Can laboratory experiments reach regimes relevant for the oceanic dynamics?

Costanza Rodda, Clement Savaro, Antoine Campagne, Miguel Calpe Linares, Pierre Augier, Joël Sommeria, Thomas Valran, Samuel Viboud, and Nicolas Mordant
Université Grenoble Alpes, Laboratoire des Écoulements Géophysiques et Industriels, Saint Martin d’Hères, France
(costanza.rodda@univ-grenoble-alpes.fr)

Atmospheric and oceanic energy spectra are characterized by global scaling laws, suggesting a common mechanism driving the energy route to dissipation. Although several possible theories have been proposed, it is not clear yet what the phenomena contributing the most to the energy at the different spatial scales are. One possible scenario is that internal gravity waves, which can be ubiquitously found in the atmosphere and the ocean and play a fundamental role in the energy transfer, cause the observed spectral slopes at the mesoscales in the atmosphere and submesoscales in the oceans. In the context of this open field of investigation, we present an experimental study where internal gravity waves are forced at a given frequency by the oscillating walls of a large pentagonal-shaped domain filled with a stably stratified fluid. The setup is built inside the 13-meters-diameter tank at the Coriolis facility in Grenoble, where geophysical regimes (with high Reynolds number and low Froude) can be achieved and rotation can also be added. The purpose of our investigation is to determine whether it is possible to induce a wave turbulence cascade by forcing internal waves at the large scales. Following a previous study\(^1\), where instead of the pentagonal a square domain was utilized, we obtained the velocity field employing time-resolved particle image velocimetry and then calculated the energy spectra. The previous study inside a square domain showed some evidence of a cascade, but it was strongly affected by 2D modes that sharpened the spectrum. Therefore, we changed the domain shape to a pentagon to reduce this finite-size effect. When the waves are forced at frequency \(\omega_F=0.4N\), our data shows that the spectra follow the scaling law \(\omega^{-2}\) at frequencies larger than the forcing frequency and extending beyond \(N\). The experimental spectra strikingly resemble the characteristic Garret-Munk spectrum measured in the ocean. As the interaction of weakly non-linear waves dominates the dynamics at frequencies smaller than the buoyancy frequency \(N\), we can conclude that the experimental spectra are generated by weak internal wave turbulence driving the turbulent cascade at the high-frequency end of the spectrum.
