MARTIAN DUST DYNAMICS CONSTRAINED BY OMEGA/MARS EXPRESS ORBITAL DATA.

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Introduction: Dust is omnipresent within Mars's atmosphere [1] and at its surface [2]. These small, micrometer-sized particles are one of the major features of Mars modern climate [3] and may also represent a key factor controlling some current surface properties such as composition [4] and activity [5]. Multiple orbital and surface observations have already revealed the main features of the dust seasonal cycle (e.g. [1, 3]). However, some characteristics are still imperfectly known, such as the different lifting mechanisms, the preferential locations where dust settles down, and the driving forces of Global Dust Storms (GDS). Recently, it has been suggested that Recurring Slope Lineae (RSL) [6] may be primarily connected to the dust cycle [5, 7]. Our work aims at better understanding where, when and how dust moves on Mars. This may help understanding how the different spatial scales, from global dust storm to local phenomena such as RSL, are connected. We start with the development of a new method to identify local dust storms in Mars Express observations.

Data and method: We use the 1 to 2.5 µm "C-channel" (and "L-channel": 2.55-5.1 µm for spectral criteria) of OMEGA [8], an imaging spectrometer that has observed the surface with a typical spatial sampling of 1 km over three Martian years (2004-2010). We have developed a new method to detect the presence of dust in the atmosphere in this dataset. This method is based on the 2 µm carbon dioxide (CO_2) absorption band. When the atmosphere is "clear" (without dust or cloud), photons travel a given distance in the atmosphere. This distance through CO_2 is reduced if an aerosols layer is present. If we are able to predict the expected CO_2 path without atmospheric dust, then it should be possible to detect anomalously weak CO_2 path length resulting from the presence of dust or clouds in the atmosphere.

We first developed a basic physical model to link the CO_2 optical depth without dust to pressure, surface albedo and solar incidence angle. Pressure is the main parameter: it characterises the amount of CO_2 in the atmosphere as a function of geographical position and season. It is extracted from a climate model [9]. Solar incidence angle controls the geometry of photons' path as viewing geometry is nadir. Surface albedo modifies the proportion of photons measured by the instrument after surface contact. This model has been calibrated using observations without dust. Observations have been selected inside typical clear atmospheric periods/locations according to previous TES observations [10]. We paid a particular attention on filtering water ice both as clouds and at the surface, using spectral criteria at 1.5 microns and 3.5 microns [11, 12]. Indeed, water ice is a potential aerosols contributor and it has also a large absorption band around 2 µm.

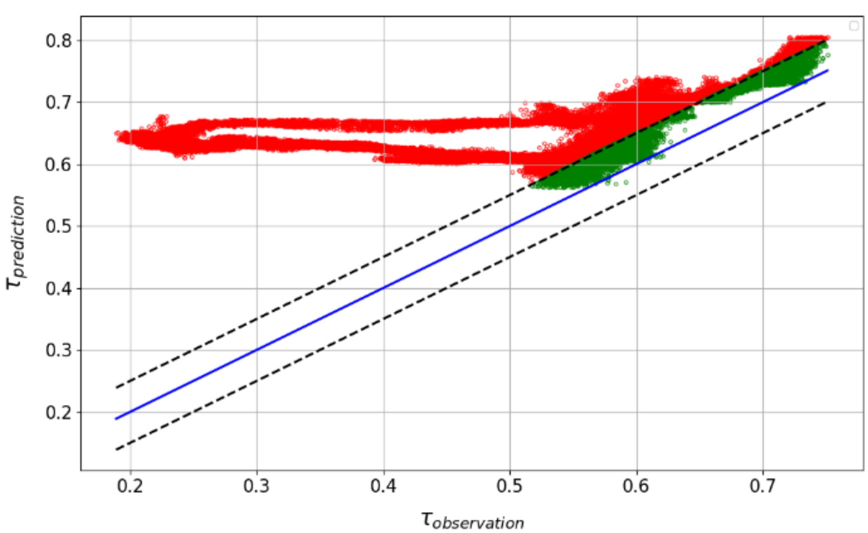

Figure 1: Comparison between the predicted CO_2 optical depth ($\tau_{prediction}$) without atmospheric dust storm and the observed optical depth ($\tau_{observation}$) in OMEGA observation #1212_3 obtained at L_S 135° (red and green dots). The $y = x$ line is in blue, surrounded by two dashed black lines for the $\pm 2\,\sigma$ uncertainties shell. Pixels with $\tau_{observation} \leq \tau_{prediction} - 2\,\sigma$ are in red: their CO_2 optical depth is reduced due to the presence of atmospheric dust.

