Risks in hydrological modelling due to uncertainties in discharge determination

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1. Introduction

The aim of this study is to quantify the effect of discharge errors on the performance and parameters of a conceptual hydrological model for discharge prediction. This can direct future discharge determination methods and research, and may improve short- and long-term discharge predictions supporting flood and drought risk management.

2. Study area and data

The study area consists of two catchments in the Meuse River basin in Belgium, France and Luxembourg: the Ourthe (1597 km^2) and the Chiers (2207 km^2). Daily precipitation, temperature, potential evapotranspiration and discharge data for the period 1968-1997 are used. The meteorological series are corrected for elevation and prepared for the two catchments using data provided by KMI (Belgian Royal Meteorological Institute) and Météo France. The discharge series have been obtained from SETHY/WACONDAH (Belgium) and DIREN Lorraine (France).

3. Methods

The conceptual hydrological model HBV (Lindström *et al*., 1997) lumped for each catchment with a daily time step is used to simulate the continuous discharge regime. Calibration is carried out using the SCEM-UA algorithm (Vrugt *et al*., 2003) and a combined objective function *Y* (Akhtar *et al*., 2009) incorporating the relative volume error (*RVE*) and the Nash-Sutcliffe (*NS*) coefficient.

Two types of discharge errors are distinguished: measurement errors and errors in the rating curve. Adapted discharge time series incorporating six different error sources in discharge determination are constructed by stochastically disturbing the original observed discharge time series. The model is calibrated for the original and each of the adapted discharge series.

The quality of the adapted discharge time series is assessed using two quality functions based on similar quality functions for rainfall time series introduced by Andréassian *et al*. (2001). The first function, Quality Of Discharge (*QOD*), considers the quality of the shape of the hydrograph and is comparable with the *NS* coefficient. The second function, *BALANCE*, looks at the difference in water balance between the original and adapted discharge series and is comparable with *RVE*.

4. Results

Figure 1 shows that systematic errors (relative and absolute) and an outdated rating curve have a considerable influence on model performance, while random errors with autocorrelation have some influence and the other error sources have a negligible effect. A small positive systematic error results in a slightly larger value of *Y* compared to the original discharge series for both the Ourthe and the Chiers. In general, positive systematic errors result in a better model performance than (the same) negative systematic errors.

Results show that the effects of errors on parameters are large if the effects on model performance are large as well and vice versa. Figure 2 shows the influence of systematic relative measurement errors on the model parameters. Open symbols indicate a negative systematic error and filled symbols indicate a positive systematic error. Parameters controlling the water balance are influenced by systematic errors and parameters related to the shape of the hydrograph are influenced by random errors, although to a lesser extent.

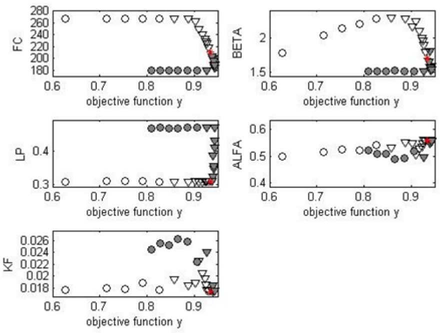

Figure 2 Relation between objective function Y and HBV model parameters for Ourthe for systematic relative errors.

5. Conclusions

Systematic errors and an outdated rating curve have a considerable influence on model performance, while random errors with autocorrelation have some influence and the other error sources have a negligible effect. The effects of discharge errors on parameters are large if the effects on model performance are large as well and vice versa.

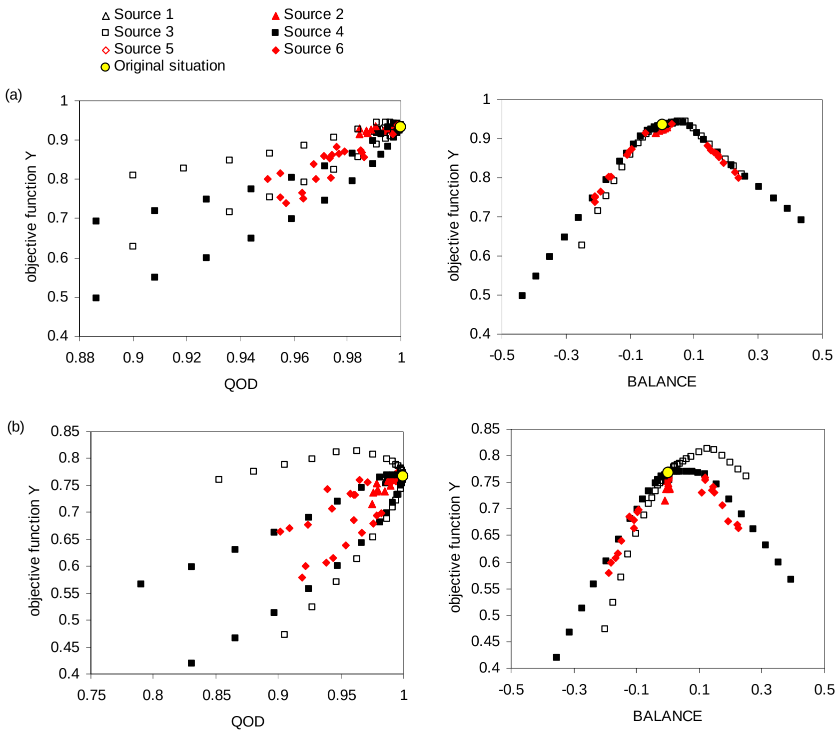

Figure 1 Effect of error sources on relations between quality functions QOD and BALANCE, and objective function Y for (a) Ourthe and (b) Chiers. Source 1: random errors without autocorrelation; source 2: random errors with autocorrelation; source 3: systematic relative errors; source 4: systematic absolute errors; source 5: errors in the rating curve caused by the properties of high water events and hysteresis effects; source 6: effects of an outdated rating curve.

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