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Enabling new technology

Sandbar and shoreline behaviour along a man-made curved coast

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Introduction

Sandbars, submerged ridges parallel to the shoreline, are found along many wave-dominated beaches throughout the world. Sandbar and shoreline are known to move in the cross-shore direction, to vary in planshape from linear, two-dimensional (2D) to undulating, three-dimensional (3D), and to couple their 3D shapes (Fig 1). This natural behaviour gets disturbed when man nourishes the beach or shoreface with sand, a common-practice measure against coastal erosion.

Recently, a large, concentrated nourishment (Sand Engine) was constructed with a strongly curved coast that protruded 1 km into the sea (Fig 1). How such a nourishment affects sandbar and shoreline behaviour is unknown. **Here the objective is to describe the spatio-temporal variability in sandbar and shoreline behaviour along a man-made, curved coastline.**

Data and methods

- 2.4-year data set of daily low-tide Argus video images from Sand Engine mega-nourishment (21.5 Mm^3 or >8900 olympic swimming pools)
- Detection of sandbar and shoreline in images (Fig. 1c) and computation of morphometric parameters at North and South side:
  - -Mean position X_{mn} [m] (Cross-shore migration)
  - -Distance between sandbar and shoreline ΔX_{mn} [m]
  - -Standard deviation *Std* [m] (2D versus 3D)
  - -Cross-correlation R^2 (Morphological coupling)

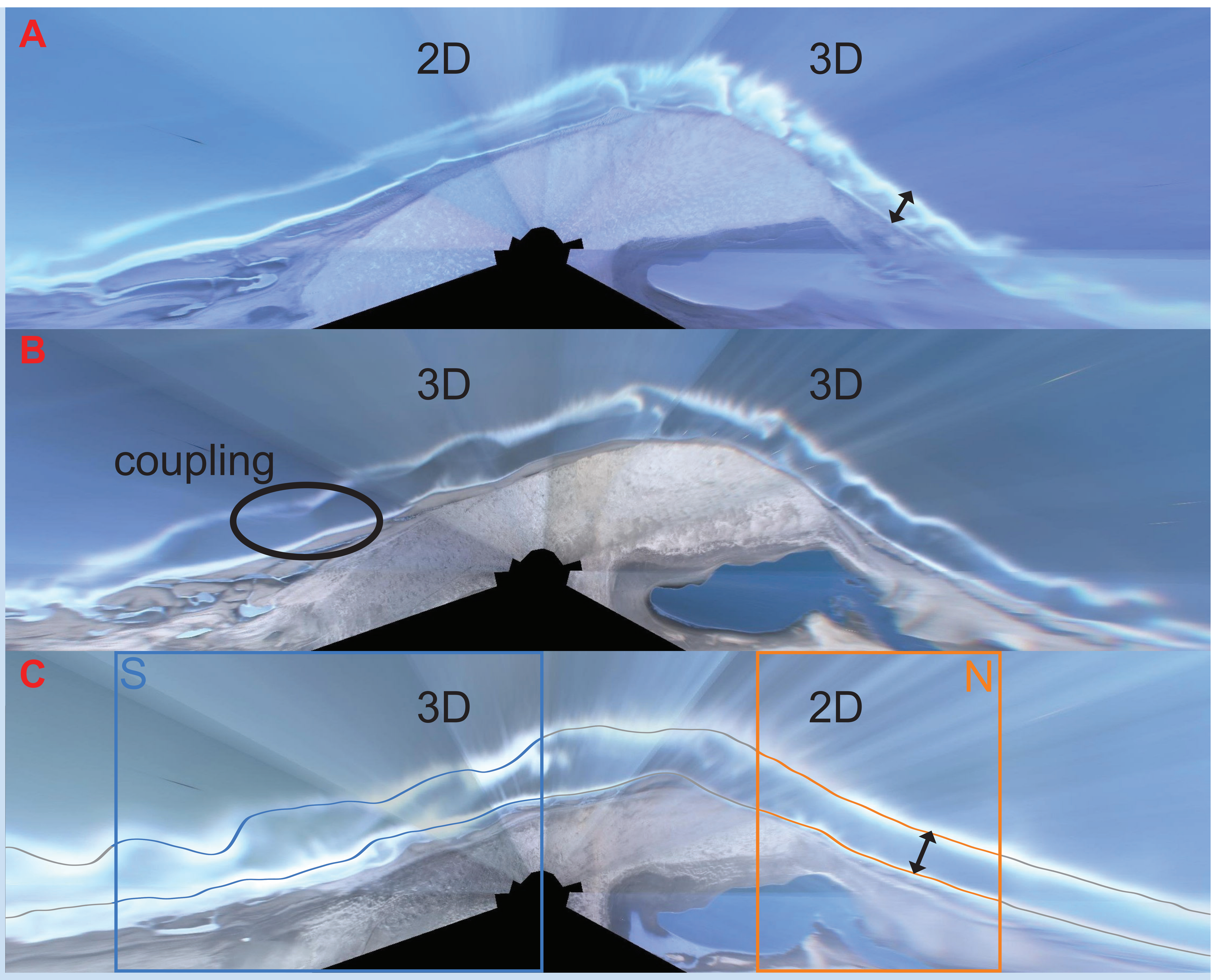

Figure 1. Planview 10-min time-averaged images wherein white lines of preferential wave breaking indicate sandbar (outer) and shoreline (inner). Sandbar and shoreline morphology vary alongshore and in time.

