AN ALL-SCALE ANELASTIC MODEL FOR GEOPHYSICAL FLOWS: DYNAMIC GRID DEFORMATION

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Abstract

We have developed an adaptive grid-refinement approach for simulating geophysical flows on scales from micro to planetary. Our model is nonoscillatory forward-in-time (NFT), nonhydrostatic, and anelastic. The major focus in this effort to date has been the design of a generalized mathematical framework for the implementation of deformable coordinates and its efficient numerical coding in a generic Eulerian/semi-Lagrangian NFT format. The key prerequisite of the adaptive grid is a time-dependent coordinate transformation, implemented rigorously throughout the governing equations of the model. The transformation enables mesh refinement indirectly via dynamic change of the metric coefficients, while retaining advantages of Cartesian mesh calculations (speed, low memory requirements, and accuracy) conducted fully in the computational domain. Diverse test results presented in this paper --- simulations of a traveling stratospheric inertia-gravity-wave packet (with numerically advected dense-mesh region) and an idealized climate of the Earth (with analytically prescribed adaptive transformations) --- clearly demonstrate the potential and the efficacy of the new deformable grid model for tracing targeted flow features and dynamically adjusting to prescribed undulations of model boundaries.

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