

## Nonlinear Sciences &gt; Chaotic Dynamics

# The dynamics of the gradient of potential vorticity

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The transport of the potential vorticity gradient  $\nabla\{q\}$  along surfaces of constant temperature  $\theta$  is investigated for the stratified Euler, Navier-Stokes and hydrostatic primitive equations of the oceans and atmosphere using the divergenceless flux vector  $\mathbf{B} = \nabla Q(q) \times \nabla\theta$ , for any smooth function  $Q(q)$ . The flux  $\mathbf{B}$  is shown to satisfy  $\partial_t \mathbf{B} - \text{curl}(\mathbf{U} \times \mathbf{B}) = -\nabla \text{div}[\mathbf{U} Q'(q)] \times \nabla\theta$ , where  $\mathbf{U}$  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  $\mathbf{B}$  is not frozen into the flow of  $\mathbf{U}$  when  $\text{div} \mathbf{U} \neq 0$ . The result may apply to measurements of potential vorticity and potential temperature at the tropopause.

Comments: 8 pages, 1 figure. Comments welcome! Accepted at J Phys A

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