OBSERVATIONS OF THE POLAR CAPS OF MARS BY OMEGA/MEX IN THE VISIBLE RANGE.

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Introduction: The OMEGA imaging spectrometer on board Mars Express has been observing the Martian surface and atmosphere since January 2004. The observations so far cover 16 years, more than 8 Martian years. Observations of polar caps can only be performed by OMEGA when the sun is high enough above the horizon, during local spring and summer. The orbit of Mars Express is highly elliptical (300 km x 10500 km), with a precession motion of the line apsides by 360° every 1.6 years. The local time decreases by ~ 1 hour / month due to the combined effects orbit plane precession and Mars orbital motion. Contrary to sun-synchronous orbiters (e.g. MRO), this means that observations at the same Ls for successive Martian years are obtained at quite different spatial resolutions (from 300 m to 11 km/pixel) and local times (secondary to L_s for lighting at high latitudes).

The OMEGA image cubes initially covered a wavelength range from 0.37 µm to 5.09 µm with three channels: "VIS" channel (96 spectral bands from 0.36 - 1.05 µm); "C" channel (128 spectral bands from 0.93 µm - 2.7 µm); "L" channel (128 spectral bands from 2.53 µm - 5.09 µm). The "C" and "L" channels rely on a cryo-cooler for bringing the temperature of the detector down to its operational range (~ 80 K). The "C" cooler became non-operational in June 2010, far beyond its expected lifetime. In January 2016, functional issues were encountered when operating the "L" channel, so that most recent OMEGA observations have been implemented with the "VIS" channel alone.

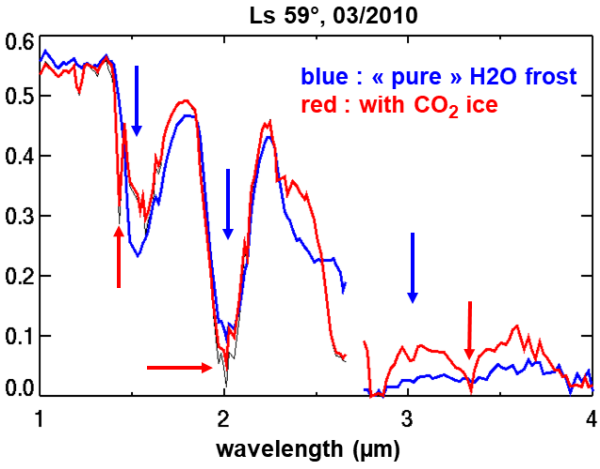

Fig. 1: signatures of H_2O frost and CO_2 ice observed by OMEGA in 2010 with the "C" and "L" channel.

Evolution of instrumental capabilities: The three successive configurations of OMEGA (all three channels until June 2010, then "VIS" + "L" until January 2016 then "VIS") have a major impact on the capability for identifying ice-covered areas, for discriminating between CO2 ice and H2O ice and for obtaining information on particle size. As shown in Fig. 1, CO_2 ice and H_2O ice present major absorption bands in the "C" and "L" channels (contrary to the "VIS" channel). One can still rely on "VIS" albedo for identifying ice-covered areas as most have reflectance higher than 50%, to be compared to ~ 45% for dust-covered areas. Observations of ice-covered areas with all three channels are available during more than 3 Martian years, and seasonal cap processes are relatively stable from Martian year to Martian year. This made it possible to identify spectral ratios in the "VIS" range with diagnostic capabilities between bright dust, H_2O ice and CO_2 ice, in particular the ratio between 0.506 µm and 0.618 µm (see Fig. 2).

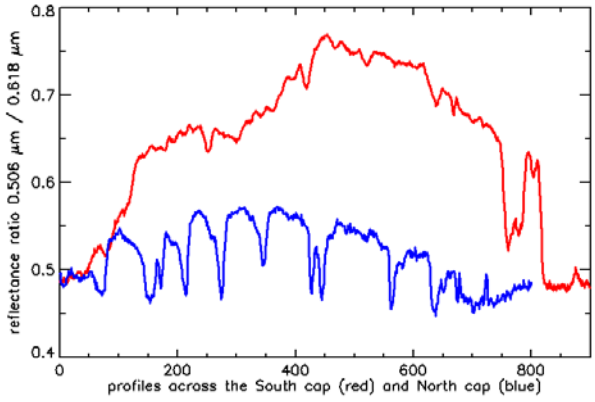

Fig. 2 profiles of the 0.506 µm / 0.618 µm ratio across the south cap (dominated by CO_2 ice) and North cap (dominated by H_2O ice). Bluer regions correspond to ice covered regions as identified from absorption features in the "C" and "L" channels.

Caution is however needed when using "VIS" spectral ratios as there can be a major impact of aerosols in this spectral range. Furthermore, one also needs to check for high albedo as dark terrains can be much bluer than dust-covered bright terrains. While the initial capabilities cannot be restored, an extended time coverage is of interest for investigating the stability of polar processes and the impact of specific global dust storms (2007, 2018) on polar processes.

