Coupled behaviour within a double sandbar system

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Introduction

Nearshore sandbars vary in shape from alongshore ridges to remarkably periodic alongshore undulations in cross-shore position (crescentic sandbars). In a double sandbar system, the shape of the inner bar may be coupled to that of the outer bar, implying that the inner bar features do not evolve independently from those in the outer bar. This coupling is similar to the correspondence between crescentic sandbars and shoreline perturbations, resulting in an alongshore alternation in beach width.
Our aim is to characterise the temporal and spatial variability involved in the coupling within a double sandbar system.

Figure 1: Location of the study site.

Methodology

We use a 9.3-year data set of daily time-exposure images, collected at the Gold Coast, Australia (Figure 1). The high-intensity, alongshore continuous bands in these images reflect the bar crest lines (Figure 2). Using cross-correlation, we determine coupling between the inner and outer bar crest lines.

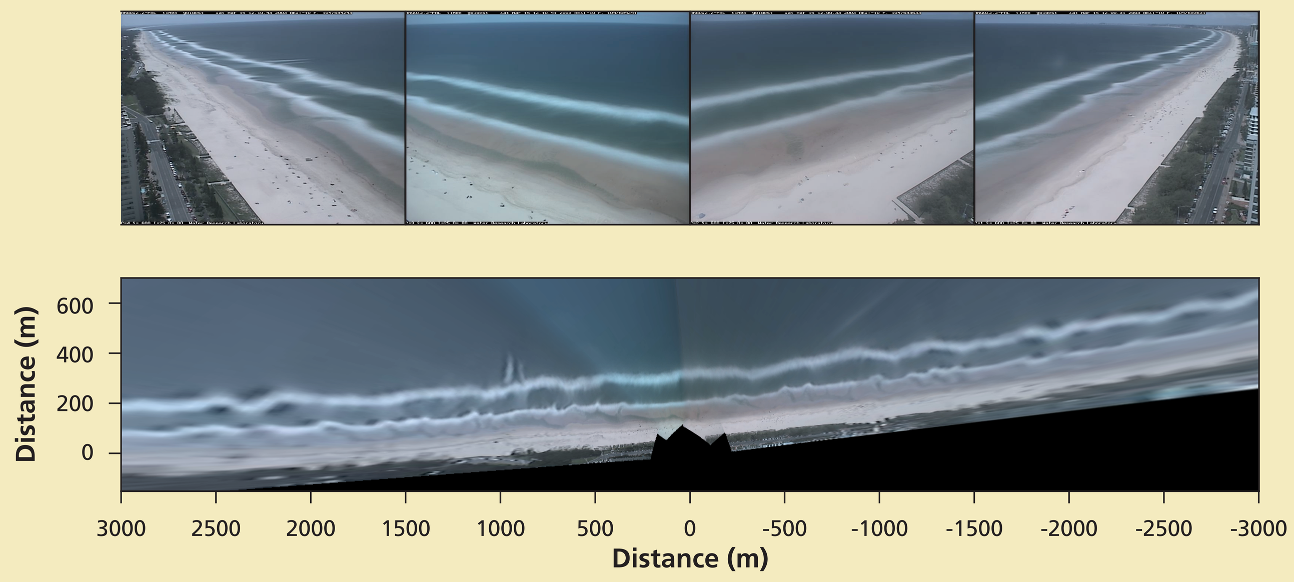

Figure 2: The four oblique, 10-min time-exposure images are merged and rectified to yield a plan view image. The two alongshore white lines represent wave breaking on the sandbars.

Results

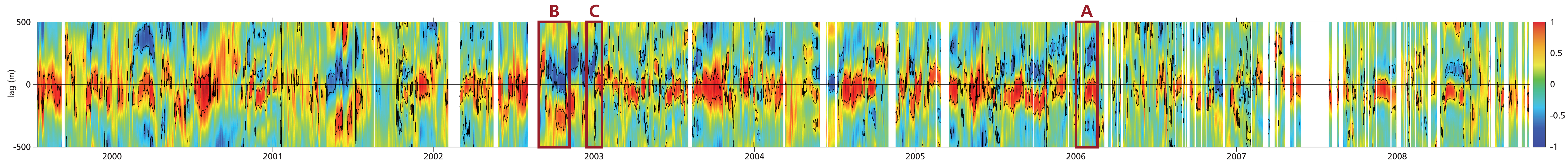

Figure 3: Cross-correlograms of the inner and outer-bar crest lines versus time. The black contours are the 95% significance level for nonzero correlation. The barlines couple for at least 5 consecutive days during 40% of the total period.

