



**HAL**  
open science

## Ozone in the Martian atmosphere observed by TGO/NOMAD-UVIS solar occultations

Arianna Piccialli, Ann Carine Vandaele, Yannick Willame, Anni Määttänen,  
Loïc Trompet, Justin Erwin, Frank Daerden, Lori Neary, Shohei Aoki,  
Sébastien Viscardy, et al.

### ► To cite this version:

Arianna Piccialli, Ann Carine Vandaele, Yannick Willame, Anni Määttänen, Loïc Trompet, et al.. Ozone in the Martian atmosphere observed by TGO/NOMAD-UVIS solar occultations. 16th Europlanet Science Congress 2022, Sep 2022, Granada, Spain, Spain. pp.EPSC2022-1027, 10.5194/epsc2022-1027 . insu-04292299

**HAL Id: insu-04292299**

**<https://insu.hal.science/insu-04292299v1>**

Submitted on 17 Nov 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Europlanet Science Congress 2022  
Palacio de Congresos de Granada, Spain  
18 September – 23 September 2022

EPSC Abstracts

Vol. 16, EPSC2022-1027, 2022

<https://doi.org/10.5194/epsc2022-1027>

Europlanet Science Congress 2022

© Author(s) 2022. This work is distributed under  
the Creative Commons Attribution 4.0 License.



# Ozone in the Martian atmosphere observed by TGO/NOMAD-UVIS solar occultations

Arianna Piccialli et al.

**Introduction:** The NOMAD-UVIS instrument on board the ExoMars Trace Gas Orbiter has been investigating the Martian atmosphere with the occultation technique since April 2018 [1]. In the solar occultation mode, it is mainly devoted to studying the climatology of ozone and aerosols content [2,3,4].

We analyzed almost two Mars Years of ozone vertical distributions acquired at the day-night terminator, corresponding to more than 8300 solar occultations, acquired between April 2018 (MY 34,  $L_S=163^\circ$ ) and November 2021 (MY 36,  $L_S=132^\circ$ ).

**Retrieval method(s):** As in the work of [5], the NOMAD-UVIS ozone retrievals proved more difficult than expected due to the presence of spurious detections of ozone caused by instrumental effects, high dust content, and very low values of ozone. This led us to compare the results from three different retrieval approaches:

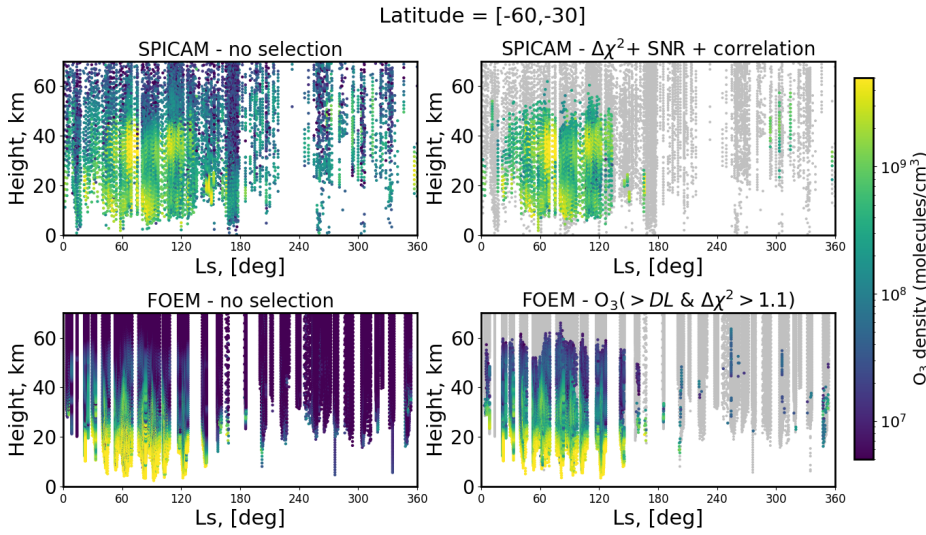
- an onion peeling method (OP);
- a full occultation Optimal Estimation Method (FOEM), and
- a direct onion peeling method (DOP).

