Energetic budget of Direct Numerical Simulations in a turbulent stratified flow

Ernesto Horne*†[1], Louis Gostiaux[1], and Alexandre Delache[1]

[1]Laboratoire de Mecanique des Fluides et d'Acoustique (LMFA) – CNRS : UMR5509, Ecole Centrale de Lyon, Université de Lyon – 36 Av Guy de Collongue 69134 ECULLY CEDEX, France

Abstract

The local mixing produced by turbulence in the ocean interior plays a crucial role in its global energy budget. This mixing drives large scale dynamics, as evidence in the meridional overturning circulation (MOC). The circulation is produced thanks to the downward transport of energy from the surface to the deep bottom of the ocean, possible thanks to vertical mixing. Many processes produce mixing in the ocean. Nevertheless, the proportion of energy transferred from turbulent structures to effective mixing is very difficult to measure in the ocean, and the details of the distribution of the injected energy is yet not fully understood.

In order to answer these questions, a set of 3D Direct Numerical Simulations (DNS) of a turbulent stratified flow are performed by solving Navier-Stokes equation under Boussinesq approximation. A classical Fourier pseudo-spectral method is used with 1024 grid points. A porous penalization region is introduced to take into account non-flux conditions at the bottom and at the top of the box, and we assume periodicity in the horizontal plane. A turbulent velocity field is introduced at t=0 which perturbs the initially stable buoyancy profile.

One can distinguish the full buoyancy field associated with the potential energy Ep, and the sorted buoyancy field associated to the background potential energy Eb. The horizontal average of the instantaneous buoyancy field can be used to compute Ep, while the horizontal average of the instantaneous 3D vertically sorted buoyancy field can be used to compute Eb. Ep will contain the energy increase produced by the mixing within the flow in addition to the energy fluctuations associated to the reversible vertical buoyancy flux of waves and overturns. In contrast, the variation Eb is associated only to the irrevesible mixing produced in the flow.

The energetic budget is performed for simulations ranging the Reynolds number between 1000 and 2100 and the Richardson numbers between 3.4 and 14.

*Speaker

†Corresponding author: ernesto.horne@ec-lyon.fr