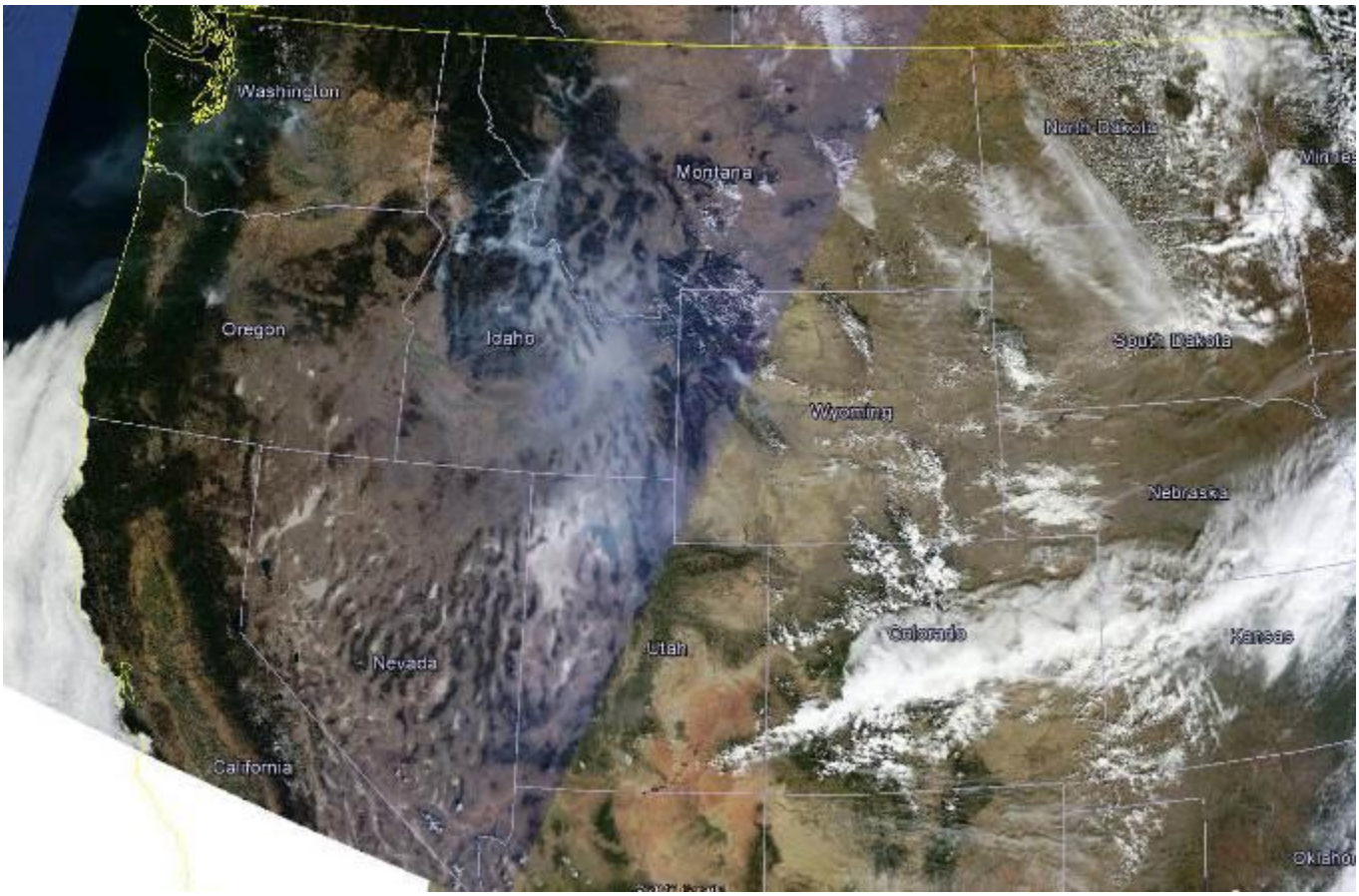
Utah Division of Air Quality



September 17, 2012 Western Wildfire Smoke

Exceptional Events – $PM_{2.5}$ from Wildfire

Logan Monitoring Station – September 18 and 21, 2012
Ogden Monitoring Station – September 17, 2012

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Introduction

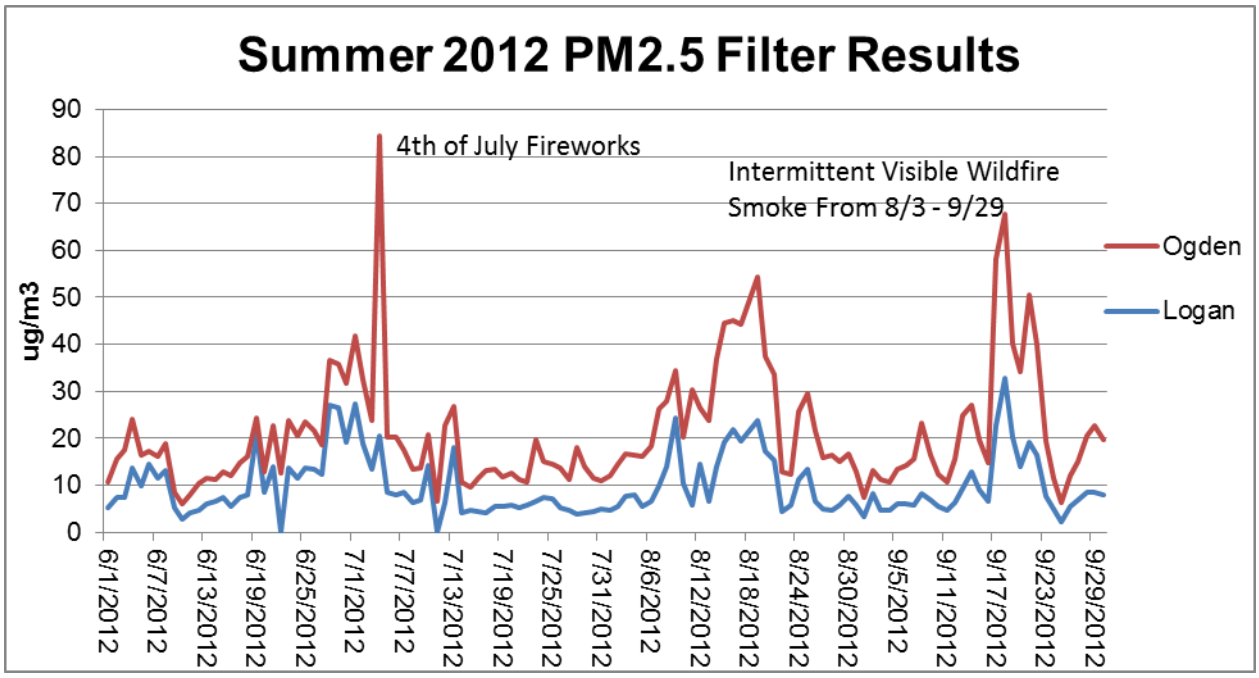
The Code of Federal Regulations (CFR) provides the definition and criteria for determining whether air quality data is impacted by an exceptional event. The 40 CFR 50.1(j) definition states that "exceptional event means an event that affects air quality, is not reasonably controllable or preventable, is an event caused by human activity that is unlikely to recur at a particular location or a natural event, and is determined by the Administrator in accordance with 40 CFR 50.14 to be an exceptional event." The demonstration to justify data exclusion as outlined in 40 CFR 50.14(c)(3)(iv-v) specifies that evidence must be provided that:

1. The event meets the definition of an exceptional event;
2. The event is associated with a measured concentration in excess of normal historical fluctuations, including background;
3. There is a clear causal relationship between the measurements under consideration and the event that is claimed to have affected air quality in the area;
4. There would have been no exceedance or violation but for the event; and
5. The demonstration must include a public comment process and documentation of such to the Environmental Protection Agency (EPA).

