EPSC Abstracts
Vol. 12, EPSC2018-699, 2018
European Planetary Science Congress 2018

Calibration of the NOMAD-UVIS channel

Cédric Depiesse (1), Yannick Willame (1), Ann Carine Vandaele (1), Ian R. Thomas (1), David Bolsée (1), Eddy Neefs (1), Sophie Berkenbosch (1), Roland Clairquin (1), Manish R. Patel (2), Jon Mason (2), Mark Leese (2), Brijen Hathi (2), Mike J. Wolff (3), R. Todd Clancy (3), Francesca Altieri (4), Giancarlo Bellucci (4), Jose-Juan Lopez-Moreno (5), Tanguy Thibert (6) and the NOMAD team
(1) Royal Belgian Institute for Space Aeronomy, Belgium, (2) Open University, UK, (3) SSI - Space Science Institute, Boulder, USA (4) Italian National Institute for Astrophysics, Italy, (5) IAA-CSIC, Spain, (6) Centre Spatial de Liège, Belgium (cedric.depiesse@aeronomie.be)

Abstract

NOMAD (Nadir and Occultation for MArs Discovery) [1,2] is one of the four instruments on-board the ExoMars 2016 Trace Gas Orbiter (TGO). It consists of three high-resolution spectrometers (SO, LNO and UVIS). We present here the calibration of the NOMAD-UVIS channel.

1. The NOMAD-UVIS channel

The NOMAD-UVIS channel consists of a grating spectrometer in the Czerny-Turner configuration ranging from 200 nm to 650 nm with a resolution of 1.5 nm and a second order filter. Observations are obtained both in nadir and Solar Occultation (SO) through two dedicated telescopes. A mechanical selector drives the optical fibers to the entrance of the spectrometer. The detector is a CCD with [256 x 1024] pixels that can operate in full frame or vertically binned mode, where the latter is used to increase the signal-to-noise ratio and to reduce the data rate.

2. Ground calibration campaign

The calibration campaign took place at the Centre Spatial de Liège during thermal tests performed just before the integration of NOMAD onto TGO. The calibration measurements were performed at 5 different temperatures from -15° to +20°C. The Optical Ground Support Equipment (OGSE) consisted of a structure containing a set of 3 radiometrically calibrated lamps covering the bandwidth of the NOMAD-UVIS channel: 4 Pen-Ray lamps and an absorption cell containing SO_2 gas facing the nadir telescope, where the assembly was aligned using lasers. The SO will operate in transmittance and as it is considered to be a self-calibrating observation, no specific ground calibration was performed. Assessment of the performance will rely on in-flight relative measurements and direct solar observations.

3. Results of the calibration

The analysis of the data obtained during the calibration campaign have allowed us to characterize the response of the spectrometer and to convert the raw data into real physical quantities (i.e., radiometric calibration):

- We have determined a mask for the “bad pixels” (essentially a list of the identified problematic pixels);

- The dark current is subtracted using measurements recorded before and after each set of observations. This approach allows on to take into account the variation of the temperature during an observation. The same process is used for in-flight data;

- The linearity of the detector’s response as function of both the integration time and the temperature;

- The pixel-wavelength relation (i.e., wavelength calibration) based on the lines of the Pen-Ray lamps and confirmed by in-flight measurements of solar lines. No temperature-dependence of the wavelength was observed;

- The radiometric calibration was determined using the 3 standard lamps to cover the wavelength range of UVIS;

- characterization of a straylight component, which is much larger in the UV that would be ideal (see next section).

4. The straylight issue

A significant straylight signal has been identified, but unfortunately well after the calibration of the flight model calibration campaign. To better characterize it, we have used the NOMAD "flight spare" model. Tests and measurements with this model show that there are two components of the straylight. One "internal" (or in-band), coming from light within the bandwidth of the spectrometer (200 nm – 650 nm) called UV-visible straylight. A second component originates from outside the observed range (650 nm – 1100 nm), which we call IR straylight. The calibration must treat these two components explicitly, but separately. The UV-visible straylight will be corrected using the Zhong method [3] which consist in characterizing the instrument's response toa set of monochromatic laser sources that cover the instrument's spectral range. One obtains a spectral stray light signal distribution matrix that quantifies the magnitude of the spectral stray light signal within the instrument. By use of these data, a spectral stray light correction matrix is derived and the instrument's response can be corrected with a simple matrix multiplication. For the IR straylight component, we studied it using a set of 50 nm bandpass filters. This allowed us to derive the quantity of straylight for each wavelength interval. The current method to IR straylight characterization requires a robust estimation of the actual radiance in the 650 to 1100nm spectral range. This is currently achieved using a typical IR radiance spectrum of Mars rescaled to the value measured at 600nm with the NOMAD-UVIS channel (wavelength where the straylight quantity is minimum in the spectrometer). The result for the straylight removal method obtained on the spare model is then extrapolated to the flight model.

Acknowledgements

The NOMAD experiment is led by the Royal Belgian Institute for Space Aeronomy (BIRA-IASB), 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 MICIIN through Plan Nacional (AYA2009-08190 and AYA2012-39691), by UK Space Agency through grant ST/P000886/1, as well as and Italian Space Agency through grant 2018-2-HH.0.

References

[1] Vandaele, A.C., et al.: Science objectives and perfrmances of NOMAD, a spectrometer suite for the ExoMars TGO mission, Planet. Space Sci., Vol. 119, pp 233-249, 2015.

[2] Neefs, E., et al.: NOMAD spectrometer on the ExoMars trace gas orbiter mission: part1 – design, manufacturing and testing of the infrared channels, Appl. Opt., Vol. 54(28), pp 8494-8520, 2015.

[3] Y. Zong, S. Brown, B. Johnson, K. Lykke, and Y. Ohno, "Simple spectral stray light correction method for array spectroradiometers," Appl. Opt. 45, 1111-1119 (2006).