SEASONAL ICES AT THE MARS PHOENIX LANDING SITE: OBSERVATIONS FROM HIRISE AND CRISM.

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Introduction: The Mars Phoenix mission landed at 68.2N, 234.3E (areocentric) on 25 May 2008, in an area that is covered during part of the year with the seasonal CO_2 ice cap. Phoenix was tasked with studying the high-latitude environment, including ground ice and polar processes related to the water, carbon dioxide, and dust cycles.

Phoenix made ground observations between solar longitude (Ls) ~80 and Ls~145. However, for a complete understanding of the H_2O, CO_2, and dust cycles at the landing site, year-round observations are needed. In this study, we use targeted high-resolution VIS-NIR spectra from Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) aboard Mars Reconnaissance Orbiter (MRO), to determine when ices appear at the Phoenix landing site, how their grain sizes and relative abundances evolve through time, and what controls sublimation patterns during the spring defrosting period. Images from the High-Resolution Imaging Science Experiment (HiRISE) aboard MRO were used to estimate ice depth during the winter and spring.

Methods: Forty-nine CRISM FRTs taken during the summer, fall, winter, and spring, were atmospherically corrected to Lambert Albedo using the DISORT radiative transfer method [1-3]. Each CRISM pixel was considered a non-linear mixture of three components: CO_2 ice, water ice, and soil (we used a Mars analogue material: dehydrated palagonite described by Clark et al. 1995). A Hapke model was used to model the mixtures, using both an intimate mixture model and a two-layered model [4].

Winter and spring ice depths at the landing site were estimated using pairs of VIS images from HiRISE: one summer frame and one spring frame covering the same area for each scene. For each pair, rock heights were estimated based on shadow lengths in the ice-free summer image, then compared to rock "heights" in the ice-covered spring image. The difference in "heights" was taken as a minimum ice depth.

Results: Afternoon (3pm local solar time) water ice first appeared in the Phoenix landing area in mid-summer (Ls~165), and the ice bands deepened as summer ended. The absoprtions fit ~10 μm water ice. No CO_2 ice was observed before Ls~181 (our last observation before winter).

Depite poor viewing conditions in the winter, the winter spectrum is dominated by extremely deep CO_2

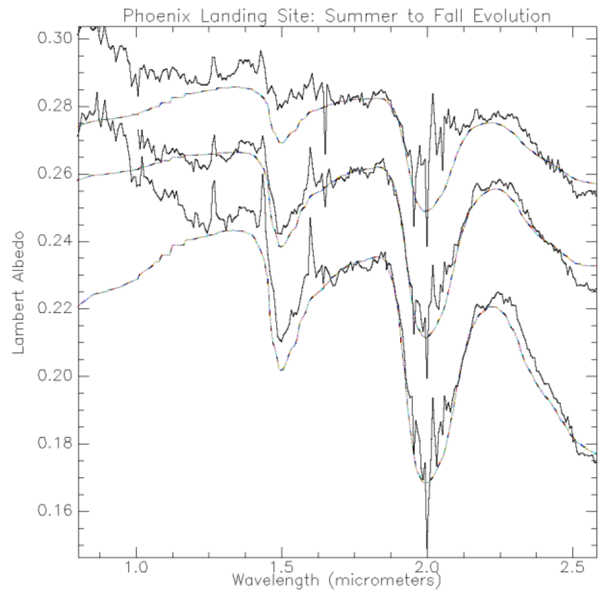

Figure 1: CRISM spectra (solid line) and model results (dashed line) for Ls=165 (top), 167 (middle), and 181 (bottom), showing onset of water ice during late summer.

