Calibration of a Parsimonious Rainfall-Runoff Model: a Sensitivity Analysis from Local to Regional Scale

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Abstract: Using a 4.25-year calibration period and 9 sub-basins (7 to 166 km^2) located in the Alzette river basin (Grand Duchy of Luxembourg), an analysis of relationships between optimal at-site parameters (OMP) of the conceptual HRM model and physical basin descriptors (PBD) was carried out in order to compare the model efficiency obtained for four regionalization procedures. The first procedure (P1) consisted in a spatial classification of basin response into 'physical' homogeneous clusters according to the OMP-PBD relationships. The second procedure (P2) is a regression-based approach which uses regional equations between OMP and PBD. The third procedure is a lumped regional procedure (P3) which estimates simultaneously a regional parameter set for all the basins. The last procedure is based on a spatial regional approach (P4) which used the semi-distributed version of the HRM model and fits simultaneously a regional parameter set for all the basins according to their geological heterogeneity. Significant correlation with some basin characteristics and noticeably, the permeability of geological formations and land uses (forest, grassland, cropland), could be found for two of the three free model parameters. The goodness-of-fit for the procedure P1 was slightly weaker than the calibration performs on each basin individually. Among the two procedures meaningful for transposition to ungauged basins, the spatial approach (P4) was close to the individual calibration procedure, and outperformed the regionalization of lumped parameters (P2), which was nearly as poor as the lumped regional model (P3). Although these results were obtained for calibration mode only, procedure P4, with few parameter values, should provide good predictions in validation mode.

Keywords: Conceptual rainfall-runoff model; HRM model; Regionalization; Alzette basin; Luxembourg.

1. INTRODUCTION

Hydrological regionalization can be defined as a spatial classification and/or translation of hydrologically meaningful data [Hendricks, 1990]. The current research in regionalization aims at adding a spatial dimension to model parameters and thus transpose the results obtained on a local scale to a larger scale. As reported by Seibert [1999], a main difficulty in the application to basins of different sizes might be that parameter values in a lumped or a semi-distributed conceptual rainfall-runoff model are effective parameters at basin scale. Thus, it is interesting to know whether a regional parameter set which provides as accurate simulations as local ones (i.e. at basin scale) can be found. Furthermore, by looking for relationships between optimized parameter values and measurable physical descriptors, the model could be applied on non monitored basins within the region of interest for runoff prediction [Post and Jakeman, 1999]. Consequently, the existence of these relationships with objectively optimized parameters would support the physical basis of the model.

This study concentrates on 9 monitored sub-basins within the transnational Alzette basin (1176 km^2), a relatively small and fairly homogeneous region (Figure 1) from a climatic, hydrological and physiographical point of view [Pfister et al., 2000]. Using hourly rainfall-runoff series, the main goals were to apply the simple conceptual rainfall-runoff HRM model [Leviandier et al., 1994] in these basins for analysing the at-site variability of the optimal parameter values (OMP) with respect to basin attributes (PBD) and testing the sensitivity of the HRM model performance to the regionalization methods performed for its parameterisation.

The uncertainty in parameter determination influences the reliability of regional relationships between physical descriptors and optimal parameter values. A parsimonious and efficient model must therefore be used.