Tracking Wildfire Smoke During the 2012 Idaho Smokepocalypse:
Techniques and Lessons Learned

- NW-AIRQUEST Annual Meeting,
- June 7, 2013

Featherville, Idaho, during the Trinity Ridge fire, Summer 2012

Introduction

- 2012 = bad fire year
- Impacts from smoke
  - 55 exceedances in Salmon, 4 in Treasure Valley, 20 in Pinehurst, 4 in Franklin (many more communities without FRMs impacted)
  - health impacts: schools in Salmon, masks in Riggins, athletic practices in Treasure Valley
  - economic impacts: tourism, outdoor recreation
- Our task
  - support AQ forecasters with information
  - protect public health
  - document exceedances

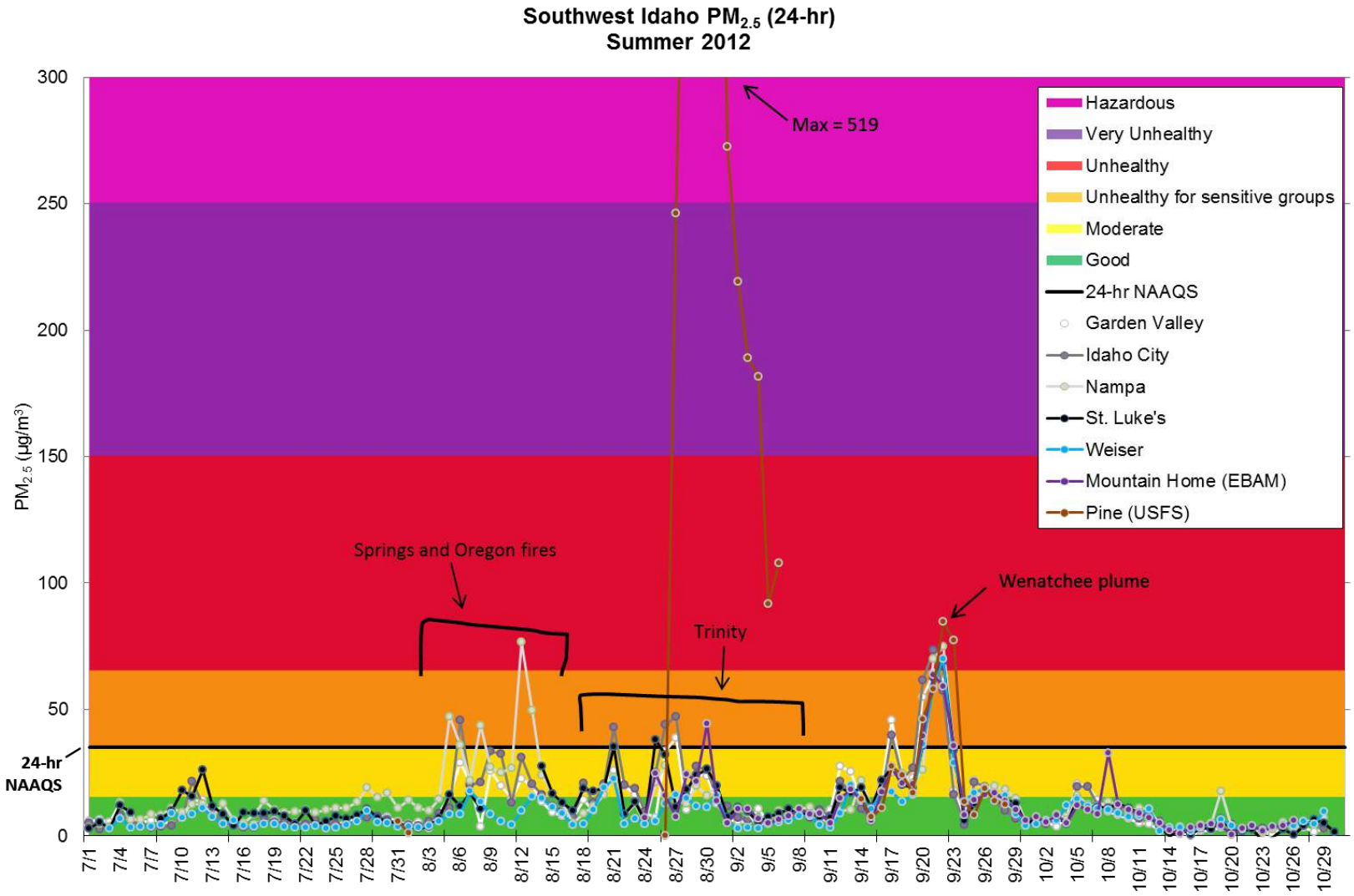
Introduction, cont'd.

- Part I: What happened
  - timeline
  - monitor data
  - geographical summary
- Part II: Tracking the smoke
  - daily reports
  - satellite data
  - models
- Part III: Insights on smoke behavior in Idaho
- Part IV: Leveraging daily reports to document exceptional events

Part I: Monitor and Geographical Summary of Smoke Impacts

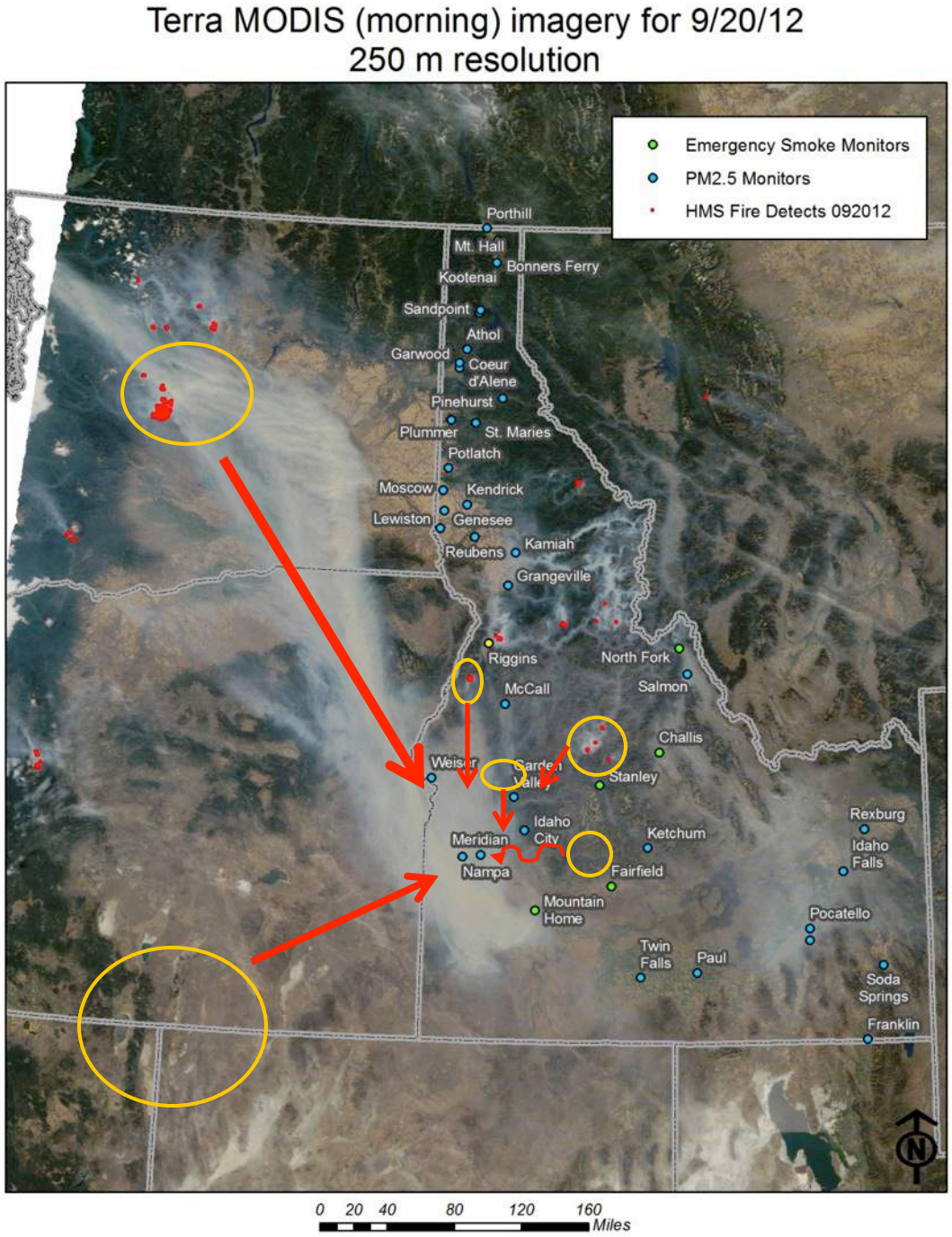
- Split into regions that were similarly impacted
- Identify which fires affected region during which time period
- Monitor data
  - 24-hr. averages from $PM_{2.5}$ monitors (TEOM, FRM, nephelometer, E-BAM, USFS monitors)
  - period – July 1 to October 29 (main fire impacts from August 1 to September 30)
- Schematic maps highlight source regions

Southwest Idaho – monitor data

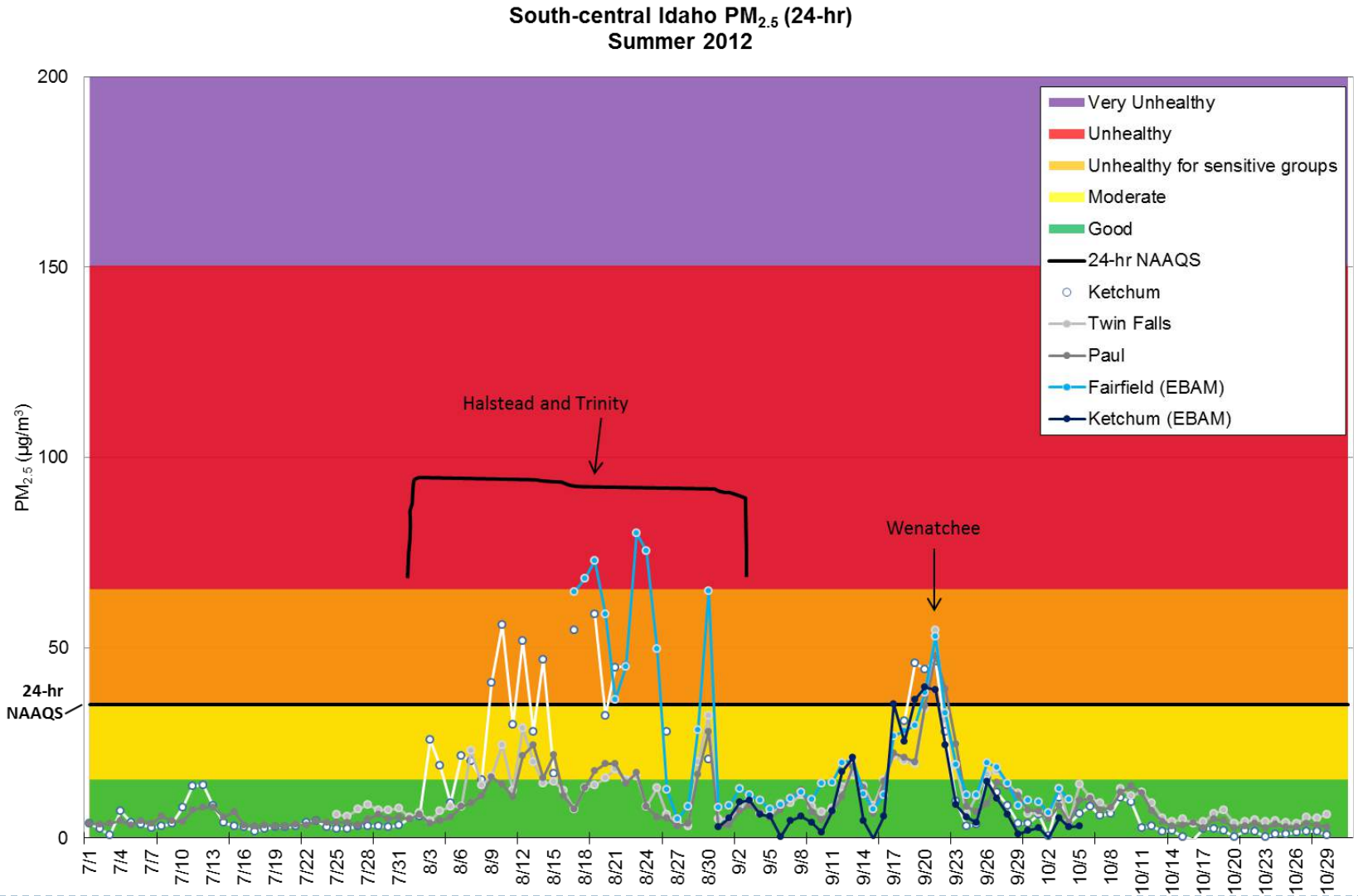


Southwest Idaho – smoke behavior

- Received smoke from all directions, local and regional
- Affected by synoptic flows and local drainage
- SW: northern CA, Barry Point Fire
- NW: Wenatchee Complex
- N: Sheep Fire, Springs Fire
- NE: Halstead Fire
- E: Trinity Ridge

