Wildland Fire Emissions and Smoke Forecast Modeling with the BlueSky Framework

(Smoke Modeling supporting Wildfire and Rx Fire Operations)

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USDA Forest Service, Pacific Northwest Research Station

6/2015 George Mason University

Conference on Atmospheric Transport and Dispersion Modeling

Photo Seattle Times, 9/2012

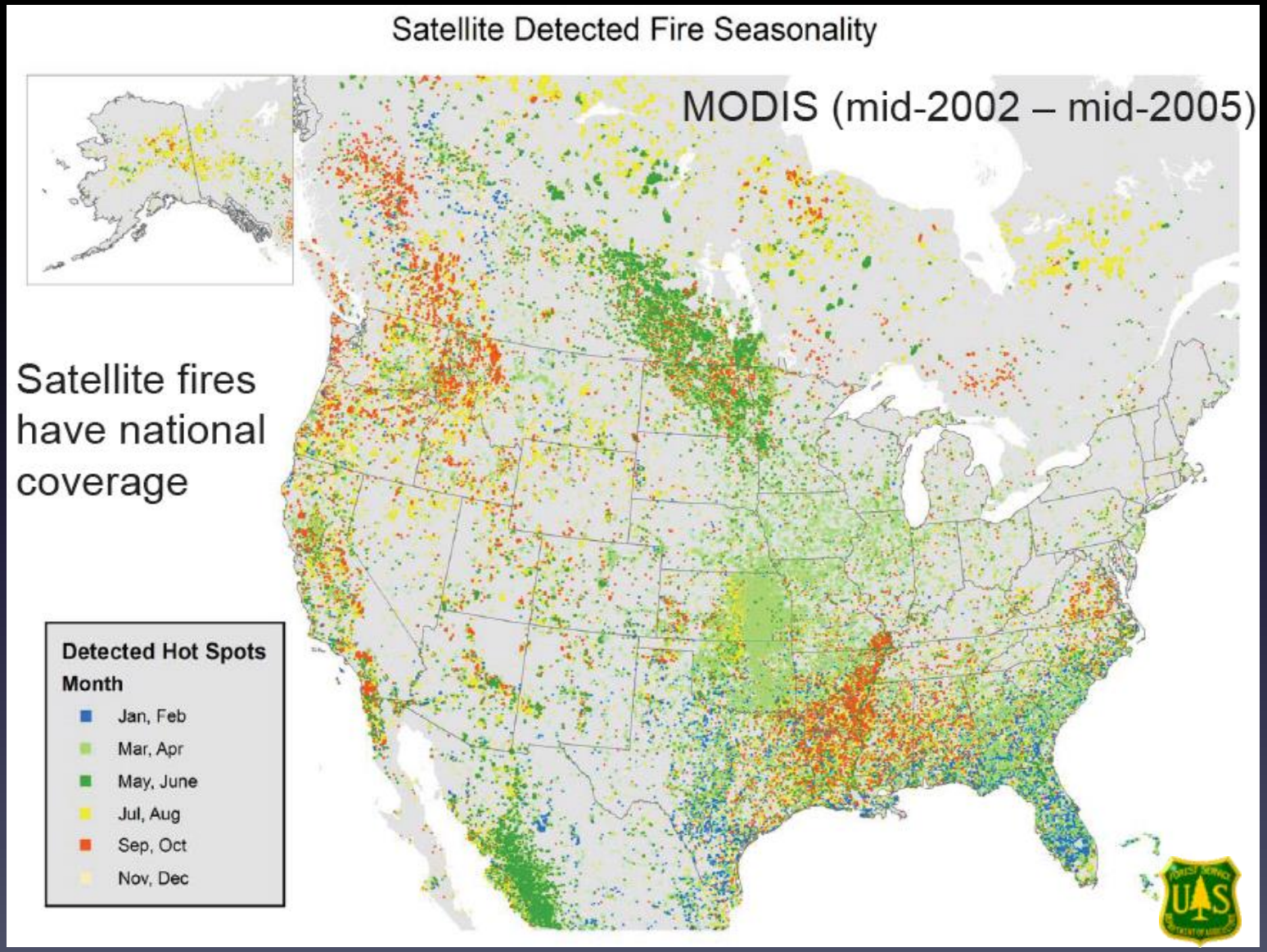
Partners:

- Desert Research Institute, esp. Tim Brown
- Scion Research, esp. Tara Strand
- USFS Fire and Aviation Management, esp. Pete Lahm
- USFS Wildland Fire RD&A, esp. Tim Sexton, Lisa Elenz, Tami Parkinson
- USFS RSAC
- collaborators at every USFS Research Station and every USFS Region
- Sonoma Technology, Inc., esp. Sean Raffuse
- US DOI
- EPA / Office of Air Quality Planning & Standards, esp. Tesh Rao
- NOAA National Weather Service
- NWCG Smoke Committee
- University of Washington and Washington State University
- many others

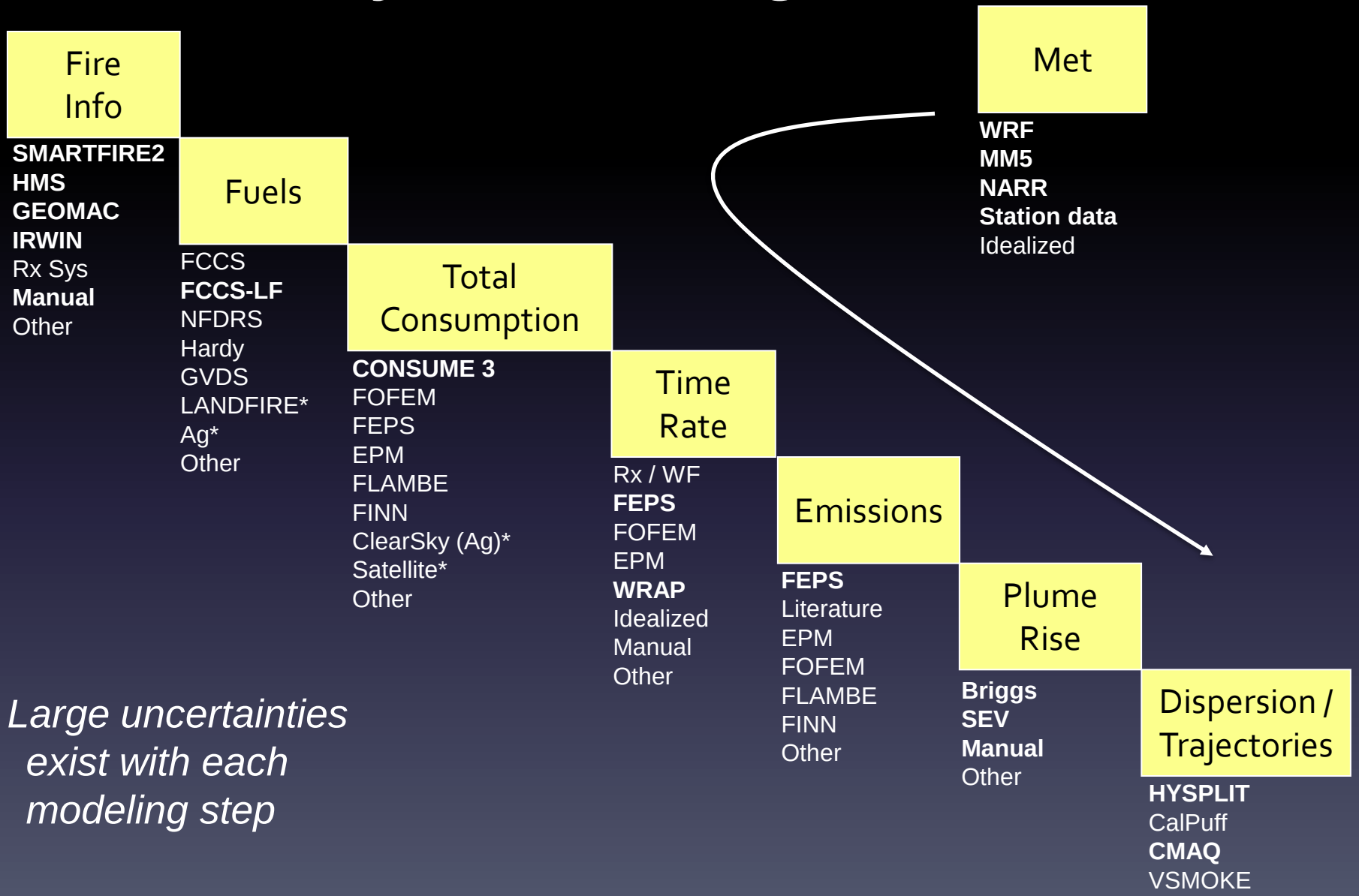
Funding:

- USFS F&AM
- USFS WF RD&A
- US DOI
- NASA
- EPA
- Joint Fire Science Program

… Fire Happens



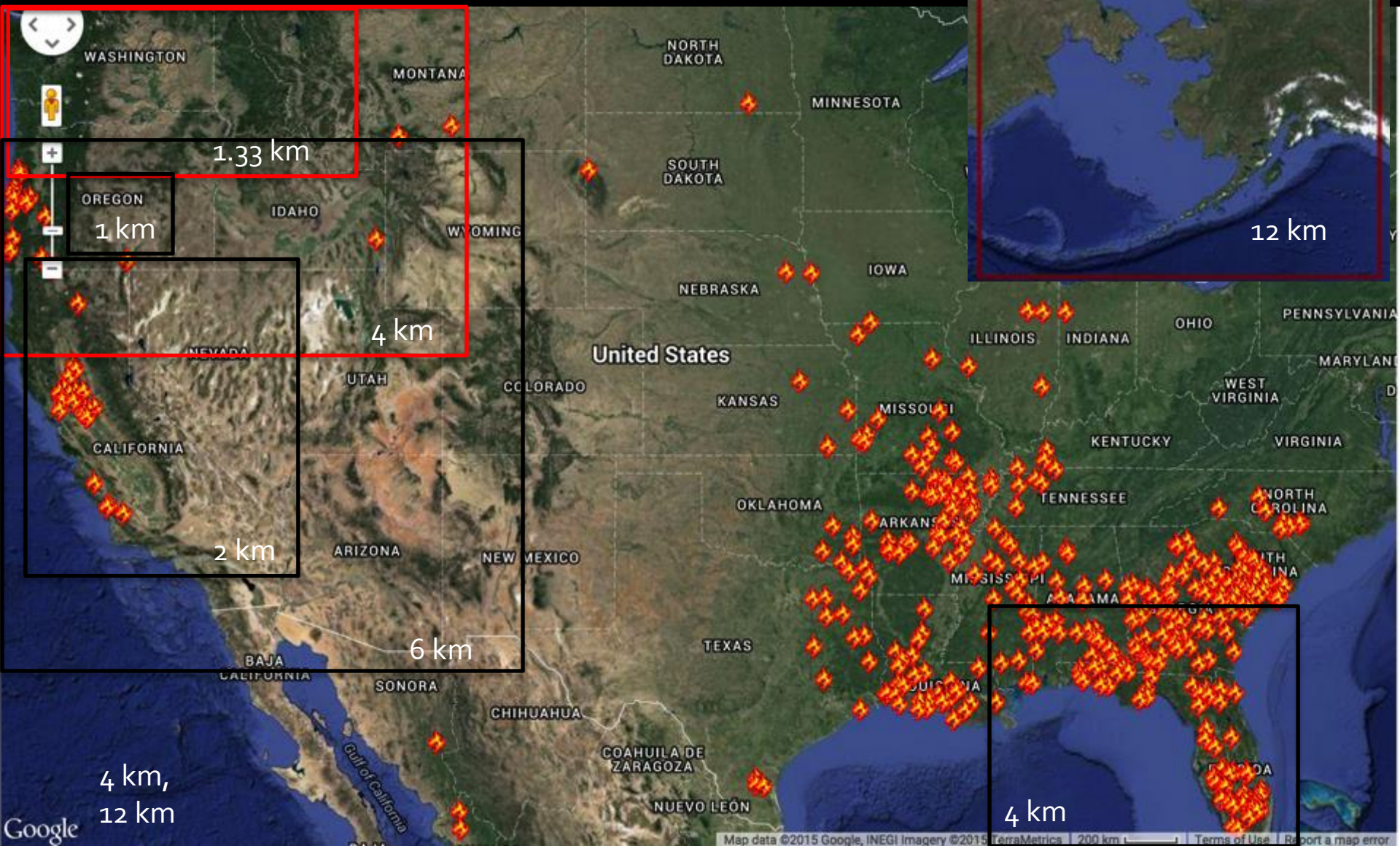
BlueSky Modeling Framework



Large uncertainties exist with each modeling step

Daily BlueSky Production Runs
1/31/2015 Satellite Fire Detections

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



The website provides information on status of the runs

Pacific Northwest (Washington / Oregon / Idaho and beyond):
Uses meteorological forecast data from the NWRMC regional model runs

DAILY	**1.33 km met** 48 hr forecast	00Z	No Fires I KMZ	No Fires I KMZ	(today) KMZ
	4 km met 72 hr forecast	00Z	MAP I KMZ	No Fires I KMZ	(today) KMZ

No Fires

California / Nevada:
Uses meteorological forecast data from the CANSAC regional model runs

DAILY	**2 km met** 72 hr forecast	12Z	Expected: 12hrs	**Error**	(yesterday) KMZ
		00Z	Overdue	MAP I KMZ	(yesterday) KMZ
	6 km met 72 hr forecast	12Z	Expected: 10hrs	MAP I KMZ	(yesterday) KMZ
		00Z	MAP I KMZ	MAP I KMZ	(today) KMZ

Successful!

