METEOROLOGICAL PREDICTIONS FOR MARS2020 EXPLORATION ROVER HIGH-PRIORITY LANDING SITES

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Introduction:

The Mars Regional Atmospheric Modeling System (MRAMS) is used to predict meteorological conditions that are likely to be encountered by the Mars 2020 Rover at several proposed landing sites during entry, descent, and landing (EDL). The meteorology during the EDL window at most of the sites is dynamic. The intense heating of the lower atmosphere drives intense thermals and mesoscale thermal circulations. Moderate mean winds, wind shear, turbulence, and vertical air currents associated with convection are present and potentially hazardous to EDL [1]. Eleven areas with specific high-priority landing ellipses of the 2020 Rover, are investigated: the eight high-priority remaining NE Syrtis, Nili Fossae, Jezero Crater Delta, Holden Crater, Southwest Melas Basin, Mawrth Vallis, , Columbia Hills and Eberswalde and the three of the recently rejected East Margaritifer Chloride, McLaughlin Crater and Nili Fossae Carbonates. MRAMS was applied to the landing site regions using nested grids with a spacing of ~3 km on the innermost grid that is centered over each landing site (see example on Figure 1). MRAMS is ideally suited for this investigation; the model is explicitly designed to simulate Mars' atmospheric thermal circulations at the mesoscale and smaller with realistic, high-resolution surface properties [2, 3]. Atmospheric circulation (see example on Figure 2) and vertical profiles of horizontal wind speeds, vertical wind speeds, and air temperature (see examples on Figures 3, 4 and 5), are studied to evaluate risks during EDL phase of the mission. For some landing sites simulations, two example configurations –including or not Hellas basin in the mother domain- were generated, in order to study how the basin affects the innermost grids circulations. Afternoon circulations at all sites pose some risk for entry, descent, and landing. Most of the atmospheric hazards are not evident in current observational data or general circulation model simulations and can only be ascertained through mesoscale modeling of the region. Deciding where to go first and then designing a system that can tolerate the environment would greatly minimize risk.

Methodology:

The simulation is configured with 5 grids. The innermost grid has a horizontal grid spacing of 2.96km. The model is run for 5 sols. Initialization and boundary condition data are taken from a NASA Ames GCM simulation with column dust opacity driven by zonally-averaged TES retrievals. Vertical dust distribution is given by a Conrath-ν parameterization that varies with season and latitude.

Water vapor cycle on Mawrth Valley:

Atmospheric transport is the driving mechanism in the absence of a local source for the water vapor cycle on Mars. The primary source of water vapor to the atmosphere is the northern polar cap during the Spring and early Summer. Once the winter CO_2 retreats, the underlying polar water ice is exposed and begins to sublimate. The water is transported equatorward where it is manifested in the tropical aphelion cloud belt. If transport is assumed to be the result of the Hadley Cell, then the polar water is carried aloft in the northern high latitude rising branch before moving equatorward and eventually toward the southern high latitudes [4, 5], see Figure 6. If this is the case, then the equatorial surface regions are moistened only once the water has moved to the southern hemisphere, descended to the surface, and is then moved northward at the surface back toward the equator. At the same time, it is likely that transient waves (e.g., storm systems) as well as boundary currents associated with planetary-scale stationary waves also advect and mix water equatorward.

New numerical experiments are being performed looking for evidence of a direct transport connection of the Mars2020 Mawrth Vallis landing site to the northern polar regions. Mawrth, an ancient water outflow channel with light-colored clay-rich rocks, is in the mid-latitude north hemisphere (Oxia Palus quadrangle), and is the closest Mars2020 landing site to north polar cap. We are studying if moist air in northern spring/summer makes it to Mawrth at Ls90 and Ls180, two periods with high column abundance of water vapor at mid/high latitudes [6], see figure 7. The objective is to study if circulation (mean or regional) is favorable for transport water vapor from north polar cap to Mawrth Vallis to activate hygroscopic salts and/or chlorides. If affirmative, it should be a go-to site due to habitability implications.

MRAMS was not run with an active water cycle although it has that capability. Future simulations with an active water cycle will help to better quantify the fate of water.

Conclusions:

Most of the atmospheric hazards are not evident in current observational data or general circulation model simulations and can be only be ascertained through mesoscale modeling of the region, providing estimates of the atmospheric hazards at potential landing sites. GCM models are important for identifying regions where synoptic-scale circulations and winds are favorable.

The meteorology during the EDL window at most of the sites is dynamic. Moderate mean winds, wind shear and vertical air currents associated with convection are present and potentially hazardous to EDL.

Afternoon circulations at all sites may pose some risk to entry, descent and landing. Vertical shear of the horizontal wind can induce unwanted oscillations of the EDL system.

Vertical variations of the vertical wind can also be hazardous.

If moist air in northern spring/summer makes it to Mawrth Vallis at Ls90 and Ls180 and feed hygroscopic salts and/or chlorides, it should be a go-to site due to habitability implications.

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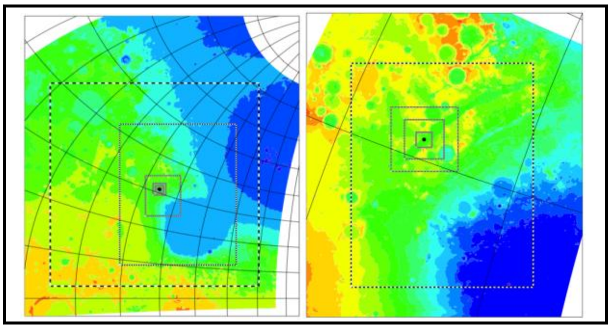

Figure 1: Horizontal Grid Spacing applied to Nili Fossae landing site.

