A general class of multirate Runge-Kutta methods for coupled atmosphere-ocean models

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Coupled atmosphere-ocean models are applied for studying physical processes at the air-sea interface. The exchange at the air-sea interface, i.e. at the coupling interface, is conducted in each integration step. However, to reduce computational and energy costs for large simulations, individual time steps are used for the atmosphere and ocean part. The exchange at the air-sea interface is then conducted either with the large time step of the slow ocean component or with an even larger individual time step.
Multirate Runge-Kutta methods are an approach for efficient integration of differential equations with different time scales. The main idea of multirate approaches is the splitting or partitioning of a problem into several time scaled parts. The simplest splitting type is a linear combination.
A general formulation of a class of multirate Runge-Kutta methods is presented which can be applied to split problems with an arbitrary number of additive parts. This class of methods also allows different time scales for each part, with no restrictions on the choice of time scales.
Furthermore, a method for a problem split into three parts is developed and presented as well as illustrated with a simulation of a coupled atmosphere-ocean model.

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