WIDESPREAD LOW-LATITUDE DIURNAL CO_2 FROST ON MARS. S. Piqueux[1*], A. Kleinböhl[1], P. O. Hayne[1], N. G. Heavens[2], D. M. Kass[1], D. J. McCleese[1], J. T. Schofield[1], J. H. Shirley[1], [1]Jet Propulsion Laboratory, California Institute of Technology, USA, [2]Department of Atmospheric and Planetary Sciences, Hampton University, *Sylvain.Piqueux@jpl.nasa.gov

Introduction: We use Mars Reconnaissance Orbiter Mars Climate Sounder (MCS) atmospherically corrected surface observations to map and characterize the distribution of nighttime temperatures consistent with the occurrence of CO_2 frost on Mars. We show that low-latitude nighttime CO_2 frost on Mars is widespread. At the meeting, we will present an analysis of data acquired during a dedicated observation campaign in December 2016 aiming at refining the mass and optical properties of these frost deposits.

Results: MCS atmospherically corrected nighttime surface temperatures [1] at 32µm are consistent with the presence of diurnal CO_2 frost detected on nearly all dusty, bright, low thermal inertia terrains (**Fig. 1**). Thus ~60% of the Martian surface experiences surface frost at some point during the Mars Year –MY– (~95% of all terrains with thermal inertias < 100 J m^{-2} K^{-1} $s^{-1/2}$). Nighttime surface temperatures consistent with CO_2 frost are observed seasonally (**Fig. 2, 3**) at nearly all latitudes, except between 20°S and 40°S where no low thermal inertia units exists. The seasonal distribution of CO_2 frost is controlled by latitude, elevation, and presence of water ice clouds in addition to the surface thermophysical properties. Lesser factors are the seasonal pressure cycle, dust loading, and insolation variations linked to Mars' orbital eccentricity (**Fig. 3**). Energy and mass balance modeling indicate that the equivalent CO_2 ice thickness can reach up to a few hundreds of microns at sunrise, but is most often much thinner depending on location and season. Models predict typical survival times of less than one hour after sunrise, making this frost a difficult target for reflected light instruments. Such low amounts of frost account for <<0.1 % of the atmospheric mass on the surface at any time, and are not anticipated to influence the local/global pressure cycle. Surface temperature observations acquired at variable local times in December 2016 will help refine both the cooling rate, and the timing of formation of the first CO_2 frost.

Discussion: This recurring condensation and sublimation cycle may have a significant influence on the thermophysical properties of the Martian surface and the global climate. While virtually all dusty surfaces receive frost at some point during the MY, the rest of the Martian surface, where frost is not observed, is characterized by indurated regolith with variable fractions of sand and rocks (*Units B* and *C* in [2]), as confirmed by landers and rovers traverses (e.g., [3,4,5]).

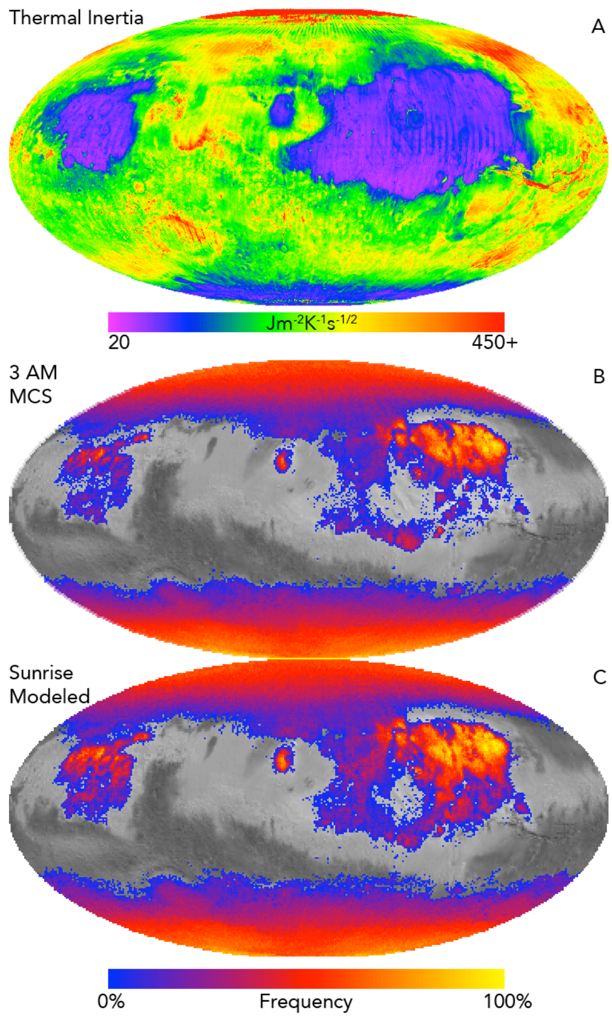

Fig. 1: A: Surface layer thermal inertia [2] versus frequency of CO_2 frost presence over one MY at 3AM (as observed by MCS, B) and at sunrise (modeled, C). High frequencies (yellow) indicate that CO_2 ice is present at night over most of the year, whereas blue signals regions where CO_2 is rarely present. Regions where CO_2 is never detected are not colorized (TES albedo background).

