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Effects of mud supply on large-scale estuarine morphology

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Sandy river estuaries have great economic and ecologic values, but a better understanding is required about the effect of mud on large-scale morphodynamics to optimise maintenance strategies. Very few studies actually include sand-mud interaction effects on morphodynamics on decadal and centennial timescales due to model limitations and lack of spatially and temporally dense data of mud in the bed. Here we study effects of cohesive sediment supply on equilibrium estuary shape, bar-channel patterns and dynamics, during formation from idealised initial conditions over a time scale of centuries and millennia.
On the basis of related modelling and experimentation of river and delta patterns we hypothesise that mud will settle into mud flats flanking the estuary that resist erosion and thus self-confine and narrow the estuary and reduce braiding index and channel-bar mobility.
We applied the process-based numerical model Delft3D in depth-averaged mode starting from idealised convergent estuaries. Mixed sediment was modelled with an active layer and storage module with fluxes predicted by the Partheniades-Krone relations for the cohesive regime, and Engelund-Hansen for the non-cohesive regime depending on the fraction of mud. This was subjected to a range of different mud inputs from the river or from the sea and a range of river discharge and tidal amplitudes.
Our modelling results show that mud is predominantly stored in mudflats on the sides of the estuary. Higher mud concentration at the river inflow leads to narrower and shorter estuaries. Channels within the estuary also become narrower due to increased cohesion in the channel banks. This trend is confirmed in preliminary experiments. However, channels do not increase in depth; this is in contrast with what is observed in rivers and we do not yet fully understand this. Migration rates of channels and bars and bar splitting and merging also reduce with increasing mud concentration. For higher discharge channel avulsions occur further upstream and bars become more elongated. Consequently, estuaries become less convergent with larger discharge. The effects of waves and marine mud on morphology are still under investigation.