POTENTIAL SUB-MICROMETER-THICK FROST EVENTS AND SOIL WATER CONTENT AT GALE CRATER: CALCULATIONS FROM MSL/REMS MEASUREMENTS.

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Introduction: In this study we analyze the highest confidence simultaneous measurements of relative humidity and ground temperature to identify potential frost events at the surface of Gale Crater during the first 800 sols of the MSL mission. We find that the most likely surface frost events occurred at Dingo Gap Dune during sols 530-535, at an unnamed terrain between Kylie and Kimberley during sols 555-560, and at Kimberley during sols 610-615. In all cases, the identified events occurred between 4 and 6 am. An order-of-magnitude estimate for the thickness of the frost layer indicates that it is below the order of micrometers. Additionally, we analyze the relation between relative humidity and ground temperature to calculate the soil water content accounted for by adsorbed water in equilibrium with the atmosphere along the rover's traverse.

Data: We have only used REMS relative humidity (*RH*) and ground temperature (T_g) measurements [1,2] that satisfy the following conditions: (1) *RH* measurements are obtained during the first three seconds after which the sensor has been turned off for more than 30 minutes to avoid spurious effects due to heating, (2) T_g measurements with the highest confidence are averaged over an interval of 5 minutes centered at the simultaneous *RH* measurement with a minimum of 30 T_g data points to reduce the uncertainty. Both sets of values are shown in Fig. 1.

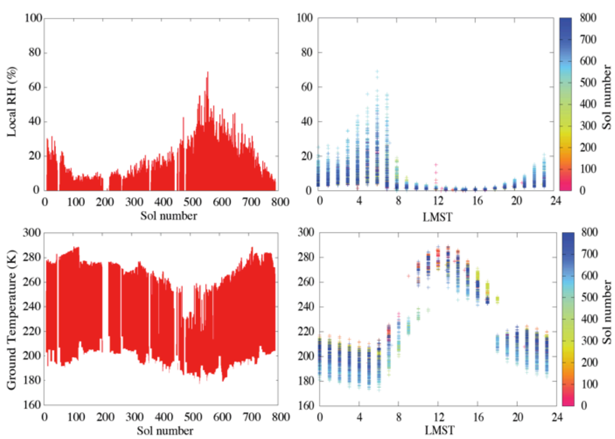

Fig 1. (Top) REMS *RH* measurements with the highest confidence level. The left figure shows maximum values of *RH* on each sol, while the right figure shows the *RH* measurements sorted out in hourly bins. (Bottom) Same as on top, but for REMS T_g measurements.

Sub-micrometer-thick frost events at Dingo Gap and Kimberley?: We calculate the frost point (T_f) using simultaneous values of *RH* and T_g shown in Fig. 1. Then, we identify the most likely frost events by obtaining the times at which the pair of values T_g and T_f satisfy the next two conditions: (1) $T_g < T_f$ and (2) the function $Y = (T_f - T_g)/(\Delta T_f + \sigma_{Tg})$ is maximized. Here, ΔT_f stands for the uncertainty in the frost point, while σ_{Tg} stands for the standard deviation of T_g. Following this procedure, the most likely surface frost events occurred at Dingo Gap Dune during sols 530-535, at an unnamed terrain between Kylie and Kimberley during sols 555-560, and at Kimberley during sols 610-615, as shown in Fig. 2.

Soil Water Content at Gale in Equilibrium with the Atmosphere: We calculate the soil water content (*SWC*) accounted for by adsorbed water in equilibrium with the atmosphere by applying the BET theory [4] to REMS values of *RH* and T_g. We only use *RH* values between 0 and 30 % (see Fig. 1), which correspond to the range in which the BET theory can be applied with the highest confidence. In addition to *RH* and T_g values, the surface specific area (*A*) and enthalpy of adsorption of the soil to which water vapor molecules adhere need to be known. We take these values from [4]. Fig. 3 shows the *SWC* along the rover's traverse for three different types of materials: JSC Mars-1 (A = 106 m^2/g), Smectite SWy-2 (A = 52.5 m^2/g) and Dunite (A = 2.83 m^2/g). Independent estimations of *SWC* by DAN [5] show average daily values of about 2 wt%, which is consistent with specific surface areas > ~10 m^2/g.

References: [1] Harri, A-M., et al. (2014) *JGR*, *119.9*, 2132-2147. [2] Martínez, G. M., et al. (2014) *JGR*, *119.8*, 1822-1838. [3] Möhlmann, D. (2008) *Icarus*, *195.1*, 131-139. [4] Pommerol, A., et al. (2009) *Icarus*, *204.1*, 114-136. [5] Mitrofanov, I. G., et al. (2014) *JGR*, *119.7*, 1579-1596.

