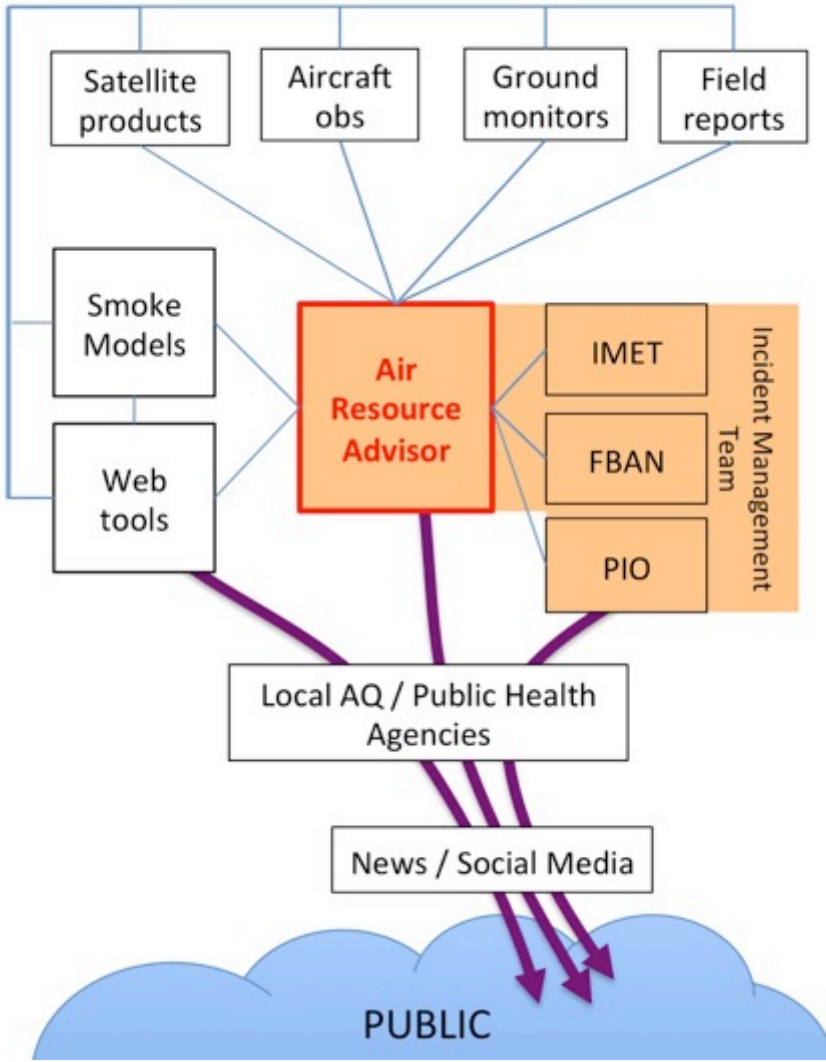
Smoke Modeling and Tools
Supporting Wildland Fire Operations

Sim Larkin, Susan O'Neill
USDA Forest Service
Pacific Northwest Research Station

February 27, 2017
NASA Health and Air Quality Applied Sciences Team (HAQAST) Meeting
Seattle, WA

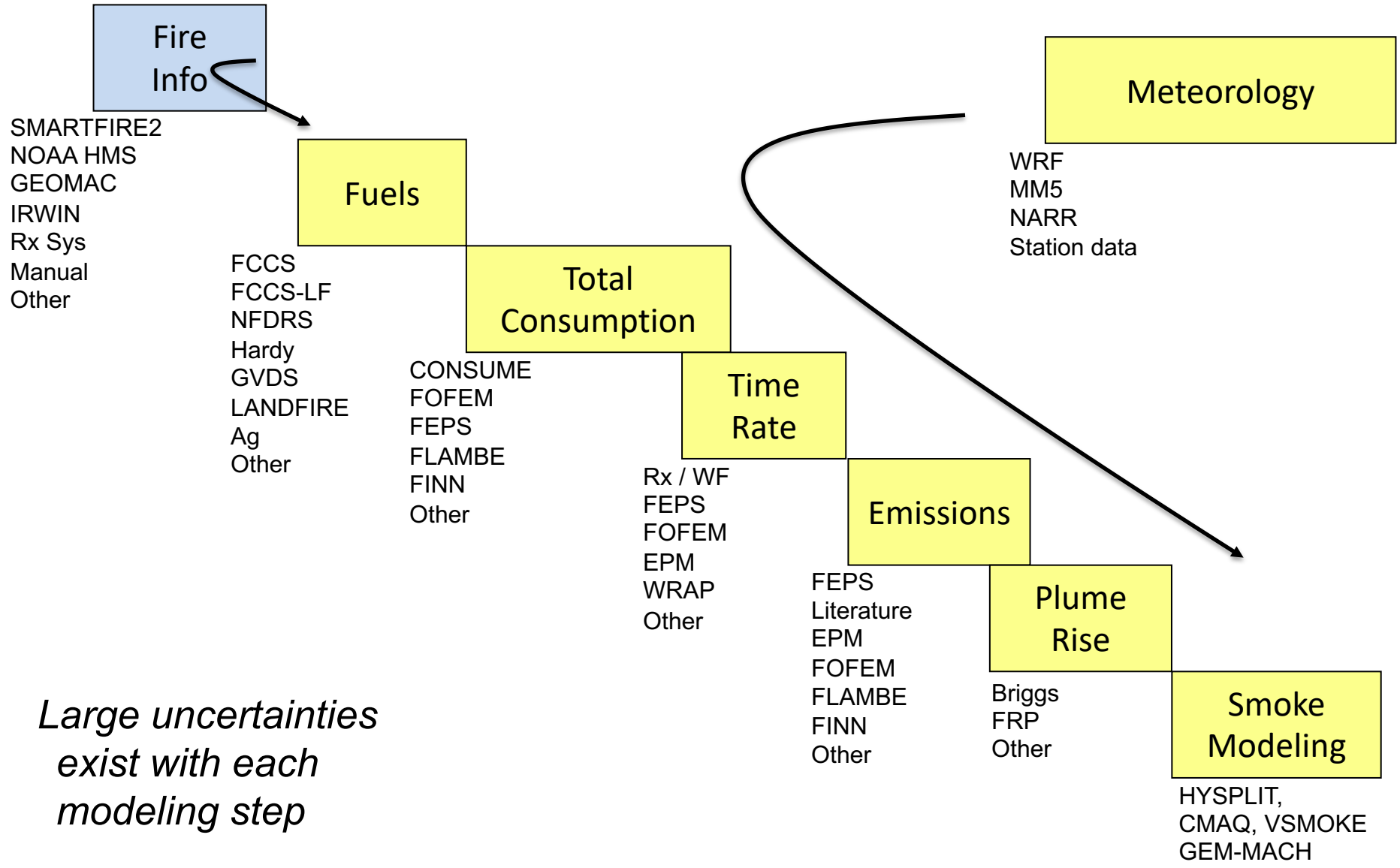


Partners

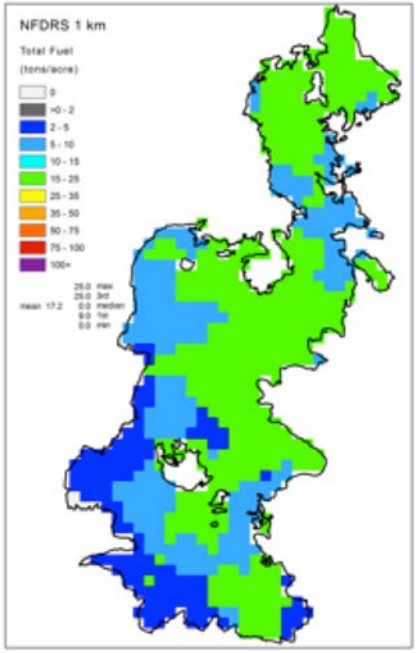
Work described here done in partnership with:

- National Weather Service
- US Forest Service
- National Park Service
- EPA
- CDC
- Environment and Climate Change Canada
- Joint Fire Science Program
- University of Washington
- Desert Research Institute
- *many others*

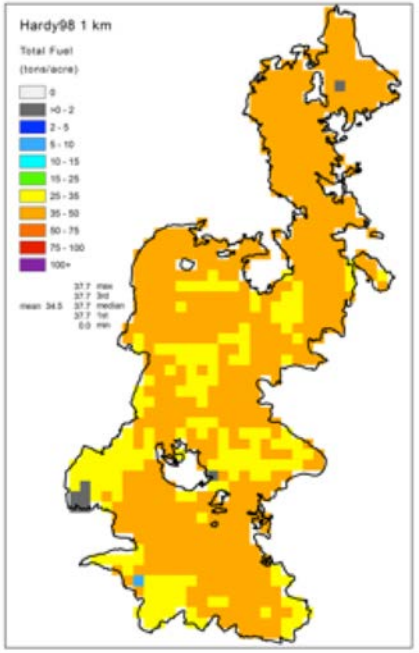
BlueSky Smoke Modeling Framework
Components to Calculating Fire Emissions



