EPSC Abstracts
Vol. 12, EPSC2018-661, 2018
European Planetary Science Congress 2018

The NOMAD Spectrometer Suite on ExoMars Trace Gas Orbiter: First Results from the Commissioning and Nominal Science Phases

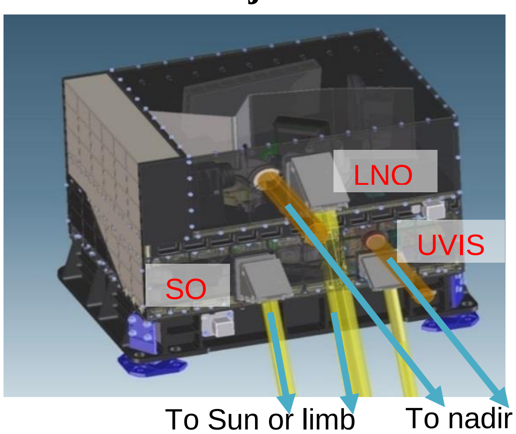
Ian R. Thomas (1), Ann Carine Vandaele (1), Séverine Robert (1), Loïc Trompet (1), Shohei Aoki (1,2, 3), Cédric Depiesse (1), Yannick Willame (1), Valérie Wilquet (1), Arianna Piccialli (1), Bojan Ristic (1), Claudio Queirolo (1), Frank Daerden (1), Justin T. Erwin (1), Lori Neary (1), Sébastien Viscardy (1), Sophie Berkenbosch (1), Roland Clairquin (1), Bram Beeckman (1), Eddy Neefs (1), Jon Mason (4), Manish R. Patel (4), Giancarlo Bellucci (5), José Juan Lopez Moreno (6) and the NOMAD Team.

(1) BIRA-IASB, Brussels, Belgium; (2) Fonds National de la Recherche Scientifique, Belgium, (3) Tohoku University, Japan, (4) Open University, U.K; (5) IAPS/INAF, Rome, Italy; (6) IAA/CSIC, Granada, Spain (ian.thomas@aeronomie.be)

Abstract

NOMAD, one of four scientific instruments on the ExoMars Trace Gas Orbiter, is a suite of spectrometers operating in the ultraviolet, visible and infrared spectrum. It was launched in 2016 and, at the time of writing, has just started the nominal science phase after one month of in-orbit commissioning. This presentation will describe some of the first results from all three spectrometers within NOMAD, in addition to detailing our plans for making future observations and analysing the incoming data to increase our understanding of Mars.

1. Scientific Objectives



Detection and mapping of new and existing gas species are the highest priority science objectives for NOMAD [4]. Many atmospheric constituents that can be measured are important markers of geophysical and/or biogenic activity, and therefore detecting the presence of such molecules and mapping their sources and sinks will greatly improve our knowledge of the red planet. Optical properties, such as particle size distributions of dust and ice aerosols, and measurements of the UV surface radiation environment will also be repeatedly monitored by NOMAD over the course of the TGO mission, in addition to the continued mapping of water, carbon, ozone and other climatologic cycles occurring in the atmosphere of Mars [4].

2. The NOMAD Channels

There are two main types of observations performed by NOMAD:

Solar occultations, where the sun is continually observed as the instrument field of view passes through the atmosphere, have extremely high signal to noise ratios, but can only be performed when the orbital position of the spacecraft allows such observations to be made.

Nadir observations, where the instrument field of view is pointed towards the surface directly below the spacecraft, and reflected sunlight is observed. These observations can be measured on all orbits, but the trade-off is a lower signal to noise ratio than for solar occultations.

When atmospheric vertical profiles from solar occultations - taken by the SO and UVIS channels - and spectra from nadir observations - taken by the LNO and UVIS channels - are combined, they will provide an immense dataset for probing the composition of the atmosphere in great detail. Both infrared channels have a similar spectral range (2.2-4.3µm for SO; 2.2-3.8µm for LNO) and very high spectral resolution (~0.1-0.2cm^{-1} for SO and ~0.15-0.25cm^{-1} for LNO, depending on wavenumber) allowing gas absorption lines to be measured in unprecedented detail [1]. The infrared spectral range covers many major and minor constituents, such as CO_2, CO, H_2O, HDO, NO_2, N_2O, O_3, CH_4, C_2H_2, C_2H_4, C_2H_6, H_2CO, HCN, OCS, SO_2, HCl, HO_2, and H_2S [3,4]. UVIS operates in the 200-650nm region, with a spectral resolution of ~1.2-1.6nm, providing crucial data on the ultraviolet and visible regions of the spectrum - observing simultaneously with the SO and LNO channels - to detect O_3, SO_2, dust/ice opacities and clouds, among others [2].

