Effects of topography on Venus' atmospheric general circulation inferred from GCM experiments

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Venus' topography modifies the lower-atmospheric structure and produces stationary waves, which might induces conspicuous variation of cloud-top zonal flow (Bertaux et al. 2016) and large-scale stationary bow-shaped brightness pattern (Fukuhara et al. 2017) over the Aphrodite Terra. Our GCM experiments with the topography show that (1) the near-surface subrotation is formed in and around high lands and mountains, (2) weakly stable layer is formed at 10-20 km at low latitudes, and (3) the zonal wind is weakened at the cloud top over the Aphrodite Terra. The third result is similar to the slowness of the cloud-top zonal wind around the Aphrodite Terra (Bertaux et al. 2016). The topographical effects on Venus' atmosphere general circulation are investigated using a T21L52 Venus AGCM at Atmosphere and Ocean Research Institute, Univ. Tokyo (Ikeda 2011), in which the topographical data and radiative code are incorporated. In the control experiment (Exp. C), at the first step, the equilibrium state is calculated in a long-term GCM experiment with nudging zonal wind to the reference state in the lower atmosphere. Next, the nudging-free experiment is started from the equilibrium state obtained from the first-step nudging run. For comparison, zero terrain height is assumed in the flat-surface experiment (Exp. F). For the simulated zonal-mean structure, the midlatitude jets of ~120 m/s and equatorial fast flow of ~90 m/s are formed around the cloud top. The poleward flow of >8 m/s is seen above the jet and that of ~1 m/s is confined within the equatorward flank of the jet core. The indirect circulation is formed within the jet core. Although the north-south asymmetry of the zonal-mean structure due to the topography is very small, the near-surface subrotation of <0 m/s is formed above the Aphrodite Terra and Maxwell Montes, where the angular momentum is supplied. The static stability in and above the upper cloud layer is high, and the atmosphere is weakly stable around 40 km in Exps. C and F. Weakly stable layer is seen at 10-20 km in Exp. C, whereas it is not apparently seen in Exp. F. 4-8 day waves, thermal tides and stationary waves are seen in the cloud layer. The zonal wind averaged over a Venus day slows by a few meters per second at 69 km over the Aphrodite Terra, whereas it becomes somewhat fast below 65 km. The vertical structure of the equatorial zonal wind of the simulated stationary wave is consistent with that in Yamamoto and Takahashi (2009). Although large-scale stationary bow-shaped waves are not formed in the model, the cloud-top temperature spatially varies above the Aphrodite Terra.

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