

# Supporting Information for ”A new morphodynamic instability associated to the cross-shore transport in the nearshore”

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## Introduction

In this Supporting Information document, some results are described in more detail, with the help of the three extra figures S1-S3 and the four extra text paragraphs S1-S4. Text S1-S3 describe results that are shown in Figures S1-S3, respectively. Text S4 describe results that are not illustrated by any Figure.

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**Figure S1.** Default simulation: time development of the instability for  $r = 0.4$ . Depth contours every 0.1 m. Alongshore and cross-shore coordinates in m. Yellow and blue colours represent the emerged and submerged beach, respectively.

**Text S1.** Figure S1 shows the time development of the instability for  $r = 0.4$  from a small localized perturbation (default simulation). Initially, the bathymetry evolves quickly near the perturbation, where a couple of transverse bars form. Also, undulations form near the lateral boundaries ( $t = 1$  d). Gradually, the instability spreads through all the domain in the shoaling zone giving rise to transverse bars. At some spots, the morphology is relatively regular but at others it is quite complex with several length scales. Also, the signal of the initial perturbation is lost as time goes on. During some time lapses, the morphological changes seem to slow down (e.g., between  $t = 3$  d and  $t = 4$  d). The shoreline progrades but not uniformly, small alongshore undulations develop. In general, the model runs stop after some time. This happens when some sand bar rises above sea level as the model does not include the processes that govern this situation in nature. Sometimes, unrealistically deep troughs or morphodynamic noise develop as the processes that in nature would counteract the positive feedback are not included by our idealized model. Nevertheless, the model successfully describes the existence or not of positive feedback and the morphology that tends to emerge. Of course, the final steps before model breakdown must be regarded with care. Interestingly, this breakdown occurs in general after a time long enough to elucidate the main characteristics of the emerging morphology. For example, for the default simulation, this occurs after  $t = 60$  d.

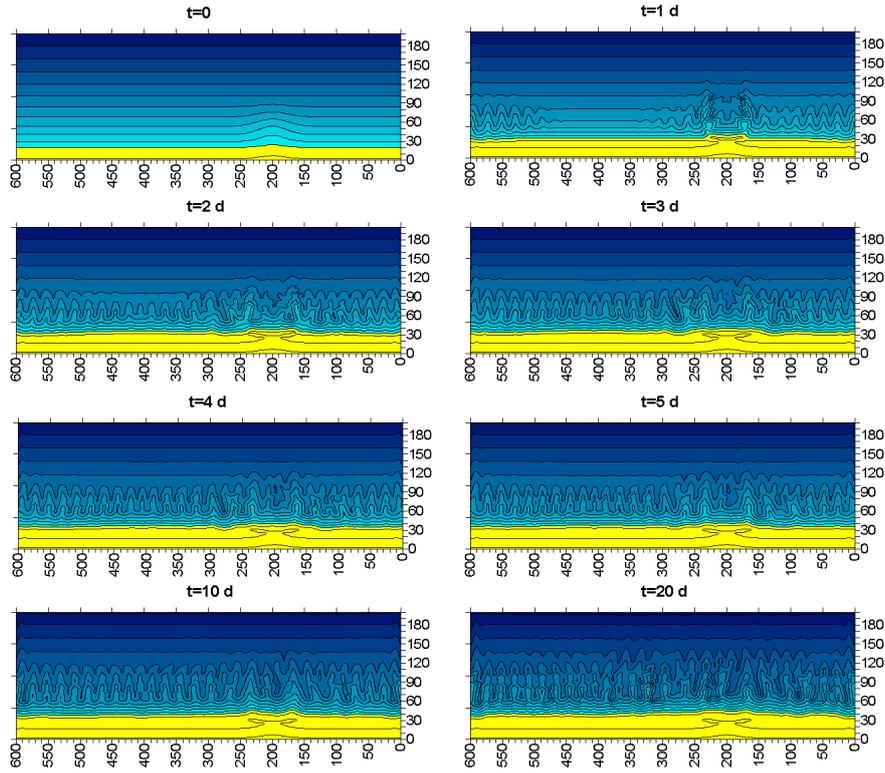
**Figure S2.** Morphology for  $t = 10$  d starting with different initial conditions: a) small bump on the shoreline, b) noise from the lateral boundaries and c) random bathymetric perturbations. Depth contours every 0.1 m. Yellow and blue colours represent the emerged and submerged beach, respectively.

**Text S2.** Figure S2 shows the morphology for  $t = 10$  d and for different initial perturbations: an undulation in the shoreline, small noise from the lateral boundaries and random perturbations distributed inside the domain. In all cases, although the details of the time evolution may be different, the final morphology encompasses transverse bars with a similar alongshore wavelength of 21 m. The final morphology for the two first cases is quite similar but for the random perturbation the morphology is more irregular and intricate.

