Length scales of stratified turbulence : new insight on Thorpe displacements statistics from in situ oceanic measurements and high resolution Direct Numerical Simulations

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Abstract

The Earth hydrosphere, which is the combined mass of water found on, under, and over the surface of our planet, belongs for 97% in mass to the oceans. Characteristic length scales of anisotropic turbulence, as the Ozmidov scale $L_o = \sqrt{\epsilon/N^3}$ and the Zeman scale $L_z = \sqrt{\epsilon/(2\Omega)^3}$ - first introduced [1] by Mory and Hopfinger in 1985 - are inescapable features for whom is interested in the dynamics of the rotating stratified ocean. More precisely, the estimate the Ozmidov lengthscale is one of the keystones of any vertical turbulent diffusion parametrization, which governs vertical exchanges of heat, salt and nutrients in global oceanic circulation models [2].

Among the candidates for good proxies of the Ozmidov scale L_o, the Thorpe scale L_t, based on adiabatic re-ordering of in situ measured density profiles, is commonly used [3]. Recently, we developped at the NIOZ accurate (noise level < 0.1mK) temperature sensors which, when stiffly attached to a vertical mooring line, provide high sampling rate (1Hz) time series of temperature profiles with vertical resolution of O(1m), over vertical spanning of O(100m) [4]. If density and temperature are approximately proportional, the Thorpe displacement technique can be used to estimate the temporal and (to some extent) spatial variability of turbulent heat flux in the highly turbulent - but stratified - oceanic bottom boundary layer [5]. As a derivate further estimate, the vertical eddy diffusivity can beestimated as well, however, for the latter one needs a value for the mixing efficiency.

We will present several examples of such measurements, as well as a discussion on the statistical distribution of the Thorpe displacement values (which are positive/negative, and whose rms is the Thorpe scale L_t). These results are compared with the Thorpe displacements computed in high resolution 3D Direct Numerical Simulations, providing a new insight on the characteristic length scale of stratified turbulence.

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