FORWARD-IN-TIME DIFFERENCING FOR FLUIDS: SIMULATION OF GEOPHYSICAL TURBULENCE[1]

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Abstract

The Earth's atmosphere and oceans are essentially incompressible, highly turbulent fluids. Herein, we demonstrate that nonoscillatory forward-in-time (NFT) methods can be effi-ciently utilized to accurately simulate a broad range of flows in these fluids. NFT methods contrast with the more traditional centered-in-time-and-space approach that underlies the bulk of computational experience in the meteorological community. We challenge the common misconception that NFT schemes are overly diffusive and therefore inadequate for high Reynolds number flow simulations, and document their numerous benefits. In particular, we show that, in the absence of an explicit subgrid-scale turbulence model, NFT methods offer means of implicit subgrid-scale modeling that can be quite effective in assuring a quality large-eddy-simulation of high Reynolds number flows. The latter is especially important where complications such as large span of scales, density stratification, planetary rotation, inhomogeneity of the lower boundary, etc., make explicit modeling of subgrid-scale motions difficult. Theoretical discussions are illustrated with examples of meteorological flows that address the range of applications from micro turbulence to climate.

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