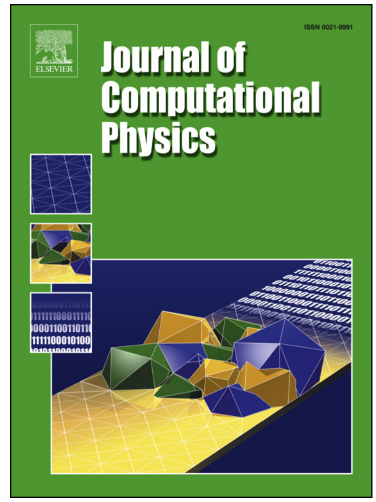

A finite-volume module for simulating global all-scale atmospheric flows

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A finite-volume module for simulating global all-scale atmospheric flows

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Abstract

The paper documents the development of a global nonhydrostatic finite-volume module designed to enhance an established spectral-transform based numerical weather prediction (NWP) model. The module adheres to NWP standards, with formulation of the governing equations based on the classical meteorological latitude-longitude spherical framework. In the horizontal, a bespoke unstructured mesh with finite-volumes built about the reduced Gaussian grid of the existing NWP model circumvents the notorious stiffness in the polar regions of the spherical framework. All dependent variables are co-located, accommodating both spectral-transform and grid-point solutions at the same physical locations. In the vertical, a uniform finite-difference discretisation facilitates the solution of intricate elliptic problems in thin spherical shells, while the pliancy of the physical vertical coordinate is delegated to generalised continuous transformations between computational and physical space. The newly developed module assumes the compressible Euler equations as default, but includes reduced soundproof PDEs as an option. Furthermore, it employs semi-implicit forward-in-time integrators of the governing PDE systems, akin to but more general than those used in the NWP model. The module shares the equal regions parallelisation scheme with the NWP model, with multiple layers of parallelism hybridising MPI tasks and OpenMP threads. The efficacy of the developed nonhydrostatic module is illustrated with benchmarks of idealised global weather.

Key words: atmospheric models, hierarchical modelling, non-oscillatory forward-in-time schemes, gravity waves, numerical weather prediction
PACS:

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