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Venus superrotation simulated by an AGCM with a new radiative transfer model

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A maintenance mechanism of the superrotation in the Venus atmosphere is investigated by using an atmospheric general circulation model (AGCM). We have constructed a new radiative transfer model for the Venus AGCM. This radiation model can treat absorption, scattering, and emission processes due to the gases and the atmospheric particles from short-wave to long-wave region. The surface temperature and temperature distribution close to observations can be reproduced in the radiative-convective equilibrium calculation; convection layer extends from the surface to about 40 km altitude. The role of various radiatively active gases is investigated by computing the radiative-convective equilibrium without each absorber. The results imply that the effect of each gas depends on treatments of line profile of gas absorption and the CO_2 continuum opacity.

The new radiation model has been incorporated into the CCSR/NIES/FRCGC AGCM. Zonal flow of about 50 m s^{-1} is reproduced at the equatorial cloud top. Momentum transport associated with thermal tides play an important role in maintenance of the mean zonal flow in the cloud layer. The sensitivity to uncertainties in the distribution of the unknown UV absorber near the cloud top is examined. This test indicates that the superrotation in the middle atmosphere is affected by the distribution of the UV absorber. Although superrotational flow is maintained in the middle atmosphere, the zonal wind is much weaker than observations under the cloud layer. Although the mean meridional circulation contributes to the momentum balance of the superrotaion in the middle atmosphere, it does not efficiently transport the angular momentum necessary to maintain the superrotation. It is suggested that the meridional circulation driven by this radiation model does not have sufficient strength to maintain the superrotation.

A simulation which includes momentum transport by small-scale gravity waves is performed to examine the maintenance mechanism of the superrotation below the cloud. Although greater energy flux of eastward gravity waves is required to assume, the superrotation in the lower atmosphere is maintained by critical level absorptions of gravity waves in this simulation.

Keywords: Venus, superrotation, AGCM