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Signatures of Biogeomorphic Feedbacks in Salt-Marsh Systems

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Salt-marsh ecosystems which play a large role in the bio-geomorphological evolution of intertidal areas. Dense stands of halophytic vegetations which populate salt marshes largely control the dynamics of these ecosystems influencing marsh hydrodynamics and sediment transport through enhanced flow resistance and settling, and direct particle capture by plant stems. Moreover, plants are also known to increase vertical accretion through direct organic accretion. Field evidence and the results of biomorphodynamic models indeed show that the interplay between physical and biological processes generates some striking biological and morphological patterns at different scales. One such pattern, vegetation zonation, consists in a mosaic of vegetation patches, of approximately uniform composition, displaying sharp transitions in the presence of extremely small topographic gradients. Here we develop a two-dimensional model which describes the mutual interaction and adjustment between tidal flows, sediment transport and morphology mediated by vegetation influence. The model allows us describe the coupled evolution of marsh platforms and channel networks cutting through them. A number of different scenarios were modelled to analyze the changes induced in bio-geomorphic patterns by plants with different characteristics, within marshes characterized by different drainage densities, or subjected to changing environmental forcing such as rates of relative sea level rise and sediment supply. Model results emphasize that zonation patterns are a signature of biogeomorphic feedbacks with vegetation acting as a landscape constructor which feeds back on, directly alters, and contributes to shape tidal environments. In addition, model results show that biogeomorphic feedbacks critically affect the response and the resilience of salt-marsh landscapes to changes in the environmental forcing.