Nonlinear Reflection of Internal Gravity Waves onto a slope

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Abstract

The interaction of internal waves on sloping topography is one of the process that cause mixing and transport in oceans. The mixing caused by internal waves is considered to be an important source of energy that is needed to bring back deep, dense water from the abyss to the surface of the ocean, across constant density surfaces. Apart from the vertical transport of heat downwards) and mass (upwards), internal waves are also observed to induce horizontal mass transport through an irreversible mean flow. Mixing and wave induced mean flow may be considered as the processes that transfer wave induced energy to smaller and larger scales respectively. The process of mixing has been a subject of intense research lately. However, the process of wave induced mean flow and their dynamic impact await serious study. The present study involves this wave induced mean flow, its generation and energetics.

The nonlinear subcritical reflection of internal waves from a sloping boundary is studied using laboratory experiments carried out on the Coriolis Platform at Grenoble and, 2D and 3D numerical simulations done using a non-hydrostatic code. In the experiment, a plane wave is produced using a wave generator and is made to reflect normally on a sloping bottom in a uniformly stratified fluid. We consider both rotating and non-rotating cases. The numerical simulation mimicks the laboratory setup with an initial condition of an analytical plane wave solution in a vertical plane limited by a smooth envelope to simulate the finite wave generator.

The nonlinear interaction of the incident and reflected waves produce, apart from higher harmonics, a strong irreversible wave induced mean flow which grows in time and is localised in the interacting region. The finite extent of the wave generator allows the mean flow to recirculate in the horizontal plane, resulting in a dipolar potential vorticity field. Moreover, the generation of mean flow and higher harmonics, along with dissipative effects, diminishes the amplitude of reflected wave. We study the momentum and energy budget of the process in order to understand the mechanism of generation of mean flow, its interaction with the wave and account for the loss of wave energy upon reflection.

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