3. Observations

All channels of NOMAD are highly configurable, and therefore planning observations effectively is a high priority for the team. The SO and LNO channels do not typically measure the entire spectral range in each observation. Instead, specific spectral ranges are chosen based on the absorption lines visible, and are measured repeatedly throughout a single nadir or solar occultation. The optimum number of spectral regions chosen is a trade-off between SNR and molecular detection: the greater the number of spectral ranges measured in an observation, the more molecules can be measured simultaneously, but at the expense of SNR. For solar occultations, SNR is not an issue, therefore up to 12 spectral regions are measured every occultation; however in nadir signals are much lower therefore normally only 2, 3 or 4 spectral regions are used. Also, the noise is reduced when the instrument temperature is lower; therefore LNO is not run on every orbit, allowing NOMAD to remain in its optimum thermal range. Similar options exist for UVIS, namely variations in integration time, and whether to run in binned or unbinned detector mode (the latter gives higher SNRs but requires more data volume).

Observations are chosen based on solar illumination angle, interesting surface sites, available data rates, etc. At present the allocated data volume is very high, however this will decrease as we move towards solar conjunction, forcing all the instruments on board to prioritise certain observations over others. All these trade-offs must be studied and the results fed back into the planning of future observations to optimise the science return from NOMAD.

4. Results

The nominal science phase has just begun, and so results at present are limited. NOMAD has performed one month of nadir-only measurements in the spacecraft commissioning period, and has now started the nominal science period where normal solar occultations measurements can be performed. Special measurements, such as limb measurements, grazing solar occultations (where the tangent altitude never reaches the surface), and *fullscans* (where the whole spectral range is measured) are all to be tested in this nominal science phase, plus a wide range of calibration measurements are to be performed also. Results from all types of observations will be analysed and presented.

5. Summary and Conclusions

At the time of writing this abstract, the nominal science period has just begun and the incoming data is just starting to be calibrated and analysed. By the time of the conference, around 5 months of data will have been taken, and once analysed there will be many results to report. The aim of this presentation is to give the audience a general overview of the observations, data acquired, initial results, and future plans for the three channels onboard NOMAD.

Acknowledgements

The authors would like to thank everyone who has contributed to the design, construction, testing, operations and management of NOMAD and the TGO. The NOMAD experiment is led by the Royal Belgian Institute for Space Aeronomy (IASB-BIRA), assisted by Co-PI teams from Spain (IAA-CSIC), Italy (INAF-IAPS), and the United Kingdom (Open University). This project acknowledges funding by the Belgian Science Policy Office (BELSPO), with the financial and contractual coordination by the ESA Prodex Office (PEA 4000103401, 4000121493), by the Spanish Ministry of Economy, Industry and Competitiveness, by FEDER funds under grant ESP2015-65064-C2-1-P (MINECO/FEDER), and by the UK Space Agency through grant ST/P000886/1 and Italian Space Agency through grant 2018-2-HH.0. This research was also performed as part of the “Excellence of Science” project “Evolution and Tracers of Habitability on Mars and the Earth” (FNRS 30442502) and supported by the BrainBe SCOOP and CRAMIC (FNRS) projects.

References

[1] Neefs et al.: NOMAD spectrometer on the ExoMars trace gas orbiter mission: design, manufacturing and testing of the infrared channels. Appl. Opt. 54:28. 2015.

[2] Patel et al.: NOMAD spectrometer on the ExoMars trace gas orbiter mission: part 2 - design, manufacturing and testing of the UVIS channel. Appl. Opt. 56:10. 2017.

[3] Robert, S., et al., "Expected performances of the NOMAD/ExoMars instrument", Planetary and Space Science, 124 94-104. 2016

[4] Vandaele A.C. et al.: Science objectives and performances of NOMAD, a spectrometer suite for the ExoMars TGO mission. PSS, 119:15. 2015.