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Global characteristics of gravity waves in the upper atmosphere of Mars as measured by MAVEN/NGIMS

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Abstract

Gravity waves (GWs) are omni-present in stratified atmospheres such as Earth, Mars and Titan's [1][2][3]. These perturbations have been observed at Mars by previous spacecraft such as Mars Global Surveyor (MGS) and more recently the Mars Atmosphere and Volatile EvolutionN (MAVEN) mission [4][5][6].

GWs are generated from a diverse range of sources including flow over topography, atmospheric instabilities and volatile convection, however any process which perturbs the atmosphere could generate GWs. Many modelling studies have shown the significance of the effects of GWs for an accurate description of the atmosphere [7][8]. GWs carry energy and momentum as they propagate upwards and have been found to slow down or reverse mean flows in the upper atmosphere. The deposition of wave energy has the potential to either warm or cool the atmosphere, dependent on local atmosphere conditions [8].

We have performed a comprehensive study of gravity waves in Mars' upper atmosphere. Using in situ data from the Neutral Gas and Mass Spectrometer (NGIMS) onboard MAVEN we have been able to characterise waves from nearly 4000 orbits [9]. We use density and temperature profiles to extract waves. We interpret these waves as vertical structures and characterise them by their amplitude and wavelength. We compare our results to those found using data from MGS, Odyssey (ODY) and MAVEN [2][5][6]. By using solar zenith angle and Mars-Sun distance as proxies for temperature, we have investigated correlations between temperature and GW characteristics. Large variations in amplitude are observed over the sampled zenith angle range. No such trend is found for wavelengths. By comparing pre- and post-periapsis profiles, we find that the largest variations are found in the coolest regions of the atmosphere, such as on the nightside. We discuss these results in the context of future aerobraking missions.

References

[1] Fritts, D. C. (1984), Gravity wave saturation in the middle atmosphere: A review of theory and observations, Rev. Geophys., 22(3), 275–308

[2] Fritts, D. C., L. Wang, and R. H. Tolson (2006), Mean and gravity wave structures and variability in the Mars upper atmosphere inferred from Mars Global Surveyor and Mars Odyssey aerobraking densities, J. Geophys. Res., 111, A12304

[3] Mueller-Wodarg, I. C. F., R. V. Yelle, N. Borggren, and J. H. Waite Jr. (2006), Waves and horizontal structures in Titan's thermosphere, J. Geophys. Res., 111, A12315

[4] Keating, G., Bougher, S., Zurek, R., Tolson, R., Cancro, G., Noll, S. Babicke, J. (1998). The Structure of the Upper Atmosphere of Mars: In Situ Accelerometer Measurements from Mars Global Surveyor. Science, 279(5357), 1672-1676

[5] Creasey, J. E., J. M. Forbes, and G. M. Keating (2006), Density variability at scales typical of gravity waves observed in Mars' thermosphere by the MGS accelerometer, Geophys. Res. Lett., 33, L22814,

[6] Yiğit, E., S. L. England, G. Liu, A. S. Medvedev, P. R. Mahaffy, T. Kuroda, and B. M. Jakosky (2015), High - altitude gravity waves in the Martian thermosphere observed by MAVEN/NGIMS and modeled by a gravity wave scheme, Geophys. Res. Lett., 42, 8993–9000

[7] Medvedev, A. S., E. Yiğit, P. Hartogh, and E. Becker (2011), Influence of gravity waves on the Martian atmosphere: General circulation modeling, J. Geophys. Res., 116, E10004

[8] Medvedev, A. S., & Yiğit, E. (2012). Thermal effects of internal gravity waves in the Martian upper atmosphere. Geophysical Research Letters, 39(5).

[9] Mahaffy, P. R., Benna, M., King et al. (2015). The Neutral Gas and Ion Mass Spectrometer on the Mars Atmosphere and Volatile Evolution Mission. Space Science Reviews, 195(1-4), 49-73