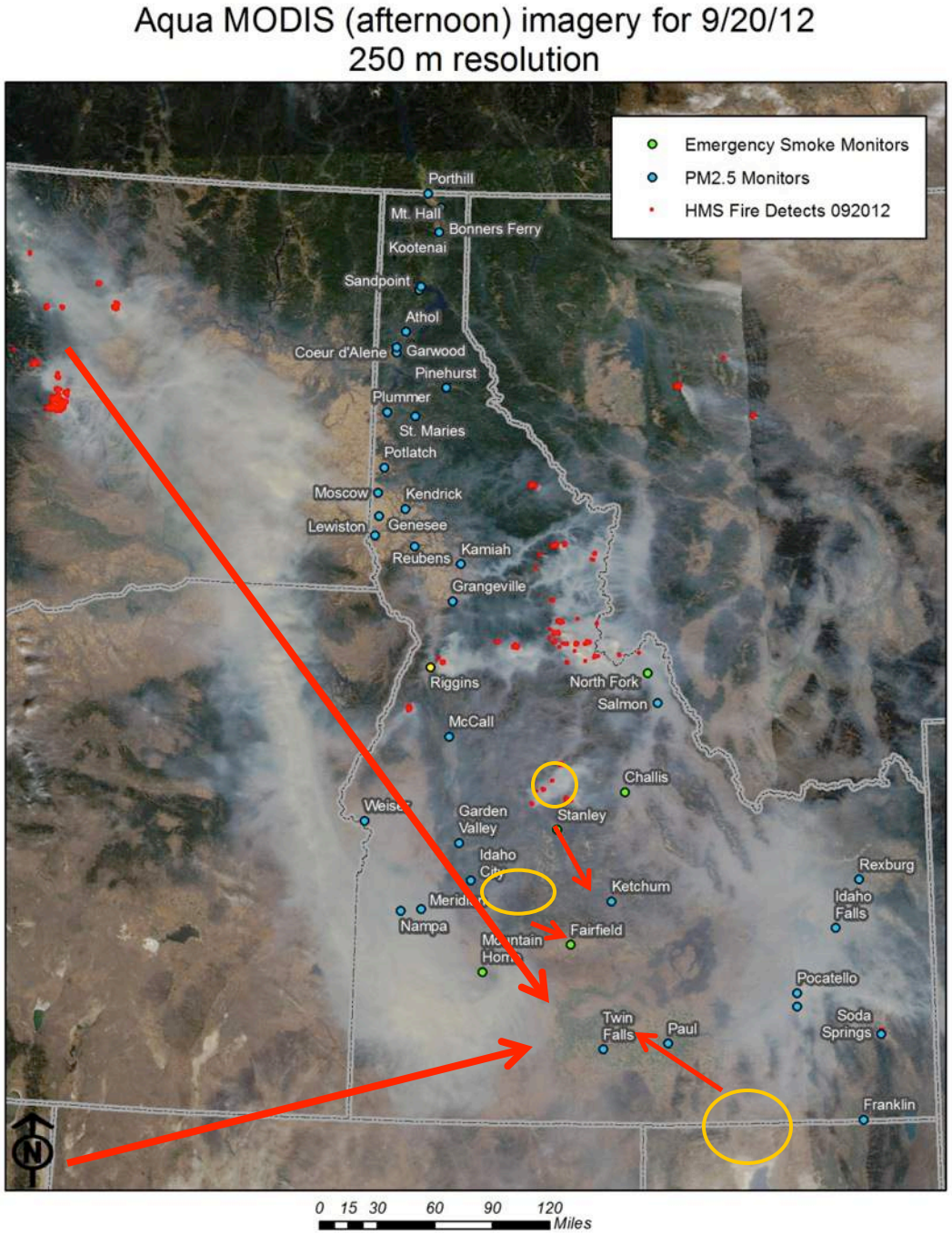


Southcentral Idaho – monitor data

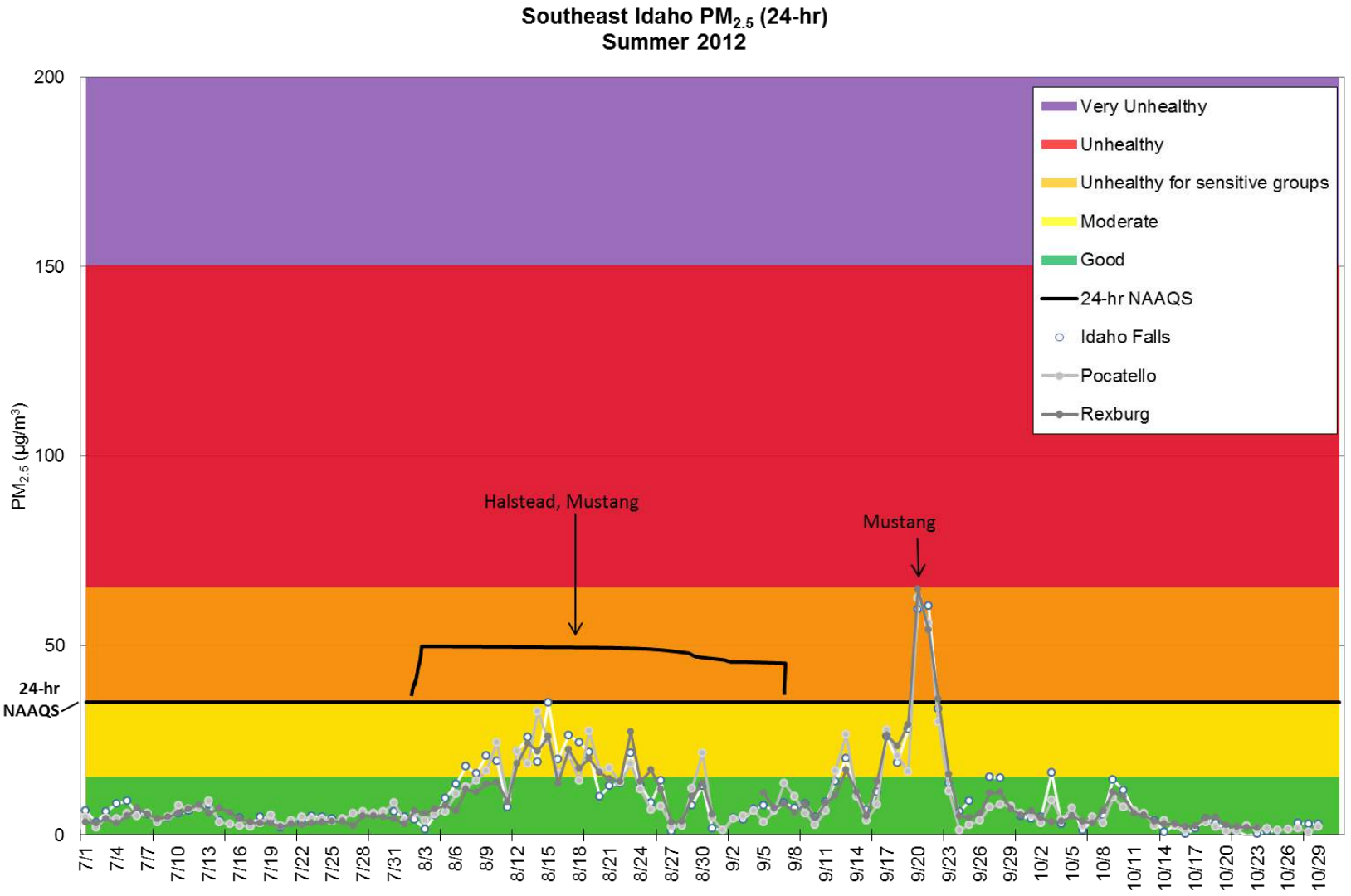


Southcentral Idaho – smoke behavior

- Received smoke from local and regional sources
- SW: northern CA, Barry Point Fire
- NW: Trinity Ridge, Wenatchee Complex
- N: Halstead Fire
- SE: Minidoka Complex

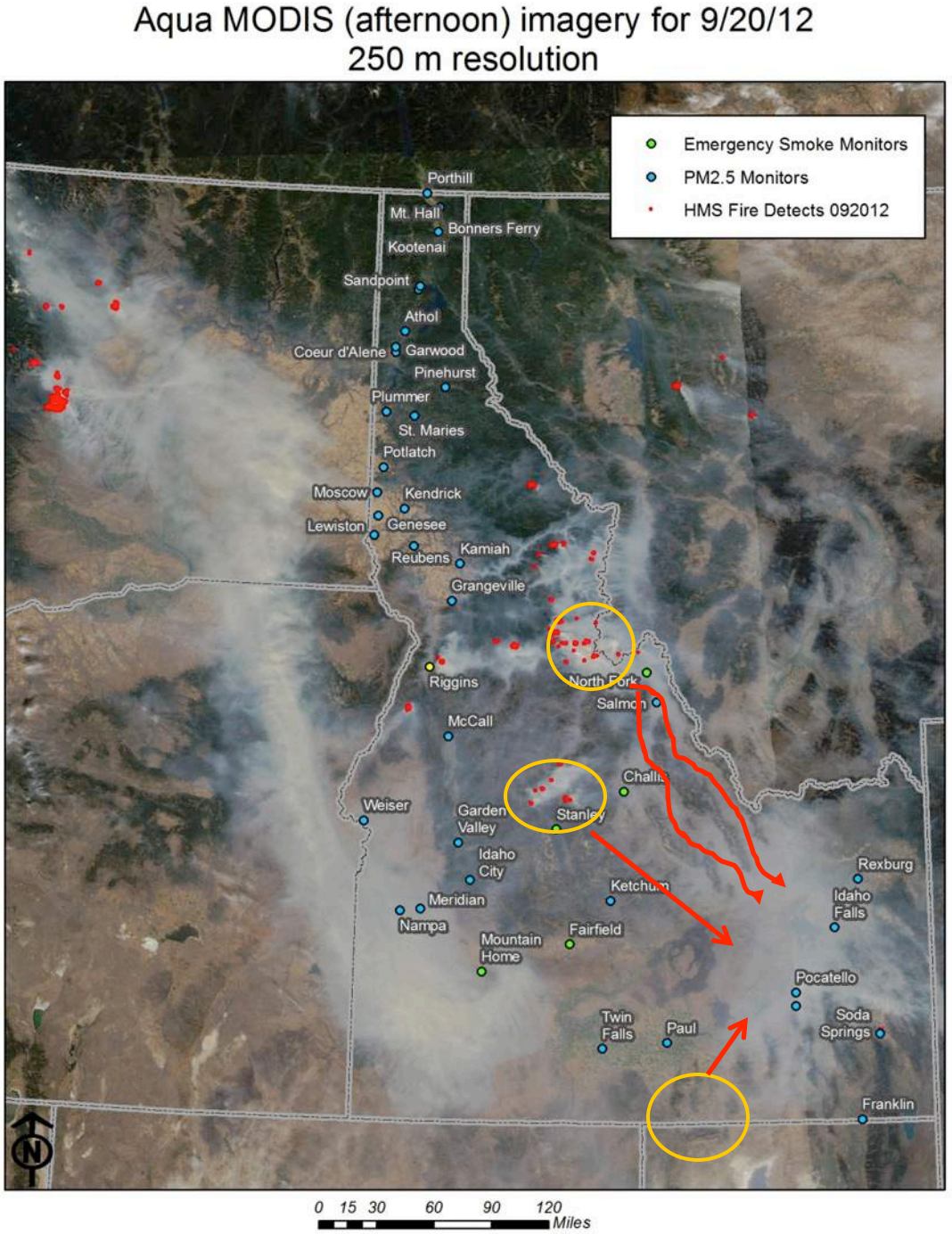


Southeast Idaho – monitor data

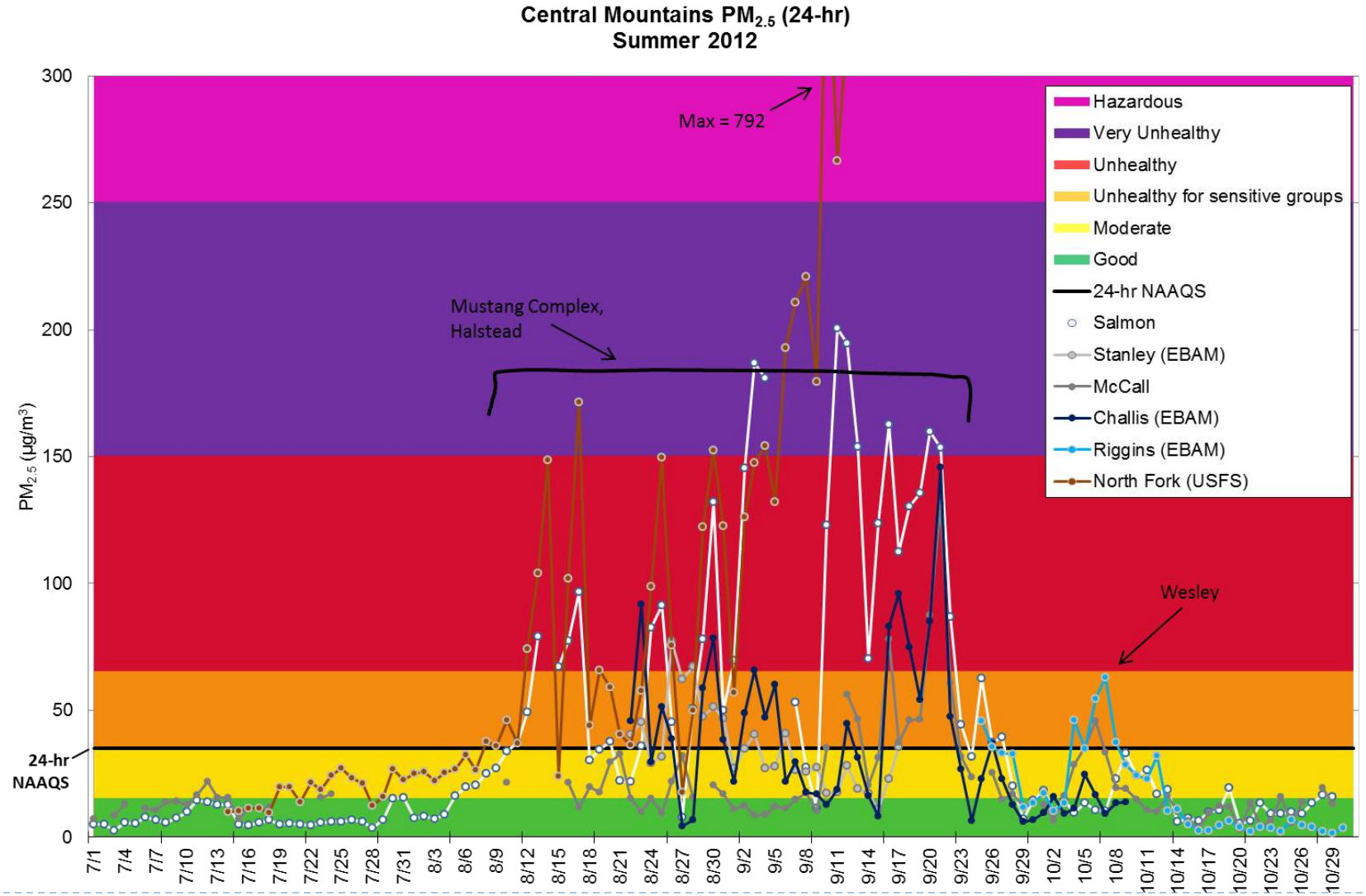


Southeast Idaho – smoke behavior

- Received synoptic and drainage flows
- NW: Halstead Fire
- N: Mustang Complex
- SW: Minidoka Complex

