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Investigation of the 2018 Global Dust Event from ACS-TIRVIM on board ExoMars/TGO

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Abstract

We report on the analysis of thermal infrared emission spectra recorded by ACS-TIRVIM on board the ExoMars Trace Gas Orbiter (TGO). We focus on the period 13 March 2018 till 15 July 2018, covering quiescent and dusty conditions. From these observations, we retrieve temperature vertical profiles from 5 to 45 km as well as integrated dust and water ice opacity at various local times. The retrieved temperature profiles are in excellent agreement with co-located observations by Mars Climate Sounder, a limb-viewing radiometer onboard Mars Reconnaissance Orbiter. The global dust event resulted in an up to 40K temperature increase in the middle atmosphere. We will discuss these results compared to Global Climate Model (GCM) simulations run with MY34 dust scenario. We will also present and discuss the atmospheric state resulting from the assimilation of TIRVIM temperature profiles into the LMD Mars GCM.

1. Introduction

The ExoMars Trace Gas Orbiter (TGO), a mission by the European Space Agency (ESA) and Roscosmos, was launched in March 2016 and reached its final, near-circular 400 km orbit around Mars on 7 April 2018. On board TGO, the Atmospheric Chemistry Suite (ACS) is a set of three spectrometers including a thermal-infrared channel, TIRVIM. In nadir observing mode, this instrument aims at monitoring the Martian atmosphere (thermal structure and aerosol content) at various local times, latitudes and seasons. Here we report on 1) the analysis of TIRVIM observations acquired just before and during the MY34 global dust event and 2) the assimilation of the retrieved temperature vertical profiles into the LMD Mars Global Climate Model (GCM).

2. ACS-TIRVIM observations and analysis

TIRVIM is a Fourier-transform spectrometer covering the range 600-6000 cm^{-1} (1.7–17μm) with a spectral resolution of 1.2 cm^{-1} [4]. We focus here on nadir observations in the range 600-1300cm^{-1}, covering absorption by CO_2 (centered at 667 cm^{-1}), water ice clouds (~ 820 cm^{-1}) and dust (~ 1100 cm^{-1}). We have developed a radiative-transfer model coupled to a retrieval algorithm that exploits TIRVIM thermal emission spectra to simultaneously retrieve vertical profiles of the temperature from 5 to 45 km, surface temperature, and integrated optical depth of dust and water ice clouds [2]. This algorithm was tested and validated against synthetic observations generated under various conditions (local time, seasons, latitude, aerosol load, ...).

We have analysed TIRVIM data acquired between 13 March 2018 (MY34 L_s = 143) and 15 July 2018 (L_s = 211), which capture the onset and development of the MY34 global dust storm (GDS). The retrieved temperature profiles have been validated against thousands of co-located measurements acquired by the Mars Climate Sounder around 3am and 3pm, a limb-viewing radiometer onboard Mars Reconnaissance Orbiter [3]. The agreement between the two data sets is very satisfactory: temperature differences seldom exceed +/- 4K and mostly pertain to the difference in vertical resolution (about 10 km for TIRVIM, 5 km for MCS profiles).

The advantage of the TIRVIM data set over previous instruments comes from the TGO orbit, which is not sun-synchronous and was designed to sample a complete daily cycle every 55 days. From the available ~2-week observing period corresponding to a global-scale dust event (end of June till 15 July 2018), TIRVIM was sampling low to mid-latitudes at local times 4 to 8 AM and 4 to 8 PM. An example of temperature map derived from TIRVIM at 7PM is shown in Figure 2, compared to the 3PM temperature derived from MCS for the same dates: one can notice the more rapid cooling of the middle atmosphere at low latitudes compared to mid-latitudes. Comparison of these temperature fields to GCM simulations run with MY34 dust scenario is in progress. We shall also present analyses of the variations of integrated dust opacity, including diurnal variations.

