Technical Support Document For The May 22, 2008 Exceptional Event

Prepared by the Technical Services Program
Air Pollution Control Division
June 10, 2009

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1.0 Introduction

In July 1987, EPA promulgated National Ambient Air Quality Standards (NAAQS) for Particulates with an aerodynamic diameter of 10 microns or less (PM_{10}). This is a size that can be inhaled into the alveolar regions of the lungs. The standard had two forms, a 24-hour standard of 150 ug/m^3 and an annual arithmetic mean standard of 50 ug/m^3. The 24-hour standard is attained when the expected number of exceedances for each calendar year, averaged over three years, is less than or equal to one. The estimated number of exceedances is computed quarterly using available data and adjusting for missing sample days. A data recovery of 75 percent is needed for each calendar quarter to be considered a valid quarter of data. The annual standard was revoked in December 2006.

A PM_{10} exceedance of 227 ug/m3 was monitored in Lamar at the Power Plant site (100 N. 2nd Avenue) on May 22, 2008. The PM10 concentration at the Lamar Municipal Complex site (104 E. Parmenter St.) on May 22, 2008, while not an exceedance at 123 ug/m3, was clearly elevated relative to PM10 concentrations on May 21, 2008 (78 ug/m3) and May 23, 2008 (55 ug/m3). The elevated levels at both sites coincided with successive low pressure systems creating widespread high winds and gusty conditions that brought blowing dust to the area.

EPA's Natural Events Policy enables states to demonstrate that PM_{10} exceedances were caused by natural events (volcanic and seismic activities, wildland fires, or high winds) and therefore are not to be taken into account in determining compliance with NAAQS. The Natural Events Policy requires that sufficient documentation be submitted to EPA to demonstrate:

1. That an event occurred that meets the definition of a natural event. This can include monitored particulate data, videos and photographs of the event, eyewitness accounts, and news accounts.
2. That there is a cause and effect relationship between the event and the exceedance. This can include meteorological data, receptor analyses, dispersion modeling, etc.
3. Should a PM_{10} NAAQS violation occur due to a natural event, a Natural Events Action Plan (NEAP) should be implemented.

In this report, the Air Pollution Control Division (APCD) provides documentation to support that the PM_{10} exceedance monitored in Lamar on May 22, 2008 was caused by a natural event. It should be noted that a NEAP has been in place for Lamar since 1998.

2.0 Ambient Particulate and Meteorological Data

On Thursday May 22, 2008, Lamar Colorado recorded an exceedance of the twenty-four-hour PM10 standard with a concentration of 227 ug/m3 at the Lamar Power Plant. A twenty-four-hour PM10 concentration of 123 ug/m3 was measured at the Lamar Municipal Building on May 22. An intense surface low-pressure system was centered over Southeast Colorado with a strong upper level cut-off low over the Great Basin. Figures 1 and 2 show surface weather and 500 height analyses, respectively (combined with satellite infrared imagery) for 12Z May 22, 2008 (5 AM MST, May 22). The central pressure of the low-pressure system ranged from 985 to 987 mb while over southeast Colorado. The central pressure of the storm is significant since storms of about 1000 mb or lower were identified as a typical precondition for blowing dust in eastern Colorado when soils are dry (see reference for the *Natural Events Action Plan for High Wind Events – Lamar, Colorado* at the end of this document).

Sustained winds and gusts in eastern and southeastern Colorado exceeded blowing dust criteria. Many sites showed wind speeds in excess of 30 miles per hour (mph) and gusts in excess of 40 mph. These are the speed and gust thresholds for blowing dust that apply in southeastern Colorado when surface soils are dry (see reference for the *Natural Events Action Plan for High Wind Events – Lamar, Colorado* at the end of this document). Table 1 below lists wind speeds and gusts for Lamar, Colorado on May 22. The 30 mph blowing dust threshold applies to hourly average winds. Wind speed observations at stations like Lamar are often made just prior to the reported hour of observation. In most cases, these recorded speeds are not hourly average speeds but represent a several-minute average. If these spot observations show that speeds are above the 30 mph threshold for successive hours, then it can be reasonably assumed that hourly average winds are also above 30 mph. Winds at Lamar were above the blowing dust thresholds for several hours on May 22, and gusts were as high as 58 mph.

High winds were the norm across eastern and southeastern Colorado on May 22, 2008. Figure 3 provides a snapshot of wind directions and gust speeds in eastern Colorado for 2 PM MST, with southerly winds in Lamar and gusts of 30 to 59 mph throughout the region. Tables 2 through 4 list wind and weather observations for Burlington, Colorado; Springfield, Colorado; and La Junta, Colorado, respectively, for the period with strongest winds. Each of these sites experienced wind speeds or gusts well above the blowing dust thresholds for at least several hours during the day. Many stations recorded winds of 31 to 46 mph with gusts of 40 to 66 mph for much of the afternoon and early evening. Burlington, for example, measured winds of 44 mph with a gust to 62 mph at 4:36 PM MST. Springfield recorded winds of 45 mph with a gust of 66 mph at 2:55 PM MST. Haze and/or greatly reduced visibilities (likely due to dust) were reported at both Burlington and Springfield during periods of high winds. Burlington CO (KITR) the first National Weather Service (NWS) station to the north of Lamar reported several hours of visibilities reduced to between .8 and 4 miles due to haze during the afternoon of May 22, 2008. A ceiling of 100 to 400 feet due to an obscuration was reported for three of these hours. Satellite pictures for this time period continue to show a dry slot over eastern Colorado during this time. The satellite images along with the very low relative humidity values reported in Tables 1 through 4 provide strong evidence that the obscuration was from blowing dust and not from clouds or precipitation.

Figure 4 shows that abnormally dry to moderate drought conditions prevailed in eastern and southeastern Colorado on May 6, 2008. Figure 5 shows that there was a significant soil moisture deficit in southeastern Colorado in April of 2008; and this deficit spread southward into Texas, southwestern Kansas, Oklahoma, and New Mexico.

This same storm system caused significant blowing dust in New Mexico and points south on May 21. A NOAA Operational Significant Event Imagery (OSEI) satellite product in Figure 6 shows blowing dust plumes in the southwestern U.S. and northern Mexico identified by NOAA scientists. Figures 7 and 8 provide additional satellite evidence for large-scale blowing dust in New Mexico on May 21. NOAA 24-hour HYSPLIT back trajectories for a several-hour period at Lamar on May 22 (the windiest period in southeast Colorado - each hour from 11 AM MST to 6 PM MST) in Figure 9 show that the air mass over Lamar on May 22 had its origins in New Mexico and Texas on May 21. Figures 10 and 11 show the relationships between these back trajectories and PM10 exceedances and blowing dust on the previous day. Twenty-four hour PM10 concentrations in southern New Mexico ranged from near 200 ug/m3 to just over 1000 ug/m3 on May 21. Back trajectories clearly suggest that some of the PM10 in the atmosphere over Lamar on May 22 may have been transported from the dust storm stricken areas of New Mexico on May 21.

While strong winds hit northeastern Colorado on May 22, including portions of the Front Range, Denver metro PM10 concentrations were only between 30 and 50 ug/m3. These winds were on the upslope side of the low pressure and may not have tapped into the blowing dust sources in New Mexico. In addition, Front Range concentrations during high wind events rarely approach those from Lamar. Land use, surface roughness, soil conditions, and vegetative cover are significantly different in these two regions of the state.

Figures 12 and 13 show the relationship between all 24-hour PM10 concentrations at the Lamar Power Plant and Municipal Building, respectively, and the daily maximum 2-minute wind gust for the period from January 1, 2004, though February 2009. Figure 14 shows the frequency of occurrence of days with 2-minute gusts at specific speeds. These figures clearly show that PM10 exceedance concentrations of 150 ug/m3 or greater have only occurred when wind gusts were in excess of 40 mph, and gusts above this speed occur on less than 5% of the days in the period. The linear regression lines show that PM10 concentrations across the range increase in a statistically significant manner with increasing wind gust speeds. This is a signature of a region under the influence of blowing dust, and it is not surprising for an area that was at the heart of the great Dust Bowl of the 1930s. In contrast, anthropogenic pollutants from combustions sources and secondary particulate processes tend to decrease in concentration with increasing wind speeds

K-means Cluster Analysis has been applied to Lamar Power and Municipal PM10 concentrations, Lamar 30-day total precipitation for each PM10 monitoring day, and Lamar daily maximum wind gust speeds for each monitoring day (see Table 5). 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 PM10 concentrations associated with strong winds, low soil moistures, and blowing dust by providing mean values for these 4 variables for 5 distinct categories of PM10 events. The period of record considered was from January 2004 through March 2009. The 30-day total precipitation values appear to be a better metric for blowing dust conditions than shorter-term totals.

