Wind-Stress Dust Lifting in a Mars Global Circulation Model: Representation across Resolutions

Conference or Workshop Item

Wind-Stress Dust Lifting in a Mars Global Circulation Model: Representation across Resolutions

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1. Wind-Stress Dust Lifting on Mars

The formation of dust storms on Mars (**Fig. 1**) is thought to be driven by dust lifting due to near-surface wind stress[1, 2, 3]. Accurately representing this dust lifting within Global Circulation Models (GCMs) is important in order to gain a full understanding of Martian climatology and the dust storm cycle.

The global model resolution typically used to study the Martian climate is useful in representing large-scale weather patterns, but smaller scale phenomena (e.g. near-surface winds driven by local topography) cannot be accurately depicted at this resolution.

Higher resolution simulations are required in order to better represent small-scale atmospheric events. However, few studies have explored in detail how the results of GCM experiments are affected by changing the resolution of the model.

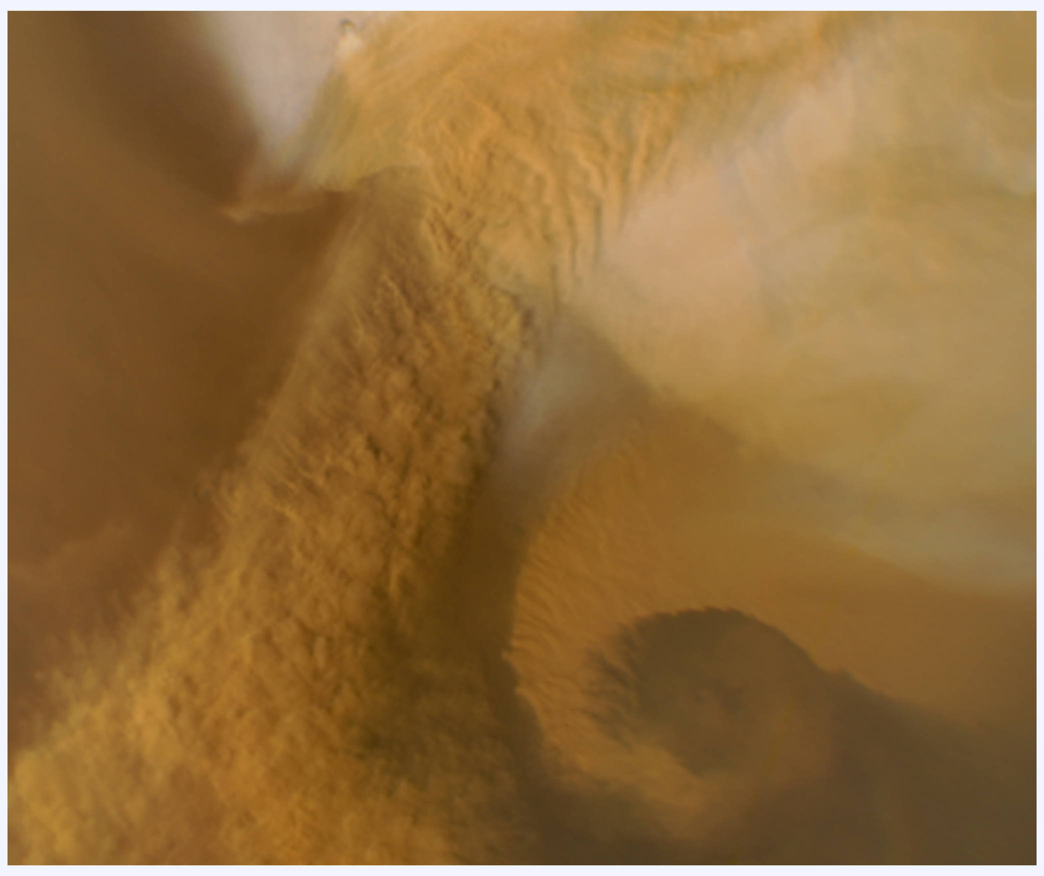


Figure 1. MARCI view of a north polar spiral storm. *Image credit: NASA/JPL-Caltech/MSSS.*

2. Modelling the Martian Atmosphere

The Mars Global Circulation Model (MGCM)[4] is a global, three-dimensional model of the Martian atmosphere. Large-scale dynamic circulations and physical processes are modelled explicitly, while smaller scale processes are parameterised.

Within the wind-stress dust lifting parameterisation, Martian surface dust is lifted when near-surface wind stress exceeds a selected threshold[5]. Similar parameterisations exist within several Mars GCMs[2, 6, 7].

