Aerosol nadir retrieval from NOMAD/UVIS on board Exomars TGO

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Introduction:

Aerosols are key components of Martian radiative transfer. Airborne dust is ubiquitous on the planet and influences the climate by absorbing shortwave radiation, resulting in a local warming of the atmosphere. Dust loading follow a cycle where it is present in lower concentration during the "cooler" aphelion season, and shows a repeatable pattern from year to year [Smith 2009]. While for the second part of the year, i.e. during the "warmer" perihelion season, the dust loading is larger. The warmer temperatures favor the formation of many local dust storms, some of can grow to a regional scale or even become global. The period L_S = 200-300° is sometimes called the "dust storm season" and the formation of these storms can arise differently each year, introducing an important interannual variability [Smith 2008].

Ice clouds are related to the water cycle. They form due to adiabatic cooling of upward where the water vapor condenses on dust particles where the temperature is low enough. These clouds can be observed having several forms, such as: 1) the cloud belt forming during "cooler" aphelion around the equator [Smith 2004, 2009], responsible for the asymmetry in the water vapor transport from one hemisphere to the other [Clancy et al., 1996]; 2) the polar hoods that appears above the polar regions during the winter [Benson et al., 2010, 2011]; 3) and the orographic clouds that are present above tallest volcanoes for a large part of the year often [Benson et al., 2003, 2006].

The UVIS instrument and data:

The NOMAD ("Nadir and Occultation for MArs Discovery") spectrometer suite on board the ExoMars Trace Gas Orbiter (TGO) has been designed to investigate the composition of Mars' atmosphere using a suite of three spectrometers operating in the UV-visible and infrared. NOMAD is a spectrometer operating in ultraviolet, visible and infrared (near-IR) wavelengths covering large parts of the 0.2-4.3 µm spectral range [Vandaele et al., 2018].

The UV-visible "UVIS" instrument covers the spectral range from 200 to 650 nm and can perform solar occultation, nadir and limb observations [Patel et al., 2017]. The main purpose of UVIS is dedicated to the analysis and monitoring of ozone, dust and ice clouds.

In the present work, we have used the radiometrically calibrated data [Willame et al., 2022], including a step for straylight removal [Mason et al., 2022]. UVIS ultraviolet measurements suffer from a significant NIR contamination.

Methodology:

Nadir UV measurements are useful to study these dust and ice clouds, and allow one to derive climatologies to analyze their cycles (annual, diurnal). We have used a similar methodology as in [Willame et al., 2017] to simultaneously retrieve the dust and ice cloud optical depth (OD), ozone and surface reflectance from UVIS nadir measurements between 220 and 320 nm. The present work focuses on the results of the aerosol retrieval. We use the LIDORT radiative transfer code [Spurr et al., 2001, 2017] with the aerosol properties from [Wolff et al., 2009, 2010] for dust and from [Wolff et al 2010, 2019] for ice clouds.

Ice clouds are very bright and reflective in the UV, especially compared to dust and surface, both of which are quite absorbing. However, it is not always an easy task to disentangle the three respective contributions due to a lack of diagnostic spectra. The presence of a relatively thick cloud, overlying dust, generally produces a large increase of the UV signal and can be easily retrieved from wavelengths around 300-320 nm, where the impact of dust is weak. However, an increase of the surface reflectance can produces a similar effect to that of a cloud, making these two parameters often not independent, and thus not fitted simultaneously. The contribution from an ice surface is large and, as a result, we do not retrieve ice clouds when such a surface is possibly present (predicted by GEM-GCM [Daerden et al., 2019; Neary & Daerden., 2018]). The surface ice albedo is fitted as Lambertian in that case. The contribution from regolith surface is significantly smaller and the choice of fitting ice cloud OD or surface reflectance depends on whether a cloud is obviously present: if a cloud is present, cloud OD is fitted and the surface albedo is kept fixed, else the surface reflectance is fitted using the Hapke formalism [Hapke 2005]. The sensitivity to dust is maximized around 220-230 nm, outside of the Ozone Hartley absorption (maximum around 255 nm).

Preliminary results:

In the present work, we will present preliminary results of UV retrievals from the nadir geometry observations. We will present and discuss spatial and seasonal distribution of ice clouds and dust.

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