Nonhydrostatic dynamical core of an atmospheric general circulation model on a Yin-Yang grid

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1. Introduction

Grid systems for dynamical core of atmospheric general circulation model (AGCM) has been argued in the many previous studies, however, the best grid system has not been determined since both advantages and disadvantages are different in each grid system. We employed Yin-Yang grid and introduced nonhydrostatic dynamical core for our AGCM. Yin-Yang grid is one of the composite grids, which can obtain same advantages of other composite grids, and is superior in switching regional and global configurations that feature is suitable for simulating atmospheric flows in various scales. In order to obtain the advantages, we validated our model using two- and three-dimensional (2D and 3D) idealized test cases, and discussed reliabilities of our nonhydrostatic dynamical core.

2. Model descriptions and validation test cases

Our model is constructed using Yin-Yang grid, and it employs fully compressible nonhydrostatic equations for the dynamical core, using our original formulations (Baba et al. (2010)). 3rd-order upwind scheme and 3rd-order Runge-Kutta scheme of Wicker and Skamarock (2002) are basically used for computing advection and time integration, respectively. Spatial discretization for other terms is done with 2nd-order finite difference method on the Arakawa-C grid. 2D and 3D test cases are performed. In the 2D test cases, cases 1, 2, 5 and 6 cases of Williamson benchmark test cases (Williamson et al. 1992) are performed. 3D features are tested using global mountain gravity wave (Qian et al. 1998), Held-Suarez (Held and Suarez 1994) and life cycle experiments (Polvani et al. 2004).

3. Results and discussions

Our model can simulate all flow fields of 2D cases qualitatively well. Error analysis in the case 1 and case 2 of 2D test cases reveals that our model accuracy is 2nd-order. In the cases 5 and 6, conservation errors are analyzed for invariant values. The analysis shows that our model conservation is acceptable for the 2D cases.

Global mountain gravity wave experiments are performed with varying overset configurations, horizontal resolution and steepness of the mountain. Reasonable gravity waves are simulated and the results are almost identical regardless of the differences of horizontal resolutions and overset configurations. Held-Suarez experiments show that 3D feature of our model is improved as the resolution increases, and the conservation depends on the accuracy of the method for connecting Yin and Yang grids. In addition, conservation of our model in long-term integration is found to be acceptable. Influence of the overset region on the small-scale dynamics is tested on the life cycle experiment. Nevertheless the initial perturbation is given at the different points, the flow fields and error growth trends are almost identical (Fig.1).

These results indicate validity of our model, and the model can simulate both large and small scale dynamics accurately with acceptable spatial and conservation errors.

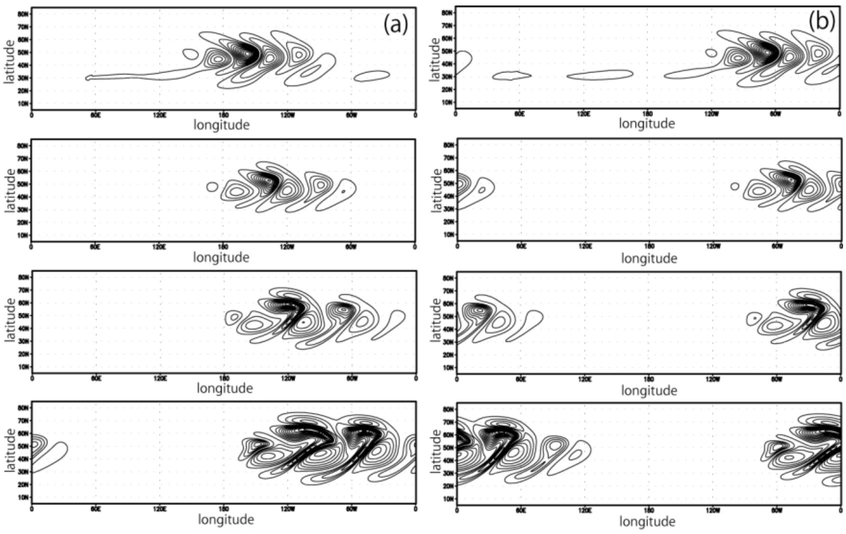

Figure 1: Vorticitity fields of life cycle experiment for during 12 days. Figures (a) and (b) are for different overset configurations.

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