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A framework for quantification of groundwater dynamics – redundancy and transferability of hydro(geo-)logical metrics

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A new framework for quantification of groundwater dynamics has been proposed in a companion study (Haaf et al., 2017). In this framework, a number of conceptual aspects of dynamics, such as seasonality, regularity, flashiness or inter-annual forcing, are described, which are then linked to quantitative metrics. Hereby, a large number of possible metrics are readily available from literature, such as Pardé Coefficients, Colwell's Predictability Indices or Base Flow Index. In the present work, we focus on finding multicollinearity and in consequence redundancy among the metrics representing different patterns of dynamics found in groundwater hydrographs. This is done also to verify the categories of dynamics aspects suggested by Haaf et al., 2017. To determine the optimal set of metrics we need to balance the desired minimum number of metrics and the desired maximum descriptive property of the metrics. To do this, a substantial number of candidate metrics are applied to a diverse set of groundwater hydrographs from France, Germany and Austria within the northern alpine and peri-alpine region. By applying Principle Component Analysis (PCA) to the correlation matrix of the metrics, we determine a limited number of relevant metrics that describe the majority of variation in the dataset. The resulting reduced set of metrics comprise an optimized set that can be used to describe the aspects of dynamics that were identified within the groundwater dynamics framework. For some aspects of dynamics a single significant metric could be attributed. Other aspects have a more fuzzy quality that can only be described by an ensemble of metrics and are re-evaluated. The PCA is furthermore applied to groups of groundwater hydrographs containing regimes of similar behaviour in order to explore transferability when applying the metric-based characterization framework to groups of hydrographs from diverse groundwater systems. In conclusion, we identify an optimal number of metrics, which are readily available for usage in studies on groundwater dynamics, intended to help overcome analytical limitations that exist due to the complexity of groundwater dynamics.

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