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Interactive comment on "Emerging crescentic patterns in modeled double sandbar systems" *by* Giovanni Coco et al.

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We thank Reviewer 2 for the constructive comments. Our reply to each comment is shown below.

* Besides elaborating on the motivation for the study and embedding of the results, it would be insightful for the reader if these authors in particular (given their shared experience with this type of model and other modelling approaches) could provide a (brief) reflection as to why LSA is particularly suitable for tackling this study.

-> This is now addressed in the introduction. The whole paragraph now reads "In this contribution we aim to systematically address the role of initial bathymetry on the coupling between sandbars, an area that so far has received only limited attention

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Discussion paper

\citep[see also][]{price2014}. Specifically, we wish to investigate if sandbar coupling can freely emerge or if it is always the response of a sandbar to the development of a pattern in the other sandbar. We use linear stability analysis so that we can better focus on initial growth of the features and on the interactions that cause the emergence of the sandbar patterns. Adoption of a partly analytical approach also ensures the possibility of performing an exploration of the parameter space in a minimal amount of time, especially compared to nonlinear simulations. Other modelling studies of morphological evolution of double barred beaches also used linear stability analysis to analyze the depth- and wave-averaged equations coupled to sediment transport and morphological evolution. \cite{calvete07} used linear stability analysis to show that the initial cross-shore beach profile can be as important as wave height in determining the growth rate and alongshore spacing of crescentic bars. The work of \cite{klein06} for example showed that the magnitude of the longshore current and wave height are directly related to the preferred spacing and the growth rate, respectively."

* Would the use of, for example, a nonlinear model lead to similar conclusions regarding the emergence of the patterns? Why (not)? The discussion section includes a reflection on the use of LSA herein (L274-289), but please mention in the methodology section what makes LSA suitable for answering the research question.

-> We now discuss the suitability of LSA in the introduction. We also changed the discussion to address the different role of LSA and nonlinear models. The text now reads: "The transition from forced to fully coupled occurs smoothly in the parameter space that has been examined. Since our analysis of the model dynamics is linear, the concept of coupling is limited to the initial morphological formation and, since linear stability analysis focuses on the fastest growing wavelength, coupling at half of the outer bar wavelength cannot occur. Also, we do not simulate the nonlinear interactions between competing wavelengths, which might lead to coupling over longer time scales (days to weeks) or the final equilibrium configuration. Both important aspects can be studied using analysis that include nonlinear mode interactions and that are suited to

study the long-term evolution and possibly the equilibrium of these systems.. ”

*OTHER COMMENTS * Abstract: Please include the aim, or knowledge gap, in the abstract. The abstract now starts with a description of the approach, followed by the description of the results in Line 5.

-> We have modified the opening of the abstract into: “Double sandbar systems often characterize the surfzone of wave-dominated beaches and display a variety of poorly-explained spatial configurations. Here, we explore the morphodynamic stability of double-barred beaches using a model based on linear stability analysis.”

* L9 it is unclear what is meant by “inner bar-modes are dominant” -> Please describe what “inner-bar modes” are, and also what other modes there are.

-> We have avoided making reference to “inner-bar dominant modes”. The text now reads: “Our analysis indicates that modes of which the amplitude of the inner sandbar perturbation is larger than that of the outer sandbar are dominant for large height/depth differences between the two sandbars crests and small offshore wave heights. Patterns related to the outer sandbar dominate for small values of the difference in sandbar depth.”

* L92-96 Somewhere here, when introducing the use of the model, elaborate on the reason for opting for a model based on LSA.

-> Both reviewers have asked for this and we have changed the introduction and discussion accordingly.

* L177 Transverse bars are mentioned here for the first time -> Please mention these in the introduction section as features that may appear coupled to the sandbar pattern (Ribas et al 2014, Ocean Dynamics).

-> The introduction now reads: “The \cite{short93} model also indicates that beach configurations can involve coupling between the sandbars and/or coupling between the inner sandbar and the shoreline, where transverse sandbars can also be present

\citep{ribas2015}. Notice we prefer to refer to the paper by Ribas et al. (Review of Geophysics, 2015), in which a full review of mechanisms leading to transverse sandbars is given.

* L185-189 This paragraph belongs in the methods section, including figure 5. The choice for focusing on delta(D) and delta(x) should be elaborated upon, probably in the introduction (somewhere in L78-92). Why not, for example, investigate the effect of changing the cross-shore slope (which, admittedly, inherently includes changes in cross-shore distance and bar depth, but also bar volume)? For sake of clarity, it is also worth noting that delta(D) here means changing the depth of the outer bar, while keeping the inner bar depth the same.

