Geophysical Research Abstracts, Vol. 8, 03487, 2006
SRef-ID: 1607-7962/gra/EGU06-A-03487

Impact of channel geometry and rotation on the trapping of internal tides

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The generation and propagation of internal tides has been studied with an isopycnic three-dimensional numerical ocean model. We consider the response of a uniformly stratified sea in a channel which is forced by a barotropic tide on the open boundary in the west. The tide progresses into the channel and forces internal tides over a continental slope and shelf in the east. The channel has a zonal length of 1200 km and a meridional width of 191.25 km. The bottom profile has been varied. In a series of four experiments we show how the cross-channel geometry affects the propagation and trapping of internal tides and we discuss the zonal penetration scale of wave energy, away from the continental slope. In particular it is found that a cross-channel bottom slope constrains the penetration of the internal tidal energy. This is because internal tidal beams maintain their inclination with respect to the vertical when reflecting from a sloping bottom and, as a consequence, focus their energy. Each focusing reflection is accompanied by refraction and supports the eventual trapping of the internal tide onto the cross-channel direction. Near the critical depth, edge waves carry part of the energy further away from the continental slope. In this case, focusing reflection and accompanying refraction towards the cross-channel direction are offset by subsequent defocusing reflection and refraction towards the along-channel direction.

In case of rotation, in the absence of any cross-channel slope, the generated internal tide would manifest itself as a combination of an outgoing internal Kelvin wave, hugging the Northern coast, as well as a set of outgoing as well as trapped internal Poincare cross-channel modes. In the presence of cross-slope variations in depth, near the continental slope the Poincare waves no longer bear the characteristics of the wave attractor predicted by 2D-theory, while the Kelvin wave near the northern wall preserves the 2D-attractor, also present in the nonrotating case. The modified Kelvin wave acts as a secondary internal wave generator along the whole Northern shore.