The effect of wave directional spreading in morphological models: hindcast of the impact of the Saint Nicholas storm on the Belgian coast

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1. Introduction

The morphological response of beach and dune systems to coastal storms often shows significant alongshore variability (De Winter et al., submitted) and modelling is increasingly performed in 2D mode. However, 1D cross-shore models are still commonly used, e.g. for larger timescales. The 1D approach neglects alongshore variability in sediment transport due to alongshore differences in the bathymetry, but also due to alongshore variation in wave run-up due to wave directional spreading.

2. The Saint Nicholas storm

A storm occurred in the North Sea on 5 and 6 December 2013 and is also known as "Xaver" or "Sinterklaasstorm". Along the Belgian coast, this storm resulted in high surge levels (highest recorded water levels since 1953) combined with significant wave heights of up to 2.7 m, which have a return period on the order of 1 year on the Belgian coast.

122 cross-shore profiles were surveyed using GPS three days before the storm. These were compared to an airborne lidar survey executed 4 days after the storm to provide a dataset of beach profile change along the entire Belgian coastline (~67 km).

3. Model results

Profiles were modelled in XBeach v1.21.3657 (Roelvink et al., 2009) using the standard settings in both 1D and 2D. The 2D configuration used an alongshore uniform bathymetry based on the pre-storm survey profiles. Erosion volumes were generally overestimated by the model, which is likely due to the use of the default calibration coefficients. For several profiles, the 1D model displays significant deviations from the 2D model results. Since both the 1D and 2D model use an alongshore uniform bathymetry, this is attributed to the directional spreading effect, which is not fully resolved in the 1D model.

Judging by the erosion volumes, a small number of alongshore grid rows (ny = 5 or ny = 8) appear to be sufficient to capture most of the 2D effect of directional spreading.

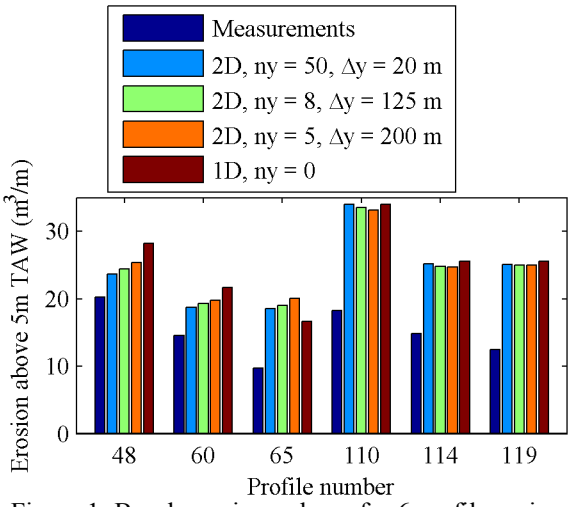

Figure 1: Beach erosion volume for 6 profiles using different model configurations.

4. Conclusions

The impact of the Saint Nicholas storm on the Belgian coast was modelled using XBeach in 1D and 2D. The 1D model does not resolve directional spreading, leading to differences in sediment transport predictions. A 2D model with a small number of alongshore grid rows reproduces the effect of directional spreading at a computational cost that is lower than a full 2D model configuration.

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