# Utah Division of Air Quality

## Exceptional Event Demonstration
## Ozone Exceedances at

**Beach, Brigham City, Harrisville and Hawthorne Monitoring Stations**

## Due to 2012 Wildfires

## Event Date – August 12, 2012

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# Introduction

An exceptional event, as defined in 40 CFR §50.1(j), is an event that:

- ❖ Affects air quality;
- ❖ Is not reasonably controllable or preventable; and
- ❖ Is caused by human activity that is unlikely to recur at a particular location or is a natural event.

As specified in 40 CFR 50.14(c)(3)(iv), to justify the exclusion of air quality data from National Ambient Air Quality Standards determination, the following must be demonstrated:

1. The event was not reasonably preventable;
2. There was a clear, causal relationship between the 8-hour ozone concentrations at the impacted monitors and the specified event;
3. The measured values were in excess of normal historical fluctuations; and
4. No exceedance would have occurred but for the event.

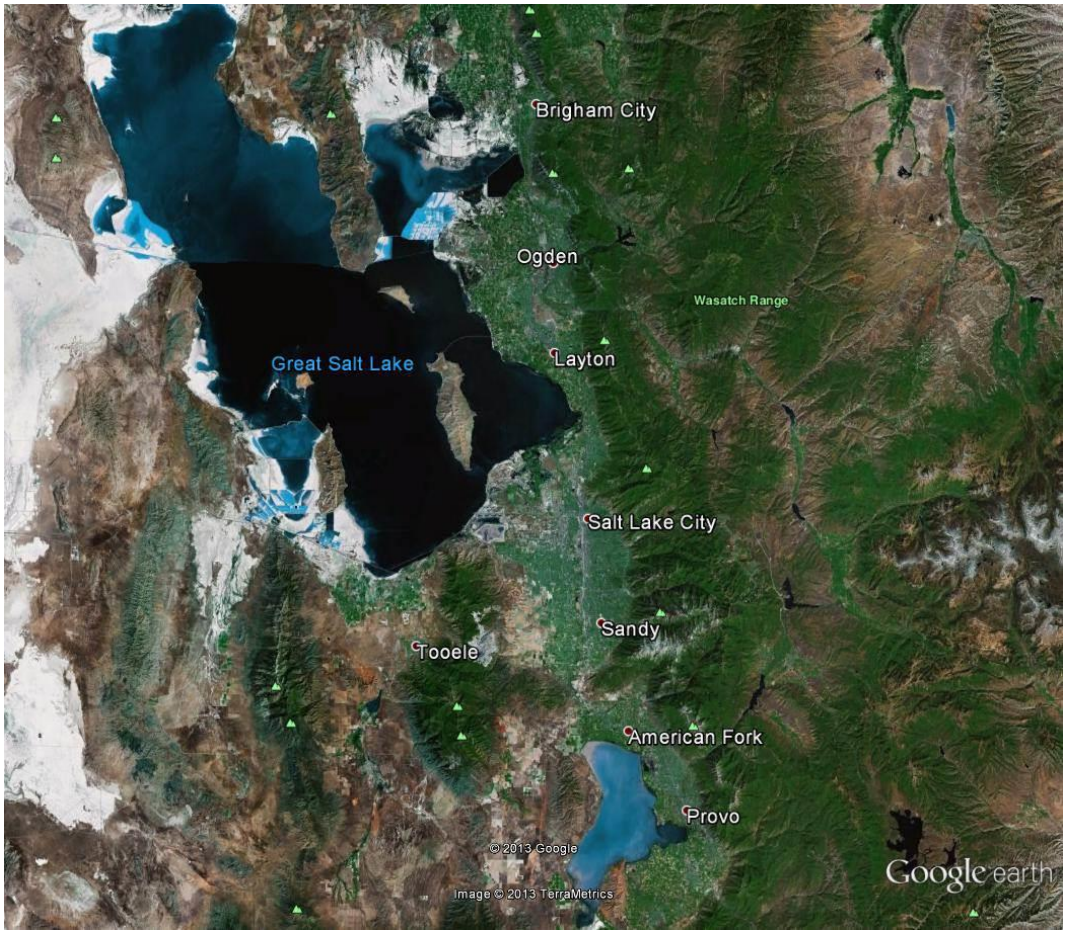
This report documents that the exceedances of the ozone 8-hour standard of 75 ppb that occurred on August 12, 2012, meet the above criteria because regional wildfires contributed to the exceedances and that the natural wildfires could not be reasonably prevented or controlled.

Ozone 8-hour Exceedances:

- Beach – 80 ppb
- Brigham city – 78 ppb
- Harrisville – 81 ppb
- Hawthorne – 82 ppb

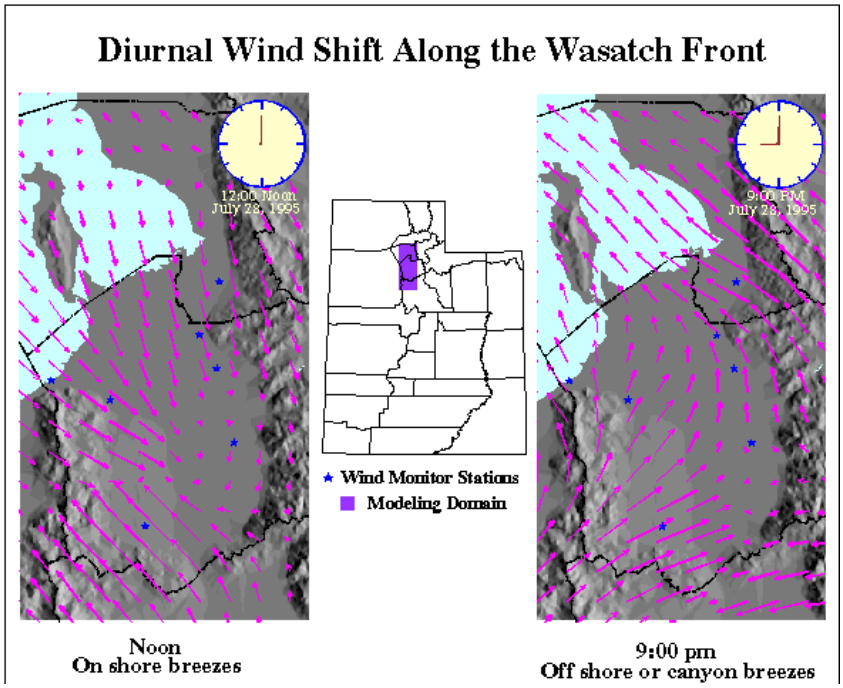
# Setting

The Wasatch Front is a metropolitan region in the north-central part of Utah. It consists of a chain of cities and towns stretched along the Wasatch Range from approximately Santaquin in the south to Brigham City in the north. Roughly 80% of Utah's population resides in this region, as it contains the major cities of Salt Lake City, Provo and Ogden. The Wasatch Front is long and narrow. Though most residents of the area live between Ogden and Provo (a distance of 80 miles), which includes Salt Lake proper, the fullest built-out extent of the Wasatch Front is 120 miles long and an average of 5 miles wide. Along its length, the Wasatch Front never exceeds a width of approximately 18 miles because of the natural barriers of lakes and mountains. To the east, the Wasatch Mountains rise abruptly several thousand feet above the valley floors, climbing to their highest elevation of 11,928 feet at Mount Nebo (bordering Utah Valley). The area's western boundary is formed by Utah Lake in Utah County, the Oquirrh Mountains in Salt Lake County, and the Great Salt Lake in northwestern Salt Lake, Davis, Weber, and southeastern Box Elder counties.




Prevailing winds in the Wasatch Front shift over the course of a day in the summer months. Night and early morning winds blow from the land towards the Great Salt Lake and this trend reverses as the day progresses.

This image portrays the diurnal wind pattern typical of the Wasatch Front. This pattern results in large part from the mountainous terrain and large water bodies along the Wasatch Front. Winds generally flow out over the lake



during the night and early morning hours as the land cools off more quickly than the surface of the lake. This process is reversed during the afternoon and evening hours when the lake surface is cooler than the surface of the land.

Actual prevailing winds for the event day are shown in Figure 1 for the northern Wasatch Front (Brigham City) and Figure 2 for the central Wasatch Front (Hawthorne). The winds on August 12 were predominately from the southwest at Brigham City and the southeast for Hawthorne.