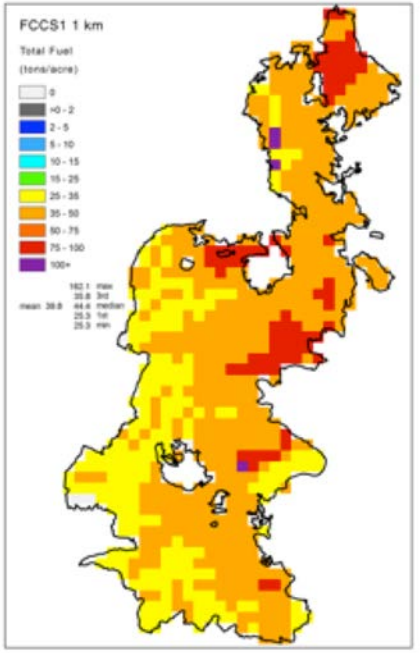
Large uncertainties exist with each modeling step



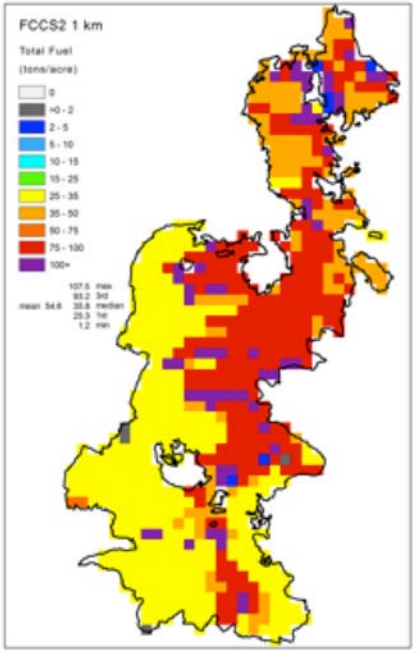
NFDRS



HARDY



FCCS

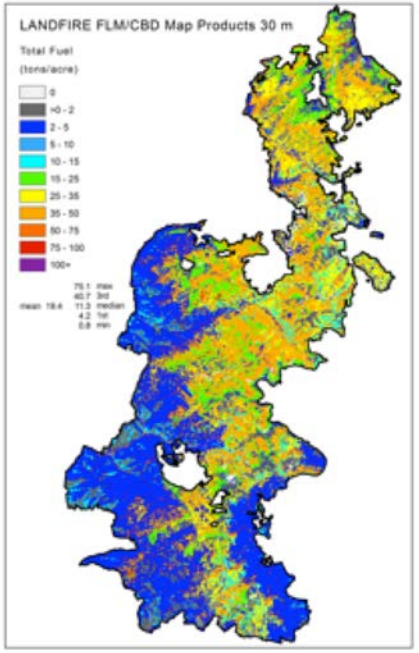


FCCS-LF

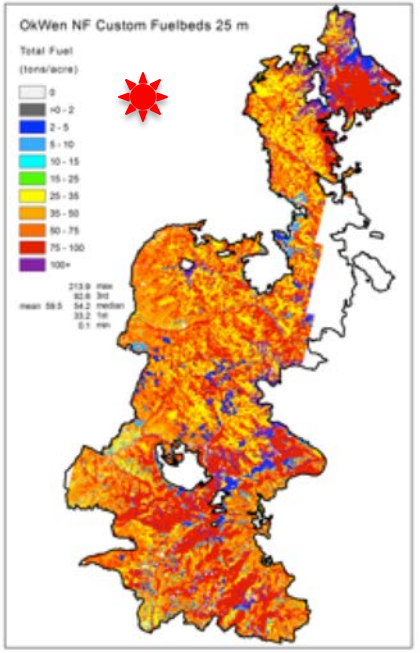
SEMIP Smoke and Emissions Model Intercomparison Project

TRIPOD FIRE CASE
TOTAL FUELS
Top: 1-km maps
Bot: High-res maps

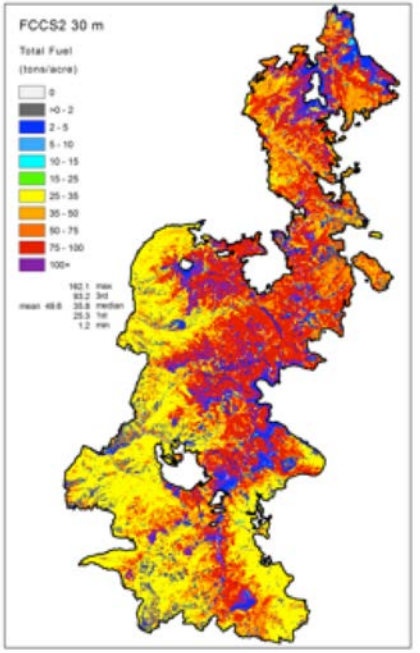
Larkin et al., Forest Ecol. Manage., 317 (2014), 61-69.