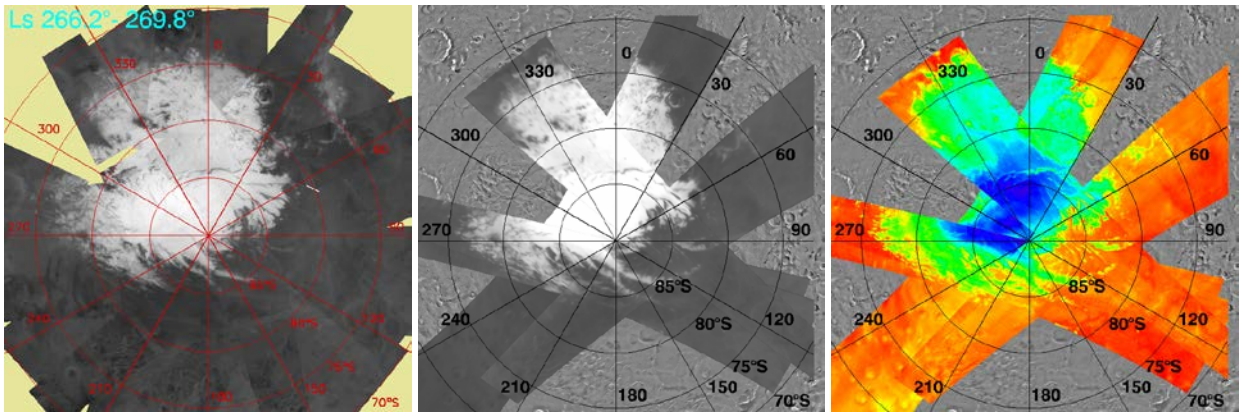

Fig. 3, left: albedo at 1.3 µm ("C" channel) of the South seasonal cap shortly before the summer solstice in 2005 (from [1]); center: albedo at 0.615 µm ("VIS" channel) in the same Ls range (266 -269°) in 2018; right: ratio 0.508 µm / 0.618 µm (from redder to bluer) in 2018. Slight mismatches in overlap result from different incidences.

Results: ***Retreat of the South seasonal cap;*** 6 "VIS" cubes obtained from October 10 to October 15, 2018 made it possible to obtain a near comprehensive map of "VIS" albedo and spectral slope shortly before the summer equinox with a resolution of 2.5 km/pixel. The center and right panels show the consistency between albedo and slope for identifying ice (CO_2 ice in that L_s range). The extent of the south seasonal cap is remarkably similar to that observed at a higher resolution (1 km/pixel) in 2005 (left panel) both for the main cap and for outliers, with a few minor discrepancies (e.g. more extended frost deposits in 2018 at 90°E and 120°E). This is of interest as the 2018 observations were obtained a few months after a major global dust storm, while there was no global dust storm in 2005. The last stages of the retreat are also quite similar in 2005 and 2018 (Fig. 4). The impact of such events in terms of high latitude dust deposition (which would promote sublimation) seems to be minimal.

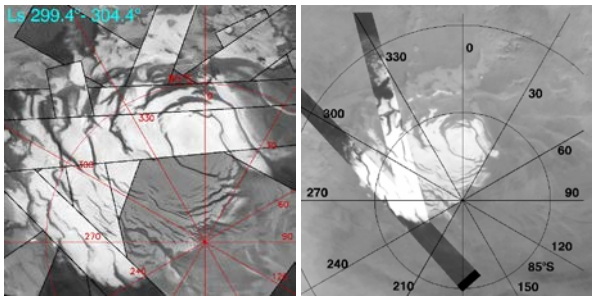

Fig. 4: last stages of the retreat (Ls 300-305°) in 2005 (left, 1.3 µm) and in 2018 (right, 0.615 µm)

Observations of the North perennial cap: cubes obtained from high altitude in December 2017 (Ls 101°) provide extended coverage at low resolution (8 km/pixel) shortly after the sublimation of seasonal frost. They demonstrate that combining albedo and slope information is required when dark terrains are present, as they are nearly as blue as large-grained water ice. The low albedo and reddish "VIS" spectral slope of the region at 60°E, 80° - 85° N indicates that it is significantly more contaminated by dust end of 2017 than in 2005 ([2],[3])

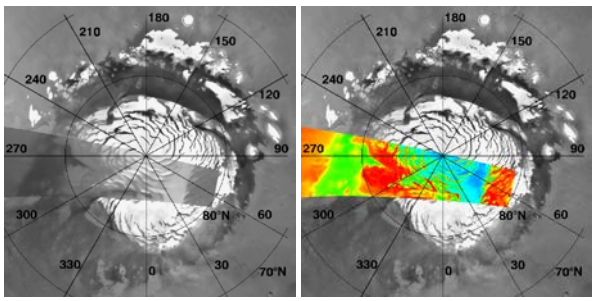

Fig. 5: albedo at 0.615 µm (left) and "VIS" spectral slope of the North cap at Ls 101° end of 2017.

Conclusion: The "VIS" channel observations can be used for extending time coverage over more than 8 Martian years, using earlier OMEGA observations with more extended spectral coverage for confirmation of the validity of the selected spectral criteria in the "VIS" range. Several 100 cubes are available per Martian year at N and S high latitudes, which make it is possible to compare evolutions with or without major dust storms.

References:

[1] Langevin Y. et al., 2007, JGR, **112**, E08S12 ; [2] Langevin Y. et al., 2005, Science **307**, p. 1581-1583 [3] Apperé T. et al. (2011) JGR **116**, E05001