MODELING THE INITIAL IMPACT OF STORM EVENTS ON THE DEFORMATION AND MIGRATION OF FULL-GROWN SAND WAVES

A DELFT3D MODELING STUDY

Sand waves are dynamic rhythmic bed patterns of several meters in height and are created by tidal circulation cells. They migrate over the continental shelf and thereby interfere with human interventions such as (energy) infrastructure. The hydrological and morphological effects during wind and surface wave action on the sand wave dynamics determine the extreme sand wave dynamics and are therefore of interest for marine construction works. Therefore, in this study wind and surface wave action is implemented to a Delft3D model, which is based on Van Gerwen (2018), by allowing surface elevation and coupling to SWAN. Wind and surface wave conditions with a return period of 100 years are tested on full-grown sand waves to determine the morphological changes after 2.5 days of continuous wind and wave conditions.

The results show that the inclusion of wind results in an opposed directed bottom flow. Surface waves on the other hand increase the flow in direction of the wave propagation. However, the sediment transport is larger in ebb-direction due to larger turbulence. In total, the morphological response during storms is larger due to surface waves compared to wind action. The combination of wind and waves results in sediments migrating anti-wave-directed towards the previous sand wave slope. However, during large storms (one-in-100-year North Sea scenario), sediment settles when reaching the slope of the next sand wave, thereby resulting in wave-directed sand wave migration. In total, the flattening of a sand wave during a once-in-a-100-years storm of 2.5 days is about as large as 20 years of tidal sand wave growth, making surface wave influences a crucial factor in modeling sand wave dynamics.

Highlights

- Sand wave steepness and height are reduced during storms.
- Surface waves result in much larger morphologic changes compared to wind-driven shear stress.
- During storms with large surface waves, sediments are transported anti-wave-directed, although sand waves migrate wave-directed.
- The effect of storms can result in morphological change that takes decades to recover

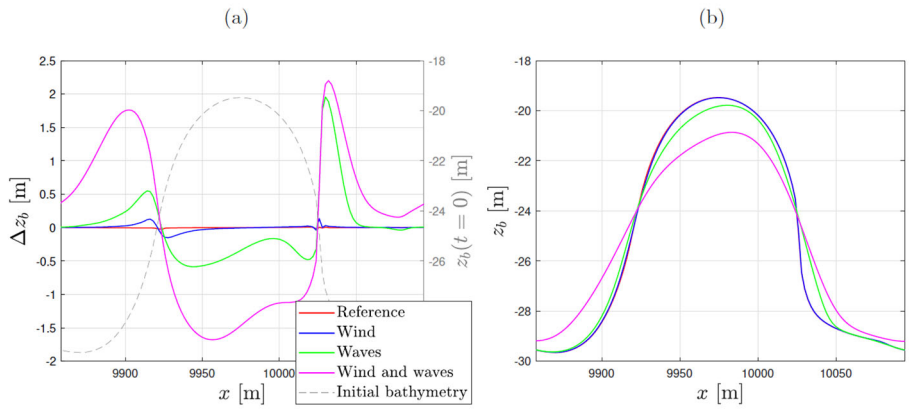

Figure 1: The morphological change after 5 tidal cycles (about 2.5 days) of a full grown sand wave, either exposed to normal tidal conditions (Reference, red), or to once-in-a-100-years storm conditions in combination with tide, either only implementing Wind (blue), only surface waves (green) or the combination of wind and surface wave action (pink). Figure a) shows the local change in bed level and b) shows the final bathymetries.

Gerwen, W. van, B. W. Borsje, J. H. Damveld, and S. J. M. H. Hulscher (2018). "Modelling the effect of suspended load transport and tidal asymmetry on the equilibrium tidal sand wave height". In: Coastal Engineering 136, pp. 56–64. doi: https://doi.org/10.1016/j.coastaleng.2018.01.006.

Thom Goesten

Graduation Date:
13th July, 2023

Graduation committee:
University of Twente
Dr.ir. B.W. Borsje
Dr.ir. J.H. Damveld
P.H.P. Overes MSc

UNIVERSITY OF TWENTE.