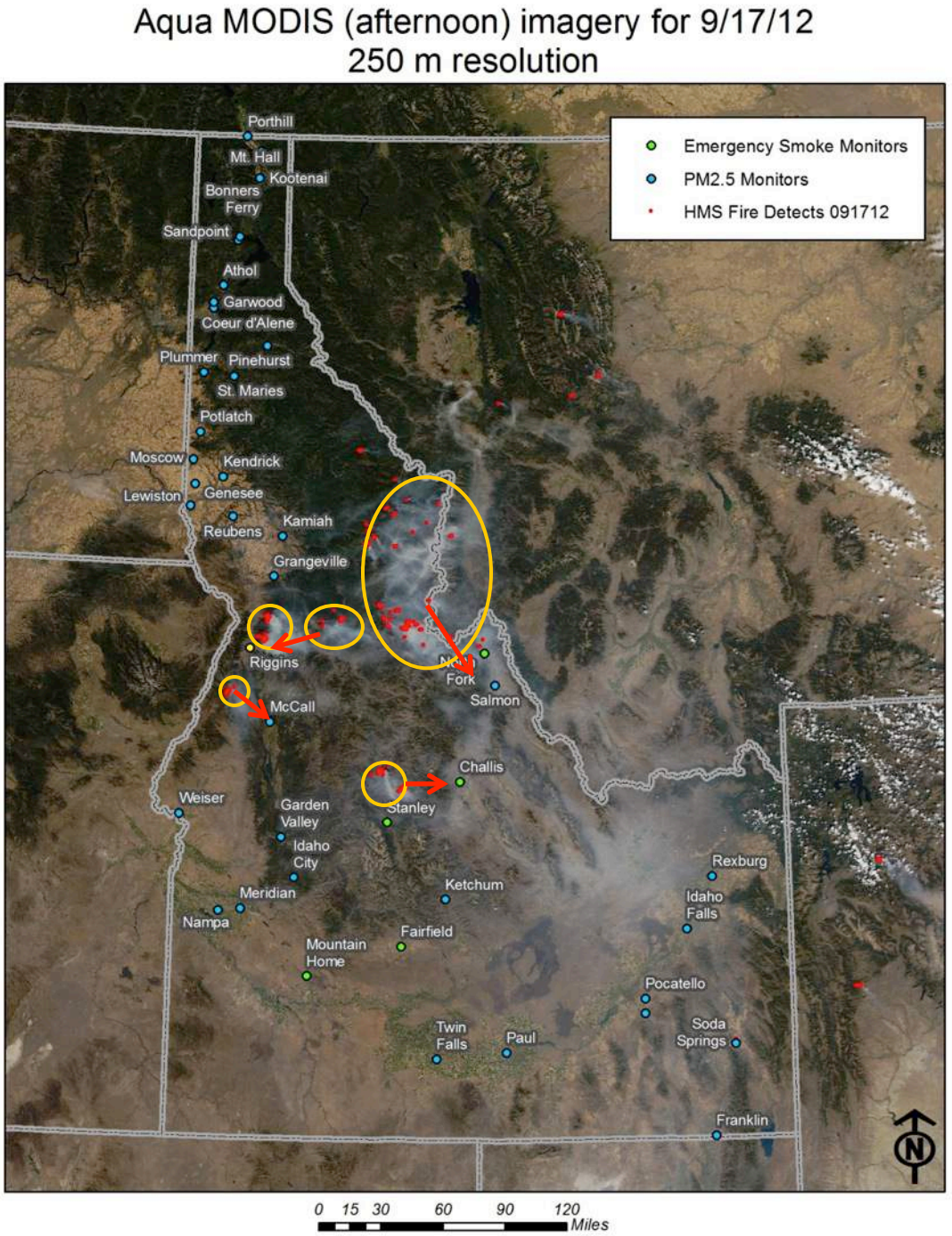


Central Mountains – monitor data

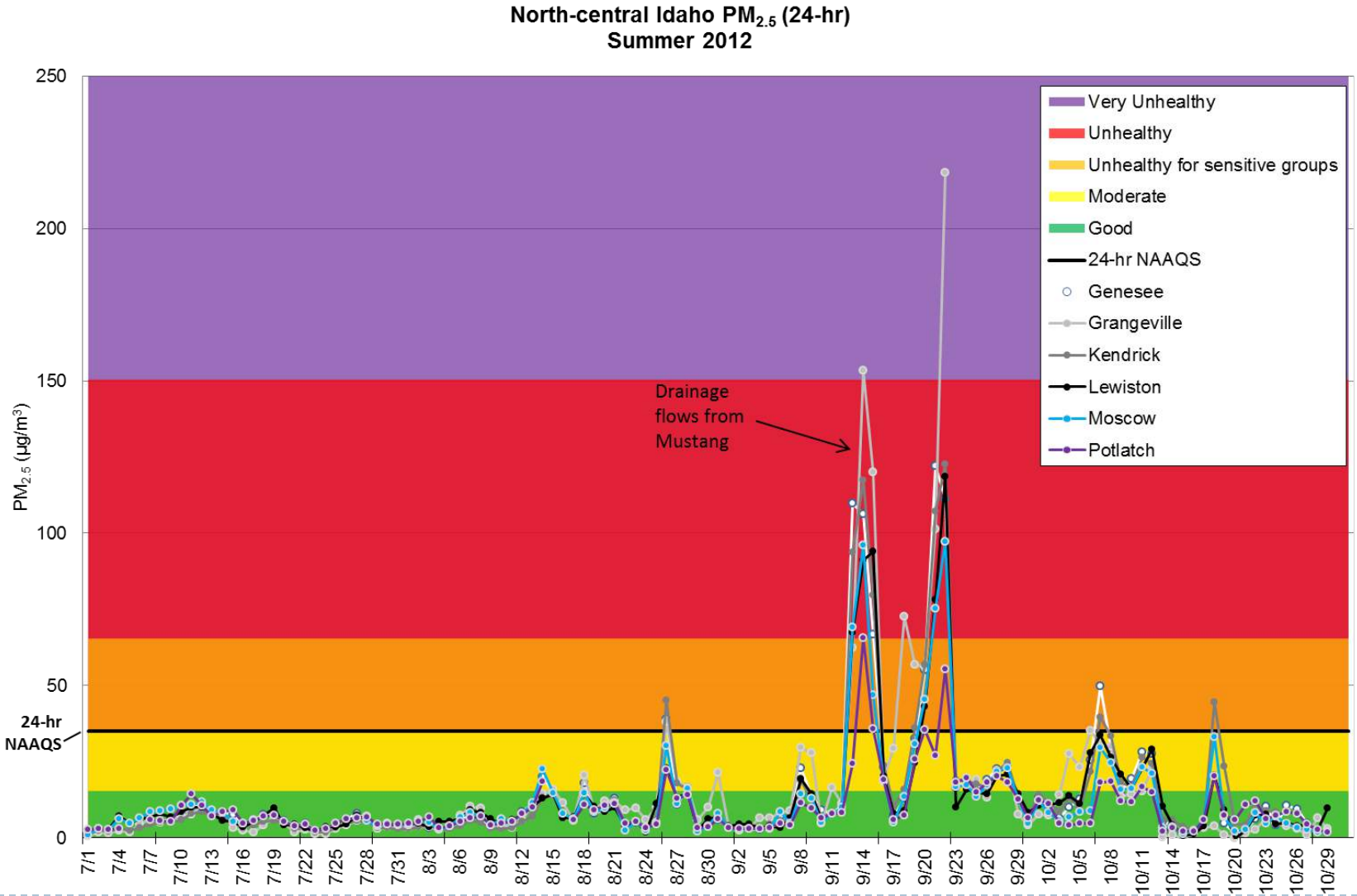


Central mountains – smoke behavior

- Hard hit
- Local drainage flows particularly dominant
- Halstead Fire
- Mustang Complex
- McGuire Complex
- Sheep Fire
- Wesley Fire

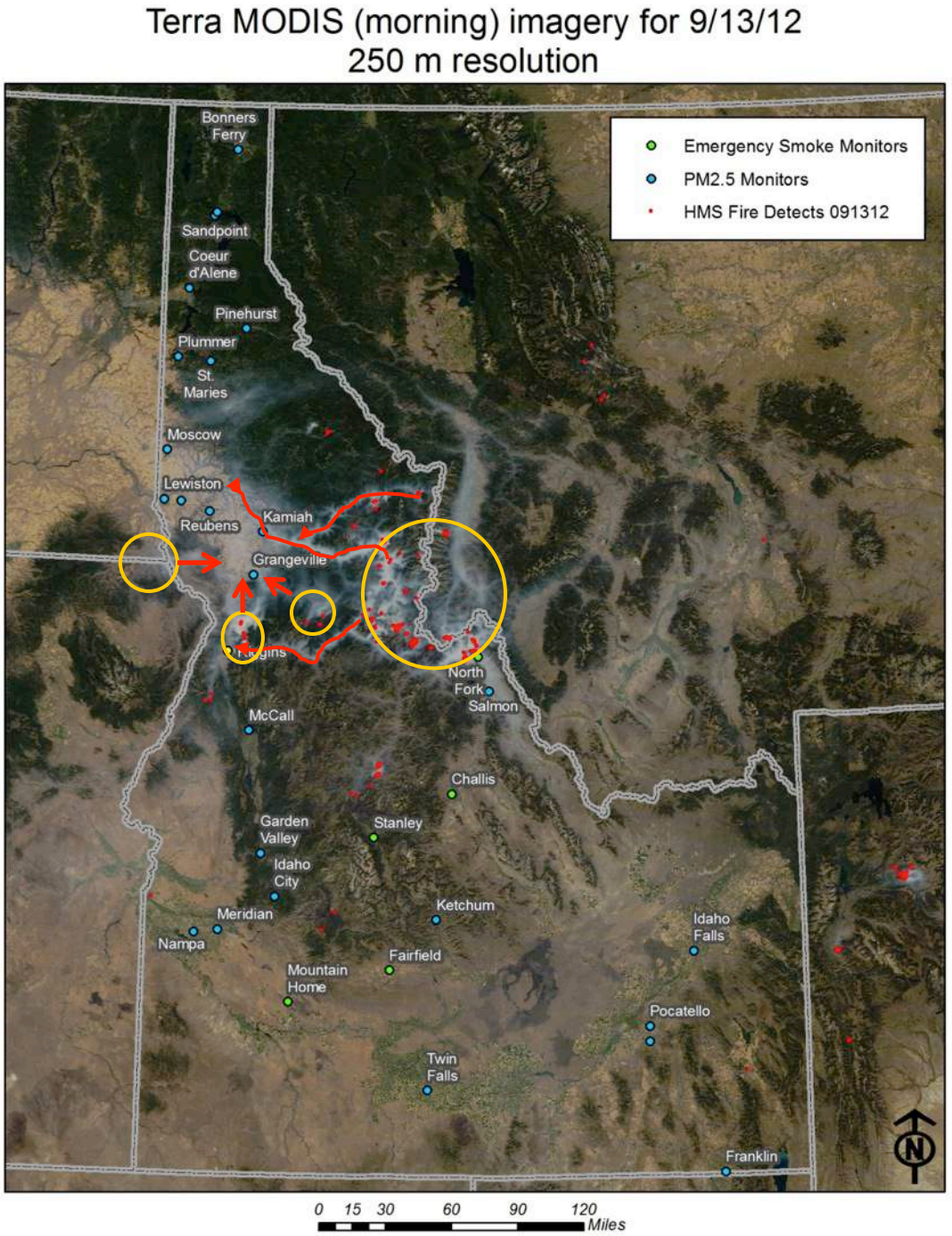


Northcentral Idaho – monitor data

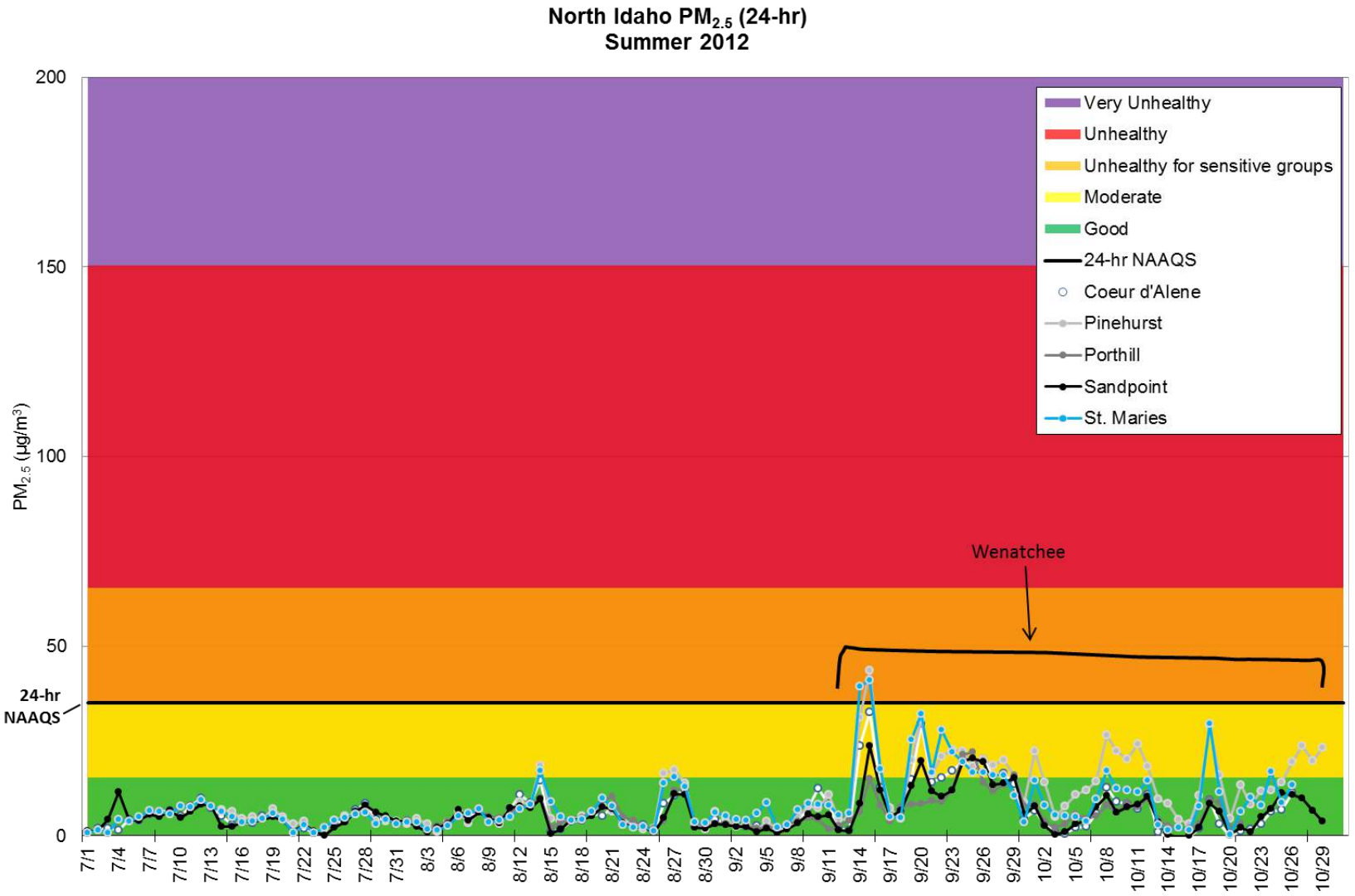


Northcentral Idaho – smoke behavior

- Drainage flows from Mustang and McGuire important sources.
- Mustang Complex
- McGuire Complex
- Cache Creek
- Wesley Fire