An accurate parameterisation will lift a representative dust mass, and the geographical distribution of this dust lifting will change throughout the year, affecting patterns of dust storm formation and development.

We have completed multi-year simulations to investigate how modifying the horizontal and vertical resolutions of the MGCM affect the quantity, timing and location of wind-stress dust lifting.

3. Results

Increasing the Horizontal Resolution

In experiments with fixed lifting parameters, we find that increasing the horizontal resolution of the model results in more dust being lifted by wind stress, across a wider geographical range (**Fig. 2**).

This was anticipated; increasing model resolution improves the representation of small-scale topography-induced atmospheric phenomena, such as slope winds and polar cap edge turbulence.

Initial results suggest that as horizontal resolution is increased, the total mass of dust lifted through this process tends towards an asymptotic curve (**Fig. 3**).

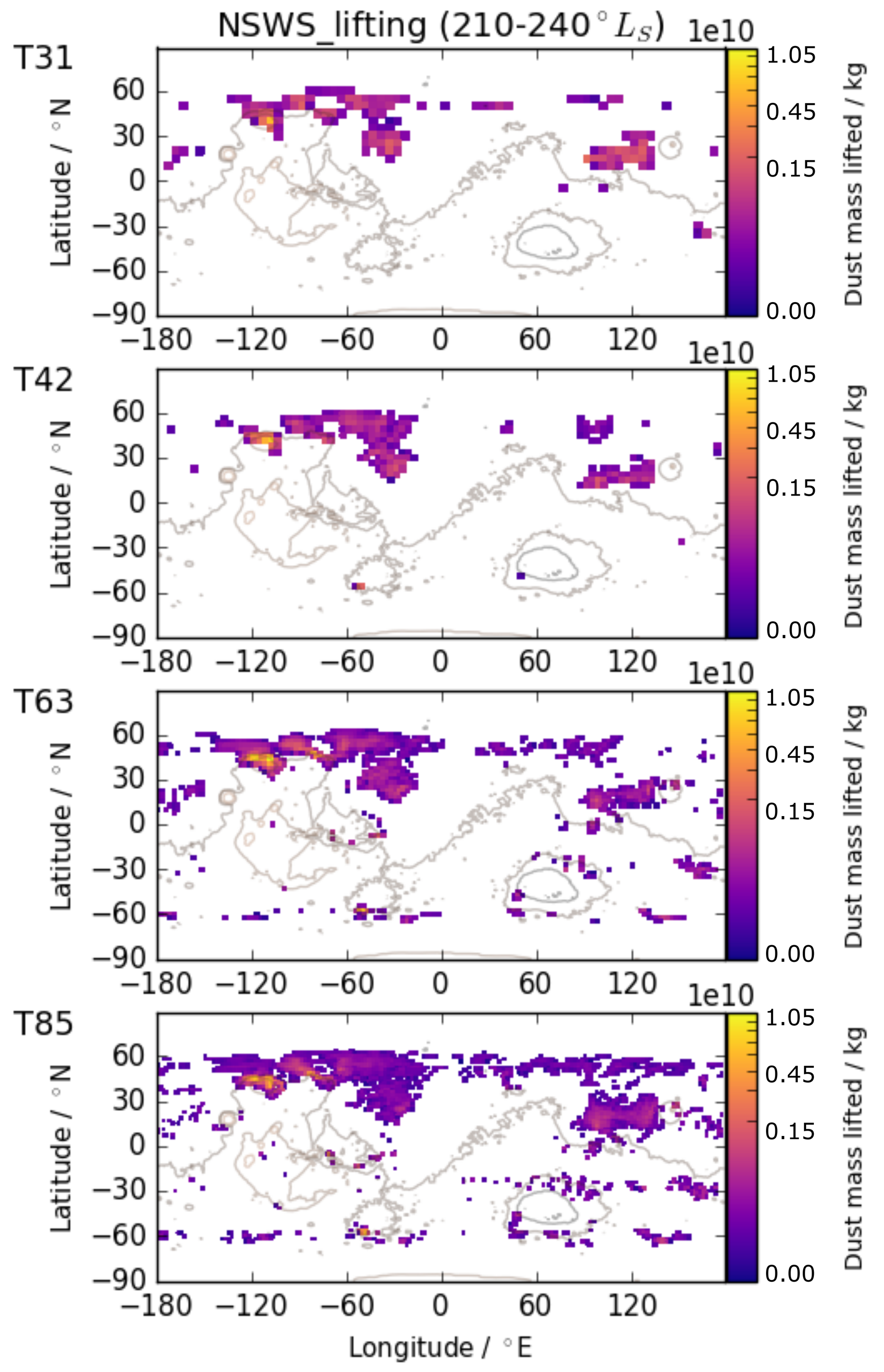


Figure 2. Patterns of wind-stress dust lifting in experiments utilising a range of horizontal resolutions (see **Fig. 4**). Brighter colours denote higher amounts of lifted dust. (White areas indicate zero dust lifted.)

