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Meteorological predictions for Mars 2020 Exploration Rover high-priority landing sites

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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]. Nine areas with specific high-priority landing ellipses of the 2020 Rover are investigated: NE Syrtis, Nili Fossae, Nili Fossae Carbonates, Jezero Crater Delta, Holden Crater, McLaughlin Crater, Southwest Melas Basin, Mawrth Vallis and East Margaritifer Chloride. Vertical profiles and cross-sections of winds are studied.. Afternoon circulations at all sites pose some risk to entry, descent, and landing. Most of the atmospheric hazards are not evident in current observational data and general circulation model simulations and can only be ascertained through mesoscale modeling of the region. Deciding where to go first and then designing a passive landing systems that could tolerate the environment would greatly minimize risk.

MRAMS simulation configuration

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 [6] simulation with column dust opacity driven by zonally-averaged TES retrievals. Vertical dust distribution is given by a Conrath-v parameterization that varies with season and latitude.

Subsurface model

11 soil levels
1mm initial layer depth
1.5m bottom layer depth
Initialized from AMES GCM

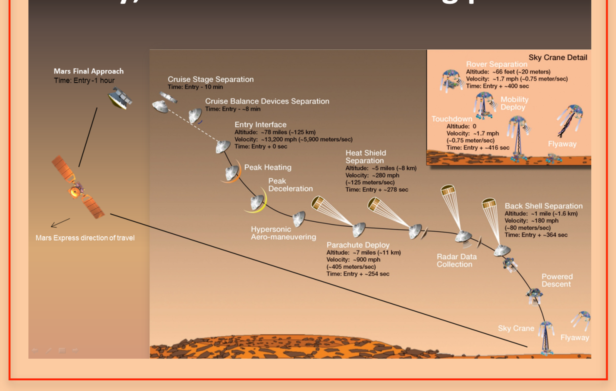
Vertical Grid Spacing

14.54m: First atmospheric layer
30m: Initial vertical grid spacing
1.12: Geometric stretch factor
2500m: Maximum grid spacing
50: Number of vertical grid points
51 km: Model top