The OP method is similar to that used for Mars and Venus stellar occultations [6,7]. The FOEM and DOP approaches are based on ASIMUT-ALVL, the BIRA-IASB radiative code [8,9].

The main challenge was to find reliable criteria to exclude spurious detections of  $O_3$ , and we finally adopted two criteria for filtering: i) a detection limit, and ii) the  $\Delta\chi^2$  criterion. Both criteria exclude spurious  $O_3$  values especially near the perihelion, where based on the simulations from a general circulation model, we do expect very low values of ozone.

## Comparison of filtering methods between UVIS and SPICAM:

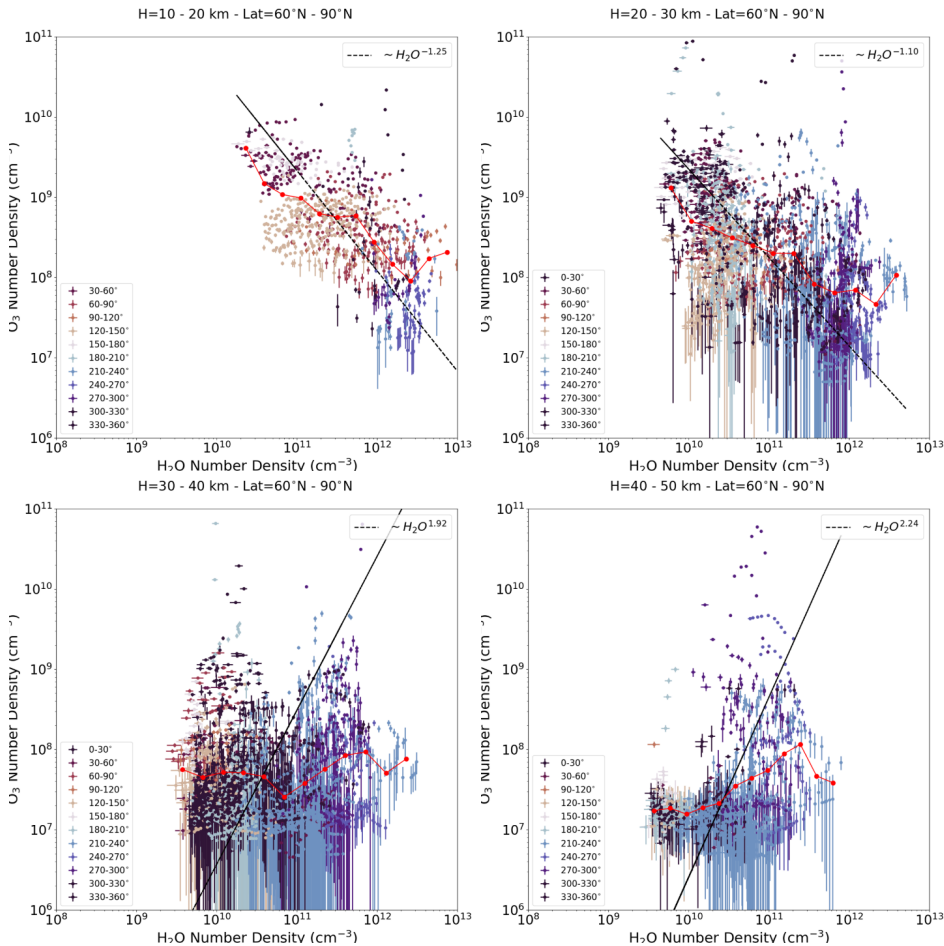
We compared the results of filtering with SPICAM-UVIS observations. The SPICAM team applied very similar criteria for filtering their data to the ones implemented here [5]. Even if the two instruments observed during different Martian Years, the agreement on the filtered  $O_3$  retrievals is very good, and both filtering approaches lead to very similar results (see **Figure 1**).