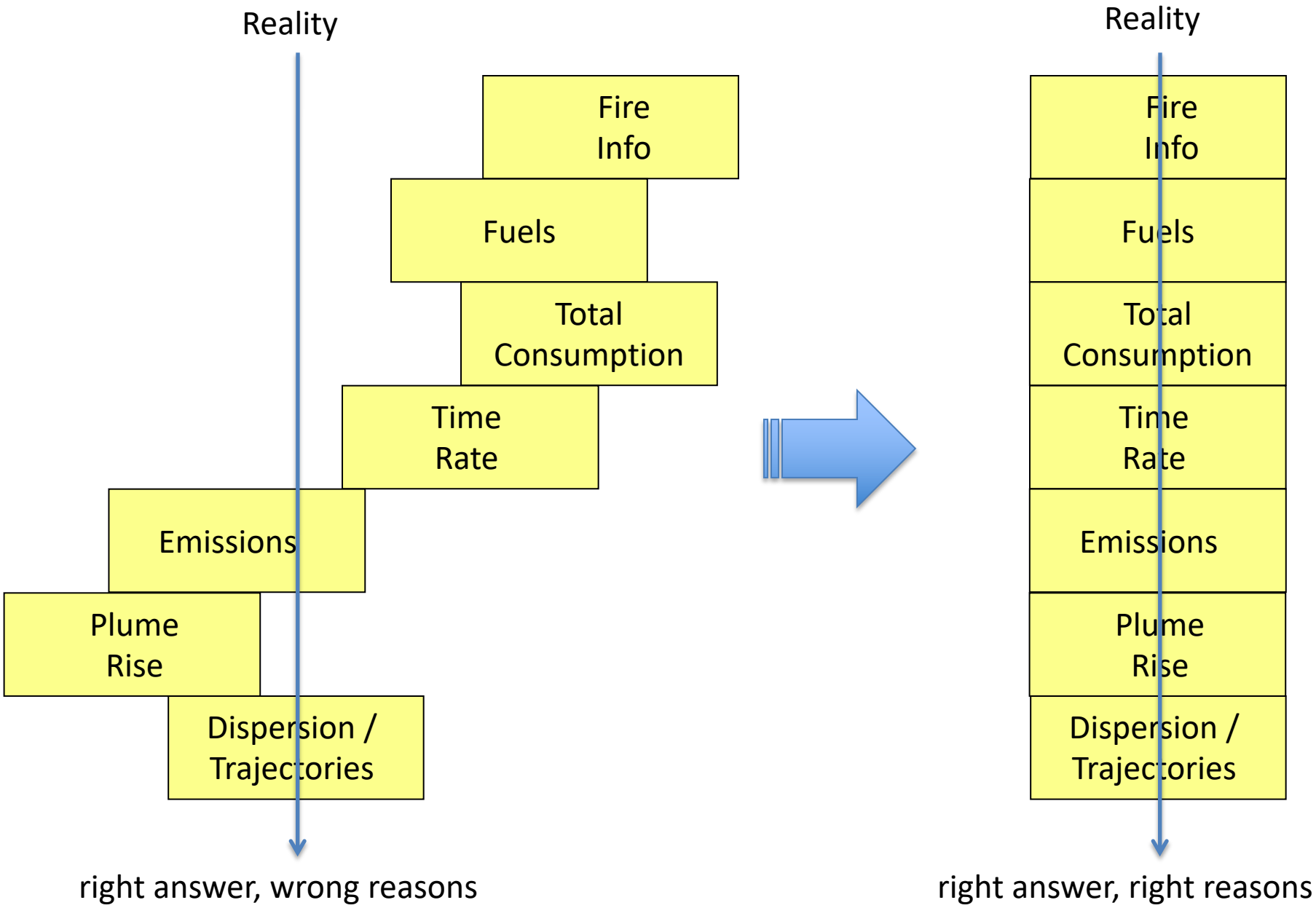
LANDFIRE



OK-WEN FOREST

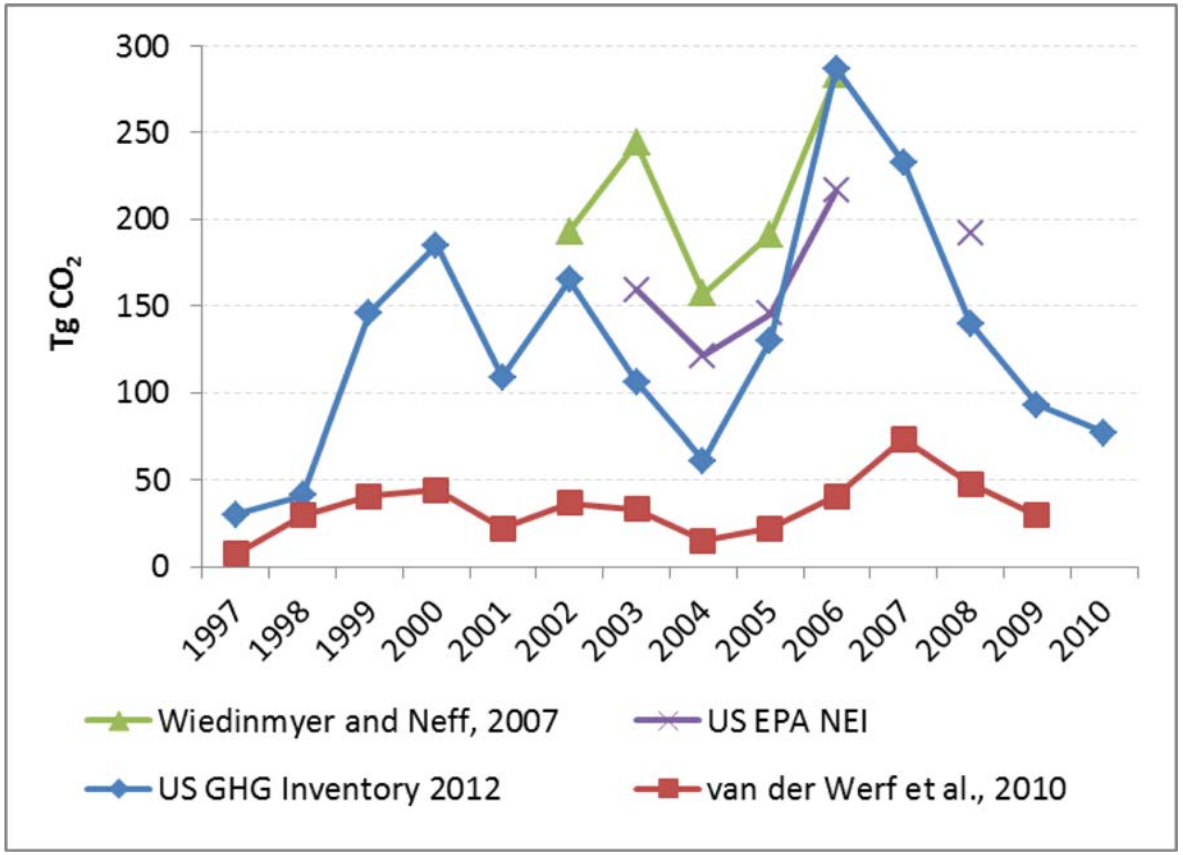


FCCS-LF


Reality
Fire Info
Fuels
Total Consumption
Time Rate
Emissions
Plume Rise
Dispersion / Trajectories
right answer, wrong reasons
Reality
Fire Info
Fuels
Total Consumption
Time Rate
Emissions
Plume Rise
Dispersion / Trajectories
right answer, right reasons

Different models = different results

- Fire emissions estimates differ; Methodologies differ
  - e.g., satellite emissions vs. ground based
  - changes over time as models, datasets update
- Differences can be large



Larkin et al. Forest Ecol. Manage. (2013), http://dx.doi.org/10.1016/j.foreco.2013.09.012

Some Conclusions

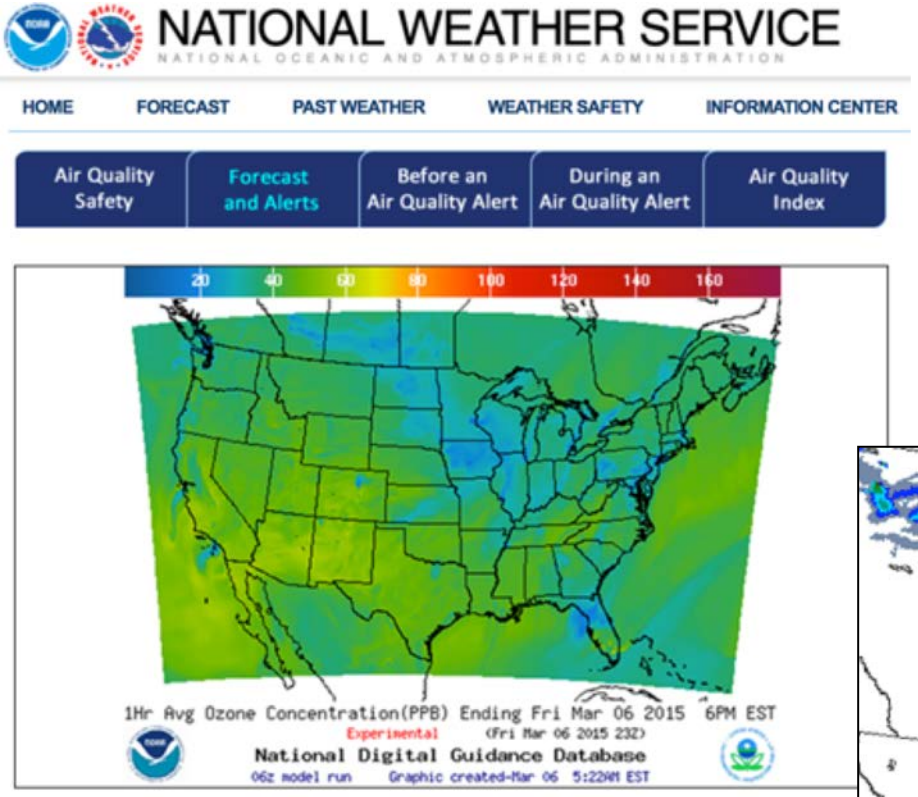
Source of biggest uncertainty depends on use:

- For emissions from a given fire: fuels
  (emissions factors for lesser species)
- For smoke from a given fire: plume rise/fire timing
- For regional emissions inventory: fire info & fuels
  (emissions factors for lesser species)
- For regional air quality: fire info & plume rise

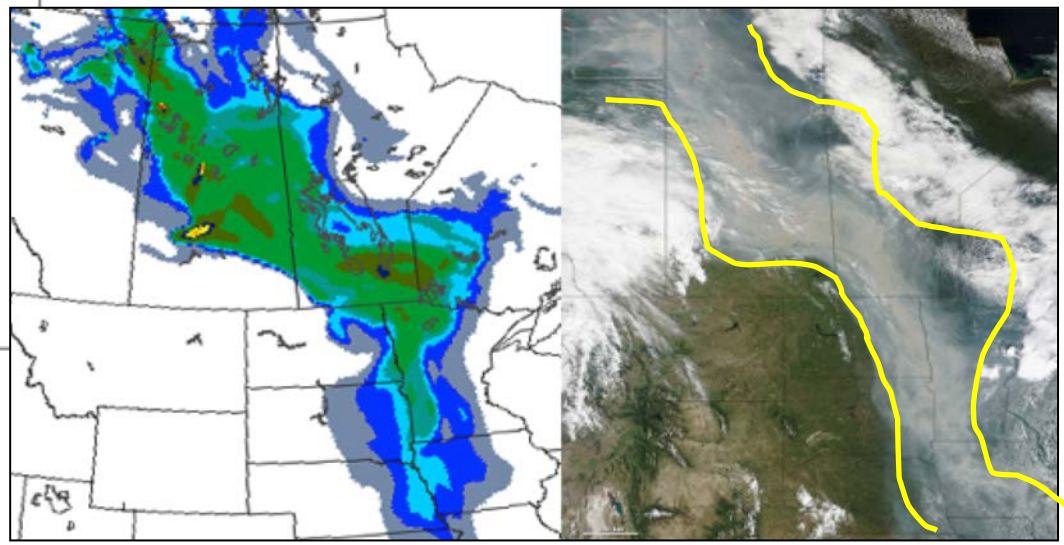
  - *Generalized answers; specific cases can vary*

Larkin et al., Forest Ecol. Manage., 317 (2014), 61-69.

