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The impact of drought on groundwater - an analysis of dynamics indices

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When dealing with drought, the primary concern is to quantify the impact of drought on the water resources we depend on most. In case of Central Europe these are groundwater resources. Most of the recent works on the impact of drought on groundwater investigated the absolute changes in observed or modeled hydraulic groundwater heads. Although investigating absolute changes is valuable, additional knowledge can be gained when taking the characteristic dynamics of change into account. In this study, we analyzed various aspects of the dynamics in hydraulic groundwater heads to characterize the responses of groundwater resources to droughts. Thereby, we used observed time series of hydraulic groundwater head from observation wells (from here on 'groundwater time series'), which are the primary source of information on groundwater systems. We define 'groundwater dynamics' as fluctuation patterns in groundwater time series and used a set of statistical indices to characterize various aspects of groundwater dynamics. Examples include Kirchner's recession constant, l-moments, Pardé coefficients or the Hurst exponent. The temporal change of groundwater dynamics indices was analysed during and after the benchmark drought events of 2003 and 2015 in a dataset of about 900 groundwater time series from southern Germany. The results show that values for indices of flashiness (i.e. Richard-Baker index) generally decrease, while values for indices of memory (i.e. Hurst exponent) increase, suggesting diminished responsiveness of groundwater systems to recharge events, and increased dominance of regional flow systems. The degree of change in dynamics as well as the time of recovery to normal conditions varies with hydrogeological controls such as aquifer depth, conductivity and distance to boundaries such as streams. The study on groundwater drought dynamics may add a different perspective to the understanding of the response of groundwater systems to drought events. The indices help to show the dependence of groundwater dynamics on particular hydrogeological controls at the gauges and may therefore guide assessments on the vulnerability of hydrological systems to groundwater drought.