Study of Observing Methods of Atmospheric Gravity Waves on Mars by Using Terahertz Band Spectroscopy Sensor

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We are studying the design of the terahertz heterodyne spectroscopy sensor (THSS) with a view to the subpayload installation of next-generated Mars projects such as the proposed international Mars Ice Mapper mission (NASA, JAXA, CSA, ASI). THSS does not require a background source like the sun and thus has the advantage of being able to perform limb sounding / nadir observation over a wide range of latitudes, longitudes, altitudes, and local-times. It also has a feature that it is less susceptible to the absorption by dust and aerosols. Therefore, even during the dust storm season, the boundary layer that governs Mars' weather and material transport is observable. It also allows observation of atmospheric wind velocity fields.

THSS with frequency wide-band and high resolution mode spectrometers targets the observation of water vapor, carbon monoxide, and other trace molecules related to atmospheric oxidation processes from near surface layers and boundary layers to high altitudes of over 100 km. With this system, we will be able to address the information about the material circulations including water in the atmosphere, surface layer, photo-chemical reaction network, and weather and climatic environment on Mars. In this research, we will report on how we can capture the influence of atmospheric gravity waves on Mars using this THSS.

Recently, it has been discussed that atmospheric gravity waves contribute to sudden weather change, cloud and aerosol formations, climate, radiative forcing, etc. On Mars, the breaking of atmospheric gravity waves at a height of 100 to 130 km has recently been observed by the mid-infrared observation of the Trace Gas Orbiter (Starichenko et al. JGR Planets, 128, 2021). It is important to understand the contribution of atmospheric gravity waves to the transport of energy and materials to the upper layer.

In this study the time-dependent three dimensional dataset of temperature, pressure and carbon monoxide with a time and spatial resolution of 10s and 1.1 degrees (67 km) was simulated by the atmospheric general circulation model (GCM) including the effect of atmospheric gravity waves. The radiative transfer model with the dataset was calculated to derive the 460 GHz band rotational transition spectrum of carbon monoxide in the form of pseudo Nadir observation toward the Nadir direction with spatial resolution of 5 km (antenna diameter of 45 cm) from the satellite, assuming that the season is summer in the southern hemisphere and that the satellite passes along LST15:00 at 300 km altitude. As a result of this analysis, it was found that by comparing the intensity of absorption spectrum with the spatially surrounding moving average, fine intensity fluctuations of about 10 K caused by gravity waves could be significantly obvious. This suggests the possibility that the global time and spatial fluctuations in the temperature on Mars caused by atmospheric gravity waves can be captured two or three dimensionally by using THSS. Verifications for other longitudes and seasons is also planned in the future.

Keywords: Terahertz band heterodyne spectroscoy , Martian Atmosphere, Radiative transfer model, , Atmospheric gravity wave , GCM