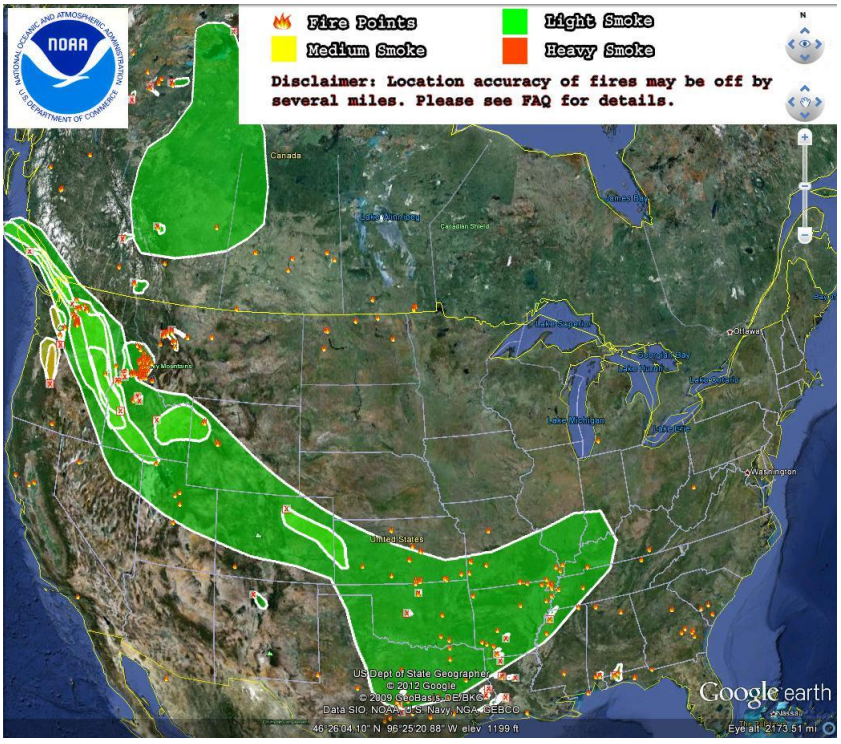
This report provides documentation that the $PM_{2.5}$ violations that occurred on September 17, 18, and 21, 2012 were the result of exceptional events and that these events meet the criteria for data exclusion under the Exceptional Events Rule, as described above. The violations were a direct result from smoke from regional wildfires caused by natural events that primarily occurred outside of Utah jurisdictional boundaries that were not reasonably controllable or preventable.

Conceptual Model

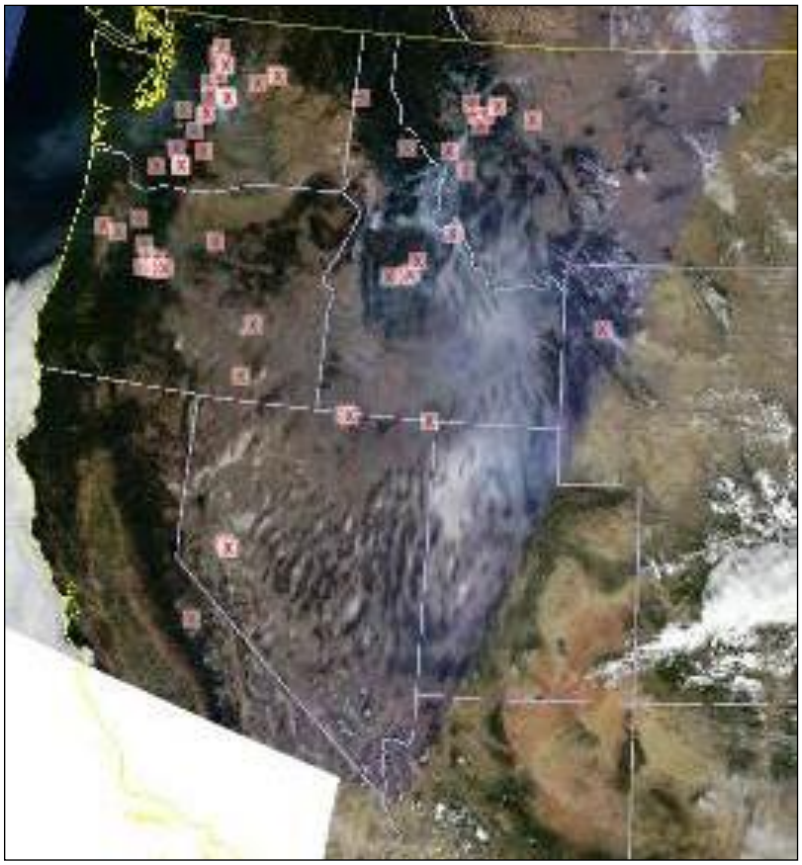
Excessive hot and dry conditions across western states lead 2012 to be one of the worst wildfires years. Wildfire smoke was visible in portions of the Wasatch Front starting in June and became heavy in August through September. The following graph shows the summer 2012 $PM_{2.5}$ 24-hr filter concentrations for the Logan and Ogden monitoring stations.



The smoke map for September 20, 2012, taken from the US Air Quality Smog Blog (http://alg.umbc.edu/usaq/), a daily diary of air quality in the U.S., prepared using information from satellites, ground-based measurements, and models indicates smoke emanating from Washington State to the southwestern states.



Massive regional and local wildfires began in August, ending in late September, resulted in smoke and particulate matter throughout northern Utah. Smoke over Washington, California, Utah, Nevada, Idaho and parts of Colorado is clearly visible from the satellite image taken on September 18, 2012. The same fire locations shown on the smoke map above are shown as “Xs” on the visible satellite image.



Three violations of the 24-hr $PM_{2.5}$ standard of 35 µg/m^3 occurred at the following monitoring stations:

- Logan monitoring station:
  September 18, 2012 – 36.3 µg/m^3

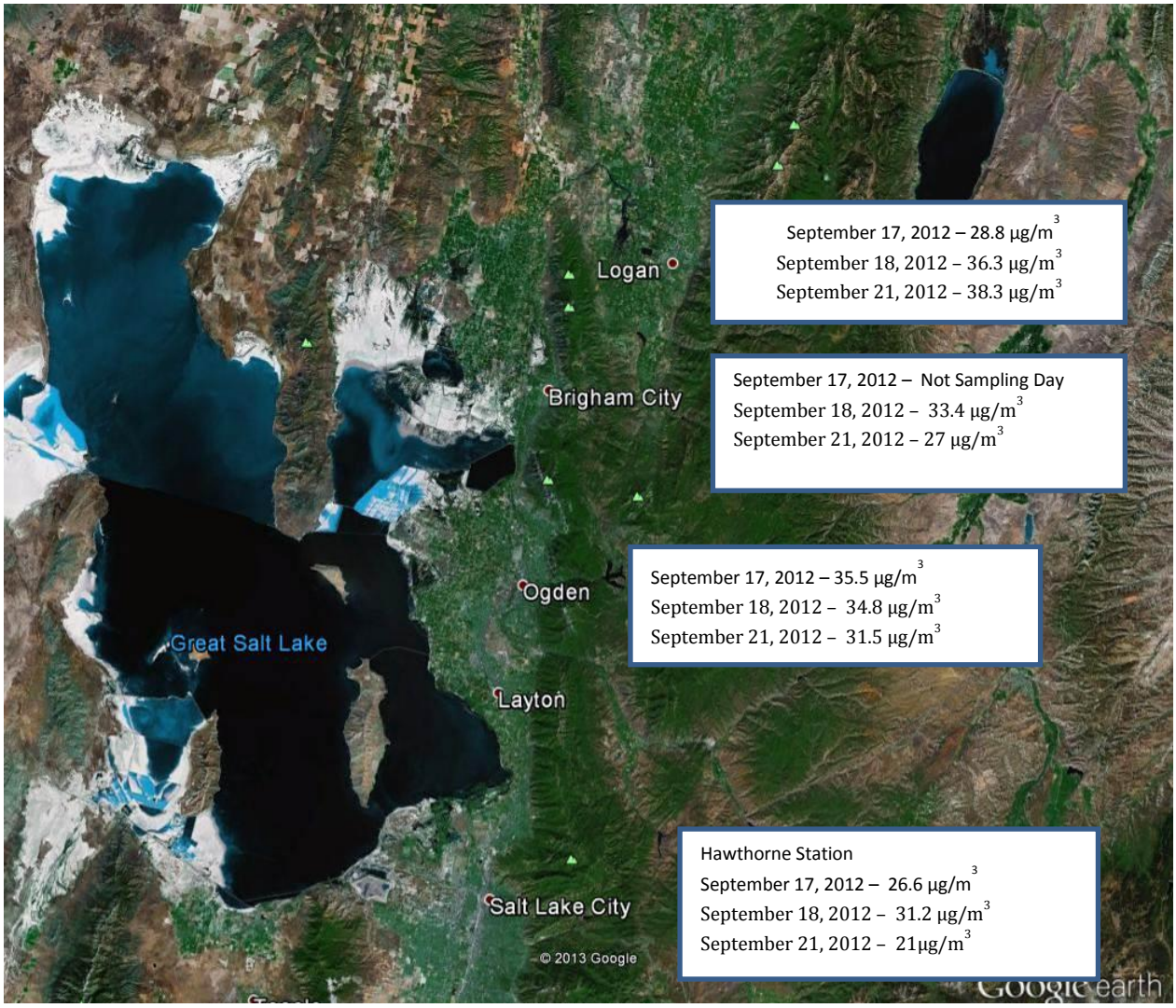
  September 21, 2012 – 38.3 µg/m^3

- Ogden Monitoring Station:
  September 17, 2012 – 35.5 µg/m^3

Setting and Air Quality Impact

The Logan monitoring station is located in the downtown area in Logan, Cache County. The Ogden monitoring station is also located in a metropolitan area within the City of Ogden, Weber County.

