Geophysical Research Abstracts
Vol. 18, EGU2016-6577, 2016
EGU General Assembly 2016

Long-Wave Runup on a Plane Beach: An Experimental and Numerical Investigation

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In this study the runup generated by leading depression single sinusoidal waves as a very basic representation of a tsunami is investigated through physical and numerical experiments. The results are compared against existing analytical expressions for the long-wave runup of periodic sinusoidal waves. It can be shown that shallow water theory is applicable for the investigated type of waves. Furthermore, we demonstrate how such a comparative, inter-methodological work contributes to the understanding of shoreline motion of long waves. The produced data set may serve as a novel benchmark for leading depression sinusoidal waves.

The experimental study was conducted using an innovative pump-driven wave generator that is capable of generating arbitrarily long waves which might even exceed the length of the wave flume. Due to the complex control problem for the chosen type of wave generator, spurious over-riding small-scale waves were unavoidable in some of the experiments. The numerical simulations were carried out with a one-dimensional Runge-Kutta discontinuous Galerkin (RKDG) non-linear shallow water model. It incorporates a high fidelity wetting and drying scheme. The sinusoidal waves are generated in a constant depth section attached to a linearly sloping beach, have periods between 20 and 100 seconds and surf similarity parameters between 4.4 and 15.6.

In a first qualitative analysis the evolution of the runup elevation and velocity is compared. In order to quantify analytical, numerical and experimental data, the wave similarity measured by the Brier score, maximum run-up and run-down height, as well as run-up/run-down velocities are utilized as metrics. As a starting point, periodic and non-periodic clean sinusoidal waves are compared numerically to rule out differences due to the single sinusoidal wave generation in the wave flume. On further analysis, significant differences in experimental and analytically expected values are observed. However, with the combination of analytical, numerical, and experimental data it can be demonstrated that the spurious over-riding small-scale waves are the main source of the observed deviations between analytical expression and experimental values. The numerical model serves as a linking element between theoretical and measured results. It can therefore rigorously explain differences between experimental and theoretical setup and the influence of small-scale spurious pollution.