Comparison of Seasonal Temperature Variations, Albedo Variations, and Sublimation Activity for CO_2 ice and H_2O ice Near the Martian South Pole. Paras Angell[1] and P. R. Christensen[1], [1]Mars Space Flight Facility School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287. Email: Paras.Angell@asu.edu

Introduction: The Martian south polar cap is a dynamic region covered with a seasonal layer of CO_2 ice and some H_2O ice. Every spring and summer dramatic changes transpire as the CO_2 sublimates. The sublimation is accompanied by distinct surface processes in different south polar regions. In the 'cryptic terrain' [1], dark spots and streaks form on the surface due to basal sublimation of the CO_2 ice slab [1, 2]. Near the edge of the perennial southern polar cap an exposed H_2O ice unit [3] is revealed after the seasonal CO_2 ice layer sublimates.

This project investigates the seasonal temperature variations and albedo variations in these two Martian south polar regions with the goal of understanding the CO_2 sublimation processes and the differences between regions covered with H_2O ice and CO_2 ice.

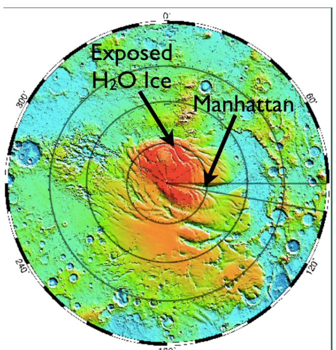

Figure 1. MOLA map [4] of the Martian South Pole, showing location of the Manhattan region (86° S, 99° E) in the cryptic terrain, and location of Exposed H_2O ice at (85.4° S, 10° E). Colors represent elevation.

Methods: The two regions studied are shown in Figure 1. In the Manhattan region, centered near 86° S, 99° E in the cryptic terrain, the areas of interest are labeled A1, A2, A3 (Figure 2). In an exposed water ice region, centered near 85° S, 10° E, the areas of interest are labeled A4, A5, A6 (Figure 5).

Visible images taken by the Thermal Infrared Imaging System (THEMIS) [5] were examined to study the progression of CO_2 sublimation activity during spring and summer. Average albedo values for each area were calculated from the calibrated THEMIS visible albedo products [5].

THEMIS infrared (band 9) images (Figure 5) were analyzed using JMARS software [6] to calculate the average surface temperature for each area. Surface temperatures were studied as a function of solar longitude (Ls) for Mars years 30, 31, 32, and 33.

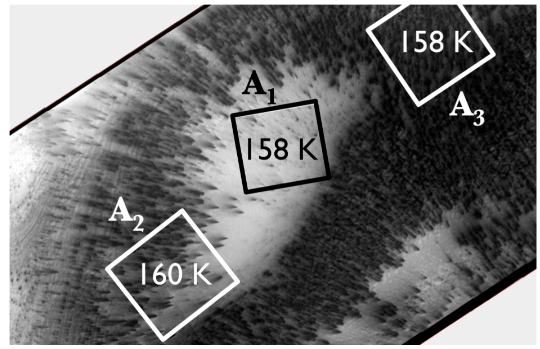

Figure 2. Effects of CO_2 sublimation and regolith deposition. Visible THEMIS Image of a region near 86°S, 99°E at Ls 213° for Mars year 31.

Results: During early spring at Ls 175° the Manhattan region the surface is covered with CO_2 ice, with a surface temperature of ~140 K. There are many dark spots on areas A2 and A3, but very few on A1.

Figure 2 shows a visible image taken at Ls 213°. Area A1 has some dark spots, while area A2 has many dark streaks oriented towards the west. A3 seems to be covered with a layer of dark material. The surface temperatures have warmed up to around 160 K.

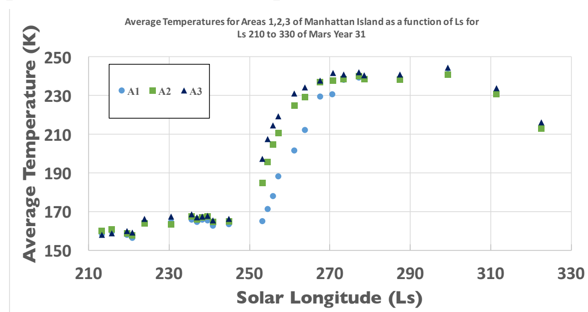

Figure 3: Average surface temperatures for areas A1, A2, A3 as a function of Ls for Mars year 31 showing the sharp rise in temperature at Ls 250°

Figure 3 shows variation of average surface temperature of the three regions, A1, A2, and A3 as a function of solar longitude, Ls. The temperature increases gradually throughout spring until around Ls 250°. Then, between Ls 250° and 270°, there is a sharp rise in the surface temperature. This sharp rise in temperature corresponds to the crocus date [7] when most of the CO_2 has sublimated. This steep increase is repeatable from year-to-year and occurs consistently close to Ls 250°.

Figure 4 shows how the visible THEMIS albedos for areas A1, A2, and A3 vary with solar longitude for Mars year 32. The albedo of the scene decreases as spring progresses. Albedo values increase again and peak around Ls 245°, which correlates with the beginning of the sharp rise in temperatures at that Ls. The variation of albedos with solar longitude for Mars year 33 has a similar trend.