The Google map below shows the locations of Logan and Ogden within northern Utah. The $PM_{2.5}$ concentrations spanning the event days are shown on the map for Logan and Ogden, as well as the nearby cities of Brigham City and Salt Lake City.



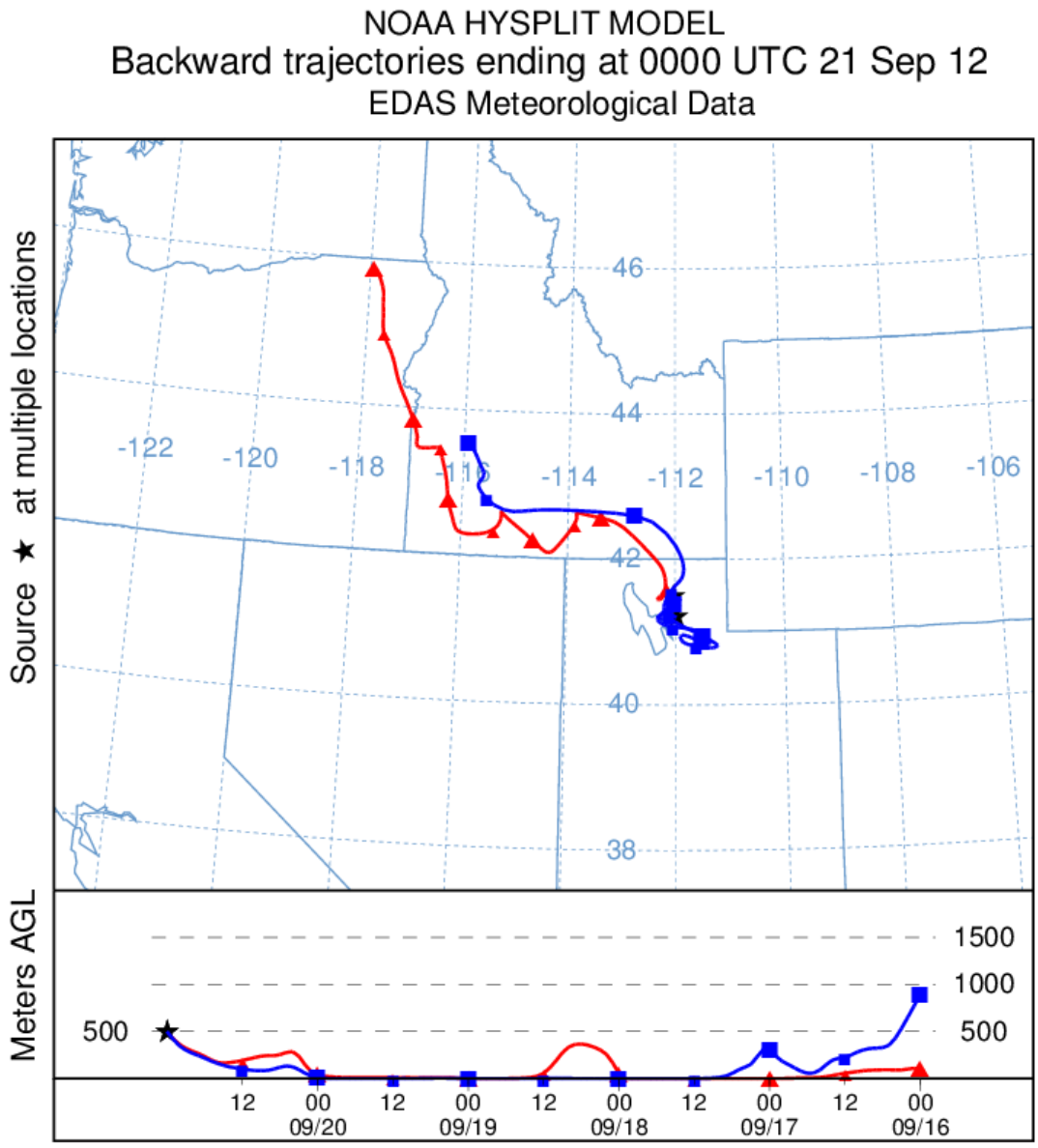
The $PM_{2.5}$ concentrations across northern Utah were significantly elevated consistent with the smoke map and visible satellite image.

The following sections present evidence that these violations were directly due to the wildfire smoke.

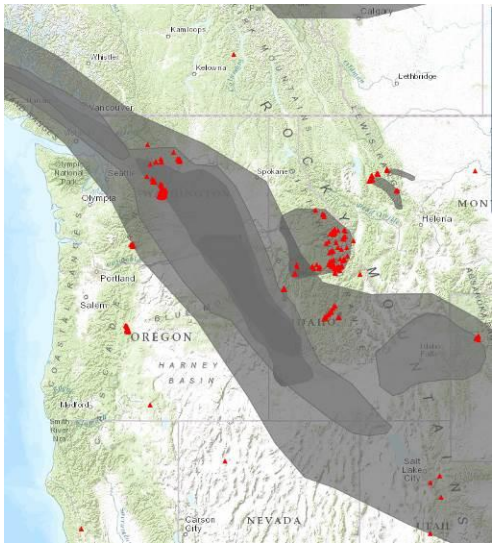
Clear Causal Relationship

Smoke Trajectory

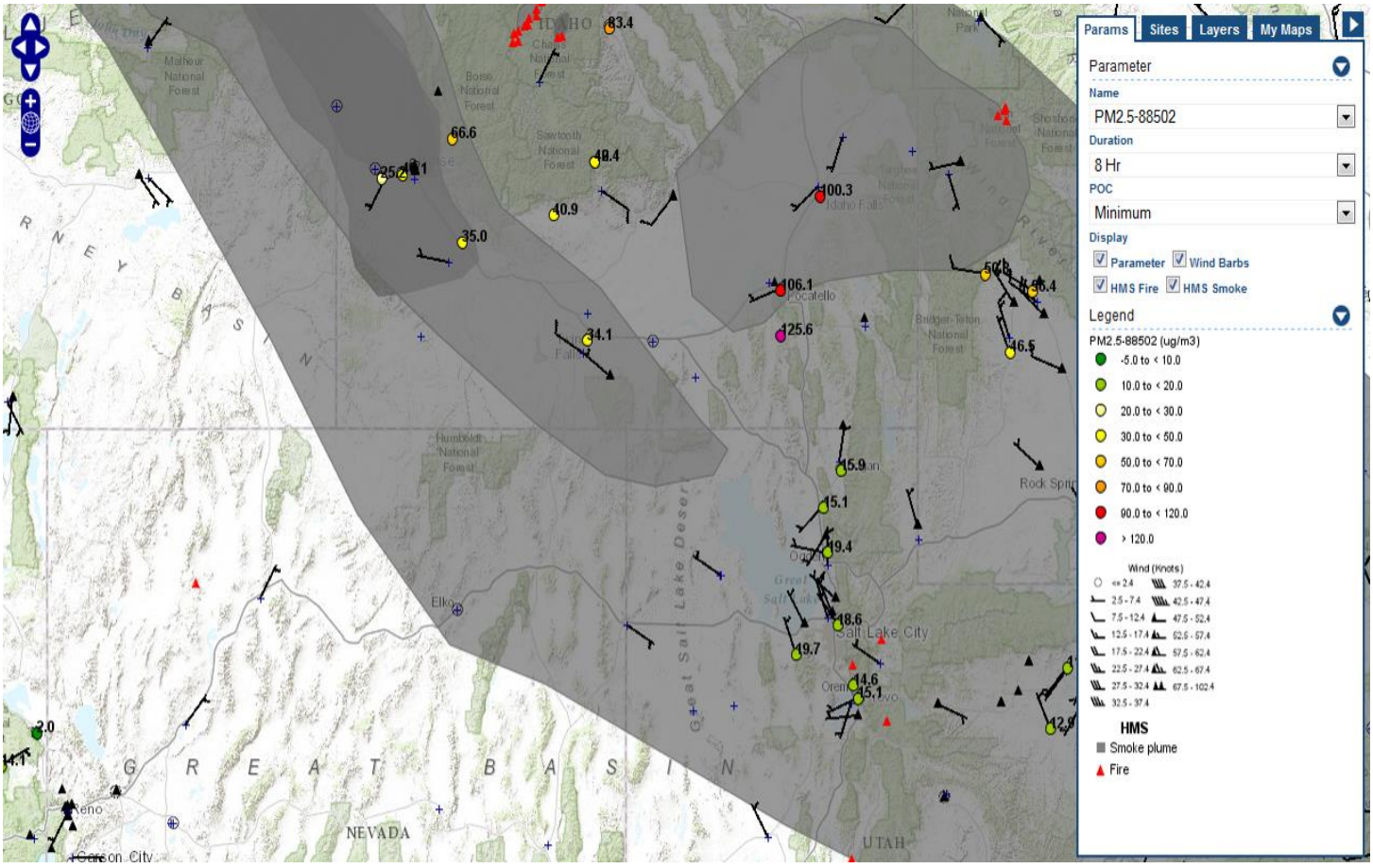
The five day back trajectory Hysplit modeling starting on September 21 for Ogden (blue) and Logan (red) indicates that most of the smoke reaching the two monitoring stations was from the Idaho wildfires.



