SEASONAL FROST AT THE PHOENIX LANDING SITE. M. L. Searls[1], M. T. Mellon[1], S. Cull[2], C. J. Hansen[3]. [1]Laboratory for Atmospheric and Space Physics, University of Colorado (mindi.searls@lasp.colorado.edu), [2]Washington University in St. Louis, [3]Jet Propulsion Laboratory.

Introduction: A critical component to understanding the volatile inventory and climate of Mars is to understand the exchange of CO_2 and H_2O between the atmosphere and surface. The ability of the seasonal polar caps to trap up to 25% of the atmosphere during the winter months reinforces the important role these condensates play in meteorological processes [1]. Knowledge of the spatial and temporal distribution of the surface frost can help to constrain atmospheric models and provide clues to understanding the current and past climate cycles.

The extensive coverage of HiRISE (High Resolution Imaging Science Experiment) images in preparation for the Phoenix Lander provides a unique opportunity to analyze the seasonal retreat of the CO_2 and H_2O frost layer near the Phoenix landing site. The Phoenix lander touched down on the surface of Mars in the ice rich permafrost of the martian artic (68.2ºN, 234.3ºE). The terrain in this region is dominated by polygonal patterned ground which results from thermal contraction cracking of an ice cemented ground. Although ground ice at a depth of ~5 cm persists stably year-round in the Phoenix region [2], surface ice is stable only during the cold winter months. Models of CO_2 frost depth show that, for an ice table depth of 5 cm, CO_2 frost would begin to condense out of the atmosphere mid fall at Ls ~220 and remain on the surface until the beginning of northern spring (see Figure 1). Although the formation of the polar hood in the fall prevented imaging of the formation of the CO_2 condensate, the atmospheric conditions allowed for imaging of the defrosting process.

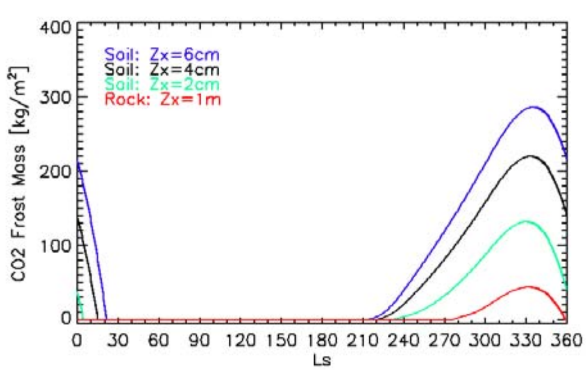

Fig. 1: Model of CO_2 frost mass as a function of solar longitude (Ls) showing the increase in surface frost in the winter months (Ls = 270-360) for various ice table depths (Zx) and surface compositions.

Seasonal Frost Observations: In Figure 2, a time lapse series of HiRISE images shows the progression of seasonal defrosting of this polygon-rich terrain. During the winter months layers of H_2O and CO_2 frost coat the surface. The polygon troughs are preferentially filled, replacing the polygonal patterns with broad decimeter-scale undulations. Large rocks on the surface remain visible, which is consistent with estimates of the thickness of the seasonal CO_2 cover of ~25 cm at 68ºN as provided by the Mars Orbiter Laser Altimeter [3]. CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) analysis shows that CO_2 frost dominates the spectral signature in late winter with traces of H_2O ice and an albedo of ~0.4 [4].

As winter progresses into spring, frost sublimates from the polygon interiors first leaving polygon troughs clearly marked. CRISM spectral data show a transition from CO_2 frost dominated to H_2O frost dominated with the passage of time [4]. As the H_2O frost dissipates, the HiRISE images show a dramatic increase in atmospheric haze obscuring surface features.

Regional Variations in Frost: In addition to the temporal variations in frost, spatial variations can also be found from one geologic unit to the next. The Phoenix lander touched down in the lowland bright geologic unit as described in [5]. The lowland unit is broken up into 2 subunits (bright and dark) based on differences in albedo that can be at least partially attributed to a higher rock abundance in the dark unit. A comparison of HiRISE and CRISM data within these regions shows that the frost lingers longer in the lowland bright geologic unit vs. the lowland dark geologic unit (see figure 3). The increased rock abundance and hence increase in thermal inertia within the lowland dark unit can account for some of this discrepancy, however, the morphology of the units likely plays a role as well. As can be seen in Figure 3, the image of the lowland bright unit displays two distinct polygon distributions (5 and 20 m) as noted by [6]. The lowlands dark unit lacks the larger, 20 m, polygonal pattern. The frost preferentially fills the polygon troughs in both units, however, the deeper troughs of the 20 m polygons within the bright unit leads to an overall increase in the amount of frost within this unit.

