The effect of the washover geometry on sediment transport during inundation events

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Introduction

- Many washover systems at the Wadden Islands are closed off by artificial sand-drift dikes (Figure 1).
- We hypothesize that during overwash and inundation the barrier islands experience an influx of sediment.
- Partial re-opening of the sand-drift dikes is considered.
- It is unknown how local washover geometries influence the hydrodynamics and sediment transport from the beach to the hinterland.

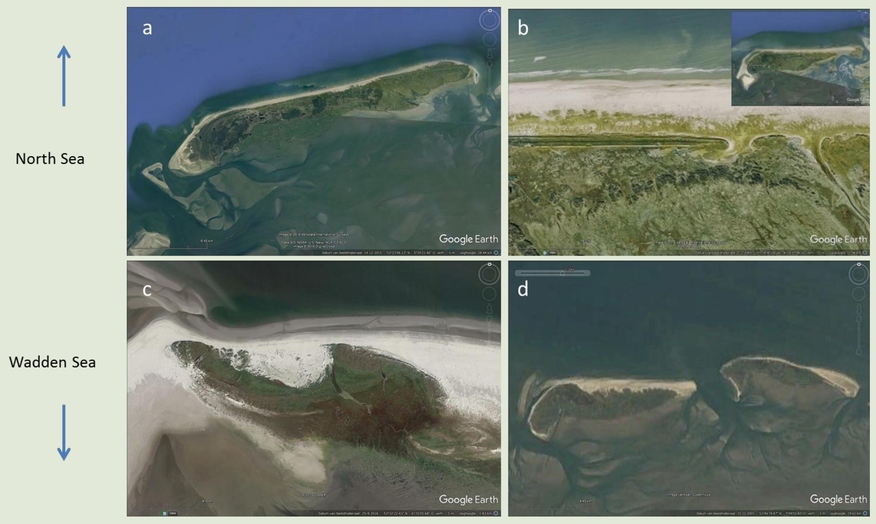


Figure 1. a) Terschelling, the Netherlands. A large sand-drift dike prevents inundation. b) Schiermonnikoog, the Netherlands. The sand-drift dike is partly destroyed by a storm in 1976. c) Rottumeroog, the Netherlands. This washover is created during a storm in 2013. d) Spiekeroog (left) and Wangeroog. Spiekeroog did never have sand-drift dikes, Wangeroog is completely closed off.

Research question

How are the hydrodynamics and sediment transport of a washover system influenced by washover dimensions and beach characteristics?

Methods

- The model XBeach is used in 2D and morphostatic mode to simulate the hydrodynamics and sediment transport for different washover geometries.
- The reference profile (Figure 2) is based on a washover at Schiermonnikoog. All the simulations are summarized in Table 1.
- A constant water level of 2.5 m is applied (i.e. no tide).
- Constant wave forcing with an offshore wave height of 5.4 m, a wave period of 8.5 s and a wave direction of 45 degrees is used.
- All output is averaged over 1 hour.

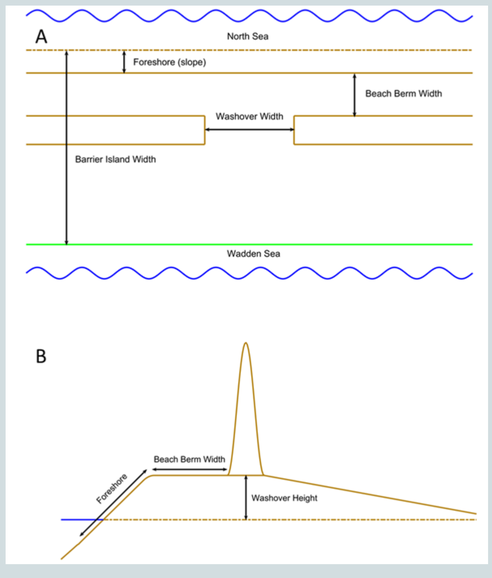
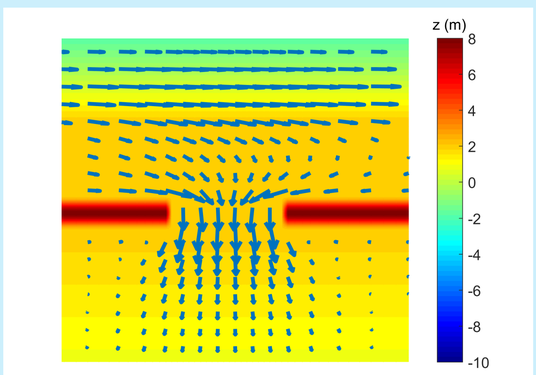


Figure 2. a) Top view of a typical washover system. The beach at the North Sea side consists of a gently sloping foreshore and a flat beach berm. The washover is an opening of the dune row. Onshore of the washover opening and dunes is typically a salt marsh. b) Side view, where the foreshore, beach berm and washover height are indicated. This profile includes a dune or washover opening, depending on the alongshore location. Note that the y-axis is exaggerated.

Series	Washover width (m)	Washover height (m)	Beach Berm width (m)	Foreshore slope (m/m)
Default	200	2.0	300	0.01
Vary washover width and height	50, 100, 200, 300, 400, 500, 600	1.7, 2.0, 2.3	300	0.01
Vary beach berm width	200	2.0	10, 50, 100, 200, 300	0.01
Vary foreshore slope	200	2.0	300	0.01, 0.02, 0.03, 0.05, 0.1

Table 1. Overview of all simulations

Results – Reference simulation



- Currents accelerate trough the washover opening.

