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# Preliminary results on sensitive search of minor species using the first data of TGO/NOMAD

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## Abstract

Nadir and Occultation for Mars Discovery (NOMAD) onboard ExoMars Trace Gas Orbiter (TGO) has started the science measurements on 21 April, 2018. We present the preliminary results on the sensitive search of minor species in the Martian atmosphere from the first data measured by TGO/NOMAD.

## 1. The NOMAD instrument

NOMAD is a spectrometer operating in the spectral ranges between 0.2 and 4.3 µm onboard ExoMars TGO [1]. NOMAD has 3 spectral channels: a solar occultation channel (SO – Solar Occultation; 2.3-4.3 µm), a second infrared channel capable of nadir, solar occultation, and limb sounding (LNO – Limb Nadir and solar Occultation; 2.3-3.8 µm), and an ultraviolet/visible channel (UVIS – UV visible, 200-650 nm). The infrared channels (SO and LNO) have high spectral resolution ($\lambda/d\lambda \sim 20{,}000$) provided by echelle grating in combination with an Acousto-Optic Tunable Filter (AOTF) which selects diffraction orders [2]. The concept of the infrared channels are derived from the Solar Occultation in the IR (SOIR) instrument [3] onboard Venus Express. The sampling rate for the solar occultation measurement is 1 km, which provides unprecedented vertical resolution spanning altitudes from the surface to 200 km. Nadir sounding by the LNO channel will acquire spectra with an instantaneous footprint of 0.5 x 17 $km^2$, which allows us to obtain maps of trace gases and aerosols in the Martian atmosphere.

One of the most remarkable capabilities of NOMAD is its high spectral resolution in the near infrared range. It allows us (1) to investigate vertical profiles of the atmospheric constituents (such as carbon dioxide, carbon monoxide, water vapor, and their isotopic ratio) and (2) to perform sensitive search of organic species (such as $CH_4$, $C_2H_4$, $C_2H_6$, $H_2CO$) and other trace gases (such as HCl, HCN, $HO_2$, $H_2S$, $N_2O$, OCS) by solar occultation measurements by the SO channel, and (3) to obtain maps of the atmospheric constituents (such as carbon dioxide, carbon monoxide, water vapor, and their isotopic ratio), across the planet by nadir viewing by the LNO channel.

## 2. Search of the minor species

In this study, we focus on the sensitive search of minor species such as $C_2H_2$, $C_2H_4$, $C_2H_6$, HCl, HCN, $H_2CO$, and $HO_2$ using the data measured by the SO channel.

Based on the expected performance, we calculated theoretical detections limit of the minor species by NOMAD [4]. These results for the minor species listed above are summarized in Table 1. We note that these estimations were performed based on the radiative transfer calculation for clear sky conditions. Thus, we expect that the actual detection limits will be slightly higher than the values shown in Table 1. In the presentation, the preliminary results of the analysis using the first data will be discussed.

Table 1: The minor species investigated in this study, their upper limits (3-sigma) by the previous studies, and their theoretical detection limits by NOMAD solar occultation measurements at 20 km by the SO channel [4].

| Species | Upper limits by the previous studies (column-integrated) | Theoretical detection limits by NOMAD SO channel (at 20 km alt.) |
|---|---|---|
| $C_2H_2$ | 3 ppb [5] | 0.03 ppb |
| $C_2H_4$ | 4 ppb [6] | 0.2 ppb |
| $C_2H_6$ | 0.2 ppb [6] | 0.03 ppb |
| HCl | 0.3 ppb [7] | 0.03 ppb |
| HCN | 2 ppb [6] | 0.03 ppb |
| $H_2CO$ | 4 ppb [6] | 0.04 ppb |
| $HO_2$ | 200 ppb [6] | 1 ppb |
| $H_2S$ | 2 ppb [8] | 4 ppb |
| $N_2O$ | 65 ppb [6] | 0.2 ppb |
| OCS | 70 ppb [9] | 0.3 ppb |

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