Sandbar and shoreline behaviour

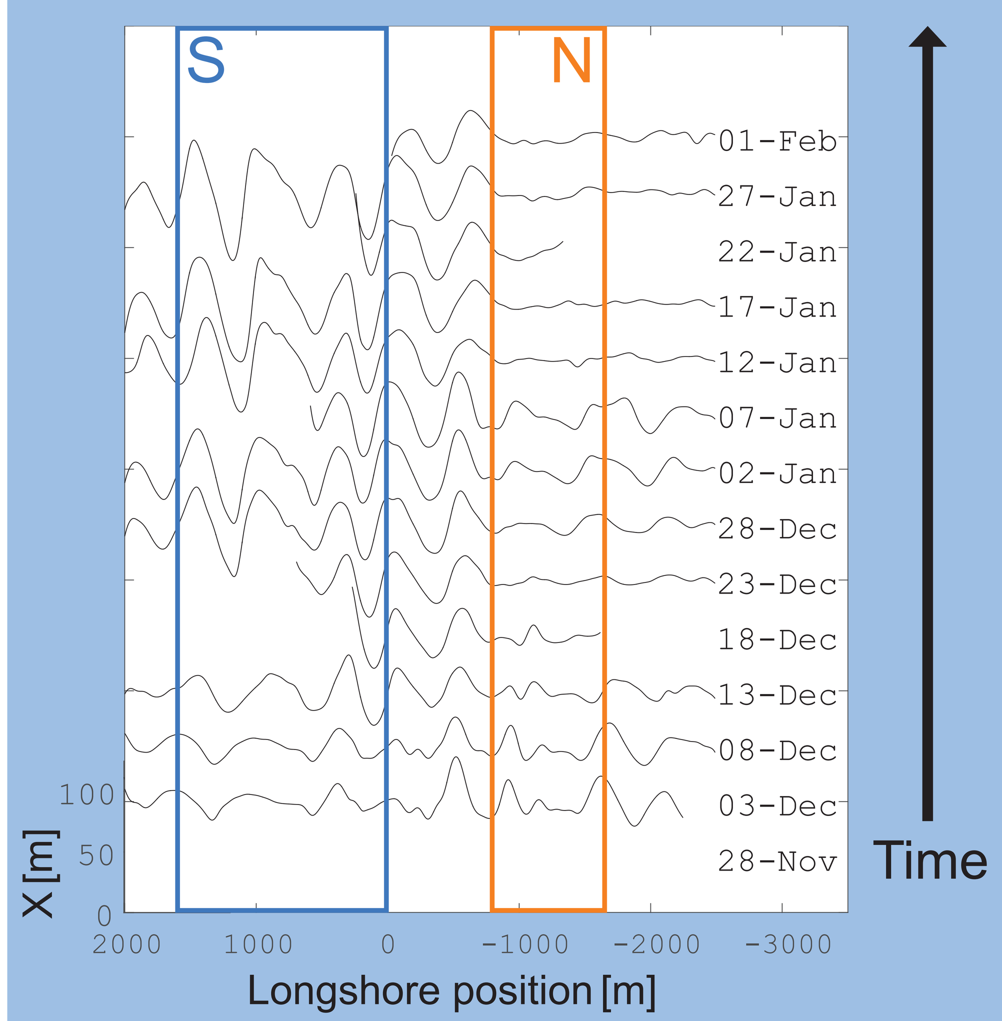

Figure 2(left). Example of temporal change of undulations in the sandbar. Note that the undulations grow at southern side, whereas they are absent at the northern side. Amplitudes of 10-50 m, and wavelengths of 350-800 m are found.

