



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

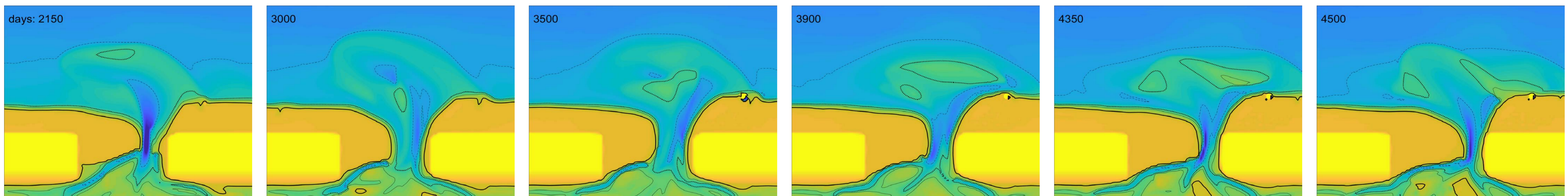
Introduction

- 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.
- Often, cyclic behavior of shoal formation, migration and attachment to the downdrift island is observed.
- The Ameland Inlet changes from a one-channel-system to a two-channel-system and back during one cycle.

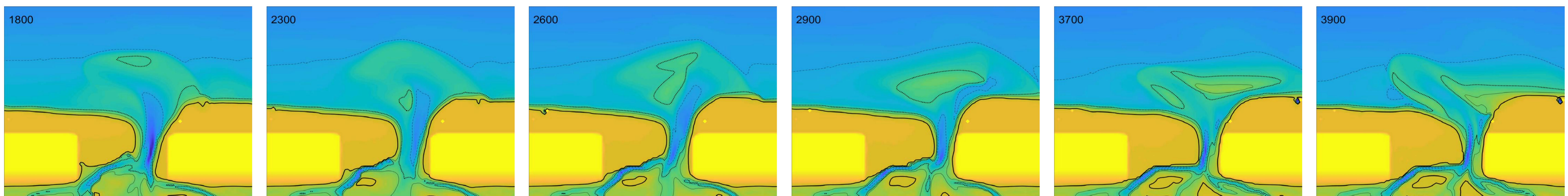
Main Question

What are the mechanisms of the observed cyclic behavior?

