UTILIZING A NUMERICAL WEATHER PREDICTION MODEL FOR DUST FORECASTING

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Previous Dust Modeling Efforts

Dust Modelling and its Applications to the Border Region
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Introduction
Windblown dust comprises 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 airborne dust concentrations with the peak of student absences (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.

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 of observed weather maps and statistics based on in-situ weather and PM concentration data.

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


Acknowledgements
This work was funded by the NASA REASON project, in collaboration with the University of New Mexico (CMMN054AA19A), through the University of Arizona department of Atmospheric Sciences and Institute of Atmospheric Physics. Dr. S. Caskey of Sandia National Laboratories and Dr. K. Benedict of University of New Mexico provided student absentee data and MODIS 12 data.

Project Website:
Dust Concentration Forecast from DREAM

Sprigg (2009)

Dust concentration too high. Soil moisture wrong?
Did not resolve Summer convective winds
Took too long to run.
Difficult to upgrade
## Forecast Results for Dust Storm Days, .5 mi visibility or less at PHX

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<th>4</th>
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Criteria for convection verification: winds $>$10 m/s and/or rapid temperature drop. Sites include KPHX, KIWA, KLUF, KDVT.

Dust storm days courtesy of JJ Brost, NWS Tucson
Day 2 to 3 Forecast Skill

- WRF can provide accurate non-convective wind forecasts up to 72 hours in advance.
- Monsoon season forecasts are less accurate due to the chaotic nature of convection. Over the past few years, accuracy has improved for day 2 forecasts.
3 Day Wind Forecast for Casa Grande

![Graph showing 3 day wind forecast with observed data in black and forecast data in green. The graph indicates wind speed in m/s from 0 to 12, with time from 00 to 24 hours. Day 3 forecast shows an increase in wind speed.](image)
Model Deficiencies

- High resolution land surface cover data errors common: incorrect classifications, incorrect locations, out of date.
- Soil moisture poorly represented as large errors can exist both spatially and temporally.
- Model does not explicitly forecast wind gusts.
- Does not forecast dust.
Initialized 5cm Soil Moisture(%) at KBOI
Solutions

- Update land use data with corrected and/or more recent data. Yuma county and urban/suburban land use data has been corrected/replaced.
- Assimilate soil moisture directly from a network of sensors and/or use MODIS NDVI data to infer soil moisture.
- Develop gust forecast product using a blend of 10m/80m winds and/or alternative PBL options and add a DCAPE forecast for the convective season.
- WRF-Chem can be used to model dust creation and advection. Must turn off chemistry for operational use due to extreme computational requirements.
Use NDVI as proxy for Soil moisture. Note reduction of NDVI over the 3 month period.
10/80m Wind Forecast

Black=Observed, Red=80m Forecast, Green=10m Forecast
Department of Atmospheric Sciences/UofA Expertise

- Eric Betterton: physics of dust transport, air quality, chemistry
- Ave Arellano: data assimilation, WRF Chem
- Chris Castro: NWP, regional climate
- Paul Brown (Ag): meteorological measurements
- Mike Leuthold: operational modeling
Wind Erosion Modeling

Mass flux:
- Creep (rolling): 800-2000 μm $D_p$
- Saltation (hopping): 100-800 μm $D_p$
- Suspension (wind blown dust): <100 μm $D_p$

Greeley-Iversen erosion threshold curve
Kon et al., Int. J. Min. Reclamation & Env. 21, 198 (2007)
The Arizona Meteorological Network