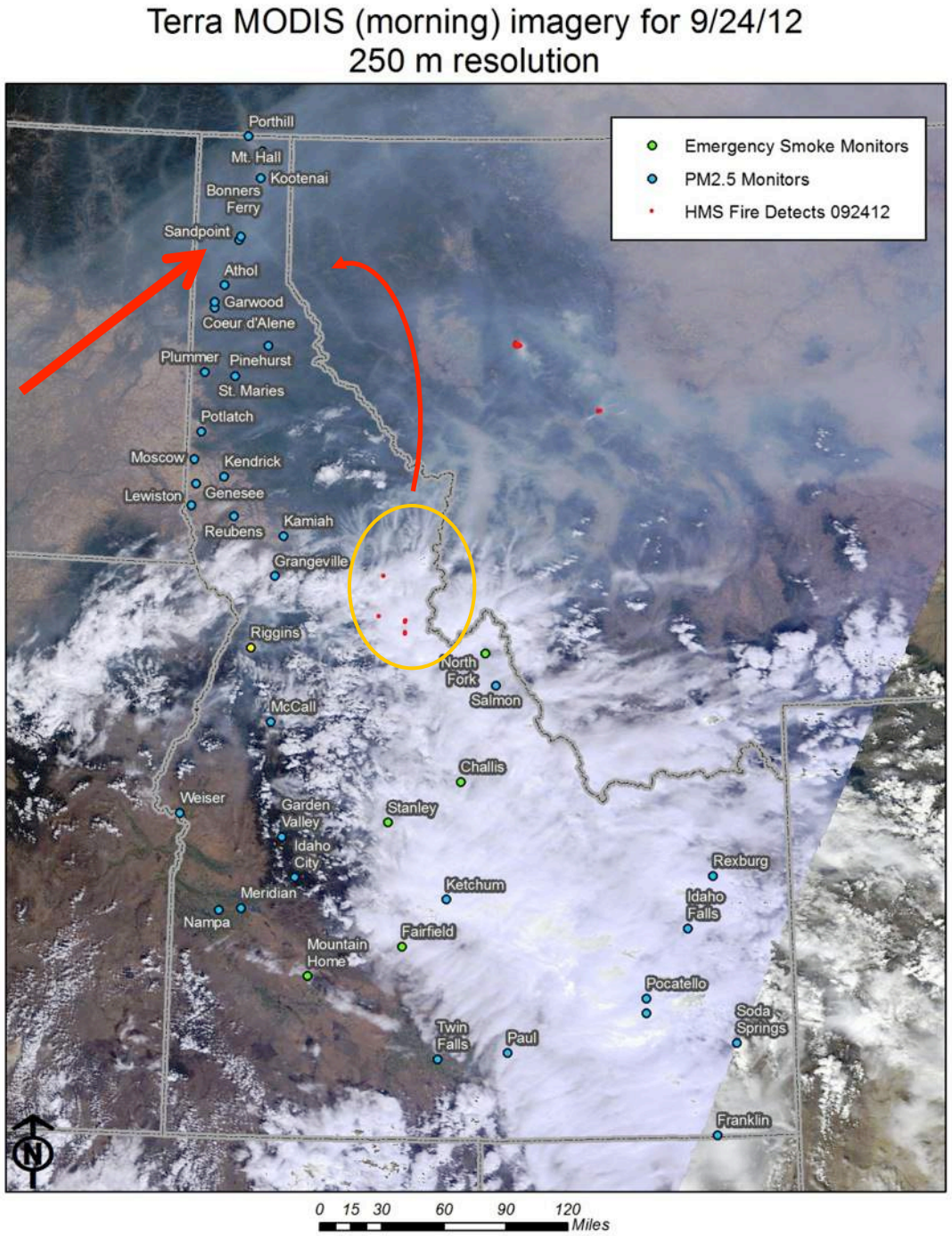


North Idaho – monitor data



North Idaho – smoke behavior

- Late season impacts
- Wenatchee Complex
- Mustang
- Canadian fires?

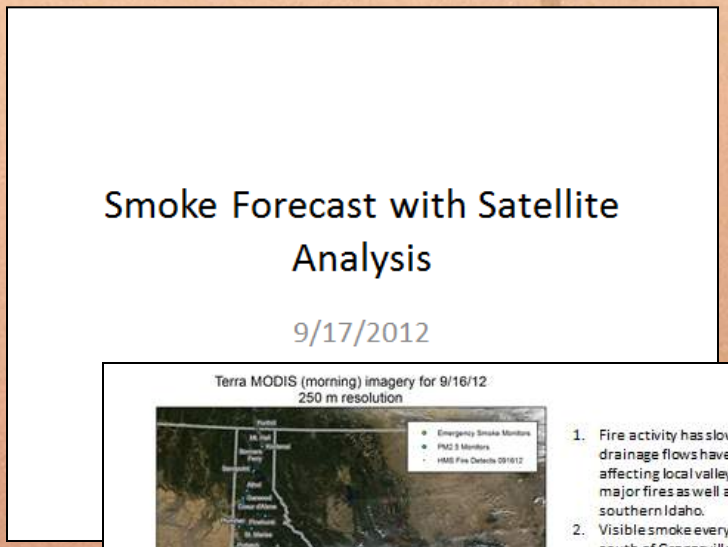


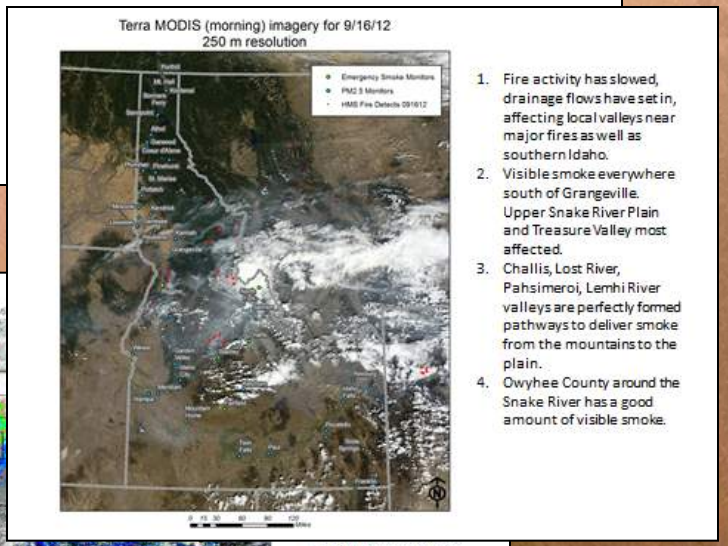
Part I: Summary

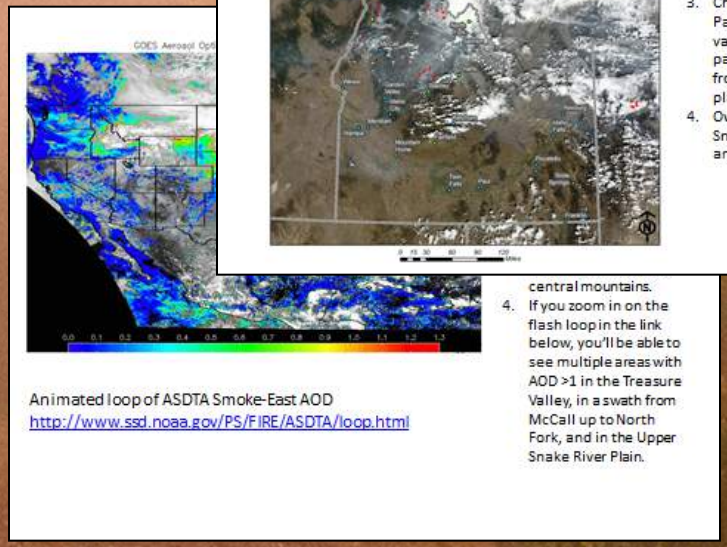
- All regions of Idaho were impacted by wildfire smoke during the summer of 2012.
- Central mountains saw the worst conditions, the Panhandle was the least impacted.
- Many regions received smoke from multiple quadrants and from both local and regional fires.
- Terrain-constrained drainage flows were important.

Part II: Tracking the Smoke - Techniques

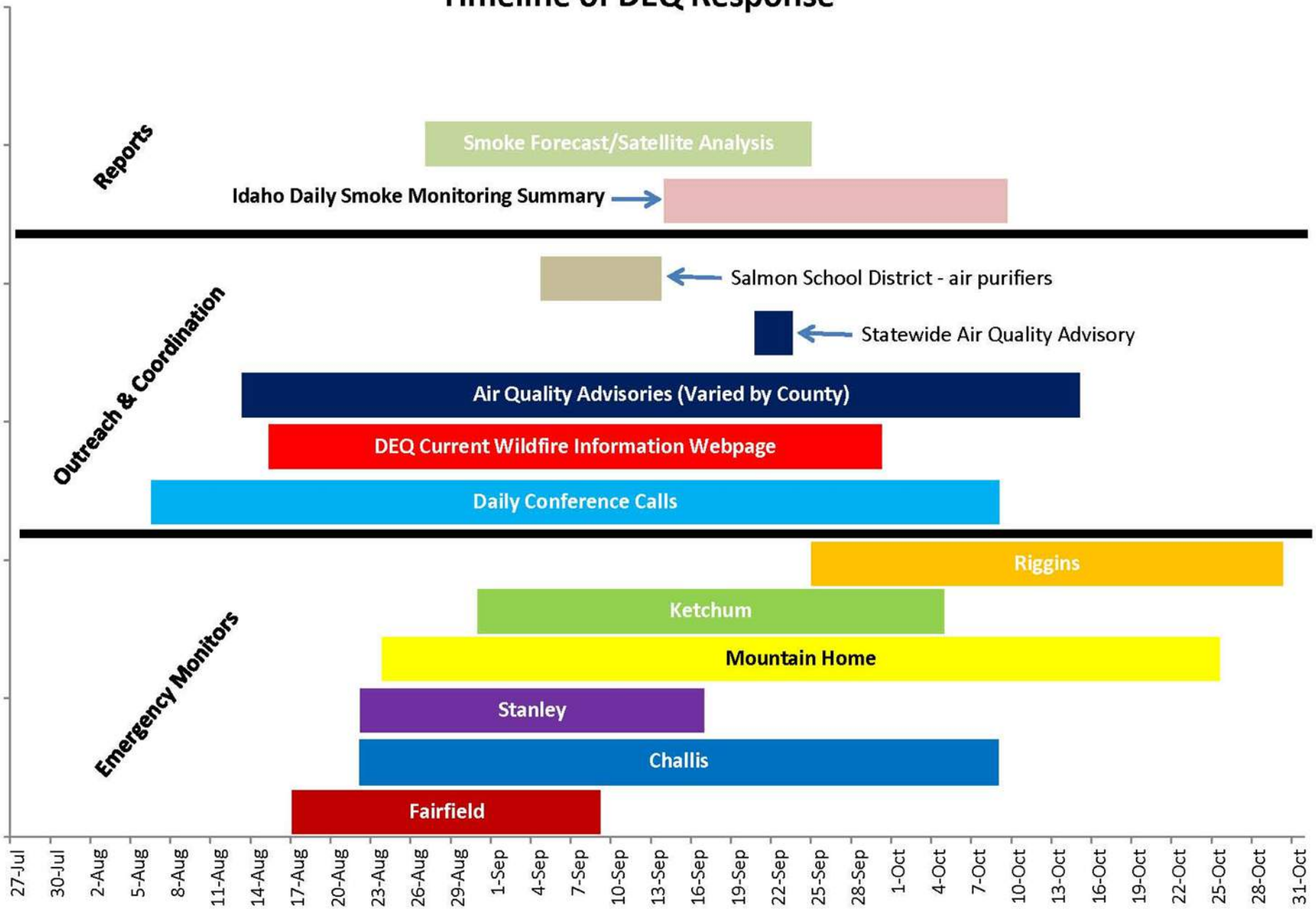
- Wildfire call
  - Forest Service reports
  - NWS weather forecasts
- Daily satellite reports
  - smoke behavior analysis
  - model forecast
  - distributed to DEQ air quality forecasters by 2 pm for decision support
- Additional Reports
  - monitor summary
  - HYSPLIT trajectories
  - BlueSky outputs
  - Stage 1 alert maps





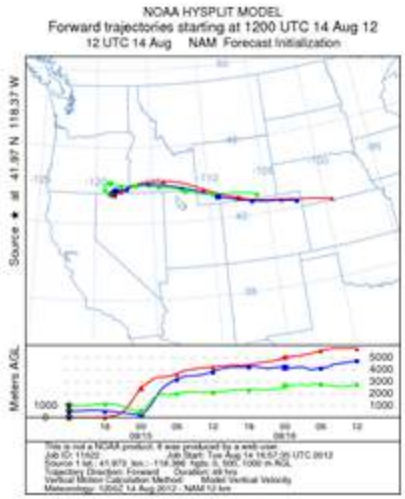


Timeline of DEQ Response



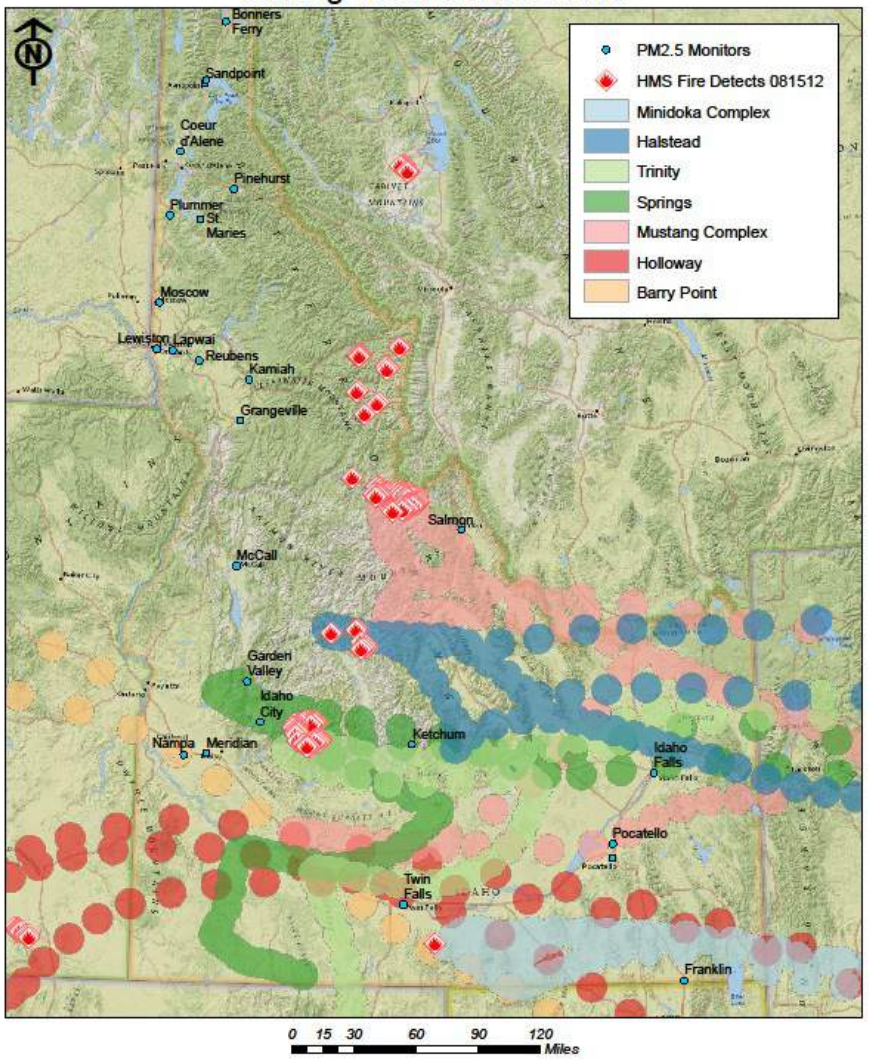
HYSPLIT Trajectories

Holloway (418,000 acres) - 48 hour forecast from 8/14/12 1200 UTC



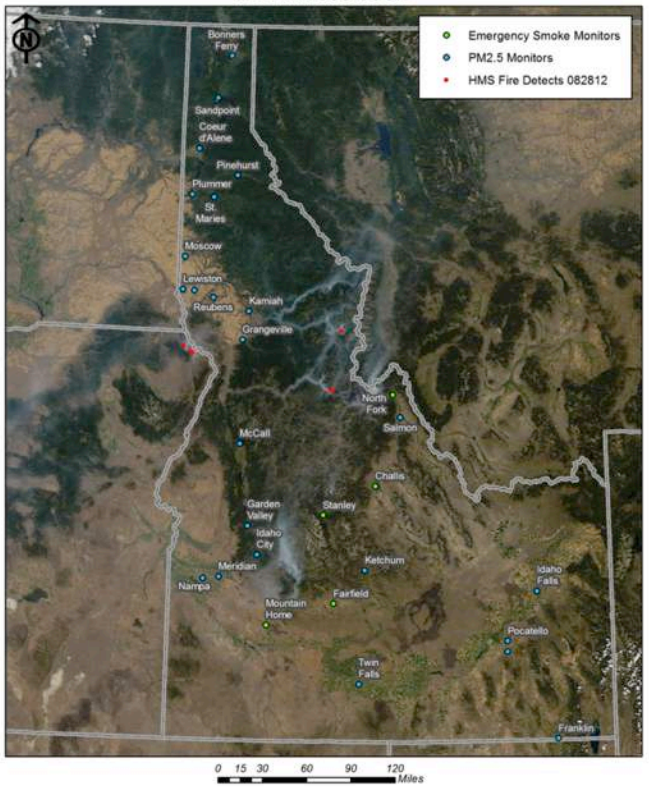
Boise surface, then lofting over Twin and Franklin