The AirNow-Tech Navigator compiles data from state and tribal air quality agencies onto a GIS platform, thereby allowing users to layer smoke plume(s), fire location(s), air quality data (non-quality assured), and other parameters of interest, such as wind barbs. The image to the right is of September 20, 2012, at 1300 hours MST, showing fire locations (red markers) and smoke plumes (gray shading) in northern to central Utah emanating from Idaho, Oregon, and the Pacific Northwest.



We can gain a better understanding why $PM_{2.5}$ levels were elevated during the event period by focusing in on northern Utah on September 20, 2012 and overlaying fire locations, smoke plumes, 8-hr $PM_{2.5}$ concentrations, and wind barbs.



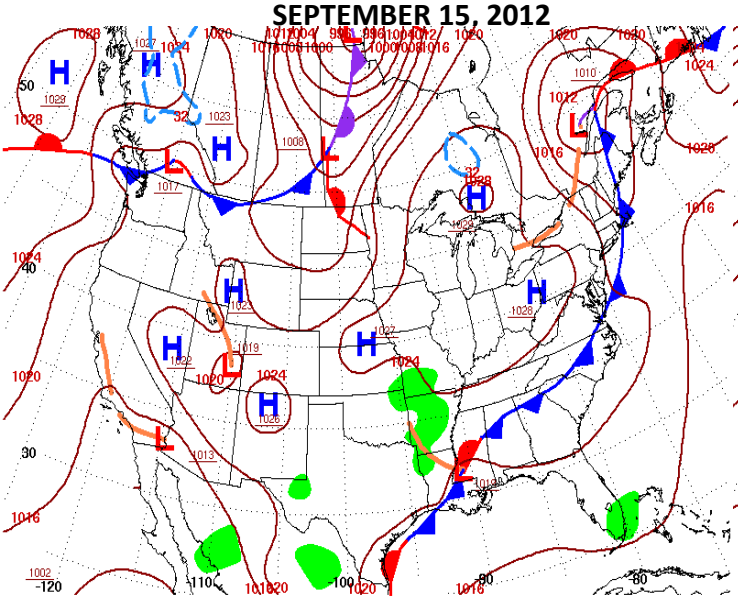
We can establish that there were multiple smoke plumes that eventually combined in Utah as the plumes moved down wind of the fires. The highest 8-hr $PM_{2.5}$ concentrations at that time were around Pocatello, Idaho at 125.6 µg/m^3. Wind speeds were minimal, ranging from 2.5 to 7.4 mph, with a general trend towards the southeast, consistent with the direction of the smoke plume. At these low wind speeds, local meteorology and topography have a greater influence on $PM_{2.5}$ concentrations at individual monitoring stations.

Meteorology

A developing cold front on September 15 and 16th drove atmospheric smoke towards Utah. The high pressure system on the 17th drove surface winds and smoke over the northern monitoring stations. This was supported aloft with winds at the 500 milibar level shifting from west to east on the 15th, 16th, and 17th. Once the front passed, a surface high pressure system formed and remained in place from the 18th through the 22nd, this allowed smoke to remain resident in northern Utah.

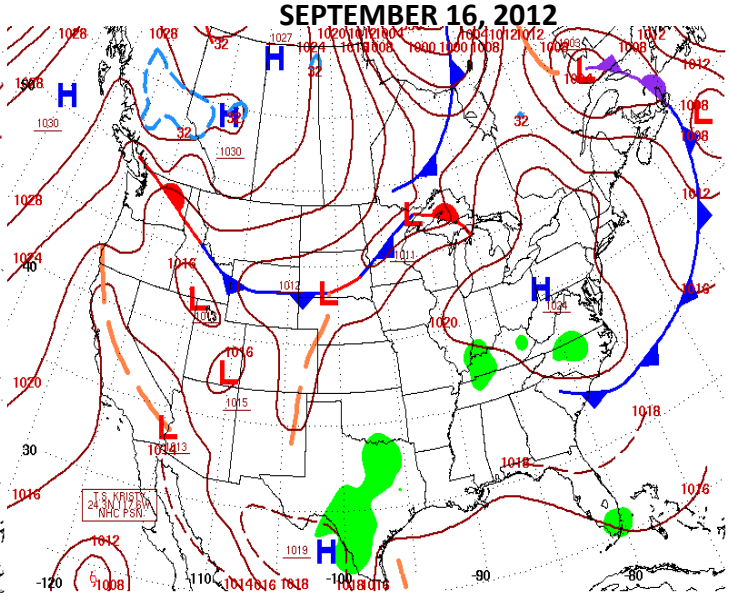
Aloft the winds decreased in speed and remained out of the north on the 18th, and changed direction from a Northwest and West Northwest flow on the 19th and 20th. With the addition of an upper level high located over the Gulf of California and migrating north over California and Nevada on the 21st. The high started to propagate to the East on the 22nd allowing the formation of a cold front, which had a greater impact on Utah on the evening of the 23rd. A cold front and a low moved the smoke out of the area on the evening of September 23. Aloft the winds shifted out of the south with increased speed.

SEPTEMBER 15, 2012



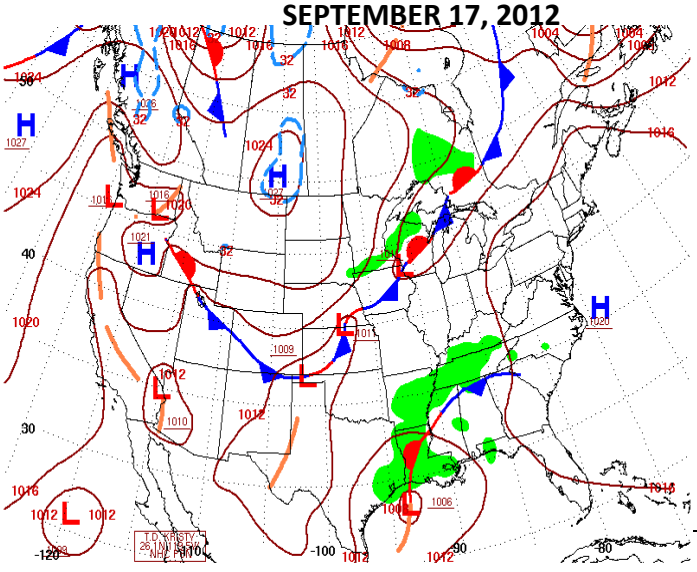
Surface Weather Map at 7:00 A.M. E.S.T.