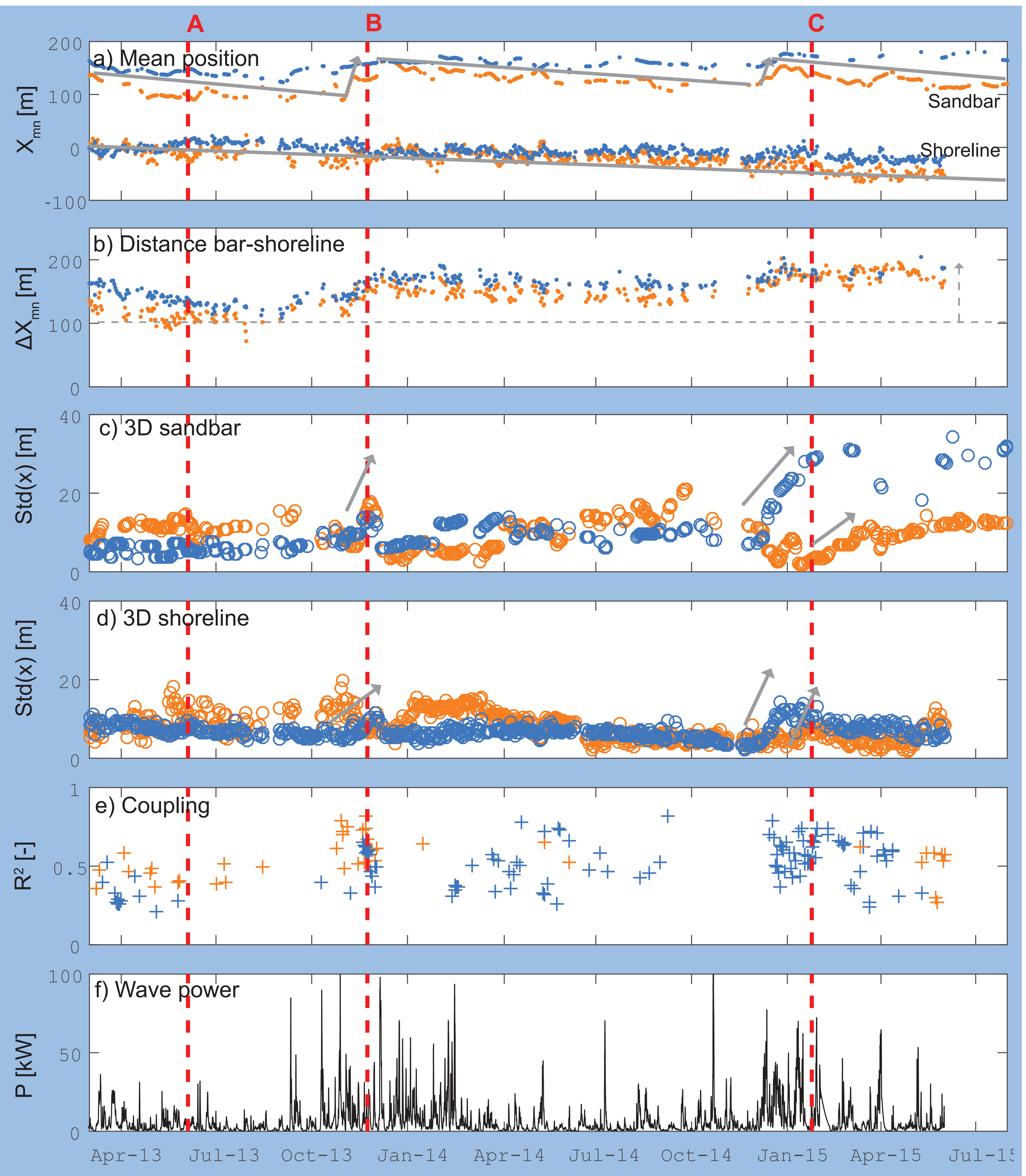

Figure 3(right). The full 2.4-year timeseries of four morphometric parameters showing bar and shoreline behaviour at the northern and southern side.

Similarities

- *Sandbar migrates rapidly offshore in winter, and gradually onshore in summer (gray lines (a))*
- *No net migration of sandbar (a)*
- *Linear retreat of shoreline (gray lines (a))*
- *Mean distance between sandbar and shoreline increases (arrow (b))*
- *3D morphology increases during winter after storms (arrows (c,d))*
- *3D morphology more pronounced in sandbar than in shoreline (c,d)*
- *Planshape of sandbar varies more (2D to 3D to 2D) than planshape of shoreline (c,d)*

Differences

- *Timing of offshore migration, decay and growth of 3D morphology (c,d)*
- *Coupling predominantly at southern side, when 3D morphology is pronounced (blue crosses dominate (e))*

Compared to straight coasts*

- Similar seasonal cycle of on- and offshore migration, but at Sand Engine no net offshore migration at interannual timescales that dominates elsewhere
- Similar post-storm 3D morphology, but at Sand Engine more pronounced (amplitudes of 10-50 m vs. 5-40 m, wavelengths of 350-800 m vs. 250-3000 m)

*Van Enckevort & Ruessink, 2003a. Cont. Shelf Res. 23; Van Enckevort & Ruessink, 2003b. Cont. Shelf Res. 23; Ojeda et al., 2008. Coast. Eng. 55; Ruessink & Kroon, 1994. Mar. Geol. 121.

Conclusions

The sandbar and shoreline along the curved Sand Engine coast show:

- a seasonal on- and offshore migration and post-storm 3D morphology, both typical at the Holland coast
- a timing difference in response (offshore migration, decay and growth of 3D morphology) with the same imposed offsshore wave forcing, and a preference side of morphologic coupling