PhD Proposal under the supervision of Thierry DAUXOIS

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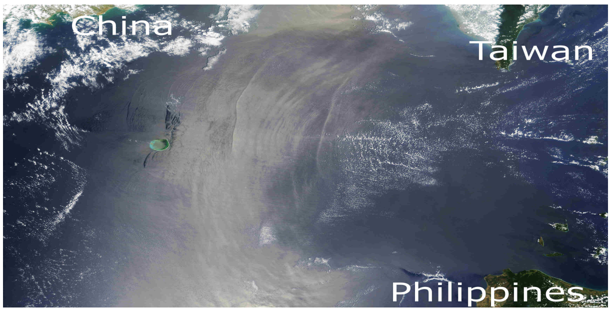
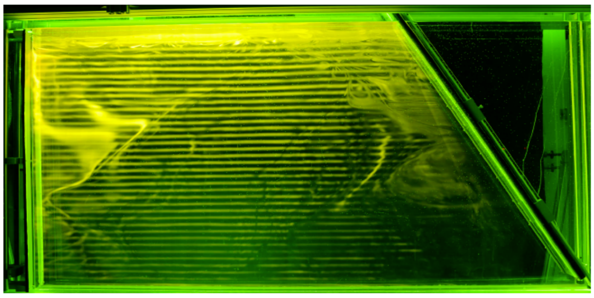
Rim Currents Induced by Internal Wave Attractors in Enclosed Basins



Internal gravity waves propagate in density-stratified fluids owing to the restoring force of buoyancy. They are ubiquitous in the ocean and their amplitude may be large enough for these waves to be observed in satellite images as striking band-like features that travel for thousands of kilometers across the ocean (see picture). In terms of global budgets, the most energetic part of the internal wave activity is indeed located in the deep ocean where measurements and associated modeling still lack confidence. For example, Garrett & Munk proposed in 1979 an empirical internal wave spectrum whose relevance and universality is still under scrutiny. This is a key problem for oceanography, as the internal wave field of the oceans involves a considerable amount of energy that can be used for mixing and therefore affect the Earth's climate. Internal waves are also important for the transport of sediments and plankton, and in the context of plasma physics and astrophysics.

From the physicist's point of view, internal gravity waves are particularly interesting. They are transverse waves that do not respond to our classical perception of wave phenomena. Their group and phase velocities are perpendicular, their reflection laws are completely different from the usual Snell-Descartes laws, the Huyghens-Fresnel diffraction laws are not valid anymore, ... All these properties lead to paradoxes that are very interesting from the 'fundamental physics' point of view. Moreover, the above properties, which are consequences of an anisotropic dispersion relation due to gravity, are also encountered for inertial waves (in presence of rotation) or plasma waves (in presence of a magnetic field), and also in the astrophysical context, a domain where interest for internal waves is developing very fast.

The main topic is to study the **baroclinic flow of a rotating stratified fluid in a parabolic basin in response to a barotropic tidal forcing**. According to recent numerical simulations, nonlinearities in the near-shore internal tide produce an azimuthally independent 'set-up' of the isopycnals that in turn drives an approximately geostrophically balanced, cyclonic, near-shore, sub-surface jet. The jets rely neither on the wind nor on local topographic features yet provide a simple mechanism for driving cyclonic subsurface currents at continental slopes that is dynamically consistent with observations.



The Ph-D student will **develop the experimental set-up**, and study this baroclinic flow, in the laboratory using different kinds of forcing. The stratification will be reproduced using *salt water* in a relatively large tank, since we want to reduce viscous effects by attaining a rather large Reynolds number. Internal wave fields will be visualized using Particle Image Velocimetry, the well-established experimental technique that determines velocity field data through cross correlation investigations of trajectories of glass microspheres seeding the flow. Post-processing of field measurements with high spatial and temporal resolution over long durations is central. One will take advantage of elaborated signal processing analysis (Hilbert transform, bicoherence, time-frequency analysis, ...).

Within the linear regime, the formation of a nice internal wave attractor is expected. Its destabilization when nonlinearities become important and the possible generation of an associated mean-flow should lead of the appearance to a rim current. The possible subsequent destabilization of this current will also be studied. The role of the different boundary conditions will finally be explored. Connections with the dynamics of real enclosed basins such as the Baltic, Black and Caspian seas will be considered.

Collaborations: The PhD student will be part of the internal wave group (T. Dauxois, S. Joubaud, P. Odier), and will work in particular with a post-doc Timothée Jamin. He/she will also benefit from an important collaboration with Evgeny Ermanyuk, Deputy Director of the Lavrentyev Institute of Hydrodynamics in Novosibirsk (Russian Federation).