Technical Support Document for the April 16, 2013, Telluride Exceptional Event

Colorado Department of Public Health and Environment

Prepared by the Technical Services Program
Air Pollution Control Division
Colorado Department of Public Health and Environment

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Executive Summary

In 2005, Congress identified a need to account for events that result in exceedances of the National Ambient Air Quality Standards (NAAQS) that are exceptional in nature (e.g., not expected to reoccur or caused by acts of nature beyond man-made controls). In response, EPA promulgated the Exceptional Events Rule (EER) to address exceptional events in 40 CFR Parts 50 and 51 on March 22, 2007 (72 FR 13560). On May 2, 2011, in an attempt to clarify this rule, EPA released draft guidance documents on the implementation of the EER to State, tribal and local air agencies for review. The EER allows for states and tribes to "flag" air quality monitoring data as an exceptional event and exclude those data from use in determinations with respect to exceedances or violations of the NAAQS, if EPA concurs with the demonstration submitted by the flagging agency.

Due to the semi-arid nature of parts of the state, Colorado is highly susceptible to windblown dust events. These events are often captured by various air quality monitoring equipment throughout the state, sometimes resulting in exceedances or violations of the 24-hour PM_{10} NAAQS. This document contains detailed information about the large regional windblown dust event that occurred on April 16, 2013. The Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD) has prepared this report for the U.S. Environmental Protection Agency (EPA) to demonstrate that the elevated PM_{10} concentrations were caused by a natural event.

On April 16, 2013, a powerful spring storm system caused multiple exceedances of the twenty-four hour PM_{10} NAAQS in west-central and southwest Colorado. These PM_{10} sample values include Telluride (265 $\mu g/m^3$), Durango (419 $\mu g/m^3$), Pagosa Springs (295 $\mu g/m^3$), Alamosa Adams State College (237 $\mu g/m^3$), and Mt. Crested Butte (187 $\mu g/m^3$). For this report, the focus was on Telluride (08-113-0004). A report will be developed at a later date for other locations.

All of the noted April 16, 2013, twenty-four-hour PM_{10} concentrations were above the 99th percentile concentrations for their locations. The statistical and meteorological data clearly shows that but for this regional high wind blowing dust event, Telluride would not have exceeded the 24-hour NAAQS on April 16, 2013.

Specifically, the high value in Telluride on April 16, 2013, was the consequence of strong southwesterly prefrontal winds in combination with dry conditions, which caused significant blowing dust across much of Arizona, northwest New Mexico, southeast Utah and southwest Colorado. Widespread restrictions to visibility occurred in southwest Colorado on that day.

EPA's June 2012 *Draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule* states "the EPA will accept a threshold of a sustained wind of 25 mph for areas in the west provided the agencies support this as the level at which they expect stable surfaces (i.e., controlled anthropogenic and undisturbed natural surfaces) to be overwhelmed..." In addition, in both eastern and western Colorado it has been shown that wind speeds of 30 mph or greater and gusts of 40 mph or greater can cause blowing dust (see reference for the Technical Support Document for the January 19, 2009 Lamar Exceptional Event and Appendix A - Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). For this blowing dust event, hourly wind speeds of 50 mph and gust to 66 mph were recorded in the area.

The Albuquerque, Flagstaff, and Grand Junction NWS Forecast Offices issue weather warnings and advisories for northeast Arizona, most of New Mexico, eastern Utah, and western and southwestern Colorado. The APCD also issued blowing dust advisories for April 16, 2013.

The blowing dust climatology for the Four Corners area indicates that the area can be susceptible to blowing dust when winds are high. Landform imagery shows that northeastern Arizona and southeastern Utah in particular have experienced a long-term pattern of wind erosion and blowing dust when winds have been southwesterly and blowing into western and southern Colorado. Forecast products from the Navy Aerosol Analysis and Prediction System model provide evidence for a widespread blowing dust event in the Four Corners states, suggesting that significant source regions for dust in Colorado are located in arid regions of Arizona, New Mexico and Utah. NOAA HYSPLIT forward and backward trajectories provide clear supporting evidence that dust from desert regions of Arizona, northwest New Mexico and southeast Utah caused the PM_{10} exceedances measured across portions of west-central and southwest Colorado on April 16, 2013.

MODIS and GOES satellite imagery show that the Painted Desert and Four Corners area in general were source regions for the blowing dust on April 16, 2013. This is consistent with the climatology for many dust storms in Colorado as described in the Grand Junction, Colorado, Blowing Dust Climatology report. The Drought Monitor map of the western U.S. for April 16, 2013, shows that soils across northeastern Arizona, most of Utah, and parts of western Colorado had below normal soil moisture. The observations of winds above blowing dust thresholds and restricted visibilities in the areas of concern demonstrate that this is a natural event that cannot be reasonably controlled or prevented.

The Center for Snow and Avalanche Studies has been studying the effects of wind-blown desert dust from Arizona, New Mexico, and Utah on snowpack albedo and snowmelt in the San Juan Mountains of Colorado. The Center for Snow and Avalanche Studies lists April 16, 2013, as a Dust-on-Snow event for the 2012/2013 water year. In addition, the snow depth analysis illustrates that the mountains surrounding Telluride had 16 to 100 inches of snow cover in the hours before the dust storm of April 16, 2013. These data provide strong evidence that a widespread, regional, blowing dust event caused exceedances at these locations rather than local sources.

Friction velocities provide a measure of the near-surface meteorological conditions necessary to cause blowing dust. Friction velocities were high enough to sustain blowing dust over undisturbed soils in northern Arizona, northwest New Mexico, southeast Utah, and west-central and southwest Colorado during this event.

The PM_{10} exceedance in Telluride on April 16, 2013, would not have occurred if not for the following: (a) dry soil conditions over northeast Arizona, northwest New Mexico, most of Utah, and parts of western Colorado with 30-day precipitation totals below the threshold identified as a precondition for blowing dust in northeastern Arizona; (b) a surface low pressure system and cold front that were associated with a strong upper-level trough that caused strong prefrontal surface winds over the area of concern; and (c) friction velocities over regions of northern Arizona, northwest New Mexico, and southeast Utah that were high enough to allow entrainment of dust from natural sources with subsequent transport of the dust to Colorado in strong winds. The PM_{10} exceedances at Telluride and other locations were due to an exceptional event associated with regional windstorm-caused emissions from erodible soil sources over a large area of northeast Arizona, northwest New Mexico, most of Utah, and parts of western Colorado. These sources are not reasonably controllable during a significant windstorm under abnormally dry or moderate drought conditions.

APCD is requesting concurrence on exclusion of the 265 μg/m^3 PM_{10} value from Telluride (08-113-0004) on April 16, 2013. (APCD will request concurrence on exclusion of other PM_{10} values taken on the same day at a later date.)

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1.0 Exceptional Events Rule Requirements

In addition to the technical requirements that are contained within the EER, procedural requirements must also be met in order for EPA to concur with the flagged air quality monitoring data. This section of the report lays out the requirements of the EER and discusses how the APCD addressed those requirements.

1.1 Procedural Criteria

This section presents a review of the procedural requirements of the EER as required by 40 CFR 50.14 (Treatment of Air Quality Monitoring Data Influenced by Exceptional Events) and explains how APCD fulfills them.

The Federal EER requirements include public notification that an event was occurring, the placement of informational flags on data in EPA's Air Quality System (AQS), submission of initial event description, the documentation that the public comment process was followed, and the submittal of a demonstration supporting the exceptional events flag. ACPD has addressed all of these procedural and documentation requirements.

Public notification that event was occurring (40 CFR 50.14(c)(1)(i))

APCD issued Blowing Dust Advisories for Western and South Central Colorado advising citizens of the potential for high wind/dust events on April 16, 2013. This area includes: Telluride, Alamosa, Durango, Pagosa Springs and Crested Butte. The advisories that were issued on April 16, 2013, can be viewed at: http://www.colorado.gov/airquality/forecast_archive.aspx?seeddate=04%2f16%2f2013 and are included in Appendix B.

Place informational flag on data in AQS (40 CFR 50.14(c)(2)(ii))

APCD and other applicable agencies in Colorado submit data into EPA's AQS. Data from both filter-based and continuous monitors operated in Colorado are submitted to AQS.

When APCD and/or another agency operating monitors in Colorado suspects that data may be influenced by an exceptional event, APCD and/or the other operating agency expedites analysis of the filters collected from the potentially-affected filter-based air monitoring instruments, quality assures the results and submits the data into AQS. APCD and/or other operating agencies also submit data from continuous monitors into AQS after quality assurance is complete.

If APCD and/or the applicable operating agency have determined a potential exists that the sample value has been influenced by an exceptional event, a preliminary flag is submitted for the measurement when the data is uploaded to AQS. The data are not official until they are certified by May 1st of the year following the calendar year in which the data were collected (40 CFR 58.15(a)(2)). The presence of the flag can be confirmed in AQS.

Notify EPA of intent to flag through submission of initial event description by July 1 of calendar year following event (40 CFR 50.14(c)(2)(iii))

In early 2011, APCD and EPA Region 8 staff agreed that the notification of the intent to flag data as an exceptional event would be done by submitting data to AQS with the proper flags and the initial event descriptions. This was deemed acceptable, since Region 8 staff routinely pull the data to review for completeness and other analyses.

On April 16, 2013, PM_{10} sample values greater than 150 $\mu g/m^3$ were taken at multiple sites across southwestern Colorado during the high wind event that occurred that day. In addition to the monitor located in Telluride, these monitors included Durango, Pagosa Springs, Alamosa (at Adams State

College), Crested Butte and Mt. Crested Butte. All of these monitors are operated by APCD in partnership with local operators.

Document that the public comment process was followed for event documentation (40 CFR 50.14(c)(3)(iv))
APCD posted this report on the Air Pollution Control Division's webpage for public review. APCD opened a 30-day public comment period on August 30, 2013. Email notification was also provided to local officials. Any comments received will be submitted to EPA, consistent with the requirements of 40 CFR 50.14(c)(3)(iv).

Submit demonstration supporting exceptional event flag (40 CFR 50.14(a)(1-2))
At the close of the comment period, and after APCD has had the opportunity to consider any comments submitted on this document, APCD will submit this document, along with any comments received (if applicable), and APCD's responses to those comments, to EPA Region VIII headquarters in Denver, Colorado. The deadline for the submittal of this demonstration package is June 30, 2016.

1.2 Documentation Requirements

Section 50.14(c)(3)(iv) of the EER states that in order to justify excluding air quality monitoring data, evidence must be provided for the following elements:

a. The event satisfies the criteria set forth in 40 CFR 501(j) that:
   (1) the event affected air quality,
   (2) the event was not reasonably controllable or preventable, and
   (3) the event was caused by human activity unlikely to recur in a particular location or was a natural event;
b. There is a clear causal relationship between the measurement under consideration and the event;
c. The event is associated with a measured concentration in excess of normal historical fluctuations; and
d. There would have been no exceedance or violation but for the event.

2.0 Meteorological analysis of the April 16, 2013, blowing dust event and PM_{10} exceedance – Conceptual Model and Wind Statistics

On April 16 of 2013, a powerful spring storm system caused an exceedance of the twenty-four hour PM_{10} standard at multiple monitors in south-central and southwest Colorado, including Telluride which reported a concentration of 265 $\mu g/m^3$. This high reading and other PM_{10} concentrations across Colorado are plotted on the map for April 16, 2013, in Figure 1. The exceedances were the consequence of high winds from an intense area of surface low pressure system combined with a vigorous cold front. These surface features were associated with a deep upper-level trough that was moving across the western United States. The surface winds were predominantly out of a south to southwesterly direction and moved over dry soils in northeast Arizona and northwest New Mexico producing significant blowing dust. This single storm system caused blowing dust during various time intervals on April 16, 2013, but was most prolific during the late morning and afternoon hours.

EPA's June 2012, draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule states "the EPA will accept a threshold of a sustained wind of 25 mph for areas in the west provided the agencies support this as the level at which they expect stable surfaces (i.e., controlled anthropogenic and undisturbed natural surfaces) to be overwhelmed…". In addition, in both eastern and western Colorado it has been shown that wind speeds of 30 mph or greater and gusts of 40 mph or greater can cause blowing dust (see reference for the Technical Support Document for the January 19, 2009 Lamar Exceptional Event and Appendix A – Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). For this blowing dust event, it has been assumed that sustained winds of 30 mph and higher or wind gusts of 40 mph and higher can cause blowing dust in northeast Arizona, northwest New Mexico and southwest Colorado.

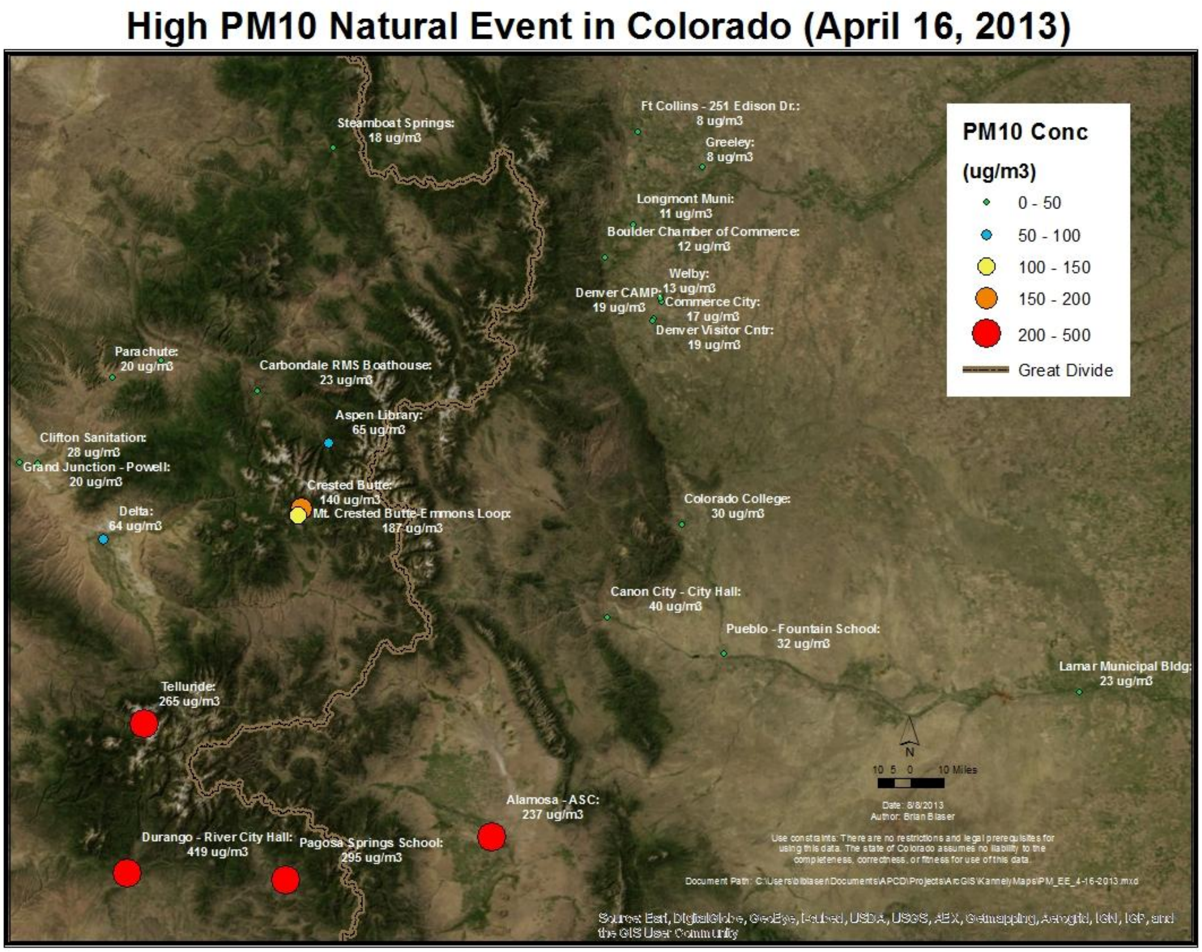


Figure 1: 24-hour PM_{10} concentrations for April 16, 2013**.**

The surface weather associated with the storm system of April 16, 2013, is presented in Figure 2, Figure 3 and Figure 4 - the surface analyses for 5 PM MST April 15, 2013, and 5 AM and 5 PM MST April 16, 2013 respectively. Significant surface features during this period of time included a stationary front draped across southwest Colorado and southern sections of Utah and Nevada. Surface low pressure along this front strengthened and moved northeastward into central Colorado. A cold front also developed in the southwestern United States which eventually moved into southwest Colorado by the afternoon of April 16, 2013.

The upper level trough associated with this storm system is shown in Figure 5 through Figure 8. Figure 5 and Figure 6 show the 700-mb height analysis maps for 5 PM MST April 15, 2013, and 5 AM MST April 16, 2013, respectively, while Figure 7 and Figure 8 display the 500 mb height analysis maps for the same time period. The 700 mb level is roughly 3 kilometers above mean sea level (MSL) and the 500 mb level is generally located approximately 6 kilometers above MSL. These four charts show that a deep trough of low pressure was present in the upper levels of the atmosphere preceding the blowing dust event of April 16, 2013, and that it was moving into the southwestern United States.

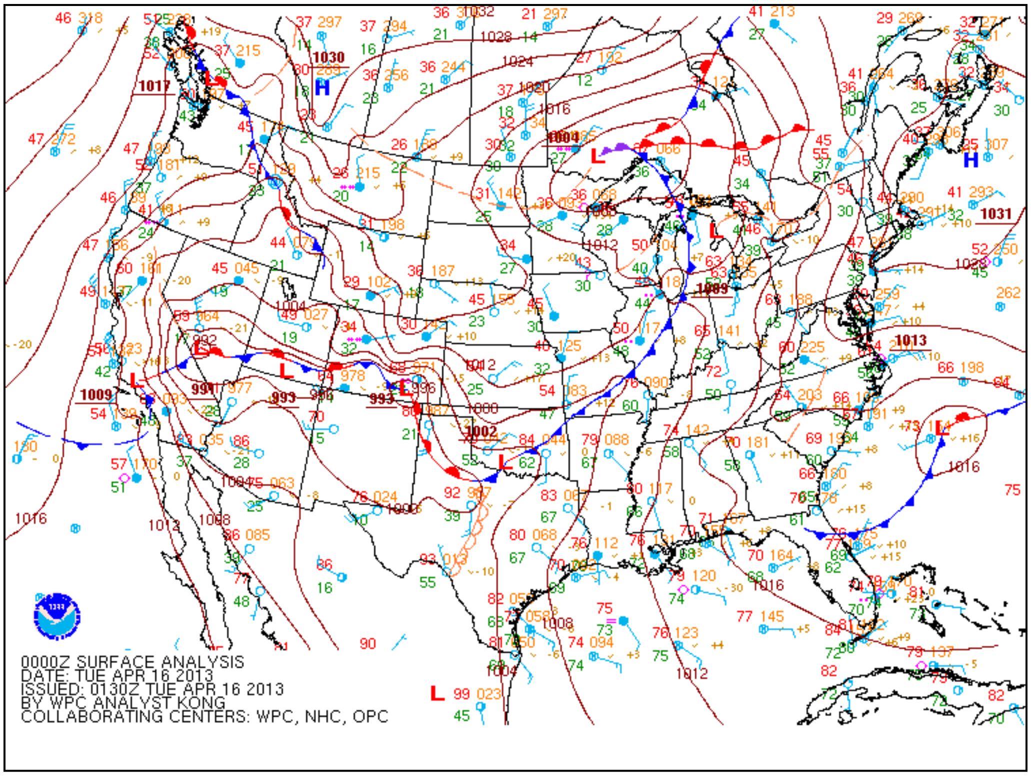


Figure 2: Surface Analysis for 00Z April 16, 2013, or 5 PM MST April 15, 2013.
(source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

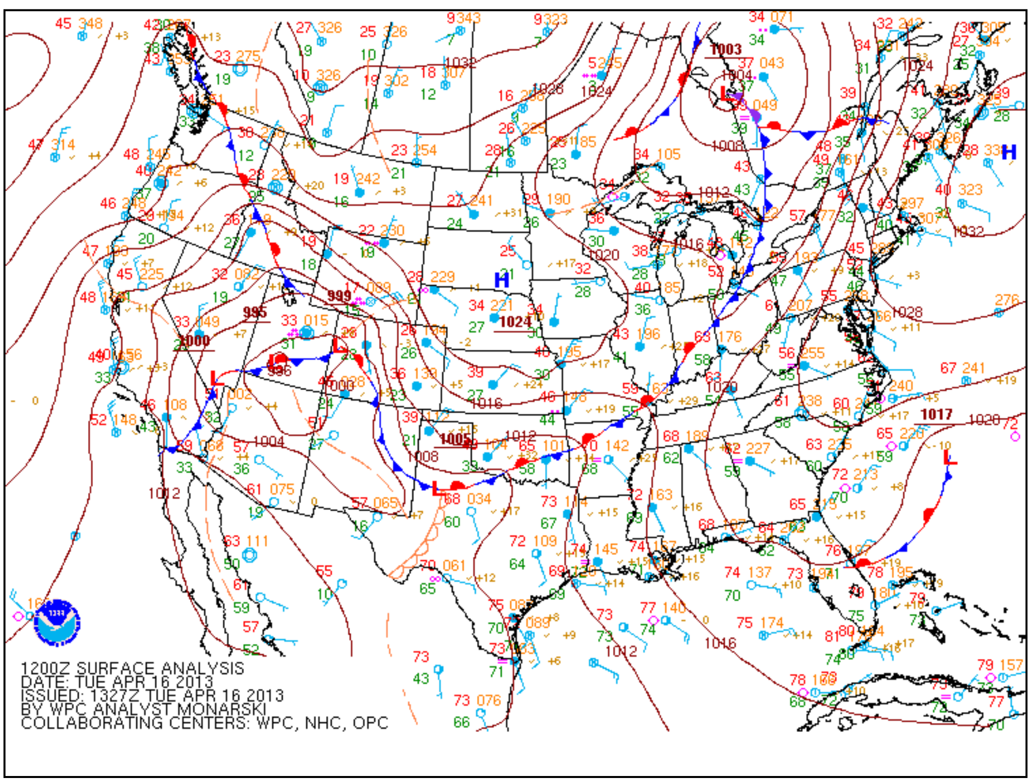


Figure 3: Surface Analysis for 12Z April 16, 2013, or 5 AM MST April 16, 2013.
(source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

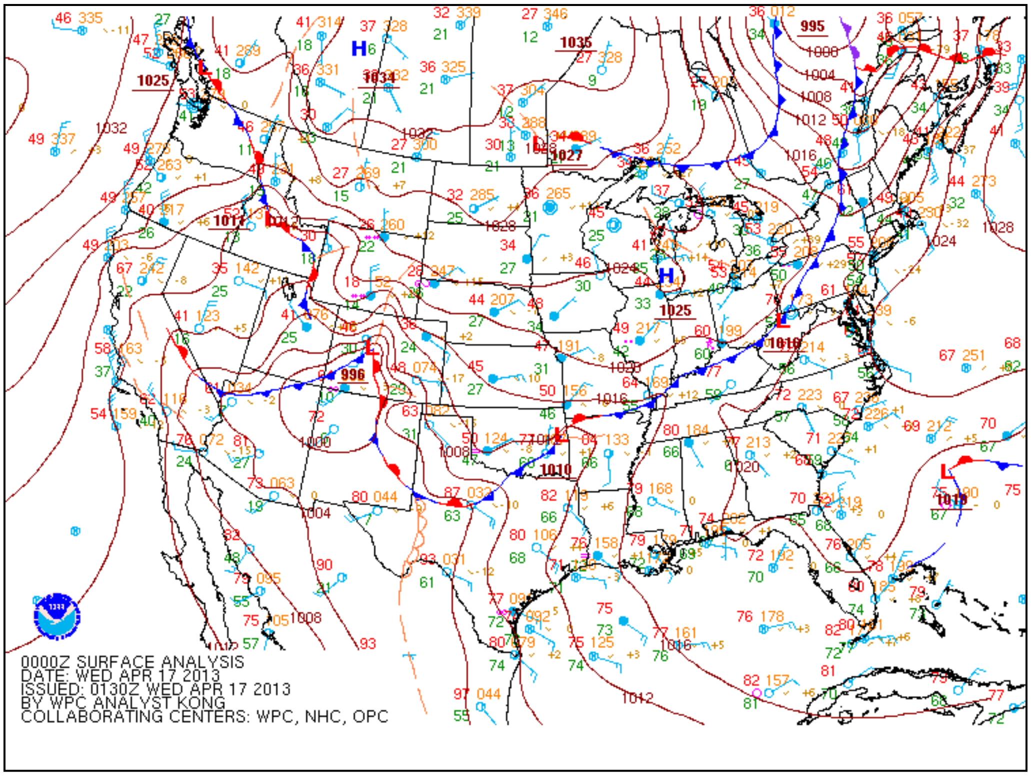


Figure 4: Surface Analysis for 00Z April 17, 2013, or 5 PM MST April 16, 2013.
(source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

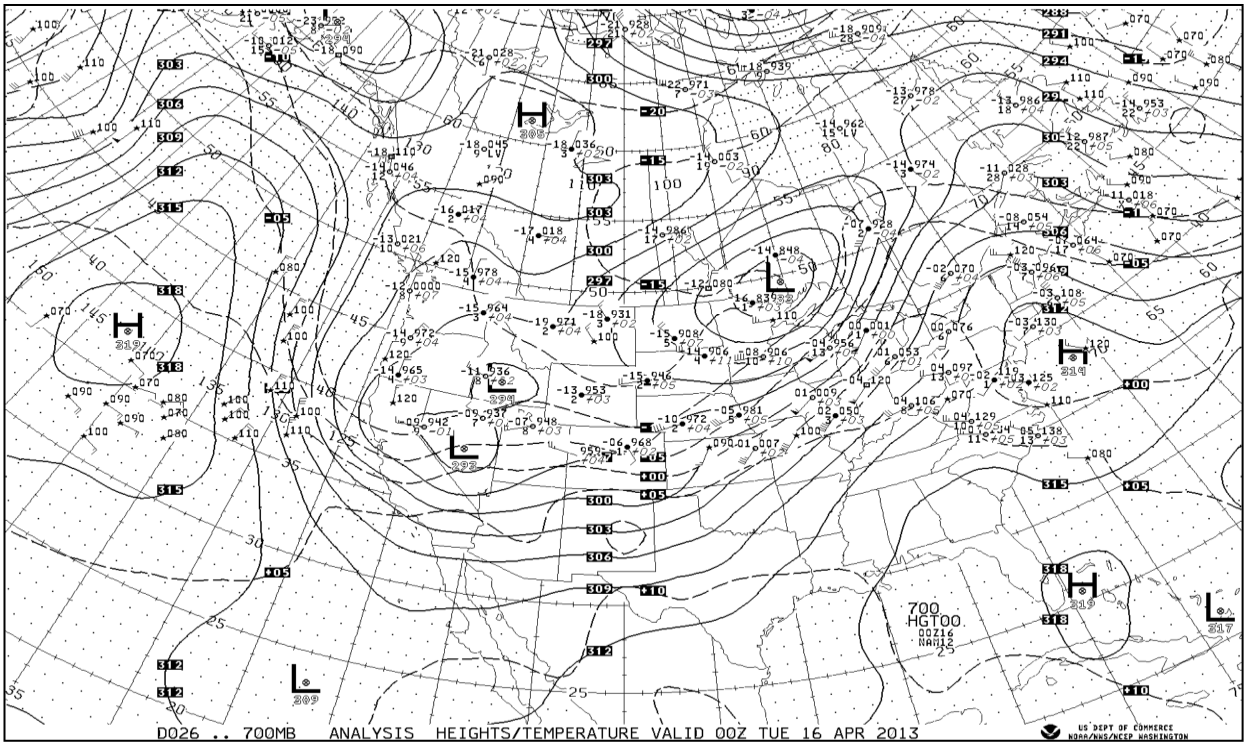


Figure 5: 700 mb (about 3 kilometers above mean sea level) analysis for 00Z April 16, 2013, or 5 PM MST April 15, 2013.

(source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

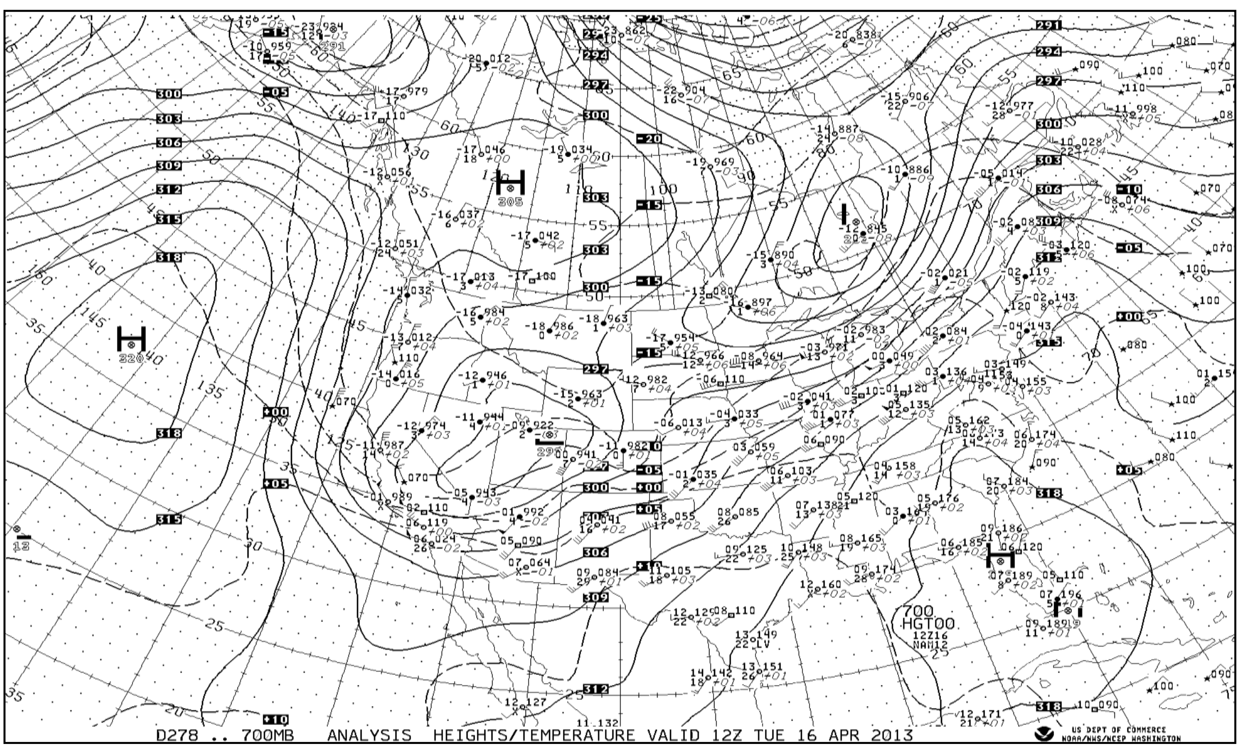


Figure 6: 700 mb (about 3 kilometers above mean sea level) analysis for 12Z April 16, 2013, or 5 AM MST April 16, 2013.

(source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

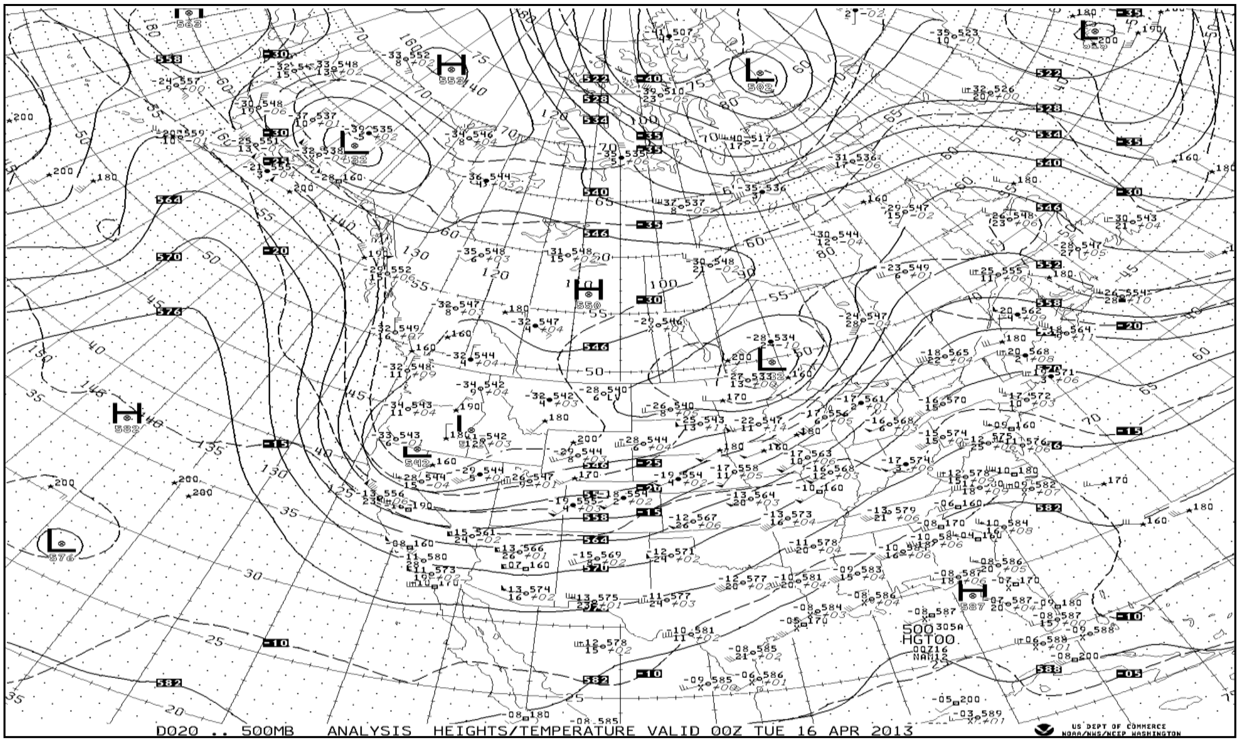


Figure 7: 500 mb (about 6 kilometers above mean sea level) analysis for 00Z April 16, 2013, or 5 PM MST April 15, 2013.
(source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

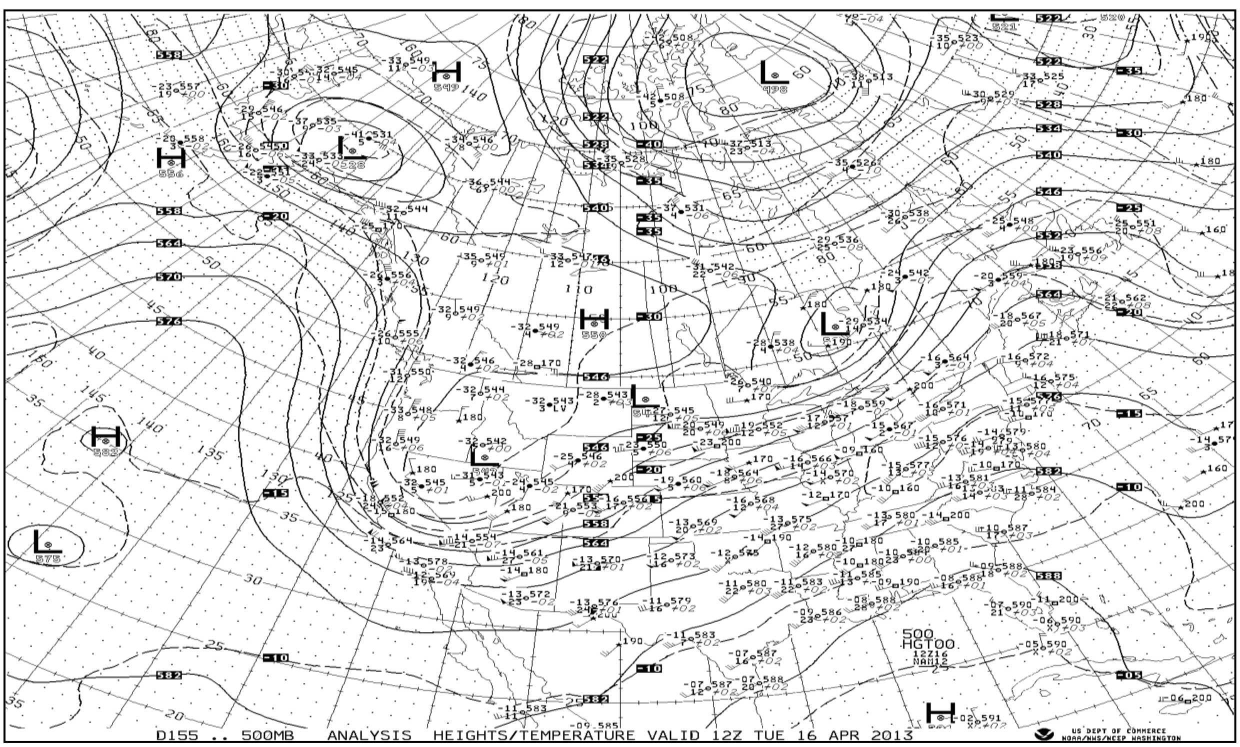


Figure 8: 500 mb (about 6 kilometers above mean sea level) analysis for 12Z April 16, 2013, or 5 AM MST April 16, 2013.
(source: http://nomads.ncdc.noaa.gov/ncep/NCEP)

Figure 9, Figure 10 and Figure 11 show the NARR (North American Regional Reanalysis) jet stream maximum winds rotating around the base of the 700 mb trough at 11pm MST April 15, 2013, and 5am and 11am MST April 16, 2013, respectively. At the 700 mb level, peak winds stretched from southern California northeastward into western New Mexico. This jet streak included a broad area of 40-60 knot winds located over the arid Four Corners region of Arizona, New Mexico, Utah and Colorado with the most intense wind bands over the Painted Desert of northeast Arizona. Figure 12 shows the 500 mb trough and corresponding wind speeds at 11am MST April 16, 2013. A very strong band of 500 mb winds near the base of the trough can once again be found over the Four Corners, ranging anywhere from 60 to 100 knots.

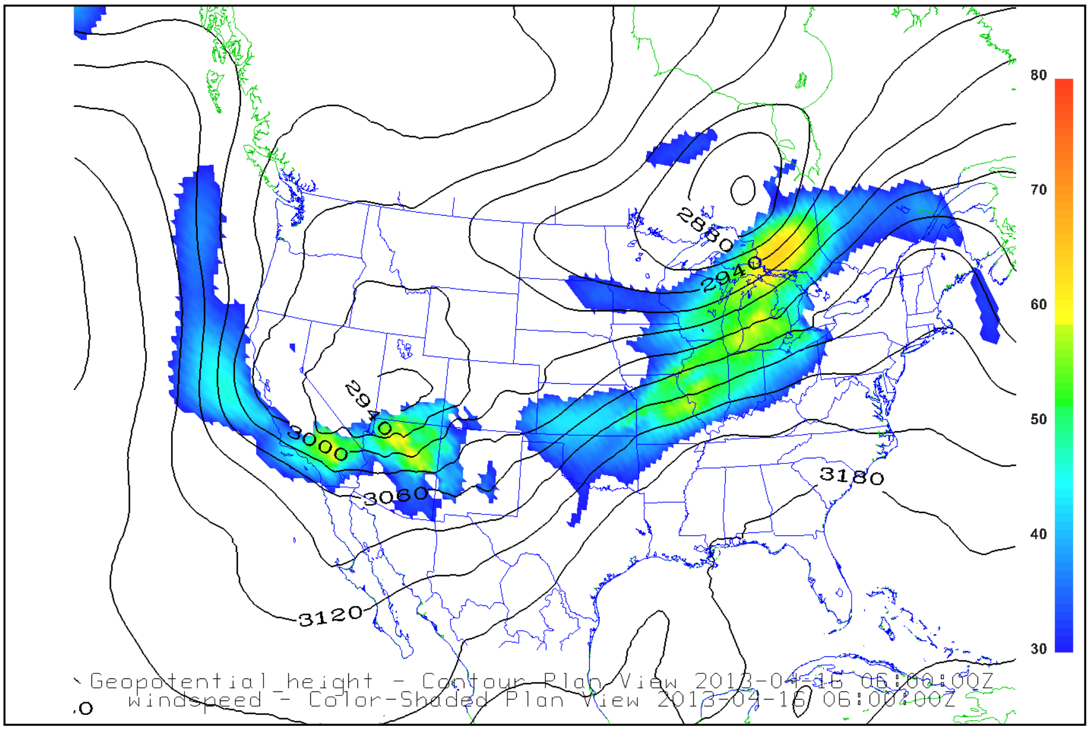


Figure 9: NARR 700 mb analysis for 06Z April 16, 2013, or 11 PM MST April 15, 2013, showing wind speeds in knots.
(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)

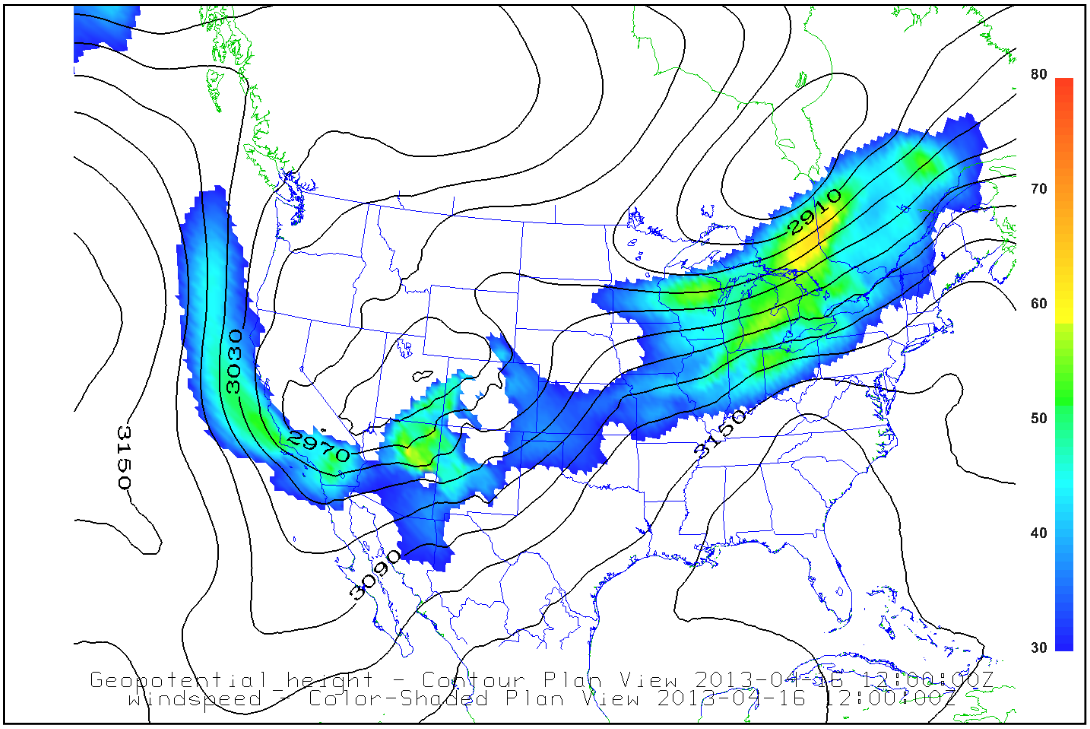


Figure 10: NARR 700 mb analysis for 12Z April 16, 2013, or 5 AM MST April 16, 2013, showing wind speeds in knots.

(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)

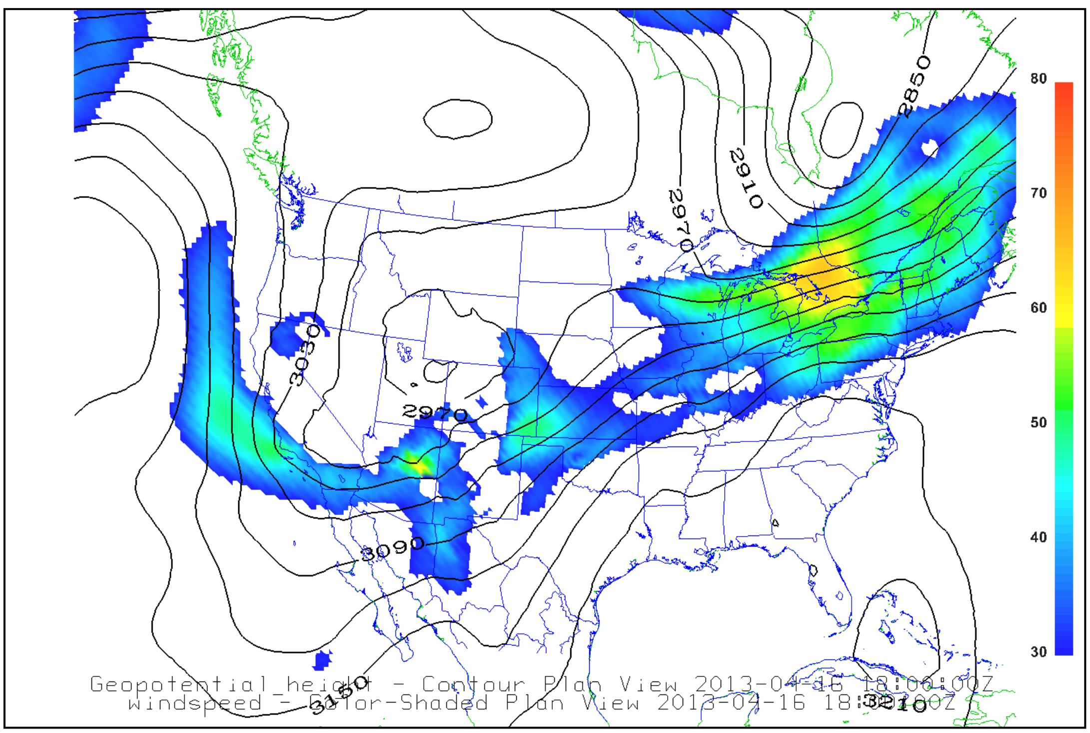


Figure 11: NARR 700 mb analysis for 18Z April 16, 2013, or 11 AM MST April 16, 2013, showing wind speeds in knots.

