MESOSCALE AND LARGE EDDY SIMULATIOSN OF DUST DEVILS IN AMAZONIS PLANITIA, MARS. L. K. Fenton[1] and T. I. Michaels[2], [1]Carl Sagan Center at the SETI Institute, Mountain View, CA, 94043, USA (lfenton@carlsagancenter.org), [2]Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO, 80302, USA.

Introduction: The first dust devils identified (from orbit) on Mars were found in high resolution (60-80 m/px) Viking Orbiter images, mostly in Amazonis Planitia [1]. Recent surveys of martian dust devils using MOC images agree with this earlier work, finding that Amazonis Planitia produces the largest number of dust devils, lifting enough dust to significantly contribute to the background dust opacity on Mars during northern spring and summer [2,3].

Vertical vortices form at the vertices of convective cells in the planetary boundary layer (PBL), and they may become visible as dust devils if they reach the surface and are strong enough to entrain dust [4]. As a result, their distribution provides information on the structure and circulation of the daytime PBL. The Amazonis dust devils are much larger than their terrestrial counterparts, with widths up to 1 km and heights up to ~8.5 km [e.g., 2]. Although not all dust devils reach this height (most are ~1-2 km high in this region), the height of the tallest dust devils are generally thought to indicate a lower limit of the PBL height.

Despite being a potentially significant source of ambient atmospheric dust, as well as the only visible and measurable portions of the highly complex three-dimensional turbulent convection that occurs within the PBL, little is known about the nature or cause of the particularly large vortices in Amazonis Planitia: how do they grow to such heights and why do they do so in only in this location? We seek to address these questions by modeling the atmosphere both at the mesoscale and with high resolution large eddy simulations.

Mesoscale Simulations: The Mars Regional Atmospheric Modeling System (MRAMS) is a non-hydrostatic, finite-difference, limited domain mesoscale model [5,6]. It can perform LES when the subgrid scale turbulence is modified to explicitly model eddies down to the domain resolution, based on the method of [7]. Mesoscale simulations of Amazonis Planitia were run at $L_s = 120^o$, the height of the dust devil season [2], nesting down three times to a horizontal grid resolution of 20 km. The final domain spanned ~1420 km horizontally (71 x 71 grid points), with 60 vertical layers ranging in thickness from 30 m near the surface to 2.3 km near the top. The simulation was run for more than four sols to gain insight into any sol-to-sol variations that may occur.

Mesoscale Results: A snapshot of winds in the domain at 13.8h local time (in the center of the domain) shows that, even at the coarse grid spacing, vigorous convective activity is apparent over the low thermal inertia region (see Fig. 1). At the northern edge of the low thermal inertia region (~60 tiu) is a sharp gradient to a higher thermal inertia (~180 tiu) surface. As might be expected from these varying surface parameters, the model predicts that conditions are different on either side of this contact. Crossing from lower to higher thermal inertia, the surface temperature cools, causing cooler air temperatures (primarily through radiative transfer mechanisms), lowering the planetary boundary layer (PBL) height, and increasing the local air density. As a result of the density gradient and small topographic slopes, a wind blows from the high to the low thermal inertia region in the afternoon (an effect similar to an "onshore flow" common in coastal regions on Earth). This advection of cooler air over the low thermal inertia region would increase dry convective instability, intensifying the already vigorous convection over the hotter surface. We suggest that this mesoscale interaction may enhance dust devil formation on Amazonis Planitia, and that it may be partially responsible for the large size and density of dust devils in this region.

Large Eddy Simulations (LES): To appropriately model convective activity, it is necessary to perform LES in the regions of interest. We have run two simulations: one in the low thermal inertia region where the MOC surveys [2,3] were performed, and a second to the north where the thermal inertia is higher and few dust devils have been observed. The simulations were run under idealized conditions, such that the LES setup did not include topography, time-dependent mesoscale forcing, and the domains had periodic boundary conditions to effectively simulate the atmosphere over a vast plain.

Both LES were run with the same characteristics. The horizontal grid spacing was 100 m, spanning 24 km in each direction (240 x 240 grid points). The 99 vertical layers in the domains ranged in thickness from 4 m at the surface to 150 m near the top (at ~12 km). Each simulation was run from before sunrise (~5h) to after sunset of a single sol. Initial conditions, such as air temperatures, were taken from the Amazonis Planitia mesoscale simulation. The initial wind profile was set to 5 m/s at all heights.

LES Results: Overall, predictions from the two LES are very similar. As may be expected, the simulation for the low surface thermal inertia case produces higher surface and air temperatures, and convective activity develops more quickly than over the higher thermal inertia terrain. Under these idealized circumstances, the model does not predict an unusually large density of dust devils in either location.

