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Exploring the effects of an improved vertical discretization in ICON

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The vertical discretisation in the Icosahedral Nonhydrostatic modelling framework (ICON) is formulated in a generalized height-based system with Lorenz-type staggering, where scalars (density, exner pressure, tracer mass fractions) are defined at cell centers, whereas vertical velocity is defined at cell interfaces. Conceptionally we distinguish between the dynamical core, which integrates the momentum equation, the thermodynamic equation and the air mass continuity equation, and the transport module, which integrates a variable number of tracer mass continuity equations.

For the dynamical core, the spatial discretisation methods applied in the vertical are mostly of second-order. In particular this applies to the approximation of vertical gradients, the interpolation from cell centers to cell interfaces as well as to the computation of advective fluxes.

For vertical tracer transport, however, higher order flux computation methods like the Piecewise Parabolic Method (PPM) or the Parabolic Spline Method (PSM) are available in ICON. Both methods build on parabolic reconstructions of scalar subgrid distributions, as well as higher-order explicit and implicit schemes for estimating unknown interface values.

In this work the key question to be answered is whether any benefit can be gained from replacing the existing second-order methods for vertical interpolation and flux reconstruction in the dynamical core by those higher order methods, which are more or less readily available from the PPM and PSM implementation.

We will present preliminary results from applying both variants of the dynamical core (with and without improved vertical discretisation) to an idealized global baroclinic instability test case. Potential improvements in the structure of the simulated baroclinic instability at a fixed resolution will be set in relation to the increase in computational costs.