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Science objectives and Expected performances of NOMAD, an ExoMars TGO instrument

Séverine Robert (1), Ann Carine Vandaele (1), Ian Thomas (1), Frank Daerden (1), Cédric Depiesse (1), Rachel Drummond (1), Lori Neary (1), Yannick Willame (1), José Juan Lopez-Moreno (2), Julio Rodriguez-Gomez (2), Manish R. Patel (3), Giancarlo Bellucci (4), and the NOMAD Team

(1) Belgian Institute for Space Aeronomy, Brussels, Belgium (severine.robert@aeronomie.be), (2) Instituto de Astrofisica de Andalucia CSIC, Granada, Spain, (3) Open University, Milton Keynes, UK, (4) Institute for Space Astrophysics and Planetology, Roma, Italy

Abstract

NOMAD, the "Nadir and Occultation for MArs Discovery" spectrometer suite is part of the payload of the 2016 ExoMars Trace Gas Orbiter Mission. This instrument suite will probe the atmosphere of Mars in the infrared, visible and ultraviolet regions covering 0.2 - 0.65 and 2.2 - 4.3 μm. Thanks to its very high spectral resolution and multiple channels and observational modes, NOMAD will be able to detect a wide range of atmospheric trace gases, many of which are important markers of geophysical and/or biogenic activity.

We will present the instrument, its science objectives and the performances we expect based on simulations we have done so far.

1. Introduction

NOMAD is one of four instruments on board the ExoMars Trace Gas Orbiter, scheduled for launch in January 2016 and to begin nominal science mission around Mars in late 2017. It consists of a suite of three high-resolution spectrometers which will generate a huge dataset of Martian atmospheric observations during the mission, across a wide spectral range.

The instrument will be delivered for spacecraft integration during the course of 2015. It is however important to already prepare the planning activities that will begin as soon as the Science Phase starts (expected in November 2017). One important issue is to determine the levels of detection for the different possible targets, and to derive optimal observation parameters (specific spectral interval, integration times, accumulations, etc.). Radiometric models have been developed for the three channels in order to obtain the expected Signal-to-Noise (SNR) ratios.

Detection limits for key species were obtained according to a simple methodology. The best spectral ranges (both in the UV and IR) were studied for each molecule and each observation mode.

2. The NOMAD instrument

NOMAD [2] is composed of 3 channels: a solar occultation only channel (SO) operating in the infrared wavelength domain, a second infrared channel capable of doing nadir, but also solar occultation and limb observations (LNO), and an ultraviolet/visible channel (UVIS) that can work in all observation modes. The spectral resolution of SO and LNO surpasses previous surveys in the infrared by more than one order of magnitude. It offers an integrated instrument combination of a flight-proven concept (SO is a copy of SOIR on Venus Express), and innovations based on existing and proven instrumentation (LNO is also based on SOIR on board Venus Express (VEx) and UVIS has heritage from the ExoMars lander), that will provide mapping and vertical profile information at high spatio-temporal resolution.

3. Science Objectives

An order-of-magnitude increase in spectral resolution over previous instruments will allow NOMAD to map previously unresolvable gas species, such as important trace gases and isotopes. CO, CO_2, H_2O, C_2H_2, C_2H_4, C_2H_6, H_2CO, CH_4, SO_2, H_2S, HCl, O_3 and several isotopologues of methane and water will be detectable, providing crucial measurements of the Martian D/H ratios. It will also be possible to map the sources and sinks of these gases, such as regions of surface volcanism/outgassing and atmospheric production, over the course of an entire Martian year, to further constrain atmospheric dynamics and climatology. NOMAD will also continue to monitor the Martian water, carbon, ozone and dust cycles, extending existing datasets made by successive space missions in the past decades, and to derive surface UV radiation levels. Using SO and LNO in combination with UVIS, aerosol properties such as optical depth, composition and size distribution can be derived for atmospheric particles and for distinguishing dust from ice aerosols.

4. Expected Performances

ASIMUT-ALVL, a line-by-line radiative transfer code developed at IASB-BIRA [5], is used to simulate spectra in the 0.7 - 4.5 μm range as would be measured by the instrument and under various atmospheric conditions obtained from the IASB-BIRA GCM, GEM-Mars [1]. Random noise has then been added to the simulated spectra to match the real instrument characteristics of each channel: SNRs have been derived using a model that simulates the real instrument (e.g. transmission properties of optical components, expected in-flight instrument temperatures, detector responsivities, etc.) in [6] for the UV channel and in [4] for the IR channel.

Although the treatment is different for solar occultation and nadir observations, the philosophy to determine the detection limits is the same: simulate a series of spectra with known abundances of the target species, add noise, apply a retrieval method to fit the abundances, compare with the input values. We will detail the procedure for both solar occultation and nadir observations, and for all 3 channels.

5. Summary and Conclusions

We will show that NOMAD will be capable of measuring a long suite of species that are or could be present in the atmosphere of Mars. The solar occultation technique is a very powerful observational method allowing for the retrieval of high spatial vertical profiles of the target molecules from the upper layers of the atmosphere down to the surface or near-surface depending on the loading in dust and particles. The nadir observations will provide maps of a series of constituents that will permit the determination of sources and sinks, as well as put constraints on some surface processes.

The detection limits obtained will be presented at EPSC and published in [3].

Acknowledgements

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