Long-term marsh growth and retreat in an online coupled hydrodynamic, morphodynamic and ecological model

Salt marshes are widely regarded as pristine ecosystems serving multiple ecological functions. Submerged salt marsh have the ability to attenuate wave energy, which makes them suitable as a natural way of flood protection. Coastal engineers, managers and policy makers are looking to preserve and restore these salt marshes in salt marsh creation and restoration projects. However, salt marshes are known as highly dynamic ecosystems and significant changes in their total covered area over decadal timescales have been observed in the past.

Numerical models are often used to study the physical processes driving the decadal evolution of salt marsh ecosystems. In most of these models the establishment of new vegetation is either neglected or included as an idealized stochastic function. In such models, each grid cell has an equal chance of vegetation establishment, even though their physical properties i.e. the hydro- and morphodynamic characteristics are different. Recent field and flume experiments suggest that the chances of seedling establishment (i.e. the establishment of new vegetation) may be a function of bed level dynamics. These theories state that if sediment is eroded underneath a seedling with a rate greater than the growth rate of their roots, seedlings will be uprooted and subsequently fail to establish. On the other hand, if sedimentation occurs over a rate which is greater than the growth rate of the seedlings, seedlings will be buried and thus fail to establish as well. The Windows of Opportunity concept accounts for, and describes, this relation between bed level dynamics and seedling establishment. The concept was combined with a model governing the growth and decay of established salt marsh vegetation and implemented in a numerical model (D-Flow FM).

The model results suggest that the establishment of pioneering vegetation on bare unvegetated mudflats is an important process for the formation of tidal channels. Once a few patches of vegetation are established, flowing water concentrates between these laterally expanding patches of established vegetation. The flowing water increases the bed shear stress leading to erosion which initiates the formation of tidal channels. Due to the erosion between these vegetation patches seedlings are unable to root within these first tidal channel outlines. The rate at which seedlings establish subsequently affects the spatial layout of the tidal channels as well as their width and depth. In case of high vegetation rates, narrow and deep tidal channels are formed which follow the direction of the tidal flow. With slower vegetation rates wider tidal channels are created which erode less quickly and show a clear meandering pattern.

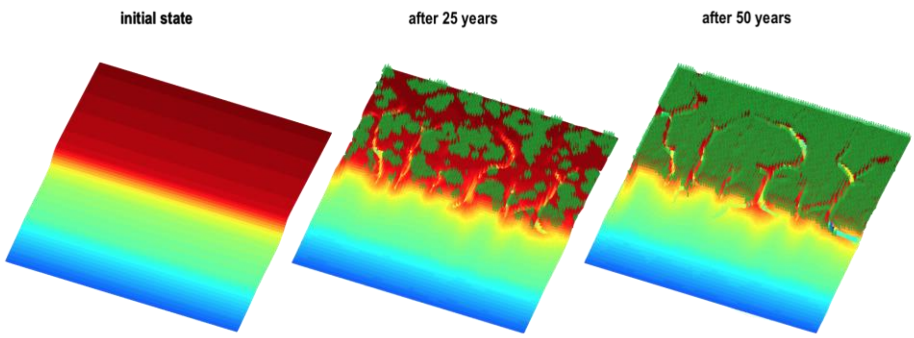

Figure 1: Impression of the model results showing the biogeomorphological evolution from initial state to developed marsh

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