Clusters 1, 3, and 4 represent normal conditions with low PM10 and low winds and/or high 30-day precipitation, and these clusters represent the majority of days. Cluster 2 represents an intermediate blowing dust scenario with moderate gusts, moderate PM10, low precipitation, and a count of 198 days. Cluster 5 represents the significant blowing dust cases with high PM10, the lowest 30-day precipitation, and the highest wind gusts (with 15 days in the cluster). Figures 14 and 15 show Lamar Power and Municipal PM10, respectively, versus 30-day precipitation by cluster. Exceedances have only occurred with 30-day precipitation totals of 0.6 inches or less. Finally Figure 16 shows that high daily maximum wind gusts of 40 mph represent less than 5% of the days in the record. Without wind-driven dust, the exceedance of May 22, 2008, would not have occurred; and this is clearly a case of an exceptional event associated with blowing dust (windstorm-caused emissions from soil sources over a large area of New Mexico and southeastern Colorado are not reasonably controllable or preventable.)

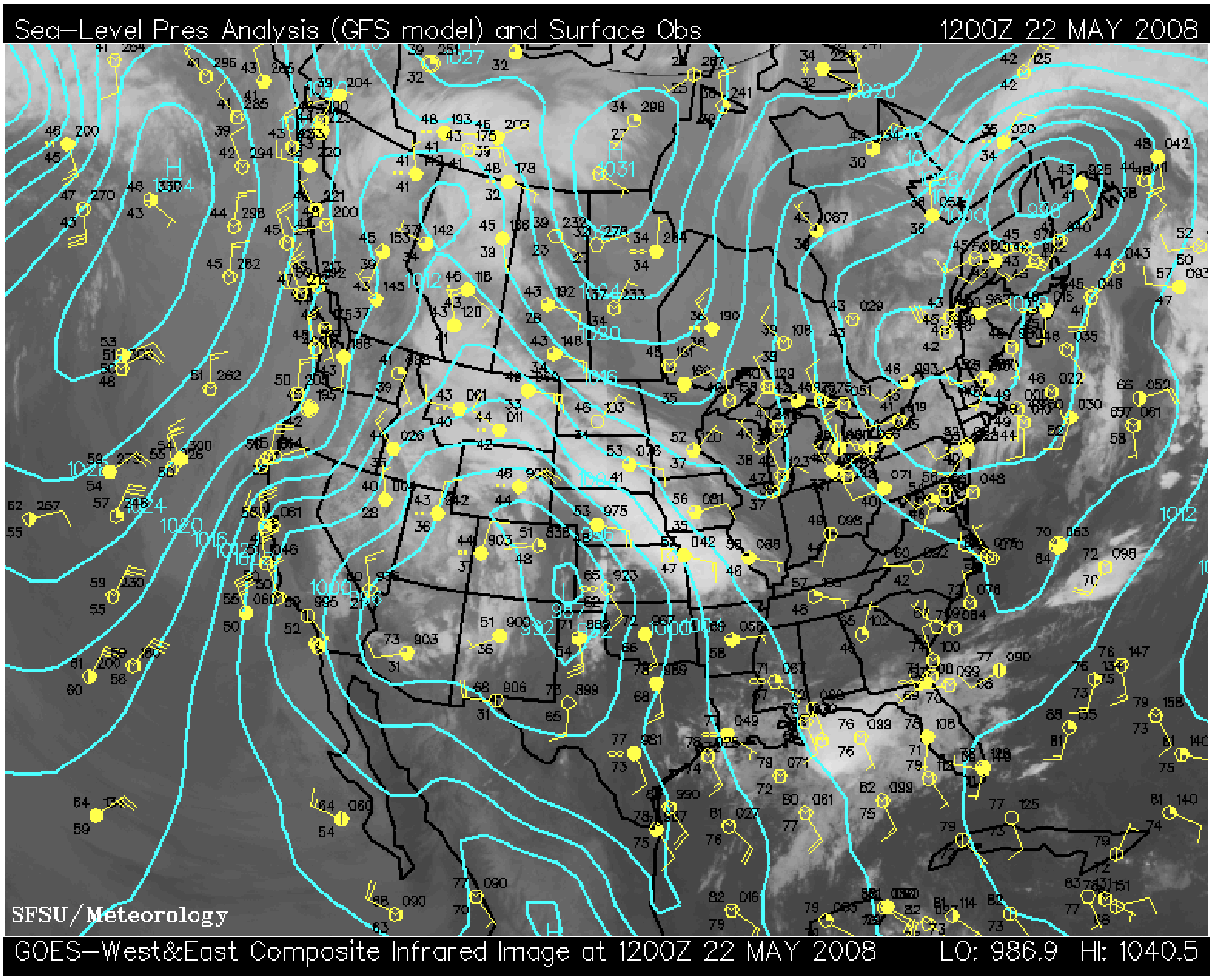


Figure 1. Infrared satellite image and surface weather analysis for 12Z May 22, 2008, or *5 AM MST May 22*, 2008 (from San Francisco State University: http://squall.sfsu.edu/crws/archive/sathts_arch.html).

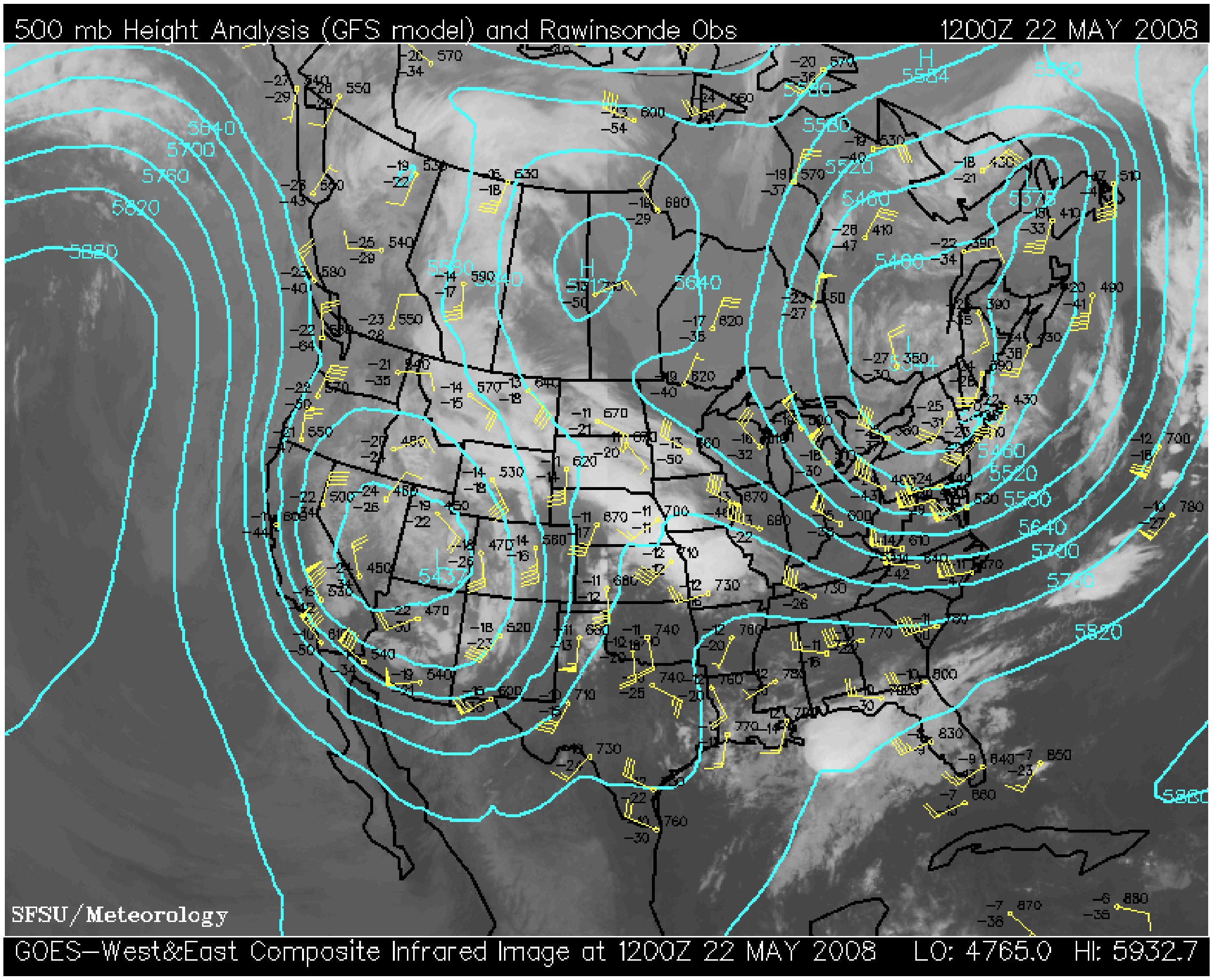


Figure 2. Infrared satellite image and 500 mb analysis (from the GFS model) for 12Z May 22, 2008, or *5 AM MST May 22*, 2008 (from San Francisco State University: http://squall.sfsu.edu/crws/archive/sathts_arch.html).

Table 1. Wind and weather observations for Lamar, Colorado

Reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 22, 2008. Speeds at or above the blowing dust thresholds have been highlighted in yellow.

