Application of GCM to the Venus middle atmosphere dynamics

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Recently the full-physics Venus General Circulation Models (GCMs) are developed by several research groups (e.g., Lebonnois et al. 2010). Ikeda et al. investigate the maintenance mechanism of Venus' atmospheric superrotation by using a newly developed Venus GCM, in which radiative transfer is calculated. Although realistic thermal structure is reproduced in the model, the superrotation is not fully developed in the lower atmosphere. Similar results are seen in simplified GCMs using a realistic solar heating rate. Ikeda et al. and Yamamoto & Takahashi (2009) suggest that some eddy momentum sources or/and additional diabatic heating should be also considered as unknown driving forces of the lower-atmospheric superrotation in Venus atmospheric modeling.

Although such an open issue on the lower atmosphere still remains, we need to investigate the middle-atmospheric data stored by previous and recent Venus missions. As an alternative of the full-physics Venus GCM covering a height range of 0 to 100 km, we are developing Venus Middle Atmosphere General Circulation Model (VMAGCM), in order to focus on dynamics of superrotation and planetary-scale waves observed in the cloud layer. In the present study, the planetary-scale equatorial waves with the periods of 4-6 days and zonal wavenumber 1 are forced at 30 km. In the presence of meridional circulation and thermal tides, dynamical effects of the equatorial waves are examined using the VMAGCM simplified by Newtonian cooling.

In the case that the forced planetary wave is not set in the model, the superrotation is weak in the middle atmosphere. Diurnal and semi-diurnal thermal tides are predominant at the cloud top. In addition, the 6-day wave is generated in the middle atmosphere. In the case of the equatorial 5.5-day wave forced at the bottom boundary, the superrotation is fully developed at the cloud top and cloud base. The forced 5.5-day wave is seen at the cloud base, while the 4-day wave generated in the atmosphere is seen at the cloud top. These waves may correspond to the equatorial 5.5-day NIR marking (Crisp et al., 1991) and 4-day UV dark band (Rossow et al. 1980).

By further model development and comparison with observations, we plan to investigate the equatorial and polar dynamics of the Venus middle atmosphere. In the future work, the observational data will be combined into the model.