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A CONSISTENT ILES FRAMEWORK FOR ALL-SCALE ATMOSPHERIC DYNAMICS

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A consistent ILES framework is developed for conservative integrations of soundproof and the fully compressible nonhydrostatic equations of motion for all-scale atmospheric dynamics, comprising low Mach number, high-Reynolds number, rotating stratified flows under gravity. The reduced soundproof PDEs and the compressible Euler PDEs are formulated as a generalised system of conservation laws for mass, momentum and entropy that facilitates the design of a sole principal algorithm for its integration. The development relies on non-oscillatory forward-in-time transport methods [1] with proven ILES properties [2], applied consistently to all dependent variables of the generalised system. Semi-implicit time-discretisation of the buoyant and rotational forcings enhances the stability and the accuracy of integrations. Furthermore, when the compressible equations are solved, the framework allows for either an explicit or implicit representation of acoustic modes, thus providing, respectively, the reference and large-time-step variants of compressible solutions. The latter is competitive in computational efficiency with soundproof schemes. In essence, the differences between the soundproof and compressible integrators reduce to the selection of either a prescribed or a numerically prognosed density, and extension of the generalised Poisson solver [3] to a bespoke Helmholtz solver. The numerical advancements and the relative merits of soundproof and compressible PDEs are illustrated with canonical simulations of planetary baroclinic instability and the breaking of a deep stratospheric gravity waves, archetypes of planetary weather and nonhydrostatic mesoscale dynamics.

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