Dust Trends in the Southern High Plains

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Abstract

In the semiarid Southern High Plains of North America, elevated dust levels are almost always associated with regional wind erosion events. Thus, measurements of atmospheric dust concentration provide an indirect measure of wind erosion activity within the Southern High Plains. In the Lubbock, Texas area, various government programs have provided funding for the measurement of total suspended particulates (TSP) from 1961 to the end of 1982. Changes in environmental law brought an end to the measurement of TSP due to a shift in the regulatory focus toward particulate matter with a median diameter less than 10 microns (PM_{10}). This sudden change disrupted a potentially valuable long-term TSP dust record. Recent TSP measurements obtained over a two-year period by the USDA-Agricultural Research Service provide data necessary to compare present dust levels with those taken from 1961 to 1982. The results indicate a continuing reduction of TSP over the past four decades which suggests a substantial decrease in wind erosion activity within the Southern High Plains.

Keywords: Wind erosion, dust, particulate matter, air quality.

Introduction

As we head into the 21st century, it is only natural that we ask whether progress has been made in reducing wind erosion of agricultural lands during the past century. Certainly, our understanding of the wind erosion process has improved partly due to wind erosion research and this research has led to changes in agricultural practices. In addition, conservation programs, such as the Soil Bank Program and the Conservation Reserve Program, have influenced land-use patterns across wind-erosion sensitive regions of the United States (Ervin and Lee, 1994). The ultimate question is whether changing practices and changing land-use patterns have reduced the frequency and intensity of regional wind erosion events?

One method of monitoring changing wind erosion patterns is to set up numerous single-field experiments where field-scale erosion processes, such as sediment transport and soil loss, are measured directly with sediment samplers (Stout and Zobeck, 1996; Fryrear *et al*., 1991; Chepil, 1946). To monitor wind erosion over a large region in this way would require the installation of a large number of samplers in a large number of fields and it would require a tremendous labor force to service these samplers.

A simpler alternative is to use dust measurements as a surrogate for direct measurements of wind erosion processes (Stout *et al*., 1999). It is well known that wind erosion produces dust and, within remote agricultural regions that lack other significant sources of particulate matter, dust levels are often positively correlated with regional wind erosion activity. Thus, under restricted conditions, tracking dust concentration over a long period can provide a valuable record of long-term variability in wind erosion activity.

Past Work

There have been many attempts to define long-term variations in dust storm frequency through the use of visibility observations (Bernier, 1995; Lee and Tchakerian 1995; Lee *et al.*, 1994; Wigner and Peterson, 1987; Changery, 1983; Goudie, 1983; Pollard, 1977; Orgill and Sehmel, 1976; Pecille, 1973). Before 1993, visibility was routinely estimated each hour by National Weather Service (NWS) observers who attempted to see fixed objects at known distances from the station (Orgill and Sehmel, 1976). When visibility decreased to less than 7 miles, a note was made as to the reason for the reduced visibility. In semiarid agricultural regions, the occurrence of blowing dust was often reported as the cause of reduced visibility and, as a result, NWS surface observations provide a valuable record of blowing dust that often extends as far back as 1947.

Unfortunately, visibility is a subjective measurement that depends upon the judgement of the observer and the observer's ability to detect distant objects (Orgill and Sehmel, 1976). Thus, two observers may describe the same conditions differently and it follows that observations taken at two different locations by two different observers may not be directly

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comparable. Certainly direct measurements of dust concentration would be preferable.

Direct measurements of particulate matter have been obtained at various times in many major cities in the United States by state and federal regulatory agencies concerned with air pollution. The purpose of these monitoring programs has been to establish whether a city was in compliance with current air quality standards. The focus of these monitoring programs has changed through the years as air quality standards for particulate matter have changed.

