

# DSMC simulations of internal gravity waves propagating and dissipating in the Martian upper thermosphere and exosphere

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The effects of internal gravity wave propagation and dissipation in the Martian upper thermosphere and exosphere on the density, circulation, and temperature of the background atmosphere have been studied using a multi-species Direct Simulation Monte Carlo (DSMC) model of Terada et al. (2016). This paper shows results of local simulations of a vertically propagating gravity wave mode in the Martian dayside upper thermosphere and exosphere under the conditions of the observation period of the Mars Atmosphere and Volatile Evolution (MAVEN) satellite. The results reveal that gravity waves which produce wave-like density perturbations around the exobase observed by Neutral Gas Ion Mass Spectrometer (NGIMS) instrument onboard the MAVEN satellite [e.g. Yigit et al., 2015; Terada et al., 2017] must have a vertical wavelength of at least 200 km, if they are propagated from the lower and middle atmosphere. We also find that a gravity wave harmonic with a 200 km vertical wavelength significantly heats and accelerates the upper thermosphere and the exosphere, increasing the mixing ratio of CO<sub>2</sub> above 150 km. The calculated horizontal acceleration rate is ~1200 m/s/sol, and the calculated heating rate is ~100 K/sol. The calculated rate of increase in CO<sub>2</sub> mixing ratio is ~80 %/sol around the ionopause, which can probably cause an increase in the escape flux ratios of CO<sub>2</sub><sup>+</sup>/O<sup>+</sup> and O<sub>2</sub><sup>+</sup>/O<sup>+</sup>.

## References

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