Mars albedo changes during 2004 – 2010. M. Vincendon[1], J. Audouard[1], F. Altieri[2], J.P Bibring[1], B. Gondet[1], Y. Langevin[1], A. Ody[1], F. Poulet[1] [1]Institut d'Astrophysique Spatiale (Université Paris Sud, 91400 Orsay, France, mathieu.vincendon@ias.u-psud.fr), [2]Istituto di Astrofisica e Planetologia Spaziali (INAF, Rome, Italy).

Introduction: Mars surface "albedo" characterizes the amount of incoming solar energy absorbed and reflected by the surface. This quantity is related to the physical properties of the upper surface layer (composition, texture) and is needed for energy balance calculations (climatic simulations, thermal inertia retrievals). Mars surface albedo is known to change over seasons and years, essentially due to bright dust redistribution over darker underlying terrains [1]. The intense monitoring of Mars over the last decades has provided new constraints but also new questions about these changes [e.g. 2,3,4]. Uncertainties notably remain about the gradual versus catastrophic and cyclic versus perennial nature of some of these changes [3,4], and about their potential impact on the climate of Mars [5,6] and on the detectability of exposed surface components [7]. We use the OMEGA visible and near-IR imaging spectrometer onboard Mars Express to (1) quantify precisely the surface albedo, i.e. the surface hemispherical reflectance corrected from atmospheric scattering, photometric effects and integrated over solar wavelengths, and (2) follow surface changes arisen over the last eight years.

Method: OMEGA collects the sunlight reflected by the surface and atmosphere of Mars from 0.3 to 5 µm. Calculating surface albedo from these measurements is not straightforward due to several issues. First, measurements are performed from orbit through the atmosphere which contains gas and aerosols with variable concentrations. We remove the contribution of the background dust aerosols component using a radiative transfer code [8], recent aerosols optical properties retrievals [9], and aerosols optical depth measurements performed by the MERs during the Mars Express mission [10]. Observations containing water ice clouds are removed using spectroscopic identification of ice. Secondly, not all solar wavelengths are properly measured: we restrict the OMEGA range to [0.43 – 2.5 µm] to avoid instrumental issues [11], major gas absorptions and thermal emission. 97% of the solar flux is covered using an extrapolation of OMEGA measurements down to 0.25 µm with HST UV spectra [12] and interpolation within the 2 µm CO_2 gas band. Thirdly, measurements of a given place are performed in a single viewing geometry while we aim at calculating the total amount of reflected energy in all directions: we constrained an average surface phase function using OMEGA and CRISM data [13] that makes it possible to relate nadir reflectance measurements to the albedo (Figure 1). Fourthly, visible and near-IR data are collected by two separate detectors which are not perfectly co-registered. Registration differences vary from observation to observation and within a given observation. Hence, each OMEGA cube is divided in subsections shifted adequately to maximize the correlation between both detectors. Finally, additional data filtering and global mapping procedures as described in [14] are implemented to derive albedo maps.

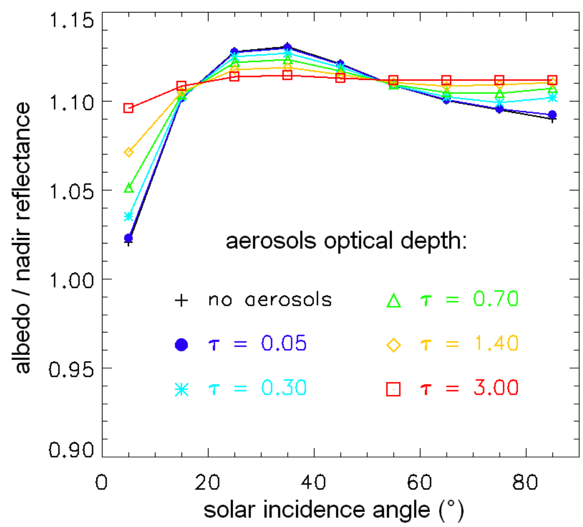

Figure 1: Relation to link the hemispherical reflectance ("albedo") to the measured nadir reflectance factor, as a function of solar incidence angle [13]. Various aerosols optical depth conditions are shown (colors). Nadir reflectance underestimates albedo by about 10% due to an increase of surface emission at high emergences compared to Lambert's law. At low *i* the Martian surface is on average backscattering. High aerosols optical depths correspond to strongly diffusive illumination conditions which smooth this backscattering peak.

