Physics > Fluid Dynamics

Joint downscale fluxes of energy and potential enstrophy in rotating stratified Boussinesq flows

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We employ a coarse-graining approach to analyze nonlinear cascades in Boussinesq flows using high-resolution simulation data. We derive budgets which resolve the evolution of energy and potential enstrophy simultaneously in space and in scale. We then use numerical simulations of Boussinesq flows, with forcing in the large-scales, and fixed rotation and stable stratification along the vertical axis, to study the inter-scale flux of energy and potential enstrophy in three different regimes of stratification and rotation: (i) strong rotation and moderate stratification, (ii) moderate rotation and strong stratification, and (iii) equally strong stratification and rotation. In all three cases, we observe constant fluxes of both global invariants, the mean energy and mean potential enstrophy, from large to small scales. The existence of constant potential enstrophy flux ranges provides the first direct empirical evidence in support of the notion of a cascade of potential enstrophy. The persistent forward cascade of the two invariants reflects a marked departure of these flows from two-dimensional turbulence.

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