Global distribution of gravity waves activity in Mars' lower thermosphere derived from MAVEN/IUVS stellar occultations and analyzed using two Martian General Circulation Models

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Small-scale gravity waves (GWs) are recognized as an important part of the terrestrial climate system. They affect the dynamics, composition, and thermal structure of the terrestrial middle atmosphere and thermosphere. On Mars, most of information about GWs at altitudes 0-40 km has been obtained with radio occultation techniques and temperature profiles by MCS/MRO, while GW activity in the upper atmosphere was quantified using aerobraking measurements. Since previous studies did not establish a correlation between the GW activity in the lower and upper atmosphere, questions about thermospheric sources of the perturbations still remain to be addressed. Since October 2014, comprehensive studies of the Martian atmosphere have been performed with NASA's Mars Atmosphere EvolutioN (MAVEN) mission. In-situ measurement of the upper atmosphere, down to 130 km, revealed substantial wave structures in ions and neutrals. Wave structures have also been detected by remote sensing with Imaging Ultraviolet Spectrograph (IUVS) at altitudes between 30 and 150 km. IUVS measurement provide opportunities for investigating possible links between GWs in the Martian troposphere and thermosphere.

In this paper, we use the IUVS stellar occultation measurements to characterize a global distribution of GW activity in the lower thermosphere. We focus on the data obtained between March 2015 and March 2016. Two comprehensive general circulation models (MGCMs), a GWs resolving MGCM and the Max Planck Institute MGCM incorporating a state-of-the-art GW parameterization have been used to interpret the observations. The main results of this study are as follows.

(1) The observed perturbations demonstrate GW signatures with vertical wavelengths of 10-20 km and amplitudes of up to 10 % of the mean temperature (~13 K) and 15-20 % of the mean density.

(2) The observed wave potential energy in the lower thermosphere has larger values at middle latitudes. This is contrary to the distribution of GW activity in the lower thermosphere, whose maximum is located in low latitudes, but is consistent with simulations using the two MGCMs.

(3) Our MGCM simulations demonstrate that the background winds play a major role in vertical propagation of GWs generated in the lower atmosphere, which can explain the latitudinal distribution of the GW activity. High-resolution as well as parameterization GW simulations demonstrate a consistent picture of GW-induced temperature perturbations.

(4) The observed perturbations in the lower thermosphere are most likely caused by GWs of tropospheric origin penetrated from below.

We must emphasize that the spatial coverage of the existing MAVEN/IUVS occultation data is still poor to unambiguously establish the global distribution of the GW activity in the lower thermosphere. This should be a subject of further observations. However, the presented data, at least, do not contradict the model

predictions pointing to the lower atmospheric origin of these waves.

Keywords: Mars, gravity wave, thermosphere, MAVEN