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Theoretical and numerical analysis of convergence properties of the higher order spatial schemes in the COSMO model

J. Ogaja and A. Will

Environmental Meteorology, Brandenburg University of Technology (BTU), Cottbus, Germany (ogaja@tu-cottbus.de)

The convergence properties of the spatial discretization schemes of the Runge Kutta dynamical core of the COSMO model have been investigated theoretically and numerically. The theoretical convergence of the spatial discretisation error was found to be 2nd order for all schemes. The 2D stationary mountain flow test case (stationary gravity wave) exhibited a convergence of 2 for the 2nd order advection scheme and significantly smaller convergence properties for the higher order schemes. Higher order advection schemes, the accuracy of metric terms and the parameterisation of the boundary conditions have been implemented. The individual effects of the developments will be presented and the relevance for real case studies will be discussed.

The analysis of the convergence of the spatial discretisation error was done by Taylor series expansion of the schemes implemented.

The numerical analysis was done by investigation of the results of the 2D stationary mountain flow idealized test case. The main assumptions of this test case are stationarity, z-dependency of the basic flow (u0=u0(z)) and zero vertical velocity (i.e. w0=0) and unbounded domain in the lateral and upward direction. An appropriate configuration could be developed, which allowed to keep the errors resulting from other error sources sufficiently small. The error sources controlled are the test case assumptions, the vertical discretisation and the boundary conditions. The accuracy of the test case was investigated by modification of the boundary condition parameters, vertical discretisation and simulation time. The final domain size of the test case was 500x25 km2 and the spatial resolutions investigated have been up to 1000 vertical levels and 4000 horizontal grid points. The investigation of the convergence properties for other test cases (solid body rotation and wave propagation) is ongoing. The first allows to separate the interpolation and the differencing the latter allows to separate the amplitude and the phase convergence error.

The results will be presented for spatial resolutions between 250m to 4km. They exhibit the same convergence for the maximum (L0), mean (L1) and standard deviation (L2) error norms. The differences between the horizontal and the vertical velocity convergence will be discussed.

A systematic series of simulations was conducted for all types of horizontal discretisation available and for the schemes implemented.