

MARCI Views of the Martian Polar Ices and their Evolution. W. M. Calvin¹, P. B. James², R. M. Haberle³, M. C. Malin⁴, P. C. Thomas⁵, A. J. Brown⁶, ¹Geological Sci. & Eng., University of Nevada, Reno, NV 89557, wcalvin@unr.edu, ²Space Science Institute, Boulder, CO, ³NASA Ames, Moffett Field, CA, ⁴Malin Space Science Systems, San Diego, CA, ⁵Center for Radiophysics and Space Research, Cornell University, Ithaca, NY, ⁶SETI Institute, Mountain View, CA.

Introduction: The Mars Color Imager (MARCI) on MRO consists of two optical systems (visible and ultraviolet) projecting images onto a single CCD detector [1]. The camera operates in a “pushbroom” mode such that filters are adjacent to each other on the focal plane. MARCI has two ultraviolet and five visible channels. The visible channels have a nadir scale of about 900 m and the UV channels are summed to 7-8 km nadir scale. A primary goal of the MARCI VIS images is to map climate and seasonally variable phenomena as a function of Martian season (Ls).

MRO began transition phase observations at the end of September, 2006. This corresponded to an Ls ~ 113, or after the north residual cap had retreated to its nominal summer state of coarse exposed water ice [2,3]. In mapping orbit MARCI acquires roughly 10 images a day, the vast majority covering the polar regions allowing for high time fidelity synoptic coverage of the varying albedo deposits. We now have a full martian year of observations and are able to trace the onset and retreat of seasonal frosts for both the north and south poles as well as summer season changes in residual ice deposits.

North Pole Seasonal and Residual Ices: Benson and James [4] summarized the recession of the both north and south seasonal caps as observed by MOC. They noted slight asymmetry and variations in recession of the north mostly related to topography.

Calvin and Titus [3] identified large-scale variations in the north residual ice cap using binned TES albedo data. The cap undergoes a period of defrosting up to Ls ~100 to 105, followed by frost migration and transport. These results are consistent with observations reported by Langevin et al. [2], who attributed a decrease in albedo and the change in shape of absorption bands of the central cap in early summer to sublimation of fine-grained water ice frosts. While large scale patterns remain the same, interannual variability in both the persistence and location of the highest albedo deposits has been noted. In particular, sustained bright anomalies were found in several locations.

MARCI time series from MY28 (the first MRO northern summer) shows numerous persistent small bright patches throughout the north residual cap and a sustained high albedo deposits along the ridgeline west of the Chasma Boreale. In addition to the Chasma

ridgeline numerous small spots are observed and tend to be located near the lower latitude margins of permanent ice. The bright spots along the ridge were observed by CTX and CRISM and found to disappear after a dust event, uncovering water ice-rich, but lower albedo material [5].

Observations in MY29 (the second MRO northern summer) shows significant variability in the early season (prior to Ls 100). We see retreat of normally water ice covered materials poleward from Tenius Rupes and Abalos Mensa. Significant retreat of water ice in the Gemini Scopuli, off ~60E longitude, is seen followed by refrosting beginning near Ls 95, when the sustained bright patches along the cap margins are also again seen. High albedo materials cover the area mapped as gypsum until well into the northern spring and a new high albedo deposit is seen on top of the dark deposits off the reentrant in Olympia Planum, that later disappears.



Figure 1: North Pole MARCI view on July 30, 2008, Ls 105. Defrosted regions noted in the text are evident as well as new lighter toned deposits in Olympia Undae.

South Pole Seasonal and Residual Ices: The south seasonal cap has a strong asymmetry in seasonal retreat with bright outliers in the Mountains of Mitchell as well as the development of a low-albedo and cold “cryptic” region [6,7,8]. Benson and James [4] note that the south cap recession, though asymmetric, is very similar from year to year between 1999 and 2003.

South seasonal cap recession in MY28 (the southern summer in calendar 2007 with the occurrence of a global dust storm) is similar to past recessional curves, but may have earlier loss of seasonal frost in some areas due to the large dust storm. Outlier ice deposits that have been mapped as water ice by Piqueux et al. [9] stay frosted well into the southern summer, beginning to sublime after Ls 315. These deposits also brighten in early fall suggesting cold trapping of frosts as lower temperatures return.

We have noted the presence of CO₂ frosts in the area of residual carbon dioxide ice until approximately Ls 320 [10,11]. Analysis of CRISM data shows that water ice is highly spatially variable and that many of the low albedo units still contain the spectral features of coarse CO₂ ice [10]. Early season, CO₂ frost is ubiquitous and albedo decreases over the summer, showing remnant “seasonal” ice continues to disappear until Ls 320 or later. The diagnostic CO₂ ice features at 2.28 and 2.34 μm in dark terrain are seen both early and late in the season and are associated with large pathlengths suggesting carbon dioxide ice is intermixed with soils in the dark lanes. This is similar to the situation in the north, where low albedo material darkens, but does not obscure, the ice signature. However, the southern cap has at least some regions where the ice is solid CO₂, rather than water. There is an apparent transition zone that has more water ice that occurs between high albedo residual cap units to underlying dark polar layered deposits. Late in the summer season, water ice is more apparent in dark material in some locations, especially those areas that have been previously mapped as water based on temperature. Water ice appears to be both intrinsic to the PLD and as a “patina” or surface veneer deposited by winds or cold-trapped on shaded surfaces. Based on previous mixture modeling no place surveyed appears to have more than a few % water ice, though the analysis is not yet comprehensive.

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Figure 2: South Pole MARCI view on August 30, 2007, Ls 305. High albedo region offset above the residual cap is the region mapped as water ice based on temperature.