THERMOPHYSICAL PROPERTIES OF GALE CRATER PLAINS ALONG CURIOSITY TRAVERSE. J. Audouard[1], R. E. Arvidson[2], F. Poulet[1], M. Vincendon[1] and B. Gondet[1]. [1]Insitut d'Astrophysique Spatiale – Université Paris-Sud/CNRS Orsay France, [2]Washinghton University, St. Louis, Missouri, USA. Contact: *joachim.audouard@u-psud.fr*

Introduction: Since its landing in August 2012 in Gale crater, the rover Curiosity of the Mars Science Laboratory (MSL) NASA mission has performed many 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].

On Mars, surface temperature variations are principally caused by seasonal and diurnal variation of sunlight. The temperature of the surface is the result of the radiatives exchanges occuring with the atmosphere and the thermal conduction within the subsurface. The specific thermal behavior of a surface is therefore controlled by its thermophysical properties: solar albedo (of the surface optical depth i.e. ~ 1 to 100 µm) and thermal inertia (a function of heat capacity *c*, thermal conductivity *k* and density *ρ*, expressed in $J.m^{-2}.K^{-1}.s^{-1/2}$).

While solar albedo modulates the amount of energy available for the heating of the material, thermal inertia is the tendency to resist changes in temperature i.e. the kinetic of propagation of the heat wave whitin the material. A material with a higher thermal inertia will store more heat and radiate more during the night. The thermal skin depth δ over a period P (here, a sunlight period i.e. a sol or a year) is defined as the depth at which the temperature variation is equal to the temperature variation of the surface divided by e. At three times the thermal skin depth, the temperature variations are reduced to ~ 5 % of the surface's. For a Martian sol at Gale crater, this depth is between ~ 1 cm (for dusty loose materials) and ~ 0.5 m (for rock-like materials). Underlying unvisible materials can therefore have a strong influence on the temperature of the surface.The surface temperature is therefore a complex function of the surface specific thermophysical properties and of the heterogeneity of the surface (horizontal mixing, and/or vertical heterogeneity are expected on Mars).

When comparing surface temperature measurements with energy balance model predictions, it is possible to estimate the thermophysical 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. However, the thermophysical and heterogeneity solutions are often non-unique and not sufficiently constrained by a unique surface temperature measurements (or by a few over years).

GTS/REMS provides the community with almost-continuous *in-situ* surface temperature measurements of the Martian surface along MSL traverse in Gale crater. The purpose of this work is:

- to retrieve the thermophysical properties of the rover's surroundings.
- to characterize a putative thermal signature of heterogeneity from the Gale crater plains.

Dataset: We use GTS/REMS data level 3 of the MSL mission sols 1 to 269 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.
- The rover must be still.
- The GTS measurement must be reliable (e.g. correct voltage for the detector and calibration quality).

GTS/REMS measurements are at best performed at a 1 Hz frequency. In the nominal acquisition planning, GTS data is recorded during the first five minutes of every hour. Extended acquisitions sessions occurred many times during the first sols of the mission.

GTS/REMS measurements were compared with surface temperatures observed from orbit

Method: We use a 1-D energy balance model developed at the LMD [8]. This model predicts the temperature of the surface and its evolution with time as a function of: albedo, thermal inertia, atmospheric pressure, atmospheric dust opacity, local slope and azimuth. This model has been extensively validated through comparison with Viking landers, MER Opportunity and Phoenix *in-situ* surface temperature measurements and also with TES and OMEGA orbital surface temperature measurements [9]. We set the model local slope to zero and compute a lookup table of surface temperatures (every half an hour for 360 sols) as a function of albedo and thermal inertia. This is the simple case of an homogeneous surface.

For the 270 first sols (third release of data), we define 45 positions where the rover was still and recorded GTS data spanning at least one hour. For every of these location, we look for the couple of thermophysical properties that give the closest fit (in least squares approach) to GTS/REMS data. An example is shown for one location in Figure 1.

