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Modelling long-term morphodynamic evolution of mega-nourishments

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The Zandmotor (the Netherlands, installed in 2011) is the largest beach nourishment in the world and has the purpose of mitigating the effects of climate change (de Schipper et al., 2014). Its long-term evolution was recently investigated with the Q2Dmorfo model (Arriaga et al., 2017), after calibrating and validating the model with 3-yr measured morphological data. The results shed light on its diffusion (e.g., predicting a lifetime three times larger than the expected one in the initial design) and other properties such as its alongshore migration and the feeding of sand to adjacent beaches. However, the role of the geometry of the mega-nourishment and the wave climate were not analysed.

In this contribution, a method to design an analytical mega-nourishment is applied that allows varying the initial orientation, shape, and size. This is validated by comparing its evolution with that of the real Zandmotor by forcing both of them with a 50-yr real wave climate based on 5-yr historical data, using Q2Dmorfo model. Once validated, the roles of orientation, shape and volume in the nourishment evolution are investigated. The results show that the initial shape asymmetry only affects the asymmetry in the feeding to adjacent beaches. The beach at the side of the nourishment with the largest slope of the shoreline receives more sediment, not only in the short term but also in the long term. The nourishment volume and shape factors control the diffusivity. Smaller and wider nourishments are more diffusive than larger and narrower (more localized) ones.

To examine the role of the wave climate, a simplified synthetic wave climate is constructed and validated with the evolution of the real Zandmotor bathymetry from January 2012. It is found that at least four wave incidence sectors must be considered, two representing low-angle waves and two representing high-angle waves, to have a good representation of the real climate. More incidence sectors do not improve significantly the results. The sensitivity of the nourishment evolution to the probability of occurrence of the oblique wave sectors is subsequently investigated. Results show that the wave angle has an important influence on the dynamics of mega-nourishments and should be taken into account in their design. In particular, the diffusivity decreases linearly with increasing frequency of high-angle waves. If high-angle waves dominate (frequency above 80%) erosional hotspots are formed at the sides of the nourishment. This is especially strong when the high-angle waves come mostly from one side, in which case a dramatic alongshore migration of the nourishment is also produced. A smaller but significant migration can occur with bimodal wave climates that have a certain directional asymmetry, which at the same time produce an asymmetry in the feeding to adjacent beaches.

References:

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