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A New Coupled Earth's Critical Zone Model: AgroIBIS – MODFLOW (AIM)

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Shallow groundwater may influence land surface energy, water, carbon balances and terrestrial ecosystems by altering the root zone soil moisture dynamics in 22 – 32% of the Earth's land area. However, our current understanding of the impacts of shallow groundwater on ecosystem dynamics and land surface processes is hampered by both a lack of observations and current capabilities of the state-of-the-art ecosystem models to simulate shallow groundwater as a working part of the groundwater-soil-vegetation-atmosphere (critical zone) transfer scheme. Existing models are able to simulate water and energy fluxes with highly accurate process-based approaches in a single compartment (e.g., vadose zone – HYDRUS, or groundwater – MODFLOW) or multiple compartments (e.g., groundwater & vadose zone MODFLOW-VSF, vadose zone & vegetation– Agro-IBIS) of the critical zone by oversimplifying or ignoring the other compartments. In this study, we present a newly developed critical zone model, AgroIBIS-MODFLOW (AIM). AIM is capable of simulating ecohydrological processes across the complete critical zone. AIM is a fully coupled agroecosystem/dynamic vegetation model (AgroIBIS), variably saturated flow model (HYDRUS-1D), and groundwater flow model (MODFLOW). We analyze the performance of AIM by comparing the model with saturated and unsaturated flow experiments as well as results from other models. Moreover, to demonstrate AIM's potential for simulating ecohydrological processes and feedbacks, we present a hypothetical watershed scale case where the indirect impacts of land use change on agricultural productivity due to altered groundwater recharge and water table depth.