Figure 3. Flow field for the default simulation. Currents accelerate trough the washover opening and are in cross-shore direction. The arrows indicate the magnitude and direction of the flow.

Results – Varying washover width and height

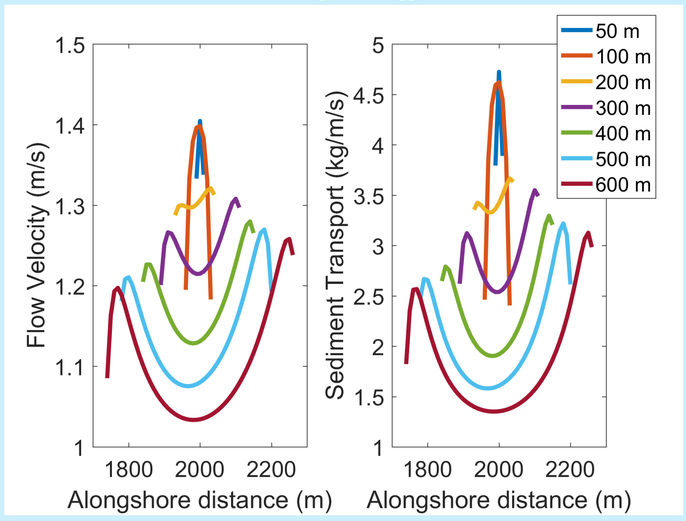


Figure 4: Flow velocities and sediment transport along the whole opening for different washover widths for a washover height of 2.0 m.

- For wide washover openings, currents and sediment transport peak at the edges, while they peak in the middle for narrow openings.
- Flow velocities in the middle of the washover openings reduce when the openings become wider.
- From a width of 200-300 meters the increase in total sediment transport through the whole washover opening reduces.
- Total sediment transport is largely influenced by the washover height.

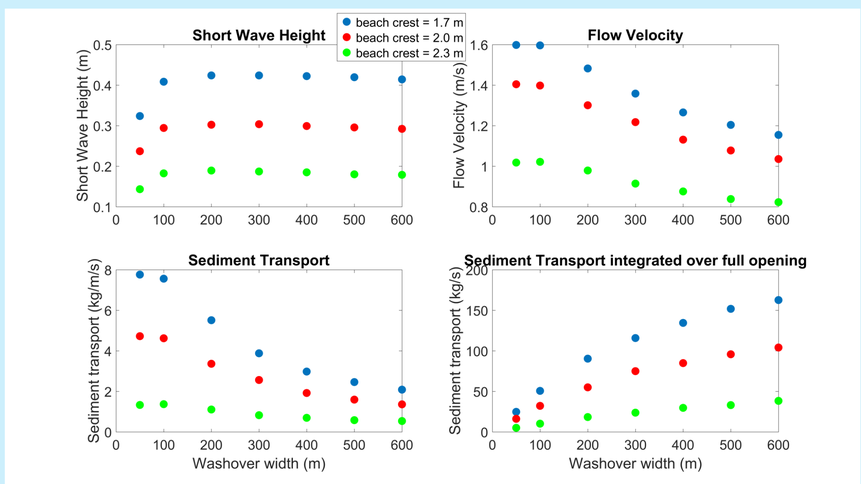


Figure 5: Short wave height, flow velocity and sediment transport at the middle of the washover opening, and total sediment transport through the entire opening.

Results – Varying beach slope and width

- The beach berm width hardly influences the sediment transport at the washover opening.
- The foreshore slope affects the sediment transport for extreme steep slopes only.

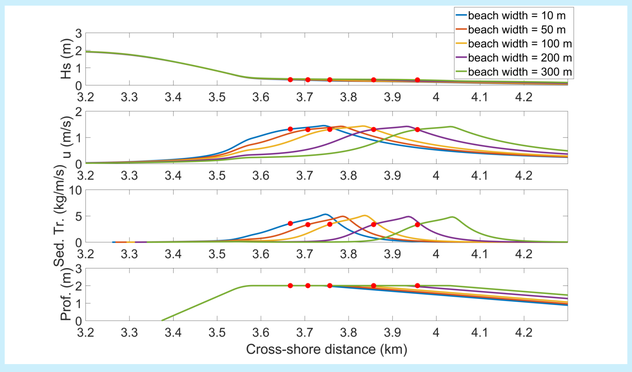


Figure 6. Short wave height (Hs), flow velocity (u) and sediment transport for different profiles that vary in beach berm width. The red dots mark the middle of the specific washover opening.

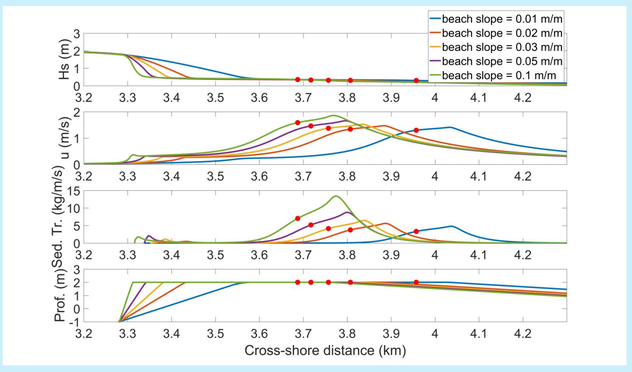


Figure 7: Short wave height (Hs), flow velocity (u) and sediment transport for different profiles that vary in foreshore slope. The red dots mark the middle of the opening.

Conclusions

- The washover height has a large impact on the total sediment transport through the opening.
- Wider washover openings reduce the flow velocity trough the opening, which effects total sediment transport.
- The beach width and slope have limited effect on the total sediment transport through the washover opening.