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Modelling the effect of mechanical deformation on the peatland carbon stock resilience

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Mathematical models of peatland growth have been developed for many purposes, including understanding the effect of past or future climate change on peatland carbon accumulation. This is important because peatland contains a vast amount of carbon and has a significant role in the global carbon cycle through carbon dioxide and methane exchange with the atmosphere. In general, the models produced so far suffer from the fact that the mechanical process has an essential role in the peatland carbon stock resilience because they only focus on ecohydrological feedback. We propose a one-dimensional mathematical model that includes ecological, hydrological, and mechanical feedback on the peatland through the poroelasticity concept, which coupling between fluid flow and solid deformation. The formulation is divided into two categories, fully saturated and unsaturated, to accommodate peatland characteristics. We compare the numerical solution of the fully saturated case with analytical solutions of Terzaghi's problem for validation. We assume that peat is an elastic material with flat, impermeable, and stiff substrate properties. Based on the initial simulation results, we find that compression reduces the thickness of acrotelm, leading to the shorter residence time of plant litter, and consequently, higher cumulative carbon is obtained. Furthermore, mechanical deformation of the pore structure effectively maintains carbon stock in the peatland against climate change because it reduces water table depth fluctuations.