



## **CO<sub>2</sub> and temperature retrievals in the Mars atmosphere from solar occultation by NOMAD-SO and ACS-MIR: performance and cross validation.**

Miguel Angel Lopez-Valverde, Bernd Funke, Brittany Hill, Francisco Gonzalez-Galindo, Shohei Aoki, Loic Trompet, Ian Thomas, Geronimo Villanueva, Justin Erwin, Kevin Olsen, et al.

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## CO<sub>2</sub> and temperature retrievals in the Mars atmospheric occultation by NOMAD-SO and ACS-MIR: performance validation.

**Miguel Angel Lopez-Valverde** et al.

### Abstract

We present simultaneous retrievals of vertical profiles of CO<sub>2</sub> and temperature obtained from a small selection of observations by the NOMAD-SO [1] and ACS-MIR [2] instruments on board the ExoMars *Trace Gas Orbiter* (TGO). The two sets of each instrument's observations are sufficiently close in time and space so that the atmospheric variability can be compared, making a meaningful comparison of the performance of both instrument channels possible. This is an on-going validation of both instruments. We will present a small selection of retrievals that can be used for comparison with those obtained and as a first step into the mutual validation of NOMAD-SO and ACS-MIR.

### 1. Instruments and observations

Our work is focussed in the NOMAD-SO and the ACS-MIR channels, those specifically devoted to CO<sub>2</sub> retrieval during solar occultation. Several groups in the NOMAD and ACS teams are performing retrievals of species abundances and temperature, which are reported in this conference [3,4]. We focus on the retrieval of CO<sub>2</sub> and temperature in the 2.7  $\mu\text{m}$  band using this gas in the spectra region covered by SO and ACS [5]. The spectra correspond to calibrated transmission spectra of diffraction orders 164 and 165 and from MIR position 4 spectra. About a dozen strong CO<sub>2</sub> lines are observed at very high tangent altitudes, around 170-180 km. The present study targets at both solar occultation and emission observations, but unfortunately, due to some unexpected miss-alignments among the different channels in each instrument, a simultaneous observation of the solar disc as it emerges or hides behind the atmosphere is not possible in the ACS, an entirely simultaneous observation of the solar disc as it emerges or hides behind the atmosphere is not possible in the ACS and MIR channels. Instead this work studies the inversions from the two channels in nearly coincident observations, which changes in latitude, longitude, solar longitude and time.

### 2. Retrieval Scheme

We have performed the present retrievals using an inversion code previously used in the Earth upper atmosphere by the MIPAS instrument on board the Envisat mission [6]. The inversion scheme, which has been re-

sounding in emission from the OMEGA spectrometer on board the Mars Express spacecraft [7], observations. At the core of the inversion scheme is the forward model KOPRA (Karlsruhe Optimize Algorithm [8] ) and the inversion processor (RCP), jointly developed by the Institute for Meteorology the IAA [9].

As mentioned above we used here CO<sub>2</sub> calibrated transmittances obtained from routine processing injection into the inversion algorithm, a *pre-processing* of every orbit or scan is performed in order to remove spurious effects. These are essentially two: residual spectral shifts and artificial bending in single spectral effects changes from order to order and between SO and ACS. In spite of these differences, the pre-processing is applied to both signals, and is actually performed with the same Python code. Further, the ILS associated with the spectra is reproduced by a double gaussian, whose detailed description (parameters describing their FWHM and peak position) is also a precise determination by the user, as apparently it slightly varies with time and observing conditions.

It is specially useful to obtain both density and temperature information from a single scan, and this is the main goal of the study. The simultaneous retrieval from a given scan actually derives a CO<sub>2</sub> density profile, and after an inversion step a temperature profile assuming hydrostatic equilibrium. An adjustment for the pointing is also introduced, and the interference from species like H<sub>2</sub>O are also considered during the inversion to obtain the best fits.

### 3. Results

We will discuss the first comparisons of CO<sub>2</sub> and temperatures from NOMAD-SO and ACS-MIR, using the inversion code. The retrievals perform in a similar manner, as in both cases the number of lines, the spectral region are similar. Small differences in noise and spectral resolution have some impact but do not prevent sounding the Mars atmosphere up to the upper thermosphere with just one single scan. Averaging of multiple scans gives resolutions around 4-6 km in the middle atmosphere (50-100 km), both in CO<sub>2</sub> and temperature. The dust loading and in general degrades below about 30 km and above 150 km due to saturation and noise.

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