SEPTEMBER 16, 2012



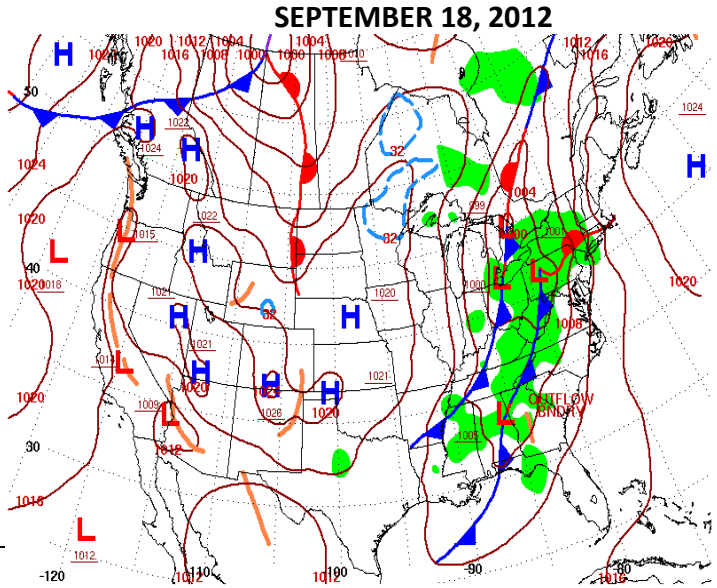
Surface Weather Map at 7:00 A.M. E.S.T.

SEPTEMBER 17, 2012



Surface Weather Map at 7:00 A.M. E.S.T.

SEPTEMBER 18, 2012



Surface Weather Map at 7:00 A.M. E.S.T.

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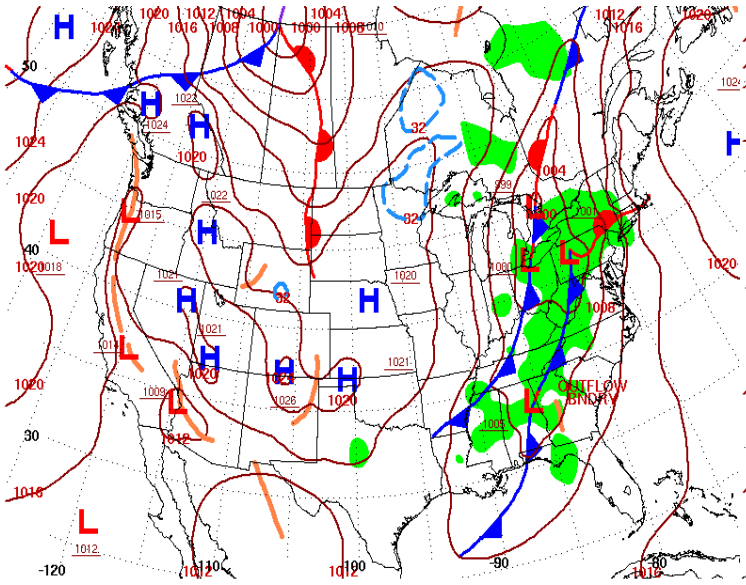
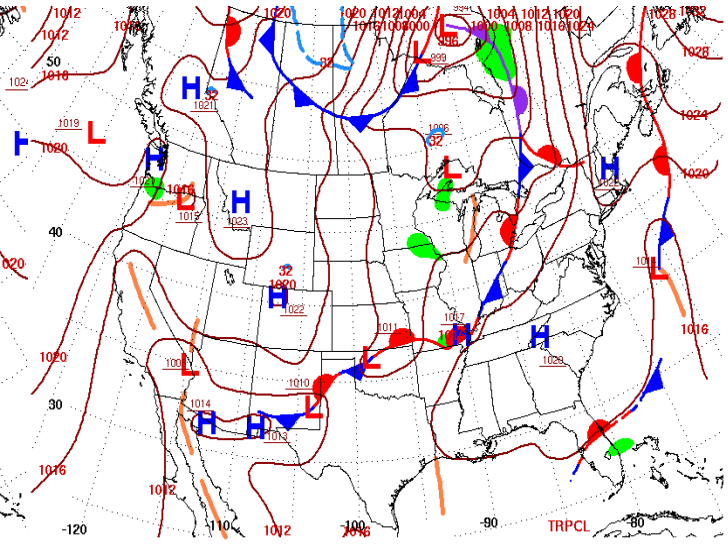


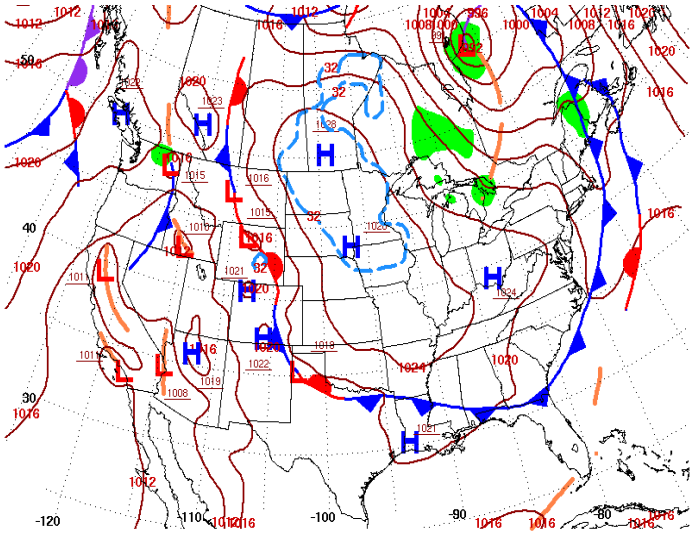
Surface Weather Map at 7:00 A.M. E.S.T.

SEPTEMBER 21, 2012



Surface Weather Map at 7:00 A.M. E.S.T.

SEPTEMBER 23, 2012



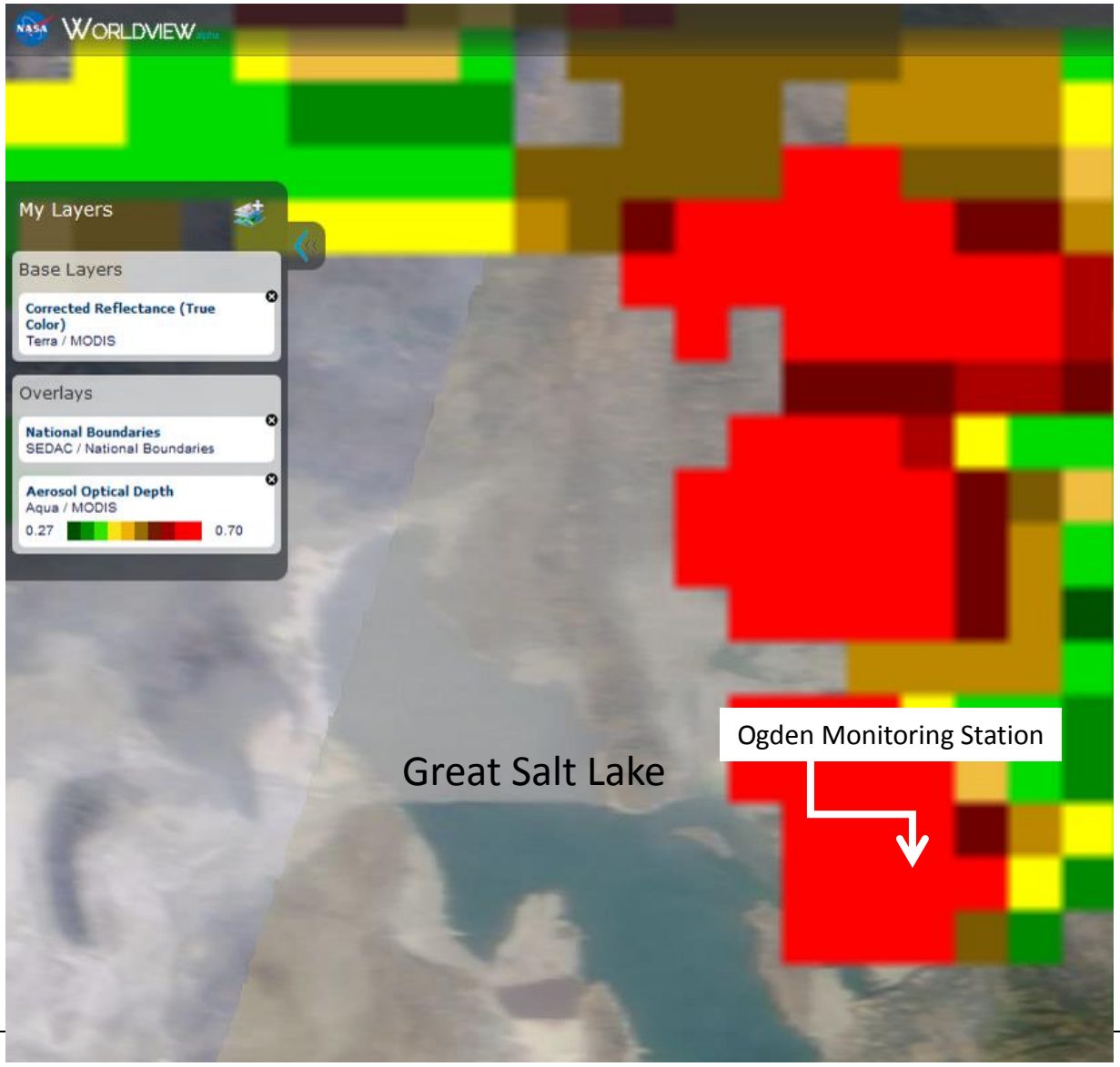
Surface Weather Map at 7:00 A.M. E.S.T.

