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Turbulent mixing layer growth and internal waves formation: laboratory simulations

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Models of the structure of stratified oceans and lakes as well as the atmosphere use bulk parameters to predict a variety of processes that control the ecology of natural systems. The success of such approach in predicting even small scale phenomena has not a parallel in modeling turbulent. Particularly the interaction of convective turbulence and the density interface is not well understood. Analytic solutions for such turbulent motion are not available and there appears to be little hope of finding such solutions in the near future. The present experiments simulate the deepening of a convective mixed layer in a stratified lake. LIF visualizations, temperature measures and velocity field detection through Particle Tracking Velocimetry and Feature Tracking were employed to examine the effect of convective-driven perturbation at the mixed layer when no vertical shear occurs. The model used for laboratory experiments is a tank with glass sidewalls of dimension 40'40'41 cm3 in the two horizontal and vertical directions respectively. The working fluid is distilled water. Pollen is used as passive tracer. A stable stratification, e.g. a positive vertical temperature gradient, is generated by means of two connected tanks. After being stratified, the chamber is heated from below, to simulate the solar radiation effects and to cause penetrative convection. Temperature profiles are measured inside the tank by mobile thermocouples. The LIF technique was used to visualize the evolution of the convective layer and to derive its law of growth through image analysis. The threshold method and the gradient method were employed. Both are based on determining the height of the interface between the stable and unstable portions of the stratified fluid using the luminosity distribution within the image. The threshold method consists in introducing a suitable threshold value while the gradient method computes the vertical gradient of luminosity and chooses the interface height as its maximum. When studying turbulent convective phenomenon such penetrative convection, it can be considered that dispersion is mostly

due to transport by large organized structures while diffusion can be neglected. A way of dealing with the dispersion topic is through the formulation of the transilient turbulence theory. The main output of the theory is the transilient matrix that accounts for all the mixing processes resolved by the grid spacing, from smallest eddy traced by the pollen particles to the medium and large coherent structures over the entire mixed layer depth. The Transilient Matrix describes the mass exchange in a given amount of time due to the convective motion occurring within the mixing layer. In particular it provides the probability that a particles being at a time t* at a given depth can be found after the time interval Dt* at a given and different depth. The quantities of interest are made non-dimensional through scale factors.