Nonlinear Sciences > Chaotic Dynamics

The dynamics of the gradient of potential vorticity

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The transport of the potential vorticity gradient $\bnabla{q}$ along surfaces of constant temperature θ is investigated for the stratified Euler, Navier-Stokes and hydrostatic primitive equations of the oceans and atmosphere using the divergenceless flux vector $\bdB = \bnabla Q(q)\times\bnabla\theta$, for any smooth function $Q(q)$. The flux $\bdB$ is shown to satisfy $$ \partial_t\bdB - {curl} (\bU\times\bdB) = - \bnabla\big[qQ'(q) {div} \bU\big]\times\bnabla\theta, $$ where $\bU$ is a formal transport velocity of PV flux. While the left hand side of this expression is reminiscent of the frozen-in magnetic field flux in magnetohydrodynamics, the non-zero right hand side means that $\bdB$ is not frozen into the flow of $\bU$ when ${div} \bU \neq 0$. The result may apply to measurements of potential vorticity and potential temperature at the tropopause.

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