The influence of washover dimensions and beach characteristics on the sediment transport during inundation

Daan Wesselman[1], Maarten van der Vegt[1], Renske de Winter[1],
[1]Department of Physical Geography, Utrecht University, The Netherlands, email: d.a.wesselman@uu.nl

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.
- Re-opening of the sand-drift dikes is considered.
- It is unknown how washover geometry influences the hydrodynamics and sediment transport.

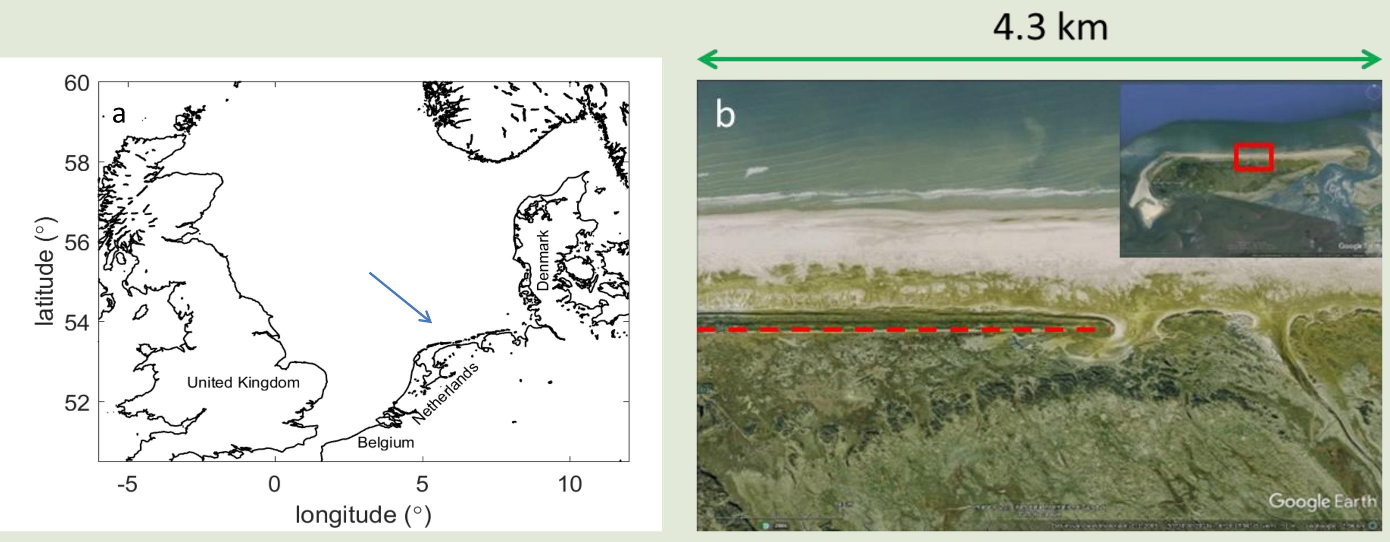

Figure 1. a) North Sea Basin. The arrow indicates the position of Schiermonnikoog, a Dutch Wadden Island b) Satellite image of Schiermonnikoog. The red dashed line marks the sand-drift dike.

Research questions

- How do hydrodynamics, sediment transport and morphology change depend on washover dimensions and beach characteristics?
- How important is the tide for morphology change during inundation?

Methods

- XBeach in 2D mode was used to simulate the hydrodynamics, sediment transport and morphology change for different washover geometries (Figure 2).
- Model forced by either constant water level of 2.5 m, or by tide-varying water levels. Constant offshore wave height 5.4 m, period 8.5 s and direction 45 degrees.

