

SPRING EVOLUTION OF THE NORTHERN SEASONAL CONDENSATES ON MARS FROM OMEGA ON MARS EXPRESS

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Introduction: Seasonal condensates are one of the most important martian meteorological processes. The determination of the physical state and coexistence modes of the ices and dust composing the seasonal condensates, as well as their extent, abundance and temporal evolution, are of prime importance for the understanding of the deposition and sublimation processes of volatiles on Mars. The spatial and temporal distributions of the condensates are strongly linked with the seasonal cycle of CO₂ and H₂O exchanges between the surface and the atmosphere. The knowledge of these distributions should help to constrain these cycles. They may also provide clues to understand the current and past climatic cycles through inter-annual evolutions. Before the Mars Express mission (ESA) the evolution of the seasonal condensates have been essentially monitored by the albedo and temperature changes of the surface [1, 2, 3].

OMEGA observations: The OMEGA imaging spectrometer aboard Mars Express allows to directly monitor the abundance, physical state and distribution of the CO₂, water and dust components of the condensates through their visible and near-infrared spectral signatures. We report on the 2006 evolution of the northern seasonal condensates, from winter solstice to their complete sublimation around summer solstice.

Evolution of the seasonal condensates extent: The seasonal condensates were monitored using three parameters : reflectance at 1.08 μ m as a proxy of the albedo, CO₂ ice band depth at 1.43 μ m and H₂O ice band depth at 1.5 μ m. Maps of these parameters were created for 23 Ls intervals.

The seasonal condensates evolution in term of albedo is mostly the same as the ones observed by [1, 2, 3] in 2000 and 2002. The recession is first axisymmetric then much less symmetric after Ls 50°. Condensates albedo increases during the recession. Further analysis should help to constrain the origin(s) of this effect: a combined ice grain size and aerosols optical depth effect, or a process removing the dust from the ice, or a photometric effect of the ice?

CO₂ ice and H₂O ice distributions are also axisymmetric from Ls 350° to 50°. H₂O ice extends southern of

CO₂ ice, thus a CO₂-free water ice annulus surrounds the CO₂ ice rich deposits [4]. This annulus was first detected on the basis of temperature measurements [1]. Low H₂O ice band depth is detected southern of this water ice annulus, likely mostly due to absorption by water ice in clouds forming the polar hood. After Ls 50°, CO₂ ice distribution becomes patchy until complete disappearance at Ls 80°. However, between Ls 50° and 70°, the CO₂ ice signature reappears at locations where it had disappeared. H₂O ice distribution is no more axisymmetric after Ls 50°, assuming the kind of polygonal form observed for the albedo distribution. It recesses until reaching the permanent cap at Ls ~100°.

Boundaries of the seasonal condensates in term of albedo, CO₂ ice and H₂O ice were retrieved from the dataset (see Figure 1).

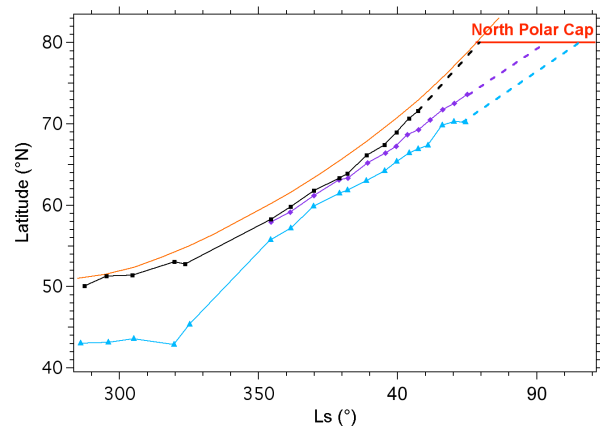


Figure 1: Comparison between seasonal condensates boundaries. All boundaries are zonally averaged. Black: CO₂ ice boundary (OMEGA). Purple: albedo boundary (OMEGA). Blue: H₂O ice boundary (OMEGA). Orange: IR boundary (TES).

First we notice that the water ice annulus is very extended before the beginning of the recession at Ls 320°. Its ~8° extension likely corresponds to daily water frost observed by the Viking Lander 2 [5]. After Ls 350°, the water ice annulus is only 2° extended and widens to more than 3° after Ls 35°. The albedo boundary of the condensates does not correspond to their outer limit, i.e. the water ice limit. Water ice detected

southern of the albedo limit probably corresponds to dusty water ice segregated with defrosted soil. CO₂ ice is systematically detected southern the TES crocus line which is the thermal stability limit of CO₂ ice [6]. CO₂ ice southern the TES crocus line is likely segregated with water ice whose temperature is above CO₂ ice temperature.