Aerosol Optical Depth

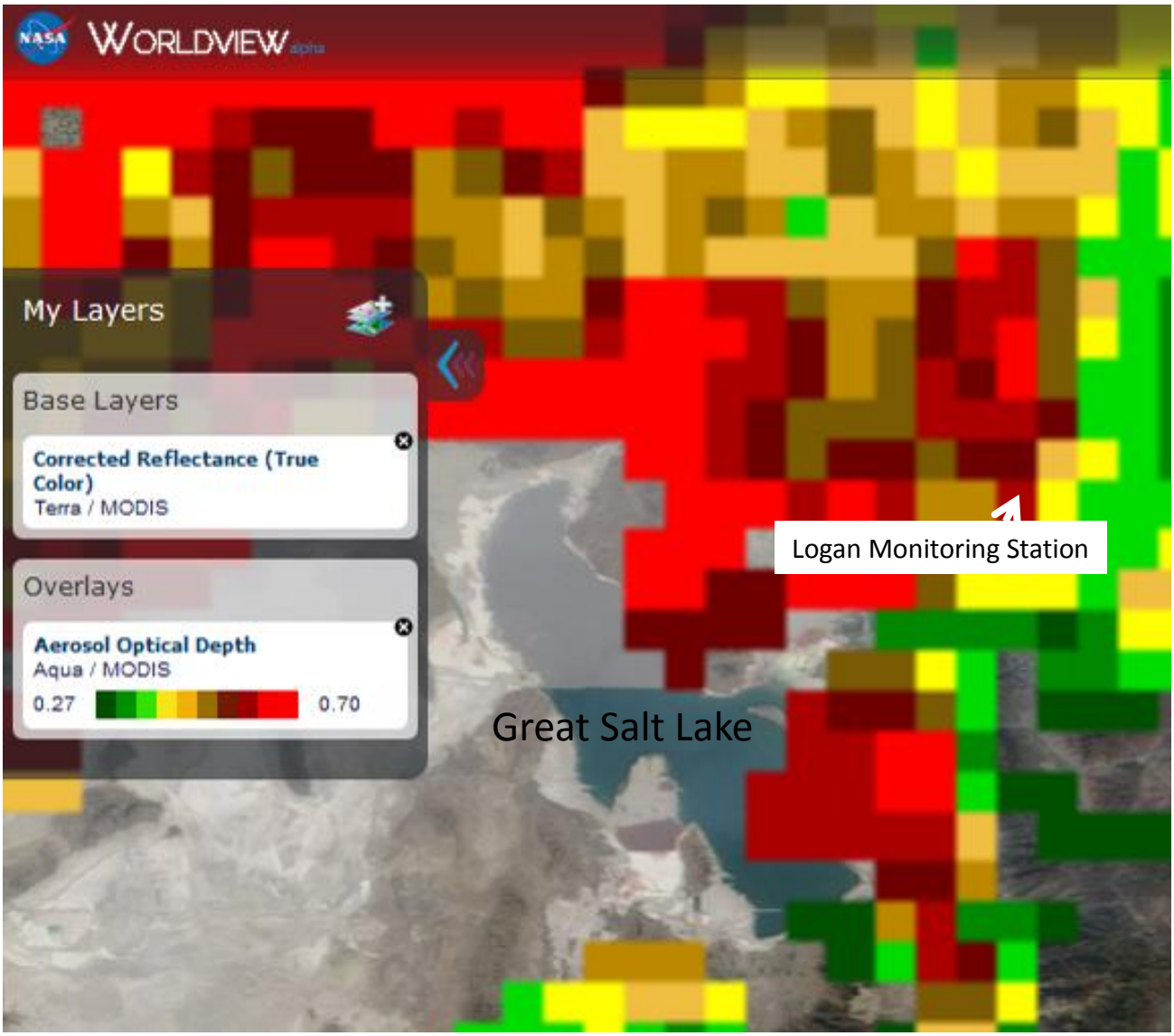
Aerosol optical Depth (AOD) is a measure of atmospheric extinction through a vertical column of atmosphere as sensed by a satellite's visible sensor. The higher the AOD value, the more aerosols are within a column. AOD measurements can provide supporting evidence of the presence of $PM_{2.5}$ from smoke. As the AOD approaches 1, it is an indicator of heavy pollution. AOD conversion to PM2.5 mass concentration is dependent on many variables and location, however, a relative relationship has been established by NASA as follows:

AOD 0.6 - 36 µg/m^3
AOD 1.5 - 90 µg/m^3.

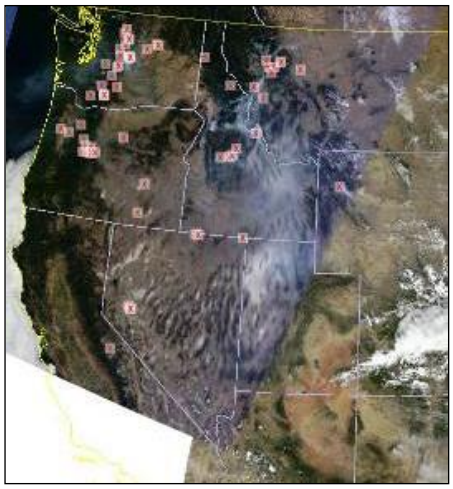
This satellite image of northern Utah on September 17, 2012, shows the smoke and AOD. Note the high AOD in red over Ogden. The legend indicates an AOD at 0.7 or about 36 µg/m^3 of $PM_{2.5}$. The actual measurement was 35.5 µg/m^3.



This satellite-AOD image was taken on September 21, 2012. The AOD around the Logan monitoring station is color coded red or a $PM_{2.5}$ of about 36 µg/m^3. The actual measurement was 38.3 µg/m^3.

