AN OPPORTUNITY TO CHARACTERIZE THE MARTIAN DUST SPIRIT: ATMOSPHERIC DUST OPTICAL DEPTH CALCULATED USING OMEGA/MARS EXPRESS. Y. Leseigneur[1] and M. Vincendon[1], [1]Institut d'Astrophysique Spatiale, Université Paris-Saclay, CNRS, Orsay, France (yann.leseigneur@ias.u-psud.fr).

Introduction: Dust, composed of micrometer-sized particles, is an important component of both the atmosphere and the surface of Mars. This high albedo material modifies heat balance while being highly mobile: it is thus a major contributor to current Mars atmosphere and surface dynamics. Numerous studies realized from the Martian orbit or from the ground already provided information on dust spatial and time distribution (e.g., [1], [2], [3]). However, some characteristics of the dust cycle remain uncertain. This is notably related to the fact that dust movements occur over a large range of spatial scale, from Recurring Slope Lineae (RSL) to Global Dust Storm (GDS), and with important interannual variability ([4], [5]). Further global monitoring of dust movements with high spatial sampling and over several years may help improving our knowledge about Martian dust. Here we present a new method used to derived atmospheric dust optical depth using OMEGA observations acquired between 2004 and 2010, i.e. over three Martian Years (MY).

Data and method: The near-infrared imaging spectrometer OMEGA [6] onboard Mars Express collected about 8300 observations over that time range, with a spatial sampling typically close to 1 km.

First, we analyze the prominent 2 µm atmospheric CO_2 absorption band to detect dust, as airborne dust reduces atmospheric optical paths. We have developed a model to predict the CO_2 optical depth τ_{CO_2} under clear atmospheric conditions: observed CO_2 optical depths are compared to these predictions to derive the difference "$\Delta\tau_{CO_2}$", an index sensitive to dust. More details about this first part of the method can be found in [7].

Then, we calibrate this $\Delta\tau_{CO_2}$ using the dust optical depth measured by the Mars Exploration Rovers (MER: Spirit and Opportunity) [2], which operated during the same period as OMEGA. Concomitant MER/OMEGA observations are used to characterize the relation between $\Delta\tau_{CO_2}$ (OMEGA) and τ_{MER}, which notably depends on solar incidence angle and albedo. This relation is then extrapolated to the whole OMEGA dataset to calculate dust optical depth (τ_{dust} as a function of time and place).

Results and discussion: The OMEGA dataset allows to produce global seasonal maps of dust optical depth with a spatial coverage typically greater than 50% for most 60° wide intervals in solar longitude (L_s). We provide an example in Figure 1 for $L_s = 120 – 180°$ of

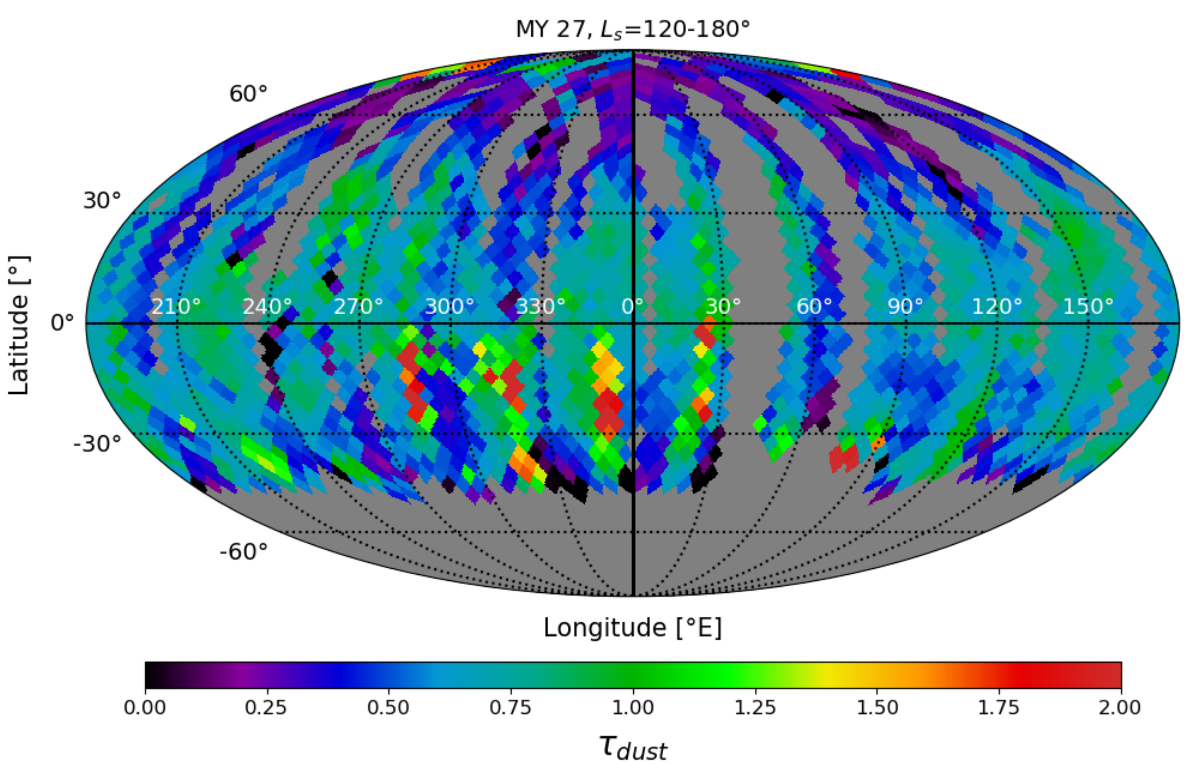

Figure 1: Atmospheric dust optical depth map of Mars during MY 27 at L_s = 120 - 180°, derived from the OMEGA dataset (see text for details).

