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Incorporation of an evolutionary algorithm to estimate transfer-functions for a parameter regionalization scheme of a rainfall-runoff model

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This contribution presents a framework, which enables the use of an Evolutionary Algorithm (EA) for the calibration and regionalization of the hydrological model COSEROreg.
COSEROreg uses an updated version of the HBV-type model COSERO (Kling et al. 2014) for the modelling of hydrological processes and is embedded in a parameter regionalization scheme based on Samaniego et al. (2010). The latter uses subscale-information to estimate model via a-priori chosen transfer functions (often derived from pedotransfer functions). However, the transferability of the regionalization scheme to different model-concepts and the integration of new forms of subscale information is not straightforward. (i) The usefulness of (new) single sub-scale information layers is unknown beforehand. (ii) Additionally, the establishment of functional relationships between these (possibly meaningless) sub-scale information layers and the distributed model parameters remain a central challenge in the implementation of a regionalization procedure.
The proposed method theoretically provides a framework to overcome this challenge. The implementation of the EA encompasses the following procedure: First, a formal grammar is specified (Ryan et al., 1998). The construction of the grammar thereby defines the set of possible transfer functions and also allows to incorporate hydrological domain knowledge into the search itself. The EA iterates over the given space by combining parameterized basic functions (e.g. linear- or exponential functions) and sub-scale information layers into transfer functions, which are then used in COSEROreg. However, a pre-selection model is applied beforehand to sort out unfeasible proposals by the EA and to reduce the necessary model runs. A second optimization routine is used to optimize the parameters of the transfer functions proposed by the EA. This concept, namely using two nested optimization loops, is inspired by the idea of Lamarckian Evolution and Baldwin Effect (Whitley et al., 1994), which might be understood as the idea that acquired characteristics during the lifetime of an individual can be transferred between generations. A hierarchical objective function is used for the model evaluation. This enables model preemption (Tolson et al., 2010) and reduces the amount of model evaluations in the early stages of optimization.
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