(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)

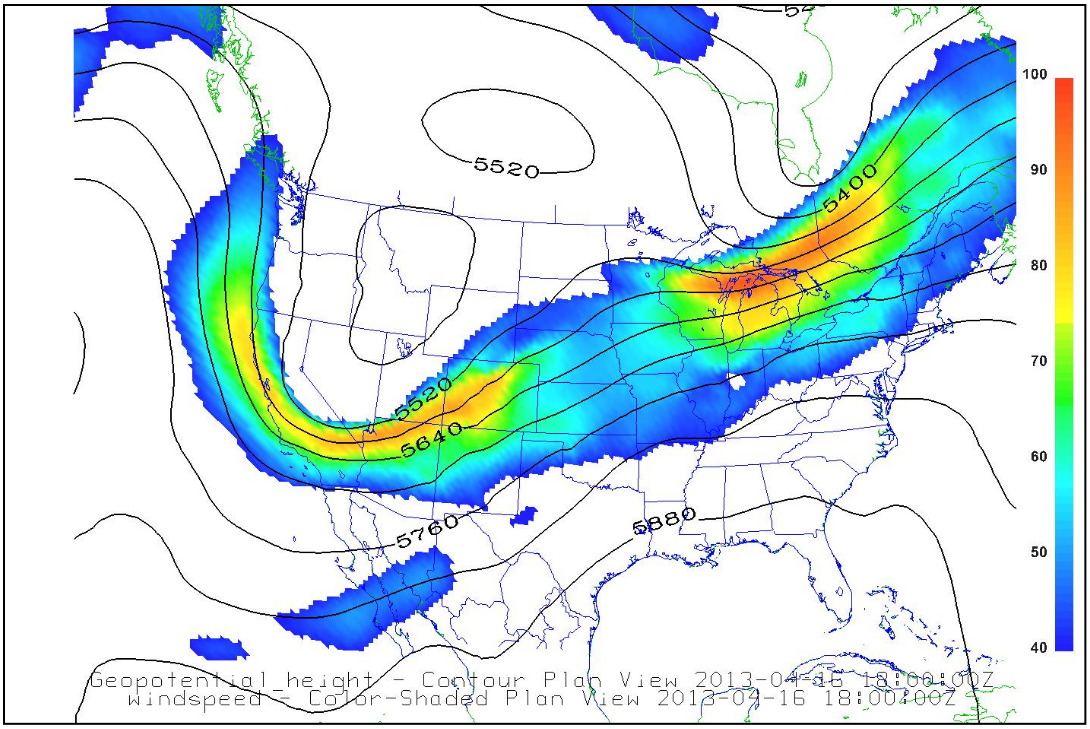


Figure 12: NARR 500 mb analysis for 18Z April 16, 2013, or 11 AM MST April 16, 2013, showing wind speeds in knots.
(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)

The upper level trough (observed at both the 700 and 500 mb level) affected winds near the surface in two ways. First, it intensified a surface low-pressure system (shown in Figure 2 through Figure 4) with tight pressure gradients which produced strong winds at the surface. Second, momentum associated with the strong winds aloft at the base of the trough was transferred to the surface because of deep vertical mixing in the area of the strong winds aloft. Figure 13, Figure 14 and Figure 15 show the height of the top of the mixed layer in kilometers above MSL at 11 PM MST on April 15, 2013, and 5 AM and 11 AM MST on April 16, 2013, respectively. In Figure 13 and Figure 14, mixing of 3 to 6 kilometers above MSL is located over the Four Corners. Mixing to this degree would have been sufficient to transfer momentum to the surface from the zone of strong winds at 700 mb located over the Four Corners during the same time frame (Figure 9 and Figure 10). By 11 AM MST on April 16, 2013, (Figure 15), mixing had increased significantly over the region to 5 to 7 kilometers above MSL. This magnitude of deep mixing would have allowed the transport of not only the strong 700 mb winds over the Four Corners shown in Figure 11, but also the very intense 500 mb winds shown in Figure 12 down to the surface.

The combination of strong winds aloft, deep mixing and the tight pressure gradients associated with the surface low pressure system caused surface winds of up to 50 mph across the region with gusts to 66 mph. Winds of this strength can easily cause blowing dust if soils are dry. Recall that wind speeds of 30 mph or greater and/or gusts of 40 mph or higher have been shown to cause blowing dust in Colorado (see reference for the *Technical Support Document for the January 19, 2009, Lamar Exceptional Event* and Appendix A - Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). When blowing dust occurs with strong winds at the surface and aloft combined with deep mixing as was observed during the April 16, 2013, event, dust can be suspended for many hours and transported long distances. These conditions are the hallmarks of a regional dust transport event.

The synoptic weather conditions on April 16, 2013, (illustrated in Figure 3 through Figure 15) show that the conditions necessary for widespread strong gusty winds and transport of blowing dust were in place over the area of concern.

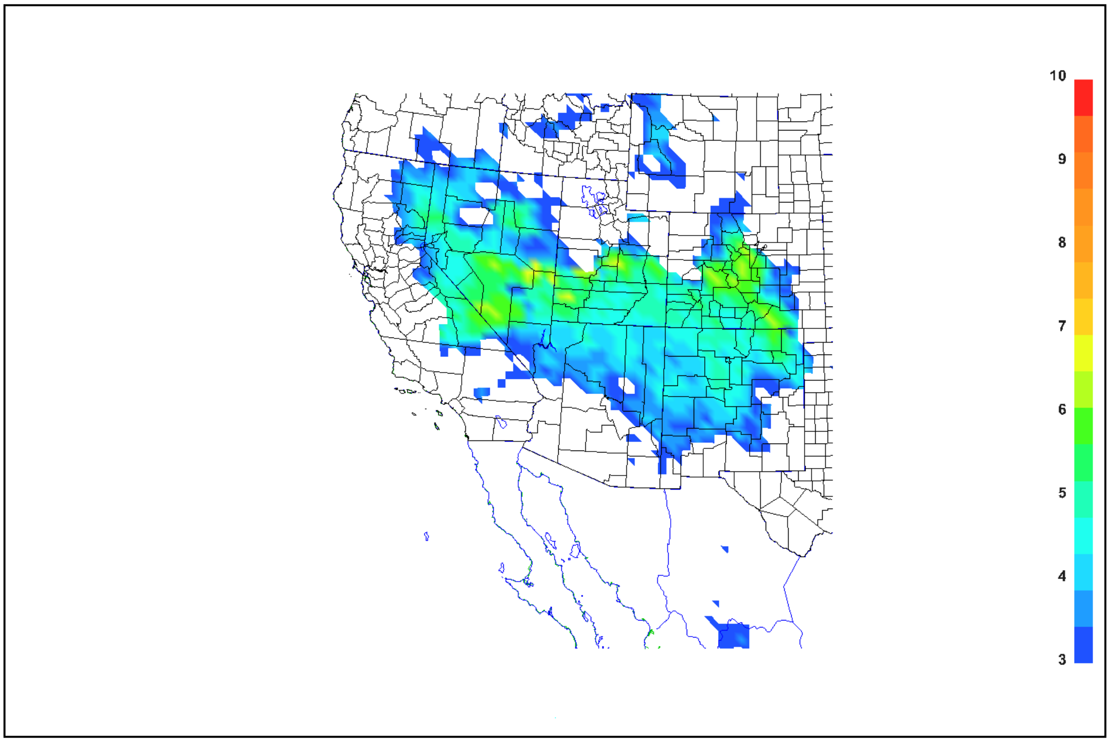


Figure 13: Height of the mixed layer in kilometers above mean sea level from the NARR at 06Z April 16, 2013, or 11 PM MST April 15, 2013.
(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)

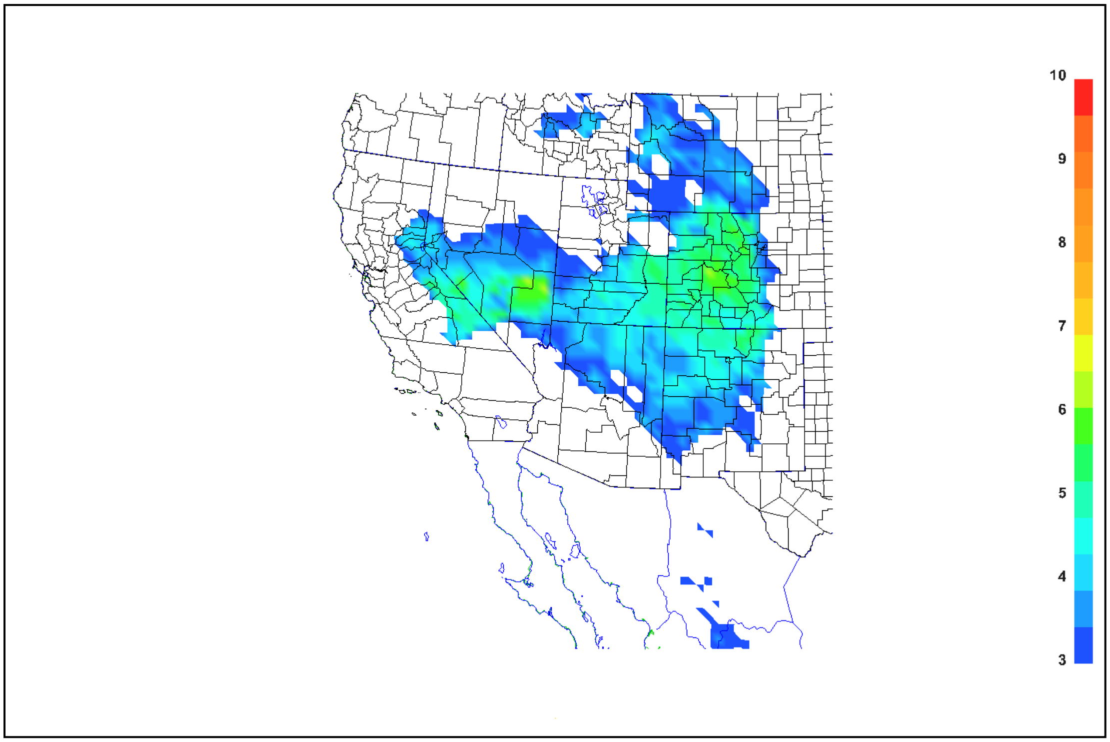


Figure 14: Height of the mixed layer in kilometers above mean sea level from the NARR at 12Z April 16, 2013, or 5 AM MST April 16, 2013.
(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)

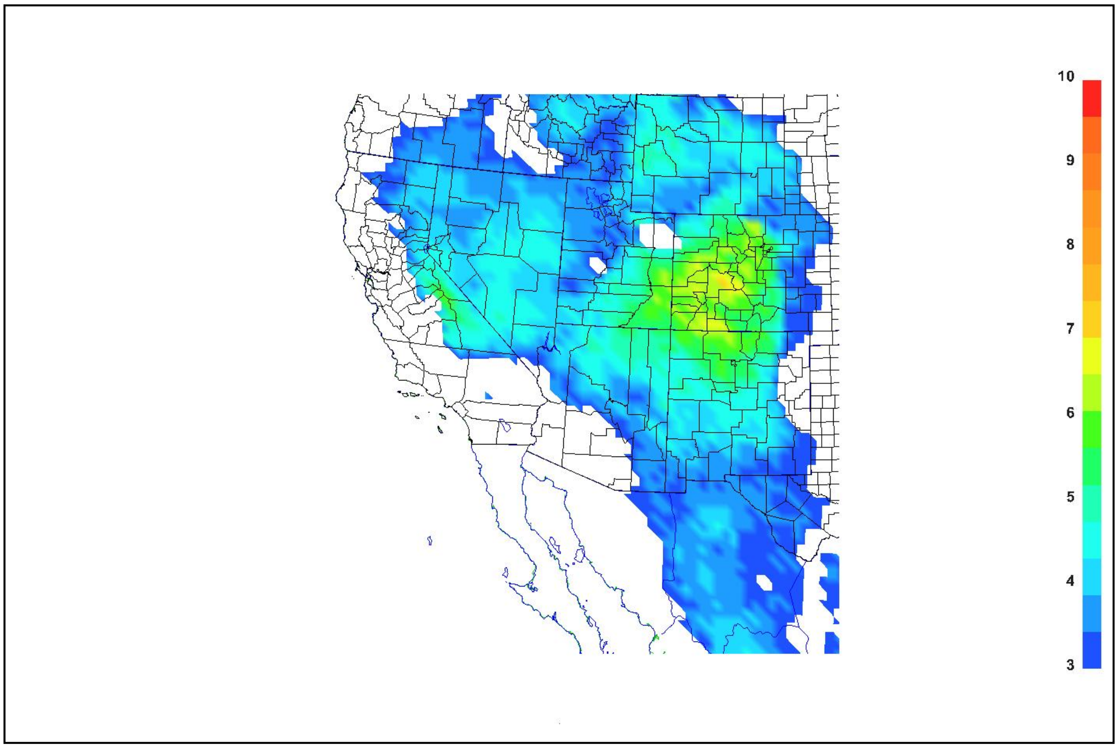


Figure 15: Height of the mixed layer in kilometers above mean sea level from the NARR at 18Z April 16, 2013, or 11 AM MST April 16, 2013.
(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)

Figure 16 through Figure 19 present synoptic-scale weather maps centered over Denver, CO which include individual surface observations for 10:43 AM, 1:43 PM, 3:43 PM and 5:43 PM MST April 16, 2013, respectively. These maps cover Colorado and the areas of Arizona, Utah, and New Mexico that were upwind of the portions of Colorado that experienced exceedances of the PM_{10} standard. These surface analyses illustrate that winds above 30mph with gusts above 40 mph occurred in many areas both near the surface low pressure complex and south of the cold front shown in Figure 2 through Figure 4.

On the map in Figure 16, the station observation for Farmington, NM (FMN) approximately 20 miles south of the Colorado state line in northwestern New Mexico shows a dollar sign ($). The dollar sign is the weather symbol for dust or sand raised by wind at the time of the observation. Within three hours (1:43 PM MST, Figure 17), several station plots in south-central and southwest Colorado indicated reduced visibilities and displayed the weather symbol of infinity (∞). The infinity sign is the weather symbol for haze. Haze is often reported during dust storms, and in dry and windy conditions, haze typically refers to blowing dust (see the following link for the description of haze published by the National Oceanic and Atmospheric Administration (NOAA): http://www.crh.noaa.gov/lmk/?n=general_glossary).

At 3:43 PM MST (Figure 18), Telluride (TEX) reported haze and a visibility of 5 statute miles (SM). Observations of haze continued for several hours in Telluride with the visibility hitting a low of 3 SM between 4:55 PM MST and 6:55 PM MST, including the observation displayed in Figure 19 (5:43 PM MST). Additional surface weather maps not included here show that haze and blowing dust were also reported in other parts of Arizona, New Mexico and Colorado on April 16, 2013.

Surface weather maps show evidence of widespread blowing dust and winds above the threshold speeds for blowing dust on April 16, 2013.

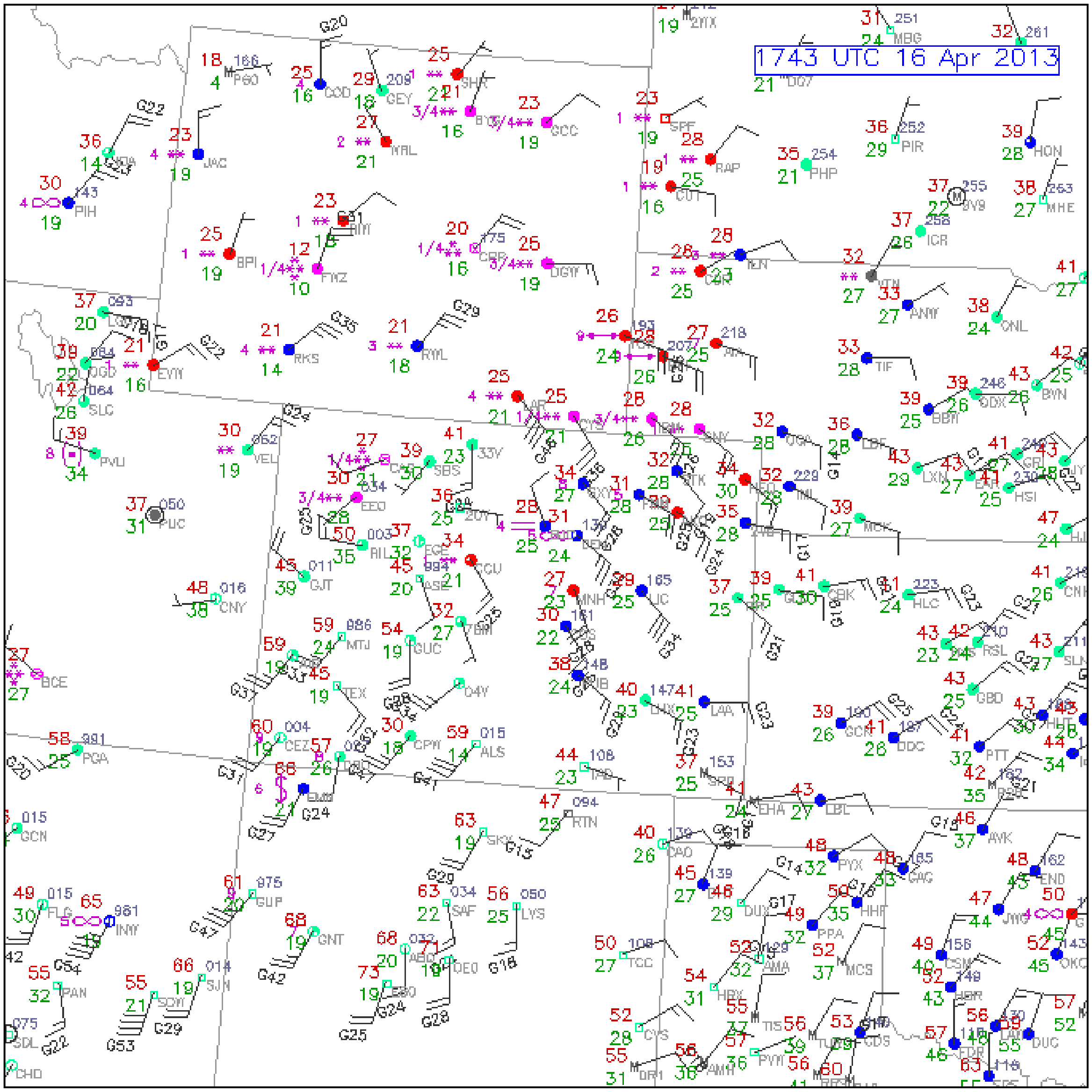


Figure 16: NCAR RAP Real-Time Weather Data website DEN sector surface analysis for 1743Z April 16, 2013, or 10:43 AM MST April 16, 2013.
(source: http://www.rap.ucar.edu/weather/)

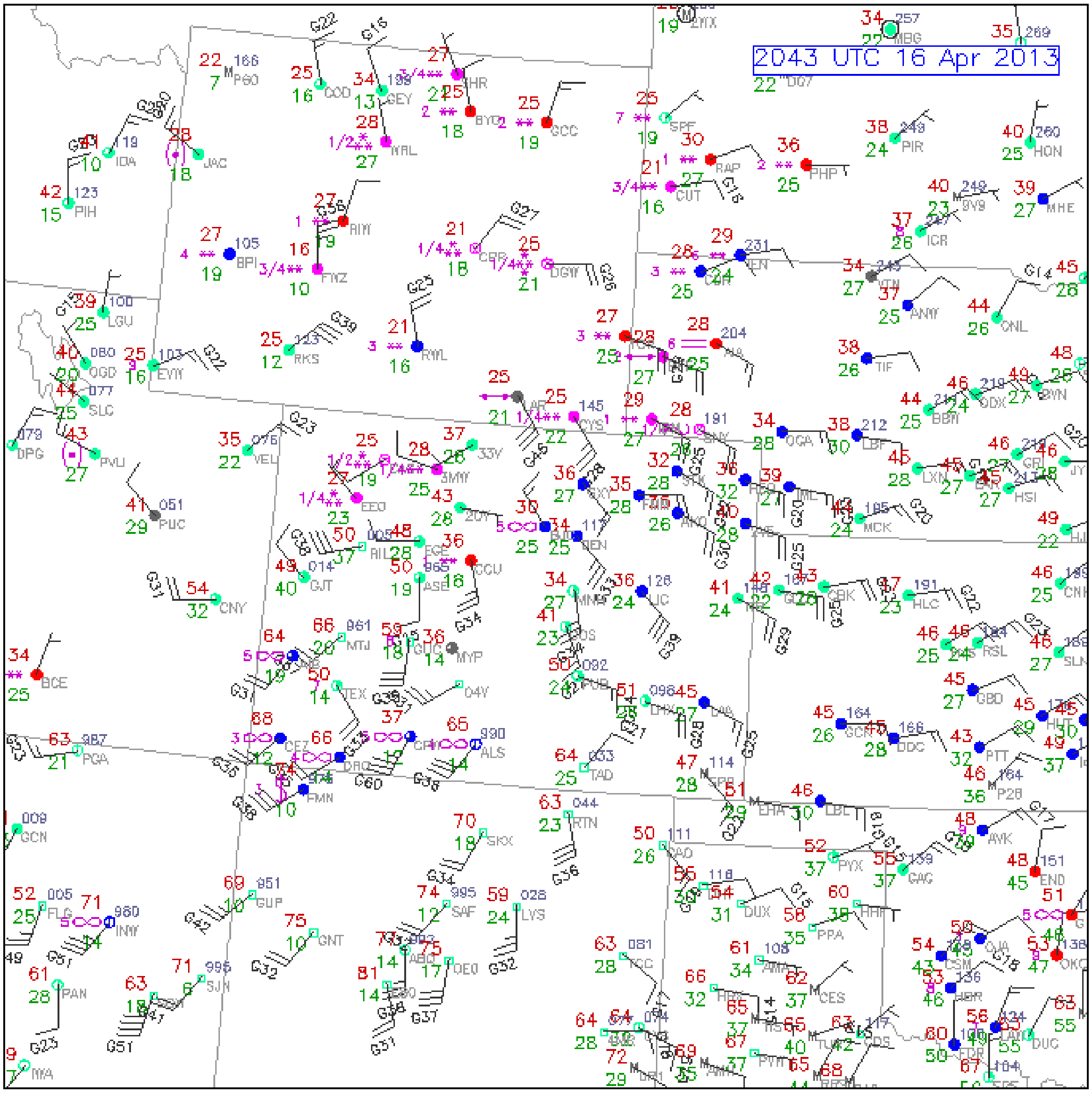


Figure 17: NCAR RAP Real-Time Weather Data website DEN sector surface analysis for 2043Z April 16, 2013, or 1:43 PM MST April 16, 2013.
(source: http://www.rap.ucar.edu/weather/)

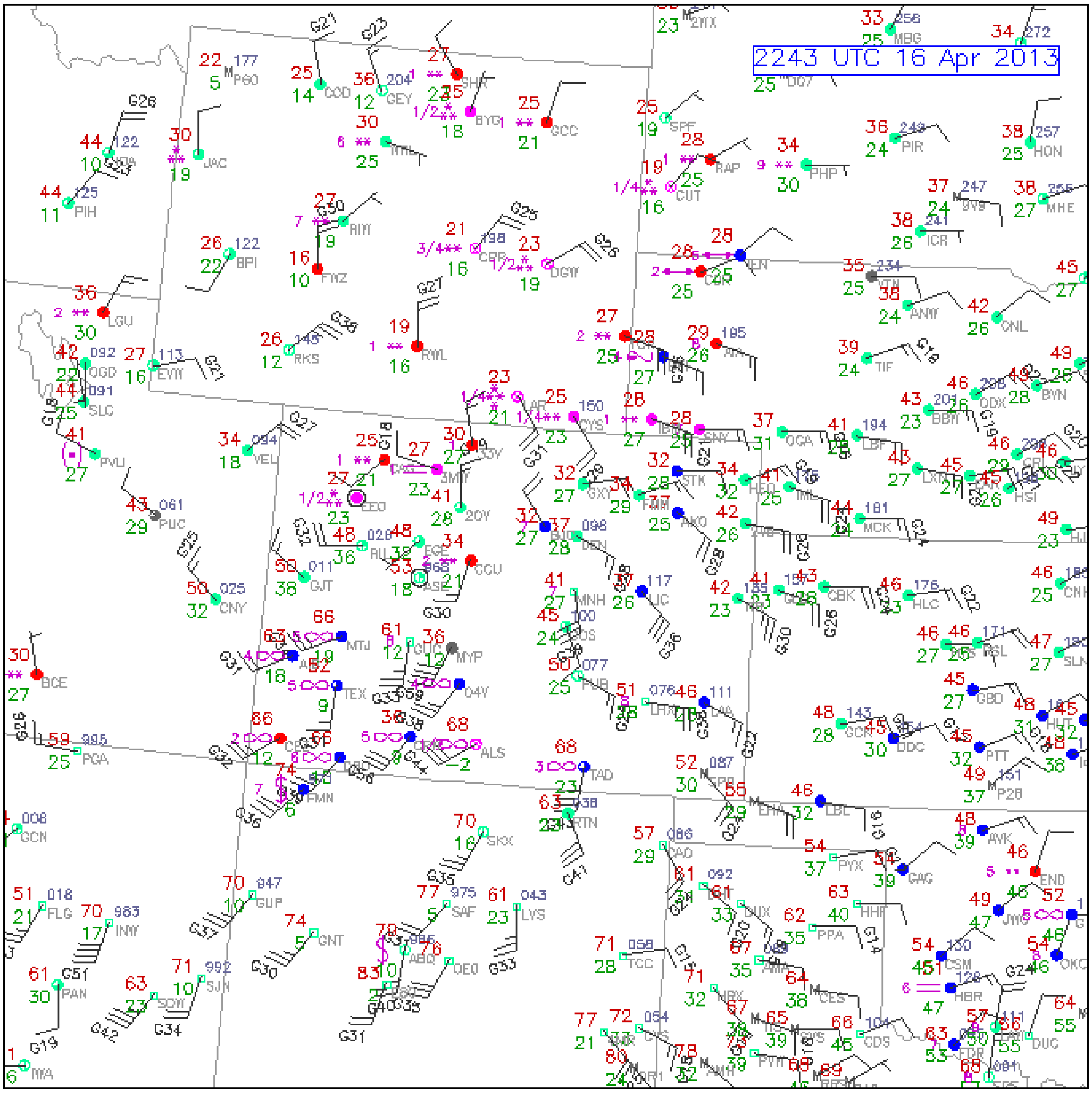


Figure 18: NCAR RAP Real-Time Weather Data website DEN sector surface analysis for 2243Z April 16, 2013, or 3:43 PM MST April 16, 2013.
(source: http://www.rap.ucar.edu/weather/)

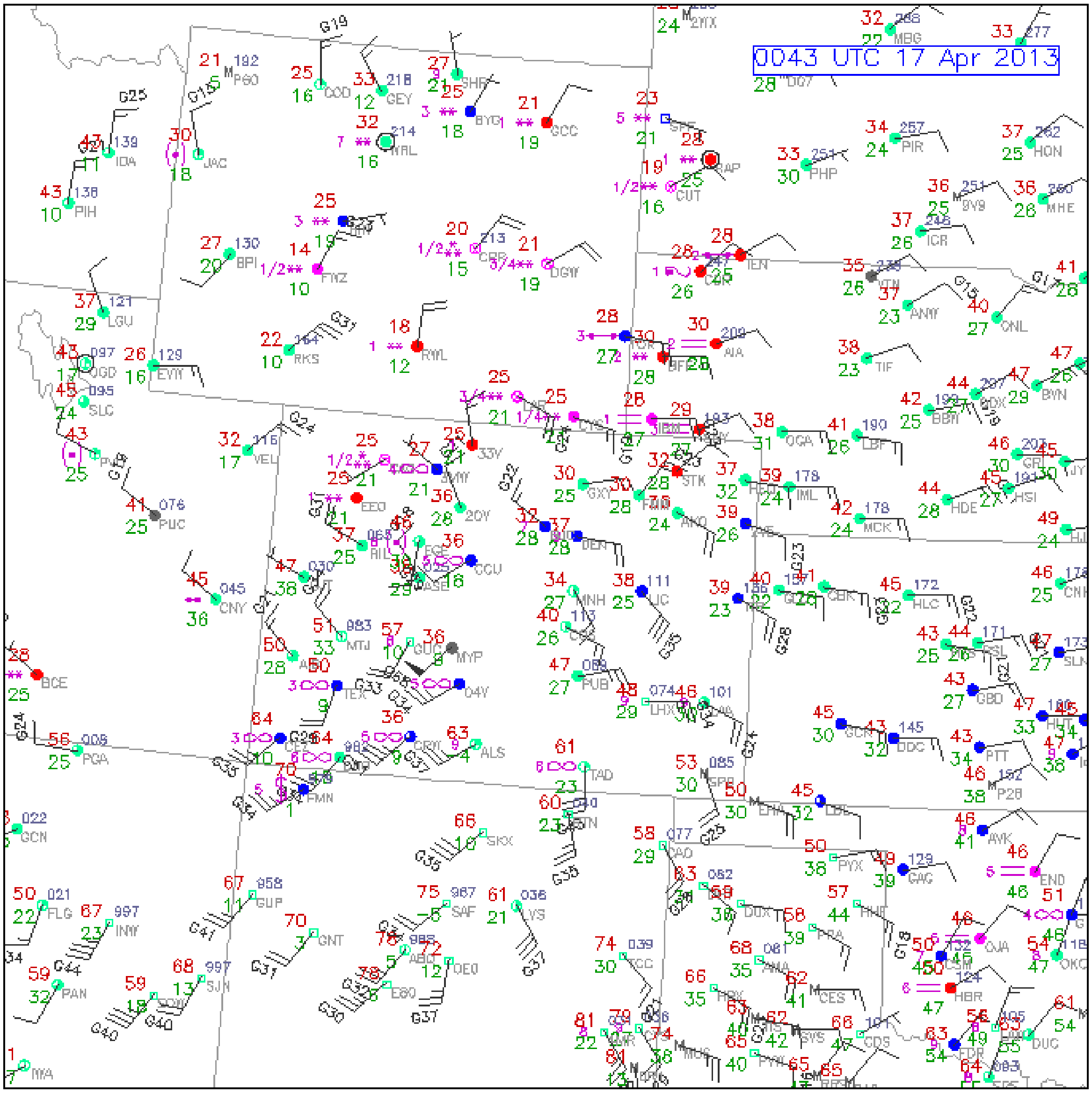


Figure 19: NCAR RAP Real-Time Weather Data website DEN sector surface analysis for 0043Z April 17, 2013, or 5:43 PM MST April 16, 2013.
(source: http://www.rap.ucar.edu/weather/)

To build on the data from these synoptic maps, hourly surface weather observations were gathered from several reporting stations located in Colorado, New Mexico and Arizona for April 16, 2013. Figure 20 provides a reference map containing the locations of all the stations utilized for this analysis. Telluride is denoted in bold and caps.

Table 1 lists observations for the PM_{10} exceedance location of Telluride. Observations that are climatologically consistent with blowing dust conditions are highlighted in yellow. Table 2 through Table 8 contain the surface observations from sites that are in close vicinity to Telluride, or are in or near areas in northeast Arizona and northwest New Mexico that are known sources for blowing dust (see reference for Appendix A – Grand Junction, Colorado, Blowing Dust Climatology at the end of this document). At these locations sustained wind speeds were as high as 50 mph with wind gusts up to 66 mph. Both of these values are well above the blowing dust thresholds already identified.

Collectively these weather observation sites experienced many hours of reduced visibility along with sustained wind speeds and gusts at or above the thresholds for blowing dust.

Observations of sustained wind speeds and gust speeds above the blowing dust thresholds and reduced visibilities on April 16, 2013, at weather stations in northeast Arizona, northwest New Mexico and southwest Colorado show that a regional dust storm event occurred under south to southwesterly flow prior to a cold front passage. The observations contribute to the body of evidence that shows that a regional dust storm caused the PM_{10} exceedances at the monitoring sites in question.

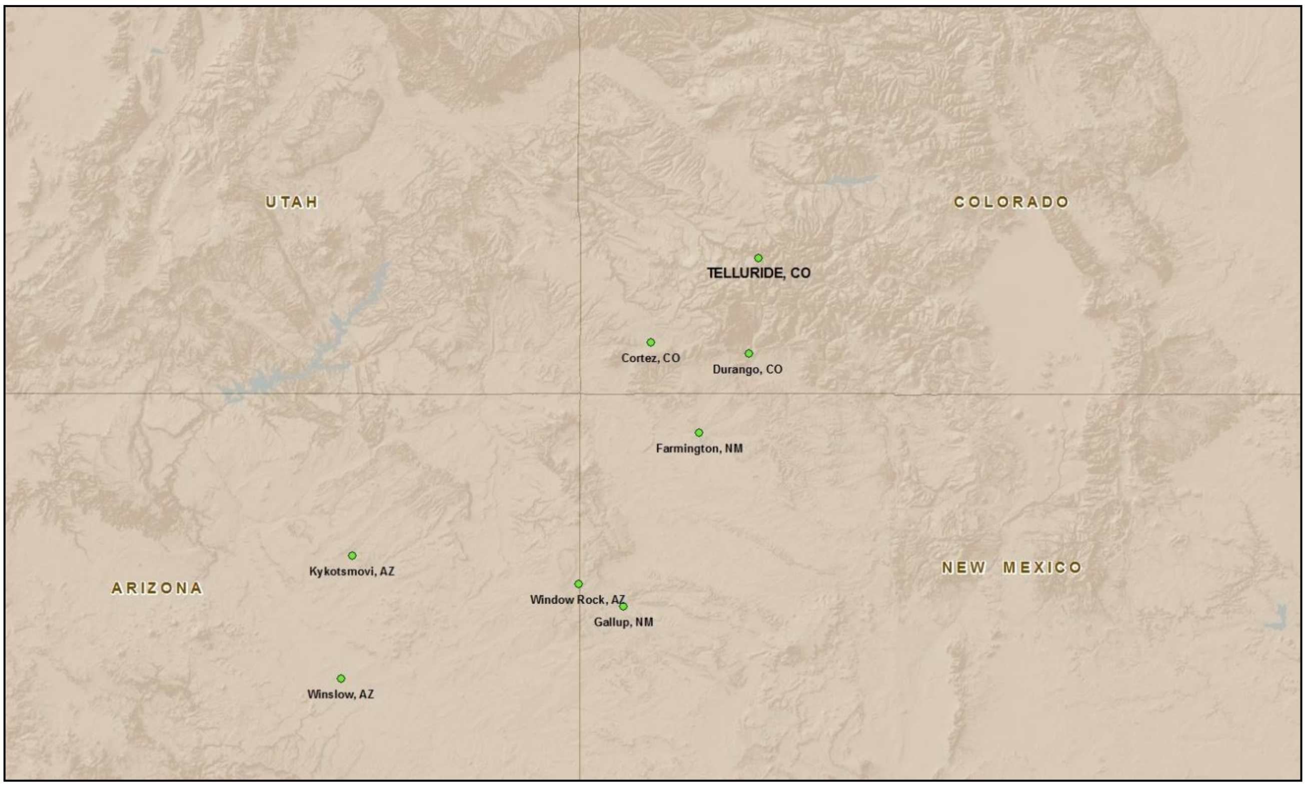


Figure 20: Weather observation stations for April 16, 2013, meteorological analysis.

Table 1: Weather observations for Telluride, Colorado on April 16, 2013.
(source: http://www.met.utah.edu/mesowest/)

Time MST April 16	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:55	41	38	13	39	200		10
1:55	39	41	17	24	170		10
2:55	39	41	18	31	180		7
3:55	37	48	7		100		7
4:55	37	44	20	31	180	haze	5
5:55	37	38	25	35	170		7
6:55	37	38	24	38	170		10
7:55	41	36	12	38	210		10
8:55	43	31	17	43	150		7
9:55	45	33	13	37	180		7
10:55	46	34	9	30	130		10
11:55	48	29	23	38	180		10
12:55	50	23	29	53	180		10
13:55	52	22	22	38	210		7
14:55	52	22	24	47	180		7
15:55	52	17	15	41	180	haze	4
16:55	52	17	12	25	200	haze	3
17:55	50	18	14	21	200	haze	3
18:55	46	25	14	23	210	haze	3
19:55	45	26	9	20	210	haze	4
20:55	43	31	9	18	210	haze	5
21:55	41	41	15	28	190		7
22:55	41	36	20	36	200		10
23:55	39	41	10	32	150		10

Table 2: Weather observations for Cortez, Colorado on April 16, 2013.
(source: http://www.met.utah.edu/mesowest/)

Time MST April 16	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
6:53	50	34	4				10
7:53	55	26	22	28	190		10
8:53	59	22	27	36	190		10
9:17	61	20	28	37	200	haze	6
9:53	60	20	22	36			9
10:53	64	18	30	37			8
11:13	64	16	35	43	200	haze	2
11:17	64	16	33	43	190	haze	3
11:19	64	16	32	43	210	haze	2
11:24	64	18	22	40	210	haze	3
11:32	66	15	29	45	210	haze	2
11:41	64	16	28	38	200	haze	3
11:53	65	16	21	37	240	haze	6
12:48	68	13	35	44	200	haze	1.25
12:53	69	13	30	44	200	haze	1
12:58	70	13	25	39	210	haze	2
13:03	68	14	23	37	230	haze	3
13:14	70	12	31	38	210	haze	1.75
13:22	70	11	31	41	230	haze	1.25
13:24	68	11	27	41	230	haze	2
13:26	68	11	30	41	230	haze	3
13:53	68	11	21	41	220	haze	3
14:38	66	11	29	41	230	haze	2.5
14:53	68	11	29	41	230	haze	2.5
15:03	66	11	24	44	240	haze	2
15:10	66	12	28	37	240	haze	2
15:53	66	11	29	39	230	haze	2
16:06	64	12	30	40	230	haze	2
16:13	64	12	24	40	230	haze	2
16:28	64	12	24	38	230	haze	2
16:36	64	12	29	40	230	haze	2
16:53	64	12	30	43	230	haze	2.5
17:13	64	12	30	41	220	haze	2.5
17:21	64	12	29	40	230	haze	3
17:53	62	15	28	38	220	haze	4

Table 3: Weather observations for Durango, Colorado on April 16, 2013.
(source: http://www.met.utah.edu/mesowest/)

Time MST April 16	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	41	46	0				10
1:53	40	53	4		40		9
2:53	45	45	4		170		10
3:53	45	45	12		200		8
4:53	45	43	12		200		8
5:53	44	45	4			haze	6
6:53	46	43	6		150		8
7:53	51	39	17	23	190		10
8:53	54	34	18	35	210		10
9:53	57	30	17	28	190		8
10:53	59	25	22	33	220	haze	5
11:11	61	22	22	33	200	haze	5
11:53	63	19	21	36	200	haze	6
12:33	64	16	17	33	240		7
12:53	66	15	20	35	230	haze	5
13:25	66	13	23	40	240	haze	4
13:53	67	12	28	38	230	haze	5
14:00	66	12	31	41	210	haze	5
14:28	66	13	25	48	250	haze; squalls	6
14:36	66	12	24	43	220	haze	5
14:53	67	12	31	44	220	haze	5
15:25	66	11	27	47	230	haze	6
15:38	66	11	29	45	220	haze	6
15:53	66	11	23	37	240	haze	6
16:53	64	12	28	39	220	haze	6
17:53	62	12	18	39	240	haze	4
18:53	58	16	21	29	250	haze	3
19:53	54	22	16	22	250	haze	5
20:53	51	27	10		270	haze	6
21:53	50	29	10		260	haze	6
22:53	48	32	9		250		9
23:53	45	38	6		190		10

Table 4: Weather observations for Kykotsmovi (Hopi), Arizona on April 16, 2013.
(source: http://www.met.utah.edu/mesowest/)

Time MST April 16	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:13	53	39	27	36	199		
1:13	51	36	28	44	202		
2:13	50	42	27	41	199		
3:13	50	46	23	41	217		
4:13	49	41	21	33	214		
5:13	48	41	23	31	199		
6:13	48	42	27	40	199		
7:13	50	40	21	40	214		
8:13	53	36	26	34	199		
9:13	57	30	26	37	204		
10:13	59	24	32	41	222		
11:13	60	23	25	43	226		
12:13	62	21	22	35	234		
13:13	64	20	27	39	224		
14:13	64	19	30	46	232		
15:13	64	18	29	43	227		
16:13	62	15	29	44	237		
17:13	60	18	29	42	235		
18:13	58	21	24	39	239		
19:13	53	21	22	36	232		
20:13	50	20	18	29	222		
21:13	47	27	13	23	261		
22:13	44	31	11	19	273		
23:13	41	40	11	16	336		

Table 5: Weather observations for Window Rock, Arizona on April 16, 2013.
(source: http://www.met.utah.edu/mesowest/)

Time MST April 16	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	47	40	17	28	210		10
1:53	45	42	12	17	210		10
2:53	44	41	12	18	210		10
3:53	42	43	4		210		10
4:53	44	47	20	32	210		10
6:53	46	51	22	39	210		10
7:53	50	41	31	41	220		10
8:53	54	30	28	44	200		10
9:53	59	21	35	48	200		10
10:53	61	16	37	52	200		10
11:53	64	12	31	48	230		10
12:53	65	11	31	50	220		9
13:53	65	9	40	56	210	haze	6
14:53	66	9	32	47	230		10
15:53	64	10	30	48	230		10
16:53	62	13	32	47	220		10
17:53	59	16	28	41	220		10
18:53	54	20	16	32	210		10
19:53	51	21	18	38	210		10
20:53	50	24	25	39	230		10
21:53	47	42	13		240		10
22:53	45	49	16	22	250		10
23:53	43	45	7		260		10

Table 6: Weather observations for Winslow, Arizona on April 16, 2013.
(source: http://www.met.utah.edu/mesowest/)

Time MST April 16	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:56	56	34	31	43	210		7
1:56	55	37	35	45	220		10
2:56	55	32	31	43	210		10
3:56	55	30	33	44	210		10
4:56	54	32	36	47	200		10
5:56	53	35	40	53	200		10
6:56	54	35	40	52	200		10
7:56	58	29	47	60	200	haze	5
8:56	62	22	47	61	200	haze	5
9:56	63	22	45	60	200	haze	3
10:56	65	17	50	62	210	haze	5
11:56	68	13	47	66	210		8
12:56	71	11	43	58	220		8
13:56	71	11	43	59	220	haze	5
14:56	70	13	43	60	220		9
15:56	70	13	45	59	200		10
16:56	69	17	37	52	190		10
17:56	67	19	43	51	210		10
18:56	63	23	33	46	220		10
19:56	59	29	29	40	210		10
20:56	56	35	16		220		10
21:56	53	41	10		220		10
22:56	51	42	10		270		10
23:56	48	47	6		250		10

Table 7: Weather observations for Farmington, New Mexico on April 16, 2013.
(source: http://www.met.utah.edu/mesowest/)

Time MST April 16	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
7:53	56	34	24	31	190		9
8:53	60	28	17	28	190		9
9:03	61	27	16	24	190		8
9:53	65	21	22	28	220	haze; blowing dust	4
10:06	66	19	18	28	210	haze; blowing dust	6
10:13	66	18	23	31	210	haze; blowing dust	6
10:53	69	12	28	36	220	haze; blowing dust	4
11:53	73	8	30	39	240	haze; blowing dust	5
12:53	74	8	36	44	240	haze; blowing dust	3
13:53	75	8	29	41	220	haze; blowing dust	5
14:53	74	7	33	41	230	blowing dust	7
15:53	72	8	28	40	240	haze; blowing dust	6
16:17	72	7	30	37	230	blowing dust	7
16:53	70	6	28	39	240	haze; blowing dust	5
17:53	67	8	24	35	240	blowing dust	7
18:51	63	14	22	29	250	haze; blowing dust	4
18:53	63	13	18	29	250	haze; blowing dust	5
19:53	59	18	18		260	blowing dust	10
20:07	57	19	16	23	270	blowing dust	7
20:53	57	22	20	27	270	haze; blowing dust	6
21:53	54	28	17	25	270	blowing dust	8
22:19	54	28	17	24	270	blowing dust	9
22:53	53	32	17		270	blowing dust	10
23:53	49	34	7		240	blowing dust	10

Table 8: Weather observations for Gallup, New Mexico on April 16, 2013.
(source: http://www.met.utah.edu/mesowest/)

Time MST April 16	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
0:53	49	36	14		210		10
1:53	48	39	21	27	210		10
2:53	48	35	25	38	200		10
3:53	48	37	21	37	200		10
4:53	46	43	10	21	210		10
5:53	44	51	12		190		10
6:53	48	46	10	17	210		10
7:53	54	34	30	37	210		10
8:53	58	27	31	48	220		10
9:53	61	20	38	54	220		9
10:53	66	15	33	46	220		10
11:53	67	13	30	45	210		10
12:53	69	10	30	48	230		10
13:53	70	10	29	45	220		10
14:53	70	10	30	43	220		10
15:53	67	11	33	47	210		10
16:53	67	11	31	47	220		10
17:53	63	15	28	47	220		10
18:53	58	18	25	35	230		10
19:53	54	22	20	32	230		10
20:53	51	26	13		230		10
21:53	48	30	9		220		10
22:53	48	35	13		240		10
23:53	46	47	10		230		10

The Albuquerque, Flagstaff and Grand Junction National Weather Service (NWS) forecast offices issue weather warnings and advisories for northeast Arizona, most of New Mexico, eastern Utah and western and southwest Colorado. The weather warnings and advisories issued by theses offices for April 16, 2013, are presented in Appendix B. Additionally, the Colorado Department of Public Health and Environment (CDPHE) issued a Blowing Dust Advisory on the morning of April 16, 2013, for a large portion of western and south-central Colorado, including Telluride. This advisory can also be found in Appendix B.