48-hour HYSPLIT forward trajectories from significant fires starting 12 UTC 08/15/2012



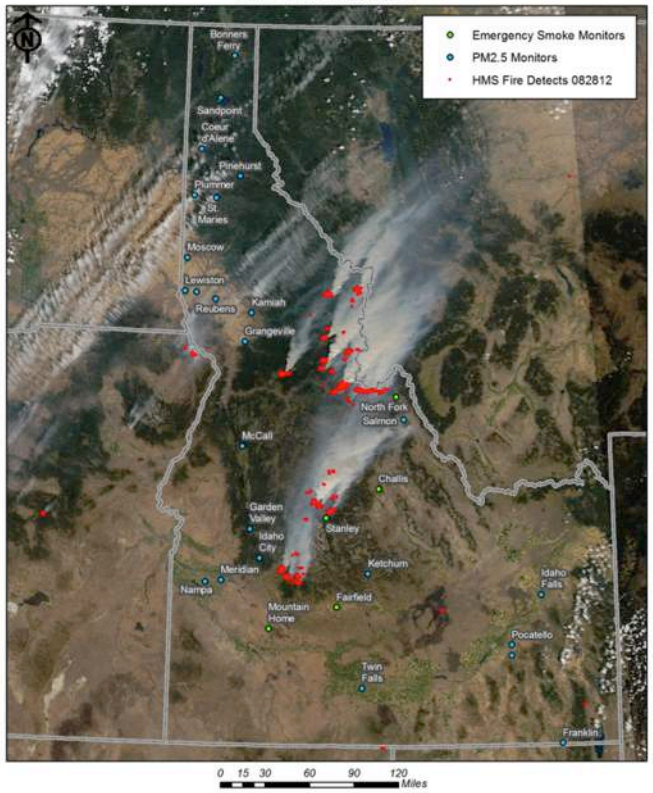
True Color (RGB) Imagery

Terra MODIS (morning) imagery for 8/28/12
250 m resolution



1. Spectacular drainage flows are visible in the region of the Mustang Complex.
2. Southeast Idaho is clear,

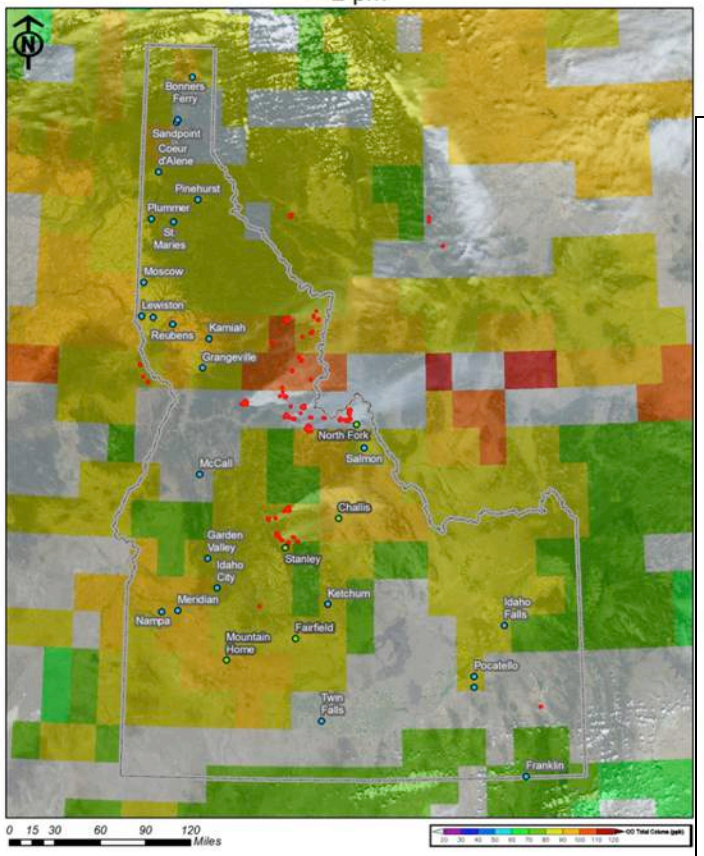
Aqua MODIS (afternoon) imagery for 8/28/12
250 m resolution



1. Extremely vigorous burning is evident in the afternoon imagery. The Mustang Complex now covers an enormous area and a new fire has sprung up north of the Salmon River (McGuire Complex).
2. Strong winds blow the the plumes to the NNW into Montana (from Mustang) and towards Salmon (from Halstead).
3. Mixed smoke and high cirrus are crossing the Panhandle, bringing smoke from the CA and central OR fires.

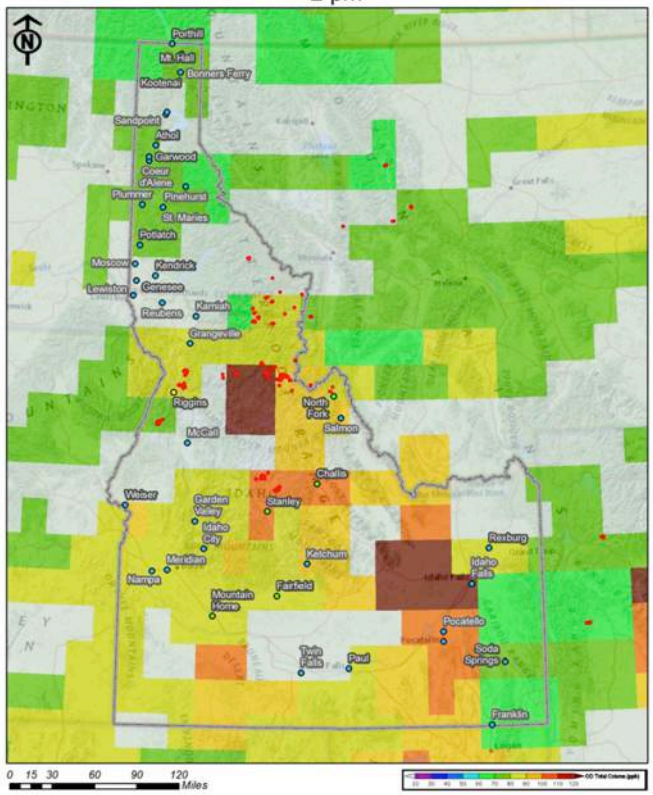
AIRS Carbon Monoxide (total column)

AIRS total column CO for 9/03/12
~ 2 pm



AIRS satellite total column CO:

AIRS total column CO for 9/17/12
~ 2 pm

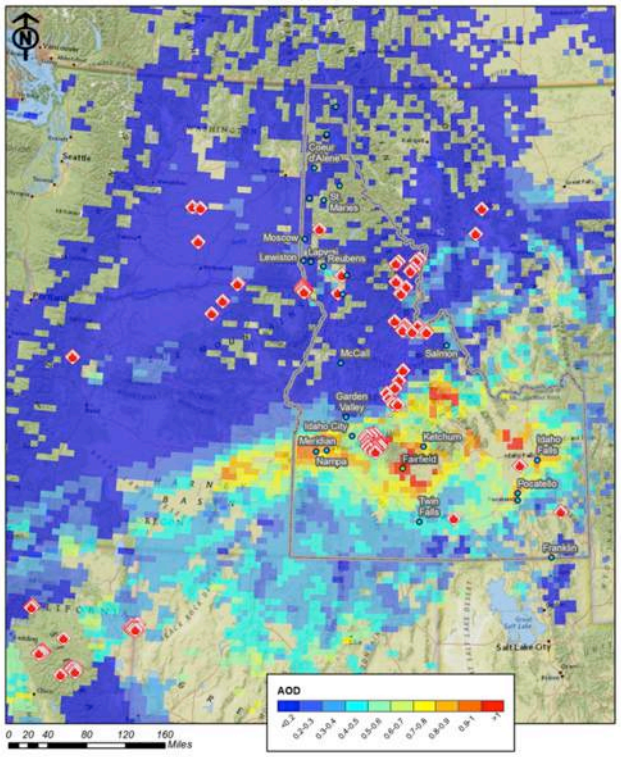


AIRS satellite total column CO:

- CO values are better than yesterday, but the southern tier of the state still registers significant values.
- The two patches of 120 ppb total column CO typify two dynamics that have been occurring during these stable weather patterns.
- The first, between Riggins and North Fork, picks up an area where smoke production is high (McGuire Complex) and the plume is hanging out in the local area.
- The second, at the base of the valleys that connect Salmon and Challis to the Snake River Plain, identifies a region of transport, where the smoke from the north has drained through the topography to the south.

AIRS Aerosol Optical Depth (total column)

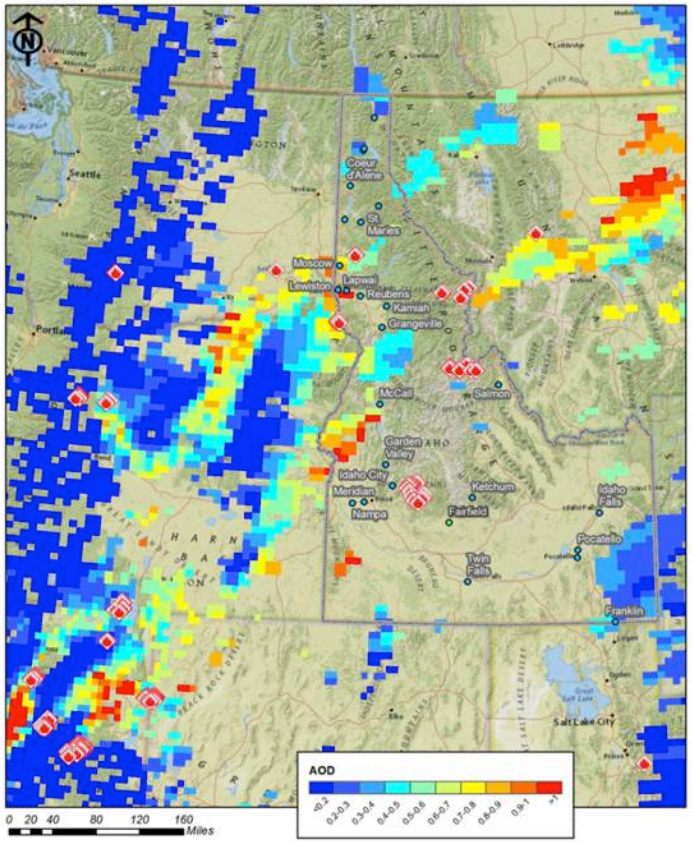
Aqua AOD (aerosol optical depth, total column) for 8/22/12 afternoon



Aerosol Optical Depth

- This image quantifies the aerosol on the previous slide. AOD is a measurement that defines the amount of light extinction from aerosol scattering in the total

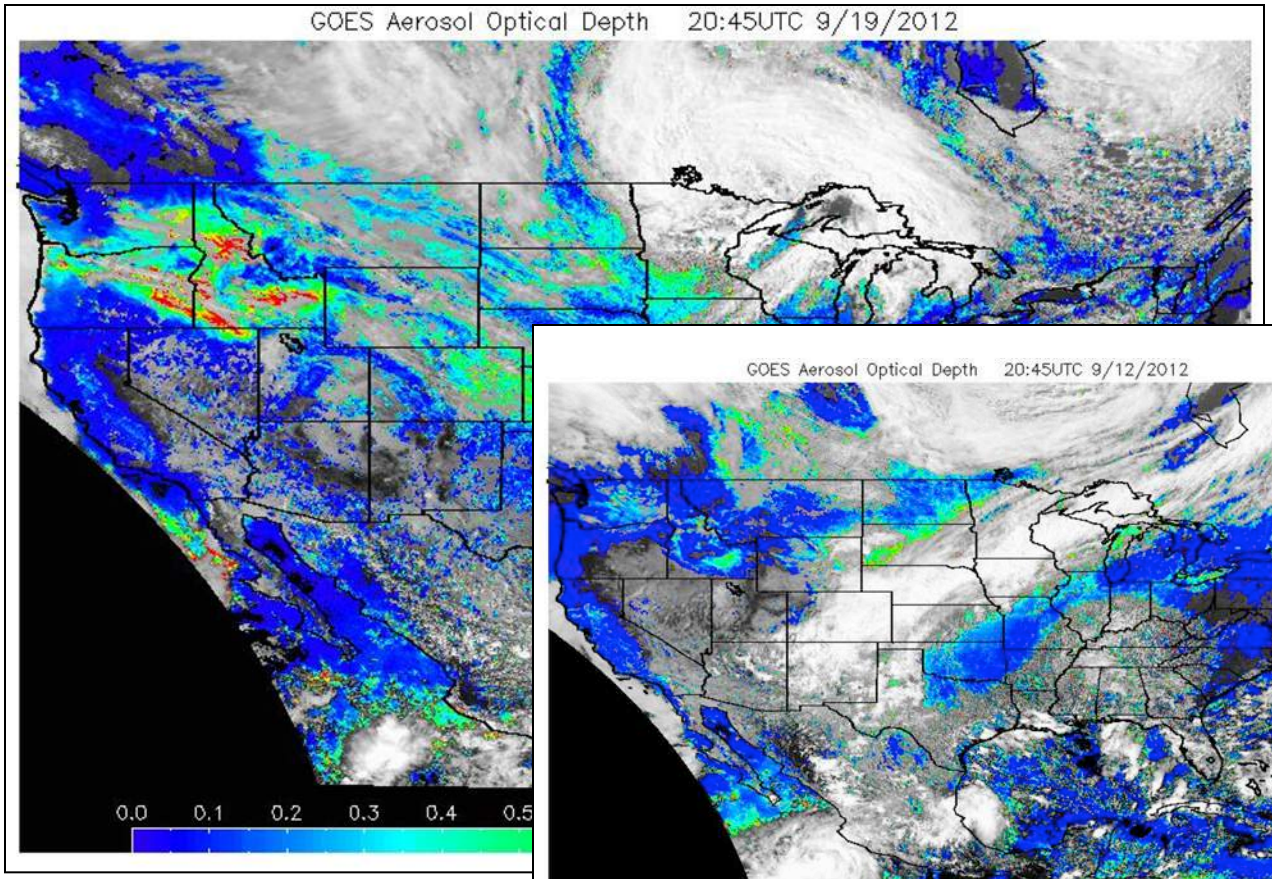
Aqua AOD (aerosol optical depth, total column) for 8/21/12 afternoon



Aerosol Optical Depth

- This image quantifies the aerosol on the previous slide. AOD is a measurement that defines the amount of light extinction from aerosol scattering in the total atmospheric column.
- Blue pixels indicate typical background levels while yellow, orange, and red indicate increasing amounts of aerosol. Anything above 1 is considered very polluted.
- Areas that show no pixels are no data: either obscured by cloud or values below detection.
- The spatial patterns of high AOD in this map are similar to those captured by the AIRS CO sensor (see slide 8), yet are more highly resolved.
- Use this map in conjunction with the true-color image to more adequately determine areas of smoke vs. cloud.

