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CO₂ density and temperature profiles of Mars atmosphere: first retrievals from the ACS MIR solar occultations

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Abstract

The Atmospheric Chemistry Suite (ACS) began nominal science operations in April 2018 onboard the Trace Gas Orbiter (TGO) of the ExoMars mission. The mid-infrared channel (MIR) of the instrument is a cross-dispersion echelle spectrometer dedicated to solar occultation measurements in the 2.3–4.3 μm range [1]. This experiment achieves the signal-to-noise ratio SNR~3000 with the instrumental resolving power of >50,000. It is able to accomplish the most sensitive measurements of the trace gases ever present in the Martian atmosphere. In parallel, the tiniest atmospheric layers – even up to 200 km – may be probed along the occultation line of sight measuring in strong CO₂ absorption bands (2.7 and 4.3 μm). It gives us possibility to retrieve density, scale height and temperature of the Martian thermosphere.

In this paper we present first results of CO₂ density and temperature retrievals from the ACS MIR solar occultations. The statistics of observations counts a few sunsets and sunrises per day in the both Martian hemispheres. Each session is devoted to a spectral interval correspondent to one of ten positions of the secondary MIR grating [1]. Such coverage allows measuring all significant CO₂ bands in the 2.3–4.3 μm range orbit by orbit. Depending on absorption line intensities and its temperature behavior several transition bands were selected for density and temperature retrievals at different altitude ranges. An example of absorption band around 4.3 μm is presented in Figure 1. Here strongest transitions R18e...R38e are shown at different temperatures on a background of weak ones (1a). This spectral interval is suitable to measure high atmospheric altitudes: 100-200 km (1b). Those strong lines are clearly detected at 200 km. Except the main isotope ¹⁶O¹²C¹⁶O, a few others (¹⁶O¹²C¹⁸O, ¹⁶O¹³C¹⁶O) are also analyzed by the MIR, providing additional

possibility to study the oxygen and carbon isotopic ratios.

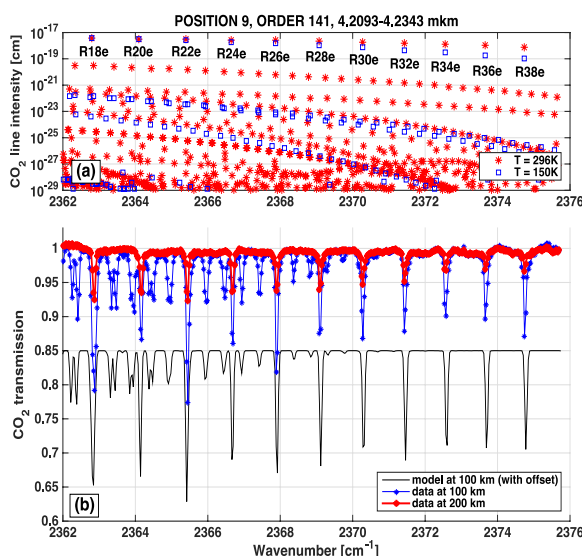


Figure 1: An example of CO₂ absorption measurement at 4.3 μm band at high altitudes of Martian atmosphere. (a): line intensities at temperatures 296 K (red stars) and 150 K (blue squares), calculated from HITRAN 2016. (b): transmission spectra, measured at 100 km (in blue) and at 200 km (in red) in echelle order #141, 25th April. To compare, modeled transmission (in black, with offset) was estimated for 100 km on a basis of the MCD (<http://www-mars.lmd.jussieu.fr>).

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