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Can a hydrological model be efficient and robust at the same time?

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It has been shown in various experiments that many conceptual rainfall-runoff models experience difficulties to simulate annual or longer-term variations of the streamflow (e.g. Coron et al., 2014). Whether this problem is inherent to the structure of the model in question or could be solved by a change of the calibration procedure is still a matter of debate: for example, the work of Coron (2013) tended to show that no parameter set able to solve the issue can be found, while Fowler et al. (2018) argued that such parameter sets exist, and should be identifiable by a change of objective function.

The aim of this study is to explore further the existence of such a parameter set in the case of the GR4J model (Perrin et al., 2003). Parameters sets were in particular tested against their ability to provide efficient (i.e. with good performance) and robust (i.e. transposable in time) discharge simulations over three flow ranges (low, mean and high flows). To this purpose, a large number of parameters sets of GR4J were sampled in 545 French and Australian catchments. The obtained performances were confronted to those obtained with automatic calibration with a range of objective functions focusing on diverse streamflow ranges.

Because of our large catchment set, we were able to identify a variety of cases: catchments for which highly robust parameter sets exist, catchments for which relatively robust parameter sets exist, and catchments for which no robust parameter sets can be found. Compared to the best sampled parameters sets, those derived through automatic calibration often yielded poorer performances regarding at the same time efficiency and robustness of the discharge simulations over the three flow ranges. We discuss the link between model failures and catchments characteristics, as well as the ability of the GR4J model to adequately simulate streamflow on different timescales and flow regimes.