The medium/high thermal inertia of these indurated units indicates that regolith particles are able to develop and maintain infinitesimal amounts of cement [6] of unknown composition [7], offering a continuous medium for efficient heat conduction between grains, resulting in increased thermal conductivity and inertia. In contrast, regolith compaction and induration processes cannot be prevalent in the low thermal inertia regions. We hypothesize that the recurring growth of CO_2 crystals on or within the top surface layer exclusively occurring in the dusty low thermal inertia regions at mid to low latitudes generates sufficient upper regolith disruption to prevent induration and mechanical bonding of soil particles.

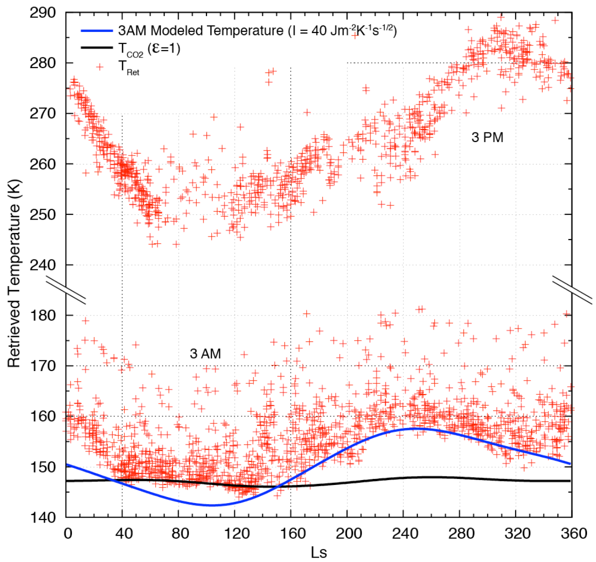

Fig. 2: Seasonal trends in retrieved surface temperatures near the Equator in Arabia Terra (25-31°E, 3°S-3°N) at 3PM (245-290K) and 3AM (145-180K). The blue curve shows 3AM-modeled temperatures assuming a thermal inertia of 40 $Jm^{-2}K^{-1}s^{-1/2}$ (chosen to illustrate the lower bound trend), ignoring CO_2 frost condensation. The black curve indicates the theoretical local CO_2 frost point temperature. A domain exists (40<Ls<150) where the coldest surface temperatures deviate from the model prediction and remain close to the local frost point, suggestive of a buffered surface temperature at ~148K with an emissivity nearing 1.

The relatively rapid sublimation after sunrise might also result in surficial gardening of the very top regolith, maintaining high regolith porosity and further preventing mechanical bonding of soil particles.

In addition, the deposition of surface CO_2 may be a trigger and enabler for various dynamic surface features observed in these regions such as slope streaks, found to be ubiquitous in the areas where we have observed or predicted formation of diurnal CO_2 ice [8,9]. The fluidization of the avalanching material [10] could be enabled by subliming CO_2 ice right after sunrise. While a quantitative validation of this hypothesis is beyond the scope of this work, [11] confirms that regolith fluidization enabled by subliming surface CO_2 ice is a viable scenario to explain slope movement on Mars.

If the low latitude CO_2 ice cycle described in this abstract is indeed a key element maintaining dusty regions, this self maintaining cycle might be fundamental to nurture a large surface reservoir of mobile dust available for lifting in the atmosphere.

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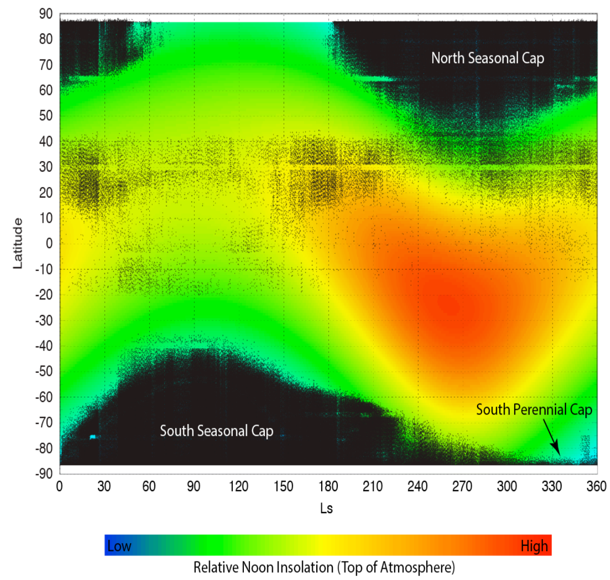

Fig. 3: Latitudinal distribution of CO_2 frost (black dots) versus season using data acquired by MCS between MY28 (Ls 110°) and MY 32 (Ls 160°). Diurnal condensation and sublimation of CO_2 frost on the caps or their margins are not discussed in this abstract. Color background is the relative noon insolation at the top of the atmosphere.

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