AEROSOLS ABOVE THE SOUTH POLAR CAP OF MARS AS OBSERVED BY OMEGA: A PROGRESS REPORT.

M. Vincendon, Y. Langevin[1], F. Poulet[1], J.P. Bibring[1], B. Gondet[1] and the OMEGA team. [1]Institut d'Astrophysique Spatiale, CNRS/Université Paris 11, Orsay, France, mathieu.vincendon@ias.fr.

Introduction:
Atmospheric dust has a significant impact on OMEGA observations of the south polar cap of Mars in the near-IR [1, 2]. We present a progress report on the analysis of the contribution of airborne dust in OMEGA observations of southern regions of Mars covered with CO_2 ice. This study covers a period which ranges from mi-winter (L_S ~ 140°) to mid-summer (L_S ~ 300°). We focus on the C-channel of OMEGA [0.95µm - 2.65µm] which contains major ice absorption features.

Methods:
We use the method of [3] to separate the respective contribution of aerosols and surface. This method uses a Monte-Carlo based model of radiative transfer and overlapping observations acquired at short time intervals with different geometries. The radiative transfer model assumes a Lambertian surface, a single-lobed Henyey-Greenstein phase function with g=0.63 and a single scattering albedo equal to 0.974 for the aerosols. We have built a look-up table of observed reflectance factors (defined by I/F/cos(i)) as a function of the geometry of observation, the optical depth of aerosols and the Lambert albedo of the surface. Each observation then depends only on two parameters at each wavelength: the optical depth of aerosols τ and the Lambert albedo of the surface A_L. If two observations or more of a same surface A_L with the same aerosols loading τ are acquired by OMEGA with different geometries, we can infer A_L and τ.

Results:
Coupled observations with significant variations of the solar incidence angle during short time periods have been obtained by OMEGA around the summer solstice and for latitudes between 70°S and 80°S. These observations are used to retrieve the spectrum of the surface CO_2 ice once the aerosols contribution has been removed (Figure 1).

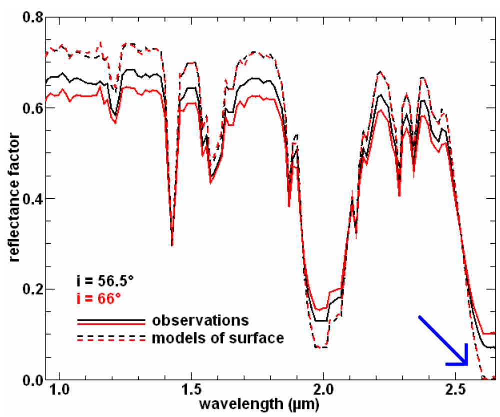

Figure 1: Observations (solid lines) of a region covered with CO_2 ice (316°E, 78°S) with different solar incidence angles i. Black: i=56° (L_S 263); red: i=66° (average of 2 observations taken less than 1° of L_S before and after that at i=56° to minimize effects of optical depth variations). The best fit between reconstructed surface spectra (dotted lines) is obtained for τ(2.65µm)=0.6. The reflectance of the surface is ~ 0 at 2.60-2.65µm (arrow).

In most places of the cap, the reflectance of the surface at 2.6-2.65µm (saturated CO_2 ice band) is lower than 1%, whereas it reaches up to 10% in original observations which contain the aerosols contribution. This is not true when the surface ice is significantly contaminated by dust, e.g. in the "cryptic region" [1, 4], or when sub-pixel spatial mixing of ice and ice-free regions occurs (e.g. at the edge of the south seasonal cap during the recession).

One Emission Phase Function (EPF) sequence has been carry through above the south permanent cap (~86°S, ~345°E) at L_S 288° (orbit 2139). This observation mode is ideally suited for the separation of aerosols and surface contribution [5, 6]. This observation also shows that the contribution of the surface CO_2 ice at 2.65µm is less than 1% (Figure 2).

