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HCl Variability in the Martian Atmosphere observed with ExoMars-TGO/NOMAD during 6 years of Solar Occultations

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NOMAD [1] (Nadir and Occultation for MArs Discovery) is a multi-channel spectrometer onboard the ExoMars 2016 Trace Gas Orbiter (TGO), which began its observations in April 2018. Among other two (LNO and UVIS), the Solar Occultation (SO) channel covers the infrared (IR) spectrum from 2.3 to 4.3 μm (2320 to 4350 cm^{-1}). Composed of an echelle grating in Litrow configuration, a total of 6 diffraction orders (with a typical width from 20 to 35 cm^{-1}) are selected during each solar occultation using an Acousto-Optical Tunable Filter (AOTF) with a sample rate of about ~1 s, allowing a vertical resolution of typically 1 km. The high spectral resolution ($\lambda/\Delta\lambda$ ~17000) and the relatively low signal to noise ratio of this instrument (~2500) make NOMAD SO suitable for the detection of hydrogen chloride HCl. This trace species, although until now considered to be a negligible compound in the Martian atmosphere [2, 3], it has been detected systematically by two instruments onboard TGO: the Atmospheric Chemistry Suite (ACS) [4] and more recently NOMAD [5]. Several works suggest the surface of Mars to be a source of chloride minerals and perchlorate salts [6], which along with interactions surface-atmosphere could allow for chlorine photochemistry happening on the martian atmosphere. On Earth, one of the main sources of HCl is the volcanic activity [7], so the detection of this species on Mars may be an indicator of active geological processes. Multiple ongoing studies are trying to characterize the climatology of HCl on Mars, currently not completely understood, looking for possible relationships between temperature and other atmospheric species such as dust or water vapor.

At the IAA we have carried out a study with the objective of identifying not only sources but seasonal variability of HCl by analyzing NOMAD spectra. This early study [8] using a simplified processing pipeline allowed us to detect HCl during the perihelion season of MYs 34 and 35, confirming previous results from [5]. Here, as a follow-up work of that study, we applied a modified

version of our IAA-CSIC NOMAD processing pipeline [9-12] in order to increase the sensitivity required for the detection of weak HCl absorption lines, we have analyzed a total of 2536 solar occultations measured during Martian Years 34, 35 and 36. Among those modifications, we improved the methodology used for the characterization of the spectral continuum, now being able to detect systematic oscillations with amplitudes similar to the measurement noise (10^{-4} in transmittance). We have performed retrievals using NOMAD spectra from diffraction orders 129 (2899 - 2922 cm^{-1}) and 130 (2921 - 2945 cm^{-1}). In order to obtain robust HCl detections, we used the spectra from three detector bins on each ocucltation, retrieving an independent vertical profile form each bin. We present HCl vertical profiles and the seasonal variability of this species from a climatological view, revealing possible links with water vapor and dust.

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References

1. Vandaele, A. C. (2018). *Space Science Reviews*, 214, 1-47.
2. Hartogh, P. (2010). *Astronomy & Astrophysics*, 521, L49.
3. Villanueva, G. L. (2013). *Icarus*, 223(1), 11-27.
4. Korablev, O. (2021) . *Science Advances* 7, eabe4386.
5. Aoki, S. (2021). *Geophysical Research Letters* 48, e2021GL092506.
6. Glavin, D. P. (2013). *Journal of Geophysical Research: Planets* 118, 1955–1973.
7. Graedel, T. (1995) . *Global Biogeochemical Cycles* 9, 47–77.
8. Belmote-Gimenez, A. (2023) *Mater Thesis, University of Granada*.