Development of Yin-Yang Grid Global Model Using a New Dynamical Core ASUCA

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1. Introduction

Yin-Yang grid is a composite mesh proposed by Kageyama and Sato (2004). The technique allows us to create a global weather prediction model using a regional dynamical core. In 2009, Japan Meteorological Agency (JMA) initiated a fundamental research to develop a global non-hydrostatic model, and a Yin-Yang grid model, which is planned to use a regional model ASUCA (Ishida et al. 2010), has been one of candidates for a further development.

Many types of Yin-Yang grids have been proposed (Qaddouri and Lee 2011, Baba et al. 2010, Peng et al. 2006). The selection of the procedures is depending on discretization methods and advection or flux calculation schemes. The finite volume method with the boundary region exchange method (Sugimura et al. 2006) is examined in this study.

2. Non-hydrostatic model ASUCA

ASUCA is a regional NWP model developed by JMA, and will come into operation in the near future as a very high resolution (2km grid) operational forecasting system. ASUCA adopts features below;

- The finite volume method is used with a flux limiter by Koren (1993), which contributes to the monotonicity and conservation of scalar predictors,
- The general coordinate transformations are used, and it can accommodate some map projections, including
  - the Lambert conformal conic projection for regional forecasts
  - the latitude - longitude projection necessary for Yin-Yang grid.
- ASUCA adopts a Runge-Kutta time integration scheme proposed by Wicker and Skamarock (2002).

3. Global Model: ASUCA-Global

Various measures to compose a global model are examined using ASUCA and Yin-Yang grid, and the boundary region exchange method is found to be a suitable way for the finite volume method.

Figure 1 shows a 264 hour forecast result starting from 12 UTC 1 January 2014. 0.25 deg (about 28km) grids are used, and the time step length is 60 seconds. So far, no convective parameterization is used in this test.

There is no inconsistency found near the border (green line) between the Yin and Yang grid systems. The system is found to be computationally stable even when no numerical diffusion / viscosity are used.

Figure 2 shows execution times for a 72 hour forecast at HITACH SR16000 M1. The execution times are in inversely proportion to the number of nodes. This figure shows a good scalability with the system.

4. Summary

A Yin-Yang grid model with the finite volume method has been developed using the regional dynamical core ASUCA. Even when no numerical diffusion or viscosity is used, the system is found to be computationally stable. The system also shows a good scalability. Suitable physical parameterizations are needed for more realistic meteorological simulations.

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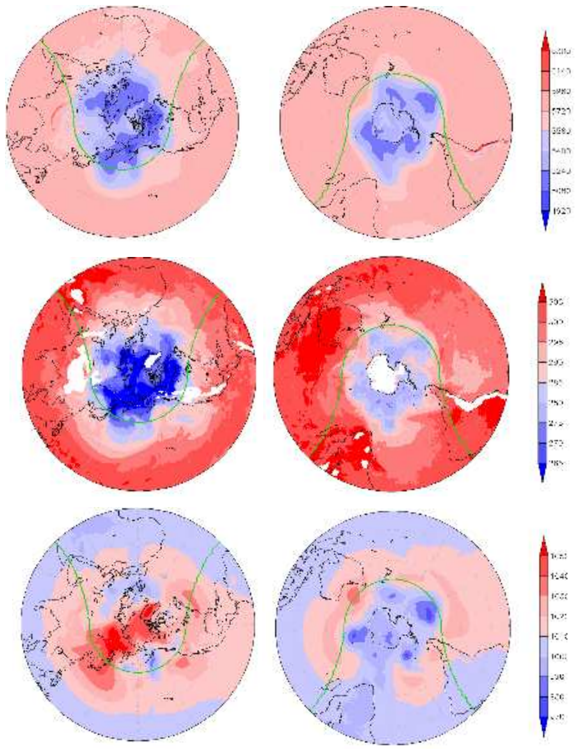

Figure 1 Results of a 264 hour forecast starting at 12 UTC 1 January 2014. The upper panels show height [m] of 500hpa level. The middle panels are distributions of potential temperature [K] at 850hPa, and the lowers are sea-level pressure for 12UTC 12 January 2014. The left panels indicate results for the northern hemisphere; the rights are for the southern hemisphere.

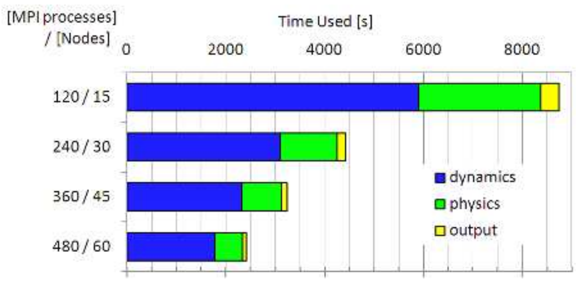

Figure 2 Execution times for a 72 hour forecast using different number of nodes / MPI processes. Dynamics, physics, and output indicate execution times used in each process. Time for MPI communication between the Yin / Yang grid systems is mainly involved in “dynamics”.