THE GLOBAL THREE DIMENSIONAL DISTRIBUTION AND TEMPERATURE OF NEAR-SURFACE MARTIAN GROUND ICE: NEW RESULTS FROM MGS TES. D. A. Paige and J. M. Scherbenski[1]
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Summary: We have discovered significant global-scale seasonal thermal anomalies in the MGS TES surface temperature observations that coincide spatially with the Odyssey GRS observations of enhanced near-surface hydrogen abundance [1]. The TES thermal anomalies can be explained quantitatively by the widespread presence of cold, high thermal inertia material within millimeters to centimeters of the surface that we interpret as evidence for ground ice that must extend to depths of many meters. The results provide significant insights into the properties and processes that govern the behavior of Martian water under current climatic conditions, the surface geology of the planet, as well as much higher resolution Martian ground ice maps than have been previously available.

Details: Using techniques originally developed for the analysis of Viking IRTM data [1] [2], TES diurnal and seasonal temperature variations are compared to the results of a one-dimensional radiative-convective model, and best-fit surface thermal and reflective properties are mapped. The baseline thermal model includes the radiative and convective effects of the Martian atmosphere, and assumes surface thermal properties that are homogenous with depth. Seasonal thermal anomalies are identified by comparing the best-fit baseline model-derived albedos with the measured TES albedos. Such a comparison reveals the presence of significant (5-10K) thermal anomalies at a wide range of latitudes. Both negative and positive anomalies are observed, depending on latitude and season, and these anomalies are well correlated with the hydrogen abundance maps produced by GRS.

To map the depth to the ground ice, the TES data are compared to the results of a more sophisticated model with surface thermal properties that are inhomogeneous with depth. In this two-layer model, a low thermal inertia surface layer is assumed to overlie high thermal inertia material that extends to great depth below. The depth to the high inertia material is a free parameter, which can be determined for each mapped region by first constraining the inhomogeneous model's surface albedo to equal the TES measured albedo, and then comparing the model's predicted diurnal and seasonal surface temperatures to those observed by TES. In regions where thermal anomalies are observed, the two-layer model provides much better fits to the TES observations than the homogeneous model.

The results of the fitting procedure yield three distinct types of data products – all of which can be produced as a function of Martian season. The first are maps of the thermal inertia of the surface layer. The second are maps of the depth to the high thermal inertia subsurface layer. The third are maps of the temperature of the top of the high thermal inertia subsurface layer. In the model, the thermal inertia of the subsurface layer is not directly constrained by observations. However, the magnitude lower layer's effect on surface temperatures is proportional to the lower layer's thermal inertia, so at any location, a minimum value can be found. Furthermore, the maximum possible thermal inertia for the lower layer is bounded by the maximum possible thermal inertia of rock/ice. If the high thermal inertia subsurface material is assumed to contain water ice, maps of model-predicted annual maximum temperatures for the top lower layer can be used to estimate implied near-surface water frost-point temperatures. This provides constraints on the abundance of near-surface water vapor in the atmosphere assuming that the ice is close to being in equilibrium with the present climate.

Implications: Our analysis of the TES observations provides additional strong evidence for the widespread global-scale presence of near-surface ground ice on Mars. The ice has high thermal inertia, which is consistent with GRS results indicating high water to soil ratios [1]. The maps we will present at the meeting will show signifcatly more spatially resolved, three-dimensional views of the present distribution of Martian ground ice than have been available previously. These maps will be correlated with topography, images, geological maps, soil thermal and reflectance properties, and atmospheric water vapor abundance datasets, to produce a much clearer picture of the properties and processes that are responsible for its global distribution.

References: [1] Boynton et al., Science 297, 81-85, 2002. [2] Paige, D. A., J. E. Bachman and K. D. Keegan, J. Geophys. Res. 99, 24,959-25,991, 1994. [3] Paige, D. A. and K. D. Keegan, J. Geophys. Res. 99, 24,993-26,013, 1994.