MARTIAN SOUTH POLAR TERRAINS IN SPRING: I. MULTI-INSTRUMENTAL OBSERVATIONS

K.-Michael Aye[1], Antoine Pommerol[1], Ganna Portyankina[1], Nicolas Thomas[1], and Candice J. Hansen[2]. [1]Physikalisches Institut, Universität Bern, 3012 Bern, Switzerland (aye@space.unibe.ch), [2]Planetary Science Institute, Tucson, Arizona

Introduction: Spring evolution of the surface layer in Martian south polar terrains is constantly monitored by the set of instruments onboard Mars Reconnaissance Orbiter (MRO) spacecraft. The combination of cameras with different spatial ground resolutions (CTX and HiRISE) and spectral data (CRISM) allows to investigate the behaviour of extended areas and small feature evolution. The instruments provide temporal coverage high enough to monitor promptly changing phenomena of south polar terrains. We used these instruments to gain further insights into the spring evolution of the areas known to exhibit exotic CO_2 ice phenomena [1, 2, 3, 4].

Notable is the circumstance that CTX data, despite its much lower resolution compared to HiRISE, is very useful for its higher temporal coverage. This is essential to determine boundary conditions for our modeling of specific processes (Fig. 1).

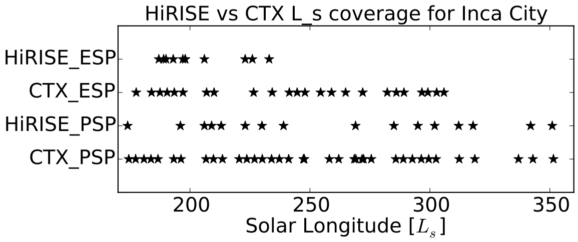

Figure 1: Comparison of the temporal data density of the CTX and HiRISE instruments (PSP=primary science phase, ESP=extended science phase of MRO). The CTX coverage is notably better and becomes important for discovering rapid changes on the surface.

Large scale evolution: Contrary to the intuitive expectation that during spring the CO_2 frost-covered surface becomes progressively darker through sublimation by exposing more of the contaminations of the ice, all our observations indicate clearly a brightening phase approximately between L_s of 200 and 250°. Widely observed surface features that can serve as a means for identifying different stages of surface development are the so called fans. They are assumed to be created by surface deposition of mineral dust and sand from CO_2 sublimation jets. The variations of the surface albedo and CO_2 band strength shown in Fig. 2 indicate two (Inca City) to three (Ithaca) evolutionary steps. First we see a decrease of both the CO_2 band strength and albedo until $L_s = 190 - 210°$, then a significant increase until $L_s = 240 - 260°$ and a rapid decrease until the complete defrosting of the ground.

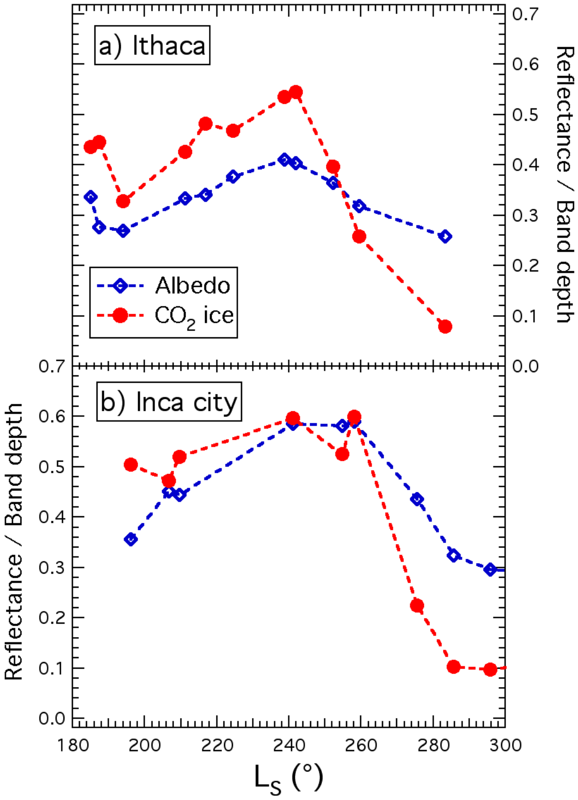

Figure 2: Evolution of albedo and CO_2 during spring in the Ithaca and Inca City regions. The plotted 'albedo' is defined as the reflectance in the continuum at 1.14 μm, the 'CO_2-ice' as the depth of the CO_2 band at 1.4 μm (see [5] and [6] for precise definitions)

Also HiRISE and CTX data allow us to outline several distinctive stages in development of surface layer. Very early observations potentially show the same darkening phase as CRISM, but due to very low light conditions and the uncertainty in the amount of scattered light (in the very first images the sole source of illumination), we cannot un-ambiguously confirm this phase by imaging data. A bright halo phase around fans starting mostly before $L_s = 200°$ can be identified, which is followed by a general surface brightening phase starting between $L_s = 195 - 230°$. Halo and brightening phases appear to end by subliming