Time in GMT (May 22-23)	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
3:53	60	26	8		220	clear	10
2:53	69	18	13		230	mostly clear	10
1:53	72	15	21	33	230	clear	10
0:53	76	11	35	43	220	clear	10
23:53	78	9	40	48	200	clear	10
19:53	86	9	46	58	200	clear	10
18:53	85	9	40	53	180		10
17:53	86	10	33	44	190	clear	10
16:53	84	14	25	33	180	clear	10
15:53	82	21	26	38	180	clear	10
14:53	78	31	25	32	180	clear	10
13:53	72	46	25	35	170	clear	10
12:53	67	47	7		230	clear	10

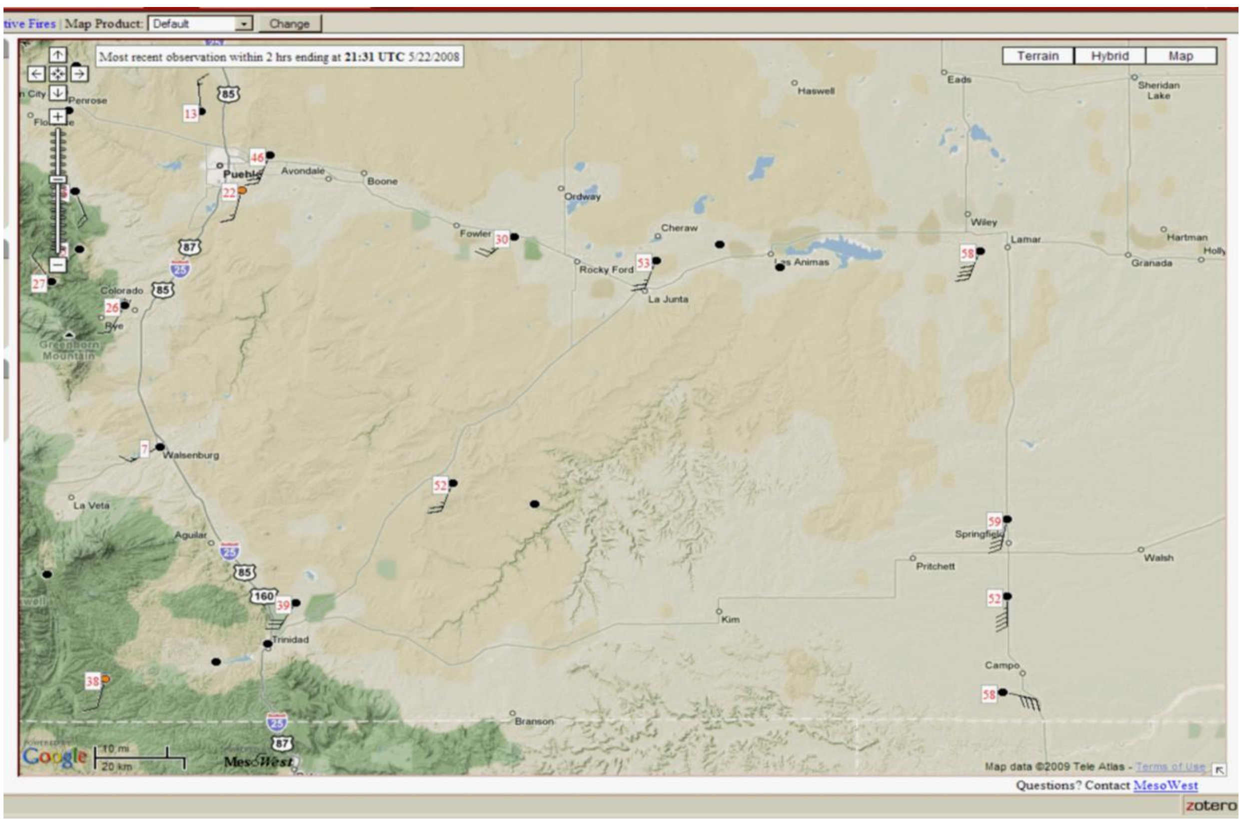


Figure 3. Wind directions and gust speeds in southeastern Colorado at 2:31 PM MST on May 22, 2008 (http://www.met.utah.edu/mesowest/).

Table 2. Wind and weather observations for Burlington, Colorado

Reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 22, 2008. Speeds at or above the blowing dust thresholds have been highlighted in yellow. Weather and visibility levels indicative of blowing dust have also been highlighted in yellow.

Time in GMT (May 22-23)	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
1:53	69	12	20	32	210	clear	10
1:09	73	9	33	48	200	haze	5
0:53	73	11	44	55	210	haze	2
0:34	75	10	33	48	200	haze	5
0:26	75	10	37	53	200	haze	2.5
23:56	77	11	40	49	200	haze	3
23:53	78	11	36	52	200	haze	1.25
23:36	79	12	44	62	200	haze	0.75
22:55	81	13	45	56	190	haze	1.5
22:42	81	13	37	53	200	haze	3
22:22	82	11	40	58	200	haze	1.5
22:07	82	10	40	60	190	haze	1
21:57	82	10	36	56	190	haze	1
21:53	84	10	41	56	200	haze	0.75
21:50	84	10	45	56	190	haze	0.75
21:23	84	10	38	52	180	haze	1.25
21:06	84	10	38	58	180	haze	0.75
20:53	84	11	43	60	180	haze	1
20:51	84	11	37	54	180	haze	1.25
20:40	84	11	44	58	190	haze	0.5
20:19	84	11	38	55	180	haze	1.5
20:11	84	11	39	54	180	haze	2.5
19:58	86	12	41	55	180	haze	1.75
19:53	84	12	38	49	170	haze	4
19:28	84	14	40	51	170	haze	3
18:53	73	55	32	40	110	mostly clear	10

Table 3. Wind and weather observations for Springfield, Colorado

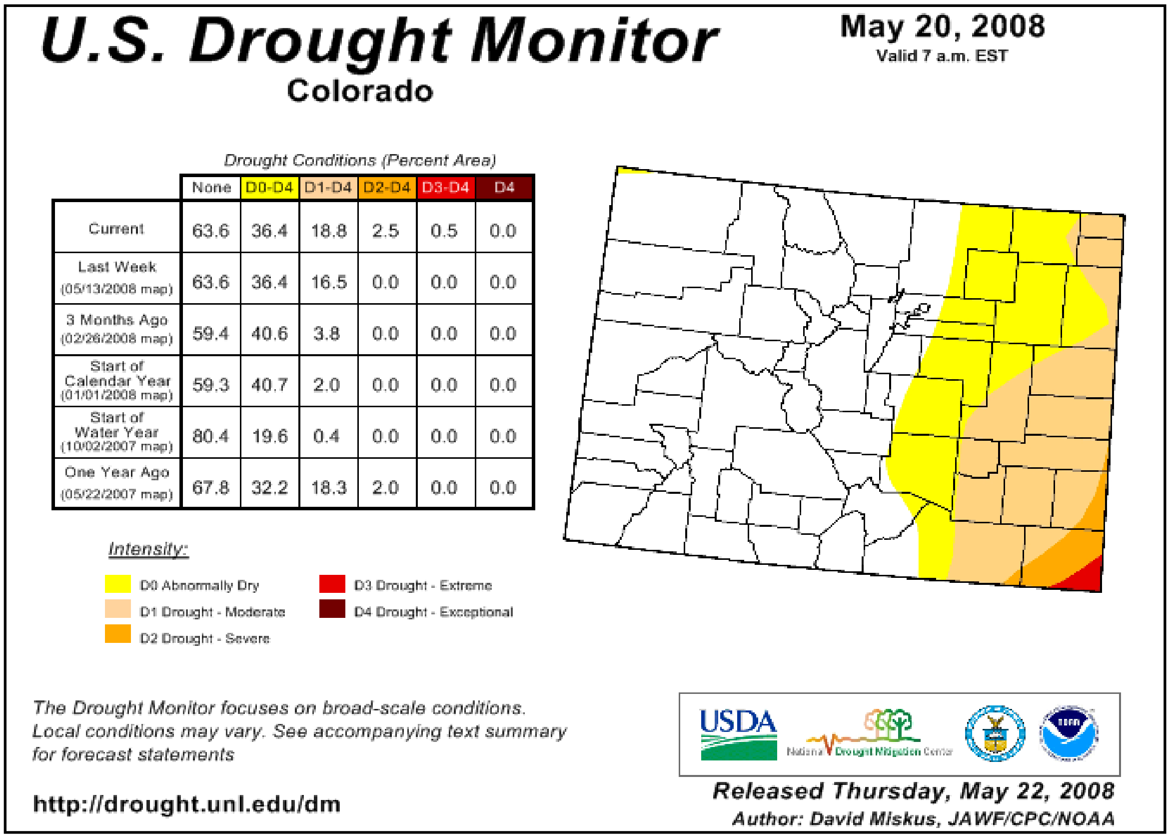
Reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 22, 2008. Speeds at or above the blowing dust thresholds have been highlighted in yellow. Visibility levels indicative of blowing dust have also been highlighted in yellow.

