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Temperature distribution in Mars atmosphere as measured by the ACS-MIR/ExoMars-TGO solar occultations

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Abstract

We report results from the first year of temperature distribution retrievals in Mars atmosphere from the solar occultation measurements, being performed by the Atmospheric Chemistry Suite (ACS) onboard the ExoMars Trace Gas Orbiter (TGO). Statistics of observations provides almost regular time coverage including the beginning of the Martian global dust storm in June 2018 (LS≈190, MY34). Temperature variability before and during the storm is studied at altitudes from 3-30 km up to 80-100 km.

1. Introduction

The ACS instrument began nominal science operations in April 2018 on board the TGO of the ExoMars mission. The mid-infrared channel (MIR) of ACS is a cross-dispersion echelle spectrometer dedicated to solar occultation measurements in the 2.3–4.2 µm range [1]. This experiment achieves the signal-to-noise ratio SNR~3000 with the instrumental resolving power of >30,000. 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 CO_2 absorption bands (e.g. 2.7 µm, and 4.3 µm).

Each occultation session covers a spectral interval with one or a few CO_2 absorption bands appropriate for density, scale height and temperature retrievals in the Martian atmosphere. In the current study we use several set of spectroscopic lines (e.g. at 2.5-2.6 µm, ~3.15 µm, and ~4 µm) and the hydrostatic equilibrium condition to determine temperature profiles from the retrieved CO_2 local densities.

At the moment, we present results from the first year of ACS MIR temperature profile retrievals in the solar occultation mode. Statistics of observations provides almost regular time coverage including the beginning of the Martian global dust storm in June 2018 (L_S≈190, MY34). Temperature variability before and during the storm is studied at altitudes from 3-30 km up to 80-100 km.

2. Measurements

ACS Middle InfraRed channel (ACS-MIR) is a cross-dispersion echelle spectrometer, operating in the 2.3–4.2 µm range [1]. The echelle orders are dispersed along the x-axis and separated along the y-axis of the focal plane by a secondary grating, making full use of the 2-D detector array.

The spectrometer is devoted to solar occultation measurements to perform vertical profiling of the atmosphere with altitude field of view around 0.5-2 km. Each occultation occurs at a fixed position of the secondary grating that cover spectral interval of ~0.3 µm including 10-15 diffraction orders of the echelle grating. Figure 1 demonstrates an example of CO_2 transmission spectra measured and best fitted in two MIR positions: 5 at 2.51 µm and 12 at 3.15 µm.

Figure 1: Examples of ACS-MIR spectral windows in diffraction orders 237 at 2.51 µm (left), and 189-190 at 3.15 µm (right), measured at tangent heights 12 and 19 km, used for the retrieval of CO_2 density.

3. Conclusions

Retrievals of CO_2 density are possible from many spectral windows (echelle orders) of ACS-MIR, and in parallel with minor species. Temperature is extracted from the hydrostatic equilibrium condition, and it gives us link to the dust storm behaviour with altitude, temporal and latitude distributions.

Validation of our results with analogous studies, e.g. MCS/MRO [2] and NOMAD/TGO [3], are in progress.

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