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Storms, devils and dust on Mars

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Through unprecedented high-resolution modeling, the dynamics of small-scale dusty circulations key to the Martian dust cycle is explored.

Background The thin veil of suspended dust particles in the Martian atmosphere absorbs incoming sunlight mainly in visible wavelengths (and outgoing infrared radiation), which locally warms the Martian troposphere. Airborne dust is therefore a crucial climate component on Mars which impacts atmospheric circulations at all scales. At the same time, the amount of dust in the atmosphere is controlled through lifting and transport by winds at various scales, mainly through dust storms and dust devils. Hence studying those mesoscale-to-microscale meteorological events remains of key interest to better understand the Martian climate. In particular, the interplay between lifting, transport, sedimentation is addressed here, along with the possible feedbacks between transported dust and atmospheric dynamics [4]. To that purpose, high-resolution mesoscale modeling [5] and large-eddy simulations [6] are employed.

Storms Mesoscale simulations with radiatively-active transported dust are carried out and analyzed to determine the evolution of a typical regional dust storm with space and time (Fig. 1). The mesoscale model is forced at the boundaries of its limited-area domain with large-scale conditions at the season and location of the dust storm event monitored through OMEGA spectrometry by [3]. Initial conditions are set so that the dust disturbance (and the subsequent dust mixing ratio in the atmosphere) ressembles the observed storm as far as opacity and width is concerned; the storm is then free to evolve. A sensitivity study complements the analysis through simulations with/without the radiative effect of transported dust, with/without lifting, with/without nonhydrostatic contributions. Of particular interest are the strong vertical velocities obtained within a regional dust storm [4] and the occurrence of detached layers [2].

Devils Vortices associated to the vigorous Martian boundary layer convection are known to have an enhanced ability to both lift and inject dust in the atmosphere, forming dust devils. Large-Eddy Simulations (LES) are particularly helpful so as to get insights into such phenomena; however, the simulated width for convective vortices was too large in models compared to observations [5]. Here, LES with unprecented grid spacing of 10 m are carried out to account for the correct properties of those phenomena (Fig. 2) thought to significantly impact the Martian dust cycle. The statistics of simulated vortices can be compared to actual dust devil statistics monitored *in-situ* [1].

Further work Applying our mesoscale tools to other planetary environments is under consideration to investigate their small-scale atmospheric phenomena.

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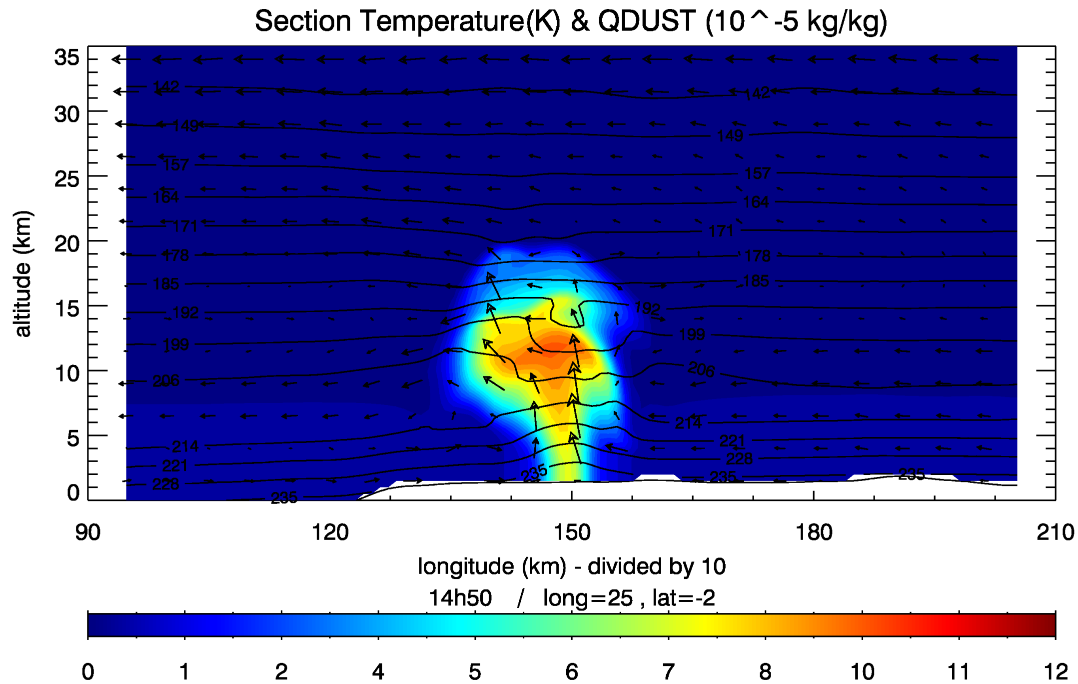

