EPSC Abstracts
Vol. 12, EPSC2018-334, 2018
European Planetary Science Congress 2018

CO_2 variations in the Martian lower thermosphere from IUVS-MAVEN airglow observations.

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Abstract

IUVS-MAVEN limb observations have been performed since 2014. We have analyzed almost four years of observations focusing on the O(^{1}S) 297.2 nm dayglow emission line. We have developed an automatic methodology to retrieve the CO_2 column densities near 80 km, a region difficult to probe by other techniques. We present nearly two Martian years of observations of pressure variations at different latitudes and comparisons with MCD model predictions. Generally, the best agreement is reached following scaling down of the MCD values from 0.3 to 0.8 to fit the observations. This result was previously expected on the basis of model comparisons with ultraviolet occultation measurements.

1. Introduction

The production of the O(^{1}S) atoms in the Martian dayglow was first modelled by Fox and Dalgarno (1979). They predicted a first peak around 130 km and the presence of a second, brighter maximum near 90 km resulting from dissociation of CO_2 by solar Lyman-α radiation. They explained the presence of the lower peak by the deeper penetration of this radiation into the Martian lower thermosphere. This is a consequence of the low value of the CO_2 absorption cross section at 121.6 nm, which is coupled with the high intensity of the solar Lyman-α flux reaching the planet. The lower peak was first observed by IUVS (Jain et al. 2015). It was later shown (Gérard et al., ESLAB 2018 Symposium) that the observations are fully compatible with photodissociation of CO_2 as the major source of O(^{1}S) atoms. These conditions make the lower peak a sensitive indicator of the CO_2 column density. In this work we quantify the changes of the lower peak characteristics from the set of MAVEN observations. This method makes it possible to extract the seasonal and latitude variations at the altitude level of the lower peak.

2. IUVS observations

The data used in this study have been downloaded from NASA's Planetary Data System (PDS) archives. Three different processing levels of the data are available. Level 1A data corresponds to the raw instrument readouts in data numbers per bin. Level 1B data provide calibrated instrument readouts in kR/nm and include background subtraction and ancillary data. Level 1C data includes calibrated brightness of individual emissions that has been reduced by isolating emission features and spatial binning to facilitate processing: The dayglow spectra include many different atomic and molecular emissions, including the spectral feature from oxygen at 297.2 nm. Each emission may be identified by its wavelength and its expected relative intensity. The brightness of any atomic or molecular feature is determined by using a multiple linear regression method to fit the various components of each observed spectrum following convolution with the instrumental line spread function.

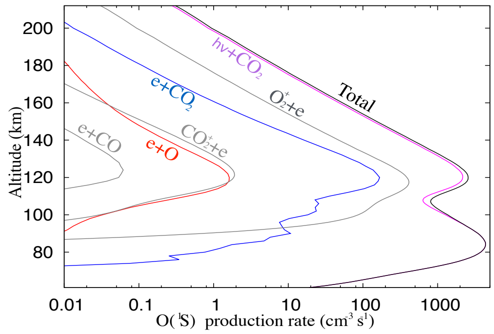

Figure 1: Production rate of O(^{1}S) state. It is clearly seen that CO_2 photodissociation is the main excitation process below 200 km and the only one for the lower emission peak.

3. Methodology

Comparisons with our model calculations confirm that photodissociation of CO_2 is the major source of O(^{1}S) atoms below 200 km and the largely dominant excitation process of the lower emission peak. Simulations have also indicated that the upper emission peak does not significantly influence the altitude and the intensity of the lower peak for observations of the limb profiles. A direct consequence is that the altitude of the lower peak of 297.2 nm dayglow is solely controlled by the overlying column density of CO_2, while the maximum brightness essentially depends on the flux of solar Lyman-α.This flux is directly measured on board MAVEN by the EUVM instrument.

Since the altitude of the lower peak directly depends on the overlying column of CO_2, its value may be used as an indicator of the seasonal/latitudinal variations of the thermospheric CO_2 distribution and therefore of the changes of altitude of the τ=1 level. These altitude changes correspond to variations of the height of the isobars that are controlled by the seasonal and latitudinal pressure variations and the dust load in the lower atmosphere.

Acknowledgements. This research is supported by the PRODEX program of ESA, managed with the help of the Belgian Science Policy Office (BELSPO).

References

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