Warnings and advisories issued by the NWS and CDPHE show that strong winds and areas of blowing dust were expected across this region on April 16, 2013.

Figure 21 shows the NOAA HYSPLIT 12-hour forward matrix trajectories (Draxler and Rolph, 2012) for northeast Arizona and northwest New Mexico starting at 5 AM MST April 16, 2013, (see the following link for more information on HYSPLIT from the NOAA Air Resources Laboratory: http://ready.arl.noaa.gov/HYSPLIT.php). This analysis clearly shows the transport of air from these areas into southwest Colorado on April 16, 2013. HYSPLIT 12-hour back trajectories for 2 PM MST April 16, 2013, in Telluride (approximately when visibility started to deteriorate – see Table 1) are presented in Figure 22. This figure also visibly illustrates that Arizona and portions of northwest New Mexico were source regions for air transported into Telluride on April 16, 2013.

NOAA HYSPLIT forward and backward trajectories provide clear supporting evidence that dust from arid regions of Arizona and northwest New Mexico caused the PM_{10} exceedances measured in Telluride, Colorado, on April 16, 2013.

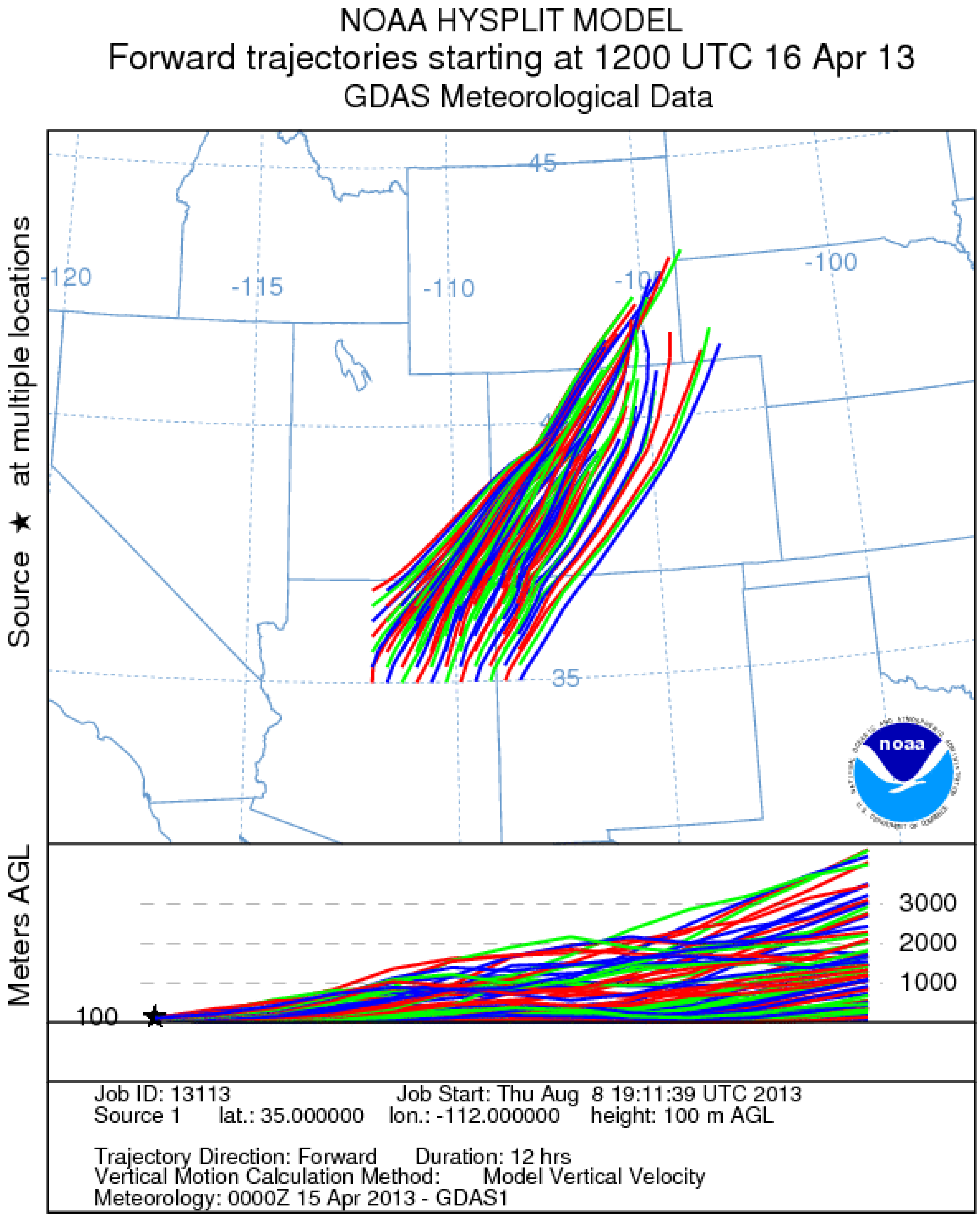


Figure 21: NOAA HYSPLIT 12-hour forward trajectories for northeast Arizona and northwest New Mexico for 5 AM MST April 16 (12Z April 16), 2013, to 5 PM MST April 16, 2013.
(source: http://ready.arl.noaa.gov/HYSPLIT.php)

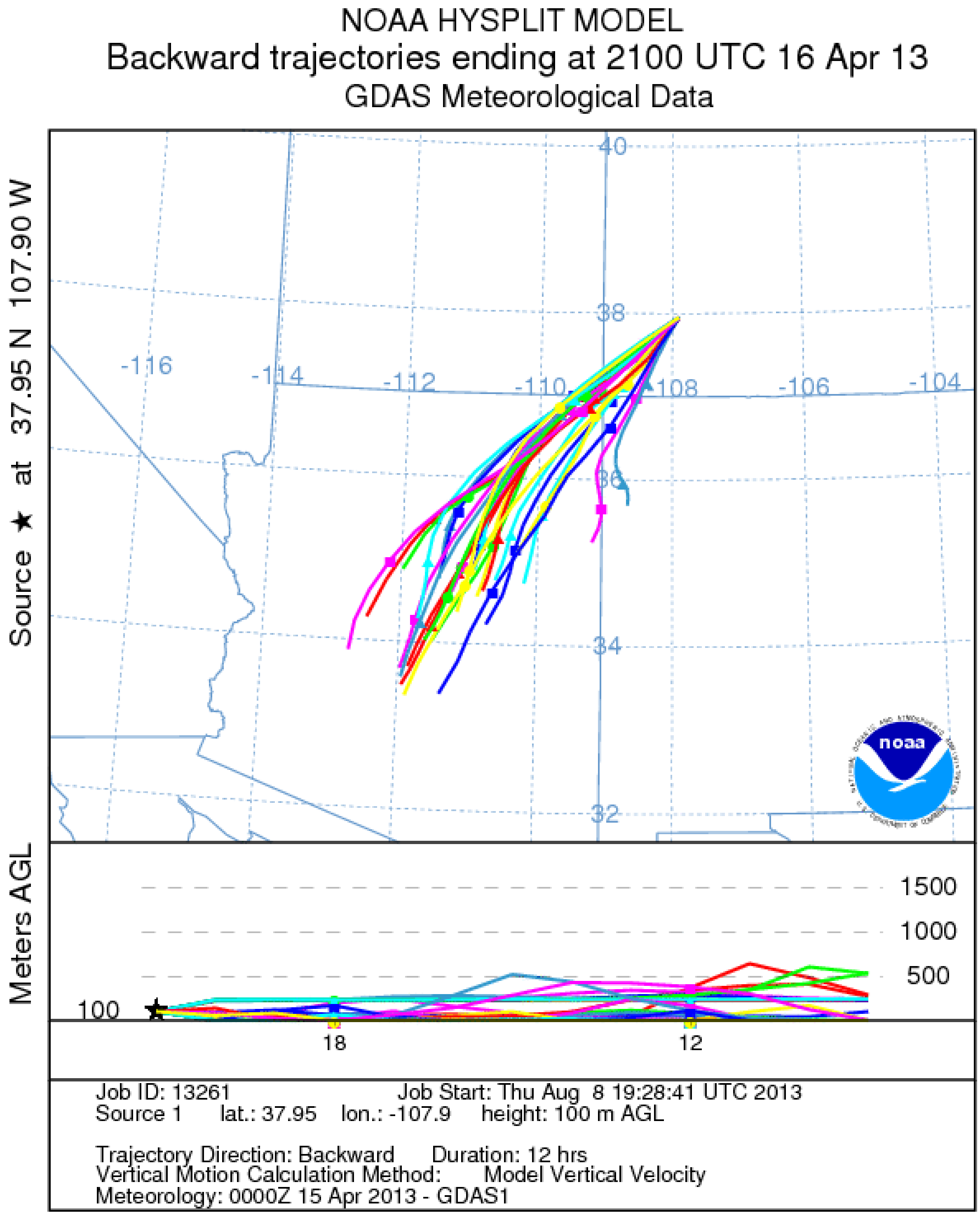


Figure 22: NOAA HYSPLIT 12-hour back trajectories for Telluride, CO for each hour from 2 AM MST April 16, 2013, to 2 PM MST April 16 (21Z April 16), 2013.
(source: http://ready.arl.noaa.gov/HYSPLIT.php)

Figure 23 shows the output for blowing dust from the Navy Aerosol Analysis and Prediction System (NAAPS) Global Aerosol Model for 11 AM April 16 (18Z April 16), 2013. The NAAPS system models blowing dust emissions and transport based on soil moisture content, soil erodibility factors and a variety of meteorological factors known to be conducive to blowing dust (for a description of NAAPS see: http://www.nrlmry.navy.mil/aerosol_web/Docs/globaer_model.html).

The forecast panel in the lower left of Figure 23 shows an area of highly elevated surface dust concentrations over much of northeast Arizona, northwest New Mexico, southeast Utah and southwest Colorado. This model output suggests that the Four Corners region was a major source region for blowing dust on April 16, 2013.

Forecast products from the Navy Aerosol Analysis and Prediction System model provide evidence for a widespread blowing dust event, suggesting that significant source regions for dust in Colorado were located in the arid Four Corners area.

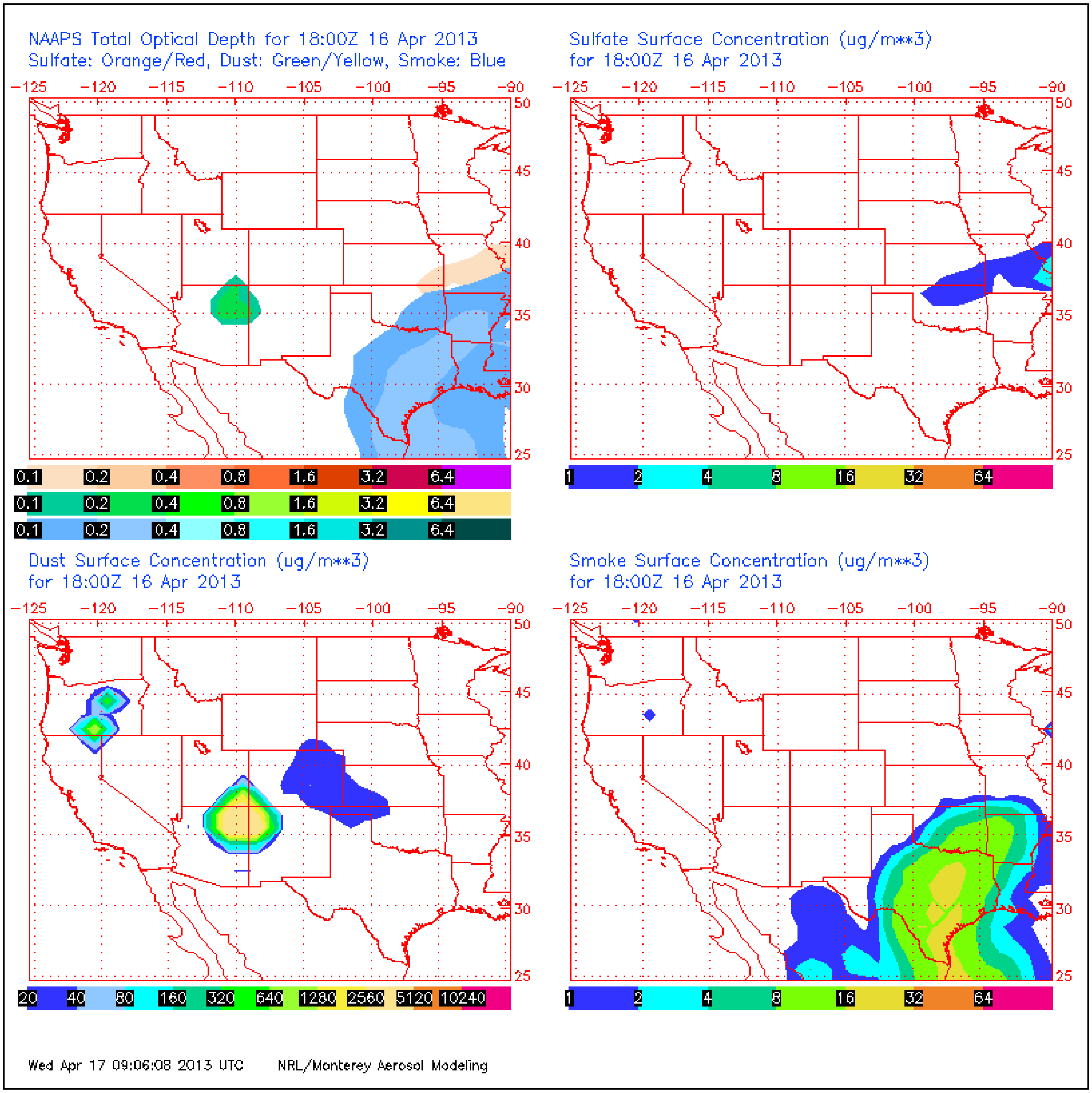


Figure 23: NAAPS forecasted dust concentrations for 11 AM MST April 16 (18Z April 16), 2013. **(source: http://www.nrlmry.navy.mil/aerosol-bin/aerosol/display_directory_all?DIR=/web/aerosol/public_html/globaer/ops_01/wus/)**

The winter snow pack in the mountainous areas of southwest Colorado is often near its seasonal peak in April. The snow covers and moistens the soil which greatly reduces the potential for windblown dust from local sources. Figure 24 shows the snow depth analysis for southwest Colorado on April 15, 2013, at 5:00 PM MST. The snow depth analysis illustrates that the mountains surrounding Telluride had 16 to 100 inches of snow cover in the hours before the dust storm of April 16, 2013.

Individual station observations provide further evidence to the extent and depth of snow cover across the region. NOHRSC (National Operational Hydrologic Remote Sensing Center) observation stations were selected based on the prevailing wind direction in Telluride on April 16, 2013. With the wind predominantly out of a south to southwest direction during the dust event, stations located to the south and southwest of Telluride were analyzed including the Telluride Ski Resort, El Diente Peak and Lizard Head Pass. The precise locations of these stations and their proximity to the Telluride monitoring station are provided on the map in Figure 25.

Figure 26 through Figure 28 present the snow cover measurements at Telluride Ski Resort, El Diente Peak and Lizard Head Pass respectively, for the time period of 11 PM MST April 14, 2013 – 11 PM MST April 15, 2013. Telluride Ski Resort which is located at 12,224 ft. above MSL and just a few miles to the south-southwest of the Telluride monitoring station reported 60-65 inches of snow cover. Meanwhile El Diente Peak and Lizard Head Pass are both located roughly 15-25 miles to the southwest of the Telluride monitor. Measurements at those locations show a snowfall depth in the 35-40 inch range.

Snowpack and snow cover data for the mountains in southwest Colorado that were upwind from Telluride on April 16, 2013, demonstrate that blowing dust and elevated PM_{10} observed in Telluride were not likely to have been from local sources as the ground was covered in deep snow. Snow cover data provides strong evidence that a widespread, regional blowing dust event caused the exceedance at Telluride rather than local sources.

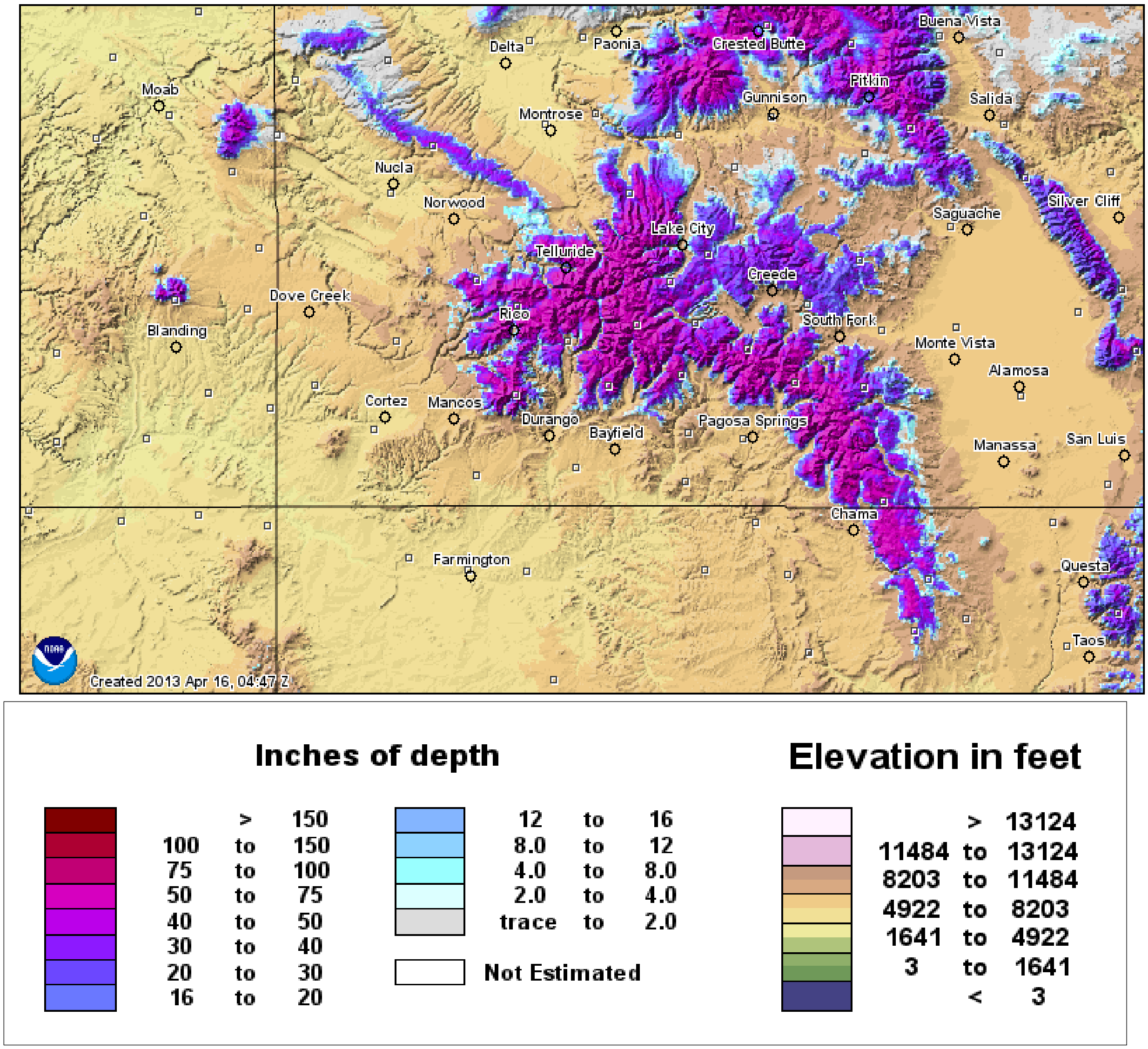


Figure 24: Southwest Colorado snow depth for 5 PM MST April 15, 2013.
(source: http://www.nohrsc.noaa.gov/interactive/html/map.html)

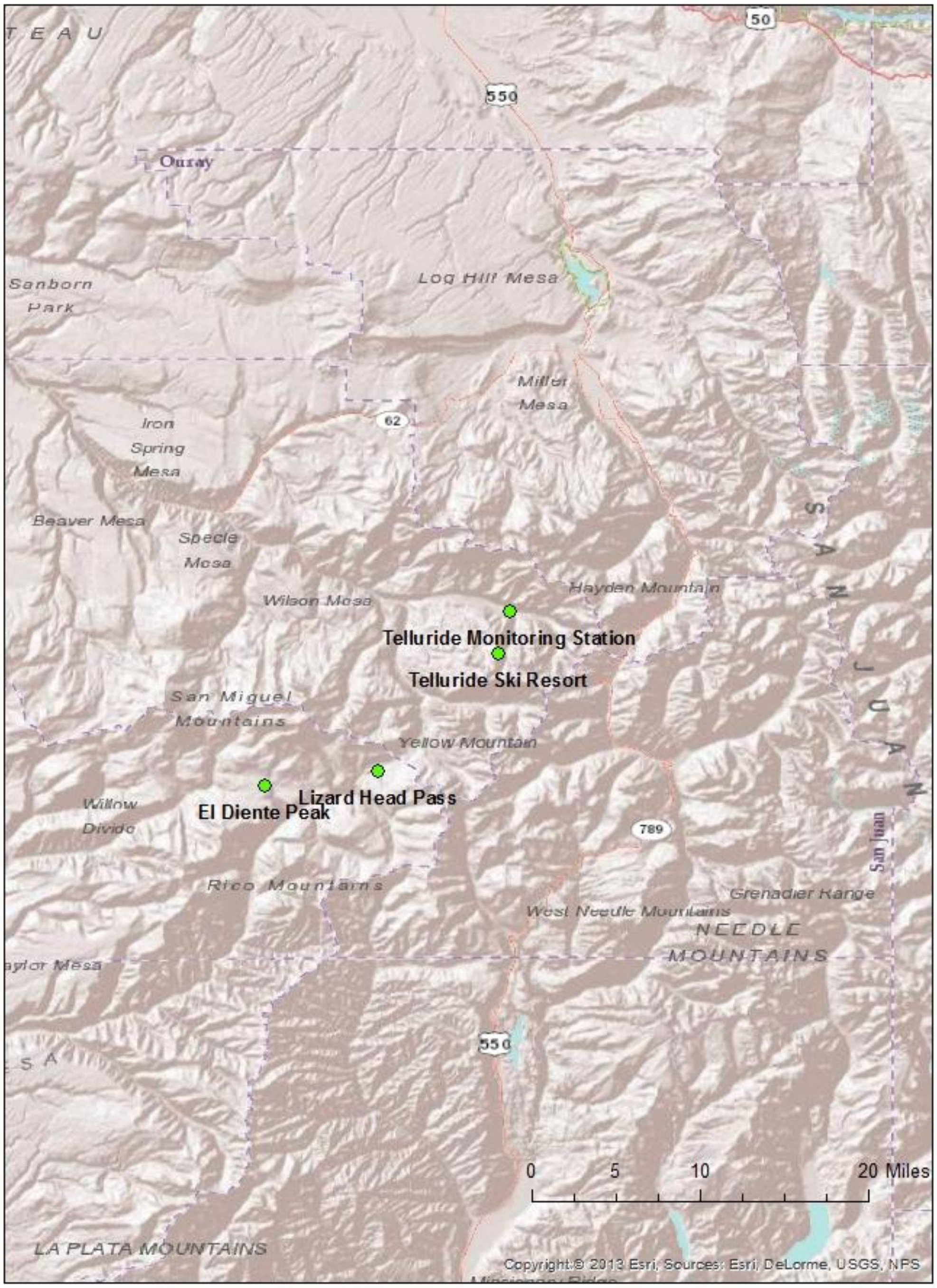


Figure 25: NOHRSC observing stations for April 16, 2013, meteorological analysis.

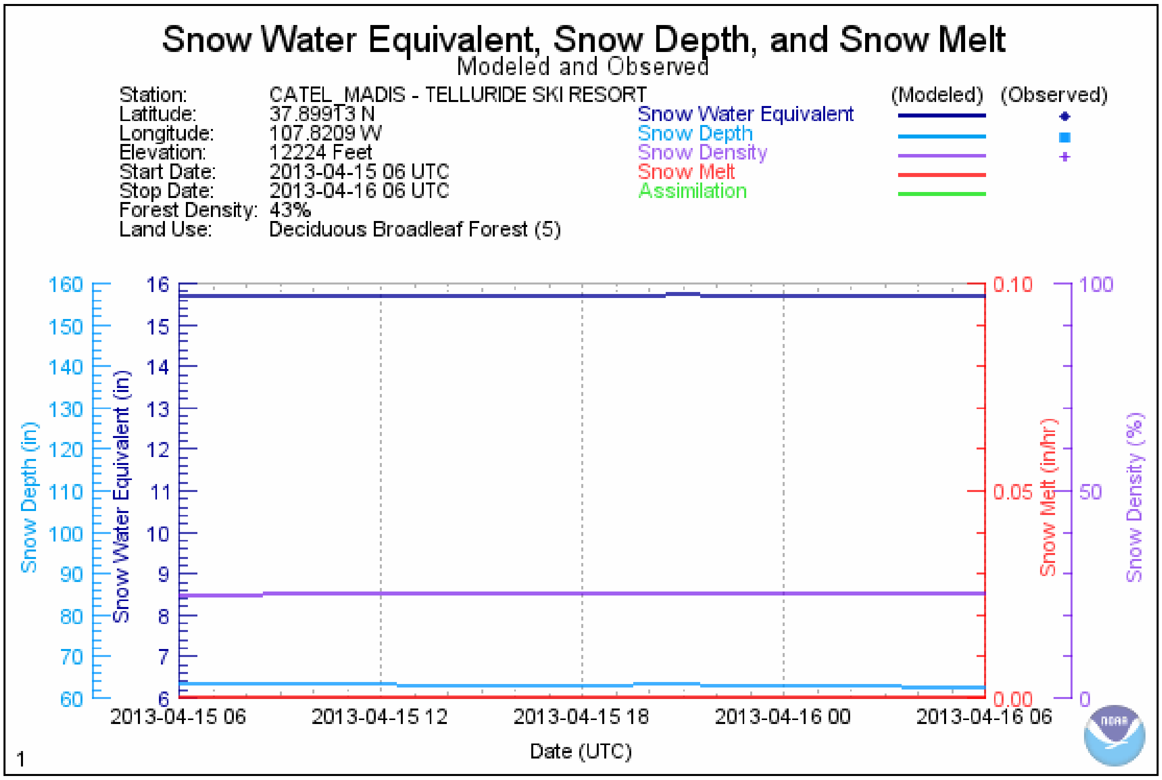


Figure 26: Telluride Ski Resort snow depth, 11 PM MST April 14, 2013 - 11 PM MST April 15, 2013. **(source: http://www.nohrsc.noaa.gov/interactive/html/map.html)**

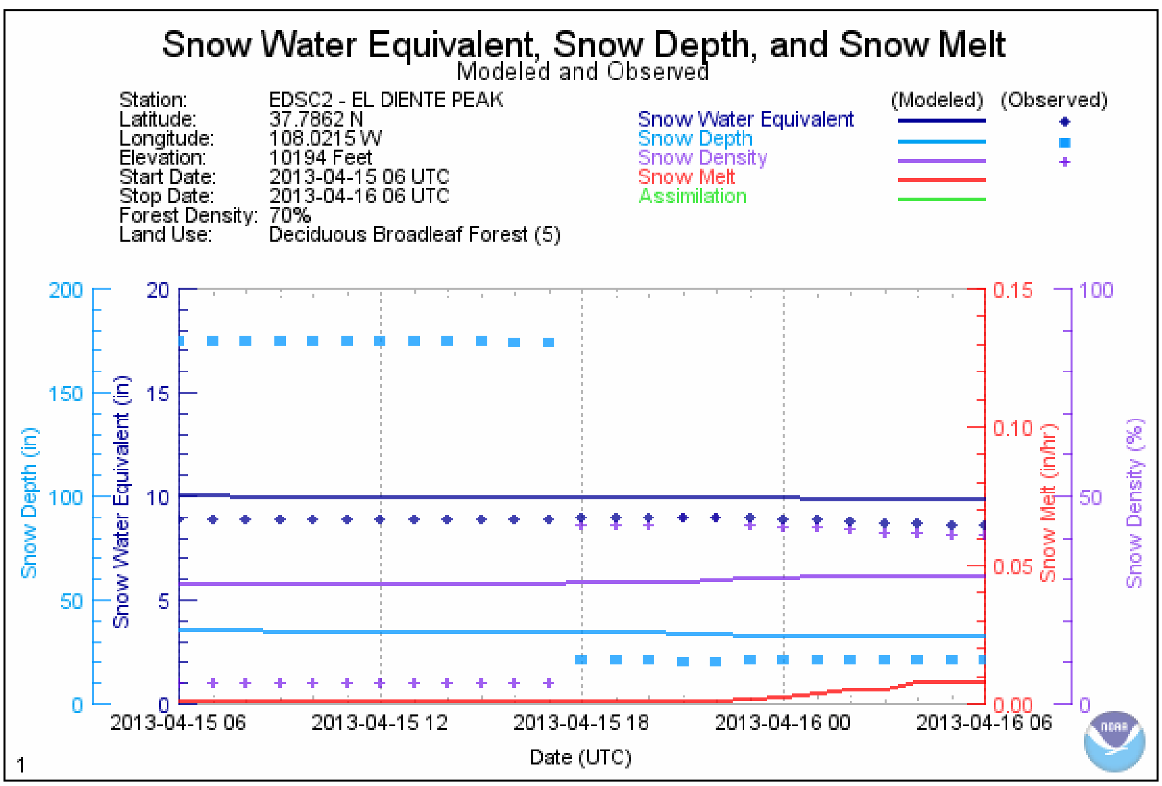


Figure 27: El Diente Peak snow depth, 11 PM MST April 14, 2013 - 11 PM MST April 15, 2013. **(source: http://www.nohrsc.noaa.gov/interactive/html/map.html)**

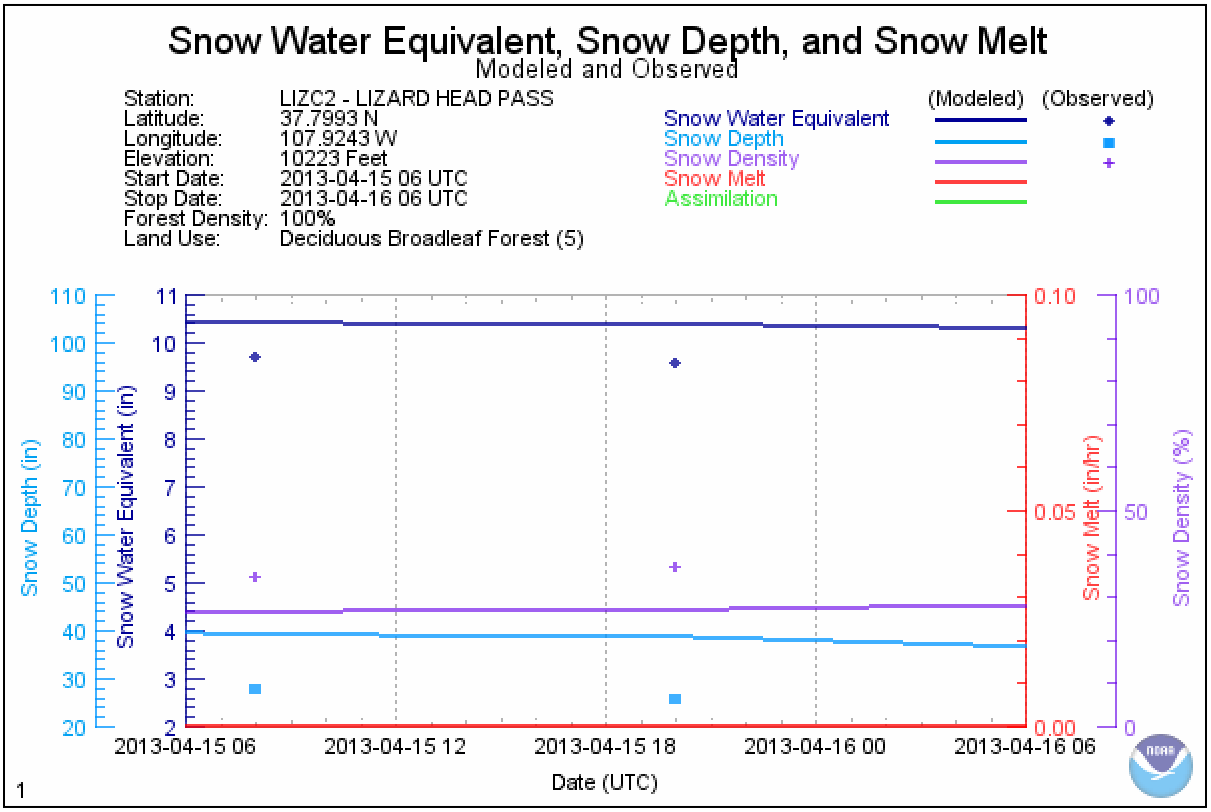


Figure 28: Lizard Head Pass snow depth, 11 PM MST April 14, 2013 - 11 PM MST April 15, 2013. **(source: http://www.nohrsc.noaa.gov/interactive/html/map.html)**

The Center for Snow and Avalanche Studies has been studying the effects of wind-blown desert dust from Arizona, New Mexico and Utah on snowpack albedo and snowmelt in the San Juan Mountains of southwest Colorado for over 10 years. Figure 29 is the Center's log of events that are associated with deposits or layers of wind-blown dust on or within the snowpack at the Senator Beck Basin Study area at Red Mountain Pass, which is approximately 6 miles to the southeast of Telluride.

The Center for Snow and Avalanche Studies lists April 15-17, 2013 (highlighted in Figure 29) as a Dust-on-Snow event for a location in very close proximity to Telluride during the 2012/2013 water year. This provides clear supporting evidence that a regional blowing dust event with long-range transport caused the PM$_{10}$ exceedance in Telluride, Colorado on April 16, 2013.

As of: 5/24/2013

Colorado Dust-on-Snow (CODOS)

Dust-on-Snow Deposition Events Log

Thanks to our original National Science Foundation research grants for collaborative research (grants ATM-0432327 to Painter at National Snow and Ice Data Center and ATM-0431955 to Landry at Center for Snow and Avalanche Studies), and to the subsequent support of the Colorado Dust-on-Snow program by Colorado water districts the State of Colorado, the U.S. Bureau of Reclamation, and others, this program has accumulated several seasons of dust-on-snow observations at our Senator Beck Basin Study Area (SBBSA) at Red Mountain Pass, summarized in the table below. It is reasonable to assume that our skill at detecting dust-on-snow events has improved and that we may have failed to observe very small events during the early years of this work. Therefore the table represents an absence of events in grey for the first two years of observation but thereafter indicates an absence of observed events as "0" (zero).

Dust-on-Snow Events Documented per Month, by Winter
Senator Beck Basin Study Area at Red Mountain Pass – San Juan Mountains

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
2002/2003					2		1			**3**
2003/2004							2	1		**3**
2004/2005	0	0	0	0	0	1	2	1	0	**4**
2005/2006	0	0	1	0	1	1	3	2	0	**8**
2006/2007	0	0	1	0	1	1	3	1	1	**8**
2007/2008	0	0	0	0	0	3	3	1	0	**7**
2008/2009	1	0	1	0	1	4	5	0	0	**12**
2009/2010	1	0	0	0	0	1	4	3	0	**9**
2010/2011	0	0	0	0	1	3	3	4	0	**11**
2011/2012	0	2	1	0	0	3	2	4	0	**12**
2012/2013	0	1	0	0	1	3	4	*1*		

Dates of the events, by winter/spring season, were as follows (WY = Water Year):

2002/2003 (WY2003): Feb 3, Feb 22, Apr 2-3
2003/2004 (WY 2004): Apr 17, Apr 28, May 11
2004/2005 (WY 2005): Mar 23, Apr 4, Apr 8, May 9
2005/2006 (WY 2006): Dec 23, Feb 15, Mar 26, Apr 5, Apr 15, Apr 17, May 22, May 27
2006/2007 (WY 2007): Dec 17, Feb 27, Mar 27, Apr 15, Apr 18, Apr 24, May 4, Jun 6
2007/2008 (WY 2008): Mar 16, Mar 26-27, Mar 30-31, Apr 15, Apr 21, Apr 30, May 12
2008/2009 (WY 2009): Oct 11, Dec 13, Feb 27, Mar 6, Mar 9, Mar 22, Mar 29, Apr 3, Apr 8, Apr 15, Apr 24, Apr 25
2009/2010 (WY 2010): Oct 27, March 30, April 3, April 5, April 12, April 28, May 9, May 11, May 22
2010/2011 (WY 2011): Feb 19, Mar 6, Mar 17, Mar 21, April 8, April 21, April 29, May 9, May 18, May 26, May 29
2011/2012 (WY2012): Nov 5, Nov 13, Dec 31, Mar 6, Mar 18, Mar 26, Apr 1, Apr 6, May 18, May 23, May 25, May 26
2012/2013 (WY2013): Nov 9, Feb 8-9, Mar 6-7/8, Mar 17-18, Mar 21-22, Apr 8, Apr 14, Apr 15-17, Apr 30, May 23

Figure 29: Dust-on-Snow Deposition Events Log at the Senator Beck Basin Study Area at Red Mountain Pass, Colorado.
(source: http://www.snowstudies.org/dust/SBBSA/summary_2013.html)

Figure 30 shows the MODIS Aqua satellite image for the Four Corners region of Arizona, New Mexico, Utah and Colorado at approximately 12:50 PM MST (1950Z) April 16, 2013. Plumes of blowing dust are clearly visible originating in northwest New Mexico and the Painted Desert region of northeast Arizona. Those plumes extend to the northeast spreading dust into southwest Colorado and southeast Utah. Figure 31 shows the GOES visible satellite imagery for the same general area at 2:45 PM MST (2145Z). This image illustrates the vast geographic extent of blowing dust in the region and the transport of this dust well into southwest Colorado.

Satellite-generated data products also indicate that a regional dust storm caused the PM_{10} exceedance in Telluride. Figure 32 displays the AIRS (Atmospheric Infrared Sounder) Dust Score for the Four Corners region on April 16, 2013 (see the following link for more information on Dust Score and other AIRS variables: http://disc.sci.gsfc.nasa.gov/nrt/data-holdings/airs-nrt-products/airs-nrt-products#WMS). The tan to reddish brown colored pixels represent dust scores greater than 360, which is indicative of dust particles. Notice that much of the southwest corner of Colorado recorded a dust score in excess of 400. The interior non-shaded area over the San Juan Mountains (which includes at least part of Telluride proper) can be explained by cloud cover interference with the dust score algorithms. Figure 30 and Figure 31 both show cloud cover in the same general area as the zone of lower or missing dust scores in southwest Colorado.

MODIS and GOES satellite imagery and derived products show that the Painted Desert and Four Corners area in general were source regions for blowing dust in southwest Colorado on April 16, 2013. This is consistent with the climatology for many dust storms in Colorado as described in the Grand Junction, Colorado, Blowing Dust Climatology report contained in Appendix A at the end of this document.