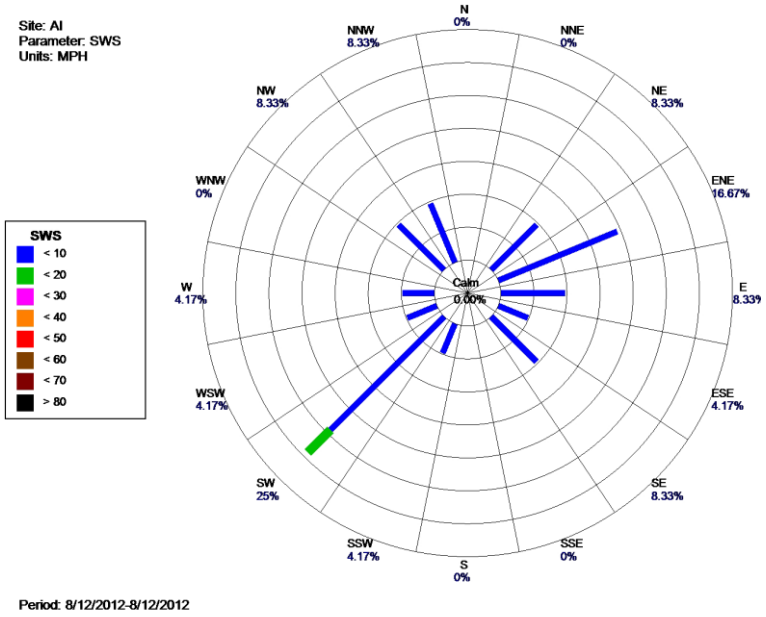



**Figure 1 - Brigham City**

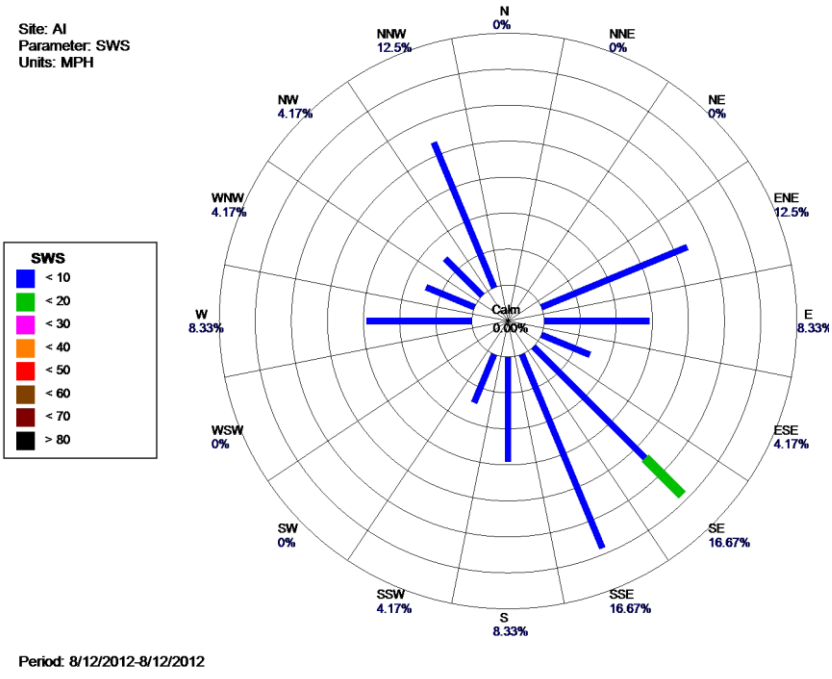



**Figure 2 - Hawthorne**

## Conceptual Model

Ozone is formed in the atmosphere by reactions involving volatile organic compounds (VOCs) and oxides of nitrogen ($NO_x$) in the presence of sunlight. Anthropogenic emissions contributing to ozone formation include mobile, stationary and area sources. Wildfires also emit substantial amounts of $NO_x$ and VOC that may contribute to ozone formation. The ozone season in the Wasatch Front occurs from May through September, coinciding with the wildfire season.

Excessive hot and dry condition in 2012 across western states resulted in at least 70 large natural wildfires west of the Mississippi by August 12, 2012 (National Interagency Coordination Center). The fire map to the right shows the major active western fires on August 12, 2012. The Pinyon fire in Herriman (5,771 acres) and the Faust fire in Vernon (22,045 acres) both started on August 5, 2012 as a result of lightning strikes, and continued to burn on the day of the ozone event. These fires were not depicted by the National Interagency Coordination Center on this map at the time of the event because they were relatively small in comparison to the raging western fires, however, our trajectory analysis shows that they contributed to the ozone exceedances.



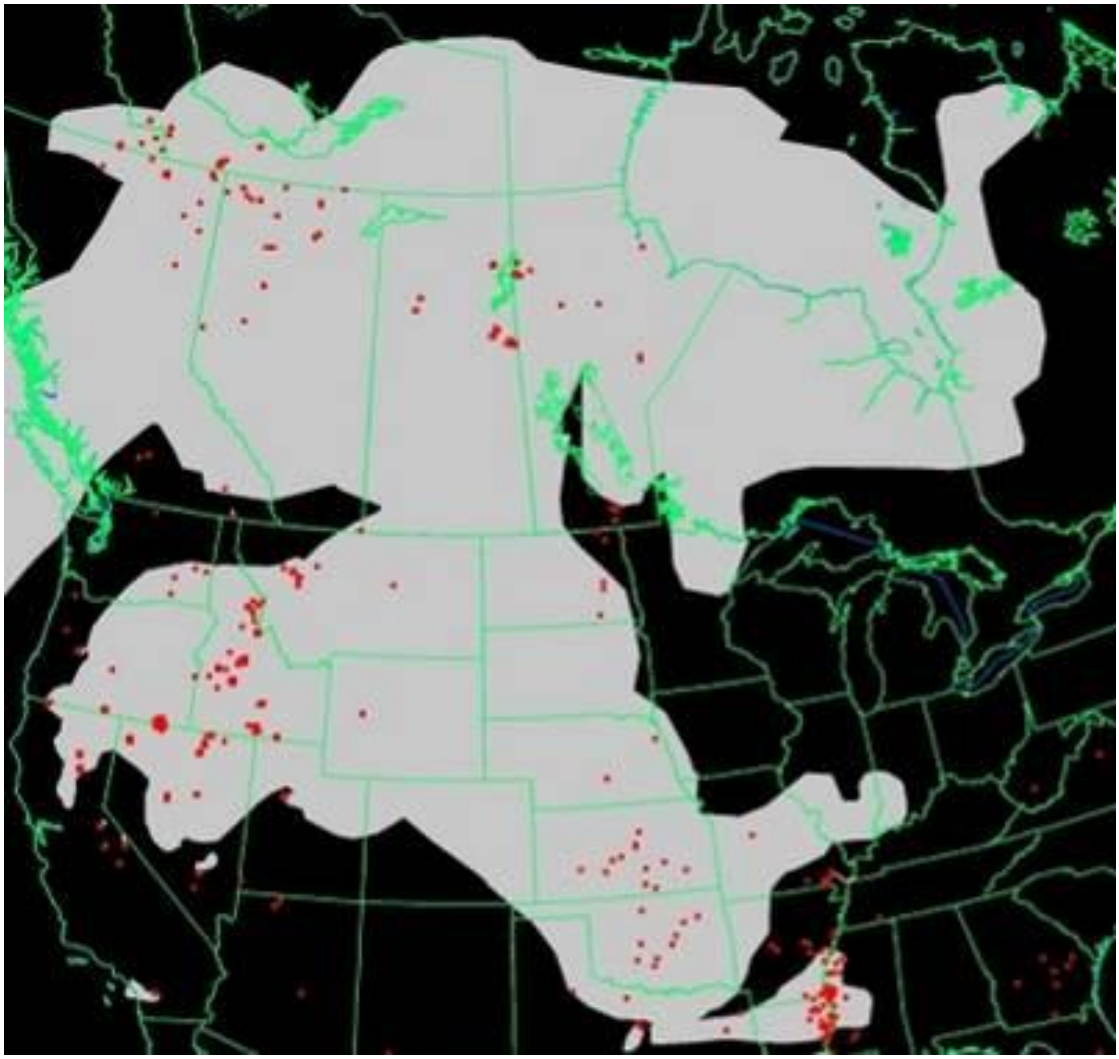
The locations of the local fires and ozone exceedances are shown on this image.

