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SPICAM dayglow measurements: a tool to retrieve CO_2 vertical density profile and exospheric temperatures

A.Stiepen (1), J.C. Gérard (1), S. Bougher (2), F. Montmessin (3) and J.-L. Bertaux (3)

(1) Laboratoire de Physique Atmosphérique et Planétaire, Université de Liège, Liège, Belgium, (2) Atmospheric, Oceanic and Space Sciences, University of Michigan, (3) Laboratoire Atmosphères, Milieux, Observations Spatiales, Université de Versailles Saint-Quentin, France
(arnaud.stiepen@ulg.ac.be Tel: +32-43669781)

Abstract

We analyze the behavior of the CO_2^+ and CO Cameron ultraviolet dayglow in the atmosphere of Mars through a large dataset of dayside grazing limb observations performed by the Spectroscopy for Investigation of Characteristics of the Atmosphere of Mars (SPICAM) on board the Mars Express spacecraft. Limb profiles are studied to retrieve the temperature of the Martian exosphere and its variability with season, latitude and solar activity. We use a one-dimensional chemical-diffusive model to retrieve the main features of the emissions and constrain the temperature and density vertical profiles of the main components of the Martian atmosphere.

1. Introduction

CO_2^+ and CO Cameron ultraviolet emissions in the dayside of Mars have been first observed during the Mariner 6 mission [1]. The CO_2^+ emission at 289 nm arises from the relaxation of the CO_2^{+*} molecule in the $B^2\Sigma^+$ state to the $X^2\Pi$ state. CO_2^{+*} molecules are produced mainly in the dayside of Mars through photoionisation and photoelectron impact, as following [2,3]:

$$CO_2 + h\nu \rightarrow CO_2^{+*} + e^- \quad (1)$$

$$CO_2 + e^- \rightarrow CO_2^{+*} + 2e^- \quad (2)$$

The CO Cameron bands range from 170 nm to 270 nm and correspond to the forbidden transitions of CO molecules excited into the $a^3\Pi$ state to the ground state. CO molecules are supposed to be excited to the $a^3\Pi$ state following these processes [4,5,6]:

$$CO + e^- \rightarrow CO^* + e^- \quad (3)$$

$$CO_2 + e^- \rightarrow CO^* + O^* + e^- \quad (4)$$

$$CO_2 + h\nu \rightarrow CO^* + O^* \quad (5)$$

$$CO_2^+ + e^- \rightarrow CO^* + O \quad (6)$$

2. Observations

Dayside airglow ultraviolet emissions of the CO Cameron bands and the CO_2^+ doublet in the Martian atmosphere have been observed with the Spectroscopy for Investigation of Characteristics of the Atmosphere of Mars on board the Mars Express spacecraft. A large amount of limb profiles has been obtained which makes it possible to analyze the variability of the brightness and altitude of the emission peak. SPICAM is composed of an ultraviolet and an infrared spectrometer. Its ultraviolet domain ranges from 118 nm to 320 nm.

3. Achievements

Previous studies [7] focused on a smaller dataset for LS:[90,180]. We propose to extend this preliminary study to both hemispheres for all seasons. The limb profiles peak intensities and altitudes of the CO

Cameron and CO_2^+ emissions are compared with factors such as solar zenithal angle, solar flux, solar longitude, … Limb profiles scale heights and thus exospheric temperatures are compared with previous study [8]. Correlations between the CO_2^+ and CO Cameron emissions are known to be strong [7] as they share the same root molecule, CO_2. Thus, these emissions are a good tracer of the CO_2 density vertical profile and its variability. We furthermore use a Monte-Carlo model to retrieve the main features of the CO_2^+ and CO Cameron emissions. Comparisons of retrieved exospheric temperatures are made with corresponding simulations from the coupled MGCM-MTGCM [9]. Variability of these temperatures with season, solar cycle, and latitude will be investigated.

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