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Ecohydrological interactions in oxygen-limited vegetation ecosystems

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Tidal environments are characterized by extremely high biodiversity and primary productivity (comparable to tropical rain forests) and they mediate flood effects and the sea action on the coast. A deep understanding and modelling of these environments requires the explicit description of wetland physical and ecological processes as fully interacting components. The evolution of a wetland system is, in fact, governed by the strongly coupled evolution of their ecological, hydrological, morphological and biological components.

In this paper we study the aeration conditions of marsh soils (and the corresponding oxygen availability) as determined by tidal forcing and plant root respiration. We use a mathematical model based on Richards' equation of saturated/unsaturated subsurface flow in a schematic tidal salt marsh to study the space-time dynamics of water saturation and the conditions leading to a permanent preferentially aerated zone. The soil aeration patterns arising in the system highlight the central role of vegetation in increasing soil aeration and the influence of different soil characteristics on oxygen availability. We also develop an air-water two-phase model, which relaxes some key assumptions intrinsic to the Richards' approach, to study the air-phase dynamics and its effects on aeration conditions in a one-dimensional soil column. The resulting aeration times are increased with respect to those obtained using Richards' equation, but

the behaviour of the system is qualitatively unchanged. We define an aeration time as the time of persistence of unsaturated conditions within a tidal cycle. High values of aeration time identify a preferential aeration zone, where possibly plant colonization may start, or artificial plant colonization may have a greater probability of success. Moreover, for a more complete understanding of ecohydrological processes in salt marsh systems, we determine the threshold permeability/evapotranspiration values for which a permanently aerated layer develops.

Keywords: tidal environments, ecohydrology