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Laboratory experiments on stratified and rotating turbulence 2D structure

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Oceanic and atmospheric flows may be considered as turbulent motions under the constraints of geometry, stratification and rotation. At large scales these flows tend to be along isopycnal surfaces due to the combined effects of the very low aspect ratio of the flows (the motion is confined to thin layers of fluid) and the existence of stable density stratification. The effect of the Earth's rotation is to reduce the vertical shear in these almost planar flows. The combined effects of these constraints are to produce approximately two-dimensional turbulent flows called geophysical turbulence, where the main forcing occurs at the Rossby deformation Radius. The role of the spectra of steady and decaying turbulence is important as well as its topology, then a large range of scales has to be taken into account. When mixing and dispersion processes are studied, the behaviour of reactants or pollutants is seen to depend of the vorticity and energy spectra. When molecular mixing has to be accounted, the range of scales spans from hundreds of Kilometres to the Bachelor or Kolmogorov sub millimetre scales. Oscillating grid experiments across a density interface measuring entrainment and grid decaying non steady mixing experiments are evaluated. The local vorticity is evaluated confirming the trapping of tracers in the strong vertical regions in 2D flows, but showing also that hyperdiffusion may also occur.

In a strictly two-dimensional flow with weak dissipation, energy input at a given scale is transferred to larger scales, because these constraints stop vortex lines being stretched or twisted. Physically this upscale energy transfer occurs by merging of vortices and leads to the production of coherent structures in the flow. This scenario is an attractive model for geophysical flows which are known to contain very energetic vortices, mesoscale oceanic eddies and atmospheric highs and lows that show the dominant length scale at the Rossby deformation Radius, in the limit of very high Rossby numbers and high Richardson numbers, the enstrophy is seen to oscilate with a time dependent frecuency.