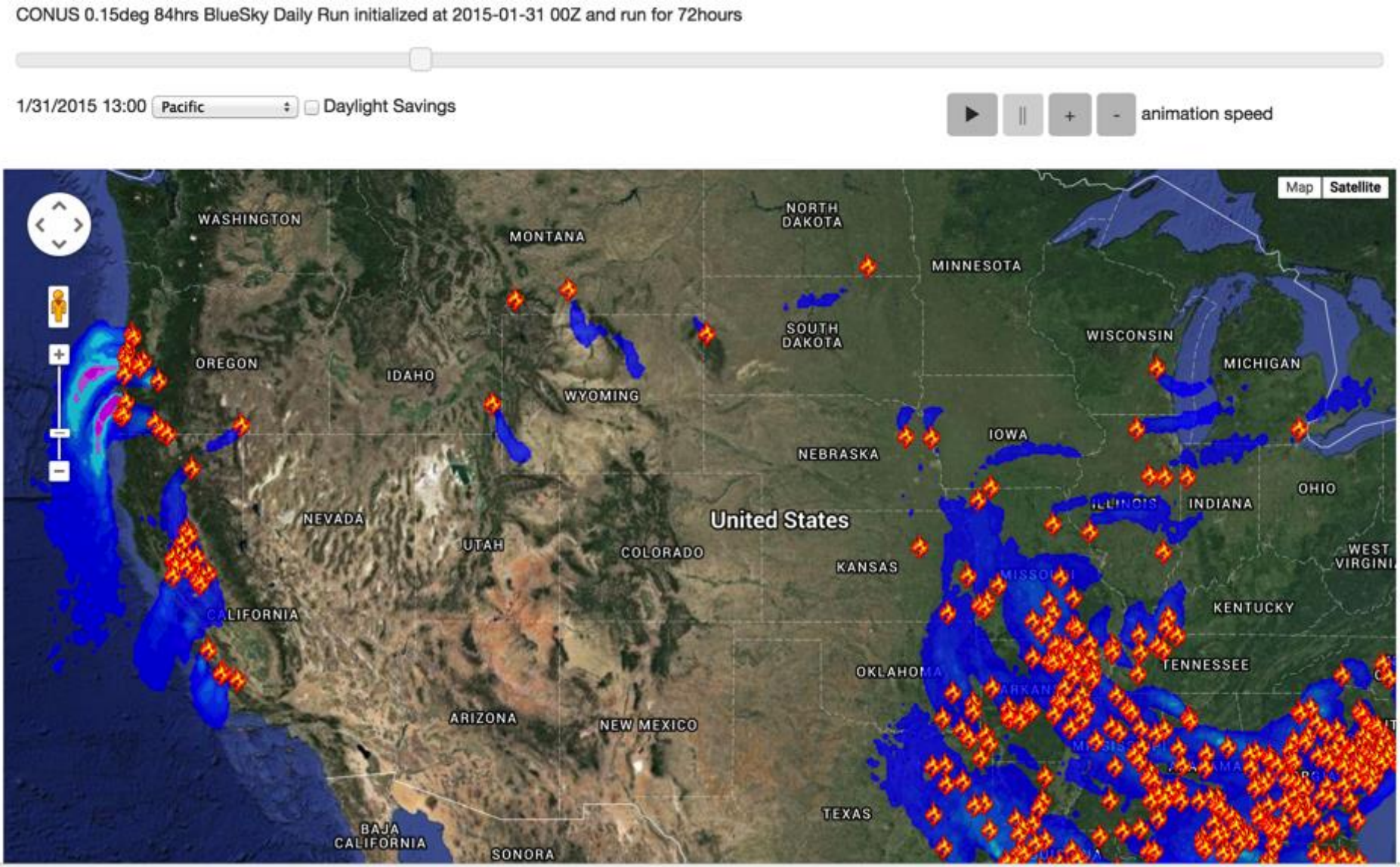
Running late….

Failures show up in red.

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

Daily BlueSky Production Runs
1/31/2015 Satellite Fire Detections & PM2.5, 12km

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



Wildland Fire Air Quality Response Program

- Air Resource Advisors
- Deployed to Incident Command Teams and Geographic Area Commands
- Modeling, Monitoring, Messaging
- Dispatches: 13 - 2012, 25 - 2013, over 40 - 2014

Values from Wednesday, August 21, 2013

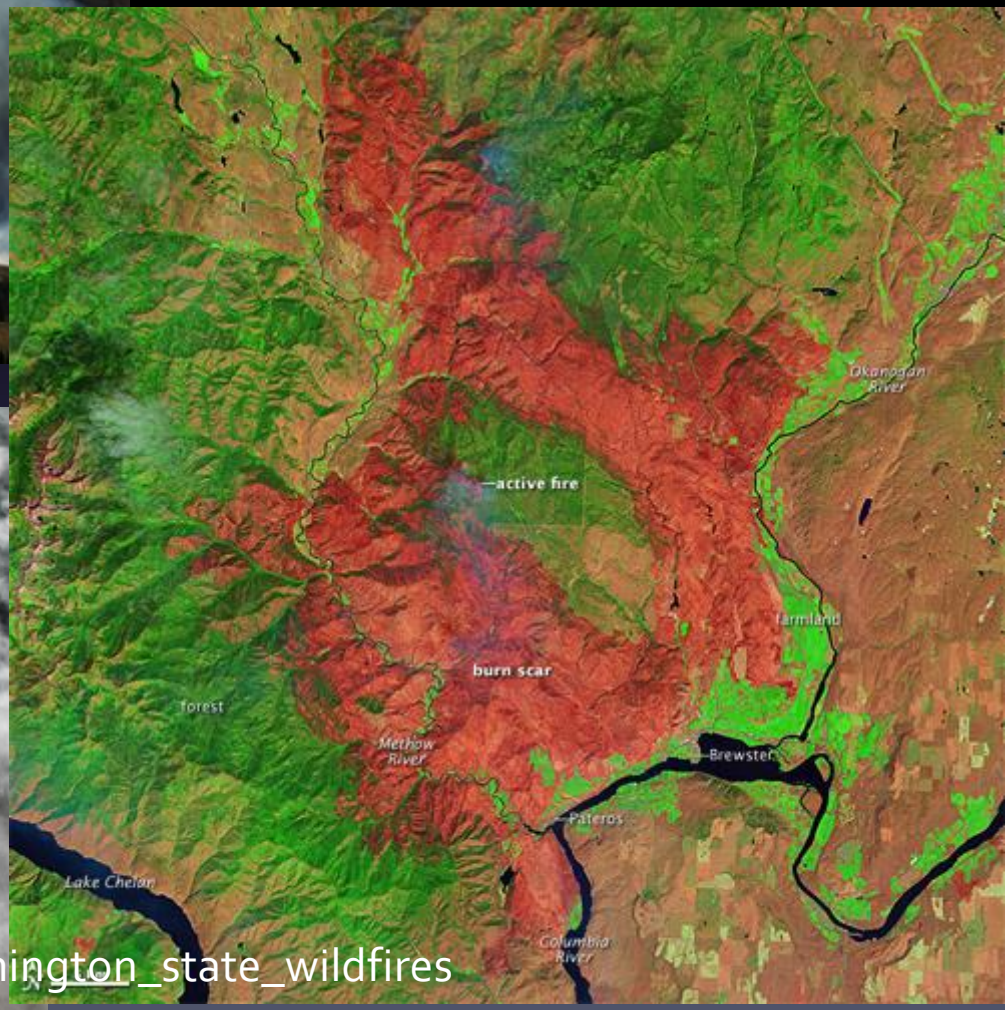
Site	24-hour PM2.5 (µg/m³)	1-hour Max PM2.5	Level of Health Concern	Meaning	Actions to Protect Yourself
Chiloquin Glendale Ashland Roseburg	7 9 9 10	16 18 23 13	Good	Air quality is satisfactory and poses little or no health risk	None
Provolt Klamath Falls Cave Junction Grants Pass Silverton Medford Crater 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.

Oregon Wildfire Air Quality Summary Report
Rick Graw, US Forest Service
Wednesday, August 22, 2013

Air Quality Summary: Yesterday, air quality deteriorated in The Dalles and Dufor due to smoke from the Government Flats Complex in north central Oregon. Smoke remained in the "good" to "moderate" levels in southwestern Oregon, except for Shady Cove, where air quality reached the "unhealthy" category. Additionally, air quality deteriorated in Silverton to "moderate" conditions.

- Smoke Monitoring Cache – 20 E-Samplers
- Trainings: 2012, 2013, 2014
- Pete Lahm – Coordinator

Carlton Complex
Washington State 2014
250,000 acres



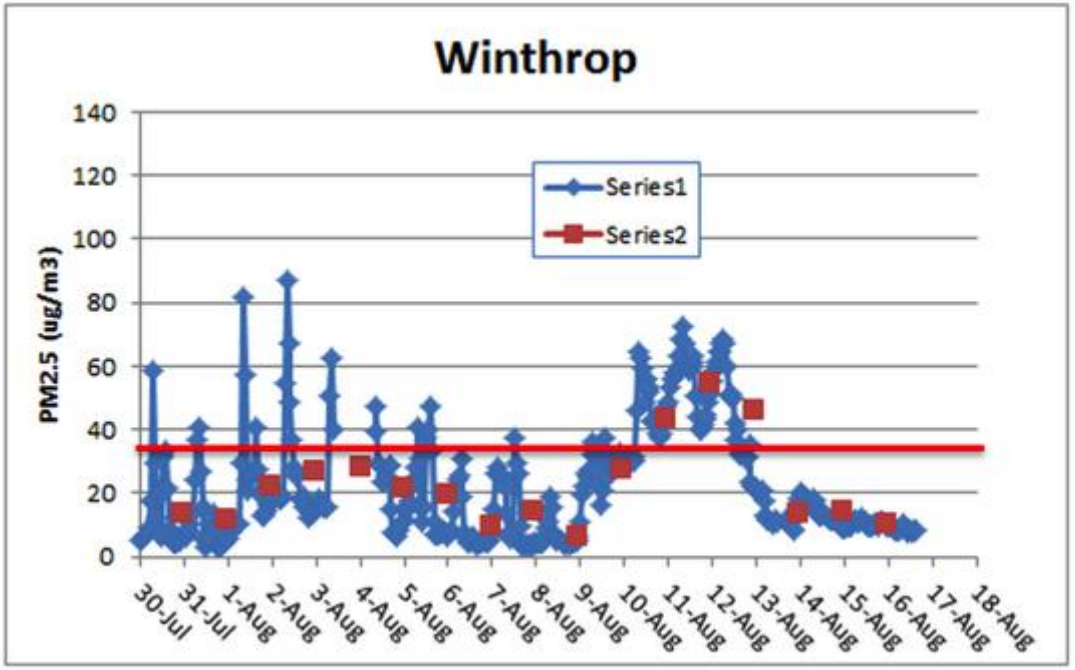
http://en.wikipedia.org/wiki/2014_Washington_state_wildfires

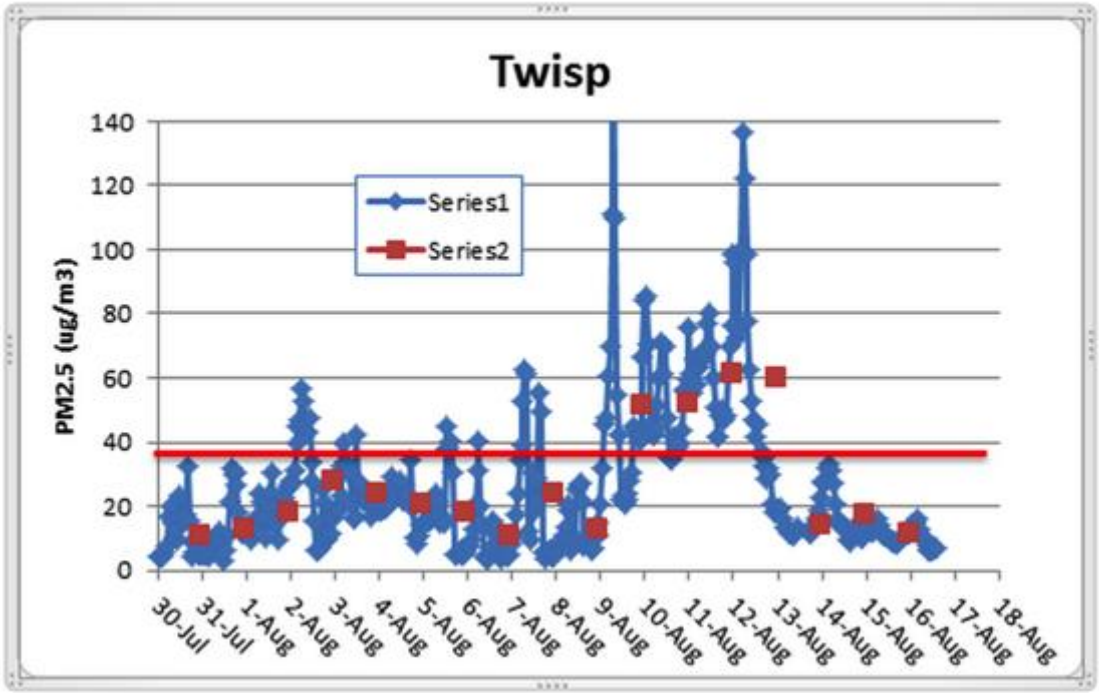
Carlton Complex August 2014

Washington Smoke Blog

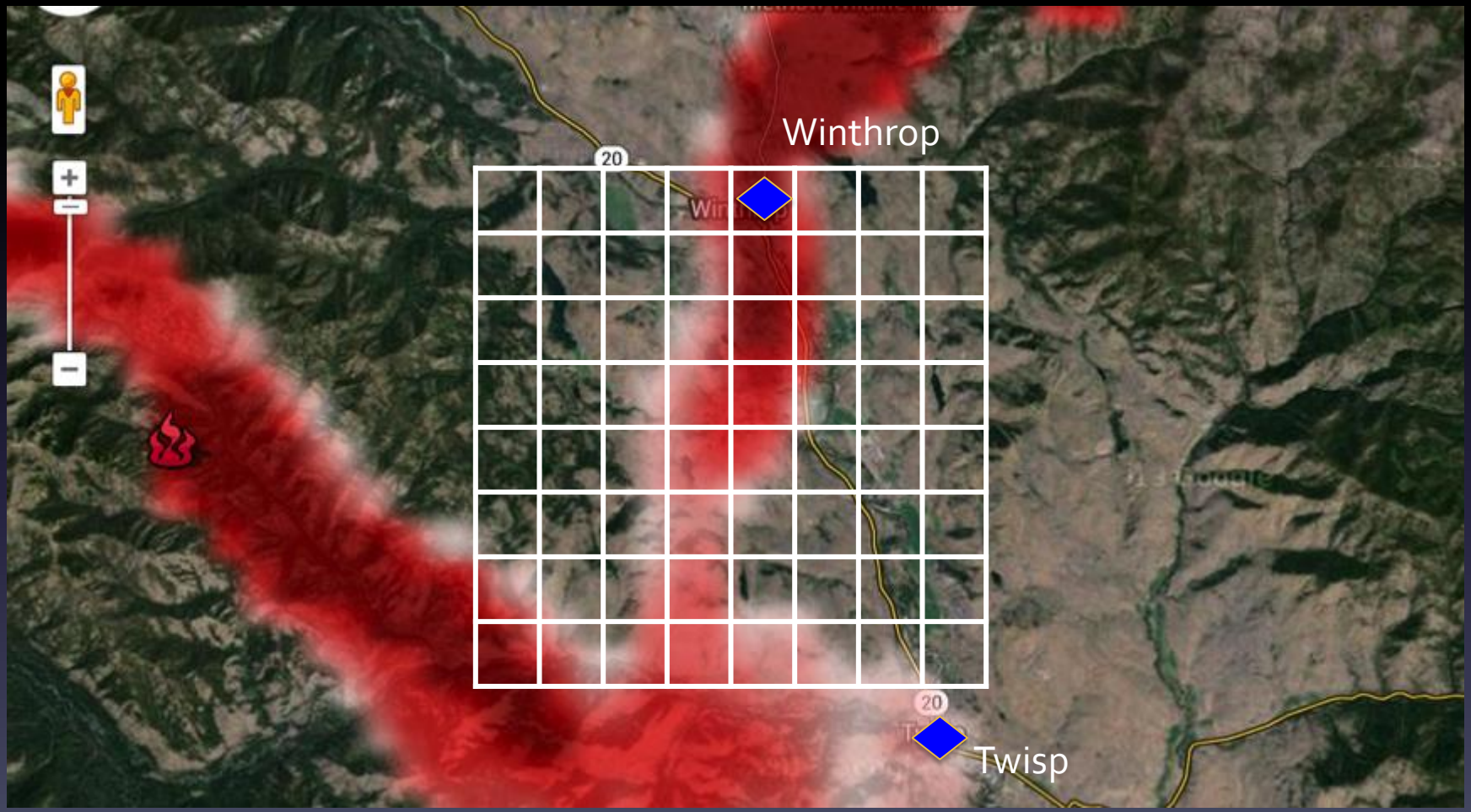
On this gorgeous, clear day with no smoke, let's take a look at the differences between two air quality monitors located less than 9 miles apart in the same Methow Valley. The blue graphs indicate 1-hr average concentrations of PM2.5 while the red data points are 24-hr averages. Note that while the 24-hr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