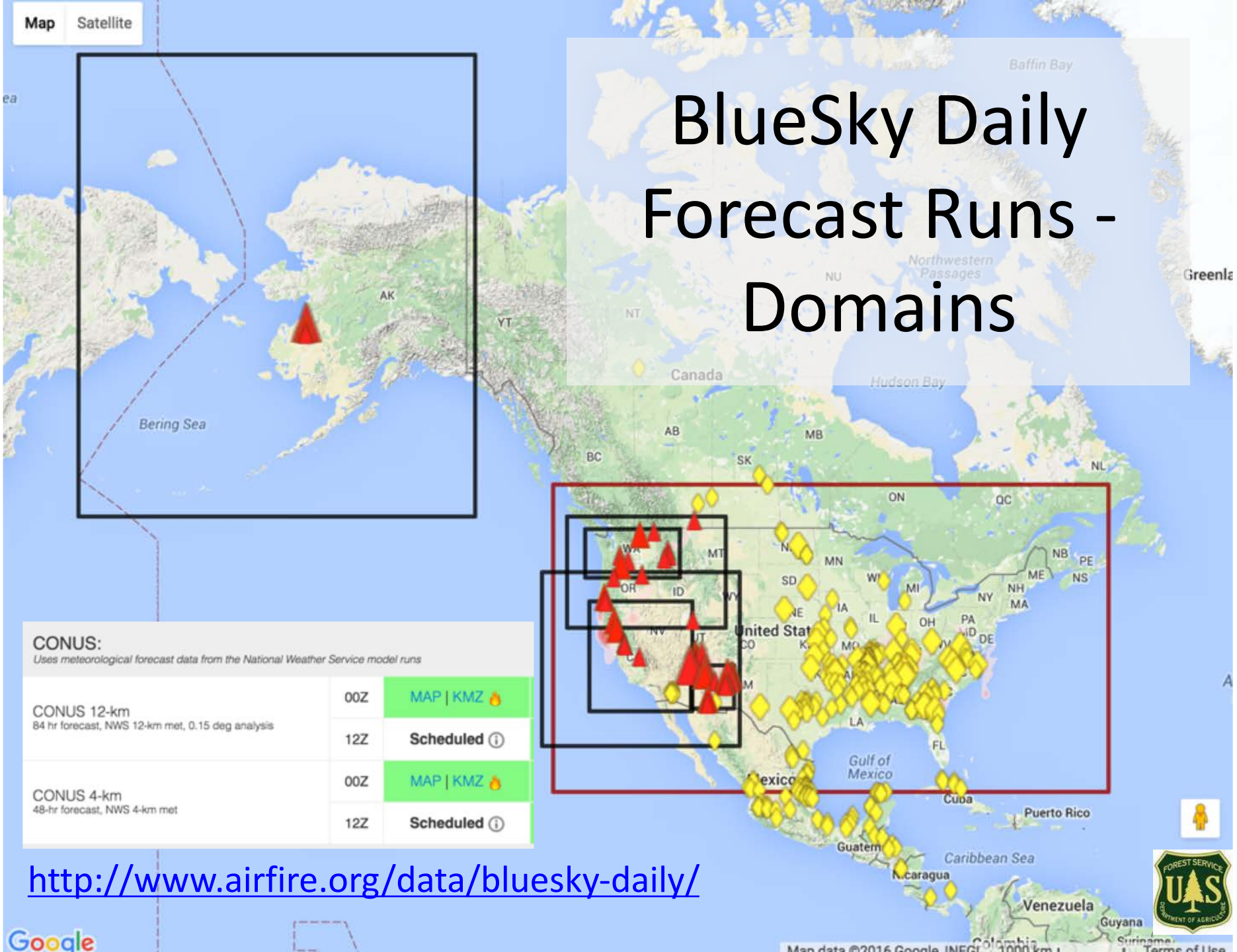
Smoke Forecasts



FIREWORK - ECCC



BlueSky Daily Forecast Runs - Domains



CONUS:
Uses meteorological forecast data from the National Weather Service model runs

CONUS 12-km 84 hr forecast, NWS 12-km met, 0.15 deg analysis	00Z	MAP | KMZ
	12Z	Scheduled
CONUS 4-km 48-hr forecast, NWS 4-km met	00Z	MAP | KMZ
	12Z	Scheduled

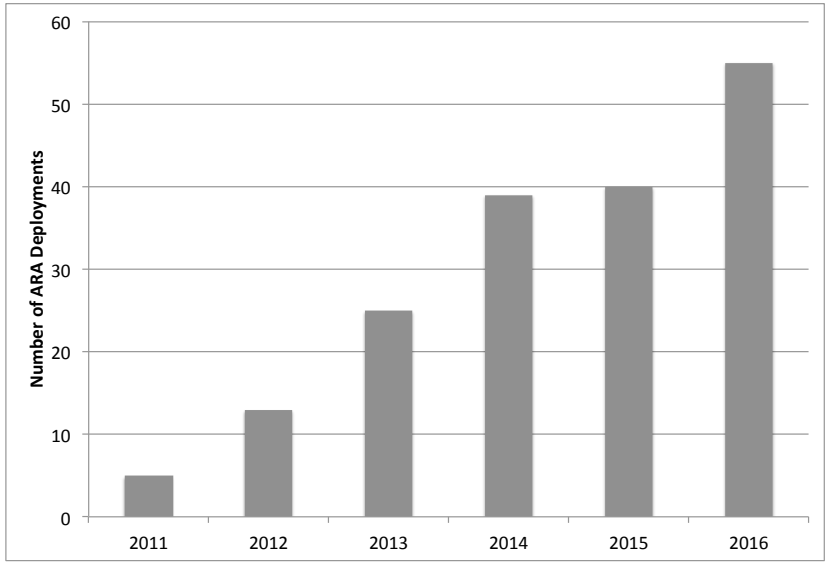
http://www.airfire.org/data/bluesky-daily/

Wildland Fire Air Quality Response Program

Search

http://www.wildlandfiresmoke.net/

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



Pete Lahm – Coordinator

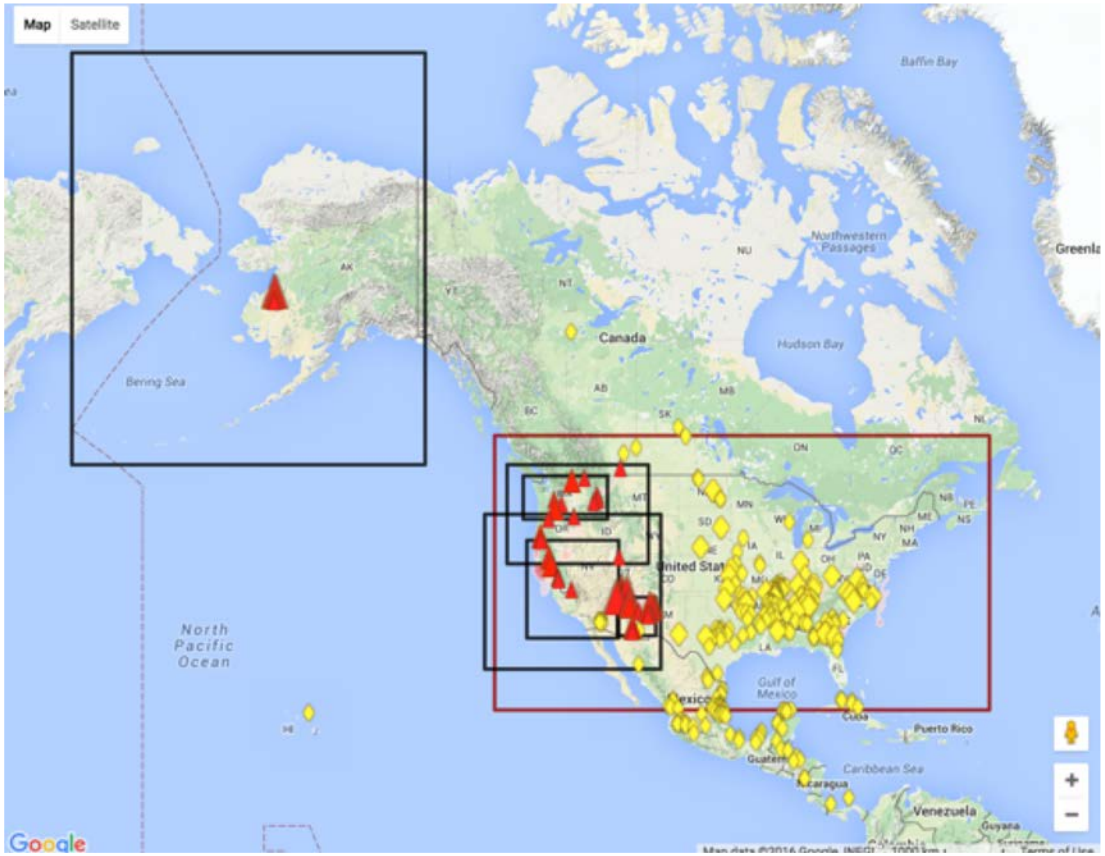
Values from Wednesday, August 21, 2013

Site	24-hour PM2.5 (µg/m³)	1-hour Max PM2.5	Level of Health Concern	Meaning	Actions to Protect Yourself
Chiloquin Glendale Ashland Roseburg	7 9 9 10	16 18 23 13	Good	Air quality is satisfactory and poses little or no health risk	None
Provolt Klamath Falls Cave Junction Grants Pass Silverton Medford Crater Lake	12 13 14 15 19 20 22	23 20 30 35 33 51 61	Moderate	Air quality is acceptable for most. There may be a moderate health concern for a small number of people.	Unusually sensitive people should consider reducing prolonged or heavy outdoor exertion.
None	-	-	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.	People with heart or lung disease, children and adults should reduce prolonged or heavy outdoor exertion. Everyone one else, should limit prolonged or heavy exertion
Shady Cove The Dalles	60 101	210 288	Unhealthy	Everyone may begin to experience more serious health effects.	The following groups should avoid all physical outdoor activity: People with heart or lung disease, children and older adults. Everyone else should avoid prolonged or heavy exertion.

