How island slopes effect wave shape and transformation during island inundation

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Introduction

The vertical growth of barrier islands is important for their survival in times of sea level rise. During overwash and island inundation sediment is transported onshore and can potentially lead to island growth. Dunes and dikes are protecting the barrier islands, but are also cutting off the sand supply to the area landwards of the protection. To evaluate the feasibility of restoring these processes by re-opening dikes and dunes, and to be able to determine design criteria for openings, the effect of regional aspects during inundation need to be known. For example, the steepness of the beach slope can vary significantly in the Netherlands and will impact wave heights and the shapes of waves during the shoaling and breaking process and thereby effect sediment transport.

Research questions

How does the steepness of the beach slope influence infragravity and sea-swell wave heights and shapes during island inundation?

Methods

Model description and set-up

SWASH (Zijlema et al., 2011) is used to simulate the transformation of low-frequency (LF, ~0.005-0.05 Hz) and high-frequency (HF, ~0.05-1 Hz) waves on varying beach slopes (Figure 1b.). Our design criteria is based on observations collected on Schiermonnikoog, which are also used for validation. For the validation the real bottom profile is used.

Settings:

- profile (cross-shore) mode, grid size 0.5m, time step 0.0125s, simulation period 4 hrs
- 2 vertical layers, sponge layer (500m) at the basin boundary
- bottom friction: Mannings roughness coefficient = 0.019
- boundary conditions: wave height 5.9m, wave period 12s, water level 2.65m

Data analysis

The wave shape is determined by skewness (long, shallow troughs and high narrow crests), which increases for increasing positive numbers, and asymmetry (forward pitched shape), which increases with negative numbers. Asymmetry and skewness are only shown for wave heights > 0.2m.

Model-data comparison

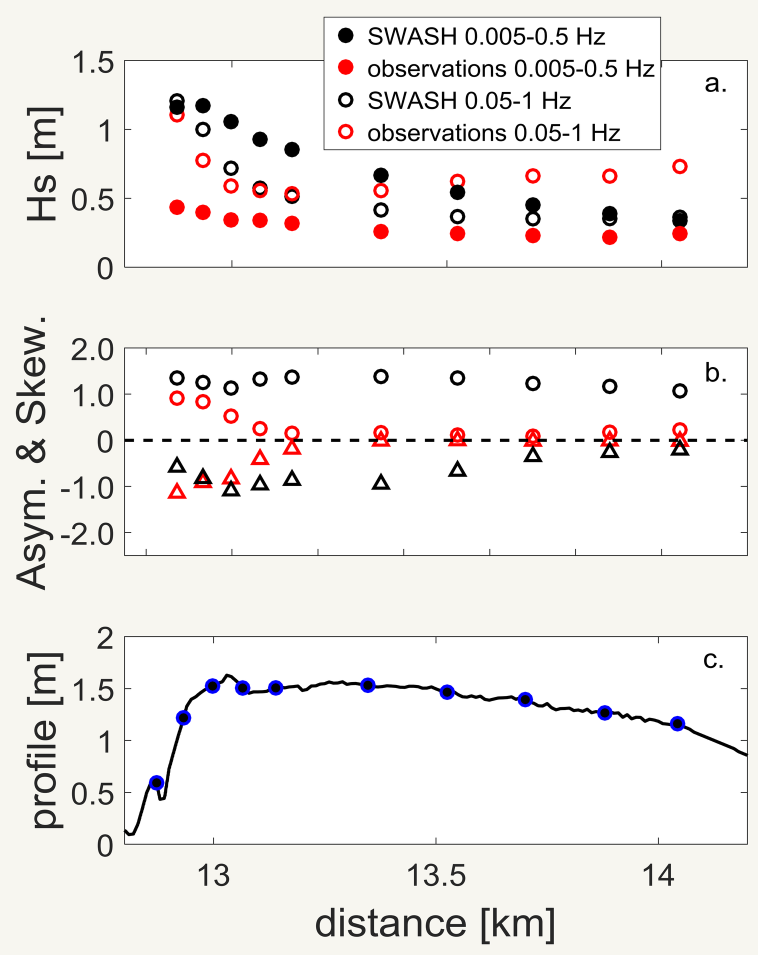

Figure 1 . Model results for high-frequency (HF) and low-frequency (LF) significant wave heights (Hs, a.), HF asymmetries triangles) and skewness (b. circles) compared to observations. Instrument locations (blue dots in c.) are shown on the island profile. The North Sea is to the left, the Wadden Sea is to the right.

Main findings

- Overall satisfactory agreement for HF wave heights, asymmetry and skewness before the crest; reduced agreement after crest due to the influence of incoming waves from the Wadden Sea (neglected in the model).
- LF wave height overprediction is probably due to directional spread (cannot be included in profile mode).
- SWASH is assumed appropriate for slope inter-comparisons.

