Horizontal structure of wind and temperature associated with transient waves observed at the cloud top of Venus

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The mystery of the fast-rotating atmosphere on Venus is well known as the name of the super-rotation. At the cloud top altitude of ~ 70 km, the super-rotation reaches 100 m s^{-1}, and many types of atmospheric waves are found as periodical signals in winds and temperatures. Planetary-scale waves are one of the important clues to maintain the super-rotation by transporting angular momentum and heat. Continuous observations by the Ultraviolet Imager (UVI) onboard the Venus Climate Orbiter Akatsuki enable us to carry out cloud-tracking wind measurements. Transient waves with periods of 4-day and 5-day waves propagate faster and slower than the mean zonal winds, and they are called Kelvin and Rossby waves, respectively. We found a prominent 5-day Rossby-like wave consisting of equatorially symmetric planetary-scale vortices with zonal wavenumber 1 [Imai et al., 2019]. However, their structures and dynamical characteristics have not been clarified.

In this study, we newly analyzed the LIR images and performed a comparative analysis by using cloud-tracked winds derived from the Ultra-Violet Imager (UVI) and temperatures from the Longwave Infrared Camera (LIR) onboard Akatsuki. The LIR usually observes the thermal radiation of 10 μm wavelength from the cloud tops. We extracted the annual region from each image with an emission angle (e) range of e = 50º ±3.5º to analyze the brightness temperature variation at a certain altitude. The dominant temperature variation due to the thermal tide was subtracted as the fixed component in the local time, and then, the horizontal temperature disturbances with 4-day or 5-day periodical components were successfully reproduced. We carefully evaluated the differences in the sensing altitude between the UVI and LIR images based on the structure of thermal tides structures by GCM model and observations. Since the vertical wavelength is relatively long, angular momentum and heat fluxes induced by the 5-day Rossby wave can be estimated for the first time. The angular momentum transport was almost zero, but the poleward heat transport was significant with a magnitude ~ 3 K m s^{-1}. In the case of the Kelvin wave, the vertical wavelength might be shorter than the Rossby wave, and we demonstrate the structure of a 4-day wave under assumptions in the direction of vertical propagation.

Keywords: Venus, Akatsuki, Rossby wave, Kelvin wave