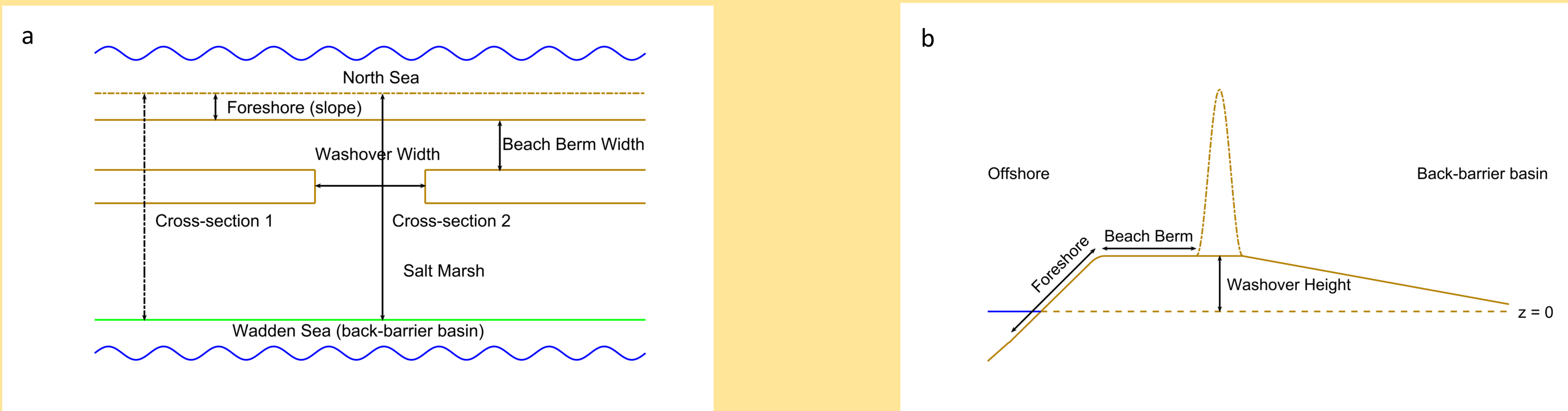

Figure 2. a) Top view of a typical washover system. The beach at the North Sea side consists of a gently sloping foreshore and a flat beach berm. The washover is an opening of the dune row. b) Side view, where the foreshore, beach berm and washover height are indicated. Vertical scale is exaggerated.

Results

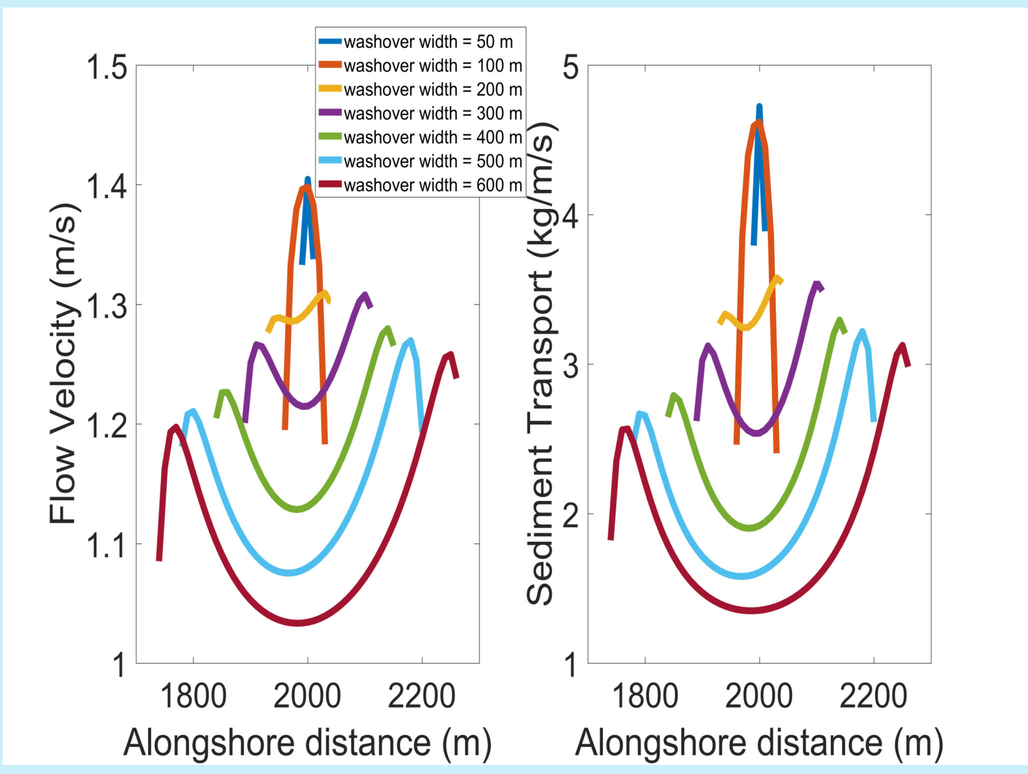

Figure 3. Cross-shore flow velocity and sediment transport in washover gap as function of washover width.

Currents accelerate through the washover opening.

For wide washover openings, currents and sediment transport peak at the sides, while they peak in the middle for narrow openings.