-> We have moved this paragraph to the end of the previous section, including the figure. We also specifically address in the text how we changed delta(D). We appreciate that the study could have been performed changing the beach slope but, since the beach slope changes with delta(x) and delta(D) we thought that a focus on those parameters would be more insightful.

* L287-288 Here it is mentioned that “model predictions are in qualitative agreement with observations of the Truc Vert double sandbar system”. How do they agree? Please explain or show by means of a comparitive figure.

-> We have modified the text to clarify why they agree. We also noticed the text contained a wrong reference which we have now changed to Castelle et al. (2015). The new text reads: “Although the objective of this contribution is limited to a numerical analysis of the possible unstable patterns arising in double sandbar configurations, model predictions are in qualitative agreement with observations of the Truc Vert (France) double sand bar system (Castelle et al., 2015) where transverse bars are coupled to inner bars during moderate conditions, and inner-outer bar coupling is observed for more energetic conditions (we stress that parameter settings are not necessarily representative of Truc Vert).”

* L288-289 Here is mentioned that bathymetries of coupled sandbars are scarce, obstructing the comparison of the model with field observations. Could a general comparison of measured delta(D) give some insight into the validity or probability of the model results, or do you expect delta(D) to differ when bars couple? How do the findings of this study translate to future field studies? Please reflect on this.

-> Our study indicates that delta(D) is an important variable in determining the configuration of the emerging pattern. Bathymetric measurements before and after the emergence of sandbar patters would certainly allow model predictions.

The text now reads: “Lack of detailed and systematic measurements of bathymetric evolution of coupled sandbar systems remains the biggest obstacle to model testing in this area of research. We envisage that future development in the extraction of bathymetry from video images will be hugely beneficial to this area of research.”

* L271-273 (and elsewhere) The model shows that large waves lead to a shoreline that couples to the outer bar. Does this correspond to the observation of coupling between shoreline embayments and the outer bar shape during a severe storm, by Castelle et al (2015)?

-> Although the objective of this contribution is limited to a numerical analysis of the possible emerging patterns arising in double sandbar configurations, model results are in qualitative agreement with observations of the Truc Vert (France) double sand bar system \citep{castelle2015}, where transverse bars are coupled to inner bars during moderate conditions, and inner-outer bar coupling is observed for more energetic conditions (we stress that parameter settings are not necessarily representative of Truc Vert). Lack of detailed and systematic measurements of bathymetric evolution of coupled sandbar systems remains the biggest obstacle to model testing in this area of research. We envisage that future development in the extraction of bathymetry from video images will be hugely beneficial to this area of research \citep{van2008beach}.”

* L293-294 “Our results indicate .. single unstable mode.” -> This is indeed a key point

of this study. This statement would be even stronger if it was posed as the problem or hypothesis you wish to tackle with this study (also see my comment above).

-> We have modified the Introduction where the aim of the study is discussed. It now reads: “In this contribution we aim to systematically address the role of initial bathymetry on the coupling between sandbars, an area that so far has received only limited attention (Price et al., 2014). Specifically, we wish to investigate if sandbar coupling can freely emerge or if it is only the response of a sandbar to the development of a pattern in the other sandbar.“

*TECHNICAL CORRECTIONS * L9 two sandbars crests -> two sandbar crest

-> Done.

L84 THESE authors named this PHENOMENON

Done.

* L93 hydrodynamic conditions and INITIALLY LONGSHORE-UNIFORM cross-shore sandbar profile (as stated in L157-158: (alongshore...considered).

-> Done.

* L142 z_b = mean bed level, not mean sea level

-> Done. Following comments by another reviewer, we have rewritten the description of the variables at the beginning of the section and revised the rest of the notations.

* L246 fastest growing mode (instead of modes)?

-> Done.

* L266 intermediate (without –s)

-> Done.

* Figures 4 and 6: Why do the alongshore extents (y-axis limits) of the subplots vary?

Wouldn't it be clearer (calmer) to make these the same?

-> The reason for the difference in extension along the coast is that always two wavelengths are shown. In the cross-shore direction, 700m is always displayed.

* Figure 4, middle row: For consistency, use "outer" bar pattern instead of "offshore"

-> We have modified text and figures and now only "outer" bar pattern" is used.

* Figure 7 labels x-axes and Figure 8 titles: for consistency, use small x (instead of X)

-> Figures 5, 7, 8 and 9 have been modified so that only Delta x (lower case) appears throughout the manuscript.

* Figure 10 Mention somewhere that the colors refer to the modes in Figure 9.

-> We have added "The colors refer to the modes in Figure 9" in the caption of Figure 10.

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