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Predicting in ungauged basins using a parsimonious rainfall–runoff model

Thomas Skaugen (1), Ivar Olav Peerebom (1), and Anna Nilsson (2)

(1) HydrologyDept.,Norwegian Water Resources and Energy Directorate, Oslo, Norway (ths@nve.no), (2) Centre for ecological and Evolutionary Synthesis, Dept. of Biology, University of Oslo, Norway

Prediction in ungauged basins is a demanding, but necessary test for hydrological model structures. Ideally, the relationship between model parameters and catchment characteristics (CC) should be hydrologically justifiable. Many studies, however, report on failure to obtain significant correlations between model parameters and CCs. Under the hypothesis that the lack of correlations stems from non-identifiability of model parameters caused by overparameterization, the relatively new parameter parsimonious DDD (Distance Distribution Dynamics) model was tested for predictions in ungauged basins in Norway. In DDD, the capacity of the subsurface water reservoir M is the only parameter to be calibrated whereas the runoff dynamics is completely parameterised from observed characteristics derived from GIS and runoff recession analysis. Water is conveyed through the soils to the river network by waves with celerities determined by the level of saturation in the catchment. The distributions of distances between points in the catchment to the nearest river reach and of the river network give, together with the celerities, distributions of travel times, and, consequently unit hydrographs. DDD has 6 parameters less to calibrate in the runoff module than, for example, the well-known Swedish HBV model. In this study, multiple regression equations relating CCs and model parameters were trained from 84 calibrated catchments located all over Norway and all model parameters showed significant correlations with catchment characteristics. The significant correlation coefficients (with p- value < 0.05) ranged from 0.22-0.55. The suitability of DDD for predictions in ungauged basins was tested for 17 catchments not used to estimate the multiple regression equations. For 10 of the 17 catchments, deviations in Nash-Suthcliffe Efficiency (NSE) criteria between the calibrated and regionalised model were less than 0.1. The median NSE for the regionalised DDD for the 17 catchments, for two different time series was 0.66 and 0.72. Deviations in NSE between calibrated and regionalised models are well explained by the deviations between calibrated and regressed parameters describing spatial snow distribution and snowmelt, respectively. This latter result indicates the topic for further improvements in the model structure of DDD.