Flow velocities and sediment transport in the middle of the washover openings reduce when the openings become wider.

Sediment transport mainly driven by flow, effect of waves small.

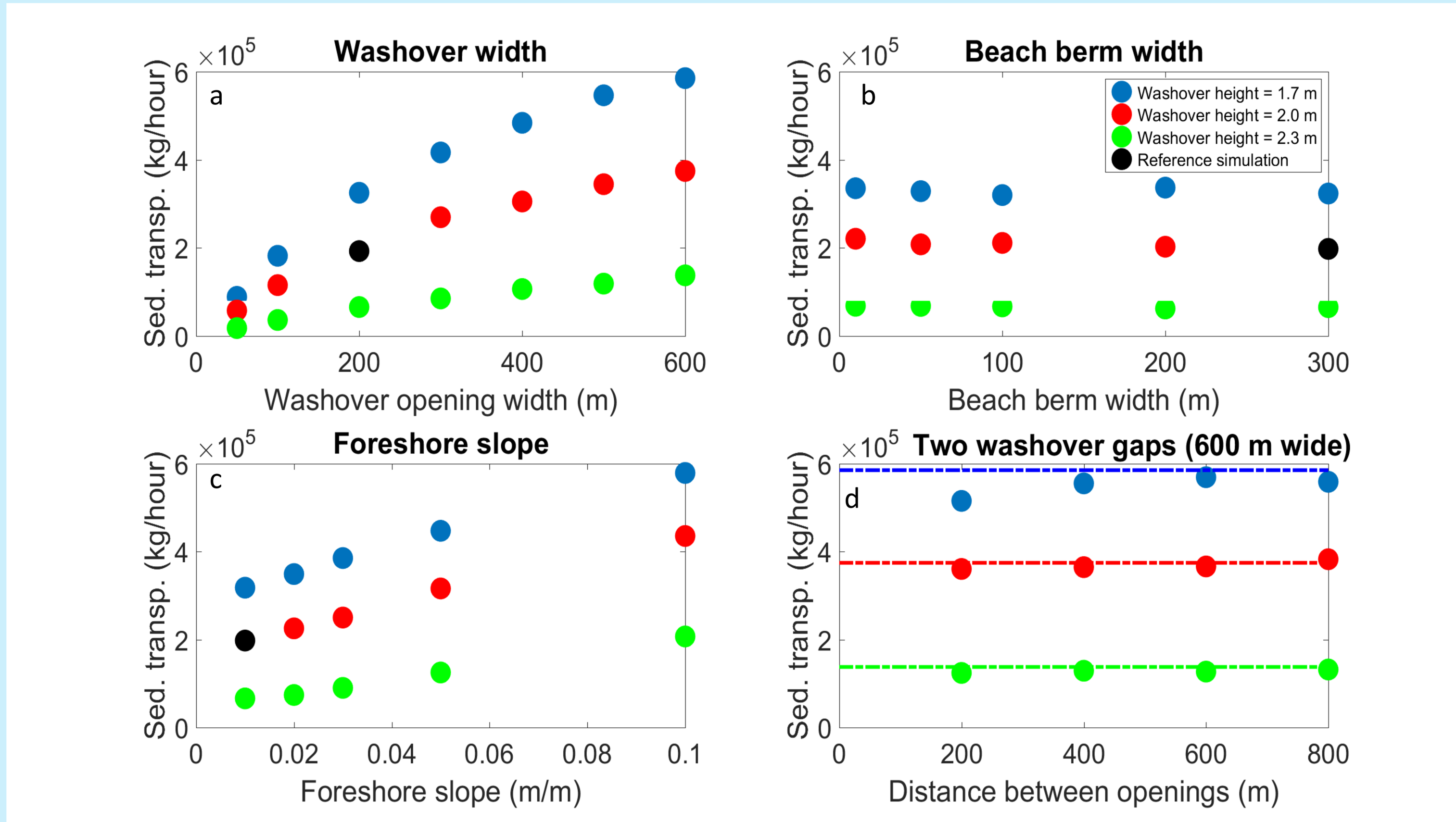

Figure 4. Width-integrated sediment transport as a function of a) Washover widths, b) Beach berm widths and c) Foreshore slopes, for different washover heights. d) Simulations with two subsequent washover openings of 600 m wide, with different distances between the openings. For a comparison, the dashed lines represent the simulations with only one opening of 600 m wide.

