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Probing the evolution of the Martian atmosphere during the 2018 global dust storm using MAVEN/IUVS OI 297.2 nm emission

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1. Introduction

Dust storms in the Martian atmosphere have been observed since the arrival of the Mariner 9 mission. This phenomenon can have a local or global coverage of the planet. In this work we are using a remote sensing methodology based on OI 297.2 nm dayglow limb scan observations in order to track changes in a fixed pressure level (Gkouvelis et al. submitted). We are using IUVS observations of the last two dust storms of Martian years (MY) 33 and 34 in order to study the time scales of the perturbations of the atmosphere. Martian year 33 was a local event while MY 34 was global in nature.

2. IUVS observations

MAVEN entered in a Martian Orbit in September 2014 (Jacosky et al. 2014). One of the eighth scientific instruments on board is the Imaging Ultraviolet Spectrometer (IUVS) (McClintock et al. 2015). IUVS supports two spectroscopic modes, using two separate gratings that provide the required resolving power. One of the two operates near normal incidence and covers the 110-340 nm range with a resolving power ~250. In this work we analyze data collected in the atmospheric limb scan observation mode. We are using the extracted emission line intensity of atomic oxygen at 297.2 nm. In the data reduction, the data points are separated into vertical bins of 5 km for the purpose of the homogeneity of the data. The observations are available at the NASA Planetary Data System (PDS) at four levels of processing. We use level 1C, version 13, IUVS data available from the PDS public archives.

3. Methodology

The method used to analyze the newly discovered OI 297.2 nm lower emission peak is described in Gkouvelis et al. (2018) and Gkouvelis et al. (submitted). It is based on the simple physical mechanism that is described by the Chapman layer theory of one monochromatic radiation interacting with one absorber. It is then possible to analytically calculate where the optical depth of Lyman-α reaches unity in CO_2 and to determine the CO_2 slant column density, depending on the solar zenith angle (SZA). The constant slant column density for unit optical depth is $1.5x10^{19}$ cm^{-2}. Integration of the production rate along the line of sight affects the altitude of the peak of the limb profile and lowers it by 5±0.5 km, independently of the SZA. This offset of the peak also increases the slant column density to the constant value of $N_0=(2.2\pm0.2)x10^{19}$ cm^{-2}. For a vertical solar flux incident and since the CO_2 makes 96% of the atmospheric composition, we can calculate the pressure P0 at the emission peak with a vertical uncertainty of about 1 km leading to a value $P0=(39\pm3)x10^{-3}$ Pascal. It is then possible to follow this pressure level just by detecting the peak altitude of the vertical emission profile. To account for the SZA effect, we follow the procedure described by Gkouvelis et al. (submitted).

4. Results

We have analyzed more than 500 limb scans from which we have determined 303 altitude values of the reference isobar P_0. The isobar variation ranges from 75 and up to 95 km, a result that agrees with the amplitude of the previous dust storm of MY 33. In figure 1 we show this isobar variation in terms of latitude and solar longitude. The time evolution of this atmospheric region is obvious. However, the main result from our analysis is that the P_0 isobar is found to be higher in the latitude region close to the equator and south pole. Later, uniformity of the P_0 altitude was observed over all latitudes. This pattern will be compared with other indicators of the dust load evolution in the lower atmosphere.

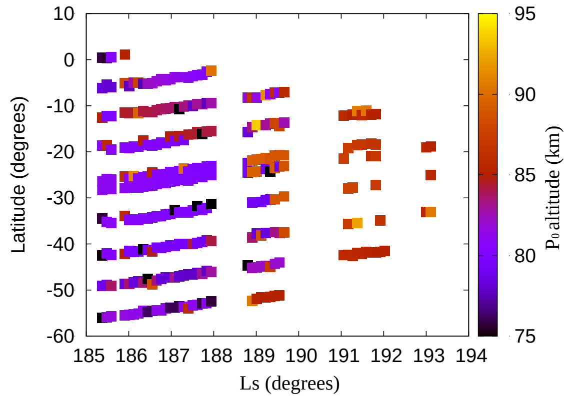

Figure 1: time evolution of the 39 mPa level before and during the onset of the June 2018 dust storm. Equatorial latitudes were first affected by the storm. The perturbation propagated southward until it equally affected all latitudes.

5. Discussion

This remote sensing method makes it possible to probe the motion of a constant isobar level as a function of time, season, latitude and atmospheric dust load. Comparison with other time periods, both dust-free and during other Martian years, indicates that the altitude variation during this period results from the combination of two concurrent effects. One is the closer distance of Mars to the sun resulting from the elliptical orbital motion of the planet. The second one is the perturbation of the Martian thermal structure caused by increased solar radiation absorption by the dust.

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