MODELING DIURNAL TEMPERATURE VARIATION ON MARS USING THEMIS INFRARED DATA AND KRC NUMERICAL MODEL: A STUDY OF THREE SITES. J. K. Serla[1] and P. R. Christensen[1], [1]Mars Space Flight Facility, School of Earth and Space Exploration, Arizona State University, 201 E. Orange Mall, Tempe, AZ 85281 (jserla@mars.asu.edu).

Introduction: For planetary surfaces, thermal inertia can be defined as the tendency of a surface to resist changes to its temperature [1, 2, 3, 4]. Surfaces predominantly made of bedrock remain cooler during the day because they can diffuse heat to the subsurface efficiently, and remain warmer during the night because the diffused heat from the subsurface is radiated back through the surface. Surfaces predominantly made of dust or sand size particles, that cannot diffuse heat to the subsurface efficiently heat up during the day and cool down during the night. As a result, sand and dust sized particles experience a greater diurnal temperature variation than bedrock. This implies that sand and dust have lower thermal inertia than bedrock material. Thermal inertia is therefore a useful parameter in determining the particle sizes on the surface.

Mathematically thermal inertia is defined as:

$$P = \sqrt{k\rho C}$$

where k is the thermal conductivity, ρ is the bulk density and C is the specific heat of the material. None of these physical quantities can be measured directly via remote sensing techniques. They all require contact methods for measurements. As a result, to determine thermal inertia of a surface from orbit, diurnal temperature variation measurements along with numerical modeling tools are necessary.

The orbits of Mars Global Surveyor that had Thermal Emission Spectrometer (TES) and Mars Odyssey that has Thermal Emission Imaging System (THEMIS) onboard were not conducive to acquiring diurnal temperature variation data. Mellon Jakosky model was used to derive TES thermal inertia values and KRC numerical model is being used to derive THEMIS thermal inertia values. THEMIS thermal inertia values are determined from single nighttime temperature measurements using lookup tables created from KRC runs [4].

In this study, we "seasonally corrected" THEMIS data using KRC numerical model to compute diurnal temperature variation of a particular region of interest.

Methods: For the test run of the model, we selected a 100m × 100m area (one THEMIS pixel) at the center of an 800m diameter crater centered at 18.4820N, 77.3783E. This crater was selected because it is in the Jezero crater, the recently selected landing site for the Mars 2020 rover.

To perform the analyses, we acquired all the available band-9 THEMIS BTR (Brightness Temperature Record) images of the region. Band-9 data is usually the best for surface information as it is least affected by the atmosphere [6]. These images were taken during different seasons (L_s) and at different times of the day (LTST). We extracted the L_s and LTST information from these images to be used in the KRC runs. The KRC OnePoint mode requires latitude, L_s, LTST, elevation, slope, azimuth, thermal inertia, albedo and dust opacity as input parameters. We obtained the slope, azimuth and elevation information from the Mars Orbiter Laser Altimeter (MOLA) data. TES data was used to obtain Lambert Albedo and an initial value for thermal inertia.

The first KRC OnePoint run was performed by plugging in all the above information for the same seasons as the THEMIS data. This gave the model computed surface kinetic temperatures (KRC Temperatures) as output. The difference between the THEMIS temperatures and KRC temperatures was calculated (ΔT). The next KRC OnePoint run was made keeping all the parameters same, changing the season to $L_s = 0$ (or any other season so that the seasonal effects are normalized). This is the KRC season-corrected data. Since the Martian climate is fairly predictable barring global events [7], adding ΔT to the KRC season-corrected data would be representative of what THEMIS would have measured at $L_s = 0$ (had it been possible to measure diurnal variation using THEMIS). A diurnal temperature curve was fit to this season-corrected data.

