Experimental study of the initial growth of a localized turbulent patch in a stably stratified fluid

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Turbulent patches are commonly encountered events in the ocean, yet many questions remain open concerning the mixing characteristics of these patches in stably stratified environments [1, 2]. Previous studies of the wakes of self-propelled bodies [3, 4] and one/two-dimensional mechanically stirred patches [5, 6] provided detailed descriptions of the growth rates and report on a finite interval of growth of the patches. It was proposed that there is a time instant $N\,t = 2 \div 4$, that depends on stratification and forcing (or a degree of mixing) at which the initial fast growth of the patch halts. After that time, if the patch is forced, it can grow slowly through a mechanism of internal waves or if it is not continuously forced (like a wake), then it collapses and creates horizontal intrusions. There is no detailed information available, however, of the inner structure of the patch, its degree of mixing, or the role of the turbulent/non-turbulent interface between the inside and outside of the patch for its growth and following collapse.

We perform experiments of a three-dimensional, finite patch of turbulence which is formed by an oscillating grid in both fresh water using an index-of-refraction-matched stably stratified solution. Optical measurements including synchronized particle image velocimetry and planar laser induced fluorescence have been performed to capture the life cycle of the patch from its initial growth until it reaches a critical height followed by its eventual collapse (see Fig. 1). The simultaneous capture of density and velocity allows for an assessment of both the in-patch distributions of the turbulent kinetic energy, enstrophy, buoyancy and buoyancy flux and relate those to the outer parameters. In addition, we can understand better the mechanisms that control the time of collapse and describe the small scale properties of the turbulent interface between the patch and the surrounding fluid. The experimental data suggest that the density boundary becomes sharper as the grid-generated turbulence increases and that the 3D patch growth slows down after $N\,t \approx 4$ and stops completely at $N\,t \approx 6$.

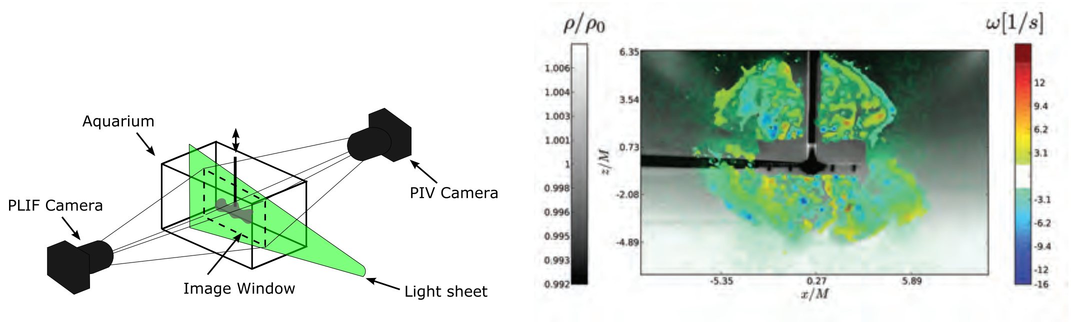

Fig. 1: (left) Experimental setup scheme. (right) Vorticity field, $\omega_z(x, y)$ superimposed on the grey scale representation of the buoyancy map (brighter regions are heavier fluid) of a linearly stratified fluid. PIV analysis is performed using the open source software package, OpenPIV, `http://www.openpiv.net`

References

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