Tidal wave amplitude $A = 1$ m



Tidal wave amplitude $A = 0,9$ m



Stage 1

Stage 2

Stage 3

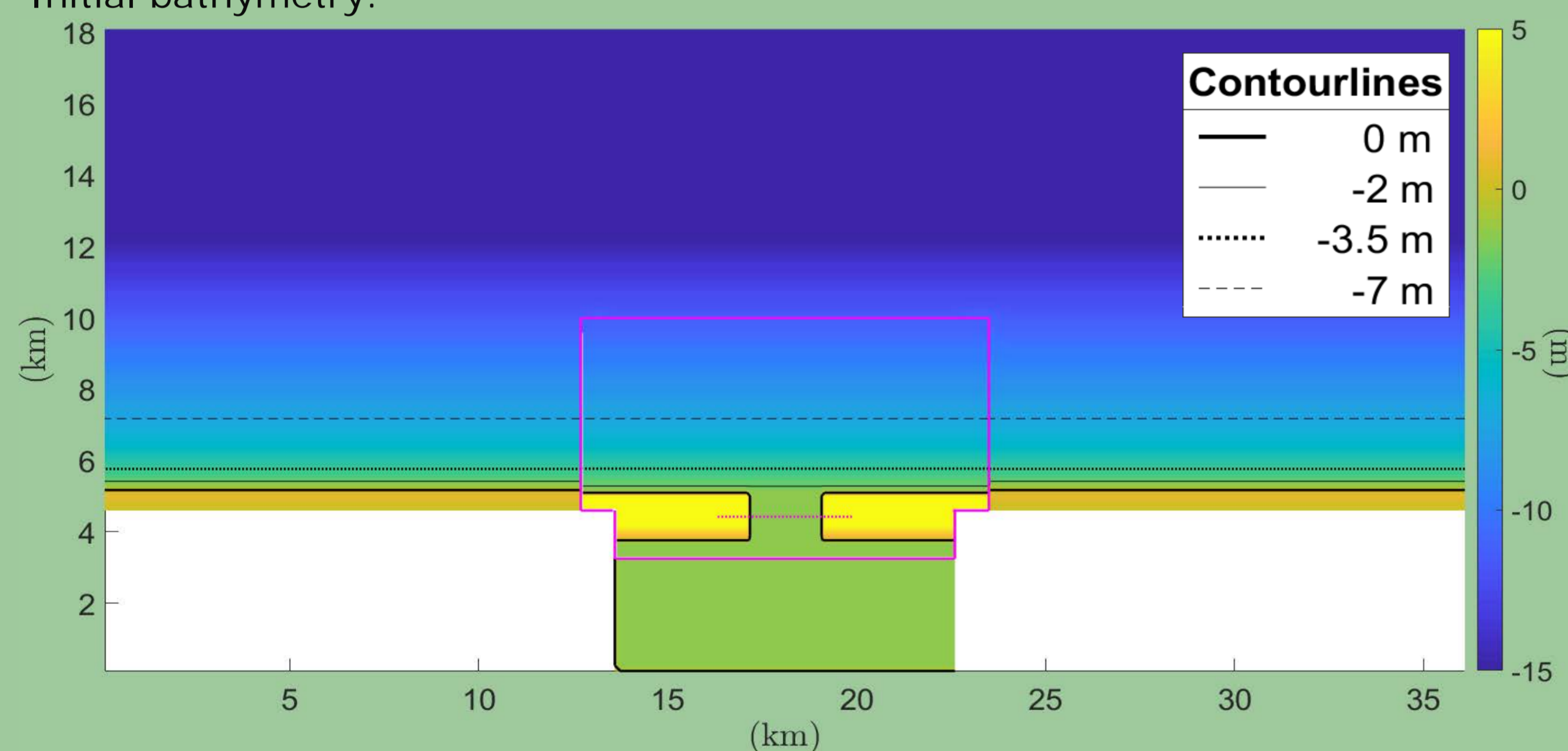
Stage 4

Stage 5

Stage 6

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 (amplitude A).
- Waves from NW: wave height $H_s = 2$ 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

- During the modeled shoal migration, clockwise rotation of the main channel and subsequent channel breaching is found.
- The period between successive shoals decreases with decreasing tidal amplitude.
- Larger waves result in faster shoal dynamics and smaller time scales.
- In most model runs, the formation of shoals is triggered by a (temporary) decrease in tidal prism and export of sediment. However, in some other model runs, shoal formation is found with constant tidal prism and import/export.

Watch full simulations



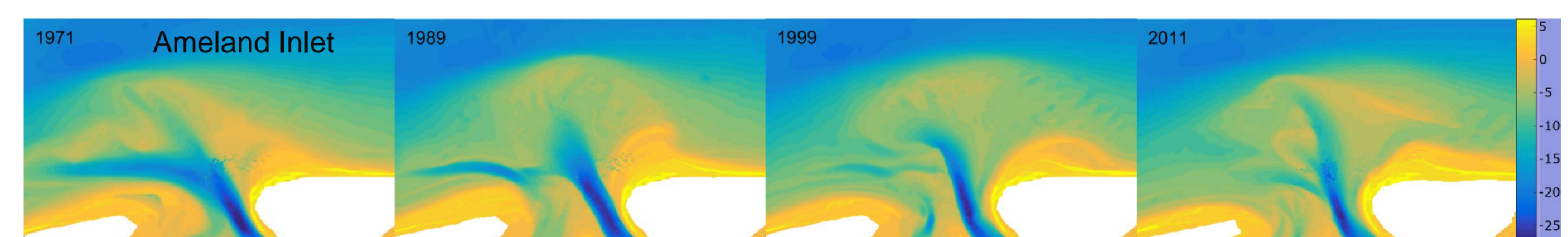
(A=1 m)



(A=0.9 m)



