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An analysis of multiobjective calibration strategies and their implications in hydrological modelling

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A conceptual hydrological model contains several parameters that have to be estimated by a process of matching observed and modelled watershed behaviour through a calibration process. The requirement that a model simulation matches several aspects of the system response has led the calibration problem towards a multi-objective approach.

In this work we compare two multi-objective calibration approaches, each of one representative of a different calibration philosophy.

The first is an 'all at once' calibration approach, and consists of calibrating all parameters with respect to a common set of objectives in one calibration stage. This approach results in a set of Pareto solutions representing the tradeoffs between the selected objectives.

The second is a 'stepped' calibration approach, which implies a step-wise calibration of sets of parameters that are associated with a certain process behaviour. This approach replicates the steps followed by hydrologists in manual calibration and develops a 'globally optimal' parameter set.

The comparison is performed considering the same set of objectives for the two approaches, and two model structures of different level of complexity. The difference in the two approaches, their reciprocal utility, as well as the practical implications involved in their application are analysed and discussed by means of a practical example, consisting of simulating the rainfall-runoff behaviour of a watershed located in

the experimental Alzette river basin, Grand Duchy of Luxembourg.

We show that the two approaches are not necessarily conflicting but can be complementary. The first approach provides useful information about the deficiencies of a model and therefore helps the model development, while the second attempts at determining a solution that is consistent with the data available. We also show that with increasing model complexity the model becomes more accurate. For the first approach this results in narrowing the Pareto space, and for the second in reducing the distance of the solutions corresponding to the various calibration steps. This shows that the benefit of a multi-objective calibration becomes less evident when the model becomes more complex and able to simulate the system response.