Evolution on specific regions: Values of the albedo, CO₂ ice band depth at 1.43 μ m and H₂O ice band depth at 1.5 μ m were monitored at specific regions, one which exhibits typical seasonal condensates behavior and the other exhibiting an atypical behavior.

Typical behavior: Figure 2 shows the evolution of the three parameters in a region located at 65°E, 71°N. CO₂ ice band depth decreases as soon as Ls 0° and the absorption band disappears at Ls ~45°. Albedo and H₂O ice band depth first gradually increase then sharply decrease from Ls 40° to ~66°. The water ice annulus reaches this region at Ls ~45°, when CO₂ ice disappears.

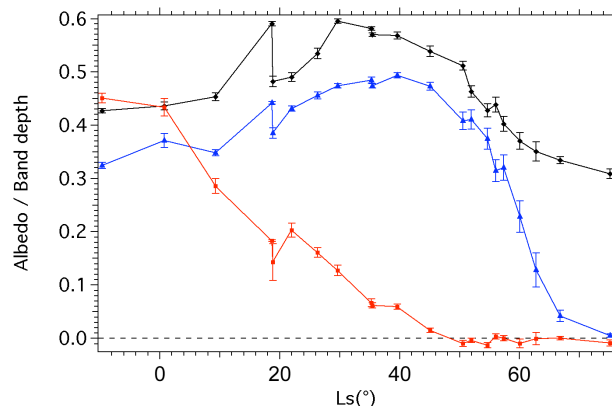


Figure 2: typical seasonal behavior of albedo and ice band depth. Black: albedo. Blue: H₂O ice band depth at 1.5 μ m. Red: CO₂ ice band depth at 1.43 μ m.

Atypical behavior: Figure 3 shows an atypical behavior observed at 347°E, 76°N. A sharp decrease of the CO₂ ice band depth is observed between Ls 35° and 50° correlated with a sharp increase of the H₂O ice band depth. The albedo stays constant during this period. Then at Ls 59° CO₂ ice band depth suddenly increases to 25% and H₂O ice band depth decreases. Both ices are no more detected after Ls 80°.

This atypical behavior is observed on the circumpolar dark dunes field, on the walls of Chasma Boreale and inside North permanent cap chasmata.

The process responsible for this behavior may be linked with the water ice annulus. Water ice sublimating in this annulus could recondense on the northern

CO₂ ice rich deposits which would act as a cold trap [7]. A H₂O ice veneer would form, hiding the CO₂ ice

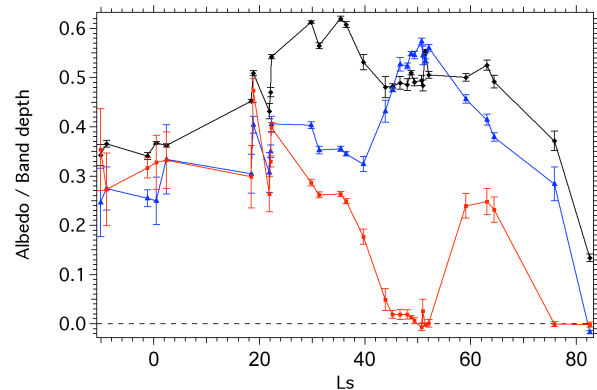


Figure 3: atypical behavior of albedo and ice band depth. Black: albedo. Blue: H₂O ice band depth at 1.5 μ m. Red: CO₂ ice band depth at 1.43 μ m.

signature. Radiative transfer modelling in layered media [8] using optical constants of CO₂ and H₂O [9,10] has shown that a 0.1 mm thick layer of H₂O ice is enough to hide the CO₂ ice signature. Then the sublimation of CO₂ ice would break up the H₂O ice veneer, revealing the CO₂ ice signature.

Conclusion: Northern seasonal condensates differ from the southern ones by the amount of H₂O ice involved. Stability temperature of water ice is higher than CO₂ ice one. Therefore a water ice annulus surrounds the CO₂ ice rich deposits. An atypical behavior is observed for CO₂ ice signatures, involving a complex interplay between H₂O frost, CO₂ ice, probably dust and the underlying terrains. The understanding of the various processes occurring during the condensates recession will provide clues to constrain the seasonal cycle of CO₂ and H₂O exchanges between the surface and the atmosphere.

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