# Clear Causal Relationship

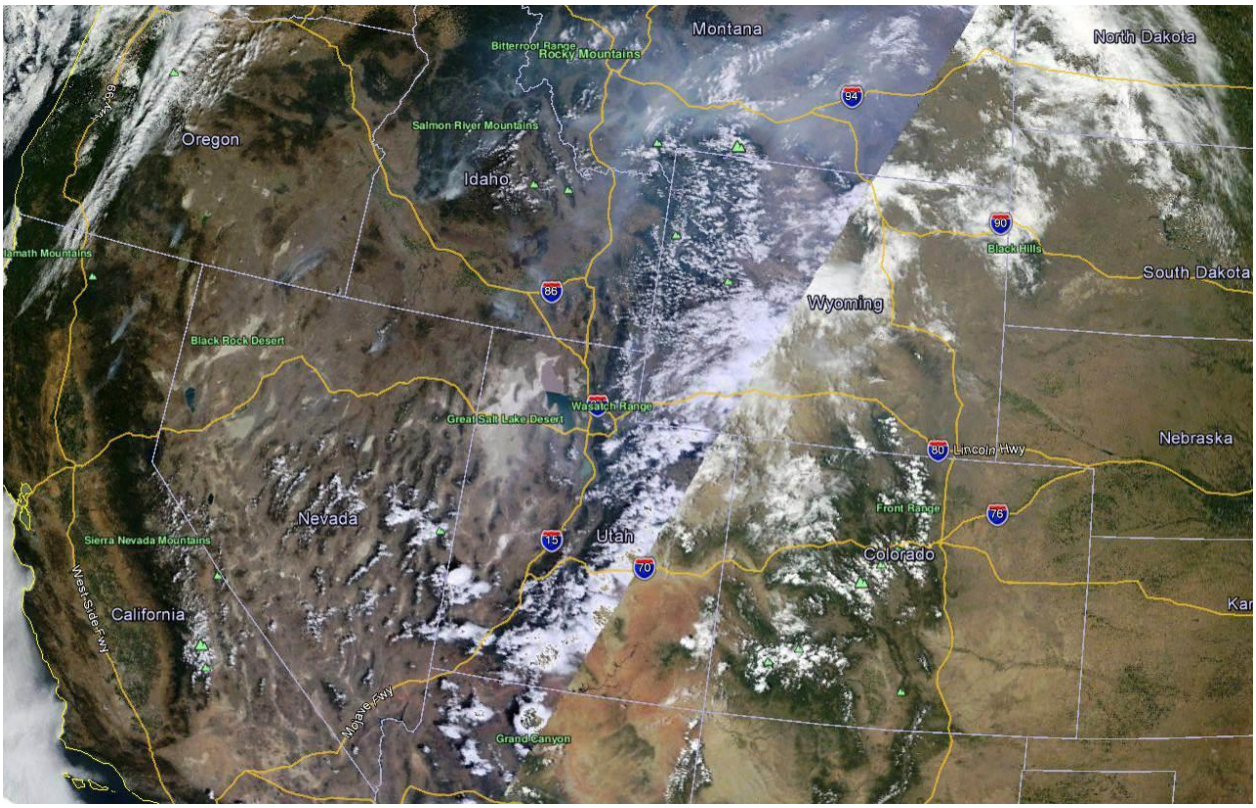
## *Visible Smoke*

Dr. Dan Jaffe and Nichol Wigder of the University of Washington, reported at an EPA sponsored wildfire and ozone exceptional events meeting (February 2013) that they conducted a critical review of 132 articles on wildfires and ozone. They concluded that when ozone generation related from wildfire smoke occurs, it generally does so one to three days downwind of wildfires. With this in mind, it is important to evaluate the wildfire smoke pattern at least three days before the event.

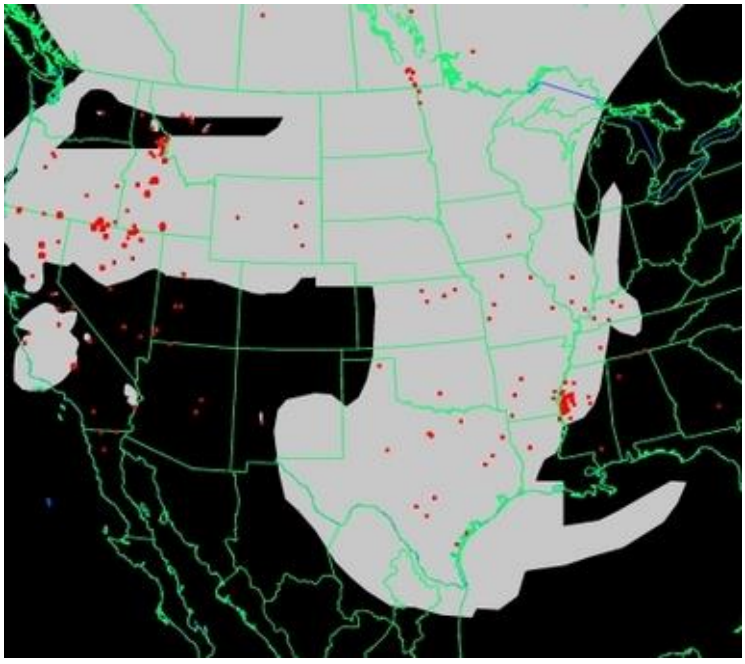
The National Oceanic and Atmospheric Administration (NOAA) smoke map for August 9 shows fire locations as red dots and smoke projection as gray shaded areas covering northern Utah.



The visible satellite image for August 9 confirms smoke (light gray-whitish layer) throughout most of Utah. Heavy smoke (darker gray layer) can be seen over portions of Idaho and Montana.

