Study of geophysical flows by experiments in the Coriolis platform and numerical simulations of stratified turbulence forced by waves and vortices

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The effects of medium and small scale motions in the atmosphere and the oceans are important for many issues, as for example mixing (of dynamical conserved quantities, salt, temperature, CO_2 or pollutants...), phytoplankton blooms and statistical forecast of extreme weather events. The largest atmospheric and oceanic numerical models starts to resolve these scales, but surprisingly, the dynamics of these motions is overall poorly understood. Even though improvement of the resolution of satellite measurements is such that they are now able to provide meaningful data on these scales, our knowledge is still mainly based on simple moored, towed and dropped measurements from which can be computed statistical quantities such as spectra and structure functions. Interestingly, the spectra measured at different places and instants usually exhibit the same features (Garrett & Munk, 1979; Munk, 1981). For example, the vertical spectra usually follow 3 particular scaling laws.

In fluids influenced by system rotation and density stratification as the atmosphere and the oceans, there are two kinds of linear modes, the internal waves and modes with 0 linear frequency usually called "vortices". Many predictions have been derived from weak wave turbulence theory, but it is necessary to assume that the effects of the vortices are negligible (for a review, see Staquet & Sommeria, 2002). The oceanic spectra are usually interpreted as being due to internal waves only, without vortices, but observations indicate that in many regions of the oceans and the atmosphere, there are also vortices. Recently, it has been shown that turbulence involving vortices can also product spectra similar to observations (Lindborg, 2006; Riley & Lindborg, 2008; Augier et al., 2015).

In order to test these different theories, experiments in the Coriolis platform and fine-resolution idealized numerical simulations of strongly stratified flows forced by waves and/or vortices will be carried out. The effect of system rotation will also be investigated. Different statistical quantities will be computed and compared to the equivalent quantities obtained from geophysical measurements. For the numerical tasks, the intern will use and develop an open-source object-oriented parallel pseudo-spectral code (FluidSim). Since the code is partly written in Python, She/He will develop high-level skills in modern programming. Another important task will be to gather information from the bibliography on geophysical flows. We will chose together with the intern how the work will be split between numerics and experiments.

You are welcome to visit our laboratory to discuss and see the Coriolis platform.

References

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