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Influence of the topographically induced sediment flux on the morphodynamic equilibria and their stability in short tidal embayments

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The initial formation of bottom patterns observed in many tidal embayments is investigated by considering the temporal evolution of small two-dimensional bottom perturbations on an underlying width-averaged equilibrium bottom profile. The geometry of the model domain consists of a semi-enclosed, rectangular basin. The water motion at the entrance of the embayment is prescribed by a sea surface elevation that consists of a leading tidal constituent (M_2 tide) and its first overtide (M_4 tide). The water motion is described by the depth averaged shallow water equations. Sediment is only transported as suspended load. In this formulation the flux associated with the gradient in the bed profile, the topographically induced sediment flux, is retained. The bed changes due to convergences and divergences of the suspended sediment flux.

First, we shortly discuss the width averaged equilibrium solutions and their dependency on model parameters and boundary conditions. We show that the topographically induced sediment flux is essential to get a good comparison with observations. Although the width-averaged solutions are stable with respect to width-averaged perturbations, it is found that these morphodynamic equilibria can become linearly unstable for small two-dimensional bottom perturbations. This is due to the interactions between tidal currents, sediment transport and bathymetry if the vorticity generated by bottom friction torques is strong enough. Calculating the growth rates and spatial patterns of these perturbations, gives us the corresponding two-dimensional linear stability. When the topographically induced sediment flux contributes to the sediment transport, the growth rates are much smaller than when this flux is neglected. Furthermore, the channel shoal system patterns change considerably. In case the topographically induced sediment flux is not considered, the perturbations are situated at the seaward boundary. If this flux is included, the perturbations can be found at the seaward side (relatively large grainsize) or at the landward side of the embayment (relatively small grains). The stability and the dependency of the spatial patterns on the grain size is discussed in detail and explained physically.