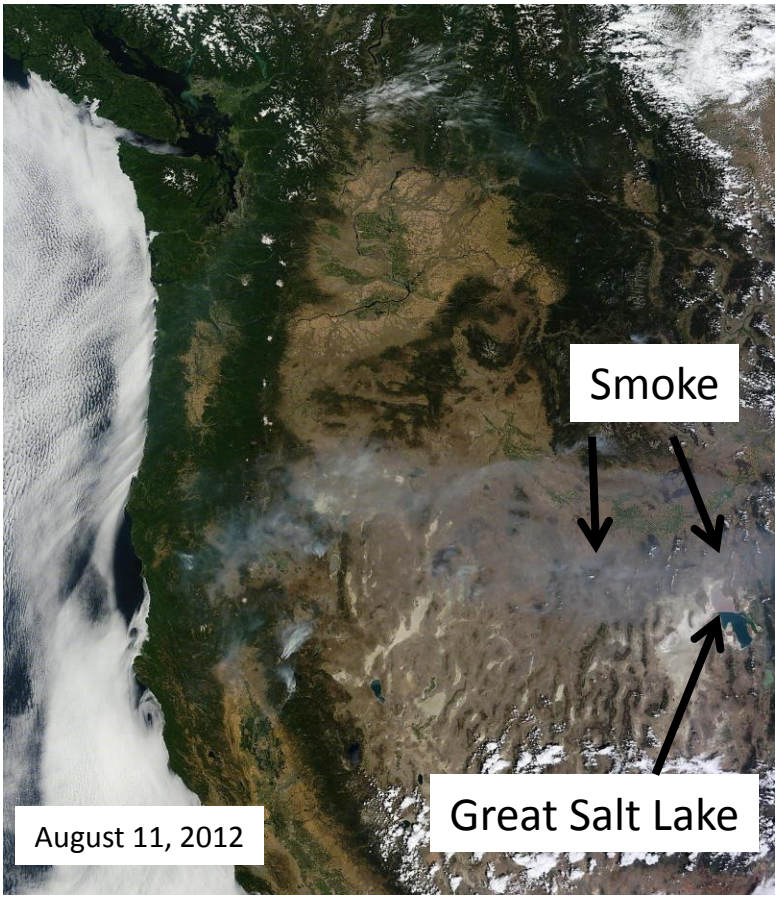


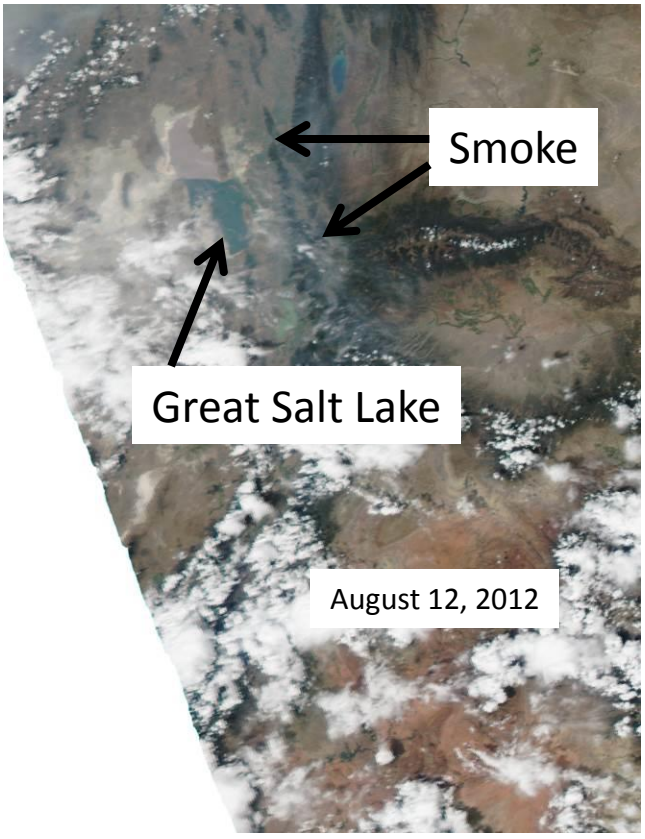

The NOAA smoke map for August 10 projected smoke north of the Utah border. Visual satellite observation for that day is limited due to cloud cover that obscured the view. The Incident Information System reported that the Pinyon fire was about 60% contained, which may have reduced the amount of smoke on the 10th. However, by the 11th, smoke projections again indicated smoke across northern Utah.



August 11, 2012

Satellite observations confirmed smoke in northern Utah on the 11th and again on the event day, the 12th.



The photograph of Salt Lake City taken mid-day on the 12th, confirms the presence of smoke in the valley.

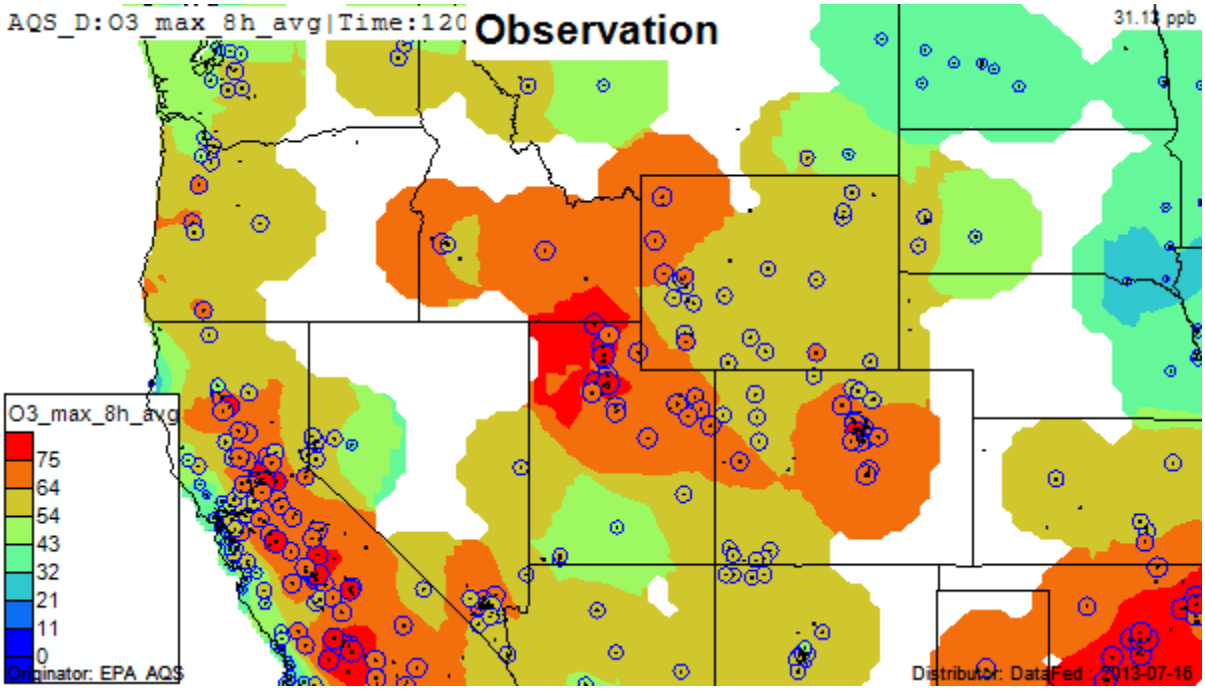
This close-up image, taken on August 12, shows smoke as a light white haze throughout the Wasatch Front. For reference sake, the image includes the locations of the Faust and Pinyon fires and the monitoring stations with their ozone exceedance levels.

## *Affected Air Quality*

The following table presents the 8-hour average ozone levels from August 11 – 13, 2012. Ozone levels on the 12th exceeded the standard. The ozone at Harrisville was also at 75 ppb on the 11th, which is probably also related to wildfire smoke.

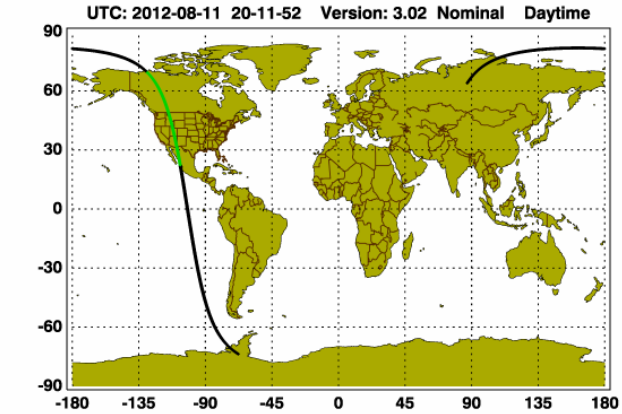
| 8-hour Ozone Average (ppb) | 8/11/2012 | 8/12/2012 | 8/13/2012 | Standard |
|---|---|---|---|---|
| Beach | 66 | 80 | 67 | 75 |
| Brigham City | 71 | 78 | 63 | 75 |
| Harrisville | 75 | 81 | 67 | 75 |
| Hawthorne | 73 | 82 | 64 | 75 |

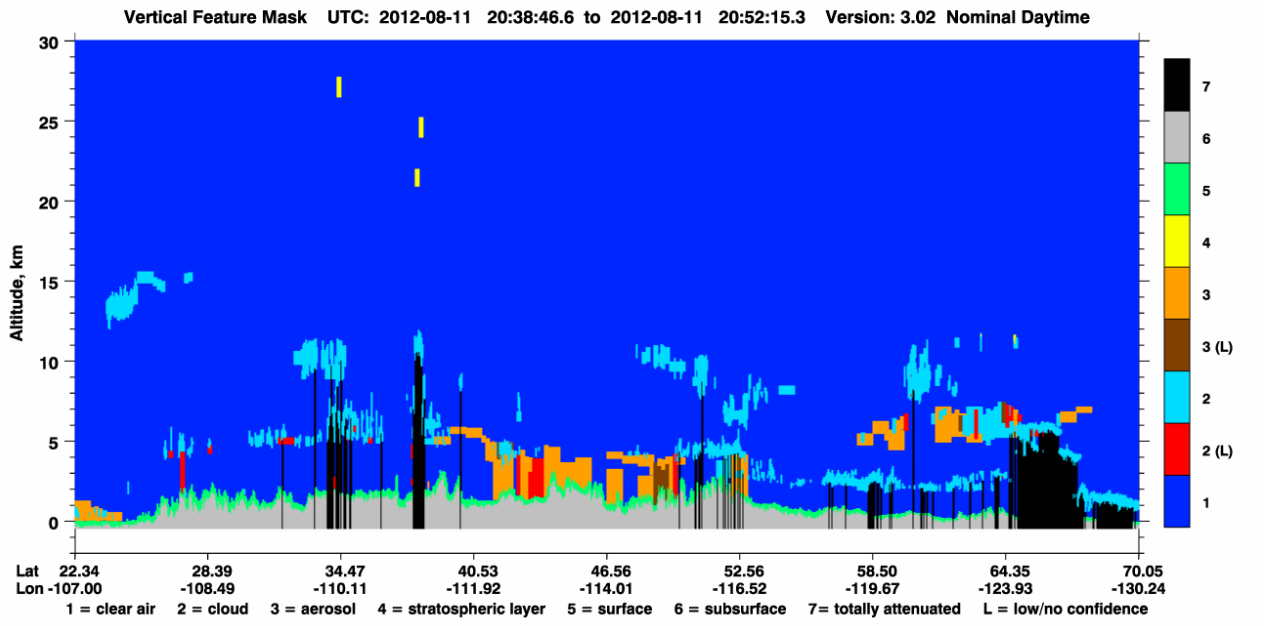
This figure shows the regional 8-hour average ozone levels on the event day in ppb. Ozone is concentrated in northern Utah, consistent with the smoke map images shown above.



