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Bio-morpho-geomechanical modelling of salt marshes

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Salt marshes contribute to a wide range of ecosystem services including biodiversity preservation, water quality maintenance, coastal protection and stabilization, carbon storage, and socio-economic benefits. The prediction of the elevation dynamics of a salt marsh platform is crucial to forecast its future behavior under potential changing scenarios. Salt marsh elevation is governed by biological, sedimentological, and geomechanical processes. Vegetation decomposition, sedimentation, and consolidation of shallow deposits concur in defining the marsh topography and its possible evolution in response to relative sea level rise (RSLR), i.e. sea level rise and deep land subsidence. A number of studies have been carried out over the last decade where purely bio-morphological or purely geomechanical models have been developed to understand the possible evolution of such valuable ecosystems. The former, which mainly span decadal to century time intervals, lump the subsurface processes in an overall value of RSLR; the latter, which usually cover century to millennium time ranges, sum-up the processes occurring on the land surface in an external loading term. In this work we propose a novel two-dimensional physically-based model where the bio-morphological (surficial) and geomechanical (subsurface) processes are simultaneously accounted for. The model couples two state-of-the-art modules recently published: the first describes the time and space evolution of the elevation of a tidal platform in relation to the accretion rates because of inorganic sediment transport and biological processes controlling organic sediment productivity; the latter simulates the main hydro-geomechanical processes occurring during the accretion of coastal lands using an adaptive mesh accounting for large deformations, sedimentation of new material on the surface, and variation of the hydraulic and mechanical properties with the effective stress. A few numerical experiments are proposed to show the potentiality of the proposed 2D coupled model. The feedback of the surficial on the subsurface processes and vice versa, together with their effects on the salt marsh evolution in relation to RSLR are highlighted.