COMBINING MARS 2020/MEDA, MRO/MCS, AND EMARS DATASETS TO PRODUCE VERTICAL PROFILES OF TEMPERATURE AT JEZERO CRATER, MARS.

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Introduction: We aim to construct the vertical profile of temperature at Jezero Crater from the surface up to about 20 km during Martian Year 36 using a wide range of available data. Then, we plan to analyze seasonal and diurnal variations of this profile as a function of the radiative and dynamic environment. We also plan to compare Jezero profiles to profiles from other Martian years and other locations on Mars using reanalysis data.

Datasets:

M2020/MEDA: The temperature observations provided by the Mars Environmental Dynamics Analyzer (MEDA) are the basis of this investigation [1-3]. MEDA temperature observations are available at 1.4 m from the Air Temperature Sensor (ATS) and at the ground and at about 40 m from the Thermal Infrared Sensor (TIRS). Moreover, MEDA measures downwelling atmospheric IR flux and aerosol content at a variety of local times [4], allowing comparisons between the radiative and thermal environment.

Other in-situ measurements: At Gale Crater aboard the Curiosity rover, the Rover Environmental Monitoring System (REMS) measures temperature on the ground and at 1.5 m and has done so since MY 31 [5]. Additional near-surface temperature measurements are available from the InSight lander and the Mini-TES instruments aboard the MER rovers [6,7].

MRO/MCS: Mars Climate Sounder (MCS) retrieves vertical profiles of temperature, dust, and water ice at approximately 3 AM and 3 PM from the limb of Mars [8]. MCS retrievals are available between about 10 and 80 km. Fields are reported at 105 standard pressure levels approximately 1 km apart, and MCS has a vertical resolution of about 5 km. Due to the observing geometry of MCS, near-surface observations, particularly within 10 km of the Martian surface, are of limited availability in the MCS dataset. While this issue may be lessened by improved retrievals in the future, MRO also serves as a relay for Perseverance, and therefore MCS rarely observes the atmosphere directly above Jezero Crater.

EMM/EMIRS: EMIRS possesses full local time coverage and synoptic observations of the disk of Mars [9], meaning that Jezero Crater is observed nearly half the time. The vertical resolution of EMIRS is 10 km, implying that the vertical profile is less detailed than the MCS profile and more sensitive to loss of near-surface data, though the viewing geometry should lead to less near-surface data loss than MCS.

Modeling:

SCM: To fill in the gap between MEDA and MCS or EMIRS, we use the one-dimensional University of Helsinki/Finnish Meteorological Institute adsorptive subsurface–atmosphere column model (SCM) [10,11]. The SCM simulates temperature profiles up to 40 km, with increased near-surface grid resolution, and the profiles have been validated against Mini-TES observations. Furthermore, SCM also provides a way to simulate the effects of diurnally varying dust column opacity on the radiative and thermal environment, thus supporting analyses of MEDA observations.

EMARS: We use the Ensemble Mars Atmosphere Reanalysis System (EMARS) to provide large-scale and dynamical context. EMARS incorporates TES and MCS observations into the GFDL Mars Global Climate Model (MGCM) using the local ensemble transform Kalman filter (LETKF) data assimilation scheme [12]. The MEDA and SCM-derived temperature profiles provide an opportunity to determine how well EMARS performs near the Martian surface, and EMARS itself can possibly shed light on spatiotemporal differences in inversions across the Martian tropics.

OpenMARS: OpenMARS combines the UK version of the LMD GCM with TES and MCS observations using the Analysis Correction (AC) scheme [13]. The advantage of comparing two reanalyses is that common features are likely to exist in the Martian atmosphere.

Initial Results: Initial studies have focused on the effect of diurnal variation of dust on SCM vertical profiles. Both dust and ice aerosols vary substantially over the course of a sol in MEDA observations [4]. This diurnal variation could have a large effect on temperatures throughout the day that is not captured by Mars models or reanalyses.

One of the initial studies conducted is a simple sensitivity study. We assume that the mean dust column opacity during a sol is 1, and we vary the dust opacity as a function of local time, as shown in Figure 1, with dust minimized at noon. The effect of the change in amplitude on surface temperature is shown in Figure 2.

