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Importance of topographically induced sediment fluxes on equilibrium bed profiles and their linear stability in tidal embayments

M.C. ter Brake (1), H.M. Schuttelaars (1)

(1) Delft Institute of Applied Mathematics, Delft University of Technology, Mekelweg 4, 2628 CD Delft, The Netherlands. (M.C.terBrake@tudelft.nl, H.M.Schuttelaars@tudelft.nl)

To study the spatial and temporal behaviour of bottom patterns observed in many tidal embayments, an idealized morphodynamic model is developed and analyzed.

The geometry of the model domain consists of a semi-enclosed, rectangular basin. We force the water motion at the entrance of the embayment by prescribing sea surface elevation that consists of a leading tidal constituent (M2 tide) and its first overtide (M4 tide). To describe the water motion, we solve the depth averaged shallow water equations. Sediment is only transported as suspended load. Contrary to many other models that use a depth-averaged suspended load description, the suspended sediment fluxes induced by topographic variations are included. The bed changes due to convergences and divergences of the suspended sediment flux.

This system of equations allows for morphodynamic equilibrium solutions that only depend on the along-channel position (i.e. are uniform in the cross-sectional direction). By comparing model results (for realistic forcing) with observations in the Wadden Sea, we show and explain that it is essential to include the suspended sediment fluxes induced by topographic variations: observed embayment lengths are in the order of 15-20 km, if we neglect the topographically induced suspended sediment flux, maximum embayment lengths in the order of 3-5 km are found. Inclusion of these fluxes results in morphodynamic equilibrium profiles that resemble the width averaged profiles as observed in inlets in the Wadden Sea.

Apart from influencing the underlying one-dimensional equilibrium profile, the topographically induced fluxes influence the linear stability of these equilibria as well. We will discuss this influence for both one-dimensional (a decrease of stability compared with the case without the topographically induced flux) and two-dimensional perturbations and explain this physically.