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CO2 Abundance Profiles in the Mars Upper Atmosphere from Solar Occultation Measurements by NOMAD and ACS on board ExoMars TGO

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Background

Carbon dioxide, the major compound of the Martian atmosphere, is well mixed up to the turbopause, by definition, and is governed by molecular diffusion above. The altitude of this layer, however, and the actual distribution of CO_2 at thermospheric altitudes are not well described observationally given the difficulty of its remote determination at these altitudes, and the scarcity of in-situ measurements so far, in spite of a wave of recent data from MAVEN [1,2]. Since the Trace Gas Orbiter (TGO) started its nominal science phase in April 2018, solar occultation measurements from two of its instruments on board, NOMAD and ACS, permit a systematic mapping of the CO_2 abundance from the upper thermosphere down to tropospheric altitudes [3,4]. These observations present a unique opportunity to explore the atmospheric vertical structure (composition and temperature) at high vertical resolution [5]. This work is devoted to the inversion of these datasets with a common inversion scheme that we recently started to apply to both instruments.

The NOMAD SO Channel

The NOMAD instrument has three channels, two in the IR and one in the UV, capable of operating in different observation modes: solar occultation, nadir and limb [4,6]. The SO channel in the IR was specifically designed to perform atmospheric observations via solar occultation geometry. This channel ranges from 2.2 - 4.2 µm, uses an acousto-optical tunable filter (AOTF) along with an echelle grating in order to select and define different diffraction orders. The spectral width of every order's windows varies from 20 to 35 cm^{-1}, with a resolution of close to 0.15 cm^{-1} (resolving power ~25000). We focused here on the orders located around 2.7 µm, covering part of the strongest CO_2 ro-vibrational band in this spectral range.

The ACS MIR Channel

The ACS instrument also has three channels and its performance and characteristics have been previously described in [3]. Our work primarily uses MIR, the ACS cross dispersion echelle spectrometer devoted to solar occultation in the 2.3 - 4.2 µm range, very similar to the NOMAD SO channel, and with a combined sensitivity and spectral resolution also similar to the NOMAD SO [5]. We focus here in position 5, which includes diffraction orders around 2.6 µm, i.e. sampling the same spectral window as the selected NOMAD SO data.

Retrieval Scheme

In this talk, we present the first retrievals of CO_2 from a small selection of solar occultation measurements from NOMAD and ACS, after applying a common inversion scheme. This scheme is an adaptation of an inversion code initially developed for use in Earth's atmosphere remote satellite. It uses a line-by-line radiative transfer code called KOPRA, primarily used for emission spectra, coupled to an inversion processor [7,8]. It has been validated against other radiative transfer code and used in numerous chemistry studies of stratospheric and mesospheric emissions [9]. The adaptation to Mars included the implementation of new routines in KOPRA to simulate instrumental functions for both NOMAD/SO and ACS/MIR. The datasets selected are Level 0 (raw detector) data around 2.6 μm with tangent pointings at mesospheric and thermospheric altitudes. They were cleaned from well known instrumental artefacts, binned in a similar altitude grid to form 1-D vertical profiles, and converted to limb atmospheric transmittances before application of the inversion. Some examples of retrieved CO2 profiles will be presented and discussed.

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