Shoreline response to sequence of storms: complex process-based or simple behaviour-oriented modelling?

Bruno Castelle

CNRS Research Scientist, University of Bordeaux / UMR EPOC

b.castelle@epoc.u-bordeaux1.fr

Shoreline position along wave-dominated sandy coasts varies over a wide range of temporal and spatial scales in response to a variety of processes (Stive et al., 2002). On timescales of years down to days and even hours for single storms, changes in wave energy arriving at the coast is the dominant process impacting shoreline change with cross-shore surf and swash sediment transport processes dictating changes in shoreline position.

Over the last decades, a number of complex process-based models have been developed to simulate and further predict beach changes (e.g. De Vriend et al., 1993; Nicholson et al., 1997; Roelvink et al., 2009). Among these models, the open source process-based Xbeach model is designed to assess the natural coastal response during time-varying storm and hurricane conditions, including dune erosion, overwash and breaching. A series of full-scale laboratory test cases (Deltaflume, The Netherlands) are presented showing that the model can simulate the rapid erosion of beaches pending calibration for each test case (Castelle et al., 2013), therefore limiting the applicability of this approach to predict storm impacts. In addition, computation costs and misspecifications of the physics and boundary conditions prevent them from properly predicting shoreline evolution on large timescales (months to years). These misspecifications of the physics typically cascade up through the scales resulting in an inescapable build-up of errors and unreliable simulations.

Instead, simple empirically-based behaviour-oriented models can lead to more reliable long-term evolution than do parameterizations of much smaller-scale processes in process-based models, as evidenced in many geomorphological systems (Murray, 2007). Behaviour-oriented shoreline evolution models typically relate the rate of cross-shore shoreline displacement to the wave energy and the wave energy disequilibrium between the wave energy and the equilibrium wave energy that would cause no change to the present shoreline location (e.g. Yates et al., 2011; Splinter et al., 2013). The application of such a model to a high-energy beach (Truc Vert, SW France) is presented (Castelle et al., in revision). The model shows that Truc Vert beach responds predominantly at seasonal timescales rather than at individual storm frequency. The first winter storms drive the most pronounced erosion events because both the wave energy disequilibrium and erosion change potential are large. Results reveal that erosion rate driven by a given storm is determined, non-surprisingly, by the storm characteristics, but more importantly by the recent (days to months) history of both the wave field and the beach morphology. This type of simple behaviour-oriented models also appears suitable to predict shoreline evolution on beaches responding predominantly at individual storm frequency rather than at seasonal timescales, such as the East Coast of Taiwan exposed to Typhoons. Yet, these models have not been applied to such an environment so far.