The ICON dynamical core project: modelling strategies and preliminary results

Luca Bonaventura, Erich Roeckner
Max Planck Institut für Meteorologie
Bundesstraße 55,20146, Hamburg, Germany
e-mail: bonaventura@dkrz.de, roeckner@dkrz.de
Detlev Majewski
Deutscher Wetterdienst
Frankfurter Straße 135, Offenbach, Germany
e-mail: detlev.majewski@dwd.de

The ICON project is a joint development effort of MPIfM and DWD to achieve a unified climate and NWP model. The aim of the project is to overcome many of the shortcomings of current GCMs by appropriate finite volume discretizations on geodesic icosahedral grids.

The model under development in the ICON project will use the fully elastic, nonhydrostatic Navier-Stokes equations, which provide a framework that is sufficiently general for meteorological applications on most scales relevant for numerical weather prediction and climate simulation. In order to couple most consistently stratospheric and mesospheric chemical processes to the dynamics, air will be considered as a multicomponent medium. Conservation of air and tracer mass and consistency of the discretization of the continuity equations for air and tracers will be guaranteed.

As an intermediate step, a semi-implicit discretization for the shallow water equations has been developed. In contrast to other recent discretization approaches on the icosahedral grid (see e.g. [2], [4]) the proposed discretization uses the triangular Delaunay cells of the icosahedral grid as control volumes. It achieves mass and potential enstrophy conservation, thus replicating the results of [3] for standard rectangular C grids. The Raviart-Thomas finite element of order zero is used to reconstruct a uniquely defined velocity field from the velocity components normal to the cell sides, which are the discrete model variables along with the cell averaged value of the geopotential height. A predictor corrector approach along the lines of [1] is used for the discretization of the nonlinear advection terms. The results obtained with a preliminary implementation on an idealized test case (see e.g. [5]) are shown in figure 1. Extensions of the same technique to the Euler equations for global nonhydrostatic modelling are currently being investigated.

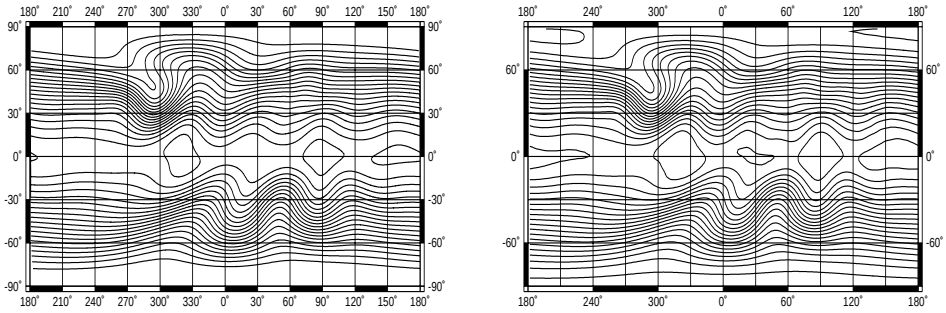

Figure 1: Height field at day 10 for test case 5 of [5] computed by the mass conservative shallow water model on the triangular icosahedral grid with 81920 triangles (left) and by the NCAR reference spectral model at resolution T63 (right). Contours spacing is 50 m.

References

[1] Shian-Jiann Lin and Richard B. Rood. An explicit flux-form semi-Lagrangian shallow water model on the sphere. *Quarterly Journal of the Royal Meteorological Society*, 123:2477–2498, 1997.

[2] Todd D. Ringler, Ross P. Heikes, and David A. Randall. Modeling the atmospheric general circulation using a spherical geodesic grid: A new class of dynamical cores. *Monthly Weather Review*, 128:2471–2490, July 2000.

[3] R. Sadourny. The dynamics of finite difference models of the shallow water equations. *Journal of the Atmospheric Sciences*, 32:680–689, 1975.

[4] H. Tomita, M. Tsugawa, M.Satoh, and K.Goto. Shallow water model on a modified icosahedral grid by using spring dynamics. *Journal of Computational Physics*, 174:579–613, 2001.

[5] David L. Williamson, John B. Drake, James J. Hack, Rüdiger Jakob, and Raul N. Swarztrauber. A standard test set for numerical approximations to the shallow water equations in spherical geometry. *Journal of Computational Physics*, 102:221–224, 1992.