**Figure 1:** An example of the effect of the selection criteria for SPICAM-UV and NOMAD-UVIS observations for a latitude band (-60°;-30°). Left panels show the ozone vertical distribution before applying the filtering; right panels shows O<sub>3</sub> profiles after the selection criteria.

**The O<sub>3</sub>-H<sub>2</sub>O relationship:** Water vapor was observed by the infrared channel of the NOMAD SO. The results from a first analysis can be found in [10], while an extended dataset is presented in a companion abstract [11]. Water vapor and ozone are measured simultaneously, which allows us to investigate the water-ozone correlation, the key to addressing the atmospheric chemistry on Mars.

We present correlation plots of O<sub>3</sub> vs. H<sub>2</sub>O at high latitudes (60°-90°, both hemispheres), and at the equator (30°S-30°N). It is important to notice that during a solar occultation experiment at the terminator, ozone may exhibit rapid changes due to photolysis that are uncorrelated to water vapor. As an example, we show the 60°N-90°N latitude region (**Figure 2**): a clear anti-correlation is observed at lower altitudes, up to 40 km. O<sub>3</sub> is roughly proportional to (H<sub>2</sub>O)<sup>-1.0</sup> up to 30 km and a variation with L<sub>s</sub> seems also present.



**Figure 2:** O<sub>3</sub> (cm<sup>-3</sup>) vs. H<sub>2</sub>O (cm<sup>-3</sup>) vertical profiles measured simultaneously by NOMAD-UVIS at high latitudes in the Northern

hemisphere (60°N-90°N). (a) 10 – 20 km; (b) 20 – 30 km; (c) 30 – 40 km; (d) 40 – 50 km. Colours indicate the Ls interval. The black line shows the function  $O_3 = H_2O^x$ , with x varying with the altitude range.

**Impact of gradients at the Martian terminator:** Rapid variations in species concentration at the terminator have the potential to cause asymmetries in the species distributions along the line of sight (LOS) of a solar occultation experiment. Ozone, in particular, displays steep gradients across the terminator of Mars due to photolysis [12]. Nowadays, most of the retrieval algorithms for solar and stellar occultations rely on the assumption of a spherically symmetrical atmosphere. However, photochemically induced variations near sunrise/sunset conditions need to be taken into account in the retrieval process in order to prevent inaccuracies.

We investigated the impact of gradients along the LOS for the retrieval of ozone under sunrise/sunset conditions. We used the diurnal variations in the ozone concentration obtained from photochemical model calculations together with an adapted radiative transfer code.

**References:** [1] Vandaele et al. (2015), *PSS*. [2] Patel et al. (2021), *JGR (Planets)*. [3] Khayat et al. (2021), *JGR (Planets)*. [4] Neefs, E., et al. (2015) *Applied Optics*. [5] Määttänen et al. *Icarus*, in review. [6] Quémerais et al. (2006), *JGR (Planets)*. [7] Piccialli et al. (2015), *PSS*. [8] Vandaele et al., (2008), *JGR (Planets)*. [9] Piccialli et al. (2021), *Icarus*. [10] Aoki et al. (2019), *JGR (Planets)*. [11] Aoki et al., (2021) *EPSC*. [12] Lefèvre, et al. (2008), *Nature*.

**How to cite:** Piccialli, A., Vandaele, A. C., Willame, Y., Määttänen, A., Trompet, L., Erwin, J., Daerden, F., Neary, L., Aoki, S., Viscardy, S., Thomas, I., Depiesse, C., Ristic, B., Mason, J., Patel, M., Wolff, M., Khayat, A., Bellucci, G., and Lopez-Moreno, J. J.: Ozone in the Martian atmosphere observed by TGO/NOMAD-UVIS solar occultations, Europlanet Science Congress 2022, Granada, Spain, 18–23 Sep 2022, EPSC2022-1027, <https://doi.org/10.5194/epsc2022-1027>, 2022.



## Discussion

Discussion on Slack