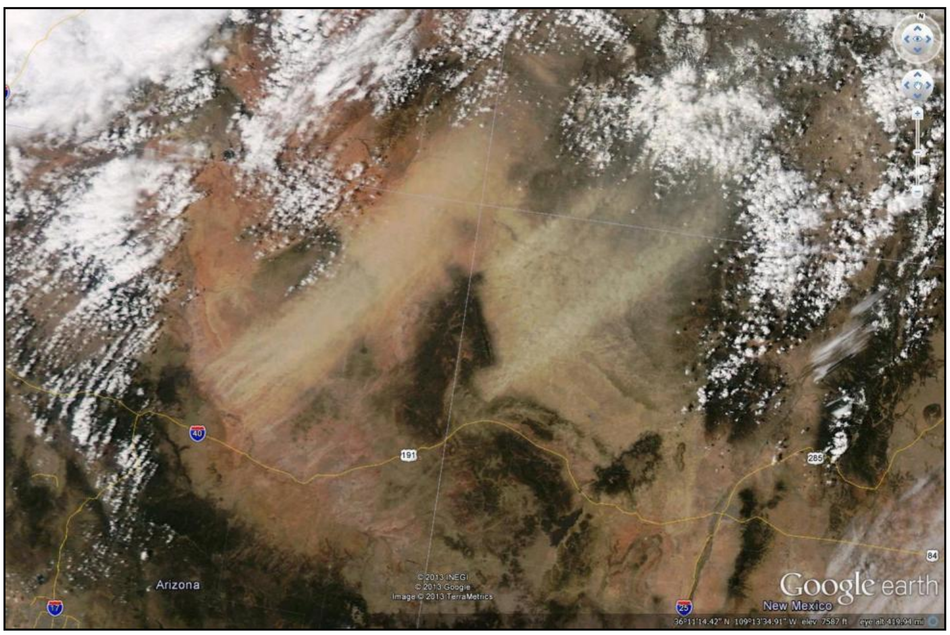


Figure 30: MODIS Aqua satellite afternoon image of the Four Corners region on April 16, 2013. **(source: http://ge.ssec.wisc.edu/modis-today/index.php)**

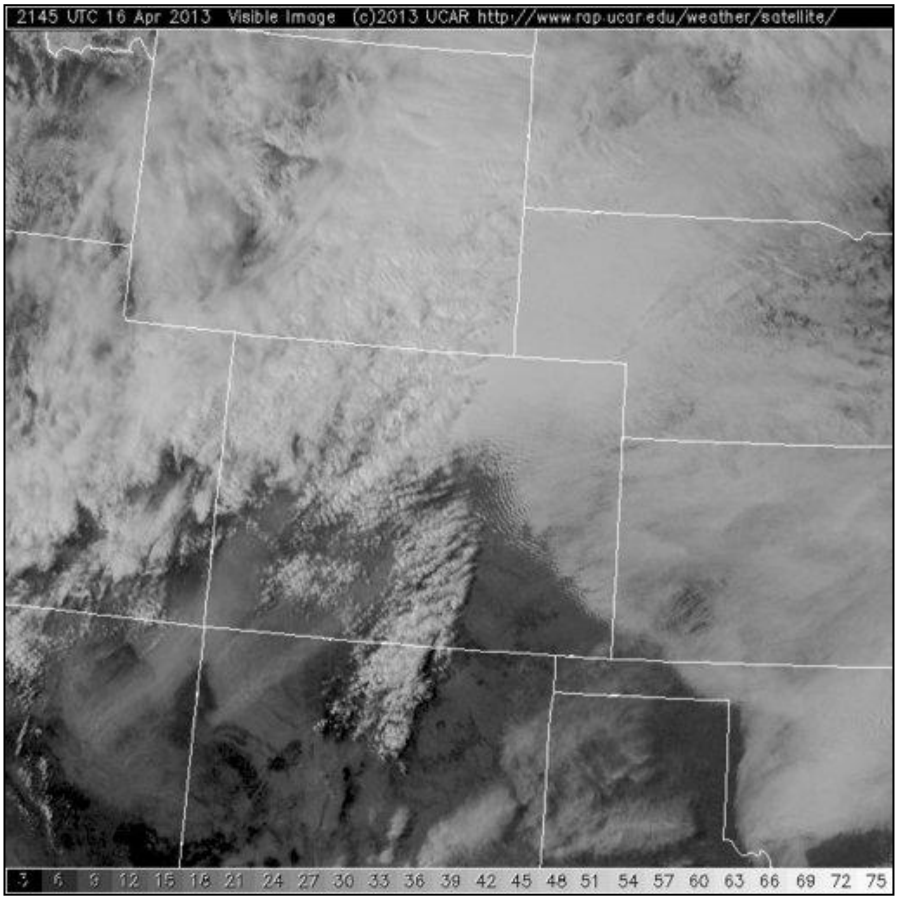


Figure 31: GOES visible satellite image for 2:45 PM MST (2145Z), April 16, 2013.
(source: http://www.rap.ucar.edu/weather/satellite)

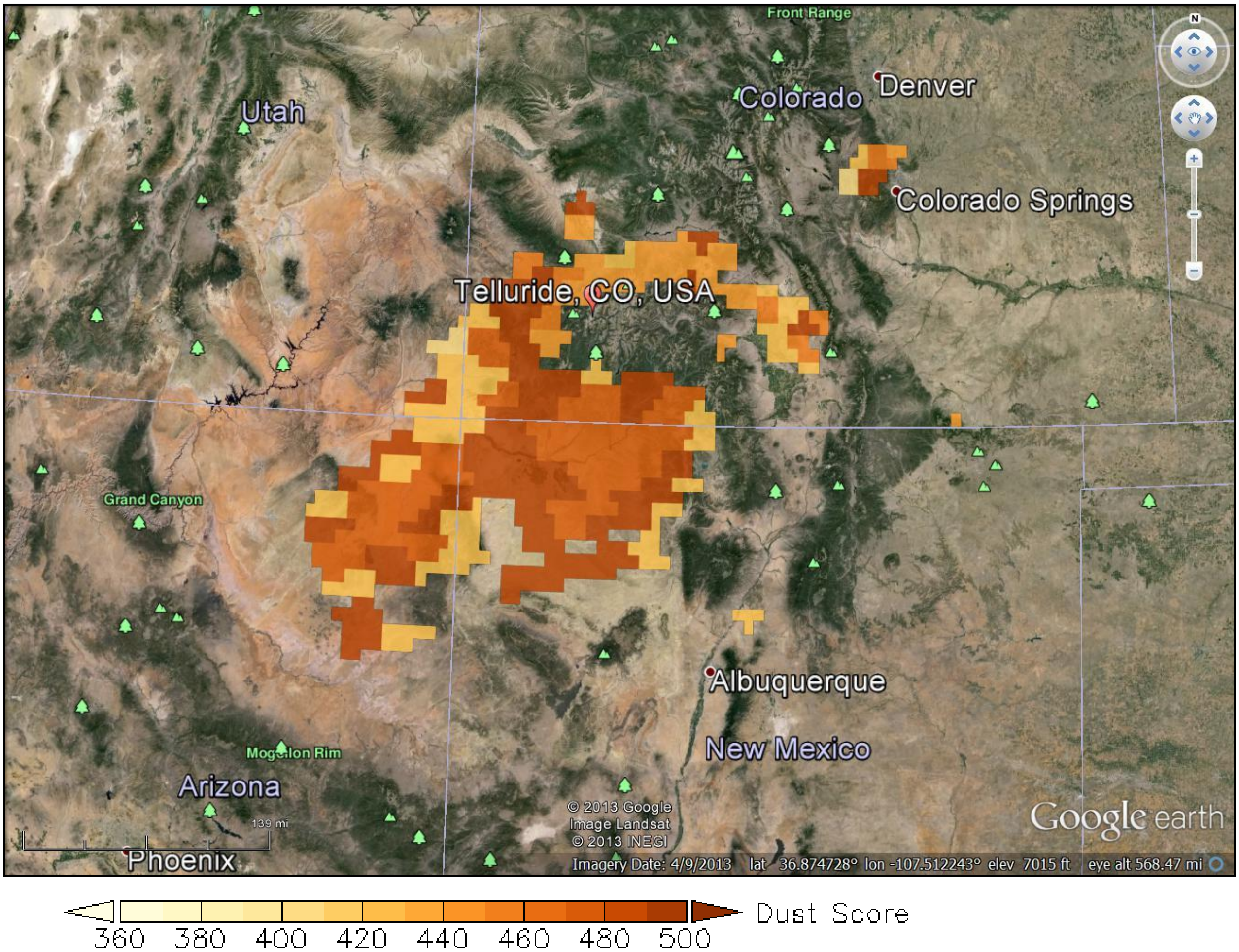


Figure 32: AIRS Dust Score for April 16, 2013.
(source: http://www.earthdata.nasa.gov/labs/worldview)

The Smoke Text Product from the National Oceanic and Atmospheric Administration (NOAA) Satellite Services Division - Descriptive Text Narrative for Smoke/Dust Observed in Satellite Imagery through 1545Z April 16, 2013 (8:45 AM MST April 16, 2013) (http://www.ssd.noaa.gov/PS/FIRE/DATA/SMOKE/2013D161604.html) describes widespread dust across the Four Corners region on April 16, 2013:

> "Very strong Swly winds are kicking up a large area of moderate dust/sand with numerous appox. 1Km wide parallel bands with very dense conditions…particularly in AZ along the flats/canyon rim SW and NE of the Little Colorado River, from around Tuba City to Winslow; also in the Chinle Valley (particularly SW sources); and in NM along US-491 from Shiprock to Gallup. **This dust and sand then covers all of SE Utah and SW Colorado**, moving NNE and more N toward the frontal zone across N UT/SW WY, but becomes thinner the further from the sources."

NOAA scientists with expertise in the analysis of dust storms have indicated that a regional dust storm in Arizona and New Mexico transported dust into southwest Colorado on April 16, 2013.

Figure 33 shows the total precipitation in inches for the southwestern United States for March 2013. It shows that a large portion of northeast Arizona and northwest New Mexico received less than 0.5 inches of precipitation during March 2013. Additionally, it should be noted that precipitation of less than 0.5 inches was reported in this region during the first half of April leading up to the April 16, 2013 dust event as evidenced in Figure 34. Combining the data from Figure 33 and Figure 34, we can extrapolate that a large portion of northeast Arizona and northwest New Mexico received 0.5 inches of precipitation or less during the March 1-April 15, 2013 time frame. This is an approximate precipitation threshold, below which, blowing dust can occur in the Painted Desert area when winds are above the blowing dust thresholds. This precipitation threshold is reported in Appendix A which shows that blowing dust can occur in northeastern Arizona source regions when soils are dry (typically less than 0.5 inches in a 30-day period at Hopi, Arizona) and winds are strong.

Furthermore, the Drought Monitor report for the western United States as of 5:00 AM MST April 16, 2013 (Figure 35) reveals that drought conditions in most of northeast Arizona and northwest New Mexico were categorized in the "Moderate" to "Extreme" range. ***Soils in the Four Corners area of northeast Arizona, northwest New Mexico and southeast Utah were dry enough to produce blowing dust when winds were above the thresholds for blowing dust.***

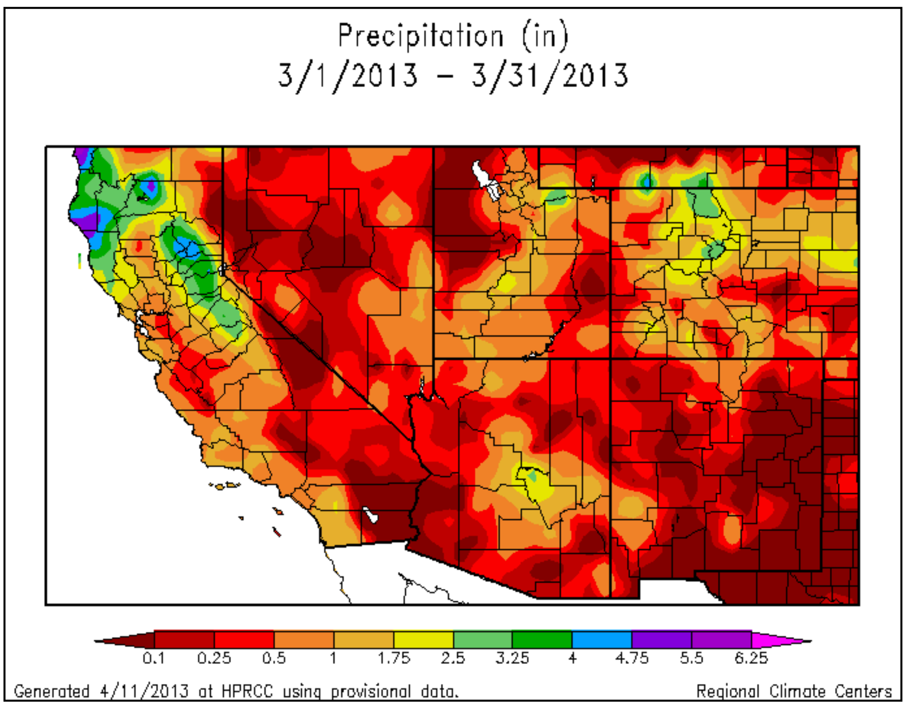


Figure 33: Total precipitation in inches for March 2013.
(source: http://www.hprcc.unl.edu/maps/current/index.php?action=update_region&region=WRCC).

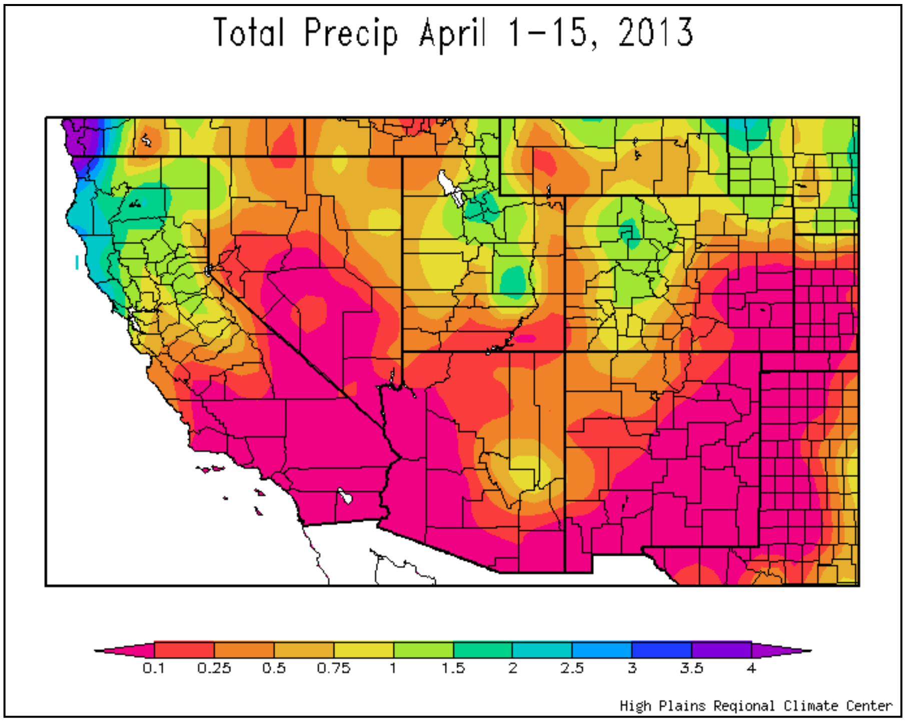


Figure 34: Total precipitation in inches for April 1- April 15, 2013.
(source:
http://www.hprcc.unl.edu/maps/current/index.php?action=update_region&region=WRCC).

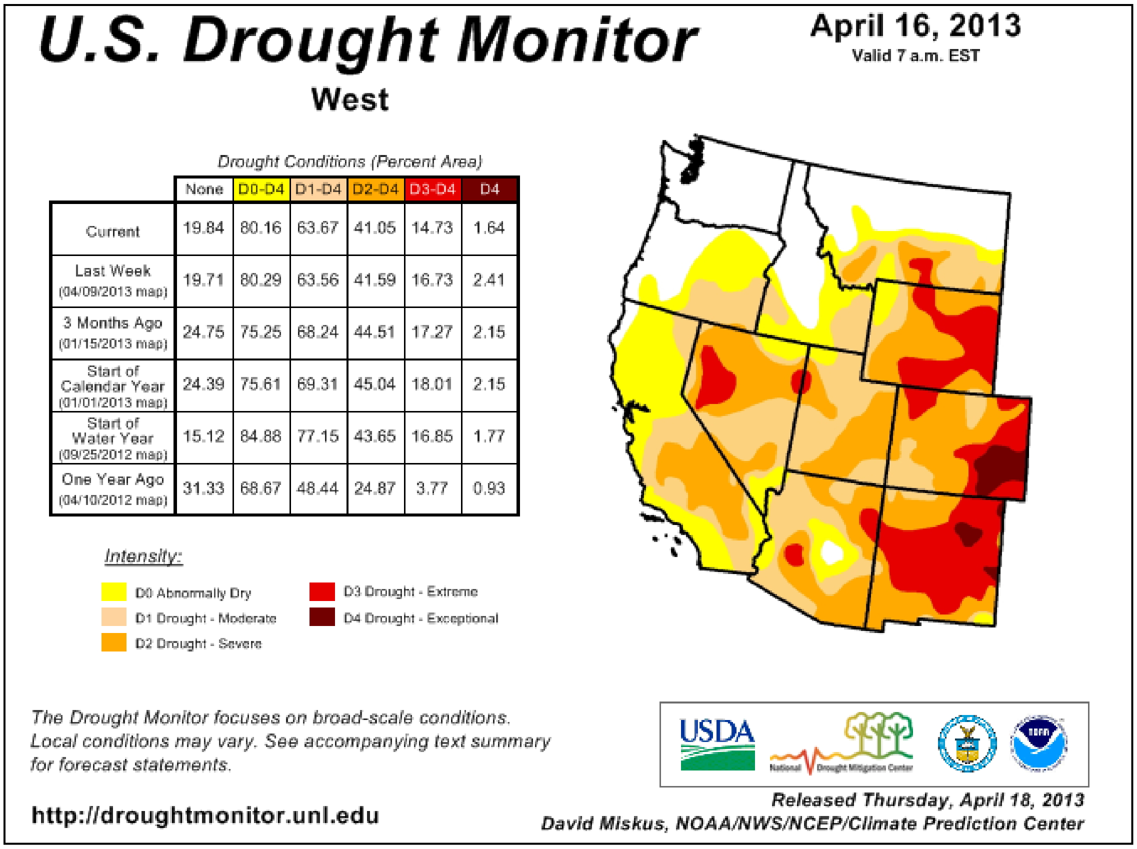


Figure 35: Drought conditions for the western United States at 5 AM MST April 16, 2013. **(source: http://droughtmonitor.unl.edu/archive.html)**

In a 1997 paper, "Factors controlling threshold friction velocity in semiarid and arid areas of the United States" (Marticorena et al., 1997), the authors characterized the erodibility of both disturbed and undisturbed desert soil types. The threshold friction velocity, which is described in detail in this paper, is a measure for conditions necessary for blowing dust and is higher for undisturbed soils and lower for disturbed soils.

Friction velocities have been calculated for 11 AM MST April 16, 2013, and 5 PM MST April 16, 2013, using the 12km NAM (North American Mesoscale Model). These friction velocities are presented in Figure 36 and Figure 37, respectively. According to Marticorena and coauthors (1997), even undisturbed desert soils normally resistant to wind erosion will be susceptible to emission of blowing dust when threshold friction velocities are greater than about 1.0 to 2.0 meters per second. These figures show that a wide area of northern Arizona, western New Mexico and southwest Colorado had friction velocities above 1.0 meters per second during the late morning and afternoon hours of April 16, 2013.

During the late morning of April 16, 2013, high friction velocity values were present in northwest New Mexico and within the Little Colorado River Valley and Painted Desert region of northeast Arizona (Figure 36). This is the same area where MODIS and GOES imagery clearly shows blowing dust originating during the early afternoon hours (Figure 30 and Figure 31, respectively) and also where 30-day precipitation totals were near or below 0.5 inches (Figure 33 and Figure 34). Note that blowing dust will typically only occur where friction velocities are high and the soils are dry and not protected by vegetation, forest cover, boulders, rocks, etc. This would tend to discount the possibility of dust from local sources in and near Telluride, but would reinforce the case that blowing dust originated in the desert and more arid sections of northeast Arizona and northwest New Mexico on April 16, 2013.

The elevated friction velocities shown in Figure 36 and Figure 37, the data on soil moisture conditions presented elsewhere in this report and the prevalence of winds above blowing dust thresholds (all occurring in traditional source regions in northeast Arizona and northwest New Mexico) prove that this dust storm was a natural event that was not reasonably controllable or preventable.

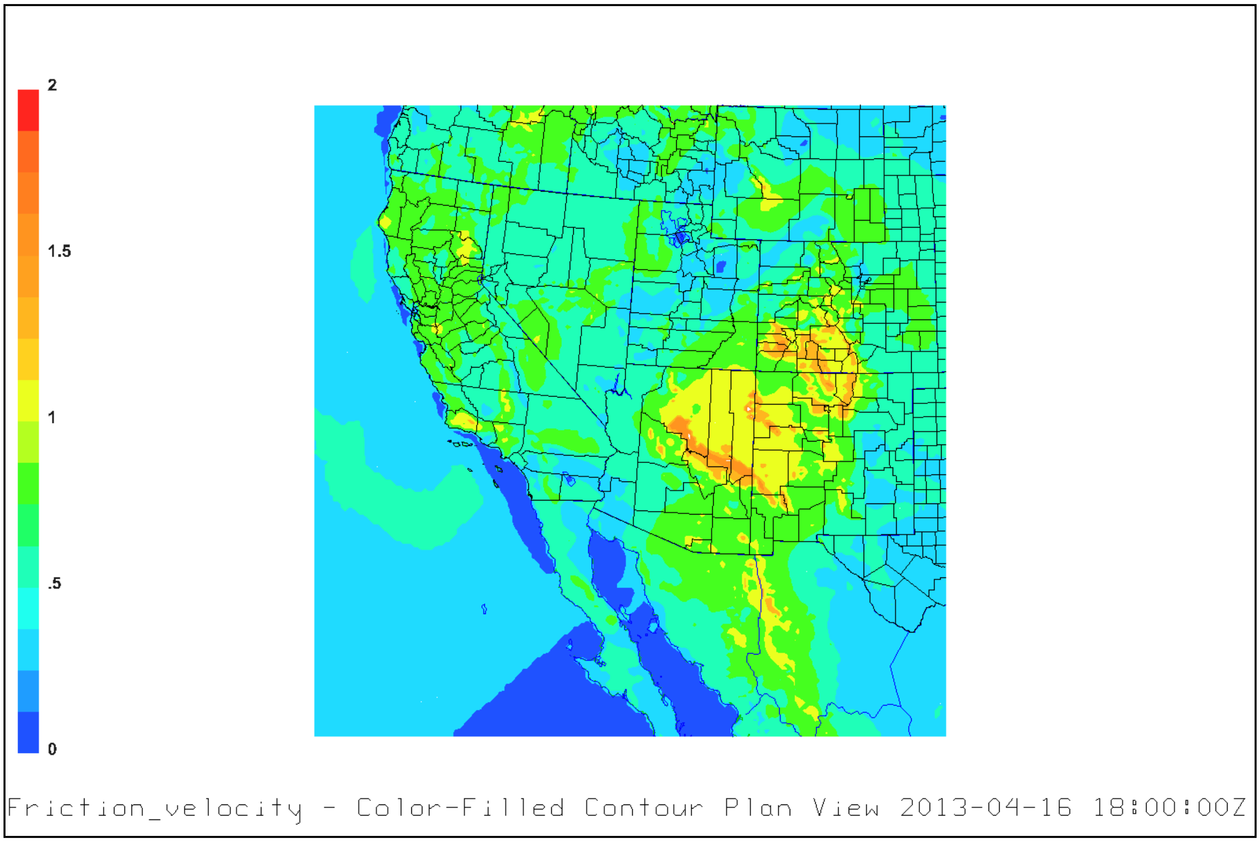


Figure 36: 12km NAM friction velocities in meters/second at 11 AM MST April 16 (18Z April 16), 2013.
(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)

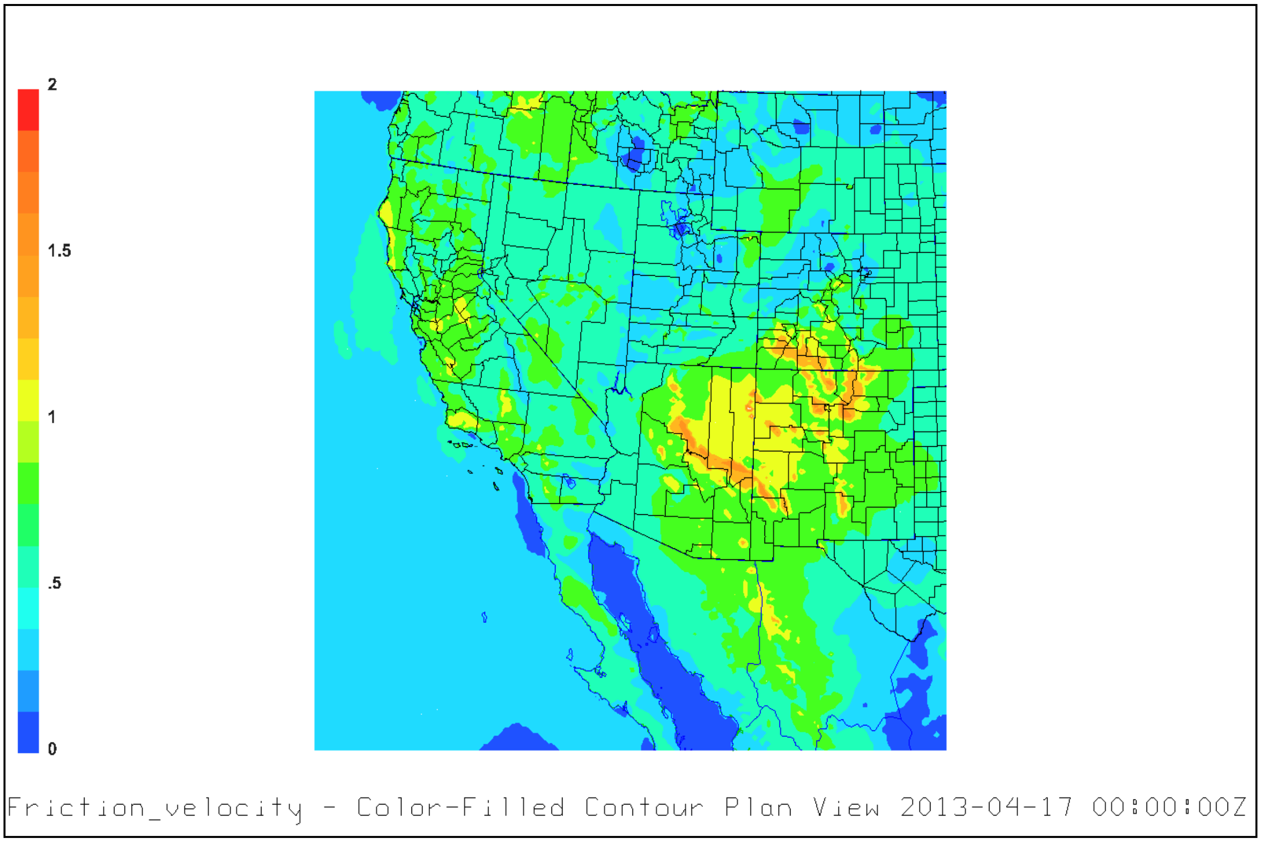


Figure 37: 12km NAM friction velocities in meters/second at 5 PM MST April 16 (00Z April 17), 2013. **(data source: http://nomads.ncdc.noaa.gov/data.php?name=access#hires_weather_datasets)**

3.0 Evidence-Ambient Air Monitoring Data and Statistics

3.1 Event Summary

On April 16, 2013, a strong upper atmospheric trough combined with an intensifying surface low pressure system and strong cold front moved across Colorado. During this interval PM_{10} sample values greater than 150 µg/m^3 were taken at multiple sites across southwestern Colorado, including Telluride (265 µg/m^3), Durango (419 µg/m^3), Pagosa Springs (295 µg/m^3), Alamosa Adams State College (237 µg/m^3), and Mt. Crested Butte (187 µg/m^3). The high values were the consequence of strong southwesterly prefrontal winds beginning early on April 16, 2013, and extending through much of the day in combination with dry conditions which caused significant blowing dust across much of Arizona, northwest New Mexico, and southwest Colorado. The focus of this exceptional event document is for Telluride (08-113-0004). Additional documentation will be provided at a later date for other sites.

3.2 Historical Fluctuations of PM_{10} Concentrations in Telluride

This evaluation of PM_{10} monitoring data for sites affected by the April 16, 2013, event was made using valid samples from PM_{10} samplers from 2008 through available samples in 2013. APCD has been monitoring PM_{10} concentrations in these areas since 1985. Data in this analysis for sites affected by the event are from January 2008 through (generally) June of 2013. The overall data summary for the affected sites is presented in Table 9, all data values are presented in µg/m^3:

Table 9: April 16, 2013, Event Data Summary.

Evaluation	Alamosa ASC	Pagosa Springs	Crested Butte	Mt. Crested Butte	Durango	Telluride
4/16/2013	**237**	**295**	**140**	**187**	**419**	**265**
Mean	24.1	23.7	24.6	16.5	21.5	18.3
Median	19	20	21	14	17	14
Mode	17	16	10	9	18	11
St. Dev.	27.1	21.2	17.3	12.3	26.2	22.5
Variance	735.9	450.6	299.7	150.8	688.4	508.1
Minimum	1	2	5	1	3	1
Maximum	440	349	174	187	419	354
Count	1775	1846	650	1926	632	626

As this table demonstrates the spatial scope of this event, addressed elsewhere in this document, was broad and had an impact on PM_{10} concentrations at multiple sites covering an extensive geographical area. Since this document will address only the sample in Telluride sample only that data set will be discussed in detail; APCD will submit additional documentation addressing samples affecting attainment status in Alamosa, Pagosa Springs, Mt. Crested Butte, and Durango at a later date. A snapshot summary of data from all those sites affected by the event is presented in Table 10, along with the approximate percentile value that data point represents for each site for their unique historical data sets, for the month of the event (every sample in any April), and for the year of the event. All percentile calculations presented in this section were made using the entire dataset, including known high wind events. There is no difference between the two datasets (with and without high wind events) in regards to percentile calculations. Percentile calculations for all sites affected by the event are presented in Table 10, only the sample in Telluride will be discussed in detail.

Table 10: April 16, 2013, Site Percentile (All Affected Sites).

Evaluation	*Alamosa ASC*	*Pagosa Springs*	Crested Butte	*Mt. Crested Butte*	*Durango*	*Telluride*
4/16/2013	**237**	**295**	**140**	**187**	**419**	**265**
Overall	99.6%	99.9%	99.8%	Max Value	Max Value	99.8%
All April	98.3%	99.4%	98.2%	Max Value	Max Value	98.2%
2013	Max Value	Max Value	Max Value	Max Value	Max Value	Max Value

The Telluride sample of 265 $\mu g/m^3$ is the largest sample in 2013 (through June), the second highest in any April and the second highest in the dataset. Additionally, the samples at Alamosa ASC, Pagosa Springs, Mt. Crested Butte and Durango are exceptional within their own datasets for any evaluation criteria.

The overall magnitude and broad geographical extent of affected sites suggests that there was a common contribution to each sample from other than local sources.

Those data sets for sites with samples for which exclusion is being requested are further summarized by month. As with previous submittals these summaries the data presents no obvious 'season'; PM_{10} levels at any particular site in Colorado do not necessarily fluctuate by season. Of greater importance affecting day-to-day, typical PM_{10} concentrations are local sources, e.g. road sanding and sweeping, local burning from agriculture and residential heating, vehicle contributions via road dust, unpaved lots or roads, etc. While the historic monthly mean values for the affected sites can be higher during the winter and spring months there is little month-to-month variation. Additionally, some of the sites exhibit monthly medians over these periods (winter and early spring) that are generally lower than other months of the year. This time frame (winter and early spring) is that which is most likely to experience the regional meteorological and dry soil conditions necessary for this type of event and are discussed elsewhere in this document. Although the maximum values for these months (winter and early spring) are the highest in the data set the 'typical' data (i.e. day-to-day, reflective of local conditions) are similar or lower than the same 'typical' data for the rest of the year. The summary data for the month of April (all samples in any April from 2008 - 2013) and for 2013 for all affected sites are presented in Table 11**:**

Table 11: April 16, 2013, PM_{10} Evaluation by Month and Year.

	Alamosa ASC		**Pagosa Springs**		**Crested Butte**		**Mt. Crested Butte**		**Durango**		**Telluride**	
	April	2013	April	2013	April	2013	April	2013	April	2013	April	2013
Mean	34.1	30.2	34.8	27.9	30.8	21.7	21.3	16	42	25.6	21.5	21.4
Median	19	21	23	21	23	18	16	13	18.5	18	18.5	15
Mode	16	10	23	13	12	7	12	12	13	18	14	11
St. Dev.	51.0	36.2	46.2	36.6	30.7	20.5	23.6	15.6	74.5	56.0	57.1	36.0
Variance	2599	1309	2133	1337	942	419	559	242	5548	3132	3262	1299
Minimum	1	4	2	3	6	6	1	4	6	5	3	3
Maximum	389	237	349	295	174	140	187	187	419	419	354	265
Count	174	141	169	157	57	51	168	155	58	52	58	51

The PM_{10} sample on April 16, 2013, at Telluride of 265 $\mu g/m^3$ is the second largest sample recorded among all April samples, is the maximum value for all 2013 data, and is the second largest sample value for the entire dataset. The one sample greater, 354 µg/m^3 on April 05, 2010, is also associated with a high wind event. There are 2214 samples in this dataset.

The sample of April 16, 2013, clearly exceeds the typical samples for this site.

The following plots graphically characterize the Telluride PM_{10} data and demonstrate the extent to which the event sample is exceptional. The first, Figure 38, is a simple time series; both samples in this dataset (2008 – 2013) greater than 150 µg/m^3 is identified. Note the overwhelming number of samples occupying the lower end of the graph; an interested reader can count the number of samples greater than 100 µg/m^3. Of the 626 samples in this data set, less than 1% are greater than 100 µg/m^3.

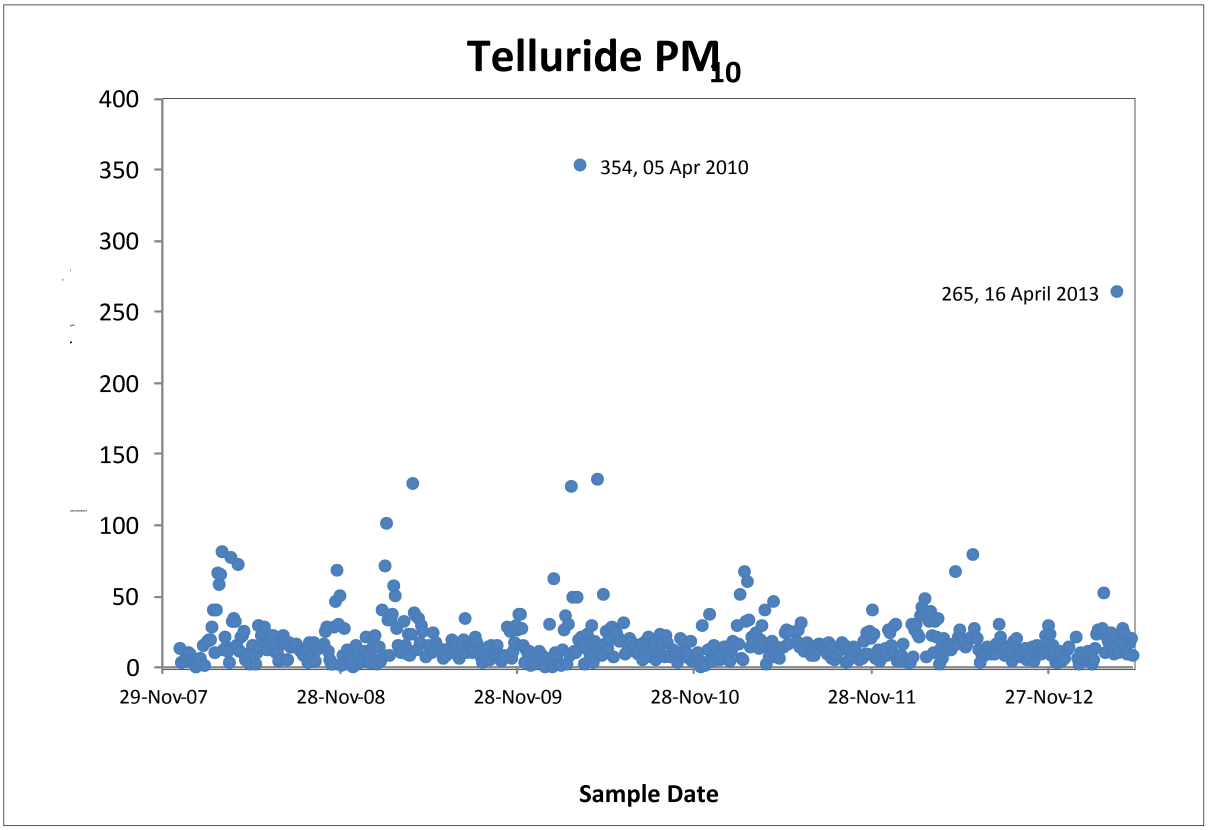


Figure 38: Telluride PM_{10} Time Series.

Figure 39 is a simple histogram, demonstrating the overwhelming weight of samples on the low end of the curve. This range of data can be considered typical, representing contributions from local sources. Nearly 75% of the samples in this data set are less than 20 µg/m^3. Even in the highly variable months of winter and early spring over 90% of the samples are less than 50 µg/m^3.

Clearly the sample of April 16, 2013, exceeds what is typical for this site.

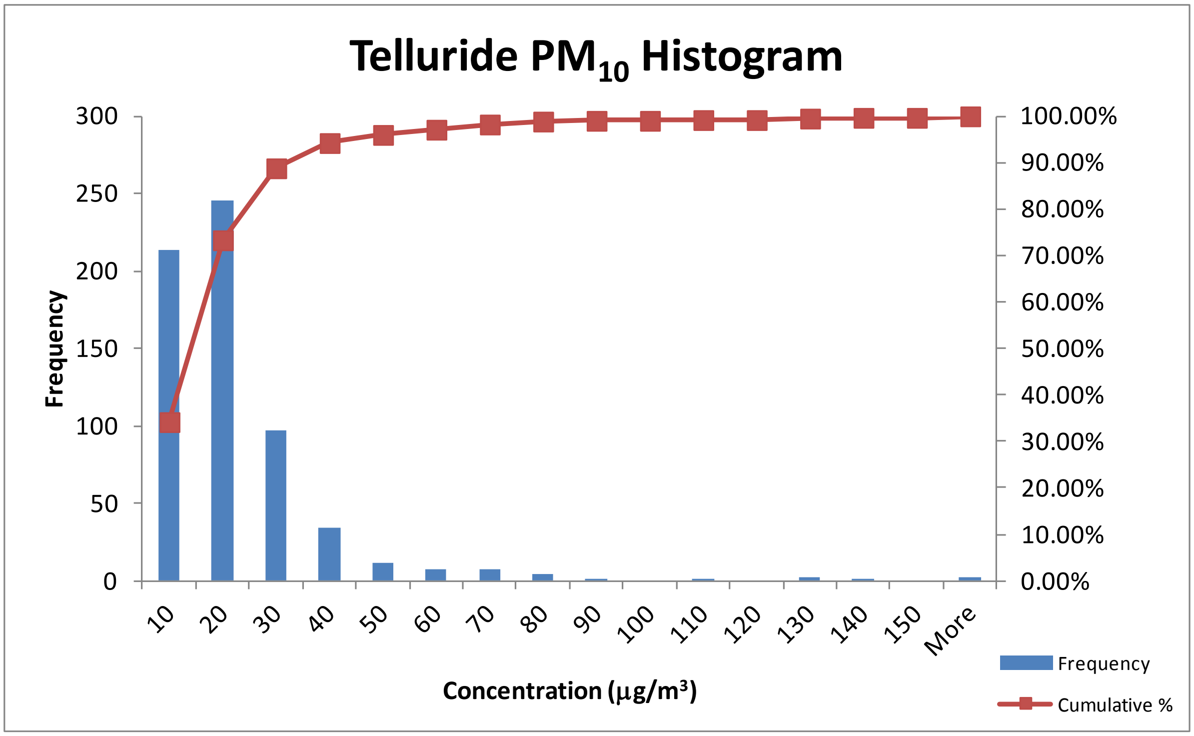


Figure 39: Telluride PM_{10} Histogram.

The monthly box-whisker plot in Figure 40 highlights the consistency of the majority of data from month to month. Note the greater variability (wider inner-quartile range) and greater range of the data through the winter and early spring months that's accompanied by typically greater monthly maxima. Recall, this time period experiences a greater number of days with meteorological conditions similar to those experienced on April 16, 2013. Although these high values affect the variability and central tendency (average) of the dataset they aren't representative of what is typical at the site.

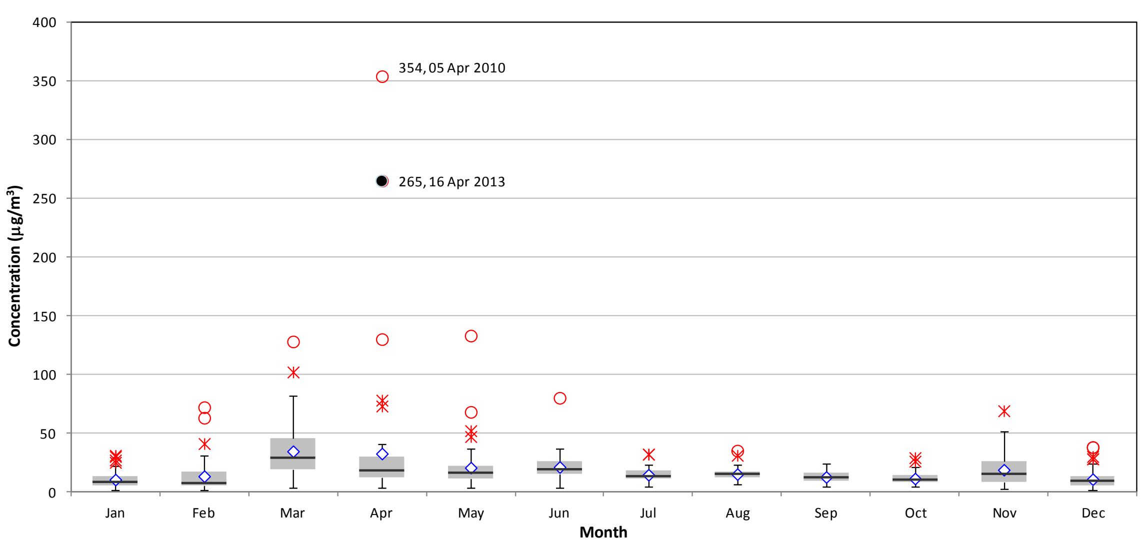


Figure 40: Telluride PM_{10} Box-whisper Plot.

The box-whisper plots graphically represent the overall distribution of each data set including the mean (◇), the inner quartile range (IQR, defined to be the distance between the 75th% and 25th%), the median (represented by the horizontal black line) and two types of outliers identifed in these plots: outliers greater than 75th% +1.5*IQR (✳)and outliers greater than 75th% + 3*IQR (○). The outliers that satisfy the last criteria and are greater than 150 µg/m^3 are labeled with sample value and sample date. Each of these outliers is associated with a known high-wind event.

The presence of the extreme values distorts the graph, losing definition and distorting information presented across the range where the majority of data resides. The same plot graphed to 100 µg/m^3, which includes almost 99% of all the data, is presented in Figure 41.

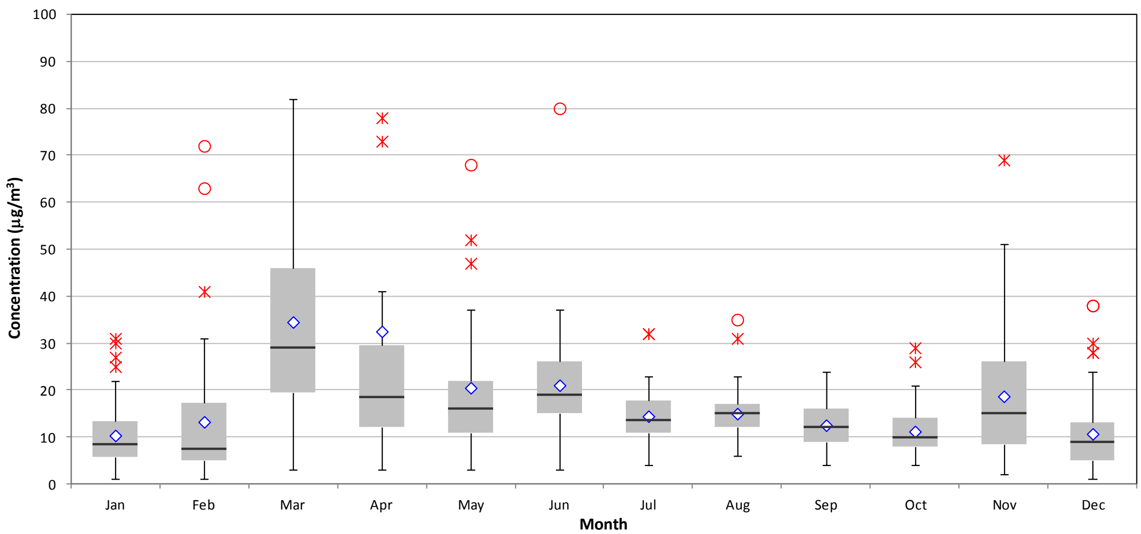


Figure 41: Telluride PM_{10} Box-whisper Plot, Reduced Scale.

Note the degree to which the data in early spring spring, including April, are skewed. The April mean (32.4 µg/m^3) is greater than the April 75th percentile value (29.5 µg/m^3). This is due to the presence of two extreme values and can create the perception that those months experiencing these high wind events are somehow 'dirtier' than other months of the year

The sample of April 16, 2013, clearly exceeds the typical data at this site.

3.2 Clear Causal Relationship

Wind speeds around the region (Southwest Colorado, Northeast Arizona, Northwest New Mexico) increased early in the morning of April 16, 2013, and stayed elevated through early morning of April 17, 2013, gusting to speeds in excess of 50 mph. The charts in Figure 42 display wind speed (mph) as a function of date from four widely dispersed stations throughout the region. Every one of these stations, despite being in completely disparate locations, exhibits nearly the same behavior in regards to the sustained high winds on April 16, 2013.

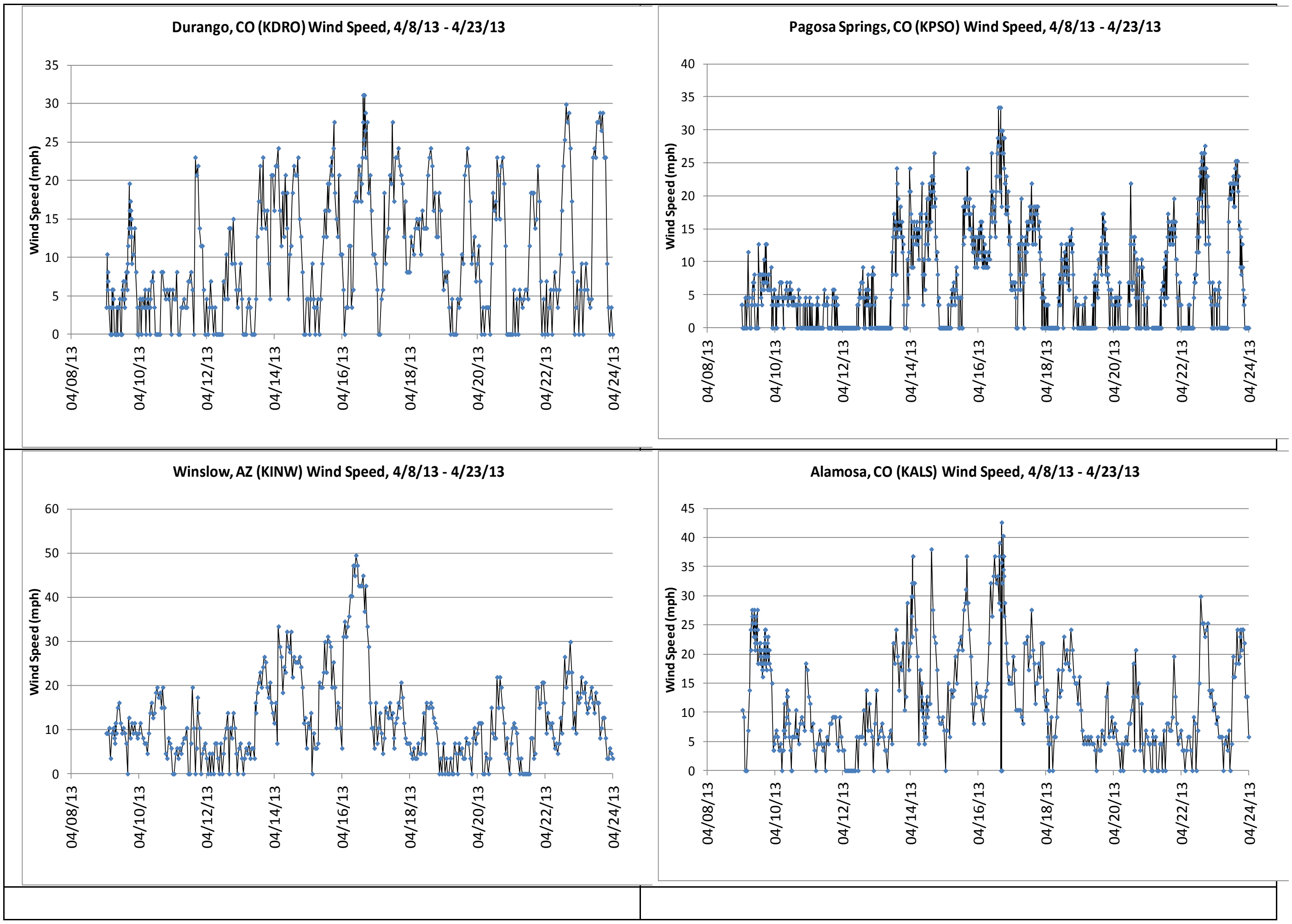


Figure 42: Wind Speed (mph) Various Stations, 04/08/2013 – 04/23/2013.