GOES AOD (ASDTA Smoke – East AOD)

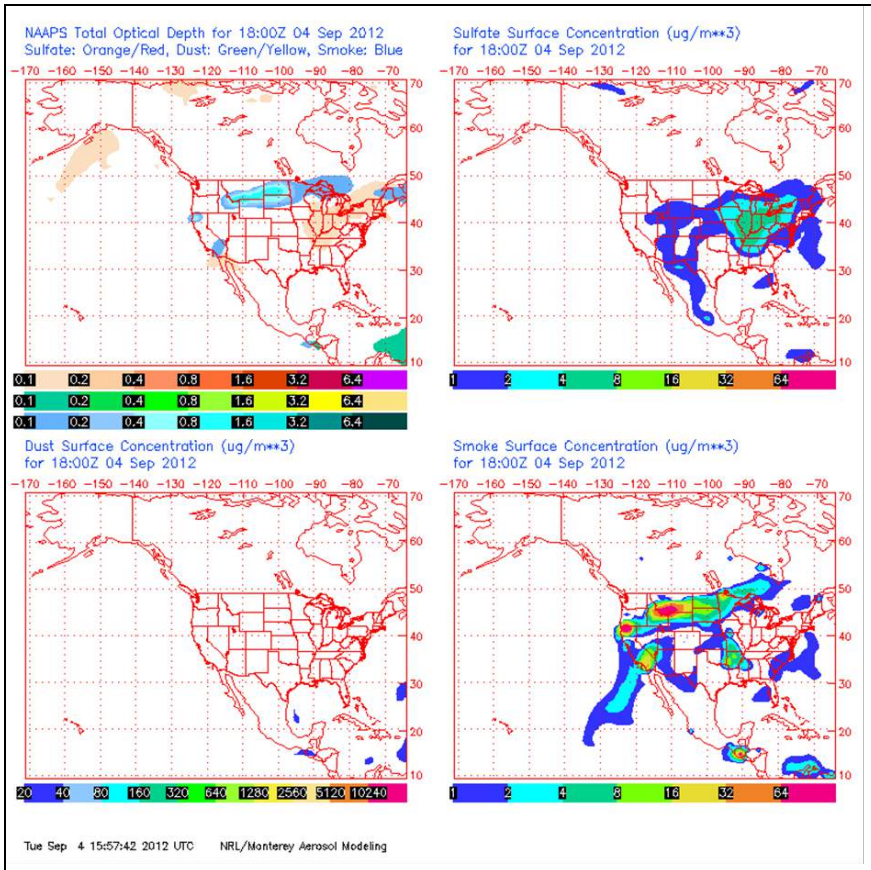


Animated loop of ASDTA Smoke-East AOD
http://www.ssd.noaa.gov/PS/FIRE/ASDTA/loop.html

ASDTA (Automated Smoke Detection and Tracking Algorithm) Smoke-East AOD

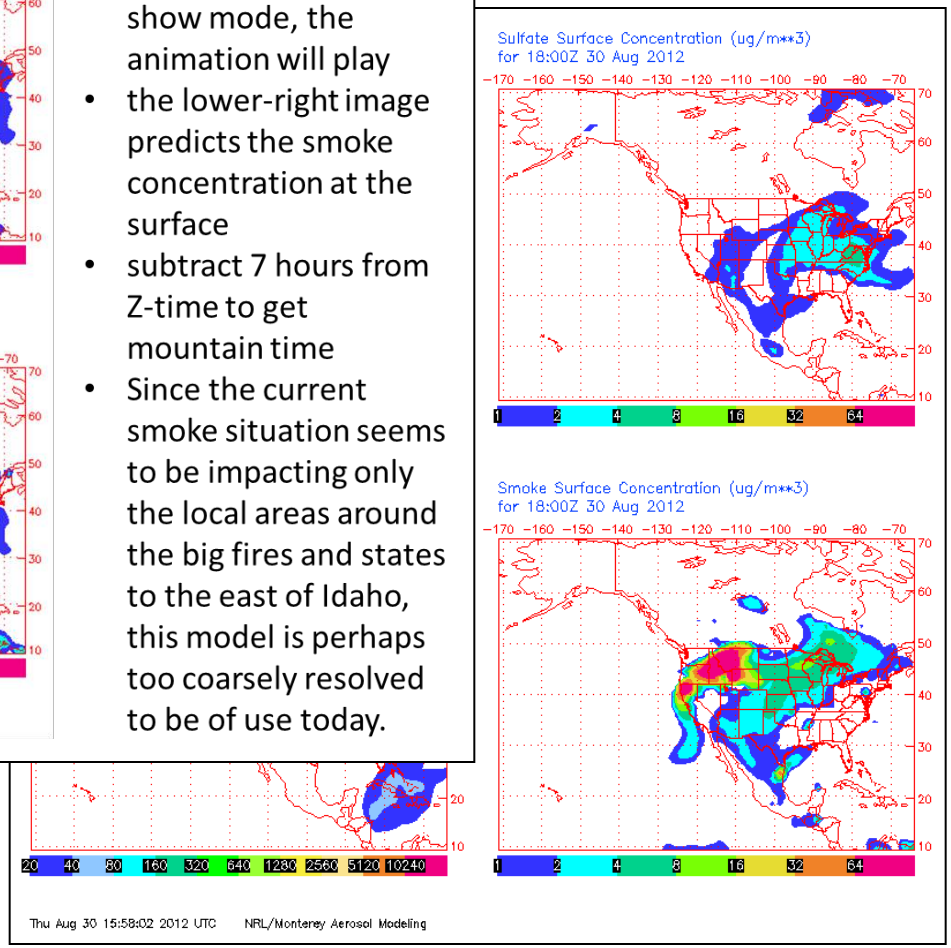
1. This image was taken at about the same time as the MODIS true color image in the first slide.
2. Total column AOD really picked up the patch of smoke in the Upper Snake River Plain (up to 0.6) and the smoke traveling south from the Sheep/Wesley fires in the southwest.
3. At least one pixel in the Mustang Complex achieves 1.2, a very high value on the AOD index.

NAAPS NRL Aerosol Forecast Model

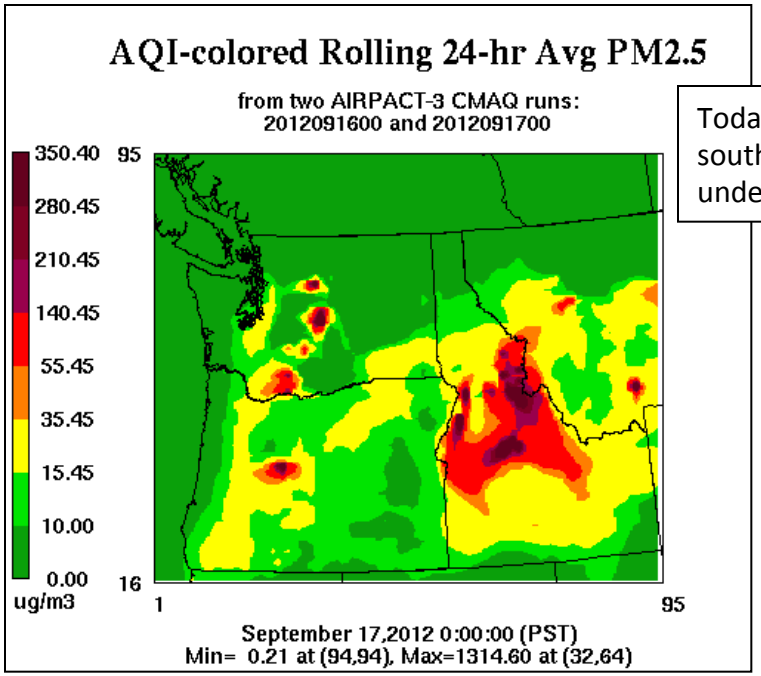


NRL Aerosol Forecast:

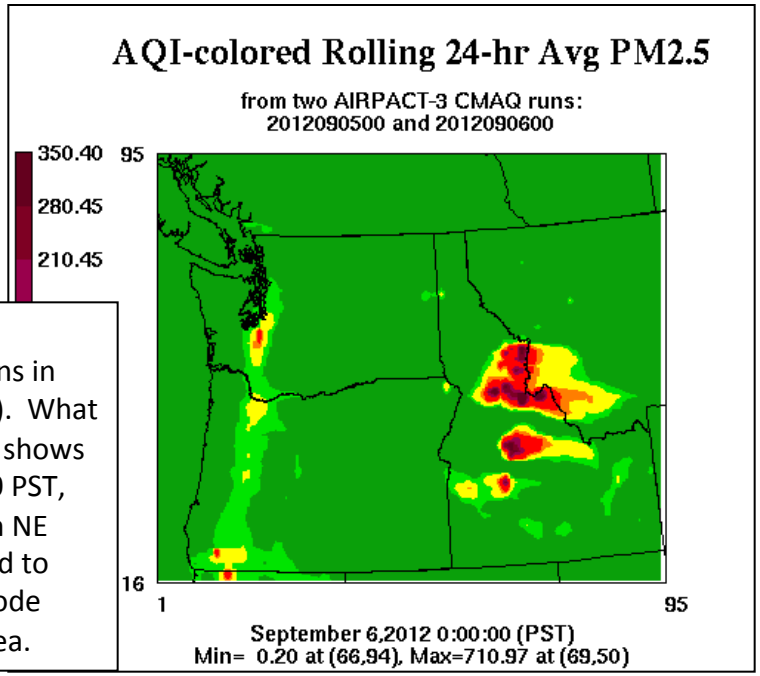
- if you run this in slide show mode, the animation will play
- the lower-right image predicts the smoke concentration at the surface
- subtract 7 hours from Z-time to get mountain time
- Since the current smoke situation seems to be impacting only the local areas around the big fires and states to the east of Idaho, this model is perhaps too coarsely resolved to be of use today.



AIRPACT-3 with wildfire emissions

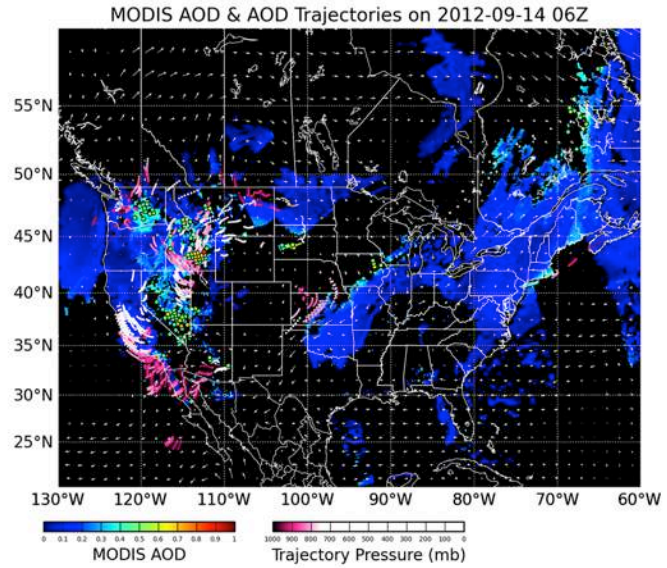


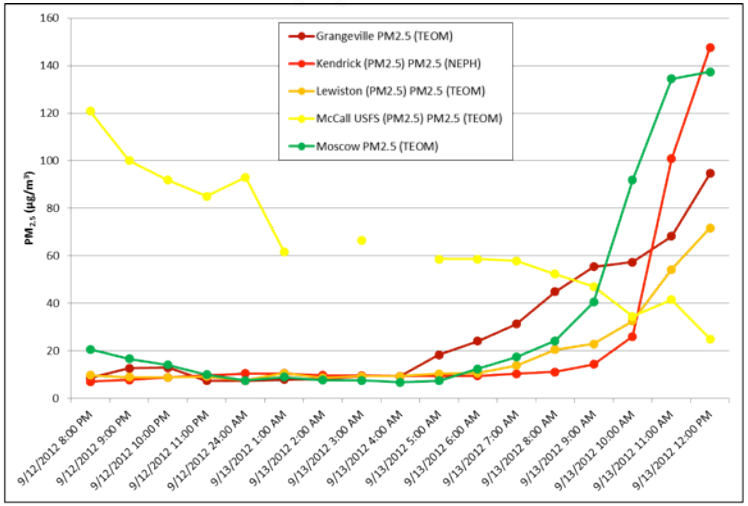
Today's model captures the smoke drift into southern Idaho and the general stagnation under high pressure.



AIRPACT is working out their emissions problems somewhat, though the emissions in Boise and at Trinity are suspect (too high). What is interesting about this forecast is that it shows the plumes blowing east until about 2300 PST, then the wind switches to northerly, then NE and the plumes subsequently swing round to the south and southwest. This doesn't bode well for Valley County or the Lewiston area.

IDEA



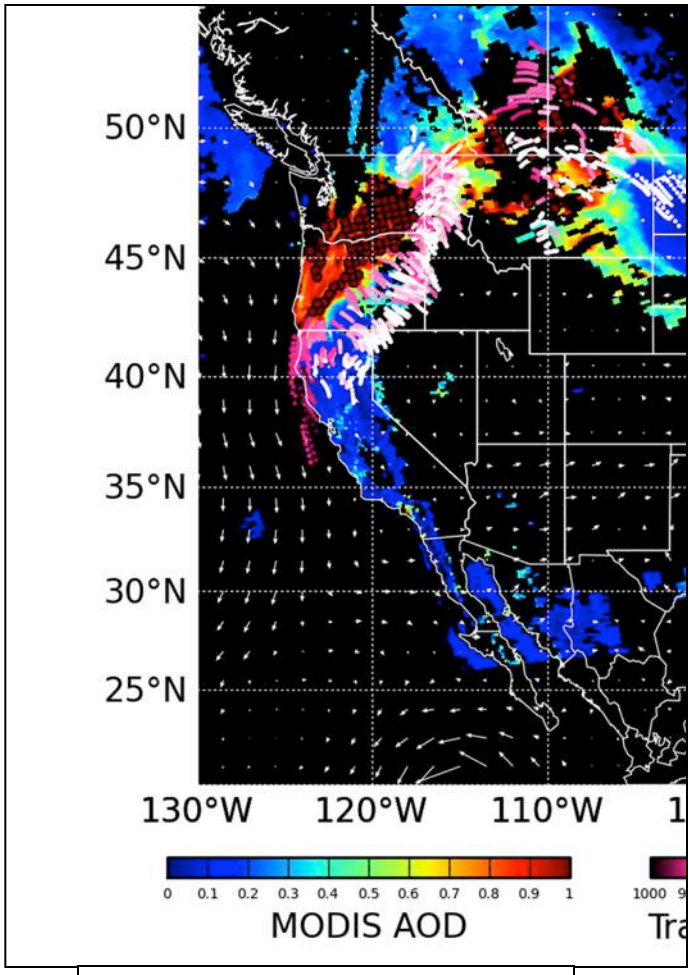


IDEA Model

http://cimss.ssec.wisc.edu/imapp/idea-i/aqua/index.php?action=view_product

Click on the link for the full animation.

