The Effect of Model Resolution on Wind-Stress Dust Lifting Within the LMD/UK Mars Global Circulation Model

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**THE EFFECT OF MODEL RESOLUTION ON WIND-STRESS DUST LIFTING WITHIN THE LMD/UK MARS GLOBAL CIRCULATION MODEL**

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**Introduction:**
We have investigated how the representation of surface dust lifting by near-surface wind stress within a global circulation model varies across a range of modelling resolutions.

Our aim was to study two aspects of this dust lifting through increasing horizontal resolution: the locations at which dust was lifted from the surface and the total amount of dust lifted.

**Modelling Martian surface dust lifting:**
This work uses the UK version of the LMD Mars Global Circulation Model ("the MGCM"). The MGCM is a global, multi-level spectral model of the lower and middle regions of the Martian atmosphere. The UK version of the model uses a truncated series of spherical harmonics to represent horizontal variations in atmospheric fields, with the field values stored as coefficients of the spherical harmonic functions (Hoskins and Simmons, 1975; Read and Lewis, 2004). These field values are transformed onto a three-dimensional grid in order to complete calculations involving parameterisations of physical processes.

The horizontal resolution of the model is defined by the total wavenumber of the spherical harmonic series: for example, a spectral resolution with a series of wavenumber 31 corresponds roughly to a computational grid of 36 latitude by 72 longitude points. This “T31” spectral resolution results in a physical horizontal resolution of 5° latitude by 5° longitude.

**Discussion and future work:**
**Dust lifting locations.** The friction velocity, $u^*$, is derived within the MGCM from large scale wind speeds. Wind speeds within a given area are affected by a change in model resolution: increasing the resolution improves the modelled representation of local slopes. At higher resolutions there is consequently a more detailed resolution of local slope winds, producing higher near-surface wind speeds within regions of varying terrain height.

The dust lifting regions in the higher resolutions shown in Figure 1 are associated with the latitude of the north polar ice cap edge. The terrain height variations at the cap edge are expected to produce local
slope winds; these are not well enough represented in the lower resolution simulations to initiate dust lifting by near-surface wind stress.

A similar effect can be identified in the results shown in Figure 2. The higher resolution simulations exhibit scattered dust lifting regions around ~60° latitude, the latitude of the edge of the south polar ice cap; these dust lifting regions are not evident in the results from the lower resolution simulations.

Dust lifting by near-surface wind stress is generally considered to be the primary dust lifting process associated with Martian dust storms (e.g. Strausberg et al., 2005; Basu et al., 2006; Wilson, 2011). We can compare dust lifting regions in our results with orbital observations of dust storms as a proxy for identifying dust lifting regions on the surface.

The dust lifting regions shown in Figure 1 correlate with observations of high latitude storms forming at this location during Northern Hemisphere spring (Cantor et al., 2010). Areas of Northern Hemisphere dust lifting shown in Figure 2 correlate with locations that have been observed to generate ‘flushing’ storms during Southern Hemisphere summer (Wang, 2007).

To complement the global depictions of dust lifting regions across increasing model resolutions, we are planning to compare in detail a range of local regions that display differing dust lifting rates across resolutions. We will again compare these results with observations of dust storms in those regions.

**Total dust lifted.** While the results from the
lowest resolution simulations appear to produce a linear plot, the result from the highest resolution simulation so far completed does not continue this trend. Our results suggest that, within the MGCM, the quantity of dust lifted annually by near-surface wind stress may tend towards a ‘plateau’ as the resolution increases; the point at which this occurs cannot currently be estimated accurately.

Higher resolution simulations are planned (e.g. T127, corresponding to a physical horizontal resolution of 1.25° latitude by 1.25° longitude, and T170, corresponding to 0.94° latitude by 0.94° longitude) that will extend the data available in assessing the trend of total dust mass lifting with increasing resolution.

Acknowledgements: The authors wish to thank the UK Space Agency for funding under grant ST/M00306X/1 and the UK Science and Technology Facilities Council for funding under grant ST/L000776/1.

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