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How hydrological droughts are controlled in three different models

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During natural hydrological drought, water flow is mainly controlled by the release of storage water. Therefore, the simulation of hydrological droughts highly depends on how storage of water is represented in the model structure. In this study, we conducted sensitivity analyses on parameters of three frequently used hydrological models (HBV, SAC, and VIC) for the simulation of drought duration and drought deficit over 605 basins across the contiguous United States. By relating the parameters of each model to their corresponding processes, we could identify the processes that drive the simulation of hydrological drought in the different models. Finally, we related these processes to four climate indicators (mean yearly temperature, mean winter temperature, seasonality, and aridity). The sensitivity analysis revealed that parameters from the same processes are sensitive in HBV and SAC such as snow, shallow layer, and ET parameters. VIC, however, displayed deviant behaviour: in most instances, drought simulations were mainly driven by deep layer parameters. When relating the sensitivity analysis to climate indicators, all three models had snow parameters dominating in cold regions. Moving towards warmer regions, SAC and HBV increasingly relied on mainly ET parameters, while in VIC, deep layer parameters were most sensitive. Also when focusing on aridity, VIC relied on different types of parameters than SAC and HBV. The results of this study show that different models use different parameters that represent different processes to simulate hydrological drought. This implies that direct interpretation of dominant processes during drought cannot be based on models only, but always needs support from observations of drought related variables.