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A new offline dust cycle model that includes dynamic vegetation

Sarah Shannon and Daniel Lunt
University of Bristol, School of Geographical Science, Bristol, United Kingdom (sarah.shannon@bristol.ac.uk)

Current offline dust cycle models are unable to predict variability in the extent of arid and semi-arid regions caused by the transient response of vegetation cover to the climate. As a consequence, it is not possible to test whether inter-annual variability in the dust loading is caused by vegetation changes or other processes. A new dust cycle model is presented which uses the Lund-Potsdam-Jena dynamic global vegetation model (Sitch et al., 2003) to calculate time varying dust sources. Surface emissions are calculated by simulating the processes of saltation and sandblasting (Tegen et al., 2002). Dust particles are transported as independent tracers within the TOMCAT chemical transport (Chipperfield, 2006). Dust is removed from the atmosphere by gravitational settling and sub-cloud scavenging. To improve the performance of the model, threshold values for vegetation cover, soil moisture, snow depth and threshold friction velocity, used to determine surface emissions are tuned. The effectiveness of three sub-cloud scavenging schemes are also tested. The tuning experiments are evaluated against multiple measurement datasets.

The tuned model is used to investigate whether changes in vegetation cover in the Sahel can explain the four-fold increase in dust concentrations measured at Barbados during the 1980s relative to the 1960s (Prospero and Nees, 1986). Results show there was an expansion of the Sahara in 1984 relative to 1966 resulting in a doubling of emissions from the Sahel. However, this alone is not enough to account for the high dust concentrations measured at Barbados. This finding adds strength to the hypothesis that human induced soil degradation in North Africa may be responsible for the increase in high dust concentrations at Barbados during the 1980s relative to the 1960s.

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