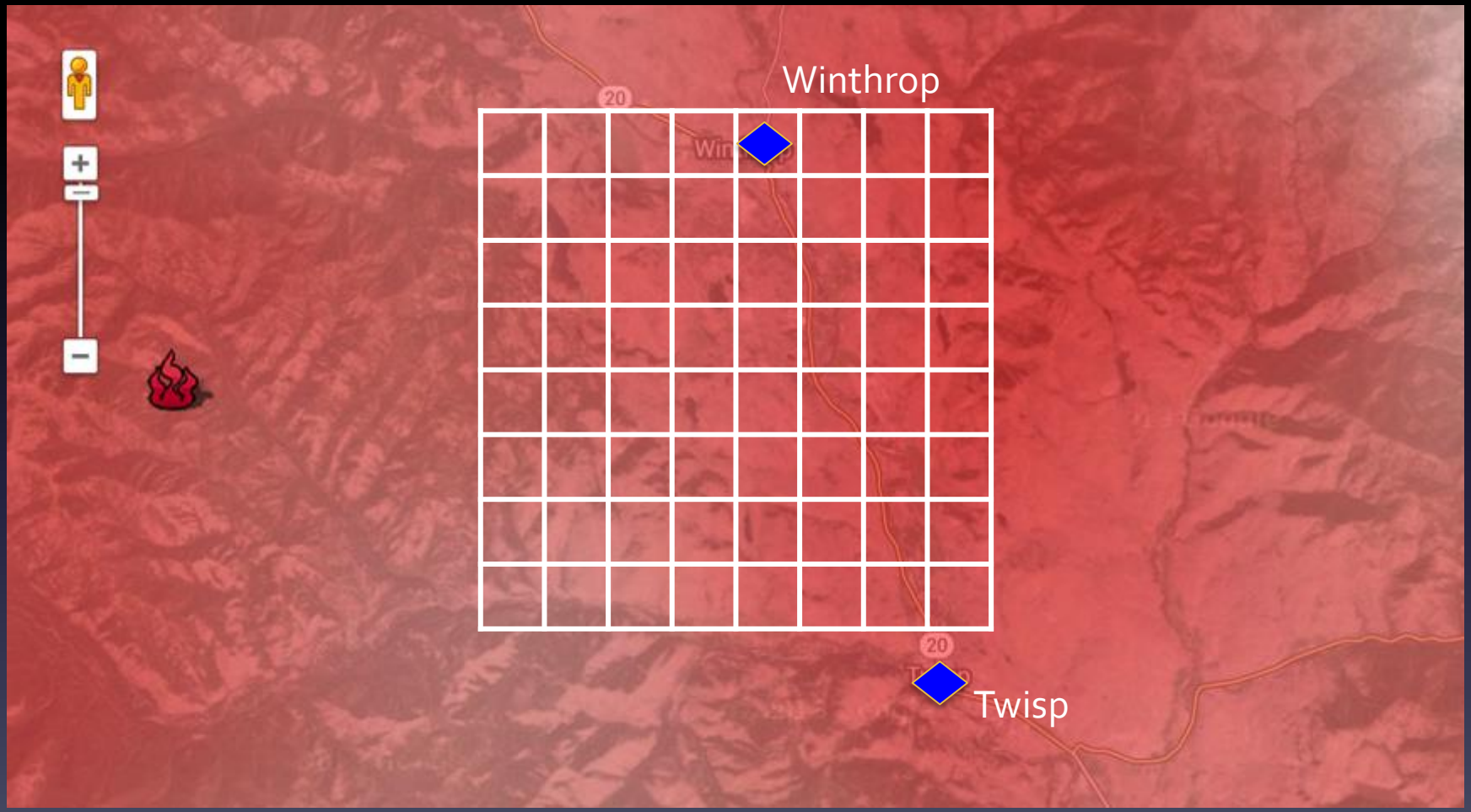




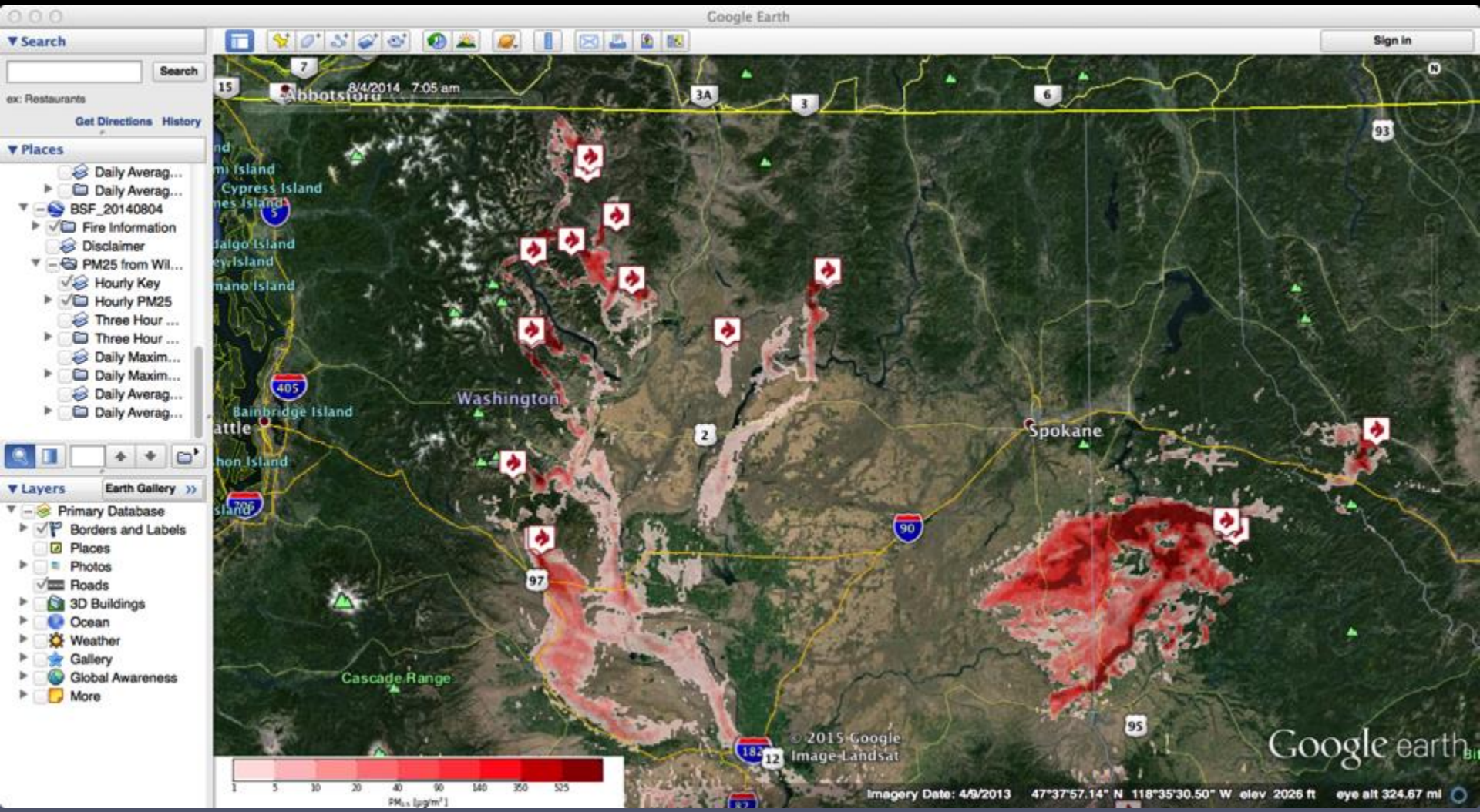
Carlton Complex, 8/4/2014 6am, 1.33 km Domain



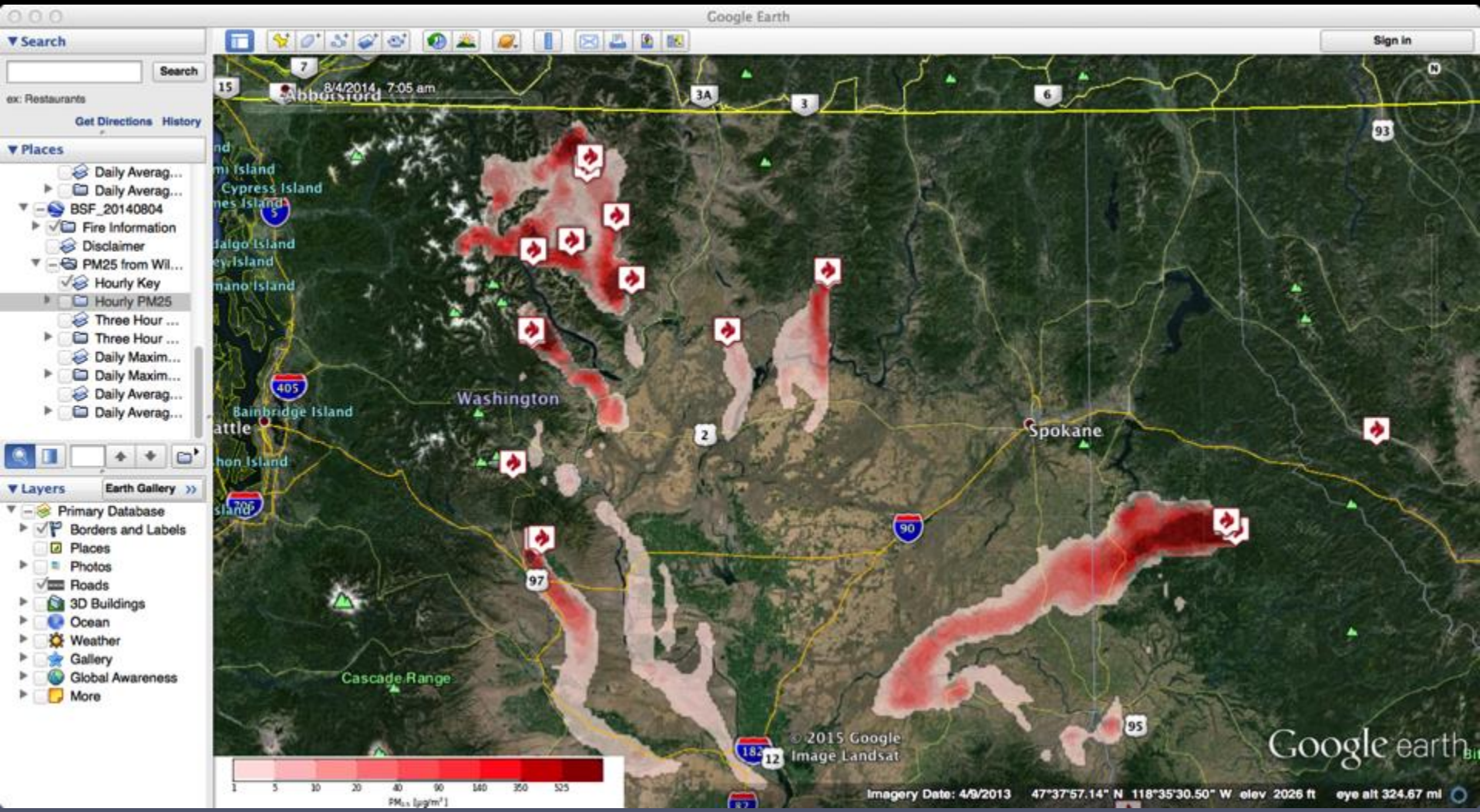
Carlton Complex, 8/4/2014 6am, 12 km Domain



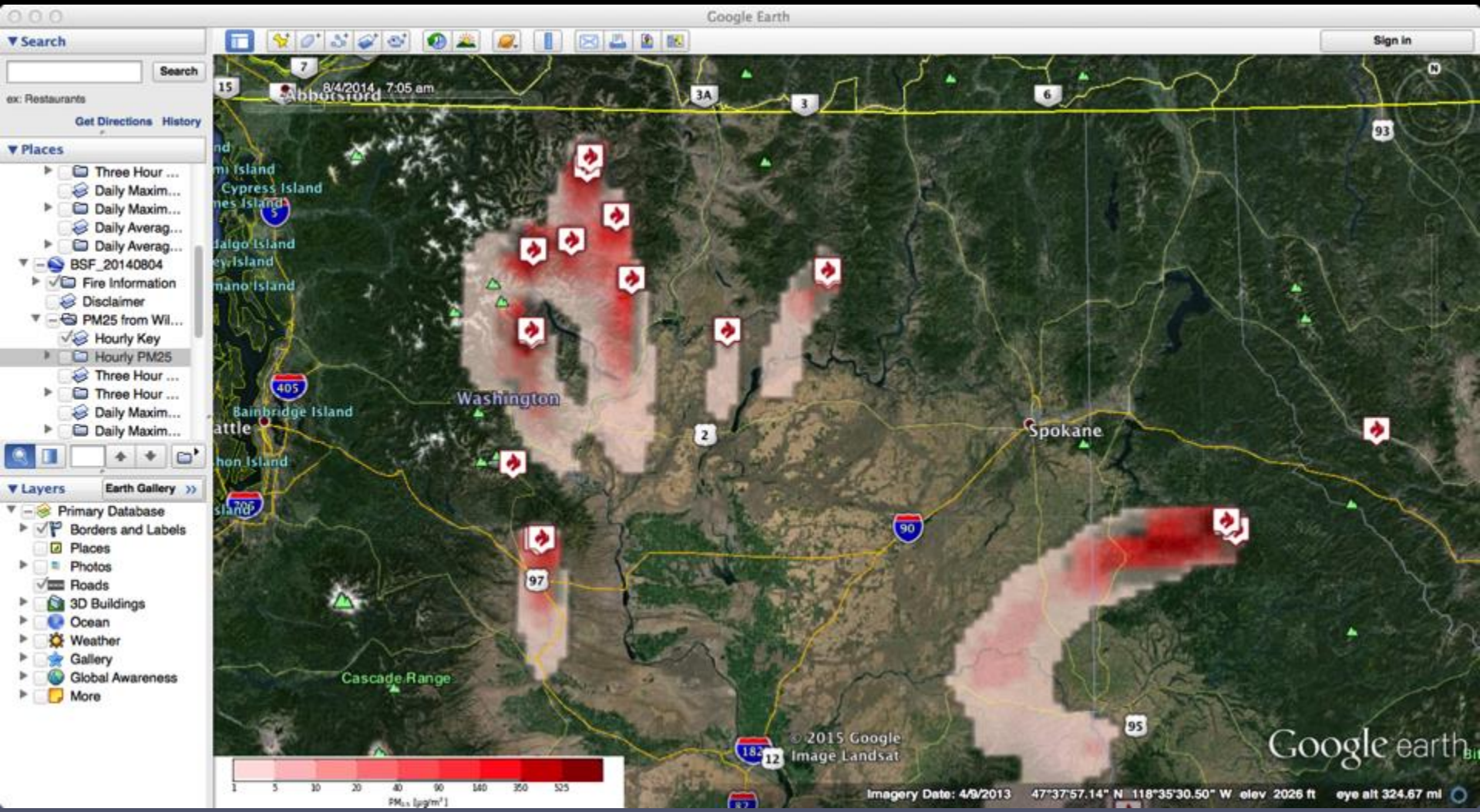
BlueSky PM2.5 from Wildfires
1.33 km UW WRF Domain
8/4/2014 7am PT



