Numerical study of the convective structure in Venus atmosphere

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Abstract

Our purpose is to support the observation performed by AKATSUKI (Venus Climate Orbiter) by developing a numerical fluid dynamics model (cloud resolving model) and providing a lot of numerical simulation data. The motion of Venus' cloud-level convection and the propagation of gravity wave driven by convection obtained by our numerical simulation are very useful to analysis the cloud morphology at various altitudes and characteristics of gravity wave obtained by AKATSUKI. By comparing our numerical simulations data and the observation data of AKATSUKI, it is expected that atmospheric structure of Venus' cloud-level will be more clearly understood.

Reasons for using JSS2

Supercomputer is used for developing and running our cloud resolving model. To reproduce the structure of convective motion and gravity wave propagation, it is necessary that the resolution of the model is set to be several tens to several hundred meters. To avoid the influence of the computational boundary and to compare with AKATSUKI's data, horizontal region of hundreds to thousands of kilometers is required. The numerical simulations with such high resolution and wide computational region can be performed using supercomputer only.

Achievements of the Year

A three-dimensional calculation with high vertical resolution and large domain is performed to obtain the structure of convective motion and the propagation of gravity waves. The reasons why we use high vertical resolution and large domain are as follows. (1) In the previous three-dimensional simulation (Lefevre et al., 2017), horizontal domain is relatively small (36 km) and vertical resolution is relatively coarse (dz=60 m). (2) Our previous two-dimensional studies indicate that relatively small vertical resolution is required to discuss the heat and momentum transports associated with gravity waves.

Our results show that motion in the convective layer and gravity wave propagation are obtained successfully (Fig. 1-3). In the convective layer, vertical velocities of upward and downward motion are about 2 m/s. This value is consistent with the result of Imamura et al. (2014). Above the convection layer ($z > 55$ km), the gravity waves driven by convection and perturbations caused by gravity waves are observed. The amplitudes of potential temperature deviation and vertical velocity increase with height. Detailed analysis of the obtained results of our series of numerical simulations is a future work.

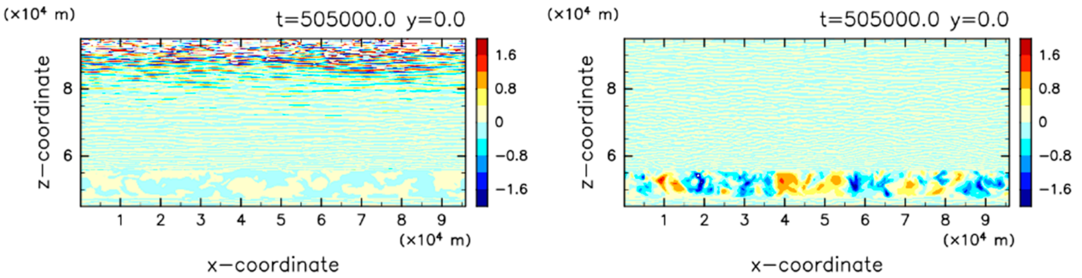

Fig. 1: X-Z cross section of potential temperature deviation from horizontal mean, and vertical velocity for z = 45 km - 95 km

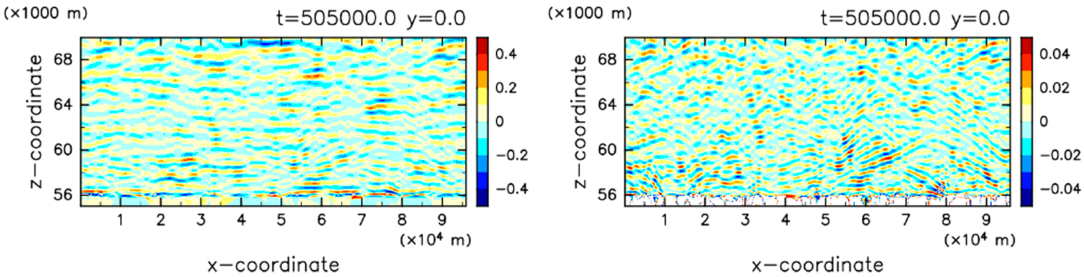

Fig. 2: The enlarged figure of the region where gravity wave are driven by convection (z = 55 km - 70 km) in Fig. 1.

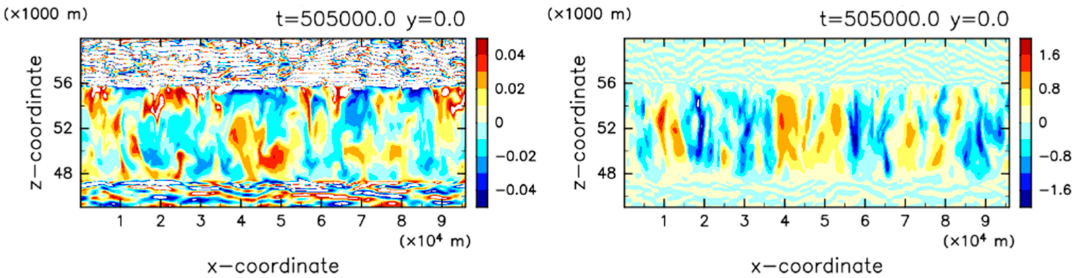

Fig. 3: The enlarged figure of the convective layer (z = 45 km - 60 km) in Fig. 1.

Publications

- Poster Presentations

Sugiyama, K., Odaka, M., Nakajima, K., Ishiwarari, M., Imamura, T., Hayashi, Y.-Y., 2018: A Three-dimensional Numerical Simulation of Venus' Cloud-level Convection, JPGU meeting 2018, 2018/05, Makuhari Messe (Japan).

Usage of JSS2

- **Computational Information**

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	128 - 1024
Elapsed Time per Case	100 Hour (s)

- **Resources Used**

Fraction of Usage in Total Resources*1 (%): 0.04

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	356,945.64	0.04
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	267.53	0.28
/data	2,465.25	0.04
/ltmp	976.56	0.08

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage: Percentage of usage relative to each resource used in one year.