In the Lubbock area, samples of total suspended particulates (TSP) were obtained from 1961 to 1982 at a site located on the north side of downtown Lubbock (Cowgill, 1970). Sampling frequencies varied from once every two weeks to once a week. Sampling was suspended from 1983 to 1986; then in 1987, a sampling program focused on particulate matter with a mass median aerodynamic diameter less than 10 microns (PM_{10}) was initiated. Unfortunately, there is no simple relationship that allows one to reliably predict TSP from measured values of PM_{10}, thus, the TSP record essentially stopped in 1983 and since then there has been no TSP monitoring in the Lubbock area until this experiment was initiated in 1997.

Experiment

The USDA-Agricultural Research Service began a program of continuous sampling of TSP on October 1, 1997, at a site located 6 km northwest of the site used during the 1961 to 1982 sampling programs. To obtain a regionally representative measure of TSP, careful attention was paid to the placement of the sampling system. Locations where a single eroding field might dominate the measurements were avoided since such local dust conditions may not represent true regional conditions. A grassland site was chosen since it would not be a significant dust source and the site would not change appreciably through time as surface conditions in the surrounding agricultural region varied seasonally. Such a site provides TSP measurements that reflect true regional dust conditions as they change with time.

A satisfactory site was found within north Lubbock, Texas, at Lubbock Lake Landmark State Historical Park. Contrary to its name, the landscape of Lubbock Lake is predominantly grassland with a total area of 1.5 km^2. This permanent grass cover contrasts sharply with the surrounding agricultural land which can quickly change from fully vegetated to completely bare in a matter of days. The noneroding grassland provides a buffer zone between the surrounding agricultural fields and the sampling location. For winds blowing out of the East, South, and West the nearest agricultural field is more than 1 km away. The grass buffer zone to the North is only 200 m due to a hay field that is located just north of the park boundary.

A sampling system was constructed to allow for the collection of a continuous series of daily TSP samples. The system, shown schematically in Fig. 1, is powered by a 12-volt battery that is charged by a solar panel during the day. This feature allows the tower to be placed in remote locations where standard electrical power is not available. The key components of the tower include a data logger, that also serves as a controller, and eight filter assemblies attached to an Airmetrics Minivol[2] air pump through a Samplivalve[2] fluid switch. A vacuum switch is used to power a backup pump if the primary pump should fail.

Dried and pre-weighed 47-mm diameter polycarbonate filters (0.6 m pore size) are mounted in each of the eight filter assemblies. The Samplivalve fluid switch connects the active sampling pump to one of the eight filter assemblies so that air is pulled through a specific filter for twenty-four hours. At midnight, the fluid switch steps to the next filter assembly so that air is pulled through the next filter for twenty-four hours. This process is repeated as the system cycles through all eight filters in a continuous loop. Every few days, exposed filters are replaced by fresh filters. Exposed filters are then dried and weighed to determine the daily mass collected. PM_{10} concentration is calculated by dividing each sample mass by the total volume of air that passed through the filter in twenty-four hours (7.2 m^3) and the result is reported in units of micrograms per cubic meter of air.

[2] Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

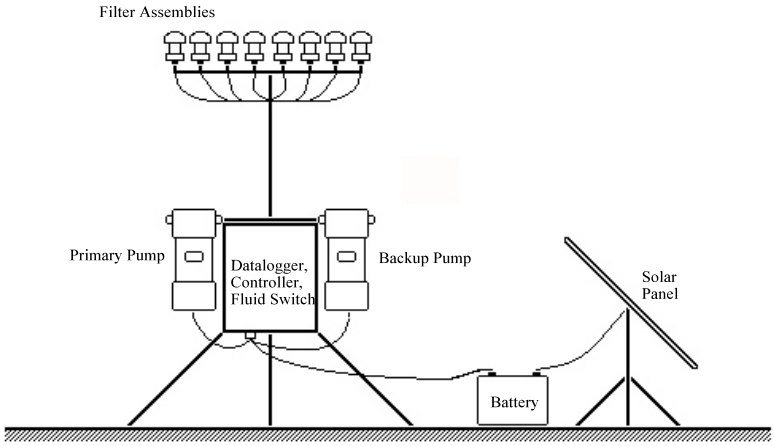

Figure 1. Schematic diagram of the dust sampling system.

