TIME VARIATIONS OF LOW ALBEDO REGIONS OF MARS IN THE OMEGA/MEx DATASET. M. Vincendon[1], Y. Langevin[1], A. Pommerol[2], M. J. Wolff[3], J.-P Bibring[1], B. Gondet[1], D. Jouglet[1], F. Poulet[1], [1]Institut d'Astrophysique Spatiale, CNRS/Université Paris Sud, Orsay, France (mathieu.vincendon@ias.u-psud.fr), [2]Laboratoire de Planétologie de Grenoble, UJF/CNRS, Bât. D de Physique, B.P. 53, 38041 Grenoble Cedex 9, France, [3]Space Science Institute, 18970 Cavendish Road, Brookfield, WI 53045, USA.

Introduction: The visible albedo of Mars has been known to vary with time since the first earth-based telescopic observations. While most variations are generally attributed to variations of the aerosols contribution [1], long term deposits of bright dust on previously dark regions have also been detected [2, 3]. We investigate the time variations of dark albedo regions with OMEGA/MEx observations covering two Martian years (2004 – 2007). We consider the relative contributions of surface and aerosols, which can vary with both time and lightening conditions.

Data: OMEGA has observed the Martian surface since the beginning of 2004 with a nominal nadir pointing mode. Almost all the planet has been mapped with frequent overlaps. We have established time sequences of near-IR spectra of dark terrains (Figure 1). High resolution OMEGA tracks (width < 10km) that do not overlap exactly are also considered for improving the time resolution of our sequences. This implies that analyzed regions are homogeneous for scales of a few tenths of kilometers.

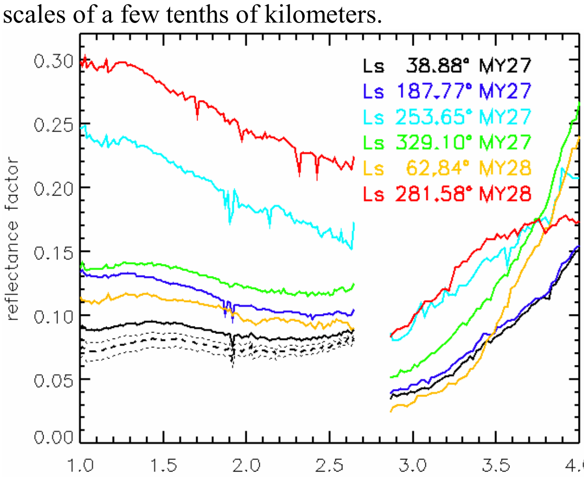

Figure 1: Solid lines: time sequence of observed spectra of a region at 70.1°E, 13.2°N (Syrtis Major). The y-axis correspond to the "Reflectance Factor" (RF), i.e. I/F/cos(i): it is constant for a lambertian surface without change and without coverage by aerosols. A wide diversity of spectra is observed. Black: low atmospheric contribution. Yellow: water ice clouds [4]. Light blue: a strong decreasing slope is observed at high solar incidence angle (80°). Red: July 2007 dust storms. Dark blue and green: significant differences in spectral slope. Dotted lines: estimated surface spectrum free of aerosols contribution from a correction applied to the black spectrum; estimated uncertainties are indicated.

Surface photometric effects: Surface photometric effects are estimated using laboratory measurements of minerals reflectance spectra obtained with a spectro-gonio-radiometer [5]. Observed variations of the RF with incidence angle for a nadir viewing geometry are between ±4% and ±12% for different Martian surface analogues (Figure 2). Expected surface photometric effects are therefore significantly weaker than observed variations (RF from 0.07 to 0.30 in Figure 1).

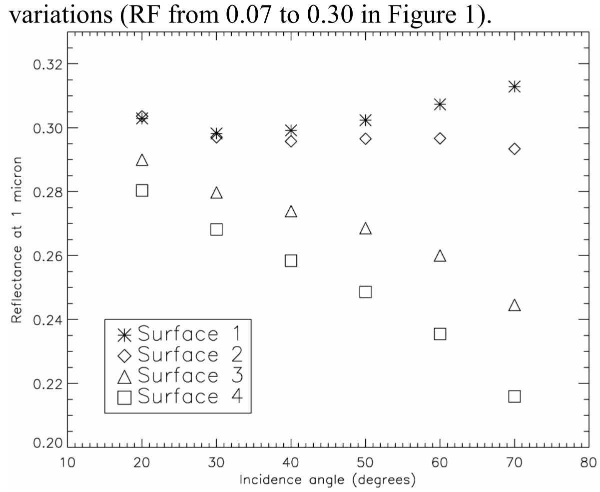

Figure 2: Laboratory measurements of the reflectance factor at 1μm for a nadir viewing geometry and different incidence angles. The surface of Mars is simulated by a volcanic stuff covered by different amount of rock analogues. The percentage of rock coverage varies from 0% (surface 1, stars) to 20% (surface 4, squares), in agreement with orbit measurements [6].

