Northern Seasonal Condensates on Mars by Omega/Mars Express.

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Introduction: The determination of the physical state and coexistence modes of the ices and dust composing the seasonal condensates, as well as their temporal evolution, are of prime importance for the understanding of the microphysics of the sublimation/condensation/deposition processes of volatiles. The spatial and temporal distributions of the condensates constrains the seasonal cycle of volatile exchange (mainly CO_2 and H_2O) between the surface and the atmosphere. They also provide some clues to understand the current and past climatic cycles through the study of inter-annual evolutions. Before the Mars Express mission (ESA) the evolution of the seasonal condensations have been essentially monitored by following the albedo and temperature changes of the surface. The two most recent studies of that kind have been performed with the TES spectrometer and the MOC camera onboard the Mars Global Surveyor [1,2]. Since January 2004 the OMEGA imaging spectrometer allows to directly monitor the abundance, physical state and distribution of the CO_2, water and dust components of the condensates through their visible and near-infrared spectral signatures (Figures 1a and 1b).

OMEGA observations: The OMEGA instrument covers a spectral range extending from the visible to the beginning of the thermal infrared (0.35 - 5.1 µm) with a resolution varying from 14 to 23 nm. Its spatial resolution varies from less than 300 m to a few kilometres depending on the position of the spacecraft on its elliptic orbit. More than fifty observations of the northern seasonal condensates have been recorded by OMEGA at different longitudes and times (Ls = 330° to 90°) until complete sublimation occurs around summer solstice [3]. We report the evolution of the physical state of the northern seasonal condensates, their spatial distribution and their temporal evolution.

Physical State: Comparisons of series of spectra collected along a meridian (Figs. 1a and 1b) in spectro-images covering latitudes from less than 50° to the north pole clearly show a continuum evolution of the seasonal ice deposits from CO_2-rich ice to dusty water ice, then to bare hydrated soil. Statistical analyses (Minimum Noise Fraction Transform) performed on several observations show this trend very clearly (Fig. 2) when going to lower latitudes at a fixed time or when looking at the time evolution of the condensates at a given place, away from the north permanent cap. The initial sublimation of CO_2 ice leads to the progressive enrichment in water ice and dust of the CO_2-rich seasonal deposits. Then a spatial segregation of dusty water ice from the CO_2 ice occurs to finally form a thin CO_2-free dusty water ice layer. Finally the progressive sublimation of water leads to an ice-free hydrated soil (at least in the probed dust optical layer) that can start to warm up, as witnessed by the increasing thermal contribution in the spectra.

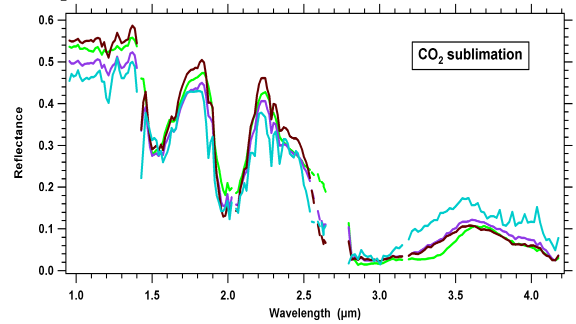

Figure 1a: Spectral evolution from CO_2-rich (blue) to H_2O-rich (green) area with decreasing latitude (Ls=8.6°).

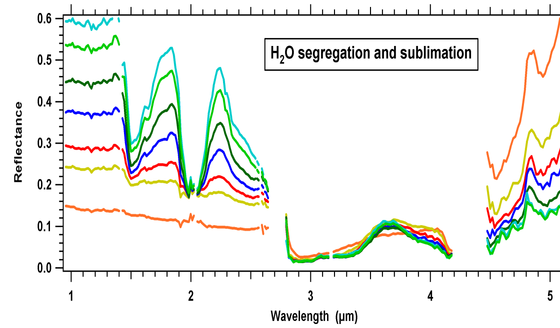

Figure 1b: Subsequent evolution of the spectra from H_2O-rich to bare (and hotter) hydrated soil (Ls=8.6°).

Spatial Distribution: We define a series of spectral classes (color coded) depicting the progressive evolution of the condensates from the distribution of the spectra in the principal component space of the statistical analysis (Fig. 2). The transition from CO_2 sublimation to H_2O sublimation process (light green class #10) as well as the location of the complete disappearance of water ice are clearly defined (orange class #15) in this plot. When projected on the image these classes show a relatively well organized latitude dependence revealing the sublimation sequence (Fig. 3). Only a few area, including some recent condensation on crater rims and a few particular geological features, depart from this general trend. These results should provide strong constraints on the GCM models monitoring the H_2O and CO_2 ices sublimation and condensation [Forget et lal., this issue].

Spectra extracted at different stages of the ice sublimation sequence have been modelled using our radiative transfer code in layered media [4] and optical constants of CO_2 and H_2O ices [5, 6]. These modelling allow us to determine the coexistence modes, the abundances and the grain sizes of CO_2 ice, H_2O ice and dust and their evolution with latitude and time. From these

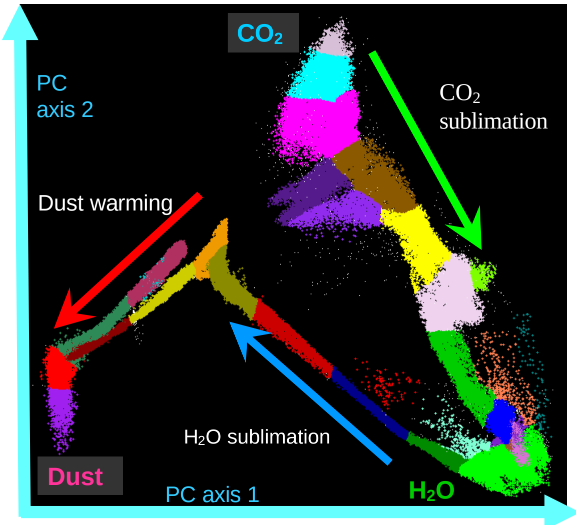

Figure 2: Statistical plot of the data (orbit 231), with spectral classes, for the first 2 principal axes of the MNF transform. It clearly shows the evolution path from CO_2-rich ice to dusty H_2O ice to warming hydrated soil.