Results: We show in Figure 2 a series of albedo maps obtained in the area of Propontis where significant changes have been previously reported (e.g., [3]). A hundred of observations has been obtained by OMEGA in this area for various MY and L_S. We have constructed six global maps with a 32 ppd resolution to highlight surface changes as a function of year and season. As we account for photometry and global aerosols trends, observed changes correspond to surface changes and/or localized atmospheric dust events. These latter can be isolated from surface changes with successive overlapping observations. Major non-cyclic (over 4 MY) changes are observed in this area. The main dark area albedo is about 0.12 at the beginning of MY27. Global cleaning then occurred between L_S 180° and L_S 295° during the dust storm season with an average albedo decreased to 0.07. The area remained cleaned during MY28 up to the onset of the global dust storm. No significant changes are observed after storm decay at L_S 10-15°. On the contrary, increases of albedo occurred during the dust storm season of MY29 (between L_S 185° and L_S 200°, and again afterward), resulting in a persistent dust cover (0.22 albedo) observed during the clear season of MY30 (L_S 0° - 135°).

Conclusion: We have calculated bolometric hemispherical surface albedo with OMEGA using an atmospheric radiative transfer correction and a non Lambertian surface model. The numerous overlapping observations gathered at various solar longitudes over the last four Mars years show major and non cyclic surface albedo changes, which make it possible to pursue previous efforts to quantify and constrain albedo changes on Mars.

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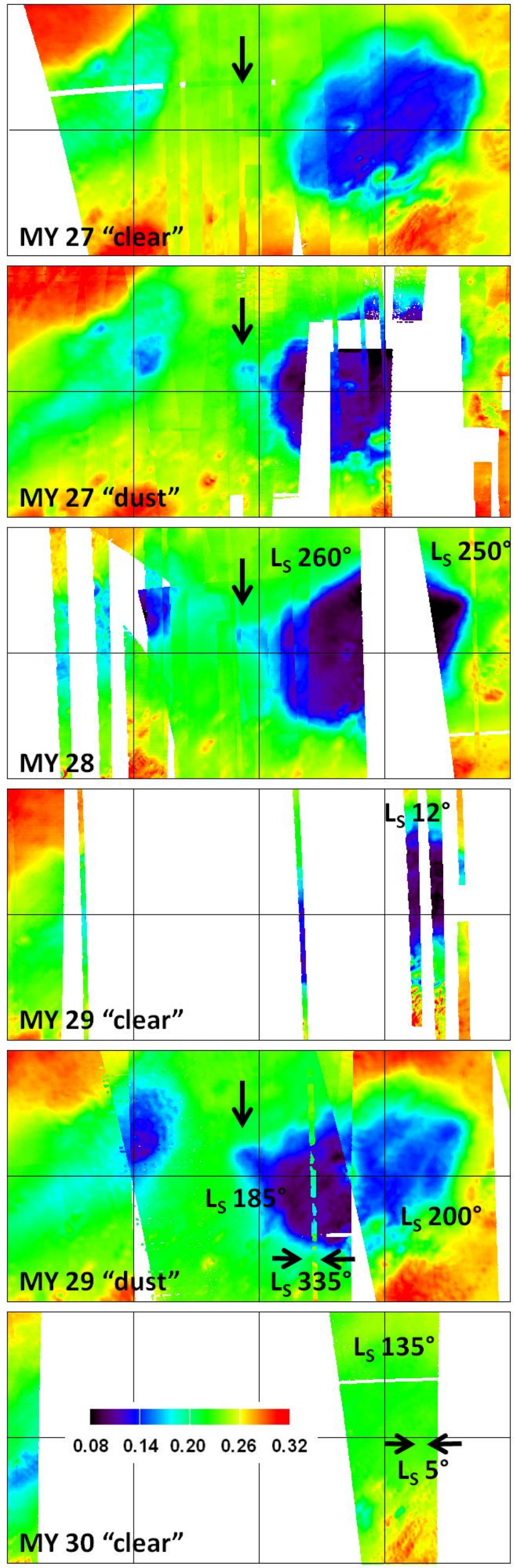

Figure 2: Surface albedo changes observed in the area of Propontis between 2004 and 2010. Each image is centered on 177°E, 32°N (north is on top; width: 20° longitude, 10° latitude). Data are mosaicked over 6 periods: MY27 “clear” (clear atmospheric conditions from L_S 330° in MY26 to Ls 130°); MY27 “dust” (dust storm season, L_S 130° - 360°), MY28 (L_S < 265° prior to July 2007 global dust storm), MY29 clear/dust (idem MY27), and MY30 (L_S 0 - 135°). Significant changes are observed with both progressive shifts of boundaries (black arrow) and major changes in albedo levels (between 0.07 and 0.22 for the main dark area).