- Smoke Monitoring Cache:
  20 E-Samplers
  6 EBAMS
  Carbon Monoxide
- Trainings: 2013, 2014, 2015, 2016, 2017

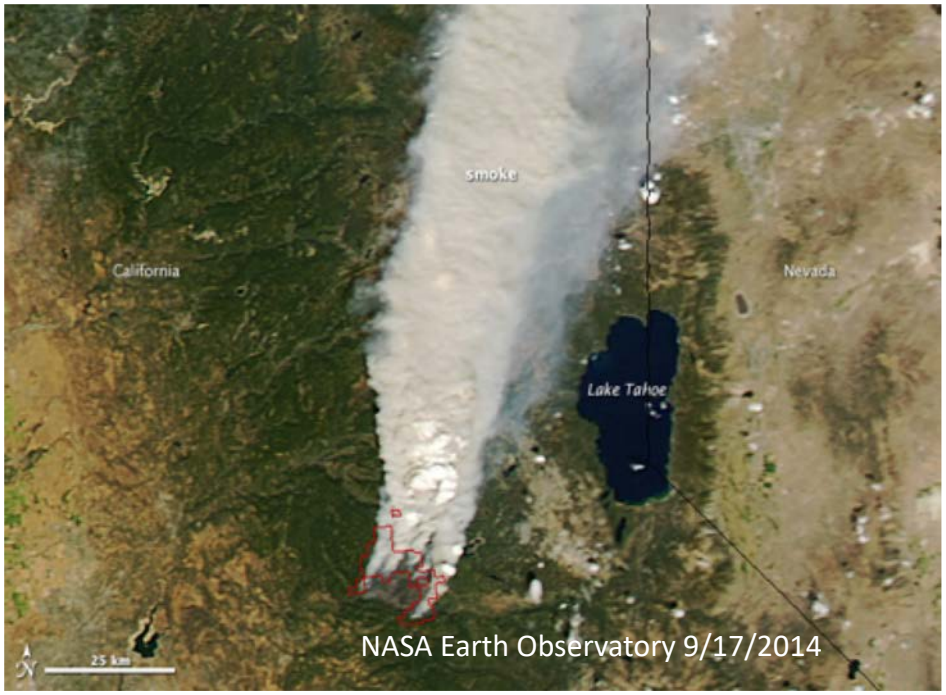
Tailored Smoke Predictions Delivered to Incident Command Teams

- Existing Domains
  - 2-km CA/NV
  - 6-km Western US
  - 1.33-km WA/ID
  - 4-km PNW
  - 12-km CONUS
  - 12-km Alaska
  - 4-km CONUS (48-hr)
  - 1-km various
- Partnerships: NWS, UW, DRI
- NOAA HMS Satellite detections

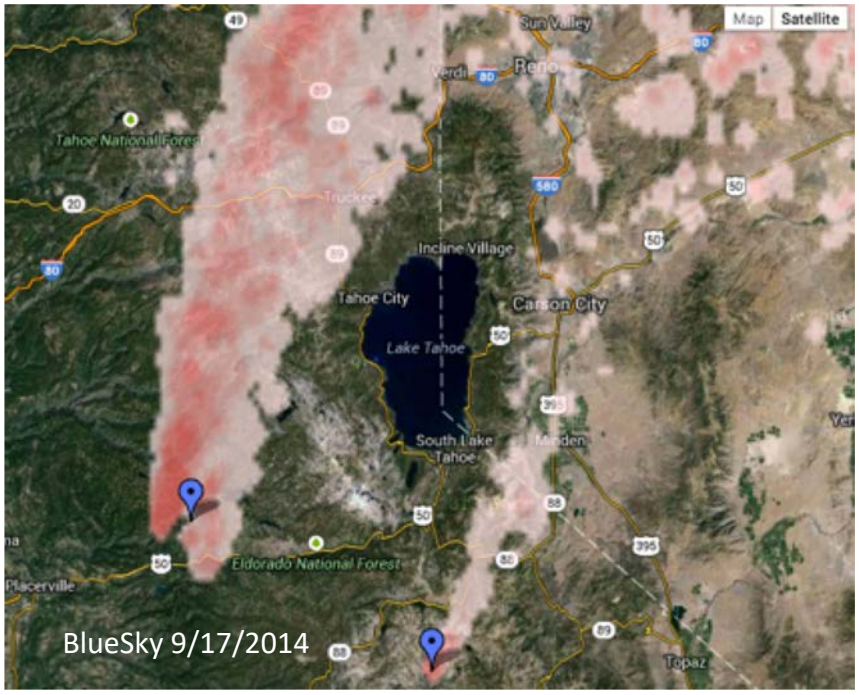


- HYSPLIT – Primary near-surface 1-hr PM2.5

Smoke Predictions Delivered to Incident Command Teams



NASA Earth Observatory 9/17/2014



BlueSky 9/17/2014

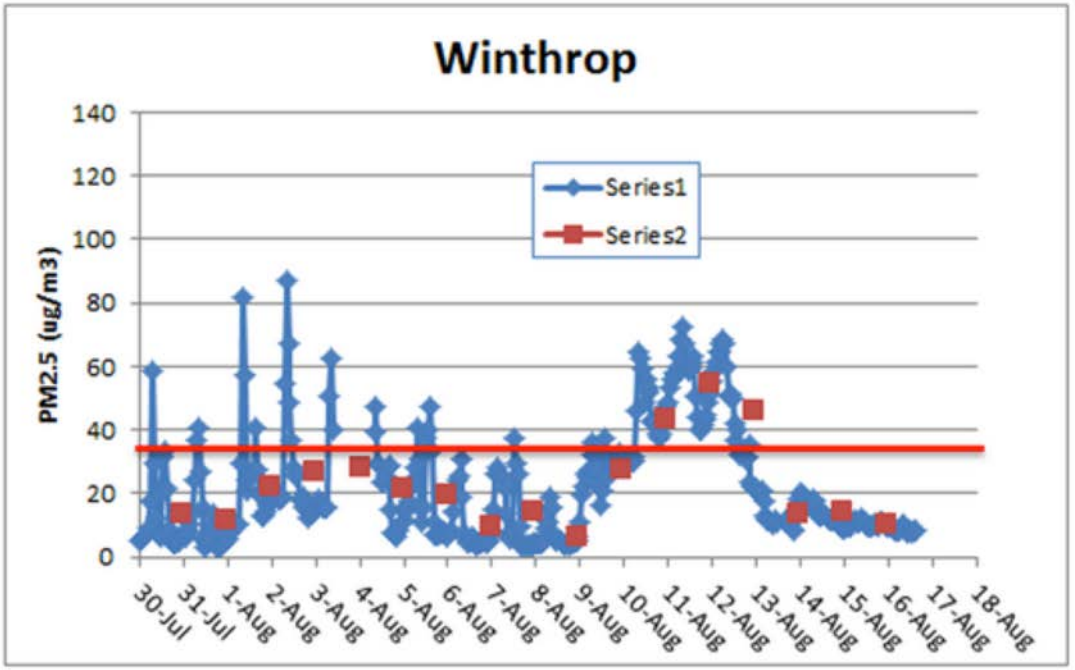
- King Wildfire 9/17/2014
- El Dorado National Forest
- 97,000 acres burned
- Ignited 9/13/2014

