Dust Modelling and its Applications to the Border Region

Dazhong Yin, William A. Sprigg, Brian Barbaris and Patrick Shaw
Institute of Atmospheric Physics
The University of Arizona

Introduction

Windblown dust composes a significant portion of atmospheric particulate matter (PM) along the U.S. Mexico border and is known to have adverse effects on human health and transportation. Prediction of high PM events associated with windblown soil would be beneficial to these areas of human welfare. Work is under way at the University of Arizona to model such events. The goal of this project is to accurately predict dust concentrations in space and time by incorporating NASA earth science observations with the models. Findings of the research include improved model results with updated finer resolution NASA earth observations and the association of high air-borne dust concentrations with the peak of student absentees (see figure below). Once validated, these models can serve as powerful tools in the forecast of dust episodes in the border region of the southwest U.S. and Northern Mexico.

Dust Modelling

The Dust REgional Atmosphere Model (DREAM), developed by Nickovic et al. (2001), is the model of this study. It is a transport module coupled with the NCEP Eta weather forecasting model. The dust module incorporates dust production, advection, diffusion and deposition into the weather model. The amount and location of dust particles lifted into the atmosphere are determined from land cover, soil texture, soil moisture and surface wind drag. Dust source regions are obtained primarily from NASA MODIS land cover data.
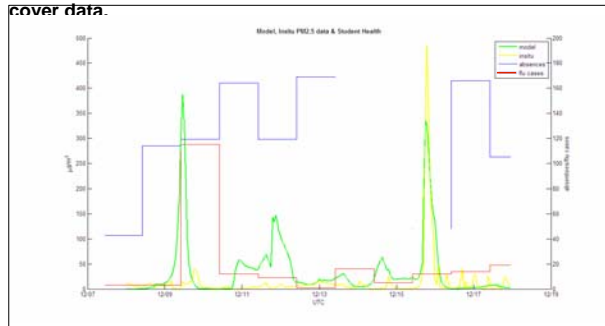

Health statistics from 2003 Lubbock, TX test case are plotted with dust storm model and in-situ data. Student absentees peak after observed and modelled peaks in the dust concentrations, but there appears to be little correlation with influenza. Providing schools with an advanced warning of a dust event could reduce the number of absences.

Border Experiment

An experiment was carried out to determine the contribution of Mexican source regions to border dust storms. Two dust storm cases from December 2003 were simulated using the DREAM model. Each case was examined with two sets of desert dust sources. The first used desert dust sources in the the whole U.S. Mexico domain, while the second used desert dust sources in the U.S. only.

The two 2003 dust storms (December 8-10 and December 15-17) were caused by synoptic forcing and affected Southern New Mexico, West Texas and Northern Mexico. Sustained winds as high as 20 m/s triggered the saltation and suspension of dust particles into the atmosphere and allowed for long range transport. Each case was simulated with and without Mexico source regions. Validation was performed by comparison with observed weather maps and statistics based on in-situ weather and PM concentration data.
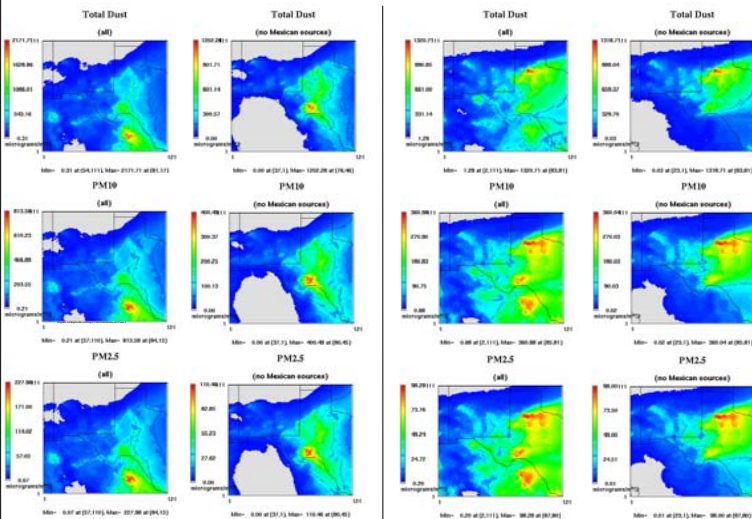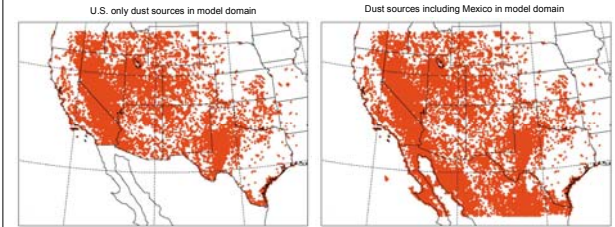
Model surface concentrations (µg/m³) for two 2003 test cases: average concentrations of case 1 with (column 1) and without (column 2) Mexican source regions. Average concentrations of case 2 with (column 3) and without (column 4) Mexican source regions. Modelled statistics show that as much as 40% of dust concentrations can be attributed to Mexican source regions.

U.S. only dust sources in model domain

Dust sources including Mexico in model domain

Conclusions

Two December 2003 dust storms were simulated using a dust transport model. Each was operated using U.S. plus Mexico desert dust sources and U.S. only sources. It was found that northern Mexico contributes to the dust loading and concentrations by as much as 40%. These results show a coordinated effort in ecosystem protection and resource management by the U.S. and Mexico is necessary to control dust pollution in this region. Dust modelling can identify key sources and contribute significantly to dust control strategies.

References

Yin, D. and W.A.Sprigg. (In press). Modelling airborne dust pollution in the southwest united states: A trans-boundary perspective. In Papers from the 6th Conference on Research & Resource Management in Southwestern Deserts; Sky Alliance, Tucson. 32 pp.

Yin, D., S. Nickovic, B. Barbaris, B. Chandy, W. A. Sprigg; 2005; Modeling wind-blown desert dust in the southwestern United States for public health warning: a case study; Atmospheric Environment, 39, 6243-6254

Acknowledgements

Project Website:
http://www.atmo.arizona.edu/faculty/research/dust/dust.html