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

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 height and occurrence).

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

<table>
<thead>
<tr>
<th>Class</th>
<th>Wave height Hs (m)</th>
<th>Occurrence (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.61</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>3.42</td>
<td>7.4</td>
</tr>
<tr>
<td>3</td>
<td>3.98</td>
<td>2.6</td>
</tr>
<tr>
<td>4</td>
<td>4.33</td>
<td>0.8</td>
</tr>
<tr>
<td>5</td>
<td>5.38</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>5.61</td>
<td>0.3</td>
</tr>
</tbody>
</table>

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.

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.