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Dispersive effects during long wave runup on a beach

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In this study we investigate the effects of dispersion on long wave runup. It has been stated in the literature that dispersive effects are not so important for wave runup, therefore nondispersive nonlinear shallow water theory is widely used for runup calculations instead of numerically not very stable dispersive models. However, we found out that most of such statements are based on solitary wave (KdV soliton) propagation. We take an advantage of rich experimental data collection of different long wave types (single pulses, sinusoidal waves, bi-harmonic waves, and frequency modulated wave trains) performed in the Large Wave Flume (GWK), Hannover, Germany, and simulate it using two models: (i) non-dispersive nonlinear shallow water theory and (ii) dispersive Bousinessq type model based on the modified Peregrine system. The nonlinear shallow water model uses the finite volumes method and is based on the second order in space UNO_2 reconstruction. The dispersive Bousinessq type model uses the finite differences method.

Shown, that for long positive pulses (T = 20 s), dispersive effects are not so important and nonlinear shallow water theory can be used. However, for periodic sinusoidal and bi-harmonic pulses of the same period (T = 20 s), the dispersive effects result in significant wave transformation during its propagation and therefore, have a strong impact on its runup. These effects cannot be captured by nonlinear shallow water model, which underestimates wave runup. Such a difference between positive pulses and periodic waves can be explained by existence of higher frequencies in periodic waves spectra compare to solitary wave spectra. And although the wave periods for this two wave types are the same, their dynamics is rather different. The situation becomes even more complicated for a more complex frequency modulated wave train (T decreases from 20 s to 10 s). In this case, due to shorter wave periods and even higher frequencies in the spectrum, the dispersion effects are essential.