ANALYSIS OF CURIOSITY GTS/REMS SURFACE TEMPERATURE MEASUREMENTS. J. Audouard[1,2], S. Piqueux[3], F. Poulet[2], M. Vincendon[2], R. E. Arvidson[4] and A. D. Rogers[1], [1]Stony Brook University, NY, USA, [2]Institut d'Astrophysique Spatiale (UPSUS/CNRS), Orsay, France; [3]Jet Propulsion Laboratory, California Insitute of Technology, Pasadena, CA, USA; [4]Washington University, St. Louis, MO, USA. Contact: joachim.audouard@stonybrook.edu

Introduction

Since landing in August 2012 in Gale crater, the rover Curiosity of the Mars Science Laboratory (MSL) NASA mission has performed numerous measurements to characterize its surroundings according to its science objectives [1]. In this work, we analyse the data of the Rover Environmental Monitoring Station (REMS) instrumental suite [2], and specifically of its Ground Temperature Sensor (GTS) surface temperature measurements [3].The temperature of the Martian surface is a complex function of the surface specific thermo-physical properties (thermal inertia and albedo) and of the heterogeneity of the surface (horizontal mixing, and/or vertical heterogeneity, both expected on Mars).

When comparing surface temperature measurements with energy balance model predictions, it is possible to estimate the thermo-physical properties of a surface. This method has been used by [4, 5, 6, 7] to infer the thermal inertia of the Martian surface using "single point" orbital surface temperature measurements. In the case of *in-situ* Curiosity surface temperature measurements, GTS/REMS data is recorded on a 1Hz sampling basis, for an average on-time of a few hours per sol. This unprecedented dataset thus allows for more refined thermo-physical properties and regolith heterogeneity retrievals and can potentially reveal some processes which remain not accounted for in the energy balance models. This interest of GTS/REMS data has recently been emphazised by a couple of studies [8, 9], revealing that the GTS/REMS dataset effectively holds some information about processes influencing the temperature of Gale crater floor that remain to be understood.

We have performed an independent study of GTS/REMS surface temperature data using a different LMD-derived energy balance code and fitting method that those of [8, 9]. The purpose of this work is to retrieve the thermo-physical properties of the regolith along Curiosity traverse, and to study and discriminate the non-simulated thermal behavior caused by regolith heterogeneities and neglected processes in the energy balance code.

Dataset

We use GTS/REMS data level 3 (as described in [2]) of the MSL mission sols 1 to 583 downloaded from the NASA PDS. We select only data according to the following criteria :

- The field of view of GTS does not include any MSL-induced shadows.
- The rover must be still.
- The GTS measurement must be reliable (e.g. correct voltage for the detector and calibration quality).

Method

We identified a few hundred "stops" where Curiosity was still and GTS/REMS was turned on for at least a few hours. We use an Energy Balance Code derived from the LMD GCM [10] that was used for thermal inertia retrievals from orbital surface temperature data [7]. For each stop, there is a unique combination of thermal inertia and albedo that best fits GTS/REMS data in the least square sense. Data-resolution comparison between these best-fit surface temperature simulations and the actual data yield to a diurnal residual thermal behavior given the limitations of the surface temperature simulations (vertical and horizontal homogeneity) and the complexity of the real Martian regolith. Various processes un-accounted for in our model such as temperature-dependancy of the thermo-physical properties [11] or the influence of the Curiosity nuclear power source are then added to the model, thus allowing an assessment of the different contributors to the observed thermal behavior.

Comparison with orbital data

We have performed a systematic comparison of GTS/REMS data with co-observations of surface temperature at the rover location from orbit by the OMEGA onboard Mars Express and THEMIS onboard Mars Odyssey instruments, which were used to globaly infer the thermo-physical properties of the Martian surface [6, 7]. At any time of day, GTS/REMS are systematically cooler than orbital co-observations. This characteristic might reveal the influence of Curiosity's nuclear power source, which is expected to heat the surface around the rover and thus inside the GTS field of view.