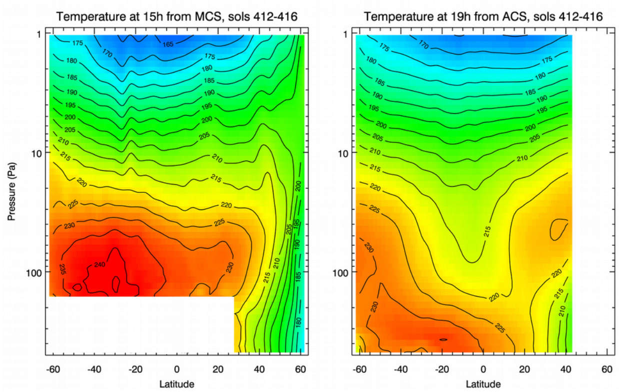

Figure 2: Latitude-pressure cross section of the temperature as retrieved from MCS at 3PM [3] (left panel) and from ACS-TIRVIM at 7PM (this work, right panel). Both temperature maps correspond to data acquired on 2-6th July, 2018 (Ls=204, MY34).

3. Data assimilation

We have developed a data assimilation scheme based on the LMD Mars GCM [1] and the Local Ensemble Transform Kalman Filter (LETKF) [5]. The LETKF is an ensemble-based assimilation scheme where we typically use 16 ensemble members and multiplicative inflation to adjust the background ensemble error covariance. First results of the assimilation of TIRVIM temperature profiles are encouraging: as seen in Figure 2, the analysis reproduces the ~40K temperature increase induced by the GDS in the middle atmosphere compared to a climatology scenario [6]. We shall report on the impact of the GDS on meridional circulation, which is revealed via assimilation. Current work is focused on combining assimilation of TIRVIM observations with MCS profiles, to sample the local time of day more fully.

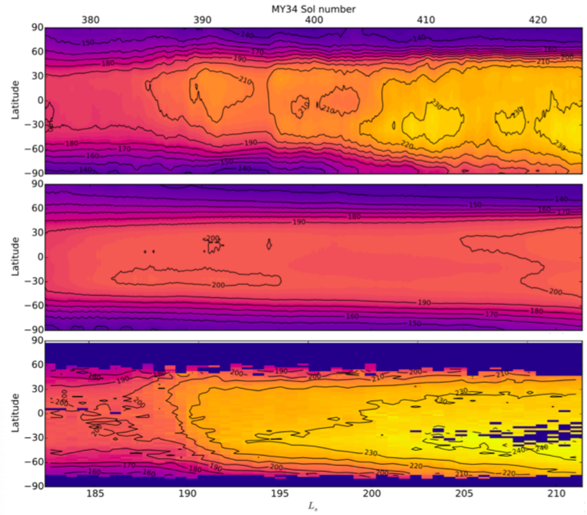

Figure 2: Temperature at 100Pa at 3PM before and during the MY34 GDS. Top: LETKF analysis. Middle: Free-running GCM using the Mars Climate Database 'climate' scenario. Bottom: MCS temperatures (not assimilated).

Acknowledgements

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References

[1] Forget, F. et al.:Improved general circulation models of the Martian atmosphere from the surface to above 80 km, JGR, Vol. 104, p. 24155-24175, 1999.

[2] Guerlet, S. et al., EGU General Assembly, 2019.

[3] Kleinbohl, A. et al.:Two-dimensional radiative transfer for the retrieval of limb emission measurements in the martian atmosphere, JQSRT, Vol. 187, p. 511-522.

[4] Korablev, O. et al.: The Atmospheric Chemistry Suite (ACS) of Three Spectrometers for the ExoMars 2016 Trace Gas Orbiter, SSR, Vol. 214, 2018.

[5] Navarro, T. et al.: The Challenge of Atmospheric Data Assimilation on Mars, ESS, Vol. 4, p. 690-722, 2017.

[6] Young, R.M.B. et al., EGU General Assembly, 2019.