CHARACTERIZATION OF DUST ACTIVITY ON MARS FROM MY27 TO MY32 BY PFS-MEX OBSERVATIONS

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Introduction: Dust is one of the most variable and meteorologically important factor of the Martian atmosphere. It shows large temporal and spatial variability, and intensive radiative activity [1]. Airborne dust influences atmospheric temperature and has a significant effect on the general circulation of the Martian atmosphere [2]. During day, dust absorbs solar radiation leading to warming of the lower atmosphere by diabatic heating. The infrared radiation absorbed or emitted to space by dust during day and night can modulate the intensity of the radiative warming and cooling of the atmosphere [3], [4].

Results: The relative spatial distribution and seasonal evolution of dust is found to be very similar in the various years in the 180° - 360° range of Ls (except for MY 28). Thus, we separate the study of dust activity during global dust storm in MY 28 and during typical dusty conditions in other Martian years. In the Ls = 180°-200° (Fig. 1a), the dust activity mainly develops over the south-west regions of Hellas, over Argyre basin, and in the region between Syrtis Major and Isidis Planitia. Smaller scale dust activities are also observed over a few areas in the Tharsis region, along Valles Marineris and at ~60°S latitude for almost all longitudes. The total amount of atmospheric dust over these regions increases continuously during the southern spring season (Figs. 1 b-c). As the lifting continues, dust begins to be transported northward by the global circulation [5], [6]. The dust also travels in the east-west direction, toward the north and northeast regions of Hellas in agreement with previous analyses of MOC and MARCI images [3]. Significant amounts of dust are also observed closer to the South Pole and especially around the perihelion (Ls = 251°; Figs. 1d-f). The maximum extent of the dust activity occurs every year in the seasonal range Ls = 240° to 260°, when dust opacity (~0.8) is observed over the whole southern hemisphere, and up to 30°N. At the same time, areas of persistently low values of the dust opacity (< 0.1) are found over some regions between 30°N and 60°N, especially during the Ls = 240° to 300° interval (Fig.1d–f). Large dust opacity is observed in most of the southern hemisphere (Fig. 1g).

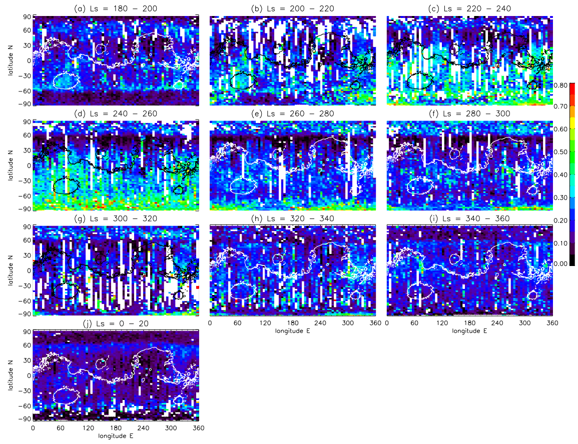

Figure 1: Spatial maps of total dust opacities with a topography contour. The maps have been built by averaging data on a 3° latitude-, 5° longitude- and 20° Ls spaced regular grid from all MYs investigated in this analysis, except for MY 28.

The dust activity reduces in late southern summer and early fall seasons (Figs. 1h and 1i). In MY28 during southern spring, we observe the dust opacity over some places (more than two regions) gets larger than 0.6 (Fig.2b). This happens already at Ls = 200-235° (Fig. 2b), when significant amounts of dust are lifted up in the atmosphere over the south polar cap edge regions, west of Tharsis Montes, and west of Hellas in Noachis Terra. We only have sparse data in the 235°-270° Ls seasonal range of MY 28 (Fig. 2c). With respect to a typical Martian year, the maximum of dust activity in MY 28 occurs later in the year, between 270° and 305° of solar longitude, when high amounts of dust persist over most of the tropical and sub-tropical regions (Fig. 2d). In this period, the total dust opacity still exceeds 2 in some locations (before data binning). Large dust opacities (up to 1.5 or more) are also observed in the Ls interval of 305° to 340°, especially over the southern tropics (Fig. 2e). This is very different from what we observe during a non-global dust storm year, where the total dust opacity is typically lower than 0.2 (Fig. 1h). Consistent to THEMIS observations [7], PFS observations show the maximum activity of the MY 28 global dust storm is confined between low northern and mid southern latitudes.