Time in GMT (May 22-23)	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
5:55	48	40	0				10
4:55	55	33	0				10
3:55	57	28	5		230		10
2:55	63	24	5		220		10
1:55	68	19	13	18	210		10
0:55	72	16	26	36	210		10
21:55	75	14	45	66	180		5
20:55	79	16	39	59	190		10
19:55	79	14	39	55	170		10
18:55	79	13	38	56	180		4
17:55	79	13	44	56	170		3.5
16:55	79	14	31	44	170		10
15:55	77	18	20	32	160		10
14:55	73	47	24	38	150		10
13:55	70	53	25	39	150		10
12:55	66	60	22	33	140		10
11:55	61	55	14	18	130		10
10:55	63	55	11	18	140		10
9:55	66	60	18	23	140		10
8:55	66	88	21	28	150		10
7:55	66	94	22	28	130		10
6:55	66	88	22	28	120		10

Table 4. Wind and weather observations for La Junta, Colorado

Reported by the University of Utah MesoWest site (http://www.met.utah.edu/mesowest/) for May 22, 2008. Speeds at or above the blowing dust thresholds have been highlighted in yellow.

Time in GMT (May 22-23)	Temperature Degrees F	Relative Humidity in %	Wind Speed in mph	Wind Gust in mph	Wind Direction in Degrees	Weather	Visibility in miles
5:53	53	44	10		290	clear	10
4:53	57	31	7		210	partly cloudy	10
3:53	59	31	7		200	clear	10
2:53	58	36	7		250	clear	10
1:53	64	27	13		260	clear	10
0:53	73	13	29	41	200	clear	10
23:53	75	14	30	39	200	clear	10
22:53	75	14	29	46	200	clear	10
21:53	76	12	33	47	200	clear	10
20:53	76	12	25	53	200	clear	10
19:53	80	13	32	45	180	clear	10
18:53	79	16	30	48	200	clear	10
17:53	81	12	30	44	170	clear	10
16:53	79	14				clear	10
15:53	75	21	12		240	clear	10
14:53	68	30	3		150	clear	10
13:53	63	40	7		220	clear	10
12:53	60	40	12		240	clear	10
11:53	57	44	12		230	clear	10
10:53	58	40	12		250	clear	10
9:53	59	36	8		210	clear	10
8:53	62	34	10		210	clear	10
7:53	66	26	10		210	clear	10



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	63.6	36.4	18.8	2.5	0.5	0.0
Last Week (05/13/2008 map)	63.6	36.4	16.5	0.0	0.0	0.0
3 Months Ago (02/26/2008 map)	59.4	40.6	3.8	0.0	0.0	0.0
Start of Calendar Year (01/01/2008 map)	59.3	40.7	2.0	0.0	0.0	0.0
Start of Water Year (10/02/2007 map)	80.4	19.6	0.4	0.0	0.0	0.0
One Year Ago (05/22/2007 map)	67.8	32.2	18.3	2.0	0.0	0.0

Figure 4. Drought status for the Colorado on May 20, 2008 (source: the USDA, NOAA, and the National Drought Mitigation Center at: http://drought.unl.edu/dm/archive.html).

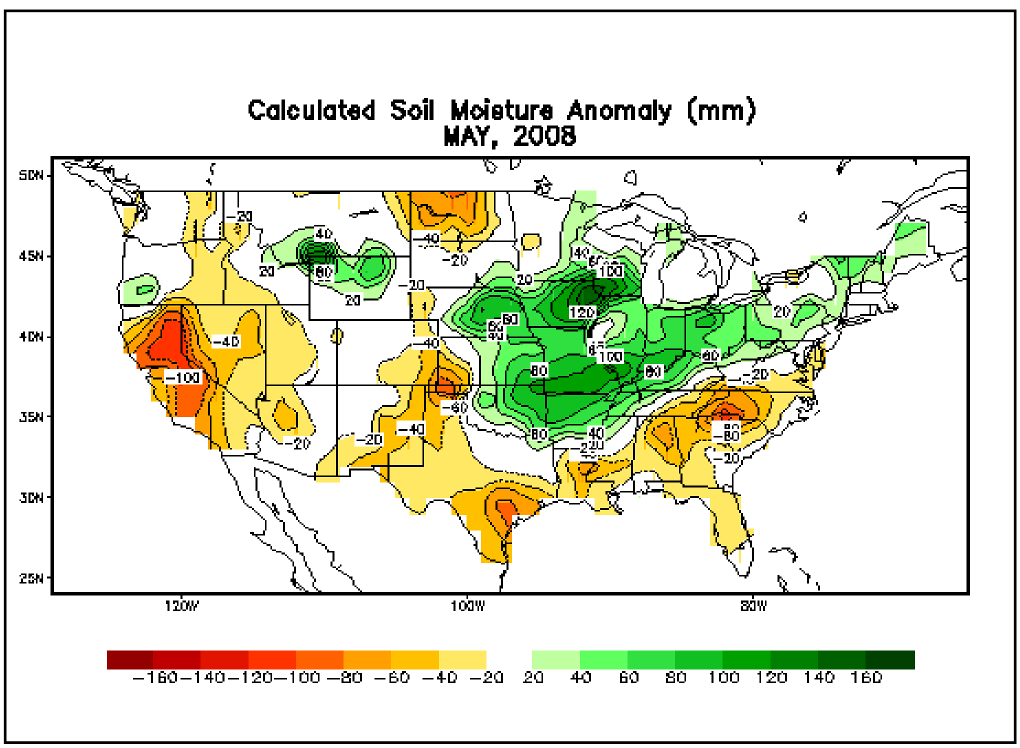


Figure 5. Calculated Soil Moisture Anomaly (mm) May, 2008 (http://www.ncdc.noaa.gov/img/climate/research/2008/may/cpc-soil-moist-anom-200806.gif).

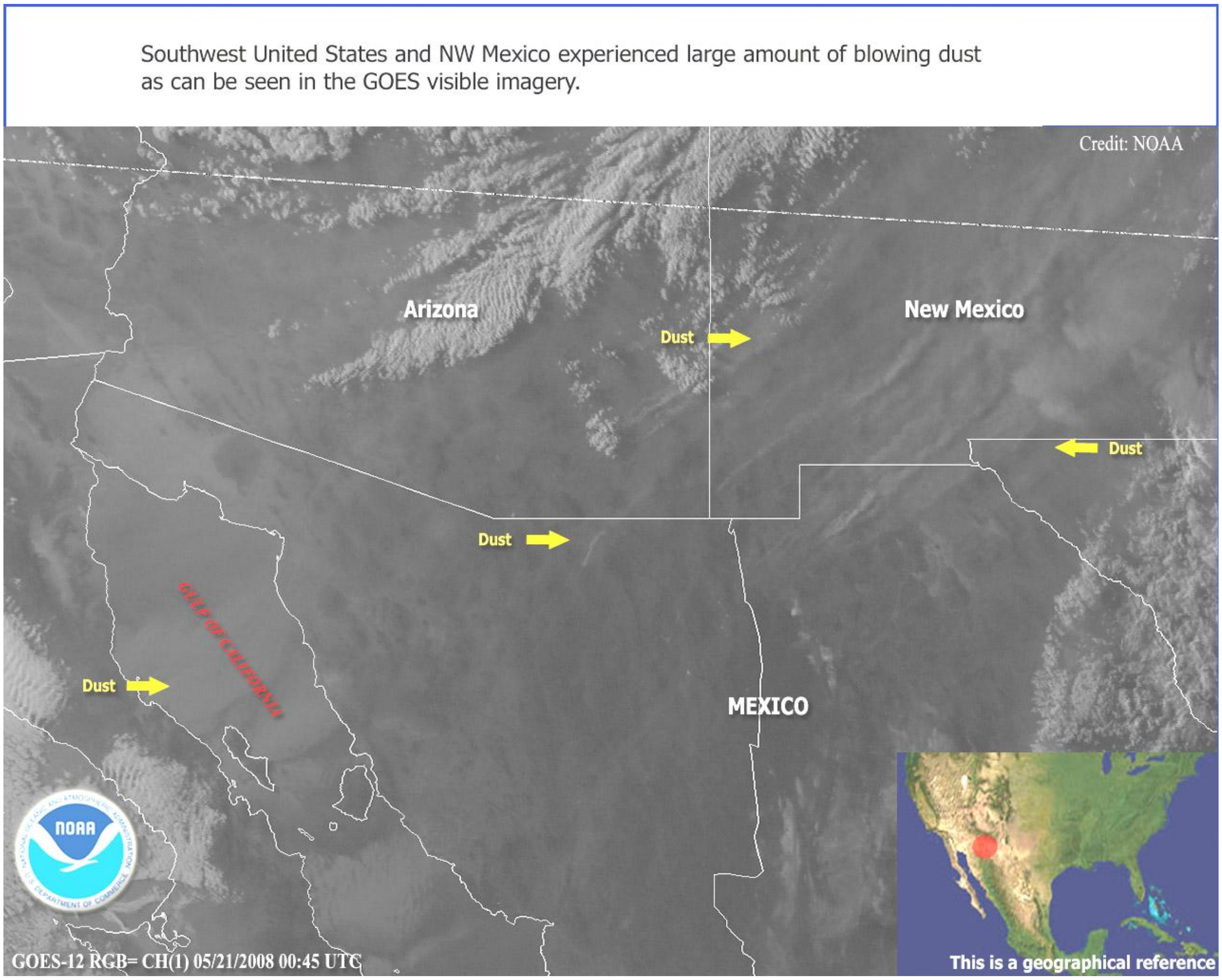


Figure 6. Plumes of blowing dust are visible across southern Arizona, New Mexico, northern New Mexico, and the Gulf of California in this NASA MODIS satellite image. (source: http://www.osei.noaa.gov/Events/Dust/US_Southwest/2008/DSTusmx142_G12.jpg)

