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A novel non-hydrostatic, semi-implicit, semi-Lagrangian scheme for limited-area NWP models

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SISL schemes require separation of forcing terms in Lagrangian dynamic equations to the main, linear terms and supplementary non-linear disturbances, with the subsequent application of implicit and explicit time-discretizations to the linear and nonlinear parts, respectively. At that, the choice of the reference state, in respect to which the linear part is constructed, is an important issue. A conventional choice so far has been to take the reference-state temperature constant.

In this paper, a novel approach is developed, in which the reference temperature $T^r(p,t)$, a function of pressure p and time t, is chosen as the area-mean of the actual temperature $T(x,y,p,t)$ at the fixed pressure level. Due to this, the reference temperature T^r is rather close to the actual temperature T at every instant and in every point. Consequently, the implicit linear terms will include the maximum of the complete forcing, while the nonlinear supplementation, proportional to the temperature fluctuations $T' = T - T^r$, is minimal. As a result, the precision and stability characteristics of the SISL scheme would improve considerably.

The approach is realized as a nonhydrostatic hybrid-coordinate extension to the limited area model HIRLAM. The created numerical scheme is checked both in the artificial orographic flow experiments and in the realistic forecast conditions. Model allows 1 minute time-step at 0.5 km horizontal and 100 level vertical resolution.