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CO_2 and Temperature vertical profiles in the Martian atmosphere from solar occultation measurements at 2.7 micron by instruments NOMAD and ACS on board the Exomars Trace Gas Orbiter

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Introduction

Vertical profiles of CO2 and temperature with good vertical resolution are key measurements to characterize the Martian atmosphere, although difficult to obtain from remote observations [1]. For the first time these vertical profiles can be routinely obtained with a solar occultation technique by the instruments NOMAD and ACS on board the Exomars Trace Gas Orbiter [2,3]. A state-of-the-art retrieval scheme designed to derive atmospheric profiles of CO2 and temperature from the bottom to the top of the Martian atmosphere [4] is adapted to solar occulation and applied to exploit the operational sounding of these two instruments. The final goal of this on-going work is to characterize the Martian thermal structure from the troposphere up to the thermosphere with unprecedented vertical resolution and also to cross-validate both TGO instruments as best as possible, with a single retrieval code and entirely consistent data analysis approaches.

Retrieval approach

This work is focussed on the solar occultation channels NOMAD-SO and ACS-MIR, in routine operations since April 2018. To exploit these unique datasets, it is of paramount importance to examine the performance of the two instruments and to cross-validate their retrieval results as accurately as possible. For this purpose we apply a flexible and well tested Earth atmosphere retrieval scheme [5,6,7], to both of them, after adaptation to Mars atmospheric conditions [4] and the necessary accomodation of these channels characteristics [8]. The retrievals use calibrated

transmittance spectra to tackle three targets, CO2 density, temperature, and dust loading, in a simultaneous global-fit inversion, with updated hydrostatic equilibrium in every iteration, including contaminant species like H2O, and after a pre-processing/data cleaning analysis which is also similar in both instruments. A first error analysis is performed for both instruments with the help of synthetic retrievals and a series of sensitivity tests performed with the same inversion scheme and similar treatment of the key error terms (measurement noise and systematics).

Comparison of results

We will present data obtained in the 2.7 μm region, dominated by a well known ro-vibrational band of CO2, and sampled by NOMAD-SO in a mixture of diffraction orders that are used routinely in the operational sounding in the vertical. Similarly, we used 3 consecutive orders in one of the ACS-MIR difraction positions, which contain a sufficient number of CO2 lines in the same 2.7 μm band with the capability to sample the whole atmosphere, up to about 180 km, in a single vertical scan. For both instruments the sounding of the lowest troposphere is limited by the amount of atmospheric dust, which is also retrieved simultaneously with CO2 and temperature. We will compare the vertical profiles obtained in a small sample of profiles from each instrument which span different seasons, latitudes and atmopheric dust loadings, during the first year of TGO operations. The comparisons take into account that the two instruments' individual solar occulation scans are non-coincident in time and space. Comparions are also peformed with results from similar efforts by other groups in the NOMAD and ACS teams [9]. Two important applications of the obtained retrievals are : (i) to supply the most appropriate inputs to the retrieval of other atmospheric species from the same instruments and the same scans, without the need to assume a prior or first guesses from global circulation models (GCM), see companion contributions to this conference [10,11], and (ii) to validate predictions from these GCMs, and therefore, to help to improve them, particularly at high altitudes and at the terminator, where these datasets are particularly valuable [1].

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