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A numerical study on the role of cross-shore profile shape on wave run-up

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Wave runup is a fundamental process in shaping the beachface and in causing dune and beach erosion. It is also a critical parameter to predict coastal hazards since extreme runup may generate overtopping of coastal structures and flooding of coastal region. Research has related runup to wave parameters and beach slope. However, morphological characteristic of the cross-shore profile have not been taken into account in detail. Natural beaches usually present cross-shore profilescharacterized by the presence of sandbars. The strong dependence between wave breaking and water depth implies that the presence of sand bars, specifically their cross-shore position and shape, can determine the characteristics of wave breaking and therefore of runup elevation.
We simulate swash motions on different single-barred beach profiles using SWASH, a one-dimensional nonlinear shallow water equations model.Fifteen bathymetries are defined varying different geometricvariables of a barred beach profile: the depth of the bar crest, the cross-shore position of the bar crest, the depth of the bar trough, the beach-face slope, the slope offshore of the sandbar and tidal level. A wave generation algorithm able the reproduce the incoming primary wave field in conjunction with super-harmonics and sub-harmonic induced by nonlinear interactions forces the numerical simulations.
Runup elevation over different barred beach profiles suggests a strong dependencewith sandbar shape and position. Our results show a strong influence of crestand trough depths on runup elevation, especially for the most energetic cases. Forshallower bar crests, the largest waves break over the bar dissipating more energy andresulting in smaller runup elevations. A shallower bar trough dissipates more energyfor broken or unbroken waves, causing smaller runup in all wave cases. A comparison between therunup over barred beach configurations and over a uniform slope beach withsimilar features shows that the overly simplifying the shape of the cross-shore beach profile (i.e. using a linear slope) may induce an overestimation of runup elevation of the order of 35 to 50%.