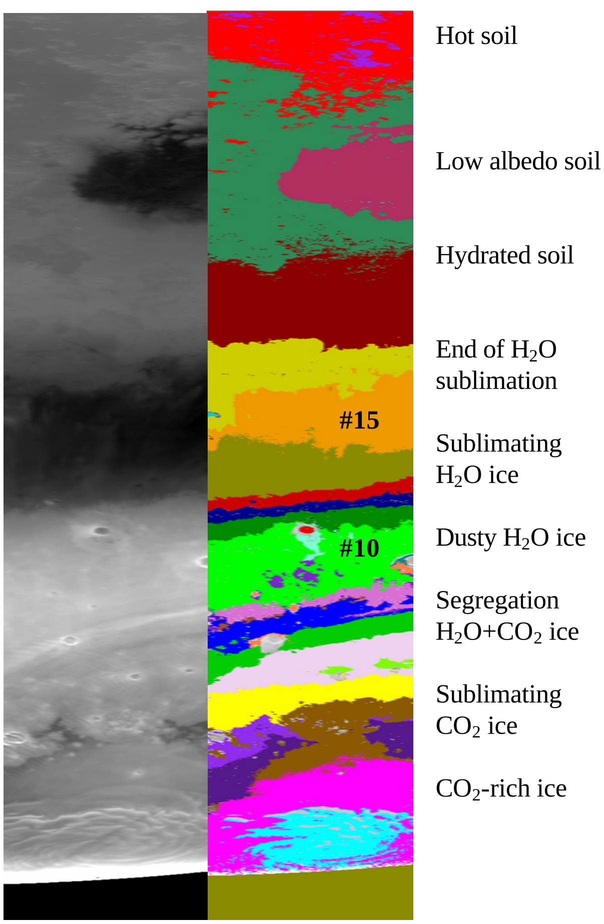

Figure 3: Image at 1.37 µm (IR continuum) of the northern condensates (left) and statistical classes depicting their progressive evolution with latitude (right) (Ls=8.6°).

results the microphysical processes acting during the sublimation sequence can be studied.

Temporal Evolution: The temporal evolution of the spatial distribution of CO_2 and H_2O ices has been followed during the recession of the seasonal condensates (from Ls=330° to Ls=90°) (Fig. 4). After the progressive recession to higher latitude of the CO_2 and H_2O sublimation lines, the sublimation of the CO_2 ice covering the permanent cap occurs around Ls=50°, but with some persisting in throughs and at a few other places until about summer solstice (Ls=90°) when only water ice remain on the permanent cap [3]. At about the same time the H_2O ice crocus line merges with the border of the permanent cap uncovering the surrounding hydrated soil.

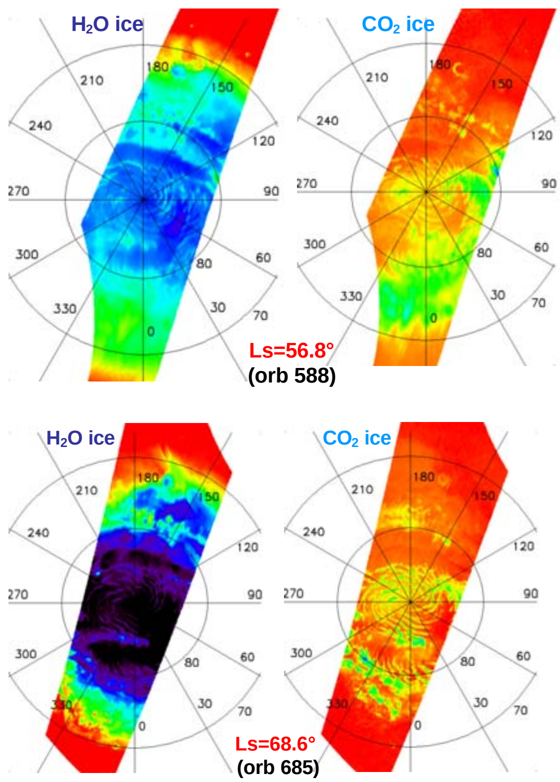

Figure 4: Qualitative maps of H_2O and CO_2 ice distribution (from band depths) at two late stages of recession for the seasonal condensates (rainbow scales with dark blue corresponding to high abundance).

References: [1] Kieffer H.H. and Titus T.N. (2001) *Icarus* 154, 131-144; [2] James P.B. and Cantor B.A (2001) *Icarus* 154, 162-180; [3] Langevin Y. et al. (2005) submitted; [4] Douté S. and Schmitt B. (1998) *JGR E*, 103, 31367-31390; [5] Quirico E. and Schmitt B. (1997) *Icarus*, 127, 354-378. [6] Grundy W. and Schmitt B. (1998) *JGR E*, 103, 25809-25822.

Acknowledgments: This work is supported by contracts from the CNES “Système Solaire” program.