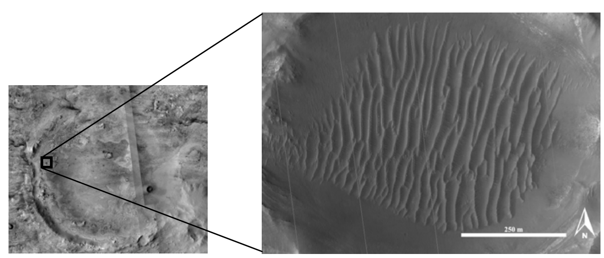

Figure 1: CTX images of the Jezero crater and the zoomed-in view of an 800m diameter crater centered at 18.4820N, 77.3783E. The study area has dimensions of 100m × 100m or one THEMIS pixel. This zoomed-in CTX image shows ripple-like features assumed to be composed of fine-grained material on the crater bed.

Diurnal curves corresponding to five other thermal inertia values were also generated and fit to the season-corrected THEMIS data. The value of thermal inertia that better fit the season-corrected THEMIS data was used in the next iteration. We repeated the entire analyses till a reasonably good fit of diurnal temperature curve was obtained.

Preliminary Observations and Discussion: From the diurnal curves, we can notice that the daytime temperatures fit better to lower thermal inertia values and the night time temperatures fit better to the higher thermal inertia values. Historically nighttime thermal inertia values have been considered to be more representative of the surface because they are free from albedo and topography effects. But, visual cues from CTX images and the better fit of daytime temperatures to lower thermal inertia values suggest a lower thermal inertia value for the surface. One possible reason for the discrepancy could be the landscape being far from simple. We assumed lateral and longitudinal homogeneity of the surface, which is likely an oversimplification in this case. What looks like sand-sized particles in the CTX images, could actually be more complex. It is possible that the surface has some amount of cementation or that there is some heterogeneity in the subsurface. There could be a number of other factors and physical processes in play that could better explain what we see in the analyses. We are currently working on determining those factors and constraining the model better for further runs.

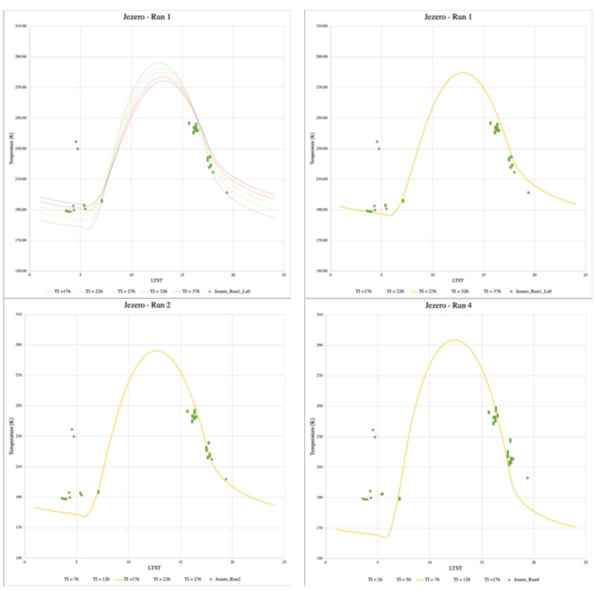

Figure 2: Top left panel shows the corrected THEMIS temperatures with diurnal temperature fits corresponding to five different thermal inertia values. Top right panel shows the nature of the fit for a TI of 276 $Jm^{-2}K^{-1}s^{-½}$. Bottom left panel shows the nature of fit for a TI of 176 $Jm^{-2}K^{-1}s^{-½}$. Bottom right panel shows the nature of fit for a TI of 76 $Jm^{-2}K^{-1}s^{-½}$. These TI values are obtained by iteratively refining the closeness of fit to the seasonally corrected temperature data.

Ongoing and Future Work: In order to deterministically demonstrate the capability of this technique, we are now planning on studying "simple" (laterally and longitudinally homogenous) surfaces. The two candidates we are currently looking at are both dune fields, one to the north east of Jezero Crater and the other a dune field in Gale crater that MSL visited. Both of these dune fields are active and so we can be more confident of their homogeneity both laterally and longitudinally. Showing that the model works well at these homogenous sites will be crucial before expanding the study to more complex regions with heterogenous subsurface. The gale crater site also serves to provide some ground truth data to compare the model results against.

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Acknowledgements: This work was carried out with the help and support of the Mars Space Flight Facility and the THEMIS teams.