Identifying Dust Storms as Natural Events for Regional Haze and Particulate Matter in West Texas

Executive Summary

•EPA is requiring states to reduce regional haze to natural background (NB) conditions by 2064. There is no agreed upon way to estimate NB.

•In west Texas dust storms are natural events which cannot be controlled.

•TCEQ proposes an explicit set of criteria that identify dust storms using air quality, meteorological, and satellite data.

•Dust storm events identified in the 2000 to 2004 baseline period.

•50 dust storm events at Guadalupe Mountains –Dust Storms are the majority of the NB.

•The TCEQ estimate for Guadalupe Mountains NB, is in the range of 10.6 to 14 deciviews (dv). this is much greater than EPA's default estimate of seven dv. This affects the glide slope for controlling anthropogenic sources.

•24 dust storm events at Big Bend are insufficient to calculate NB. International transport of anthropogenic pollutants appears to be equal to or greater than that of the dust storms.

Documentation of a typical intense dust storm post from the TCEQ website;

http://www.tceq.state.tx.us/compliance/monitoring/air/monops/sigevents03.html

"West Texas Dust Storm April 15, 2003

Images

Satellite Animation	C12 PM10 and PM2.5
True-Color Satellite	C12 Wind
True-Color Satellite Comparison 4/15/2003 vs 4/16/2003	C12 Temperature and Humidity
Web Cam Animation from Chelsea Street	C12 PM10 and Wind Gusts
Web Cam Animation from the McDonald Observatory	C37 PM10 and Wind Gusts
Surface Weather Analysis 1:00 p.m. MDT	C12/C37 PM10
West Texas PM2.5	C12/C40 PM2.5
C37 PM10 and Visibility	C40 PM2.5 and Wind Gusts

Description

The worst dust storm since April of 2001 swept across West Texas on Tuesday, April 15, 2003. High winds associated with a strong low pressure system centered in Colorado kicked up large plumes of dust from parts of northern Mexico, southern New Mexico, and West Texas.

The University of Texas at El Paso (UTEP) Continuous Air Monitoring Station (CAMS) 12 recorded a peak one-hour PM10 average of 4,724 micrograms per cubic meter ($\mu g/m^3$) for the hour from 1:00 to 2:00 p.m. Mountain Daylight Time (MDT) and had a 24-hour average of 718 $\mu g/m^3$. The Ascarate Park CAMS 37 had a peak one-hour PM10 average of 4,710 $\mu g/m^3$ for the hour from 1:00 to 2:00 p.m. MDT and a 24-hour average of 715$\mu g/m^3$. The daily average PM10 at both sites rated as Hazardous on the U.S. Environmental Protection Agency (EPA) Air Quality Index (AQI) scale.

The satellite animation shows dust originating in northern Mexico blowing across much of West Texas and parts of southern New Mexico. The largest dust plume originates on the north side of a large dry lake bed about 50 miles west-southwest of El Paso as shown in the true-color satellite image (courtesy of the National Aeronautic and Space Administration).
The El Paso Airport reported visibility as low as to 1/8 mile with blowing dust at 1:03 p.m. MDT and a peak wind gust of 66 miles per hour (mph) at 1:09 p.m. MDT. The Guadalupe Pass automatic weather station reported a minimum visibility of 1/2 mile at 3:29 p.m. MDT and a peak wind gust of 98 mph at 1:54 p.m. MDT.

The highest peak wind gust measured in the El Paso air monitoring network was 68 mph at Lower Valley CAMS 36 at 1:35 p.m. MDT. Two additional sites measured wind gusts above 60 mph. McDonald Observatory CAMS 317 to the east of El Paso measured a maximum wind gust of 61 mph at 6:05 p.m. Central Daylight Time (CDT). Ascarate Park CAMS 37 reported visibilities less than 5 miles from 10:10 a.m. to 4:35 p.m. MDT with a minimum visibility of 0.4 mile at 12:40 p.m. and 1:05 p.m. MDT."

Data Used to Document Dust Storms. All Data Are Public!