Sediment transport through washover opening is most sensitive to the washover dimensions.

Beach characteristics and the distance between two subsequent openings are less important.

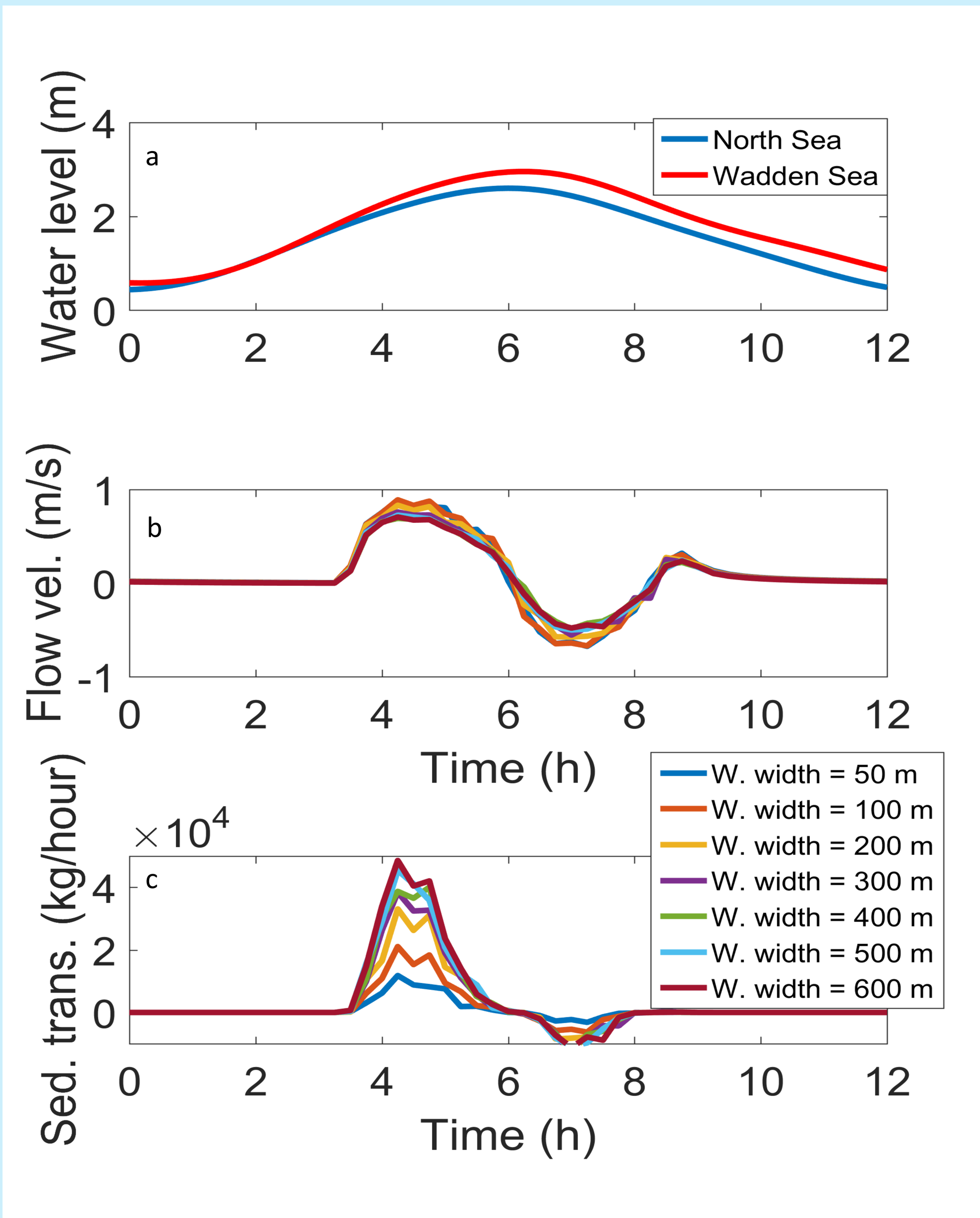

Figure 5. a) Tidal curves for the North Sea and Wadden Sea (back-barrier). b) Flow velocity and c) sediment transport in the middle of the washover. Positive and negative means onshore and offshore respectively.

The local tide of Schiermonnikoog influences the currents and thereby the sediment transport significantly.

The storm-averaged, width-integrated sediment transport amounts to 0.2 – 1.2 * 10^4 kg/hour.