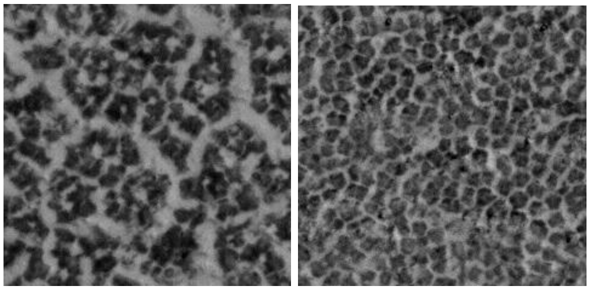

Fig. 3: Subsets of HiRISE images acquired 1 day apart demonstrating the frost and geomorphic variations between the Lowland Bright (left) and Lowland Dark (right) geologic units. Subsets are ~75 m wide. (PSP_007141_2485 and PSP_007128_2485)

Discussion: Why does frost preferentially fill the polygon troughs? An analysis of the local rock distribution around the Phoenix lander shows a statistical increase in rock population within the polygon troughs as compared to the polygon centers [7]. These results are consistent with redistribution of rocks via cryoturbation of thermal-contraction crack polygons. However, the resulting increase in thermal inertia would lead to more rapid sublimation in the troughs and the relatively shallow trough depths (typically <20 cm [8]) indicates that shadows will not play a significant role in cold trapping the frost. Aeolian reworking of the surface frost could help to preferentially deposit frost within topographic lows which would form a cold trap for future condensates. Aeolian reworking would require that the frost be particulate in nature versus slab ice. The relatively dark albedo for the CO_2 frost could be indicative of slab ice, but the dark albedo could also be caused by dust covered CO_2 frost. Thermal Emission Spectrometer (TES) results indicate that slab ice is the dominant component of the polar cap at latitudes outside of the polar night; however, there is evidence to support the presence of fine grained surface ice [9]. The above discussion assumes that the ice table depth is stable throughout the Phoenix region. If the ice table is deeper under the troughs than the polygon centers this could also cause the condensates to linger in the troughs longer (see figure 1).

References: [1] Kieffer H. H. and Titus T. N. (2001) *Icarus, 154,* 162-180. [2] Mellon M. T. (2008) *JGR*, E00A25. [3] Smith D. E. et al. (2001) *Science, 294,* 2141. [4] Cull S. et al. (2009) *LPSC.* [5] Seelos K. D. et al. (2008) *JGR, 113,* E00A13. [6] Mellon M. T. (2008) *JGR*, *113*, E00A23. [7] Heet T. L. et al. (2008) *AGU*, abstract U11B-0020. [8] Mellon M. T. et al (2009) *LPSC*. [9] Titus T. N. et al. (2001) *JGR, 106(E10),* 23181-23196.

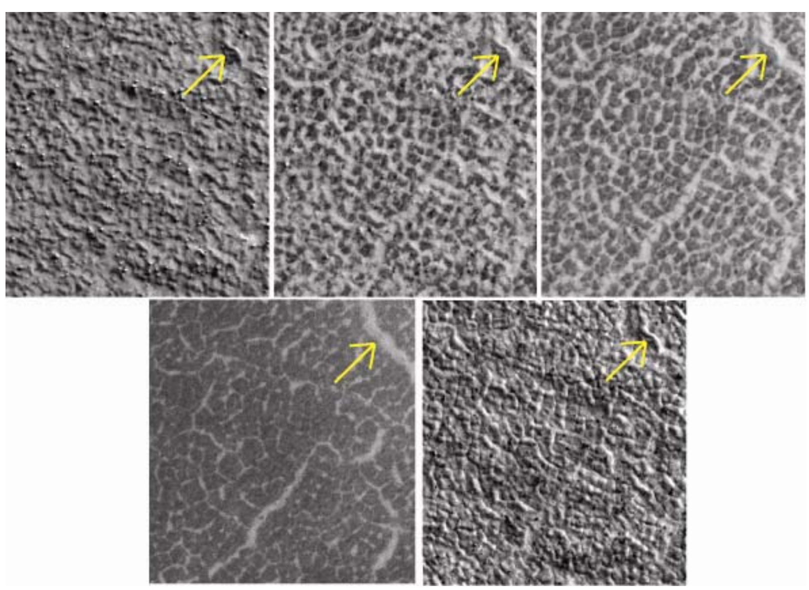

Fig. 2: Time-lapse view of seasonal defrosting. The first image of the series (upper-left) was acquired on Ls = 11 and shows continuous frost cover. The next three images (Ls = 24, 29,37) show discontinuous frost preferentially located in the polygon troughs and an increase in atmospheric haze. In the lower-right we see a frost free image from mid-summer (Ls = 154). Note that these images do overlap with arrows pointing to the same feature in each image. Each subset is ~100 m wide.