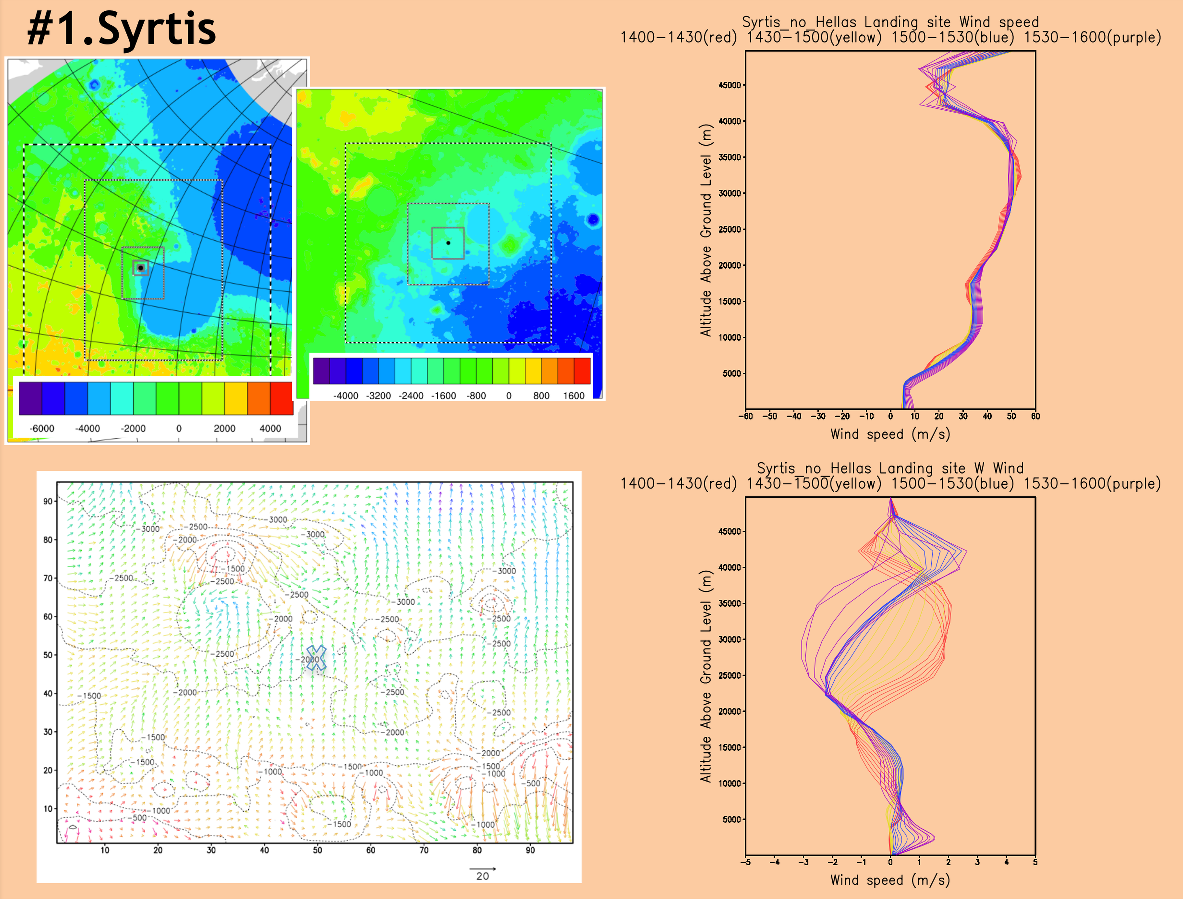
Physics

Subgrid-scale level 2.5 TKE parameterization.
NASA Ames two-stream, correlated-k radiation.
Topo shadowing and slope radiation effects.
Monin-Obukhov surface layer.
Water microphysics not active.
CO_2 ice statically placed from GCM.
Conductive regolith model

