OS22B-08 1630h

Instability Mechanism for the Growth of Longshore Sand Bars

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The shape of the cross-shore beach profile is typically considered to be the superposition of a long-term average (or equilibrium) profile plus shorter-term variations that include formation and migration of alongshore uniform sand bars. Remarkably, after decades of research, there are not any widely accepted models for the formation of these longshore bars. One of the physical mechanisms presented in the past to explain bar formation is the break-point bar mechanism. It is based on the idea of a bar growing at the breaker point of the incident wave field because of the possible convergence of offshore sediment transport due to undertow (mainly inside the surf zone) and the onshore transport due to wave skewness. The goal of this paper is to understand quantitatively this mechanism.

The coupling between a cross-shore sediment transport model and a random wave transformation model is described using an idealized approach. Equilibrium profiles are considered to be a slow response of the beach (months to years) to long-term averaged forcing, whereas growth and dynamics of alongshore uniform bars can be related to local changes in the wave-induced sediment transport with a typical time scale ranging from days to months. The hypothesis of our work is that these two morphodynamical processes can be distinguished and studied separately, at least in certain circumstances, because the involved time scales are quite different.

Stability analysis of this system indicates that growth of bars results from a self-organization process. Our analysis yelds normal modes that look like longshore bars. Two different growing modes are obtained, both with the crest at the break-point but with different trough positions and growth rates. The first type has the main trough inside the surf zone and its growth time is a few months and the second type of bar has the trough outside the surf zone and a larger (and probably unrealistic) growth time of some years. Both types of topography perturbations are associated with a perturbation of the wave height that has a maximum shifted onshore with respect to the crest of the bar. This appears to be a necessary condition for break-point bar growth.