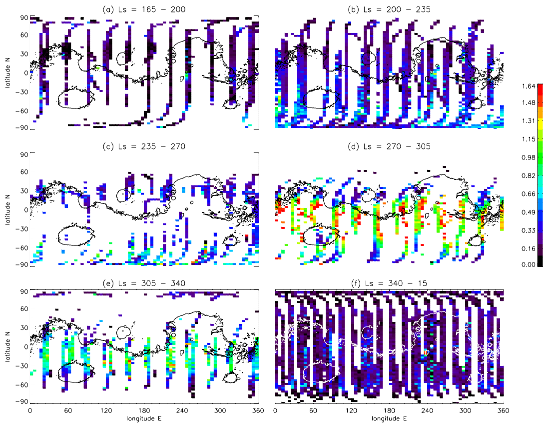

Figure 2: Spatial maps of total dust opacities with a topography contour for the global dust storm in MY 28 (daytime observations) during: a. Ls = 165° - 200°, b. Ls = 200° - 235°, c. Ls = 235° - 270°, d. Ls = 270° - 305°, e. Ls = 305° - 340°, f. Ls = 340° - 15°.

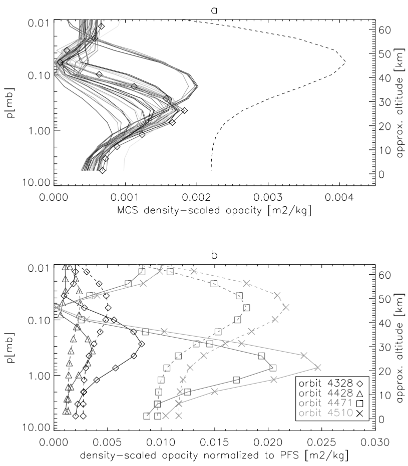

Figure 3: (a) MCS dust vertical profiles [m^2/kg] zonally averaged, selected for latitude region from 25°S to 45°S during Ls interval from 240° to 275° in MY 29. The profile considered as a "typical" for the selected region and time is plotted with diamonds. The MCS dust vertical profile in MY 28 at Ls = 280° averaged for latitudes from 30°S to 30°N is plotted as a dashed line (b) MCS vertical density-scaled opacities normalized to PFS total dust opacities. Solid lines show the "best" MCS profiles in MY29 (as close as possible in time and location to the four selected PFS observations). Dashed lines are for the averaged zonal-mean profile in MY28 presented in (a).

We also investigate the effect of dust on atmospheric temperatures by using MCS dust vertical profiles normalized to PFS dust opacities (Fig.3). Fig.4 presents the calculated sum of heating (H) and cooling (Q) rates at each pressure level (net values, Q+H) by using MCS dust vertical profiles. The qualitative effect of dust on the thermal structure is similar in all our calculations with different assumptions of dust profiles. We always observe a significant net heating of the atmospheric layers just above the peak altitude of dust opacity due to absorption of the visible solar radiation, and a net cooling in the first two or three atmospheric scale heights due to radiative cooling. The net heating rate increases with total dust opacities.

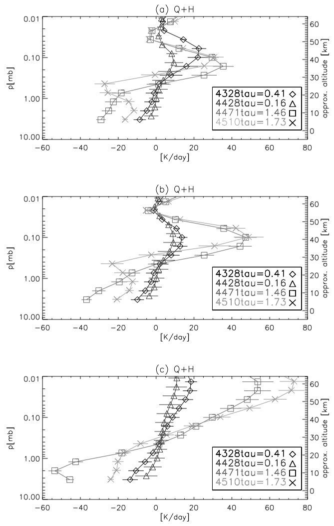

Figure 3: Net heating and cooling rates calculated for (a) "best" and (b) "typical" MCS dust profiles in MY; (c) mean MCS dust profile during the global dust storm of MY 28, averaged in the region from 30°S to 30°N at Ls = 280°.

Conclusions: We provided the global characterization of the dust activity observed by the PFS during six full Martian years [8]. A significant net heating of the atmospheric layers just above the peak altitude of dust opacity and net cooling of atmosphere close to the surface are observed.

References:

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Acknowledgements: This work has been performed under the UPWARDS project. This project has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No633127.