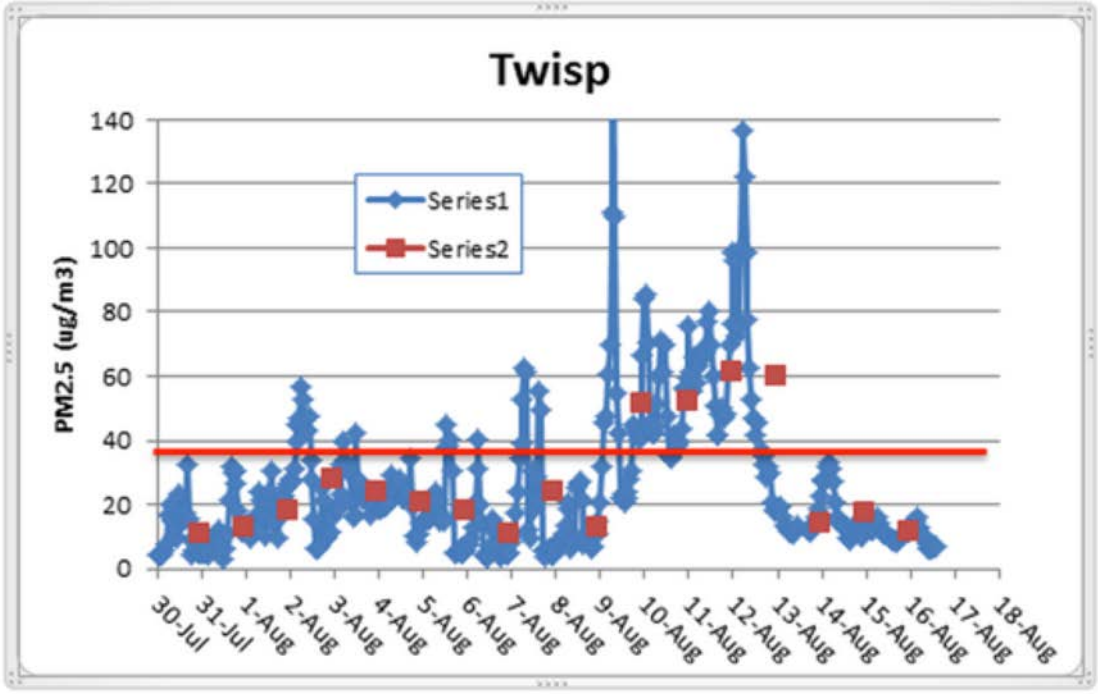
Carlton Complex August 2014

Washington Smoke Blog

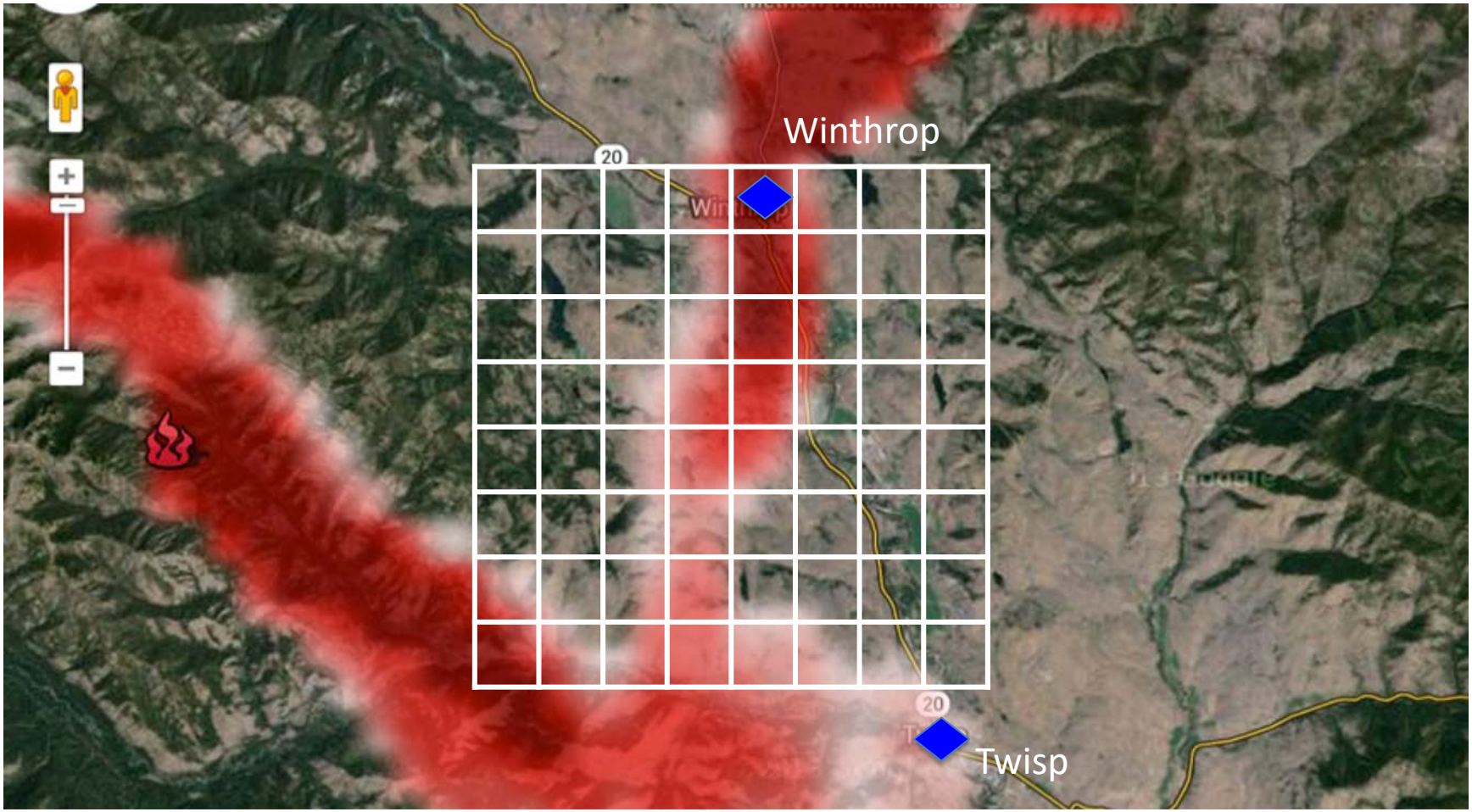
On this gorgeous, clear day with no smoke, let's take a look at the differences between two air quality monitors located less than 9 miles apart in the same Methow Valley. The blue graphs indicate 1-hr average concentrations of PM2.5 while the red data points are 24-hr averages. Note that while the 24-hr 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

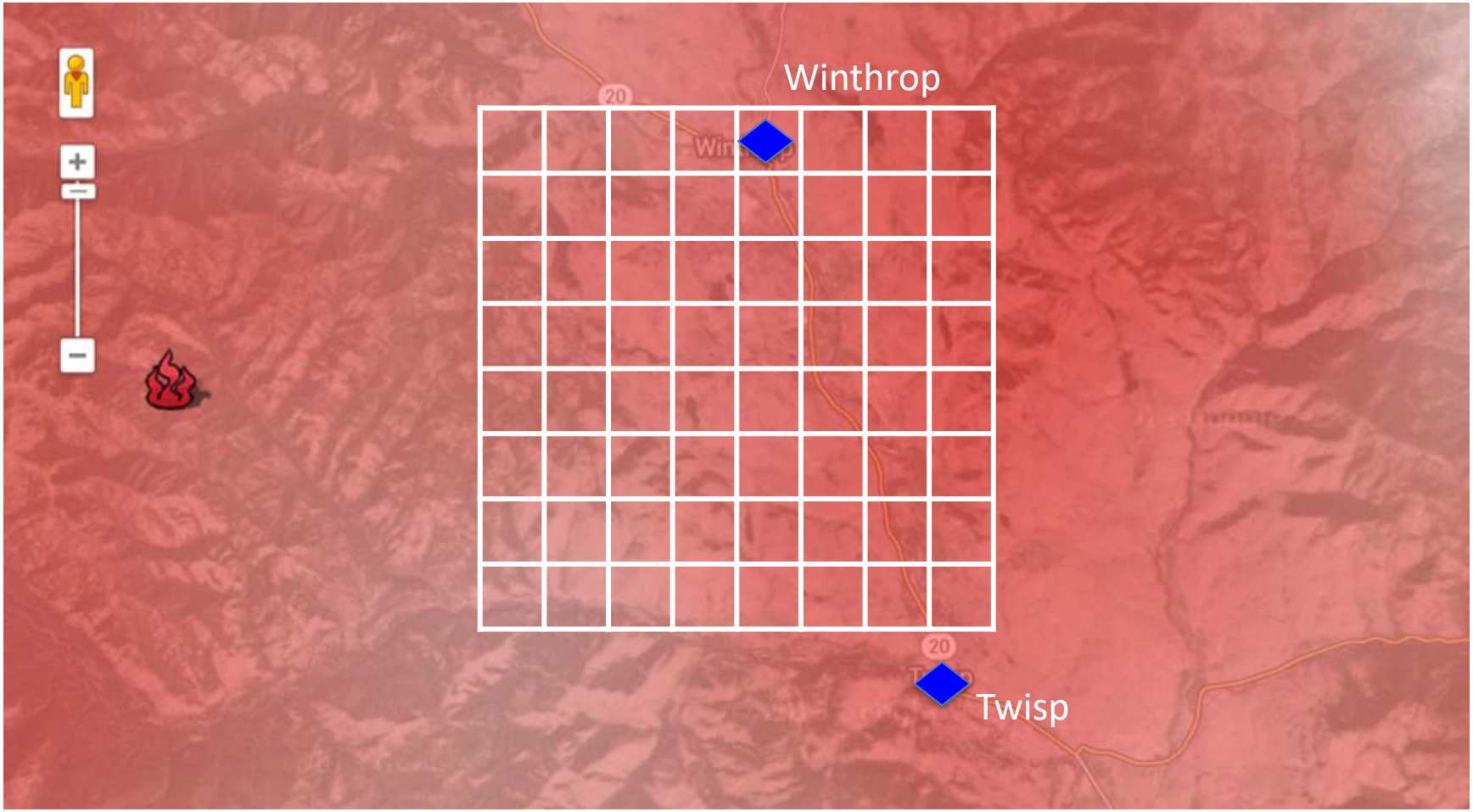




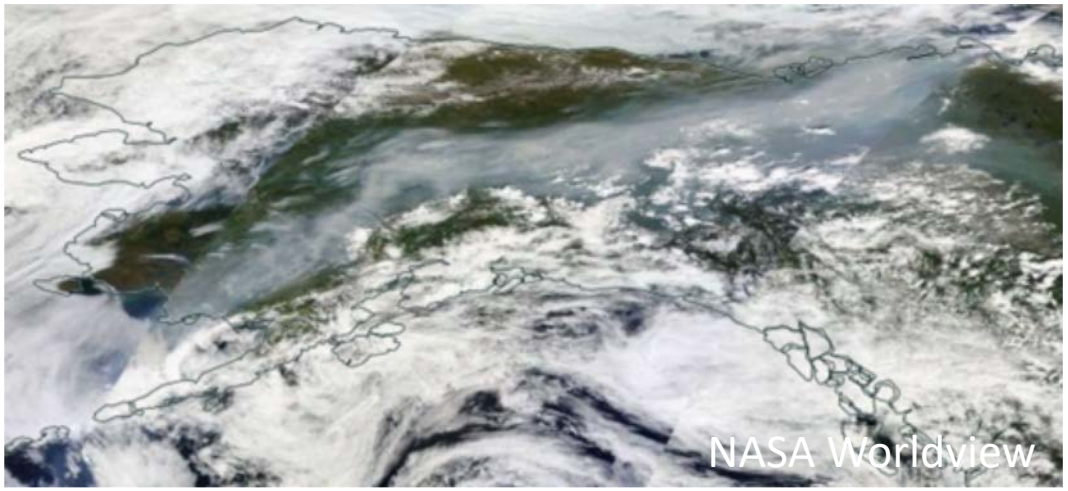
Carlton Complex, 8/4/2014 6am, 1.33 km Domain