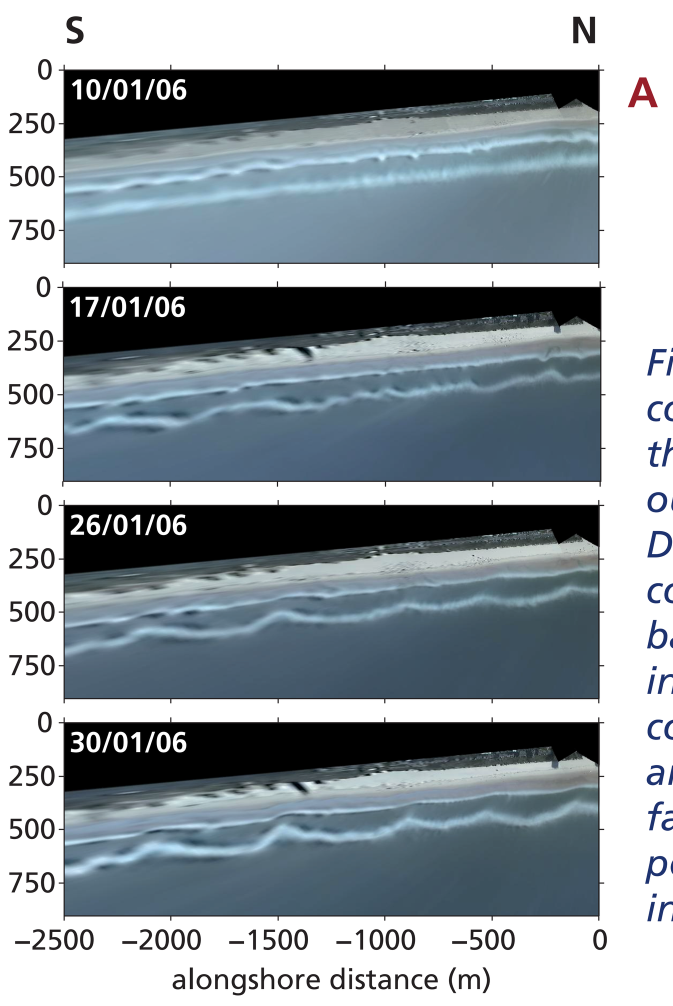

Figure 4: In-phase coupling between the inner and outer barlines. During 80% of the coupling events the barlines are coupled in-phase (a positive correlation), that is, an outer bar horn facing a shoreward perturbation of the inner barline.

