

Ondes internes et modes vorticaux dans les écoulements stratifiés

Internal waves and vortical modes in stratified flows

V. Labarre, P. Augier, G. Krstulovic, S. Nazarenko



Geophysical flows: rotation and stratification



⇒ contain eddies and waves

Model: NS, Boussinesq, constant stratification

$$\nabla \cdot \mathbf{v} = 0,$$

$$\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} = -\nabla p + b\mathbf{e}_z + \nu \Delta \mathbf{v} + \mathbf{F}_v,$$

$$\frac{\partial b}{\partial t} + \mathbf{v} \cdot \nabla b = -N^2 v_z - \kappa \Delta b + \mathbf{F}_b,$$

Internal gravity waves: $\omega_{\mathbf{k}} = N \frac{k_h}{k}$

How waves and eddies impact the flows?

Turbulent fluxes? Spectra? ...
in different regimes.

Energy cascade predictions:

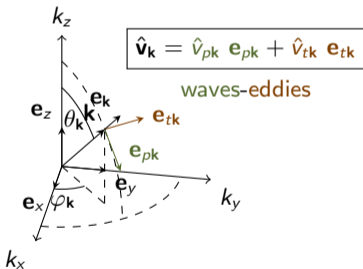
$$E(k_h, k_z) \propto k_h^{-5/3} k_z^{-3}$$

$$E(k_h, k_z) \propto k_h^{-5/2} k_z^{-3/2}$$

$$E(\omega) \propto \omega^{-2}$$

⇒ difficult to test

System of waves (in simulations)?

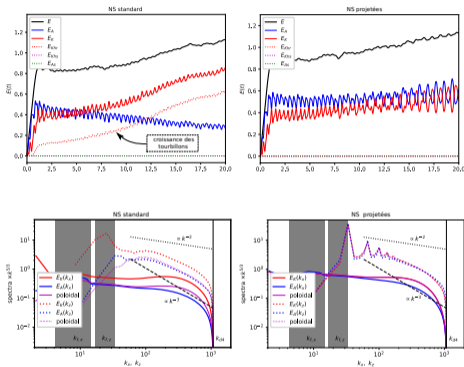


Preliminary results: small simulations

Standard NS

vs

Projected NS



[1] <https://www.pexels.com/photo/underwater-photography-of-ocean-2397651/>.

[2] P. Caillol and V. Zeitlin. Kinetic equations and stationary energy spectra of weakly nonlinear internal gravity waves. 2000.

[3] C. Garrett and W. Munk. Internal waves in the ocean. 1979.

[4] E. Lindborg. The energy cascade in a strongly stratified fluid. 2006.

[5] A. Mohanan, C. Bonamy, M. Linares, and P. Augier. FluidSim: Modular, Object-Oriented Python Package for High-Performance CFD Simulations. 2019.