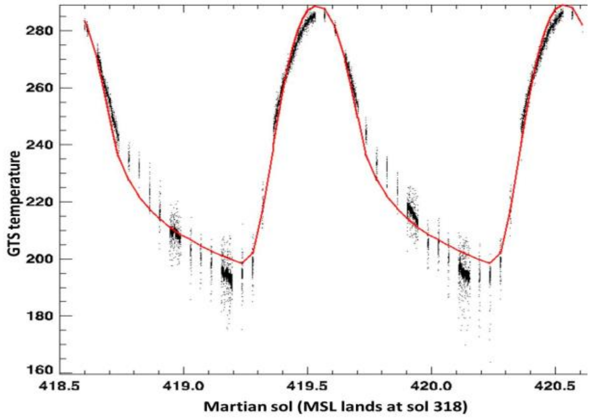

Figure 1. *GTS/REMS (black) and simulated (red) surface temperatures as a function of time. Red curve parameters are:albedo = 0.26 and thermal inertia = 240 J.m^{-2}.K^{-1}.s$^{-1/2}$). Uncertainties on simulated temperature and on GTS/REMS are ~1 K.*

Results: We look for the best fit to GTS/REMS data for every selected location. The result is shown in Figure 2. GTS/REMS measurements are then compared to the best fit of simulated temperature and the average difference T_{REMS}-T_{model} as a function of local time is shown in Figure 3 for the first 270 sols of MSL mission. Discrepancies between observed and predicted for an ideal surface temperatures are complex but systematical with always anomalous (compared to ideal surface) night time and mid-day coolings and anomalous dawn and dusk heatings.

Discrepancies between predicted ideal temperatures and GTS/REMS data are time-dependant, reveraling either that a diurnal atmospherical process has a strong influence on the GTS temperature, or that the plains of Gale crater present heterogeneities that remain quite the same sol after sol (MSL location after MSL location). This would exclude local horizontal mixing as a source for the heterogeneity and favorites a regional unnacounted for slope (to the west).

Prospects: The model also allows us to define two layers for the subsurface of underlying material, thermal inertia of material at the surface and depth of the first layer. We will explore the potential effect of local slopes and subsurface layering to explain the observed anisothermality.

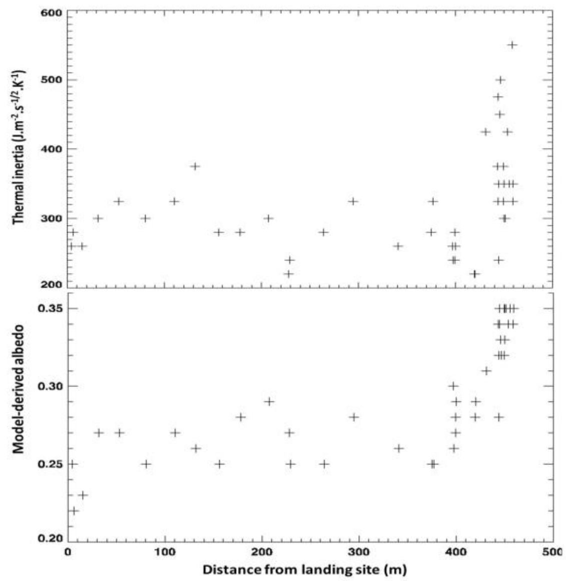

Figure 2. *Thermal inertia (top) and albedo (bottom) derived for 45 selected MSL locations during its first 270 sols as a function of their distance to the landing site. The low albedo of the immediate surrounding of the landing site is remarkable, as well as the higher thermal inertia of the Glennelg area.*

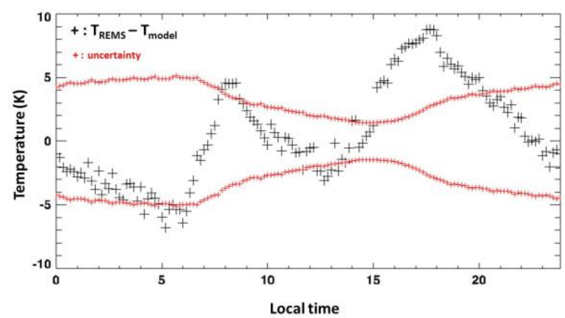

Figure 3. *Mean residual temperature as a function of local time for the selected MSL locations. Anomalous thermal behavior is observed in GTS data but with a strong day-to-day regularty.*

References: [1] Grotzinger, J.P. et al. (2012), *Space Sc. Review, 170(1-4)*, 5-56. [2] Gomez-Elvira, J. et al. (2012), *Space Sc. Review*, 170(1), 583-640. [3] Sebastian, E. et al. (2010), *Sensors*, 10, 9211-9231. [4] Kieffer, H. H. et al. (1977), *JGR*, 82, 4249-4291. [5] Mellon, M. T. et al. (2000), *Icarus*, 148, 437-455. [6] Fergason, R. L. et al. (2006), *JGR*, 111, E12004. [7] Audouard, J. et al. (2014), submitted to *Icarus*. [8] Forget, F. et al. (1999), *JGR*, 104, 24155-24175. [9] See B. Gondet's abstract of OMEGA observations of Gale crater at this conference.