The effect of tides and storm surges on sediment transport during overwash events

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Introduction

Many barrier systems all over the world are **threatened** by the effects of **sea level rise**. If sediment is abundant and the rate of sea level rise is small, barrier islands can maintain their shape by moving landward, a process called rollover. The **landward transport of sediment** could occur via **washover openings** in the dunes during storm conditions. This results in overwash and inundation of the gaps and flooding of the land behind these gaps. To protect the Wadden Islands in the Netherlands from flooding, artificial sand-drift dikes that close the overwash gaps were constructed in previous centuries. Recently in the Netherlands, the **re-activation of the washover inlets** was considered by the local coastal zone management to stimulate sediment deposition behind the dunes.

Field measurements

- 10 stand-alone pressure transducers and 2 instrument rigs containing an Acoustic Doppler Velocimeter (ADV) are installed.
- Cross-shore array from the North Sea side to the Wadden Sea side of Schiermonnikoog (Fig 1) .
- Alongshore uniform, beach crest is at 1.6 m above mean sea level.

Model study

- Validation with field data, followed by simulations based on storm characteristics
- Inundation classes: 25 years of **water level data** in the North Sea and Wadden Sea, and **wave data** in the North Sea are used to make a storm classification (Fig 2 for waterlevels, Table 1 for wave heigt and occurence).

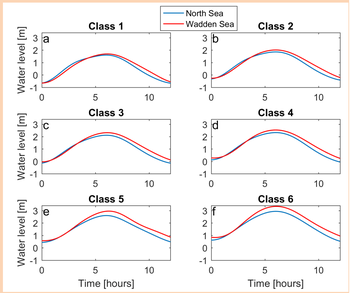

Fig 2 Water level curves used as boundary conditions for each class. Red is station Schiermonnikoog (Wadden Sea), blue is station Huibertgat (North Sea) (Fig 1c).

Class	Wave height Hs (m)	Occurence (per year)
1	2.61	23
2	3.42	7.4
3	3.98	2.6
4	4.33	0.8
5	5.38	0.5
6	5.61	0.3

Table 1: Per hydrodynamic class: significant wave height and occurrence. Offshore wave data optioned at Wave Buoy Schiermonnikoog Noord (Fig 1c).

Research aims

1. Validate the 1D version of the process-based model XBeach for hydrodynamic parameters (i.e. water levels, short and IG wave heights and flow velocities) during overwash and inundation for North Sea conditions.

2. Extend our knowledge on hydrodynamic processes and sediment transport during overwash and inundation for mesotidal conditions.

Fig 1 a) North Sea Basin, b) Satellite image of North and Wadden Sea, c) Satellite image Schiermonnikoog, in red the measurement array.

Xbeach validation

- Model-data comparison shows good agreement (Fig 3).
- Water depths and short wave heights across the island were simulated accurately with very high r^2 values and a small positive bias.
- IG wave heights were slightly underestimated.
- Cross-shore flow velocities resulted in somewhat lower but still sufficient r^2 values and a slightly higher bias.

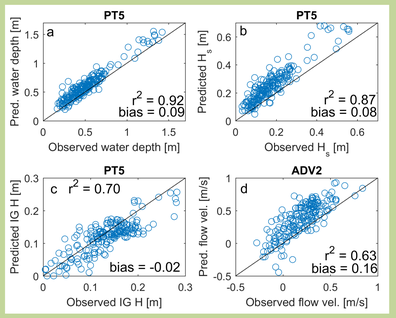

Fig 3. Observed versus predicted mean parameters for all inundations, for PT5 and ADV2. The black lines indicate the 1:1 position. a) Water depth b) Short wave height c) IG wave height d) Flow velocity

Long-term sediment transport

- During a tidal cycle the water level between North and Wadden Sea is different (Fig 2)
- This is a crucial aspect for the sediment transport across the island tail. It resulted in a smaller or even reversed current and reduced the net sediment transport (Fig 4)
- Furthermore, we found the cumulative effect of relatively mild storms (Class 1, 2 Table 1) to be more important for the long-term sediment transport than the cumulative effect of large, more rare North Sea storms (Class 5, 6 Table 1).

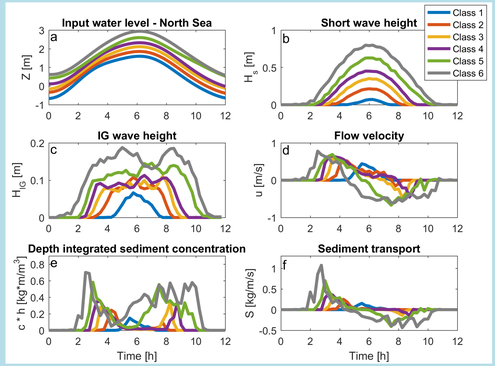

Fig 4 a) Input North Sea water level curves (Fig2). Output of all inundation classes as function of time, averaged over 15 minutes and calculated at the beach crest. b) Short wave height. c) IG wave height. d) Cross-shore flow velocity. Positive is in the direction of the Wadden Sea e) Depth-integrated sediment concentration f) Sediment transport. Positive is in the direction of the Wadden Sea.

Conclusions

- Based on the XBeach model-data comparison the model can be used for further analysis
- The accumulated effect of gentle storms on sediment transport is more important than the accumulated effect of larger storms.
- For meso-tidal barrier systems like the Wadden Sea, the dynamics of the back-barrier have to be taken into account