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Stress testing drought from the bottom up: recharge scenarios to quantify streamflow drought sensitivity

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Extreme low flows and streamflow droughts follow precipitation and temperature anomalies in temporal sequence, but are actually caused by decreased recharge and depleted storage outflow. Thus, the analysis of the response of streamflow drought to global change needs to incorporate more of a bottom-up perspective within the hydrological system. We present a novel set of synthetic recharge scenarios (stress test scenarios) to quantify the streamflow drought sensitivity of a diverse set of catchments with manifold streamflow regimes in Switzerland. The scenarios are embedded into a model framework. The bucket-type model HBV is used to systematically decrease recharge rates as initial conditions of summer drought seasons and specific drought events. The stress tests are based on different what-if questions which can be easily explained to stakeholders in the water management sector: What would have happened if a) the recharge year before the drought year had been replaced, b) different recharge periods directly before specific drought events had been reduced to a data-derived worst-case minimum level, c) a recharge drought with a distinct probability (e.g. 5%) had been preceded the historical drought event? Additionally, a synthetic dry-out stress test sorts the recharge series from wet to dry years to identify potential tipping points in recharge-drought-sensitivity for different streamflow regimes. The results indicate that not all extreme drought events occur in typical drought years. For a comprehensive stress testing it is crucial to identify the specific drought event onset and to quantify the remaining snowpack at the time of the drought onset. The stress test scenarios assessed different generic types of summer streamflow droughts in Switzerland (e.g. early, mid and late summer events or interrupted events) and found a range of shorter and longer recovery times depending on catchments' storage. This research on the sustainability of water resources during periods of drought should shift paradigm towards more emphasis on event analysis and the role of storage.