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Steady, Free Circulation in a Stratified Quasi-Geostrophic Ocean

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ABSTRACT

Steady solutions in which quasi-geostrophic potential vorticity is constant along a streamline of the flow are derived for a baroclinic ocean. Friction, transfer by geostrophic eddies, and wind forcing are treated as high-order effects that serve only to remove the indeterminacy of completely free flow. Solutions are obtained that are a generalization to a baroclinic ocean of Fofonoff's barotropic calculations. The vortex stretching permitted by stratification is found to allow gyres in which, in an integral sense, lateral down-gradient eddy transfer of potential vorticity, q , balances the wind-stress curl. Beneath the surface layer, the effect of eddies is then to make q uniform if q contours close on themselves

Our simple solutions have many features in common with observations of the subtropical recirculation and with the cream flows obtained from eddy-resolving, quasi-geostrophic numerical models. In particular, the southern margin of the recirculation is found to recede progressively toward the line of zero wind-stress curl with increasing depth, the isopycnals sloping downward toward the northern boundary of the subtropical gyre.

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