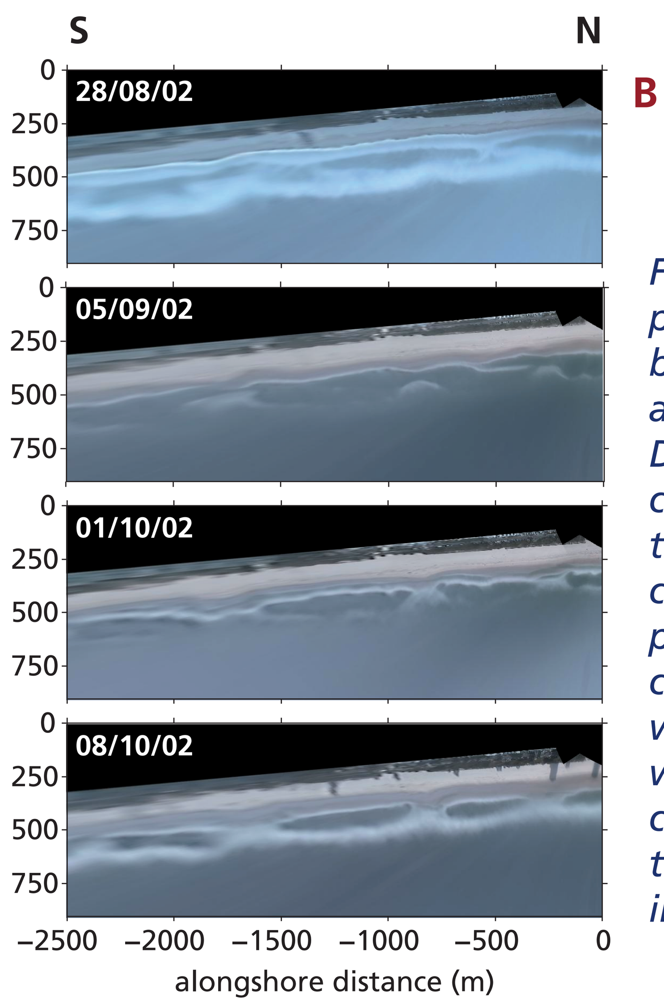

Figure 5: Out-of-phase coupling between the inner and outer barlines. During 20% of the coupling events the barlines are coupled out-of-phase (a negative correlation), where the onshore welding of the crescent horn leads to a seaward bulge in the barline.

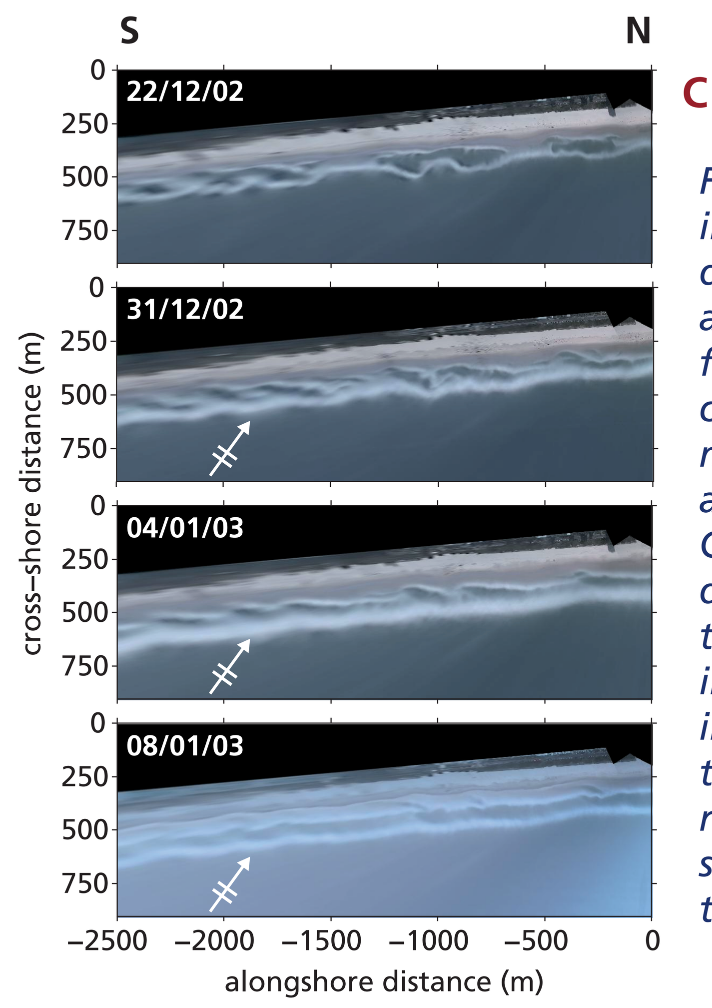

Figure 6: Obliquely incident waves deform the inner and outer barline features and cause them to migrate differently alongshore. Coupling disappears due to oblique wave incidence (80% in time) or due to morphological resets during heavy storms (20% in time).