## *Aerosol Optical Depth*

Aerosols are small particles suspended in the atmosphere. Smoke from forest fires contributes to atmospheric aerosols that can be measured by satellite. Measurements from satellites and ground stations show that many aerosols remain in the environment for long periods and can be carried by winds hundreds of miles from their origin. Aerosol observations from the CALIPSO satellite verify that smoke was present in the region and that the smoke reached down to ground level. The closest CALIPSO trajectory to the event location was on the afternoon on August 11, 2012.

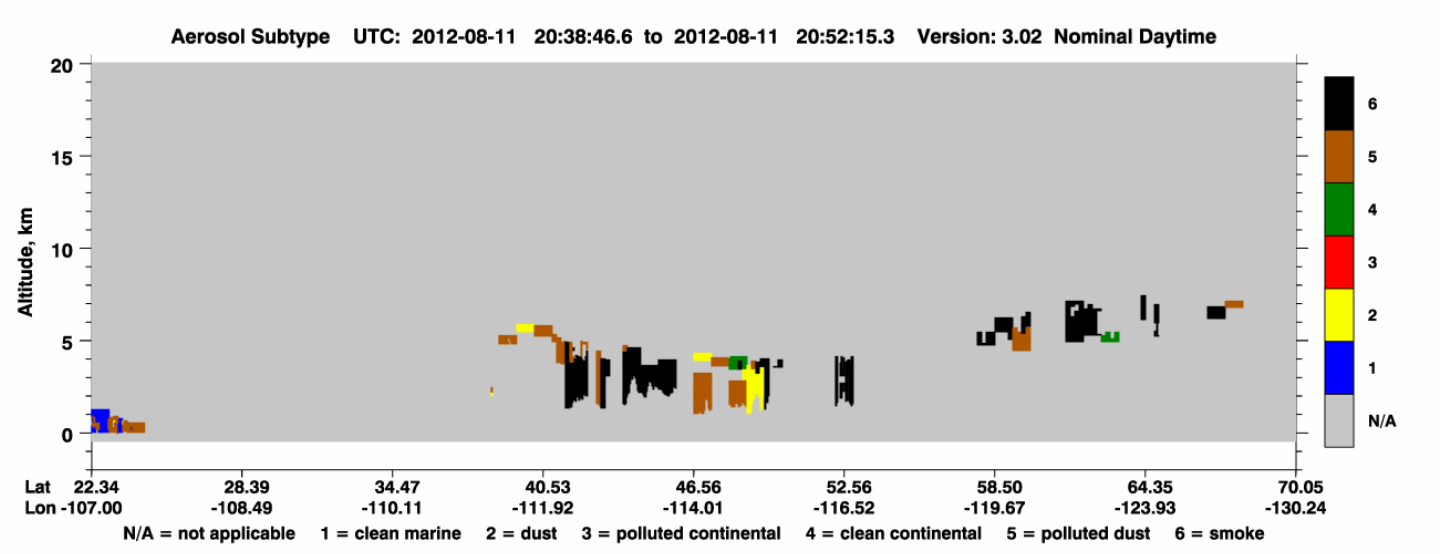



The vertical profile is interpreted by combining the numeric key at the bottom with the color chart on the right. The green code #5 is ground level. The tan color code #3 is the aerosol measurement. Using the Hawthorne monitoring station coordinates of 40.73, -111.87, we can see that aerosols were present to ground level.

| | Lat | Lon |
|---|---|---|
| Brigham City | 41.49289 | -112.01775 |
| Harrisville | 41.30266 | -111.98641 |
| Hawthorne | 40.73436 | -111.87201 |

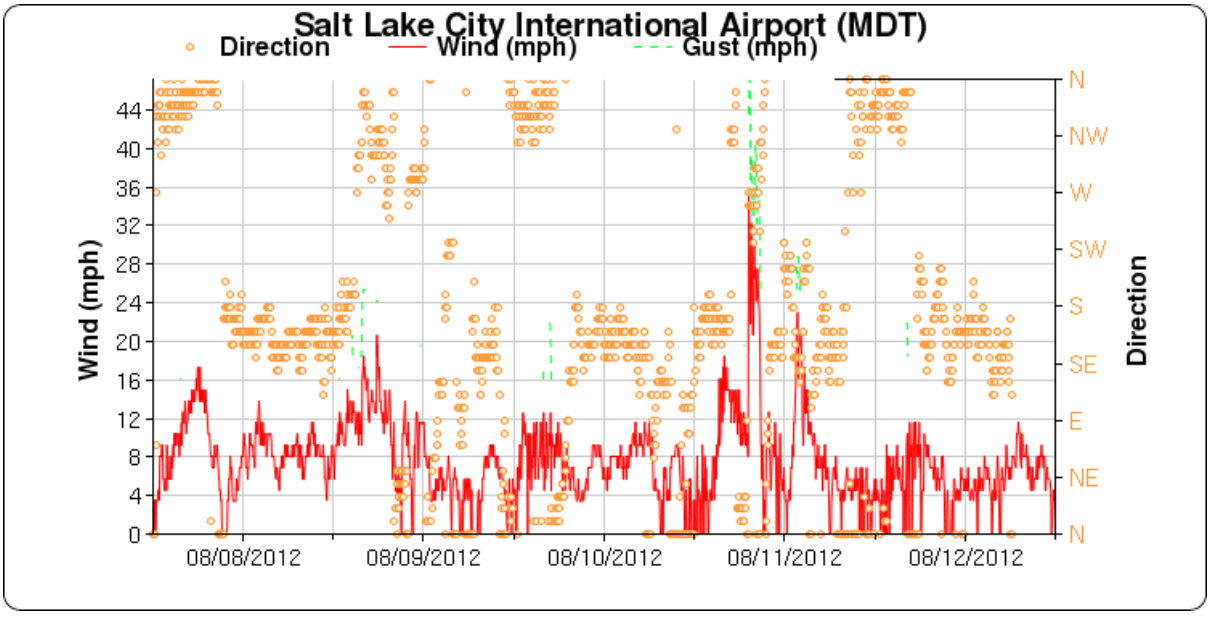
Looking at the same coordinates, CALIPSO categorizes the aerosol as smoke, black color code #6.