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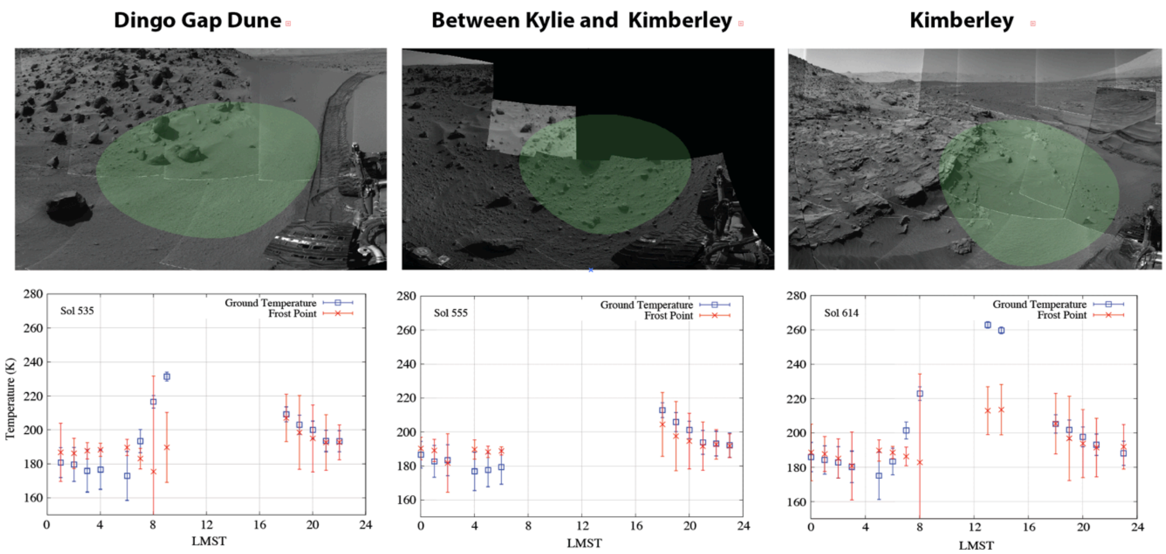

Fig 2. (Top) Navcam mosaics showing the terrain monitored by the REMS ground temperature sensor in green at Dingo Gap Dune on sol 535, a terrain between Kylie and Kimberley on sol 555, and Kimberley on sol 614. (Bottom) Diurnal evolution of the ground temperature and frost point for the sols during which the surface frost events are most likely. The ground temperature falls below the frost point during a few hours on each sol. An upper limit order-of-magnitude estimation indicates that the thickness of the frost layer formed is below the order of micrometers. The rate of increase of the thickness of the frost layer formed by freezing is calculated using the thermal velocity of water vapor molecules and the number density of water vapor molecules [3].

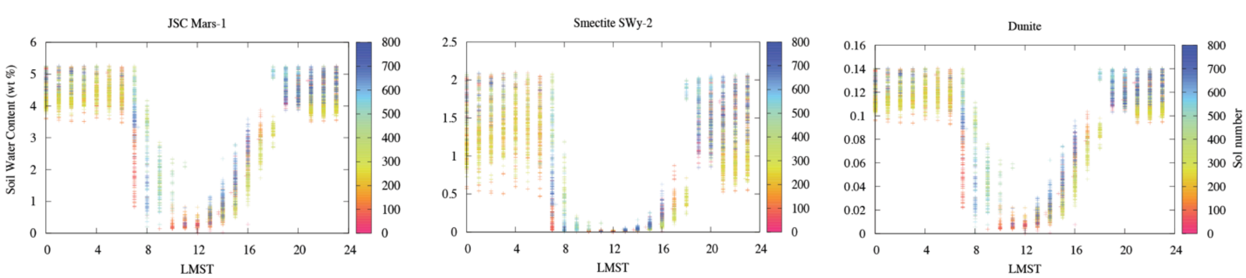

Fig 3. *SWC* at Gale Crater along the rover's traverse for three different types of soil: JSC Mars-1 (left), Smectite SWy-2 (middle) and Dunite (right). *SWC* values are calculated by applying the BET theory to REMS *RH* and T_g measurements and by considering experimentally determined values of the specific surface area and enthalpy of adsorption [4].