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Venus GCM simulations for the coupling between the thermosphere and the lower atmosphere through planetary-scale waves

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In recent years, importance of planetary-scale waves for dynamics of the Venusian upper atmosphere has been recognized. For example, Forbes and Knopliv [2007] suggested propagations of planetary-scale waves originated in the cloud deck to the thermosphere from reanalysis of the Magellan spacecraft data. In addition, recent simulation studies suggest importance of tidal waves for the superrotation in the Venusian cloud deck [Takagi and Matsuda, 2007].

In order to investigate the effects of the diurnal tide, semidiurnal tide, and Kelvin wave on the Venusian mesosphere and thermosphere, we have performed simulations in consideration of the planetary-scale waves. The planetary-scale waves are generated by moving the geopotential fluctuations, which would be caused by the waves, with phase speeds of the waves at the lower boundary. The thermal tides and Kelvin wave rotate around Venus with phase speeds of 3 m/s (eastward) and -115 m/s (westward). We determine the amplitudes of the geopotential fluctuations assuming that the geopotential fluctuations cause the observed zonal wind fluctuations: 10 m/s for both the thermal tides and Kelvin wave based on Rossow et al. [1990] and Del Genio and Rossow [1990].

The simulation results show that the diurnal tide cannot propagate upward above 80 km. The semidiurnal tide has little influence on the mesospheric wind velocity though the semidiurnal tide propagates up to about 90 km. The Kelvin wave propagates up to about 110 km and fluctuates the mesospheric wind velocity. The effects of the upward momentum transport by the Kelvin wave on the thermospheric westward wind, which has been observed before, are negligible. The O_2 nightglow emission has been observed in the nightside at about 95 km. Our result shows that the Kelvin wave causes the wind velocity fluctuations with a period of 4 days in the nightside at about 95 km. The result suggests that the Kelvin wave should cause the temporal variations of the O_2 nightglow distribution in the nightside with a period of 4 days.