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Multi-scale, multi-year investigations of H_2O ice deposits observed in late summer, at the time of minimum extent of the Southern polar cap of Mars

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Abstract

Extended regions exhibiting water ice signatures have been observed by OMEGA on Mars Express at the boundary of the CO_2 perennial cap during the first months of operation of the mission [1]. This period in late summer (Ls 335°-340°) corresponds to the minimum extent of the ice coverage around the South pole. The retreat of the South seasonal cap, spectrally dominated by CO_2 frost [2, 3] ends at Ls 310° - 315° for years which do not present a global dust storm [4], and the first signs of H_2O frost re-condensation are observed before the fall equinox (Ls 0°). A large outlier had been identified by OMEGA observations at longitudes from 290°E to 10°E. It was shown to extend over an area representing ~ 25% of the surface of the perennial cap by Themis observations [5]. The H_2O covered regions at the boundary of the cap and within the outlier have an intermediate albedo (30-35%) between that of the perennial cap (> 60%) and that of surrounding terrains (~ 20%).

These southern surface H_2O ice deposits constitute a major source of atmospheric H_2O at the end of the Southern summer. They are much smaller in extent than the northern perennial cap and they are exposed to sunlight for 2 months in late summer instead of 6 months in the North over the whole summer. This is in line with the highly asymmetric seasonal cycle of atmospheric water [6, 7].

In late 2009, OMEGA observations of the South cap at the time of minimum extent (Ls 340°) showed a much larger extent of H_2O ice signatures compared to what had been observed in early 2004 [1]. H_2O ice covered regions appeared homogeneous at the km scales corresponding to OMEGA observations. A series of CRISM observations were planned for the next southern fall season (mid-2011), in order to further investigate the time variability of the southern H_2O ice deposits within the outlier at the 20 m scale (CRISM high resolution mode). Combining OMEGA and CRISM observations demonstrates that variegation of surface H2O ice is mainly observed at km scales. The results also demonstrate that the extent of the outlier in 2011 is more similar to 2004 than to 2009. Coverage of these areas with HIRISE made it possible to investigate the characteristics of the regions exhibiting surface H_2O ice deposits at the sub-meter scale. They appear extremely diverse at these scales, specific areas exhibiting dark spots a few m in diameter with a contrast which decreases from Ls 315° (last stages of the retreat of the seasonal CO2 cap) to Ls 350° (recondensation of H_2O frost close to the equinox). These features can be attributed to surface dust contamination of ice deposits. Other areas within the outlier exhibit small pits and late brightening of regions several 100 m in extent, which can be attributed to H_2O ice recondensation. These results demonstrate the complexity of surface-atmosphere interactions relevant to the water cycle of Mars at high southern latitudes.

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