1) Air Quality Data Collected by Texas and Local Programs

2) Air Quality Data Collected by the Federal Government

3) A federal project called the Interagency Monitoring of Protected Visual Environments (IMPROVE) collects haze data

4) Data Collected by the National Weather Service (NWS)

5) Satellite Data

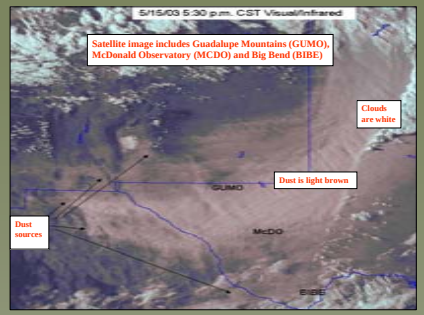
6) Photographic Visibility Data - TCEQ and the National Park Service (NPS)

Set Scientific Criteria for Documenting Dust Storms

1) Nine criteria chosen based on analysis of available data.

2) Dust storm is documented if at least three of the criteria are met.

3) Criteria are the same as in El Paso Particulate Matter Natural Events Action Plan.



Documentation of Dust Storm Natural Events Using IMPROVE Speciated Data:

IMPROVE samples and analyses PM2.5 every third day at both Big Bend and Guadalupe Mountains National Parks. Using the new "IMPROVE equation" IMPROVE computes total aerosol light extinction adding the of individual PM light extinction components from seven measured species. These are:

- •Mass of ammonium sulfate;
- •Mass of ammonium nitrate;
- •Mass of organic carbon;
- •Mass of elemental carbon;
- •Mass of sea salt;
- •Mass of fine soil estimated by using the major crustal elements; and
- •Coarse mass.

Table 1 shows the results for analysis of all sampling days between 2000 and 2004 at the two Texas' parks. Only part of the table is shown to conserve space. It includes:

- •Site and date of the measurements;
- •Total light extinction by particles for the 24 hour sampling period (b PM);
- •The deciview for the 24 hour sampling period (dv);
- •An x indicating that the dv was in the worst 20 percent of all days (top 20 percent);
- •The maximum one hour extinction (Max ext) measured by an on site optical instrument;
- •The maximum one hour relative humidity during the event (Max RH);
- •The fraction of the b PM attributed by coarse mass and fine soil (crustal fraction)
- •Brief comments describing whether the event was initially identified as a dust storm day by an observer and the nature of the peak in bPM at that site. The transmissometer is identified as trans and the nephelometer is identified by neph; &
- •Which of the nine dust storm criteria were met in this specific day.(Criteria met)

Figures 5 to 7 show a progression of images from the McDonald Observatory camera documenting dust storm Criteria 8 being met on April 15, 2003.

Figure 5: Mc Donald Observatory On a Clear Day

The visibility is less than 8 dv since the farthest peak is about 160 km from the camera.

Figure 6: View from McDonald Observatory at the Start of the Dust Storm on April 15, 2003

The twin peaks in the upper section of the image are the farthest objects visible.
Visibility is about 25 dv since more distant targets have been obscured.

Figure 7: View from McDonald Observatory at the Worst of the Dust Storm on April 15, 2003
Most of the image is obscured by the dust storm. The density of the haze in this image is uniform. The deciview value is about 50 dv or greater. Most PM and optical instruments do not accurately measure these high concentrations.

Dust Storm Criteria

1) Can be identified by the meteorological evaluation (uniform haze, high wind speeds at the source of the dust, dry conditions in the source areas prior to the dust storm, radar images, back trajectory analysis, etc.);

2) Continuous PM and visibility instruments show a rapid rise in concentrations associated with a change in the weather (convective modification of the boundary layer, thunderstorm outflows, passage of cold fronts, etc.). Only dry events with the relative humidity below 50 percent are considered to be dust storms. The thresholds for one hour are: $PM_{2.5}$ >40 $\mu g/m^3$; PM_{10} > 150 $\mu g/m^3$; b_{scat} >60 m^{-6}, visual range<10 km (6 miles);

3) When the 24 hour average PM light extinction exceeds 33 inverse mega meters (15 deciviews). In addition the crustal material (fine soil and coarse PM) must make up at least 50 percent of the 24 hour particulate light extinction estimated from ambient measurements using the IMPROVE data and the new IMPROVE Equation;

4) When the 24 hour average $PM_{2.5}$ mass is greater than 20$\mu g/m^3$ and more than 50 percent of its mass is crustal based on the chemical speciation data;

5) When the 24 hour average PM_{10} greater than 150 $\mu g/m^3$ and more than 50 percent of its mass is crustal;

6) If the sampling instrument(s) fails due to filter clogging or reads full scale, and other observations strongly suggest that a dust storm has occurred;

7) Satellite information indicates dust events with spatial scales greater than 10 km;

8) Photographic information shows a large scale uniformity of the haze associated with the change in the weather event; and

9) Airport or other observers report "dust storms", "blown dust", "haze" or visibility reduced below 10 km at sites greater than 10 km from the monitoring site under consideration:

Calculation of Natural Background

•Assume the all of the light extinction on dust storm days is due to the dust storm. This estimates the upper bound of the natural background.