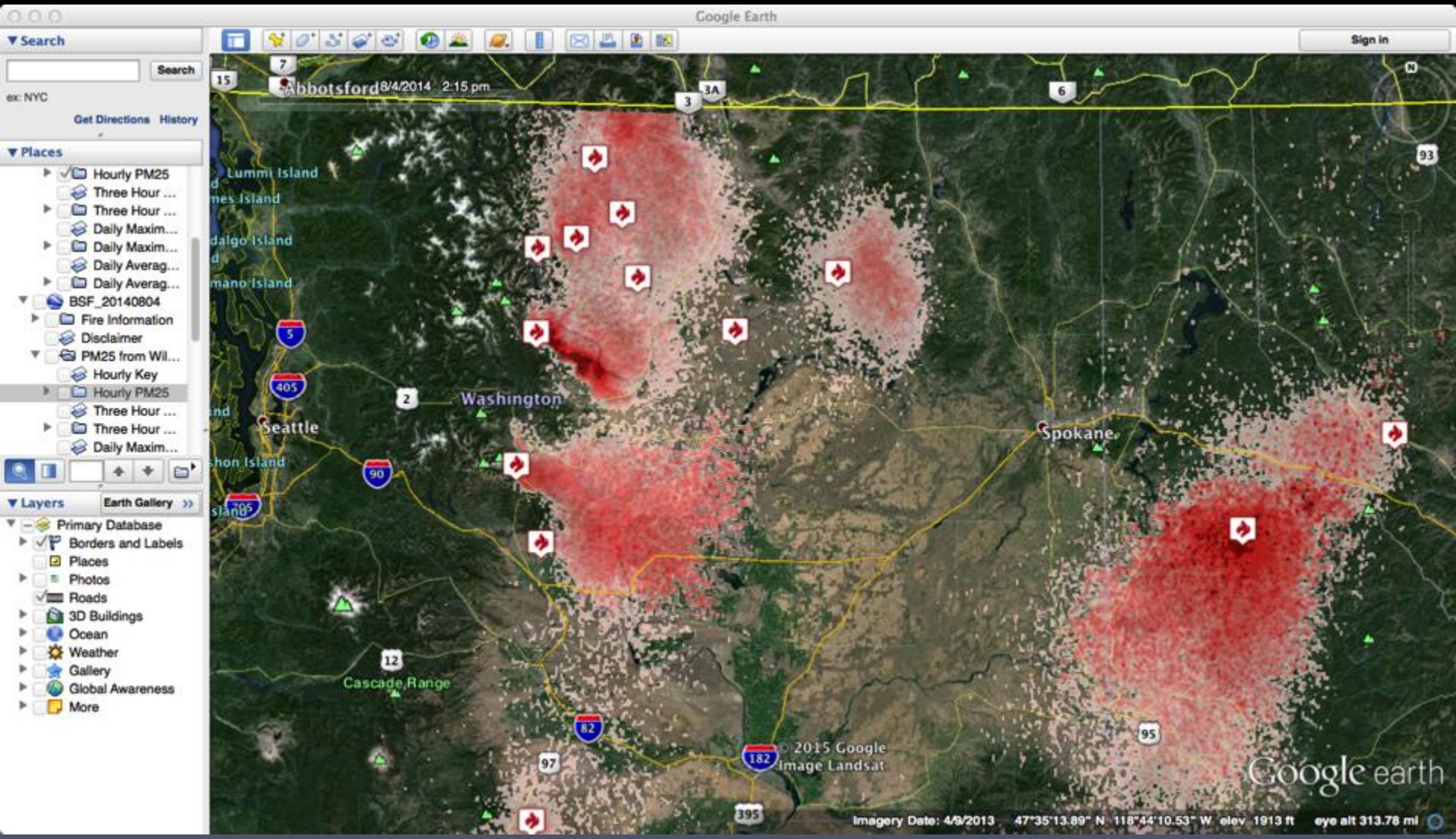
BlueSky PM2.5 from Wildfires
4 km UW WRF Domain
8/4/2014 7am PT



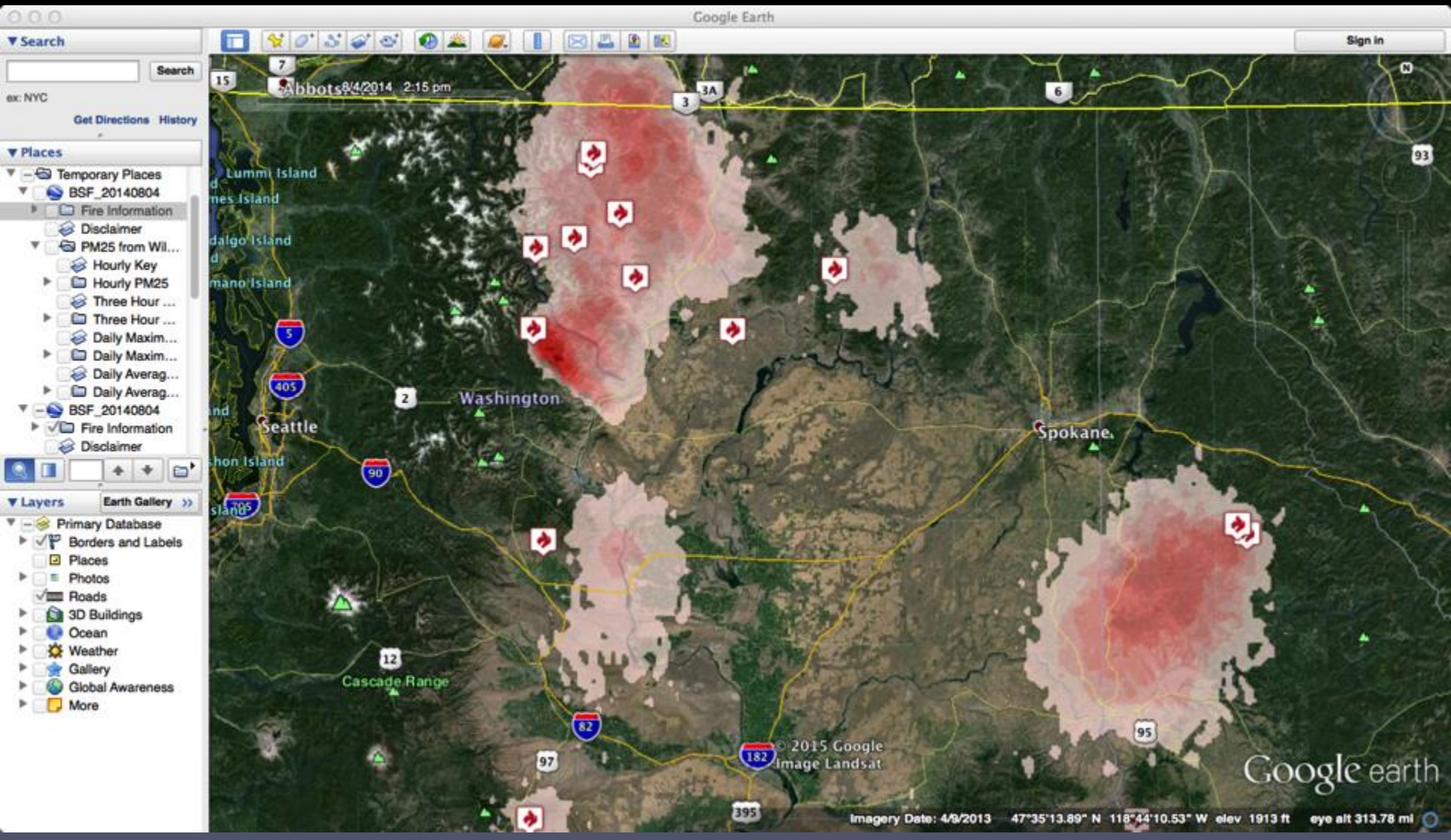
BlueSky PM2.5 from Wildfires
12 km NWS NAM Domain
8/4/2014 7am PT



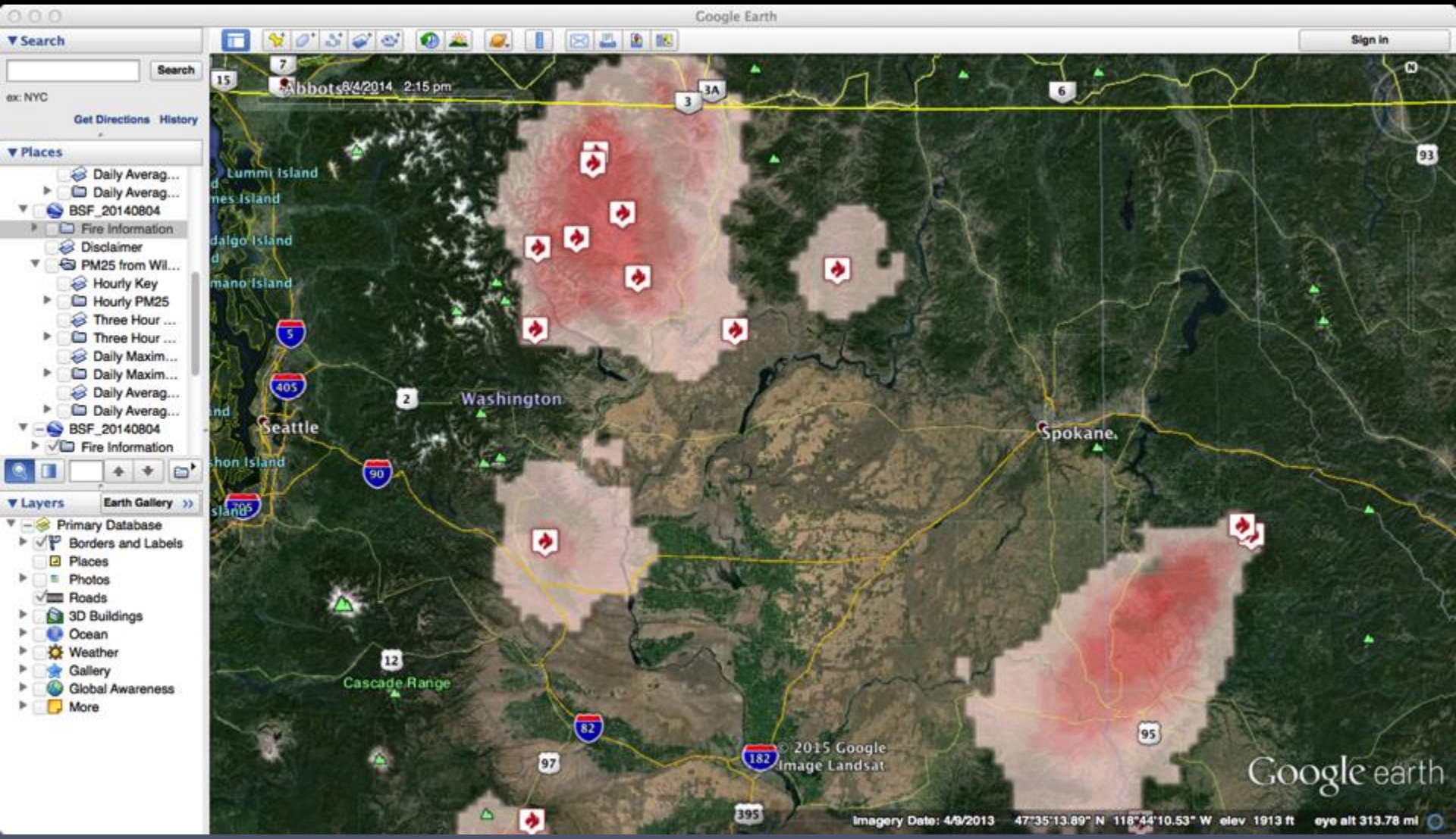
BlueSky PM2.5 from Wildfires
1.33 km UW WRF Domain
8/4/2014 2pm PT



BlueSky PM2.5 from Wildfires
4 km UW WRF Domain
8/4/2014 2pm PT



BlueSky PM2.5 from Wildfires
12 km NWS NAM Domain
8/4/2014 2pm PT



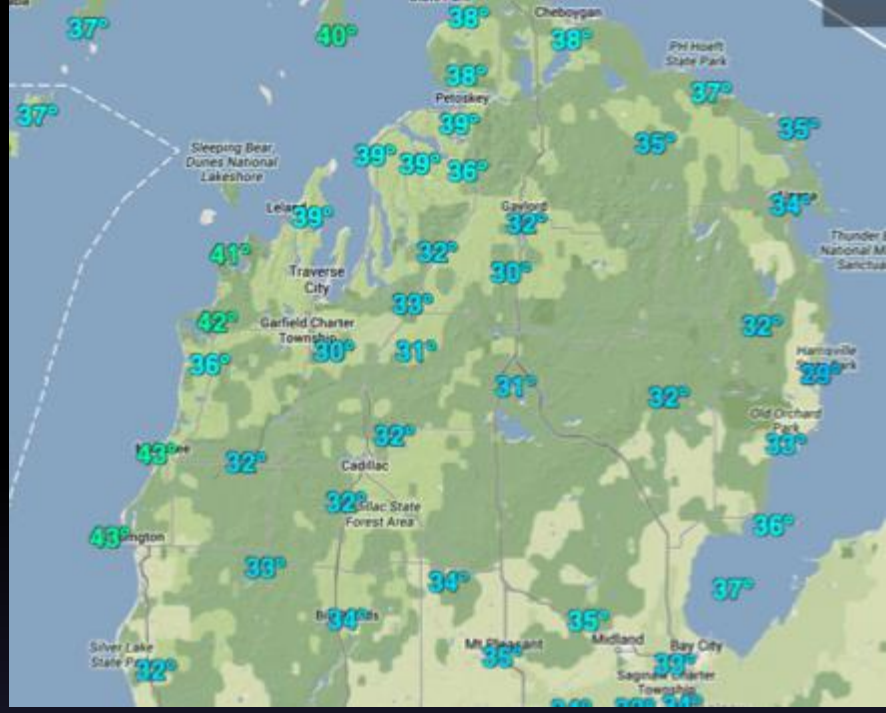
Interpreting Model Runs

- What question are you trying to answer?
  - When/where will smoke effects occur
  - Will there be an exceedence to the AQ standards?

- Get as much information as possible on what went into the model runs – includes fuels, weather, fire location, fire size, etc.
- Familiarize yourself with model limitations
- Familiarize yourself with monitor limitations
- Compare different model outputs (different domains, resolutions, etc.)
- Mentally adjust output to compensate for known inaccuracies (too many acres, dispersion down wrong drainage, etc.)