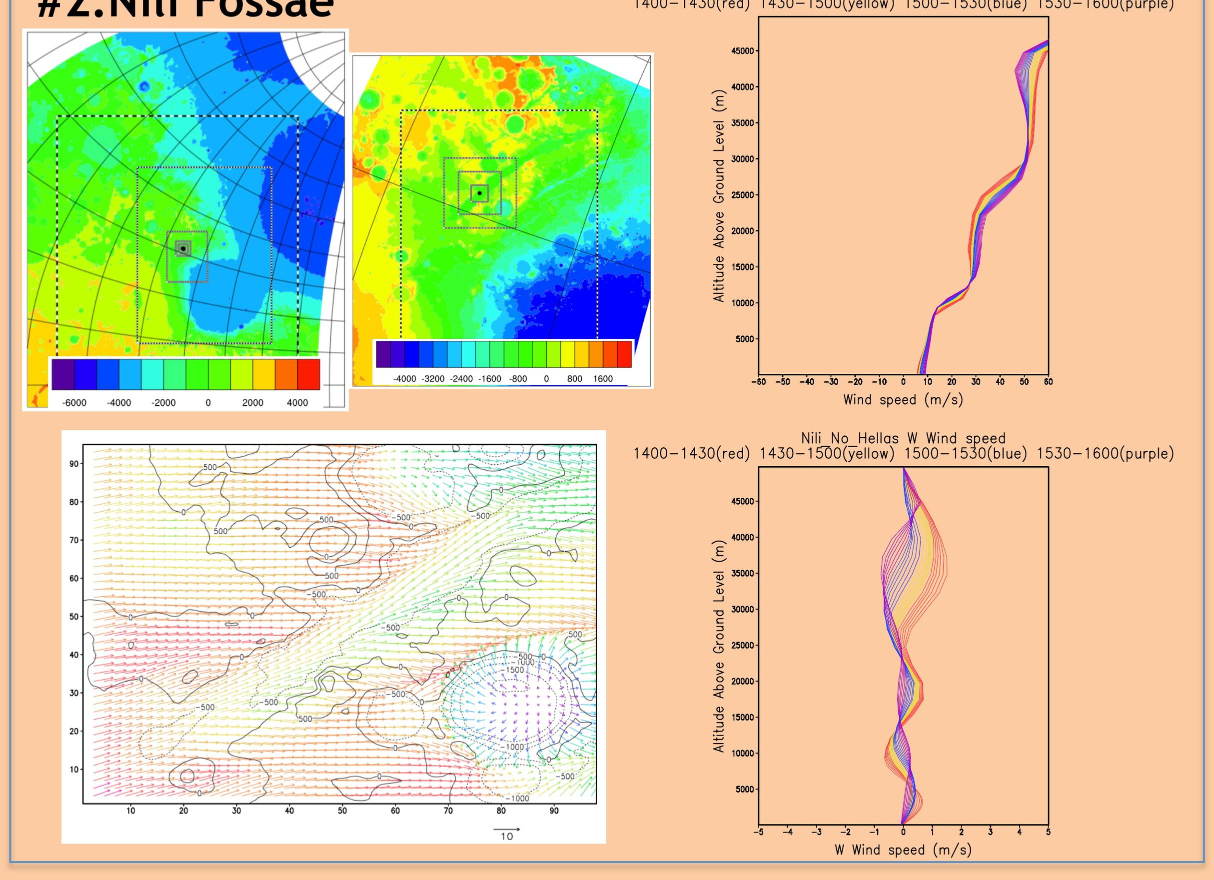
Entry, Descent and Landing phase



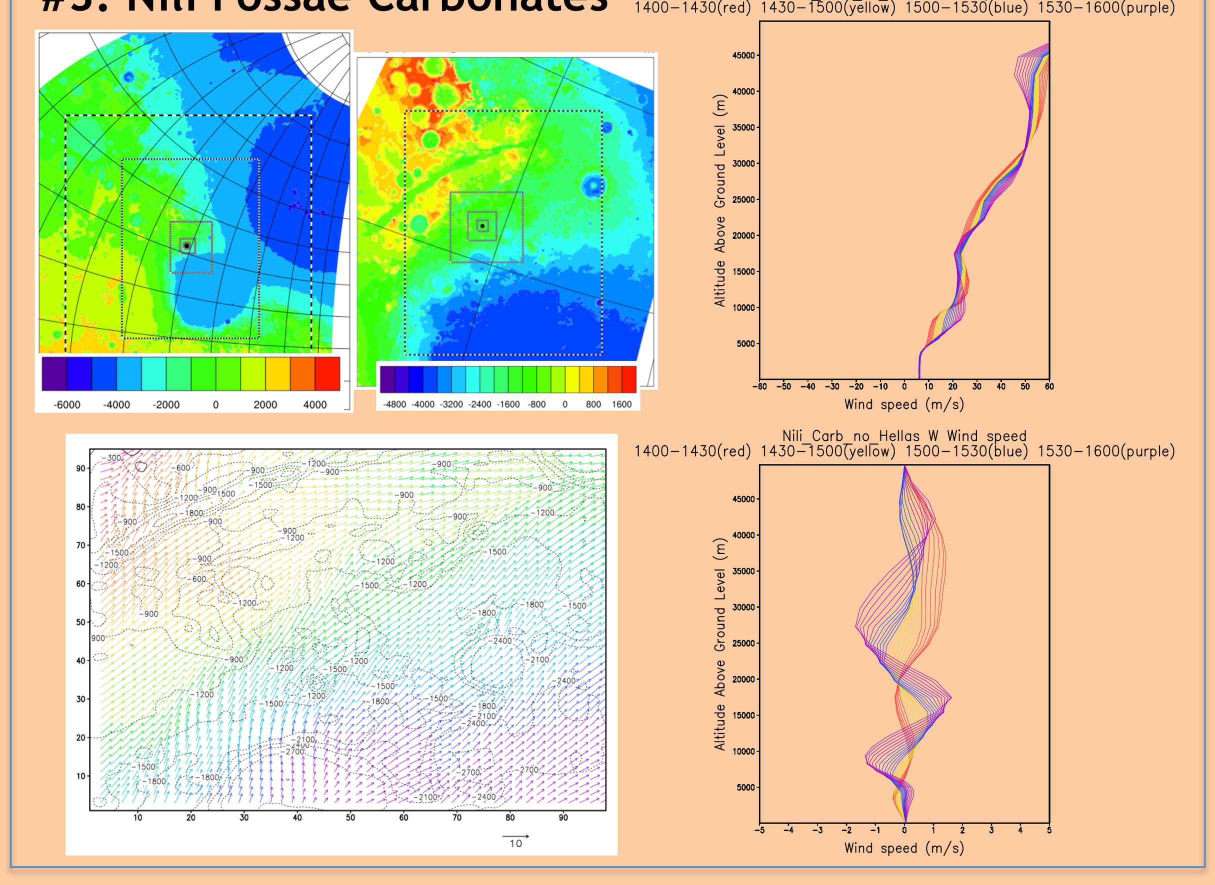
#1.Syrtis



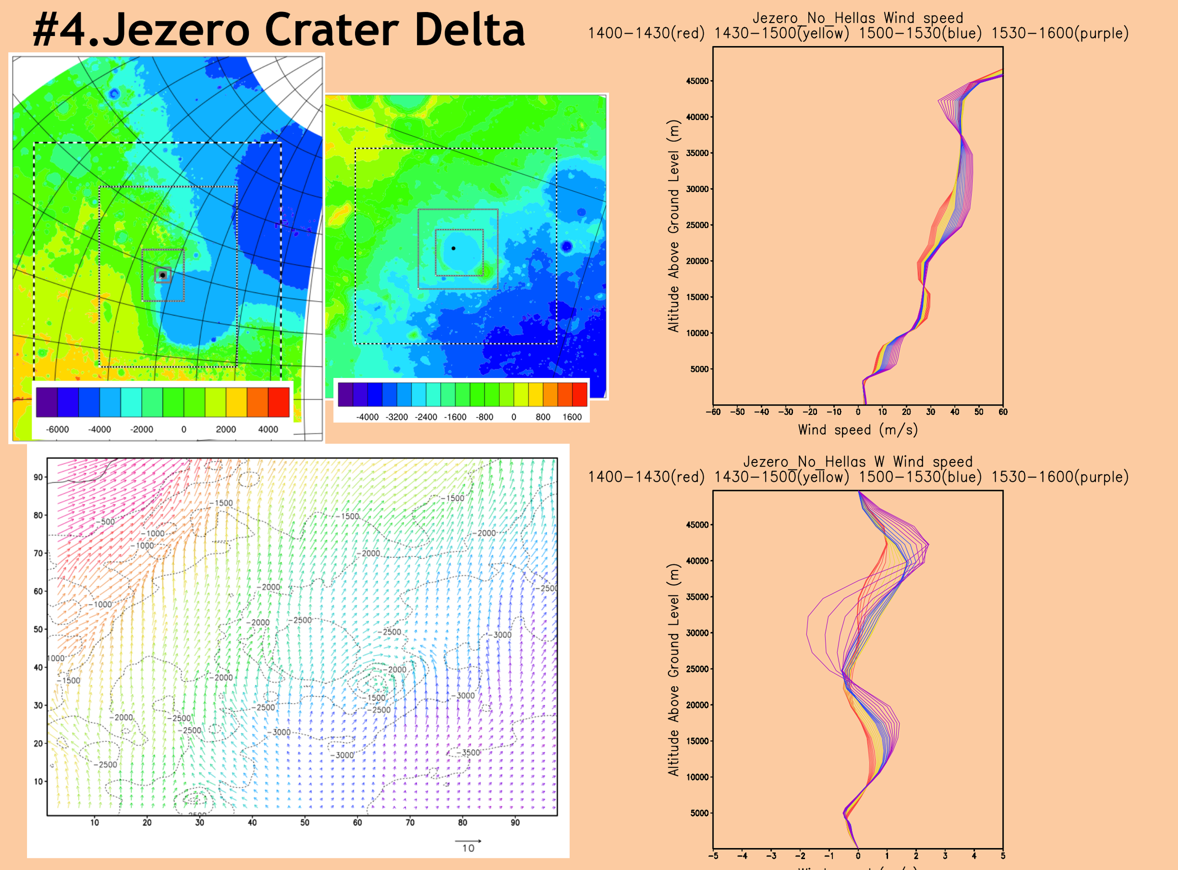
#2.Nili Fossae



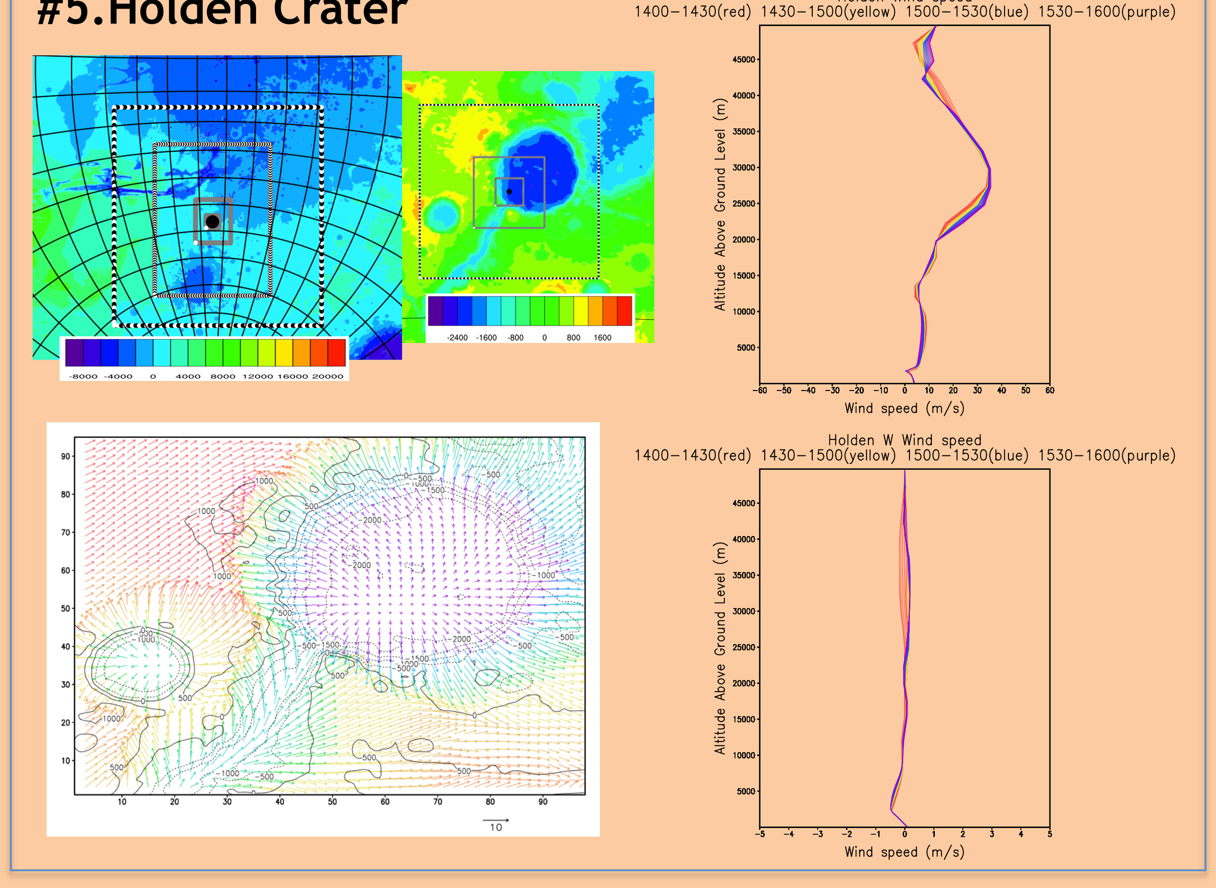
