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Long Surface Wave Dynamics along a Convex Bottom

I. Didenkulova (1), E. Pelinovsky (2), and T. Soomere (1)

(1) Institute of Cybernetics, Tallinn, Estonia (ira@cs.ioc.ee, +372 6204151), (2) Department of Nonlinear Geophysical Processes, Institute of Applied Physics, Nizhny Novgorod, Russia (pelinovsky@gmail.com, +7 3814365976)

Long linear wave transformation in a basin of varying depth is studied for a case of a convex bottom profile with an exponent 4/3. This bottom geometry provides the "non-reflecting" wave propagation at least in the framework of the one-dimensional shallow water equation. In this case, shoaling effects are very strong, and wave reflection occurs in the immediate vicinity of the shoreline. The existence of traveling wave solutions (which propagate without reflection) in this geometry is established through construction of a 1:1 transformation of the general 1D wave equation to the analogous wave equation with constant coefficients. The general solution of the Cauchy problem consists of two traveling waves propagating in opposite directions and allows a detailed description of the wave field (vertical displacement and depth-averaged flow). It is found that generally a zone of weak current is formed between these two waves. Waves are reflected from the coastline so that their profile is inverted with respect to the calm water surface. Long wave runup on a beach with this profile is studied for the sine pulse, KdV soliton and N-wave. It is shown that in certain cases the runup height along the convex profile is considerably larger than for beaches with a linear slope. The analysis of wave reflection from the border of a shallow coastal area of constant depth and a section with the convex profile shows that a transmitted wave always has a sign-variable shape. Results of the wave transformation above the convex beach and beaches following a general power law are compared. This simplified model demonstrates the potential importance of the tsunami wave transformation along convex beaches.