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Finite elements used in the vertical discretization of the fully compressible forecast model ALADIN-NH

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The ALADIN-NH is a fully compressible spectral limited area NWP model being designed on the basis of ARPEGE/IFS global forecasting system in frames of the ALADIN consortium.

The hybrid terrain-following vertical coordinate of Laprise (1992) together with the finite difference scheme of Simmons and Burridge (1981) was used for vertical discretization since the beginning of the project. This scheme is only first order accurate for given non-uniform spacing of vertical levels. An alternative finite element (FE) vertical discretization was implemented in the ECMWF global forecast model
IFS by Untch and Hortal (2004) and adapted to the hydrostatic version of ALADIN with the accuracy being enhanced to forth order in between nodes and even to eight order at the nodes. Here the only vertical operations to be evaluated in FE representations are vertical integrals, while products of variables are evaluated in physical space.

We describe an extension of the FE vertical discretization to the fully compressible ALADIN-NH model with not only the representation of vertical integrals, but with vertical first and second derivatives being present in the system of equations and treated in FE manner as well. In the proposed implementation of the FE method we aimed at the
comparable stability properties as for the FD method in both idealized experiments and real simulations with accuracy enhanced in dependence on the order of basis functions used for its design. We describe the basic equations and their FE vertical discretization together with the semi-implicit time scheme and the consequences that the usage of
FE method in vertical has on its design. Further, we summarize results of idealized test cases and compare the proposed method with the finite difference method on real case experiments.