Rainfall intensity and groundwater recharge: evidence from ground-based observations in East Africa

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ABSTRACT

Global greenhouse-gas emissions serve to warm Africa more rapidly than the rest of the world. The intensification of precipitation that is associated with this warming strongly influences terrestrial water budgets. This shift toward fewer but heavier rainfall events is expected to lead to more frequent and intense floods as well as more variable and lower soil moisture. However, its impact on groundwater recharge is unclear and in dispute. We review evidence from long (1 to 5 decades) time series of groundwater levels recorded in deeply weathered crystalline rock aquifers systems underlying land surfaces of low relief in Uganda and Tanzania. Borehole hydrographs consistently demonstrate a non-linear relationship between rainfall and recharge wherein heavy rainfalls exceeding a threshold contribute disproportionately to the recharge flux. Furthermore, rapid responses observed in groundwater levels to rainfall events reveal vadose-zone velocities that greatly exceed rates that might reasonably be modelled for soil matrices using the Richards equation. The role of preferential pathways in enabling rain-fed recharge via soil macropores is incompatible with the recharge pathways and soil conditions assumed from FAO soil-matrix classifications in continent-scale (WaterGAP, PCR-GLOBWB) and catchment-scale (SWAT, MODFLOW) recharge models. Our results suggest that: (1) the intensification of rainfall may favour groundwater recharge and support groundwater-based adaptations to longer droughts and lower soil moisture under climate change; and (2) recharge models assuming direct recharge via soil matrices may underestimate soil-infiltration capacities and, hence, recharge.