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

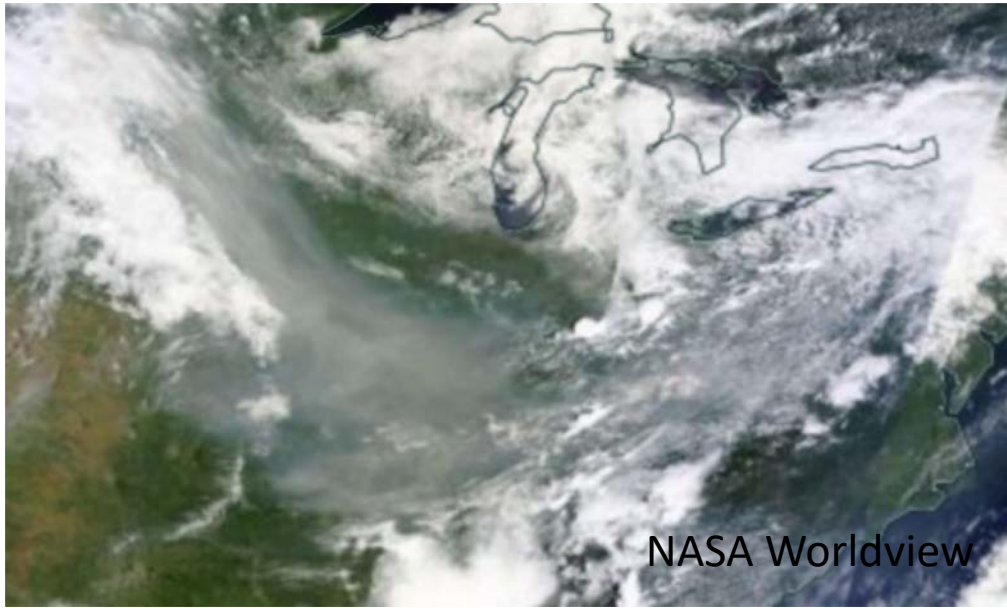


Learning a lot about model resolution



Alaska – to heck with 1km, we want 12km!

Lower 48, western US – its all about complex terrain and drainage flows … until we get Canadian smoke!



Washington Wildfires 2015
1,005,423 acres

Air Quality Summary Report - Chelan and Methow Valley Fire Thursday, August 21, 2015

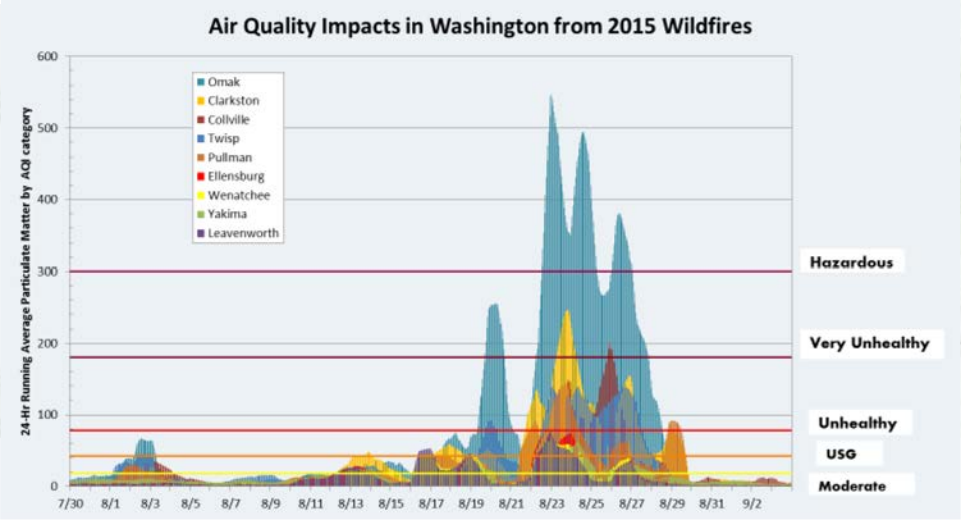
Prepared by: Carolyn Kelly & Andrea Holland

Friday: A continued increase in fire activity from multiple fires including the Reach, Wolverine, Black Canyon, First Creek, McFarland, & Blankenship fires could create widespread smoky/hazy conditions for most of central Washington again today. Chelan should see smoke throughout the day with heavier amounts in the evening. Wenatchee and Leavenworth can expect to see some clear skies with little or no smoke until the evening. Manson will see light smoke in the morning, heavier smoke after noon, and potentially hazardous levels later in the evening. Methow Valley will see smoke throughout the day with heavier smoke beginning early afternoon and increasing into the night.

Saturday: Active fire behavior in the area should have Chelan and Manson seeing smoke throughout the day. Wenatchee and Leavenworth should see light smoke clearing out through the day. Methow Valley will see varying levels of smoke throughout the day as well.

Sunday: Chelan, Manson, and Methow Valley should expect to see smoke throughout the day and Wenatchee and Leavenworth should see smoke through the day clearing out later on.

Site	August 21 Today Air Quality	August 22 Saturday Air Quality	August 23 Sunday Air Quality	Comments
Chelan	Good Hazardous	Hazardous Unhealthy	Unhealthy	As winds shift later in the day on Friday, smoke from the Okanogan Complex will be driven down through the Columbia River Valley.
Manson	Moderate Hazardous	Unhealthy	Unhealthy	
Methow Valley	Moderate Unhealthy	Moderate Unhealthy	Unhealthy	
Leavenworth	Good Moderate	Moderate Good	USG	
Wenatchee	Good Moderate	Moderate Good	USG	



Smoke Outlooks

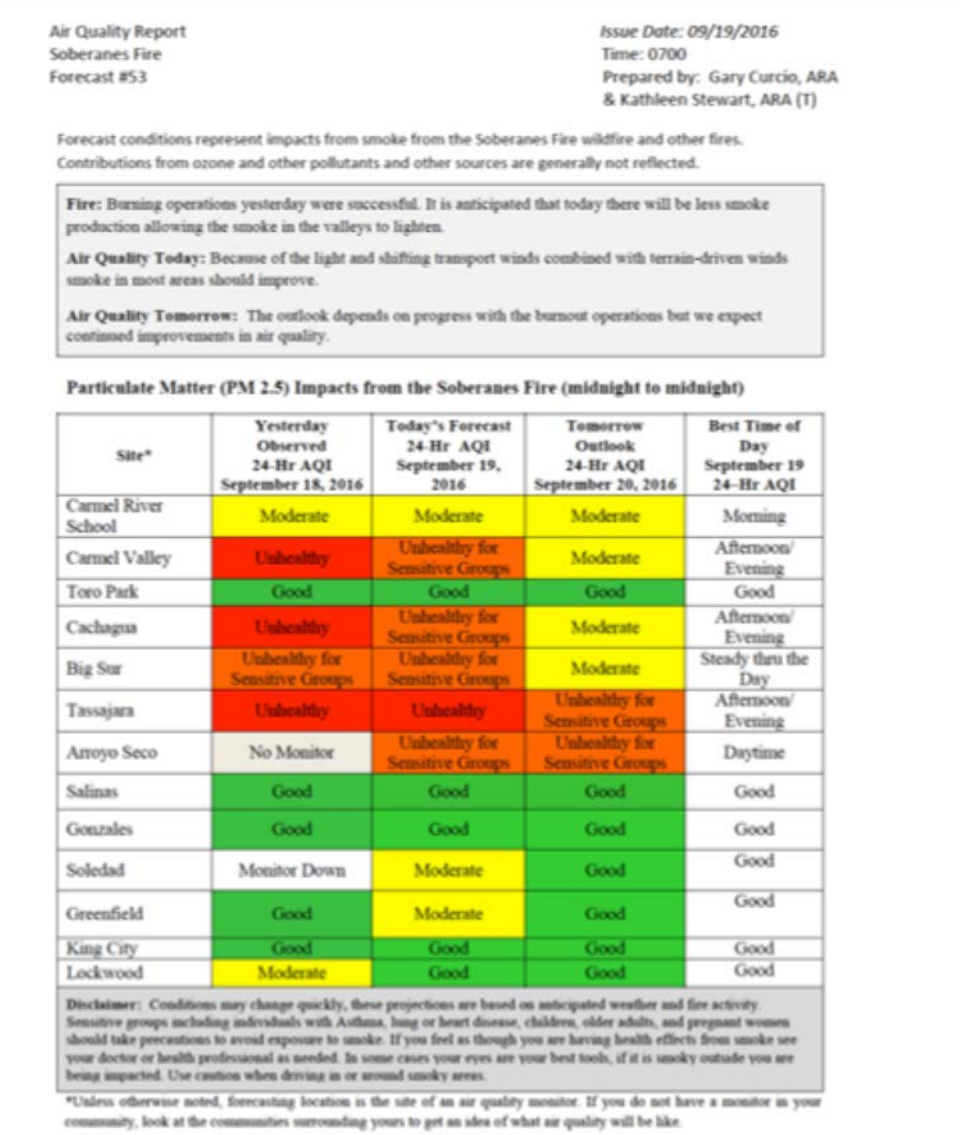
Smoke outlook for next 2 days

1-2 pages

Aimed for public dissemination/posting

Typically include:

- Discussion of conditions
- Table of specific cities and forecast
- Map of forecast
- Information on Air Quality Index scale



Air Quality Report
Soberanes Fire
Forecast #53

Issue Date: 09/19/2016
Time: 0700
Prepared by: Gary Curcio, ARA
& Kathleen Stewart, ARA (T)

Forecast conditions represent impacts from smoke from the Soberanes Fire wildfire and other fires. Contributions from ozone and other pollutants and other sources are generally not reflected.

Fire: Burning operations yesterday were successful. It is anticipated that today there will be less smoke production allowing the smoke in the valleys to lighten.

Air Quality Today: Because of the light and shifting transport winds combined with terrain-driven winds smoke in most areas should improve.

Air Quality Tomorrow: The outlook depends on progress with the burnout operations but we expect continued improvements in air quality.