#3. Nili Fossae Carbonates



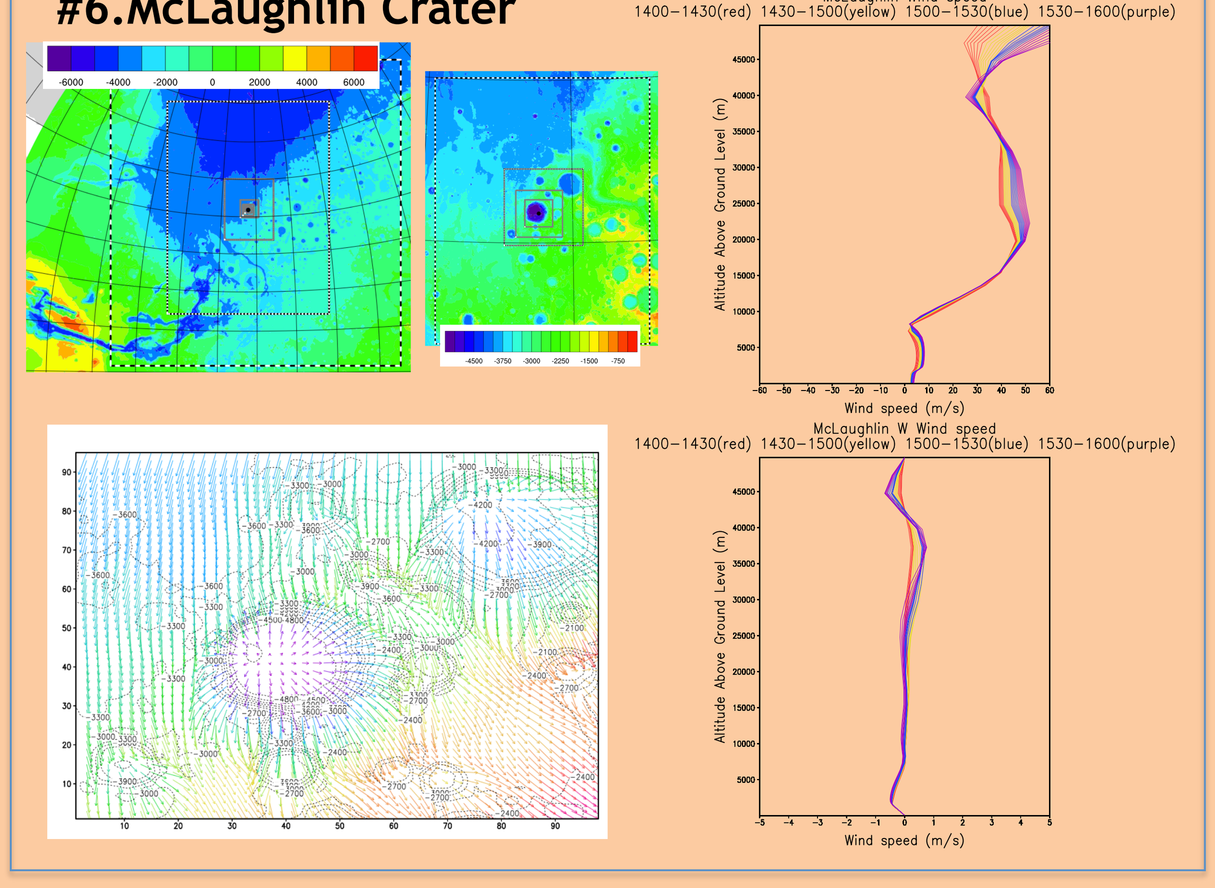
#4.Jezero Crater Delta



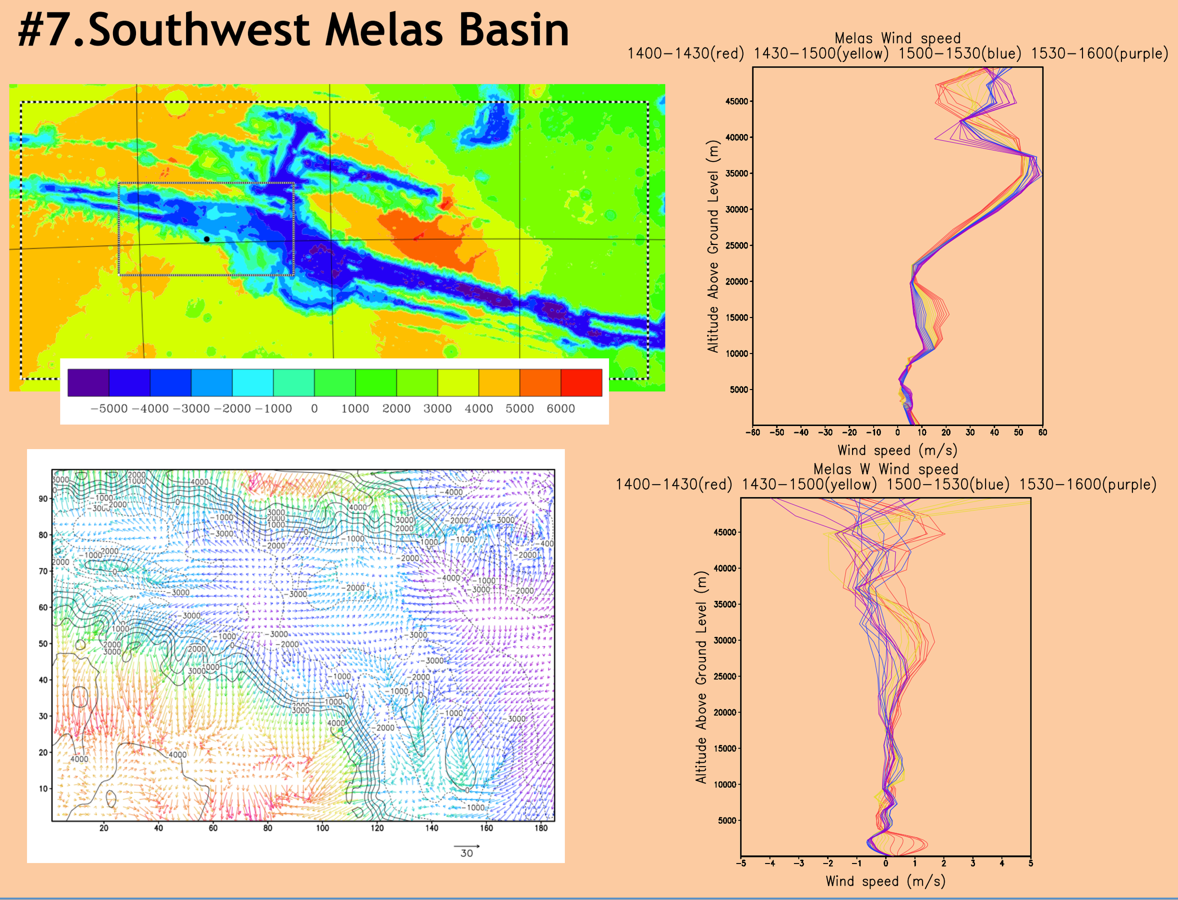
#5.Holden Crater



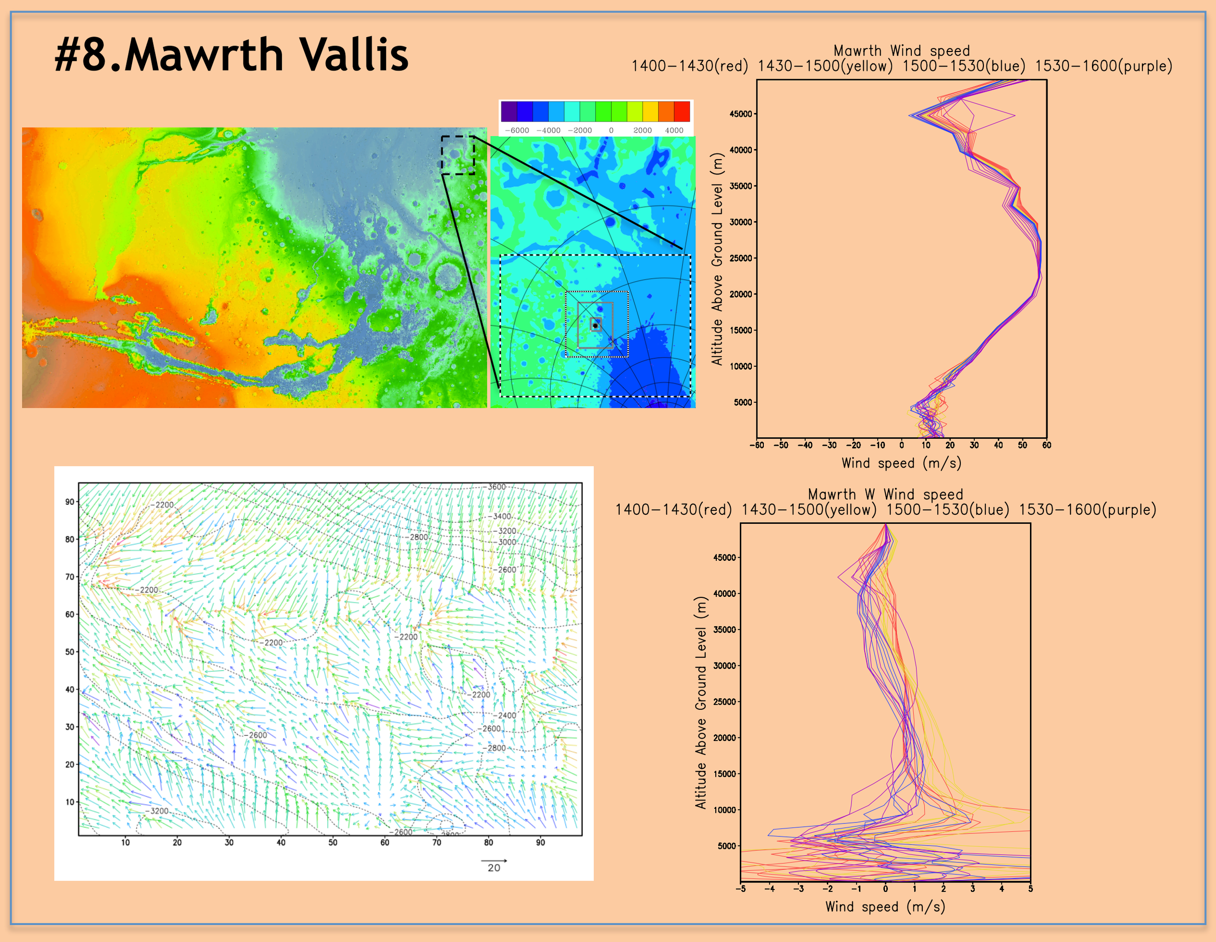