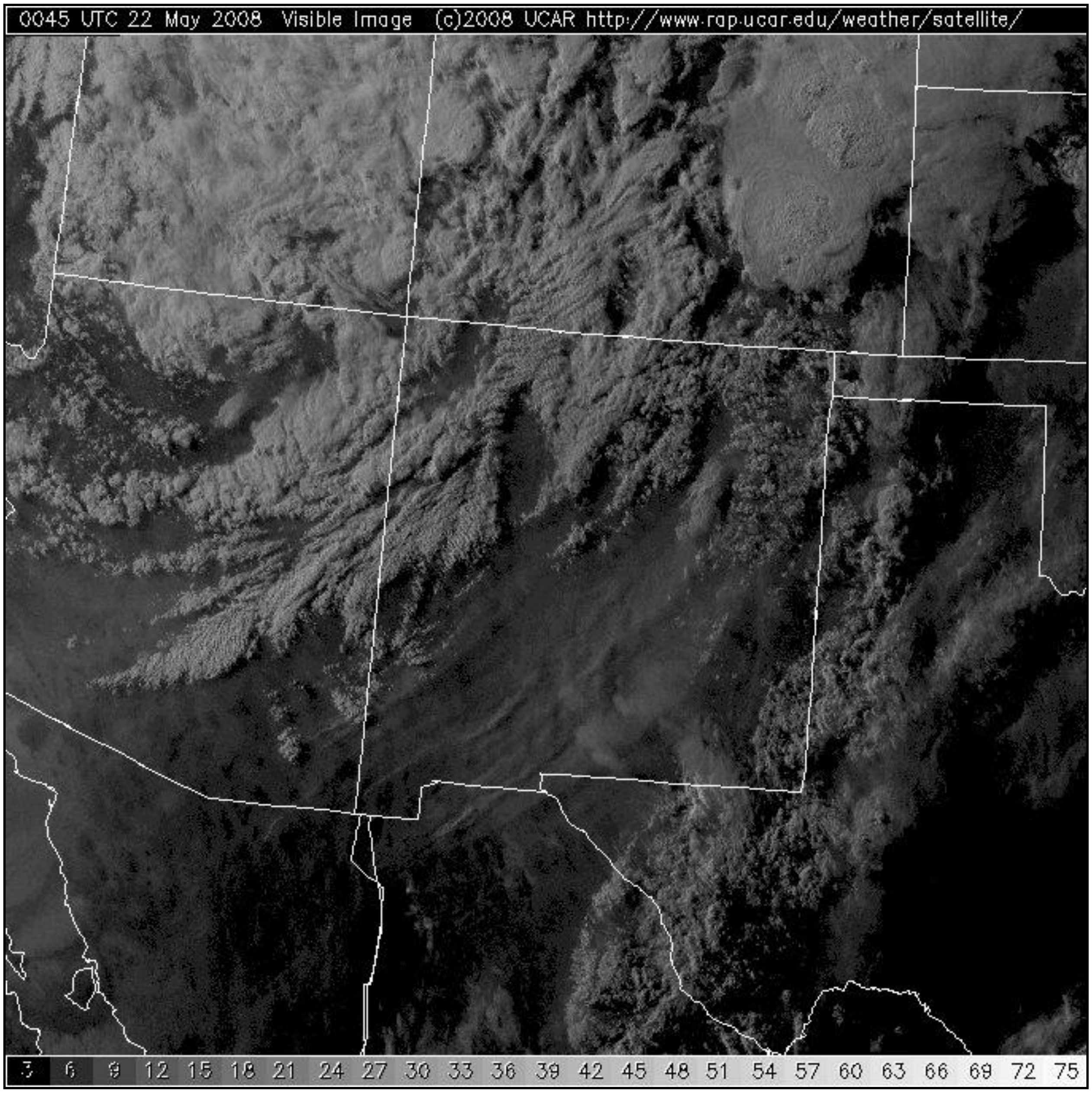


Figure 7. Visible satellite image of the southwestern U.S. for 6:45 PM MDT on May 21, 2008, showing pronounced southwest to northeast trending plumes of blowing dust in New Mexico.

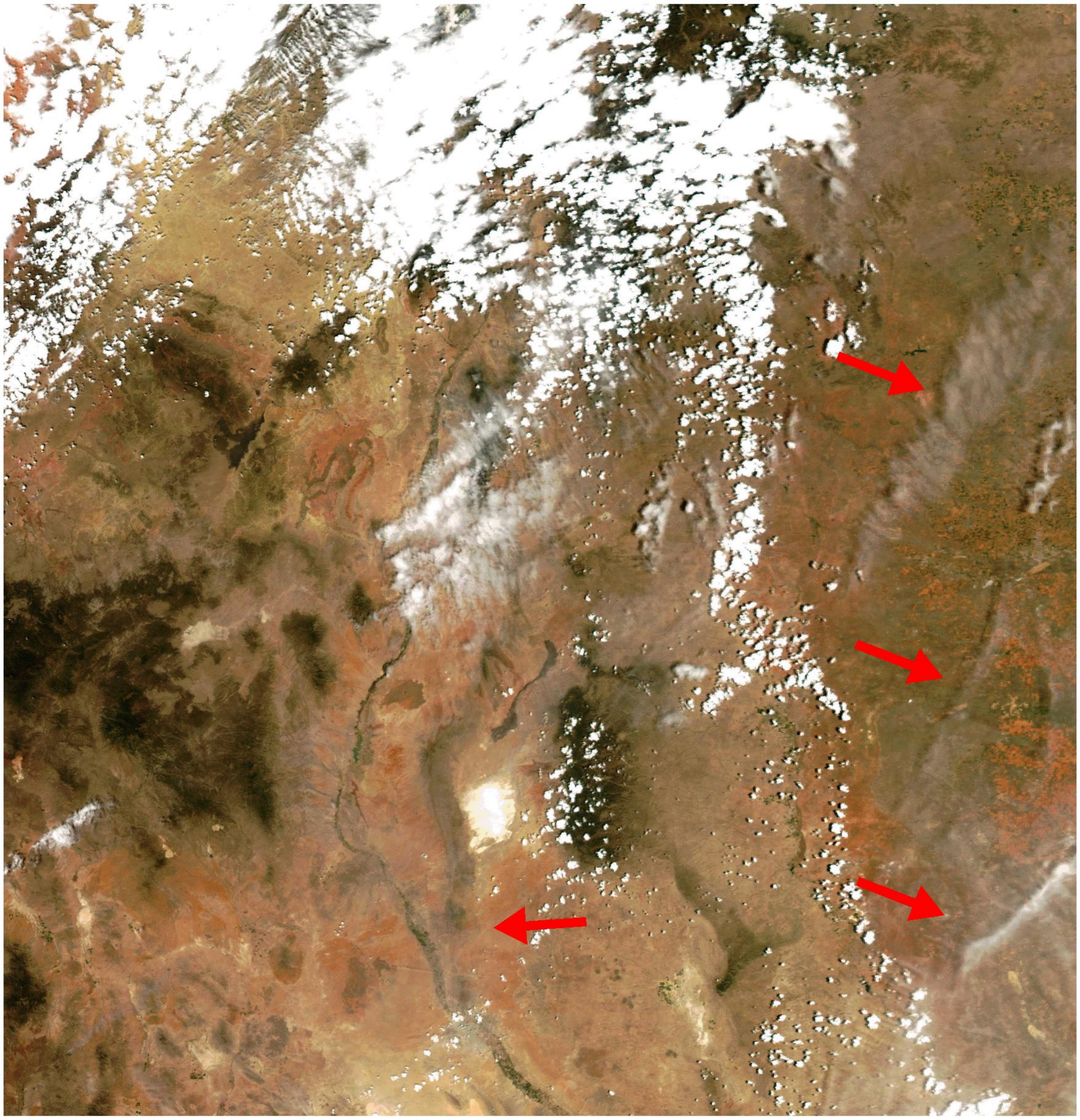


Figure 8. Visible satellite image of New Mexico at 1:40 PM MST. Plumes and areas of blowing dust are marked with an arrow (http://activefiremaps.fs.fed.us/imagery.php?op=fire&passID=51054&month=5&year=2008).