Figure 43 plots PM_{10} concentrations from the affected sites in Colorado for the period for seven days prior to and following the sample(s) of April 16, 2013.

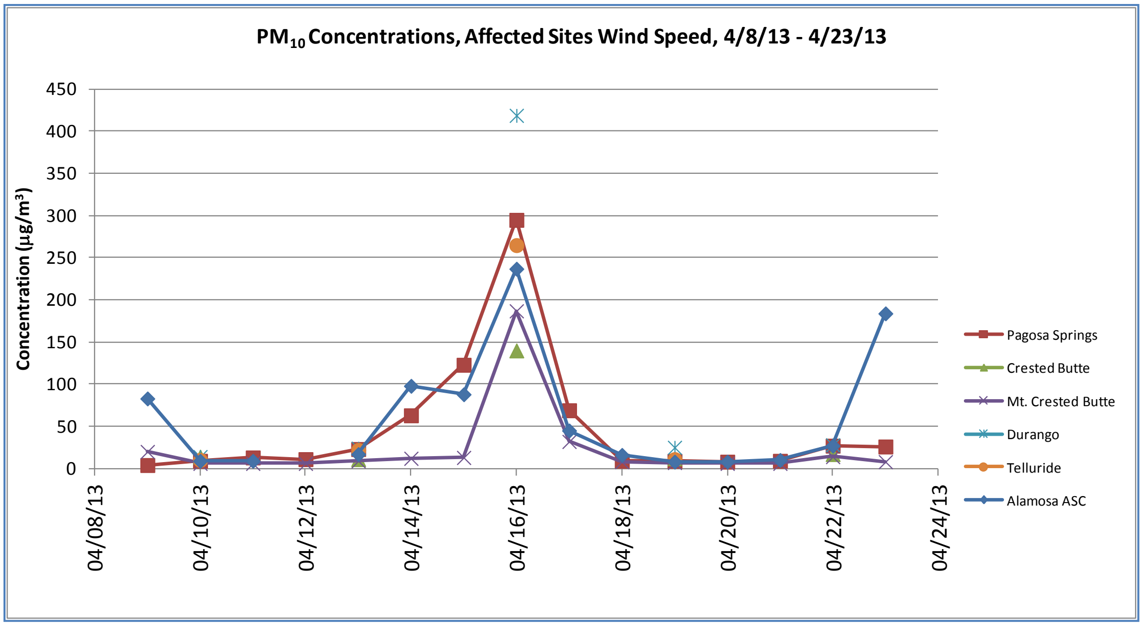


Figure 43: PM_{10} Concentrations, Affected Sites, 04/08/2013 – 04/23/2013.

Figure 43 mimics the plots for wind speed, suggesting an association between the regional high winds and PM_{10} concentrations at the affected sites. Although not every sample in the region from April 16 is in excess of 150 elevated $\mu g/m^3$ the elevated concentrations are clearly associated with the elevated wind speeds.

Given the spatial dislocation of the sites (meteorological and PM_{10}) the relationship between the two data sets would suggest that the regional high winds had an effect on PM_{10} samples across a broad spatial region in Colorado.

3.4 No Exceedance But For the Event

Monthly percentile plots in Figure 44 demonstrate a high degree of association between monthly median values and relatively high monthly percentile values, e.g. the r^2 value between the Telluride monthly 90th percentile value and the Telluride monthly median is 0.82. As the percentile value decreases (i.e. 85%, 75%, etc) the correlation between those values and the median increases sharply. The Telluride monthly percentile plot is presented in Figure 44:

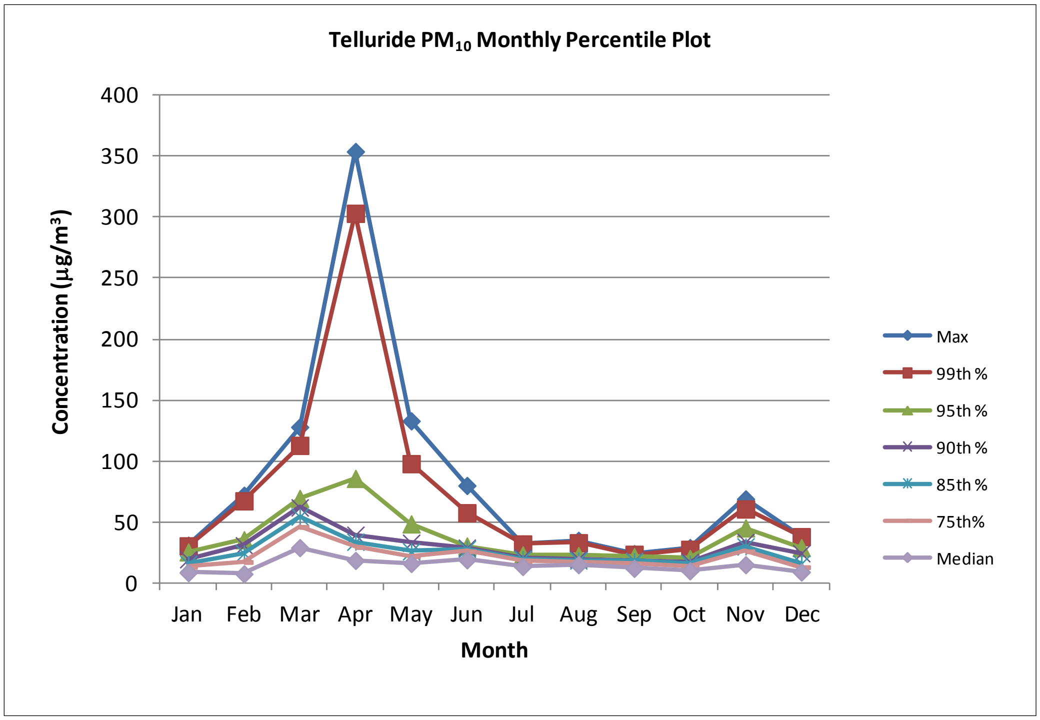


Figure 44: Monthly PM_{10} Percentile Plots.

It is certainly the case that monthly median values are indicative of typical, day to day concentrations. Additionally, there is a range of samples that are a product of normal variation subject to typical, day to day local effects. This range may be restricted to percentile values that are well correlated with the median. For the data set of concern in this document the percentile value that is reflective of typical, day to day variation is the 80th percentile value ($r^2 = 0.92$). Nearly all of the variation in the monthly 80th percentile values of this data set can be explained by the variation in monthly median. In contrast, a reasonable estimate of the contribution to the event from local sources for these data sets may be the monthly 90th percentile values (r2 = 0.82). The portion of the sample concentration remaining from these monthly percentile values would be the sample contribution due to the event. Table 12 identifies various percentile values that are representative of the maximum contribution due to local sources from Telluride selected from all April data. In Table 12, the range estimate in the 'Est. PM_{10} Contribution' column is derived using the difference between the actual sample value and the 85th percentile as the minimum (reasonable) event contribution estimate and the difference between the actual sample value and the 75th percentile as the maximum (conservative) event contribution estimate. This column represents the range of estimated contribution to the April 16, 2013, Telluride sample from the high wind event.

Table 12: Estimated Maximum Event PM_{10} Contribution – Telluride.

Site	Event Day Concentration (µg/m^3)	April Median (µg/m^3)	April Average (µg/m^3)	April 80th % (µg/m^3)	April 90th % (µg/m^3)	Est. Conc. Above Typical (µg/m^3)
Telluride	265	19	32.5	33	40	**225 - 232**

Clearly, there would have been no exceedance but for the additional contribution to the PM_{10} samples provided by the blowing dust event.

4.0 News and Credible Evidence

Southwestern dust found in snow across Colorado

***Author:* Associated Press**
POSTED: 11:30 AM MDT Apr 19, 2013

- Print
- Email
-

KTVI via CNN

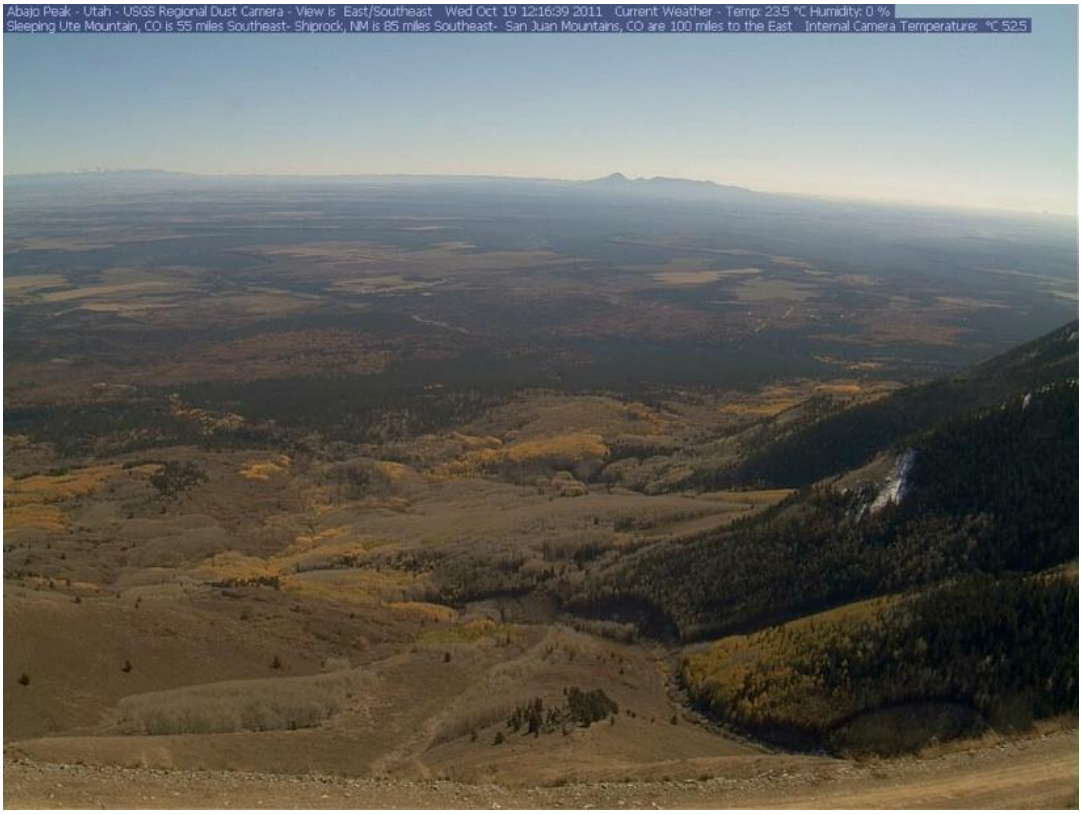
DENVER -
Dust blown in from the Southwest settled on snow through much of Colorado during this week's storm and will eventually affect how fast the snowpack melts.

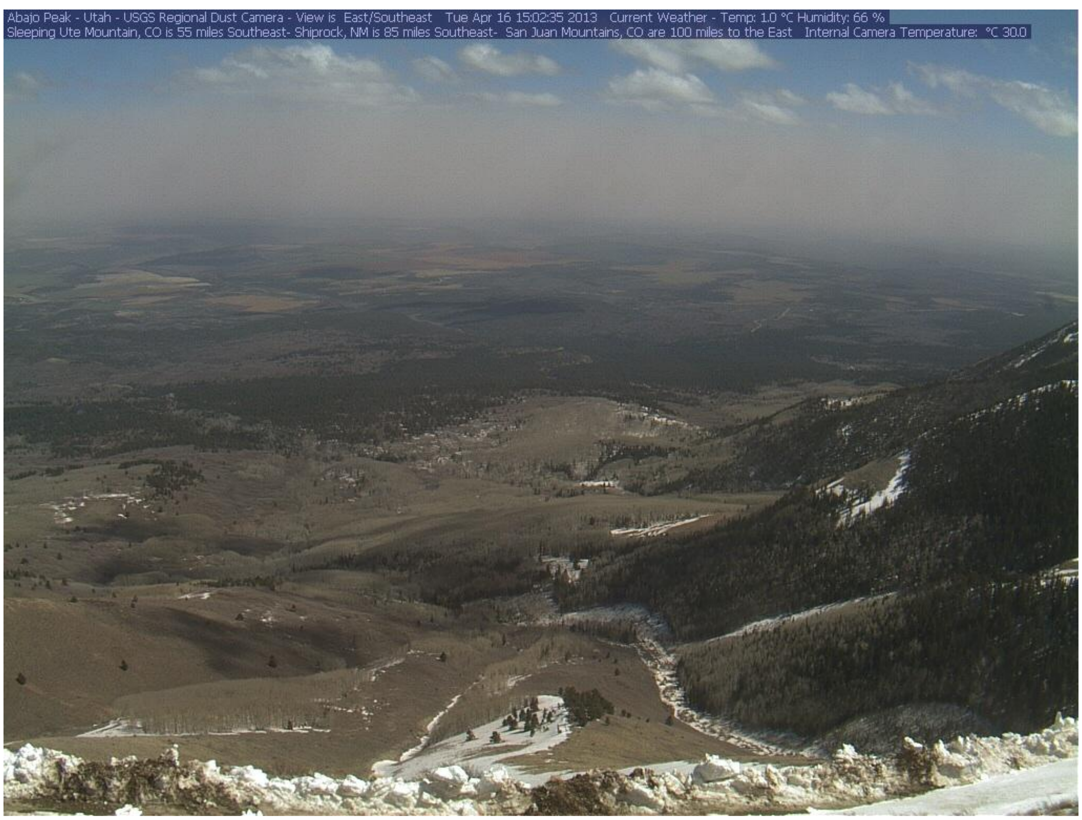
Researchers say it fell in Steamboat Springs, Fort Collins, Summit County, and the San Juan mountains. It was also seen in the Denver area.

Chris Landry of the Center for Snow and Avalanche Studies has been surveying the conditions for water providers. He said Friday that if more clean snow keeps falling, the impact of the dust will be delayed. However, he said once this week's snow layer and another deeper layer of dust from an April 8 storm are exposed, the snowmelt will accelerate because the dust absorbs sunlight.

NOAA (NOAH) researcher Jeffrey Deems compares the effect to wearing a dark t-shirt on a sunny day.

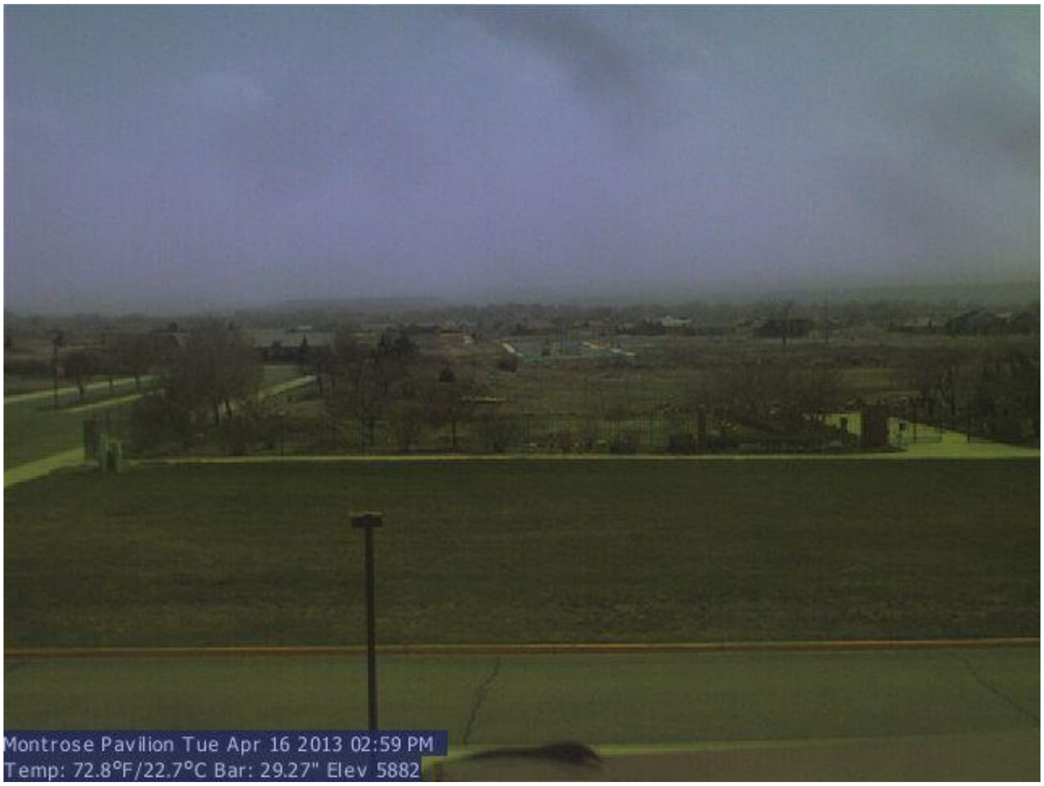
Contrasting webcam views of Abajo Peak:





Buena Vista webcam on April 16, 2013:

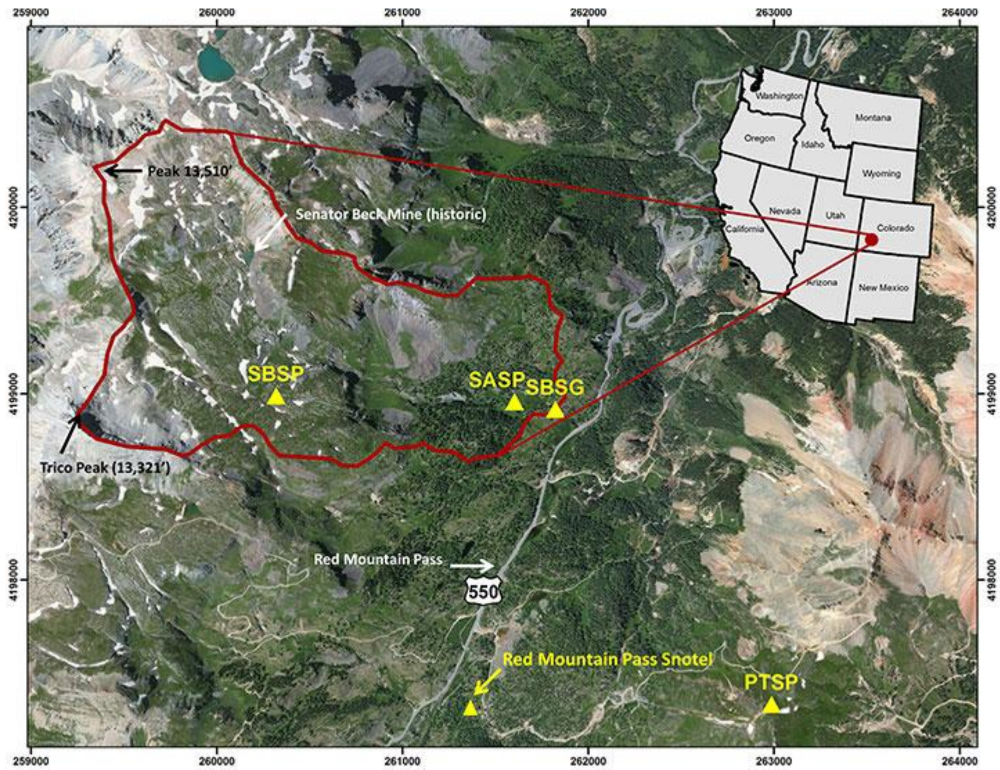
Montrose webcam on April 16, 2013:



Pagosa Springs webcam on April 16, 2013:

CENTER FOR SNOW & AVALANCHE STUDIES

COLORADO DUST-ON-SNOW PROGRAM WY 2013 SUMMARY



Summary | Dust Log | Winter Storms and Wind | Snowpack| Melt Rate | Stream Flows | New and Ongoing Research |Program Funding

SUMMARY

Water Year 2013 entered late winter with dismal snowpack development at ten of eleven CODOS dust-on-snow monitoring sites, Willow Creek Pass being the single exception. Through March 2013, snowpack SWE totals at all other sites resembled or even fell short of the very dry winter of WY 2012, raising concerns about back-to-back drought seasons. That broadly consistent spatial pattern in scant precipitation began to diverge in April, 2013. CODOS sites in the northern Front Range and Colorado River headwaters benefitted most from a series of April and May winter storms that augmented snowpacks and eventually resulted in average or even above average peak SWE levels on average or later-than-average dates. In the southwestern mountains, fewer and/or smaller April/May storms failed to offset the dry beginning to WY2013 winter. CODOS sites in the San Juan Mountains experienced, for the second year, substantially sub-par peak SWE values, on near-average dates. In between, the Central Mountains, Hoosier Pass, Park, and northern Gore ranges came closer to but still fell short of average snowpacks.

At the CSAS Senator Beck Basin Study Area at Red Mountain Pass, the primary CODOS monitoring site, WY2013 produced a total of ten separate dust-on-snow events, a lower total count than in the past three seasons. However, the actual mass of dust deposited at Senator Beck Basin in WY 2013 was greater than in any prior season, including the “Martian Winter” of WY 2009**. Dust season began at Senator Beck Basin in November with a single event, February and March delivered four additional events, but the vast majority of dust deposition occurred during events D6 on April 8th and the long-duration D8 event of April 15-17.** As of late March, dust layers observed at Senator Beck Basin were either weak or not present at CODOS sites farther north and east, creating some hope that WY 2013 might be dust-free in parts of the state. Then, dust events D6 and D8 spelled the end to that possibility with significant depositions statewide near the top of the snowpack.

Good news of deep snow in Colorado foiled by dust that will speed melt

By Jason Blevins

The Denver Post

POSTED: 04/18/2013 06:08:40 PM MDT20 COMMENTS| UPDATED: 4 MONTHS AGO

The blessed snow that blanketed the high country and bolstered emaciated snowpacks this week was swirling with dirty trouble.

Little specks of Arizona, New Mexico and Utah rode in on the potentially record-setting 61-hour storm and promise to hasten snowmelt.

And then, below that fresh layer of sun-absorbing, snow-melting dust is an uncommonly dense layer from an April 8 dust storm — the sixth of the season, or "D6" — that will send the snowmelt down in surging torrents, drowning hope for a sustained release deep into summer.

"None of the dust events we had last year were comparable to the April 8 event we had this year," said Chris Landry, executive director of the Center for Snow and Avalanche Studies in Silverton, who has studied dust events and the impact on snowpack in southern Colorado for the last decade.

The state has heralded recent storms that pushed snowpacks in every basin in the state beyond last year's record-low levels, floating hope that the still-growing snowpacks could dampen the impact of the sustained drought. But the dust storms — eight so far this year and more possibly on the way — will melt this year's snow faster than last year's, thanks to what Landry described as "the latent, very acute dust effect that's now inevitable."

There is hope. More snow — as in several feet piling deep and hiding the latest dust from penetrating sunshine — could delay the deluge.

Water managers across Colorado, many of whom fund Landry's research, lament the late-season dirt. That dark layer covering even the deepest snowpack prevents the slow and steady runoff that keeps rivers rolling and reservoirs replenished.

Instead, the runoff comes down at once, forcing precious water that could irrigate fields in July and float rafts in August to run through the state months early.

"Snowpack above 9,000 feet is our biggest water storage, and our best reservoir, and we want to keep water in that reservoir as long as possible," said Jim Pokrandt with the Colorado River Water Conservation District. "The worse these dust layers are, you get the snow (disappearing) quicker and that affects late-season base flows in streams. The effects are felt from high elevation down to where we use the water for irrigation."

Still, Pokrandt noted, at least "there is more snow to melt," especially in the Colorado River Basin, which saw its snow-water-equivalent climb from 72 percent of average in early February to 97 percent of average after Wednesday's storm.

http://www.denverpost.com/breakingnews/ci_23057359/good-news-deep-snow-colorado-foiled-by-dust?source=rss

Historical Weather For The Last Twelve Months in Telluride, Colorado, USA

Location

This report describes the historical weather record at the Telluride Regional Airport (Telluride, Colorado, United States) during the last 12 months. This station has records back to February 1987.

Telluride, Colorado has a humid continental climate with warm summers and no dry season. The area within 25 miles of this station is covered by *forests*(98%)

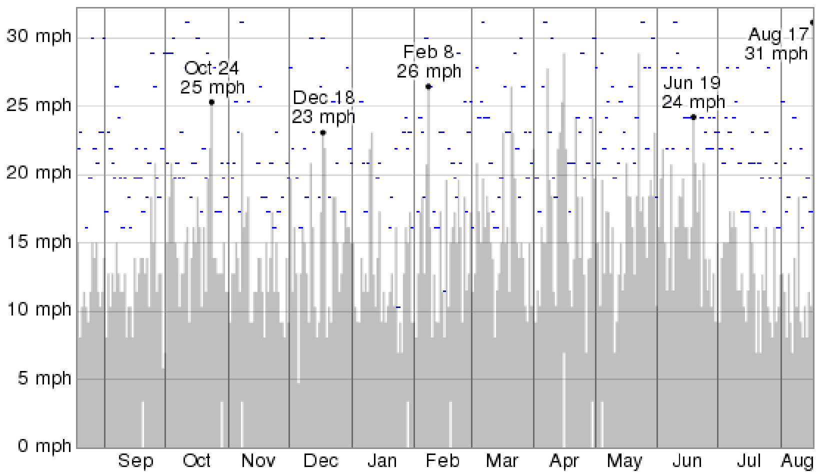
(Excerpt:)

Wind

The highest *sustained wind speed* was 31 mph, occurring on August 17; the highest *daily mean wind speed* was 17 mph (April 16); and the highest wind *gust speed* was 53 mph (April 16).

The *windiest month* was April, with an average wind speed of 7 mph. The *least windy month* wasAugust, with an average wind speed of 4 mph.

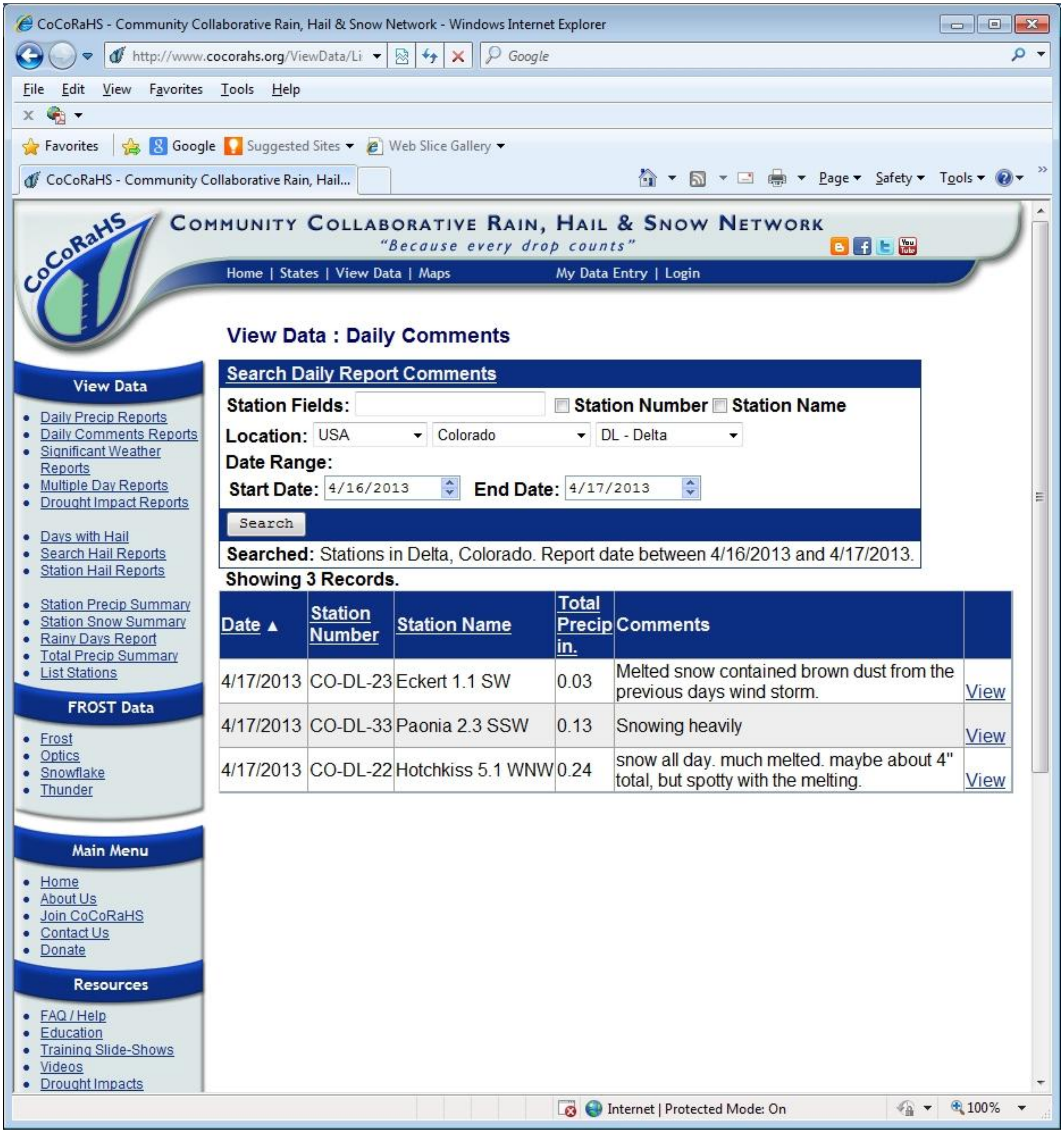
Wind Speed

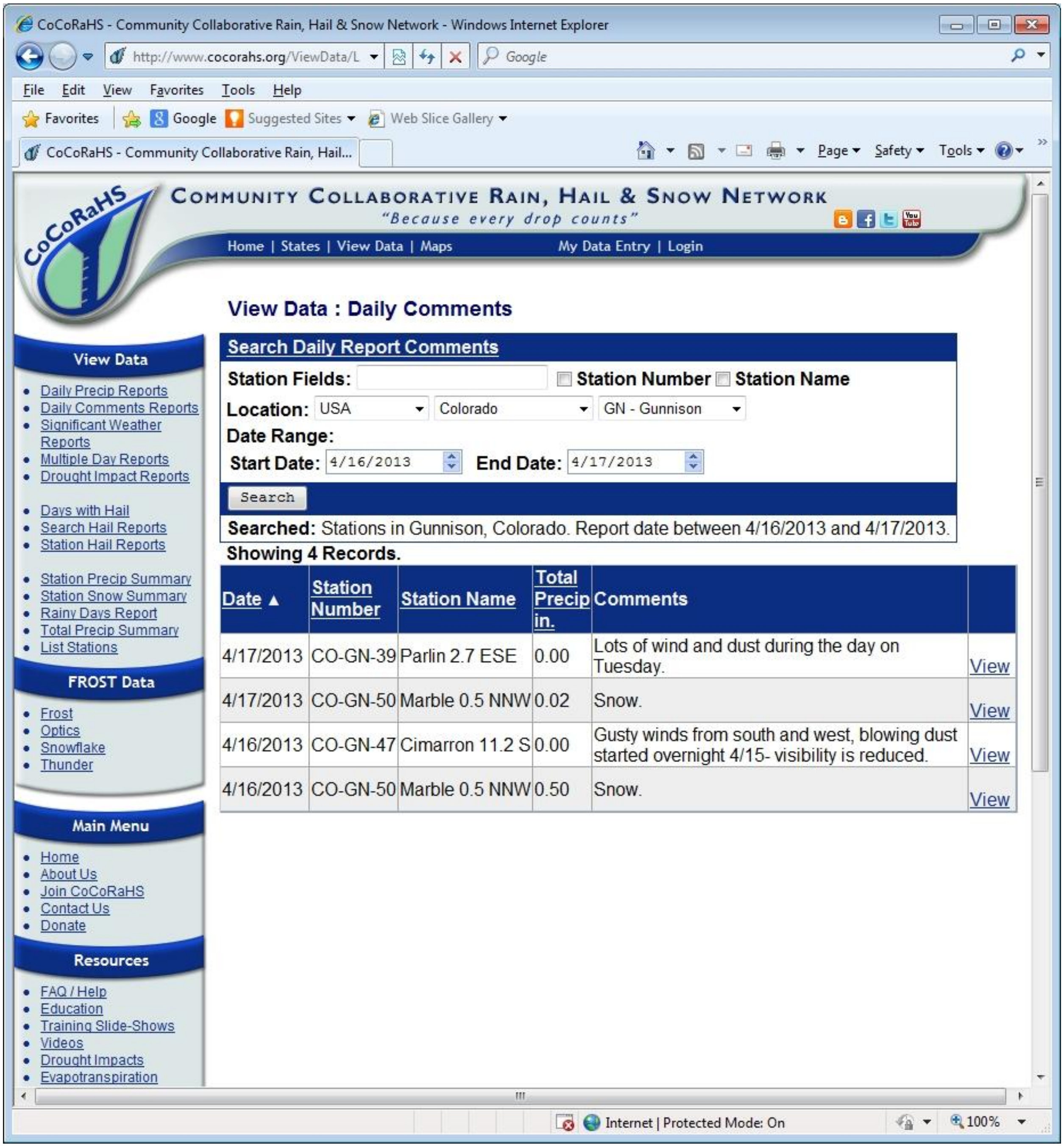


The daily low and high wind speed (light gray area) and the maximum daily wind gust speed (tiny blue dashes).

http://weatherspark.com/history/31757/2013/Telluride-Colorado-United-States

Community Collaborative Rain, Hail, & Snow Network reports:

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Station Fields: ☐ Station Number ☐ Station Name

Location: USA | Colorado | GN - Gunnison

Date Range:

Start Date: 4/16/2013 **End Date:** 4/17/2013

Search

Searched: Stations in Gunnison, Colorado. Report date between 4/16/2013 and 4/17/2013.

Showing 4 Records.

Date ▲	Station Number	Station Name	Total Precip in.	Comments	
4/17/2013	CO-GN-39	Parlin 2.7 ESE	0.00	Lots of wind and dust during the day on Tuesday.	View
4/17/2013	CO-GN-50	Marble 0.5 NNW	0.02	Snow.	View
4/16/2013	CO-GN-47	Cimarron 11.2 S	0.00	Gusty winds from south and west, blowing dust started overnight 4/15- visibility is reduced.	View
4/16/2013	CO-GN-50	Marble 0.5 NNW	0.50	Snow.	View

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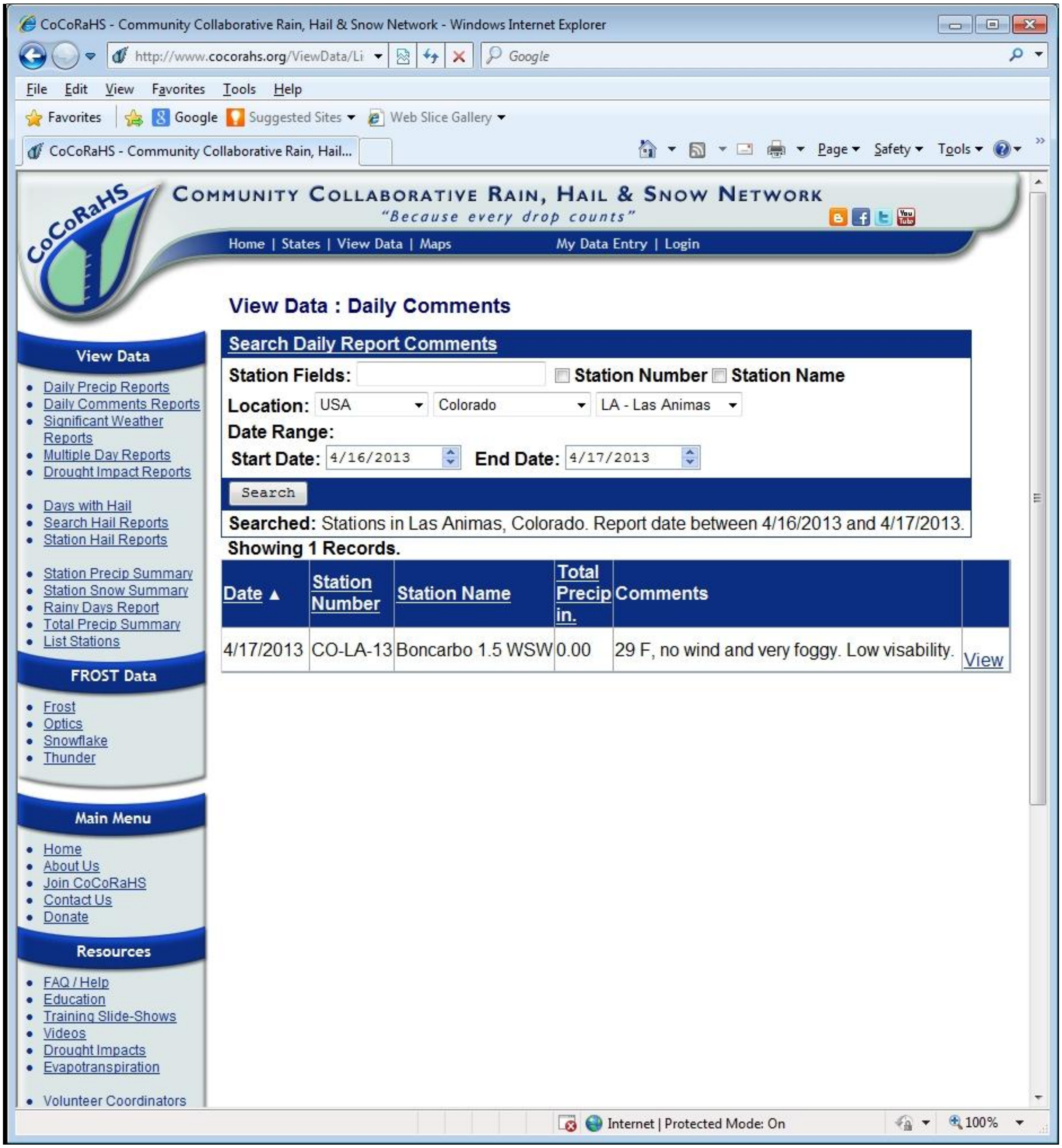
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Station Fields:
Station Number
Station Name
Location: USA Colorado LA - Las Animas
Date Range:
Start Date: 4/16/2013
End Date: 4/17/2013
Search
Searched: Stations in Las Animas, Colorado. Report date between 4/16/2013 and 4/17/2013.
Showing 1 Records.
Date ▲
Station Number
Station Name
Total Precip in.
Comments
4/17/2013
CO-LA-13
Boncarbo 1.5 WSW
0.00
29 F, no wind and very foggy. Low visability.
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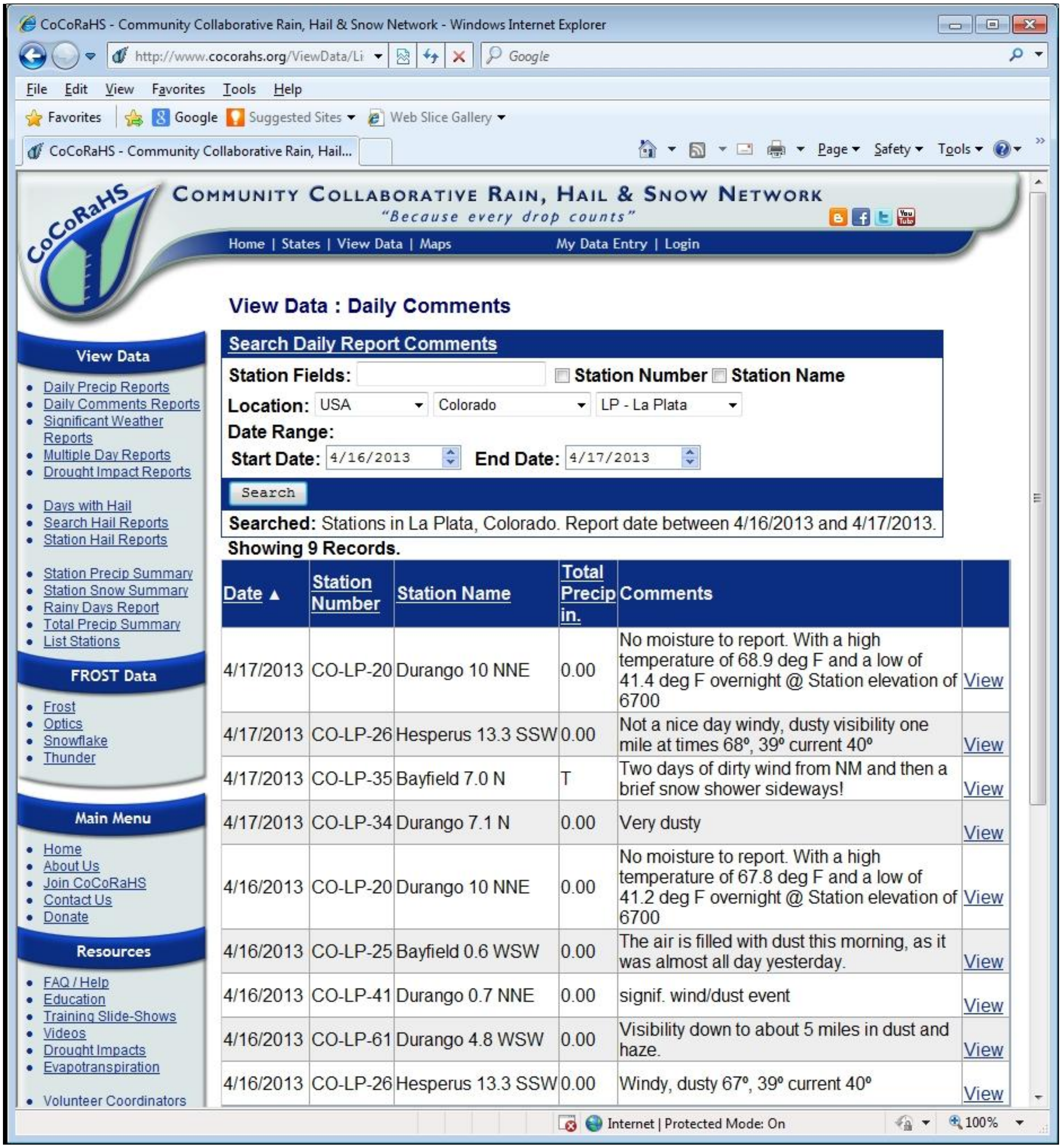

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Search Daily Report Comments

Station Fields: ☐ **Station Number** ☐ **Station Name**

Location: USA | Colorado | LP - La Plata

Date Range:

Start Date: 4/16/2013 **End Date:** 4/17/2013

Search

Searched: Stations in La Plata, Colorado. Report date between 4/16/2013 and 4/17/2013.

Showing 9 Records.

