Large-scale river and estuary modeling with mud and vegetation

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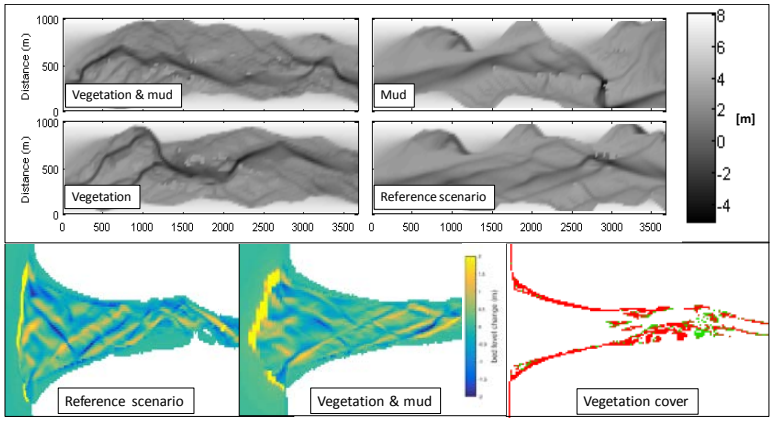
Introduction

We hypothesise that large-scale planform shape and development of estuaries are, like rivers, partly determined by stabilizing and destabilizing effects induced by mud and eco-engineering species (Kleinhans, 2010). We investigate those effects on planform geometry and bar patterns along the river-estuary continuum to enhance understanding of morphological long-term development.

Methods

We combined a morphological depth-averaged 2D model within the software Delft3D with a dynamic vegetation model coupled to flow resistance (Oorschot et al., 2015). The vegetation model represents species-specific settling, growth, and mortality which allow analysis of their impact on flow and sediment patterns as well as effects vice versa. The model was set up for the main fluvial and estuarine species with stabilizing eco-engineering effects in the Scheldt system. We investigated the role of mud, and its interaction with vegetation through active layer modelling and excess shear-stress relations for erosion and sedimentation.

Results



Vegetation focusses flow into channels and stabilizes bars and banks in rivers and estuaries. Mud enhances stabilization and modifies morphology. However, mud mostly settles where vegetation settles, whereas mud in isolation only deposits on the higher floodplains. In estuaries, mud does not settle on mid-estuary bars. For a combination of both factors we showed a further enhancement of the mud fraction with mud accumulation in areas where the vegetation is located.

Upper part: Bathymetry of an idealized river with different combinations of mud and vegetation after 300 years. Lower part: Bathymetry of an idealized estuary after 80 years. Blue areas are scour, yellow areas sedimentation. Right picture represents vegetation cover per cell.

Conclusions

The numerical model allows a quantitative representation of hydraulic and morphological processes in the fluvial and estuarine zone including the role of biomorphodynamics and mud. In comparison with the long-term development of the Scheldt system, the inclusion of several eco-engineering types and their interaction with mud and vegetation will allow determination of processes induced by typical eco-engineering species.

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