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Mars dust properties by means of TGO/NOMAD UVIS and LNO channels nadir data analysis

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Abstract
Here we analyse nadir data from both the UVIS and LNO channels of the NOMAD spectrometer [1], onboard ExoMars/TGO, to obtain information about Martian dust densities and grains sizes. The combined dataset is analyzed with the MITRA radiative transfer tool [2,3,4]. The method is validated on a NOMAD orbit registered during the 2018 global dust storm to assess its most critical issues and is currently being extended to the whole available spatially and temporally coincident UVIS and LNO nadir data.

Introduction

The investigation of the presence and distribution of trace gases on Mars is fundamental to understand the atmosphere past evolution and provides insights on the research of biotic activities. Recent studies focused on the 2018 global-scale dust event as observed from the TGO instruments demonstrate that Martian dust can affect the abundance and distribution of atmospheric trace gases [5,6,15], making it a driver for their evolution. Suspended dust on Mars drives the planet’s thermal structure and climate [7], heating the lower atmosphere through absorption in the VIS-NIR spectral range [8] and efficiently radiating heat to space through IR emission [9,10,8,11]. These heating and cooling mechanisms affect the water-ice clouds formation, strengthen the mean meridional circulation and can drive deep localized convection, leading to variations and redistributions of water vapour abundances [6,15]. For the above reasons, the understanding of dust properties is mandatory in order to correctly investigate the vertical distribution of Martian trace gases.

Observations

The NOMAD spectrometer operates with three channels in the ultraviolet/visible spectral range (UVIS channel) and in the infrared (LNO and SO channels) in nadir, limb and solar occultation geometries. Although the instrument has been mainly conceived to study the trace gases in the atmosphere of the red planet, it can also provide valuable information regarding the properties of Martian dust. In this regard, in this work we use the UVIS and LNO channels nadir data to construct a dataset of spatially and temporally coincident data to study the microphysical properties of Martian dust.

Method

The UVIS spectral range alone (0.20–0.65 µm) does not allow to disentangle with high precision the information related to the dust density from that of dust grains sizes. The use of both the ultraviolet/visible and infrared ranges together is mandatory in order to obtain these properties. Indeed, we show that while the order of magnitude of the dust optical depth can be inferred from the UVIS data alone, dust grains sizes can be retrieved only by studying how the observed spectra bend between visual and near infrared wavelengths. For the purpose of the analysis presented here we use only LNO orders covering the wavelength range 2.20-2.65 µm, which is approximately free from gaseous absorption and, hence, it is suitable to investigate dust properties. We use the MITRA radiative transfer model and inversion algorithm to retrieve dust densities and grain sizes. We take the temperature-pressure profiles from the Mars Climate Database (MCD, [12]) and use the dust optical constants from [13]. The procedure followed to derive the surface albedo spectra, needed in the forward model, is based on the SAS method [14] applied to the OMEGA dataset. For this reason, we use UVIS data only down to 0.4 µm to avoid extrapolating the information of the surface albedo at wavelengths shorter than OMEGA lower spectral limit. This method is tested and validated on a NOMAD observation acquired on the 8th of June 2018 during a global dust storm and is now being extended to all spatially and temporally coincident observations of UVIS and LNO channels. If no coincident LNO observations are available for a certain UVIS orbit, we apply the MITRA tool to the UVIS spectral range alone to obtain the dust integrated optical depth.

Summary

The presented method allows to study the properties of Martian dust obtaining information on grains densities and sizes whenever temporally and spatially coincident UVIS and LNO observations are available. When this is not possible, the analysis is performed on the UVIS data alone to obtain the dust integrated optical depth. Through the application of this method to the whole NOMAD dataset we aim to produce a set of dust properties associated to each observation with a precision that is only achievable by exploiting the combined UVIS and LNO spectral ranges.

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