New Data Products from the Mars Odyssey Accelerometer: Report on Scientific Implications, Data Processing, Validation and Archiving.

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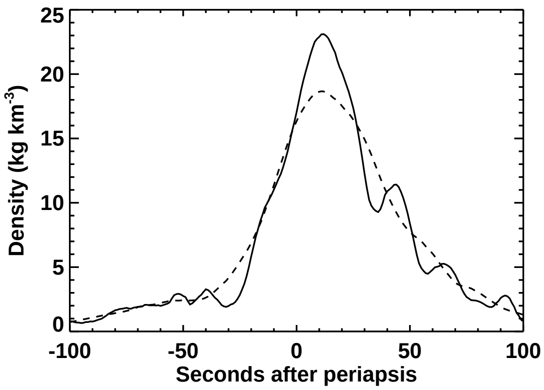

Figure 1: Density profiles from orbit P011. Both ρ_7 (solid line) and ρ_{39} (dashed line) are shown.

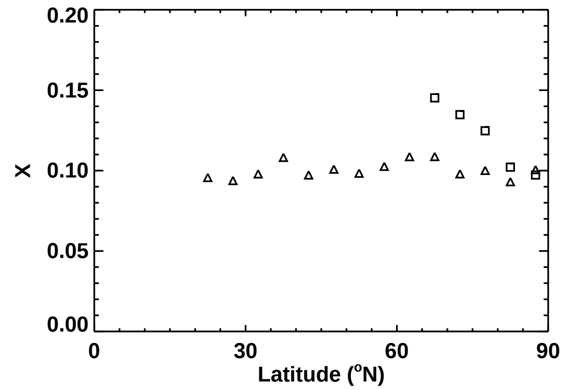

Figure 2: Measure of small-scale structure, X, for dayside (squares) and nightside (triangles). Mean values for 5° latitude bins are plotted.

Some preliminary Mars Odyssey Accelerometer data products are available at the PDS (densities and density scale heights at periapsis (about 100 km), 110 km, and 120 km altitude), but these are described by the PDS as being mostly undocumented and they have not been peer-reviewed. In this work, density profiles and other data products have been derived from measured accelerations. Data products are available online, are being prepared for delivery to the PDS, and are being used for scientific analysis.

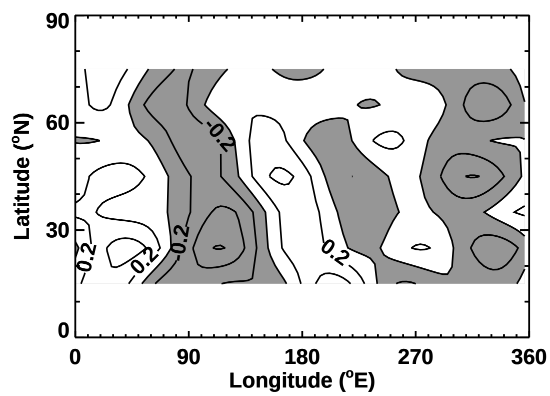

Figure 3: Contour plot of normalized fitted densities at 120 km for outbound dayside data. Contour intervals are 0.2 (dimensionless) and negative regions (low densities) are shaded.

Data Processing

Accelerometer (ACC) data from Mars Odyssey (ODY) were delivered to the PDS in non-standard formats. Time series of densities along ODY's trajectory were derived from aerodynamic accelerations using the drag equation and the aerodynamic database. A non-vertical density profile was obtained for both the inbound and outbound legs of 329 aerobraking orbits. Fits to these density profiles were performed to obtain reference densities and density scale heights at 100, 110, 120, 130 and 140 km.

Validation of Data Products

Some preliminary ODY ACC constant altitude data products, the aerobraking team's results, are currently available at the PDS. Analysis of their times and positions suggests that this work and the aerobraking team's work used different reference areoids. Differences between densities and density scale heights at 110 km and 120 km in this work and the aerobraking team's work are about 10%. Half of the differences in density, but not density scale height, can be attributed to areoid differences.