Date ▲	Station Number	Station Name	Total Precip in.	Comments	
4/17/2013	CO-LP-20	Durango 10 NNE	0.00	No moisture to report. With a high temperature of 68.9 deg F and a low of 41.4 deg F overnight @ Station elevation of 6700	View
4/17/2013	CO-LP-26	Hesperus 13.3 SSW	0.00	Not a nice day windy, dusty visibility one mile at times 68°, 39° current 40°	View
4/17/2013	CO-LP-35	Bayfield 7.0 N	T	Two days of dirty wind from NM and then a brief snow shower sideways!	View
4/17/2013	CO-LP-34	Durango 7.1 N	0.00	Very dusty	View
4/16/2013	CO-LP-20	Durango 10 NNE	0.00	No moisture to report. With a high temperature of 67.8 deg F and a low of 41.2 deg F overnight @ Station elevation of 6700	View
4/16/2013	CO-LP-25	Bayfield 0.6 WSW	0.00	The air is filled with dust this morning, as it was almost all day yesterday.	View
4/16/2013	CO-LP-41	Durango 0.7 NNE	0.00	signif. wind/dust event	View
4/16/2013	CO-LP-61	Durango 4.8 WSW	0.00	Visibility down to about 5 miles in dust and haze.	View
4/16/2013	CO-LP-26	Hesperus 13.3 SSW	0.00	Windy, dusty 67°, 39° current 40°	View

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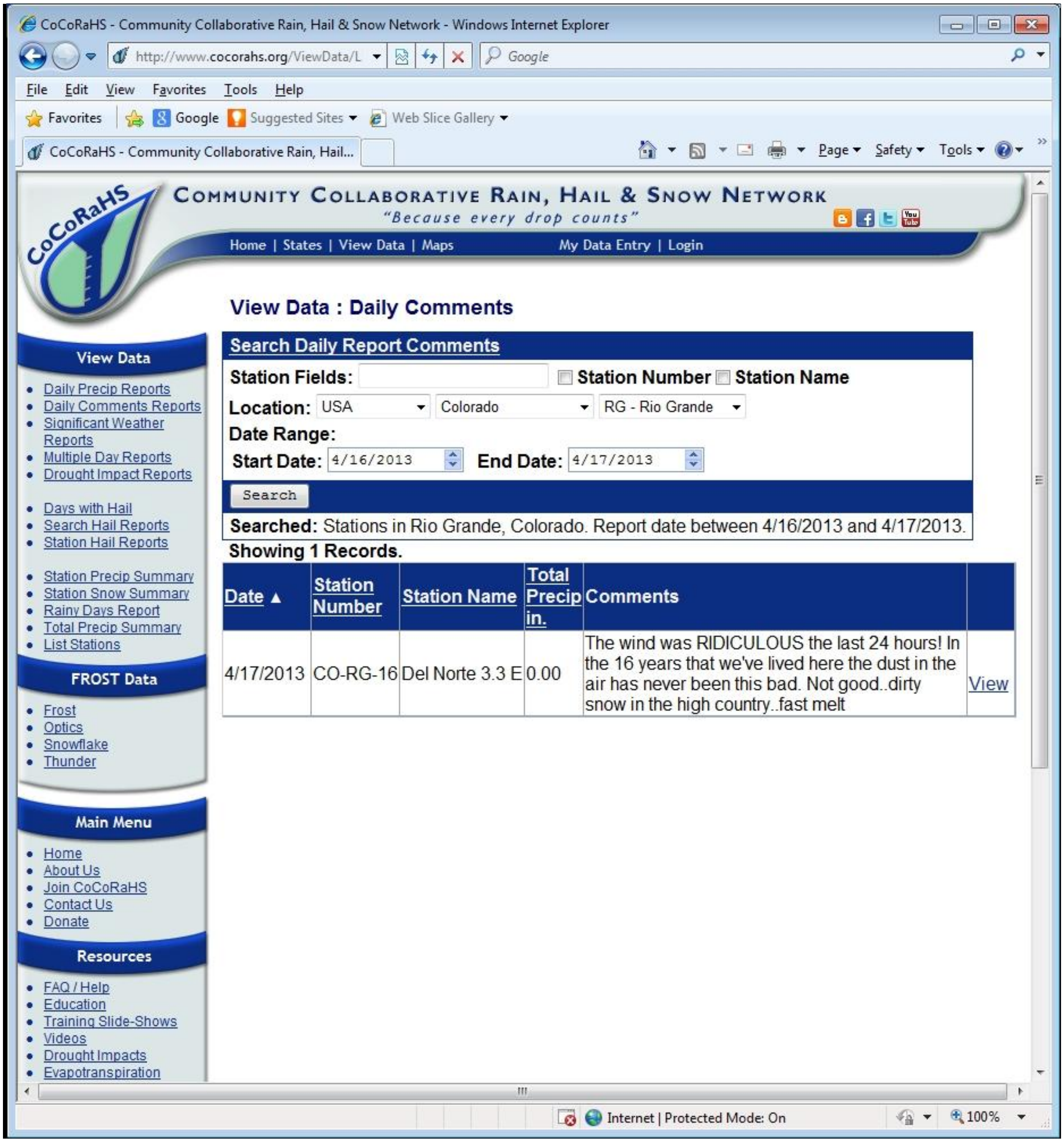
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Station Fields:
Station Number
Station Name
Location: USA Colorado RG - Rio Grande
Date Range:
Start Date: 4/16/2013
End Date: 4/17/2013
Search
Searched: Stations in Rio Grande, Colorado. Report date between 4/16/2013 and 4/17/2013.
Showing 1 Records.
Date ▲
Station Number
Station Name
Total Precip in.
Comments
4/17/2013
CO-RG-16
Del Norte 3.3 E
0.00
The wind was RIDICULOUS the last 24 hours! In the 16 years that we've lived here the dust in the air has never been this bad. Not good..dirty snow in the high country..fast melt
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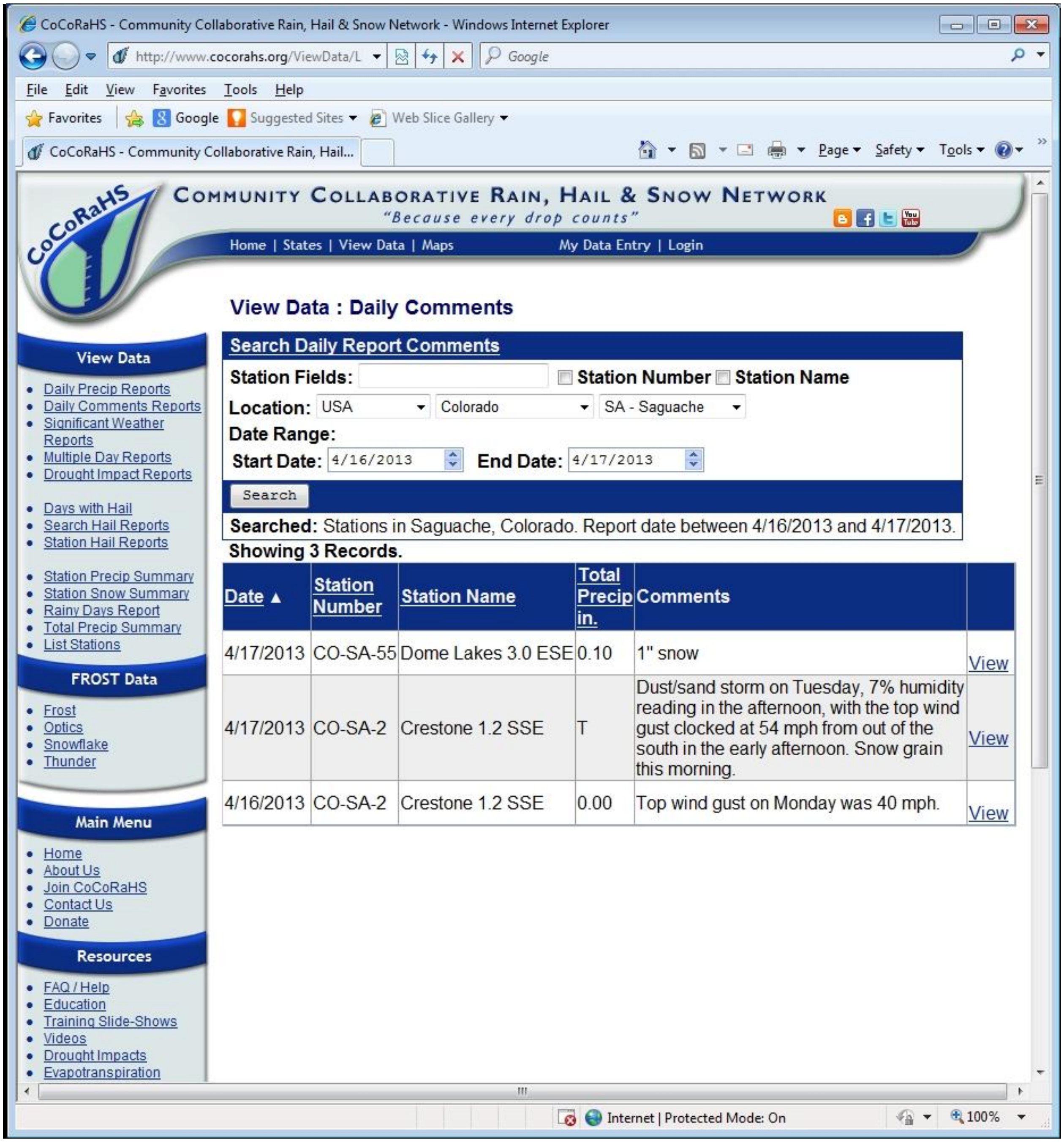
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Search Daily Report Comments
Station Fields: Station Number Station Name
Location: USA Colorado SA - Saguache
Date Range:
Start Date: 4/16/2013 End Date: 4/17/2013
Search
Searched: Stations in Saguache, Colorado. Report date between 4/16/2013 and 4/17/2013.
Showing 3 Records.
Date ▲ | Station Number | Station Name | Total Precip in. | Comments
4/17/2013 | CO-SA-55 | Dome Lakes 3.0 ESE | 0.10 | 1" snow | View
4/17/2013 | CO-SA-2 | Crestone 1.2 SSE | T | Dust/sand storm on Tuesday, 7% humidity reading in the afternoon, with the top wind gust clocked at 54 mph from out of the south in the early afternoon. Snow grain this morning. | View
4/16/2013 | CO-SA-2 | Crestone 1.2 SSE | 0.00 | Top wind gust on Monday was 40 mph. | View
Internet | Protected Mode: On
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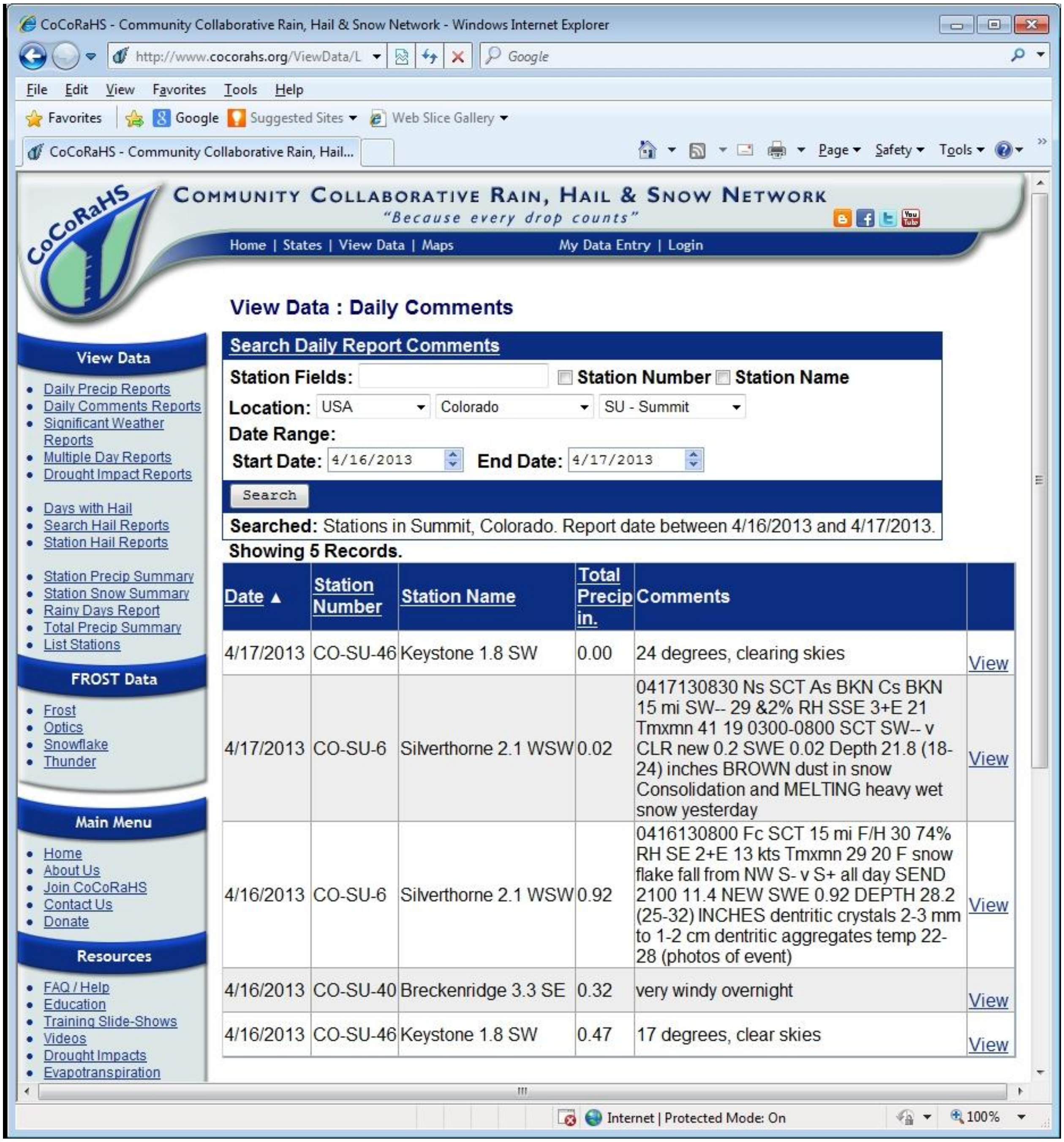

Date ▲	Station Number	Station Name	Total Precip in.	Comments	
4/17/2013	CO-SU-46	Keystone 1.8 SW	0.00	24 degrees, clearing skies	View
4/17/2013	CO-SU-6	Silverthorne 2.1 WSW	0.02	0417130830 Ns SCT As BKN Cs BKN 15 mi SW-- 29 &2% RH SSE 3+E 21 Tmxmn 41 19 0300-0800 SCT SW-- v CLR new 0.2 SWE 0.02 Depth 21.8 (18-24) inches BROWN dust in snow Consolidation and MELTING heavy wet snow yesterday	View
4/16/2013	CO-SU-6	Silverthorne 2.1 WSW	0.92	0416130800 Fc SCT 15 mi F/H 30 74% RH SE 2+E 13 kts Tmxmn 29 20 F snow flake fall from NW S- v S+ all day SEND 2100 11.4 NEW SWE 0.92 DEPTH 28.2 (25-32) INCHES dentritic crystals 2-3 mm to 1-2 cm dentritic aggregates temp 22-28 (photos of event)	View
4/16/2013	CO-SU-40	Breckenridge 3.3 SE	0.32	very windy overnight	View
4/16/2013	CO-SU-46	Keystone 1.8 SW	0.47	17 degrees, clear skies	View

http://www.cocorahs.org/State.aspx?state=CO

5.0 Not Reasonably Controllable or Preventable: Local Particulate Matter Control Measures

While it is likely that some dust was generated within the local communities as gusts from the regional dust storm passed through the area, the amount of dust generated locally was easily overwhelmed by, and largely unnoticeable as compared to the dust transported in from the source regions of the dust storm. The following sections will describe in detail the regulations and programs in place designed to control PM_{10} in each affected community. These sections will demonstrate that the event was not reasonably controllable, as laid out in Section 50.1(j) of Title 40 CFR 50, within the context of reasonable local particulate matter control measures.

The following subsections describe in detail applicable Best Available Control Measures (BACM), reasonable control measures, applicable federal, state, and local regulations, appropriate land use management, and an analysis of potential areas of local soil disturbance for Telluride during the April 16, 2013 event. This information shall confirm that no unusual anthropogenic actions occurred in Telluride on April 16, 2013.

Regulatory Measures- State
The Division's regulations on PM_{10} emissions are summarized in Table 13.

Table 13: State Regulations Regulating Particulate Matter Emissions.

Rule/Ordinance	Description
Colorado Department of Public Health and Environment Regulation 1- Emission Control For Particulate Matter, Smoke, Carbon Monoxide, And Sulfur Oxides	Regulates emissions of particulates, smoke, sulfur dioxide, and nitrogen oxides and establishes limits on these pollutants from covered sources. Applicable sections include but are not limited to: Everyone who manages a source or activity that is subject to controlling fugitive particulate emissions must employ such control measures and operating procedures through the use of all available practical methods which are technologically feasible and economically reasonable and which reduce, prevent and control emissions so as to facilitate the achievement of the maximum practical degree of air purity in every portion of the State. Section III.D.1.a) Anyone clearing or leveling of land greater than five acres in attainment areas or one acre in non-attainment areas from which fugitive particulate emissions will be emitted are required to use all available and practical methods which are technologically feasible and economically reasonable in order to minimize fugitive particulate emissions.(Section III.D.2.b) Control measures or operational procedures for

Rule/Ordinance	Description
	fugitive particulate emissions to be employed may include planting vegetation cover, providing synthetic cover, watering, chemical stabilization, furrows, compacting, minimizing disturbed area in the winter, wind breaks and other methods or techniques approved by the Division. (Section III.D.2.b) Any owner or operator responsible for the construction or maintenance of any existing or new unpaved roadway which has vehicle traffic exceeding 200 vehicles per day in the attainment/maintenance area and surrounding areas must stabilize the roadway in order to minimize fugitive dust emissions (Section III.D.2.a.(i))
Colorado Department of Public Health and Environment Regulation 3- Stationary Source Permitting and Air Pollutant Emission Notice Requirements	Construction Permit required if a land development project exceeds 25 acres and spans longer than 6 months in duration (Section II.D.1.j)
Colorado Department of Public Health and Environment Regulation 4- New Wood Stoves and the Use of Certain Woodburning Appliances During High Pollution Days	Regulates wood stoves, conventional fireplaces and woodburning on high pollution days. Prohibits the sale and installation a wood-burning stove in Colorado unless it has been tested, certified, and labeled for emission performance in accordance with criteria and procedures specified in the Federal Regulations and meets emission standards. (Section II) Section III regulates pellet stoves. Section IV regulates masonry heaters. Section VII limits the use of stoves on high pollution days.
Colorado Department of Public Health and Environment Regulation 6- Standards of Performance for New Stationary Sources	Implements federal standards of performance for new stationary sources including ones that have particulate matter emissions. (Section I)
Colorado Department of Public Health and Environment Regulation 9- Open Burning, Prescribed Fire, and Permitting	Prohibits open burning throughout the state unless a permit has been obtained from the appropriate air pollution control authority. In granting or denying any such permit, the authority will base its action on the potential contribution to air pollution in the area, climatic conditions on the day or days of such burning, and the authority's satisfaction that there is no practical alternate method for the disposal of the material to be burned. Among other permit conditions, the authority granting the permit may impose conditions on wind speed at the time of the burn to minimize smoke impacts on smoke-sensitive areas. (Section III)
Colorado Department of Public Health and	Applies to all emissions sources in Colorado

Rule/Ordinance	Description
Environment- Common Provisions Regulation	When emissions generated from sources in Colorado cross the state boundary line, such emissions shall not cause the air quality standards of the receiving state to be exceeded, provided reciprocal action is taken by the receiving state. (Section II A)
Colorado Department of Public Health and Environment- Air Quality Standards, Designations and Emission Budgets	Telluride has a mobile source emissions budget of 1,108 pounds-per-day for PM_{10} (Section V.A.4.J). The emissions budget establishes a cap on mobile source emissions and is administered though the transportation conformity regulations.
Colorado Department of Public Health and Environment- State Implementation Plan, Specific Regulations for Nonattainment-Attainment/Maintenance Areas (Local Elements)	Section II- Documents the specific PM_{10} control strategies for Telluride and San Miguel County
Federal Motor Vehicle Emission Control Program	The federal motor vehicle emission control program has reduced PM_{10} emissions through a continuing process of requiring diesel engine manufacturers to produce new vehicles that meet tighter and tighter emission standards. As older, higher emitting diesel vehicles are replaced with newer vehicles, the PM_{10} emissions in areas will be reduced.

Control Measures Included in the Attainment/Maintenance Plan

The Telluride area will rely on the control programs listed below to demonstrate maintenance of the 24-hour PM_{10} standard through 2021. No emission reduction credit has been taken in the attainment/maintenance demonstration for any other current State or local control programs and no other such programs, strategies, or regulations shall be incorporated or deemed as enforceable measures for the purposes of this maintenance demonstration.

The attainment/maintenance plan takes credit for the following federally-enforceable control measures, which, except where otherwise noted, are included in the SIP:

Federal fuels and tailpipe standards and regulations

Current federal regulations concerning motor vehicles, fuels, small engines, diesels, and non-road mobile sources. While credit is taken for these federal requirements, they are not part of the Colorado SIP.

Woodburning

The Town of Telluride and San Miguel County have adopted wood and coal burning emission reduction measures in addition to the requirements of Air Quality Control Commission Regulation 4 (approved by EPA as part of the federal SIP in 1997), referenced in Table 13. These wood and coal burning controls were adopted and implemented throughout the 1980s and early 1990s, were approved by EPA in 1994, and are defined in detail in Section II. A of the “State

Implementation Plan-Specific Regulations for Nonattainment – Attainment/Maintenance Areas" (Local Elements) referenced in Table 13.

Stationary Sources
Emissions from stationary sources of pollution are regulated by several Air Quality Control Commission Regulations. These regulations (No. 1, No. 3, No. 6, and The Common Provisions) are referenced in Table 13.

As an attainment/maintenance area since August 14, 2001, the State and federal attainment PSD permitting requirements remain in effect in the Telluride area. This program requires the application of Best Available Control Technology when constructing new or modified major stationary sources.

Street Sanding Controls
The Town of Telluride has a town-wide street sweeping program that provides for town streets to be swept approximately two hundred and thirty days a year. This effort removes between 750 and 1200 cubic yards of sediment from the streets each year, greatly improving the air quality. The town utilizes two Tennant Company mechanical sweepers. There is a requirement that any user that applies street sanding material in the Telluride attainment/maintenance area must use materials containing less than two percent fines. This strategy was adopted in 1994 and approved by EPA in 1996, and it is defined in detail in Section II.B. of the "State Implementation Plan-Specific Regulations for Nonattainment –Attainment/Maintenance Areas (Local Elements) referenced in Table 13.

Construction Mitigation Plan
Article 11 of Telluride's Municipal Code houses the town's Construction Mitigation Plan (CMP). The purpose of the CMP is to reduce air and other pollution caused by dust, dirt, silt, trash, construction debris and other materials that could migrate from a construction site. The CMP also requires the revegetation of sites used in the construction process which are not otherwise revegetated as part of the construction project.

Windblown Dust from Disturbed Soils
Examination of available satellite imagery in Telluride has shown very limited construction and soil disturbance within the village since 2003, particularly south of the PM_{10} monitor. The monitor is only 2 blocks north from the base of the ski resort, and available land south of the monitor is essentially built out. One 1.4 acre project was constructed approximately ½ mile WSW of the monitor sometime between June 2005 and August 2011. As construction to the south of the monitor was finished before 2011, any construction activities are unlikely to have played a role in the April 2013 exceedance.

Figure 45: June 2005 and August 2011 Google Earth views of Telluride Village, with one project of 1.4 acre new construction.

6.0 Summary and Conclusions

APCD is requesting concurrence on exclusion of the 265 μg/m^3 PM_{10} value from Telluride (08-113-0004) on April 16, 2013. (APCD will request concurrence on exclusion of other PM_{10} values taken on the same day at a later date.)

On April 16, 2013, a powerful spring storm system caused multiple exceedances of the twenty-four hour PM_{10} NAAQS in west-central and southwest Colorado. These PM_{10} sample values include Telluride (265 μg/m^3), Durango (419 μg/m^3), Pagosa Springs (295 μg/m^3), Alamosa Adams State College (237 μg/m^3), and Mt. Crested Butte (187 μg/m^3).

The statistical and meteorological data clearly shows that but for this high wind blowing dust event, Telluride would not have exceeded the 24-hour NAAQS on April 16, 2013. The PM_{10} exceedances on April 16, 2013, would not have occurred if not for the following: (a) dry soil conditions over southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico; (b) a combination of strong surface low pressure and a cold front associated with an intense upper-level trough that was moving across the western United States that created conditions necessary for widespread strong gusty winds over the area of concern; and (c) elevated friction velocities and the deep mixing of the blowing dust from desert regions of Arizona, northwest New Mexico, and southeast Utah.

Surface weather maps for the Four Corner States show evidence of widespread blowing dust and winds above the threshold speeds for blowing dust on April 16, 2013. This surface analysis shows that winds were as high as 50 mph and wind gusts were as high as 66 mph. These speeds are above the thresholds for blowing dust identified in EPA draft guidance and in detailed analyses completed by the State of Colorado. These PM_{10} exceedances were due to an exceptional event associated with regional windstorm-caused emissions from erodible soil sources over a large area of southeastern Utah, northeastern Arizona, and portions of extreme northwestern New Mexico. These sources are not reasonably controllable during a significant windstorm under abnormally dry or moderate drought conditions.

The blowing dust climatology for the Four Corners area indicates that the area can be susceptible to blowing dust when winds are high. Landform imagery shows that northeastern Arizona and southeastern Utah in particular have experienced a long-term pattern of wind erosion and blowing dust when winds have been southwesterly and blowing into western and southern Colorado. Forecast products from the Navy Aerosol Analysis and Prediction System model provide evidence for a widespread blowing dust event in the Four Corners states, suggesting that significant source regions for dust transported into Colorado were located in arid regions of Arizona, Utah, and New Mexico. NOAA HYSPLIT forward and backward trajectories provide clear supporting evidence that dust from desert regions of northwest New Mexico and Arizona caused the PM_{10} exceedances measured across portions of southwest Colorado on April 16, 2013. Soils in the Four Corners area and in northeast Arizona and extreme northwestern New Mexico in particular were dry enough to produce blowing dust when winds were above the thresholds for blowing dust.

Both wind speeds and soil moisture in the Four Corners area and northeastern Arizona were conducive to the generation of significant blowing dust. Multiple sources of data for the event in question and analyses of past dust storms in this area prove that this was a natural event and, more specifically, a significant natural dust storm originating in northeastern Arizona and northwestern New Mexico and spreading into southwestern Colorado.

Friction velocities in a wide area of northeast Arizona, northwest New Mexico, southeast Utah, and southwest Colorado were above 1.0 meters per second on April 16, 2013. Even undisturbed desert soils normally resistant to wind erosion will be susceptible to blowing dust when friction velocities are greater than about 1.0 to 2.0 meters per second. Note that blowing dust will typically only occur where these values are high and the soils are dry and not protected by vegetation, forest cover, boulders, rocks, etc. This is why blowing dust occurred in the desert and more arid areas of northern Arizona, northwestern New Mexico, southeastern Utah, and southwestern Colorado on April 16, 2013. The elevated friction velocities, the data on soil moisture conditions, and the prevalence of winds above blowing dust thresholds (all occurring in traditional source regions in northeastern Arizona and northwestern New Mexico) prove that this dust storm was a natural event that was not reasonably controllable or preventable.

MODIS Terra satellite image shows that the Four Corners region including Utah, Arizona, New Mexico, and Colorado were sources regions for blowing dust on April 16, 2013. This is consistent with the climatology for many dust storms in Colorado as described in the Grand Junction, Colorado, Blowing Dust Climatology report contained in Appendix A of this document. The observations of winds above blowing dust thresholds and restricted visibilities in the areas of concern demonstrate that this is a natural event that cannot be reasonably controlled or prevented.

The Center for Snow and Avalanche Studies has been studying the effects of wind-blown desert dust from Arizona, New Mexico, and Utah on snowpack albedo and snowmelt in the San Juan Mountains of Colorado. The Center for Snow and Avalanche Studies lists April 16, 2013, as a Dust-on-Snow event for the 2012/2013 water year, and this provides clear supporting evidence that a regional blowing dust event with long-range transport caused the PM_{10} exceedances measured across portions of Colorado on April 13, 2013. In addition, the snow depth analysis illustrates that the mountains surrounding Telluride had 16 to 100 inches of snow cover in the hours before the dust storm of April 16, 2013. These data provide strong evidence that a widespread, regional, blowing dust event caused exceedances at these locations rather than local sources.

But for the dust storm on April 16, 2013, this exceedance at Telluride (08-113-0004) would not have occurred.

7.0 References

Draxler, R.R. and Rolph, G.D., 2012. *HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (http://ready.arl.noaa.gov/HYSPLIT.php)*. NOAA Air Resources Laboratory, Silver Spring, MD.

Marticorena, B., G. Bergametti, D. Gillette, and J. Belnap, 1997, Factors controlling threshold friction velocity in semiarid and arid areas of the United States, *Journal of Geophysical Research 102 D19*, 23,277-23, 287.

Technical Services Program, Air Pollution Control Division, Colorado Department of Public Health and Environment, November 22, 2011, *Technical Support Document for the January 19, 2009 Lamar Exceptional Event.*

United States Environmental Protection Agency, June 2012, *Draft Guidance on the Preparation of Demonstrations in Support of Requests to Exclude Ambient Air Quality Data Affected by High Winds under the Exceptional Events Rule*.

Appendix A- Grand Junction, Colorado, Blowing Dust Climatology January 24, 2012

There can be significant transport of regional blowing dust into Grand Junction from source regions in Utah and Arizona. While there are sources for wind-blown dust within the Grand Valley and Grand Junction itself, there is evidence from the analysis of soil features, wind and precipitation climatology, and statistical analyses of Grand Junction exceedances of the PM_{10} standard that regional sources often play a significant role during these blowing dust events. This document provides a weight of evidence analysis for dust transport into Colorado.

Grand Junction, Colorado, is located in a part of the country that is largely arid to semi-arid. Figure A-1 through A-3 show the annual average precipitation for Colorado, Arizona, and Utah, respectively. Grand Junction is in the Grand Valley of Western Colorado where the annual precipitation is typically less than 10 inches. Northeastern Arizona, which is frequently upwind of Grand Junction during blowing dust events, receives between 5 and 15 inches of precipitation each year. The Colorado River Basin in eastern and southeastern Utah, which is also frequently upwind of Grand Junction during blowing dust events, also receives 5 to 10 inches per year.

Figure A-4 shows the 1971-2000 monthly normal precipitation amounts for Grand Junction, Colorado. The annual average for this time period is 8.99 inches. The wettest months are March through May and August through October. The driest months are January, February, June, July, November, and December. These months receive an average of 0.57 inches per month. The annual monthly average precipitation is 0.75 inches.

Arid to semi-arid soils make much of the region susceptible to blowing dust. The map in Figure A-5 shows that portion of the Colorado Plateau (circled in red) where modern wind erosion features are common and clearly visible in Google Earth images. These features include longitudinal dunes and other sand or soil erosion structures with a predominant southwest to northeast orientation. This orientation is the result of the predominant southwesterly flow that occurs during high wind and blowing dust events in the region. Figures A-6 through A-12 present aerial views of ubiquitous erosion features in northeastern Arizona and southeastern Utah. The Painted Desert of northeastern Arizona is frequently the source for much of the blowing dust in the Four Corners region. Figure A-13 provides a particularly good satellite image of a blowing dust event originating in the Painted Desert and extending northeastward across the junction of the Four Corners (source: NASA Tera satellite, http://earthobservatory.nasa.gov/IOTD/view.php?id=37791). Strong southwesterly winds caused this blowing dust event.

The text that accompanies this image on NASA's Earth Observatory 10th Anniversary page follows below:

> "A dust storm struck northeastern Arizona on April 3, 2009. With winds over 145 kilometers (90 miles) per hour reported near Meteor Crater, east of Flagstaff, the storm reduced visibility and forced the temporary closure of part of Interstate 40, according to *The Arizona Republic.*
>
> The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured this image on April 3, 2009. Clear skies allow a view of multiple source points of this dust storm. The source points occur along an arc that runs from northwest to southeast.
>
> This dust storm occurred in the area known as Arizona's Painted Desert, and the dust plumes show why. Whereas many dust plumes are uniform in color, these plumes resemble a band of

multicolored ribbons, ranging from pale beige to red-brown, reflecting the varied soils from which the plumes arise. The landscapes of the Painted Desert are comprised mostly of Chinle Formation rocks—remains of sediments laid down during the time of the first dinosaurs, over 200 million years ago."

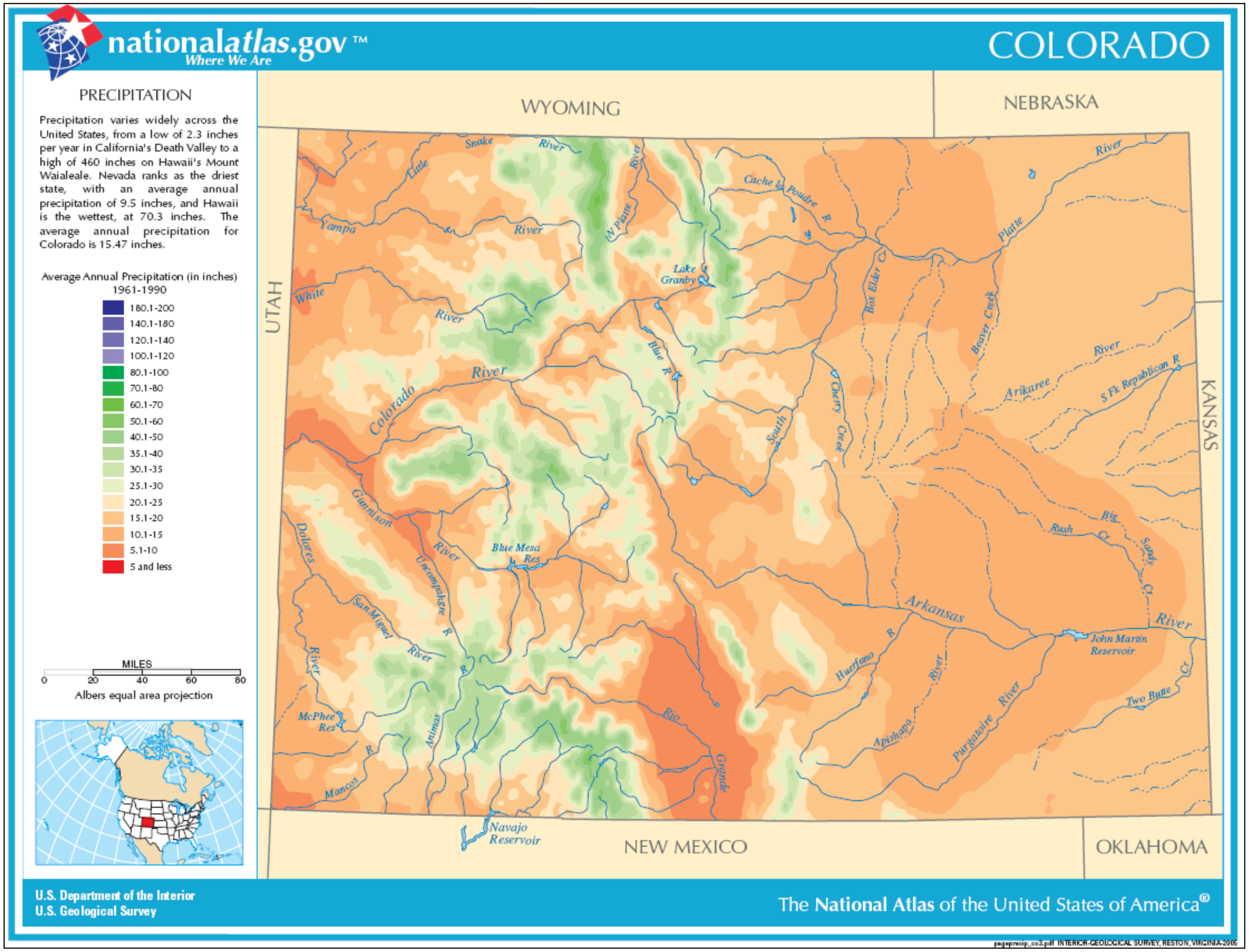

Figure A-1. Average annual precipitation in Colorado based on 1961-1990 normals.

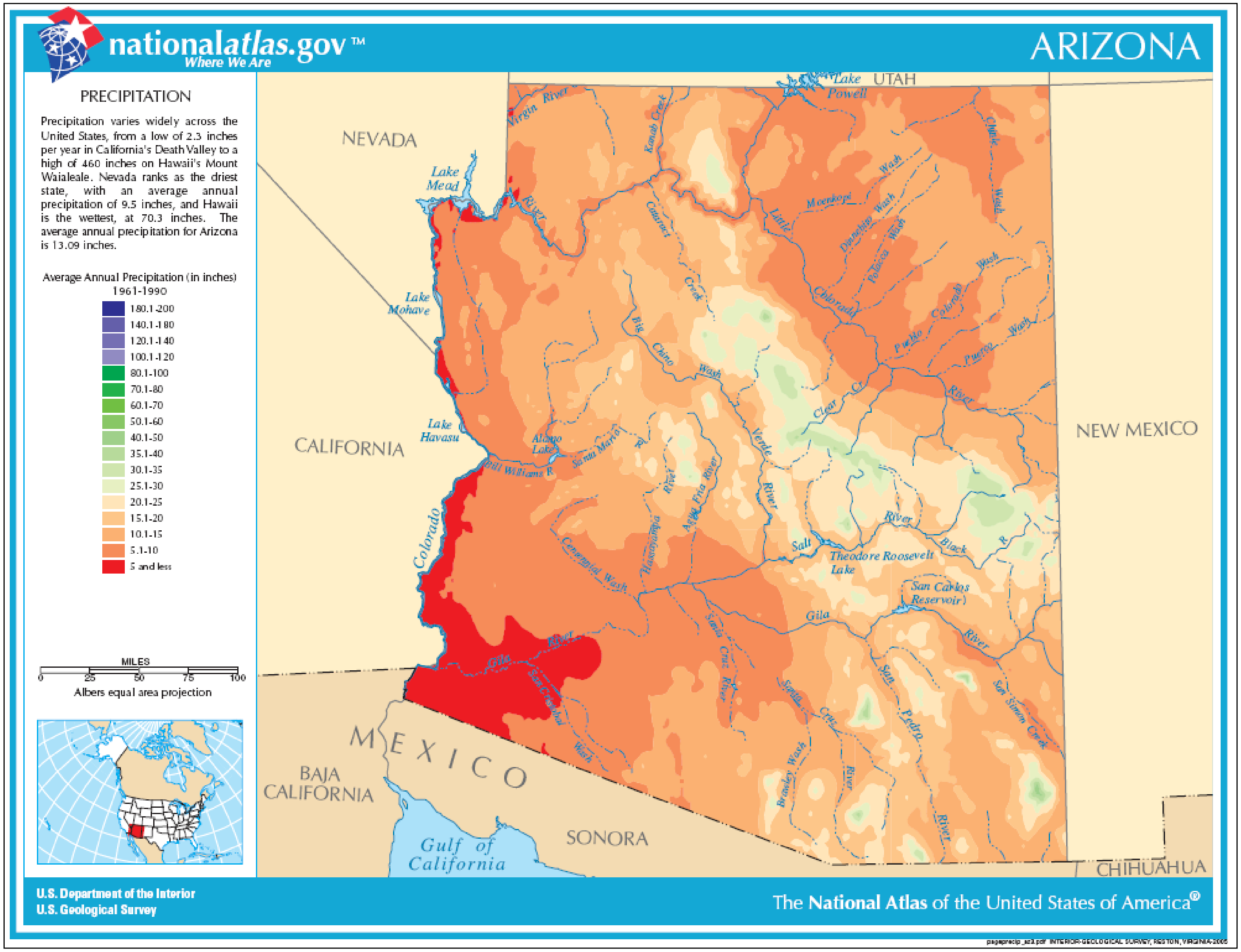

Figure A-2. Average annual precipitation in Arizona based on 1961-1990 normals.

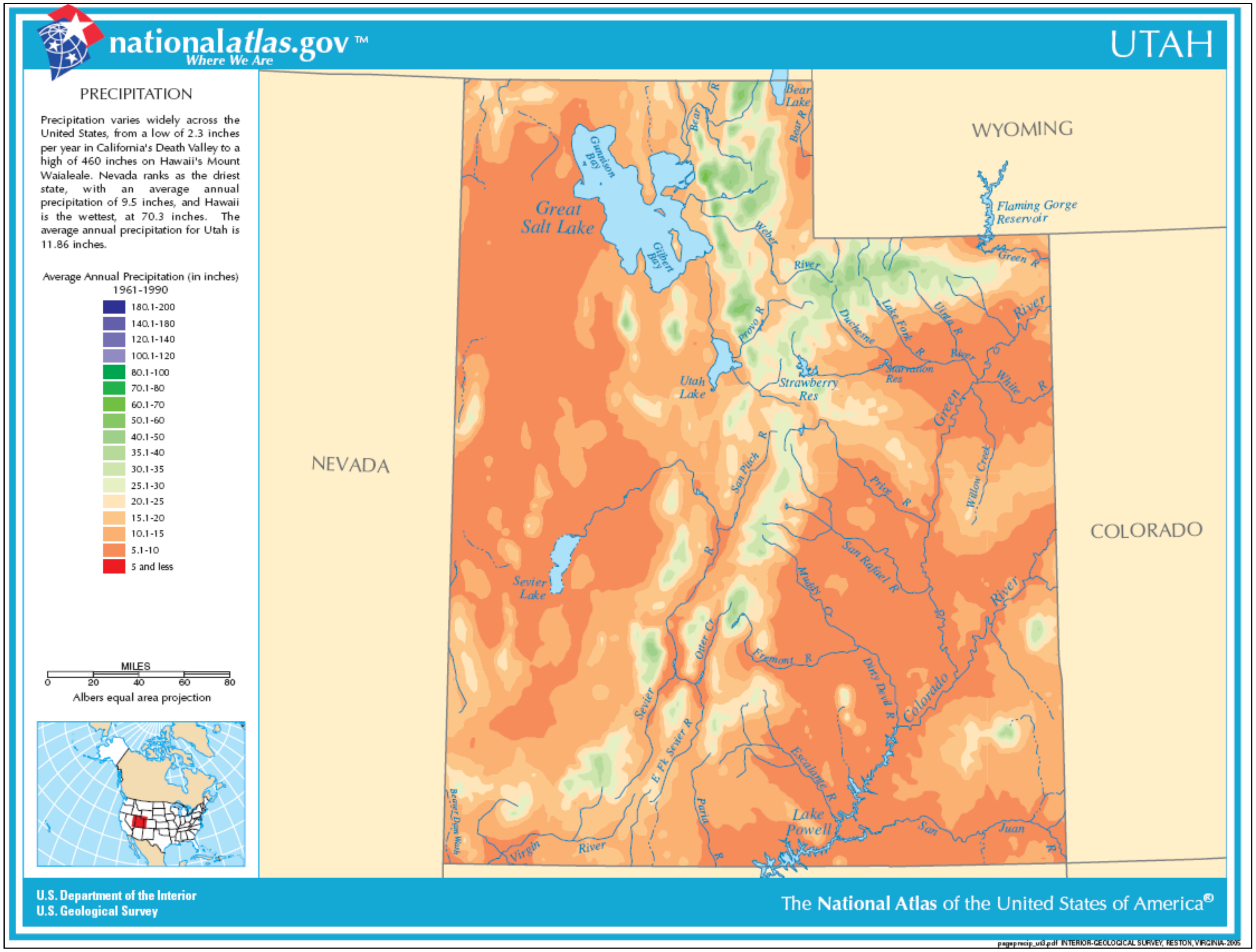

Figure A-3. Average annual precipitation in Utah based on 1961-1990 normals.

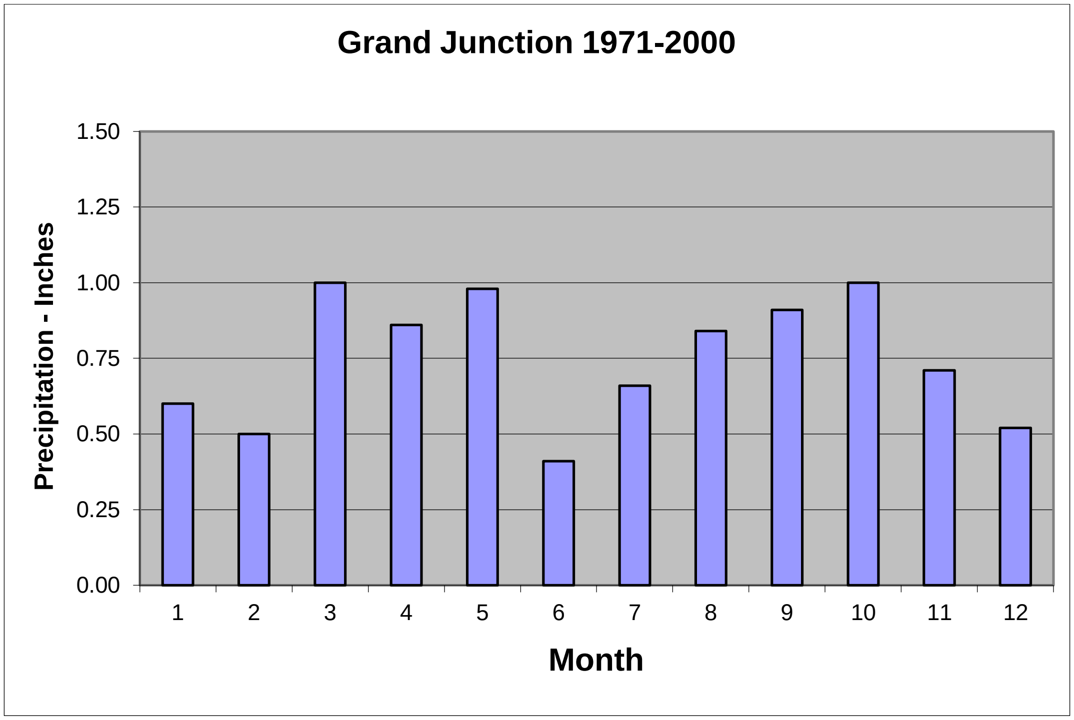

Figure A-4. 1971-2000 monthly normal precipitation in Grand Junction Colorado.