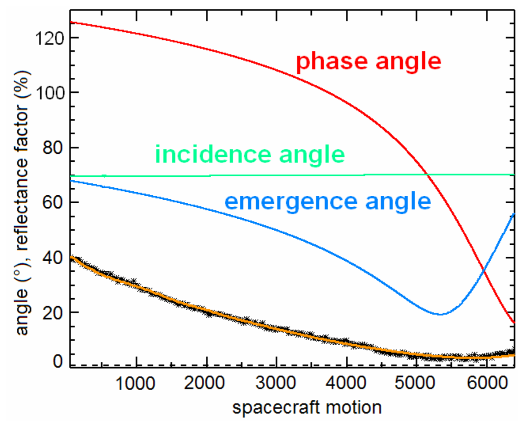

Figure 2 : EPF sequence of orbit n°2139 above the permanent south CO_2 cap of Mars. The observed variations of the reflectance factor at 2.635µm (saturated surface CO_2 ice band) are indicated with black stars. The best fit to this sequence (yellow line) is obtained with an optical depth of 0.17 and with a Lambert albedo of the surface of 0.7% (dotted line).

Mapping of the optical depth of aerosols:
The CO_2 ice band at 2.6-2.65µm is rapidly saturated and appears as such in most OMEGA observations of the south cap [1, 2]. The atmospheric CO_2 band at 2.7 µm has no impact below 2.65 µm. When observations with different geometries are available, we have shown that the observed signal at 2.6-2.65µm is almost entirely due to aerosols scattering, with only a minor contribution of the surface (<1% in reflectance factor). The signal at 2.6-2.65µm is therefore an indicator of the total optical depth of aerosols when the surface of CO_2 ice is free of dust. Variations of the reflectance factor with optical depth are monotonous for a perfectly absorbing surface. We can therefore use the observed reflectance factor at 2.6-2.65µm to model the

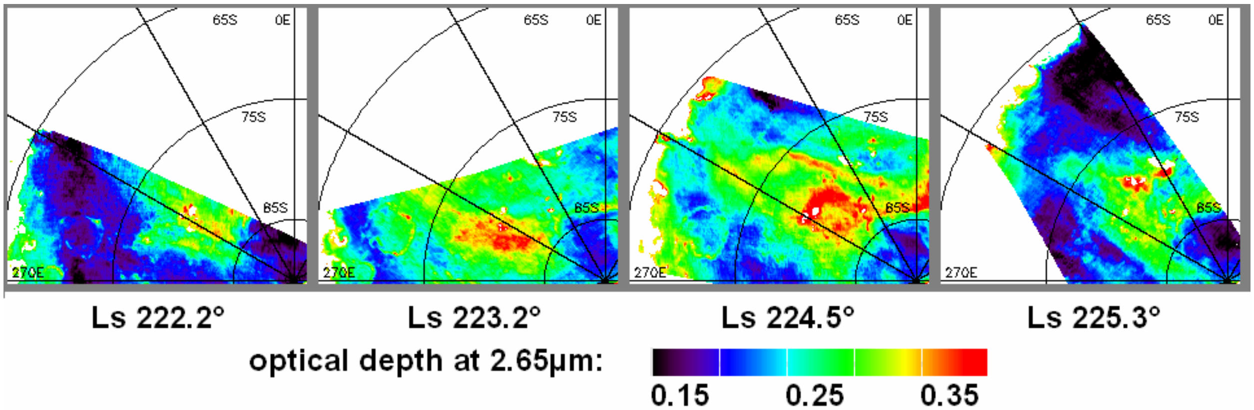

Figure 3 : Map of the optical depth of aerosols at 2.6µm above the south seasonal CO_2 cap of Mars. Strong variations of the optical depth of atmospheric dust are observed over a few sols (~1° of L_S). Areas corresponding to localized surface dust patches (e.g. 330°E, 78.5°S) have been removed.

optical depth of aerosols using our look-up table populated by the Monte-Carlo model. Considering the huge OMEGA dataset, it is then possible to map the optical depth of atmospheric dust at 2.6µm above clean regions of the cap with a temporal scale of 0.5° of L_S between L_S 220° and L_S 300°, and with the spatial resolution of OMEGA (typically 1 to 10km in polar regions). The extent of the regions where we can infer the optical depth decreases as the recession of the seasonal cap goes on. An example of mapping is provided in Figure 3.

