

Department of Geographical Science, University Road, University of Bristol, Bristol BS8 1SS  
sarah.shannon@bristol.ac.uk

## Abstract

Observations show that dust from the Sahara/Sahel has a peak emission in Summer while dust from Asia has a maximum emission in Spring. The aim of this work is to investigate what determines this variability using a dust cycle model. A series of experiments are carried out to test the impact of varying 1. vegetation cover 2. soil moisture and 3. wind speed on surface dust emissions. Results show that wind speed is the largest contributor to the variability in global surface emissions. In Asia changes in soil moisture contribute the variability but to much lesser extent than wind speeds

## The dust model

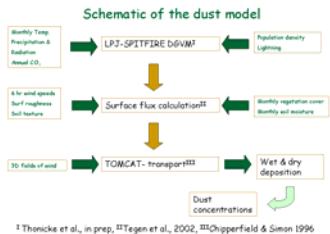


Figure 1: The dust model consists of three parts.

- I. The LPJ-SPLITFIRE dynamic global vegetation model is used to simulate the distribution of vegetation cover as it changes with varying climate and CO<sub>2</sub>. This is modified version of the Lund-Potsdam-Jena DGMV (Sitch et al., 2003) that includes a fire disturbance component. Dust emission is allowed from regions with low vegetation cover and soil moisture.
- II. The dust flux is calculated by modelling the processes of saltation and sandblasting. Surface dust emissions are related to the cube of the wind speed above a threshold value. The model is driven by 6 hourly wind speeds from ERA-40 reanalysis. The particle size distribution is determined from the soil type at the surface using the Zolner soil texture map.
- III. Dust is transported as independent tracers in the chemical transport model TOMCAT. Particles are removed by gravitational settling and turbulent mixing at the surface. Removal by sub cloud scavenging by large scale and convective precipitation is also included.

## Model validation

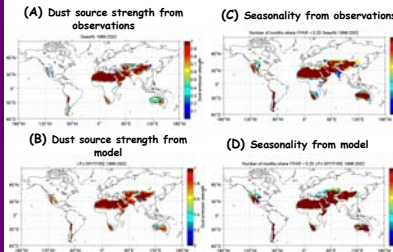


Figure 2: Comparison of simulated dust source regions with remote sensing data

- On the left we can see a comparison of the annual mean dust emission strength calculated from (A) LPJ-SPLITFIRE FPAR and (B) seaWIFS FPAR. There is good agreement between the model and the observations with the exception of Australia where the model underestimates the amount of vegetation cover. This may be due the fact that LPJ-SPLITFIRE does not simulate shrub type plant functional types which are important in this region.

- Figures C and D show the number of months when a grid cell is an active year while the boundaries are active for only part of the year.

## Seasonality in dust emissions

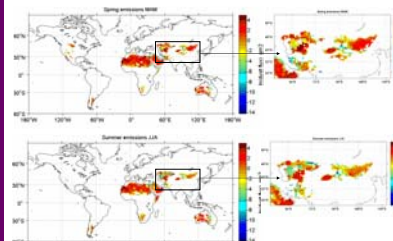


Figure 3: Spring (top) and summer (bottom) surface fluxes for the year 1988. More dust is emitted from Asia in Spring than summer. This may be due to high wind speeds or a reduction in soil moisture or vegetation cover. Which parameter causes the seasonality?

## Model Validation

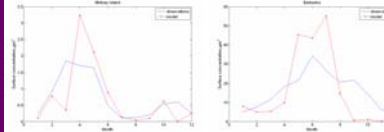


Figure 4: Comparison of modelled surface dust concentrations with observations for sites in the North Atlantic and the Pacific. Data courtesy of Joseph Prospero, University of Miami.

- The model data corresponds to surface concentrations of a tracer with diameter of 0.01µm. For comparison the modelled data has been scaled to match the mean of the observations

- The Pacific site at Midway Island receives dust from Asia. We can that the model does a reasonable job at simulating the spring time peak at this site.

- Dust from the Sahara/Sahel is transported across the Atlantic to the site at Barbados. We can see that the model captures the summer time peak.

## Experiments

A series of experiments are carried out to test the impact varying

- Vegetation cover
  - Soil moisture
  - Wind speed
- on the surface dust flux.

In the experiment 1 all the three parameters are allowed to vary seasonally and inter-annually. In experiments 2, 4 and 6 each parameter is allowed to vary seasonally. In experiments 3, 5 and 7 each parameter is fixed such that it does not vary through out year.

	Expt1	Expt2	Expt3	Expt4	Expt5	Expt6	Expt7
Vegetation	Vary	Seasonal	Annual mean	Vary	Vary	Vary	Vary
Soil moisture	Vary	Vary	Vary	Seasonal	Annual mean	Vary	Vary
Wind speed	Vary	Vary	Vary	Vary	Vary	Seasonal	Annual mean

Table 1: details the parameters that are varied or fixed for each of the experiments.

## Results

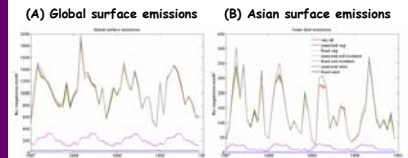


Figure 5: Figure (A) shows the global surface fluxes for the years 1987-1990 for each of the seven experiments. We can see that varying the soil moisture and vegetation cover does not have a large impact in the global dust flux. However, there is a dramatic response to changes in wind speed.

Figure (B) shows the surface fluxes for Asia. Again, the wind speeds dominate the variability. We can see that moisture plays a role in determining the variability but changing vegetation cover does not have a significant impact.

## Conclusions

Changes in wind speeds dominate the variability in global dust emissions

In Asia changes in soil moisture contribute to the variability but to a much lesser extent than wind speeds

## Future work

- The longest record of dust concentrations has been measured at Barbados. This time series shows decadal changes in surface concentrations. We will evaluate whether the observed variability has been caused by changes in wet deposition or large scale circulation patterns

- Include seven additional particle sizes in the dust model

- Modify the wet deposition scheme to use size dependant scavenging coefficients.

## Acknowledgements

This project is funded by the By the Marie Curie Research and Training network GREENCYCLES project, reference number: MRTN-CT-2004-512464

Chipperfield, M. P. a. P. S. (1996). "The TOMCAT Offline Transport Model. Part II: Dynamics and Advection." *Technical report, GCAM*.

Tegen, I., S. Harrison, et al. (2002). "Impact of vegetation and preferential source areas on global dust aerosol: Results from a model study." *Journal of Geophysical Research* 107(D14): 4076.

Sitch, S., B. Smith, et al. (2003). "Evaluation of ecosystem dynamics, plant geography and terrestrial carbon cycling in the LPJ dynamic global vegetation model." *Global Change Biology* 9: 161-185.