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A fully coupled wave resolving hydro-morphodynamical model to predict beachface evolution within a storm

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Abstract.
Sea storms change the shape of natural beaches, affecting this important environment. The evolution that occurs within a single storm is not yet well understood and modelled. Its knowledge is important in understanding the mechanisms involved in coastal erosion. The present study proposes an accurate and computationally efficient numerical prediction method for beachface evolution during an individual storm.

A fully coupled hydro-morphodynamical numerical solver has been developed from the previous work of Briganti et al. (2012). The one-dimensional Non-Linear Shallow Water Equations are coupled with a bed evolution relationship and solved simultaneously by means of a TVD-MacCormack scheme. Preliminary analysis of the accuracy of the model performance was conducted against available analytical solutions and numerical results for single swash event.
A suitable hydro-morphodynamic absorbing-generating condition at the seaward boundary has been developed. It prescribes the incoming wave while allows the wave reflected back by the beach to leave the domain. This boundary condition is fully coupled and based on the solution of the Riemann Equations, following previous work by Kelly and Dodd (2009). The performance of this technique was compared with existing, hydrodynamic-only boundary conditions.

The evolution of an impermeable beach described by Dodd et al. (2008) was used as a reference case. Here only the bed load is considered in the sediment transport. The evolution of an erodible idealised beach is studied during 4000 regular waves cycles, comparable with the time scale of a storm event.
The proposed model proved itself able to describe the shoreline retreat caused by the process of erosion of the beach. It experienced an increasing erosion in the upper (shoreward) and mid parts of the swash zone, with net offshore sediment transport, while the growth of a breaker bar occurred in the lower swash zone. The erosive action resulted of decreasing intensity in time, even though a fully developed steady state was not achieved at the end of the simulation. The produced evolution pattern is in very good agreement with the cited reference case and also qualitatively consistent with a typical eroding beachface in field conditions. On the other hand, the lower swash area shows higher sensitivity to the particular boundary condition applied.

The obtained results exhibit the capability of the present model to predict the evolution of the beachface in the time scale of a storm. The physical consistency showed by the proposed model gives confidence to apply it to more complex cases, closer to field conditions.

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