Dust Observations for Models – DO4Models

Richard Washington\(^1\), Giles Wiggs\(^1\), James King \(^1\), Karsten Haustein\(^2\), David Thomas\(^3\), Helen Brindley\(^2\), Jonathan Murray\(^2\), Rob Bryant \(^3\), Frank Eckardt \(^4\), Bruce Hewitson \(^4\), Kathryn Vickery \(^6\)

\(^1\) University of Oxford, UK; \(^2\) Imperial College London, UK; \(^3\) University of Sheffield, UK; \(^4\) University of Cape Town, South Africa; \(^5\) University of Southampton, UK; \(^6\) Met Office Hadley Centre, Exeter, UK

1. Introduction

Climate and weather prediction depend on numerical models. Most of the climate models included in the Coupled Model Intercomparison Project 5 (CMIP5) which will underpin the Intergovernmental Panel on Climate Change 5th Assessment Report (IPCC AR5) include a dust module. This is because dust is known to play an important role in the Earth system, particularly in the radiation budget.

Dust emission schemes in some climate models are relatively simple. Many are tuned to represent observed background aerosol concentrations thousands of kilometres from source regions. Representations of dust emission in some models were developed from idealised experiments such as those conducted in wind tunnels. It has been difficult to improve current model dust emission schemes because of the paucity of observations from key dust sources.

Dust Observations for Models (DO4Models) is a NERC funded project designed to gather data from source regions at a scale sympathetic to climate model grid box resolution.

DO4Models Aims

1. Produce a new data set at an appropriate scale for climate models which characterises surface erodibility and erosivity in dust source areas from remote sensing and fieldwork.
2. Evaluate observed erodibility and erosivity influence on dust emissions at the climate model scale.
3. Develop and optimise the dust emission scheme for the Met Office regional model (HadGEM3-RA) using dust source area data sets.
4. Assess observed erodibility and erosivity drivers to determine which components make the largest improvement to physically-based dust emission simulations in climate models.

DO4Models Project Organisation

DO4Models research comprises the following tasks:

1. Characterisation of representative wind-driven sediment flux source areas from remote sensing.
2. Field Observations of Dust Emissions
3. Numerical Modelling

Core DO4Models Institutions

University of Oxford (Lead Institution): Field observations and Modelling, Richard Washington (DO4Models Principal Investigator), Giles Wiggs (Lead Field Observations), David Thomas, James King (Postdoc, Field Observations), Karsten Haustein (Postdoc, Modelling), Imperial College London: Earth Observation, Helen Brindley, Jonathan Murray (postdoc Earth Observations)
University of Sheffield: Earth Observation and Field Observations, Rob Bryant
University of Cape Town: Field Observations, Frank Eckardt, Kathryn Vickery, Bruce Hewitson
University of Southampton: Field Observations, Jo Nield

DO4Models is funded by NERC

2. Details of the DO4Models Field Observations

Choice of Sites

DO4Models requires a dust source region that emits dust regularly and which is isolated from other sources so that measurements of atmospheric dust loadings are known to have been produced at the instrumented source region rather than emitted by distant sources and transported to the instrumented site.

Southem hemisphere sources, notably those in southern Africa, are isolated, tend to be surrounded by savannah and have relatively low background dust concentrations with little transported dust. These sites are ideal. Three southern African source areas stand out, namely Elosha and Makgadikgadi Pans and the Namib dry river valleys. Sua Pan, within Makgadikgadi, Botswana, was chosen for the first instrumentation period from July-October 2011 and 2012. Sua Pan is at 20° 33’S, 26° 00’E at 900m asl.

In the Boreal winter of 2013 the project will instrument a series of dry river valleys among the Namib coast.

Sua Pan Site Instrumentation

The pan was instrumented with equipment arrays at 11 sites over a 12 km x 12 km square exactly matching that of a regional climate model.

3. Early results

a) Earth Observation: Dust detection

An intensive surface measurement campaign in 2011 revealed surface soil moisture to be the limiting erodibility variable. Soil moisture and potential dust emissions were interpolated from 100 of the 144 km\(^2\) grid. This pattern evolved over the campaign period. Based on MODIS moisture interpretation, late rains in April/May exacerbated the potential for dust hotspots to develop.

b) Erodibility characteristics of Sua Pan

Wind roses at 6m height for 10-38m/s, where 9m/s is an approximate emission threshold, point to enhanced easterly wind regime as the key contribution to erosivity (right) – each wind rose is positioned approximately according to the instrumentation in the grid. Grid identifiers (e.g. B3) defined for each rose. The windspeed maximum is at the leading edge of the pan.

c) Erosivity characteristics of Sua Pan

Cumulative daily DustTrak time series show nearly double the number of deflation events in 2012 compared with 2011 (right) although the largest single event is in 2011. Preferred sources within the pan, consistent with the Earth Observation work, are particularly evident in 2012 (colour relates to different locations on the sand pan).

d) Numerical Modelling

Simulated box model flux for the DO4Models Sua grid (thick grey lines) and individual locations on the grid (dotted coloured lines based on the Marticorena and Bergametti 1995 (MB95) emission scheme. The drag partition scheme and the moisture correction are used. Dots are the observed flux. Problems include the offset in threshold shear velocity between observed and modelled dust flux and the omission of direct entrainment at lower wind speeds.

Contact

Richard Washington, DO4Models PI, Climate Research Lab, Oxford University Centre for the Environment, South Parks Road, Oxford, OX1 3ZP richard.washington@ouce.ox.ac.uk