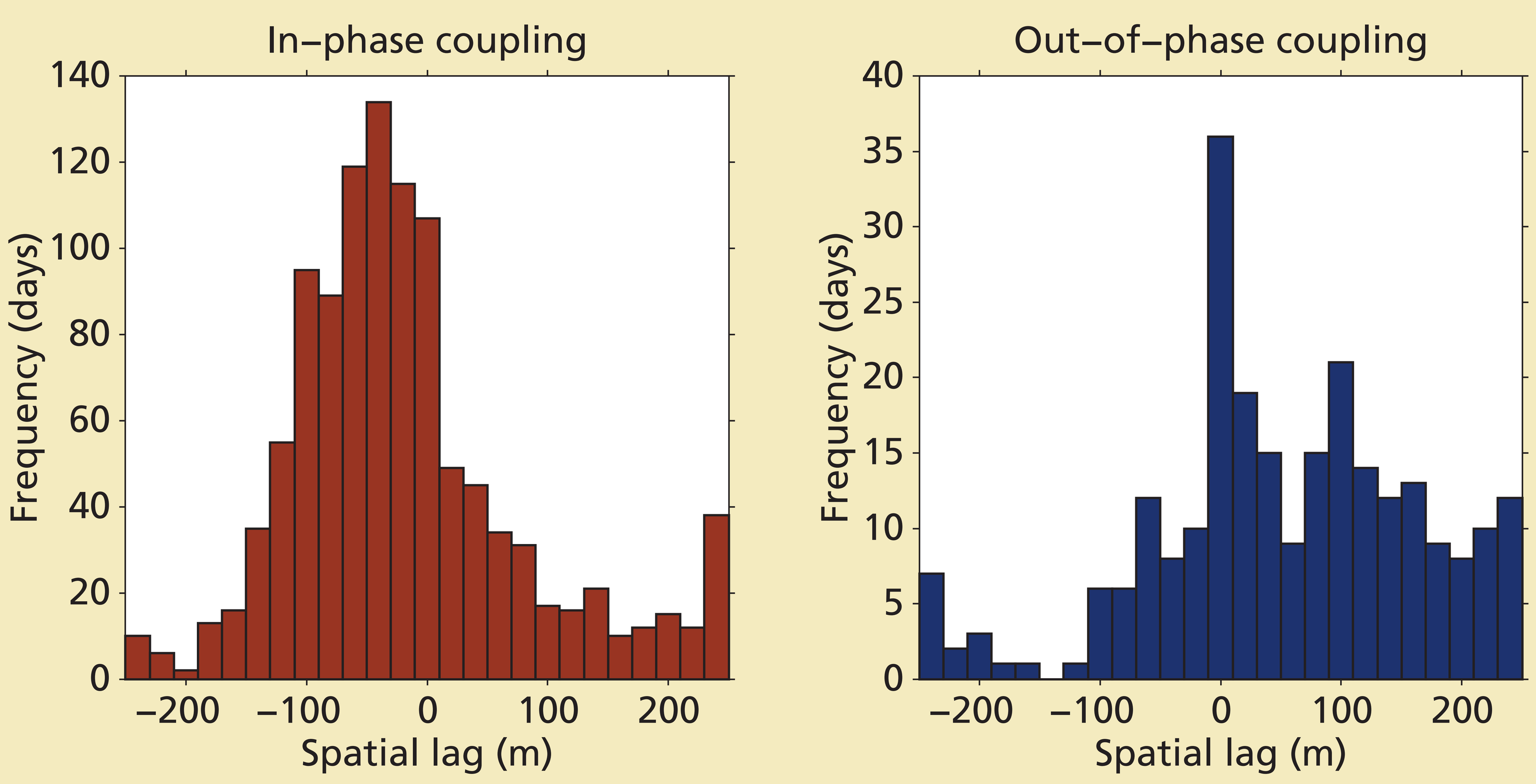

Figure 7: In-phase coupling (left) generally coincides with a negative spatial lag (mode of -40 m), which means the inner barline shape is positioned to the north of the corresponding outer bar shape. Out-of-phase coupling (right), on the other hand, exhibits a bimodal distribution of lags and either coincides with a zero-lag (mode of 0 m, exactly 180° out-of-phase) or a positive spatial lag (mode of 100 m). The observed lags are apparent from the examples above (Figures 4, 5 and 6) and correspond to the dominant south-easterly angle of wave incidence (30° shore-normal).

Conclusions

- The inner and outer barlines are coupled frequently (at least 40% of the time).
- The inner bar predominantly (80%) couples in-phase with a slight northward displacement with respect to the outer bar.
- Alongshore migration of crescentic patterns may either cause a phase-shift of the coupled pattern or result in the uncoupling of the composite bar system.
- Understanding the evolution of a double sandbar system requires insight into the interaction between the inner and outer bar.

Geosciences