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Statistics for long wave run-up on a slopping beach: theoretical predictions and experimental data

Ira Didenkulova (1,2), Denys Dutykh (3), and Dmitry Senichev (2)

(1) Marine Systems Institute, Tallinn, Estonia (didenkulova@mail.ru), (2) Nizhny Novgorod State Technical University n.a. R.E. Alekseev, Nizhny Novgorod, Russia, (3) CNRS-LAMA UMR 5127, Université Savoie Mont Blanc, Campus Scientifique, 73376 Le Bourget-du-Lac, France

The prediction of possible flooding and properties of the water flow on the coast is an important practical task for physical oceanography and coastal engineering. That explains the multitude of empirical formulas describing run-up characteristics available in the engineering literature. These formulas are mostly specific for different geographic areas due to local characteristics of sea bed bathymetry, coastal topography, wind and wave regimes. Numerical simulation of these processes should be carried out within fully-nonlinear Euler or Navier–Stokes equations including effects of wave breaking and dissipation in the near-bottom boundary layer. In the case of an irregular incoming wave field such large scale simulations are not possible for sufficiently long time intervals, which are required for reliable statistics.

This situation improves in the case of long waves, when the basic hydrodynamical model is based on nonlinear shallow water theory. For a beach of constant slope, the nonlinear shallow water equations have rigorous analytical solution, which substantially simplifies the mathematical formulation. In (Didenkulova et al. 2011) we used this solution to study statistical characteristics of the vertical displacement of the moving shoreline and its horizontal velocity. The influence of the wave nonlinearity was approached by considering modifications of probability distribution of the moving shoreline and its horizontal velocity for wave of different amplitudes. It was shown that wave nonlinearity did not affect the probability distribution of the velocity of the moving shoreline, while the vertical displacement of the moving shoreline was affected substantially demonstrating the longer duration of coastal floods with an increase in the wave nonlinearity.

However, this analysis did not take into account the actual transformation of irregular wave field offshore to oscillations of the moving shoreline on a slopping beach. In this study we would like to cover this gap by means of extensive numerical simulations. The modeling is performed in the framework of nonlinear shallow water equations, which are solved using a modern shock-capturing finite volume method. Although the shallow water model does not pursue the wave breaking and bore formation in a general sense (including the water surface overturning), it allows shock-wave formation and propagation with the speed given by Rankine-Hugoniot jump conditions, which to some extent approximates wave breaking. The scheme is second order accurate thanks to the UNO_2 special reconstruction. It was described and validated in (Dutykh et al. 2011a) and has already been successfully used to simulate wave run-up on random beaches (Dutykh et al. 2011b).

For simplicity the incident wave field offshore is taken Gaussian in the present study, however, this distribution can be easily changed in the numerical code. Similar to (Didenkulova et al. 2011), in order to study influence of wave nonlinearity during wave propagation to the coast we consider waves of different amplitudes and the corresponding modifications of statistics of the moving shoreline. We also consider wave fields with a different bandwidth, so that we can see the influence of the bandwidth of the incoming wave field on statistics of wave run-up on a beach. Available experimental data are used for validation of numerical results (Denissenko et al. 2011).

P. Denissenko, I. Didenkulova, E. Pelinovsky, J. Pearson. Influence of the nonlinearity on statistical characteristics of long wave runup. Nonlinear Processes in Geophysics 18, 967-975 (2011).

I. Didenkulova, E. Pelinovsky, A. Sergeeva. Statistical characteristics of long waves nearshore. Coastal Engineering 58, 94-102 (2011).

D. Dutykh, T. Katsaounis, D. Mitsotakis. Finite volume schemes for dispersive wave propagation and runup. J. Comput. Phys. 230 (8), 3035-3061 (2011a).

D. Dutykh, C. Labart, D. Mitsotakis. Long wave run-up on random beaches. Phys. Rev. Lett. 107, 184504 (2011b).