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MAVEN Aerobraking Campaign of 2019 and the Resulting Accelerometer Measurements: Wave Features in the Martian Thermosphere

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Abstract

The Mars thermosphere (above approximately 120 km) has been probed in-situ for over two Mars years using Accelerometers on board the Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft [4]. This region is affected by EUV-UV radiation and particle energy deposition from the Sun and by energy and momentum deposition via upward propagating waves (i.e. tides, planetary waves and gravity waves) originating from the lower atmosphere. Densities derived from these accelerometer measurements were obtained during Nominal Science Orbits (periapsis altitudes > 150 km) and during Deep Dip campaigns (when periapsis was lowered to ~120-135 km) for specified 1-week intervals. Nine Deep Dip campaigns have been conducted thusfar during the MAVEN mission. The latest sampling focuses upon ~2-months of Aerobraking operations, when periapsis was lowered to ~123-132 km for the primary purpose of orbit modification in preparation for the relay operations planned for MAVEN spacecraft. This Aerobraking operations also provides a 2-month extended campaign of “Deep Dip like” sampling, which can be used to extend upper atmosphere characterization by several MAVEN instruments, including the Accelerometer. For this study, longitude wave structures are characterized that have been observed over ~135 to 150 km during this Aerobraking campaign.

1. Introduction

Accelerometer measurements of the Martian mass density structure in the thermosphere were obtained during the recent MAVEN aerobraking campaign. MAVEN aerobraking occurred over Ls ~ 340 to 3 (near Vernal equinox), spanning Mars Years 34 and 35. Aerobraking corridor sampling on 272 orbits was conducted over 12-February to 30-March, 2019, with periapsis altitudes as low as ~132 to 123 km. Accelerometer signal to noise was poor above 150 km. The spatial coverage (at periapsis) spanned ~5°S to 54°S latitude, while the solar local time (SLT) progressed from SLT ~ 22 to 17 hours (eventually crossing the evening terminator). Thus, the sampling below 150 km occurred mostly in the southern hemisphere and on the nightside. This lower thermosphere sampling afforded the opportunity to collect measurements in one of the coldest parts of the Mars atmosphere and near the mesopause.

2. Analysis of Accelerometer Data

For this study, longitude wave structures are characterized that have been observed over ~135 to 150 km. Sorting of densities was performed as a function of 5-km reference altitude bins and discrete latitude swaths yielding density plots as a function of longitude. A wave fitting routine was also applied to extract the magnitude and phasing of each wave#1-5 component. The goal here is to investigate the coherence of the waves (amplitude and phasing) from lower to upper thermosphere altitudes during this sampling period. Comparisons are also made with longitude wave structures observed previously by other Accelerometer instruments on other spacecraft [1, 2, 3]. These longitude wave features are produced by coupling with the lower-middle atmosphere via upward propagation of planetary waves and tides of various mode types.

3. Summary and Conclusions

Accelerometer sampling over ~135 to 150 km during the Aerobraking campaign revealed large variations in density with longitude near the Equinox season, and nightside local solar times. The amplitudes of these waves decreased with increasing altitude; lower latitude amplitudes are also observed to be larger than those poleward of ~25° latitude. Finally wave fitting thusfar seems to point to wave #2 and wave #3 harmonics as the dominant components at equatorial latitudes. Comparisons are made with corresponding MGS and MRO longitude wave features previously studied. Finally, connections between the middle and upper atmosphere are being investigated (elsewhere) using MRO/Mars Climate Sounder measurements at ~0.02 Pa (~90-97 km) during this Aerobraking sampling period.

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