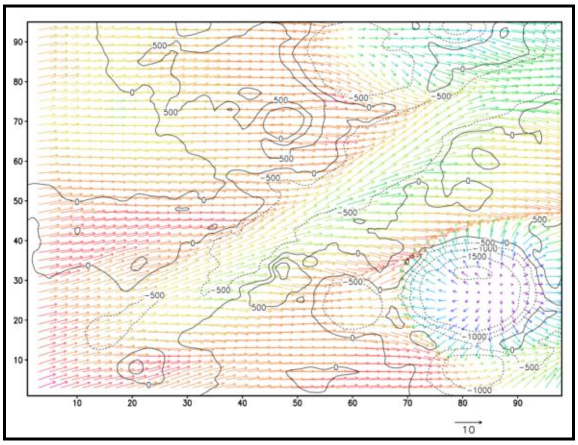

Figure 2: Atmospheric circulation of Nili Fossae landing site.

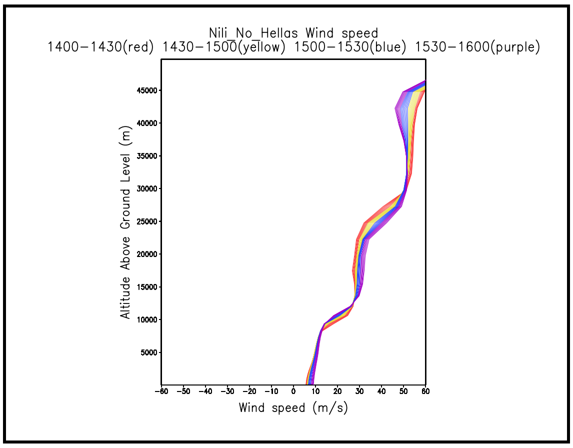

Figure 3: Horizontal wind speed vertical profile of Nili Fossae landing site.

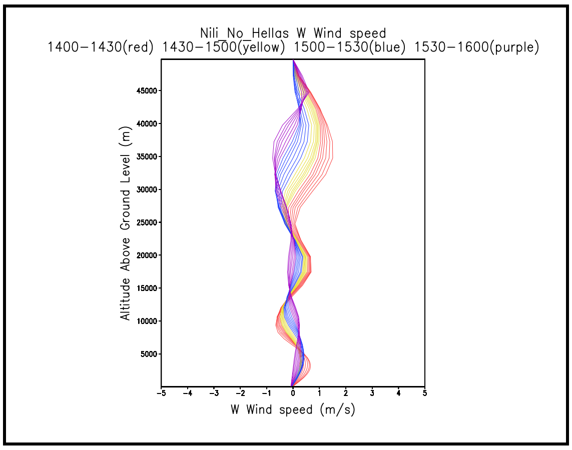

Figure 4: Vertical wind speed vertical profile of Nili Fossae landing site.

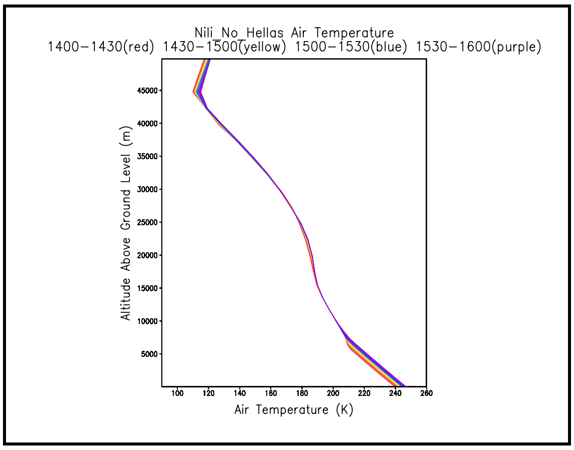

Figure 5: Air temperature vertical profile of Nili Fossae landing site.

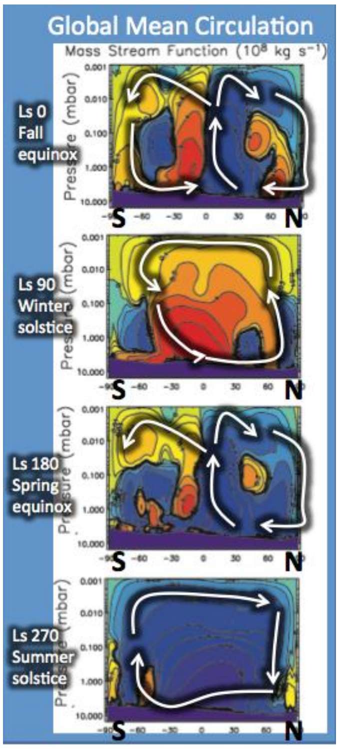

Figure 6: The seasonal planetary latitudinal gradient of temperature sets up a large-scale pressure gradient that drives a meridional circulation.

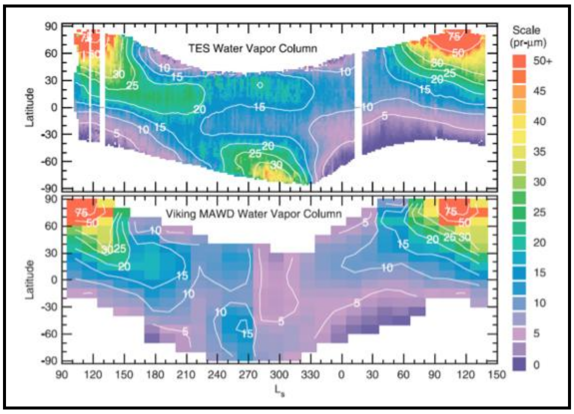

Figure 7: The column abundance of water vapor as a function of Ls and latitude: (top) as observed by TES. Contours show a smoothed representation of the results, and (bottom) as observed by Viking MAWD [Jakosky and Farmer, 1982].