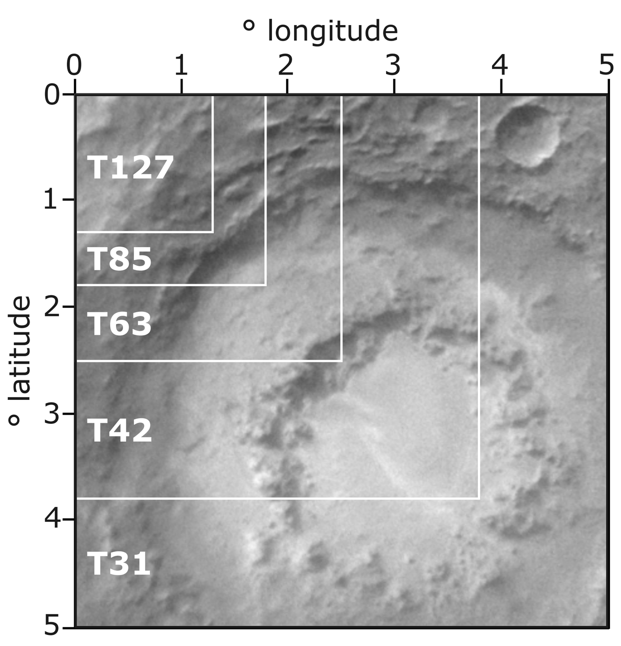


Figure 4. Approximate physical gridbox sizes across resolutions. *Image credit: MSSS/MGS/JPL/NASA* (Lowell Crater).

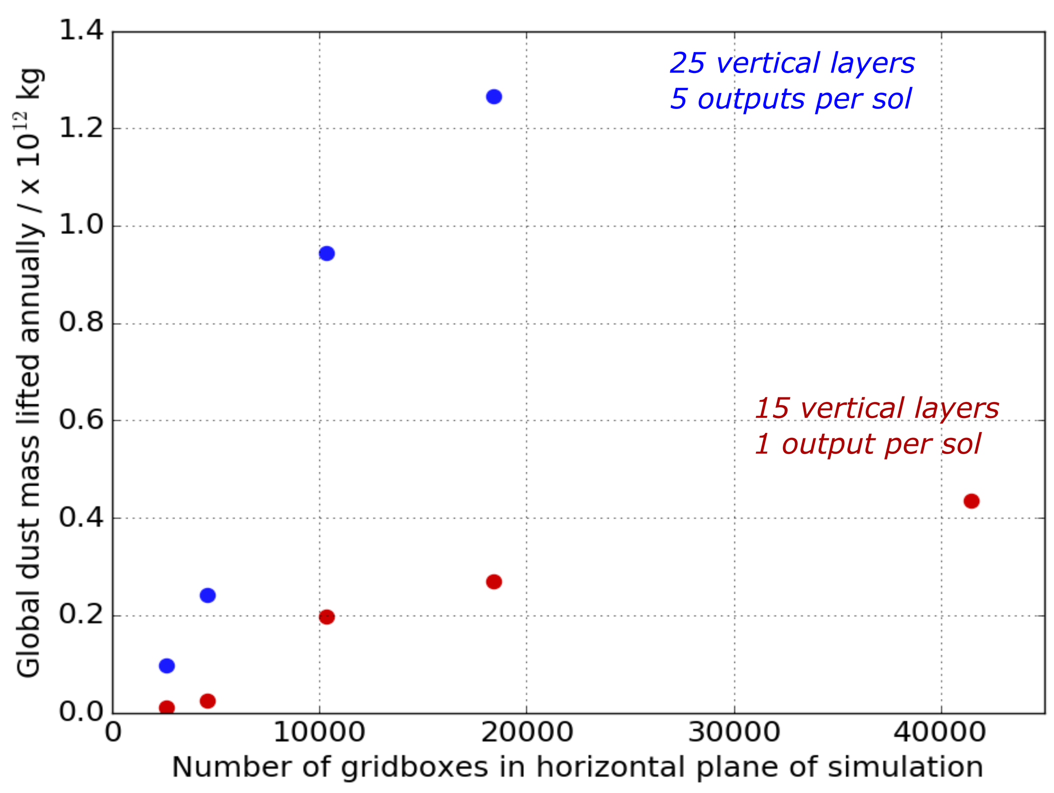


Figure 3. Global dust mass lifted by wind-stress through one Martian year, across multiple horizontal resolutions (T31 to T127, see **Fig. 4**). Initial high resolution results show an apparent asymptotic trend in the amount of surface dust lifted as resolution is increased.