Washover opening erodes, deposition landward of opening.

The tidal cycle leads to much less morphology change compared to stationary conditions.

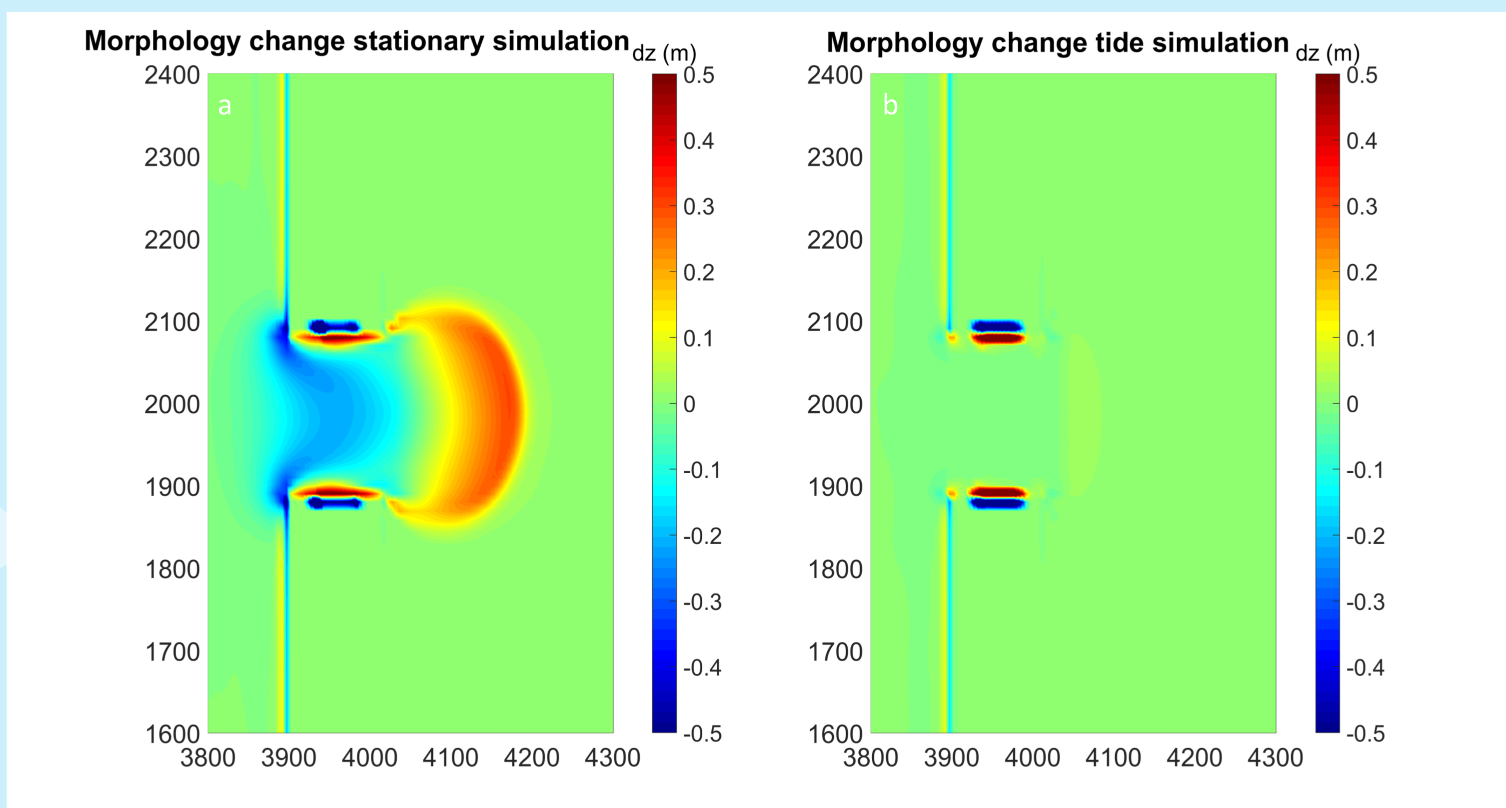

Figure 6. Morphology change for the reference simulation after a) 3 hours of stationary conditions b) one tidal cycle as shown in Figure 6a.

Conclusions

- The washover dimensions have a larger impact than the beach characteristics on the hydrodynamics, total sediment transport through the opening and morphology change during storm events.
- The local tidal patterns can be a limiting factor for storm-induced morphology change.