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Robust estimation of hydrological parameters in the context of flood forecasting in small catchments

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Operational flood forecasting in small and fast responding catchments is a challenging task. Even more physically-based models consist of conceptual parts with hydrological parameters to be calibrated. A robust estimation of these parameters is neither straightforward nor unique. Normally this calibration task is understood as a mathematical optimization problem for a given objective, eg. the Nash-Suttcliff Efficiency criterion of the simulated and observed runoff. The hydrological parameters are adapted within their feasible range to optimize the model efficiency. The result is a single best performing single parameter set. In reality such a best performing parameter set does not exist and the calibration result depends strongly on the used data. That means for instance that possible small measurement errors are not considered and therefor parameters get overfitted. The estimated overfitted parameter sets are often not robust and fail in validation.

A new approach to deal with this problem is the ROPE algorithm. The idea of this approach is that a model calibration is not understood as an optimization procedure but as a search of many robust parameter sets. The assumption is that robust parameter sets can be found statistically deep within a cloud of good performing parameter sets. The result of this algorithm is a set of robust performing parameters. The good parameters are estimated by Monte-Carlo simulations and an objective function. Deep parameters are found by the halfspace depth which can by applied to problems with arbitrary dimension. This method can be applied iteratively with different objectives to estimate a set of multi-criterial robust parameters. Furthermore advanced problems as different dominant runoff processes for different flood events can be tackled by a pre-event classification, e.g. moist/dry conditions or advective/convective prceipitation) and a clustering of the good performing parameters in the case of a non-convex cloud. In operational mode the best suiting class for the current event can be selected to provide a good prognosis. All parameter sets of the according class are applied and it is possible to get a robust stochastic runoff prediction.

The developed approach was applied to the small test catchment Rietholzbach situated a the pre-alpine mountainous region in Switzerland. 24 characteristic storm events were selected, evaluated and classified. The physically bases rainfall-runoff model WaSiM-ETH with the Richards approach was calibrated for each event by state-of-the-art algorithms and ROPE. The resulting parameter sets were cross-validated for all events, regarding different possible classifications. The result is a more reasonable description of the runoff process in the context of storm events. This forms the base of a future flood forecasting framework considering parameter and model uncertainties in an appropriate way.