EPSC Abstracts
Vol. 11, EPSC2017-194, 2017
European Planetary Science Congress 2017


# Martian atmospheric $O_3$ retrieval development for the NOMAD-UVIS spectrometer.

**W. Hewson (1)**, J.P. Mason(1), M. Leese(1), B. Hathi(1), J. Holmes(1), S.R. Lewis(1), P.G.J Irwin(2), and M.R. Patel(1).
(1) School of Physical Sciences, Faculty of Science, Technology, Engineering and Mathematics, The Open University, Walton Hall, Milton Keynes, U.K., (2) Atmospheric Physics, Clarendon Laboratory, Parks Road, Oxford, U.K.
(will.hewson@open.ac.uk)

## Abstract

The composition of atmospheric trace gases and aerosols is a highly variable and poorly constrained component of the martian atmosphere, and by affecting martian climate and UV surface dose, represents a key parameter in the assessment of suitability for martian habitability. The ExoMars Trace Gas Orbiter (TGO) carries the Open University (OU) designed Ultraviolet and VIsible Spectrometer (UVIS) instrument as part of the Belgian-led Nadir and Occultation for MArs Discovery (NOMAD) spectrometer suite. NOMAD will begin transmitting science observations of martian surface and atmosphere back-scattered UltraViolet (UV) and visible radiation in Spring 2018, which will be processed to derive spatially and temporally averaged atmospheric trace gas and aerosol concentrations, intended to provide a better understanding of martian atmospheric photo-chemistry and dynamics, and will also improve models of martian atmospheric chemistry, climate and habitability. Work presented here illustrates initial development and testing of the OU's new retrieval algorithm for determining $O_3$ and aerosol concentrations from the UVIS instrument.

## 1. Introduction

UVIS is part of the NOMAD instrument suite [1, 2] on board the joint ESA–Roscosmos ExoMars mission orbiting Mars, and is an UV / visible imaging spectrometer operating in nadir and solar occultation modes between 200–650 nm, with <2 nm spectral resolution. The main objectives of UVIS are to improve the $O_3$ climatology and deliver information on the aerosol content and variability of the martian atmosphere. $O_3$ is a highly reactive gas in the martian atmosphere, and through assimilation of $O_3$ measurements made by UVIS into martian chemical transport models, understanding of martian atmospheric chemistry is set to be greatly improved.

## 2. Retrieval model

The back-scattered signal sensed by UVIS is composed of solar light scattered by surface and atmospheric constituents of Mars, with absorbing signatures of trace gases imprinted on this signal. The simultaneous contribution of these factors in varying quantities make the separation of each scattering and absorbing component (e.g. aerosols and trace gases) a complex procedure. To estimate atmospheric quantities of components contributing to sensed radiation in this manner, the NEMESIS radiative transfer model [3] is employed in an iterative least squares fitting procedure to simulate martian atmospheric radiances and provide a best-fit against UVIS observed values. Modelled radiances take into account the instrument's viewing geometry, together with *apriori* profiles of atmospheric parameters.

Using this method, the new OU optimal estimation $O_3$ retrieval is being developed for application to data from the UVIS instrument. In addition to nadir soundings of the martian atmosphere, the retrieval will be applied to solar occultations with the instrument looking at the Sun through the atmosphere perpendicular to the martian surface, presenting an opportunity for novel insights into atmospheric chemistry, and therefore of particular interest to the modelling community.

## 3. Development results

NEMESIS was originally developed for simulation of radiances in the near infra-red, and requires further work, presented here, to allow operation in the UV. Initial development and validation of the retrieval will be illustrated, using several experimental atmospheric scenarios for upper bounds of the retrieval's intended operating range, incorporating a variety of atmospheric chemical and aerosol loads. For proof of concept whilst awaiting operational UVIS L1B data, we also apply the retrieval to SPICAM data from the

Mars Express instrument to derive $O_3$ concentrations spatially and temporally. These data will then be applied to an inter-comparison against existing martian $O_3$ and aerosol retrievals, as well as model fields from OU colleagues.

## 4. Future work

The OU retrieval will be extended to simulate UV multiple scattering in the martian atmosphere, offering the ability to retrieve limb occultation soundings and better characterise the aerosol load to significantly improve estimates of martian $O_3$ and other trace gases. In further work the retrieval model will be coupled to data from the Mars Climate Database, providing an improved *apriori* for the retrieval.


## Acknowledgements

The authors gratefully acknowledge the support of the UK Space Agency and the Science and Technology Funding Council.


## References


[1] M.R. Patel et al. "NOMAD spectrometer on the ExoMars trace gas orbiter mission: part 2—design, manufacturing, and testing of the ultraviolet and visible channel". In: *Appl. Opt.* 56.10 (2017), pp. 2771–2782. DOI: 10.1364/AO.56.002771.

[2] A.C. Vandaele et al. "Science objectives and performances of NOMAD, a spectrometer suite for the ExoMars TGO mission". In: *Planetary and Space Science* 119 (2015), pp. 233–249. DOI: 10.1016/j.pss.2015.10.003.

[3] P.G.J. Irwin et al. "The NEMESIS planetary atmosphere radiative transfer and retrieval tool". In: *Journal of Quantitative Spectroscopy and Radiative Transfer* 109.6 (2008), pp. 1136–1150. DOI: 10.1016/j.jqsrt.2007.11.006.