金星雲層を想定した鉛直対流の 3 次元数値計算

杉山 耕一朗 [1]; 川畑 拓也 [2]; 小高 正嗣 [3]; 中島 健介 [4]; 石渡 正樹 [3]; 今村 剛 [5]; 林 祥介 [6]
[1] JAXA 宇宙科学研究所; [2] 株) テクノスジャパン; [3] 北大・理・宇宙; [4] 九大・理・地惑; [5] JAXA 宇宙科学研究所; [6] 神戸大・理・地惑

A Three-dimensional Numerical Simulation of Venus' Cloud-level Convection

Ko-ichiro Sugiyama[1]; Takuya Kawabata[2]; Masatsugu Odaka[3]; Kensuke Nakajima[4]; Masaki Ishiwatari[3]; Takeshi Imamura[5]; Yoshi-Yuki Hayashi[6]
[1] ISAS/JAXA; [2] Tecnos Japan Inc.; [3] Cosmosciences, Hokkaido University; [4] Earth and Planetary Sciences, Kyushu University; [5] ISAS/JAXA; [6] Earth and Planetary Sciences, Kobe University

Although convection has been suggested to occur in the lower part of Venus' cloud layer by some observational evidences, its structure remains to be clarified. To date, a few numerical studies try to simulate Venus' cloud-level convection (Baker et al., 1998, 2000; Imamura et al., 2014), but the model they utilized is two-dimensional. It is difficult to attempt direct comparison between the results of their simulations and the observations. Here we report on the results of our numerical simulations performed in order to investigate a possible three-dimensional structure of Venus' cloud-level convection.

We use the convection resolving model developed by Sugiyama et al. (2009). The model is based on the quasi-compressible system (Klemp and Wilhelmson, 1978), and is used in the simulations of the atmospheric convections of Jupiter (Sugiyama et al., 2011,2014) and Mars (Yamashita et al., submitted). We perform two experiments. The first one, which we call Ext.B, is based on Baker et al. (1998). A constant turbulent mixing coefficient is used in the whole computational domain, and a constant heat flux is given at the upper and lower boundaries as a substitute for radiative forcing. The second one, which we call Exp.I, is based on Imamura et al. (2014). The sub-grid turbulence process is implemented by Klemp and Wilhelmson (1989), and an infrared heating profile obtained in a radiative-convective equilibrium calculation (Ikeda, 2011) is used. In both of the experiments, the temporally averaged solar heating profile is used. The spatial resolution is 200 m in the horizontal direction and 125 m in the vertical direction. The domain covers 128 km x 128 km horizontally and altitudes from 40 km to 60 km.

Obtained structures of convection moderately differ in the two experiments. Although the depth of convection layer is almost the same, the horizontal cell size of Exp.B is larger than that of Exp.I; the cell sizes in Exp.B and Exp.I are about 40 km and 25 km, respectively. The vertical motion in Exp.B is asymmetric; updrafts are widespread and weak (˜3m/s), whereas downdrafts are narrow and strong (˜10m/s). On the other hand, the vertical motion in Exp.I is nearly symmetric and weaker (˜2m/s) compared with those in Exp.B. The difference of convective structure results from the different vertical distributions of implemented infrared heating. Namely, the intense downdrafts in Exp.B are forced by the strong cooling concentrated near the top of the convection layer. In Exp.I, the heating is distributed in a thick layer; the net heating is positive from 47 km to 49 km altitudes, and is negative from 49 km to 56 km altitudes. This profile of net heating makes vertical motion relatively symmetric.