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Impacts of salt marsh plants on tidal channel initiation and inheritance

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Tidal channel networks are the most prominent and striking features visible in tidal wetlands. They serve as major pathways for the exchange of water, sediments, nutrients and contaminants between the wetland and the adjacent open water body. Previous studies identified topography guided sheet flows, as the predominate process for tidal channel initiation. Guided through differences in local topography, sheet flows are able to locally exceed bottom shear stress thresholds, initiating scouring and incision of tidal channels, which then further grow through head ward erosion. The fate of these channels after plant colonization is described in literature as being inherited into the salt marsh through vegetation induced bank stabilization (further referred to as vegetation stabilized channel inheritance). In this study we present a combination of flume experiments and modelling simulations elucidating the impact of vegetation on tidal channel initiation. We first studied the impact of plant properties (stiff: Spartina alterniflora versus flexible: Scirpus mariqueter) on local sediment transport utilizing a flume experiment. Then a coupled hydrodynamic morphodynamic plant growth model was set up to simulate plant colonization by these two different species in the pioneer zone at the mudflat – salt marsh transition. Based on the model we investigated the ramifications of interactions between vegetation, sediment and flow on tidal channel initiation. We specifically compared the effect of vegetation properties (such as stiffness, growth velocity and stress tolerance) on emerging channel patterns, hypothesizing that vegetation mediated channel incision (vegetation induced flow routing and differential sedimentation/erosion patterns leading to tidal channel incision) plays an active role in intertidal landscape evolution. We finally extended our model simulation by imposing pre-existing mudflat channels with different maximum depths, to investigate the impact of existing channels on vegetation mediated channel incision. This simulated landscape development was then compared to aerial photographs from the Scheldt estuary (the Netherlands) and the Yangtze estuary (China). Our results suggest a significant impact of plant properties on tidal channel network emergence, specifically in respect to network drainage density and channel width. This emphasizes the repercussions of vegetation mediated channel incision on estuarine landscape development. Further do our results point to the existence of a threshold in pre-existing mudflat channel depth favoring either vegetation stabilized channel inheritance or vegetation mediated channel incision processes. Increasing depth in mudflat channels favors flow routing via these channels, leaving less flow and momentum remaining for the interaction between vegetation, sediment and flow and therefore vegetation mediated channel incision. This threshold will be influenced by field specific parameters such as hydrodynamics (tidal range, waves, and flow), sediments and predominant plant species. Hence our study not only demonstrates to importance of plant properties on landscape development it also shows that vegetation stabilized channel inheritance or vegetation mediated channel incision are two occurring mechanisms depending on ecosystem properties, adding important information for salt marsh management and conservation.