Geophysical Research Abstracts
Vol. 18, EGU2016-2054, 2016
EGU General Assembly 2016

Run-up of nonlinear long waves in bays of finite length: 1-D analytical theory and 2-D numerical computations

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Run-up of long waves in sloping bays is studied analytically in the framework of the 1-D nonlinear shallow-water theory. By assuming that the wave flow is uniform along the cross-section, the 2-D nonlinear shallow-water equations are reduced to a linear semi-axis variable-coefficient 1-D wave equation via the generalized Carrier-Greenspan transformation (Rybkin et al., JFM 2014). A spectral solution is developed by solving the linear semi-axis variable-coefficient 1-D equation via separation of variables and then applying the inverse Carrier-Greenspan transform. The shoreline dynamics in U-shaped and V-shaped bays are computed via a double integral through standard integration techniques. To compute the run-up of a given long wave a numerical method is developed to find the eigenfunction decomposition required for the spectral solution in the linearized system. The run-up of a long wave in a bathymetry characteristic of a narrow canyon is then examined.