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Implementation of multirate time integration methods for air pollution modelling

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Abstract. Explicit time integration methods are characterised by a small numerical effort per time step. In the application to multiscale problems in atmospheric modelling, this benefit is often more than compensated by stability problems and step size restrictions resulting from stiff chemical reaction terms and from a locally varying Courant-Friedrichs-Lewy (CFL) condition for the advection terms. Splitting methods may be applied to efficiently combine implicit and explicit methods (IMEX splitting). Complementarily multirate time integration schemes allow for a local adaptation of the time step size to the grid size. In combination, these approaches lead to schemes which are efficient in terms of evaluations of the right-hand side. Special challenges arise when these methods are to be implemented. For an efficient implementation, it is crucial to locate and exploit redundancies. Furthermore, the more complex programme flow may lead to computational overhead which, in the worst case, more than compensates the theoretical gain in efficiency. We present a general splitting approach which allows both for IMEX splittings and for local time step adaptation. The main focus is on an efficient implementation of this approach for parallel computation on computer clusters.

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