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The effect of modelling wave-current-topography interactions on the formation of sand ridges on the shelf

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INTRODUCTION

On many inner shelves of coastal seas, in depths between 6 and 30 m, shoreface-connected sand ridges are observed. These bottom undulations have elongated crests with a typical alongshore spacing of a few kilometers and heights between 1 and 6 m. The seaward ends of the crests are shifted upstream with respect to their shoreface attachments, thereby making an angle of 20^o to 35^o with respect to the coastline. Field data suggest that their formation is due to the joint action of waves (stirring the sediment) and a longshore storm-driven flow (causing net sand transport).

Previous model studies (e.g. Trowbridge, 1995) have shown that the initial formation of the ridges can result from morphodynamic self-organization, i.e. a positive coupling between small topographic perturbations superimposed on the initially alongshore uniform equilibrium state and the induced small hydrodynamic perturbations can lead to convergence of sand transport over the ridges. Linear stability analysis is a good tool to investigate this possible feedback, giving information about the spacing and growth rates of the initially dominant modes. Model results show fair agreement with field data, but it requires careful tuning of model parameters (Walgreen et al., 2002). This is a consequence of the fact that important physical processes are still missing. In these models wave properties only depend on the undisturbed equilibrium depth profile and refraction and shoaling due to the presence of ridges is not accounted for.

In this presentation results of a new model will be presented that includes these new mechanisms. Application of a linear stability analysis to the nearshore region of a straight barred coast already showed the importance of these mechanisms (Calvete et al., 2003).

RESULTS

A linear stability analysis has been performed of a modified version of the model of Walgreen et al. (2002), which now also involves the refraction of waves due to bedforms and the dissipation of wave energy over the ridges. Results indicate that wavelengths become smaller above ridge crests and larger in the troughs. Wave orbital velocities increase over the ridges as well as the angle of wave incidence (measured with respect to the shore normal). The dissipation of wave energy becomes important because of the presence of the ridges, causing a decrease in wave height. Therefore, wave radiation stresses will no longer be negligible and will also contribute to longshore currents.

CONCLUSIONS

The present results clearly show that wave characteristics are highly dependent on bedforms present on the sea bottom. In turn, the wave characteristics significantly affect the growth and migration of the ridges. Thus, in order to properly simulate the long-term behaviour of sand ridges the explicit coupling between waves and the bottom topography needs to be modelled.

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