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Tipping points in hydrology: attribution of regime shifts using historical climate simulations and dynamical system modeling

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The Sahel (the semi-arid fringe south of the Sahara) experienced a severe drought in the 70s-90s. During this drought, an hydrological regime shift was observed for most watersheds in the Central Sahel: runoff has significantly increased despite the rainfall deficit. Did the drought cause this regime shift ? What if the drought did not happen ? To answer these questions, we introduce a simple dynamical model that represents feedbacks between soil, vegetation and runoff at the watershed scale and at the annual time step. This model is forced with annual rainfall and evaluated using long-term observations of runoff from selected watersheds. We find that the model forced with observed rainfall reproduces well the observed regime shift in runoff. For the attribution of the regime shift to the drought, we rely on two sets of historical rainfall simulations from CMIP6 global climate models: fully-coupled simulations that do not reproduce the drought, and atmosphere-only simulations (AMIP) that represent the drought. Our results show that a regime shift would have been unlikely without the drought. This approach will be extended to identify areas that are likely to experience an hydrological regime shift in the future.

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