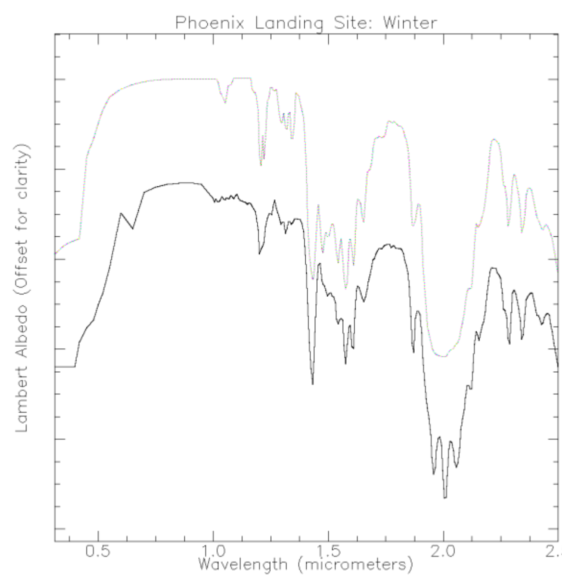

Figure 2: CRISM spectra (solid line) and model results (dashed line) for Ls=344, showing deep CO_2 ice bands. The hash marks around 2.0 microns are due to the atmospheric removal technique.

ice bands, indicating very coarse-grained CO_2 ice (centimeter scale, possibly in slab form). A slight 2.3 µm turndown and 1.5 µm absorption indicate that there is some water ice mixed in with the CO_2; however, it cannot be much, since even a few weight percent of water ice is enough to produce deep water ice absorptions. Based on shadow lengths, ice depth during the winter is estimated as ~35-40 cm, consistent with thermal modeling [5].

During the spring defrosting period, spectra become dominated by water ice absorptions due to a very small amount of water ice overlying CO_2 ice. (Our modeling shows that just 5 mg/cm^2 layer of water ice is enough to completely mask CO_2 ice absorptions). As spring progresses, the depth of the CO_2 bands decreases, which we interpret as the CO_2 ice grains breaking into finer pieces and sublimating. The CO_2 ice disappears by Ls~34. Water ice is completely gone by Ls~60. Ice depth decreases steadily through spring, from ~35 cm at Ls=0 to <5 cm at Ls=30.

References: [1] Stamnes et al. (1998) Applied Optics 27:2502-2509, [2] Arvidson et al. (2005), [3] Arvidson et al. (2008) JGR [4] Hapke (1993) Cambridge UP, [5] Mellon et al. (2008) JGR.

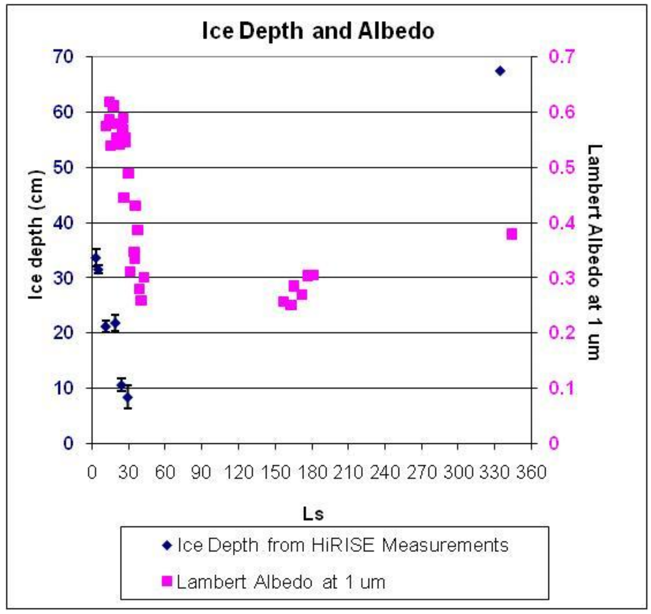

Figure 3: Ice depth (blue, left axis) measured from HiRISE frames, and Lambert Albedo at 1 micron (pink, right axis) measured from CRISM cubes, versus solar longitude (Ls).