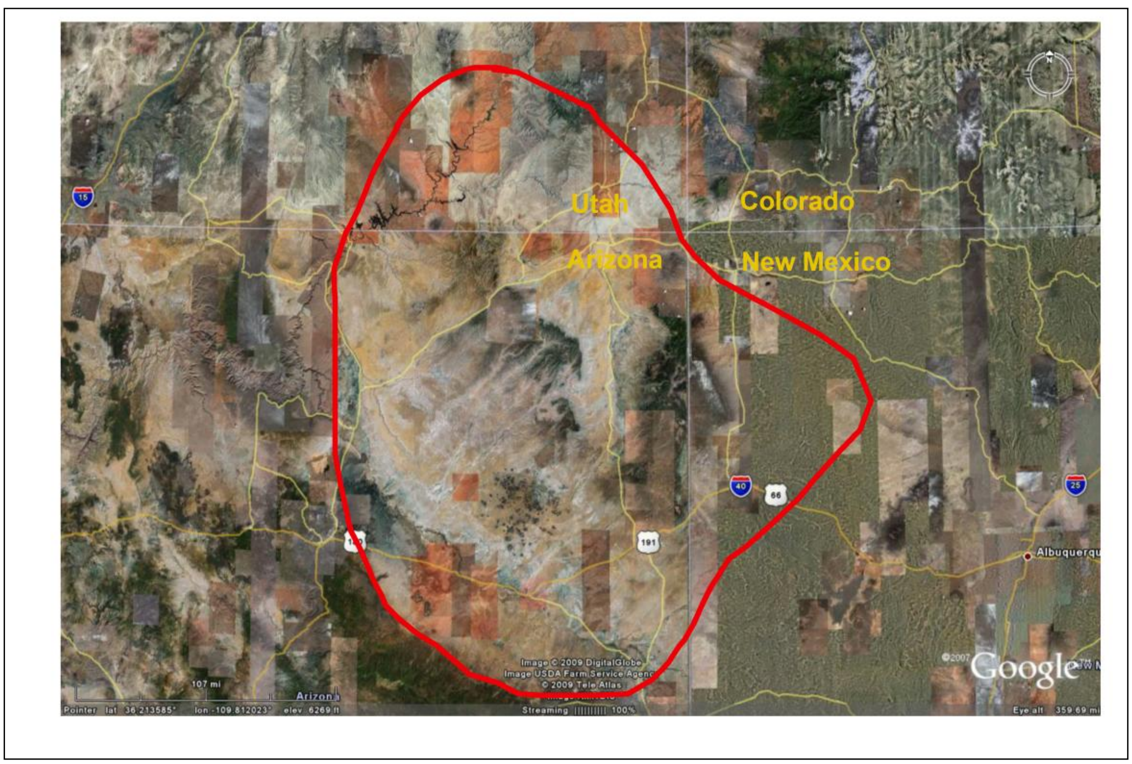

Figure A-5. The portion of the Colorado Plateau in Utah, Arizona, and New Mexico that exhibits widespread surface soil and sand erosion features in Google Earth imagery. Much of the highlighted area within Arizona is within the Painted Desert.

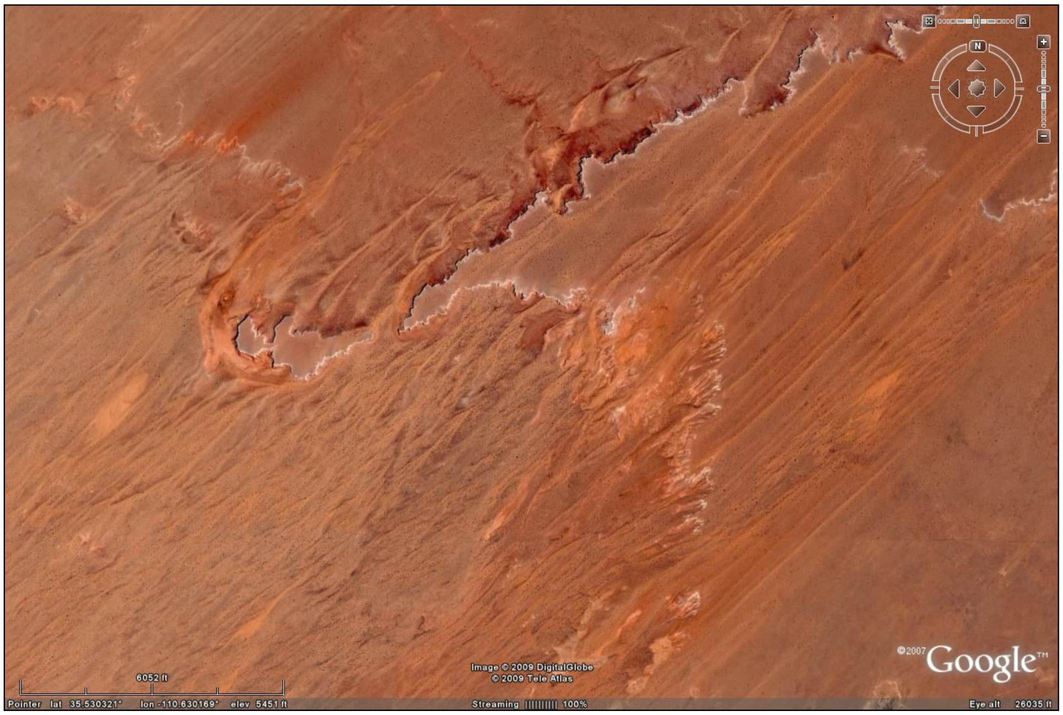

Figure A-6. Southwest to northeast soil and sand erosion structures in southeastern Utah.

Figure A-7. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).

Figure A-8. Southwest to northeast soil and sand erosion structures in southeastern Utah.

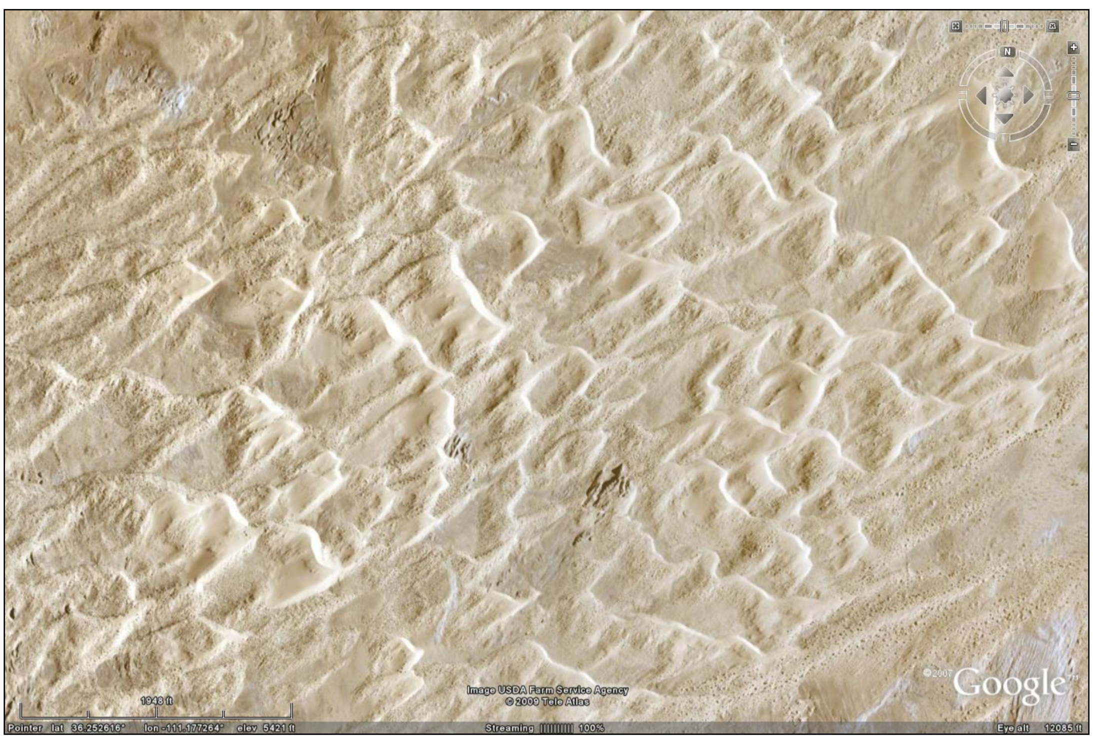

Figure A-9. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert). The slip faces of dunes (lighter bands) face in the direction of wind flow – toward the northeast.

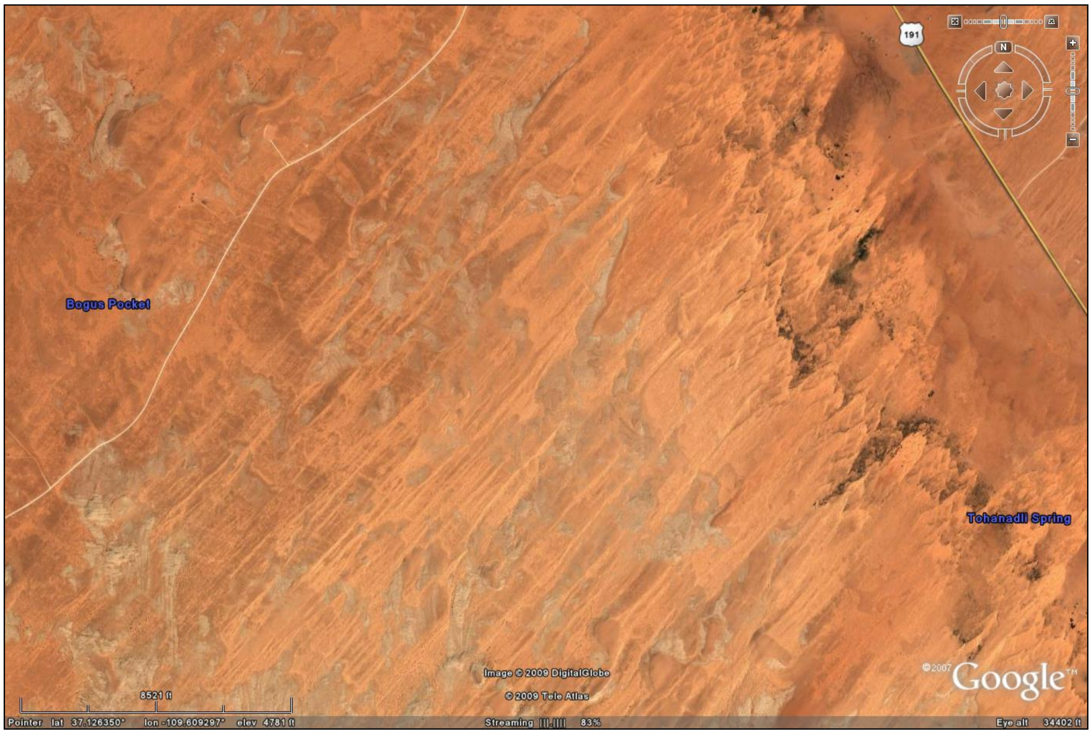

Figure A-10. Southwest to northeast soil and sand erosion structures in southeastern Utah.

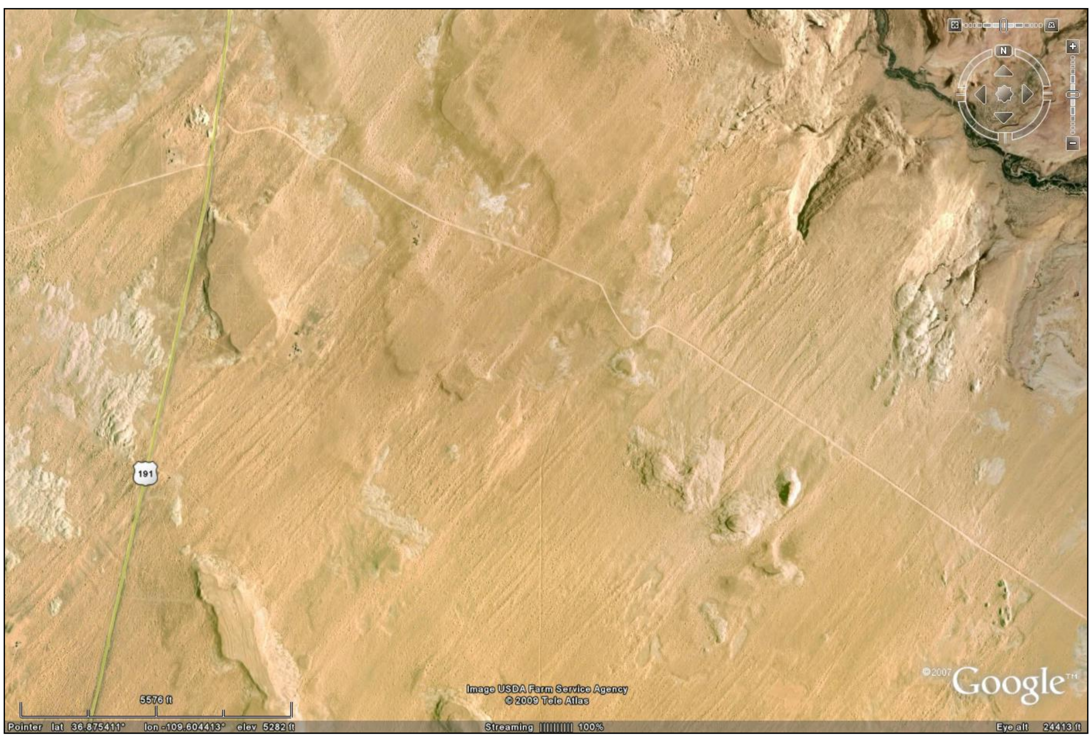

Figure A-11. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).

Figure A-12. Southwest to northeast soil and sand erosion structures in northeastern Arizona (Painted Desert).

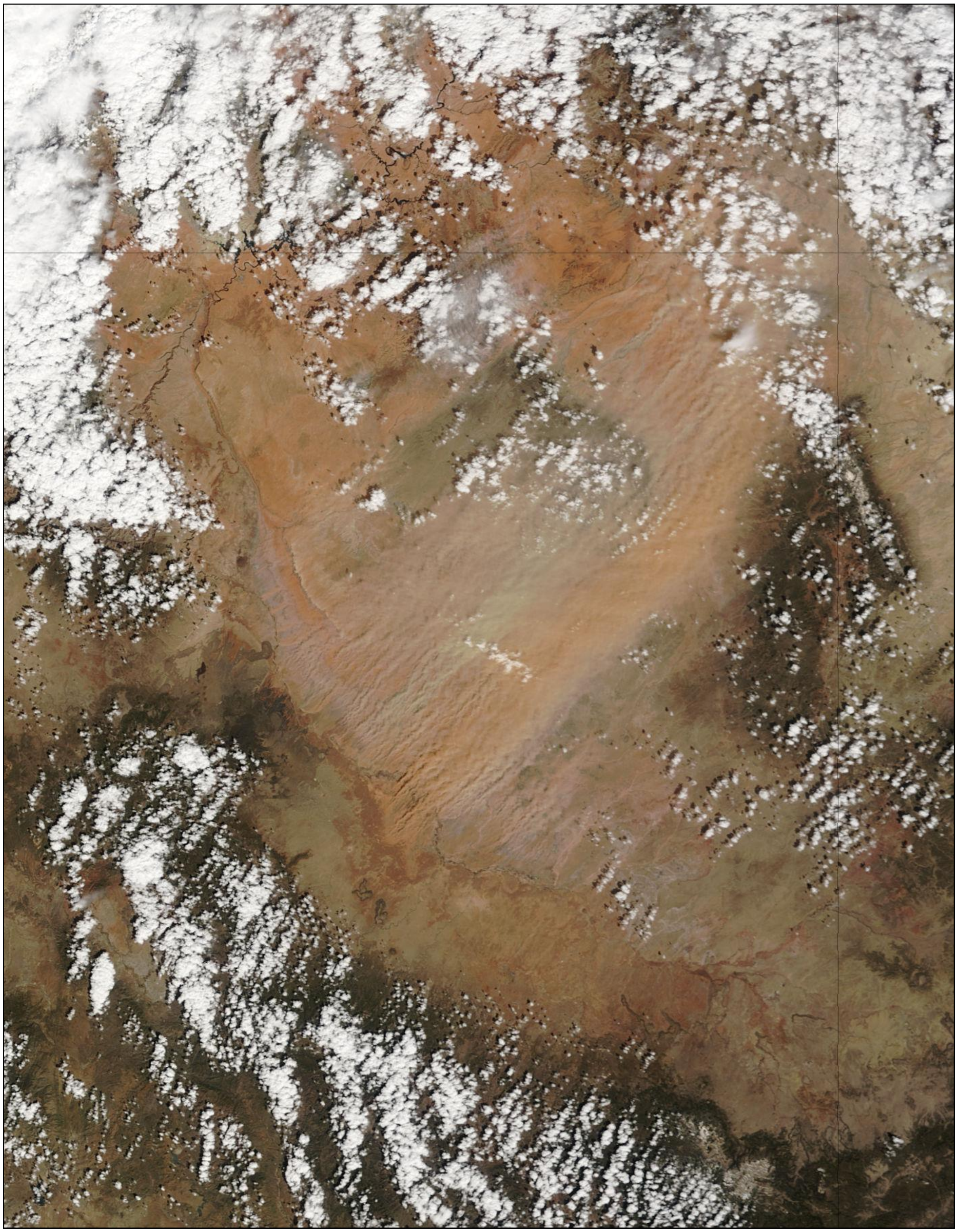

Figure A-13. NASA Tera satellite image of a dust storm on April 3, 2009, in southwesterly flow over the Painted Desert of northeastern Arizona (http://earthobservatory.nasa.gov/IOTD/view.php?id=37791).

Figure A-14 displays the surface weather map for this event (00Z April 4, 2009, or 5 PM MST April 3, 2009). A strong low pressure system in southern Colorado, strong southwesterly winds in the Four Corners area, and the blowing dust symbol (infinity sign) at Farmington (New Mexico) and Cortez (Colorado) are evident in this map. Blowing dust in this region is frequently associated with southwesterly flow.

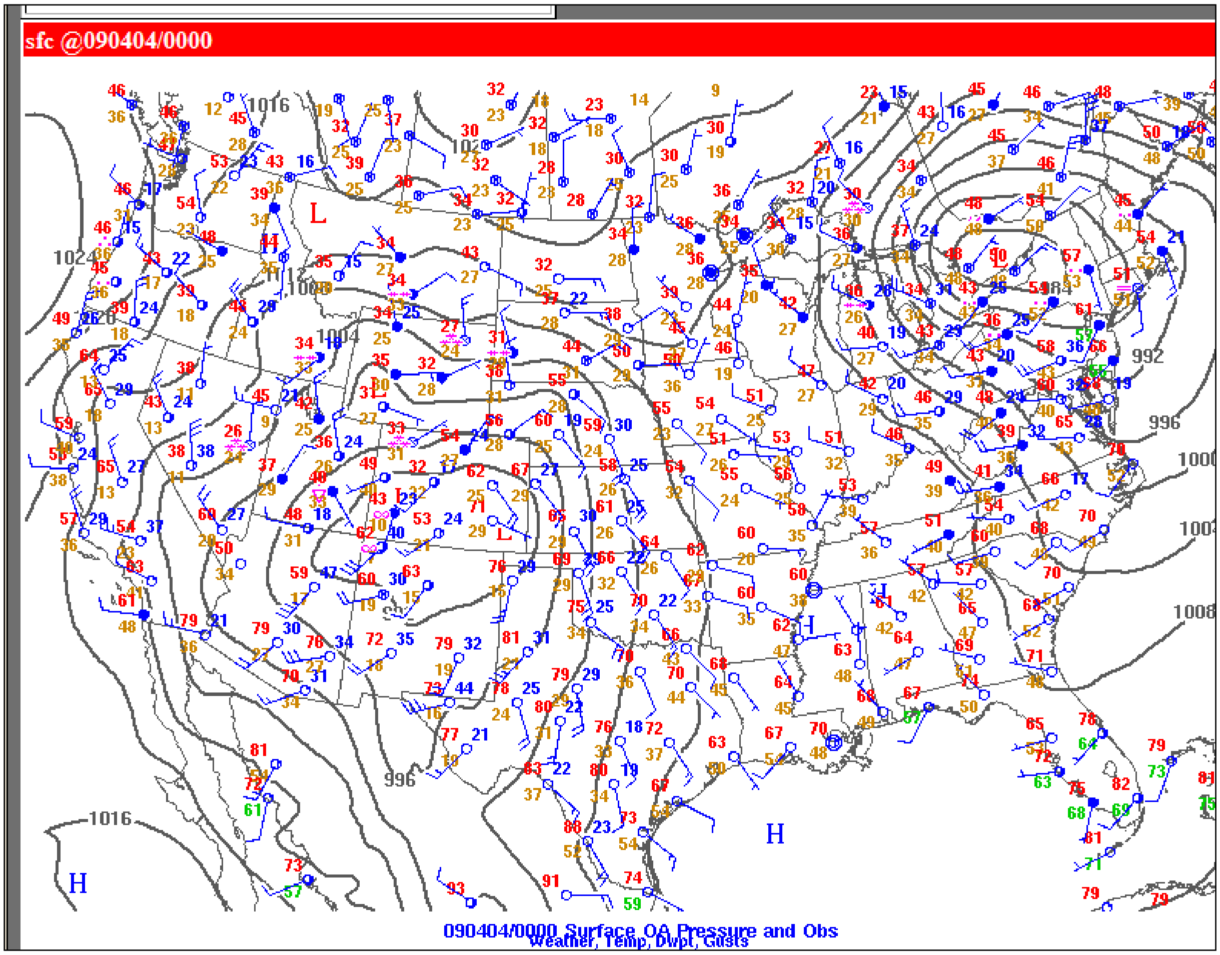

Figure A-14. Surface weather map for 00Z April 4, 2009, (5 PM MST April 3, 2009), showing a strong low pressure system in southern Colorado, strong southwesterly winds in the Four Corners area and the blowing dust symbol (infinity sign) at Farmington (New Mexico) and Cortez (Colorado).

A USGS map of the Colorado Plateau in Figure A-15 shows the prevalence of eolian or wind-blown sand deposits in southeastern Utah and northeastern Arizona. An analysis of the annual frequency of dust storms (Orgill and Sehmel, 1976) in the western half of the U.S. suggests that portions of eastern and western Utah and northeastern Arizona are source regions for blowing dust (see Figure A-16). Soil and sand structures point to the prevalence of southwesterly flow during blowing dust events, and precipitation climatology highlights the potential for blowing dust across much of the region. In addition, an analysis of back trajectories associated with high PM_{10} concentration events in Grand Junction discussed in the next section of this document supports the conclusion that soils in Arizona and Utah are likely significant contributors to PM_{10} measured during many dust storms affecting Grand Junction.

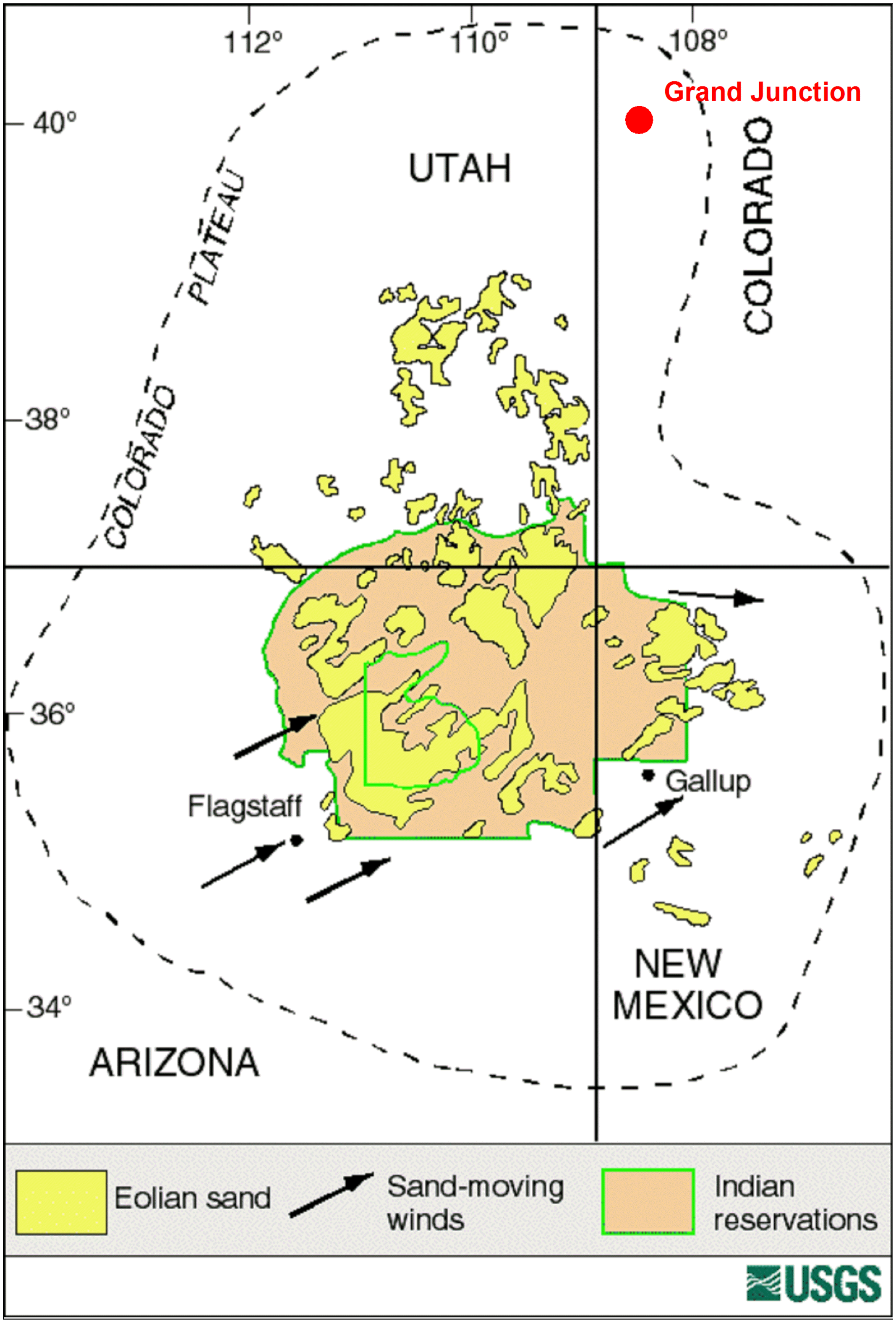

Figure A-15. USGS map of eolian sand features on the Colorado Plateau (http://geochange.er.usgs.gov/sw/impacts/geology/sand/).

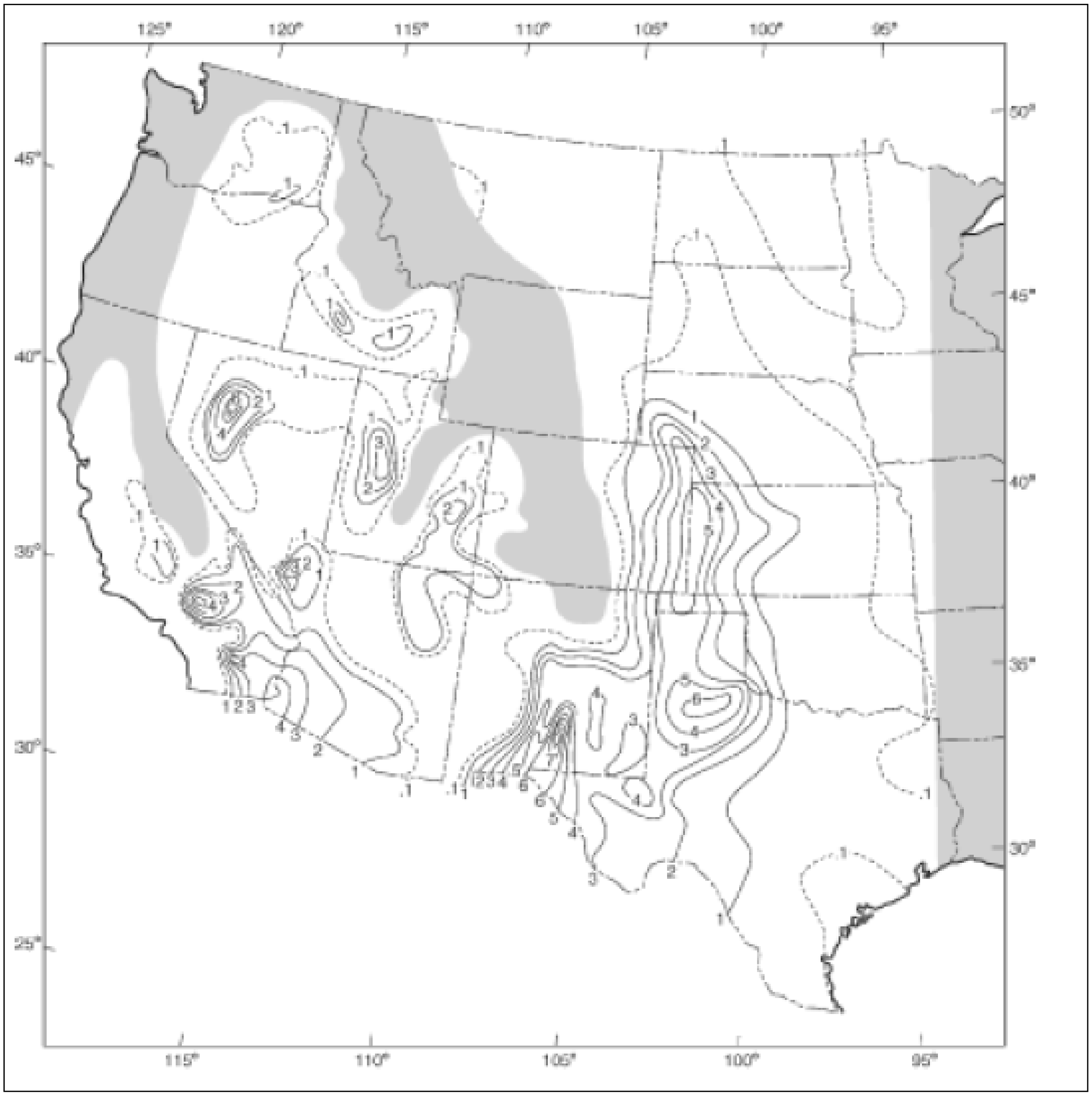

Figure A-16. Number of dust storms per year from: Orgill, M.M., Sehmel, G.A., 1976. Frequency and diurnal variation of dust storms in the contiguous USA. **Atmospheric Environment 10**, 813-825.

NOAA HYSPLIT 36-hour back trajectories were calculated for Grand Junction for the eight 24-hour periods from 2004 through early 2009 with the Powell monitor PM_{10} concentrations in excess of 75 $\mu g/m^3$, strong regional winds, and dry soils. Trajectories were modeled every 4 hours for each day. Data presented later in this document provides evidence that the moderate to high PM_{10} levels on these days were from blowing dust. The 6 back trajectories for each day were calculated for an arrival height of 500 meters using EDAS40 data and model vertical velocities (see: http://www.arl.noaa.gov/HYSPLIT.php). The eight days used in the analysis and the Powell monitor concentrations measured on these days are presented in Table A-1.

The back trajectories for these high-concentration days are shown in Figure A-17. Transport was generally from the west through southwest. A high density of trajectory points is found in northeast Arizona and southeast Utah. Most of these trajectories in Figure A-17 are also consistent with transport from or across suspected or known blowing dust source regions highlighted in Figures A-5, A-13, A-15, and A-16.

Table A-1. Grand Junction Powell monitor days with concentrations in excess of 75 c and blowing dust conditions (from 2004 through early 2009).

Year	Month	Day	Powell 24-hour PM_{10} concentration in c
2005	4	19	197.8
2008	4	15	116.1
2008	4	21	103.6
2004	9	3	102
2006	3	3	98.3
2008	5	21	86.7
2008	4	30	83.5
2006	6	7	77.9

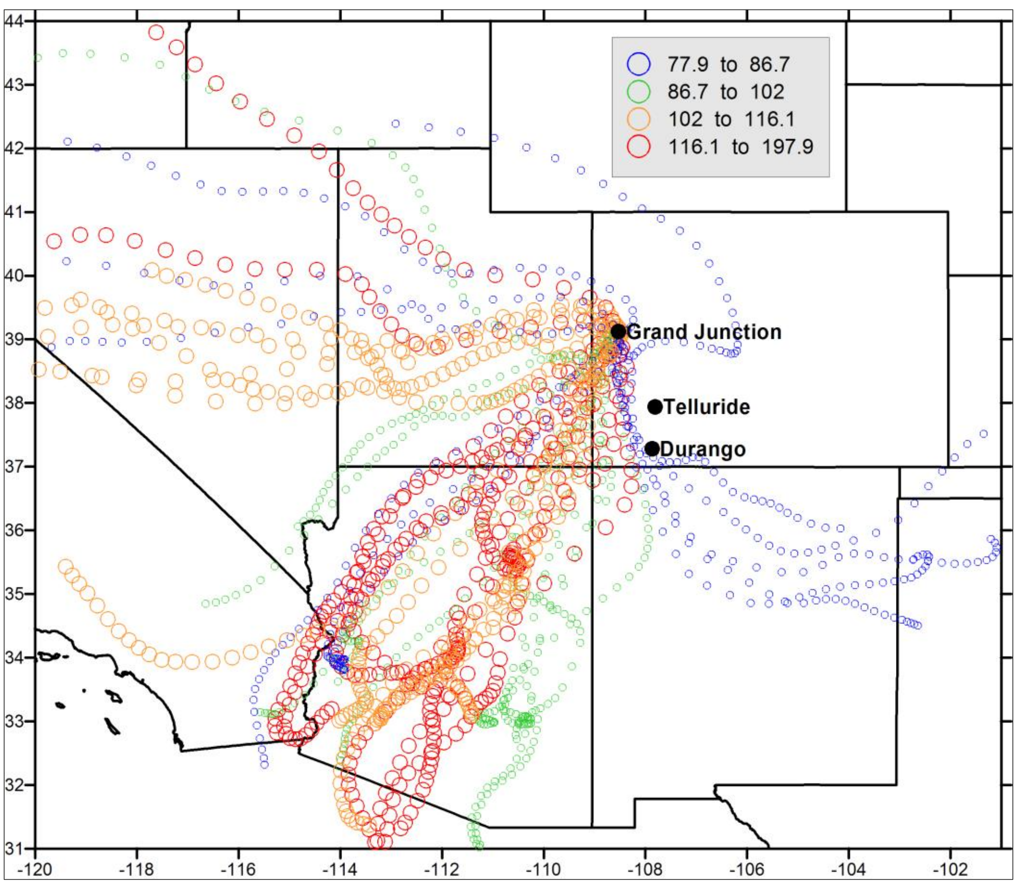

Figure A-17. NOAA HYSPLIT 36-hour back trajectories for Grand Junction for those eight 24-hour periods from 2004 through early 2009 with the Powell monitor PM_{10} concentrations in excess of 75 c, strong regional winds, and dry soils. Trajectory points are sized and color-coded to reflect 24-hour PM_{10} concentrations in c. Trajectories were calculated every 4 hours for each day.

The trajectories in Figure A-17 point to the possibility that, at times, dust from Utah and Arizona can have a major impact on Grand Junction and less of an impact elsewhere in western Colorado. This non-homogeneity is possible given the fact that dust storms are frequently organized into discreet plumes from discreet areas that maintain their integrity for long distances. An example of this can be seen in Figure A-18 that shows plumes of dust in New Mexico during a windstorm on May 20, 2008.

Figure A-19 shows the NOAA HYSPLIT back trajectories for the highest concentration day during the 2004 through early 2009 period: April 19, 2005. Twenty-four hour back trajectories for each hour during the period with high winds (using EDAS40 data and 500-meter arrival heights) show that the back trajectories for Grand Junction were more likely to have crossed the Painted Desert and southeastern Utah than those for Telluride and Durango, which measured lower PM_{10} concentrations on this day.

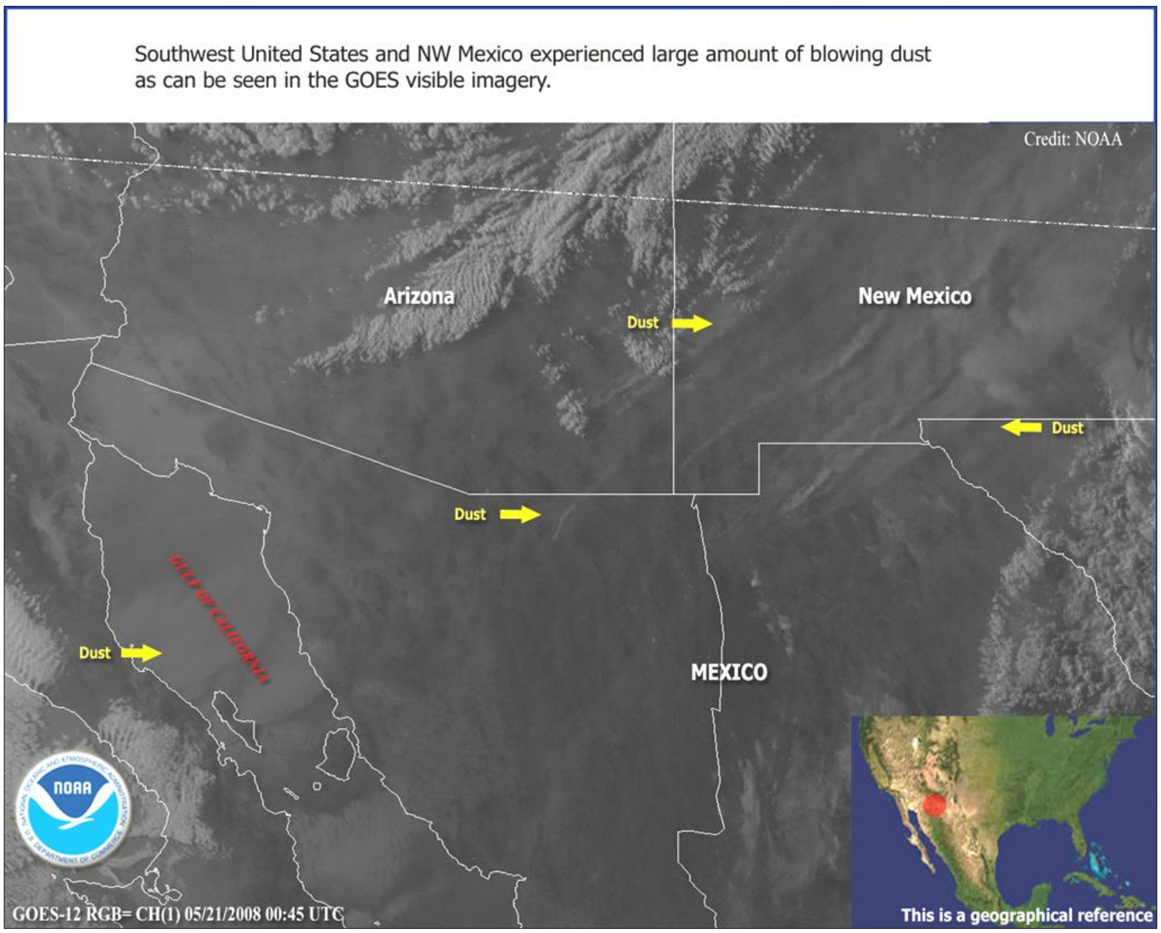

Figure A-18. Discreet plumes of blowing dust in New Mexico, Mexico, and Arizona visible in GOES satellite imagery for May 20, 2008 (http://www.osei.noaa.gov/Events/Dust/US_Southwest/2008/DSTusmx142_G12.jpg).

K-means cluster analysis has been applied to Grand Junction Powell PM_{10} concentrations, Grand Junction and

Painted Desert 30-day total precipitation for each PM_{10} monitoring day, and Grand Junction and Painted Desert daily maximum wind gust speeds for each monitoring day. K-means cluster analysis is a statistical method for identifying clusters or groupings of values for many variables. For environmental variables, these clusters often represent distinct processes, conditions, or events. In this case, cluster analysis differentiates PM_{10} concentrations associated with strong winds, low soil moistures, and blowing dust by providing mean values for these 5 variables for 5 distinct categories of PM_{10} events. The period of record considered was from January 2004 through March 2009. The Hopi weather station located in the central portion of the Painted Desert was used to represent Painted Desert conditions in northeastern Arizona, and the Grand Junction National Weather Service station was used to represent Grand Junction conditions. The 30-day total precipitation values appear to be a better metric for blowing dust conditions than shorter-term totals.

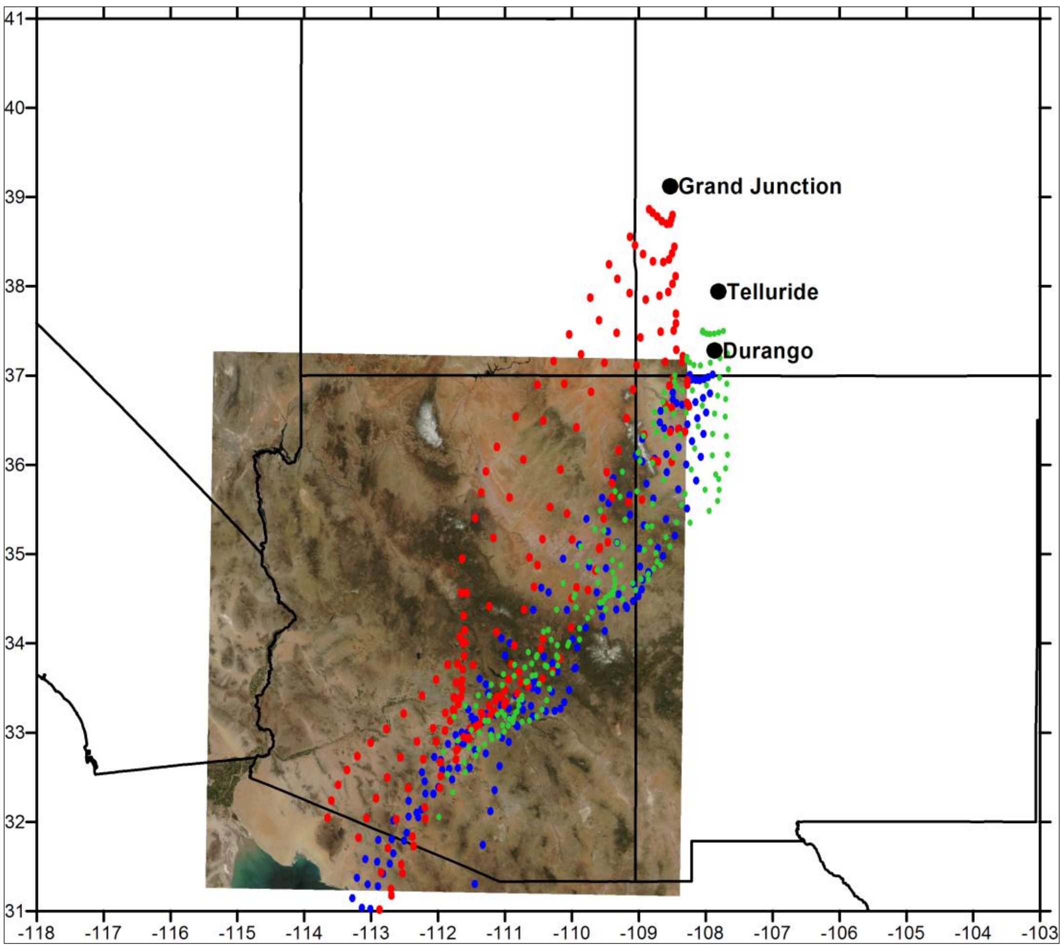

Figure A-19. 24-hour NOAA HYSPLIT back trajectories for every hour from 1500 MST to 2200 MST for Grand Junction (red), Telluride (green), and Durango (blue) for the dust storm of April 19, 2005.

The results of the cluster analysis are presented in Table A-2 below. Cluster 1 represents high soil moisture conditions, moderate gust speeds, and low PM_{10} concentrations. Cluster 2 represents very low soil moisture, moderate PM_{10}, and low gust speeds. Cluster 3 represents low soil moisture, moderate gusts, and low PM_{10}. Cluster 4 represents moderate soil moisture, low gusts, and low PM_{10}. Finally, Cluster 5 represents high PM_{10}, high gusts, and low soil moisture. Cluster numbers, Grand Junction Powell PM_{10} concentrations, and Grand Junction daily maximum gust speeds are plotted in Figure A-20.

