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Wave-induced mean flow by three-dimensional internal gravity wave reflection onto a slope

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Several processes lead to mixing and transport in the ocean, among those being the interaction of the internal gravity wave field with bottom topography. The latter process is considered in the present work, through joint laboratory experiments on the Coriolis platform and three-dimensional numerical simulations.

The basic configuration is a plane wave of finite extent reflecting onto a sloping bottom in a uniformly stratified fluid. The incident wave propagation is upslope implying that the reflected wave is focused: its wave vector and energy density are those of the incident wave times a factor greater than 1, referred to as the focusing factor γ, which depends upon the angle of the sloping bottom and of the incident wave.

As expected, the interaction between the incident and reflected waves produces harmonic waves, but an irreversible wave-induced mean flow also grows in the interacting region between those waves, whose amplitude may be larger than that of the incident wave. This mean flow is contributed by nonlinear and dissipative effects, its amplitude being proportional to the incident wave amplitude squared and to the fluid viscosity.

Focusing appears to have an essential contribution to this mean flow. Analytical modelling of the mean flow acceleration shows indeed that this acceleration is contributed by the sum of three terms, associated with the incident wave, the reflected wave and the interaction between those waves: the main contribution comes from the reflected wave component, its amplitude being proportionnal to γ^5. Comparatively, this amplitude is proportional to 1 for the incident wave and to γ for the interacting component.

Unlike in the atmosphere, the role of this wave-induced mean flow on internal gravity wave dynamics has been completely overlooked in the ocean and should clearly deserve further study.

Reference

Grisouard N., Leclair M., Gostiaux L. & Staquet C. 2013 Large scale energy transfer from an internal gravity wave reflecting onto a simple slope. *Proceedings of the IUTAM Symposium on Waves in Fluids* (Moscow, June 2012). Editor: Institution of the Russian Academy of Sciences A. Ishlinsky, Institute for Problems in Mechanics of the RAS. Elsevier publ. (to appear)