論文の内容の要旨

論文題目

Vertical wavenumber spectra of gravity waves in terrestrial planetary atmospheres

（地球型惑星における大気重力波の鉛直波数スペクトル）

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Vertical wavenumber spectra of gravity waves have been used as an indicator of generation, propagation and dissipation processes of them in the studies of Earth's atmospheric dynamics. In this study, by using the vertical temperature profiles obtained by the radio occultation measurements on ESA's Venus Express and NASA's Mars Global Surveyor missions, we studied small-scale temperature perturbations which are thought to be manifestations of gravity waves and calculated their vertical wavenumber spectra for the first time. Temperature profiles newly retrieved from Venus Express open-loop data were used for Venus. Open-loop data are generally suitable to the detection of small-scale structures such as gravity waves because of their high temporal resolution. In our analysis we can only use X-band data, then we cannot separate contributions from the ionosphere and neutral atmosphere. To deal with this problem, the upper boundary of the atmosphere is

set to prevent the temperature profile from being affected by the contribution from the ionosphere. The comparison of the temperature profiles obtained from open-loop data and closed-loop data showed that they are almost consistent with each other except that the open-loop results capture more small-scale structures. For Mars, on the other hand, publicly-released temperature profiles were used.

In the analysis of Venusian atmosphere, temperatures in the altitude ranges of 65-80 km and 75-90 km are analyzed separately, and vertical wavenumber spectra which cover the wavelengths of 1.4-15 km are obtained for each altitude region. Then, they are classified into seven latitude regions. The spectra generally show features similar to those observed in the Earth's atmosphere: the spectral density declines with wavenumber with the logarithmic spectral slope of -3 to -3.8 and the spectrum flattens at large-wavelength end. The power is larger at 75-90 km than at 65-80 km. It was also found that the power is basically larger in the high latitude than in the low latitude and that the power is maximized around 45°N-75°N.

In the Martian case, temperatures in the altitude ranges of 3-20 km and 15-32 km are analyzed separately, and vertical wavenumber spectra which cover wavelengths of 2.5-17 km are obtained for each altitude region. Then, they are classified into five latitude regions and four seasons. The spectra generally show features similar to those observed in the Earth's and Venusian atmospheres: the spectral density declines with wavenumber with the logarithmic spectral slope of -3 to -3.6 and the spectrum flattens at large-wavelength end. The power does not depend noticeably on the altitude and is maximized basically in the equatorial region (15°S-15°N) in any seasons.

The obtained spectra tend to follow the semi-empirical spectrum of saturated gravity waves, which has been developed in the studies of Earth's gravity waves, at wavelengths 3-8 km in the Venusian high latitude and at wavelengths 2.5-8 km in the Martian equatorial region. Although the process determining the wavenumber spectrum is still under debate, there is a possibility that gravity waves in these planetary atmospheres are dissipated by saturation as well as radiative damping. Based on this scenario the coefficients of turbulent diffusion associated with wave breaking were tentatively estimated.