Increasing the Vertical Resolution

We also find that increasing the number of vertical layers within a simulation results in more wind-stress dust lifting, in total and across more widespread locations (**Fig. 5**).

Our initial findings suggest that lower resolutions (i.e. those utilising relatively few vertical layers) may not fully capture the variation in wind speeds that is present in the lower atmosphere at certain locations across the surface (**Fig. 6**).

Experiments completed using the MGCM typically use simulations of up to 35 vertical layers. We suggest that, depending on the precise phenomena being investigated, this may not be a high enough vertical resolution to correctly represent the behaviour of the Martian atmosphere.

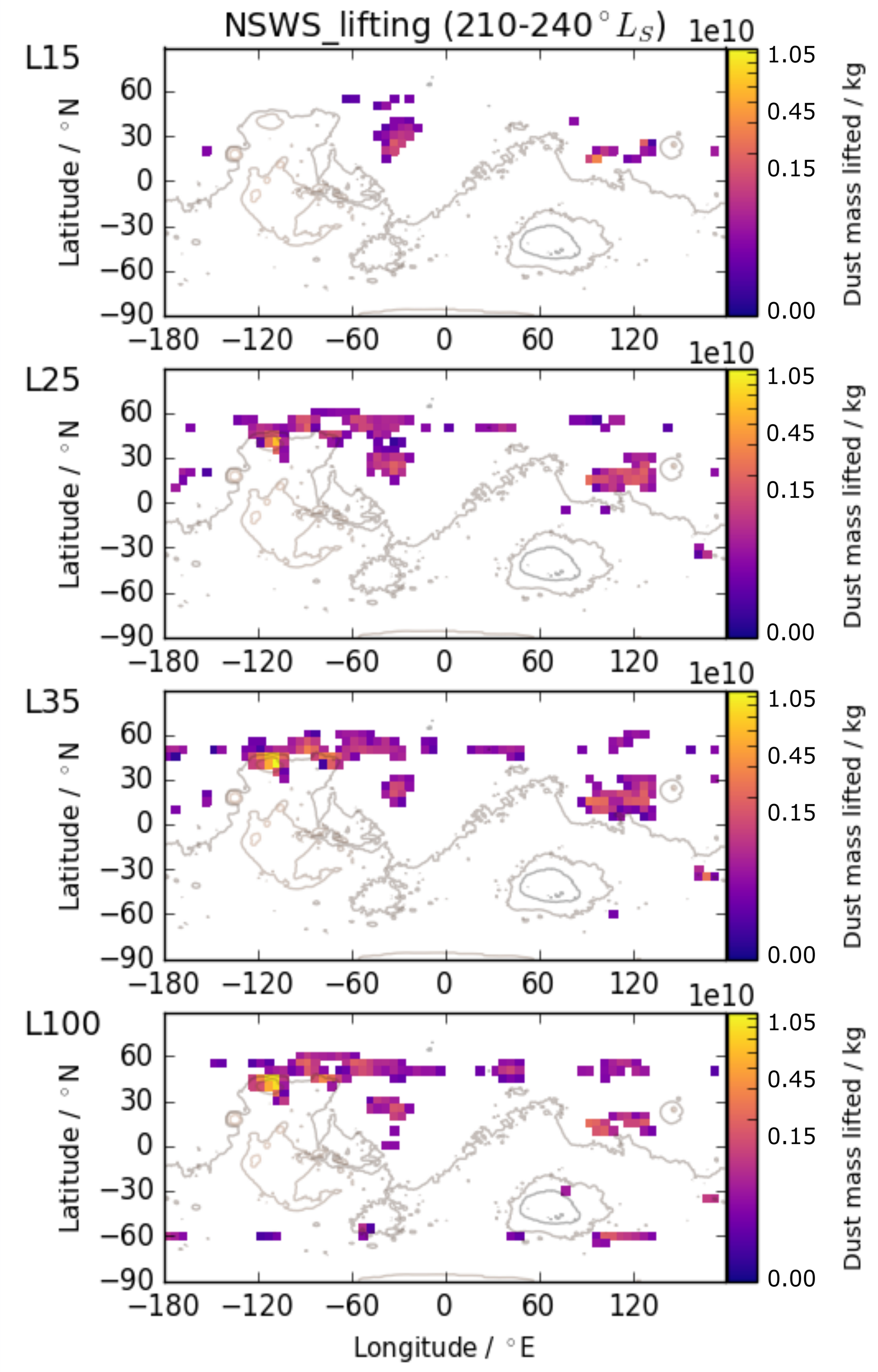
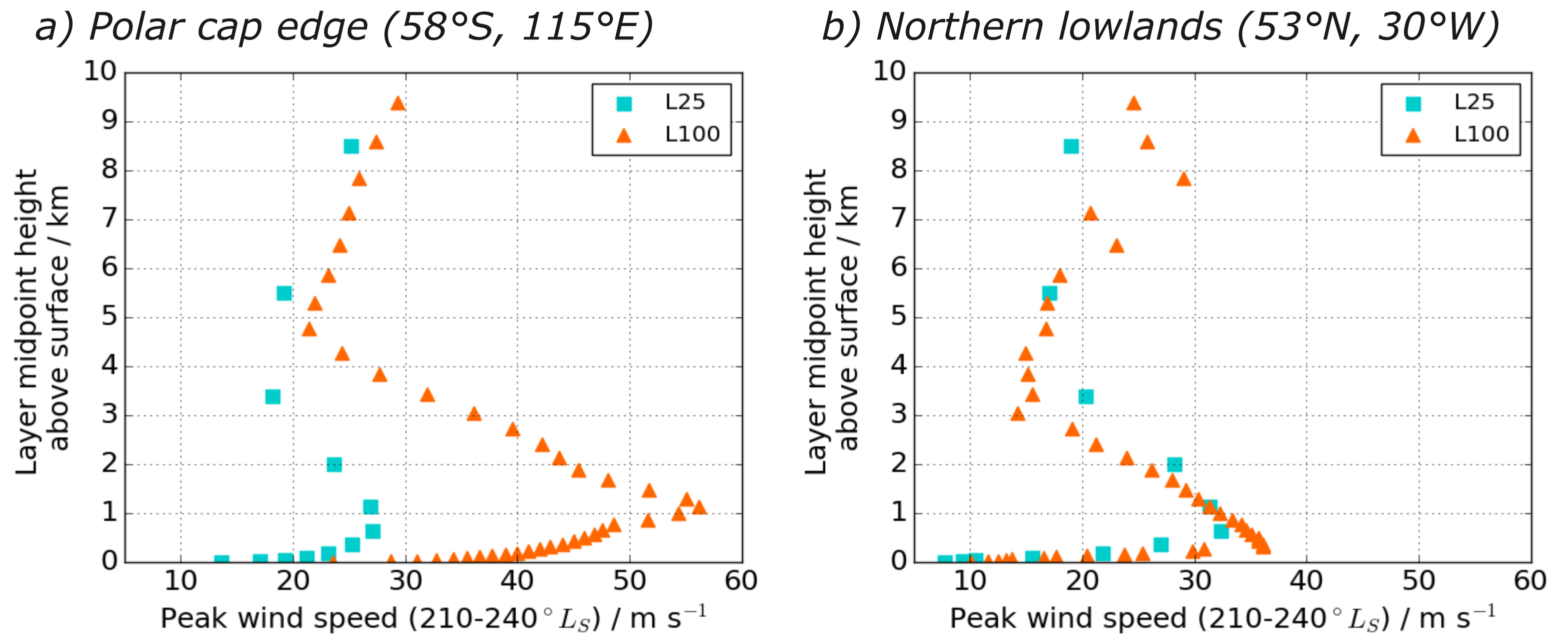


Figure 5. Patterns of wind-stress dust lifting in experiments utilising different numbers of vertical layers, L15 to L100 (at T31 horizontal resolution, see **Fig. 4**). Colours as in **Fig. 2**.

Figure 6. Vertical atmospheric profiles of peak wind speeds, during mid Southern Hemisphere spring (210-240° L_S), in models of different vertical resolutions (25 and 100 layers).
Two selected surface locations are shown: a) a polar cap edge location in which a potential high speed jet is resolved at the higher resolutions, and b) a northern lowlands location which does not evidence the same behaviour.



5. Conclusion

We find that increasing the MGCM horizontal resolution results in more wind-stress dust lifting, due to improved representation of small-scale atmospheric phenomena.

Initial results suggest that as resolution is increased, the total mass of dust lifted globally through this process tends towards an asymptotic curve.

We also find that increasing the MGCM vertical resolution results in more widespread wind-stress dust lifting. Our results highlight potential low-level winds that are not identified in simulations using fewer vertical levels.

We suggest that MGCM experiments using too few atmospheric vertical layers may not adequately represent the behaviour of the Martian atmosphere.

References

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