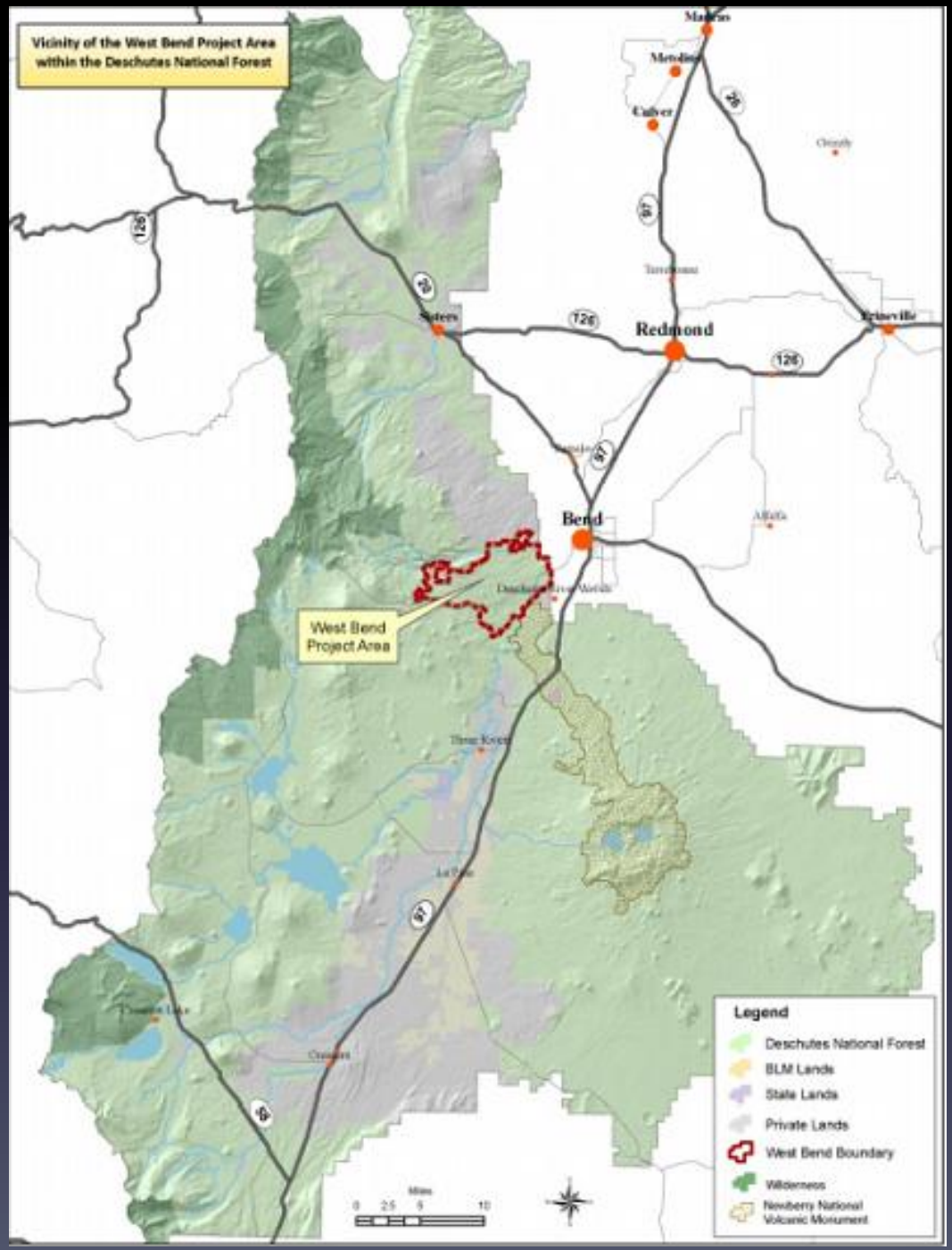
Example: Carleton Complex, Washington State, 2014

Forecasting smoke is not like forecasting temperature;



it is closer to forecasting precipitation.

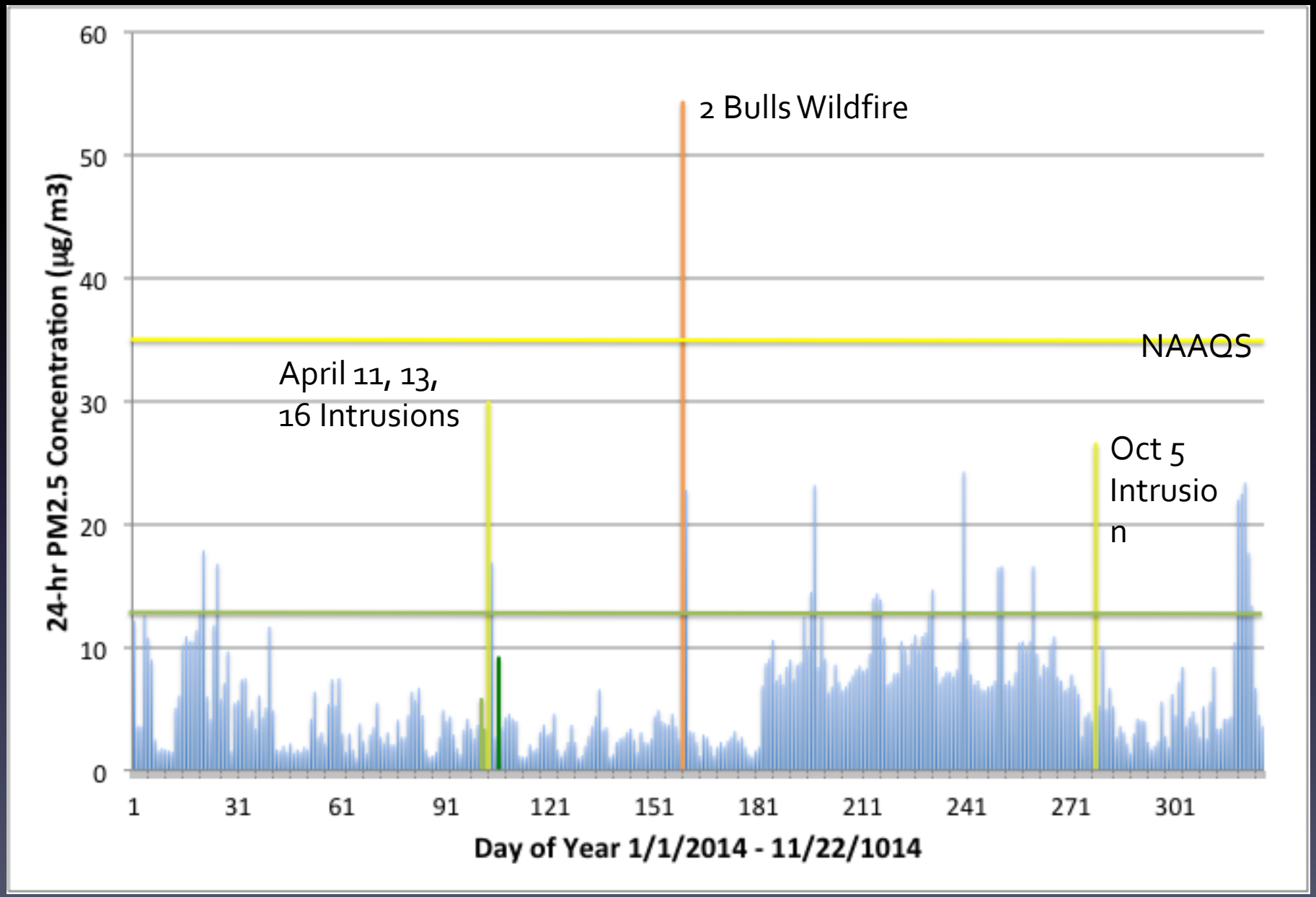
But, *smoke forecasting often lacks the data, the human forecaster, and the probabilistic language of precip forecasting*



Land Management in the Wildland Urban Interface

West Bend Vegetation Management Project Location

Bend Intrusions 24-hr PM2.5

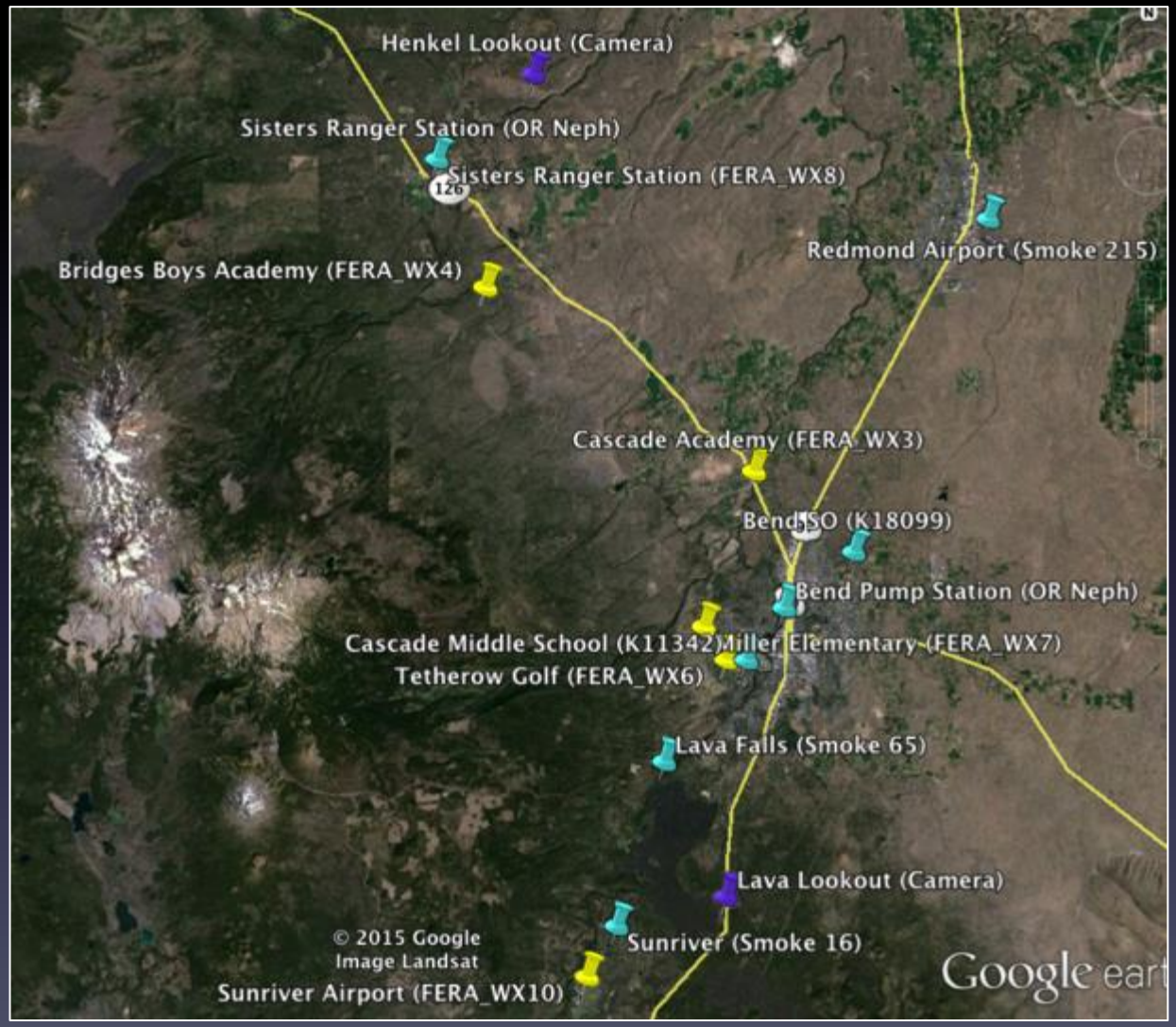


Research Project

- Investigate fuel conditions leading to smoke incursions
- Investigate meteorological conditions leading to smoke incursions
- Smoke modeling of intrusions

Monitor Locations

- E-Samplers (blue)
- Meteorological Station (yellow)
- Camera (purple)
- Fall 2014
- Spring 2015



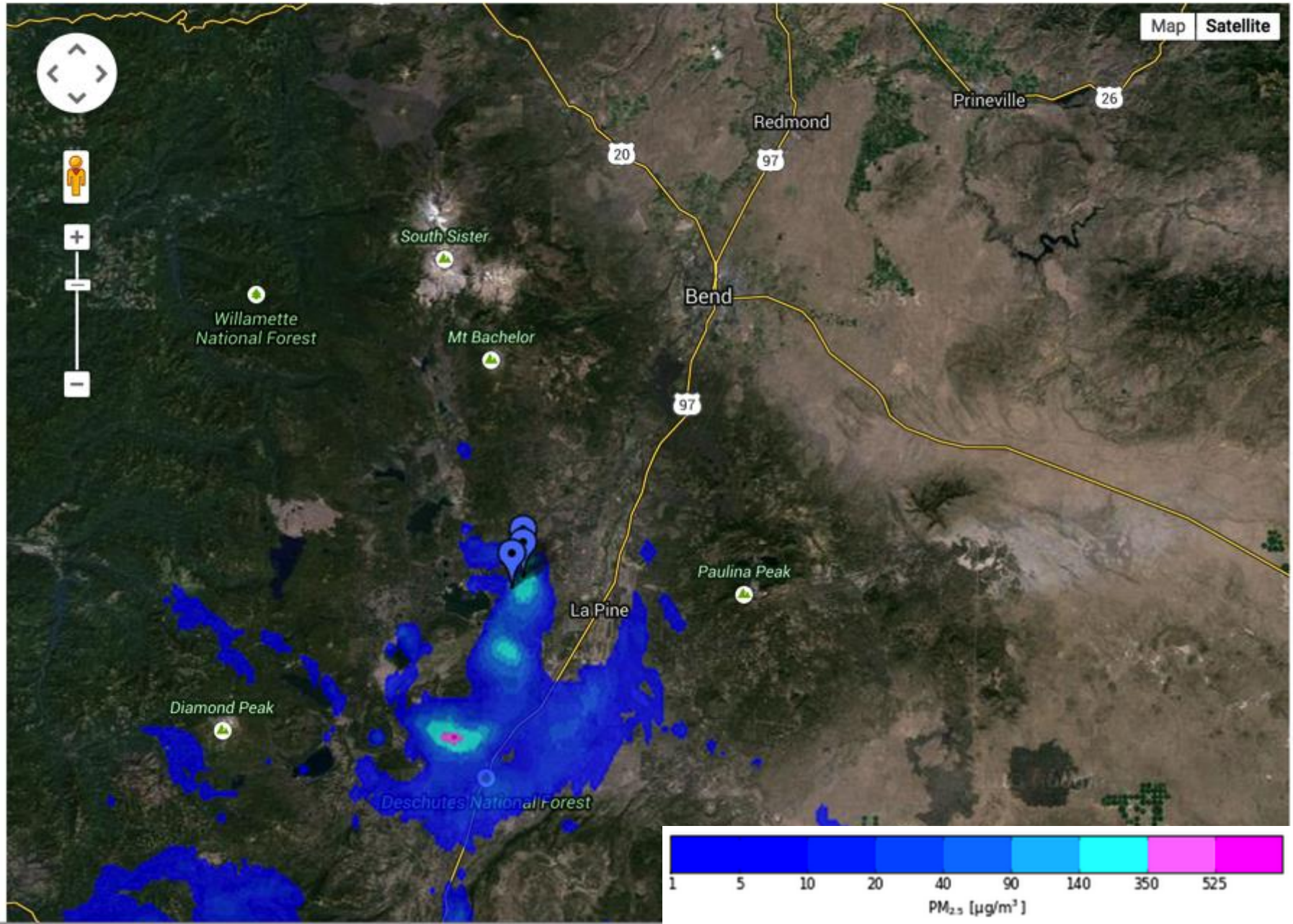
October 5, 2014 Smoke Intrusion

- 3 Rx fires SW of Bend
- Approximately 50 acres each
- Ignited from 11am-1pm PDT
- Maximum 1-hr PM2.5 concentration of 96 $\mu g/m^3$ at 2am, another peak of 94 $\mu g/m^3$ at 8am
- 24 hr average PM2.5 = 27 $\mu g/m^3$

