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Multi-site calibration of a distributed hydrological model

K. Schröter (1), M. Ostrowski (1), D. Muschalla (1), A. Klawitter (2), C. Velasco-Forero

(1) TU-Darmstadt, Section for Engineering Hydrology and Water Management (Contact schroeter@ihwb.tu-darmstadt.de), (2) Aquadrat Consulting Engineers (Contact a.klawitter@a2i.de), (3) GRAHI-UPC, Group of Applied Research on Hydrometeorology (Contact velasco@grahi-upc.edu)

Quantitative information about catchment internal states and fluxes are of increasing interest for water resources management and hydrological problems. Crucial factors to provide realistic predictions at internal locations of a basin are temporal and spatial patterns of precipitation along with other climatologic variables, soil types, sub-soils and prevailing soil moisture as well as land use and topography. Spatially distributed models are required to process such information and to represent catchment internal dynamics.

Yet, given the detail of spatial discretisation distributed models need large amounts of data and a high number of parameters have to be specified. Even if process parameters have a direct physical significance they can only partly be defined a priori. Owing to differences in measurement and model scale as well as sub-grid variability effective parameter values have to be determined by inverse modelling techniques for the specific application case.

The calibration of distributed models is a challenging task because of the high number of independent parameters to be estimated. Further, besides the reproduction of discharges at the catchment outlet the internal flows simulated need to be validated in order to confirm the appropriateness of the structural approximation of the model and to exclude compensation effects within the basin.

The presented work examines the value of a multi objective evolutionary algorithm for the automatic calibration of a distributed hydrological model. The model discretises the catchment in square grids which are the minimum units to represent spatial heterogeneity. For each grid cell vertical (effective rainfall, infiltration, percolation, evapotranspiration) and lateral (direct runoff, interflow, base flow) process rates are determined depending on actual soil moisture conditions. Four parameters are introduced to express land use characteristics; five parameters are required for soil moisture modelling. Parameters have to be specified for each grid cell. For runoff routing another parameter has to be specified for each type of river cross section specified.

To narrow the dimensionality of the calibration problem and at the same time preserve the spatial pattern of catchment characteristics surrogate parameters are introduced. Land use and soil parameters are related to these auxiliary parameters via functional relations and pre-specified ratios reducing the problem to seven parameters which are subject to calibration.

The optimisation approach pursued simultaneously considers discharge observations at multiple sites within the catchment for the identification of parameter values. The optimisation yields a sample of Pareto-optimum parameter sets, i.e. the simulations based on these parameter sets reproduce overall and internal system dynamics most closely in terms of the applied objective functions. The results from the multi-site calibration approach are compared with results obtained from a calibration with regard to discharge observations at the basin outlet only. The comparison is carried out for the hydrographs at the basin outlet and at the different internal sites both for the calibration events and additional validation events.

First results show that the variation range of Pareto-optimum parameter values increases for the multi site calibration approach. The evaluation of model predictive performance at internal evaluation sites indicates that the multi site Pareto-optimum parameter sets achieve a better reproduction of internal system dynamics. These preliminary results are currently substantiated by analysis of further events.