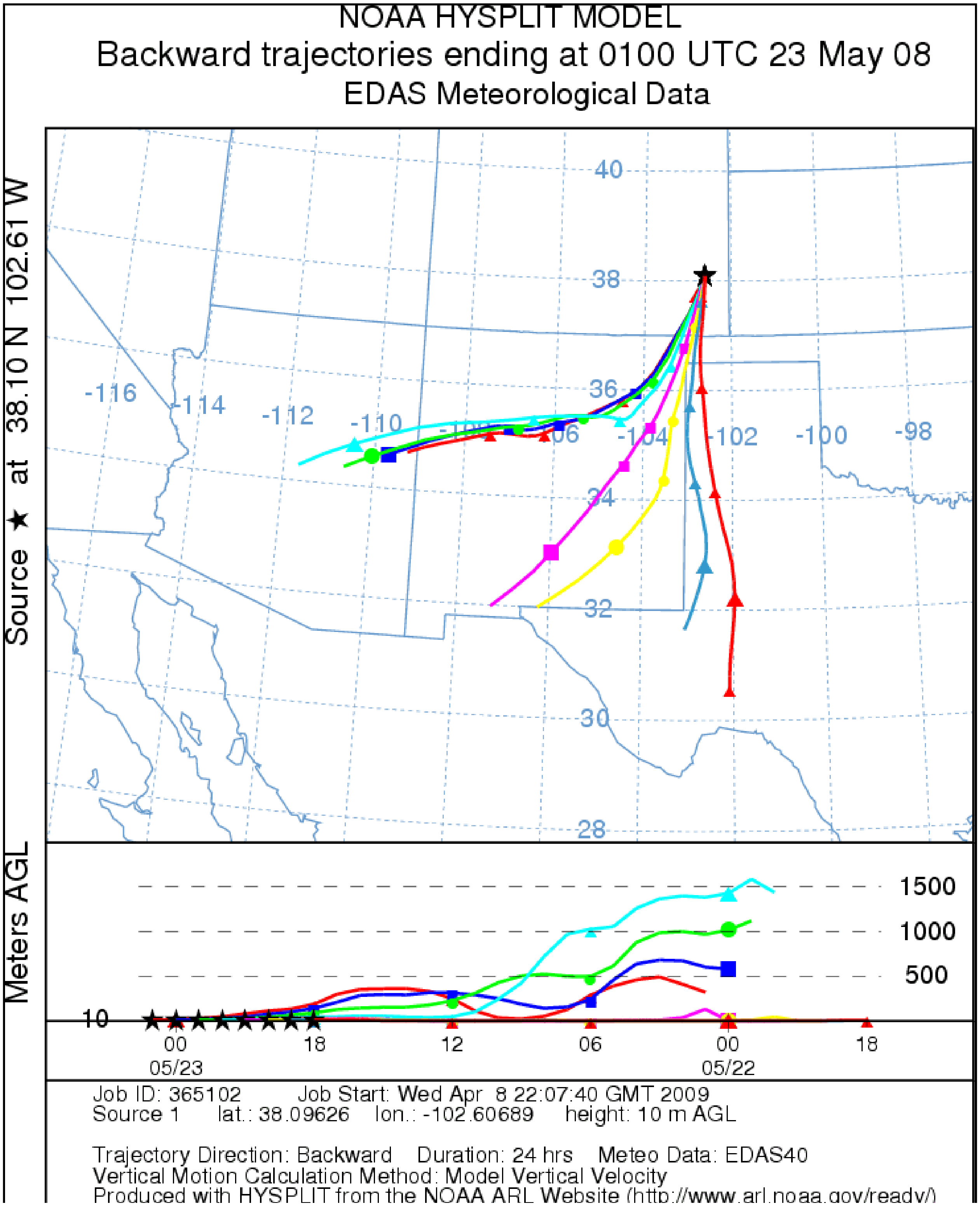


Figure 9. NOAA HYSPLIT 24-hour back trajectories for Lamar Colorado for each hour from 11 AM MST to 6 PM MST on May 22, 2008.

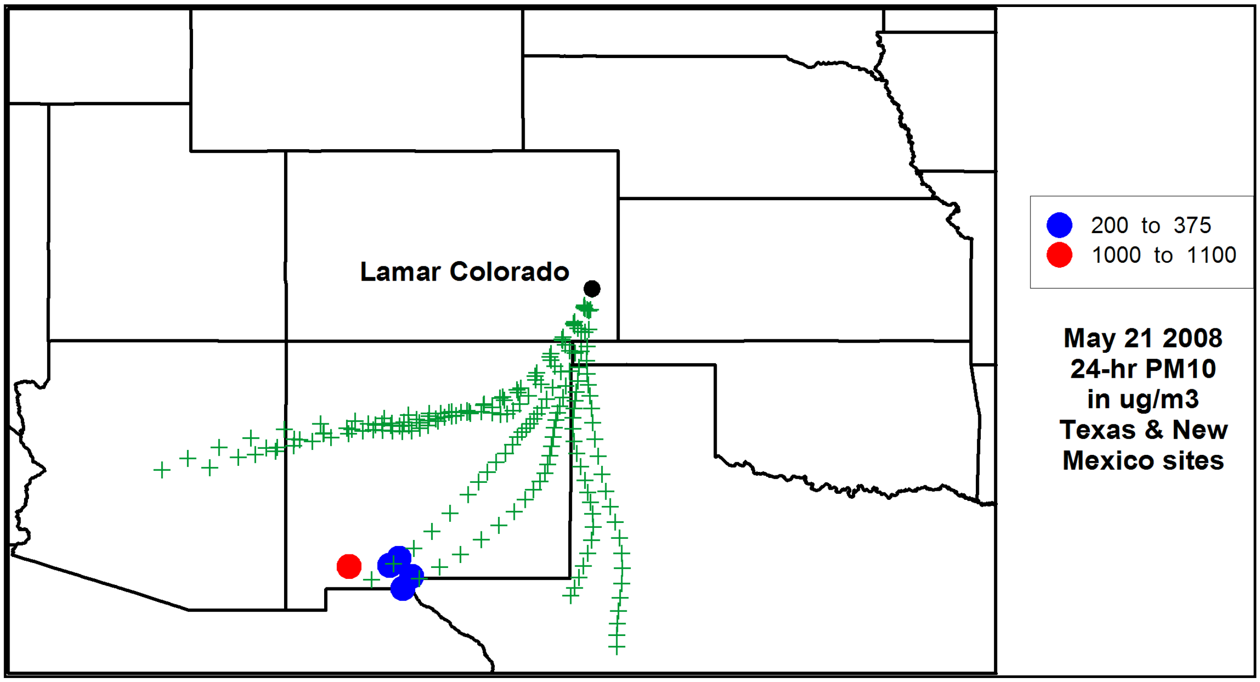


Figure 10. NOAA HYSPLIT 24-hour back trajectories for Lamar Colorado from Figure 9 and May 21 PM10 exceedance concentrations in southern New Mexico and Texas.

