Martian Dust Devils: When to Watch for Them

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MARTIAN DUST DEVILS: WHEN TO WATCH FOR THEM

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Introduction: This work investigates surface dust lifting by Martian dust devils within a global-scale computer model, and has revealed unexpected behaviour in the timings of these atmospheric events. This work aims to improve current knowledge of the function played by dust devils in the Martian dust cycle: understanding how dust devils contribute to the dust loading of the Martian atmosphere is key to understanding the planet's current climate, and to making predictions of the environment that future landers and rovers will encounter.

Dust is present within the atmosphere of Mars as a constant background haze, its presence affecting local winds, the global climate, and the formation and development of dust storms. Dust is lifted from the surface of the planet primarily by winds; this lifting is implemented in models through representations of near surface wind stress and dust devils.

Dust devils are named after the similar features observed on Earth: near-surface atmospheric vortices that are visible due to the particles they lift from the ground and entrain in a vertical, upwardly spiralling column of air [1]. Martian dust devils were first identified in Viking Orbiter images [2] and have since been observed in a large number of images captured by Mars orbiting missions, as well as in multiple images returned from rovers on the surface [3, 4].

Existing predictions of Martian dust devil short-term behaviour are largely informed by observations of dust devils on Earth. Orbital and lander or rover observations of Martian dust devils are often temporally limited in their coverage, either due to viewing periods in the case of orbital platforms [5] or due to power considerations and local weather patterns that can affect lander and rover operation [6].

Method: This work uses a Mars Global Circulation Model (MGCM) to investigate global dust devil activity over an extended period of time. The MGCM in use at The Open University is a computer model of a dynamic planetary atmosphere, simulating global atmospheric circulation [7]. The model divides the planetary atmosphere into a three dimensional grid; physical processes are modelled within this grid, either explicitly, in the case of very large scale processes, or, in the case where a process takes place on a smaller scale than the model can resolve, through parameterisation.

Results: While dust devil activity on Earth is seen to peak in the early-to-mid afternoon, the results from our simulations display an unexpected bimodal distribution of dust devil activity, with considerable surface dust lifting by dust devils occurring in the early-to-mid morning (Figure 1). The hourly distribution of dust devil activity is location-dependent, but areas displaying high levels of morning activity are widely spread across the surface of Mars (Figure 2).

These results have been directly compared to dust devil observations made by a number of landers and rovers, considering the sites and seasons at which these platforms were able to make observations. Model correlation with surface observations varies by location. Further work is required to explore the causes of the unexpected morning dust lifting.

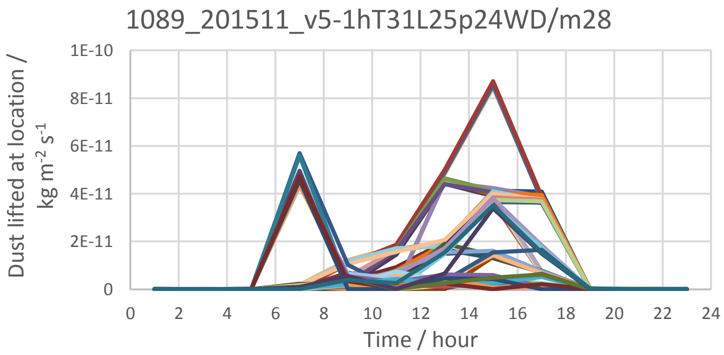

Figure 1: Model results of dust lifted by dust devils at the Viking Lander 2 site, showing two peaks in dust lifting at ~0900 and ~1500 local time.

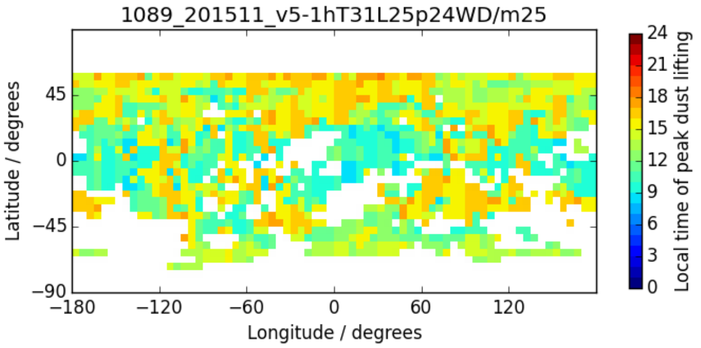

Figure 2: Model results of the global daily distribution of peak dust devil activity, showing areas with high levels of morning dust lifting (blue) and afternoon dust lifting (yellow).

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