Particulate Matter (PM 2.5) Impacts from the Soberanes Fire (midnight to midnight)

Site*	Yesterday Observed 24-Hr AQI September 18, 2016	Today's Forecast 24-Hr AQI September 19, 2016	Tomorrow Outlook 24-Hr AQI September 20, 2016	Best Time of Day September 19 24-Hr AQI
Carmel River School	Moderate	Moderate	Moderate	Morning
Carmel Valley	Unhealthy	Unhealthy for Sensitive Groups	Moderate	Afternoon/ Evening
Toro Park	Good	Good	Good	Good
Cachagua	Unhealthy	Unhealthy for Sensitive Groups	Moderate	Afternoon/ Evening
Big Sur	Unhealthy for Sensitive Groups	Unhealthy for Sensitive Groups	Moderate	Steady thru the Day
Tassajara	Unhealthy	Unhealthy	Unhealthy for Sensitive Groups	Afternoon/ Evening
Arroyo Seco	No Monitor	Unhealthy for Sensitive Groups	Unhealthy for Sensitive Groups	Daytime
Salinas	Good	Good	Good	Good
Gonzales	Good	Good	Good	Good
Soledad	Monitor Down	Moderate	Good	Good
Greenfield	Good	Moderate	Good	Good
King City	Good	Good	Good	Good
Lockwood	Moderate	Good	Good	Good

Disclaimer: Conditions may change quickly, these projections are based on anticipated weather and fire activity. Sensitive groups including individuals with Asthma, lung or heart disease, children, older adults, and pregnant women should take precautions to avoid exposure to smoke. If you feel as though you are having health effects from smoke see your doctor or health professional as needed. In some cases your eyes are your best tools, if it is smoky outside you are being impacted. Use caution when driving in or around smoky areas.

*Unless otherwise noted, forecasting location is the site of an air quality monitor. If you do not have a monitor in your community, look at the communities surrounding yours to get an idea of what air quality will be like.

Smoke Outlooks

Smoke outlook for next 2 days

1-2 pages

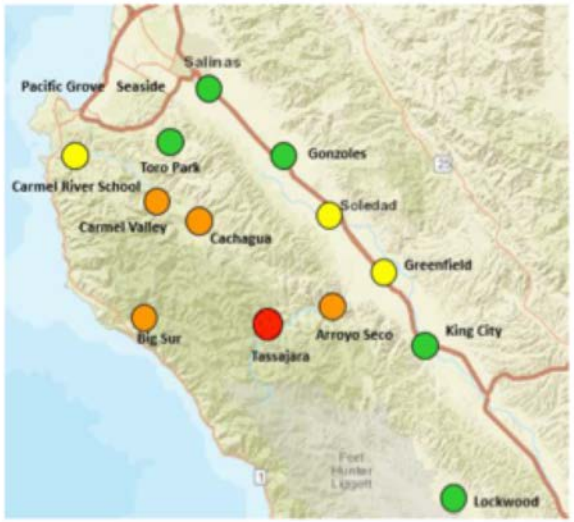
Aimed for public dissemination/posting

Typically include:

- Discussion of conditions
- Table of specific cities and forecast
- Map of forecast
- Information on Air Quality Index scale

Air Quality Report
Soberanes Fire
Forecast #53

Issue Date: 09/19/2016
Time: 0700
Prepared by: Gary Curcio, ARA & Kathleen Stewart, ARA (T)



Use the Air Quality Index to plan your activities

The Air Quality Index (AQI) is a measure used for reporting daily air quality. It tells you how clean or polluted your air is for the day, and what associated health effects might be a concern.

AQI Index	Actions to Protect Yourself
Good	None
Moderate	Unusually sensitive people should consider reducing prolonged or heavy outdoor exertion.
Unhealthy for Sensitive Groups - USG	People with heart or lung disease, children and older adults should reduce prolonged or heavy outdoor exertion. Everyone else should limit prolonged or heavy exertion.
Unhealthy	The following groups should avoid all physical outdoor activity: People with heart or lung disease, children and older adults. Everyone else should avoid prolonged or heavy exertion.
Very Unhealthy	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors.
Hazardous	The following groups should remain indoors and keep activity levels low: People with heart or lung disease; children and older adults. Everyone else should avoid prolonged or heavy exertion.

Views of smoke from fire: Jamesburg- http://cens.jamesreserve.edu/activejpg/cam2_hastings.jpg
Big Sur- http://www.nepenthebigsur.com/images/b.jpg
California Smoke Blog - http://californiasmokeinfo.blogspot.com/
Monterey Air Resource Board - http://mbard.org/
AirNow - http://airnow.gov/index.cfm?action=airnow.main

Response (a small sample)

Thank you, the **USFS** and the federal partners, for not only being on the front lines of the firefighting efforts, but also on the front lines of this public information campaign to help protect the public from the effects of wildfire smoke.

- Larry Calkins, Oregon Department of Environmental Quality

Just like the experts forecasted this was another record wildfire year in WA state. … Smoke forecasting in a complex science that requires high levels of training and years of on the ground experience to accomplish successfully. The **ARA**'s are well trained individuals who typically bring supplemental mobile air monitoring resources and a background in smoke forecasting tools and communication to and help residents and local leaders make important decisions about their communities exposure to the wildfire smoke.

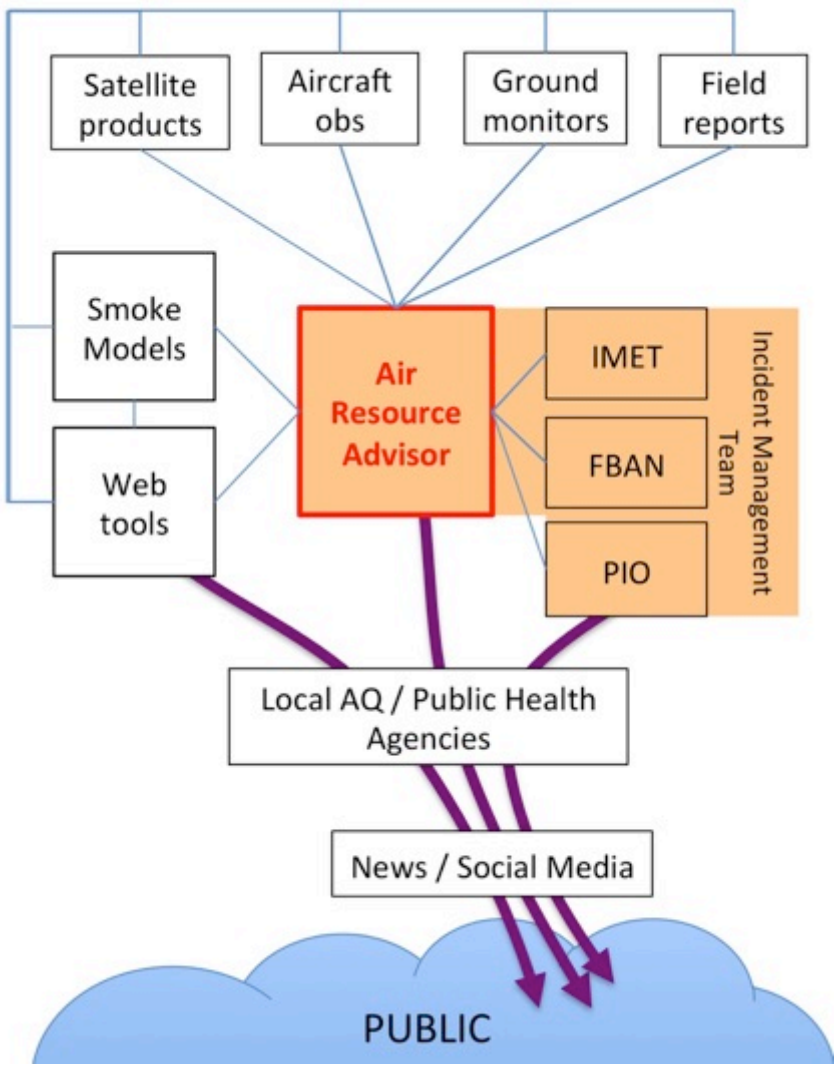
- Sean Hopkins, Washington State Department of Ecology

Over the last few years wildfire activity has been devastating for the EPA Region 10 states and the Reservations. Along with this devastation has come the significant impact on air quality. … it is critical that we can convey an accurate and timely message to agencies and the public regarding health impacts. … the position of **Air Resource Advisor** has been most beneficial. They have been able to translate what is happening on the ground along with the use of appropriate modeling and other tools to communicate to the public. They act as a conduit between those fighting the fire, those concerned with the impact of the fire and the public. Their ability to establish monitoring stations, attend public meetings and report on the current situation and outlook, has been a strong force that has held what could have appeared to be a chaotic situation into one that is more managed and controlled. And we all know that the greatest fear is that of the unknown. Thanks to the tremendous efforts of the NFS and the **ARA**'s during these difficult times.

- Gary Olson, EPA Region 10

NASA HAQAST

- Goal: facilitate the adoption and use of earth observations directly into the decisions, communications and response of wildfire Incident Command Teams and local public health agencies during wildfire smoke events.
- Earth Observations:
  - Information Synthesis
  - Dissemination and Delivery
  - Smoke Model Evaluation
  - Improve the Science of Smoke Modeling



Thank you

Special thanks to our funders in this work:

More information:

Sim Larkin
larkin@fs.fed.us
206-321-2013

Susan O'Neill
smoneill@fs.fed.us
206-732-7851