•Assume that only the crustal portion of the light extinction on dust storm days. This estimates the lower bound of the natural background

•Assume that dust storm activity will be similar throughout the period from 2000 to 2064.

•Assume in 2064 all of the worst days will be dust storm since anthropogenic sources have been controlled.

•Remove anthropogenic days in descending order of dv from the 2000-2004 data.

•When you arrive at the number of dust storm observations that are equal to 90 percent of the total number of observations in a five year period, stop. Take the dv value associated with this observation as an estimate of the natural background.

This technique works very well for Guadalupe Mountains. Using the dust storm data yields an estimate of 14 dv for the upper bound for the natural background. The lower bound is 10.6 dv. Using the default EPA analyses yields a much smaller natural background of seven dv.

Analysis of continuous (hourly) light extinction and relative humidity data.

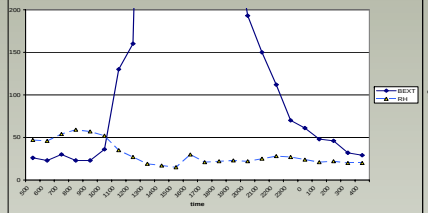


Figure 3: Comparison of Light Extinction (b_{ext}) from Aerosols and Relative Humidity (RH) during a Major Dust Storm in the Guadalupe Mountains National Park on April 15, 2003

Light extinction peaks at about 4 pm. Scale is reduced to show relative humidity. This period was dry.

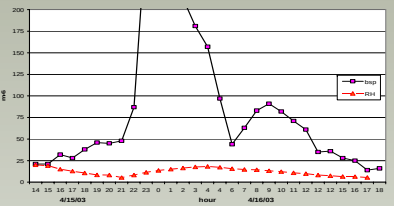


Figure 4: Comparison of Light Extinction (b_{ext}) from Aerosols and Relative Humidity (RH) during a Major Dust Storm in the Big Bend National Park on April 15, 2003

Light extinction peaks at about midnight instead of 4:00 pm at GUMO. This reflects the transport time to the Big Bend area. This period was dry.

Transcontinental Dust Storms

TCEQ has found intercontinental transport of crustal material from dust storms seldom reaches intensities for the top 20 percent events in Big Bend and Guadalupe National Parks in 2000-2004. The intercontinental dust storms from the Saharan Desert or East Asia do not appear as clearly in satellite images over land as do the West Texas dust storms, making them more difficult to track.

Analysis of the ratios of the crustal elements suggest that the June 20, 2004 event originated outside the Chihuahuan Desert since had different elemental ratios compared to the other dust storms at Big Bend. A Saharan Dust storm was observed in eastern portions of Texas from June 17, 2004 to June 20, 2004. This dust storm may have reached as far inland as Guadalupe Mountains but the measurements for that day are missing. The intercontinental transport events have contributed some indeterminate amounts of haze in West Texas on other days that are not among the 20 percent haziest days.

Table 1 (partial): Probable Dust Storm Days at Big Bend and Guadalupe Mountains National Parks 2000-2004

