Aspect-ratio effects on Burger number unity Boussinesq flows

Derivation and Analysis of Nonlinear Evolution Equations for Multiscale Physics

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Abstract

Rotating and stably stratified Boussinesq flow is investigated for Burger number unity for small and unit aspect-ratio domains. To achieve Burger number unity, the non-dimensional rotation and stratification frequencies (Rossby and Froude numbers respectively) are both small and set equal to each other. When Rossby and Froude are very small the vortical energy in both unit and small aspect-ratio domains achieve k^{-3}quasi-geostrophic spectral scaling. However, the wave energy spectrum for the small aspect ratio domain shows scaling that is very different from the well-known k^{-1} scaling observed for the same asymptotics at unit aspect-ratio. Visualization of the wave component of the horizontal velocity in the small aspect ratio domain reveals a tendency towards a layered structure while there is no evidence of layering in the unit aspect ratio case. We conclude that the behavior for asymptotically small Rossby and Froude in unit Burger number flows has significant dependence on the domain aspect-ratio.

The small aspect-ratio Boussinesq simulation described was computed on anisotropic grid of 2048 x 2048 x 512 points, with at least five timesteps used to resolved the fastest wave frequencies. The simulation and analysis took about 15 million CPU hours on the Argonne Leadership Computing Facility, Blue Gene/P (Intrepid).