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Interactive model evaluation and selection via an optimization-based top-down approach using hydrological signatures

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The model selection in the context of hydrological modelling requires essential understanding about the dominant physical controls on watersheds' responses. Generally, modellers employ top-down or bottom-up approaches to identify the minimum level of complexity that reproduces the functional behavior of a watershed represented by historical data. This research formalizes an optimization-based framework for top-down model evaluation and selection, whereby a structurally flexible hydrologic model (called RAVEN) is calibrated with respect to both goodness-of-fit measures and hydrological signatures using a multi-criteria optimization algorithm. The signatures implemented in the calibration quantify the model capability with respect to different aspects of the watershed's behaviour. Therefore, starting from the simplest model structure, the modeller can monitor the information explored in the calibration process (e.g., failure in the satisfaction of the signatures corresponding to low- or high-flows) and increase the model complexity accordingly. Preliminary results suggest that the proposed top-down framework can turn into an interactive signature-based model design that enables the modeller to tune the hydrologic model so that the watershed's behaviour is fully reproduced, i.e. model outcomes meet all hydrological signatures. Applying the proposed framework to different small to large watersheds would demonstrate how physical controls vary with climate and watersheds' characteristics. Thus, multiple watersheds will be considered in this study ranging from small catchments in Canada to the Grand River Watershed with the area of 7000 km2 located in Ontario, Canada. Moreover, RAVEN is a computationally efficient hydrologic model and its multi-criteria calibration involves parallel computing, all of which significantly reduce the computational expenses of the proposed framework.