Removal of aerosols contribution in albedo map: OMEGA albedo maps at 1.08 µm of the CO_2 ice cap [2] are obtained by overlapping OMEGA tracks of the reflectance factor at 1.08µm (continuum of the ice spectrum). Assuming no changes in the optical properties of the surface and a low impact of aerosols, overlapping tracks should be consistent if the surface is lambertian. Acceptable mosaics are obtained in [2] without correcting for surface photometric effects or aerosols effects. However, significant differences are occasionally observed (Figure 4). The relationship between the optical depth at 1.08µm and that at 2.65µm can be inferred from observations of ice-free regions during a period of strong optical depth change, using the method of [3]. Observations of large-grained CO_2 ice with saturated bands at 1.43 and 2µm in addition to that at 2.6µm can also been used to constrain the wavelength dependence of the optical depth [1]. From these observations, we obtain a consistent ratio of 1.9 between the optical thicknesses at 1.08 µm and 2.65 µm over most places and periods of the south cap. As the optical depth of aerosols at 2.65µm is known above ice-covered region, we can remove the contribution of aerosols at 1.08µm by comparing the measured reflectance factors in the continuum with a look-up table of reflectance factor as a function of Lambert albedo of the surface. This method provides satisfactory results (Figure 4): the major discrepancies between overlapping tracks are indeed due to aerosols and they can be removed with our method.

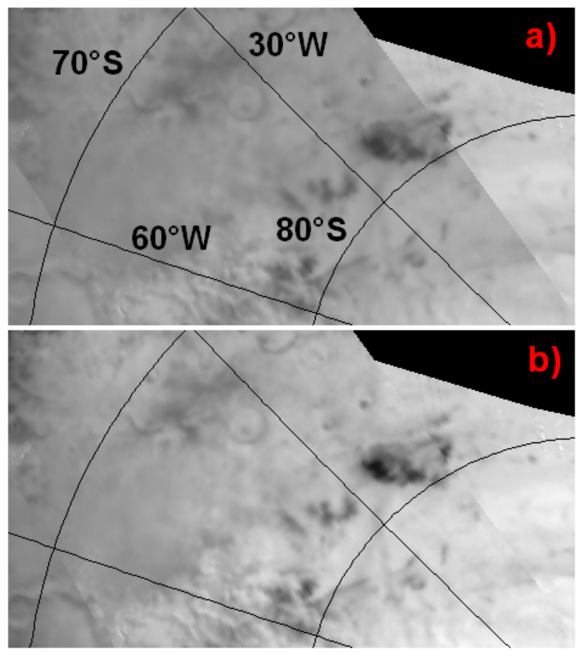

Figure 4 : Removal of aerosols contribution in albedo maps of the CO_2 south cap. a) 2 observations obtained at L_S 224.5° and L_S 225.3° are overlapped. Differences in the albedo level of a few % are observed. b) These differences disappear once the removal of aerosols effects is applied.

References:
[1] Langevin Y. et al., *Nature*, **442**, 7104, 790 (2006).
[2] Langevin Y. et al., *J. Geophys. Res*., accepted (2007)
[3] Vincendon M. et al., *J. Geophys. Res.,* accepted (2007).
[4] Kieffer H.H. et al., *J. Geophys. Res*., **105**, 9653 (200).
[5] Clancy R. T. et al., *J. Geophys. Res.,* **108**(E9), 5098 (2003). [6] Vincendon M. et al., *LPSC XXXVIII*, this conference.