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Vertical propagation and wind speed acceleration of planetary-scale waves at the cloud level of Venus

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In this study, we reveal temporal variation of the super-rotation of Venus atmosphere and spatial structures of planetary scale atmospheric waves at the cloud top level by deriving wind speeds and their variations at the cloud top from UV (365 nm) images taken by Venus Monitoring Camera (VMC) onboard Venus Express of European Space Agency. Because VMC has taken many cloud images covering from low to high latitudes of the southern hemisphere, well suited for derivation off wind speeds and their variations. We applied a newly-developed cloud tracking method (Ogohara et al., 2012; Kouyama et al., 2012) to these images and found that the equatorial zonal wind speed changes quasi-periodically, alternating ”fast season” (over 100 m s^{-1}) and ”slow season” (below 90 m s^{-1}) every ˜100 earth days.

From spectral analysis of the wind speed and the cloud brightness variations, planetary-scale 5 day period variations were identified in the zonal and meridional wind speeds in the fast season of background zonal wind speeds. The phase speed of the 5-day period variations is slower than the background wind speed. The phase relationship between the zonal and meridional winds implies that the 5-day variation is a manifestation of a Rossby wave. On the other hand, planetary-scale 4 day period variations were identified in zonal wind speeds and cloud brightness in the slow season. The phase speed of the 4-day period variations is faster than the background wind speed. These results are consistent with previous studies from Pioneer Venus observations (Del Genio and Rossow, 1990; Rossow et al., 1990).

From the numerical results based on Covey & Schubert (1982), we found that the Kelvin wave originating from the lower atmosphere can propagate vertically into the cloud top level in the slow period. On the other hand, the Rossby wave can propgate in the fast period. Therefore, the time variation of the super-rotation could be affected by these waves. In this study, we will evaluate the angular momentum transport by these waves based on the derived parameters from our analysis.

Keywords: Venus, super-rotation, atmospheric waves