EPSC Abstracts
Vol. 13, EPSC-DPS2019-636-1, 2019
EPSC-DPS Joint Meeting 2019

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

Thermosphere density inferred from the ExoMars Trace Gas Orbiter aerobraking campaign

S.L. Bruinsma (1), **J.C. Marty (1)**, I. Müller-Wodarg (2), H. Svedhem (3), P. Rosenblatt (4)
(1) CNES, Toulouse, France, (2) Imperial College, London, United Kingdom, (3) ESA/ESTEC, Noordwijk, Netherlands, (4) Laboratoire de Planétologie et Géodynamique, Université de Nantes, France, (jean-charles.marty@cnes.fr)

Abstract

The aerobraking phase of the ExoMars TGO spacecraft, from March 2017 to February 2018 (split into two phases by a solar conjunction), was used to reduce the orbital period from 24 hours to about 2 hours and an apocenter altitude of 1000 km. It was achieved by lowering the orbit perigee (at 3S and 7:30 LST at the beginning, drifting south) to approximately 105 km, reached in April 2017, and rotating the solar array to be almost perpendicular to the satellite speed vector during the deep dips in order to enhance the atmospheric drag effect. Accelerometer data of the aerobraking phase is processed to infer total densities and compared to models such as MarsGRAM and MCD.

1. Introduction

We processed the TGO aerobraking phase accelerometer data to infer total densities. ESA planned this campaign to lower the spacecraft naturally, i.e., to save fuel. The attitude quaternions are used to correctly orient the spacecraft bus and solar arrays in inertial space, which is necessary to accurately compute the exposed surface in the ram direction. The precise orbit computed by ESOC/Flight Dynamics was used to locate the measurements. The (engineering) accelerometers provide measurements with a good signal-to-noise ratio at low altitude, close to the pericenter. At that altitude, the other surface forces are negligible.

2. Methodology

At the beginning of the aerobraking phase, one acceleration profile per day is obtained, whereas up to 9 profiles per day can be obtained at the end of the phase. The calibrated accelerations, at low altitude essentially due to aerodynamic drag, are then used to infer total density using a model for satellite shape and the aerodynamic drag coefficient Cd. The uncertainty in the derived density is the sum of a systematic part due to the uncertainty in Cd, and a noise and bias (not completely resolved after calibration) part due to the accelerometers. The same methodology has been applied to VEX data [1].

3. Observed density

Density data was obtained for 287 out of the total of 347 days; not all days could be processed because of the solar conjunction, during which period the pericenter altitude was raised for spacecraft safety. The valid density profiles cover the altitude range 105 – 127 km. Higher altitudes lead to noisy and bad observations due to the low sensitivity of the accelerometer. Figure 1 presents this behavior of the measurements, compared to the predicted accelerations with the MarsGRAM 2005 model [2].

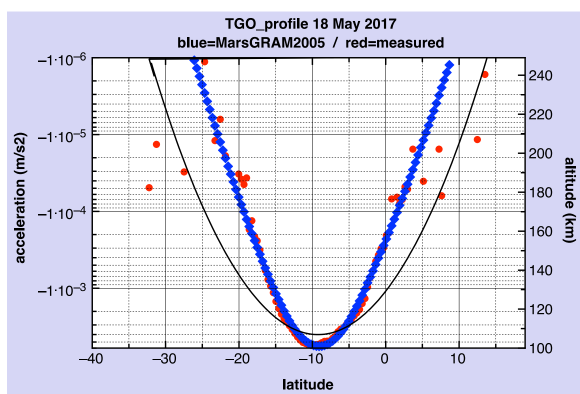

Figure 1: Observed and modeled accelerations vs altitude for 18 May 2017.

The observed density profiles are compared to model densities of MarsGRAM 2005 and MCD5.3 [3]. The bias and standard deviations of the density ratios (observation/model density) are computed per arc and for the entire aerobraking phase, and the day-to-day variability is also determined.

4. Summary and Conclusions

The density calculations, and notably the attitude of TGO in aerobraking mode, have been analysed. Comparisons to models such as MarsGRAM and MCD are made. The in-situ thermosphere density measurements will be used to infer the global structure and variability of the Martian upper atmosphere, including analyses of atmospheric waves. This will be done in a separate, joint presentation. In the Science Phase of the mission (circular orbit at 400 km), which started in April 2018, only daily-mean densities can be derived by means of precise orbit determination. This will be done in a later stage.

Acknowledgements

S.B. and J.-C.M. thank CNES for their support.

References

[1] Müller-Wodarg, I., Bruinsma, S., Marty, J.C., and Svedhem, H.: In situ observations of waves in Venus's polar lower thermosphere with Venus Express aerobraking, Nature Physics volume 12, pages 767–771 (2016)

[2] Justus C. G. et al. (2005) "Mars Aerocapture and Validation of Mars-GRAM with TES Data", 53rd JANNAF Propulsion Meeting.

[3] Millour, E., Forget, F., Lewis, S.R., 2015. Mars Climate Database v5.2 User Manual. URL: http://www-mars.lmd.jussieu.fr/mars/info_web/user_manual_5.2.pdf.