#6.McLaughlin Crater



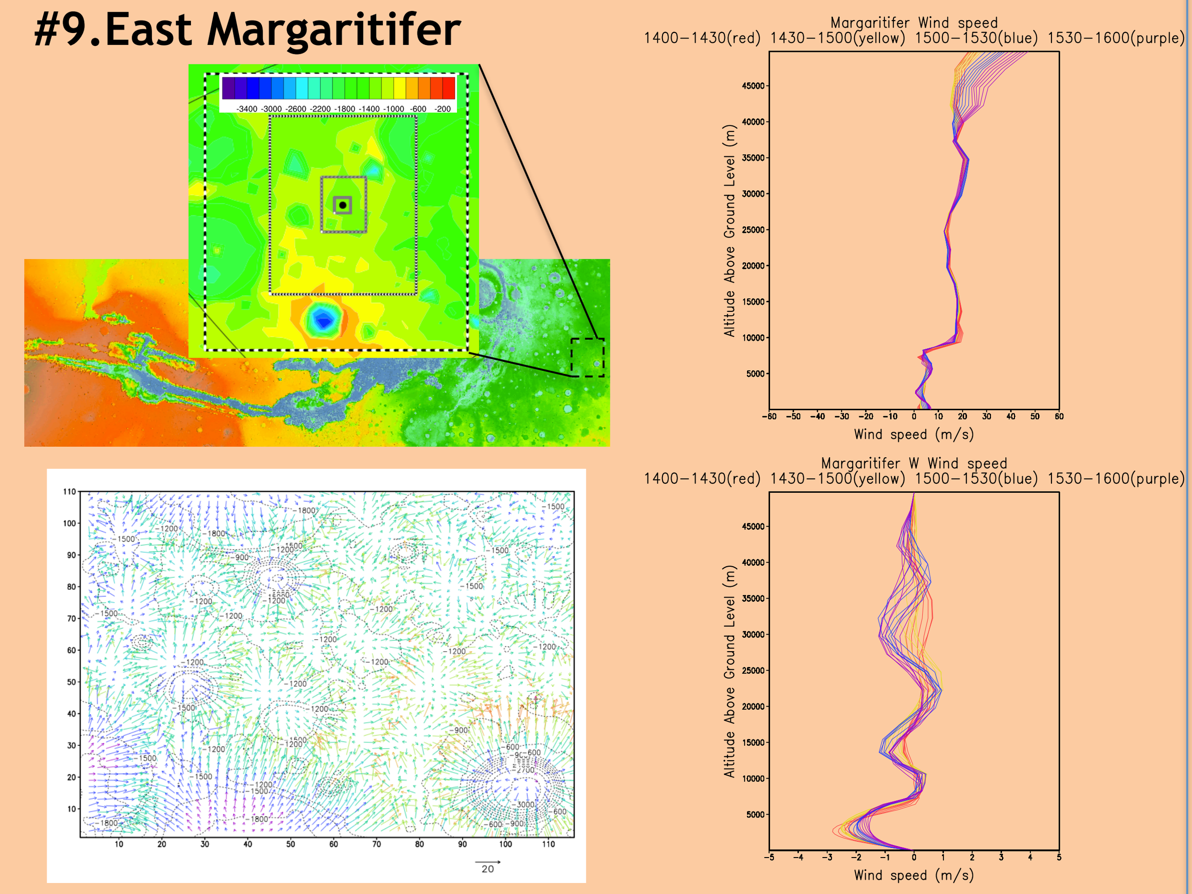
#7.Southwest Melas Basin



#8.Mawrth Vallis



#9.East Margaritifer



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 window during 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 pose some risk (significant risk in some cases) 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

[1] Rafkin, S. C. R., and T. I. Michaels (2003), J. Geophys. Res., 108(E12), 8091. [2] Michaels, T. I., and S. C. R. Rafkin (2008), J. Geophys. Res.-Planets, 113. [3] Toigo, A. D., and M. I. Richardson (2003), J. Geophys. Res., 108(E12), 8092. [4] Tyler, D., J. R. Barnes, and E. D. Skyllingstad (2008), J. Geophys. Res.-Planets, 113(E8). [5] Vasavada A. et al. (2012) Space Science Review, Volume 170, Issue 1-4, pp 793-835.

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