Geophysical Research Abstracts,
Vol. 11, EGU2009-92, 2009
EGU General Assembly 2009

Nonlinear Long-Wave Deformation and Runup in a Basin of Varying Depth

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Nonlinear transformation and runup of long waves of finite amplitude in a basin of variable depth is analyzed in the framework of 1D nonlinear shallow-water theory. The basin depth is slowly varied far offshore and joins a plane beach near the shore. A small-amplitude linear sinusoidal incident wave is assumed. The wave dynamics far offshore can be described with the use of asymptotic methods based on two parameters: bottom slope and wave amplitude. An analytical solution allows the calculation of increasing wave height, steepness and spectral amplitudes during wave propagation from the initial wave characteristics and bottom profile. Three special types of bottom profile (beach of constant slope, and convex and concave beach profiles) are considered in detail within this approach. The wave runup on a plane beach is described in the framework of the Carrier-Greenspan approach with initial data, which come from wave deformation in a basin of slowly varying depth. The dependence of the maximum runup height and the condition of a wave breaking are analyzed in relation to wave parameters in deep water.