EPSC Abstracts
Vol. 6, EPSC-DPS2011-404-1, 2011
EPSC-DPS Joint Meeting 2011

NOMAD, a spectrometer suite for Nadir and Solar Occultation observations on the ExoMars Trace Gas Orbiter

A.C. Vandaele (1), J.-J. López-Moreno (2), M. R. Patel (3), G. Bellucci (4) , F. Daerden (1), R. Drummond (1), E. Neefs (1) , J. Rodriguez Gomez (2), and the NOMAD team
(1) Planetary Aeronomy, IASB-BIRA, Brussels, Belgium (a-c.vandaele@aeronomie.be), (2) Instituto de Astrofisica de Andalucia IAA-CSIC, Granada, Spain, (3) Planetary and Space Science Research Institute PSSRI, Open University, Milton Keynes, UK, (4) Istituto di Fisica dello Spazio Interplanetario IFSI, Roma, Italy

Abstract

NOMAD, the "Nadir and Occultation for MArs Discovery" spectrometer suite has been selected by ESA and NASA to be part of the payload of the ExoMars Trace Gas Orbiter mission 2016. This instrument suite will conduct a spectroscopic survey of Mars' atmosphere in the UV, visible and IR regions covering the 0.2-0.65 and 2.2-4.3 µm spectral ranges. NOMAD's observation modes include solar occultation, nadir and limb observations. The nadir mode will provide detailed trace gas mapping. (see also Daerden et al., same session)

1. The NOMAD instrument

The Nadir and Occultation for MArs Discovery (NOMAD) instrument 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. NOMAD 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 based on SOIR/VEX and UVIS has heritage from the ExoMars lander), that will provide mapping and vertical profile information at high spatio-temporal resolution. The three channels have each their own ILS and optical bench, but share the same single interface to the S/C.

1.1 SO Channel

The SO channel operates at wavelengths between 2.2 and 4.3 µm, using an echelle grating with a groove density of 4 lines/mm in a Littrow configuration in combination with an Acousto-Optic Tunable Filter (AOTF) for spectral window selection, see Fig. 1. The width of the selected spectral windows varies from 20 to 35 cm^{-1} depending on the selected diffraction order. The detector is an actively cooled HgCdTe Focal Plane Array. SO achieves an instrument line profile resolution of 0.15 cm^{-1}, corresponding to a resolving power $\lambda/\Delta\lambda$ of approximately 25000.

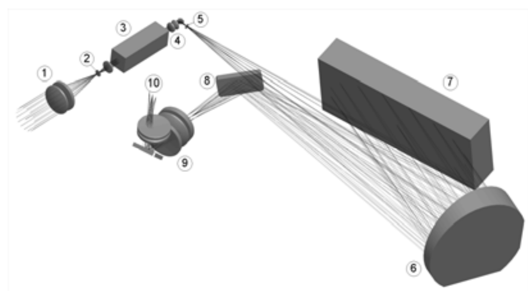

Fig. 1: SO schematics

1.2 LNO Channel

The optical layout of LNO is identical to that of SO (AOTF - echelle spectrometer- cooled detector, see Fig. 1). LNO will be measuring in the wavelength range between 2.2 and 3.8 µm. To fulfil the SNR requirement, a number of low risk and easy-to-implement measures are taken to increase the signal throughput as well as to reduce the thermal background of the instrument, e.g. increasing the length of the slit from 30' to 100' and using longer integration times, appropriate pixel binning, and accumulation of spectra. Another solution is to increase the width of the slit, to admit more light, giving a higher SNR, but reducing the spectral resolution. For the LNO channel, a lollypop shape slit is proposed, offering high resolution spectra (same as the SO channel, $\lambda/\Delta\lambda \sim 25000$) as well as spectra at a lower resolution but with a higher SNR value. The latter will be used in nadir for mapping low-abundance species, once the high resolution part has demonstrated their detection.

1.2 UVIS Channel

The UVIS channel operates in the wavelength domain between 200 and 650 nm. It is a full copy of the instrument designed for the ExoMars lander, with additional telescopic entrance optics for application in orbit.