Site	Date	bPM	Dv	top 20 percent	Max hourly ext	Max RH percent	crustal fraction	Comments, other verification	Criteria met
GUMO	3/4/2003	78	**22**	x		55	0.85	West Texas DS 3/4/03 missing trans	3, 5, 7, 9
GUMO	3/16/2003	31	**14**		161	39	0.76	dry trans peak 3/16/03	1, 2, 3
BIBE	3/19/2003	14	**9**		24	31	0.69	West Texas DS 3/18/03 neph dry peak 3/18/03	1, 2, 7, 9
GUMO	***3/19/2003***	***20***	***11***		***307***	***87***	***0.72***	***West Texas DS 3/18/03, moist late in 3/19/03***	***1, 2, 9***
BIBE	3/28/2003	39	**16**	x		59	0.76	West Texas DS 3/27/03 neph missing	1, 2, 3, 6, 7, 8, 9
GUMO	3/28/2003	14	**8**		80	20	0.3	West Texas DS 3/27/03 trans dry peak	1, 2, 7, 9
BIBE	4/6/2003	33	**15**			7	0.79	West Texas DS 4/5-6/03 neph missing	3, 7, 8, 9
GUMO	4/6/2003	15	**9**		45		0.6	West Texas DS 4/5/03, trans peak 4/5-6/03	1, 2, 7, 9
BIBE	4/15/2003	47	**17**	x	316	25	0.45	West Texas DS 4/15/03 neph dry peak 4/15/03	1, 2, 7, 8, 9
GUMO	4/15/2003	129	**26**	x	815	35	0.79	West Texas DS 4/15/03, dry trans peak 4/15/03	1, 2, 3, 4, 6, 7, 8, 9
BIBE	4/18/2003	15	**9**		24	23	0.66	El Paso DS 4/17/03 neph dry peak 4/17/03	1, 2, 9
GUMO	4/18/2003	49	**18**	x	636		0.84	El Paso DS 4/17/03, dry trans peak 4/17-18/03	1, 2, 3, 7, 9
BIBE	4/24/2003	27	**13**		67	12	0.63	dry neph peak 4/23-24/03	1, 2, 8, 9
GUMO	4/24/2003	30	**14**		60	28	0.72	dry trans peak 4/23-24/03	1, 2, 9
BIBE	4/30/2003	14	**9**		33	51	0.27	dry neph peak 4/29-30/03	1, 2, 9
GUMO	4/30/2003	34	**15**	x	93	29	0.68	dry trans peak 4/29-30/03	1, 2, 3, 9
GUMO	5/9/2003	40	**16**	x	94	12	0.62	dry trans peak 5/9/03	1, 2, 3
GUMO	5/15/2003	109	**25**	x		14	0.76	El Paso DS 5/15/03, missing trans	3, 4, 6, 7, 9

The complete Table 1 shows that 70 out of 74 recommended dust storm events meet at least three of the dust storm criteria. Three of the events were not meeting the criteria were wet days. One day was missing too much data.

The EPA requirement that PM in blown dust must be at least 85 percent crustal material was found to predict only four of the dust storms in 2000-2004. Analysis of Table 1 strongly suggests that threshold of the crustal to total extinction ratio be about 50 percent be used to begin documentation of a dust storm event. Only one dust storm was missed by the ratio criteria at BIBE, on April 15, 2003, because the crustal to total extinction ratio was only 0.45

•Many of these events are also in the worst 20 percent of haze days at their site.

•The dust storm at GUMO on April 15, 2003, meets eight out of the nine criteria.

•All of the dust storm days should be considered when estimating the "natural background" in the regional haze rule.

•The GUMO site has the majority of the dust storms during this period with 50 out of 74 events.

•The concentrations at BIBE and GUMO do not correlate with each other. An independent estimate of natural background will be needed for each site.

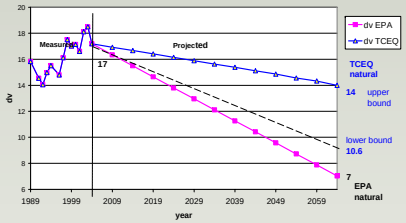


Figure 8: Comparisons of Predicted dv and Glide Slope by EPA and TCEQ at Guadalupe Mountains 2000 to 2064

Discussion

Dust storm events are recurring air pollution episodes that are not controllable by Texas. The Chihuahuan Desert has fine soils which are entrained in moderate to high winds.

Recommendations Regarding Dust Storms

TCEQ has shown that it can accurately identify naturally occurring dust storms in West Texas by combining various public sources of information. Based on detailed analysis of the complete data for the years 2000-2004 TCEQ recommends:

1) The criteria described in above be used by EPA for documenting dust storms in West Texas and at other Class 1 sites located in or near the Chihuahuan Desert or impacted by dust from the Chihuahuan as natural events.

2) The visibility impairment caused by coarse mass and fine soil on all dust storm days documented in the above manner be considered part of the natural visibility conditions at these Class 1 areas.

These events will significantly increase the deciview value for natural conditions above EPA's default values. This change will affect the glide slope used in calculating progress in reducing anthropogenic impacts on regional haze at Class 1 areas.

TCEQ

The Dust Storm Effects on Natural Haze

Identifying Dust Storms as Natural Events for Regional Haze and Particulate Matter in West Texas

Please contact Stuart Dattner at (512) 239-1811 if you have any questions or comments