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Bottom pattern formation in a tidal embayment

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Tide-dominated inlet systems, such as those located in the Wadden Sea, display complex morphological behaviour. The objective of this study is to gain further insight into the physical mechanisms responsible for the observed migration of channels and their branching in these embayments. For this purpose a two-dimensional nonlinear idealized model has been developed.

The geometry, representing the tidal inlet, is assumed to be rectangular with fixed side-walls and an erodible bed. The water motion is described by the depth-averaged shallow water equations, where the Coriolis effect is neglected. The transport of suspended sediment is modeled by a depth-integrated advection-diffusion equation and is restricted to diffusive processes only. The bed changes due to the convergences and divergences of the suspended sediment flux.

The initial formation of channels is investigated by performing a two-dimensional linear stability analysis, of a one-dimensional equilibrium bed profile. When the friction parameter exceeds a critical value, small bottom perturbations become unstable and start to grow. The unstable bottom perturbations resemble the initial formation of bed forms in the shallower areas. This result is similar to that obtained using Delft3D for the initial formation of a channel shoal system.

Using the Delft3D modelling system the growth of the initial bed forms has been simulated for a long time, resulting in migration and branching of channels and shoals. These patterns eventually form a channel and shoal system covering the entire embayment. To get a better understanding of the physical processes involved, two-dimensional nontrivial morphodynamic solutions are studied using the idealized model. Close to the critical value in the friction parameter, finite amplitude bed forms are found. These bed forms are in morphodynamic equilibrium. By slowly increasing the bottom friction parameter in this model non-trivial morphodynamic equilibrium profiles for a larger bottom friction parameter value are obtained. The bed forms are located closer to the seaward side of the inlet. The physical processes involved in initiating these channel and shoal systems and their sensitivity to model parameters will be discussed and the physical mechanisms will be explained.