- BlueSky Simulations
- HYSPLIT Trajectories
- 1-km NWS Fire Weather Domain
- 4-km PNW WRF Domain from University of Washington

10/4/2014 22:00 Pacific Daylight Savings

▶ || + - animation speed



10/4/2014 23:00 Pacific Daylight Savings

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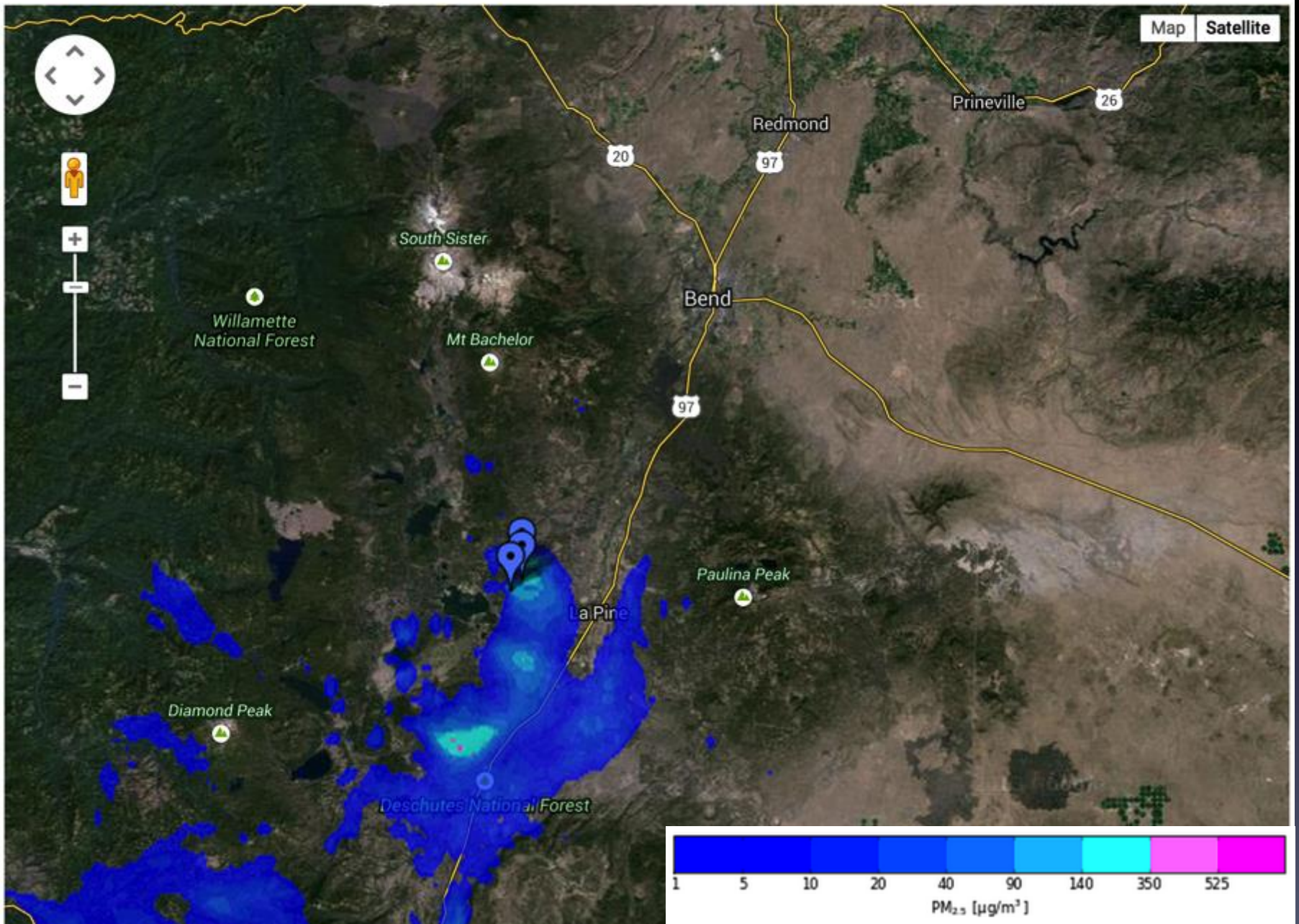
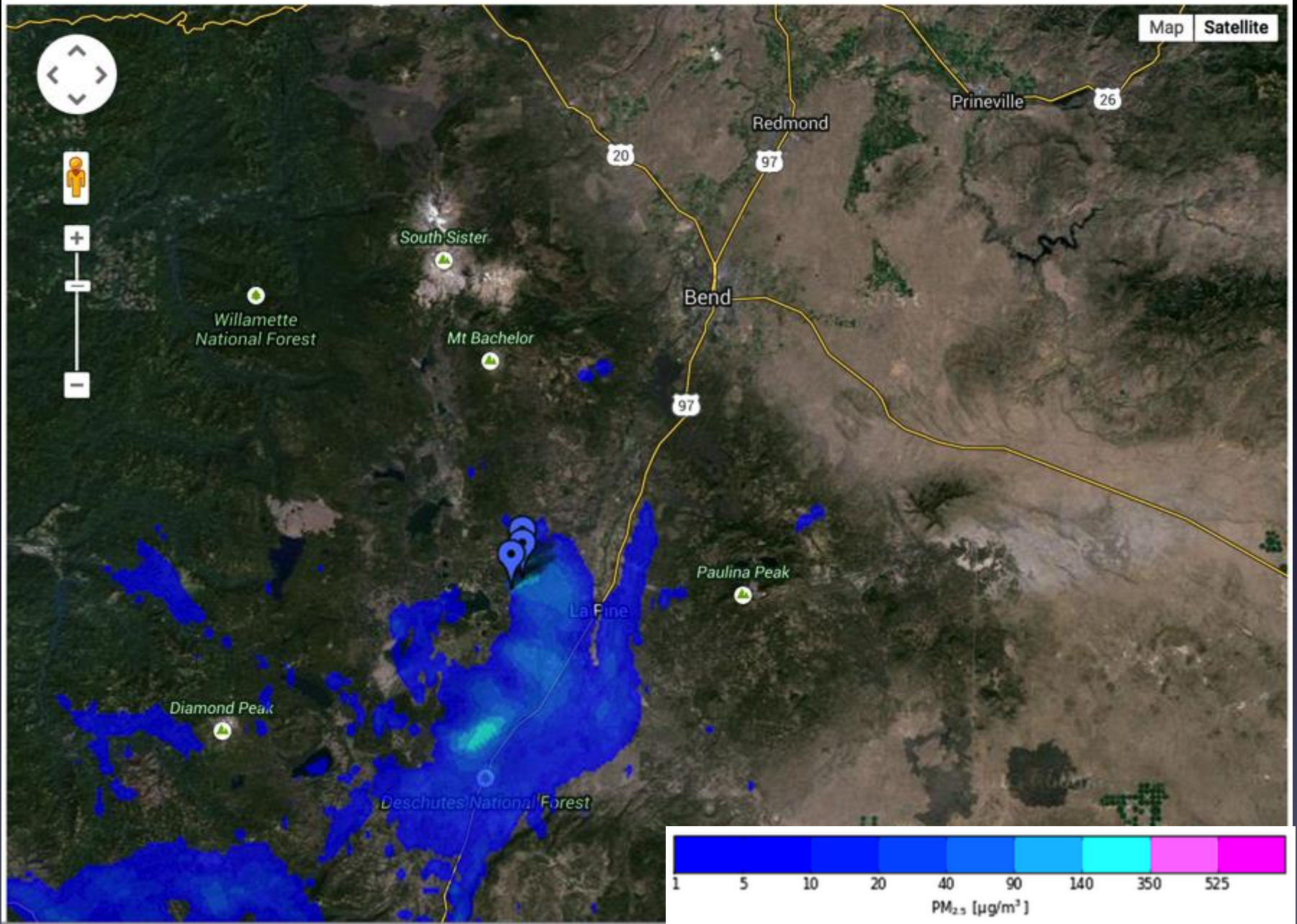


10/5/2014 0:00 Pacific Daylight Savings

animation speed



10/5/2014 1:00 Pacific Daylight Savings

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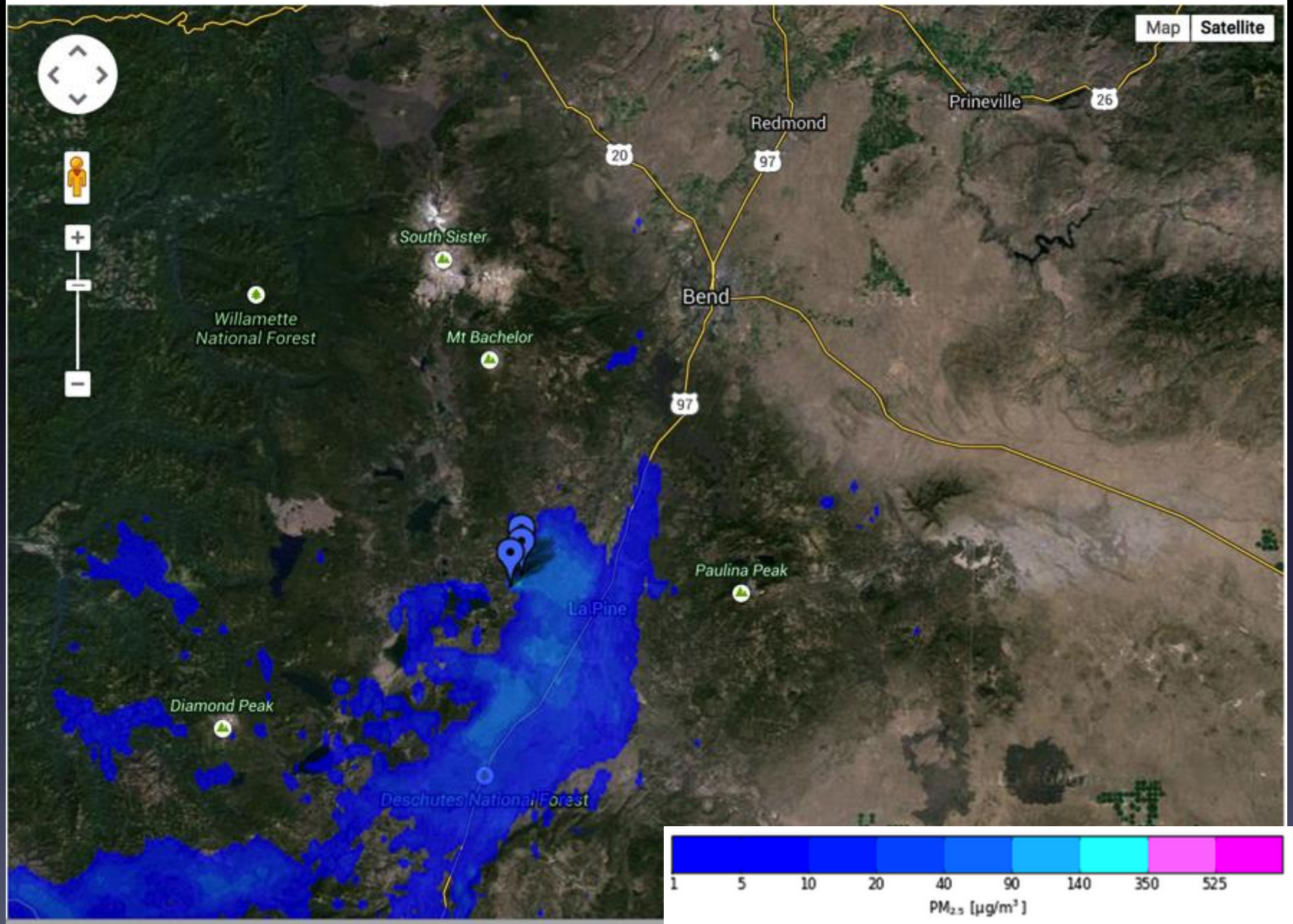

10/5/2014 2:00 Pacific Daylight Savings

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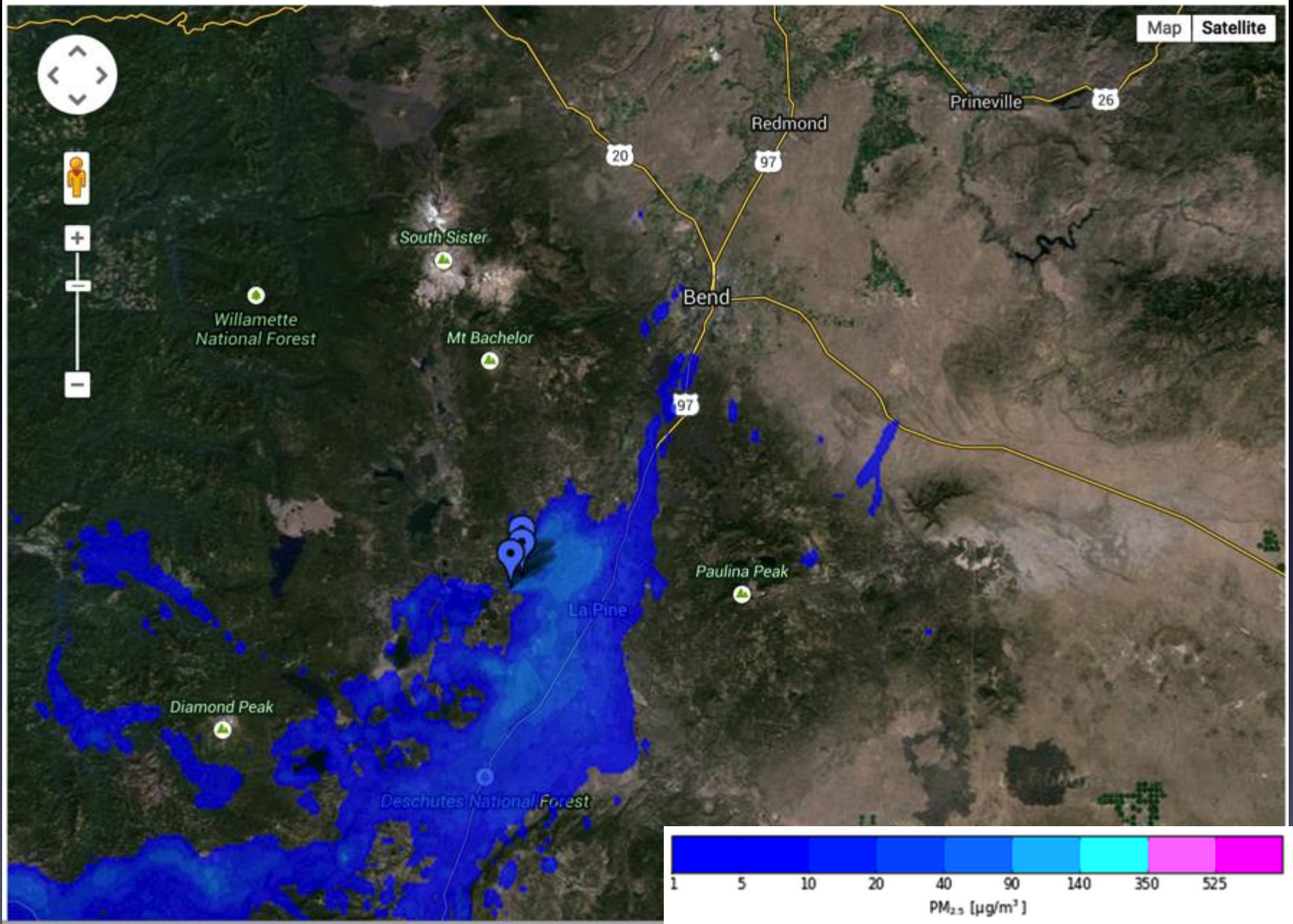