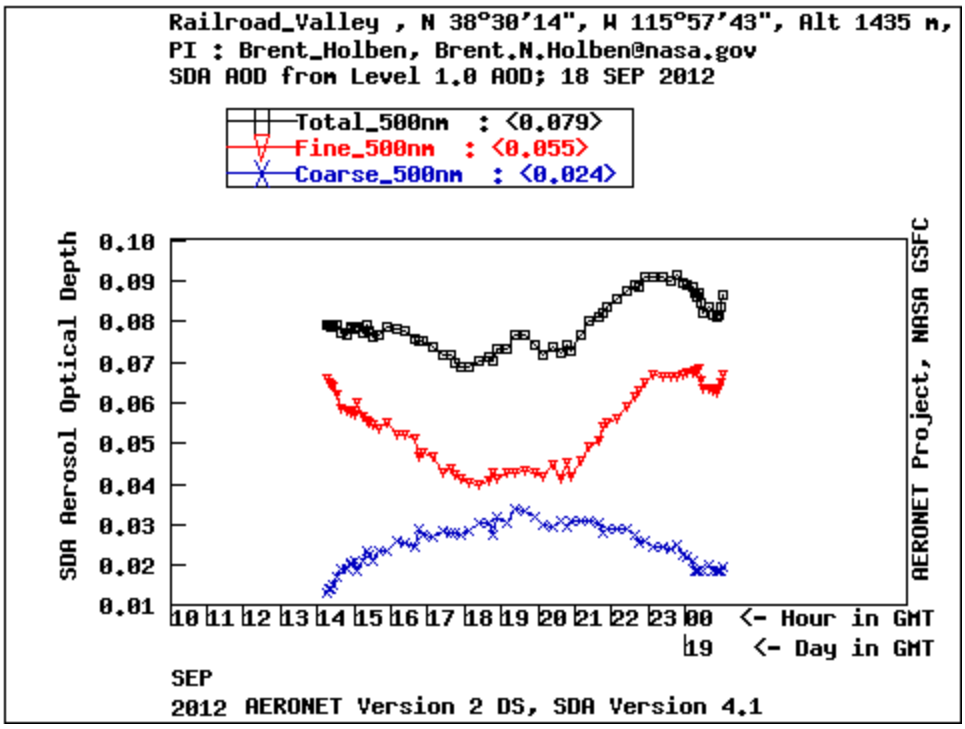


Particle Distribution



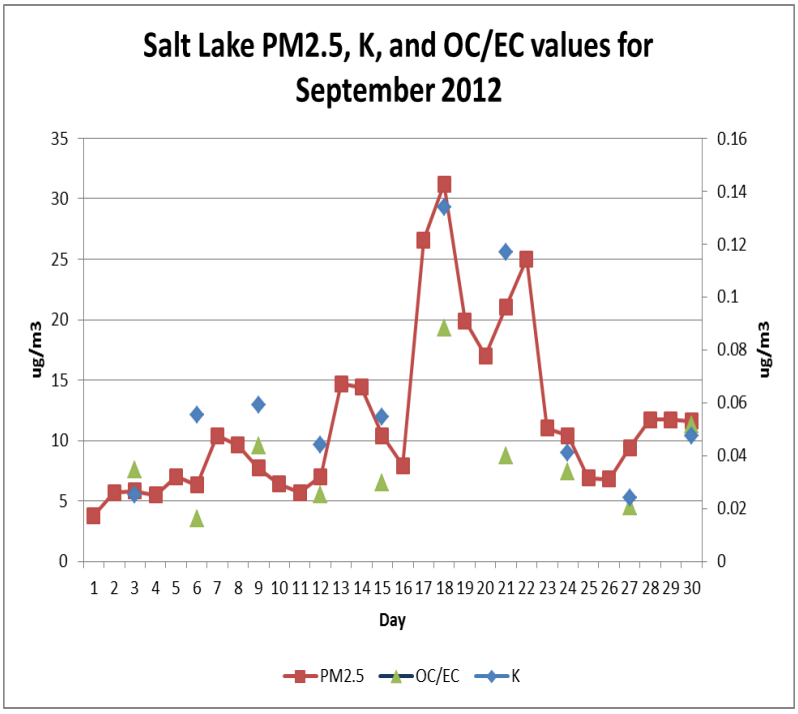
The AERONET program is a federation of ground-based remote sensing aerosol networks established by NASA. The program provides a database of aerosol optical, mircrophysical and radiative properties for aerosol research and characterization. The AERONET sites were carefully located outside major polluted areas so that their measurements are minimally impacted by anthropogenic sources. The nearest AERONET site to Utah that could be used to characterize smoke from the western fires in 2012 is the Railroad Valley site, located in eastern Nevada. While this site was not in the direct path of the Idaho smoke that reached Utah on the exceptional event days, it was receiving broad bands of smoke from western fires during the 2012 wildfire season, as seen on the satellite image of September 18, 2012. Therefore, this analysis is generally helpful in characterizing the aerosol.

This AERONET AOD analysis is for September 19, 2012. The black line represents the total aerosol, the red line represents the fine or $PM_{2.5}$ fraction and the blue line represents the coarse fraction. Dust and smoke contribute to the fine fraction. The course fraction increased during the day indicating that dust was present, which is somewhat expected given the desert location of the Railroad Valley station. While the coarse fraction declined during evening hours, the fine fraction substantially increased. This may be due to increased smoke during evening hours from wildfire smoldering that often occurs at night time. The AERONET AOD fraction analysis, taken together with the visible satellite image, provides a causal relationship for the regional presence of wildfire smoke.

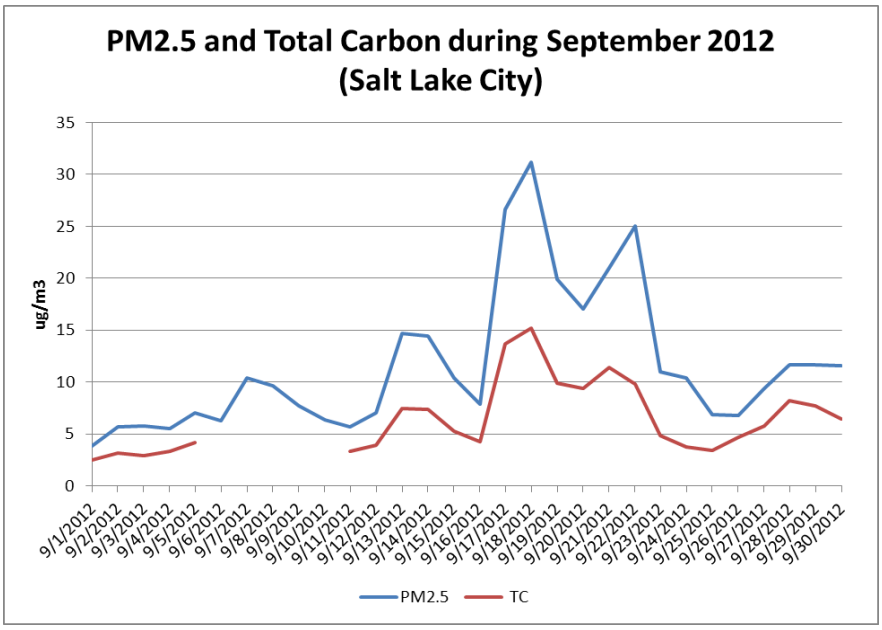


Fire Tracers

Potassium (k), organic and elemental carbon are reliable indicators of wood smoke. This graph shows an excellent correlation between the organic and elemental carbon fraction (OC/EC), elemental potassium and the $PM_{2.5}$ for the Hawthorne monitoring station speciated filters during September. The wood smoke indicators increase with $PM_{2.5}$ on the event days.



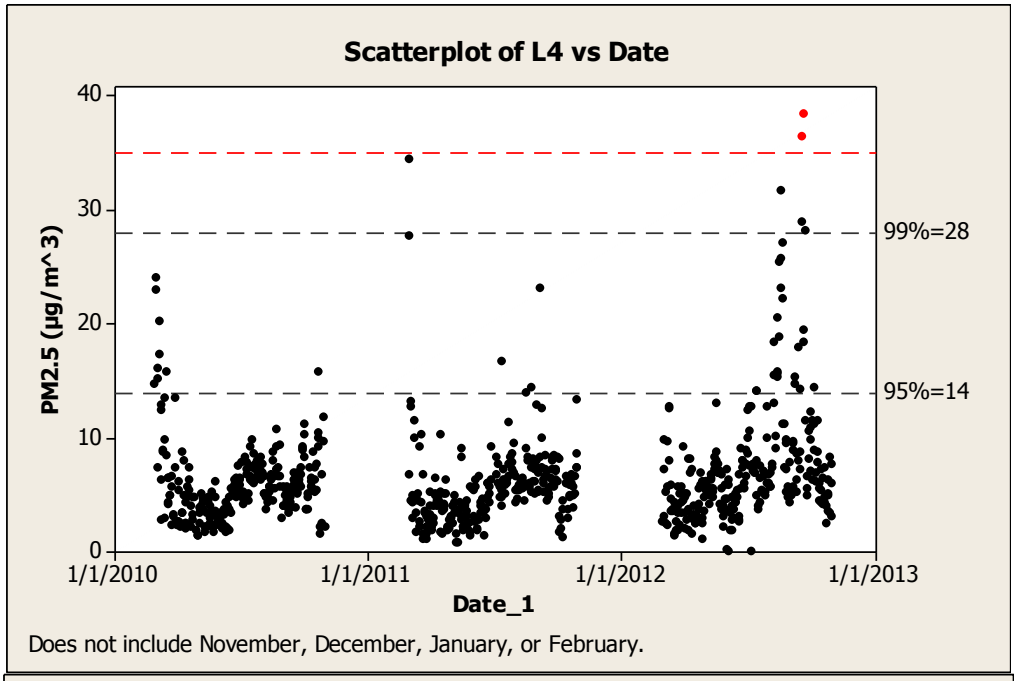
Another way to look at the influence of organics from wildfire is to plot total organics and $PM_{2.5}$. Again, we see an excellent correlation between the parameters and the event days.

