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The behaviour of water vapour in the middle atmosphere at the dusty season on Mars with ACS/TGO

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Abstract

The water vapour vertical distribution is a capable gauge for the relative roles of the various sources, sinks and processes that control the Martian water cycle. However, its behaviour is still poorly studied. Since 2018 the ExoMars 2016 Trace Gas Orbiter allows to measure the vertical water distribution with high accuracy and excellent coverage [1]. Here we present results of the Atmospheric Chemistry Suite (ACS) instrument NIR channel for the first year of TGO observations covering the dusty season from Ls 160° to Ls 360° of the Martian year 34. During the global and regional dust storms, which happened during the MY34 water vapour profiles have shown an extremely dynamic behaviour, sharply departing from model predictions.

1.Introduction

While the water vapor horizontal and seasonal variability has been extensively explored by nadir-observing instruments, which sense the vertically integrated columns of water vapor, its vertical distribution has only been monitored by one instrument, SPICAM onboard the Mars Express mission, supplying information to characterize the missing dimension needed for a three-dimensional understanding of water seasonal cycle [2-3]. Unfortunately, the Mars Express occultations are limited in season/location, and the profiling accuracy of SPICAM is perfectible. The vertical distribution of water and its behavior in the middle atmosphere, its interannual and seasonal variability is still poorly understood.

Recent findings proved that water vertical distribution plays a major role in the hydrogen escape processes on Mars and the water loss from the atmosphere [4, 5]. Contrarily to our previous understanding, it has been discovered that water molecules reaching altitudes of 80 km in the perihelion season on Mars can be a direct source of escaping hydrogen [1-3].

2.Observations

The Atmospheric Chemistry Suite (ACS) began nominal science operations in March 2018 onboard the Trace Gas Orbiter (TGO) of the ExoMars mission [6]. ACS is a set of three spectrometers (NIR, MIR, and TIRVIM) intended to observe Mars atmosphere. The spectrometers can measure the vertical distribution of water vapour in different spectral bands providing wide coverage of altitudes.

The H_2O profile is best measured with the strong 2.6 μm band by MIR channel. MIR will be sensitive up to 100 km with the accuracy better than 1 ppm. However, measuring the 2.6 μm band with MIR requires a special secondary grating position, and these sensitive H_2O measurements can be implemented only during dedicated campaigns. Routine monitoring of water profiles is planned with the NIR channel in the 1.38 μm band with an accuracy better than 10 ppm at 100 km. Such measurements are performed in parallel with any other ACS channel.

The near-infrared channel (NIR) is a spectrometer operating in the range of 0.7–1.7 μm with a resolving power of $\lambda/\Delta\lambda \sim 25{,}000$. It is designed to operate in nadir and in solar occultation modes. The spectrometer employs an acousto-optic tuneable filter (AOTF) to select diffraction orders in an echelle spectrometer. During one measurement cycle it registers ten different diffraction orders, each corresponding to an instantaneous spectral range of 10-20 nm.

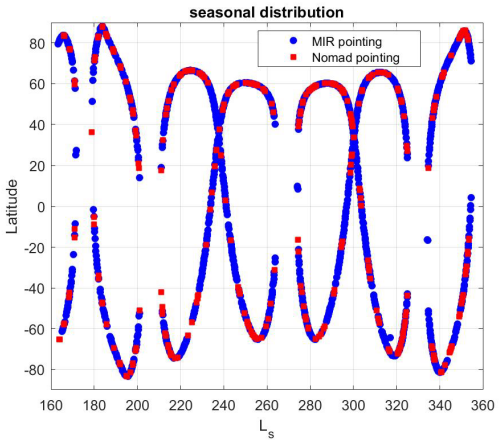

Figure 1. Seasonal and latitudinal coverage of NIR occultations for the first year of TGO observations.

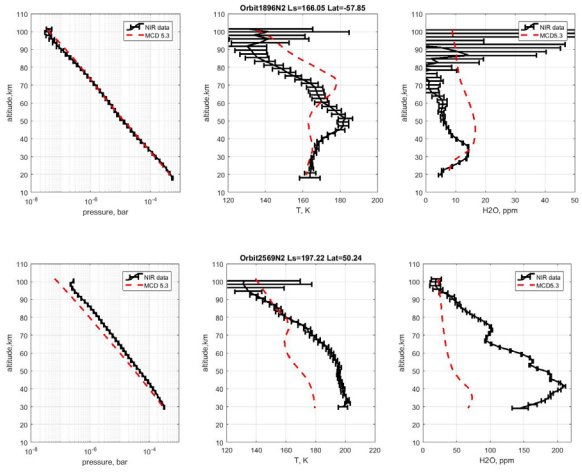

Figure 2. Examples of the NIR retrieval for temperature and water mixing ratio before (top) and after (bottom) the beginning of the global dust storm 2018 (MY34).

The NIR channel allows simultaneous measurements of the temperature and pressure profiles in the atmosphere using the 1.56 µm CO_2 band, and the water density in the 1.38 µm band. Such measurements allow retrieving the water mixing ratio profile with higher accuracy, free from a systematic bias introduced by model atmospheric profiles.

In this talk, we will describe the first year of observations of the vertical water distribution obtained by NIR channel spanning altitudes from 0 to 100 km. The second part of the Martian year 34 was marked by one global and one regional dust events. Simultaneous measurements of the water vapour mixing ratio, temperature and dust vertical distribution and formation of water ice clouds allow constraining the complex water behaviour during the dusty seasons with attempts to compare and understand it with modern general circulation model [7].

Acknowledgements

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