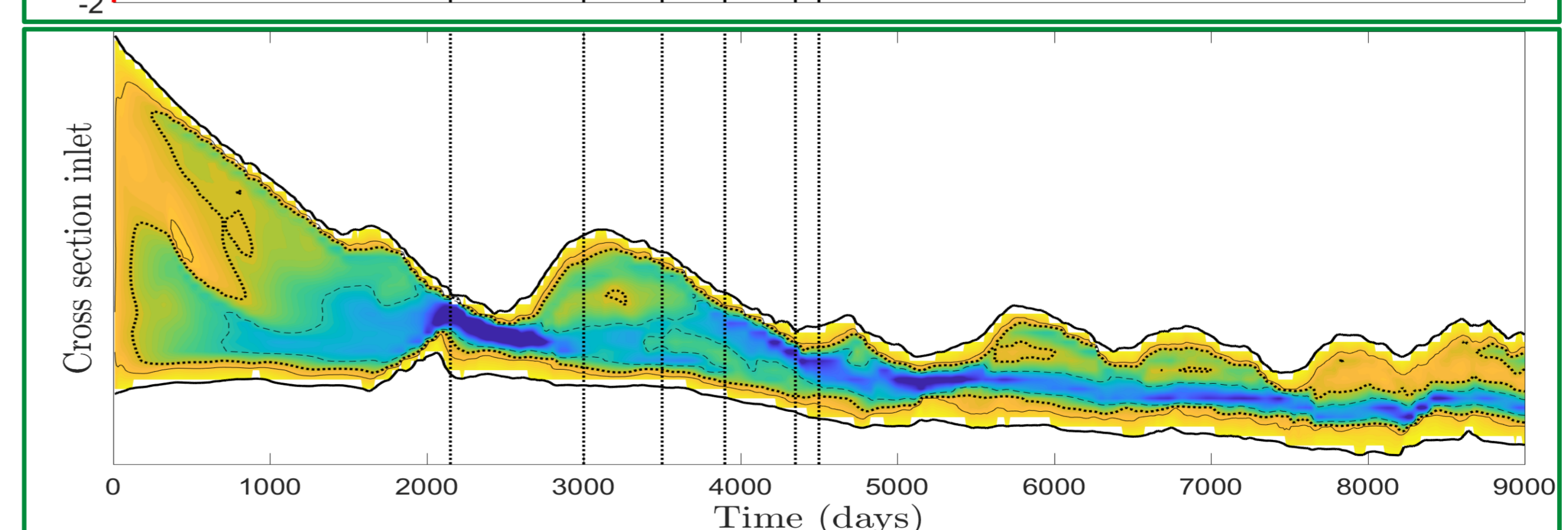
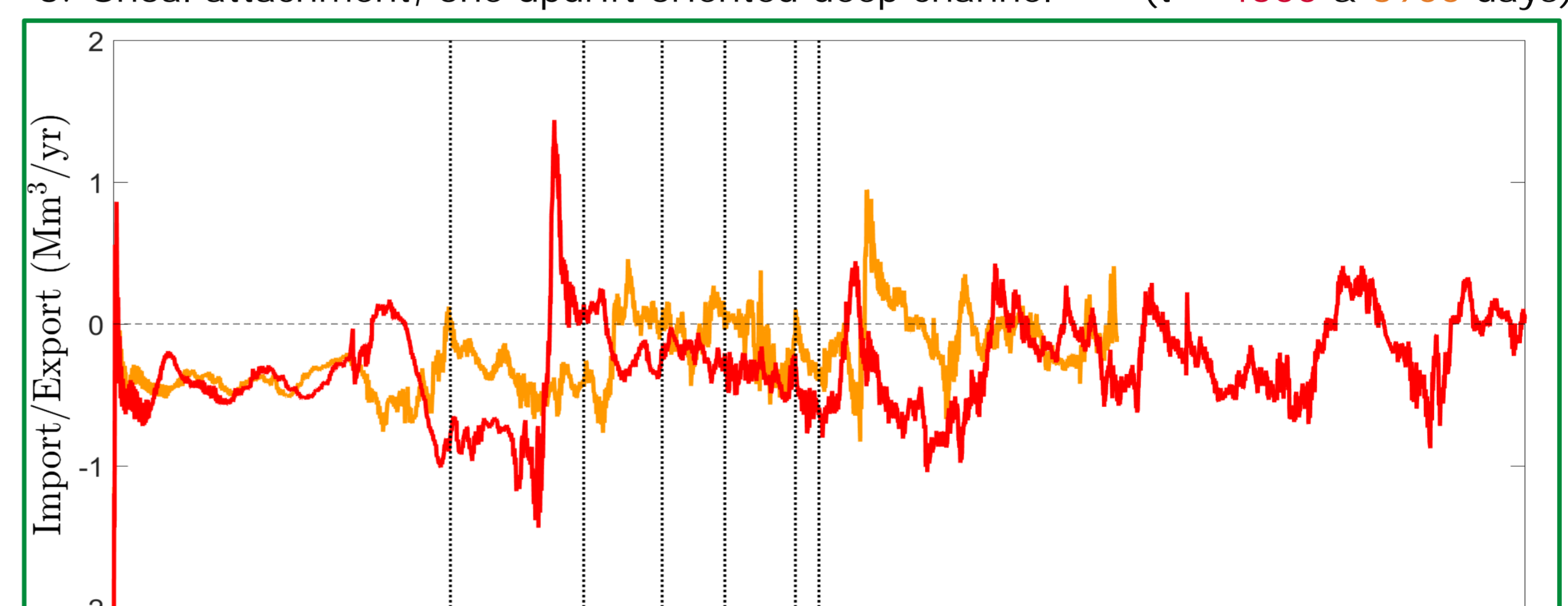
(Hs=1.5 m)



Results

Stages in cyclic behavior:

- Fully-developed ebb-tidal delta, one deep channel (t = 2150 & 1800 days)
- Shoal formation, second channel forming (t = 3000 & 2300 days)
- Shoal growth, clockwise rotation channel (t = 3500 & 2600 days)
- Seaward growth of shoal (t = 3900 & 2900 days)
- Shoal migration, channel breaching (t = 4350 & 3700 days)
- Shoal attachment, one updrift oriented deep channel (t = 4500 & 3900 days)



Conclusions

One-channel/two-channel transformations are an inherent feature of modeled periodic shoal dynamics and are similar to the Ameland Inlet.

Model results suggest that the observed cyclic behavior is the result of a morphodynamic feedback effect.

Larger waves and smaller tides result in smaller time scale.