## *Smoke Transport*

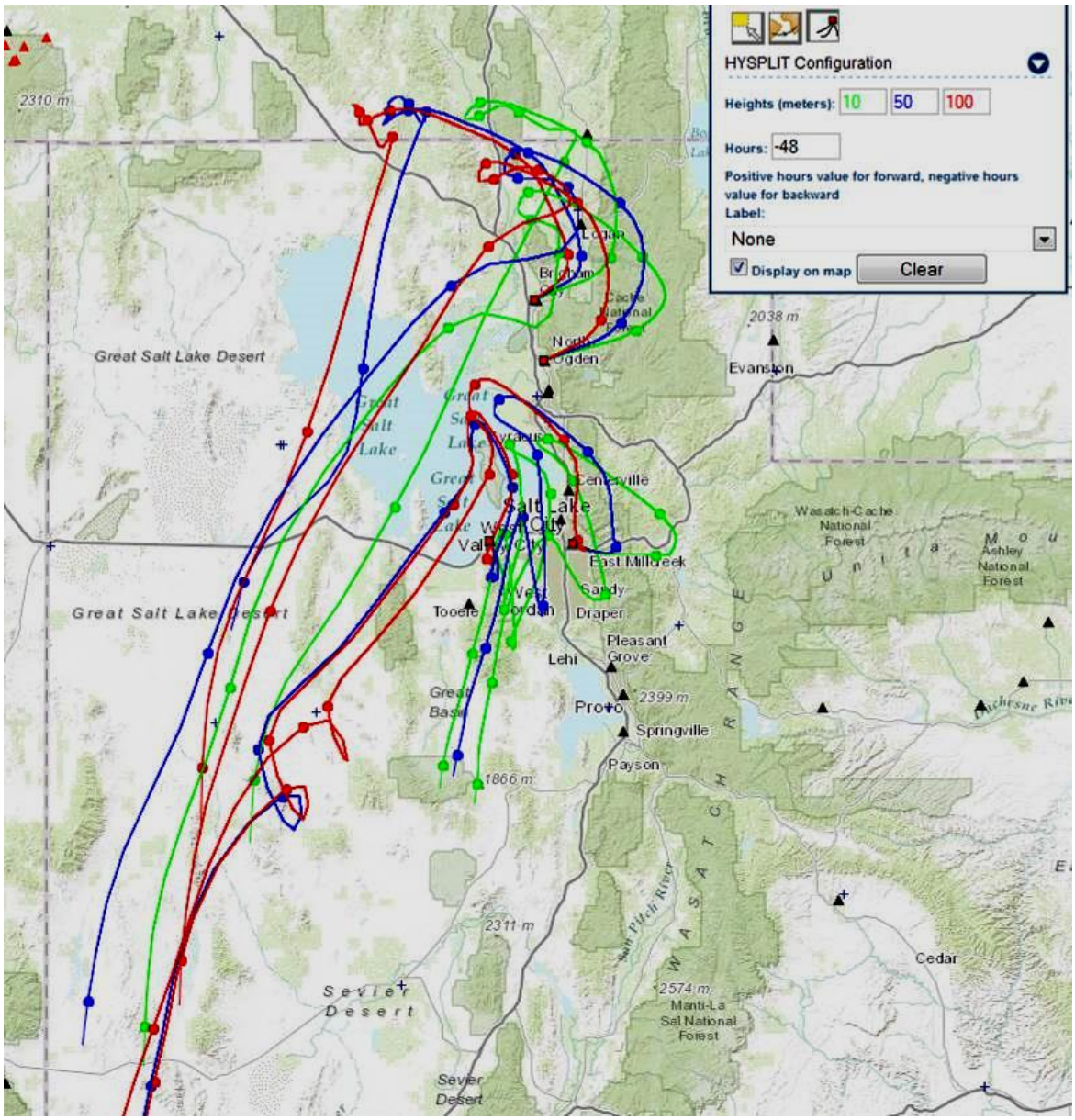
### Meteorology

Transport patterns can be deduced from the wind patterns covering a 5-day period leading to the ozone exceedances. Predominate winds followed the typical diurnal pattern described in the Introduction. Wildfires were present in northern and southern directions consistent with wind patterns. Surface wind speeds varied from stagnant to 36 mph.

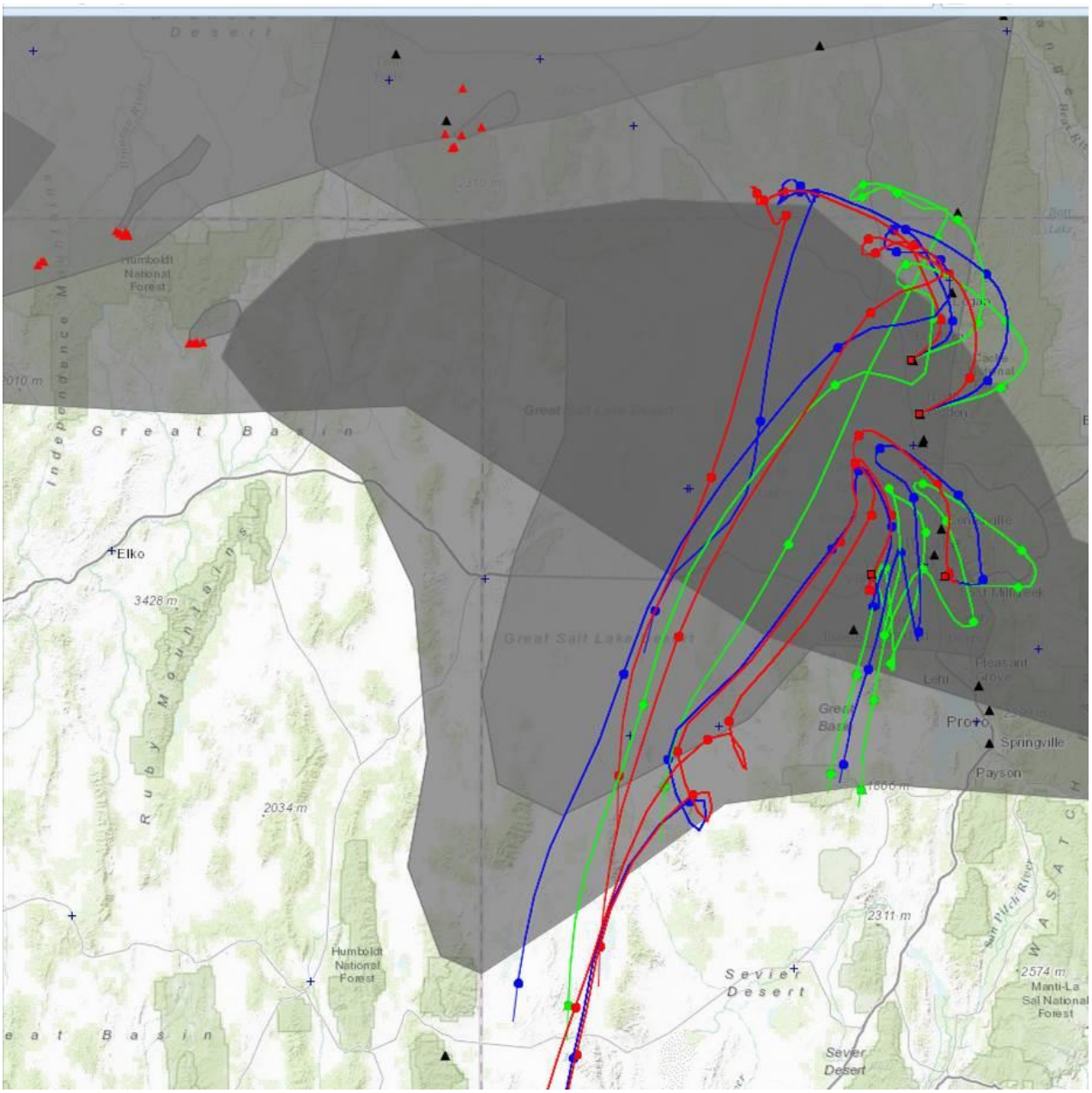


## Back Trajectory

The 48-hour back trajectory (at 10, 50 and 100 meters at 0500 MST) is plotted for each monitoring site using the EPA tool, AirNOW-Tech Navigator. Southerly winds transported smoke from the Pinyon and Faust fires to the monitoring stations 48-hours before the exceedances. Within 24-hours, there was a shift to the north transporting smoke most likely from Idaho fires.