10/5/2014 3:00 Pacific Daylight Savings

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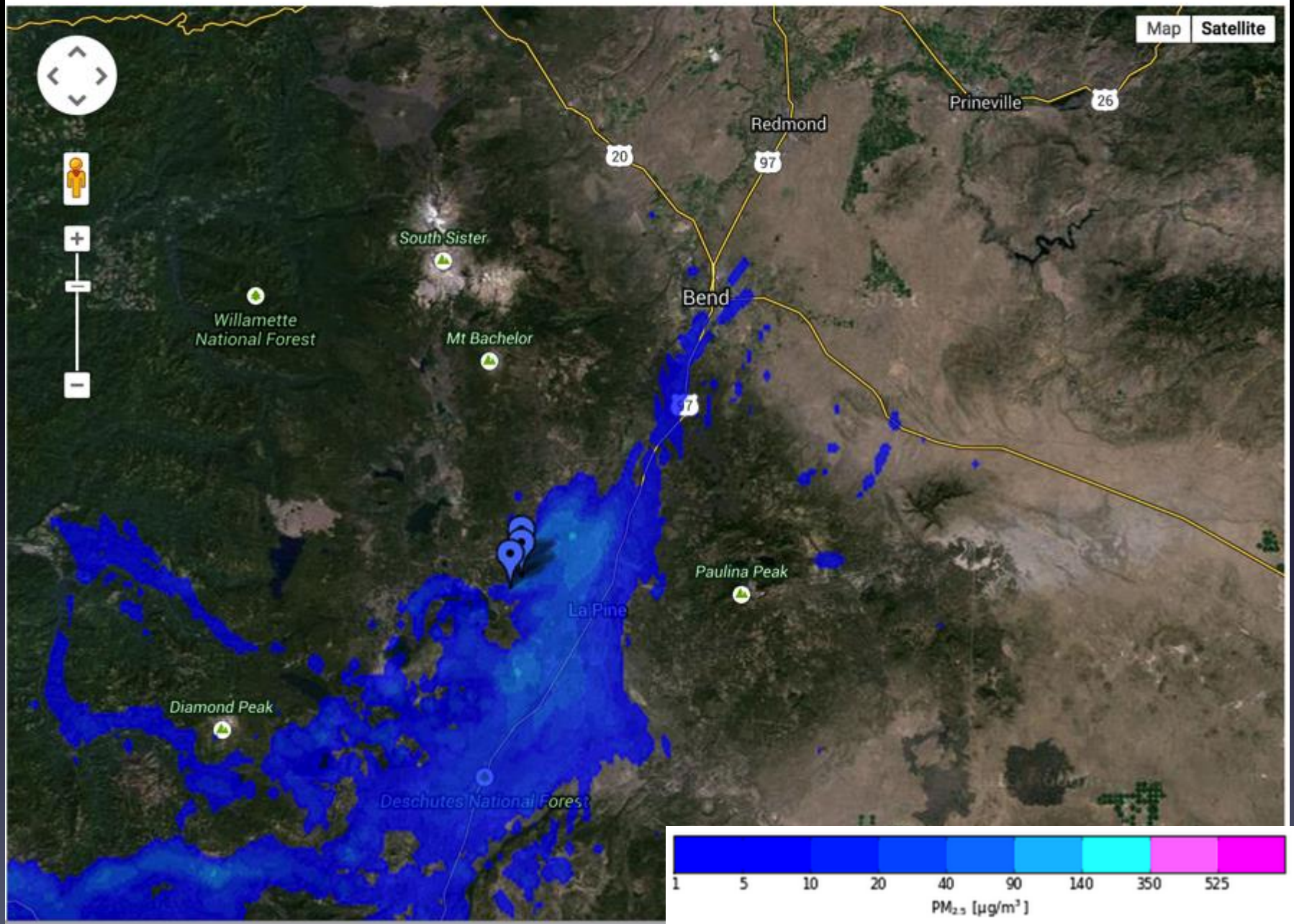

10/5/2014 4:00 Pacific Daylight Savings

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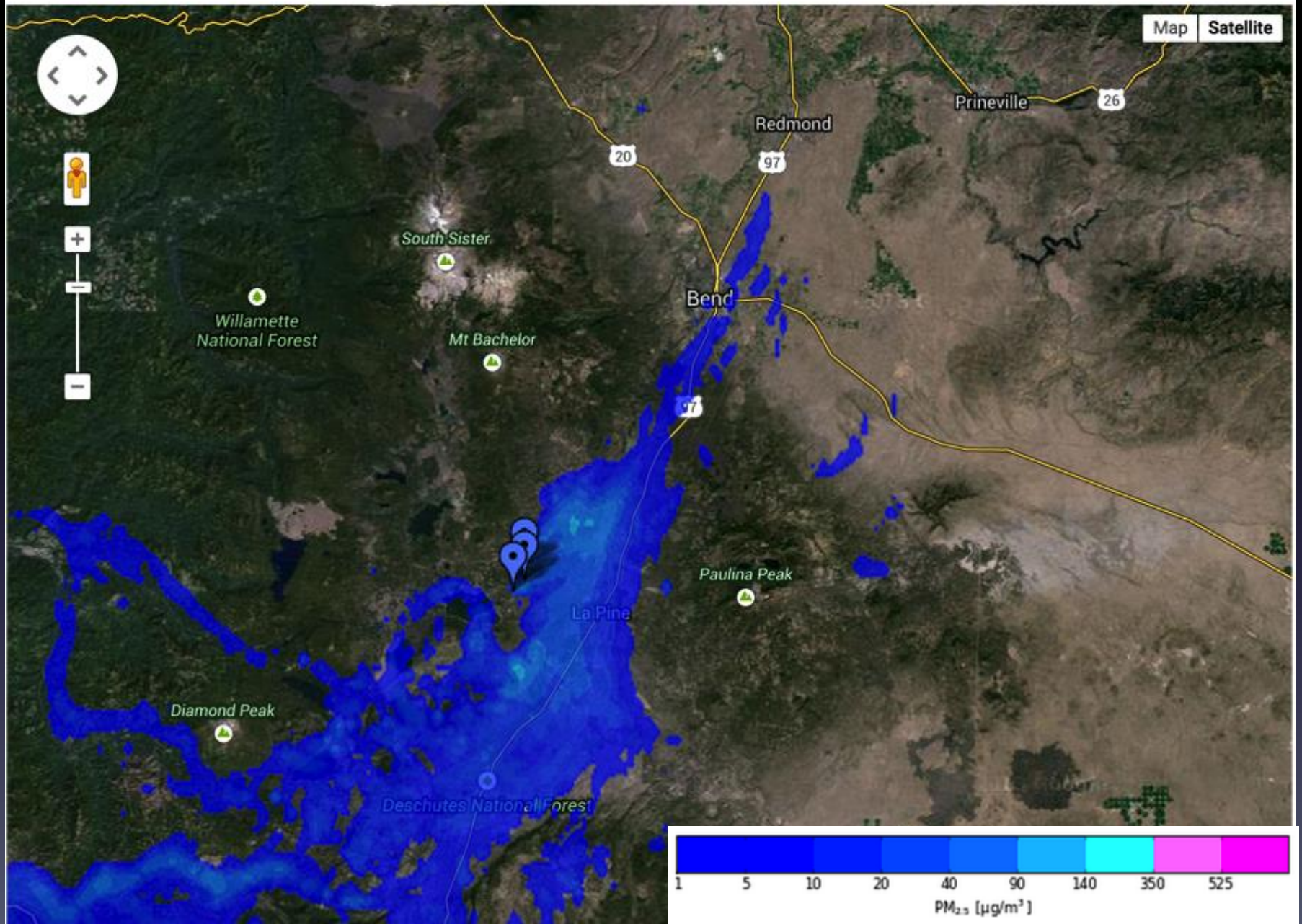

10/5/2014 5:00 Pacific Daylight Savings

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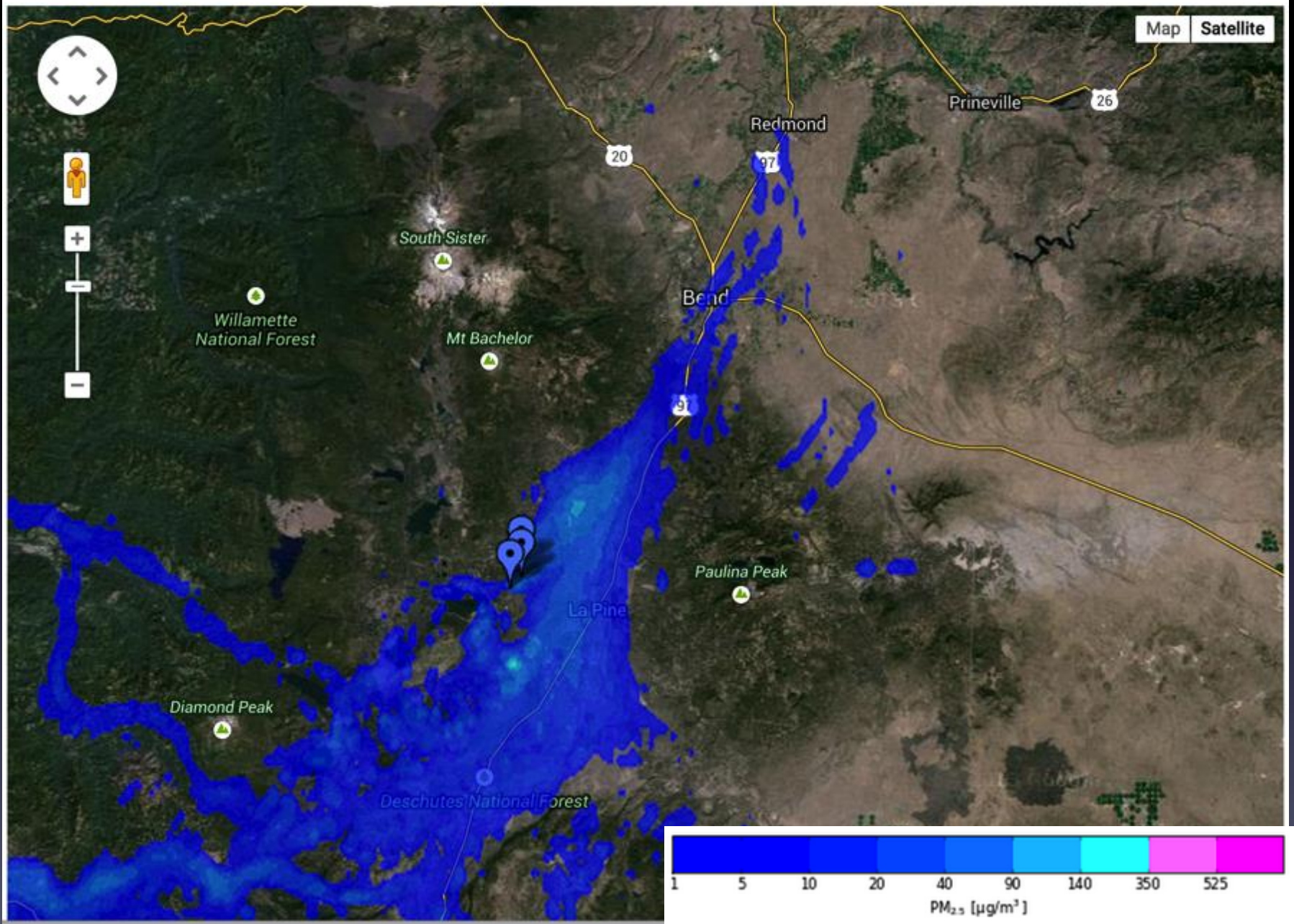
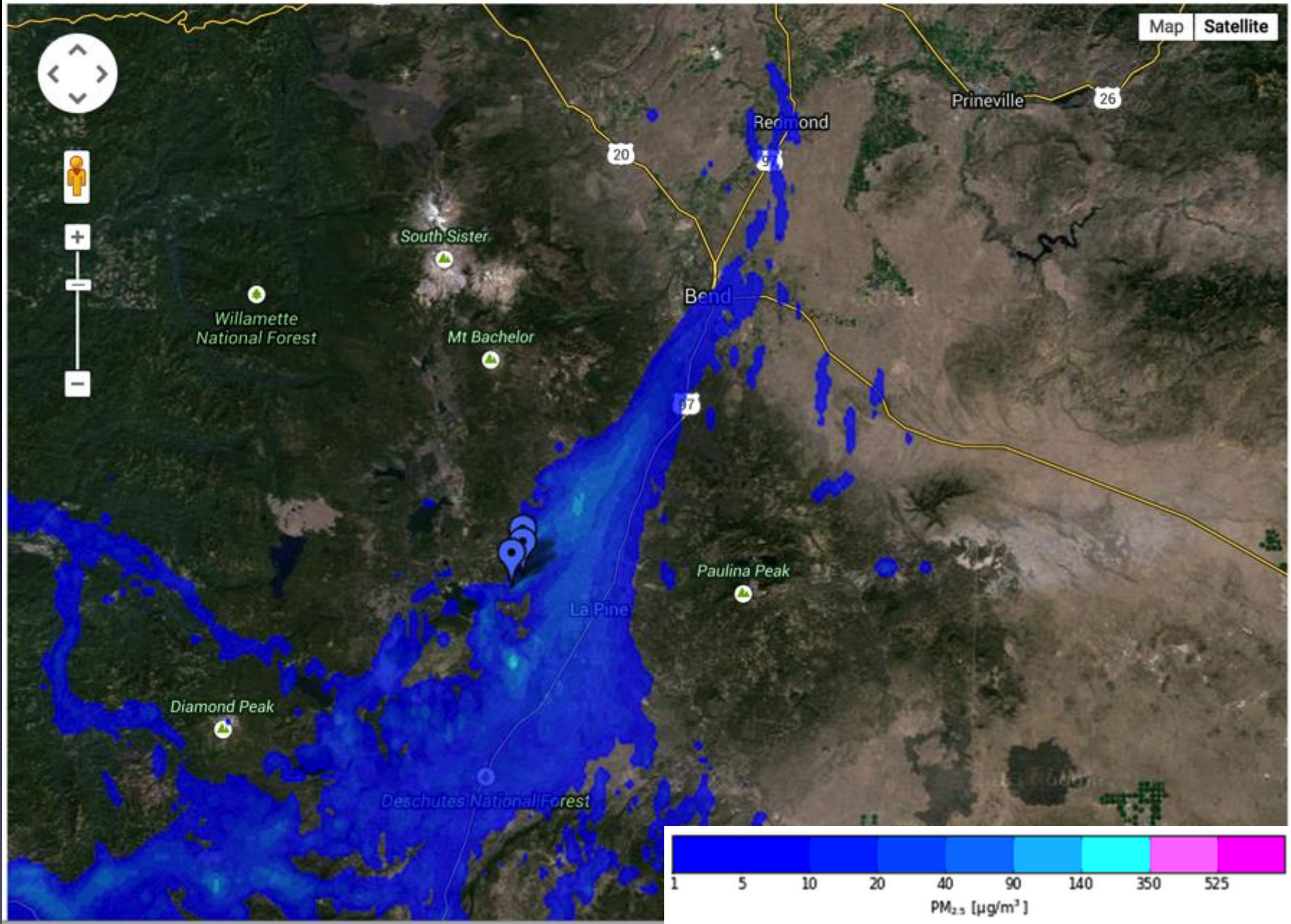
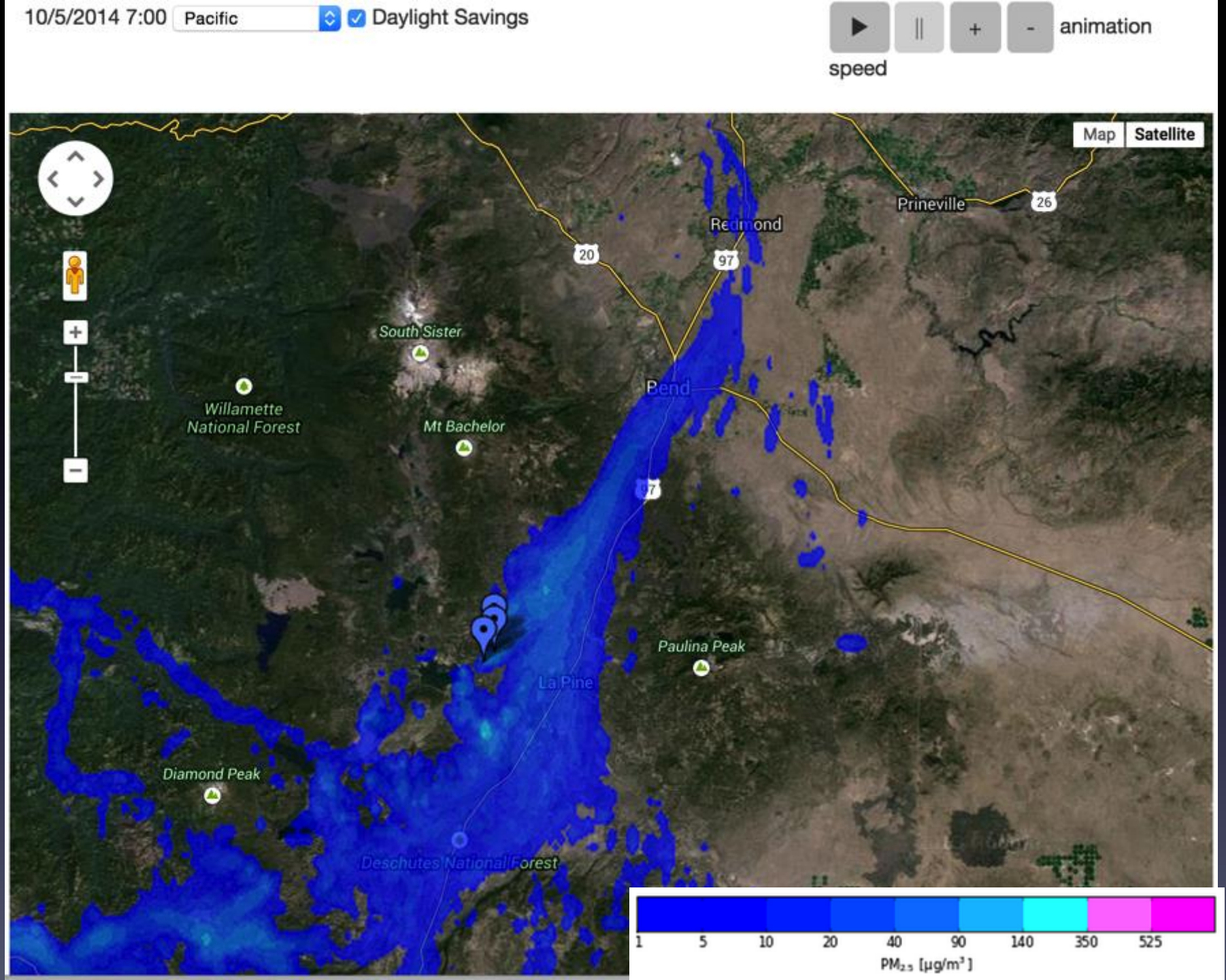