Aerosols contribution: For each time sequence we have applied a small correction of aerosols effect to the spectrum obtained at the lowest optical depth according to MER/PanCam measurements [7] and using the method of [8]. From this surface spectrum we have looked for the optical depth at 0.9µm and the spectral dependence of the optical depth that provide the best fit of each observed spectra. We use the radiative transfer model and the aerosols properties described in [8]. Resulting modeled optical depths for 11 mid-latitude dark regions are indicated on Figure 3 above MER/PanCam direct measurements [7]. The good agreement between the modeled optical depths and the ground truth provided by the Rover indicates that most variations of dark terrains seen in the OMEGA dataset are due to variations of the contribution of aerosols with time or lightening conditions. This is also the case during the decay of the July 2007 global dust storms, which indicate that no major surface dust deposits persist at that time on the analyzed dark regions. [9] attributes the negative continuum slope between 1µm and 2.5µm that is observed above dark terrains to a coating of fine dust. From our analysis we conclude that this spectral slope can be almost entirely attributed to aerosols for the regions analyzed here.

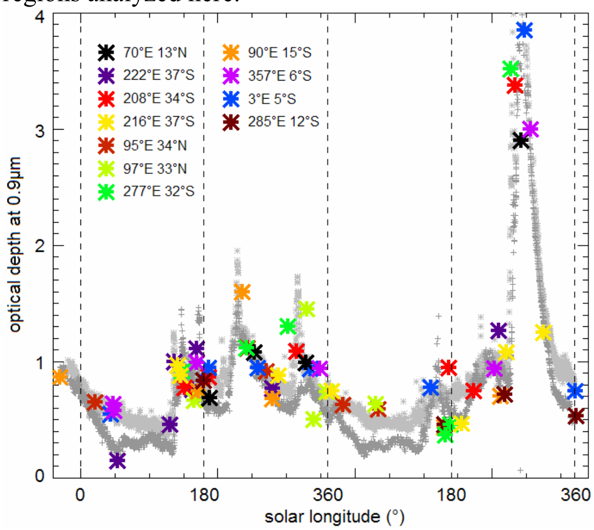

Figure 3: Optical depths at 0.9 µm. Color stars: model results for OMEGA observations of dark terrains situated at mid-latitudes (40°S-40°N). Dark grey crosses: PanCam/Spirit measurements; Light grey stars: PanCam/Opportunity measurements [7].

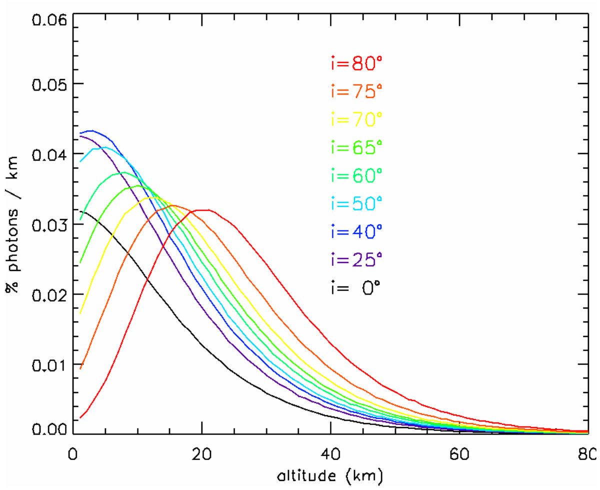

Figure 4: Distribution of photons as a function of the altitude of the first scattering event with aerosols for different solar incidence angles, using the Monte-Carlo approach of [8]. The dust optical depth varies with altitude with a scale height of 11.5km. The total optical depth is 1. The altitude at which photons interact with aerosols increases with incidence angle.

Variations of the particle size of aerosols: The variations of spectral slope of the observed spectra with time and photometric angles are therefore mainly related to aerosols. The retrieved ratio of optical depth between 1µm and 2.5µm is strongly correlated with the solar incidence angles: high ratios corresponding to a mean particle size smaller than 1µm are observed at high solar incidence angles (70° - 80°). At such incidence angles, the mean altitude of the first scattering event reaches ~ 20 km (Fig. 4) compared to less than 10 km for incidences < 50°. This is consistent with the decrease of particle size with altitude observed by [10]. The mean particle size of the aerosol layer increases during dust storms [11, 12]. However, the altitude of scattering events increases at higher optical depth, which results in a small apparent particle size for the corresponding observations (red curve in fig. 1).

Conclusion: Observed variations of the reflectance of dark terrains in the OMEGA nadir dataset from 2004 to 2007 are predominantly due to variations of the contribution of aerosols with lighting conditions and solar longitude, surface photometric effect or dust deposits playing only a minor role. Optical depths derived from the reflectance of mid-latitudes dark terrains (40°S-40°N) are consistent with the similar trends observed at both MER sites [7]. This confirms that aerosol optical thickness is relatively homogeneous over low to mid-latitudes at a given time. The spectral characteristic of aerosols varies with time and photometric angles. These variations are predominantly due to variations of the mean apparent particle size of aerosols, notably linked with variations of the altitude of interaction of photons with aerosols in relation with solar incidence angle or optical depth. These observations set constraints on methods of surface reflectance spectra recovery in the near-IR [8, 13].

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