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Ground-Atmosphere Interactions at Gale: Determination of the Surface Energy Budget, Thermal Inertia and Water Sorption on the Regolith

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The analysis of the Surface Energy Budget (SEB) yields insights into the local climate and the soil-atmosphere interactions, while the analysis of the thermal inertia of the shallow subsurface augments surface observations, providing information about the local geology. The Mars Global Surveyor Thermal Emission Spectrometer and the Mars Odyssey Thermal Emission Imaging System have measured near subsurface thermal inertia from orbit at scales of $\sim 10^4$ m^2 to ~ 10 km^2. Here we report analysis of the thermal inertia at a few locations at Gale Crater at scales of 100 m^2. The thermal inertia is calculated by solving the heat conduction equation in the soil using hourly measurements by the Rover Environmental Station (REMS) ground temperature sensor as an upper boundary condition. Three Sols representative of different environmental conditions and soil properties, namely, Sol 82 at Rocknest (RCK), Sol 112 at Point Lake (PL) and Sol 139 at Yellowknife Bay (YKB) are analyzed in detail. The largest thermal inertia (I) value is found at YKB, I = 445 J m^{-2} K^{-1} s$^{-1/2}$ or 445 tiu (thermal inertia unit), followed by PL with I= 300 tiu and RCK with$I$ = 280 tiu [1]. These values are consistent with the type of terrain imaged by MastCam and with previous satellite estimates at Gale Crater [2,3].

The SEB is calculated by using all REMS data products as well as dust opacity values derived from MastCam measurements, whereas previously, the SEB has been calculated using numerical models only [4]. At each location and during the daytime, the SEB is dominated by the downwelling shortwave (SW) solar radiation ($\sim$450-500 W/m^2) and the upwelling longwave (LW) radiation emitted by the surface ($\sim$300-400 W/m^2). The sum of these two terms accounts for at least 70% of the net surface heating rate between 0900 and 1400 local solar time. At nighttime, the SEB is dominated by the upwelling LW radiation emitted by the surface ($\sim$50-100 W/m^2) and the downwelling LW radiation from the atmosphere ($\sim$50 W/m^2). When the wind speeds exceed 10 m/s at night, the turbulent heat flux can be as large as 25 W/m^2, thus playing a secondary but significant role in the SEB.

Finally, we estimate the amount of adsorbed water exchanged between the shallow subsurface and the atmosphere at diurnal time scales. We use subsurface temperature profiles, obtained by solving the heat conduction equation in the soil using the calculated value of I, and adsorption and desorption isotherms [5] to analyze critically the correlation between the soil wetness measured by the Dynamic Albedo of Neutrons instrument and the relative humidity measured by REMS.

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