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Effects of temporal variability on HBV model calibration

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Abstract

This study aimed to investigate the effects of temporal variability on the optimization of the Hydrologiska Byråns Vattenbalansavedlning (HBV) model, as well as the calibration performance using manual optimization and average parameter values. By applying the HBV model to the Jiangwan Catchment, whose geological features include lots of cracks and gaps, simulations under various schemes were developed: short, medium-length, and long temporal calibrations. The results show that, with long temporal calibration, the objective function values of the Nash-Sutcliffe efficiency coefficient (*NSE*), relative error (*RE*), root mean square error (*RMSE*), and high flow ratio generally deliver a preferable simulation. Although *NSE* and *RMSE* are relatively stable with different temporal scales, significant improvements to *RE* and the high flow ratio are seen with longer temporal calibration. It is also noted that use of average parameter values does not lead to better simulation results compared with manual optimization. With medium-length temporal calibration, manual optimization delivers the best simulation results, with *NSE*, *RE*, *RMSE*, and the high flow ratio being 0.563 6, 0.122 3, 0.978 8, and 0.854 7, respectively; and calibration using average parameter values delivers *NSE*, *RE*, *RMSE*, and the high flow ratio of 0.481 1, 0.467 6, 1.021 0, and 2.784 0, respectively. Similar behavior is found with long temporal calibration, when *NSE*, *RE*, *RMSE*, and the high flow ratio using manual optimization are 0.525 3, −0.069 2, 1.058 0, and 0.980 0, respectively, as compared with 0.490 3, 0.224 8, 1.096 2, and 0.547 9, respectively, using average parameter values. This study shows that selection of longer periods of temporal calibration in hydrological analysis delivers better simulation in general for water balance analysis.

Keywords: HBV model; Model calibration; Jiangwan Catchment; Temporal variability

1. Introduction

Use of water balance models to predict upcoming low and high flow has been increasing, especially in relation to current hydrological issues, including imbalance of the water supply and demand (Xiong and Guo, 1999), climate change (Guo et al., 2002; Booij, 2005), dynamic variation of saturated areas (Bari and Smettem, 2006), and land use change (Elfert and Bormann, 2009). Through the law of conservation of mass, the relationship between water inflow, outflow, and storage in a specified catchment is mathematically derived by the water balance model, whose parameters represent the behaviors of the catchment.

The Hydrologiska Byråns Vattenbalansavedlning (HBV) model, which was developed by the Swedish Meteorological and Hydrological Institute (SMHI) in 1972, is a widely used water balance model. Its capability in conducting hydrological analysis related to the water balance is well known and it has been used in more than 30 countries (Bergstrom, 1992). Das et al. (2008) have shown strong performance of the distributed HBV model. Several important strengths of the HBV model are its physically based parameters, which are useful due to the simplicity of linking them to physical attributes; the unexcessive number of free parameters as compared with other

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