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Large-scale calibration of conceptual rainfall-runoff models for two-stage probabilistic hydrological post-processing

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Probabilistic hydrological modelling methodologies often comprise two-stage post-processing schemes, thereby allowing the exploitation of the information provided by conceptual or physically-based rainfall-runoff models. They might also require issuing an ensemble of rainfall-runoff model simulations by using the rainfall-runoff model with different input data and/or different parameters. For obtaining a large number of rainfall-runoff model parameters in this regard, Bayesian schemes can be adopted; however, such schemes are accompanied by computational limitations (that are well-recognized in the literature). Therefore, in this work, we investigate the replacement of Bayesian rainfall-runoff model calibration schemes by computationally convenient non-Bayesian schemes within probabilistic hydrological modelling methodologies of the above-defined family. For our experiments, we use a methodology of this same family that is additionally characterized by the following distinguishing features: It (a) is in accordance with a theoretically consistent blueprint, (b) allows the exploitation of quantile regression algorithms (which offer larger flexibility than parametric models), and (c) has been empirically proven to harness the "wisdom of the crowd" in terms of average interval score. We also use a parsimonious conceptual rainfall-runoff model and 50-year-long monthly time series observed in 270 catchments in the United States to apply and compare 12 variants of the selected methodology. Six of these variants simulate the posterior distribution of the rainfall-runoff model parameters (conditional on the observations of a calibration period) within a Bayesian Markov chain Monte Carlo framework (first category of variants), while the other six variants use a simple computationally efficient approach instead (second category of variants). Six indicative combinations of the remaining components of the probabilistic hydrological modelling methodology (i.e., its post-processing scheme and its error model) are examined, each being used in one variant from each of the above-defined categories. In this specific context, the two large-scale calibration schemes (each representing a different "modelling culture" in our tests) are compared using proper scores and large-scale benchmarking. Overall, our findings suggest that the compared "modelling cultures" can lead to mostly equally good probabilistic predictions.