The effect of atmospheric gravity waves on the water upward transport on Mars

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Abstract

It is now widely recognized that atmospheric gravity waves (GWs) in the lower atmosphere play an important role in the terrestrial mesosphere and thermosphere. They affect the dynamics, composition, and thermal structure [Fritts and Alexander, 2003]. Wavelike perturbations ubiquitously exist on Mars as well. Larger amplitude (10 times than that on Earth) [Terada et al., 2017] could have the significant effect on the Martian atmosphere. GWs are expected to induce vertical mixing in the Martian upper atmosphere by driving planetary-scale circulation via momentum deposition and by generating turbulence. The vertical mixing induced by such high-altitude waves should play a crucial role in controlling the homopause height. The homopause height has a large influence on thermospheric composition and atmospheric escape [Imamura et al., 2016]. Recently, high-altitude water vapor was identified by SPICAM [Maltagliati et al., 2013] especially in the southern summer at perihelion. The unexpected GW activity we found in the southern summer may be a potent source mechanism to transport atmospheric molecules and aerosols into the upper atmosphere of Mars [Nakagawa et al., submitted].

In this study, we use the IUVS stellar occultation measurements onboard MAVEN to characterize a global distribution of wavelike perturbations, the convective instability, the homopause height, and the aerosol opacity, in order to address the effect of the waves on the molecular upward transportation. The convective instabilities, which implies the saturation (breaking) or GWs drag via turbulence, widely found in mesosphere and lower thermosphere. Much more

instabilities were found in 40-100 km altitude at perihelion. This potentially imply the acceleration of meridional circulation at this altitude range, providing the transported water from the southern hemisphere to high northern hemisphere at perihelion. Certain degree of correlations was suggested between the wave activity, the homopause height, and the aerosol opacity in the middle atmosphere. Water vapor might be able to transported to higher altitudes with higher homopause height. The photodissociation rate of water vapor by solar UV irradiance may provide an additional source of hydrogen escape. Consequently, we propose a hypothesis that the vertical mixing and the acceleration of the meridional circulation due to GWs breaking (drag) may be able to explain the high-altitude water vapor and its seasonal variations.