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Classification of regimes of internal solitary waves transformation over a shelf-slope topography

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The internal waves shoal and dissipate as they cross abrupt changes of the topography in the coastal ocean, estuaries and in the enclosed water bodies. They can form near the coast internal bores propagating into the shallows and re-suspend seabed pollutants that may have serious ecological consequences. Internal solitary waves (ISW) with trapped core can transport masses of water and marine organisms for some distance. The transport of cold, low-oxygen waters results in nutrient pumping. These facts require development of classification of regimes of the ISWs transformation over a shelf-slope topography to recognize 'hot spots' of wave energy dissipation on the continental shelf.

A new classification of regimes of internal solitary wave interaction with the shelf-slope topography in the framework of two-layer fluid is proposed. We introduce a new three-dimensional diagram based on parameters α ,β , γ. Here α is the nondimensional wave amplitude normalized on the thermocline thickness $\alpha = a_{in}/h_1$ ($\alpha > 0$), β is the blocking parameter introduced in (Talipova et al., 2013) that is the ratio of the height of the bottom layer on the the shelf step h_{2+} to the incident wave amplitude a_{in}, $\beta = h_{2+}/a_{in}$ ($\beta > -3$), and γ is the parameter inverse to the slope inclination ($\gamma > 0.01$).

Two mechanisms are important during wave shoaling: (i) wave breaking resulting in mixing and (ii) changing of the polarity of the initial wave of depression on the slope. Range of the parameters at which wave breaking occurs can be defined using the criteria, obtained empirically (Vlasenko and Hutter, 2002). In the three-dimensional diagram this criteria is represented by the surface $f_1(\beta, \gamma) = 0$ that separates the region of parameters where breaking takes place from the region without breaking. The polarity change surface $f_2(\alpha, \beta) = 0$ is obtained from the condition of equality of the depth of upper layer h_1 to the depth of the lower layer h_2. In the two-layer stratification waves of depression may be converted to wave of elevation at the 'turning point' ($h_2 = h_1$) as they propagate from deep water onto a shallow shelf.

Thus intersecting surfaces f_1 and f_2 divide three-dimensional diagram into four zones. Zone I located above two surfaces and corresponds to the non breaking regime. Zone II lies above 'breaking' surfaces but below the surface of changing polarity and corresponds to regime of changing polarity without breaking. Zone III lies above surface of changing polarity but below 'breaking' surfaces and corresponds to regime of wave breaking without changing polarity. Zone IV that located below two surfaces and corresponds to the regime of wave breaking with changing polarity.

Regimes predicted by diagram agree with results of numerical modelling, laboratory and observation data. Based on the proposed diagram the regions in α, β, γ space with a high energy dissipation of ISW passed over the shelf-slope topography are distinguished.

References

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