The data in Figure A-20 clearly show that the highest PM_{10} concentrations tend to occur in Cluster 5 with gusts above 40 mph. The only exceedance in this period occurred on a day with a peak gust of 43 mph. Cluster 2 is likely to be indicative of wintertime inversion conditions with lighter winds and moderately elevated PM_{10}. Figure A-21 shows the concentrations and cluster values associated with Hopi station daily maximum gust speeds. The overall pattern is similar. The highest concentration day is associated with a peak gust of 47 mph at Hopi. All of the days/events presented in Figure A-17, A-19, and Table A-1 were classified as Cluster 5.

Table A-2. K-means cluster analysis means for Grand Junction PM_{10} and meteorological variables.

Cluster Variables	Cluster 1 Means	Cluster 2 Means	Cluster 3 Means	Cluster 4 Means	Cluster 5 Means
Powell 24-hour PM_{10} in c	24.5	37.3	24.3	21.8	74.9
Hopi Wind Gust in mph	20.8	18.0	32.5	20.7	40.5
Grand Junction Wind Gust in mph	20.4	16.5	31.8	19.6	43.1
Grand Junction 30-day Precipitation	1.7	0.4	0.5	0.8	0.6
Hopi 30-day Precipitation	1.8	0.2	0.5	0.7	0.3
Count	85	120	170	147	24

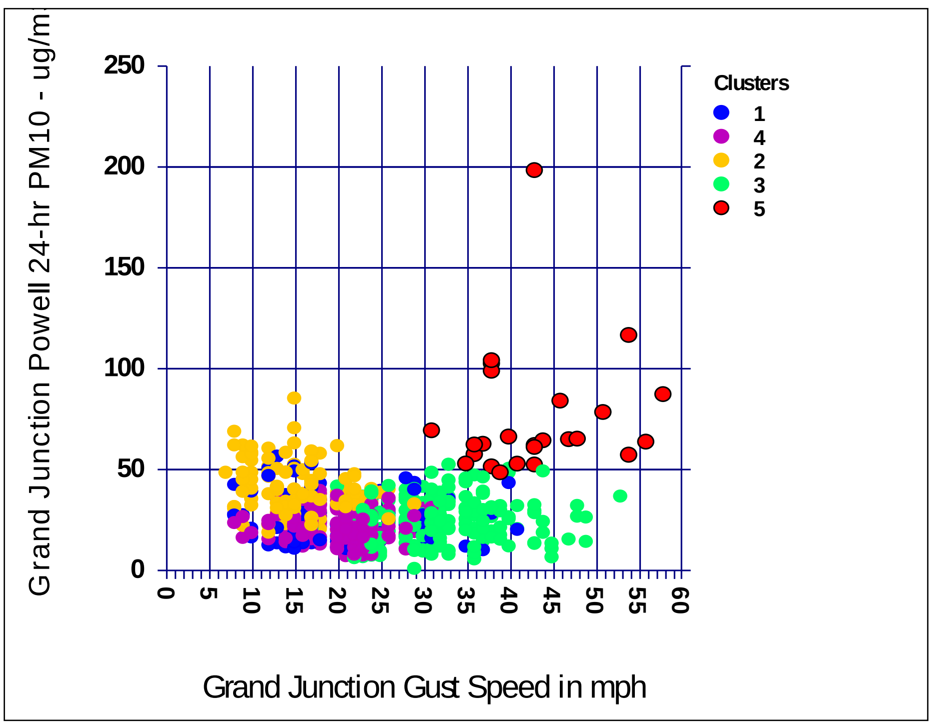

Figure A-20. Grand Junction Powell 24-hour PM_{10} concentrations versus Grand Junction gust speed by cluster.

Figures A-22 and A-23 show Powell PM_{10} concentrations versus Grand Junction and Hopi 30-day precipitation totals, respectively, by cluster. The blowing dust group, Cluster 5, is generally associated with 30-day precipitation totals of less than 1.00 inches at Grand Junction and less than 0.50 inches at Hopi. While this is not proof that the measured dust in Grand Junction is from Arizona, it adds to the weight of evidence that the Painted Desert makes a significant contribution to PM_{10} concentrations in Grand Junction during many blowing dust events. Of interest in this regard are the two high concentrations (greater than 100 c) that occurred when Grand Junction 30-day precipitation totals were greater than an inch (see Figure A-22). One of these occurred when transport was from the southwest. On this day (April 21, 2008) the NOAA Satellite Smoke Text Archive reported the following (see http://www.ssd.noaa.gov/PS/FIRE/smoke.html):

"Blowing dust is seen over most of Utah (and part of western Nevada) and the dust is moving toward the northeast, reaching into northwestern Colorado and southern Wyoming."

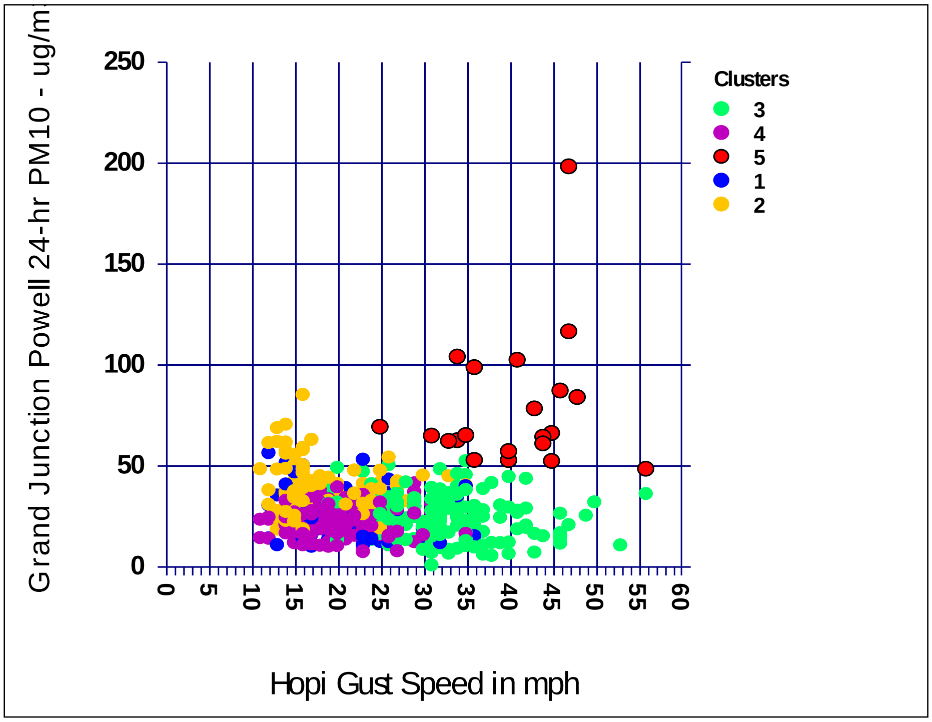

Figure A-21. Grand Junction Powell 24-hour PM_{10} concentrations versus Hopi gust speed by cluster.

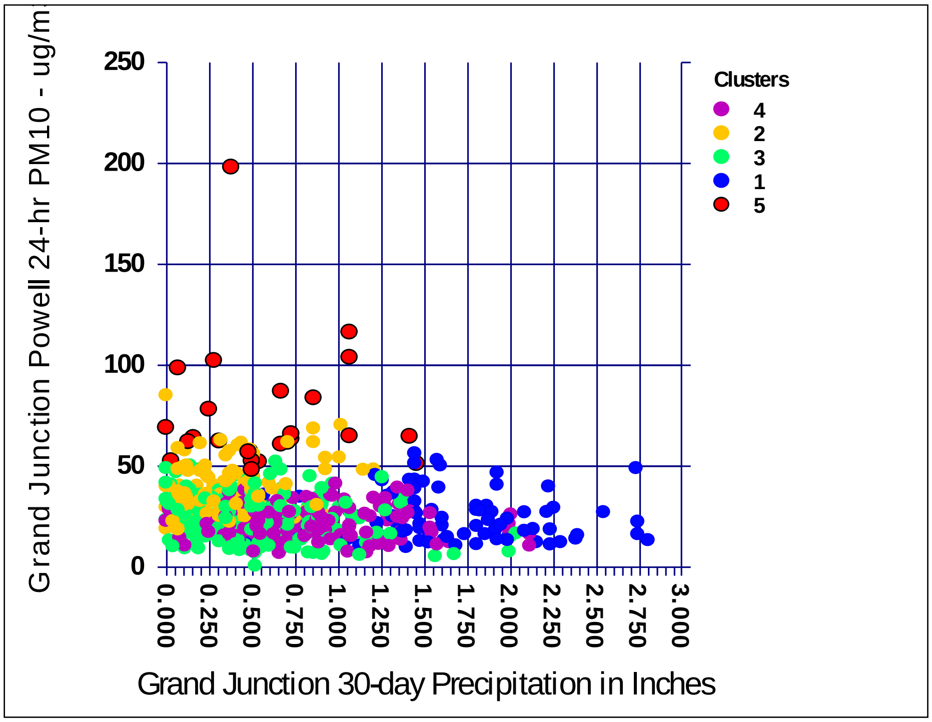

Figure A-22. Grand Junction Powell 24-hour PM_{10} concentrations versus Grand Junction 30-day total precipitation by cluster.

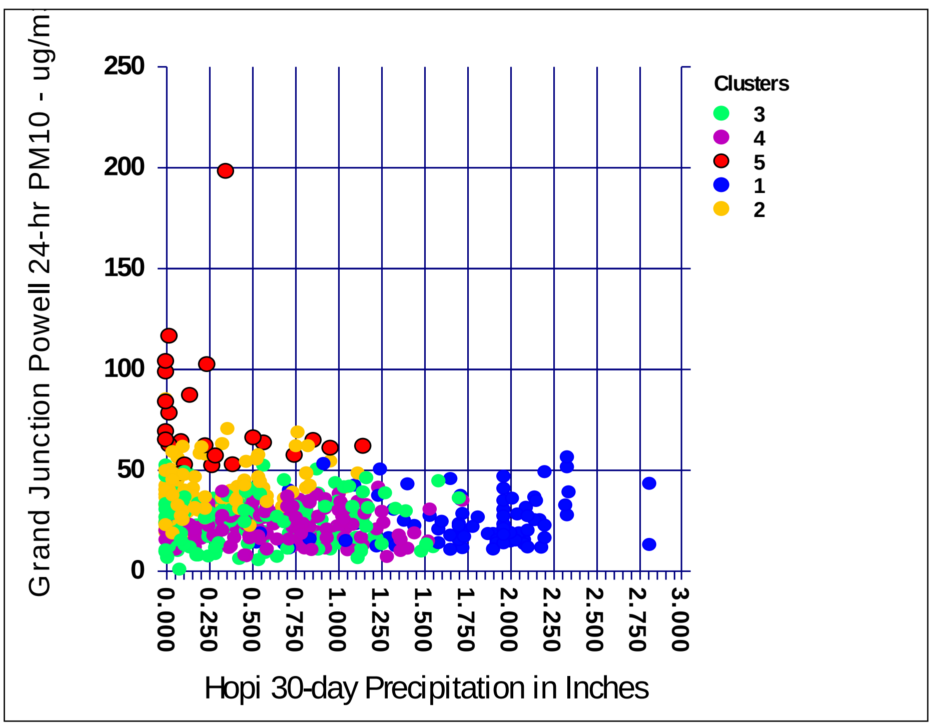

Figure A-23. Grand Junction Powell 24-hour PM_{10} concentrations versus Hopi 30-day total precipitation by cluster.

The other occurred on April 15, 2008, when the flow was from Arizona and southeast Utah. The transport conditions, the discrepancy between high recent precipitation in Grand Junction and low recent precipitation at Hopi for these two days, and, in one case, analyst discussion of what was visible in satellite images suggest that much of the dust might have originated from outside of the Grand Junction environment.

Figure A-24 shows Grand Junction Powell 24-hour PM_{10} concentrations versus peak gust wind directions at the Little Delores RAWS weather station about 25 miles west-southwest of Grand Junction. Grand Junction is situated on the floor of the Grand Valley, a major northwest to southeast trending basin than can force or channel synoptic scale flows. As a result, surface wind directions in Grand Junction may not be useful indicators of the direction of longer-range transport. Little Delores is on the Umcompahgre Plateau, and winds here are more likely to reflect the larger-scale transport directions for the region. This graph indicates that high PM_{10} at Grand Junction (Cluster 5) is associated with winds from the south-southeast to west-southwest at Little Delores. These directions point to dust sources in southeast Utah and northeastern Arizona. This is further evidence that dust from these areas may make a significant contribution to PM_{10} measured in Grand Junction during blowing dust events.

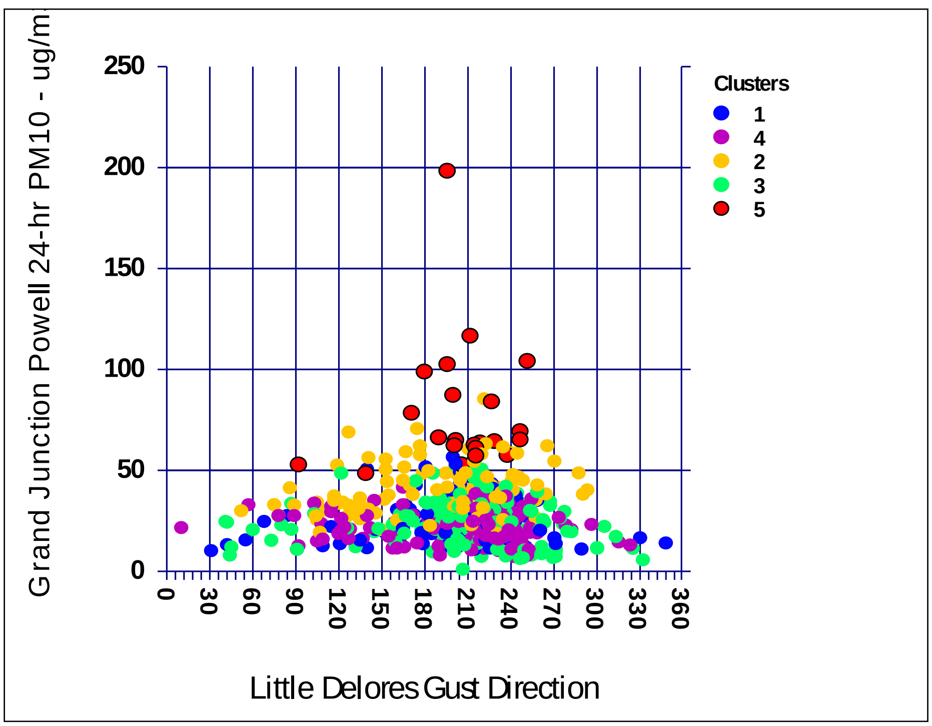

Figure A-24. Grand Junction Powell 24-hour PM_{10} concentrations versus peak gust wind directions at the Little Delores RAWS weather station, by cluster.

Figure A-25 presents monthly percentiles for Grand Junction gust speeds. Wind gusts generally considered to be high enough for significant blowing dusts (40 mph or higher) are within the upper 5 to 15 percent during each month of the year. Consequently, these events can be viewed as exceptional rather than normal. Gusts in this category can occur any month of the year, but are most likely in March, April, May and October. Figure A-4 shows that in Grand Junction these are typically among the wettest months of the year. It is in drier years, therefore, that blowing dust may be most prevalent during the spring and fall months. January, February, and

June are typically very dry, and might be expected to have a significant proportion of blowing dust events.

Figures A-26 and A-27 show histograms for Grand Junction and Hopi wind gusts, respectively. The 95th percentile gust speed for Grand Junction is 43 mph. For Hopi it is 41 mph. For both sites, it is clear that gusts in the range that is associated with blowing dust are the exception rather than the rule. Cluster analysis also shows that the blowing dust events represent only 4% of the PM_{10} sample days (from Table A-2, Cluster 5 had 24 cases out of a total of 546). The weight of evidence presented in this document clearly suggests that source regions in Arizona and Utah can have a significant impact on PM_{10} concentrations in Grand Junction during blowing dust events and that these events occur when dry soils are affected by winds of exceptional strength. Control of these sources, which are outside of Colorado, may not be reasonably achievable or possible.

The precipitation climatology for the Four Corners area indicates that the area can be susceptible to blowing dust when winds are high. Landform imagery shows that northeastern Arizona and southeastern Utah in particular have experienced a long-term pattern of wind erosion and blowing dust when winds have been southwesterly and blowing into western and southern Colorado. Back trajectories, case studies, satellite imagery, and statistical analyses have also shown that northeastern Arizona and southeastern Utah are a significant source for blowing dust transported into Colorado. Elevated PM_{10} *in Grand Junction during windstorms is generally associated with wind gusts of 40 mph or higher at Grand Junction and Hopi in northeastern Arizona and southwesterly flow in Grand Junction. Elevated* PM_{10} *in Grand Junction is generally associated with 30-day precipitation totals of less than 1.00 inches at Grand Junction and less than 0.50 inches at Hopi.*

Reference:

Orgill, M.M., Sehmel, G.A., 1976. Frequency and diurnal variation of dust storms in the contiguous USA. **Atmospheric Environment 10**, 813-825

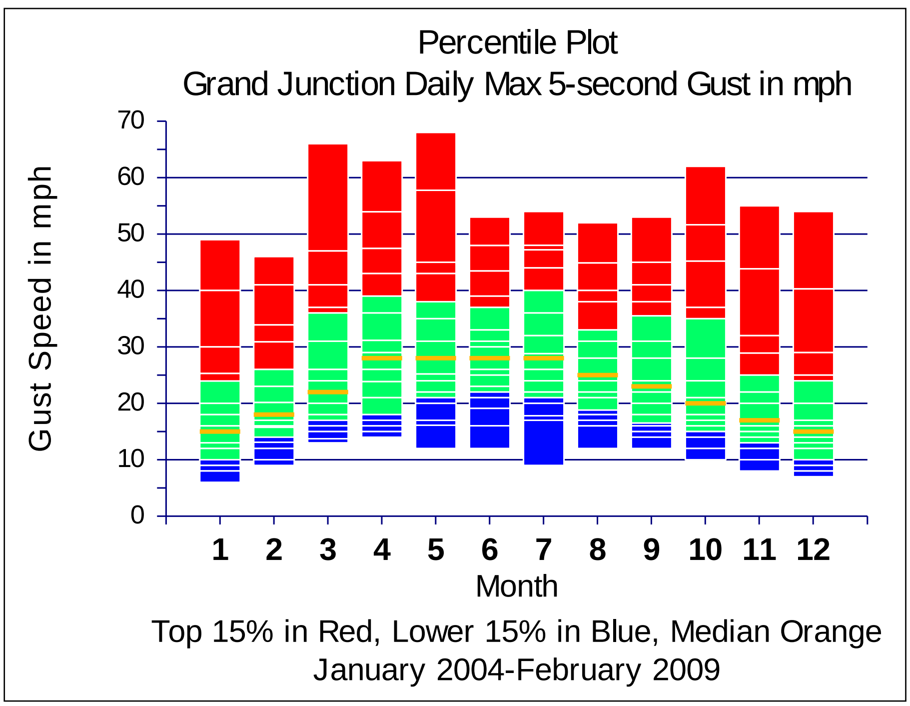

Figure A-25. Percentile plot of Grand Junction daily maximum 5-second gust speed in miles per hour showing that gusts of 40 mph or greater always occur within the top 15 percentile speeds for each month of the year.

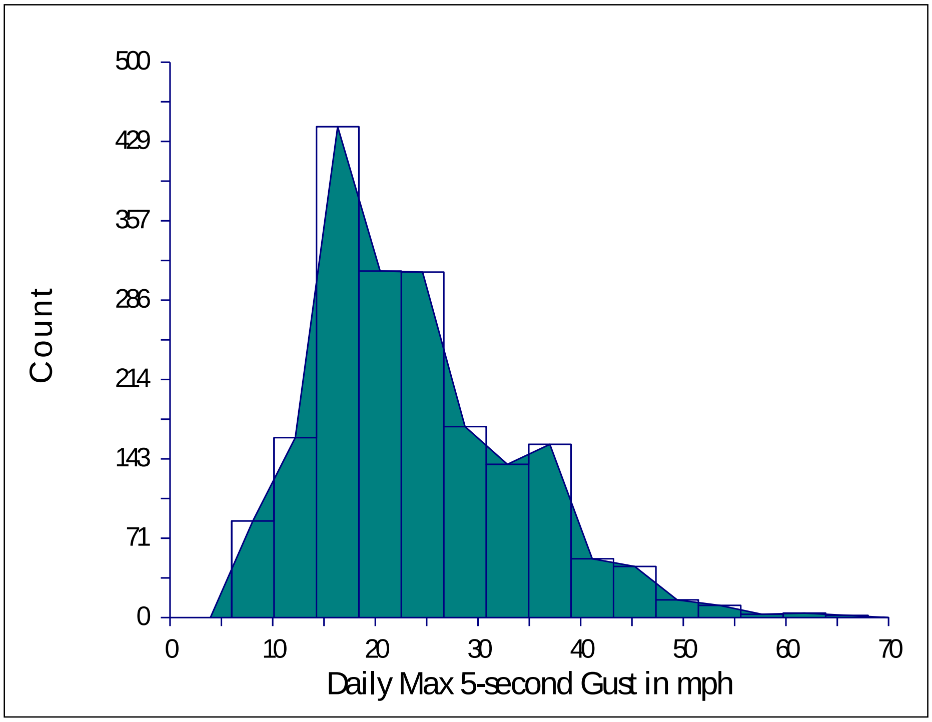

Figure A-26. Histogram of daily maximum 5-second wind gusts at Grand Junction based on January 2004 – February 2009.

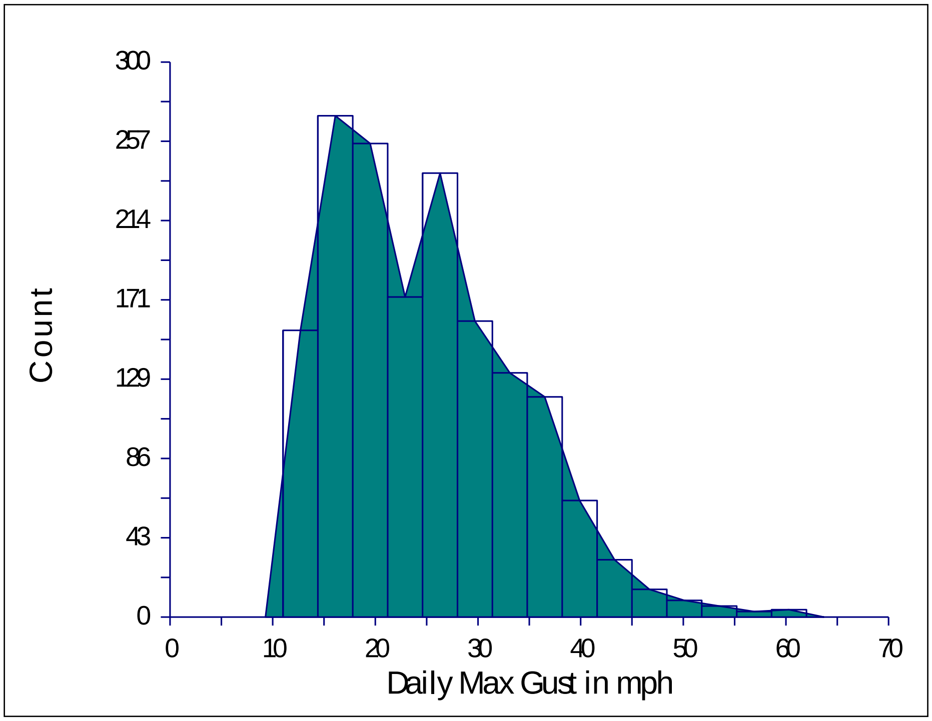

Figure A-27. Histogram of daily maximum 5-second wind gusts at Hopi based on January 2004 – February 2009.

Appendix B - Weather Warnings and Blowing Dust Advisories for April 16, 2013

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693
WWUS75 KGJT 161020
NPWGJT

URGENT - WEATHER MESSAGE
NATIONAL WEATHER SERVICE GRAND JUNCTION CO
420 AM MDT TUE APR 16 2013

COZ021-022-UTZ022-161830-
/O.NEW.KGJT.WI.Y.0005.130416T1900Z-130417T0200Z/
FOUR CORNERS/UPPER DOLORES RIVER-ANIMAS RIVER BASIN-
SOUTHEAST UTAH-
INCLUDING THE CITIES OF...CORTEZ...DOVE CREEK...MANCOS...
DURANGO...BAYFIELD...IGNACIO...BLANDING...BLUFF...MEXICAN HAT
420 AM MDT TUE APR 16 2013

...WIND ADVISORY IN EFFECT FROM 1 PM THIS AFTERNOON TO 8 PM MDT
THIS EVENING...

THE NATIONAL WEATHER SERVICE IN GRAND JUNCTION HAS ISSUED A WIND
ADVISORY...WHICH IS IN EFFECT FROM 1 PM THIS AFTERNOON TO 8 PM
MDT THIS EVENING.

* TIMING...STRONG WINDS WILL DEVELOP EARLY THIS AFTERNOON AND
  CONTINUE INTO THE EARLY EVENING.

* WINDS...SOUTHWEST 20 TO 30 MPH WITH GUSTS TO 50 MPH.

* VISIBILITY...BLOWING DUST WILL LIMIT VISIBILITY.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A WIND ADVISORY MEANS THAT A SIGNIFICANT WIND EVENT IS EXPECTED
OR OCCURRING. WINDS THIS STRONG CAN MAKE DRIVING DIFFICULT. USE
EXTRA CAUTION.

PEOPLE...ESPECIALLY THOSE WITH RESPIRATORY ILLNESSES... HEART
DISEASE...THE ELDERLY...AND CHILDREN ARE RECOMMENDED TO STAY
INDOORS AND AVOID PROLONGED OUTDOOR EXERCISE OR HEAVY EXERTION
DUE TO WIND-BLOWN DUST.

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817
WWUS75 KFGZ 161454
NPWFGZ
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URGENT - WEATHER MESSAGE
NATIONAL WEATHER SERVICE FLAGSTAFF AZ
754 AM MST TUE APR 16 2013

...VERY WINDY CONDITIONS TODAY THROUGH TUESDAY...

A SPRING STORM SYSTEM WILL BRING STRONG SOUTHWEST WINDS TO MUCH OF NORTHERN ARIZONA TODAY. THE STRONGEST WINDS ARE EXPECTED ACROSS THE LITTLE COLORADO RIVER VALLEY...THE NORTHERN SLOPES OF THE WHITE MOUNTAINS AND PORTIONS OF THE MOGOLLON RIM. AREAS OF BLOWING DUST WILL LIKELY AFFECT TRAVEL ACROSS MUCH OF NORTHEAST ARIZONA...INCLUDING INTERSTATE 40...HIGHWAYS 87...364...AND 191.

AZZ013-014-016-017-162300-
/O.EXP.KFGZ.WI.Y.0004.000000T0000Z-130416T1500Z/
/O.CON.KFGZ.HW.W.0002.130416T1500Z-130417T0200Z/
LITTLE COLORADO RIVER VALLEY IN NAVAJO COUNTY-
LITTLE COLORADO RIVER VALLEY IN APACHE COUNTY-
EASTERN MOGOLLON RIM-WHITE MOUNTAINS-
INCLUDING THE CITIES OF...WINSLOW...HOLBROOK...SNOWFLAKE...
ST. JOHNS...SPRINGERVILLE...SHOW LOW
754 AM MST TUE APR 16 2013

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL 7 PM MST THIS EVENING...
...WIND ADVISORY HAS BEEN UPGRADED TO A WARNING...

* TIMING...WINDS WILL RAPIDLY STRENGTHEN THROUGH THE MORNING HOURS.

* WINDS...SOUTHWEST 25 TO 35 MPH WITH GUSTS 45 TO 55 MPH EARLY... INCREASING TO 30 TO 40 MPH WITH GUSTS OF 55 TO 65 MPH.

* IMPACTS...WINDS THIS STRONG CAN MAKE DRIVING DIFFICULT... ESPECIALLY FOR HIGH PROFILE VEHICLES. MINOR PROPERTY DAMAGE AND SPOTTY POWER OUTAGES ARE POSSIBLE WITH THE STRONGEST GUSTS. AREAS OF DENSE BLOWING DUST ARE POSSIBLE ACROSS THE LITTLE COLORADO RIVER VALLEY...AFFECTING TRAVEL ALONG INTERSTATE 40.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A WIND ADVISORY MEANS THAT SUSTAINED WINDS OF 30 TO 39 MPH...OR GUSTS FROM 40 TO 57 MPH...ARE EXPECTED. WINDS THIS STRONG CAN MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES. CONSIDER SECURING LOOSE BELONGINGS ON YOUR PROPERTY.

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ012-015-162300-
/O.CON.KFGZ.HW.W.0002.000000T0000Z-130417T0200Z/
LITTLE COLORADO RIVER VALLEY IN COCONINO COUNTY-
WESTERN MOGOLLON RIM-
INCLUDING THE CITY OF...FLAGSTAFF
754 AM MST TUE APR 16 2013

...HIGH WIND WARNING REMAINS IN EFFECT UNTIL 7 PM MST THIS EVENING...

* WINDS...SOUTHWEST 25 TO 35 MPH WITH GUSTS 45 TO 55 MPH... INCREASING TO 30 TO 40 MPH WITH GUSTS OF 55 TO 65 MPH.

* IMPACTS...WINDS THIS STRONG CAN MAKE DRIVING DIFFICULT... ESPECIALLY FOR HIGH PROFILE VEHICLES. MINOR PROPERTY DAMAGE AND SPOTTY POWER OUTAGES ARE POSSIBLE WITH THE STRONGEST GUSTS. AREAS OF DENSE BLOWING DUST ARE POSSIBLE ACROSS THE LITTLE COLORADO RIVER VALLEY...AFFECTING TRAVEL ALONG INTERSTATE 40.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A HIGH WIND WARNING MEANS A HAZARDOUS HIGH WIND EVENT IS EXPECTED OR OCCURRING...WITH SUSTAINED WIND SPEEDS GREATER THAN 40 MPH OR GUSTS GREATER THAN 58 MPH. WINDS THIS STRONG CAN CAUSE PROPERTY DAMAGE. CONTINUE TO MONITOR THE LATEST FORECASTS. ADDITIONAL WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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AZZ004>007-009>011-039-040-162300-
/O.CON.KFGZ.WI.Y.0004.000000T0000Z-130417T0200Z/
KAIBAB PLATEAU-MARBLE AND GLEN CANYONS-GRAND CANYON COUNTRY-
COCONINO PLATEAU-NORTHEAST PLATEAUS AND MESAS HWY 264 NORTHWARD-
CHINLE VALLEY-CHUSKA MOUNTAINS AND DEFIANCE PLATEAU-
BLACK MESA AREA-NORTHEAST PLATEAUS AND MESAS SOUTH OF HWY 264-
INCLUDING THE CITIES OF...FREDONIA...PAGE...
GRAND CANYON VILLAGE...SUPAI...CHINLE...KAYENTA...WINDOW ROCK...
GANADO...DILKON
754 AM MST TUE APR 16 2013

...WIND ADVISORY REMAINS IN EFFECT UNTIL 7 PM MST THIS EVENING...

* WINDS...SOUTHWEST 25 TO 35 MPH WITH GUSTS OF 45 TO 55 MPH.

* IMPACTS...WINDS THIS STRONG CAN MAKE DRIVING DIFFICULT... ESPECIALLY FOR HIGH PROFILE VEHICLES. AREAS OF DENSE BLOWING DUST ARE ALSO POSSIBLE...ESPECIALLY ACROSS THE CHINLE VALLEY INCLUDING KAYENTA...MANY FARMS...CHINLE. TRAVEL MAY BE SEVERELY IMPACTED.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A WIND ADVISORY MEANS THAT SUSTAINED WINDS OF 30 TO 39 MPH...OR GUSTS FROM 40 TO 57 MPH...ARE EXPECTED. WINDS THIS STRONG CAN

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MAKE DRIVING DIFFICULT...ESPECIALLY FOR HIGH PROFILE VEHICLES.
CONSIDER SECURING LOOSE BELONGINGS ON YOUR PROPERTY. ADDITIONAL
WEATHER INFORMATION IS ON THE WEB AT WWW.WEATHER.GOV/FLAGSTAFF.

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793
WWUS75 KABQ 161025
NPWABQ

URGENT - WEATHER MESSAGE
NATIONAL WEATHER SERVICE ALBUQUERQUE NM
425 AM MDT TUE APR 16 2013

...VERY WINDY CONDITIONS FOR MUCH OF NORTHERN AND WESTERN NEW
   MEXICO TODAY AND EARLY TONIGHT...
...HIGH WINDS POSSIBLE SOUTH-CENTRAL AREAS WEDNESDAY...

.STRONG SOUTHWEST WINDS WILL RETURN TO MUCH OF NORTHERN AND
CENTRAL NEW MEXICO TODAY AS A BROAD UPPER LEVEL LOW PRESSURE
SYSTEM CROSSING THE GREAT BASIN STEERS THE JET STREAM OVER THE
STATE. PLENTY OF SUNSHINE WILL ENABLE DEEP VERTICAL MIXING IN THE
ATMOSPHERE...WHICH WILL TRANSFER THE STRONGER MOMENTUM ALOFT TO
THE SURFACE WITH WIND GUSTS FROM 45 TO POTENTIALLY OVER 55 MPH.
THE STRONG WINDS WILL DEVELOP DURING THE MORNING HOURS OVER THE
WESTERN MOUNTAINS...AS WELL AS THE WEST CENTRAL HIGHLANDS AND
PLATEAU. THE POTENTIAL EXISTS FOR THE STRONG WINDS TO SPREAD TO
LOCATIONS FARTHER EAST DURING THE AFTERNOON. AREAS OF BLOWING DUST
WILL RESTRICT VISIBILITY AT LOWER ELEVATIONS. WINDS WILL GRADUALLY
WEAKEN WITH SUNSET THIS EVENING...LINGERING LONGEST OVER THE
HIGHER MOUNTAIN PEAKS.

NMZ502-505-506-161800-
/O.UPG.KABQ.WI.Y.0020.130416T1200Z-130417T0300Z/
/O.NEW.KABQ.HW.W.0006.130416T1200Z-130417T0300Z/
CHUSKA MOUNTAINS-WEST CENTRAL PLATEAU-WEST CENTRAL MOUNTAINS-
425 AM MDT TUE APR 16 2013

...HIGH WIND WARNING IN EFFECT UNTIL 9 PM MDT THIS EVENING...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A HIGH
WIND WARNING...WHICH IS IN EFFECT UNTIL 9 PM MDT THIS EVENING.
THE WIND ADVISORY IS NO LONGER IN EFFECT.

* LOCATION...THE WEST-CENTRAL AND CHUSKA MOUNTAINS...AND WEST
  CENTRAL PLATEAU. THIS INCLUDES THE INTERSTATE 40 CORRIDOR
  BETWEEN THE ARIZONA STATE LINE AND THE CONTINENTAL DIVIDE.

* WINDS...SOUTHWEST 30 TO 40 MPH WITH GUSTS UP TO 60 MPH.

* TIMING...VERY WINDY CONDITIONS ACROSS THE HIGHER TERRAIN NEAR
  DAYBREAK WILL EXPAND TO LOWER ELEVATION LOCATIONS BEGINNING
  AROUND LATE MORNING. STRONG...POTENTIALLY DAMAGING WINDS ARE
  MOST LIKELY BETWEEN 3 PM AND 8 PM.

* VISIBILITY...LOCALLY REDUCED BELOW 1 MILE AT TIMES IN DUST
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PRONE AREAS.

* LOCAL IMPACTS...WIND GUSTS TO 60 MPH WILL RESULT IN EXTREMELY HAZARDOUS DRIVING CONDITIONS... ESPECIALLY ON ROADS OR STRETCHES OF HIGHWAYS THAT ARE ORIENTED NORTHWEST TO SOUTHEAST. MOTORISTS OF HIGH PROFILE VEHICLES SHOULD CONSIDER DELAYING TRAVEL AS DANGEROUS CROSS WINDS WILL IMPACT TRAVEL. WINDS OF THIS MAGNITUDE MAY RESULT IN PROPERTY DAMAGE. LOOSE OR LIGHT-WEIGHT OBJECTS MAY BECOME AIRBORNE.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

REMEMBER...A HIGH WIND WARNING MEANS DAMAGING WINDS ARE IMMINENT OR HIGHLY LIKELY. SUSTAINED WIND SPEEDS OF AT LEAST 40 MPH OR GUSTS OF 58 MPH OR MORE CAN LEAD TO PROPERTY DAMAGE.

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NMZ501-503-504-509>524-527>529-161800-
/O.EXB.KABQ.WI.Y.0020.130416T1700Z-130417T0300Z/
NORTHWEST PLATEAU-FAR NORTHWEST HIGHLANDS-NORTHWEST HIGHLANDS-
SAN FRANCISCO RIVER VALLEY-SAN JUAN MOUNTAINS-JEMEZ MOUNTAINS-
WEST SLOPES SANGRE DE CRISTO MOUNTAINS-
NORTHERN SANGRE DE CRISTO MOUNTAINS ABOVE 9500 FEET/RED RIVER-
SOUTHERN SANGRE DE CRISTO MOUNTAINS ABOVE 9500 FEET-
EAST SLOPES SANGRE DE CRISTO MOUNTAINS-UPPER RIO GRANDE VALLEY-
LOWER CHAMA RIVER VALLEY-SANTA FE METRO AREA-
ALBUQUERQUE METRO AREA-LOWER RIO GRANDE VALLEY-
SANDIA/MANZANO MOUNTAINS-ESTANCIA VALLEY-CENTRAL HIGHLANDS-
SOUTH CENTRAL HIGHLANDS-RATON RIDGE/JOHNSON MESA-
FAR NORTHEAST HIGHLANDS-NORTHEAST HIGHLANDS-
425 AM MDT TUE APR 16 2013

...WIND ADVISORY IN EFFECT FROM 11 AM THIS MORNING TO 9 PM MDT THIS EVENING...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A WIND ADVISORY...WHICH IS IN EFFECT FROM 11 AM THIS MORNING TO 9 PM MDT THIS EVENING.

* LOCATION...MUCH OF THE WESTERN TWO-THIRDS OF NEW MEXICO TO INCLUDE AREAS ALONG AND WEST OF A LINE FROM RATON TO CLINES CORNERS TO SOCORRO. THIS ALSO INCLUDES THE ALBUQUERQUE AND SANTA FE METRO AREAS AND SIGNIFICANT PORTIONS OF THE INTERSTATE 25 AND INTERSTATE 40 CORRIDORS.

* WINDS...SOUTHWEST 25 TO 35 MPH WITH GUSTS OF 50 TO 55 MPH.

* TIMING...SOUTHWEST WINDS STEADILY INCREASING LATE MORNING TOWARD MIDDAY...PEAKING IN STRENGTH BETWEEN 3 PM AND 8 PM BEFORE GRADUALLY DIMINISHING BY MID-EVENING.

* VISIBILITY...LOCALLY REDUCED BELOW 1 MILE AT TIMES IN DUST PRONE AREAS.

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* LOCAL IMPACTS...STRONG CROSS WINDS WILL IMPACT TRAVEL...
  ESPECIALLY ON ROADS OR STRETCHES OF HIGHWAYS ORIENTED NORTHWEST
  TO SOUTHEAST. LOOSE AND LIGHT-WEIGHT OBJECTS MAY BECOME
  AIRBORNE. BLOWING DUST IMPACTS WILL LIKELY BECOME SIGNIFICANT IN
  DUST PRONE LOCATIONS...ESPECIALLY ALONG THE RIO GRANDE
  VALLEY...AND ESTANCIA BASIN.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE TRAVELLING. SUDDEN GUSTS
OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA
ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ507-508-161800-
/O.CON.KABQ.WI.Y.0020.130416T1200Z-130417T0300Z/
WEST CENTRAL HIGHLANDS-SOUTHWEST MOUNTAINS-
425 AM MDT TUE APR 16 2013

...WIND ADVISORY REMAINS IN EFFECT UNTIL 9 PM MDT THIS EVENING...

* LOCATION...THE SOUTHWEST MOUNTAINS TO INCLUDE THE UPPER GILA
  REGION...AND WEST CENTRAL HIGHLANDS.

* WINDS...SOUTHWEST 25 TO 40 MPH WITH GUSTS UP TO 55 MPH.

* TIMING...SOUTHWEST WINDS STEADILY INCREASING LATE MORNING TOWARD
  MIDDAY...PEAKING IN STRENGTH BETWEEN 3 PM AND 8 PM BEFORE GRADUALLY
  DIMINISHING BY MID-EVENING.

* VISIBILITY...LOCALLY REDUCED BELOW 1 MILE AT TIMES IN DUST
  PRONE AREAS.

* LOCAL IMPACTS...STRONG CROSS WINDS WILL IMPACT TRAVEL...
  ESPECIALLY ON ROADS OR STRETCHES OF HIGHWAYS ORIENTED NORTHWEST
  TO SOUTHEAST. LOOSE AND LIGHT-WEIGHT OBJECTS MAY BECOME
  AIRBORNE. BLOWING DUST IMPACTS WILL LIKELY BECOME SIGNIFICANT IN
  DUST PRONE LOCATIONS...ESPECIALLY INTERSTATE 40 NEAR THE RIO
  PUERCO.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOTORISTS SHOULD EXERCISE CAUTION WHILE TRAVELLING. SUDDEN GUSTS
OF WIND MAY CAUSE YOU TO LOSE CONTROL OF YOUR VEHICLE. EXTRA
ATTENTION SHOULD BE GIVEN TO CROSS WINDS.

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NMZ525-526-539-540-161800-
/O.NEW.KABQ.HW.A.0006.130417T1600Z-130418T0300Z/
UPPER TULAROSA VALLEY-SOUTH CENTRAL MOUNTAINS-
EASTERN LINCOLN COUNTY-SOUTHWEST CHAVES COUNTY-
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425 AM MDT TUE APR 16 2013

...HIGH WIND WATCH IN EFFECT FROM WEDNESDAY MORNING THROUGH WEDNESDAY EVENING...

THE NATIONAL WEATHER SERVICE IN ALBUQUERQUE HAS ISSUED A HIGH WIND WATCH...WHICH IS IN EFFECT FROM WEDNESDAY MORNING THROUGH WEDNESDAY EVENING.

* LOCATION...MUCH OF LINCOLN AND SOUTHWEST CHAVES COUNTIES TO INCLUDE RUIDOSO...CAPITAN...AND DUNKEN.

* WINDS...WEST TO SOUTHWEST 30 TO 40 MPH WITH GUSTS TO 60 MPH.

* TIMING...STRONG...POTENTIALLY DAMAGING WINDS ARE EXPECTED BETWEEN 11AM AND 8PM WEDNESDAY.

* VISIBILITY...LOCALLY REDUCED BELOW 1 MILE AT TIMES IN DUST PRONE AREAS.

* LOCAL IMPACTS...WIND GUSTS TO AROUND 60 MPH WILL RESULT IN EXTREMELY HAZARDOUS DRIVING CONDITIONS... ESPECIALLY ON ROADS OR STRETCHES OF HIGHWAYS THAT ARE ORIENTED NORTH TO SOUTH. MOTORISTS OF HIGH PROFILE VEHICLES SHOULD CONSIDER DELAYING TRAVEL AS DANGEROUS CROSS WINDS WILL IMPACT TRAVEL. WINDS OF THIS MAGNITUDE MAY RESULT IN PROPERTY DAMAGE. LOOSE OR LIGHT-WEIGHT OBJECTS MAY BECOME AIRBORNE. BLOWING DUST IMPACTS WILL BE MOST CRITICAL NEAR AND WEST OF CARRIZOZO.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

REMEMBER...A HIGH WIND WATCH MEANS CONDITIONS ARE FAVORABLE FOR A POTENTIALLY DAMAGING HIGH WIND EVENT IN AND CLOSE TO THE WATCH AREA. SUSTAINED WIND SPEEDS OF AT LEAST 40 MPH OR GUSTS OF 58 MPH OR MORE CAN LEAD TO PROPERTY DAMAGE. MONITOR THE LATEST FORECASTS AT WEATHER.GOV/ABQ...LISTEN TO NOAA WEATHER RADIO OR YOUR FAVORITE MEDIA OUTLET.

Air Quality Notifications

Blowing Dust Advisory

Issued for western and south-central Colorado

Issued by Colorado Department of Public Health and Environment

Issued at 9:30 AM Tuesday, April 16, 2013

Affected Area: western and south-central Colorado, including Moffat, Rio Blanco, Garfield, Mesa, Delta, Montrose, Ouray, San Miguel, Dolores, San Juan, Montezuma, La Plata, Hinsdale, Mineral, Archuleta, Cornejos, Rio Grande, Saguache, Alamosa, and Costilla counties. Cities include, but are not limited to Craig, Meeker, Rifle, Grand Junction, Delta, Montrose, Telluride, Cortez, Durango, Pagosa Springs and Alamosa.

Advisory in Effect: 10:00 AM Tuesday 4/16/2013 to 8:00 PM Tuesday 4/16/2013

Public Health Recommendations: If significant blowing dust is present and reducing visibility to less than 10 miles across a wide area, *People with heart or lung disease, older adults, and children in the affected area should reduce prolonged or heavy indoor and outdoor exertion*.