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Retrieval of Martian CO vertical profiles from NOMAD solar occultation measurements

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Abstract

NOMAD (*Nadir and Occultation for Mars Discovery instrument*), is a spectrometer suite onboard Exo Mars Trace Gas Orbiter having within its main scientific objectives the observations of the trace gases in the Martian atmosphere [1]. Here we focus on the retrieval of carbon monoxide (CO) vertical profiles with high vertical resolution. CO is an important trace species which acts as both photochemical and dynamical tracers. We retrieve CO from the solar occultation (SO) observation of the NOMAD orders (186 – 191) using a state-of-the-art retrieval method [2]. The observational dataset covers a wide range of latitudes and seasons. This permits us to study the impact of different conditions such as dust-storm seasons (local and global), southern summer and winter on the CO vertical profiles over different regions.

Introduction

CO is originated in the upper Martian atmosphere by the photolysis of CO_2 and destroyed by the hydroxyl (OH) radicals in the lower atmosphere. Hydroxyl radicals thus recycle CO into CO_2 [3]. The study of the CO vertical distribution is important to understand the photo-chemical stability of the atmosphere. CO not only links the chemistry of the carbon and odd hydrogen chemical families but is a long-lived species which also serves as a dynamical tracer. By far the current knowledge of CO vertical profiles is largely unconstrained due to lack of systematic measurements. Though the column density of CO has been measured by instruments like CRISM [4] (*Compact Reconnaissance Imaging Spectrometer for Mars*) for a wide range of latitudes and seasons for multiple Martian years, the lack of its regular mapping in the vertical, limits a full understanding of its distribution and variability. Very recently, CO density profiles were reported from ACS (*Atmospheric Chemistry Suite*) observations [5] which found a significant depletion in CO mixing ratio during the 2018 global dust storm. NOMAD is performing routine solar occultation measurements since April 2018. Our aim

here is to retrieve CO vertical profiles from these measurements with the best achievable precision and resolution and to investigate its distribution and variability through the different seasons and latitudes.

Retrieval of CO from NOMAD SO orders 186 – 190

We present vertical profiles of CO retrieved from a subset of NOMAD solar occultations. The SO channel of NOMAD operates in the 2.3 – 4.3 μm [3] where strong absorption lines for CO lie. In particular, the diffraction orders 186 (4180.32 cm^{-1} - 4213.88 cm^{-1}) - 191 (4292.69 cm^{-1} - 4327.16 cm^{-1}) allow for a good quality CO retrieval from 10 to about 100 km tangent altitudes. However, the recorded spectra suffer from calibration issues [6] such as bending and spectral shifts, in addition to variable systematic and random noise components. At IAA we have developed a cleaning procedure which correct the spectra for possible bending and spectral shift and makes it usable for a precise inversion of CO densities. We use the line-by-line radiative transfer model KOPRA (Karlsruhe Optimized and Precise Radiative transfer Algorithm) [2] as forward model, which was adapted to Mars and to the NOMAD instrument characteristics, in conjunction with an interactive solver (RCP) to retrieve CO from the cleaned spectra. Here we present a summary of this on-going work, which builds on a chain of retrievals of atmospheric aerosols, temperatures and density profiles derived from the same NOMAD scan but different diffraction orders, to obtain vertical profiles of CO in a consistent manner. We will also present first comparisons with Mars GCM results.

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