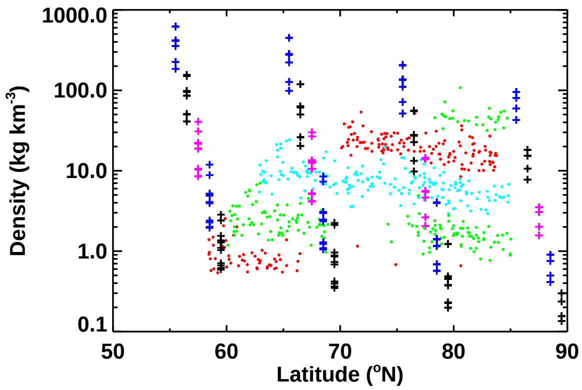

Figure 4: Dayside MTGCM (crosses) and ODY (small filled circles) densities. MTGCM densities at X° latitude and 100 (110, 120, 130, 140) km are plotted at X°-2° (X°-1°, X°, X°+1°, X°+2°). Colours indicate altitude. Dark blue crosses correspond to 100 km and 130 km, with large densities at 100 km clearly distinguishable from small densities at 130 km. Black crosses correspond to 110 km and 140 km. Pink crosses correspond to 120 km. Small filled green circles correspond to 100 km and 130 km. Small filled red circles correspond to 110 km and 140 km. Small filled light blue circles correspond to 120 km.

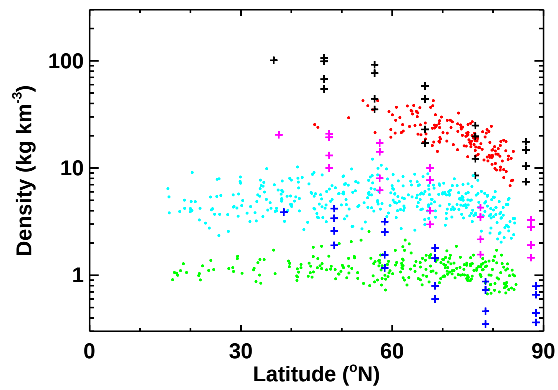

Figure 5: As Figure 4, but nightside densities. Data and simulations are shown at 110, 120 and 130 km.

Science — Small-Scale Structure

Density profiles were derived from 7-second and 39-second averages of acceleration data. Oscillatory small-scale structure is present in the 7-second density profiles, as shown in Figure 1. This can be quantified by the following figure-of-merit, X:

$$Y = 2\frac{(\rho_7 - \rho_{39})}{(\rho_7 + \rho_{39})} \qquad X = \sqrt{\overline{Y^2}}$$

where ρ_7 and ρ_{39} are 7-second and 39-second densities, respectively, and $\overline{Y^2}$ is the mean value of Y^2. Results are shown in Figure 2. Small-scale structure is probably due to gravity waves, and is therefore affected by conditions in the lower atmosphere that control gravity wave excitation and upward propagation [1]. The typical value of X for ODY is 0.1, slightly larger than typical values for MGS, which are shown in Figure 4a of reference [2].

Science — Thermal Tides

Thermal tides were responsible for zonal variations in MGS density measurements at fixed latitude, season, altitude and LST [3]. Zonal density variations attributable to thermal tides are also present in ODY density measurements. Figure 3 shows the zonal structure as a function of latitude for inbound densities at 120 km on the nightside. The zonal structure is coherent over large meridional distances, as seen in dayside MGS data [3].

Science — Comparison to Predictions

The Mars Thermospheric General Circulation Model (MTGCM) has predicted the state of the atmosphere under conditions appropriate for ODY aerobraking [4]. Density comparisons are shown in Figures 4 and 5

References

[1] J. E. Creasey, J. M. Forbes, and G. M. Keating. Density variability at scales typical of gravity waves observed in Mars' thermosphere by the MGS accelerometer. *Geophys. Res. Lett.*, 33:L22814, November 2006. doi: 10.1029/2006GL027583.

[2] P. Withers. Mars Global Surveyor and Mars Odyssey Accelerometer observations of the martian upper atmosphere during aerobraking. *Geophys. Res. Lett.*, 33:L02201, January 2006. doi: 10.1029/2005GL024447.

[3] P. Withers, S. W. Bougher, and G. M. Keating. The effects of topographically-controlled thermal tides in the martian upper atmosphere as seen by the MGS accelerometer. *Icarus*, 164:14–32, July 2003.

[4] S. W. Bougher, S. Engel, R. G. Roble, and B. Foster. Comparative terrestrial planet thermospheres 3. Solar cycle variation of global structure and winds at solstices. *J. Geophys. Res.*, 105:17669–17692, 2000.