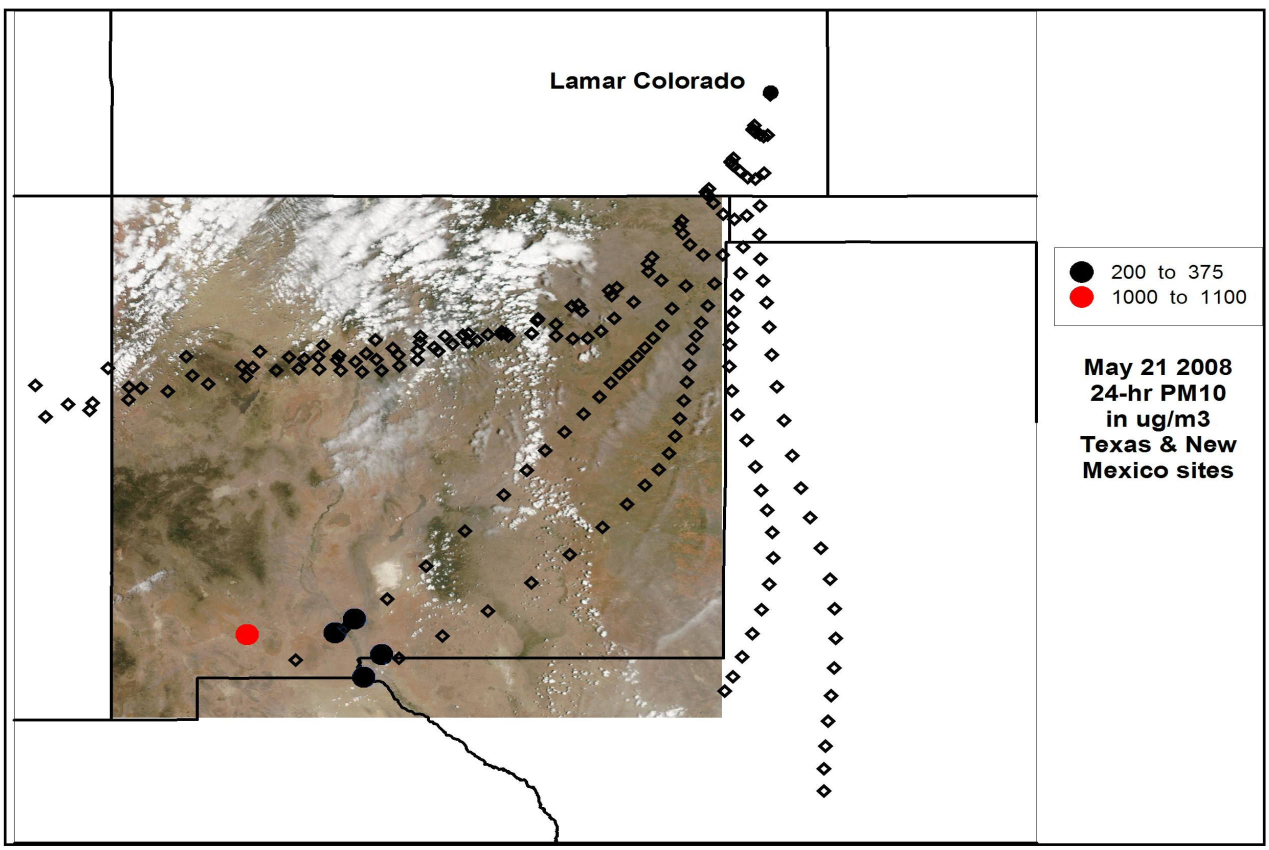


Figure 11. NOAA HYSPLIT 24-hour back trajectories for Lamar Colorado from Figure 9, May 21 PM10 exceedance concentrations in southern New Mexico and Texas, and May 21 visible satellite image from Figure 8.

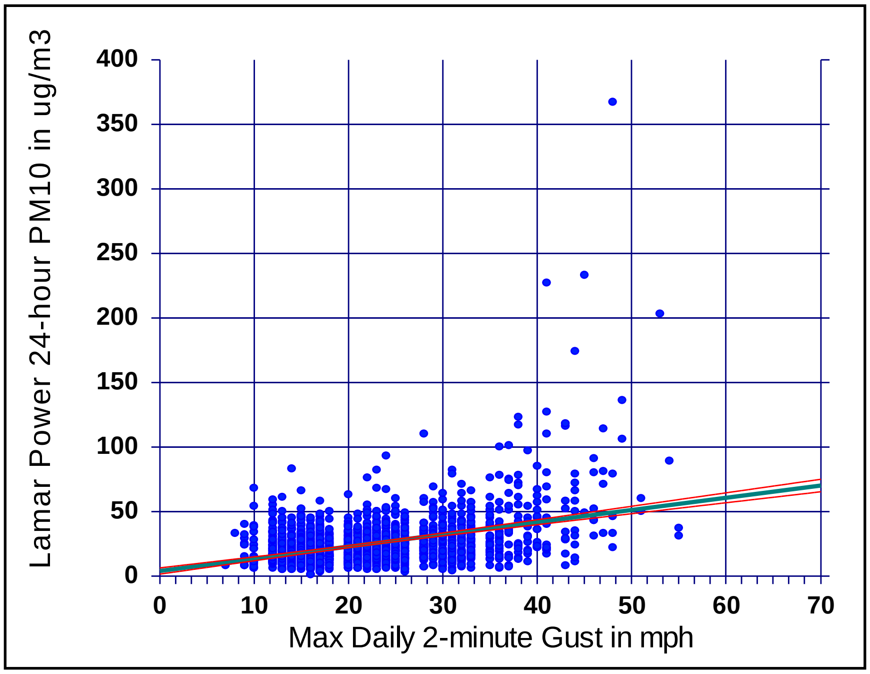


Figure 12. Lamar Power Plant 24-hour PM10 concentrations in ug/m3 versus Lamar daily maximum 2-minute wind speed in mph for January 2004 through February 2009 – with linear regression and regression confidence interval.

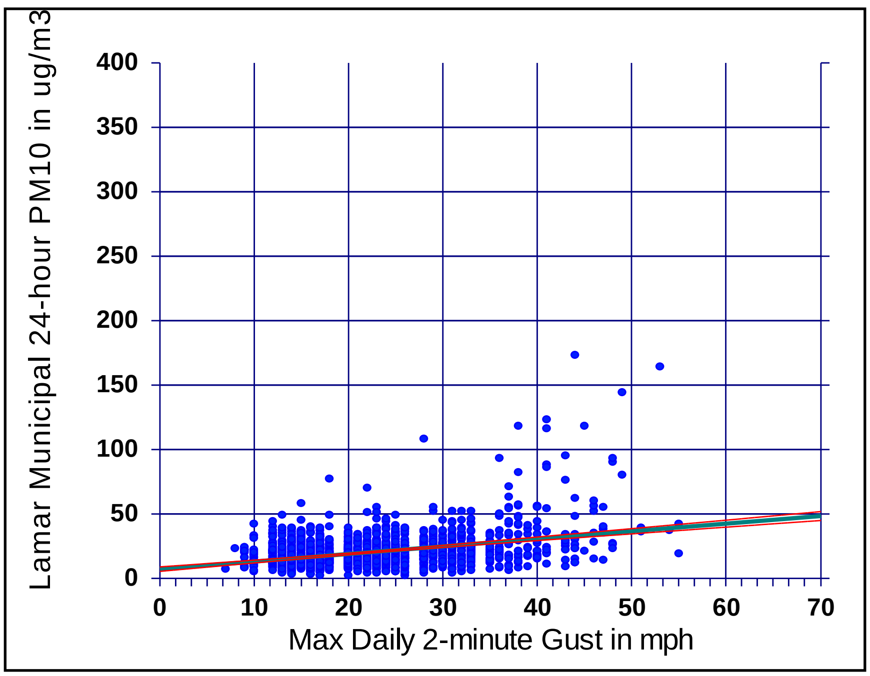


Figure 13. Lamar Municipal Building 24-hour PM10 concentrations in ug/m3 versus Lamar daily maximum 2-minute wind speed in mph for January 2004 through February 2009 – with linear regression and regression confidence interval.

Table 5. K-means cluster analysis means for Lamar PM10 and meteorological variables.

Cluster Variables	Cluster 1 Means	Cluster 2 Means	Cluster 3 Means	Cluster 4 Means	Cluster 5 Means
Lamar Power 24-hour PM10 in ug/m3	22.7	52.3	22.5	19.2	154.9
Lamar Municipal 24-hour PM10 in ug/m3	18.0	38.3	20.6	16.0	111.9
Lamar Wind Gust in mph	35.6	36.8	27.6	19.6	52.6
Lamar 30-day Precipitation	0.8	0.8	3.7	0.6	0.4
Count	535	198	298	798	15

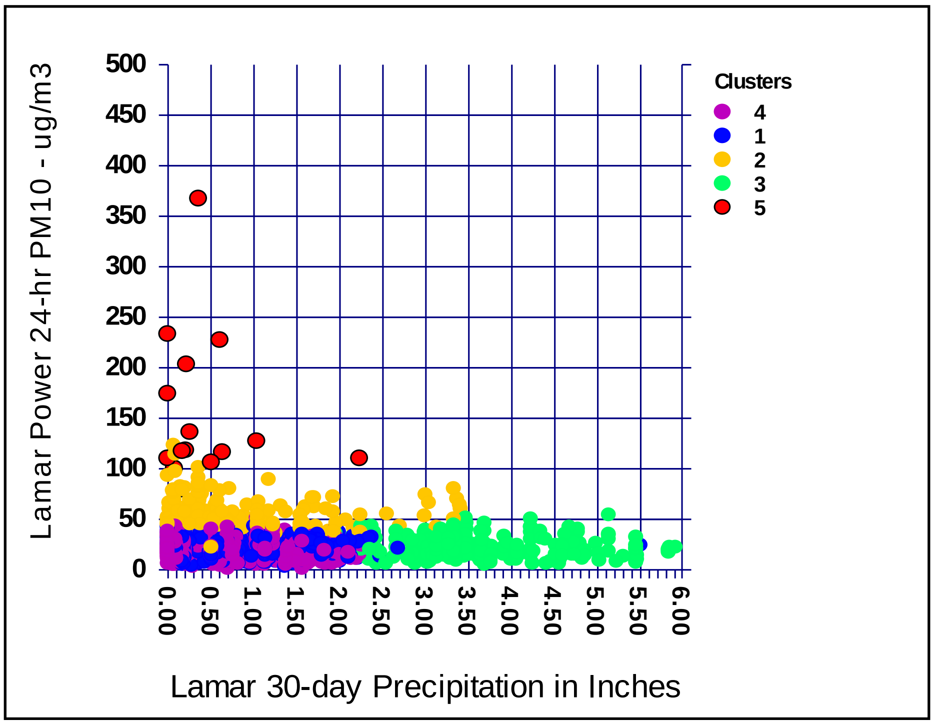


Figure 14. Lamar Power Plant 24-hour PM10 concentrations in ug/m3 versus Lamar 30-day total precipitation by cluster for 2004 through early 2009. Cluster 5 is the blowing dust cluster.

