Regionalization for uncertainty reduction in flows at ungauged basins

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1. Introduction

One of the aims of the Predictions in Ungauged Basins (PUB) initiative is to reduce the predictive uncertainty in modelled flows at ungauged basins. The objective of this study is to contribute to this aim through application of a regionalization method to 56 well-gauged basins in the United Kingdom.

2. Data

Daily basin precipitation and daily mean discharge for 56 basins throughout England and Wales for the period 1980-1990 originating from the Data60UK dataset are used. Hourly actual temperature, dew point temperature and wind speed, and sunshine hours obtained at meteorological stations in England and Wales for the period 1983-1990 originating from the British Atmospheric Data Centre database are adopted for the calculation of daily basin potential evapotranspiration with the Penman-Monteith formula. Finally, elevation, basin size, land use and geological data for the 56 basins originating from the Catchment Spatial Information pages of the National River Flow Archive are used.

3. Methodology

The conceptual hydrological model HBV (Lindström et al., 1997) lumped for each of the 56 basins in England and Wales with a daily time step is used to simulate the continuous discharge regime. Calibration of HBV for 48 basins is done using Monte Carlo simulation and a multiple objective function incorporating four single objective functions: good agreement between observed and modelled discharge volumes (relative volume error *RVE*), hydrographs (Nash-Sutcliffe coefficient *NS*), high flows (*NS* for high flows *NSH*) and low flows (*NS* for low flows *NSL*).

The regionalization model comprises all relations between calibrated model parameters and physical catchment characteristics implemented in the HBV model. The calibrated basins to be included in the regionalization relations are selected based on both a *RVE* ranging from -5% to 5% and a *NS* above 0.75. Fourteen physical basin characteristics are selected based on previous research on regionalization and HBV (e.g. Hundecha and Bárdossy, 2004; Merz and Blöschl, 2004; Booij, 2005) and data availability. Relations between calibrated parameters and physical basin characteristics are established using single and multiple linear regression analysis.

Validation of the regionalization model is done for 8 basins. The model parameters for these basins, regarded as ungauged, are estimated using the established regionalization model, and moreover using optimized and default parameter values.

4. Results

The results for 17 calibration basins in Figure 1 show a trade-off between different objectives, where HBV has most difficulty with simulating low flow behaviour for these UK basins. Statistically significant single and multiple regression relations for 6 out of 7 calibration parameters have been derived. Three of these relations still are questionable on the basis of hydrological interpretation. The results for 8 validation basins in Figure 1 show that differences between the regionalization and optimized model are considerable for most basins. The default model performed better than the regionalized model for 19 out of 32 single objective functions.

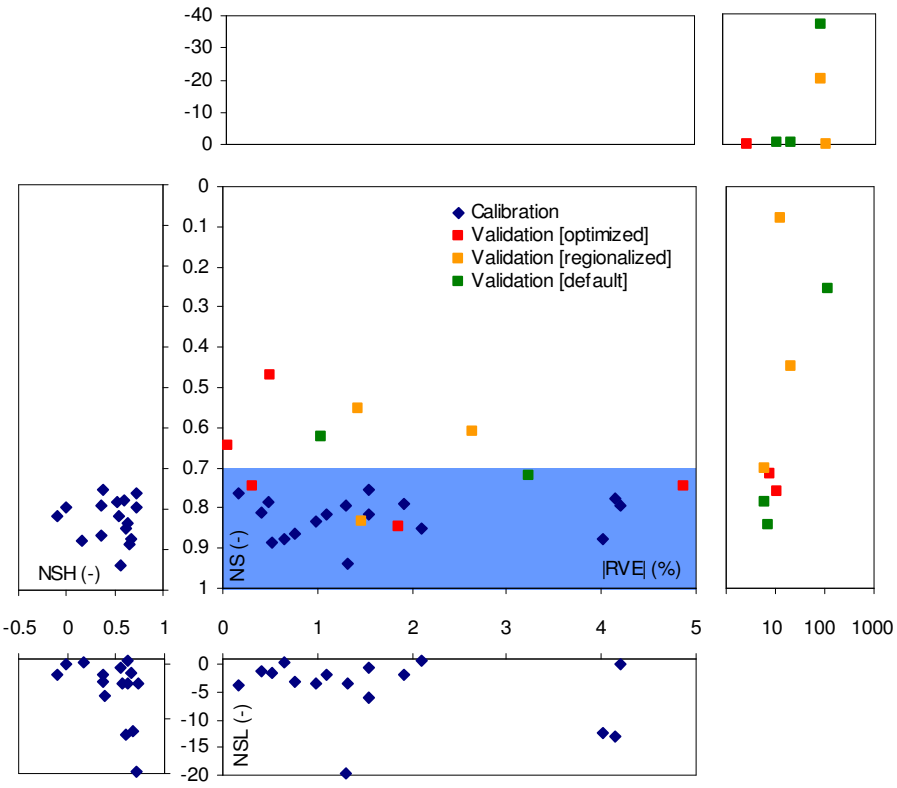

Figure 1: Objective function values (NS, |RVE|, NSL, NSH) for optimized parameter sets for 17 calibration basins and objective function values (NS, |RVE|) for optimized, regionalized and default parameter sets for 8 validation basins.

5. Conclusions

The validation of a regionalization model for model parameter estimation at ungauged basins revealed that it does not perform satisfactorily. Moreover, it can be concluded that using default parameter values seems to favour using regionalized parameter values. Therefore, the applicability of the classical approach of regionalization for HBV aiming at simulating all aspects of the hydrograph is questioned.

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