HOW TIDES AND WAVES ENHANCE AEOLIAN SEDIMENT TRANSPORT AT THE SAND MOTOR MEGA NOURISHMENT

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INTRODUCTION

In this paper we will present a two-dimensional application of the Windsurf modeling framework on the Sand Motor mega-nourishment in The Netherlands that allows for detailed simulation of the interaction between subtidal and subaerial processes.

Expanding knowledge concerning the close entanglement between subtidal and subaerial processes in coastal environments initiated the development of the open-source Windsurf modeling framework that enables us to simulate multi-fraction sediment transport due to subtidal and subaerial processes simultaneously. The Windsurf framework couples separate model cores for subtidal morphodynamics related to waves and currents (Delft3D Flexible Mesh; Lesser et al., 2004) and storms (XBeach; Roelvink et al., 2009) and aeolian sediment transport (AeoLiS; Hoonhout et al., 2016). AeoLiS is a recent process-based model for supply-limited multi-fraction aeolian sediment transport that includes limiting effect of soil moisture, sediment sorting and beach armoring in aeolian sediment transport modeling.

WINDSURF

The Windsurf framework bridges three gaps in our ability to model long-term coastal morphodynamics:

1. Differences in time scales. XBeach is best known for its surfbeat model that typically acts on a time scale of a storm, while aeolian processes simulated by AeoLiS typically act on a time scale of seasons to years. The difference in time scales is a major problem for numerical models, as it tends to result in infeasible computational times. By creating an online coupling between models, cores can be optimized (e.g. numerical schemes and time steps) to their specific simulated processes. In the Windsurf framework, for example, we use alternatingly Delft3D-FM during calm conditions and XBeach during storm conditions.
2. Land/water boundary. Typically models either act on the subtidal domain (e.g. Delft3D-FM and XBeach) or the subaerial domain (e.g. AeoLiS). In both types of models the waterline is the effective model border. By creating an online coupling between models, the artificial divide in numerical modeling between land and water is abandoned. In the Windsurf framework we detail the interaction between subtidal and subaerial processes using the AeoLiS model.
3. Differences in meshes. Windsurf accommodates the nesting of state-of-the-art flexible meshes as used in Delft3D-FM with traditional structured meshes as used in XBeach and AeoLiS. Seamless interpolation enables virtually unlimited combination of model cores and knowledge.

SANDMOTOR

The Windsurf framework is applied to the Sand Motor mega-nourishment. The Sand Motor is virtually permanently exposed to tides, waves and wind and is consequently highly dynamic. In order to understand the complex morphological behavior of the Sand Motor, it is vital to take both subtidal and subaerial processes into account. The ultimate aim of this study is to identify governing processes in aeolian sediment transport estimates in coastal environments and improve the accuracy of long-term coastal morphodynamic modeling.

The Sand Motor is an artificial sandy peninsula extruding from the Dutch coast about 1 kilometer into the North Sea (Stive et al., 2013). About 70% of the Sand Motor area is located above 3m+MSL and is therefore uniquely shaped by wind. Significant erosion of these dry areas is observed in the first half year after the construction of the Sand Motor. After 6 months erosion diminished to as little as 2 cm/year due to the establishment of a beach armor layer. Surrounded by these elevated dry and nowadays relatively static areas, the Sand Motor accommodates both a dune lake and lagoon. Over the past four years bi-monthly bathymetric and topographic measurements show a significant infilling of both the lagoon and dune lake with aeolian sediment deposits that exceed the total erosion of the elevated dry areas significantly. The imbalance between erosion and deposition indicates that another sediment source is available, which is the moist intertidal area.

In contrast to the dry beach, no armor layer can be established in the intertidal zone due to periodic flooding. Consequently, during low tide non-armored intertidal beaches are susceptible for wind erosion and, although moist, may provide a larger aeolian sediment supply than the vast dry beach areas. Hence, subtidal processes significantly influence the subaerial morphology and both need to be accounted for to understand the long-term morphodynamic behavior of the Sand Motor.

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