P2.3 METEOROLOGICAL CHARACTERISTICS OF A SEVERE WIND AND DUST EMISSION EVENT; SOUTHWESTERN USA, 6-7 APRIL 2001

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1. INTRODUCTION

On 6 April 2001 a strongly forced convective system produced high winds across portions of west Texas. These severe winds reached damaging levels over parts of the southern Panhandle, with wind speeds in excess of 35 m/s being measured at West Texas Mesonet sites in that area. The large area of impact coupled with on-going drought conditions led to a large amount of blowing dust to be lofted into the troposphere.

The synoptic scale conditions causing this severe high wind event included a developing surface cyclone to the north of the region, a dryline across the domain, and tropospheric conditions to support high wind and convective storms.

During the next several days, the airborne dust raised by this system was transported northward and eastward, eventually ending up as far north as Ontario, Canada, where dust-laden rainfall was observed several days after the initial lofting of the aerosols.

This paper will document the conditions that were present during the initiation of the severe windstorms, the processes causing widespread emission of dust, the synoptic scale trajectories that followed the lofting of the dust, and the eventual gravitational settling of some of the airborne aerosols far from the source region.

2. SYNOPTIC DISCUSSION

At 00 UTC 5 April, a deep upper level trough was centered over the west coast of North America, extending as far south as Mexico. A strong jet maximum with winds in excess of 150 kts had passed through the base of the trough, causing the trough to deepen. Southerly surface winds ahead of the system had established a deep, moist boundary layer over much of the southern Great Plains.

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At 12 UTC 6 April, the strong upper-level jet was moving out of Mexico and into the lee of the Rockies. During the day a vigorous short wave disturbance associated with this system moved to the northeast, aiding in the formation and deepening of a surface low-pressure center in eastern Colorado. Reported pressure falls were as high as 5 mb in 3 hr. Strong pressure gradients associated with this developing system forced high winds over much of the southern Great Plains.

In addition, a dryline extended from the Davis Mountains in southwest Texas, northward along the Texas-New Mexico border and into the western Texas panhandle. Deep tropospheric mixing to the west of the dryline led to the transport of additional high momentum air from aloft.

Warm, humid conditions in the boundary layer air mass preceding the dryline, combined with dynamic adiabatic cooling in the middle troposphere, resulted in unstable conditions across much of the Southern High Plains. By 00 UTC 7 April a line of severe thunderstorms developed along the dryline in the Texas Panhandle, providing yet another source for high wind. Some of these thunderstorms had supercellular characteristics early in the life cycle, but transitioned quickly to more linear characteristics of a squall line.

By 12 UTC 7 April, the surface low had migrated into the northern Great Plains, and was centered near the borders of Minnesota, North Dakota, and South Dakota. The high-amplitude upper level trough had flattened out significantly, as the progression of the upper level jet on the previous day. The jet had moved northeastward and was centered southwest of the Great Lakes. The short wave as seen from 850-mb up to 500-mb had intensified and formed a progressive cut-off low nearly vertically stacked above the surface low.

By 00 UTC 8 April the surface low was continuing to progress to the east-northeast, reaching southeastern Canada. The trough continued to deamplify and the tropospheric winds weakened accordingly (not shown). This weakening of the overall flow had implications for the associated dust transfer, as the dust falls began

to be observed in the Great Lakes region and southern Canada.

3. DUST TRANSPORT DISCUSSION

The deepening trough, strong pressure gradient, downward transport of momentum behind the dryline, and thunderstorm outflow, all forced high winds extending from the northern Chihuahuan Desert of Mexico into the southern Great Plains of the USA. Large dust plumes were raised from these regions on the afternoon of April 6 local time. The Lubbock, Texas and Midland, Texas National Weather Service Forecast Offices issued rare Dust Storm Warnings for much of west Texas and far southeastern New Mexico. In Lubbock, thick blowing dust persisted throughout the late afternoon; surface visibility was less than 2 miles for approximately 4 hours and briefly diminished to less than a quarter mile as the dryline passed through the city between 5 and 6 PM local time. Sustained wind speeds in excess of 50 kts, with gusts exceeding 75 kts, were reported across much of the region.

The Southern High Plains region around Lubbock, Texas is in itself one of the dustiest regions in North America (Orgill and Sehmel, 1976), where wind erosion of unvegetated or disturbed soils in agricultural lands is the main source of particulate matter. In early April the cotton crop in west Texas has not yet been planted and large areas of bare soil are exposed to the wind, making it the historical peak of the dust season (Bernier *et al.*, 1998). Recent research (Prospero *et al.*, 2002) has also indicated the prevalence of dust emission from a region of dry lake beds and sparsely-vegetated desert lands on the fringes of the Chihuahuan Desert in Mexico. Agricultural development on the edges of this naturally desiccated area in Chihuahua has increased its susceptibility to wind erosion, and huge dust plumes may sometimes be seen being emitted from these sites in GOES visible satellite imagery (M. Bleiweiss, personal communication, 2001); such was the case in the April 6 event.

