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TGO limb observations and addititonal possibilities for upper atmosphere science on Mars

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Abstract

The Martian mesosphere and thermosphere (altitudes above 50-60 km), is not the primary target of the Trace Gas Orbiter (TGO) but TGO is exploring the region, both during the aerobraking phase and, after April 21st, 2018, during the science phase using several geometries and instrumentation. Further upper atmospheric science could be obtained during the nominal mission if some "additional" observational modes were implemented ([2]). These would add capabilities to explore the limb off-the-terminator. However some of the new target emissions are weak and variable. In this work we will review the performance of the two key instruments on board TGO for atmospheric science, NOMAD and ACS, and revisit the potential for pursuing those additional observation modes.

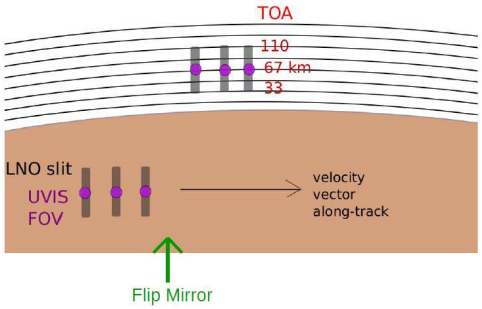

Figure 1: Illustration of the use of NOMAD LNO's flip mirror to observe the limb (at a fixed elevation) during the nadir mapping phase.

1. Introduction

During the TGO regular science phase, the Martian upper atmosphere is routinely explored remotely by means of its three nominal observing modes, nadir, solar occultation and limb pointing (using NOMAD's flip mirror, see Figure 1), and by combining the 2 solar occultation spectrometers on board, NOMAD and ACS, which cover from the UV to the IR. This is a superb configuration to detect trace species but also to measure faint absorptions from the solar flux at high altitudes and to investigate atmospheric emissions off-the-terminator ([2]).

Lopez-Valverde et al. (2018) made simulations of possible UV and IR emissions which could be observed with the nominal observing modes, and proposed a few "additional" observational modes for TGO. In particular they mentioned the possibility to perform inertial limb scans, nadir boresight slews, and fixed limb tracking. The obvious goal is to extend the local time of the upper atmosphere observations. None of their additional modes is currently contemplated in the science phase but they would add capabilities to explore the limb off-the-terminator (i.e. the nightside and dayside hemispheres). In particular, they could be useful to improve:

- vertical profiles of minor species and dust
- the daily cycle of minor species
- detection of airglow emissions outside the terminator

Some of their simulations for these modes correspond to solid predictions, some to likely detections, and other ones may be at the limit of detection. Using the better characterization of NOMAD and ACS performances that we will have after the first months of regular operations, we will review those possibilities to study the Mars upper atmosphere with TGO.

Table 1: Characteristics of the NOMAD and ACS channels (before the Science Phase)

Instrument and Channel	Range (μm)	Resolution (cm^{-1})	LIMB FOV$^{\aleph}$	NESR *
NOMAD SO	$2.2 - 4.2$	$0.15-0.22$	1×14	8×10^{-10}
NOMAD LNO	$2.3 - 3.8$	$0.3-0.5$	2×67	$2 \times 10^{-8} - 6 \times 10^{-10}$
NOMAD UVIS	$0.2 - 0.65$	~ 1.5 nm	1×1	$10 - 8 \times 10^{-6}$
ACS NIR	$0.76 - 1.6$	0.4	5×50	$5 \times 10^{-7} - 4.5 \times 10^{-10}$
ACS MIR	$2.3 - 4.3$	0.085	0.5×7.5	5×10^{-10}
ACS TIRVIM	$2 - 17$	$0.25-1.3$	70×70	$\sim 2 \times 10^{-8} - 10^{-9}$

$\aleph$ Limb Field-Of-View in km.

$\star$ Noise Equivalent Spectral Radiance units: $W/cm^2/cm^{-1}/sr$. Estimations based on [4], [3] and [1]

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