Planetary-scale streak structures produced in a high-resolution simulation of Venus atmosphere

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Night-side images of Venus taken by the IR2 camera onboard the Venus Climate Orbiter/AKATSUKI has shown many features of the lower cloud layer. One prominent feature is a bright planetary-scale streak structure extending from high-latitudes to low latitudes on both hemispheres. IR2 night-side images capture infrared radiated from the near-surface atmosphere, and the infrared can be blocked by clouds. Therefore, bright regions indicate thin-cloud regions.

We have performed a high-resolution simulation of the Venus atmosphere by a simplified general circulation model, which is based on AFES: the Atmospheric general circulation model For the Earth Simulator. The horizontal resolution is T159 (i.e., about 0.75 deg x 0.75 deg grids) and the vertical resolution is about 1 km with the model top at 120 km. In the model, the atmosphere is dry and simply forced by the solar heating with the diurnal change and Newtonian cooling that relaxes the temperature to the horizontally uniform basic temperature which has a virtual static stability of the Venus atmosphere. In the basic temperature profile, we have introduced a low-stability (0.1 K/km) layer from 55 km to 60 km, which is suggested by the recent radio occultation observation. We have explored waves (Sugimoto et al. 2014ab), polar vortex (Ando et al. 2016), and kinetic energy spectra (Kashimura et al. 2014) in the simulated atmosphere with the above model settings (some with lower resolution).

In this study, we have found that a planetary-scale streak structure similar to that observed by the IR2 night-side image is produced in the vertical velocity field above the low-stability layer in the simulated atmosphere. Large streaks are shown by strong downward flow. This is consistent with the observation because the downward flow can decrease cloud amounts and make a thin-cloud region. Seen from above the pole, the simulated streak structure shapes a huge spiral extending from the polar vortex to low latitudes. Such spiral may correspond to that observed by VIRTIS onboard Venus Express. The streak structures on both hemispheres are synchronized, that is the streak structures located in the same longitude.

We have also performed numerical experiments with increasing the static stability of the "low-stability layer". The streak structure does not appear in the case that the stability is set to 2.0 K/km. Our results suggest that the neutral stability layer plays an important role on the formation of the planetary-scale streak structure. The fact that our simplified atmospheric GCM has produced the structure similar to the cloud pattern observed in the Venus atmosphere implies that the cloud pattern is dominated by the atmospheric circulation.

Keywords: simulation of Venus atmosphere, IR2, streak structure, low-stability layer

