Physical characterization of the south seasonal cap of Mars during its recession from OMEGA observations

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Introduction The high latitudes of Mars are covered by a seasonal CO_2 ice deposit. The time and space evolution of the CO_2 distribution as well as its physical state and texture constrains many atmospheric and surface processes involving the latter compound but also H_2O and dust. The imaging spectrometer OMEGA on board Mars Express has been scrutinizing the seasonal changes in the south polar region from mid winter (Ls=127°) to the end of recession (Ls=305°), extending to the pole only after spring equinox. In the spectral range of OMEGA operation (0.37-5.10 μm), CO_2, H_2O, and to a lesser extent dust, display numerous and distinctive absorption bands that allow us to recognize and characterize different classes of icy terrains with unprecedented accuracy.

Methods Automatic detection of CO_2, H_2O, and dust coupled with statistical techniques (PCA and ICA) applied to the OMEGA images differentiate several types of icy terrains according to their composition and their physical properties. Then we extract the purest spectra of these terrains and model them to obtain quantitative values for the physical parameters e.g. abundances, granularity, layer thicknesses. For that purpose a radiative transfer algorithm calculates the spectral reflectance of layered, icy, and dense materials taking into account shadowing effects due to macroscopic roughness. Each layer can have a granular or a compact (icy matrix with inclusions) texture.

Results Before equinox the seasonal cap is mostly composed of a clear slab of CO_2 ice ~ 30 cm thick, with typically 0.02 to 0.06 % in volume of dust and H_2O ice inclusions. Starting at Ls=210-230° the recession of the seasonal cap becomes longitudinally asymmetric with the appearance of the cryptic region, a cold region with relatively low albedo. The modeling shows that the cover of CO_2 remains continuous although it is reduced in thickness (100 to 150 mm) and is contaminated by dust (up to 7 weight %) and water (up to 0.42%) in a thin upper layer. The dust contamination accelerates the sublimation of CO_2 and, by Ls=242°, patches of ice-free terrains appear while the thickness of the CO_2 slab is decreasing. The regression is much slower for the rest of the cap since the albedo of the CO_2 layer overlying its mineral substratum remains higher.