Development of a new dynamical core "ASUCA" at JMA

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1. Introduction

The Japan Meteorological Agency (JMA) nonhydrostatic model (JMANHM) is used to study a regional climate change in the vicinity of Japan under the framework of the "Projection of the change in future weather extremes using super-high-resolution atmospheric models" supported by the KAKUSHIN Program of the Ministry of MEXT. In order to promote this study, it is important to develop a new dynamical core which is higher accurate and higher computationally efficient. Therefore we are developing a new dynamical core, to which the results of recent researches are introduced. The new dynamical core is named ASUCA.

2. Outline of ASUCA

Flux-form fully compressible equations are applied as governing equations for the model. The prognostic variables are ρu, ρv, ρw, $\rho\theta_m$, ρq_x and ρ, where u, v and w are the components of wind velocity, ρ is the total mass density, q_x is a ratio of the density of a water substance x to the total mass density, respectively. In order to use the same state equation in the dry and moist system, $\theta_m = \theta(\rho_d/\rho + \varepsilon\rho_v/\rho)$ is introduced, where ε is a ratio of the Rv to the Rd. The equations are transformed using general coordinate transformations.

The equations are discretised using the finite volume method. The flux limiter function proposed by Koren (1993) is employed for monotonicity, which avoids numerical oscillations. The third-order Runge-Kutta scheme is adopted for time integration of the system. The terms responsible for the sound waves and gravity wave are treated using a split-explicit time integration scheme. Another time-splitting is also used to treat vertical advection of water substances with a fast terminal velocity (such as rain or graupel).

3. Experiment Results

A numerical experiment for nonhydrostatic scale inertia gravity waves, originally proposed by Skamarock and Klemp (1994), was carried out. The configurations used were identical to those in their paper with the exception of the time step of ASUCA, which was 60 s. The left and right parts of Fig. 1 show the numerical solutions obtained using ASUCA and the analytical solution, respectively. The numerical result is quite similar to the analytical solution.

The results of another numerical experiment for non-linear density current in which the result obtained by Straka et al. (1993) is usually used as a benchmark are shown in Fig. 2. The time steps are 1 s for $\Delta x = 50$ m and 2 s for $\Delta x = 100$ m. Both results are comparable to those of the benchmark.

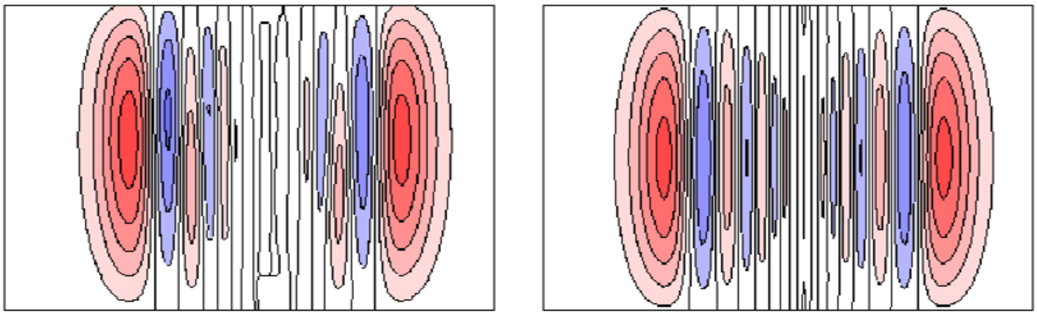

Fig 1: Inertia gravity test by Skamarock and Klemp (1994): Perturbation of θ at t = 3000 s of the numerical solution by ASUCA (left) and the analytical solution (right).

Fig 2: Non-linear density current test by Straka et al. (1993): Contours of θ at t = 15 min. The region is the same as that in Fig. 1 for Straka et al. (1993). The figures show the results obtained using ASUCA with $\Delta x = 50$ m (left) and $\Delta x = 100$ m (right).

References

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