Exploration of the dynamics of mega nourishments with a cellular automata model

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Introduction

At sandy coastlines nature-based solutions have been applied for several decades already, through ongoing sand nourishments for maintaining coastal flood protection. Recently, the scale of sand nourishments has been upscaled significantly, significantly modifying the original coastal landscape. Examples of such mega nourishments are the Sand Motor (SM) and Hondsbossche Dunes (HD). Cellular Automata (CA) models are a promising tool to study the beach-dune morphology that emerges at such mega nourishments from the combined effects of aeolian processes, hydrodynamic processes, groundwater dynamics and vegetation dynamics, as well as the biophysical interactions between these dynamics. However, a realistic representation of mega nourishments with CA models is not yet possible. The aim of this study is to extend an existing CA model to allow for the long-term development of mega nourishments.

Methods

We extend an existing CA model for the combined development of Dunes, Beaches and Vegetation (DuBeVeg) (Galiforni Silva et al., 2018) by including longshore sediment transport and coastline retreat, sand armouring of the beach, and the formation of beach scarps due to wave action. The newly included physical processes were combined with aeolian, hydrodynamic, groundwater, and vegetation dynamics that were already represented in the model. The model was evaluated for a schematized version of the SM, by comparing the shape and typical scale of the simulated dunes with the real dunes that have developed on the SM since its construction in 2011.

Results & Outlook

The preliminary results show that the processes added to the model, combined with the previously included processes, can produce realistic predictions of the development of the SM. The Gaussian function that is implemented to represent longshore transport (Arriaga et al., 2017) can successfully represent the retreat of the SM in a 10-year simulation (Figure 1). Dune shapes, dimensions and spacing simulated by the model also agree with the dune formation observed at the SM over the past 10 years: embryo dunes have an average spacing of about 30 m, aligned with the prevailing wind direction, and an average height of about 1 m. These results indicate that the extended DuBeVeg model can be used to assess the realization of the intended goals of mega nourishments for different configurations and scenarios, e.g. permanent vs. transient nourishments, or different shapes and dimensions of the initial nourishment.

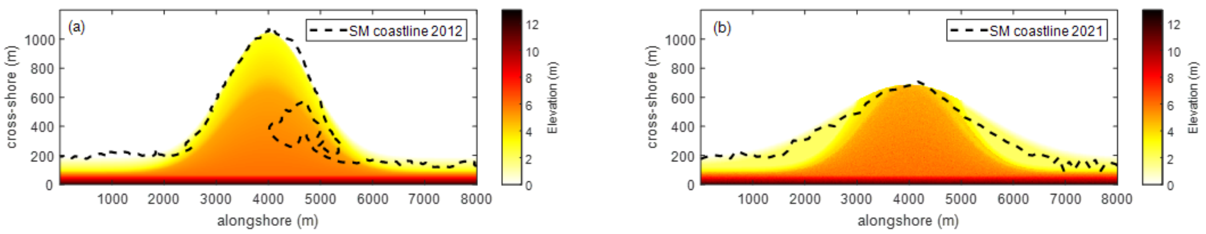

Figure 1: The extended DuBeVeg model of the SM: (a) initial topography, (b) final topography after a 10-year simulation.

References

Arriaga J, Rutten J, Ribas F, Falqués A. & Ruessink G (2017). Modeling the long-term diffusion and feeding capability of a mega-nourishment. *Coastal Engineering*, 121, 1–13.
Galiforni Silva F, Wijnberg, KM, de Groot AV, Hulscher SJMH (2018). The influence of groundwater depth on coastal dune development at sand flats close to inlets. *Ocean Dynamics*, 68 (7), 885–897.