Discussion: The cause of the high dust devil density in Amazonis Planitia may be related to mesoscale interactions not yet accounted for in the LES. To test this hypothesis, we are currently adding mesoscale forcing to the MRAMS LES. We will present results from this augmentation and make comparisons with the more idealized LES results.

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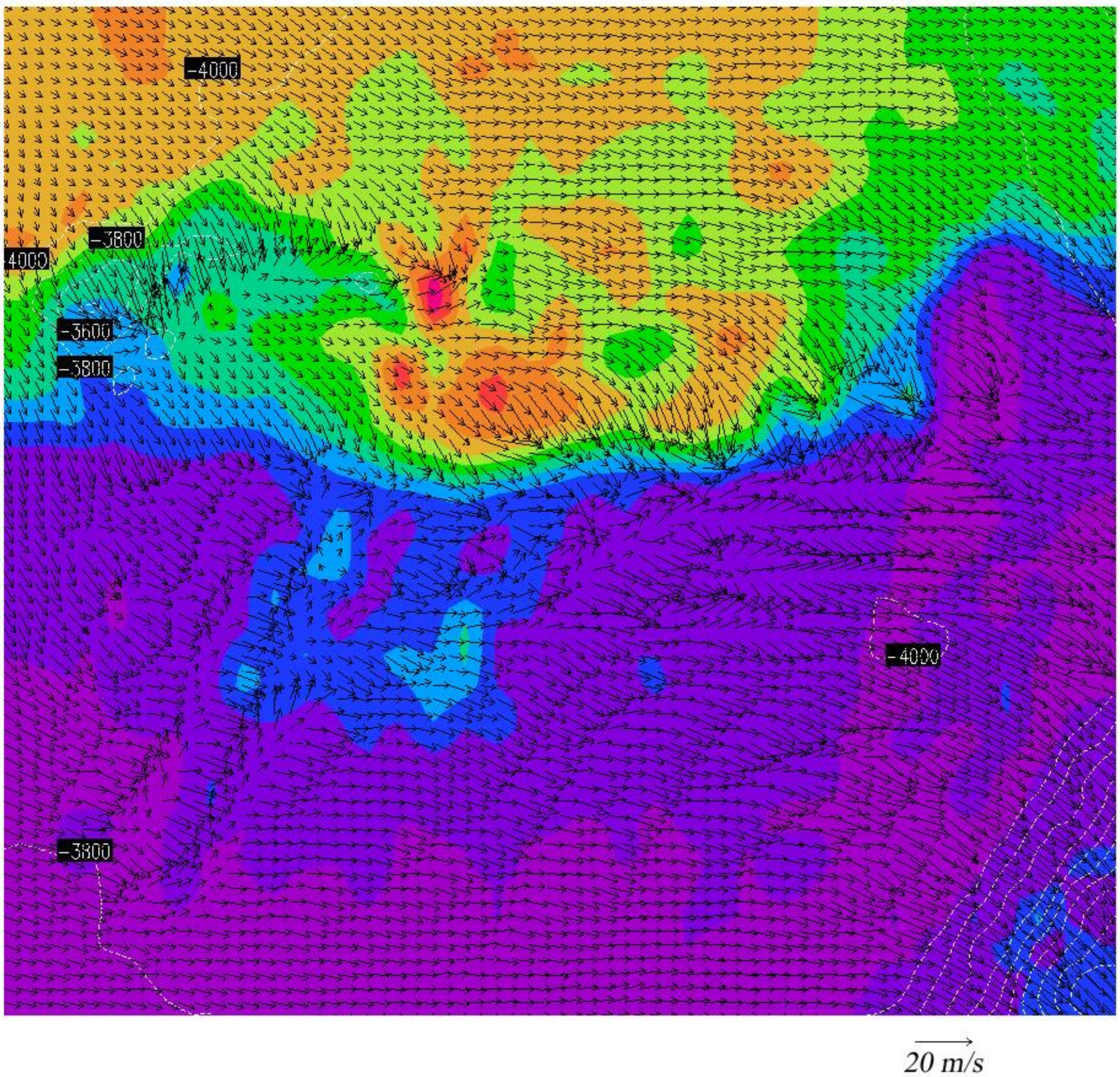

Figure 1. MRAMS mesoscale surface winds over Amazonis Planitia at 13.8h local time, L_s = ~120º. The center of the grid is at 35.5º N, 200º E. Shaded contours represent nighttime thermal inertia; white contours and numbers correspond to elevation (note the edge of the Olympus Mons aureole in the lower right). Large, orbitally-observed dust devils form mainly where the thermal inertia is very low. Their occurrence there may be enhanced by a mesoscale atmospheric interaction with the sharp contact with a higher thermal inertia surface to the north – note the strong northerly winds at the contact.