The most severe dust storms in the Southern Great Plains are generally associated with rapidly deepening surface cyclones in eastern Colorado that cross the panhandles of Oklahoma and Texas in spring. The large pressure gradients and dry air entrained around the southwest side of these systems support the strongest and most persistent regional dust outbreaks and can result in long-distance transport of aerosols across North America (Bernier *et al.*, 1998: Gill *et al.*, 2000). The dryline is primarily a mesoscale phenomenon that regularly produces dramatic but shorter-lived dust plumes that are transported generally within the state of Texas. In the case of April 6, 2001, both these conditions were present, and augmented by the incoming Pacific front combined to raise dust plumes over a large area which merged over the Southern High Plains of Texas and transported aerosols far beyond the region.

The U.S. Navy Aerosol Analysis and Prediction System (NAAPS, incorporating a NOGAPS-based aerosol emission and transport model: http://www.nrlmry.navy.mil/aerosol/Docs/globaer_model.html) has shown a good ability to document the emission and accurately forecast the transport path of dust aerosol from southwest North America (Gill *et al.*, 2000). NAAPS tracking of this event (Figure 1) indicated that a significant stream of dust was entrained into the synoptic circulation and quickly transported to the northeast along and east of the track of the cyclone, reaching the Great Lakes region by late 7 April and northeastern North America by early 8 April 2001.

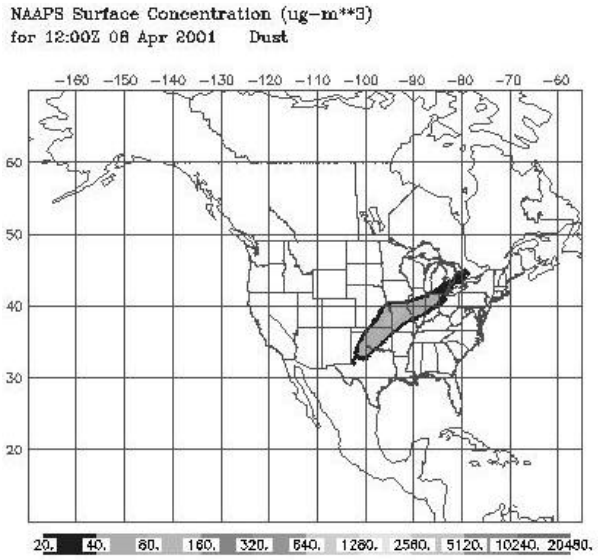

Figure 1. NAAPS dust output for North America, 12Z 08 April 2001, showing swath extending from Texas Panhandle into southern Ontario. Graphic courtesy of D. Westphal, Naval Research Lab.

Rain samples collected in Ontario, Canada and western Pennsylvania as part of an acid deposition-monitoring network on 7 April were observed to contain unusual deposits of reddish to yellowish dust. Tracer analysis using electron microscopy indicated that the particles contained in the "red rain" in the Northeast were indistinguishable from dust collected in Lubbock during the 6 April storm, and other potential source areas for the dust in the precipitation (such as Asia) have been ruled out.

Dust lofted in the Southwest was apparently very quickly transported thousands of kilometers to the northeast by the strong cyclone. Dust from the southern Great Plains was routinely transported to the

northeastern USA during the "Dust Bowl" years, and a 1999 event transported dust from west Texas to the fringes of the Great Lakes (Gill *et al.*, 2000), but this marks the greatest distance from which dust originating in the Southwest has been noticeably deposited in recent years.

This dust event was unusual in several regards. An extremely large amount of dust was advected into West Texas from as far as central Chihuahua, Mexico to the southwest, augmenting additional widespread dust emission from the strong dryline crossing the Southern High Plains. The combination produced the unusually extreme dust storm condition in Lubbock. This large mass of mineral aerosol picked up in west Texas, New Mexico, and Chihuahua was entrained into the atmosphere and apparently transported thousands of kilometers to the north and east by the prevailing flows in the lower and middle troposphere. Due to the extreme nature of the winds, substantial amounts of dust were lofted and transported.

4. CONCLUSIONS

Widespread high winds forced by synoptic scale pressure gradient force, mesoscale dryline processes, and storm scale outflow produced a significant blowing dust event over the southern plains during the period of 6-8 April 2001. The lofted dust was transported from areas of West Texas, New Mexico and northern Mexico across the United States and deposited in the Great Lakes region. The U.S. Navy Aerosol Analysis and Prediction System did a good job tracking and predicting the transport of the dust plume across the mid-western US and into southern Canada. While the lofting of the aerosols was tied to multiple forcing mechanisms, the fallout of dust seemed to correspond to the weakening of the upper troposheric flow on April 8.

5. REFERENCES

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