TOWARD CO_2 SURFACE ICE PROPERTIES OF MARTIAN TERRAINS WITH THE NOMAD/LNO CHANNEL DATA. G. Cruz Mermy[1], F. Schmidt[1], F. Daerden[2], I. R. Thomas[2], B. Ristic[2], S. Robert[2], M. R. Patel[3], G. Bellucci[4], F. Altieri[4], J.-J. Lopez-Moreno[5], A. C. Vandaele[2] and the NOMAD Team.
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The surface of Mars is a place of constant interactions between CO_2, water and dust cycles. Thus, the characterization of the physical properties of the icy deposits allow to effectively constrain the climate history of the CO_2 ice condensation / sublimation, water and dust impurities. Here we propose to investigate the surface properties such as the ice thickness, compactness, volume proportion and size of the impurities of the Martian terrains in the IR using data of the NOMAD/LNO channel.

Introduction: Previous study of the Martian terrains showed that condensation and sublimation of CO_2 are part of the current major Martian climatic cycle leading to seasonal deposits. A theoretical model [1] proposes a link between the physical properties of the CO_2 ice and the seasonal activity such as cold jets and 'spiders'. However, no jet has been observed in activity and the physical properties of the ice have not been fully investigated, such as the role of the impurities on the geyser mechanism and their potential link to other morphological evidence (gullies, dark flow activities…). The NOMAD LNO [2] channel on board ESA TGO spacecraft is able to cover the IR spectral range (2.3 – 3.8 µm) with a high spectral resolution of about 0.3 nm and an instantaneous footprint of 8.5 km^2 in nadir mode. Initially designed to derive trace gas abundance in the atmosphere at various local times, it is suited for a precise determination of the microphysical state of the ice trough space and time, including local time variability.

Dataset: The LNO spectrometer uses an AOTF crystal to select diffraction order to be measured. This work will focus on particular orders, where CO_2 ice displays strong absorption features, such as order 158 covering the 2.88-2.90 µm spectral range. Despite the low inclination angle of TGO's orbit, the spacecraft flew over the southern hemisphere where seasonal deposits were identified.

Method: Our team has recently developed a radiative transfer model for compact ice [3] able to estimate the ice thickness, its compactness and the characteristics of the impurities (composition, quantity, grain size, roughness) that was validated on laboratory measurements [4]. We have also developed a rapid method of data inversion / assimilation, particularly suited to massive remote sensing data [5] and showed that this approach is valid for Mars. A first study showed that the CO_2 ice is in translucent state in the Richardson crater [5] using CRISM hyperspectral images. To properly investigate surface ice properties with the LNO data, we first have to perform the radiometric calibration to establish the radiance of the spectra recorded. Then, the absorption features from the atmosphere have to be corrected. Finally, the radiative transfer model will be used to retrieve surface properties, as shown in Figure 1.

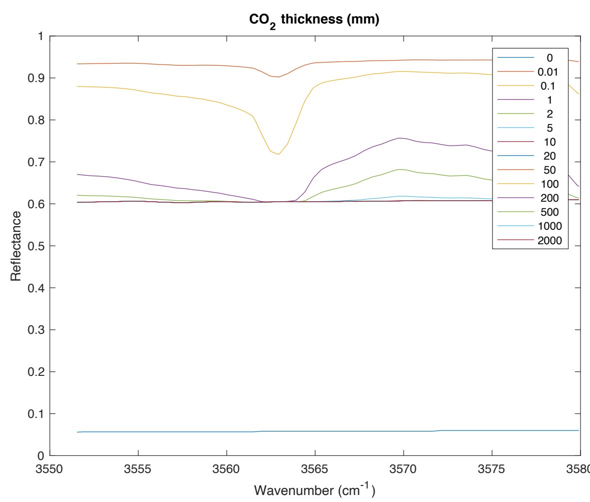

Figure 1: Top: Synthetic spectrum variation related to the evolution of the CO_2 ice thickness for the diffraction order 158.

Radiometric Calibration: Before going toward a spectral inversion of the NOMAD data, we need to properly estimate the conversion factor between the dimensionless Digital Number (ADU) measured by the detector and the expected radiance (in $W.m^{-2}.cm^{-1}.sr^{-1}$). To do so, one way is to use observation of the sun by the LNO and to compare those observations with a simulation under the same condition. The shape of the AOTF transfer function and the grating blaze function has to be accurate to ensure a proper radiometric calibration. We propose such calibration using three solar fullscan (every diffraction order is measured multiple time during a sun observation) that combines simulation and signal processing to properly model the LNO responsivity as shown figure 2.

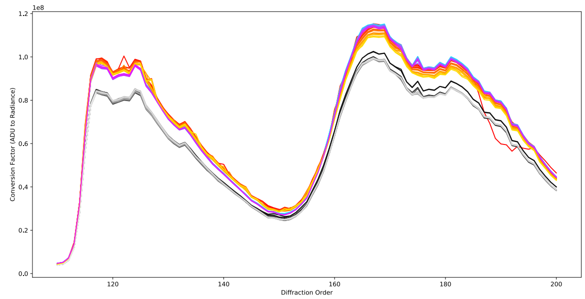

Figure 2: Conversion factor from ADU to radiance estimated using three solar fullscan (2018/07/02, 2018/11/01 and 2019/03/14) of the LNO Channel. The color-code refers to each fullscan while the color variation refers to each sequence within a solar fullscan.

Results show that the calibration factor is quite stable within 20% margin but this empirical calibration method is limited because the AOTF transfer function and the grating Blaze Function are temperature dependent.

Perspectives: This study will be done at high spectral resolution allowing deciphering of complex mixture effects [6]. We also plan to produce new maps of spatial and temporal evolution of ice microphysics on Mars.

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