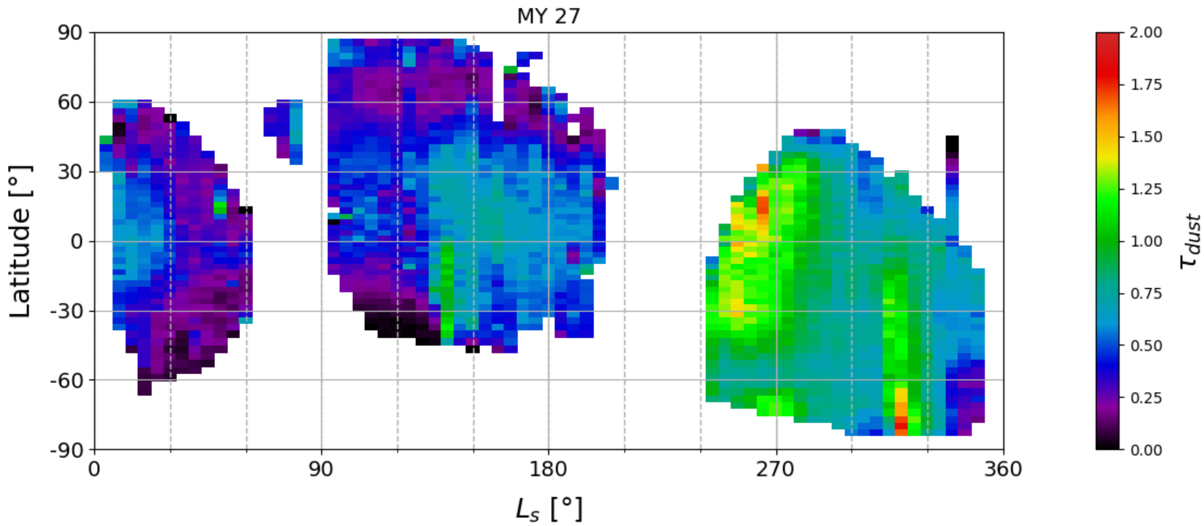

Figure 2: OMEGA dust optical depth as a function of solar longitude (L_s) and latitude for MY 27. For each L_s range (5° width), the mean of global map in τ_{dust} (such as Figure 1) is computed over all longitudes.

MY 27. This season typically corresponds to the onset of atmospheric dust activity after the clear season (e.g., [2]). Overall, we observe low dust optical depths at high northern latitudes (≤ 0.5), moderate values at equatorial latitudes (≈ 1) and localized events with high optical depths (≥ 2) in the southern hemisphere. These trends are broadly consistent with optical depths simultaneously derived at thermal IR wavelengths [3]. One of the patches of high dust optical depth values is located between 315°E and 330°E, and between 45°S and 30°S. This area includes Hale Crater where a first early pulse of RSL activity is observed at that season [8]. This indicates that large-scale atmospheric dust events may be connected to local surface dust movements occurring at RSL location. This map can also help us to identify local dust storm events in the OMEGA dataset. For example, the area at 25°E and 3°S has a very high dust optical depth and corresponds to an OMEGA observation previously used to characterize in details the properties of a local dust storm [9].

We can also explore the time variability of dust using latitude/solar longitude diagrams (see an example in Figure 2, covering MY 27). There is an overall good agreement with thermal studies such as [3] (see their Fig. 16). Some differences can however be noted. For example, high atmospheric dust values observed between $L_s =$ 140° and 200° in OMEGA near-IR dataset seem to correspond to a shorter time range in thermal IR data. This difference could be related to the fact that remote observations may not be similarly sensitive to all particle sizes, while the average size of atmospheric dust is known to change with time, depending on the competition between lifting and settling processes [10]. Finally, we can notice that "C-storms", as defined by [11], are also captured with OMEGA data between $L_s =$ 310° and 330°.

Conclusion: We have developed a new method to detect atmospheric dust using OMEGA data. The method relies on CO_2 absorption band at 2 µm. We implemented a calibration procedure based on MER "ground truth" measurements to compute a near-IR dust optical depth, and thus global maps (Figure 1) and latitude/solar longitude diagrams (Figure 2). Overall, results are in good agreements with previous studies based on thermal IR observations. This dataset may be used to connect dust activity over several spatial scales. For example, preliminary results indicate that large scale atmospheric dust events may be related to local RSL activity occurring at Hale Crater.

Acknowledgments: The OMEGA/Mex data are freely available on the ESA PSA at https://archives.esac.esa.int/psa/#!Table%20View/OMEGA=instrument.

References:

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