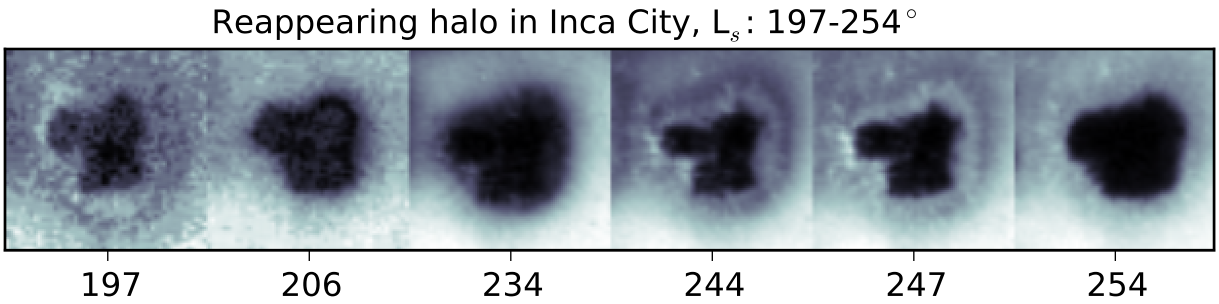

Figure 3: Development of a halo around a jet fan in Inca City over time as seen by CTX (All numbers are L_s of Martian year 29; scale for each subframe is 300x300 m). The first halo at L_s 197 has disappeared at 206, starts to reappear at 234, and after a full development in the 240ies has disappeared again at L_s 254. Note how the shape of the dark substrate of L_s 234 reappears almost exactly at the end (Each subframe has been contrast-stretched independently).

the bright patches of ice, exposing the previously seen shapes of the fan material, starting around $L_s \geq 250°$. Starting from around $L_s \geq 280°$, all CO_2 ice is sublimed, but in small patches it can be seen up to these times.

At the different locations of interest of the south polar terrains these phases happen at slightly different but comparable times, showing partially overlapping. For example, currently only in Inca City (81°S, 296°E) we observe two bright halo phases: one around $L_s = 190°$ and the other one at around $L_s = 230 - 240°$. Brightening of the general surface ends here only at $L_s = 260°$.

Ithaca region (85.2°S, 181.5°E) shows an earlier surface darkening than Inca City, starting between $L_s = 240 - 250°$.

In the Giza area (84.8°S, 65.7°S) bright halos appear at $L_s = 187°$ and are never observed to disappear before the general defrosting, while brightening in this area starts as late as $L_s = 230°$.

This leads us to the conclusion that bright halos and brightening, while generically related, are independent processes.

Small features evolution: Fan shaped deposits have been studied comparatively between the different areas of interests and we will report on the identified categorizations and introduce a nomenclature for fan shapes and sizes. Bright halos have been discovered to reappear in the Inca City region of Martian years 28 and 29 due to CTX's higher temporal coverage. An example of a halo development over time in CTX data is shown for the year 29 in Fig. 3. These halos can be resolved by HiRISE in much more details. With this high degree of precision we are able to determine that bright halos always develop on the very same places, where dark fans were observed before.

Interpretation: Both phenomena, general brightening of the surface and bright halos, are related to the contamination of the top layer of CO_2 ice by dark particles (dust and sand) and their consequent movement through (or even out of) the ice. The very first particle coverage comes from the eruptions of CO_2-sand-dust mixtures created by the sub-ice sublimation of CO_2 (see [7] in these proceedings and [8]). The concentration of dust/sand particles and their sizes differ significantly inside the dark fans and on the average surface: fine dust uniformly covers complete areas of jet activity, while heavier sand rests closer to the apparent sources of fans, creating different shapes dependent on wind and topography. These different concentrations can lead to different timing in dust and sand movement inside the ice and hence different apparent evolution of the surfaces.

References: [1] H. H. Kieffer, et al. (2000) *Journal of Geophysical Research* 105:9653 `doi`. [2] N. Thomas, et al. (2010) *Icarus* 205:296 `doi`. [3] C. J. Hansen, et al. (2010) *Icarus* 205:283 `doi`. [4] G. Portyankina, et al. (2010) *Icarus* 205:311 `doi`. [5] A. Pommerol, et al. (2010) *Journal of Geophysical Research (Planets)* submitted. [6] Y. Langevin, et al. (2007) *Journal of Geophysical Research (Planets)* 112:8 `doi`. [7] G. Portyankina, et al. (2011) in *Lunar and Planetary Institute Science Conference Abstracts*. [8] N. Thomas, et al. (2011, in press) *Icarus*.

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