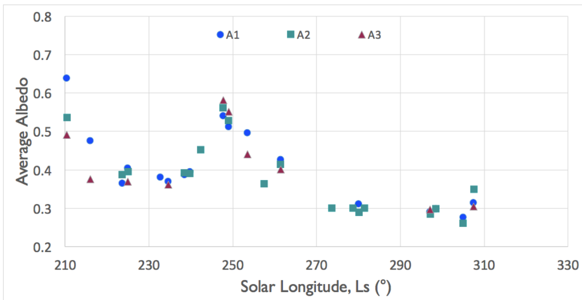

Figure 4. Plot of average albedos as a function of solar longitude for areas A1, A2, A3 for Mars year 32.

In the exposed water ice region, in early spring all areas are covered with a continuous layer of CO_2 ice, and have the same temperature ~150 K at Ls 204°. Figure 5 shows an infrared image taken at Ls 337°, in late summer after the crocus date. Three thermally distinct units are revealed. A4 is colder than A5, and A6 is significantly warmer than both A4 and A5. The boundaries between units are observed to be stable over several Mars years.

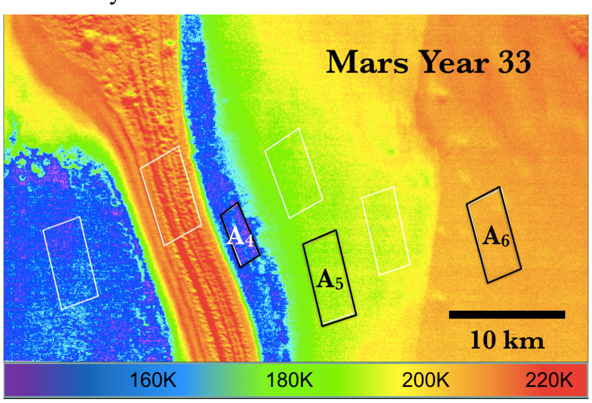

Figure 5: Thermally distinct units revealed after CO_2 sublimation in THEMIS infrared image at Ls 337°. Colors represent temperature.

Figure 6 shows how the average surface temperature changes with solar longitude. After Ls 280°, the surface temperatures differentiate between three units: CO_2 ice, H_2O ice, and regolith. Each unit has a different temperature based on its composition. A study of albedo variation reveals that albedos for the three areas are similar during spring. After Ls 280°, the albedos differentiate. The CO_2 ice has the highest albedo (0.60), H_2O ice has intermediate albedo (0.42), while regolith has the lowest albedo (0.33).

Investigation of THEMIS infrared images in this region in late summer for Mars Year 33 reveals that the H_2O ice unit extends more than 100 km. This indicates that H_2O ice is widespread around the southern perennial polar cap.

Discussion: Surface temperatures in Manhattan increase gradually during spring (Ls 170° - 250°) as regolith gets deposited on the surface. The sharp rise in temperature corresponding to sublimation of CO_2 ice starts consistently around Ls 250°. The maximum temperatures of ~245K correspond to the defrosted terrain. Visible albedos show a peak in albedo near Ls 245°, which could be due to formation of water ice frost [8] or surface brightening.

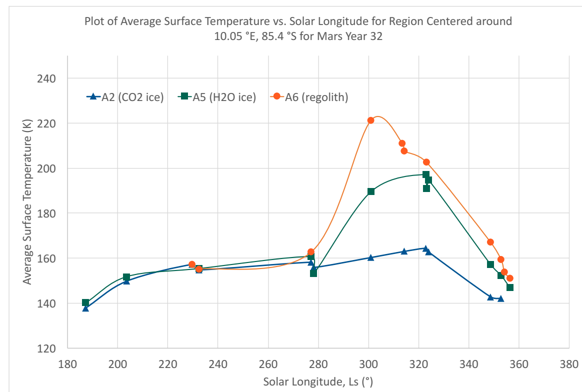

Figure 6. Average Surface Temperature vs. Ls for CO_2 ice, H_2O ice, and regolith (Mars Year 32).

In the exposed water ice region, during spring, areas A4, A5, and A6 have the same surface temperature which increases gradually from 140 K to 160 K. After Ls 280°, the surface temperatures differentiate between three units: CO_2 ice, H_2O ice, and regolith. H_2O ice has an intermediate albedo between those of CO_2 ice and regolith. Area A5 is identified as H_2O ice [3] based on its temperature (190 ± 3 K) and higher albedo than regolith. Future work will include detailed analysis of THEMIS albedo products, investigating other areas outside the cryptic region, and exploring the extended water ice region.

References: [1] Kieffer, H.H., et al. (2006). *Nature 442*, 793–796. [2] Hansen, C.J. et al. (2010) *Icarus 205,* 283–295. [3] Kieffer et al. (2003), *Science*, 299, 1048. [4] NASA Image Credit, MOLA Science Team. [5] Christensen et al. (2009), *AGU Fall Meeting Abstracts*. [6] Christensen et al. (2004) *Space Sci. Rev. 110*. [7] Kieffer, H.H., et al. (2001) *Icarus 154* (1) 162-180. [8] Forget, François. *Solar System Ices*, 477-507, 1998. [9] Piqueux, et al. (2003) *J. Geophys. Res.*, 108 (E8), 5084.