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Viability and performance of grid-point solvers for solving the implicit problem of the dynamical core AROME

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Semi-implicit semi-lagrangian algorithms are often used for hydrostatic models and allow a good efficiency by using long time steps. Moreover, the spectral method is able to compute with a great accuracy horizontal derivatives and to make easier the inversion of the implicit problem at each time step. This problem to be solved in space comes from the temporal implicit discretization which allows to stabilize the model for large time steps, thereby making the forecast potentially more efficient than with models using explicit temporal discretizations.

For AROME, the limited-area model of Météo-France, it has been chosen to extend the spectral semi-implicit semi-lagrangian method in the mass-based coordinate system to non-hydrostatic equations. At each time step a transform from grid-point space to spectral space and back are performed. Because of their non local nature, these transforms require global (all-to-all) communications in order to transfer the information from distant points of the domain. The computational cost, reasonable today, could increase on future computing architectures.

Météo-France needs to keep an efficient operational non-hydrostatic model by improving the scalability of the AROME model, and consequently by substituting the spectral solver to a grid-point one. Indeed, it has been established that iterative methods in Krylov spaces are among the most efficient for solving the grid point problem and have good scalability properties.

The aim of this study is to explore the viability and the convergence of these grid-point methods in bidimensional idealised test cases, and in almost operational configurations in real cases. First results showed these methods are as viable as similar non-hydrostatic models. A definition of a stop criterion is also discussed and some basic preconditionning techniques are introduced to improve the rate of convergence of the iterative method. Now, our aim is to improve stability properties of AROME with steep slopes.