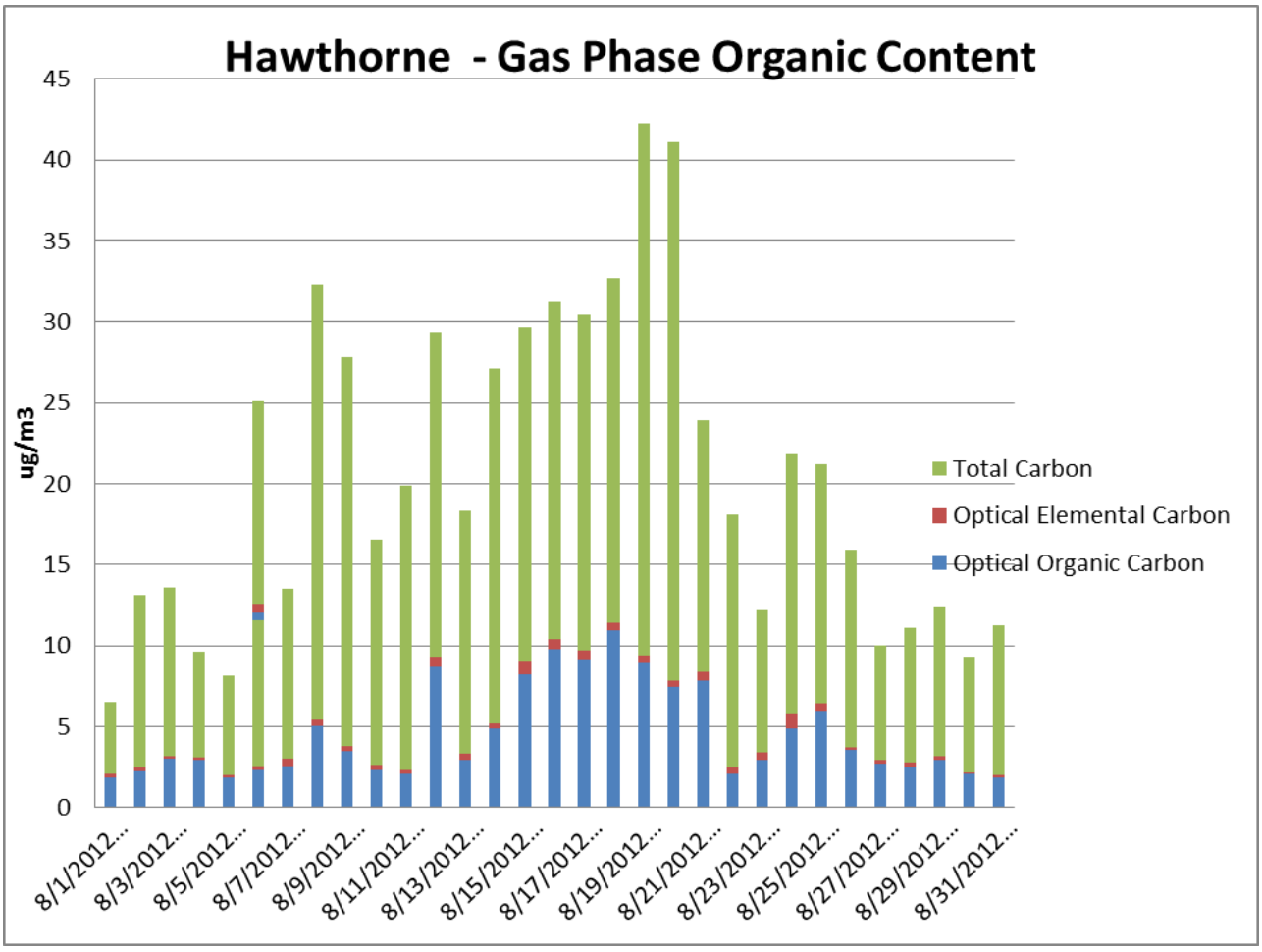


The same trajectories are shown overlaid with fire locations (red triangles) in Idaho and Nevada and smoke plumes (gray shading) as forecasted by the AirNOW-Tech Navigator. The Navigator does not show the Pinyon and Faust fires, it does however show smoke in that area. This image supports our assumption that the smoke that was transported to the monitoring stations shifted from the south (Pinyon and Faust fire smoke) to the north (Idaho fires) within 24-hours.



## *Fire Biomarker*

Organic carbon is a reliable biomarker, or indicator of wood smoke. This graph shows that the organic carbon, measured at the Hawthorne monitoring station, increased over six-fold on the event day, August 12th, from the day before.



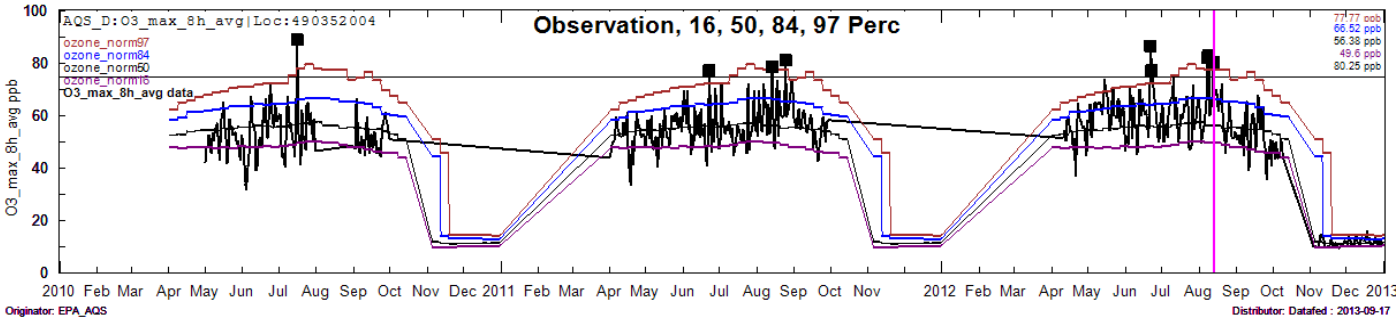
## *Historical Fluctuation*

Historical fluctuation plots are presented for each monitoring station. The plots were generated by the DataFed software program. DataFed is a web-based software that is designed to assist air quality analysts by drawing upon the EPA regulatory database AQS and atmospheric data. EPA has supported the tool development for exceptional events analysis.

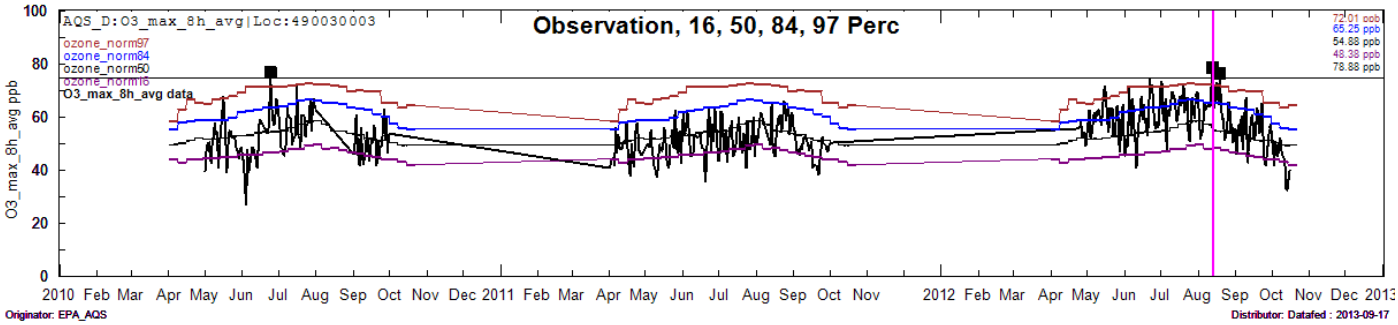
The pink vertical lines represent the exceptional event date. Black boxes represent ozone exceedances, while the black line shows the ozone standard. Historical fluctuation is shown as a series of plots based on the rolling average of the 16th, 50th, 84th, and 97th percentile, arranged from lowest to highest so that the 97th percentile is the top red line.

- Beach – 80 ppb
- Brigham city – 78 ppb
- Harrisville – 81 ppb
- Hawthorne – 82 ppb

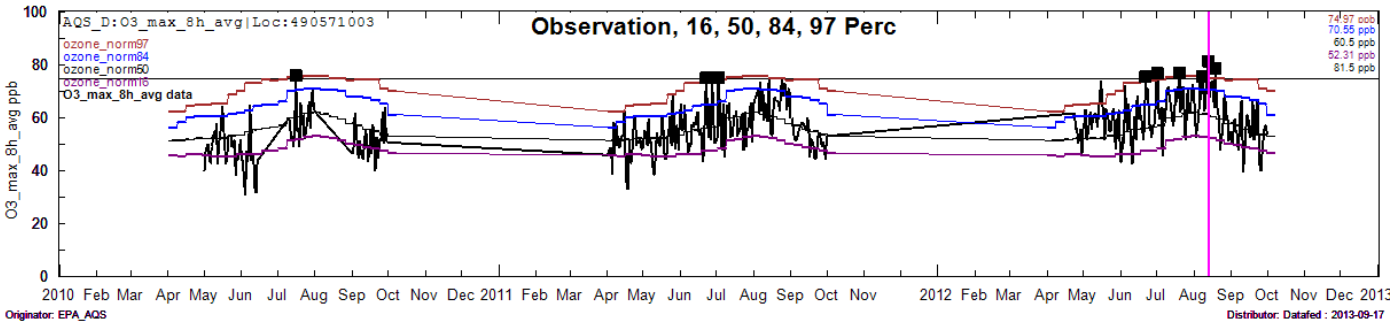
Beach - 80 ppb is above the 97th percentile.



