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How to constrain multi-objective calibrations using water balance components for an improved realism of model results

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Accurate discharge simulation is one of the most common objectives of hydrological modeling studies. However, a good simulation of discharge is not necessarily the result of a realistic simulation of hydrological processes within the catchment. To enhance the realism of model results, we propose an evaluation framework that considers both discharge and water balance components as evaluation criteria for hydrological models. In this study, we integrated easily available expert knowledge such as average annual values of surface runoff, groundwater flow, and evapotranspiration in the model evaluation procedure to constrain the selection of good model runs. For evaluating water balance and discharge dynamics, the Nash-Sutcliffe efficiency (NSE) and percent bias (PBIAS) were used. In addition, the ratio of root mean square error and standard deviation of measured data (RSR) was calculated for individual segments of the flow duration curve to identify the best model runs in terms of discharge magnitude. Our results indicate that good statistics for discharge do not guarantee realistic simulations of individual water balance components. Therefore, we recommend constraining the ranges of water balance components to better capture internal and external fluxes of the hydrological system, even if trade-offs between good statistics for discharge simulations and reasonable amounts of the water balance components are unavoidable.