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Comparison of modelled nearshore transverse sandbars with field observations

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Patches of several transverse sand bars have been observed in the surf zone of open beaches spaced with a remarkable alongshore periodicity (from 20 to 200 m). A transverse bar is an elongated accumulation of sand attached to the low-tide shoreline that extends inside the surf zone with an oblique orientation up to 1 m depth. Due to the preferred breaking of waves at shallow areas, the white surface rollers over the bars are the clearest signal in the video-images that are collected hourly at different sites in the world. More than 40 events of formation and evolution of bar patches were recently described at Noordwijk beach, the Netherlands, using this technique. Bar migration and shape, with the crests deviating from the shore-normal against the alongshore current flow (up-current orientation), were evaluated. Wave conditions during bar presence were also determined.

A possible explanation for the formation of this type of bars is based on the concept of morphodynamic self-organization. Topographic perturbations superimposed on an alongshore uniform beach induce hydrodynamic perturbations, which can lead to convergence of sand transport over the bars, hence producing a positive feedback. Linear Stability Analysis (LSA) is a convenient tool to investigate the possible feedbacks. In order to explain the formation of transverse sandbars a model based on LSA has been extended to include the dynamics of surface rollers and the corresponding turbulence-induced sediment re-suspension at the inner surf zone. The model describes feedbacks between waves, rollers, depth-averaged currents and bed evolution, so that self-organized processes can develop. The main outcome of the LSA model is the initial shape, growth and migration of different possible patterns, together with the recognition of the physical processes behind their growth.

Model results are compared with the field observations of transverse bar characteristics at Noordwijk beach. The modelled shape of one of the obtained patterns, the up-current oriented bars, agrees with that of the observed ones. Moreover, the wave conditions measured during transverse bar presence, with a persistently large angle of wave incidence, is essential for the physical process found to be responsible for up-current bar formation. Positive feedback leading to realistic formation of such up-current oriented bars only occurs if the re-suspension of sediment due to the bore turbulence created by the rollers is included in the model. In that case, the depth-averaged sediment concentration decreases seaward across most of the inner surf zone, which, in combination with an offshore-directed flow over the bars due to current deflection, leads to accumulation of sediment in the crest areas.

The up-current oriented shape, the wavelength (around 50 m) and the growth rate (of the order of one day) of the modelled bars are in good agreement with observations at Noordwijk. However, modelled migration speeds (several tens of meters per day) are higher than those measured in the field. Both in the model and in the observations, the most favourable conditions for bar formation are obliquely incident intermediate waves of short periods.