Grid Refinement in ICON

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We describe the implementation of grid refinement in the atmosphere component of the ICOsahedral Nonhydrostatic (ICON) modeling system. It basically follows the classical two-way-nesting approach known from widely used mesoscale models like MM5 or WRF, but differs in the way how feedback from fine grids to coarser grids is applied. Moreover, the ICON implementation supports vertical nesting in the sense that the upper boundary of a nested domain may be lower than that of its parent domain. Compared to the well-established implementations on quadrilateral grids, new methods had to be developed for interpolating the lateral boundary conditions from the parent domain to the child domain(s) on triangular grids. These are based on radial basis functions (RBFs) and partly apply direct reconstruction of the prognostic variables at the required grid points, whereas gradient-based extrapolation from parent to child grid points is used in other cases. The technical implementation on the unstructured ICON grid is based upon sorting the boundary interpolation points at the beginning of the grid-point index vector, so that computations on boundary interpolation points can be excluded by appropriate start indices without the need of IF masks. The run-time flow control is written such that limited-area domains can be processed identically to nested domains except for the lateral boundary data supply.

To demonstrate the functionality and quality of the grid nesting in ICON, we present idealized tests based on the Schär mountain wave test case (Schär et al., 2002) and the Jablonowski-Williamson test case (Jablonowski and Williamson, 2006). The results show that the numerical disturbances induced at the nest boundaries are small enough to be negligible for real applications. This is confirmed by experiments closely following the configuration used for operational numerical weather prediction at DWD, which demonstrate that a regional refinement over Europe has a significant positive impact on the forecast quality in the northern hemisphere.

References
