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Seamless integration of hydrostatic, soundproof and fully compressible equations

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When written in conservation form for mass, momentum, and density-weighted potential temperature, and with Exner pressure in the momentum equation, the pseudoincompressible model and the hydrostatic model only differ from the full compressible equations by some additive terms. This structural proximity can be faithfully transferred to a numerical discretization providing seamless access to all three analytical models.

This lecture will discuss the theoretical background of the models from the perspective of asymptotic analysis and it will introduce the numerical scheme proposed recently by Benacchio and the author (MWR, 147, 2019).

The semi-implicit second-order scheme discretizes the rotating compressible equations by evolving full variables, and, optionally, with two auxiliary fields that facilitate the construction of an implicit pressure equation. Time steps are constrained by the advection speed only as a result. Borrowing ideas on forward-in-time differencing, the algorithm reframes the authors'previously proposed schemes into a sequence of implicit midpoint step, advection step, and implicit trapezoidal step.

The proposed scheme generalizes the authors'acoustics-balanced initialization strategy to also cover the hydrostatic case in the framework of an all-scale blended multimodel solver.

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