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TWO-PHASE MODELING OF AIR AND WATER FLOW IN INTERTIDAL MARSHES

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Summary. Wetlands, such as lagoons and estuarine environments, are dynamic ecosystems in transition between terrestrial environments and deep water aquatic systems connected by floods and tide. These delicate intertidal zones are characterized by a high biodiversity and by a strong hydrological connection between the atmosphere and the subsurface mainly in terms of air fluxes: a complete description of the hydrological dynamics requires the determination of the air budget as determined by its inflow from the atmosphere through the soil surface, by its seepage through the soil in the root zone, and by its consumption by plant roots.
The presence of air can significantly affect the mobility of water in the soil, thereby impacting soil aeration, hence plant selection and the morphodynamics of the wetlands. Richards equation is not able to account for the actual fluxes of air, therefore the simulation of flow in salt marshes, where the effect of the entrapped air on the water infiltration in the soils may not be neglected, requires a different approach.
Here we develop a two-phase flow model based on a pressure formulation to simplify the treatment of complex and nonlinear boundary conditions that arise at the soil-atmosphere interface due to the interplay between evapo-transpiration during emersion periods and tidal fluctuations during submersion.
The formulation ensures accurate elemental expansion of saturation time derivative through a proper definition of the capacity coefficient and high order ODE temporal discretization. The numerical model discretizes the water and air mass conservation equations by means of linear finite elements combined with high accuracy stiff ODE solvers to ensure accurate mass balance calculation. The resulting nonlinear system of equations is solved using inexact Picard or Newton-Quasi Newton techniques with globalization.