Abstract View

Volume 12, Issue 12 (December 1982)

Journal of Physical Oceanography
Article: pp. 1417–1436 | Abstract | PDF (1.32M)

North Atlantic Potential Vorticity and Its Relation to the General Circulation

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(Manuscript received February 15, 1982, in final form July 15, 1982)

DOI: 10.1175/1520-0485(1982)012<1417:NAPVAI>2.0.CO;2

ABSTRACT

Maps and sections of the large-scale North Atlantic potential vorticity q are presented. Here q is $fd\rho/dz$, where f is the Coriolis frequency, ρ the potential density and z the vertical coordinate. They bear on the general circulation, and on geostrophic waves, instability and turbulence in many ways; both Eulerian and Lagrangian mean circulations proceed along isostrophes, q=constant, in a zero-dissipation region. In a resting fluid q varies simply as the sine of the latitude, but we show here that the wind-driven circulation reshapes the q-field, creating “bowls” and “plateaus” which allow the flow to cross latitude circles. The implied nature of the western boundary current is very different than in classical frictional theory. The maps show a region of uniform potential vorticity in the wind gyre (σ_θ=26.5–27.0) which fills the ocean between 15–37° N and 20–80°W. Such regions were prominent features of a circulation theory of Rhines and Young (1982a,b). At deeper levels, and close to surface outcrops of the density layers, the isostrophes are “open,” extending over a vast latitude range in mid-ocean. They provide flow paths, for example, which connect the Labrador Sea and the subtropical deep ocean without the need of dissipation of potential vorticity.

The maps of q show where the North Atlantic is susceptible to baroclinic instability. The generalized Rayleigh criterion for instability is satisfied in a large region south of the center of the wind gyre, between 10 and 32°N. This supports the idea that eddy production is a strong feature of the subtropical mid-ocean regions.

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