Model results for slope comparisons

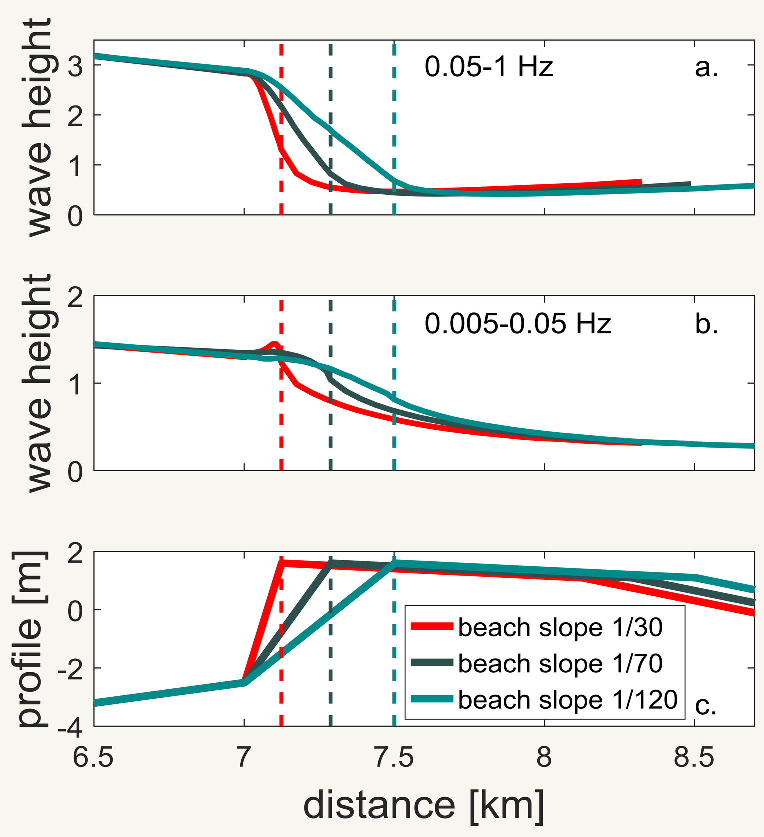

Figure 2. HF (a.) and LF (b.) predictions of wave heights for three different profiles (c.). The vertical dashed lines show the locations of the beach crests.

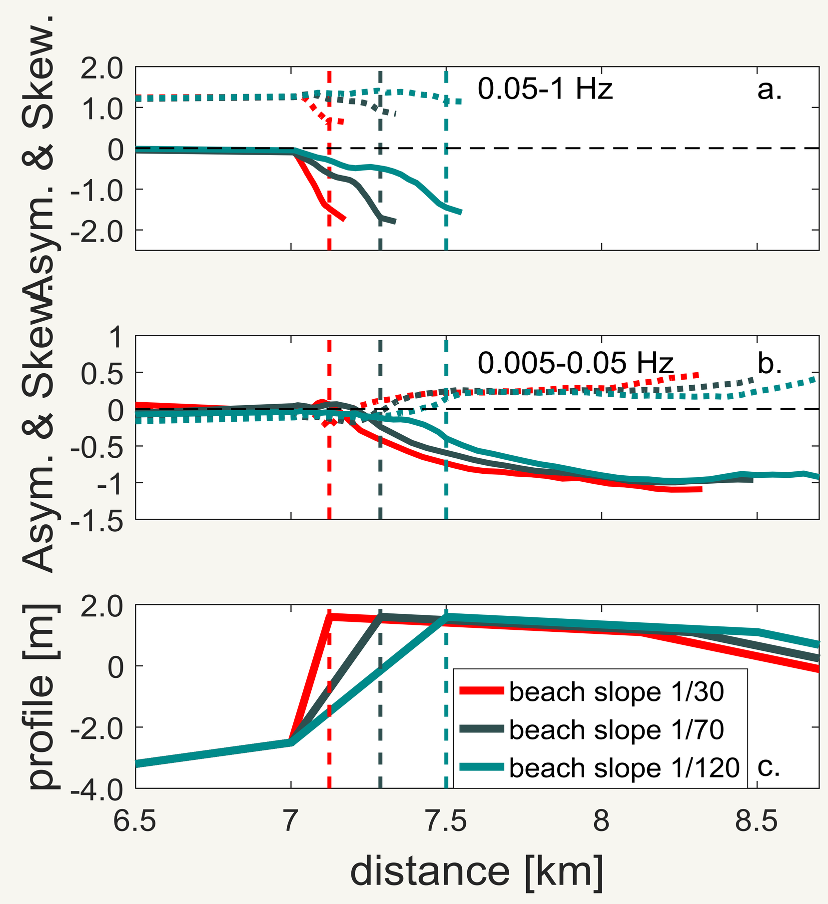

Figure 3. HF (a.) and LF (b.) predictions of wave asymmetries (solid lines) and skewness (dotted lines) for the same profiles (c.) as in figure 2.

Main findings

- HF and LF waves are higher at and landward of the crest for the steep slope; on steep slope, LF wave heights initially increase.
- HF asymmetries increase on all slopes indicating wave breaking
- LF skewness and asymmetries increase after crest for steeper slopes, while they already increases on the slope for 1/120 slope. HF and LF skewness increases for gentle slope indicating further shoaling.
- Higher waves for the steep slope could increase sediment stirring and transport landward of the crest, while shoaling and breaking on the gentle slope could potentially increase the transport on the slope compared to steep slopes.

Acknowledgements

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References

Zijlema, M., Stelling, G., Smit, P., 2011. *Coastal Engineering*, 58 (10), 992-1012.