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The importance of being coupled: Stable states and catastrophic shifts in tidal eco-morphodynamics

M. Marani (1), A. D'Alpaos (2), S. Lanzoni (1), L. Carniello (1), and A. Rinaldo (1)

(1) Dept. IMAGE, University of Padova, Padova, ITALY (marani@idra.unipd.it), (2) Dept. of Geosciences, University of Padova, Padova, ITALY

Tidal landforms and ecosystems exist in a delicate balance between rates of sea level changes, sediment availability, driving erosion and deposition processes, and local subsidence. Predicting the response of tidal geomorphologies is thus important in view of the ecological, cultural and socio-economic importance of endangered tidal environments worldwide. Here we illustrate a point model of the coupled evolution of tidal landforms, halophytic vegetation and benthic microbial assemblages, forced by tides, sediment availability, wind regime, and relative sea-level change. Wind climate and tidal amplitude variations, which are likely to affect intertidal erosion and deposition processes, are also accounted for and the extent of their influence is explored. The model represents a significant improvement over previous similar formulations because it incorporates more realistic consolidation processes and tidal forcings and allows the explicit simulation of observed conditions. The model is applied to the significant case study of the Venice Lagoon and the conditions under which alternative stable states and punctuated equilibrium dynamics may emerge are examined. Hysteretic switches between stable states may arise because of differences in the threshold values of relative sea level rise inducing transitions from vegetated to unvegetated equilibria and viceversa.