Results

At first order, GTS/REMS data is well reproduced by the Energy Balance Code best fits. Figure 1 shows an example where the residual ΔT is about 10 K throughout the sol over a total signal of ~100 K. The residual ΔT are surprinsigly stable throughout the mission (sol-to-sol as well as stop-to-stop), relatively independent of the location of the rover and of the thermo-physical properties of its surroundings. Figure 2 shows the average diurnal ΔT for a few stops or collection of stops (“traverse 1” and “traverse 2”) and it

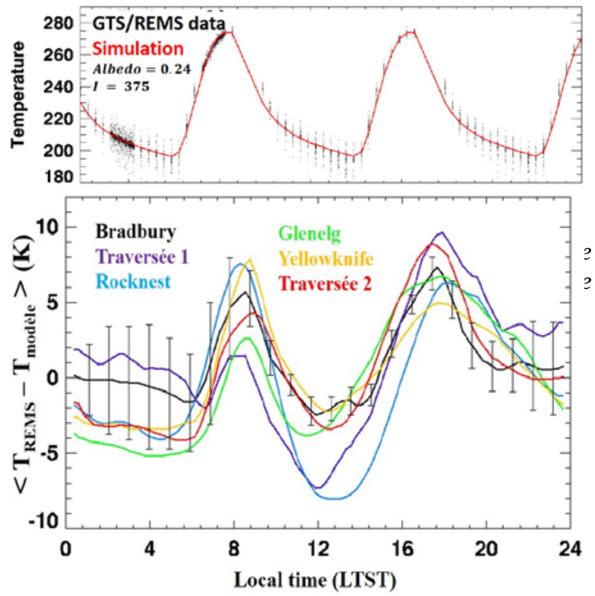

Figure 2. *Average residual ΔT (GTS minus best fit simulations) as a function of local time for a few stops or collection of stops (in red and purple). Error bars (shown only for Bradbury) represent the 3-sigma dispersion of the ΔT.*

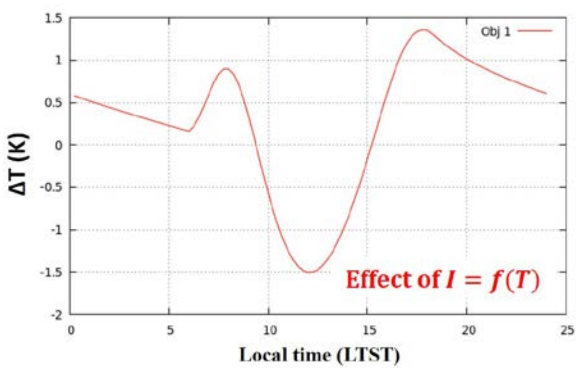

Figure 3. *Effect of temperature dependancy of themal inertia simulated at Rocknest*

can be seen that the non-accounted for thermal behavior is very regular: nighttime temperature measurements are always cooler that expected regarding the low daytime temperatures. Similarly, the morning heating happens to be really fast and the afternoon cooling is unexpectedly slow.

Deciphering the different contributors to this ΔT is ongoing, and first progress towards the integration and the impact of the temperature-dependency of thermal inertia are promising and will be presented and discussed at the conference. Figure 3 shows the ΔT caused by these previously-neglected processes in our Energy Balance Code; it can already be seen that the shape of the diurnal ΔT is the same as the one measured by GTS/REMS with a lower amplitude (~3 K) (compare Figures 2 and 3). Additionnal T-dependant effects will be discussed.

We will also attempt to simulate the impact of the Curiosity nuclear power source by adding an energy input into the Energy Balance Model. Impact of mesoscale atmospheric processes (such as turbulences) will also be discussed. Our purpose is to estimate the impact of these different factors (T-dependancy of thermal inertia, impact of nuclear power source, mesoscale effect…) onto the GTS/REMS data in order to be left with a smaller ΔT that would be caused by the regolith thermo-physical heterogeneities.

References

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