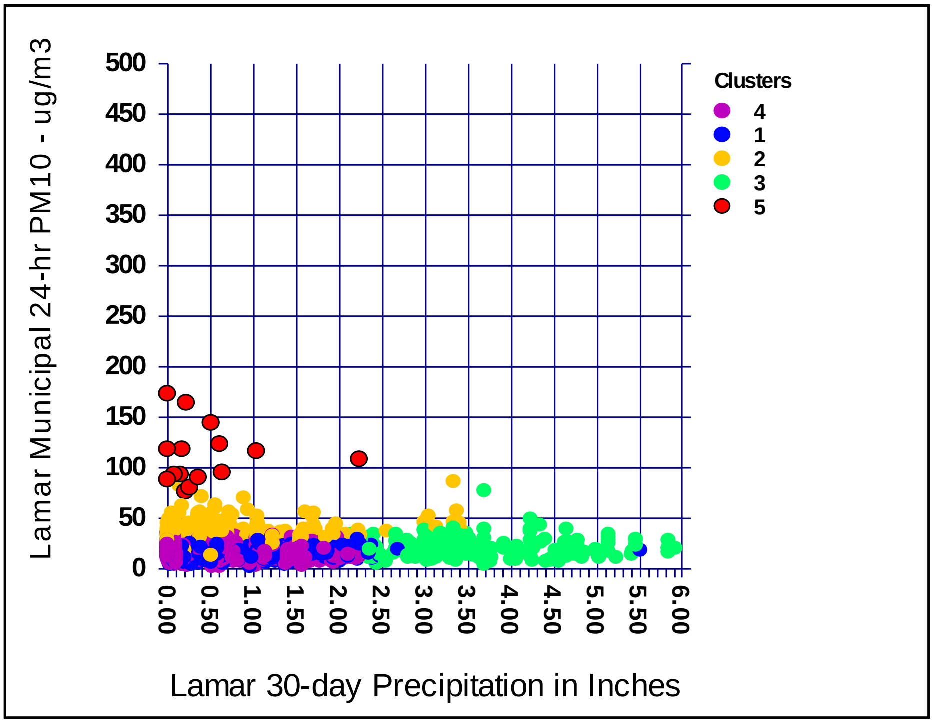


Figure 15. Lamar Municipal 24-hour PM10 concentrations in ug/m3 versus Lamar 30-day total precipitation by cluster for 2004 through early 2009. Cluster 5 is the blowing dust cluster.

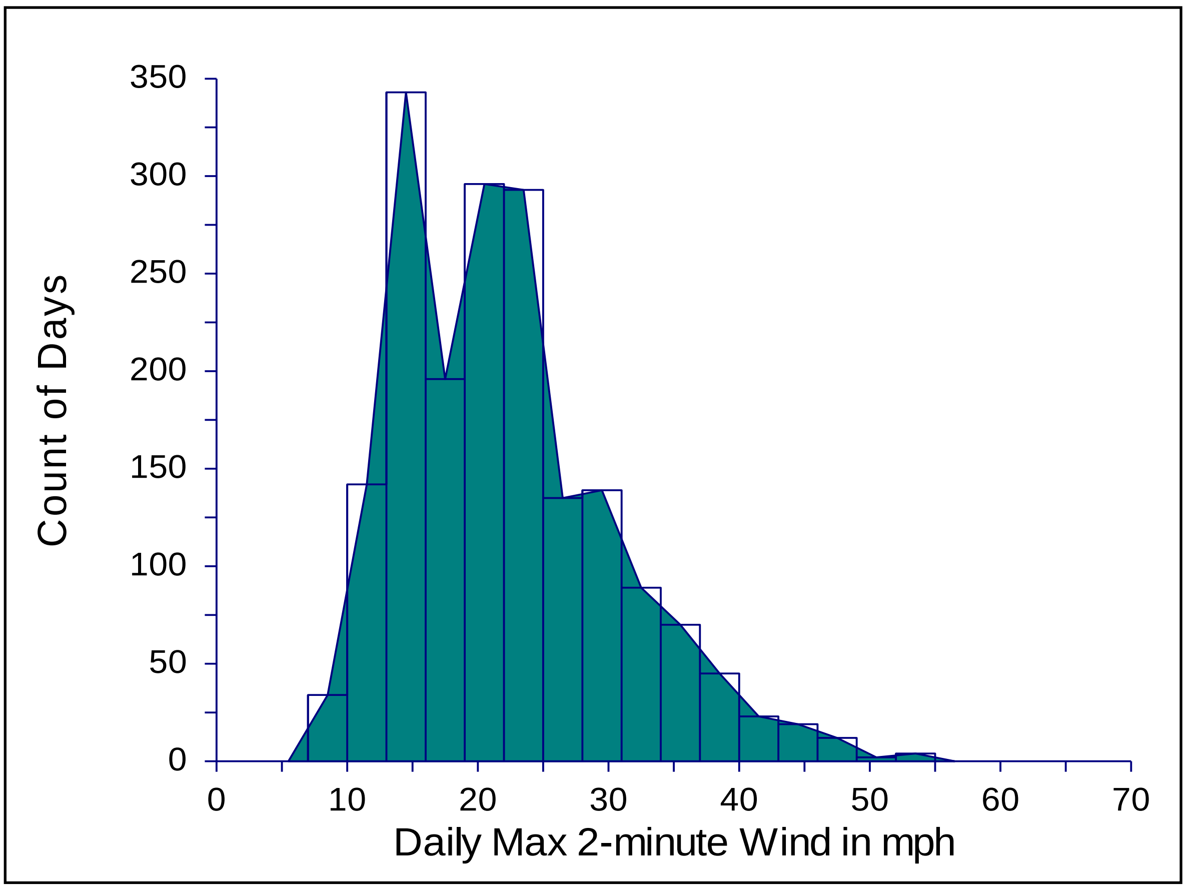


Figure 16. Histogram of the Lamar Airport daily maximum 2-minute wind speed in mph for January 2004 through February 2009 – gusts over 40 mph occur on fewer than 5% of the days in this period.

3.0 News Accounts

FEMA

National Situation Update: Thursday, May 22, 2008

Homeland Security Threat Level: YELLOW (ELEVATED).

Significant National Weather

Midwest
The threat of severe storms, with a chance of dangerous tornadoes, is forecast for central and western Nebraska and Kansas today. Heavy showers are possible today in parts of Missouri. Gusty winds are forecast across the Plains through this evening. A Red Flag Warning is in effect for Kansas until 11:00 pm EDT as a result of gusty winds and low humidity.

South
Scattered showers and thunderstorms are forecast for eastern Oklahoma, eastern Texas, western Tennessee, southern Georgia and Florida today. Severe storms may develop over western Oklahoma this evening, bringing the possibility of tornadoes. Heavy to excessive rainfall is forecast late tonight along the central Gulf Coast and will shift eastward tomorrow night. A Red Flag Warning is in effect for Oklahoma and Texas until 11:00 pm EDT as a result of gusty winds and low humidity.

West
The east slopes of mountain ranges in Montana and Wyoming can get heavy rainfall which could increase the flooding threat from rivers already running full with snow-melt runoff. In Utah, heavy snow is forecast for the higher elevations of the Wasatch and Uinta Mountains. A Red Flag Warning is in effect for Colorado and southern New Mexico until 11:00 pm EDT as a result of gusty winds and low humidity.

Northeast
Showers are forecast for much of the Northeast today. Showers will keep the temperatures across the region, below normal from the 40s southwest New York northwest Pennsylvania to the 70s in most of Virginia and south western West Virginia. (NWS, Media Sources)

NOAA Model Projects Fewer, But More Intense Atlantic Hurricanes Late This Century

Greenhouse Gases Have Little Impact in Tropical Storm and Hurricane Numbers

A new model simulation of Atlantic hurricane activity for the last two decades of this century projects fewer hurricanes overall, but a slight increase in intensity for hurricanes that do occur. Hurricanes are also projected to have more intense rainfall, on average, in the future. The findings are reported in a study by scientists at NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, N.J. "This study adds more support to the consensus finding of the Intergovernmental Panel on

4.0 Laboratory And Field Data

INTER-MOUNTAIN LABS

IML Air Science
555 Absaraka
Sheridan WY 82801
(307) 674-7506
www.imlairscience.com

Particulate Sampler Field Envelope

Network: LAMAR POWER PLANT

Sampler ID: Pm10 (#4) 5025

Filter Number: 619829

Sample Date: May 22, 2008

Time Off: 60918

Time On: 59478

Run Time: 1440

Tech: Ronald C Manning

PSTG

ΔP on	ΔP off
3.10	3.10

Comments:

Very Windy

INTER-MOUNTAIN LABS

IML Air Science
555 Absaraka
Sheridan WY 82801
(307) 674-7506
www.imlairscience.com

Particulate Sampler Field Envelope

LAMAR MUNICIPAL COMPLEX

Network ____________ Sampler ID PM10-3-4060

Filter Number 619469

Sample Date 5-22-08

Time Off 71715

Time On 70283

Run Time 1432

Tech. ____________

PSTG

ΔP on	ΔP off
3.10	3.00

Comments:

5.0 Reference

Colorado Department of Public Health and Environment, City of Lamar, Prowers County Commissioners, *Natural Events Action Plan for High Wind Events – Lamar, Colorado*, April 1998.