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Laboratory and numerical study of interaction of large amplitude internal solitary waves with local obstacle, narrows and steep slopes

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This investigation was motivated by growing interest to the estimating of effects caused by large amplitude internal solitary waves (ISW) on submerged structures and bottom sediments in the shallow parts of seas and lakes. The study focuses on local scale phenomena: non-linear transformation of waves,instability and mixing. The laboratory experiments were carried out in a flume, 7 m long, 0.4 m wide and 1.5 m high. A two-layer free surface water system with upper and bottom layer thicknesses h1 and h2, respectively, and water depth H was studied. The ISWs were generated following Michallet & Ivey (1999) by generating a collapsing water mass. The evolution and transformation of ISWs were recorded by capacity gauges submerged in water at several locations. The density profile was obtained by traversing a micro-conductivity probe over depth. The 3D non-hydrostatic free surface model developed by Kanarska & Maderich (2003) for stratified flows was used to simulate evolution and transformation of ISWs. The non-linear subgrid-scale parameterization of eddy viscosity and diffusivity (Siegel & Domaradzki, 1994; Skyllingstad & Denbo, 1994) was implemented in the model to parameterize small-scale mixing. A detailed comparison with our laboratory experiments and experiments by Chen et al. (2007) on the generation of ISW by collapse of a volume of fluid was done to calibrate model constant. Three series of experiments and simulations were done. In the first series, the interaction of ISW-depressions of amplitude a in a thin upper layer with thickness $h_1$with a rectangular bottom obstacle was investigated. It was found that for $0.4 < a \ / \ (H - h_1)$ the

ISW-interface was breaking and a vortex pair was formed at the upwind side of the obstacle. In the second series the passing ISW-depression through the smooth local lateral constriction was studied for the cases when the characteristic length of the constriction was less, greater and approximately equal to the wave length of the nonlinear disturbance. Sharp steepening of the wave accompanied by a growth of the amplitude and subsequent breaking were observed in the narrow constriction. The flows in the passing ISWs were supercritical, and they were separated from the rest of the fluid by hydraulic jumps with intensive mixing. The third series of laboratory experiments was conducted to investigate the dynamics of ISW of depression type that are reflecting from a steep slope. The characteristics of reflection and dissipation were obtained for a range of the bottom inclination of 12^o-60^o, including cases with composite slopes. The difference between the mixing processes for ISW depression and elevation type was studied numerically. The modeling results support the classification diagram of Chen et al. (2007)for the evolution of ISWs of depression and elevation type.

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