The Icosahedral Nonhydrostatic (ICON) modelling framework: Basic formulation, NWP and high-performance computing aspects, and its perspective towards a unified model for seamless prediction

Günther Zängl, Daniel Reinert, Florian Prill, Martin Köhler, Slavko Brdar

Deutscher Wetterdienst, Offenbach, Germany

Marco Giorgetta, Leonidas Linardakis, Luis Kornblueh

Max-Planck-Institute for Meteorology, Hamburg, Germany

An overview is given of the present development status of the Icosahedral Nonhydrostatic (ICON) modeling framework, which is being developed jointly at the German Weather Service (DWD) and the Max-Planck-Institute for Meteorology (MPI-M). Its nonhydrostatic dynamical core is formulated on an unstructured icosahedral-triangular C-grid and uses the edge-normal wind component, the vertical wind speed, density and virtual potential temperature as prognostic variables. Time integration is performed with a second-order predictor-corrector scheme that is fully explicit in the horizontal and implicit for the terms entering into vertical sound wave propagation. To achieve computational efficiency, time splitting is applied between the dynamical core on the one hand and tracer advection and the physics parameterizations on the other hand, the time step ratio usually being 5. Moreover, the variable inner loop length enabled by the unstructured grid formulation allows efficient usage of a variety of computational platforms. For typical numerical weather prediction (NWP) applications, ICON is between a factor of 3 and 4 faster than the hydrostatic GME presently operational at DWD. In addition, ICON exhibits much better scaling properties than the GME due to the absence of global communication (except for optional diagnostic calculations).

Extensive NWP tests reveal that—after appropriate tuning of the physics parameterizations—ICON exhibits significantly better NWP forecast skills than GME. The flexibility and maturity of ICON will also be demonstrated with a case study of tropical cyclone Haiyan (which devastated the Philippines in November 2013), applying the two-way nesting capability in order to achieve a convection-permitting mesh size of 2.5 km in the inner domain. Moreover, a limited-area mode has recently been developed for ICON that in the mid-term future will allow to use it as a unified model for the whole chain of operational applications.