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Reflexion of a plane wave from a slope and wave-induced mean flow

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The locations and processes of mixing in the ocean have been the subject of an intense debate for more than fifteen years, when it was discovered from in situ measurements that mixing in the interior of the ocean was ten times smaller than required from global balance arguments to maintain the thermal equilibrium of the ocean. The rôle of the boundaries in mixing processes was put forward to account for this 'missing mixing', as it was sometimes referred to, renewing past interest on that topic. Several boundary processes may indeed lead to mixing, among those being the interaction of the internal gravity wave field with bottom topography. The latter process is considered in the present work.

Our purpose is indeed to investigate energy transfers resulting from the interaction of a plane wave with a simple slope from joint laboratory experiments and numerical simulations. The plane of the incident wave is normal to the slope so that, at least in the inviscid limit, the problem may be studied in that plane. Two-dimensional numerical simulations have therefore been conducted, using the MITgcm and Symphony-NH (Auclair et al. 2011) numerical codes, complemented by three-dimensional simulations to explore the flow behavior outside this plane, for reasons explained below. The laboratory experiments were conducted on the Coriolis platform in Grenoble, leading to a meter-scale configuration (see Grisouard 2010 for a description of the experimental set-up).

The motivation of this work was to validate theoretical predictions by Thorpe (J. Fluid Mechanics, 1987) according to which second order resonant interactions involving the incident and reflected waves may occur for certain values of the slope angle and of the incident wave direction. In our experiments, the slope angle was fixed and the wave frequency was varied within a range of values containing those for which resonant interactions are expected.

Surprisingly, the laboratory experiments did not show any detectable occurrence of resonant interactions for the wave frequency values predicted by Thorpe. Instead, a strong mean flow was observed in the region where the incident and reflected waves superpose. Hence, an intrinsic frequency shift by Doppler effect results from this mean flow, which accounts from the non finding of resonant interactions. But the experiments put forward an unexpected component of the motion, namely the mean flow, whose occurrence and properties are the focus of this talk.

It is actually well-known that waves, such as sound waves or surface gravity waves, induce an irreversible mean flow if the waves propagate in a dissipative medium, because of nonlinear effects. Consistently, in the present case, the mean flow occurs where the incident and reflected waves superpose and may therefore interact. We also found that the mean flow amplitude, which should be proportional to the square of the wave amplitude, grows in time as dissipative effects are cumulative in time. As a consequence, its amplitude may become as large as the incident wave amplitude implying that the mean flow can become a significant component of the flow dynamics. Because of stratification and geometrical constraints, this mean flow is horizontal and three-dimensional and therefore does not appear in the two-dimensional numerical simulations. Further analysis will be presented during the talk.

To our knowledge, previous laboratory experiments of wave reflexion on a simple slope were quasi-two-dimensional, which may account for the fact that no occurrence of a strong mean flow was pointed out by the authors. Our message is that mean flows induced by dissipative internal wave fields may be a significant component of the motion and should no longer be ignored.

References

Auclair F., C. Estournel, J. Floor, M. Herrmann, C. N'Guyen P. Marsaleix 2011 A non-hydrostatic algorithm for free-surface ocean modelling. *Ocean Modelling*, in press, doi:10.1016/j.ocemod.2010.09.006.

Grisouard N. 2010 Nonlinear reflexions and refractions of internal gravity waves. PhD thesis (in french), University of Grenoble.