10/5/2014 6:00 Pacific Daylight Savings

animation

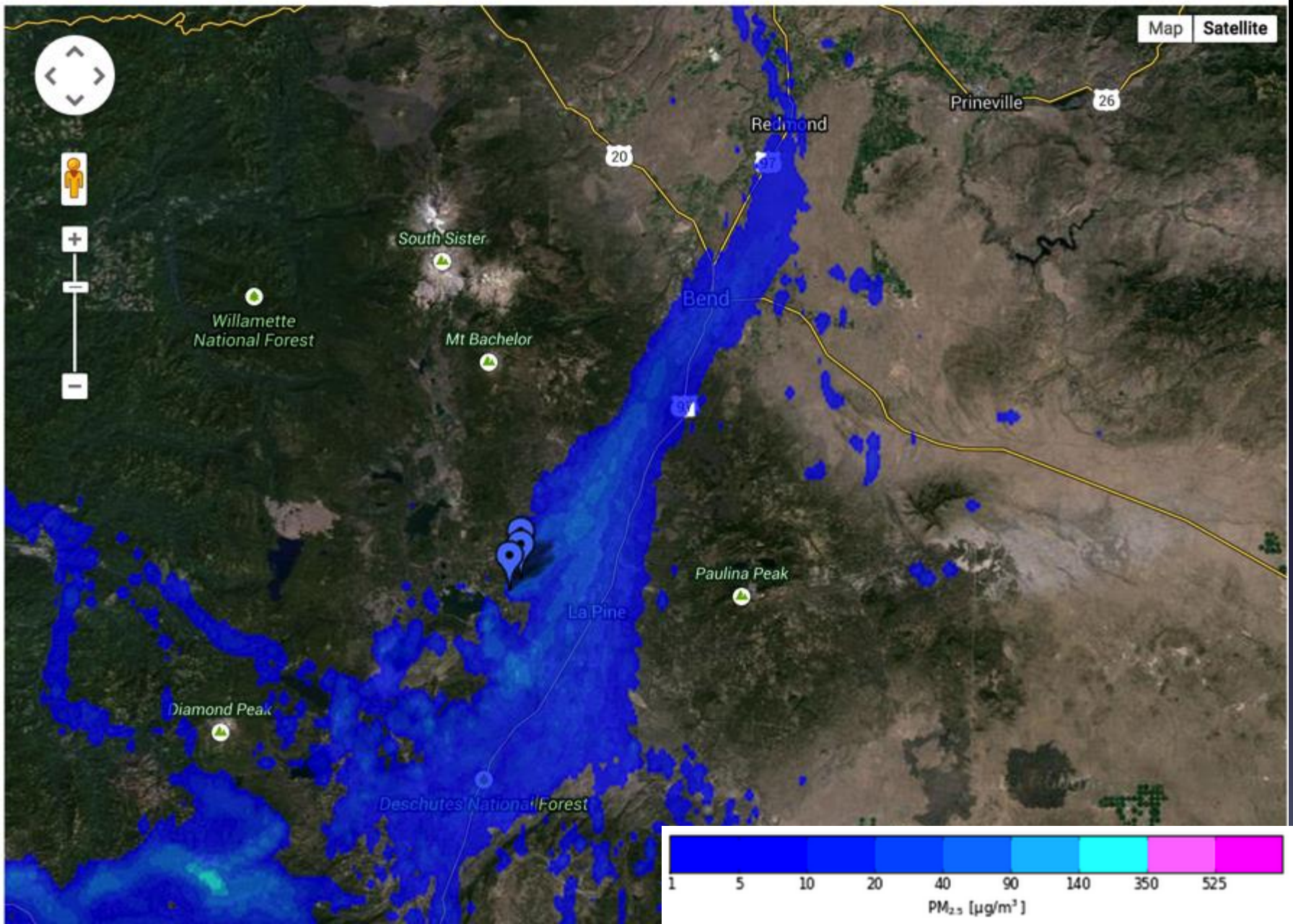
speed




10/5/2014 7:00
Pacific
Daylight Savings
animation
speed
Map
Satellite
Prineville
26
Redmond
20
97
South Sister
Willamette
National Forest
Mt Bachelor
Bend
97
Paulina Peak
La Pine
Diamond Peak
Deschutes National Forest
1
5
10
20
40
90
140
350
525
PM2.5 [µg/m³]

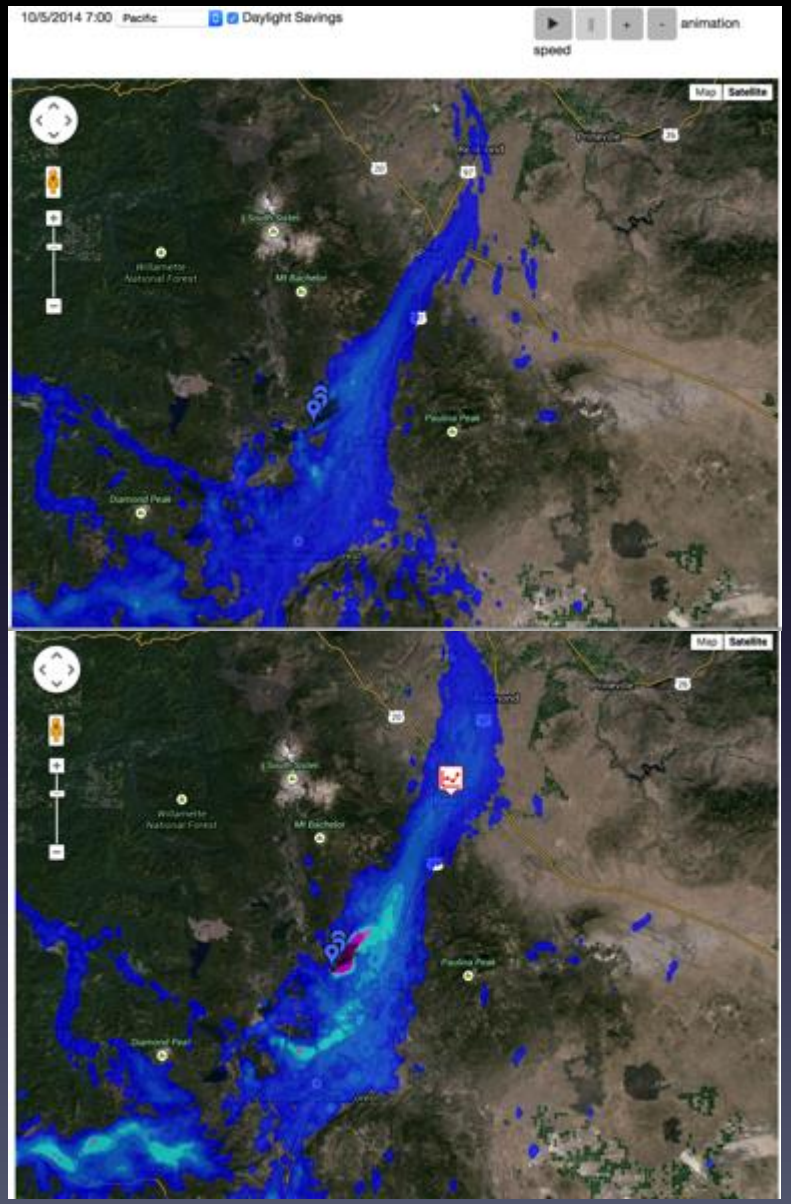
10/5/2014 8:00 Pacific Daylight Savings

▶ || + - animation speed



Smoke Modeling Results

- 1-km domain captured the timing of the smoke transport to Bend
- 1-km results did not simulate concentrations well (maximum of 12 $\mu g/m^3$)
- 4-km results did not simulate timing or concentrations well
- Increased the smoldering consumption 4 times
  - 1-km domain: Peak concentration of 37 $\mu g/m^3$
  - 4-km domain: Peak concentration did not change much (from 5 to 8 $\mu g/m^3$). Timing of smoke into Bend did not improve



BlueSky Playground – allows users to do custom runs

playground.airfire.org

BlueSky Playground

playground.airfire.org/home.php

Apple iCloud Facebook Twitter Wikipedia Yahoo! News Popular

playground 2.0 beta

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

Logged in as **miriam** | Log Out

Home

Welcome to BlueSky Playground!

Use BlueSky Playground to model your fires, estimate pollutant emissions, and predict downwind smoke concentrations.

- To get started, create one or more *emissions scenarios* to model your fires. You simply specify the size, type, and location of the fires; then you can choose to accept defaults, or you can modify specific details about fuel loading, moisture, etc. After creating an emissions scenario, you can choose to create a dispersio
- Creating a *dispersion scenario* allows you to c the predicted hourly $PM_{2.5}$ concentrations.

Create New Emissions Scenaric

Model your fire's emissions.

View Existing Emissions Scenar

View and edit your saved emissions

View Existing Dispersion Scena

View and edit your saved dispersion

Current & Future Work/Activities

- BlueSky Canada & include Canadian Emissions
- NOAA HYSPLIT – Updating BSF
- BlueSky-lite
- Updated Emission Factors
- Continue working with the Interagency Wildfire Air Quality Response Program
- Cloud computing to make predictions much faster

Many thanks to a cast of thousands (OK, maybe 10's). Here's an incomplete list (in no particular order):

Sue Ferguson
Sim Larkin
Susan O'Neill
Candace Krull
Ramesh Narasimhan
Roger Ottmar
Sonoma Tech, Inc.
Janice Peterson
Miriam Rorig
Robert Solomon
Joel Dubowy
Pete Lahm
Susan Prichard

Susan O'Neill
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Wildland Fire Decision Support System

June

- Moisture across the West has reduced the Above Normal areas to central California and southwestern Arizona.

- Drier areas in the Northern Rockies, Northwest and the Southeast will begin to transition to Above Normal.

- Above Normal conditions with continue in Alaska's eastern Interior and most of Hawaii.

- Below Normal fire potential covers much of the central U.S. after prolonged heavy rains.

July

- Above Normal fire potential will spread into the Northwest, the Northern Rockies and the Great Basin.

- Above Normal fire potential will continue across central and southern California, southwestern Arizona, and spread into the Nevada Sierra Front. Hawaii will also remain in Above Normal potential.

- Above Normal fire potential will expand through Georgia and the Carolinas while most of the central U.S. and Alaska will return to normal seasonal conditions.

August through September

- Above Normal fire potential will continue across the Northwest, the Northern Rockies, the Great Basin and parts of central and southern California, and Hawaii.