Geophysical Research Abstracts, Vol. 7, 05582, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05582

A unified model approach from meso to global scales

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The Nonhydrostatic Mesoscale Model (NMM) has been developed within the WRF effort building on NWP experience. Namely, the nonhydrostatic dynamics were formulated relaxing the hydrostatic approximation in a successful regional hydrostatic NWP formulation. In this way the validity of the model dynamics is extended to nonhydrostatic motions, and the preferred features of the hydrostatic formulation are preserved. The nonhydrostatic extension is introduced through add–on module that can be turned on or off. The extra computational cost of the nonhydrostatic dynamics is low, or nonexistent if the nonhydrostatic extension is switched off at coarser resolutions, which makes this approach attractive for models designed for a wide range of horizontal resolutions, and in particular for unified global and regional forecasting systems. In order to explore the capabilities of the formulation on larger spatial and temporal scales, a global version of the model is being developed.

In the model, “isotropic” horizontal finite differencing is employed that conserves a variety of basic and derived dynamical and quadratic quantities. Among these, the conservation of energy and enstrophy improves the accuracy of the nonlinear dynamics of the model on all scales, and renders the model suitable for extended global integrations. In the vertical, the hybrid pressure-sigma coordinate is used. The forward-backward scheme is used for horizontally propagating fast waves, and an implicit scheme is used for vertically propagating sound waves. The Adams-Bashforth scheme is applied for non-split horizontal advection of the basic dynamical variables and for the Coriolis force. In order to eliminate stability problems due to thin vertical layers, the Crank-Nicholson scheme is used to compute the contributions of vertical advection. In the initial global version “rigid wall” polar boundary conditions are specified and polar filtering is used. Another approach to the problem of spherical geometry is also being considered.

Despite the complexity of the finite differencing, the computational efficiency of the global model estimated on the basis of the performance of the existing serial code is competitive with computational efficiency of semi-Lagrangian models. The accuracy of extended experimental forecasts with currently used modest horizontal resolution of about 110 km is also encouraging. Successful completion of this project will allow the use of the same model dynamics on a very wide range of spatial scales, from LES studies to climate simulation. Moreover, the high computational efficiency of the model promises the possibility of application of nonhydrostatic dynamics on the global scale when the single digit resolutions become affordable.