ASSIMILATION OF OBSERVATIONS FROM ACS/TIRVIM ON BOARD EXOMARS TGO INTO THE LMD MARS GCM. R. M. B. Young[1], S. Guerlet[1], E. Millour[1], F. Forget[1], T. Navarro[1,2], L. Montabone[3], N. Ignatiev[4], A. Grigoriev[4], A. Shakun[4], A. Trokhimovskiy[4], F. Montmessin[5], and O. Korablev[4], [1]Laboratoire de Météorologie Dynamique (LMD/IPSL), Sorbonne Université, Centre National de la Recherche Scientifique, École Polytechnique, École Normale Supérieure, Paris, France (ryoung@lmd.jussieu.fr), [2]Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles, CA, USA, [3]Space Science Institute, Boulder, CO 80301, USA, [4]Space Research Institute (IKI), 84/32 Profsoyuznaya, 117997 Moscow, Russia, [5]LATMOS/IPSL, UVSQ Université Paris-Saclay, UPMC Univ. Paris 06, CNRS, Guyancourt, France.

Introduction: The ExoMars Trace Gas Orbiter (TGO), a collaborative project between the European Space Agency (ESA) and Roscosmos (Russia), was successfully inserted into Mars orbit on 19 October 2016, and reached its final 400km science orbit on 7 April 2018. TGO began taking observations as part of commissioning operations in March 2018. At the Laboratoire de Météorologie Dynamique (LMD) we are responsible for data assimilation of observations from the Atmospheric Chemistry Suite (ACS) thermal infrared channel (TIRVIM) on board TGO into the LMD Mars Global Climate Model (GCM) [1].

Observations: ACS/TIRVIM is a thermal infrared spectrometer with spectral range 1.7–17μm, whose main purpose is to continuously monitor the Martian environment in nadir in support of solar occultation measurements by ACS's near-infrared and mid-infrared channels [2]. ACS/TIRVIM measures radiance spectra from which can be retrieved vertical profiles of atmospheric temperature, as well as surface temperatures and vertically-integrated amounts of dust, water ice, and other aerosols, at various local times, latitudes and seasons.

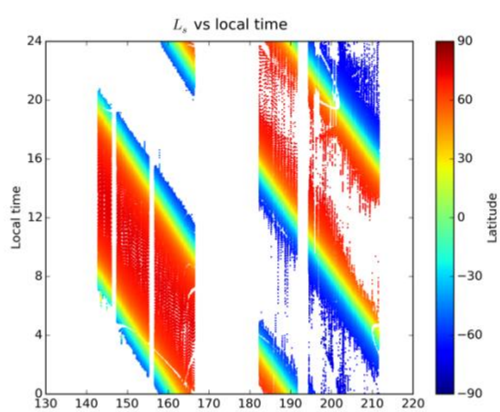

Figure 1: Available atmospheric temperature profiles retrieved from ACS/TIRVIM observations between 13 March and 15 July 2018, showing the local time of day and latitude for each profile.

This work focuses on atmospheric temperatures retrieved from nadir thermal emission spectra taken between 13 March 2018 (MY34 L_s = 142.88) and 15 July 2018 (MY34, L_s = 211.43). These have been calibrated and then retrieved using a line-by-line radiative transfer model [3]. The observations cover various local times of day with full coverage in longitude every 7-10 days, over +/- 75 degree latitude, with vertical coverage between 3-45 km altitude (Fig. 1). A first for Mars data assimilation is the systematic coverage of all local times of day over a 55 Martian day cycle, which has not been possible hitherto, but which TGO's orbit was designed for.

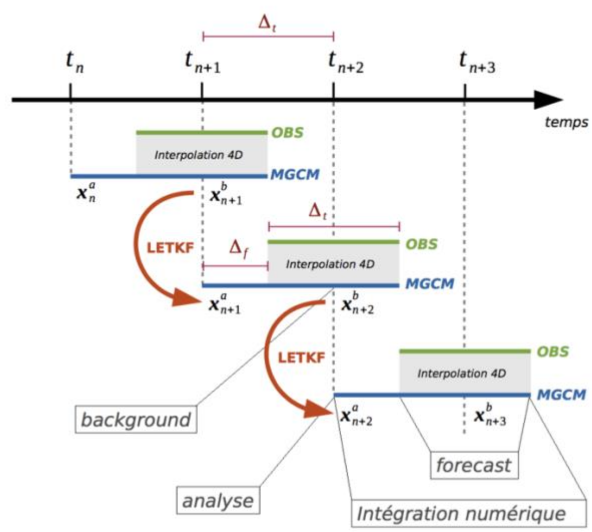

Figure 2: Schematic of the LMD Mars data assimilation cycle using the LETKF [4].

Model and assimilation: The LMD Mars GCM is a detailed model of Mars' atmosphere that includes representations of the dust cycle, water cycle, boundary layer, subsurface, aerosols, upper atmosphere, and other parametrizations relevant to the Martian environment [1].

The data assimilation scheme is based on the Local Ensemble Transform Kalman Filter (LETKF) [5, 6]. 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 (Fig. 2).

Assimilation of Martian atmospheric data provides a significant challenge for ensemble-based data assimilation schemes [6]. Not only are the observed quantities available to assimilate – temperature, dust, and water ice – strongly inter-dependent, but Mars' atmosphere is markedly less chaotic than the Earth's. This means the problem of filter divergence can be severe; at certain places and times of year the ensemble converges rather than diverges over time, and so model bias comes to dominate the background ensemble in a way that cannot be alleviated by synoptic variability; often the ensemble spread does not enclose new observations as they become available.

Results: We focus on the MY34 Global Dust Storm (GDS), which began in early June 2018. The GDS has a significant effect on the atmospheric state, particularly its thermal state (Fig. 3) and meridional circulation, which is revealed via assimilation. The diurnal and semi-diurnal tide are also strengthened.

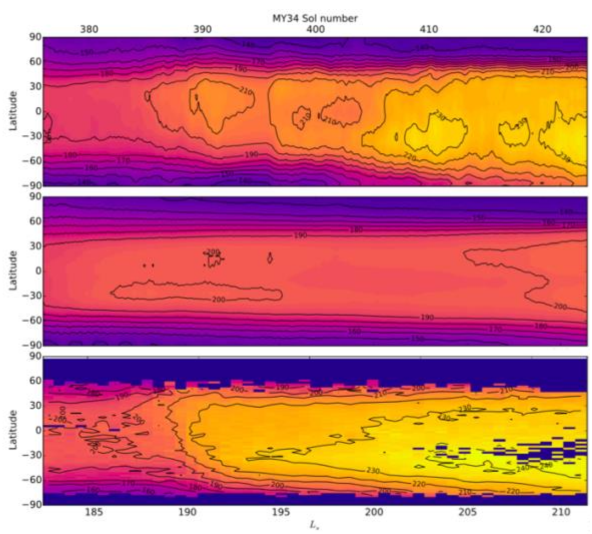

Figure 3: Temperature at 100Pa at 3PM local mean time before and during the MY34 GDS. Top: LETKF analysis. Middle: Free-running GCM using the Mars Climate Database 'climate' dust scenario (representative of a non-GDS year). Bottom: Mars Climate Sounder temperatures at the same time and place (not assimilated).

We shall report on the differences between the assimilation and a free-running model, particularly at local times of day that have not been observed prior to TGO.

We shall also report on progress combining assimilation of ACS observations with profiles from Mars Climate Sounder on board NASA's Mars Reconnaissance Orbiter, to fill in anticipated gaps in the ACS observational record and to sample the local time of day more fully.

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