Balance between calibration objectives in hydrological modelling

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1. Introduction

Different hydrological conditions are commonly expressed by different objective functions, which can be combined into multi-objective functions for calibration purposes. However, it is generally not known which balance between objectives should be used. The aim of this study is to compare three different measures to assess the optimal balance between calibration objectives.

2. Data

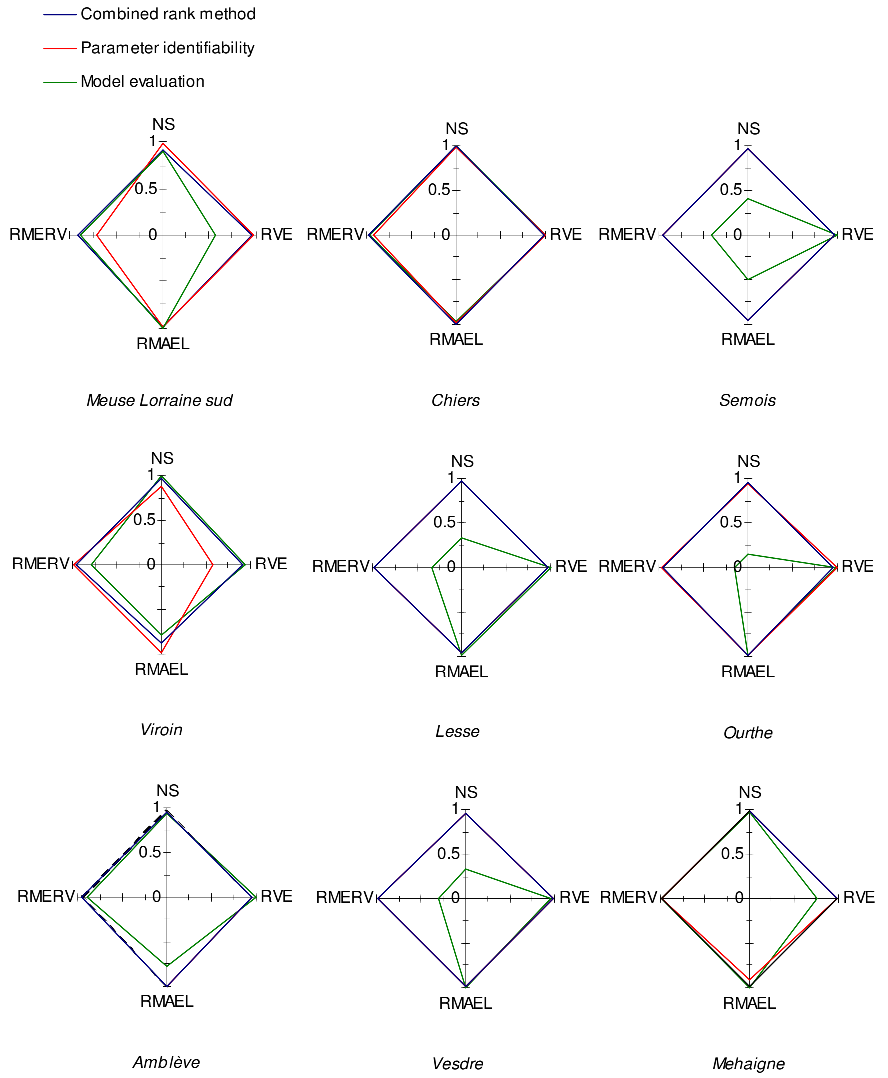
Daily spatially averaged precipitation, potential evapotranspiration and temperature, and daily mean discharge for nine catchments in Belgium and France (size between 350 and 2500 km^2) for the period 1968-1997 have been used. The precipitation, potential evapotranspiration and temperature series have been corrected for elevation.

3. Methodology

The hydrological model HBV (Lindström et al., 1997) lumped for each of the nine catchments with a daily time step is used to simulate the continuous discharge regime. This application is a modified version of the model used by Booij (2005). Calibration of HBV is done using Monte Carlo simulation.

The three measures to assess the optimal balance between different objectives are a combined rank method, parameter identifiability assessment and model evaluation. The combined rank method ranks single objective function (SOF) values in descending performance order, scales each rank number, takes the minimum of multiple scaled rank numbers for each model run and defines the optimum run as the maximum of these minima. The parameter identifiability is determined analogously to the method of Wagener et al. (2003). Model evaluation comprises the comparison of the model performance for the calibration and validation period using the average difference between SOFs from calibration and validation.

Four objectives are included in each measure: good agreement between observed and modelled discharge volumes (relative volume error *RVE*), hydrographs (Nash-Sutcliffe coefficient *NS*), high flows (relative mean error in modelling 10-year and 100-year return values *RMERV*) and low flows (relative mean absolute error in modelling low flows *RMAEL*). The contributions of these objectives to the specific measure are varied to find the optimal balance between the objectives for each measure.



Meuse Lorraine sud *Chiers* *Semois*

Viroin *Lesse* *Ourthe*

Amblève *Vesdre* *Mehaigne*

Figure 1: Balance between four objectives (water balance - RVE, hydrograph - NS, high flows RMERV, low flows - RMAEL) expressed as scaled rank number for maximum values of three measures (combined rank method, parameter identifiability and model evaluation).

4. Results

The results for nine catchments in Figure 1 indicate that differences in the optimal balance between the combined rank method and parameter identifiability on the one hand and model evaluation on the other hand are considerable. The theoretically optimal balance would be a situation without trade-off between single objectives. For some catchments and measures, this situation is almost obtained. On average, the combined rank method's performance is somewhat better than the parameter identifiability's performance (respectively 3.6% and 5.0% from theoretical optimum), where the model evaluation's performance is considerably less (22.4% from theoretical optimum).

5. Conclusions

The combined rank method results in an almost optimal balance between calibration objectives. Since the implementation of this method is less complicated than that of the parameter identifiability measure, this method is recommended for use in future studies.

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