SPRING EVOLUTION OF MARS’ NORTHERN SEASONAL CONDENSATES FROM OMEGA ON MARS EXPRESS. T. Appéré¹, B. Schmitt¹, S. Douté¹, Y. Langevin², F. Forget¹ and J.-P. Bibiring³, ¹Laboratoire de Planétologie de Grenoble, BP 53, 38041 Grenoble Cedex 9, France (thomas.appere@obs.ujf-grenoble.fr), ²Institut d’Astrophysique Spatiale, Université Paris-Sud, Orsay, ³Laboratoire de Modélisation Dynamique, Université Paris 6, Paris, France.

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 martian year (MY) 27-28 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 1.08μm as a proxy of the albedo, CO₂ ice band depth at 1.43μm and H₂O ice band depth at 1.50μm. Maps of these parameters were created for 24 Ls intervals and boundaries of the seasonal condensates retrieved when it was possible (see Figure 1). First we notice that the H₂O ice boundary is systematically shifted south of the CO₂ ice boundary, 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]. It 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 ~3° by Ls 40°. After Ls 50°, the CO₂ ice distribution becomes patchy, thus no CO₂ ice boundary is drawn. The albedo boundary of the condensates has been visually determined. It does not correspond to their outer limit, i.e. the water ice limit. A shift of ~2° of latitude is observed between these two limits. Water ice detected southern of the albedo limit probably corresponds to dusty water ice segregated with defrosted soil. This segregation occurs at a lower scale than the OMEGA pixel scale but can be observed on many Hi-Rise pictures (see photo PSP_007372_247). CO₂ ice boundary is systematically shifted ~2° south of the TES crocus line for which threshold was set at 165K [6]. CO₂ ice and H₂O ice equilibrium temperatures at 9 mbars are respectively 150K and 205K [7]. The TES crocus line does not correspond to the disappearance of CO₂ ice on the surface but to the rise of surface temperature due to a segregation between CO₂ and H₂O ices. The CO₂ ice boundary is defined as the end of this segregation with the total disappearance of CO₂ ice on the surface.

Evolution of the seasonal condensates extent: Values of the albedo, CO₂ ice band depth at 1.43μm and H₂O ice band depth at 1.50μm 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 64°E, 71°N. We observe a decrease of the CO₂ ice band depth correlated with a H₂O ice band depth increase from Ls 0°
to Ls 50°. It likely corresponds to a segregation between CO₂ ice and H₂O ice. Then albedo and H₂O ice band depth decrease from Ls 40° to ~65°. This decrease is likely due to a segregation between H₂O ice and defrosted soil.

![Figure 2: Typical seasonal behavior of albedo and ices band depth. Black: albedo. Blue: H₂O ice band depth at 1.50μm. Red: CO₂ ice band depth at 1.43μm.](image)

*Atypical behavior:* Figure 3 shows the kind of evolution observed on the circumpolar dark dunes field and on North permanent cap chasmas. The CO₂ ice absorption band gradually disappears from Ls 30° to 50°. It is correlated with a H₂O ice band depth increase. Then the CO₂ ice signature strongly reappears and the H₂O ice band depth decreases. The CO₂ ice band depth resumes decreasing at Ls ~65° until disappearance of CO₂ ice at Ls 75°, while H₂O ice disappears at Ls 83°. Albedo decrease after Ls 70° is likely due to segregation between H₂O ice and defrosted soil.

![Figure 3: Atypical behavior of albedo and ices band depth. Black: albedo. Blue: H₂O ice band depth at 1.50μm. Red: CO₂ ice band depth at 1.43μm.](image)

We propose a scenario for the reappearance of the CO₂ ice signature. Soon after spring sunrise, the CO₂ ice sublimes but not the H₂O ice trapped in it. A H₂O ice layer gradually overlies the sublimating CO₂-rich ice. Some water vapor coming from the water ice annulus may also be cold trapped on the CO₂-rich ice [8]. The H₂O ice layer gradually hides the CO₂ ice signature, which would explain the early disappearance of the CO₂ ice signature and the increase of the H₂O ice signature. Radiative transfer modelling in layered media [9] using optical constants of CO₂ and H₂O [10, 11] has shown that a 0.1 mm thick layer of H₂O ice is enough to hide the CO₂ ice signature. The increasing CO₂ ice sublimation flux would disrupt the overlying H₂O ice layer, revealing the CO₂ ice signature. Spectral modelling using our radiative transfer code [9] is ongoing to test this evolution scenario.

**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-rich ice deposits. Spatial segregation may occur between CO₂-rich ice and H₂O ice, then between H₂O ice and defrosted soil. 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.