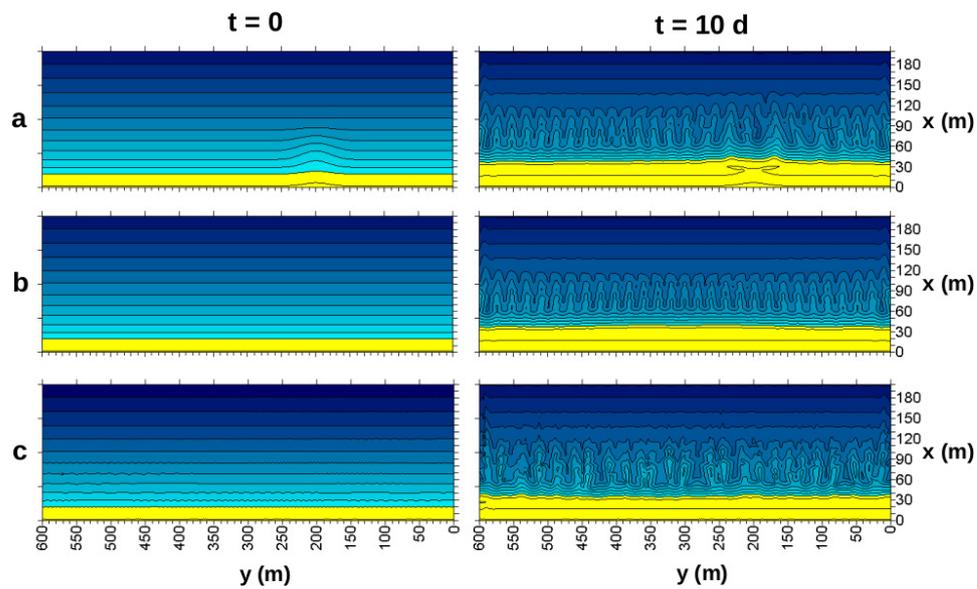
**Figure S3.** Four panels at the top: morphology at  $t = 20$  d and for different alongshore sizes,  $a_y$ , of the averaging box for the bathymetry. Depth contours every 0.1 m. Yellow and blue colours represent the emerged and submerged beach, respectively. Panel at the bottom: dependence of the alongshore wavelength of the bar system on  $a_y$ .

**Text S3.** The alongshore size,  $a_y$  has a strong influence on the shape and wavelength of the transverse bar system, as seen in Figure S3. For small  $a_y$  the morphology is quite complex and noisy, and the spacing between the bars is small. In contrast, as  $a_y$  increases, it becomes smoother and the spacing increases. It is found that the wavelength increases roughly linearly with  $a_y$ ,  $L \approx 10 + 1.3 a_y$  (in m). For  $a_y = 50$  m, few bars form and it is hard to identify their spacing. For even larger  $a_y$ , the bars do not grow inside the domain, only some undulation or some noise near the lateral boundaries become apparent.

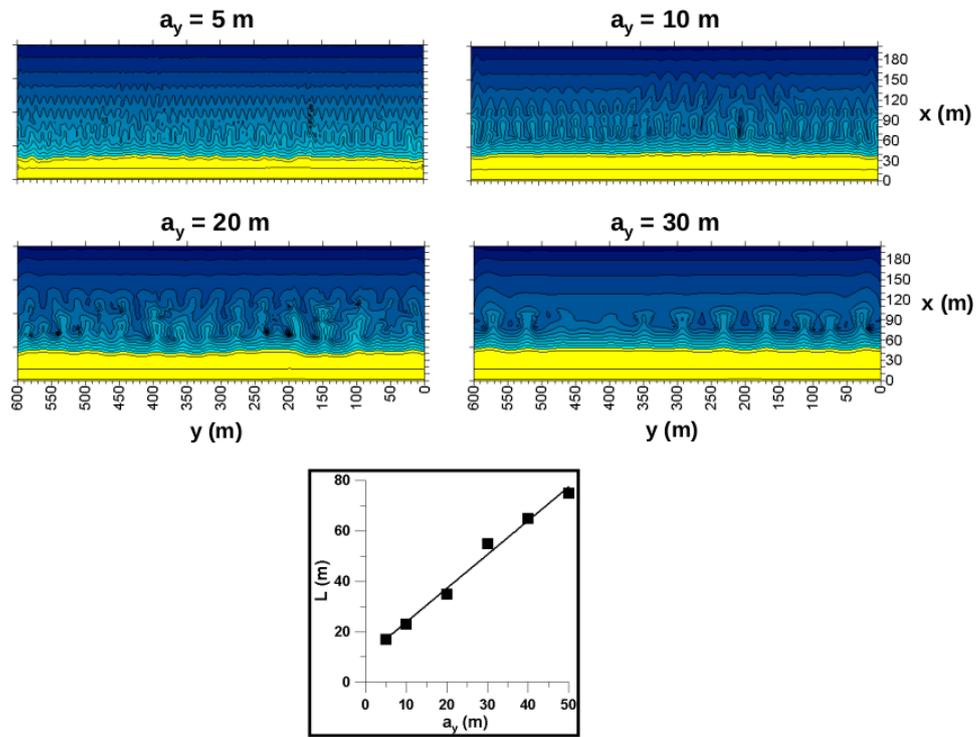
**Text S4.** It is found that  $T_p$  has almost no direct influence on the instability, the morphology after 10 d being very similar for  $T_p = 1, 2, 3$  s. It seems that the wavelength of the bars tends to slightly grow with  $T_p$ . Notice, however, that  $T_p$  affects indirectly the bar spacing because the appropriate  $a_y$  depends on the wavelength of the wave forcing. The shape of the bars is also similar by varying  $H_s$  (0.14, 0.28, 0.42 m), although their cross-shore length increases with  $H_s$  and the wavelength tends to increase too.



**Figure S1.** Default simulation: time development of the instability for  $r = 0.4$ . Depth contours every 0.1 m. Alongshore and cross-shore coordinates in m. Yellow and blue colours represent the emerged and submerged beach, respectively.



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**Figure S3.** Four panels at the top: morphology at  $t = 20$  d and for different alongshore sizes,  $a_y$ , of the averaging box for the bathymetry. Depth contours every 0.1 m. Yellow and blue colours represent the emerged and submerged beach, respectively. Panel at the bottom: dependence of the alongshore wavelength of the bar system on  $a_y$ .