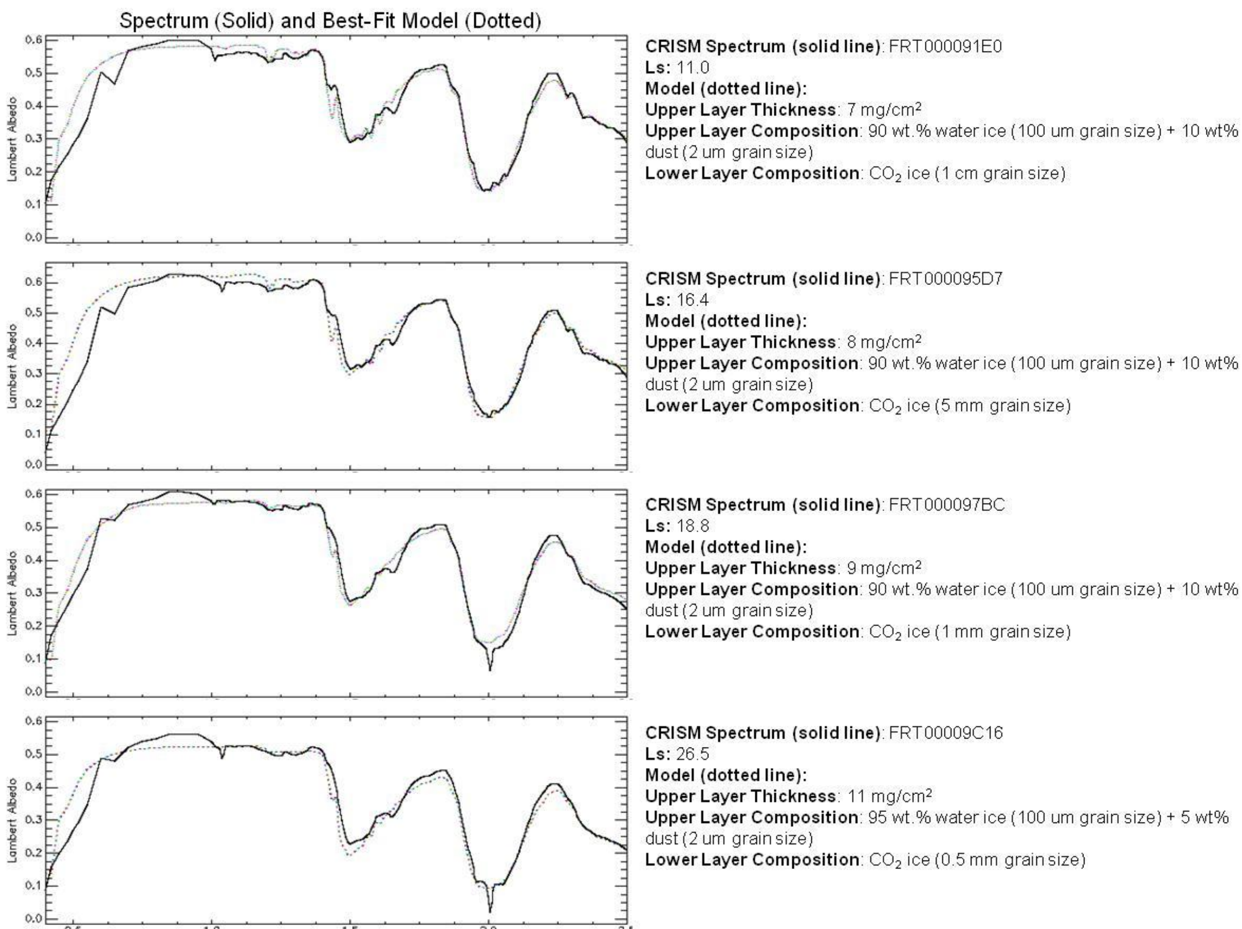

Figure 4: CRISM spectra (solid lines) and model results (dotted lines) during spring defrost period.