EPSC Abstracts
Vol. 7 EPSC2012-504 2012
European Planetary Science Congress 2012

Characterization of OMEGA/MEx CO_2 non-LTE limb observations on the dayside of Mars

A. Piccialli (1), P. Drossart (2), M.A. Lopez-Valverde (3), F. Altieri (4), A. Määttänen (5), B. Gondet (6), O. Witasse (1), J. P. Bibring (6)

(1) ESA, ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands, (2) LESIA, Observatoire de Paris, 5 place Janssen, 92195 Meudon, France, (3) IAA, Glorieta de la Astronomía, 18008 Granada, Spain, (4) IAPS – INAF, via del Fosso del Cavaliere 100, 00133 Rome, Italy, (5) LATMOS/CNRS, Université Versailles Saint-Quentin-en-Yvelines (UVSQ), Guyancourt, France, (6) IAS, Orsay University, 91405 Orsay, France. (arianna.piccialli@esa.int / Fax: +31-(0)-71-565-4697)

1. Introduction

The upper atmosphere of a terrestrial planet is a region difficult to sound, both by in-situ and remote sounding [1]. This atmospheric region is characterized by non–local thermodynamic equilibrium (non-LTE) that occurs when collisions between atmospheric species are not enough efficient in transferring energy. The CO_2 non-LTE emission at 4.3 µm originates in the upper layers of the atmosphere and is a feature common to the three terrestrial planets with an atmosphere (Venus, Earth, and Mars). It provides a useful tool to gain insight into the atmospheric processes at these altitudes [2].

Non-LTE fluorescent emissions were first observed in the Earth's upper atmosphere in CO_2 bands at 15 and 4.3 µm [3] and were later observed on several planets in different spectral bands. Ground-based observations of CO_2 laser bands at 10 µm in the atmospheres of Venus and Mars [4] were interpreted as non-LTE emissions by several atmospheric models developed in the 1980s [5]. On Jupiter, Saturn and Titan non-LTE emissions were identified in the CH_4 band at 3.3 µm [6]. More recently, CO_2 non-LTE emission at 4.3 µm was detected in the upper atmosphere of Mars and Venus by the PFS (Planetary Fourier Spectrometer) and OMEGA (Visible and Infrared Mapping Spectrometer) experiments on board the European spacecraft Mars Express [7, 8, 9] and by VIRTIS (Visible and Infrared Thermal Imaging Spectrometer) on board the European Venus Express [10]. These observations led to the development of a more comprehensive non-LTE model for the upper atmosphere [9, 11]. According to these models, during daytime the solar radiation in several near-IR bands from 1 to 5 µm produce enhanced state populations of many CO_2 vibrational levels which cascade down to lower states emitting photons in diverse 4.3 µm bands. These emissions produce what is observed.

2. Observations

The OMEGA/MEx experiment, combining imaging and spectroscopy in the near infrared, is acquiring a very large dataset of dayside limb observations of the upper atmosphere of Mars in the wavelength range 0.38-5.1 µm [12] and with an instantaneous field of view (IFOV) of 1 mrad/pixel, corresponding to a vertical spatial resolution of few kilometers. Since January 2004, more than 170 dayside limb observations have been acquired at various locations, seasons and illuminations (Fig. 1).

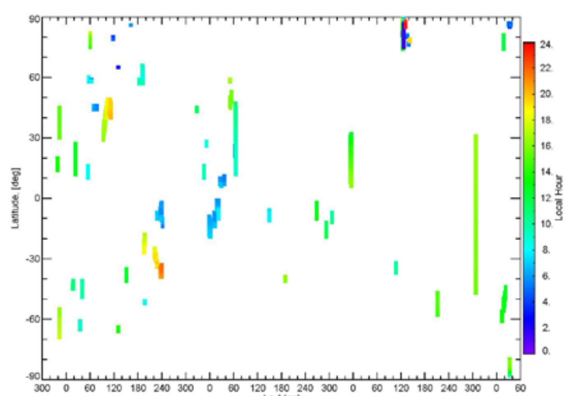

Figure 1: distribution of dayside limb spectra binned 2º in Ls (solar longitude) and latitude. The colour scale indicates the local hour.

3. Results

The variability of the non-LTE emission with latitude, altitude, solar illumination (SZA) and season was analyzed and compared to predictions derived by non-LTE model. Fig. 2 shows the SZA-altitude cross section of radiance at 4.3 µm. Both the altitude and the intensity of the peak emission change with SZA. The peak emission is slightly affected up to ~40º SZA. At larger SZA values both the intensity and the altitude of the peak decline. These results are in agreement with the theoretical expectations for a solar fluorescent emission [11].

