumption Day 1



hour (local time)	Flaming (%)	Smoldering and Residual (%)
0	0	0
4	0	0
8	0	0
12	6	3
16	6	6
20	0	2

Legend: ■ Flaming ■ Smoldering and Residual



Air Resources Laboratory

Advancing Atmospheric Science and Technology through Research

- ARL Home
- HYSPLIT Model
- READY
 - READY News
 - Transport & Dispersion
 - [Get/Run HYSPLIT >>](#)

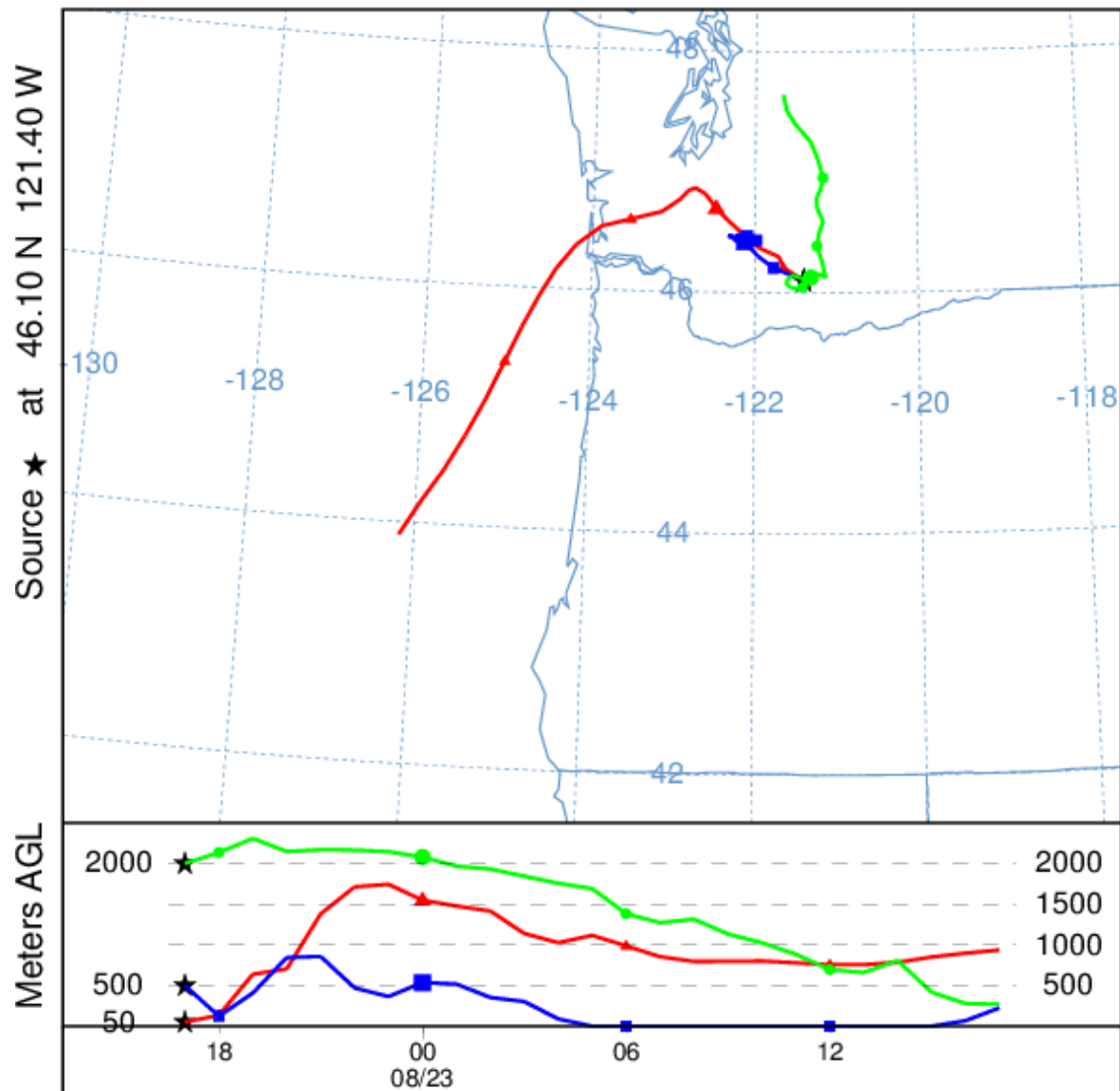


HYSPLIT Trajectories

- Parcel of Air Travels in the Wind Field
- Same Trajectory for a 50 acre burn as a 500 acre burn
- Simulate Effect of Plume Rise
- Spot Weather Forecasts

<https://ready.arl.noaa.gov/HYSPLIT.php>

HYSPLIT Trajectory Example



Job ID: 111386 Job Start: Fri Feb 2 23:01:25 UTC 2018
 Source 1 lat.: 46.100000 lon.: -121.400000 hgts: 50, 500, 2000 m AGL

Trajectory Direction: Forward Duration: 24 hrs
 Vertical Motion Calculation Method: Model Vertical Velocity
 Meteorology: 1200Z 22 Aug 2015 - HRRR

Thank you!

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

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