The surface temperature is increased at all times of day due to diurnal variation in dust opacity, but the increase is most pronounced at noon and for large amplitudes. This makes sense because greater amplitudes of diurnally varying dust decrease the amount of dust in the atmosphere, primarily at noon. This allows more insolation to reach the surface and warm it.

The 40 m temperature (Figure 3) is decreased at all times of day due to diurnal variation of dust. Sunlight was not absorbed by the atmosphere as much during the day because there was less dust to scatter the sunlight.

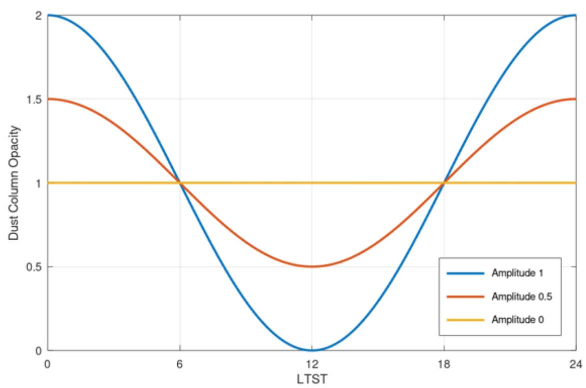

Figure 1. Dust column opacity variation over a sol in the SCM sensitivity study. Three of the eleven amplitudes used in the study are shown here.

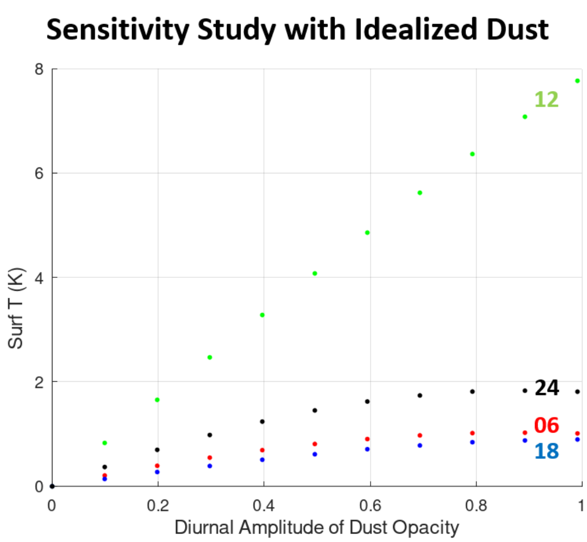

Figure 2. Surface temperature (K) increase due to diurnally varying dust at four local times (06, 12, 18, and 24 LTST), relative to the case where dust column opacity is a constant 1 throughout the sol.

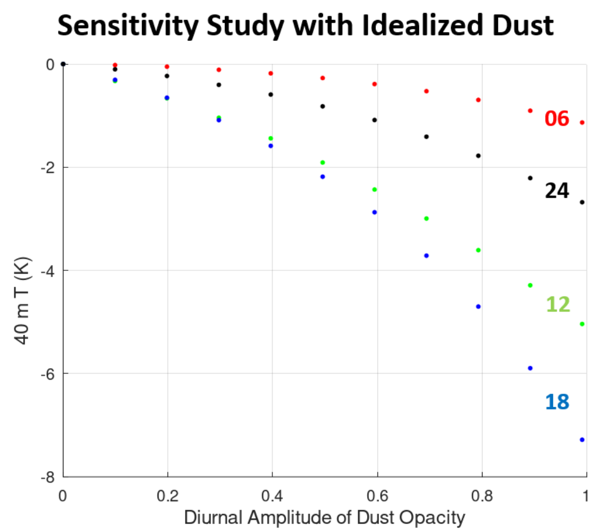

Figure 3. As Figure 2, but the 40 m T (K) increase due to diurnally varying dust.

Ongoing Work: When possible, MEDA profiles will be extended into the free atmosphere using MCS and EMIRS observations. Fitting the SCM to MEDA and MCS/EMIRS would permit an estimation of the planetary boundary layer depth at 3 AM and 3 PM. Comparisons to EMARS and OpenMARS profiles may suggest alternate means of interpolation and PBL depth assessment. Finally, the use of reanalyses will permit us to assess how similar Jezero Crater is to other locations in the Martian tropics.

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