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Planetary Waves, Dynamics, and Minor Species Distribution in the Martian Atmosphere observed with PFS/MEX data

G. Sindoni (1), M. Giuranna (1), D. Grassi (1), V. Formisano
(1) Institute of Physics of the Interplanetary Space (IFSI-INAF), Rome, Italy (giuseppe.sindoni@ifsi-roma.inaf.it)

Abstract

We retrieve atmospheric water vapour and carbon monoxide abundances from nadir data acquired by the Planetary Fourier Spectrometer (PFS) on board of the Mars Express orbiter. The analyzed absorption bands are those centred on 3845 cm^{-1} (2.6 μm) and on 4235 cm^{-1} (2.36 μm), respectively. The geographical distribution of water vapour and carbon monoxide in the Martian atmosphere highlights longitudinal wave phenomena. These could be related to the existence of atmospheric planetary waves. The longitudinal trends show a sinusoidal behaviour of the gaseous concentration with wave numbers s = 1 for CO and s = 2 for H_2O, prevalently. The comparison between these trends and vertical thermal profiles, measured by PFS, suggests a relation between the wave number and the vertical distribution of the examined gasses.

1. Introduction

The general circulation of Mars is characterized by strong eastward winds in the fall-winter hemisphere. The interaction of this flow with zonally varying topography excites quasi-stationary waves, which take the form of planetary waves for forcing at the largest horizontal scales [1]. The stationary waves can influence the stability of the atmosphere, enhancing the formation of disturbances at certain longitudes and impeding their formation at others [2]. An indirect yet efficient way to detect and characterize such a complex dynamical process is to study the effects on the atmospheric temperatures [3]. Our results suggest that these effects can also affect the distribution of minor gasses.

2. Dataset and Analysis

The Planetary Fourier Spectrometer (PFS) on board the ESA Mars Express (MEX) mission [4] can probe the Mars atmosphere in the infrared spectral range between 200 and 2000 cm^{-1} (5-50 μm) with the Long Wavelength Channel (LWC) and between 1700 and 8000 cm^{-1} (1.2-5.8 μm) with the Short Wavelength Channel (SWC).

We study the water vapour and carbon monoxide atmospheric distribution. Although there are several H_2O and CO absorption bands in the spectral range covered by PFS, we use the 3845 cm^{-1} (2.6 μm) and the 4235 cm^{-1} (2.36 μm) bands for the analysis of water vapour and carbon monoxide, respectively, because they are less affected by instrumental problems with respect to the other bands in the rest of the PFS spectral interval. Moreover, these bands are out of the thermal range limit, thus avoiding calibration problems due to thermal inversions in the PFS/SWC spectrum.

The gaseous concentrations are retrieved by using an algorithm developed for this purpose [5].

The thermal profiles are retrieved using the approach described in Grassi et al. (2005) [6].

The PFS/SW dataset used in this work covers almost three Martian years, from Ls = 62° of MY 27 (orbit 634) to Ls = 340° of MY 29 (orbit 7327).

3. Results and Conclusions

Our data show a sinusoidal behaviour of the gaseous concentration as a function of longitude, for latitudinal strips. The wave numbers observed are s = 1 for CO and s = 2 for H_2O, prevalently. The same waveform can be observed also in the corresponding thermal profiles. The relation between their wave numbers and the altitude in which they occur can give us some indication about the vertical distribution of the involved gasses. Moreover, the study of the amplitude of planetary waves as a function of the variable Martian conditions can be useful for a better understanding and modelling of the atmospheric dynamics of Mars.

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