One year of observations of dust and water ice aerosols performed by ACS TIRVIM and NIR

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EPSC Abstracts
Vol. 13, EPSC-DPS2019-1316-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

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1. Introduction

Aerosols play a big role in the atmospheric circulation, thermal structure, and climate of Mars [1, 2]. Dust particles cause changes in atmospheric dynamics and inflation of the atmosphere through the solar heating of the atmosphere [1]. Water ice particles play fundamental role in photochemistry and transport of volatiles on Mars [1, 3]. Knowledge of the spatial and temporal distribution of dust and water ice aerosols is highly important for better understanding of dust and water cycles on Mars.

The ExoMars Trace Gas Orbiter (TGO) is a joint ESA-Roscosmos mission to Mars. It began orbiting Mars in October 2016 and started its observations in April 2018, just before the beginning of the 2018 global dust storm at the beginning of June (solar longitude Ls ≈ 189°). The main target of TGO is measurements of vertical structure of the Martian atmosphere by solar occultation method on morning and evening terminators. In this work, we will present analysis of retrieved dust and water ice aerosol properties from ACS TIRVIM and ACS NIR simultaneous observations during the first year on the orbit of Mars.

2. Instrument description

The Atmospheric Chemistry Suite (ACS) is a set of three infrared spectrometers (NIR, MIR, and TIRVIM) featuring high accuracy, high resolving power and a broad spectral coverage (0.7–17 μm) [4].

2.1. TIRVIM

TIRVIM is a Fourier-transform spectrometer capable of operation in nadir and solar occultation modes. In occultations, TIRVIM is operated mostly in 'climatology' mode, covering the full spectral range of 1.7–17 μm every 0.4 s with spectral resolution ⩽1 cm^{-1} [5]. Aerosol properties from TIRVIM solar occultation data were retrieved from 19 wavelengths in the spectral range of 2−6 μm (1700-5000 cm^{-1}), chosen outside of strong-gas-absorption bands. To increase the signal-to-noise ratio, the spectra were averaged using the simple moving mean within a spectral window of 50 cm^{-1} centred at the chosen wavenumbers.

2.2 NIR

NIR is an echelle spectrometer, with selection of diffraction orders performed by an acousto-optical tuneable filter. It operates in nadir and solar occultation modes and covers the spectral range 0.7–1.7 μm. During an occultation, ACS NIR measures 10 preselected diffraction orders in two seconds, including the absorption bands of H_2O, CO, CO_2 and O_2. For the aerosol retrieval, diffraction orders centred at 0.76, 0.86, 0.99, 1.38, and 1.57 μm were used.

3. Method of analysis

The first step in retrieval procedure is calculation of aerosol transmission profile. For TIRVIM, it is straightforward and standard for all solar occultation experiments. The reference spectrum for an occultation I_0 is obtained when observing the Sun out of the atmosphere. Inside the atmosphere solar radiance I is attenuated by aerosols. Transmittances are obtained by dividing the spectra measured through the atmosphere by the reference spectrum recorded outside the atmosphere: $T_\nu = I_\nu/I_0$. For NIR, the spectra fitting and the aerosol transmission profile retrieval follow the method described for the SPICAM Mars Express 1.38-μm band [6, 7].

The second step, retrieval of the extinction vertical profiles is identical to the one used for SPICAM and

SPICAV solar occultations [8, 9]; that is by making use of the standard 'onion peeling' method.

The final step involved Mie modelling of the spectral dependence of the extinction coefficient, assuming known optical properties for the aerosol fits to the experimental data to retrieve vertical profiles of the size distribution and number density, as described in [9]. To distinguish between water ice and dust particles, we applied the optimal-estimation retrieval scheme independently for both types and made the decision based on the fit quality (Fig. 1 and Fig. 2).

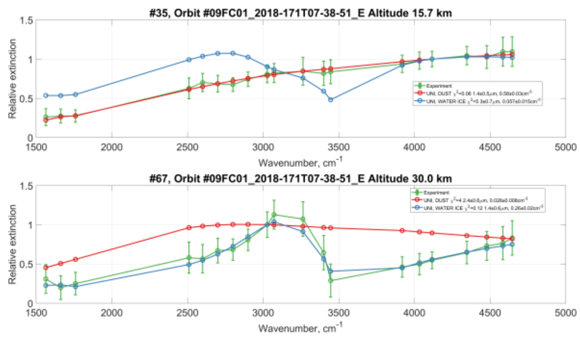

Fig. 1: Results of the fitting procedure. Measured normalized extinction (green line with error bars) and fitted results for water ice particles (blue) and dust particles (green) for orbit #9FC_E (20 June 2018).

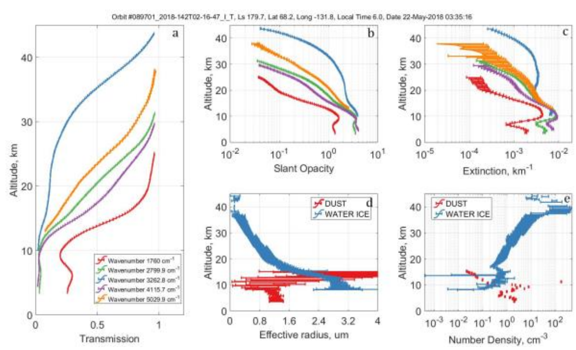

Fig. 2: Retrieved vertical profiles of transmission (a), slant opacity (b), and extinction coefficient (c), particle effective radius (d), and number density (e) from orbit #897_I (22 May 2018).

4. Summary and Conclusions

We present a method, allowing to distinguish between dust and water ice aerosols and to obtain their radius and number density vertical profiles from combined datasets of the TIRVIM and NIR channels of ACS.

In this work, we will present analysis of retrieved dust and water ice aerosol properties from the first year of observations on the orbit of Mars.

Acknowledgements

ExoMars is the space mission of ESA and Roscosmos. The ACS experiment is led by IKI Space Research Institute in Moscow. The project acknowledges funding by Roscosmos and CNES. Science operations of ACS are funded by Roscosmos and ESA. M. Luginin acknowledges the support from the Ministry of Science and Higher Education of the Russian Federation, grant №14.W03.31.0017.

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