- Very interesting IDEA run today. The model initializes on high AOD from yesterday afternoon's Aqua overpass in the Upper Snake River Plain, at Riggins, in the Treasure Valley, and from Challis north all the way through the Mustang Complex. The first hours show surface trajectories travelling south, then, at about 14Z on the 13th (7 am), the winds come around and the trajectories travel northwest.
- So last night, McCall, Weiser, Treasure Valley received smoke from the north, while after this morning the area will be receiving the remnants of the smoke that occupied the Upper Snake River Plain yesterday. Fires on the east side of the state will be sending smoke off to Montana again.



NW Regional domain

Monitor data illustrating the early morning wind shift. At 5 am, monitors north of the main fires start to rise (Grangeville, Kendrick, Lewiston, Moscow), while McCall, to the south, continues to drop.

Part II: Smoke Tracking Summary

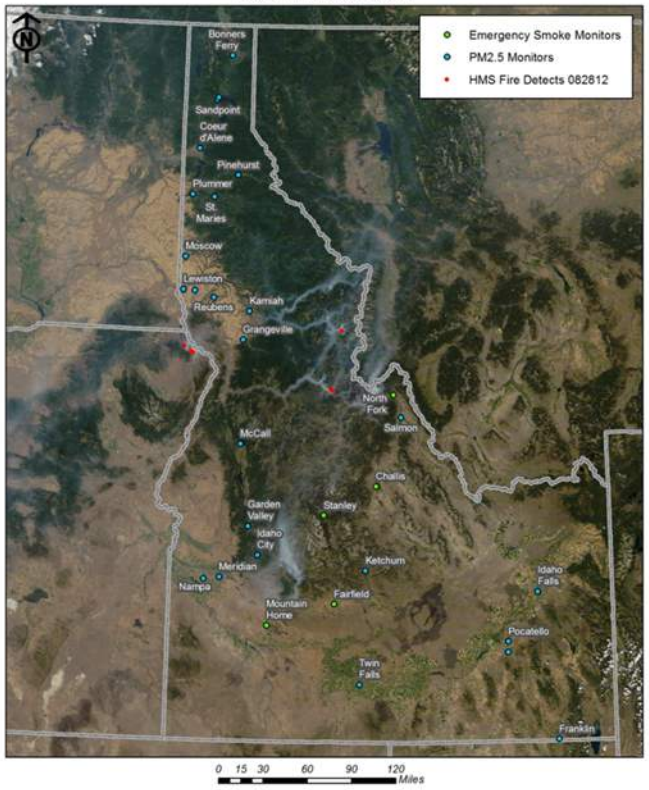
- Daily satellite reports provided technical support to regional air quality forecasters
- Satellite data were placed in context with geographical data in a GIS format
- Smoke behavior described and visualized with true color imagery
- Smoke thickness quantified (in a relative sense) by AOD and CO products
- A variety of models forecast future smoke movement

Part III: Insights on Smoke Behavior in Idaho

- Diurnal drainage/synoptic flow patterns became clear after continued observation
- Monitor network not necessarily designed to capture impacts of wildfire smoke
- Insights from 2012 season will help us with future air quality forecasting

Insights on Smoke Behavior in Idaho

Terra MODIS (morning) imagery for 8/28/12
250 m resolution



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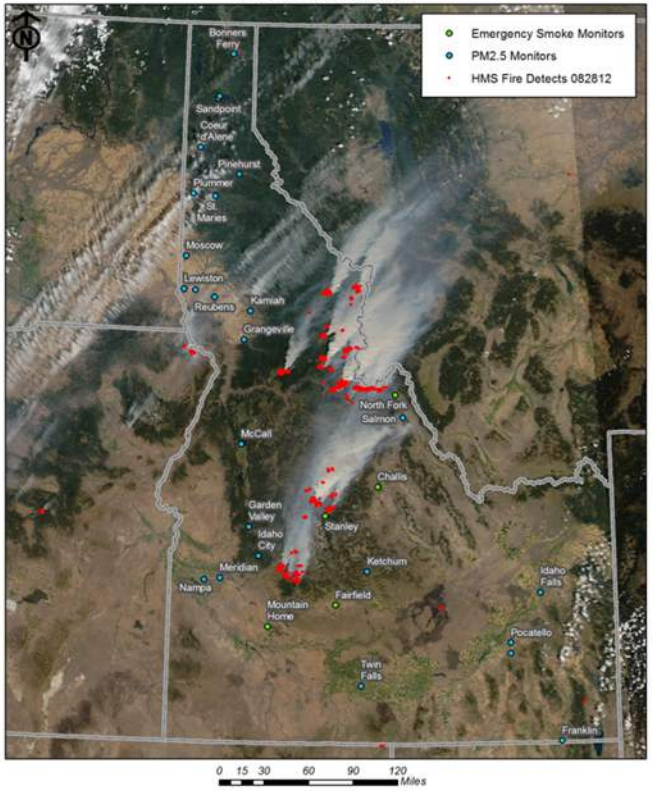

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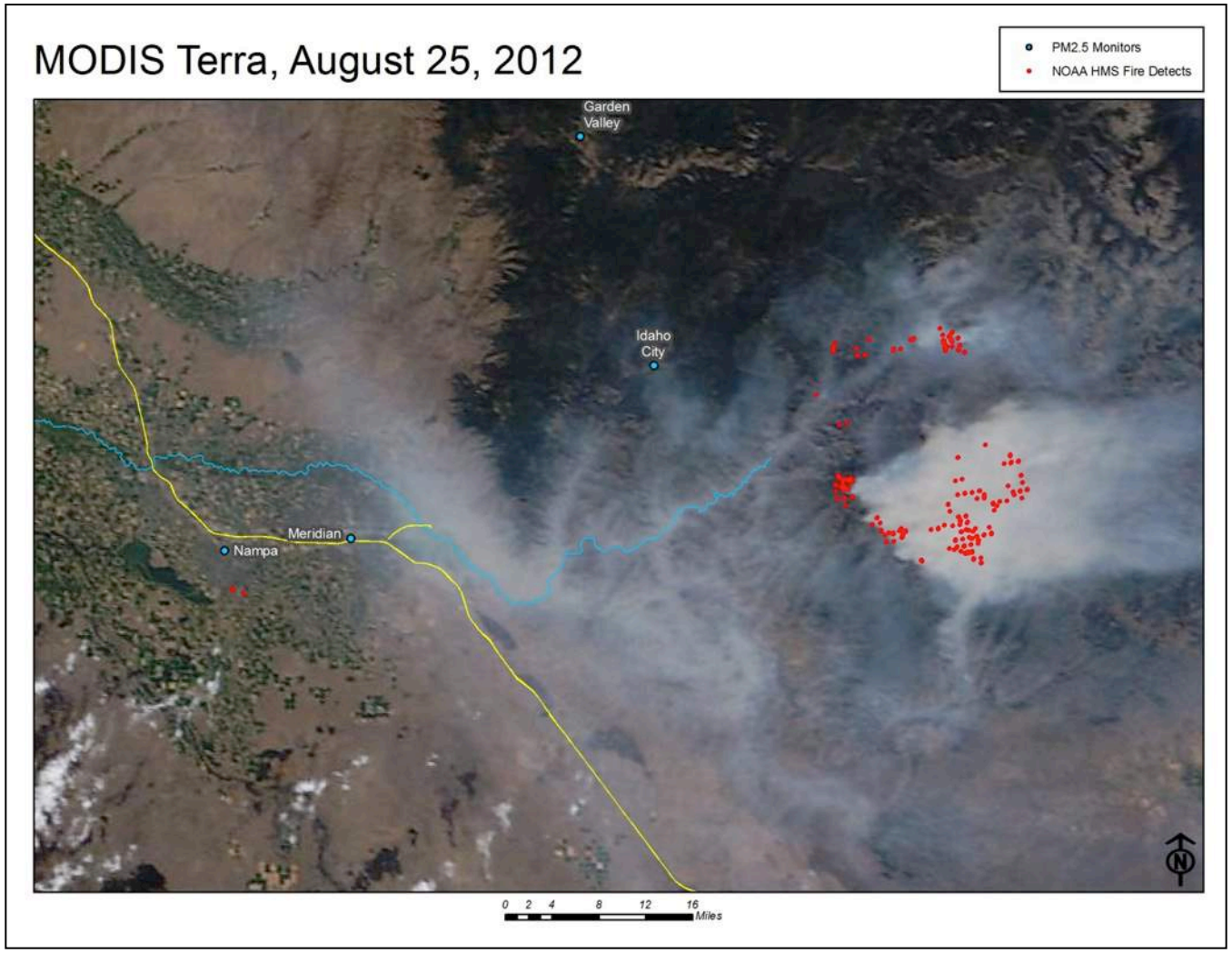
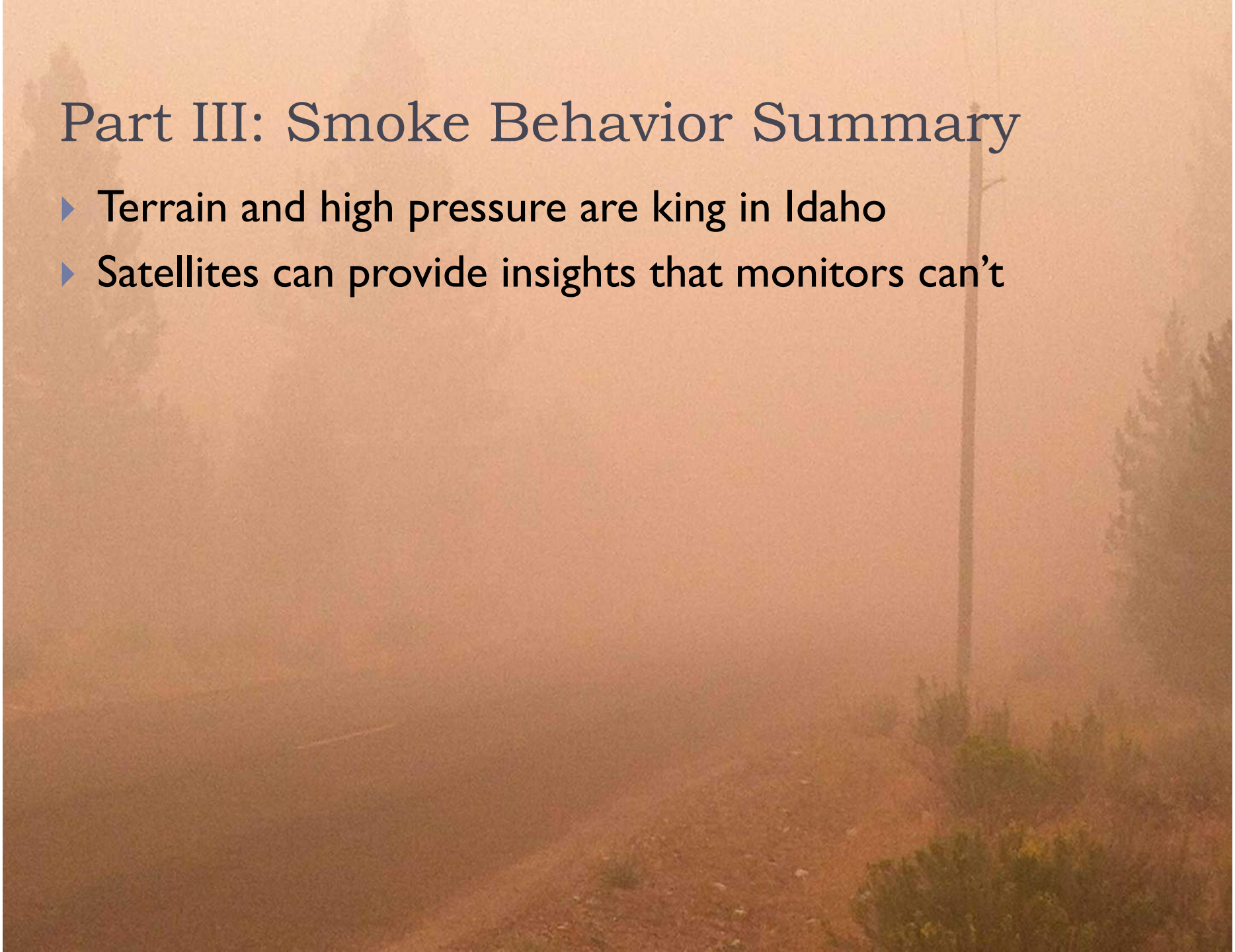
Insights on Smoke Behavior in Idaho



Part III: Smoke Behavior Summary

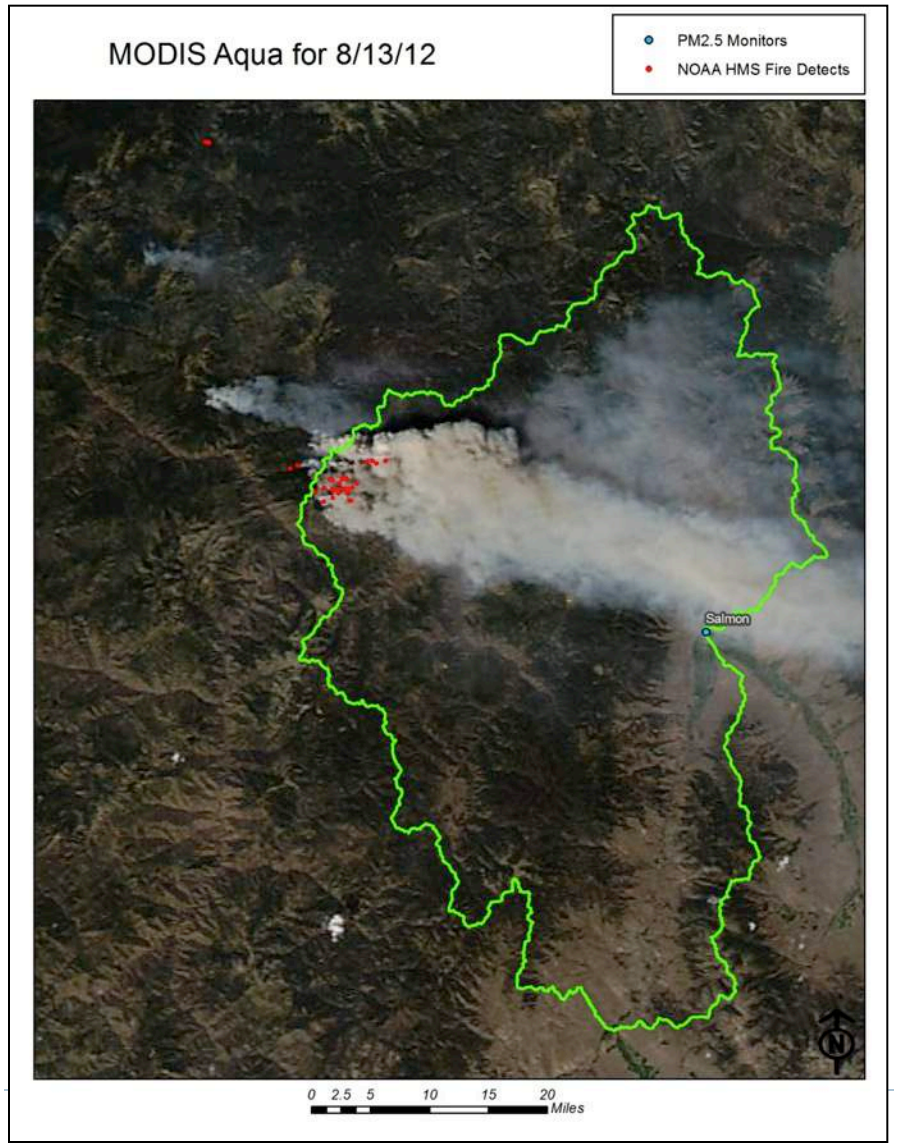
- Terrain and high pressure are king in Idaho
- Satellites can provide insights that monitors can't