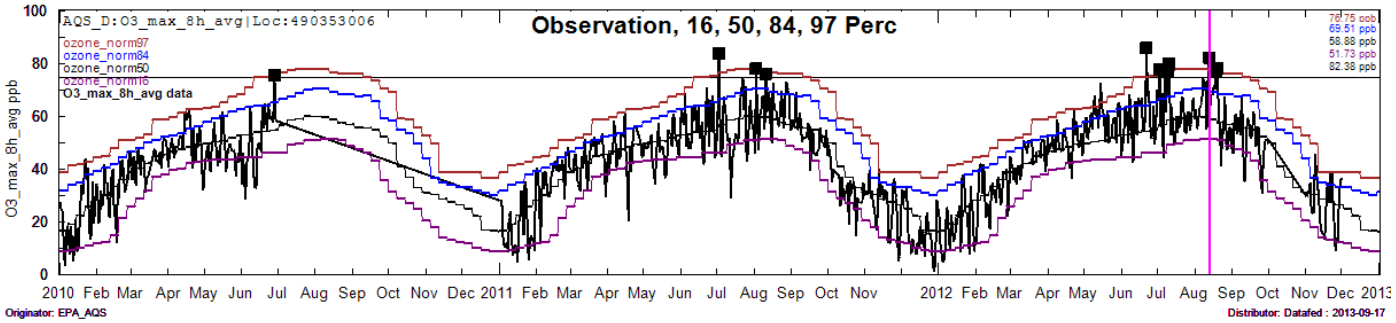

Brigham City – 78 ppb is above the 97th percentile.



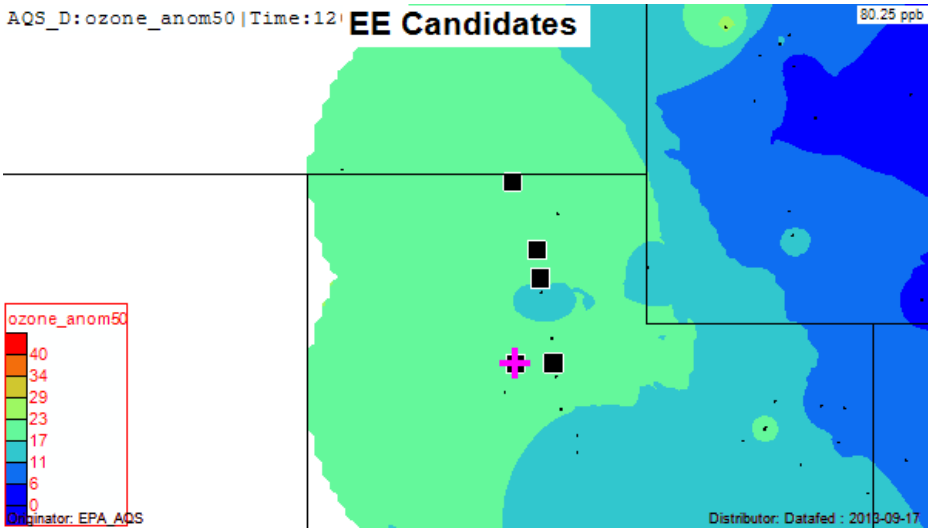

Harrisville - 81 ppb is above the 97th percentile.



Hawthorne – 82 ppb is above the 97th percentile.




DataFed has an exceptional events candidate feature (shown below) that predicts where exceptional events may occur and anomalous values that may be associated with the event. DataFed predicts that all four sites plus the Logan site are exceptional events candidates. The 8-hour zone value for Logan was just under the standard at 74 ppb.




The anomalous value predicted by DataFed that may be contributed to the event is 17 ppb. The following section will present a regression analysis that indicates the exceptional event contribution to be 16 ppb.

# No Exceedance But For the Event

## *Regression Analysis*

Dr. Dan Jaffe is professor of atmospheric and environmental chemistry at the University of Washington. Dr. Jaffe is actively engaged in ozone transport research. Jaff et. Al., have developed a regression model that will be published in the Environmental Science & Technology journal where the residual values represent the ozone contribution from wildfire. According to the regression analysis for this event in Salt Lake and Utah counties, wildfires contributed 16 ppb of ozone. Assuming continuity across the Wasatch Front, if we subtract 16 ppb from each monitoring station value, the ozone levels fall below the 75 ppb standard.

- Beach: 80 – 16 = 64 ppb
- Brigham city: 78 – 16 = 62 ppb
- Harrisville: 81 – 16 = 65 ppb
- Hawthorne: 82 – 16 = 66 ppb

Dr. Jaffe's regression analysis can be found in the Appendix.

## *No Unusual Local Emissions*

DAQ staff evaluated compliance records for the event day and staff found no evidence to suggest that anthropogenic emission-generating activities differed significantly between the event day and non-event day. No violations were issued for ozone related contribution activities on or about the event day.

Burning is prohibited during this time of the year. Compliance records show that no violations of the burning rule occurred.

The DAQ meteorology staff issued a yellow-voluntary action air quality alert for the event day. During yellow alert days, the public is asked to reduce driving and use mass transit.

The only difference from the typical emissions pattern was the presence of the wildfire smoke.

# Conclusions

1. The ozone exceedances meet the definition of an exceptional event because it:

- ❖ Affected air quality;
- ❖ Was due to natural wildfires that are not reasonably controllable or preventable; and
- ❖ The wildfires were caused by lightning strikes which are defined in the rule as a natural event.

2. The ozone exceedance data can be excluded because:

- ❖ The event was not reasonably preventable;
- ❖ A weight of evidence approach was presented that supports a clear, causal relationship between the 8-hour ozone concentrations at the impacted monitors and the specified event;
- ❖ The measured values were in excess of normal historical fluctuations;
- ❖ There were no unusual anthropogenic emissions other than the wildfire smoke; and
- ❖ No exceedance would have occurred but for the event based on compliance records showing no unusual emissions and the regression and DataFed analyses that indicate that wildfire smoke contributed to ozone levels to exceed the standard.

# Mitigation

The Exceptional Events Rule requires states to "take appropriate and reasonable actions to protect public health from exceedances or violations of the national ambient air quality standards." The intent of this section is to describe the State of Utah's air quality public health protection programs.

## *Utah Air Quality Public Notifications*

The DAQ website includes air quality forecasting for today and the next two days. The Air Monitoring Center (AMC) provides air pollution information based on daily air quality status. The AMC data is used to determine the relationship of existing pollutant concentrations to the National Ambient Air Quality Standards. There is a three tiered air quality alert system: Green, Yellow (alert days), and Red (actions days). There are five health advisory categories: good, moderate, unhealthy advisories for sensitive groups, and very unhealthy. The AMC advisory is calculated for five major pollutants including ground-level ozone, particulate pollution (particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide. The index also incorporates recommendations for actions to take on days when concentrations are in the red zone, to mitigate the effects of pollution for affected groups and recommendations for industry and citizens that help reduce pollution levels. The outreach program information consolidated in the three day forecast includes the Summer and Winter Control Programs and Choose Clean Air information, as well as consideration for natural hazards like wildfires and dust storms. The web site includes additional information natural hazards.

The UDEQ also offers an electronic mail server (Listserv). Subscribers are automatically notified by e-mail when unhealthy air pollution levels are forecast for the Wasatch Front.

In addition to web site alerts, DAQ also notifies the media in order to maximize public distribution.

# APPENDIX

# REGRESSION ANALYSIS