Figure 1: Results of a $dx = 10$ km mesoscale run in Meridiani ($L_s = 135°$). Dust mass mixing ratio is shown 1.5 h after starting with a $\tau = 4$ disturbance with $r = 30$ km and $\Delta z = 10$ km. Vertical wind reaches 6 m s^{-1}.

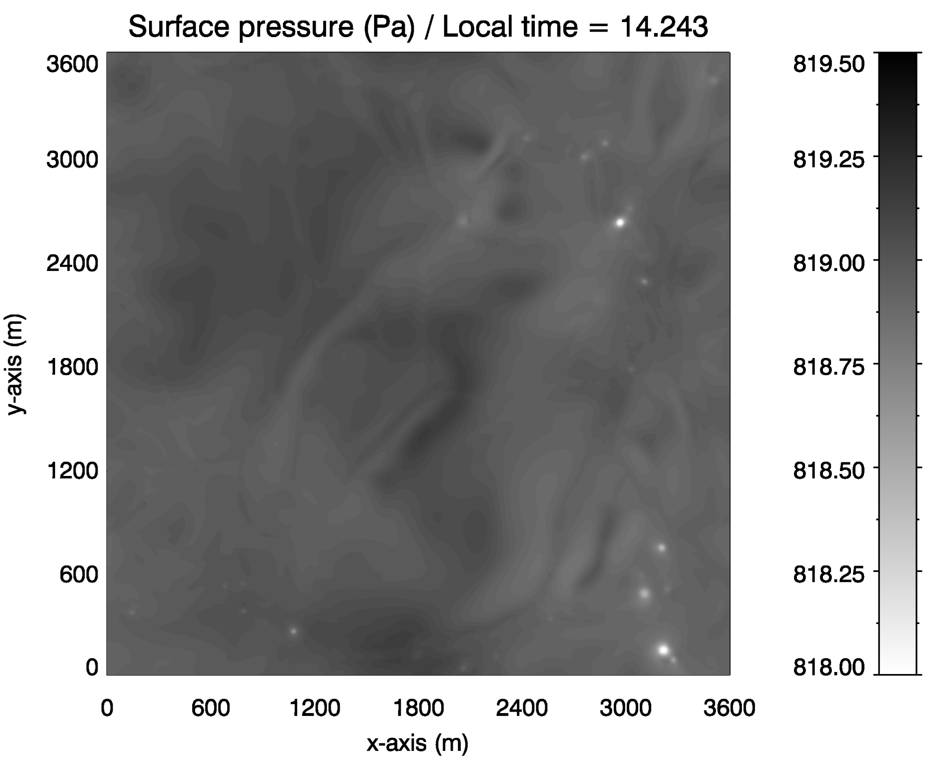

Figure 2: Results of a $dx = 10$ m Large-Eddy Simulation (LES) in an high-latitude plain similar to the Phoenix landing site ($L_s = 90°$). White dots denote low-pressure cores i.e. convective vortices that would form dust devils.