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ON TIME STEPPING FOR METEROLOGICAL APPLICATIONS USING THE DISCONTINUOUS GALERKIN METHOD

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We introduce a dynamic core based on the Discontinuous Galerkin method, implemented within the Dune software framework (www.dune-project.org/fem). We first study the efficiency, and scalability of the code using an explicit time stepping scheme and also compare it with the operational COSMO model in cooperation with the German Weather service. Our results clearly demonstrate the effectiveness and efficiency of the DG scheme in general but meteorological problems have special features which makes the method not always usable in these situations. One of the main problems is caused by the wave speeds separation and the unisotropy in the grid. This leads to prohibitive small time step sizes to obtain a stale explicit time stepping scheme. To overcome this problem we investigate implicit and semi implicit methods. This part of a dynamical core accounts for a significant proportion of the overall runtime and has to run very efficiently and scale to hundreds of thousands of processor cores.

Our starting point is a matrix free Newton-Krylov solver. A major advantage of this approach is its low memory consumption and that it does not require to compute a jacobian of the non-linear spatial operator. A major problem however is the difficulty of constructing a suitable preconditioner. We study an approach based on a special linearized operator and investigate different simplifications to reduce the complexity of the computations.

The Implicit time stepping can be accelerated by solving a linear elliptic problem in each time step (Schur complement or Helmholtz equation). We study the efficiency of a matrix-free parallel geometric multigrid code with a vertical line smoother based on a simplistic discretization of the Helmholtz problem. We demonstrate the scalability of the solver on up to 65536 cores of the Hector supercomputer. We investigate different options to make use the tensor structure of the underlying mesh, which is unstructured in the horizontal but structured in the vertical. We demonstrate the effectiveness of our method for different test cases.