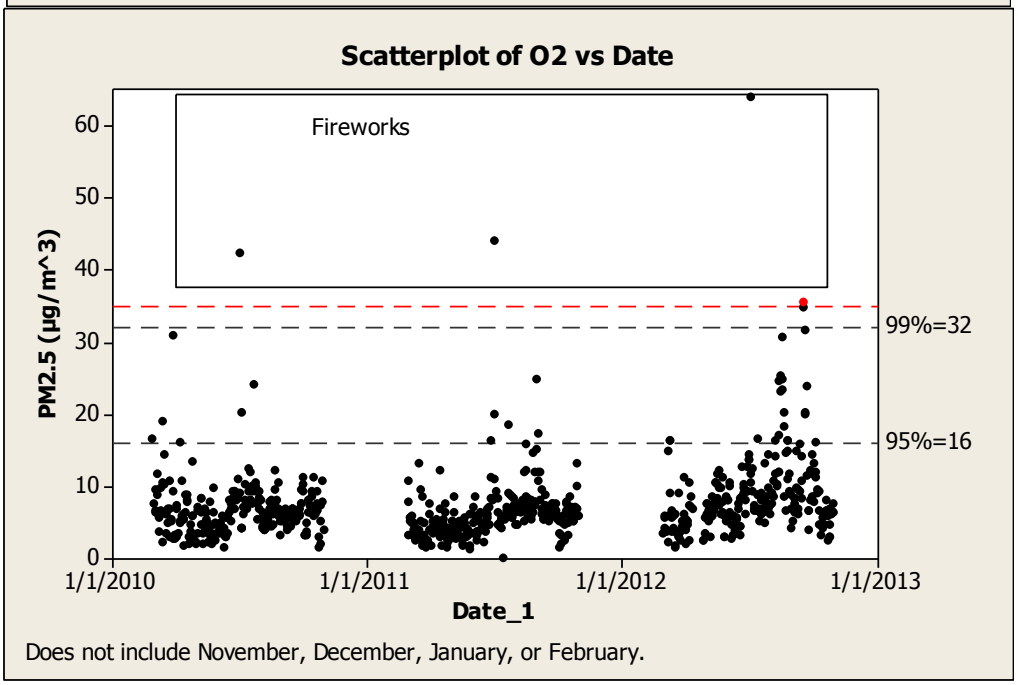


Historical Fluctuation

The following plots show the $PM_{2.5}$ data from 2010 – 2013, excluding the winter time inversion periods from November to February for the Logan (L4) and Ogden (O2) sites. The red dots are the exceptional events data points.

The exceptional events data for Logan exceed the 99 percentile, verifying that if not for the event, the exceedances would not have occurred.





Likewise, the exceptional event at the Ogden site also exceeded the 99 percentile and is only surpassed by former exceptional events caused by Fourth of July fireworks.

No Exceedance But For the Event

Background Conditions

The table presents maximum September PM2.5 filter values (in µg/m^3) for years 2011 and 2012. September 2011 was a low wildfire month representing background levels. 2012 $PM_{2.5}$ filter values for both monitoring stations exceeded background levels.

	Logan	**Ogden**
2012	38.3	35.5
2011	23.1	24.7
Difference	**15.2**	**10.8**

Wildfire Apportionment

We can attribute the $PM_{2.5}$ contribution from the wildfires by subtracting the event day values from background values on a daily basis. 2011 is used as background because it was a low wildfire year.

Logan Monitoring Station PM2.5 Values (µg/m3)		**PM2.5 Values During Wildfire Dates (µg/m3)**		**Difference Between Dates=Source Apportionment (µg/m^3)**
9/17/2011	4.4	28.8	9/17/2012	24.4
9/18/2011	5.5	**36.3***	9/18/2012	**30.8***
9/19/2011	5.1	19.4	9/19/2012	14.3
9/20/2011	4.7	18.3	9/20/2012	13.6
9/21/2011	5.7	**38.3***	9/21/2012	**32.6***

*Event Days

Ogden Monitoring Station PM2.5 Values (µg/m^3)		**PM2.5 Values During Wildfire Dates (µg/m3)**		**Difference Between Dates=Source Apportionment (µg/m3)**
9/16/2011	6.5	8.3	9/16/2012	1.8
9/17/2011	5.9	**35.5***	9/17/2012	**29.6***
9/18/2011	6.2	34.8	9/18/2012	28.6

*Event Day

Anthropogenic sources

There were no other known anthropogenic sources other than the western wildfires during the event days that could contribute to these levels of $PM_{2.5}$ increases across the entire northern Utah region.

The State Fire Marshal and the State Forester invoked fire bans under their separate authorities in August when state wildfire potential became high. The Governor and the Bureau of Land Management also invoked a ban on target shooting under their authorities.

Reasonable Controls

The Exceptional Events Rule requires that states have in place reasonable controls during exceptional events. The DAQ smoke management plan includes regulations that address open burning, prescribed burning and wildfire management.

- R307-202. Emission Standards: General Burning. This rule regulates when general burning can be conducted under permits issued by local fire authorities. Open burning periods are established in different parts of the state when the atmosphere can safely disperse smoke and when wildfire hazard is low. This rule also prohibits the burning of certain materials.

- R307-204. Emission Standards: Smoke Management. This rule is designed to mitigate the impact on public health of prescribed fires and wildfires by establishing strict requirements of land owners, state and federal agencies that conduct prescribed fires and actions necessary by the wildfire coordinators during a wildfire event. The state smoke manager (a Bureau of Land Management employee) processes all prescribed fire requests prior to submitting those requests for DAQ director approval. He assures that prescribed fire plans contain a smoke mitigation plan and that the burn will comply with R307-204.

The Department of Natural Resources has fire management jurisdiction in unincorporated and forest lands through R652-120.

- R652-120. Wildland Fire. The State Forester enforces open burning of yard waste through a burn permit in unincorporated lands in the same manner as R307-202 which is designed for incorporated lands. This rule also deals with fire management and suppression and prescribed fire management.

Rule effectiveness is a measure of regulatory compliance and is determined by calculating the compliance percentage. DAQ conducted 454 source inspections statewide in 2012 and found only one violation related to open burning. Based on this statistics, the rule effectiveness for particulate matter regulations related to burning was essentially 100%.

Mitigation

1. Utah rule R302-202 prohibits open burning and burning of waste materials without a permit.

2. A smoke management rule and plan, R307-204, helps minimize smoke from other sources during an event. The rule and plan states that new prescribed fires and new wildland fire use events would not be approved if there was a potential to exceed the NAAQS.

3. News release during an event advise citizens of the potential health impacts of smoke from wildfires.

4. Web sites about emissions from wildfire are posted on the DEQ web site. They cover the health impacts of PM and actions a person could take to minimize exposure to PM.

Conclusions

1. 2012 was one of the worst western wildfire years. Wildfire smoke was visible throughout the summer of 2012, resulting in elevated $PM_{2.5}$ levels.

2. The three violations of the $PM_{2.5}$ 24-hr standard would have not occurred but for the wildfire smoke. A weight of evidence approach was used in this report to support that conclusion by applying analysis of satellite imagery, remote sensing tools, fire tracers and statistical analysis.

3. Wildfire smoke contributed 29.6 to 32.6 $\mu g/m^3$ of $PM_{2.5}$.

4. There were no other known anthropogenic sources other than the western wildfires during the event days that could contribute to these levels of $PM_{2.5}$ across northern Utah.

5. Reasonable controls are in place and no foreseeable measures could be put into place to avoid or control naturally derived wildfires. Further, the wildfires were located outside Utah jurisdictional boundaries.

6. This documentation supports the exclusion of the three violations under the Exceptional Events Rule.