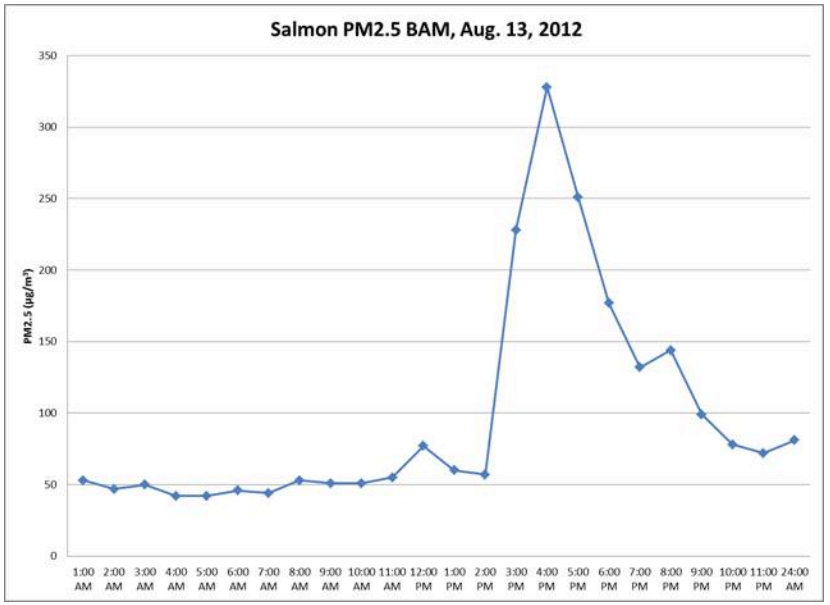


Part IV: Leveraging Operational Reports for EE Analysis

- Much of the data required for EE wildfire analysis has already been collected, interpreted, and archived in the daily reports
- Observations and insights made during the wildfire season can be combined into a conceptual model

Leveraging Operational Reports for EE Analysis





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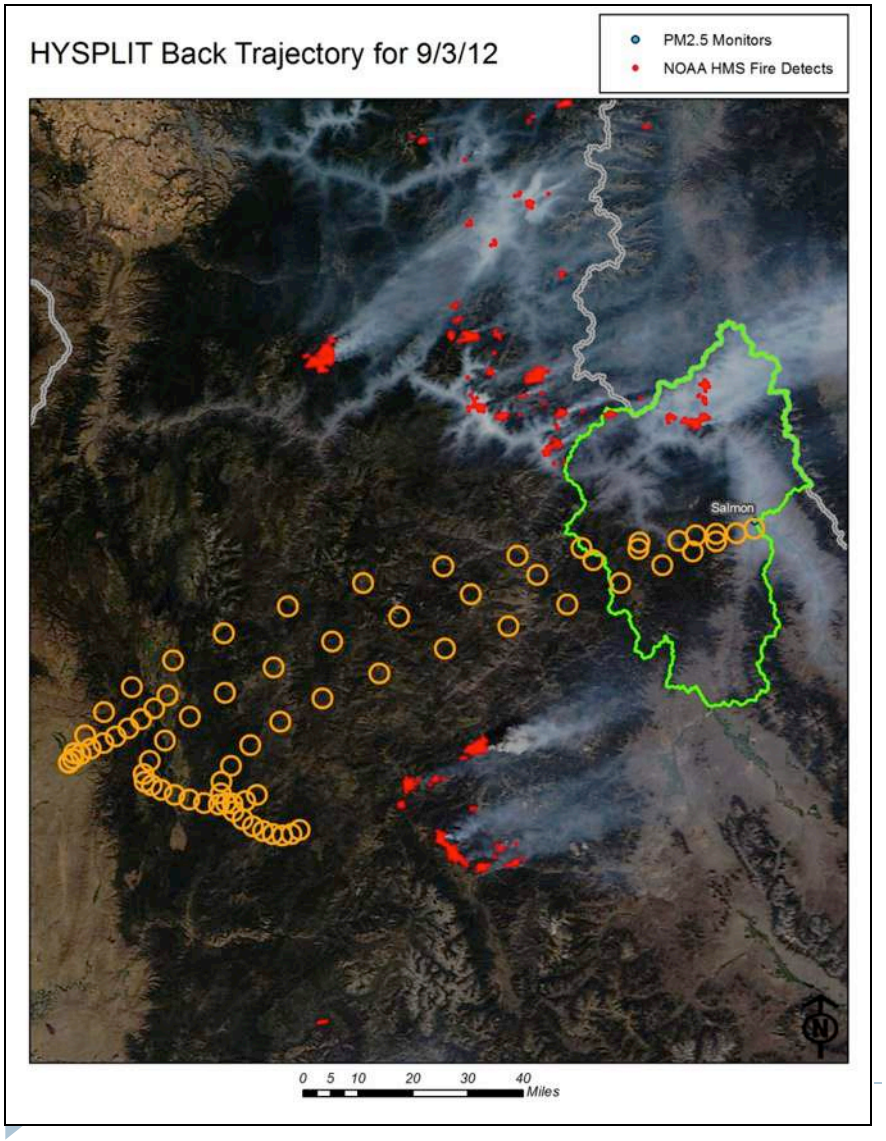

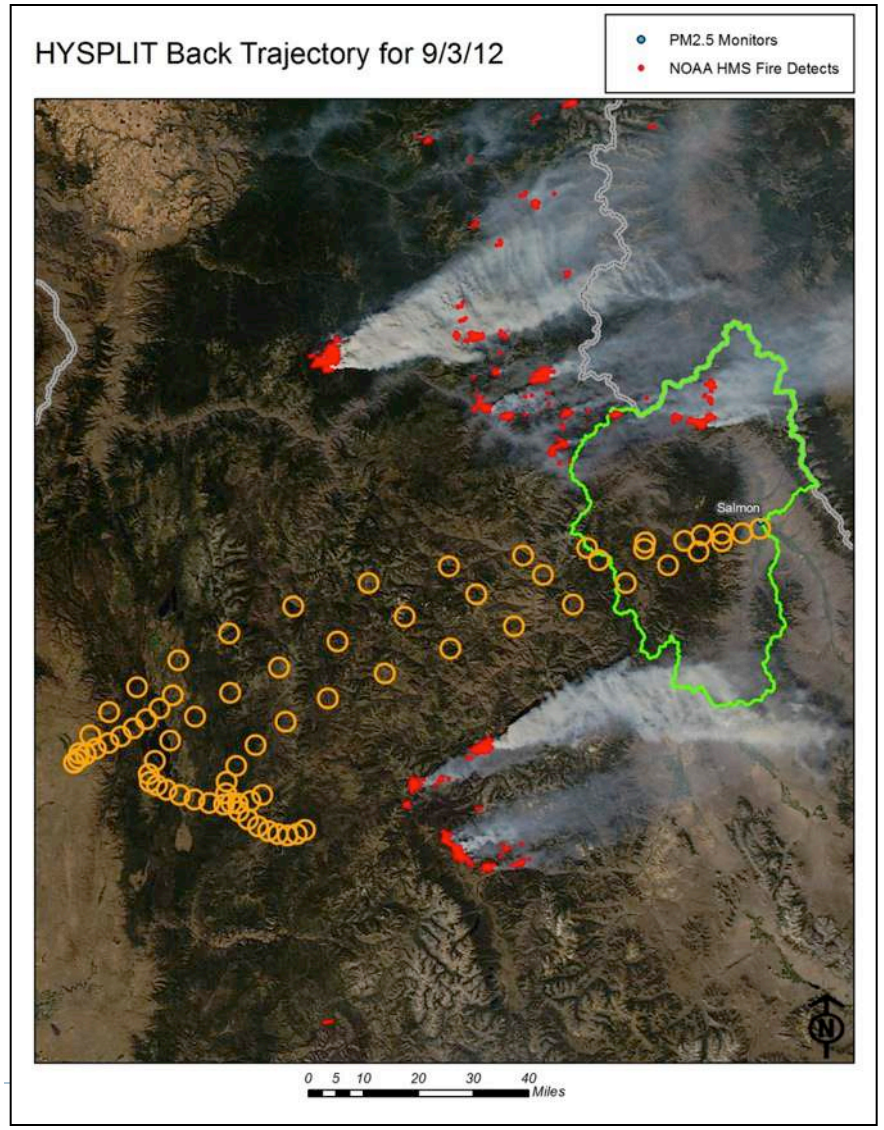

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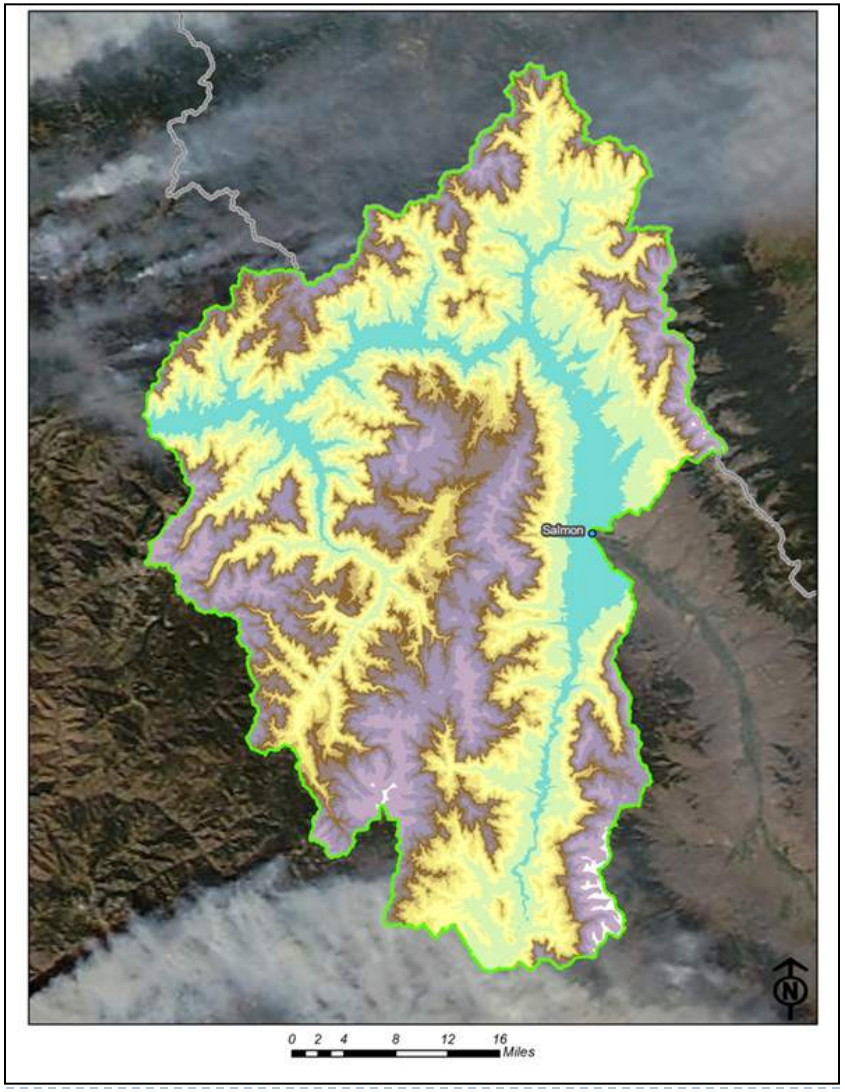

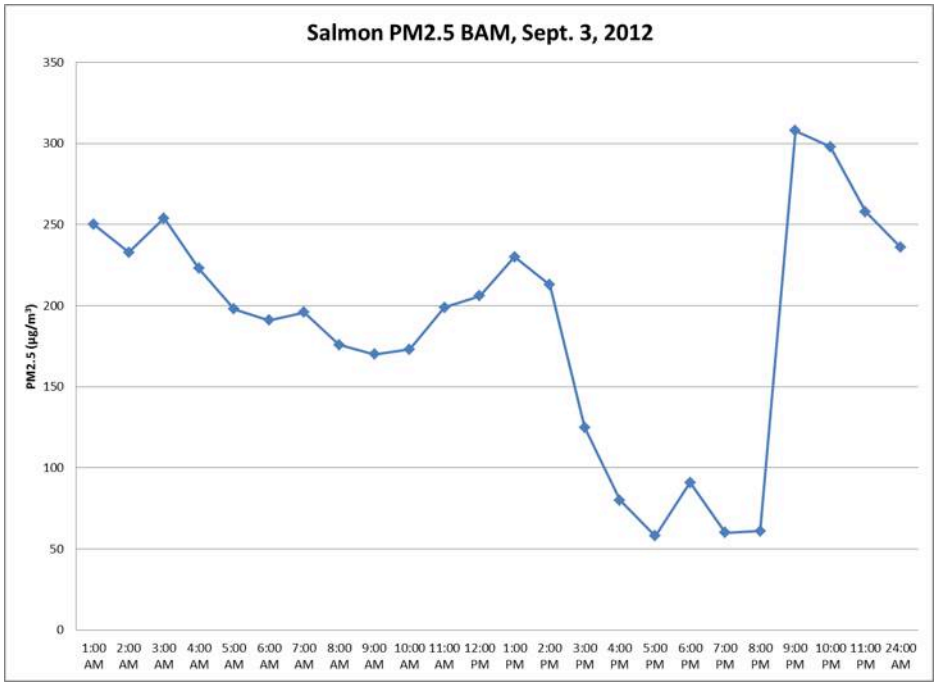

Part IV: EE Summary

- It's going to be a big job, but some of the work has already been done.
  - data compilation
  - conceptual model

Conclusions

- 2012 was a big fire year
- Satellite data + GIS = value-added informational products to support AQ forecasting
- Smoke movement under high pressure conditions is terrain-dependent
- Data gathered and products created during operational phase can be re-used for EE documentation phase