Cyclic behavior of ebb-tidal deltas from model simulations: the role of waves and tides

Introduction

- Ebb-tidal deltas are shallow sandy features located seaward of tidal inlets and are important for coastal safety in barrier systems.
- They act as a shield for incoming (storm) wave energy and they are a source of sediment for the barrier islands and the back-barrier basin.
- The Ameland Inlet changes from a one-channel-system to a two-channel-system and back during one cycle.

Main Question

What are the mechanisms of the observed cyclic behavior?

Results

Methodology

- Modeling with Delft3D/SWAN
- Initial bathymetry:
  - High spatial (50 m) and temporal (12 s) resolution.
  - Hydrodynamic forcing: combination of tides and waves.
  - Tides: semi-diurnal tidal wave with amplitude $A = 1.2$ m.
  - Waves from NW: wave height $H_w = 2$ m and period $T_m02 = 7.5$ s.
  - Sediment transport formulation: Van Rijn et al. (2004), bed-load and suspended load ($d_{50} = 0.25$ mm). Morphological acceleration factor $M_{fac} = 20$.

Discussion

- The period between successive shoals decreases with decreasing tidal amplitude.
- Larger waves result in faster shoal dynamics and smaller time scales.

Conclusions

Changes in the inlet - similar to the one-channel/two-channel transformation of the Ameland Inlet - are an inherent feature of the modeled periodic shoal dynamics.

Model results suggest that the observed cyclic behavior is the result of feedbacks among the periodically changing inlet configuration, waves, tidal currents and import/export.

During the modeled shoal migration, clockwise rotation of the main channel and subsequent channel breaching is found.

Stages in cyclic behavior:

1. Fully-developed ebb-tidal delta, one deep channel with import of sediment
2. Shoal formation forced by export of sediment, second channel forming
3. Shoal growth due to wave action, clockwise rotation channel
4. Seaward growth of shoal as a result of ebb flow, two-channel inlet
5. Wave processes forces shoal migration, breaching event provides a more efficient channel position
6. Shoal attachment, one updrift oriented deep channel