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Eddy-shape signature in Thorpe's displacement profiles : advances in characterization of turbulent overturns.

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The detection of inversions in density profiles is commonly used to find locations of vigorous mixing in the ocean. When turbulence, induced by shear or internal wave breaking, is strong enough to overturn the isopycnals, dense water masses can come upon less dense water, leading to an unstable configuration and to mixing. Thorpe (1977) has proposed to compute the local displacement of fluid parcels by adiabatically sorting the density profile, and the variance of this so-called Thorpe's displacement is used as an estimate of the size of turbulent eddies. Thorpe's displacement is also related, via the Ozmidov scale, to the turbulent eddy diffusity and the turbulent dissipation rate, using the formulas from Dillon (1982).

Still, little is known about the precise scenario leading to the observed inversions. Thorpe (1977) suggests that internal wave breaking or Kelvin-Helmholtz instabilities can produce inversions. We wanted to see if more information about the dynamics of the overturn could be retrieved from the displacement profile itself. When displayed as function of z, the displacement points d(z) reveals a characteristic zig-zag shape. The zig-zag itself consists of branches with different slopes. Using model-overturns, we show that the inner slope equals 1/2 for a half-turn solid body rotation, while a more sophisticated Rankine vortex overturn model, here employed on half a turn in the vertical, has slopes slightly larger then 1/2 in the interior and larger than 1 along the sides. Also, when the vortex advecttion is longer than half a turn, the Z shape splits itself in different subsets, but still with the same slopes as for a half-turn. In the case of a mixed layer, possibly observed after mixing has occured, displacement points fill a parallelogram with side-edges having a slope of 1.

The models are used to interpret overturn shapes in NE-Atlantic Ocean data from moderately deep, turbulent waters above Rockall Bank (off Ireland) and from deep, weakly-stratified waters above Mount Josephine (off Portugal). Dynamically, most overturns are found to resemble the Rankine vortex model overturn and very few a solid body rotation.

Thorpe, S. A. Turbulence and Mixing in a Scottish Loch Royal Society of London Philosophical Transactions Series A, 1977, 286, 125-181

Dillon, T. M. Vertical Overturns: A Comparison of Thorpe and Ozmidov Length Scales J. Geophys. Res., AGU, 1982, 87, 9601-9613

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