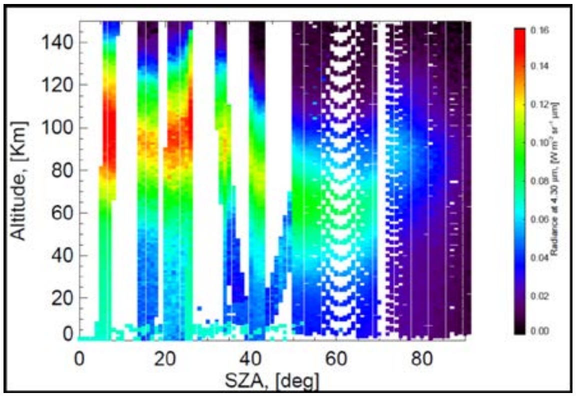

Figure 2: map of OMEGA radiances at 4.30 µm versus SZA and altitude. 10 OMEGA cubes were used for this plot.

We are currently studying the behaviour of the instrument during limb sounding by determining the exact size and shape of the instantaneous field of view, the pointing error and the actual noise level, in order to detect potential bias or systematic errors. Once the characterization of the dataset available is achieved, OMEGA limb observations of non-LTE emissions will be used to estimate the temperature and the density variability of the upper mesosphere/lower thermosphere. Density variations are not well known on Mars at these altitudes, the only information being obtained from aerobraking observations at a fixed local time [13] and more recently by the Mars Express ultraviolet spectrometer SPICAM [14]. However, most data acquired by SPICAM was obtained at nighttime, thus not allowing studying the diurnal cycle in detail. OMEGA dayside observations will add new information in this direction. Also, we plan to exploit the good vertical resolution of OMEGA to learn about non-LTE processes in the upper atmosphere and their variation with altitude, from the study of the different CO_2 bands contribution profiles.

References

[1] Mueller-Wodarg, I. C. F. (2005), Planetary Upper Atmospheres, in: "Advances in Astronomy: From the Big Bang to the Solar System", edited by Michael Thompson, Imperial College Press, London, ISBN 1-86094-577-5.

[2] Lopez-Puertas, M., and Taylor, F. W.: Non-LTE radiative transfer in the atmosphere, *World Scientific Publishing*, Singapore, 2001.

[3] Curtis, A. R., et al.; Thermal Radiation in the Upper Atmosphere, *Proceedings of the Royal Society of London*, Series A, Mathematical and Physical Sciences, Vol. 236, Is. 1205, pp. 193-206, 1956

[4] Deming, D., et al.; Observations of the 10-micron natural laser emission from the mesospheres of Mars and Venus, *Icarus*, Vol. 55, pp. 347-355, 1983.

[5] Deming, D., and Mumma, M. J.; Modeling of the 10-micron natural laser emission from the mesospheres of Mars and Venus, *Icarus*, Vol. 55, pp. 356-368, 1983.

[6] Drossart, P., et al.; Fluorescence in the 3µm bands of methane on Jupiter and Saturn from ISO/SWS observations, The Universe as Seen by ISO. Eds. P. Cox & M. F. Kessler. ESA-SP 427., p. 169.

[7] Formisano, V., et al.; Observations of non-LTE emission at 4-5 microns with the planetary Fourier spectrometer abord the Mars Express mission, *Icarus*, 2006.

[8] Drossart, P., et al.; Limb observations of infrared fluorescence of CO_2 from OMEGA/Mars Express, *Second workshop on Mars atmosphere modelling and observations*, February 27 - March 3 2006 Granada, Spain, 2006.

[9] López-Valverde, et al.; Analysis of CO_2 non-LTE emissions at 4.3 µm in the Martian atmosphere as observed by PFS/Mars Express and SWS/ISO, *PSS*, Vol. 53, pp. 1079-1087, 2005.

[10] Gilli, G., et al.; Limb observations of CO_2 and CO non-LTE emissions in the Venus atmosphere by VIRTIS/Venus Express, *JGR*, Vol. 114, 2009.

[11] López-Valverde, M. A., et al.; Modeling the atmospheric limb emission of CO_2 at 4.3 µm in the terrestrial planets, *PSS*, 2010.

[12] Bibring, J. P., et al.; OMEGA: Observatoire pour la Minéralogie, l'EAU, les Glaces et l'Activité, ESA SP 1240, pp. 37-49, 2004.

[13] Theriot, M., et al.; *AAS/Division for Planetary Sciences Meeting*, Vol. 38, pp. 73.02, 2006.

[14] Forget, F., et al.; The density and temperatures of the upper martian atmosphere measured by stellar occultations with Mars Express SPICAM, *JGR*, Vol. 114, Is. E1, 2009.