Results and Discussion

Past measurements of TSP were obtained through a public request to the Texas Natural Resources Conservation Commission (TNRCC). These data were averaged for each year from 1961 to 1982 and the results are plotted as diamonds in Fig. 2. The annually-averaged TSP values exhibit considerable scatter that may indicate year-to-year variability produced by normal climatic variations. There is, however, also a noticeable downward trend indicating a general reduction of TSP concentration with time. Fitting a trend line to the EPA-TNRCC TSP data yields a negative slope of -2.6 g/m^3 per year.

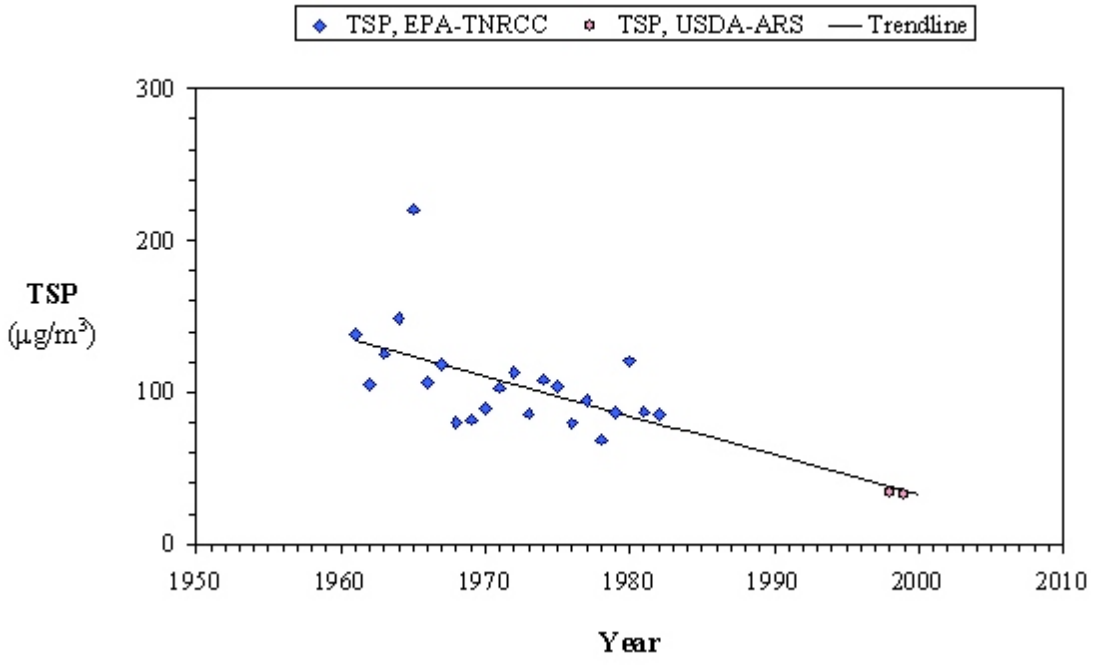

Figure 2. Plot of annual-average dust concentration (TSP) as a function of time for Lubbock, Texas.

The USDA-ARS sampling system operating at the Lubbock Lake site has collected samples for two full years – 1998 and 1999. The annual-average concentrations for each of these years are plotted as circles in Fig. 2. The results indicate a

continuing reduction of TSP concentration during the last four decades. In fact, the trendline, which was calculated based on the EPA-TNRCC data alone, appears to extend directly to the USDA-ARS TSP values for 1998 and 1999. One can interpret this downward trend as an indication that wind erosion activity is decreasing in frequency and intensity in the Southern High Plains.

Acknowledgments. I would like to thank James R. Golden for his significant contributions to this project. James constructed this unique sampling system and helped to design many of its key features. In addition, he has routinely changed filters and serviced the samplers when necessary.

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