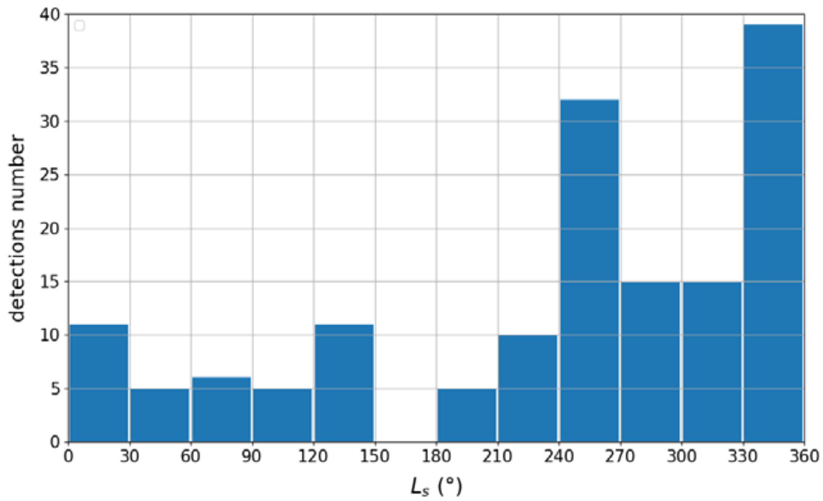

Figure 2: Seasonal trend of atmospheric high dust content detections. A preliminary version of the algorithm is applied on 10% of the dataset. The trend is not corrected from observational biases such as observation density.

We then generate a predicted CO_2 optical depth value associated with any OMEGA pixel. If the observed value is less than the predicted one, it's indicative of dust in the atmosphere. We illustrate this approach on Figure 1 with an OMEGA cube previously known to contain a dust storm [13, 14]. We observe two components in this observation: one (green points) follows the "y=x" line with a slight shift, it probably reflects background well-mixed dust; the other one (red) clearly deviates from expected values and indicate the presence of a local dust storm.

Results and discussion: This detection method has been automatized with appropriate filtering criteria (e.g., for water ice) and detection thresholds to minimize false positives. It may thus be applied to most of the entire OMEGA dataset (around 10,000 observations). We apply a preliminary version of the detection algorithm to 10% of the data, sampled on the three Martian years covered by OMEGA near-IR C-channel. A positive detection corresponding to dust storm or high atmospheric dust loading was derived in 15% of these observations.

The time distribution of these detections is shown in Figure 2. At first order, we observe the well-known typical seasonal atmospheric dust variations measured e.g. by rovers [1]. The dataset notably illustrates the early summer pause in atmospheric dust activity that may be related to RSL timing [5]. Actually, it has been recently noticed that RSL southern hemisphere activity may be composed of several pulses, e.g. three pulses for Hale crater [15]. The timing of these three pulses indeed astonishingly correlates with the timing of A, B and C storms has defined by [16], which further suggest some links between both phenomena.

The spatial distribution of dust detections reveals detections in well-known sources of dust storms such as Hellas [3] or polar cap edges where thermal contrasts are high. At northern latitudes, we observe that dust storm detections are concentrated in Acidalia Planitia, similarly to RSL [17], which may also illustrate the link between both phenomena.

Conclusion: We have developed a new method to detect dust storms with OMEGA. It relies on the identification of reduced atmospheric optical path using the CO_2 absorption at $\lambda \sim 2$ µm. The method has been successfully tested on a data subset. First results reveal an overall dust behavior consistent with known seasonal and spatial trends, and also highlight some proximity between RSL and dust storms.

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

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