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Strongly nonlinear dynamics of internal waves and gravitational currents in a rectangular basin

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The energy flux into lakes is supplied mainly by wind which drives surface waters and generates internal long-periodic basin-scale standing waves (seiches). Field experiments indicate that the internal wave field has a continuous spectrum, ranging from these basin-scale waves to waves with frequencies approaching the maximum buoyancy frequency. Possible mechanisms to transfer energy from basin-scale waves to small-scale motions include nonlinear steepening, shear instability, shoaling and reflection at sloping boundaries and interaction with topography. Such processes are fundamentally nonhydrostatic and they are characterized by inverse impact of small scales perturbations on large scale motions.

In this paper the particularities of the strongly nonlinear dynamics of the degeneration of basin-scale waves in a rectangular closed basin filled with two water bodies of different density were investigated with a 3D non-hydrostatic model (Kanarska-Maderich, 2003). We extended the classification of Horn et.al. (2001) of the possible flow regimes depending on the amplitude of the initial basin-scale wave and the depth at the undisturbed position of the interface to include the gravitational current regimes when the interface crosses the upper and/or lower boundary of the basin. A number of numerical experiments reproduce strongly nonlinear regimes of the transformation of initial basin-scale motion, which is accompanied by the formation of gravitational currents, Kelvin-Helmholtz instability, undular bores and soliton generation. The effects of sloping boundaries on hydrodynamics of solitary waves with moderate amplitudes were also investigated. The obtained results can help in the interpretation of numerous observations of mixing processes in real lakes.