Abstract View

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Available Potential Energy for MODE Eddies

N.A. Bray and N.P. Fofonoff

Woods Hole Oceanographic Institution, Woods Hole, MA 02543

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ABSTRACT

Available, potential energy (APE) is defined as the difference between total potential plus internal energy of a fluid in a gravity field and a corresponding reference field in which the fluid is redistributed (leveled) adiabatically to have constant stably-stratified densities along geopotential surfaces. Potential energy changes result from local shifts of fluid mass relative to geopotential surfaces that are accompanied by local changes of enthalpy and internal energy and global shifts of mass (because volumes of fluid elements are not conserved) that do not change enthalpy or internal energy. The potential energy changes are examined separately by computing available gravitational potential energy (GPE) per unit mass and total GPE (TGPE) per unit area.

A technique for estimating GPF, in the ocean is developed by introducing a reference density field (or an equivalent specific volume anomaly field) that is a function of pressure only and is connected to the observed field by adiabatic vertical displacements. The full empirical equation of state for seawater is used in the computational algorithm. The accuracy of the estimate is limited by the data and sampling and not by the algorithm itself, which can be made as precise as desired.

The reference density field defined locally for an ocean region allows redefinition of dynamic height ΔD (potential energy per unit mass) relative to the reference field. TGPE per unit area becomes simply the horizontal average of dynamic height integrated over depth in the region considered. The reference density surfaces provide a precise approximation to material surfaces for tracing conservative variables such as salinity and potential temperature and for estimating vortex stretching between surfaces.

The procedure is applied to the MODE density data collected in 1973. For each group of stations within five 2-week time windows (designated Groups A–E) the estimated GPE is compared with the net APE based on the Boussinesq approximation and to the low-frequency kinetic energy measured from moored buoys. Changes of potential energy of the reference field from one time window to the next are large compared with the GPE within each window, indicating the presence of scales larger than the station grid.

An analysis of errors has been made to show the sensitivity of the estimates to data accuracy and sampling frequency.

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Headquarters: 45 Beacon Street Boston, MA 02108-3693
DC Office: 1120 G Street, NW, Suite 800 Washington DC, 20005-3826
amsinfo@ametsoc.org Phone: 617-227-2425 Fax: 617-742-8718