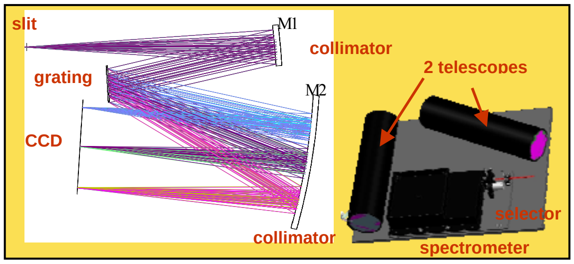

Fig. 2: UVIS schematics

2. Observation modes

NOMAD's observation modes complement each other and provide information in different spatial dimensions and at flexible temporal sampling rates:
(1) *Solar occultation* mode provides high-resolution vertical profiles of trace gas absolute abundances together with aerosol extinction, pressure, atmospheric density, and temperature at a vertical sampling equal to or lower than 1 km (in all channels). The duration of a typical SO measurement cycle is 1 s. Up to 6 different AOTF frequencies can be selected, meaning that up to 6 different wavelength intervals can be recorded in 1 s. This provides a total integration and/or accumulation time for each of the selected spectral intervals of 160 ms. If needed, the number of selected wavelength intervals can be reduced, thus increasing the integration time for each interval and hence the SNR. The instantaneous field of view of the SO channel is limited by the apparent size of the solar disk (21') and by the slit dimension (2', the long side of the slit). The resulting field of view corresponds to a 1 km x 10 km slice of atmosphere for typical S/C attitudes. A one-second cycle corresponds to a vertical sampling of 1 km for typical S/C attitudes. Each of the 6 successive measurements performed during this second, however, corresponds to a vertical sampling of 180 m. For UVIS a 1 km x 1 km slice of atmosphere at the limb is probed every 250 ms, leading to a vertical sampling of less than 300 m for typical S/C attitudes.
(2) *nadir* mapping mode provides vertical columns with spatial footprints of ~ 0.5 km x 68 km (along track) and 17 km x 51 km (cross track) for LNO measurements (for integration times ~ 15 s), and of 8 km x 5 km for UVIS (for integration times ~ 1 s). As the CO_2 column abundance is retrieved at the same time, systematic error sources (topography, surface shadowing) are eliminated and fractional column densities are determined.
(3) *limb* mode provides limited additional mapping capability and vertical information.

3. Spatial and temporal coverage

NOMAD permits the full exploitation of the orbit. From a 74° inclined orbit, the latitudes covered in solar occultation range from 87°N to 88°S with good revisit time at various solar longitudes. The nadir coverage between ±74° latitude provides global spatial sampling on average every 3 to 4 sols with varying local times. Due to the nature of the orbit, there will be occasional repeated ground tracks offering better temporal sampling of a given region.

The NOMAD Team: Allen M., Alonso-Rodrigo G., Altieri F., Aparicio del Moral B., Barrero-Gil A., Bellucci G., Berkenbosch S., Biondi D., Bolsee D., Bonnewijn S., Candini G.C., Clancy T., Daerden F., Depiesse C., Delanoye S., Drummond R., Formisano V., Funke B., Fussen D., García-Comas M., Geminale A., Gérard J.-C., Gillotay D., Giuranna M., González-Galindo F., Jeronimo Zafra J., Kaminski J., Karatekin O., Leese M., López Moreno J.J., López-Puertas M., López-Valverde M., Mahieux A., Mateshvili N., McConnell J., Meseguer J., Morales R., Mumma M., Neary L., Neefs E., Patel M.R., Pastor-Morales M.C., Perez-Grande I., Renotte E., Ringrose T., Ristic B., Robert S., Rodriguez Gomez J., Saggin B., Sanz R., Sanz Andres A., Sindoni G., Smith M., Thibert T., Vandaele A.C., Villanueva G., Whiteway J., Wilquet V.

Acknowledgements

The research program was supported by the Belgian Federal Science Policy Office and the European Space Agency (ESA PRODEX program). IAA participation is funded by MICIIN through Plan Nacional Ref. AYA2009-08190. UVIS support provided by the Open University. Italian participants acknowledge the support from ASI.