2019 Fall AGU, San Francisco, CA 9-13 December, Abstract Submission (Abstract #512777

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Extratropical Large-Scale Traveling Weather Systems in the Southern Hemisphere on Mars

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Abstract Text:

From late-autumn through early-spring, the middle- and high-latitudes of both hemispheres of Mars and its predominantly carbon-dioxide atmosphere support mean equator-to-pole thermal contrasts, and then, support a strong mean westerly polar vortex. Observations from orbiting spacecraft indicate that this intense mean baroclinicity-barotropicity supports large-scale eastward traveling weather systems (i.e., transient, traveling synoptic-period waves, on the order of the Rossby deformation scale). On Earth, extratropical weather disturbances arise from wind-shear instabilities, and these are critical components of the terrestrial global circulation. So it is the case for Mars. Large-scale traveling weather systems on Mars serve as agents in the transport of heat, momentum and scalar and tracer quantities (e.g., atmospheric dust, water-vapor, ice clouds, chemical species, etc). Such weather systems interact with other large-scale atmospheric circulation components, namely, quasi-stationary (i.e., forced Rossby) modes; global thermal tidal modes; and then, upon large-/continental- geographical scales, up-slope/down-slope flows amongst high relief, low relief, impact basins, and volcanic rises, and more.

The character of Mars' traveling extratropical weather disturbances in its southern hemisphere during late winter through early spring is investigated using a high-resolution Mars global climate model (i.e., Mars GCM), and one from the Agency's Mars Climate Modeling Center (MCMC) based at the NASA Ames Research Center. The climate model includes several complex atmospheric physical packages. With such physics modules, our global climate simulations present comparatively well with observations of the planet's current water cycle (Haberle et al., 2019). The climate model is "forced" with an annual dust cycle (i.e., nudged based on MGS/TES observations).

Compared to the northern-hemisphere counterparts, the southern synoptic-period weather disturbances and accompanying frontal waves have smaller meridional and zonal scales, and are less intense. Influences of the zonally asymmetric (i.e., east-west varying) topography on southern large-scale weather are investigated, in addition to large-scale up-slope/down-slope flows and the diurnal cycle. A southern storm zone in late winter and early spring presents in the western hemisphere via orographic influences from the Tharsis highlands, and the Argyre and Hellas impact basins. Geographically localized transient-wave activity diagnostics are constructed that illuminate dynamical differences amongst the simulations and these are presented.