IMPROVING THERMAL MODEL CAPABILITY FOR THE PLANETARY SCIENCE COMMUNITY.

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Introduction: Planetary surface temperatures are frequently measured by instruments on landers, rovers, and orbiters, and provide an excellent means to quantitatively constrain the physical nature of near-surface regolith and inform the understanding of past and present geophysical processes. While the availability, diversity, and potential of remotely sensed temperature data to solve critical scientific questions increases continuously, the use of reliable dedicated numerical tools to enable the interpretation of that data poses significant challenges to specialists and nonspecialists alike. Here we describe recent improvements aiming at enhancing and expanding the capability of KRC [1], a well-established thermal model, and facilitating its access for data analysis to the broader planetary and engineering communities.

Overview of New Capabilities: KRC was originally designed in preparation for the Mariner 69 mission and for the analysis of thermal data acquired at Mars. Since then, new capabilities have been added, while maintaining the original desire for speed (i.e. ~1s for full surface/subsurface diurnal and annual calculation for Mars).

New Bodies. Any rotating body can be modeled, using KRC, including planets, satellites, asteroids, comets, exoplanets, tidally locked bodies, as well as planets with ancient orbital configurations (Fig. 1).

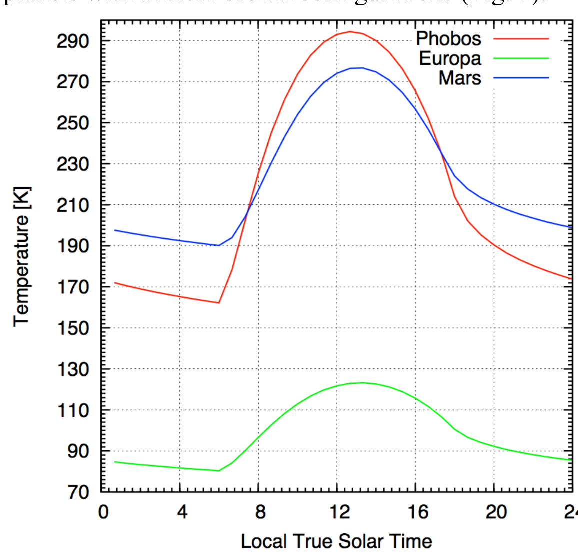

Fig. 1: Example of surface temperatures modeled for one diurnal cycle on Phobos, Europa, and Mars.

Eclipses. KRC can now handle eclipses, either rare (such as lunar eclipses, or Phobos/Deimos eclipses on Mars, using user-defined information, for example the timing of the events) or occurring daily (as would be the case with Galilean satellites, Fig. 2, using KRC's own ephemerids). This functionality has required the possibility to set heat forcing from nearby bodies, and we note that this functionality can be set up for runs not involving eclipses.

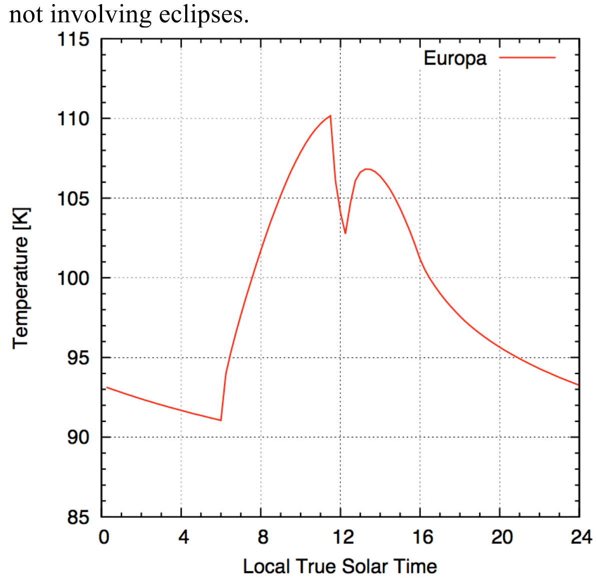

Fig. 2: Example of a diurnal temperature cycle on Europa including eclipse by Jupiter centered at noon.

Subsurface Properties. KRC includes fully tunable subsurface properties with depth (density, specific heat, conductivity, to emulate H parameter-like configurations [2]), geothermal heat flow, ability to output subsurface temperatures (Fig. 3).

Surface Properties. A library of photometric functions has been added for airless bodies (Minnaert, Lommel-Seeliger, Kheim, etc.), and radiatively coupled surfaces can now be modeled. Any atmospheric condensable gas of chosen partial pressure can be modeled, and its presence on the surface modifies the surface emissivity/albedo appropriately.

Distribution: Unlike the vast majority of planetary thermal models used for scientific research, KRC is freely distributed to the community, including full documentation. The KRC source code can be downloaded at http://krc.mars.asu.edu/ (Fig. 4), which links to both a dedicated repository where the user can find

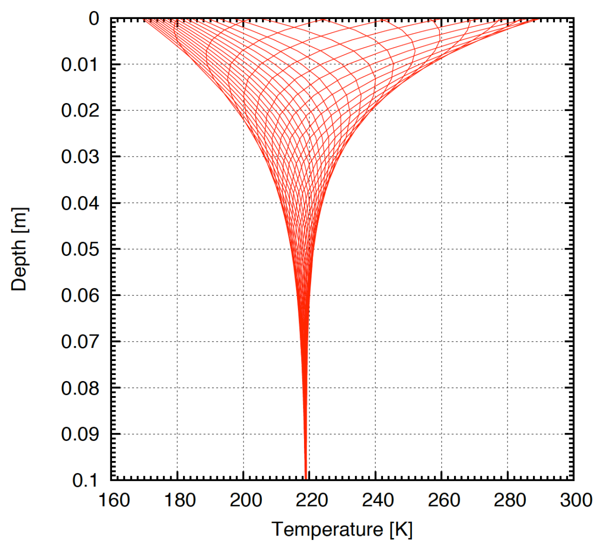

Fig. 3: Example of diurnal surface and subsurface temperatures for Mars.

retired versions of the code. Once stable versions have been validated, the code will be uploaded to the NASA GitHub site. A user mailing list has been set up and updates subscribers on new releases. User subscription procedure found at http://krc.mars.asu.edu.

Validation: New KRC releases usually include added functionalities. Each new version is tested against previous versions to determine the reproducibility of results from one version to the next (Fig. 5). Validation reports are generated, and will be distributed in a standardized format through the wiki (not available at the time of submission of this abstract).

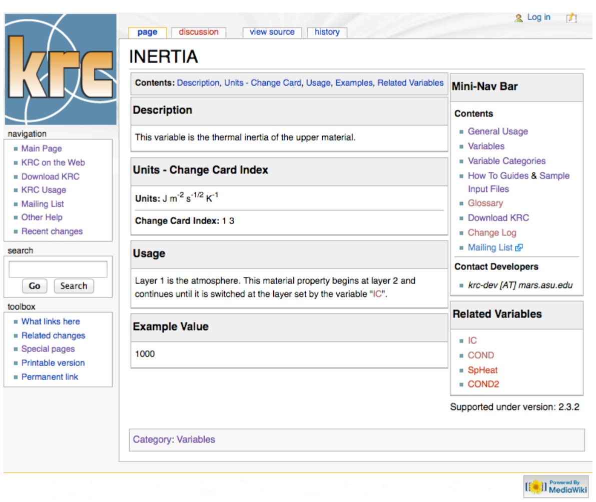

Fig. 4: Screenshot of the wiki page used to disseminate information to the KRC users.

User-friendly Interfaces: Manipulating KRC directly through the modification of input files is uneasy and prone to errors. We have developed a web interface for entry-level users (http://krc.mars.asu.edu/web_tool/), as well as a davinci (http://davinci.mars.asu.edu) interface. The davinci interface is in beta testing, and not available for distribution at the time of submission of this abstract. It will be distributed to the community through the KRC website.

Future Plans: Funded plans include the addition of new capabilities: 1) temperature-dependent emissivity, 2) fully temperature-dependent regolith properties with depth (only partially the case currently). A major redesign of the code is scheduled for 2018 or 2019 (KRC v4.) and will include these new functions. Contact SP if you are a user and would like to add items to this wish list. A future version of the KRC wiki will include a wishlist page.

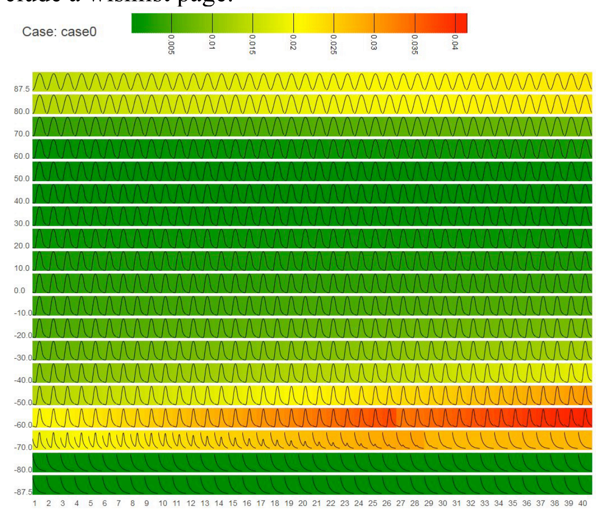

Fig. 5: Example of validation illustration. Map of the difference between diurnal temperature curves for different model versions, identical runs otherwise.

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